Report as of FY2007 for 2006ID60B: "A geochemical investigation of groundwater sources in the Blackfoot River and Snake River floodplain"

Publications

Project 2006ID60B has resulted in no reported publications as of FY2007.

Report Follows

Blackfoot River
Groundwater-Surface Water
Interface Investigation
Blackfoot, ID

Preliminary Data and Report
6/25/07

Groundwater-Surface Water Interface Investigation – Blackfoot, ID

I. Introduction

The Eastern Snake River Plain Aquifer (ESPA) is a Sole Source Aquifer (EPA, 1990) and vital to over 400,000 people as a source of irrigation and drinking water. The Snake River is equally vital for irrigators who pump from its aquifers for crops and stock water. Recent drought has caused concern for upper Snake River tributaries which are dependent on recharge from the aquifer. Land managers note that water being pumped from the ESPA for agricultural and domestic use may impact flow of the Blackfoot River at Blackfoot, Idaho. Knowledge of the hydraulic connection of groundwater to the river channel is critical to floodplain management of the Blackfoot River. While considerable work has been done to evaluate how agricultural practices impact flows in the Snake River, little is know how these practices impact tributaries. The Blackfoot River is particularly sensitive because it runs parallel and close to the Snake River for approximately 30 miles, and intensive agriculture exists in the floodplain between the two rivers. Further, the boundary for the heavily used ESPA groundwater model used by numerous agencies does not include the upper Blackfoot River watershed. Consequently, the impacts of agricultural practices on flows in the Blackfoot River are not well understood. Flow levels in the Blackfoot River are of interest to numerous agencies and stakeholders. For example, seventeen segments of the Blackfoot River are listed as impaired on the Federal Clean Water Act 303(d) list. Currently, an interagency effort is being organized to evaluate the water resources in the Blackfoot River watershed. This proposal outlines an initiative to bring Boise State University into this working group.

A key first order problem from a water management perspective is simply delineating the watershed boundary through the shared floodplain between the Snake and Blackfoot rivers (SBR). Are groundwater withdrawals from specific wells coming from the Snake River watershed, the Blackfoot River watershed, or a mixture of both? We propose to evaluate relative proportions of Blackfoot River water and Snake River water in wells across the Snake/Blackfoot floodplain and to map hydraulic heterogeneities due aquifer withdrawal using geochemical tracer techniques.

Objectives:

1. Conduct a reconnaissance investigation of surface water and groundwater in the Snake and Blackfoot watersheds upstream of the SBR floodplain to identify isotopic and geochemical signatures.
2. Sample groundwater wells in the SBR floodplain for isotopes and apply mixing models to determine relative proportions of Snake River and Blackfoot River water.

II. Discussion

Geochemical tracers

Over the past decade, radiogenic isotopes have been increasingly applied to studies of catchment hydrology, water-rock reaction and weathering (Bullen and Kendall, 1998). These solute isotopes contribute to the study of surface and groundwaters through their potentially distinctive fingerprints derived by mineral-fluid reaction, which in turn may distinguish water flowpaths through different hydrogeological units. When combined with O and H isotopic compositions of waters, these stable and radiogenic isotopes become powerful tools to constrain or test the validity of theoretical hydrogeological models of water sources, reaction paths and fluid flowpaths in catchments and aquifers.

Sr is soluble in most surface and groundwaters during the chemical weathering of mineral surfaces. Leaching of Sr derived from minerals with contrasting time-integrated Rb/Sr will lead to the inheritance of distinct isotopic compositions in reacting waters dependent upon the matrix flowpath and the reaction rates of the constituent minerals. These Sr isotope signatures can be used to determine the source and mixing of isotopically distinct water masses, and the degree and extent of mineral-specific water-rock reactions. (McNamara, 2006).

Groundwater Recharge

Long term hydrologic drought has affected Idaho agricultural regions, particularly areas that depend on groundwater allocations. This drought has had a negative effect on recharge to the ESPA and, in combination with pumping from the aquifer, has had a negative effect on groundwater discharge to local river channels. Peters et al. (2001) analyzed initiation of drought timing from groundwater recharge to groundwater discharge. A confounding factor was lack of understanding of how physical aquifer characteristics influence propagation of surface water drought through groundwater discharge near streams.

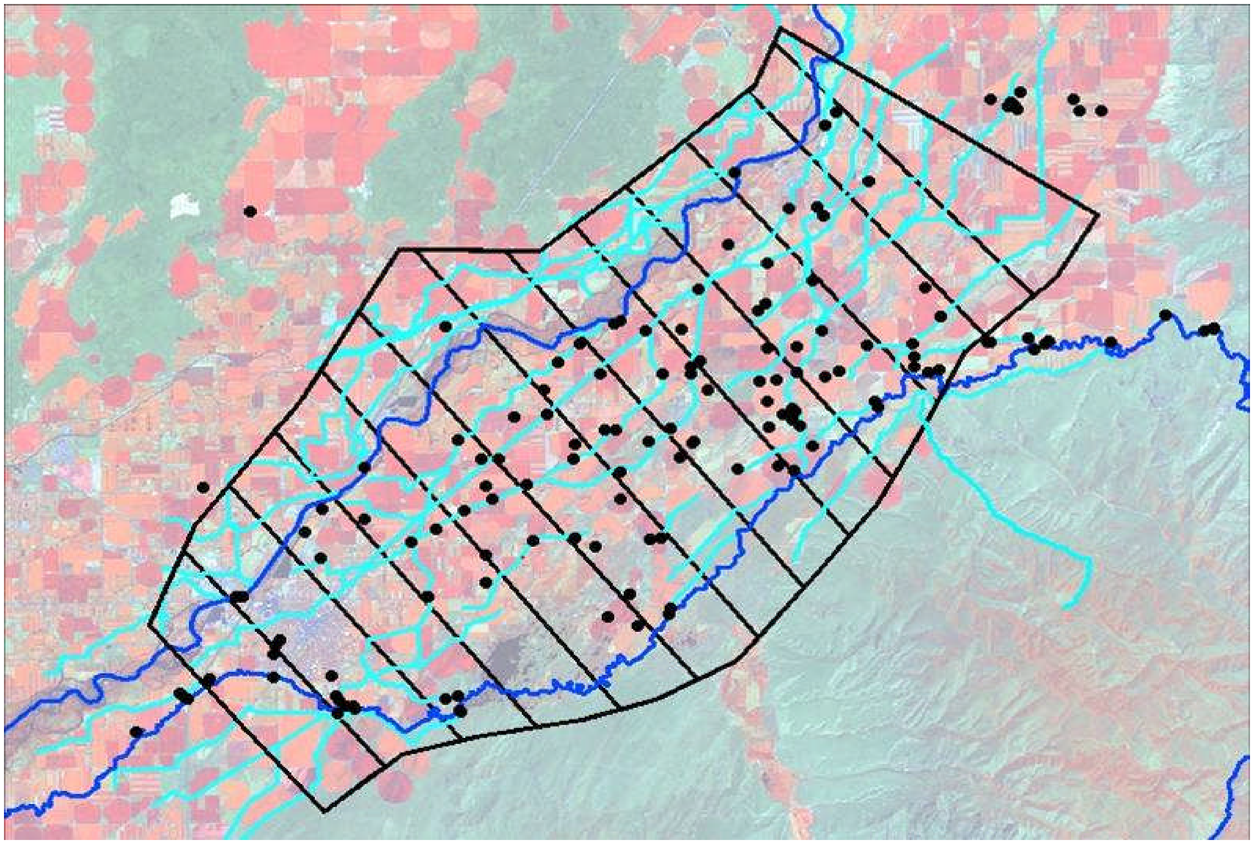
Peters et al. (2003) studied systematically how droughts are propagated from recharge to groundwater heads and discharge regions, and evaluated how aquifer characteristics affect propagation. A synthetic recharge function was defined and the groundwater system was simulated as a linear reservoir with a reservoir coefficient representing the aquifer characteristics. This work enabled derivation of analytical expressions, which express the drought duration and deficit in terms of the decrease in recharge, change in discharge and calculation of a reservoir coefficient.

Groundwater Connectivity to Surface Water

Understanding the spatial variability in hydraulic connection of aquifer to river channel is critical to floodplain management. Lamontagne et al. (2005) studied isotopic signatures within riparian zones where aquifer-surface water exchange was thought to occur on a time scale commensurate with stream hydrograph variations. The resulting patterns in environmental tracers suggest that groundwater in one floodplain had varied origins, including bank recharge, diffuse rainfall recharge, and vertical recharge in the floodplain. Similar isotopic signatures from wells at the bank were found in adjacent stream locations. Lamontagne (2004) found that groundwater in a floodplain has several origins including lateral bank recharge, diffuse vertical rainfall recharge, floodplain close to the river (<100 m). Simpson and Herzog (1991) found that bank recharge could be characterized by low Cl^- and high H^2 and that similar isotopic compositions of cold water wells were observed in surface water less than 75m away.

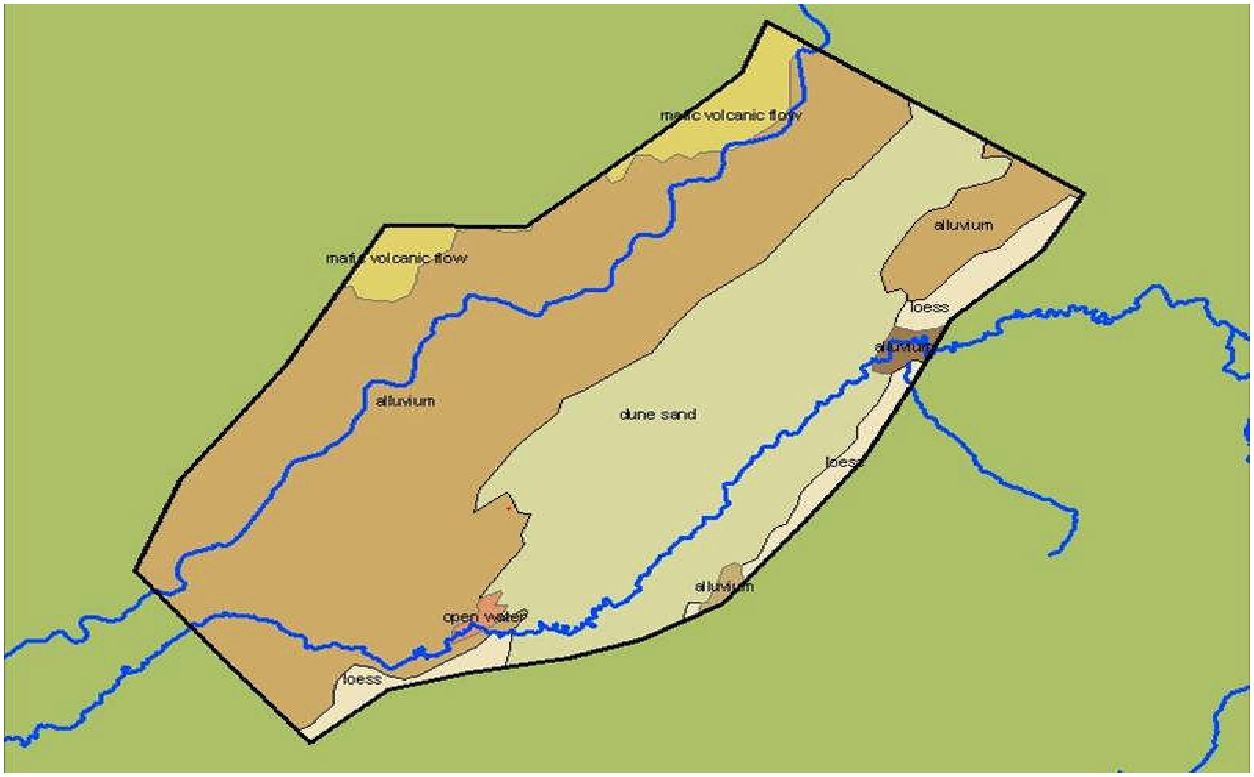
III. Blackfoot Geochemical Tracer Project

The Blackfoot Watershed is roughly 700,000 ac., 130 mi. in length, with annual average flows of 2,140 cfs (USGS). The Blackfoot Valley is roughly 50 sq. mi. in size. The last 30 mi. of the Blackfoot River are included in the study site. Ten transects between the Blackfoot River and Snake River have been constructed such that each transect is roughly 5-7 mi. in length. Forty-five wells were sampled from June-October 2006 within the same range as all ten transects. Canals which run through this area were also sampled. Both the Snake River and Blackfoot River were sampled during this same time period.



IV. Basin Lithology

The study area is mainly alluvium, a mix of clay, fine sands and gravels. Mafic outcrops were observed north of the Snake River.



Site geology, IDWR.

Well logs for the study area suggest an alluvial horizon roughly 100-150 ft deep with deeper wells containing basalt at 200+ ft. River and canal banks contain sandy clay, and sandy gravels. No basalt outcropping was observed near the Blackfoot River (south side of study area).

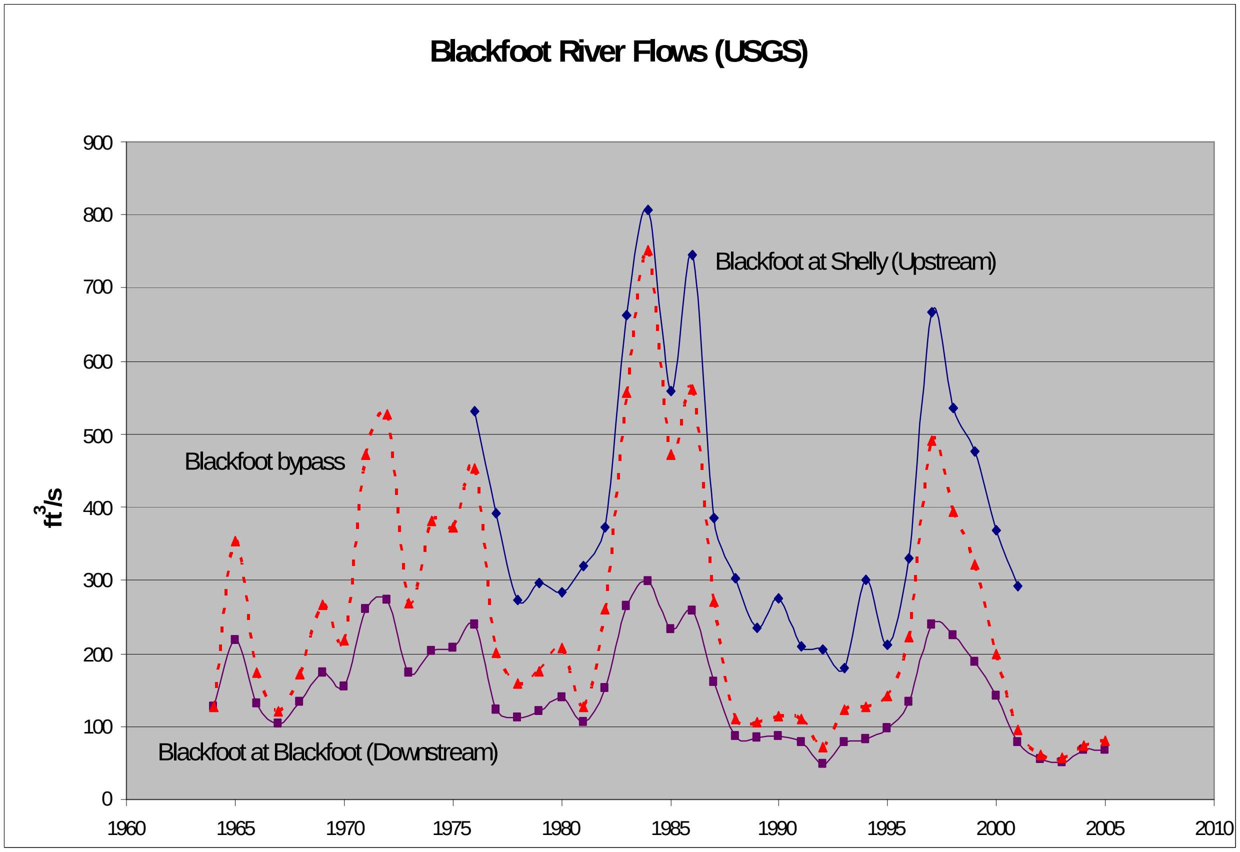
Little geologic information exists for the Blackfoot River Basin. The Portneuf Basin south of the study area contains similar overlapping alluvial flows from the Bonneville Flood. Sedimentary sands, sandy gravels and clays can be observed in this basin as well. The Portneuf aquifer has been characterized as an unconfined, leaky, sandy-clay aquifer and overlies a deep, confined aquifer with known depth of 950 ft. Like the Portneuf, the unconfined shallow Blackfoot aquifer overlies a deep aquifer of unknown depth.

This aquifer system is mainly silty gravel, and sands up to 300-500 feet thick. These sediments are very permeable, unconfined gravels and may be comprised of silty gravels of low permeability below 150 ft. (Welhan et al., 2002). Basalt inclusions are found in many of the wells logs at depths below 100 ft. The hydraulic response of the sand and gravels to extraction infers that vertical hydraulic conductivity is much lower than horizontal hydraulic conductivity. High permeability and anisotropy are characteristic of the horizontal flow in the formation (CH2M-Hill, 1994).


Upper Blackfoot River (August, 2006).

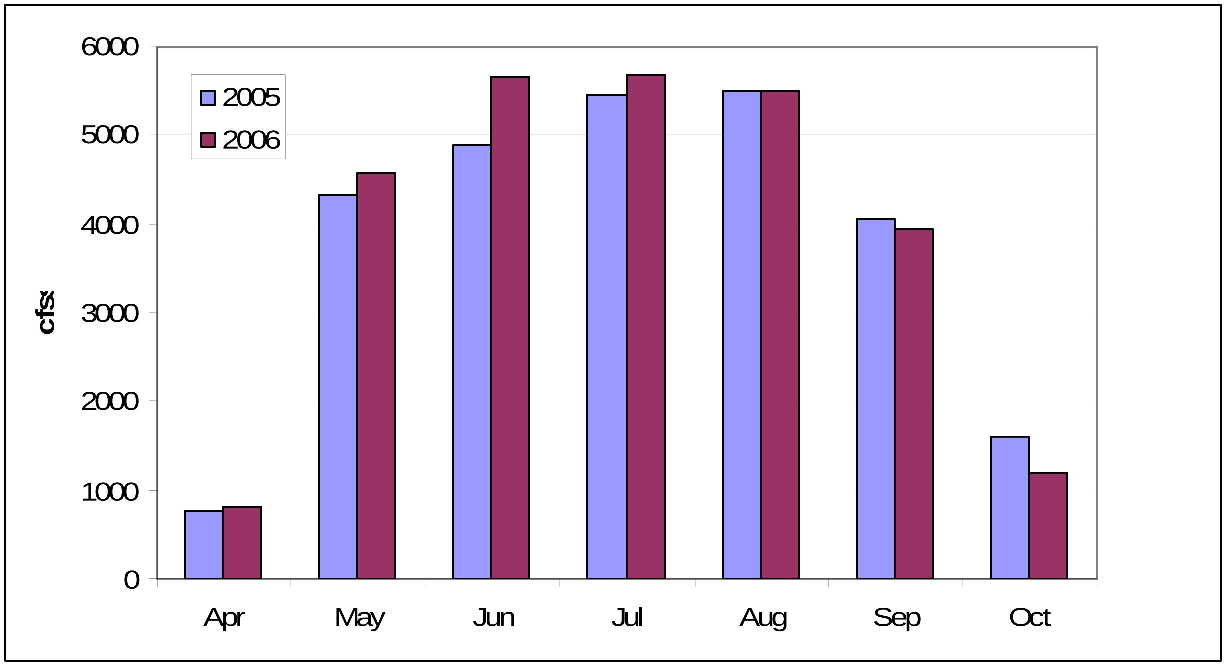
V. Flow Data

Flow data currently exists for 2005, 2006 IDWR monitored diversions to both the Blackfoot and Snake Rivers. IDWR does not monitor flow in the rivers. USGS data is currently available for 2005. Preliminary USGS flow data for 2006 has been received, and is currently being analyzed along with geochemical data to calculate mass balance in irrigation wells and rivers.



USGS Ave. yearly flows (1964-2005).

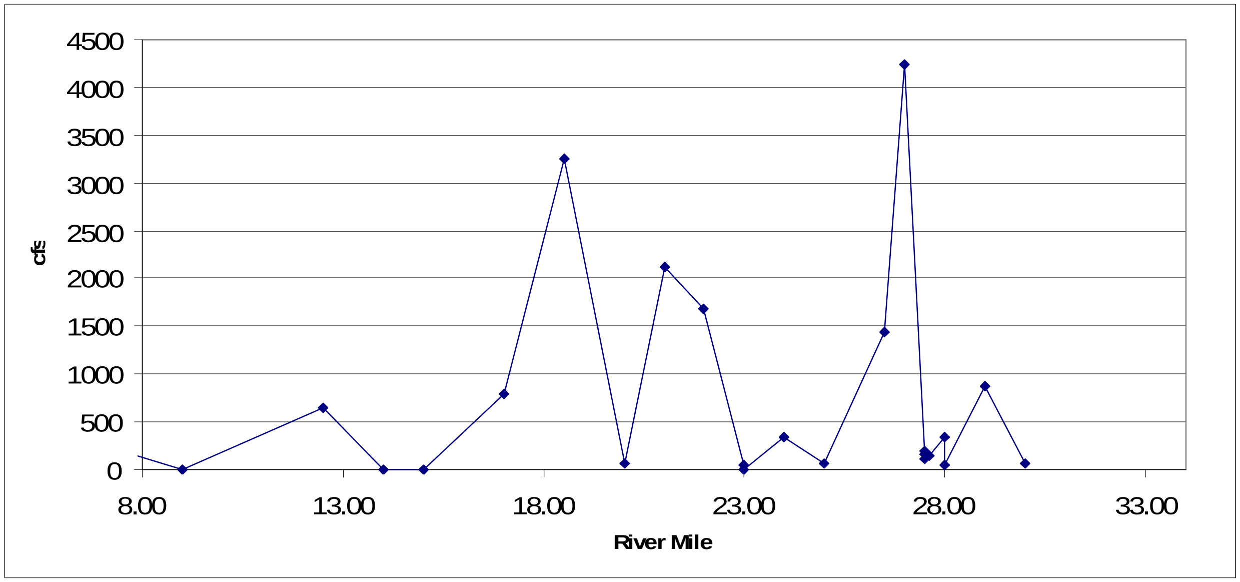
Blackfoot River Diversions - Flow totals



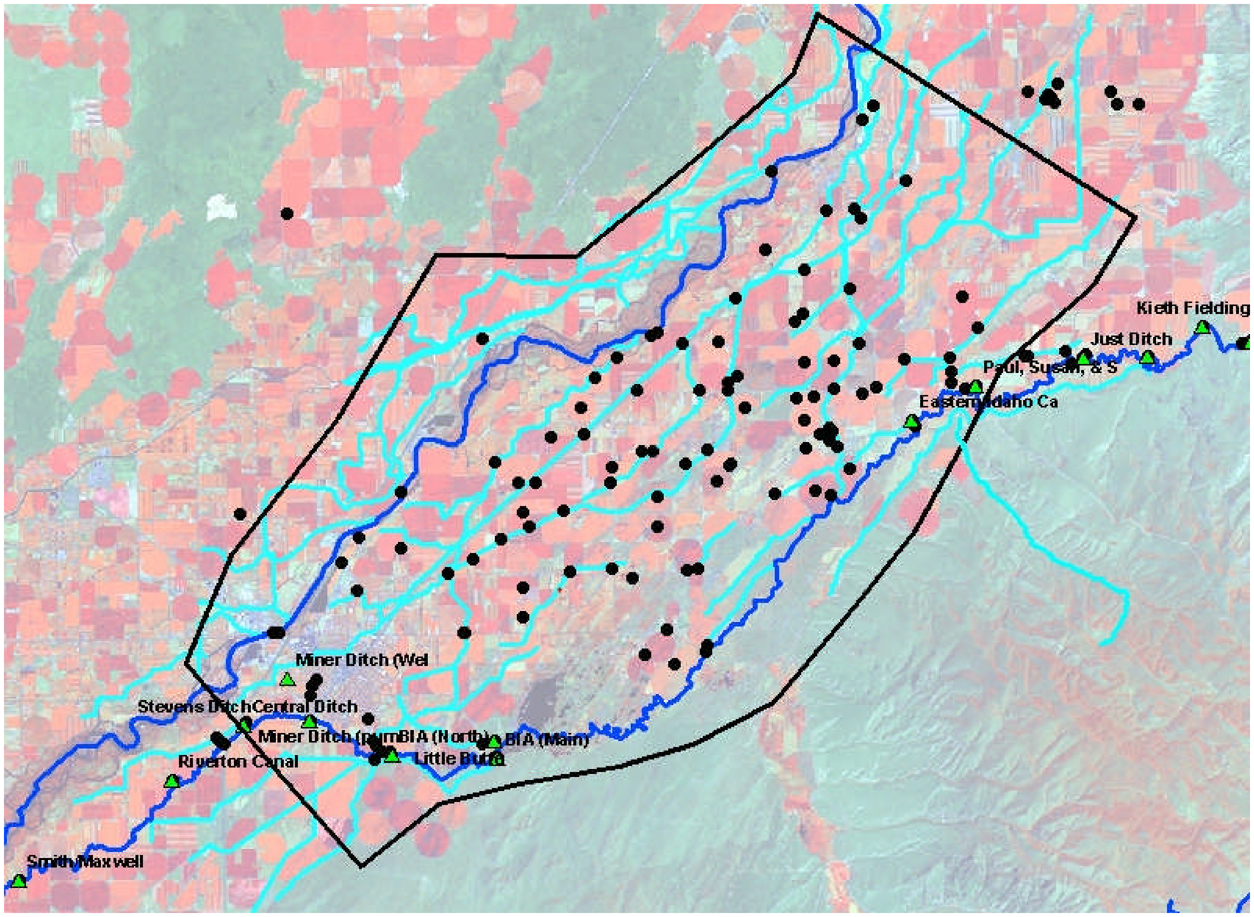
Blackfoot River – monthly diversion rate (cfs) 2005, 2006.

Data is currently availalble for IDWR-monitored returns to the Blackfoot River for 2005, 2006.

Reservation Canal, Sand Creek, Willow Creek all return to the Blackfoot River in the northern side of the study area. Return data for 2006 has not been acquired yet.



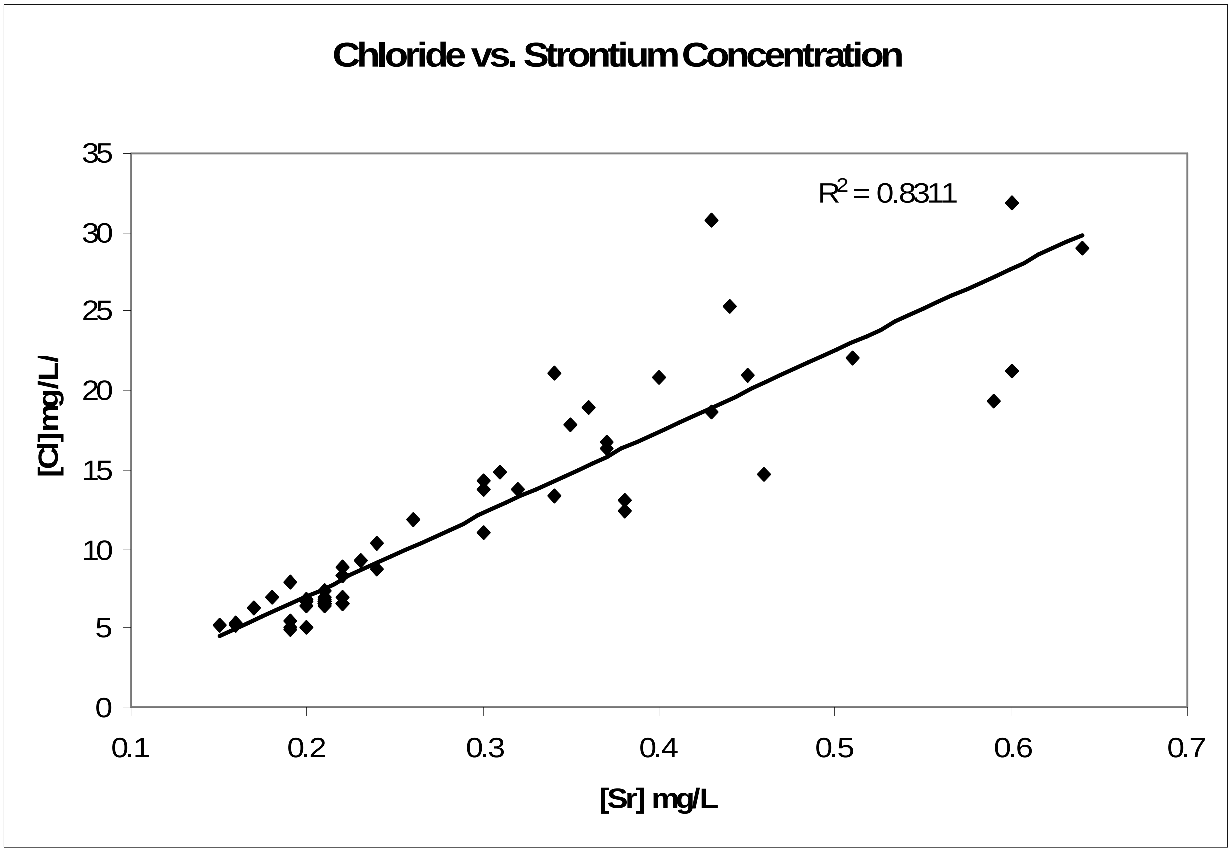
Blackfoot River diversions (June, July, Aug., 2006) from river mile 0 of the last 30 miles.

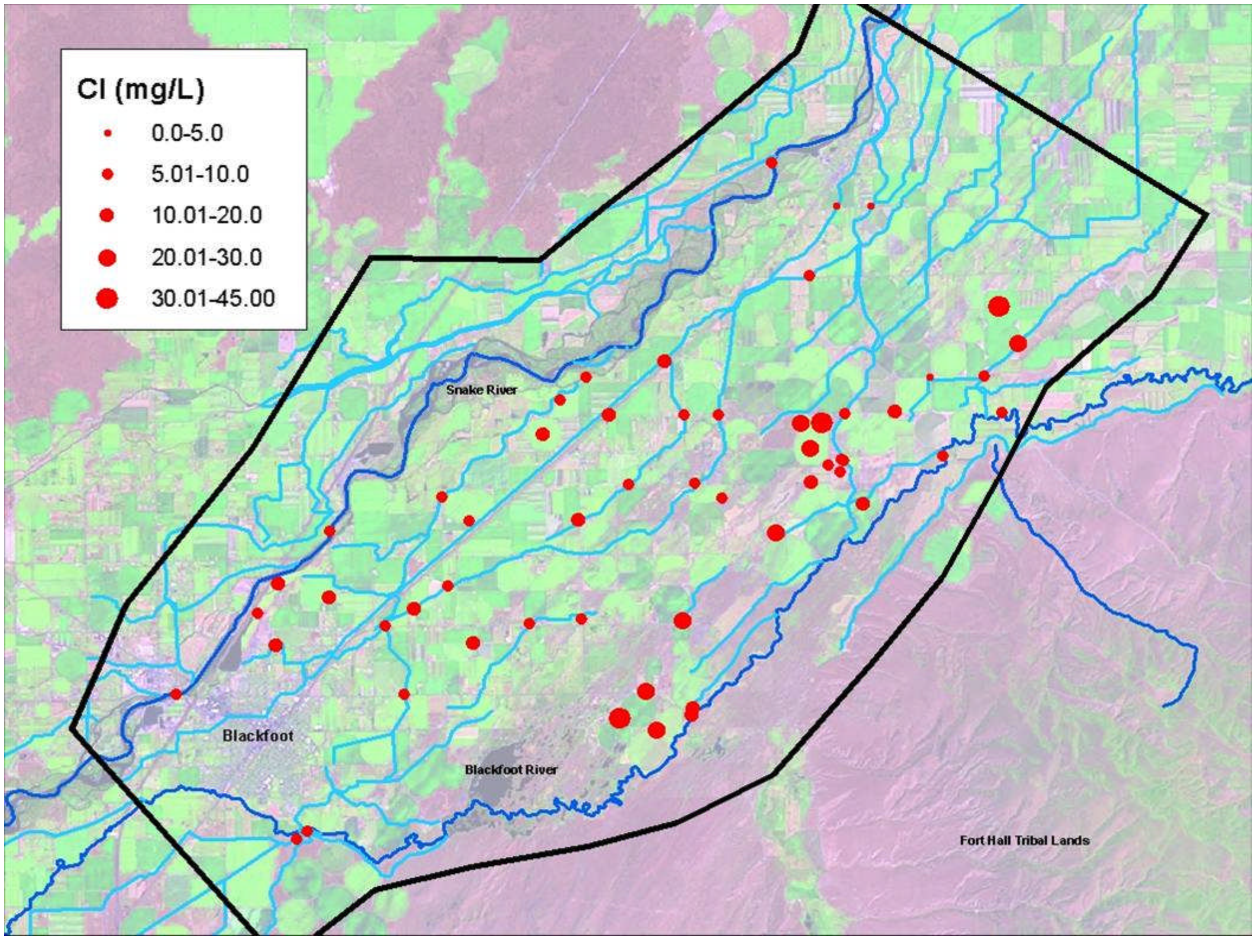


IDWR Diversion Monitoring Sites, 2006.

VI. Water Chemistry

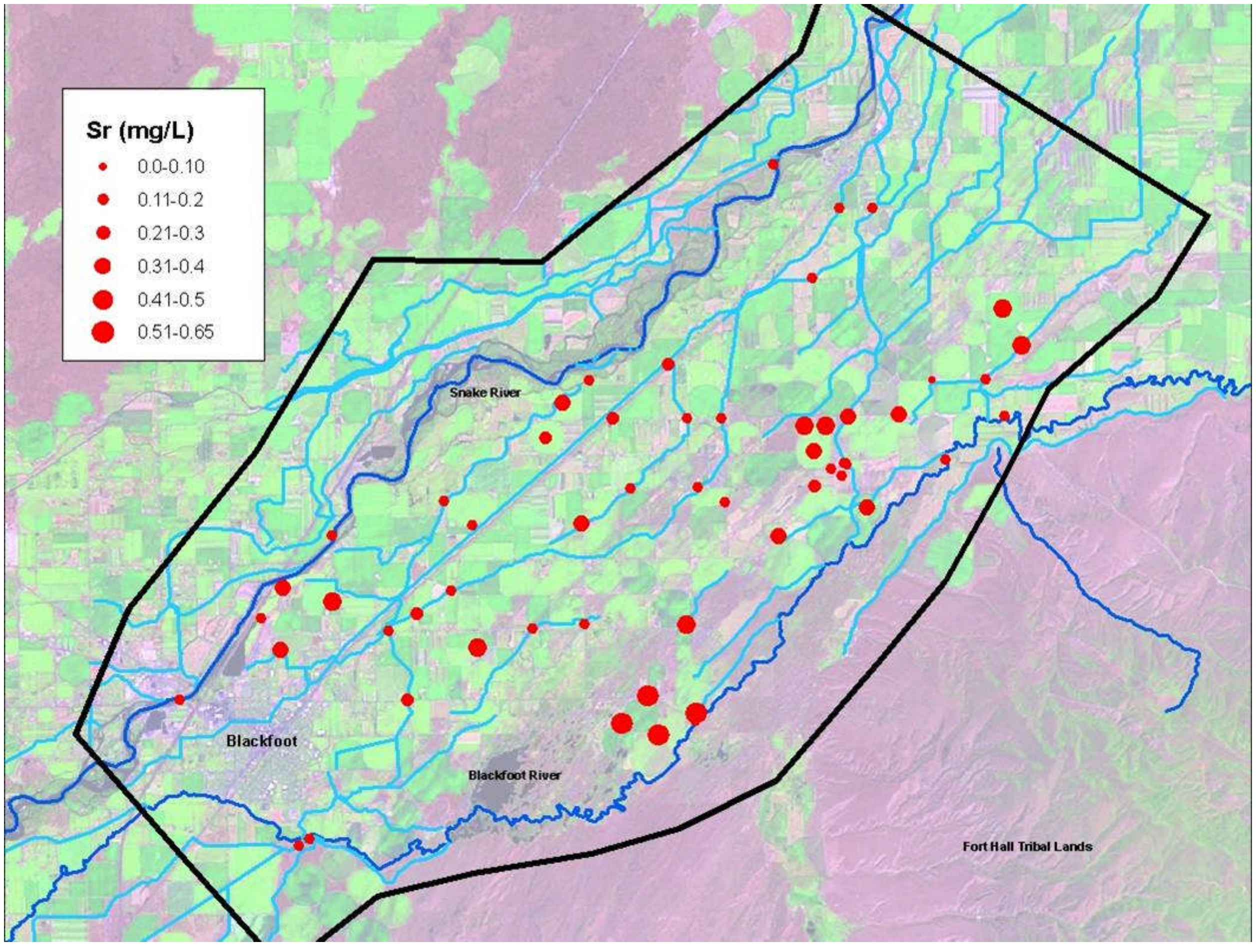
During the 2006 irrigation season, river, canal water and irrigation well samples were collected at 70 sites. The sites were analyzed for total Sr, Pb, U and Cl. The first 32 well samples have been analyzed for major cations and anions. Five river samples (those upstream and downstream of study area) have been analyzed for major cations and anions, ph and alkalinity (CaCO3). Irrigation well, Blackfoot and Snake River samples are currently being analyzed for Sr and U isotope ratios.



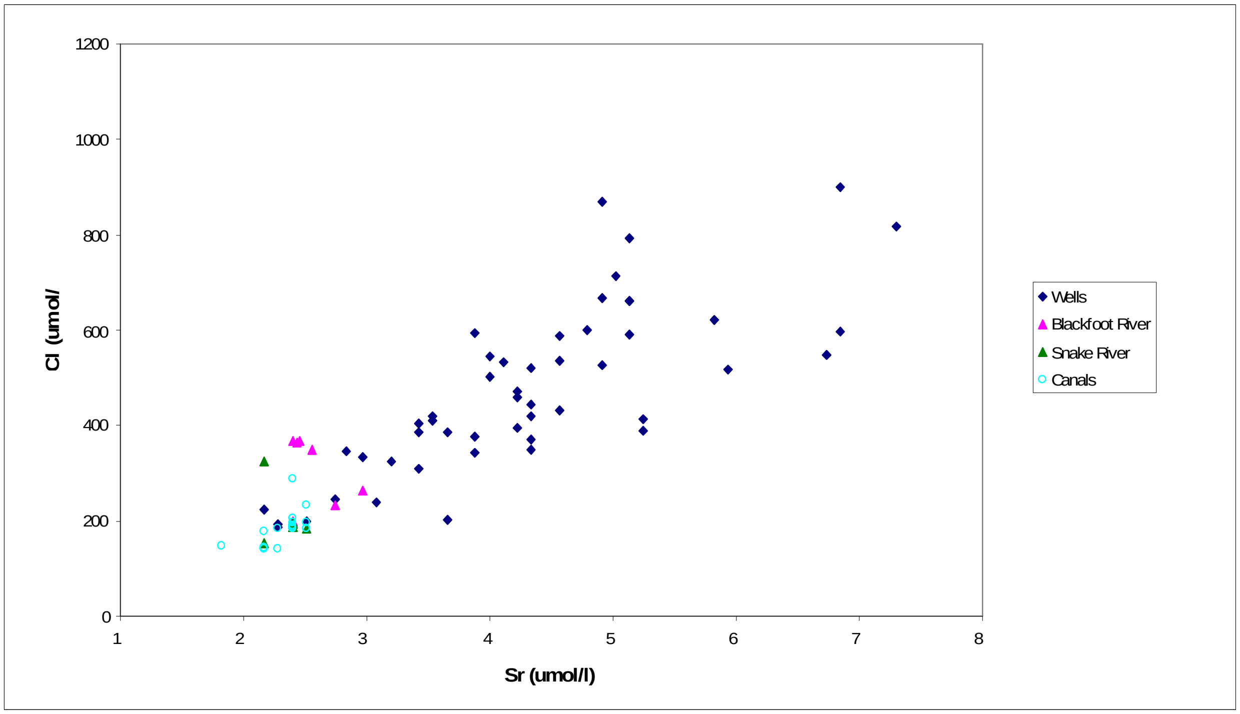


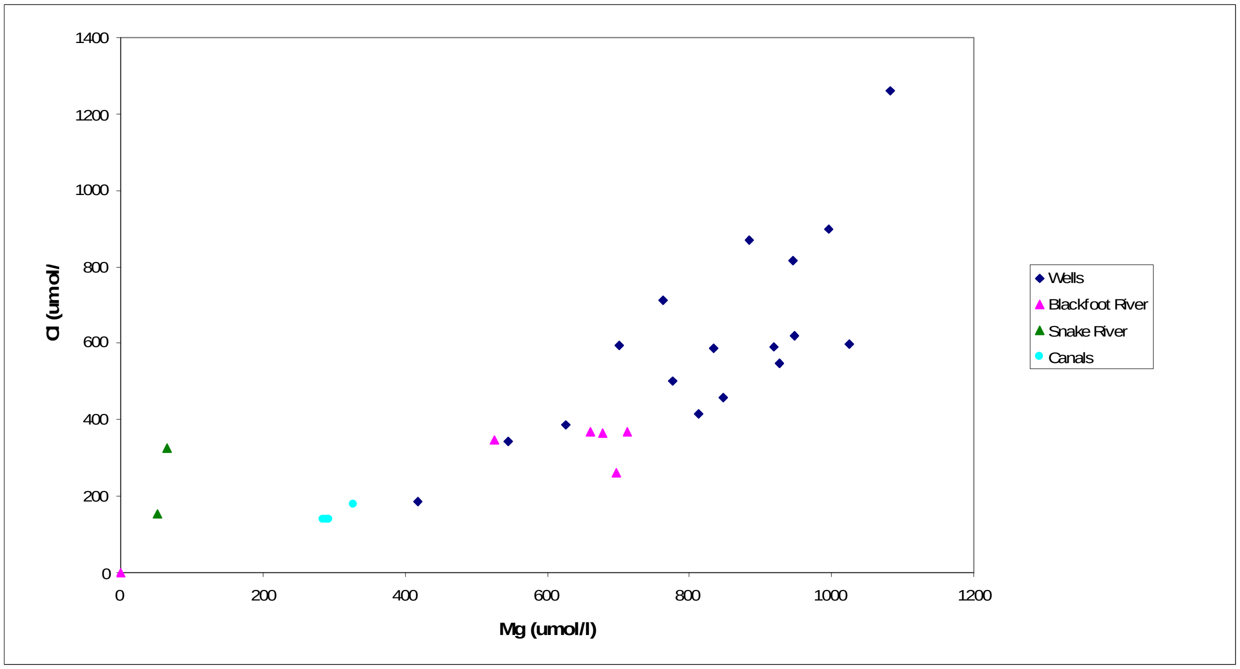
Chloride concentrations appear to be greater in wells near the base of the Blackfoot Mountains, and closer to the border with the Blackfoot River. Chloride well concentrations closer to the Snake River floodplain appear to be lower by 0.2 mg/L on average. Canal concentrations appear to be lower as well, though do not vary much from the Snake River water concentrations.

Canal water levels for 2006 may be higher due to the increase in flows during the 2006 irrigation season (April 15-November 1). Canal substrate is mainly sandy clay, and clayey sand. Major canals throughout the Blackfoot Valley are roughly 20 ft. wide and 10-15 ft. at mid-channel. The canals mainly filled to capacity during the irrigation season. Increased flows most-likely diluted species concentrations at these location.



Of interest is the difference between upstream and downstream water chemistry within the study site. Upstream Blackfoot River water appears have lower concentrations than downstream sites (by ~0.2mg/L) for Sr, Ca, Na, SO4, and higher levels (by 0.1mg/L) of Br, K, Mg, Cl. Well concentrations are much higher than all river samples in SO4, Sr, Ca, NO3 and lower in Br, K, Mg, Cl. The higher NO3 concentrations could be due to slow moving waters which are accumulating fertilizer leachates. Lower Br, Cl ratios in well vs. surface water were found to be similar to those in a similar Arizona study suggesting the effect of evapo-concentration on irrigation well water (Phillips et al, 1998).

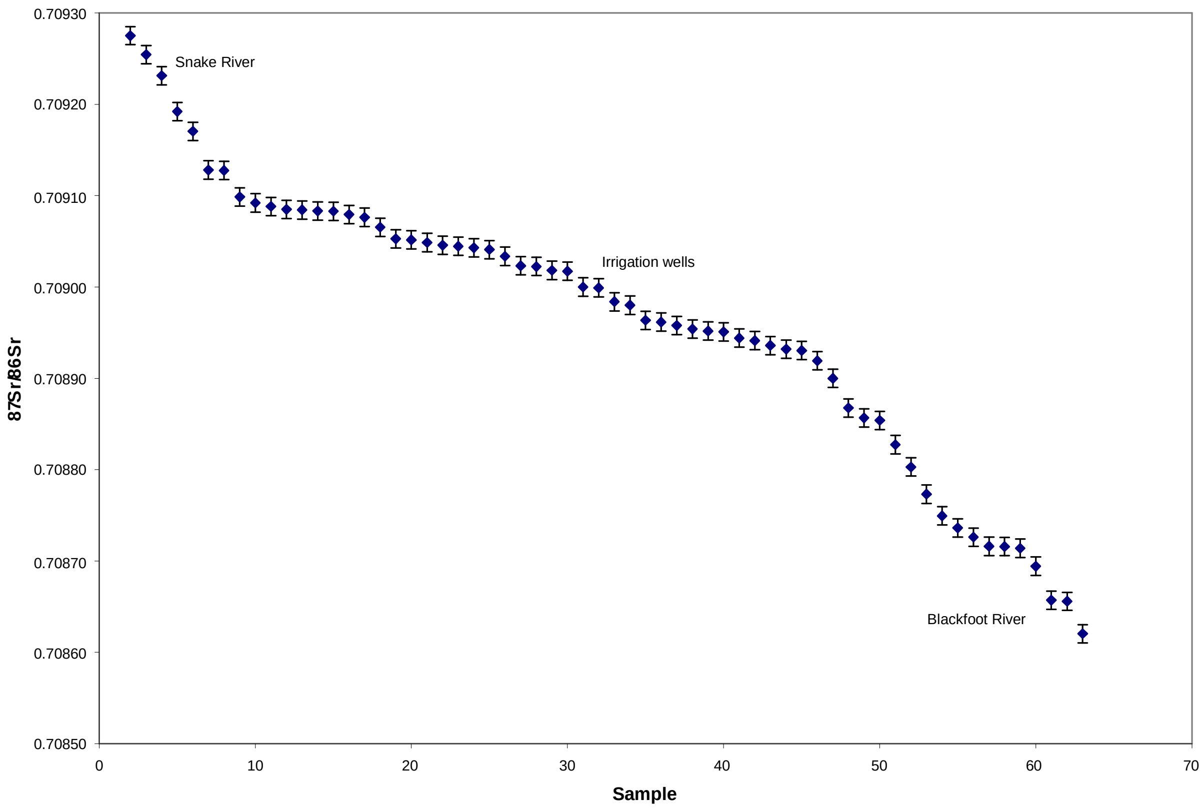




Plotting Cl vs. Mg, we find that there is a clear difference between the Mg concentrations in Snake River water vs. Blackfoot River water, and that wells are more influenced by Blackfoot River water. Canal water is clearly a mixture, of both, and this is expected due to the lengthy canal network associated with both rivers. The Cl vs. Sr plot shows this relationship as well, Although it shows wells and canals are clearly influenced by both rivers. In comparison, the Cl, Mg plot shows a more definitive break between river end members and mixing potentials.

Strontium Isotopes

Currently surface water and well samples are being analyzed for Sr isotope signatures. Total Sr concentrations are higher for Snake River water and irrigation wells, where water most-likely comes from a source higher in ^{87}Sr. Many of the irrigation wells also have a higher than expected Sr isotope ratio. Slower-moving well water has had significant time to accumulate Sr from surrounding sands and gravels high in Sr and Ca. Well mixing is influenced more by Snake River water closer to this source, whereas well mixing near the Blackfoot River is more influenced by this source.



Sr isotope ratio data for the Blackfoot Valley. Samples collected 2006-2007.

VII. Projected Timeline

Currently, no further data collection is planned. Laboratory and statistical analysis is expected to be completed by August, 2007.

Reference

Lamontagne, S. ,Fred W. Leaney and Andrew L. Herczeg 2005 Groundwater–surface water interactions in a large semi-arid floodplain: implications for salinity management *Hydrol. Process.* 19, 3063–3080.

Peters, E., P J. Torfs, H. van Lanen and G. Bier (2003) Published Propagation of drought through groundwater—a new approach using linear reservoir theory *Hydrol. Process.* 17, 3023–3040.

Phillips, F. M., Mills, S., Hendrickx, M. H., Hogan, J. 1998. Environmental tracers applied to quantifying causes of salinity in arid-region rivers: results from the Rio Grande Basin, Southwestern USA. Earth & Environmental Science Department, New Mexico Tech, Socorro, NM

Welhan, J. and Meehan, C. 1994. Hydrogeology of the Pocatello aquifer: implications for well head protection strategies; Proc., 30th Eng. Geology and Geological Engineering Symposium, Boise, March 23-25, 1994.

Welhan, J.A., Meehan, C. and Reid, T.V. 1996. The lower Portneuf River valley aquifer: a geologic and hydrologic model, and implications for wellhead protection strategies; Final Report, EPA Wellhead Protection Demonstration Project and City of Pocatello Aquifer Geologic Characterization Project.

	pH	Alk CaCO3 mg/L	Fl mg/L	Cl mg/L	Nitrite as N mg/L	Sulfate mg/L	NO3-N	Phos. as P mg/L	Na mg/L	Mg mg/L	K mg/L	Ca mg/L	Br ug/L
BFR-14	7.79	144.00	n.a.	13.02	n.a.	25.41	n.a.	n.a.	9.89	16.06	3.29	35.74	38.73
BRF-15	7.94	140.00	0.24	12.97	n.a.	25.37	0.01	n.a.	9.95	16.48	3.35	36.11	38.44
BFR-16	7.94	160.00	n.a.	13.03	0.01	25.39	0.01	n.a.	10.12	17.30	3.36	39.55	36.07
BFR-17	7.87	140.00	n.a.	12.32	0.01	31.21	0.03	0.16	11.30	12.77	3.05	39.02	32.84
SNAKE9	8.02	139.00	0.97	11.53	0.01	29.75	0.07	n.a.	11.82	9.87	2.60	35.70	29.14
LOWSNAKE	8.12	140.32	n.a.	6.80	n.a.	30.13	n.a.	n.a.	11.43	10.55	2.03	34.19	29.50
PJENSEN	7.30	150.00	0.68	12.22	n.a.	38.72	1.58	n.a.	11.65	13.24	3.30	55.25	33.37

Blackfoot River Upstream samples = BFR14, BFR15, BFR 16
Blackfoot River Downstream sample = BFR17
Snake River Upstream = Snake9
Snake River Downstream = LowSnake
sample Pjensen is an irrigation well with Oct. 2006 water level = 18.4 ft.

SampleID	Fl mg/L	SO4 mg/L	Br ug/L	Na mg/L	Mg mg/L	K mg/L	Ca mg/L	HCO3 mg/L	Cl mg/L	Sr mg/L	Sample Location	Owner Name
606-356	0.49	18.73						234.00			Blackfoot River	
606-359	0.47	20.05	22.09	7.07	8.47	1.76	34.50	245.00	5.21	0.16	Blackfoot River #1	
606-360	0.45	19.44	22.25	6.94	8.40	1.80	34.10	300.00	5.25	0.16	Blackfoot River #2	
606-361	0.45	20.01	23.45	6.89	12.34	1.97	36.67	203.00	10.3	0.24	Blackfoot River #3	
606-362	n.a.	22.42	28.99	9.35	16.94	2.73	60.32	254.00	9.3	0.23	Blackfoot River #4	
606-363	0.44	21.18	24.89	7.96	11.96	2.19	47.79	278.00	7.01	0.18	Blackfoot River #5	
606-364	0.43	19.59	24.12	7.52	10.28	2.00	39.58	245.00	6.29	0.17	Blackfoot River #6	
606-365	0.31	22.54	29.82	8.26	14.31	2.65	52.54	235.00	8.86	0.22	Blackfoot River #7	
606-366	0.30	21.23	21.28	7.01	7.91	1.71	32.20	231.00	5.12	0.15	Blackfoot River #8	
606-685	0.37	22.08	24.15	6.72	8.51	1.92	36.11	243.00	4.95	0.19	BFR9	
606-686	0.38	22.22	22.73	6.66	8.58	1.83	36.39	213.00	4.95	0.19	BFR10	
606-687	0.37	22.88	23.63	6.55	8.53	1.82	36.49	217.00	5	0.2	BFR11	
606-687	0.37	22.88						215.00	5	0.22	BFR12	
606-687	0.38	23.32	23.63	6.55	8.53	1.82	36.49	213.00	5	0.19	BFR13	
606-688	0.40	22.85	26.41	7.59	9.63	2.03	40.11	234.00	5.43	0.19	Snake1	

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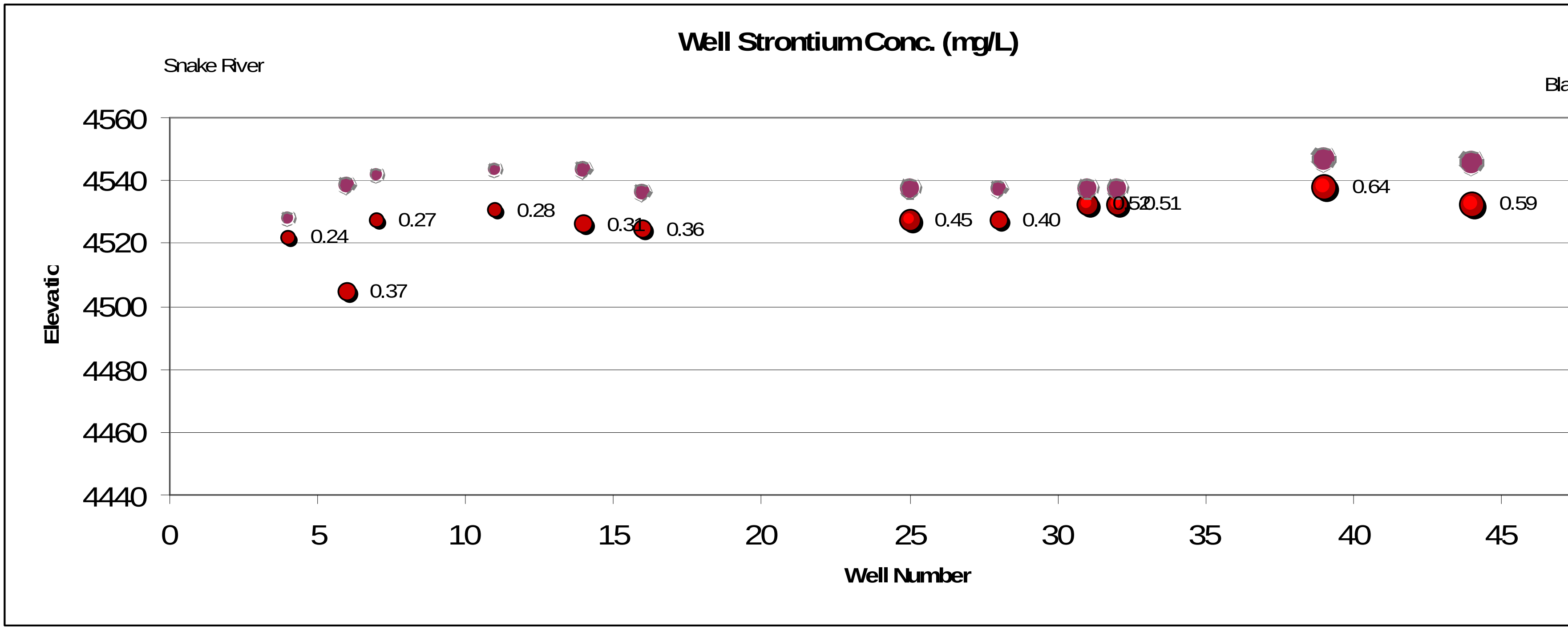
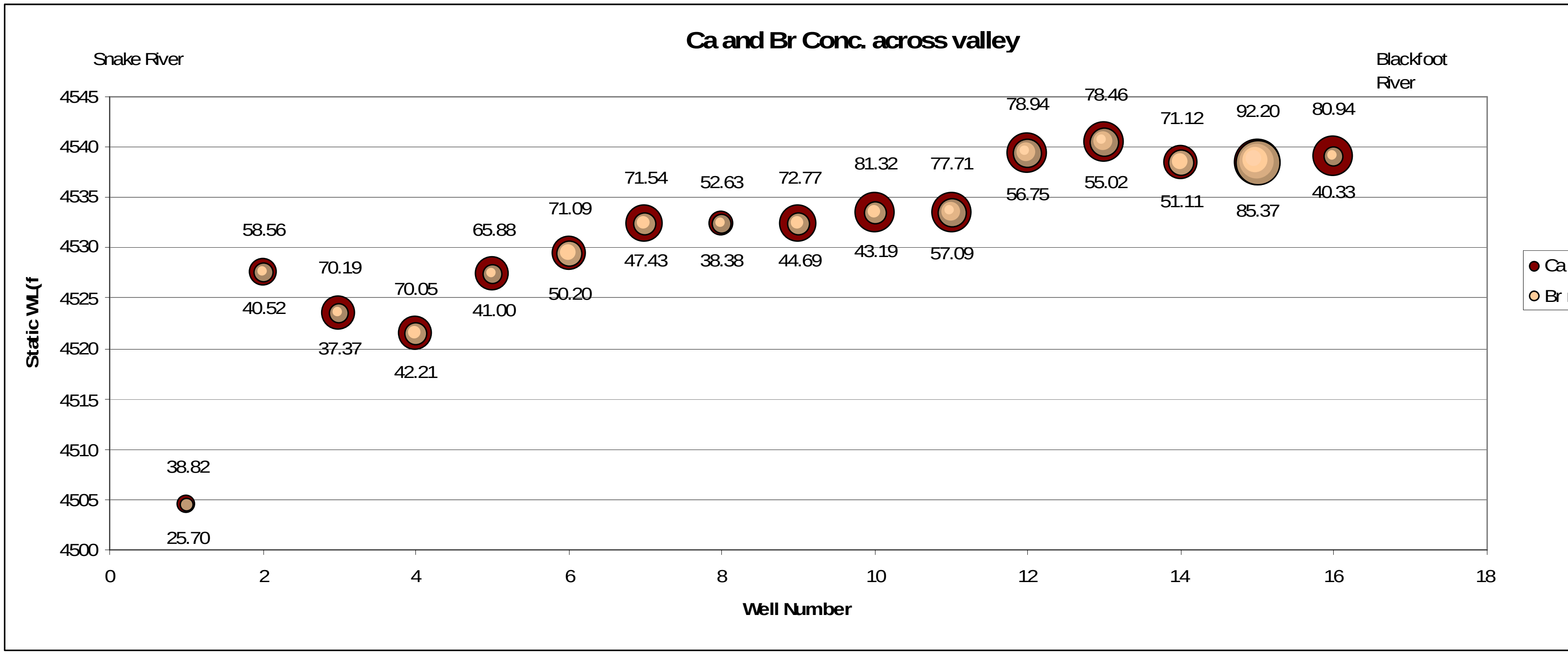
SampleID	Fl mg/L	SO4 mg/L	Br ug/L	Na mg/L	Mg mg/L	K mg/L	Ca mg/L	HCO3 mg/L	Cl mg/L	Sr mg/L	Sample Location	Owner Name
606-669	0.59	22.41	25.70	9.59	10.18	2.36	38.82	205.00	6.61	0.2	Groundwater	DSheiss
606-679	0.60	66.84	40.52	19.85	17.04	3.59	58.56	245.00	21.1	0.34	Groundwater	Mickelsen4
606-673	0.42	38.26	37.37	14.55	19.75	4.02	70.19	265.00	14.7	0.46	Groundwater	Wassia1
606-676	0.27	42.12	42.21	12.28	20.60	3.84	70.05	234.00	16.3	0.37	Groundwater	Mickelsen1
606-682	0.34	54.70	41.00	13.61	18.85	3.68	65.88	202.00	17.8	0.35	Groundwater	MClausen3
606-677	0.55	89.42	50.20	26.29	21.50	4.47	71.09	273.00	30.8	0.43	Groundwater	Mickelsen2
606-670	0.28	48.99	47.43	15.65	23.05	4.55	71.54	222.00	22	0.51	Groundwater	LButler1
606-684	0.43	38.68	38.38	14.46	15.23	3.46	52.63	223.00	13.7	0.3	Groundwater	GPratt2
606-683	0.34	56.60	44.69	16.64	20.27	4.67	72.77	194.00	20.8	0.4	Groundwater	GPratt1
606-678	0.55	71.77	43.19	16.20	18.54	4.11	81.32	275.00	25.3	0.44	Groundwater	Mickelsen3
606-671	0.48	64.73	57.09	22.53	24.90	5.23	77.71	238.00	21.2	0.6	Groundwater	Goleson1
606-675	0.27	68.97	56.75	19.54	24.22	4.76	78.94	267.00	31.9	0.6	Groundwater	BShoemaker1
606-674	0.32	67.53	55.02	16.52	22.98	5.02	78.46	276.00	29	0.64	Groundwater	BRamey1
606-672	0.42	56.63	51.11	19.50	22.52	4.77	71.12	213.00	19.4	0.59	Groundwater	RBradley1
606-680	0.35	70.08	85.37	14.75	26.29	4.43	92.20	235.00	44.7	0.5	Groundwater	MClausen1
606-681	0.27	54.86	40.33	13.55	22.35	4.07	80.94	212.00	21	0.45	Groundwater	MClausen2


Well Strontium Conc. (mg/L)
Snake River
Bla
4560
4540
4520
4500
4480
4460
4440
Elevatic
0
5
10
15
20
25
30
35
40
45
Well Number
0.24
0.37
0.27
0.28
0.31
0.36
0.45
0.40
0.52
0.51
0.64
0.59


Ca and Br Conc. across valley
Snake River
Blackfoot River
Static WL(f
Well Number
Ca
Br
38.82
25.70
58.56
40.52
70.19
37.37
70.05
42.21
65.88
41.00
71.09
50.20
71.54
47.43
52.63
38.38
72.77
44.69
81.32
43.19
77.71
57.09
78.94
56.75
78.46
55.02
71.12
51.11
92.20
85.37
80.94
40.33

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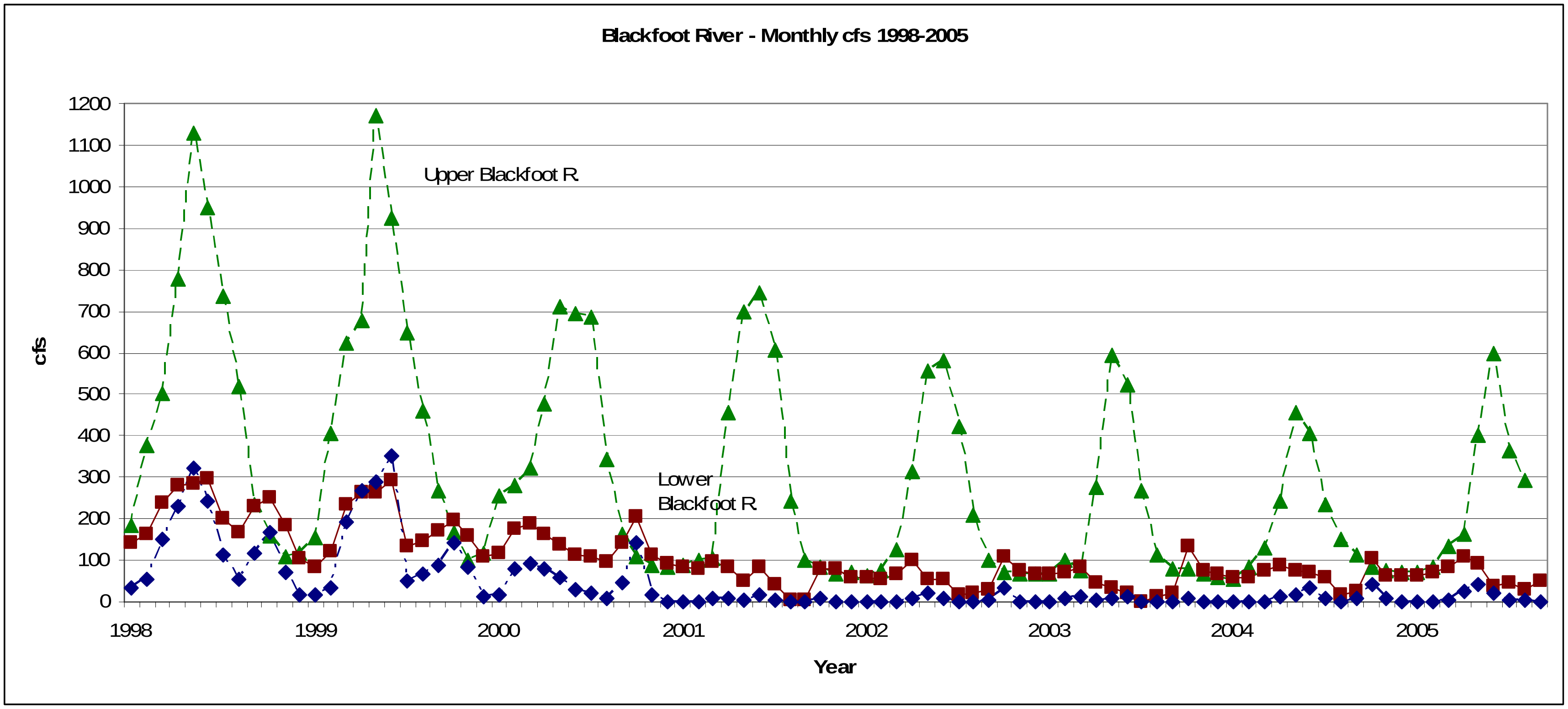
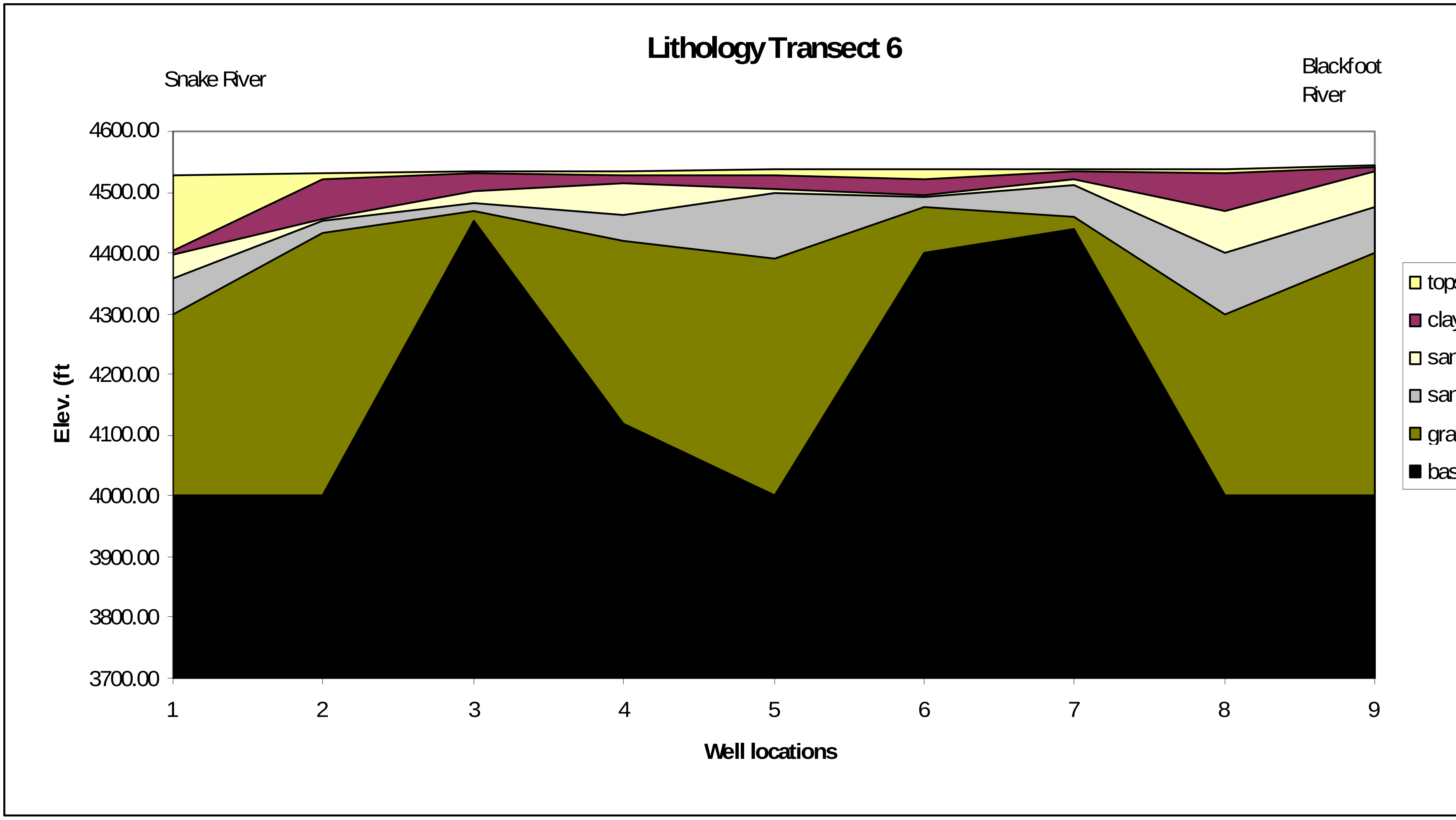


Monthly flows for 3 USGS gages, Blackfoot River (1998-2005).



Lithology Transect 6
Snake River
Blackfoot River
4600.00
4500.00
4400.00
4300.00
4200.00
4100.00
4000.00
3900.00
3800.00
3700.00
Elev. (ft
1
2
3
4
5
6
7
8
9
Well locations
top
clay
san
san
gra
bas

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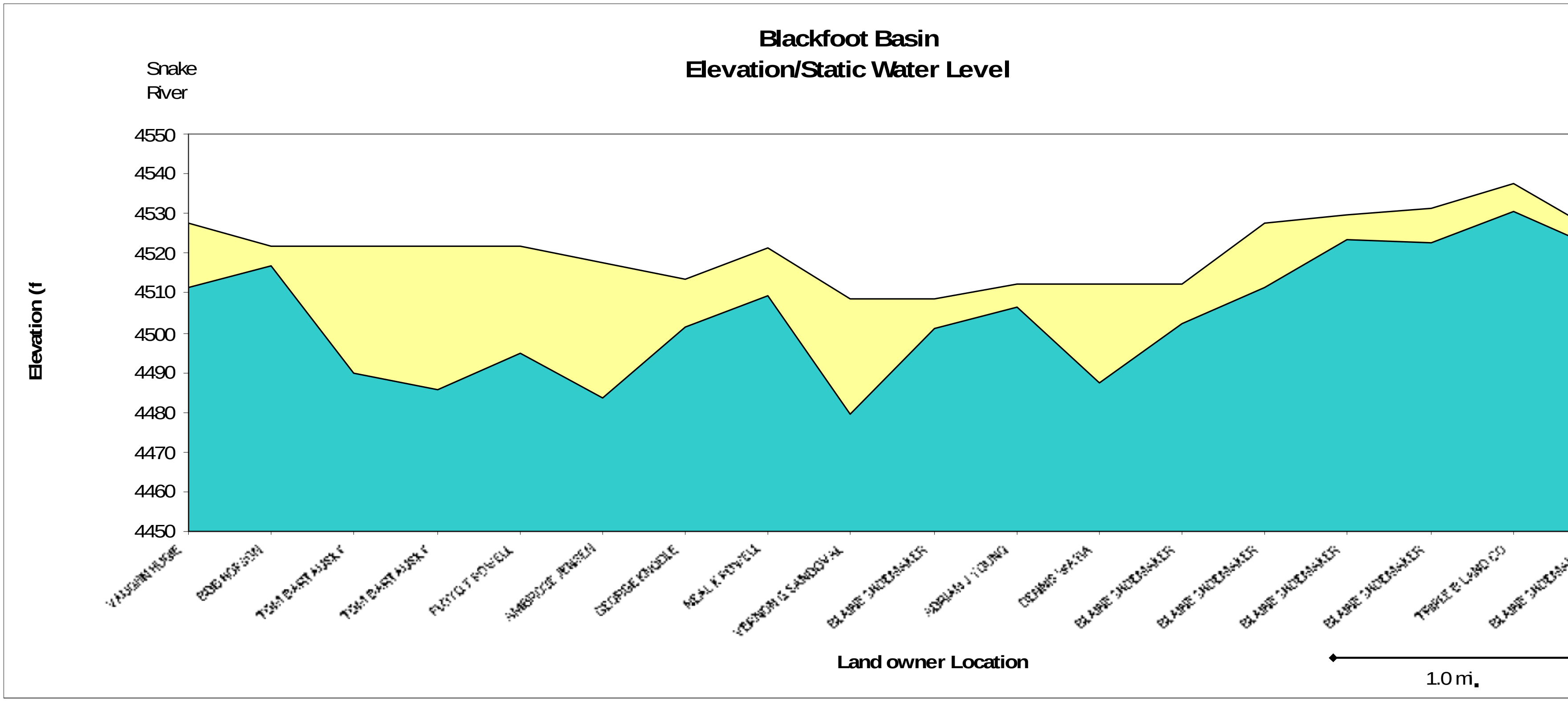
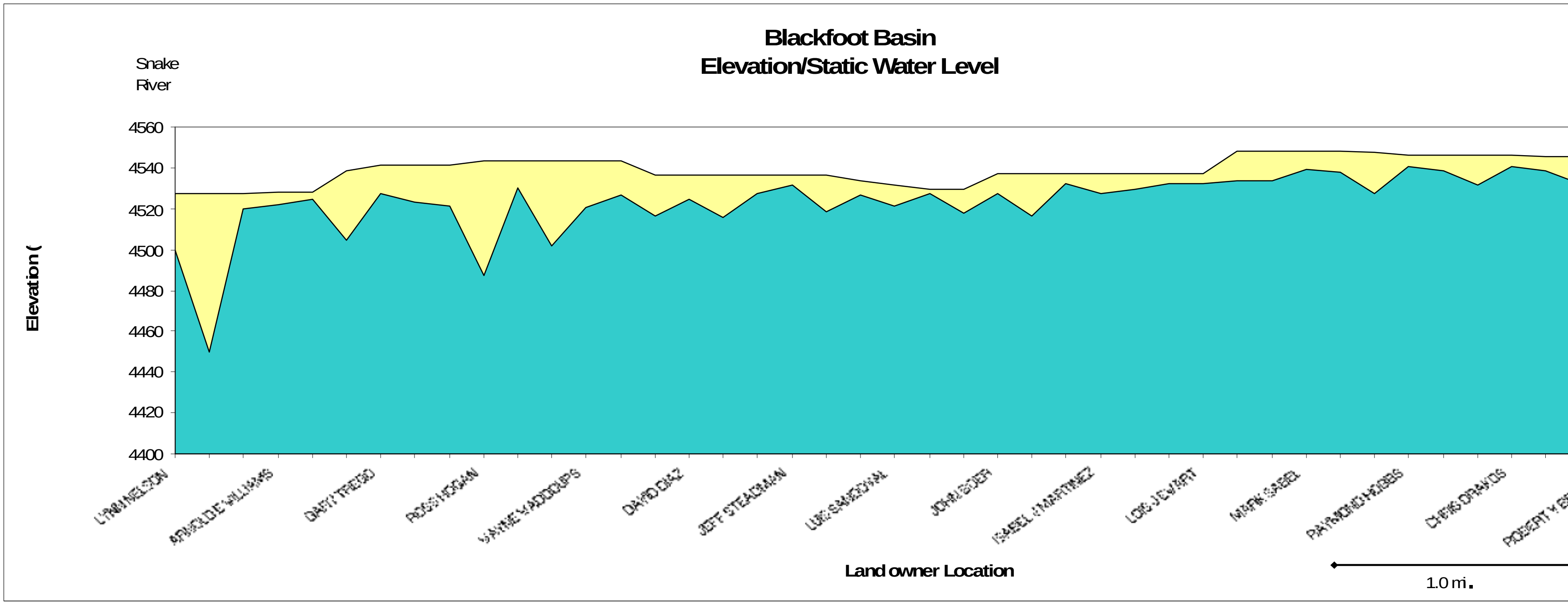
Transect 5



Blackfoot Basin
Elevation/Static Water Level
Snake
River
4550
4540
4530
4520
4510
4500
4490
4480
4470
4460
4450
Elevation (f
Land owner Location
1.0 mi.

Transect 6



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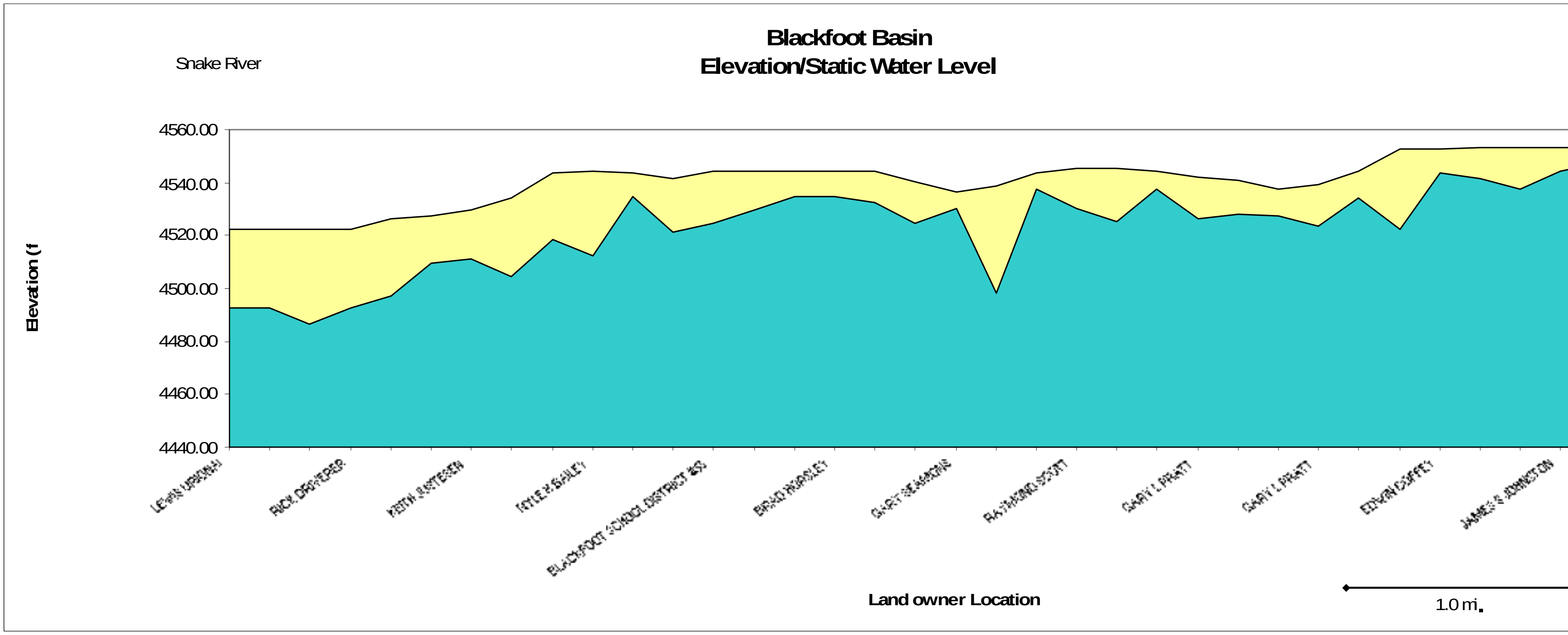
Transect 7


Blackfoot Basin
Elevation/Static Water Level
Snake River
4560.00
4540.00
4520.00
4500.00
4480.00
4460.00
4440.00
Elevation (f
GARY L PRATT
GARY L PRATT
Land owner Location
1.0 mi.