Powertech (USA) Inc.
Docket No. 40-9075-MLA
Docketed USNRC
March 14, 2014
Office of the Secretary

Jerri Baker
705 North River Street
Hot Springs, SD
57747
605-891-8824

Office of the Secretary
Rulemakings and Adjudications Staff
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555-001

Docket No. 40-9075-MLA
ASLBP No. 10-898-02-BD01

2/22/2014

To Whom This May Concern,

I am writing with great concerns about this insitu mining project. I worked in Rifle, CO on the two UMTRA sites where I was exposed to the toxic levels of metals,enclosed is a recent hair anyalsis. While I am thankful that the government is trying to clean up it's surface mining messes from the 50's, it is a fact that uranium mining is dangerous to all living things. Currently, there are no available chelators or complexing agents that have been established to be effective for uranium retention associated with long-term, low-level exposure to uranium. Times are changing, our earth is in danger of becoming totally toxic and I believe it is time to step back and review the damage we are doing and the legacy we are leaving for the future.

The area in which Powertech proposes to mine is already a mine. This is very dangerous not only for the people doing the mining, but all of the communities around it. How will the company protect the workers or the public? No SOP measures were listed, in fact I found little about the previous mines. When questioned in court the company has yet to explain exactly how they plan to mine in those pit areas. This area is in need of midigation measures that would stop the water from running into the two tributaries that are located on the site, and to protect the surrounding homes, people that are down stream, and the local communties, from contaminants that are in the up to 90 mile an hour winds that blow in different directions through this whole state.

Clean water is the most precious of all our resources and is dwindling all over the U.S. I ask that you reconsider your decesion, and not allow a foreign company to mine with our only water source. Please read Executive Order 12898 entitled "Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations." Please read the documents enclosed that support my opposition to this project. I have done my best to limit the information to a few pages, there are more reasons and proof not to do this, than for.

Respectfully,

Jerri Baker

Jerri Baker

Jerri Baker
Docket No. 40-9075-MLA
ASLBP No. 10-898-02-MLA-BD01

Wind Speeds
~~Documents~~ that were taken from away from the proposed site, therefore are not accurate. Winds of up to 90 mile an hour have been reported./Tornado hit 2013, very close to the site.

## Figure 7

Newcastle Wind Data Summary

**1/1/2002 - 8/31/2011**

**Hourly Data**

| | | Average | Max | Min |
|---|---|---|---|---|
| Wind Speed (mph) | | 6.84 | 31.23 | - |
| Sigma Theta (°) | | 19.39 | 86.10 | 0.00 |
| Wind Direction | | | | |
| | N | 6.71 | 29.40 | - |
| | NNE | 4.60 | 28.19 | 0.06 |
| | NE | 4.38 | 27.31 | 0.03 |
| | ENE | 4.35 | 26.96 | - |
| | E | 5.89 | 27.87 | 0.04 |
| | ESE | 7.75 | 25.11 | 0.02 |
| | SE | 8.51 | 23.96 | 0.19 |
| | SSE | 7.69 | 25.66 | 0.13 |
| | S | 6.38 | 22.48 | 0.11 |
| | SSW | 5.55 | 23.26 | 0.00 |
| | SW | 5.90 | 25.23 | 0.03 |
| | WSW | 6.41 | 25.18 | 0.02 |
| | W | 7.11 | 25.77 | 0.12 |
| | WNW | 8.93 | 27.69 | 0.04 |
| | NW | 11.05 | 31.23 | 0.07 |
| | NNW | 9.55 | 29.93 | 0.06 |

Predominant wind direction was from the NE sector, accounting for 16.6% of the winds, the average wind direction was 31°.

**Data Recovery**

| | | Possible (hours) | Reported (hours) | Recovery |
|---|---|---|---|---|
| Wind Speed | | 84720 | 81975 | 96.76% |
| Sigma Theta | | 84720 | 81975 | 96.76% |
| Wind Direction | | 84720 | 81975 | 96.76% |

# Rare tornado touches down in KOTA Territory

*Posted: Jun 12, 2008 3:01 PM MDT*

According to the National Weather Service, a tornado touched down in the western Black Hills between Newcastle and Lead Tuesday evening. Susan Sanders, a National Weather Service meteorologist confirmed a tornado occurred after she surveyed damage in the area.

The tornado first touched down three and a half miles southeast of Four Corners, Wyoming about 6:50 pm MDT and blew down trees along Beaver Creek Road. A continuous path of downed trees was noted from just southeast of the Beaver Creek Campground in the South Dakota portion of the Black Hills National Forest northeastward to Forest Service Road 110, or about a distance of three and a half miles. Large pine, spruce, and aspen trees were blown down and many were snapped. Based on the type of damage, winds were estimated at 110 mph, giving the storm a rating of EF1 on a scale of EF0 to EF5. No structure damage was observed.

Doppler radar indicated the tornado initially developed around 6:50 pm MDT and dissipated around 7:06 pm MDT. No one witnessed the tornado.

While tornadoes in the Black Hills are not as common as on the surrounding plains, they do occur, the NWS release said. The last tornado reported in the Black Hills was a brief funnel sighted northwest of Custer on July 7, 2001.



KOTA TERRITORY NEWS

Telephone:
Fax:

Search for it here...

KOTA TERRITORY NEWS

Web
Site
Search...

RADAR
FORECAST



# Confirmed tornado strikes south of Hill City

*Posted: Aug 12, 2013 11:29 AM MDT*

Tornado sirens blare across the central Black Hills, as a confirmed EF-1 tornado touches down a mere two miles from Hill City.

A close call for campers, and anyone out Needles Highway, ground zero for the destruction.

The heaviest damage was along Highway 87 (Needles Highway) just east of Highway 385.

Droves of trees were twisted and flattened, so much so that the road was blocked for awhile.

Even Monday morning crews were still working to remove trees from along side the road and power lines in the area.

Also with this storm was large hail, and torrential rain. Hail in some cases exceeding three inches in diameter.

Snow plows were sent out along Highway 385 as the storm made it's way south of Custer, to clear the hail that piled up on the highway.

We spoke to campers at the Crooked Creek Resort, a mere half mile from where the tornado touched down about their horrifying experience.

"It was horrible, we were fearing we'd lose everything. The motorcycle, the camper, the awning. We came out to hold down the awning and I know it sounds crazy but I was lifted up off the ground," says Joanne Moore of Wisconsin.

The National Weather Service surveyed the damage. They rated the tornado an EF-1 on the Enhanced Fujita Scale, the scale goes from zero to five. An EF-5 would have wind speeds exceeding 200 miles per hour.



KOTA TERRITORY NEWS

Jerri Baker
Docket No. 40-9075-MLA
ASLBP No. 10-898-02-MLA-BD01

Your own document, is there actually enough uranium there to warrant another mining project, when the last ones were not cleaned up?

NUREG/CR-6870

# Consideration of Geochemical Issues in Groundwater Restoration at Uranium In-Situ Leach Mining Facilities

Manuscript Completed: December 2006
Date Published: January 2007

Prepared by
J.A. Davis, G.P. Curtis

U.S. Geological Survey
Menlo Park, CA 94025

A. Schwartzman, NRC Project Manager

Prepared for
Division of Fuel, Engineering and Radiological Research
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001
NRC Job Code Y6462

**Table 5. Crow Butte (Nebraska) Mine Unit No. 1 Restoration Results (Crow Butte Resources, 2000b). All units in mg/L except for pH (standard units), radium (pCi/L), and specific conductivity (micromho/cm).**

| Parameter | Baseline Water Quality | Post-Mining Average Water Quality | Post-Restoration Average Water Quality | Stabilization Period Average Water Quality |
|---|---|---|---|---|
| Alkalinity | 293 | 875 | 321 | 347 |
| Ammonium | 0.37 | 0.277 | 0.08 | 0.12 |
| Arsenic | 0.002 | 0.021 | 0.024 | 0.017 |
| Barium | 0.1 | <0.10 | <0.10 | <0.10 |
| Bicarbonate | 344 | 1068 | 392 | 421 |
| Boron | 0.93 | 1.22 | 0.4 | 0.46 |
| Cadmium | 0.006 | <0.01 | <0.005 | <0.005 |
| Calcium | 12.5 | 88.7 | 16.0 | 19.9 |
| Carbonate | 7.2 | 0 | <1.0 | 1.9 |
| Chloride | 204 | 583 | 124 | 139 |
| Chromium | <0.03 | <0.05 | <0.05 | <0.05 |
| Copper | 0.017 | 0.035 | <0.01 | <0.01 |
| Fluoride | 0.69 | 0.41 | 0.55 | 0.54 |
| Iron | 0.044 | 0.078 | <0.05 | 0.09 |
| Lead | 0.031 | <0.05 | <0.05 | <0.01 |
| Magnesium | 3.2 | 23 | 4.4 | 5.3 |
| Manganese | 0.11 | 0.075 | 0.01 | 0.02 |
| Mercury | 0.001 | <0.001 | <0.001 | <0.001 |
| Molybdenum | 0.069 | 0.487 | <0.10 | 0.10 |
| Nickel | 0.034 | 0.068 | <0.05 | <0.01 |
| Nitrate | 0.05 | 1.01 | <0.10 | <0.11 |
| Nitrite | 0.01 | N/A | <0.10 | <0.1 |
| pH | 8.5 | 7.35 | 7.95 | 8.18 |
| Potassium | 12.5 | 30.0 | 13.0 | 13.2 |
| Radium-226 | 229.7 | 786 | 246.7 | 303 |
| Selenium | 0.003 | 0.124 | 0.001 | <0.002 |
| Silica | 16.7 | N/A | 13.6 | 14.4 |
| Sodium | 412.2 | 1117 | 315 | 352 |
| Specific Cond. | 1947 | 5752 | 1620 | 1787 |
| Sulfate | 356.2 | 1128 | 287 | 331 |
| TDS | 1170.2 | 3728 | 967 | 1094 |
| Uranium | 0.092 | 12.2 | 0.963 | 1.73 |
| Vanadium | 0.066 | 0.96 | 0.26 | 0.11 |
| Zinc | 0.036 | 0.038 | <0.01 | <0.02 |

N/A means not available

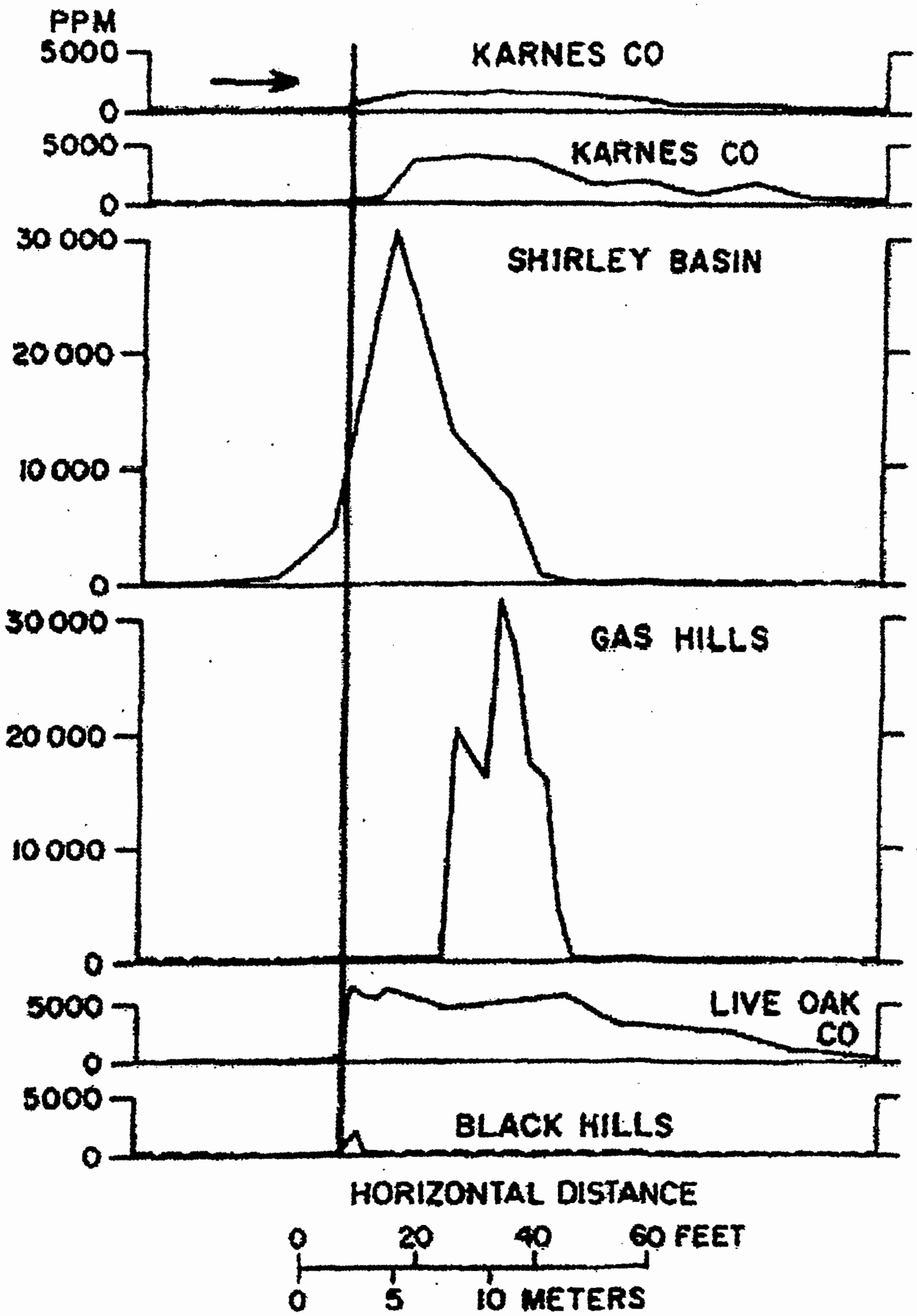



**Figure 5. Concentration and distribution of uranium in various roll front deposits (after Harshman, 1974).**



NIOn D..

Jerri Baker
Docket No. 40-9075-MLA
ASLBP No. 10-898-02-MLA-BD01

Earth Quake just above proposed site.

**NEWS**

[0] My Saved Articles

# Small Quake Shakes Southern Black Hills, Evacuates Sanford Lab

December 12, 2013, 11:18 AM
Updated: December 12, 2013, 1:27 PM


Sanford Underground Research Facility





RAPID CITY, SD - A small early morning earthquake rumbled in the Black Hills on Thursday.

Sensors detected the quake in Custer State Park near the Black Hills Playhouse and Center Lake at about 2:45 a.m. The location is about eight miles south of Mount Rushmore.

Officials with the Sanford Underground Research Facility say their staff safely evacuated a few of their underground labs after the quake was felt there around 8:50 a.m. Thursday morning.

Lab personnel will inspect the lab to make sure there are "no unusual circumstances" before allowing re-entry. Lawrence County Emergency Management was also notified and is on standby at Sanford Lab.

The U.S. Geological Survey says the quake registered 3.5 on the Richter scale at a depth of four kilometers.

The USGS says it is unlikely that many felt the quake unless they were very close to the epicenter.



(/NEWSDETAIL.CFM/PRESCRIBED-BURNS-PLANNED-TO-ENHANCE-SD-ELK-HABITAT/?ID=157333) PREVIOUS STORY (/NEWSDETAIL.CFM/PRESCRIBED-BURNS-PLANNED-TO-ENHANCE-SD-ELK-HABITAT/?ID=157333)

NEXT STORY (/NEWSDETAIL.CFM/HY-VEE-OFFERS-HOLIDAY-SPECIALS-THROUGH-FACEBOOK/?ID=157336) (/NEWSDETAIL.CFM/HY-VEE-OFFERS-HOLIDAY-SPECIALS-THROUGH-FACEBOOK/?ID=157336)

12/12/13 - Prescribed Burns Planned To Enhance SD Elk Habitat (/newsdetail.cfm/prescribed-burns-planned-to-enhance-sd-elk-habitat/?id=157333)

12/12/13 - Hy-Vee Offers Holiday Specials Through Facebook (/newsdetail.cfm/hy-vee-offers-holiday-specials-through-facebook/?id=157336)

**Most Popular Today**

1. Retail & Restaurants
Irish Pub Coming To Downtown Sioux Falls (/newsdetail.cfm/irish-pub-coming-to-downtown-sioux-falls/?id=160492)

2. Tourism
Alabama To Play At South Dakota State Fair (/newsdetail.cfm/alabama-to-play-at-south-dakota-state-fair/?id=160437)

3. Health Care
Sanford Health Buys $30 Million Software System For Hospitals, Clinics (/newsdetail.cfm/sanford-health-buys-30-million-software-system-for-hospitals-clinics/?id=160493)

4. Banking/Finance
Capital One Users Raise Concerns Over User Agreement (/newsdetail.cfm/capital-one-users-raise-concerns-over-user-agreement/?id=160406)

5. Retail & Restaurants
Signet Jewelers Buying Zale For About $690M (/newsdetail.cfm/signet-jewelers-buying-zale-for-about-690m/?id=160435)

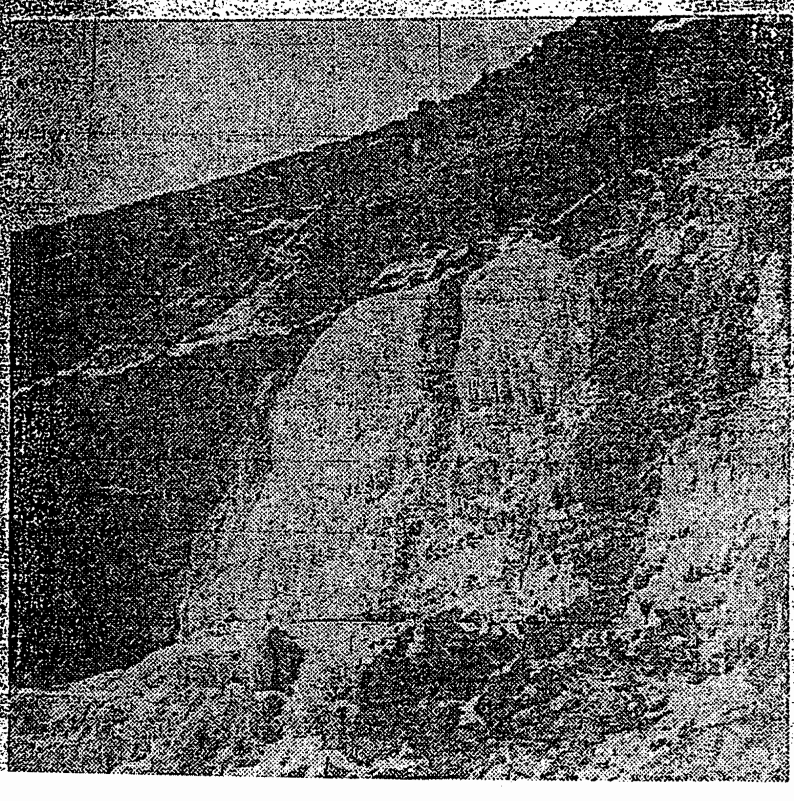
Show More

Jerri Baker
Docket No. 40-9075-MLA
ASLBP No. 10-898-02-MLA-BD01

Old article from the 60's showing how connected aquifers are with the wetlands./Drawing by Dr. Perry Rahn of the SD School of Mines of the aquifers below.

EXHIBIT 815

Beautiful frozen waterfalls adorn the sheer 130 foot walls of the new open pit uranium mine opened last fall by Mines Development, Inc., of Edgemont. The open pit mining operation is near the end of the tunnel operations of the old Triangle mines northeast of Burdock which were dynamited with 25 cases of explosives after which some 339,000 cubic yards of earth were excavated to create the gigantic hole. The largest and most spectacular of the great waterfalls was hidden in the shadows of the setting sun and could not be photographed. These beautiful sights will not be seen by many . . . . no visitors allowed and, within a few months, the hole will be filled again. For more about this man-made phenomena, see the column, "That Reminds Me" in this issue.



Herald - Tribune

January 26, 196.

26

From a report by: Perry H. Rahn, [illegible]

Powertech proposes to inject the Minnelusa Fm. and Deadwood Fm. with wastewater.

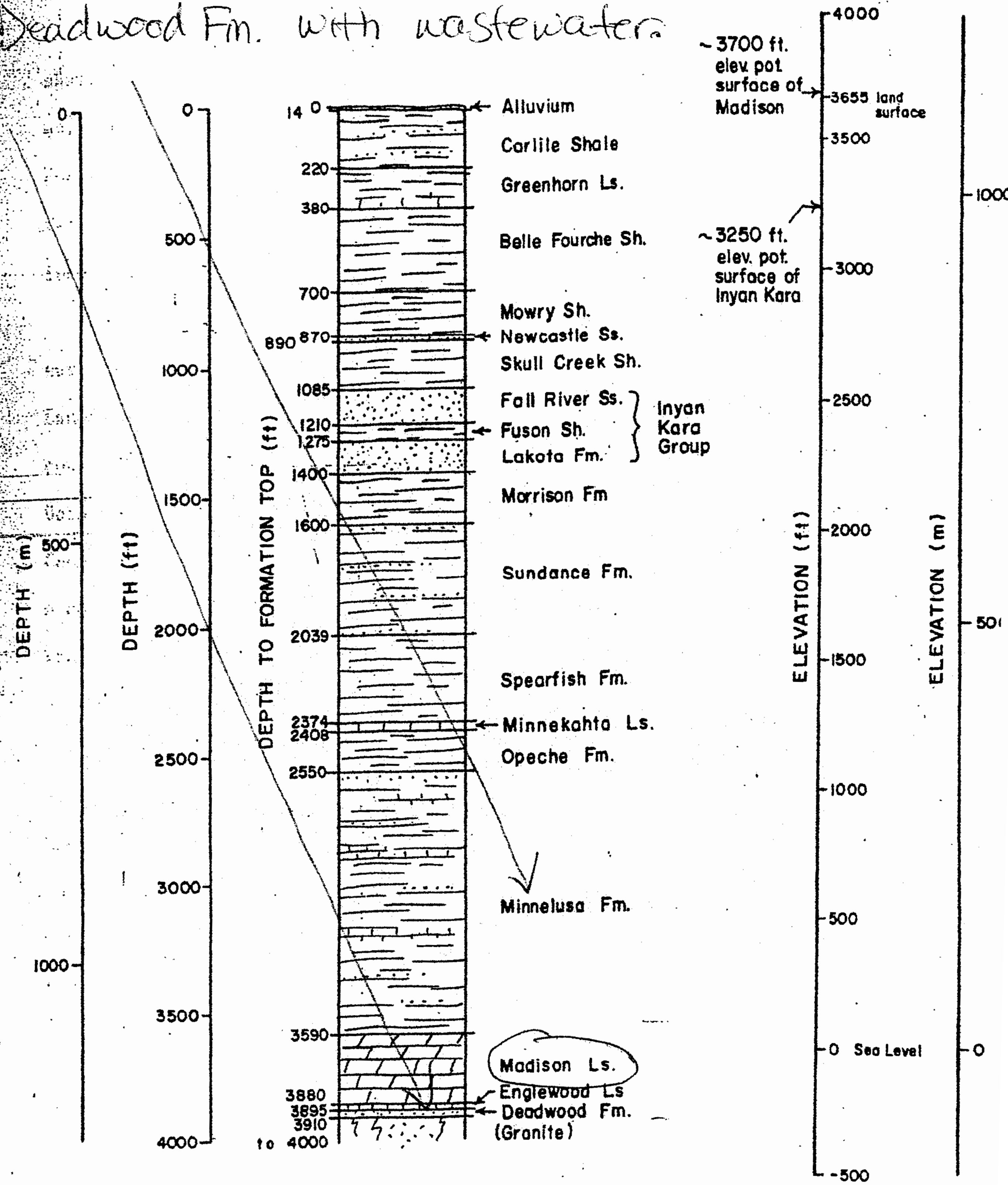



Figure I - 8. Log of well at Black Hills Ordinance Depot Well #1 (Location: NE1/4 of SE1/2, Sec. 3, T10S, R2E).

Rosenthal, W. M., et al., 1985, Evaluation of shale hosted low-level radioactive waste disposal site in semi-arid environment: Final Report, US DOE, Low-level Waste Management Program, SDSM&T, Sept. 1985.

Jerri Baker
Docket No. 40-9075-MLA
ASLBP No. 10-898-02-MLA-BD01

Flood just above the proposed site. Washed down through site tributaries./First photo taken of Pass Creek, miles down the road. At least 20ft across. (Climate change, issues not represented in the FEIS) (Public Safety) The tributaries run into the Cheyenne River, then the Missouri, Mississippi and finally the ocean.

# Hopper Train Derailment Jul. 8 Near Dewey Due to Washout

TRIBUNE
www.EdgemontTribune.com tribune@gwtc.net
Serving the SW South Dakota neighborhoods of Edgemont, Dudley, Burdock, Dewey, Provo, Cottonwood, Igloo, Rumford, Minnekahta Jct., Mule Creek Jct., Cascade, Maitland, Hot Springs, Oelrichs, Smithwick, Oral, Ardmore, Pringle, and Buffalo Gap

*Derailment north (west) of Dewey*
*Photo by Gary Weishaupl*

*by Anne Cassens*

At about 1:30 a.m. on July 8th, an Edgemont train crew operating Union Pacific engines approached the 496 mile marker just north past Dewey, SD, traveling at an estimated 45 mph, when they say what appeared to be water on the tracks. They immediately began slowing down. Seconds later a wall of water hit the train.

Very localized heavy rain had swept burned trees and other debris from the east into the area, washing out ballast below the tracks. Although Dewey had just around 0.7" of rain, there were places that had nearly 5" and this water was rushing toward its Beaver Creek drainage.

The crew managed to get the heavy engines through the stretch of damaged track, but some of the empty coal cars were not so lucky. A total of 37 cars derailed and 13 of those overturned. Crew members were Edgemont-based Shannon Clyde and CE Meyers. After the train came to a stop, the crew received a flash flood warning on the radio!!

Along a five mile stretch from Milemarker 496 to 501, there were several sections of rail suspended in the air, with all the ballast washed away. In just under 30 hours, railroad repair crews had the five mile piece repaired. How many days would this have taken 100 years ago?

Some of the gravel (ballast) washed into John Holmes' hay field west of the tracks.

Holmes reported that he went to look at the water at 5 a.m., "I was amazed to see the whole Line Creek Bottom covered with water. There was a big river running where there hadn't been any water all summer." He saw water twelve feet deep in his hayfield.

He also described the water speed at the damaged track area, "Up where the wreck occurred they said that the water was so swift that it washed the train eight feet sideways with the train still on the tracks. The water was over the tracks in numerous places."


Red Canyon

Jerri Baker
Docket No. 40-9075-MLA
ASLBP No. 10-898-02-MLA-BD01

Drop in U.S. Underground water levels has accelerated-USGS (depletion)

ARTICLE

Follow Reuters

# Drop in U.S. underground water levels has accelerated -USGS



May 20 (Reuters) - Water levels in U.S. aquifers, the vast underground storage areas tapped for agriculture, energy and human consumption, between 2000 and 2008 dropped at a rate that was almost three times as great as any time during the 20th century, U.S. officials said on Monday.

The accelerated decline in the subterranean reservoirs is due to a combination of factors, most of them linked to rising population in the United States, according to Leonard Konikow, a research hydrologist at the U.S. Geological Survey.

The big rise in water use started in 1950, at the time of an economic boom and the spread of U.S. suburbs. However, the steep increase in water use and the drop in groundwater levels that followed World War 2 were eclipsed by the changes during the first years of the 21st century, the study showed.

As consumers, farms and industry used more water starting in 2000, aquifers were also affected by climate changes, with less rain and snow filtering underground to replenish what was being pumped out, Konikow said in a telephone interview from Reston, Virginia.

Depletion of groundwater can cause land to subside, cut yields from existing wells, and diminish the flow of water from springs and streams.

Agricultural irrigation is the biggest user of water from aquifers in the United States, though the energy industry, including oil and coal extraction, is also a big user.

The USGS study looked at 40 different aquifers from 1900 through 2008 and found that the historical average of groundwater depletion - the amount the underground reservoirs lost each year - was 7.5 million acre-feet (9.2 cubic kilometers).

From 2000 to 2008, the average was 20.2 million acre-feet (25 cubic kilometers) a year. (An acre-foot is the volume of water needed to cover an acre to the depth of one foot.)

One of the best-known aquifers, the High Plains Aquifer, also known as the Oglala, had the highest levels of groundwater depletion starting in the

1960s. It lies beneath parts of **South Dakota**, Nebraska, **Wyoming**,
182 Colorado, Kansas, Oklahoma, Texas and New Mexico, where water demand from agriculture is high and where recent drought has hit hard.

98 Because it costs more to pump water from lower levels in an aquifer, some farmers may give up, or irrigate fewer fields, Konikow said. Another problem with low water levels underground is that water quality can deteriorate, ultimately becoming too salty to use for irrigation.

89 "That's a real limit on water," Konikow said. "You could always say that if we have enough money, you build a desalization plant and solve the problem, but that really is expensive."



## More From Reuters

*May 09*

*May 08*

*May 15*

*May 16*

*May 09*

## From Around the Web

*(Allstate Blog)*

*(Animal Planet)*

*(Red Bull)*

*(Envita)*

*(Makers)*

## Videos From Reuters




## Add your comment

Post to Facebook



## Comments (19)

Jerri Baker
Docket No. 40-9075-MLA
ASLBP No. 10-898-02-MLA-BD01

Draft SEIS and the FSEIS are not written in way that makes it easy for the public to find out exactly what is going to happen on this project. Public health issues concerning the radiological hazzards already present and washing down tributaries is not properly represented in the FEIS. There is a present and true danger even before the mining begins. Cattle in area are "hot" and still allowed to graze in this area. (Public Safety-water and air)

EXHIBIT 807

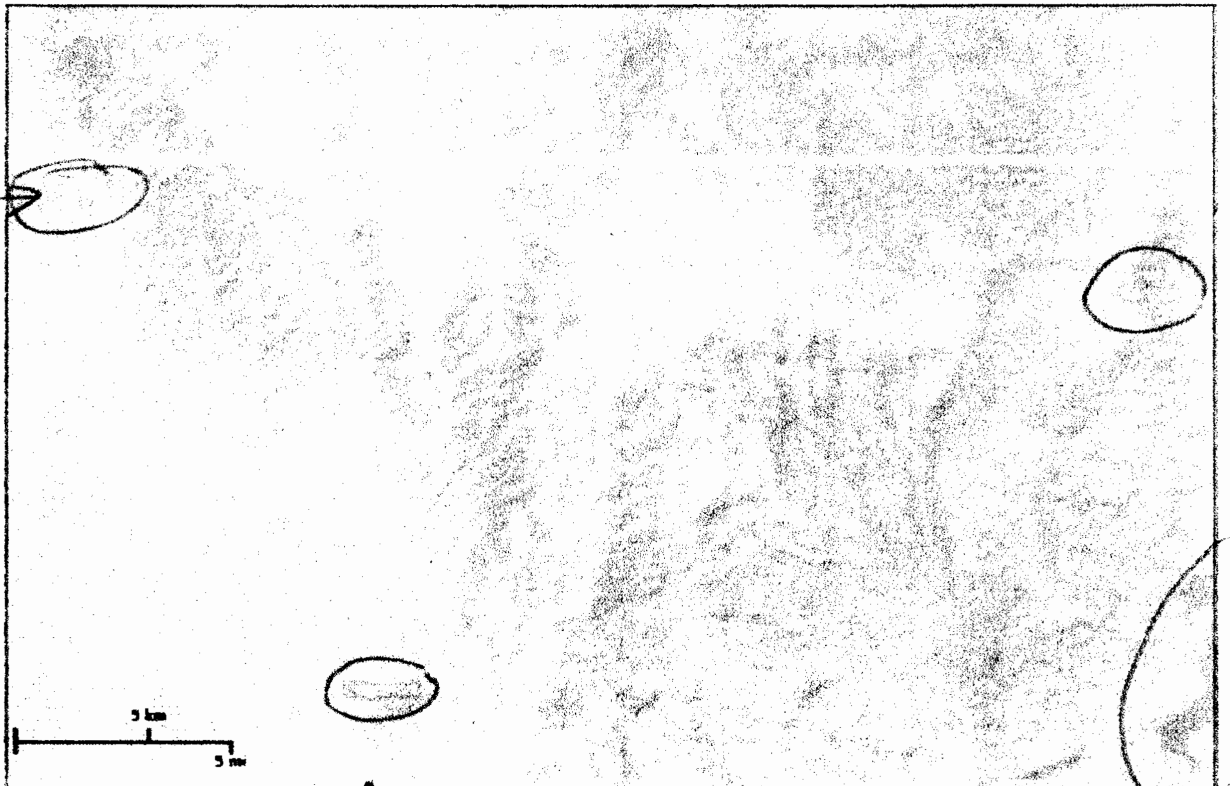
U.S. Fish and Wildlife Service

# National Wetlands Inventory

Distance

Aug 27, 2013

Darrow




Hot Springs

**Status**

Digital
Scan
Non-Digital
No Data

Edgemont

This map is for general reference only. The US Fish and Wildlife Service is not responsible for the accuracy or currentness of the base data shown on this map. All wetlands related data should be used in accordance with the layer metadata found on the Wetlands Mapper web site.

**User Remarks:**

**Edgemont, Hot Springs, Site**

The laboratory analytical data reports are provided in Appendix B.

### 4.3 Analysis of Concentration of Radium in Soil

The purpose of the following analysis is to determine the baseline distributions of radium-226 concentrations in site soils.

#### 4.3.1 Surface Soil Concentrations in Overall Data Set

In the set of 80 surface samples, the mean and median radium-226 concentrations are 2.9 and 1.3 pCi/g, respectively. Q1 and Q3 are 1.1 and 1.7 pCi/g, respectively (Table 4-1). The IQR is 0.6. The mode is 1.1 pCi/g (12 observations). One result (0.45 pCi/g, Sample Location SMA-18) was a low outlier. Thirteen values exceeded 2.3 pCi/g, the cutoff for high outliers.

The soil data were fitted to normal and lognormal distributions. The p-values for both distributions are less than 0.005, indicating that at a 95% confidence level ($p = 0.05$), the distributions are non-normal and non-lognormal.

Considering that the data do not fit normal or lognormal distributions, and clear differences in the gamma-ray count rates obtained in the surface mine and main permit areas are indicative of differences in the levels of gamma-emitting radionuclides therein, the set of surface soil data was divided into surface mine and main permit area subsets, as discussed in the following sections.

#### 4.3.2 Surface Soil Concentrations in Surface Mine Area

Twenty-five surface soil samples were collected in the surface mine area. The mean and median radium-226 concentrations in the surface mine area are 5.9 and 1.4 pCi/g respectively. Q1 and Q3 are 1.0 and 2.75 pCi/g, respectively. The IQR is 1.75. The mode is 1.0 pCi/g (3 observations).

The data were compiled into a histogram and fitted to a normal distribution and a lognormal distribution. When tests for goodness of fit were applied to the distributions, the associated p-values were both less than 0.005 for the normal and lognormal distributions. These low p-values denote the hypotheses that the data came from a normal distribution or a lognormal distribution are rejected at a 95% confidence level.

There are five values exceeding 5.9 pCi/g, the cutoff for outliers. The outliers are the radium-226 concentrations in the five biased samples, all collected in the surface mine area. All of the other samples (75 of 80) were placed randomly in undisturbed areas. The five biased samples are not sufficient to characterize radium-226 concentrations in impacted areas.

With the outliers omitted from the surface mine area data set, the process of fitting its histogram was repeated. The resulting p-values were 0.006 (for normal distribution) and 0.418 (lognormal distribution). The p-value for the data being a lognormal distribution is greater than 0.05, thus the distribution is accepted as lognormal, with statistical significance.

# FYI: CUT FROM THE NRC DRAFT SEIS, DEWEY-BURDOCK PROJECT

## 4.7 Air Quality Impacts

As described in GEIS Section 4.4.6, potential environmental impacts to air quality could occur during all phases of the ISR facility lifecycle (NRC, 2009a). Nonradiological air emission impacts primarily involve fugitive road dust from vehicles traveling on unpaved roads and combustion engine emissions from vehicles and diesel equipment. In general, any nonradiological emissions from pipeline system venting, resin transfer, and elution would be expected to be at such low levels that they would be negligible Such emissions were not considered in the analysis. Radon could also be released from well system relief valves, resin transfer, or elution. Potential radiological air impacts, including radon release impacts, are addressed in the Public and Occupational Health and Safety Impacts analyses in SEIS Section 4.13.

2.1.1.1.6.1 Gaseous or Airborne Particulate Emissions

Gaseous or airborne particulate emissions generated during the life of the Dewey-Burdock ISR Project would primarily consist of fugitive dusts, combustion engine exhaust, radon gas emissions from various stages of the processing system, and uranium particulate emissions from yellowcake drying (Powertech, 2009a).

Classification as a major or minor source is the purview of the regulatory authority, SDDENR. NRC staff acknowledge that SDDENR has not yet conducted the formal air quality permitting for the proposed Dewey-Burdock ISR Project (see Table 1.6-1). In the absence of a formal

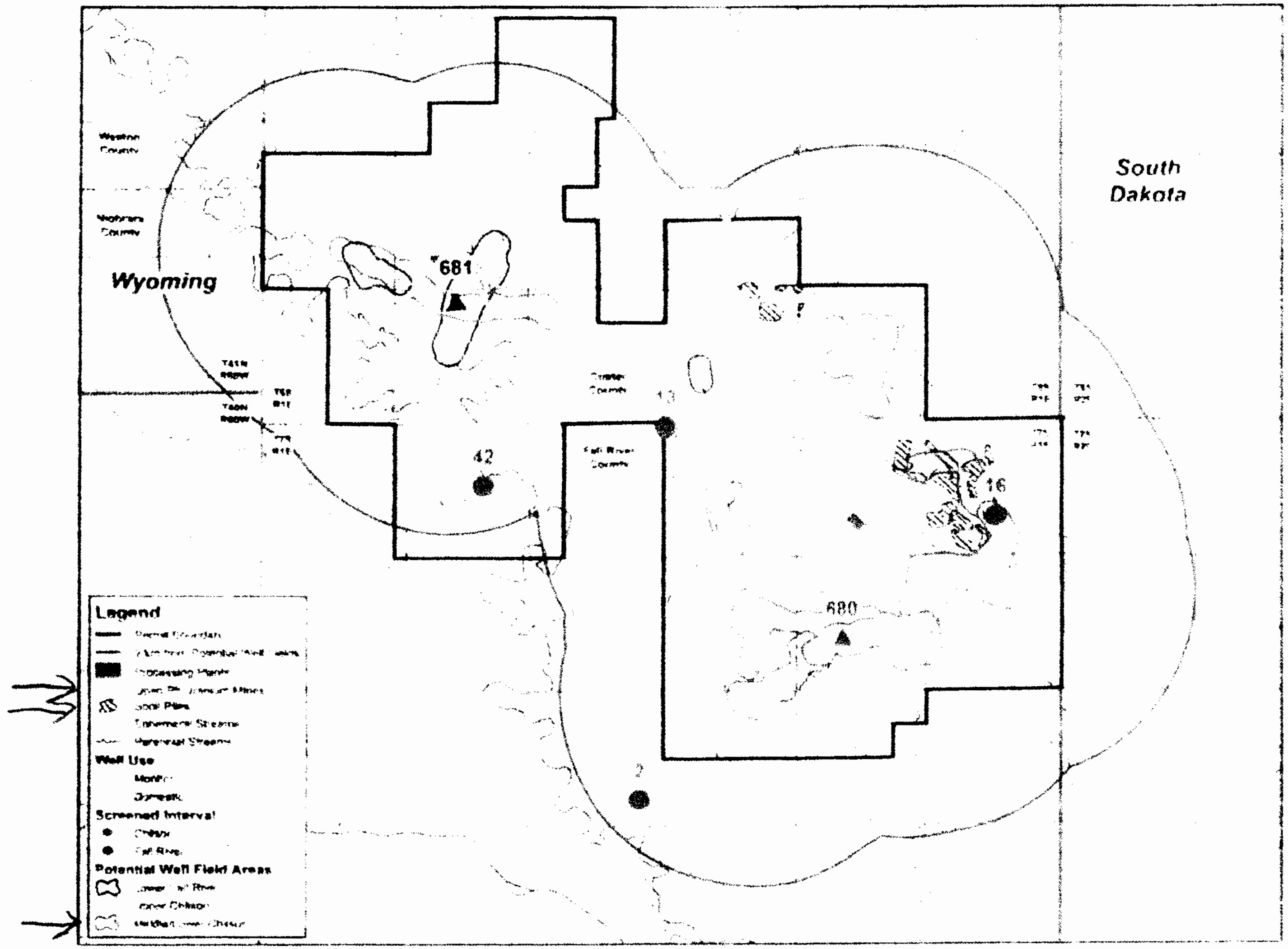
# LIQUID BY PRODUCTS

regulations. Liquid byproduct material generated by the proposed Dewey-Burdock ISR Project will contain chemical and radiological constituents including uranium and radium (Powertech, 2011).

The applicant proposed deep Class V well injection, land application, or a combination of these processes for managing liquid byproduct material. The particular waste management option used will affect how wastes are treated and will determine the final disposal method. As described in SEIS Chapter 1, the proposed options require the applicant to obtain all applicable federal and South Dakota permits, in addition to an NRC license, before it operates the facility. Alternative wastewater disposal options are described in SEIS Section 2.1.1.2. However, the applicant did not propose using these alternative methods.

The applicant's proposed deep Class V well injection disposal option involves drilling wells at the project site to dispose of liquid byproduct material. A typical deep injection well design is shown in Figure 2.1-11. The applicant submitted a permit application to EPA to construct four to eight UIC Class V deep injection wells to inject liquid byproduct material into the Minnelusa and Deadwood Formations; the application is currently under review (Powertech,

# Baseline Groundwater Sampling Wells of Interest




The whole pit has spoil piles See photo.

# EXHIBIT 804

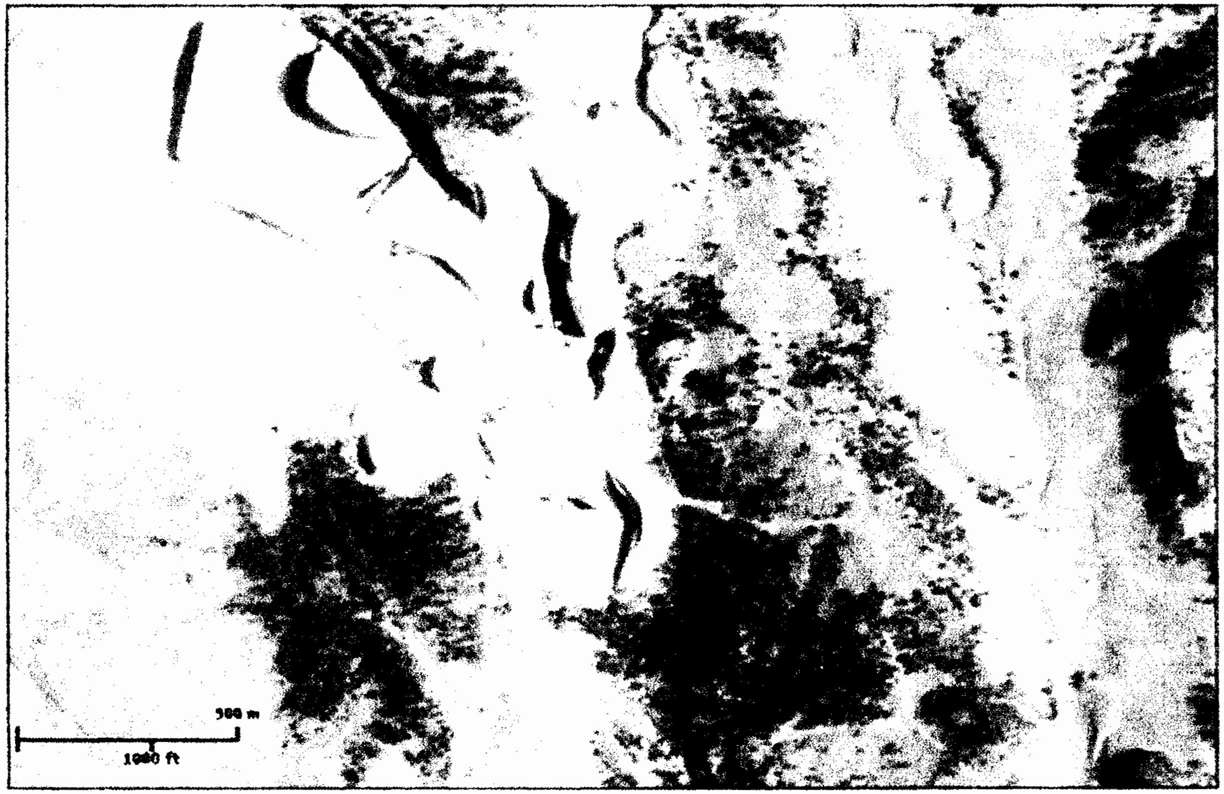
U.S. Fish and Wildlife Service

National Wetlands Inventory

~~Triangle~~

Darrow Mine

**Aug 25, 2013**




## Wetlands

Estuarine and Marine Deepwater

Freshwater Pond

Lake

Riverine

Other

This map is for general reference only. The US Fish and Wildlife Service is not responsible for the accuracy or currentness of the base data shown on this map. All wetlands related data should be used in accordance with the layer metadata found on the Wetlands Mapper web site.

**User Remarks:**

## EXHIBIT 821

U.S. Fish and Wildlife Service

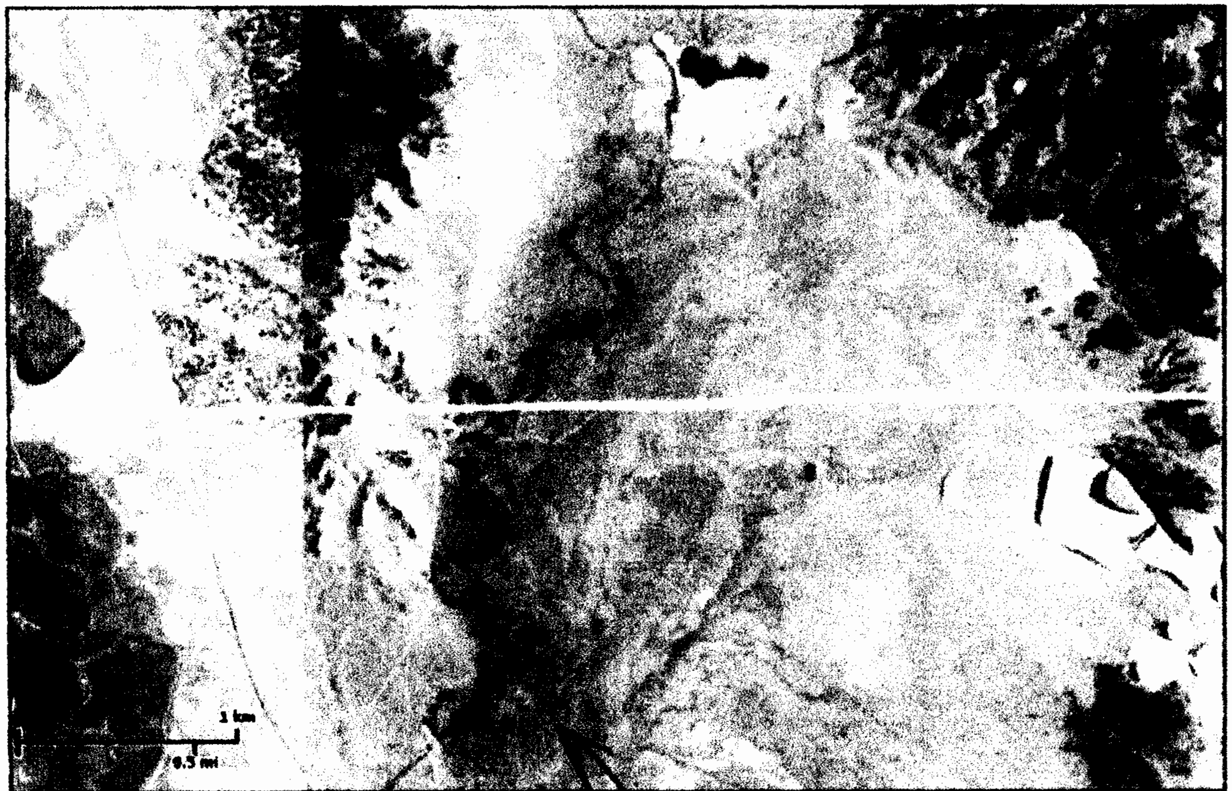
# National Wetlands Inventory

**Pass Creek**

**Aug 26, 2013**

**No operational layers selected or no legend available**

Beaver Creek

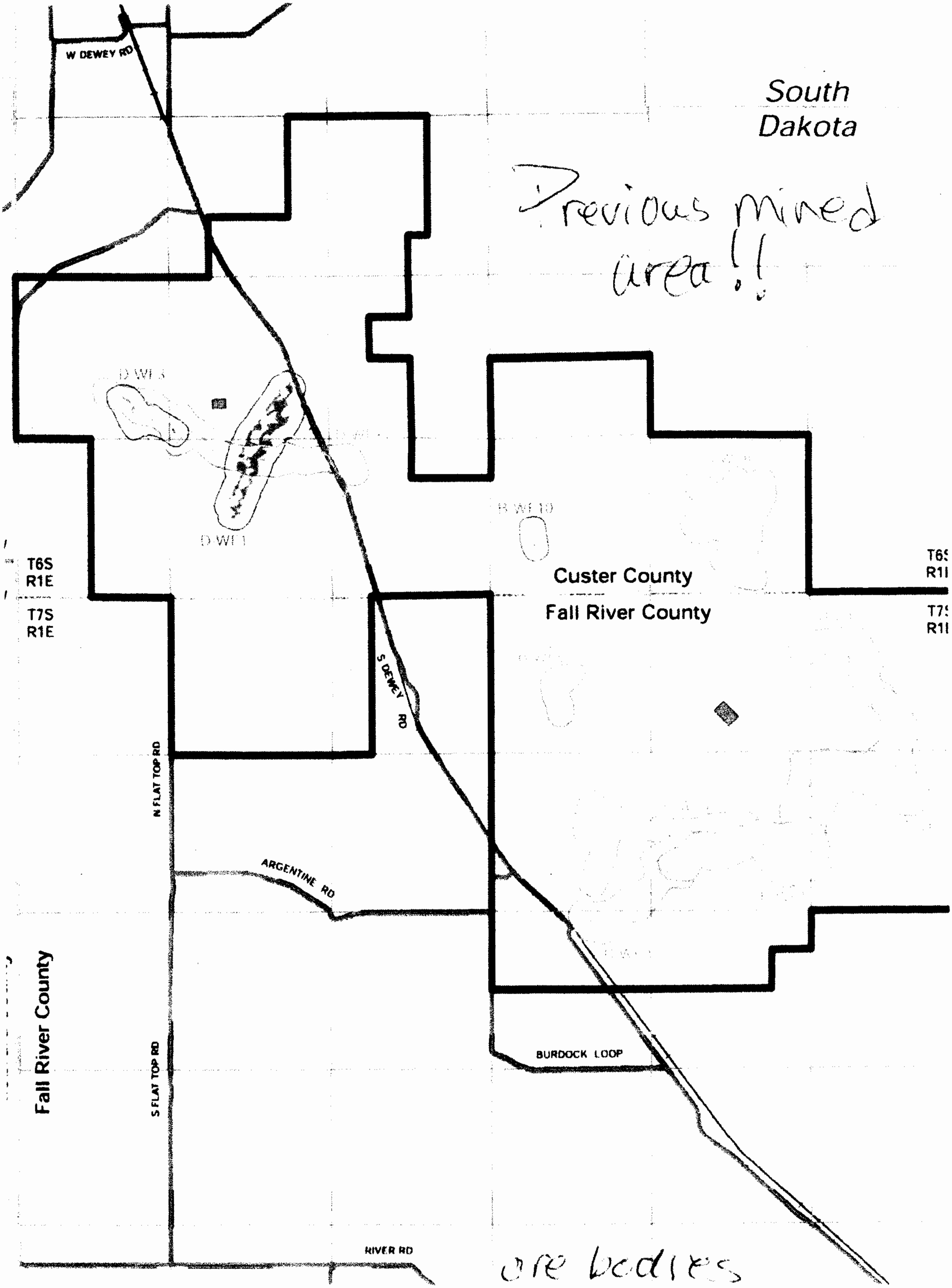



Pass Creek

This map is for general reference only. The US Fish and Wildlife Service is not responsible for the accuracy or currentness of the base data shown on this map. All wetlands related data should be used in accordance with the layer metadata found on the Wetlands Mapper web site.

**User Remarks:**

**Pass creek runs into the Cheyenne River. Located in the center of map.**


W DEWEY RD
South Dakota
Previous mined area!!
D WE 1
T6S
R1E
T7S
R1E
Custer County
Fall River County
S DEWEY RD
N FLAT TOP RD
ARGENTINE RD
Fall River County
S FLAT TOP RD
BURDOCK LOOP
RIVER RD
ore bodies

| Dewey-Burdock Surface Water Sampling Location | | CHR01 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | | Cheyenne River Upstream | | | | | | |
| Date and Time Collected | | 7/31/2007 2:35:00 PM | 9/5/2007 5:30:00 PM | 9/26/2007 12:01:00 PM | 10/17/2007 2:00:00 PM | 11/19/2007 9:45:00 AM | 3/9/2008 2:15:00 PM | 4/16/2008 3:30:00 PM |
| Lab ID | | R07080019 .001 | R07090098 .001 | R07090368 .001 | R07100295 .002 | R07110229 .001 | R08030091 .004 | R08040220 .001 |
| Analyte | Units | Result | Result | Result | Result | Result | Result | Result |
| Selenium, Total | mg/L | 0.002 | 0.002 | 0.003 | <0.001 | <0.001 | 0.001 | <0.001 |
| Silica, Total | mg/L | NM | NM | NM | NM | NM | 45.4 | 6.3 |
| Silver, Total | mg/L | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| Sodium, Total | mg/L | NM | NM | NM | NM | NM | 191 d | 1140 |
| Thorium 232, Total | mg/L | NM | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| Uranium, Total | mg/L | 0.0223 | 0.0142 | 0.015 | 0.032 | 0.0316 | 0.0043 | 0.0365 |
| Vanadium, Total | mg/L | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Zinc, Total | mg/L | <0.01 | <0.01 | <0.01 | <0.01 | 0.02 | 0.05 | <0.01 |
| **Metals, Total, Speciated** | | | | | | | | |
| Selenium-IV, Total | mg/L | NM | NM | NM | <0.001 | <0.001 | <0.001 | <0.001 |
| Selenium-VI, Total | mg/L | NM | NM | NM | <0.001 | <0.001 | <0.001 | <0.001 |
| **Radionuclides, Dissolved** | | | | | | | | |
| Lead 210, Dissolved | pCi/L | NM | NM | <1 | 3.2 | <1 | NM | NM |
| Polonium 210, Dissolved | pCi/L | NM | NM | <1 | 1.6 | 1.7 | NM | NM |
| Radium 226, Dissolved | pCi/L | NM | NM | <0.2 | 0.5 | <0.2 | 0.2 | 0.3 |
| Thorium 230, Dissolved | pCi/L | NM | NM | <0.2 | <0.2 | <0.2 | 0.1 j | 0.3 |
| **Radionuclides, Suspended** | | | | | | | | |
| Lead 210, Suspended | pCi/L | NM | NM | <1 | <1 | <1 | NM | NM |
| Polonium 210, Suspended | pCi/L | NM | NM | <1 | <1 | 2.3 | NM | NM |
| Radium 226, Suspended | pCi/L | NM | NM | <0.2 | <0.2 | 0.6 | 1.2 j | -0.1 j |
| Thorium 230, Suspended | pCi/L | NM | NM | <0.2 | 0.9 | 3.8 | 0.8 | 0.2 j |
| **Radionuclides, Total** | | | | | | | | |
| Gross Alpha, Total | pCi/L | 16.9 | 18.7 | 33.8 | 34.2 | 27 | 5.1 j | 5.7 j |
| Gross Beta, Total | pCi/L | 21.9 | <2 | 21.9 | 21.3 | <2 | 4.8 j | 9.2 j |
| Gross Gamma, Total | pCi/L | NM | NM | NM | 1070 | <20 | <20 | 0 j |
| Lead 210, Total | pCi/L | NM | NM | <1 | NM | <1 | NM | NM |
| Polonium 210, Total | pCi/L | NM | NM | <1 | NM | 4 | NM | NM |
| Radium 226, Total | pCi/L | <0.2 | <0.2 | <0.2 | NM | 0.6 | 1.5 | 0.1 j |
| Thorium 230, Total | pCi/L | NM | NM | <0.2 | NM | 3.8 | 0.8 | 0.5 |
| **Data Quality Parameters** | | | | | | | | |
| A/C Balance (± 5) | % | 0.0317 | -2.45 | -4.68 | -0.301 | -0.593 | -4.49 | 1.81 |
| Anions | meq/l | 83.7 | 49 | 91.5 | 95.6 | 105 | 20.8 | 86.1 |
| Cations | meq/l | 83.8 | 46.7 | 83.3 | 95 | 104 | 19 | 83.1 |
| Solids, Total Dissolved Calculated | mg/L | 5590 | 3230 | 5970 | 6370 | 7040 | 1280 | 5720 |
| TDS Balance (0.80 - 1.20) | dec. % | 1.06 | 0.99 | 0.98 | 1.03 | 1 | 0.98 | 0.99 |

- AMS-05: 123.7 for 303 monitored days, projected to 149 mrem/yr
- AMS-06: 88.0, for 164 monitored days projected to 196 mrem/yr
- AMS-07: 145.3 for 303 monitored days, projected to 175 mrem/yr
- AMS-BKG: 167.8 for 303 monitored days, projected to 202 mrem/yr

Excluding the result at AMS-02, the range of exposure rates (114 to 202 mrem/yr) and average (165 mrem/yr) is similar to average worldwide exposures to natural radiation sources comprised of comic radiation, cosmogenic radionuclides, and external terrestrial radiation reported in the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) Report to the General Assembly, Sources and Effects of Ionizing Radiation, Annex. The typical ranges of average worldwide exposures reported in this reference document are to 60 to160 mrem/yr.

## 10.0 FOOD SAMPLING

To determine baseline radionuclide concentrations in local food, Powertech collected three tissue samples (one of liver [DBAT-03], two of meat [DBAT-01, DBAT-02]) from a locally grazing cow on June 25, 2008. The samples were analyzed for natural uranium, radium-226, lead-210, and polonium-210. The results are listed in Table 10-1.

For the majority of analytes, the reported concentrations are at or below LLDs that, in turn, exceed the LLDs recommended in RG 4.14. This is evident for all reported concentrations of natural uranium, radium-226 and polonium-210 in Sample DBAT-01, and lead-210 in all three samples. There are only three cases where radionuclide concentrations exceed LLDs. Radium-226 concentrations are 0.003 and 0.06 pCi/g in Samples DBAT-01 and DBAT-02. The concentration of polonium-210 in Sample DBAT-03 is 0.02 pCi/g.

## 11.0 SUMMARY AND CONCLUSIONS

The results of the Dewey-Burdock baseline field investigation documented herein indicate the following:

- Baseline gamma-ray count rates have been obtained across the permit area. Twenty-five percent of the count rates were lower than 11,395 cpm. Seventy-five percent of the count rates were below 14,437 cpm. Three distinct populations of gamma-ray count rates were observed: an anomalous 600-acre portion of the main permit area, the main permit area itself, and the surface mine area. Considered individually, each has non-parametric count-rate distributions.
- Elevated levels of radioactivity, as characterized by gamma readings greater than 17,945 cpm in the main permit area and 20,270 cpm in the surface mine area, occur in the

Jerri Baker
Docket No. 40-9075-MLA
ASLBP No. 10-898-02-MLA-BD01

Colorado UMTRA site./Issues dealing with uranium mining that are unacceptable. (Public Safety Issues that are not properly addressed)

EXHIBIT 800

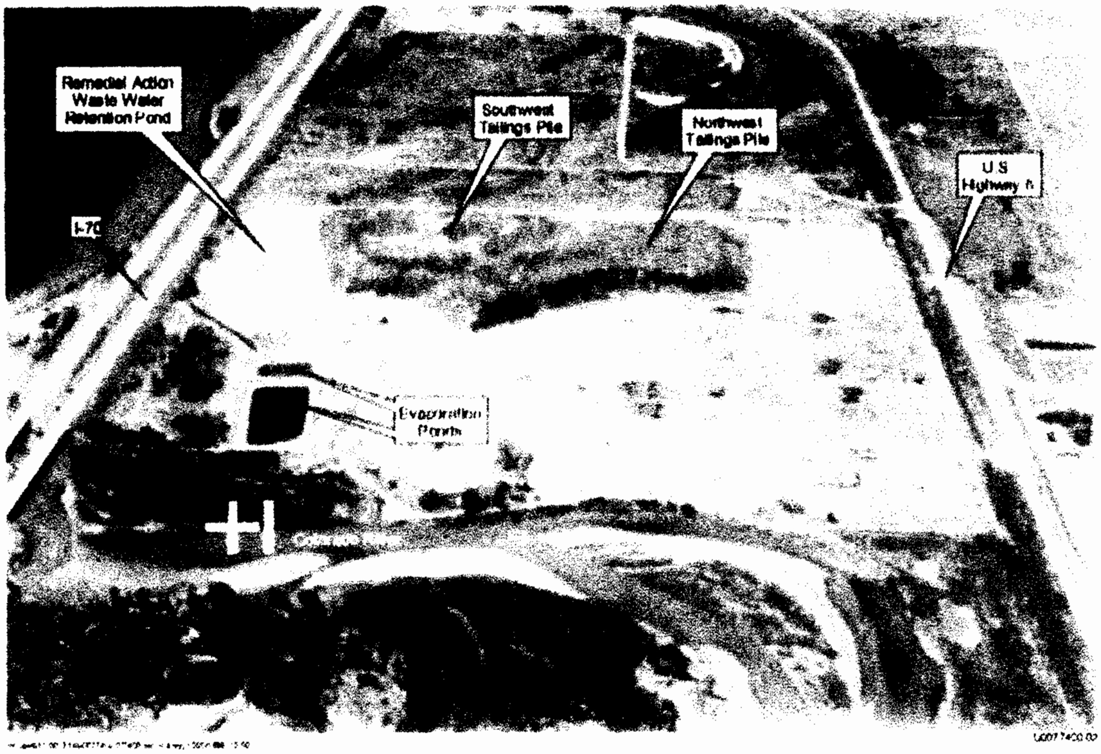



*Figure 3. August 1989 View Looking West at the New Rifle Millsite before UMTRA Project Surface Removal of Tailings Piles*

## 1.4 Overview of Contaminant Sources

Some ground water contamination probably resulted from rainwater and snowmelt percolating through tailings and stockpiled ore at the site. The area of potential ground water infiltration is located at the east end of the site, shown as the former ore storage area on Figure 2. The primary contaminants would have been the more water-soluble components of the ore, such as uranium, calcium, and sulfate. The source of calcium and sulfate would have been gypsum, which was associated with the ore. In addition to the uranium and vanadium, ores contained other metals such as selenium, molybdenum, and arsenic. Process chemicals, such as ammonium chloride and sulfuric acid, were an additional source of ground water contamination. Some of these chemicals remained on the sandy tailings that were transported by slurry and deposited on the west end of the site, and other solutions were sent to the gypsum and vanadium settling ponds.

2010

# 20 Canadian Doctors Resign Over Uranium Mining Proposal

SEPT-ILES, Quebec — Led by a group of medical doctors, 1,000 residents of Sept-Iles gathered Dec. 13 to condemn plans for uranium mining on Quebec's North Shore.

In an unprecedented public protest, 20 of the local hospital's physicians — psychiatrists, family doctors, anesthetists, a lung specialist, surgeons, and gynecologists — resigned as a group. It's the only hospital in the city, 550 miles northeast of Montreal. The mining critics point to its historical contamination of drinking water, environmental destruction and irreversible health hazards. In their letter to the federal minister of health, the physicians said, "We regret the effect that this mass exodus will have ... but we believe it to be contrary to our code of ethics to not warn the authorities."

*Canwest* reported that the doctors "fear for their own families' health as well as for the health of the population in the region." As a result of the action, the government in Quebec has announced the creation of a special committee to study the potential risks of uranium exploration and mining on health and safety. British Columbia and Nova Scotia have banned uranium mining in their provinces, but Quebec has not. Canadian mines produce about 20 percent of the world's uranium supply. — *The Canadian Press*, Dec. 4 & 14; *the Montreal Gazette*, Dec. 5 & 7; Quėbec solidaire news release, Dec. 7; & *Canwest News Service*, Dec. 5, 2009

1.1d jenow

Color injection - with waste

Lain
Marcun

**NC STATE UNIVERSITY**

# Radiation Safety and ALARA

## Environmental Health & Safety Center
## Radiation Safety Division
## 515-2894

### What is ALARA ?

ALARA is an acronym for As Low As Reasonably Achievable. This is a radiation safety principle for minimizing radiation doses and releases of radioactive materials by employing all *reasonable methods*. ALARA is not only a sound safety principle, but is a ***regulatory requirement*** for all radiation safety programs.

### What is the basis for ALARA ?

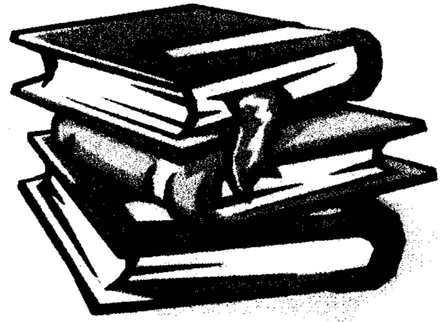
**Current radiation safety philosophy is based on the conservative assumption that radiation dose and its biological effects on living tissues are modeled by a relationship known as the "*Linear Hypothesis*". The assertion is that every radiation dose of any magnitude can produce some level of detrimental effects which may be manifested as an increased risk of genetic mutations and cancer. Thus, the NCSU radiation safety program attempts to lower doses received by radiation workers by utilizing practical, cost effective measures.**

### How is ALARA Implemented ?

An effective ALARA program is only possible when a commitment to safety is made by all those involved. This includes the Radiation Safety Division staff, the Radiation Safety Committee, research faculty and all radiation workers. The **NCSU Radiation Safety Manual** provides the guidelines for the responsibilities and good practices which are consistent with both the ALARA concept and the regulatory requirements of the North Carolina Administrative Code (Title 15A Chapter 11). These guidelines and regulations require not only adherence to legal dose limits for regulatory compliance, but also ALARA investigation dose levels which serve as alert points for initiating a review of the work practices of a radiation worker.

### The Radiation Safety Committee and ALARA

The NCSU Radiation Safety Committee (RSC) is an essential element in the successful application of the ALARA concept. The RSC has the responsibility to review



proposed experimental protocols and the qualifications of the Principal Investigator (PI) before authorization is granted for the possession of radioactive materials or radiation-producing devices. The RSC delegates authority to the Radiation Safety Division (RSD) thru the Radiation Safety Officer (RSO) for implementation of the ALARA concept. The RSO is responsible for reviewing the occupational radiation doses of all workers with particular attention to those workers for which the ALARA investigation level is exceeded. The RSC performs an annual review of the radiation safety program in regard to operating procedures and dose records which reflect the efficacy of the ALARA effort.

### The Radiation Safety Division and ALARA

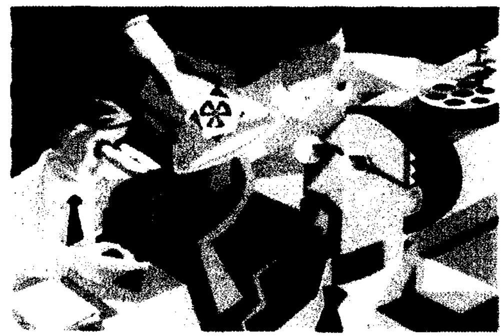
The RSO provides guidance for the ALARA program as the manager and technical supervisor of the Radiation Safety Division. In turn, the RSD staff are responsible for contributing to the success of the ALARA program in the following ways :

1) Providing technical support and guidance to the PIs and their staff for implementation of the ALARA concept.
2) Performing routine lab inspections to identify possible ALARA issues.
3) Monitoring g of worker radiation doses with the assignment of dosimetry and use of bioassays as deemed appropriate.
4) Reviewing occupational doses and respond to situations in which the investigation levels are exceeded.
5) Providing training and consultation to workers to ensure doses are maintained ALARA.

### PIs, Radiation Workers and ALARA

The PI and research staff, with the support of the RSD, should ensure that the ALARA principle is being used in all lab operations. This includes the proper use of shielding and dosimetry combined with contamination control techniques. All employees bear a responsibility for their own personal safety in such work areas as:

1) Awareness of potential radiation hazards, exposure levels and safety controls in their work areas.
2) Awareness of operating and emergency procedures.
3) Awareness of practices that do not seem to follow the ALARA philosophy.
4) Compliance with reporting incidents and possibly unsafe working conditions to their supervisors and, if appropriate, to the RSD staff.
5) Compliance with wearing personnel dosimetry and ensuring it's return to the RSD at the proper exchange frequency.
6) Compliance with providing bioassay samples to



the RSD as needed.

### Mitigation of External Radiation Exposures

The three (3) major principles to assist with maintaining doses ALARA are :

1) **TIME** – minimizing the time of exposure directly reduces radiation dose.
2) **DISTANCE** – **doubling** the distance between your body and the radiation source will divide the radiation exposure by a factor of 4.
3) **SHIELDING** - using absorber materials such as Plexiglas for beta particles and lead for X-rays and gamma rays is an effective way to reduce radiation exposures.

DOCTOR'S DATA INC.

LAB #: H140201-2001-1
PATIENT: Jerri Baker
ID: BAKER-J-01030
SEX: Female
AGE: 48

CLIENT #: 35968
DOCTOR: Olga Turnquist, ND

902 N River St
Hot Springs, SD 57747 USA

# Toxic & Essential Elements; Hair

## TOXIC METALS

| | | RESULT µg/g | REFERENCE INTERVAL | PERCENTILE 68th 95th |
|---|---|---|---|---|
| Aluminum | (Al) | 6.9 | < 7.0 | |
| Antimony | (Sb) | 0.11 | < 0.050 | |
| Arsenic | (As) | 0.038 | < 0.060 | |
| Barium | (Ba) | 0.80 | < 2.0 | |
| Beryllium | (Be) | < 0.01 | < 0.020 | |
| Bismuth | (Bi) | 0.27 | < 2.0 | |
| Cadmium | (Cd) | 0.11 | < 0.050 | |
| Lead | (Pb) | 5.3 | < 0.60 | |
| Mercury | (Hg) | 0.07 | < 0.80 | |
| Platinum | (Pt) | < 0.003 | < 0.005 | |
| Thallium | (Tl) | 0.003 | < 0.002 | |
| Thorium | (Th) | < 0.001 | < 0.002 | |
| Uranium | (U) | 0.13 | < 0.060 | |
| Nickel | (Ni) | 0.65 | < 0.30 | |
| Silver | (Ag) | 2.0 | < 0.15 | |
| Tin | (Sn) | 0.42 | < 0.30 | |
| Titanium | (Ti) | 0.34 | < 0.70 | |
| Total Toxic Representation | | | | |

## ESSENTIAL AND OTHER ELEMENTS

| | | RESULT µg/g | REFERENCE INTERVAL | PERCENTILE 2.5th 16th 50th 84th 97.5th |
|---|---|---|---|---|
| Calcium | (Ca) | 6010 | 300- 1200 | |
| Magnesium | (Mg) | 230 | 35- 120 | |
| Sodium | (Na) | 14 | 20- 250 | |
| Potassium | (K) | 6 | 8- 75 | |
| Copper | (Cu) | 23 | 11- 37 | |
| Zinc | (Zn) | 690 | 140- 220 | |
| Manganese | (Mn) | 0.12 | 0.08- 0.60 | |
| Chromium | (Cr) | 0.53 | 0.40- 0.65 | |
| Vanadium | (V) | 0.27 | 0.018- 0.065 | |
| Molybdenum | (Mo) | 0.059 | 0.020- 0.050 | |
| Boron | (B) | 0.40 | 0.25- 1.5 | |
| Iodine | (I) | 1.7 | 0.25- 1.8 | |
| Lithium | (Li) | 0.025 | 0.007- 0.020 | |
| Phosphorus | (P) | 141 | 150- 220 | |
| Selenium | (Se) | 0.77 | 0.55- 1.1 | |
| Strontium | (Sr) | 27 | 0.50- 7.6 | |
| Sulfur | (S) | 45600 | 44000- 50000 | |
| Cobalt | (Co) | 0.046 | 0.005- 0.040 | |
| Iron | (Fe) | 19 | 7.0- 16 | |
| Germanium | (Ge) | 0.047 | 0.030- 0.040 | |
| Rubidium | (Rb) | 0.008 | 0.007- 0.096 | |
| Zirconium | (Zr) | 0.10 | 0.020- 0.42 | |

## SPECIMEN DATA

COMMENTS:

Date Collected: 01/24/2014
Date Received: 02/01/2014
Date Completed: 02/04/2014
Methodology: ICP/MS

Sample Size: 0.198 g
Sample Type: Head
Hair Color:
Treatment:
Shampoo:

## RATIOS

| ELEMENTS | RATIOS | RANGE |
|---|---|---|
| Ca/Mg | 26.1 | 4- 30 |
| Ca/P | 42.6 | 1- 12 |
| Na/K | 2.33 | 0.5- 10 |
| Zn/Cu | 30 | 4- 20 |
| Zn/Cd | > 999 | > 800 |

Jerri Baker
Docket No. 40-9075-MLA
ASLBP No. 10-898-02-MLA-BD01

In 1978 the Christensen Ranch insitu mine began. The City of Gillette, Wyoming or surrounding towns did not have Madison wells. Four years into mining, they had 41%, today they use 93%. Cities on the edge of the Madison aquifer in Wyoming are dwindling or out of Madison drinking water.
This is proof of depletion. Our river is the Madison aquifer. (Depletion)

*TABLE 7.2*

*CITY OF GILLETTE SOURCE WATER PRODUCTION 1978 – 2007*

| Year | Wasatch Formation Wells [1] | | Ft. Union Formation Wells | | Fox Hills Formation Wells | | Madison Formation Wells [2] | | Total Production |
|---|---|---|---|---|---|---|---|---|---|
| | (MG) | % of Total | (MG) | % of Total | (MG) | % of Total | (MG) | % of Total | (MG) |
| 1978 | 82.1 | 13% | 393.6 | 62% | 156.1 | 25% | - | - | 631.8 |
| 1979 | 172.0 | 21% | 479.3 | 58% | 172.0 | 21% | - | - | 823.4 |
| 1980 | 172.0 | 19% | 499.2 | 56% | 227.8 | 25% | - | - | 899.0 |
| 1981 | 116.3 | 9% | 477.4 | 38% | 141.4 | 11% | 505.7 | 41% | 1,240.8 |
| 1982 | - | - | 266.5 | 28% | 233.6 | 25% | 445.4 | 47% | 945.6 |
| 1983 | - | - | 270.5 | 23% | 266.9 | 22% | 654.3 | 55% | 1,191.6 |
| 1984 | - | - | 306.6 | 26% | 163.6 | 14% | 691.5 | 60% | 1,161.7 |
| 1985 | - | - | 481.0 | 36% | 114.0 | 9% | 734.1 | 55% | 1,329.1 |
| 1986 | - | - | 427.2 | 35% | 23.5 | 2% | 778.1 | 63% | 1,228.8 |
| 1987 | - | - | 359.4 | 33% | 19.9 | 2% | 703.8 | 65% | 1,083.1 |
| 1988 | - | - | 321.0 | 24% | 100.7 | 8% | 918.2 | 69% | 1,339.9 |
| 1989 | - | - | 270.5 | 22% | 293.3 | 24% | 653.0 | 54% | 1,216.7 |
| 1990 | - | - | 336.0 | 27% | 219.0 | 18% | 682.7 | 55% | 1,237.6 |
| 1991 | - | - | 298.5 | 24% | 242.1 | 20% | 681.0 | 56% | 1,221.6 |
| 1992 | - | - | 220.9 | 17% | 176.1 | 14% | 897.1 | 69% | 1,294.1 |
| 1993 | - | - | 259.7 | 23% | 67.8 | 6% | 782.0 | 70% | 1,109.5 |
| 1994 | - | - | 264.9 | 19% | 217.3 | 16% | 910.1 | 65% | 1,392.4 |
| 1995 | - | - | 295.8 | 24% | 143.9 | 12% | 775.0 | 64% | 1,214.7 |
| 1996 | - | - | 259.3 | 22% | 143.9 | 12% | 775.1 | 66% | 1,178.3 |
| 1997 | - | - | 260.8 | 21% | 109.0 | 9% | 883.4 | 70% | 1,253.2 |
| 1998 | - | - | 424.8 | 30% | 25.4 | 2% | 957.9 | 68% | 1,408.1 |
| 1999 | - | - | 417.1 | 30% | 25.9 | 2% | 961.0 | 68% | 1,404.0 |
| 2000 | - | - | 397.4 | 23% | 59.3 | 3% | 1,259.1 | 73% | 1,715.8 |
| 2001 | - | - | 351.7 | 18% | 62.7 | 3% | 1,534.3 | 79% | 1,948.6 |
| 2002 | - | - | 355.6 | 22% | 60.7 | 4% | 1,191.5 | 74% | 1,607.8 |
| 2003 | - | - | 310.7 | 18% | 50.2 | 3% | 1,337.9 | 79% | 1,738.8 |
| 2004 | - | - | 373.7 | 22% | 71.2 | 6% | 1,247.7 | 73% | 1,692.2 |
| 2005 | - | - | 410.7 | 22% | 57.3 | 3% | 1,418.0 | 75% | 1,886.0 |
| 2006 | - | - | 394.5 | 22% | 71.1 | 4% | 1,296.7 | 74% | 1,762.3 |
| 2007 | - | - | 355.8 | 22% | 59.9 | 4% | 1,228.9 | 75% | 1,644.6 |
| Average | | | | 351.3 | | 125.9 | | 922.4 | 1,326.7 |
| Min. % | | | | 17% | | 2% | | 41% | |
| Max. % | | | | 62% | | 25% | | 79% | |
| Avg. % | | | | 28% | | 11% | | 65% | |

Notes:
[1] Wasatch Formation Wells Taken Off Line in 1981.
[2] Madison Formation Wells Placed On Line in 1982.
[3] 2004 Formation Production through August.

Jerri Baker
Docket No. 40-9075-MLA
ASLBP No. 10-898-02-MLA-BD01

Wyoming towns having to pump water from miles away. (Depletion)

# Madison: Bid out soon to build 22 miles of pipeline

Continued from Page A1

lishes is four parts per million — and we're sitting at half of that at two parts per million."

Taste wise, the new wells are similar to the existing ones — they're very hard, Cole said.

The Department of Health and Human Services and EPA officials have recommended since 2011 that fluoride levels in U.S. drinking water be lowered because of links to dental problems. The move followed a government study showing that two out of five teens have tooth streaking or spots — dental fluorosis — caused by too much fluoride, which can lead to pitting of the teeth.

Fluoride, while helping reduce tooth decay significantly, is now present in a wide variety of dental products, making it much more ubiquitous than when it was first introduced in the drinking water supply, the study found.

## So how's the Madison project going?

The goals of the test well project were essentially to evaluate two wells and ensure that they can meet a minimal yield of 1,400 gallons per minute per well.

The second goal was to determine the effects of the acid frack performed on those wells. It was done because the city wanted to increase the 800 to 900 gallons-a-minute yield of the wells. Once the acid frack was performed, the wells began yielding 1,500 and 1,600 gallons a minute.

An acid frack is an enhancement which, by opening up the crevasses in the formation, boosts the well's productions, Utilities Director Kendall Glover said.

"It's used on a normal basis for water wells and gas wells," Glover added.

But the process did delay the project. The first two test well projects are finally complete and all that's left is some cleanup of the access roads and around the test well sites.

It is expected that the work will be complete and ready for council's acceptance by the end of the month, Cole said.

Layne Christensen was awarded the bid in September 2011 to build those wells with a low bid of $6.9 million. By the time the project was ready to actually start, Layne Christensen and the city signed a contract for $7.5 million to do the job. But the year-long job needed to do four change orders, which totaled $1.2 million, putting the amount of that contract currently at $8.7 million.

## Moving forward

Cole said a new, large Madison contract is going out to bid as soon as he and his staff are through tying some state permits in a bow. The goal is to be ready to put out the first advertisement by July 19.

Whichever company gets the bid award will take on the task of building 22 miles of Madison pipeline at a cost the city expects to be between $42 million to $50 million, Cole said.

There was a bid opening for a similar-sized project in Cheyenne two months ago and the bids came in quite a bit lower than what the engineer had estimated.

"I'm really pushing that we can make a bid award this summer, so we can take advantage of some of those costs," Cole said.

Jerri Baker
Docket No. 40-9075-MLA
ASLBP No. 10-898-02-MLA-BD01

Wide-book to the Geology of the Black Hills. 2009 page 20/ Photo is of breccia pipe that broke into the Cascade Falls area 2013. /USGS pub 2005 Cascade from the Minnelusa. (Fractures)

Guide book to the Geol. of the Black Hills S. Dakota
Lufkin, Redden, Lisenbee, Loomis 2004 (orig. '97)

Dakota Sandstone (his name for the main aquifer) underlay most of the state, and giving the approximate depth required for wells to reach this aquifer.

The main aquifers of the Black Hills are the sandstones of the Inyan Kara Group (which include the Fall River and Lakota Formations), Minnelusa Formation, Deadwood Formation, and the cavernous rocks of the Pahasapa (Madison) Limestone. Figure 3.1 shows a general cross section across the Black Hills and how these aquifer units crop out at higher elevations where they are recharged by rainfall and surface waters. The higher elevations where water enters the aquifers provide a gravity or hydrostatic head which causes the ground water to move to lower elevations, provided that the aquifer unit is overlain by an *aquaclude,* or an impermeable rock unit. The movement of water is very slow in sandstones (as little as a few feet per year), but in cavernous carbonate rocks or breccia zones in other rocks, it can travel much faster. For example, wells in the Pahasapa Limestone may have yields of several hundred gallons per minute, in contrast to wells in sandstone that typically yield tens of gallons of water per minute.

From Figure 3.1, it is obvious that water wells drilled outside of the Cretaceous Hogback reach the various aquifer units at different depths, with the shallowest being the Lakota-Fall River sandstones of the Inyan Kara Group. All of the aquifer units exposed in the Black Hills, however, do not extend as a blanket across the state. The Pahasapa and Deadwood Formations, for example, pinch out due to unconformities on the south side of the dome and also farther to the east.

Although you would assume that the water should go down the outcrop slope of the aquifer, this is not always true in small areas. For example, where Boxelder Creek disappears in sinkholes in the Pahasapa Limestone (the Madison aquifer) northwest of Rapid City, dye added to the water was recovered in wells drilled into this formation in Rapid City in the Rapid Creek drainage basin. This indicates that the water moved laterally but down slope to the lower elevation of the cavernous Pahasapa below Rapid City.

It is possible to tell the source of ground water from its chemistry and also its temperature. For example, "cold" water in the municipal wells at Edgemont is too hot to comfortably shower in during the hot summer months, and the water contains very small amounts of trace elements such as Li and Cs. The latter elements are not harmful, but their source is from the Precambrian rocks which lie at greater depths than the Minnelusa Formation, which is the aquifer tapped by Edgemont wells. Obviously, some water has moved upward from the "basement" rocks. Precambrian schists and granite are not good primary aquifers where they are unweathered, but deep weathering and fracturing of these rocks occurred before the younger Deadwood Formation was deposited across the weathered zone.

The Deadwood thins and, in fact, is generally absent (as are lower Paleozoic rocks in the Edgemont/Hot Springs area), which permits some water from the Precambrian weathered zone and along fractures to move upward into the Minnelusa and Pahasapa. This "deeper" water is also warmer, so one can understand how the town of Hot Springs got its name.

Some aquifers also "leak" water to overlying aquifers. When the southern part of the Black Hills was mapped in detail during the uranium mining in the 1950s, U.S. Geological Survey geologists noted many *breccia pipes* exposed up the slope of the Black Hills dome. It was recognized that these pipes were due to solution of deeper, buried soluble rocks (largely gypsum). The breccia pipes permitted the transfer of water from deeper aquifers to shallow aquifers when erosion produced topography similar



Please read the whole document

Pubs usgs gov/sir/2005/5160 /PDF/FT-PART 2 .pdf



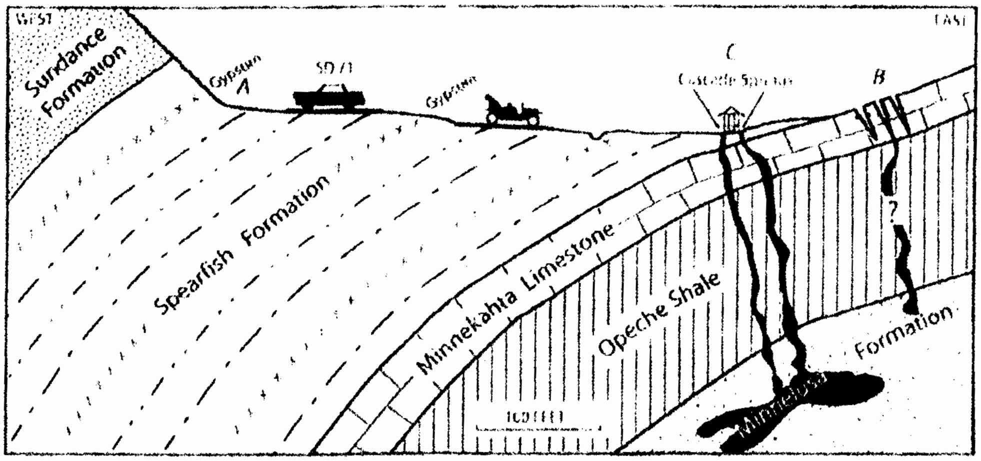



**Figure 14.** Cross section through the area of the gazebo at Cascade Springs showing localities to be examined, and breccia pipes, believed to be former conduits for the springs, extending up from dissolution cavities in the Minnelusa Formation at depth. Fractured Minnekahta shown in figure 16 lies about 100 feet above the gazebo at locality B. Green shale of the Stockade Beaver Member of the Sundance Formation caps the Spearfish west of S.D. highway 71.

The other "pipe", about 150 feet to the west as noted by Hayes (1999), is characterized by a gypsum bed that is downwarped a few feet, and beds above and below are not affected.

The many veinlets represent a zone where much gypsum has been removed by solution and/or have been intruded into the surrounding rock from the parent bed by processes not fully understood. Broken beds of gypsum several feet thick merge laterally into gypsum-red bed breccia (fig. 15C) and veinlets. The impression is that the original bedded gypsum at this locality has been modified by solution removal, injection into veins, contortion by expansion, and brecciation. It is possible that much of the original mass of gypsum has been removed. Also, anhydrite, which may have been the original form of calcium sulfate, when converted to gypsum, may have expanded considerably to create the force for vein injection and bed crumpling. However, several beds at the northernmost end of the exposure along SD 71 were X-rayed and no anhydrite was found in veins or beds, only gypsum (John Johnson, USGS, pers. comm.).

### B. Fractures ("pull apart") in the Minnekahta Limestone

Walk several hundred feet to the west along the highway and pass through an open gate before the parking lot at Cascade Springs and climb up the slope. Bedding in the Minnekahta wobbles a bit, but the dip averages about 20° to the southwest. Many large fractures (fig. 16 are found in a zone between 70 and 100 feet vertically above the base of the slope in an area about 150 feet long. The fractures are more than 10 feet deep in places, and probably extend the entire 40-foot thickness of the Minnekahta. They are as much as 10 feet wide and have various orientations, including N. 35° E., E.-W., N. 5° E., and N. 70° E., following prominent joint directions. There are three possible origins that might be considered for these structures: (1) subsidence due to solution of gypsum below, (2) gravity sliding on the soft sediments of the Opeche Shale, and (3) a combination of sliding and weakening of material below by solution. An initial impression is that these fractures are caused by tension due to downhill sliding. An interesting comparison with similar fractures in the Moenkopi Formation related to dissolution of salt at depth in the Holbrook basin (Epstein and Johnson, 2003) will be made. There are many small-scale structures, folds and faults, such as those described at mileage 4.5, that have been attributed to gravity sliding, believed to have occurred after erosion had exposed the surface of the Minnekahta (Epstein, 1958; Brobst and Epstein, 1963).

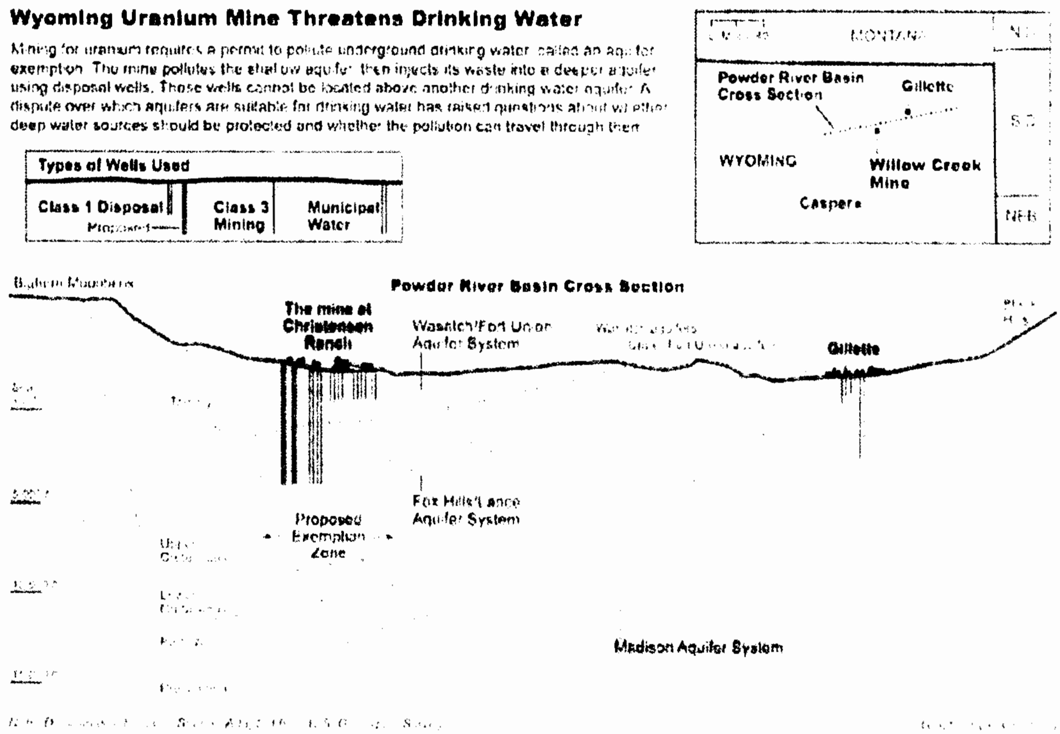
Jerri Baker
Docket No. 40-9075-MLA
ASLBP No. 10-898-02-MLA-BD01

Map of Madison and other aquifers in Wyoming. (Depletion)

Injection Wells
**The Hidden Risks of Pumping Waste Underground**

# Graphic: Uranium Mining at a Wyoming Ranch

A battle over uranium mining at Christensen Ranch, a remote 35,000-acre tract in Wyoming, could shape decisions nationwide as mining surges in drought-stricken areas. Below see how uranium mining at the Wyoming ranch could affect drinking water resources. | Related story »




Donate
ProPublica
© Copyright 2012
Pro Publica Inc
About Us
Staff
Contact
Jobs
Complaints and Corrections
Privacy Policy and Other Terms
FAQ
Sign up for Daily email
Become a fan on Facebook
Follow us on Twitter
See staff Twitter accounts
Download our apps for:
iPhone | Android
Listen to our Podcast
Subscribe via RSS
Steal Our Stories
Unless otherwise noted, you can republish our stories for free if you follow these rules

# Safeguard the public interest

Support ProPublica's award-winning investigative journalism
Donate
Steal Our Stories follow these rules Privacy Policy Sign up for our email list

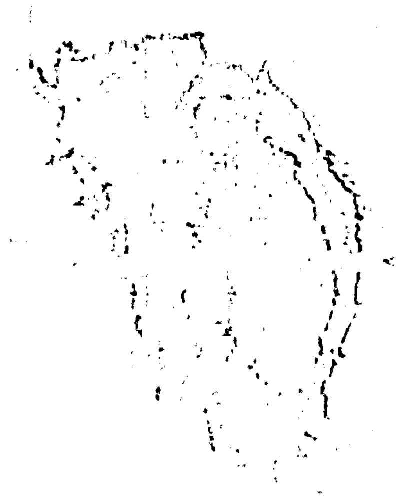
Jerri Baker
Docket No. 40-9075-MLA
ASLBP No. 10-898-02-MLA-BD01

Madison aquifer information. Simulation of groundwater flow in the Madison and Minnelusa aquifers, Black Hills area, USGS (Fractures)

EARTH

# MADISON AQUIFER

## What Is The Madison Aquifer?



The Madison aquifer is that part of the Madison Limestone that is saturated with ground water. The Madison Limestone is a rock formation, composed of limestone, that is exposed in the Black Hills area. It is sometimes called Pahasapa Limestone. It is a hard, crystalline rock that is composed of calcium carbonate and calcium-magnesium carbonate. This rock is slightly soluble in rainwater, enough so that caves and passageways have been dissolved in the Madison Limestone by infiltrating ground water . Well-known caves, such as Wind Cave and Jewel Cave, were formed in this way in the Madison Limestone. Water in the Madison aquifer is contained in these underground caves and fractures. Because the Madison aquifer contains drinking-quality water in the Black Hills area, many wells are drilled into it for water supplies in places such as Rapid City and Spearfish.

## Where Is The Madison Aquifer Found?

The Madison Limestone is exposed in a band around the Black Hills uplift (shown as limestone plateau and limestone in Figure 1), but it is also present in the subsurface beneath the ground in parts of Wyoming, Montana, North Dakota, South Dakota, and Nebraska. It extends into the region of South Dakota east of the Missouri River. It is not present in the higher Black Hills in the area of Mount Rushmore and Harney Peak, because the limestone layer has been eroded away in these locations.

## Why Is It Important?

About 90% of South Dakota's population relies on ground water from aquifers such as the Madison for drinking water supplies. The Madison aquifer is vitally important because it contains approximately 66 million acre-feet of drinking-quality water in South Dakota. Cities such as Rapid City use water from wells drilled into the Madison aquifer. Unfortunately, in some places the aquifer is too far beneath the surface for the water to be economically pumped for use. The water in the Madison will become more important in the future, as South Dakota's population grows and more people require water from scarce and dwindling supplies.

Heat in the Earth's interior, where the Madison is deep below the ground, causes some of the water in the aquifer to be very warm. Near Philip and Midland, the Madison contains water that is almost 160 degrees Fahrenheit (71 degrees C). This makes the Madison a valuable geothermal resource, although this hot water is often unsuitable for drinking because of its high mineral content. This heat is used to warm a school and some municipal buildings and homes.

**How Productive Are Wells In The Madison Aquifer?**

The Madison is one of South Dakota's most productive aquifers, but well yields can vary tremendously. Some wells in the Rapid City and Spearfish areas can produce more than 1,000 gallons (about 3800 liters) per minute. Some of these are flowing artesian wells that will produce more than 500 gallons (almost 1900 liters) per minute without pumping. Other wells sometimes are less productive and might yield only 20 to 30 gallons (75 to 113 liters) per minute.

**Conservation Measures**

The outcrop area where the Madison Limestone is exposed around the Black Hills is the recharge zone of the aquifer, where rainwater and snowmelt infiltrate into the rock and replenish this underground reservoir. Water in the Madison aquifer flows through fractures, pores, and caves in the rock, and usually does not receive the natural filtering that most ground water undergoes as it seeps through soil and sediments. Some streams, such as Boxelder Creek and Spring Creek, lose their flow to sinkholes in the Madison. Protection of the aquifer's recharge areas from pollution by sewage, gasoline, and industrial activities can help preserve the water quality of the aquifer.

**Glossary**

**Acre-foot** - the amount of water that will cover one acre of land to a depth of one foot.
**Artesian well** - a well in which the water is under sufficient pressure that it rises partway up in the well without the assistance of pumping. A flowing artesian well will flow at the surface.
**Geothermal** - referring to the heat from the earth's interior.
**Ground water** - all water below the land surface.
**Recharge zone** - that area through which water in an aquifer is replenished either by runoff, by infiltration from precipitation, or by underground flow from connected aquifers.
**Sinkhole** - a funnel-shaped depression in the land surface through which surface water drains into underground channels.

**Written by:**
Arden D. Davis, Dept. of Geology and Geological Engineering, SDSM&T, Rapid City, SD. 1995

**Reviewed by:**
Ralph K. Davis, Dept. of Geology, University of Arkansas, Fayetteville, AR 72701.

Publication of the *Madison Aquifer* fact sheet was funded by the West Dakota Water Development District, Rapid City, SD.

# Simulation of groundwater flow in the Madison and Minnelusa aquifers, Black Hills area

27 November 2012
U.S. Geological Survey, Rapid City, South Dakota
Principle Investigator and Project Chief: Andrew J. Long, PhD

## Executive summary

The Madison and Minnelusa aquifers are critically important water resources that were a primary focus of the Black Hills Hydrology Study of the 1990s. These aquifers have a large influence on surface-water systems and provide the most important source of groundwater for municipal, domestic, agricultural, and industrial use in the area. Rapidly increasing demand from these aquifers may affect groundwater availability and surface-water resources.

This document describes a proposed study to construct a groundwater flow model of the Madison and Minnelusa aquifers for the Black Hills and surrounding area to help address hydrologic questions on local and regional scales. Several parties in the Black Hills area, including the National Park Service and the Black Hills National Forest, have sought answers to questions concerning groundwater—the primary water supply for this area. These questions are summarized by three questions of broad scope: (1) What is the influence of regional groundwater flow on local groundwater flow? (2) What is the aquifer sensitivity in different areas to pumping and drought? (3) How might future data collection efforts be planned most effectively? These questions are difficult, or impossible, to answer objectively without rigorous quantification of numerous local and regional hydrologic influences on groundwater. A three-dimensional groundwater flow model for the Black Hills area would provide these estimates better than any other known method. The U.S. Geological Survey (USGS) previously has developed site-specific models of the Madison and Minnelusa aquifers for the Rapid City and Spearfish areas. The need for updated models in these and other areas is expected to continue in the future. For example, the National Park Service recently has expressed a desire for a groundwater model of the southern Black Hills.

Developing a regional groundwater flow model that includes the entire Black Hills area will have several benefits over a continuation of site-specific modeling efforts:

1. Developing a single regional model would be more cost effective than multiple smaller models.
2. Simulation of site-specific areas (e.g., Rapid City) is more accurate when placed within a regional flow model.
3. Artesian springs are critical water sources that capture groundwater from regional areas and thus are best simulated with a regional model.
4. The model grid can be modified for high-resolution simulations in any area of special interest or to answer specific hydrologic questions (e.g., the effects of pumping in a small area).

5. As additional future questions arise, other hydrologic scenarios can be cost-effectively evaluated without the need for new site-specific models.

Until recently, the success of developing a meaningful and useful model for the entire Black Hills area would have been questionable. Fourteen years of data collection have occurred since the Black Hills Hydrology Study resulting in a wealth of available data, and this combined with our improved conceptual understanding of groundwater flow in the area and the recently developed modeling capabilities make this effort now feasible. The model will be designed to address current objectives and hydrologic questions but also will have a generic underlying structure for adaptation to future objectives and model refinement. This model is envisioned as a long-term tool that will be available for numerous future studies and will symbiotically benefit multiple interested parties. Objectives are to (1) better understand the influence of regional groundwater flow on local groundwater; (2) assess the effects of pumping and drought on groundwater availability; and (3) help guide further data collection efforts.

If multiple interested parties contribute to this effort, the cost to any one party will be minimized, and all will benefit. For 2011 and 2012, the combined contributions from the National Park Service and the Black Hills National Forest were $101,650, or 11% of the total estimated cost of $960,000. Contingent on availability of funding through its Cooperative Water Program , USGS will plan to contribute matching funds for contributions from local or state governments in a ratio of at least 40 percent USGS funds to 60 percent local/state funds. The remaining funding will be spread over the next four years (2013-2016) or more, depending on annual funding levels. Several local agencies have expressed potential interest in participation, including the cities of Rapid City and Spearfish, Lawrence County, and the West Dakota Water Development District.

## Introduction

The Madison and Minnelusa aquifers are critically important within the complex hydrogeologic framework of the Black Hills area. These aquifers were a primary focus of the Black Hills Hydrology Study of the 1990s for several reasons. These aquifers have a dominating influence on area surface-water systems in several critical settings (Driscoll and others, 2001) including (1) large springs in the headwaters of many major streams; (2) sinking streams, or loss zones, along the eastern flanks of the Black Hills where substantial groundwater recharge occurs; and (3) large artesian springs that provide stream base flow downstream from the Black Hills. These aquifers provide the most important source of groundwater for municipal, domestic, agricultural, and industrial use in the area. Rapidly increasing demand in numerous communities and suburban areas may affect groundwater availability and surface-water resources. Availability of groundwater varies with annual, decadal, or longer-term changes in climate. In response to climatic changes and possibly groundwater withdrawals, water levels for the Madison aquifer have changed by more than 100 ft in some places in less than a decade, both increasing and decreasing. Understanding groundwater flow is essential for assessing and managing groundwater resources. Numerical simulation of groundwater flow is the most common method for assessing the effects of multiple influences on aquifers, including groundwater use, natural spring flow, variability in precipitation and streamflow, population growth, long- and short-term climatic changes, and contaminant transport.

This proposal describes an approach for construction and application of a numerical groundwater flow model of the Madison and Minnelusa aquifers for the Black Hills and surrounding area. The overarching approach is to develop a generalized Black Hills flow model that will help to answer current hydrologic questions as well as to serve as the underlying framework for current and future focused studies and refined flow simulation in localized areas. Such a model will benefit multiple governmental agencies and other parties interested in water management, will be available for future studies, and could be refined and updated for any particular area of interest. Until recently, the success of developing a meaningful and useful numerical model for the entire Black Hills area would have been questionable. However, the current wealth of data for the area combined with the most recent modeling and optimization software and computing power, such as cloud computing, results in a high likelihood of success.

A wealth of new data useful for modeling has been collected since the Black Hills Hydrology Study was completed, which included data through 1998. New datasets include (1) 14 years of streamflow, spring flow, and groundwater levels for continuous gages and manual measurements, which adds an additional wet and dry cycle to the record; (2) multiple groundwater tracers (e.g., chlorofluorocarbons, stable isotopes, tritium, major ions) collected at about 70 sites and used to better characterize groundwater flow, conduit networks, and groundwater transit times; (3) microgravity measurements to estimate effective porosity and better characterize unconfined aquifer zones; and (4) several years of stable-isotope time-series data for selected wells and streams.

## Problem

Local and federal agencies in the Black Hills area are seeking answers to questions regarding groundwater availability, the effects of current or future groundwater extraction or drought, the proportions of regional groundwater inflow and local recharge in particular areas, the capture zones of springs and wells, and the influence of springs and wells on flow directions and hydraulic gradients. These questions are difficult, or impossible, to answer objectively without a thorough quantification of myriad hydraulic influences and stresses on any given area. The influence of regional groundwater flow on local hydrologic responses is particularly difficult to quantify. A three-dimensional groundwater flow model would provide these estimates better than any other known method, but such a model does not exist for the entire Black Hills area. Without the availability of a calibrated regional model, smaller models would need to be developed independently to address issues in site-specific areas, which is an inefficient approach. Smaller areas for which models previously have been developed include part of the northern Black Hills (Greene and others, 1999) and the Rapid City area (Putnam and Long, 2009). Considering the complexity of the Black Hills hydrogeologic framework, the value of the water resources, and the abundance of hydrologic issues and questions, many needs for additional modeling efforts are foreseen in the near future. Developing one regional model has several advantages over developing separate smaller models for specific areas. These advantages are (1) it would be a more cost effective approach, (2) simulation of site-specific areas is more hydrologically accurate when nested within the context of regional flow, and (3) artesian springs capture groundwater flow from large, possibly regional, areas that can be simulated with a regional model but not with small-area models. The latter item is particularly important in the northern and southern Black Hills, where regional flow sweeps around the Black Hills toward the east and mixes with local recharge.

## Objectives °Æ§ ≥£Ø∞•

Study objectives are to (1) better understand the influence of regional groundwater flow on local groundwater; (2) assess the effects of pumping and drought on groundwater availability; and (3) help guide further data collection efforts.

The primary focus of the proposed model will be in and near the Black Hills where water from the Madison and Minnelusa aquifers is used extensively. Areas of complex hydrogeology, such as where Tertiary intrusive rocks have disrupted parts of the Madison and Minnelusa aquifers, will be simplified to a level that can be represented by the model. When constructing a model, one of the first considerations is the locations of boundaries, which frequently are set arbitrarily if a natural aquifer boundary, such as a recharge area, does not exist in proximity to the area of interest. These arbitrary boundaries generally are flux boundaries across which simulated groundwater flows horizontally through a cross-section of an aquifer. To minimize artificial boundary effects, flux boundaries will be set far from populated areas of interest and much wider than the limits of the Black Hills Hydrology Study (Figure 1). The focus area near the Black Hills (Figure 2) will have smaller model cells and will be given more weight in model calibration than other areas of the model.

Specifically, this model will be a three-dimensional numerical groundwater flow model for the Madison and Minnelusa aquifers in and near the Black Hills of South Dakota, constructed in MODFLOW (Harbaugh, 2005). The model for the Rapid City area (Putnam and Long, 2009) will be incorporated into the regional model, with a similar model cell size. Model grid cells will increase in size outside of the Rapid City area. Automated procedures for constructing the model from an independent geospatial database in ArcGIS will allow for efficient grid refinement in particular areas of interest for future focused modeling studies. These automated procedures will consist of utilities that interface between the geospatial database and MODFLOW. Hydrogeologic data or estimates, including aquifer tops, aquifer bottoms, potentiometric surfaces, well locations, recharge, and hydraulic conductivity, will be stored in the geospatial database.

The scope of the project includes a data-collection component, which will provide hydrochemical tracer data useful for calibrating the model to flow directions and groundwater mixing. The project consists of two phases: (1) a hydrogeologic framework and conceptual model and (2) a numerical groundwater flow model.

## 0≤• ∂@Ø|µ≥@Ð• ≥¥@° ¥@Ø⁄Ð ° Æ§ ° ∂° ©° ¢¨• §° ¥

In developing numerical flow models, a large part of the effort involves collecting and analyzing data, constructing surfaces for aquifer tops, bottoms, and potentiometric surfaces, and so forth. However, as a result of various previous investigations, many of the basic data components necessary for developing a numerical flow model already exist. The Black Hills Hydrology Study (area shown in Figure 1) included numerous investigations that were summarized by Carter and others (2002; 2003) and Driscoll and others (2002). Other previous investigations with detailed information for focused areas of study in the northern, southern, and eastern Black Hills include Long and Putnam (2002), Putnam and Long (2007a 2007b; 2009), and Long and others (2008; 2012). Regional data beyond the Black Hills also are available from numerous other investigations listed in the "References Cited" section. Geologic maps and cross sections for the Black Hills are available from Strobel and others (1999) and Redden and DeWitt (2008).

## Hydrologic ±µ• ≥¥@Ø⁄Ð ¥Ø¢• °§§≤• ≥≥• §

**Í ╙ĂĆ╠ Ő╘ ╧ť** The model will be used to assess and better understand regional groundwater flow in relation to the Black Hills area and the relative mixture of local recharge and regional flow, which might originate from as far away as the eastern flanks of the Rocky Mountains in Wyoming. This is of particular importance at the northern and southern tips of the Black Hills, where local and regional flow converges. The capture zones of artesian springs, the influence of these springs on the mixing of regional and local flow, and the relative proportions of regional and local spring flow will be assessed. Also, the converging and mixing of recharge on the western flank of the Black Hills with regional flow from farther to the west will be assessed.

**Í ╙ĂĆ╠ Ő╘ Ăĳ ╧ť** The effects of increased groundwater demand as a result of potential population growth will be evaluated by simulating additional pumping from existing or hypothetical production wells. One transient simulation will be executed for each of 5 to 7 areas on the eastern side of the Black Hills between Spearfish and Hot Springs. Potential evaluation areas include Spearfish, Sturgis, Rapid City, Hermosa, Hot Springs, or other areas between these cities (e.g. near Whitewood, Summerset, or Buffalo Gap). The final selection of evaluation sites and pumping rates will be determined by consulting with project cooperators. A pumping period of 10 to 30 years will be simulated for each area (not to exceed the length of the transient calibration period). Declines in hydraulic head and spring flow as a result of the additional pumping will be evaluated. Artesian springs to be evaluated are described by Driscoll and Carter (2001, fig. 12 and table 2). Water table springs for the Madison aquifer to be evaluated include springs at the headwaters of streams on the western outcrop of the Madison Limestone (limestone headwater springs; Driscoll and Carter, 2001). At the end of the pumping periods, the simulated aquifers will be allowed to recover, and the recovery time for hydraulic head and spring flow will be evaluated for each of the pumping areas. Aquifer recovery will be simulated until full recovery is achieved. GWM is groundwater management process (Ahlfeld and others, 2005) developed for MODFLOW that might be useful for this purpose.

One or more drought periods similar to those that occurred in western South Dakota between 1930 and 1960 (Driscoll and others, 2000) will be simulated, and the resulting declines in hydraulic head will be shown on a map of the focus area, and spring-flow declines will be evaluated.

[illegible] Because data collection can be costly, an objective assessment of future groundwater data collection scenarios would be useful. Model predictive uncertainty analysis, as described in Doherty (2010) and Fienen and others (2010), will be used to assess possible scenarios. Specifically, this will indicate what new data would reduce the model's uncertainty if these data were acquired at some future time. Future revisions of the model, as well as other future hydrologic studies, will benefit from this assessment. GWM might be useful in this application.

## Approach

The MODFLOW finite-difference groundwater flow modeling software will be used to construct the model and simulate groundwater flow (Harbaugh, 2005). The grid will be coarse near model boundaries (~15-km spacing) and finer within the focus area (300-500-m spacing; Figure 2). The highest resolution will occur in the Rapid City area, with a grid spacing of about 150 m. The coarse-gridded areas will have few model cells with a small effect on execution times but will minimize artificial boundary effects. One method for varying the size of grid cells is to vary the widths of model rows and columns in the desired area, as described in Harbaugh (2005). This method was used by Long and Putnam (2008) and Putnam and Long (2009). Another method is to use the Local Grid Refinement (LGR) capability that is now available for MODFLOW-2005 (Mehl and Hill, 2007). This option allows nested grids of fine resolution within an otherwise coarse-gridded model. Also, the USGS soon plans to release a new version of MODFLOW that allows for much more freedom in the structure of the model's grid and will allow grid cells to be almost any shape desired. For example, small triangular grid cells could be used for the Rapid City area and could increase in size outward in all directions. This versatility would easily accommodate small cells in any area of interest where high resolution simulation is desired.

The full extent of the Madison and Minnelusa aquifers in the model area will be simulated, each with two model layers, similarly to the approach of Putnam and Long (2009). Outside of the focus area, the Madison and Minnelusa aquifers each will be simulated as one layer unless additional information indicates benefits to simulating them with two layers each. The Englewood Limestone underlies and has similar properties to the Madison Limestone, and this formation will be combined with the lower Madison aquifer layer. Upward flow into the Madison aquifer layer from underlying aquifers will be simulated, but the model will not be calibrated for these underlying aquifers, which consist of the Whitewood, Winnipeg, and Deadwood aquifers. This method was used in the numerical model by Putnam and Long (2009). These three aquifers will be combined into one model layer, hereafter referred to as the *sub-Madison* layer and will be included in the model for the purpose of providing a lower model inflow boundary only. The rate of this flow component will be estimated by the method used by Long and Putnam (2002) for the eastern-central Black Hills, which was also was used in the numerical model by Putnam and Long (2009). This method uses Darcy's law and the difference in hydraulic head between the Madison and Deadwood aquifers to estimate a flow rate. This estimated flow rate will be assigned as recharge to outcrops of the Whitewood, Winnipeg, and Deadwood aquifers and allowed to leak upward into the Madison aquifer. As a minimum areal extent, the sub-Madison layer will be included below exposed areas of the Madison aquifer, with the option of a larger areal extent if necessary for upward flow.

Some of the Phase 1 tasks have been completed or are in progress. This proposal describes the project in its entirety, including completed tasks.

### *0®˚≥• ở—( π§≤ØB• Ø'ØB@¶°≠ •∑Ø´ °Æ§ £ØÆ• ∝¥µ°¨≠ Ø§•¨*

A hydrogeologic framework will be assembled primarily on the basis of existing data from numerous sources (see References cited). The first step is to define the model area and hydrogeologic boundary conditions (e.g., head-dependent, no-flow, specified-flux, or constant-head boundaries). Figure 2 shows the approximate model area. The exact model area and focus area will be finalized after further examination of data and literature. The second step is to define altitudes of the tops and bottoms of the hydrogeologic units as they will be represented by model layers. The third step is to define general potentiometric surfaces for the hydrogeologic units. Fourth, recharge from direct precipitation and sinking streams, evapotranspiration, and discharge to springs and streams will be estimated on the basis of available data. Groundwater pumping will be obtained from publically available water use data (U.S. Geological Survey, 2011). If necessary, data on water permitting for South Dakota, Wyoming, and Montana will be acquired. Manual flow measurements will be made at selected springs and streams where continuous gages do not exist one or more times during the study and will be used as model calibration data. Geochemical data consisting of stable isotopes of oxygen and hydrogen ($\delta^{18}O$, $\delta^{2}H$) and major ions will be collected at sinking streams, wells, and springs for use as natural tracers. Samples will be analyzed at the USGS Isotope Laboratory in Reston, Virginia and the USGS National Water Quality Laboratory in Denver, Colorado. Sampling will consist of about 50-70 samples, collected either once at each site or multiple times at few sites. These data, together with existing geochemical data, will be used to better characterize groundwater flow directions and mixing and also in model calibration or to help assess model uncertainty (e.g., how well does the model simulate flow directions and mixing determined by natural tracers). Hydraulic conductivity estimates will be assembled where available from aquifer tests and previous groundwater flow models. Because these estimates are sparse, hydraulic conductivity will be estimated primarily during the model calibration phase. All assembled data and estimates will be used to describe the groundwater flow system conceptually, which will then become the basis for a numerical flow model.

Groundwater recharge will be estimated using the method of Westenbroek and others (2010), which is a soil-water-balance (SWB) model that uses precipitation, temperature, land-use, and soil-type data. Methods similar to SWB also are available and possibly will be used as a comparison to SWB.

Recharge near sinking streams and hydrologic processes in semi-saturated cavernous aquifer zones in the Black Hills are poorly understood because of lack of data and complexity of these areas. A pilot project to test the capabilities of microgravity measurements for assessment of transient groundwater storage processes in recharge areas of the Black Hills currently is near completion. Results indicate that microgravity methods are useful for characterizing physical properties and flow processes in recharge areas of the Madison and Minnelusa aquifers (Koth and Long, 2012 *in review*), and this information could not be obtained from previously applied methods. Microgravity investigations will continue in previously studied areas because longer data records for these areas will better constrain gravity-based effective porosity estimates and other flow characterizations. Microgravity investigations may be applied to areas not previously studied if, at some time, this is determined to be more useful than continuation at current measurement locations.

Nuclear magnetic resonance (NMR) is a geophysical method that has been used successfully in karst aquifers. This is the same technology that is routinely used in medical imaging; i.e., magnetic resonance imaging (MRI). NMR can be used to determine the depth and volume of groundwater, particularly in aquifers with large porosity and large voids, such as karst aquifers. NMR can be applied over an area of the land surface, imaging to depths of 150 meters in some cases, or as a down-hole tool in boreholes. NMR initially will be tested in areas where microgravity methods have been applied, and the combination of these two methods to characterize recharge areas will be tested. Additional NMR work may be used with or without microgravity, depending on what is found to be useful.

Some combination of microgravity and NMR investigations will be conducted at existing microgravity survey areas, and additional measurement areas may be added. The number of measurement areas and the relative effort invested in the two methods will be determined as data are collected and analyzed. Effort will be allocated according to what is most efficient for obtaining useful data to characterize recharge areas.

**Phase 1 tasks**

1. *Identify and assemble existing data sources* – Several categories of data have been previously described.

2. *Define model area and boundary conditions* – The approximate model area shown in Figure 2 will be revised as necessary after further examination of previous studies, which describe the geology and hydrology of the model area. Particular attention will be given to the southern model extent, at or near the limit of the Madison aquifer.

3. *Construct datasets for aquifer tops and bottoms* – Several contour maps of formation tops and thicknesses cover different parts of the model area. These will be merged or matched at the edges of the individual map extents for continuous surfaces across the model area. These will be checked for consistency in the three-dimensional hydrogeologic framework.

4. *Construct datasets for potentiometric surfaces* – Several contour existing maps of potentiometric surfaces cover different parts of the model area and will be merged similarly to what is described for the aquifer tops and bottoms.

5. *Construct datasets for hydraulic conductivity* – Estimates from previous modeling studies and aquifer tests will be assembled. These will provide initial values that will be refined during model calibration.

6. *Interpolate spatial and temporal precipitation for Black Hills* – Data from precipitation gages will need to be interpolated between gages. This has been completed for 1931-1998 (Driscoll and other, 2000) but will need to be updated for 1999-2012.

7. *Apply the soil water balance (SWB) method to estimate areal recharge from precipitation* – This method is described by Westenbroek and others (2010).

8. *Estimate groundwater recharge from sinking streams* – This will involve assembling streamflow records for existing gages and estimating recharge rates on the basis of maximum streamflow loss rates indicated by Hortness and Driscoll (1998). Recharge rates also will need to be estimated for ungaged streams and when maximum loss rate estimates are not available.

9. *Estimate and construct datasets for spring and stream discharge* – Discharge records for springs and gaining streams will be assembled when available. In some cases, these will be determined by estimating stream base flow at gages downstream from springs or gaining streams.

10. *Acquire or estimate groundwater-use data*

11. *Collect geochemical and flow data* – Geochemical data include stable isotopes of oxygen and hydrogen ($\delta^{18}O$, $\delta^{2}H$) and major ions. Flow rates will be measured at selected springs and streams.

12. *Analyze geochemical samples* – Samples will be sent USGS laboratories

13. *Apply microgravity and NMR methods* – Geophysical methods primarily include microgravity work, but new geophysical methods are continually being developed and might be found useful for this project. Wells will be site visited when necessary for quality control of elevation or water-level data.

14. *Report writing including figure and table preparation.*

15. *Respond to review comments and reciprocate reviews* – The review process is essential to a quality scientific report.

***0®ʳ≥ Õ–3¥ °§π≥¥ ¥ °Æ§ ¥≤ Æ≥◎Æ≢Æ≢ • ≤@° ¨¶Ø∑ ≠ Ø§• ¨***

Data and estimates from Phase 1 will be used to develop a numerical groundwater flow model for the regional area shown in Figure 2 using MODFLOW-2005 (Harbaugh, 2005) or an updated version of MODFLOW if available. The model of the Rapid City area (Putnam and Long, 2009) and the model of the Spearfish area (Greene and others, 1999) will be incorporated into the regional model. Hydraulic conductivity values used in these models will be used as initial, or pre-calibration, values for the regional model. These values may change during calibration of the regional model because of differences in boundary conditions between the small models and the regional model. The regional model first will be calibrated to steady-state flow conditions, where all inflows and outflows are constant in time. Initial estimates of model parameters, such as hydraulic conductivity values, will be refined by adjusting these values to achieve similarity between observed and simulated hydraulic-head and flow values. The abundance of hydraulic-head values makes this an effective method for estimating hydraulic conductivity. The parameter optimization software PEST will be used to achieve this calibration (Doherty, 2005). This state-of-the-art software eliminates the need for inefficient trial-and-error parameter adjustment. A relatively new and powerful method known as *pilot points* described in Doherty (2005) will be used in model calibration. This method interpolates hydraulic conductivity values in each model cell between pilot points, where the optimization occurs.

Once the steady-state calibration is complete, the model will be executed in transient mode, which will simulate a specific historical time period of up to 20-30 years of record for annual data. Model calibration will be refined in this mode to achieve optimum similarity between temporal changes in observed and simulated hydraulic-head and flow values on an annual basis.

**Phase 2 tasks**

1. *Format all data for MODFLOW input files and construct model* – Data stored in ArcGIS will be exported to populate model cells. Data stored in other formats will be formatted for MODFLOW input.
2. *Link MODFLOW model to PEST optimization software* – PEST runs as a parent program to MODFLOW. Several instruction files need to be created so that PEST can read MODFLOW output. Debugging the PEST instruction files generally is part of this process.
3. *Calibrate steady-state model to measured data* – The model is calibrated to average flow conditions in this step. This is a lengthy process with many stages of increasing model complexity and parameter definition and categorization.
4. *Execute and calibrate transient model to historical data* – This process is similar to Task 3, except that the model is calibrated to long-term records. Parameter estimates from the steady-state calibration will be used as initial estimates.
5. *Define spring capture zones and ratio of regional flow* – Backward particle tracking from spring discharge points will be conducted on the calibrated model to determine spring capture zones. The point of origin for these particles will determine the ratio of regional flow for each spring.
6. *Assess spatial aquifer sensitivity to pumping and drought* – A series of model executions will be conducted, where one simulated well will be pumped for each execution. Average drawdown in proximal cells will be determined for each pumped well, and a map of relative drawdown will be created. An extended drought period will be simulated as previously described, and a map showing the resulting hydraulic-head decline at the end of this period will be created.
7. *Determine the focus of future data collection efforts – A model predictive uncertainty analysis will be conducted to determine areas and types of data that, if collected, would decrease the model's predictive uncertainty.*

8. *Report writing including figure and table preparation*

9. *Respond to review comments and reciprocate reviews*

## Potential ¶µ¥µ≤• ≥¥µ§®≥

Hydrologic scenarios related to increased water use, additional pumping wells, or extreme climatic conditions, such as drought, could be simulated for particular areas of interest. Refined model calibration for these areas might be necessary, and grids with finer resolution could be nested into these areas. Contaminant-transport simulations could be conducted to investigate water-quality issues. One potential approach for these investigations might be to simulate flow in discrete conduits in the Madison aquifer for areas where knowledge of conduit locations exist. The conduit-flow process for MODFLOW-2005 (Shoemaker, 2008) could be applied in this case. Plans for the new version of MODFLOW include pipe-flow simulation capability, which also could be used for this purpose. Hypothesis testing for conduit flow and conduit locations could be applied in areas for which knowledge of conduit locations is lacking. The model will be constructed such that flow in the Precambrian aquifer in the Black Hills also could be simulated in the future. GWM might be useful in many future studies involving this model.

The proposed model will be available and useful for studies long into the future, both within and outside of the USGS. The USGS South Dakota Water Science Center consistently has had experienced staff with groundwater modeling expertise for more than 25 years, and is committed to continuing this past record. For most of this time, there have been at least two hydrologists with groundwater modeling experience on staff, with additional assistance from several part-time students. Kyle Davis, a recent graduate with groundwater modeling experience, has recently been hired as a permanent employee. All numerical models are archived electronically according to USGS protocol for the purpose of future use. These archives include all model input files, the executable program (e.g., MODFLOW), model input and output data in ArcGIS format, and documentation describing how to execute the model. All archived models are available upon request to the public. For example, the groundwater flow model for the Rapid City area (Putnam and Long, 2009) currently is being used by Colorado State University for research in karst aquifers. Another example of a USGS model that was first documented and published but later updated is a groundwater flow model of the Ogallala and Arikaree aquifers in South Dakota. The model first documented by Long and others (2002) was later updated with improved estimates of recharge, current hydrologic conditions, higher grid resolution, and an assessment of potential future hydrologic scenarios (Long and Putnam, 2008).

## BudgetŴimelineŴA§ ∞≤Ø§µ£¥≥

The project is planned for completion within a 6-year period at an estimated cost of $960,000 (Table 1). The budget represents the project in its entirety, including all completed tasks. Assuming that the USGS Cooperative Water Program continues in the future, the USGS will contribute matching funds for any contributions from local or state governments. Funding provided by Federal agencies cannot be matched by the USGS. For 2011 and 2012, the combined contributions from the National Park Service and the Black Hills National Forest are equal to $101,650, or 11% of the total cost. Additionally, several local agencies have expressed potential interest in participation, including the cities of Rapid City and Spearfish, Lawrence County, and the West Dakota Water Development District. The USGS and Rapid City currently are engaged in a cooperative program involved groundwater flow modeling and Rapid City has expressed especially keen interest in regional model development.

Two USGS Scientific Investigations Reports to document data and results for each of the two phases of this study and are planned for publication in 2014 and 2016, respectively. The first report will describe the hydrogeologic framework and conceptual model on which the numerical model will be built. The second report will document calibration of the numerical model, results of groundwater flow simulations, and an assessment of future data needs.

**Table 1. Budget and timeline. Funding by Federal fiscal year indicates time frame for planned tasks.**

[L - labor; LA - laboratory analyses; P - publications; Tv - travel; V - vehicle; Tu - tuition; Sh - shipping; C - Software or computing]

| | Cost in Federal fiscal year | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Cost type |
| **[illegible]** | | | | | | | |
| Identify and assemble existing data sources | $8,800 | | | | | | L |
| Define model area and boundary conditions | $3,800 | | | | | | L |
| Construct aquifer top and bottom surfaces | $17,700 | | | | | | L |
| Construct potentiometric surfaces | | $14,400 | | | | | L |
| Create datasets for hydraulic conductivity | | $18,400 | | | | | L |
| Interpolate spatial & temporal precip for Black Hills | | $8,200 | | | | | L |
| Apply SWB to estimate areal recharge | | $18,500 | $19,200 | | | | L |
| Estimate stream recharge | | $12,300 | | | | | L |
| Estimate & build datasets for spring and stream discharge | | $16,300 | | | | | L |
| Acquire or estimate groundwater use | | | $4,200 | | | | L |
| Collect geochemical and flow data | | | $7,700 | $27,000 | $3,900 | | L |
| Analyses of geochemical samples | | | $2,800 | $9,800 | $30,300 | | LA |
| Apply microgravity and NMR methods | | $77,500 | $70,300 | | | | L |
| Report writing including figure & table prep | | $16,400 | $22,800 | $17,700 | | | L |
| Respond to review comments & reciprocate reviews | | | | $10,900 | | | L |
| **[illegible]** | | | | | | | |
| Format all data for Modflow input files and build model | | | $42,500 | | | | L |
| Link Modflow model to PEST optimization software | | | $27,600 | | | | L |
| Calibrate steady-state model to measured data | | | $26,500 | $64,400 | | | L |
| Execute and calibrate transient model to historical data | | | | $24,900 | $99,800 | | L |
| Define spring capture zones and ratio of regional flow | | | | | $13,100 | | L |
| Assess spatially aquifer sensitivity to pumping & drought | | | | | | $13,700 | L |
| Determine focus of future data collection efforts | | | | | | $25,000 | L |
| Report writing including figure & table prep | | | | | $23,700 | $57,400 | L |
| Respond to review comments & reciprocate reviews | | | | | | $13,700 | L |
| **[illegible]** | | | | | | | |
| Report 1 processing, layout, printing | | | | $18,200 | | | P |
| Report 2 processing, layout, printing | | | | | | $18,900 | P |
| Tech assist on PEST software | | | $5,500 | | | | Tv, L |
| Vehicle for field work | | $2,500 | $2,500 | $2,500 | | | V |
| Cloud computing service | | | $5,000 | $5,000 | $5,000 | $3,000 | C |
| Training & travel | | $3,000 | $5,000 | $5,000 | | | Tu, Tv |
| Shipping | | $500 | $1,000 | $800 | $200 | | Sh |
| Software | | $4,000 | $300 | $300 | $300 | $300 | C |
| **Fiscal year totals** | **$30,300** | **$192,000** | **$242,900** | **$186,500** | **$176,300** | **$132,000** | |
| | | | | **Project total** | | **$960,000** | |

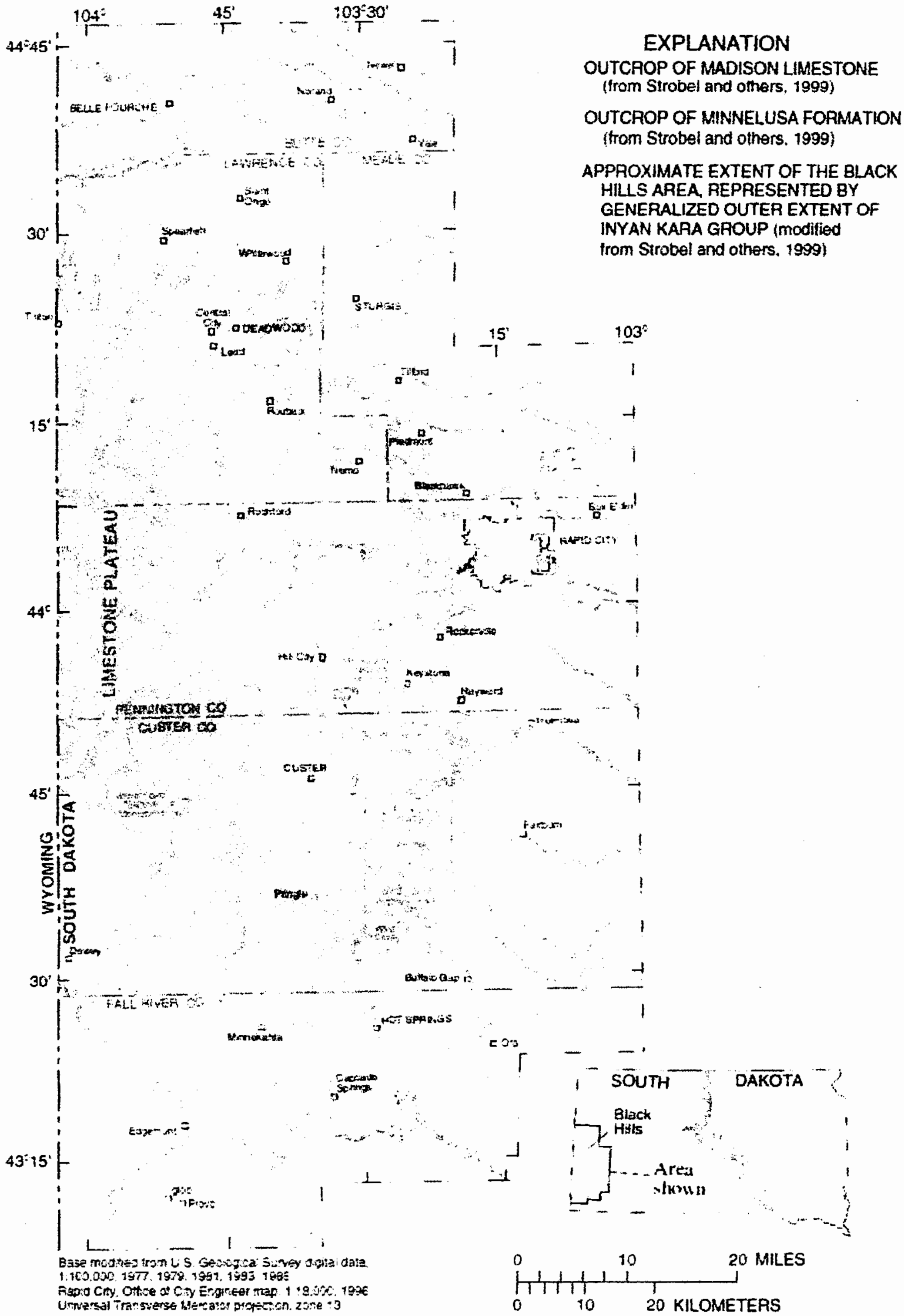
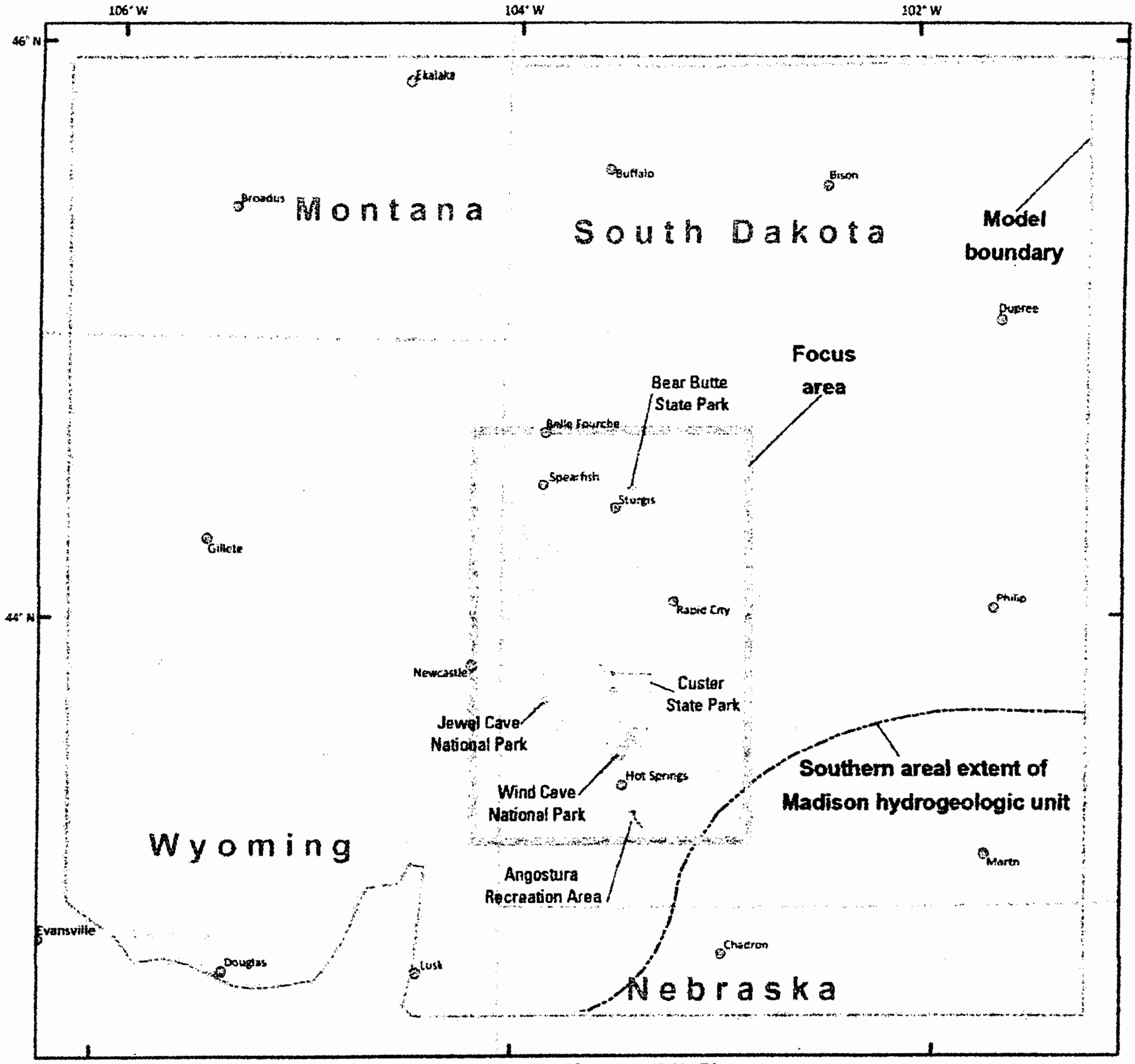



**Figure 1. Area of investigation for the Black Hills Hydrology Study (From Driscoll and others, 2002).**




Base from U.S. Geological Survey digital data, 1997, 1:100,000
Modified albers equal area conic projection.

0 20 40 MILES

0 20 40 KILOMETERS

Geology modified from Strobel and others (1999).

EXPLANATION

| | | |
|---|---|---|
| Hydrogeologic units | National Parks | Lusk Cities with labels |
| Minnelusa aquifer | South Dakota State Parks | |
| Madison aquifer | States | |

**Figure 2. Potential model boundaries and focus area for groundwater flow simulation.**

## References cited


Carter, J.M., Driscoll, D.G., and Sawyer, J.F., 2003, Ground-Water Resources in the Black Hills Area, South Dakota: U.S. Geological Survey Water-Resources Investigations Report 03-4049, 36 p.

Carter, J.M., Driscoll, D.G., Williamson, J.E., and Lindquist, V.A., 2002, Atlas of water resources in the Black Hills area, South Dakota: U.S. Geological Survey Hydrologic Atlas 747, 120 p.

Doherty, J., 2005, Pest: Model-Independent Parameter Estimation, User Manual 5th ed. (5th ed.), Watermark Numerical Computing, variously paged p.

Doherty, J., 2010, Methodologies and Software for PEST-Based Model Predictive Uncertainty Analysis, Watermark Numerical Computing, 157 p.

Driscoll, D.G., Carter, J.M., Williamson, J.E., and Putnam, L.D., 2002, Hydrology of the Black Hills area, South Dakota: U.S. Geological Survey Water-Resources Investigations Report 02-4094, 150 p.

Driscoll, D.G., Hamade, G.R., and Kenner, S.J., 2000, Summary of precipitation data for the Black Hills area of South Dakota, water years 1931-98: U. S. Geological Survey Open-File Report 00-0329, 151 p.

Driscoll, D.G., and Carter, J.M., 2001, Hydrologic conditions and budgets for the Black Hills of South Dakota, through water year 1998: WRIR 2001-4226, 143 p.

Fienen, M.N., Doherty, J.E., Hunt, R.J., and Reeves, H.W., 2010, Using prediction uncertainty analysis to design hydrologic monitoring networks: Example applications from the Great Lakes water availability pilot project: U.S. Geological Survey Scientific Investigations Report 2010–5159, 44 p.

Greene, E.A., Shapiro, A.M., and Carter, J.M., 1999, Hydrogeologic characterization of the Minnelusa and Madison aquifers near Spearfish, South Dakota: U.S. Geological Survey Water-Resources Investigations Report 98-4156, 64 p.

Harbaugh, A.W., 2005, MODFLOW-2005 : the U.S. Geological Survey modular ground-water model--the ground-water flow process: U.S. Geological Survey Techniques and Methods 6-A16, variously paged p.

Hortness, J.E., and Driscoll, D.G., 1998, Streamflow losses in the Black Hills of western South Dakota: U. S. Geological Survey Water-Resources Investigations Report 98-4116, 99 p.

Koth, K.R., and Long, A.J., 2012, Microgravity Methods for Characterization of Groundwater Storage Changes and Aquifer Properties in the Karstic Madison Aquifer in the Black Hills of South Dakota: U.S. Geological Survey Scientific Investigations Report XX-2012, *in review*

Long, A.J., Ohms, M.J., and McKaskey, J.D.R.G., 2012, Groundwater Flow, Quality (2007-2010), and Mixing in the Wind Cave National Park Area, South Dakota: U.S. Geological Survey Scientific Investigations Report 2011-5235

Long, A.J., and Putnam, L.D., 2002, Flow-System Analysis of the Madison and Minnelusa aquifers in the Rapid City area, South Dakota - Conceptual model: U.S. Geological Survey Water-Resources Investigations Report 02-4185, 100 p., 3 plt.

Long, A.J., and Putnam, L.D., 2008, Simulated groundwater flow in the Ogallala and Arikaree aquifers, Rosebud Indian Reservation area, South Dakota—Revisions with data through water year 2008 and simulations of potential future scenarios: U.S. Geological Survey Scientific Investigations Report 2010–5105, 64 p.

Long, A.J., Sawyer, J.F., and Putnam, L.D., 2008, Environmental tracers as indicators of karst conduits in ground water in South Dakota, USA: Hydrogeology Journal, v. 16, no. 2, p. 263-280.

Mehl, S.W., and Hill, M.C., 2007, The U.S. Geological Survey modular ground-water model—Documentation of the multiple-refined-areas capability of local grid refinement (LGR) and the boundary flow and head (BFH) package: U.S. Geological Survey Techniques and Methods 6-A21, 13 p.

Putnam, L.D., and Long, A.J., 2007a, Analysis of Ground-Water Flow in the Madison Aquifer using Fluorescent Dyes Injected in Spring Creek and Rapid Creek near Rapid City, South Dakota, 2003-2004: U.S. Geological Survey Scientific Investigations Report 2007-5137

Putnam, L.D., and Long, A.J., 2007b, Characterization of Ground-Water Flow and Water Quality for the Madison and Minnelusa Aquifers in Northern Lawrence County, South Dakota: U.S. Geological Survey Scientific Investigations Report 2007-5001, 61 p.

Putnam, L.D., and Long, A.J., 2009, Numerical Groundwater-Flow Model of the Minnelusa and Madison Hydrogeologic Units in the Rapid City Area, South Dakota: U.S. Geological Survey Scientific Investigations Report 2009-5205, 81 p.

Redden, J.A., and DeWitt, E., 2008, Maps showing geology, structure, and geophysics of the central Black Hills, South Dakota: U.S. Geological Survey Scientific Investigations Map 2777, 44 p., 2 sheets p.

Shoemaker, W.B., Kuniansky, E.L., Birk, S., Bauer, S., and Swain, E.D., 2008, Documentation of a Conduit Flow Process (CFP) for MODFLOW-2005: U.S. Geological Survey Techniques and Methods, Book 6, Chapter A24, 50 p.

Strobel, M.L., Jarrell, G.J., Sawyer, J.F., Schleicher, J.R., and Fahrenbach, M.D., 1999, Distribution of hydrogeologic units in the Black Hills Area, South Dakota: U.S. Geological Survey Hydrologic Investigations Atlas HA-0743

U.S. Geological Survey, 2011, Water use in the United States: U.S. Geological Survey database, accessed December 2, 2011, at *http://water.usgs.gov/watuse/*.

Westenbroek, S.M., Kelson, V.A., Dripps, W.R., Hunt, R.J., and Bradbury, K.R., 2010, SWB-A modified Thornthwaite-Mather Soil-Water-Balance code for estimating groundwater recharge: U.S. Geological Survey Techniques and Methods 6-A31, 52 p.

Jerri Baker
Docket No. 40-9075-MLA
ASLBP No. 10-898-02-MLA-BD01

Public opinion and news articles.

Capital Journal Pierre, SD

A4

Wed 1-22-14

**Our opinion**

# It's not just our backyard – it's the nation's backyard

Some days here at the Capital Journal we receive almost more letters than we can print about uranium mining. You'll see a few of them on this page today.

It's easy to understand why this topic gets people who oppose uranium mining to sit down and write. People in the Black Hills area are concerned about possible threats they perceive to their environment and especially their water. They want state officials and state lawmakers to read their letters and understand their concerns.

We want that very same thing of our state lawmakers and our officials.

Because something is different in this case from the ordinary "Not In My Backyard" syndrome, and a couple of our letter-writers today put a finger on it: It's tourism. The Black Hills area is home to the closest thing America has to a national shrine. People who love the things this country stands for, both Americans and visitors from other lands, make the trek to Mount Rushmore because it's one of the things in America you just have to see. They take in the Badlands and Wind Cave National Park while they are at it, and along the way, some of them discover why Custer State Park could very well be the best state park in the entire United States.

It's not just our backyard where this debate over uranium mining is taking place – it's the nation's backyard. Let's discuss this issue very, very thoroughly and err on the side of caution where the Black Hills are concerned.

June 25, 26 2013

# Pavillion group spells out water study concerns

By THE ASSOCIATED PRESS

CHEYENNE — People who live in a central Wyoming gas field with tainted groundwater are pressing Gov. Matt Mead for more details about how Wyoming plans to take over and carry on with a U.S. Environmental Protection Agency investigation into the contamination.

They ask whether they might be able to weigh in on the investigation — funded with $1.5 million from the Encana Corp. subsidiary that owns the Pavillion gas field — considering nobody sought their input about the change in plans before the governor's office and EPA jointly announced the shift last week.

"Our main concern is that we were not consulted during your planning process and your plan does not give us any process for input as the investigation moves forward," the group Pavillion Area Concerned Citizens said in a letter to Mead dated Monday and delivered Tuesday. "We were extremely disappointed to learn that we were the last to know."

The letter also asks for details about any upcoming meetings about the new state investigation, how the local residential water wells will be tested, whether the state will address health problems Pavillion-area residents say are caused by the pollution, and if the state investigators will seek public comment.

Pavillion-area farmer John Fenton, chairman of the group, signed the letter.

Mead spokesman Renny MacKay described the change in plans as a decision that needed to be made between the EPA and state. Wyoming officials also consulted in advance with Encana. Mead held a conference call with Pavillion residents after the announcement.

He said the governor planned to make the announcement an hour later but a draft news release outlining the deal had been leaked to The Associated Press and the news agency was preparing a story.



RC Journal

## IN BRIEF

### Western creek water shut off

**PIERRE**| State officials say drought conditions in western South Dakota have forced them to issue shut-off orders to 10 holders of junior water rights along Battle Creek near Hermosa.

State Environment and Natural Resources Secretary Steve Pirner says the shut-off orders are intended to protect the domestic use of water, which has the highest priority under state law. Domestic use includes livestock watering and is not subject to shut-off orders.

— Associated Press

Over 1400 people have signed this petition, we will have half of the County this Summer.

**As concerned citizens, we ask our officials to stop all uranium mining until it can be proven that mining will not damage our water or reduce the amount of water available to our families, ranches, businesses, and communities.**