HYDROGEOLOGIC ANALYSIS OF THE WATER SUPPLY FOR THE CITY OF BANCROFT, CARIBOU COUNTY, IDAHO

PRELIMINARY DRAFT

IDAHO WATER RESOURCES RESEARCH INSTITUTE
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January 17, 2002

TECHNICAL ASSISTANCE FOR RURAL GROUND WATER DEVELOPMENT WITHIN IDAHO

OVERVIEW

Nitrate and fecal coliform occur in the Bancroft city water supply wells. This report summarizes a study that the IWRRI Technical Assistance for Rural Ground Water Development Within Idaho project team completed to assist the city in mitigating this problem. The study provides hydrogeologic data accommodating these specific objectives:

- Delineate the aquifer supplying water to the Bancroft wells and the location of recharge for this aquifer.
- Determine possible sources of contamination that may cause the water quality problems.
- Identify possible ground water targets available for future development.
- Determine the reliability of the new water supply source.

Bancroft resides in northwestern Gem Valley. Sedimentary rocks form the mountains adjacent to the valley while basalt and unconsolidated fine-grained sediments fill the valley. These fine grained sediments include sand, silt, and clay deposited by ancient lakes and streams. A clay-rich layer sandwiched between basalt lava flows underlies the City of Bancroft. This clay layer probably provides protection to the underlying aquifer.

There are two ground-water flow systems in Gem Valley. One flows northwesterly and the other flows southerly. Bancroft lies over the ground water system with a northwesterly flow direction. Recharge occurs from canal leakage and precipitation on the valley floor and surrounding mountains. Ground water discharges in the Portneuf River, a tributary of the Snake River.

Contamination in the two supply wells likely results from nitrate and fecal coliform-bearing water traveling on a clay rich confining layer, then passing through this layer via poorly constructed wells. A comparison of nitrate levels in nearby USGS monitoring wells indicates localized nitrate contamination to the supply wells because nitrate levels remained constant while the city supply wells increased.

The basalt aquifer offers a reliable water supply source. USGS monitored wells indicate that water levels have remained constant over 74 years, providing evidence of adequate recharge for a sustained water supply. Wells throughout the valley also show the aquifer is capable of supplying an adequate volume of water to the city.

Insufficient well log data for the two city supply wells hinders a thorough analysis regarding well rehabilitation and reducing or stopping contamination. Therefore the safest course of action is development of new wells. New wells developed south of Bancroft will eliminate possible sources of contamination within the city. These wells will require proper sealing to a depth below the clay-rich confining layer, preventing any surface contamination from entering the aquifer via the wells. Adoption of a sampling program should follow well construction in order to recognize any water quality deterioration since elevated nitrate concentrations occur in the aquifer above the natural background level.

INTRODUCTION

The city of Bancroft, located in the Gem Valley of Southeastern Idaho, obtains domestic water from two wells: City Well #1 and Railroad Well #2 (Figures 1 & 2). These two wells serve approximately 450 people (IDEQ, 2002). City Well #1 provides the primary supply of water while Railroad Well #2 serves as a backup when the city requires additional water. Both wells derive ground water from a basalt aquifer that underlies most of Gem Valley.

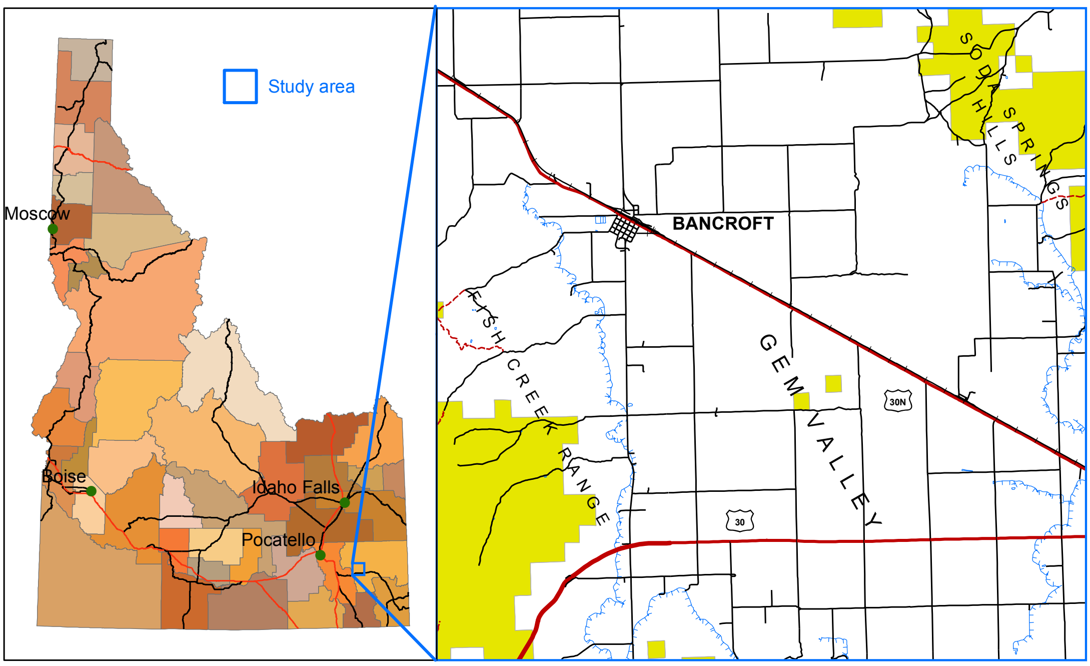

Figure 1: Location of the City of Bancroft, Caribou County, Idaho.

STATEMENT OF PROBLEM

Concentrations of fecal coliform and nitrate occur in both wells, causing water quality problems for the city. In addition to water quality, city officials expressed concern regarding location of both wells with respect to the Federal Emergency Management Agency's (FEMA) 100-year floodplain. In 1962, a large precipitation and melt event flooded most of Bancroft. As a result, FEMA defined a 100-year floodplain for the city (Figure 2). A well located within the floodplain may increase the risk of contamination from surface events.

PURPOSE AND OBJECTIVES

This project provides hydrogeologic information to the City of Bancroft regarding ground water development. The study consists of two components: 1) to evaluate the current

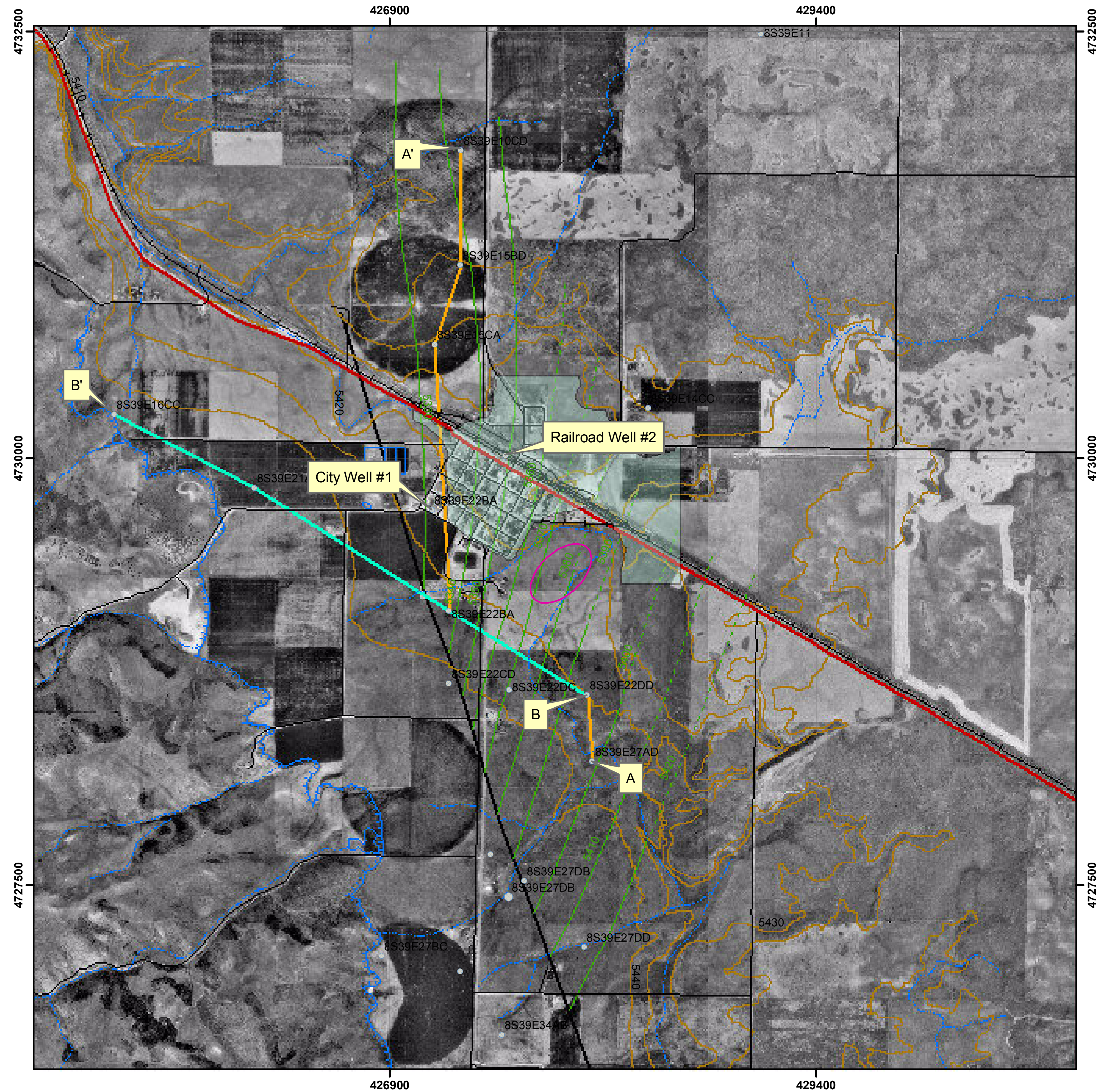

FIGURE 2: UNDERLYING CLAY BED AND PROPOSED WELL LOCATION FOR BANCROFT STUDY AREA, CARIBOU COUNTY, IDAHO

N

0 0.25 0.5 1 Miles

Scale 1:24,000

Projection: NAD_1987_UTM_12N

Data Sources: USGS, IDWR, Inside Idaho

Ground water
- proposed well location area

Cross-sections
- A - A'
- B - B'

Hydrology
- canal
- streams
- intermittent stream

Transportation
- road class 3
- road class 4
- road class 2, highway 30N

Clay bed
- clay bed
- clay bed extrapolated

Well yield [gpm]
- < 50
- 50 - 100
- > 100

Railroad
- railroad

Miscellaneous
- 100-yr floodplain
- fault

Elevation [ft]
- elevation contour

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supply wells and possible contamination sources and 2) to propose a new well location along with construction techniques intended to minimize the risk of contamination. Specific objectives include:

- Delineate the aquifer supplying water to the Bancroft wells and the location of recharge for the system.
- Determine possible sources of contamination leading to the water quality problems.
- Identify possible ground water targets available for future development.
- Determine the reliability of the new water supply source.

GROUND WATER DEVELOPMENT CONCEPTS

Ground water occurs and moves through interconnected fractures and intergranular pore space in an aquifer. It moves under the force of gravity in an aquifer from higher elevation recharge areas to lower elevation discharge areas. Most recharge results from infiltration of precipitation, though some occurs from streams and lakes at elevations higher than the water table. Typical discharge areas include springs, streams and lakes. Ground water moves slowly, generally less than 10 feet per day.

Subsurface geology provides strong controls on water movement within an aquifer. Therefore, an understanding of the subsurface distribution of unlithified sediment, lithified rock, faults, and their physical properties generally leads to a commensurate understanding of ground water flow systems. Mapping surface rock outcrops and reviewing logs of material penetrated by wells helps interpret these features.

Sustainable well development requires less ground water use than aquifer recharge because removal of water results in some water level decline with an associated reduction in natural discharge. The basis for proper ground water development requires characterizing natural ground water discharge from springs and seeps, knowing the discharge of interconnected streams, and understanding the quantity and location of annual aquifer recharge. Additionally, municipal water supplies need a recharge zone protected from contamination because contaminants can mix with ground water and contaminate the municipal supply.

GEOLOGY

Bancroft resides in the northwestern portion of Gem Valley between the Fish Creek Mountain Range and Soda Spring Hills (Figure 1). Deformed Paleozoic and Tertiary-age sedimentary rocks form the mountains, while basalt lava flows and unconsolidated fine-grained sediments fill the valley. These sediments include beds of sand, silt, and clay deposited from ancient lakes and streams.

REGIONAL GEOLOGY

Gem Valley, one of many intermountain valleys in southeastern Idaho, formed during development of the Basin and Range physiographic province over the last several million years. Normal faults that formed during this period dropped the valley floor down relative to the surrounding mountains so rocks identical to those in the mountains underlie the valley floor at depth. Geologic and paleontologic studies by Bright (1963) show that Gem Valley contained a lake, named Lake Thatcher, from about 600,000 years to 30,000 years before present. Lake Thatcher predates glacial Lake Bonneville, which filled much of the western Great Basin 12,000 to 15,000 years ago. Clay-rich sediments with interlayered sand and silt settled from Lake Thatcher, and now occupy much of the valley. Volcanoes formed contemporaneously and spilled basaltic lava flows into the lake. One of the larger volcanoes formed in Gem Valley immediately west of Soda Point. This feature, still visible today, provided enough lava to fill the valley above the level of Lake Thatcher. Due to the topography formed by the volcano, surface waters in northern Gem Valley flow north to the Portneuf River then into the Snake River drainage while the Bear River flows south into Utah.

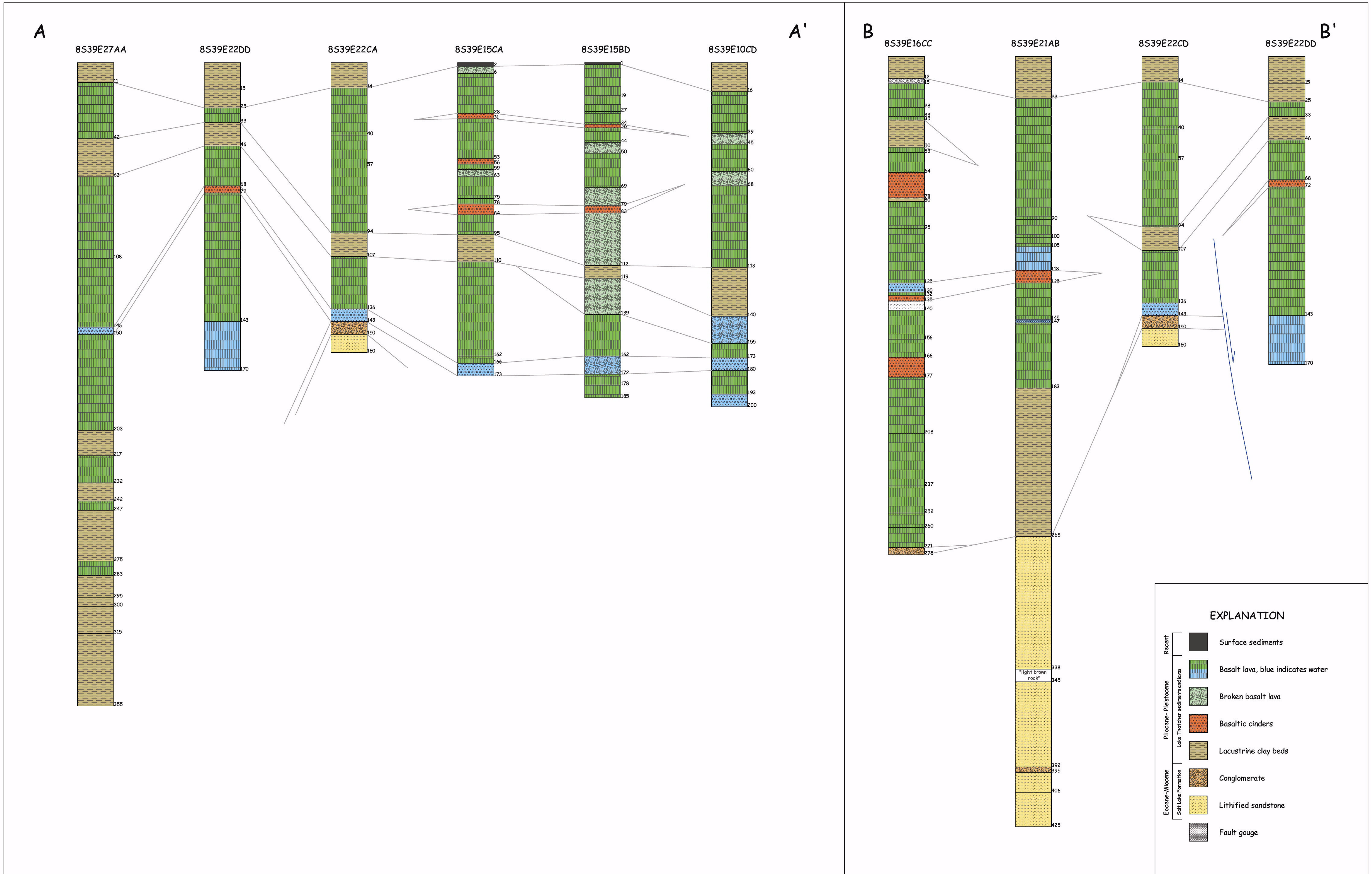
PROJECT AREA GEOLOGY

Drill holes and surface rock exposures show that basalt lavas and interlayered clay beds accumulated in the Bancroft area. The basalt flows vary in thickness, with some flows over 50 feet thick (Bright, 1963). Shrinkage fractures formed when the lavas cooled and created pathways for ground water flow. Clay beds, deposited during periods of volcanic quiescence, form less permeable layers, called confining layer, between the fractured basalt lavas.

All of these units formed nearly horizontally, but post depositional faulting tilted the layers slightly to the northwest. An examination of well logs revealed a confining layer of clay-rich sediments important to ground water development. City Well #1 and Railroad Well #2 draw water from fractured basalt lava flows that reside below the overlying sequence of clay-rich sediments and basalts. The fence diagrams in Figure 3 show correlations between the geologic units identified in wells located around the City of Bancroft. Lines A-A’ and B-B’ in Figure 2 correspond to the fence diagrams shown in Figure 3. City Well #1 penetrates the clay layer approximately 80 feet below the ground surface while Railroad Well #2 intercepts it roughly 70 feet below the ground surface. The clay layer probably provides protection to the underlying aquifer from surface contaminates.

HYDROGEOLOGY

Ground water flows from recharge areas (generally in the mountains where precipitation is higher) via higher hydraulic conductivity zones (aquifers) to discharge areas (springs, seeps, and discharge to streams or lakes). An understanding of well-development potential requires accurate delineation of these ground water flow systems (recharge to discharge areas). City Well #1 and Railroad Well #2 penetrate a basalt aquifer interbedded with fine-grained sediments. This basalt aquifer is important to the city of Bancroft since it provides the only viable drinking water supply source.



IWRRI	Data by BRO	Vertical Scale 1 inch = 50 feet; No horizontal Scale	FIGURE 3; FENCE DIAGRAMS ALONG SECTIONS AA' AND BB'
Grid North	11/05/2002		BANCROFT AREA DRILL HOLE CORRELATION CHARTS

REGIONAL HYDROGEOLOGY

Norton (1981) indicates that a ground water divide, located near the Last Chance Diversion and the Extension Canal (Figure 4), separates Gem Valley into two flow systems. A northwesterly ground water flow system discharges in the Porneuf River northwest of Bancroft while a southerly flow system discharges into the Bear Riverthrough and springs in Black Canyon. The diversion and canal serve as a primary source of recharge into both systems via leakage. Leakage from surrounding canals and precipitation falling on the Soda Springs Hills, Fish Creek range, the Bear River Mountains, and the valley floor provide additional recharge.

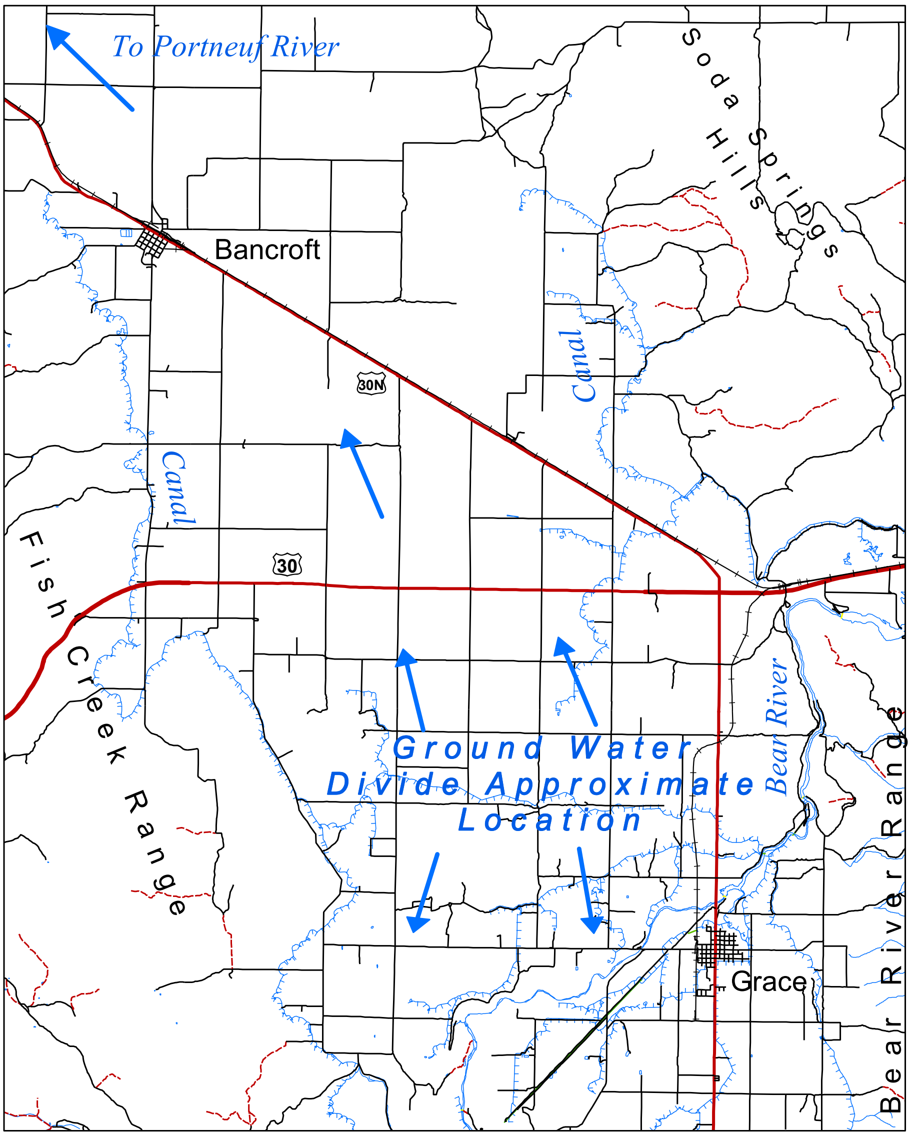


Figure 4 - Ground water flow direction and divide for Gem Valley.

PROJECT AREA HYDROGEOLOGY

The community of Bancroft lies north of the ground water divide, where ground water flows in a northwesterly direction and discharges into the Portneuf River (Figure 4). Potentiometric contours for the aquifer, derived from well log data on file with the Idaho Department of Water Resources (IDWR), demonstrate that water flows northerly towards the Portneuf River (Figure 5) and supports Norton's (1981) interpretation of the northwestern ground water flow system. Recharge occurs from leakage by the West Branch, Soda, and Extension Canals, and precipitation on the valley floor, Soda Spring Hills, and Fish Creek Mountain Range. Recharge also occurs from irrigation water unused by plants.

BANCROFT WELL DATA

Bancroft first completed City Well #1 prior to 1977 when IDWR started storing well logs. Though no written information exists on the original well, city officials mentioned that it was hand dug. Information regarding depth and lithologies cut in the hand dug portion well is unavailable. The City Well #1 well log shows that in 1993 the city had the well reamed from 6 inches to 7 and 7/8 inches between depths of 103 feet to 212 feet. The total depth of the well is 212 feet and the static water level is 97 feet below ground surface. No information regarding Railroad Well #2 was found for analysis. Lack of adequate information regarding well construction and water levels hinders an analysis of the two Bancroft wells. However IDWR and the United States Geological Survey (USGS) provide static water level and water quality data for other nearby wells within the northern half of Gem Valley.

WATER QUALITY ANALYSIS IN WELLS

Elevated nitrate levels occur throughout the aquifer, however both City Well #1 and Railroad Well #2 measure close to the maximum contaminant level (MCL) of 10 mg/L and have higher concentrations than the surrounding wells in the northern half of Gem Valley. Figure 6 shows locations of the USGS monitoring wells, the Bancroft City wells, and the most recent reported nitrate concentrations. It is important to note that the USGS wells are located up gradient from City Well #1 and Railroad Well #2, based on water table contours in Figure 6, therefore water flows towards Bancroft from these wells. An analysis comparing USGS monitoring wells and the Bancroft wells suggests the problem is well construction rather than nitrate contamination in the entire aquifer (Figure 7). Figure 7 shows that both city wells originally contained nitrate concentrations around the elevated background concentrations of the aquifer. However in recent years the city wells' nitrate concentrations increased while other wells remained relatively constant.

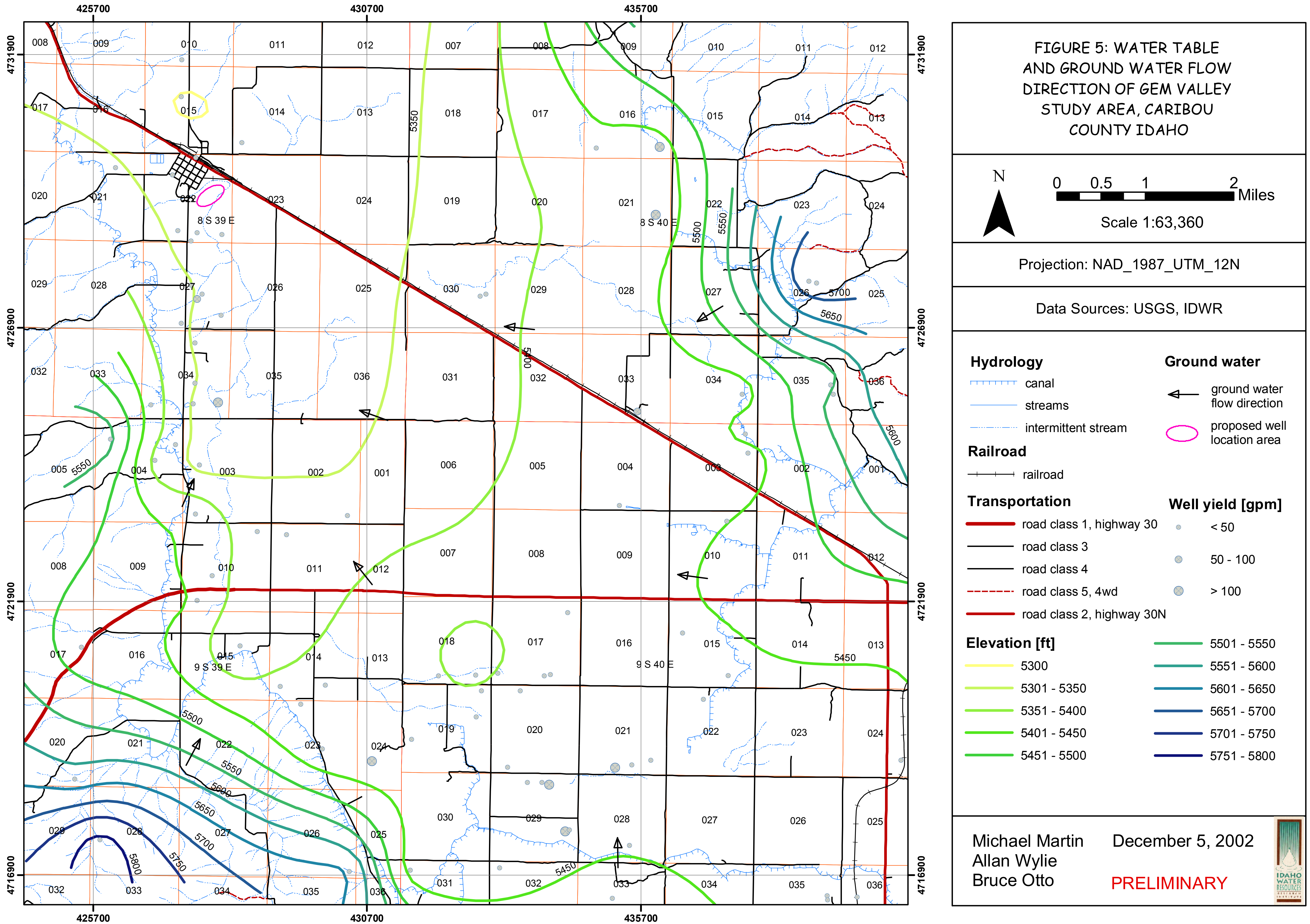


FIGURE 5: WATER TABLE AND GROUND WATER FLOW DIRECTION OF GEM VALLEY STUDY AREA, CARIBOU COUNTY IDAHO
N
0 0.5 1 2 Miles
Scale 1:63,360
Projection: NAD_1987_UTM_12N
Data Sources: USGS, IDWR
Hydrology
canal
streams
intermittent stream
Railroad
railroad
Transportation
road class 1, highway 30
road class 3
road class 4
road class 5, 4wd
road class 2, highway 30N
Elevation [ft]
5300
5301 - 5350
5351 - 5400
5401 - 5450
5451 - 5500
5501 - 5550
5551 - 5600
5601 - 5650
5651 - 5700
5701 - 5750
5751 - 5800
Ground water
ground water flow direction
proposed well location area
Well yield [gpm]
< 50
50 - 100
> 100
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425700
430700
435700
4731900
4726900
4721900
4716900
8 S 39 E
8 S 40 E
9 S 39 E
9 S 40 E

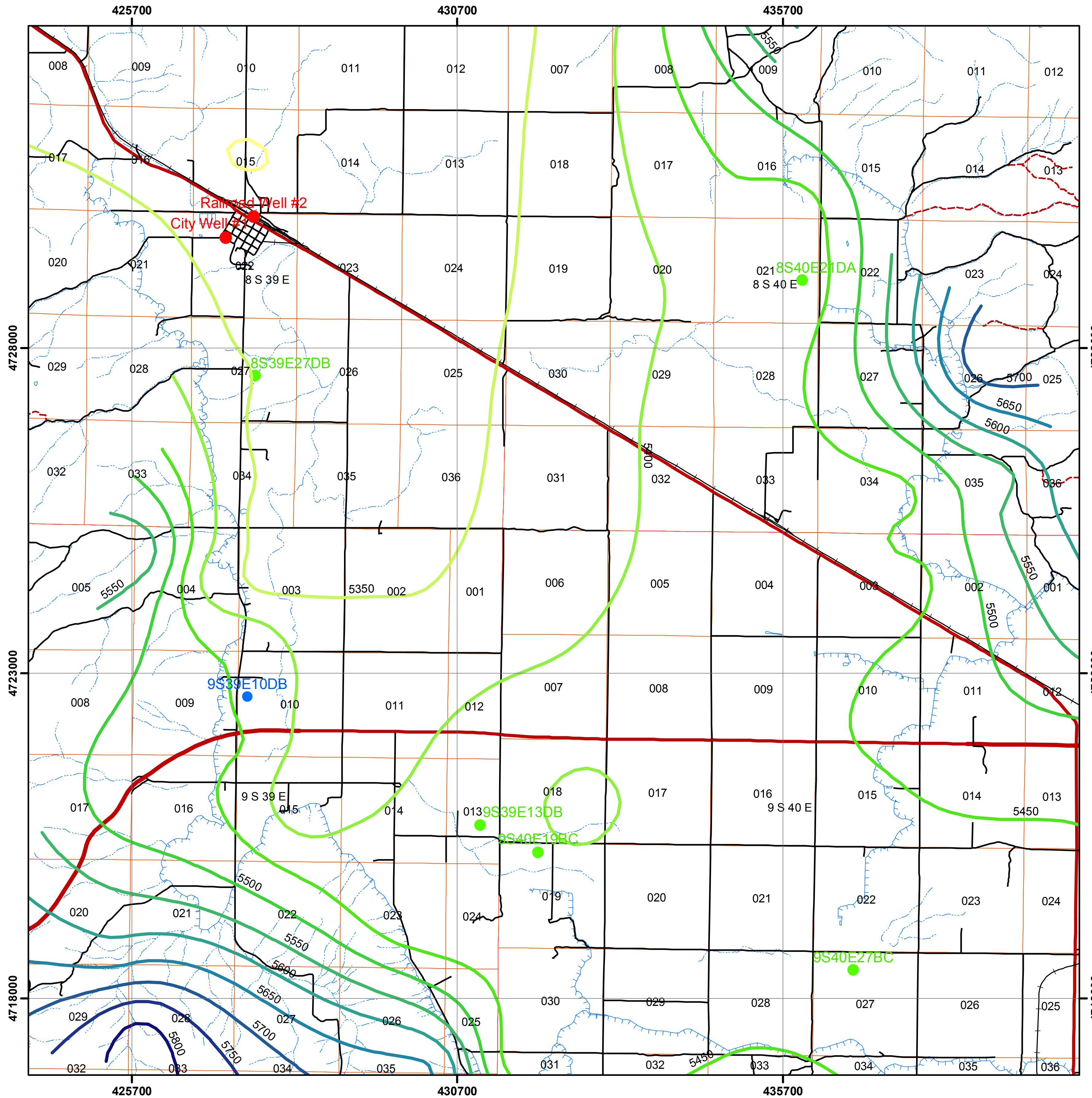

FIGURE 6: NITRATE CONCENTRATIONS OF THE BANCROFT CITY SUPPLY WELLS AND USGS MONITORING WELLS IN THE GEM VALLEY STUDY AREA, CARIBOU COUNTY, IDAHO

N

0 0.5 1 2 Miles

Scale 1:63,360

Projection: NAD_1927_UTM_12N

Data Sources: USGS, IDWR

Hydrology
- canal
- streams
- intermittent stream

Railroad
- railroad

Transportation
- road class 1, highway 30
- road class 3
- road class 4
- road class 5, 4wd
- road class 2, highway 30N

Water Quality [mg/L]
- < 2
- 2 - 7
- > 7

Elevation [ft]
- 5300
- 5301 - 5350
- 5351 - 5400
- 5401 - 5450
- 5451 - 5500
- 5501 - 5550
- 5551 - 5600
- 5601 - 5650
- 5651 - 5700
- 5701 - 5750
- 5751 - 5800

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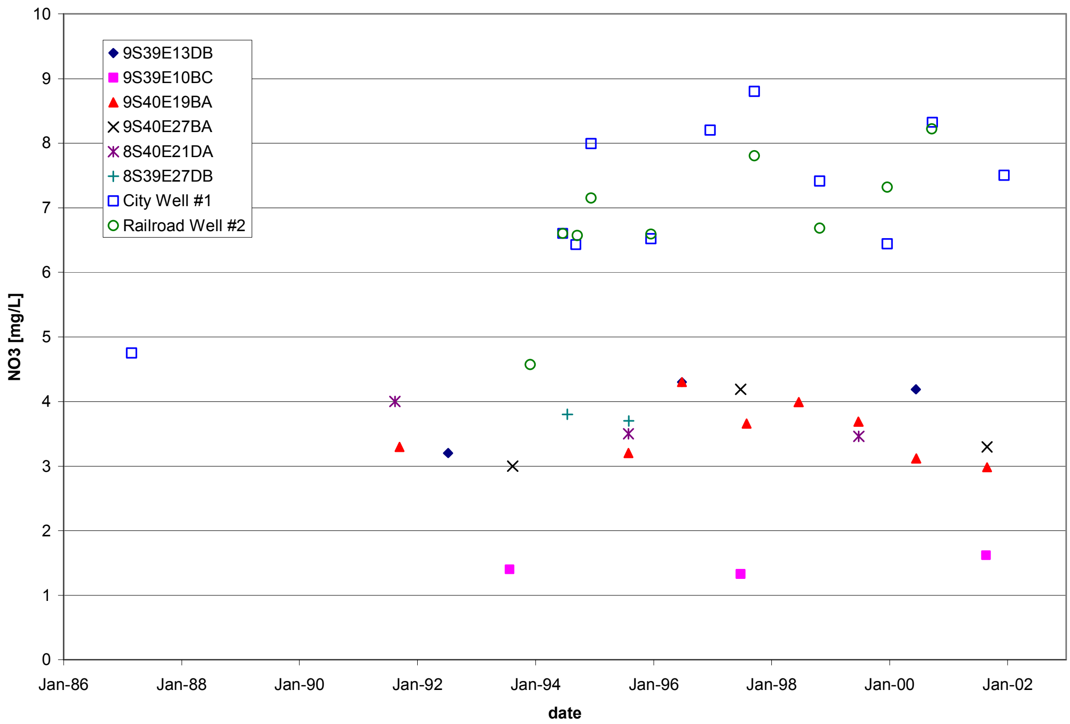

Figure 7 - Nitrate concentrations for the Bancroft supply wells and USGS monitored wells.

BASALT AQUIFER ANALYSIS

The basalt aquifer offers a reliable water supply source for the city. Several wells monitored by the USGS indicate that water levels have remained constant over the past 74 years, providing evidence of adequate recharge for a sustained water supply (Figure 8). In addition to adequate recharge, well yields within the basalt aquifer range from 20 gallons per minute (GPM) for individual domestic use to greater than 1000 GPM for irrigation use (Figure 5). These data provide evidence that a properly constructed well in the basalt aquifer can supply sufficient water to the city of Bancroft. Unfortunately, there is no yield data for the city wells however City Well #1 and Railroad Well #2 currently yield an adequate volume of water.

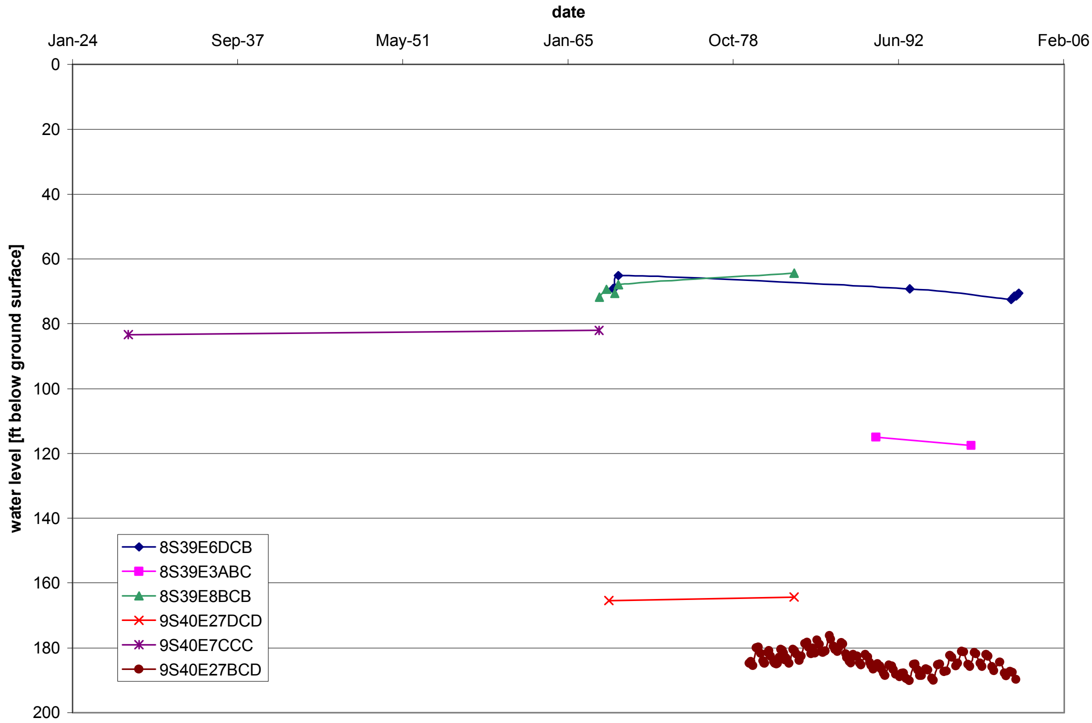

Figure 8: Ground water levels for USGS monitoring wells within the Gem Valley study area.

DISCUSSION OF RESULTS

Water quality issues, including concentrations of fecal coliform and nitrate, pose problems to the long-term viability of the existing wells. Figure 2 shows that the city of Bancroft resides above a clay rich confining layer interbedded between basalt flows. This layer probably reduces vertical movement of any potentially contaminated water, therefore protecting the underlying ground water by forcing contaminants to migrate horizontally above the layer. Poor well construction of both City Well #1 and Railroad Well #2 likely explains how contaminants enter the Bancroft water supply system, however definitive data are not available to confirm this possibility. The contaminants traveling above the confining layer probably enter the underlying basalt aquifer by passing through the clay beds via inadequately sealed wells. Potential contaminant sources listed within the source water assessment report (IDEQ, 2002) include underground storage tanks, above ground storage tanks, roads, and railroads. If these potential sources become actual sources, the contaminants are likely to travel on the clay layer then pollute the basalt aquifer via traveling down inadequately sealed wells. The agrichemical business southeast of town represents a possible source of contamination omitted from the source water assessment report. Nitrate contamination from this possible source would likely follow the same flow path as described earlier. The portion of town north of the railroad tracks uses septic tanks rather than the municipal sewer system. These septic tanks may play a role in nitrate contamination observed in the municipal wells.

Potential contamination in the Bancroft urban area and 100-year flood events will probably not impact a well located south of town. Contamination sources, listed in the source water assessment report, may not impact a new well due to location of the well up gradient from town and most contamination sources. In addition the protective ability of the clay-rich confining layer will minimize the impact of contamination from nearby sources. Potential contamination sources residing southeast of the surface exposure of the clay beds pose a concern because contaminants entering this part of the system may flow toward the proposed well. These sources include State Highways 30 and 30N, railroads, and agricultural lands.

The basalt aquifer underlying the protective clay-rich confining layer is the best available target for ground water development within the Bancroft area due to adequate recharge and well yield. Figure 5 shows the proposed location of this well within Gem Valley and Figure 2 shows the proposed well with respect to Bancroft and the FEMA 100-year floodplain. Adequate recharge occurs from a variety of sources and implies a sufficient water supply to the city. Well yields, obtained from well logs throughout Gem Valley, shows that a properly constructed well can provide the needed quantity of water. Sealing the new well to a depth below the clay-rich confining layer will prevent any contaminants perched on the confining layer from entering the water supply via the well. In a properly sealed well, the confining layer in coordination with the sealant will limit the risk of contamination from any potential sources above the confining layer. Christman and others (2002) studied well seals on 35 monitoring and water wells in Illinois and Iowa. They concluded that seals were intact where the sealing material consisted of high-solids bentonite grout and hydrated bentonite chips and pellets. Other well sealants were porous or cracked leading to improperly sealed wells and potential contamination problems. This research shows the importance of using proper sealing materials during well construction preventing a contamination situation similar to the city supply wells.

CONCLUSIONS AND RECOMMENDATIONS

City Well #1 and Railroad Well #2 are likely poorly constructed, therefore providing avenues through which nitrate and fecal coliform contaminants move through the clay-rich confining layer. There is inadequate information regarding well construction to develop a rehabilitation plan to reduce or stop nitrate and fecal coliform contamination. The City of Bancroft should abandon the existing municipal wells and install new ones.

The basalt aquifer is the best target for ground water development. Ground water flows northwesterly, therefore new wells located south of town will eliminate contamination sources from within the city. Figures 2 and 4 show the recommended target area for new wells.

The clay-rich confining layer overlying the aquifer will provide protection from contamination if the city adopts proper well construction techniques. A high-solids bentonite grout or hydrated bentonite chips and pellets will provide the best seal and prevent ground water contamination. The sealant must reach a depth below the confining layer for prevention of contamination, approximately 45 feet below ground surface in the recommended target area. The specific depth, however, should be determined based on the depth to the clay layer when drilled.

The entire aquifer apparently contains elevated nitrate levels above the natural background of less than 1 mg/L but below the MCL (Parilman, 2000). A sampling program should be adopted for the new well to ensure that water quality continues to remain relatively constant and to detect any possible rise from the current levels.

ACKNOWLEDGEMENTS

The authors accept responsibility for the interpretations expressed in this document. These views do not necessarily reflect those of the United States Environmental Protection Agency, the University of Idaho or any other institution. Rather, they reflect our opinions as shaped by our observations and experiences in the field, interpretation of the scientific and technical literature and our understanding of input provided by our colleagues and representatives from Bancroft, Idaho. We, the authors, accept full responsibility for any omissions or misinterpretations of facts.

This work was funded through grant number X97008601 from the United States Environmental Protection Agency region 10 to the University of Idaho Water Resources Research Institute and the Idaho Geologic Survey. We thank the representatives from Bancroft, Idaho for their contributions and the Idaho Geologic Survey for providing peer reviews and publishing this work. Representatives from Bancroft include Mayor Lester Woods, water system operator Steve Grant, and city engineer Clarence Kemp.

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LIST OF FIGURES

APPENDICES

PRELIMINARY DRAFT

APPENDIX A

ACTUALL UTM
X => 427145.5446
Y => 4729698.246

Form 238-7
11/91

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

WELL DRILLER'S REPORT

RECEIVED
JUL - 9 1993
Department of Water Resources
Eastern District Office

USE TYPEWRITER OR BALLPOINT PEN

State law requires that this report be filed with the Director, Department of Water Resources within 30 days after the completion or abandonment of the well.

1. WELL OWNER

Name: City of Bancroft
Address: Bancroft, Id,
Drilling Permit No. ____
Water Right Permit No. ____

2. NATURE OF WORK

☐ New well ☐ Deepened ☐ Replacement
☐ Well diameter increase ☒ Modification
☐ Abandoned (describe abandonment or modification procedures such as liners, screen, materials, plug depths, etc. in lithologic log, section 9.)

3. PROPOSED USE

☐ Domestic ☐ Irrigation ☐ Monitor
☐ Industrial ☐ Stock ☐ Waste Disposal or Injection
☐ Other ____ (specify type)

4. METHOD DRILLED

☒ Rotary ☒ Air ☐ Auger ☐ Reverse rotary
☐ Cable ☐ Mud ☐ Other ____ (backhoe, hydraulic, etc.)

5. WELL CONSTRUCTION

Casing schedule: ☐ Steel ☐ Concrete ☐ Other ____

Thickness	Diameter	From	To
____ inches	____ inches	+ ____ feet	____ feet
____ inches	____ inches	____ feet	____ feet
____ inches	____ inches	____ feet	____ feet

Was casing drive shoe used? ☐ Yes ☒ No
Was a packer or seal used? ☐ Yes ☒ No
Perforated? ☐ Yes ☒ No
How perforated? ☐ Factory ☐ Knife ☐ Torch ☐ Gun
Size of perforation? ____ inches by ____ inches

Number	From	To
____ perforations	____ feet	____ feet
____ perforations	____ feet	____ feet
____ perforations	____ feet	____ feet

Well screen installed? ☐ Yes ☐ No
Manufacturer ____ Type ____
Top Packer or Headpipe ____
Bottom of Tailpipe ____

Diameter ____ Slot size ____ Set from ____ feet to ____ feet
Diameter ____ Slot size ____ Set from ____ feet to ____ feet
Gravel packed? ☐ Yes ☐ No ☐ Size of gravel ____
Placed from ____ feet to ____ feet

Surface seal depth ____ Material used in seal: ☐ Cement grout ☐ Bentonite ☐ Puddling clay ☐ ____
Sealing procedure used: ☐ Slurry pit ☐ Temp. surface casing ☐ Overbore to seal depth
Method of joining casing: ☐ Threaded ☐ Welded ☐ Solvent Weld ☐ Cemented between strata

Describe access port ____

6. LOCATION OF WELL

Sketch map location **must** agree with written location.

N / W / E / S

Subdivision Name ____
Lot No. ____ Block No. ____
County: Caribou
NE 1/4 NW 1/4 Sec. 22, T. 8 N ☐ S ☒ R. 39 E ☒ W ☐

7. WATER LEVEL

Static water level 97 feet below land surface.
Flowing? ☐ Yes ☒ No G.P.M. flow ____
Artesian closed-in pressure ____ p.s.i.
Controlled by: ☐ Valve ☐ Cap ☐ Plug
Temperature 49 °F. Quality Good
Describe artesian or temperature zones below.

8. WELL TEST DATA

☐ Pump ☐ Bailer ☐ Air ☐ Other ____

Discharge G.P.M.	Pumping Level	Hours Pumped

9. LITHOLOGIC LOG

Hole was drilled years ago. to Depth of 210 ft. 6" sub pump would not go below 105 ft, Video shows 4 ft. of 6" pipe in hole from 103 to 107 we drilled this out and reamed hole to dia. of 7 7/8" from 100 to 212 ft.

Bore Diam.	Depth From	Depth To	Material	Water Yes	Water No
7 7/8	100	212	lava w/crevice + fract-ures.	X	

the well apears to have a good surface seal its inside a 10 ft. sq. bldg. w/ cement floor.

10.

Work started 6-9-93 finished 6-11-93

11. DRILLER'S CERTIFICATION

I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Firm Name Nelson Firm No. 215
Address Soda Springs Date 6-18-93
Signed by Drilling Supervisor R. Nelson
and
(Operator) [signature]
(If different than the Drilling Supervisor)

USE ADDITIONAL SHEETS IF NECESSARY — FORWARD THE WHITE COPY TO THE DEPARTMENT

Figure 1A: Well log for City Well #1.

APPENDIX B

Table 1B: Water level data for USGS monitoring wells.

8S39E6DCB		8S39E8BCB		9S40E7CCC		9S40E27DCD		8S39E3ABC	
date	bgs [ft]	date	bgs [ft]	date	bgs [ft]	date	bgs [ft]	date	bgs [ft]
10/29/1968	69.15	8/31/1967	71.87	8/20/1928	83.4	6/11/1968	165.45	8/1/1990	115
12/6/1968	68.87	4/10/1968	69.44	8/25/1967	82	10/28/1983	164.31	6/20/1998	117.62
3/25/1969	65.13	12/6/1968	70.63	4/10/1968	86.2				
5/27/1993	69.22	3/27/1969	67.87						
10/19/2001	72.57								
1/17/2002	71.42								
3/18/2002	71.42								
5/30/2002	70.58								

Table 2B: Water level data for USGS monitoring well - 9S40E27BCD.

9S40E27BCD							
date	bgs [ft]	date	bgs [ft]	date	bgs [ft]	date	bgs [ft]
2/6/1980	184.74	9/4/1984	178.71	9/14/1989	182.09	5/11/1995	190.04
3/25/1980	184.3	11/15/1984	178.36	11/21/1989	182.79	9/13/1995	185.27
5/15/1980	185.51	1/4/1985	179.91	1/23/1990	184.55	11/8/1995	185.01
9/10/1980	179.98	3/19/1985	181.81	3/12/1990	185.55	3/25/1996	187.36
11/5/1980	179.74	5/2/1985	180.1	5/7/1990	186.57	5/29/1996	187.22
1/8/1981	181.75	7/10/1985	181.57	9/25/1990	184.91	9/17/1996	182.37
3/24/1981	184.09	9/9/1985	177.58	11/26/1990	185.64	11/20/1996	182.93
4/14/1981	184.69	11/21/1985	179	1/11/1991	186.56	3/17/1997	185.61
5/18/1981	184.84	1/22/1986	181.19	3/20/1991	187.85	5/15/1997	184.82
8/19/1981	181.51	3/4/1986	181.55	5/6/1991	188.51	9/8/1997	181.19
9/21/1981	180.9	5/21/1986	180.95	9/5/1991	185.39	11/14/1997	181.25
11/3/1981	182.55	9/23/1986	176.3	11/19/1991	185.63	3/19/1998	185.1
2/9/1982	184.35	11/6/1986	177.33	1/9/1992	186.68	5/14/1998	185.75
3/22/1982	184.83	1/27/1987	179.49	3/23/1992	188.21	9/24/1998	181.45
5/4/1982	184.98	3/10/1987	180.52	7/15/1992	188.89	11/18/1998	181.89
6/15/1982	184.8	5/27/1987	181.18	9/15/1992	187.9	3/25/1999	184.73
7/26/1982	182.99	7/9/1987	179.95	11/19/1992	187.84	5/17/1999	185.75
9/7/1982	180.5	9/23/1987	178.47	1/27/1993	189.4	9/20/1999	182.07
10/26/1982	180.71	11/10/1987	178.81	3/29/1993	189.74	11/15/1999	182.59
12/6/1982	181.66	1/27/1988	181.89	5/10/1993	190.15	3/20/2000	185.87
1/12/1983	183.7	3/8/1988	183.09	9/21/1993	185.12	5/11/2000	187.04
3/2/1983	183.25	5/16/1988	184.15	11/4/1993	185.05	11/8/2000	184.39
5/24/1983	184.81	7/5/1988	184.72	1/20/1994	186.9	3/26/2001	187.87
9/19/1983	180.56	9/15/1988	182.12	3/21/1994	188.52	5/14/2001	188.63
11/8/1983	180.85	11/28/1988	182.58	5/10/1994	188.6	9/18/2001	187.38
1/5/1984	182.03	1/5/1989	182.6	9/19/1994	186.53	11/21/2001	187.56
3/27/1984	183.99	3/23/1989	184.72	11/22/1994	186.81	3/14/2002	189.76
5/29/1984	182.57	5/4/1989	185.24	3/22/1995	189.36		

APPENDIX C

Table 1C: Nitrate concentration data for the Bancroft and USGS monitoring wells.

City Well #1		Railroad Well #2		9S40E19BA		9S39E13DB	
date	NO3 [mg/L]	date	NO3 [mg/L]	date	NO3 [mg/L]	date	NO3 [mg/L]
3/1/1987	4.75	12/1/1993	4.57	9/13/1991	3.3	7/9/1992	3.2
6/20/1994	6.6	6/20/1994	6.6	7/31/1995	3.2	6/26/1996	4.3
9/9/1994	6.43	9/19/1994	6.57	6/27/1996	4.3	6/14/2000	4.19
12/12/1994	7.99	12/12/1994	7.15	8/1/1997	3.66		
12/18/1995	6.52	12/18/1995	6.59	6/20/1998	3.99		
12/18/1996	8.2	9/18/1997	7.8	6/24/1999	3.69		
9/18/1997	8.8	10/27/1998	6.68	6/15/2000	3.12		
10/27/1998	7.41	12/20/1999	7.32	8/28/2001	2.98		
12/20/1999	6.44	9/22/2000	8.22				
9/26/2000	8.32						
12/12/2001	7.5						

Table 2C: Nitrate concentration data for the USGS monitoring wells.

9S39E10BC		9S40E27BA		8S40E21DA		8S39E27DB	
date	NO3 [mg/L]	date	NO3 [mg/L]	date	NO3 [mg/L]	date	NO3 [mg/L]
7/27/1993	1.4	8/13/1993	3	8/15/1991	4	7/19/1994	3.8
6/25/1997	1.33	6/25/1997	4.19	8/1/1995	3.5	8/2/1995	3.7
8/23/2001	1.62	8/28/2001	3.3	6/27/1999	3.46		