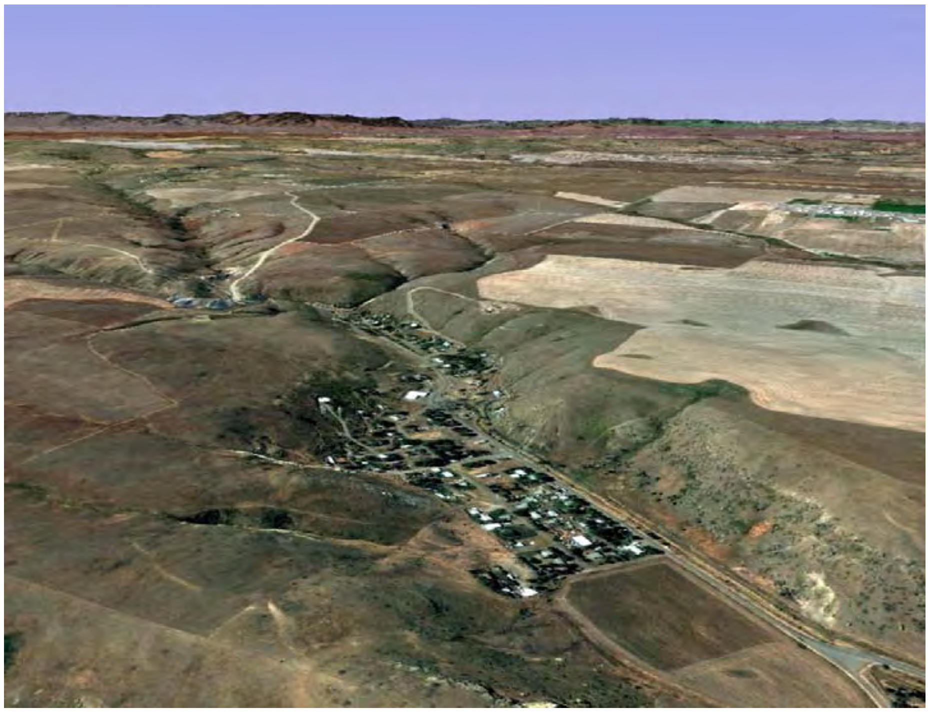
SANDCOULEE WATER DISTRICT

WATER SUPPLY ASSESSMENT



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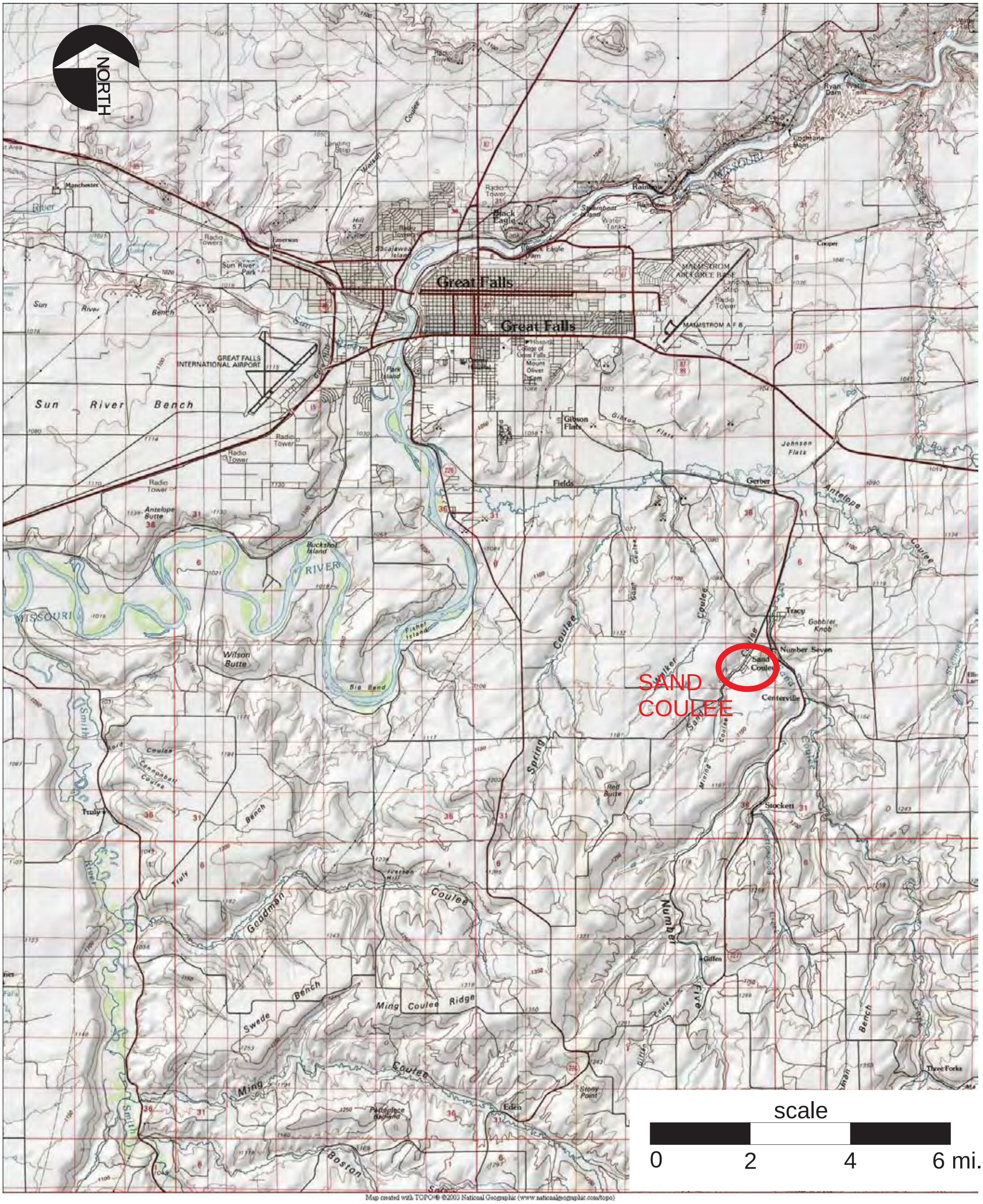
1.0 INTRODUCTION

The town of Sand Coulee is located about eight miles southeast of Great Falls in Cascade County, Montana (Figure 1-1). The town lies within the Sand Coulee drainage and within an area of extensive historic coal mining activities. The town relies on a network of water supply wells for their community water system, and has experienced a decline in well yields raising concerns about the adequacy and reliability of the current system as a community water supply. At the request of the Montana Department of Environmental Quality (DEQ), Hydrometrics conducted an evaluation of the current community water supply system, potential reasons for the documented reductions in well yields, and options for improving the quantity and reliability of the Sand Coulee municipal groundwater supply. This report presents the methods and results of the Sand Coulee water supply evaluation, and options for developing a more reliable source of potable water for the Sand Coulee Water District (Water District).

1.1 PURPOSE AND SCOPE

The Water District presently relies on groundwater wells completed in lower Kootenai Formation sandstone and upper Morrison Formation coal as the sole water source for the community water supply system. The wells, however, are subject to severe mineral encrustation that results in well deterioration and recurring problems with declining production rates.

Potential water sources for a public water supply are limited in the Sand Coulee area due to impacts to surface water and shallow groundwater from acid mine drainage (AMD). Mine drainage has also dewatered much of the overlying Kootenai formation, which under normal conditions is a common source aquifer for groundwater development in the area.



SAND COULEE WATER SUPPLY ASSESSMENT	**SAND COULEE LOCATION MAP**	**FIGURE 1-1**

K:\PROJECT\10039\FIG 1-1 LOCATION MAP.CDR

The purpose of this report is to assess three specific water supply options that were identified in the initial scoping process for this project, which include the following:

1. Development of additional conventional wells in the Kootenai Formation with an assessment of measures necessary to address encrustation problems and minimize associated production losses.

2. Installation of a horizontal well in the Kootenai Formation to obtain higher production yields and minimize conditions conducive to encrustation.

3. Development of one or more deep wells in the Madison Formation.

This report provides a detailed assessment of each of these options including an evaluation of both the technical and regulatory issues required for implementation, and a preliminary estimate of implementation costs. The technical assessment examines drilling and well construction requirements, potential yields, and potential operational and maintenance issues. The regulatory assessment evaluates permitting issues associated with each option including water rights permitting through the Department of Natural Resources and Conservation (DNRC), and public water supply permitting through the DEQ. The cost assessment provides a preliminary evaluation of potential costs for implementation of each alternative. The primary purpose of the cost assessment is to aid in the selection of a preferred alternative. Projected costs for the preferred alternative will ultimately be established based on final design considerations and actual bids from drilling and construction contractors.

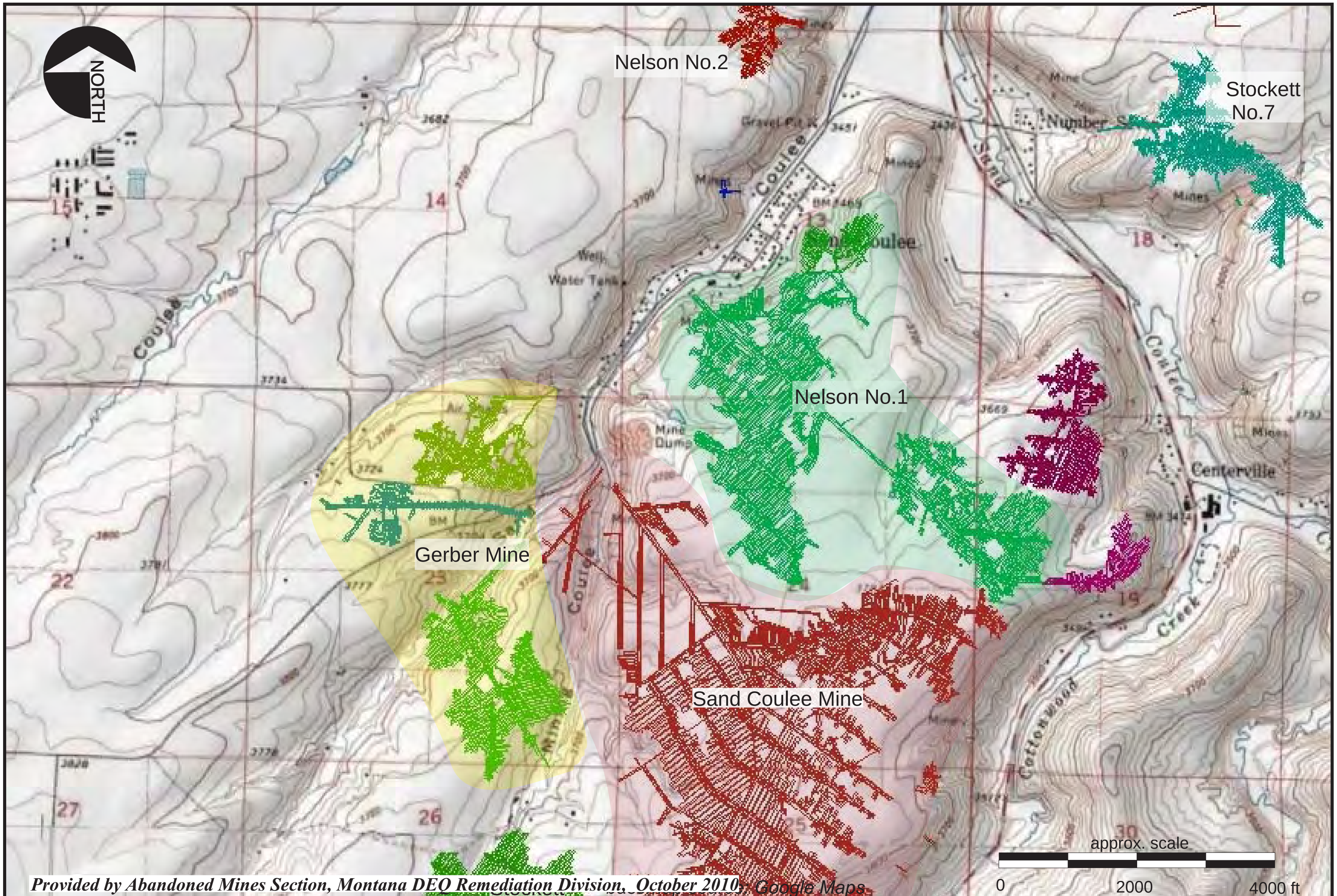
1.2 PROJECT BACKGROUND

Sand Coulee is a small unincorporated residential community of about 180 people located approximately eight miles southeast of Great Falls, Montana (Figure 1-1). Sand Coulee was founded as a coal mining town in the late 1800s and became one of the central hubs for coal mining activity in the Great Falls Coal Field. By the turn of the century the coal reserves in the Sand Coulee Mine were largely mined out in the immediate vicinity of Sand Coulee and mining activity began to shift to outlying areas. In 1904 the Sand Coulee Mine was shut down. Mining continued in the nearby Nelson and Gerber mines through the 1930's (Figure 1-2), but by the 1940's all of the large-scale mines had ceased operations (RTI, 2009) leaving the town surrounded by an extensive network of abandoned underground workings.

Groundwater percolating into the mines from the overlying Kootenai Formation partially flooded the underground workings and produced AMD contaminating area surface waters (Sand Coulee, Mining Coulee and Sand Coulee Creek, Figure 1-2) and shallow groundwater within Sand Coulee drainage. Despite extensive reclamation efforts, AMD from these abandoned mines continues to contaminate the creeks and shallow aquifer.

Because of the difficulty of siting and maintaining adequate wells within the coulee, a group of residents formed the Sand Coulee Water Users Association in 1959 to develop a community water supply system that would meet their water supply needs. The water users association sold water bonds and constructed their first well on the terrace outside of town. They also constructed a storage tank and a distribution main (DEQ, 2000; NCI, 2010). In late 2009, the water users association formed the Sand Coulee Water District (NCI, 2010).

Most of the original infrastructure installed in 1959 for the Sand Coulee Water Users Association is still in use by the Water District with the exception of the well installed in 1960, which collapsed in 1996 and was abandoned in 2000. The water users association attempted several times to expand the capacity of the community water supply by installing additional wells, but mineral encrustation problems resulted in declining production rates over time and progressive deterioration of the wells. Of the four wells installed by the association between 1960 and 2008, only the two most recent wells are still in operation, with one well taken out of use and a second well abandoned. The wells are located outside on a terrace above the coulee floor immediately west of the town (Figure 1-3). The construction and operational characteristics of these wells are discussed in detail in Section 1.4 of this report.



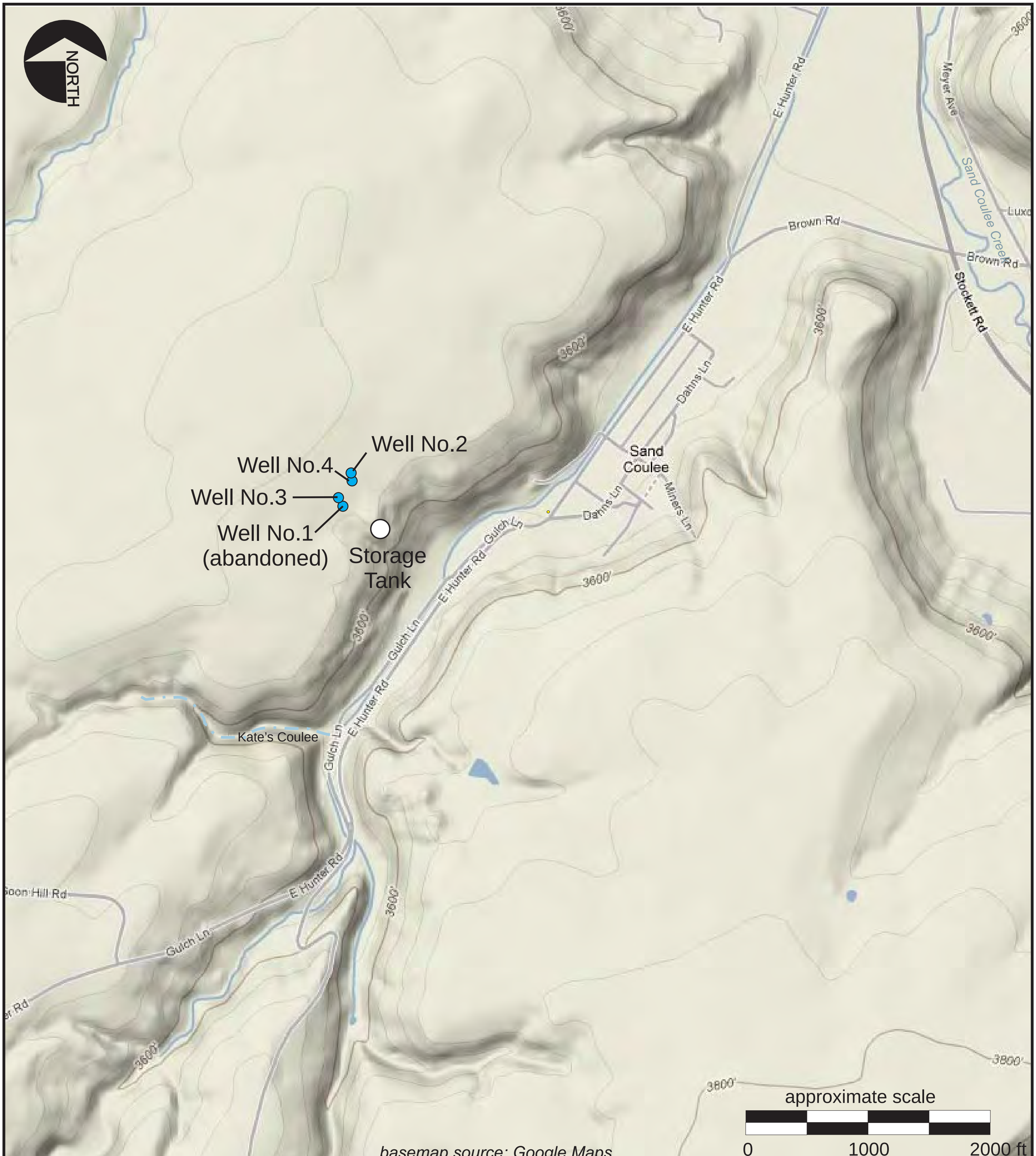
SAND COULEE WATER
SUPPLY ASSESSMENT

COAL MINES AND MAPPED UNDERGROUND WORKINGS IN SAND COULEE AREA

FIGURE

1-2

K:\PROJECT\10039\FIG Coal Mine Workings.cdr



SAND COULEE WATER SUPPLY ASSESSMENT

SAND COULEE WATER DISTRICT WELL FIELD AND STORAGE TANK LOCATIONS

FIGURE 1-3

K:\PROJECT\10039\FIG1 XSEC.CDR

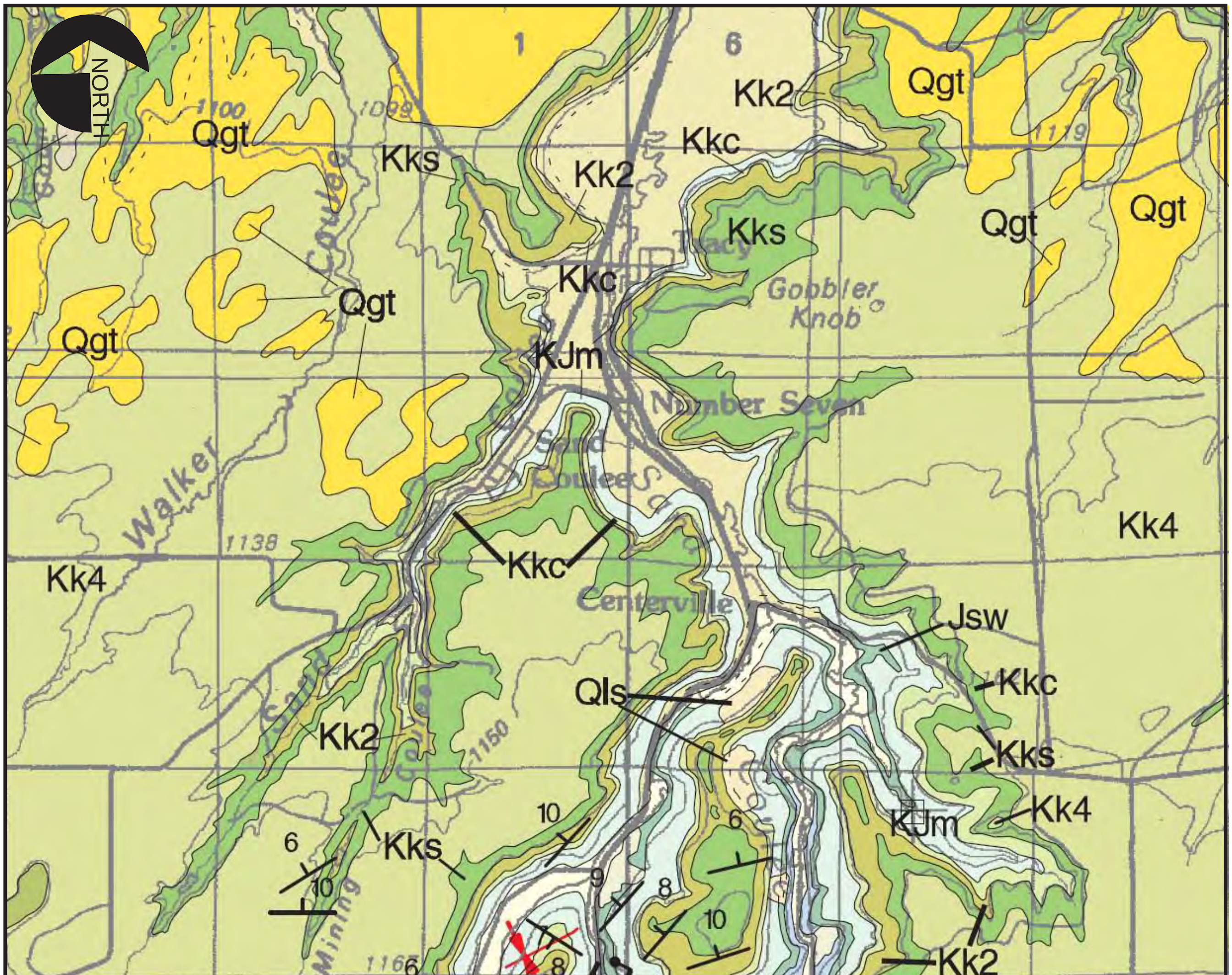
1.3 TOPOGRAPHIC AND HYDROGEOLOGIC SETTING

The topography in the Sand Coulee region is characterized by broad upland terraces sloping gently northward from the base of the Little Belt Mountains. These terraces are incised by narrow, steep sided coulees, which generally contain ephemeral streams. At Sand Coulee, the relief between the bottom of the coulee and the surrounding upland area is on the order of 200 to 250 feet. The creek that flows through Sand Coulee, referred to as the "Rusty Ditch", is an un-named tributary to Sand Coulee Creek. The creek at Sand Coulee originates about six miles southwest of town and joins the main stem of Sand Coulee Creek at Tracy approximately one mile downstream. The creek is spring fed and reportedly has little flow until it begins to receive recharge from abandoned mine drainage beginning about one mile upstream of Sand Coulee (WESTECH/Hydrometrics, 1982). Streamflow is ephemeral and typically ranges from 0 to 3 cubic feet per second (cfs) in the vicinity of the town. The stream quality is heavily impacted by acid mine drainage.

The geology of the area (shown on Figure 1-4) consists of a relatively flat lying sequence of Paleozoic sedimentary rocks that are exposed along the walls of the incised coulees. The formations slope gently to the north and west in the Sand Coulee area, which exposes progressively older formations in the upstream drainages to the south. The general stratigraphy in the Sand Coulee area is shown in Figure 1-5 and described below.

The Kootenai Formation underlies the upland terraces surrounding Sand Coulee and is exposed in outcrop on the steep sidewalls of the coulee. The Kootenai Formation is calcareous, cemented sandstone with alternating layers of mudstone and is generally between 350 and 400 feet thick in the Great Falls area (Wilke, 1983). The upper portion of the Kootenai Formation has been eroded in the Sand Coulee area, resulting in a thickness of approximately 180 feet in the well field area. The basal member of the Kootenai Formation is coarser-grained, cross-bedded sandstone with beds of conglomeratic pebble sandstone.

The Kootenai Formation generally yields moderate amounts of groundwater (5 to 50 gallons per minute [gpm]) and is widely used as a water source for domestic and stock wells in the



Source: Montana Bureau of Mines and Geology Open File Report MBMG 407, 2000.

Qal ALLUVIUM (Holocene)

Qac ALLUVIUM AND COLLUVIUM, Undivided (Holocene)

Qls LANDSLIDE DEPOSIT (Holocene and Pleistocene)

Qgt GLACIAL TILL (Pleistocene)

KOOTENAI FM

Kk4 Pale-reddish-brown to light-brownish gray medium-bedded sandstone interbedded with very dark-reddish-brown mudstone

Kks Light-yellowish-brown-weathered, well sorted, well cemented, resistant quartz sandstone

Kk2 Fine-grained planar-bedded light-gray sandstone with red or purple mottling

Kkc Cross-bedded, moderately well-sorted quartz sandstone with coarse-grained sandstone, or chert-pebble conglomerate at the base.

KJm MORRISON FM Subbituminous coal bed and dark-gray carbonaceous shale at top of formation grading to greenish gray mudstone with interbedded lenses of calcaneous sandstone

Jsw SWIFT FM Orangish-brown, gray or tan, calcareous, sandstone and interbeds of gray-weathered shale.

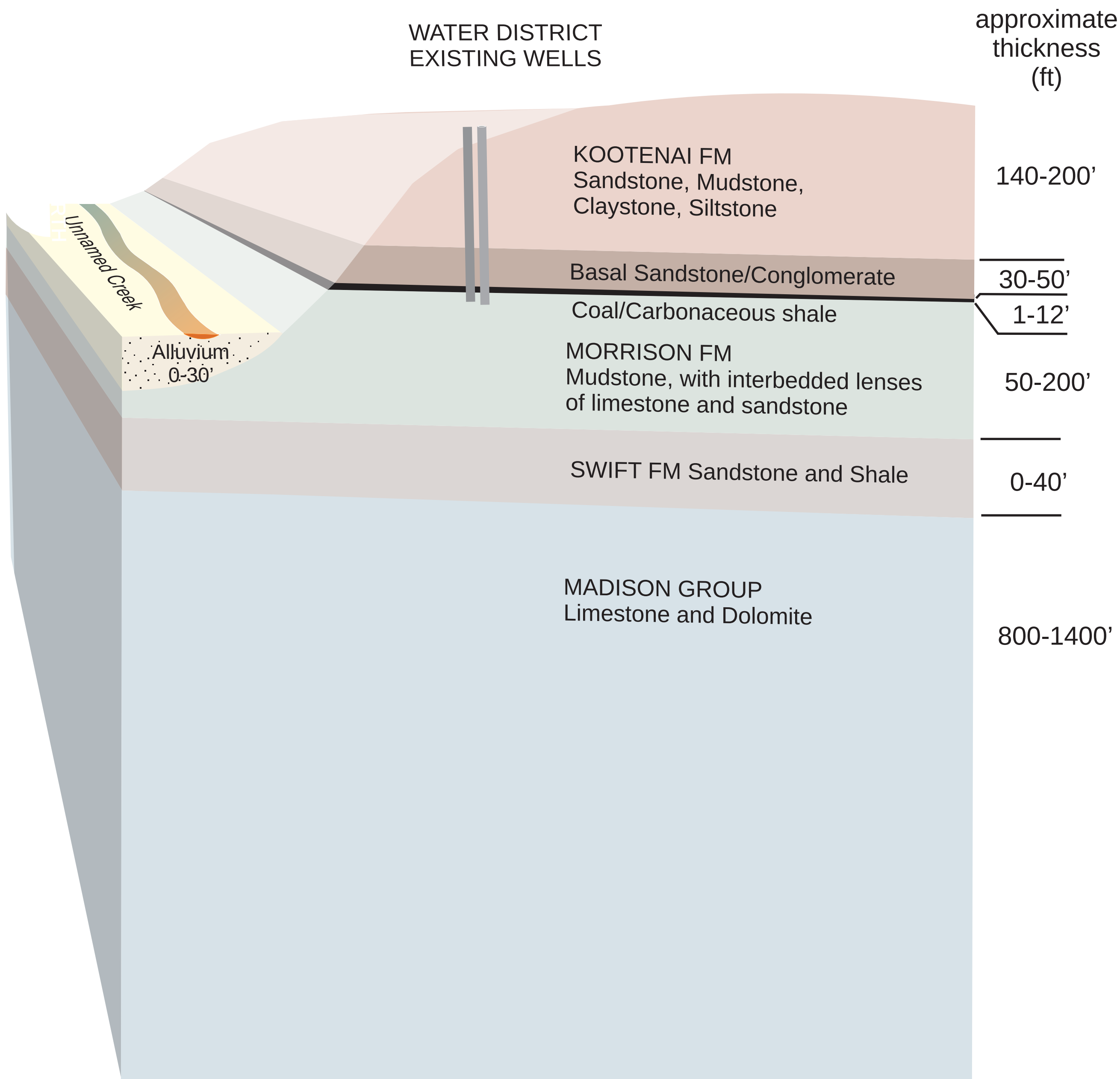
Mmc MADISON GROUP - MISSION CANYON LIMESTONE

approx. scale

0 2000 4000 6000 ft

Sand Coulee Water District Water Supply Assessment	GEOLOGIC MAP	FIGURE 1-4

k:\project\10039\Geologic Map.cdr



not to scale

After: Hydrometrics, 1981

SAND COULEE WATER DISTRICT
WATER SUPPLY ASSESSMENT

GENERALIZED STRATIGRAPHIC CROSS SECTION OF THE SAND COULEE DRAINAGE

FIGURE 1-5

K:\PROJECT\10039\FIG1 XSEC.CDR

Great Falls area (Wilke, 1983). The Sand Coulee Water Supply District wells receive groundwater inflow in part from the lower Kootenai Formation, which has about 25 feet of saturated thickness in the well field area. Since the Kootenai Formation is stratigraphically above the area mine workings, it is not impacted by mine drainage.

The Morrison Formation underlies the Kootenai and is generally between 120 and 180 feet thick in the Great Falls area (Wilke, 1983). The Morrison Formation has a coal seam and dark gray carbonaceous shale at the upper contact with the Kootenai Formation. The coal seam and carbonaceous shale are exposed in outcrop at discrete locations along the west slope of Sand Coulee. The coal seam receives recharge from the overlying Kootenai Formation and can yield moderate amounts of groundwater. The Sand Coulee Water District wells are completed in this coal unit of the upper Morrison and the coal appears to be one of the sources of groundwater inflow to the wells.

Light gray limestone and low permeability grey-green mudstone/shale make up the lower Morrison. The lower Morrison also reportedly contains some sandstone lenses that are tapped by a few wells in the Sand Coulee area that produce limited yields (WESTECH/Hydrometrics, 1982).

The Morrison Formation is underlain by the Swift Formation, a calcareous, coarse- to fine-grained sandstone with interbeds of shale ranging from 0 to 40 feet thick in the Sand Coulee area (WESTECH/Hydrometrics, 1982). Few wells are completed in the Swift formation in the project area. Goers (1968) concluded that recharge to the Swift Formation is limited by the low permeability shale beds in the overlying Morrison Formation and by updip truncation of the Swift Formation along the little Belt Mountains.

The Swift Formation is underlain by the Madison group Mission Canyon and Lodgepole Formations, which are generally referred to together as the Madison Limestone. The thickness of the Madison Limestone in the Great Falls area ranges from 1,200 to 1,700 feet

(Smith, 2008) and consists of massive to thick-bedded limestone with thin, chert interbeds transitioning downward into thinner-bedded limestone and mudstone.

Groundwater is present in the Madison where fractures or solution cavities have developed. The Madison is widely used as a water source for domestic, stock and irrigation wells in the Great Falls area and further south towards the Little Belt Mountains (Smith, 2008). Well yields from wells completed in the Madison average 30 gpm in this area (see Section 2.3), however, yields up to 1,000 gpm are reported in some wells and the Madison is believed to be a primary source of recharge to Giant Springs, one of the largest freshwater springs in the United States (Wilke, 1983; Smith, 2008).

1.4 WATER DISTRICT WATER SUPPLY WELLS

1.4.1 Well Construction and Well Yields

Sand Coulee Water User Association has installed four water supply wells on the terrace west of Sand Coulee between 1960 and 2008 (Figure 1-3). Well construction information for each of the wells is summarized in Table 1-1. The first well was drilled in February 1960 and was completed to a depth of 210 feet below ground surface (bgs). The upper 34 feet of the hole was cased with 6-inch steel and the remainder of the borehole was left uncased to the completion depth of 210 feet. The well log (Appendix A) indicates that Well No. 1 produced 45 gpm at the time of completion. Water was produced during drilling in the sandstone between 138 feet and 192 feet, and from 198 feet to 210 feet. Although the well is deep enough to penetrate the upper Morrison, there is no record in the well log of encountering the coal seam that is typically present at the upper contact with the Morrison Formation.

TABLE 1-1. WELL CONSTRUCTION SUMMARY

Well Name:	Well No. 1	Well No. 2	Well No. 3	Well No. 4
Installation Date	2/4/1960	10/11/1973	8/2/1999	3/1/2008
Operational Status	Abandoned 5/5/2000	Taken out of use Feb 2010	In use	In use
Drilling Contractor	Soennichsen Drilling Co.	Pat Byrne	Pat Byrne	Pat Byrne
GWIC Well ID	31883	2254	177478	241877
DNRC Water Right No.	C005057-00	C006174-00	G070692-00	C005057-00
Elevation	3680	3670	3670	
Reported Yield at time of installation	45 GPM	60 GPM	50 GPM	30 GPM
Current Yield	--	5 GPM	18 GPM	20 GPM
Aquifer/Formation	Kootenai Sandstone & Morrison Coal	Kootenai Sandstone & Morrison Coal	Kootenai Sandstone & Morrison Coal	Kootenai Sandstone & Morrison Coal
Total Depth (TD)	210 feet	210 feet	181 feet	212 feet
Static Water Level (SWL) depth at time of installation	134 feet	150feet	150.5 feet	154.5
Casing	6-inch steel to 34 feet Open hole 34-210 feet	8-inch steel to 31 feet 5-inch PVC from 11-210 feet	6-inch steel to 38 feet 5-inch PVC from 11-181 feet	6-inch steel to 139' Open hole to 139-212 feet
Screened Interval	Open Hole: 34-210'	Slotted casing but no data on interval Open ended casing	Slotted 165-173', open ended casing?	Open hole: 139-212 feet

Well locations shown on Figure 1-3

The water rights records (Appendix A) refer to the 1960 well as the No. 2 well, and make reference to an earlier well installed in 1920 to a depth of 194 feet as the No. 1 well. However, no well log or other information was found for the earlier well and the 1960 well is now commonly referred to as Well No. 1.

A second well (referred to as Well No. 2 in all current documents) was installed in October 1973, also to a depth of 210 ft. The construction of Well No. 2 was similar to Well No. 1, with 8-inch diameter steel casing set to a depth of 34 ft and the remainder of the borehole left uncased to the completion depth of 210 feet. The well log for the Well No. 2 (Appendix A) indicates the well produced 60 gpm at the time of completion. Water was encountered during drilling in sandstone and coal from 184 to 187 feet, and from black clay and shale from 187 feet to 210 feet. The primary water production appears to come from the coal seam at the top of the Morrison and the sandstone at the lower contact of the Kootenai.

Although the exact date of installation is not known, PVC casing was installed in Well No. 2 some time after completion (possibly when Well No. 3 was installed in 1999). Well 2 currently has 5-inch PVC casing extending from 11 feet to 210 feet below ground surface (bgs), with vertical saw-cut slots and an open bottom. Although the exact purpose is not known, the PVC may have been installed to avoid the borehole caving problem encountered at Well No. 1. Whatever the purpose, the well yield at Well No. 2 declined over time and the well was taken out of production in February 2010. Preliminary testing of this well by Hydrometrics in June 2010 indicated water level drawdown from the static water level of 156 feet bgs to the pump intake at 173 feet in less than three minutes of pumping at 10 gpm. The current yield of the No. 2 well based on recovery rates from the preliminary test appears to be on the order of 5 gpm, or less than 10% of its original yield.

The borehole in Well No. 1 reportedly collapsed in July 1996 and a replacement well (Well No. 3) was drilled in August 1999 (DEQ, 2000). Well No. 3 was completed to a depth of 181 feet with 6-inch steel casing to 38 feet and 5-inch PVC casing from a depth of 11 feet to 181 feet. The PVC casing has saw-cut slots from 165 feet to 173 feet (see Table 1-1 and well log in Appendix A for well completion details). The well log indicates that the well produced 50 gpm at the time of completion. Minor water was encountered during drilling in sandstone layers between 150 feet and 160 feet, approximately 15 gpm from sandstone between 160 feet and 170 feet, and minor water from the coal seam at 170 to 175 feet. No water production was described from the black shale encountered from 175 feet to 181 feet. According to the water system operators, Well No. 3 is currently producing about 12 gpm, which is about 25% of its original reported yield.

The Water Users Association installed a fourth well in March of 2008 to make up for declining production rates at the existing wells. Well No. 4 was constructed with 6-inch steel casing set to a depth of 139 feet and the remainder of the borehole left uncased to the completion depth of 212 feet. The well log for Well No. 4 (Appendix A) indicates the well produced 30 gpm at the time of completion. According to the well log, water was encountered during drilling in sandstone at the base of the Kootenai Formation and in "black shale" from 179.5 to 180, which represents the top of the Morrison Formation. Muddy gray shale is described from 180 to 210 feet. The primary water-producing zone appears to be the base of the Kootenai and the top of the Morrison.

The driller reported 18.7 feet of water level drawdown in Well No. 4 after 50 hours of pumping at a rate of 30 gpm. The specific capacity of the well based on this data is 1.6 gpm per foot of drawdown. The estimated aquifer transmissivity based on this specific capacity is 430 ft^2/day (Driscoll, 1986), which represents a moderate aquifer transmissivity.

The current yield of Well No. 4 was briefly tested by Hydrometrics during a field visit in July 2010. The well yield was approximately 20 gpm at that time. The static water level in the well was 154 feet bgs and the pumping water level was 175 feet bgs. The calculated specific capacity (yield per foot of drawdown) was 0.9 gpm/foot. This specific capacity represents a 44% decline since the well was installed only two years earlier. The well was subsequently redeveloped by a local driller using an air rotary drill rig, with no significant improvements in well yield noted.

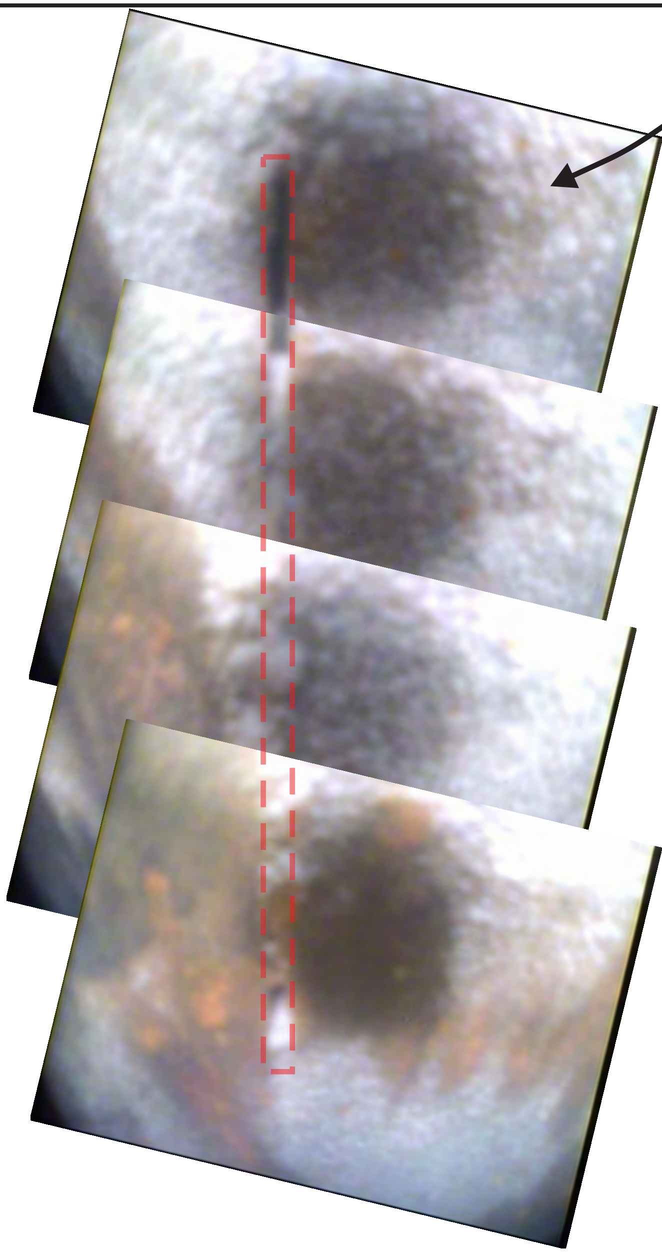
1.4.2 Source of Declining Well Yields

According to driller's notes (Well No. 4 well log-Appendix A) and discussions with the water system operators, declines in yield at the Sand Coulee Water District wells are believed to be related to mineral encrustation in the wells, which reduces the permeability of the well bore over time. However, no specific investigations have been conducted to characterize the problem or assess the causes. The Water Users Association has made periodic attempts to restore well yields through redevelopment and acidification; however, these measures have proven ineffective at preventing an overall decline in production rates.

Mineral encrustation is typically caused by precipitation of carbonate scale and/or microbial oxidation of iron, manganese and silica. These processes are promoted by high flow velocities where water enters the well, or if there is entrainment of oxygen in the water due to excessive drawdown and turbulence in the well. Hydrometrics conducted additional testing to evaluate the potential for mineral encrustation within the wells to be the cause of observed declines in the sustainable yields of the Water District wells.

Measurement of Operational Water Levels - Hydrometrics was able to measure water levels during pumping at Well No. 2, but initial attempts to get operational water level measurements from Well No. 3 and Well No. 4 were unsuccessful due to access problems. A stilling tube was later installed in Well No. 4 that allowed accurate drawdown measurements to be recorded during well operation. During subsequent testing, water levels in Well No. 2 dropped from 156 feet bgs to 173 feet bgs (the level of the pump intake) within minutes of switching the well on at a pumping rate of 10 gpm. Drawdown to the pump intake results in aeration and turbulence within the well that is conducive to scaling and encrustation. The initial testing at Well No. 4 also showed water level drawdown to the pump intake (184 feet) at the operational pumping rate of 24 gpm. The discharge rate was reduced to approximately 20 gpm, which raised the water level to approximately 175 feet.

Downhole Video of Well No. 2 and Well No. 4 -The pumps were pulled from Well No. 2 and Well No. 4 and a downhole video camera was used to inspect the condition of the wells. Copies of the downhole videos are included in the attached DVD. Well No. 2 is cased with 5-inch diameter slotted PVC (saw-cut) and Well No. 4 is uncased below a depth of 141 feet. Both wells showed evidence of heavy mineral encrustation over portions of the well. The video of Well No. 2 shows only light mineral scale to a depth of 184 feet. Below 184 feet there is a heavy accumulation of platey dark grey/orange scale on the sides of the casing that almost completely seals off the saw cut casing slots (Figure 1-6). According to the drilling log, this depth appears to correspond to the contact between the Kootenai and Morrison formations, which was identified as a water-producing interval. Below a depth of 190 feet the scale becomes light gray and less platey in appearance. There is little scale development



Photos of encrusted slot at depth of 189 feet. Red dashed line shows original dimension of slot. Small openings at top and bottom of slot remain open. Gray/orange scale coats the sides of the white PVC well casing.

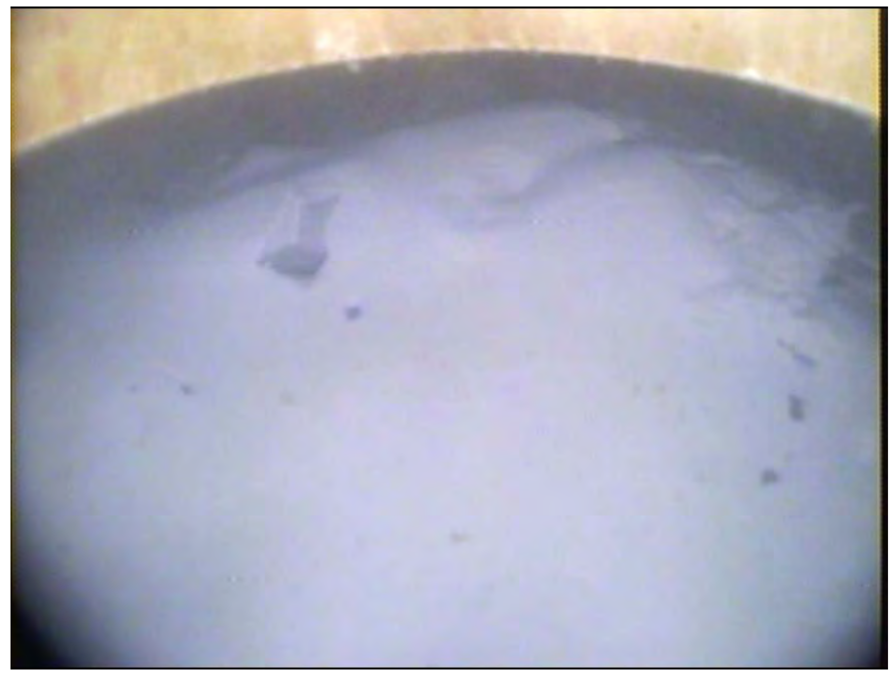


Photo of white precipitate accumulated at bottom of well (210 feet). Lower edge of PVC casing that is visible at top of photo shows no scale at this depth.

SAND COULEE WATER DISTRICT WATER SUPPLY ASSESSMENT	**WELL NO.2** **DOWNHOLE VIDEO IMAGES**	**FIGURE** **1-6**

K:\PROJECT\10039\FIG Well 2 Images.cdr

below 195 feet, however there appears to be a fine white precipitate in the bottom of the well at 210 feet (Figure 1-6).

In Well No. 4, the downhole video shows heavy accumulations of orange-to light grey scale developing on the sides of the borehole below 160 feet (Figure 1-7). The contact with the Morrison Formation is evident at 180 feet and there are accumulations of a white snow-like precipitate on rock surfaces at the contact (Figure 1-7). The mineral encrustation decreases in the lower portion of the borehole and there is a gradual color change to a paler gray scale. There is a loose accumulation of the coarser platey mineral scale in the bottom of the well (Figure 1-7).

Water samples were collected from Well No. 3 and scale/solids from Well No. 2 to evaluate the relative chemistries. The scale material was collected by using a 4-inch bailer to repeatedly retrieve water and suspended solids over the length of the borehole. Suspended solids in the collected water were settled and the water was decanted off to retrieve the solids fraction from the sample. The solids were composed of hard platey scale fragments, brown/grey clayey fragments and finer brown/gray mud. The following samples of Well No. 2 scale were submitted to Energy Laboratory in Helena, Montana for analysis of scale.

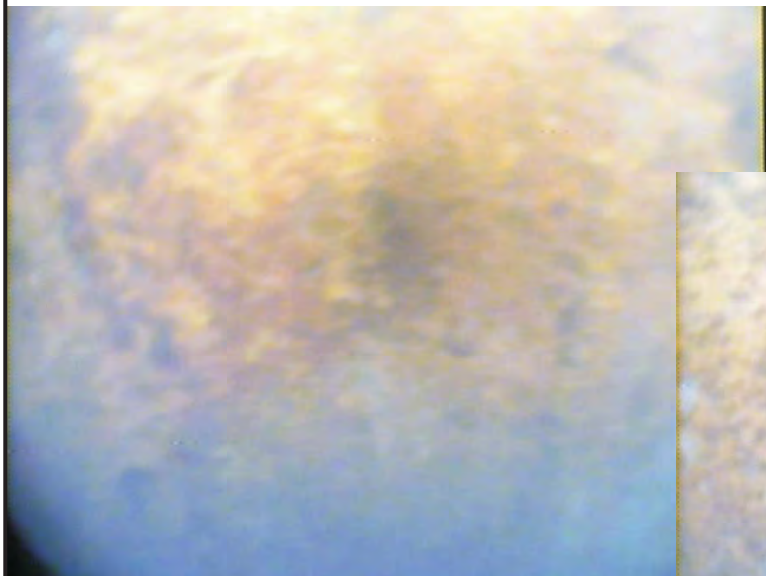
Sample 2A – suspended solids still in solution after decanting off most of the water. The sample was filtered by Energy Labs using a 0.45-micron filter and analyses were conducted on the solids fraction.

Sample 2B – solid fragments of clayey material retrieved from the bottom of the well

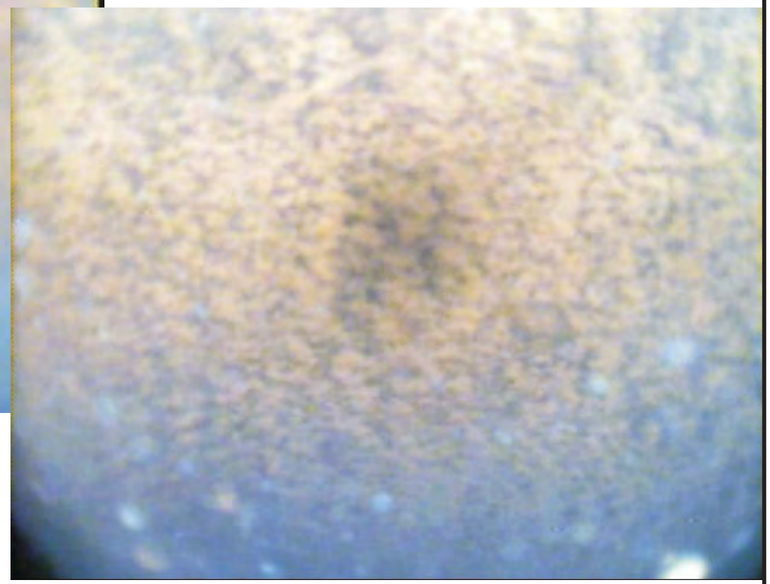
Sample 2C – hard platey mineral scale that appears to coat the sides on the PVC casing at and above the pump depth.

The laboratory analytical reports are included in Appendix B. The results are summarized in Table 1-2.

Orange mineral encrusted bedrock borehole at 160 feet.



Orange mineral encrusted bedrock borehole at 176 feet.



White mineral precipitate at upper contact with Morrison at 181 feet.

Accumlated hard mineral scale at bottom of borehole at 208 feet.

SAND COULEE WATER DISTRICT WATER SUPPLY ASSESSMENT	**WELL NO.4 DOWNHOLE VIDEO IMAGES**	**FIGURE** **1-7**

K:\PROJECT\10039\FIG Well 4 Images.cdr

TABLE 1-2. ANALYTICAL RESULTS FOR SOLIDS RECOVERED FROM WELL NO. 2

Parameter	No. 2a	No. 2b	No. 2c	Units
Moisture	78.8	8.7	7.3	wt%
Loss on Ignition at 550C	79.7	15.8	15.9	wt%
Chloride (Qualitative)	Trace	Trace	Trace	
Sulfate (Qualitative)	Absent	Absent	Absent	
Sulfide (Qualitative)	Absent	Absent	Absent	
Carbonate (Qualitative)	Absent	Absent	Present	
Lime as Ca(OH)2	Not analyzed	Not analyzed	2.29	wt%
Lime as CaCO3	Not analyzed	Not analyzed	3.1	wt%
Sulfur (Total)	0.08	0.19	0.25	wt%
Carbon (Total)	0.28	2.0	1.0	wt%
Aluminum (Total HF Digestion)	1.7	0.9	6.5	wt%
Barium (Total HF Digestion)	< 0.1	< 0.1	< 0.1	wt%
Calcium (Total HF Digestion)	< 0.1	0.3	0.2	wt%
Iron (Total HF Digestion)	0.3	37.2	7.8	wt%
Magnesium (Total HF Digestion)	< 0.1	0.2	0.3	wt%
Manganese (Total HF Digestion)	< 0.1	0.2	< 0.1	wt%
Silicon (Total HF Digestion)	6.1	4.3	26.0	wt%

The suspended solids sample, No. 2a, is composed predominantly of aluminum and silicon with large amounts of water, which is a common composition for clay minerals. Sample 2b, in contrast, is predominantly iron which the lab analyst believed is an iron oxide (John Hager, personal communication 10/28/2010). Results for sample 2C, which represents the hard mineral scale on the casing walls, represents a more complex mixture of carbonate, iron, aluminum and silicon. The carbonate in this sample dissolved readily when fresh scale surfaces were exposed to acid. The outer surface of the scale was significantly less reactive to acid.

The water sample from Well 3 was obtained after a period of sustained pumping. The analytical results (Appendix B, Table 1-3) show the water to be a magnesium-bicarbonate type, with near-neutral pH and moderate total dissolved solids (TDS) concentration. TDS concentrations in the July 2010 sample and an October 2000 sample collected by the Montana Bureau of Mines and Geology (MBMG) (also shown in Table 1-3) were 536 and

501 mg/L, respectively. The low concentration of silica compared with bicarbonate in the MBMG sample indicates preferential dissolution of carbonate rather than silicate minerals from the aquifer matrix (as expected based on the local geology), and the relative concentrations of magnesium and calcium may also indicate weathering of dolomite and/or precipitation of calcite (or exchange of calcium for sodium). Trace metal concentrations are low, but detectable concentrations of iron, manganese, and zinc are present.

TABLE 1-3. WELL NO. 3 WATER QUALITY RESULTS

Parameter	MBMG Sample Concentration (Well 3 -- 10/16/2000)	Hydrometrics Sample Concentration (Well 3 -- 7/12/2010)
pH (lab)	7.03 s.u.	7.2 s.u.
conductivity (lab)	895 µmhos/cm	912 µmhos/cm
Calcium	60.2 mg/L	57 mg/L
Magnesium	74.6 mg/L	76 mg/L
Sodium	21.0 mg/L	21 mg/L
Potassium	3.64 mg/L	4.0 mg/L
Chloride	11.3 mg/L	11 mg/L
Sulfate	90.4 mg/L	120 mg/L
Bicarbonate (as HCO3)	472 mg/L	450 mg/L
Total alkalinity (as $CaCO_3$)	387 mg/L	370 mg/L
Iron	0.139 mg/L	0.16 mg/L
Manganese	0.066 mg/L	0.09 mg/L
Silica (SiO_2)	6.89 mg/L	not analyzed

In order to further evaluate the possible causes of scale formation within the Sand Coulee water supply wells from a geochemical perspective, water chemistry results for the Well No. 3 sample were reviewed using the speciation/modeling program PHREEQCI (USGS, 2002). Among other capabilities, the PHREEQCI program calculates speciation of solution components, as well as saturation indices for possible solid species (precipitates) that might be expected to form under equilibrium conditions given the solution water chemistry. Data obtained from the MBMG sample (Table 1-3) was used as input for the model. As shown in Table 1-3, the chemical composition of the October 2000 and July 2010 samples is very similar; however, the October 2000 analytical results include additional parameters of interest for geochemical modeling (such as silica). Based on the similarity of the two samples, the results of the PHREEQCI model, should be applicable to current well conditions.

The input and output files for the PHREEQCI model are included in Appendix C. Of particular interest for the Well No. 3 geochemistry is an examination of the calculated saturation indices. The saturation index (SI) is calculated from the ratio of concentrations observed in the solution to the solubility product constant for the mineral, and is a measure of whether a solution is undersaturated, oversaturated, or near saturation with respect to the solubility of a particular mineral species. If $SI < 0$, the mineral is undersaturated, if $SI > 0$, the mineral is oversaturated, and an $SI = 0$ indicates a thermodynamic equilibrium condition. In general, SI values relatively close to 0 (about ±0.5 to 1.0) suggest the possible presence of the mineral.

A review of the speciation output file for the Well No. 3 samples shows that a number of carbonate-bearing species are near saturation in the groundwater, including calcite ($CaCO_3$, SI = -0.14), dolomite ($CaMg(CO_3)_2$), SI = -0.01), and magnesite ($MgCO_3$, SI = -0.63). In addition, a mixed ferric/ferrous hydroxide ($Fe_3(OH)_8$), SI = -0.23), jarosite ($KFe_3(SO_4)_2(OH)_6$, SI = -0.74) and several forms of silica (chalcedony, SI = -0.24, cristobalite, SI = -0.44, quartz, SI = 0.23) are near saturation as well. Iron carbonate (siderite), another potential solid species, shows an SI of -1.70 in the Well No. 3 sample, indicating clear undersaturation compared with the other species listed. The speciation calculation results suggest that it is possible that mixing of carbonate-bearing groundwater (perhaps in equilibrium with dolomite) with reduced iron-bearing groundwater (perhaps from a coal-bearing layer) within the well bore is producing iron hydroxide precipitate. Aeration and oxidation of reduced iron due to excess well dewatering and turbulent flow at the well intake may add to the formation and precipitation of iron hydroxide minerals.

While geochemical equilibrium modeling may provide useful information on possible solid phases based on measured water chemistry, the results should be viewed with caution. Field and laboratory analysis of some of the solid scale material indicated carbonate phases are present (i.e., sample evolved CO2 on addition of hydrochloric acid). Other potential scale/precipitate material was not considered in the geochemical modeling, including aluminum hydroxides, since solution aluminum concentrations were below detection limits. Finally, the simple equilibrium model prepared for this analysis does not account for reaction kinetics, or some of the potential complexities inherent to the situation at the well such as redox effects from repeated drawdown and recharge, variable inflow rates from fractures with variable water chemistry, potential degassing of carbon dioxide and microbe induced redox changes. Water chemistry from the different producing zones would help clarify whether mixing of different waters is contributing to scaling problems in the wells. Mineralogical analyses of scale samples may also provide more definitive results, but these analyses were beyond the scope of the current investigation.

1.5 WATER SUPPLY DEMAND

NCI (2010) recently completed a report estimating current and projected water supply demands for the Sand Coulee Water District. According to NCI, the Sand Coulee Water District serves 73 single family residences on a year-round basis with an estimated average daily demand of 18,100 gallons per day (19 gpm based on a 16-hour demand-day) and a calculated peak day demand of 72,400 gallons per day (76 gpm based on 16-hour demand-day). The average daily demand calculated by NCI to accommodate future population growth is 22,500 gpd (24 gpm based upon a 16-hour demand-day) with a maximum daily demand of 90,000 gpd (96 gpm based upon a 16-hour demand-day).

NCI compared these estimated demands to the actual yield of the Water District wells. The two existing wells were reportedly producing approximately 66,240 gpd (46 gpm with both wells pumping continuously) at the time of the NCI investigation. That flow rate is less than half of the flow rate estimated for the projected maximum day demand. NCI notes that the 96 gpm maximum day demand does not consider DEQ requirements for back-up supply.

DEQ specifies that the total developed groundwater source capacity for public water supply systems must equal or exceed the design maximum day demand with the largest producing well out of service (Circular DEQ-1). The Sand Coulee Water District therefore would need a fourfold increase in yield from their well field to bring their system into compliance with DEQ public water supply standards.

1.6 WATER RIGHTS

The Department of Natural Resources and Conservation website has six water rights listings for the Sand Coulee Water District. These water rights are associated with the District's wells; however, they do not all represent separate water rights. Some of the rights are duplicative and some have been transferred between wells. The water rights are shown with their associated wells in Table 1-4 and the water right abstracts are presented with the well logs in Appendix A.

TABLE 1-4. WATER DISTRICT WATER RIGHTS-

Well Name	Installation Date	Operational Status	DNRC Water Right No.	WR Priority Date	Max Flow Rate	Max Volume
No.1 (original)	12/31/1918	Presumed Abandoned	41QJ-5056-00 41QJ-5057-00	12/31/1918	35 GPM 35 GPM	3.0 AC-FT 76 AC-FT
No.2 (original) Well No.1 (current)	2/4/1960	Abandoned 5/5/2000	41QJ-5058-00 41QJ-213044	12/31/1959 7/5/1960	32 GPM 32 GPM	83.0 AC-FT 45,15 AC-FT
Well No.2 (current)	10/11/1973	Taken out of use Feb 2010	41QJ-6174-00	8/1/1975	60 GPM	Actual up to 10 AC-FT
Well No.3 replaced No.1 (current)	8/2/1999	In use	41QJ-70692-00	12/20/1988	40 GPM	40.33 AC-FT
Well No.4 (replaced original No.1)	3/1/2008	In use	41QJ-5057-00 version 2	12/31/1918	30 GPM	48.3 AC-FT

There is some confusion in the records related to the well numbering, which has changed over time. There are two separate water rights (5056 & 5057) listed with a priority date of December 31, 1919 and a flow rate of 35 gpm, which were claimed by the Sand Coulee Water Users Association when it was formed in 1959 for an existing well described as the

No. 1 well. The Sand Coulee Water Users Association also filed a separate claim (5058) with a priority date of December 31, 1959 and a flow rate of 32 gpm for the new well that was in the process of being installed at that time. Another duplicate claim (213044) with the same flow rate was filed in July 1960 when the new well was actually completed and put into use. The original filing on this well referred to it as the No. 2 well. As described in Section 1.4.1 however, this well has since been referred to as Well No. 1, creating some confusion in the record with subsequent water right filings.

A new water right (6164) of 60 gpm was filed in August 1975 for Well No. 2 installed by the Sand Coulee Water Users Association in October 1973. The Water District has an additional water right (70692) with a priority date of December 20, 1988. All of the information listed on the Abstract for this water right (well depth, static water level and casing diameter) matches the completion information for the District's Well No. 3; however, Well No. 3 was not installed until 1999 as a replacement well for the current Well No. 1. It is not clear what the original filing on this water right was for or when it was transferred to Well No. 3.

When Well No. 4 was installed in 2008, the original Well No. 1 water right (5057) was transferred to Well No. 4. There appears to be two versions of the 5057 abstract on the DNRC website, showing the original abstract and the updated version.

Because some of the water rights are duplicative and some represent water right transfers it is difficult to ascertain the total water right held by the District, but it appears to be on the order of 130 gpm and close to 100 acre-feet per year. This would be sufficient to meet the projected needs identified by NCI, however, DNRC may require quantification of historical use prior to approving a transfer of these existing water rights unless it is for a simple replacement well application. Water rights permitting issues for each of the specific source development options are discussed in Section 2.

2.0 WATER SUPPLY ALTERNATIVES

As described in Section 1, a key objective of the Sand Coulee water supply evaluation was to assess and compare three distinct options for improving the quantity and reliability of the current community water supply system. The three options include: 1) completing additional conventional wells in the Kootenai Formation; 2) completing a horizontal well in the Kootenai Formation (which would reduce/eliminate pumping requirements and may alleviate the current scaling issue); and 3) completing a deeper well in the Madison Limestone. These options are assessed below based on technical feasibility, regulatory feasibility and relative costs for development. Information gained through the abbreviated well testing and water/scale analyses and modeling, as described in Section 1.4, was instrumental in evaluating the various options.

2.1 OPTION 1 - CONVENTIONAL WELLS IN THE KOOTENAI FORMATION

One alternative for improving the Water District's water supply is to install additional wells in the Kootenai Formation and implement both design modifications and more aggressive maintenance measures to reduce the potential for scaling and mineral encrustation in the wells.

2.1.1 Well Design Modifications

Several design modifications are recommended to minimize the potential for mineral encrustation:

- Any new wells should not be completed across two separate formations with varying water quality. The wells should be screened in either the lower Kootenai sandstone or the Morrison coal, but not in both. This may reduce the available yield of the wells, but improve the scaling characteristics.

- The upper portion of the saturated zone (to a depth of approximately 170 feet, should be cased off to prevent water from cascading into the well in the drawdown interval when the well is pumped.

- The pumping rates should be limited to approximately 20 gpm to minimize drawdown related aeration and turbulence in the well.

- Finally, all of the wells should have stilling tubes installed to facilitate water level monitoring in the wells.

Final decisions regarding well completion requirements and optimum pumping rates would need to be made on individual wells at the time of drilling. Decisions would be based on an evaluation of the major producing zones in each borehole and the specific capacity of any new well(s) as determined through appropriate testing as described below.

2.1.2 Well Testing and Maintenance

While design modifications may significantly reduce rates of mineral encrustation, they are unlikely to completely eliminate the problem. Therefore, an active program of testing and maintenance is critical to limit or prevent continued deterioration of the wells over time. Step drawdown tests should be conducted on any new wells after completion to document the relationship between drawdown and well yield (specific capacity), and well loss verses formational loss (well efficiency). Periodic measurements (i.e. at least semi-annually) of static and operational water levels should be taken to identify any significant decrease in the operational efficiency of the wells over time. These results should be reviewed annually and decisions made regarding the need for preventative maintenance and/or rehabilitation.

Prior to rehabilitating a well, a down-hole video is recommended to determine where scale and mineral encrustations are forming. Recent redevelopment of Well No. 4 by surging the lower section of the well with air resulted in no improvement in yields. The hard mineral scale shown in downhole images filling the screen slots and formational fractures will require more aggressive treatment methods applied directly to the area of scale formation.

Testing of the hard mineral scale showed that acid is capable of breaking down the scale; however, the outer surfaces of the scale were much less reactive. A combination of mechanical and chemical rehabilitation techniques would therefore be most successful in removing these hard mineral encrustations. Mechanical tools, such as wire brushes, disk swabs or surge blocks would need to be combined with airlift pumping and chemical treatment of the well. For chemical treatment, there are a number of granular acid treatments on the market that are safe to handle that are designed to clean iron, magnesium, and calcium carbonate scale from wells (i.e. Cotey Chemical's Liquid Acid Descaler; CETCO Drilling Product's DPA). These products also contain chelating agents that suspend mineral scale once it has been dislodged so that it can be pumped out of the well. Step drawdown tests should be performed after completing rehabilitation to document the well efficiency and effectiveness of rehabilitation efforts.

2.1.3 Number and Location of Additional Wells

In order to meet the minimum design flow rate of 96 gpm identified by NCI, the Water District would need to install at least four and probably five conventional wells in the Kootenai or Morrison Formations. The increased number of wells reflects the additional yield constraints discussed above.

Any new wells should be spaced at greater distances than provided by the existing wells. Based on a Theis analysis of distance-drawdown relationships for the local Kootenai Formation aquifer, well spacings of less than about 200 feet could result in significant interference drawdown effects (greater than 10 feet of interference drawdown) during periods of extended pumping. These cumulative drawdown effects would not only contribute to excessive drawdown, reduced well yield and higher pumping costs, but could also contribute to mineral encrustation due to greater groundwater aeration rates within the well.

Limitations imposed on well spacing by the Water District's current easement area should be considered when evaluating the option of additional conventional wells within the Kootenai Formation.

2.1.4 Public Water Supply Permitting

Installation of new water supply wells would require review and approval by the DEQ Public Water Supply Bureau. For groundwater development, well permitting for a public water supply involves the following multistep process:

1. Well design – A proposed design for a well (or in this case multiple wells) would need to be prepared showing, among other things, proposed casing type and thickness, anticipated depths, screens or perforated intervals, pump types and elevations, surface collars, testing criteria and other details. DEQ generally takes a month or less to review and approve these relatively simple designs.

2. Updated Source Water Delineation and Assessment Report (SWDAR) - DEQ would require an updated SWDAR documenting that there are no immediate hazards that would threaten water quality at the proposed well locations.

3. Well installation and testing –The wells can only be installed and tested after receiving DEQ approval for the designs and locations. Once installed, they need to be tested for yield and drawdown. The general requirement for demonstrating adequate yield in a public water supply well is a 24-hour pumping test at 1.5 times the proposed design flow rate with 8 hours of drawdown stabilization. In discussions with the department (Denver Frazier, personal communication 10/29/10) the Department indicated they may accept one 24-hour test at 1.5 times the design yield combined with shorter tests (8 hours) at the remaining wells depending on their stabilization characteristics. If the yield and drawdown appear reasonable, water samples for analysis of organics, inorganics, nutrients, synthetic organic compounds (SOCs), volatile organic compounds (VOCs), radionucleides and nutrients would need to be collected and submitted for analysis.

4. Delivery system design – After well yield and drawdown are known, plans and specifications for the system to deliver water from the well or wells to the distribution system would need to be prepared and submitted to DEQ for approval. In Sand Coulee's case, this design would consist of buried pipe from the well sites to the existing storage tank. For relatively simple systems like this, DEQ generally has been reviewing and approving plans within a few weeks.

5. Delivery system construction – Following approval of plans and specifications, the delivery system could be constructed. This would be done by a contractor selected by a competitive bid process. Once completed, as-built plans would need to be submitted to DEQ verifying that construction was completed according to the approved plans and specifications.

6. Delivery system testing – the completed delivery system must be pressure tested and chlorinated as final steps in the construction and permitting process.

7. Final testing – Upon completion, a final sample is required for bacteriological analyses. If no bacteria are detected in the system, the new well or wells can be put into production.

2.1.5 Water Rights Permitting

DNRC has a simplified water rights filing process for installation of a replacement well (Replacement Well Notice Form 634); however, the department has indicated that a replacement well application would not apply to any additional points of diversion beyond the currently permitted number (Doug Mann, Personal Communication). Under Option 1 there would be more wells than there are with the current system, although each well would be pumping at a lower rate. Installation of more wells than the existing number would trigger more comprehensive permitting requirements including a detailed quantification of historical use, an evaluation of physical and legal availability, a hydrologic assessment of potential impacts to surface water, and development of a mitigation plan to address any adverse effects (see Section 2.3.4). This more comprehensive filing could take a year or more to complete.

The DNRC also requires pumping tests to be conducted to document aquifer characteristics and demonstrate adequate yield. For multiple wells this would normally consist of one extended pumping test (72 hours) and shorter (8 hours) tests on the individual wells.

2.2 OPTION 2 - HORIZONTAL WELL IN THE KOOTENAI FORMATION

As previously discussed, the potential for encrustation of a well can be kept to a minimum by having the greatest screen length possible to reduce groundwater entrance velocities, and by minimizing drawdown in the well to prevent turbulence and aeration of the water column in the well. It is difficult to achieve these design goals at Sand Coulee with a conventional well design because the saturated thickness of the formation is limited and the yields produced by the Kootenai Formation are already comparatively low. However, a well or wells drilled horizontally into the base of the Kootenai would make it possible to utilize a much longer screen length, and the screen would be less susceptible to dewatering/aeration because the horizontal orientation of the well screen would maximize the head over the screen and spread the stress to the aquifer over a larger area. A horizontal well also would not require a submersible pump. Instead it would gravity drain, which would further minimize turbulence in the well.

Horizontal wells, however, have some disadvantages and limitations. A horizontal well would be significantly more expensive to drill than a conventional well and it would require the right aquifer conditions to produce adequate yields. In addition, there are no local drillers that have horizontal well drilling capability.

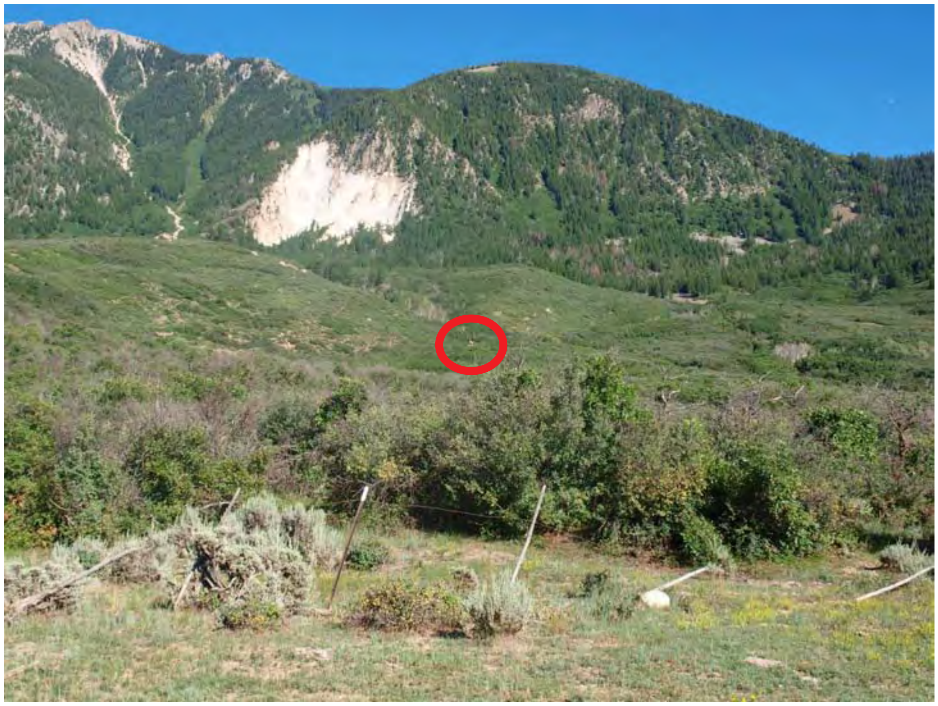
Well drilling companies that install horizontal wells include Directed Technologies Drilling, Inc. of Port Orchard, Washington and Layne Christiansen of Denver, Colorado. Directed Drilling provided information on a similar water supply project that they completed. They installed two horizontal wells into a hillside for a community water supply in Paonia, Colorado. The wells on that project were constructed of 2-inch stainless steel and were 250 feet and 280 feet long. The first 180 feet of the borehole was unsaturated, so the completion included screens approximately 70 and 100 feet in length. The drilling rig used on that job is approx. 22 feet long by 5 feet wide on steel tracks. An air hammer with a direct push pressure of 24,000 lbs is used to drive the casing. The cost to install the wells on the Paonia project was approximately $120,000 and the town used a grant to cover the costs. Photos of the project provided by Directed Drilling Technologies are shown in Figure 2-1.

Layne Christiansen out of Denver indicated that they also have a broad range of experience installing horizontal wells in the northwest for water supply projects. All of the examples they discussed with us were for much higher flow volumes than the Sand Coulee project.

2.2.1 Well Design and Yield

For purposes of this assessment, we have assumed a 4-inch diameter, 500-foot long horizontal well installed into the Kootenai Formation near the base of the coulee wall. Alternately, the well could be installed on top of the bluff using directional drilling techniques, but the costs would be several times greater.

The calculated steady-state yield from a 500-foot horizontal well using the transmissivity characteristics at Well No. 4 is only 60 gpm, however, this is based on the estimated transmissivity for the lowest yielding of the four Water District well sites. Yield of a horizontal well would also be influenced by fracture orientation and the vertical distribution of fractures in the formation. Horizontal fractures may be difficult to intercept with a horizontal well. It is therefore important to establish the fracture characteristics and aquifer properties in the proposed well location prior to proceeding with this option. Test wells have been included for this purpose as described in Section 2.2.2.



Paonia Project Drill Pad Location

Horizontal Drill Rig on Drill Pad

SAND COULEE WATER DISTRICT
WATER SUPPLY ASSESSMENT

DIRECTED DRILLING TECHNOLOGIES
PAONIA PROJECT PHOTOS

FIGURE

2-1

2.2.2 Well Testing and Maintenance Issues

The target formation and elevation of the well cannot be determined without additional testing. To properly design and evaluate a horizontal well, we have included costs (Section 3) for installing and testing two conventional monitoring wells in the area of the proposed well to more fully characterize producing zones and identify target depths in either the Kootenai or the Morrison Formations.

If a horizontal well is ultimately installed, the free flowing yield of the well should be tested periodically (i.e. semi-annually) to establish whether there is any decline in yield due to encrustation. Because a horizontal well would be free flowing, down-hole video and well maintenance would be much more difficult to perform if encrustation were to develop.

2.2.3 DEQ Public Water Supply Permitting

Public Water Supply permitting would entail similar procedures as Option 1. The DEQ does not have established standards for completion and testing of a horizontal well, and they therefore have indicated it may require some deviations from established procedures for a conventional well (Denver Frazier, personal communication), although they did not provide specifics. Because of the uncertainties associated with permitting and design of a non-conventional well, the time frame for permitting approval would probably be greater. Installation of a single horizontal well would not bring the system into compliance with DEQ requirements for back-up source capacity. DEQ design requirements stipulate that the system be capable of meeting the maximum day demand with the largest producing well out of service (DEQ Circular 1, Section 3.2.1.1). This would require either an additional horizontal well or additional conventional wells in the Kootenai as a back-up contingency.

2.2.4 DNRC Water Rights Permitting

As with Option 1, DNRC would require pumping tests to be conducted to establish aquifer characteristics, establish that there is adequate yield and provide information necessary to assess the potential for adverse effects to existing water rights. DEQ does not have specific protocol for testing of horizontal wells and therefore a specific plan of testing would need to be developed and reviewed with DNRC staff prior to testing.

Although in theory, it would be possible to file for a water right change as a replacement well, it is not clear whether the DNRC would accept this or whether a change in point of diversion would need to be filed with more comprehensive supporting analyses. DNRC staff could not provide a definitive answer on this issue (Doug Mann, Personal Communication) and indicated that they would need to look into this question further before providing a definitive answer. If a horizontal well could not be permitted as a replacement well, it is likely that quantification of historical use could be required as part of the change application. In that case, the permitted rate and volume would be limited to what could be demonstrated as historical use. Increased use would trigger a new appropriation request, which is a much more detailed permitting process (see description in Section 2.3.4).

2.3 OPTION 3 - MADISON AQUIFER DEEP WELL (S)

Another alternative for improving the water districts water supply would be to complete one or more deep wells into the Madison aquifer. Madison Group limestone is present at an estimated depth of approximately 400 feet below the ground surface at the Water District's well field location (Smith, 2008).

2.3.1 Potential Depth and Yield of a Madison Well

Madison wells in the Sand Coulee, Stockett and Centerville area yield between 5 and 100 gpm. Most of these wells are completed 100 feet to 300 feet into the Madison limestone. There is only one deep Madison well on record in this area at the nearby Big Stone Colony, where a gas exploration well was completed to the base of the Madison that was subsequently converted to a water well. The Big Stone Colony well is listed on the GWIC database as 1,400 feet deep and reportedly yields in excess of 150 gpm (unverified estimate).

To further assess the potential to complete a higher yielding well in the Madison aquifer, Hydrometrics compiled available information from the Montana Bureau of Mines and

Geology GWIC database on Madison wells completed within a 4-mile radius of the site. The well locations, total well depths (TD), static water level depths (SWL) and reported well yields (in gpm) for these wells are shown on Exhibit 1.

There are 116 wells listed as completed in the Madison aquifer within four miles of the site. GWIC statistics for these wells including reported yields and depths are tabulated in Appendix D. The wells have an average reported yield of approximately 30 gpm. Twenty-five of the wells have reported yields of 50 gpm or greater (21% of the total). There are 60 Madison wells shown in the immediate Sand Coulee, Stockett, Centerville and Tracy area. Of these wells, nine report yields in excess of 50 gpm (15% of the total). While these statistics provide a general indication of the potential for achieving higher yields in the Madison, several factors should be considered when evaluating the results. Wells completed for domestic water supply typically stop drilling when sufficient yields are encountered. As a result very few of the domestic wells penetrate more than 200 to 300 feet into the Madison or yield more than 30 gpm; however there are some deeper wells (up to 500 feet) that still report minimal yields (<10 gpm).

The GWIC records for the Madison aquifer confirm that higher yielding conditions (greater than 50 gpm) are present at least locally in many areas, but there is no assurance that these higher yields can be achieved at this site without completing and testing a deep well. Because the depth to the Madison is greater than 400 feet at the site, we have assumed a drilling depth of 800 to 1,000 feet for a Madison well. The actual depth may be less if sufficient water is encountered at a higher elevation; however, since the Water District would benefit from a high producing well it is likely a deeper well would be necessary to fully establish the potential yield of the Madison aquifer at this location. Depending on the yield, one or more wells may ultimately be needed to meet water supply demands. Presumably the existing wells could remain as a back-up alternative, however the flow rates of the existing wells are not sufficient to meet DEQ's requirement for a back-up water supply. DEQ design requirements stipulate that the system be capable of meeting the maximum day demand with the largest producing well out of service. To bring the current system into full compliance with DEQ's design standards would therefore require completion of at least two Madison wells.

2.3.2 Well Testing and Maintenance

The Madison aquifer does not contain the same chemistry as the Kootenai/Morrison aquifer, which should reduce the likelihood of the encrustation problem that afflicts the current Water District wells. Since the water is derived from a calcium carbonate aquifer at considerable depth, scaling is possible and similar monitoring and control measures described above should be performed on the well. This includes testing the baseline well efficiency and yield through a step-drawdown test and periodic operational discharge/drawdown measurements to verify there are no efficiency losses over time. If there are efficiency losses related to build-up of calcium carbonate scale, the well should be amenable to acid treatments similar to those described for Option 1.

2.3.3 DEQ Public Water Supply Permitting

Public water supply permitting through DEQ for this option would be similar to the requirements described under Option 1, which include:

1. Submittal of a well design and an updated SWDAR to DEQ for review;
2. Installation and testing of the well (24-hour pumping test at 1.5 times the design yield);
3. Water quality sampling;
4. Delivery system design, installation and testing; and
5. Final pressure testing, chlorination, and analysis for bacteria.

2.3.4 DNRC Water Rights Permitting

As with Option 1, DNRC would require pumping tests to be conducted to determine aquifer characteristics, establish adequate yield and provide information necessary to assess the potential for adverse effects to existing water rights. Because the well would be completed in a different aquifer than the original wells it does not appear that it would be possible to file a simple replacement well application to transfer water rights from the existing wells. Instead it would be necessary to file for a change in the point of diversion on the existing water rights and a new appropriation for any expanded use. A new appropriation filing would be required since a change in the water right fixes that water right at historical use rates. Since Sand Coulee has no documentation of historical pumping rates, an analysis would need to be completed based on the number of service connections and the amount of irrigation under the current system. Under these circumstances the proposed design yield of 96 gpm would likely be considered an expansion of use.

An expansion of the existing use would trigger an additional permitting requirement related to the fact that Sand Coulee lies in a basin closed to surface water appropriations. In a basin closed to surface water appropriations, a detailed assessment is required on new appropriations to demonstrate that there will not be depletion of surface water due to groundwater withdrawals. The Department assumes virtually all withdrawals ultimately result in a direct depletion of recharge to downgradient surface waters, therefore new appropriations typically require either a mitigation plan to be developed that results in increased groundwater recharge, or retirement of another existing water right to offset the amount of depletion in time and place.

These permitting requirements are much more complex than a replacement well application. The Department estimates that the processing time for an application that is correct and complete is 210 days; however, the process more commonly takes a year or more to complete depending on the complexity of the issues identified during the review. The application process entails the following:

- Completing and filing an Application for a Beneficial Water Use Permit. This requires information on the intended use, place of use, point of diversion, source of supply, amount of water to be used, diversion facilities, and other particulars of the proposed appropriation.

- Preparing a Criteria Addendum to the application demonstrating that water is physically available at the proposed point of diversion, legally available in the amount and for the period requested, that water rights of a prior appropriator will not be adversely affected, and that the proposed means of diversion is adequate.

- Preparing a Hydrologic Assessment Report if the site is in a basin closed to surface water appropriations. The report must include among other things, an analysis of net depletion and adverse effects to surface water. A mitigation plan or change request on an existing water right is required to address adverse effects.

- After receiving this information DNRC will conduct a completeness review and ask the applicant to respond to any deficiencies. DNRC typically requests additional information depending on the complexity of the application.

- Once the application is determined to be complete the Department will issue a Preliminary Determination to grant or deny the application (within 120 days of determining the application is correct and complete).

- An environmental review is also made to determine whether the proposed project will have significant environmental impacts and whether an environmental impact statement is needed.

- Public Notice is made of the application by posting information in a newspaper. DNRC also may contact or send notice to nearby water rights holders.

- Existing water users may file objections to the application. If objections are found to have a basis and cannot be resolved, an administrative hearing is held. The hearings examiner then considers all the information in the record and issues a decision.

- Once the well is completed and the water is put to use, the owner submits a Notice of Completion of Groundwater Development to the DNRC

Addressing the closed basin surface water depletion issues would likely be the most challenging and complex part of this process. The Department has indicated that the Water District could potentially offset a portion of their withdrawal by discontinuing pumping from their existing Kootenai wells (Doug Mann, personal communication; Russ Levens, personal communication). The remaining difference between the historical use and the proposed withdrawal rate would still require mitigation. The simplest way to address this requirement would be to purchase a contract for water from the Canyon Ferry reservoir equal to the amount of mitigation water still required to address the stream depletion. According to Mark Beattie at the Bureau of Reclamation (personal communication 11/4/2010), mitigation water from the reservoir would cost approximately $35 per acre-foot to purchase, plus 30 to 40 cents an acre-foot for operation and maintenance costs. Sand Coulee could need 10 to 30 acre-feet of water per year for mitigation under this scenario. The actual amount would need to be determined based on a detailed assessment of current use.

3.0 COST ASSESSMENT

Comparative costs have been assessed for the design, permitting, installation and testing of each of the source options. These costs represent rough estimates intended for comparison purposes only, and are not intended for budgeting purposes. Final cost estimates will need to be developed on the selected alternative based on final designs with direct input from contractors. Cost estimates for each option are summarized in Table 3-1.

TABLE 3-1. COST COMPARISON SUMMARY

TASK	Option 1	Option 2	Option 3
Public Water Supply Well Engineering Design and Updated SWDAR	$4,000	$4,500	$4,000
Monitoring Well Installation & Pumping Tests	--	$21,150	--
Water Supply Well Installation	$91,200	$164,000	$67,300
Aquifer Testing	$32,200	$6,100	$10,000
Water Rights Application	$17,500	$5,000	$17,500
Delivery System, Pumphouse, Pump Controls Design, Installation and Testing	$80,050	$39,700	$37,800
Install Pumps, Final Testing, Survey & As-Builts	$47,000	$16,200	$42,200
TOTAL	**$271,950**	**$256,650**	**$178,800**
Back-up Source Capacity Contingency*		**$416,650**	**$300,000**

** Total cost if a second well is included to meet DEQ back-up source capacity requirement*

The assumptions used in developing costs for each option are as follows:

- Option 1 assumes installation and testing of five 180-foot deep, steel cased wells with stainless steel well screens completed in the Kootenai Aquifer.

- Option 2 assumes installation and testing of one 500-foot long horizontal well and two 180-foot deep monitoring wells. Costs for water rights permitting assume DNRC would allow the wells to be permitted as a replacement well; however, DNRC has not provided confirmation of this. If DNRC requires permitting as either a new source or new point of diversion costs would be similar to Options 1 and 3. Additional costs are shown for installation and permitting of a second well to bring the system into compliance with DEQ source capacity requirements.

- Option 3 assumes installation and testing of one 1,000-foot deep steel-cased well, however, total costs are also shown that include installation and permitting of a second well to bring the system into compliance with current DEQ source capacity requirements.

The costs for Option 1 are comparatively high due to the greater number of wells, which translates into additional testing and capital costs for pumps and piping. Water rights permitting costs assume the permitting cannot be accomplished through replacement well applications. Option 1 costs do not include the purchase of additional land to site the wells and well head protection areas, which would likely be required for this alternative.

Option 2 has the highest drilling costs and will require additional monitoring wells and testing prior to installation of the well. Option 2 also assumes water rights permitting can be accomplished through replacement well applications. Option 2 costs do not include purchase of land at the base of the bluff for the well and well house.

Option 3 has the lowest drilling costs despite the fact that it represents slightly more drilling footage than Option 1 because it has less required surface casing and well screen. If the objective is simply to increase the yield of the existing system to meet current demands, it may be possible to accomplish this with a single Madison well, however, at least two wells would be necessary to meet DEQ requirements for back-up capacity. Option 3 has the highest permitting costs and assumes filing will be required for a Change in the Point of Diversion, a New Appropriation, a Basin Closure Hydrologic Assessment and a Mitigation Plan.

These costs do not include operation and maintenance (O&M) costs. Option 1 would have the highest maintenance costs due to the number of wells and the likelihood that active testing and maintenance will be required on an annual basis to prevent scaling and encrustation of the well screens. Option 2 would have the lowest costs if the well design is successful in limiting scale development, however, the rate of scale development can't be readily established and preventative maintenance for scaling and encrustation would be difficult on this well design. Option 3 may have estimated mitigation costs of $700 to $1,000 per year that will add to ongoing O&M costs.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Option 1 has a number of disadvantages, which include significantly higher O&M costs due to the greater number of wells, the likely need for additional property to adequately space the wells, and potential for ongoing problems with scaling and mineral encrustation. The cost to implement Option 1 is lower than the other options if contingencies for installation of back-up wells are included.

Option 2 has distinct advantages in terms of minimizing the potential for scale encrustation but is the most expensive to implement. There is also a relatively high degree of uncertainty with Option 2 regarding the potential yield of a horizontal well. Although well design and lack of pumping are expected to reduce the potential for scaling and reduced well yield with time, the long-term potential for scaling and mineral encrustation cannot be completely ruled out.

Option 3 is the most likely to minimize future problems with scaling and mineral encrustation, but the yield of the Madison cannot be established without installation of a deep, expensive well. Permitting is also most complex for this option and would likely require purchase of mitigation water from Canyon Ferry Reservoir on a long-term basis to offset the increase in use compared to historical use.

Based on this analysis we believe the third option, which calls for completion of a deep well in the Madison is likely to provide the most reliable water source for the Water District wells over the long-term. It should be realized however, that all options have an associated risk. For this option, the yield of the Madison has not been established. However, even the average yield for wells completed in the Madison aquifer in this region (30 gpm) would nearly double the current capacity of the system and would be less prone to the rapid deterioration in yield as would existing or additional wells completed within the shallower Kootenai/Morrison wells.

5.0 REFERENCES

DEQ, 2000, Source Water Delineation and Assessment Report. Sand Coulee Water Users Association Public Water System PWSID # MT0000325. April 13, 2000.

Driscoll, F.G. 1986, Groundwater and Wells, 2nd Edition, Johnson Screens, St. Paul Minnesota. p.572.

Goers, J. W., 1968. Geology and Groundwater Resources, Stockett-Smith River Area, Montana: Unpub. M.S. Thesis, University of Montana.

NCI, 2010, Sand Coulee Water District Water PER.

RTI, 2009. Great Falls Coal Field: Historical Overview. Prepared by Renewable Technologies Incorporated for the Mine Waste Clean-up Bureau, Montana Department of Environmental Quality, June 2009.

Smith, L.N, 2008. Montana Bureau of Mines and Geology, Groundwater Atlas 7, Part B Map 3. Open File-Version September 2008.

USGS, 2002, PHREEQCI -- A Graphical User Interface for the Geochemical Computer Program PHREEQC. Version 2.17.5-4799, September 7, 2010. Available at http://wwwbrr.cr.usgs.gov/projects/GWC_coupled/phreeqci/.

WESTECH, Hydrometrics, Inc., 1982. Investigation of Acid Drainage from Abandoned Coal Mines and Assessment of Potential Methods of Impact Abatement. February 19, 1982.

Wilke, K.R. 1983, Appraisal of water in Bedrock Aquifers, Northern Cascade County, Montana. Montana Bureau of Mines and Geology Memoir 54.

APPENDIX A

WELL LOGS AND WATER RIGHTS ABSTRACTS

File No. ...

TRIPLICATE

Original Well No.1 (4) (4)

NOT CODED

020938

013 T. 19N R. 4E 14D

County Cascade

Montana Bureau of Mines and Geology

Well #1
Elev. 3680
217 KOTN
INV 03V01979

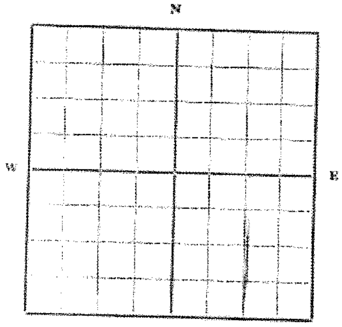
CODED

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
OFFICE OF STATE ENGINEER

Declaration of Vested Groundwater Rights

(Under Chapter 237, Montana Session Laws, 1961)

1. Sand Coulee Water Users Association of Sand Coulee
(Name of Appropriator) (Address) (Town)
County of Cascade State of Montana
have appropriated groundwater according to the Montana laws in effect prior to January 1, 1962, as follows:



SE 1/4 Sec. 14 T. 19N R. 4E

Indicate point of appropriation and place of use, if possible. Each small square represents 10 acres.

BB

2. The beneficial use on which the claim is based supplying water to the Sand Coulee area residences

3. Date or approximate date of earliest beneficial use; and how continuous the use has been No. 1 Well 1920 Town water No. 2 Well July 5, 1960. Daily use of residences

4. The amount of groundwater claimed (in miner's inches or gallons per minute) No. 1 Well 12 gals. per min. No. 2 Well 45 gals. per min. (Current Well No.1)

5. If used for irrigation, give the acreage and description of the lands to which water has been applied and name of the owner thereof not applicable

6. The means of withdrawing such water from the ground and the location of each well or other means of withdrawal Wells. Two wells located on E½E½ Sec. 14, Twp. 19 N., Rge 4 E., M.P.M., Cascade County, Mont.

7. The date of commencement and completion of the construction of the well, wells, or other works for withdrawal of groundwater No 1 Well 1920 No. 2 Well, drilling begun 2-4-60. Pumping begun July, 5, 1960.

8. The depth of water table No. 1 Well unknown. No. 2 Well 134 feet. 135

9. So far as it may be available, the type, size and depth of each well or the general specifications of any other works for the withdrawal of groundwater No. 1 Well, drilled well, 6 inch casing to depth of 16 feet. Well 194 feet deep. No. 2 Well, drilled well, 6 inch casing to depthof 34 feet. Well 210 feet deep.

10. The estimated amount of groundwater withdrawn each year 1,505,625 gals.

11. The log of formations encountered in the drilling of each well if available No. 1 Well unavailable. No. 2 Well, Log available from State Board of Health.

12. Such other information of a similar nature as may be useful in carrying out the policy of this act, including reference to book and page of any county record Easement Rental Agreement with Edward Ingman & Josephine Ingman, Oct. 1, 1959---Book 15 Page 507 Recorders Office. Easement Deed with Edward Ingman & Josephine Ingman, Oct. 6, 1959---Book 293, Page 9 Recorders Office.

SAND COULEE WATER
USERS ASSOCIATION
SAND COULEE, MONTANA

By George Mittal
Sec.-Treas.

Date 1-15-62

Three copies to be filed by the owner with the County Clerk and Recorder of the county in which the well is located.

Please answer all questions. If not applicable, so state, otherwise the form will be returned.

Original to the County Clerk and Recorder; duplicate to the State Engineer; Triplicate to the School of Mines and Quadruplicate for the Appropriator.

M: 31884

013 19N 04E 14 DADA CASCADE

FORM No. 603 New 7-73

CURRENT WELL NO.2

STATE OF MONTANA

Department of Natural Resources and Conservation

CODED

File No.

WHITE — DEPARTMENT

020956

NOV 21 1975

Montana

WELL LOG REPORT

State law requires that this form be filed by the water well driller on any water well completed by him on and after July 1, 1973 within sixty (60) days after completion of the well.

1. WELL OWNER: Name Sand Coulee Water Users Assn. Address Sand Coulee, Montana

2. WELL LOCATION: County Cascade DADA ¼ ¼ ¼, Sec. 14, Twp. 19N N-S, Rg. 4E E-W

3. PROPOSED USE: ___ Domestic ___ Stock x Municipal ___ Industrial ___ Lawn and Garden ___ Irrigation ___ Other (*if other, specify*) e/u

4. METHOD DRILLED: x Cable ___ Bored ___ Forward Rotary ___ Reverse Rotary ___ Jetted ___ Other (*if other, specify*)

5. WELL CONSTRUCTION:
Diameter of hole 6 inches. Depth 210 ft.
Casing: ___ Steel ___ Plastic ___ Concrete ___ Threaded x Welded ___ Other (*if other, specify*)
Pipe Weight: Dia.: From: To:
__ lb/ft. 6 5/8 inches 0 feet 31 feet
___ lb/ft. ___ inches ___ feet ___ feet
___ lb/ft. ___ inches ___ feet ___ feet
Was perforated pipe used? ___ Yes x No
Length of pipe perforated ___ feet
Was casing left open end? x Yes ___ No
Was a well screen installed? ___ Yes x No
Material ___ Dia. ___ inches
(*stainless steel, bronze, etc.*)
Perforation type: ___ slots ___ holes
Size ___ set from ___ feet to ___ feet
Size ___ set from ___ feet to ___ feet
Size ___ set from ___ feet to ___ feet
Was a packer or seal used? ___ Yes x No
If so, what material ___
Well type: ___ Straight screen ___ Graveled
Was the well grouted? ___ Yes x No
To what depth? ___ feet
Material used in grouting ___
Well head completion: Pitless adapter x
12" above grade yes Other ___
(*If other, specify*) ___
Was the well disinfected? x Yes ___ No

6. WATER LEVEL:
Static water level 60 ft. below land surface
If flowing: closed-in pressure ___ psi
GPM flow ___ through ___ inch pipe
Controlled by: ___ Valve ___ Reducers
___ Other, *specify* ___

7. WELL TEST DATA: ___ Pump x Bailer ___ Other
(*If other, specify*) ___
Pumping level below land surface:
160 ft. after 1 hrs. pumping 60 gpm
___ ft. after ___ hrs. pumping ___ gpm

8. WELL LOG: 217 KOTN

Depth (ft.) From	To	Formation
0	8	Top soil
8	27	Broken rock
27	60	Brown - gray shale
60	68	Gray sandstone
68	[illegible]	Brown shale
[illegible]	68	Gray sandy shale
68	70	Red shale
70	81	Gray shale
81	87	Hard black shale
87	120	Gray sandy shale
120	124	Gray sandstone
124	135	Hard gray lime
135	156	Gray sandstone
156	187	[illegible]
187	210	Black clay & shale

Kootenai

LAB: 820497
ALT: 3690 ±10
GEO: 217KOTN
INV: 06V01997

(*Use separate sheet if necessary*)

9. DATE STARTED: 10-4-1973 BB

10. DATE COMPLETED: 10-11-1973

11. WAS WELL PLUGGED OR ABANDONED? ___ Yes ___ No
If so, how ___

12. DRILLER'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

Pat Crowe Drilling 134
Driller's or Firm Name *License No.*

Williams Rd., Great Falls, Montana
Address

[signature]
Signed by *Date*

M.2254

19N 04E 14 D

FORM E. S. 26--2500 TRIP.--6-55

Original Well No.2, Current Well No.1

(Elev. above sea level 3725.........)
Top of Ground

#2well

MONTANA STATE BOARD OF HEALTH

Division of Environmental Sanitation

Helena, Montana

WELL DRILLER'S REPORT

Driller's Registration No.............

Driller Soennichsen Drilling Co. Address Great Falls, Mont.

Owner of Well Sand Coulee Water Users Association

Exact Location of Well $E\frac{1}{2}SE\frac{1}{4}$ of Sec. 14 Township 19 N. Range 4

Nearest Post Office Sand Coulee, Mont. County Cascade

Water to be Used for City Water Supply

Drilling Begun 2-4-60 Well Finished 2-18-60

0 to 8ft. Surface
8ft. to 10 ft Sandstone
10ft. to 13ft. Shale
13ft to 16 ft. Sandstone
16ft. to 28ft. Shale
28ft. to 52ft. Sandstone
52ft. to 68ft. Shale
68ft. to 70ft. Sandstone
70ft. to 76ft. Shale
76ft. to 81ft. Sandstone
81ft. to 83ft. Shale
83ft. to 120ft. Sandstone (yellow)
120ft. to 133ft. Shale
133ft. to 192ft. Sandstone (water)
192ft. to 195ft. Shalerock and Slate
195ft. to 198ft. Clay
198ft. to 210ft. Sandstone (water)

210'

Water Level

Indicate on the diagram the character and thickness of the different strata met with in drilling, such as soil, clay, shale, gravel, rock or sand, etc. Show depth at which water is encountered, thickness and character of water-bearing strata and height to which the water rises in the well.

Casing Record

BB

Size of Pipe	Kind and Weight of Material Used	From (Feet)	To (Feet)	PERFORATIONS Kind Size	From (Feet)	To (Feet)
6" O.D.	Iron	0	34			

PLUGGED ABANDONED

Describe the type of joints in casing Fine Thread Coupling

This well was plugged and abandoned May 5th 2000.

Describe any screens used None

We used 56 sacks of Medium Bentonite chips, hydrated every 2 sacks above the water level in the well.

Capacity of Well 45 gal. Per Minute (In Gallons or Barrels)

How Determined By Pump (Pump, Bailer, Weir, Etc)

Pat J Byrne
License #318
May 19 2000

46'

Signed [signature]

Date February 18, 1960

DUPLICATE — TO BE GIVEN TO CUSTOMER

Show exact depth of bottom.

M. 31883

STATE OF MONTANA
SS:
COUNTY OF CASCADE

George Mittal, having been first duly sworn, deposes and says:

That he is an officer, to-wit: The Secretary-Treasurer of the SAND COULEE WATER USERS ASSOCIATION, a Montana corporation, and is of lawful age; that said SAND COULEE WATER USERS ASSOCIATION is the appropriator and claimant of the order and water right mentioned in the foregoing declaration of vested ground water rights and is the corporation whose name is subscribed and seal is affixed thereto as the appropriator and claimant, and that he knows the contents of the said foregoing notice and that the matters and things stated therein are true.

George Mittal

SUBSCRIBED and SWORN to before me this *15th* day of January, 1962.

Ella Murray
Notary Public for the State of Montana
Residing at: *Sand Coulee, Mont.*
My commission expires: *Dec. 2, 1962*

(NOTARIAL SEAL)

STATE OF MONTANA, } ss.
County of Cascade.
I hereby certify that the within instrument was filed in this office on
JAN 16 1962
Date
at *10:50* o'clock *A.* M.
J. L. LENNON
County Clerk and Recorder.
By *[signature]* Deputy.

190046 14

MONTANA WELL LOG REPORT

Well ID# Well No.3

Form No. 603 R2-99

This log reports the activities of a licensed Montana well driller and serves as the official record of work done within the borehole and casing and describes the amount of water encountered. **This form is to be completed by the driller and filed with DNRC within 60 days of completion of the work.** **Acquiring Water Rights is the well owner's responsibility and is not accomplished by the filing of this report.**

Well log information is stored in the Groundwater Information Center at the Montana Bureau of Mines and Geology (Butte) and water right information is stored in the Water Rights Bureau records (Helena).

For fields that are not applicable, enter NA. Optional fields have a grayed background. Record additional information in the REMARKS section.

1. WELL OWNER:
Name Sand Coulee Water Users
Mailing address Sand Coulee, MT 59472

2. WELL LOCATION: List ¼ from smallest to largest
DROA NE ¼ NE ¼ SE ¼, Section 14
Township 19 N S Range 4 E W County Cascade
Lot ____, Tract/Blk ____ Subdivision Name ____
Well Address ____
GPS ☐ Yes ☐ No
Latitude ____ Longitude ____
Error as reported by GPS locator (± feet) ____
Horizontal datum ☐ NAD27 ☐ WGS84

3. PROPOSED USE: ☐ Domestic ☐ Stock ☐ Irrigation ☑ Public water supply ☐ Monitoring Well ☐ Other: ____

4. TYPE OF WORK:
☑ New well ☐ Deepen existing well ☐ Abandon existing well
Method: ☐ Cable ☑ Rotary ☐ Other: ____

5. WELL CONSTRUCTION DETAILS:

Borehole:
Dia. 9 in. from 0 ft. to 38 ft.
Dia. 6 in. from 38 ft. to 181 ft.
Dia. ____ in. from ____ ft. to ____ ft.

Casing:
Steel: Wall thickness .250 ☐ Threaded ☑ Welded
Dia. 6 5/8 in. from +2 ft. to 38 ft.
Dia. ____ in. from ____ ft. to ____ ft.

Plastic: Pressure Rating 160# lbs. ☐ Threaded ☑ Welded
Dia. 5.00 in. from +1 ft. to 181 ft.
Bottom 2 joints are 250# PVC 5" OD

Perforations/Slotted Pipe:
Type of perforator used Skill Saw
Size of perforations/slots 1/8 in. by 6 in.
27 no. of perforations/slots from 165 ft. to 173 ft.
____ no. of perforations/slots from ____ ft. to ____ ft.

Screens: ☐ Yes ☑ No
Material ____
Dia. ____ Slot size ____ from ____ ft. to ____ ft.
Dia. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel Packed: ☐ Yes ☑ No
Size of gravel ____
Gravel placed from ____ ft. to ____ ft.

Packer: ☑ Yes ☐ No
Type Shale Trap Depth(s) 140

Grout: Material used Medium Bentonite chips
Depth from 0 ft. to 38 ft. OR ☐ Continuous feed

6. WELL TEST DATA:
A well test is required for all wells. (*See details on well log report cover.*)
☐ Static water level 150.5 ft. below top of casing **or**
☐ Closed-in artesian pressure ____ psi.
How was test flow measured:
(bucket/stopwatch) weir, flume, flowmeter, etc ____
Yellowstone groundwater closure area only - Water Temperature ____ °F
☐ AQUIFER TEST DATA FORM ATTACHED

Test - 1 hour minimum
Drawdown is the amount water level is lowered below static level.
All depth measurements shall be from the top of the well casing.
Time of recovery is hours/minutes since pumping stopped.

Air test*
____ gpm with drill stem set at ____ ft. for ____ hours
Time of recovery ____ hrs/min. Recovery water level ____ ft.

OR Bailer test*
____ gpm with ____ ft. of drawdown after ____ hours
Time of recovery ____ hrs/min. Recovery water level ____ ft.

OR Pump test*
Depth pump set for test 170 ft.
50 gpm pump rate with 4 ft. of drawdown after 2 hrs pumping
Time of recovery <2 (hrs)/min. Recovery water level 150.5

OR Flowing Artesian*
____ gpm for ____ hours
Flow controlled by ____

**During the well test the discharge rate shall be as uniform as possible. This rate may or may not be the sustainable yield of the well. Sustainable yield does not include the reservoir of the well casing.*

7. WELL LOG:

Depth, Feet From	To	Material color/rock and type/descriptor (example: blue/shale/hard, or brown/gravel/water, or brown/sand/heaving)
		SEE ATTACHED SHEET

☐ ADDITIONAL SHEETS ATTACHED

8. DATE WELL COMPLETED: 7/29/99

9. REMARKS:

10. DRILLER/CONTRACTOR'S CERTIFICATION:
All work performed and reported in this well log is in compliance with the Montana well construction standards. This report is true to the best of my knowledge.
Name, firm, or corporation (print) PAT BYRNE DRILLING, INC.
Address 245 Gerber Road Great Falls, MT 59405
Signature [signature]
Date 8/2/99 License no. 318

MBMG ID# 177478

Montana DNRC P.O. BOX 201601 HELENA, MT 59620-1601 444-6610

DEPARTMENT—BUREAU COPY

Sand Coulee Water Users Assoc. Well Log:
 # 1 Replacement Well

0	8	Top soil, floating sandstone rock, shaly
8	11	Brown sandstone
11	13	Gray sandstone
13	17	Hard gray and brown sandstone
17	23	Gray and rusty brown shale
23	25	Red shale
25	28	Gray shale
28	28	Yellow lense
28	30	Gray shale
30	34	Hard gray sandstone
34	35	Verigated shale
35	45	Gray and rusty brown sandstone
45	60	Verigated sandy shale
60	73	Dark gray shale
73	87	Dark gray sandstone / sandy shale
87	116	Rusty brown and gray sandstone soft
116	145	Gray sandstone w/ some rusty brown turning to light brown sugary sandstone then gray sugary sandstone
145	150	No return, very fractured
150	160	Gray sandstone (small returns)
160	170	Darker gray sandstone (encountered water, air lifting about 10-15gpm)
170	175	Coal (small returns)
175	181	Dark gray to black shale

MONTANA WELL LOG REPORT

This well log reports the activities of a licensed Montana well driller, serves as the official record of work done within the borehole and casing, and describes the amount of water encountered. This report is complied electronically from the contents of the Ground-Water Information Center (GWIC) database for this site. Acquiring water rights is the well owner's responsibility and is NOT accomplished by the filing of this report.

Other Options

Plot this site on a topographic map

Site Name: SAND COULEE WATER USERS #4
GWIC Id: 241877
DNRC Water Right: C005057-00

Section 1: Well Owner

Owner Name
SAND COULEE WATER USERS #4
Mailing Address
SAND COULEE POST OFFICE

City	State	Zip Code
SAND COULEE	MT	59472

Section 2: Location

Township	Range	Section	Quarter Sections
19N	04E	14	NE¼ NE¼ SE¼

County	Geocode
CASCADE	

Latitude	Longitude	Geomethod	Datum
47.3981	111.1771	NAV-GPS	NAD83

Altitude	Method	Datum	Date

Addition	Block	Lot

Section 3: Proposed Use of Water

PUBLIC WATER SUPPLY (1)

Section 4: Type of Work

Drilling Method: ROTARY

Section 5: Well Completion Date

Date well completed: Saturday, March 01, 2008

Section 6: Well Construction Details

Borehole dimensions

From	To	Diameter
0	150	10
150	212	6

Casing

From	To	Diameter	Wall Thickness	Pressure Rating	Joint	Type
-2	139	6.6	0.28		WELDED	A53B STEEL

There are no completion records assigned to this well.

Annular Space (Seal/Grout/Packer)

From	To	Description	Cont. Fed?
0	150	CEMENT	

Section 7: Well Test Data

Total Depth: 212
Static Water Level: 154.5
Water Temperature:

Pump Test *

Depth pump set for test 182 feet.
30 gpm pump rate with 18.7 feet of drawdown after 50.5 hours of pumping.
Time of recovery 0.17 hours.
Recovery water level 155 feet.
Pumping water level _ feet.

** During the well test the discharge rate shall be as uniform as possible. This rate may or may not be the sustainable yield of the well. Sustainable yield does not include the reservoir of the well casing.*

Section 8: Remarks

CASING IS CEMENTED INTO CONSOLIDATED SANDSTONE MEMBER THAT CARRIES WATER. THE HISTORY OF THE TOWNS WELLS IS THAT THEY ENCRUST AND NEED TO BE REDEVELOPED. WE HAVE COMPLETED THIS WELL "OPEN HOLE" TO FACILITATE THE FUTURE REDEVELOPEMENT OF THE WATER ZONE.

Section 9: Well Log

Geologic Source
217KOTN - KOOTENAI FORMATION

From	To	Description
0	2	TOP SOIL AND RED CLAY
2	9	RED GRAY YELLOW WEATERED SHALES AND BROKEN SANDSTONES
9	13	GRAY SANDSTONE
13	15	RED AND GRAY SHALE
15	25	RUSTY TO GRAY TO BROWN SANDSTONE SMALL WATER ENCOUNTERED AT 25
25	40	GRAY SHALE
40	58	GRAY SANDSTONE SOME RUSTY
58	72	RED AND GRAY SANDY SHALE
72	102	DARK GRAY SHALE W/ SOME HARD SEAMS
102	103	GRAY SANDSTONE W/ PYRITE
103	107	RED AND GRAY SHALE / DRILLED W/ RUSTY MUD COLOR
107	122	RUSTY BROWN SANDSTONE
122	179.5	GRAY / DARK GRAY AND BROWN SANDSTONE WATER ENCOUNTERED AT BOTTOM OFSECTION
179.5	181	BLACK SHALE / SOME WATER

181	212	DARK GRAY AND MUDDY GRAY SHALE

Driller Certification

All work performed and reported in this well log is in compliance with the Montana well construction standards. This report is true to the best of my knowledge.

Name:	PAT BYRNE
Company:	PAT BYRNE DRILLING INC
License No:	WWC-318
Date Completed:	3/1/2008

STATE OF MONTANA
DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
1424 9TH AVENUE P.O.BOX 201601 HELENA, MONTANA 59620-1601

GENERAL ABSTRACT

Water Right Number: 41QJ 213044 00 STATEMENT OF CLAIM
Version: -- POST DECREE
Version Status: ACTIVE
Late Claim: B

Owners: SAND COULEE WATER DISTRICT
PO BOX 97
SAND COULEE, MT 59472 0097

Priority Date: July 5, 1960
Enforceable Priority Date: June 30, 1973

Type of Historical Right: FILED

CLAIM FILED LATE 12/20/88 . AS MANDATED BY SECTION 85-2-221(3), MCA, THIS CLAIM IS SUBORDINATE, AND THEREFORE JUNIOR, TO ALL INDIAN AND FEDERAL RESERVED WATER RIGHTS AND ALL VALID TIMELY FILED CLAIMS BASED ON STATE LAW.

Purpose (use): MUNICIPAL

Maximum Flow Rate: 32 GPM

Maximum Volume: 45.15 AC-FT

Source Name: GROUNDWATER
Source Type: GROUNDWATER

Points of Diversion and Means of Diversion:

ID	Govt Lot	Qtr Sec	Sec	Twp	Rge	County
1		SENESE	14	19N	4E	CASCADE

Period of Diversion: JANUARY 1 to DECEMBER 31
Diversion Means: WELL

Period of Use: JANUARY 1 TO DECEMBER 31

Purpose (use): MUNICIPAL
Place of Use: (1 total records)

ID	Acres	Govt Lot	Qtr Sec	Sec	Twp	Rge	County
1			SENESE	14	19N	4E	CASCADE

Geocodes/Valid:

Remarks:
STARTING IN 2008, PERIOD OF DIVERSION WAS ADDED TO MOST CLAIM ABSTRACTS, INCLUDING THIS ONE.

OWNERSHIP UPDATE RECEIVED
OWNERSHIP UPDATE TYPE 608 # 80290 RECEIVED September 8, 2010

STATE OF MONTANA

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

1424 9TH AVENUE P.O.BOX 201601 HELENA, MONTANA 59620-1601

GENERAL ABSTRACT

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PO BOX 97
SAND COULEE, MT 59472 0097

Priority Date: July 5, 1960

Enforceable Priority Date: June 30, 1973

Type of Historical Right: FILED

CLAIM FILED LATE 12/20/88 . AS MANDATED BY SECTION 85-2-221(3), MCA, THIS CLAIM IS SUBORDINATE, AND THEREFORE JUNIOR, TO ALL INDIAN AND FEDERAL RESERVED WATER RIGHTS AND ALL VALID TIMELY FILED CLAIMS BASED ON STATE LAW.

Purpose (use): MUNICIPAL

Maximum Flow Rate: 32 GPM

Maximum Volume: 45.15 AC-FT

Source Name: GROUNDWATER

Source Type: GROUNDWATER

Points of Diversion and Means of Diversion:

ID	Govt Lot	Qtr Sec	Sec	Twp	Rge	County
1		SENESE	14	19N	4E	CASCADE

Period of Diversion: JANUARY 1 to DECEMBER 31

Diversion Means: WELL

Period of Use: JANUARY 1 TO DECEMBER 31

Purpose (use): MUNICIPAL

Place of Use: (1 total records)

ID	Acres	Govt Lot	Qtr Sec	Sec	Twp	Rge	County
1			SENESE	14	19N	4E	CASCADE

Geocodes/Valid:

Remarks:

STARTING IN 2008, PERIOD OF DIVERSION WAS ADDED TO MOST CLAIM ABSTRACTS, INCLUDING THIS ONE.

OWNERSHIP UPDATE RECEIVED

OWNERSHIP UPDATE TYPE 608 # 80290 RECEIVED September 8, 2010

STATE OF MONTANA

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

1424 9TH AVENUE P.O.BOX 201601 HELENA, MONTANA 59620-1601

GENERAL ABSTRACT

Water Right Number: 41QJ 5056 00 STATEMENT OF CLAIM
Version: -- POST DECREE
Version Status: ACTIVE

Owners: SAND COULEE WATER DISTRICT
PO BOX 97
SAND COULEE, MT 59472 0097

Priority Date: December 31, 1918
Enforceable Priority Date: December 31, 1918

Type of Historical Right: USE

Purpose (use): MULTIPLE DOMESTIC

Maximum Flow Rate: 35 GPM

Maximum Volume: 3.00 AC-FT
Households: 2

Maximum Acres: 0.50

Source Name: WELL
Source Type: GROUNDWATER

Points of Diversion and Means of Diversion:

ID	Govt Lot	Qtr Sec	Sec	Twp	Rge	County
1		SENESE	14	19N	4E	CASCADE

Period of Diversion: JANUARY 1 to DECEMBER 31
Diversion Means: WELL

Period of Use: JANUARY 1 TO DECEMBER 31

Purpose (use): MULTIPLE DOMESTIC
Place of Use: (1 total records)

ID	Acres	Govt Lot	Qtr Sec	Sec	Twp	Rge	County
1	0.50		SENESE	14	19N	4E	CASCADE
Total:	0.50						

Geocodes/Valid:

Remarks:

THE WATER RIGHTS LISTED FOLLOWING THIS STATEMENT ARE MULTIPLE USES OF THE SAME RIGHT. THE USE OF THIS RIGHT FOR SEVERAL PURPOSES DOES NOT INCREASE THE EXTENT OF THE WATER RIGHT. RATHER IT DECREES THE RIGHT TO ALTERNATE AND EXCHANGE THE USE (PURPOSE) OF THE WATER IN ACCORD WITH HISTORICAL PRACTICES.
5056-00 5057-00

STARTING IN 2008, PERIOD OF DIVERSION WAS ADDED TO MOST CLAIM ABSTRACTS, INCLUDING THIS ONE.

STATE OF MONTANA

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

1424 9TH AVENUE P.O.BOX 201601 HELENA, MONTANA 59620-1601

GENERAL ABSTRACT

Water Right Number: 41QJ 5058 00 STATEMENT OF CLAIM
Version: -- POST DECREE
Version Status: ACTIVE

Owners: SAND COULEE WATER DISTRICT
PO BOX 97
SAND COULEE, MT 59472 0097

Priority Date: December 31, 1959
Enforceable Priority Date: December 31, 1959

Type of Historical Right: USE

Purpose (use): MUNICIPAL

Maximum Flow Rate: 32 GPM

Maximum Volume: 83.00 AC-FT

Source Name: GROUNDWATER
Source Type: GROUNDWATER

Points of Diversion and Means of Diversion:

ID	Govt Lot	Qtr Sec	Sec	Twp	Rge	County
1		SWNESE	13	19N	4E	CASCADE

Period of Diversion: JANUARY 1 to DECEMBER 31
Diversion Means: WELL

Period of Use: JANUARY 1 TO DECEMBER 31

Purpose (use): MUNICIPAL
Place of Use: (1 total records)

ID	Acres	Govt Lot	Qtr Sec	Sec	Twp	Rge	County
1			SENESE	13	19N	4E	CASCADE

Geocodes/Valid:

Remarks:

STARTING IN 2008, PERIOD OF DIVERSION WAS ADDED TO MOST CLAIM ABSTRACTS, INCLUDING THIS ONE.

WHENEVER THE WATER RIGHTS FOLLOWING THIS STATEMENT ARE COMBINED TO SUPPLY WATER FOR THE CLAIMED PURPOSE, EACH IS LIMITED TO THE HISTORICAL FLOW RATE AND PLACE OF USE OF THAT INDIVIDUAL RIGHT. THE SUM TOTAL VOLUME OF THESE WATER RIGHTS SHALL NOT EXCEED THE AMOUNT PUT TO HISTORICAL AND BENEFICIAL USE. 5058-00, 5057-00.

OWNERSHIP UPDATE RECEIVED

OWNERSHIP UPDATE TYPE 608 # 63723 RECEIVED October 28, 2008

OWNERSHIP UPDATE TYPE 608 # 80290 RECEIVED September 8, 2010

STATE OF MONTANA

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

1424 9TH AVENUE P.O.BOX 201601 HELENA, MONTANA 59620-1601

GENERAL ABSTRACT

Water Right Number: 41QJ 5058 00 STATEMENT OF CLAIM

Version: -- POST DECREE

Version Status: ACTIVE

Owners: SAND COULEE WATER DISTRICT
PO BOX 97
SAND COULEE, MT 59472 0097

Priority Date: December 31, 1959

Enforceable Priority Date: December 31, 1959

Type of Historical Right: USE

Purpose (use): MUNICIPAL

Maximum Flow Rate: 32 GPM

Maximum Volume: 83.00 AC-FT

Source Name: GROUNDWATER

Source Type: GROUNDWATER

Points of Diversion and Means of Diversion:

ID	Govt Lot	Qtr Sec	Sec	Twp	Rge	County
1		SWNESE	13	19N	4E	CASCADE

Period of Diversion: JANUARY 1 to DECEMBER 31

Diversion Means: WELL

Period of Use: JANUARY 1 TO DECEMBER 31

Purpose (use): MUNICIPAL

Place of Use: (1 total records)

ID	Acres	Govt Lot	Qtr Sec	Sec	Twp	Rge	County
1			SENESE	13	19N	4E	CASCADE

Geocodes/Valid:

Remarks:

STARTING IN 2008, PERIOD OF DIVERSION WAS ADDED TO MOST CLAIM ABSTRACTS, INCLUDING THIS ONE.

WHENEVER THE WATER RIGHTS FOLLOWING THIS STATEMENT ARE COMBINED TO SUPPLY WATER FOR THE CLAIMED PURPOSE, EACH IS LIMITED TO THE HISTORICAL FLOW RATE AND PLACE OF USE OF THAT INDIVIDUAL RIGHT. THE SUM TOTAL VOLUME OF THESE WATER RIGHTS SHALL NOT EXCEED THE AMOUNT PUT TO HISTORICAL AND BENEFICIAL USE. 5058-00, 5057-00.

OWNERSHIP UPDATE RECEIVED

OWNERSHIP UPDATE TYPE 608 # 63723 RECEIVED October 28, 2008

OWNERSHIP UPDATE TYPE 608 # 80290 RECEIVED September 8, 2010

STATE OF MONTANA

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

1424 9TH AVENUE P.O.BOX 201601 HELENA, MONTANA 59620-1601

GENERAL ABSTRACT

Water Right Number: 41QJ 6174 00 GROUND WATER CERTIFICATE
Version: -- ORIGINAL RIGHT
Version Status: ACTIVE

Owners: SAND COULEE WATER DISTRICT
PO BOX 97
SAND COULEE, MT 59472 0097

Priority Date: August 1, 1975 at 13:00 PM
Enforceable Priority Date: August 1, 1975 at 13:00 PM

Purpose (use): MUNICIPAL

Maximum Flow Rate: 60 GPM

Maximum Volume: THIS RIGHT IS LIMITED TO THE ACTUAL AMOUNT USED UP TO 10 ACRE-FEET

Source Name: GROUNDWATER
Source Type: GROUNDWATER

Points of Diversion and Means of Diversion:

ID	Govt Lot	Qtr Sec	Sec	Twp	Rge	County
1		E2SE	14	19N	4E	CASCADE

Period of Diversion: JANUARY 1 to DECEMBER 31
Diversion Means: WELL
Well Depth: 210 FEET
Static Water Level: 150 FEET
Pump Size: 5

Purpose (use): MUNICIPAL
Period of Use: JANUARY 1 TO DECEMBER 31

Place of Use: (1 total records)

ID	Acres	Govt Lot	Qtr Sec	Sec	Twp	Rge	County
1			E2SE	14	19N	4E	CASCADE

Geocodes/Valid:

Remarks:

OWNERSHIP UPDATE RECEIVED
OWNERSHIP UPDATE TYPE 608 # 80290 RECEIVED September 8, 2010

APPENDIX B

LABORATORY ANALYTICAL REPORTS

ANALYTICAL SUMMARY REPORT

August 06, 2010

Hydrometrics Inc
3020 Bozeman Ave
Helena, MT 59601

Workorder No.: H10070205

Project Name: 10039 Sand Coulee

Energy Laboratories Inc received the following 1 sample for Hydrometrics Inc on 7/14/2010 for analysis.

Sample ID	Client Sample ID	Collect Date	Receive Date	Matrix	Test
H10070205-001	Well 3	07/12/10 14:40	07/14/10	Drinking Water	Metals by ICP/ICPMS, Dissolved Metals by ICP/ICPMS, Drinking Water Alkalinity Anion - Cation Balance Conductivity Hardness as CaCO3 Anions by Ion Chromatography Nitrogen, Nitrate + Nitrite pH Metals Digestion by EPA 200.2 Preparation for TDS Solids, Total Dissolved

This report was prepared by Energy Laboratories, Inc., 3161 E. Lyndale Ave., Helena, MT 59604. Any exceptions or problems with the analyses are noted in the Laboratory Analytical Report, the QA/QC Summary Report, or the Case Narrative.

The results as reported relate only to the item(s) submitted for testing.

If you have any questions regarding these test results, please call.

Report Approved By: Wanda Johnson
Login Supervisor

Digitally signed by
Wanda Johnson
Date: 2010.08.06 10:04:57 -06:00

CLIENT: Hydrometrics Inc
Project: 10039 Sand Coulee
Sample Delivery Group: H10070205

Report Date: 08/06/10

CASE NARRATIVE

DOMESTIC WATER ANALYSIS EXPLANATIONS:
Alkalinity-is a measure of the water's capacity to neutralize acid. Water with a high alkalinity (above 300 mg/L), when boiled for an extended period of time, may form a deposit or develop an unpleasant taste. Water with a very low alkalinity (below 30 mg/L) corrodes pipes and plumbing.

Bicarbonate- is a buffer ion in water, derived from carbonate rocks and atmospheric CO2. Water with pH 7.8 will be 60-90% buffered by bicarbonate. If water is heated, bicarbonate can combine with calcium or magnesium to form scale which can clog pipes and precipitate in sinks and laundry.

Calcium-is an essential human nutrient for bones and teeth. Excessive calcium with magnesium produces hard water, which causes taste problems, scale in pipes, tubs, and sinks and excessive soap consumption. Water softeners remove calcium but replace it with sodium, which may be harmful to people on low sodium diets.

Carbonate-along with bicarbonate, this ion accounts for the buffering capacity of waters with a pH greater than 9. It is most often present as salts (CaCO3, MgCO3) which precipitate at a high pH.

Chloride-less than 250 mg/L is recommended to prevent unpleasant taste. The normal range for drinking water is 5-20 mg/L. High values may be an early indicator of contamination. Chloride also makes water more corrosive towards the distribution system.

Conductivity (Specific Conductance)- a measure of the water's ability to conduct an electrical current, it increases as the amount of dissolved minerals increase. Conductivity is used as a check on the total dissolved solids in the water.

Hardness-caused mainly by calcium and magnesium, it produces incrustation on pipes, kitchen utensils, and tubs as well as excessive soap consumption. Upon heating, hard water may form scale deposits, alternately, soft water may result in a corrosion of water pipes. In general, 80-100 mg/L is considered acceptable, 200–500 mg/L is considered tolerable, and greater than 500 mg/L is considered unacceptable.

Iron- the level of 0.3 mg/L is a general guideline based on aesthetics and taste. It is an essential human nutrient; however, at levels greater than 0.3 mg/L, it stains laundry and plumbing fixtures, and causes undesirable taste in beverages. When exposed to air, iron precipitates causing a reddish-brown color.

Magnesium-is an essential human nutrient for the heart and nervous system. Greater than 50 mg/L may have a laxative effect on first time users. Guidelines are often based on aesthetics (taste). Along with calcium, magnesium contributes to water hardness.

Nitrate + nitrite as N- 10 mg/L maximum contaminant level. Acutely toxic in infants under 6 months of age, nitrate produces a blood disorder called methemoglobinemia (blue baby syndrome), which limits the amount of oxygen the bloodstream can carry.

pH- is an aesthetic parameter. Low pH may cause corrosion of water pipes-while high pH may cause incrustation of pipes.

Potassium-is an essential human nutrient. It is necessary for nerve impulses. Moderate concentrations are acceptable, but greater than 2000 mg/L may be harmful to nervous and digestive systems.

Sodium-is an essential human nutrient necessary for nerve impulses. If a water softener is used to remove hardness, calcium is replaced by sodium. People on low sodium diets using water softeners should have the sodium level of their water checked and consult a physician. Less than 20 mg/L is ideal.

Sulfate-is recommended to be below 500 mg/L for health and aesthetic reasons. The major physiological effects when exceeded are catharsis (laxative effect) and gastrointestinal irritation. Sulfate may produce noticeable taste.

Total dissolved solids- represents the dissolved minerals in water. High values- above 1500 mg/l – may cause taste, corrosion, scaling and a laxative effect.

LABORATORY ANALYTICAL REPORT

Client:	Hydrometrics Inc	**Report Date:**	08/06/10
Project:	10039 Sand Coulee	**Collection Date:**	07/12/10 14:40
Lab ID:	H10070205-001	**DateReceived:**	07/14/10
Client Sample ID	Well 3	**Matrix:**	Drinking Water

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.2	s.u.		0.1		A4500-H B	07/14/10 16:56 / zeg
Conductivity	912	umhos/cm		1		A2510 B	07/15/10 16:16 / zeg
Solids, Total Dissolved TDS @ 180 C	536	mg/L		10		A2540 C	07/16/10 16:25 / zeg
INORGANICS							
A/C Balance (± 5)	-2.67	%		0.01		A1030 E	07/28/10 15:20 / hm
Alkalinity, Total as CaCO3	370	mg/L		4		A2320 B	07/16/10 13:28 / zeg
Bicarbonate as HCO3	450	mg/L		4		A2320 B	07/16/10 13:28 / zeg
Carbonate as CO3	ND	mg/L		4		A2320 B	07/16/10 13:28 / zeg
Chloride	11	mg/L		1		E300.0	07/17/10 18:23 / hm
Sulfate	120	mg/L	D	2		E300.0	07/17/10 18:23 / hm
Hardness as CaCO3	455	mg/L		1		A2340 B	07/29/10 15:04 / sld
NUTRIENTS							
Nitrogen, Nitrate+Nitrite as N	4.43	mg/L		0.05	10	E353.2	07/19/10 12:24 / stp
METALS, DISSOLVED							
Aluminum	ND	mg/L		0.1		E200.8	07/28/10 16:41 / dck
Arsenic	ND	mg/L		0.005		E200.8	07/28/10 16:41 / dck
Cadmium	ND	mg/L		0.001		E200.8	07/28/10 16:41 / dck
Calcium	57	mg/L		1		E200.7	07/20/10 15:34 / sld
Copper	ND	mg/L		0.01		E200.8	07/28/10 16:41 / dck
Iron	0.16	mg/L		0.03		E200.7	07/20/10 15:34 / sld
Lead	ND	mg/L		0.01		E200.8	07/28/10 16:41 / dck
Magnesium	76	mg/L		1		E200.7	07/20/10 15:34 / sld
Manganese	0.09	mg/L		0.01		E200.8	07/28/10 16:41 / dck
Potassium	4	mg/L		1		E200.7	07/20/10 15:34 / sld
Sodium	21	mg/L		1		E200.7	07/20/10 15:34 / sld
Zinc	0.04	mg/L		0.01		E200.8	07/28/10 16:41 / dck
METALS, TOTAL (CONTRACT LAB MT00945)							
Iron	0.20	mg/L		0.03		E200.7	07/28/10 17:03 / sld

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
D - RL increased due to sample matrix.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

QA/QC Summary Report

Client: Hydrometrics Inc
Project: 10039 Sand Coulee

Report Date: 08/06/10
Work Order: H10070205

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: A2320 B										Batch: 100716A-ALK-W
Sample ID: MBLK1_100716A	Method Blank					Run: TITTR_100716A				07/16/10 11:43
Alkalinity, Total as CaCO3		2	mg/L	0.9						
Sample ID: LCS1_100716A	Laboratory Control Sample					Run: TITTR_100716A				07/16/10 11:51
Alkalinity, Total as CaCO3		620	mg/L	4.0	102	90	110			
Sample ID: H10070185-002AMS	Sample Matrix Spike					Run: TITTR_100716A				07/16/10 12:43
Alkalinity, Total as CaCO3		720	mg/L	4.0	96	90	110			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Client: Hydrometrics Inc **Report Date:** 08/06/10
Project: 10039 Sand Coulee **Work Order:** H10070205

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: A2510 B								Analytical Run: COND_100715A		
Sample ID: ICV_100715A		Initial Calibration Verification Standard							07/15/10 16:11	
Conductivity		1000	umhos/cm	1.0	101	90	110			
Method: A2510 B								Batch: 100715A-COND-PROBE-W		
Sample ID: LCS2_100715A		Laboratory Control Sample				Run: COND_100715A			07/15/10 16:12	
Conductivity		1410	umhos/cm	1.0	100	90	110			
Sample ID: H10070205-001ADUP		Sample Duplicate				Run: COND_100715A			07/15/10 16:19	
Conductivity		912	umhos/cm	1.0				0.1	10	

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Client: Hydrometrics Inc
Project: 10039 Sand Coulee

Report Date: 08/06/10
Work Order: H10070205

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: A2540 C										Batch: 9257
Sample ID: MB-9257		Method Blank				Run: ACCU-124 (14410200)_100716				07/16/10 16:24
Solids, Total Dissolved TDS @ 180 C		4	mg/L	1						
Sample ID: LCS-9257		Laboratory Control Sample				Run: ACCU-124 (14410200)_100716				07/16/10 16:25
Solids, Total Dissolved TDS @ 180 C		1000	mg/L	10	100	90	110			
Sample ID: H10070247-002ADUP		Sample Duplicate				Run: ACCU-124 (14410200)_100716				07/16/10 16:27
Solids, Total Dissolved TDS @ 180 C		130	mg/L	10					5	
Sample ID: H10070247-005AMS		Sample Matrix Spike				Run: ACCU-124 (14410200)_100716				07/16/10 16:29
Solids, Total Dissolved TDS @ 180 C		1060	mg/L	10	93	80	120			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Client: Hydrometrics Inc **Report Date:** 08/06/10
Project: 10039 Sand Coulee **Work Order:** H10070205

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: A4500-H B									Batch: 100714A-PH-W	
Sample ID: ICV1_100714A		Laboratory Control Sample				Run: PH_100714B			07/14/10 16:55	
pH		7.00	s.u.	0.10	100	99	101			
Sample ID: H10070205-001ADUP		Sample Duplicate				Run: PH_100714B			07/14/10 16:57	
pH		7.16	s.u.	0.10				0.1	2	

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Client: Hydrometrics Inc **Report Date:** 08/06/10
Project: 10039 Sand Coulee **Work Order:** H10070205

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E200.7										Analytical Run: ICP1-HE_100720A
Sample ID: ICV	5	Initial Calibration Verification Standard								07/20/10 12:51
Calcium		38.1	mg/L	1.0	95	95	105			
Iron		4.04	mg/L	0.030	101	95	105			
Magnesium		40.1	mg/L	1.0	100	95	105			
Potassium		38.4	mg/L	1.0	96	95	105			
Sodium		41.8	mg/L	1.0	104	95	105			
Sample ID: ICSA	5	Interference Check Sample A								07/20/10 13:22
Calcium		463	mg/L	1.0	93	80	120			
Iron		190	mg/L	0.030	95	80	120			
Magnesium		534	mg/L	1.0	107	80	120			
Potassium		0.0149	mg/L	1.0		0	0			
Sodium		0.0334	mg/L	1.0		0	0			
Sample ID: ICSAB	5	Interference Check Sample AB								07/20/10 13:25
Calcium		505	mg/L	1.0	101	80	120			
Iron		189	mg/L	0.030	94	80	120			
Magnesium		555	mg/L	1.0	111	80	120			
Potassium		21.2	mg/L	1.0	106	80	120			
Sodium		21.9	mg/L	1.0	109	80	120			
Sample ID: CCV	5	Continuing Calibration Verification Standard								07/20/10 15:18
Calcium		24.7	mg/L	1.0	99	90	110			
Iron		2.46	mg/L	0.030	98	90	110			
Magnesium		23.4	mg/L	1.0	93	90	110			
Potassium		25.2	mg/L	1.0	101	90	110			
Sodium		26.0	mg/L	1.0	104	90	110			
Sample ID: ICSA	5	Interference Check Sample A								07/20/10 17:28
Calcium		458	mg/L	1.0	92	80	120			
Iron		176	mg/L	0.030	88	80	120			
Magnesium		513	mg/L	1.0	103	80	120			
Potassium		0.0164	mg/L	1.0		0	0			
Sodium		0.0327	mg/L	1.0		0	0			
Sample ID: ICSAB	5	Interference Check Sample AB								07/20/10 17:31
Calcium		487	mg/L	1.0	97	80	120			
Iron		181	mg/L	0.030	90	80	120			
Magnesium		534	mg/L	1.0	107	80	120			
Potassium		20.5	mg/L	1.0	102	80	120			
Sodium		20.9	mg/L	1.0	104	80	120			
Method: E200.7										Batch: R63848
Sample ID: ICB	5	Method Blank				Run: ICP1-HE_100720A				07/20/10 13:35
Calcium		ND	mg/L	0.1						
Iron		ND	mg/L	0.002						
Magnesium		ND	mg/L	0.02						

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Client: Hydrometrics Inc **Report Date:** 08/06/10
Project: 10039 Sand Coulee **Work Order:** H10070205

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E200.7										Batch: R63848
Sample ID: ICB	5	Method Blank				Run: ICP1-HE_100720A				07/20/10 13:35
Potassium		ND	mg/L	0.04						
Sodium		ND	mg/L	0.1						
Sample ID: LFB	5	Laboratory Fortified Blank				Run: ICP1-HE_100720A				07/20/10 13:38
Calcium		9.27	mg/L	1.0	93	85	115			
Iron		0.990	mg/L	0.030	99	85	115			
Magnesium		9.88	mg/L	1.0	99	85	115			
Potassium		10.3	mg/L	1.0	103	85	115			
Sodium		10.3	mg/L	1.0	103	85	115			
Sample ID: LFB	5	Laboratory Fortified Blank				Run: ICP1-HE_100720A				07/20/10 14:57
Calcium		9.54	mg/L	1.0	95	85	115			
Iron		0.977	mg/L	0.030	98	85	115			
Magnesium		9.65	mg/L	1.0	97	85	115			
Potassium		10.2	mg/L	1.0	102	85	115			
Sodium		10.0	mg/L	1.0	100	85	115			
Sample ID: H10070133-004BMS2	5	Sample Matrix Spike				Run: ICP1-HE_100720A				07/20/10 15:12
Calcium		50.5	mg/L	1.0	103	70	130			
Iron		1.90	mg/L	0.040	95	70	130			
Magnesium		26.0	mg/L	1.0	95	70	130			
Potassium		22.3	mg/L	1.0	98	70	130			
Sodium		32.4	mg/L	1.0	95	70	130			
Sample ID: H10070133-004BMSD2	5	Sample Matrix Spike Duplicate				Run: ICP1-HE_100720A				07/20/10 15:15
Calcium		53.0	mg/L	1.0	115	70	130	4.8	20	
Iron		2.06	mg/L	0.040	103	70	130	7.8	20	
Magnesium		27.7	mg/L	1.0	103	70	130	6.2	20	
Potassium		22.0	mg/L	1.0	96	70	130	1.4	20	
Sodium		31.5	mg/L	1.0	91	70	130	2.8	20	
Sample ID: LFB	5	Laboratory Fortified Blank				Run: ICP1-HE_100720A				07/20/10 16:42
Calcium		9.15	mg/L	1.0	92	85	115			
Iron		0.936	mg/L	0.030	94	85	115			
Magnesium		9.39	mg/L	1.0	94	85	115			
Potassium		10.2	mg/L	1.0	102	85	115			
Sodium		9.94	mg/L	1.0	99	85	115			

Qualifiers:

RL - Analyte reporting limit. ND - Not detected at the reporting limit.

QA/QC Summary Report

Client: Hydrometrics Inc **Report Date:** 08/06/10
Project: 10039 Sand Coulee **Work Order:** H10070205

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E200.7										Analytical Run: ICP1-HE_100728C
Sample ID: ICV		Initial Calibration Verification Standard								07/28/10 13:56
Iron		3.88	mg/L	0.030	97	95	105			
Sample ID: ICSA		Interference Check Sample A								07/28/10 14:11
Iron		187	mg/L	0.030	93	80	120			
Sample ID: ICSAB		Interference Check Sample AB								07/28/10 14:14
Iron		197	mg/L	0.030	99	80	120			
Sample ID: CCV		Continuing Calibration Verification Standard								07/28/10 16:48
Iron		2.48	mg/L	0.030	99	90	110			
Sample ID: ICSA		Interference Check Sample A								07/28/10 19:50
Iron		195	mg/L	0.030	98	80	120			
Sample ID: ICSAB		Interference Check Sample AB								07/28/10 19:53
Iron		194	mg/L	0.030	97	80	120			

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E200.7										Batch: R64070
Sample ID: ICB		Method Blank				Run: ICP1-HE_100728C				07/28/10 16:57
Iron		ND	mg/L	0.002						
Sample ID: LFB		Laboratory Fortified Blank				Run: ICP1-HE_100728C				07/28/10 17:00
Iron		1.01	mg/L	0.030	101	85	115			
Sample ID: H10070205-001CMS2		Sample Matrix Spike				Run: ICP1-HE_100728C				07/28/10 17:07
Iron		2.36	mg/L	0.040	108	70	130			
Sample ID: H10070205-001CMSD2		Sample Matrix Spike Duplicate				Run: ICP1-HE_100728C				07/28/10 17:10
Iron		2.22	mg/L	0.040	101	70	130	6.1	20	
Sample ID: LFB		Laboratory Fortified Blank				Run: ICP1-HE_100728C				07/28/10 18:45
Iron		0.991	mg/L	0.030	99	85	115			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Client: Hydrometrics Inc **Report Date:** 08/06/10
Project: 10039 Sand Coulee **Work Order:** H10070205

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E200.8										Analytical Run: ICPMS204-B_100728A
Sample ID: ICV STD	7	Initial Calibration Verification Standard								07/28/10 14:36
Aluminum		0.248	mg/L	0.10	99	90	110			
Arsenic		0.0492	mg/L	0.0050	98	90	110			
Cadmium		0.0255	mg/L	0.0010	102	90	110			
Copper		0.0508	mg/L	0.010	102	90	110			
Lead		0.0467	mg/L	0.010	93	90	110			
Manganese		0.242	mg/L	0.010	97	90	110			
Zinc		0.0504	mg/L	0.010	101	90	110			
Sample ID: ICSA	7	Interference Check Sample A								07/28/10 14:43
Aluminum		44.5	mg/L	0.10	111	70	130			
Arsenic		0.000166	mg/L	0.0050						
Cadmium		0.000473	mg/L	0.0010						
Copper		0.00163	mg/L	0.010						
Lead		0.000100	mg/L	0.010						
Manganese		0.00261	mg/L	0.010						
Zinc		0.00141	mg/L	0.010						
Sample ID: ICSAB	7	Interference Check Sample AB								07/28/10 14:49
Aluminum		44.7	mg/L	0.10	112	70	130			
Arsenic		0.0116	mg/L	0.0050	116	70	130			
Cadmium		0.0116	mg/L	0.0010	116	70	130			
Copper		0.0243	mg/L	0.010	122	70	130			
Lead		8.90E-05	mg/L	0.010		0	0			
Manganese		0.0255	mg/L	0.010	127	70	130			
Zinc		0.0125	mg/L	0.010	125	70	130			
Sample ID: ICV STD	7	Initial Calibration Verification Standard								07/28/10 15:10
Aluminum		0.268	mg/L	0.10	107	90	110			
Arsenic		0.0524	mg/L	0.0050	105	90	110			
Cadmium		0.0275	mg/L	0.0010	110	90	110			
Copper		0.0543	mg/L	0.010	109	90	110			
Lead		0.0495	mg/L	0.010	99	90	110			
Manganese		0.260	mg/L	0.010	104	90	110			
Zinc		0.0543	mg/L	0.010	109	90	110			
Sample ID: ICSA	7	Interference Check Sample A								07/28/10 15:16
Aluminum		44.3	mg/L	0.10	111	70	130			
Arsenic		0.000167	mg/L	0.0050						
Cadmium		0.000407	mg/L	0.0010						
Copper		0.00141	mg/L	0.010						
Lead		9.70E-05	mg/L	0.010						
Manganese		0.00271	mg/L	0.010						
Zinc		0.00142	mg/L	0.010						
Sample ID: ICSAB	7	Interference Check Sample AB								07/28/10 15:40
Aluminum		45.5	mg/L	0.10	114	70	130			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Client: Hydrometrics Inc **Report Date:** 08/06/10
Project: 10039 Sand Coulee **Work Order:** H10070205

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E200.8										Analytical Run: ICPMS204-B_100728A
Sample ID: ICSAB	7	Interference Check Sample AB								07/28/10 15:40
Arsenic		0.0118	mg/L	0.0050	118	70	130			
Cadmium		0.0117	mg/L	0.0010	117	70	130			
Copper		0.0239	mg/L	0.010	119	70	130			
Lead		8.20E-05	mg/L	0.010		0	0			
Manganese		0.0259	mg/L	0.010	130	70	130			
Zinc		0.0126	mg/L	0.010	126	70	130			
Sample ID: ICV STD	7	Initial Calibration Verification Standard								07/28/10 20:08
Aluminum		0.261	mg/L	0.10	104	90	110			
Arsenic		0.0501	mg/L	0.0050	100	90	110			
Cadmium		0.0262	mg/L	0.0010	105	90	110			
Copper		0.0503	mg/L	0.010	101	90	110			
Lead		0.0475	mg/L	0.010	95	90	110			
Manganese		0.251	mg/L	0.010	100	90	110			
Zinc		0.0498	mg/L	0.010	100	90	110			
Sample ID: ICSA	7	Interference Check Sample A								07/29/10 10:09
Aluminum		45.0	mg/L	0.10	112	70	130			
Arsenic		0.000152	mg/L	0.0050						
Cadmium		0.000370	mg/L	0.0010						
Copper		0.00145	mg/L	0.010						
Lead		9.90E-05	mg/L	0.010						
Manganese		0.00240	mg/L	0.010						
Zinc		0.00164	mg/L	0.010						
Sample ID: ICSAB	7	Interference Check Sample AB								07/29/10 10:16
Aluminum		45.1	mg/L	0.10	113	70	130			
Arsenic		0.0117	mg/L	0.0050	117	70	130			
Cadmium		0.0116	mg/L	0.0010	116	70	130			
Copper		0.0235	mg/L	0.010	117	70	130			
Lead		9.50E-05	mg/L	0.010		0	0			
Manganese		0.0255	mg/L	0.010	128	70	130			
Zinc		0.0121	mg/L	0.010	121	70	130			
Method: E200.8										Batch: R64068
Sample ID: ICB	7	Method Blank				Run: ICPMS204-B_100728A				07/28/10 16:21
Aluminum		ND	mg/L	0.0002						
Arsenic		ND	mg/L	3E-05						
Cadmium		ND	mg/L	1E-05						
Copper		ND	mg/L	3E-05						
Lead		ND	mg/L	1E-05						
Manganese		0.0002	mg/L	2E-05						
Zinc		ND	mg/L	0.0006						
Sample ID: LFB	7	Laboratory Fortified Blank				Run: ICPMS204-B_100728A				07/28/10 16:28
Aluminum		0.0503	mg/L	0.10	101	85	115			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Client: Hydrometrics Inc **Report Date:** 08/06/10
Project: 10039 Sand Coulee **Work Order:** H10070205

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E200.8									Batch: R64068	
Sample ID: LFB	7	Laboratory Fortified Blank				Run: ICPMS204-B_100728A			07/28/10 16:28	
Arsenic		0.0505	mg/L	0.0050	101	85	115			
Cadmium		0.0504	mg/L	0.0010	101	85	115			
Copper		0.0494	mg/L	0.010	99	85	115			
Lead		0.0506	mg/L	0.010	101	85	115			
Manganese		0.0512	mg/L	0.010	102	85	115			
Zinc		0.0522	mg/L	0.010	104	85	115			
Sample ID: H10070205-001BMS	7	Sample Matrix Spike				Run: ICPMS204-B_100728A			07/28/10 16:48	
Aluminum		0.134	mg/L	0.10	100	70	130			
Arsenic		0.0510	mg/L	0.0050	101	70	130			
Cadmium		0.0504	mg/L	0.0010	100	70	130			
Copper		0.0495	mg/L	0.010	97	70	130			
Lead		0.0510	mg/L	0.010	102	70	130			
Manganese		0.136	mg/L	0.010	100	70	130			
Zinc		0.0920	mg/L	0.010	94	70	130			
Sample ID: H10070205-001BMSD	7	Sample Matrix Spike Duplicate				Run: ICPMS204-B_100728A			07/28/10 16:54	
Aluminum		0.135	mg/L	0.10	102	70	130	0.7	20	
Arsenic		0.0506	mg/L	0.0050	101	70	130	0.8	20	
Cadmium		0.0503	mg/L	0.0010	100	70	130	0	20	
Copper		0.0494	mg/L	0.010	97	70	130	0.3	20	
Lead		0.0505	mg/L	0.010	101	70	130	0.9	20	
Manganese		0.136	mg/L	0.010	101	70	130	0.4	20	
Zinc		0.0912	mg/L	0.010	93	70	130	0.9	20	

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Client: Hydrometrics Inc
Project: 10039 Sand Coulee

Report Date: 08/06/10
Work Order: H10070205

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E300.0							Analytical Run: IC101-H_100716A			
Sample ID: ICV071610-12	2	Initial Calibration Verification Standard							07/16/10 18:49	
Chloride		12	mg/L	1.0	97	90	110			
Sulfate		51	mg/L	1.0	102	90	110			
Sample ID: CCV071610-86	2	Continuing Calibration Verification Standard							07/17/10 17:00	
Chloride		24	mg/L	1.0	96	90	110			
Sulfate		50	mg/L	1.0	100	90	110			
Method: E300.0									Batch: R63760	
Sample ID: ICB071610-13	2	Method Blank				Run: IC101-H_100716A			07/16/10 19:05	
Chloride		ND	mg/L	0.5						
Sulfate		ND	mg/L	1						
Sample ID: LFB071610-14	2	Laboratory Fortified Blank				Run: IC101-H_100716A			07/16/10 19:21	
Chloride		24	mg/L	1.0	96	90	110			
Sulfate		50	mg/L	1.2	99	90	110			
Sample ID: H10070214-002AMS	2	Sample Matrix Spike				Run: IC101-H_100716A			07/17/10 19:12	
Chloride		29	mg/L	1.0	97	90	110			
Sulfate		280	mg/L	1.2		90	110			A
Sample ID: H10070214-002AMSD	2	Sample Matrix Spike Duplicate				Run: IC101-H_100716A			07/17/10 19:28	
Chloride		29	mg/L	1.0	98	90	110	0.1	20	
Sulfate		280	mg/L	1.2		90	110	0.5	20	A

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

A - The analyte level was greater than four times the spike level. In accordance with the method % recovery is not calculated.

QA/QC Summary Report

Client: Hydrometrics Inc | **Report Date:** 08/06/10

Project: 10039 Sand Coulee | **Work Order:** H10070205

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E353.2										Analytical Run: NUTRIENTS_100719B
Sample ID: ICV-1		Initial Calibration Verification Standard								07/19/10 11:07
Nitrogen, Nitrate+Nitrite as N		1.04	mg/L	0.050	104	90	110			
Sample ID: ICB		Initial Calibration Blank, Instrument Blank								07/19/10 11:18
Nitrogen, Nitrate+Nitrite as N		-0.0100	mg/L	0.050		0	0			
Sample ID: CCV-34		Continuing Calibration Verification Standard								07/19/10 12:14
Nitrogen, Nitrate+Nitrite as N		0.520	mg/L	0.050	104	90	110			
Method: E353.2										Batch: A2010-07-19_5_NO3_01
Sample ID: LCS-2		Laboratory Control Sample				Run: NUTRIENTS_100719B				07/19/10 11:09
Nitrogen, Nitrate+Nitrite as N		18.2	mg/L	0.10	99	90	110			
Sample ID: LFB-3		Laboratory Fortified Blank				Run: NUTRIENTS_100719B				07/19/10 11:11
Nitrogen, Nitrate+Nitrite as N		1.06	mg/L	0.050	106	90	110			
Sample ID: MBLK-7		Method Blank				Run: NUTRIENTS_100719B				07/19/10 11:20
Nitrogen, Nitrate+Nitrite as N		ND	mg/L	0.01						
Sample ID: H10070214-001CMS		Sample Matrix Spike				Run: NUTRIENTS_100719B				07/19/10 12:27
Nitrogen, Nitrate+Nitrite as N		1.13	mg/L	0.050	105	90	110			
Sample ID: H10070214-001CMSD		Sample Matrix Spike Duplicate				Run: NUTRIENTS_100719B				07/19/10 12:30
Nitrogen, Nitrate+Nitrite as N		1.14	mg/L	0.050	106	90	110	0.9	20	

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

Workorder Receipt Checklist

Hydrometrics Inc

H10070205

Login completed by: Wanda Johnson

Reviewed by: BL2000\ablackburn

Reviewed Date: 7/20/2010

Date Received: 7/14/2010

Received by: TLL

Carrier name: Hand Del

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐
Custody seals intact on shipping container/cooler?	Yes ☐	No ☐	Not Present ☑
Custody seals intact on sample bottles?	Yes ☐	No ☐	Not Present ☑
Chain of custody present?	Yes ☑	No ☐	
Chain of custody signed when relinquished and received?	Yes ☑	No ☐	
Chain of custody agrees with sample labels?	Yes ☑	No ☐	
Samples in proper container/bottle?	Yes ☑	No ☐	
Sample containers intact?	Yes ☑	No ☐	
Sufficient sample volume for indicated test?	Yes ☑	No ☐	
All samples received within holding time?	Yes ☑	No ☐	
Container/Temp Blank temperature:	5.9°C		
Water - VOA vials have zero headspace?	Yes ☐	No ☐	No VOA vials submitted ☑
Water - pH acceptable upon receipt?	Yes ☐	No ☑	Not Applicable ☐

Contact and Corrective Action Comments:

Sample poured off from unpreserved sample & preserved with 2mls of Sulfuric Acid for Nutrients. Sample poured off from unpreserved sample & preserved with 2mls of Nitric Acid for metals sample. Wj

CHAIN OF CUSTODY RECORD

Hydrometrics, Inc.®

~~2727 Airport Road~~ 3020 Bozeman • Helena, Montana 59601 • (406) 443-4150

PROJ. NO.	PROJECT NAME
10039	Sand Coulee

SAMPLERS: (Signature) [signature]

DATE	TIME	COMP	GRAB	SAMPLE NUMBER	NO. OF CON-TAINERS	Commons UF/RAW	Nutrients UF/H_2SO_4	Diss. Metal F/HNO_3 (see remarks)	CN UF/NaOH	Total Metals UF/HNO_3	Total Recoverable Metals UF/HNO_3	BTEX	TPH	Domestic Water Analysis (see remarks)	REMARKS
7/12/10	14:40		X	Well 3	2			X						X	H10070205-001

Relinquished (Signature)	Date/Time	Received by: (Signature)	Lab	P.O. #	Shipped via: Bus, Fed Ex, UPS Other___ Air Bill #___
[signature]	7/14/10 1159		5.9° on ice - hand del.		

Relinquished (Signature)	Date/Time	Received by: (Signature)
[signature]		

Remarks
Domestic Water Analysis - Major ions, pH, SC, Alk, TDS, hardness, Nitrate-N, Total iron
Dissolved metals - Fe, Al, Mn, Cu, Pb, Zn, As, Cd - routine reporting limits

Relinquished (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time
		[signature]	7/14/10 12:00

Enclosed: ☐ Parameter sheet w/detection limits
☐ QA/QC standard mixing instructions ☐ Cover letter
☐ Other

Split Samples:
[] Accepted [] Declined ___ Signature

HFORM-1-5/99

Return results & electronic copy to: ~~Computer Dept. at address at top of page~~ Bill Thompson

ANALYTICAL SUMMARY REPORT

November 12, 2010

MT DEQ
PO Box 200901
Helena, MT 59620-0901

Workorder No.: H10100078

Project Name: Sand Coulee

Energy Laboratories Inc received the following 4 samples for MT DEQ on 10/4/2010 for analysis.

Sample ID	Client Sample ID	Collect Date	Receive Date	Matrix	Test
H10100078-001	Well No. 2a	09/30/10 16:30	10/04/10	Aqueous	Metals by ICP/ICPMS, Dissolved Metals by ICP/ICPMS, Total Alkalinity Conductivity Anions by Ion Chromatography pH Metals Digestion by EPA 200.2 Preparation, Dissolved Filtration
H10100078-002	Well No. 2a	09/30/10 16:30	10/04/10	Solid	Metals by ICP/ICPMS, Total Total Carbon Loss on Ignition at 550 Moisture, % Dry Basis HF Digestion, Total Metals Qualitative Analyses Report Total Sulfur
H10100078-003	Well No. 2b	09/30/10 16:30	10/04/10	Solid	Same As Above
H10100078-004	Well No. 2c	09/30/10 16:30	10/04/10	Solid	Metals by ICP/ICPMS, Total Total Carbon Lime as $CaCO_3$, % Loss on Ignition at 550 Moisture, % Dry Basis HF Digestion, Total Metals Lime Percentage Qualitative Analyses Report Total Sulfur

This report was prepared by Energy Laboratories, Inc., 3161 E. Lyndale Ave., Helena, MT 59604. Any exceptions or problems with the analyses are noted in the Laboratory Analytical Report, the QA/QC Summary Report, or the Case Narrative.

The results as reported relate only to the item(s) submitted for testing.

If you have any questions regarding these test results, please call.

Report Approved By:

Assistant Laboratory Manager - Helena

Digitally signed by
Jon Hager
Date: 2010.11.13 13:03:29 -07:00

CLIENT: MT DEQ
Project: Sand Coulee
Sample Delivery Group: H10100078

Revised Date: 11/12/10
Report Date: 10/27/10

CASE NARRATIVE

Tests associated with analyst identified as ELI-B were subcontracted to Energy Laboratories, 1120 S. 27th St., Billings, MT, EPA Number MT00005.

LABORATORY ANALYTICAL REPORT

Revised Date: 11/12/10
Report Date: 10/27/10
Collection Date: 09/30/10 16:30
DateReceived: 10/04/10
Matrix: Aqueous

Client: MT DEQ
Project: Sand Coulee
Lab ID: H10100078-001
Client Sample ID Well No. 2a

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.4	s.u.		0.1		A4500-H B	10/11/10 18:37 / zeg
INORGANICS							
Alkalinity, Total as CaCO3	380	mg/L		4		A2320 B	10/11/10 18:37 / zeg
Chloride	5	mg/L		1		E300.0	10/20/10 18:09 / abb
Sulfate	35	mg/L		1		E300.0	10/20/10 18:09 / abb
METALS, DISSOLVED							
Aluminum	ND	mg/L		0.1		E200.8	11/03/10 22:53 / dck
Calcium	27	mg/L		1		E200.7	11/02/10 13:04 / sld
Iron	ND	mg/L		0.03		E200.7	11/02/10 13:04 / sld
Magnesium	72	mg/L		1		E200.7	11/02/10 13:04 / sld
Manganese	ND	mg/L		0.01		E200.8	11/03/10 22:53 / dck
Potassium	3	mg/L		1		E200.8	11/03/10 22:53 / dck
Silicon	2.0	mg/L		0.1		E200.8	11/03/10 22:53 / dck
Silica	4.4	mg/L		0.2		E200.8	11/03/10 22:53 / dck
Sodium	23	mg/L		1		E200.7	11/02/10 13:04 / sld
METALS, TOTAL							
Aluminum	8.3	mg/L		0.1		E200.8	10/18/10 14:05 / dck
Calcium	51	mg/L		1		E200.8	10/18/10 14:05 / dck
Iron	5.16	mg/L		0.03		E200.8	10/18/10 14:05 / dck
Magnesium	83	mg/L		1		E200.8	10/18/10 14:05 / dck
Manganese	0.31	mg/L		0.01		E200.8	10/18/10 14:05 / dck
Potassium	8	mg/L		1		E200.8	10/18/10 14:05 / dck
Silicon	18.9	mg/L		0.1		E200.8	10/18/10 14:05 / dck
Silica	40.4	mg/L		0.2		E200.8	10/18/10 14:05 / dck
Sodium	28	mg/L		1		E200.8	10/18/10 14:05 / dck

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

		Revised Date:	11/12/10
Client:	MT DEQ	**Report Date:**	10/27/10
Project:	Sand Coulee	**Collection Date:**	09/30/10 16:30
Lab ID:	H10100078-002	**DateReceived:**	10/04/10
Client Sample ID	Well No. 2a	**Matrix:**	Solid

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL CHARACTERISTICS							
Moisture	78.8	wt%		0.2		A2540 G	10/14/10 12:00 / eli-b
Loss on Ignition at 550C	79.7	wt%		0.01		A2540 G	10/14/10 12:00 / eli-b
QUALITATIVE ANALYSES							
Carbonate	Absent					Qualitative	10/15/10 13:30 / eli-b
Chloride	Trace					Qualitative	10/15/10 13:30 / eli-b
Sulfate	Absent					Qualitative	10/15/10 13:30 / eli-b
Sulfide	Absent					Qualitative	10/15/10 13:30 / eli-b
CHEMICAL CHARACTERISTICS							
Sulfur, Total	0.08	wt%		0.01		Leco	10/18/10 12:21 / eli-b
METALS, TOTAL HF DIGESTION							
Aluminum	1.7	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b
Antimony	ND	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b
Arsenic	ND	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b
Barium	ND	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b
Beryllium	ND	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b
Cadmium	ND	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b
Calcium	ND	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b
Chromium	ND	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b
Cobalt	ND	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b
Copper	ND	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b
Gold	ND	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b
Iron	0.3	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b
Lead	ND	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b
Lithium	ND	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b
Magnesium	ND	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b
Manganese	ND	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b
Molybdenum	ND	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b
Nickel	ND	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b
Phosphorus	ND	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b
Potassium	0.4	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b
Selenium	ND	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b
Silicon	6.1	wt%	B	0.1		SW6010B	10/16/10 04:17 / eli-b
Silver	ND	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b
Sodium	ND	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b
Strontium	ND	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b
Thallium	ND	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b
Tin	ND	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b
Titanium	0.1	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b
Vanadium	ND	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b
Zinc	ND	wt%		0.1		SW6010B	10/16/10 04:17 / eli-b

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
B - The analyte was detected in the method blank.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

		Revised Date:	11/12/10
Client:	MT DEQ	**Report Date:**	10/27/10
Project:	Sand Coulee	**Collection Date:**	09/30/10 16:30
Lab ID:	H10100078-002	**DateReceived:**	10/04/10
Client Sample ID	Well No. 2a	**Matrix:**	Solid

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
METALS, TOTAL HF DIGESTION							
REMARKS							
Sample Appearance and Analyst Comments	-					-	10/22/10 13:00 / eli-b

The sample was a thin, brown sludge. The sample was dried at 105C before carbon and sulfur analysis. Besides water, it appears to be composed predominantly of silicon, which indicates the presence of soil or rock.

Report Definitions:	RL - Analyte reporting limit.	MCL - Maximum contaminant level.
	QCL - Quality control limit.	ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Revised Date: 11/12/10
Client: MT DEQ — **Report Date:** 10/27/10
Project: Sand Coulee — **Collection Date:** 09/30/10 16:30
Lab ID: H10100078-003 — **DateReceived:** 10/04/10
Client Sample ID Well No. 2b — **Matrix:** Solid

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL CHARACTERISTICS							
Moisture	8.7	wt%		0.2		A2540 G	10/14/10 12:00 / eli-b
Loss on Ignition at 550C	15.8	wt%		0.01		A2540 G	10/14/10 12:00 / eli-b
QUALITATIVE ANALYSES							
Carbonate	Absent					Qualitative	10/15/10 13:30 / eli-b
Chloride	Trace					Qualitative	10/15/10 13:30 / eli-b
Sulfate	Absent					Qualitative	10/15/10 13:30 / eli-b
Sulfide	Absent					Qualitative	10/15/10 13:30 / eli-b
CHEMICAL CHARACTERISTICS							
Sulfur, Total	0.19	wt%		0.01		Leco	10/18/10 12:21 / eli-b
METALS, TOTAL HF DIGESTION							
Aluminum	0.9	wt%		0.1		SW6010B	10/16/10 04:21 / eli-b
Barium	ND	wt%		0.1		SW6010B	10/16/10 04:21 / eli-b
Calcium	0.3	wt%		0.1		SW6010B	10/16/10 04:21 / eli-b
Iron	37.2	wt%		0.1		SW6010B	10/16/10 04:21 / eli-b
Magnesium	0.2	wt%		0.1		SW6010B	10/16/10 04:21 / eli-b
Manganese	0.2	wt%		0.1		SW6010B	10/16/10 04:21 / eli-b
Silicon	4.3	wt%	B	0.1		SW6010B	10/16/10 04:21 / eli-b
REMARKS							
Sample Appearance and Analyst Comments	-					-	10/22/10 13:00 / eli-b

The sample was a moist, brown solid. Besides water, it appears to be comosed predominantly of an iron compound and carbon. Silicon indicates the presence of soil or rock.

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
B - The analyte was detected in the method blank.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

		Revised Date:	11/12/10
Client:	MT DEQ	**Report Date:**	10/27/10
Project:	Sand Coulee	**Collection Date:**	09/30/10 16:30
Lab ID:	H10100078-004	**DateReceived:**	10/04/10
Client Sample ID	Well No. 2c	**Matrix:**	Solid

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL CHARACTERISTICS							
Moisture	7.3	wt%		0.2		A2540 G	10/14/10 12:00 / eli-b
Loss on Ignition at 550C	15.9	wt%		0.01		A2540 G	10/14/10 12:00 / eli-b
CHEMICAL CHARACTERISTICS							
Lime as Ca(OH)2	2.29	%	*	0.07	0.1	USDA23c	10/22/10 08:54 / eli-b
Lime as CaCO3	3.1	%		0.1		USDA23c	10/22/10 08:54 / eli-b
QUALITATIVE ANALYSES							
Carbonate	Present					Qualitative	10/15/10 13:30 / eli-b
Chloride	Trace					Qualitative	10/15/10 13:30 / eli-b
Sulfate	Absent					Qualitative	10/15/10 13:30 / eli-b
Sulfide	Absent					Qualitative	10/15/10 13:30 / eli-b
CHEMICAL CHARACTERISTICS							
Sulfur, Total	0.25	wt%		0.01		Leco	10/18/10 12:21 / eli-b
METALS, TOTAL HF DIGESTION							
Aluminum	6.5	wt%		0.1		SW6010B	10/16/10 04:25 / eli-b
Barium	ND	wt%		0.1		SW6010B	10/16/10 04:25 / eli-b
Calcium	0.2	wt%		0.1		SW6010B	10/16/10 04:25 / eli-b
Iron	7.8	wt%		0.1		SW6010B	10/16/10 04:25 / eli-b
Magnesium	0.3	wt%		0.1		SW6010B	10/16/10 04:25 / eli-b
Manganese	ND	wt%		0.1		SW6010B	10/16/10 04:25 / eli-b
Silicon	26.0	wt%	B	0.1		SW6010B	10/16/10 04:25 / eli-b
REMARKS							
Sample Appearance and Analyst Comments	-					-	10/22/10 13:00 / eli-b

The sample was a brown solid. It appears to be composed predominantly of silicon, which indicates the presence of soil or rock. The other major constituents found were aluminum and an iron compound.

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
* - The result exceeds the MCL.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.
B - The analyte was detected in the method blank.

QA/QC Summary Report

Client: MT DEQ
Project: Sand Coulee

Revised Date: 11/12/10
Report Date: 10/27/10
Work Order: H10100078

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: A2320 B										Batch: R66054
Sample ID: MBLK		Method Blank				Run: MAN-TECH_101011A				10/11/10 18:12
Alkalinity, Total as CaCO3		2	mg/L	0.3						
Sample ID: LCS-83110		Laboratory Control Sample				Run: MAN-TECH_101011A				10/11/10 18:22
Alkalinity, Total as CaCO3		620	mg/L	4.0	103	90	110			
Sample ID: H10090482-008AMS		Sample Matrix Spike				Run: MAN-TECH_101011A				10/11/10 20:44
Alkalinity, Total as CaCO3		730	mg/L	4.0	90	90	110			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Revised Date: 11/12/10

Client: MT DEQ
Report Date: 10/27/10

Project: Sand Coulee
Work Order: H10100078

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: **A4500-H B**							Analytical Run: MAN-TECH_101011A			
Sample ID: **ICV-1632**		Initial Calibration Verification Standard							10/11/10 18:03	
pH		7.00	s.u.	0.10	100	99	101			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Client: MT DEQ
Project: Sand Coulee

Revised Date: 11/12/10
Report Date: 10/27/10
Work Order: H10100078

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E200.7										Analytical Run: ICP1-HE_101102A
Sample ID: ICV	4	Initial Calibration Verification Standard								11/02/10 10:45
Calcium		39.3	mg/L	1.0	98	95	105			
Iron		4.06	mg/L	0.030	101	95	105			
Magnesium		39.7	mg/L	1.0	99	95	105			
Sodium		39.7	mg/L	1.0	99	95	105			
Sample ID: CCV-1	4	Continuing Calibration Verification Standard								11/02/10 10:51
Calcium		25.4	mg/L	1.0	102	95	105			
Iron		2.55	mg/L	0.030	102	95	105			
Magnesium		25.1	mg/L	1.0	100	95	105			
Sodium		24.7	mg/L	1.0	99	95	105			
Sample ID: ICSA	4	Interference Check Sample A								11/02/10 11:02
Calcium		486	mg/L	1.0	97	80	120			
Iron		186	mg/L	0.030	93	80	120			
Magnesium		536	mg/L	1.0	107	80	120			
Sodium		0.0160	mg/L	1.0		0	0			
Sample ID: ICSAB	4	Interference Check Sample AB								11/02/10 11:05
Calcium		480	mg/L	1.0	96	80	120			
Iron		184	mg/L	0.030	92	80	120			
Magnesium		526	mg/L	1.0	105	80	120			
Sodium		20.0	mg/L	1.0	100	80	120			
Sample ID: CCV	4	Continuing Calibration Verification Standard								11/02/10 12:45
Calcium		24.2	mg/L	1.0	97	90	110			
Iron		2.47	mg/L	0.030	99	90	110			
Magnesium		24.2	mg/L	1.0	97	90	110			
Sodium		23.8	mg/L	1.0	95	90	110			
Sample ID: ICSA	4	Interference Check Sample A								11/02/10 15:31
Calcium		468	mg/L	1.0	94	80	120			
Iron		178	mg/L	0.030	89	80	120			
Magnesium		515	mg/L	1.0	103	80	120			
Sodium		0.0162	mg/L	1.0		0	0			
Sample ID: ICSAB	4	Interference Check Sample AB								11/02/10 15:34
Calcium		476	mg/L	1.0	95	80	120			
Iron		183	mg/L	0.030	91	80	120			
Magnesium		506	mg/L	1.0	101	80	120			
Sodium		19.6	mg/L	1.0	98	80	120			
Method: E200.7										Batch: R66763
Sample ID: ICB	4	Method Blank				Run: ICP1-HE_101102A				11/02/10 11:37
Calcium		ND	mg/L	0.1						
Iron		0.005	mg/L	0.002						
Magnesium		0.03	mg/L	0.02						

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Client: MT DEQ
Project: Sand Coulee

Revised Date: 11/12/10
Report Date: 10/27/10
Work Order: H10100078

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E200.7										Batch: R66763
Sample ID: ICB	4	Method Blank				Run: ICP1-HE_101102A				11/02/10 11:37
Sodium		ND	mg/L	0.1						
Sample ID: LFB	4	Laboratory Fortified Blank				Run: ICP1-HE_101102A				11/02/10 11:40
Calcium		9.70	mg/L	1.0	97	85	115			
Iron		0.994	mg/L	0.030	99	85	115			
Magnesium		9.75	mg/L	1.0	97	85	115			
Sodium		9.63	mg/L	1.0	96	85	115			
Sample ID: H10110013-003AMS2	4	Sample Matrix Spike				Run: ICP1-HE_101102A				11/02/10 12:27
Calcium		73.1	mg/L	1.0	103	70	130			
Iron		2.05	mg/L	0.040	101	70	130			
Magnesium		40.2	mg/L	1.0	99	70	130			
Sodium		27.4	mg/L	1.0	95	70	130			
Sample ID: H10110013-003AMSD2	4	Sample Matrix Spike Duplicate				Run: ICP1-HE_101102A				11/02/10 12:30
Calcium		71.2	mg/L	1.0	93	70	130	2.6	20	
Iron		2.00	mg/L	0.040	99	70	130	2.4	20	
Magnesium		39.1	mg/L	1.0	94	70	130	2.6	20	
Sodium		27.7	mg/L	1.0	97	70	130	1.2	20	

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Revised Date: 11/12/10
Client: MT DEQ **Report Date:** 10/27/10
Project: Sand Coulee **Work Order:** H10100078

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E200.8										Analytical Run: ICPMS204-B_101017A
Sample ID: ICV STD	8	Initial Calibration Verification Standard								10/17/10 17:22
Aluminum		0.251	mg/L	0.10	100	90	110			
Calcium		2.62	mg/L	0.50	105	90	110			
Iron		0.248	mg/L	0.030	97	90	110			
Magnesium		2.63	mg/L	0.50	105	90	110			
Manganese		0.247	mg/L	0.010	99	90	110			
Potassium		2.63	mg/L	0.50	105	90	110			
Silicon		0.492	mg/L	0.10	98	90	110			
Sodium		2.58	mg/L	0.50	103	90	110			
Sample ID: ICSA	8	Interference Check Sample A								10/17/10 17:30
Aluminum		39.8	mg/L	0.10	100	70	130			
Calcium		118	mg/L	0.50						
Iron		97.4	mg/L	0.030	97	70	130			
Magnesium		41.4	mg/L	0.50						
Manganese		0.00214	mg/L	0.010						
Potassium		40.3	mg/L	0.50						
Silicon		0.00199	mg/L	0.10		0	0			
Sodium		104	mg/L	0.50						
Sample ID: ICSAB	8	Interference Check Sample AB								10/17/10 17:50
Aluminum		39.8	mg/L	0.10	99	70	130			
Calcium		116	mg/L	0.50	96	70	130			
Iron		98.6	mg/L	0.030	99	70	130			
Magnesium		41.4	mg/L	0.50	103	70	130			
Manganese		0.0226	mg/L	0.010	113	70	130			
Potassium		40.1	mg/L	0.50	100	70	130			
Silicon		0.00185	mg/L	0.10		0	0			
Sodium		104	mg/L	0.50	104	70	130			
Sample ID: ICV STD	8	Initial Calibration Verification Standard								10/18/10 00:44
Aluminum		0.250	mg/L	0.10	100	90	110			
Calcium		2.62	mg/L	0.50	105	90	110			
Iron		0.251	mg/L	0.030	98	90	110			
Magnesium		2.64	mg/L	0.50	106	90	110			
Manganese		0.248	mg/L	0.010	99	90	110			
Potassium		2.63	mg/L	0.50	105	90	110			
Silicon		0.487	mg/L	0.10	97	90	110			
Sodium		2.57	mg/L	0.50	103	90	110			
Sample ID: ICSA	8	Interference Check Sample A								10/18/10 00:51
Aluminum		40.3	mg/L	0.10	101	70	130			
Calcium		120	mg/L	0.50						
Iron		98.7	mg/L	0.030	99	70	130			
Magnesium		40.7	mg/L	0.50						
Manganese		0.00178	mg/L	0.010						

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Revised Date: 11/12/10
Client: MT DEQ
Report Date: 10/27/10
Project: Sand Coulee
Work Order: H10100078

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E200.8										Analytical Run: ICPMS204-B_101017A
Sample ID: ICSA	8	Interference Check Sample A								10/18/10 00:51
Potassium		41.2	mg/L	0.50						
Silicon		0.00212	mg/L	0.10		0	0			
Sodium		102	mg/L	0.50						
Sample ID: ICSAB	8	Interference Check Sample AB								10/18/10 00:57
Aluminum		39.9	mg/L	0.10	100	70	130			
Calcium		118	mg/L	0.50	98	70	130			
Iron		98.2	mg/L	0.030	98	70	130			
Magnesium		40.5	mg/L	0.50	101	70	130			
Manganese		0.0225	mg/L	0.010	113	70	130			
Potassium		40.6	mg/L	0.50	101	70	130			
Silicon		0.00174	mg/L	0.10		0	0			
Sodium		102	mg/L	0.50	102	70	130			
Sample ID: ICV STD	8	Initial Calibration Verification Standard								10/18/10 12:43
Aluminum		0.252	mg/L	0.10	101	90	110			
Calcium		2.64	mg/L	0.50	105	90	110			
Iron		0.251	mg/L	0.030	98	90	110			
Magnesium		2.63	mg/L	0.50	105	90	110			
Manganese		0.250	mg/L	0.010	100	90	110			
Potassium		2.67	mg/L	0.50	107	90	110			
Silicon		0.494	mg/L	0.10	99	90	110			
Sodium		2.63	mg/L	0.50	105	90	110			
Sample ID: ICSA	8	Interference Check Sample A								10/18/10 12:50
Aluminum		40.8	mg/L	0.10	102	70	130			
Calcium		120	mg/L	0.50						
Iron		99.9	mg/L	0.030	100	70	130			
Magnesium		40.7	mg/L	0.50						
Manganese		0.00207	mg/L	0.010						
Potassium		40.8	mg/L	0.50						
Silicon		0.00211	mg/L	0.10		0	0			
Sodium		102	mg/L	0.50						
Sample ID: ICSAB	8	Interference Check Sample AB								10/18/10 12:57
Aluminum		40.6	mg/L	0.10	101	70	130			
Calcium		119	mg/L	0.50	99	70	130			
Iron		100	mg/L	0.030	100	70	130			
Magnesium		40.7	mg/L	0.50	102	70	130			
Manganese		0.0225	mg/L	0.010	113	70	130			
Potassium		41.2	mg/L	0.50	103	70	130			
Silicon		0.00196	mg/L	0.10		0	0			
Sodium		104	mg/L	0.50	104	70	130			
Sample ID: ICV STD	8	Initial Calibration Verification Standard								10/19/10 01:56
Aluminum		0.254	mg/L	0.10	102	90	110			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Client: MT DEQ
Project: Sand Coulee

Revised Date: 11/12/10
Report Date: 10/27/10
Work Order: H10100078

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E200.8								Analytical Run: ICPMS204-B_101017A		
Sample ID: ICV STD	8	Initial Calibration Verification Standard							10/19/10 01:56	
Calcium		2.66	mg/L	0.50	107	90	110			
Iron		0.260	mg/L	0.030	102	90	110			
Magnesium		2.60	mg/L	0.50	104	90	110			
Manganese		0.248	mg/L	0.010	99	90	110			
Potassium		2.68	mg/L	0.50	107	90	110			
Silicon		0.493	mg/L	0.10	99	90	110			
Sodium		2.58	mg/L	0.50	103	90	110			
Sample ID: ICSA	8	Interference Check Sample A							10/19/10 02:03	
Aluminum		40.4	mg/L	0.10	101	70	130			
Calcium		119	mg/L	0.50						
Iron		99.7	mg/L	0.030	100	70	130			
Magnesium		40.5	mg/L	0.50						
Manganese		0.00222	mg/L	0.010						
Potassium		41.0	mg/L	0.50						
Silicon		0.00266	mg/L	0.10		0	0			
Sodium		102	mg/L	0.50						
Sample ID: ICSAB	8	Interference Check Sample AB							10/19/10 02:10	
Aluminum		39.9	mg/L	0.10	100	70	130			
Calcium		119	mg/L	0.50	99	70	130			
Iron		99.8	mg/L	0.030	100	70	130			
Magnesium		40.1	mg/L	0.50	100	70	130			
Manganese		0.0232	mg/L	0.010	116	70	130			
Potassium		41.1	mg/L	0.50	103	70	130			
Silicon		0.00252	mg/L	0.10		0	0			
Sodium		102	mg/L	0.50	102	70	130			
Method: E200.8									Batch: 10269	
Sample ID: MB-10269	9	Method Blank				Run: ICPMS204-B_101017A			10/18/10 13:38	
Aluminum		0.0008	mg/L	0.0008						
Calcium		0.01	mg/L	0.01						
Iron		0.001	mg/L	0.0009						
Magnesium		ND	mg/L	0.006						
Manganese		ND	mg/L	3E-05						
Potassium		0.09	mg/L	0.04						
Silicon		0.002	mg/L	0.001						
Sodium		0.2	mg/L	0.02						
Silica		0.005	mg/L	0.003						
Sample ID: LCS-10269	9	Laboratory Control Sample				Run: ICPMS204-B_101017A			10/18/10 13:45	
Aluminum		2.50	mg/L	0.10	100	85	115			
Calcium		27.6	mg/L	1.0	110	85	115			
Iron		2.58	mg/L	0.030	103	85	115			
Magnesium		25.9	mg/L	1.0	104	85	115			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Revised Date: 11/12/10
Client: MT DEQ **Report Date:** 10/27/10
Project: Sand Coulee **Work Order:** H10100078

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E200.8										Batch: 10269
Sample ID: LCS-10269	9	Laboratory Control Sample				Run: ICPMS204-B_101017A				10/18/10 13:45
Manganese		2.50	mg/L	0.010	100	85	115			
Potassium		26.4	mg/L	1.0	105	85	115			
Silicon		4.90	mg/L	0.10	98	85	115			
Sodium		26.7	mg/L	1.0	106	85	115			
Silica		10.5	mg/L	0.21	98	85	115			
Sample ID: H10100078-001BMS3	9	Sample Matrix Spike				Run: ICPMS204-B_101017A				10/18/10 14:12
Aluminum		36.1	mg/L	0.10	222	70	130			S
Calcium		190	mg/L	1.0	111	70	130			
Iron		20.5	mg/L	0.030	123	70	130			
Magnesium		212	mg/L	1.0	103	70	130			
Manganese		12.8	mg/L	0.010	100	70	130			
Potassium		143	mg/L	1.0	107	70	130			
Silicon		64.8	mg/L	0.10	183	70	130			S
Sodium		159	mg/L	1.0	105	70	130			
Silica		139	mg/L	0.21	183	70	130			S
Sample ID: H10100078-001BMSD3	9	Sample Matrix Spike Duplicate				Run: ICPMS204-B_101017A				10/18/10 14:18
Aluminum		35.2	mg/L	0.10	215	70	130	2.5	20	S
Calcium		188	mg/L	1.0	110	70	130	1.1	20	
Iron		20.0	mg/L	0.030	119	70	130	2.8	20	
Magnesium		210	mg/L	1.0	102	70	130	1	20	
Manganese		12.6	mg/L	0.010	98	70	130	1.6	20	
Potassium		142	mg/L	1.0	107	70	130	0.8	20	
Silicon		62.2	mg/L	0.10	173	70	130	4	20	S
Sodium		158	mg/L	1.0	104	70	130	0.5	20	
Silica		133	mg/L	0.21	173	70	130	4	20	S

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

S - Spike recovery outside of advisory limits.

QA/QC Summary Report

Revised Date: 11/12/10
Report Date: 10/27/10
Work Order: H10100078

Client: MT DEQ
Project: Sand Coulee

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E200.8										Analytical Run: ICPMS204-B_101103A
Sample ID: ICV STD	4	Initial Calibration Verification Standard								11/03/10 20:44
Aluminum		0.247	mg/L	0.10	99	90	110			
Manganese		0.244	mg/L	0.010	98	90	110			
Potassium		2.58	mg/L	0.50	103	90	110			
Silicon		0.482	mg/L	0.10	96	90	110			
Sample ID: ICSA	4	Interference Check Sample A								11/03/10 20:48
Aluminum		38.5	mg/L	0.10	96	70	130			
Manganese		0.00216	mg/L	0.010						
Potassium		39.2	mg/L	0.50						
Silicon		0.00233	mg/L	0.10		0	0			
Sample ID: ICSAB	4	Interference Check Sample AB								11/03/10 20:53
Aluminum		37.7	mg/L	0.10	94	70	130			
Manganese		0.0217	mg/L	0.010	109	70	130			
Potassium		38.8	mg/L	0.50	97	70	130			
Silicon		0.00197	mg/L	0.10		0	0			
Sample ID: ICV STD	4	Initial Calibration Verification Standard								11/04/10 03:13
Aluminum		0.250	mg/L	0.10	100	90	110			
Manganese		0.250	mg/L	0.010	100	90	110			
Potassium		2.49	mg/L	0.50	100	90	110			
Silicon		0.477	mg/L	0.10	95	90	110			
Sample ID: ICSA	4	Interference Check Sample A								11/04/10 03:17
Aluminum		38.2	mg/L	0.10	96	70	130			
Manganese		0.00211	mg/L	0.010						
Potassium		39.5	mg/L	0.50						
Silicon		0.00240	mg/L	0.10		0	0			
Sample ID: ICSAB	4	Interference Check Sample AB								11/04/10 03:22
Aluminum		38.0	mg/L	0.10	95	70	130			
Manganese		0.0217	mg/L	0.010	108	70	130			
Potassium		39.2	mg/L	0.50	98	70	130			
Silicon		0.00203	mg/L	0.10		0	0			
Sample ID: ICV STD	4	Initial Calibration Verification Standard								11/04/10 20:16
Aluminum		0.249	mg/L	0.10	100	90	110			
Manganese		0.243	mg/L	0.010	97	90	110			
Potassium		2.52	mg/L	0.50	101	90	110			
Silicon		0.481	mg/L	0.10	96	90	110			
Sample ID: ICSA	4	Interference Check Sample A								11/04/10 20:20
Aluminum		37.5	mg/L	0.10	94	70	130			
Manganese		0.00206	mg/L	0.010						
Potassium		39.2	mg/L	0.50						
Silicon		0.00247	mg/L	0.10		0	0			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Revised Date: 11/12/10

Client: MT DEQ **Report Date:** 10/27/10

Project: Sand Coulee **Work Order:** H10100078

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E200.8										Analytical Run: ICPMS204-B_101103A
Sample ID: ICSAB	4	Interference Check Sample AB								11/04/10 20:25
Aluminum		37.3	mg/L	0.10	93	70	130			
Manganese		0.0213	mg/L	0.010	107	70	130			
Potassium		38.8	mg/L	0.50	97	70	130			
Silicon		0.00249	mg/L	0.10		0	0			
Sample ID: ICSA	4	Interference Check Sample A								11/05/10 08:28
Aluminum		37.7	mg/L	0.10	94	70	130			
Manganese		0.00195	mg/L	0.010						
Potassium		39.8	mg/L	0.50						
Silicon		0.00250	mg/L	0.10		0	0			
Sample ID: ICSAB	4	Interference Check Sample AB								11/05/10 08:32
Aluminum		37.8	mg/L	0.10	95	70	130			
Manganese		0.0212	mg/L	0.010	106	70	130			
Potassium		40.8	mg/L	0.50	102	70	130			
Silicon		0.00222	mg/L	0.10		0	0			
Method: E200.8										Batch: R66830
Sample ID: ICB	4	Method Blank				Run: ICPMS204-B_101103A				11/03/10 21:20
Aluminum		0.0007	mg/L	0.0002						
Manganese		3E-05	mg/L	2E-05						
Potassium		ND	mg/L	0.02						
Silicon		ND	mg/L	0.0002						
Sample ID: LFB	4	Laboratory Fortified Blank				Run: ICPMS204-B_101103A				11/03/10 21:24
Aluminum		0.0494	mg/L	0.10	97	85	115			
Manganese		0.0490	mg/L	0.010	98	85	115			
Potassium		49.8	mg/L	0.50	100	85	115			
Silicon		0.200	mg/L	0.10	100	85	115			
Sample ID: H10110013-006AMS	4	Sample Matrix Spike				Run: ICPMS204-B_101103A				11/04/10 00:40
Aluminum		0.0498	mg/L	0.10	98	70	130			
Manganese		0.925	mg/L	0.010		70	130			A
Potassium		4.41	mg/L	1.0		70	130			S
Silicon		8.95	mg/L	0.10		70	130			A
Sample ID: H10110013-006AMSD	4	Sample Matrix Spike Duplicate				Run: ICPMS204-B_101103A				11/04/10 00:45
Aluminum		0.0507	mg/L	0.10	100	70	130		20	
Manganese		0.924	mg/L	0.010		70	130	0.2	20	A
Potassium		4.47	mg/L	1.0		70	130	1.4	20	S
Silicon		8.92	mg/L	0.10		70	130	0.4	20	A

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

A - The analyte level was greater than four times the spike level. In accordance with the method % recovery is not calculated.

S - Spike recovery outside of advisory limits.

QA/QC Summary Report

Client: MT DEQ
Project: Sand Coulee

Revised Date: 11/12/10
Report Date: 10/27/10
Work Order: H10100078

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E300.0								Analytical Run: IC101-H_101020A		
Sample ID: ICV102010-12	2	Initial Calibration Verification Standard								10/20/10 09:40
Chloride		26	mg/L	1.0	103	90	110			
Sulfate		110	mg/L	1.0	106	90	110			
Sample ID: CCV-102010-30	2	Continuing Calibration Verification Standard								10/20/10 14:36
Chloride		26	mg/L	1.0	105	90	110			
Sulfate		100	mg/L	1.0	102	90	110			
Method: E300.0										Batch: R66331
Sample ID: ICB102010-13	2	Method Blank				Run: IC101-H_101020A				10/20/10 09:57
Chloride		ND	mg/L	0.2						
Sulfate		ND	mg/L	0.5						
Sample ID: LFB102010-14	2	Laboratory Fortified Blank				Run: IC101-H_101020A				10/20/10 10:13
Chloride		26	mg/L	1.0	103	90	110			
Sulfate		100	mg/L	1.1	103	90	110			
Sample ID: H10100051-003AMS	2	Sample Matrix Spike				Run: IC101-H_101020A				10/20/10 16:31
Chloride		26	mg/L	1.0	103	90	110			
Sulfate		100	mg/L	1.1	100	90	110			
Sample ID: H10100051-003AMSD	2	Sample Matrix Spike Duplicate				Run: IC101-H_101020A				10/20/10 16:47
Chloride		26	mg/L	1.0	104	90	110	0.6	20	
Sulfate		100	mg/L	1.1	103	90	110	3.1	20	

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Revised Date: 11/12/10
Client: MT DEQ **Report Date:** 10/27/10
Project: Sand Coulee **Work Order:** H10100078

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B										Analytical Run: SUB-B155661
Sample ID: QCS	29	Initial Calibration Verification Standard								10/15/10 10:33
Selenium		0.80	mg/L	0.10	100	89.5	110.5			
Silicon		7.8	mg/L	0.050	98	89.5	110.5			
Aluminum		3.9	mg/L	0.10	98	89.5	110.5			
Antimony		0.78	mg/L	0.029	98	89.5	110.5			
Arsenic		0.78	mg/L	0.10	98	89.5	110.5			
Barium		0.77	mg/L	0.10	96	89.5	110.5			
Beryllium		0.38	mg/L	0.010	94	89.5	110.5			
Cadmium		0.39	mg/L	0.010	97	89.5	110.5			
Calcium		39	mg/L	1.0	96	89.5	110.5			
Chromium		0.78	mg/L	0.050	97	89.5	110.5			
Cobalt		0.78	mg/L	0.020	97	89.5	110.5			
Copper		0.78	mg/L	0.010	98	89.5	110.5			
Iron		4.0	mg/L	0.030	99	89.5	110.5			
Lead		0.77	mg/L	0.050	97	89.5	110.5			
Lithium		0.82	mg/L	0.10	102	89.5	110.5			
Magnesium		37	mg/L	1.0	93	89.5	110.5			
Manganese		3.9	mg/L	0.010	97	89.5	110.5			
Molybdenum		0.78	mg/L	0.10	98	89.5	110.5			
Nickel		0.78	mg/L	0.050	97	89.5	110.5			
Phosphorus		7.8	mg/L	0.10	98	89.5	110.5			
Potassium		38	mg/L	1.0	94	89.5	110.5			
Silver		0.40	mg/L	0.010	101	89.5	110.5			
Sodium		39	mg/L	1.0	97	89.5	110.5			
Strontium		0.78	mg/L	0.10	98	89.5	110.5			
Thallium		0.80	mg/L	0.018	100	89.5	110.5			
Tin		0.79	mg/L	0.011	99	89.5	110.5			
Titanium		0.80	mg/L	0.00062	100	89.5	110.5			
Vanadium		0.78	mg/L	0.10	97	89.5	110.5			
Zinc		0.78	mg/L	0.010	97	89.5	110.5			
Sample ID: ICSA	29	Interference Check Sample A								10/15/10 10:48
Selenium		-0.038	mg/L	0.10		0	0			
Silicon		0.0020	mg/L	0.050		0	0			
Aluminum		520	mg/L	0.10	103	80	120			
Antimony		-0.040	mg/L	0.029		0	0			
Arsenic		0.018	mg/L	0.10		0	0			
Barium		0.0024	mg/L	0.10		0	0			
Beryllium		6.0E-05	mg/L	0.010		0	0			
Cadmium		0.0060	mg/L	0.010		0	0			
Calcium		450	mg/L	1.0	90	80	120			
Chromium		0.0074	mg/L	0.050		0	0			
Cobalt		-0.0031	mg/L	0.020		0	0			
Copper		0.0038	mg/L	0.010		0	0			
Iron		200	mg/L	0.096	102	80	120			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Client: MT DEQ
Project: Sand Coulee

Revised Date: 11/12/10
Report Date: 10/27/10
Work Order: H10100078

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B								Analytical Run: SUB-B155661		
Sample ID: ICSA	29	Interference Check Sample A							10/15/10 10:48	
Lead		-0.14	mg/L	0.050		0	0			
Lithium		0.0036	mg/L	0.10		0	0			
Magnesium		500	mg/L	1.0	101	80	120			
Manganese		-0.0062	mg/L	0.010		0	0			
Molybdenum		-0.014	mg/L	0.10		0	0			
Nickel		-0.0024	mg/L	0.050		0	0			
Phosphorus		0.030	mg/L	0.10		0	0			
Potassium		0.062	mg/L	1.0		0	0			
Silver		0.00057	mg/L	0.010		0	0			
Sodium		0.068	mg/L	1.0		0	0			
Strontium		0.021	mg/L	0.10		0	0			
Thallium		0.013	mg/L	0.018		0	0			
Tin		-0.025	mg/L	0.011		0	0			
Titanium		-0.0089	mg/L	0.00062		0	0			
Vanadium		-0.0025	mg/L	0.10		0	0			
Zinc		-0.057	mg/L	0.010		0	0			
Sample ID: ICSAB	29	Interference Check Sample AB							10/15/10 10:52	
Selenium		0.91	mg/L	0.10	91	80	120			
Silicon		10	mg/L	0.050		0	0			
Aluminum		500	mg/L	0.10	100	80	120			
Antimony		0.99	mg/L	0.029	99	80	120			
Arsenic		1.0	mg/L	0.10	103	80	120			
Barium		0.50	mg/L	0.10	101	80	120			
Beryllium		0.46	mg/L	0.010	92	80	120			
Cadmium		0.98	mg/L	0.010	98	80	120			
Calcium		450	mg/L	1.0	91	80	120			
Chromium		0.49	mg/L	0.050	98	80	120			
Cobalt		0.48	mg/L	0.020	97	80	120			
Copper		0.52	mg/L	0.010	105	80	120			
Iron		200	mg/L	0.096	101	80	120			
Lead		0.85	mg/L	0.050	85	80	120			
Lithium		1.1	mg/L	0.10	111	80	120			
Magnesium		500	mg/L	1.0	100	80	120			
Manganese		0.49	mg/L	0.010	98	80	120			
Molybdenum		0.97	mg/L	0.10	97	80	120			
Nickel		0.96	mg/L	0.050	96	80	120			
Phosphorus		10	mg/L	0.10	101	80	120			
Potassium		21	mg/L	1.0	107	80	120			
Silver		1.1	mg/L	0.010	106	80	120			
Sodium		19	mg/L	1.0	97	80	120			
Strontium		1.0	mg/L	0.10	101	80	120			
Thallium		0.99	mg/L	0.018	99	80	120			
Tin		0.97	mg/L	0.011	97	80	120			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Revised Date: 11/12/10

Client: MT DEQ **Report Date:** 10/27/10

Project: Sand Coulee **Work Order:** H10100078

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B										Analytical Run: SUB-B155661
Sample ID: ICSAB	29	Interference Check Sample AB								10/15/10 10:52
Titanium		0.98	mg/L	0.00062	98	80	120			
Vanadium		0.48	mg/L	0.10	96	80	120			
Zinc		0.92	mg/L	0.010	92	80	120			
Sample ID: ICSA	29	Interference Check Sample A								10/16/10 12:06
Selenium		-0.036	mg/L	0.10		0	0			
Silicon		0.0057	mg/L	0.050		0	0			
Aluminum		480	mg/L	0.10	96	80	120			
Antimony		-0.0082	mg/L	0.029		0	0			
Arsenic		0.024	mg/L	0.10		0	0			
Barium		0.0024	mg/L	0.10		0	0			
Beryllium		-0.00010	mg/L	0.010		0	0			
Cadmium		0.0067	mg/L	0.010		0	0			
Calcium		480	mg/L	1.0	95	80	120			
Chromium		-0.00021	mg/L	0.050		0	0			
Cobalt		-0.00081	mg/L	0.020		0	0			
Copper		0.0048	mg/L	0.010		0	0			
Iron		190	mg/L	0.096	93	80	120			
Lead		-0.12	mg/L	0.050		0	0			
Lithium		0.0033	mg/L	0.10		0	0			
Magnesium		490	mg/L	1.0	98	80	120			
Manganese		-0.0052	mg/L	0.010		0	0			
Molybdenum		-0.013	mg/L	0.10		0	0			
Nickel		6.0E-05	mg/L	0.050		0	0			
Phosphorus		0.019	mg/L	0.10		0	0			
Potassium		0.056	mg/L	1.0		0	0			
Silver		-0.0015	mg/L	0.010		0	0			
Sodium		0.048	mg/L	1.0		0	0			
Strontium		0.023	mg/L	0.10		0	0			
Thallium		0.00067	mg/L	0.018		0	0			
Tin		-0.025	mg/L	0.011		0	0			
Titanium		-0.0091	mg/L	0.00062		0	0			
Vanadium		-0.0042	mg/L	0.10		0	0			
Zinc		-0.052	mg/L	0.010		0	0			
Sample ID: ICSAB	29	Interference Check Sample AB								10/16/10 12:10
Selenium		0.91	mg/L	0.10	91	80	120			
Silicon		10	mg/L	0.050		0	0			
Aluminum		500	mg/L	0.10	100	80	120			
Antimony		0.97	mg/L	0.029	97	80	120			
Arsenic		1.0	mg/L	0.10	101	80	120			
Barium		0.56	mg/L	0.10	112	80	120			
Beryllium		0.52	mg/L	0.010	103	80	120			
Cadmium		1.0	mg/L	0.010	104	80	120			
Calcium		510	mg/L	1.0	101	80	120			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Revised Date: 11/12/10
Client: MT DEQ **Report Date:** 10/27/10
Project: Sand Coulee **Work Order:** H10100078

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B										Analytical Run: SUB-B155661
Sample ID: ICSAB	29	Interference Check Sample AB								10/16/10 12:10
Chromium		0.51	mg/L	0.050	101	80	120			
Cobalt		0.50	mg/L	0.020	100	80	120			
Copper		0.54	mg/L	0.010	108	80	120			
Iron		200	mg/L	0.096	99	80	120			
Lead		0.82	mg/L	0.050	82	80	120			
Lithium		1.2	mg/L	0.10	116	80	120			
Magnesium		500	mg/L	1.0	100	80	120			
Manganese		0.52	mg/L	0.010	104	80	120			
Molybdenum		1.0	mg/L	0.10	103	80	120			
Nickel		0.95	mg/L	0.050	95	80	120			
Phosphorus		10	mg/L	0.10	102	80	120			
Potassium		22	mg/L	1.0	108	80	120			
Silver		1.1	mg/L	0.010	109	80	120			
Sodium		20	mg/L	1.0	99	80	120			
Strontium		1.1	mg/L	0.10	112	80	120			
Thallium		0.98	mg/L	0.018	98	80	120			
Tin		0.94	mg/L	0.011	95	80	120			
Titanium		0.99	mg/L	0.00062	99	80	120			
Vanadium		0.52	mg/L	0.10	103	80	120			
Zinc		0.89	mg/L	0.010	89	80	120			
Method: SW6010B										Batch: B_49807
Sample ID: MB-49807	30	Method Blank				Run: SUB-B155661				10/16/10 04:10
Aluminum		ND	wt%	0.007						
Antimony		ND	wt%	0.03						
Arsenic		ND	wt%	0.02						
Barium		ND	wt%	0.0002						
Beryllium		ND	wt%	8E-05						
Cadmium		ND	wt%	0.0006						
Calcium		0.03	wt%	0.02						
Chromium		0.002	wt%	0.002						
Cobalt		ND	wt%	0.002						
Copper		ND	wt%	0.0009						
Gold		0.005	wt%	0.004						
Iron		0.009	wt%	0.001						
Lead		0.02	wt%	0.01						
Lithium		ND	wt%	0.0004						
Magnesium		0.02	wt%	0.006						
Manganese		0.0005	wt%	0.0002						
Molybdenum		ND	wt%	0.005						
Nickel		ND	wt%	0.001						
Phosphorus		ND	wt%	0.02						
Potassium		ND	wt%	0.007						
Selenium		0.04	wt%	0.03						

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Revised Date: 11/12/10

Client: MT DEQ **Report Date:** 10/27/10

Project: Sand Coulee **Work Order:** H10100078

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B										Batch: B_49807
Sample ID: MB-49807	30	Method Blank				Run: SUB-B155661				10/16/10 04:10
Silicon		1	wt%	0.007						
Silver		0.002	wt%	0.0008						
Sodium		ND	wt%	0.01						
Strontium		0.009	wt%	8E-05						
Thallium		ND	wt%	0.02						
Tin		ND	wt%	0.01						
Titanium		0.0010	wt%	0.0006						
Vanadium		ND	wt%	0.002						
Zinc		ND	wt%	0.002						
Sample ID: LCS3-49807	10	Laboratory Control Sample				Run: SUB-B155661				10/16/10 04:14
Aluminum		5.37	wt%	0.10	88	50	150			
Calcium		2.40	wt%	0.10	90	50	150			
Iron		3.75	wt%	0.10	94	50	150			
Magnesium		0.977	wt%	0.10	79	50	150			
Manganese		0.0546	wt%	0.10	99	50	150			
Potassium		2.02	wt%	0.10	101	50	150			
Silicon		26.0	wt%	1.0	99	50	150			
Sodium		0.548	wt%	0.10	99	50	150			
Titanium		0.412	wt%	0.10	90	50	150			
Zinc		0.0420	wt%	0.10	96	50	150			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Revised Date: 11/12/10
Client: MT DEQ **Report Date:** 10/27/10
Project: Sand Coulee **Work Order:** H10100078

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: USDA23c										Batch: B_R155967
Sample ID: LCS-R155967		Laboratory Control Sample				Run: SUB-B155967				10/22/10 08:54
Lime as CaCO3		7.50	%	0.10	94	50	150			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

Workorder Receipt Checklist

MT DEQ

H10100078

Login completed by: Tracy L. Lorash
Reviewed by: BL2000\ablackburn
Reviewed Date: 10/26/2010

Date Received: 10/4/2010
Received by: rlt
Carrier name: Hand Del

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐
Custody seals intact on shipping container/cooler?	Yes ☐	No ☐	Not Present ☑
Custody seals intact on sample bottles?	Yes ☐	No ☐	Not Present ☑
Chain of custody present?	Yes ☑	No ☐	
Chain of custody signed when relinquished and received?	Yes ☑	No ☐	
Chain of custody agrees with sample labels?	Yes ☐	No ☑	
Samples in proper container/bottle?	Yes ☑	No ☐	
Sample containers intact?	Yes ☑	No ☐	
Sufficient sample volume for indicated test?	Yes ☑	No ☐	
All samples received within holding time?	Yes ☑	No ☐	
Container/Temp Blank temperature:	21.8°C		
Water - VOA vials have zero headspace?	Yes ☐	No ☐	No VOA vials submitted ☑
Water - pH acceptable upon receipt?	Yes ☐	No ☑	Not Applicable ☐

Contact and Corrective Action Comments:

Total metals sample split and preserved with 2ml nitric acid in lab. Tl 10/5/10.

ENERGY LABORATORIES

Chain of Custody and Analytical Request Record

PLEASE PRINT- Provide as much information as possible.

Company Name: Hydrometrics, Inc	Project: Sand Coulee	Sample Origin State:MT	EPA/State Compliance: Yes ☐ No ☒
Report Mail Address: 3020 Bozeman Ave Helena, 59601	Contact Name: Bill Thompson; Phone/Fax: 443-4150 ext. 130	Email: wthompson@hydrometrics.com	Sampler: (Please Print) Bill Thompson
Invoice Address: same	Invoice Contact & Phone: Same as above	Purchase Order: Direct bill DEQ Abandoned mines (contact: Tom Henderson 841-5052	Quote/Bottle Order:

Special Report/Formats – ELI must be notified prior to sample submittal for the following:

☐ DW ☐ GSA ☐ POTW/WWTP ☐ State: ____ ☐ Other: ____

☐ A2LA ☐ EDD/EDT(Electronic Data) **Format:** ____ ☐ LEVEL IV ☐ NELAC

ANALYSIS REQUESTED

Number of Containers; Sample Type: A W S V B O (Air Water Soils/Solids Vegetation Bioassay Other)

SEE ATTACHED | Normal Turnaround (TAT)

RUSH: Contact ELI prior to **RUSH** sample submittal for charges and scheduling – See Instruction Page

SAMPLE IDENTIFICATION (Name, Location, Interval, etc.)	Collection Date	Collection Time	MATRIX	Ca, Mg, Na, K, SO4, Cl, HCO3, Silica, Fe, Al, Mn, ph	Scale Analysis	Lime per RP	Comments
1 Well No.2a	9/30/10	16:30	Water*	X			*Filter water/Save Filtrate
2 Well No.2a	9/30/10	16:30	Solids*		X		*Filtrate from above sample
3 Well No.2 b	9/30/10	16:30	Solids		X		
4 Well No.2 c	9/30/10	16:30	Solids		X	+	
5							
6							
7							
8							
9							
10							

LABORATORY USE ONLY: Shipped by: [signature] | Cooler ID(s): Cooler | Receipt Temp 21.8 °C | On Ice: Yes No (circled) | Custody Seal Intact Y N (N circled) | Y N | Signature Match Y N | H10100078

Custody Record MUST be Signed

Relinquished by (print):	Date/Time:	Signature:	Received by (print):	Date/Time:	Signature:
Bill Thompson	10/4/10 1146	[signature]			
Relinquished by (print):	Date/Time:	Signature:	Received by (print):	Date/Time:	Signature:
Sample Disposal: Return to Client: ____ Lab Disposal: ____			Received by Laboratory: Roxanne Jeans	10.4.10 11:49	[signature]

In certain circumstances, samples submitted to Energy Laboratories, Inc. may be subcontracted to other certified laboratories in order to complete the analysis requested.

APPENDIX C

WELL NO. 3 PHREEQCI MODEL INPUT AND OUTPUT

```
DATABASE C:\Program Files (x86)\USGS\Phreeqc Interactive 2.17.4799\database\minteq.v4.dat
SOLUTION 1 10/16/2000 Sand Coulee Well 3
    temp      12.6
    pH        7.21
    pe        4
    redox     pe
    units     mg/l
    density   1
    Ca        60.2
    Alkalinity 387
    K         3.64
    Mg        74.6
    Cl        11.3
    Na        21
    S(6)      90.4
    Fe        0.139
    Si        6.89
    Mn        0.066
    -water    1 # kg
```

```
   Input file: J:\mark w\sand_coulee4.pqi
  Output file: J:\mark w\sand_coulee4.pqo
Database file: C:\Program Files (x86)\USGS\Phreeqc Interactive 2.17.4799\database\minteq.v4.dat

------------------
Reading data base.
------------------

	SOLUTION_MASTER_SPECIES
	SOLUTION_SPECIES
	SOLUTION_SPECIES
	PHASES
	PHASES
	SURFACE_MASTER_SPECIES
	SURFACE_SPECIES
	END
------------------------------------
Reading input data for simulation 1.
------------------------------------

	DATABASE C:\Program Files (x86)\USGS\Phreeqc Interactive
2.17.4799\database\minteq.v4.dat
	SOLUTION 1 10/16/2000 Sand Coulee Well 3
	    temp      12.6
	    pH        7.21
	    pe        4
	    redox     pe
	    units     mg/l
	    density   1
	    Ca        60.2
	    Alkalinity 387
	    K         3.64
	    Mg        74.6
	    Cl        11.3
	    Na        21
	    S(6)      90.4
	    Fe        0.139
	    Si        6.89
	    Mn        0.066
	    water    1 # kg
-------------------------------------------
Beginning of initial solution calculations.
-------------------------------------------

Initial solution 1.	10/16/2000 Sand Coulee Well 3

-----------------------------Solution composition------------------------------

	Elements           Molality       Moles

	Alkalinity       6.346e-003  6.346e-003
	Ca               1.503e-003  1.503e-003
	Cl               3.189e-004  3.189e-004
	Fe               2.491e-006  2.491e-006
	K                9.316e-005  9.316e-005
	Mg               3.071e-003  3.071e-003
	Mn               1.202e-006  1.202e-006
	Na               9.140e-004  9.140e-004
	S(6)             9.416e-004  9.416e-004
	Si               1.147e-004  1.147e-004

----------------------------Description of solution----------------------------

                                       pH  =   7.210
                                       pe  =   4.000
                        Activity of water  =   1.000
                           Ionic strength  =  1.365e-002
                       Mass of water (kg)  =  1.000e+000
                    Total carbon (mol/kg)  =  7.229e-003
                       Total CO2 (mol/kg)  =  7.229e-003
                      Temperature (deg C)  =  12.600
                  Electrical balance (eq)  =  1.613e-003
 Percent error, 100*(Cat-|An|)/(Cat+|An|)  =   9.23
                               Iterations  =  11
```

sand_coulee4.pqo
Total H = 1.110222e+002
Total O = 5.553275e+001

----------------------------Distribution of species----------------------------

Species		Molality	Activity	Log Molality	Log Activity	Log Gamma
H+		6.921e-008	6.166e-008	-7.160	-7.210	-0.050
OH-		6.920e-008	6.146e-008	-7.160	-7.211	-0.051
H2O		5.551e+001	9.998e-001	1.744	-0.000	0.000
C(4)	7.229e-003					
HCO3-		6.145e-003	5.497e-003	-2.212	-2.260	-0.048
H2CO3		8.948e-004	8.948e-004	-3.048	-3.048	0.000
MgHCO3+		1.050e-004	9.342e-005	-3.979	-4.030	-0.051
CaHCO3+		6.853e-005	6.143e-005	-4.164	-4.212	-0.047
CO3-2		5.139e-006	3.237e-006	-5.289	-5.490	-0.201
MgCO3		3.887e-006	3.887e-006	-5.410	-5.410	0.000
CaCO3		3.302e-006	3.302e-006	-5.481	-5.481	0.000
NaHCO3		3.182e-006	3.182e-006	-5.497	-5.497	0.000
NaCO3-		7.787e-008	6.966e-008	-7.109	-7.157	-0.048
MnHCO3+		7.256e-008	6.482e-008	-7.139	-7.188	-0.049
FeHCO3+		2.832e-008	2.539e-008	-7.548	-7.595	-0.047
Ca	1.503e-003					
Ca+2		1.352e-003	8.518e-004	-2.869	-3.070	-0.201
CaSO4		7.883e-005	7.883e-005	-4.103	-4.103	0.000
CaHCO3+		6.853e-005	6.143e-005	-4.164	-4.212	-0.047
CaCO3		3.302e-006	3.302e-006	-5.481	-5.481	0.000
CaOH+		1.008e-009	9.033e-010	-8.997	-9.044	-0.047
Cl	3.189e-004					
Cl-		3.189e-004	2.841e-004	-3.496	-3.546	-0.050
MnCl+		2.538e-010	2.267e-010	-9.595	-9.644	-0.049
MnCl2		9.100e-014	9.100e-014	-13.041	-13.041	0.000
MnCl3-		7.972e-018	7.121e-018	-17.098	-17.147	-0.049
FeCl+2		1.878e-018	1.196e-018	-17.726	-17.922	-0.196
FeCl2+		2.541e-021	2.270e-021	-20.595	-20.644	-0.049
FeCl3		6.449e-026	6.449e-026	-25.191	-25.191	0.000
Fe(2)	8.867e-007					
Fe+2		8.108e-007	4.737e-007	-6.091	-6.324	-0.233
FeSO4		4.624e-008	4.624e-008	-7.335	-7.335	0.000
FeHCO3+		2.832e-008	2.539e-008	-7.548	-7.595	-0.047
FeOH+		1.298e-009	1.159e-009	-8.887	-8.936	-0.049
Fe(OH)2		4.920e-014	4.920e-014	-13.308	-13.308	0.000
Fe(OH)3-		2.524e-015	2.255e-015	-14.598	-14.647	-0.049
Fe(3)	1.604e-006					
Fe(OH)2+		1.560e-006	1.395e-006	-5.807	-5.855	-0.048
Fe(OH)3		3.977e-008	3.977e-008	-7.400	-7.400	0.000
Fe(OH)4-		4.158e-009	3.720e-009	-8.381	-8.429	-0.048
FeOH+2		1.660e-011	1.057e-011	-10.780	-10.976	-0.196
FeSO4+		7.730e-016	6.906e-016	-15.112	-15.161	-0.049
Fe+3		5.898e-016	2.084e-016	-15.229	-15.681	-0.452
Fe(SO4)2-		8.550e-018	7.475e-018	-17.068	-17.126	-0.058
FeCl+2		1.878e-018	1.196e-018	-17.726	-17.922	-0.196
Fe2(OH)2+4		5.002e-020	5.829e-021	-19.301	-20.234	-0.934
FeCl2+		2.541e-021	2.270e-021	-20.595	-20.644	-0.049
Fe3(OH)4+5		2.958e-024	1.029e-025	-23.529	-24.988	-1.459
FeCl3		6.449e-026	6.449e-026	-25.191	-25.191	0.000
H(0)	6.104e-026					
H2		3.052e-026	3.062e-026	-25.515	-25.514	0.001
K	9.316e-005					
K+		9.288e-005	8.274e-005	-4.032	-4.082	-0.050
KSO4-		2.788e-007	2.494e-007	-6.555	-6.603	-0.048
Mg	3.071e-003					
Mg+2		2.828e-003	1.781e-003	-2.548	-2.749	-0.201
MgSO4		1.340e-004	1.340e-004	-3.873	-3.873	0.000
MgHCO3+		1.050e-004	9.342e-005	-3.979	-4.030	-0.051
MgCO3		3.887e-006	3.887e-006	-5.410	-5.410	0.000
MgOH+		3.935e-008	3.533e-008	-7.405	-7.452	-0.047
Mn(2)	1.202e-006					
Mn+2		1.085e-006	6.339e-007	-5.965	-6.198	-0.233
MnHCO3+		7.256e-008	6.482e-008	-7.139	-7.188	-0.049
MnSO4		4.428e-008	4.428e-008	-7.354	-7.354	0.000
MnCl+		2.538e-010	2.267e-010	-9.595	-9.644	-0.049
MnOH+		1.096e-010	9.787e-011	-9.960	-10.009	-0.049

```
   MnCl2                9.100e-014  9.100e-014   -13.041   -13.041     0.000
   MnCl3-               7.972e-018  7.121e-018   -17.098   -17.147    -0.049
   Mn(OH)3-             4.794e-020  4.283e-020   -19.319   -19.368    -0.049
   Mn(OH)4-2            3.545e-026  2.257e-026   -25.450   -25.646    -0.196
Mn(3)          1.214e-028
   Mn+3                 1.214e-028  4.290e-029   -27.916   -28.367    -0.452
Mn(6)          0.000e+000
   MnO4-2               0.000e+000  0.000e+000   -56.150   -56.346    -0.196
Mn(7)          0.000e+000
   MnO4-                0.000e+000  0.000e+000   -62.514   -62.566    -0.052
Na             9.140e-004
   Na+                  9.086e-004  8.094e-004    -3.042    -3.092    -0.050
   NaHCO3               3.182e-006  3.182e-006    -5.497    -5.497     0.000
   NaSO4-               2.184e-006  1.954e-006    -5.661    -5.709    -0.048
   NaCO3-               7.787e-008  6.966e-008    -7.109    -7.157    -0.048
O(0)           0.000e+000
   O2                   0.000e+000  0.000e+000   -44.814   -44.813     0.001
S(6)           9.416e-004
   SO4-2                7.263e-004  4.574e-004    -3.139    -3.340    -0.201
   MgSO4                1.340e-004  1.340e-004    -3.873    -3.873     0.000
   CaSO4                7.883e-005  7.883e-005    -4.103    -4.103     0.000
   NaSO4-               2.184e-006  1.954e-006    -5.661    -5.709    -0.048
   KSO4-                2.788e-007  2.494e-007    -6.555    -6.603    -0.048
   FeSO4                4.624e-008  4.624e-008    -7.335    -7.335     0.000
   MnSO4                4.428e-008  4.428e-008    -7.354    -7.354     0.000
   HSO4-                2.103e-009  1.875e-009    -8.677    -8.727    -0.050
   FeSO4+               7.730e-016  6.906e-016   -15.112   -15.161    -0.049
   Fe(SO4)2-            8.550e-018  7.475e-018   -17.068   -17.126    -0.058
Si             1.147e-004
   H4SiO4               1.145e-004  1.149e-004    -3.941    -3.940     0.001
   H3SiO4-              2.132e-007  1.898e-007    -6.671    -6.722    -0.051
   H2SiO4-2             1.479e-013  9.475e-014   -12.830   -13.023    -0.194

------------------------------Saturation indices-------------------------------

        Phase               SI log IAP  log KT

        Anhydrite        -2.10   -6.41   -4.31  CaSO4
        Aragonite        -0.35   -8.56   -8.21  CaCO3
        Artinite         -7.08    3.43   10.51  MgCO3:Mg(OH)2:3H2O
        Birnessite      -13.62    4.47   18.09  MnO2
        Bixbyite        -13.78  -13.48    0.30  Mn2O3
        Brucite          -6.04   11.67   17.71  Mg(OH)2
        Calcite          -0.14   -8.56   -8.42  CaCO3
        CH4(g)          -66.59 -109.59  -43.00  CH4
        Chalcedony       -0.24   -3.94   -3.70  SiO2
        Chrysotile       -6.56   27.13   33.69  Mg3Si2O5(OH)4
        CO2(g)           -1.73  -19.91  -18.18  CO2
        Cristobalite     -0.44   -3.94   -3.50  SiO2
        Dolomite(disordered)  -0.61  -16.80  -16.19  CaMg(CO3)2
        Dolomite(ordered)  -0.01  -16.80  -16.79  CaMg(CO3)2
        Epsomite         -3.88   -6.09   -2.21  MgSO4:7H2O
        Fe(OH)2          -5.47    8.10   13.56  Fe(OH)2
        Fe(OH)2.7Cl.3     5.76    2.72   -3.04  Fe(OH)2.7Cl.3
        Fe2(SO4)3       -39.49  -41.38   -1.89  Fe2(SO4)3
        Fe3(OH)8         -0.23   19.99   20.22  Fe3(OH)8
        Ferrihydrite      2.20    5.95    3.75  Fe(OH)3
        Goethite          5.00    5.95    0.95  FeOOH
        Greenalite       -4.40   16.41   20.81  Fe3Si2O5(OH)4
        Gypsum           -1.79   -6.41   -4.62  CaSO4:2H2O
        H-Jarosite       -7.33  -17.67  -10.35  (H3O)Fe3(SO4)2(OH)6
        Halite           -8.21   -6.64    1.57  NaCl
        Hausmannite     -17.14   47.09   64.23  Mn3O4
        Hematite         12.33   11.90   -0.44  Fe2O3
        Huntite          -4.13  -33.28  -29.15  CaMg3(CO3)4
        Hydromagnesite  -14.18  -21.29   -7.11  Mg5(CO3)4(OH)2:4H2O
        K-Jarosite       -0.74  -14.55  -13.81  KFe3(SO4)2(OH)6
        Lepidocrocite     4.58    5.95    1.37  FeOOH
        Lime            -22.82   11.35   34.17  CaO
        Maghemite         5.51   11.90    6.39  Fe2O3
        Magnesioferrite   4.59   23.57   18.98  Fe2MgO4
        Magnesite        -0.63   -8.24   -7.61  MgCO3
        Magnetite        15.00   19.99    4.99  Fe3O4
        Manganite        -5.91   19.43   25.34  MnOOH
```

```
        Melanterite       -7.30   -9.66   -2.36  FeSO4:7H2O
        Mg(OH)2(active)  -7.12   11.67   18.79  Mg(OH)2
        Mirabilite        -7.81   -9.52   -1.72  Na2SO4:10H2O
        Mn2(SO4)3        -62.29  -66.75   -4.47  Mn2(SO4)3
        MnCl2:4H2O       -16.09  -13.29    2.80  MnCl2:4H2O
        MnSO4            -12.61   -9.54    3.08  MnSO4
        Na-Jarosite       -3.51  -13.55  -10.05  NaFe3(SO4)2(OH)6
        Natron            -9.86  -11.67   -1.81  Na2CO3:10H2O
        Nesquehonite      -3.75   -8.24   -4.49  MgCO3:3H2O
        Nsutite          -13.03    4.47   17.50  MnO2
        O2(g)            -42.60   44.84   87.44  O2
        Periclase        -11.06   11.67   22.73  MgO
        Portlandite      -12.43   11.35   23.78  Ca(OH)2
        Pyrochroite       -7.71    8.22   15.93  Mn(OH)2
        Pyrolusite       -12.81   30.64   43.45  MnO2
        Quartz             0.23   -3.94   -4.17  SiO2
        Rhodochrosite     -1.12  -11.69  -10.57  MnCO3
        Sepiolite         -5.10   11.52   16.63  Mg2Si3O7.5OH:3H2O
        Sepiolite(A)      -7.26   11.52   18.78  Mg2Si3O7.5OH:3H2O
        Siderite          -1.70  -11.81  -10.12  FeCO3
        SiO2(am-gel)      -1.12   -3.94   -2.82  SiO2
        SiO2(am-ppt)      -1.08   -3.94   -2.86  SiO2
        Thenardite        -9.91   -9.52    0.39  Na2SO4
        Thermonatrite    -12.39  -11.67    0.72  Na2CO3:H2O

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End of simulation.
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Reading input data for simulation 2.
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End of run.
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APPENDIX D

GWIC DATABASE FOR MADISON WELLS

GWIC DATABASE FOR MADISON WELLS

Madison_Wells.M NUMBER	Madison_Wells.D NRC_NO	Madison_Wells.SITE_NAME	Madison_Wells. LATITUDE	Madison_Wells. LONGITUDE	Madison_Wells. TOT_DEPT	Madison_Wells. PWL	Madison_Wells. SWL	Madison_Wells. RECOV_WL	Madison_Wells. YIELD
2244		KUJALA RICHARD	47.413805	-111.161565	158	135	0	0	30
2245		KRAVULLA MIKE	47.4058	-111.156355	170	72	36	0	25
2247		SWANSON GARY	47.4044	-111.1548	185	150	121	0	20
2249		KAVULLA GEORGE	47.401149	-111.165367	328	0	165	0	3
2284		TOWN OF STOCKETT	47.3548	-111.1658	830	0	300	0	50
2285		HEAL WELL-2 TRACY	47.4144	-111.1486	220	0	69.5	0	0
2289		TRACY WATER USERS CORPORATION	47.4119	-111.1536	191	150	150	0	25
2293		MCEWEN LARRY	47.404838	-111.152961	162	155	143	0	40
2294	C1873-00	LUOMA MARTIN J	47.402952	-111.151796	210	175	175	0	60
2295		TERRY NET*.75 MI NW OF CENTERVILL	47.3961	-111.1525	175	0	79.76	0	11
2296		CENTERVILLE SENIOR CITIZENS CENT	47.3922	-111.1438	200	0	124.3	0	0
2301	19027	BEHRENT THOMAS	47.3888	-111.1375	107	95	31	0	7
2302		HEAL GEORGE * CENTERVILLE MT *	47.3919	-111.1416	410	0	0	0	7
2303		SUTICH PETE * CENTERVILLE BEHIND	47.3905	-111.1427	365	0	0	0	9
2305		CENTERVILLE BAR - WELL 1	47.3898	-111.1437	210	0	144.74	0	0
2307		ST PIUS X CENTER * CENTERVILLE MT	47.3872	-111.1405	0	0	0	0	0
2308	C21421-00	GUISTI BRIAN AND MERVA MICHAEL P	47.383909	-111.147294	290	285	205	0	15
2309	C26954-00	GUISTI RONALD AND JUDITH	47.383909	-111.147294	235	230	160	0	25
2311		KNOX DUANE E AND ELANE* DW-01	47.389278	-111.135463	258	0	150	0	10
2312		TAMIETTI WILLIAM	47.3888	-111.1355	220	0	120	0	0
2438		MBMG RESEARCH WELL Q-A1	47.4394	-111.1747	125	0	100	0	10
31857		LARKFORD GARY	47.413211	-111.254352	520	0	368	0	13
31858		WARNER STAN	47.409048	-111.256517	405	400	335	0	11
31860		HENDRICKSON LOU	47.412135	-111.232713	403	350	100	0	3
31866		FRANCETICH JOSEPH	47.393699	-111.186208	216	28	0	0	13
31868		MAPSTON ALBERT AND ELIZABETH	47.399754	-111.16601	257	0	170	0	14
31872		FRANCETICH JOSEPH	47.409683	-111.164817	216	0	175	0	13
31878	C69367-00	JOHN JARVI ESTATE	47.397428	-111.160217	300	290	266	266	16
31879		PEO CHARLES AND LINDA	47.397428	-111.157642	175	175	130	0	20
31886		FRANCETICH JOSEPH	47.393699	-111.186208	216	28	0	0	13
31892	C66898-00	KNAUP RICHARD	47.40666	-111.23201	400	0	315	0	22
31898	C6122-00	SWARTZENBERGER GEROLD	47.384763	-111.195376	586	585	515	0	5
31899	C68162-00	CHARTIER RICHARD	47.372549	-111.158322	400	0	217	217	18
31916		HABEL ED	47.43513	-111.15256	245	140	75	0	35
31918	C19724-00	CLAY SGT EDWARD	47.414125	-111.146261	280	0	120	0	0
31920		TRACY WATER USERS CORPORATION	47.4121	-111.1525	228	152	152	152	100
31922	C16444-00	ROGERS JIM	47.40248	-111.152378	386	0	160	160	80
31926		SURMI WILLIAM	47.40531	-111.153543	165	156	148	0	12
31927	C30041553	HERING ALDEN K	47.40531	-111.153543	187	180	165	0	16
31929	C68142-00	ELLER EMMET AND BONNIE	47.401537	-111.153543	175	140	130	130	35
31931	C4650-00	KINNA BOB	47.393993	-111.144226	430	410	180	0	6
31932		CENTERVILLE SCHOOL DISTRICT 5	47.388517	-111.141576	398	0	0	0	11
31935	C024427-00	CENTERVILLE SCHOOL DISTRICT 5	47.3877	-111.14	262	250	150	0	30
31938		SLAUGHTER BILLIE B AND BARBARA J	47.390662	-111.134683	228	225	170	0	10
31939	C26978-00	KNOX DUANE	47.387895	-111.136243	344	221	118	0	50
33513		VOELLER MARCUS J.	47.451467	-111.202497	435	210	160	0	18
33569		KIND STEPHEN AND MARILYN	47.441	-111.2318	150	0	100	0	12
33572	C068155-00	BERTI JUSTIN AND FLORENTINA	47.445159	-111.169175	267	245	125	0	50
33573		L JOHNSON INC.	47.448346	-111.159493	317	0	0	0	1000
33574		LYMAN HOWARD	47.445615	-111.163366	697	0	0	0	4000
33575		UDALL RON	47.443794	-111.174985	266	250	137	0	55
33576	C061486-00	SCOTT JAMES	47.449712	-111.167884	240	75	75	0	30
33578	C064865-00	DIGE ROBERT AND INGOLD E W	47.449712	-111.17563	244	200	130	0	50
33579	C064740-00	SPURGEON DON	47.447891	-111.173048	254	230	150	0	50
33610	61448	JOHNSON GENE	47.436951	-111.137736	343	121	120	0	33
33612	74537	PEARSON DOUG	47.445213	-111.135319	250	0	147	147	60
122946	C68114-00	HOLZHEIMER WESLEY AND KIMBERLY	47.429647	-111.229371	105	0	85	0	20
122947		CENTERVILLE SCHOOL DISTRICT 5	47.3898	-111.1423	300	270	165	165	100
123393		BALLINGER DAVID AND ELIZABETH	47.448801	-111.174339	244	240	130	130	30
123395	71629	SHUMAKER GENE	47.437875	-111.12972	245	0	128	128	65
123492		HALL KYRON	47.411361	-111.257238	475	0	368	0	20
123493	C77874-00	BIG STONE COLONY	47.398811	-111.207231	560	450	380	0	30
123494		NEARY BOB	47.405367	-111.255542	550	0	372	0	15
123495	C72974-00	SHUMAKER TRUCKING AND EXCAVATI	47.365164	-111.173706	700	0	634	0	22
123499		OCONNELL LEROY AND CHARMAYNE	47.396822	-111.152378	261	210	169	169	20
123636	C094914-00	CENTERVILLE WATER USERS ASSOCIA	47.391	-111.1442	460	340	175	0	43
125083	79466	LEWIS WILLIAM B OR ALYCE A	47.449712	-111.17563	271	200	140	0	50
125190	C79487-00	LAROCQUE FRED	47.380628	-111.193345	655	0	448	448	50
126078		KNAUP RICHARD	47.41228	-111.23337	450	0	342	0	15
127956		CHAMBERLIN VIRGIL R	47.4391	-111.1558	2172	0	0	0	0
129230		CHARTIER RICHARD	47.376965	-111.190833	432	367	367	367	35
130732		MCMILLAN GORDON AND CHARLENE	47.406266	-111.159574	200	0	109	109	30
139022		KONESKY GEORGE AND DIANE	47.36952555	-111.2397018	675	0	525	0	25
139023	C88173-00	JENKINS MIKE	47.427	-111.1248	540	0	210	210	50
145600		VINNING BRIAN	47.411361	-111.260125	482	0	390	0	15
145602	C90412-00	KOPPANY MICHELLE	47.4311	-111.1515	220	0	138	138	30
145616	C090376-00	DICKMAN DAVE	47.442286	-111.205143	400	300	230	230	35
145619	C101567-00	BYRNE PAT AND JOYCE	47.4458	-111.1568	220	200	125	0	50
146636	C30002287	VINNING BRIAN	47.411361	-111.260125	480	0	390	390	30
148870		ROSSMILLER DANA	47.424047	-111.12137	540	0	240	240	60
149855	30028244	HALKO PATRICK M & JAMI L	47.409683	-111.162215	210	0	90	0	60
152609	C100550-00	HEPFNER JOE	47.391743	-111.143291	420	230	165	170	8
158292	C100602-00	GROCE RANDY AND JOYCE	47.409683	-111.164817	325	0	133	123	30
158293		DORAN DAN	47.396963	-111.162148	300	0	108	0	30
158294		CHARTIER RICHARD	47.387061	-111.183868	350	0	168	0	20
158295	C30047126	MAYERNIK CLEM AND MILLY	47.404367	-111.154707	200	0	80	0	65
159224	C100532-00	GRIFFIN STEVE	47.404405	-111.162148	180	0	138	0	30
165473	C30026115	PRILL DAN	47.417011	-111.157012	180	0	106	106	35
165474	C105774-00	ROGERS JIM	47.40248	-111.154707	168	0	72	72	20
165613	C103270-00	RUSSELL KEN AND TONIA	47.404367	-111.152378	250	0	85	85	9
166933	C103314-00	ERIKSON GEORGE AND BARBARA	47.402545	-111.156999	180	170	128	0	35
178365		CHARTIER ERNEST	47.376241	-111.168578	31	14	14	0	10
184410	C30001659	REIMERS STEVE	47.366087	-111.15704	561	0	310	312	17
184415		NARDINGER PHIL	47.3899	-111.143291	240	0	163	0	35
186470	C113621-00	CHARTIER RICHARD	47.37886	-111.226563	600	540	540	540	9
186474	C113678-00	HAKOLA ED	47.38865	-111.19315	700	0	418	419	12
186950	C30000878	NARDINGER PHIL	47.413347	-111.170021	280	0	160	160	60
193214	C30002290	JAAP STEVE	47.416912	-111.248578	420	0	224	224	30
193216	C30001592	JARVI KEN AND ALVIN	47.395103	-111.156999	415	0	221	221	5
196510	C30000876	MOTIL RICHARD	47.398911	-111.256959	585	429	383	383	18
203943		INGMAN EDDIE AND CINDY	47.40248	-111.152378	358	0	178	178	12
205577		ROBERTSON BOB	47.373348	-111.226357	740	0	593	593	50
205599		MCEWEN LARRY AND MARLENE	47.404367	-111.152378	216	0	173	173	35
205642		DILLEY OTIS	47.393993	-111.144226	505	0	172	172	22
210883	C30042637	GUISTI RON	47.427732	-111.15256	220	0	137	137	65
210914		SAPPINGTON KENNTH AND VICTORIA	47.396822	-111.152378	171	0	140	160	40
217192		"NELSON, RON"	47.4367	-111.2193	160	0	103	103	15
220731	C30030280	"BACK, ROY"	47.439	-111.2228	160	0	88	88	60
223973	30027844	"MCKELVEY, CONN"	47.4226	-111.1207	540	0	392	392	20
224432	C30028714	"SAVINO, ANTHONY"	47.4523	-111.1983	210	0	161	161	35
227473		KT LAND CO.	47.390737	-111.178453	280	0	205	205	10
230156		CHARTIER KORY	47.357875	-111.173871	670	0	470	470	35
230686	30028610	WALTERS RICHARD AND ELAINE	47.3936	-111.1932	636	0	420	420	39
231134		BIG STONE COLONY	47.39887	-111.20782	572	0	472	480	30
234606	30028720	ZIGAN AL AND CATHYE	47.4076	-111.2472	683	0	402	379	24
239025	C30030277	MOULTRAY LAMONTE	47.4527	-111.1967	230	0	149	149	35

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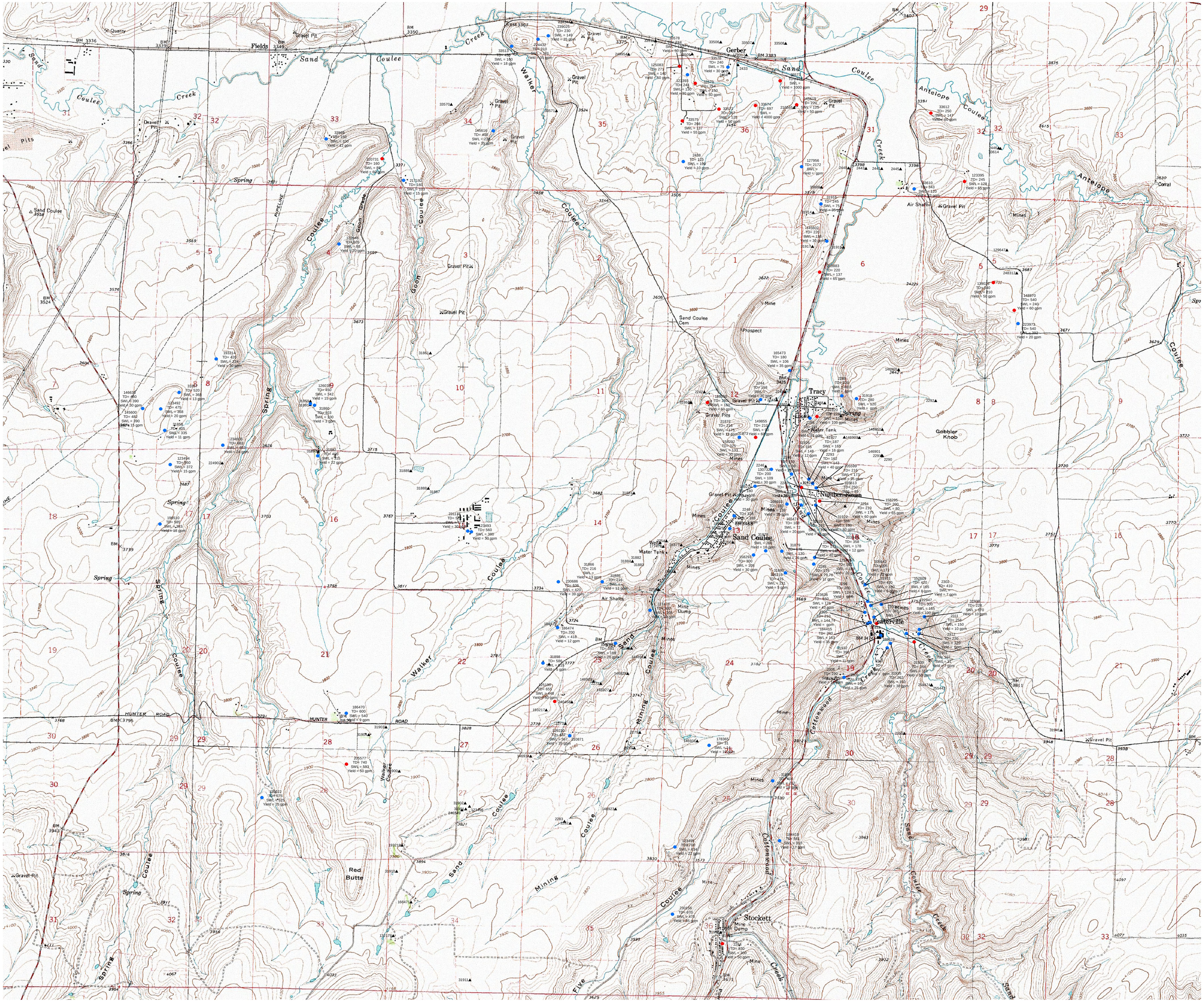

N

0 750 1,500 3,000 4,500
Scale in Feet

Legend

- ● Madison Formation <50 gpm yield
- ● Madison Formation >50 gpm yield
- ▲ Other Formation Wells

EXHIBIT 1
GWIC WELLS WITHIN 4 MILES OF
SAND COULEE WATER SUPPLY WELLS

V:\10039\GIS\MADISON_WELLS.MXD