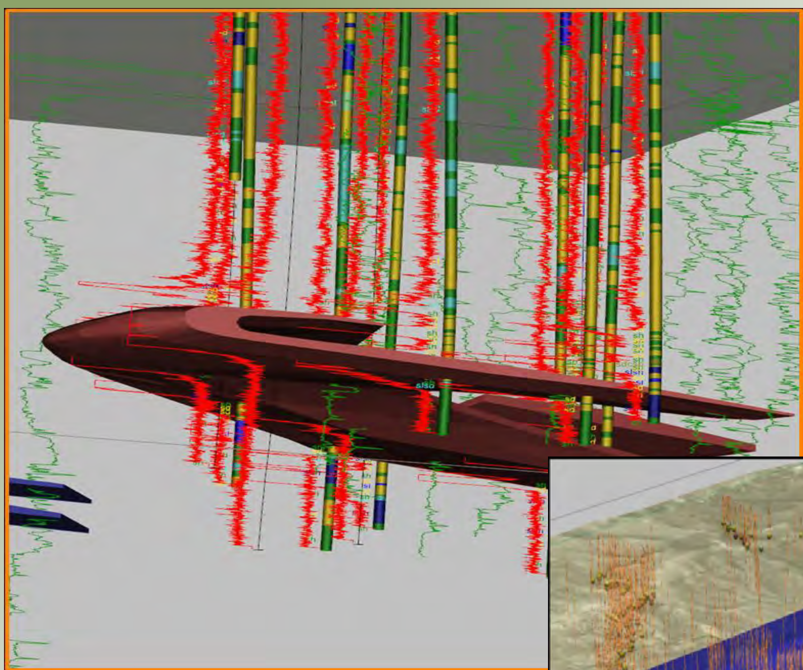
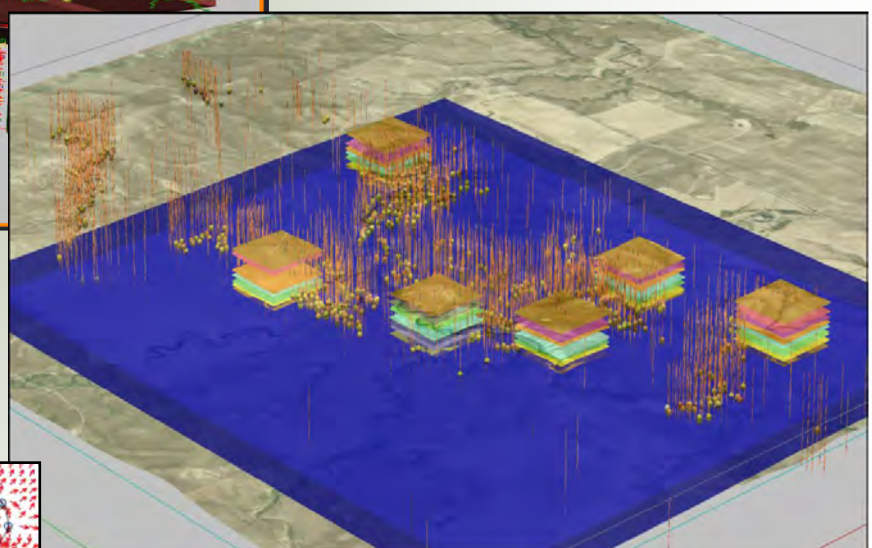
SEI014A

Ross ISR Project USNRC License Application
Crook County, Wyoming





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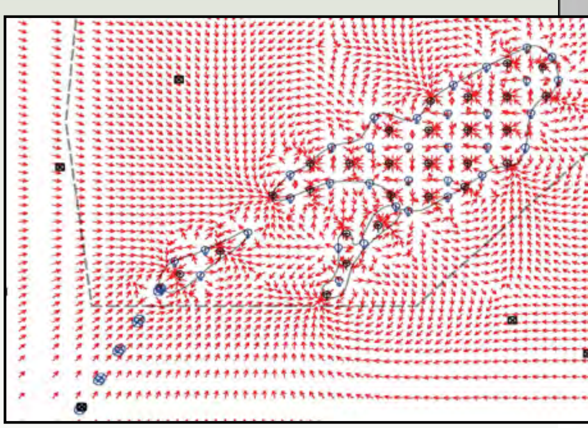

Technical Report
Volume 1 of 6
Sections 1.0 through 2.11

STRATA ENERGY

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LIST OF ABBREVIATIONS/ACRONYMS

AADT	Average Annual Daily Traffic
AASHTO	American Association of State Highway and Transportation Officials
ACL	Alternate Concentration Limit
ADT	Average Daily Traffic
AEA	Atomic Energy Act
ALARA	As Low As Reasonably Achievable
ALI	Annual Limits on Intake
AMC	Antecedent Moisture Condition
AMV	Ammonium Metavanadate
ANSI	American National Standards Institute
AOI	Area of Influence
AP	Airport
APE	Area of Potential Effect
AQD	Air Quality Division
AQS	Air Quality System
ASME	American Society of Mechanical Engineers
ASOS	Automated Surface Observing System
ASTM	ASTM International (formerly American Society for Testing and Materials)
ATV	All-Terrain Vehicle
B.P.	Before the Present Time
BACT	Best Available Control Technology
BGL	Below Ground Level
BHNF	Black Hills National Forest
BKS	BKS Environmental Associates, Inc.
BLM	U.S. Bureau of Land Management
BLS	Bureau of Labor Statistics
BMP	Best Management Practice
BNSF	BNSF Railway (formerly Burlington, Northern & Santa Fe)
BPT	Best Practicable Technology
BSM	Buckskin Mine
CAA	Clean Air Act
CAAA	Clean Air Act Amendments of 1990
CAD	Computer Aided Design
CAGR	Compounded Annual Growth Rate
CBNG	Coal Bed Natural Gas
CBW	Containment Barrier Wall
CCEMA	Campbell County Emergency Management Agency
CCMH	Campbell County Memorial Hospital
CCSD	Campbell County School District
CEDE	Committed Effective Dose Equivalent
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act

LIST OF ABBREVIATIONS/ACRONYMS (CONTINUED)

CESQG	Conditionally Exempt Small Quantity Generator
CFR	Code of Federal Regulations
CGA	Compressed Gas Association
Commission	U.S. Nuclear Regulatory Commission
COOP	Cooperative Observer Program
COS	Central Operator Station
CPP	Central Processing Plant
CR	County Road
CREG	Consensus Revenue Estimating Group
CWA	Clean Water Act
D&D	Decommissioning and Decontamination
DAC	Derived Air Concentration
DDE	Deep Dose Equivalent
DEQ	Department Environmental Quality
DFM	Dry Fork Mine
DHS	Department of Homeland Security
DM	Deep Monitoring Zone
DM&E	Dakota, Minnesota & Eastern Railroad Corporation
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EC	Electrical Conductivity
EHS	Environmental Health and Safety
EIA	U.S. Department of Energy, Energy Information Administration
EIS	Environmental Impact Statement
EMR	Emergency Medical Responder
EMT	Emergency Medical Technician
EO	Executive Order
EOR	Enhanced Oil Recovery
EPA	U.S. Environmental Protection Agency
ER	Environmental Report
ESA	Endangered Species Act
EXREFA	External Reference Area
FCC	Federal Communications Commission
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FRP	Fiber Reinforced Plastic
FSA	Farm Service Agency
GDP	Gross Domestic Product
GEIS	Generic Environmental Impact Statement
GER	Generic Environmental Report (NMA 2007)
GPS	Global Positioning System
GR	Gamma Ray

LIST OF ABBREVIATIONS/ACRONYMS (CONTINUED)

GSP	Gross State Product
GT	Grade-Thickness
HAP	Hazardous Air Pollutant
HDPE	High Density Polyethylene
HEC	Hydrologic Engineering Center
HEPA	High Efficiency Particulate Air
HMI	Human Machine Interface
HMR	Hazardous Material Regulations
HMS	Hydrologic Modeling System
HPS	Health Physics Society
HRI	Hydro Resources, Inc.
HVAC	Heating Ventilation and Air Conditioning
HWL	High Water Line
IAEA	International Atomic Energy Act
IBC	International Building Code
ICRP	International Commission on Radiological Protection
ID	Inside Diameter
IDLH	Immediately Dangerous to Life and Health
IML	Inter-Mountain Laboratories
IMPROVE	Interagency Monitoring of Protected Visual Environments
IR	Intake Rate
ISL	In-situ Leach
ISR	In-situ Recovery
ISR GEIS	Generic Environmental Impact Statement for In-situ Leach Uranium Milling Facilities (NUREG-1910)
IX	Ion Exchange
JFD	Joint Frequency Distribution
LBA	Lease By Application
LCI	Lost Creek, Inc.
LiDAR	Light Detection and Ranging
LLD	Lower Limits of Detection
LOI	Letter of Intent
LQD	Land Quality Division
LSA	Low Specific Activity
MARSSIM	Multi-Agency Radiation Survey & Site Investigation Manual
MCL	Maximum Contaminant Level
MCS	Master Control System
MDA	Minimum Detectable Activity
MDC	Minimum Detectable Concentration
MET	Meteorological Monitoring Site
MIT	Mechanical Integrity Testing

LIST OF ABBREVIATIONS/ACRONYMS (CONTINUED)

MLS	Mass Layoff Statistics
MOA	Memorandum of Agreement
MSHA	Mine Safety & Health Administration
NAAQS	National Ambient Air Quality Standards
NAD	North American Datum
NAD83	North American Datum 1983
NADP	National Atmospheric Deposition Program
NAICS	North American Industry Classification System
NAIP	National Agriculture Imagery Program
NAPG	North American Power Group
NASS	National Agricultural Statistics Service
NCHRP	National Cooperative Highway Research Program
NCRP	National Council on Radiation Protection & Measurements
NEPA	National Environmental Policy Act
NFO	Newcastle Field Office
NFPA	National Fire Protection Association
NHPA	National Historic Preservation Act
NIOSH	National Institute for Occupational Safety and Health
NMA	National Mining Association
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRC	U.S. Nuclear Regulatory Commission
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NRPB	National Radiation Protection Board
NSPS	New Source Performance Standards
Nubeth	Nubeth Joint Venture
NUREG	Publication Prepared by NRC Staff
NUREG/ CR	Publication Prepared by NRC Contractors
NWI	National Wetlands Inventory
NWL	Normal Water Line
NWP	Nationwide Permit
NWS	National Weather Service
OD	Outside Diameter
ODP	Office of Domestic Preparedness
OOEA	Office of Outreach and Environmental Assistance
OSD	Optically Stimulated Dosimeter
OSHA	Occupational Safety & Health Administration
OSL	Optically Stimulated Luminescence
OSLI	Office of State Lands and Investments
OSM	U.S. Office of Surface Mining Reclamation and Enforcement

LIST OF ABBREVIATIONS/ACRONYMS (CONTINUED)

OSR	Optical Synchrotron Radiation Monitor
OZ	Ore Zone Monitoring Interval
P&A	Plugged and Abandoned
PCB	Polychlorinated Biphenyl
PCPI	Per Capita Personal Income
PFYC	Potential Fossil Yield Classification System
pH	Hydrogen ion activity
PLC	Programmable Logic Controller
PLIC	Public Lands Information Center
$PM_{2.5}$	Particulate Matter 2.5 Microns or Less
PM_{10}	Particulate Matter 10 Microns or Less
PMF	Probable Maximum Flood
PP	Polypropylene
PPE	Personal Protective Equipment
PRB	Powder River Basin
PSD	Prevention of Significant Deterioration
PSHA	Probabilistic Seismic Hazard Analysis
PSM	Process Safety Management
PTE	Potential to Emit
PV	Pore Volume
PVC	Polyvinyl Chloride
PVD	Pore Volume Displacement
QA	Quality Assurance
QAM	Quality Assurance Manual
QC	Quality Control
Quad	Quadrangle
R	Range or Roentgens
r	Resistivity
R&D	Research and Development
RAP	Restoration Action Plan
RCRA	Resource Conservation and Recovery Act
RFFA	Reasonably Foreseeable Future Actions
RG	Regulatory Guide
RMP	Risk Management Program
RO	Reverse Osmosis
RPP	Radiation Protection Program
RSO	Radiation Safety Officer
RWP	Radiation Work Permits
SA	Surficial Aquifer
SAIPE	Small Area Income and Poverty Estimates
SAR	Sodium Adsorption Ratio
SCS	Soil Conservation Service

LIST OF ABBREVIATIONS/ACRONYMS (CONTINUED)

SDI	Subsurface Drip Irrigation
SDWA	Safe Drinking Water Act
SEIS	Supplemental Environmental Impact Statement
SER	Safety Evaluation Report
SERP	Safety and Environmental Review Panel
SHPO	State Historic Preservation Office
SHWD	Solid and Hazardous Waste Division
SIP	State Implementation Plan
SM	Shallow Monitoring Zone
SODAR	Sonic Detection and Ranging
SOP	Standard Operating Procedure
SP	Spontaneous Potential
SPCC	Spill Prevention, Control, and Countermeasure
SS	Stainless Steel
Strata	Strata Energy, Inc.
SWPPP	Storm Water Pollution Prevention Plan
T	Township
T&E	Threatened and Endangered
TBNG	Thunder Basin National Grassland
TDS	Total Dissolved Solids
TEDE	Total Effective Dose Equivalent
TENORM	Technologically Enhanced Naturally Occurring Radioactive Material
TEOM	Tapered Element Oscillating Microbalance
TF	Thermal Fluid
TGLD	Task Group on Lung Dynamics
THC	Total Hydrocarbons
THPO	Tribal Historic Preservation Office
TLD	Thermoluminescent Dosimeter
TPI	Total Personal Income
TPQ	Threshold Planning Quantity
TQ	Threshold Quantity
TR	Technical Report
TRV	Target Restoration Value
TSCA	Toxic Substances Control Act
UBC	Uniform Building Code
UCL	Upper Control Limit
UDC	Uranyl Dicarbonate
UIC	Underground Injection Control
UMTRCA	Uranium Mill Tailings Radiation Control Act of 1978
UP	Union Pacific Railroad
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation

LIST OF ABBREVIATIONS/ACRONYMS (CONTINUED)

USCB	U.S. Census Bureau
USDA	U.S. Department of Agriculture
USDW	Underground Source of Drinking Water
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UTC	Uranyl Tricarbonate
UTM	Universal Transverse Mercator Coordinate System
UW	University of Wyoming
VOC	Volatile Organic Compound
VRM	Visual Resource Management
WAAQS	Wyoming Ambient Air Quality Standards
WAQSR	Wyoming Air Quality Standards and Regulations
WARMS	Wyoming Air Resources Monitoring System
WDAI/EA	Wyoming Department of Administration and Information, Economic Analysis Division
WDEQ	Wyoming Department of Environmental Quality
WGFD	Wyoming Game and Fish Department
WL	Working Level
WNA	World Nuclear Association
WOGCC	Wyoming Oil and Gas Conservation Commission
WOHS	Wyoming Office of Homeland Security
WoUS	Water of the U.S.
WQD	Water Quality Division
WRCC	Western Regional Climate Center
WSEO	Wyoming State Engineer's Office
WSGS	Wyoming State Geological Survey
WW	Warm-Water
WWC	Western Water Consultants, Inc. or WWC Engineering
WWDC	Wyoming Water Development Commission
WYCRO	Wyoming Cultural Records Office
WYDOT	Wyoming Department of Transportation
WYNDD	Wyoming Natural Diversity Database
WYPDES	Wyoming Pollutant Discharge Elimination System

UNITS OF MEASURE

%	percent
% g	percent of gravitational acceleration
°	degrees
°C	degrees Celsius
°F	degrees Fahrenheit
ac	acre
ac-ft	acre-feet
ac-ft/yr	acre-feet per year
bcy	bank cubic yards
Bq/l	Becquerel per liter
cfm	cubic feet per minute
cfs	cubic feet per second
Ci/yr	Curies per year
cm	centimeter
cm/s	centimeters per second
cpm	counts per minute
cu ft	cubic feet
cy	cubic yards
cy/wk	cubic yards per week
cy/yr	cubic yards per year
dBA	A-weighted decibels
dpm	disintegrations per minute
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
dv	deciview
ft	feet
ft amsl	feet above mean sea level
ft/day	feet per day
ft/ft	foot per foot
ft^3	cubic feet
g	grams or gravitational acceleration
g/L	grams per liter
gpd	gallons per day
gpm	gallons per minute
gpm/ft^2	gallons per minute per square foot
ha	hectares
hp-hours	horsepower hours
hr	hour
in	inches
in/year	inches per year
kg	kilograms
km	kilometers
kV	kilovolts

UNITS OF MEASURE (CONTINUED)

kWh	kilowatt hours
lb	pounds
lb/mo	pounds per month
lbs	pounds
lbs/yr	pounds per year
m	meters
m/s	meters per second
m^2	square meters
m^3	cubic meter
m^3/hr	cubic meters per hour
Ma	mega annum
MeV	megaelectron volts
mg	milligrams
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mg/m^3	milligrams per cubic meter
mg/yr	milligrams per year
MGD	million gallons per day
mi	miles
mi/mi^2	miles per square mile
mi^2	square miles
mm	millimeters
MM	million
mmhos/cm	millimhos per centimeter
mph	miles per hour
mR	milli Roentgens
mrem	millirem
mrem/yr	millirems per year
mSv	millisievert
mSv/yr	millisieverts per year
MW	megawatts
µCi	microcuries
µCi/mL	microcuries per milliliter
µg	micrograms
µg/L	micrograms per liter
µg/m^3	micrograms per cubic meter
µmhos/cm	micromhos per centimeter
µR/hr	micro Roentgens per hour
µrem/hr	microrems per hour
µS/cm	microSiemens per centimeter
µSv	microsievert

UNITS OF MEASURE (CONTINUED)

NTU	nephelometric turbidity unit
pCi/g	picocuries per gram
pCi/L	picocuries per liter
pCi/m^2/s	picocuries per square meter per second
ppm	parts per million
psi	pounds per square inch
rad/d	rad per day
s.u.	standard units
tpy or t/y	tons per year
WL	working levels
yr	year(s)

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1.0 PROPOSED ACTIVITIES

Strata Energy, Inc. (Strata) is submitting this Technical Report (TR) to the United States Nuclear Regulatory Commission (NRC) as part of a combined source and 11e.(2) byproduct material license application to construct and operate an in situ leach uranium recovery (ISR) facility at the proposed Ross project site in Crook County in the State of Wyoming (proposed project). An NRC combined source and 11e.(2) byproduct material license is required to recover uranium by ISR extraction techniques, under the provisions of the Atomic Energy Act of 1954 (AEA), as amended by the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA) as well as Title 10 U.S. Code of Federal Regulations (CFR), Part 40, "Domestic Licensing of Source Materials." This section summarizes the proposed activities including the nature of the facilities, equipment, and procedures to be used in the proposed project.

1.1 Licensing Action Requested

The following TR is being submitted to the NRC on behalf of Peninsula Energy Ltd, (dba) Strata Energy Inc. (Strata), for a combined source and 11e.(2) byproduct material license to construct and operate the proposed Ross ISR Project. The proposed project is located in Crook County, Wyoming, 21.5 miles north of Moorcroft and adjacent to the ranching community of Oshoto. The proposed project consists of ISR wellfields, uranium processing facilities, and associated infrastructure.

The license application and accompanying reports have been prepared using guidelines and standards from both state and federal agencies. The TR was prepared in accordance with the format presented in NUREG-1569, Standard Review Plan for In Situ Leach Uranium Extraction Applications (NRC 2003). The State of Wyoming also has authority to regulate mines in Wyoming; therefore, a Wyoming Department of Environmental Quality (WDEQ) Permit to Mine/Class III Injection Permit will also be required. The TR incorporates information required by the WDEQ/LQD rules and regulations.

1.2 Project History

Uranium exploration efforts in the 1950s and 1960s in the Powder River Basin of Wyoming led to a number of discoveries, starting in the Pumpkin Buttes Uranium District of Johnson and Campbell counties. Nuclear Dynamics

and Bethlehem Steel Corporation formed the Nubeth Joint Venture (Nubeth), to develop new uranium mining districts in the western U.S. with specific attention focused on northeastern Wyoming's Powder River Basin.

The initial discovery of uranium near Oshoto was made by a Mr. Albert Stoick using a hand held scintillometer during an over-flight of the area. This was followed by macroscopic sampling efforts and then regional exploration work by the joint venture group (Buswell 1982). In late 1970, airborne radiometric surveys in an area north of Moorcroft indicated large, low-order gamma ray anomalies in an area encompassing over 350 square miles. Host formations were believed to be the Late Cretaceous Lance and Fox Hills Formations. The uranium district was therefore named the Lance District.

Beginning in late 1970 and continuing in 1971, anomalous gamma ray areas were mapped and sampled with low-grade mineralization and alteration fronts discovered. A review of conventional oil and gas geophysical logs in the area confirmed anomalous gamma intercepts at depths above the regional confining layer (Pierre Shale). An aggressive land and mineral acquisition phase followed along with an exploration drilling program covering more than 110,000 acres and 3 million feet of drilling.

Nubeth received a WDEQ/LQD License to Explore (No. 19) in August 1976 with modifications to accommodate research and development activities in 1978. Nubeth filed for an NRC source material license in November 1977 with approval in April 1978 (SUA-1331). A Research and Development (R&D) site was constructed in Section 18 of Township 53 North, Range 67 West. The R&D site consisted of a single five spot well pattern, with four injection wells and one recovery well, and a plant with ion exchange, elution and precipitation equipment capable of producing yellowcake slurry. The R&D plant was capable of processing 90 gpm of recovered lixiviant. The lixiviant composition at the R&D facility utilized sodium carbonate as the complexing agent and hydrogen peroxide as the oxidant. Hydraulic control at the site was accomplished with buffer wells, which were meant to serve as a hydraulic barrier and keep the lixiviant within the well pattern. The R&D site was operated from August 1978 through April 1979 and recovered only small amounts of uranium. Approximately 50% of the process equipment in the plant was never used. No precipitation of a uranium product took place and all of the recovered uranium was stored as a uranyl carbonate solution.

After recovery tests were completed, the single five-spot used in the test was restored using groundwater sweep. Restoration was completed in February 1983 and ND Resources (formerly Nubeth) was notified by the WDEQ that the restoration was satisfactory on April 25, 1983. Final approval for the R&D site decommissioning was granted by the regulatory agencies in 1983 through 1986. Addendum 1.2-A contains relevant regulatory correspondence for the Nubeth R&D Project including final restoration approval from WDEQ and NRC and the final site decommissioning report from NRC.

The overall success of the R&D site was limited based on injection problems which eventually led to the premature shutdown of the test. These problems were attributed to fines and organic material buildup in the wellfields and although filtering equipment was used, it was insufficient. The injection rate ranged from 2.5 to 4 gpm in each injection well and 0.3 to 2 gpm in each buffer well. Recovery well flow rates ranged from 5 to 14 gpm. The highest U_3O_8 grade achieved was 54 mg/L, which occurred when the lixiviant concentration was aggressively increased during the period of February through April 1979. Chemical addition ended shortly after, and the target U_3O_8 grade was never reached. According to a summary report on production feasibility done by In-Situ Consulting in 1979, it was estimated that uranium production could average about 800 pounds per day using a 3,000 to 4,000 gpm plant. However, due to the declining price of uranium, full scale facility permitting and construction did not occur.

Despite the problems associated with operating the R&D site, it proved that economic concentrations of uranium could be recovered within the proposed project area using the ISR process with a sodium-bicarbonate based lixiviant. The information obtained from the R&D site helped Strata to make the decision to develop a full-scale ISR facility at this location. Key benefits derived from the R&D site include:

- Perceived ability to achieve exemption of the mineralized aquifer,
- Indications of good geologic confinement of the ore-bearing interval,
- Confirmation of fundamental hydrogeologic hypothesis regarding groundwater flow and behavior,
- Information to provide focus for potential regulatory or operational technical issues,

- A basis for studies pertaining to hydrology, geology, wildlife, vegetation, soils, climatology and radiology,
- The ability to decrease disturbance to both the surface and subsurface based on data collected in the past, and
- Demonstration of successful reclamation, groundwater restoration and facility decommissioning.

Peninsula Energy Ltd initiated mineral acquisition in the Lance District in 2007 and 2008. Exploration drilling programs conducted in 2008 and 2009 confirmed significant uranium resources in the Ross area. Strata Energy incorporated in 2009 to facilitate drilling and provide a regulatory foundation for NRC combined source and 11e.(2) byproduct material license, WDEQ/LQD Permit to Mine applications, and other necessary permitting mechanisms for the proposed project.

1.3 Corporate Entities Involved

Strata's license application, including its ER and TR, are submitted by Strata Energy, Inc., a United States-based corporation registered in the State of Wyoming. Strata is the wholly owned subsidiary of Peninsula Energy, Ltd, an Australian registered company. The Australian corporate office is located at 477 Hay Street, Level 1, Subiaco, Western Australia, Australia. The corporate headquarters of Strata are located at 406 W. 4th Street, Gillette, Wyoming. Peninsula Energy, Ltd is a publicly traded corporation with shares traded (PEN) on the Australian Securities Exchange.

For purposes of conducting NRC-licensed ISR operations, Strata will be the holder of the NRC combined source and 11e.(2) byproduct material license, and its managers and employees will be solely responsible for complying with NRC's financial and technical qualification regulations under 10 CFR Part 40 and Appendix A Criteria, as well as relevant license conditions, guidance and policy.

1.4 Project Location and Setting

The proposed project is located in Crook County, Wyoming, 21.5 miles north of Moorcroft and adjacent to the ranching community of Oshoto, Wyoming. The proposed project area encompasses approximately 1,721 acres. Figure 1.4-1 provides a general location of the site. Figure 1.4-2 depicts the proposed project area on USGS 7.5-minute topography.

The proposed project area is located in an area utilized for livestock grazing, dry land hay production, and oil production. The community of Oshoto, adjacent to the proposed project area, includes 11 residences within 2 miles (3.2 km) of the proposed project boundary. Access to the site is by county road 68 (D Road) and county road 164 (New Haven Road), which proceed north of Interstate 90 approximately 23 miles to the proposed project area. Bentonite mining and recreation are other activities in the vicinity of the proposed project.

1.5 Land Ownership

Surface ownership within the proposed license area comprises deeded, State of Wyoming, and federal lands managed by the United States Department of Interior Bureau of Land Management (BLM). A more detailed description of land use and ownership near the proposed project area is presented in Section 3.1 of the ER.

1.6 Ore Body Description

Uranium targeted for production within the proposed project area is located in permeable sandstones of the Late Cretaceous Lance and Fox Hills Formations. The epigenetic roll fronts deposited in the Oshoto area demonstrate patterns similar to those across the Powder River Basin. The uranyl-bearing groundwater moved downdip with emplacement of uranium as a coating on sand grains primarily due to factors such as permeability, reducing groundwater conditions, and groundwater flow (Buswell 1982). The roll front geometry at the proposed project area can vary due to differences in the depositional environment of the host sandstones. The deeper, Fox Hills alteration fronts are generally thicker and more massive due to the near-shore environment into which the sediments were deposited. Lower Lance Formation sandstones were deposited in a fluvial environment resulting in narrower, often stacked channel systems containing the mineralization. Due to the variability of the depositional environment and hence controls on groundwater movement, the roll fronts in the proposed project area are complex with constantly increasing resource estimates. At this time, resources within the proposed project area exceed 5.5 million pounds of uranium and based on current roll front projections are likely to increase as more exploration drilling results become available.

1.7 ISR Methods and Recovery Process

ISR operations at the proposed project will consist of two steps: recovering mineralized uranium from the ore body and processing the uranium-rich solution into yellowcake.

Recovery of uranium from the ore body will be accomplished by oxidation and dissolution using a recovery solution called lixiviant. The lixiviant is composed of native groundwater fortified with an oxidant such as hydrogen peroxide or oxygen, and a complexing agent such as sodium bicarbonate or carbon dioxide. The lixiviant will be injected into the ore-bearing sandstone through a series of injection wells. As the lixiviant moves through the ore body, uranium will be oxidized and then mobilized. The pregnant lixiviant is then removed from the ore body by recovery wells.

The wells at the proposed project will be arranged in five spot, seven spot, direct line drive, or staggered line drive patterns. The well pattern used will depend on the spatial extent of the ore zone and will be designed for optimum uranium recovery. Examples of well patterns are shown in Figure 1.7-1. Five and seven spot patterns are generally used on wider ore bodies, while direct line drive and staggered line drive patterns will be used on narrower ore bodies. Any combination of well patterns may be used to fit the specific characteristics of the ore body. Injection and recovery wells will have identical construction and completion methods so that the flow direction can be reversed to optimize uranium recovery or groundwater restoration. A ring of monitor wells completed in the ore zone will surround the wellfield areas. In addition, monitor wells completed in the overlying and underlying water-bearing zones will also be installed. These wells will be monitored and sampled on a regular basis to ensure that the injected lixiviant stays within the exempted aquifer and the wellfield areas.

The recovery fluid or pregnant lixiviant will be transferred to the central processing plant (CPP) where pressurized down-flow ion exchange (IX) columns using uranium-specific resin will strip the uranium complexes from the lixiviant. The loaded resin is then conveyed to the elution circuit where a concentrated brine solution removes the uranium and simultaneously regenerates the resin. The resultant eluate then runs through a precipitation circuit where hydrogen peroxide is added to precipitate uranium as uranium oxide slurry. The slurry is then thickened, filtered, dried, and packaged as dry

yellowcake in sealed containers for shipment. The CPP also will include a separate vanadium recovery processing circuit.

1.8 Operating Plans, Design Throughput, and Production

Strata is requesting that the proposed Ross Project CPP be licensed to produce up to 3 million pounds of yellowcake per year. Strata's license application also requests authorization to receive and process uranium-loaded resins from satellite ISR facilities. These include facilities owned and/or operated by Strata, by other ISR licensees, and other water treatment entities generating uranium-loaded IX resins that are the same as or substantially similar to those generated at ISR facilities. Based on this request, Strata's license application includes a detailed assessment of potential transportation, resin off-loading and handling, and waste management impacts associated with the production of up to 3 million pounds of yellowcake per year and includes the receipt and processing of the aforementioned uranium-loaded IX resins. Strata understands that the NRC requires bonding criteria for determining permissible operations for each license. Accordingly, Strata proposes that, for purposes of receiving and processing uranium-loaded IX resins from the aforementioned entities, NRC grant a license condition permitting the receipt and processing of such resins so long as the processing of such resins does not require material changes in the process operation for the proposed Ross CPP and there are no anomalous materials or constituents in the aforementioned resins. Strata's Safety and Environmental Review Panel (SERP) will be required to review and evaluate the receipt of any such uranium-loaded IX resins and certify that these two conditions have been satisfied prior to receiving and off-loading any such resins at the proposed CPP.

The ion exchange circuit will be designed to handle a flow rate up to 7,500 gpm and produce 750,000 lbs of uranium annually over an 4 to 8 year period. The CPP will have the capacity to process up to 3 million lbs of U_3O_8 per year from the proposed Ross ISR operations as well as future ISR facilities operated by Strata and other uranium-loaded resin generators as discussed above. The acceptance of loaded resin from outside sources along with future amendment areas in the Lance District could potentially extend the life of the CPP facilities at the proposed project to 10 to 20 years or more.

The capacity of the CPP is larger than would be justified by the proven reserves at the proposed project alone. The primary consideration concerning

the chosen plant size is that the Ross area occupies only a small portion of the roughly 56-square mile Lance District, where Strata is actively exploring for additional reserves. In addition, having excess capacity in the CPP during operation of the proposed Ross ISR wellfields will allow Strata to run more recovery wells for a longer period of time, even after their optimal uranium recovery rates have passed, which will reduce the amount of water consumed during restoration and improve overall uranium recovery for the project. Another benefit to having excess capacity in the CPP will be an increased safety factor due to plant equipment operating at less than the maximum limits at which they were designed.

The wellfields at the proposed Ross ISR Project will be divided into two Mine Units which will be further separated into wellfield modules. Wellfield modules will be used to delineate the portion of each Mine Unit assigned to a specific central collection facility called a module building. This type of facility is typically referred to in other ISR applications as a header house. It is currently anticipated that both Mine Units will contain a total of 15-25 modules.

During uranium recovery, more groundwater will be removed from recovery wells than is injected. The difference between the recovered and injected solution is referred to as the production bleed and will establish a hydraulic gradient toward the recovery wells. The gradient will reduce the risk of lateral excursions and provide greater hydraulic control of the wellfields. Proposed operating plans include an average 1.25% production bleed supported by groundwater modeling which is detailed in Addendum 2.7-H.

Based on ore zone agitation leach tests and the Nubeth pilot plant data, it is predicted that vanadium will be mobilized along with uranium during the oxidation and dissolution process. Metallurgical testing conducted by Strata has determined that removing and processing vanadium may be economically viable at the proposed project; therefore, the CPP will include a circuit to separate and package vanadium oxide through a precipitation process. Details of the vanadium circuit are discussed in Section 3.2 of this report.

Restoration activities on wellfields where operations have been completed will be conducted concurrently with active operations at the proposed project. Strata proposes a 1,100 gpm total restoration flow with 75 gpm groundwater sweep and 1,025 gpm reverse osmosis treatment followed by stability phase monitoring.

1.9 Project Schedule

Baseline data acquisition efforts in support of the proposed Ross ISR Project were initiated in July 2009 and commenced in earnest in October 2009 with a letter of intent and subsequent pre-license briefings of NRC and WDEQ/LQD staff. As data and information became available, follow-up quarterly meetings were held to familiarize the staffs with the project and address site-specific technical issues. Table 1.9-1 summarizes the meetings held with the NRC and public. Beyond these outreach efforts, Strata had continuously “data mined” public records pertaining to ISR permitting in general and the Ross Project specifically at both the State and Federal level for requests for additional information (RAI) and comments as they became available. A portion of these requests, (with locations where requests are addressed in both the TR and ER) are included as Addendum 1.9-A. The RAIs have been utilized to demonstrate Strata’s awareness of other ISR applications and the complexities faced by contemporary licensing actions. More importantly, the RAIs and comments have allowed Strata to provide the level of detail necessary to demonstrate technical proficiency in its NRC and LQD applications. Strata’s intent, documented in Addendum 1.9-A, has been to address a representative set of the RAIs and comments from previous applications, and in doing so, hopes to facilitate the review by permitting agencies. Strata intends on updating Addendum 1.9-A during the review process as a tool for NRC staff evaluations of the proposed Ross ISR Project.

Strata anticipates that, after the issuance of its requested combined source and 11e.(2) byproduct material license, its WDEQ/LQD Permit to Mine and other required licenses/permits, construction of the first group of wellfield modules, the CPP and associated facilities, including lined retention ponds and other facilities will commence. After the initial wellfield package is completed and approved, ISR operations will commence immediately. When ISR operations are complete in the first group of modules, Strata will begin operation of the next group of modules and commence groundwater restoration at depleted modules. For the duration of the proposed Ross project, Strata intends to operate in the standard “phased” mode with one group of modules in active ISR operations while the preceding group of modules are in groundwater restoration. Subsequent modules will be developed on the same phased basis to ensure that all NRC requirements for active ISR operations and groundwater restoration are satisfied. The proposed project schedule for construction,

operations, groundwater restoration, and final decommissioning and decontamination (D&D) is provided as Figure 1.9-1.

After active ISR operations in a given group of modules cease, Strata will perform groundwater restoration in that group of modules consistent with pre-operational baseline water quality and in accordance with 10 CFR Part 40, Appendix A, Criterion 5(B)(5). When groundwater restoration is completed in a module, Strata will commence site D&D activities for that module in accordance with NRC regulations in 10 CFR Part 40, Appendix A and associated guidance and policies. These activities include, but are not limited to: (1) well abandonment and plugging; (2) removal of piping, tanks, module buildings and other ancillary facilities; (3) cleanup of surface soils to 10 CFR Part 40, Appendix A, Criterion 6 requirements; and (4) re-vegetation of disturbed areas. A site-specific Restoration Action Plan (RAP), which includes surface reclamation and groundwater restoration is found in Addendum 6.1-A of this report.

Strata will adhere to the timelines in decommissioning regulations of 10 CFR Part 40.42. NRC and WDEQ/LQD will both be notified and a plan submitted for regulatory review and approval prior to commencing groundwater restoration. If, at that time, groundwater restoration is estimated to take longer than 24 months, Strata will provide an explanation and alternate schedule as allowed under 10 CFR Part 40.42(i).

When active ISR operations, groundwater restoration, and surface reclamation are completed for all Ross wellfield modules and loaded resin is no longer being received from other resin generator facilities, Strata will engage in final D&D of the CPP and associated facilities and structures.

1.10 Waste Management and Disposal

Liquid and solid waste from the proposed project will be classified by one of the following types; AEA-regulated waste and non-AEA-regulated waste. The major sources of AEA-regulated liquid waste generated from the proposed project will include brine generated from the treatment of the production bleed and groundwater restoration water and excess permeate generated from production and restoration treatment which is not recycled back to the wellfields. Other AEA-regulated liquid waste will include process waste water from plant operations, waste water from activities in the wellfield, and waste water from equipment and personnel decontamination. Non-AEA-regulated

liquid waste will include TENORM (technologically enhanced naturally occurring radioactive materials), storm water runoff, waste petroleum products and chemicals, and domestic waste water.

AEA-regulated solid waste will include filtrate and spent filter media, scale and sludge from equipment maintenance, contaminated soil, damaged IX resin, contaminated solids from ISR wells, contaminated PPE, and contaminated materials and equipment from decommissioning that cannot be decontaminated to approved levels. Non-AEA-regulated solid waste will include domestic solid waste, construction debris, solid hazardous waste, and decontaminated material and equipment.

Several disposal options for AEA-regulated liquid waste are proposed. These include deep well injection in Class I wells, evaporation in lined retention ponds, use as plant make-up water, treatment and surface discharge through a Wyoming Pollutant Discharge Elimination System (WYPDES) permit and irrigation through land application systems. Liquid waste discharges will meet all effluent limits required by relevant regulations and permits. Although land application is discussed as a liquid waste disposal option throughout this TR, additional information is needed before it can be employed at the Ross ISR Project. Prior to utilizing land application as a disposal option, Strata will amend its combined source and 11e.(2) byproduct material license along with revising the WDEQ Permit to Mine. Furthermore, any additional permits or licenses required to operate a land application system will be obtained before implementation.

Solid AEA-regulated waste material will be stored on-site until it can be shipped to an NRC-approved 11e.(2) disposal facility. Strata will secure an 11e.(2) waste disposal agreement prior to operations as discussed in Section 4.3 of this report.

Domestic solid wastes such as office trash and spent equipment parts not associated with uranium recovery will be collected and stored on-site and periodically removed to an off-site sanitary landfill permitted by the WDEQ Solid and Hazardous Waste Division (WDEQ/SHWD). Liquid wastes such as used oil, hydraulic fluid, cleaners, solvents, and degreasers will be recycled or disposed of offsite at a permitted hazardous waste facility or by other EPA approved disposal methods. It is currently planned that domestic sewage will be disposed of in conventional septic/leach field systems. However, alternative systems may be evaluated as facility construction draws near. Domestic sewage disposal systems will be permitted through the WDEQ Water Quality Division (WDEQ/WQD).

1.11 Groundwater Restoration, Decommissioning and Site Reclamation

Groundwater restoration activities will be performed concurrently with active operations at the proposed Ross ISR Project. The goal of restoration will

be to restore groundwater quality consistent with pre-operational conditions. Affected groundwater at the proposed project will be restored in accordance with the criteria listed in 10 CFR Part 40, Appendix A, Criterion 5(B)5 which are defined as the pre-operational water quality or a maximum contamination level (MCL), whichever is higher, or an alternate contamination limit (ACL). Restoration will be accomplished using one or a combination of the following techniques:

- ♦ Groundwater Sweep: Groundwater will be pumped from wellfields, which will result in the inflow of native groundwater to the wellfield.
- ♦ Groundwater Transfer: Groundwater is transferred from a wellfield in restoration to a wellfield that is in active operation.
- ♦ Reverse Osmosis with Permeate Injection: Groundwater is pumped from the wellfield and treated using ion exchange and reverse osmosis. The treated water is then reinjected.
- ♦ Groundwater Recirculation: Groundwater is pumped from the recovery wells and recirculated into the injection wells in the same wellfield.

When restoration criteria are met, the restoration stabilization monitoring program will commence. The purpose of the restoration stabilization monitoring program is to ensure that the concentrations of concern do not increase abnormally following restoration.

The decommissioning of surface and subsurface facilities in individual wellfields will commence after groundwater restoration and stabilization have received final regulatory approval. Wellfield decommissioning includes the plugging and abandonment of all wells and the removal of wellfield piping. Surface facilities and support structures that are no longer required and will not be turned over to landowners or other parties will also be removed.

At the conclusion of operational activities and after restoration of all wellfields have been approved, the proposed Ross ISR Project will be completely decommissioned. Affected areas, buildings, ancillary equipment, and all process equipment will be decontaminated for unrestricted release or disposed at an NRC-approved facility. The land will be returned to the approximate surface topography and drainage patterns that existed prior to disturbance. Vegetation will be re-established using a WDEQ/LQD-approved seed mixture.

Decommissioning and reclamation are discussed in more detail in Section 6 of this report.

1.12 Financial Assurance

Pursuant to 10 CFR Part 40 and Appendix A, Criterion 9, Strata will provide adequate financial assurance for the proposed project. NRC currently requires that ISR license applicants include a Restoration Action Plan (RAP) or the equivalent in a license application to provide NRC Staff with preliminary financial assurance cost estimates for all aspects of the proposed project, including groundwater restoration, surface reclamation, and D&D of proposed facilities. In the past, NRC Staff has reviewed and approved the format associated with a RAP from Hydro Resources, Inc. (HRI) for its Crownpoint Uranium Project in the State of New Mexico. It is Strata's intent to provide NRC Staff with a stand-alone RAP in accord with the RAP format used by HRI, while accounting for updated NRC Staff requirements. The RAP for the proposed project is included as Addendum 6.1-A.

Pursuant to Criterion 9, licensees are required to submit annual financial assurance updates reflecting potential changes (upwards or downwards) in costs for specific licensed activities resulting from inflation, changes in equipment or personnel costs or new activities proposed to be started or completed prior to the proceeding annual update. In order to be granted a license, an applicant must propose and receive NRC approval of financial assurance cost estimates for the phase of the project that will exist prior to the next annual update; but the applicant is not required to provide the actual financial assurance mechanism supporting that NRC-approved cost estimate until licensed operations commence. Pursuant to these requirements, Strata will comply with Criterion 9 requirements for these annual financial assurance updates and will have in place, an NRC-approved financial assurance mechanism after receiving its NRC license but before beginning active ISR operations.

1.13 Engineering and Design

This report contains preliminary designs for the CPP area hydraulic control structures and waste facilities. These designs were prepared to provide provisional layouts in order to better characterize the expected operating conditions, potential environmental impacts and potential public and

occupational health effects for the proposed project. Final designs will be included in a separate document, Addendum 3.1-A, Ross ISR Project Facilities Engineering Report, which will be updated at a later date.

Table 1.9-1. Summary of Quarterly Public Meetings Held With The NRC

Date	Accession #	# of Attendees	# From Public	Presentation Topics
10/29/2009	ML093420004 ML093370646 ML093370598	17	0	Presented a detailed overview of the proposed Ross in situ recovery project and sought comments on its proposed pre-operational sampling and monitoring program.
2/17/2010	ML100620791 ML100500022 ML100500023 ML100620649	12	2	Updated preoperational monitoring plan.
4/13/2010	ML101310147 ML101100537 ML101310096	12	2	Update of agency coordination, cultural and historic resources surveys, and preoperational monitoring.
9/9/2010	ML102780537 ML102530427 ML102530530 ML102780542	13	4	Discussed the following aspects of the proposed project: (i) ongoing licensing activities; (ii) baseline program milestones; (iii) status of technical and environmental reports; and (iv) unique conditions at the site.
10/26-28/2010	ML103210247	17	8	Familiarized NRC staff with the proposed Ross in-situ recovery site. NRC staff reviewed the application to identify major acceptance or technical review issues.

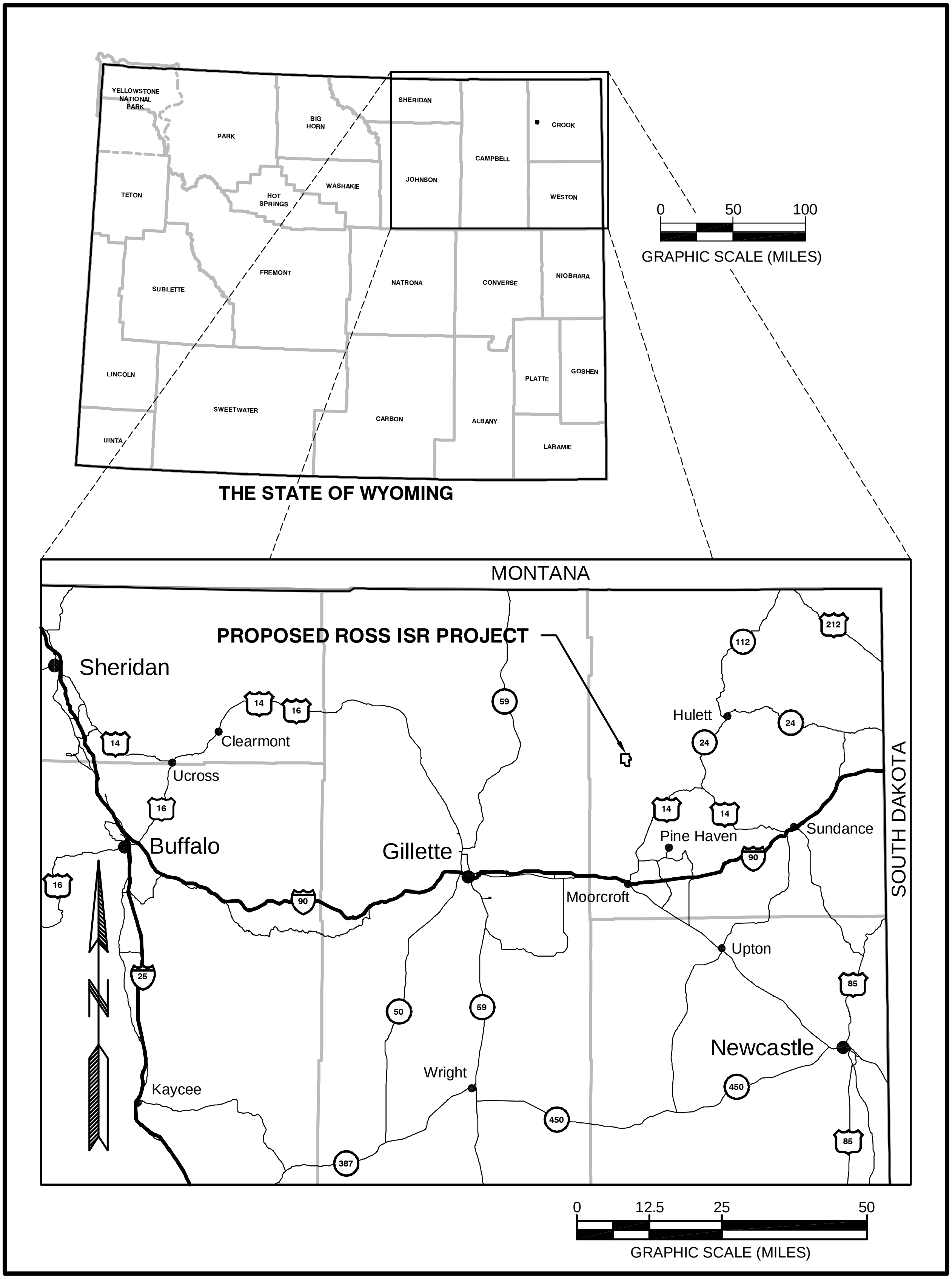

Figure 1.4-1. General Project Location

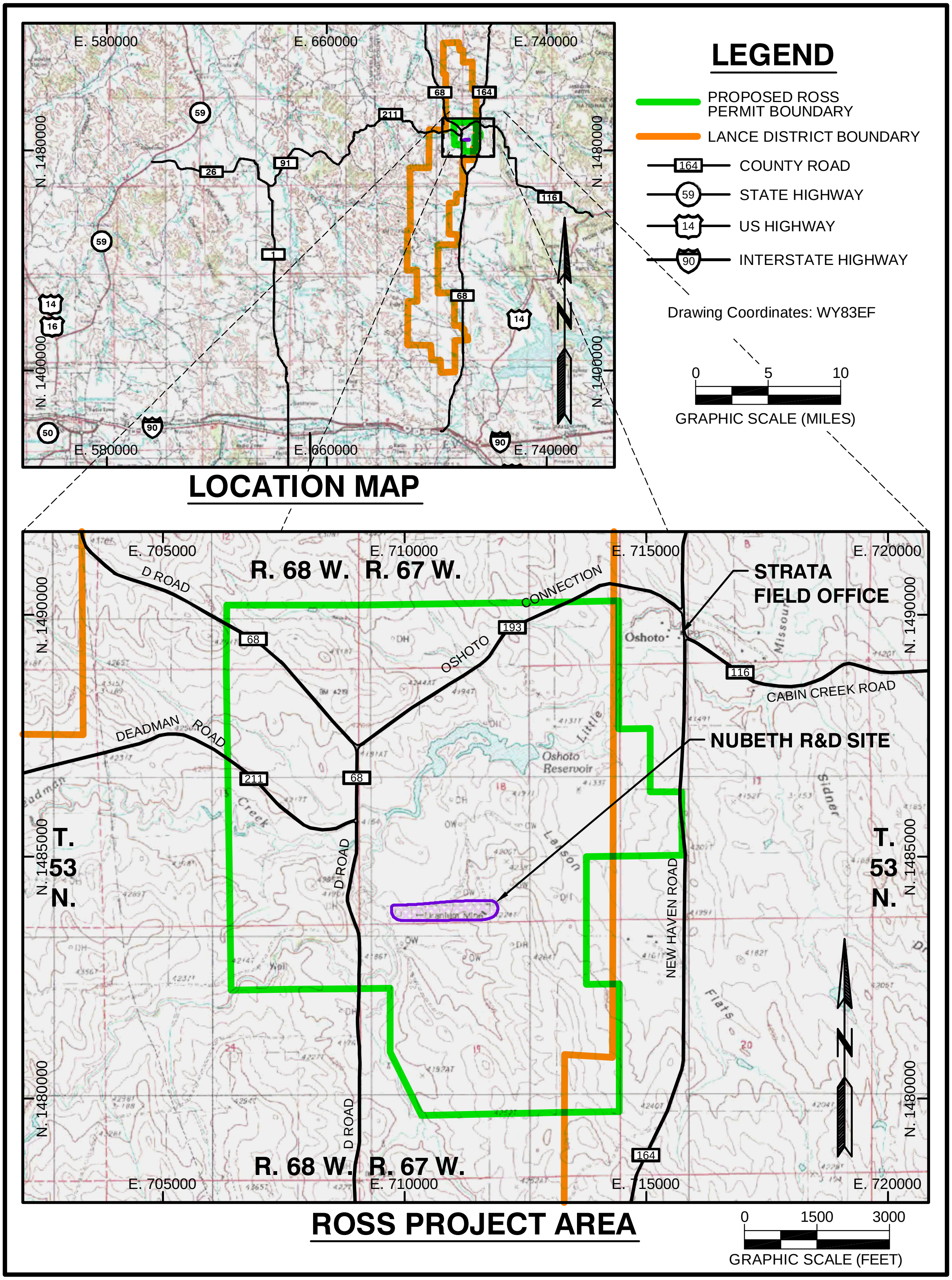

Figure 1.4-2. Proposed Project Area

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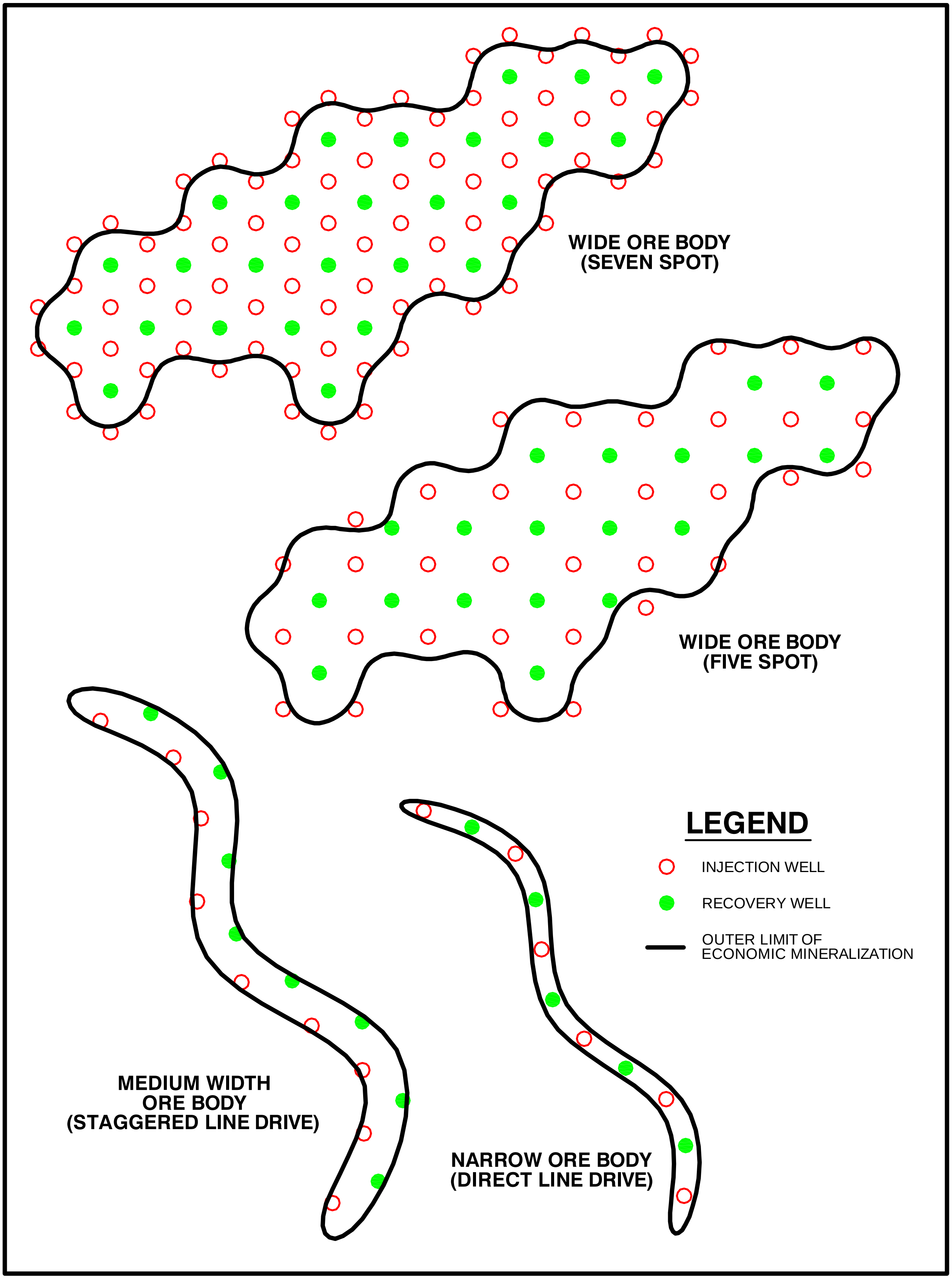
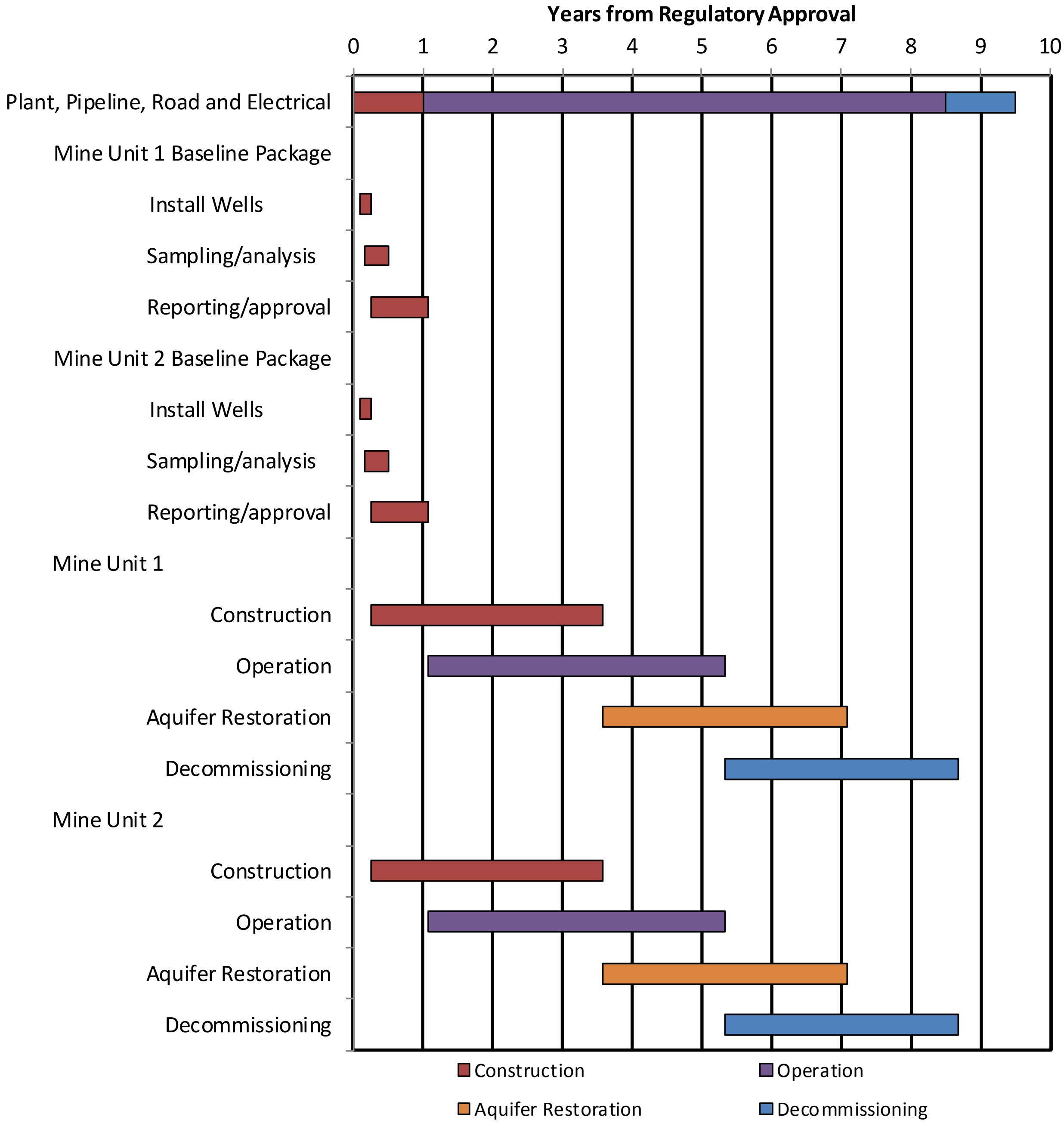


Figure 1.7-1. Proposed Wellfield Patterns

Figure 1.9-1. Ross Project Proposed Timeline



1.14 References

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2.0 SITE CHARACTERIZATION

This chapter describes the existing conditions of the physical, biological, cultural, and socioeconomic resources in the general Oshoto analysis area which includes the proposed project area. More detailed discussion of several of these environmental features is included in the accompanying Environmental Report.

2.1 Site Location and Layout

The proposed Ross ISR Project is located in Crook County, in northeastern Wyoming, adjacent to the ranching community of Oshoto and 21.5 miles north of the town of Moorcroft. The proposed project boundary occupies portions of Sections 7, 18, and 19 of Township 53 North, Range 67 West, and portions of Sections 12, 13, and 24 of Township 53 North, Range 68 West.

The proposed permit area is approximately 1,721 acres. Of the 1,721 acres, approximately 45 acres, or 2.6% will be designated as a controlled area. The controlled area is defined as the industrial area of the project, i.e., the area within the CPP fence. Access to this area will be controlled with coded and remotely controlled gates. The CPP will be designated as a restricted area. Only authorized, appropriately trained individuals will be permitted access to the CPP. The restricted area at the proposed project will be approximately 1.7 acres, or 0.1% of the proposed permit area.

Surface ownership within the proposed project area includes private, federally owned, and state owned land. The distribution of surface ownership is summarized in Table 2.1-1, and depicted on Figure 2.1-1. Mineral leases in the proposed project area will be private, state, and federally owned. Mineral ownership is also shown on Figure 2.1-1. Land use around the area is primarily livestock grazing, dry land hay production, and oil production.

Natural features near the proposed project area include Devils Tower National Monument (approx. 12 miles east), the Missouri Buttes (approx. 9 miles east), the Thunder Basin National Grassland (approx. 8 miles northwest) and the Black Hills National Forest (approx. 14 miles east). Detailed discussion of land ownership and use is included in Section 3.1 of the accompanying ER. Figure 2.1-2 shows the general proposed project area relative to nearby population centers, transportation links, political boundaries, and natural features.

The permit boundary is bisected by the upper reaches of the Little Missouri River, which only flows in response to rainfall or snowmelt. Other streams within the proposed project area are also ephemeral. The area within

the project boundary is located within the semi-arid west region and the elevation ranges from around 4,100 to 4,300 ft above mean sea level.

Access to the site from the south is on Interstate 90 to Moorcroft, and then north on D Road (CR 68) and the New Haven Road (CR 164), approximately 23 miles. The proposed main access to the plant facilities and wellfields is off of the New Haven Road. Wellfields to the north and south of the plant facility will be accessed by secondary roads.

The CPP will be located in the northeast quarter of the southeast quarter of Section 18, Township 53 North, Range 67 West. The coordinates of the CPP are 44.57563°N and 104.94664°W, (NAD 83). The CPP and support facilities are located on lands that have been previously cultivated for dry land farming use. The area is relatively flat and is located in the lower portion of a minor ephemeral tributary. Runoff from the CPP area will be collected to ensure that contaminants are not released to the environment. The storm water runoff plan for the CPP area is discussed in Section 3.1 of this report.

In July of 2010, Strata employed Aero-Graphics Inc to conduct a Light Detecting and Ranging (LiDAR) flight survey of the permit area. LiDAR is an optical sensing technology that measures the properties of scattered light in order to find the distance to objects. Sensors on an aircraft measure the elapsed time it takes to send and receive laser pulses off of the ground surface. Sensors are then coordinated with information about the position and altitude of the sensor to produce fairly high accuracy survey data. Using the LiDAR survey data, Strata was able to construct topographic contours in two foot intervals for the proposed project area. Figure 2.1-3 shows the surface contours generated from the LiDAR, as well as the proposed locations of the CPP buildings, pipelines, roads, deep injection wells, lined retention ponds and wellfields. Also depicted is the location of the Nubeth R&D project. The surface water features near the CPP are discussed in Section 2.7.

Table 2.1-1. Distribution of Surface Ownership

Private Ownership		State Ownership		Federal Ownership (BLM)		Total Area
Acres	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**
1367.2	79.4	314.1	18.3	40.0	2.3	1721.3

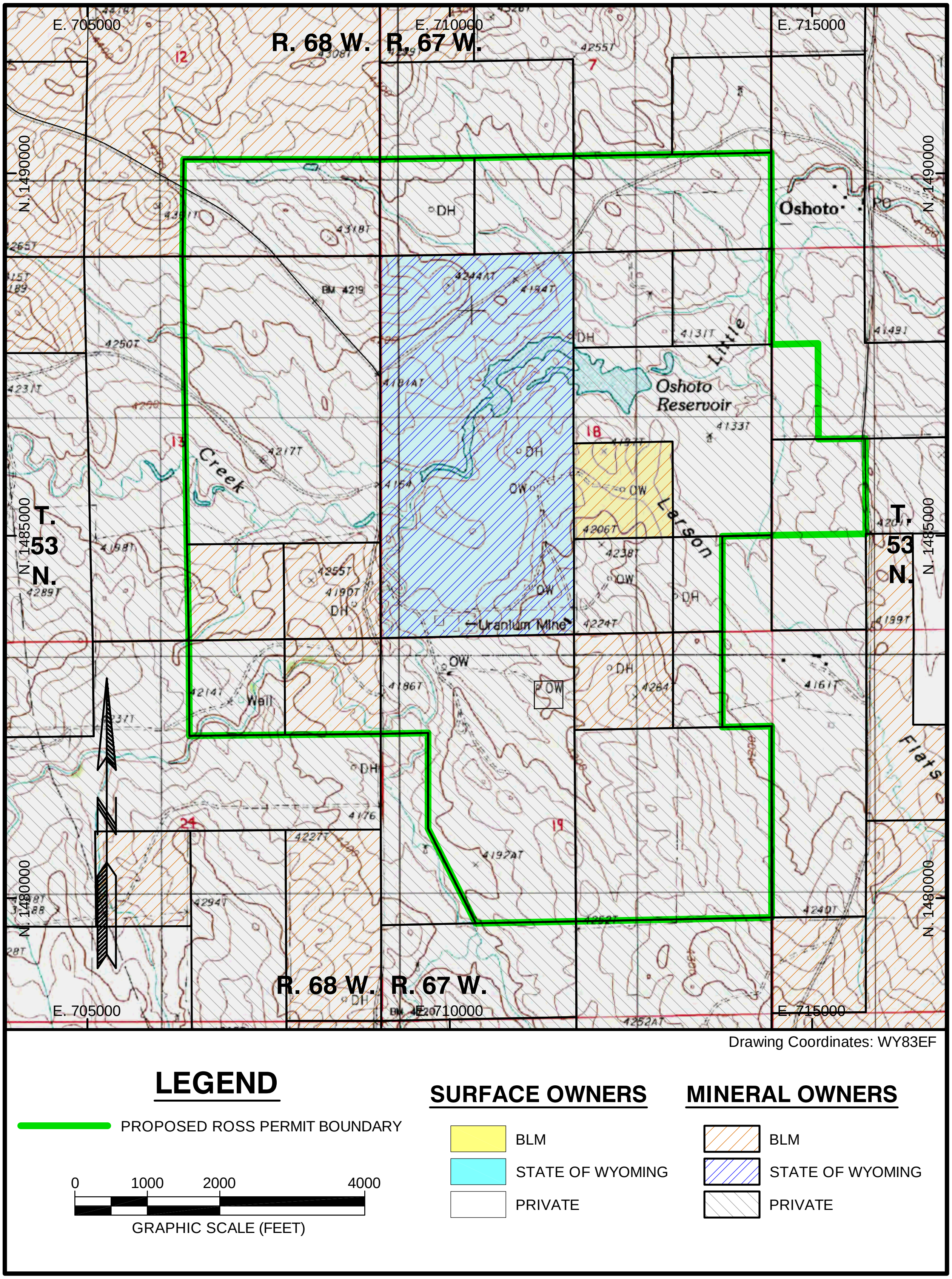
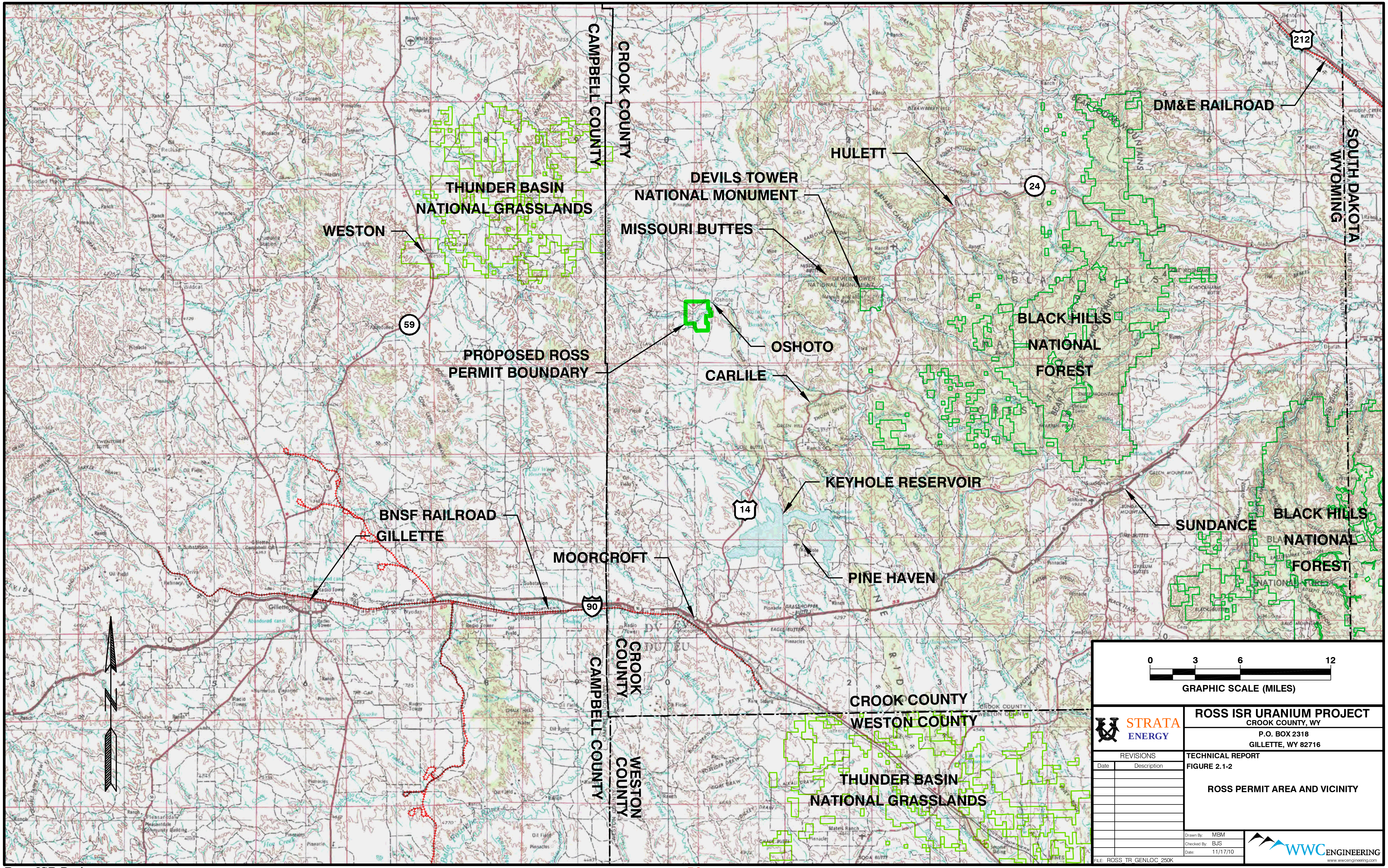
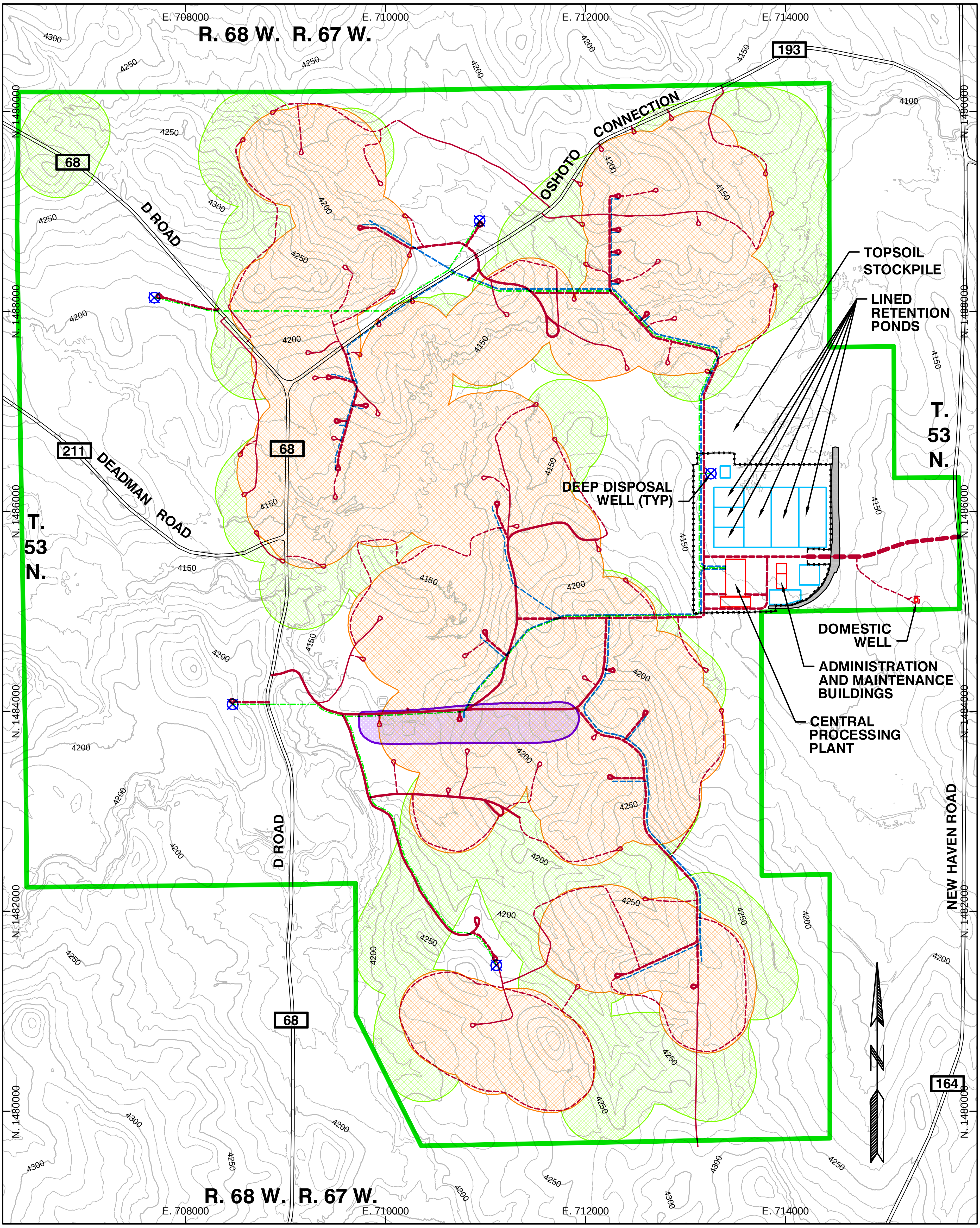


Figure 2.1-1. Surface and Mineral Ownership


CAMPBELL COUNTY
CROOK COUNTY
DM&E RAILROAD
212
SOUTH DAKOTA
WYOMING
HULETT
24
DEVILS TOWER
NATIONAL MONUMENT
THUNDER BASIN
NATIONAL GRASSLANDS
WESTON
MISSOURI BUTTES
59
OSHOTO
BLACK HILLS
NATIONAL
FOREST
PROPOSED ROSS
PERMIT BOUNDARY
CARLILE
KEYHOLE RESERVOIR
14
BNSF RAILROAD
GILLETTE
SUNDANCE
BLACK HILLS
NATIONAL
FOREST
MOORCROFT
PINE HAVEN
90
CROOK COUNTY
CAMPBELL COUNTY
CROOK COUNTY
WESTON COUNTY
WESTON COUNTY
THUNDER BASIN
NATIONAL GRASSLANDS
0 3 6 12
GRAPHIC SCALE (MILES)
STRATA ENERGY
ROSS ISR URANIUM PROJECT
CROOK COUNTY, WY
P.O. BOX 2318
GILLETTE, WY 82716
REVISIONS
Date
Description
TECHNICAL REPORT
FIGURE 2.1-2
ROSS PERMIT AREA AND VICINITY
Drawn By: MBM
Checked By: BJS
Date: 11/17/10
FILE: ROSS_TR_GENLOC_250K
WWC ENGINEERING



Basemap: 10' Contours from May 2010 Flight

Drawing Coordinates: WY83EF

ROSS PROJECT AREA

LEGEND

- PROPOSED ROSS PERMIT BOUNDARY
- 164 COUNTY ROAD
- NUBETH R&D LOCATION
- APPROXIMATE WELLFIELD PERIMETER
- WELLFIELD PERIMETER ACCOUNTING FOR FUTURE DRILLING

FACILITIES

- PROPOSED CONVEYANCE PIPELINE
- PROPOSED DEEP DISPOSAL WELL PIPING
- PROPOSED PRIMARY ACCESS ROAD
- EXISTING SECONDARY ACCESS ROAD
- PROPOSED SECONDARY ACCESS ROAD
- EXISTING 2-TRACK ROAD
- PROPOSED TERTIARY ROAD
- PROPOSED DEEP DISPOSAL WELL

0 500 1000 2000
GRAPHIC SCALE (FEET)

STRATA ENERGY

REVISIONS

Date	Description

ROSS ISR PROJECT
CROOK COUNTY, WY
P.O. BOX 2318
GILLETTE, WY 82716

TECHNICAL REPORT
FIGURE 2.1-3

ROSS PROPOSED FACILITIES AND SURFACE CONTOURS

Drawn By: MBM
Checked By: WCF
Date: 11/23/10

FILE: ROSS_TR_FACILITIES_TOPO

WWC ENGINEERING
www.wwcengineering.com

K:\Peninsula_Minerals\09142\DWGS_WY83E\ROSS_TR_FACILITIES_TOPO.dwg, TR_FIGURE_2.1-3, 12/23/2010 11:32:53 AM

2.2 Land Use

The following sections are a summary of the land use within the proposed project region. A more detailed description is included in Section 3.1 of the ER. A discussion of water use within the proposed project area is included in Section 2.7 of this report.

2.2.1 Current Land Use

The proposed Ross ISR Project is located in western Crook County, approximately 21.5 miles north of Moorcroft (2009 population est. 926), 33 miles northeast of Gillette (2009 population est. 28,726), and 30 miles northwest of Sundance (2009 population est. 1,339). The proposed project area is located in the northwest quadrant of the Nebraska–South Dakota–Wyoming Uranium Milling Region as defined in the Generic Environmental Impact Statement for ISL facilities (ISR GEIS) (NRC 2009a). Surface ownership within the proposed project area is primarily private, with intermingled State and federal (BLM).

The proposed project area consists of gently rolling topography and large, open expanses of grassland, hayland, and shrubland. Located in the backdrop towards the east is a view of Devils Tower National Monument and the Black Hills National Forest (BHNF). The proposed project area is rural in character, with minor industrial development from oil activities. Human influence is evident in existing grazing activities and facilities (e.g., stock tanks and fences), oil production facilities, transportation corridors, and infrastructure that support these activities.

Areas of disturbance within the proposed project area include roads, utilities, oil wells, and activities associated with agriculture (including livestock and hay production). Several county roads and unnamed local access roads border or traverse the proposed project area. D Road (CR 68) and New Haven Road (CR 164) will be the primary access routes to the proposed project area.

Within the proposed project area, existing land uses include: livestock grazing on rangeland, oil production, crop production, communication and power lines, transportation, recreation, reservoirs, and wildlife habitat. The mapped land use categories within 5 miles of the proposed project area include the following (Anderson et al. 1976): mixed rangeland, herbaceous rangeland, cropland and pasture, industrial, evergreen forest land, and reservoirs. Mixed

rangeland covers 59.2% of the proposed project area followed by herbaceous rangeland at 21.4% of the proposed project area.

In 2007 Crook County generated $39.6 million from the sale of livestock, poultry and their products (USDA-NASS 2010). In 2009, 81.8% of the total livestock inventory for Crook County was cattle and the remaining 18.2% was breeding sheep and lambs. There are also about 3,000 horses and ponies in Crook County.

Wheat, hay and oats were the only crops commercially grown within Crook County in 2008 (USDA-NASS 2010). There is a small portion (42 acres) of land in the southeast corner of the proposed project area used for commercial crop production. According to the vegetation study conducted for this project, in 2010 the cropland was seeded to wheat, but it has also been used for the production of oats and barley in the past.

There are currently no residences within the proposed project area however, there are 10 residences located within a 2-mile (3.2- km) radius of the proposed project area. The nearest residence to the proposed project boundary is 690 feet north-northeast of the easternmost portion of the proposed project boundary.

Crook County offers a variety of recreation opportunities. Some of the major attractions include Devils Tower National Monument, BHNF and Keyhole State Park. Some of the recreational opportunities within these areas include hunting, camping, hiking, horseback riding, biking, boating and fishing.

There is limited opportunity within the proposed project area for large game hunting, including mule deer, white-tailed deer and pronghorn. Sage grouse, wild turkeys, and small game are present and may also be hunted in the general vicinity. In general, publicly owned lands (i.e. State or BLM-administered federal lands) are open to hunting if legal access is available. State land can be accessed via County Road 193, but the BLM land cannot be accessed by public road.

Aquatic habitat is very limited by the ephemeral nature of surface waters in the proposed project area. Public fishing opportunities are likewise very limited. Oshoto Reservoir, an in-channel impoundment on the Little Missouri River, is partially located on State land. The WGFD does not stock the reservoir and it is not managed by any private agency, but native fish are present in the reservoir.

Wyoming is a state with active mineral development. Crook County has an abundance of mineral resources, including coal, oil, gas, bentonite, sand, gravel, gypsum, limestone, uranium, and vanadium (Crook County 1998). There are a total of 192 oil and gas wells within 2 miles of the proposed project area. Of these, only 19 are producing wells, which typically target the Minnelusa Formation. The majority of the oil and gas wells located within the proposed project area and 2-mile buffer are plugged and abandoned.

There are no nuclear fuel cycle facilities or operational uranium recovery facilities located within 50 miles (80 km) of the proposed project area (NRC 2010a). The nearest uranium hexafluoride conversion facility is in Metropolis, Illinois.

The ISR GEIS (pg. 3.1-4) identified one potential future ISR uranium recovery facility near Aladdin, which is about 40 miles east-northeast of the Ross ISR Project. Three other potential uranium recovery projects have been identified within 50 miles of the Ross ISR Project. These include the Bayswater Uranium Corporation Elkhorn, Wyoming Project about 17 miles northeast; the Bayswater Alzada, Montana Project about 36 miles north-northeast; and the Ur-Energy/Bayswater Hauber Project about 13 miles north-northeast of the proposed project area (Bayswater 2010a and 2010b, Ur-Energy 2010).

2.2.2 Land Use Plans

Land use within the proposed Ross ISR Project is affected by two land use plans. Federal surface and mineral leases within the proposed project area are managed by the BLM according to the Newcastle Resource Management Plan (BLM 2000). Crook County has also implemented a land use plan. In addition to these two land use plans, state-owned lands and minerals within the proposed project area are subject to the rules and regulations of the OSLI. A potential conflict exists between mineral exploration and development and other land resource uses such as livestock grazing, wildlife habitat, and cultural resources.

Under the proposed action and no action alternatives, existing land uses within the proposed project area are likely to continue in the foreseeable future. These include but are not limited to livestock grazing (cattle and horses), hay production, oil production, transportation, and recreation. These land uses are consistent with existing land use plans and have generally remained unchanged for many years. Future residential development in the

proposed project area will likely be limited by the large land tract size and distance of more than 20 miles to the nearest public water and sewer service areas. The potential for significant future oil and gas development is low and the proposed project area does not overlie any coal seams targeted for CBNG production, so there is no potential for future CBNG development. Sand or gravel extraction might also occur within the proposed project area.

2.3 Population Distribution

The following section is a summary of the population distribution within the proposed project region. A more detailed description is included in Section 3.10 of the ER.

2.3.1 Population

The area within an 80-kilometer (km) radius of the project site includes portions of Crook, Campbell, and Weston Counties in Wyoming, as well as small portions of two counties in Montana (Powder River and Carter) and very small parts of two counties in South Dakota (Butte and Lawrence). The proposed project area is located in western Crook County.

The direct social zone of influence for the Proposed Action socioeconomic baseline includes the towns and unincorporated areas within Crook County, which hosts the uranium deposits and therefore will benefit from mineral production tax revenues, and nearby Campbell County, which has the nearest urban area (Gillette) and therefore is a potential source of labor, services and materials to support the ISR operation.

Towns within Crook County and their 2000 populations include Hulett (408), Moorcroft (807), Pine Haven (222) and Sundance (1,161). Towns in Campbell County and their 2000 populations include Gillette (20,288) and Wright (1,347). The towns of Upton (2000 population 872) and Osage (2000 population 215), Wyoming, in Weston County, are within the 80-km radius of the proposed project area but not likely to be directly affected by the ISR recovery operation. Likewise, the unincorporated community of Alzada, Montana (2000 population 92) is within the 80-km radius but will not be directly affected. (USCB 2000)

Gillette, Wyoming, the closest urban area to the proposed project area, is approximately 80 km via road southwest of the proposed project area and Campbell County and will likely serve as a regional logistics hub and source of workers and supplies for the Ross ISR Project. Moorcroft, Wyoming is within about 23 miles from the proposed project area and could be a source of employees and place of residence for project staff.

The most recent verifiable population data for Campbell and Crook counties comes from the 2000 Federal census. More recent population estimates are available from the Wyoming Department of Administration and

Information, Economic Analysis Division (WDAI/EA 2010). Both counties grew faster than the State as a whole between 2000 and 2009. Campbell and Crook Counties' populations increased by 30.5% and 13% respectively within this time period, compared with the State average of 10.2%. Between 2000 and 2009, the City of Gillette grew by 46.2%. This is largely attributable to the growth in the energy sector, including CBNG, conventional oil and gas, coal mining, and power plant construction.

The population of Wyoming is projected to increase by 16.5% from 2008 to 2030. Campbell County, and its communities Gillette and Wright, are projected to grow at over 2.5 times the State average through 2030, while Crook County and its communities are projected to grow about 12% faster than the State as a whole.

2.3.2 Demography

Demographic data for Crook and Campbell county populations were collected and compared to the State of Wyoming as a whole. Demographic data collected included sex, age, race, and household size. Review of the data in Section 3.10.2 of the ER indicates that the population of Campbell County is younger than the State average, has more people per household, more households with individuals under 18 years of age and fewer households with individuals over 65 years of age, and slightly more female householders with no husband present and with their own children. Conversely, the population of Crook County is older than the State average with an older median age, smaller percentage of households with individuals under 18 years of age, and a higher percentage of households with persons 65 years of age or older. In Crook County the percentage of female householders with no husband present is below the State average, as is the percentage of female householders living with their own children under 18 years of age.

Racial data for the two counties show that the local population is predominantly white, with both counties having a smaller percentage of minorities than the State average. At 3.5%, the Campbell County percentage of Hispanics or Latinos was nearly four times that of Crook County in 2000, but still well below the State average of 6.4%.

2.4 Historic, Scenic, and Cultural Resources

The following sections are a summary of the historic, scenic, and cultural resources within the proposed project region. A more detailed description is included in Sections 3.8 and 3.9 of the ER.

2.4.1 Regional/Site History

Cultural resources, which are protected under the National Historic Preservation Act (NHPA) of 1966, are nonrenewable remains of past human activity. This portion of Wyoming appears to have been inhabited by aboriginal hunting and gathering people for more than 13,000 years. Frison's (1978, 1991) chronology for the Northwestern Plains divides occupations from early to late into the Paleoindian, Early Plains Archaic, Middle Plains Archaic, Late Plains Archaic, Late Prehistoric, Protohistoric, and Historic periods.

Crook County was formed in 1875. It is named for Brigadier General George Crook, a commander during the Indian Wars. The dryland farming/homesteading movement was the most substantial historic expansion, occurring from the 1910s to the 1930s. The Great Depression resulted in government assistance programs of the mid-to-late 1930s, which affected the settlement patterns of this region. Post-war ranching (1945-present) is the latest historic theme.

The Texas Trail, which operated from 1876 to 1897, was used to move cattle as far north as Canada. Most of the early cattle herds passed through Wyoming and were used to establish Montana's ranching industry. As cattleman recognized the value of Wyoming's grasslands, several large cattle ranches were established. Due to extreme weather conditions the era of the cattle baron ended which provided an opening for Wyoming's sheep industry.

The dry land farming movement of the late 19th and early 20th centuries had a profound effect on the settlement of northeastern Wyoming during the years around World War I. The most intensive period of homesteading activity in northeastern Wyoming occurred in the late 1910s and early 1920s. Promotional efforts by the state and the railroads, the prosperous war years for agriculture in 1917 and 1918, and the Stock Raising Act of 1916 with its increased acreage (but lack of mineral rights) all contributed to this boom period.

During the 1920s the size of homesteads in Wyoming nearly doubled and the number of homesteads decreased, indicating the shift to livestock raising (LeCompte and Anderson 1982). In April of 1932, portions of northeast Wyoming were eligible for a drought relief program. The Northeast Wyoming Land Utilization Project began repurchasing the sub-marginal homestead lands and making the additional acres of government land available for lease. Two million acres within five counties, including about 560,000 acres of federal owned lands, were included in the Thunder Basin Project (LA-WY-1) to alter land use and to relocate settlers onto viable farmland.

During the development program to rehabilitate the range, impounding dams were erected, wells were repaired, springs developed, and homestead fences removed while division fences were constructed for the new community pastures. The government paid former farmers to remove homesteads and their efforts were so successful, that almost no trace remains. The remaining subsidized ranches were significantly larger and provided a stabilizing effect on the local economies. The Thunder Basin Grazing Association, the Spring Creek Association, and the Inyan Kara Grazing Association were formed to provide responsible management of the common rangeland.

Uranium was first discovered in Wyoming in 1918 near Lusk. Nuclear Dynamics and Bethlehem Steel Corporation formed the Nubeth Joint Venture (Nubeth), to develop new uranium recovery districts in the western U.S. with specific attention focused on northeastern Wyoming's Powder River Basin.

The initial discovery of uranium near Oshoto was made by Albert Stoick during an over-flight of the area. This was followed by macroscopic sampling efforts and then regional exploration work by the joint venture group (Buswell 1982). Nubeth received a WDEQ/LQD License to Explore (No. 19) in August 1976 and an NRC combined source and 11e.(2) byproduct material license in April 1978 (SUA-1331). A Research and Development (R&D) site was constructed and operated from August 1978 through April 1979. No precipitation of a uranium product took place and all of the recovered uranium was stored as a uranyl carbonate solution. Final approval for the R&D site decommissioning was granted by the regulatory agencies in 1983 through 1986.

2.4.2 Cultural Resources Survey

The goal of a Class I and Class III cultural resources survey is to locate and evaluate for the National Register of Historic Places (NRHP) all cultural resources 50 years and older that have exposed surface manifestations within the proposed project area. A Wyoming Cultural Records Office (WYCRO) file search was conducted on February 9, 2010, by archeologists from GCM Services, Inc. (Butte, Montana), prior to the Class III field work. GCM also conducted a Class III Cultural Resources Evaluation for the Ross ISR Project The goal of the survey is to locate and evaluate for the National Register of Historic Places (NRHP) all cultural resources 50 years and older that have exposed surface manifestations within the proposed project area.

Cultural sites were evaluated within the framework of the NRHP. Each site's integrity of location, design, setting, materials, workmanship, feeling and association were considered as well as the site's ability to meet four other criterions. These include sites that: a) are associated with events that have made a significant contribution to the broad patterns of our history, b) are associated with the lives of persons significant in our past, c) embody distinctive characteristics, or d) have yielded, or may be likely to yield, information important in prehistory or history.

The Class I literature search revealed one site that was found in 1995 during an inventory for a phone line or fiber optic line. This site was not relocated during the 2010 Class III survey and had apparently been destroyed as a result of reconstruction of the D Road. The Class III Cultural Resource Inventory for the proposed project area contains information that falls under the confidentiality requirements for archeological resources under the National Historic Preservation Act, Section 304 (U.S.C. 470w-3(a)). Results of the Class I and Class III Cultural Resources surveys are included as Addendum 3.8-A in the ER. This survey is considered privileged and confidential per 10 CFR Section 2.390(a)(3).

2.4.3 Paleontological Resources

The formations exposed on the surface of the Ross ISR Project are the Late Cretaceous Lance Formation and Fox Hills Formation, which have a good potential to produce a variety of fossils (USFS 2001).

The BLM uses the Potential Fossil Yield Classification System (PFYC), to classify geological units, usually at the formation or member level, according to the probability that they will yield paleontological resources that are of concern to land managers. The PFYC includes the following five primary classes of geologic units: class 1, very low; class 2, low; class 3, moderate or unknown, class 4, high; and class 5, very high. BLM considers the Lance Formation to fulfill either the PFYC Class 4 or Class 5, depending on the nature of bedrock exposures present (BLM 2008). Lesser amounts of the proposed project area are covered by Quaternary alluvium, which is generally recognized to have a low potential for vertebrate or scientifically significant invertebrate fossils and is a PFYC Class 1 or 2. Paleontological survey are provided in Addendum 3.8-A of the ER.

2.4.4 Tribal Consultations

Native American heritage sites can be classified as prehistoric or historic. Some may be presently in use as offering, fasting, or vision quest sites while other sites may include rock art, stone circles, various rock features, fortifications or battle sites, burials, and locations that are sacred or part of the oral history and heritage but have no man-made features.

No Native American heritage, special interest, or sacred sites have been formally identified and recorded to date directly associated with the proposed project. If any sites or localities are identified at a later date, appropriate action must be taken to address concerns related to those sites. The nearest Indian reservation to the proposed project area is the Northern Cheyenne Indian Reservation in Montana (approximately 91 miles northwest).

A review of literature indicates that Devils Tower is a sacred area for several Plains Tribes (Hanson and Chirinos 1991). Six tribes have historical and geographical ties while over 20 tribes have potential cultural affiliation with Devils Tower National Monument (NPS 2010). Traditional ceremonial activities which demonstrate the sacred nature of Devils Tower to American Indians include personal rituals, group rituals, and sacred narratives.

Pursuant to NRC regulations under the NHPA, NRC staff has the responsibility for consulting with Indian Tribes potentially affected by the Proposed Action. Following the receipt and acceptance of a license application for a specific action, the NRC will meet or communicate with all known Federally-recognized tribes in the area with a potential interest to establish

protocol and procedures for government-to-government interaction on the matter. Twenty-four tribes have been identified as potentially having concerns about actions in the PRB (NPS 2010).

Strata commits to ongoing monitoring of historic and cultural resources as project development progresses. Mitigation measures proposed for conserving and reducing potential impacts to historic and cultural resources are discussed in Section 5.8 of the ER. These measures include avoidance, consultations with historic and tribal organizations, pre-construction surveys, and an internal management control program which outlines surveys and management of historic and cultural resources.

2.4.5 Visual and Scenic Resources

Visual sensitivity levels are determined by people's concern for what they see and the frequency of travel through an area. Four areas of managed land are located within 20 miles of the Ross ISR Project, including Devils Tower National Monument, Thunder Basin National Grassland, Keyhole State Park, and Black Hills National Forest.

The Visual Resource Management (VRM) system is the basic tool used by BLM to inventory and manage visual resources on public lands. The VRM system includes a visual resource inventory and an analysis or visual resource contrast rating. In accordance with the BLM Handbook H-8410-1, a visual resource inventory can be created using three categories (BLM 2010). These categories include scenic quality, visual sensitivity, and distance zones.

The visual resource inventory categories are used to develop VRM management classes. VRM objectives are developed to determine how the land should be managed to protect the scenic quality. The four objectives are used to describe increasing levels of change within the characteristic landscape. The objectives range from a Class I, which preserves the existing character of the landscape, to a Class IV which provides management for activities which require major modifications of the existing character of the landscape.

The area considered for visual resources includes the proposed project area and a 2-mile (3.2-km) buffer area. No developed parks or recreation areas are located within the visual resources study area. Landscapes are characterized by a gently rolling topography and large, open expanses of upland grassland, pasture/hayland, sagebrush shrubland, and intermittent riparian drainages. Intermittent streams are fed by ephemeral drainages which

seasonally drain the adjacent uplands. There are also areas of altered landscape within the study area, including nine residences, oil production facilities, transportation facilities, agricultural activities, and environmental monitoring installations.

In Campbell County, the land near the proposed project area is categorized as VRM Class IV, while the land surrounding the proposed project area in Crook County is categorized as VRM Class III. The visual resources study area occurs entirely within Crook County and is therefore categorized as VRM Class III (BLM 2001).

A site specific VRM evaluation was conducted in October 2010 on the proposed project area using the BLM methodology. The scenic quality inventory for the visual resource study area was evaluated based on the key factors of landform, vegetation, water, color, influence of adjacent scenery, scarcity, and cultural modifications. The scenic quality field inventory shows that the visual resource evaluation rating calculated for the study area is 11.25 out of a possible 32. No further evaluation is required since the visual resource evaluation rating is below 19 (NRC 2003b).

2.5 Meteorology, Climatology, and Air Quality

2.5.1 Meteorology and Climatology

The proposed Ross ISR Project is located in a semi-arid or steppe climate. The region is characterized seasonally by cold harsh winters, hot dry summers, and relatively warm moist springs and autumns. Temperature extremes range from roughly -25°F in the winter to 100° F in the summer. The "last freeze" occurs during late May and the "first freeze" mid-to-late September.

Yearly precipitation totals are typically between 10 and 15 inches. The region is prone to severe thunderstorm events throughout the spring and early summer months and much of the annual precipitation is attributed to these events. In a typical year, the area will see 4 or 5 severe thunderstorm events (as defined by the National Weather Service criteria) and 40 to 50 thunderstorm days. Autumn stratiform rain events also contribute to precipitation totals, but to a lesser degree. Snow frequents the region throughout winter months (40-50 in/year), but generally provides less moisture than rain events.

Windy conditions are fairly common to the area. Nearly 5% of the time hourly wind speed averages exceed 25 mph. The predominant wind direction is southerly with the wind blowing out of that direction roughly 20% of the time. A north/northwest secondary mode with higher wind speeds is also present. Surface wind speeds are relatively moderate at a year-round, hourly average of 10 to 11 mph. Higher average wind speeds are encountered during the winter months while summer months experience lower average wind speeds.

For the regional analysis, meteorological data were compiled from 14 sites surrounding the Ross ISR Project. Hourly wind speed, wind direction, precipitation and temperature data were acquired through the Western Regional Climate Center (WRCC) (2010) for 11 Cooperative Observation Program (COOP) and Automated Surface Observing System (ASOS) sites operated by the National Weather Service (NWS). In addition, meteorological data from the Buckskin Mine (BSM) and the Dry Fork Mine (DFM) were obtained through Inter-Mountain Laboratories (IML). The latter two sites are operated in compliance with regulations set forth by WDEQ/AQD for air quality monitoring. The site-specific analysis used meteorological data from the Ross ISR meteorological station, with comparisons to data from the nearby Thunder Basin National Grassland (TBNG) monitoring station as well as the Gillette

Airport (Gillette AP) station. Table 2.5-1 provides the station ID, coordinates, and period of operation for all sites. See Figure 2.5-1 for MET station locations.

These 14 sites have been analyzed collectively to provide a regional climatic temperature and precipitation analysis that includes the proposed project area. The TBNG, Gillette AP, BSM and DFM sites were analyzed for the regional wind summaries. The 11 NWS sites have been incorporated into the snowfall discussion as none of the mine sites record snowfall data. At the project site, hourly average meteorological data have been collected for the year 2010. These site-specific data include wind speed, wind direction, sigma theta, temperature, relative humidity, precipitation, evaporation and evaporation pan water temperature. The nearest available long-term monitoring site is TBNG, where these same parameters are logged (except for precipitation and evaporation) on an hourly interval. Data from this site were retrieved for 2003 through 2007. The TBNG monitoring site is approximately 18 miles from the project site. The closest NWS operated station which continuously records all weather parameters is the Gillette AP site, some 35 miles to the west-southwest.

A regional overview is presented first. This section includes a discussion of the maximum and minimum temperature, relative humidity, annual precipitation including snowfall estimates, and a brief wind speed and direction summary. The BSM, DFM and Gillette AP sites are used in the regional wind analysis. A combination of these and NWS monitoring stations is analyzed for the regional overview of temperature, snowfall and total precipitation.

A site specific analysis follows the regional overview. Most of this analysis is based on the on-site monitoring. It is supplemented by the longer-term TBNG, Gillette AP and BSM meteorological data, with many of the same meteorological parameters listed previously. An in-depth wind analysis summarizes average wind speeds and directions, wind roses, wind speed frequency distributions, and a joint frequency distribution to characterize the on-site wind data by stability class. A discussion of monthly and seasonal data is included for the temperature and wind parameters. Beyond wind and temperature patterns, general climate and upper atmosphere data from the regional evaluation are deemed to be representative of the project site.

2.5.1.1 Regional Overview

2.5.1.1.1 Temperature

The annual average temperature for the region is approximately 46° to 47°F. Table 2.5-2 lists monthly and annual average temperatures for three meteorological stations representative of the region. These include:

1) Gillette AP, roughly 35 miles southwest of the project site
2) BSM, roughly 30 miles west-southwest of the project site
3) DFM, roughly 25 miles west-southwest of the project site

Figure 2.5-2 presents a graph of the data in Table 2.5-2. Data for the BSM and DFM sites represent the last ten years (2000-2009), while the Gillette AP data reflect the last five years (2005-2009). As illustrated, average temperatures from the three sites exhibit remarkable agreement. July has the highest average monthly temperature (74°F), followed by August (70°F). December records the lowest average temperatures for the year (25°F), followed by January (26°F). Along with average temperatures, Table 2.5-2 shows minimum and maximum monthly temperatures for the three sites. These extreme temperatures are also quite similar, with low temperatures during the respective recording periods reaching around -21°F and high temperatures reaching around 104°F.

Large diurnal temperature variations are found in the region due in large part to its high altitude and low humidity. Figure 2.5-3 depicts the monthly diurnal temperature variation for the BSM site from 2000 through 2009. Spring and summer daily variations of 25°F are common with maximum temperature variations of 30° to 40°F observed during extremely dry periods. Less daily variation is observed during the cooler portions of the year as fall and winter have average variations of 10° to 15°F.

The lesser variation in daily temperature can be attributed to the more stable atmospheric conditions in the region during the fall and winter months. Stable periods have much lower mixing heights and accompanying lapse rates allowing for less temperature variation. At this latitude the winter sun provides much less daytime heating due to its lower angle and shorter daylight hours.

Daily maximum temperatures in the project region average approximately 60°F and daily minimum temperatures average approximately 30°F. July has the highest maximum temperatures with averages near 90°F

while the lowest minimum temperatures are observed in January with averages near 10°F. Isotherm maps of interpolated annual average minimum and maximum temperatures are shown in Figure 2.5-4 and Figure 2.5-5, respectively.

2.5.1.1.2 Relative Humidity

The Gillette AP and TBNG are the only sites included in the regional analysis that record relative humidity (or dew point) data. The graph in Figure 2.5-6 charts monthly average relative humidity values for these two sites. The Gillette AP data reflect the period from 2005 through 2009, while the TBNG data represent 2003 through 2007. It can be seen on Figure 2.5-6 that July has the lowest relative humidities averaging around 45%. This is due primarily to the fact that warmer air requires more moisture to become saturated. The winter months of December, January and February bring colder air, which requires less moisture to become saturated and therefore tends to exhibit higher relative humidity. These months show relative humidities from 60% to 70%. Table 2.5-3 presents relative humidity values in tabular form. The overall average relative humidity is 58% at Gillette AP and 61% at TBNG.

Relative humidity is a temperature-based calculation which reflects the fraction of moisture present relative to the amount of moisture contained in saturated air at that temperature. The latter is a function of saturation vapor pressure, which increases with temperature. Since warm air requires more moisture to become saturated, it tends to have lower relative humidity than cooler air. Therefore, maximum relative humidity values occur more frequently in the cooler early mornings while minimum values typically occur during the warmer mid afternoon hours. Average annual readings at the Gillette AP from 2005 through 2009 were 70% and 40% for mornings and afternoons, respectively (Figure 2.5-7). The summer months exhibit a much greater variation in relative humidity between morning and afternoon values due to greater temperature variations.

2.5.1.1.3 Precipitation

The region is characterized by moderately dry conditions. The Gillette AP site received measurable (>0.01 in) precipitation on an average of 87 days per year between 2005 and 2009. Average annual precipitation during that period was nearly 12 inches per year. In general, the project region has an annual

average from 10 to 15 inches, with higher averages in the Black Hills (Figure 2.5-8). Spring showers and thunderstorms produce over half of the precipitation. May is typically the wettest month of the year (Figure 2.5-9); with most of the region receiving an average greater than 2 inches for that month. January, by contrast, is the driest month of the year with precipitation averaging generally 0.5 inch or less. The winter months (December-February) typically account for less than 10% of the yearly precipitation totals. A secondary minimum is also evident during August, when atmospheric conditions are more stable and the absence of convective activity limits storm development.

Severe weather does arise throughout the region, but is limited on average to 5 or 6 severe events per year. These severe events are generally split between hail and damaging wind events. Tornadoes can occur but on rare occasions, with less than one tornado per county per year (Martner 1986).

Average annual snowfall in the proposed project area is about 50 to 60 inches. Major snowstorms (more than 5 in/day) are relatively infrequent in the region. The region experiences less than three major snowstorms per year. Monthly snowfall averages for eight NWS sights are presented in Figure 2.5-10. Sundance has the highest annual snowfall of all the sites in the region, with an average of 76 inches. This is due to snow events which occur on the western flank of the northern Black Hills as a result of orographic lifting of the prevailing westerly flow of air. The interpolated values (Figure 2.5-11) show average snowfall of 50 to 60 inches per year in the project vicinity. This range is slightly lower than that indicated in the Wyoming Climate Atlas (Martner 1986) which lists averages for this part of northwestern Crook County at 60 to 70 inches. This difference may be attributable to drought conditions in the region during the last 10 years.

2.5.1.1.4 Wind Patterns

Year-round wind speeds in the area average between 10 and 11 mph. Table 2.5-4 shows considerable agreement among the three representative sites, both for annual and monthly averages. The Gillette AP site averaged 10.5 mph for the 2005-2009 period analyzed in this study. BSM averaged 10.8 mph and DFM averaged 9.9 mph. The differences in average wind speeds between BSM and DFM can be attributed to monitor locations. The BSM meteorological station is situated on a ridge while the DFM station is located in

a valley. Mean monthly average wind speeds are lowest in July and highest in January and April. Figure 2.5-12 graphs the monthly average wind speeds at these three monitoring sites.

Table 2.5-4 also shows monthly maximum hourly wind speeds. High wind events are fairly common in this region; wind data from all three sites show every month recording peak hourly wind speeds greater than 30 mph during the five-year period analyzed.

Figures 2.5-13, 2.5-14 and 2.5-15 show five-year wind roses for the three sites. Some variation can be accounted for by local topography, but all three figures show bimodal winds with a north-northwesterly component and a south-southeasterly component. Spring and summer generally exhibit southeasterly winds as the predominant direction, with north/northwest winds dominating the fall and winter seasons. The highest wind speeds tend to occur from the north- northwesterly direction.

2.5.1.1.5 Cooling, Heating, and Growing Degree Days

Figure 2.5-16 summarizes the monthly cooling, heating, and growing degree days for Weston, Wyoming, a NWS meteorological monitoring site roughly 20 miles west of the proposed project area. The data are assumed to be indicative of the proposed project area due to its proximity and comparable elevation.

The heating and cooling degree days are included to show deviation of the average daily temperature from a predefined base temperature. In this case, 55° F has been selected as the base temperature. The number of heating degree days is computed by taking the average of the high and low temperature occurring that day and subtracting it from the base temperature. The calculation for growing and cooling degree days is the same, except that the base temperature is subtracted from the average of the high and low temperature for the day. Negative values are disregarded for both calculations.

As expected, the graphs of heating degree days and cooling degree days are inversely related and the number of growing and cooling degree days per month is identical when the same base temperature is chosen. The maximum number of heating degree days occurs in January, at over 1,000 degree days. This coincides with January having the lowest minimum average temperature. Conversely, July registers the most cooling/growing degree days with 500,

which also corresponds to July having the highest maximum average temperature.

2.5.1.2 Site Specific Analysis

2.5.1.2.1 Introduction

The site specific discussion is limited to on-site meteorological data collected in 2010, data from the Gillette AP site for the same monitoring period, data from BSM for years 2000 through 2009, and meteorological data from the nearby TBNG site collected during the five-year period from 2003 through 2007. Siting of the Ross ISR Project meteorological station and subsequent, on-site monitoring activities have been conducted in accordance with the Monitoring Plan, detailed in ER Addendum 3.6-A. Monitored parameters and instrument specifications associated with on-site monitoring are presented in Table 2.5-5. A photograph of the on-site monitoring station appears in Figure 2.5-17.

The Gillette AP data (from the National Weather Service) provide a basis for assessing to what degree the on-site Ross ISR data are representative of the entire region. Data from the TBNG site are not current enough to serve this purpose, but the site is included to incorporate nearby wind monitoring results from a longer period of record. The TBNG site is located 18 miles west of the Ross ISR Project, with topographic features similar to the proposed project area. Since temperature data from TBNG were deemed invalid, the 10-year temperature data from BSM were used. The BSM site is 30 miles west-southwest of the proposed project area and the Gillette AP site is 35 miles west-southwest of the proposed project area. In all four cases, the surrounding area is characterized by rolling hills, minor ridges and ephemeral drainages. The vegetation types are mainly confined to native grasses with some sage brush and very sparse woody plants.

Site specific meteorological data are provided in ER Addendum 3.6-B. Figure 1 in ER Addendum 3.6-B provides a meteorological summary for the Ross ISR project site for the year 2010. The averages, maximums, and minimums are specified for each parameter recorded at the site (except for precipitation which shows the total). This figure also shows data recovery rates greater than 95% for all parameters. The Gillette AP site was used for comparison to on-site data during the same monitoring period. Figure 2 in ER

Addendum 3.6-B provides a 2010 meteorological summary for the Gillette AP site.

2.5.1.2.2 Temperature

The annual average project site temperature is similar to the regional average temperature at approximately 45°F. The maximum temperature for 2010 was 98°F and the minimum temperature was -16°F (ER Addendum 3.6-B Figure 1).

Figure 3 in ER Addendum 3.6-B shows the monthly average for the proposed project site in comparison to temperatures for a longer period of record at the BSM site. ER Addendum 3.6-B Figure 4 compares monthly average temperatures between the proposed project site and the Gillette AP for the same 12-month period. Based on these comparisons and the temperature data summarized in the regional analysis above, it appears that the proposed project site experiences temperature patterns quite typical of the area. Table 1 in ER Addendum 3.6-B provides the monthly on-site temperature data in tabular form. Daily average temperatures range from 20°F in the winter months to about 70°F in the summer months.

Figure 5 in ER Addendum 3.6-B shows the on-site, diurnal temperature variation by season. The difference between average daytime and nighttime temperatures is greater during the summer and fall than during the winter and spring. Large diurnal temperature swings in the fall of 2010 may be attributable to an unusually warm and dry September and October.

2.5.1.2.3 Wind Patterns

Figure 6 in ER Addendum 3.6-B presents a wind rose for the proposed project site during the 12-month monitoring period (2010). For comparison, Figure 2.5-18 shows a wind rose for the TBNG site during the 5-year monitoring period (2003-2007). Both wind roses exhibit a strong southerly wind component, although TBNG has more southwesterly winds and fewer northwesterly winds than the proposed project site. Figures 7 through 9 in ER Addendum 3.6-B show monthly wind roses for the project site. The predominant wind direction is southerly for all months except May, where south-southeasterly winds predominated. Based on the correlation between one year of on-site data and 5 years of data at the nearby TBNG, year 2010 appears to be typical of long-term wind conditions.

Despite the prevalence of southerly winds, the highest wind speeds at the Ross ISR site tend to occur from the northwest. This phenomenon is even more evident at the Gillette AP site during the same year of monitoring (Figure 10 in ER Addendum 3.6-B), and reinforced somewhat by the 5-year wind rose at Gillette AP (Figure 2.5-13). Northwest winds are generally associated with weather fronts moving through the region. During periods of fair weather, particularly in the summer months, high pressure located over the northern plains produces moderate south/southeasterly winds in the proposed project area. Synoptic weather systems generally interrupt this pattern, producing high north-northwesterly winds. Spring experiences the greatest variability in wind direction with secondary modes as a result of the synoptic scale transition period that occurs during this time. Low pressure regions develop on the lee side of the Rockies bringing southeasterly winds during storm development. As the low pressure systems form and move off with the general atmospheric flow, winds switch to a north-northwesterly direction.

The average wind speed for the proposed project site was 11.6 mph during the 12 months of monitoring. Winds at the nearby TBNG site averaged 11.2 mph over the 5-year period studied. Figure 11 in ER Addendum 3.6-B compares on-site monthly average wind speeds with Gillette AP data for the same 12-month monitoring period. While the on-site wind speeds are slightly higher, they exhibit the same seasonal pattern observed at Gillette AP. These results indicate the on-site 2010 wind speed data are representative of long-term, regional conditions. The monthly average wind speeds at the project site and TBNG are shown in Figure 12 in ER Addendum 3.6-B. The graph shows higher wind speeds in the winter and spring, peaking in April.

Figure 13 in ER Addendum 3.6-B provides a breakdown of wind speeds by wind direction at the Ross ISR site. Winds blow most frequently from the southerly direction, as discussed above, while northwesterly winds tend to be the strongest. Easterly winds have the lowest average velocities. Figure 14 in ER Addendum 3.6-B shows the wind speed frequency distribution for the site. The cumulative distribution demonstrates that winds exceed 18 mph about 10% of the time, and they exceed 8 mph about 50% of the time. Figures 15 through 18 in ER Addendum 3.6-B present the same information as Figure 13 in ER Addendum 3.6-B, except on a quarterly basis.

The Joint Frequency Distribution (JFD) provides more detail on wind speed distribution by wind direction and atmospheric stability class (Table 2 in

ER Addendum 3.6-B). Each entry in the table represents the fraction of the time the wind blows within the given stability class, wind speed range, and direction. Pasquill stability classes are determined using the standard deviation of horizontal wind direction (Sigma Theta) method.

The JFD shows the frequencies of hourly average wind speed for each direction based on atmospheric stability class. 63% of all winds at the project site fall into stability class D which represents near neutral to slightly unstable conditions. The light winds which accompany stable environments can be seen by the stability class F summary (stable), where hourly average wind speeds are all less than 6.9 mph. Tables 3 through 6 in ER Addendum 3.6-B present the same information as Table 2 in ER Addendum 3.6-B, except by individual quarters.

Figure 19 in ER Addendum 3.6-B shows the on-site, diurnal variation in average wind speed by season. Daytime wind speeds average higher than nighttime wind speeds, and the difference is more pronounced during spring and summer than during winter and fall. This phenomenon is related to the difference in diurnal temperature swings and the degree of atmospheric mixing associated with each season.

2.5.1.2.4 Precipitation

Figure 20 in ER Addendum 3.6-B compares monthly precipitation at the project site during 2010 to average monthly precipitation at BSM over the previous 10-year period. On-site data reflect a wetter-than-normal early summer and a drier-than-normal fall. Figure 21 in ER Addendum 3.6-B shows monthly precipitation totals at the on-site and Gillette AP monitoring stations for the same 12-month monitoring period. While the Gillette AP site received more rain in May, precipitation for the rest of the year was comparable between the two sites.

2.5.1.2.5 Evaporation and Relative Humidity

An evaporation gauge was installed at the Ross ISR Project meteorological station in late June 2010. Evaporation data were collected from the time of installation to late October, when the gauge was decommissioned to prevent freeze-up. Figure 22 in ER Addendum 3.6-B shows average monthly evaporation for the Gillette AP site over a 22-year period. It also shows evaporation totals at the project site during 2010, for those months in which

monitoring occurred. The monthly totals are very similar, indicating on-site pan evaporation rates can be expected to resemble regional evaporation rates.

Evaporation rates are related to surface air temperatures, water temperatures, wind speed and relative humidity. It has been shown that air temperatures and wind speeds in the project area are typical of the region as a whole. Water temperatures in the evaporation pan paralleled air temperatures. The graph in Figure 23 in ER Addendum 3.6-B compares the two temperatures. Pan temperature cycles tend to be smoother but often amplified due to mid-day solar radiation, and tend to lag behind the air temperature cycle due to the high specific heat of water.

Figures 1 and 2 in ER Addendum 3.6-B show the average on-site and Gillette AP relative humidities for 2010. These are 66.7% and 60.4% respectively, indicating that on-site data are fairly representative of the region. The on-site humidities may be slightly higher due to the Oshoto Reservoir located near the center of the proposed project area.

Figure 24 in ER Addendum 3.6-B graphs the on-site diurnal variation in average relative humidity by season. Summer and fall exhibit greater fluctuations in relative humidity due to the larger diurnal temperature swings and the direct relationship between the air temperature and the maximum amount of water vapor the air will hold.

2.5.1.3 Monitoring Site Justification and Specifications

The proposed project is situated in northeast Wyoming, with the foothills of the northern Black Hills a few miles to the east. The rationale for the meteorological monitoring site (MET) is documented in the Ross ISR Monitoring Plan (IML 2010a), which is included as ER Addendum 3.6-A. A map of all air monitoring locations relative to the project boundary is presented in Figure 2.5-19. The MET station appears in the upper left corner of the map.

Table 2.5-5 lists the meteorological instruments employed at the Ross ISR Project MET site. The table shows instrument models, accuracy specifications, and instrument heights above the ground. Figure 2.5-17 shows the monitoring tower and instruments, solar panels, and the evaporation gauge.

Meteorological data collection, management and reporting methods at the project site conform to NRC atmospheric dispersion modeling requirements

for uranium milling operations, and meet the acceptance criteria established in the NRC's NUREG-1569. The on-site monitoring program was developed according to NRC Regulatory Guide 3.63, "Onsite Meteorological Measurement Program for Uranium Recovery Facilities – Data Acquisition and Reporting." The meteorological monitoring program also meets WDEQ requirements for land and air quality permit applications and compliance. Hourly average values for wind speed, wind direction, sigma theta, temperature, relative humidity, precipitation and evaporation are measured by field instruments and recorded by continuous data loggers, all operated and maintained by IML Air Science. Data recovery exceeded 95% for the 12-month monitoring period. All hourly data have been downloaded to IML Air Science's relational database. The database software provides for quality assurance, invalidation of suspect or erroneous data, and various forms of data analysis and presentation.

2.5.1.4 Upper Atmosphere Characterization

The nearest upper-air data available from the National Weather Service are from Rapid City, South Dakota, approximately 100 miles southeast of the proposed project area. Rapid City is approximately 1,000 ft lower in elevation than the proposed project area and is situated on the opposite side of the Black Hills. Therefore, upper-air data from Rapid City may be ill suited to represent the Ross ISR Project site.

WDEQ/AQD has provided statewide mixing heights to be used in dispersion modeling with the Industrial Source Complex (ISC3) model. These are based on the methods of Holzworth (1972) as applied to Lander, located in central Wyoming. For modeling purposes, the annual average mixing heights are assigned according to stability class as follows:

Class A	3,450 meters
Class B	2,300 meters
Class C	2,300 meters
Class D	2,300 meters
Class E	10,000 meters
Class F	10,000 meters

Stability classes E and F are given an arbitrarily high number to indicate the absence of a distinct boundary in the upper atmosphere.

In August of 2000, IML Air Science conducted SODAR (sonic detection and ranging) monitoring at the Black Thunder Mine (IML 2001), located

approximately 80 miles south of the Ross ISR Project site. The purpose of this monitoring was to support a comprehensive study of NO_x dispersion characteristics following overburden and coal blasting events. The SODAR instrument provided 3D wind speeds, wind directions, temperatures, temperature gradients, and other atmospheric parameters as a function of height above the ground. The vertical range of the SODAR was 1,500 meters, with a sounding performed every 15 minutes. Each sounding resulted in a calculated "inversion height/mixing height" (the two terms are used interchangeably by the SODAR system supplier). These mixing heights were downloaded into a database and queried, with results shown in Table 2.5-6. Morning and afternoon time intervals were taken from EPA modeling guidance.

The SODAR definition of mixing height appears somewhat ambiguous, and these measurements were all taken in August. Therefore, they are presented here as an additional data source. It is recommended that the WDEQ/AQD mixing heights be used as direct meteorological inputs to the MILDOS-AREA model.

2.5.1.5 Bodies of Water and Special Terrain Features

There are two significant bodies of water that may affect the meteorology of the project site. The first is Keyhole Reservoir, located 20 miles south of the proposed project area, can hold approximately 100,000 acre-ft of water. It is fed and drained by the Belle Fourche River. The second is Oshoto Reservoir, located inside the proposed Ross ISR permit boundary. Evaporation from these reservoirs, coupled with predominant southerly breezes, could slightly influence relative humidity measurements in the proposed project area. As evidenced by the above discussion of relative humidity data, however, it is not likely that this influence is substantial.

The nearest mountain ranges to the project site are:

1. the Bighorn Mountains, approximately 100 miles to the west
2. the Black Hills, approximately 20 miles to the east

It is believed that the Black Hills exert some effect on the meteorology of the proposed project area. This may include shielding of easterly winds and channeling of predominant winds into a north-south pattern. As discussed above, the Black Hills also affect precipitation patterns. As storms track from

west to east, upslope air movement near the Black Hills contributes to cooling of the air and moisture condensation.

2.5.1.6 Conclusion

The proposed project region lies in a semi-arid climate in the upper Northern High Plains. The landscape is composed of rolling hills, small drainages and ridges covered with native grasses, sparse sage brush, and some woody areas in the low lying valleys.

Data collected at the Ross ISR Project meteorological station, the TBNG meteorological station, the BSM meteorological station and the Gillette AP meteorological station were all analyzed in the site specific analysis. The TBNG site, located 18 miles west of the Ross ISR Project, was included to compare on-site wind data with the closest available wind data from a longer period of record. The TBNG site is located 18 miles west of the Ross ISR Project, with topographic features comparable to the proposed project area. The BSM and Gillette AP sites were included to supplement the TBNG site in cases where data from the latter were either invalid or not yet posted.

The region experiences average daily maximum temperatures near 90° in July and average daily minimum temperatures around 10° F in January. The site average temperature is expected to be 47° F with extremes of -25° to +100 F. The region is semi arid with annual average precipitation between 10 and 15 inches. Spring and early summer precipitation events are responsible for the majority of the yearly average.

The region is characterized by annual average wind speeds of 10 to 12 mph. Winds at the project site are expected to average about 11 mph annually, with summer averages dipping below 9 mph and winter averages reaching 12 mph. The predominant wind directions are from the south, south-southeast and north-northwest.

On-site monitoring during 2010 demonstrates that meteorological conditions in the area of the proposed project are very similar to conditions in the region as a whole. One possible exception is the prevailing wind direction, for which on-site monitoring shows a stronger southerly component than most of the monitoring stations in the region. This departure from regional conditions was somewhat unexpected, although it is supported by the 2003-2007 wind rose for TBNG. It also became the basis for revising the Ross ISR Project air monitoring plan, as discussed in ER Addendum 3.6-A.

2.5.2 *Air Quality*

The purpose of this section is to provide background information on air quality issues, including the regulatory framework and current regional air quality conditions, in the Ross ISR Project area. The regulatory background is presented in the context of both state and federal air quality standards and permitting requirements. Air quality in the proposed project area is summarized on the basis of extensive monitoring of regulated air pollutants. The Powder River Basin of northeastern Wyoming is one of the most heavily monitored regions in the country, and the northern portion of the Powder River Basin contains numerous air quality monitoring stations within a 50-mile radius of the Ross ISR Project.

2.5.2.1 Regulatory Background

Ambient air quality and air pollution emissions are regulated under federal and state laws and regulations. In Wyoming, the WDEQ/AQD is responsible for managing air quality through state regulations promulgated in the Wyoming Air Quality Standards and Regulations (WAQSR) and through the Wyoming State Implementation Plan (SIP). WDEQ/AQD has also been delegated authority by the EPA to implement federal programs of the CAA.

The WDEQ/AQD implements WAQSR and CAA requirements through various air permitting programs. A proponent initiating a project must undergo new source review and obtain a pre-construction permit or a permit waiver authorizing construction of the project. The permitting process can require Best Available Control Technology (BACT) analysis for both major and minor sources of air emissions. This process ensures that the project will comply with the air quality requirements at the time of construction. To ensure on-going compliance, WDEQ/AQD also implements an operating permit program that can require on-going monitoring of emissions sources and/or source control systems.

2.5.2.1.1 National Ambient Air Quality Standards

The CAA requires the EPA to establish NAAQS to protect public health and welfare. These standards define the maximum level of air pollution allowed in the ambient air. The Act established NAAQS for six pollutants, known as "criteria" pollutants, which "… cause or contribute to air pollution which may be reasonably anticipated to endanger public health or welfare and the

presence of which in the ambient air results from numerous or diverse mobile or stationary sources." The six criteria pollutants are lead, nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), ozone (O_3) and particulate matter (PM_{10} and $PM_{2.5}$), where PM_{10} is coarse particulates with mean aerodynamic diameters less than 10 microns and $PM_{2.5}$ is fine particulates with a diameter of 2.5 microns or less.

The CAA and CAA Amendments allow states to promulgate additional ambient air standards that are at least as stringent, or more stringent, than the NAAQS. A list of the criteria pollutants regulated by the CAA, assumed background concentrations for the proposed project area, and the currently applicable NAAQS set by the EPA for each, are presented in Table 2.5-7. The Wyoming Ambient Air Quality Standards (WAAQS), set by the WDEQ/AQD, are also listed in this table. In some instances, the Wyoming standards are more stringent than the NAAQS, which apply nationwide.

During the new source review process, applicants must demonstrate that the facility will not cause or significantly contribute to exceedance of these standards. These demonstrations are made via atmospheric dispersion modeling or other means, including monitoring data approved by the WDEQ/AQD administrator.

2.5.2.1.2 Attainment/Non-Attainment Area Designations

Pursuant to the CAA, the EPA has developed a method for classifying existing air quality in distinct geographic regions known as air basins, or air quality control regions. For each federal criteria pollutant, each air basin (or designated portion of a basin) is classified as in "attainment" if the area has "attained" compliance with (that is, not exceeded) the adopted NAAQS for that pollutant, or is classified as in "non-attainment" if the levels of ambient air pollution exceed the NAAQS for that pollutant. Areas for which sufficient ambient monitoring data are not available to define attainment status are designated as "unclassified" for those particular pollutants.

States use the EPA method to designate areas within their borders as being in "attainment" or "non-attainment" with the NAAQS. Existing air quality throughout most of the Powder River Basin in Wyoming, including the proposed project area, is designated an attainment area for all pollutants. However, the town of Sheridan, Wyoming, located in Sheridan County about 120 miles northwest of the proposed project area, is a moderate non-

attainment area for PM_{10} due to localized sources and activity within the town. There are no other non-attainment areas within 150 miles of the proposed project area.

2.5.2.1.3 Prevention of Significant Deterioration (PSD)

Under requirements of the CAA, the EPA has established PSD rules, intended to prevent deterioration of air quality in attainment (and unclassified) areas. Increases in ambient concentrations of NO_2, SO_2, and PM_{10} are limited to modest increments above the existing or "baseline" air quality in most attainment areas of the country (Class II areas discussed below), and to very small incremental increases in pristine attainment areas (Class I areas discussed below).

For the purposes of PSD, the EPA has categorized each attainment area within the United States into one of three PSD area classifications. PSD Class I is the most restrictive air quality category, and was created by Congress to prevent further deterioration of air quality in national and international parks, national memorial parks and national wilderness areas of a given size threshold which were in existence prior to 1977, or those additional areas which have since been designated Class I under federal regulations (40 CFR 52.21). All remaining areas outside of the designated Class I boundaries were designated Class II areas, which allow a relatively greater deterioration of air quality over that in existence in 1977, although still within the NAAQS. No Class III areas, which would allow further degradation, have been designated.

The federal land managers have also identified certain federal assets with Class II status as "sensitive" Class II areas for which air quality and/or visibility are valued resources.

The closest Class I area to the proposed Ross ISR Project is Wind Cave National Park in South Dakota, located about 100 miles east-southeast of the proposed project area. The next closest Class I area is the Badlands Wilderness Area, located about 120 miles to the southeast. The closest sensitive areas are the Class II Devils Tower National Monument, the Class II Cloud Peak Wilderness Area and the designated Class I Northern Cheyenne Indian Reservation (in Montana), which are approximately 10, 110 and 80 miles from the proposed project area, respectively.

PSD regulations limit the maximum allowable increase (increment) in ambient PM_{10} in a Class I airshed resulting from major stationary sources (new

or modified) to 4 μg/m^3 (annual geometric mean) and 8 μg/m^3 (24-hour average). Increases in other criteria pollutants are similarly limited. Specific types of facilities listed in the PSD rules which emit, or have the potential to emit (PTE), 100 tons per year (tpy) or more of PM_{10} or other criteria air pollutants, or any other facility which emits, or has the PTE, 250 tpy or more of PM_{10} or other criteria air pollutants, are considered major stationary sources and must therefore demonstrate compliance with those incremental standards during the new source permitting process. However, fugitive emissions are not counted against the PSD major source applicability threshold unless the source is so designated by federal rule (40 CFR 52.21). Bentonite mines and surface coal mines in northeastern Wyoming have generally not been subject to permitting under the PSD regulations because the mine emissions fall below these applicability thresholds.

2.5.2.1.4 Best Available Control Technology (BACT)

All sources being permitted within Wyoming must meet state-specific BACT requirements, regardless of whether the source is subject to state/federal PSD review. During new source review, a BACT analysis is developed for the proposed project. The BACT analysis must evaluate all control options for relevant pollutants on the basis of technical, economic and environmental feasibility. BACT for mining operations in the Powder River Basin is largely dictated by categorical control requirements defined in the WAQSR. BACT decisions are mandated through the new source review pre-construction permit.

2.5.2.1.5 New Source Performance Standards (NSPS)

The NSPS are a program of "end-of-stack" technology-based controls/approaches required by the CAA and adopted by reference into the WAQSR. These standards, which apply to specific types of new, modified or re-constructed stationary sources, require the sources to achieve some base level of emissions control. In Wyoming these standards are typically less stringent than state-level BACT limits.

2.5.2.1.6 Federal Operating Permit Program

The CAA Amendments of 1990 required the establishment of a facility-wide permitting program for larger sources of pollution. This program, known as the Federal Operating Permit Program, or "Title V" (codified at Title V of the

1990 CAA Amendments), requires that "major sources" of air pollutants obtain a federal operating permit. Under this program, a "major source" is a facility that has the PTE more than 100 tpy of any regulated pollutant, 10 tpy of any single hazardous air pollutant (HAP), or 25 tpy or more of any combination of HAPs, from applicable sources. The operating permit is a compilation of all applicable air quality requirements for a facility and requires an ongoing demonstration of compliance through testing, monitoring, reporting and recordkeeping requirements. Fugitive emissions from mines do not contribute to the Title V applicability determination; only point sources are considered.

2.5.2.1.7 Summary of Pre-Construction Permitting Procedures

The WDEQ/AQD administers a permitting program to assist the agency in managing the state's air resources. Under this program, anyone planning to construct, modify, or use a facility capable of emitting designated pollutants into the atmosphere must obtain an air quality permit to construct. ISR uranium mines fall into this category. A new ISR facility, milling operation, or a modification to either of these, must be permitted by WDEQ/AQD, pursuant to the provisions of WAQSR Chapter 6, Section 2. Under these provisions, a successful permittee must demonstrate that it will comply with all applicable aspects of the WAQSR including state and federal ambient air standards.

When a permittee decides to construct a new ISR operation, or modify an existing operation so as to cause an increase in criteria pollutant emissions, they must submit an application, which is reviewed by WDEQ/AQD new source review staff and the applicable WDEQ/AQD field office. Typically, a company will meet with the WDEQ/AQD prior to submitting an application to determine issues and details that need to be included in the application. Such an application will include the standard application form, BACT measures that will be implemented, and an inventory of point and fugitive sources of the various regulated pollutants for the facility in question. In particular, emissions of oxides of nitrogen (NO_x) and particulates (PM_{10}) must be quantified. In some cases, WDEQ/AQD may require emissions inventories for other sources in the vicinity, and air quality modeling analyses addressing cumulative impacts in the region.

If modeling is required, it must address annual average impacts only. Short-term PM_{10} modeling is not required by WDEQ/AQD, nor does WDEQ/AQD consider it to be an accurate representation of short-term

impacts. A memorandum of agreement between EPA Region VIII and the state of Wyoming (January 24, 1994) allows WDEQ/AQD to conduct monitoring in lieu of short-term modeling for assessing mining-related impacts in the Powder River Basin. WDEQ/AQD has generally required PM_{10} monitoring at surface coal mines in the Powder River Basin. It has not imposed monitoring requirements on bentonite mines or ISR facilities, which typically emit much lower quantities of particulates.

The permit application is reviewed by WDEQ/AQD to determine compliance with all applicable air quality standards and regulations. This includes review of compliance with emission limitations established by NSPS, review of compliance with ambient standards through modeling analyses, and establishment of control measures to meet BACT requirements. The WDEQ/AQD proposed permit conditions are sent to public notice for a 30-day review period after which a final decision on the permit is made (or a public hearing is held prior to a final permit decision).

2.5.2.2 Existing Air Quality

WDEQ monitors air quality through an extensive network of air quality monitors throughout the state. Particulate matter is generally measured as PM_{10}. The eastern portion of the Powder River Basin has an extensive network of PM_{10} monitors operated by the mining industry due to the density of coal mines in the region (Figure 2.5-20). There are also monitors in Sheridan, Gillette, Arvada and Wright, Wyoming.

This network is sited to measure ambient air quality and to infer impacts from specific sources. Source-specific monitors may also be used for developing trends in PM_{10} concentrations. WDEQ uses data from this monitoring network to identify potential air quality problems and to anticipate issues related to air quality. With this information, the WDEQ can stop or reverse trends that negatively affect the ambient air. Part of that effort has resulted in the formation of a coalition involving the counties, coal companies and CBNG operators to focus on minimizing dust from roads.

The WDEQ may also take enforcement action to remedy a situation where monitoring shows a violation of any standard. If a monitored standard is exceeded at a specific source, the state agency may initiate enforcement against that source. In those instances, the state agency may use a negotiated settlement agreement to seek corrective action.

WDEQ operates two visibility monitoring stations in the Powder River Basin, both of which are Interagency Monitoring of Protected Visual Environments (IMPROVE) sites. One of these sites, Thunder Basin National Grassland (TBNG), is located north of Gillette and roughly 18 miles west of the Ross ISR Project. This site includes a nephelometer, a transmissometer, an aerosol monitor (IMPROVE protocol), and meteorological instruments to measure wind speed, direction, temperature, and relative humidity. The site is also equipped with a digital camera and analyzers for ozone and nitrogen oxides (NO, NO_2, NO_x). The second visibility monitoring station is located west of Buffalo and includes a nephelometer, a transmissometer, an aerosol monitor (IMPROVE), meteorological instruments to measure wind speed, direction, temperature, and relative humidity, plus a digital camera.

Air quality monitoring equipment for NO_2 within the Powder River Basin includes a Wyoming Air Resources Monitoring System (WARMS) operated by the BLM to detect sulfur and nitrogen concentrations near Buffalo, Sheridan, and Newcastle and a National Atmospheric Deposition Program (NADP) monitoring system for precipitation chemistry in Newcastle. AQD operates ambient NO_x monitoring systems near the Belle Ayr and Antelope mines. An additional NO_x monitor is located at the Tracy Ranch near the Black Thunder mine.

2.5.2.2.1 Particulates

The federal and state standards for particulate matter pollutants are presented in Table 2.5-7.

2.5.2.2.1.1 Regional Particulate Concentrations – PM_{10}

WDEQ/AQD requires monitoring data to document the air quality at all of the Powder River Basin mines. Each mine monitored PM_{10} for a 24-hour period every six days at multiple monitoring sites through the end of 2001. This frequency was increased by the WDEQ/AQD to one in every three days at many sites beginning in 2002. Continuous PM_{10} monitoring in the Powder River Basin began in 2001 and the number of continuous monitors has increased steadily since. As a result, the eastern Powder River Basin is one of the most densely monitored areas in the country (see Figure 2.5-20). Table 2.5-8 uses the annual arithmetic average of all sites to summarize these data.

The long-term trend in particulate emissions was relatively flat from 1980 through 1998, despite a six-fold increase in coal production and a ten-fold increase in overburden stripping associated with coal mining. This relatively flat trend in particulate emissions is due in large part to the BACT requirements of the Wyoming air quality program. These control measures include watering and chemical treatment of roads, limiting the amount of area disturbed, temporary revegetation of disturbed areas to reduce wind erosion, and expedited final reclamation.

The increased PM_{10} concentrations in 1999 and 2000 (Table 2.5-8) may be related to drought conditions as well as increases in coal and overburden production at the Powder River Basin mines, and coincident increases in other natural resource development activities such as CBNG.

The average annual PM_{10} concentration increased from 15.3 $\mu g/m^3$ in 1997 to 24.4 $\mu g/m^3$ in 2000. The average monitored concentrations decreased to 19.6 $\mu g/m^3$ in 2004, but increased to 25.4 $\mu g/m^3$ by 2007.

County roads are also responsible for some portion of the fugitive dust related to transportation. To help address this problem, nearby Campbell County, CBNG and oil production companies and coal mine operators formed a coalition to implement the most effective dust control measures on a number of county roads. Measures taken have ranged from the implementation of speed limits to paving of heavily traveled roads. The coalition has utilized chemical treatments and alternative road surface materials to control dust as well as closing roads where appropriate or necessary and rebuilding existing roads to higher specifications. The coalition requested money from the Wyoming State Legislature to fund acquisition of Rotomill (ground up asphalt) to be mixed with gravel for use in treating some of the roads in the Powder River Basin. The Rotomill/gravel mixture has been demonstrated to be effective in reducing dust; the life of the mixture on treated roads is estimated to be from five to six years.

There are five surface coal mines within roughly 30 miles of the Ross ISR Project. PM_{10} compliance with the NAAQS and WAAQS 24-hour standards at these mines (and by inference, in the proposed project area) has been demonstrated using continuous PM_{10} monitors and high-volume samplers. Table 2.5-9 presents a summary of PM_{10} monitoring at the northernmost mine (Buckskin) during a recent, 8-year period (2002-2009). Table 2.5-10 summarizes results from the samplers in operation at the other four mines. As

a result of these monitoring programs, all five mines have been deemed "in compliance" by WDEQ/AQD.

All of the mines operate in accordance with a Quality Assurance Project Plan specific to each mine. Tables 2.5-9 and 2.5-10 summarize the monitors that are currently or have been in operation at the five mines. The maximum and 2nd maximum annual PM_{10} results are also presented. It can be seen that among these mines the 24-hr PM_{10} NAAQS of 150 μg/m³ was exceeded three times. The Wyodak mine recorded a value of 165 μg/m³ in 2005. In 2007 the Rawhide and Eagle Butte mines recorded 178 μg/m³ and 168 μg/m³, respectively. All three values were deemed "Exceptional Events" by WDEQ/AQD due to high winds.

2.5.2.2.1.2 Regional Particulate Concentrations – $PM_{2.5}$

The WDEQ/AQD operates a $PM_{2.5}$ particulate sampler at Buckskin Mine's North Tapered Element Oscillating Microbalance (TEOM) and meteorological monitoring site (Air Quality System (AQS) I.D. 560051899). This site is located approximately 30 miles west of the proposed project area. The sampler operates for 24 hours every 3rd day, according to AQD and EPA sampling guidelines. A summary of the last five years of monitoring is presented in Table 2.5-11.

It can be seen that annual ambient concentrations have averaged roughly one third of the annual $PM_{2.5}$ NAAQS. The maximum 24-hr concentration during the five-year period was 30.9 μg/m³ in 2008, slightly lower than the 24-hr NAAQS of 35 μg/m³.

According to a WDEQ/AQD-approved ambient air monitoring plan, the North TEOM site is positioned to measure particulate impacts from the Buckskin Mine, which produces approximately 27 million tons of coal per year. Therefore, the data in Table 2.5-11 include considerable particulate impacts from a nearby mining operation and do not represent the ambient air in the proposed project area. This monitor nevertheless demonstrates compliance with the NAAQS for $PM_{2.5}$.

2.5.2.2.2 Gaseous Pollutants

Aside from particulate emissions, other pollutants that have been extensively monitored near the proposed project area include oxides of nitrogen (NO_x) and ozone.

2.5.2.2.2.1 Regional NO_2 Concentrations

The criteria pollutant associated with NO_x is nitrogen dioxide. Federal and state standards for NO_2 are shown in Table 2.5-7 above. NO_2 is a product of incomplete combustion at sources such as gasoline- and diesel-burning engines or from mine blasting activities. Incomplete combustion during blasting may be caused by wet conditions, incompetent or fractured geological formations, deformation of bore holes, and other factors.

Annual mean NO_2 concentrations have been periodically measured in the Powder River Basin since 1975. The annual mean NO_2 concentrations recorded by those monitoring efforts have all been well below the 100 $\mu g/m^3$ standard. The highest annual mean concentration recorded to date was 22 $\mu g/m^3$ at two separate sites between March 1996 and April 1997. Monitored NO_2 concentrations in the Powder River Basin for a recent five-year period are summarized in Table 2.5-12. Figures 2.5-21 and 2.5-22 show the locations of the Belle Ayr and Antelope mine NO_x monitoring sites, both south of Gillette. The Tracy Ranch site is located roughly midway between these two, and about 80 miles south of the Ross ISR Project site.

EPA has recently adopted a new NO_2 standard which applies to the 98th percentile of the daily high hourly averages. The standard, along with related statistics from the TBNG site (see regional map, Figure 2.5-1), appears in Table 2.5-13. Of the NO_2 monitoring sites in northeast Wyoming, this site is closest to the proposed project area. Table 2.5-13 demonstrates that the maximum daily highs for each year, representing the 99th percentile, are still well below the standard of 0.100 ppm.

In the mid-to late-1990s, the Office of Surface Mining Reclamation and Enforcement (OSM) received complaints from several citizens about blasting clouds from several mines in the Powder River Basin. EPA expressed concerns that NO_2 levels in some of those blasting clouds may have been sufficiently high at times to cause human health effects. In response to those concerns, several studies have been conducted, the mines have modified their blasting techniques, and the WDEQ has imposed additional blasting restrictions at a limited number of mines.

In addition to the requirement for modified blasting practices, WDEQ/AQD requires modeling of annual average NO_2 impacts on ambient air

as a condition for permitting any new or modified surface mine or large stationary emission source.

2.5.2.2.2.2 Regional Ozone (O_3) Concentrations

Ozone is a regulated air pollutant that can cause respiratory health effects in people with chronic respiratory problems. Although not one of the criteria pollutants, ozone develops in the atmosphere as a result of other pollutants such as NO_x and volatile organic compounds (VOCs) called precursors. In March 2008 the EPA promulgated a new NAAQS for ozone. The ozone standard was lowered from 0.08 ppm to 0.075 ppm based on the fourth highest 8-hour average value per year at a site, averaged over three years. Ozone readings have on occasion exceeded this new standard in the Upper Green River Basin of Wyoming where certain conditions promote ozone formation. These are believed to be strong temperature inversions, low winds, snow cover, bright sunlight and industrial emissions of VOCs and NO_x. As a result of the high ozone values and the recently lowered standard, on March 12, 2009, Governor Freudenthal submitted a recommendation to the EPA that the agency should designate the Upper Green River Basin as an ozone nonattainment area.

The northern Powder River Basin is still considered an ozone attainment area. Table 2.5-14 shows maximum, mean, and 4th highest daily maximum 8-hour averages for the last five years at a monitor 20 miles west of the proposed Ross ISR Project. While no violations occurred, it is apparent that ambient air in the proposed project area is close to the new ozone standard. This may reflect increased oil and gas activities in the area, increased ozone transport from other regions, or both.

Table 2.5-1. Meteorological Stations Included in Climate Analysis and Parameters Monitored

Name	Agency	Lat	Long	Elev (ft)	Years Operation	Wind Speed	Wind Direction	Temp.	Precip.	Evap.	Relative Humidity	Snow
Buckskin Mine	EPA	44.47	-105.55	4270	1986-2009	X	X	X	X			
Dry Fork Mine	EPA	44.36	-105.42	5910	1995-2009	X	X	X	X			
Thunder Basin	EPA	44.66	-105.29	3864	1999-2009	X	X				X	
Ross ISR	NRC	44.59	-104.98	4669	2010	X	X	X	X	X	X	
Gillette AP	NWS	44.34	-105.54	4354	1902-2009	X	X	X	X	X	X	X
Devils Tower	NWS	44.58	-104.71	3862	1959-2009			X	X			X
Weston	NWS	44.64	-105.30	3530	1951-2009			X	X			X
Moorcroft	NWS	44.27	-104.95	4262	1903-2009			X	X			
Gillette ESE	NWS	44.26	-105.49	4640	1931-2009			X				
Echeta	NWS	44.48	-105.90	4000	1949-2009			X	X			X
Biddle	NWS	45.09	-105.34	3330	1919-2009			X				
Albin	NWS	45.21	-104.26	3310	1945-2009			X	X			
Leiter	NWS	44.85	-106.29	4160	1945-2009			X	X			
Hulett	NWS	44.69	-104.60	3758	1945-2010			X	X			X
Sundance	NWS	44.41	-104.36	4200	1945-2010			X	X			X

Source: IML (2009a), IML (2010b), WRCC (2010), Curtis and Grimes (2007), WDEQ/AQD (2010)

Table 2.5-2. Annual and Monthly Temperature Statistics for Region

MONTH	Average Temperature (°F) BSM	DFM	Gillette AP	Minimum Temperature (°F) BSM	DFM	Gillette AP	Maximum Temperature (°F) BSM	DFM	Gillette AP
Jan	25.2	26.9	26.8	-19.1	-14.4	-15.0	61.9	63.2	63.0
Feb	25.9	27.2	28.3	-22.4	-19.2	-21.0	64.2	62.5	64.0
Mar	33.5	34.6	36.1	-13.6	-10.3	-15.0	77.7	77.5	80.0
Apr	43.4	44.1	43.2	0.8	2.0	8.0	79.0	79.8	80.0
May	53.3	53.1	52.9	16.6	18.1	17.0	90.4	89.3	90.0
Jun	63.1	63.2	63.0	32.5	33.1	31.0	101.8	100.7	98.0
Jul	73.8	74.5	73.5	39.8	44.4	38.0	103.1	102.9	106.0
Aug	70.3	70.4	69.6	37.2	37.2	39.0	101.2	99.3	100.0
Sep	59.3	60.0	59.5	27.7	31.8	25.0	94.2	94.6	96.0
Oct	44.3	45.2	44.1	7.9	6.3	5.0	87.7	86.9	88.0
Nov	35.5	36.9	37.3	-7.0	-5.9	-9.0	75.6	76.4	76.0
Dec	24.3	26.1	23.6	-22.1	-19.8	-21.0	59.8	61.4	60.0
Year-Round	46.0	46.9	46.5	-22.4	-19.8	-21.0	103.1	102.9	106.0

Sources: IML (2009a), IML (2010b), WRCC (2010)
Note: see Table 2.5-1 for period of record

Table 2.5-3. Monthly and Annual Average Relative Humidity

MONTH	Average Relative Humidity (%)		Minimum Relative Humidity (%)		Maximum Relative Humidity (%)	
	TBNG	Gillette AP	TBNG	Gillette AP	TBNG	Gillette AP
Jan	68.4	61.4	36.3	12.0	95.1	92.0
Feb	69.5	64.5	37.3	12.0	94.7	96.0
Mar	65.2	61.2	23.3	9.0	97.5	100.0
Apr	61.9	60.8	23.0	9.0	96.3	100.0
May	62.9	62.5	34.1	14.0	94.6	100.0
Jun	58.9	59.2	28.7	7.0	91.9	100.0
Jul	45.4	46.7	17.0	5.0	91.2	97.0
Aug	46.7	47.9	21.6	5.0	86.8	96.0
Sep	52.9	49.7	17.6	4.0	94.4	100.0
Oct	62.0	63.2	24.1	5.0	98.5	100.0
Nov	64.8	56.8	36.5	11.0	94.9	96.0
Dec	69.5	64.3	42.5	8.0	90.8	96.0
Year-Round	60.7	58.2	17.0	4.0	98.5	100.0

Sources: WDEQ/AQD (2010), WRCC (2010)
Note: see Table 2.5-1 for period of record

Table 2.5-4. Gillette AP Monthly Wind Parameters Summary and Comparison to Nearby Mines (2000 through 2009)

	Average Wind Speed (mph)			Maximum Wind Speed (mph)		
MONTH	**BSM**	**DFM**	**Gillette AP**	**BSM**	**DFM**	**Gillette AP**
Jan	11.1	10.0	12.4	45.5	38.3	46.0
Feb	10.6	9.9	10.7	47.3	38.5	48.0
Mar	11.3	10.7	11.6	45.8	39.1	43.0
Apr	11.9	11.0	11.5	40.4	37.0	35.0
May	11.9	10.6	10.7	45.5	38.9	39.0
Jun	10.4	9.3	9.0	42.7	32.2	38.0
Jul	9.7	8.8	8.8	36.6	34.1	32.0
Aug	10.2	9.5	9.1	44.8	41.2	33.0
Sep	10.2	9.3	9.8	33.9	31.2	33.0
Oct	10.6	9.7	10.4	40.3	34.7	38.0
Nov	10.7	9.6	11.1	40.2	34.2	41.0
Dec	11.1	9.9	11.1	43.5	36.7	36.0
Year-Round	10.8	9.9	10.5	47.3	41.2	48.0

Sources: IML (2009a), WRCC (2010)

Table 2.5-5. Ross ISR MET Station Equipment List

Ross ISR Met Station					
Parameter	**Instrument**	**Range**	**Accuracy**	**Threshold**	**Instrument Height**
Wind Speed	RM Young 05305 Winder Monitor AQ	0 to 112 mph	±0.4 mph or 1% of reading	0.9 mph	10 meters
Wind Direction	RM Young 05305 Winder Monitor AQ	0 to 360°	±3°	1.0 mph	10 meters
Temp.	Vaisalla HMP50-L15 Temp and RH Probe	-25° to 50°C	±0.5°C @ given range	-- ° C	2 meters
Relative Humidity	Vaisalla HMP50-L15 Temp and RH Probe	0 to 98%	±3% at 20°C	--	2 meters
Precip.	Hydrologic Services TB3/0.01P Tipping Bucket Rain Gauge	Temp: -20° to 50°C	±0.5% @ 0.5 in/hr rate	--	1 meter
Evaporation	Novalynx 255-100 Evaporation Gauge	0 to 944"	0.25%	--	1 meter
Evaporation Pan Temperature Gauge	Fenwal 107 Temperature Probe	-35° to 50°C	±0.2°C @ 0 - 60°C, ±0.4°C @ -35°C	--	1 meter
Data Logger	Campbell Scientific CR1000 Data Logger	--	--	--	--

Source: IML (2010a)

Table 2.5-6. Black Thunder SODAR Results

Time Period (Filtered)	Number of Data Points	Average Mixing / Inversion Height
Morning (2 am – 6 am)	193	641 meters
Afternoon (12 pm – 4 pm)	152	1,052 meters

Source: IML (2001)

Table 2.5-7. Assumed Background Air Pollutant Concentrations and Applicable Standards, in μg/m³

Criteria Pollutant	**Averaging Time[1]**	**Background Concentration**	**Primary NAAQS[2]**	**Secondary NAAQS[2]**	**WAAQS**	**PSD Class I Increments**	**PSD Class II Increments**
Carbon Monoxide	1-hour	3,336[4]	40,000	40,000	40,000	---	---
	8-hour	1,381	10,000	10,000	10,000	---	---
Nitrogen Dioxide	Annual	5[5]	100	100	100	2.5	25
	1-hour	16[5]	187	---	---	---	---
Ozone	8-hour	70[6]	157	157	157	---	---
Sulfur Dioxide	1-hour	162[7]	200	---	---	---	---
	3-hour	181[7]	----	1,300	1,300	25	512
	24-hour	62[7]	365	---	260	5	91
	Annual	13[7]	80	---	60	2	20
PM_{10}[8]	24-hour	54[9]	150	150	150	8	30
	Annual	13[9]	---	---	50	4	17
$PM_{2.5}$[8]	24-hour	13[10]	35	35	65	---	---
	Annual	4[10]	15	15	15	---	---

Notes:

1. Annual standards are not to be exceeded; short-term standards are not to be exceeded more than once per year
2. Primary standards are designed to protect public health; secondary standards are designed to protect public welfare. Source EPA (2010a)
3. All NEPA analysis comparisons to the PSD increments are intended to evaluate a threshold of concern and do not represent a regulatory PSD Increment Consumption Analysis.
4. Data collected by Amoco at Ryckman Creek for an eight-month period during 1978-1979, summarized in Riley Ridge EIS (BLM 1983).
5. Data collected at Thunder Basin National Grassland, Campbell County, Wyoming in 2002.
6. Data collected at Thunder Basin National Grassland, Campbell County, Wyoming in 2002-2004 (8-hour 4th high).
7. Data collected by Black Hills Power & Light at Wygen 2, Campbell County, Wyoming in 2002.
8. On October 17, 2006, EPA published final revisions to the NAAQS for particulate matter that took effect on December 18, 2006. The revision strengthens the 24-hour $PM_{2.5}$ standard from 65 to 35 μg/m³ and revokes the annual PM_{10} standard of 50 μg/m³. The State of Wyoming will enter into rulemaking to revise the WAAQS.
9. Data collected at the Eagle Butte Mine, Campbell County, Wyoming in 2002.
10. Data collected at the Buckskin Mine in 2002.

Table 2.5-8. Summary of PM_{10} Monitoring in Wyoming's Powder River Basin

	µg/m³ from 1997 to 2007	
Year	**Number of Monitors**	**Average Concentration**
1997	18	15.3
1998	19	15.8
1999	20	21.4
2000	23	24.4
2001	28	23.4
2002	32	21.9
2003	34	20.8
2004	36	19.6
2005	36	21.1
2006	36	23.9
2007	35	25.4

Source: EPA (2010b)

Table 2.5-9. Buckskin Mine Annual PM_{10} Monitoring Results

Year	Quarter	North Avg	North High	North 2nd High	West Avg	West High	West 2nd High	MM Tons Coal	MM BCY Overburden
2002	1	14.9	37.5	34.1	12.9	34.9	30.9		
	2	20.0	95.7	73.4	18.3	60.9	43.4		
	3	25.1	181.7	71.0	21.9	70.5	57.9		
	4	11.1	29.3	22.6	11.5	25.7	23.3		
	Annual	17.8	181.7	95.7	16.2	70.5	60.9	18.3	36.5
2003	1	10.9	35.1	29.8	10.7	49.7	23.4		
	2	15.6	56.3	42.7	14.2	41.3	39.2		
	3	29.2	77.6	76.9	26.5	80.1	63.0		
	4	15.1	47.6	40.3	18.0	202.4	139.1		
	Annual	17.7	77.6	76.9	17.4	202.4	139.1	17.5	31.9
2004	1	14.5	53.7	47.5	13.4	47.3	41.4		
	2	18.7	116.3	41.1	16.8	74.9	33.3		
	3	20.1	42.3	40.2	17.7	38.5	33.7		
	4	13.6	40.1	33.8	11.7	27.7	25.6		
	Annual	16.7	116.3	53.7	14.9	74.9	47.3	20.3	29.5
2005	1	14.0	78.5	47.0	12.7	48.5	30.9		
	2	16.4	68.8	58.7	14.9	48.5	46.6		
	3	25.3	60.0	51.6	24.4	61.1	53.8		
	4	13.1	42.2	41.3	12.3	57.1	32.8		
	Annual	17.2	78.5	68.8	16.1	61.1	57.1	19.6	26.1
2006	1	13.1	41.9	38.3	14.7	54.1	47.2		
	2	21.7	72.1	60.7	19.0	58.6	49.6		
	3	34.2	101.4	84.7	28.5	63.7	58.5		
	4	16.9	63.6	58.2	14.1	39.0	34.5		
	Annual	21.5	101.4	84.7	19.1	63.7	58.6	22.8	27.1
2007	1	18.9	244.0	59.9	17.0	177.7	62.9		
	2	20.2	102.5	59.0	19.6	75.3	54.5		
	3	40.2	107.3	84.6	31.1	72.5	68.9		
	4	18.4	75.6	65.9	13.6	53.7	42.8		
	Annual	24.4	244.0	107.3	20.3	177.7	75.3	25.3	31.7
2008	1	14.9	81.0	66.5	13.3	58.8	47.4		
	2	17.7	53.0	46.9	15.8	46.1	38.6		
	3	38.6	96.6	82.2	25.8	60.1	50.8		
	4	26.3	91.7	78.7	16.2	77.5	55.7		
	Annual	24.4	96.6	91.7	17.8	77.5	60.1	26.1	50.8
2009	1	18.8	70.3	66.3	10.7	37.0	28.2		
	2	19.2	67.5	62.4	13.4	30.6	30.1		
	3	28.6	102.2	81.2	23.0	50.6	45.5		
	4	18.5	61.3	58.3	12.7	65.9	57.5		
	Annual	21,3	102.2	81.2	15.0	65.9	57.5	25.4	60.9

Source: IML (2009b)

Table 2.5-10. Northern Powder River Basin Mines Annual PM_{10} Monitoring Results

		Dry Fork		Eagle Butte			Rawhide		Wyodak	
Year	**Mine Sampler**	**DF-1**	**DF-3N & 3M**	**EB-2**	**EB-5**	**EB-3N & 3S**	**Hilltop (TEOM)**	**North (TEOM)**	**Site 1**	**Site 4 (TEOM)**
2002	Max 24-hr	85	49	143	54	74	N/A	N/A	52	N/A
	2nd High 24-hr	79	34	66	36	66	N/A	N/A	48	N/A
2003	Max 24-hr	96	45	65	47	76	N/A	N/A	52	N/A
	2nd High 24-hr	95	33	61	34	76	N/A	N/A	50	N/A
2004	Max 24-hr	73	25	62	40	66	61	43	79	131
	2nd High 24-hr	70	24	61	33	64	39	42	62	92
2005	Max 24-hr	113	29	60	49	115	76	61	129	165*
	2nd High 24-hr	107	27	53	48	85	70	59	69	126
2006	Max 24-hr	112	68	73	47	99	72	78	96	143
	2nd High 24-hr	103	44	60	46	93	72	75	71	95
2007	Max 24-hr	109	44	168*	41	144	107	178*	143	129
	2nd High 24-hr	101	40	65	39	139	101	84	100	122
2008	Max 24-hr	74	28	69	49	91	104	66	91	123
	2nd High 24-hr	72	28	67	41	82	91	65	83	103
2009	Max 24-hr	28	24	64	26	61	84	110	101	96
	2nd High 24-hr	26	23	49	22	58	72	69	91	72

*Exceeded 24-hr standard of 150 $\mu g/m^3$; WDEQ/AQD deemed Exceptional Event due to high winds
N/A – Sampler not installed
Source: IML (2009b)

Table 2.5-11. Ambient $PM_{2.5}$ Concentrations at Buckskin Mine ($\mu g/m^3$)

Year	Average $PM_{2.5}$	Annual $PM_{2.5}$ NAAQS Standard	Max 24-hr $PM_{2.5}$	24-hr NAAQS Standard
2005	5.1	15	14.2	35
2006	5.2	15	26.9	35
2007	5.3	15	20.7	35
2008	6.2	15	30.9	35
2009	6.2	15	15.9	35

Source: EPA (2010b)

Table 2.5-12. Average Annual Ambient NO_2 Concentrations ($\mu g/m^3$)

Year	Antelope Mine	Belle Ayr Mine	TBNG	Campbell Co.	Tracy Ranch
2003	7.5	13.2	5.6	13.2	
2004	2.9	10.3	3.8	9.4	5.5
2005	5.5	9.5	8.4	7.5	7.2
2006	5.1	14.4	8.1	5.7	11.2
2007			3.8	7.5	6.9
2008			8.0	19.7*	
2009	2.7	27.4	7.8	17.6*	17.0*

* Average of daily maximum 1-hour averages
Sources: EPA (2010b), IML (2009b) with unit conversions

Table 2.5-13. Thunder Basin National Grassland Daily High 1-Hour NO_2 Monitoring Results

Year	Max Daily High[1]	Avg Daily High[1]	NAAQS[2]
2005	0.021	0.005	0.100
2006	0.032	0.004	0.100
2007	0.021	0.004	0.100
2008	0.014	0.004	0.100
2009	0.014	0.004	0.100

1 Units are parts per million – Source: EPA (2010b)
2 National standard based on 98th percentile
Source: EPA (2010b)

Table 2.5-14. Thunder Basin National Grassland Ozone Monitoring Results

Year	Max Daily 8-hr High[1]	Mean Daily 8-hr High[1]	4th High Daily 8-hr High[1]	NAAQS[2]
2005	0.068	0.042	0.063	0.075
2006	0.075	0.045	0.072	0.075
2007	0.081	0.044	0.072	0.075
2008	0.078	0.049	0.074	0.075
2009	0.071	0.047	0.062	0.075

[1] Units are parts per million (ppm) – Source: EPA (2010b)
[2] National standard based on 8-hr rolling average

Figure 2.5-1.   NWS, IMPROVE Site and Coal Mine Meteorological Stations

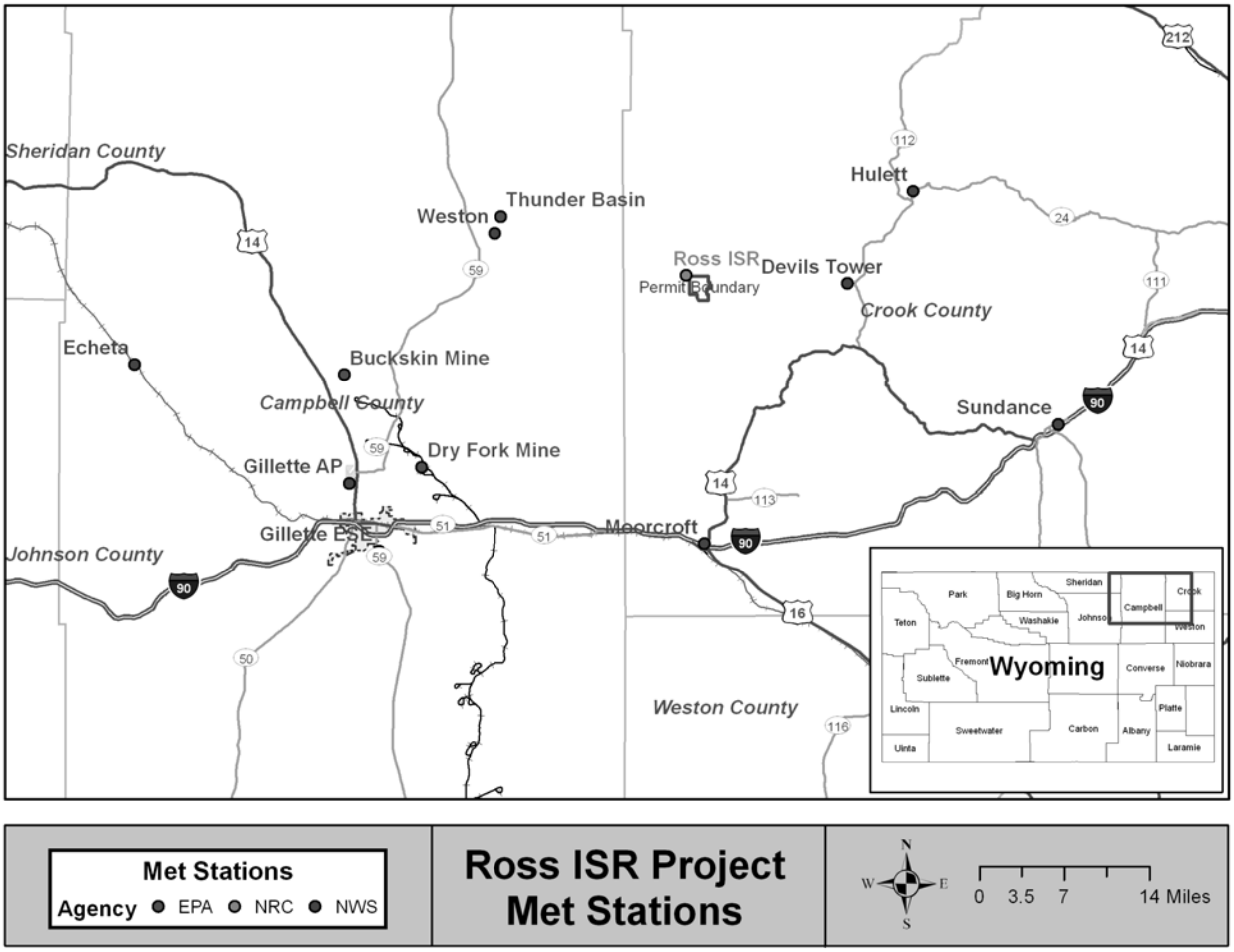


Figure 2.5-2. Regional Average Temperatures
Sources: IML (2009a), WRCC (2010)

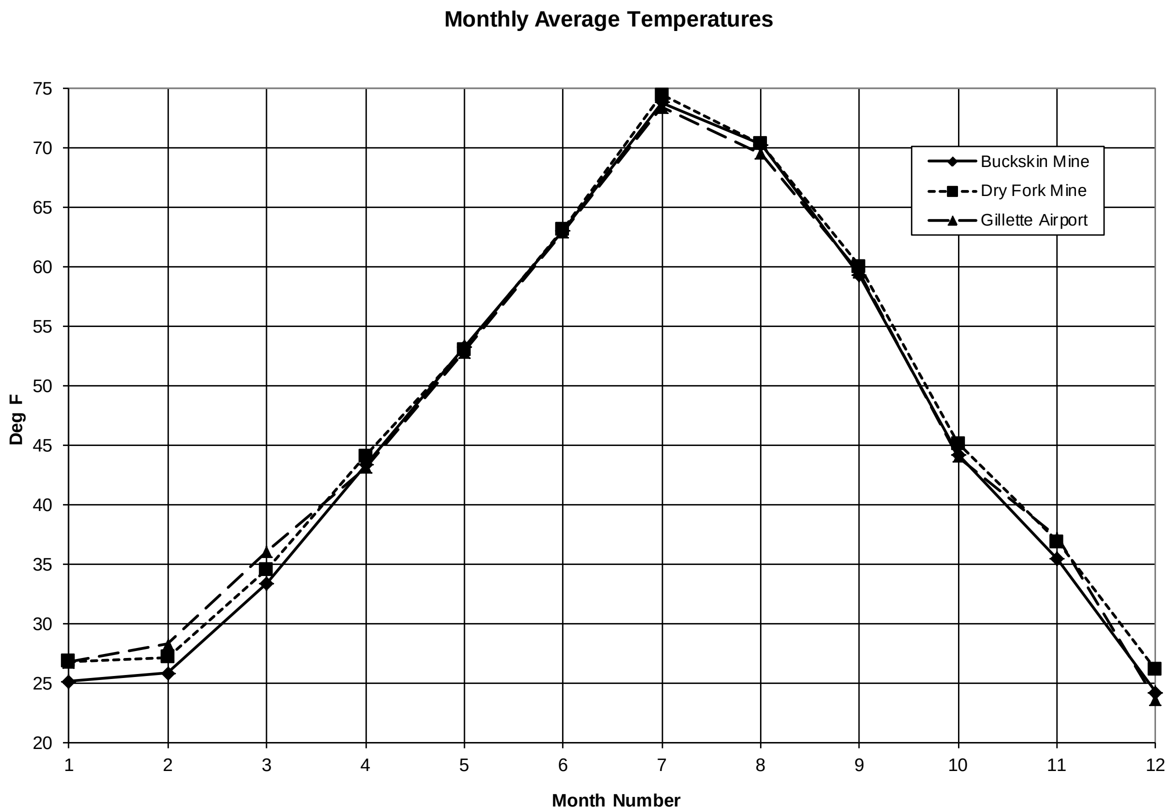


Figure 2.5-3. Buckskin Mine Monthly Diurnal Temperature Variations (From 2000 through 2009)
Source: IML (2009a)

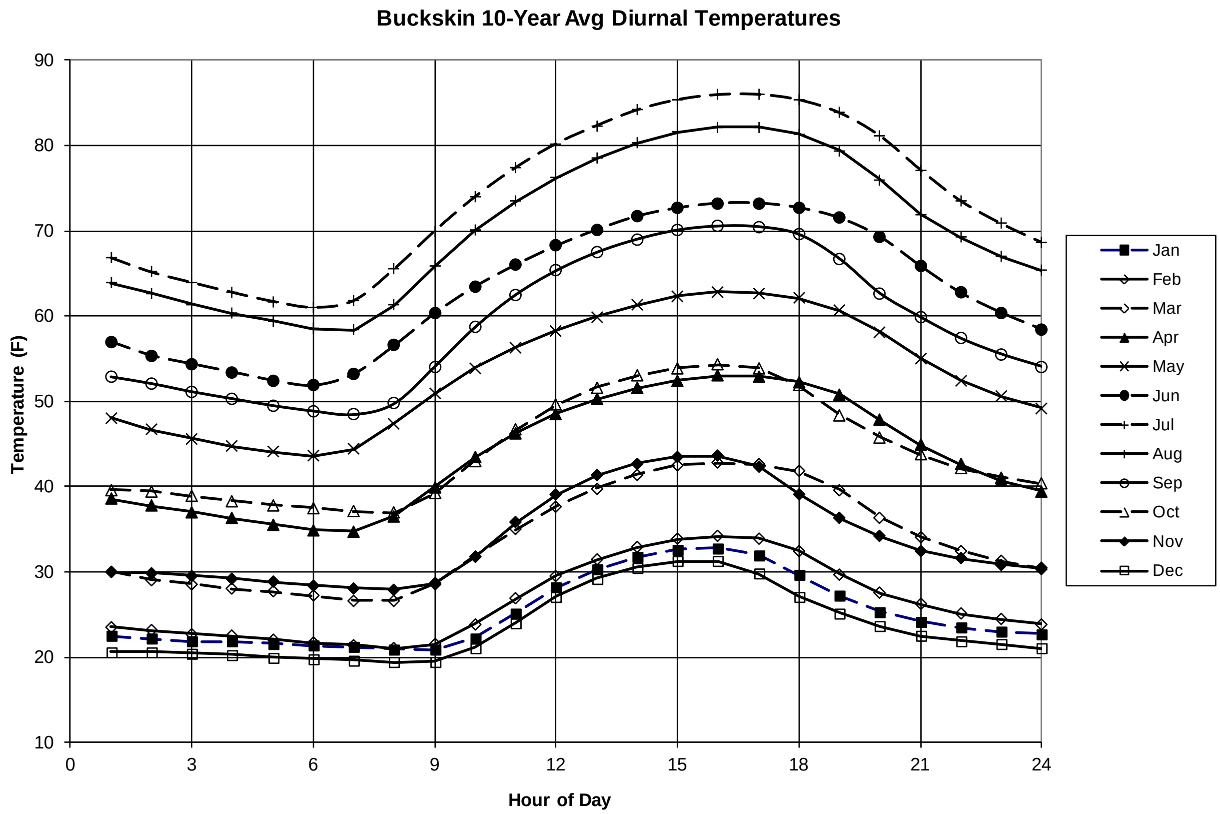


Figure 2.5-4. Regional Annual Average Minimum Temperatures
Source: WRCC (2010)

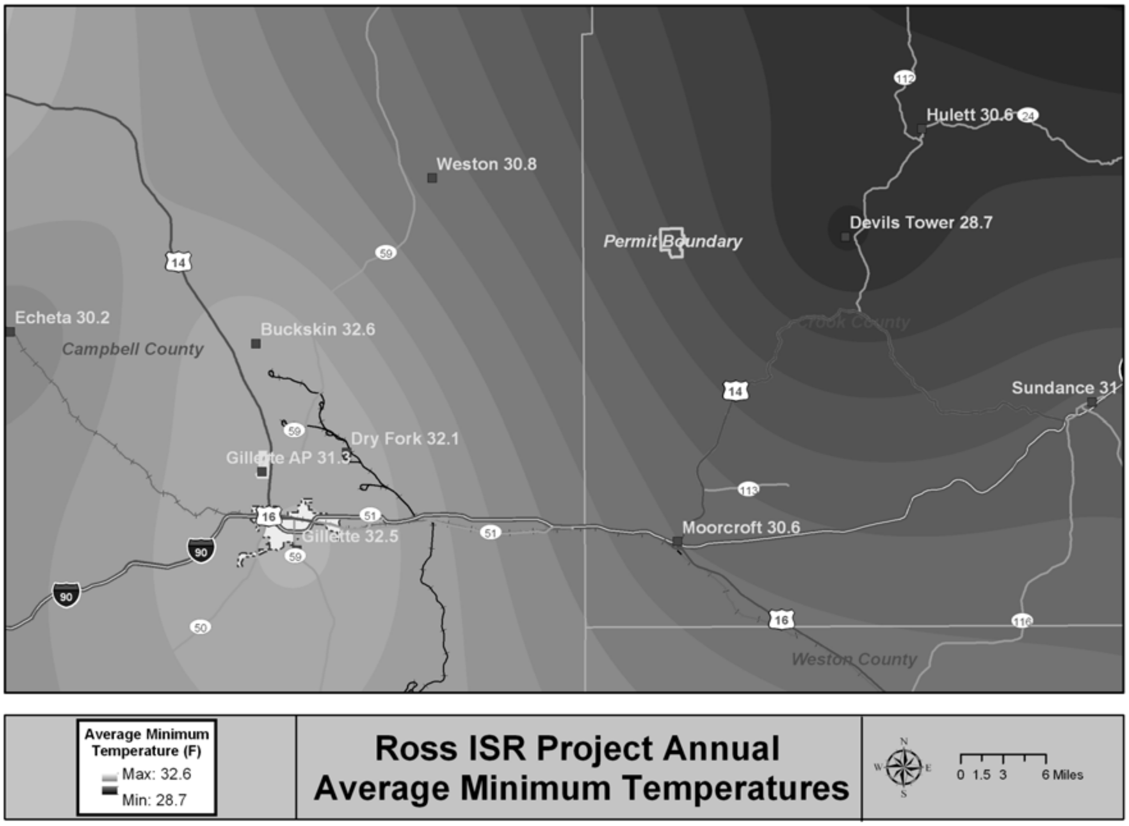


Figure 2.5-5. Regional Annual Average Maximum Temperatures
Source: WRCC (2010)

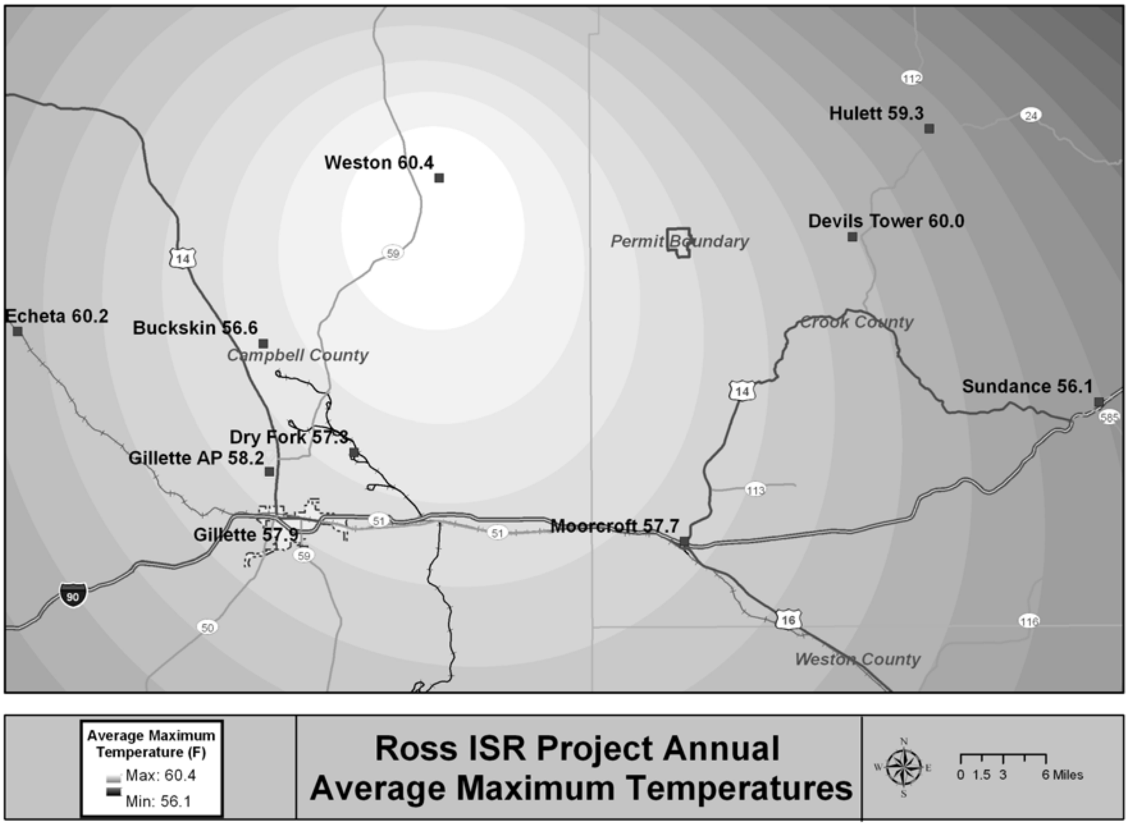


Figure 2.5-6. Mean Monthly Relative Humidity for Gillette AP and TBNG
Sources: WRCC (2010), WDEQ/AQD (2010)

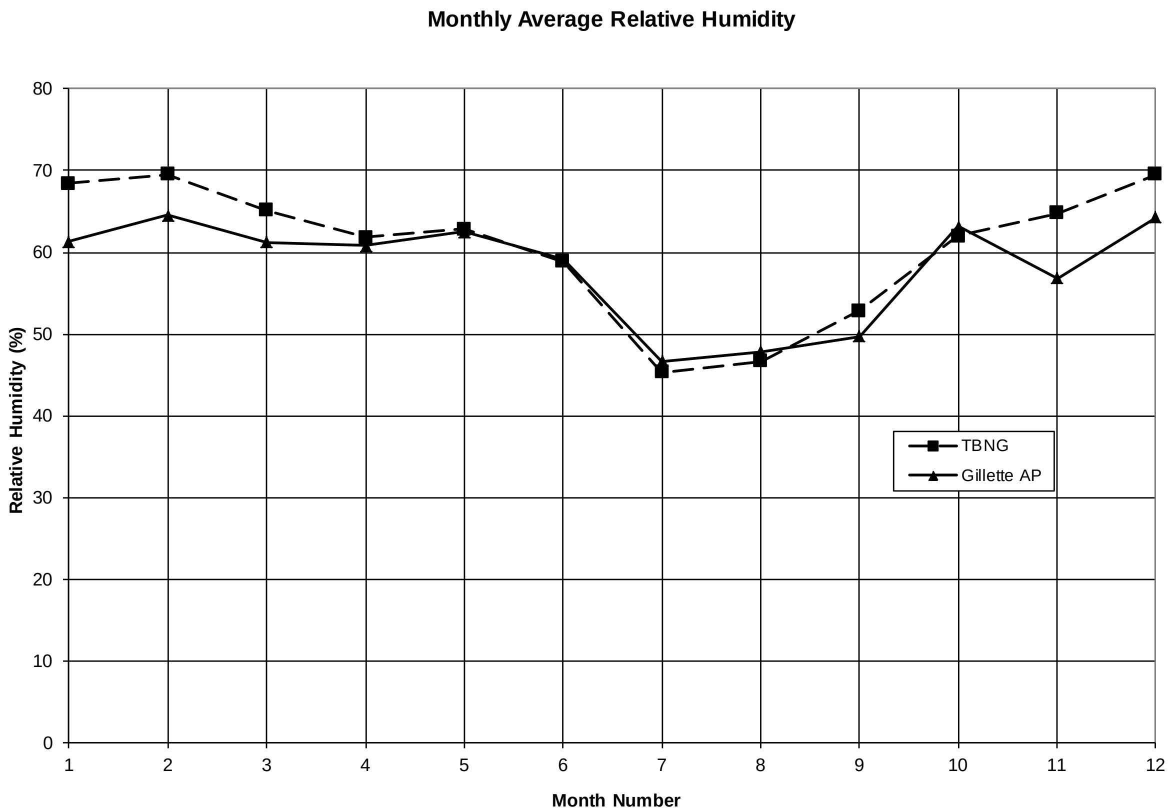


Figure 2.5-7. Diurnal Average Relative Humidity for Gillette AP
Source: WRCC (2010)

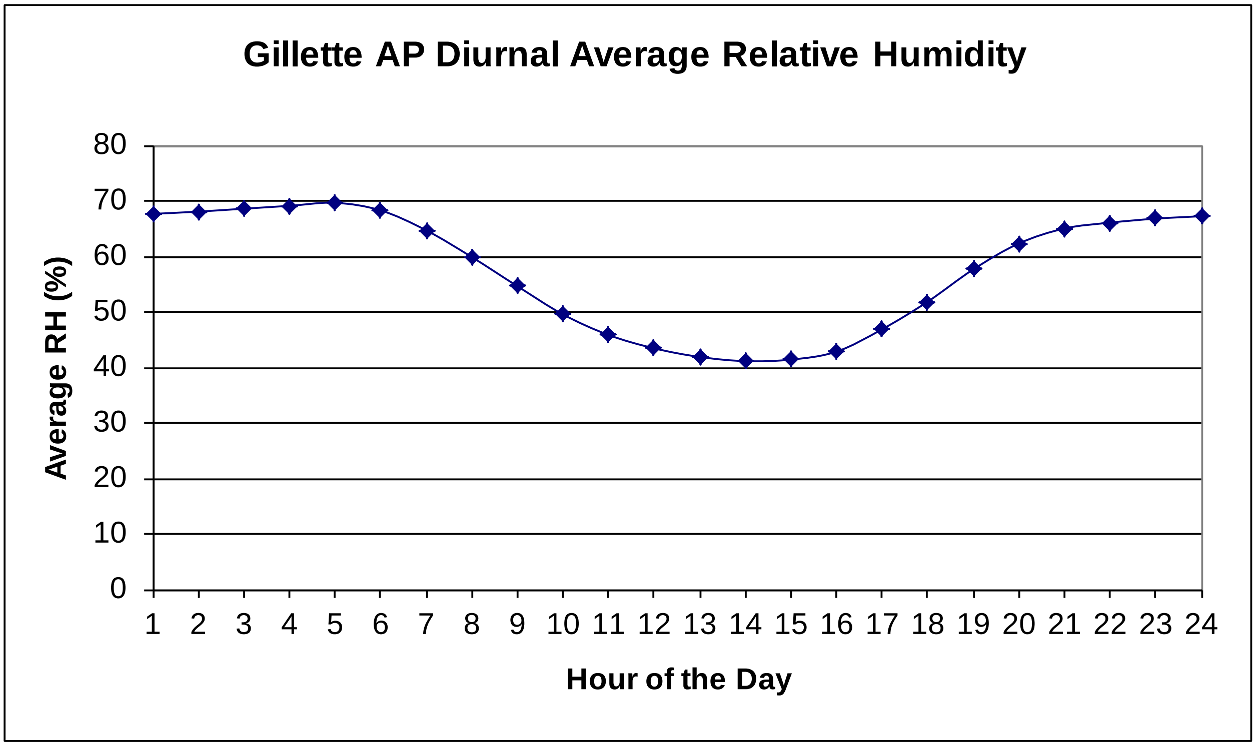


Figure 2.5-8. Regional Annual Average Precipitation
Source: WRCC (2010)

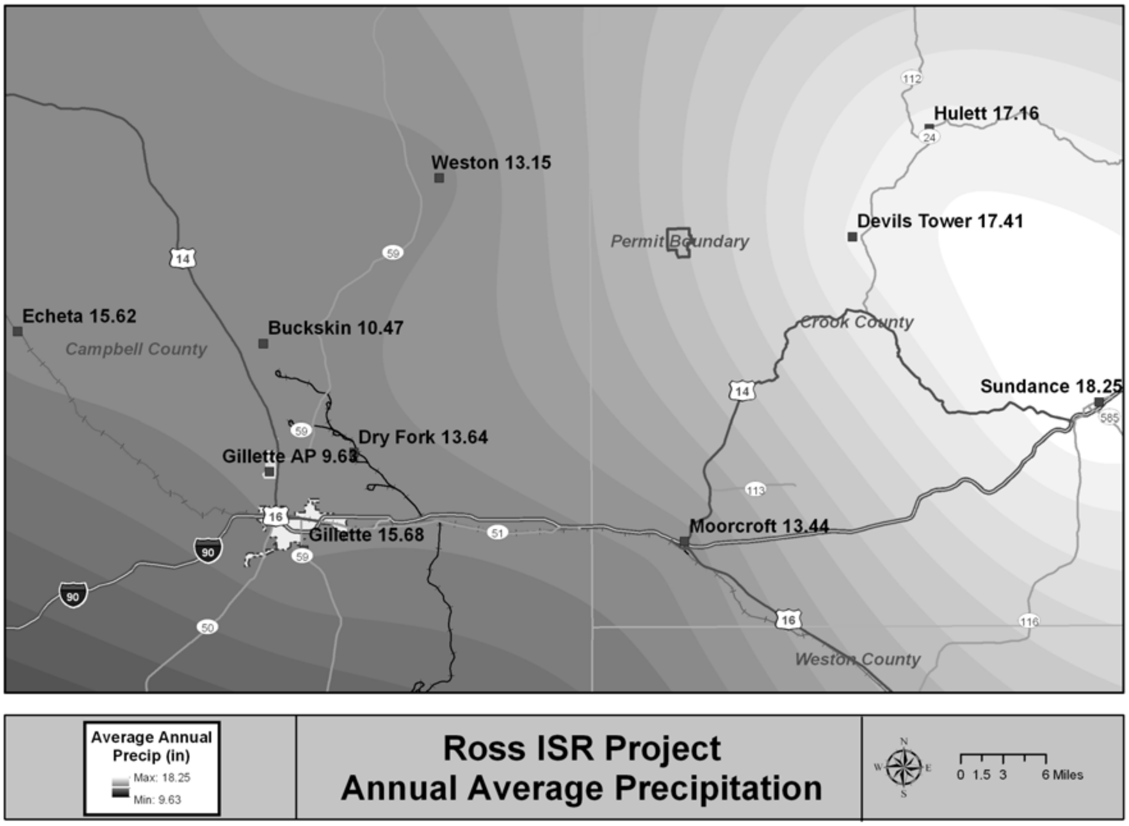


Figure 2.5-9. Gillette AP Monthly Average Precipitation
Source: WRCC (2010)

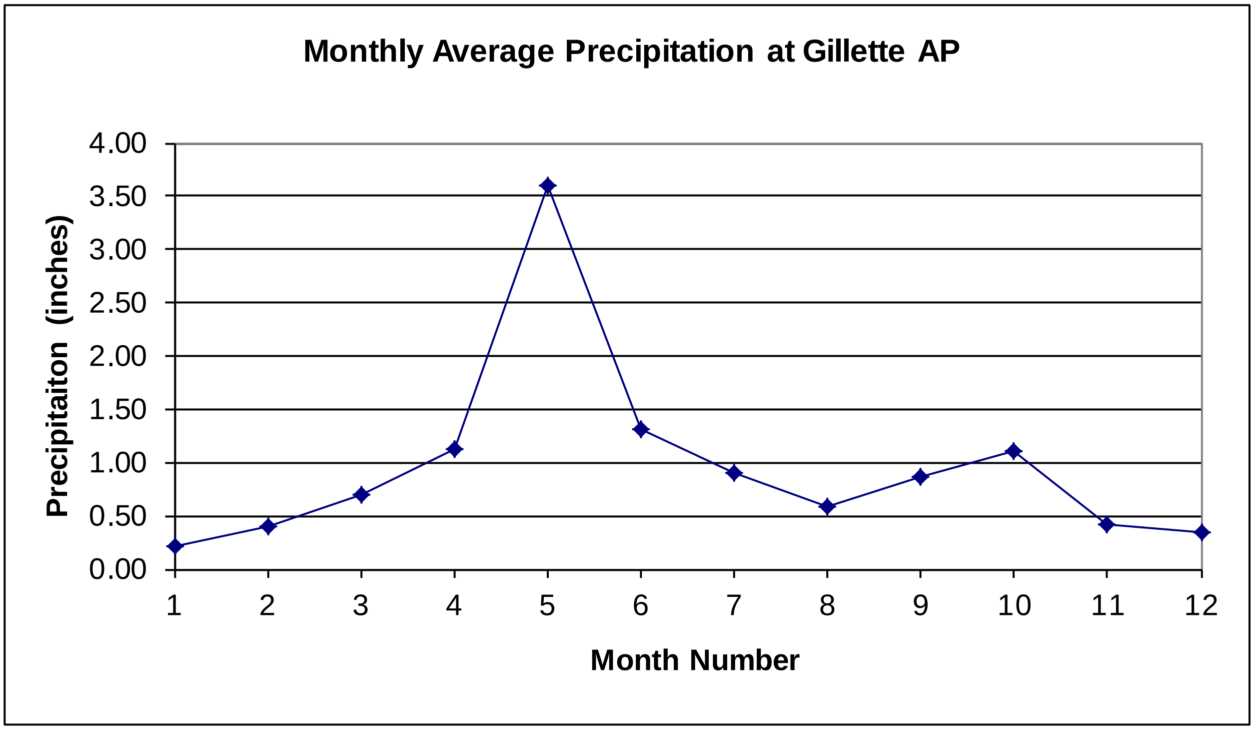


Figure 2.5-10. NWS Station Monthly Snowfall Averages
Source: NCDC (2007)

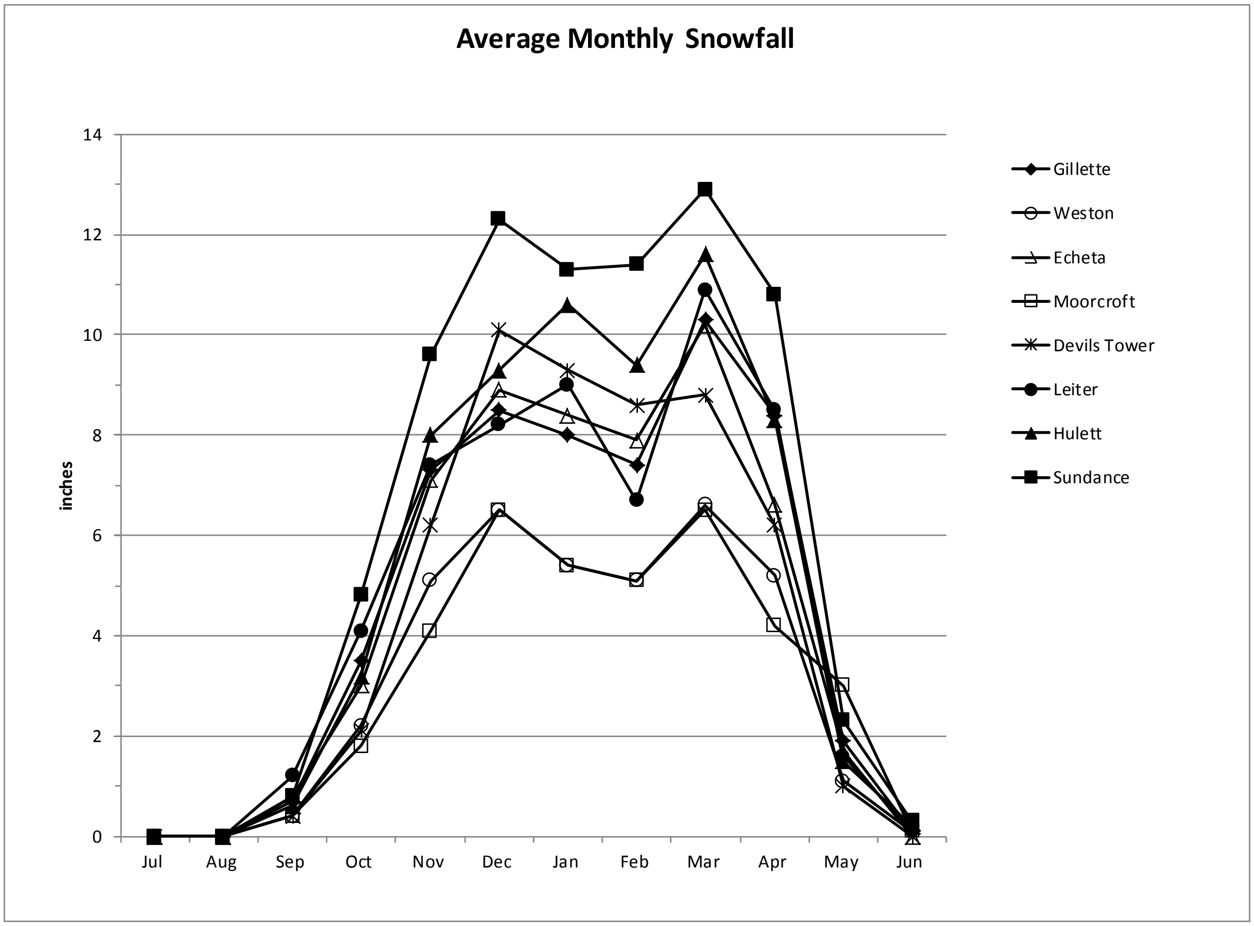


Figure 2.5-11. Regional Annual Average Snowfall
Source: WRCC (2010)

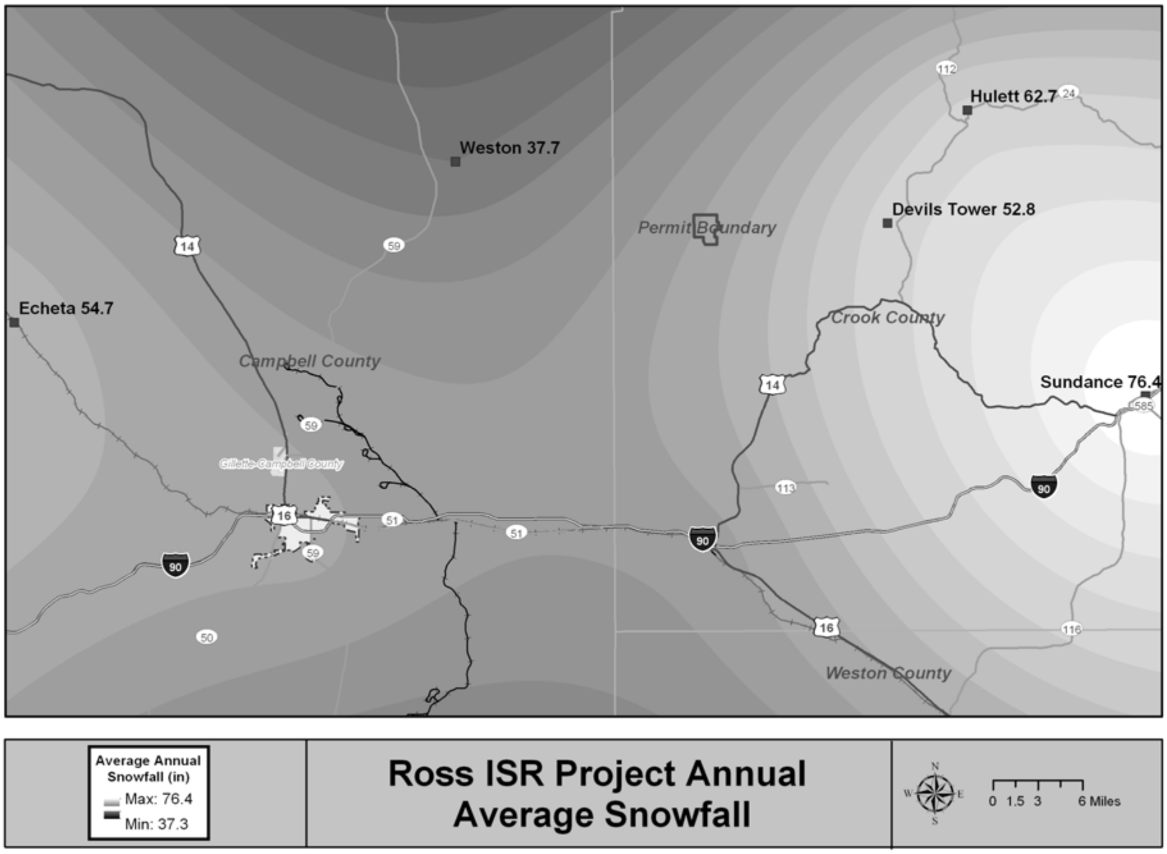


Figure 2.5-12. Regional Wind Speeds by Month
Sources: IML (2009a), WRCC (2010)

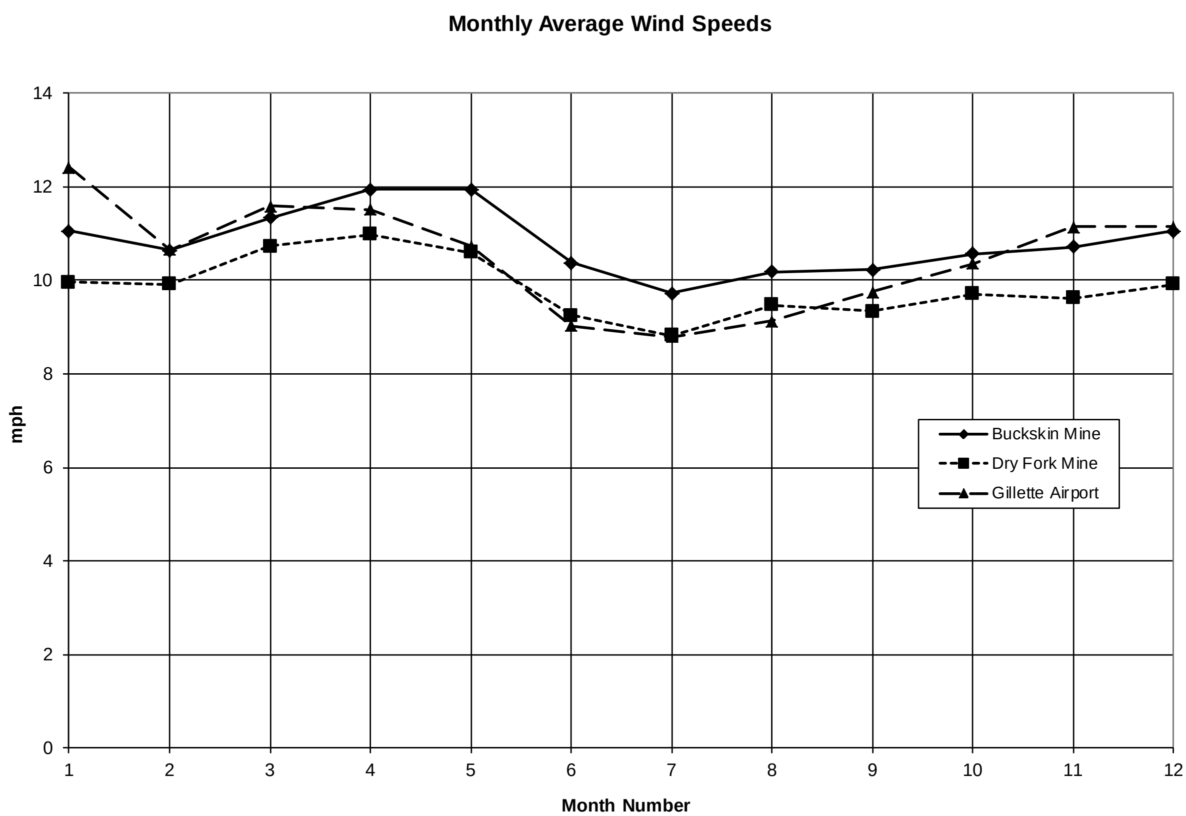


Figure 2.5-13. Gillette AP 5-Year Wind Rose
Source: WRCC (2010)

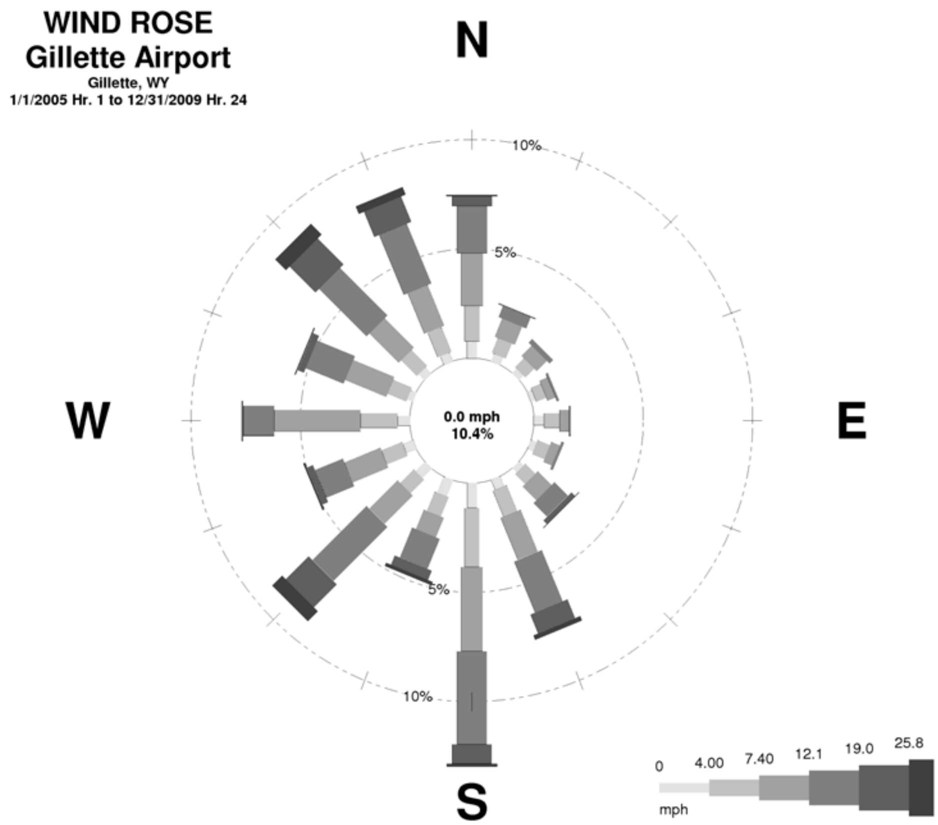


Figure 2.5-14. Buckskin Mine 5-Year Wind Rose
Source: IML (2009a)

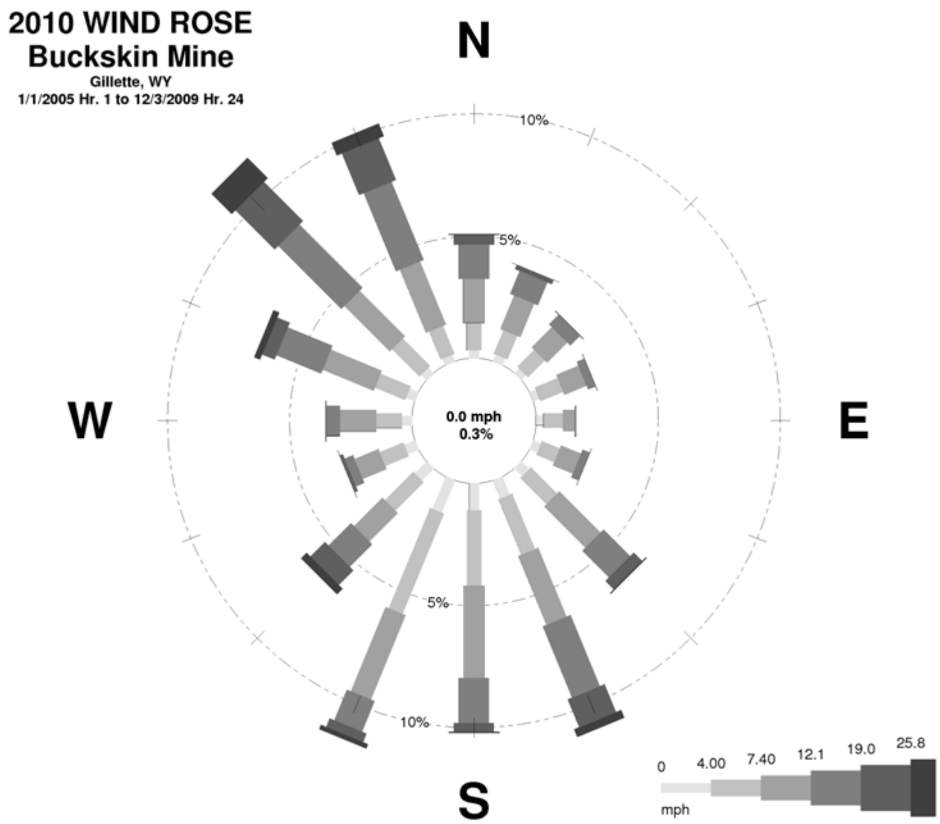


Figure 2.5-15. DFM 5-Year Wind Rose
Source: IML (2009a)

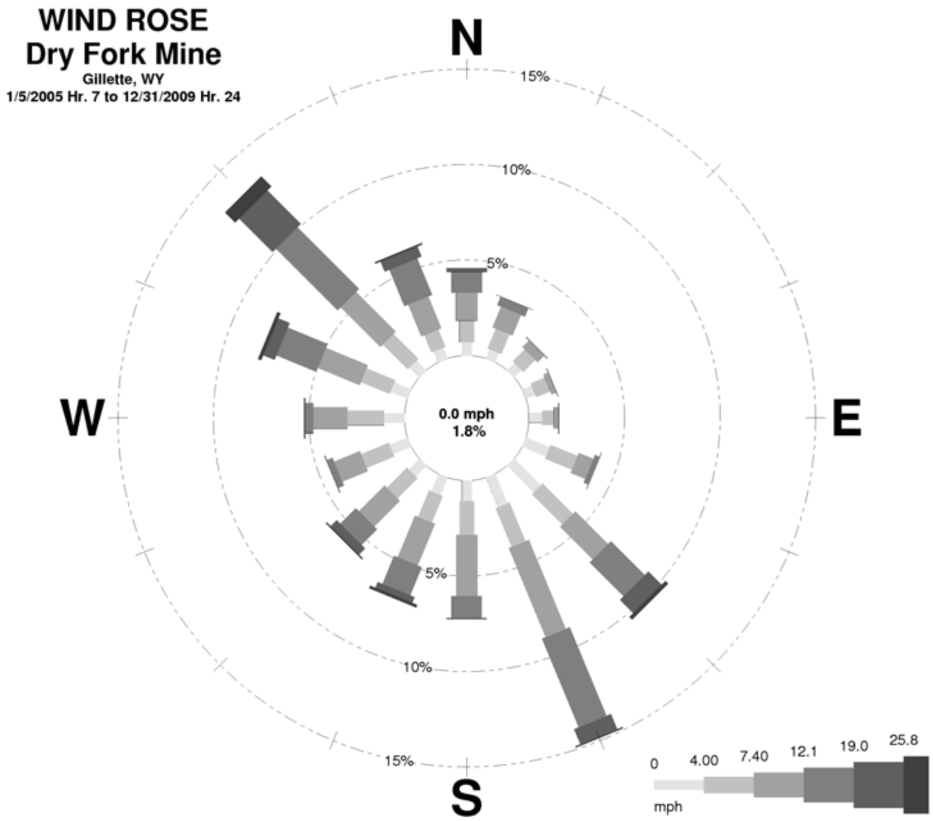


Figure 2.5-16. Gillette Airport Cooling, Heating, and Growing Degree Days
Source: WRCC (2009)

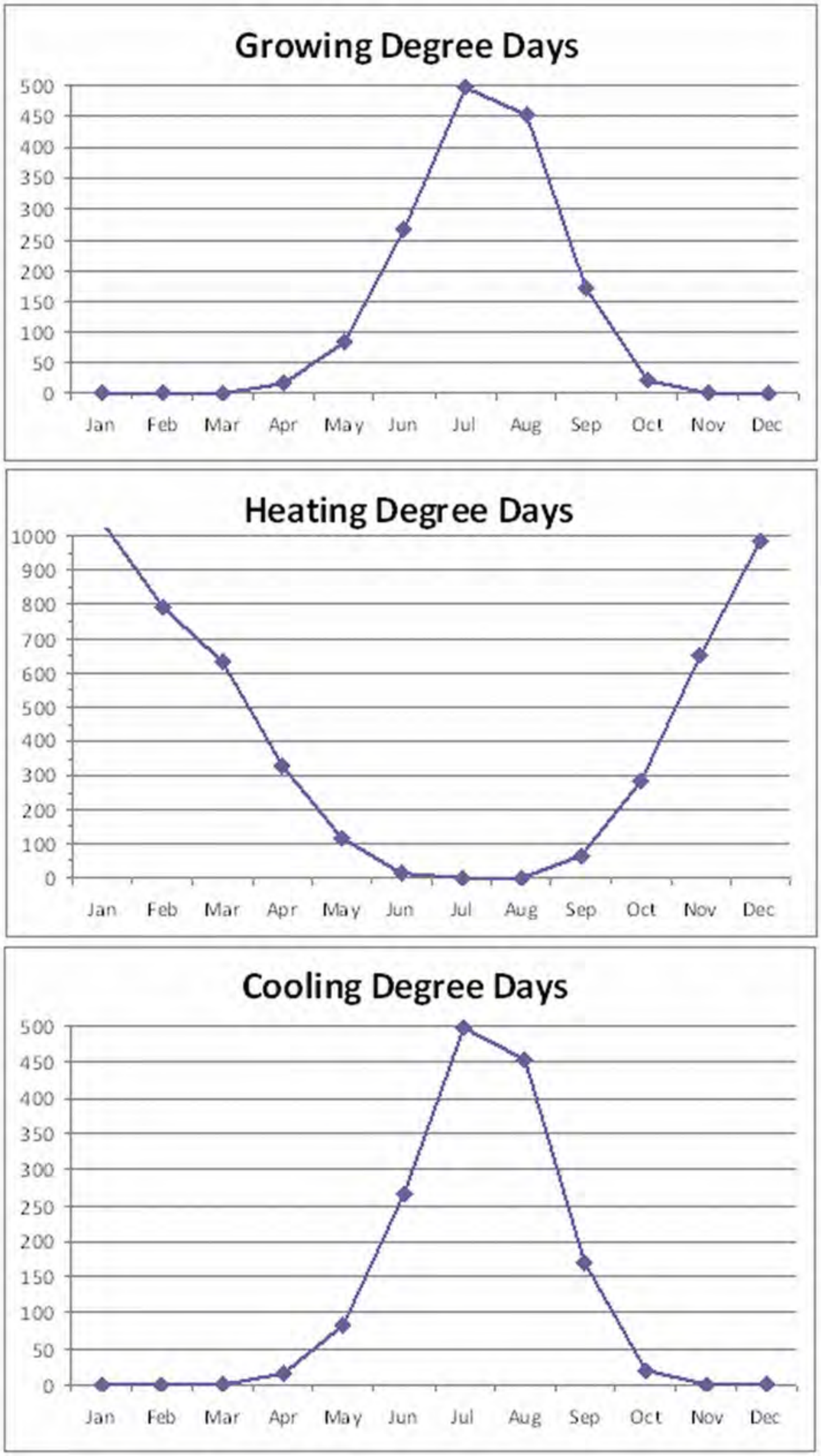


Figure 2.5-17. Ross ISR Project Meteorological Monitoring Station

Figure 2.5-18. TBNG Wind Rose
Source: WDEQ/AQD (2010)

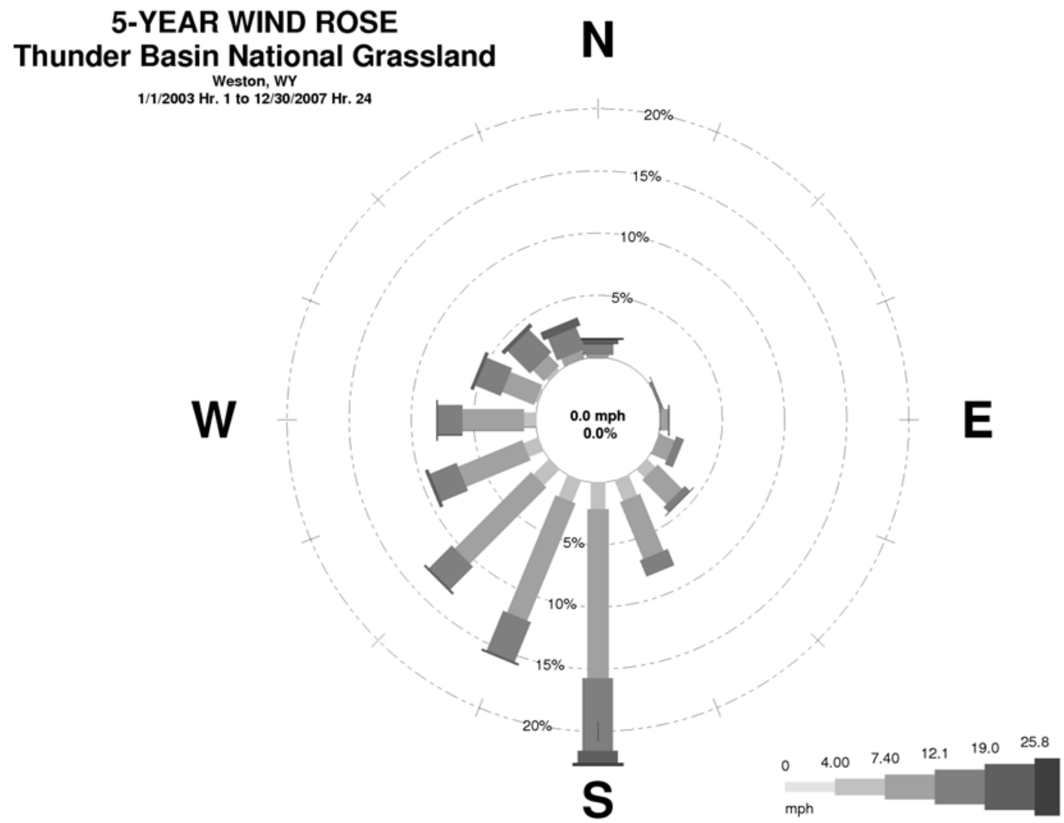


Figure 2.5-19. Ross ISR Meteorological Monitoring Sites

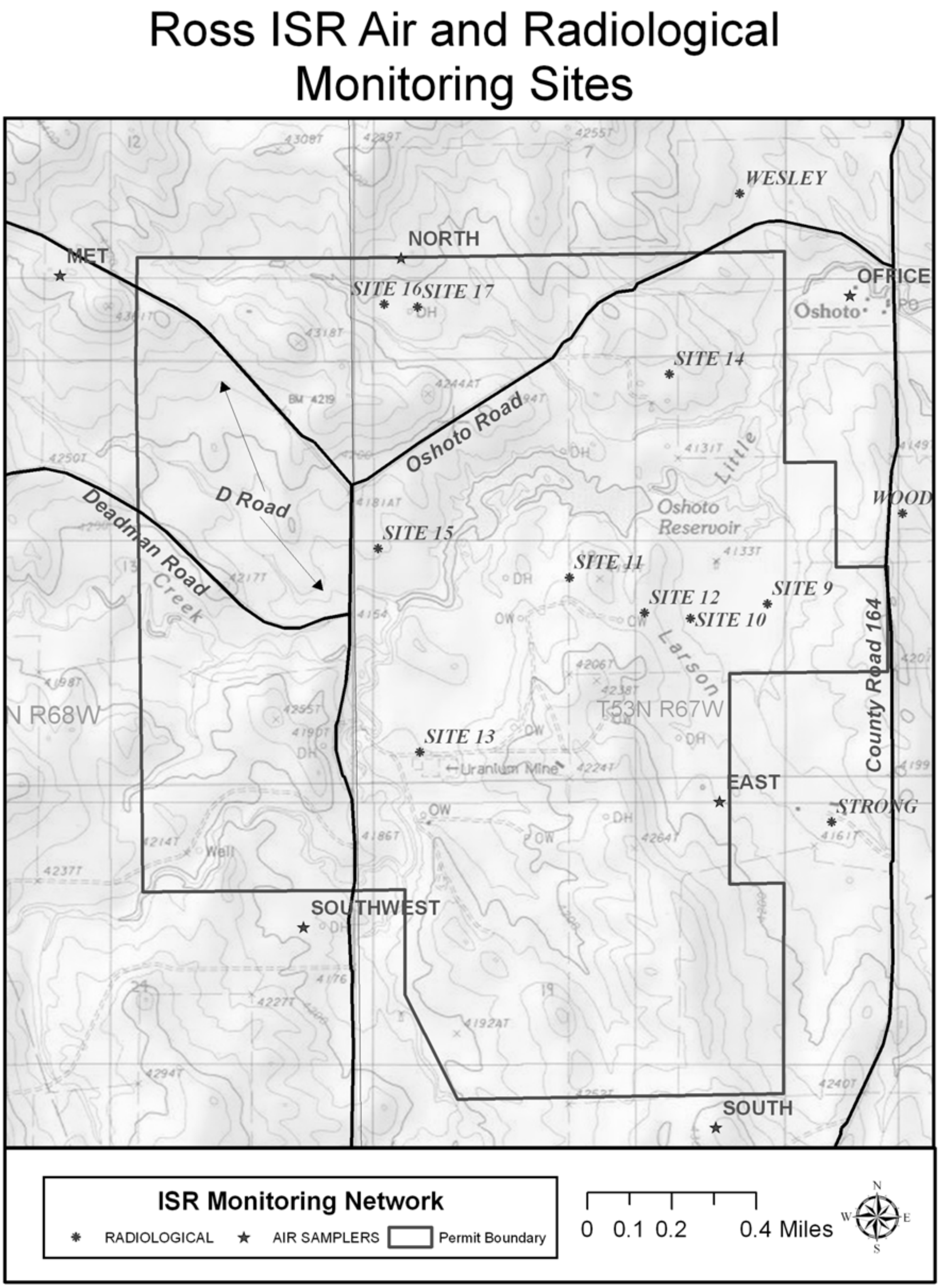


Figure 2.5-20. Active PM_{10} Monitoring Stations in Northeastern Wyoming

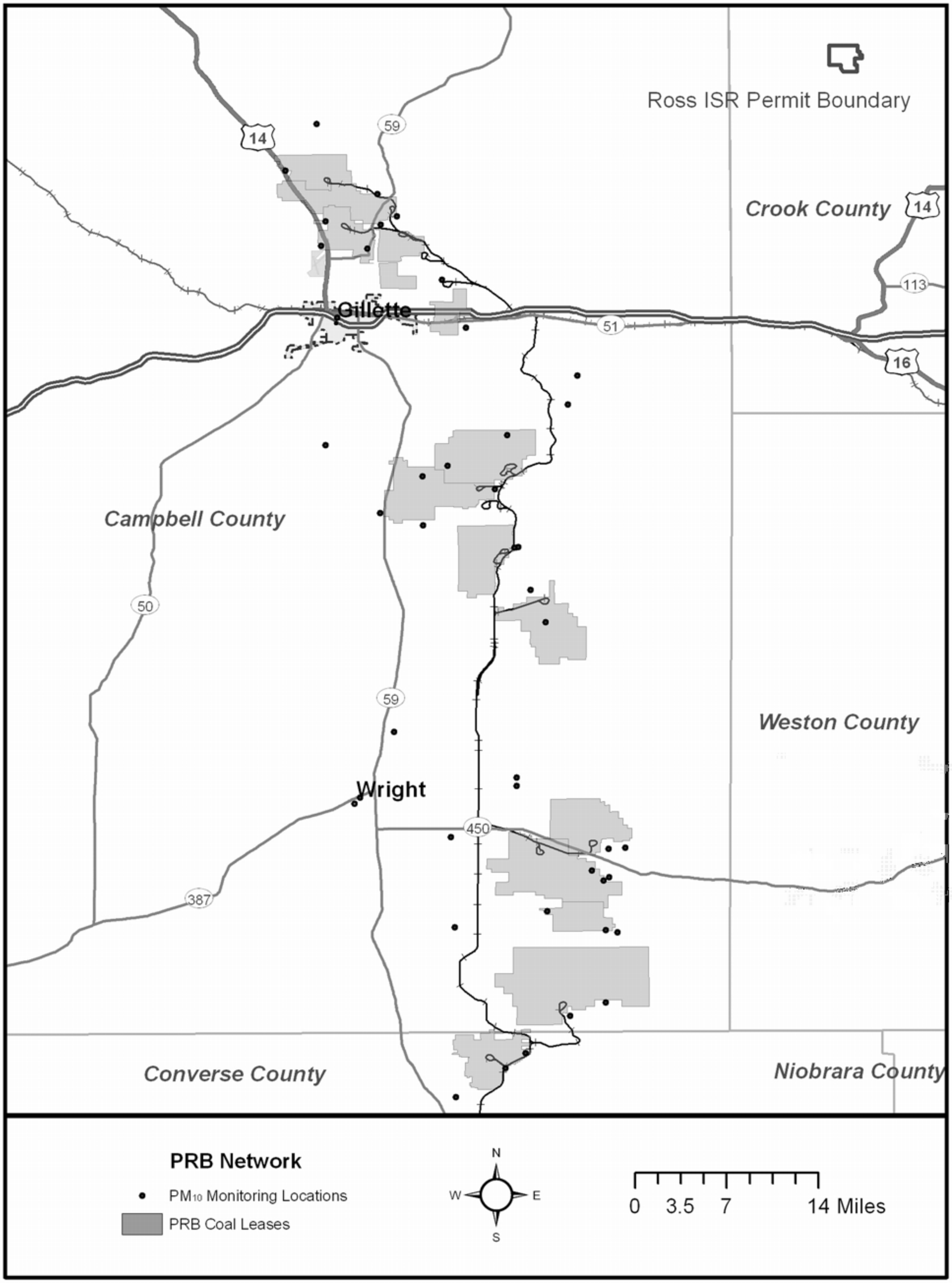


Figure 2.5-21. Belle Ayr NO_x Monitor Location

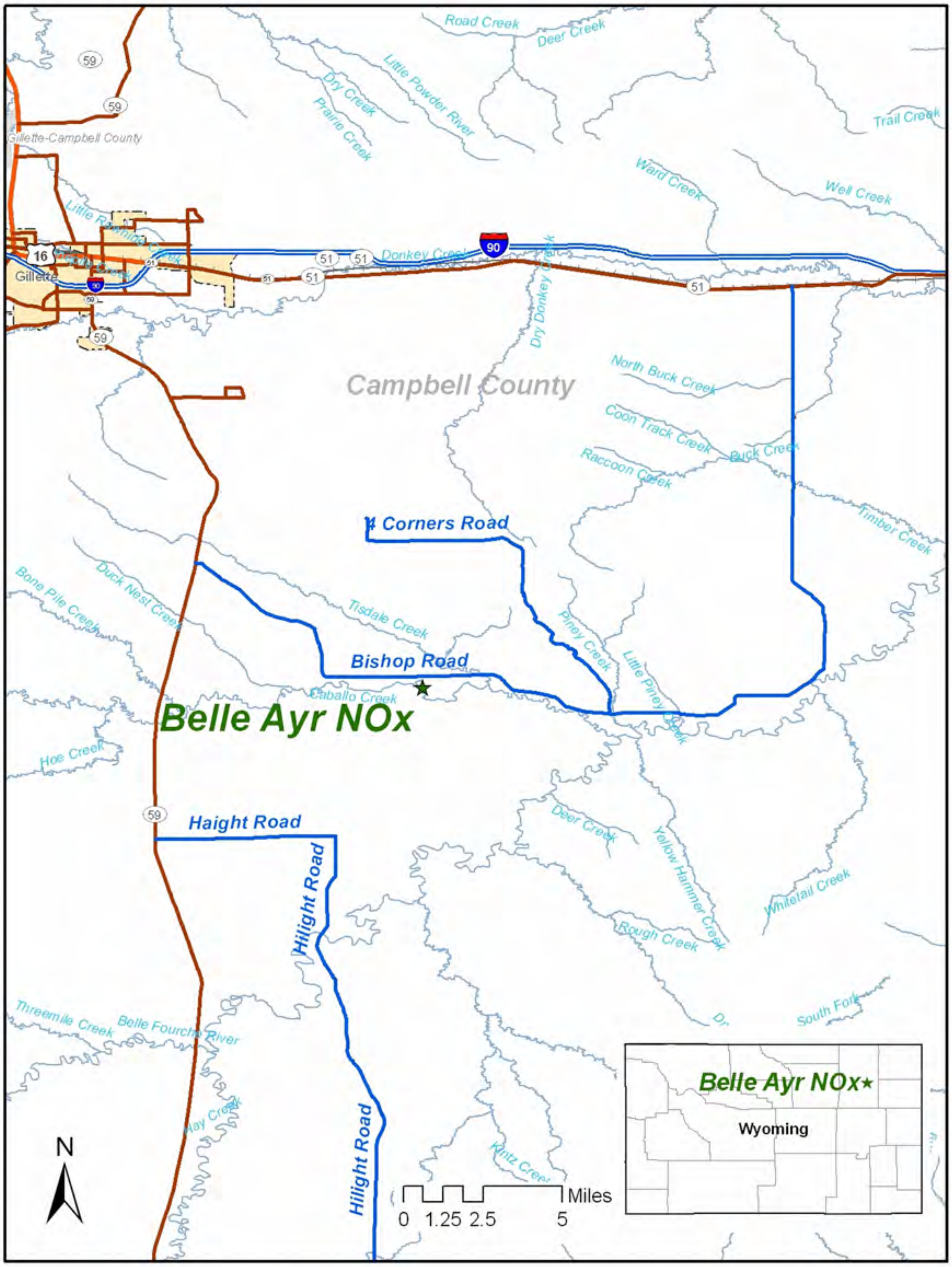
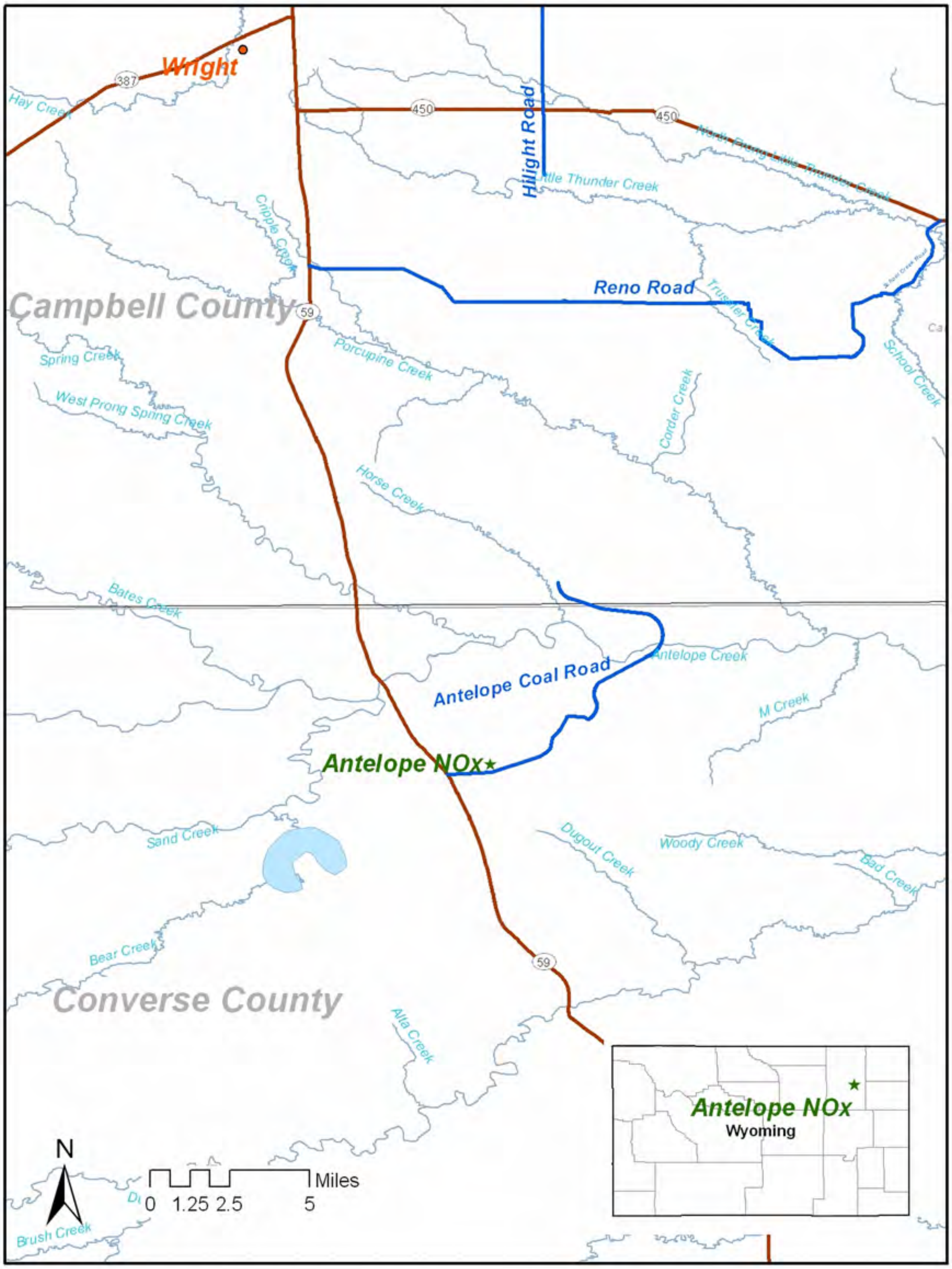


Figure 2.5-22. Antelope NO_x Monitor Location



2.6 Geology and Soils

The regional geology and seismology related to the Lance District in general, and the local geology and seismology specifically related to the Ross ISR Project area are described in this section. Detailed information regarding the structure, stratigraphy, and ore mineralogy of the proposed project area are discussed to the extent that 10 CFR Part 40.32(e) allows Strata to obtain sufficient subsurface information by exploration drilling. Also included in this section is a detailed description of the soils characteristics of the proposed project area.

2.6.1 Regional Setting

2.6.1.1 Structural Geology

The Lance District is geographically located along the west side of Crook County in northeastern Wyoming. It is structurally situated between two major tectonic features: the Black Hills uplift to the east and the Powder River Basin to the west. Both of these structural features are related to the Laramide Orogeny (uplifts of the Rocky Mountain region). The Black Hills of South Dakota and Wyoming are commonly referred to as a classic example of doming of the basement (Lisenbee 1978). The Black Hills uplift is the easternmost and least deformed of the Laramide uplifts of the Rocky Mountain region (Lisenbee 1978). Figure 2.6-1 depicts the regional tectonic setting. The structural relief of this uplift is of a moderate nature compared to other uplifts of the Wyoming province (Lisenbee 1978).

Structural deformation that developed the Black Hills uplift and Powder River Basin was initiated in the Late Cretaceous and Early Tertiary (Paleocene) as Laramide crustal stresses. Erosion accompanied uplifting, and sediments stripped off from the growing uplift filled the structural basin that was synchronously developed to the west during the Laramide Orogeny. The depositional environments at that time consisted of near sea level low-relief streams, flood plains, sloughs, and swamps that were inland of the open sea that lay to the northeast. Through the Paleocene and into the Eocene, the Powder River Basin subsided intermittently, followed by periods of stability resulting in the accumulation of several thousand feet of interbedded sands, silts, clays and coal deposited in a near sea level environment. Deposition of the Paleocene Fort Union Formation and Eocene Wasatch Formation was

followed by the deposition of the Oligocene White River Group, which covered the Powder River Basin (Lisenbee 1988). The White River Group sediments were deposited with angular unconformity across most of the eroded roots of the uplift as well. During the Oligocene and Miocene Epochs, extensive volcanism to the west provided a source of thick accumulations of tuffaceous sediments that extended over much of the Powder River Basin and covered all but the highest mountain ranges (Mears 1993).

The age of the major regional uplift that resulted in the removal of most of the White River Group and formed the present-day Black Hills has been established as late Oligocene, or possibly as late as Pliocene (Whitcomb and Morris 1964 and Lisenbee 1988). Several erosional cycles in the stream valleys suggest that uplifting and exhumation has continued throughout the Tertiary Period. Uplifting may even prevail at the present time as streams in the Black Hills region apparently are downcutting (Whitcomb and Morris 1964). The north-northeast trending drainages in the Powder River Basin have continued their downcutting through recent time resulting in the present topography of the area (Mears 1993).

The Black Hills uplift is a broad north-trending domal structure approximately 180 miles long and 75 miles wide with its core comprised of Precambrian basement rocks. The intrusion of several large igneous masses into the rocks underlying the area accompanied the uplifting. The tectonic map of the Black Hills uplift and eastern Powder River Basin is depicted in Figure 2.6-2. In detail, the uplift is not a simple fold, but rather consists of two primary, north-trending en-echelon structural blocks, the western block and the eastern block. The flanks of the uplift display different characteristics, with a sharp monoclinal break on the west side of the western block and a broad arch on the east side of the eastern block (Lisenbee 1988). The structurally highest part of the uplift is on the eastern block centered on the exposed Precambrian core. The western block is bounded on the west by the Black Hills monocline. The north-trending monocline separates the gently west-dipping strata of the Powder River Basin from the uplift for a strike length of approximately 150 miles. The maximum values of westerly dips in the rotated limb range from 15 degrees west to vertical along strike (Lisenbee 1988).

The Powder River Basin, which borders the western flank of the Black Hills uplift, is a structurally asymmetric Tertiary intermontane basin having primarily Tertiary-age rocks exposed at the surface. The synclinal axis of the

basin is located along and near its western margin. Along the basin's eastern margin the structural dip of the sedimentary units is 1-2 degrees basinward. As described by Lisenbee (1988), the resistant Paleozoic strata are dramatically exposed in the monoclines along the western margin of the Powder River Basin and form an impressive topographic front at the eastern flank of the Big Horn Mountains approximately coincident with the uplift margin. In contrast, the eastern basin margin is undistinguished topographically. The Cretaceous units are only rarely reflected in topography at the Black Hills monocline, so the uplift and basin are at roughly the same elevation for much of their shared length.

2.6.1.2 Stratigraphy

The regional stratigraphy of the Black Hills uplift and adjacent Powder River Basin includes Precambrian crystalline basement rocks, Paleozoic, Mesozoic and Cenozoic sediments, along with some localized occurrences of igneous intrusive rocks. The regional stratigraphic column is depicted in Figure 2.6-3. The rocks of western Crook County are predominantly clastic and range from claystone to fine-grained sandstone. Some coarse and conglomeratic sandstone and massive limestone occur near the base of the stratigraphic sequence at great depth below land surface. This sedimentary series is underlain by igneous and metamorphic rocks of Precambrian age (Whitcomb and Morris 1964). Figure 2.6-4 depicts the regional bedrock geologic map. Sedimentary rocks of Mississippian age and older are not exposed on the surface along the northern and western flanks of the Black Hills uplift, nor are the Precambrian age crystalline basement rocks (Robinson et al. 1964). Sediments exposed in the Lance District are primarily limited to Lower (or Early) and Upper (or Late) Cretaceous and Quaternary age with the vast majority of the Tertiary age sediments being eroded away.

The Lower Cretaceous sedimentary units include the Lakota and Fall River Formations of the Inyan Kara Group. These sediments represent a transitional environment with terrestrial fluvial sequences grading into marginal marine sediments as the Cretaceous Interior Seaway inundated a stable land surface. Sandstone deposits of the Fall River Formation are known to be uraniferous both locally and regionally (Robinson et al. 1964). Uranium occurrences in the Carlile, Hulett Creek, and Elkhorn Creek areas were mined by a number of companies during the 1950s and 1960s from sandstones of the Fall River Formation.

Following deposition of the near-shore Fall River sediments, the Cretaceous Interior Seaway inundated large portions of present day North America. The resulting thick sequence of marine intervals are comprised of the Skull Creek Shale, Muddy Formation, Mowry Shale, Belle Fourche Shale, Greenhorn Formation, Carlile Formation, Niobrara Formation and Pierre Shale. Total thickness of these Lower and Upper Cretaceous intervals in the Lance District can exceed 5,000 feet.

As the Cretaceous Period drew to a close, the seas of the Interior Seaway were in retreat (Lisenbee 1988). In the area of the future Black Hills uplift and the Powder River Basin, offshore marine deposits of the Pierre Shale grade upward into transitional marine sediments of the near shore Fox Hills Formation. The Fox Hills Formation is an erratic near-shore sand development deposited during regression of the Upper Cretaceous sea (Dunlap 1958). It has been divided by Dodge and Spencer (1977) into lower and upper units. Sediments of the lower Fox Hills were deposited in marginal marine, foreshore, and shore-face environments (Dodge and Spencer 1980). Unconformably overlying the lower Fox Hills rocks are estuarine sediments of the upper Fox Hills Formation (Dodge and Spencer 1977 and 1980). Dominated by near-shore, fine-grained sandstones, the Fox Hills Formation is a primary uranium host in the Lance District and portrays initiation of Laramide Orogenic events in the region. The transition from marginal marine to terrestrial sedimentation patterns is apparent in the Fox Hills, with a generally fining upward sequence typical of the Powder River Basin.

Continued Laramide Orogenic activity resulted in deposition of the Lance Formation, which lies conformably upon the Fox Hills Formation. The Lance records the deposition of continental deposits following the withdrawal of the Upper Cretaceous sea in the Powder River Basin (Dunlap 1958). Marine influence on sediment distribution terminated with the sandstones and mudstones of the Lance Formation. The Lance was deposited on a relatively stable platform located in what is now northeastern Wyoming. Resulting depositional environments have been interpreted as being fluviodeltaic in origin (Dodge and Powell 1975, Dodge and Spencer 1977, Dodge and Spencer 1980). The Lance Formation consists of fluvial channel sandstones that make up about one-third of the formation (Connor 1992); the rest of the formation is composed of interchannel mudstone and sandstone (Dodge and Powell 1975). The Lance channel sandstones are pale yellowish- or greenish-brown, fine-

grained to very fine-grained elongate sand bodies, ranging from 3 feet to over 150 feet in thickness with a source area from uplifts in western Montana (Dodge and Powell 1975). The interchannel sediments are finer grained and composed of medium- to dark-gray, sandy clay that swells when wet, and pale-reddish-brown to gray, tuffaceous mudstones (Dodge and Powell 1975). Thin interchannel muddy sandstones are interlayered with the thicker sandstones, and the mudstones commonly contain degraded plant debris but lignite and coaly shales are conspicuously absent.

Paleontological data also represent a change from near-shore marine conditions of the Fox Hills Formation to fluviodeltaic conditions of the Lance Formation. The Fox Hills rocks contain marine type fossils and the Lance rocks contain numerous disarticulated bones of dinosaurs and other terrestrial reptiles (Dodge and Powell 1975). Robinson et al. (1964) used the lowest brown carbonaceous shale or swelling clay bed as the Fox Hills-Lance contact. Within the Powder River Basin, the combined Lance and Fox Hills thicken from less than 700 feet in the north to more than 3,300 feet in the south; there is little change in thickness from east to west (Connor 1992). Deposition of the Lance Formation ended at the Cretaceous-Tertiary boundary. Studies have indicated that rainfall amounts increased dramatically, accompanied by greater amounts of sandy sediments and eventually by the development of widespread peat accumulating swamps in the upper part of the Paleocene (Connor 1992). Deposition of fluvial sandstones, floodplain mudstones and coals document a continued continental influence on sedimentation through the overlying Fort Union Formation.

The Fort Union Formation of Paleocene age consists primarily of fluvial lenticular siltstones and sandstones and floodplain claystones and mudstones that contain subbituminous coal and carbonaceous shale. The Fort Union-Lance contact is unconformable throughout the Rocky Mountain area and marks the break between Cretaceous and Tertiary time (Dunlap 1958). The general lithology of the Fort Union-Lance is similar and no consistent marker denoting the contact can be identified over the Powder River Basin. Some geologists pick the contact at the first coal bed encountered (Dunlap 1958). The upper two-thirds of the Lance contains no coal seams (Brown 1958). The upper parts of the Fort Union Formation (the Tongue River Member) host the very rich coal seams mined near the center of the Powder River Basin north and south of the city of Gillette, Wyoming.

2.6.2 Proposed Project Area

2.6.2.1 Structural Geology

Due to the Black Hills monocline, there is a steepening of the regional stratigraphic dip, which is essentially horizontal, to nearly vertical along the eastern edge of the proposed Ross ISR Project area. The rocks in this area have been rotated as a result of the flexure on the steeply inclined limb of the monocline (Buswell 1982). As indicated on the bedrock geologic map (Figure 2.6-4), the entire proposed project area lies within the outcrop of the Lance Formation, while the other two formations of interest (Fox Hills and Pierre Shale) crop out within ½ mile of the proposed project area's eastern boundary. A generalized geologic cross-section depicting the Black Hills monocline in the vicinity of the proposed project area is shown in Figure 2.6-5. An 85 degree dip to the west was measured at an outcropping of the Pierre Shale located approximately ¼ mile east of the proposed project area, while structural dips within the proposed project area were measured at 1 to 2 degrees (basinward) at outcrops of the Lance Formation.

With the obvious exception of the Black Hills monocline, there are no significant structural features in the proposed project area. No faults of major displacement exist within the proposed project area; however, minor localized slumps, folds and differential compaction features are common. Lineal features originally interpreted by Buswell (1982) as structural faults are now believed by Strata to actually be depositional rather than structural in origin. Strata conducted a rigorous analysis of the data utilized by Buswell and, as explained below, concluded that depositional irregularities and differential compaction of dissimilar textures account for the minor changes in dip and/or thicknesses of beds.

In 1982, M.D. Buswell completed his M.S. Thesis on the subsurface geology of the Oshoto Uranium District for the South Dakota School of Mines and Technology. The study area for Buswell's thesis is roughly the same area as the Ross ISR Project. Buswell's thesis presents a map of the structural contours on the base of the Upper Fox Hills, which illustrates the locations of six, roughly east-west trending structural faults in the currently proposed project area (Figure 2.6-6). Displacement on these suspected subsurface faults was estimated to range between 10 and 30 feet. To support his interpretation, Buswell stated that, "slickensides were present on the fault surface" in a core

sample that intersected a fault, and that, “sandstone was displaced against shale.” In addition, he cited the results of an aquifer pumping test conducted near suspected faults that suggested the “presence of hydrologic barriers in the area,” and “that the barrier is fault related.” Buswell’s observation of what he thought was a fault surface in a single core sample is considered conjectural and a subjective judgment call. As for the aquifer test cited by Buswell, the groundwater hydrologist (P.A. Manera) who conducted and analyzed the test stated in his report (Manera 1978) that the changing permeability and lateral discontinuity in the stratigraphy was the more probable reason for some observation wells to be hydrologically isolated rather than structural faulting causing no-flow boundary conditions.

In an effort to verify the existence of the faults that Buswell suspected, and to identify and quantify the displacement of those faults, Strata developed a series of detailed geologic cross sections drawn normal to the fault traces. Only recently surveyed drill holes from the Nubeth R&D project database that was developed in the 1970s by Nuclear Dynamics (later ND Resources) were used to construct the cross sections. A review of the historic information regarding the drilling program contained in the Nubeth database indicated that the original drill holes were never surveyed. A great majority of the historic Nubeth holes were capped with a cement plug containing a metal tag that identified the old hole number. Utilization of a metal detector was successful in locating these old holes, and once identified, they were surveyed by Bearlodge Ltd. Inc. of Sundance, Wyoming. Many of the Nubeth holes posted on the historic maps in the database were mislocated and had erroneous collar elevations. As of June 18, 2010, approximately 300 of the Nubeth project holes had been surveyed in the proposed Ross Project area.

The effort by Strata to verify the existence of the structural faults interpreted by Buswell also included a review of structure contour maps of distinctive stratigraphic horizons across the proposed project area. The top and bottom elevations of specific horizons (e.g., base of the upper Fox Hills sandstone) having distinct geophysical log signatures were calculated only from drill holes having correct surveyed collar elevations, and were used to prepare the structure contour maps. The structure contour map for each respective stratigraphic interval of importance with respect to the proposed Ross ISR Project area is addressed within Section 2.6.2.2.

A detailed review of the cross sections along with the structure contour maps indicate that the east-west faults as mapped by Buswell in the proposed project area are not perceptible. What do appear to exist, however, are localized slumps and differential compaction features overprinted on an undulating or rolling terrain. In the sections where there is an apparent dip change and an indicated displacement in the range of 10 to 12 feet, these minor displacements most likely relate to undulating or rolling terrain, common in the Pierre Shale and overlying basal Fox Hills, and/or differential compaction of sandstone versus shale. These local features do not consistently carry through more than one to two cross sections, further evidence for lack of faulting.

Buswell, in his thesis, acknowledged that he had access to ND Resources' drill hole database for his analysis. Buswell presumably would have used the USGS topographic map to visually locate and estimate drill hole collar elevations because the Nubeth holes had not been surveyed. The original USGS topographic map for this area was the Oshoto 15-minute quadrangle, which was issued in 1954 and had a contour interval of 40 feet. Minor fault displacement of 10 to 30 feet, as suspected by Buswell, could be accounted for by erroneous drill hole collar elevations. The use of stratigraphic information from unsurveyed drill holes within a very complex stratigraphic section is problematic and discredits any subsurface geologic structural interpretation. Therefore, Strata does not consider Buswell's structural fault interpretations to be valid. A copy of M.D. Buswell's M.S. Thesis is included in Addendum 2.6-A.

2.6.2.2 Stratigraphy

Detailed analysis of the subsurface stratigraphy and mineralogy of the proposed Ross Project area began in the early 1970s with the first uranium exploration and development efforts in the Oshoto area. Beginning in 1971, Nuclear Dynamics began a multi-phased drilling program in the Lance District. The initial, wide-spaced drilling phase provided information on stratigraphic correlations of the Lance Formation and the first identification of oxidation-reduction boundaries and mineral intercepts. From 1971 to 1975, thousands of exploration holes were drilled to delineate roll front uranium deposit boundaries and provide information for the economic evaluation of uranium deposits. From 1975 to 1977, exploration efforts emphasized the development of a mineable ore deposit in the Oshoto area. In 1978, Nuclear Dynamics formed a joint venture with Bethlehem Steel called the Nubeth Joint Venture. That year Nubeth developed and briefly operated a pilot ISR plant within the

proposed project area. All exploration efforts in the Oshoto area ended in 1979 upon completion of an initial test of the leach chemistry, concurrent with a sharp decrease in interest in nuclear energy following the Three Mile Island Incident. Nubeth discontinued their Oshoto project in 1983.

In 2007 and 2008, Strata initiated mineral acquisition in the Lance District and acquired a portion of the Nubeth drill hole database. Strata subsequently began confirmation drilling and exploration drilling for the Ross ISR Project in September 2008. Strata continued with exploration and development drilling in 2009 and also acquired the complete historic Nubeth database that same year. As of June 18, 2010, there were 1,115 surveyed drill holes and 962 unsurveyed drill holes within a ½-mile radius of the proposed Ross Project area. Core samples were collected from 14 of the surveyed holes.

The main objective of Strata's program of rotary mud and core drilling was to confirm the presence of the historic uranium mineralization and enhance the understanding of the area's geology. A geophysical log (resistivity, spontaneous potential and gamma radioactivity) of each hole is used to help interpret the subsurface stratigraphy in parallel with lithologic logging of drill cuttings. Core samples also provide detailed lithologic data for stratigraphic correlations. Unsurveyed Nubeth holes have been and continue to be located by Strata and surveyed. Strata has also completed 27 monitor wells in the proposed project area, which are included in the total number of surveyed drill holes. Addendum 2.6-B in this TR includes a tabulation of all drill holes and core holes located within the proposed project area that provide valid subsurface information.

Specific to the proposed Ross ISR Project area, the stratigraphic sequence of importance is, in descending order: recent unconsolidated surficial deposits including residual soils, colluvium and alluvium, Lance Formation, Fox Hills Formation, and Pierre Shale. Figure 2.6-7 depicts the stratigraphic nomenclature that is used within the proposed project area. This figure illustrates the geophysical log and corresponding lithology obtained from exploration drill hole number RMR008, the location of which is shown on Figure 2.6-4. This particular drill hole was chosen as the "type log" for the proposed project area due to the clarity of the geophysical logs and the associated stratigraphic descriptions from land surface to the top of the Pierre Shale. The Pierre Shale conformably underlies the Fox Hills Formation, which is divisible into upper and lower units (Dodge and Spencer 1980). Upper Fox

Hills strata comprise the lower mineralized horizon (designated herein as the FH horizon having uranium roll fronts **A** through **D**). Overlying the Fox Hills is the Lance Formation. The boundary between these formations is conformable. Mineralization also occurs in the lower Lance (designated herein as the LT horizon having roll front uranium deposit **E**). Recent unconsolidated surficial deposits (i.e., residual soils, colluvium and alluvium) lie unconformably upon the Lance Formation.

A total of 371 geophysical logs that were of sufficient resolution and considered most representative of the stratigraphy were selected for the preparation of six geologic cross sections that are used to illustrate the subsurface stratigraphy of the proposed project area. These cross sections, which are constructed both parallel and perpendicular to the local dip, are included in Addendum 2.6-C as Figures 2 through 34. Due to the large number of geophysical logs that were used to construct the cross sections, each one was broken up into segments for illustration purposes. For example, Figures 2 through 13 are Segments 1 through 12, respectively, of cross section A-A'. Figure 1 in Addendum 2.6-C illustrates the locations of the cross sections and the individual segments that make up each section.

Descriptions of each of these stratigraphic units and the important implications they have from groundwater hydrological and ISR operational perspectives are discussed below in ascending order.

2.6.2.2.1 Sub-Pierre Shale

Formations older than the Upper Cretaceous Pierre Shale are listed on the Regional Stratigraphic Column (Figure 2.6-3). The eastern edge of the proposed Ross ISR Project area lies essentially along the trace of the Black Hills monocline, as depicted on the bedrock geology map (Figure 2.6-4). As such, the outcrops of seven Upper and Lower Cretaceous formations (Niobrara, Carlile Shale, Greenhorn Formation, Belle Fourche, Mowry, Newcastle, and Skull Creek) underlying the Pierre Shale occur within roughly 2 miles of the proposed project area. The Pierre Shale in this area is a massively thick marine shale that is considered a regional confining layer. The older, underlying formations are therefore sufficiently separated by the Pierre from the overlying Fox Hills and Lance formations so as to not be of interest here, with the following exception. An analysis of the geology and water quality of potential injection zones was performed to evaluate the optimum targets available at the proposed

project area for Class I wastewater injection wells. As such, the Cambrian-age Deadwood and Flathead formations were selected as the optimum target injection interval. The Class I UIC permit application for the proposed Ross ISR Project was prepared by Petrotek and is included in Addendum 4.2-A. Based on Petrotek's geologic analysis, the Deadwood and Flathead formations will likely be encountered at depths of approximately 8,163 and 8,565 feet below land surface, respectively.

2.6.2.2.2 Pierre Shale

The Pierre Shale, of Upper Cretaceous age, is the oldest formation of interest for the Ross ISR Project. As indicated on Figure 2.6-7, the stratigraphic horizon nomenclature for the Pierre Shale is "KP" within the proposed project area.

As indicated on the bedrock geology map (Figure 2.6-4), the Pierre Shale crops out approximately ¼ mile east of the proposed project area. Outcrops of Pierre Shale are poorly exposed, but are distinguishable in the subsurface by electric logs and core (Buswell 1982). Typically, historic Nubeth and recent Strata drill holes have been terminated in the top of the Pierre Shale. Therefore, the description of the full Pierre Shale section included herein is based on information obtained from other sources. The Pierre Shale is comprised of massive, dark grey to black silty shales with relatively uniform composition. *Siphonites*, trace fossils identified in core samples, give indication of a marine environment of deposition (Dodge and Spencer 1980).

Based upon the thickness of the outcrop on the bedrock geology map (Figure 2.6-4) and geophysical logs from oil wells located in the general area, the Pierre Shale appears to be approximately 2,200 feet thick in the proposed project area. Depths to the top of the Pierre Shale within the proposed project area range from roughly 500-650 feet in the northeastern quadrant, 690-870 feet in the southeastern quadrant, 740-920 feet in the southwestern quadrant, and 860-980 feet in the northwestern quadrant. Spontaneous potential (SP) and resistivity (R) logs for drill holes that penetrated the Pierre Shale, such as drill hole RMR008 (Figure 2.6-7), and logs for oil wells typically indicate the absence of water-bearing zones. Locally, the upper Pierre Shale is void of any permeable water-bearing strata. Due to its thickness and low permeability, the Pierre Shale is considered the lower groundwater confining unit within the proposed Ross ISR Project area. The Pierre provides a significant hydraulic

barrier between water bearing intervals within the older, underlying Cretaceous, Mesozoic, and Paleozoic formations and the younger, overlying Upper Cretaceous Fox Hills/Lance formations. Additional discussions on the hydraulic characteristics of the Pierre Shale are included in Section 2.7.

2.6.2.2.3 Fox Hills Formation

The bedrock geology map, Figure 2.6-4, depicts the Upper Cretaceous Fox Hills Formation cropping out along the eastern boundary of the proposed Ross Project area. In the vicinity of Oshoto, Dodge and Spencer (1980) divided the Fox Hills Formation into lower and upper units, based on differences in color, bedding, trace fossils, lithology and texture.

2.6.2.2.3.1 Lower Fox Hills Formation

The lower Fox Hills Formation, as described by Buswell (1982), consists of two sand members separated by interbedded shales and silts. The lower of the two, or basal, sand horizons is comprised of sandstones with thin interbeds of shale and siltstone, capped by a calcareous-cemented sandstone. The contact between the underlying Pierre Shale and the lower Fox Hills Formation basal sand horizon is gradational, with the basal sandstone typically exhibiting a coarsening upward with a very sharp upper contact with overlying shales and siltstones. As indicated on Figure 2.6-7, the stratigraphic horizon nomenclature for the basal sandstone in the lower Fox Hills is “FS,” and its thickness is generally found to be around 20 to 35 feet.

Overlying the FS horizon is an interval comprised of dark gray to black shale, claystone and mudstone. This interval is described herein as the basal Fox Hills Lower Confining Unit (or aquitard). The stratigraphic horizon nomenclature used herein for this shale unit in the lower Fox Hills is “BFH,” and its thickness is generally around 30 to 50 feet within the proposed project area (Figure 2.6-7).

The upper of the two sand horizons in the lower Fox Hills consists of thin bedded sandstones and interbeds of shales, siltstones, and calcareous-cemented sandstones (Buswell 1982). Typical of this sand interval, the lower contact is sharp, then fining upward to a gradational upper contact. The stratigraphic horizon nomenclature used herein for this upper sand horizon in the lower Fox Hills is “BFS” (Figure 2.6-7), and it is believed to be continuous throughout the proposed project area. With respect to this sand member’s

significance to the proposed Ross ISR Project, and in particular to the occurrence of groundwater in the Oshoto area, it is the first water-bearing interval that lies stratigraphically below the uranium ore-bearing sands in the upper Fox Hills Formation. Groundwater monitoring wells have been installed in this saturated interval, which demonstrates hydraulic continuity and the same basic lithologic characteristics throughout the proposed project area (refer to Section 3.4). This areally continuous sand interval is also referred to as the deep monitoring zone, or "DM" interval.

Structure contour maps that depict the elevations of the upper and lower surfaces of the DM interval (or BFS horizon), as well as an isopach map that depicts the DM interval's thickness within and near the proposed project area are included in Addendum 2.6-D as Figures 1, 2, and 3, respectively. The thickness of the DM interval ranges from around 10-30 feet and averages about 16.5 feet thick within the proposed project area. Within the proposed project area, depths to the top of the DM zone range from roughly 480-620 feet in the northeastern quadrant, 500-680 feet in the southeastern quadrant, 600-760 feet in the southwestern quadrant, and 550-790 feet in the northwestern quadrant.

Conformably overlying the BFS horizon (DM aquifer) is an interval comprised of thin interbeds of black to dark gray shales, siltstones and claystones. This shale unit contains the marine trace fossil *Thalassinoides*, which is the only trace fossil found in the lower Fox Hills (Dodge and Spence 1980). This shale interval is also described as the basal Fox Hills Lower Confining Unit. The stratigraphic horizon nomenclature used herein for this aquitard is "BFH" (Figure 2.6-7). The DM interval is separated from the upper Fox Hills sandstones by this shale unit. An isopach map that depicts the thickness of the BFH shale interval, which is also referred to as the Lower Confining Unit, within and near the proposed project area is included in Addendum 2.6-D as Figure 4. The thickness of this confining shale interval ranges from around 10-50 feet and averages about 32 feet thick within the proposed project area. Additional discussions on the confining properties of the BFH Lower Confining Unit shale aquitard, which is believed to be continuous throughout the proposed project area, are included in Section 2.7.

2.6.2.2.3.2 Upper Fox Hills Formation

Buswell (1982) determined that there are two types of sandstone deposits that are prevalent within the upper Fox Hills Formation in the Oshoto area: 1) thick-bedded, blocky sandstones, and 2) thin, interbedded sandstones, siltstones and shales.

The blocky sandstones are light gray to gray, well to moderately well sorted, and fine-grained. Intraformational shale pebble conglomerates commonly occur at, or slightly above, the basal contact between upper and lower Fox Hills. Shale clasts are well rounded and have been found in core to range up to 6 inches in diameter.

The thin, interbedded sandstones, siltstones, and shales represent either low percentage sands or high alternation rate areas. Sandstones range from olive green to gray, fine- to very fine-grained, and moderately to poorly sorted. Black shales to dark gray siltstones are slightly bioturbated (disturbed by organisms), and Dodge and Spencer (1980) identified brackish-water pelecypods in the same unit. Coalified leafy matter and small carbonaceous fragments are present in core samples.

Uranium mineralization occurs in the marginal marine sandstones of the upper Fox Hills Formation, which are primary production targets of the Ross ISR Project. The upper Fox Hills sandstones make up the lower portion of the mineralized zone, and as depicted on Figure 2.6-7, the stratigraphic horizon nomenclature used herein for the upper Fox Hills mineralized zone is "FH." Mineralization occurs in three to four discontinuous interbedded sandstones and the roll front uranium deposits have the letter designations of **A**, **B**, **C**, and **D**, in ascending order (Figure 2.6-7). Within the proposed project area, the FH horizon ranges in thickness from around 50 to 65 feet.

The FH horizon is also the lower portion of the ore zone aquifer, or what is referred to herein as the "OZ" monitoring interval. The upper portion of the mineralized zone, which also is the upper portion of the OZ aquifer, is within the overlying Lance Formation.

2.6.2.2.4 Lance Formation

The bedrock geology map, Figure 2.6-4, shows that the proposed Ross Project area lies virtually within the outcrop of the Upper Cretaceous Lance Formation. The Lance Formation sediments are poorly exposed at the surface,

but are distinguishable in the subsurface core and electric logs (Buswell 1982). The Fox Hills-Lance contact is rarely exposed, but the marine beds of the Fox Hills are directly overlain by fluviodeltaic sandstone and mudstone of the Lance Formation. Only the lower section of the Lance Formation occurs in the proposed project area.

As described in Section 2.6.1.2, the Lance Formation on the eastern side of the Powder River Basin consists of a mixture of thicker fluvial channel sandstone and thinner floodplain interchannel clays, mudstones, and very fine-grained sandstones. The depositional environment of the Lance created a stratigraphy that is complicated and vertically heterogeneous. In general, the lower Lance Formation sediments are comprised of multiple sand bodies bounded by abundant shales and siltstones.

Buswell's investigation of the Lance Formation in the Oshoto area included the lower 100 to 150 feet of the formation above the Fox Hills boundary. Within this section of the formation, Buswell described two depositional sandstone packages with opposing sand body geometry. Both deposits are related in that deposition occurred in a continental setting, but were influenced by varied local processes active in a progradational coastal setting. Streamflow directions throughout Lance sedimentation in northeastern Wyoming are predominantly south to southeast (Dodge and Powell 1975). Sandstones were deposited as distributary channels and crevasse splays on a lower coastal or delta plain.

The following description of the Lance Formation sediments is taken from M.D. Buswell's 1982 M.S. Thesis on the subsurface geology in the Oshoto area:

> The lowest sand package of the Lance Formation is comprised of narrow, rejoining fluvial channel deposits. Channel sandstones form sharp upper and lower contacts and display abrupt boundaries with laterally equivalent interchannel sediments. The sandstone deposits in the lowest section are divided into thick bedded sandstones and thin, interbedded sandstone, siltstone, and shale. Thick-bedded sandstones are gray to light gray, fine- to very fine-grained, and often have clasts of carbonaceous fragments and coalified woody materials. Interbedded sediments have dark brown and gray organic-rich shales, black lignitic shales, and dark gray, very fine-grained sandstones and siltstones. Basal Lance distributaries formed a complex rejoining channel pattern that probably resulted from rapid and repeated channel diversions. Sandstones form a net of north-south oriented sand bodies within this section. These sand bodies are typically narrow and straight, rejoining

channels trending roughly north-south that extend out of the Oshoto area.

Located above the lower Lance channel-interchannel deposits are sediments comprised of small, east-west-trending sandstones, which are fine- to very fine-grained. The types of sand bodies occurring within this section are multiple narrow east-trending shoestring sandstones and a singular, broad, wedge-shape sandstone that grades easterly into multiple shoestring sand channels. Sand trends extend west out of the Oshoto area. Lateral boundaries for individual sand bodies are abrupt. These sand bodies are bounded by abundant dark gray shales and siltstones. (Buswell 1982)

The Lance Formation is of particular importance to the Ross ISR Project. Uranium mineralization occurs in the fluvial sandstones of the basal Lance Formation, which, combined with the uranium mineralization of the upper Fox Hills sandstones (FH horizon), are primary production targets of the Ross ISR Project. The basal Lance sandstones comprise the upper portion of the mineralized zone, and as depicted on Figure 2.6-7, the stratigraphic horizon nomenclature used herein for the lower Lance mineralized zone is "LT." Mineralization occasionally occurs in the LT horizon as roll front uranium deposits having the letter designation of **E** (Figure 2.6-7). Within the proposed project area, the LT horizon ranges in thickness from around 30 to 40 feet. The uranium ore-bearing sands of the upper Fox Hills Formation (FH horizon) and lower Lance Formation (LT horizon) are saturated and capable of transmitting groundwater. Monitoring wells have been installed in this saturated interval, which demonstrates hydraulic continuity and is referred to as the ore zone aquifer, or the "OZ" monitoring interval, throughout the proposed project area.

Structure contour maps that depict the elevations of the upper and lower surfaces of the OZ interval, as well as an isopach map that depicts the OZ interval's thickness within and near the proposed project area are included in Addendum 2.6-D as Figures 5, 6, and 7, respectively. The thickness of the OZ interval ranges from around 100-180 feet and averages about 136 feet thick within the proposed project area. Within the proposed project area, depths to the top of the OZ interval range from roughly 250-430 feet in the northeastern quadrant, 300-500 feet in the southeastern quadrant, 410-660 feet in the southwestern quadrant, and 400-650 feet in the northwestern quadrant.

Overlying the OZ aquifer is a sequence of thinly interbedded, gray to dark gray mudstones, claystones, siltstones, and very fine-grained sandstones. As depicted on Figure 2.6-7, the stratigraphic horizon nomenclature used for the

Ross ISR Project for these predominantly floodplain deposit intervals are, in ascending order, "LC," "LS," "LR," "LQ," "LP," "LO," and "LN." Overall, the thickness of this entire sequence typically ranges from about 55 to 145 feet. These very fine-grained sediments that lie directly above the OZ aquifer have been determined to be areally continuous throughout the proposed project area and impermeable to groundwater flow (refer to Section 3.4). An isopach map of the LC horizon aquitard, which is also referred to as the Upper Confining Unit (Figure 2.6-7), within the proposed project area is included in Addendum 2.6-D as Figure 8. The thickness of this confining unit ranges from around 20-80 feet and averages about 43 feet thick within the proposed project area. Additional discussions on the confining properties of the LC horizon Upper Confining Unit aquitard are included in Section 2.7.

A stratigraphic sequence of fine-grained fluvial sandstones and interbedded claystones and siltstones lies directly above the very fine-grained mudstones and claystones that are described in the preceding paragraph. This interval of saturated permeable material will yield enough water to wells that can be put to beneficial use to be considered an aquifer. As depicted on Figure 2.6-7, the stratigraphic horizon nomenclature used for the Ross ISR Project for this saturated fluvial sandstone interval is, in ascending order, "LM," "LL," and "LK." With respect to this sandstone interval's significance to the proposed Ross ISR Project, and in particular to the occurrence of groundwater in the Oshoto area, it is the first water-bearing interval that lies stratigraphically above the targeted uranium ore-bearing sands of the upper Fox Hills/lower Lance (OZ aquifer). This sandstone interval is the first areally consistent saturated zone encountered when drilling in the Oshoto area. Monitoring wells have been installed throughout the proposed project area in this saturated interval, which demonstrates hydraulic continuity and is referred to as the shallow monitoring zone, or "SM" aquifer (refer to Section 2.7). Structure contour maps that depict the elevations of the upper and lower surfaces of the SM interval, as well as an isopach map that depicts the SM interval's thickness within and near the proposed project area are included in Addendum 2.6-D as Figures 9, 10, and 11, respectively. The thickness of the SM interval ranges from around 60-170 feet and averages about 112 feet thick within the proposed project area. Within the proposed project area, depths to the top of the SM interval range from roughly 100-250 feet in the northeastern quadrant, 150-350 feet in the southeastern quadrant, 300-450 feet in the

southwestern quadrant, and 250-450 feet in the northwestern quadrant. Additional discussions on the SM interval is included in Section 2.7.

Overlying the SM aquifer is a sequence of interbedded floodplain deposits of mudstones, claystones and siltstones and fluvial channel sandstones. As depicted on Figure 2.6-7, the stratigraphic horizon nomenclature used for the Ross ISR Project for these predominantly floodplain deposit intervals are, in ascending order, “LG,” “LF,” “LE,” “LD,” “LB,” and “LA.” These very fine-grained sediments act to confine the SM aquifer. A structure contour map that depicts the elevations of the upper surface of the confining unit (aquitard) above the SM interval, and an isopach map that depicts its thickness within and near the proposed project area are included in Addendum 2.6-D as Figures 12 and 13, respectively. The thickness of the confining unit above the SM interval ranges from around 20-120 feet and averages about 60 feet thick within the proposed project area.

Sandy units within the LB and LA horizons are locally saturated. With adequate recharge and permeability, groundwater occurs locally within some of the fluvial sandstones of the upper-most Lance Formation within the proposed project area. Monitoring wells have been installed in these horizons within the proposed project area to monitor the surficial aquifer, or what is referred to as the “SA” interval. Additional discussion on the SA interval is included in Section 2.7.

2.6.2.2.5 Stratigraphic Continuity

The uninterrupted connection or persistence of the various stratigraphic units/intervals throughout the proposed Ross Project area is clearly depicted on the geologic cross sections contained in Addendum 2.6-C. A fence diagram that graphically illustrates the spatial relationships of the various geologic units/intervals that demonstrate hydraulic continuity and exhibit similar lithologic characteristics within the proposed project area is shown on Figure 2.6-8. Only drill holes located along geologic cross sections A-A', B-B', and D-D' that penetrated the DM interval were used in the construction of the fence diagram. The top of the reference sections are located from the existing ground surface and the depths to the contacts between the various intervals coincide with those depicted on the respective geologic cross sections. Due to the three-dimensional projection of the reference sections, the vertical and horizontal scales are not consistent throughout the diagram.

The cross sections and fence diagram demonstrate that the upper Fox Hills/lower Lance production zone (referred to as the OZ aquifer) is stratigraphically continuous and hydraulically isolated from the overlying upper Lance by areally continuous and impermeable mudstones and claystones (referred to as the LC horizon aquitards or the Upper Confining Unit). The geologic cross sections and the fence diagram not only demonstrate the continuity of the confinement provided by the overlying units but also the continuity of the confinement provided by the basal Fox Hills siltstone-claystone unit (referred to as the BFH horizon aquitards or the Lower Confining Unit) and the underlying Pierre Shale.

2.6.3 Ore Mineralogy and Geochemistry

The following description is from the Wyoming State Geological Survey on the origin of uranium deposits:

> "Uranium occurs nearly everywhere on the planet, even in sea water, but may become concentrated in ore deposits under the right geological conditions and processes. Uranium is usually found in porous sedimentary rocks such as sandstones or conglomerates, but some large deposits are associated with igneous and metamorphic rocks. Uranium atoms are similar in size and chemical properties to calcium atoms, so as rocks form, uranium often substitutes for calcium in minerals such as plagioclase (very common in granites). Thus, calcium-rich rocks such as granite typically contain more uranium than other rocks, and are thought to be the source of many uranium ore deposits. Particles ejected from ancient volcanoes – particles often chemically similar to granitic rocks – are another possible source of uranium ore deposits. These two possibilities are still the center of debate among scientists trying to determine the source of uranium deposits.
>
> Groundwater carries the leached uranium from the source rock – either Precambrian igneous and/or metamorphic basement rock or large-volume volcanic ash fall deposits – and re-deposits it upon migrating into a reducing environment within the aquifer. In-situ leach mining reverses that process to recover uranium." (WSGS 2010a)

C-shaped roll fronts and tabular ore bodies in the proposed project area developed when Upper Cretaceous sediments were uplifted in the early Tertiary and exposed to oxidizing, uranyl-bearing groundwater. Groundwater entering the system initially migrated down the stratigraphic dip. When strike-oriented sand channels were encountered, groundwater was diverted primarily northward. The source of the uranium in the Upper Cretaceous rocks may have

been the uranium-rich tuffaceous rocks of the Oligocene age White River Formation that covered the whole northeastern Wyoming area to a depth of several hundred feet (Buswell 1982).

Uranium targeted for production within the proposed project area is located in permeable sandstones of the Upper Cretaceous Lance and Fox Hills formations. Briefly, the epigenetic roll fronts deposited in the Oshoto area demonstrate patterns similar to those across the Powder River Basin. The uranyl-bearing groundwater moved downdip with emplacement of uranium as a coating on sand grains primarily due to factors such as permeability, reducing groundwater conditions, and groundwater flow (Buswell 1982).

The roll front geometry at the proposed project area is complex due to the variability of the depositional environment of the host sandstones and hence controls on groundwater movement. Active, passive, and stagnant roll fronts formed in response to the differential migration of groundwater through a heterogeneous aquifer. Active alteration tongues coincide with thick, permeable, transmissive channel sands of the Fox Hills and Lance formations. Passive and stagnant fronts tend to be associated with channel flanks or low-permeability, organic-rich interchannel sediments (Buswell 1982).

Uranium grade and thickness of roll front deposits are dependent upon the rate and volume of uranyl-bearing groundwater crossing the geochemical interface. Both the orientation of the roll front to groundwater flow and the size of the channel sand have a direct bearing on uranium deposition. The richest ore deposits are found at the terminus of alteration projections associated with large channel systems (Buswell 1982).

The alteration process not only changes the color, but also alters the mineralogy of the host sandstones. The color of unaltered reduced sandstone is light to dark gray; the darkening agents consist of organic material, dark accessories and fine-grained pyrite. Altered oxidized sandstone contains subtle iron oxide staining where former carbonaceous matter and pyrite were present. Kaolinized feldspar is typically a greenish-gray to bleached and occasionally has a pink to tan-buff appearance. The presence of pyrite and carbonaceous material along with rapid facies changes of the sandstone host to silty clayey sediments are the major controls on uranium precipitation. Thinning of sandstones and diminished grain size (siltstones-claystones) likely slowed the advance of the uranium-bearing solutions and further enhanced the chances of precipitation (Buswell 1982).

The two horizons targeted for ISR uranium production in the proposed project area, one in the upper Fox Hills (FH horizon) and one in the Lower Lance (LT horizon), vary from thick, fine-grained cut and fill argillaceous sandstones to fine-grained sandstones with numerous facies changes (marginal marine environment) occurring within short distances. Uranium mineralization occurs in depositional environments as both roll fronts and tabular ore bodies.

Based on drilling to date, the two main mineralized horizons are found at depths ranging from 410 to 700 feet below the surface within the proposed project area. The main mineralized horizons trend in a north-south to northeast-southwest direction. The average dimensions of the mineralized roll fronts and tabular bodies are 115 feet wide by 14 feet thick and 2,000 to 3,000 feet long. The mineralization grade averages 500 ppm eU_3O_8. Historically, the horizons were broken out into numerous sub-horizons. Because of the complexity of correlating these narrow, discontinuous zones the decision was made to group the horizons. The richest mineralized zone occurs in the middle part of the FH horizon sand; it is about 70 feet thick and contains the most significant portion of the total resources within the proposed project area. The LT horizon, approximately 30 to 40 feet thick, is an interbedded sandstone-siltstone-mudstone zone and contains minor mineralization.

A petrographic analysis of a core sample from the 1977 push-pull test hole SP758R was completed by Rocky Mountain Geochemical Corporation (1977). The composition of the core ranged from fine- to medium-grained sandstone to very fine-grained siltstone with lenses of clay and minor calcite throughout. The core is typical of many Wyoming uranium deposits. The composition of the sandstone consists of the following:

- 60% quartz
- 35% feldspar (50% plagioclase and 50% orthoclase)
- 5% clay (montmorillonite)
- approximately 1% organic material
- <1% pyrite
- <1% carbonate

According to the petrographic analysis performed by Rocky Mountain Geochemical Corporation, the principal uranium minerals are uraninite, a uranium oxide, and coffinite, a uranium silicate. Vanadium in the form of

vanadinite (a lead chlorovanadate [$Pb_5(VO_4)_3Cl$]) and carnotite (a hydrated potassium uranyl vanadate [$K_2(UO_2)_2(VO_4)_2$ $3H_2O$]) is also found in association with the uranium at an average ratio of 0.6 (vanadium) to 1.0 (uranium).

Petrographic analyses were completed by Core Laboratories of Houston, Texas in September 2009, on three thin sections from core samples obtained from two borings, RMRD0003 and RMRD0004. The following was revealed from those analyses:

> "The composition of the ore zone sandstones are predominantly fine grained, moderately well sorted, argillaceous sandstone (>10% matrix). Sand grains are typically subangular to sub rounded. Compaction appears to be light in the sandstones to moderate in the argillaceous sandstone, as point-to-point contact areas are more common than the long grain contacts.
>
> The argillaceous sandstone has a subarkose composition with abundant monocrystalline quartz and moderate to common feldspar and minor lithic components. Trace to minor amounts of polycrystalline quartz, metamorphic rock fragments, carbonate rock fragments, sandstone rock fragments, argillaceous rock fragments, clay-replaced grains, kaolinite-replaced grains, and chert. Accessory grains include micas, heavy minerals and plant fragments and clay pellets.
>
> Syntaxial quartz overgrowths and clay (kaolinite chlorite) are the primary authigenic minerals observed in the argillaceous sandstone; these are rare to minor in other samples. The authigenic chlorite appears to be more grain-coating than grain replacing; kaolinite is more commonly observed as grain-replacement.
>
> Other authigenic minerals noted include calcite, pyrite and titanium oxides. Both the detrital clay and some of the authigenic clay have very similar composition (illitic); they are distinguished by their distribution and their morphology. The clay in the argillaceous sandstone has a reddish color in reflected and transmitted light suggesting partial replacement/precipitation to hematite.
>
> The two sandstone samples contain abundant primary intergranular pores and are of excellent reservoir quality. The argillaceous sandstone contains moderate amounts of primary pores and fair reservoir quality; detrital and authigenic clay are the primary causes of the reduced reservoir quality. Secondary pores are of minor abundance in all samples and do not significantly affect the reservoir quality."

Section 1.7 in this TR describes the ISR uranium recovery and processing of uranium at the proposed Ross ISR Project.

2.6.4 Historic Uranium Exploration/Development Activities

Historic exploration activities in the proposed Ross ISR Project area can be summarized as follows:

- 1971 - Nuclear Dynamics begins exploration drilling in the Lance Project Area.
- 1978 - Nuclear Dynamics forms a Joint Venture with Bethlehem Steel (Nubeth Joint Venture) to develop the Project.
- 1978 - Nubeth Joint Venture develops and briefly operates a pilot plant ISR in the south-central portion of what will become the proposed Ross Project area.
- 1983 - The Project is discontinued by Nubeth.
- 2008 - Strata acquires mineral rights covering most of the proposed Ross Project area and begins confirmation drilling of historic resources plus exploration drilling. Strata also acquires a portion of the historic Nubeth database.
- 2009 - Strata continues with exploration and development drilling and also acquires the original complete Nubeth database.
- 2010 - Exploration and development drilling is ongoing by Strata in the proposed Ross Project area and expansions of the known mineralized zones are progressing.

During initial exploration efforts by Nubeth and predecessors, in excess of 1,500 holes were drilled in the current permit boundary with at least another 200 within a ½ mile buffer around the permit. In order to best utilize the data acquired for the project, Strata initiated a hole finding and surveying program in 2008. Due to the presence of metal plugs in the shallow subsurface of each hole, a metal detector was utilized to accurately locate the holes, stake them and then re-survey using a conventional coordinate system (versus a local system). Data capture for resource and stratigraphic purposes utilized Gemcom Gems software which enabled Strata to develop a three dimensional geologic model for the project. Table 1 of Addendum 2.6-E summarizes critical statistics for the exploration/delineation hole finding and plugging program. While abandonment methods met all State of Wyoming requirements at the time procedures have evolved with a number of exploration/delineation holes plugged with cement and plug gel indicated on the summary table. The data derived from these exploratory boreholes forms the core of the geologic model and resource evaluation for the project. A tabulation of the

exploration/delineation holes is provided in Addendum 2.6-B while an exhibit depicting all of the holes and wells installed during the early development of the project is provided in Addendum 2.6-E.

Research and development efforts by Nubeth led to the installation of 47 wells within and adjacent to the proposed permit boundary. Table 2.6-2 summarizes the well locations and depths. Three primary areas of interest were apparent during the R&D phase of the project; the initial hydrologic test area in support of licensing, the phase I test pattern and associated monitor wells and a phase II area. In addition, four clusters of three wells per cluster were installed in preparation for permit level hydrologic characterization. Figures 1, 2 and 3 in Addendum 2.6-E portray the locations of the wells.

Well installation procedures were similar across the project. Typically, a 5 inch pilot hole was drilled past the anticipated completion depth, geophysically logged then the hole was reamed to 8¾ to 9½ inches. Normal casing type was PVC though some fiberglass was used during the R&D phase with nominal diameters from 4 inches to 5½ inches. Centralizers and a cementing shoe were utilized during casing installation and all wells were cemented around the annulus. After the cement had cured, the well was re-entered and the cementing shoe was drilled out. Screen was typically 2 inch, 3 inch or 4 inch and used .010 to .020 inch slots. Note that some of the shallow, surficial aquifer wells had only 20 to 40 feet of casing cemented at the surface then an open-hole completion.

Nubeth records indicate that most wells were plugged and abandoned per LQD guidelines. The exceptions included two wells (789V and 19XX) which were purchased by operators of the adjacent oil field to be used to stimulate oil production through a water flood system and two injection wells (20X and 83X) which were abandoned with grout from the bottom with a drill rig due to casing integrity issues. A fourth well (22X) in the SW Hydrologic cluster was turned over to a local landowner and is no longer in use. Typical abandonment involved setting a cement plug 5-10 feet below ground surface (probably several bags of neat cement), cutting the PVC 2-3 feet below ground surface, re-contouring and re-seeding. Brass caps like those utilized on the exploration/delineation holes were apparently <u>not</u> left in the wells as Strata has been unable to locate many of the installations.

2.6.5 Soils

Soils within the proposed project area were evaluated by BKS Environmental Associates, Inc. (BKS) of Gillette, Wyoming in 2009 and 2010. All 1,721.3 acres of the proposed project area were included in the final soil mapping of the Ross ISR Project. Soils in the proposed project area are typical for semi-arid grasslands and shrublands in the Western United States. Parent material included colluvium, residuum, and alluvium. Most soils are classified taxonomically as Aridic Argiustolls, Ustic Haplargids, or Ustic Torrifluvents. The physical and chemical properties of topsoil and subsoil were compared to WDEQ/LQD suitability standards. The primary limiting factors included high sodium adsorption ratio (SAR), high clay texture, alkaline pH, and calcareous soils.

Following is a description of the soil survey methodology and a summary of the survey results. Complete results are provided in addenda. Refer to ER Addendum 3.3-A for tables, ER Addendum 3.3-B for soil mapping unit descriptions, ER Addendum 3.3-C for sampled soil series descriptions, ER Addendum 3.3-D for soil laboratory analysis, ER Addendum 3.3-E for prime farmland designation and ER Addendum 3.3-F for photographs.

2.6.5.1 Soil Survey Methodology

Baseline soils inventories for the proposed project area consisted of refinement of the current USDA Natural Resources Conservation Service (NRCS) mapping for Crook County, Wyoming. The soils in Crook County were studied and mapped to an Order 3 scale by the NRCS between 1960 and 1977.

Field mapping was conducted according to techniques and procedures outlined in the National Cooperative Soil Survey. WDEQ/LQD Guideline 1 (August 1994 Revision) was used as a guide during all phases of the study (WDEQ/LQD 1994).

A reconnaissance of the proposed project area was done by field personnel during in 2009. Soil profiles were examined on a widely scattered basis according to physiographic configuration. Information derived from these profiles was used to determine which soils are likely to occur on specific landscape positions. Following the reconnaissance survey, a higher intensity Order 1-2 soil survey was conducted during June and August 2010. Actual soil boundaries were identified in the field by exposing additional soil profiles to

determine the nature and extent of soil series in the proposed project area. The soil boundaries were delineated on a 1:6,000 orthophoto.

For purposes of the soil survey, the major disturbance of the Proposed Action was assumed to be the plant site. Soils were evaluated for two plant site options. The primary plant site option is located in the NE¼, SE¼ of Section 18, T53N, R67W. Intensive sampling was conducted on the primary plant site option. The alternate plant option is located in the S½, SW¼ of Section 7, T53N, R67W.

WDEQ/LQD approved the soil sampling methodology during a meeting in Sheridan, Wyoming on December 9, 2009. Intensive sampling was conducted on the primary plant site option and 10 samples were sent to the lab. The alternate plant site option was sampled at one pedon per series for a total of five samples sent to the lab. Soil series located outside of the plant site options were also sampled at one pedon per series for a total of 11 samples sent to the lab. Due to the close proximity of the alternate plant site, one sample location (No. 42) was used to represent both the entire proposed project area and the alternate plant site option.

All soil samples were collected with a Giddings truck mounted auger or hand auger to paralithic contact or a maximum depth of 60", whichever was shallower. Sampled profiles were described in the field, to the extent possible, by the physical and chemical nature of each profile horizon. Backhoe pits were not utilized for soil sampling. Sample locations were identified on a base map and global positioning system (GPS) locations were collected with hand-held Garmin GPS units. Soil samples were placed in clean, labeled, polyethylene plastic bags, and sealed to limit sample drying. Samples were kept as cool as possible, but were not stored on ice. Samples were analyzed for pH, SAR, electrical conductivity (EC), saturation %, texture, coarse fragments, boron, selenium, and organic matter.

2.6.5.2 Soil Survey Results

The following provides a summary of the soil survey results for the proposed project area. Detailed results are summarized in ER Addenda 3.3-A through 3.3-F. General topography of the area ranged from nearly level uplands to steep hills, ridges, and breaks. The soils occurring in the proposed project area were generally a sandy or coarse texture on hills, ridges, and breaks with clayey or fine-textured soils occurring on nearly level uplands and

near drainages. The proposed project area contains moderate and deep soils on level upland areas and drainages with shallow soils located on hills, ridges, and breaks. Figure 2.6-9 depicts the baseline soils within the proposed project area, and Table 2.6-1 summarizes the soil mapping results.

The primary purpose of the 2009 and 2010 fieldwork was to characterize the soils within the proposed project area in terms of topsoil salvage depths and physical and chemical properties. Of the 98 sites within the proposed project area that were evaluated in the field, 26 sites were evaluated in detail through written profile descriptions and laboratory analysis. Laboratory analyses are included in Appendix D7 of the WDEQ/LQD Permit Application. Laboratory soil texture analysis did not include percent fine sands. Field observations of fine sands within individual pedestals as well as sample site topographic position were used in conjunction with laboratory analytical results to determine series designation. In several of the pedestal sampling locations, laboratory analysis yielded finer or coarser than expected textures (based upon field observations). Where textures are not typical for the series, it is noted in the Range of Characteristics (according to field observations and lab analysis) in the soil series descriptions.

Approximate topsoil salvage depths of the map unit series ranged from 0.25 to 5.0 feet. Within the proposed project area, suitability of soil as a plant growth medium is generally affected by physical factors such as high clay texture and high saturation percentages. Chemical limiting factors included SAR, selenium, EC, pH, and calcium carbonate. Table 2.6-2 provides the criteria that WDEQ/LQD use to establish the suitability of topsoil. This table is reproduced from WDEQ/LQD Guideline 1, which notes that these are guidelines and not enforceable suitability standards. Based on comparison with WDEQ/LQD Guideline 1, marginal material was found in 16 of the 26 sampled profiles. Unsuitable material was found in 7 of the 26 sampled profiles. Based on laboratory analysis and field observations, marginal and unsuitable material parameters primarily consisted of texture, selenium, SAR, and pH.

Based on the 2009 and 2010 fieldwork with associated field observations and subsequent chemical analysis, the recommended topsoil average salvage depth over the Ross ISR proposed project area was determined to be 1.36 feet.

The hazard for wind and water erosion within the proposed project area varies from negligible to severe, based on the soil mapping unit descriptions. The potential for wind and water erosion is mainly a factor of surface

characteristics of the soil, including texture and organic matter content. Given the slightly coarser texture of the surface horizons throughout the majority of the proposed project area, the soils are slightly more susceptible to erosion from wind than water.

Prime farmland was assessed by Jason Nehl, NRCS Resource Specialist in Sundance, Wyoming. No prime farmland was indicated within the proposed project area.

2.6.6 Seismology

2.6.6.1 Seismic Hazard Review

The seismic hazard review was based on analysis of available literature and historical seismicity for the proposed project area. Appendix A to 10 CFR Part 40 presents criteria relating to the operation of uranium mills and the disposition of tailings or wastes. Criterion 4 of that Appendix lists site and design criteria that must be adhered to whether tailings or wastes are disposed of above or below grade. Criterion 4(e) deals with seismic hazards and states that, "The impoundment may not be located near a capable fault that could cause a maximum credible earthquake larger than that which the impoundment could reasonably be expected to withstand. As used in this criterion, the term 'capable fault' has the same meaning as defined in section III (g) of Appendix A of 10 CFR Part 100. The term 'maximum credible earthquake' means that earthquake which would cause the maximum vibratory ground motion based upon an evaluation of earthquake potential considering the regional and local geology and seismology and specific characteristics of local subsurface material."

There are no capable faults (i.e., active faults) with surface expression mapped within or near the proposed project area, according to the USGS (2009a). The closest capable faults to the site are located in central Wyoming, 270 km (168 miles) to the west-southwest. Section 2.6.2.1 describes how faults previously mapped in the area by Buswell (1982) were the result of limited survey data.

2.6.6.2 Seismicity

The following discussion of seismicity in Wyoming and the proposed project area is based primarily on Wyoming State Geological Survey Information Pamphlet 6 (Case and Green 2000), Seismological Characterization

for Crook County (Case, Toner and Kirkwood 2002), and 100 Years of Earthquakes in the Wyoming Region (WSGS 2010b).

Earthquakes are common in Wyoming and have occurred in every county in the State over the past 120 years. Most of these have occurred in the northwestern part of the State (see Figure 2.6-10). Only two earthquakes with a magnitude greater than 2.5 (Richter Magnitude Scale) or intensity greater than III (Modified Mercalli Intensity Scale) have been recorded in Crook County and only nine in Campbell County. Magnitude is an instrumentally determined measure of the size of an earthquake and the total energy released. Each one-step increase in magnitude equates to a 32 times increase in associated seismic energy (e.g., a magnitude 7.5 earthquake releases approximately one thousand times more energy than a magnitude 5.5 earthquake, or 32 times 32). Intensity is a qualitative measure of the degree of shaking an earthquake imparts on people, structures, and the ground. For a given earthquake, intensities can vary depending upon the distance from the epicenter. Table 2.6-3 presents a summary of the Modified Mercalli Intensity Scale, equivalent Richter magnitude, and approximate peak ground acceleration associated with each scale category.

Natural earthquakes in Wyoming occur because of movements on existing or newly created faults or movements of (or in) the magma chamber beneath Yellowstone National Park. Most historical earthquakes have occurred as a result of movements on faults not exposed at the surface. These deeply buried faults, which are not expected to generate earthquakes with magnitudes greater than 6.5, have not been studied in detail. A series of Quaternary (within the past 1.65 million years) faults exposed at the surface in Wyoming, however, have activated and generated earthquakes from hundreds to thousands of years ago. Future earthquakes with magnitudes from 6.75 to 7.5 are expected to occur along those exposed Quaternary faults. As discussed in the preceding section, no Quaternary faults have been mapped within 270 km of the proposed Ross license area.

As shown in Table 2.6-3, earthquakes generally do not result in ground surface rupture unless the magnitude of the event is greater than 6.5. Because of this, areas of the state that do not have active faults exposed at the surface, such as the proposed project area, are generally thought not to be capable of having earthquakes with magnitudes over 6.5. See Figure 2.6-11 which shows the probability of an earthquake with magnitude greater than or equal to 6.5 in

the vicinity of the proposed project area. This figure was prepared using the USGS Probabilistic Seismic Hazard Analysis (PSHA) model (USGS 2009b). Earthquakes with magnitudes less than 6.5 would cause little damage in specially built structures but could cause considerable damage to ordinary buildings and severe damage to poorly built structures. Some walls could collapse. Underground pipes would generally not be broken and ground cracking would not occur or would be minor.

2.6.6.3 Historic Seismicity Near Proposed Project Area

Only three magnitude 3.0 and greater earthquakes have been recorded in or around Crook County (Case, Toner, and Kirkwood 2002, WSGS 2010b). One occurred near Sundance on February 3, 1897. The intensity IV-V earthquake severely shook the Shober School on Little Houston Creek southwest of Sundance. Many residents of Sundance reported hearing three loud reports resembling the explosion of a boiler or a great blast (Case, Toner and Kirkwood 2002). The other recorded Crook County earthquake occurred near Moorcroft in November 2004. It had a magnitude of 3.7, which corresponds to an intensity level of III (WSGS 2010b).

On February 18, 1972 a magnitude 4.3 earthquake occurred approximately 18 miles east of Gillette near the Crook-Campbell County line. No damage was reported (Case, Toner, and Kirkwood 2002).

2.6.6.4 Seismic Risk

The Uniform Building Code (UBC) contains information and guidance on designing buildings and structures to withstand seismic events. The current (1997) UBC Seismic Zone Map divides Wyoming into five zones (Zones 0 to Zone 4) defined in part by the probability of having a certain level of ground shaking (horizontal acceleration) in 50 years (See Figure 2.6-12). Horizontal acceleration in the UBC Seismic Zone Map is provided in terms of percent of gravitational acceleration (%g).

The UBC criteria are as follows:

Zone	Effective Peak Acceleration (%g)
0	<5
1	5 to 10
2	10 to 20
3	20 to 30
4	>30

The UBC based these criteria on the assumption that there was a 90% probability that the above values would not be exceeded in 50 years, or roughly a 100% probability that the values would be exceeded in 475 to 500 years.

Crook County is in UBC Seismic Zone 0, which suggests that there is a 90% probability that an earthquake with an acceleration of 5%g would not occur within any 50-year period. Such acceleration, however, is less than would be suggested through newer building codes. Recently, the UBC has been replaced by the IBC, which is based on probabilistic analyses (Case, Toner, and Kirkwood 2002), as discussed below.

Some regulations require an analysis of the earthquake potential in areas where active faults are not exposed (such as the area around the Ross ISR Project area), and where earthquakes are tied to buried faults with no surface expression. Regions with a uniform potential for the occurrence of such earthquakes are called tectonic provinces. The USGS identified tectonic provinces in a report titled "Probabilistic Estimates of Maximum Acceleration and Velocity in Rock in the Contiguous United States" (Algermissen and others 1982).

Within a tectonic province, earthquakes associated with buried faults are assumed to occur randomly and are sometimes referred to as "floating earthquakes" (Case, Toner, and Kirkwood 2002). Sometimes regulations or prudent design requires that a floating earthquake be used for design of a facility. Usually, those regulations also specify at what distance a floating earthquake is to be placed from a facility. For example, for uranium mill tailings sites, NRC requires that a floating earthquake be placed 15 km from the site, and that earthquake is then used to determine what horizontal accelerations may occur at the site. A magnitude 6.25 floating earthquake placed 15 km from any structure in Crook County would generate horizontal accelerations of approximately 15%g at the site. That acceleration is about three times what would be found from the UBC Seismic Zone Map and would be adequate for designing certain facilities at a uranium mill tailings site but may be too conservative for less critical sites, such as a landfill (Case, Toner, and Kirkwood 2002). Critical facilities, such as dams, usually require a more detailed probabilistic analysis of random earthquakes.

2.6.6.5 Probabilistic Seismic Hazard Analysis

The USGS publishes probabilistic acceleration maps for 500-, 1000- and 2500-year time frames. The maps show what accelerations may be met or exceeded in those time frames by expressing the probability that the accelerations will be met or exceeded in a shorter time frame. For example, a 10% probability that a peak ground acceleration may be met or exceeded in 50 years is roughly equivalent to a 100% probability of exceedance in 500 years. The IBC uses a 2,500-year map as the basis for building design, vs. the 500-year map used for the UBC zone map. The IBC maps reflect current perceptions on seismicity in Wyoming (Case, Toner, and Kirkwood 2002). In many areas of Wyoming, ground accelerations shown on the USGS maps can be increased due to local soil conditions. If fairly soft, saturated sediments are present at the surface, and seismic waves are passed through them, surface ground accelerations will usually be greater than would occur if only bedrock was present. In this case, the ground accelerations shown on the USGS maps would underestimate the local hazard, as they are based upon accelerations that would be expected if firm soil or rock were present at the surface.

Based on the 500-year map (10% probability of exceedance in 50 years) (Figure 2.6-13a), the estimated peak horizontal acceleration in the proposed project area is about 2.7%g. This relates to an intensity IV earthquake (see Table 2.6-3) which would be felt by many people indoors, few outdoors, and would feel similar to a heavy truck passing nearby. Based on the 1000-year map (5% probability of exceedance in 50 years) (Figure 2.6-13b), the estimated peak horizontal acceleration at the site is about 4%g. This relates to an earthquake at the low end of intensity V, which would be felt by almost everyone, would awaken some people, move small objects, may shake trees and poles, and could crack plaster and break dishes. For the 2,500-year map (2% exceedance probability in 50 years) the estimated peak horizontal acceleration at the site is about 7.5%g, which according to Table 2.6-3 would still relate to an intensity V earthquake.

With a limited historic record, it is nearly impossible to determine when a 2,500-year event last occurred in Crook County. Because of the uncertainty involved, and based on the fact that the new IBC utilizes 2,500-year events for building design, the Wyoming State Geologic Survey (WSGS) suggests that the 2,500-year probabilistic map (Figure 2.6-13c) be used for seismic analysis in design of critical facilities in this part of Wyoming. This conservative approach

is in the interest of public safety (Case, Toner, and Kirkwood 2002). The CPP and other Ross ISR Project buildings will be conservatively designed on the basis of the 2,500-year probabilistic map (2% probability of exceedance in 50 years) in accordance with WSGS recommendations.

Table 2.6-1. Soil Mapping Unit Acreages

Map Symbol	Map Unit Description	Permit Acreage	% Permit Area	Salvage Depth[1] (ft)	Volume of Topsoil[2] (acre-ft)
AB	Absted very fine sandy loam	257.75	14.97	0.83	213.93
AS	Ascalon fine sandy loam	277.57	16.13	0.83	230.39
BI	Bidman loam	90.36	5.25	1.92	173.50
CU	Cushman very fine sandy loam	47.90	2.78	1.83	87.66
FO	Forkwood loam	338.54	19.67	1.67	565.36
HA	Haverdad loam	38.70	2.25	0.25	9.67
LI	Limon silty clay loam	69.99	4.07	0.31	21.70
NU	Nunn clay loam	220.36	12.80	3.00	661.07
SH	Shingle clay loam	59.57	3.46	0.92	54.80
ST	Stetter clay	58.13	3.38	0.29	16.86
TA	Tassel fine sandy loam	49.49	2.87	0.42	20.78
TE	Terro sandy loam	87.78	5.10	1.50	131.68
UL	Ulm clay loam	60.80	3.53	1.14	69.32
UL-NC	Ulm – non-calcareous variant	5.29	0.31	5.00	26.43
VO	Vona fine sandy loam	41.06	2.38	1.25	51.32
WATER	Water	18.02	1.05	0.00	0.00
Average Topsoil Salvage Depth[3]			**---**	**1.36**	
	Total	**1,721.31**	**100.0**	**---**	**2,334.46**

[1] Found in Appendix D7 of WDEQ/LQD Permit Application. These salvage depths take in account all 26 sample locations.
[2] Calculated by multiplying permit acreage by salvage depth in feet, as shown in Table II-1 (Topsoil Volume Summary) of WDEQ/LQD Guideline 1.
[3] Calculated as the average of the weighted average salvage depths found in Appendix D7 of WDEQ/LQD Permit Application.

Table 2.6-2. WDEQ/LQD Topsoil Suitability Criteria

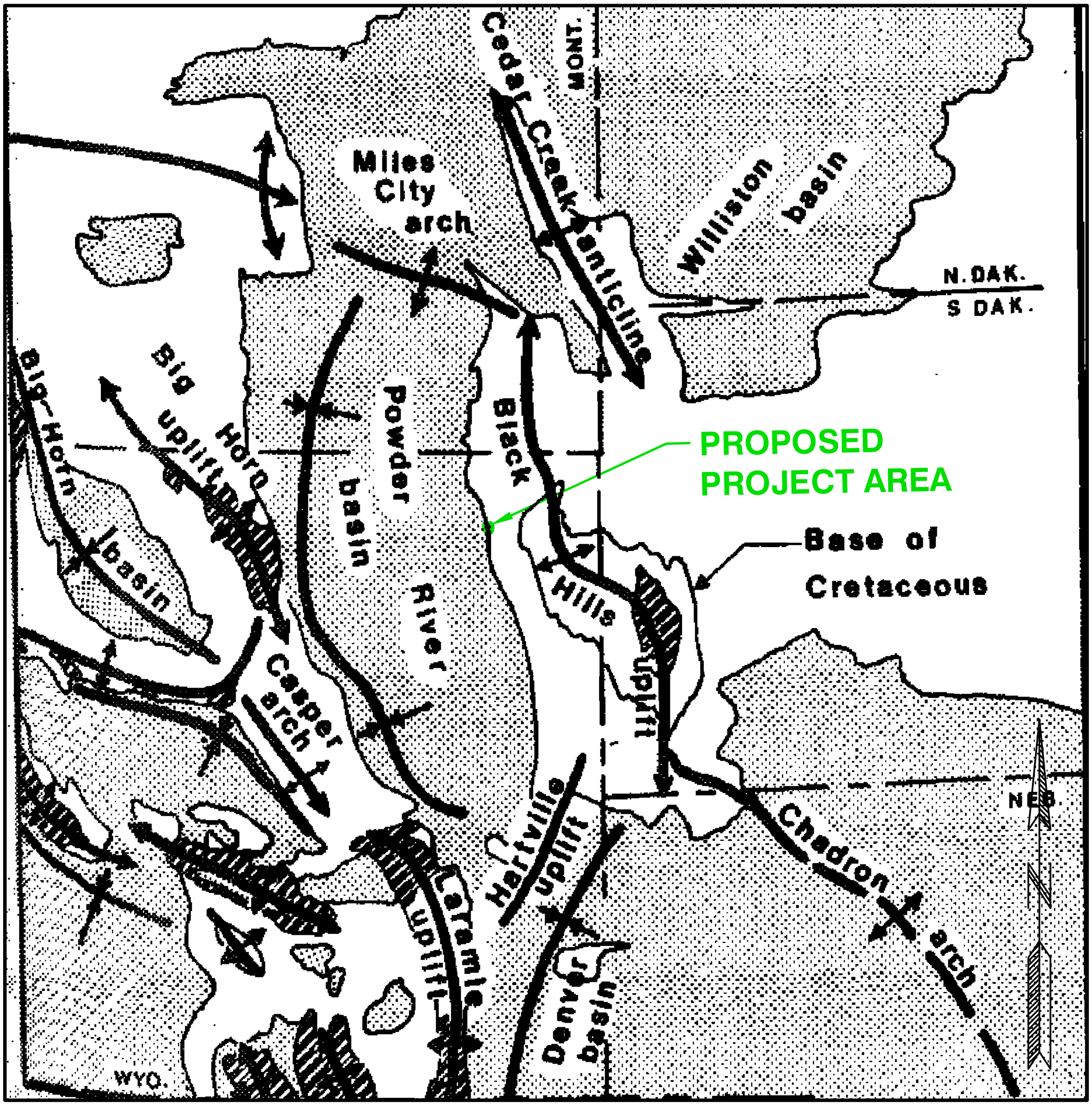
Parameter	Suitable	Marginal[1]	Unsuitable
pH	5.5-8.5	5.0-5.5 8.5-9.0	<5.0 >9.0
EC (Conductivity) mmhos/cm	0-8	8-12	>12
Saturation Percentage	25-80	<25 >80	
Texture		clay, silty clay, sand	
SAR[2]	0-10	10-12[3] 10-15	>12[3] >15
Selenium	<0.1 ppm	>0.1 ppm	
Boron	<5.0 ppm		>5.0 ppm
Coarse Frag (% vol)	<25%	25-35	>35%

1 Evaluated on an individual basis for suitability.
2 As an alternative to SAR calculations, ESP (exchangeable sodium percentage) can be determined. ESP should be determined if suitable SAR value is exceeded.
3 For fine textured soils (clay >40%)
Source: WDEQ/LQD Guideline 1, Table I-2

Table 2.6-3. General Terms Regarding Earthquake Intensity and Magnitude

Intensity	Equivalent Richter Magnitude	Description	Peak Ground Acceleration (%g)
I	1.0 – 2.0	Felt by very few people; barely noticeable.	< 0.17
II	2.0 – 3.0	Felt by a few people, especially on upper floors.	0.17 – 1.4
III	3.0 – 4.0	Noticeable indoors, especially on upper floors, but may not be recognized as an earthquake.	0.17 – 1.4
IV	4.0	Felt by many indoors, few outdoors. May feel like heavy truck passing by.	1.4 – 3.9
V	4.0 – 5.0	Felt by almost everyone, some people awakened. Small objects moved. Trees and poles may shake.	3.9 – 9.2
VI	5.0 – 6.0	Felt by everyone. Difficult to stand. Some heavy furniture moved, some plaster falls. Chimneys may be slightly damaged.	9.2 - 18
VII	6.0	Slight to moderate damage in well built, ordinary structures. Considerable damage to poorly built structures. Some walls may fall.	18 - 34
VIII	6.0 – 7.0	Little damage in specially built structures. Considerable damage to ordinary buildings, severe damage to poorly built structures. Some walls collapse.	34 - 65
IX	7.0	Considerable damage to specially built structures, buildings shifted off foundations. Ground cracked noticeably. Underground pipes broken. Wholesale destruction. Landslides.	65 - 124
X	7.0 – 8.0	Most masonry and frame structures and their foundations destroyed. Ground badly cracked. Landslides. Wholesale destruction.	> 124
XI	8.0	Total damage. Few, if any, structures standing. Bridges destroyed. Wide cracks in ground. Waves seen on ground.	> 124
XII	8.0 or greater	Total damage. Waves seen on ground. Objects thrown up into air	> 124

Case and Green 2000; Case, Toner, and Kirkwood 2002; and Michigan Tech University 2010.



Information modified from Figure 2 in Lisenbee (1978).

0 35 70 140
GRAPHIC SCALE (MILES)

Regional tectonic setting of the Black Hills uplift at the easternmost margin of the Wyoming province. Diagonal pattern indicates Precambrian basement, dotted pattern indicates Tertiary deposits. Approximate location of axes of uplifts and basins shown with heavy line.

Figure 2.6-1. Regional Tectonic Setting

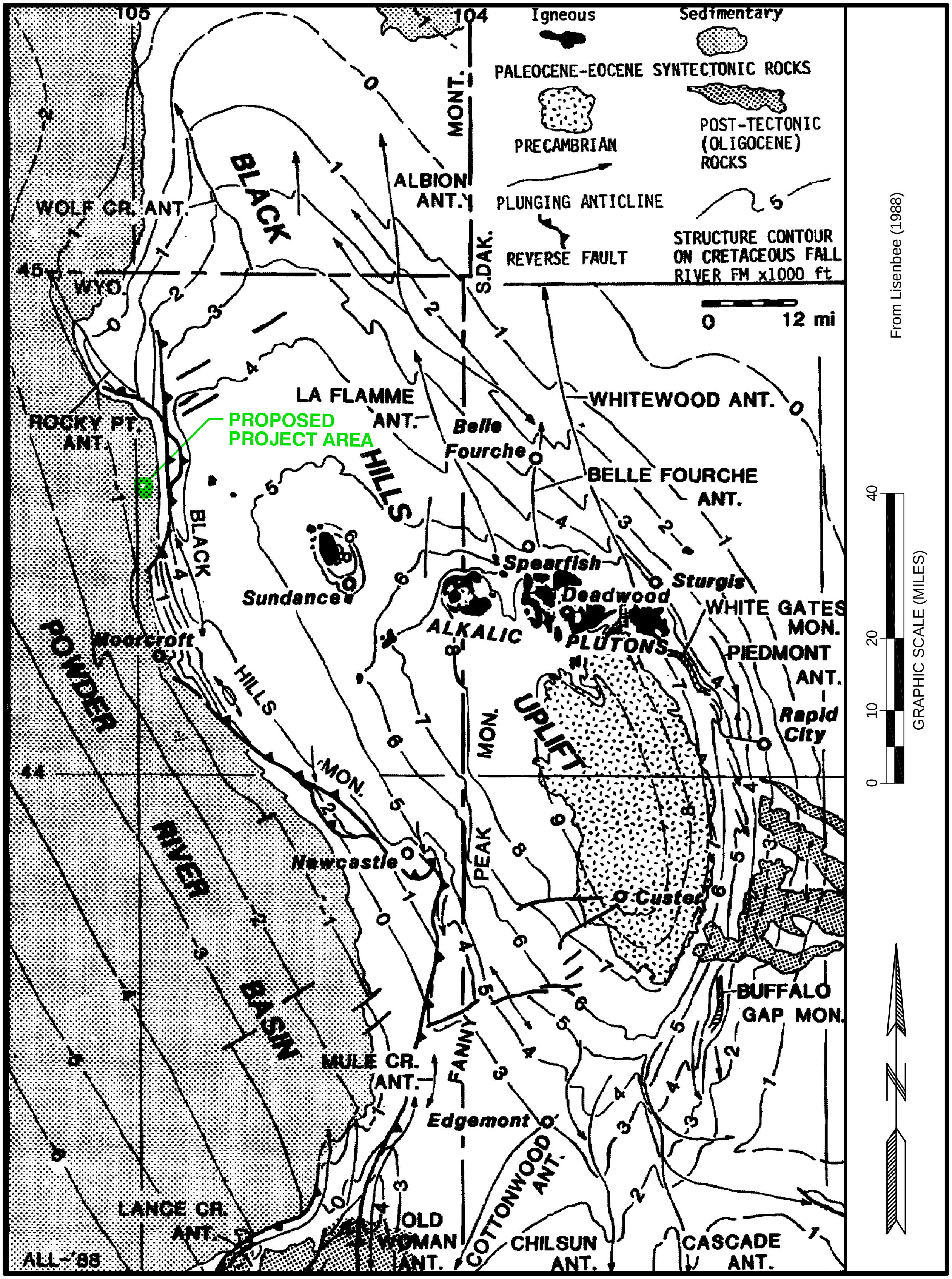


Figure 2.6-2. Tectonic Map of the Black Hills Uplift and Eastern Powder River Basin

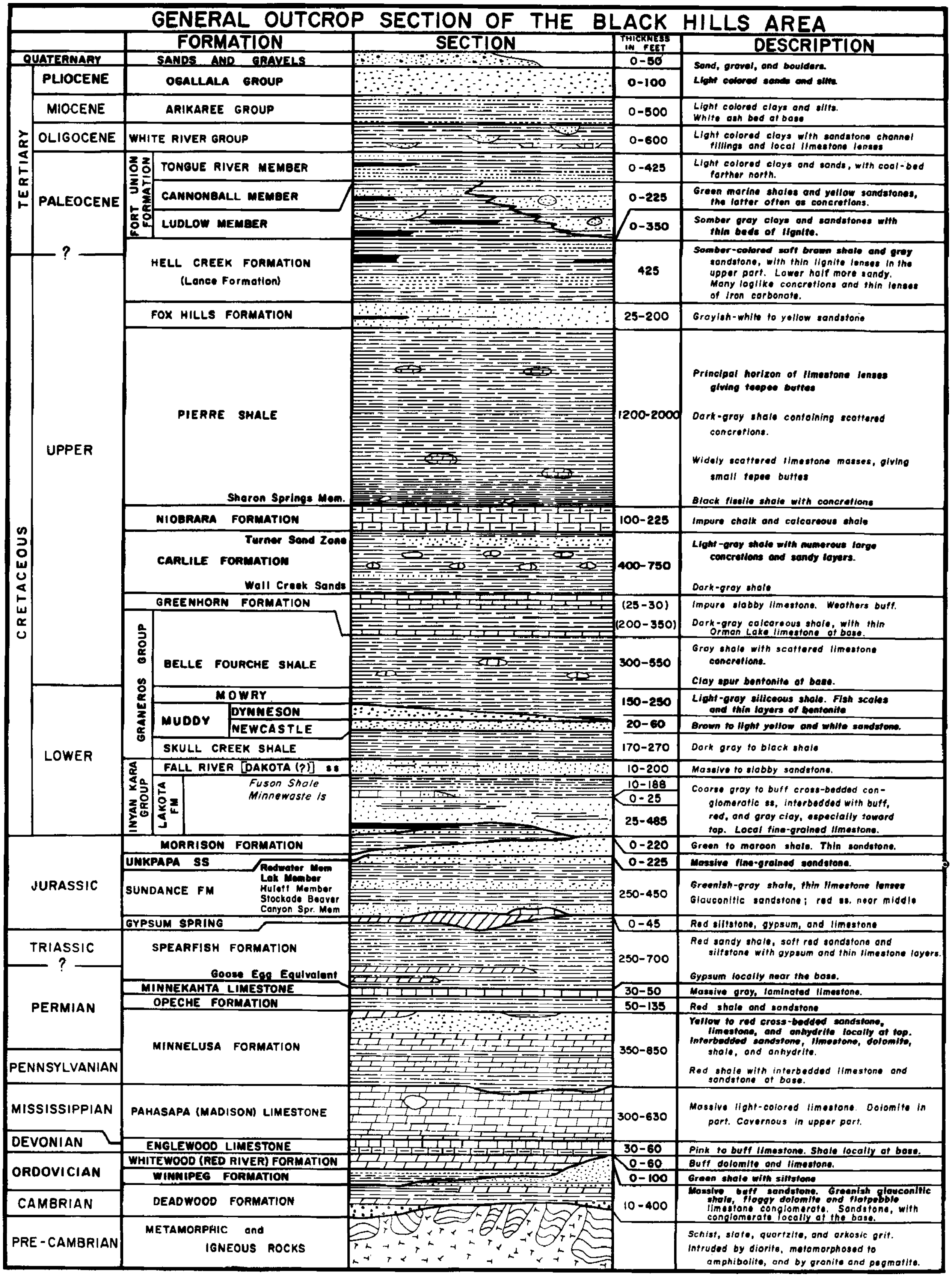
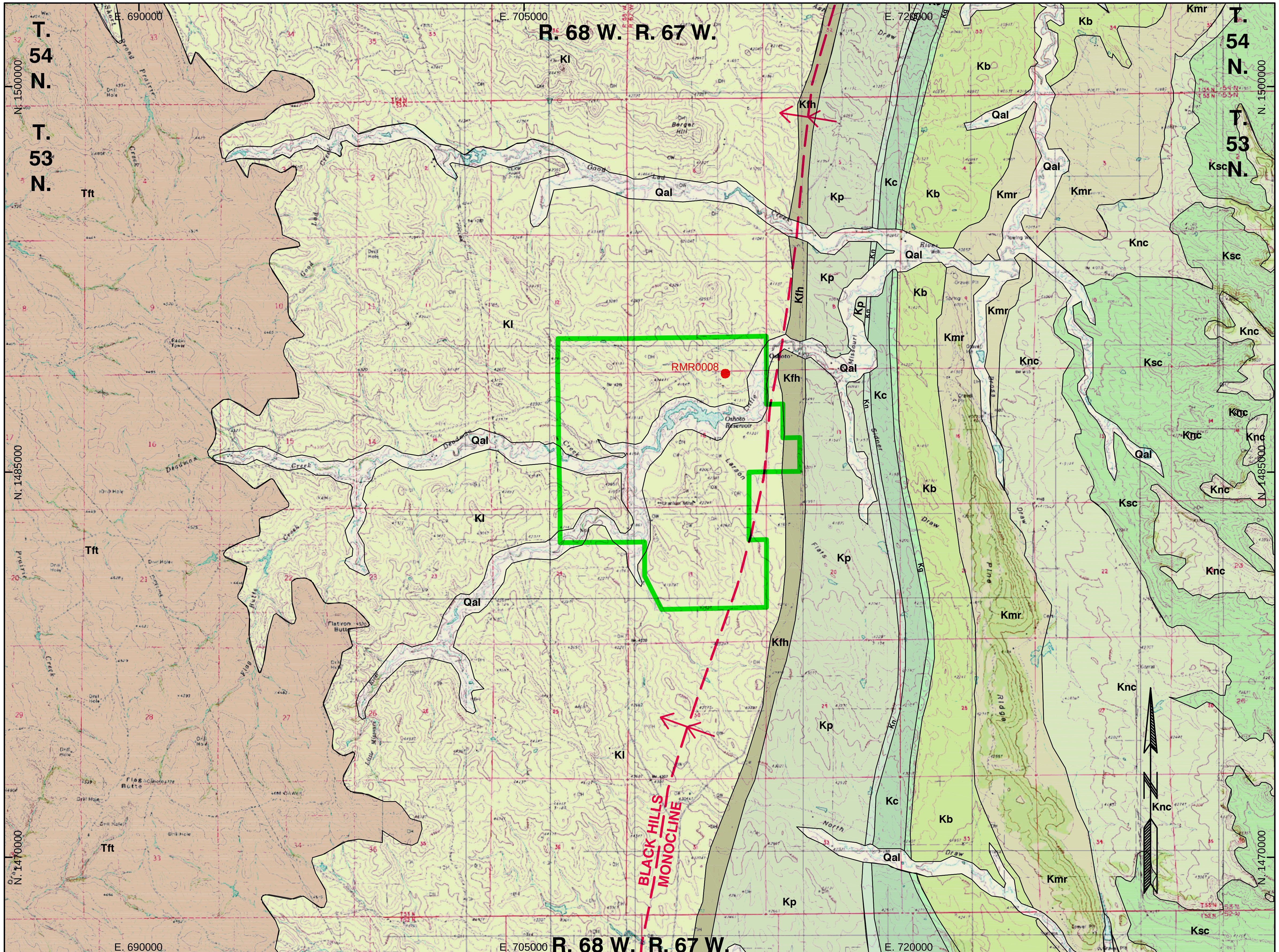


Figure 2.6-3. Regional Stratigraphic Column.
Modified from WGA Guidebook for 20th Annual Field Conference (1968)



ROSS PROJECT AREA

LEGEND

- PROPOSED ROSS PERMIT BOUNDARY
- MONOCLINAL AXIS
- RMR0008 LOCATION OF BORING FOR TYPE LOG

MAP UNITS

Qal	Alluvium (Holocene)
Tft	Fort Union Formation, Tullock Member (Tertiary)
Kl	Lance Formation (Upper Cretaceous)
Kfh	Fox Hills Formation (Upper Cretaceous)
Kp	Pierre Shale (Upper Cretaceous)
Kn	Niobrara Formation (Upper Cretaceous)
Kc	Carlile Shale (Upper Cretaceous)
Kg	Greenhorn Formation (Upper Cretaceous)
Kb	Belle Fourche Shale (Upper Cretaceous)
Kmr	Mowry Shale (Lower Cretaceous)
Knc	Newcastle Sandstone (Lower Cretaceous)
Ksc	Skull Creek Shale (Lower Cretaceous)

Adapted from Sutherland (2008) and Halberg, et al. (2002).

Drawing Coordinates: WY83EF

0 2000 4000 8000

GRAPHIC SCALE (FEET)

STRATA ENERGY

ROSS ISR PROJECT
CROOK COUNTY, WY
P.O. BOX 2318
GILLETTE, WY 82716

REVISIONS

Date	Description

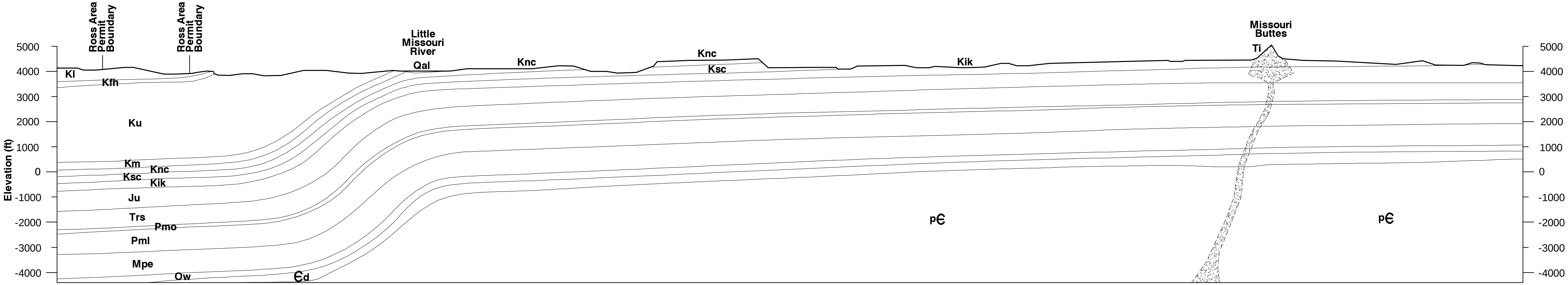
TECHNICAL REPORT
FIGURE 2.6-4

ROSS PROJECT AREA BEDROCK GEOLOGY

Drawn By: MBM
Checked By: BJS
Date: 11/17/10
FILE: ROSS_ER_GEOLOGY

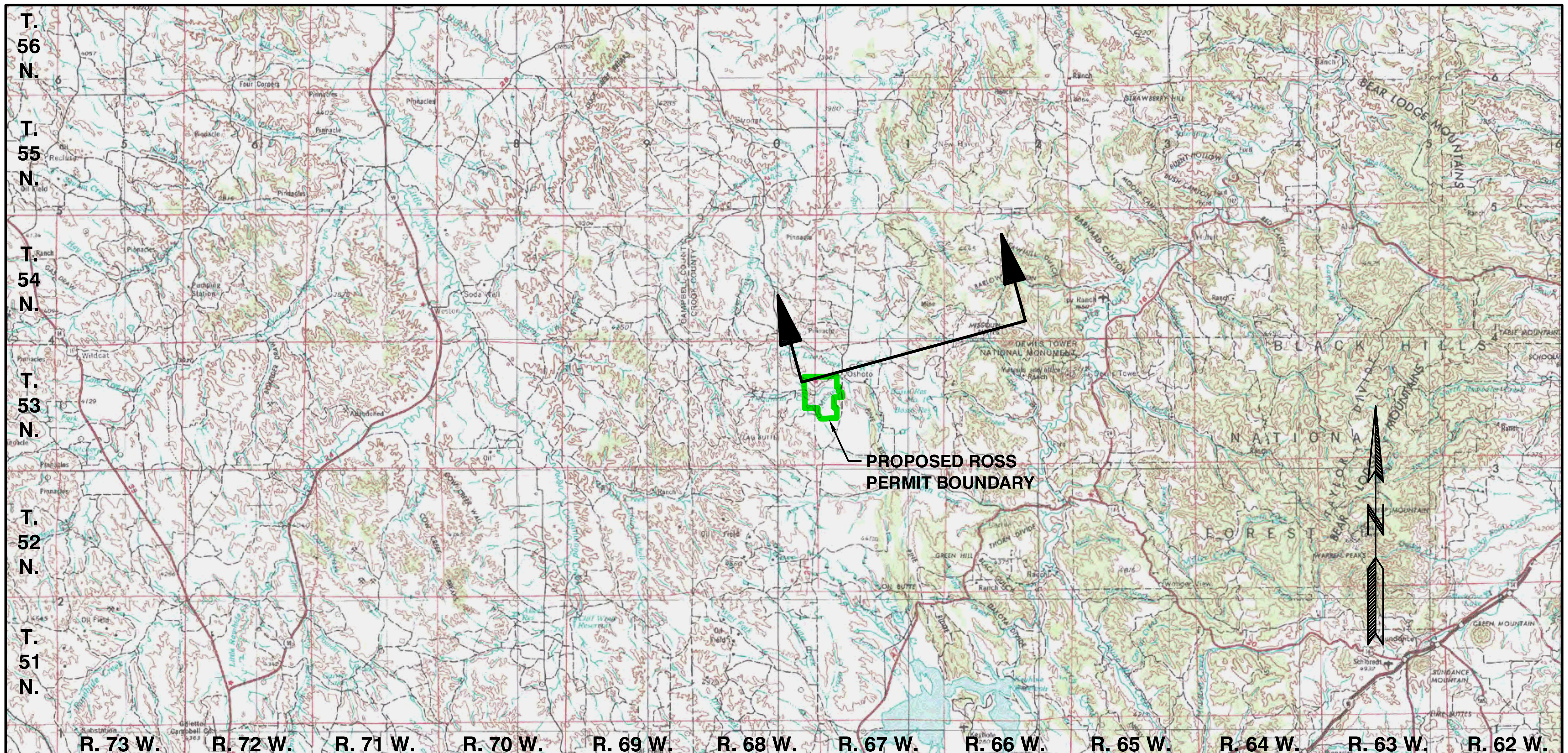
WWC ENGINEERING
www.wwcengineering.com

K:\Peninsula_Minerals\09142\DWGS_WY83E\ROSS_ER_GEOLOGY.dwg, TR_FIGURE_2.6-4, 12/18/2010 12:40:16 PM



Horizontal Distance Approximately 11 Miles →

Modified from: Whitcomb et.al., 1958
Occurence of Ground Water in the Eastern Powder River Basin and Western Black Hills
N.E. Wyoming WGA Thirteenth Annual Field Conference



CROSS SECTION LOCATION

0 3 6 12
GRAPHIC SCALE (MILES)

LEGEND

Qal	Quaternary Alluvium
Ti	Tertiary Intrusives
Kl	Lance Formation
Kfh	Fox Hills Formation
Ku	Upper Cretaceous, undivided
Km	Mowry Shale
Knc	Newcastle Sandstone
Ksc	Skull Creek Shale
Kik	Inyan Kara Group
Ju	Jurassic, undivided
Trs	Spearfish Formation
Pmo	Minnekahta Limestone and Opeche Formation
Pml	Minnelusa Sandstone
Mpe	Pahasapa and Englewood Limestones
Ow	Whitewood Limestone
Ꞓd	Deadwood Formation
pꞒ	Precambrian

STRATA ENERGY

ROSS ISR PROJECT
CROOK COUNTY, WY
P.O. BOX 2318
GILLETTE, WY 82716

REVISIONS

Date	Description

TECHNICAL REPORT
FIGURE 2.6-5

GENERALIZED GEOLOGIC CROSS SECTION DEPICTING BLACK HILLS MONOCLINE IN THE OSHOTO AREA

Drawn By: MBM
Checked By: MJE
Date: 11/22/10

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FILE: ROSS_ER_GEO_XS_PRB

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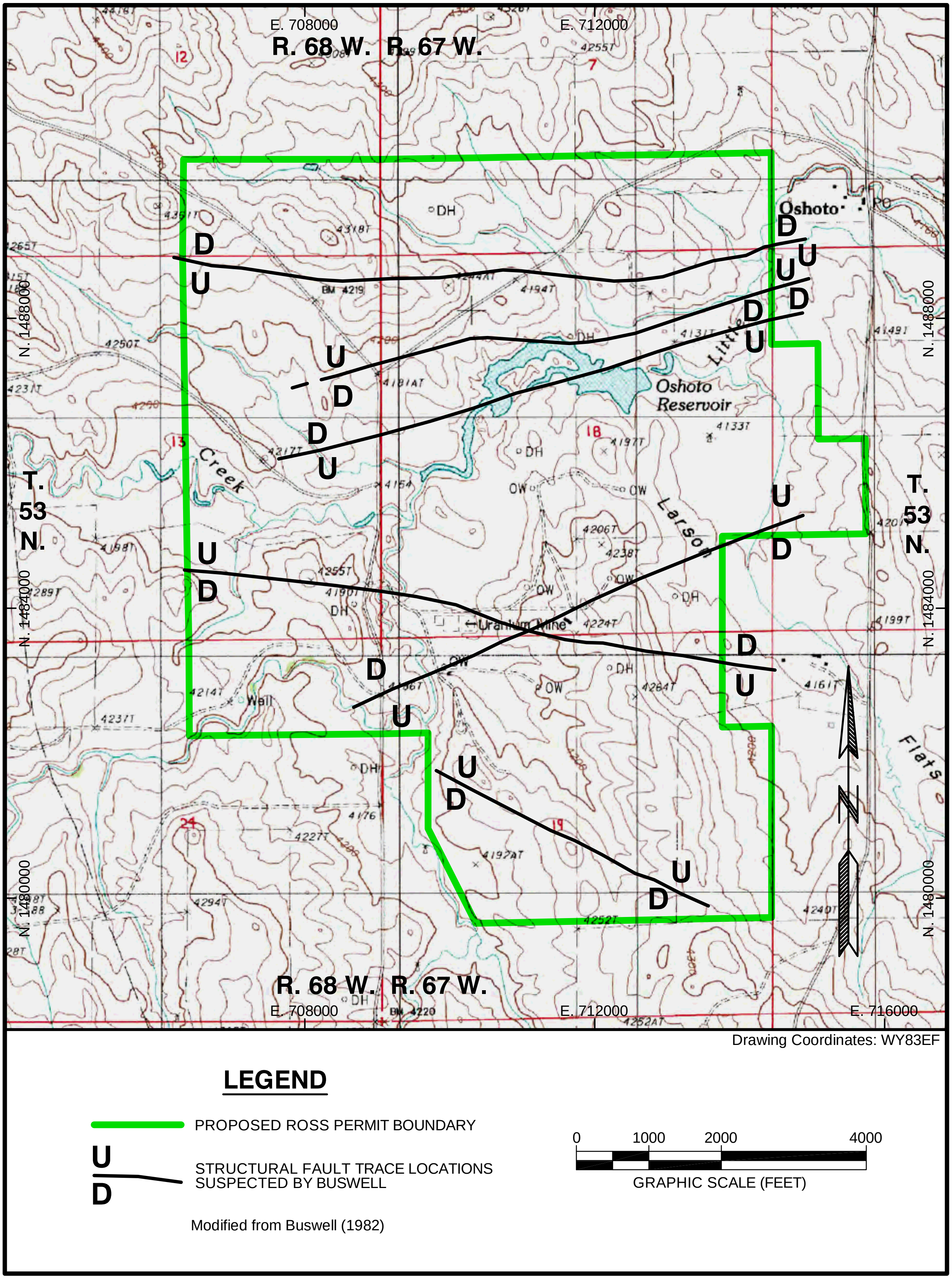
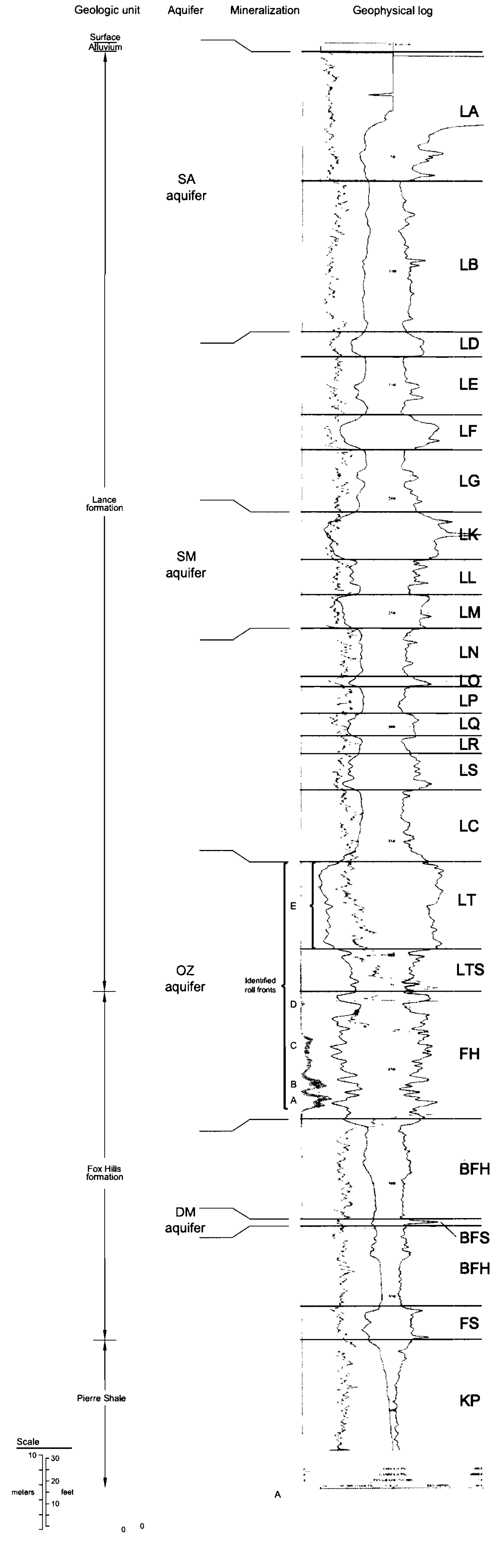


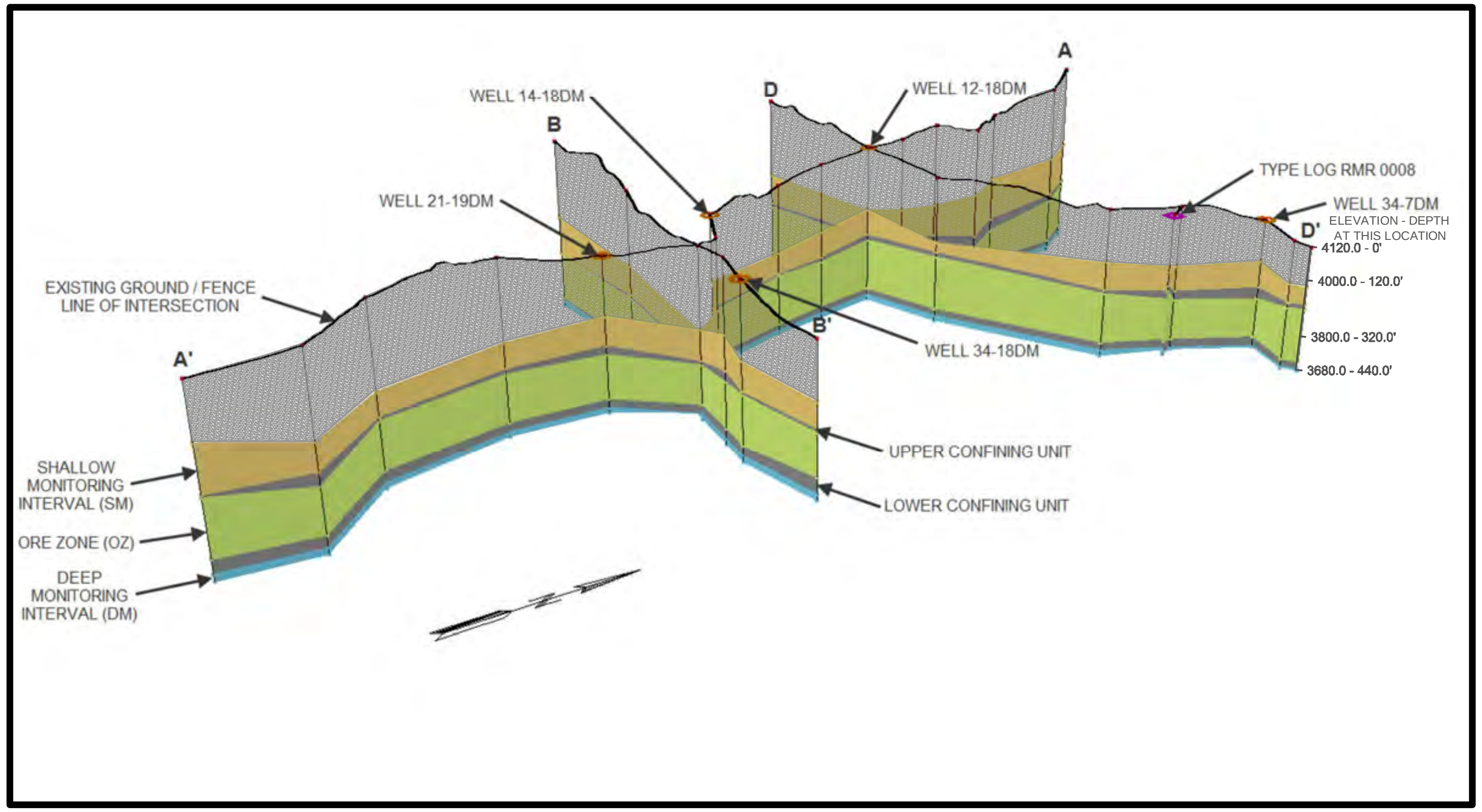
Figure 2.6-6. Buswell Interpreted Faults



Unit	Thickness	Description
Surface Alluvium	>10' variable	Unconsolidated alluvium, weathered bedrock and soil
LA	>40' variable	Sandstone (fluvial)
LB	40'–60'	Mudstone and claystone
LD	5'–20'	Sandstone (fluvial)
LE	10'–30'	Mudstone and claystone
LF	10'–20'	Sandstone (fluvial)
LG	10'–25'	Siltstone and claystone
LK	10'–20'	Sandstone (fluvial)
LL	10'–20'	Interbedded sandstone, claystone and siltstone
LM	5'–25'	Sandstone (fluvial)
LN	10'–30'	Claystone and siltstone with interbedded sandstone
LO	0'–10'	Sandstone (fluvial)
LP	5'–15'	Siltstone and claystone
LQ	5'–15'	Sandstone (fluvial)
LR	5'–15'	Siltstone and claystone
LS	10'–25'	Sandstone with interbedded siltstone and claystone
LC	20'–35'	Mudstone/claystone (Upper Confining Unit)
LT	30'–40'	Sandstone (fluvial), occasional mineralization
LTS	0'–20'	Sandstone, laterally variable and shaley in areas
FH	50'–65'	Sandstone (marine) with interbedded mudstone
BFH	30'–50'	Claystone (marine) (Lower Confining Unit)
BFS	10'–30'	Sandstone, often silty and clayey
BFH	30'–50'	Claystone (marine) (Lower Confining Unit)
FS	20'–35'	Basal sandstone, often silty and clayey
KP	2000'+	Claystone (marine)

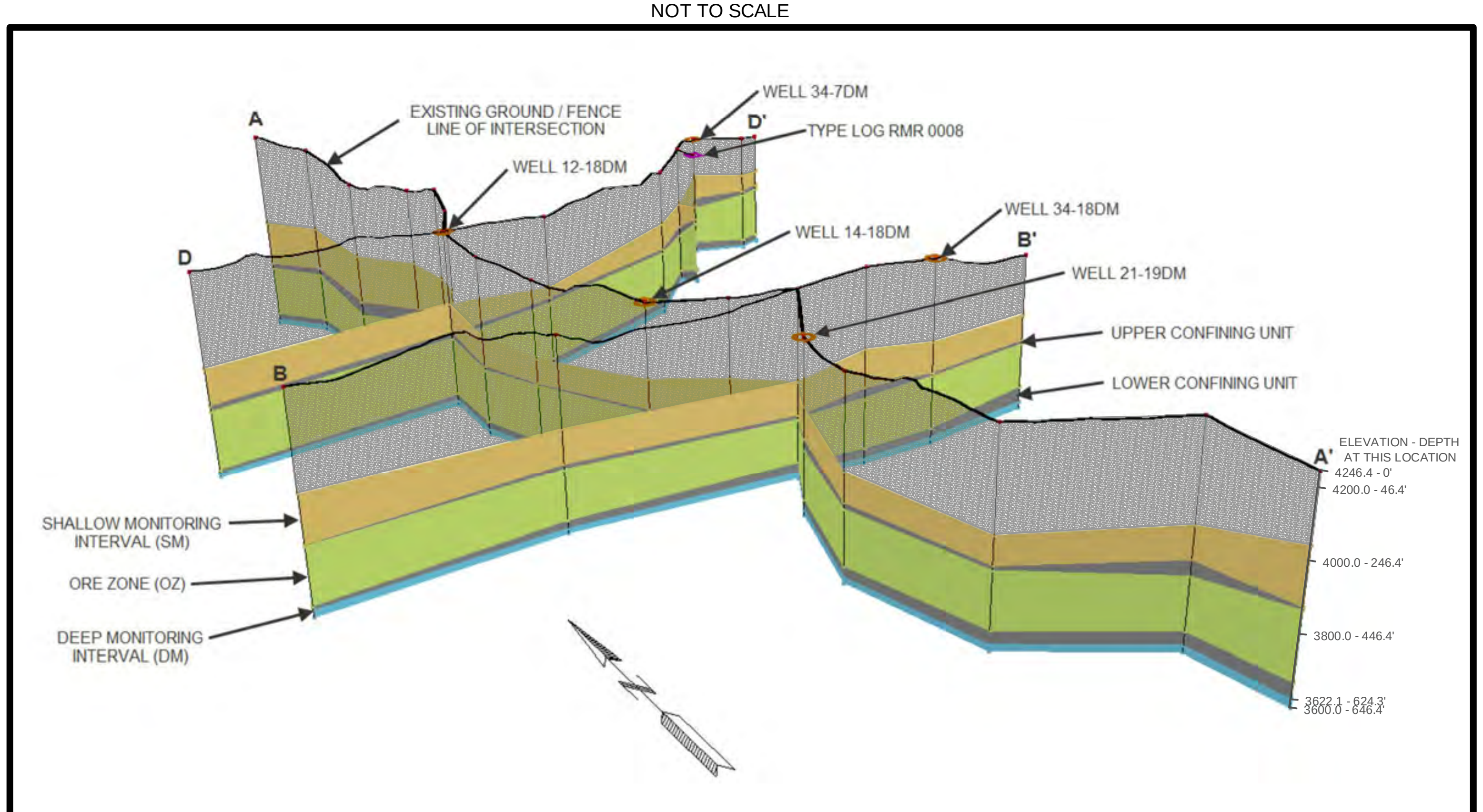
STRATA ENERGY

STRATIGRAPHIC NOMENCLATURE
Used within Proposed Ross Permit Area
Figure 2.6-7



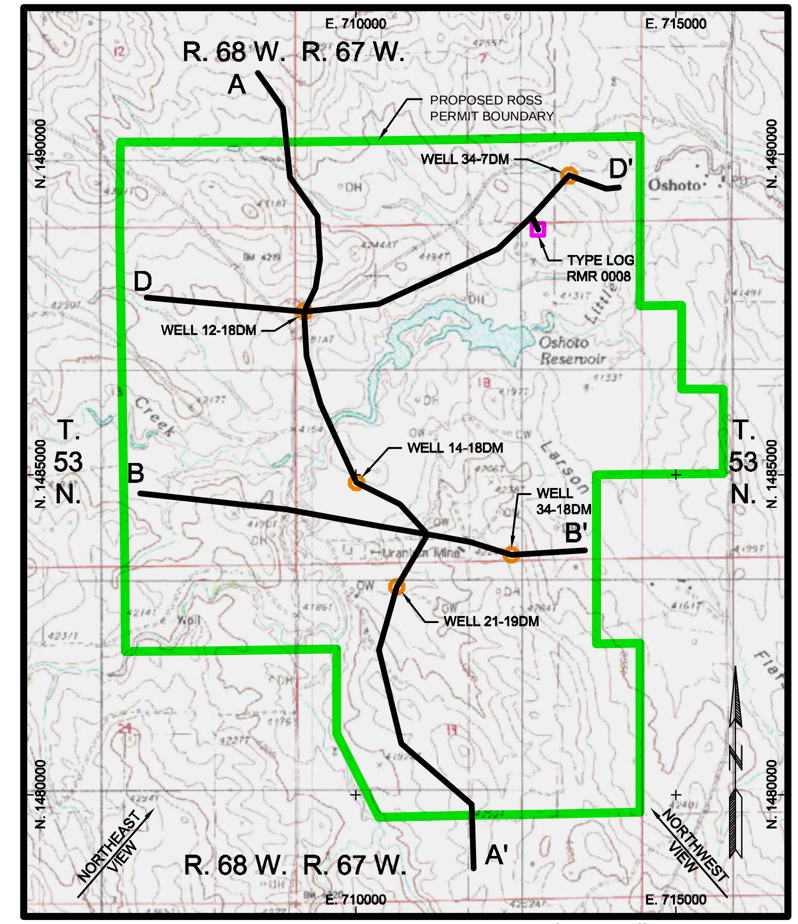
FENCE DIAGRAM - LOOKING NORTHWEST

NOT TO SCALE



FENCE DIAGRAM - LOOKING NORTHEAST

NOT TO SCALE



Drawing Coordinates: WY83EF

FENCE DIAGRAM KEY

0 1500 3000 6000

GRAPHIC SCALE (FEET)

CERTIFICATE OF GEOLOGIST

I, Benjamin J. Schiffer, hereby certify that this drawing was prepared by myself or under my direct supervision and that it correctly represents the geologic conditions described in the accompanying application which is provided to meet the requirements of the Wyoming Environmental Quality Act and its accompanying regulations.

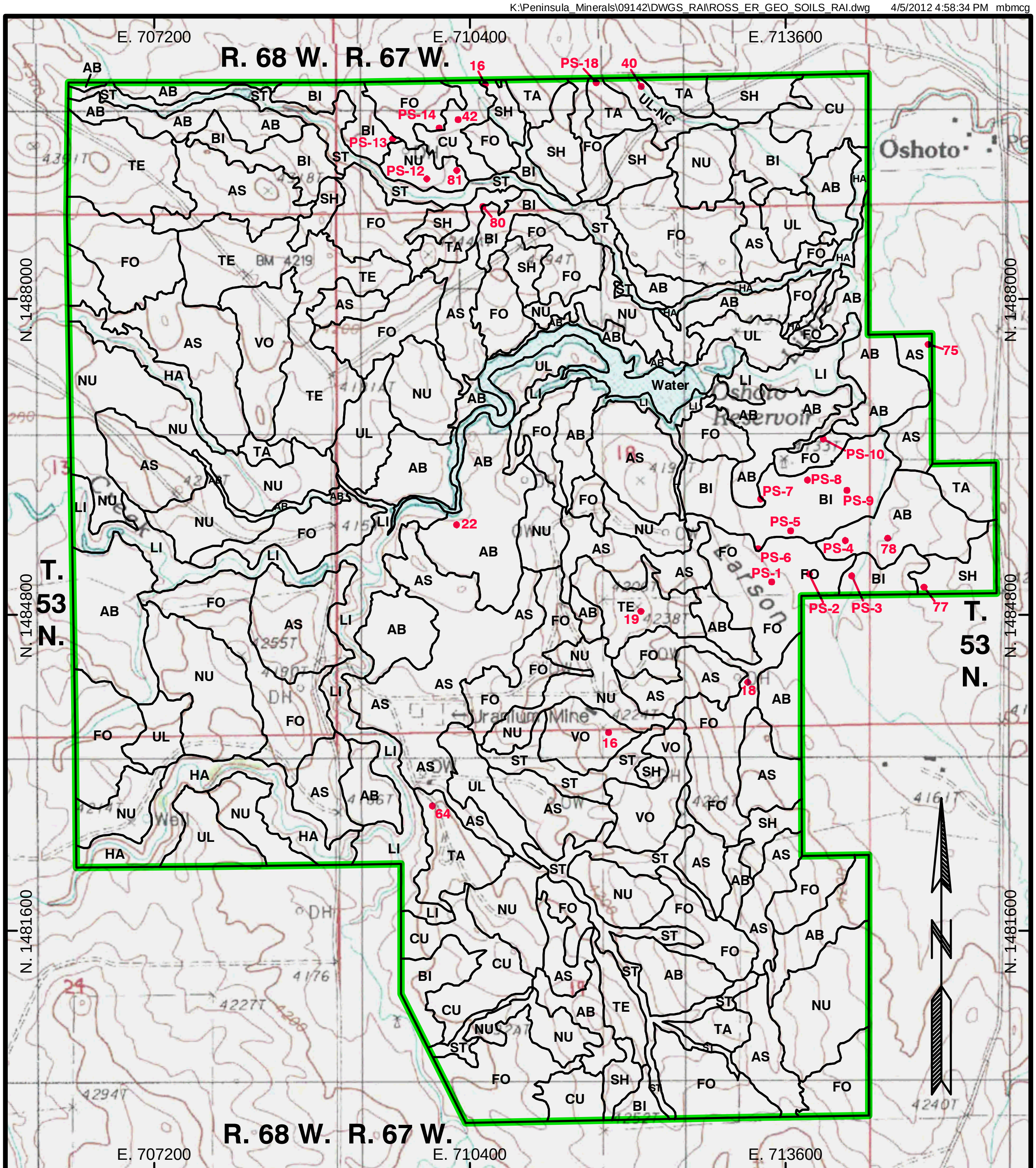
PROFESSIONAL GEOLOGIST
BENJAMIN J. SCHIFFER
PG-3446
WYOMING

NOTES:

1. THE FENCE DIAGRAM IS A GRAPHIC PERSPECTIVE OF THREE OR MORE GEOLOGIC SECTIONS SHOWING THE LATERAL EXTENT AND CORRELATION OF SUBSURFACE FORMATIONS. TO GIVE PROPER PERSPECTIVES, SCALES DIMINISH WITH DISTANCE FROM THE FOREGROUND. A FENCE-LIKE ENCLOSURE IS FORMED WHEN SEVERAL SECTIONS ARE USED TOGETHER, HAVING THE ADVANTAGE OF THREE-DIMENSIONALITY. THE TOP OF THE REFERENCE SECTIONS ARE LOCATED FROM THE EXISTING GROUND SURFACE.
2. THE FENCE DIAGRAM IS DISPLAYED WITH A 3V:1H EXAGGERATION FOR CLARITY.

STRATA ENERGY	ROSS ISR PROJECT CROOK COUNTY, WY P.O. BOX 2318 GILLETTE, WY 82716
REVISIONS Date / Description	TECHNICAL REPORT FIGURE 2.6-8 ROSS PROJECT AREA GEOLOGIC FENCE DIAGRAM
FILE: ROSS_GEO_FENCE	Drawn By: RAM Checked By: BJS Date: 11/21/10 WWC ENGINEERING www.wwcengineering.com

K:\Peninsula_Minerals\09142\DWGS_WY83E\ROSS_ER_GEO_FENCE.dwg, TR_FIGURE_2.6-8, 12/18/2010 12:57:31 PM



SOIL MAP UNITS

AB	Absted very fine sandy loam	SH	Shingle clay loam
AS	Ascalon fine sandy loam	ST	Stetter
BI	Bidman loam	TA	Tassel fine sandy loam
CU	Cushman very fine sandy loam	TE	Terro sandy loam
FO	Forkwood loam	UL	Ulm
HA	Haverdad	UL-NC	Non-calc Ulm
LI	Limon	VO	Vona fine sandy loam
NU	Nunn clay loam	WATER	Water
		00●	Soil Sample Locations

LEGEND

PROPOSED ROSS PERMIT BOUNDARY

0 800 1600 3200

GRAPHIC SCALE (FEET)

Figure 2.6-9. Baseline Soils

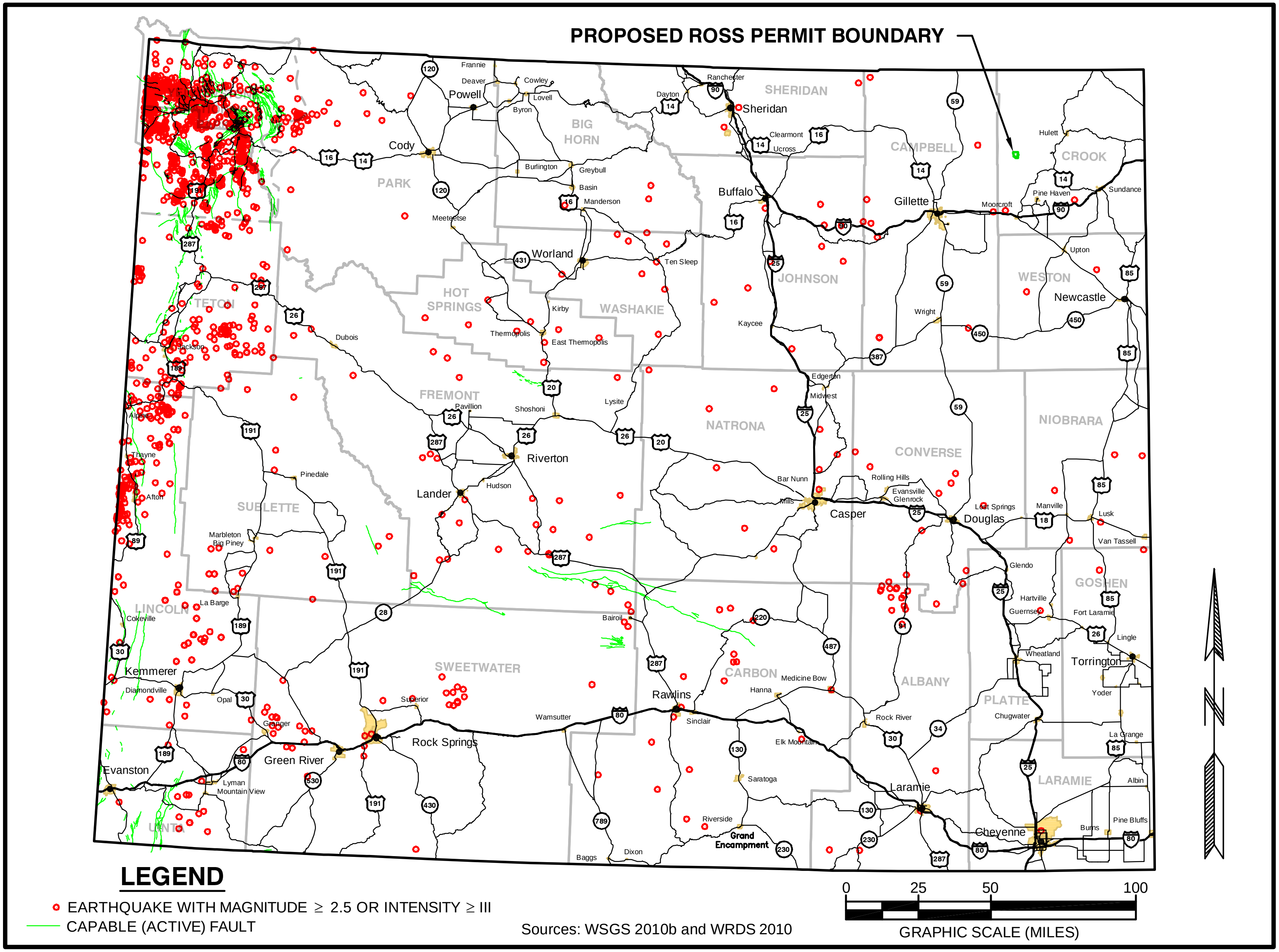


Figure 2.6-10. Historic Earthquakes in Wyoming

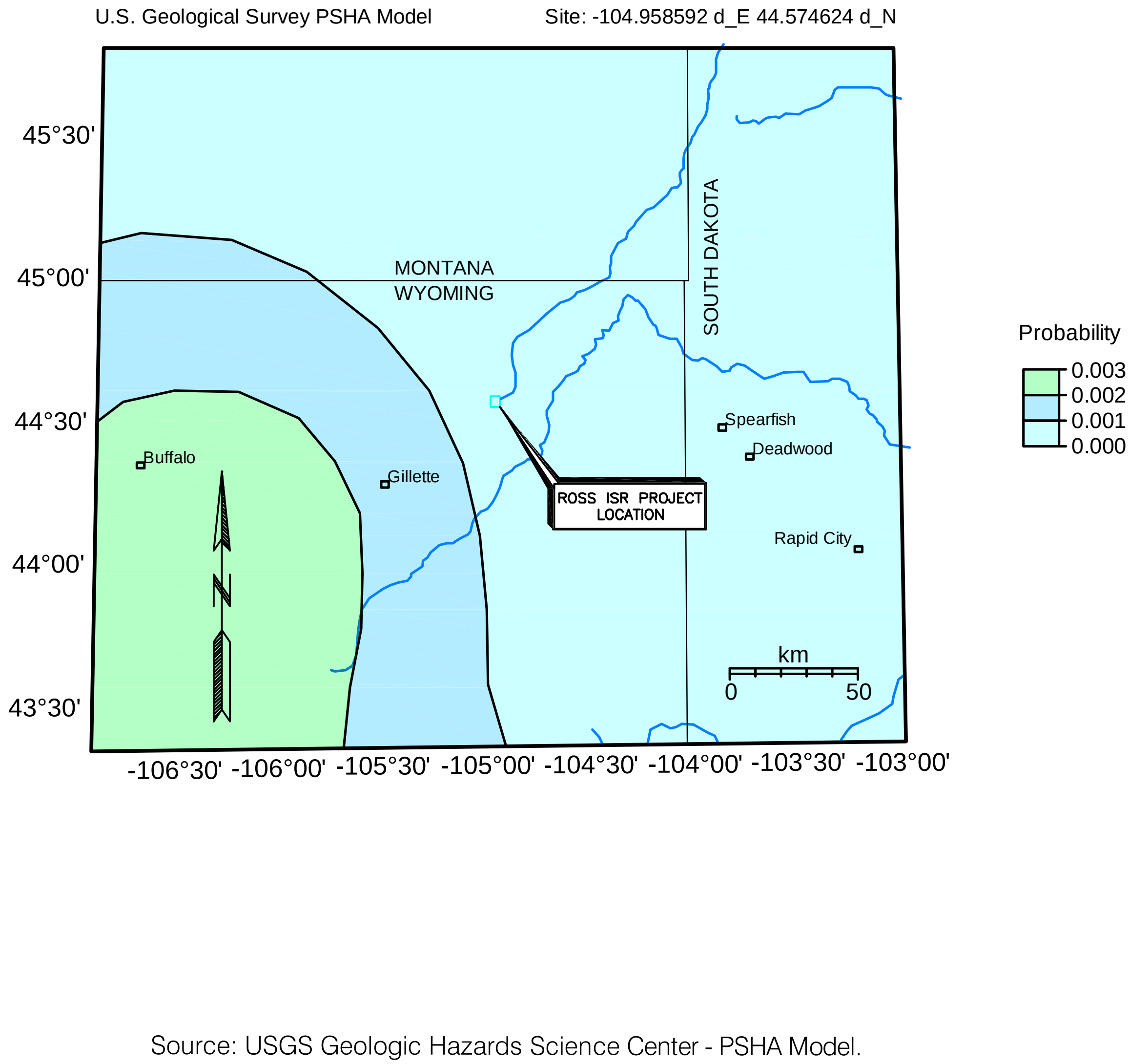
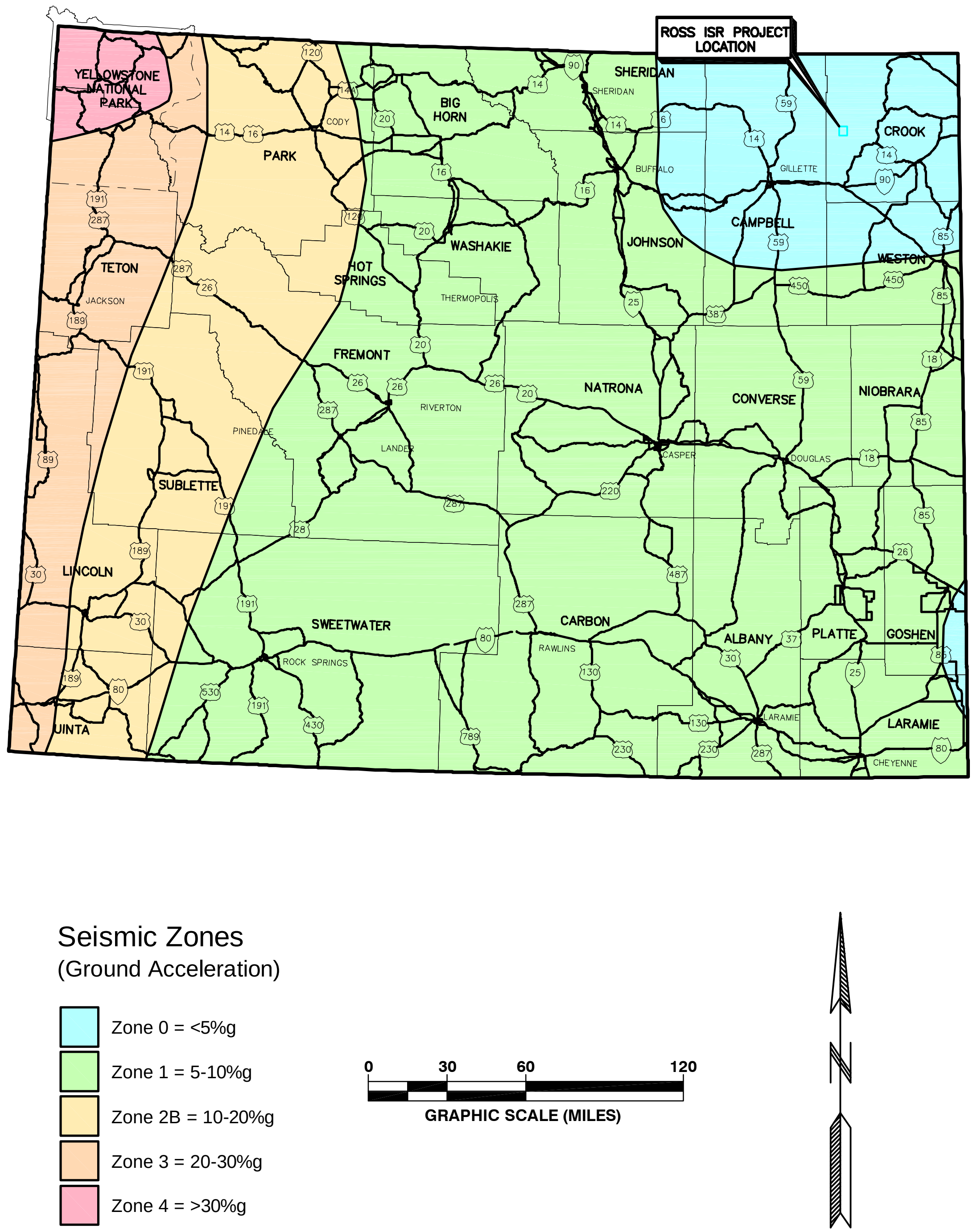


Figure 2.6-11. Probability of Earthquake with Magnitude ≥ 6.5 within 50 Years



Source: USGS Geologic Hazards Science Center - PSHA Model.

Figure 2.6-12. UBC Seismic Zone Map

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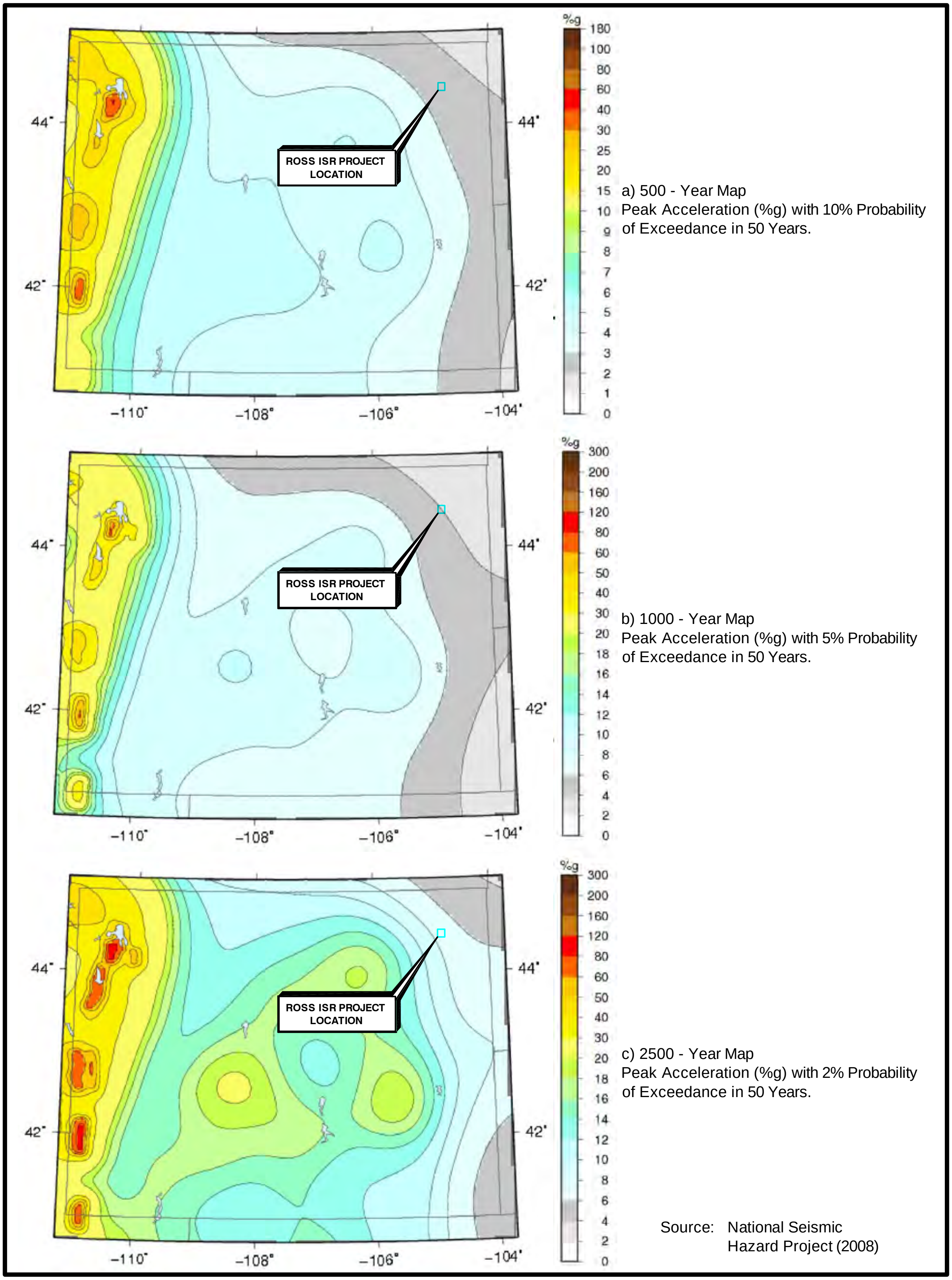


Figure 2.6-13. Seismic Hazard at the Proposed Project Area

2.7 Water Resources

The following sections describe the characterization of the hydrology at the Ross ISR Project in accordance with NUREG-1748 and NUREG-1569 (NRC 2003a and 2003b, respectively). These sections address surface water features, groundwater characteristics, and surface and groundwater quality.

2.7.1 Surface Water Hydrology

2.7.1.1 Regional Description

The Ross ISR Project is located in the upper reaches of the Little Missouri River Basin (Hydrologic Unit Code 101102). The Little Missouri River originates in northeastern Wyoming, flows through southeastern Montana, through northwestern South Dakota, and into North Dakota where it empties into the Missouri River at Lake Sakakawea. The total stream length is 405 miles, and the total drainage area is approximately 9,550 (USGS 2012) square miles. Figure 2.7-1 depicts the Little Missouri River Basin.

The proposed project area is located within the semi-arid West where evaporation exceeds annual precipitation. Evaporation and precipitation amounts for the site are discussed in Section 2.5. The area streams are in large part ephemeral, and flow only in direct response to snow melt and precipitation.

Five USGS gaging stations are located on the Little Missouri River downstream of the proposed project area (USGS 2010a). The mean annual discharge ranges from 77 cfs or 55,782 ac-ft/yr at the most upstream gaging station to 533 cfs or 386,130 ac-ft/yr at the most downstream gaging station (see Table 2.7-1). According to the University of Wyoming College of Agriculture (UW 2000), the average annual Little Missouri River discharge where it exits Wyoming is 31,000 ac-ft/yr (42.8 cfs).

Figure 2.7-2 displays the mean monthly discharge rate at the two nearest gaging stations, one of which is located in Montana and one in South Dakota. The discharge is typically lowest from November through January and highest during the months of March through June.

Table 2.7-2 presents the observed peak annual flows at the two nearest gaging stations. During the period of record for the Alzada, Montana gaging station the peak flow took place in April 1944 with an estimated discharge of

6,000 cfs. The peak flow at the Camp Crook, South Dakota gaging station took place in March 1978 with a flow of 9,420 cfs. The timing of these peak flows indicates that snow melt and spring run-off typically result in the highest flows for this portion of the Little Missouri River.

2.7.1.2 Drainage Basin Description

Surface water hydrology adjacent to and within the proposed project area is dominated by the northeastward flowing Little Missouri River and associated tributaries. The drainage basins are depicted on Figure 2.7-3. The drainage area of the Little Missouri River at the downstream boundary (Junction 10) of the proposed project area is approximately 18.2 square miles. Drainage basin geomorphology for the Little Missouri River and tributaries are presented in Table 2.7-3.

2.7.1.3 Surface Runoff Estimates

There are no long-term streamflow records within or adjacent to the proposed project area. Therefore, a U.S. Army Corps of Engineers (USACE) HEC-HMS model was developed to estimate the peaks and volumes of floods for various recurrence intervals within the proposed project area. This program was selected due to the size of the drainage area, the watershed routing functions offered by HEC-HMS, and the universal acceptance of HEC-HMS within the hydrologic sciences community. The HEC-HMS model uses a form of the NRCS (formerly SCS) Triangular Hydrograph Method, and is a parametric method of estimating flood peaks and runoff volumes from site-specific data, in addition to providing watershed routing parameters. The NRCS method was utilized for the evaluation of individual watershed hydrology, while the Muskingum method was used for routing procedures.

Procedures followed in applying these methods may be found in the HEC-HMS Users Manual (USACE 2001), HEC-HMS Technical Reference Manual (USACE 2000) and the U.S. Bureau of Reclamation Design of Small Dams (USBR 1977).

The precipitation values were determined from the National Oceanic and Atmospheric Administration (NOAA) Atlas No. 2 for Wyoming (Miller et al. 1973) and are presented in Table 2.7-4 for various return periods and frequencies. The runoff curve numbers were calculated by area-weighting the drainage basin soil types according to hydrologic soil group as determined from the soil

survey information obtained from the NRCS soil survey geographic database for Crook County, Wyoming. An antecedent moisture condition (AMC) of two (average) was used.

The input parameters and results of the HEC-HMS analyses can be found in Addendum 2.7-A, while the surface water runoff estimates are summarized in Table 2.7-5.

Miller (2003) regression equations were also applied to the watershed to compare peak discharge to the HEC-HMS analyses. Miller's equations were developed through the use of refined analytical techniques to interpret data from 364 selected continuous and partial-records streamflow gaging stations that were minimally influenced by anthropogenic activities and had at least 10 years of annual peak data. Instantaneous peak flow data through the year 2000 were also utilized in the analysis. The data were used to provide a correlation between flow and basin characteristics. The resulting information was transformed into regression equations that provide an analytical tool for estimating peak flow events where no gaging data are available. The regression calculations are shown in Addendum 2.7-B. A comparison of peak flow estimates using the method of Miller and HEC-HMS for the Little Missouri River where it exits within the proposed project area is provided in Table 2.7-6. The HEC-HMS peak flow estimates are higher than the estimates using Miller's method due in part to existing reservoirs. The Miller method is based on empirical measurements of Wyoming streams, most of which are affected by existing reservoirs. Flood inundation was calculated using the conservatively higher peak flow estimates obtained from the HEC-HMS model.

2.7.1.4 Flood Inundation Study

Peak flood levels were modeled for stream channels within the proposed project area during the 100-yr, 24-hr storm event. Cross sections were first generated at the upper and lower ends of the main stream channels within the proposed project area. Additional cross sections were added near various confluence points along the Little Missouri River within the proposed project area. Longitudinal profiles were then generated for the major channels. Cross sections and profiles were developed from the light detection and ranging (LiDAR) aerial flight topography data collected by Aero-Graphics of Salt Lake City. Then using the peak runoff values calculated from the HEC-HMS model, Manning's equation was used to estimate the peak flow depth at each cross

section. The calculated flow depths were then averaged throughout the length of the channel, and used to generate the inundation surface shown in Figure 2.7-4. The cross sections, cross section locations, channel profiles, and flow depths are provided in Addendum 2.7-C. A Manning's n of 0.030 was used in the evaluation. Cowan's method (Chow 1959), which accounts for channel materials, irregularity, cross section variance, obstructions, vegetation, and meandering, was used to estimate Manning's n.

The Oshoto Reservoir was included in the HEC-HMS model and was assumed to be full prior to the start of the 100-yr, 24-hr storm event. The storm was then routed through the reservoir and the back water during this event was used as the inundation boundary.

Flooding will be routed around the facilities area by the construction of a diversion channel, which is described in Section 3.1.9. Flood and erosion protection for the wellfields are also described in Section 3.1.9 of the TR.

2.7.1.5 Surface Water Use

A surface water rights search was completed within the proposed project area and adjacent 2 miles using the WSEO database (WSEO 2010). The search of the database indicates that 43 surface water rights exist within and adjacent to the proposed project area. A summary of each right is presented in Table 2.7-7 and shown on Figure 2.7-5. In addition to the permitted surface water rights there are at least 17 additional reservoirs within or adjacent to the permit that could not be found in the WSEO water rights database. The table shows that nearly half of the permits have been cancelled, while the remaining permits are complete, fully adjudicated, or unadjudicated.

Surface water within the proposed project area and surrounding 2-mile area is primarily used for livestock watering, with lesser amounts used for irrigation and industrial uses (primarily as a temporary water supply for oil and gas construction activities). The number and age of surface water rights provide insight into the historical water and land use in the area. Stock reservoirs account for about half of the total water rights in the search area, but if cancelled rights are neglected and stock reservoirs not listed in the WSEO database are included, the proportion climbs to about 90%. Most of the stock reservoirs were constructed before 1970 with the majority still in use today. Irrigation water rights only account for a relatively small portion (less than 10%) of the surface water rights. All of the irrigation rights were permitted

50 to 100 years ago for relatively small areas (70 acres or less). One water right for the Nubeth R&D facility evaporation reservoir signified the rise of uranium exploration in the late 1970s. Following this, there were some 15 temporary water haul permits for oil and gas activities from 1980 to 1991. Finally, the two most recent water rights were appropriated by Strata for exploration activities associated with the proposed Ross ISR Project.

2.7.1.6 Surface Water Features

The surface water features located within the proposed project area are depicted on Figure 2.7-6 and consist of several reservoirs and minor stream channels. Oshoto Reservoir (WSEO Permit No. P6046R) is the main hydrologic feature. It is located in the channel of the Little Missouri River. The only potential springs identified within the proposed project area are associated with field delineated wetlands (see Section 2.7.2.2 in this TR) or with the Little Missouri River in the vicinity of the Oshoto Reservoir (see Section 2.7.1.7.1 in this TR). Although several springs were identified on the USGS 7.5-minute topographic quadrangles covering the groundwater model domain, their locations are more than 0.5 mile from the proposed project area and their presence was therefore not verified. The closest springs or seeps that are believed to be in hydrologic communication with the ore zone aquifer at the proposed project area occur at the Lance/Fox Hills outcrop approximately 7 miles north of the site. These features are shown and discussed in more detail in Addendum 2.7-H.

2.7.1.6.1 Surface Water Monitoring Network

A surface water monitoring network was implemented to characterize surface water quantity and quality in the potentially affected area in accordance with requirements established by federal and state regulations and guidelines. The network was designed to monitor the major drainages, identify any unique hydrologic features within the proposed project area and establish baseline surface water quality.

2.7.1.6.2 Surface Water Monitoring Stations

Strata established three surface water monitoring stations within the proposed project area in March 2010. The sites were identified during a preliminary field investigation. Criteria for each station location included: 1) straight reach of stream channel, 2) proximity of the channel to an elevated

bank that has a fairly steep grade; this ensured the instruments were placed at a location where they would not be flooded, 3) the distance from the center of the channel to the instruments had to be less than 50 feet due to sensor cable length constraints, and 4) submerged channel reaches (pools) were avoided.

The stations were located at two sites on the Little Missouri River and one site on Deadman Creek, tributary to Little Missouri River. The locations of the monitoring stations are depicted on Figure 2.7-7. Station locations are summarized in Table 2.7-8.

In June 2010, Strata installed continuous stage recorders and pump samplers at each station. The stage recorders are designed to continuously measure discharge and are integrated with designated pump samplers. During installation of each stage recorder the cross section and profile of the stream channel at each station was surveyed. The survey data were used to develop a rating curve, which was programmed into the flow/sampler instrument to calculate flow rates. The pump samplers were installed to collect water quality samples during runoff events. Each pump sampler was initiated by flow stage at each station based on stream geomorphology. The water sample was automatically collected in a single container located in the instrument. Following the runoff event the water was manually transferred from the container to sample bottles and submitted to the contract laboratory for analysis.

2.7.1.6.3 Surface Water Quantity

The average and peak daily flow rates for the surface water monitoring stations are presented in Figures 2.7-8 and 2.7-9, respectively. The three surface water monitoring stations were operated continuously from June 15 to September 25, 2010. Although not decommissioned for the winter until November 2, 1010, the batteries failed and no data were recovered between September 26 and November 2, 1010. Following is a description of the surface water flows measured at the three monitoring stations.

The continuous stage recorder at SW-1 (Little Missouri River, downstream) recorded continuous flow from June 15, 2010 (the first day of continuous monitoring) through August 8, 2010. During this time the average daily flow rate ranged from 0.00 to 0.56 cfs and averaged 0.30 cfs. The peak daily flow rate during the same time interval ranged from 0.00 to 0.94 cfs and averaged 0.38 cfs. The maximum flow corresponded with a late June

precipitation event that was also observed at SW-2 and SW-3. When the 1Q10 water sample was collected from SW-1 (March 9, 2010), the flow rate was estimated at 2.5 cfs and the source of the flow was believed to be snow melt. During the 2Q10 water sample event (April 13, 2010), the flow rate had reduced to an estimated 0.25 cfs. No flow was recorded at SW-1 from August 9 through September 25, 2010.

SW-2 (Little Missouri River, upstream) was generally dry during the June 15 through September 25 time interval during which the continuous stage recorder was operated. One small flow event was recorded between June 23 and June 25. During this flow event, the average daily flow rate ranged from 0.01 to 0.63 cfs and the flow peaked at 2.5 cfs on June 24. Two other minor flow events registered at SW-2. The peak flow measured on July 6 was 0.02 cfs, and the peak flow on August 3 was 0.01 cfs. These flow events were short enough in duration that the average daily flow on these two days was 0.00 cfs. On March 9, the flow rate at SW-2 was estimated at 2.5 cfs, and on April 13 it was estimated at 0.25 cfs.

SW-3 (Deadman Creek) was dry during continuous stage recording except for the late June precipitation event. Between June 23 and June 25 the daily flow rate averaged 0.01 to 0.09 cfs and peaked at 0.20 cfs on June 24. The estimated March 9 and April 13 flow rates at SW-3 were 1.5 and 0.25, respectively.

The results of the monitoring indicate that where the streams flow into the proposed project area (SW-2, SW-3) flow is only in response to snow melt or precipitation events, indicating that both the Little Missouri and Deadman Creek at the upstream proposed permit boundary are ephemeral. The other minor tributaries within the proposed project area are also ephemeral, since no discharges other than in responses to snow melt or precipitation events were observed. The Little Missouri at the downstream proposed permit boundary (SW-1) does have flow for an extended period of the year. This is downstream of the Oshoto Reservoir. Figure 2.7-10 shows the average daily flow observed at SW-1 in relationship to the water surface elevation in Oshoto Reservoir. There appears to be some correlation between the increased flow in the Little Missouri River downstream of Oshoto Reservoir and the amount of head in the reservoir. This would indicate that some of the flow could be attributed to the stored capacity in Oshoto Reservoir. It appears that directly downstream of the

reservoir the Little Missouri River is intermittent. Stream classification is depicted on Figure 2.7-6.

2.7.1.6.4 Reservoirs

In addition to the surface water monitoring stations, Strata identified 12 existing reservoirs within or just outside the proposed project area using aerial photography, WSEO permits, and landowner interviews. Information about reservoir capacities and use is presented in Table 2.7-9. The reservoirs are depicted in Figure 2.7-6. Oshoto Reservoir (WSEO Permit No. P6046R) is the main hydrologic feature within the proposed project area. It is located in the channel of the Little Missouri River and was constructed by a compacted earth fill embankment across the channel. All other reservoirs are relatively small. Most have maximum capacities less than 2 ac-ft, and all have maximum capacities less than 10 ac-ft. As discussed previously, Oshoto Reservoir has potential to affect streamflow characteristics downstream of the reservoir. Also, based on the relationship between reservoir stage and surficial aquifer (SA) monitoring well water levels, the reservoir stage appears to influence water table elevations in its proximity (see Section 2.7.3.3.5.4).

2.7.1.7 Surface Water Quality

The surface water monitoring network included the collection of water quality samples from surface water monitoring stations and existing reservoirs. The surface water quality analysis results are reported in a format consistent with WDEQ/LQD Uranium Mining Data Submission Spreadsheets. The following sections provide a summary of the monitoring results, while complete results are included in Addendum 2.7-D, and the lab data are provided in Addendum 2.7-E.

2.7.1.7.1 Surface Water Monitoring Stations

All streams within the proposed project area, including the Little Missouri River and Deadman Creek, are classified by WDEQ/WQD as 3B streams. A Class 3B stream is defined by the WDEQ/WQD as an intermittent or ephemeral stream incapable of supporting fish populations or drinking water supplies. About 40 miles below the project the Little Missouri River becomes a class 2ABWW stream at its confluence with Government Canyon Creek. This classification signifies that it is protected as a drinking water source (2AB) and

warm-water (WW) fishery. Table 2.7-10 presents the use designations for the various surface water classifications in Wyoming streams.

Surface water sample collection began in March 2010 at the three stations described above and continued quarterly through 2010. Samples were collected in bottles provided by the contract laboratory and analyzed for constituents listed in Table 2.7-11.

Samples collected at the three surface water monitoring stations indicate that the quality of surface water within the proposed project area is relatively consistent from one sample location to the next and at different times during the year. Monitoring results from the surface water stations are summarized in Table 2.7-12, while a piper diagram of the average major ion chemistry for each station is presented in Figure 2.7-11.

The results indicate that TDS concentrations in the Little Missouri River and Deadman Creek are low to moderate, ranging from 220 mg/L to 940 mg/L. The water type of both streams is sodium bicarbonate, which is uncommon in Wyoming streams. Streams originating in the lowlands are typically dominated by sodium sulfate, while mountain streams are generally calcium bicarbonate (Miller et. al. 2004). Since streams are influenced by the geologic formations through which they flow, the results were compared to the surficial aquifer (SA zone) wells constructed by Strata as part of the regional baseline monitor well network. The results confirmed that water quality in the SA zone wells was similar to the surface water in the Little Missouri River and Deadman Creek. This indicates that there is potential communication between surface and shallow groundwater in the proposed project area.

Metal and radionuclide concentrations measured at the surface water monitoring stations were near or below detection limits, with the exception of uranium. Concentrations of uranium above the detection limit of 0.001 mg/L were measured at all three stations. Overall, the concentrations were the highest in the 2nd quarter 2010 when discharge rates in the streams were very low.

2.7.1.7.2 Reservoirs

Strata began reservoir sampling in the 3rd quarter 2009. Samples were collected on a quarterly basis through the 4th quarter 2010, when possible (i.e., when the reservoirs were not dry or frozen and when Strata had landowner permission). Reservoir samples were collected with a telescoping

dipper and transferred to sample bottles provided by the contract laboratory. Samples analyzed for dissolved constituents were filtered and preserved in the field. Table 2.7-13 provides the sample history for each reservoir.

The water quality in the reservoirs sampled within the proposed project area varied significantly. The water quality analytical results, summarized in Table 2.7-14, indicate that reservoirs constructed on the channel of the Little Missouri River and Deadman Creek had increased salinity and hardness compared to more upland reservoirs. The water quality within the main channel reservoirs was similar to that of the surface water monitoring stations. The remaining reservoirs, located away from the main channels, contained water with lower TDS. The water in all reservoirs was mildly to moderately basic, with pH generally ranging from 8 to 10 standard units.

The major ion chemistry of the water contained in each reservoir is depicted in Figure 2.7-12. The figure shows that water within the reservoirs located on Deadman Creek and the Little Missouri River (R-2 and R-6 through R-10) contained sodium bicarbonate type water, while the water type in the remaining reservoirs located in the uplands was sodium/calcium or calcium/bicarbonate. Upland reservoir R-11 receives overflow from a stock well and has sodium bicarbonate type water quality.

Total metals and radionuclide concentrations were low to undetectable for all reservoirs. The highest concentrations of uranium were measured in the reservoirs located along the Little Missouri River and Deadman Creek. Concentrations were similar to those measured at surface water monitoring stations. Few radiological constituents were measured above the detection limit. Reservoirs R-1 and R-10 measured Pb-210, while Ra-226 was detected in all but four reservoirs.

2.7.1.8 WYPDES Outfalls

Upstream from the proposed project area there are two WYPDES permitted outfalls (permit numbers WY0044296 and WY0033065). Downstream from the proposed project area there is one WYPDES outfall (permit number WY0034592). All three permits are associated with oil production facilities. The discharge points are shown in Figure 2.7-3. The facility names and operators of these permits are shown in Table 2.7-15, while the effluent limits are presented in Table 2.7-16. The effluent limits were updated when all three permits were renewed in 2009. Prior to 2009, monitoring was required for oil and grease, chloride, Ra-226 and flow rate. Following the permit renewals WDEQ/WQD updated the permitting

requirements to include pH, EC, and sulfate. Additionally, the effluent limit for chloride was revised from 230 to 2,000 mg/L.

Discharge monitoring reports from 2007 through 2009 are summarized in Table 2.7-17 for the three WYPDES-permitted outfalls. Discharge rates from the outfalls are relatively low (0 – 0.04 MGD). Chloride and Ra-226 concentrations were below permit limits. The radium levels were generally above the EPA MCL of 5 pCi/L, but drinking water standards are not applicable to these discharges. In addition, some samples from permits WY0034592 and WY0033065 exceeded the oil and grease limit. Sulfate and EC concentrations were reported for permit WY0044296 in 2009. The results indicate that these parameters are below the WDEQ/WQD permitted limits.

2.7.2 Wetlands

Projects that discharge dredge or fill material into Waters of the U.S. (WoUS), including special aquatic sites and jurisdictional wetlands, require accurate identification of wetland boundaries for the Section 404 of the Clean Water Act (CWA) permitting process. Through the Section 404 permitting process, the USACE can authorize dredge or fill activities by issuance of a standard individual permit, nationwide permit, or regional permit. The USACE makes the determination on what type of permit is needed. Construction, operation, or reclamation activities that cause disturbance or impacts to jurisdictional wetlands within the proposed project area will likely be performed in accordance with an appropriate Nationwide Permit (NWP). Possible applicable NWPs include:

- NWP 12 (utility line activities);
- NWP 14 (linear transportation projects); and
- NWP 44 (non-coal mining activities).

NWP 12, NWP 14, and NWP 44 activities cannot result in the loss of greater than 0.5 acre of WoUS per NWP permit. Impacts to Other Waters of the U.S. are not considered under the acreage limit. Final determination of jurisdictional decision lies with the USACE.

2.7.2.1 Wetland Survey Methodology

The initial step of the wetland survey was to obtain and review all pertinent, available environmental information within the proposed project

area. Existing data included USDA-NRCS soil mapping (NRCS 2010), U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) mapping (USFWS 2010), and May 2010 aerial photography. All sources of information provided relevant information on the potential occurrence and distribution of wetlands. Wetland determination sites identified in this initial step, including all NWI mapped wetland areas, were visited during the field investigation to verify if wetland characteristics were present.

Site-specific field investigations were conducted within the proposed project area by John Berry of WWC Engineering (WWC) on June 22 and 28 and July 8 and 21, 2010 in accordance with the Interim Regional Supplement to the U.S. Army Corps of Engineer's Wetland Delineation Manual: Great Plains Region (USACE 2008). Wetland determination sites were examined for hydrophytic vegetation, hydric soils, and wetland hydrology during the June and July 2010 field investigations. The locations of sample sites were determined during on-site visits to obtain the most relevant and optimal information possible. Initial assessments at each sample site began with a vegetative cover inventory. The *North American Range Plants Field Guide-Fifth Edition* (Stubbendieck et al. 1997) and the *Western Wetland Flora Field Office Guide to Plant Species* (USDA-NRCS 1988) were used to assist in vegetation species identification. Vegetative species indicator status, with respect to wetland or non-wetland, was recorded along with its percent composition within the sample area. The indicator status was obtained using the National List of Plant Species that Occur in Wetlands: Region 4 (Resource Management Group, Inc. 1994). Where possible, soil observation pits were dug to a depth of 20 inches. A Munsell Color Chart (Kollmorgan Corporation 1975) was used to record soil color, texture, and other distinguishing characteristics for each sample site. Wetland hydrology indicators were assessed. Each sample point was assessed and recorded on a site-specific wetland determination field form.

A Trimble® GeoXH GPS unit was used to delineate the boundaries of the potential wetland areas. This GPS unit is accurate to ±1 meter. Portions of the boundaries of the larger delineated areas were determined by observing distinctions in vegetation and hydrology, although soils were examined at varying intervals along the boundaries to verify the ocular delineations. Due to the similarities between potential wetland areas, it was not considered necessary to complete wetland determinations forms for all areas. Addendum 3.4-A of the ER contains photos of potential wetland areas.

The shallow, open water type was delineated using recent (May 2010) high quality aerial photography to determine areas with no apparent emergent, floating, or submergent vegetation. Other Waters of the U.S. were determined using USGS 1:24,000 quadrangle maps. Drainages (dashed lines adjusted to fit the aerial photography) were delineated as Other Waters of the U.S. if not delineated as a wetland type.

2.7.2.2 Wetland Survey Results

Table 2.7-18 and Figure 2.7-13 depict the wetland survey results. The complete wetland survey results, photographs, and correspondence with the USACE are provided in Addenda 3.4-A and 3.4-B of the ER. The 13 wetland sites indicated on the NWI mapping within the proposed project area were investigated during the 2010 field surveys. All but two of these NWI areas were included in field delineated wetlands (Figure 2.7-13). The two sites not included did not have the three characteristics for wetlands. Many of the potential wetland areas delineated during the 2010 field surveys were small (<0.1 acre) depressions that were in close proximity to each other but were distinct depressions separated by upland vegetation. A significant number of these small depression areas appeared to be influenced by groundwater, receiving seepage from the Lance Formation, which outcrops in the area.

The potential wetland areas were classified according to Cowardin et al. (1979) to more accurately describe the types of potential wetlands present within the proposed project area (Figure 2.7-13 and Table 2.7-18). Most (approximately 93%) of the potential wetland areas were man-made (diked or excavated). The vast majority of these were preliminarily classified as Palustrine, Aquatic Bed, Seasonally Flooded, Diked (PABFh). Of the areas designated as PABFh, about half were areas of open water. There were approximately 5.1 acres (22,130 linear feet x average 10-foot wide channel) of Other Waters of the U.S. identified within the proposed project area (see Figure 2.7-13).

2.7.2.2.1 Wetland Delineation and Jurisdictional Determination

A wetlands delineation report for the proposed project area was submitted to the USACE, Omaha District in Cheyenne, Wyoming in September 2010. A copy of the report is included in Addendum 3.4-A of the ER.

The USACE verification letter will be provided to NRC and WDEQ/LQD when available.

USACE jurisdictional determination of specific wetland areas will not occur until Strata applies for coverage under an appropriate NWP for specific construction activities such as pipeline installation and access road stream channel crossings. At that time, Strata will provide a site-specific mitigation plan for disturbance of jurisdictional wetlands.

2.7.3 Groundwater

This section presents a synopsis of the regional and local hydrostratigraphy, including the direction of groundwater flow and recharge/discharge characteristics. Information on the local groundwater uses, hydraulic characteristics and groundwater quality in the vicinity of the proposed Ross Project area is also presented in detail within this section. Comprehensive information on the regional and local geology, particularly structure and stratigraphy, is presented in Section 2.6.

2.7.3.1 Regional Hydrogeology

The proposed Ross ISR Project area is located on the eastern margin of the Powder River Basin and the western margin of the Black Hills Uplift. This discussion will focus on the eastern Powder River Basin. In the vicinity of the proposed project area, rocks of Upper Cretaceous age are exposed. East of the proposed project area, older rocks through Mississippian age are exposed along the western flank of the Black Hills Uplift. Quaternary-age deposits of unconsolidated alluvium and colluvium are also present. In addition to saturated alluvium and colluvium, there are a number of water-bearing bedrock strata present in the eastern Powder River Basin, ranging in age from Precambrian to Paleocene. Near the Black Hills uplift, Paleozoic strata dip rather steeply into the basin, so water supply wells completed within these rocks are typically near the outcrop. Table 2.7-19 presents the hydrostratigraphic relationships of the strata occurring in the eastern Powder River Basin.

Due to lack of major surface water sources, municipalities within the northeast corner of Wyoming rely on groundwater. Regionally, there are a number of water-bearing intervals exploited by municipalities and industrial users, depending on location. In the vicinity of the Black Hills Uplift, the

principal aquifer for municipalities is the Mississippian Madison Limestone. The city of Gillette operates a wellfield consisting of 10 wells north of the town of Moorcroft. The water is piped some 40 miles to Gillette and blended with locally-produced groundwater from the Fort Union Formation and to a lesser degree from wells completed in the Lance and Fox Hills formations. Other towns in the vicinity (Moorcroft, Sundance, Upton, Newcastle, and Hulett) utilize the Madison for municipal supply (WWDC 2010). In the vicinity of Gillette, the Fox Hills and Lance formations are typically targeted by industrial users, while smaller municipalities, subdivisions and improvement districts use wells completed within the shallower Fort Union Formation.

Regionally, recharge occurs in the outcrop areas, with groundwater moving away from the outcrop in the form of underflow through artesian aquifers, and is transmitted westward into the Powder River Basin (Whitcomb and Morris 1964). Due to the geologic dip of the strata, horizons that are accessible near the Black Hills Uplift are deeply buried in the basin center. The quality of groundwater from the Mesozoic and Tertiary formations of the Powder River structural basin (e.g., the Upper Cretaceous Lance and Fox Hills formations and the Tertiary Fort Union and Wasatch formations), like other intermontane basins in Wyoming, tends to deteriorate with increasing distance from recharge areas and with increasing depth below land surface (Mason and Miller 2005). In general, the longer water is in contact with rocks, the more mineralized it becomes (Langford 1964). Dissolved solids concentrations increase with depth and distance from the recharge sources.

2.7.3.2 Site Hydrogeology

2.7.3.2.1 Introduction

The proposed project area is situated on the Lance Formation outcrop. With the exception of the recent alluvium located in the valley floors of the Little Missouri River and Deadman Creek, and a small portion of Fox Hills Formation in the extreme eastern portion of the proposed project area, the entire proposed Ross ISR Project area is located on the Lance Formation outcrop. Underlying the Lance Formation is the Fox Hills Formation and the Pierre Shale. The Pierre Shale is a thick marine shale that yields very little water and is considered regionally as a confining unit (Langford 1964). The Fox Hills Formation is a sequence of marginal marine to estuarine sand deposits that were deposited during the eastward regression of the Upper Cretaceous Interior Seaway. In the Ross area, the Fox Hills Formation consists of an upper (FH horizon) and a lower unit (FS/BFS horizons) separated by 10 to 50 feet of

intervening shale, claystone and mudstone (BFH horizon). The FS and BFS sandstone units consist of offshore-marine and transitional-marine shale, siltstone, and fine grained sandstone and are not known to contain uranium. The FH horizon sand consists of uranium-bearing, organic, thinly-bedded claystone, siltstone, and sandstone (Dodge and Spencer 1977). Within the proposed project area, mineralization primarily occurs within the FH horizon

sand, although in localized areas mineralization occurs within the overlying Lance interval (LT horizon) sandstone.

2.7.3.2.2 Monitoring/Testing Program

The Ross ISR Project regional baseline groundwater monitoring program consists of six monitoring well clusters located across the proposed project area as shown on Figure 2.7-14. The six well clusters consist of at least four wells, each completed in a separate, consistent stratigraphic horizon intended to provide a portion of the data necessary for hydrogeologic characterization of the proposed Ross ISR Project area. The horizons/zones monitored consist of (beginning with the deepest): 1) the BFS horizon sandstone, operationally termed the deep monitor or DM unit; 2) the FH/LT horizon ore-bearing sandstone, operationally termed the ore zone or OZ unit; 3) overlying the ore zone is a persistent confining unit (LC horizon aquitard or Upper Confining Unit) 20 to 80 feet thick, and above this confining unit are the LM through LK horizon sandstones, operationally termed the shallow monitoring or SM unit; and 4) the surficial water table aquifer is operationally termed the SA unit. The DM and SM units will monitor vertical isolation of the ore zone.

The location of the monitoring well clusters was based on a number of factors, including:

- Regulatory considerations (as detailed in WDEQ/LQD Guideline 4, In Situ Mining, WDEQ/LQD Guideline 8, Hydrology, WDEQ/WQD Chapter 8, and NRC Regulatory Guide 4.14),
- Consistent/continuous water-bearing interval above and below mineralization,
- Satisfactory thickness of confining intervals,
- Proximity to existing drilling data, and
- Landowner considerations, including minimization of surface disturbance and access to sufficient aerial coverage to develop potentiometric surfaces of aquifers for characterization, to characterize spatial (both horizontally and vertically) variations in water quality.

Completion details of the wells used in the monitoring program are presented in Table 2.7-20.

Each well cluster is depicted in detail on Figures 2.7-15 through 2.7-20. Each of these figures shows the distances between wells and a cluster type log

with respective completion intervals and water level elevations. Geologic cross sections A-A' through F-F' (excepting E-E') are drawn through each of the six well clusters (see Addendum 2.6-C).

All baseline monitoring wells were constructed using conventional mud-rotary drilling techniques. At each of the six well clusters a 6¼-inch diameter pilot was drilled to a depth through the DM interval, and geophysical logs consisting of natural gamma ray (GR), resistivity (R), and spontaneous potential (SP) were acquired. Following logging, the target completion intervals for the deep monitor (DM), ore zone (OZ), shallow monitor (SM), and surficial aquifer (SA) were selected. This information was used to ensure that the regional baseline monitor wells did not over-penetrate beneath the target zone.

Each well consisted of a pilot hole drilled to the top of the target interval and reamed to 8¾ inches to allow installation of casing and screen assembly. The wells were constructed with 5-inch diameter, SDR-17 PVC well casing. PVC well centralizers were placed at 60-foot intervals to the top of the target aquifer interval. The annular space between the casing and the borehole wall was then filled with cement slurry consisting of a 14.8 to 15.0 pounds per gallon mixture of Type I cement and 2% bentonite, using positive displacement to fill the annular space from the bottom to the ground surface. After allowing the cement to cure for at least 72 hours the target intervals were underreamed to 7 inches in diameter across the entire aquifer interval. The underream intervals were again logged with a caliper tool to verify the integrity of the target interval for accepting the screen assembly and sand pack material.

The intake interval consists of 3-inch diameter, 0.010-inch slot rod-based PVC V-wire well screen with a 10-20 silica sand filter pack. Following filter pack placement, air-lift development was conducted until turbidity readings stabilized. The wells were again logged to assess the completeness of the filter pack installation. Section 3.1 includes a detailed description of well construction materials, methods, development and integrity testing. Figures 3.1-4 through 3.1-6 depict the typical monitoring well completions employed by Strata.

Dedicated submersible pumps, sounding tubes and recording pressure transducers were installed in the SM, OZ and DM wells to expedite groundwater sample collection and document groundwater elevations. Well completion data are presented in Table 2.7-20. Well locations and measuring point elevations were surveyed by Bearlodge Engineering (Sundance, Wyoming)

under the direction of a Wyoming Professional Land Surveyor. Initial and quarterly water levels are manually measured with a Waterline™ water level indicator with accuracy to ± 0.01 ft.

In July 2010 an aquifer pumping test was conducted at each well cluster, with two tests conducted at the 12-18 well cluster. The details of the aquifer testing program are presented in Addendum 2.7-F. The test results are summarized in Table 2.7-21. Detailed information about the hydraulic properties of the aquifer and confining units are included in the groundwater model (Addendum 2.7-H).

2.7.3.2.3 Hydrostratigraphy

A detailed discussion of the stratigraphy within the proposed Ross ISR Project area is presented in Section 2.6. Table 2.7-22 presents the relationships between the areal geologic formation, the proposed Ross ISR Project stratigraphic horizon/unit, the aquifer/confining unit nomenclature, and the seven layers that are contained in the groundwater model (Addendum 2.7-H). A description of each of the various aquifer/confining units, in ascending order, follows.

Pierre Shale

The Pierre Shale is roughly 2,200 feet thick in the proposed project area. Locally, the Pierre Shale is relatively uniform and void of any water-bearing strata. Site-specific hydraulic conductivity tests have not been performed for the Pierre Shale, but vertical hydraulic conductivity has been estimated on the order of 2.6×10^{-10} to 2.6×10^{-9} ft/day by Neuzil (1993) outside of the region. Other estimates of the vertical hydraulic conductivity outside of the region for the Pierre Shale are in the range of 5×10^{-8} to 5×10^{-4} ft/day (Kansas Geological Survey 1991). The Pierre Shale is described as a regional aquitard in the literature (e.g., Langford 1964, Domenico and Swartz 1990) and in the Ross area. On the east side of the proposed project area, the Pierre Shale outcrop marks the eastern extent the overlying Ross area aquifers. No wells are known to be completed within the Pierre Shale within the proposed project area.

Fox Hills Formation Aquifers

Within the proposed project area, the water-bearing sandstone intervals within the Fox Hills Formation consists of the FH, BFS and FS horizons. The BFS and FS sandstone horizons are separated by interbedded shales and silts and represent the only water-bearing strata within the lower Fox Hills Formation. Both sand units are believed to be continuous throughout the proposed project area, although in places they are relatively thin. The BFS

horizon is the nearest aquifer below the uranium-bearing sandstone (the FH horizon) in the upper Fox Hills Formation, and in terms of ISR uranium recovery operations it is referred to as the deep monitoring zone, or DM interval. The DM unit is separated from the FH sand by 10 to 50 feet of shale, claystone and mudstone. The DM unit is deeply confined, with confining heads ranging from 320 to 430 feet across the proposed project area. The upper Fox Hills mineralized zone is the FH horizon and is the lower portion of the ore zone aquifer, or what is referred to herein as the OZ monitoring interval/unit. The hydrostatic heads in the DM unit are lower than the OZ heads in some locations and higher than the OZ heads in others, but remain in close proximity across the proposed project area. Aquifer tests performed in July 2010 indicate that the DM interval is generally isolated from overlying water-bearing units. Furthermore, the water quality in the DM unit compared to that in the overlying OZ unit is distinctly different, supporting hydraulic isolation of the DM unit from overlying units. No aquifer tests have specifically been performed to determine the hydraulic conductivity of the DM unit (or BFS sandstone horizon). Based on the exceedingly low rate of recovery of the DM wells following pumping to obtain water quality samples (see DM hydrograph analysis in Addendum 2.7-G), the hydraulic conductivity of the DM zone is much lower than that of the overlying OZ units. Due to the thickness (10 to 50 feet) of the shale, claystone and mudstone interval (BFH horizon) separating the DM unit from the FH horizon, this low permeability unit is considered to be a confining interval. The BFH interval is also referred to as the basal Fox Hills Lower Confining Unit. Although vertical hydraulic conductivities are not available for this basal confining shale aquitard, vertical hydraulic conductivity is expected to be comparable to that of the Pierre Shale, i.e., 5×10^{-4} ft/day or less.

The FH horizon sandstones within the upper Fox Hills Formation contain uranium and are the primary uranium recovery target of the Ross ISR Project. The ore zone comprises these sandstones along with the overlying lower Lance Formation sandstones (LT horizon). Monitor wells have been installed in this saturated interval, which demonstrates hydraulic continuity and is referred to as the ore zone aquifer, or the OZ monitoring interval. The thickness and lithologies of the FH sandstones can vary significantly over short distances. As described in Section 2.6, the upper Fox Hills Formation ranges from thick-bedded, blocky sandstones to thin, interbedded sandstones, siltstones and shales. Within the proposed project area the gross sand thickness of the Fox

Hills Formation is approximately 150 feet, although local variations of up to 50 feet or more are not unusual. The FH sandstones, shales, and silts have been studied extensively through both core analysis and aquifer tests. Addendum 2.7-F presents the results of the 2010 aquifer testing program. A summary of past tests, both field and laboratory, conducted within the proposed project area is included in Addendum 2.7-F as well.

Lance Aquifers

The Lance Formation depositional environment has been interpreted as being fluvio-deltaic in origin (Tschudy 1975). The Lance Formation consists of a mixture of non-marine deposited sandstones and floodplain mudstones with thin beds of coal (Connor 1992). The depositional environment of the Lance Formation created a stratigraphy that is complicated and vertically heterogeneous. Within the proposed Ross ISR Project area the LT horizon sandstones of the lower Lance Formation are of particular interest because they make up the upper portion of the ore zone (OZ unit), which is saturated and demonstrates hydraulic continuity throughout the proposed project area. The basal Lance Formation uranium-bearing LT sand ranges in thickness from 30 to 40 feet within the proposed project area. Above the LT sand is a shale layer varying in thickness from 20 feet to 80 feet, locally called the LC horizon aquitard or Upper Confining Unit. The LC horizon aquitard serves as a confining unit that separates the mineralized sandstones of the FH and LT horizons (OZ aquifer) from the water bearing zone above. Information about the confining properties of the Upper Confining Unit can be found in the groundwater model in Addendum 2.7-H. The model-calibrated vertical hydraulic conductivity of the Upper Confining Unit is 6.5×10^{-6} ft/day. The water-bearing sand above the ore zone is also referred to as the shallow monitoring zone or SM aquifer comprised of the LM through LK horizon sandstones, and will be monitored during uranium recovery operations. Above the SM unit is a sequence of thin sands, shales, and silts. Many of the thin sandstones contain water; however, these sandstones are generally discontinuous, and while they may be used locally for stock and domestic wells, they are not regional.

Hydraulic parameters for the Lance Formation have not been extensively studied. Pumping tests performed on the uranium-bearing sandstone in the upper Fox Hills Formation detected no hydraulic communication between the Fox Hills uranium-bearing sandstone and the SM unit (Manera 1977 and

1978, Hamilton 1977, and Addendum 2.7-F). While the SM unit was monitored during aquifer testing, neither testing of core samples nor pumping tests have been conducted within this portion of the Lance Formation. Based on lithology, however, the hydraulic properties of the SM unit within the Lance Formation are expected to compare to those of the Fox Hills Formation.

Surficial Aquifer

The surficial aquifer (SA) within the proposed project area consists of the uppermost water-bearing interval within the upper Lance Formation and the alluvium of the Little Missouri River and Deadman Creek. The surficial aquifer is under water table conditions.

2.7.3.3 Potentiometry, Gradients, and Recharge/Discharge Areas

Using head data from the monitoring well clusters, potentiometric surfaces for the DM, OZ, SM and SA aquifer units were developed.

2.7.3.3.1 DM Unit

The DM potentiometric surface is presented on Figure 2.7-21. As stated above, the DM unit is a confined aquifer with potentiometric heads ranging from 320 to 430 feet above the top of the interval across the proposed project area. The direction of groundwater flow within the DM unit is generally from the northeast to the southwest in the northern portion of the proposed project area. Proceeding south, the direction of flow shifts to the east, and takes on a northerly component in the southeast portion of the proposed project area. Hydraulic gradients vary slightly, but are typically on the order of 50 feet per mile (approximately 0.009 ft/ft). There is a distinct trough in the DM potentiometry in the vicinity of the 21-19 well cluster. This trough is due to abstractions from an oil field water supply well (22X-19) in this area that is completed in both the DM and OZ intervals. Pumpage from over the last 30 years has apparently depressed the heads from background conditions, resulting in the trough-like feature that is readily apparent in the DM potentiometry.

Groundwater within the DM unit moves into the proposed project area from the northeast and east, and moves to the south and west from recharge areas along the Fox Hills Formation outcrop, particularly where the Little Missouri River crosses the outcrop. Groundwater flow direction within the DM

unit is generally downdip, westward into the Powder River Basin. Based on the length of time it takes for the DM monitoring wells to recover following pumping for sample collection and the chemical quality of the DM groundwater (sodium-chloride type - see Section 2.7.3.5.2.2), flow within the DM aquifer is relatively sluggish.

2.7.3.3.2 OZ Unit

The OZ potentiometric surface is presented on Figure 2.7-22. The current shape of the OZ potentiometry has been affected by some 30 years of groundwater withdrawals by oil field water source wells completed in the OZ interval, with development of a distinct cone of depression near the 21-19 well cluster. This pumping has changed the hydraulic gradient and the direction of groundwater flow throughout most of the proposed project area. The potentiometry near the 34-7 well cluster has been least affected by pumping, and has southwesterly flow direction under a gradient of approximately 50 feet per mile.

Based on estimates that are presented in Addendum 2.7-H (Groundwater Model) in the TR, approximately 150 feet of drawdown in the OZ unit has occurred in the vicinity the 21-19 well cluster since pumping began in 1980 for local oil field water flood operations. Vertical gradients have been reversed from background conditions, resulting in OZ unit potentiometric surface elevations that are now lower than DM unit potentiometric surface elevations in the southern portion of the proposed project area. The OZ unit is, however, a confined aquifer across the entire proposed project area, with potentiometric heads ranging from around 150 feet to more than 400 feet above the top of the ore zone interval. Figure 2.7-23 is an isopachous map depicting the currently available hydrostatic head above the top of the OZ aquifer across the proposed project area.

As can be seen on Figure 2.7-22, within the proposed project area groundwater in the ore zone generally moves from recharge areas along the Fox Hills Formation outcrop toward the cone of depression near the 21-19 well cluster.

2.7.3.3.3 SM Unit

The configuration of the SM potentiometry does not conform with the typical confined aquifer potentiometric surfaces for other aquifers that emanate

from the Black Hills Uplift, such as the Dakota Formation or Madison Formation confined aquifers. Typically, these aquifers possess uniformly spaced potentiometric contours that are parallel to geologic strike, with a basin-ward gradient. Based on the water surface elevations from the SM wells within the regional baseline well clusters, the potentiometry is somewhat convoluted and difficult to interpret into a cohesive surface. The difficulty in preparing a comprehensive surface using the hydrostatic heads from the six SM cluster wells is due to at least two reasons. First, the SM unit's hydrostatic pressure heads have likely declined over the last three decades as result of pumping the local oil field water source wells completed in the underlying OZ interval. Based on the modeling results (Addendum 2.7-H), nearly 30 years of pumpage has lowered SM heads roughly 10 feet in the vicinity of the 21-19 well cluster. Second, the lithology of the SM interval is discontinuous, making correlation within this unit somewhat difficult over long distances across the proposed project area. Although the SM wells are typically completed in the first sand overlying the ore zone interval, this interval may not necessarily correlate between distantly spaced well clusters. This is most apparent upon comparison between the 34-7 and 42-19 well clusters, which are located near the northern and southern borders of the proposed project area, respectively, and some 8,500 feet apart. These two well clusters, which are roughly in the same position relative to the Fox Hills Formation outcrop, show some 50 feet of head difference in the SM unit. Inspection of geologic cross section C-C' (Addendum 2.6-C) indicates that the completion interval of well 34-7SM is not exactly correlative with the completion interval of well 42-19SM. The difference in hydrostatic head between these two wells suggests that the SM unit does not behave as a single aquifer and vertical gradients are present, making preparation of a potentiometric surface for this unit problematic. For this reason, the potentiometric surface depicted on Figure 2.7-24 includes some speculation.

2.7.3.3.4 SA Unit

The surficial aquifer or SA unit is the water table aquifer within the proposed project area, and includes the alluvium of the Little Missouri River and Deadman Creek. In addition to the SA well completions at the various monitor well clusters, shallow piezometers were installed in the SA unit for a geotechnical study, one of which is dry. Well logs and completion details for these piezometers are included in Addendum 3.1-A. The increased number of

monitoring sites for the SA unit provides more detail in the SA potentiometry than in the underlying units. The SA potentiometric surface is presented on Figure 2.7-25.

The direction of groundwater flow in the surficial aquifer in the proposed project area is generally from the highlands to the lowlands, moving from both the north and south and converging on the Little Missouri River valley. Groundwater in the SA aquifer leaves the proposed project area in a northeasterly direction as alluvial underflow. Gradients within the SA aquifer are approximately 35 feet per mile, with flow converging on the Little Missouri River and its tributary, Deadman Creek.

2.7.3.3.5 Hydrograph Analysis

Water level data collection began in the proposed project area with installation of the regional baseline monitor well clusters in the fourth quarter of 2009. In March 2010, each of the DM, OZ, and SM monitor wells were fitted with recording pressure transducers, as was well 12-18SA, and continuous groundwater level hydrographs were prepared for each well starting April 1, 2010. At the five remaining SA wells, of which two were dry, manual water level measurements were collected. In June 2010, four piezometers were installed in the NW SW of Section 18, T53N, R67W as part of a geotechnical investigation. Water level data collection is ongoing.

The recording pressure transducers are non-vented, and do not compensate for water level changes in the aquifer that are the result of barometric pressure fluctuations. Therefore, the hydrographs prepared using the data from these transducers show the aquifer head fluctuations affected by changes in the barometric pressure. Barometric pressure data were collected at Strata's field office in Oshoto.

Hydrographs for each of the monitor wells and piezometers were prepared and are housed in Addendum 2.7-G. Including manual measurement, the period of record is January through October 2010. A graph of barometric pressure with a period of record from March through October 2010 is also included. A discussion of the hydrographic response during the period of record for each respective aquifer and individual well, where appropriate, follows.

2.7.3.3.5.1 DM Unit

The DM well hydrographs all have similar attributes. Due to the low permeability of this unit, each hydrograph depicts the long water level recovery period following water quality sampling events, which occurred in March, June, July-August, and October 2010. Full recovery of the DM aquifer water levels generally takes 45 to 60 days following a sampling event. To a varying extent, all DM hydrographs show minor perturbations on the order of 0.1 foot due to variation in barometric pressure. During the May-June 2010 period, water levels were more variable in the 12-18DM well, with a spike of almost 3 feet occurring in late April with another spike occurring in late May. These spikes are imprinted on the general water level increase following the March sampling event. With the exception of the 34-7DM well, all of the DM wells show a "blip" during this time frame. The cause of these spikes is unknown. The 12-18 well cluster is approximately 4,000 feet away from the oil field water supply wells located in the southern portion of Section 18. It is therefore unlikely that the hydrograph variation recorded in the 12-18DM well is due to pumpage, although the hydrograph from the 21-19DM well, which is located closer to the oil field water supply wells, depicts a very recognizable spike in the same mid- to late-April time period, although not on the same day.

2.7.3.3.5.2 OZ Unit

The amount of variability in the OZ well hydrographs is a function of the well locations relative to the oil field water supply wells in Sections 18 and 19. The wells located closest to this area (21-19OZ, 34-18OZ, 14-18OZ, and 42-19OZ) display water level fluctuations that are clearly related to pumpage. Obvious on these four hydrographs are pumping starts and stops that occurred in the late June, early July 2010 time frame. Also apparent on these four hydrographs is a rapid water level rise (over 15 feet in the 21-19OZ well) in late September 2010 that is attributed to a temporary cessation of pumping. A rapid decline in water level following this rise can be noted in the 42-19OZ, 34-18OZ and 21-19OZ well hydrographs. This decline is an indication of resumption of pumping.

The 34-7OZ well is furthest from the water supply wells, and its hydrograph displays the least variation. Other than the aquifer testing that took place over the period of record, the only obvious perturbations are related to sampling events and barometric fluctuations. The barometric fluctuations

are less than 0.5 foot. During the January through October 2010 time frame, the 34-7OZ hydrograph shows a steady increase of approximately 2 feet. Steady variations of this type are not discernable on the remaining OZ well hydrographs.

The 12-18OZ hydrograph varies within a window of approximately 2.5 feet. Based on the magnitude of the water level changes in this well, the majority of observed water level change can be ascribed to barometric pressure fluctuations, with the exception of the fluctuations in the late June, early July time period, which coincide with pumping-related water level changes in the same time frame observed in the group of four wells discussed above.

2.7.3.3.5.3 SM Unit

The hydrographs of the SM wells show much less variation than the DM and OZ units. Other than changes related to sampling events, the SM hydrographs typically vary less than 1 foot over the period of record, with the variations coinciding with changes in barometric pressure. The only exception to this observation is the 12-18SM well, the hydrograph for which shows over 3.5 feet of change from January through October 2010. Following roughly 2 feet of decline during May through June 2010, the 12-18SM hydrograph remained relatively flat during June through October 2010. The SM well hydrographs show no resemblance to the OZ well hydrographs, which is another verification that these two units are hydraulically isolated from one another.

2.7.3.3.5.4 SA Unit

For the period of April 1 through August 10, 2010, the 12-18SA well was equipped with a recording pressure transducer. The continuous groundwater level hydrograph from the 12-18SA well is presented in Addendum 2.7-G. The hydrographs for the remaining SA wells and piezometers were prepared from manual measurements. In August 2010, the transducer in the 12-18SA well was moved to the SA43-18-3 piezometer. The 12-18SA hydrograph shows approximately 5 feet of water level increase from January to June 2010. A seasonal increase in water level of this type is common in shallow, water table aquifers and indicates recharge from snow melt and spring precipitation. Of the remaining SA well hydrographs, well 14-18SA shows an increase of a little more than 2 feet from January to June 2010, with a decline of similar

magnitude from June through October. The other SA well hydrographs show general declines and increases of varying magnitude, typically of no more than 1 foot.

As discussed in Section 2.7.3.3.4, the direction of groundwater flow in the surficial aquifer generally follows the topography, moving from the highlands to the lowlands and converging on the Little Missouri River valley. As discussed in Section 2.7.1, extended periods of streamflow and increased streamflow rates observed downstream of the Oshoto Reservoir appear to correlate with higher water level elevations in the reservoir. By the same token, groundwater level elevations observed in the SA unit at monitoring sites located in the lowland areas appear to correlate with higher water level elevations in the reservoir as well.

2.7.3.4 Groundwater Use

In order to assess historical and current groundwater use, groundwater rights and unregistered water wells were evaluated within the proposed project area and within the surrounding 2-mile (3.2-km) area. Sources of data include wells registered with the WSEO (WSEO 2010), landowner interviews, and field investigations. The search revealed 119 groundwater rights and unregistered wells, the locations of which are depicted on Figure 2.7-26.

Table 2.7-23 breaks down the groundwater rights by use. Historical groundwater use began with the first domestic and livestock well in 1918. From about 1918 to 1977, groundwater was used primarily domestically and for livestock consumption, with lesser amounts of water used for irrigation. In 1977, Nuclear Dynamics permitted 14 monitor and industrial use wells associated with the Nubeth R&D site, which is described in Section 1.2. Between 1980 and 1991, many industrial and miscellaneous wells associated with oil and gas production were permitted in and around the proposed project area. These include three wells within the proposed project area (P50917W, P67746W and P67747W) that are currently used as water supply wells for EOR operations (water flooding). Addendum 2.7-H presents more detail on industrial water use within the proposed project area. In 1981, International Minerals & Chemical Corporation permitted five pits (P58895W, P58896W, P58899W, P58902W and P58905W) for dewatering and dust suppression associated with bentonite mining. According to WSEO records, the water rights were cancelled prior to 2001 at the request of the applicant. Since 1991, the only groundwater

rights that have been filed within the search area are for domestic and livestock use until 2009, when Strata obtained groundwater rights for the regional baseline monitor wells.

Table 2.7-24 summarizes the groundwater rights within the proposed project area. Groundwater use within the proposed project area follows a similar pattern to that observed within the 2-mile (3.2-km) search area, except that historical use has been livestock only (no domestic or irrigation use). More recent uses including monitoring and industrial use associated with the Nubeth R&D site and water supply for oil and gas operations.

Most of the groundwater rights represented in Table 2.7-24 have been cancelled or are no longer active. Current groundwater use is limited to 4 livestock wells, Strata's regional baseline monitor wells, and 3 industrial wells (water supply for oil and gas operations). The stock wells are completed at total depths ranging from 128 to 265 feet, which is considerably above the OZ aquifer. The currently operating industrial water use wells are completed at total depths of 536 to 750 feet. Together these wells withdraw an average of about 30 gpm from the OZ aquifer as described in Addendum 2.7-H.

A complete list of groundwater rights and unregistered water wells within the proposed project area and the surrounding 2-mile (3.2-km) area is provided in Table 2.7-25.

2.7.3.5 Groundwater Quality

Strata evaluated both regional and site specific groundwater quality to assess baseline conditions prior to ISR uranium recovery. The following sections include a description of the regional groundwater quality and a summary of baseline groundwater quality from the constructed regional baseline monitoring network wells and existing water supply wells in the vicinity of the proposed project.

2.7.3.5.1 Regional Groundwater Quality

The following sections briefly describe the regional groundwater quality in alluvial/colluvial aquifers, the Lance-Fox Hills formations, and deeper formations.

Alluvial Aquifers

Alluvial groundwater quality in the PRB is highly variable spatially but generally suitable for livestock and wildlife use. Based on the analyses of 793 alluvial groundwater samples collected in the southern PRB, the median concentration of TDS was 2,110 mg/L and the predominant chemical constituents were calcium and sulfate, although significant quantities of sodium, magnesium and bicarbonate were also present (Ogle and Calle 2006).

The proposed project area is located on the eastern flank of the PRB, near the Black Hills uplift. According to the BLM (2003), alluvial water quality tends to be better near the Black Hills than within the central part of the PRB. Based on a review of field water quality measurements from 10 alluvial wells in Crook County (USGS 2010b), the median EC was 2,100 µmhos/cm, indicating that the alluvial water quality in the vicinity is somewhat better than the average PRB alluvium. Using a conversion factor of TDS ≈ 0.65 EC (Hem 1985), the average TDS of the Crook County alluvial wells is estimated to be about 1,400 mg/L, or about two-thirds that in the PRB as a whole.

Lance-Fox Hills Aquifers

Rankl and Lowry (1990) describe water quality in the Lance Formation as being highly variable according to well depth. Shallow Lance Formation wells typically yield water of similar quality to surficial material (i.e., significant contributions of calcium and magnesium), while deep wells tend to exhibit strong sodium dominance. Some wells contain large concentrations of sulfate, while others are strongly dominated by bicarbonate and carbonate. According to Rankl and Lowry, the dominant reactions that control the chemical quality of water in the Lance Formation are cation-exchange softening and sulfate reduction.

Regional water quality data for the Lance-Fox Hills aquifers were obtained from 16 wells in Crook and Campbell counties identified as being completed in Upper Cretaceous aquifers (USGS 2010b). Table 2.7-26 summarizes the median water quality from the 16 sample results. Data from these wells indicate that the Lance-Fox Hills aquifers generally have slightly alkaline pH, moderate TDS, low hardness, strong sodium dominance, and relatively strong bicarbonate dominance, with sulfate levels ranging from very low to approximately equal to bicarbonate.

Deeper Aquifers

The deep disposal well application for the Ross ISR Project (Addendum 4.2-A) contains estimates of water quality in deeper formations, from the Minnelusa to basement. The Minnelusa and Deadwood/Flathead Formations are both expected to have TDS concentrations greater than 10,000 mg/L, while the Madison Formation likely has a TDS concentration around 1,000 mg/L in the project vicinity. These are based on calculations presented in Addendum 4.2-A.

2.7.3.5.2 Site Groundwater Quality

Baseline groundwater quality information within and near the proposed project area was obtained from three sources: the construction and sampling of a regional baseline monitoring network, sampling of existing water supply wells and an evaluation of historical data from the Nubeth R&D site. The following sections provide a detailed analysis of groundwater quality obtained from each source. Groundwater quality results are provided in Addenda 2.7-I through 2.7-L.

2.7.3.5.2.1 Regional Baseline Monitoring Network

Strata constructed a regional baseline groundwater monitoring network within the proposed project area in 2009 and 2010. The monitoring network, depicted in Figure 2.7-14, comprises six well clusters and four piezometers. Each well cluster includes four monitoring wells targeting the SA, SM, OZ and DM units. Construction details for the cluster wells are presented in Tables 2.7-20 and 2.7-27, and construction techniques are presented in Section 2.7.3.2.2.

Dedicated submersible pumps, sounding tubes and pressure transducers were installed in the SM, OZ and DM wells to expedite groundwater sample collection and document fluctuations in the groundwater systems. Because the SA wells are shallow and easily accessible with a portable pump, dedicated pumps were not installed in these wells. Cross-contamination was prevented by decontaminating the portable pump between uses. Cluster well sampling commenced in the first quarter 2010 and continued quarterly throughout the year. Prior to sample collection each well was purged using a dedicated sample pump to ensure representative samples were collected. During each well purge field parameters (pH, EC, water temperature, turbidity

and dissolved oxygen) were measured at set intervals. When field measurements became stable and/or least three casing volumes had been evacuated, sample collection was initiated. All samples were collected in bottles provided by the contract laboratory and analyzed for constituents listed in Table 2.7-11.

Immediately following well construction and development, preliminary samples were collected by air lifting water from each well. A comparison of the air lifted sample analysis with results from subsequent quarterly sample results indicated that the preliminary sample results were not representative of the regional baseline groundwater quality. Therefore, the preliminary results obtained by air lifting samples were not included in the baseline groundwater quality analysis. The air lifted sample results are included with all groundwater quality analyses in Addendum 2.7-I.

2.7.3.5.2.2 Regional Baseline Monitoring Network Results

The groundwater quality results for the regional baseline monitoring network wells indicate that each zone has distinct water quality. The lower zone (DM) is characterized by elevated chloride concentrations, while increased radionuclides distinguish the ore zone (OZ). Groundwater quality in the SM and SA aquifers is similar; however there are distinguishing characteristics.

The major ion chemistry and TDS concentrations of each aquifer provide a general indication of water quality within each zone. The three deeper zones (DM, OZ and SM) exhibited complete sodium dominance, while the surficial aquifer (SA) contained varying amounts of calcium and magnesium. The anions vary significantly. Table 2.7-28 shows that SA zone is characterized by the bicarbonate ion, with increasing sulfate levels in the SM and OZ zones followed by chloride dominance in the DM zone.

TDS generally increases with depth, from the SA zone to the OZ zone, then declines between the OZ and DM zones. The general trends in TDS and major ion chemistry are consistent with the three main zones of sedimentary basins discussed by Freeze and Cherry (1979):

1) The upper zone: active groundwater flushing with bicarbonate as the dominant anion.
2) The intermediate zone: less active groundwater circulation, with higher TDS concentrations. Sulfate is typically the dominant anion.

3) The lower zone: groundwater is increasingly sluggish. Highly soluble minerals are present due to minimal flushing. High chloride concentrations are characteristic of this zone.

Piper diagrams illustrate the variations in major ion chemistry for the wells within the regional baseline monitoring network. Figure 2.7-27 presents the average major ion chemistry of each well, while Figure 2.7-28 presents the average major ion chemistry within each zone.

The piper diagrams illustrate the differences in major ion water chemistry between zones. The SM and OZ wells have similar cation chemistry (complete sodium dominance), but the OZ wells have significantly higher sulfate than the SM wells. The SA wells appear scattered on Figure 2.7-27, demonstrating greater variability in major ion chemistry and notably in the concentrations of magnesium and calcium. As a group, the most distinct wells on the piper diagrams occur in the DM zone, since these wells are dominated by chloride.

In addition to major ion chemistry and TDS, other constituent concentrations vary between aquifers. Table 2.7-29 provides the range of concentrations for each zone. All groundwater quality results are included in Addendum 2.7-I.

The OZ zone is distinguishable from the other three zones by higher concentrations of sulfate, TDS, gross alpha, uranium and elements of the uranium decay series, including Pb-210, Po-210, Ra-226 and 228, and Rn-222. Further information on the water quality within each zone is provided below.

In addition to water quality characteristics of the different zones, Strata also evaluated the up- and down-gradient well water quality based on the location of the wells in relation to the potential wellfield modules, the CPP and lined retention ponds as recommended by NRC Regulatory Guide 4.14. The potentiometric surfaces for each aquifer were used to determine the up- and down-gradient wells. The qualitative comparison indicates that overall water chemistry did not differ significantly between the up- and down-gradient wells for each zone. The following provides a summary of water quality well gradient comparisons for each zone.

- SA zone: While the water quality varied considerably between some SA zone wells, no correlation was observed with the location of the wells in relation to the potentiometric surface (Figure 2.7-25). The most upgradient (21-19SA) and downgradient (37-7SA) SA wells

had very similar water quality in terms of major ion chemistry (both sodium bicarbonate) and TDS (both wells had TDS concentrations of about 600 to 800 mg/L).

- SM zone: Trends toward increasing TDS and a transition from sulfate to bicarbonate were observed in the downgradient direction in the SM wells. For instance, the most upgradient SM well (42-19SM) measured TDS of 830 to 1,040 mg/L and sulfate levels of about 55% of the total anions. By comparison, the most downgradient SM well (34-7SM) measured TDS levels of 1,150 to 1,260 mg/L and sulfate levels less than 35% of the total anions. One of the other upgradient SM wells (34-18SM) also measured significantly higher sulfate levels than the remaining SM wells. The two most upgradient wells also measured the lowest concentrations of radionuclides, specifically Ra-222.
- OZ zone: Because of the influence of the water supply wells used for enhanced oil recovery, the most upgradient OZ well is 34-7OZ, and the most downgradient well is 21-19OZ. A comparison between water quality in these two wells reveals no apparent spatial trends. The TDS in each ranges from 1,500 to 1,700 mg/L, and they are virtually indistinguishable on a piper diagram. The radionuclide concentrations including Ra-222 and gross alpha were also very similar.
- DM zone: Some variation in DM zone water quality was observed in relation to potentiometric surface. The most upgradient well (34-7DM) had the highest TDS (1,600-1,900 mg/L) and chloride concentrations (539-818 mg/L), while the most downgradient well (21-19DM) had much lower TDS (1,200-1,250 mg/L) and chloride (425-535 mg/L). No variation was observed in radionuclide concentrations as a function of location in the DM zone.

The average groundwater quality within each zone was compared to WDEQ class of use standards in Chapter 8 of the Wyoming Water Quality Rules and Regulations. Class I groundwater is suitable for domestic use, Class II groundwater is suitable for agricultural (i.e., irrigation) use, Class III groundwater is suitable for livestock, and Class IV groundwater is suitable for industrial use. Table 2.7-30 summarizes the probable classifications of groundwater within each zone. (Strata acknowledges that only WDEQ can formally classify groundwater within Wyoming.) A discussion of constituents exceeding the class of use standards is presented in the subsections below.

On average, the SA zone has the lowest TDS concentrations of the four zones. The groundwater in the SA zone would likely be classified as Class II or III depending on pH, sulfate and manganese concentrations. Groundwater in

the lower and upper zones (DM and SM) appears to meet Class III standards, while groundwater in the OZ zone is likely Class IV (industrial use only) due to elevated concentrations of radionuclides.

Following are detailed summaries of the water quality within each zone.

SA Zone

Groundwater quality in the four SA wells demonstrated the greatest variability of the regional baseline monitor wells. Throughout the monitoring period the 34-18SA and 42-19SA wells remained dry.

Major ion chemistry indicates that each well in the SA zone has somewhat distinct water chemistry. While all wells were dominated by sodium bicarbonate, additional ions in varying concentrations were present in the groundwater. A summary of the monitoring results for the SA zone wells is presented in Table 2.7-31.

The piper diagram of the SA wells, Figure 2.7-29, illustrates the variation in water chemistry. All of the wells exhibited sodium dominance, but two of the four also contained significant contributions from magnesium and calcium. Similarly, all four wells exhibited bicarbonate dominance, but sulfate was significant at about 30% to 40% of anions and one well measured about 12% chloride (14-18SA). TDS also varied by a factor of two among SA wells.

Few radiological constituents above detection limits were measured in the SA zone. Three of the four sampled SA wells had uranium and radium-226 concentrations slightly above the detection limits of 0.001 and 0.2 mg/L, respectively.

The groundwater in the SA wells is likely Class II or III based on a comparison with WDEQ standards as summarized in Table 2.7-32. TDS concentrations exceed the Class I standard for all wells, while sulfate and manganese concentrations exceed both Class I and II standards in two of the four wells.

A comparison of the SA zone groundwater quality to EPA drinking water standards indicates that all wells meet the primary MCLs, while few exceedances of the secondary MCLs are evident. Table 2.7-33 presents the EPA standards and exceedances for the SA wells.

SM Zone

The SM wells exhibited similar water chemistry with minor exceptions. Most SM wells were dominated by bicarbonate, while the 34-18SM and 42-19SM wells had a slight sulfate dominance. The data show that in the SM zone, sulfate makes up about 30% to 55% of the anionic concentration, while bicarbonate/carbonate make up about 40% to 70%. Monitoring results for the SM wells are presented in Table 2.7-34.

The piper diagram of the SM wells, Figure 2.7-30, shows consistent sodium dominance, variable bicarbonate/sulfate dominance and very low concentrations of calcium, magnesium and chloride.

The SM wells measured non-detect to low concentrations of selenium, uranium and radiological constituents. None of the SM wells measured detectable selenium concentrations, while two of six wells measured uranium concentrations slightly above the detection limit of 0.001 mg/L. Similarly, measurable but relatively low Ra-226 and 228 concentrations were observed in five of six wells. One well (34-7SM) also measured a detectable Pb-210 concentration (about 1.3 pCi/L).

Based on a comparison with WDEQ standards, the groundwater in the SM wells is likely Class III (suitable for livestock). Table 2.7-35 shows that the sulfate concentration in the SM zone is above Class I and II standards. Additional parameters not meeting Class I standards include TDS and ammonia.

Groundwater quality in the SM zone was also compared to EPA drinking water standards. Table 2.7-36 shows that arsenic in the four of the six wells does not meet the primary MCL of 0.01 mg/L. Fluoride, TDS, aluminum and sulfate exceeded the secondary standards.

OZ Aquifer

The groundwater quality of the individual OZ wells did not vary during the four quarters of monitoring; however, there was some minor variation in OZ zone water quality across the proposed project area. Five of the six OZ wells were characterized by sodium sulfate type water, while the 12-18OZ well exhibited sodium bicarbonate type water. Overall, the 12-18OZ well also had the lowest concentrations of major ions, while the 14-18OZ well measured the

highest concentrations of dissolved salts. Table 2.7-37 presents the quarterly groundwater monitoring results for the OZ wells.

Major ion water chemistry of the OZ wells is illustrated in Figure 2.7-31. The piper diagram shows that the 12-18OZ well was slightly dominated by bicarbonate, while the majority anion in the remaining wells was sulfate. Generally, sulfate contributes about 45% to 65% of anions, while bicarbonate/carbonate contribute 35% to 55%. Cations comprise almost exclusively sodium.

As previously discussed, groundwater quality in the OZ aquifer is distinct from the other zones due to elevated concentrations of radionuclide constituents. While all OZ wells measured increased concentrations of uranium and constituents in the uranium decay series, the highest concentrations were measured in the 12-18OZ, 14-18OZ and 34-18OZ wells. These wells measured the greatest concentrations of Rn-222, Pb-210, Po-210, and Ra-226.

A comparison of OZ aquifer groundwater quality to WDEQ standards indicates that the water is likely suitable only for industrial use (Class IV). A summary of the constituents exceeding the class of use standards is presented in Table 2.7-38. The WDEQ Class I, II and III standard for gross alpha is 15 pCi/L. The table shows that all wells exceeded the gross alpha standard. Additionally, wells 12-18OZ and 34-18OZ also exceeded the Class I, II and III combined radium-226 and 228 standard of 5 pCi/L.

The groundwater in the OZ wells was also compared to EPA drinking water standards, as summarized in Table 2.7-39. The EPA MCLs for gross alpha and combined Ra-226 and 228 are the same as the WDEQ standards. Therefore, all wells exceed the gross alpha MCL. Additionally, four of the six wells exceeded the uranium MCL and two of the six wells exceeded the Ra-226 and 228 MCL. In 1999, the EPA proposed a drinking water standard for radon of 300 pCi/L. The Rn-222 measured in all of the OZ wells exceeds the proposed EPA standard. In two of six wells, the measured Rn-222 concentration was higher than 30,000 pCi/L, or more than 100 times the proposed EPA Standard.

<u>DM Zone</u>

With two exceptions, water quality within each of the six DM wells did not vary significantly during the baseline monitoring. The exceptions occurred in the 1Q10 samples from two of the six DM wells (34-18DM and 42-19DM), where the water quality (especially chloride) varied from the latter three

quarterly sampling events in 2010. In 1Q10, the chloride concentration in 34-18DM was 139 mg/L, while the range in 2Q10 through 4Q10 was 371 to 523 mg/L). A similar difference was observed in 42-19DM. Based on the slow recovery of the DM wells (see Section 2.7.3.3.5.1) it is believed that an insufficient quantity of water could be withdrawn from these two wells during the 1Q10 sample event to obtain a truly representative sample of the formation water. This is supported by consistency in the latter three samples collected in 2010. Of the six DM wells, the highest levels of dissolved constituents were measured in well 34-7DM, including TDS, sodium, chloride, arsenic and selenium. Well 42-19DM yielded the lowest TDS and chloride concentrations. Quarterly groundwater monitoring results are presented in Table 2.7-40.

The water quality of the DM zone wells is distinct from other zones due to relatively high concentrations of chloride. The piper diagram of the DM wells, presented in Figure 2.7-32, illustrates that chloride is the dominant anion. Bicarbonate and carbonate make up the balance of anions, with less than 10% sulfate in all DM wells. The elevated chloride in the DM zone could complicate detection of potential vertical excursions of recovery solutions, which are anticipated to contain relatively high concentrations of chloride. To address this concern, sulfate is proposed as an alternate excursion indicator for the DM zone, as discussed in Section 5.7.8.

Radiological water quality results for the DM wells indicate concentrations near or below detection limits, with a few exceptions. Radium-226 and Rn-222 were measured in three of the six wells, while low concentrations of Pb-210 and Th-230 were measured in two of the six wells.

A comparison of DM zone water quality to the WDEQ groundwater class of use standards indicates that the groundwater in all DM zone wells is likely suitable for livestock (Class III) or industrial use (Class IV). Constituents exceeding Class I (domestic), II (agriculture), and III (livestock) standards are summarized in Table 2.7-41. In some samples, wells 14-18DM and 34-7DM measured gross alpha in excess of the WDEQ Class I-III standard; however, the average gross alpha concentrations in these wells for the monitoring period were below the class of use standard of 15 pCi/L.

Water quality results for the DM wells were also compared to EPA drinking water standards as presented in Table 2.7-42. Gross alpha and arsenic were the only constituents exceeding a primary MCL in one or more DM wells. All DM wells exceeded the secondary standards for TDS, chloride and

aluminum. Additionally, well 34-7DM exceeded the secondary standard for manganese.

Plant Area Piezometers

Strata installed four piezometers in and around the proposed central plant area in May 2010, as depicted in Figure 2.7-14. The piezometers, completed in the alluvium and shallow bedrock materials at depths ranging from 8.7 to 28.8 feet (see Table 2.7-20), were constructed to assess baseline groundwater in the proposed central plant area. Groundwater samples were collected from the piezometers beginning in the 2nd quarter 2010. Monitoring results are presented in Table 2.7-43.

Piezometer SA13-17-1 was dry during all sample events. Water quality varied significantly between the other three piezometers. SA43-18-3 yielded water quality typical of the SA wells of the regional baseline monitoring network, while SA43-18-1 and SA43-18-2 yielded high concentrations of dissolved salts, sulfate, selenium, uranium and gross alpha. For example, the TDS concentration in SA43-18-3 ranged from 420 to 510 mg/L, while TDS levels in SA43-18-1 and SA43-18-2 ranged from 4,190 to 7,280 mg/L.

The gross alpha concentrations were also significantly higher in SA43-18-1 (66 to 84 pCi/L) and SA43-18-2 (115 to 218 pCi/L) than SA43-18-3 (8 to 18 pCi/L). However, the average gross alpha concentration in all three piezometers exceeds the Class I-III WDEQ class of use standard. Additional parameters exceeding WDEQ Class III standards include sulfate and selenium in SA43-18-1 and SA43-18-2. Based on a comparison with WDEQ class of use standards, the water in all three plant area piezometers is likely Class IV (industrial use only) due to gross alpha and, in some cases, selenium and sulfate. The water sampled in all three piezometers exceeds the EPA primary MCL for gross alpha, and water sampled from SA43-18-1 and SA43-18-2 also exceeds the EPA primary MCLs for selenium and uranium.

The difference in water quality in the plant area piezometers is attributed to the piezometer locations in relation to the Little Missouri River and Oshoto Reservoir. As described in Section 2.7.3.3.5.4, groundwater levels in the SA unit at monitoring sites located in the lowland areas appear to correlate with water levels in Oshoto Reservoir. Piezometer SA43-18-3 is located near Oshoto Reservoir, where the surficial aquifer appears to be influenced and routinely flushed by infiltrating surface water. SA43-18-1 and SA43-18-2 are located

upgradient and significantly further from Oshoto Reservoir and the Little Missouri River. The water in these wells is likely relatively stagnant, contributing to the higher dissolved solids.

2.7.3.5.2.3 Existing Water Supply Wells

As part of the baseline groundwater inventory, Strata identified all of the currently operable water supply wells within the proposed project area and surrounding 2 km (1.2 mi) area. The wells, depicted in Figure 2.7-33 and summarized in Table 2.7-44, were identified through the groundwater rights search, landowner interviews and field investigations.

A total of 29 existing water supply wells were identified and sampled including 2 industrial wells, 15 stock wells and 12 wells used for domestic use. No domestic wells are located within the proposed project area; all sampled domestic wells were in the surrounding area. The industrial wells were permitted in the early 1980s and completed at depths of 536 and 750 feet. The majority of the stock wells were permitted through the WSEO with permit dates ranging from 1953 to 2010. According to the WSEO (2010), completion depths of permitted stock wells range from 40 to 304 feet. According to WSEO records, the completion depths for the domestic wells range from 150 to 600 feet.

The wells were sampled on a quarterly basis with sample commencement between 3rd quarter 2009 and 1st quarter 2010. Samples were collected in bottles provided by the contract laboratory and analyzed for constituents listed in Table 2.7-11. Sample results are summarized below.

<u>Industrial Wells</u>

Two industrial wells, 19XX18 and 22X-19, were sampled as part of the existing water supply well baseline groundwater monitoring. A third industrial well (789V) could not be accessed. These three wells provide water for enhanced oil recovery within the proposed project area. The 19XX18 and 789V wells are permitted as two separate wells; however, water from well 19XX18 is piped to well 789V and comingled for injection. All samples were collected from a water spigot on the line from the 19XX18 well, while water from well 789V could not be accessed. As previously stated, the 19XX18 well was utilized as the recovery well at the Nubeth R&D site prior to being converted to a water supply well for oil and gas operations in the 1980s. A discussion of the 19XX18

water quality while under ownership of Nuclear Dynamics is presented in Section 2.7.3.5.2.4.

The 19XX18 and 22X-19 wells, located within the proposed project area, have water chemistry similar to the OZ wells of the regional baseline monitoring network. This similarity in water quality would be expected since these two wells are completed in the OZ unit, although the 22X-19 is also completed in the DM zone as described in Section 2.7.3.3.1. The water in the industrial wells is dominated by sodium and sulfate ions and has moderate concentrations of TDS, as presented in Table 2.7-45.

Radiological constituents were detected in both wells, with the highest concentrations measured in the 19XX18 well. Overall, the results were consistent with the OZ wells in the regional baseline monitoring network.

Water quality in the industrial wells was compared to WDEQ class of use standards. The results indicate that the water is likely suitable for industrial use only (Class IV), due to high concentrations of Ra-226, Ra-228, and gross alpha. Similarly, the combined Ra-226 and Ra-228 and gross alpha concentrations exceed the EPA MCLs. The WDEQ and EPA standards for combined Ra-226 and Ra-228 and gross alpha are 5 and 15 pCi/L, respectively.

<u>Stock Wells</u>

Fifteen stock wells were sampled within and surrounding the proposed project area. The analytical results indicate variation in water chemistry similar to that found in the SA unit characterized in the regional baseline monitoring network.

The piper diagram presented in Figure 2.7-34 illustrates the major ion chemistry of the stock wells. The piper diagram shows that 10 of the wells are dominated by sodium, 1 is calcium dominant, and the remaining 4 have incomplete cation dominance, with a blend of sodium, calcium, and magnesium. Additionally, the figure shows that most of the wells are bicarbonate dominant, while four contain at least 30% sulfate and one is sulfate dominant. The variability in water chemistry is reflective of the variability in stock well depth, which ranges from about 40 to 300 feet.

Stock well water quality results are provided in Table 2.7-46. The sample results indicate relatively higher concentrations of selenium, uranium and/or

radiological constituents in about half of the wells. Two wells measured higher uranium and selenium levels than the regional baseline OZ wells. All of the wells measured near or below detection limits for Pb-210, Po-210, Ra-228, and Th-230. Increased concentrations of radium-226 were measured in several wells as were relatively high levels of gross alpha.

The groundwater quality of the stock wells was compared to WDEQ and EPA standards. A comparison with WDEQ class of use standards is presented in Table 2.7-47. The table illustrates the broad range of stock well water quality. About half of the stock wells do not meet the Class I, II, or III suitability criteria for gross alpha. In contrast, one well met Class I class of use standards. The remaining wells appear to meet all agricultural (Class II) or livestock (Class III) class of use standards.

The groundwater quality of the stock wells was also compared to the EPA drinking water standards. The results, presented in Table 2.7-48, indicate that the water produced by half of the wells exceeds at least one primary standard (most often uranium and gross alpha), while all but one well yielded water samples that exceed one or more secondary standards (TDS, sulfate, and/or manganese). This table is presented for comparison with other wells only, since these wells are not used as a domestic drinking water supply.

Domestic Wells

Strata sampled 12 domestic wells near the proposed project area. As shown on Figure 2.7-33, the closest domestic well (DWWELL01) is about 0.12 mile outside the proposed project area. The monitoring results are presented in Table 2.7-49.

The piper diagram of the average water quality in domestic wells, Figure 2.7-35, shows that the water in all domestic wells is sodium dominant, while four wells had calcium plus magnesium levels of about 15% to 40%. Anion dominance was divided between bicarbonate and sulfate. TDS concentrations ranged from about 500 to 2,000 mg/L.

All of the domestic wells measured near or below the detection limit for selenium, while several wells had measurable concentrations of uranium and radiological constituents, including Ra-226 and 228 and gross alpha.

The groundwater quality in nearby domestic wells was compared to WDEQ class of use standards. The results, presented in Table 2.7-50, indicate

the water generally meets class of use standards for livestock and industrial uses. In the majority of domestic wells, TDS and sulfate exceed Class I (domestic) and II (agriculture) class of use standards. Four of the wells measured gross alpha in excess of the WDEQ standard (15 pCi/L) in at least one sample.

The monitoring results for the domestic wells were also compared to EPA drinking water standards, as presented in Table 2.7-51. One well exceeded MCLs for uranium and gross alpha, and another exceeded the MCL for arsenic. Three more exceeded the MCL for gross alpha in at least one sample, although the average concentrations were less than the MCL. Based on the very limited construction information available for the nearby domestic wells and the limited availability of geologic information near the Fox Hills Formation outcrop where most of the wells are completed, it was generally not possible to assign the domestic wells to a particular completion interval.

2.7.3.5.2.4 Nubeth R&D Groundwater Quality

As part of the Nubeth R&D site, Nuclear Dynamics monitored groundwater quality during all phases of the ISR uranium recovery process, including baseline, uranium recovery, and aquifer restoration. Prior to initiating uranium recovery operations, Nuclear Dynamics developed a "five spot" wellfield including recovery, injection, buffer, sampling and monitor wells. Records for the Nubeth R&D site indicate that groundwater samples were collected from nine wells, as summarized in Table 2.7-52.

Records indicate that Nuclear Dynamics began uranium recovery operations in August 1978. Groundwater monitoring results from April 4, 1978 were used to assess baseline monitoring water quality. Key constituent concentrations for each well are summarized in Table 2.7-53.

The major ion chemistry of the wells indicates that groundwater was dominated by sodium, sulfate and bicarbonate. The majority of the wells yielded significant concentrations of gross alpha, Ra-226 and uranium. The highest radionuclide concentrations were measured in well 19X, which was utilized by Nuclear Dynamics as the recovery well for the ISR pilot project. This well is completed in the ore zone and remains in use today, as discussed in previous sections. Overall, the groundwater in the wells, with the exception of 7X and 20X, exceeded Class I-III class of use standards for gross alpha.

In mid-1979, restoration activities were initiated. During restoration and decommissioning the wells were sampled on a regular basis. The results of the last samples reported by Nuclear Dynamics are presented in Table 2.7-54. The four wells used to determine restoration success were 3X, 4X, 19X and 20X. The results show that, due to elevated gross alpha concentrations, the restored water remained suitable for industrial use only.

Table 2.7-1. Little Missouri River Mean Annual Streamflow

Parameter	**USGS Gaging Stations**				
	06334000	**06334500**	**06335500**	**06336000**	**06337000**
	Near Alzada, MT	**At Camp Crook, SD**	**At Marmarth, ND**	**At Medora, ND**	**Near Watford City, ND**
Drainage Area (mi^2)	904	1,970	4,640	6,190	8,310
Mean Annual Discharge (cfs)	77	125	307	443	533
Mean Annual Flow (ac-ft)	55,782	90,556	222,405	320,930	386,130
Period of Record	1912-1969	1904-1906 1956-2009	1939-2009	1904-1908 1924-1975 2002-2009	1935-2009

Source: USGS (2010a)

Table 2.7-2. Annual Peak Streamflow for the Little Missouri River

USGS Gage 06334000 near Alzada, MT			USGS Gage 06334500 at Camp Crook, SD		
Water Year	Date	Streamflow (cfs)	Water Year	Date	Streamflow (cfs)
1912	Apr. 06, 1912	4,550	1956	Jul. 05, 1956	3,210
1913	Apr. 01, 1913	4,250	1957	Aug. 31, 1957	2,080
1914	Aug. 03, 1914	2,630	1958	Jul. 03, 1958	1,200
1915	Jun. 13, 1915	3,600	1959	Mar. 21, 1959	2,350
1916	Mar. 12, 1916	1,490	1960	Mar. 22, 1960	3,360
1917	Apr. 11, 1917	3,250	1961	Sep. 24, 1961	359
1918	Mar. 15, 1918	2,770	1962	May 28, 1962	7,600
1919	Jul. 30, 1919	1,360	1963	Jun. 16, 1963	3,420
1920	May 12, 1920	1,740(e)	1964	Jun. 11, 1964	1,440
1921	Jun. 29, 1921	915	1965	Apr. 07, 1965	4,000
1922	Jun. 16, 1922	4,100	1966	Mar. 16, 1966	1,850
1923	Sep. 30, 1923	4,090	1967	May 8, 1967	5,600
1924	Apr. 08, 1924	4,420	1968	Mar. 04, 1968	1,570
1925	Jun. 17, 1925	4,540	1969	Mar. 25, 1969	3,660
1929	May 30, 1929	4,000	1970	Apr. 13, 1970	1,370
1930	Feb. 21, 1930	2,160	1971	Jun. 05, 1971	4,440
1931	May 28, 1931	164	1972	Mar. 09, 1972	3,720
1932	Apr. 24, 1932	4,210	1973	Jun. 21, 1973	1,790
1935	Jul. 22, 1935	1,080	1974	Apr. 24, 1974	904
1936	Mar. 07, 1936	1,320	1975	May 7, 1975	8,460
1937	Jun. 14, 1937	2,780	1976	Jun. 16, 1976	4,800
1938	May 31, 1938	794	1977	Apr. 10, 1977	1,830
1939	Mar. 24, 1939	1,420	1978	Mar. 24, 1978	9,420
1940	Aug. 19, 1940	1,600	1979	Mar. 27, 1979	2,590
1941	Jun. 11, 1941	2,820	1980	Jun. 17, 1980	58
1942	Jun. 06, 1942	3,000	1981	Jul. 28, 1981	692
1943	Mar. 27, 1943	2,500	1982	May 21, 1982	6,810
1944	Apr. 04, 1944	6,000(e)	1983	Feb. 18, 1983	3,020
1945	Mar. 14, 1945	1,100(e)	1984	May 5, 1984	3,000
1946	May 24, 1946	3,040	1985	Mar. 19, 1985	3,660
1947	Jun. 23, 1947	2,850	1986	May 10, 1986	5,430
1948	Jun. 18, 1948	3,690	1987	Apr. 06, 1987	2,240
1949	Mar. 22, 1949	2,230	1988	Mar. 27, 1988	147
1950	Apr. 12, 1950	1,860	1989	May 4, 1989	1,530
1951	Jun. 17, 1951	490	1990	May 26, 1990	2,220
1952	Apr. 01, 1952	1,400	1991	May 18, 1991	307
1953	May 29, 1953	1,630	1992	Jul. 15, 1992	563
1954	Apr. 06, 1954	792	1993	Jun. 10, 1993	3,970
1955	May 19, 1955	1,780	1994	Mar. 09, 1994	2,000
1956	Mar. 22, 1956	1,000(e)	1995	May 15, 1995	7,380
1957	Jun. 24, 1957	639	1996	May 28, 1996	3,560
1958	Apr. 30, 1958	670	1997	Apr. 21, 1997	2,800
1959	Mar. 20, 1959	929	1998	Mar. 28, 1998	1,900
1960	Mar. 24, 1960	2,130	1999	Jun. 10, 1999	1,860
1961	Sep. 23, 1961	475	2000	Feb. 26, 2000	79
1962	May 27, 1962	2,940	2001	Jun. 11, 2001	2,150
1963	Jun. 17, 1963	1,320	2002	Mar. 28, 2002	46(e)
1964	Jun. 26, 1964	846	2003	Mar. 20, 2003	750
1965	Apr. 05, 1965	2,000(e)	2004	Aug. 06, 2004	1,020
1966	Jul. 29, 1966	299	2005	May 16, 2005	834
1967	Jun. 07, 1967	2,070	2006	Apr. 22, 2006	5,350
1968	Feb. 28, 1968	800	2007	Jun. 10, 2007	1,810
1969	May 4, 1969	2,420	2008	May 7, 2008	4,700

Note: (e) estimated value
Source: USGS (2010a)

Table 2.7-3. Drainage Basin Geomorphology

Drainage Basin Designation (Subwatersheds)	Drainage Area (mi^2)	Basin Length (mi)	Valley Length (mi)	Channel Length (mi)	Basin Relief (ft)	Valley Relief (ft)	Channel Relief (ft)	Total Stream Length (mi)	Basin Relief Ratio (ft/ft)	Valley Slope (ft/ft)	Channel Slope (ft/ft)	Channel Sinuosity (ft/ft)	Drainage Density (mi/mi^2)
Deadman Creek to confluence with Little Missouri River (B1-B3, B7-B8)	8.01	4.87	5.28	6.92	648	480	480	26.6	0.0252	0.0172	0.0131	1.31	3.32
Little Missouri River to confluence with Deadman Creek (B4-B6)	6.23	3.78	4.06	5.31	480	370	370	15.3	0.0240	0.0173	0.0132	1.31	2.45
Little Missouri River (total basin to project boundary, B1-B20)	18.2	6.08	6.81	8.83	668	500	500	52.2	0.0208	0.0139	0.0107	1.30	2.87
Draw 5 (B5)	2.14	1.83	2.07	2.31	225	265	225	4.39	0.0233	0.0243	0.0184	1.12	2.06
Draw 7 (B7)	0.19	0.56	0.46	0.48	159	47	47	0.48	0.0538	0.0194	0.0185	1.04	2.53
Draw 9 (B9)	0.90	2.14	1.94	2.26	296	206	206	2.26	0.0262	0.0201	0.0173	1.16	2.51
Draw 13 (B13)	1.65	2.61	2.42	2.94	224	134	134	3.51	0.0163	0.0105	0.0086	1.21	2.13
Draw 14 (B14-B16)	0.60	1.86	1.81	1.98	294	206	206	1.98	0.0299	0.0216	0.0197	1.06	3.30
Draw 15 (B15)	0.16	0.66	0.53	0.56	158	88	88	0.56	0.0453	0.0314	0.0230	1.06	3.50
Draw 18 (B18)	0.13	0.80	0.54	0.56	178	72	72	0.56	0.0421	0.0253	0.0244	1.04	4.31

Note: Subwatersheds are depicted on Figure 2.7-3.

Table 2.7-4. Precipitation Frequency

Storm Event	Precipitation (in)	Storm Event	Precipitation (in)	Storm Event	Precipitation (in)
2yr - 24hr	1.8	2yr - 6hr	1.4	2yr - 1hr	1.0
5yr - 24hr	2.4	5yr - 6hr	1.8		
10yr - 24hr	2.8	10yr - 6hr	2.2		
25yr - 24hr	3.4	25yr - 6hr	2.6		
50yr - 24hr	3.8	50yr - 6hr	3.0		
100yr - 24hr	4.2	100yr - 6hr	3.4	100yr - 1hr	2.6

Source: Miller et al. (1973)

Table 2.7-5. HEC-HMS Peak Flow and Runoff Volumes

Stream Designation	Precipitation Distribution	Parameter (Units)	Recurrence Interval (yr)					
			2	5	10	25	50	100
Little Missouri River upstream of the confluence with Deadman Creek (J3)	SCS Type II, 24-hr General Storm	Peak (cfs)	274	632	924	1413	1763	2128
		Vol. (acre-ft)	98	195	271	396	485	578
Confluence of Deadman Creek and Little Missouri River (J4)	SCS Type II, 24-hr General Storm	Peak (cfs)	775	1714	2469	3732	4633	5583
		Vol. (acre-ft)	267	521	717	1038	1267	1505
Little Missouri River at Eastern Project Boundary (J10)	SCS Type II, 24-hr General Storm	Peak (cfs)	457	1214	2143	3719	4832	5975
		Vol. (acre-ft)	327	643	887	1289	1577	1877
Draw 5 (B5)	SCS Type II, 24-hr General Storm	Peak (cfs)	117	288	428	668	840	1020
		Vol. (acre-ft)	33	68	95	141	173	208
Draw 7 (B7)	SCS Type II, 24-hr General Storm	Peak (cfs)	9	34	56	97	127	160
		Vol. (acre-ft)	2	4	6	10	12	15
Draw 9 (B9)	SCS Type II, 24-hr General Storm	Peak (cfs)	22	72	118	201	263	331
		Vol. (acre-ft)	8	20	29	46	58	70
Draw 13 (B13)	SCS Type II, 24-hr General Storm	Peak (cfs)	102	219	311	462	570	681
		Vol. (acre-ft)	33	64	87	125	152	180
Draw 14 (Reach 8)	SCS Type II, 24-hr General Storm	Peak (cfs)	63	142	204	305	287	457
		Vol. (acre-ft)	11	22	30	44	41	64
Draw 15 (B15)	SCS Type II, 24-hr General Storm	Peak (cfs)	17	43	65	100	126	152
		Vol. (acre-ft)	3	5	7	11	13	16
Draw 18 (B18)	SCS Type II, 24-hr General Storm	Peak (cfs)	3	15	26	46	62	80
		Vol. (acre-ft)	1	2	4	6	8	9

Note: Subwatersheds are depicted on Figure 2.7-3.

Table 2.7-6 Peak Flow Estimate Comparison

Method		Recurrence Interval (yr)					
		2	5	10	25	50	100
HEC-HMS AMC II	Peak (cfs)	457	1,214	2,143	3,719	4,832	5,975
Miller (2003)	Peak (cfs)	112	303	490	804	1,096	1,445

Table 2.7-7. Surface Water Rights within 2 Miles of Proposed Project Area

Permit #	Facility Name	Priority Date	Location (Tns-Rng-Sec-¼¼)	Permitted Area (ac)	Uses	Status	Appropriator	Permitted Capacity (ac-ft)	Project Area
P732S	BERGER STOCK RESERVOIR	1/25/1954	53-67-6-SESE		STO	Fully Adjudicated	MINNIE BERGER	5.90	
P11959D	SYDNOR DITCH	8/7/1913	53-67-17-NWSE	25	IRR_SW	Unknown	THOMAS C. SYDNOR	0.36	
P2512R	SYDNOR RESERVOIR	8/4/1913	53-67-17-NWSE		IRR_SW	Unadjudicated	THOMAS C. SYDNOR	3.40	
P128R	LITTLE MISSOURI RESERVOIR	10/31/1898	53-67-18-SWNW		STO	Cancelled	GRAND ISLAND & NORTHERN RAILROAD CO.		X
P15509S	BUTTE #1 STOCK RESERVOIR	8/22/2003	53-67-18-SENE		STO	Cancelled	ANTONE SWANDA		X
P17592S	BUTTE #1 STOCK RESERVOIR	2/1/2006	53-67-18-SWSW		STO	Unadjudicated	ANTONE SWANDA** WYO STATE OFFICE OF LANDS & INVESTMENTS	1.24	X
P21242D	OSHOTO SPRINKLER IRRIGATION SYSTEM	7/15/1953	53-67-18-SWNE	70	IRR_SW	Fully Adjudicated	HARRY BERGER	1.00	X
P27819D	#1-15 SUN FEDERAL WATER HAUL	11/1/1982	53-67-18-SWSW		DRI; IND_SW; OIL; TEM	Cancelled	RAYMOND T. DUNCAN		X
P30061D	#31-14-53-68 WATER HAUL	10/17/1988	53-67-18-SWNE		DRI; IND_SW; OIL; TEM	Cancelled	PRENALTA CORP.		X
P34374D	STRATA ENERGY #3 WATER HAUL	6/28/2010	53-67-18-SESE		TEM	Complete	STRATA ENERGY		X
P6046R	OSHOTO RESERVOIR	7/15/1953	53-67-18-SWNE		IRR_SW; IND_SW	Fully Adjudicated	HARRY BERGER	172.70	X
P7913R	EVAPORATION RESERVOIR	5/16/1978	53-67-18-SWSW		IND_SW; MIS_SW	Cancelled	NUCLEAR DYNAMICS**WYO BOARD OF LAND COMMISSIONERS	17.20	X
P15506S	BUTTE #2 STOCK RESERVOIR	8/22/2003	53-67-19-NWNW		STO	Unadjudicated	ANTONE SWANDA	0.96	X
P2704S	BRISLAWN #2 STOCK RESERVOIR	2/3/1959	53-67-21-SWSW		STO	Unadjudicated	FRANCIS BRISLAWN	1.35	
P1159S	BRISLAWN #1 STOCK RESERVOIR	2/9/1955	53-67-32-NENW		STO	Unadjudicated	FRANCIS J. BRISLAWN	2.54	
P1630S	BRISLAWN NO. 1 STOCK RESERVOIR, FIRST ENLARGEMENT OF	10/24/1956	53-67-32-NENW		STO	Unadjudicated	FRANCIS J. BRISLAWN	19.07	
P6222S	BIGGERS #1 STOCK RESERVOIR	8/12/1968	53-67-32-NENE		STO	Fully Adjudicated	C. A. BIGGERS	1.92	

Table 2.7-7. Surface Water Rights within 2 Miles of Proposed Project Area (Continued)

Permit #	Facility Name	Priority Date	Location (Tns-Rng-Sec-¼¼)	Permitted Area (ac)	Uses	Status	Appropriator	Permitted Capacity (ac-ft)	Project Area
P5255S	KEVIN STOCK RESERVOIR	7/21/1965	54-67-31-SESW		STO	Unadjudicated	MAX EVANS	3.92	
P34373D	STRATA ENERGY #1 WATER HAUL	6/28/2010	53-68-1-NESE		TEM	Complete	STRATA ENERGY		
P26760D	PRAIRIE WATER HAUL #1	9/8/1980	53-68-2-SWNE		IND_SW; OIL; TEM	Cancelled	DAVIS OIL CO.		
P28140D	KEE WATER PIPELINE #1 WATER HAUL	8/22/1983	53-68-2-SENE		DRI; IND_SW; OIL; TEM	Cancelled	KEE EXPLORATION, INC.		
P28776D	KISSACK WATER HAUL #31	12/10/1984	53-68-2-SENE		DRI; IND_SW; OIL; TEM	Cancelled	KISSACK WATER & OIL, INC.		
P30666D	SPIRIT #3 WATER HAUL	7/3/1991	53-68-2-SENE		DRI; IND_SW; TEM	Cancelled	APACHE CORP.		
P27555D	FEDERAL #33-11 WATER HAUL	4/5/1982	53-68-10-NENE		DRI; IND_SW; OIL; TEM	Cancelled	BASIC EARTH SCIENCE SYSTEMS INC.		
P12824D	RUBY DITCH	11/9/1914	53-68-12-NENE	48.3	IRR_SW	Fully Adjudicated	RUBY WESLEY	0.69	
P2767R	RUBY RESERVOIR	11/9/1914	53-68-12-NENE		IRR_SW	Fully Adjudicated	RUBY WESLEY	6.60	
P15507S	DEADMAN #1 STOCK RESERVOIR	8/22/2003	53-68-13-NWSE		STO	Unadjudicated	ANTONE SWANDA	0.96	X
P15508S	DEADMAN #2 STOCK RESERVOIR	8/22/2003	53-67-18-NWSW		STO	Unadjudicated	ANTONE SWANDA	0.17	X
P17341S	ENL. DEADMAN #1 STOCK RESERVOIR	8/10/2005	53-68-13-NWSE		STO	Unadjudicated	ANTONE SWANDA	1.47	X
P26607D	SNYDER OIL ENERGY DRILLING WATER HAUL	6/4/1980	53-68-13-NESW		DRI; IND_SW; OIL; TEM	Cancelled	SNYDER OIL ENERGY DRILLING		
P26832D	SNYDER OIL WATER HAUL NO. 1	10/31/1980	53-68-13-NESW		DRI; IND_SW; OIL; TEM	Cancelled	SNYDER OIL ENERGY DRILLING		
P27242D	KISSACK PIPELINE #3	7/24/1981	53-68-13-NESW		DRI; IND_SW; OIL; TEM	Cancelled	KISSACK WATER & OIL SERVICE		
P27640D	#1 NORTH MOREL WATER LINE	5/24/1982	53-68-13-NESW		DRI; IND_SW; OIL; TEM	Cancelled	GALLAGHER DRILLING, INC.		
P28692D	33-23-53-68 GOV'T WATER HAUL	10/22/1984	53-68-13-NESW		DRI; IND_SW; OIL; TEM	Cancelled	PRENALTA CORP.		
P32841D	DEADMAN PASTURE STOCK PIPELINE	6/23/2003	53-68-13-NWSE		STO	Fully Adjudicated	ANTONE SWANDA	0.05	X

Table 2.7-7. Surface Water Rights within 2 Miles of Proposed Project Area (Continued)

Permit #	Facility Name	Priority Date	Location (Tns-Rng-Sec-¼¼)	Area (ac)	Uses	Status	Appropriator	Capacity (ac-ft)	Within Project Area
P27596D	KISSACK PIPELINE #11	5/10/1982	53-68-25-NWSW		DRI; IND_SW; OIL; TEM	Cancelled	KISSACK WATER & OIL, INC.		
P514S	RAY NO. 2 STOCK RESERVOIR	11/18/1953	53-68-25-NWSW		STO	Unadjudicated	RAY KOTTRABA	1.36	
P29206D	SANTA FE FEDERAL 26-5	9/23/1985	53-68-26-NESE		DRI; IND_SW; OIL; TEM	Cancelled	CONLEY P. SMITH		
P29368D	HAHN FEDERAL 27-12 WATER HAUL	5/1/1986	53-68-26-NWNE		DRI; IND_SW; OIL; TEM	Cancelled	CONLEY P. SMITH		
P4866S	KOTTRABA #2 STOCK RESERVOIR	2/12/1963	53-68-26-NESE		STO	Unadjudicated	RAY W. KOTTRABA	2.20	
P4869S	KOTTRABA #1 STOCK RESERVOIR	2/25/1963	53-68-26-SENE		STO	Unadjudicated	RAY W. KOTTRABA	9.67	
P513S	RAY NO. 1 STOCK RESERVOIR	11/18/1953	53-68-26-NWSW		STO	Cancelled	RAY KOTTRABA	1.00	
P7939S	KOTTRABA NO. 3 STOCK RESERVOIR	1/20/1975	53-68-26-NWSW		STO	Unadjudicated	CHARLES KOTTRABA	2.70	
Unknown	TWRES01	Unknown	53-67-7-SESE		STO	Unknown	T.J. WESLEY		X
Unknown	HBRES03	Unknown	53-67-17-NENW		STO	Unknown	HARRY BERGER		
Unknown	CSRES03	Unknown	53-67-18-SESE		STO	Unknown	CAROL STRONG		X
Unknown	CSRES04	Unknown	53-67-18-SESE		STO	Unknown	CAROL STRONG		X
Unknown	CSRES01	Unknown	53-67-19-NENE		STO	Unknown	CAROL STRONG		
Unknown	CSRES02	Unknown	53-67-19-SWNE		STO	Unknown	CAROL STRONG		X
Unknown	CSRES10	Unknown	53-67-19-NENE		STO	Unknown	CAROL STRONG		
Unknown	CSRES07	Unknown	53-67-20-NWNW		STO	Unknown	CAROL STRONG		
Unknown	CSRES08	Unknown	53-67-20-NWNW		STO	Unknown	CAROL STRONG		
Unknown	CSRES09	Unknown	53-67-20-NWNW		STO	Unknown	CAROL STRONG		
Unknown	CSRES12	Unknown	53-67-20-NWNW		STO	Unknown	CAROL STRONG		
Unknown	CSRES11	Unknown	53-67-20-SWNW		STO	Unknown	CAROL STRONG		
Unknown	CSRES05	Unknown	53-67-30-NENE		STO	Unknown	CAROL STRONG		
Unknown	CSRES13	Unknown	53-67-30-NWNE		STO	Unknown	CAROL STRONG		

Table 2.7-7. Surface Water Rights within 2 Miles of Proposed Project Area (Continued)

Permit #	Facility Name	Priority Date	Location (Tns-Rng-Sec-¼¼)	Permitted Area (ac)	Uses	Status	Appropriator	Permitted Capacity (ac-ft)	Within Project Area
Unknown	TWRES02	Unknown	53-68-12-SESE		STO	Unknown	T.J. WESLEY		X
Unknown	TSRES01	Unknown	53-68-13-NESW		STO	Unknown	ANTONE SWANDA		
Unknown	TSRES02	Unknown	53-68-13-NWSE		STO	Unknown	ANTONE SWANDA		X

Uses:

STO	Stock
IRR_SW	Irrigation
DRI	Drilling
IND_SW	Industrial
OIL	Oil Refining/Production
TEM	Temporary
MIS_SW	Miscellaneous

Source: WSEO (2010)

Table 2.7-8. Surface Water Monitoring Stations

Station	Stream	Latitude (WGS84)	Longitude (WGS84)	Legal Location (Tns-Rng-Sec-¼¼)
SW-1	Little Missouri River, Downstream	44.58801	-104.93767	53-67-6-SWSW
SW-2	Little Missouri River, Upstream	44.56989	-104.96164	53-67-19-NWNW
SW-3	Deadman Creek	44.57568	-104.96368	53-68-13-NESE

Table 2.7-9. Existing Reservoirs within the Proposed Project Area

Reservoir	WSEO Permit No.	Capacity Normal (acre-ft)	Capacity Maximum (acre-ft)	Surface Area Normal (acre)	Surface Area Maximum (acre)	Depth Normal (ft)	Depth Maximum (ft)	Shoreline Normal (ft)	Shoreline Maximum (ft)	Use Intended	Use Current
Deadman #1 Stock Reservoir[1]	P15507S	1.43	2.04	1.12	1.31	2.5	3	1,910	1,888	stock	stock
Deadman #2 Stock Reservoir[3]	P15508S		0.21		0.12		4		360	stock	stock
Oshoto Reservoir[2]	P6046R	103.37	172.7	21.2	28.1	16	18		25,547	irrigation/industrial/ stock	industrial/stock
Butte #1 Stock Reservoir[1]	P17592S	1.19	6.42	0.67	2.03	3.5	7.5	2,246	4,200	stock	stock
Butte #2 Stock Reservoir	P15506S						Removed				
TSRES01[3,4]			1.56		0.77		5		1,517	stock	stock
TSRES02[3]			1.21		1.19		3		2,006	stock	stock
TWRES01[1]		2.03	4	0.53	1.08	7.5	10	786	1,239	stock	stock
TWRES02[1]		0.49	1.53	0.27	0.54	3.5	6	568	810	stock	stock
CSRES02[1]		0.03	0.9	0.06	0.29	1	6	207	590	stock	stock
CSRES03[1]		2.68	9.46	1.31	2.48	4	7.5	1,494	1,631	stock	stock
CSRES04[1]		0.18	0.65	0.14	0.33	2.5	4.5	404	732	stock	stock

Notes:
[1] Values estimated using May 2010 LiDAR data.
[2] Values estimated using May 2010 LiDAR data and permitted area-capacity table.
[3] Water surface was at maximum capacity at the time of survey.
[4] TSRES01 is located just outside of the proposed permit area.

Table 2.7-10. Wyoming Surface Water Classes and Use Designation

	Drinking	Game Fish	Non-Game Fish	Fish Consumption	Other Aquatic Life	Recreation	Wildlife	Agriculture	Industry	Scenic Value
1	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	Yes	Yes	Yes	Yes	Yes
2AB	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2A	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
2B	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2C	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3A	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
3B	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
3C	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
4A	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
4B	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
4C	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes

Source: WDEQ/WQD 2001

Table 2.7-11. Surface Water/Groundwater Monitoring Constituents

Constituent	Holding Time	Analytical Method
pH	At time of sample	SM 4500 H B
Electrical Conductivity	28 Days	SM 2510B
Total Dissolved Solids (180)	7 Days	SM 2540
Total Suspended Solids	7 Days	SM 2540
Alkalinity, Total (As $CaCO_3$)	14 Days	SM 2320B
Nitrogen, Ammonia (As N)	28 Days	EPA 350.1
Oxygen, Dissolved	8 Hours	SM 4500-O G
Oil & Grease	28 Days	EPA 1664A
Gross Alpha	6 Months	SM 7110B
Gross Beta	6 Months	SM 7110B
Radium 226	6 Months	SM 7500-Ra B
Radium 228	6 Months	Ra-05
Turbidity	48 Hours	SM 2130
Alkalinity, Bicarbonate as HCO_3	14 Days	SM 2320B
Alkalinity, Carbonate as CO_3	14 Days	SM 2320B
Chloride	28 Days	EPA 300.0
Fluoride	28 Days	SM 4500FC
Nitrogen, Nitrate-Nitrite (As N)	28 Days	EPA 353.2
Sulfate	28 Days	EPA 300.0
Calcium	180 Days	EPA 200.7
Magnesium	180 Days	EPA 200.7
Potassium	180 Days	EPA 200.7
Sodium	180 Days	EPA 200.7
Aluminum	180 Days	EPA 200.7
Arsenic	180 Days	EPA 200.8
Barium	180 Days	EPA 200.8
Boron	180 Days	EPA 200.7
Cadmium	180 Days	EPA 200.8
Chromium	180 Days	EPA 200.7
Copper	180 Days	EPA 200.8
Iron	180 Days	EPA 200.7
Lead	180 Days	EPA 200.8
Mercury	28 Days	EPA 245.1
Molybdenum	180 Days	EPA 200.8
Nickel	180 Days	EPA 200.7
Selenium	180 Days	EPA 200.8
Uranium	180 Days	EPA 200.8
Vanadium	180 Days	EPA 200.8
Zinc	180 Days	EPA 200.7
Manganese	180 Days	EPA 200.7
Polonium 210	6 Months	OTW01 (modified)
Lead 210	6 Months	OTW01 (modified)
Thorium 230	6 Months	ACW10 (modified)

Table 2.7-12. Stream Monitoring Results

Parameter	Units	SW-1	SW-2	SW-3
Field conductivity	µmhos/cm	933 - 1200	422 - 1348	909 - 1209
Field pH	s.u.	8.06 - 8.39	7.62 - 8.35	8.5 - 8.86
Field turbidity	NTUs	9.1 - 14.14	3.86 - 11.68	14.9 - 16.29
Temperature	Deg C	1.8 - 9.8	3.2 - 7.8	2.4 - 10
Dissolved oxygen	mg/L	6.92 - 7.28	7.59 - 10.46	7.89 - 8.77
General				
Alkalinity (as CaCO3)	mg/L	331 - 497	118 - 600	357 - 586
Ammonia	mg/L	<0.1	<0.1	<0.1
Fluoride	mg/L	0.2	<0.1 - 0.3	0.1 - 0.3
Laboratory conductivity	µmhos/cm	795 - 1110	283 - 1250	794 - 1120
Laboratory pH	s.u.	8.2 - 8.7	8.1 - 8.6	8.3 - 8.8
Laboratory turbidity	NTUs	7.7 - 12.7	2.3 - 8.9	12.8 - 14.4
Laboratory dissolved oxygen	mg/L	8	10	9
Nitrate/nitrite	mg/L	<0.1	<0.1	<0.1
Total dissolved solids	mg/L	580 - 790	220 - 940	580 - 800
Total suspended solids	mg/L	<5 - 7	6 - 7	14
Major Ions				
Calcium	mg/L	17 - 37	14 - 58	24 - 32
Magnesium	mg/L	12 - 24	6 - 29	25 - 35
Potassium	mg/L	11	6 - 7	10 - 11
Sodium	mg/L	154 - 204	37 - 216	129 - 196
Bicarbonate	mg/L	404 - 542	144 - 655	435 - 619
Carbonate	mg/L	<5 - 32	<5 - 38	<5 - 47
Chloride	mg/L	7 - 8	3 - 10	4 - 7
Sulfate	mg/L	98 - 147	26 - 168	92 - 102
Metals				
Aluminum, dissolved	mg/L	<0.1 - 0.2	<0.1 - 0.2	<0.1
Arsenic, dissolved	mg/L	<0.005	<0.005	<0.005
Barium, dissolved	mg/L	<0.5	<0.5	<0.5
Boron, dissolved	mg/L	<0.1 - 0.1	<0.1	<0.1 - 0.1
Cadmium, dissolved	mg/L	<0.002	<0.002	<0.002
Chromium, dissolved	mg/L	<0.01	<0.01	<0.01
Copper, dissolved	mg/L	<0.01	<0.01	<0.01
Iron, dissolved	mg/L	0.08 - 0.33	0.14 - 0.26	0.07 - 0.34
Iron, total	mg/L	0.37 - 0.95	0.32 - 0.64	0.58 - 0.87
Lead, dissolved	mg/L	<0.02	<0.02	<0.02
Manganese, total	mg/L	0.05 - 0.17	0.05 - 0.11	0.17 - 0.21
Mercury, dissolved	mg/L	<0.001	<0.001	<0.001
Molybdenum, dissolved	mg/L	<0.02	<0.02	<0.02
Nickel, dissolved	mg/L	<0.01	<0.01	<0.01
Selenium, dissolved	mg/L	<0.005	<0.005	<0.005
Silver, dissolved	mg/L	NM	NM	NM
Uranium, dissolved	mg/L	0.008 - 0.011	0.003 - 0.02	0.009 - 0.014
Vanadium, dissolved	mg/L	<0.02	<0.02	<0.02
Zinc, dissolved	mg/L	<0.01	<0.01	<0.01
Radiological				
Ra-226, dissolved	pCi/L	<0.2	<0.2	<0.2
Ra-228, dissolved	pCi/L	<1	<1 - 1.3	<1
Gross Alpha	pCi/L	7.3 - 8.8	4 - 7.9	6 - 7.3
Gross Beta	pCi/L	8.6 - 9.7	6 - 7.4	9.8 - 11.2

NM – not measured

Table 2.7-13. Surface Water Samples of Existing Reservoirs within Proposed Project Area

Site ID	Reservoir Name	Legal Location (Tns-Rng-Sec-¼¼)	3Q09	4Q09	1Q10	2Q10	3Q10	4Q10
R-1	TWRES01	53-67-7-SESE	**X**	**X**	2	**X**	**X**	**X**
R-2	Oshoto Reservoir (P6046R)	53-67-18-SWNE	**X**	**X**	**X**	**X**	**X**	**X**
R-3	CSRES03	53-67-18-SESE	**X**	**X**	2	**X**	**X**	**X**
R-4	CSRES04	53-67-18-SESE	**X**	4	2	4	4	4
R-5	CSRES02	53-67-19-SWNE	**X**	**X**	2	**X**	**X**	2
R-6	Butte #1 Stock Reservoir (P17592S)	53-67-18-SWSW	1	1	1	1	1	**X**
R-7	TSRES01	53-68-13-NESW	1	**X**	3	3	3	3
R-8	Deadman #2 Stock Reservoir (P15508S)	53-67-18-NWSW	1	1	1	1	1	**X**
R-9	TSRES02	53-68-13-NWSE	1	4	2	4	4	4
R-10	Deadman #1 Stock Reservoir (P15507S)	53-68-13-NWSE	1	4	2	**X**	**X**	**X**
R-11	TWRES02	53-68-12-SESE	1	1	1	**X**	**X**	**X**

Notes:

X – Sample collected

1-4 – No sample collected due to:

1 – No landowner permission
2 – Dry or frozen
3 – Outside of proposed project area
4 – Reservoir located directly downstream of another reservoir; upstream reservoir sampled.

Table 2.7-14. Reservoir Monitoring Results

Parameter	Units	R-1 TWRES01	R-2 HBRES04	R-3 CSRES03	R-4 CSRES04	R-5 CSRES02	R-6 P17592S	R-7 TSRES01	R-8 P15508S	R-10 P15507S	R-11 TWRES02
Field											
Field Conductivity	µmhos/cm	147.3 - 247	654 - 1265	307 - 985	153.7	127.5 - 359	2890	2720	2700	1413 - 3640	281 - 1801
Field pH	s.u.	8.99 - 10.64	8.1 - 9.46	9 - 10.19	9.85	7.36 - 10.24	9.29	8.87	9.68	9.2 - 10.2	9.03 - 10.46
Field turbidity	NTUs	6.05 - 64.4	4.32 - 26	4.8 - 101		49.6 - 620	23.4	63	86.9	31.4 - 596	3.22 - 26.5
Temperature	Deg C	9.2 - 20.5	1.7 - 23.9	8.2 - 26.6	24.2	7.5 - 30.4	19.2	5.5	18.4	10.7 - 25.2	15.5 - 21.8
Dissolved oxygen	mg/L	3.91 - 7.21	5.34 - 9.42	4.32 - 7.66		0.46 - 8	4.88	6.78	9.87	10.14 - 11.32	4.37 - 10.73
General											
Alkalinity (as CaCO3)	mg/L	55 - 116	301 - 507	117 - 346	72	47 - 147	1090	1080	1220	639 - 1700	107 - 732
Ammonia	mg/L	<0.1	<0.1 - 0.3	<0.1 - 0.6	<0.1	<0.1 - 5.6	0.1	<0.1	<0.1	0.1 - 0.2	<0.1 - 0.1
Fluoride	mg/L	<0.1 - 0.2	0.2	<0.1 - 0.2	<0.1	<0.1	0.5	0.3	0.5	0.3 - 0.7	<0.1 - 1.7
Laboratory conductivity	µmhos/cm	129 - 231	713 - 1090	296 - 1000	143	108 - 327	2270	2000	2130	1220 - 2910	273 - 1870
Laboratory pH	s.u.	8 - 9.2	8.3 - 9.2	8.5 - 10	9.5	7.5 - 8.1	9	8.6	9.4	8.9 - 9.9	8.6 - 10
Laboratory turbidity	NTUs	4.8 - 62	3.1 - 19.1	2.4 - 101	6.2	7.6 - 490	18.7	58.4	69.4	27.3 - 392	2.2 - 24.8
Laboratory Dissolved Oxygen	mg/L	9 - 13	5 - 13	10	10	<1 - 10		12			
Nitrate/Nitrite	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Dissolved Solids	mg/L	100 - 170	460 - 730	200 - 760	100	110 - 500	1710	1360	1560	970 - 2320	210 - 1190
Total Suspended Solids	mg/L	6 - 74	<5 - 24	6 - 134	<5	58 - 252	8	62	86	37 - 530	<5 - 8
Major Ions											
Calcium	mg/L	11 - 21	15 - 29	25 - 54	16	11 - 34	18	41	13	10 - 43	5 - 38
Magnesium	mg/L	3 - 5	17 - 25	8 - 26	4	2 - 7	33	60	36	42 - 46	5 - 18
Potassium	mg/L	9 - 14	10 - 14	8 - 29	7	9 - 23	18	24	16	11 - 31	5
Sodium	mg/L	7 - 15	123 - 226	22 - 119	4	<1 - 5	515	440	494	212 - 739	24 - 427
Bicarbonate	mg/L	49 - 137	292 - 539	56 - 398	64	58 - 179	1080	1190	1030	635 - 1130	51 - 363
Carbonate	mg/L	<5 - 9	<5 - 88	5 - 43	11	<5	123	66	226	71 - 548	7 - 261
Chloride	mg/L	<1 - 4	7 - 9	3 - 9	<1	3 - 20	20	10	8	7 - 21	2 - 3
Sulfate	mg/L	4 - 8	66 - 97	32 - 169	3	<1 - 3	224	136	90	54 - 163	27 - 235
Metals											
Aluminum, dissolved	mg/L	<0.1 - 0.2	<0.1	<0.1	<0.1	0.2 - 1.4	<0.1	<0.1	<0.1	<0.1	<0.1 - 1.5
Arsenic, dissolved	mg/L	<0.005 - 0.006	<0.005 - 0.01	<0.005 - 0.022	0.009	<0.005 - 0.028	0.013	0.005	0.015	0.006 - 0.052	<0.005 - 0.007
Barium, dissolved	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Boron, dissolved	mg/L	<0.1	<0.1 - 0.1	<0.1	<0.1	<0.1	0.2	0.3	0.2	0.1 - 0.4	<0.1 - 0.6
Cadmium, dissolved	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Chromium, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron, dissolved	mg/L	<0.05 - 0.35	<0.05 - 0.06	<0.05	0.1	0.2 - 8.32	0.18	0.07	0.08	0.06 - 0.13	<0.05 - 0.8
Iron, total	mg/L	0.43 - 2.62	0.07 - 0.25	0.08 - 1.32	0.46	1.68 - 19.7	0.77	1.95	1.3	1.06 - 6.28	0.06 - 1.29
Lead, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Manganese, total	mg/L	0.02 - 0.12	0.03 - 0.16	<0.02 - 1.12	0.04	0.14 - 1.24	0.08	0.25	0.09	0.11 - 0.34	0.03
Mercury	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02 - 0.06	<0.02
Nickel, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Selenium, dissolved	mg/L	<0.005 - 0.005	<0.005	<0.005	<0.005	<0.005 - 0.006	<0.005	0.005	<0.005	<0.005	<0.005
Silver, dissolved	mg/L	<0.003	<0.003	<0.003		<0.003	<0.003		<0.003	<0.003	<0.003
Uranium, dissolved	mg/L	<0.001 - 0.001	0.006 - 0.009	<0.001 - 0.005	<0.001	<0.001	0.02	0.028	0.027	0.019 - 0.087	0.002 - 0.006
Uranium, suspended	mg/L	<0.001	<0.001	<0.001		<0.001				<0.001 - 0.003	<0.001
Vanadium, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02 - 0.03	<0.02
Zinc, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01 - 0.05	<0.01	<0.01	<0.01	<0.01	<0.01
Radiological											
Lead 210, dissolved	pCi/L	<1 - 1.29	<1	<1		<1				<1 - 1.46	<1
Lead 210, suspended	pCi/L	<1	<1	<1		<1 - 3.26				<1 - 1.55	<1
Polonium 210, dissolved	pCi/L	<1	<1	<1		<1				<1	<1
Polonium 210, suspended	pCi/L	<1	<1	<1		<1				<1	<1
Ra-226, dissolved	pCi/L	<0.2	<0.2 - 0.2	<0.2 - 0.46	0.2	<0.2 - 1.35	<0.2	0.29	<0.2	<0.2 - 0.31	<0.2
Ra-226, suspended	pCi/L	<0.2	<0.2	<0.2		<0.2 - 1.12				<0.2 - 0.3	<0.2
Ra-228, Dissolved	pCi/L	<1 - 1.34	<1 - 1.1	<1 - 1.52	<1	<1 - 1.22	<1	<1	<1	<1	<1
Th-230, dissolved	pCi/L	<0.2	<0.2	<0.2		<0.2				<0.2	<0.2
Th-230, suspended	pCi/L	<0.2	<0.2	<0.2		<0.2 - 0.28				0.28 - 0.46	<0.2
Gross Alpha	pCi/L	<2 - 3.55	3.1 - 9.5	<2 - 11.1	<2	<2 - 7.4	16.3	23	15	13.6 - 48.7	3.61 - 5.6
Gross Beta	pCi/L	8.7 - 14.3	8.1 - 22.9	8.6 - 27.6	6.9	10.5 - 28.7	20	31.4	20	12.9 - 48.5	3.9 - 11.6
QA/QC											
Anion Sum	meq/L	1.21 - 2.45	7.63 - 12.39	3.09 - 10.72	1.48	1.02 - 3.21	27.01	24.76	26.58	16.38 - 36.47	2.75 - 19.69
Cation Sum	meq/L	1.33 - 2.48	8.02 - 12.96	3.02 - 10.72	1.49	0.93 - 3.09	26.44	26.69	25.55	15.48 - 36.87	2.79 - 19.37
Total Anion/Cation Balance	%	0.45 - 4.95	0.72 - 2.47	0.01 - 2.04	0.34	0.16 - 4.62	1.07	3.74	1.97	0.55 - 2.83	0.72 - 1.97
Total Dissolved Solids (calc)	mg/L	70 - 130	430 - 690	170 - 610	80	50 - 170	1480	1360	1390	870 - 1950	150 - 680

Table 2.7-15. Nearby WYPDES Permits

Permit	Facility Name	Operator
WY0034592	Hundahl 24x-8	Wellstar Corporation
WY0033065	Gov't 33-23 Tank Battery	True Oil, LLC
WY0044296	Lease WYW66387 Wildfire A	Wildfire Partners, Inc.

Source: WDEQ/WQD (2010)

Table 2.7-16. WYPDES Effluent Limits

Constituent	WY0034592		WY0033065		WY0044296	
	2004-2009	**2009 Renewal**	**2004-2009**	**2009 Renewal**	**2004-2009**	**2009 Renewal**
Oil and grease, mg/L	10	10	10	10	10	10
Ra-226, pCi/L	60	--	60	--	60	60
Chloride, mg/L	230	2,000	230	2,000	230	2,000
Sulfate, mg/L	--	3,000	N/A	3,000	--	3,000
EC, µmhos/cm	--	7,500	N/A	7,500	--	7,500

Source: WDEQ/WQD (2010)

Table 2.7-17. Discharge Monitoring Results for WYPDES Permits

Permit	Effluent Characteristic	Concentration
WY0034592	Oil and grease, mg/L	9.6 – **13.2**
	Chloride, mg/L	65 - 88
	Radium-226, pCi/L	9.6 – 13.2
	Flow, MGD	0 – 0.013
WY0033065	Oil and grease, mg/L	6 – **22**
	Chloride, mg/L	2 – 85
	Radium-226, pCi/L	4 – 7.5
	Flow, MGD	0.033 – 0.040
WY0044296	Oil and grease, mg/L	1.2 – 8.7
	Chloride, mg/L	119 – 222
	Radium-226, pCi/L	26.9 – 53
	Flow, MGD	0.007 – 0.009
	Sulfate, mg/L	2,380
	EC, µmhos/cm	4,540

Source: WDEQ/WQD (2010)
Note: Items in bold signify an exceedance of effluent limit

Table 2.7-18. Potential Wetlands within the Proposed Project Area

Wetland Classification[1]	**Acres within Project Area**
PABFh	56.5
PABFx	0.3
PEMC	1.8
PEMCh	1.1
PEMCx	0.1
PEMF	2.6
PEMFx	0.3
PUSCh	2.3
Total[2]	**65.0**
Other Waters of the U.S.	5.1

1 Cowardin, et al. (1979):
PABFh – Palustrine, Aquatic Bed, Semipermanently Flooded, Diked; **PABFx** – Palustrine, Aquatic Bed, Semipermanently Flooded, Excavated; **PEMC**- Palustrine, Emergent, Seasonally Flooded; **PEMCh** – Palustrine, Emergent, Seasonally Flooded, Diked; **PEMCx** – Palustrine, Emergent, Seasonally Flooded, Excavated; **PEMF** – Palustrine, Emergent, Semipermanently Flooded; **PEMFx** – Palustrine, Emergent, Semipermanently Flooded, Excavated; **PUSCh** – Palustrine, Unconsolidated Shore, Seasonally Flooded, Diked

2 Total wetland acres include Wetland and Reservoir/Stockpond Map Units as noted on Table 3.5-1 of the ER.

Table 2.7-19. Stratigraphic Relationships and Hydrologic Characteristics in Recent to Pre-Cambrian units of the eastern Powder River Basin

Age	Geologic Unit	Hydrologic Characteristics
Holocene	**Alluvium**-Unconsolidated silt, sand, and occasional gravel. Underlies flood plains and bordering terraces. Thickness is typically under 25 feet, up to 50 feet in major drainages. Alluvium overlying formation of Tertiary age is typically fine to medium grained, and coarse-grained close to uplifts.	Water producing capabilities are highly variable, depending on saturated thickness and grain size distribution. Water quality is also variable. TDS concentrations range from 100 to over 4,000 mg/L, with lower TDS on basin margins and higher TDS in interior. Water type is also variable.
Paleocene	**Fort Union Formation**-Sandstone, fine-grained, and interbedded shale, carbonaceous shale and coal. Thickness about 2,300 feet in east part of basin, and about 2,900 feet in southwest part. Outcrops west of Ross Area. Dips to the west.	Major aquifer in Campbell County. City of Gillette municipal wells produce from the Fort Union Formation, which is blended with water from the City's Madison Formation wellfield. Properly designed wells can produce over 200 gpm. In the Gillette area, Fort Union Formation groundwater has TDS concentrations ranging from 300 to 600 mg/L. Water is of the sodium-bicarbonate type.
Upper Cretaceous	**Lance Formation**-Sandstone, fine-to medium-grained and interbedded sandy shale and claystone. Thickness increases southward on east side of basin from about 500 feet in northeast Campbell County to about 1,600 feet in Weston County, and from about 2,500 feet in Niobrara County to as much as 3,000 feet in southern Converse County.	Well yields typically low, but can exceed 100 gpm if screened through entire interval. Most stock/domestic wells completed in the Lance Formation tap a small part of the formation. Within the Ross area TDS concentrations in Lance Formation wells are on the order of 1,000 mg/L of sodium-bicarbonate-sulfate water.
	Fox Hills Formation-Predominantly sandstone, fine- to medium-grained, containing thin beds of sandy shale; thickness is approximately 100 feet in Campbell County, and ranges from about 125 to 200 feet in Crook and Weston Counties, and from 400 to 500 feet in Niobrara County.	Numerous industrial production wells are completed in Fox Hills Formation and overlying Lance sequence, particularly in Campbell County. Properly designed wells can produce 500 gpm or more. Within the Ross area, a number of water-flood wells are completed in the Fox Hills Formation. Based on the monitoring wells completed at Ross, well yields are in the order of 20-40 gpm. TDS concentrations in the Ross monitoring wells completed in the Fox Hills Formation are on the order of 1,350 mg/L. The water is of the sodium-bicarbonate-sulfate type.

Table 2.7-19. Stratigraphic Relationships and Hydrologic Characteristics in Recent to Pre-Cambrian units of the eastern Powder River Basin (Continued)

Age	Geologic Unit	Hydrologic Characteristics
Upper Cretaceous	**Pierre Shale**-Shale, some sandy shale and sandstone, and many beds of bentonite. Contains the Groat Sandstone Bed of the Gammon Ferruginous Member (Shannon Sandstone equivalent) in Crook and Weston Counties. Formation thickens southward from about 2,100 feet in northernmost Crook County to about 2,900 feet in central Weston County to as much as 3,100 feet in Niobrara County. Grades westward in subsurface into Lewis Shale, Mesaverde Formation and upper part of Cody Shale on west side of basin.	The sequence consisting of the Pierre Shale, Niobrara Formation, Carlile Shale, Greenhorn Formation, and Belle Fourche Shale is predominantly shale with only local lenses of sand from which small amounts of water may be derived. The Groat Sandstone Bed might be an exception but yield above 20 gpm is unlikely.
	Niobrara Formation-Calcareous shale and marl with some noncalcareous shale near base; contains many thin beds of bentonite; thickness ranges from 150 to 225 feet.	
	Carlile Shale-Shale, sandy in middle part; thickness ranges from about 450 feet to about 600 feet in northwest Crook County. Contains Turner Sandy Member in Crook and Weston Counties which is about 185 thick near Upton.	
	Greenhorn Formation-Shale, limestone and marl. Thickness variable: 125 to 370 feet in northern Crook County, 70 to 80 feet in southwest Crook County, and about 270 feet in Newcastle Osage area.	
	Belle Fourche Shale-Shale, dark gray to bluish black; contains numerous concretions and few thin beds of bentonite. About 850 thick in northwest Crook County.	

Table 2.7-19. Stratigraphic Relationships and Hydrologic Characteristics in Recent to Pre-Cambrian units of the eastern Powder River Basin (Continued)

Age	Geologic Unit	Hydrologic Characteristics
Lower Cretaceous	**Mowry Shale**-Hard siliceous shale in upper part, soft slightly siliceous shale in lower part; contains a few silty and sandy beds. Thickness increases to north in eastern part of basin, to about 250 thick in northern Crook County.	Not considered an aquifer.
	Newcastle Sandstone-Variable lithology, but mostly fine-to medium grained lenticular sandstone, with lesser amounts of siltstone and shale; thickness at most places ranges from 20 to 60 feet. As much as 100 feet thick in Newcastle area. Muddy Sandstone equivalent.	Sandstone beds in the Newcastle Sandstone and Skull Creek Shale may yield small amounts locally, but other rocks not considered water-bearing.
	Skull Creek Shale-Dark gray to black; contains a few thin beds of sandstone and siltstone. About 200 feet thick in Osage-Newcastle area.	
Lower Cretaceous	**Inyan Kara Group**-Consists of the Fall River Formation (Dakota Sandstone) and the Lakota Formation.	Wells completed in Fall River and Lakota yield from 5 to 20 gpm, with occasional higher yields; Dakota sandstone a regional aquifer on east side of Black Hills Uplift. TDS concentrations generally range from 300-3,000 mg/L of sodium-sulfate type water.
	Fall River-Sandstone fine to medium grained, with interbedded shale and siltstone, thickness generally 120 to 150 feet thick.	
	Lakota-Sandstone, conglomeratic sandstone and shale; lenticular, with rapid composition changes both laterally and vertically; thickness ranges from about 100 to 300 feet.	

Table 2.7-19. Stratigraphic Relationships and Hydrologic Characteristics in Recent to Pre-Cambrian units of the eastern Powder River Basin (Continued)

Age	Geologic Unit	Hydrologic Characteristics
Jurassic	**Morrison Formation**-Typically consists of variegated shale, with interbedded fine grained sandstone in lower part. In an area north of Newcastle and east of Osage, the Morrison consists locally in part or all of fine-grained sandstone resembling the Unkpapa Sandstone which locally replaces the Morrison at the south end of the Black Hills.	Sand zones may yield water, but most of the formation does not contain water-bearing strata.
	Sundance Formation-Shale, greenish-gray, and interbedded yellowish-gray fine grained sandstone; thickness generally between 370 and 400 feet in east part of basin. Formation consists of five members in the Black Hills, which in ascending order are the Canyon Springs Sandstone, Stockade Beaver Shale, Hulett Sandstone, Lak, and Redwater Shale.	Hulett sandstone may produce water suitable for livestock. TDS concentrations on the order of 2,500 mg/L.
	Gypsum Spring Formation-Massive white gypsum, red claystone, and gray limestone. About 125 feet thick in northern Crook County.	Well yields are minimal. High TDS.
Triassic-Permian	**Spearfish Formation**-Red shale, siltstone, sandstone, and white gypsum; contains thick beds of gypsum in lower part. Up to 825 feet thick in Crook County.	Goose Egg Formation and equivalent rocks, Spearfish Formation, Minnekahta Limestone, and Opeche Shale, rocks consist mostly of shale, gypsum, and thin-bedded limestone with minor sand. Well yields are small with higher TDS (500-3,000 mg/L the norm).
	Minnekahta Limestone-Thin-bedded limestone and dolomitic limestone; about 40 feet thick.	
	Opeche Shale-Shale, fine-grained sandstone and gypsum; 70-120 feet thick in Black Hills area.	

Table 2.7-19. Stratigraphic Relationships and Hydrologic Characteristics in Recent to Pre-Cambrian units of the eastern Powder River Basin (Continued)

Age	Geologic Unit	Hydrologic Characteristics
Permo-Penn.	**Minnelusa Formation**-Interbedded sandstone, sandy dolomite and limestone. Some shale and siltstone, occasional beds of gypsum and anhydrite. Thickness ranges from 700 to 900 feet.	Well yields range from 20 to as much as several hundred gallons per minute. Only potable near outcrop, with TDS concentrations increasing with depth. City wells at Hulett are completed in Minnelusa. Reported yield is 300 gpm/well. Minnelusa produces oil in the eastern PRB; producing wells at Ross Area are completed in Minnelusa at approximately 6,100 feet. Target for disposal wells in eastern PRB.
Mississippian	**Pahasapa (Madison) Limestone**-White to light-gray limestone, fine grained massive; cavernous in places. Thickness ranges from 900 feet in northern Black Hills to approximately 300 feet near Weston-Niobrara County line.	Where fractured and cavernous, well yields can exceed 1000 gpm. The City of Gillette's Madison wellfield is located in T49N, R67W. Yield from the 10-wellfield is 9,300 gpm from approximately 2,500 feet. TDS concentrations at the Gillette wellfield range from 590-714 mg/L. TDS concentrations increase with distance from the outcrop. Near the outcrop, TDS concentrations are less than 500 mg/L and water is of the calcium-bicarbonate type. Further from the outcrop, TDS concentration of 3,000 mg/L can be expected, and sulfate concentration increases with depth.
Ordovician	**Winnipeg Formation**-Siltstone and shale; thins southward, likely absent south of Crook County. Whitewood Dolomite - massive bedded dolomite roughly 50 feet thick. Also thins to south and is likely absent south of Crook County.	Winnipeg Formation is confining layer above Deadwood Formation. Whitewood Dolomite may yield water in small quantities.

Table 2.7-19. Stratigraphic Relationships and Hydrologic Characteristics in Recent to Pre-Cambrian units of the eastern Powder River Basin (Continued)

Age	Geologic Unit	Hydrologic Characteristics
Cambrian	**Deadwood Formation**-Massive buff sandstone, coarse-grained, conglomeratic at base. Flaggy dolomite, and flat pebble limestone conglomerate. Also contains greenish-gray glauconiticic interbedded shaly siltstones and claystones.	Minor aquifers near outcrop. Well yields of approximately 20 gpm likely.
	Flathead Sandstone-Fine- to coarse-grained sandstone, roughly 190 feet thick in eastern portion of basin. Few well penetrations due to overlying productive aquifers.	
Pre-Cambrian	**Igneous and metamorphic rocks**. Chiefly granite gneiss and schist complex of igneous and metamorphic rocks that underlie sedimentary strata in the basin and form the core of the Bighorn Mountains. Also found associated with intrusive of Tertiary age in the Black Hills such as Bear Lodge Mountains and Mineral Hill.	Yields of as much as 20 gpm may be possible locally from fractures, joints and weathered zones in areas of outcrop, but rocks may not yield any water at many locations. Chances of obtaining water decrease as depth increases. TDS concentrations generally less than 100 mg/L; water is usually calcium bicarbonate type.

Sources: Hodson et al. 1973, HKM Associates 1993, WSEO 2010

Table 2.7-20. Strata Energy/Ross ISR Project Monitor Well Construction Summary

Regional Baseline Well ID	Stratigraphic Interval/Aquifer	Location Coordinates (NAD 83, WY-E)		Ground Surface Elevation (ft amsl)	Top of Casing Elevation (ft amsl)	Hole Diameter/Depth Interval	PVC Well Casing Diameter/Depth Interval	PVC Well Screen Diameter/Depth Interval	Screened/ Aquifer Thickness (ft)	Completion Date
		Northing	Easting							
12-18 SA	Surficial	1487482	709185	4184.8	4185.8	8.75" / 0' - 103'	5" / 0' - 63'	3" / 63' - 103'	40.0	11/20/09-12/20/09
12-18 SM	Shallow	1487516	709224	4185.9	4187.1	8.75" / 0' - 352'	5" / 0' - 342'	3" / 342' - 352'	10.0	11/22/09-12/18/09
12-18 OZ	Ore Zone	1487518	709154	4186.5	4187.9	8.75" / 0' - 584'	5" / 0' - 474'	3" / 474' - 584'	110.0	11/22/09-12/16/09
12-18 DM	Deep	1487549	709191	4188.4	4189.2	8.75" / 0' - 632'	5" / 0' - 612'	3" / 612' - 632'	20.0	11/20/09-12/17/09
34-7 SA	Surficial	1489603	713334	4134.2	4135.4	8.75" / 0' - 52'	5" / 0' - 42'	3" / 42' - 52'	10.0	11/18/09-12/12/09
34-7 SM	Shallow	1489636	713363	4133.6	4134.9	8.75" / 0' - 245'	5" / 0' - 210'	3" / 210' - 245'	35.0	11/19/09-12/11/09
34-7 OZ	Ore Zone	1489623	713271	4134.9	4136.8	8.75" / 0' - 378.5'	5" / 0' - 318.5'	3" / 318.5' - 378.5'	60.0	11/19/09-11/30/09
34-7 DM	Deep	1489669	713334	4133.8	4135.3	8.75" / 0' - 487'	5" / 0' - 472'	3" / 472' - 487'	15.0	11/17/09-12/05/09
42-19 SA	Surficial	1481283	713073	4283.3	4284.2	8.75" / 0' - 108'	5" / 0' - 98'	3" / 98' - 108'	10.0	12/16/09-01/09/10
42-19 SM	Shallow	1481249	713109	4284.8	4286.1	8.75" / 0' - 290'	5" / 0' - 260'	3" / 260' - 290'	30.0	12/12/09-01/05/10
42-19 OZ	Ore Zone	1481247	713038	4281.1	4282.5	8.75" / 0' - 560'	5" / 0' - 470'	3" / 470' - 560'	90.0	11/17/09-12/05/09
42-19 DM	Deep	1481210	713075	4283.2	4284.4	8.75" / 0' - 610'	5" / 0' - 600'	3" / 600' - 610'	10.0	12/05/09-12/30/09
34-18 SA	Surficial	1483816	712431	4246.1	4247.5	8.75" / 0' - 70'	5" / 0' - 50'	3" / 50' - 70'	20.0	11/23/09-01/14/10
34-18 SM	Shallow	1483780	712468	4246.7	4247.8	8.75" / 0' - 298'	5" / 0' - 278'	3" / 278' - 298'	20.0	11/24/09-01/14/10
34-18 OZ	Ore Zone	1483785	712397	4246.0	4247.5	8.75" / 0' - 565'	5" / 0' - 460'	3" / 460' - 565'	105.0	11/30/09-01/01/10
34-18 DM	Deep	1483748	712430	4247.0	4248.3	8.75" / 0' - 620'	5" / 0' - 600'	3" / 600' - 620'	20.0	11/23/09-01/12/10

Table 2.7-20. Strata Energy/Ross ISR Project Monitor Well Construction Summary (Continued)

Regional Baseline Well ID	Stratigraphic Interval/Aquifer	Location Coordinates (NAD 83, WY-E)		Ground Surface Elevation (ft amsl)	Top of Casing Elevation (ft amsl)	Hole Diameter/Depth Interval	PVC Well Casing Diameter/Depth Interval	PVC Well Screen Diameter/Depth Interval	Screened/ Aquifer Thickness (ft)	Completion Date
		Northing	Easting							
21-19 SA	Surficial	1483326	710648	4167.4	4169.0	8.75" / 0' - 30'	5" / 0' - 20'	3" / 20' - 30'	10.0	01/04/10-01/29/10
21-19 SM	Shallow	1483289	710685	4169.6	4170.7	8.75" / 0' - 315'	5" / 0' - 260'	3" / 260' - 315'	55.0	12/23/09-01/28/10
21-19 OZ	Ore Zone	1483283	710613	4167.0	4168.3	8.75" / 0' - 468'	5" / 0' - 433'	3" / 433' - 468'	35.0	12/28/09-01/26/10
21-19 DM	Deep	1483249	710642	4168.6	4169.9	8.75" / 0' - 565'	5" / 0' - 550'	3" / 550' - 565'	15.0	12/21/09-01/27/10
14-18 SA	Surficial	1484950	710006	4155.6	4156.8	8.75" / 0' - 65'	5" / 0' - 35'	3" / 35' - 65'	30.0	12/21/09-01/23/10
14-18 SM	Shallow	1484918	710044	4154.9	4156.2	8.75" / 0' - 327'	5" / 0' - 282'	3" / 282' - 327'	45.0	12/20/09-01/22/10
14-18 OZ	Ore Zone	1484910	709972	4155.1	4156.3	8.75" / 0' - 529'	5" / 0' - 499'	3" / 499' - 529'	30.0	12/29/09-01/15/10
14-18 DM	Deep	1484876	710013	4154.8	4156.0	8.75" / 0' - 585'	5" / 0' - 570'	3" / 570' - 585'	15.0	12/18/09-01/21/10
OW1B57-1	Ore Zone	1487589	709146	4190.9	4192.0	8.75" / 0' - 529'	5" / 0' - 529'	open hole / 529' - 536'	7.0	06/18/10-06/30/10
						12.00" / 529' - 536'				
OW1B58-1	Ore Zone	1487507	709084	4187.1	4187.9	8.75" / 0' - 531'	5" / 0' - 513'	3" / 513' - 531'	18.0	06/18/10-06/30/10
OW1B60-1	Ore Zone	1487449	709164	4183.4	4184.2	8.75" / 0' - 509'	5" / 0' - 509'	3" / 509' - 525'	16.0	06/24/10-07/01/10
						12.00" / 509' - 525'				
SA43-18-1	Surficial	1485568	713105	4146.7	4148.0	8.0" / 0 - 30.5'	2" / 0 - 8.8'	2" / 8.8 - 28.8'	20.0	05/18/10
SA43-18-2	Surficial	1485026	713633	4149.3	4150.7	8.0" / 0 - 20.5'	2" / 0 - 8.6'	2" / 8.6 - 18.6'	10.0	05/18/10
SA13-17-1	Surficial	1485559	714589	4138.7	4140.0	8.0" / 0 - 13.0'	2" / 0 - 3.7'	2" / 3.7 - 8.7'	5.0	05/17/10
SA43-18-3	Surficial	1486277	713755	4132.9	4134.8	8.0" / 0 - 27.0'	2" / 0 - 13'	2" / 13 - 23'	10.0	05/18/10

Table 2.7-21. Strata Energy/Ross ISR Project Aquifer Test Summary of Hydraulic Characteristics

Regional Baseline Well ID	Well Type	Interpretation Method	Transmissivity (ft^2/day)	Hydraulic Conductivity (ft/day)	Storativity (unitless)
34-7 OZ	Pumping	Cooper Jacob Straight Line Drawdown	367.60	6.13	n/a
		Theis Recovery	172.50	2.88	n/a
42-19 OZ	Pumping	Cooper Jacob Straight Line Drawdown	12.70	0.14	n/a
		Theis Recovery	13.40	0.15	n/a
34-18 OZ	Pumping	Cooper Jacob Straight Line Drawdown	26.20	0.25	n/a
		Theis Recovery	19.80	0.19	n/a
14-18 OZ	Pumping	Cooper Jacob Straight Line Drawdown	3.80	0.13	n/a
		Theis Recovery	23.80	0.79	n/a
21-19 OZ	Pumping	Cooper Jacob Straight Line Drawdown	34.70	0.99	n/a
		Theis Recovery	25.60	0.73	n/a
12-18 OZ	Pumping	Cooper Jacob Straight Line Drawdown	116.90	1.06	n/a
		Theis Recovery	70.80	0.64	n/a
OW1B57-1	Observation	Theis Drawdown (Confined)	100.90	14.40	1.50E-04
		Cooper Jacob Straight Line Drawdown	102.20	14.60	1.50E-04
		Theis Recovery	96.70	13.80	
OW1B58-1	Observation	Theis Drawdown (Confined)	88.10	4.90	5.80E-05
		Cooper Jacob Straight Line Drawdown	88.20	4.90	5.70E-05
		Theis Recovery	80.50	4.50	
OW1B60-1	Observation	Theis Drawdown (Confined)	88.20	5.50	6.20E-05
		Cooper Jacob Straight Line Drawdown	88.40	5.50	6.10E-05
		Theis Recovery	84.50	5.30	

Table 2.7-21 Strata Energy/Ross ISR Project Aquifer Test Summary of Hydraulic Characteristics (Continued)

Regional Baseline Well ID	Well Type	Interpretation Method	Transmissivity (ft^2/day)	Hydraulic Conductivity (ft/day)	Storativity (unitless)
OW1B57-1	Pumping	Cooper Jacob Straight Line Drawdown	81.00	11.60	
		Theis Recovery	80.30	11.50	
OW1B58-1	Observation	Hantush, 1961	111.00	6.90	3.50E-05
		Theis Drawdown (Confined)	110.00	6.20	3.50E-05
		Cooper Jacob Straight Line Drawdown	137.10	7.60	1.00E-05
		Theis Recovery	92.70	5.10	
OW1B60-1	Observation	Hantush, 1961	90.80	5.70	1.30E-05
		Theis Drawdown (Confined)	90.80	5.70	1.30E-05
		Cooper Jacob Straight Line Drawdown	113.60	7.10	4.00E-06
		Theis Recovery	96.20	6.00	
12-18 OZ	Observation	Theis Drawdown (Confined)	103.90	0.94	1.10E-04
		Cooper Jacob Straight Line Drawdown	105.60	0.96	1.00E-04
		Theis Recovery	93.20	0.85	
		Min	**3.80**	**0.13**	**4.00E-06**
		Max	**367.60**	**14.60**	**1.50E-04**
		Median	**89.60**	**5.00**	**5.75E-05**

Table 2.7-22. Ross Area Geologic/Hydrologic Nomenclature

Geologic Formation	Stratigraphic Unit[1]	Aquifer Unit	Confining Unit	Groundwater Model Layer
Recent Alluvium and/or Colluvium and/or Lance Formation	Qal-LA-LB	SA	--	1
Lance Formation	LD-LG	--	Lance Aquitards	2 and 3
	LK-LM	SM	--	4
	LN-LS	--	--	--
	LC	--	Upper Confining	5
	LT-LTS	OZ	--	6
Fox Hills Formation	FH	OZ	--	6
	BFH	--	Lower Confining	7
	BFS	DM	--	--
	BFH	--	--	--
	FS	--	--	--
Pierre Shale	KP	--	Regional Confining Unit/Aquitard	--

[1] Listed in descending order; however, not all units are always present due to discontinuous nature.

Table 2.7-23. Historical Groundwater Use within 2 Miles of Proposed Project Area

Use	Number of Wells	Percent of Total	Appropriation Dates
Domestic Only	5	4%	1943 - 1995
Domestic & Stock	15	13%	1918 - 2003
Domestic, Stock & Irrigation	1	<1%	1972 - 1972
Stock Only	34	29%	1933 - 2010
Stock & Irrigation	1	<1%	1961 - 1961
Monitor	39	33%	1977 - 2010
Industrial or Miscellaneous	24	20%	1977 - 1991
Total	119	100%	1918 - 2010

Source: WSEO (2010)

Table 2.7-24. Historical Groundwater Use within the Proposed Project Area

Use	Number of Wells	Percent of Total	Appropriation Dates
Stock Only	4	8%	1949 - 2010
Monitor	38	79%	1977 - 2010
Industrial or Miscellaneous	6	13%	1977 - 1984
Total	48	100%	1949 - 2010

Source: WSEO (2010)

Table 2.7-25. Groundwater Rights within 2 Miles of Proposed Project Area

Permit #	Facility Name	Priority Date	Location (Tns-Rng-Sec-¼¼)	Total Depth (ft)	Uses	Status	Appropriator	Depth to Water (ft)	Yield (gpm)	Within Project Area
P7330P	MINNIE BERGER #1	4/22/1961	53-67-5-NWNE	222	STK	Complete	MINNIE B. BERGER		2	
P7325P	BERGER #8	8/10/1951	53-67-5-SESW	100	DOM_GW	Complete	HARRY J. BERGER		5	
P7324P	BERGER #7	9/10/1954	53-67-5-SWSW	160	STK	Complete	HARRY J. BERGER		3	
P7328P	BERGER #11	9/5/1954	53-67-6-NENE	207	STK	Complete	HARRY J. BERGER		4	
P7331P	MINNIE BURGER #2	9/14/1958	53-67-6-SESW	125	STK	Complete	MINNIE B. BERGER		3	
P7329P	BERGER #12	9/10/1918	53-67-6-SWNE	140	DOM_GW; STK	Complete	HARRY J. BERGER		3	
P55055W	NORTH WELL #5	12/15/1980	53-67-7-NESE	130	STK	Complete	S. ELMO WESLEY	30	10	
P74302W	YARD #1	3/23/1987	53-67-7-NESE	200	DOM_GW; STK	Complete	JOHN H. & RONDI L. YARD	120	10	
P191679W	DM 34-7	10/12/2009	53-67-7-SESE	487	MON	Complete	STRATA ENERGY INC	84		X
P191680W	SA 34-7	10/12/2009	53-67-7-SESE	52	MON	Complete	STRATA ENERGY INC	21		X
P191681W	SM 34-7	10/12/2009	53-67-7-SESE	245	MON	Complete	STRATA ENERGY INC	55		X
P191682W	OZ 34-7	10/12/2009	53-67-7-SESE	379	MON	Complete	STRATA ENERGY INC	84		X
P41438W	MH #2	3/16/1977	53-67-7-SESE		MON	Cancelled	NUCLEAR DYNAMICS			X
P7326P	BERGER #9	5/15/1954	53-67-8-NENW	100	STK	Complete	HARRY J. BERGER		5	
P17466W	BERGER #13	12/15/1972	53-67-8-NWSE		DOM_GW; IRR_GW; STK	Cancelled	HARRY J. BERGER		250	
P103666W	WESLEY #1	9/3/1996	53-67-8-SWSW	160	DOM_GW; STK	Complete	VESTA LOUISA WESLEY	22	25	
P55053W	BARN WELL #3	12/15/1980	53-67-8-SWSW	60	STK	Complete	S. ELMO WESLEY	15	5	
P55054W	HOUSE WELL #4	12/15/1980	53-67-8-SWSW	90	STK	Complete	S. ELMO WESLEY	10	25	
P58895W	IMC OSHOTO MINE PIT "L"	5/12/1981	53-67-9-NWNE		MIS	Cancelled	INTERNATIONAL MINERALS & CHEMICAL CORPORATION		1200	
P58896W	IMC OSHOTO MINE PIT "M"	5/12/1981	53-67-9-SENE		MIS	Cancelled	INTERNATIONAL MINERALS & CHEMICAL CORPORATION		1200	
P58899W	IMC OSHOTO MINE PIT "P"	5/12/1981	53-67-9-SESW		MIS	Cancelled	INTERNATIONAL MINERALS & CHEMICAL CORPORATION		1200	

Table 2.7-25. Groundwater Rights within 2 Miles of Proposed Project Area (Continued)

Permit #	Facility Name	Priority Date	Location (Tns-Rng-Sec-¼¼)	Total Depth (ft)	Uses	Status	Appropriator	Depth to Water (ft)	Yield (gpm)	Within Project Area
P62157W	OSHOTO CHURCH #1	10/4/1982	53-67-9-SESW	120	MIS	Cancelled	OSHOTO COMMUNITY BIBLE CHURCH	60	12	
P76190W	OSHOTO CHURCH #1	1/11/1988	53-67-9-SESW	120	MIS	Fully Adjudicated	OSHOTO COMMUNITY BIBLE CHURCH	60	15	
P77982W	ENL OSHOTO CHURCH #1	9/13/1988	53-67-9-SESW	120	DOM_GW; STK	Complete	OSHOTO COMMUNITY BIBLE CHURCH	60		
P78287W	O C B C #2	10/12/1988	53-67-9-SESW	560	DOM_GW; MIS; STK	Unknown	OSHOTO COMMUNITY BIBLE CHURCH	18	11	
P618W	ROBINSON #1	9/29/1961	53-67-10-SWSW	415	IRR_GW; STK	Unknown	RAY W. ROBINSON	390	25	
P58901W	IMC OSHOTO MINE PIT "R"	5/12/1981	53-67-16-NWNE		MIS	Cancelled	WY BOARD OF LAND COMMISSIONERS** INTERNATIONAL MINERALS & CHEMICAL CORPORATION		1200	
P58902W	IMC OSHOTO MINE PIT "S"	5/12/1981	53-67-16-SESE		MIS	Cancelled	INTERNATIONAL MINERALS & CHEMICAL CORPORATION		1200	
P58903W	IMC OSHOTO MINE PIT "T"	5/12/1981	53-67-16-SWSE		MIS	Cancelled	WY BOARD OF LAND COMMISSIONERS** INTERNATIONAL MINERALS & CHEMICAL CORPORATION		1200	
P58900W	IMC OSHOTO MINE PIT "Q"	5/12/1981	53-67-16-SWSW		MIS	Cancelled	WY BOARD OF LAND COMMISSIONERS** INTERNATIONAL MINERALS & CHEMICAL CORPORATION		1200	
P7430P	EVANS #1	8/1/1966	53-67-17-NENW	150	DOM_GW; STK	Complete	DELL B. EVANS	100	4	
P7323P	BERGER #6	8/10/1949	53-67-17-NWSW	150	STK	Complete	HARRY J. BERGER	2	3	X
P7431P	EVANS #2	6/25/1955	53-67-17-SWNE	50	DOM_GW; STK	Complete	DELL B. EVANS	10	4	
P55052W	WINDMILL WELL #2	12/15/1980	53-67-18-NENE	128	STK	Complete	S. ELMO WESLEY	25	10	X
P41440W	MH #4	3/16/1977	53-67-18-NESW	560	MON	Abandoned	NUCLEAR DYNAMICS	83		X

Table 2.7-25. Groundwater Rights within 2 Miles of Proposed Project Area (Continued)

Permit #	Facility Name	Priority Date	Location (Tns-Rng-Sec-¼¼)	Total Depth (ft)	Uses	Status	Appropriator	Depth to Water (ft)	Yield (gpm)	Within Project Area
P41439W	MH #3	3/16/1977	53-67-18-NWSE		MON	Cancelled	NUCLEAR DYNAMICS			X
P41436W	WELL #1	3/16/1977	53-67-18-SESW	536	IND_GW; MIS	Cancelled	NUCLEAR DYNAMICS	145	10	X
P41447W	RECOVERY WELL #1	11/18/1977	53-67-18-SESW	566	IND_GW	Cancelled	NUCLEAR DYNAMICS	113	15	X
P41448W	WELL #3	11/18/1977	53-67-18-SESW		MIS	Cancelled	NUCLEAR DYNAMICS		50	X
P41449W	TEST SET #1	11/18/1977	53-67-18-SESW	550	MON	Complete	NUCLEAR DYNAMICS	150		X
P67746W	789V STATE	5/11/1984	53-67-18-SESW	566	IND_GW	Unknown	DEADMAN CREEK UNIT	113	15	X
P67747W	19XX STATE	5/11/1984	53-67-18-SESW	536	IND_GW	Unknown	DEADMAN CREEK UNIT	145	10	X
P191683W	DM 12-18	10/12/2009	53-67-18-NWNW	632	MON	Complete	STRATA ENERGY INC	175		X
P191684W	SA 12-18	10/12/2009	53-67-18-SWNW	103	MON	Complete	STRATA ENERGY INC	50		X
P191685W	SM 12-18	10/12/2009	53-67-18-SWNW	352	MON	Complete	STRATA ENERGY	88		X
P191686W	OZ 12-18	10/12/2009	53-67-18-SWNW	584	MON	Complete	STRATA ENERGY	169		X
P192703W	OW1B60-1	3/24/2010	53-67-18-SWNW		MON	Incomplete	STRATA ENERGY			X
P192704W	OW1B58-1	3/24/2010	53-67-18-SWNW		MON	Incomplete	STRATA ENERGY			X
P192705W	OW1B57-1	3/24/2010	53-67-18-NWNW		MON	Incomplete	STRATA ENERGY			X
P50243W	Unknown	9/25/1979	53-67-18-SWNW	580	MON	Complete	WY BOARD OF LAND COMMISSIONERS**INC. NUCLEAR DYNAMICS	28		X
P50244W	PHASE II-2	9/25/1979	53-67-18-SWNW	434	MON	Complete	WY BOARD OF LAND COMMISSIONERS**INC. NUCLEAR DYNAMICS	28		X
P50245W	PHASE II-3	9/25/1979	53-67-18-SWNW	565	MON	Complete	WY BOARD OF LAND COMMISSIONERS**INC. NUCLEAR DYNAMICS	32		X
P50246W	PHASE II-4	9/25/1979	53-67-18-SWNW	575	MON	Complete	WY BOARD OF LAND COMMISSIONERS**INC. NUCLEAR DYNAMICS	26		X
P50247W	PHASE II-5	9/25/1979	53-67-18-SWNW	548	MON	Complete	WY BOARD OF LAND COMMISSIONERS**INC. NUCLEAR DYNAMICS	27		X
P191691W	DM 34-18	10/12/2009	53-67-18-SWSE	620	MON	Complete	STRATA ENERGY	268		X

Table 2.7-25. Groundwater Rights within 2 Miles of Proposed Project Area (Continued)

Permit #	Facility Name	Priority Date	Location (Tns-Rng-Sec-¼¼)	Total Depth (ft)	Uses	Status	Appropriator	Depth to Water (ft)	Yield (gpm)	Within Project Area
P191692W	SA 34-18	10/12/2009	53-67-18-SWSE	70	MON	Complete	STRATA ENERGY INC	70		X
P191693W	SM 34-18	10/12/2009	53-67-18-SWSE	298	MON	Complete	STRATA ENERGY INC	136		X
P191694W	OZ 34-18	10/12/2009	53-67-18-SWSE	565	MON	Complete	STRATA ENERGY INC	277		X
P191687W	DM 14-18	10/12/2009	53-67-18-SWSW	585	MON	Complete	STRATA ENERGY	156		X
P191688W	SA 14-18	10/12/2009	53-67-18-NWSW	65	MON	Complete	STRATA ENERGY	22		X
P191689W	SM 14-18	10/12/2009	53-67-18-SWSW	327	MON	Complete	STRATA ENERGY	66		X
P191690W	OZ 14-18	10/12/2009	53-67-18-SWSW	529	MON	Complete	STRATA ENERGY	157		X
P191695W	DM 21-19	10/12/2009	53-67-19-NENW	565	MON	Complete	STRATA ENERGY INC	195		X
P191696W	SA 21-19	10/12/2009	53-67-19-NENW	30	MON	Complete	STRATA ENERGY INC	9		X
P191697W	SM 21-19	10/12/2009	53-67-19-NENW	315	MON	Complete	STRATA ENERGY INC	84		X
P191698W	OZ 21-19	10/12/2009	53-67-19-NENW	468	MON	Complete	STRATA ENERGY INC	215		X
P41441W	MH #5	3/16/1977	53-67-19-NESE		MON	Cancelled	NUCLEAR DYNAMICS			X
P191699W	DM 42-19	10/12/2009	53-67-19-SWNE	610	MON	Complete	STRATA ENERGY INC	285		X
P191700W	SA 42-19	10/12/2009	53-67-19-SWNE	108	MON	Complete	STRATA ENERGY INC	108		X
P191701W	SM 42-19	10/12/2009	53-67-19-SENE	290	MON	Complete	STRATA ENERGY INC	154		X
P50917W	22X-19	1/17/1980	53-67-19-SENW	750	IND_GW	Unknown	BURLINGTON NORTHERN INC.	150	20	X
P191702W	OZ 42-19	10/12/2009	53-67-19-SWNE	560	MON	Complete	STRATA ENERGY INC	299		X
P22582P	PRAIRIE DOG #1	2/7/1973	53-67-19-SWSW	150	STK	Complete	GRACE I. REYNOLDS	20	6	
P132537W	STRONG # 1	2/8/2001	53-67-20-NWNW	330	DOM_GW; STK	Complete	GEORGE / CAROL STRONG	27		
P645W	ROBINSON #3	10/3/1961	53-67-20-NWNW	120	DOM_GW; STK	Complete	RAY W. ROBINSON	70	20	
P78474W	ROBINSON #4	11/9/1988	53-67-20-NWNW	600	DOM_GW; STK	Complete	GEORGE & CAROL STRONG	40	2	
P7318P	BERGER #1	12/30/1943	53-67-22-NWNW	300	DOM_GW	Complete	HARRY J. BERGER		5	
P7320P	BERGER #3	8/5/1961	53-67-22-NWNW	434	STK	Complete	HARRY J. BERGER	6	4	
P619W	ROBINSON #2	9/29/1961	53-67-30-NENE	120	STK	Complete	RAY W. ROBINSON	90	25	

Table 2.7-25. Groundwater Rights within 2 Miles of Proposed Project Area (Continued)

Permit #	Facility Name	Priority Date	Location (Tns-Rng-Sec-¼¼)	Total Depth (ft)	Uses	Status	Appropriator	Depth to Water (ft)	Yield (gpm)	Within Project Area
P72048W	KIEHL WATER WELL #2	2/6/1986	53-67-30-NWSE	720	IND_GW	Unknown	PETROLEUM, INC.	272	20	
P65808W	KIEHL WATER WELL #1	10/26/1983	53-67-30-SESE		IND_GW	Unknown	PETROLEUM, INC.		50	
P70181W	KIEHL WATER WELL #1	11/19/1984	53-67-30-SESE	662	IND_GW	Unknown	PETROLEUM, INC.	220	30	
P72004W	KIEHL WATER WELL #1	2/24/1986	53-67-30-SESE	662	STK	Complete	PETROLEUM**ANTONE SWANDA	220	25	
P75737W	ENL KIEHL WATER WELL #1	10/5/1987	53-67-30-SESE	662	MIS	Unknown	PETROLEUM, INC.	220		
P22585P	REYNOLDS #2	2/7/1973	53-67-30-SESW	286	STK	Complete	GRACE I. REYNOLDS	100	2	
P84615W	KIEHL WATER WELL #3	3/11/1991	53-67-30-SESW		IND_GW	Cancelled	PETROLEUM, INC.		50	
P58905W	IMC OSHOTO MINE PIT "V"	5/12/1981	53-67-33-SWNW		MIS	Cancelled	INTERNATIONAL MINERALS & CHEMICAL CORPORATION		1200	
P17177W	BLATT #1	12/12/1972	53-68-1-NENW	180	STK	Complete	PHILENA M. BLATT		1	
P23418P	KOKESH #1	12/31/1952	53-68-1-SWSW	150	STK	Complete	GRACE ZIMMERSCHIED		1	
P71108W	GOODLAD #2	9/10/1985	53-68-2-SENE	220	STK	Complete	PHILENA BLATT	100	15	
P50113W	GOODLAD WELL #3	9/27/1979	53-68-2-SWNE	40	STK	Complete	HAROLD BURCH**PHILENA BALTT	8	5	
P84665W	GOODLAD #3	3/25/1991	53-68-2-SWNW	50	STK	Complete	PHILENA BLATT	20	5	
P23421P	WOODS E. #1	12/31/1943	53-68-10-NENE	189	STK	Complete	GRACE E. ZIMMERSCHIED	90	3	
P148750W	Z-1	1/8/2003	53-68-10-SESE	410	STK	Complete	GRACE ZIMMERSCHIED	200	8	
P146029W	EVERETT NO 1	7/25/2002	53-68-11-NESW	260	STK	Complete	GRACE ZIMMERSCHIED	120	3	
P23422P	WOODS WM. #3	12/31/1955	53-68-11-NWNE	150	STK	Complete	GRACE ZIMMERSCHIED		1	
P192896W	WESLEY 2010	5/4/2010	53-68-12-SESE		STK	Incomplete	T J WESLEY		25	X
P41437W	MH #1	3/16/1977	53-68-12-SESE		MON	Cancelled	NUCLEAR DYNAMICS			X
P68906W	MOREL #14	11/5/1984	53-68-13-SESW		STK	Cancelled	GERALD M. MOREL		25	
P42868W	BESS #1	4/17/1978	53-68-14-NWSE	243	DOM_GW; STK	Complete	JAMES & BESSIE HAHN	100	15	
P72178W	SOPHIA #1A	9/9/1985	53-68-14-SESW	1011	IND_GW	Unknown	FANCHER OIL COMPANY	250	8	

Table 2.7-25. Groundwater Rights within 2 Miles of Proposed Project Area (Continued)

Permit #	Facility Name	Priority Date	Location (Tns-Rng-Sec-¼¼)	Total Depth (ft)	Uses	Status	Appropriator	Depth to Water (ft)	Yield (gpm)	Within Project Area
P72542W	ENL SOPHIA 1A	5/13/1986	53-68-14-SESW	1011	IND_GW	Unknown	FANCHER OIL COMPANY	250		
P144030W	TOWER #2	4/23/2002	53-68-23-SESW	401	DOM_GW; STK	Complete	ANTONE SWANDA	200	12	
P41442W	MH #6	3/16/1977	53-68-24-NESE		MON	Cancelled	NUCLEAR DYNAMICS			
P99263W	REYNOLDS #2	5/22/1995	53-68-24-NESE	100	DOM_GW	Complete	DAVID A. OR BETTY J. REYNOLDS	60	10	
P50883W	MOREL #4	1/11/1980	53-68-24-NWNE	150	STK	Complete	GERALD M. MOREL	50	25	X
P21128P	KOTTRABA #5	12/31/1955	53-68-24-SESW	140	STK	Complete	CHARLES & ALTA KOTTRABA	60	8	
P21129P	KOTTRABA #6	12/31/1953	53-68-24-SWSW	200	STK	Complete	CHARLES & ALTA KOTTRABA	100	8	
P150688W	TOWER #3	5/2/2003	53-68-25-NESW	460	DOM_GW; STK	Complete	ANTONE SWANDA	205	10	
P21126P	KOTTRABA #3	12/31/1951	53-68-25-NWSW	140	DOM_GW; STK	Complete	CHARLES & ALTA KOTTRABA	60	3	
P21127P	KOTTRABA #4	12/31/1933	53-68-25-NWSW	140	STK	Complete	CHARLES & ALTA KOTTRABA	60	3	
P22584P	REYNOLDS #1	2/7/1973	53-68-25-SESE	386	DOM_GW; STK	Complete	GRACE I. REYNOLDS	100	10	
P21130P	KOTTRABA #7	12/31/1948	53-68-26-SWNE	250	STK	Complete	CHARLES & ALTA KOTTRABA	100	8	
P74677W	WSW #1 WEST KIEHL UNIT	4/27/1987	53-68-36-NWNE	997	IND_GW	Unknown	PACIFIC ENTERPRISES OIL CO (USA)	460	21	
Unknown	DWWELL01	Unknown	53-67-17-SENW		DOM_GW	Unknown	DALE WOOD	Unknown		
Unknown	HBWELL06	Unknown	53-67-22-NWNW		DOM_GW	Unknown	HARRY BERGER	Unknown		
Unknown	SBWELL01	Unknown	53-68-2-SWNE		STK	Unknown	STORMY BURCH	Unknown		
Unknown	SBWELL02	Unknown	53-68-1-NESE		STK	Unknown	STORMY BURCH	Unknown		
Uses:	DOM_GW IRR_GW MIS IND_GW MON	Domestic Irrigation Miscellaneous Industrial Monitoring								

Source: WSEO (2010)

Table 2.7-26. Regional Lance-Fox Hills Water Quality

Parameter	**Unit**	**Median Concentration[1]**
pH	s.u.	8.4
TDS	mg/L	1,130
Hardness	mg/L as $CaCO_3$	16
Calcium	mg/L	6
Magnesium	mg/L	1
Sodium	mg/L	432
Bicarbonate	mg/L	803
Chloride	mg/L	34
Sulfate	mg/L	162

[1] USGS 2010b

Table 2.7-27. Regional Baseline Monitor Wells

Well ID	WSEO Permit	Northing[1] (ft)	Easting[1] (ft)	Completion Zone	Ground Surface Elevation (ft amsl)	Top of Casing Elevation (ft amsl)	Total Depth (ft)	Screen Interval (ft bgs)
12-18DM	P191683W	1487549	709191	DM	4188.4	4189.2	640	612 - 632
12-18OZ	P191686W	1487518	709154	OZ	4186.5	4187.9	600	474 - 584
12-18SM	P191685W	1487516	709224	SM	4185.9	4187.1	470	342 - 352
12-18SA	P191684W	1487482	709185	SA	4184.8	4185.8	115	63 - 103
14-18DM	P191687W	1484876	710013	DM	4154.8	4156.0	600	570 - 585
14-18OZ	P191690W	1484910	709972	OZ	4155.1	4156.3	530	499 - 529
14-18SM	P191689W	1484918	710044	SM	4154.9	4156.2	331	282 - 327
14-18SA	P191688W	1484950	710006	SA	4155.6	4156.8	70	35 - 65
21-19DM	P191695W	1483249	710642	DM	4168.6	4169.9	580	550 - 565
21-19OZ	P191698W	1483283	710613	OZ	4167.0	4168.3	470	433 - 468
21-19SM	P191697W	1483289	170685	SM	4169.6	4170.7	330	282 - 327
21-19SA	P191696W	1489326	710648	SA	4167.4	4169.0	40	20 - 30
34-7DM	P191679W	1489669	713334	DM	4133.8	4135.3	550	471 - 486
34-7OZ	P191682W	1489623	713271	OZ	4134.9	4136.8	382	321 - 376
34-7SM	P191681W	1489636	713363	SM	4133.6	4134.9	245	210 - 245
34-7SA	P191680W	1483603	71333	SA	4134.2	4135.4	60	42 - 52
34-18DM	P191691W	1483748	712430	DM	4247.0	4248.3	640	600 - 620
34-18OZ	P191694W	1483785	712397	OZ	4246.0	4247.5	570	460 - 565
34-18SM	P191693W	1483780	712468	SM	4246.7	4247.8	307	278 - 298
34-18SA	P191692W	1487816	712431	SA	4246.1	4247.5	80	50 - 70
42-19DM	P191699W	1481210	713075	DM	4283.2	4284.4	620	600 - 610
42-19OZ	P191702W	148127	713038	OZ	4281.1	4282.5	570	470 - 560
42-19SM	P191701W	148249	713109	SM	4284.8	4286.1	300	260 - 290
42-19SA	P191700W	1481283	713073	SA	4283.3	4284.2	115	97 - 107

[1] Coordinate system: Wyoming East State Plane NAD 83 U.S. Feet

Table 2.7-28. Regional Baseline Monitoring Network General Water Quality

Well Zone	Major Ion Chemistry	TDS (mg/L)
SA	Sodium bicarbonate	370 – 1,230
SM	Sodium bicarbonate-sulfate	830 – 1,340
OZ	Sodium sulfate-bicarbonate	1,140 – 2,070
DM	Sodium chloride	870 – 2,130

Table 2.7-29. Cluster Well Water Quality

Parameter	Units	Zone			
		SA	SM	OZ	DM
Field					
Field conductivity	µmhos/cm	725 - 2030	1436 - 3360	1654 - 3660	1525 - 4000
Field pH	s.u.	7.9 - 10.3	8.8 - 12.8	8.4 - 9.4	9.0 - 12.9
Field turbidity	NTUs	0.1 - 99.4	0.03 - 884	0 - 154	1 - 780
Depth to water	ft	10.6 - 50.9	52.5 - 155.7	84.0 - 303.9	83.0 – 288.0
Temperature	Deg C	9.3 - 20.2	9.6 - 18.4	10.1 - 14.4	10.1 - 21.7
ORP	millivolts	-185 - 193	-351 - 220	-233 - 257	-431 - 83
Dissolved oxygen	mg/L	1.7 - 6.1	0.8 - 8.2	0.9 - 6.7	0.9 - 7.9
General					
Alkalinity (as CaCO3)	mg/L	151 - 531	282 – 685	471 - 568	336 - 605
Ammonia	mg/L	<0.1 - 0.5	<0.1 - 2.8	0.2 - 0.8	<0.1 - 3.9
Fluoride	mg/L	0.1 - 0.5	0.8 - 2.1	0.3 - 1.2	0.8 - 1.6
Laboratory conductivity	µmhos/cm	554 - 1860	1200 - 2240	1640 - 2810	1600 - 3390
Laboratory pH	s.u.	8.1 - 10	8.7 - 11.6	8.4 - 9	8.7 - 11.7
Nitrate/nitrite	mg/L	<0.1 - 1.1	<0.1	<0.1 - 0.3	<0.1
Total dissolved solids	mg/L	370 - 1230	830 - 1340	1140 - 2070	870 – 2130
Major Ions					
Calcium	mg/L	2 - 46	<1 – 3	4 - 9	1 – 8
Magnesium	mg/L	<1 - 33	<1 – 2	1 - 3	<1 – 2
Potassium	mg/L	7 - 22	4 - 47	4 - 17	8 – 48
Sodium	mg/L	84 - 400	275 – 520	368 - 644	302 – 807
Bicarbonate	mg/L	84 - 572	<5 – 752	478 - 662	<5 – 488
Carbonate	mg/L	<5 - 193	25 – 250	8 - 52	22 – 324
Chloride	mg/L	2 - 86	2 – 8	3 - 10	139 – 818
Sulfate	mg/L	91 - 343	179 – 458	295 - 937	<1 – 234
Metals					
Aluminum, dissolved	mg/L	<0.1	<0.1 - 0.5	<0.1 - 0.5	<0.1 - 0.6
Arsenic, dissolved	mg/L	<0.005	<0.005 - 0.023	<0.005	<0.005 - 0.014
Barium, dissolved	mg/L	<0.5	<0.5	<0.5	<0.5
Boron, dissolved	mg/L	<0.1 - 0.3	0.2 - 0.7	0.3 - 0.6	0.3 – 1
Cadmium, dissolved	mg/L	<0.002	<0.002	<0.002	<0.002
Chromium, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01
Copper, dissolved	mg/L	<0.01	<0.01 - 0.02	<0.01	<0.01
Iron, dissolved	mg/L	<0.05 - 0.18	<0.05 – 0.21	<0.05 - 0.69	<0.05 - 0.40
Iron, total	mg/L	<0.05 - 5.68	<0.05 – 35	<0.05 - 3.38	<0.05 – 23.3
Lead, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02
Manganese, total	mg/L	<0.02 - 0.36	<0.02 - 0.88	<0.02 - 0.06	<0.02 - 0.37
Mercury	mg/L	<0.001	<0.001	<0.001	<0.001
Molybdenum, dissolved	mg/L	<0.02 - 0.06	<0.02 - 0.05	<0.02	<0.02 - 0.06
Nickel, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01
Selenium, dissolved	mg/L	<0.005	<0.005 – 0.009	<0.005 - 0.009	<0.005 - 0.030
Silver, dissolved	mg/L	<0.003 - 0.006	<0.003 - 0.011	<0.003	<0.003 – 0.005
Uranium, dissolved	mg/L	<0.001 - 0.007	<0.001 - 0.004	0.005 - 0.109	<0.001 - 0.003
Uranium, suspended	mg/L	<0.001	<0.001	<0.001 - 0.003	<0.001 - 0.001
Vanadium, dissolved	mg/L	<0.02	<0.02 - 0.02	<0.02	<0.02
Zinc, dissolved	mg/L	<0.01 - 1.32	<0.01 - 0.03	<0.01 - 0.02	<0.01 - 0.09
Radiological					
Lead 210, dissolved	pCi/L	<1	<1 – 5.2	<1 - 4.89	<1 - 1.2
Lead 210, suspended	pCi/L	<1	<1 – 1.1	<1 - 32.2	<1 - 1.5
Polonium 210, dissolved	pCi/L	<1	<1 – 1.9	<1 - 22.9	<1 – 1.3
Polonium 210, suspended	pCi/L	<1	<1	<1 - 35	<1
Ra-226, dissolved	pCi/L	<0.2 - 0.5	<0.2 – 3.7	0.71 - 12.01	<0.2 - 0.7

Table 2.7-29. Cluster Well Water Quality (Continued)

Parameter	Units	Zone			
		SA	SM	OZ	DM
Ra-226, suspended	pCi/L	<0.2 - 0.24	<0.2 - 0.28	<0.2 - 4.24	<0.2 - 0.8
Ra-228, dissolved	pCi/L	<1 - 1.2	<1 - 2.3	<1	<1 – 2.2
Radon-222	pCi/L	NM	<28 – 443	4580 - 35100	<25 – 242
Th-230, dissolved	pCi/L	<0.2	<0.2	<0.2	<0.2 - 0.24
Th-230, suspended	pCi/L	<0.2	<0.2 – 0.4	<0.2 - 0.95	<0.2 - 0.33
Gross alpha	pCi/L	<2 - 13.8	<2 - 12.2	15.4 - 222	<2 - 28.3
Gross beta	pCi/L	5.3 - 15.8	<2 – 319	4.2 - 43.2	3.1 - 41

Table 2.7-30. Comparison of Probable WDEQ Classes of Use

Zone	Probable WDEQ Groundwater Class	Suitability
SA	II or III	Irrigation or livestock
SM	III	Livestock
OZ	IV	Industrial
DM	III	Livestock

Table 2.7-31. SA Zone Monitoring Results

Parameter	Units	12-18SA				14-18SA				21-19SA				34-7SA				34-18SA				42-19SA			
		1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10
Field																									
Field Conductivity	µmhos/cm	811	945	725	942	1791	1909	1834	2030	973	863	984	1084	1229	1325	1294	1348								
Field pH	s.u.	9.65	8.3	9.97	8.03	9.93	8.81	8.6	8.27	8.08	8.44	7.9	8.22	9.7	9.57	9.38	10.3								
Field turbidity	NTUs	4.94	74.9	6.08	8.54	0.49	0.61	0.1	3.29	0.27	99.4	1.47	13.07	0.66	0.6	0.37	6.67								
Depth to Water	ft	50.87	48.03	47.69	48	23.32	22.78	22.93	23.79	10.56	10.82	11.02	11.52	22.62	22.92	22.06	22.33	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY
Temperature	Deg C	11.8	13.9	20.2	17.6	10.6	12.4	12.7	16	10.2	9.3	13.3	19.6	10.4	12.8	15.9	18.7								
ORP	millivolts		-118	180	-185		-103	132	-122			162	-67		63	152	193								
Dissolved oxygen	mg/L	6.14		1.82	2.01	3.5		1.74	2.46	4.69		4.33	2.87	3.35		3.63	3.1								
Dissolved oxygen, pct	%	57.4		20.6	21.7	31.8		18.1	26	42.2		43.4	29.3	30.3		41.2	36.8								
General																									
Alkalinity (as CaCO3)	mg/L	201	303	151	290	453	471	463	478	374	374	367	399	497	511	531	506								
Ammonia	mg/L	0.4	0.3	0.5	0.4	<0.1	<0.1	0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4								
Fluoride	mg/L	0.2	0.2	0.1	0.2	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.5	0.5	0.4	0.4								
Laboratory conductivity	µmhos/cm	729	829	554	835	1690	1750	1800	1860	911	937	968	974	1160	1200	1270	1190								
Laboratory pH	s.u.	9.2	8.4	9.8	8.2	9.3	8.6	8.5	8.4	8.2	8.2	8.1	8.2	9.1	9.1	9.1	10								
Nitrate/Nitrite	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.1	<0.1	1	0.3	<0.1	<0.1	<0.1	<0.1								
Total Dissolved Solids	mg/L	500	550	370	490	1160	1230	1200	1220	620	640	620	610	770	810	820	690								
Major Ions																									
Calcium	mg/L	20	43	3	46	14	17	18	22	31	26	36	30	2	2	2	3								
Magnesium	mg/L	22	31	13	33	8	9	10	12	13	11	15	13	<1	1	2	2								
Potassium	mg/L	22	16	20	16	17	11	11	13	7	9	7	8	10	11	11	13								
Sodium	mg/L	101	97	89	84	393	361	391	400	160	171	165	177	274	266	299	259								
Bicarbonate	mg/L	172	352	84	354	368	526	544	572	456	456	447	487	484	516	513	223								
Carbonate	mg/L	36	8	49	<5	91	24	10	5	<5	<5	<5	<5	60	53	66	193								
Chloride	mg/L	12	12	24	11	80	86	68	67	19	17	18	17	3	3	2	2								
Sulfate	mg/L	163	142	94	130	314	343	315	327	112	107	118	91	134	133	137	98								
Metals																									
Aluminum, dissolved	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1								
Arsenic, dissolved	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005								
Barium, dissolved	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5								
Boron, dissolved	mg/L	<0.1	<0.1	<0.1	<0.1	0.2	0.2	0.2	0.2	<0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.2								
Cadmium, dissolved	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002								
Chromium, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01								
Copper, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01								
Iron, dissolved	mg/L	<0.05	<0.05	<0.05	0.18	<0.05	<0.05	0.09	<0.05	<0.05	<0.05	0.06	<0.05	<0.05	<0.05	<0.05	<0.05								
Iron, total	mg/L	0.33	0.34	0.42	0.37	0.1	0.14	0.14	0.15	0.08	5.68	0.16	0.37	<0.05	<0.05	<0.05	0.15								
Lead, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02								
Manganese, total	mg/L	0.04	0.06	0.03	0.08	0.02	0.04	0.04	0.07	0.19	0.36	0.18	0.2	<0.02	<0.02	<0.02	<0.02								
Mercury	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001								
Molybdenum, dissolved	mg/L	0.06	<0.02	<0.02	<0.02	0.03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02								
Nickel, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01								
Selenium, dissolved	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005								
Silver, dissolved	mg/L			0.006	<0.003			<0.003	<0.003			<0.003	<0.003			<0.003	<0.003								
Uranium, dissolved	mg/L	0.003	<0.001	<0.001	<0.001	0.007	0.007	0.007	0.007	0.007	0.004	0.006	0.005	<0.001	<0.001	<0.001	<0.001								
Uranium, suspended	mg/L		<0.001	<0.001			<0.001	<0.001			<0.001	<0.001			<0.001	<0.001									
Vanadium, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02								
Zinc, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.02	1.32	0.09	<0.01	<0.01	<0.01	<0.01	<0.01								
Radiological																									
Lead 210, dissolved	pCi/L		<1	<1			<1	<1			<1	<1			<1	<1									
Lead 210, suspended	pCi/L		<1	<1			<1	<1			<1	<1			<1	<1									
Polonium 210, dissolved	pCi/L		<1	<1			<1	<1			<1	<1			<1	<1									
Polonium 210, suspended	pCi/L		<1	<1			<1	<1			<1	<1			<1	<1									
Ra-226, dissolved	pCi/L	0.28	0.24	0.2	0.4	<0.2	0.27	0.26	0.5	0.41	0.24	0.23	0.3	<0.2	<0.2	<0.2	<0.2								
Ra-226, suspended	pCi/L		0.24	<0.2			<0.2	<0.2			0.24	<0.2			<0.2	<0.2									
Ra-228, Dissolved	pCi/L	<1	<1	1	<1	<1	<1	<1	<1	<1	<1	<1	1.2	<1	<1	<1	<1								
Radon-222	pCi/L																								
Th-230, dissolved	pCi/L		<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2									
Th-230, suspended	pCi/L		<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2									
Gross Alpha	pCi/L	<2	2.7	<2	4	5.1	7.4	7.33	13.8	6.5	6.4	6.16	6.7	<2	3.8	2.65	2.4								
Gross Beta	pCi/L	15.8	13	13.5	11.2	12.1	5.9	5.99	7.9	7.4	10	6.99	5.3	7.6	7.7	7.27	7.1								
QA/QC																									
Anion Sum	meq/L	7.73	9.33	5.66	8.83	17.86	19.01	17.76	18.26	10.36	10.18	10.3	10.35	12.82	13.09	13.55	12.24								
Cation Sum	meq/L	7.75	9.31	5.6	9.03	18.86	17.57	19.02	19.84	9.73	9.9	10.35	10.46	12.27	12	13.53	11.88								
Total Anion/Cation Balance	%	0.13	0.1	0.52	1.13	2.72	3.93	3.42	4.15	3.12	1.43	0.25	0.5	2.19	4.3	0.07	1.46								
Total Dissolved Solids (calc)	mg/L	460	520	330	490	1100	1110	1090	1130	570	570	580	580	720	720	770	680								

Table 2.7-32. SA Zone Comparison with WDEQ Class of Use Standards

Well ID	Probable WDEQ Class of Use	Parameters Exceeding Class I Standards[1]	Parameters Exceeding Class II Standards[1]
12-18SA	II	TDS, manganese	
14-18SA	III	TDS, sulfate, manganese	Sulfate
21-19SA	III	TDS, manganese	Manganese
34-7SA	II	TDS	
34-18SA	Dry		
42-19SA	Dry		

[1] pH and iron were not compared to class of use standards since these constituents are easily treatable

Table 2.7-33. SA Zone Comparison with EPA Standards

Well ID	Parameters Exceeding EPA Primary MCLs	Parameters Exceeding EPA Secondary MCLs[1]
12-18SA		TDS, manganese
14-18SA		TDS, sulfate, manganese
21-19SA		TDS, manganese
34-7SA		TDS
34-18SA		
42-19SA		

[1] EPA designates secondary standards as non-enforceable contaminants that may cause cosmetic or aesthetic effects in drinking water

Table 2.7-34. SM Zone Monitoring Results

Parameter	Units	12-18SM								14-18SM								21-19SM							
		1Q10	2Q10	3Q10	4Q10	1Q11	2Q11	3Q11	4Q11	1Q10	2Q10	3Q10	4Q10	1Q11	2Q11	3Q11	4Q11	1Q10	2Q10	3Q10	4Q10	1Q11	2Q11	3Q11	4Q11
Field																									
Field Conductivity	µmhos/cm	1487	1436	1657	1642	1461	1449	1588	1467	1569	1548	1611	1781	1633	1670	1668	1653	1874	1719	2300	2190	2230	1991	1966	1945
Field pH	s.u.	9.25	9.22	9.06	8.98	8.97	9.19	9.19	8.81	9.56	9.64	9.31	9.17	9.19	9.39	9.34	8.93	10.17	9.97	9.97	9.85	10.09	9.78	9.67	9.11
Field turbidity	NTUs	1.99	0.54	0.84	0.57	11.21	14.86	2.59	26	2.53	0.6	0.09	0.05	0.3	0.41	3.9	0.6	4.06	0.12	2.61	0.49	0.74	0.08	0.03	1.79
Depth to Water	ft	88.89	90.88	91.21	91.12	85.07	81.06	78.69	76.87	66.87	66.72	66.72	66.9	63.24	61.26	59.19	58.63	85.07	84.88	84.9	85.18	82.21	79.97	77.52	77
Temperature	Deg C	11	11.8	13.9	13.3	11.4	11	11.9	11.1	10.8	11.2	11.9	11.6	10.5	10.8	12.8	10.5	10.2	11.5	13	12.4	10.4	11.4	10.8	11.1
ORP	millivolts		-190	-10	26	-151	-181	-253	-47			-200	131	-232	-245	-299	-93		36	160	137	-209	-167	-127	-18
Dissolved oxygen	mg/L		0.75	6.36	5.16		1.91	4.7	1.32	2.39	1.04	2.44	5.61		1.78	4.73	1.34	1.66	1.98	4.28	3.77		3.25	3.44	1.43
Dissolved oxygen, pct	%	32.1	16.9	63.4	53	27.1	20	42.3	12.2	21.3	10.2	22.8	51.6	43.3	17.7	48.2	12.4	15	18.7	42.9	35.6	59.8	30.4	34.7	13.4
General																									
Alkalinity (as CaCO3)	mg/L	531	528	532	534	534	532	530	528	551	556	581	582	581	583	579	579	572	602	647	633	685	628	622	619
Ammonia	mg/L	<0.1	<0.1	0.2	0.4	0.3	0.1	0.2	0.2	<0.1	<0.1	0.1	0.2	0.1	<0.1	<0.1	<0.1	<0.1	0.2	1.1	0.6	0.3	0.1	<0.1	0.2
Fluoride	mg/L	2.1	1.7	1.9	2.1	1.9	2	1.5	2	1.6	1.5	1.6	1.5	1.6	1.6	1.5	1.6	1	1	1.1	1.1	1.1	1	1.1	1.2
Laboratory conductivity	µmhos/cm	1420	1440	1430	1450	1350	1200	1520	1580	1480	1520	1560	1560	1470	1400	1710	1720	1770	1970	2000	1960	1940	1740	1680	2070
Laboratory pH	s.u.	8.8	8.8	8.7	8.8	8.8	8.8	8.8	8.8	9.2	9.1	8.9	9	9	8.8	9	8.8	9.6	9.3	9.9	9.6	9.9	9.4	9.1	8.9
Nitrate/Nitrite	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Dissolved Solids	mg/L	970	980	980	970	990	970	940	940	1020	1040	1010	1000	1050	1110	1060	1030	1270	1330	1310	1300	1340	1310	1270	1270
SAR	unitless	43.4	41.8	45.1	47.2	47.6	47.2	47.6	55.3	50.3	50.5	53.6	51.7	59.2	57.3	69.4	59.7	61.2	63.0	75.9	75.3	82.7	80.8	86.9	85.9
Major Ions																									
Calcium	mg/L	3	3	3	3	3	3	3	2	2	2	2	2	2	2	1	2	2	2	1	1	1	1	1	1
Magnesium	mg/L	1	1	1	1	1	1	1	1	<1	<1	1	1	1	1	<1	1	<1	<1	<1	<1	<1	<1	1	1
Potassium	mg/L	8	5	6	6	4	4	4	4	6	8	7	8	7	7	6	6	32	31	47	37	43	28	20	19
Sodium	mg/L	341	328	354	371	374	371	374	385	350	352	373	360	412	399	412	416	426	439	451	447	491	480	516	510
Bicarbonate	mg/L	577	578	598	573	593	579	590	583	526	566	603	599	597	622	597	628	399	532	347	491	365	560	634	643
Carbonate	mg/L	35	33	25	38	28	34	28	30	72	55	52	54	55	44	54	39	146	99	218	138	231	101	61	56
Chloride	mg/L	5	3	3	4	4	5	4	4	4	3	2	2	3	3	4	4	3	8	3	2	3	4	4	4
Sulfate	mg/L	236	218	212	216	242	221	206	213	232	241	238	230	241	227	283	234	383	396	336	335	350	366	342	359
Metals																									
Aluminum, dissolved	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Arsenic, dissolved	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.012	0.009	0.007	0.005	<0.005	0.008	0.005	<0.005	0.023	0.009	0.009	0.006	<0.005	0.006	0.006	0.006
Barium, dissolved	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Boron, dissolved	mg/L	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.5	0.5	0.6	0.5	0.6	0.5	0.6	0.2	0.5	0.6	0.6	0.6	0.6	0.6	0.6
Cadmium, dissolved	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Chromium, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron, dissolved	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron, total	mg/L	0.09	0.06	0.07	0.06	0.29	0.6	0.07	0.91	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lead, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Manganese, total	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Mercury	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nickel, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Selenium, dissolved	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.006
Silver, dissolved	mg/L			0.004	<0.003	<0.003	<0.003	0.011	<0.003			<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Uranium, dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0003	<0.0003	<0.0003	<0.001	<0.001	<0.001	<0.001	0.0008	0.0007	0.0006	<0.0003	0.003	0.003	0.004	0.003	0.0021	0.0012	0.0006	0.0005
Uranium, suspended	mg/L		<0.001	<0.001			<0.0003	<0.0003			<0.001	<0.001			<0.0003	<0.0003			<0.001	<0.001			<0.0003	<0.0003	
Vanadium, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Zinc, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
Radiological																									
Lead 210, dissolved	pCi/L		<1	<1			<1	<1			<1	<1			<1	<1			<1	<1			<1	1.5	
Lead 210, suspended	pCi/L		<1	<1			<1	1.1			<1	<1			<1	<1			<1	<1			<1	<1	
Polonium 210, dissolved	pCi/L		<1	<1			<1	<1			<1	<1			<1	<1			<1	<1			<1	<1	
Polonium 210, suspended	pCi/L		<1	<1			<1	<1			<1	<1			<1	<1			<1	<1			<1	<1	
Ra-226, dissolved	pCi/L	<0.2	0.24	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	3.7	<0.2	<0.2	0.2
Ra-226, suspended	pCi/L		<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2	
Ra-228, Dissolved	pCi/L	<1	<1	<1	2.27	<1	<1	<1	<1	<1	1.29	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Radon-222	pCi/L	309								300								353							
Th-230, dissolved	pCi/L		<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2	
Th-230, suspended	pCi/L		<0.2	<0.2			<0.2	0.4			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2	
Gross Alpha	pCi/L	<2	2.1	<2	<2	<5	<2	<5	<3	2.8	3.1	<3.5	11.2	<5	<2	<6	<5	3.1	5.4	6.6	12.2	<5	<3	<6	<4
Gross Beta	pCi/L	3.3	<6.8	<3	9.4	<8	<4	<7	<5	7.2	7	<6.8	12.4	<8	4.4	<8	<7	22.2	19	29.8	42.5	22.9	12.6	12.5	14.2
QA/QC																									
Anion Sum	meq/L	15.76	15.29	15.23	15.38	15.91	15.49	15.07	15.21	16.03	16.29	16.71	16.56	16.8	16.54	17.66	16.64	19.54	20.55	20.06	19.75	21.12	20.33	19.73	20.03
Cation Sum	meq/L	15.26	14.67	15.77	16.5	16.6	16.5	16.61	17.02	15.48	15.6	16.61	16.02	18.31	17.72	18.14	18.4	19.45	19.97	20.88	20.43	22.52	21.63	23.11	22.8
Total Anion/Cation Balance	%	1.62	2.07	1.73	3.5	2.12	3.17	4.87	5.59	1.75	2.14	0.3	1.63	4.3	3.45	1.33	5.01	0.23	1.44	1.98	1.69	3.2	3.11	7.88	6.46
Total Dissolved Solids (calc)	mg/L	910	880	900	920	950	930	910	930	920	940	970	950	1020	990	1050	1010	1190	1240	1230	1200	1300	1250	1260	1270

Table 2.7-34. SM Zone Monitoring Results (Continued)

Parameter	Units	34-7SM								34-18SM								42-19SM							
		1Q10	2Q10	3Q10	4Q10	1Q11	2Q11	3Q11	4Q11	1Q10	2Q10	3Q10	4Q10	1Q11	2Q11	3Q11	4Q11	1Q10	2Q10	3Q10	4Q10	1Q11	2Q11	3Q11	4Q11
Field																									
Field Conductivity	µmhos/cm	1788	1595	2060	2080	1960	1995	1998	1957	3360	2610	2470	2040	2120	1736	2180	2530	1897	1452	1642	1839	1951	1939	1929	2630
Field pH	s.u.	9.82	9.79	9.23	9.04	9.04	9.18	9.25	8.78	12.82	12.61	11.98	10.91	10.15	10.12	9.9	9.7	12.34	12.24	10.78	10.69	9.98	10.52	10.42	9.88
Field turbidity	NTUs	19.97	3.14	2.11	1.93	2.21	6.71	3.57	884	7.06	5.79	3.92	6.19	5.52	9.02	4.9	15.05	40.2	5.39	6.39	2.93	4.42	1.34		5.12
Depth to Water	ft	56.73	56.13	56.11	56.18	54.71	53.11	52.76	52.5	136.25	136.19	136.18	136.11	134.62	133.8	133.3	132.07	155.65	155.57	155.64	155.55	154.92	154.5	153.43	152.74
Temperature	Deg C	10.6	12.1	13.1	12.8	10.1	10.7	12.5	10.9	10.5	18.4	14.1	11.6	9.6	11.4	15.8	10.6	10.8	12	16.3	15.4	10.9	12.7	11.1	9.6
ORP	millivolts		152	177	174	-257	-224	-317	-104		68	147	-166	-272	-278	-302	-57		34	188	220	-169	-351	-51	-115
Dissolved oxygen	mg/L	2.63	4.09	6.84	5.38		2.24	6.52	1.5	1.55	8.15	v	7.37		7.38	6.98	4.46	3.3	1.78	4.95	7.06		7.49	5.8	2.08
Dissolved oxygen, pct	%	23.1	39.3	69	53.4	35.5	28.5	64.7	13.8	14	85.2	v	69.5	59	70.2	74	41.3	30.2	18.2	54.3	73.8	52.1	72.2	56.5	18.5
General																									
Alkalinity (as CaCO3)	mg/L	595	628	647	658	672	677	683	685	521	486	484	458	558	559	540	537	420	282	303	319	386	430	470	518
Ammonia	mg/L	<0.1	0.2	0.2	0.5	0.3	<0.1	<0.1	0.3	1.9	1.4	1.2	1	0.5	0.3	<0.1	<0.1	2.8	1.4	1.2	0.8	0.4	0.4	0.3	0.4
Fluoride	mg/L	0.9	1	0.9	0.9	0.8	1.1	1	1	1.4	1.3	1.2	0.9	0.9	0.9	1.1	1.1	1.6	1.5	1.5	1.4	1.2	1.1	1.4	0.9
Laboratory conductivity	µmhos/cm	1650	1840	1800	1830	1730	1620	1980	2040	2240	2190	2070	1800	1890	1720	2120	2080	1690	1540	1580	1620	1760	1760	2110	2160
Laboratory pH	s.u.	9.4	9	9	8.9	8.8	8.8	8.8	8.8	11.6	11.5	11.4	10.5	9.9	9.7	9.6	9.4	11.5	10.8	10.6	10.3	10.2	10	9.9	9.5
Nitrate/Nitrite	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Dissolved Solids	mg/L	1150	1200	1240	1260	1280	1280	1210	1260	1040	1100	1060	1140	1300	1330	1310	1310	830	970	990	1040	1200	1300	1330	1350
SAR	unitless	71.7	59.9	61.2	61.9	52.2	54.5	52.1	73.0	51.6	57.6	60.6	64.5	81.8	68.5	85.4	74.7	35.0	54.7	57.6	54.4	75.3	74.1	82.5	77.8
Major Ions																									
Calcium	mg/L	1	2	2	2	3	3	3	2	2	1	1	<1	1	2	1	2	3	1	1	1	1	1	1	2
Magnesium	mg/L	<1	1	1	1	2	2	2	1	<1	<1	<1	<1	<1	1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Potassium	mg/L	14	13	10	10	8	8	7	12	31	28	26	20	21	18	15	15	17	11	10	11	11	13	13	15
Sodium	mg/L	426	417	426	431	478	499	477	508	359	342	360	383	486	477	507	520	275	325	342	323	447	440	490	542
Bicarbonate	mg/L	508	631	674	682	731	731	752	725	<5	<5	<5	51	299	408	438	429	<5	<5	12	64	123	222	296	393
Carbonate	mg/L	107	66	57	60	43	47	40	55	168	173	189	250	188	135	114	111	137	152	175	160	171	149	136	118
Chloride	mg/L	4	7	3	3	4	4	4	4	6	5	4	3	3	4	5	5	7	5	4	4	8	5	6	5
Sulfate	mg/L	312	312	298	300	307	306	272	303	293	295	304	367	418	433	458	410	179	405	371	414	462	469	574	457
Metals																									
Aluminum, dissolved	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Arsenic, dissolved	mg/L	0.016	0.011	0.009	0.008	0.009	0.008	<0.005	0.008	0.009	0.011	0.012	<0.005	<0.005	<0.005	<0.005	<0.005	0.007	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Barium, dissolved	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Boron, dissolved	mg/L	0.4	0.5	0.6	0.6	0.5	0.7	0.6	0.6	0.2	0.2	0.3	0.4	0.4	0.5	0.5	0.5	0.3	0.4	0.4	0.4	0.8	0.4	0.5	0.5
Cadmium, dissolved	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Chromium, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron, dissolved	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.06	0.21	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron, total	mg/L	0.8	0.11	0.08	0.06	0.12	0.18	0.12	35	0.07	0.12	0.11	0.07	0.12	0.13	0.1	0.25	0.66	0.11	0.16	<0.05	0.08	<0.05	0.05	0.08
Lead, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Manganese, total	mg/L	0.03	0.02	0.02	0.02	<0.02	<0.02	0.02	0.88	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Mercury	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05	0.03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nickel, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Selenium, dissolved	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.009	<0.005	<0.005	<0.005	<0.005	0.017	<0.005	<0.005	0.005
Silver, dissolved	mg/L			<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			0.004	<0.003	<0.003	<0.003	<0.003	<0.003			<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Uranium, dissolved	mg/L	<0.001	0.001	0.002	0.001	0.002	0.001	0.0005	0.0012	<0.001	<0.001	<0.001	<0.001	0.0009	0.0007	0.0008	0.0011	<0.001	<0.001	<0.001	<0.001	<0.0003	<0.0003	<0.0003	<0.0003
Uranium, suspended	mg/L		<0.001	<0.001			<0.0003	0.0004			<0.001	<0.001			<0.0003	<0.0003			<0.001	<0.001			<0.0003	<0.0003	
Vanadium, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Zinc, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.01	<0.01	0.02	<0.01
Radiological																									
Lead 210, dissolved	pCi/L		1.34	<1			<1	5.2			<1	<1			<1	<1			<1	<1			1.8	1.5	
Lead 210, suspended	pCi/L		<1	<1			1	<1			<1	<1			<1	<1			<1	<1			<1	1.4	
Polonium 210, dissolved	pCi/L		<1	<1			<1	1.9			<1	<1			<1	<1			<1	<1			<1	<1	
Polonium 210, suspended	pCi/L		<1	<1			<1	<1			<1	<1			<1	<1			<1	<1			<1	<1	
Ra-226, dissolved	pCi/L	0.21	<0.2	<0.2	<0.2	<0.2	<0.2	0.3	0.3	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.21	<0.2	<0.2	<0.2	<0.2	<0.2
Ra-226, suspended	pCi/L		0.28	<0.2			<0.2	0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2	
Ra-228, Dissolved	pCi/L	<1	<1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.6	<1
Radon-222	pCi/L	443								35								<28							
Th-230, dissolved	pCi/L		<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2	
Th-230, suspended	pCi/L		<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2	
Gross Alpha	pCi/L	4.7	6.2	4.1	10.1	4.9	<2	<7	<6	<2	<2	<3.5	<2	<4	<4	<6	<6	<2	<2	2.78	2.8	<5	<3	<4	5.2
Gross Beta	pCi/L	8.7	10.3	5.8	9.7	<7	<3	13.6	319	18.7	17.3	16.5	11	13.2	10.4	8.4	<8	10.8	6.8	6.9	6	<7	<8	5.9	9
QA/QC																									
Anion Sum	meq/L	18.55	19.3	19.26	19.51	19.95	20.08	19.47	20.18	16.74	16.08	16.19	16.93	20	20.34	20.53	19.47	12.41	14.28	13.97	15.18	17.62	18.54	21.56	20.08
Cation Sum	meq/L	18.95	18.64	18.98	19.2	21.27	22.17	21.25	22.61	16.48	15.66	16.4	17.16	21.71	21.4	22.58	23.1	12.53	14.49	15.18	14.41	19.75	19.55	21.7	24.04
Total Anion/Cation Balance	%	1.05	1.72	0.74	0.8	3.19	4.94	4.38	5.67	0.79	1.32	0.63	0.67	4.09	2.55	4.75	8.52	0.47	0.74	4.13	2.58	5.69	2.65	0.3	8.97
Total Dissolved Solids (calc)	mg/L	1110	1130	1130	1140	1200	1230	1180	1240	1000	960	990	1050	1260	1270	1310	1270	730	920	910	950	1160	1190	1370	1330

Table 2.7-35. SM Zone Comparison with WDEQ Class of Use Standards

Well ID	Probable WDEQ Class of Use	Parameters Exceeding Class I Standards[1]	Parameters Exceeding Class II Standards[1]
12-18SM	III	TDS	Sulfate
14-18SM	III	TDS	Sulfate
21-19SM	III	Ammonia, TDS, sulfate	Sulfate
34-7SM	III	TDS, sulfate	Sulfate
34-18SM	III	Ammonia, TDS, sulfate	Sulfate
42-19SM	III	Ammonia, TDS, sulfate	Sulfate

[1] pH and iron were not compared to class of use standards since these constituents are easily treatable

Table 2.7-36. SM Zone Comparison with EPA Standards

Well ID	Parameters Exceeding Primary MCLs	Parameters Exceeding Secondary MCLs[1]
12-18SM		Fluoride, TDS
14-18SM	Arsenic	TDS
21-19SM	Arsenic	TDS, sulfate
34-7SM	Arsenic	TDS, sulfate
34-18SM	Arsenic	TDS, sulfate
42-19SM		TDS, sulfate, aluminum

[1] EPA designates secondary standards as non-enforceable contaminants that may cause cosmetic or aesthetic effects in drinking water

Table 2.7-37. OZ Monitoring Results

Parameter	Units	12-18OZ				14-18OZ				21-19OZ				34-7OZ				34-18OZ				42-19OZ			
		1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10
Field																									
Field Conductivity	µmhos/cm	1812	1654	2400	1934	3630	3660	3080	3070	3020	2630	2560	2620	2980	1992	2880	2430	2830	1930	2540	2510	2830	1876	2810	2410
Field pH	s.u.	8.99	9.02	8.56	8.44	9.42	9.07	8.77	8.75	9.11	8.99	8.78	8.6	9.2	9.29	8.77	8.85	9.39	9.18	8.77	8.62	9.12	9.14	8.97	8.5
Field turbidity	NTUs	1.18	0.97	0.23	0.13	154	25	1.61	14.08	9.07	1.3	0	1.04	2.94	0.8	0.93	0.21	45.8	3.26	0.15	1.57	4.41	2.43	0.7	0.5
Depth to Water	ft	169.93	169.79	170.74	169.31	158.1	155.17	155.4	152.45	216.63	218.18	214.35	208.04	85.54	84.88	84.94	84.02	278.31	282.71	279.99	278.2	299.9	303.94	301.31	300.62
Temperature	Deg C	11.1	12.4	13.8	14	11.1	14	12.7	11.9	10.6	12.1	12.6	12.5	10.1	11.6	12.5	11.6	10.4	12.7	13.2	13.2	10.9	12.1	13	14.4
ORP	millivolts		95	168	77			-45	16		94	76	-31		106	104	195		102	-233	-62		112	119	257
Dissolved oxygen	mg/L		1.83	2.71	6.11	1.93	1.44	2.76	2.89	2.31	2.52	1.73	2.55	4.26	3.77	1.43	3.75	2.4	2.47	2.21	3.26	2.29	6.65	0.94	2.6
Dissolved oxygen, pct	%	26.4	18.3	28.2	62.2	17.7	13.9	27	26.9	23	24.7	16.8	25.9	38.6	35.4	13.4	34	22	23.8	21.5	31.8	21.2	70	8.9	26.2
General																									
Alkalinity (as CaCO3)	mg/L	531	541	533	545	471	493	520	518	529	520	529	535	532	522	556	568	496	485	497	504	477	474	480	480
Ammonia	mg/L	0.3	0.2	0.4	0.6	0.4	0.5	0.6	0.6	0.3	0.5	0.4	0.5	0.4	0.5	0.5	0.8	0.4	0.4	0.4	0.7	0.3	0.3	0.5	0.4
Fluoride	mg/L	1.1	1.2	0.9	1.2	0.5	0.4	0.5	0.4	0.5	0.5	0.5	0.4	0.4	0.5	0.4	0.4	0.6	0.6	0.5	0.6	0.3	0.3	0.3	0.3
Laboratory conductivity	µmhos/cm	1900	1640	2160	1700	2620	2810	2780	2730	2190	2370	2280	2300	2130	2290	2250	2190	2070	2220	2260	2230	2080	1850	2200	2130
Laboratory pH	s.u.	8.6	8.6	8.6	8.7	8.9	8.6	8.6	8.6	8.7	8.6	8.5	8.6	8.7	8.7	8.4	8.8	9	8.7	8.4	8.7	8.6	8.8	8.7	8.7
Nitrate/Nitrite	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	<0.1	<0.1	<0.1	<0.1	<0.1
Total Dissolved Solids	mg/L	1340	1140	1490	1140	2020	2070	1980	1930	1600	1670	1620	1590	1590	1590	1640	1550	1530	1560	1620	1560	1500	1520	1650	1500
Major Ions																									
Calcium	mg/L	6	4	7	4	5	7	8	9	6	7	7	7	4	5	6	6	4	6	6	6	6	6	6	7
Magnesium	mg/L	2	1	2	1	2	3	3	3	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	3
Potassium	mg/L	5	4	4	4	17	11	7	6	5	6	5	6	7	12	5	8	8	6	5	6	6	6	5	7
Sodium	mg/L	438	416	516	368	624	639	644	600	537	531	574	516	533	520	546	512	542	486	557	481	499	532	547	541
Bicarbonate	mg/L	607	624	603	601	478	556	591	593	586	603	609	615	590	587	662	624	499	540	591	559	539	519	543	533
Carbonate	mg/L	20	18	24	31	48	23	21	19	29	16	18	19	29	24	8	34	52	26	8	28	21	29	21	26
Chloride	mg/L	7	4	6	4	10	10	10	9	7	9	8	7	5	5	4	4	8	8	8	6	5	4	3	3
Sulfate	mg/L	480	295	543	320	897	859	937	826	634	678	667	605	590	644	563	512	606	670	593	578	638	640	595	600
Metals																									
Aluminum, dissolved	mg/L	<0.1	<0.1	<0.1	<0.1	0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Arsenic, dissolved	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Barium, dissolved	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Boron, dissolved	mg/L	0.5	0.6	0.5	0.5	0.4	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.3	0.3	0.3	0.3
Cadmium, dissolved	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Chromium, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron, dissolved	mg/L	<0.05	<0.05	<0.05	<0.05	0.69	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron, total	mg/L	0.07	<0.05	<0.05	<0.05	3.38	0.33	0.1	0.52	0.18	0.07	<0.05	<0.05	0.09	0.1	<0.05	<0.05	1.02	0.1	<0.05	<0.05	0.11	0.05	<0.05	<0.05
Lead, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Manganese, total	mg/L	<0.02	<0.02	<0.02	<0.02	0.06	<0.02	<0.02	0.03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Mercury	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nickel, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Selenium, dissolved	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.008	<0.005	<0.005	<0.005	<0.005	<0.005	0.009	<0.005	<0.005	<0.005	<0.005
Silver, dissolved	mg/L			<0.003	<0.003			<0.003	<0.003			<0.003	<0.003			<0.003	<0.003			<0.003	<0.003			<0.003	<0.003
Uranium, dissolved	mg/L	0.07	0.033	0.069	0.033	0.096	0.109	0.109	0.085	0.017	0.008	0.024	0.005	0.041	0.038	0.044	0.028	0.062	0.059	0.046	0.041	0.011	0.01	0.01	0.009
Uranium, suspended	mg/L		<0.001	<0.001			<0.001	0.003			<0.001	<0.001			<0.001	<0.001			<0.001	<0.001			<0.001	<0.001	
Vanadium, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Zinc, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Radiological																									
Lead 210, dissolved	pCi/L		4.83	4.89			<1	1.79			<1	1.35			1.17	<1			1.88	3.02			<1	1.4	
Lead 210, suspended	pCi/L		1.7	1.87			1.18	1.04			<1	32.2			1.94	1.44			3.88	1.66			1.35	1.86	
Polonium 210, dissolved	pCi/L		22.9	22.2			1.79	5.04			<1	3.74			<1	<1			4.77	8.73			<1	<1	
Polonium 210, suspended	pCi/L		35	17.2			1.05	<1			<1	25.4			<1	<1			13.38	6.93			<1	<1	
Ra-226, dissolved	pCi/L	8.16	5	12.01	5.8	2.31	3.74	4.03	4.9	0.89	0.93	0.71	0.8	1.38	0.94	2.35	1.5	5.97	9.06	9.68	8.8	1.38	1.36	1.46	1.4
Ra-226, suspended	pCi/L		<0.2	<0.2			0.28	4.24			<0.2	<0.2			<0.2	<0.2			0.49	<0.2			<0.2	<0.2	
Ra-228, Dissolved	pCi/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Radon-222	pCi/L	32900				13500				4580				5900				35100				6460			
Th-230, dissolved	pCi/L		<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2	
Th-230, suspended	pCi/L		<0.2	<0.2			<0.2	0.95			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2	
Gross Alpha	pCi/L	222	157.5	177	93.9	173	191	165.3	183	33.5	19	47.7	18.4	69.1	46.1	56.8	48.1	175.7	111.1	76	93.8	19.4	15.4	18.7	19.6
Gross Beta	pCi/L	26.5	24.1	43.2	21.7	40.2	37.6	39.6	27.6	9.2	9.1	17.1	7.1	16.6	18.3	13.3	9.6	43.1	35.2	23.9	26.7	4.2	9.8	8.54	13.4
QA/QC																									
Anion Sum	meq/L	20.87	17.14	22.17	17.74	28.41	28.05	30.21	27.83	24.01	24.8	24.72	23.51	23.09	24.02	22.98	22.15	22.76	23.91	22.55	22.3	22.96	22.93	22.09	22.2
Cation Sum	meq/L	19.59	18.5	23.06	16.39	27.94	28.63	28.83	26.96	23.95	23.76	25.6	23.13	23.74	23.31	24.42	22.95	24.13	21.75	24.88	21.58	22.37	23.78	24.4	24.22
Total Anion/Cation Balance	%	3.17	3.82	1.96	3.95	0.83	1.02	2.34	1.57	0.11	2.14	1.75	0.81	1.38	1.48	3.04	1.78	2.92	4.72	4.92	1.64	1.29	1.81	4.96	4.34
Total Dissolved Solids (calc)	mg/L	1260	1050	1400	1030	1840	1820	1920	1760	1510	1550	1580	1460	1460	1500	1460	1380	1470	1470	1470	1380	1440	1470	1450	1450

Table 2.7-38. OZ Comparison with WDEQ Class of Use Standards

Well ID	Probable WDEQ Class of Use	Parameters Exceeding Class I Standards[1]	Parameters Exceeding Class II Standards[1]	Parameters Exceeding Class III Standards[1]
12-18OZ	IV	Ammonia, TDS, sulfate, radium-226 & 228, gross alpha	Sulfate, radium 226- & 228, gross alpha	Radium-226 & 228, gross alpha
14-18OZ	IV	Ammonia, TDS, sulfate, manganese, gross alpha	TDS, sulfate, gross alpha	Gross alpha
21-19OZ	IV	TDS, sulfate, gross alpha	Sulfate, gross alpha	Gross alpha
34-7OZ	IV	Ammonia, TDS, sulfate, gross alpha	Sulfate, gross alpha	Gross alpha
34-18OZ	IV	Ammonia, TDS, sulfate, radium-226 & 228, gross alpha	Sulfate, radium-226 & 228, gross alpha	Radium-226 & 228, gross alpha
42-19OZ	IV	TDS, sulfate, gross alpha	Sulfate, gross alpha	Gross alpha

[1] pH and iron were not compared to class of use standards since these constituents are easily treatable

Table 2.7-39. OZ Comparison with EPA Standards

Well ID	Parameters Exceeding Primary MCLs	Parameters Exceeding Secondary MCLs[1]
12-18OZ	Uranium, radium-226 & 228, gross alpha	TDS, sulfate
14-18OZ	Uranium, gross alpha	TDS, sulfate, aluminum, manganese
21-19OZ	Gross alpha	TDS, sulfate
34-7OZ	Uranium, gross alpha	TDS, sulfate
34-18OZ	Uranium, radium-226 & 228, gross alpha	TDS, sulfate
42-19OZ	Gross alpha	TDS, sulfate

[1] EPA designates secondary standards as non-enforceable contaminants that may cause cosmetic or aesthetic effects in drinking water

Table 2.7-40. DM Zone Monitoring Results

Parameter	Units	12-18DM								14-18DM								21-19DM							
		1Q10	2Q10	3Q10	4Q10	1Q11	2Q11	3Q11	4Q11	1Q10	2Q10	3Q10	4Q10	1Q11	2Q11	3Q11	4Q11	1Q10	2Q10	3Q10	4Q10	1Q11	2Q11	3Q11	4Q11
Field																									
Field Conductivity	µmhos/cm	3400	3080	2420	2420	2370	2500	2440	2820	2800	2860	2370	2410	2320	2450	2240	2810	2760	1874	2420	2390	2390	2450	2220	2790
Field pH	s.u.	12.64	12.23	10.2	9.85	9.72	9.9	9.55	9.25	10.57	10.06	9.48	9.32	9.42	9.64	9.41	9.2	10.32	10.01	9.3	9.31	9.19	9.26	9.47	8.98
Field turbidity	NTUs	21.7	6.54	3.35	2.43	5.06	4.25	1.02	1.6	122	31.2	14.03	3.31	3.21	1.4	1.2	1.01	32.4	35.4	5.02	4.2	1.88	4.67	5.07	4.41
Depth to Water	ft		175.54	176.08	175.91	174.71	172.8	173.53	173.51	157.17	156.65	158.16	156.48	153.47	152.85	151.72	151.82	196.48	196.09	196.39	196.12	193.88	192.83	192.45	193.11
Temperature	Deg C	10.5	12.4	16.3	15.9	13	12.6	13.5	12.3	11.5	12.1	13.7	12.6	10.1	12.5	15.1	11.3	10.8	14	14	14.8	10.7	12.6	13.4	12.5
ORP	millivolts		-221	-23	-106	-295	-397	-261	-99			-95	10	-132	-214	-216	-56		83	-140	14.8	-130	-130	-188	29
Dissolved oxygen	mg/L	5.08	1.14	6.69	6.55		3.81	5.04	2.45	2.72	1.97	6.03	5.91		5.62	5.81	0.86	2.8	4.26	2.58	6.76		5.14	4.71	2.35
Dissolved oxygen, pct	%	48.5	10.9	70.2	67.8	47.1	38	50.9	23.5	25.1	18.6	59.3	55.7	57.7	56	62.2	8.1	25.2	42.6	26.7	66.2	50.1	50.5	47.7	23
General																									
Alkalinity (as CaCO3)	mg/L	466	415	418	411	426	406	419	441	439	422	416	422	414	411	404	405	408	413	429	431	414	413	409	413
Ammonia	mg/L	2.4	1.4	0.9	0.6	0.7	0.5	0.5	0.1	0.6	0.4	0.5	0.5	0.5	0.4	0.4	<0.1	0.6	0.5	0.2	0.9	0.3	0.3	0.3	0.5
Fluoride	mg/L	1	0.9	1	1.2	1	1.2	1.2	1.2	1.1	1.1	1.2	1.1	1.2	1.1	1.1	1.3	1.2	1.1	1.2	1.2	1.2	1.1	1.2	1.1
Laboratory conductivity	µmhos/cm	2400	2290	2150	2180	2080	1740	2290	2390	2030	2170	2190	2150	2040	1900	2320	2350	2000	2150	2130	2170	2040	1920	2240	2340
Laboratory pH	s.u.	11.5	11.2	10	9.7	9.5	9.4	9.3	9	10	9.5	9	9.2	9.3	9.1	9.1	8.9	9.7	9.4	9.2	9.1	8.9	8.9	8.8	8.7
Nitrate/Nitrite	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Dissolved Solids	mg/L	1140	1190	1260	1240	1290	1260	1240	1240	1220	1260	1220	1240	1260	1270	1240	1150	1200	1250	1240	1250	1270	1220	1200	1240
SAR	unitless	37.8	51.6	79.1	80.2	77.7	74.8	76.1	70.9	66.1	64.2	59.6	57.8	65.3	69.2	69.0	67.3	66.5	66.4	59.4	57.2	65.7	58.8	57.3	62.1
Major Ions																									
Calcium	mg/L	8	3	1	1	2	2	2	3	2	2	3	3	3	3	3	3	2	3	3	3	3	4	4	4
Magnesium	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	1	<1
Potassium	mg/L	39	31	23	16	15	13	12	11	34	22	15	13	12	11	9	9	23	21	17	14	11	10	8	8
Sodium	mg/L	427	405	470	476	541	521	530	557	460	447	468	454	513	544	542	529	463	522	467	449	516	509	496	538
Bicarbonate	mg/L	<5	<5	159	256	324	336	379	438	188	337	399	391	366	383	396	427	246	338	398	426	433	445	455	460
Carbonate	mg/L	171	200	172	121	96	78	65	50	171	87	54	61	68	58	48	33	124	82	62	49	36	29	22	22
Chloride	mg/L	376	362	395	402	513	508	476	484	449	392	437	438	513	528	526	508	473	535	425	438	530	555	501	504
Sulfate	mg/L	30	37	29	28	25	29	23	15	23	4	1	<1	<1	<1	<1	<1	11	4	2	<1	<1	<1	<1	<1
Metals																									
Aluminum, dissolved	mg/L	0.6	0.5	0.3	0.1	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Arsenic, dissolved	mg/L	0.007	0.008	0.007	0.005	0.009	0.005	0.007	<0.005	0.008	0.005	<0.005	<0.005	<0.005	0.007	0.009	<0.005	0.006	<0.005	<0.005	<0.005	<0.005	0.005	0.007	<0.005
Barium, dissolved	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Boron, dissolved	mg/L	0.4	0.5	0.7	0.7	0.8	0.8	0.9	0.8	0.6	0.7	0.8	0.9	0.8	0.8	0.8	0.8	0.7	0.8	0.8	0.9	0.8	0.8	0.8	0.9
Cadmium, dissolved	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Chromium, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron, dissolved	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.06	0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron, total	mg/L	0.15	0.06	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	2.92	0.72	0.33	0.15	0.08	<0.05	0.07	<0.05	0.73	0.87	0.17	0.09	0.05	0.14	0.11	0.08
Lead, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Manganese, total	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	<0.02	<0.02	<0.02	0.03	0.02	<0.02
Mercury	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum, dissolved	mg/L	0.06	0.04	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nickel, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Selenium, dissolved	mg/L	0.012	0.017	0.013	0.008	0.02	0.015	0.023	0.006	0.014	0.012	0.012	0.01	0.016	0.026	0.028	<0.005	0.014	0.014	0.009	0.013	0.018	0.021	0.025	0.007
Silver, dissolved	mg/L			<0.003	<0.003	<0.003	<0.003	0.005	<0.003			<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Uranium, dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0003	<0.0003	<0.0003	<0.001	<0.001	<0.001	<0.001	0.0006	<0.0003	<0.0003	<0.0003	<0.001	<0.001	<0.001	<0.001	<0.0003	<0.0003	0.0005	<0.0003
Uranium, suspended	mg/L		<0.001	<0.001			<0.0003	<0.0003			0.001	<0.001			<0.0003	<0.0003			<0.001	<0.001			<0.0003	<0.0003	
Vanadium, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Zinc, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.02	0.01	<0.01	<0.01	0.02	<0.01	0.02	0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01
Radiological																									
Lead 210, dissolved	pCi/L		<1	<1			<1	<1			1.1	<1			<1	<1			1.16	<1			<1	<1	
Lead 210, suspended	pCi/L		<1	<1			<1	<1			<1	<1			<1	<1			1.25	<1			<1	<1	
Polonium 210, dissolved	pCi/L		<1	<1			<1	<1			<1	<1			<1	1.3			<1	<1			<1	<1	
Polonium 210, suspended	pCi/L		<1	<1			<1	<1			<1	<1			<1	<1			<1	<1			<1	<1	
Ra-226, dissolved	pCi/L	0.28	0.22	<0.2	0.4	<0.2	<0.2	<0.2	<0.2	0.35	0.21	<0.2	0.4	0.7	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Ra-226, suspended	pCi/L		<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2	
Ra-228, Dissolved	pCi/L	<1	<1	<1	<1	<1	<1	1.4	<1	<1	<1	<1	1.56	<1	1	<1	1.7	<1	<1	<1	<1	1.3	<1	2.2	<1
Radon-222	pCi/L	242								156															
Th-230, dissolved	pCi/L		<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			0.24	<0.2			<0.2	<0.2	
Th-230, suspended	pCi/L		<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2	
Gross Alpha	pCi/L	4.7	3.2	<2	<2	<5	<4	<4	<3	13.7	2.1	<3.1	28.3	<4	<4	<6	<4	<2	2.3	3.53	4.5	<5	<4	<6	<6
Gross Beta	pCi/L	24.1	18.8	12	11.8	<8	<8	<7	<8	32.3	17.2	8.24	41	7.2	<7	<7	<7	16.2	13	8.33	9.2	<8	7	<8	<8
QA/QC																									
Anion Sum	meq/L	20.6	19.32	20.15	20.19	23.55	23.11	22.34	22.85	21.98	19.65	20.74	20.84	22.79	23.16	22.98	22.49	21.8	23.5	20.66	21.03	23.3	23.96	22.36	22.55
Cation Sum	meq/L	19.97	18.51	21.07	21.14	24.01	23.12	23.49	24.61	21	20.14	20.89	20.2	22.74	24.1	23.95	23.39	20.83	23.4	20.87	20.03	22.87	22.66	22.04	23.8
Total Anion/Cation Balance	%	1.54	2.14	2.25	2.3	0.96	0.01	2.51	3.7	2.28	1.22	0.36	1.55	0.1	1.99	2.06	1.96	2.26	0.21	0.49	2.43	0.92	2.77	0.73	2.7
Total Dissolved Solids (calc)	mg/L	1160	1090	1170	1170	1350	1320	1300	1330	1230	1120	1170	1160	1290	1330	1320	1290	1220	1330	1170	1160	1310	1330	1250	1300

Table 2.7-40. DM Zone Monitoring Results (Continued)

Parameter	Units	34-7DM								34-18DM								42-19DM							
		1Q10	2Q10	3Q10	4Q10	1Q11	2Q11	3Q11	4Q11	1Q10	2Q10	3Q10	4Q10	1Q11	2Q11	3Q11	4Q11	1Q10	2Q10	3Q10	4Q10	1Q11	2Q11	3Q11	4Q11
Field																									
Field Conductivity	µmhos/cm	4000	3370	3470	3430	3730	3530	3470	3990	3380	1779	2240	2540	2460	1963	2480	2950	2890	1525	1970	2260	2240	2330	1879	2640
Field pH	s.u.	10.85	10.92	10.52	10.24	11.53	10.34	10.37	9.79	12.91	10.9	10.32	9.29	9.4	9.38	9.2	8.98	12.66	11.49	9.71	9.47	9.52	9.66	9.49	9.25
Field turbidity	NTUs	45.2	48.9	60	69.6	56.7	214	780	89	23.3	5.29	2.02	2	1.41	1.04	1.19	2.67	6.99	31.2	11.67	2.26	3.36	2.31		3.87
Depth to Water	ft	85.33	87.81	89.04	89.42	89.04	83.01	90.11	91.05	269.85	272.57	272.64	273.63	270.55	270.22	270.95	270.73	286.01	286.32	287.28	287.9	286.82	287.17	287.35	287.95
Temperature	Deg C	11.6	13.7	15.7	14.3	10.6	11.9	15.6	11.1	11.2	15.9	13.8	14.7	11.5	12.4	15.6	11.1	10.9	21.7	16	14.5	11.3	11.9	13.2	10.9
ORP	millivolts		49	-28	21	-327	-431	-279	-10		77	14	-70	-238	-362	-114	76		21	-42	-11	-110	-160	-298	-81
Dissolved oxygen	mg/L	7.66	7.77	6.7	7.92		7.33	7.06	5.05	3.9	5.42	1.6	1.18		1.09	4.58	1.68	1.86		6.73	7.32		6.98	4.54	0.88
Dissolved oxygen, pct	%	76	74.9	67.9	77.8	62	73.7	77.1	47.2	36	57.4	16.1	12	27.4	10.8	49.6	15.8	17.4		71.5	74.8	64.1	58.2	45.8	8.1
General																									
Alkalinity (as CaCO3)	mg/L	463	449	547	447	605	422	421	404	498	336	360	427	444	458	453	455	481	352	386	443	431	445	443	452
Ammonia	mg/L	0.8	1.8	2.4	1.5	2.9	1.5	1	1	3.9	0.9	1.8	0.6	0.4	0.4	0.3	<0.1	2.5	2.1	0.6	0.4	0.4	0.4	0.4	0.5
Fluoride	mg/L	0.9	1.1	0.9	0.9	0.8	1.2	1	1	1.2	1.1	1.2	1	1	1.1	1.3	1.1	1.2	1.6	1.4	1.4	1.3	1.2	1.5	1.2
Laboratory conductivity	µmhos/cm	2740	3080	3220	3100	3390	2680	3330	3370	2170	2040	1980	2210	2130	2010	2500	2530	2000	1600	1920	2040	1920	1880	2260	2240
Laboratory pH	s.u.	10	10.1	10.8	9.9	11.1	9.7	9.9	9.5	11.7	10	10	9.3	9.1	9.1	8.9	8.8	11.5	10.9	9.6	9.3	9.3	9.2	9.1	9
Nitrate/Nitrite	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Dissolved Solids	mg/L	1600	1760	1900	1860	2130	1990	1840	1820	870	1160	1110	1300	1320	1320	1310	1540	940	960	1080	1170	1140	1260	1230	1210
SAR	unitless	75.0	103.7	87.6	92.6	80.1	101.8	111.9	103.1	34.9	67.9	58.2	64.9	71.5	70.5	79.8	68.7	33.5	42.6	56.0	68.9	62.2	60.7	64.7	68.1
Major Ions																									
Calcium	mg/L	3	2	3	2	6	2	2	2	4	2	2	2	2	3	2	3	5	4	2	2	3	3	3	3
Magnesium	mg/L	2	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	<1	1	<1	<1	<1	<1	<1	<1	<1	<1
Potassium	mg/L	32	23	36	22	37	19	32	21	44	21	21	15	15	12	11	10	48	27	11	10	11	11	10	11
Sodium	mg/L	686	722	688	645	807	709	779	718	302	473	405	452	498	554	556	540	315	369	390	480	489	477	508	535
Bicarbonate	mg/L	168	143	<5	208	<5	247	205	267	<5	133	134	374	429	453	481	488	<5	<5	282	389	388	430	445	462
Carbonate	mg/L	195	199	312	166	324	132	152	111	128	137	150	72	56	52	35	33	160	195	93	74	67	56	47	44
Chloride	mg/L	699	818	539	640	638	759	696	731	139	523	371	422	526	576	575	547	182	326	345	385	451	477	463	452
Sulfate	mg/L	75	71	146	123	234	143	152	118	29	12	15	6	4	<1	1	1	42	30	9	7	5	3	3	2
Metals																									
Aluminum, dissolved	mg/L	<0.1	0.5	0.1	<0.1	0.1	0.4	0.4	0.3	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Arsenic, dissolved	mg/L	0.014	0.009	0.008	0.007	0.008	0.008	0.01	<0.005	0.007	0.007	0.008	<0.005	0.006	0.005	0.008	<0.005	0.01	0.01	0.006	<0.005	<0.005	0.005	<0.005	<0.005
Barium, dissolved	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Boron, dissolved	mg/L	0.8	0.9	0.8	1	0.8	0.9	1	0.9	0.3	0.5	0.6	0.8	0.9	1	0.9	1	0.4	0.5	0.7	0.8	0.8	0.8	0.9	0.9
Cadmium, dissolved	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Chromium, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron, dissolved	mg/L	<0.05	0.21	0.08	0.1	0.1	0.18	0.4	0.1	0.07	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron, total	mg/L	1.02	1.81	10.2	2.22	3.75	6.29	23.3	3.02	0.39	0.11	0.29	<0.05	<0.05	<0.05	<0.05	<0.05	0.21	0.36	0.31	<0.05	0.1	0.06	0.1	<0.05
Lead, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Manganese, total	mg/L	<0.02	<0.02	0.15	0.02	0.05	0.08	0.37	0.03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Mercury	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05	0.02	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.06	0.03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nickel, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Selenium, dissolved	mg/L	0.017	0.023	0.016	0.014	0.025	0.024	0.03	0.006	0.008	0.009	0.006	0.01	0.022	0.023	0.029	0.007	0.008	<0.005	0.012	0.01	0.017	0.017	0.017	0.007
Silver, dissolved	mg/L			<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			<0.003	<0.003	<0.003	<0.003	<0.003	<0.003			<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Uranium, dissolved	mg/L	0.001	0.002	<0.001	<0.001	<0.001	0.0004	0.0004	0.0004	<0.001	0.003	<0.001	<0.001	<0.0003	<0.0003	<0.0003	<0.0003	<0.001	<0.001	<0.001	<0.001	<0.0003	<0.0003	<0.0003	<0.0003
Uranium, suspended	mg/L		<0.001	<0.001			0.0006	<0.0003			<0.001	<0.001			<0.0003	<0.0003			<0.001	<0.001			<0.0003	<0.0003	
Vanadium, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Zinc, dissolved	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.09	0.02	<0.01	0.04	0.01	<0.01	0.02	<0.01	0.04	<0.01	0.04	0.02	0.04	<0.01	0.01	<0.01
Radiological																									
Lead 210, dissolved	pCi/L		<1	<1			<1	<1			<1	<1			<1	<1			<1	<1			<1	1.2	
Lead 210, suspended	pCi/L		<1	1			1.2	<1			<1	<1			<1	<1			<1	<1			<1	1.5	
Polonium 210, dissolved	pCi/L		<1	<1			<1	<1			<1	<1			<1	<1			<1	<1			<1	<1	
Polonium 210, suspended	pCi/L		<1	<1			<1	<1			<1	<1			<1	<1			<1	<1			<1	<1	
Ra-226, dissolved	pCi/L	<0.2	<0.2	<0.2	<0.2	0.2	0.3	<0.2	0.2	<0.2	<0.2	<0.2	0.3	<0.2	0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	<0.2
Ra-226, suspended	pCi/L		<0.2	0.5			0.8	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2	
Ra-228, Dissolved	pCi/L	<1	<1	<1	<1	1.1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Radon-222	pCi/L	<25								<29								<28							
Th-230, dissolved	pCi/L		<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2	
Th-230, suspended	pCi/L		<0.2	0.325			0.3	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2	
Gross Alpha	pCi/L	3.5	4.4	20	10.5	<5	<2	<7	<14	<2	<2	<3.5	3.1	<4	<4	<4	<5	<2	<2	<3.5	<2	<3	<4	<3	<4
Gross Beta	pCi/L	19.4	10.5	28	16.3	12.6	3.1	<10	<20	32.6	13.1	10.1	6.6	<7	<7	<8	<8	34.3	19.7	<6.8	8.9	<7	<7	6.1	<7
QA/QC																									
Anion Sum	meq/L	30.57	33.57	29.22	29.61	35	32.87	34.38	31.19	14.56	21.77	18.03	20.62	23.86	25.46	25.35	24.62	15.69	16.94	17.72	19.95	21.52	22.48	22.05	21.88
Cation Sum	meq/L	30.93	32.08	31.01	28.7	36.34	31.43	34.81	31.85	14.47	21.21	18.22	20.15	22.13	24.65	24.54	23.98	15.18	16.94	17.36	21.22	21.68	21.16	22.48	23.7
Total Anion/Cation Balance	%	0.57	2.27	2.96	1.54	1.88	2.24	0.61	1.04	0.29	1.29	0.52	1.17	3.74	1.62	1.62	1.3	1.64	0.01	1.03	3.09	0.38	3.02	0.97	3.98
Total Dissolved Solids (calc)	mg/L	1770	1900	1740	1700	2080	1880	1910	1830	820	1230	1030	1150	1310	1420	1420	1380	880	970	990	1150	1220	1240	1250	1270

Table 2.7-41. DM Zone Comparison with WDEQ Class of Use Standards

Well ID	Probable WDEQ Class of Use	Parameters Exceeding Class I Standards[1]	Parameters Exceeding Class II Standards[1]	Parameters Exceeding Class III Standards[1]
12-18DM	III	Ammonia, TDS, chloride	Chloride	
14-18DM	III-IV	Ammonia, TDS, chloride, boron, gross alpha	Chloride, boron, gross alpha	Gross alpha
21-19DM	III	Ammonia, TDS, chloride, boron	Chloride, boron	
34-7DM	III-IV	Ammonia, TDS, chloride, boron, manganese, gross alpha	Chloride, boron, selenium, gross alpha	Gross alpha
34-18DM	III	Ammonia, TDS, chloride, boron	Chloride, boron	
42-19DM	III	Ammonia, TDS, chloride, boron	Chloride, boron	

[1] pH and iron were not compared to class of use standards since these constituents are easily treatable

Table 2.7-42. DM Zone Comparison with EPA Standards

Well ID	Parameters Exceeding Primary MCLs	Parameters Exceeding Secondary MCLs[1]
12-18DM		TDS, chloride, aluminum
14-18DM	Gross alpha	TDS, chloride, aluminum
21-19DM		TDS, chloride, aluminum
34-7DM	Arsenic, gross alpha	TDS, chloride, aluminum, manganese
34-18DM		TDS, chloride, aluminum
42-19DM		TDS, chloride, aluminum

[1] EPA designates secondary standards as non-enforceable contaminants that may cause cosmetic or aesthetic effects in drinking water

Table 2.7-43. Plant Area Piezometer Monitoring Results

Parameter	Units	SA43-18-1			SA43-18-2			SA43-18-3			SA13-17-1		
		2Q10	3Q10	4Q10	2Q10	3Q10	4Q10	2Q10	3Q10	4Q10	2Q10	3Q10	4Q10
Field													
Field Conductivity	µmhos/cm	7490	7540	7580		8550	5630	867	814	754			
Field pH	s.u.	7.96	7.85	7.77		7.78	7.79	8.16	7.78	7.89			
Field turbidity	NTUs	881	457	604		883	>1000	>1000	52.6	210			
Depth to Water	ft	20.88	20.82	20.64	10.22	11.02	12.38	13.03	14.75	16.1	DRY	DRY	DRY
Temperature	Deg C	9.9	10.2	9.1		10	10	9	13.3	9.1			
ORP	millivolts			223			141	83		255			
Dissolved oxygen	mg/L			6.03			5.71			2.67			
Dissolved oxygen, pct	%			53			51.2			24.9			
General													
Alkalinity (as CaCO3)	mg/L	450	453	456		589	549	369	342	310			
Ammonia	mg/L	<0.1	0.2	0.4		0.2	<0.1	<0.1	<0.1	<0.1			
Fluoride	mg/L	0.3	0.3	0.1		0.6	0.3	0.7	0.9	0.6			
Laboratory conductivity	µmhos/cm	6840	7050	6810		7850	5080	761	708	632			
Laboratory pH	s.u.	7.9	8	8.2		8	8.3	8.4	8.1	8.4			
Nitrate/Nitrite	mg/L	2.2	2.3	2.1		10.5	4.5	0.4	0.4	0.5			
Total Dissolved Solids	mg/L	6600	6520	6400		7280	4190	510	430	420			
Major Ions													
Calcium	mg/L	337	339	327		325	155	21	18	20			
Magnesium	mg/L	162	181	173		264	110	13	12	12			
Potassium	mg/L	27	26	28		52	35	4	4	4			
Sodium	mg/L	1180	1330	1270		1500	908	152	133	115			
Bicarbonate	mg/L	549	553	556		719	670	435	417	370			
Carbonate	mg/L	<5	<5	<5		<5	<5	7	<5	<5			
Chloride	mg/L	53	60	53		270	134	1	<1	1			
Sulfate	mg/L	3270	4190	3960		3950	2100	65	53	45			
Metals													
Aluminum, dissolved	mg/L	<0.1	<0.1	<0.1		<0.1	<0.1	<0.1	<0.1	<0.1			
Arsenic, dissolved	mg/L	0.005	<0.005	<0.005		<0.005	0.006	<0.005	<0.005	<0.005			
Barium, dissolved	mg/L	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5			
Boron, dissolved	mg/L	0.2	0.3	<0.1		<0.1	<0.1	0.1	0.1	<0.1			
Cadmium, dissolved	mg/L	<0.002	<0.002	<0.002		<0.002	<0.002	<0.002	<0.002	<0.002			
Chromium, dissolved	mg/L	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01			
Copper, dissolved	mg/L	<0.01	0.01	<0.01		0.02	<0.01	<0.01	<0.01	<0.01			
Iron, dissolved	mg/L	<0.05	<0.05	<0.05		<0.05	<0.05	<0.05	<0.05	<0.05			
Iron, total	mg/L	19.7	4.52	24.3		19	39.8	24.6	0.8	4.67			
Lead, dissolved	mg/L	<0.02	<0.02	<0.02		<0.02	<0.02	<0.02	<0.02	<0.02			
Manganese, total	mg/L	0.95	0.37	0.9		0.54	1.1	0.45	0.05	0.13			
Mercury	mg/L	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	<0.001	<0.001			
Molybdenum, dissolved	mg/L	<0.02	<0.02	<0.02		<0.02	<0.02	<0.02	<0.02	<0.02			
Nickel, dissolved	mg/L	<0.01	0.02	0.01		0.02	0.01	<0.01	<0.01	<0.01			
Selenium, dissolved	mg/L	0.057	0.05	0.053		0.955	0.402	<0.005	<0.005	<0.005			
Silver, dissolved	mg/L		<0.003	<0.003		<0.003	<0.003		<0.003	<0.003			
Uranium, dissolved	mg/L	0.062	0.064	0.063		0.264	0.146	0.013	0.011	0.01			
Uranium, suspended	mg/L	0.003	<0.001			<0.001			<0.001				
Vanadium, dissolved	mg/L	<0.02	<0.02	<0.02		<0.02	<0.02	<0.02	<0.02	<0.02			
Zinc, dissolved	mg/L	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01			
Radiological													
Lead 210, dissolved	pCi/L	<1	<1			<1			<1				
Lead 210, suspended	pCi/L	1.98	4.1			2.33			3.81				
Polonium 210, dissolved	pCi/L	<1	<1			<1			<1				
Polonium 210, suspended	pCi/L	<1	2.09			<1			<1				
Ra-226, dissolved	pCi/L	0.53	0.3	0.7		0.45	0.5	<0.2	<0.2	<0.2			
Ra-226, suspended	pCi/L	3.45	<0.2			0.86			<0.2				
Ra-228, Dissolved	pCi/L	<1	<1	<1		<1	2.5	<1	<1	2.2			
Radon-222	pCi/L												
Th-230, dissolved	pCi/L	<0.2	<0.2			<0.2			<0.2				
Th-230, suspended	pCi/L	1.64	<0.2			<0.2			<0.2				
Gross Alpha	pCi/L	66	81.7	83.7		218	115	17	8.44	18			
Gross Beta	pCi/L	40	63.3	46.6		137	83.7	12.5	6.49	15.5			
QA/QC													
Anion Sum	meq/L	78.72	98.09	93.12		101.64	58.44	8.79	8.01	7.2			
Cation Sum	meq/L	82.07	90.21	86.65		104.54	57.16	8.89	7.76	7.07			
Total Anion/Cation Balance	%	2.08	4.18	3.59		1.4	1.1	0.55	1.56	0.88			
Total Dissolved Solids (calc)	mg/L	5300	6400	6090		6710	3770	480	430	380			

No sample collected at SA43-18-2 during 2Q10, well dry when drilled and allowed to purge and develop prior to sample collection in 3Q10.

Table 2.7-44. Sampled Water Supply Wells

Well ID	WSEO Permit	Total Depth (ft)	Permitted Use	Legal Location (Tns-Rng-Sec-¼¼)	3Q09	4Q09	1Q10	2Q10	3Q10	4Q10
19XX18	P67747W	536	IND_GW	53-67-18-SESW	**X**	**X**	**X**	**X**	**X**	**X**
22X-19	P50917W	750	IND_GW	53-67-19-SENW	1	1	**X**	**X**	**X**	**X**
CSWELL01	P132537W	330	DOM_GW; STK	53-67-20-NWNW	**X**	**X**	**X**	**X**	**X**	**X**
CSWELL03	P619W	120	STK	53-67-30-NENE	2	**X**	3	**X**	**X**	**X**
DWWELL01	Unknown	Unknown	DOM_GW	53-67-17-SWNW	**X**	**X**	**X**	**X**	**X**	**X**
HBWELL01	P7328P	207	STK	53-67-6-NENE	**X**	4	4	4	4	4
HBWELL03	P7324P	160	STK	53-67-5-SWSW	**X**	1	**X**	**X**	**X**	**X**
HBWELL04	P7326P	100	STK	53-67-8-NENW	**X**	1	**X**	**X**	**X**	2
HBWELL05	P7430P	150	DOM_GW; STK	53-67-8-SESW	**X**	1	**X**	**X**	**X**	**X**
HBWELL06	Unknown	Unknown	DOM_GW; STK	53-67-22-NWNW	1	**X**	4	4	4	4
P144030W	P144030W	401	DOM_GW; STK	53-68-23-SESW	1	1	1	1	**X**	4
P17177W	P17177W	180	STK	53-68-1-SENW	**X**	**X**	4	4	**X**	**X**
P21128P	P21128P	140	STK	53-68-24-SESW	1	1	1	**X**	**X**	**X**
P22582P	P22582P	150	STK	53-67-19-SWSW		**X**				**X**
P31770W	P31770W	600	DOM_GW	52-67-6-SENW	**X**	**X**	**X**	4	4	4
P42868W	P42868W	243	DOM_GW; STK	53-68-14-NWSE	**X**	1	5	1	1	1
P50113W	P50113W	40	STK	53-68-2-SWNE	**X**	**X**	4	4	**X**	**X**
P50883W	P50883W	150	STK		1	1	1	1	**X**	**X**
P61006W	P61006W	335	DOM_GW; STK	53-68-15-NWSW	**X**	4	4	4	4	4
P61007W	P61007W	304	STK	53-68-15-NWSW	**X**	4	4	4	4	4
P71108W	P71108W	220	STK	53-68-2-SENE	**X**	**X**	4	**X**	**X**	6
P78287W	P78287W	560	DOM_GW; STK; MIS	53-67-9-SESW	**X**	4	4	4	4	4
P84665W	P84665W	50	STK	53-68-2-NWNW	**X**	4	4	4	**X**	**X**
SBWELL01	Unknown	Unknown	STK	53-68-2-SWNE	**X**	**X**	4	**X**	**X**	**X**
SBWELL02	Unknown	Unknown	STK	53-68-1-NESE	2	2	2	**X**	**X**	**X**
TSWELL01	Unknown	Unknown	DOM_GW	53-68-8-SESE	1	**X**	4	4	4	4
TW01	P74302W	200	DOM_GW; STK	53-67-7-NESE	**X**	7	**X**	**X**	**X**	**X**
TW02	P103666W	160	DOM_GW; STK	53-67-8-SWSW	**X**	**X**	**X**	**X**	**X**	**X**
TWWELL03	P192896W	Unknown	STK	53-68-12-SESE	8	8	8	8	**X**	**X**

Notes:

X – Sample collected
1-7 – No sample collected due to:
- 1 – No landowner permission
- 2 – Well not functioning
- 3 – Well winterized – not operational
- 4 – Well outside GW sampling area (established in January 2010)
- 5 – Well dry or frozen
- 6 – Landowner request
- 7 – No access
- 8 – Well constructed August 2010

Table 2.7-45. Industrial Well Water Quality

Parameter	**Units**	**19XX18**	**22X-19**
Field			
Field conductivity	umhos/cm	2790-3120	1987-2720
Field pH	s.u.	8.5-8.8	8.9-9.0
Field turbidity	NTUs	0.3-2.1	0.2-2.9
Temperature	Deg C	8.7-14.2	10.4-13.1
Dissolved oxygen	mg/L	4.0-7.5	1.2-1.6
General			
Alkalinity (as CaCO3)	mg/L	521-659	462-472
Ammonia	mg/L	<0.1-0.2	0.3-0.5
Fluoride	mg/L	0.5-0.6	0.6-0.7
Laboratory conductivity	umhos/cm	2320-2410	1840-2080
Laboratory pH	s.u.	8.5-8.6	8.6-8.7
Nitrate/nitrite	mg/L	0.1-0.5	<0.1
Total dissolved solids	mg/L	1660-1790	1420-1520
Major Ions			
Calcium	mg/L	7-8	5-6
Magnesium	mg/L	2-3	2
Potassium	mg/L	4-5	4-5
Sodium	mg/L	499-655	444-507
Bicarbonate	mg/L	605-770	520-547
Carbonate	mg/L	15-27	13-26
Chloride	mg/L	6-8	10-13
Sulfate	mg/L	616-685	511-538
Metals			
Aluminum, dissolved	mg/L	<0.1	<0.1
Arsenic, dissolved	mg/L	<0.005	<0.005
Barium, dissolved	mg/L	<0.5	<0.5
Boron, dissolved	mg/L	0.4	0.4
Cadmium, dissolved	mg/L	<0.002	<0.002
Chromium, dissolved	mg/L	<0.01	<0.01
Copper, dissolved	mg/L	<0.01	<0.01
Iron, dissolved	mg/L	<0.05	<0.05-0.06
Iron, total	mg/L	<0.05-0.14	<0.05-0.07
Lead, dissolved	mg/L	<0.02	<0.02
Manganese, total	mg/L	<0.02	<0.02
Mercury, dissolved	mg/L	<0.001	<0.001
Molybdenum, dissolved	mg/L	<0.02	<0.02
Nickel, dissolved	mg/L	<0.01	<0.01
Selenium, dissolved	mg/L	<0.005	<0.005
Silver, dissolved	mg/L	<0.003	<0.003
Uranium, dissolved	mg/L	0.074	0.02-0.022
Uranium, suspended	mg/L	<0.001	<0.001
Vanadium, dissolved	mg/L	<0.02	<0.02
Zinc, dissolved	mg/L	<0.01	<0.01
Radiological			
Lead 210, dissolved	pCi/L	2.41-6.13	<1
Lead 210, suspended	pCi/L	1.43-2.8	1.21-1.46
Polonium 210, dissolved	pCi/L	<1-6.4	<1
Polonium 210, suspended	pCi/L	3.91-5.9	<1-1.12
Ra-226, dissolved	pCi/L	37.3-47.23	3.05-3.38
Ra-226, suspended	pCi/L	0.28-0.31	<0.2
Ra-228, dissolved	pCi/L	<1-1.65	<1-1.4
Radon-222	pCi/L	18000	9100
Th-230, dissolved	pCi/L	<0.2	<0.2
Th-230, suspended	pCi/L	<0.2	<0.2
Gross Alpha	pCi/L	167.7-324	38.5-47.9
Gross Beta	pCi/L	39.7-81.4	7.3-12.3

Table 2.7-46. Stock Well Monitoring Results

Parameter	Units	CSWELL03	HBWELL01	HBWELL03	HBWELL04	P17177W	P21128P	P22582P	P50113W	P50883W	P61007W	P71108W	P84665W	SBWELL01	SBWELL02	TWWELL03
Field																
Field Conductivity	µmhos/cm	599-682	706	1542-1862	1477-1761	794-998	964-1051	1026-1141	1440-1757	658-699	1065	1652-1940	804-983	1088-1263	789-1043	1381-1437
Field pH	s.u.	7.89-8.28	7.52	7.45-7.87	7.2-7.45	7.34-7.66	8.47-8.6	8.9-9.11	7.43-7.85	7.78-8.02	8.63	7.47-7.62	7.42-7.84	8.73-9.09	7.7-8.15	8.91-9.07
Field turbidity	NTUs	4.61-84.5		7.83-21.1	2.15-6.23	0.37-1.34	3.52-130	1.05-1.99	0.18-0.98	1.35-19.48	1.43	0.25-1.86	0.88-25	0.37-3.08	0.94-1.75	0.51-0.9
Depth to Water	ft		41.3													
Temperature	Deg C	10.4-11.6	11	8.3-11	6.6-10.2	8.3-10.1	11.2-12.1	8.7-10.5	8-9.5	10.5-11	12.5	10.5-13	9.2-11	9.9-14.4	10.4-10.8	10.9-11.5
Dissolved oxygen	mg/L	1.64-2.89		1.03-2.3	0.92-1.38	2.75-4	2.66-3.34	1.68	1.86-2.79	4.37-5.58		0.94-1.94	3.14-3.5	0.92-1.71	0.82-2.36	1.81-7.5
Dissolved oxygen, pct	%	15-26.4		9.4-20.4	8.2-11.3	24.1-35.2	24.4-30.4	15	15.4-24.1	39.3-51.5		8-18	28.3-30.7	8.3-15.7	7.7-21.1	16.7-67.6
General																
Alkalinity (as CaCO3)	mg/L	318-336	343	460-531	351-444	320-415	414-438	440-491	511-553	296-340	537	541-580	406-412	531-535	387-488	596-603
Ammonia	mg/L	<0.1-0.3	<0.1	<0.1-0.3	<0.1	<0.1	<0.1-0.1	<0.1-0.6	<0.1-0.5	<0.1-0.1	<0.1	<0.1	<0.1	<0.1-0.2	<0.1-0.2	<0.1-0.2
Fluoride	mg/L	0.1-0.2	0.1	0.2	0.2	<0.1-0.1	0.1-0.2	0.6-0.9	0.2-0.3	0.2	0.2	0.2	0.1	<0.1-0.1	<0.1-0.2	1.3-1.5
Laboratory conductivity	µmhos/cm	543-654	732	1520-1800	1620-1740	822-923	956-973	972-1120	1500-1840	588-686	1170	1660-2190	922-952	1130-1170	735-1010	1440-1490
Laboratory pH	s.u.	8.1-8.4	8	8-8.2	7.8-8	7.8-8	8.4-8.5	8.6-8.7	8-8.1	8.1-8.2	8.8	7.9-8.1	8-8.1	8.6-8.7	8.1-8.3	8.7-8.8
Nitrate/Nitrite	mg/L	<0.1	1.6	<0.1	0.9-1.2	20-22.4	1.1-1.6	<0.1	23.9-44.9	0.1-0.2	<0.1	0.2-0.6	0.9-2.4	<0.1	<0.1-0.4	<0.1
Total Dissolved Solids	mg/L	370-430	440	1140-1370	1370-1420	530-610	620-640	610-730	1060-1320	370-430	720	1160-1610	590-650	740-770	480-650	970-1000
Oil and Grease	mg/L															
Total Petroleum Hydrocarbons	mg/L															
Major Ions																
Calcium	mg/L	28-38	63	79-106	195-203	100-117	13-20	6-12	94-120	33-44	3	65-76	74-81	1-2	19-39	2-3
Magnesium	mg/L	15-20	47	44-56	58-64	27-31	7-11	3-6	52-67	16-20	1	66-98	36-37	<1	11-26	1-2
Potassium	mg/L	9	14	14-20	7	5	15-20	4-5	6-7	6-7	3	9	5-6	2-3	12-16	4-7
Sodium	mg/L	74-97	26	178-275	117-141	38-39	185-207	234-277	162-208	81	293	230-381	75-83	268-313	98-205	360-374
Bicarbonate	mg/L	379-410	419	561-648	429-542	391-507	491-514	500-536	624-675	361-414	591	660-707	495-503	592-609	472-595	657-664
Carbonate	mg/L	<5	<5	<5	<5	<5	7-13	18-31	<5	<5	32	<5	<5	20-30	<5	35
Chloride	mg/L	3-4	6	8-15	12-17	17-21	2-3	2-4	36-63	3	<1	4-7	6-8	<1-1	<1-1	2
Sulfate	mg/L	28-32	53	402-540	583-654	40-46	91-96	85-112	172-259	39-44	83	377-679	98-107	94-102	37-78	195-201
Metals																
Aluminum, dissolved	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1-0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Arsenic, dissolved	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.007	<0.005	<0.005	0.006-0.007	<0.005	<0.005
Barium, dissolved	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Boron, dissolved	mg/L	<0.1	<0.1	0.1-0.2	<0.1	<0.1	<0.1	0.2-0.3	<0.1	<0.1	0.2	<0.1-0.1	<0.1	<0.1-0.1	0.1-0.2	0.5-0.6
Cadmium, dissolved	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Chromium, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron, dissolved	mg/L	0.16-0.83	0.21	0.55-4.14	<0.05	<0.05	<0.05-0.1	<0.05-0.07	<0.05	0.07-0.09	<0.05	<0.05	<0.05-0.07	<0.05	0.06-0.2	<0.05
Iron, total	mg/L	1.3-3.94	0.8	2.33-7.22	0.07-0.95	<0.05-0.11	0.13-16.5	0.11-0.22	<0.05	0.23-1.6	0.17	<0.05-0.07	0.07-3.75	<0.05	0.12-0.61	<0.05
Lead, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Manganese, total	mg/L	0.08-0.34	<0.02	0.15-0.9	0.07-0.08	<0.02	<0.02-0.51	<0.02	0.07-0.44	0.02-0.05	<0.02	0.18-0.25	<0.02-0.05	<0.02	0.04-0.05	<0.02
Mercury	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nickel, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Selenium, dissolved	mg/L	<0.005-0.006	0.006	<0.005	<0.005	<0.005-0.005	0.103-0.165	<0.005	0.026-0.05	<0.005	<0.005	0.007-0.026	<0.005-0.009	<0.005	<0.005	<0.005
Silver, dissolved	mg/L	<0.003		<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003		<0.003	<0.003	<0.003	<0.003	<0.003
Uranium, dissolved	mg/L	<0.001-0.001	0.01	0.002-0.006	0.033-0.034	0.022-0.024	0.271-0.388	<0.001-0.003	0.173-0.212	0.025-0.028	0.001	0.064-0.113	0.056	<0.001-0.002	<0.001-0.005	<0.001
Uranium, suspended	mg/L	<0.001		<0.001	<0.001	<0.001	0.002-0.004		<0.001	<0.001		<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Zinc, dissolved	mg/L	<0.01-0.01	0.18	<0.01-0.25	0.03-0.05	<0.01	<0.01	<0.01	<0.01	0.04-0.07	<0.01	0.02-0.03	0.08	<0.01	<0.01	<0.01
Radiological																
Lead 210, dissolved	pCi/L	<1		<1	<1	<1	1.76-17.4		2.1	<1		<1	<1	<1-1.04	<1	<1
Lead 210, suspended	pCi/L	<1		<1-1.21	<1-1.8	<1	1.26-1.8		<1	<1		<1	<1	<1-1.5	<1-1.11	<1
Polonium 210, dissolved	pCi/L	<1		<1	<1	<1	<1		<1	<1		<1	<1	<1	<1	<1
Polonium 210, suspended	pCi/L	<1		<1	<1	<1	<1		<1	<1		<1	<1	<1	<1	<1
Ra-226, dissolved	pCi/L	0.3-0.4	0.27	0.77-1.03	0.28-0.52	<0.2-0.3	0.21-0.3	<0.2	0.2-0.6	<0.2-7.7	<0.2	<0.2-0.9	0.3-0.4	<0.2	<0.2-0.21	<0.2
Ra-226, suspended	pCi/L	<0.2		0.32-0.5	<0.2-0.59	<0.2	0.7-0.91		<0.2	<0.2		<0.2	<0.2	<0.2-0.7	<0.2-7	<0.2
Ra-228, Dissolved	pCi/L	<1	<1	<1-1.2	<1	<1	<1	<1-2.59	<1	<1-1.27	<1	<1-1.6	<1	<1	<1-1.22	<1
Radon-222	pCi/L				1600											
Th-230, dissolved	pCi/L	<0.2		<0.2	<0.2	<0.2	<0.58		<0.2	<0.2		<0.2	<0.2	<0.2	<0.2	<0.2
Th-230, suspended	pCi/L	<0.2		<0.2	<0.2	<0.2	0.209-0.49		<0.2	<0.2		<0.2	<0.2	<0.2	<0.2	<0.2
Gross Alpha	pCi/L	<2-5.53	5.8	7-10.1	12.1-23	12.1-19.5	178-239	2.7-2.8	78.6-100	15.4-16.9	2.3	37-59.2	26.7-37.3	<2-3.4	2.7-4.1	<3.1-6.7
Gross Beta	pCi/L	7.36-8.8	12.2	9.3-17.3	7.9-17.4	6.4-9.8	67.9-128	<3-4.1	37.3-40.7	6.4-10.1	<2	14.8-22.3	15.2-16.4	<3.7	7.6-12.3	<6.7-6.9
QA/QC																
Anion Sum	meq/L	7.05-7.47	8.24	17.83-21.51	19.75-22.92	9.26-9.89	10.36-10.8	10.72-12.25	17.03-20.39	6.82-7.8	12.47	18.97-25.99	10.4-10.86	12.64-12.8	8.56-11.41	16.12-16.39
Cation Sum	meq/L	6.78-7.33	8.46	17.32-20.83	19.72-21.56	9.03-10.12	10.19-11.34	11.34-12.69	16.27-20.7	6.64-7.5	13.08	19.46-28.63	10.08-10.74	11.81-13.76	8.62-11.07	16.01-16.65
Total Anion/Cation Balance	%	0.93-1.97	1.29	1.44-2.39	0.14-3.06	0.23-1.93	0.83-2.95	1.77-2.83	0.76-2.96	1.29-1.98	2.4	1.14-4.83	0.48-2.14	0.02-4.13	0.13-1.5	0.34-0.79
Total Dissolved Solids (calc)	mg/L	360-390	420	1030-1270	1190-1350	450-500	580-610	610-700	870-1060	360-400	710	1090-1600	540-570	690-730	450-620	570-950

Table 2.7-47. Stock Well Comparison with WDEQ Class of Use Standards

Well ID	Probable WDEQ Class of Use	Parameters Exceeding Class I Standards[1]	Parameters Exceeding Class II Standards[1]	Parameters Exceeding Class III Standards[1]
CSWELL03	III	Manganese	Manganese	
HBWELL01	I			
HBWELL03	III	TDS, sulfate, manganese	Sulfate, manganese	
HBWELL04	IV	TDS, sulfate, manganese, gross alpha	Sulfate, gross alpha	Gross alpha
P17177W	IV	TDS, gross alpha	Gross alpha	Gross alpha
P21128P	IV	TDS, manganese, selenium, gross alpha	Manganese, selenium, gross alpha	Selenium, gross alpha
P22582P	II	Ammonia, TDS		
P50113W	IV	TDS, sulfate, manganese, gross alpha	Sulfate, manganese, selenium, gross alpha	Gross alpha
P50883W	IV	Radium-226 and 228, gross alpha	Radium 226 and 228, gross alpha	Radium 226 and 228, gross alpha
P61007W	II	TDS		
P71108W	IV	TDS, sulfate, manganese, gross alpha	Sulfate, manganese, gross alpha	Gross alpha
P84665W	IV	TDS, gross alpha	Gross alpha	Gross alpha
SBWELL01	II	TDS		
SBWELL02	II	TDS		
TWWELL03	II	TDS	Sulfate	

[1] pH and iron were not used to assess the suitability of groundwater since these constituents are easily treatable

Table 2.7-48. Stock Well Comparison with EPA Standards

Well ID	Parameters Exceeding Primary Standards[1]	Parameters Exceeding Secondary Standards[1]
CSWELL01		Manganese
HBWELL01		
HBWELL03		TDS, sulfate, manganese
HBWELL04	Uranium, gross alpha	TDS, sulfate, manganese
P17177W	Gross alpha	TDS
P21128P	Selenium, uranium, gross alpha	TDS, aluminum, manganese
P22582P		TDS
P50113W	Uranium, gross alpha	TDS, sulfate, manganese
P50883W	Radium-226 and 228, gross alpha	
P61007W		TDS
P71108W	Uranium, gross alpha	TDS, sulfate, manganese
P84665W	Uranium, gross alpha	TDS
SBWELL01		TDS
SBWELL02		
TWWELL03		TDS

[1] Provided for comparison only, since these wells are not used as a drinking water supply

Table 2.7-49. Domestic Well Monitoring Results

Parameter	Units	CSWELL01	DWWELL01	HBWELL05	HBWELL06	P144030W	P31770W	P42868W	P61006W	P78287W	TSWELL01	TW01	TW02
Field													
Field Conductivity	µmhos/cm	1635-3310	2980-3430	1343-1575	1450	913	1910-3620	1167	918	737	1303	1616-2680	1889-2890
Field pH	s.u.	7.94-8.44	8.21-8.69	7.51-7.84	8.8	7.44	7.8-7.96	8.71	7.83	7.72	8.81	8.05-8.42	7.81-8.29
Field turbidity	NTUs	0-0.27	4.86-37.7	14.46-141	1.2	1.51	0.02-0.69	1.71	1.2	0.74	2540	0.19-1.35	0.56-2.05
Depth to Water	ft	148.8										27.7	20.4
Temperature	Deg C	7.8-17.3	8.4-14.8	8.5-12.6	8.9	14.8	8.2-12	10.8	12.9	16.1	10.4	7.5-13.2	5.5-13.6
Dissolved oxygen	mg/L	0.83-2.08	1.19-2.7	2.72-4.72		1.21						1.03-1.29	0.78-2.29
General													
Alkalinity (as CaCO3)	mg/L	633-792	586-647	499-543	768	443	499-504	547	490	116	587	668-836	613-654
Ammonia	mg/L	<0.1-0.1	0.4-1.2	<0.1	0.5	<0.1	<0.1	<0.1	<0.1	0.4	<0.1	<0.1-0.2	0.2-0.3
Fluoride	mg/L	0.3-0.4	0.6-0.7	0.2-0.3	2.5	0.1	0.3	0.3	0.1	1.1	0.4	1.2	0.5-0.6
Laboratory conductivity	µmhos/cm	1550-2600	2210-2690	1370-1660	1410	846	2510-2550	1250	1030	841	1300	2000-2150	1840-2190
Laboratory pH	s.u.	8.3-8.4	8.4-8.5	8-8.2	8.5	8	8.2	8.7	8.3	8	8.7	8.4-8.5	8.3-8.5
Nitrate/Nitrite	mg/L	<0.1-0.9	<0.1	<0.1-0.5	<0.1	<0.1	0.6-1.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1
Total Dissolved Solids	mg/L	1030-1920	1760-1880	1090-1160	960	520	1800-1920	810	660	580	910	1350-1440	1450-1550
Oil and Grease	mg/L				<5								
Total Petroleum Hydrocarbons	mg/L				<5								
Major Ions													
Calcium	mg/L	9-43	15-17	79-90	3	49	56-74	2	18	22	4	8-9	19-26
Magnesium	mg/L	6-33	6	33-38	2	25	23-37	1	9	5	2	4-5	8-12
Potassium	mg/L	8-14	11-13	7-8	3	16	11-14	3	8	6	4	6-8	11-13
Sodium	mg/L	393-574	558-665	229-258	397	113	514-593	321	244	148	353	438-509	466-544
Bicarbonate	mg/L	748-931	682-774	609-662	886	541	609-615	616	578	142	666	793-935	742-780
Carbonate	mg/L	5-18	8-18	<5	25	<5	<5	25	9	<5	24	8-42	<5-18
Chloride	mg/L	2-7	7-16	4-6	46	1	21-23	1	<1	6	1	4-8	8-15
Sulfate	mg/L	224-723	663-794	327-381	25	56	842-865	117	74	260	122	331-393	467-576
Metals													
Aluminum, dissolved	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Arsenic, dissolved	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.02	<0.005	<0.005	<0.005	<0.005	<0.005
Barium, dissolved	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Boron, dissolved	mg/L	0.3-0.4	0.5-0.6	0.2	0.5	<0.1	0.2-0.3	0.2	0.1	0.5	0.3	0.5-0.59	0.4-0.52
Cadmium, dissolved	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Chromium, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron, dissolved	mg/L	<0.05	0.21-1.96	0.17-1.55	<0.05	0.08	<0.05-0.9	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05-0.06
Iron, total	mg/L	<0.05	1.71-5.02	2.4-32.8	0.1	0.13	0.05-0.91	<0.05	0.16	0.14	0.22	<0.05-0.12	<0.05-0.22
Lead, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Manganese, total	mg/L	<0.02-0.02	0.03-0.07	0.08-0.17	0.08	0.08	0.04-0.15	<0.02	<0.02	0.12	<0.02	<0.02	0.02-0.03
Mercury	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nickel, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Selenium, dissolved	mg/L	<0.005-0.009	<0.005	<0.005-0.007	<0.005	<0.005	<0.005-0.006	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Silver, dissolved	mg/L	<0.003	<0.003	<0.003		<0.003						<0.003	<0.003
Uranium, dissolved	mg/L	0.004-0.02	<0.001	0.01-0.015	<0.001	0.024	0.015-0.071	<0.001	0.002	<0.001	0.004	<0.001	<0.001
Uranium, suspended	mg/L	<0.001	<0.001	<0.001		<0.001						<0.001	<0.001
Vanadium, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Zinc, dissolved	mg/L	<0.01	<0.01	<0.01-0.01	<0.01	<0.01	0.02-0.06	<0.01	<0.01	<0.01	<0.01	<0.01-0.02	0.01-0.03
Radiological													
Lead 210, dissolved	pCi/L	<1	<1	<1		<1						<1	<1
Lead 210, suspended	pCi/L	<1	1.21-1.78	<1-1.56		<1						<1	<1
Polonium 210, dissolved	pCi/L	<1	<1	<1		<1						<1	<1
Polonium 210, suspended	pCi/L	<1	8.91-9.2	<1		<1						<1	<1
Ra-226, dissolved	pCi/L	<0.2-0.86	<0.2-0.4	<0.2-0.2	0.27	0.8	0.32-0.43	<0.2	1.13	<0.2	0.46	<0.2-0.32	0.31-1.1
Ra-226, suspended	pCi/L	<0.2	<0.2	<0.2		<0.2						<0.2	<0.2
Ra-228, Dissolved	pCi/L	<1-1.66	<1-2.84	<1	<1	<1	<1	<1	<1	<1	1.17	<1	<1-1.54
Radon-222	pCi/L	1600					390						
Th-230, dissolved	pCi/L	<0.2	<0.2	<0.2		<0.2						<0.2	<0.2
Th-230, suspended	pCi/L	<0.2	<0.2	<0.2		<0.2						<0.2	<0.2
Gross Alpha	pCi/L	7.2-18.3	10.7-17.3	7.1-12.7	<2	23.9	7.8-36.8	<2	4.8	<2	10.8	<2-4.2	<2-4.61
Gross Beta	pCi/L	<2-13.2	5.1-11.8	6.4-10	3.6	23.8	12.9-17.1	<2	3.6	4.1	7.3	<2-8.55	<2-11.7
QA/QC													
Anion Sum	meq/L	17.4-30.39	25.79-28.57	17-18.61	17.32	10.07	28.2-28.71	13.43	11.34	7.97	14.32	21.5-23.9	22.59-25.36
Cation Sum	meq/L	18.28-29.96	25.79-30.51	17.03-18.73	17.63	9.84	27.32-31.63	14.24	12.44	8.11	15.75	20.03-23.14	22.76-25.55
Total Anion/Cation Balance	%	0.31-3.22	0.01-3.27	0.33-4.86	0.88	1.13	2.02-4.83	2.91	4.62	0.82	4.74	0.44-3.54	0.29-4.39
Total Dissolved Solids (calc)	mg/L	1020-1830	1610-1850	1020-1080	940	530	1780-1880	770	650	520	840	870-1370	1370-1560

Table 2.7-50. Domestic Well Comparison with WDEQ Class of Use Standards

Well ID	Probable WDEQ Class of Use	Parameters Exceeding Class I Standards[1]	Parameters Exceeding Class II Standards[1]	Parameters Exceeding Class III Standards[1]
CSWELL01	III-IV	TDS, sulfate, gross alpha	Sulfate, gross alpha	Gross alpha
DWWELL01	III-IV	Ammonia, TDS, sulfate, manganese, gross alpha	Sulfate, gross alpha	Gross alpha
HBWELL05	III	TDS, sulfate, manganese	Sulfate	
HBWELL06	II	TDS, manganese		
P144030W	II	TDS, manganese, gross alpha	Gross alpha	Gross alpha
P31770W	IV	TDS, sulfate, manganese, gross alpha	Sulfate, gross alpha	Gross alpha
P42868W	II	TDS		
P61006W	II	TDS		
P78287W	III	TDS, sulfate, manganese	Sulfate	
TSWELL01	II	TDS		
TW01	III	TDS, sulfate	Sulfate	
TW02	III	TDS, sulfate	Sulfate	

1 pH and iron were not compared to class of use standards since these constituents are easily treatable

Table 2.7-51. Domestic Well Comparison with EPA Standards

Well ID	Parameters Exceeding Primary Standards	Parameters Exceeding Secondary Standards[1]
CSWELL01	Gross alpha	TDS, sulfate
DWWELL01	Gross alpha	TDS, sulfate, manganese
HBWELL05		TDS, sulfate, manganese
HBWELL06		Fluoride, TDS, manganese
P144030W	Gross alpha	TDS, manganese
P31770W	Uranium, gross alpha	TDS, sulfate, manganese
P42868W	Arsenic	TDS
P61006W		TDS
P78287W		TDS, sulfate, manganese
TSWELL01		TDS
TW01		TDS, sulfate
TW02		TDS, sulfate

1 EPA designates secondary standards as non-enforceable contaminants that may cause cosmetic or aesthetic effects in drinking water

Table 2.7-52. Nubeth Wells

Well ID	Well Use	Sampling Time Period
3X (B-1)	Buffer	4/1978 – 10/1981
4X (B-3)	Buffer	4/1978 – 10/1981
5X (M-2)	Monitor	4/1978 – 4/1980
6X (M-4)	Monitor	4/1978 – 4/1980
7X (OSA-1)	Observation	4/1978 – 4/1980
11X (M-5)	Monitor	4/1978 – 4/1980
12X (M-1)	Monitor	4/1978 – 4/1980
19X	Recovery	4/1978 – 10/1981
20X (I-2)	Injection	4/1978 – 10/1981

Table 2.7-53. Nubeth Baseline Groundwater Quality

Well ID	Water Type	Gross Alpha (pCi/L)	Radium-226 (pCi/L)	Uranium (mg/L)
3X	Sodium sulfate	290	73	0.071
4X	Sodium sulfate	180	16	0.080
5X	Sodium sulfate	157	0.3	0.100
6X	Sodium sulfate	128	0.6	0.075
7X	Sodium sulfate	ND	0.5	0.008
11X	Sodium sulfate	112	1.4	0.079
12X	Sodium sulfate	72	2.3	0.073
19X	Sodium sulfate	310	97	0.300
20X	Sodium bicarbonate	7.7	0.6	0.006

Source: ND Resources, Inc. (1978)

Table 2.7-54. Nubeth Restoration Groundwater Quality

Well ID	Sample Date	Water Type	Gross Alpha (pCi/L)	Radium-226 (pCi/L)	Uranium (mg/L)
3X	10/4/81	Sodium sulfate	130	22	0.240
4X	10/4/81	Sodium sulfate	180	26	0.220
5X	4/24/80	Sodium sulfate	37	0.5	0.035
6X	4/24/80	Sodium sulfate	66	0.1	0.095
7X	4/24/80	Sodium bicarbonate	180	0.6	ND
11X	4/24/80	Sodium sulfate	116	1	0.082
12X	4/24/80	Sodium sulfate	111	1.6	0.076
19X	10/4/81	Sodium sulfate	300	31	0.480
20X	10/4/81	Sodium sulfate	85	20	0.068

Sources: ND Resources (1980), ND Resources (1982).

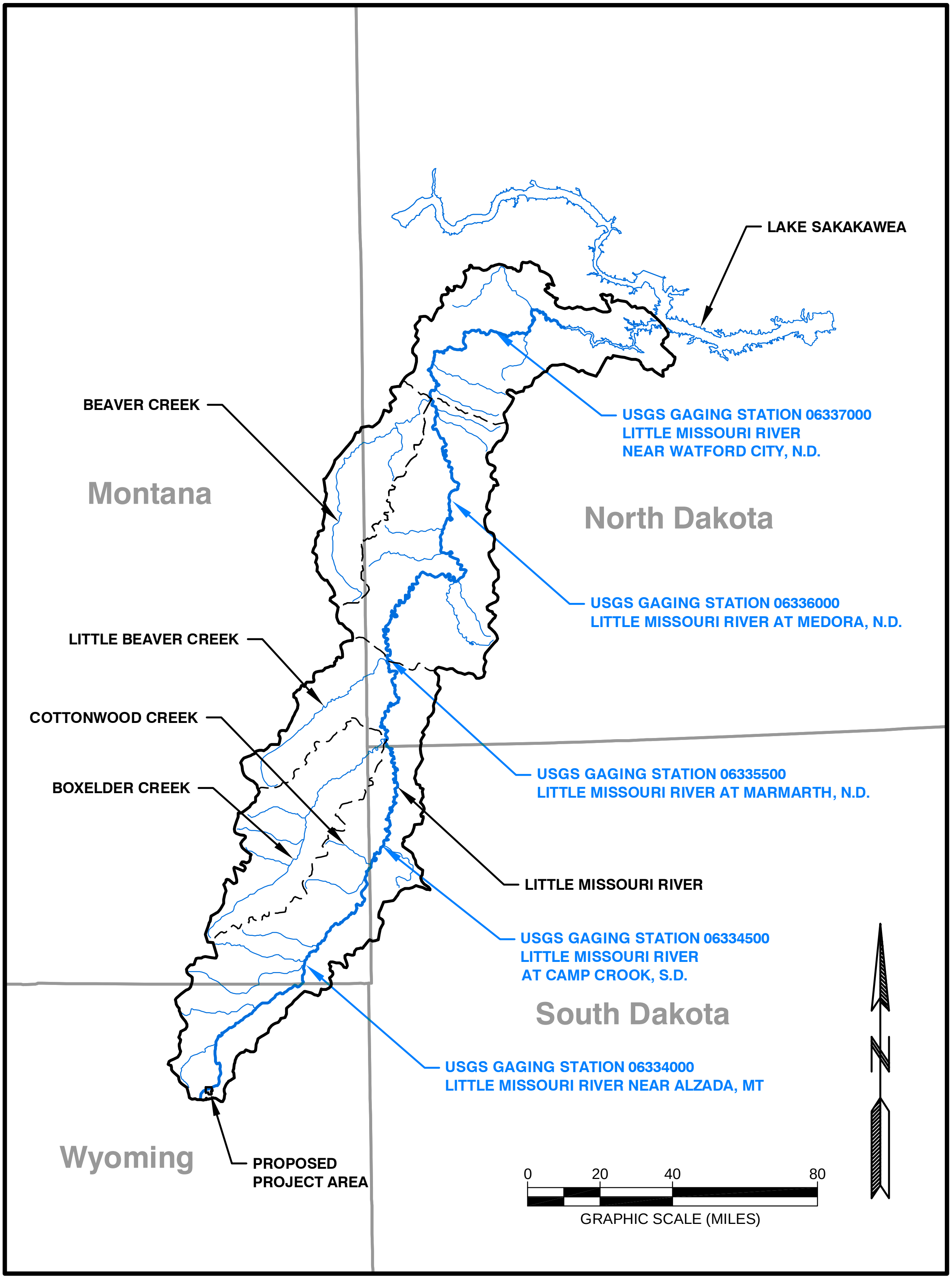
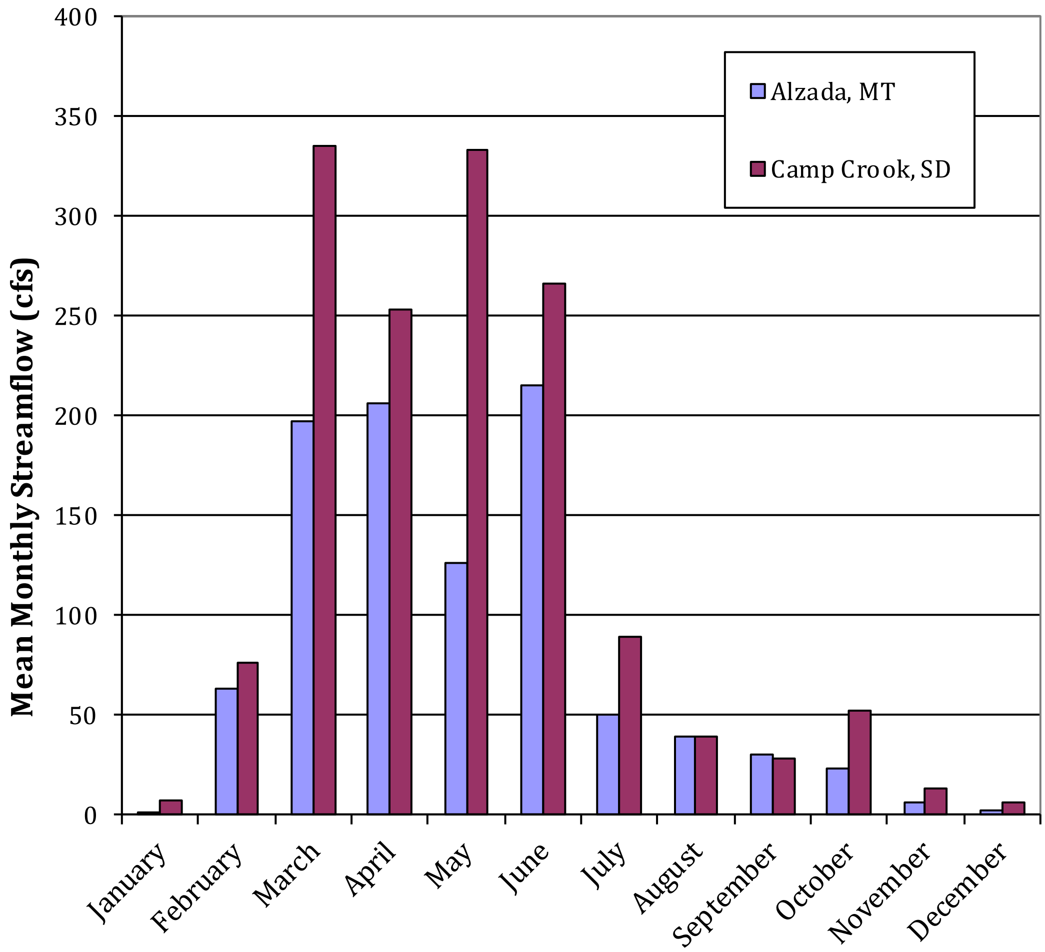
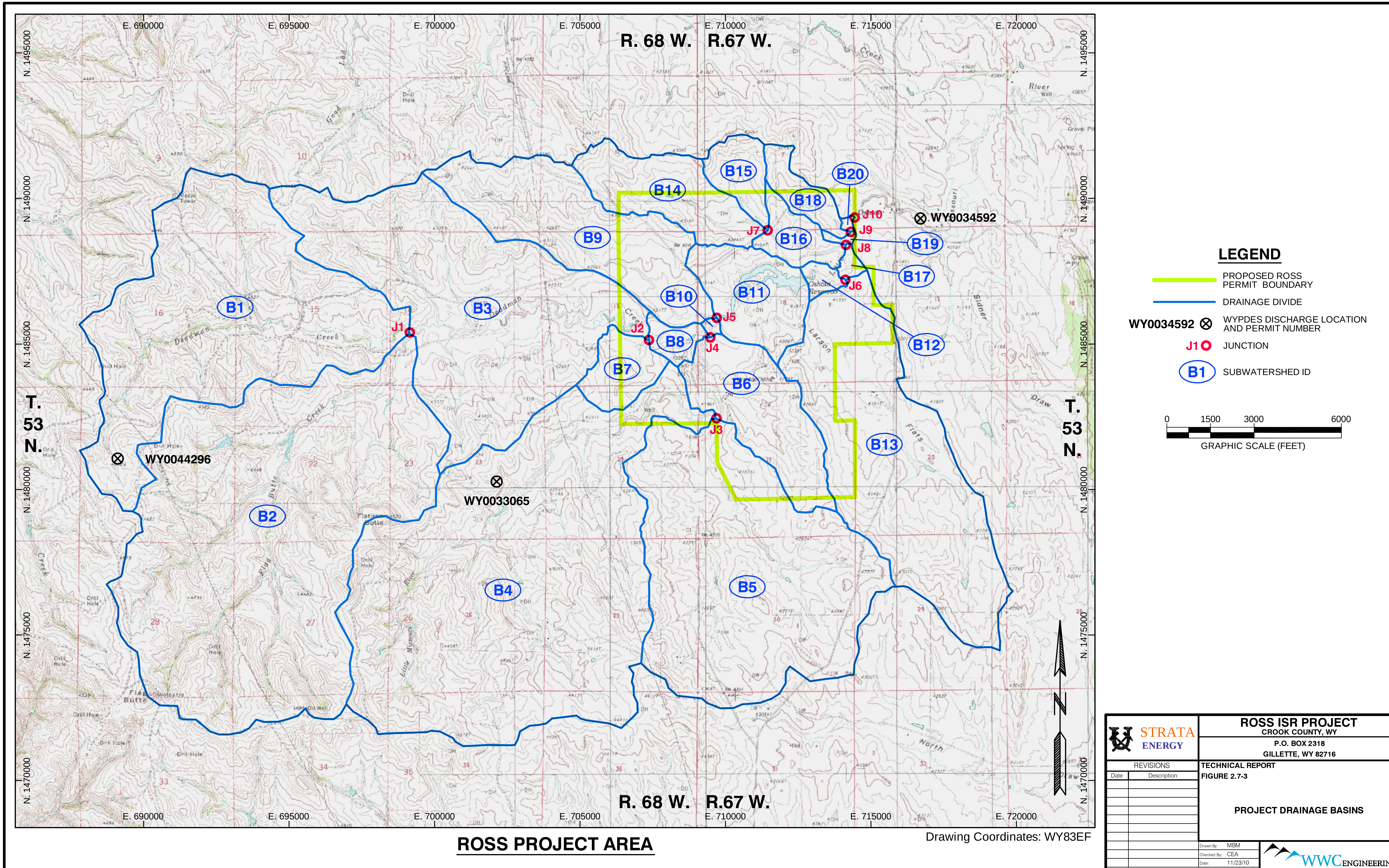


Figure 2.7-1. Little Missouri River Basin

Figure 2.7-2. Little Missouri River Mean Monthly Flow



Source: USGS 2010a



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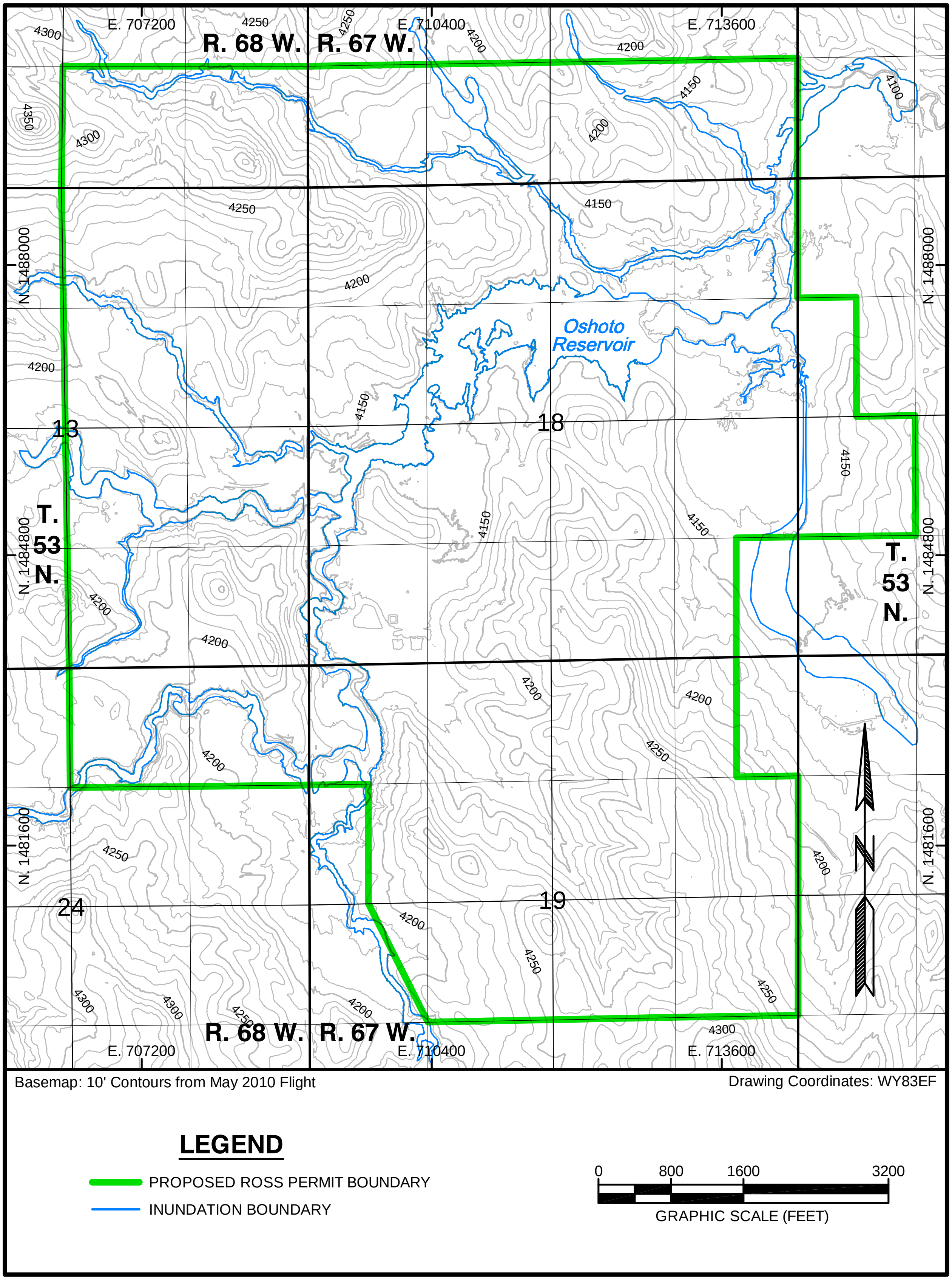

Figure 2.7-4. 100-year Flood Inundation Boundaries

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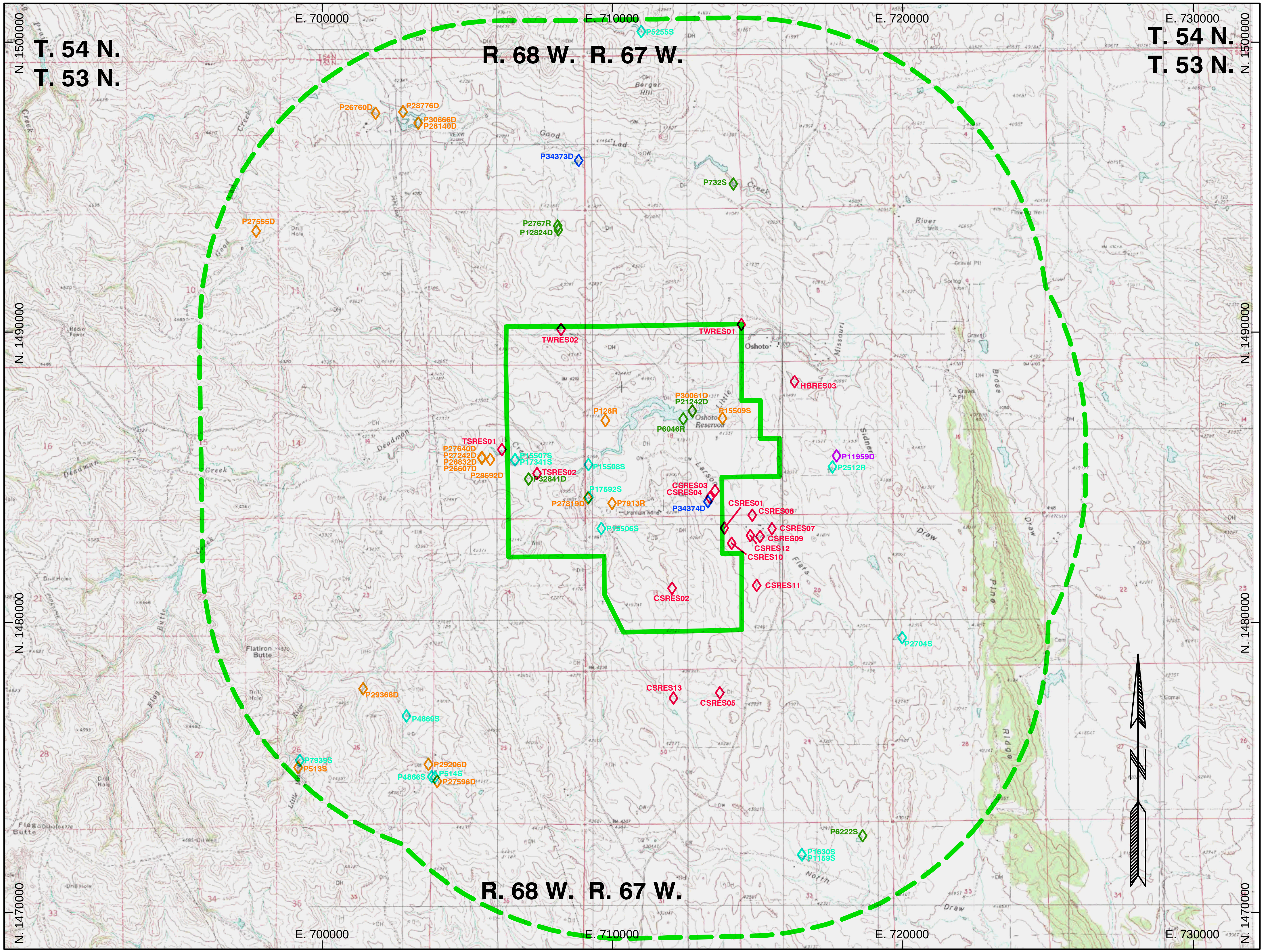

LEGEND

- PROPOSED ROSS PERMIT BOUNDARY
- 2 MILE BUFFER FROM PROPOSED PERMIT BOUNDARY
- WR NUMBER ◇ COMPLETE WATER RIGHT
- WR NUMBER ◇ UNADJUDICATED WATER RIGHT
- WR NUMBER ◇ CANCELLED WATER RIGHT
- WR NUMBER ◇ FULLY ADJUDICATED WATER RIGHT
- WR NUMBER ◇ NO STATUS LISTED IN WSEO DATABASE
- WR NUMBER ◇ NOT LISTED IN WSEO DATABASE

Source: WSEO 2010

0 1750 3500 7000
GRAPHIC SCALE (FEET)

ROSS PROJECT AREA

Drawing Coordinates: WY83EF

STRATA ENERGY

ROSS ISR PROJECT CROOK COUNTY, WY
P.O. BOX 2318 GILLETTE, WY 82716
TECHNICAL REPORT FIGURE 2.7-5
SURFACE WATER RIGHTS

REVISIONS

Date	Description

Drawn By: MBM
Checked By: JWF
Date: 12/6/10

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FILE: ROSS_ER_HYD_SW_SEO

K:\Peninsula_Minerals\09142\DWGS_WY83E\ROSS_ER_HYD_SW_SEO.dwg, TR_FIGURE_2.7-5, 12/18/2010 2:23:53 PM

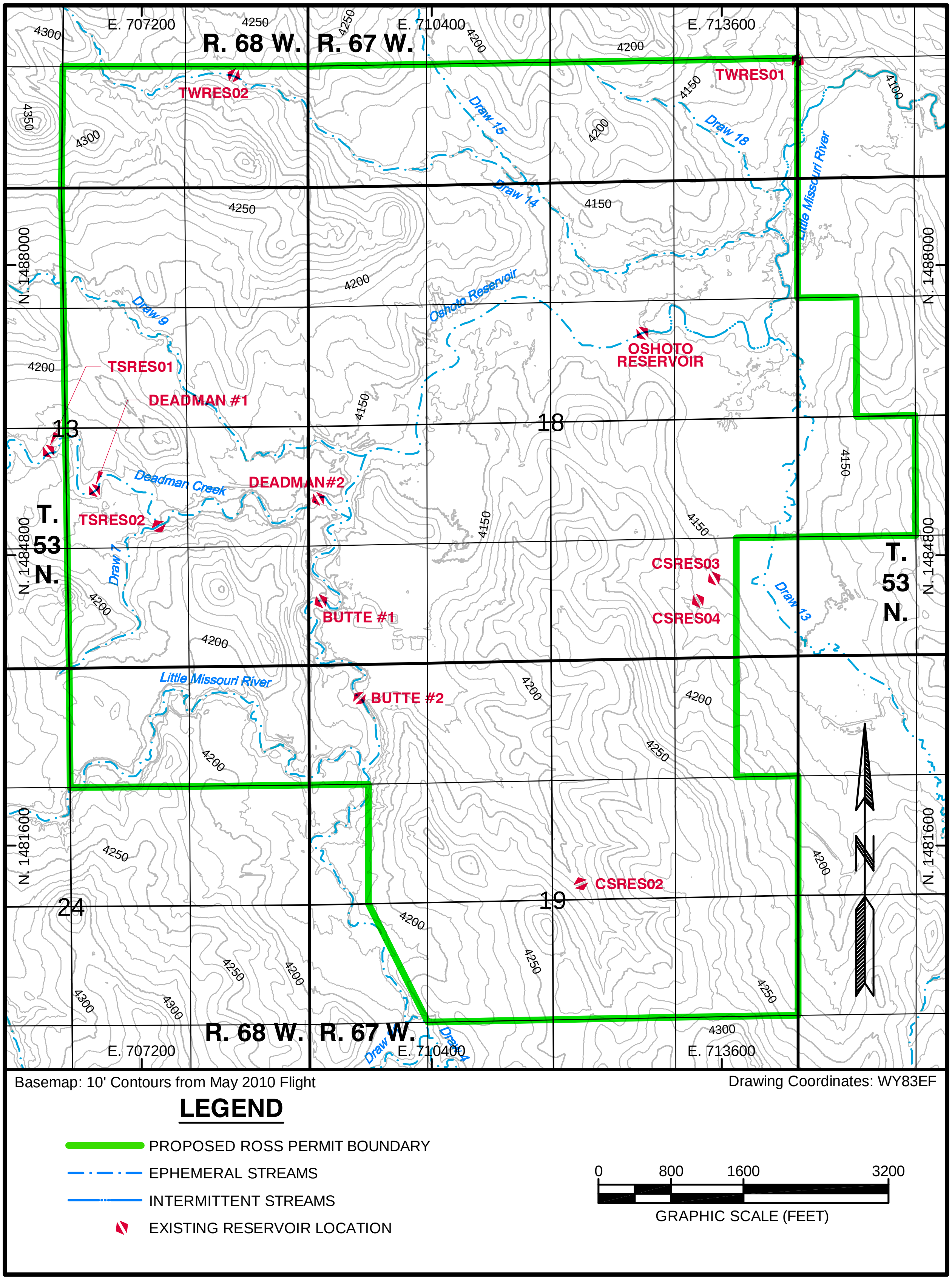


Figure 2.7-6. Surface Water Features

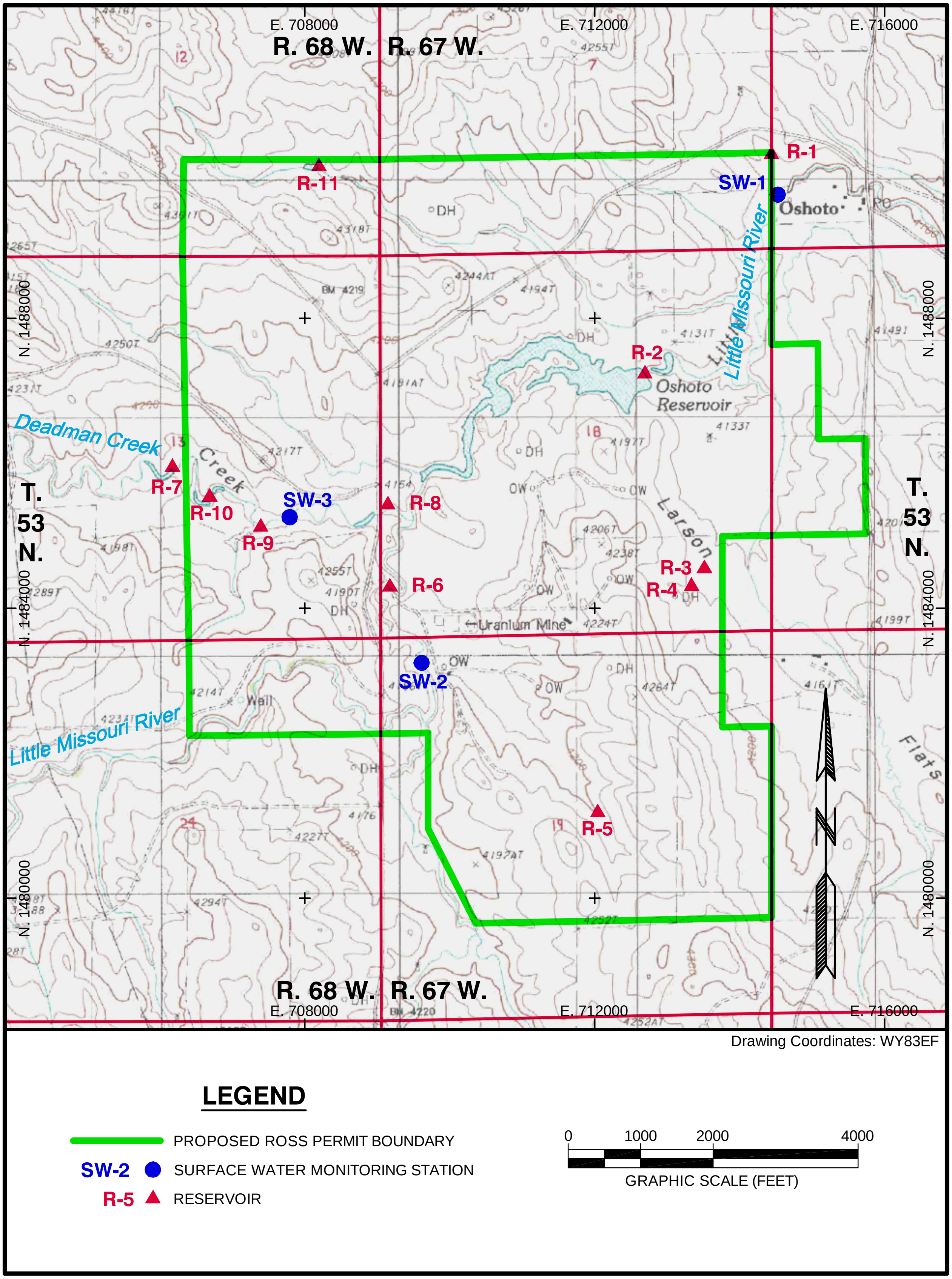
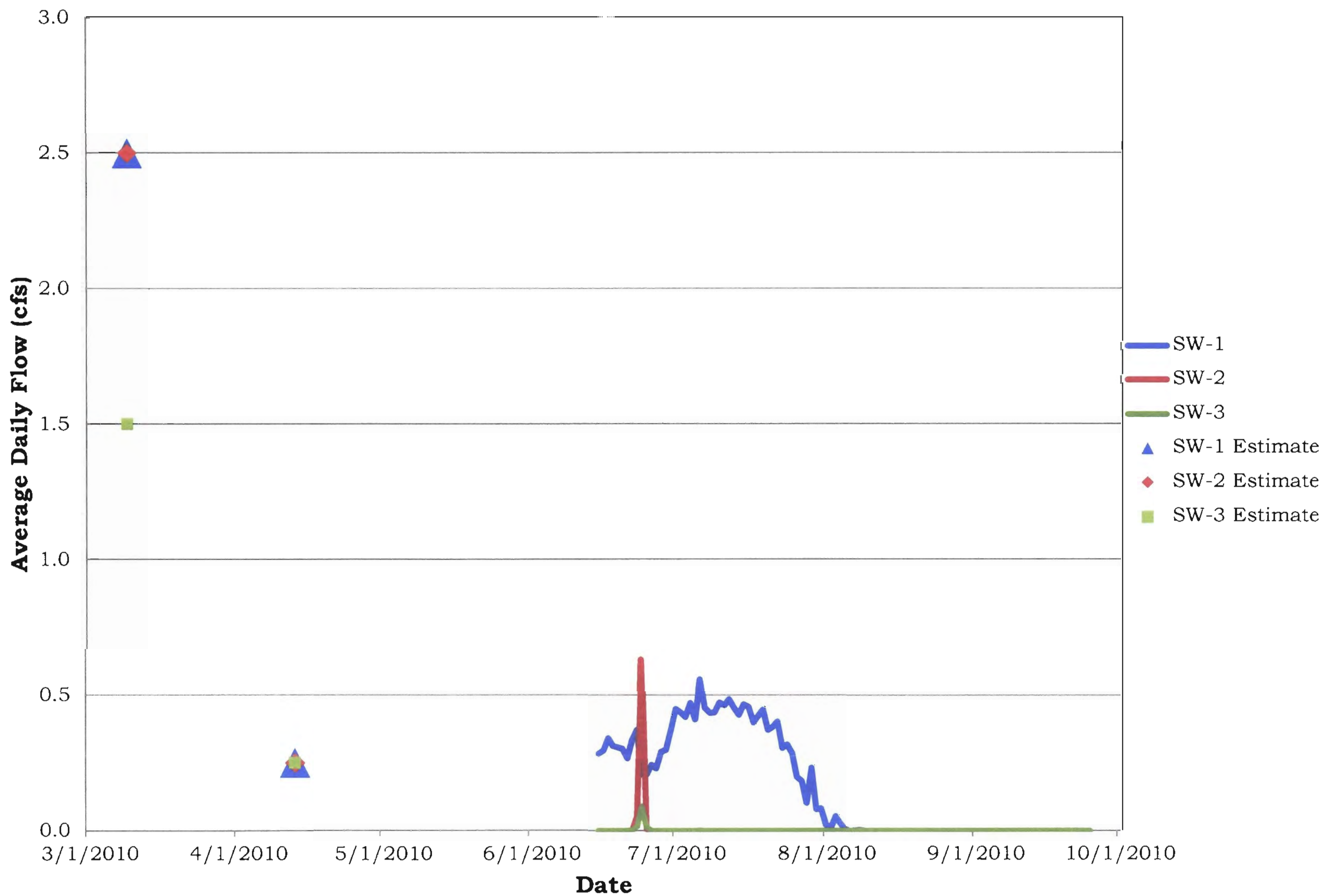


Figure 2.7-7. Surface Water Monitoring Network

Figure 2.7-8. Surface Water Monitoring Station Average Daily Flow

Note: No flow was recorded at the three sites after August 9, 2010 and no data recorded from September 25 to November 2, 2010.



Note: No flow was recorded at the three sites after August 9, 2010 and no data recorded from September 25 to November 2, 2010.

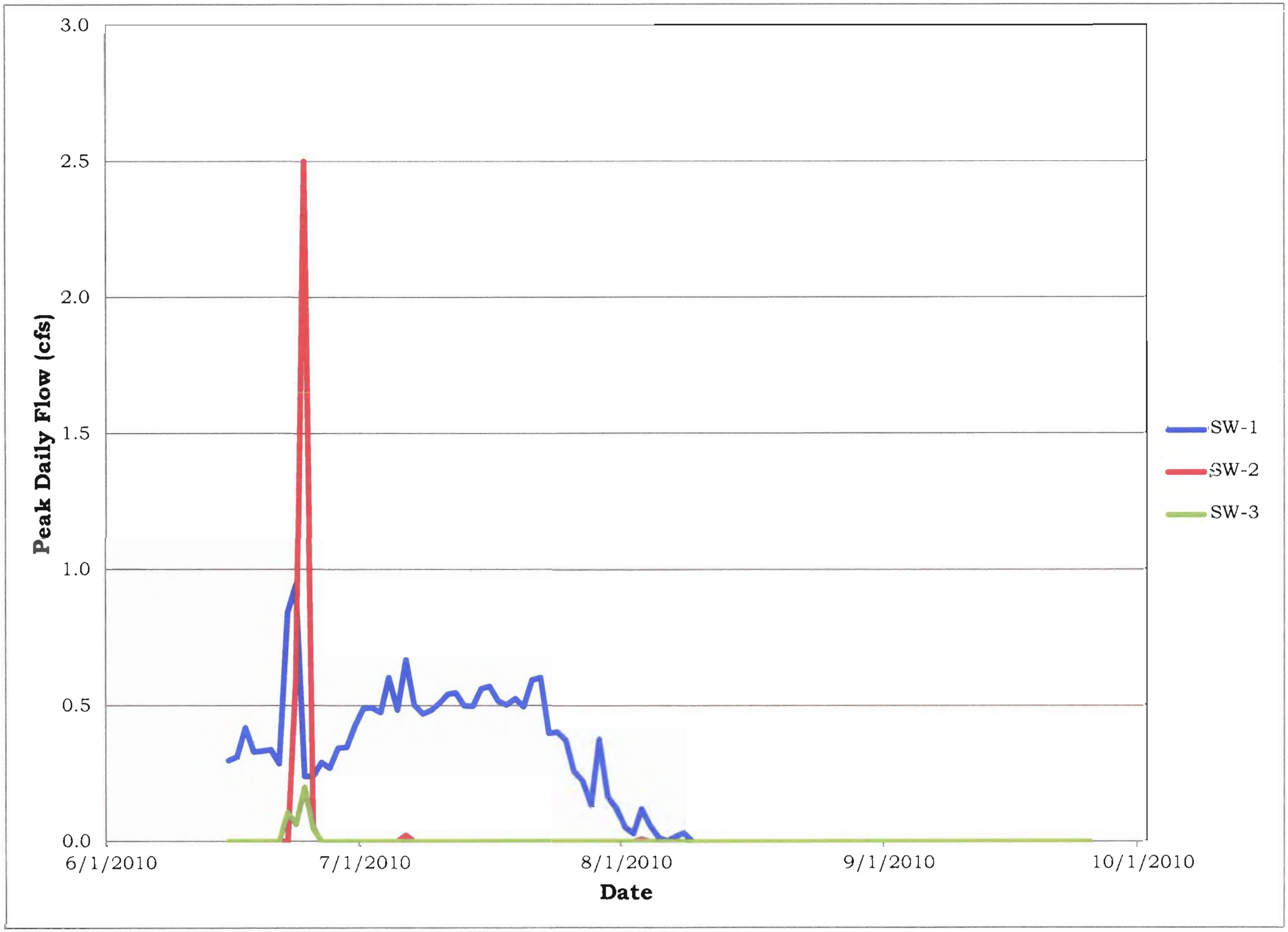
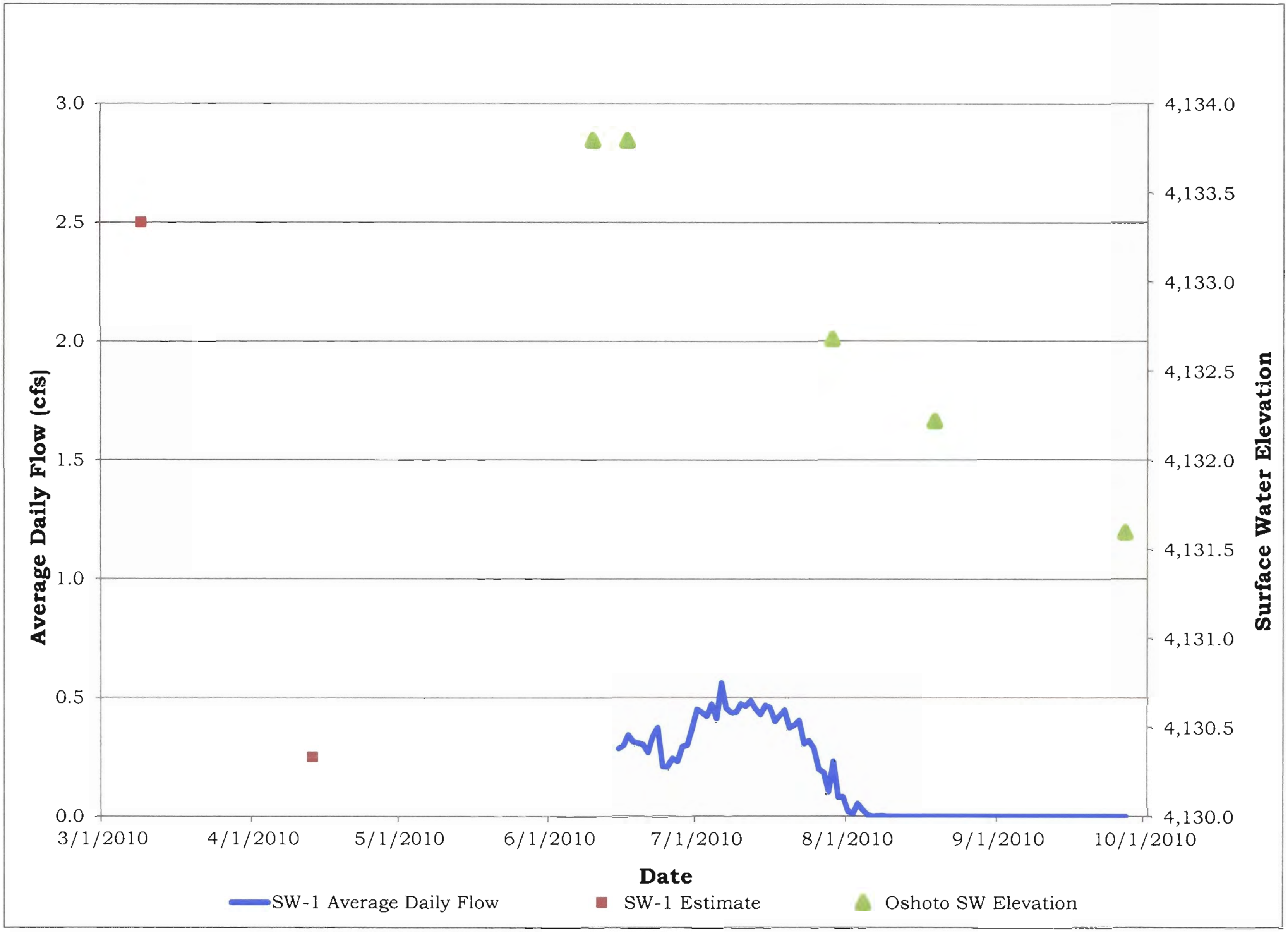


Figure 2.7-9. Surface Water Monitoring Station Peak Daily Flow



Note: No flow was recorded at the three sites after August 9, 2010 and no data recorded from September 25 to November 2, 2010.

Figure 2.7-10. Little Missouri River Flow Downstream of Oshoto Reservoir and Oshoto Reservoir Stage Elevation

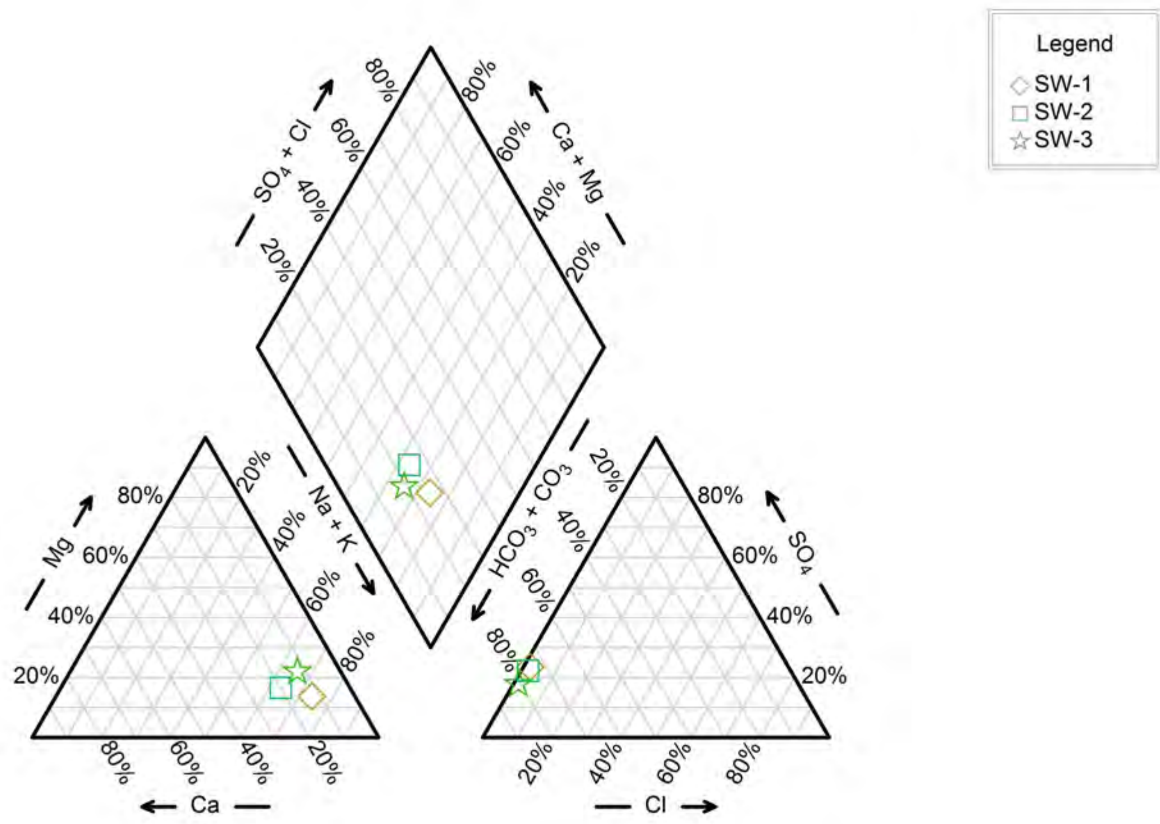


Figure 2.7-11. Surface Water Monitoring Station Piper Diagram
Note: data points represent average concentrations for each monitoring station.

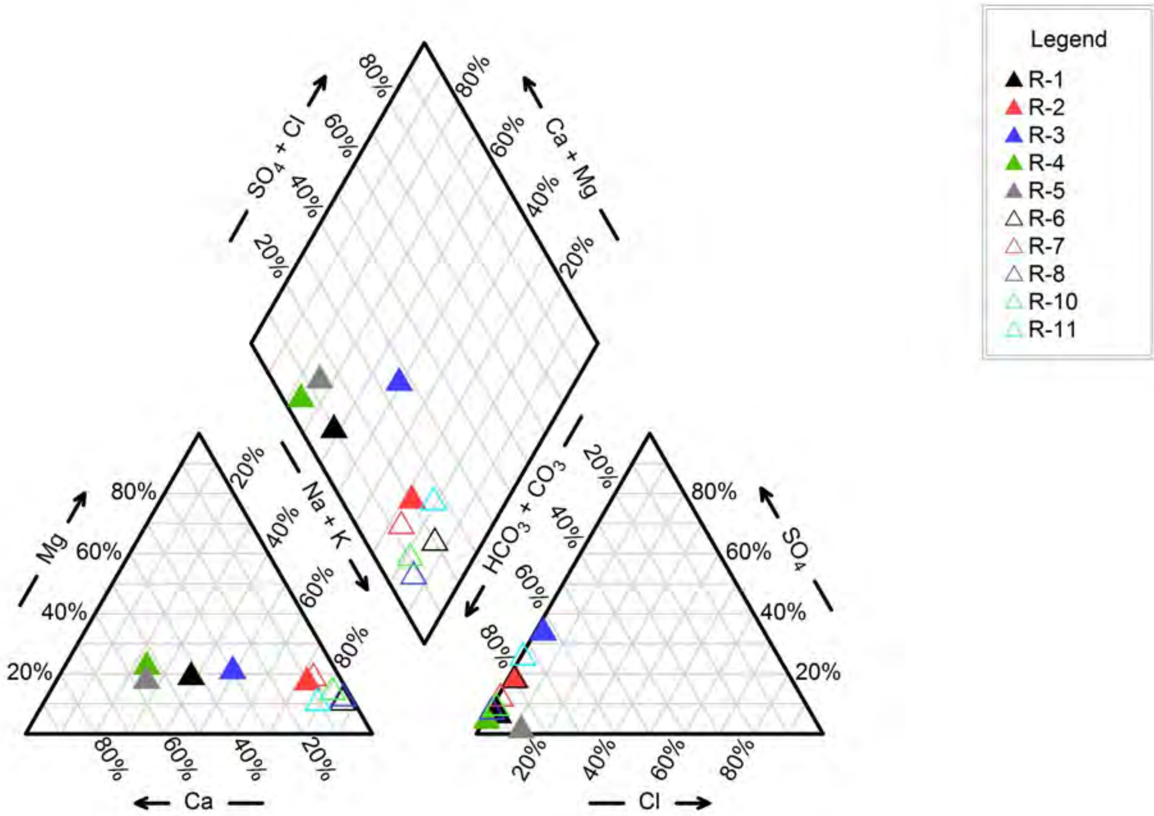
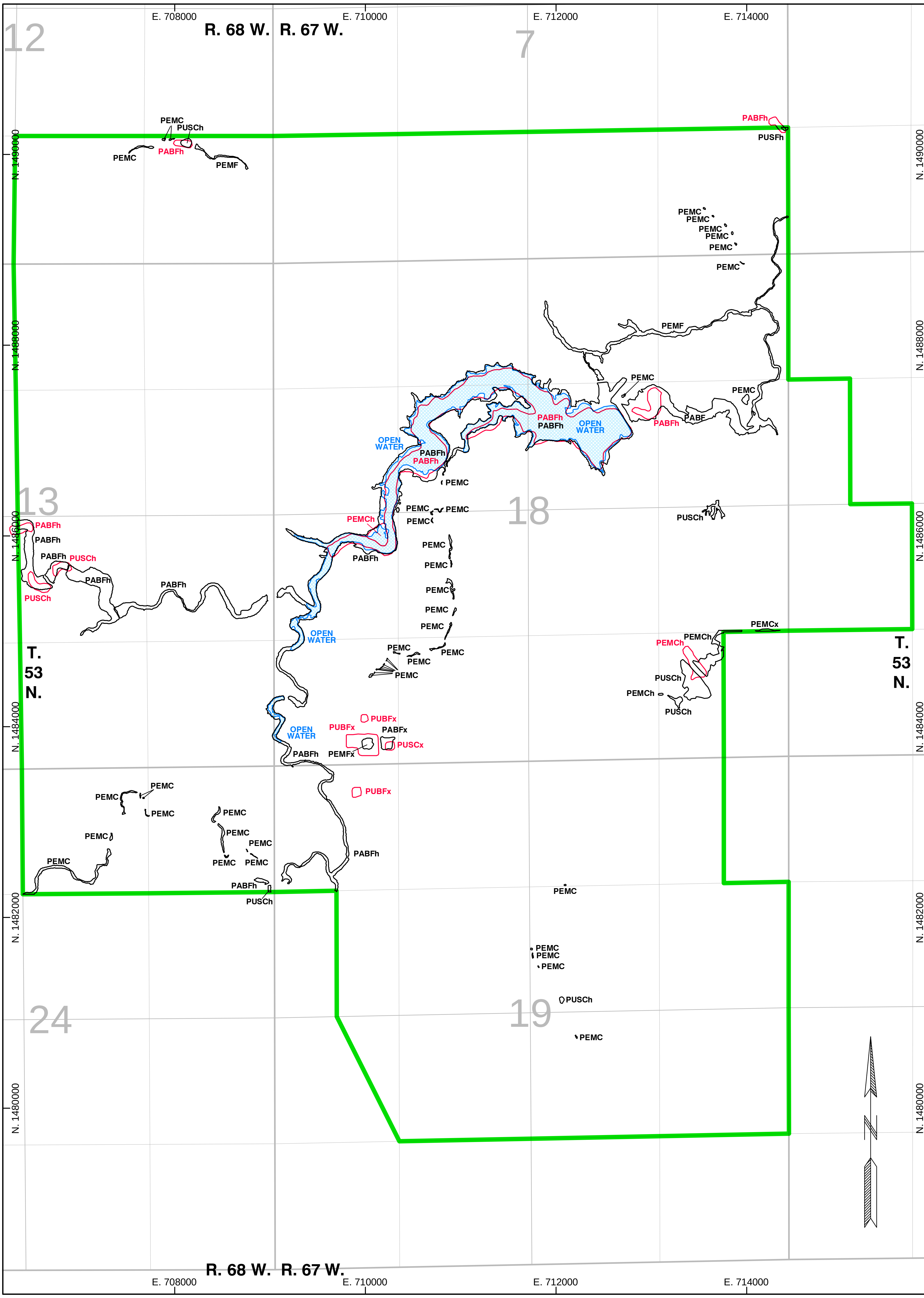


Figure 2.7-12. Reservoir Piper Diagram
Note: data points represent average concentrations for each reservoir.



Drawing Coordinates: WY83EF

WETLANDS MAP

NWI CLASSIFICATIONS (Cowardin et al. 1979)

PABFh Palustrine, Aquatic Bed, Semipermanently Flooded, Diked
PABFx Palustrine, Aquatic Bed, Semipermanently Flooded, Excavated
PEMC Palustrine, Emergent, Seasonally Flooded
PEMCh Palustrine, Emergent, Seasonally Flooded, Diked
PEMCx Palustrine, Emergent, Seasonally Flooded, Excavated
PEMF Palustrine, Emergent, Semipermanently Flooded
PEMFx Palustrine, Emergent, Semipermanently Flooded, Diked
PUBFx Palustrine, Unconsolidated Bottom, Semipermanently Flooded, Excavated
PUSCh Palustrine, Unconsolidated Shore, Seasonally Flooded, Diked
PUSCx Palustrine, Unconsolidated Shore, Seasonally Flooded, Excavated
PUSFh Palustrine, Unconsolidated Shore, Semipermanently Flooded, Diked

LEGEND

PROPOSED ROSS PERMIT BOUNDARY
PUSCx CLASSIFIED BY USFWS (NWI MAPPING)
PEMFx CLASSIFIED BY WWC
OPEN WATER

Source: NWI Mapping (USFWS 2010)
WWC Field Survey - 2010

0 500 1000 2000
GRAPHIC SCALE (FEET)

STRATA ENERGY

ROSS ISR PROJECT
CROOK COUNTY, WY
P.O. BOX 2318
GILLETTE, WY 82716

REVISIONS

Date	Description

TECHNICAL REPORT
FIGURE 2.7-13

WETLANDS AND WATERS OF THE U.S.

Drawn By: MBM
Checked By: JDB
Date: 11/6/10

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FILE: ROSS_ER_HYD_WETLANDS

K:\Peninsula_Minerals\09142\DWGS_WY83E\ROSS_ER_HYD_WETLANDS.dwg, TR_FIGURE_2.7-13, 12/18/2010 2:29:40 PM

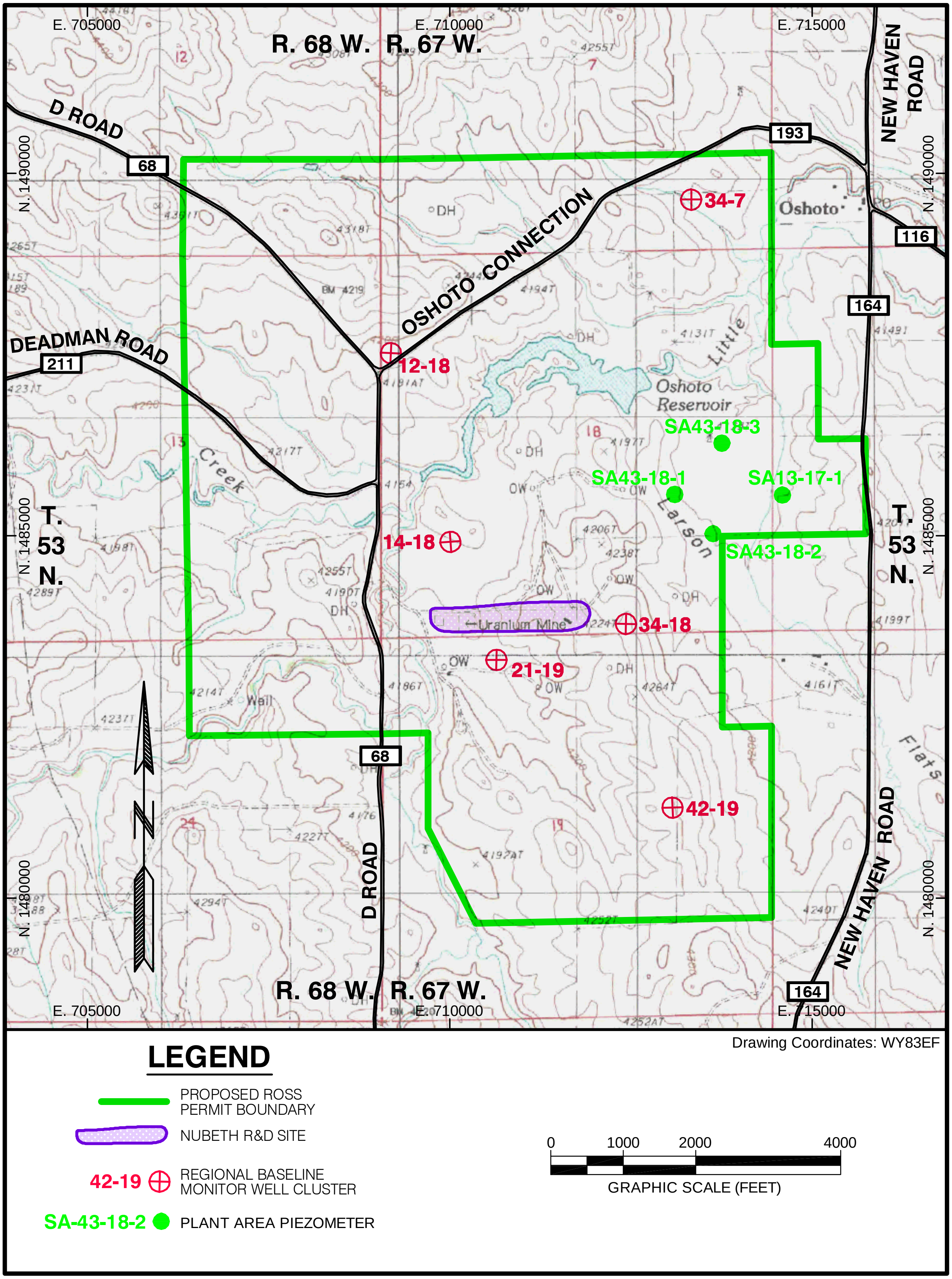
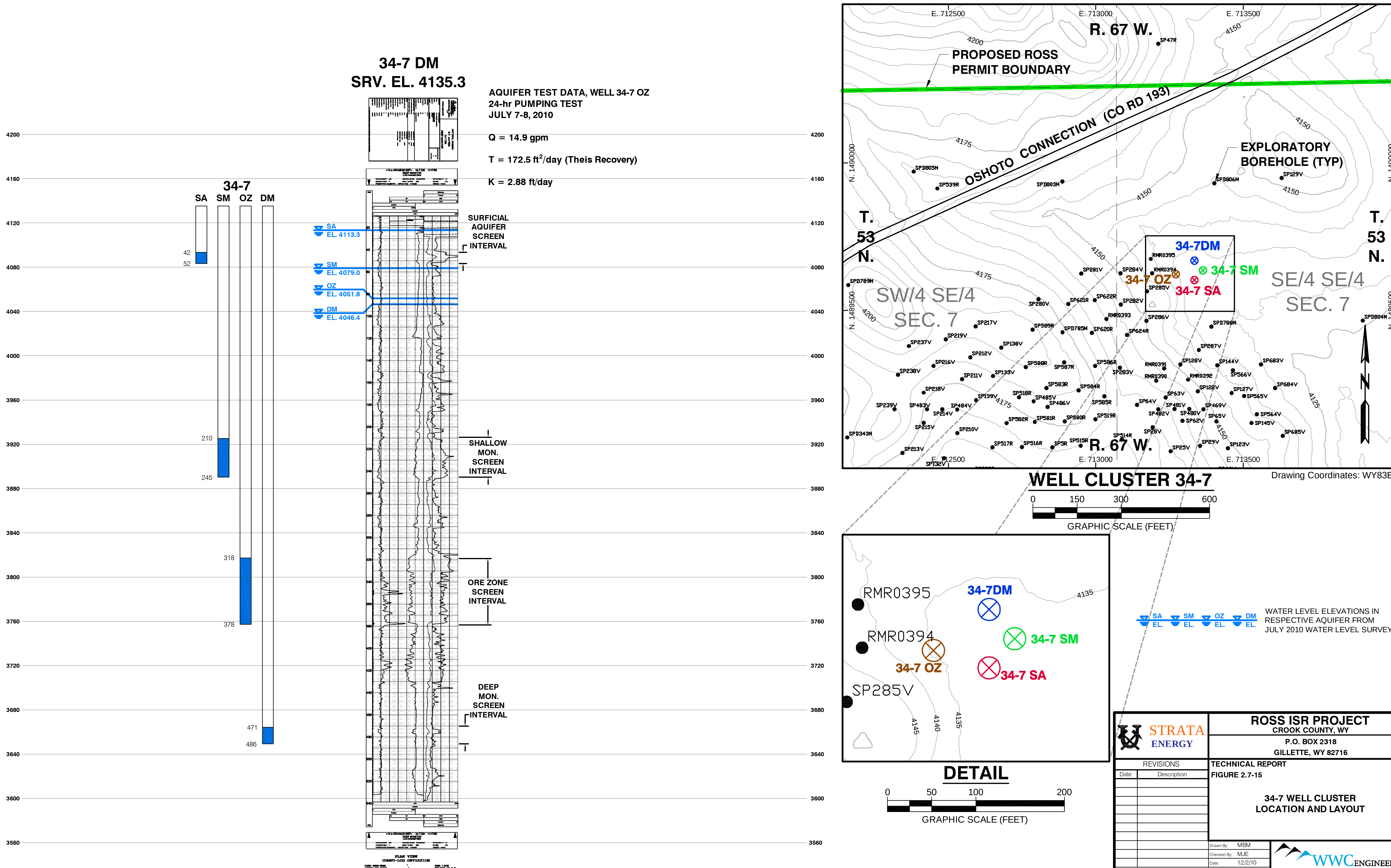


Figure 2.7-14. Regional Baseline Groundwater Monitoring Network



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Date	Description

TECHNICAL REPORT
FIGURE 2.7-15

34-7 WELL CLUSTER LOCATION AND LAYOUT

Drawn By: MBM
Checked By: MJE
Date: 12/2/10

FILE: ROSS_ATR_OW_CL_34-7

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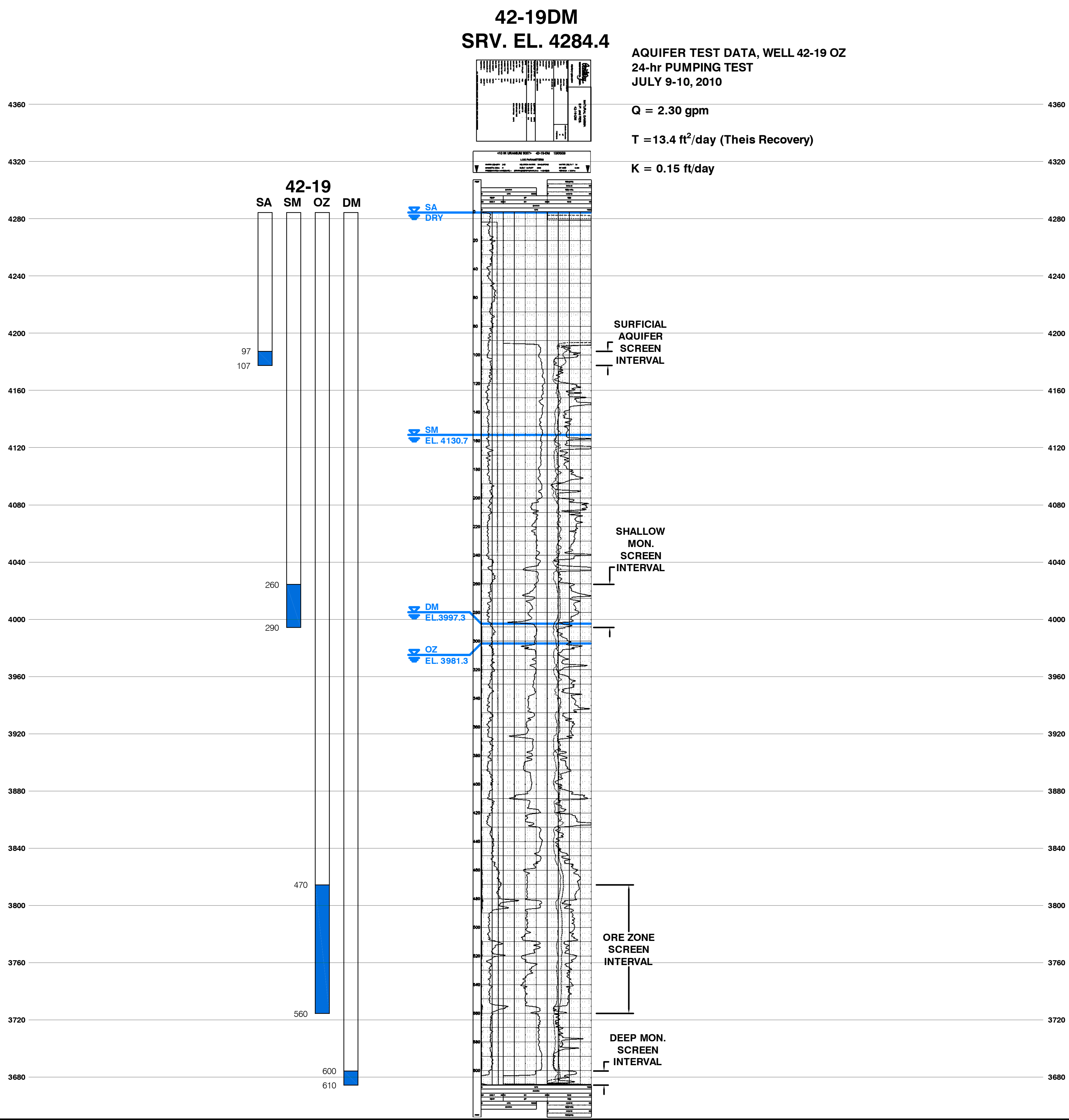
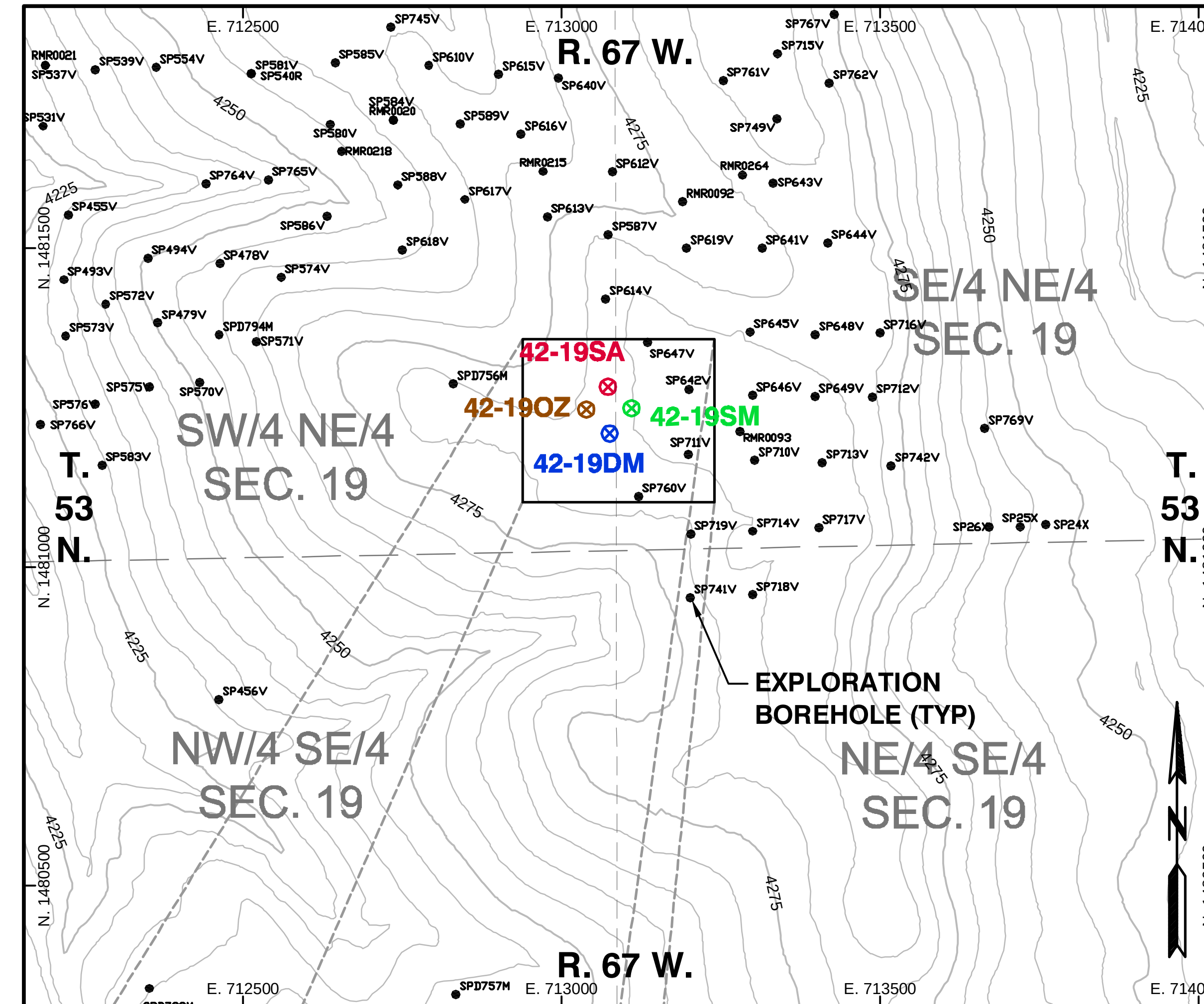
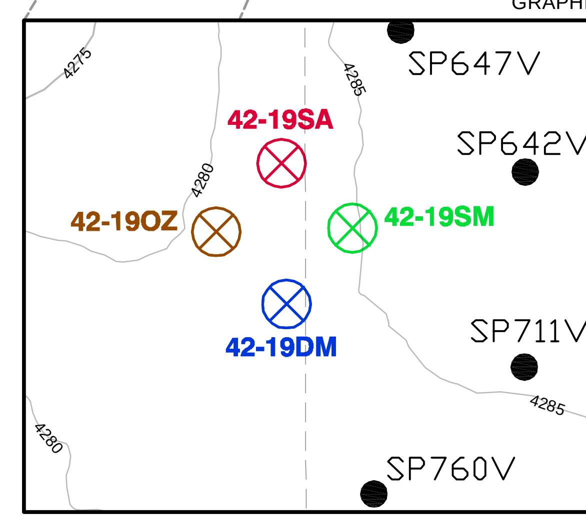




WELL CLUSTER 42-19

Drawing Coordinates: WY83EF

0 150 300 600
GRAPHIC SCALE (FEET)



DETAIL

0 50 100 200
GRAPHIC SCALE (FEET)

SA EL. SM EL. OZ EL. DM EL. WATER LEVEL ELEVATIONS IN RESPECTIVE AQUIFER FROM JULY 2010 WATER LEVEL SURVEY

STRATA ENERGY

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P.O. BOX 2318
GILLETTE, WY 82716

REVISIONS

Date	Description

TECHNICAL REPORT
FIGURE 2.7-16

42-19 WELL CLUSTER
LOCATION AND LAYOUT

Drawn By: RAM
Checked By: MJE
Date: 12/2/10

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FILE: ROSS_ATR_OW_CL_42-19

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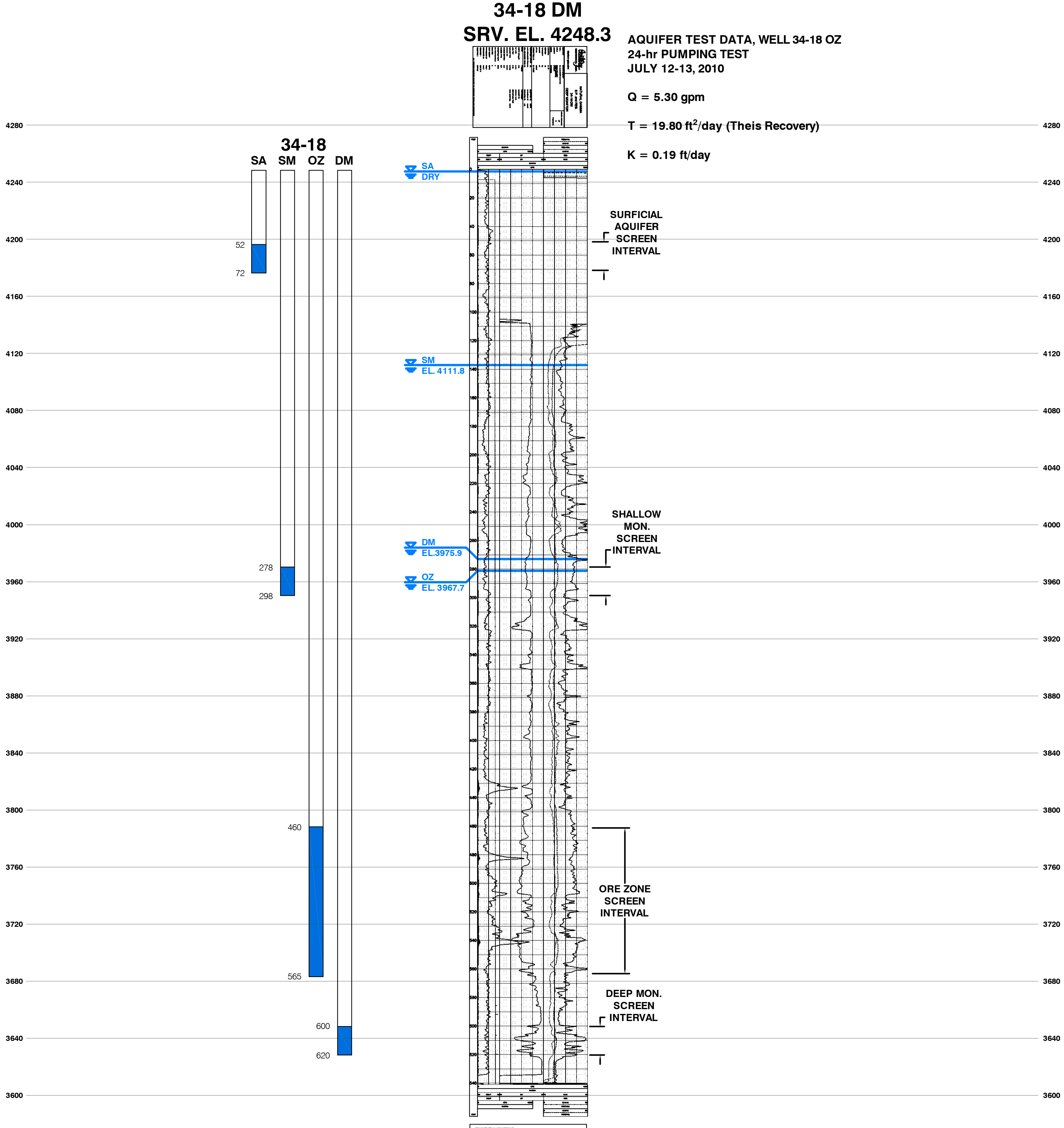

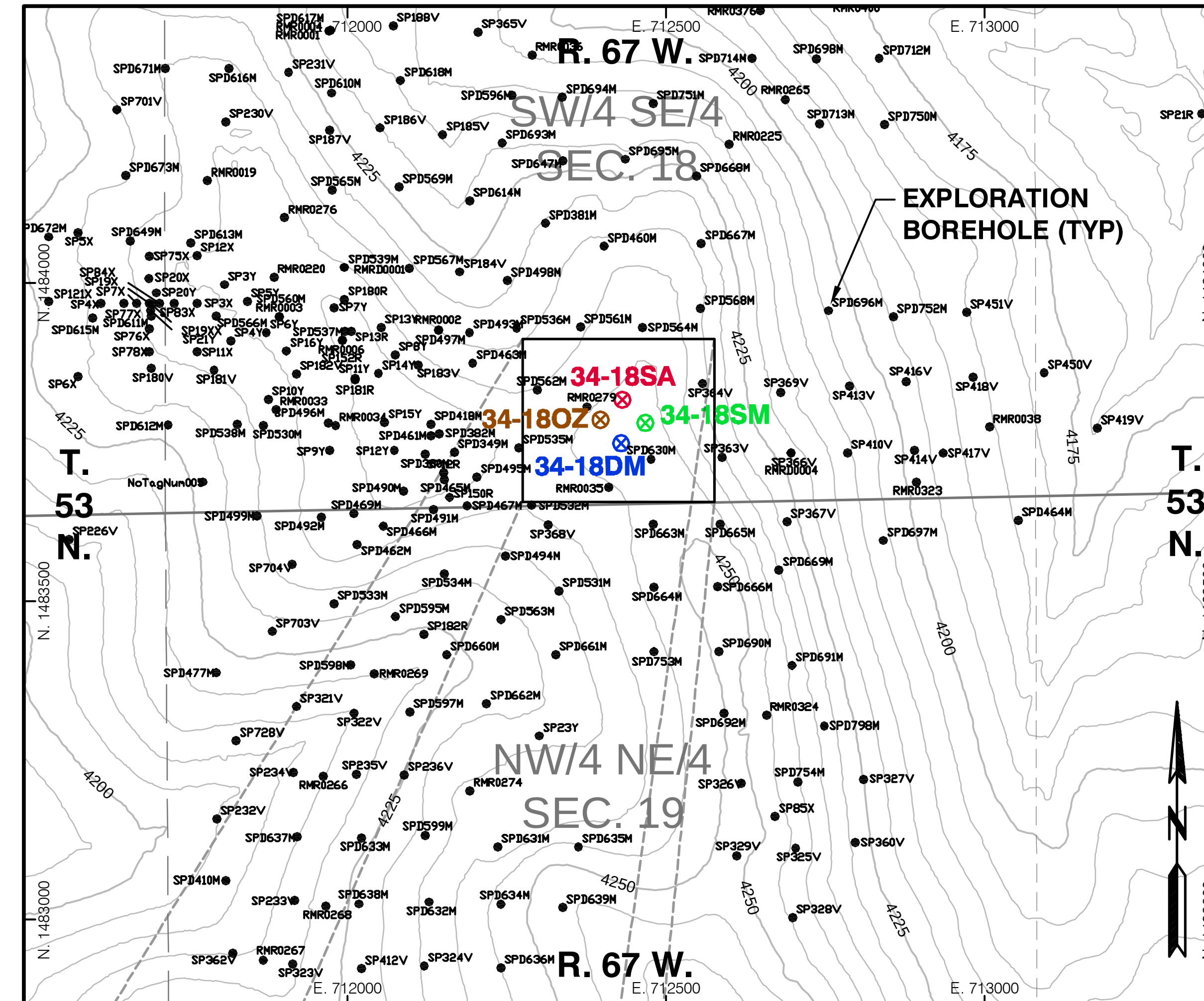

WELL CLUSTER 34-18

Drawing Coordinates: WY83EF

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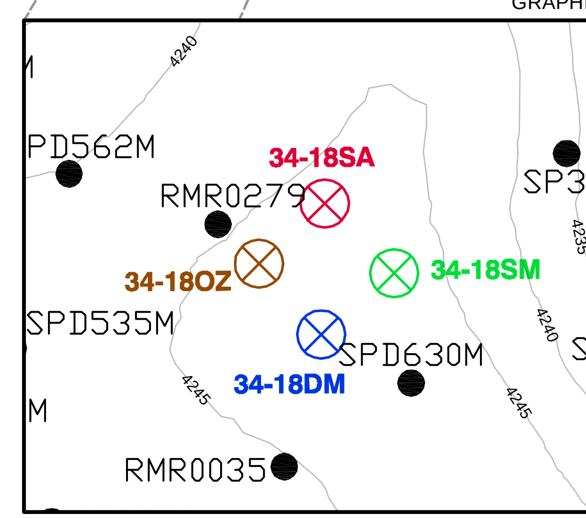
GRAPHIC SCALE (FEET)



DETAIL

0 50 100 200

GRAPHIC SCALE (FEET)

SA EL. SM EL. OZ EL. DM EL. — WATER LEVEL ELEVATIONS IN RESPECTIVE AQUIFER FROM JULY 2010 WATER LEVEL SURVEY

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REVISIONS

Date	Description

TECHNICAL REPORT
FIGURE 2.7-17

34-18 WELL CLUSTER LOCATION AND LAYOUT

Drawn By: RAM
Checked By: MJE
Date: 12/2/10

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FILE: ROSS_ATR_OW_CL_34-18

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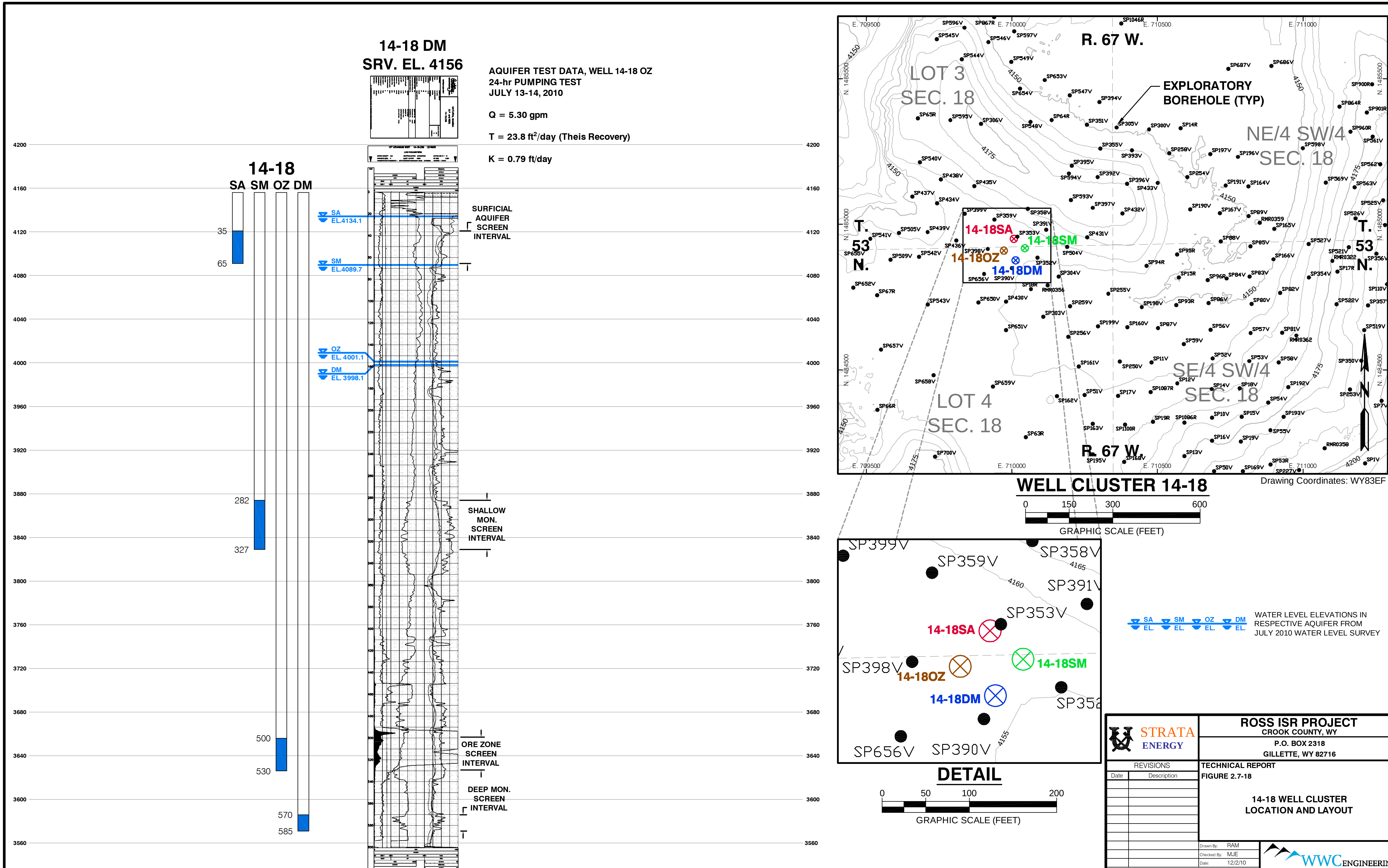

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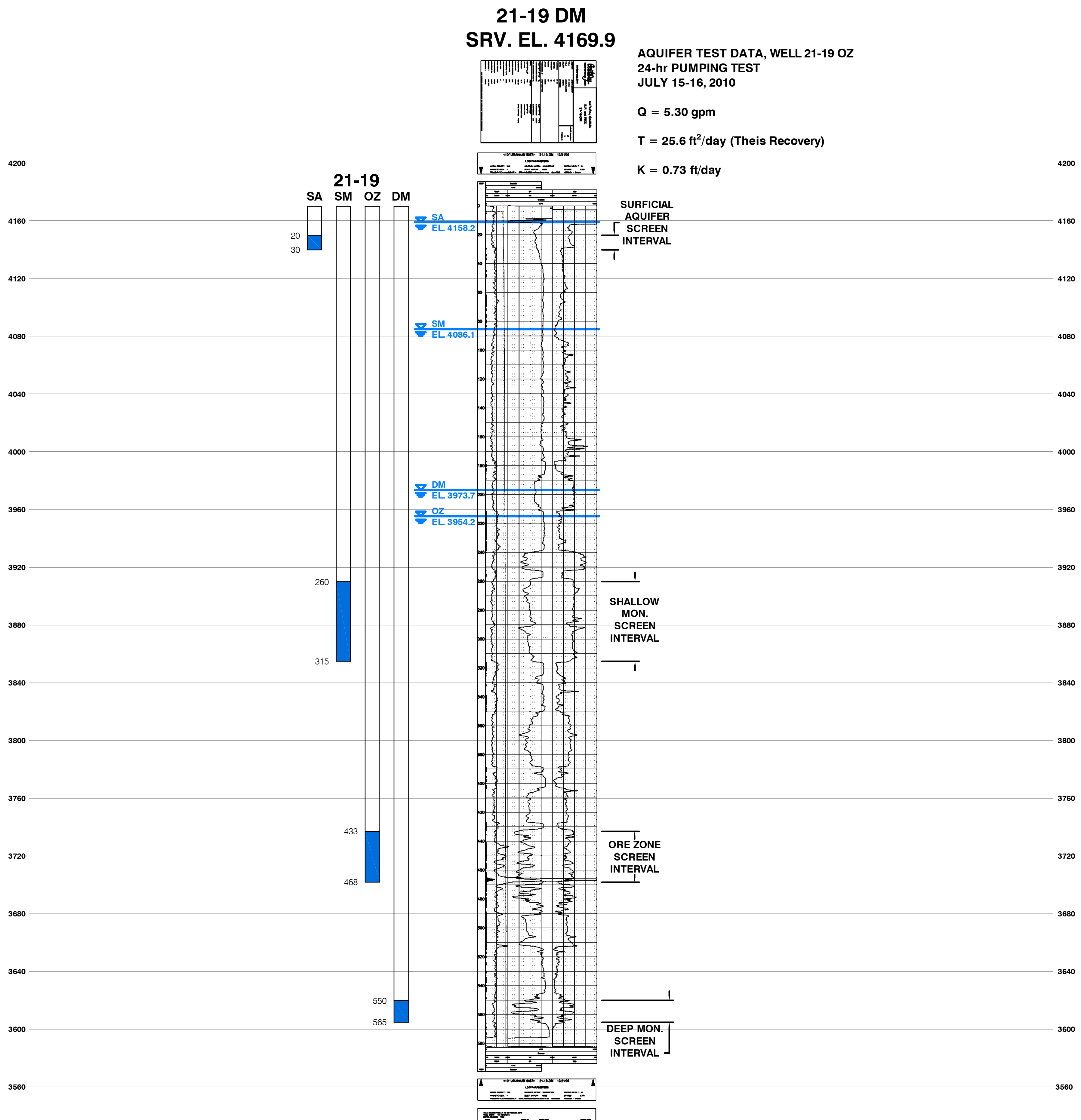

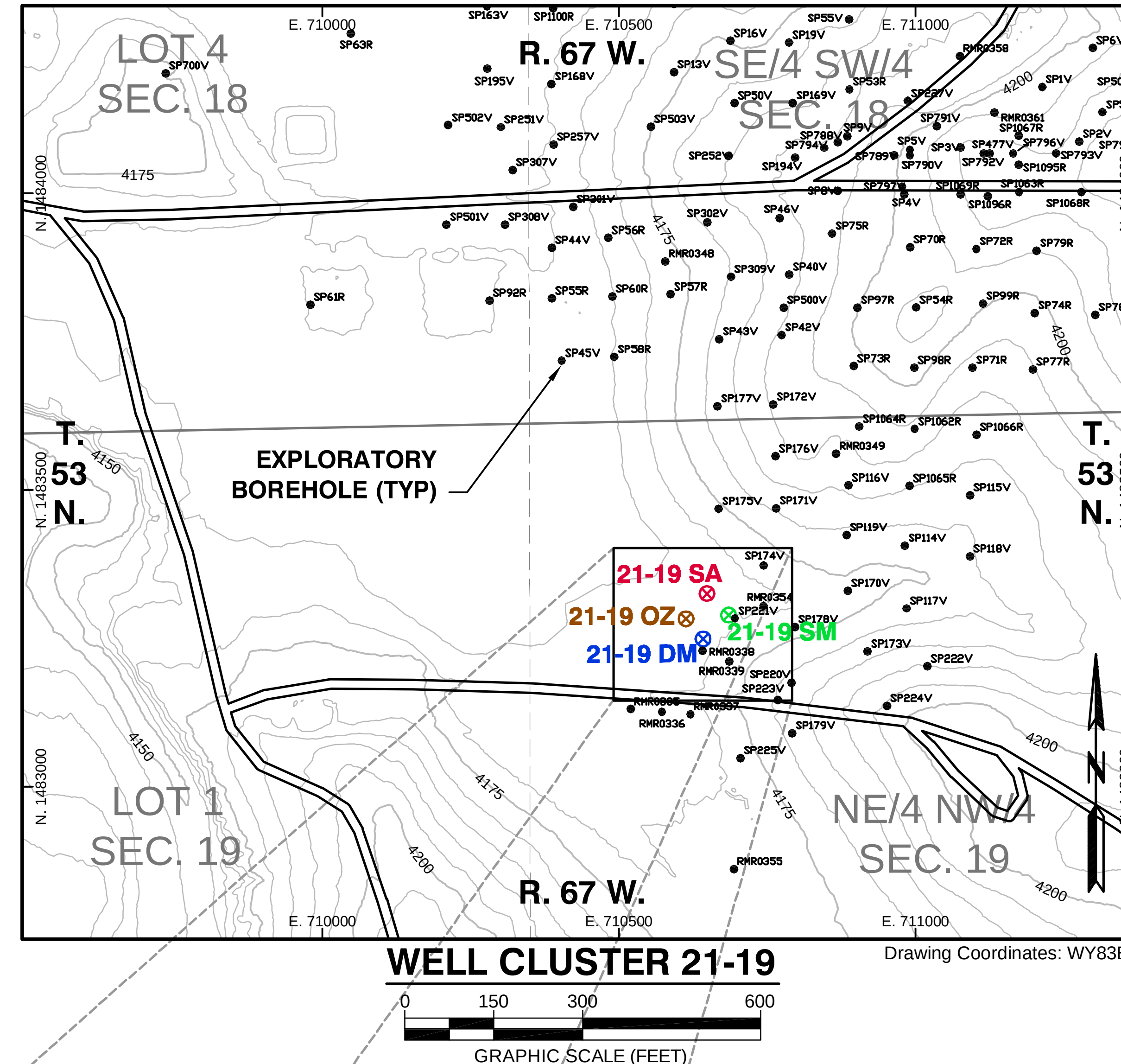

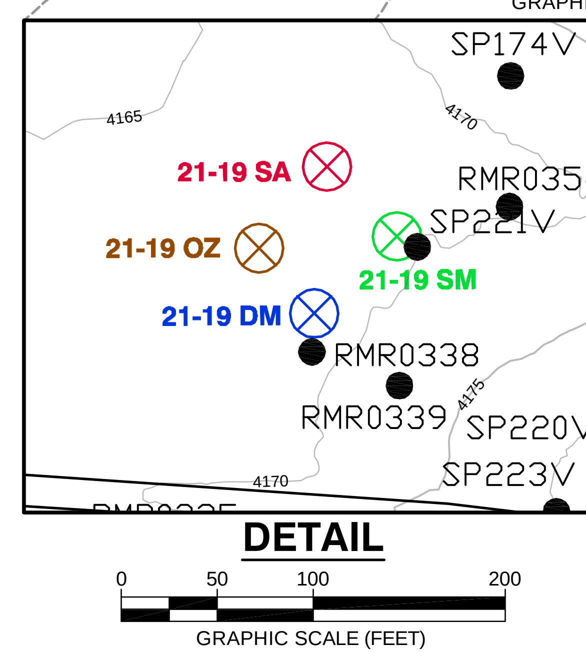

SA EL. SM EL. OZ EL. DM EL. WATER LEVEL ELEVATIONS IN RESPECTIVE AQUIFER FROM JULY 2010 WATER LEVEL SURVEY

STRATA ENERGY

ROSS ISR PROJECT
CROOK COUNTY, WY
P.O. BOX 2318
GILLETTE, WY 82716

REVISIONS	
Date	Description

TECHNICAL REPORT
FIGURE 2.7-19

21-19 WELL CLUSTER LOCATION AND LAYOUT

Drawn By: RAM
Checked By: MJE
Date: 12/2/10

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FILE: ROSS_ATR_OW_CL_21-19

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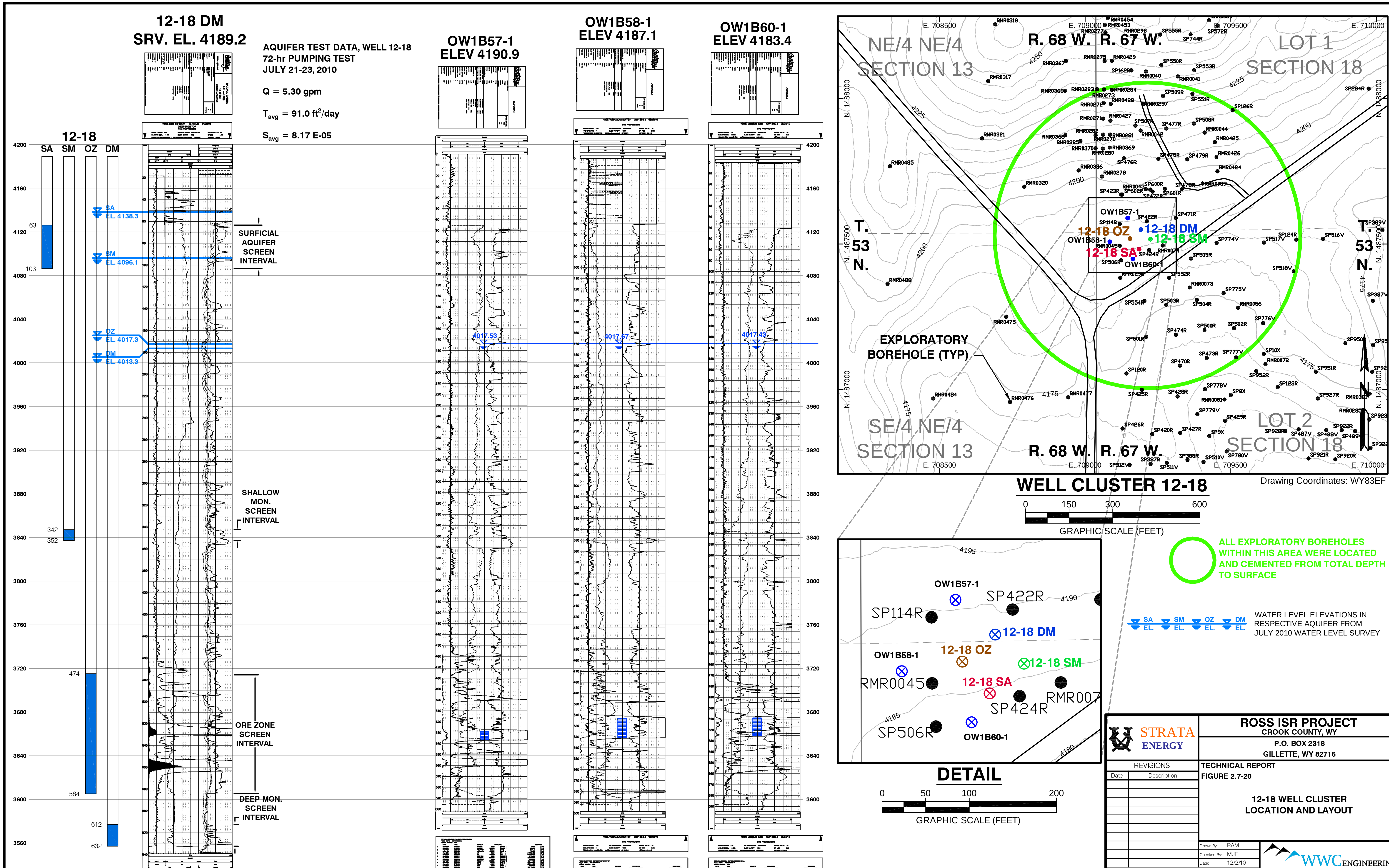
12-18 DM
SRV. EL. 4189.2
AQUIFER TEST DATA, WELL 12-18
72-hr PUMPING TEST
JULY 21-23, 2010
Q = 5.30 gpm
T avg = 91.0 ft2/day
S avg = 8.17 E-05
OW1B57-1
ELEV 4190.9
OW1B58-1
ELEV 4187.1
OW1B60-1
ELEV 4183.4
12-18
SA SM OZ DM
SA EL. 4138.3
SM EL. 4096.1
OZ EL. 4017.3
DM EL. 4013.3
4017.53
4017.67
4017.43
SURFICIAL AQUIFER SCREEN INTERVAL
SHALLOW MON. SCREEN INTERVAL
ORE ZONE SCREEN INTERVAL
DEEP MON. SCREEN INTERVAL
NE/4 NE/4 SECTION 13
LOT 1 SECTION 18
SE/4 NE/4 SECTION 13
LOT 2 SECTION 18
R. 68 W. R. 67 W.
T. 53 N.
EXPLORATORY BOREHOLE (TYP)
WELL CLUSTER 12-18
Drawing Coordinates: WY83EF
GRAPHIC SCALE (FEET)
ALL EXPLORATORY BOREHOLES WITHIN THIS AREA WERE LOCATED AND CEMENTED FROM TOTAL DEPTH TO SURFACE
WATER LEVEL ELEVATIONS IN RESPECTIVE AQUIFER FROM JULY 2010 WATER LEVEL SURVEY
DETAIL
OW1B57-1
SP422R
SP114R
12-18 DM
12-18 OZ
12-18 SM
OW1B58-1
12-18 SA
RMR0045
RMR007
SP424R
SP506R
OW1B60-1
STRATA ENERGY
ROSS ISR PROJECT
CROOK COUNTY, WY
P.O. BOX 2318
GILLETTE, WY 82716
TECHNICAL REPORT
FIGURE 2.7-20
12-18 WELL CLUSTER LOCATION AND LAYOUT
REVISIONS
Date Description
Drawn By: RAM
Checked By: MJE
Date: 12/2/10
FILE: ROSS_ATR_OW_CL_12-18
WWC ENGINEERING
www.wwcengineering.com

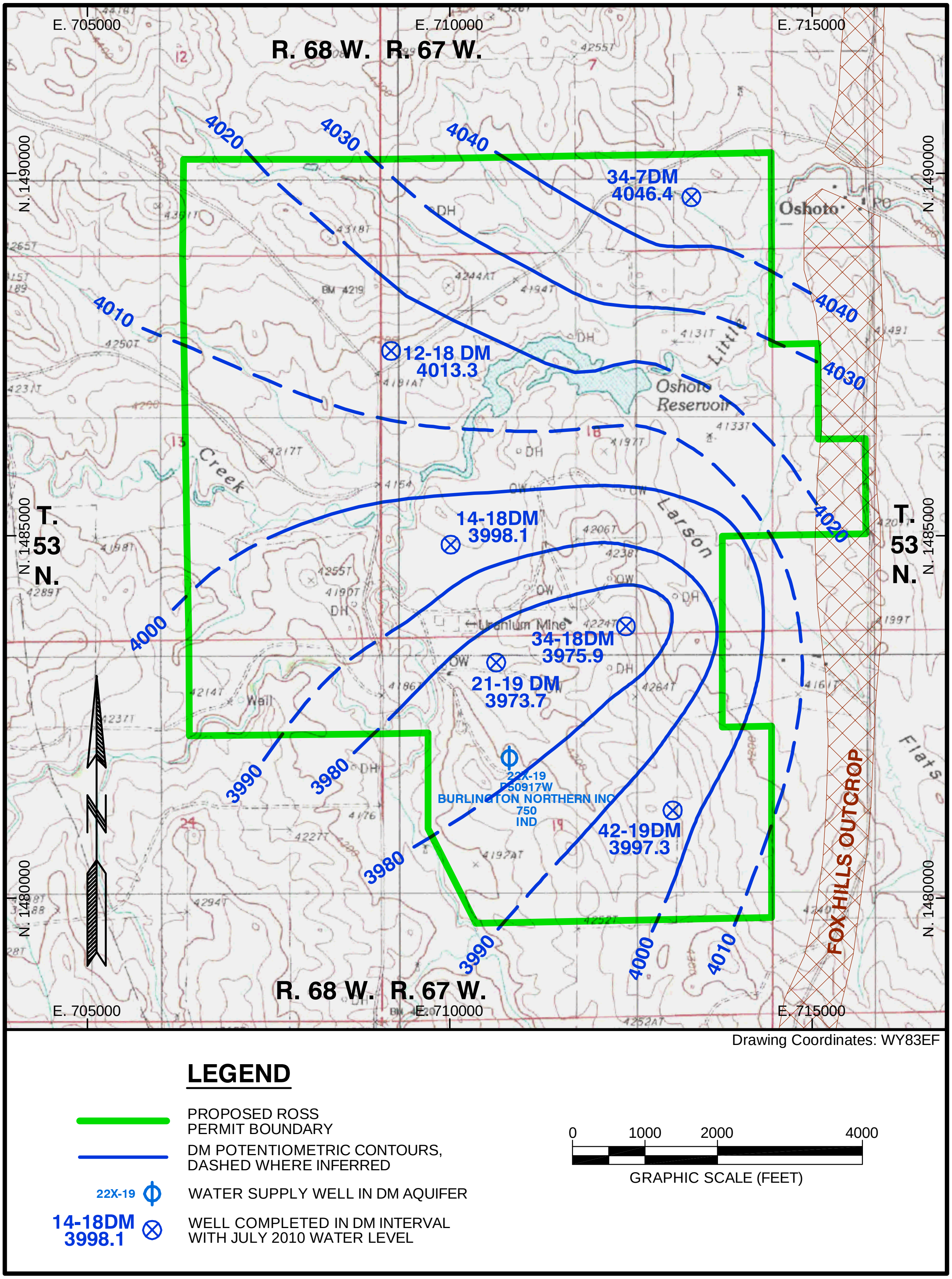

Figure 2.7-21. DM Potentiometric Contours

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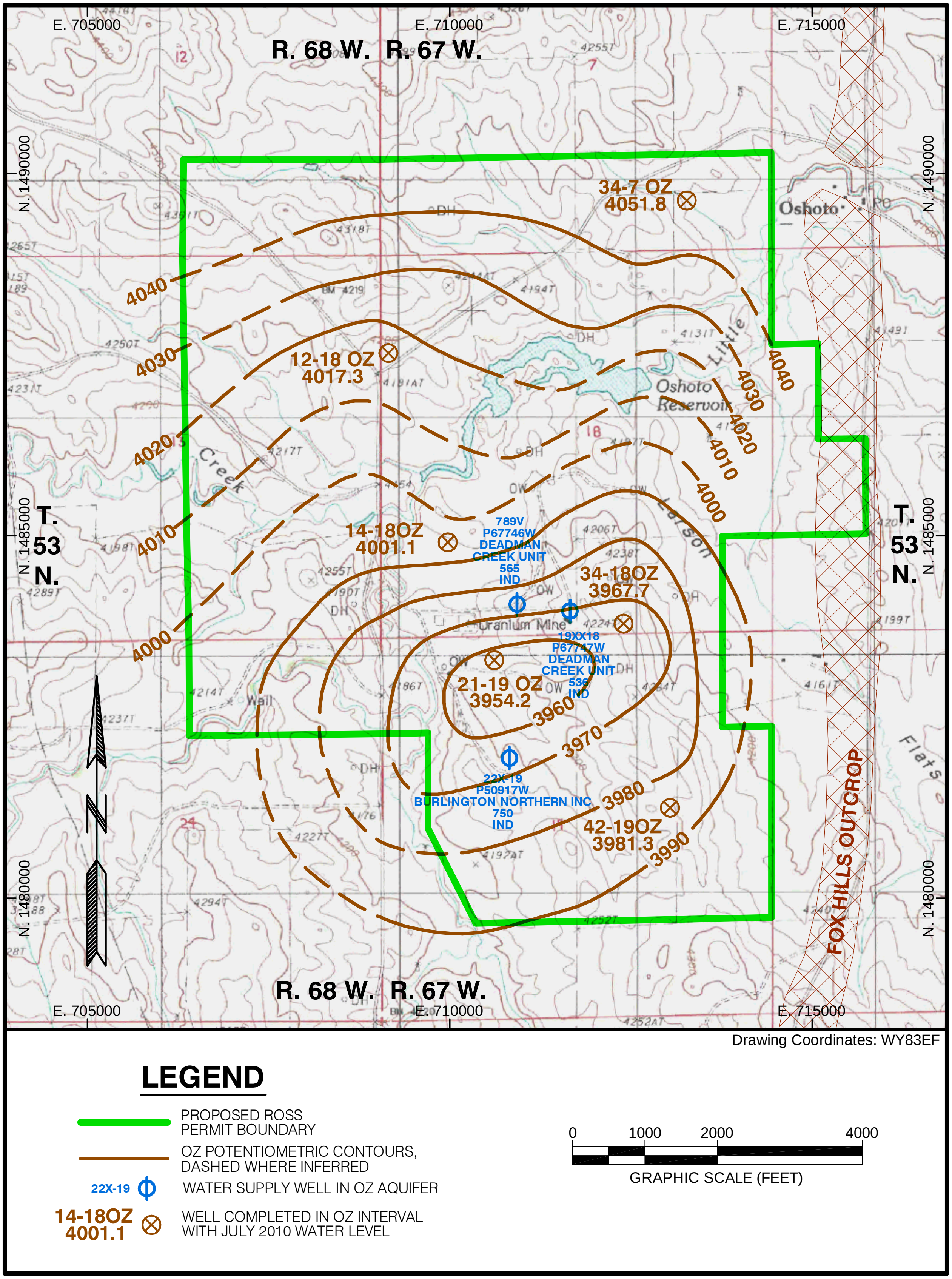
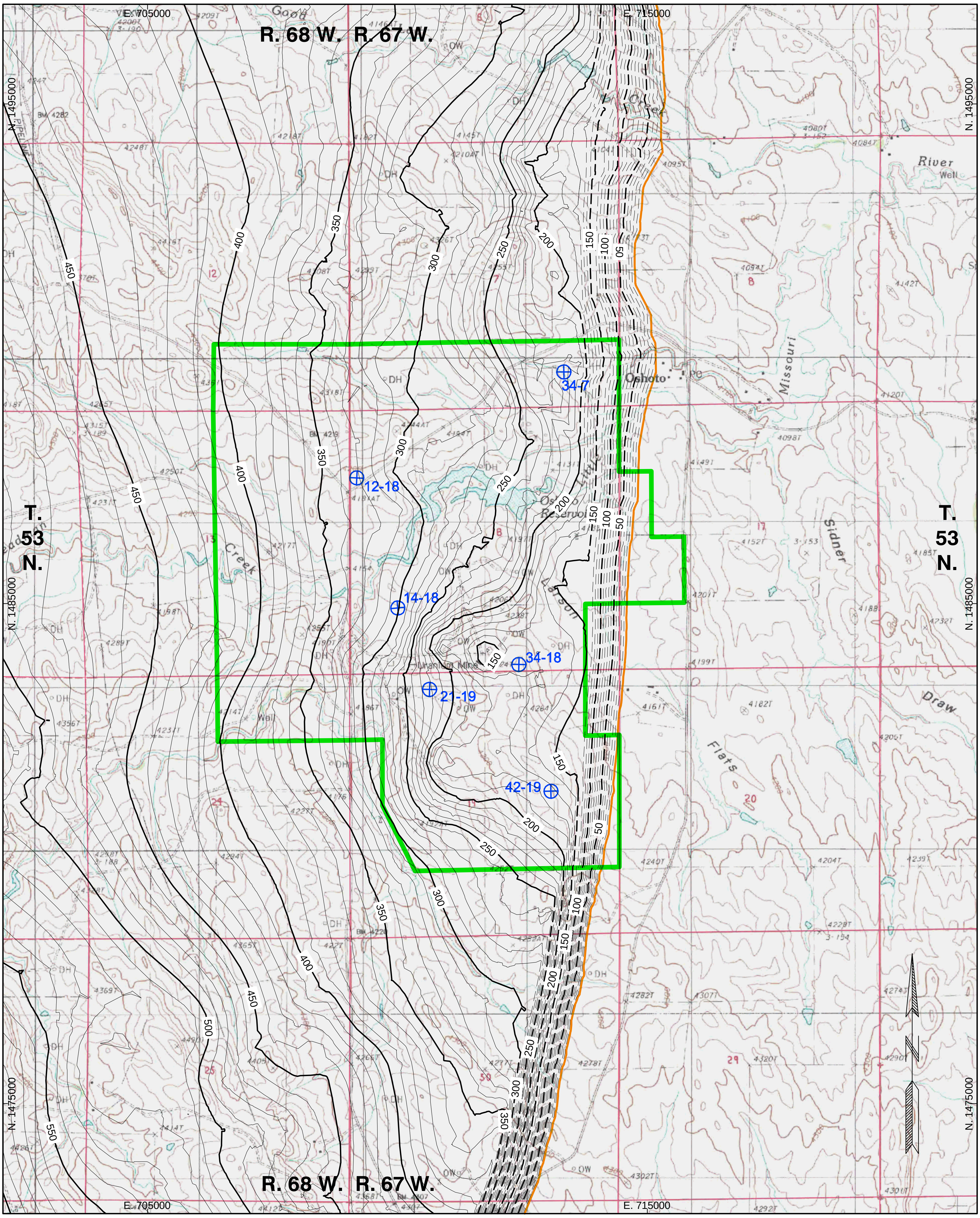


Figure 2.7-22. OZ Potentiometric Contours



Drawing Coordinates: WY83EF

LEGEND

PROPOSED ROSS PERMIT BOUNDARY

ISOPACH LINE (10' CONTOUR INTERVAL) OF POTENTIOMETRIC HEAD ABOVE ORE ZONE INTERVAL. CONTOUR LINES ARE DASHED WHERE POTENTIOMETRY AND STATIGRAPHIC STRUCTURE WERE PROJECTED ALONG THE BLACK HILLS MONOCLINE FLEXURE.

EDGE OF AQUIFER

21-19 REGIONAL BASELINE MONITOR WELL CLUSTER

NOTE:

TOP OF ORE ZONE SURFACE DERIVED FROM GEMCOM GEMS© SOFTWARE CUSTOMIZED FOR STRATA ENERGY, INC. AND DEVELOPED IN SUPPORT OF SITE SPECIFIC GROUNDWATER MODEL. 2010 POTENTIOMETRIC SURFACE GENERATED FROM GW VISTAS© GROUNDWATER MODEL USING MODFLOW. THIS FIGURE REPRESENTS THE DIFFERENCE BETWEEN THOSE TWO SURFACES.

0 1000 2000 4000

GRAPHIC SCALE (FEET)

STRATA ENERGY

ROSS ISR PROJECT
CROOK COUNTY, WY
P.O. BOX 2318
GILLETTE, WY 82716

TECHNICAL REPORT
FIGURE 2.7-23

ISOPACH OF AVAILABLE POTENTIOMETRIC HEAD IN 2010 ABOVE THE ORE ZONE AQUIFER

REVISIONS	
Date	Description

Drawn By: RAM
Checked By: BJS
Date: 11/21/10

WWC ENGINEERING
www.wwcengineering.com

FILE: ROSS_GEO_OZ_CONHEAD_ISO.DWG

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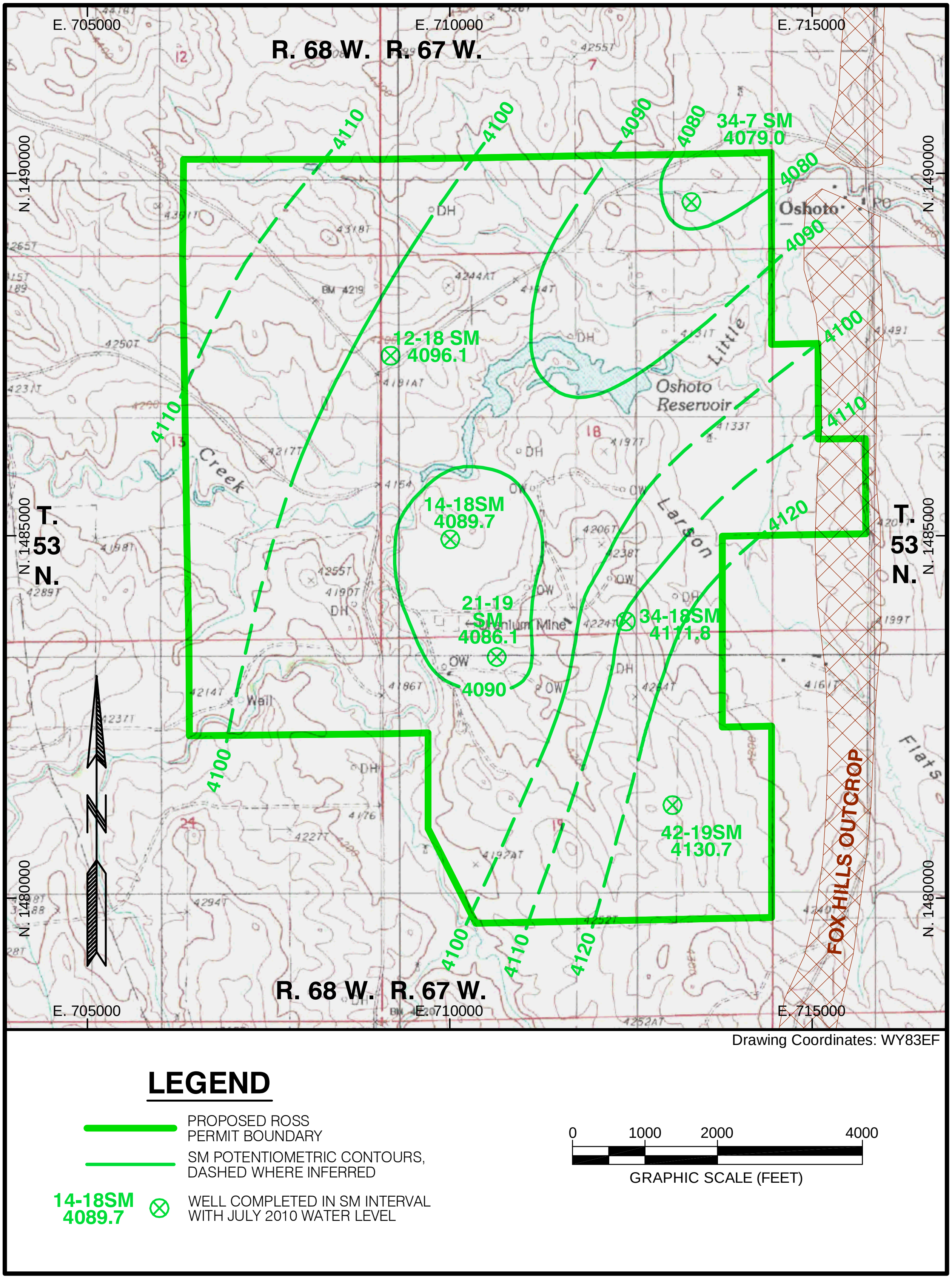

Figure 2.7-24. SM Potentiometric Contours

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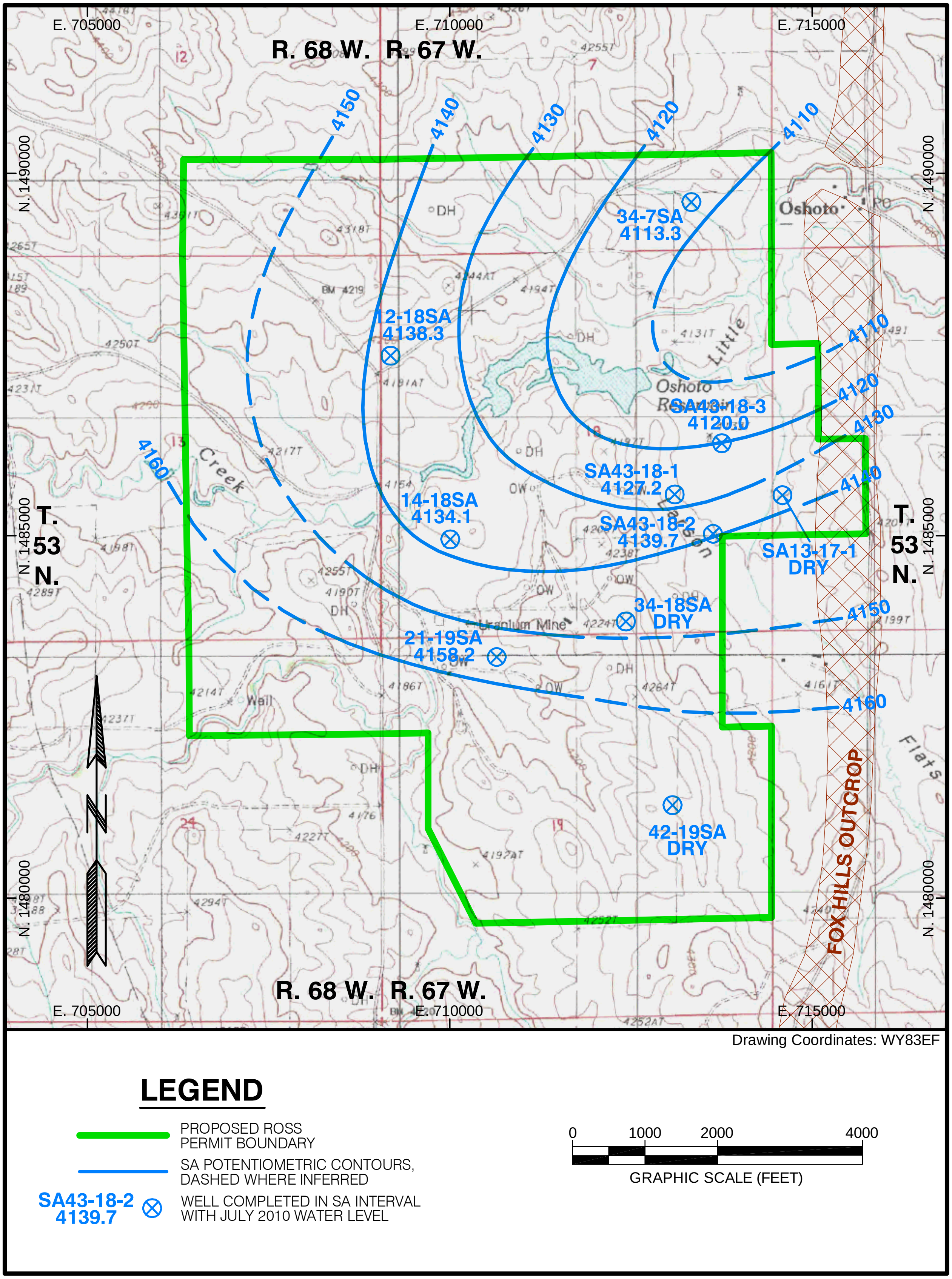

Figure 2.7-25. SA Potentiometric Contours

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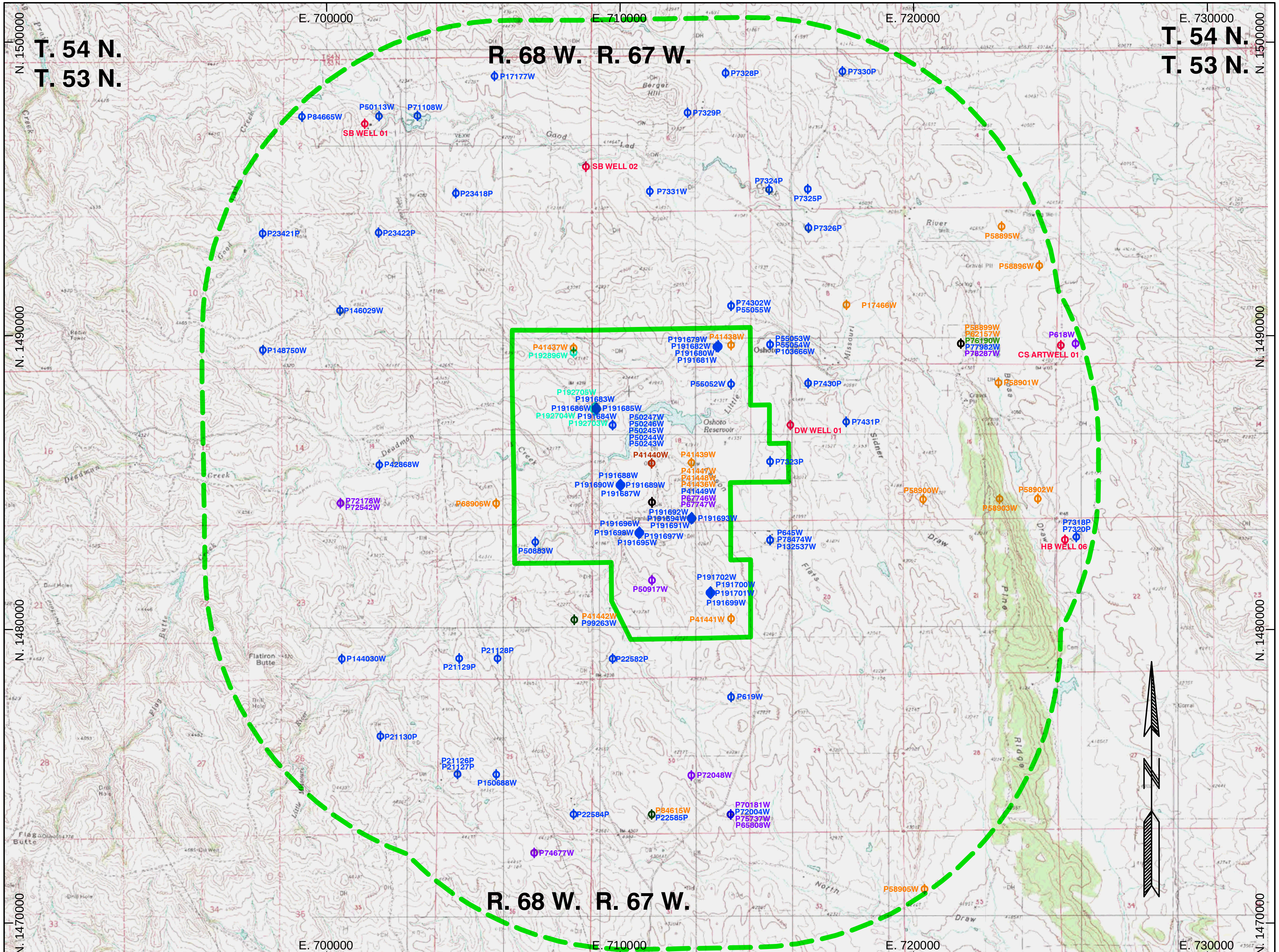

ROSS PROJECT AREA

Drawing Coordinates: WY83EF

LEGEND

- PROPOSED ROSS PERMIT BOUNDARY
- 2 MILE BUFFER FROM PROPOSED PERMIT BOUNDARY
- WR NUMBER — COMPLETE WATER WELL
- WR NUMBER — INCOMPLETE WATER WELL
- WR NUMBER — CANCELLED WATER WELL
- WR NUMBER — FULLY ADJUDICATED WATER WELL
- WR NUMBER — ABANDONED WATER WELL
- WR NUMBER — NO STATUS LISTED IN WSEO DATABASE
- WR NUMBER — NOT LISTED IN WSEO DATABASE

Source: WSEO 2010

0 1750 3500 7000
GRAPHIC SCALE (FEET)

STRATA ENERGY

ROSS ISR PROJECT
CROOK COUNTY, WY
P.O. BOX 2318
GILLETTE, WY 82716

REVISIONS	
Date	Description

TECHNICAL REPORT
FIGURE 2.7-26

GROUNDWATER RIGHTS AND UNREGISTERED WELLS WITHIN TWO MILES OF THE PROPOSED PROJECT AREA

Drawn By: MBM
Checked By: JWF
Date: 12/6/10

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FILE: ROSS_ER_HYD_GW_SEO

K:\Peninsula_Minerals\09142\DWGS_WY83E\ROSS_ER_HYD_GW_SEO.dwg, TR_FIGURE_2.7-26, 12/18/2010 2:53:17 PM

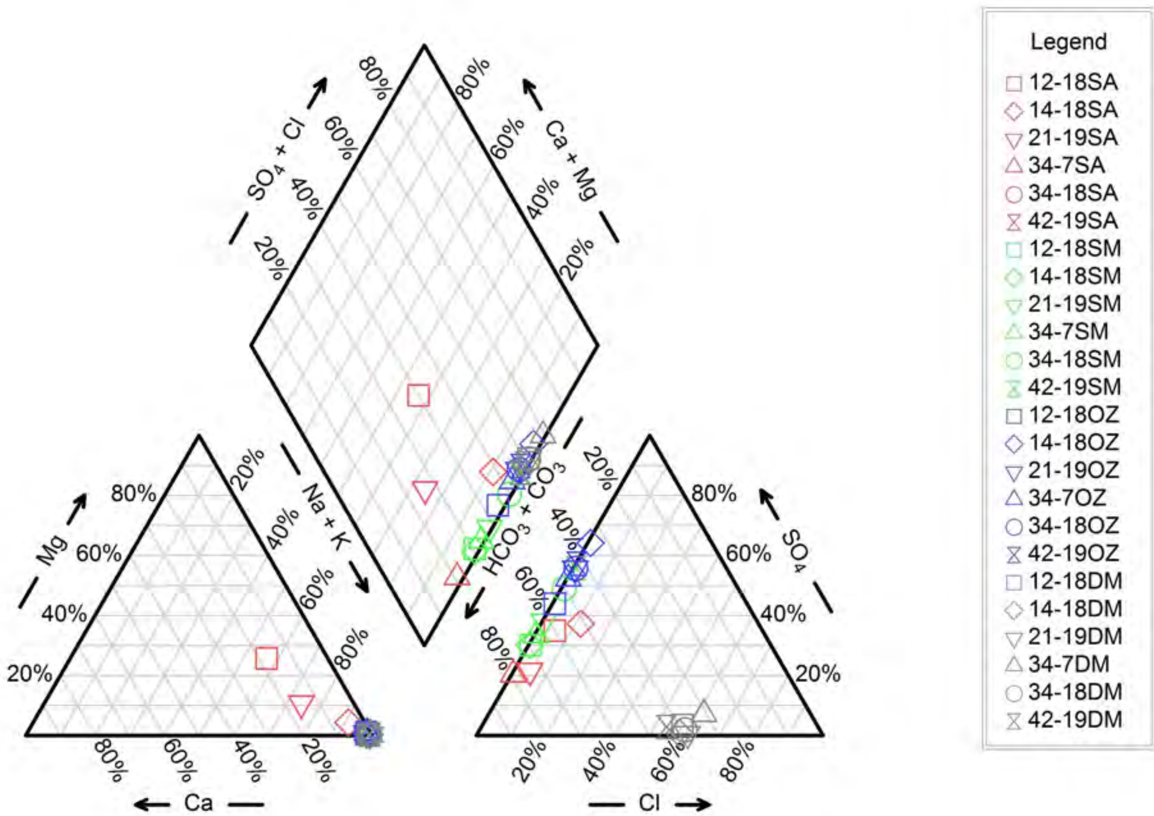


Figure 2.7-27. Regional Baseline Monitoring Network Piper Diagram

Note: data points represent average concentrations for each well.

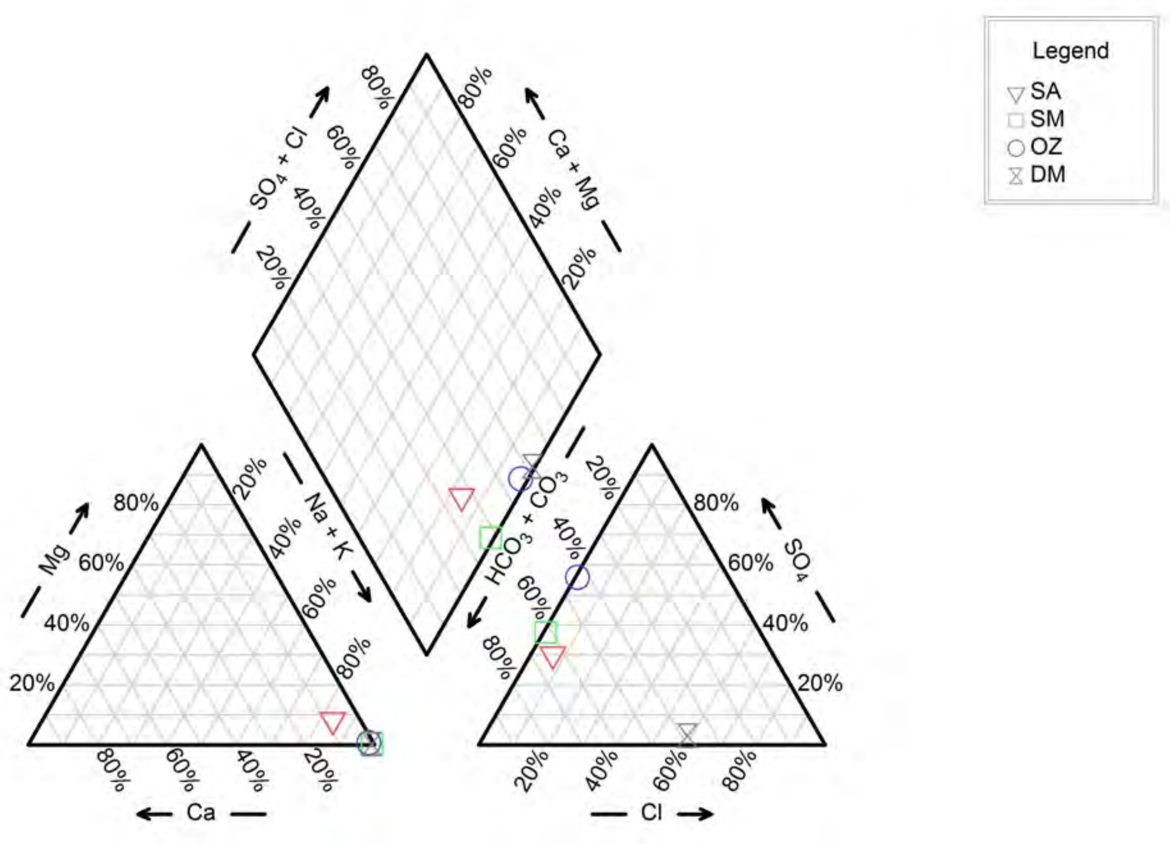


Figure 2.7-28. Regional Baseline Monitoring Network Piper Diagram by Zone

Note: data points represent average concentrations for each zone.

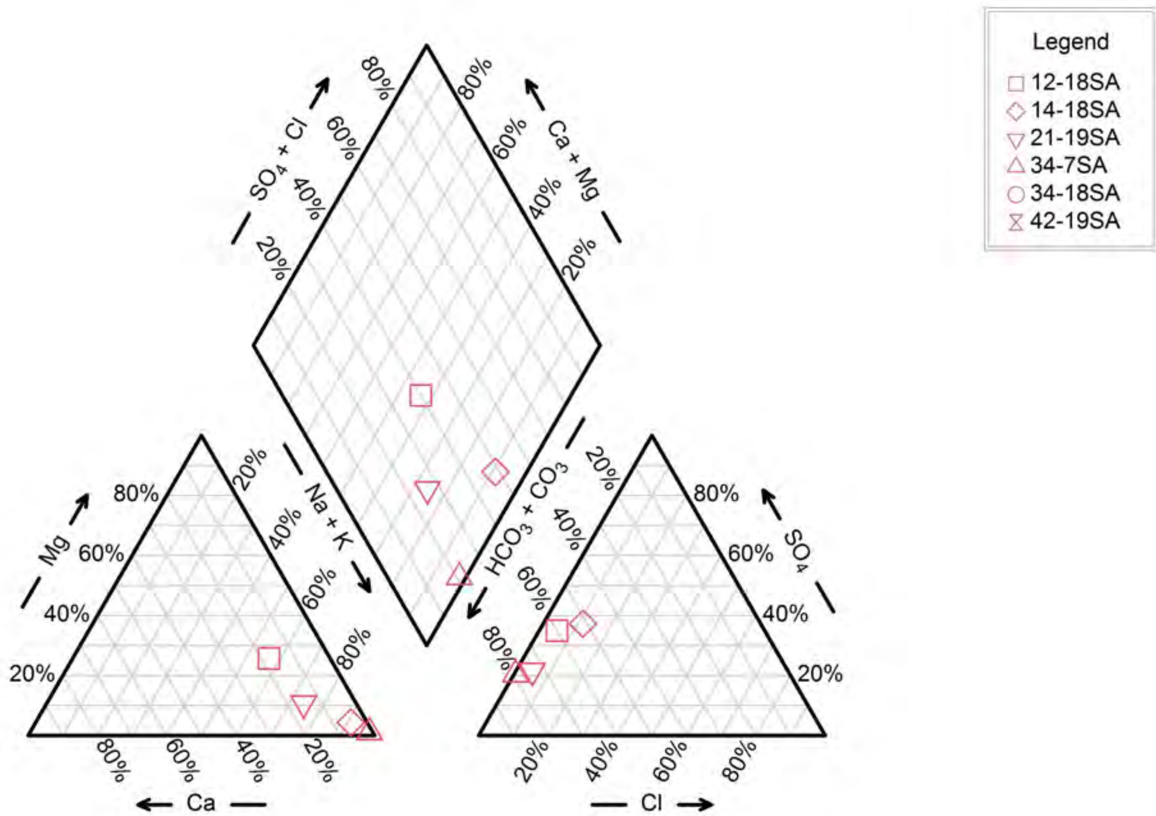


Figure 2.7-29. SA Zone Piper Diagram
Note: data points represent average concentrations for each well.

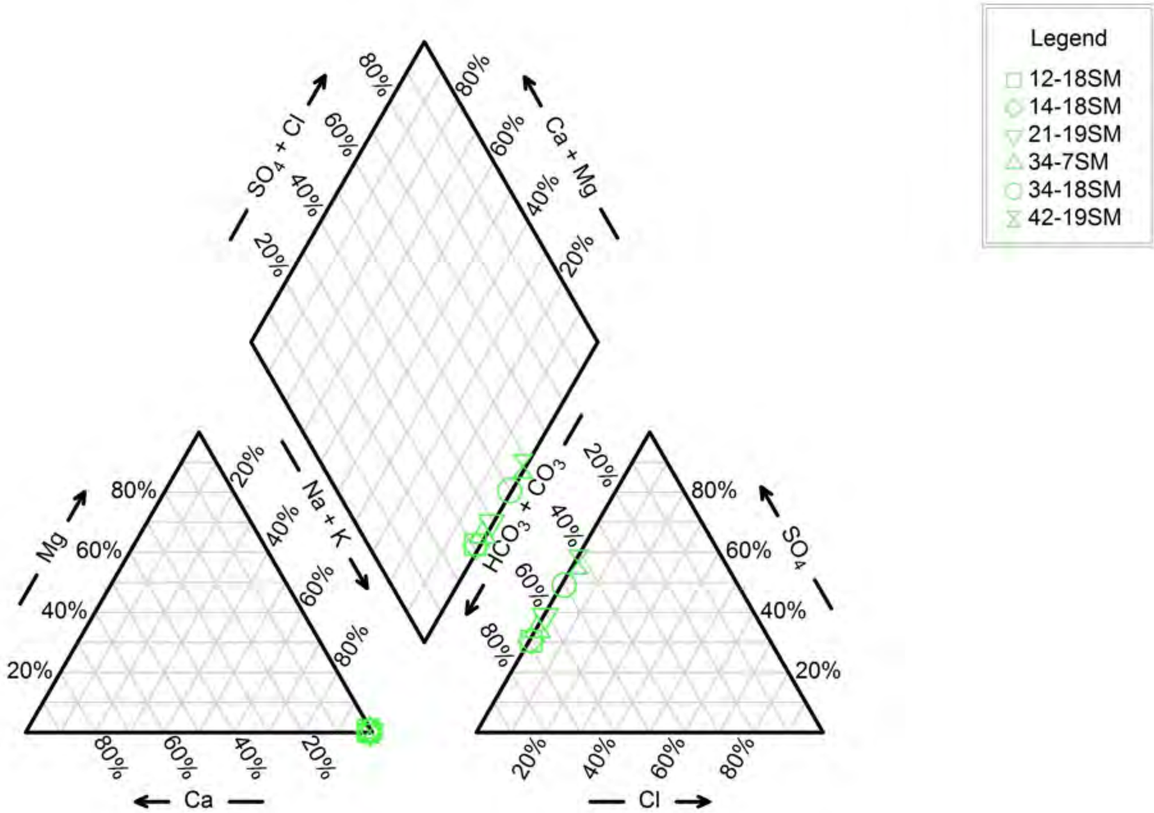


Figure 2.7-30. SM Zone Piper Diagram

Note: data points represent average concentrations for each well.

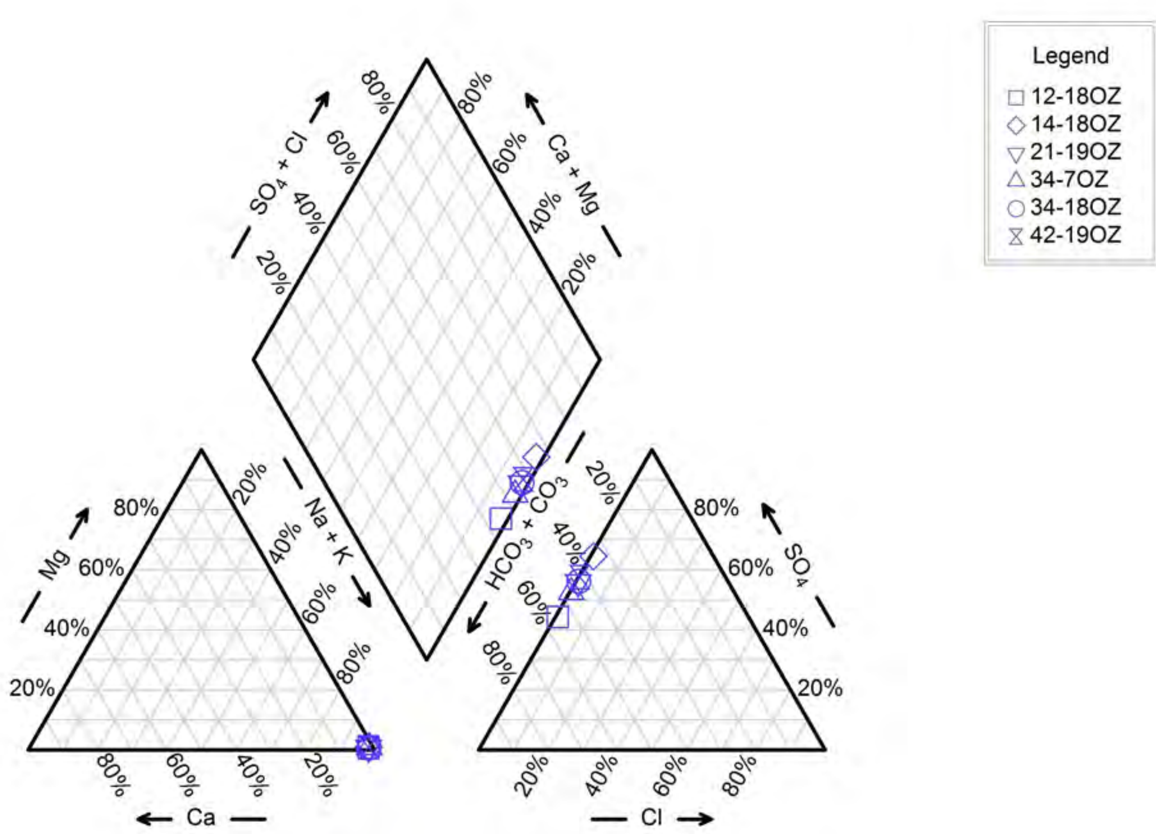


Figure 2.7-31. OZ Zone Piper Diagram

Note: data points represent average concentrations for each well.

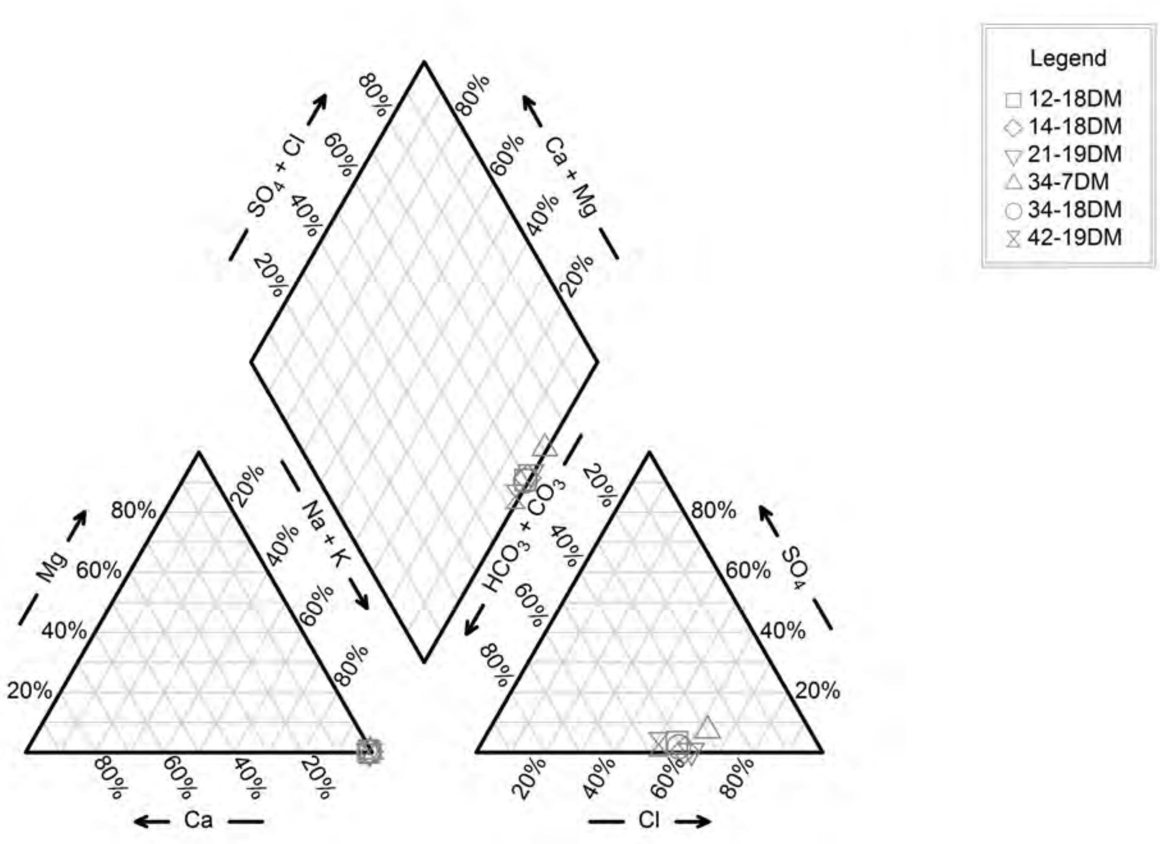
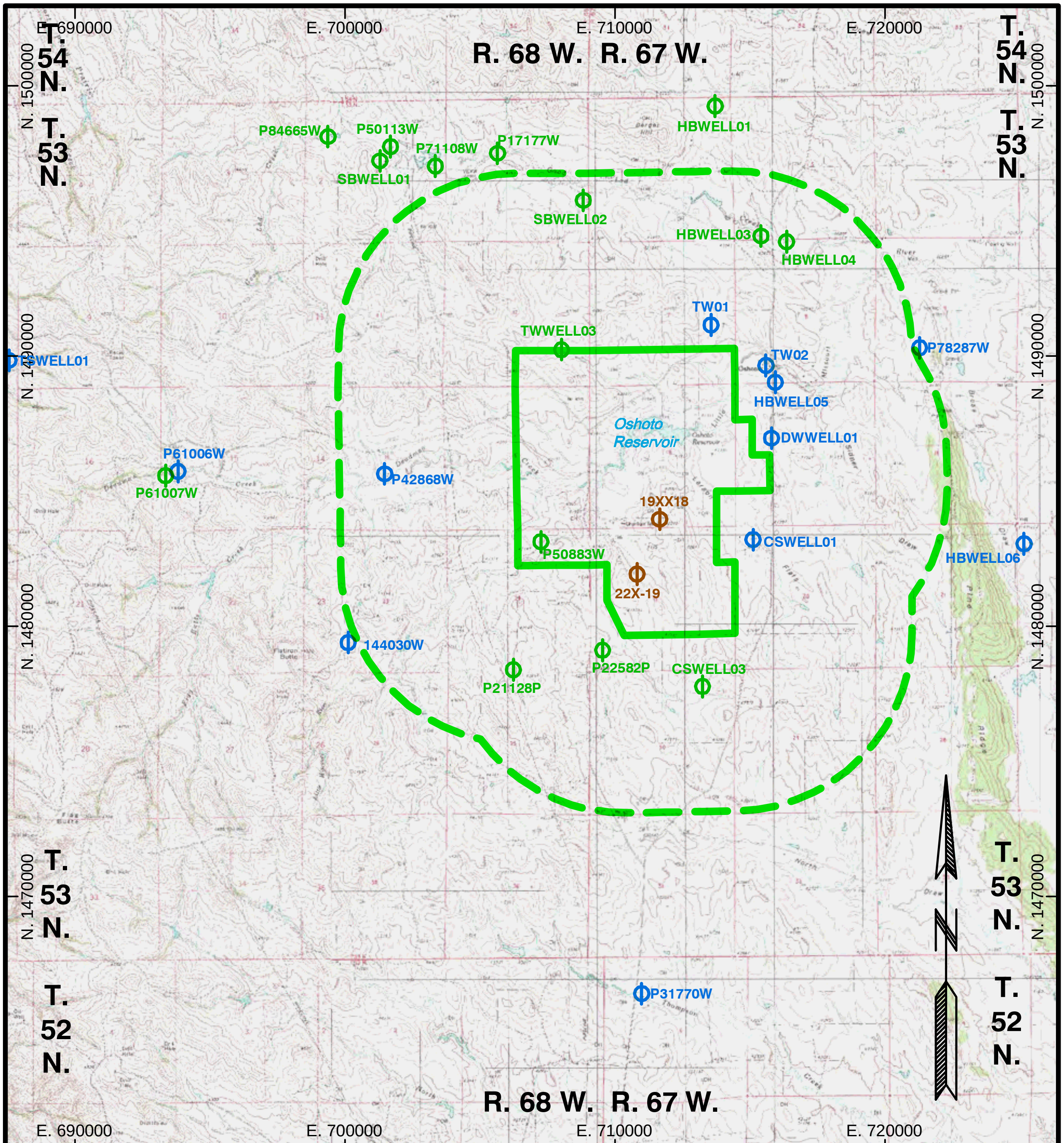


Figure 2.7-32. DM Zone Piper Diagram
Note: data points represent average concentrations for each well.



Drawing Coordinates: WY83EF

LEGEND

PROPOSED ROSS PERMIT BOUNDARY

2 KILOMETER BUFFER FROM PROPOSED PERMIT BOUNDARY

19XX18 SAMPLED INDUSTRIAL WELL

P50883W SAMPLED STOCK WELL

P42868W SAMPLED DOMESTIC WELL

Source: WSEO 2010

0 3,000 6,000 12,000

GRAPHIC SCALE (FEET)

Figure 2.7-33. Sampled Water Supply Wells

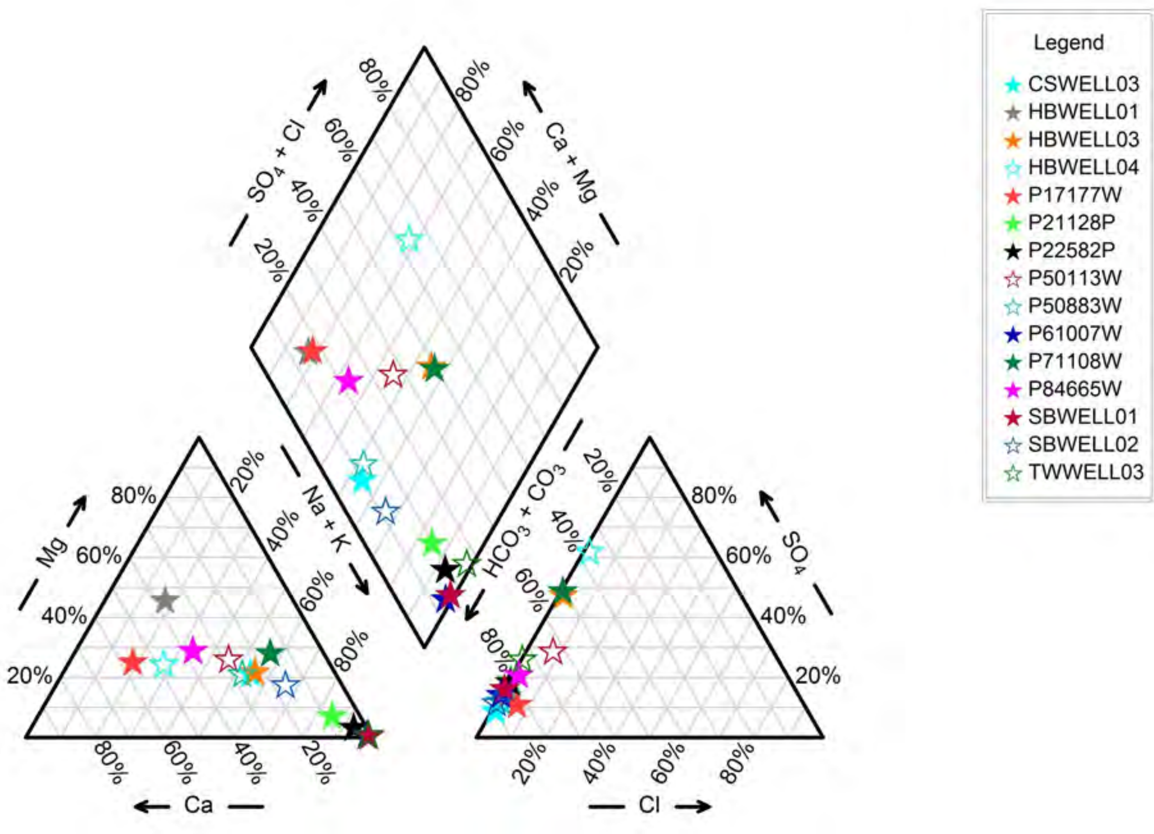


Figure 2.7-34. Stock Well Piper Diagram
Note: data points represent average concentrations for each well.

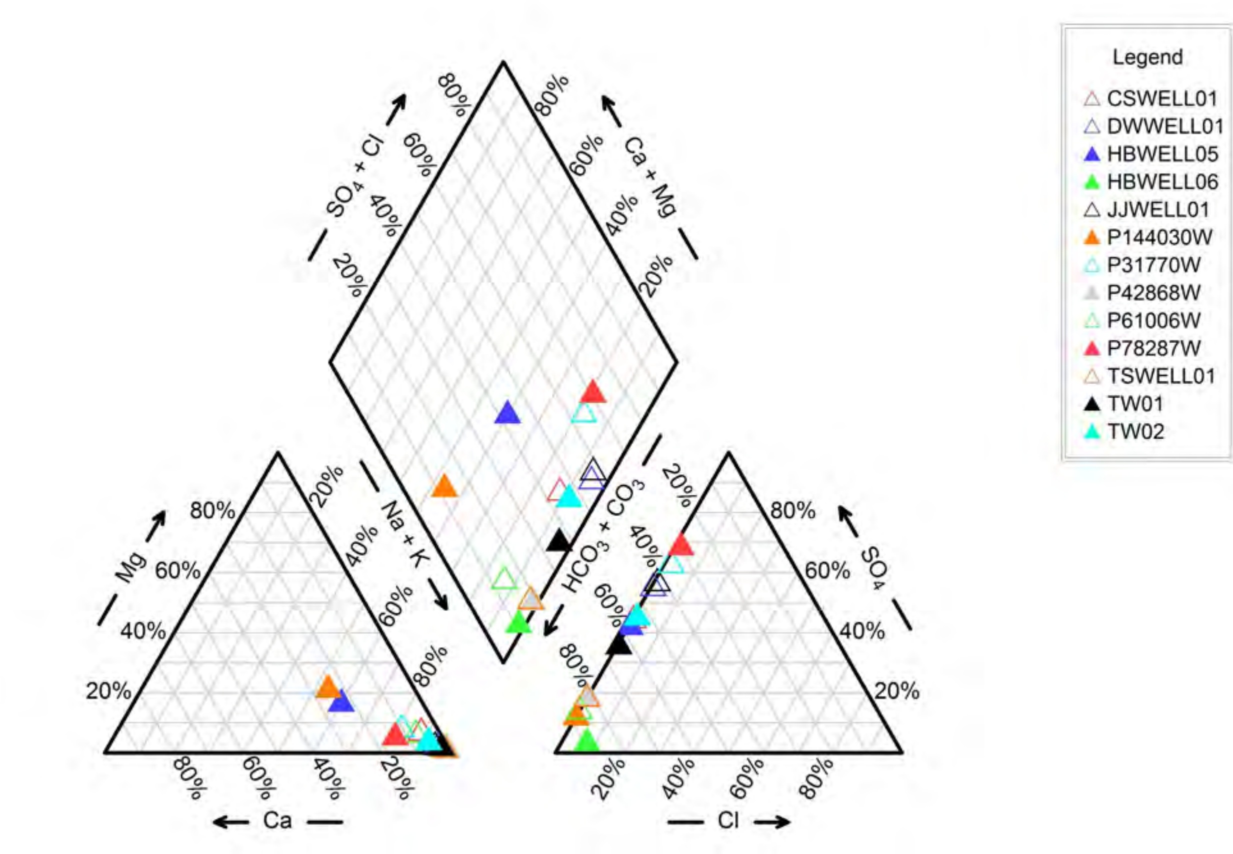


Figure 2.7-35. Domestic Well Piper Diagram
Note: data points represent average concentrations for each well.

2.8 Ecological Resources

2.8.1 Introduction

This section describes the existing ecological resources within the Ross ISR Project and addresses threatened and endangered (T&E) species that may potentially be present. Background information on ecological resources within the proposed project area was drawn from several sources, including the WGFD and USFWS records, the Wyoming Natural Diversity Database, consultations with BLM, personal contacts with WGFD and USFWS biologists, and consultation with landowners and nearby residents. A detailed discussion of ecological resources is included in Section 3.5 of the ER.

Terrestrial ecological baseline field surveys included vegetation, wetlands, and wildlife. The methodology and results are discussed below, by resource. Vegetation and wildlife surveys were conducted by Intermountain Resources of Laramie, Wyoming during fall 2009 and throughout 2010. Wetland surveys were conducted by WWC Engineering during summer 2010.

2.8.2 Regional Setting

The proposed project area is characterized by rolling, upland grasslands influenced by previous disturbance from county roads, oil and gas development, and reservoirs. The elevation within the proposed project area ranges from 4,114 feet to 4,312 feet and averages 4,190 feet above mean sea level.

2.8.3 Climate

As discussed in Section 2.5.1, the climate in the proposed project area is typical of a semiarid, high plains environment with relatively large seasonal and diurnal variations in temperature and seasonal variation in precipitation. The region is characterized seasonally by cold harsh winters, hot dry summers, and relatively warm moist springs and autumns. Temperature extremes range from roughly -25°F in the winter to 100° F in the summer. The “last freeze” occurs during late May and the “first freeze” mid-to-late September. A more detailed description of the climate at the proposed Ross ISR Project is included in Section 2.5.1.

2.8.4 Terrestrial Ecology

2.8.4.1 Vegetation

General

Vegetation sampling was conducted by Intermountain Resources, of Laramie, Wyoming. All sampling procedures and methodologies are consistent with standard industry practices and were approved by WDEQ/LQD. Detailed discussions of vegetation occurring on the proposed project area are included in Section 3.5.4 and Addenda 3.5-A through 3.5-E of the ER.

2.8.4.1.1 Vegetation Survey Results

Nine vegetation communities were documented within the proposed project area: Upland Grassland, Sagebrush Shrubland, Pastureland, Hayland, Wetland, Reservoir, Disturbed Land, Cropland, and Wooded Draw. Each community was investigated for baseline vegetation information in support of a NRC source materials license and WDEQ/LQD mine permit application. No threatened or endangered vegetation species were encountered within the proposed project area. Habitat for the Ute ladies'-tresses orchid (*Spiranthes diluvialis*) was encountered in the wetlands within the permit area. These wetlands were found primarily along Deadman Creek, Little Missouri River and along the Oshoto Reservoir. These wetland habitats were surveyed on August 11, 12 and 13 of 2010 but no orchids were observed. Typical habitat for the blowout penstemon (*Penstemon haydenii*) is not found on the permit area.

Several species of designated and prohibited noxious weeds listed by the Wyoming Weed and Pest Control Act were identified on the permit area. These species included field bindweed (*Convolvulus arvensis*), perennial sow thistle (*Sonchus arvensis*), Quackgrass (*Agropyron repens*), Canada thistle (*Cirsium arvense*), hounds tongue (*Cynoglossum officinale*), leafy spurge (*Euphorbia esula*), common burdock (*Arctium minus*), Scotch thistle (*Onopordum acanthium*), Russian olive (*Eleagnus angustifolia*) and skeletonleaf bursage (*Ambrosia tomentosa*). These species may be abundant in small localities, especially around the Oshoto Reservoir and along the Little Missouri River and Deadman Creek, but were not common throughout the area.

Selenium indicator species identified on the permit area in 2010 included two-grooved milkvetch (*Astragalus bisulcatus*), woody aster (*Xylorhiza glabriuscula*) and Stemmy goldenweed (*Haplopappus multicaulis*). These

selenium indicator species were not abundant on the permit area. Little larkspur (*Delphinium bicolor*), locoweed (*Oxytropis sericea* and *Oxytropis lambertii*) and meadow deathcamus (*Zigadenus venenosus*) were poisonous plants commonly observed on the area in limited amounts. Cheatgrass although not a state listed noxious weed was abundant on some sites within the permit area.

2.8.4.2 Wildlife

2.8.4.2.1 General Setting

Wildlife and aquatics sampling were conducted by Intermountain Resources, of Laramie, Wyoming. Detailed discussions of wildlife occurring on and adjacent to the proposed project area are included in Section 3.5.4 and Addenda 3.5-F through 3.5-I of the ER. Wildlife sampling was conducted during regular site visits and targeted surveys conducted from November 2009 through October 2010 to meet agency requirements of one year of baseline data. All sampling procedures and methodologies were consistent with standard industry practices and were approved by WGFD, BLM, and USFWS.

2.8.4.2.2 Big Game

Pronghorn (*Antilocapra americana*), mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), and white-tailed deer (*0. virginianus*) are the four big game species that occur within or near the proposed project area. Pronghorn and mule deer both are considered year-round residents.

No crucial big game habitats or migration corridors are recognized by the WGFD in the proposed project area or the surrounding 1.6 kilometers (1 mile) perimeter. Crucial range is defined as any particular seasonal range or habitat component that has been documented as the determining factor in a population's ability to maintain and reproduce itself at a certain level.

2.8.4.2.3 Other Mammals

Small and medium-sized mammalian species have the potential to occur in the proposed project area As determined through consultations with USFWS, BLM, and WGFD, no small mammal, lagomorph (hares and rabbits), black-footed ferret (*Mustela nigripes*), or bat surveys were conducted within the proposed project area.

No black-tailed prairie dog (*Cynomys ludovicianus*) colonies were located within 1.6 kilometers (1 mile) of the proposed project study area.

At the request of WGFD, surveys for swift fox (*Vulpes velox*) were conducted within the proposed permit boundary, according to WGFD survey methodologies. No swift fox were observed.

2.8.4.2.4 Raptors

Fifteen raptor species were observed during the baseline wildlife surveys. The ferruginous hawk (*Buteo regalis*), red-tailed hawk (*Buteo jamaicensis*), Swainson's hawk (*Buteo swainsoni*), American kestrel (*Falco sparverius*), and northern harrier (*Circus cyaneus*) were the most commonly seen raptor species in the area. One intact (i.e., material present) raptor nest (Swainson's hawk) was documented within the proposed permit boundary during the 2010 baseline survey period; seven additional intact nests and one nest no longer intact were recorded in the 1.6 kilometers (1 mile) survey perimeter. A ferruginous hawk pair and red-tailed hawk pair nested within the 1.6 kilometer study area perimeter in 2010 but only the red-tailed hawk successfully fledge young (2). Six raptor species of concern have been recorded within the proposed project area (bald eagle (*Haliaeetus leucocephalus*), golden eagle (*Aquila chrysaetos*), ferruginous hawk, Swainson's hawk, prairie falcon, and short-eared owl (*Asio flammeus*). All six were USWFS Birds of Conservation Concern and one (ferruginous hawk) was a BLM Sensitive Species.

2.8.4.2.5 Upland Game Birds

The wild turkey (*Meleagris gallopavo*), sage-grouse (*Centrocercus urophasianus*), sharp-tailed grouse (*Tympanuchus phasianellus*), and mourning dove (*Zenaida macroura*) were the upland game bird species observed in the proposed project survey area during baseline inventories conducted in 2010. The greater sage-grouse is a species of great concern throughout the west and is considered a "landscape species" due to its use of wide expanses of sagebrush as primary habitat during each phase of its life cycle. Searches for sage-grouse leks were completed between March 31 and April 29, 2010. Surveys were conducted between first light and approximately one hour after sunrise. Biologists searched for displaying grouse by driving 3.2 kilometer (2 mile) perimeter and making frequent stops at vantage points to scan and listen for displaying birds. Sage-grouse were historically recorded in the general

vicinity (WGFD 2010), and one lek has been documented within approximately 1.6 kilometers (1 mile) of the proposed permit boundary. The nearest active sage-grouse lek was the Cap'n Bob Lek, which is approximately 3.5 kilometer (2.2 miles)southeast of the proposed permit boundary. Potential habitat for sage-grouse is present (Upland Grassland, Sagebrush Shrubland, Pastureland, Hayland, and Reservoir/Stockpond.

There are no sage-grouse core areas or connectivity areas within or near the proposed project area (WGFD 2010).

2.8.4.2.6 Other Birds

At the request of the WGFD, breeding bird surveys were conducted within the proposed permit boundary. Transects were placed in four habitat types (Upland Grassland, Sagebrush Shrubland, Pastureland/Hayland, and Wetland/Reservoir). Twenty-seven bird species were observed during the two breeding bird surveys conducted in 2010. The Wetland/Reservoir type yielded the most species observations (19) and the Upland Grassland yielded the fewest species observation (6).

Fourteen nongame or migratory species on the USFWS Bird Species of Conservation Concern list could potentially occur within the proposed project area. Of the 14 bird species, eight have been observed within or near the area. Ten nongame or migratory bird species on the BLM Sensitive Species list could potentially occur within the proposed project area. Of the 10 bird species, four have been observed within or near the area.

2.8.4.2.7 Waterfowl, Shorebirds

As described previously, natural aquatic habitats in the proposed project area occur mainly in association with the Oshoto Reservoir and the Little Missouri River, with a several scattered stock reservoirs also present. A wetland transect was included as part of the breeding bird surveys and biologists also recorded all waterfowl/shorebirds observed during the year-long survey period. Seventeen waterfowl species and eight shorebird species were observed during the baseline inventories. The horned grebe (*Podilymbus podiceps*) and upland sandpiper (*Bartramia longicauda*) are the only USFWS Bird Species of Conservation Concern observed within or near the proposed project area.

2.8.4.2.8 Reptiles and Amphibians

No systematic reptile surveys were conducted within the proposed project area. At the request of the WGFD, amphibian call surveys were conducted at six locations within and near the proposed permit boundary.

Three aquatic or semi-aquatic amphibian species and two aquatic reptiles were recorded during the 2010 surveys: the tiger salamander (*Ambystoma tigrinum*), boreal chorus frog (*Pseudacris triseriata*), northern leopard frog, common snapping turtle (*Chelydra serpentine*), and western painted turtle (*Chrysemys picta*). All five species were heard and/or seen associated with the Oshoto Reservoir, Little Missouri River, or near stock reservoirs. All five species are common to the proposed project area and the region as a whole. The northern leopard frog was the only BLM reptile, amphibian, or fish Sensitive Species observed in the area.

2.8.4.3 Threatened, Endangered, or Candidate Species and Species

2.8.4.3.1 Federally Listed Species

No federally listed threatened or endangered vertebrate species were documented in the proposed project area during the year-long survey period. The black-footed ferret was the only federal threatened or endangered vertebrate species that could potentially occur in the proposed project area. The U.S. Fish and Wildlife Service issued a block-clearance for ferrets throughout much of the state of Wyoming in recent years, including the proposed project area in Crook County. As described previously, no black-tailed prairie dog colonies were located within or near the proposed permit boundary. The sage-grouse is listed as a Candidate Species and is discussed in the Upland Game Bird section, above.

Habitat for the Ute ladies'-tresses orchid (*Spiranthes diluvialis*) was encountered in the wetlands within the permit area. These wetlands were found primarily along Deadman Creek, Little Missouri River and along the Oshoto Reservoir. These wetland habitats were surveyed on August 11, 12 and 13 of 2010 but no orchids were observed. Typical habitat for the blowout penstemon (*Penstemon haydenii*) is not found on the permit area.

2.8.4.3.2 State Listed Species

The State of Wyoming does not maintain a discrete State List of Species but relies on the USFWS lists of Threatened or Endangered Species and Bird Species of Conservation Concern and the BLM Sensitive Species list for impacts assessment. The species included in these lists are discussed above in the appropriate sections.

2.8.5 Aquatic Resources

As discussed previously, aquatic resources are within the proposed project area limited the Oshoto Reservoir, the Little Missouri River and several stock ponds. As determined through consultations with WGFD, no systematic fish surveys were conducted within the proposed project area.

Fish tissue was analyzed for radionuclides as specified in Nuclear Regulatory Commission Guide 4.14 to establish a radiological environmental baseline.