



Clearwater Geosciences, LLP
Ground Water Development and Exploration

Injury Assessment of Ground water Impacts for Proposed Water Rights Transfer Comore Loma Subdivision

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January 2008



Executive Summary

This report documents our efforts to evaluate the potential impacts to the Eastern Snake River Plain Aquifer (ESPA) which will result from the transfer of water rights from two properties located in Bingham County to the Comore Loma Subdivision located in Bonneville County. The total volume of water proposed to be transferred amounts to 1355.2 acre-ft/yr. Two types of impacts were evaluated: 1) the potential impacts on nearby ground water users; and 2) the potential for a reduction of aquifer recharge to the Snake River. The analysis consists of two parts; development of a conceptual model evaluating the geology, geochemistry and hydrogeology and a numerical model of the aquifer using the Enhanced Snake River Plain Aquifer Model (hereafter referred to as "the IDWR model").

In this report, the general character and nature of the ESPA is described and it is compared to local subsurface conditions of the Comore Loma site. We demonstrate through consideration of the geology, water temperature, geochemistry and water table contours that the ground water beneath the Comore Loma Subdivision is significantly different from water in the ESPA. The data presented shows that a significant volume of water recharges the Comore Loma area from the mountain front to the east. A Theis calculation using measured values of transmissivity and storativity indicate that drawdown for the proposed transfer will be very minor and there will be no measurable impacts to other ground water users.

In addition, several discrepancies based on physical measurements, chemical testing and observations are cited as evidence indicating that the IDWR model needs to be modified in the area of Comore Loma in order to adequately assess potential impacts that might be caused by the proposed transfer. The most significant discrepancy between the IDWR model and the physical evidence is the difference in water table mapping. The measured water table beneath Comore Loma is over 200 ft higher and the direction of ground water flow is about 90 degrees different than the IDWR model. Obviously, with a discrepancy of this magnitude it is not possible to make an



equitable assessment of injury to the Comore Loma area using the model without modification.

We modified the model to allow simulation of ground water flow to the proposed Comore Loma wells from the mountain front to the east. This more accurately reflects the hydrogeologic conditions that exist near the Comore Loma Property. The results indicate that the transfer will have little effect on ground water and surface water users. The maximum aquifer drawdown predicted by the model at the new point of discharge in the Comore Loma Subdivision is 0.154 feet after 100 years of continuous pumping. The effects on ground water-surface water interactions on the Snake River system were minimal, with minor declines predicted (less than 1% of the transfer volume) in the majority of reaches, while several reaches showed appreciable increases (greater than 15% of the transfer volume) in the ground water-surface water interactions.

Introduction

The Comore Loma Subdivision requires additional water to meet increasing water demands. To meet these demands, water rights will be transferred from locations within the ESPA to Comore Loma. Two water rights are currently under consideration, 953.6 acre-ft/yr from the Black Rock Property located approximately at T1S, R34E Section 4, and 401.6 acre-ft/yr from the Gneiting property located approximately at T1N, R33E Section 35 and T1S, R33E Section 2. The proposed new point of diversion in the Comore Loma Subdivision is located in T1N, R39E Section 6. Figure 1 shows the location of the of the Black Rock, Gneiting, and Comore Loma properties.

There are two main concerns when transferring water rights: 1) *Will the new point of diversion adversely affect or injure nearby ground water users?* Specifically, will withdrawing water from the aquifer at the new point of diversion cause excessive declines in the water table such that nearby users will need to lower pumps, deepen wells, or be burdened with increases in electrical costs from lifting water from greater

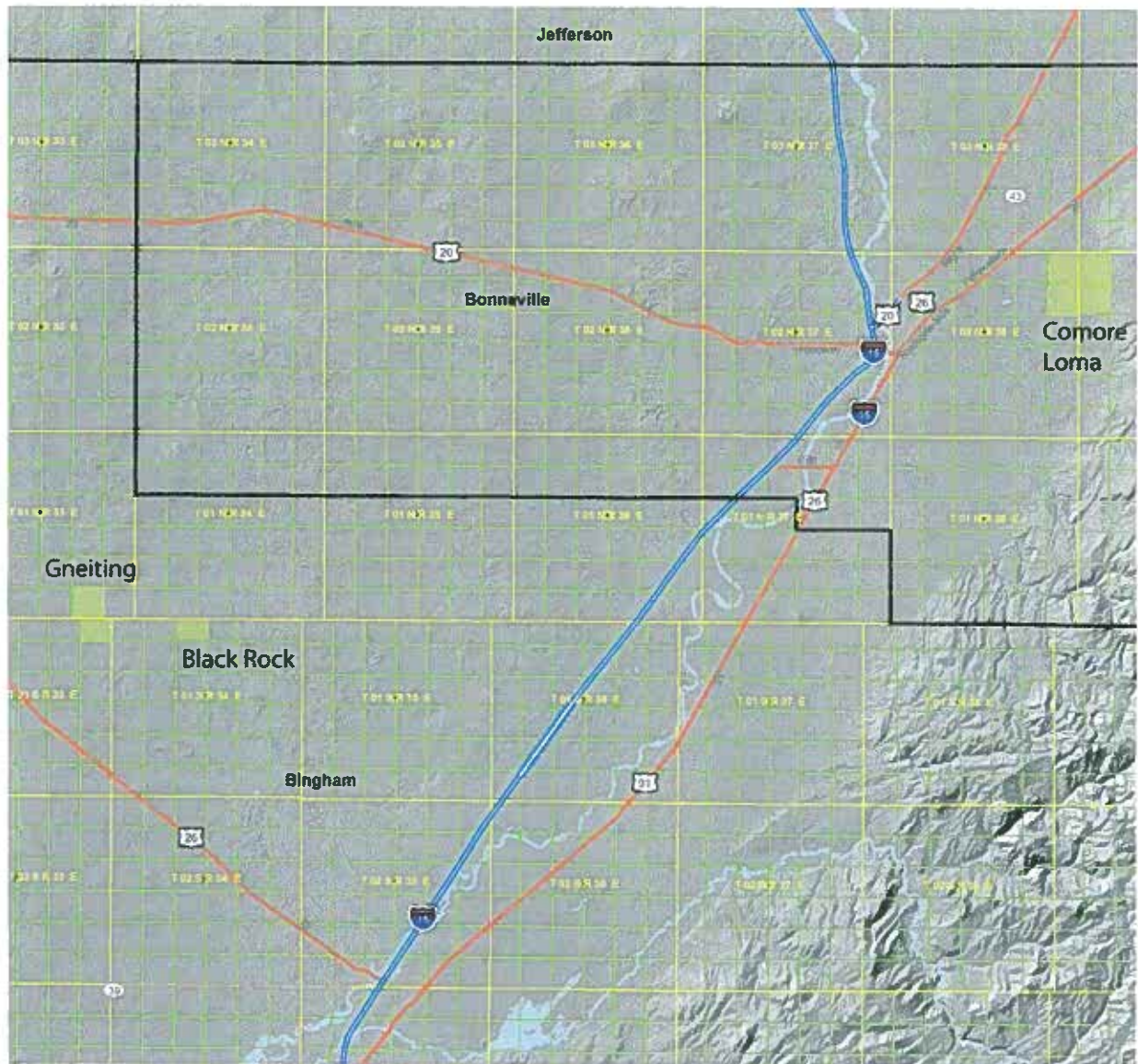


Figure 1. Location of the points of diversion for the water rights under consideration for the transfer.



depths? 2) *Will the new point of diversion have a significant and measurable effect on surface water flows in the Snake River System?* Changes in ground water-surface water interaction resulting from the transfer have the potential to impact surface water users if the transfer causes significant changes in the relationship between the aquifer and river system, e.g., decreased flows in the Snake River.

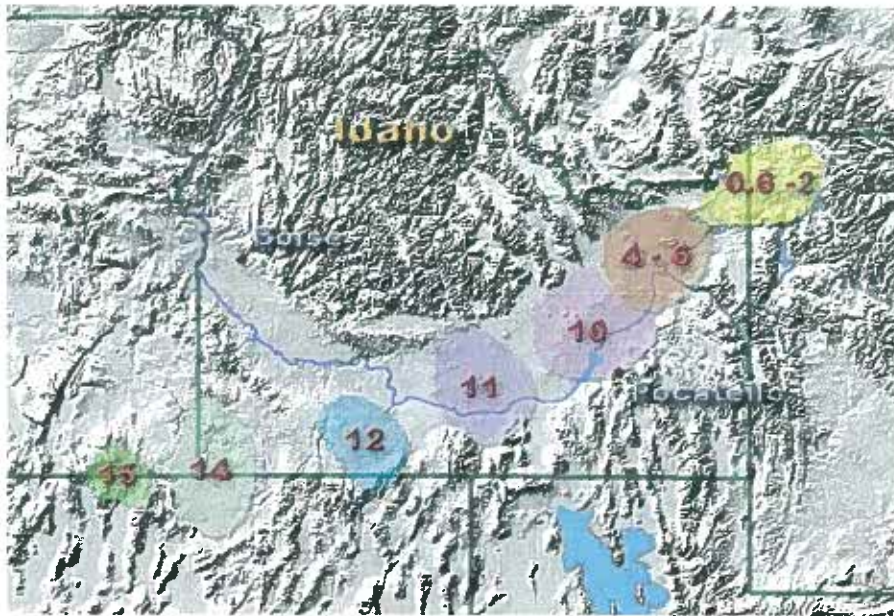
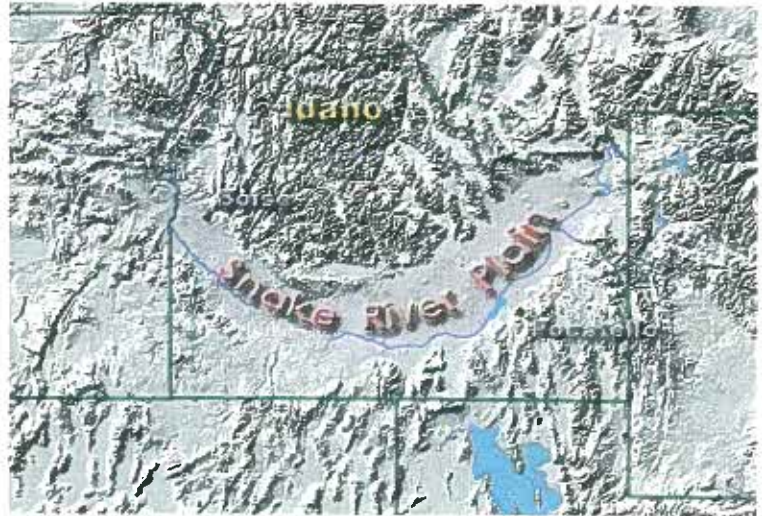
We begin our investigation by describing the physical, chemical and hydrological framework or conceptual model of the aquifer. This understanding is compared to the IDWR model and several discrepancies are identified. These data are also used to make predictive estimates of injury to nearby users using an analytical technique. The conceptual model is the basis for the numerical model and is used to guide the required modifications to make improvements to better understand the potential impacts from the proposed transfer. The second part of the report describes in detail our modeling effort. We conclude with predictive calculations of the actual impacts to be expected to ground water and surface water from the proposed transfer.

Hydrogeologic Conceptual Model

A hydrogeologic conceptual model of the aquifer has been developed for the subsurface beneath the area of Comore Loma subdivision based upon data available from previous reports and studies, data available from driller's reports for wells, water levels, water chemistry testing and other information. The conceptual model provides the framework for constructing the numerical simulation of ground water flow to be presented later in this report. This section of the report will discuss the geology, water levels and water chemistry.

Geology

Comore Loma is located adjacent to the eastern edge of the Snake River Plain east of Idaho Falls, Idaho, about 160 feet above the surface of the Plain. The Snake River Plain extends 400 miles (650 km) westward from northwest Wyoming to the Idaho-Oregon border (Figure to right). It is a broad, flat arcuate depression which is concave to the north and covers one quarter of the state of Idaho.



Elevations on the Snake River Plain decrease from the east (4,400-5,000 feet) to the west (2,950-3,900 feet). Features within the Snake River Plain become younger to the east. For example, calderas

become progressively younger from west to east. The eastern Snake River plain traces the path of the North American plate over a geologic hot spot, (upwelling magma from the earth's mantle) now centered in Yellowstone National Park. The figure above shows the location of calderas and age in millions of years. The eastern



plain cuts across Basin and Range Mountain structures, more or less parallel to North American plate motion.

The Snake River Plain has been profoundly affected by its ride over the Yellowstone hotspot during the past few million years. First, the middle crust was intruded and partially melted by mantle-derived basaltic magmas. This led to emplacement of large silicic magma chambers at very shallow depth and to violent caldera-forming rhyolitic eruptions. Then, as the area moved southwestwardly off of the hotspot, subsidence of the surface produced the elongate base of the Eastern Snake River Plain and persistent basaltic volcanism filled the basin with a thickness of up to 5000 feet or more of basalt lavas. At the same time, erosion of the surrounding mountains provided alluvial, lacustrine, and eolian clastic sediment to the basin to form sedimentary interbeds within the thick basaltic lava flow sequence (Smith, 2004).

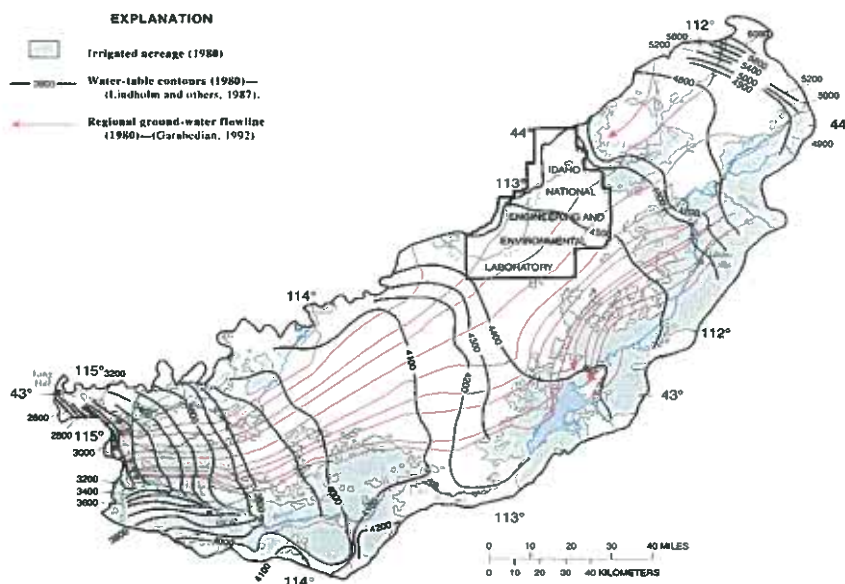
Ground water

The geologic history of the Eastern Snake River Plain created a complex system of interfingering, interlayered and transitional basalt and sediment layers creating the framework for the Eastern Snake River Plain aquifer (ESPA). Contacts between basalt flows commonly form rubbly interflow zones capable of transmitting large quantities of ground water. In contrast, flow interiors are massive, with diminished transmissivity. Hydraulic properties are controlled by flow thickness and number of interflow zones. Hydraulic conductivity is increased where basalt flows are thin and interflow zones are numerous. Conversely, hydraulic conductivity is decreased where basalt flows are thick and interflow zones are limited. Flow through this integrated system is anisotropic and heterogeneous with maximum ground water flows occurring horizontally.

Sedimentary deposits accumulating on the Snake River Plain between volcanic eruptions formed interbeds with thicknesses that can exceed 50 ft in places and consist of clay, silt, sand, and gravel. Sedimentary interbeds within the ESPA affect

ground water flow because they occupy interflow zones and typically reduce the permeability of those zones. The hydraulic effect of these interbeds is correlated to their vertical and areal distribution.

The active thickness of the ESPA is defined as that thickness through which most ground water flow occurs. The active thickness, estimated from borehole, electrical-resistivity, and water-temperature data, likely ranges from about 300 to more than 1,200 ft. Altered and mineralized basalts beneath the section of active ground water flow are characterized by greatly reduced permeability. Aquifer testing and associated ground water flow modeling assessments have indicated widely varying but generally high to very high transmissivity values in the range of 10,000 to 1,000,000 ft²/day.

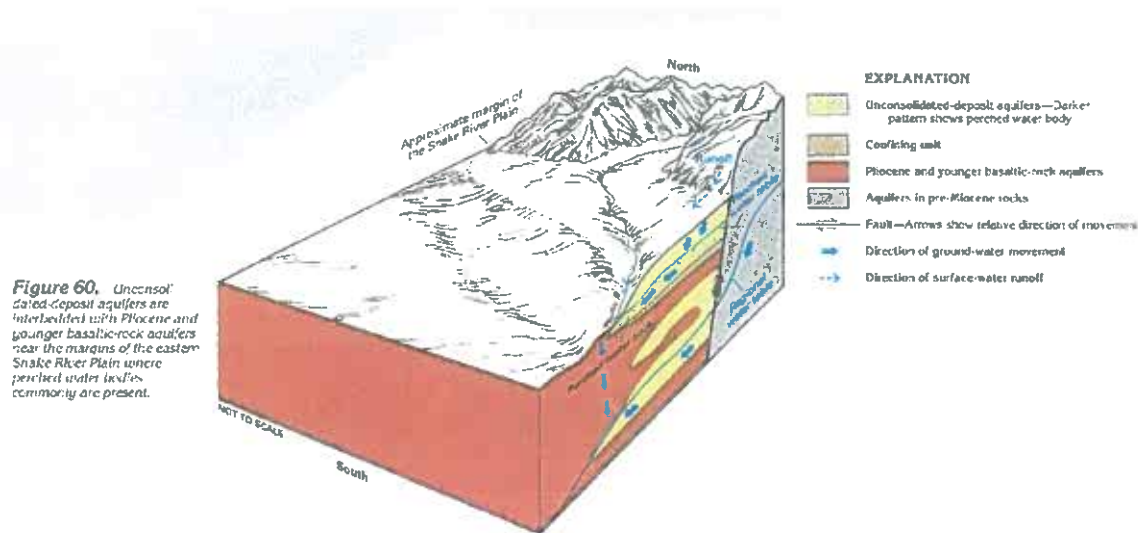


Ground water flows from northeast to southwest across the plain. The potentiometric surface drops 2,000 feet along a 190 mile flowpath (Wood and Low, 1986). However, the hydraulic

gradient is not uniform. Where the aquifer has a higher transmissivity the water table is flatter, where the aquifer transmissivity is low the hydraulic gradient is steeper. In the water table map above steeper gradients are where the contours are closer together (e.g. near Mud Lake).

The boundaries of the ESPA are described by the boundaries of the Eastern Snake River Plain. This is generally prescribed by contact of the Quaternary and Tertiary

volcanic rocks and sediments with lower permeability, crystalline rock. A conceptual diagram of this contact is shown below. The surface of the water table outside the boundaries of the ESPA is typically much steeper than the water table gradient of the ESPA.



Geology and Hydrology near Comore Loma

Comore Loma is located along the contact of the Snake River Plain and the western portion of the Idaho-Wyoming Overthrust Belt (Link, 1982). The site is located on the northern end of the Blackfoot Mountain Range, a north-south trending mountain range consisting of Paleozoic and Mesozoic sedimentary bedrock units and Cenozoic welded volcanic tuffs with associated ash deposits (Mansfield, 1952). These volcanoclastic deposits were emplaced during numerous volcanic events throughout the late Cenozoic.

Regional geologic formations consist of slightly lithified, clastic sediments of the Pliocene Salt Lake Formation, interbedded with rhyolitic tuff and volcanic ash. These older sediments are overlain by wind-blown sediments which also contain some volcanic interbeds. Isolated outcrops of volcanic tuff and ash are present in road cuts along Bone Road and Sunnyside Road east of Comore Loma. A hillside



consisting of exposed Triassic limestone, sandstone and shale is present approximately 3 miles east of the site along Sunnyside Road.

Seven wells have been drilled for the subdivision, six are production wells and the seventh is a test well. A map showing well locations for Wells 1 through 4 and a cross-section are presented in Figures 2 and 3 (from Hubbell, 1991).

Comore Loma Pumping Tests

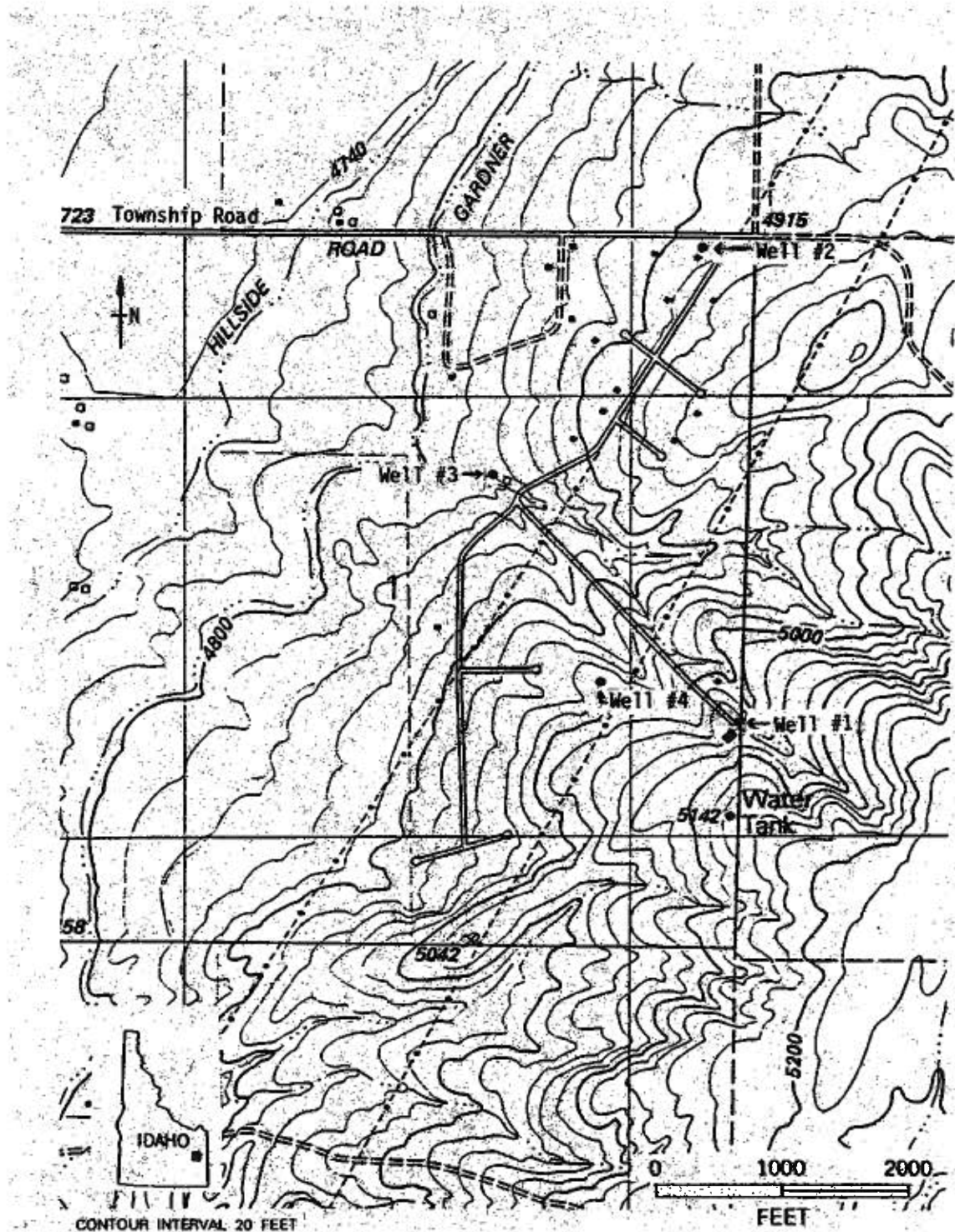
In recent years, pumping tests have been conducted in six nearby wells for certification as Idaho public water supply wells. Pumping test data from these wells, which are within a mile of Comore Loma, are presented in Table 1. The lithology in these wells consists primarily of fractured rhyolite and this geologic material is consistent with the aquifer beneath Comore Loma. The average pumping rate was 853 gpm with an average drawdown of 29 feet. The water temperature ranges from 66 to 79 degrees F, which is significantly warmer than waters typically encountered in the ESPA (~50 deg F).

Table 1 Summary of pumping test data for six nearby wells.

Well Name	flow rate gpm	duration hours	Temp. F	drawdown	Transmissivity ft ² /day	K ft/day	storativity
Comore #4	850	8	71	12	140,000	1,300	
Comore #6	1,500	24	75	53	66,000	660	
Falcon Ridge 1	395	6	66	2	130,000	2,063	
Falcon Ridge 2	395	6	66	1	121,000	1,920	
Black Hawk 1	725	5	79	19	80,000	8,900	
Black Hawk 2	1,250	24	79	85	1,100	10	0.021
Average	853	12	73	29	89,683	2,476	

The average transmissivity for the six wells is 90,000 ft²/day. The only test with an observation well measured a storativity of 0.021, which is typical for a fractured rock aquifer.

Figure 2 Map of Wells 1 through 4 for the Comore Loma Subdivision (from Hubbell, 1991)



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Potential Impact to Nearby Ground Water Users from Pumping

Estimates of drawdown can be made using analytical methods. The Theis method has been selected for calculating drawdown because 1) it is a standard method employed by many hydrogeologists, and 2) it will over-predict impacts because it assumes confined condition (i.e. the actual impact to nearby users will be less). To estimate the long-term impacts from pumping water for the proposed transfer the average pumping rate over a years time is calculated. The average flow rate for pumping 1355 ac-ft per year is 840 gpm. The calculated drawdown versus distance after 100 years of pumping continuously at 840 gpm using the average transmissivity and the storativity is presented in Figure 4. One foot of aquifer drawdown is predicted at a distance of 3.1 miles from a pumped well and a drawdown of 2 ft is predicted at 540 feet. The USGS Spreadsheet Program based on the Theis Method (Halford and Kuniansky, 2002) was used to make the calculation. This analysis indicates that a large broad cone of depression will be created in the aquifer and drawdown of one to two feet is insignificant for ground water users in the area.

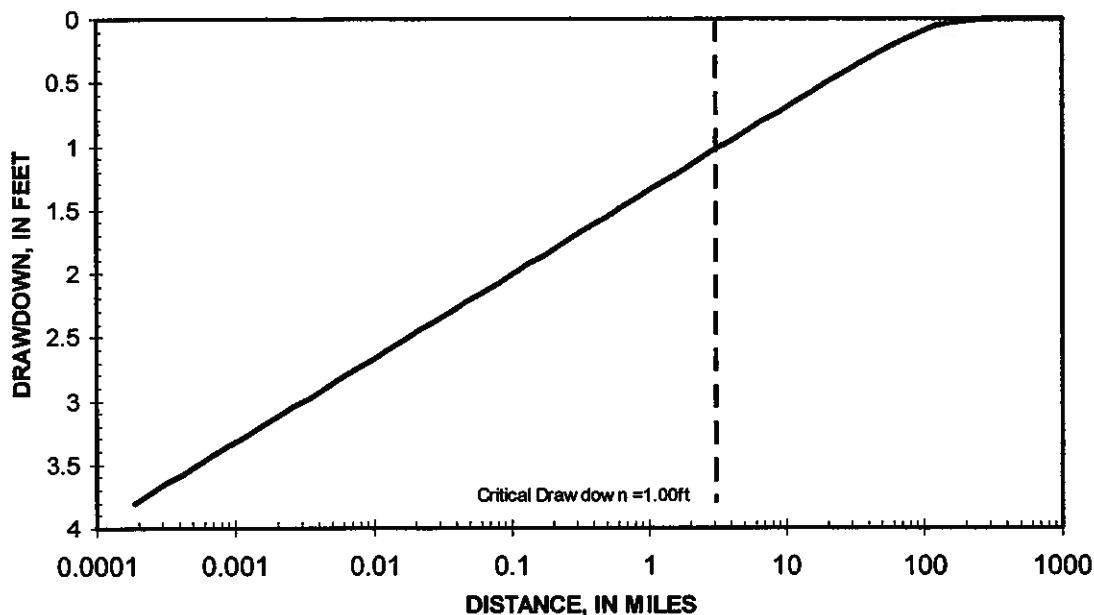


Figure 4. Predicted drawdown versus distance for pumping of a single well at 840 gpm for a period of 100 years.



Comore Loma water levels

Water levels in wells provide one of the best diagnostic tools available for characterizing aquifer flow and the connection of water bearing units within and between aquifers.

Water levels in wells in and around the Comore Loma subdivision were studied to better understand ground water flow and aquifer interaction. Due to the higher elevation of the subdivision and the nature of the rocks underlying the subdivision, there is some question of how ground water in this area interacts with the ESPA. Water levels measurements in wells were evaluated to prepare a water table map.

As a first step in preparing a water table map, water level data must be reviewed and a means developed so that measurements taken over a period of years can be correlated and contoured. Most of the available data comes from well drillers' logs and water levels recorded at the time of well drilling. These data were collected at different seasons of the year and across several decades. It is well known that aquifer water levels fluctuate on annual and longer cycles, making comparisons across different time periods problematic. It is important, therefore, to assess the variability of water levels in wells both on an annual scale and over the course of many years. Due to agricultural activities in this area, many wells exhibit large intra-annual changes corresponding to growing seasons where ground water is either being depleted through pumping or surface water in canals is recharging the aquifer.

Figure 5 shows the locations and hydrographs for wells selected as representative of aquifer conditions in the area. The red well (2N 38E Sec16) in Figure 5 has many water level measurements that show long-term and short-term aquifer water level trends. This well is 6 miles west of Comore Loma located on the Snake River Plain near the Crow Creek Irrigation Canal. Water in canals occurs during the summer irrigation season. This well exhibits consistent 20-ft annual fluctuations with peak levels occurring in the fall at the end of canal use and lowest levels occurring in mid-Spring just before water comes into the canal.

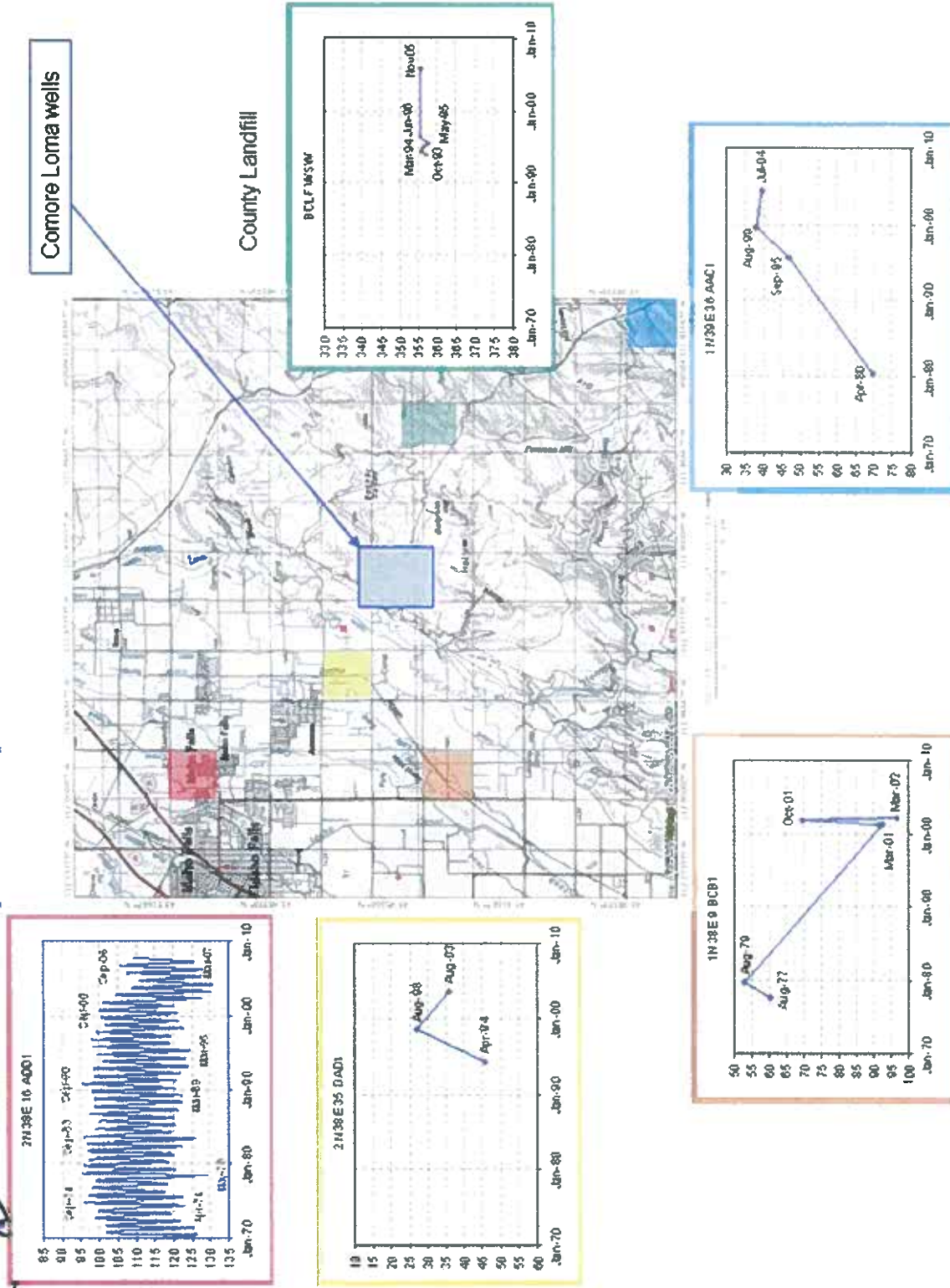


Figure 5. Colored-coded hydrographs of water level data from selected wells within a 144 square mile area covering Townships 1N-2N and Ranges 38E-39E and centered approximately on the Comore Loma subdivision.

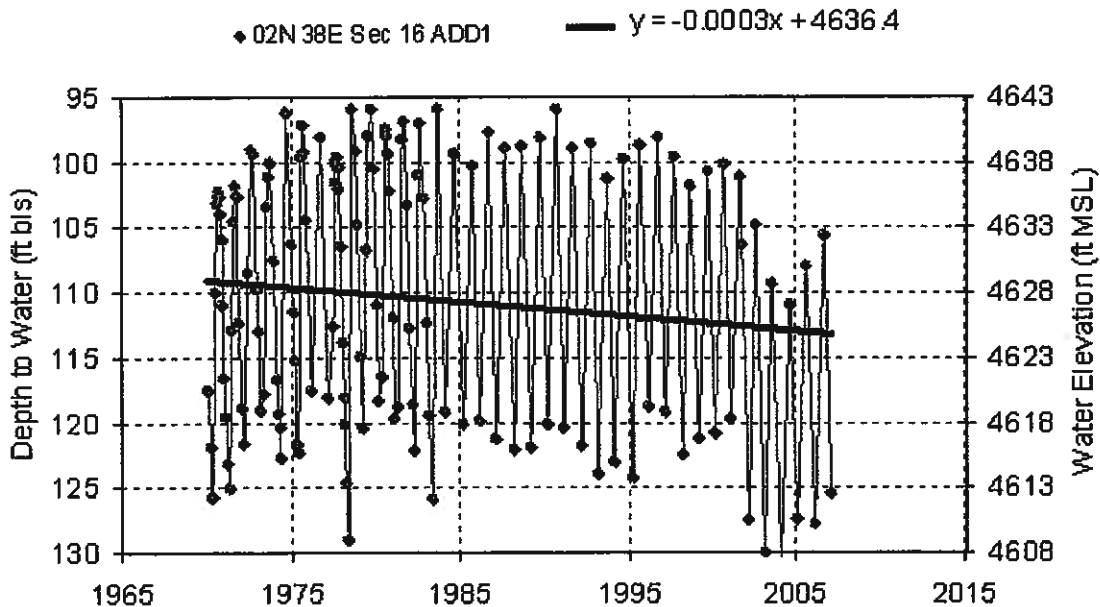


Figure 6. Hydrograph of red well in Figure 1 (2N 38E Sec 16) fitted with long-term trend line and showing equation with small (0.1 ft/yr) negative slope.

The long-term trend in the red well over 37 years is a drop of 4 feet, or approximately 0.1 ft/yr (4 ft in 37 years). This same trend is observed in many ESPA wells that are near agricultural areas where irrigation practices have converted from flood irrigation to sprinkler irrigation. Figure 6 shows a detail of this well's hydrograph with a long-term trend line fitted to it and the equation for the trend line.

Wells near Comore Loma do not have years of recorded water levels like the previously discussed red well. Four wells with the best records are shown in Figure 5. The yellow and orange wells (2N 38E Sec 35 and 1N 38E Sec 9, respectively) are both located at lower elevations than Comore Loma along the margin of the plain; these reveal some long-term changes and, at least with the orange well, intra-annual changes. Both show declining levels over time. The orange well also shows about a 25-ft change between October 2001 and March 2002.

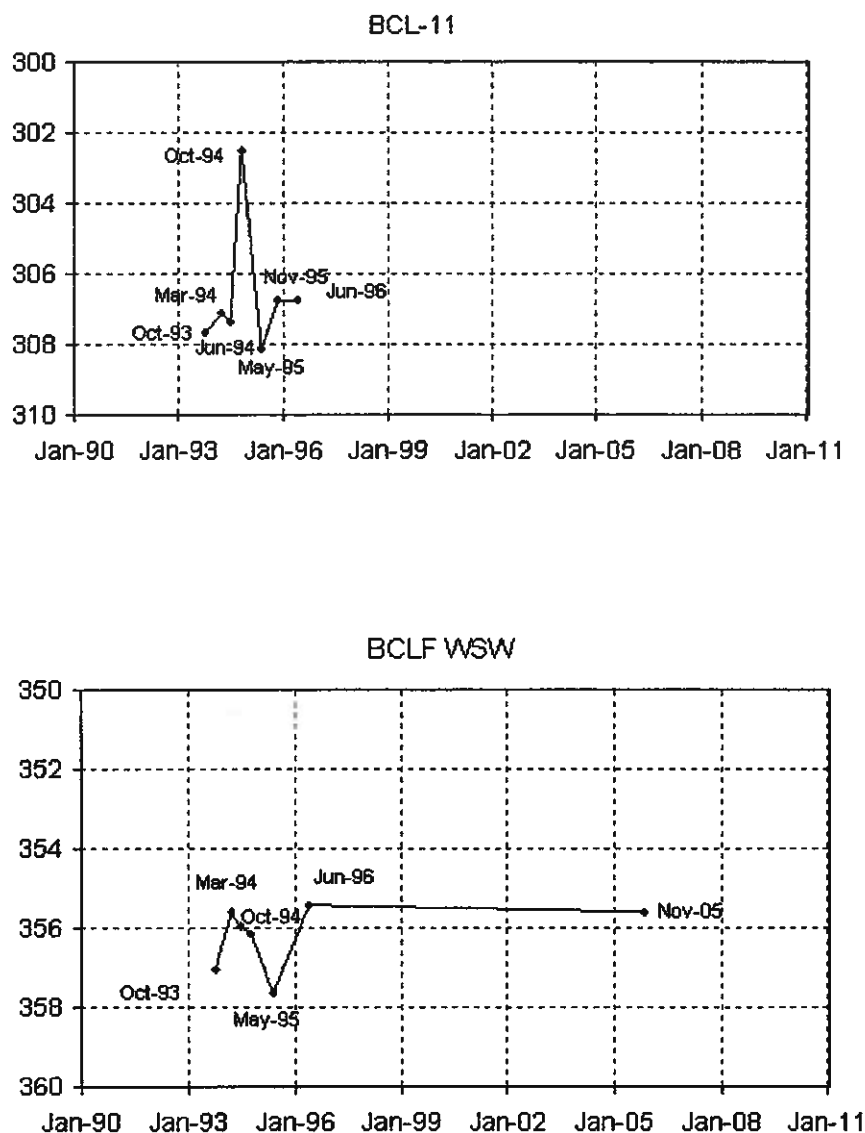


Figure 7. Comparison of two deep wells located above Comore Loma at the Bonneville County Landfill. BCLF WSW is the water supply well for the landfill and BCL-11 is a deep monitoring well. Water levels are depths below casing top (feet below land surface).



The blue well (1N 39E Sec 36) in Figure 5 is located southeast and uphill from Comore Loma. This well shows non-conformable water level history, which suggests the well may draw water from either a perched aquifer or a shallow aquifer not well-connected with the regional ground water system. The green well, to the east of Comore Loma, is the water supply well for the Bonneville County Landfill and shows unusually flat water levels over time. This well is compared in Figure 7 with a deep monitoring well located at the same landfill. The wells show some intra-annual fluctuations but appear to be out of phase with each other. The landfill water level data were only lightly regarded in constructing a water table map of the area because of the unusual hydrograph pattern over time. The hydrograph analysis proved to be of limited value because of few measurements in wells and the non-ideal or lack of apparent trending in the data. Wells were selected to try to reduce the range in dates for water levels to the same decade, centering on the year 1997 which is approximately the mid-point between recent drought and wet periods. Also, where possible, wells with recorded fall or winter water levels were given priority in selection in order to be seasonally consistent.

Thirty-seven wells were selected for use in constructing a water table map (Table 2). Figure 8 shows contour lines based on the water levels in these wells (converted to water table elevation). The contour lines are in feet above mean sea level and at 25-ft intervals. The water table beneath Comore Loma slopes steeply from the east to the west at a gradient of about 75 ft/mile.

Water Chemistry in the Comore Loma Area

The Comore Loma #6 well was recently sampled for major ions to evaluate the source of water in the well. The data for Comore Loma #6 was compared to data (USGS data and Maxim Technologies, 1997) for other wells in the vicinity as shown on Figure 9 and the data listed in Table 3. Water sources are often differentiated using the relative proportions of the major ions or salinity (specific conductance) as shown on a Piper Diagram (Figure 10). Note that most wells to the west of the Comore Loma #6 well plot in a small area on the Piper diagram. These wells are on the Snake River Plain. The piper diagram suggests that the Comore Loma # 6 well is not in the ESPA. However, this analysis assumes that other anion sources have not overprinted the wells sampled. Age dates completed on the wells near the Bonneville county landfill indicated

ground water ages of 650 to 1800 years, suggesting that the anion concentrations have not been altered by anthropogenic activities (Maxim Technologies, 1997).

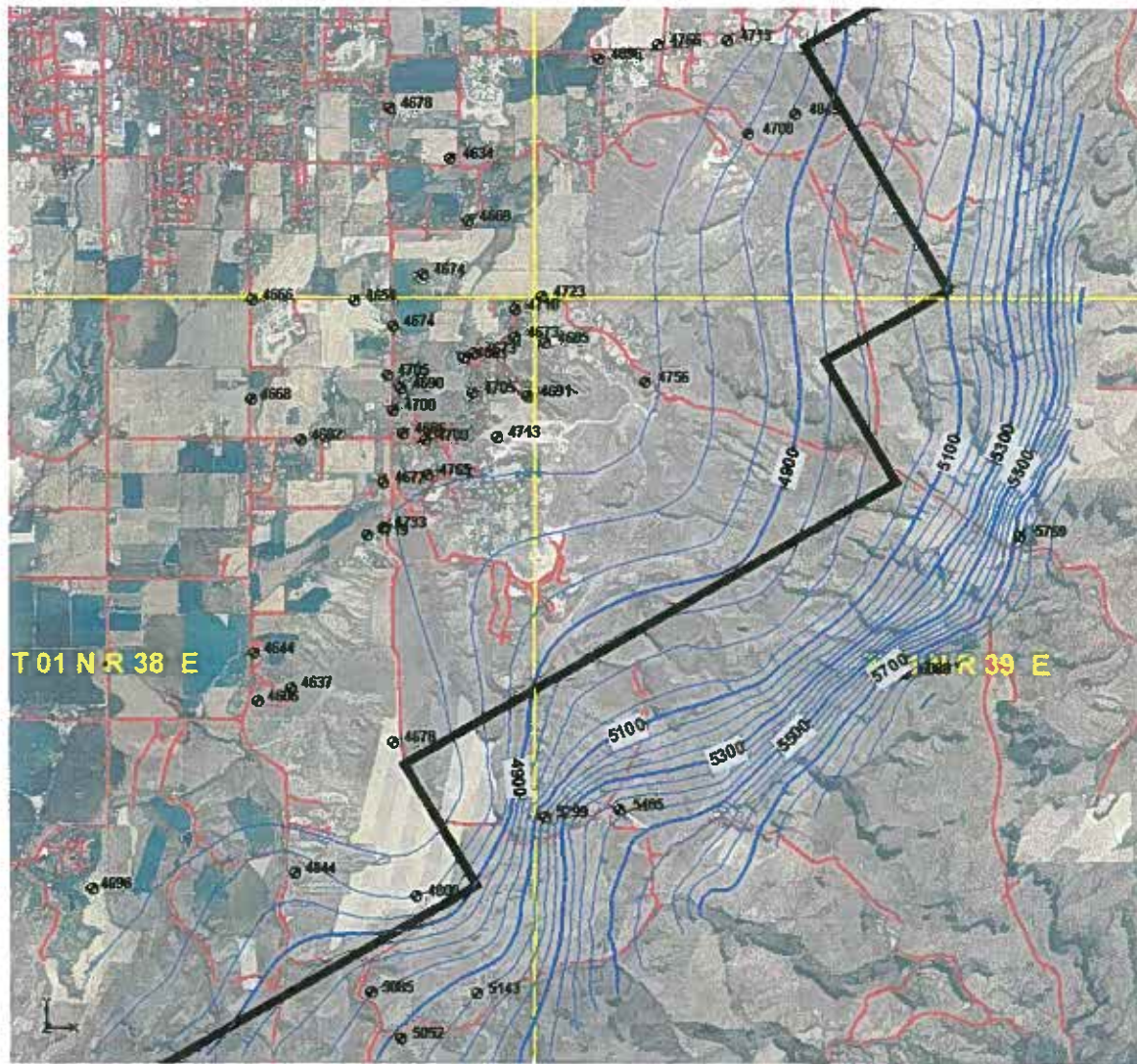


Figure 8. Contour map of the water table beneath the Comore Loma subdivision. Contours are feet above mean sea level (NGVD29) with intervals of 25 feet.

Configuration roughly represents 1997 conditions. Thirty-seven water level data were used in the map with dates ranging from 1973-2007; ten of these data range from 1996-1999 (see Table 2).



Table 2. Data for wells used to prepare maps in Figures 4-8 (all values are feet).

Map Name	Well Name	Land Elevation	Well Depth	Static Water Level (SWL)	Water Table Elevation	Date of SWL
7	HOLT, R W	4792	168	92	4700	Oct-92
8	WRIGHT, JOEL	4790	200	100	4690	Oct-98
9	MC COULEY, DUTTON	4744	162	70	4674	Aug-02
10	L D S CHURCH AMMON WARD	4708	288	42	4666	Sep-02
11	GRAYSON, STEVE	4750	100	45	4705	Nov-98
12	BRABEC, JOHN	4708	134	40	4668	Sep-98
13	JUDY, BRYCE	4822	240	150	4672	Nov-00
14	LEWIS, LARRY	4742	140	60	4682	Mar-06
15	COOK, BOB, POLO CLUB ESTATES	4830	360	130	4700	Sep-00
16	BURLKE, RICHARD	4910	205	145	4765	Oct-73
17	MAHERAS, JOHN	4944	180	138	4806	May-86
18	WEATHERSTONE, RICHARD	4808	304	164	4644	Jul-02
19	RATZLOFF, KEN	4937	420	300	4637	May-98
20	WASDEN, JEFF	4876	343	270	4606	Aug-98
21	SELLARS, GREG	5139	590	522	4617	Oct-05
22	BALL, ROGER	5013	448	328	4685	Nov-03
23	JOHNSON, MARK	4728	120	50	4678	Nov-00
24	ANDERSON, ETHAN	4744	190	110	4634	Dec-00
26	FRASER, JIM	4744	160	75	4669	Dec-97
27	KINGHORN CONSTRUCTION	4734	120	60	4674	Dec-01
28	LUJAN, HENRY	4843	220	143	4700	Sep-96
29	DENNING, MICHAEL R.	4816	248	120	4696	Oct-06
30	SUN DEVELOPMENT	4898	302	193	4705	Apr-06
31	POWELL, RICHARD R	4801	240	140	4661	Jun-98
32	POWELL, RICHARD R	4826	228	140	4686	Jun-91
33	JOHNSON, MARK	4724	200	70	4654	Mar-04
AMMON	CITY OF AMMON, WADSWORTH, DAN	4890	500	124	4766	Aug-01
BCLF	COUNTY OF BONNEVILLE LANDFILL	6122	440	353	5769	Oct-93
BLCKH1	MORGAN CONSTRUCTION	4858	270	125	4733	Oct-99
BLCKH2	BLACKHAWK VENTURES LLC	4849	320	130	4719	Jul-06
CL1	SKIDMORE, DICK	5061	450	370	4691	Oct-73
CL2	SKIDMORE, DICK	4930	295	220	4710	Nov-73
CL3	SKIDMORE, DICK	4849	323	176	4673	Jul-76
CL4	COMORE LOMA WATER CORP	4981	512	308	4673	Jul-91
CL5	COMORE DEVELOPMENT INC	5025	520	312	4713	Jun-97
CL6	COMORE LOMA DEVELOPMENT	4975	408	252	4723	Jan-06
CL7	COMORE LOMA DEVELOPMENT INC	5296	730	540	4756	Mar-07



Table 3. Data used for Comore Loma Geochemical Evaluation.

SampleID	Location	Date	Conductivity umhos/cm	Sodium mg/L	Potassium mg/L	Magnesium mg/L	Calcium mg/L	Fluoride mg/L	Chloride mg/L	Sulfate mg/L	Nitrate mg/L-N	Bicarbonate mg/L
01N 37E 11DAD1		6/26/2002	571	17.3	4.39	20.8	66.4	0.3	13	36.3	2.18	274
01N 38E 09BBC1		8/27/2002	600	18.1	4.76	21.9	69.1	0.3	18.8	38.9	2.75	303
01N 39E 14DCC1	S Bagger Creek	7/22/1957	382	12.0	2.80	13.0	46.0	0.20	16.0	9.1	--	200
02N 38E 01DAC1		12/7/1979	599	29.0	4.50	19.0	64.0	0.20	27.0	40.0	1.50	280
02N 38E 01DAC1		9/7/1992	649	22.0	5.30	23.0	79.0	0.3	23.0	49.0	3.30	315
02N 38E 16ADD1		12/7/1979	590	24.0	4.10	19.0	67.0	0.20	21.0	42.0	2.00	280
02N 38E 16DDC1		11/30/1979	579	23.0	4.10	19.0	65.0	0.20	19.0	42.0	2.00	290
02N 38E 18CBC1		8/27/2002	530	12.4	2.92	18	69.9	0.3	11.9	39.6	1.93	253
02N 38E 18CBC1		8/26/2003	528	13.7	3	18.8	69.7	0.33	11.9	38.4	1.81	332
02N 38E 18CBC1		8/30/2004	520	13.9	3.2	19	75.3	0.3	11.6	40.7	1.93	267
02N 38E 18CBC1		9/10/1998	519	15	3	19	66	0.35	11	35	2.22	260
02N 38E 27ACB1		12/5/1979	621	26.0	4.60	21.0	69.0	0.20	24.0	42.0	2.00	290
02N 38E 28ACC1		6/27/1972	259	6.40	2.20	8.00	36.0	0.40	4.0	17.0	0.010	140
02N 38E 30BAC1		8/26/2003	559	21.1	4	19.5	66	0.33	20.4	37.6	2.05	230
02N 38E 30BAC1		8/13/1998	573	22	3.8	19	66	0.34	19	35	2.25	240
02N 38E 35DAD1		8/25/2003	600	22.5	6.5	26.6	61.4	0.34	23.9	41.7	1.52	295
02N 38E 35DAD1		8/14/1998	598	21.8	6.15	26.8	57.4	0.35	19.7	33.7	1.72	281
02N 39E 05CCC1		12/7/1979	598	30.0	0.8	19.0	64.0	4.40	21	34	1.50	290
02N 39E 18ADA1		8/29/2002	612	37.2	5.27	25	46.8	0.3	45.5	38.1	1.43	236
02N 39E 30ADA1		1970-07-16	586	--	--	--	--	--	57.0	--	2.8	--
02N 39E 31	Comore Loma #6	3/31/2006	760	--	--	13	44	0.5	--	--	1.0	170
02N 39E 31	Comore Loma #6	11/7/2007	647	60	11	17	55	--	75	40	1.7	247
BCL-11	BCL-11	11/9/1995	305	0.5	2	17	54	0.18	14	2.5	--	231.11
BCL-2	BCL-2	11/9/1995	890	32	4	77	62	0.79	148	60	--	346.06
WSW	WSW	11/9/1995	324	0.5	2	14	48	0.16	11	2.5	--	225.06
01N 38E 01CDC1		8/23/1994	1760	69.0	10.0	82.0	160	0.20	280	180	5.00	360

"--" means no data

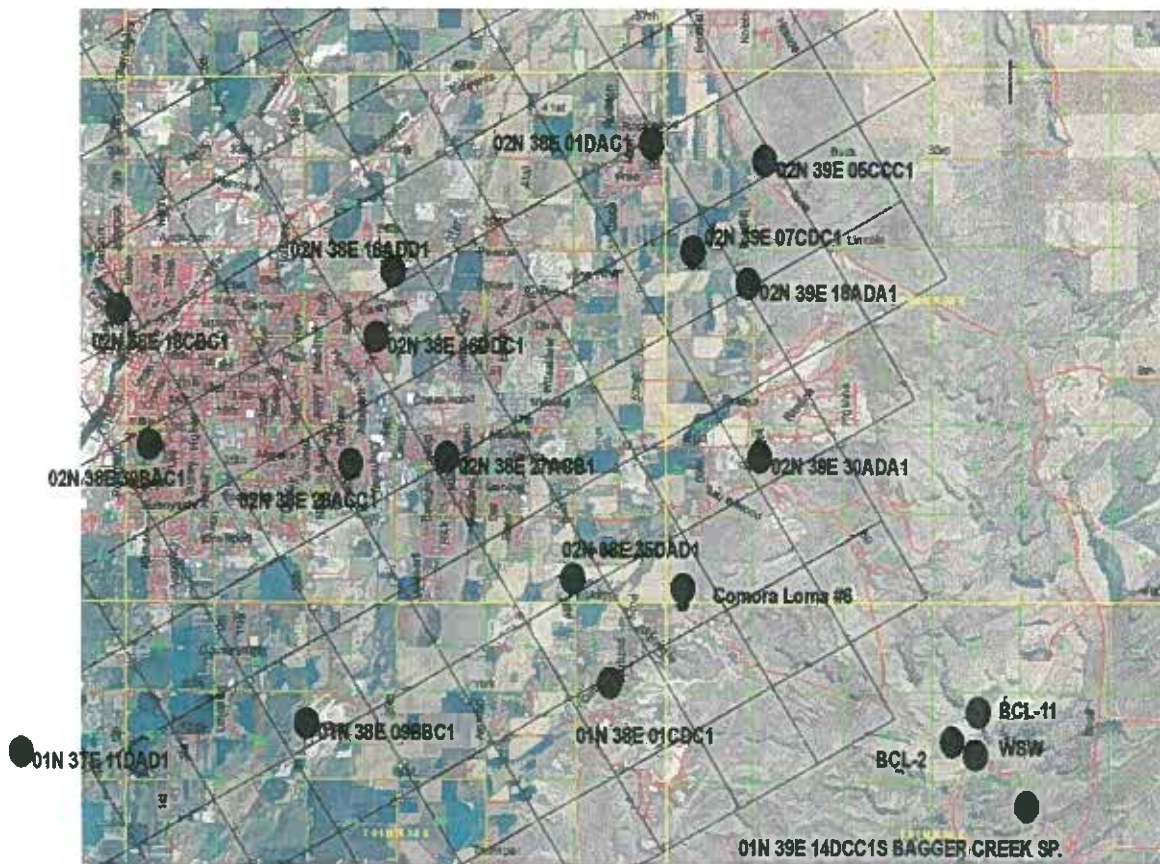


Figure 9. Map showing well locations utilized for the geochemical evaluation.

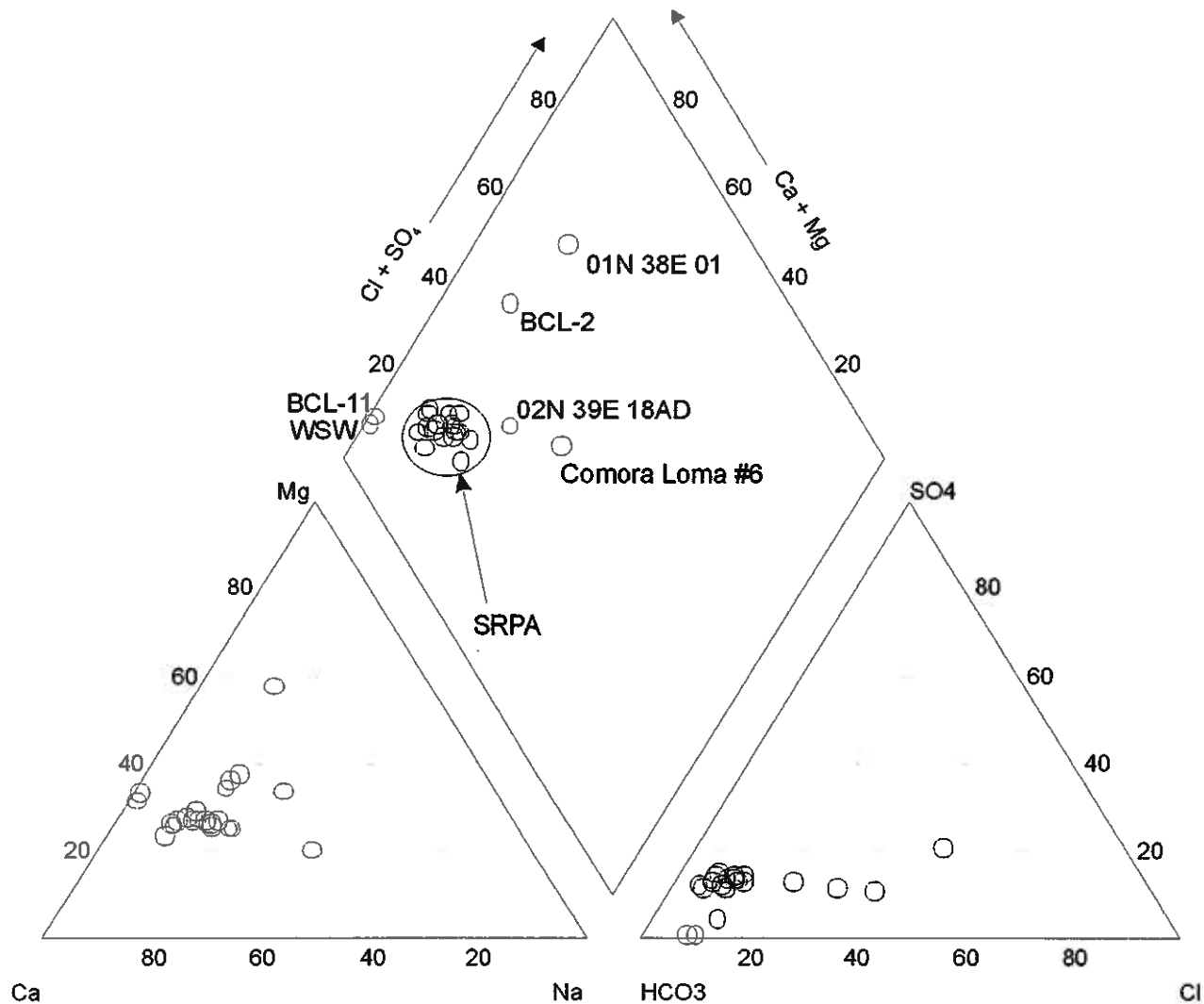


Figure 10. Piper diagram for wells near Comore Loma #6.



Another method to evaluate sources of ground water is to plot the ratio of conservative anions, such as chloride to sulfate, versus the specific conductance (Figure 11). Clustering of data points can occur when the source water for well samples is the same. Separation of data points on the plot can indicate different source waters. A limitation to this method occurs when reducing conditions are present in the aquifer, which causes sulfate concentrations to be adversely affected and influence the results of this analysis. The presence of nitrate in ground water typically indicates that oxidizing conditions are present because nitrate is removed under reducing conditions. All the wells considered in this analysis (except 02N 38E 28ACC1) have low levels of nitrate, indicating that oxidizing conditions prevail in ground water in this area. Consequently, the anion ratios method is deemed to be valid in this area and ratios are not altered by reducing conditions.

As shown in Figure 11, the plot of chloride/sulfate ratios versus conductivity indicates a distinct grouping of wells away from the characteristic grouping of ESPA wells. The ESPA water is distinguished from other water sources by having a Cl/SO_4 ratio of 0.23 to 0.67 and a specific conductance of 450 to 650 $\mu\text{mhos}/\text{cm}$ (Figure 11). Most wells to the west of the Comore Loma # 6 group together on the plot and are labeled ESPA.

Wells that draw water from other sources fall into two groups: 1) Cl/SO_4 values greater than 1 , but with conductivities less than the ESPA. This group would include the WSW and BCL-11 wells. 2) Cl/SO_4 values greater than 1, but with conductivities equal to or greater than the ESPA. The Comore Loma #6, BCL-2, and 01N 38E 01CDC1 wells would fall into this group.

Thus, the geochemical data indicates the Comore Loma #6 well draws water mostly from a water source different than the ESPA.

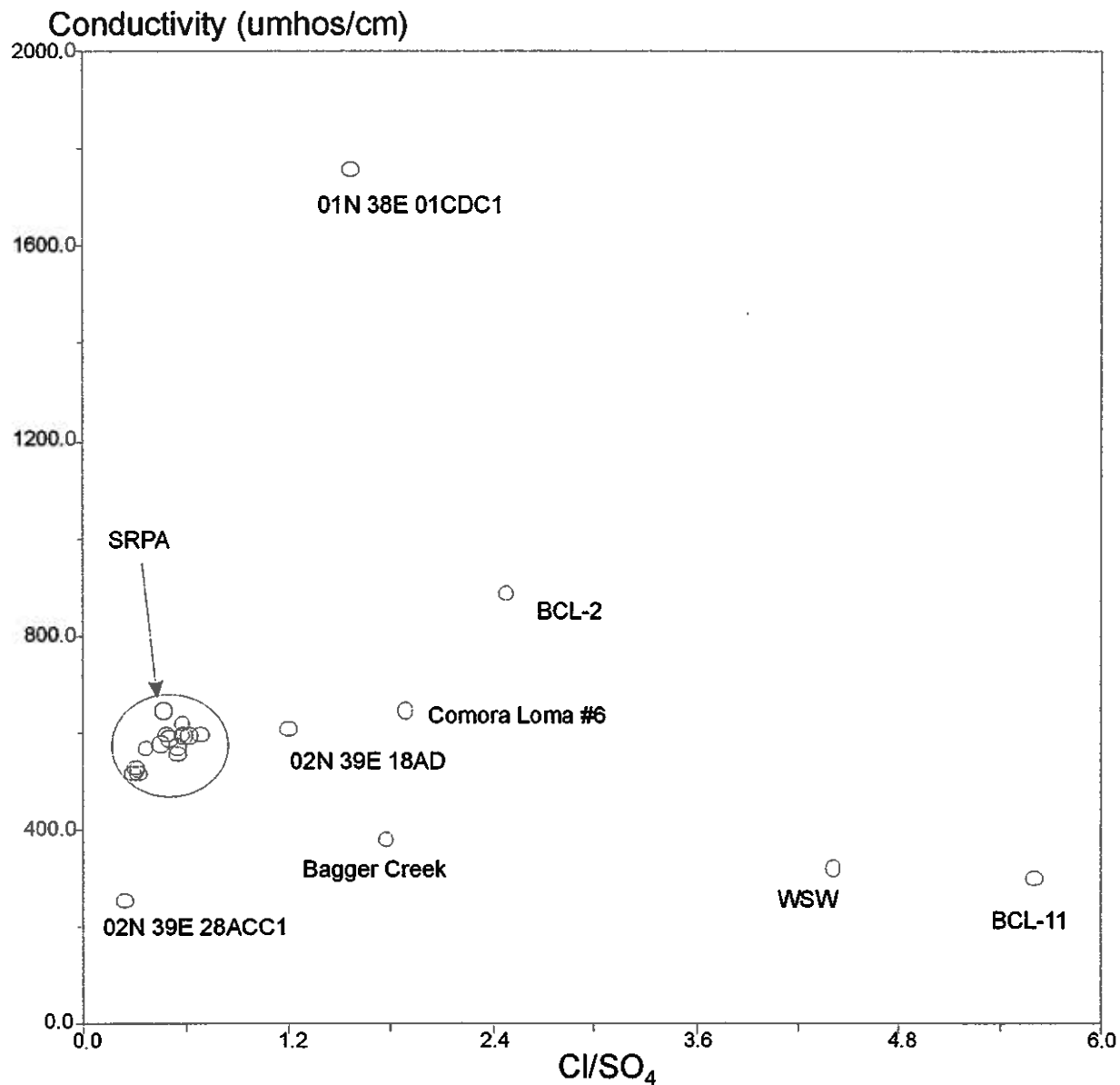


Figure 11. Plot of chloride/sulfate ratio versus conductivity for wells used in the geochemical evaluation.



Summary Discussion of the Conceptual Model

The conceptual model of the subsurface has described the regional geological and hydrological setting for this area demonstrated that Comore Loma is on the edge or immediately east of the boundary of the ESPA. This is consistent with the work of other investigations. Comore Loma is either inside or outside the boundary of the ESPA depending upon where the line is drawn. For instance the IDWR website shows the boundary of the ESPA to the west of Comore Loma, while the IDWR Ground water Model puts Comore Loma within the bounds of the ESPA. Figure 12 shows the locations of the boundary for the two mentioned studies.

Mitigation for the proposed transfer relies on the IDWR aquifer model and because Comore Loma is at the edge of the aquifer, ground water conditions must be accurately represented in the numerical simulation. Evidence will be given in this section demonstrating that water drawn from Comore Loma wells comes from outside the ESPA. However, the IDWR model does not account for subterranean contributions of ground water to the east of Comore Loma and the model will have to be modified to accurately evaluate impacts or injury from the proposed transfer.

Designers and developers of the IDWR model selected boundary conditions with the intent that the model boundaries be based on physical barriers to ground water flow (where possible). This is certainly their intent for the model boundary to the east of Comore Loma. The quote presented below from the November 2004, Model Design and Calibration Report (p 5, IDWR Technical Report 04-016) supports this statement.

Ideally model boundaries are based on physical barriers to ground water flow. A model built in this manner will have all flux into the model as irrigation, surface water or as precipitation. Since surface water is much easier to measure than ground water, this limits potential water balance errors due to calculating flux from tributary aquifers. Sometimes it is not practical to extend the model to physical boundaries in every direction and artificial boundaries are imposed. In these instances the artificial boundaries must be located to minimize their impact on prediction uncertainties.

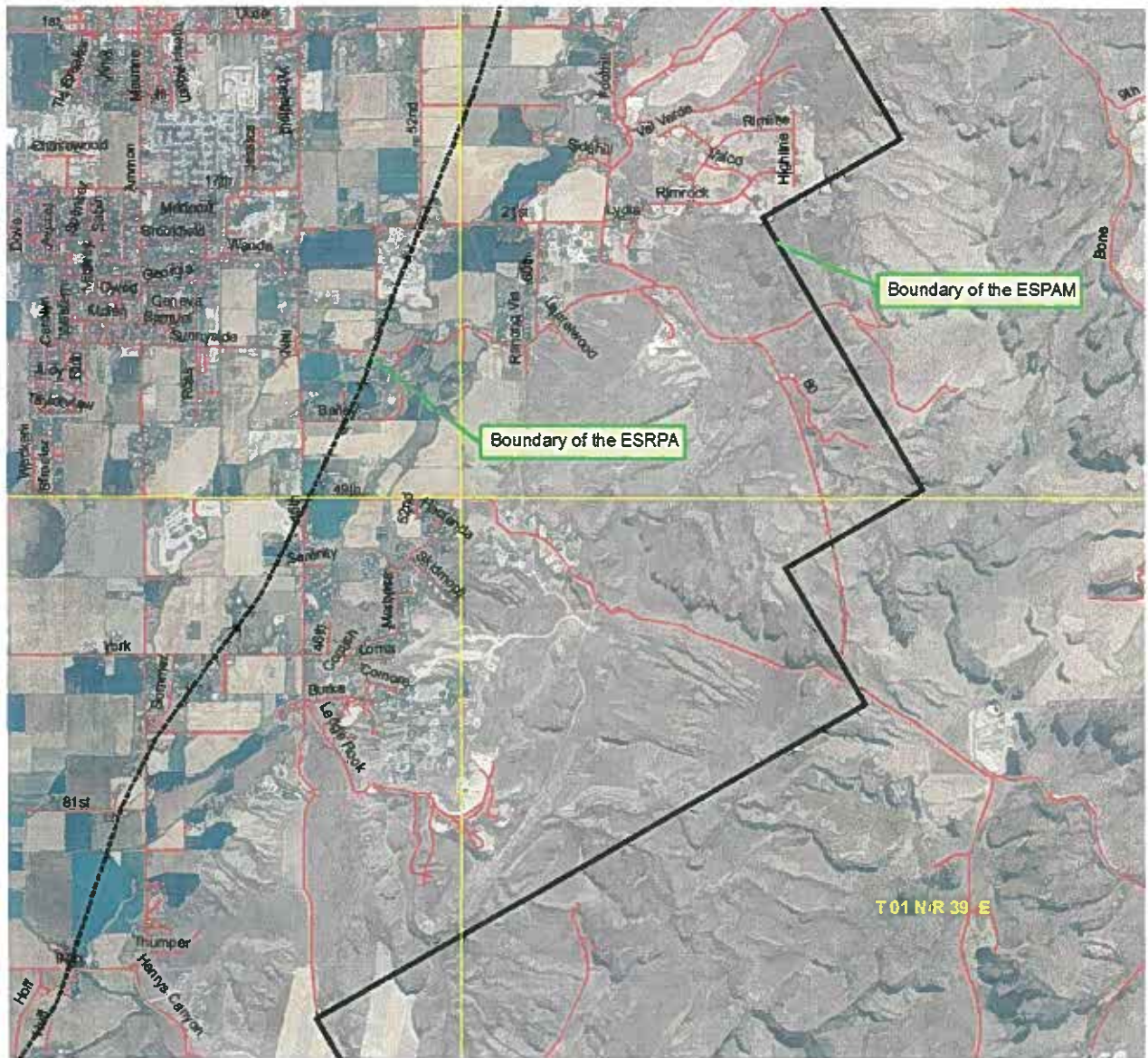


Figure 12. Different locations for boundary of the ESPA from two different studies. The line labeled boundary of the ESPA is aquifer boundary from IDWR website and the line labeled boundary of the ESPAM shows the boundary grid blocks for the IDWR Model.



Below we list the discrepancies between the conceptual model and the IDWR Model in the area of the Comore Loma Subdivision. These discrepancies indicate that the treatment of the boundary to the east as a physical barrier to ground water flow is inappropriate and can lead to inaccurate calculations of impacts.

Discrepancies between the conceptual model and IDWR Ground Water Model

- 1) **Geology** The Comore Loma Wells and nearby wells penetrate mostly rhyolite, ash, sediment and some basalt. The ESPA is typically hosted primarily in basalt and to a lesser extent sediment. Although the some of the aquifer is hosted in rhyolite (especially at depth), the vast percentage of high yield water wells in the ESPA are completed in basalt. Clearly, there is a significant difference in the geology beneath Comore Loma and the geology typical of the ESPA.
- 2) **Water Temperature** The ESPA aquifer is a cold water aquifer because it receives recharge primarily from cold waters of the Yellowstone Plateau in the form of valley underflow and surface water infiltration (canals and streams). Ground water beneath Comore Loma is much warmer than typical waters of the ESPA. This indicates that most, if not all, of the water entering Comore Loma wells comes from a different source than typical of most of the ESPA.
- 3) **Water Chemistry** The geochemical signature of water beneath the Comore Loma indicates that it has a different source and travel path than waters of the ESPA.
- 4) **Head Gradient** The water table beneath Comore Loma slopes steeply to the west at a gradient of about 75 ft/mi. The water table for most of the ESPA slopes in southwesterly direction at a gradient of about 10 ft/mile. The contrast in the slope and direction of the water table beneath Comore Loma is strikingly different than that of the ESPA. This is illustrated in Figure 13 where the water table map for the area beneath Comore Loma generated by the IDWR model is superimposed on the water table map prepared for this report. The 4595 ft contour of the IDWR model crosses the approximate center of the Comore Loma Subdivision. The water table beneath the subdivision strikes 90 degrees to this contour and ranges from about 4700 to 4725 ft. The water table beneath Comore Loma is over 200 ft higher and the direction of ground water flow is about 90 degrees



different than the IDWR map. Obviously, with a discrepancy of this magnitude it is not possible to make an accurate assessment of injury to ground water and surface water users using the model without modification.

- 5) **Recharge** The volume of water moving through a cross-sectional area in the subsurface is a function of the length of the cross-section perpendicular to the hydraulic gradient, the hydraulic gradient and the aquifer transmissivity. One can see that in the IDWR water table very little contribution of ground water is expected from outside the model boundaries because the hydraulic gradient largely parallels the cell boundaries (Figure 13). As a matter of fact, the model grid was set up so that boundary cells would parallel no flow boundaries, including flow lines and physical barriers. We know that there is a steep hydraulic gradient pointing toward the Snake River Plain beneath Comore Loma (Figure 8). A calculation is presented below for the amount of water flowing through a one mile section of the subsurface near Comore Loma.

$$\begin{aligned}\text{Flow} &= \text{length} \times \text{transmissivity} \times \text{gradient} = 5,280 \text{ ft} \times 90,000 \text{ ft}^2/\text{day} \times 75 \text{ ft}/\text{mile} = \\ &= 6,750,000 \text{ ft}^2/\text{day} \\ &= 155 \text{ acre ft per day} \\ &= 57,000 \text{ acre ft per year per linear mile}\end{aligned}$$

The preceding calculation shows that the underflow from the mountain front to the east is significant, particularly when considering that this is for only one mile and the subdivision extends along the mountain front for more than a mile. Further perspective can be gained by considering the volume of the transfer (1,355 acre ft/year) in light of the volume of recharge. The transfer amount is only 2.4% of the recharge volume entering a one mile length of the subdivision. This calculation suggests that water recharging this area mountain front to the east can easily support the proposed transfer.

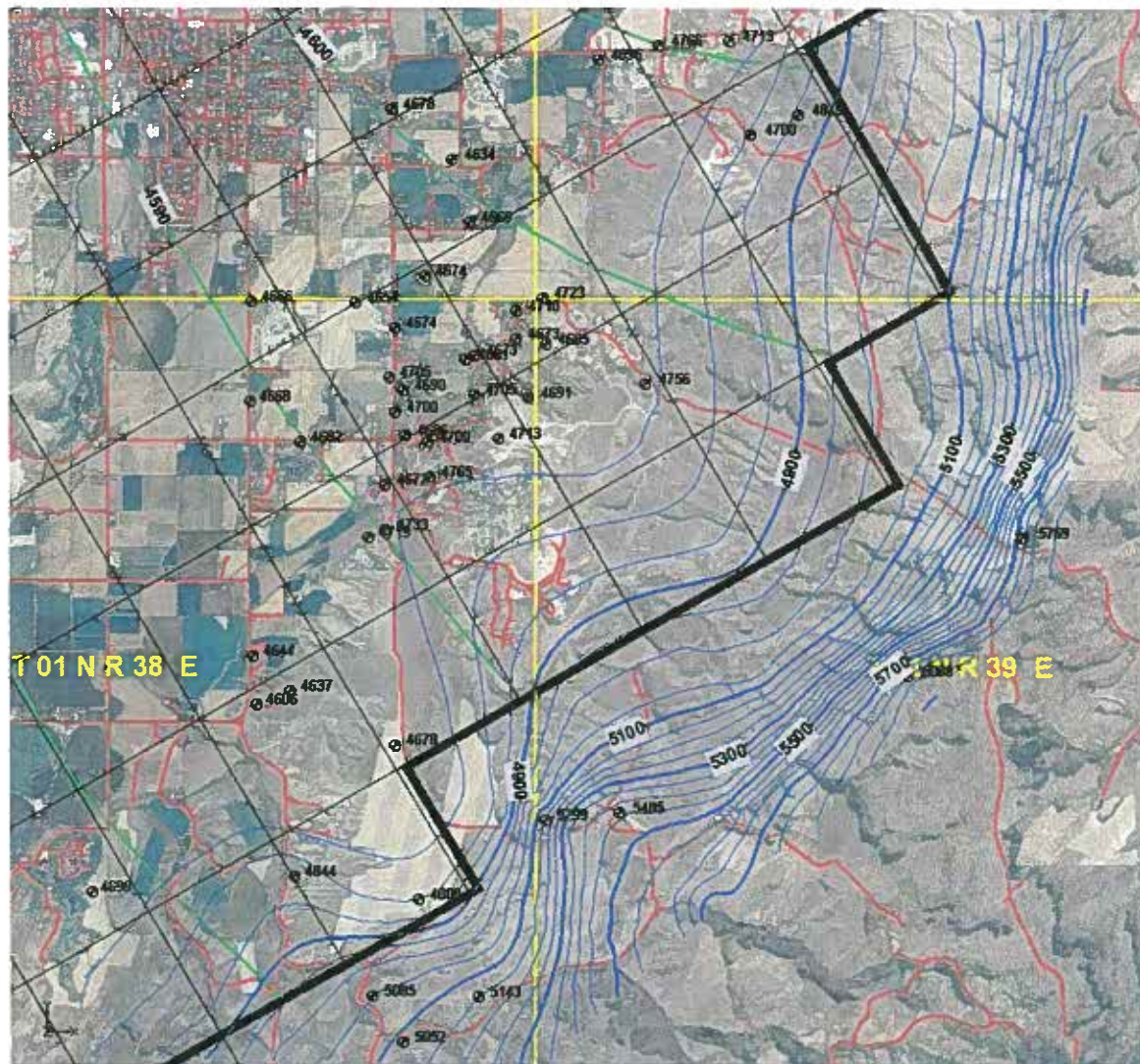


Figure 13. Superposition of IDWR water table map over water table map based on water levels in the Comore Loma area.



Summary of the Conceptual Model Investigation

The conceptual model has demonstrated through consideration of the geology, water temperature, geochemistry, and water table contours that the ground water beneath the Comore Loma Subdivision is significantly different from water in the ESPA. A significant volume of water recharges this area from the mountain front to the east. A Theis calculation using measured values of transmissivity and storativity indicates that drawdown for the proposed transfer will be very minor and no injury will be caused to nearby ground water users. Several discrepancies based on physical measurements, chemical testing and observations were cited as evidence indicating that the IDWR model needs to be modified in the area of Comore Loma to adequately assess potential injuries that might be caused by the proposed transfer.

The IDWR model is a fine tool when applied to vast areas of the ESPA, especially in the center of the plain away from the model boundaries. Edge effects are common problems in ground water models and, in this case, the problem is compounded by a lack of calibration data in the area of Comore Loma. A few simple changes to model cells along the boundary to the east will make the model accurately represent the impacts from pumping of the proposed well in the Comore Loma Subdivision. In the section to follow, we describe the modifications made to the IDWR model to better represent the actual aquifer conditions beneath and adjacent to the Comore Loma Subdivision.



Aquifer Model

Modeling Methodology

The IDWR uses the Modflow (Harbaugh et al., 2006) simulation code to model the ESPA. The simulation code was developed by the United States Geologic Survey and is available via download from its website. Clearwater Geosciences, LLP is using the Modflow 2000 version of the Modflow code, compiled as part of the Ground water Modeling System (GMS) modeling package (Version 6, BYU, 2006). The model is documented in Cosgrove et al. (2006) and provided by the Boise Office of the Idaho Department of Water Resources (IDWR).

The methods used to analyze the effects of the proposed transfer consisted of the following steps.

1) Setup the model. In order to perform the modeling and be consistent with current IDWR evaluations, we obtained the latest model files from the IDWR ftp site at <ftp://ftp.state.id.us/IDWR/Outgoing/SWCoalition/> after consultation with Rick Raymondi and Alan Wylie at IDWR. There are a number of different versions of the model, several of which contain the full version of the Modflow packages, while some are simplified versions that use superposition theory to predict impacts (superposition theory simply means aquifer drawdown or buildup is considered to be linearly related and is additive). We used data from two full IDWR versions, the “full transient” and “full steady-state”.

To simulate the effects of the proposed transfer with the IDWR model, several steps were required as outlined below:

- a) Run the unaltered steady-state model to obtain the head distribution for the entire model domain.
- b) Run the transient model using:
 - a. the head field calculated from the steady-state model as initial conditions, and
 - b. the recharge file from the steady-state model.



This step was undertaken to obtain an initial head field for the transient model and baseline water flux values for the modeled interaction between the aquifer cells and the river cells. Because we will be simulating the effects of the transfer at some point in the future the steady-state recharge values are the most appropriate to use as they represent long-term averages for the recharge function.

The initial transient simulation was run for a simulated 10,000 years to ensure a near steady-state condition in the river/drain fluxes and the water table configuration. Comparison of the head field in the vicinity of the proposed transfer location shows an excellent match between the steady-state model (from Step a) and the transient model from this step. Comparisons are shown on Figure 14.

The head field from this simulation was used as the initial condition for all subsequent simulations.

2) Map the Points of Diversion to the model grid. In order to simulate the effects of the proposed transfer, the locations of the current points of diversion must be mapped onto the model grid. This was accomplished by preparing a map with the model grid overlain with the public land survey system (PLSS) grid, and choosing the most appropriate model cell to represent the location of the points of diversion. Figure 15 shows the model grid with the PLSS grid overlain. The locations and model grid locations for the properties associated with the proposed transfer are summarized on Table 4.

Property	PLSS Location	Grid Location (row,column)
Comore Loma	T1N, R38E, Secs. 1, 12 T1N, R39E, Secs. 6, 7	79,164
Black Rock	T1S, R34E, Sec 4	69,137
Gneiting	T1N, R33E, Sec 35 T1S, R33E, Sec 2	67,134

Table 4. Summary of the locations of the properties associated with the proposed water rights transfer.



3) Prepare a MODFLOW well file. In order to simulate the effects of the proposed transfer, the locations where the water will be transferred TO and FROM need to be represented as wells in the simulation. This is simply a mass balance for the model. No new water is being pumped from the aquifer only the location of the pumping will change. The steady-state model recharge file developed and provided by IDWR accounts for the combined effects pumping and withdrawal in each grid cell. Therefore, the model already takes into account the pumping of the wells where the water will be transferred FROM. To negate this pumping from the cells of the model, the Modflow “well package” was used to reduce the withdrawal in the model recharge file by the appropriate amount. Specifically, this can be thought of as a well injecting water at the old location at the flow rate of the water right. In this case, there are two injection wells, one for Black Rock water rights and another for Gneiting water rights.

In a similar manner, the new point of the diversion (the location where the water rights are moved TO) is represented as an extraction well pumping the total flow rate of the two water rights. Table 4 summarizes the water injection and extraction for the modeled water right transfer. Note that in Table 4, the values for the current water right are acre feet per year, while the modeled rates are cubic feet per day (cfd). The IDWR water rights use units of acre-ft/yr, while the IDWR model uses units of cfd. The flows listed are equivalent but use different units to reflect differences in the IDWR water units.

Property	Current Water Right (acre-ft/yr)	New Well Function	Modeled Flow Rate (cfd)
Comore Loma	0.00	Extraction Well	-1.6173 x10 ⁵
Black Rock	953.6	Injection Well	+1.138 x10 ⁵
Gneiting	401.6	Injection Well	+4.7928 x10 ⁴

Table 4. Pumping and injection rates used for the simulations. Note that positive values indicate water injection to the aquifer while negative values indicate water extraction from the aquifer.

4) Modify the Boundary Conditions in the Vicinity of the Comore Loma Property. The boundary conditions used by the IDWR model considered the boundary of the active model grid on the east side of the Comore Loma Property as a no-flow boundary. In effect, this considers the edge of the model as an impermeable wall that does not allow water to enter the ESPA from the hills to the east. As discussed in the Conceptual Model Section, water levels, geochemistry, and water temperatures indicate that the waters are connected and that water from the higher elevations to the east feeds the wells near the boundary of model. In order to allow this interaction, the boundary of the model was modified from a no-flow boundary to a General Head Boundary (GHB). A GHB allows water to enter or leave the aquifer in response to changes in water levels, much like that used for locations where the aquifer and river reaches interact.

In order to implement the boundary changes, a number of parameters are necessary to define the amount of interaction (flow) that can occur along the boundary. The flow from the GHB is calculated by the model as (McDonald and Harbaugh, 1988):

$$Q = C_b \times dh$$

where Q is the flow into or out of the aquifer (cfd), C_b is the conductance of the boundary (ft²/day), and dh is the change in head between a reference value and the value calculated by the model for a given timestep (ft). The conductance of the boundary is often estimated as:

$$C_b = KA/b$$

where K is the hydraulic conductivity of the connection between two water bodies (ft/day), A is the area that they are connected over (ft²), and b is the thickness of the connection (ft). This is often used to represent the connection of a surface water body, such as a lake, to the aquifer. In the case of a lake, the area (A) is simply the footprint of the lake, the thickness (b) is the thickness of the lake bed sediments, and the hydraulic conductivity (K) is the hydraulic conductivity of the lake bed sediments. In our case, we need to think of these terms a bit differently, as we wish to allow water to enter the aquifer from the edge of the model domain

in response to drawdown from a pumping well. First, since flow will be entering the aquifer from the edge or side of the domain, the thickness (b) will be the saturated thickness of the aquifer, and the area (A) will then have to be the width of the cell (w) times the saturated thickness (b). Also, as transmissivity (T, and $T = Kb$, therefore $K = T/b$) is used in the model, it is convenient to modify the conductance term as follows:

$$C_b = K \frac{A}{b} = \frac{T}{b} \frac{A}{b} = \frac{T w \times b}{b} = \frac{T \times w}{b}$$

Using this equation, the conductance can be estimated from the transmissivity, aquifer thickness, and the cell width. Table 6 below summarizes the transmissivity values estimated from the IDWR inverse modeling for the cells along the eastern boundary near the Comore Loma Property. The "Cell Numbers" are shown graphically on Figure 16. As can be seen on Table 6, the transmissivity values used in the model range from approximately 300,000 to 500,000 ft²/day.

Cell Number	Location (row,column)	Transmissivity (ft ² /day)	Initial Water Table Elevation (feet)
1	76,168	293,979	4,633
2	77,167	332,233	4,618
3	78,166	366,688	4,605
4	79,166	376,854	4,602
5	80,165	408,137	4,597
6	80,164	430,431	4,595
7	80,163	455,649	4,592
8	80,162	480,868	4,588
9	81,161	484,950	4,582
10	81,160	496,340	4,580

Table 6. Locations, transmissivity estimates, and initial water table elevations for cells converted from no-flow boundaries to GHBs.



From our experience drilling and testing wells in the vicinity of Comore Loma, the values for transmissivity used in the model were higher than those estimated from real aquifer tests. The value used for transmissivity in calculating the conductance will have a significant impact on the potential for water transfer across the boundary, therefore, we chose to use actual measured values of transmissivity (which are lower than the values used in the model) in order to be conservative in our approach. Table 1 summarizes the results of 6 aquifer tests conducted near the Comore Loma Property.

Using the average value of transmissivity from Table 1, 1 mile for the width of the model cells, and an average aquifer thickness of 1,600 feet, which was determined by comparing the estimated aquifer bottom elevation of approximately 3,000 feet AMSL (obtained from Figure 16 in DDM012 [Wylie, 2004]) and the modeled initial water table elevation shown on Table 6, the resulting average conductance is $2.96 \times 10^5 \text{ ft}^2/\text{day}$. This value for conductance is a conservative value, as the lowest possible transmissivity and the highest estimated value for the aquifer thickness were used.

5) Setup flow budget zones corresponding to river reaches. Flow budget zones were created in order to evaluate the impact on the 11 river reaches of the model (listed in Tables 3 and 4 of Cosgrove et al., 2006). Using flow budget zones facilitates comparison of the model results to the IDWR transfer tool, which uses the superposition version of the model and a simplified spreadsheet for evaluating water right transfers. The output for each budget zone contains a summation of the aquifer gains and/or losses for each river reach. A comparison of the changes of flow “into” or “out of” the aquifer for each river reach before and after the transfer will aid in evaluating the potential for injury from the proposed transfer. To be consistent with the IDWR model, we created 11 flow budget zones in Modflow representing the model cells of the river reaches.

6) Define model duration and output times. The duration of transient model simulation was specified as 100 years using timesteps of approximately 10 days, with output at 6 months, 1, 2, 3½, 5, 7½, 10, 30, 50, and 100 years. We set up the model to compute the head,



drawdown, and cell to cell fluxes at each output timestep. The model output at the specified output times were then used in evaluating the effects of the proposed transfer.

Results

Two primary impacts were evaluated using the model. The first being any potential harm to nearby ground water users (i.e. aquifer decline) and the second being impacts to surface water flows (i.e. adverse changes to aquifer/river relationships). As discussed in detail below, the modeling results generally indicate that the proposed transfer will have little effect on either ground or surface water users in Eastern Idaho.

Ground water Impacts The potential harm to nearby ground water users was evaluated by examining the drawdown predicted by the model in the vicinity of the new point of diversion, located within the Comore Loma subdivision. The model predicted a maximum drawdown of 0.186 feet at the location of the well after 100 years of continuous pumping, with significantly less drawdown in distal areas. It must be noted, however, that the grid used in the model is 1 square mile, with the model essentially providing an average drawdown over the 1 square mile grid block containing the well. The predicted drawdown in adjacent grid blocks and areas farther away will likely be more representative of the actual conditions because the cone of depression created by a pumping well is steeper near the well and flatter further away. Figures 17 to 26 show the predicted drawdown at times of 6 months, 1, 3½, 5, 7½, 10, 30, 50, and 100 years, respectively. The majority of the changes in the water table occur within the first five years after the transfer, with little change evident thereafter. The values shown on the figures are positive when there is a decline in the water table and negative where the water table rises. There is a slight rise in the water table over a large area caused by retiring the Black Rock and Gneiting water rights. Conversely, there is a slight decline in water levels over a very large area caused by the transfer of the water rights to the Comore Loma Subdivision. In reality, the effects of the transfer could not be measured over the vast majority of the area. A study of depth to water level measurements in the ESPA indicated that that as a practical matter changes in water table fluctuation can not be resolved at less than 0.2 ft.



Surface Water Impacts. Impacts to the surface water system will be manifest as significant differences between the IDWR model and the modeled transfer of the flow budget zones for the river reaches. To evaluate the changes in surface-ground water relationships the difference between cumulative fluxes for each river reach was compared to the transient simulation with no transfer (data from time = 10,000 years) and the simulated transfer.

An evaluation of the transient simulation with no transfer (data from time = 10,000 years) showed that the model predicted that the Ashton to Rexburg, Near Blackfoot to Neeley, and Neeley to Minidoka river reaches were gaining water from the aquifer while the Heise to Shelley and Shelley to Near Blackfoot river reaches were losing water. All of the reaches representing the springs of the Thousand Springs area were losing water (this is expected, as they are represented as “drains” in Modflow and, by definition, can only remove water from the aquifer).

Tables 7 and 8 summarize the changes in the simulated fluxes for river reaches, in acre-ft/year and as a percentage of the water right transfer (1355.2 acre-ft/yr), respectively. The changes posted in Table 7 were calculated by subtracting the flux from the transfer simulation from the initial conditions. Thus, a negative value indicates a reduction in flux from the aquifer to the river reach and a positive value indicates an increase in flux from the aquifer to the river reach. As can be seen on Table 7, the majority of the reaches show an increase in the water entering the surface water system, with a maximum of 617 acre-ft/yr after 100 years in the Near Blackfoot to Neeley Reach and 258 acre-ft/yr in the Shelley to Near Blackfoot reach. The remainder of the reaches either gain or lose insignificant amounts of water (less than 25 acre-ft/yr). To put these values into perspective with respect to the total flow for each reach on an annual basis Table 8 posts the change in flow by reach as a percentage of the transferred water right after the transfer. The majority of the reaches have between +/- 2% change, with the two reaches which gain appreciable amounts of water (Near Blackfoot to Neeley and Shelley to Near Blackfoot) having gains of 45% and 19%, respectively.



Figures 27 to 28 show the changes predicted by the model graphically. On Figure 27, all reaches are shown except for the two reaches with appreciable changes. Figure 28 shows the two reaches with larger changes, Shelley to Near Blackfoot and Near Blackfoot to Neeley reaches. In all cases, the response to the transfer stabilized after approximately 30 years.

Figure 29 combines the data plotted on the preceding two figures showing the changes as percentages of the transferred water right. That is, the values of the predicted change in flux for each reach were divided by the transfer amount of 1355.2 acre-ft/yr, and multiplied by 100. The data are shown in this manner to demonstrate the small magnitude of the impact to the ground water-surface water system, with the maximum negative percent change being less than 1 percent.

Summary and Conclusions from Aquifer Model

A modeling study was undertaken to evaluate the potential impacts of a water rights transfer on the ESPA, moving the points of diversions from two properties in Bingham County to the Comore Loma Subdivision in Bonneville County. A modified version of the transient IDWR ESPAM, Version 1.1, was used for the evaluation. The modeling results demonstrate that there will be no net impact to the aquifer, that is, water is conserved and overall the aquifer water and surface water are not impacted at the scale of the aquifer. Modifying the eastern model boundary in the vicinity of Comore Loma allowed water to flow to the new point of diversion across the model boundary, which can be conceptually envisioned as water flowing from the mountain front to the east and to the simulated production well. The flow across the boundary over the 100 year simulation is shown on Figure 30. Approximately 970 acre-ft/year (or ~71%) of the transferred water right originates from sources outside the ESPA model.

The transfer only affects the upper four reaches of the Snake River System and these impacts are so small that they are impossible to measure. Local to the new point of diversion the maximum predicted drawdown is 0.186 feet. Maximum changes in the aquifer-surface water reach occurred in the Near Blackfoot to Neeley reach, with an increase of approximately 619



acre-ft/yr (or 45 percent of the water right), while no reaches showed a negative impact greater than 1 percent.

The conclusion of this report is that, for practical purposes, there will be no significant negative impacts to either local ground water users or surface water users.

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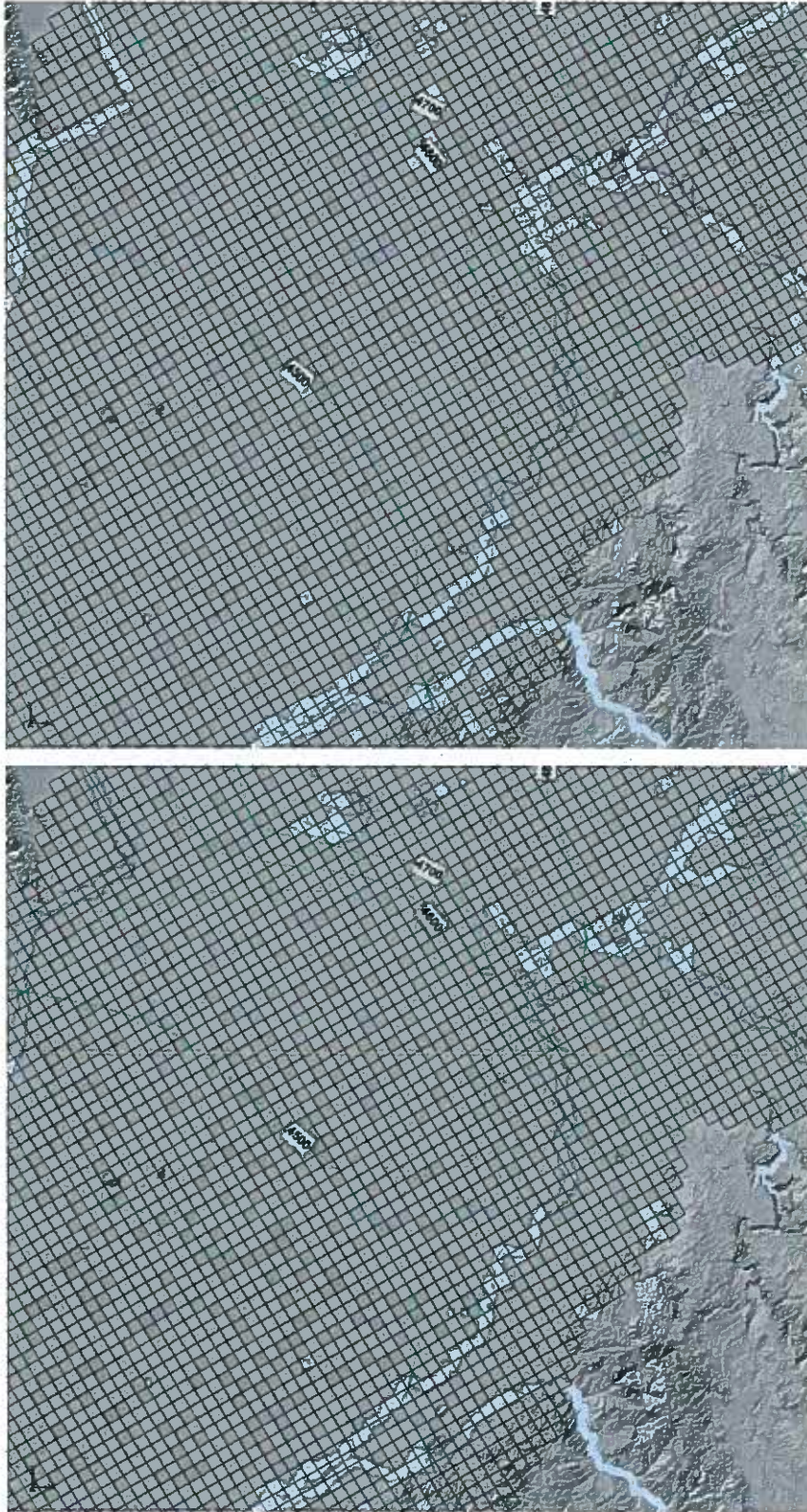


Figure 14. Maps of head distribution from the steady-state model (top) and the initial transient model (bottom, at time = 10,000 days).

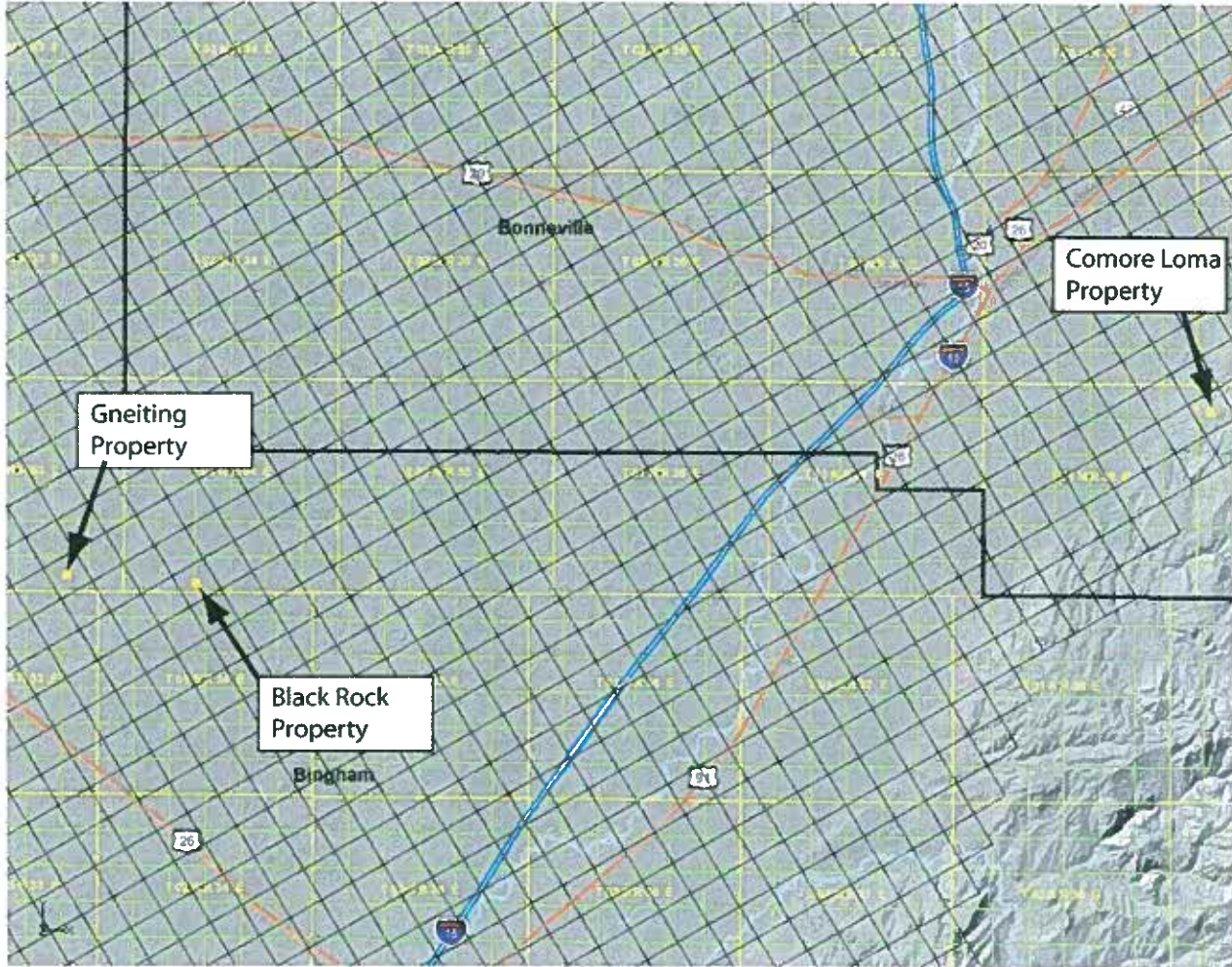


Figure 15. Map of the model grid in black with the PLSS grid in green and yellow overlain. The locations of the points of diversions for the properties associated with the proposed water rights transfer are shown with yellow dots and black arrows. County boundaries, major highways, and the river system are also shown for reference. Background image is from the 30-meter Idaho Digital Elevation Model data.

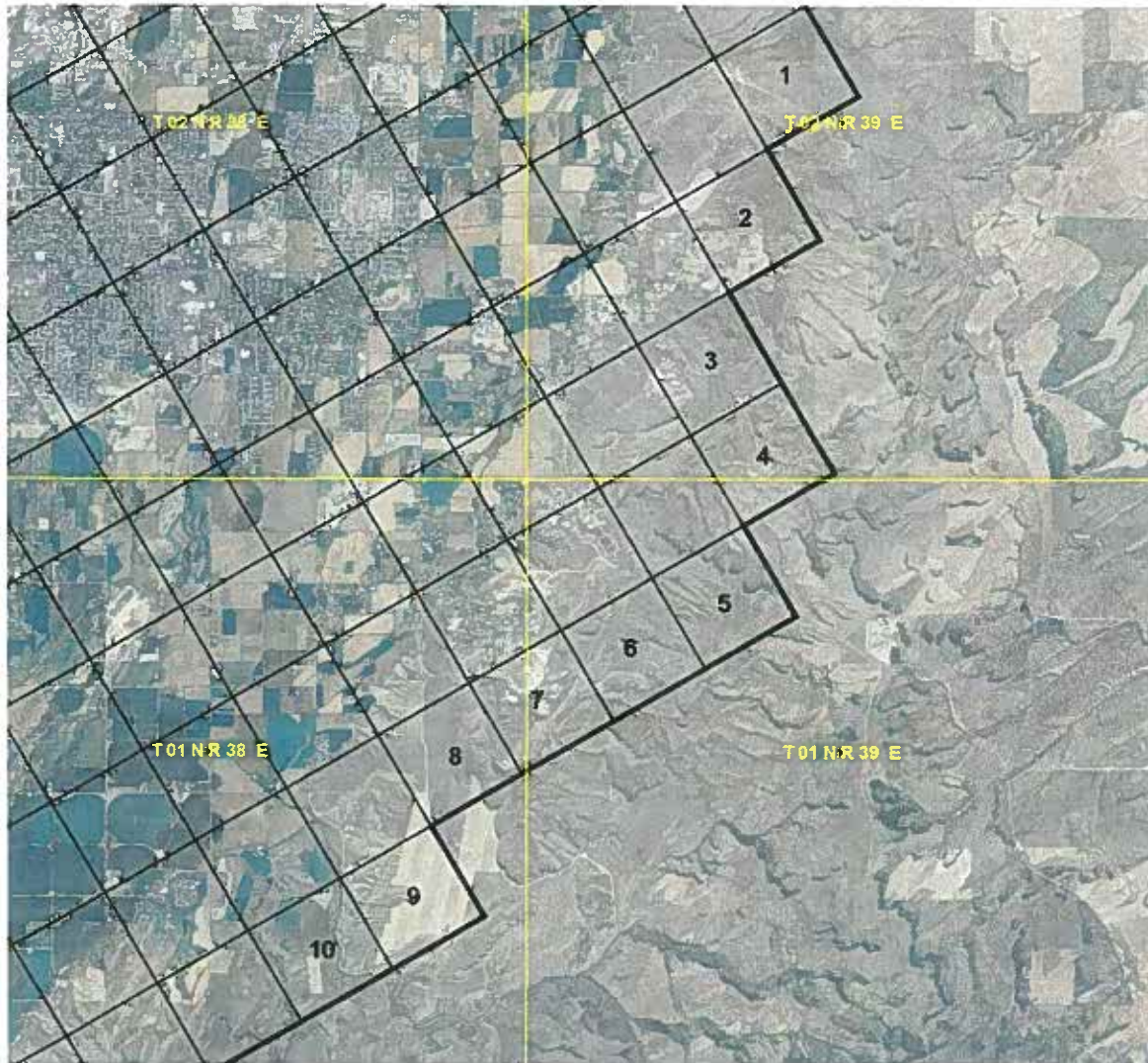


Figure 16. Location of the 10 modified model boundary cells. See Table 6 for details on the aquifer properties of these cells.

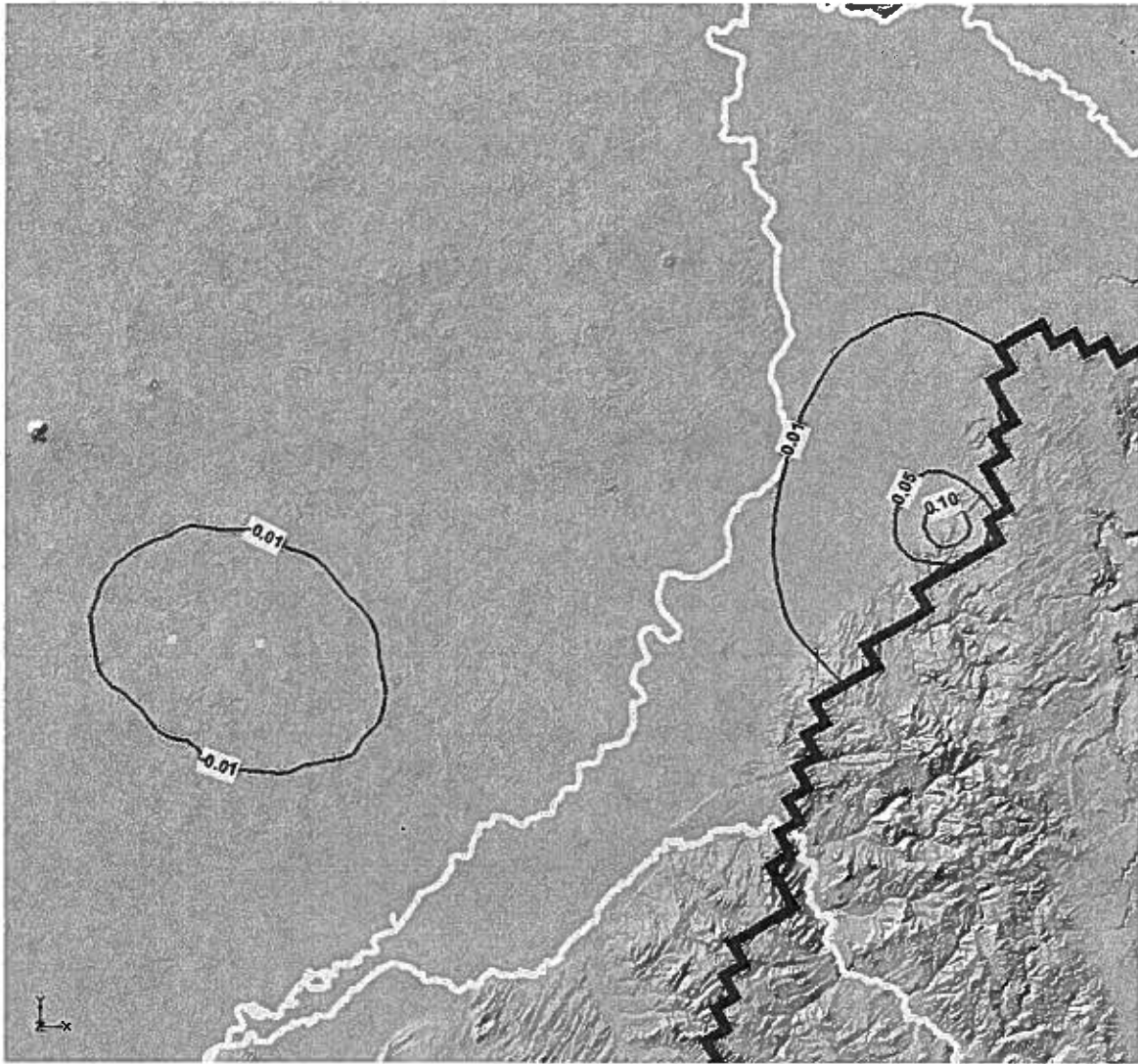


Figure 17. Drawdown predicted as a result of the transfer after 6 months of pumping.

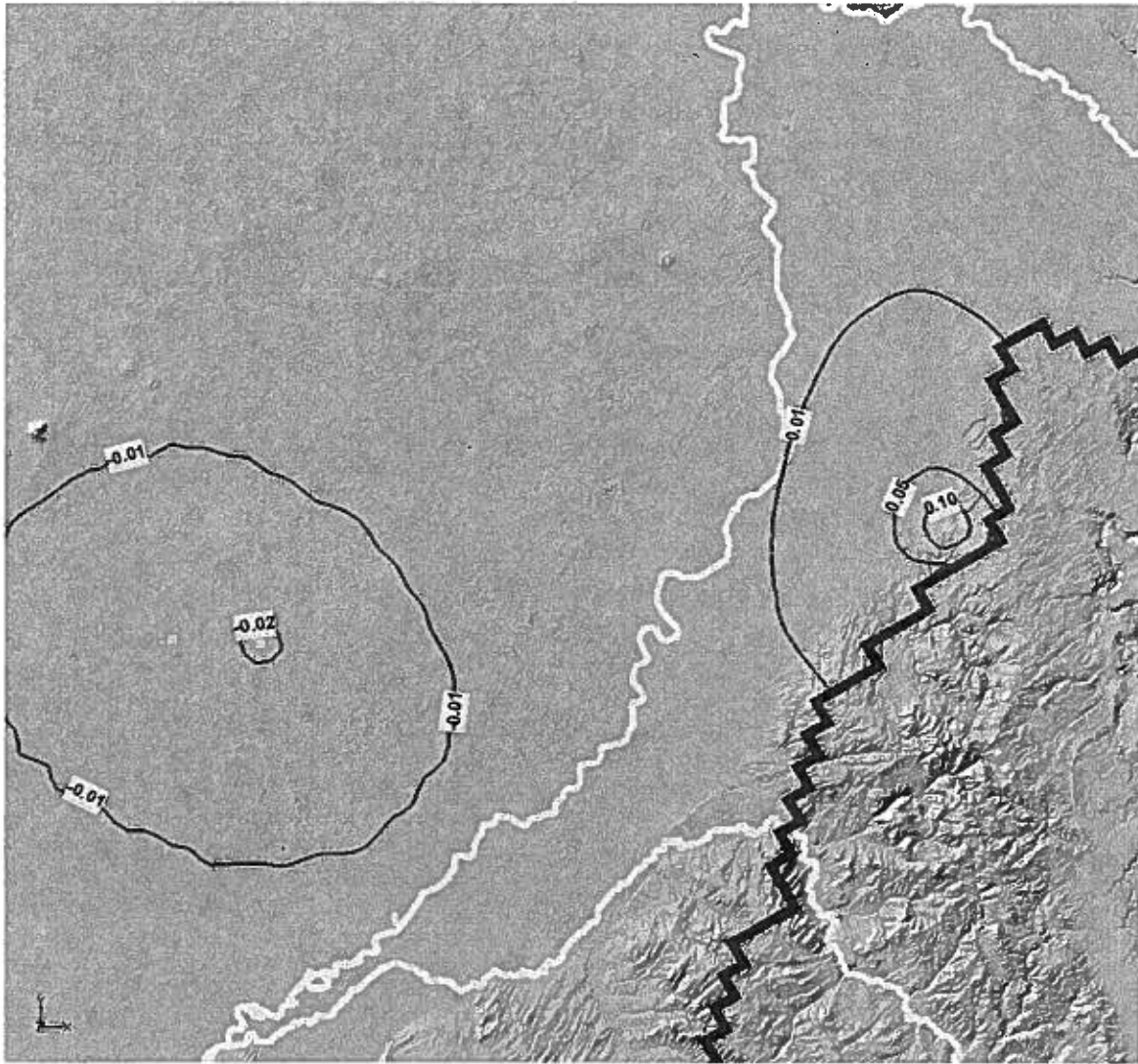


Figure 18. Drawdown predicted as a result of the transfer after 1 year of pumping.

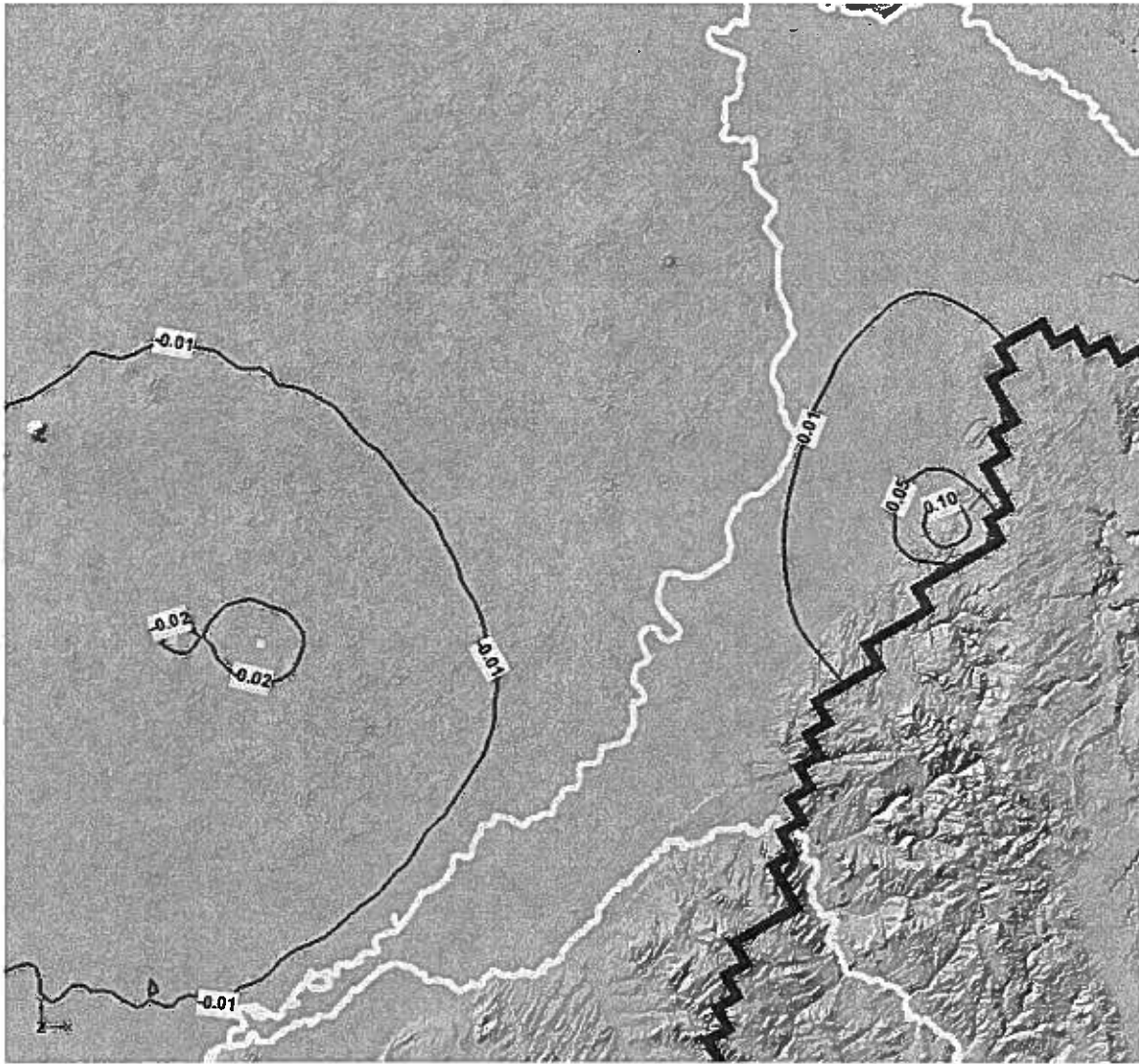


Figure 19. Drawdown predicted as a result of the transfer after 2 years of pumping.

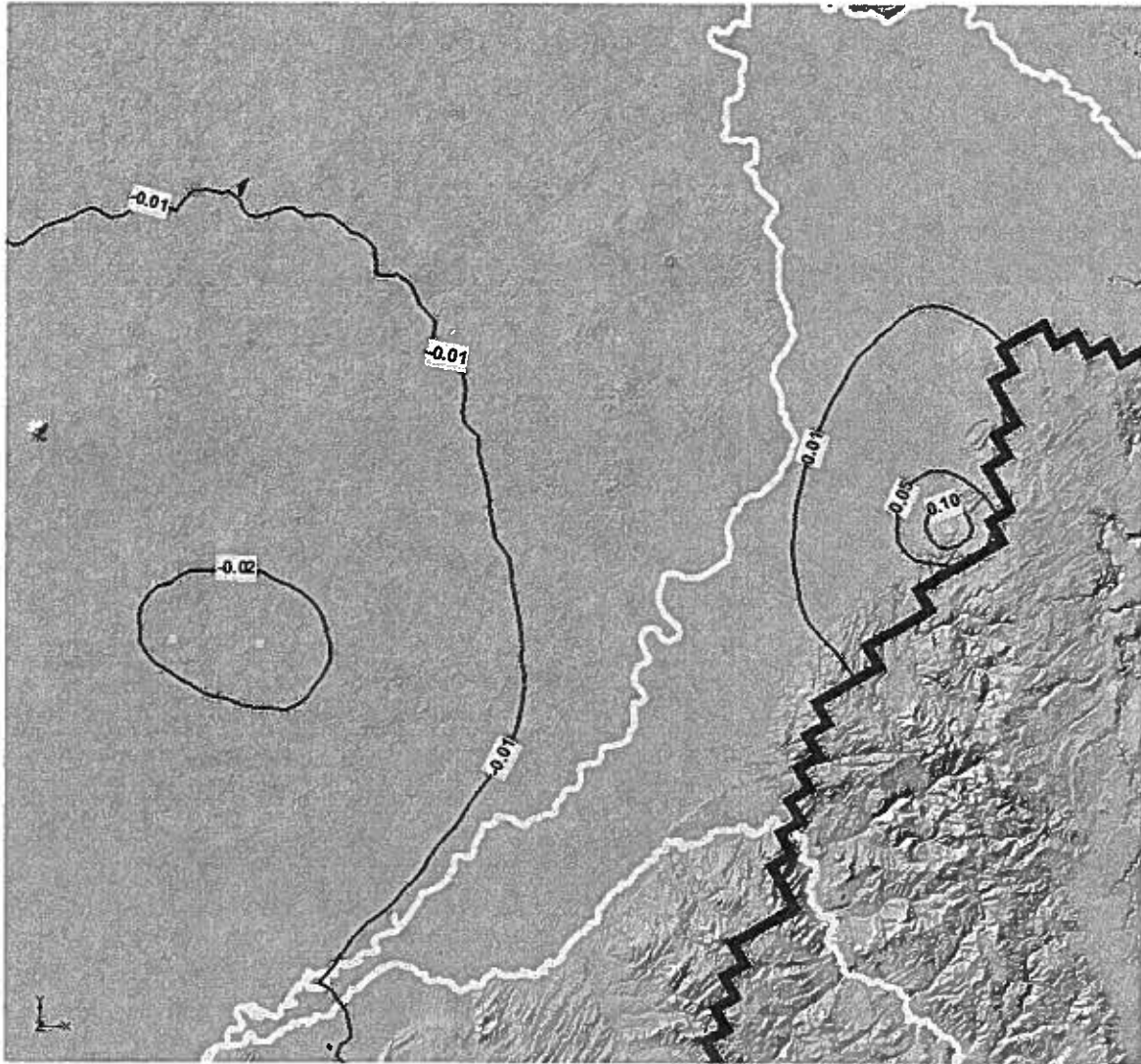


Figure 20. Drawdown predicted as a result of the transfer after 3.5 years of pumping.

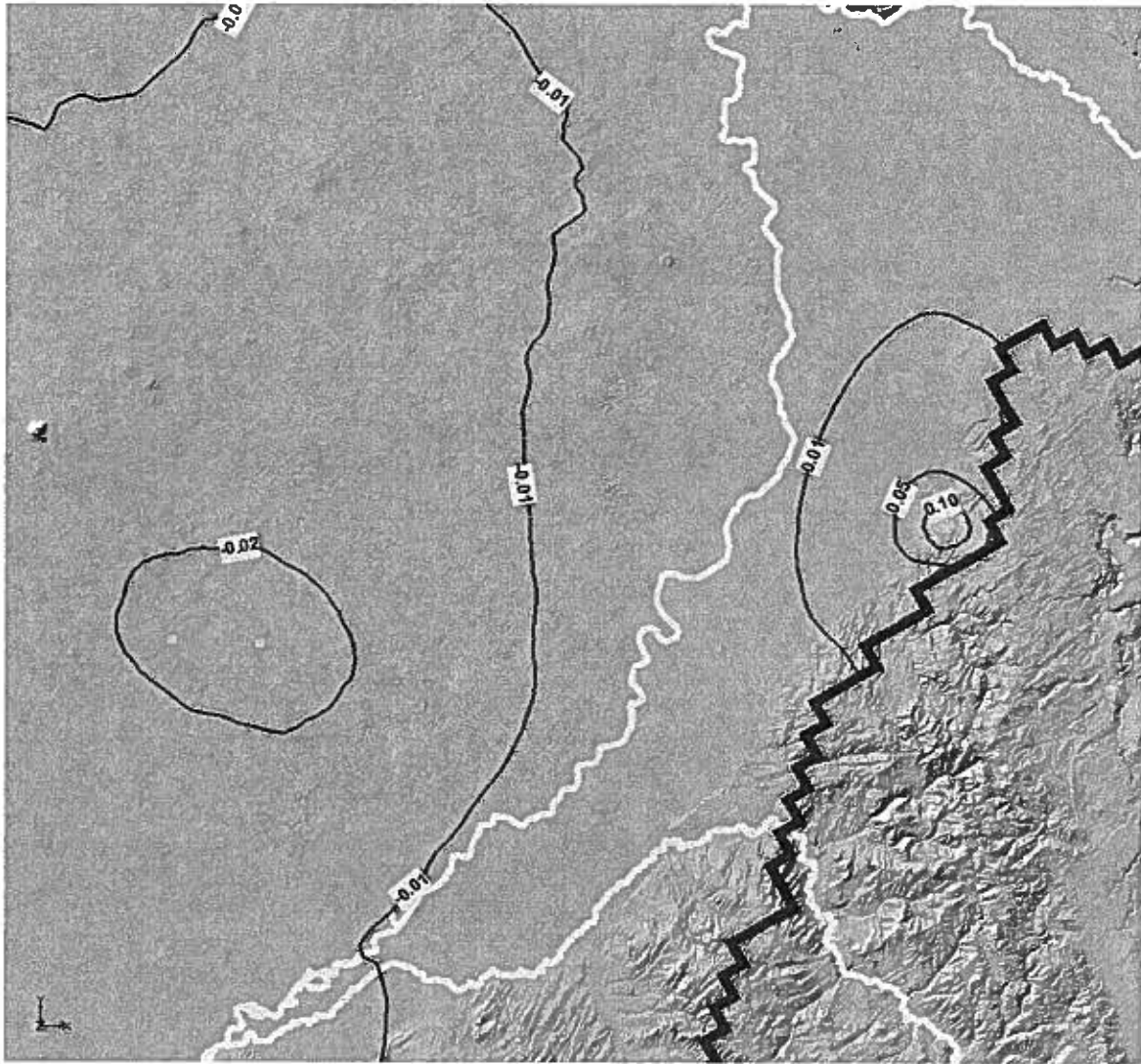


Figure 21. Drawdown predicted as a result of the transfer after 5 years of pumping.

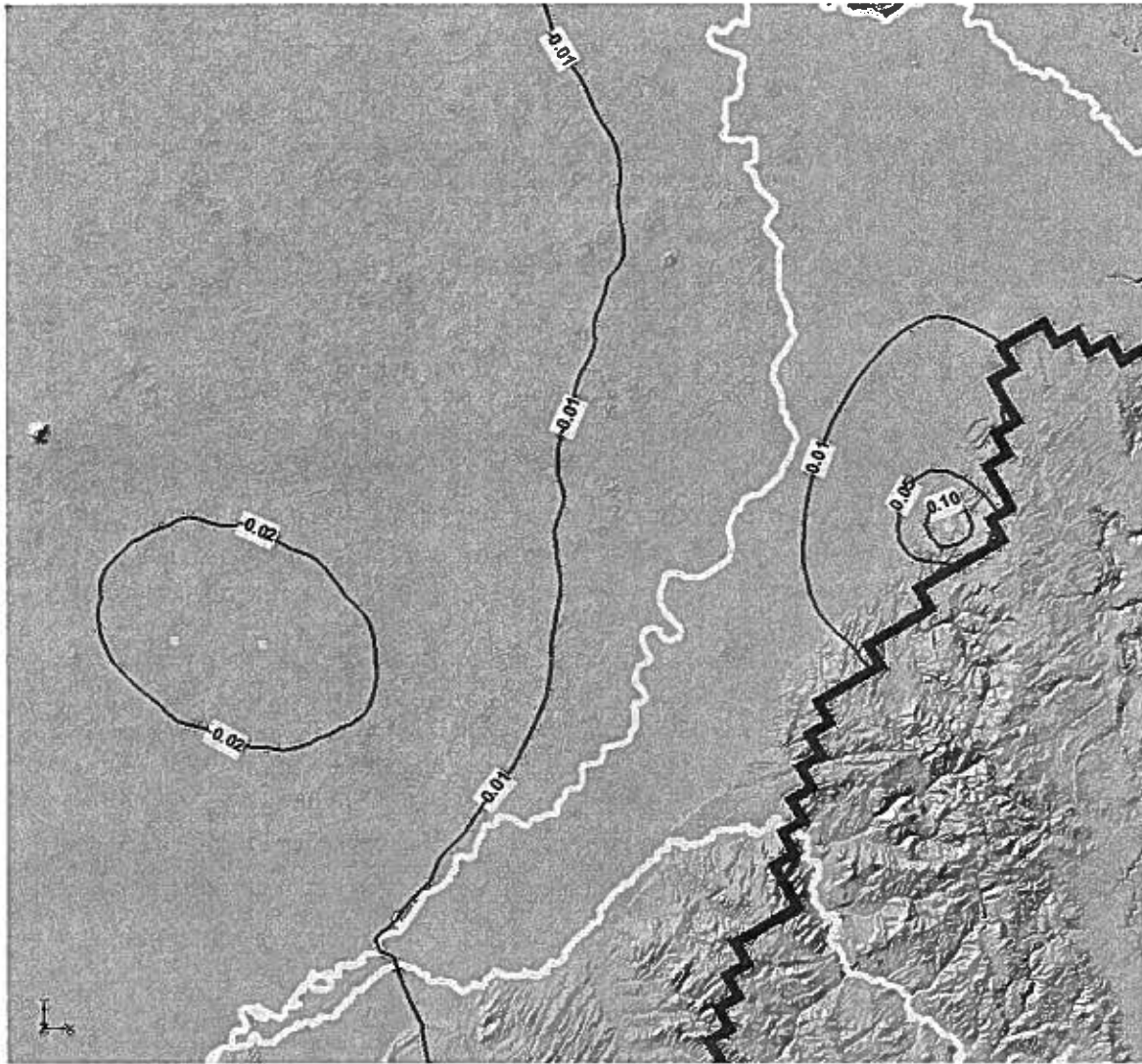


Figure 22. Drawdown predicted as a result of the transfer after 7.5 years of pumping.

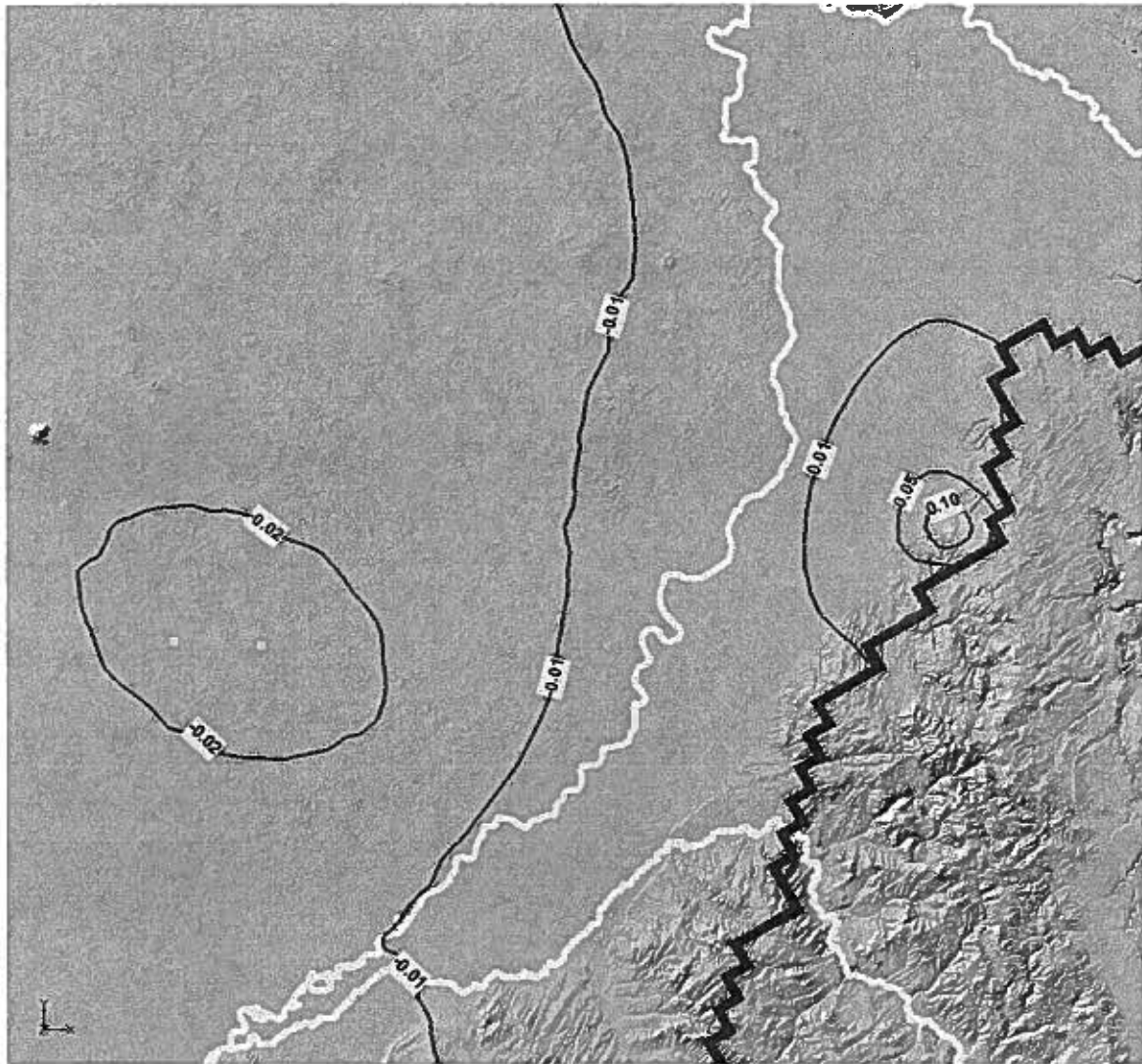


Figure 23. Drawdown predicted as a result of the transfer after 10 years of pumping.

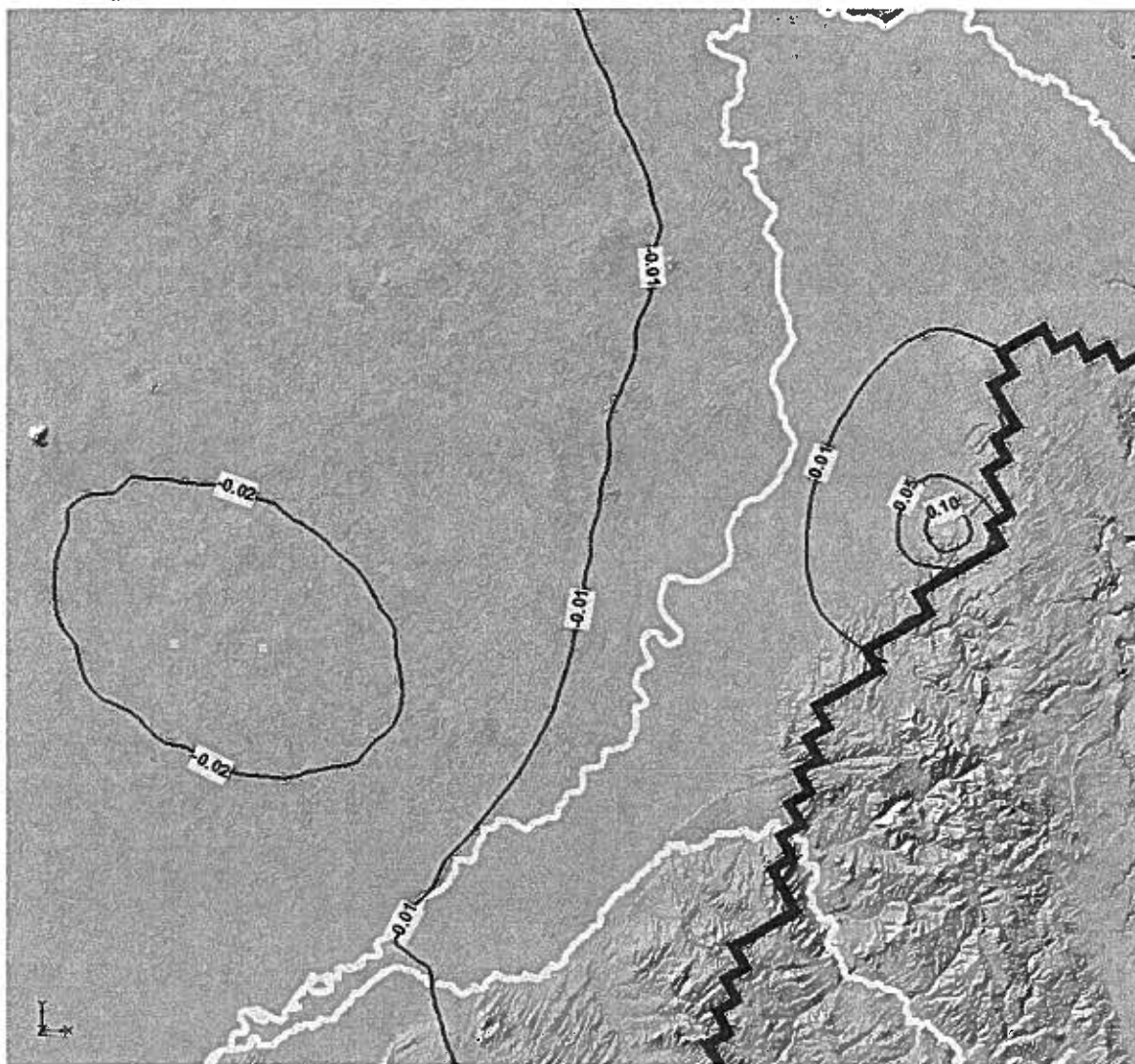


Figure 24. Drawdown predicted as a result of the transfer after 30 years of pumping.

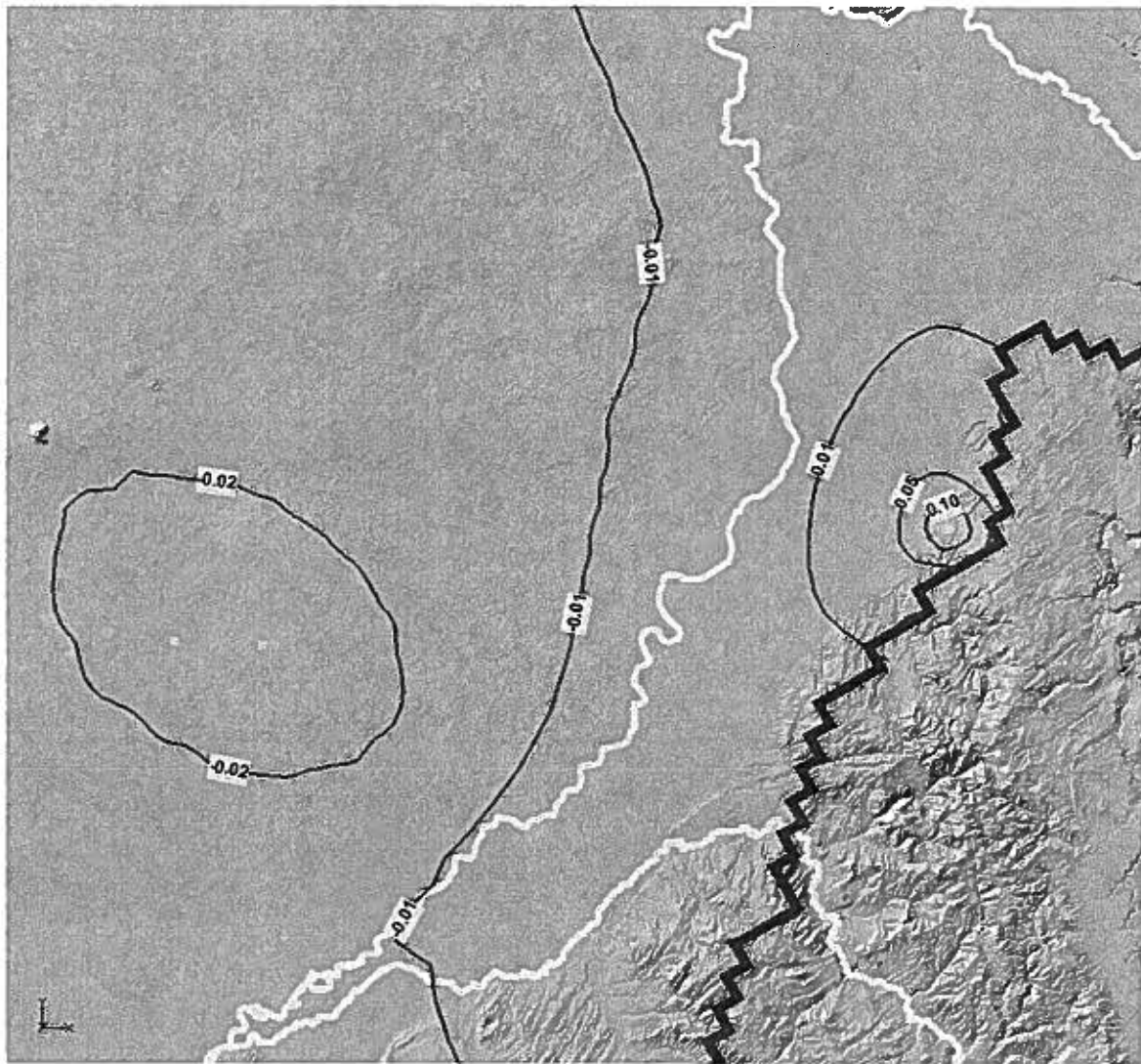


Figure 25. Drawdown predicted as a result of the transfer after 50 years of pumping.

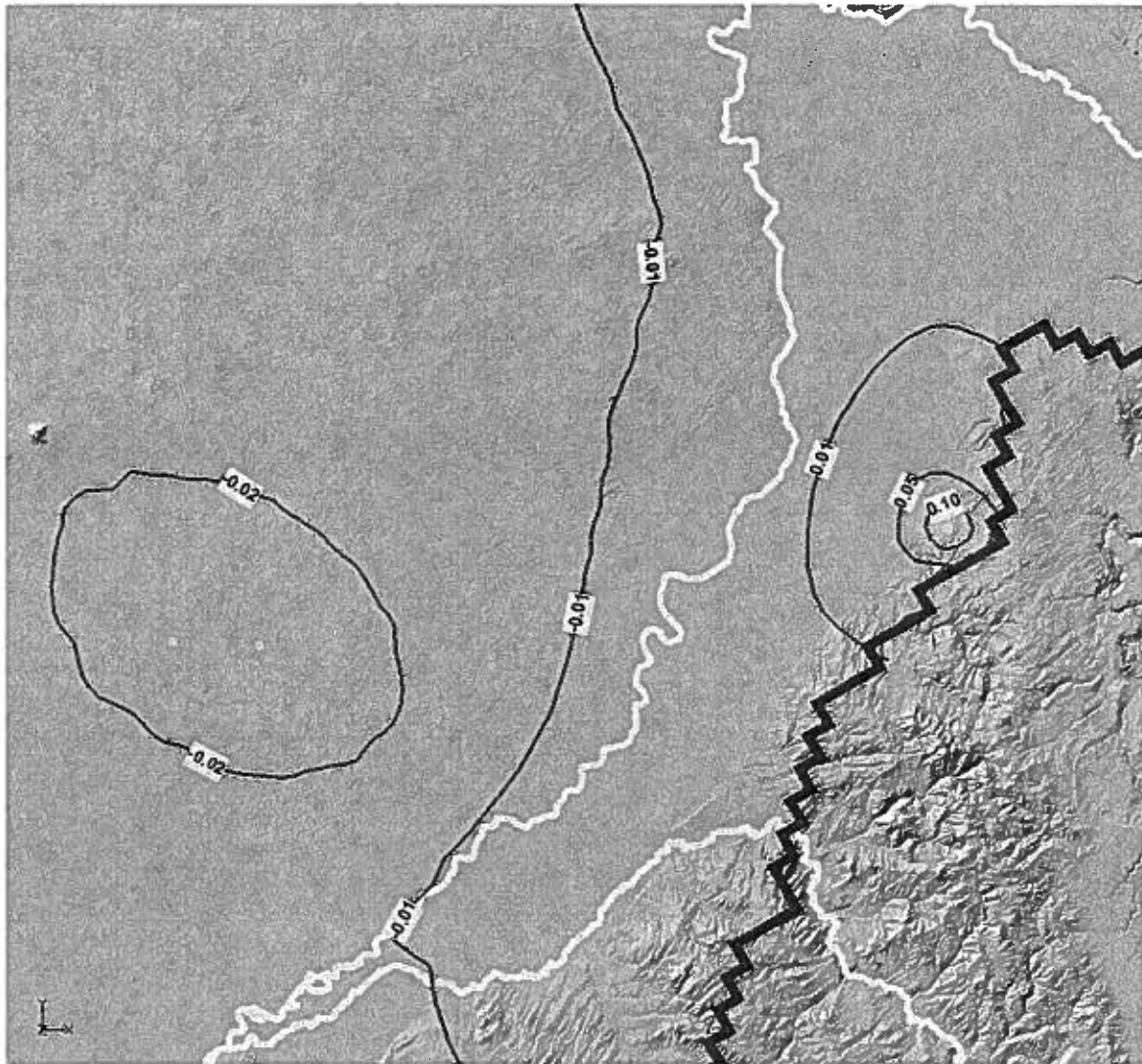


Figure 26. Drawdown predicted as a result of the transfer after 100 years of pumping.



Time (years)	Ashton to Rexburg	Heise to Shelley	Shelley to Near Blackfoot	Near Blackfoot to Neeley	Neeley to Minidoka	Devil's Washbowl to Buhl	Buhl to Thousand Springs	Thousand Springs	Thousand Springs to Malad	Malad to Malad Bancroft	
0.5	5.2	-3.4	76.6	189.4	0.7	-0.8	0.8	0.7	0.0	-0.7	0.0
1	4.8	-6.3	121.0	308.3	1.2	-0.9	0.8	0.7	0.0	-0.7	0.0
2	4.9	-6.0	168.0	424.4	2.4	-1.2	0.7	0.6	0.0	-0.8	0.0
3.5	7.0	-1.6	202.8	499.7	4.5	-1.9	0.4	0.3	0.0	-1.0	0.0
5	9.6	2.1	221.3	538.7	6.2	-3.0	-0.1	0.0	0.0	-1.2	0.0
7.5	13.5	6.1	236.8	570.2	8.6	-4.9	-0.9	-0.6	-0.1	-1.8	0.0
10	16.9	8.5	244.3	586.0	10.0	-6.6	-1.7	-1.3	-0.1	-2.2	0.0
15	21.9	11.2	251.4	601.5	11.6	-9.1	-2.7	-2.1	-0.1	-3.0	0.0
30	27.1	13.8	257.4	614.7	13.1	-12.0	-4.0	-3.1	-0.2	-3.8	-0.1
50	28.0	14.2	258.4	617.4	13.6	-12.7	-4.3	-3.3	-0.2	-4.0	-0.1
100	28.0	14.2	258.5	617.7	13.6	-12.7	-4.3	-3.3	-0.2	-4.0	-0.1

Table 7. Changes in predicted river reach flux (in ac-ft/yr) for the 11 reaches of the IDWR model in response to the proposed water right transfer. A negative value indicates a reduction in flux from the aquifer to the river reach and a positive value indicates an increase in flux from the aquifer to the river reach.



Time (years)	Ashton to Rexburg	Heise to Shelley	Shelley to Near Blackfoot	Near Blackfoot to Neeley	Neeley to Minidoka	Devil's Washbowl to Buhl	Buhl to Thousand Springs	Thousand Springs	Thousand Springs to Malad	Malad	Malad to Bancroft
0.5	0.386	-0.254	5.653	13.973	0.052	-0.057	0.058	0.051	-0.001	-0.049	0.003
1	0.356	-0.463	8.930	22.750	0.091	-0.064	0.058	0.051	-0.001	-0.052	0.003
2	0.360	-0.444	12.397	31.315	0.179	-0.086	0.050	0.044	-0.001	-0.057	0.003
3.5	0.513	-0.116	14.967	36.870	0.334	-0.143	0.027	0.025	-0.002	-0.072	0.002
5	0.710	0.154	16.333	39.754	0.457	-0.220	-0.009	-0.002	-0.003	-0.092	0.002
7.5	0.993	0.453	17.471	42.076	0.632	-0.363	-0.067	-0.048	-0.005	-0.134	0.000
10	1.246	0.630	18.026	43.243	0.735	-0.488	-0.124	-0.093	-0.007	-0.166	0.000
15	1.617	0.827	18.554	44.388	0.854	-0.672	-0.201	-0.152	-0.010	-0.220	-0.002
30	2.001	1.017	18.993	45.355	0.969	-0.886	-0.295	-0.230	-0.014	-0.280	-0.004
50	2.063	1.048	19.066	45.558	1.002	-0.935	-0.315	-0.244	-0.015	-0.292	-0.004
100	2.063	1.048	19.074	45.578	1.004	-0.938	-0.317	-0.244	-0.015	-0.295	-0.004

Table 8. Changes in predicted river reach flux (in percent of the transferred water right of 1355.2 acre-ft/year) for the 11 reaches of the IDWR Model in response the proposed water right transfer.

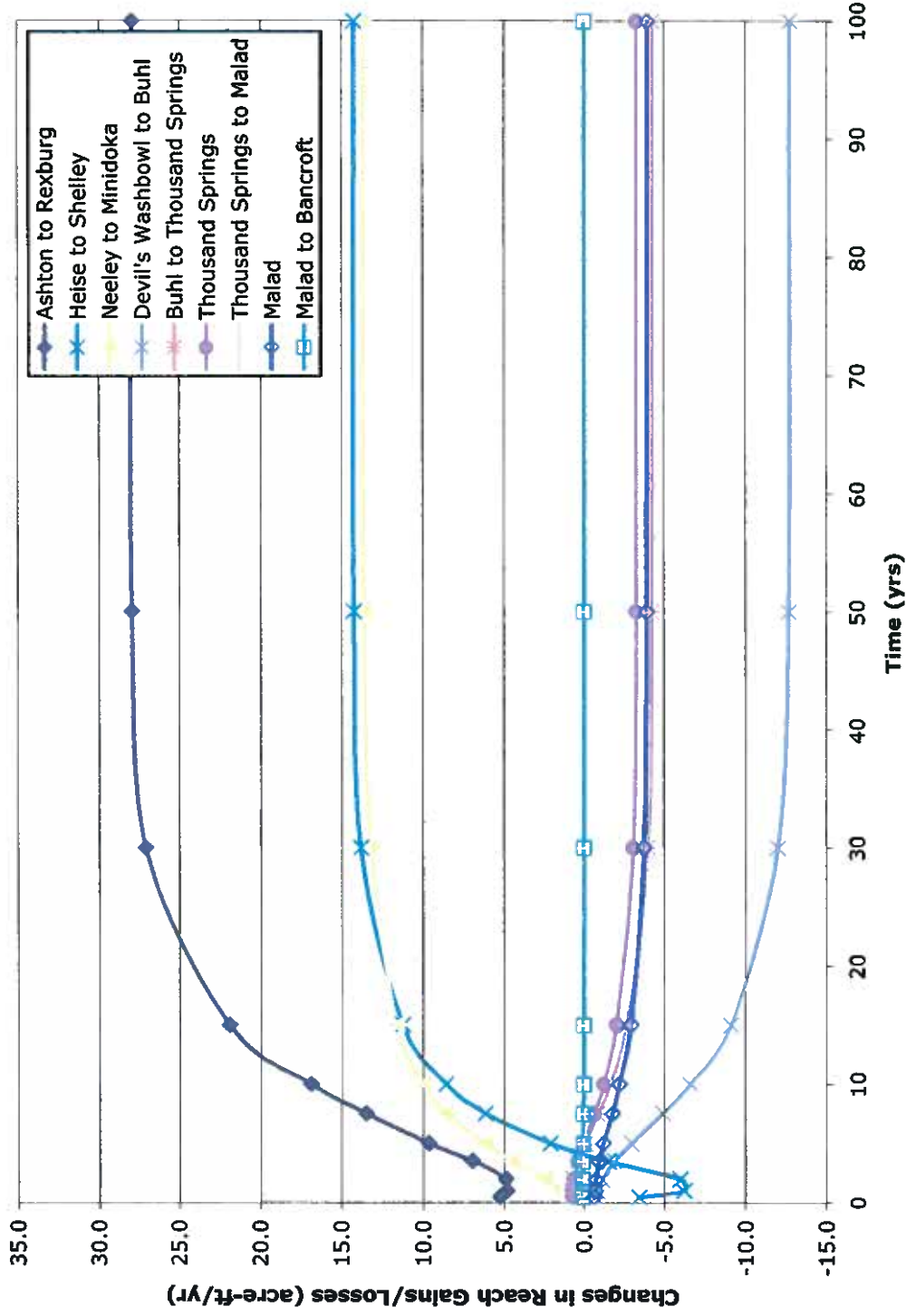


Figure 27. Changes in aquifer-surface water interactions for reaches with insignificant changes as a result of the proposed transfer.
Values are ac-ft/yr.

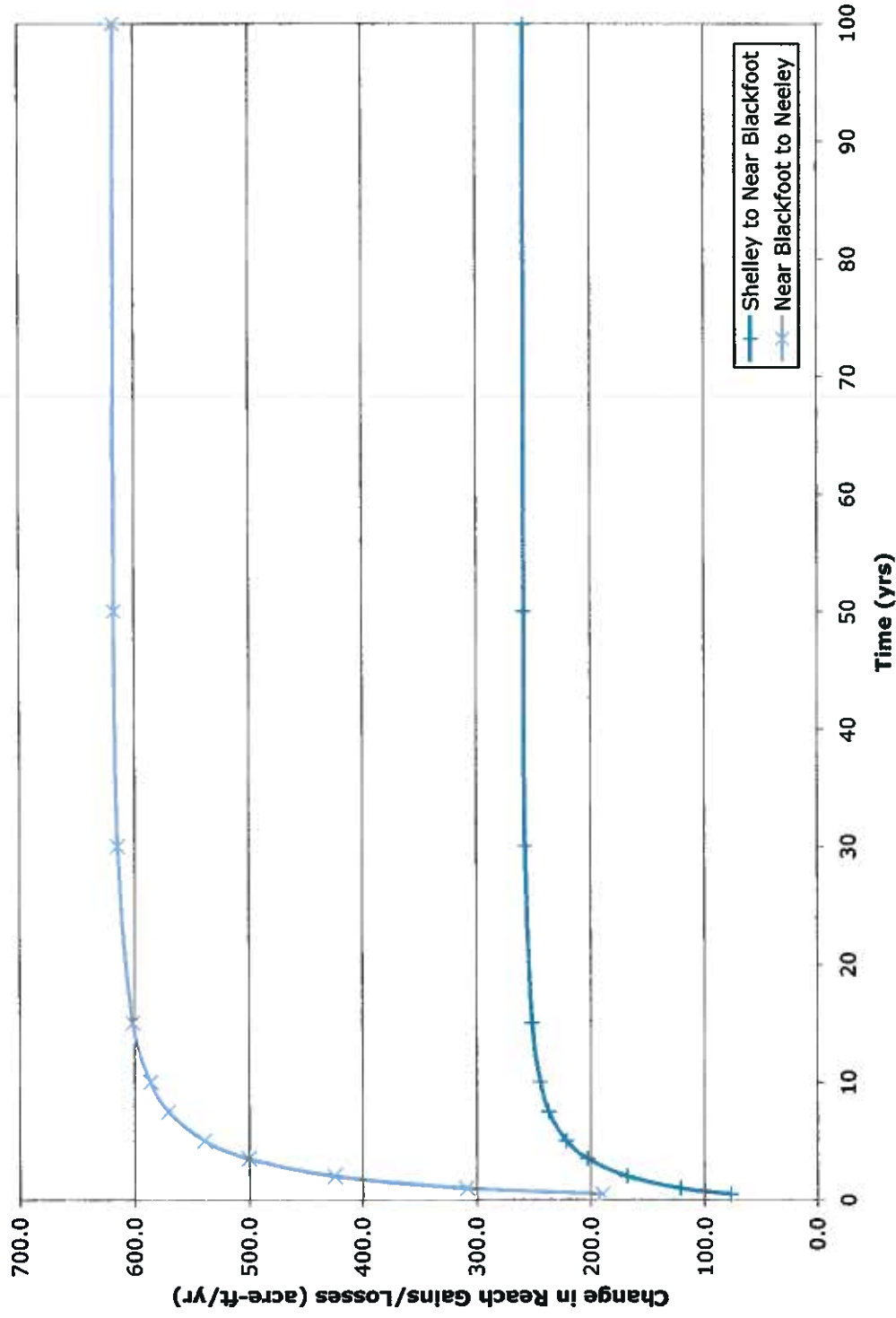


Figure 28. Changes in aquifer-surface water interactions for reaches with larger declines as a result of the proposed transfer. Values are ac-ft/yr.

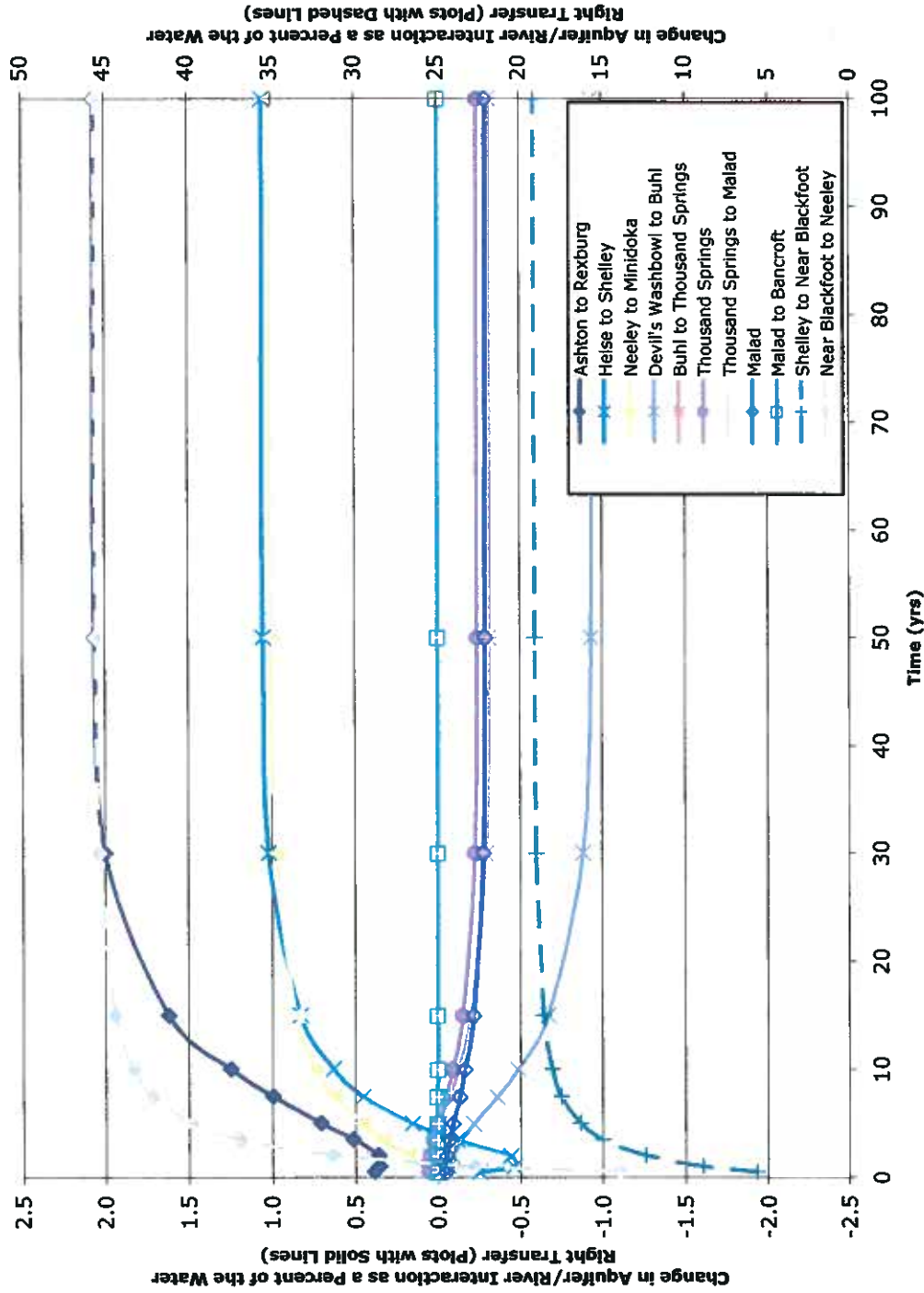


Figure 29. Changes in aquifer-surface water interactions for all reaches as a result of the proposed transfer. Values in percent of the water right being transferred (1355.2 ac-ft/yr).

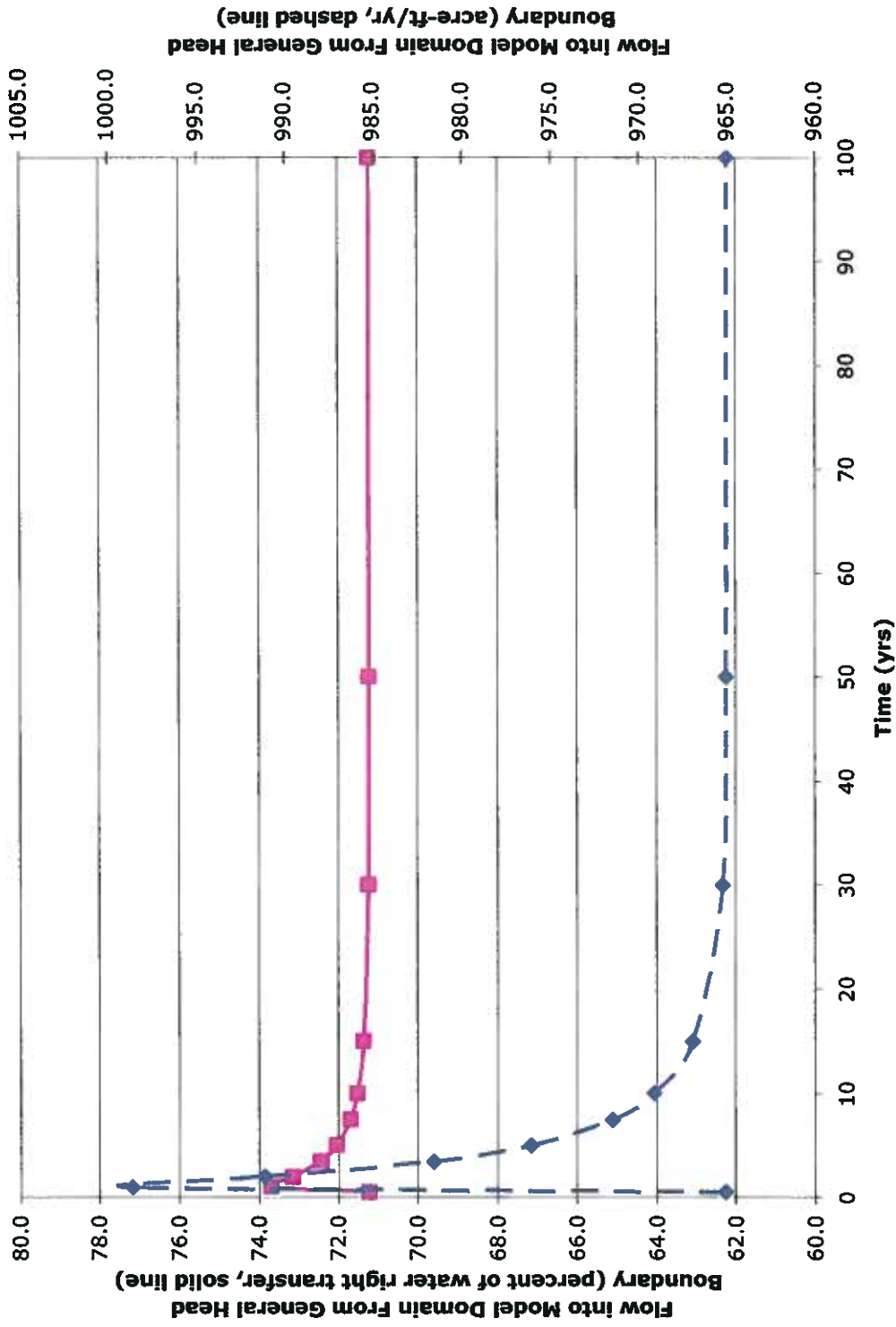


Figure 30. Plot of the flow entering the aquifer from the General Head Boundary Condition as a percentage of the transferred water right and in acre-ft/year.