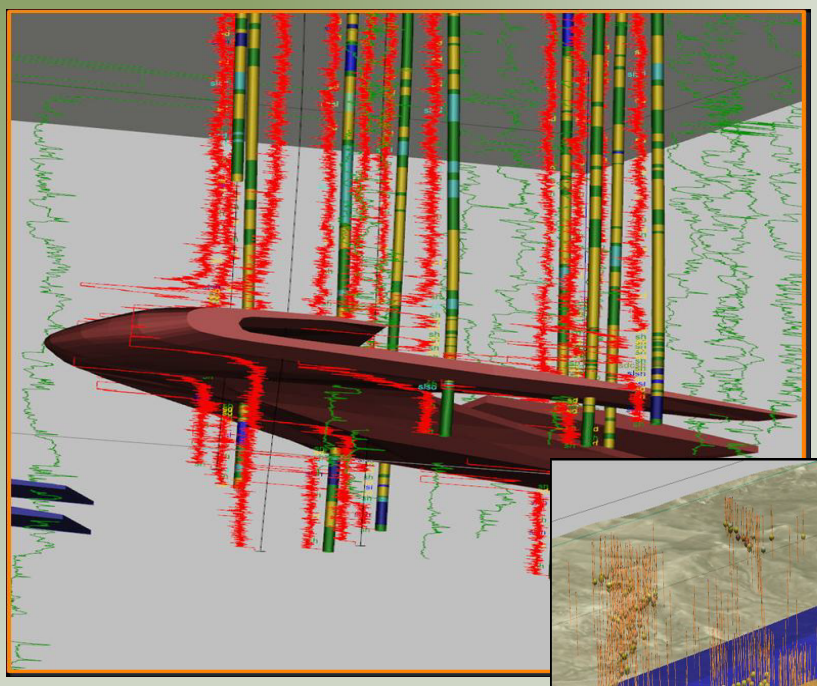
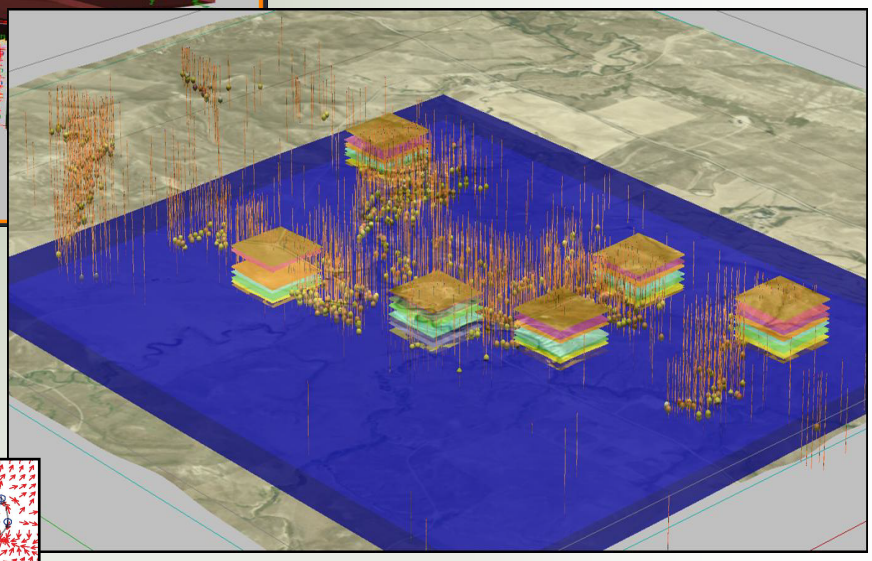
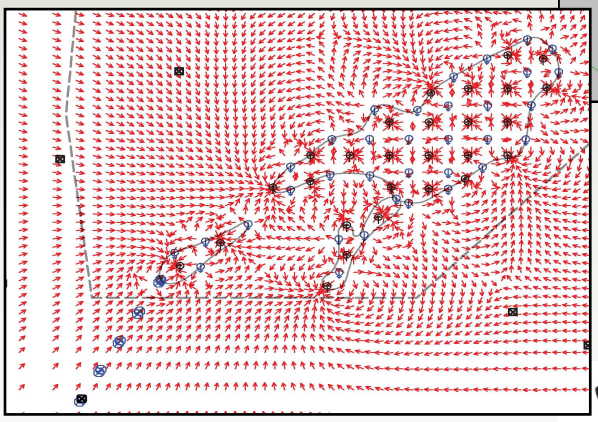
Ross ISR Project USNRC License Application
Crook County, Wyoming







December 2010

Technical Report
Volume 2 of 6
Sections 3.0 through 11.0

STRATA ENERGY

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ADDENDUM 6.1-A	Restoration Action Plan with Financial Assurance Estimate
ADDENDUM 6.4-A	RESRAD Model Supporting Documentation

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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3.0 DESCRIPTION OF PROPOSED FACILITY

The proposed project area encompasses approximately 1,721 acres. The CPP will be located in the NE¼ of the SE¼ of Section 18, Township 53N, Range 67W and will include a uranium recovery circuit, uranium elution circuit, uranium precipitation circuit, and yellowcake drying/packaging along with a vanadium removal and drying/packaging circuit. Adjacent buildings will house the administrative office, maintenance shop, and warehouse. Waste disposal facilities in the CPP area will include lined retention ponds and a Class I Injection well. The total disturbed area of the surface features at the CPP area is estimated at 51 acres. The CPP and adjacent buildings will be fenced to a height of 8 feet to exclude livestock and wildlife, and to control access to the site.

The proposed injection and recovery wellfields will occupy portions of Sections 7, 18, and 19, in Township 53N, Range 67W and portions of Sections 12 and 13 in Township 53N, Range 68W. The proposed wellfields will be divided into two Mine Unit development areas as shown on Figure 3.1-1. Mine Units will be further divided into wellfield modules. Within the proposed project, wellfield modules will be used to delineate the portion of each Mine Unit which will be 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 the proposed project will contain a total of 15-25 modules, however, ongoing delineation and development drilling activities are expected to increase the total size of the wellfields and number of modules. The wellfield injection and recovery wells will be piped individually to the module buildings which will contain manifolds and piping, along with monitoring and control equipment. The wellfield areas will be fenced to exclude livestock.

Key proposed facility characteristics include:

- Permit area = 1,721 acres,
- Production area (wellfields and CPP) = 125-145 acres,
- Production roll-front systems targeted = 5,
- Maximum recovery flow = 7,500 gpm,
- Average recovery flow = 5,075 gpm,
- Maximum restoration flow = 1,100 gpm,

- Average restoration flow = 950 gpm,
- Two Mine Units comprised of 15-25 wellfield modules,
- 1,400 to 2,200 recovery/injection wells,
- 140 to 250 monitor wells (perimeter, shallow, and deep),
- Ion-exchange recovery circuit = 750,000 lbs/year,
- Yellowcake drying/packaging capacity = 3,000,000 lbs/year,
- 119.1 ac-ft of lined retention pond storage capacity, and
- Five proposed deep disposal wells.

Figure 3.1-1 depicts the CPP area facilities including the CPP, wellfields, office, parking area, maintenance shop, warehouse, lined retention ponds, deep disposal wells, access roads, administrative and maintenance buildings, and areas where delineation drilling has indicated future wellfields may be located.

3.1 ISR Process and Equipment

3.1.1 Ore Body Description

At the proposed Ross ISR Project, uranium will be recovered from the upper Fox Hills and the lower Lance formations (see regional stratigraphic column, Figure 2.6-3). The host formations are of Cretaceous age and consist of interbedded sandstone, siltstone, and shale. Uranium deposits are found in the permeable sand zones in stacked roll fronts and tabular ore bodies. The average depth to the top of the ore is 490 feet, and the depth ranges from less than 300 to more than 700 feet. The ore thickness averages 8.9 feet. Spatial distribution of economic mineralization extends across the proposed project area as shown on Figure 3.1-2. This figure also depicts the areas where current delineation activities have indicated that mineralization may exist.

The sources of the uranium were most likely the granites eroded from the surrounding mountainous uplifts and/or volcanic material deposited in the overlying White River Formation, which was also subsequently removed by erosion in the area. The oxygenating groundwater solubilized the uranium and roll fronts were formed when the groundwater moved downdip through the permeable sand zones until contacting a reducing environment where it was precipitated and concentrated. Additional discussion is included in Section 2.6.3. A typical roll front is shown in Figure 3.1-3. The uranium occurs as interstitial fillings between sand grains and thin coatings on the sand grains.

The uranium host sands are saturated and have been determined to be confined aquifers. Natural conditions, governed by the depositional environment during the Late Cretaceous period when the Lance/Fox Hills formations were deposited (discussed in detail in Sections 2.6 and 2.7) resulted in highly heterogeneous sandstones with similarly varied permeabilities, both vertically and laterally. To quote Buswell (1982), "The heterogeneous permeability and transmissivity of the host sediments modifies the migration of the groundwater the alteration projections [roll fronts] formed in response to increased flow through the more permeable channel sandstones." The limits of mineralization also define the limits of the higher permeability sediments. Otherwise, uranium mineralization would be more ubiquitous, and not concentrated in the various roll front deposits underlying the proposed project area. Aquifer pump tests and laboratory core testing have shown that the ore zone sands have greater horizontal permeability than vertical permeability. The

horizontal to vertical anisotropy is particularly apparent within the confining shales. Laboratory core analyses data indicate the shale samples had very low conductivity values (Addendum 2.7-F), and the vertical to horizontal conductivity ratio for at least two samples was less than 0.001. The continuous shale layers above and below the host sands provide significant confinement for the recovery solutions and prevent vertical excursions.

Ore body and geologic interpretation at the proposed Ross ISR Project utilized Gemcom Gems© software. The three-dimensional, database driven geologic software platform allowed integration of historic Nubeth drilling data (approximately 1,500 holes) and recent delineation drilling (approximately 500 holes). Utilizing geophysical logs, lithologic descriptions, and contemporary surveying technology, Gems provides resource modeling and drill hole and mine planning in addition to detailed delineation of critical geologic contacts.

3.1.2 Well Construction and Integrity Testing

3.1.2.1 Well Construction Methods and Materials

The recovery and injection wells will be installed with identical completion methods (see Method 1 below) to allow the function of the wells to be changed if desired. The ability to change the well function allows for improved uranium recovery and more efficient restoration as well as an improved ability to respond to potential excursions of recovery solutions. The monitor wells will be installed utilizing Method 2 or Method 3, which are also described in detail below. Wells will be constructed of polyvinyl chloride (PVC) or fiberglass with a sufficient pressure rating to withstand the maximum anticipated injection pressure, the maximum external collapsing pressure, the maximum pressure of cementing, and in accordance with Wyoming State Engineers Office (WSEO) and WDEQ regulations. Wells at the proposed project will be constructed in accordance with WDEQ/LQD Chapter 11. Due to reported failures of screw and glue joints at similar facilities, the casings will be joined using an O-ring and spline locking system.

Method 1 (see Figure 3.1-4)

1. A pilot hole 5 to 6.5 inches in diameter is drilled through the projected mineralization zone. Geophysical logs consisting of gamma, resistivity, spontaneous potential, and deviation are then completed. From the geophysical logs, the grade of each mineralized intercept is calculated.

2. If, after geophysical logging, it is determined that the mineralization is not of sufficient quality or that the ore continuity is inadequate to warrant completion, the hole is sealed from the bottom to the top with neat cement slurry. An Abandonment Record is then completed for each sealed hole.

3. Assuming the decision is reached to complete the well, the hole is reamed to a diameter of 8 to 10 inches (a minimum of 3 inches larger than the casing OD) to a depth approximately 15 feet below the bottom of the mineralization. Alternatively, in areas where the geologist is more confident in intercepting mineralization, the initial hole may be drilled at the final diameter of 8 to 10 inches in one pass followed by the geophysical logging.

   Fiberglass or PVC casing (minimum rating of SDR 17) with an outside diameter (OD) of 5 to 6.5 inches is placed in the reamed hole to a depth approximately 10 feet below the mineralization. PVC centralizers are placed on the casing string at a maximum spacing of one per 40 feet.

4. A calculated amount of neat cement slurry mixed to the required specifications (approximate unit weight of 15 lbs./gallon) is placed inside the casing through a cementing or pump-down head. A calculated volume of displacement water is then pumped into the casing forcing the cement slurry out the bottom of the casing and up the annulus between the casing and the reamed hole until cement reaches the surface. After displacement, the valve on the cementing head is closed which holds the cement in place while hardening occurs.

5. After a minimum of four days, the well is underreamed through the mineralized zones to a diameter of 10 to 14 inches. The well annulus will be topped off with cement to the surface prior to reentry by the drilling rig. The underreaming is completed by a specialized tool utilizing retractable blades. The blades are closed for the trip down the well and are opened by pressure from the rig mud pump. The blades are held open by the weight of the drill string. After underreaming the designated zone through the casing and cement, the blades are again retracted for the trip out of the well. The well may be caliper logged as necessary to verify the correct interval has been opened. If deemed necessary, to support sand zones that are not competent, PVC screen is telescoped into the casing using a J-collar hooked to the drill pipe. The uppermost screen openings will be placed below the top of the underreamed interval and below the bottom of the annular seal. A PVC riser pipe is extended from the top of the screen approximately 10 feet. One or more k-packer(s) will provide a seal between the riser pipe and the casing. Filter sand may be placed between the screen and the underreamed hole.

6. The well is developed to remove contaminants and fines from the drilling and completion process and maximize the flow rate. A Well Installation Record is completed which contains all the details on drilling, geophysical logging, completion materials, casing depth, completion interval, and the cement mix.

7. After drying, the drill cuttings contained in the pits are covered with subsoil and the stockpiled topsoil. The ground surface is then recontoured and reseeded.

8. The well is integrity tested as discussed in Section 3.1.2.3 below.

Method 2 (see Figure 3.1-5)

1. A pilot hole 5 to 6.5 inches in diameter is drilled through the projected completion interval. Geophysical logs consisting of gamma, resistivity, spontaneous potential, and deviation are then completed.

2. The hole is reamed to a diameter of 8 to 10 inches (a minimum of 3 inches larger than the casing OD) to the top of the zone to be completed. The pilot hole below the bottom of the reamed hole is filled with drill cuttings during the reaming process.

3. Fiberglass or PVC casing (minimum rating of SDR 17) with an OD of 5 to 6.5 inches is placed in the reamed hole. PVC centralizers are placed on the casing string at a maximum spacing of one per 40 feet.

4. A calculated amount of neat cement slurry mixed to the required specifications (approximate unit weight of 15 lbs./gallon) is placed inside the casing through a cementing head. A calculated volume of displacement water is then pumped into the casing forcing the cement slurry out the bottom of the casing and up the annulus between the casing and the reamed hole until the cement reaches the surface. After displacement, the valve on the cementing head is closed which holds the cement in place while hardening occurs.

5. After a cement-hardening period of at least two days, the designated completion interval is cleaned out below the casing to the pilot hole diameter. The well annulus will be topped off with cement to the surface prior to reentry by the drilling rig. If the sand zone is competent, the completed interval may be left open and unsupported. If PVC screen is necessary, and a clean hole has been drilled, the screen assembly may be installed immediately. Underreaming of the completed interval to a larger diameter may be completed prior to the installation of the screen. The uppermost screen openings will be placed below the bottom of the casing and the annular seal. A PVC riser pipe is extended from the top of the screen approximately 10 feet. A seal between the

riser pipe and the casing is provided by one or more k-packer(s). Filter sand may be placed between the screen and the underreamed hole.

6. The well is developed to remove contaminants and fines from the drilling and completion process and maximize the flow rate. A Well Installation Record is completed which contains all the details on drilling, geophysical logging, completion materials, casing depth, completion interval, and the cement mix.

7. After drying, the drill cuttings contained in the pits are covered with subsoil and the stockpiled topsoil. The ground surface is then recontoured and reseeded

8. The well is integrity tested as discussed in Section 3.1.2.3 below.

Method 3 (see Figure 3.1-6)

1. A pilot hole 5 to 6.5 inches in diameter is drilled to the top of the projected completion interval. Geophysical logs consisting of a minimum of gamma, resistivity, and self potential are then completed.

2. The hole is reamed to a diameter of 8 to 10 inches (a minimum of 3 inches larger than the casing OD). An option for this method is to drill to the final hole diameter of 8 to 10 inches in one pass followed by the geophysical logging.

3. Fiberglass or PVC casing (minimum rating of SDR 17) with an OD of 5 to 6.5 inches is placed in the reamed hole. PVC centralizers are placed on the casing string at a maximum spacing of one per 40 feet.

4. A calculated amount of neat cement slurry mixed to the required specifications (approximate unit weight of 15 lbs./gallon) is placed inside the casing through a cementing head. A calculated volume of displacement water is then pumped into the casing forcing the cement slurry out the bottom of the casing and up the annulus between the casing and the reamed hole until cement reaches the surface. After displacement, the valve on the cementing head is closed which holds the cement in place while hardening occurs.

5. After a cement-hardening period of at least two days, the designated completion interval is drilled below the casing with a bit that is smaller than the casing inside diameter (ID). The well annulus will be topped off with cement to the surface prior to reentry by the drilling rig. Geophysical logs consisting of gamma, resistivity, spontaneous potential, and deviation are then completed in the newly drilled hole. If the sand zone is competent, the completed interval may be left open and unsupported. If PVC screen is necessary, the completion interval may be underreamed to a larger diameter prior to the installation of the

screen. The uppermost screen openings will be placed below the bottom of the casing and the annular seal. A PVC riser pipe is extended from the top of the screen approximately 10 feet. A seal between the riser pipe and the casing is provided by one or more k-packer(s). Filter sand may be placed between the screen and the underreamed hole.

6. The well is developed to remove contaminants and fines from the drilling and completion process and maximize the flow rate. A Well Installation Record is completed which contains all the details on drilling, geophysical logging, completion materials, casing depth, completion interval, and the cement mix.

7. After drying, the drill cuttings contained in the pits are covered with subsoil and the stockpiled topsoil. The ground surface is then recontoured and reseeded.

8. The well is integrity tested as discussed in Section 3.1.2.3 below.

3.1.2.2 Well Development

Following installation, the well is developed by pumping, air lifting, jetting and/or swabbing to clean and improve the hydraulic efficiency of the well. The goal will be to remove drilling fluids and fines from the completion zone to provide good hydraulic communication and maintain the natural geochemical conditions. During well development, progress will be monitored with pH, turbidity, and conductivity measurements to determine when cleanup has been achieved, as measured by stable measurement of these parameters.

Water produced during initial well development will have minimal radiological impact and is expected to meet State of Wyoming temporary WYPDES discharge standards, therefore this water will be directly discharged to the surface.

During operation, injection or recovery wells will be routinely taken off line for maintenance and enhancement, which could include air lifting, swabbing, underreaming, or chemical treatment. Examples of chemicals used for enhancement include a weak acid solution to dissolve calcite or sodium hypochlorite to eliminate bacteria. Water produced during routine stimulation of active wells will be collected and placed in lined retention ponds or injected in a deep disposal well.

3.1.2.3 Well Mechanical Integrity Testing

Prior to being placed into operation, the integrity of the wells will be verified by a pressure based mechanical integrity test (MIT). After initial testing, the well will be retested at 5-year intervals. In addition, the MIT will be repeated if the well is entered by a drilling bit, underreaming tool, or if it is suspected that well damage is possible for any reason. The well integrity information will be documented and filed on site and provided to WDEQ/LQD on a quarterly basis. As part of the well integrity documentation provided in the quarterly report, WDEQ/LQD will also be provided records which detail the quantities and procedures used for annular sealing of the wells. This information will include the cement density, quantities of cement, bentonite, and displacement water, and confirmation that cement was pumped to the surface during sealing. The quarterly report will also include required information on failed wells.

The MIT is conducted by placing inflatable packers near the top of the casing and above the screen interval. The packers are inflated and the interval between the packers is pressurized with water to the test pressure (maximum allowable injection pressure plus a safety factor of 25%). Since the maximum injection pressure (measured in the module building) is 140 psi, the integrity test will be conducted at 175 psi. This pressure must be maintained within 10% for 10 minutes to pass the MIT. An alternative to using a top inflatable packer may be utilized where the top of the casing is sealed by a specially designed flange top. A well integrity record will be completed for each tested well. If a well shows an unacceptable pressure drop during the integrity test, the packers may be reset and the equipment checked for leaks. If in successive tests the well passes the integrity requirements, the well will be deemed acceptable for use as injection, recovery, or monitor well. If a well continues to fail MIT, it will be plugged and abandoned. Any well which is abandoned due to MIT failure or has arrived at the end of its useful life will be sealed with cement slurry. Plugging and abandonment procedures are detailed in Addendum 2.6-E. Monitor wells which are abandoned due to failure of MIT, will be replaced. An abandonment record will be completed and retained on site until termination of the license.

3.1.3 ISR Process

The ISR process proposed for the Ross ISR Project mobilizes uranium through an oxidation and dissolution process using a recovery solution and a series of injection and recovery wells covering the ore body. The recovery solution, or lixiviant, is made up of an oxidant (hydrogen peroxide or gaseous oxygen) and a complexing agent (sodium bicarbonate or carbon dioxide) added to the native groundwater.

3.1.3.1 Lixiviant

The lixiviant at the Ross ISR Project will utilize gaseous oxygen (O_2) or hydrogen peroxide (H_2O_2) for the oxidant and sodium bicarbonate ($NaHCO_3$) or carbon dioxide (CO_2) for the complexing agent. The carbonate/bicarbonate lixiviant was selected due to its compatibility with minerals within the ore body. The moderate carbonate concentration in the ore bearing aquifer could lead to fouling of the recovery wells and the formation if an acid based lixiviant is used. In addition, carbonate/bicarbonate lixiviants are generally considered easier to restore than other acid based lixiviants (NRC 2009). Preliminary agitation leach testing results performed in 2010, demonstrate that these reagents will successfully mobilize the uranium into solution at concentrations typical of other similar projects. Final results of leach testing are not available, however, the optimized reagent concentrations used in the lixiviant indicate only moderate increases of other compounds during recovery, enabling successful restoration using minor and selective groundwater sweep, reverse-osmosis and stability phase reclamation efforts. Similar lixiviant makeup was used for in situ recovery at the R&D project and is being successfully used by various in situ recovery operations in Wyoming under similar conditions.

The carbonate/bicarbonate concentration in the injection solution will generally be less than 4 grams per liter (g/l) and the oxidant will generally be less than 1 g/l. The concentrations of various parameters in the lixiviant (barren or pregnant) are shown in Table 3.1-1.

3.1.3.2 ISR Chemistry

The lixiviant will be fortified with complexing agent at the CPP and then pumped to the module buildings where the oxidant addition and, potentially, CO_2 addition will be completed at the manifold. The lixiviant is then injected, passed through the ore, and the uranium enriched lixiviant is pumped from

the recovery wells and returned to the CPP. At the CPP, uranium is extracted by the IX process and the barren solutions are refortified with the oxidizing/complexing agents and circulated back to the injection wells in a continuous cycle. The recovery process will be continued in a particular wellfield until the uranium concentration in the recovered solutions is considered to be uneconomical.

Leaching (approximately neutral pH)

The in-place uranium mineral (uraninite) is oxidized to change the uranium valence from the insoluble +4 state to the soluble +6 state using hydrogen peroxide or gaseous oxygen. Oxygen is usually used due to economic and ease of use considerations. The complexed uranium is uranyl dicarbonate or uranyl tricarbonate depending on pH conditions. Due to the excess carbonate in the system, the uranyl tricarbonate will be the dominant species with a minor amount of uranyl dicarbonate existing in the solutions. Additional chemicals that may be added prior to injection include carbon dioxide to adjust the pH and provide a carbon source, and chlorine to eliminate bacteria.

The chemical reactions for the in situ recovery of uranium are shown below:

Oxidation: $UO_2 + ½\ O_2 \rightarrow UO_3$ or $UO_2 + H_2O_2 \rightarrow UO_3 + H_2O$

Complexing: $UO_3 + 2HCO_3^- \leftrightarrow [UO_2(CO_3)_2]^{2-} + H_2O$ or

$UO_3 + CO_3^{2-} + 2HCO_3^- \leftrightarrow [UO_2(CO_3)_3]^{4-} + H_2O$

3.1.4 Wellfield Design and Operation

Strata is currently in the process of delineating uranium ore within the proposed Ross project area. At this time, ISR wellfields are expected to encompass approximately 90 acres within the project area. Strata anticipates additional uranium ore will be discovered. As such, the final wellfield size is expected to increase between now and the time that the wellfields are installed. In some areas, multiple vertically stacked roll fronts have been identified. ISR operations within the stacked roll fronts will occur simultaneously, which will help to minimize the overall bleed requirements of the system. The wellfield will be divided into discrete modules with approximately 40 recovery wells per module. Wells within each module will be individually piped to a module

building where they will be manifolded together. The proposed Ross ISR Project is expected to encompass some 15 to 25 modules with the final number of modules dependent on ongoing delineation efforts.

The flow capacity of each wellfield module will range from 600 gpm to 1,000 gpm. Electrical power will be distributed to the module buildings by overhead power lines. Electrical distribution to the individual recovery and injection wells will be buried. Wellfield access roads will be constructed in accordance with regulatory guidelines.

The recovery and injection wells will be arranged in 7-spot, 5-spot, line drive, or staggered line drive patterns. The patterns will be modified to fit the ore body, and well spacing will range from 50-150 feet. In support of this application, a groundwater flare evaluation was performed using MODPATH and MODFLOW as described in Addendum 2.7-H. During the modeling exercise, it was apparent that a line drive pattern is likely to have a greater flare than a typical 5 or 7-spot. The additional flare means that increased restoration efforts will be required. In order to minimize restoration efforts, Strata plans limited use of line drive patterns. Where it is not possible to avoid the use of line drive patterns, Strata will perform additional modeling to determine the most efficient well spacing to provide the most effective restoration.

Each wellhead will be covered by an insulated fiberglass box in order to provide freeze protection and spill containment. The protective cover includes a solid base with access tunnels for well casing, electrical, and water flow lines. The solid base will act to contain small leaks and will include leak detection. Well identification plates will be installed on both the protective covers and wellheads. A typical wellhead and protective cover is depicted on Figures 3.1-7 and 3.1-8. The recovery and injection wells will be connected to the module buildings utilizing individual 1-inch to 2-inch HDPE pipelines. The pipelines will be buried to a depth of 2 to 6 feet to prevent freezing and to provide unrestricted wellfield access. Each recovery well will contain a submersible pump sized to carry solutions from the well to the module building. Injection wells will have HDPE stingers for delivery of lixiviant to the ore zone and air release valves to relieve pressure in the wells from injection.

The module buildings will be located throughout the wellfield and will be approximately 15 feet by 40 feet in size. Piping inside each module building will be HDPE, PVC, or stainless steel rated for an operating pressure greater than

the proposed maximum injection pressure. Each well line will have a totalizing flow meter, pressure transmitter, and a manual valve to control the flow rate. A small sample collection valve for each well will be included on the recovery flow lines. The recovery wells will be manifolded together on one side of the building and the injection wells will be manifolded together on the other side. Flow meters providing rate and totalizer readings will be located on the module feeder lines. All flow meters and pressure transmitters will have the capability of being monitored locally and at the CPP. Booster pumps may also be necessary to provide the design pressure of refortified barren lixiviant in the injection trunk lines and to carry pregnant lixiviant to the CPP in the recovery trunk lines. Additionally, the module buildings will contain the electrical control equipment required for the recovery pumps. The injection manifold will be fitted with a pressure limiting valve, a pressure transmitter, and oxidant dispersal equipment. A schematic of typical module building piping and instrumentation is shown in Figure 3.1-9.

The wellfield flows will be balanced based on the module injection and recovery feeder line meters. The module injection and recovery feeder line flows will be compared to the summation of the individual injection and recovery well meters. The individual well flow targets will be determined on a per pattern basis to assure that local wellfield areas are balanced on at least a weekly basis.

The maximum injection pressure will be less than the formation fracture pressure, which is typically estimated at 0.67 psi per foot of overburden (approximately 325 psi at the proposed Ross ISR Project) and less than the pressure rating for operation of the piping and other equipment. Although injection pressures are initially expected to be relatively low, the ability to inject fluids within a specific wellfield generally tends to decrease with time. In order to maintain flow rates and wellfield balance, some wells will require flexibility in their allowable injection pressure. The maximum injection pressure will be limited to 140 psi measured at the injection manifold.

While injectivity issues plagued the Nubeth R&D site, improvements to well design, well development, and filtration systems will be utilized at the proposed Ross ISR Project. Improved well construction technologies developed by other producers and field tested during regional baseline well installation include underreaming, screening and filter pack installation. Well development will employ quantitative measurements of key water quality parameters to

ensure removal of fines prior to operation. Filtration systems upstream of the IX columns will ensure that fine particles are not sent back to the injection wells. Testing of well development procedures was utilized during baseline well purging while ongoing leaching tests will assist in developing filtration system requirements.

HDPE injection and recovery feeder lines will convey lixiviant and recovery solution between the trunklines and module buildings. Feeder lines will be buried and connected to the main HDPE trunk lines, which deliver solutions to and from the CPP. Feeder line and trunk line junctions will be contained in valve manholes, located along the trunk lines. Each module building will have the capability of being isolated from the trunk lines by manually operated butterfly valves contained in the valve manholes. A typical valve manhole is depicted on Figure 3.1-10. The manholes will have leak detection devices, which will activate an audible and visible alarm at the CPP in the event of a leak. Pressure transmitters on each end of the trunk lines and feeder lines will relay pressure readings back to the CPP control room. In the event of a pressure reading that is outside of acceptable operating parameters, an audible and visual alarm will occur at the CPP. Automatic sequential shutdown of the trunk line pumps and/or module building booster pumps and recovery well pumps will then occur if operating parameters do not return to normal ranges within a specified amount of time. A booster pump station may be required on the trunk lines if the distance from the module building to the CPP exceeds initial pump capability.

During recovery operation, more solution, termed production bleed, is recovered from the wellfield than is injected. At the proposed project, the production bleed will range from 0.50% to 2.00% and will average 1.25%. At the maximum flow rate, this is equivalent to approximately 94 gpm of production bleed. Production bleed creates a cone of depression within the wellfield and maintains an inward flow of groundwater. The inflow will prevent the migration of leach solutions toward the perimeter monitor well ring. Preliminary groundwater modeling of a sample wellfield has indicated that wellfield control can be maintained with a 1.25% bleed.

Maintenance of sufficient bleed to minimize water management and consumption while eliminating the potential for hydraulic anomalies outside of the uranium recovery areas will utilize wellfield data collection and integration within a suitable reservoir engineering software platform. Wellfield data

collection will consist of individual injection and recovery rates combined with level readings in both internal baseline wells and perimeter monitor wells. MODFLOW three dimensional simulations (presented in Addendum 2.7-H) indicate that hydraulic anomalies would be quickly detected in the perimeter monitor wells, integration with injection and recovery rates on a well-by-well basis will allow for detailed controls to maintain sufficient bleed. Well efficiency deviations would be measured utilizing data from the injection manifolds.

During operation, a portion of the injection solution will be removed and processed by two phases of reverse osmosis (RO). After treatment, most of the high quality permeate will then be circulated back to the injection stream in order to make up the correct bleed amount, the remainder will be discharged to the lined temporary storage ponds for other uses or disposal. By treating part of the injection stream, Strata hopes to help maintain the water quality of the injection solution. Efforts to maintain the injection stream will reduce the buildup of salts and other dissolved constituents, which will aid in aquifer restoration. The quantity of the injection stream that will be treated will vary throughout the life of the project, depending on operating conditions such as the amount of production bleed being utilized in the wellfields, the waste management capacity, and the water quality of the injection stream.

A three-dimensional groundwater model was developed for the proposed Ross ISR Project using Groundwater Vistas as the pre-processor and the USGS code MODFLOW. As part of the modeling exercise, the calibrated model was used to evaluate an ISR simulation for the ore bodies currently delineated within the permit area. During the simulation, production bleed from ISR, groundwater sweep, and aquifer restoration were removed from the aquifer at currently estimated bleed rates for each respective ISR stage. Simulated flow volumes were based on water balance flow rates presented in Section 3.1.5 and the project schedule as presented in Figure 1.9-1. The primary purpose of this simulation was to evaluate regional impacts from the ISR operations. The simulation was a “one size fits all” simulation that did not adjust flow rates to take into account specific well field changes. For example, where the hydraulic conductivity of the formation is lower than average the production rates may need to be adjusted accordingly. This simulation did not adjust flow rates to account for different conditions. However, the “one size fits all” simulation does conservatively predict maximum impacts to the adjacent aquifer. The

simulation is described in detail within the Groundwater Model Technical Report included as Addendum 2.7-H.

During the mine simulation, it was noted that there is a potential for wellfield interference. Under a more tedious simulation, bleed rates could be optimized for each module, which would help to minimize interference. The groundwater model could be further exploited to evaluate other options to minimize the potential for wellfield interference, such as:

1. Adjusting wellfield progression. For example, it may be possible to change the order in which each module starts the various stages of ISR operations to minimize potential wellfield interference.

2. Pre-ISR aquifer conditioning, which would include transferring water from one portion of the wellfield to another portion of the wellfield prior to ISR operations in order to "level" the potentiometric surface. As noted in Addendum 2.7-H existing industrial wells within the proposed project area have developed localized cones of depression within the ore zone aquifer. Pre-ISR aquifer conditioning would minimize the effects of the remnant cones of depression on the ISR operations.

3. Adjusting the groundwater sweep portion of the restoration (i.e., doing a more selective sweep thereby reducing consumptive use). Modeling experience has shown that some portions of a wellfield are easier to restore than others based on localized aquifer hydraulic properties and wellfield geometry. Using the groundwater model, it will be possible to evaluate portions of the wellfield where restoration is expected to be less efficient, and specifically target these areas with the groundwater sweep rather than performing groundwater sweep across the entire wellfield. As a result, the sweep can be selectively targeted to the most critical portion of the wellfield, which will minimize the consumptive use of water during the sweep portion of aquifer restoration.

4. Adjusting the overall ISR schedule. Adjustments to the ISR schedule may also minimize wellfield interference.

Based on preliminary modeling experience, it is expected that a combination of these options will minimize wellfield interference issues. Furthermore, the modeling exercises are expected to lead to the development of a more efficient wellfield layout, which will help to minimize bleed as well as operational flare. Initial modeling exercises have shown that the layout can impact the overall efficiency of the wellfield. For example, during modeling exercises, areas within the modeled wellfields where water tended to stagnate were apparent. By adjusting the well locations around these low velocity zones,

it was possible to improve the wellfield efficiency in these areas. In addition, the model allows the user to adjust the wells to account for natural groundwater gradients within the wellfields and minimize interference. As a result of modeling efforts, consumptive use of water from the formation is expected to be minimized and restoration efficiency will be improved.

3.1.5 Water Balance

Uranium recovery at the Ross ISR Project will follow a "phased" mode where one group of modules may be in operation, while the preceding group of modules are in restoration. Operation will consist of three major "phases," which include an operation only phase, a concurrent operation and aquifer restoration phase, and an aquifer restoration only phase. The following section presents the typical process flow rates for each phase. Liquid waste disposal flow rates and waste management facility capacities are discussed in Section 4.2 of this report.

The operation only phase will occur early in the recovery process after the first group of modules is constructed. A typical water balance schematic and table for the operation only phase is included in Figure 3.1-11. The water balance represents the maximum recovery flow scenario of 7,500 gpm with the average bleed rate of 1.25%. During this phase, 220 gpm (variable as shown on Figure 3.1-11) of barren lixiviant will be removed from the recovery stream and routed through two phases of RO. Approximately 126 gpm of permeate will be returned to the injection stream and approximately 57 gpm will go into lined retention ponds. The resulting brine stream from the second phase RO is 37 gpm. While Figure 3.1-11 shows typical flow rates, a range of flow rates for each stream can be obtained by adjusting the RO feed. For example, zero excess permeate could be achieved if the RO feed rate was increased to the point that the final brine rate matches the production bleed. This scenario would maximize the brine rate to the lined retention ponds. Conversely, the final brine rate could be minimized by not reinjecting any RO treated permeate.

The concurrent operation and aquifer restoration phase will occur when several of the first modules of each Mine Unit have been depleted and are ready for restoration activities. As aquifer restoration is started on these modules, ISR will be ongoing in the subsequent modules. A typical water balance schematic and table for the concurrent operation and aquifer restoration phase is shown in Figure 3.1-12. The operation flow includes the maximum recovery

flow of 7,500 gpm and average bleed rate of 1.25%. The aquifer restoration flow will include 1,025 gpm from modules in the reverse osmosis and permeate injection stage of aquifer restoration, as well as 75 gpm from modules in the groundwater sweep stage. In this phase, all of the permeate is routed either to the injection stream for refortification and injection, or to the restoration injection stream. No permeate will be discharged to the lined retention ponds during the typical flows. Brine waste from the secondary RO unit will consist of 202 gpm from both the recovery and restoration streams. As in the operation only phase, it will be possible to minimize or maximize permeate and brine flow rates by adjusting the RO feed rate. The highest rate of excess permeate discharging to the lined retention ponds will occur during the first few months of the concurrent operation and aquifer restoration phase when groundwater sweep is occurring without RO reinjection to modules in aquifer restoration. While up to 0.5 PVD has been proposed for the ground water sweep phase, selective recall of lixiviants in areas identified during operations may also be utilized. Preliminary groundwater modeling indicates that there may be areas within a wellfield where local hydraulic anomalies or wellfield geometry result in extraordinary flare. By selectively sweeping these areas, the sweep will be more targeted and thus, significantly reduce the amount of water withdrawn from the aquifer.

The aquifer restoration only phase will take place when all modules have been depleted and only aquifer restoration activities are occurring. Aquifer restoration flows will be 1,100 gpm and, similar to the concurrent operation and aquifer restoration phase, no permeate will be discharged to the lined retention ponds. The brine stream during this phase will be 165 gpm. Including the typical flow of other liquid 11e.(2) byproduct material from the CPP, the total brine stream will be 190 gpm. The water balance for this phase is illustrated and tabulated in Figure 3.1-13. During this phase, excess clean water will be required for plant make up. Strata will utilize either excess permeate stored in the lined retention ponds, or increased bleed from aquifer restoration activities as necessary to supply plant make up water during this phase.

3.1.6 Monitor Well Layout and Design

The wellfields will be surrounded by perimeter monitor wells spaced 400-600 feet apart and at a distance of approximate 400-600 feet from the edge of the wellfield to detect potential excursions. Figure 3.1-14 shows the

proposed locations of perimeter monitor wells adjacent to a typical wellfield. Due to the level of ore zone aquifer confinement, simulations of recovery and aquifer restoration indicate that the 400-600-foot spacing successfully detects hydraulic anomalies in the form of water level increases well before lixiviant has moved beyond the active uranium recovery areas. Results of excursion simulations are presented in Section 5.7.8 and in Addendum 2.7-H. The perimeter monitor wells will be completed through the entire production zone unit, as intervening shales in the mineralized sandstones are discontinuous. Monitor wells completed in the aquifer underlying the ore zone (the DM unit), and monitor wells completed in the aquifer overlying the ore zone (the SM unit) will also be installed at a density of one well per 3-4 acres of wellfield to detect vertical migration. Samples will be collected from the monitor wells once every two weeks to be analyzed for the excursion parameters, which are defined in Section 5.7.8.1 of this report. In addition, dedicated pressure transducers and/or in situ water quality instruments may be used in the perimeter monitor wells to provide early detection of potential excursions of hydraulic anomalies.

Wellfield and monitor well integrity will be demonstrated as a requirement of the wellfield data package for the proposed Mine Unit. Hydrologic testing through pumping of recovery wells in the wellfield area and measuring response in surrounding perimeter monitor wells is a significant component of this package. Wellfield pumping and measured response in the perimeter monitor wells not only demonstrates wellfield integrity through similarity of completions but also allows accurate estimation of the horizontal hydraulic conductivity between the wellfield area and perimeter monitor well ring. By updating the groundwater model with wellfield-specific hydraulic conductivity estimates, a foundation for strong operational monitoring and control will be achieved as operational modeling platforms will utilize the same data during uranium recovery activities.

Fully penetrating perimeter monitor wells have been determined to be the optimal completion method for detection of a lateral excursion. Beyond the demonstrated ability to detect a hydraulic anomaly long before a geochemical change is apparent, this completion method has been used successfully at Christensen Ranch Mine and other active ISR projects. The discontinuous nature of the intervening shales in the OZ aquifer requires a more extensive well completion method to ensure vertical capture during an excursion event. Moreover, utilization of conservative indicator parameters such as EC,

alkalinity, and particularly chloride limits the potential for dilution, as described by Mayo (2010), as the intervals with the mineralization typically have higher horizontal hydraulic conductivities than the overlying and underlying sediments. Chloride concentrations measured in fully penetrating regional baseline wells and discreetly completed observation wells in the ore bearing sandstones correlate very well. In addition, the hydrogeologic system analyzed by Mayo (2010) was highly stratified and lacked the confinement measured at the proposed Ross ISR Project.

Baseline water quality and quantity will be collected from approximately 24 well clusters spaced at 1 cluster per 3-4 acres of wellfield. The baseline wellfield monitoring well clusters, as well as the currently installed regional baseline well clusters are presented in more detail in Sections 2.7 and 5.7.8. Completions for the deep (DM) and shallow (SM) monitoring wells will likely mimic the regional baseline cluster installations, while the ore zone (OZ) baseline wells will likely resemble the observation wells installed for the multi-well aquifer test with more limited, gamma based completions. These wells will be utilized as recovery wells during ISR operations.

Excluding the installation of pressure transducers in the fully penetrating monitor wells, water levels will be routinely measured during sampling in the perimeter, overlying, and underlying monitor wells in order to provide an early warning for impending wellfield problems. An increasing water level in a perimeter monitor well has shown be an indication of a local flow imbalance within the wellfield, which could result in an excursion. An increasing water level in an overlying or underlying monitor well could be caused by the migration of fluid from the production zone or by an injection well casing failure. This monitoring effort would allow corrective action to be immediately taken to locally balance the injection and recovery flows or shut down individual injection wells as necessary.

All previously drilled exploration/delineation holes that can be located on the project and are within a monitor well ring will be re-entered to total depth and sealed with cement slurry. Historic exploration holes are located using a hand-held metal detector that finds a brass cap with the borehole ID. After the holes are located, a small drilling rig sets up over the holes and drills them out to total depth. The holes are then cemented from the bottom to the surface. Details of the plugging each borehole will be recorded on an abandonment record, (examples in Addendum 2.7-F) which will be filed at the Oshoto field

office in the appropriate hole record and provided with the respective wellfield data package. Anecdotal data collected during the abandonment process will provide valuable information for future abandonment operations. For example, during abandonment of 55 boreholes in the vicinity of the 12-18 regional baseline well cluster it was noted that natural sealing of the clays above the ore zone sands is common, and that circulation of water and minor drilling fluids was necessary to get the holes sufficiently cleaned out prior to cementing.

Monitor wells installed as part of the wellfield data package will be constructed per WDEQ/LQD guidelines and a passing MIT record will be provided as part of the wellfield package provided to WDEQ/LQD and NRC.

3.1.7 Wellfield Leak Detection and Instrumentation

Wellfield control and monitoring will be conducted in the Module buildings' Programmable Logic Controllers (PLCs) and the data relayed to the Master Control System (MCS) in the control room at the CPP. The MCS will remotely monitor and be capable of shutting down any device or process at the module buildings. Starting capabilities will reside solely at the module buildings. The wellfield control philosophy at the proposed Ross ISR Project will be based around a fault hierarchy which allows adjustment through the PLC for fault settings and allowable time intervals for fault values. This will allow parameters to stabilize, such as during startup or in the event of a brief anomalous condition, before triggering a fault. In this manner, Strata will reduce the number of automatic faults and subsequent shutdowns that occur.

Flows and pressures for the main injection and recovery trunklines will be monitored continuously and displayed at the CPP control room. Proposed leak detection and monitoring equipment from the wellfields to the CPP is depicted on Figure 3.1-15. Changes in flow or pressure that are outside of normal operating parameters will result in the activation of visual and audible alarms and eventually automatic sequential shutdown of pumps and control valves if the condition is not corrected promptly. The flows and pressures of the injection/recovery feeder lines and the individual injection/recovery wells will be monitored locally at the module building and on a display located at the CPP control room. If flows and pressures are not maintained within a set operating range, a visual and audible alarm will be activated at the CPP.

Leak detection sensors will be located in the module building sumps and the valve manholes, which will trigger audible and visual alarms at the location

and at the CPP if fluid is detected. Strata may also utilize dual leak detection in these areas, which would consist of two sensors at high and low levels within the containment systems. When fluid is detected at the first sensor, an audible and visual alarm would be triggered at the location and at the CPP. If fluid is detected at the second sensor, automatic pump shutdown would occur to prevent the fluid from overflowing the containment system and contaminating the surrounding environment.

Piping and fitting leaks at the wellheads will be detected by sensors located in the well head sumps. In addition, a system will be instituted in the operating plan for an operator to inspect the interior of each well box on a weekly basis. Minor leaks or other problems will be detected and repaired in this manner to avoid the possibility of major spills. Weekly inspections of the wellheads are discussed in Section 5.3.3.

The main trunk lines and the module building feeder lines will undergo hydrostatic leakage testing with fresh water prior to burial to assure mechanical integrity. In addition, the individual injection and recovery well lines will undergo hydrostatic leakage testing after installation and before burial. The pressure tests will be conducted in accordance with manufacturer's recommendations or industry standards prior to final burial. In the event of leakage from pipelines or fittings, the defective component will be replaced. Prior to backfilling, a final inspection of all pipes, valves, thrust blocks and similar will be conducted in addition to evaluating embedment material and trench systems for potential unsuitable backfill. Installation and backfilling will follow typical quality assurance procedures, including:

- Laying of pipe at required grades and lines,
- Minimizing accumulation of water during laying or backfilling,
- Limiting lateral displacement with use of embedment material,
- Preventing contamination of pipe trench with foreign, unsuitable material,
- Covering pipe with at least 2-6 feet of material,
- Use of insulated tracer wire and warning tape,
- Use of properly sized and placed bedding material,
- Use of proper backfill material, which will not impose undue shock or unbalance to the pipe (i.e., frozen soils, mud, snow, etc.) and,

- Use of trench plugs at the appropriate spacing, particularly at or near areas of elevated groundwater.

3.1.8 CPP Site Hydraulic Control

Surface water and groundwater control at the Ross CPP will be necessary to mitigate the possibility of the release of process fluids to the surrounding environment. The following section describes the surface water and groundwater control at the Ross ISR Project CPP. All designs depicted and described in subsequent sections are preliminary at this time and should be considered permit level only until additional site data can be collected. Final construction level designs will be included in Addendum 3.1-A at a later date.

3.1.8.1 Site Surface Water Control

Storm water runoff at the Ross CPP will be collected and stored in a sediment pond. This will allow Strata to ensure that storm water runoff from the CPP area does not provide a pathway for contaminants to be released to the environment. The Ross CPP facility layout is depicted on Figure 3.1-16.

The areas directly adjacent to the CPP will be paved. Paved areas will be sloped to drain and collected by slot drains. From the slot drains, water will be conveyed through pipes to the sediment pond. The sediment pond will be constructed with the same liner and leak detection configurations as the lined retention ponds used to store permeate and brine. The sediment pond will be designed to contain the direct runoff from a 100-year, 24-hour runoff event. The runoff volume calculations ignore surface abstractions, which results in a conservative runoff estimate. After a significant storm event, the sediment pond will be immediately dewatered and routed to the deep disposal well.

3.1.8.2 Site Groundwater Control

Preliminary evaluations of the surficial aquifer (SA) potentiometry indicated the potential for relatively shallow water levels in the area near the proposed CPP site. Four 2-inch diameter piezometers surrounding the site were installed during initial shallow groundwater and geotechnical investigation drilling performed in May 2010. Materials encountered during drilling included unconsolidated silty clays and sandy, silty clays from 0-27 ft below ground level (BGL). The Lance Formation bedrock varied from 4-27 ft BGL depending on the monitor well location. Subsequent quarterly monitoring has indicated

fluctuating water levels with a typical depth to water of 8-12 ft BGL. Two wells indicate water in the shallow bedrock while the northern most well exhibits 15-17 ft of saturation in the unconsolidated materials overlying the Lance Formation. Well logs and completion details for the CPP area piezometers as well as soil laboratory results are included in Addendum 3.1-A. A cross section which uses well and borehole log data from the piezometers and previously drilled exploration boreholes is also included in this addendum. Water quantity and quality monitoring results for the surficial aquifer are detailed in Section 2.7.

Elevated water levels directly beneath the CPP site may create a higher risk of contamination in the event of a spill, as well as create construction and operational issues for the CPP and adjacent facilities. In order to mitigate these risks, a continuous containment barrier wall (CBW) (also known as a soil-bentonite slurry wall) will be constructed around the perimeter of the Ross ISR CPP site as shown on Figure 3.1-16. This structure will serve as a barrier between the shallow groundwater surrounding the CPP site and the shallow groundwater immediately beneath the plant facilities.

The CBW will consist of a highly impermeable in situ mixture of soil and bentonite that forms a continuous contaminant barrier around the entire CPP site. This wall will be 1.5 ft to 2 ft thick and will extend from the ground surface through the soil and unconsolidated surficial material to a point at a minimum of 2 ft into bedrock. Figure 3.1-17 shows a typical cross section of a CBW. The target permeability of this CBW will be less than the lowest permeability of the soils that lie beneath the CPP site. Preliminary tests indicate that the clays underlying the CPP have a permeability of about 2.8E-07 cm/sec (approximately the same as typical concrete); therefore, target permeability for the CBW will be about 5.0E-08 cm/sec. The target permeability of the CBW will be reached by adjusting the soil-bentonite mixture. A typical soil-bentonite mixture contains 3% by dry weight of bentonite.

The photograph on Figure 3.1-17 shows a typical in situ mixed soil-bentonite slurry wall being constructed. This particular wall serves as a positive cut-off to prevent seepage from passing beneath an earthen dam. These slurry walls are used very successfully in a wide variety of subsurface applications where a relatively impermeable barrier is required, including highly contaminated EPA super-fund sites. These structures have a history of

providing highly effective groundwater barriers with only minimal surface and environmental disturbance.

Construction of the CBW will be accomplished in the following steps. An excavator will be used to dig a pilot trench to a maximum depth of 3 ft BGL. The appropriate amount of dry bentonite will then be placed in the trench. A water line will be attached to the trencher and it will trench to the desired depth. The bentonite soil and water will then be mixed using the rotating chain of the trencher until the backfill is thoroughly mixed. Trenching will progress along the CBW alignment in a continuous manner with the necessary slump tests and samples being taken periodically.

Following construction of the CBW, a matrix of dewatering wells and interceptor trenches and/or underdrains (if required) will be installed and used to dewater the area inside the barrier wall. Dewatering wells will be used as needed throughout the operating life of the CPP to maintain a depressed water level on the inside of the CBW. Monitoring wells will be installed on both sides of the CBW. These wells will be monitored to ensure that there is always a negative gradient for the groundwater to flow from outside the CBW to the inside, and to monitor seepage. Any seepage and/or spillage collected on the inside of the CBW will be discharged to the lined ponds for storage or disposal. In the unlikely event of a process fluid spill, hazardous chemical spill, or failure of the disposal systems, this CBW and associated dewatering system will prevent migration of contaminated liquids from entering and contaminating shallow groundwater outside the facilities area. Approximate locations of dewatering and monitoring infrastructure are shown on Figure 3.1-16.

Dewatering and monitoring wells will be installed and subsequently plugged and abandoned according to WDEQ/WQD standards. In addition all locatable exploration holes within the CPP area fence will be abandoned from bottom to top with cement.

Further details of the CBW and dewatering system including specifications, construction plan, and quality control procedures will be included in the Ross ISR Project Facilities Engineering Report Addendum (3.1-A).

3.1.9 Flood Protection

Protection of equipment and facilities from large runoff events will typically be accomplished by placing the facilities on high ground out of the

flood plain. When facilities must be placed in or near a drainage channel, proper engineering controls will be used to ensure safety and environmental protection.

The CPP at the proposed Ross ISR Project will be partially located in the channel of an ephemeral stream. The site is located on an active dryland hayfield. Historically, the ephemeral channel once bisected the facility site but has since been adjusted to the east in order to optimize irrigation efforts. To route surface runoff around the CPP, a diversion channel capable of passing the 100-year, 24-hour runoff event will be constructed to the east of the facility. The primary access road for the CPP area will come from the east off of New Haven Road, a box culvert installed in the diversion channel will provide access for this road. The primary access road will have a 30-foot top width with 5 horizontal to 1 vertical side slopes. According to the American Association of State Highway and Transportation Officials (AASHTO) a 5:1 slope is traversable and recoverable and therefore, no guardrails will be used on the access road (AASHTO 2002).

A plan view of the diversion is shown on Figure 3.1-18 along with key hydraulic and design characteristics. Erosion control will utilize Armorflex® or a similar erosion control mat near the box culvert outlet. Given the low velocities, the berm upstream of the culvert and the remainder of the channel below the culvert will not use erosion protection but will be vegetated as soon as possible after construction.

A concrete box culvert has been preliminarily selected to convey runoff under the access road due to the large capacity required during the 100-year, 24-hour runoff event. In addition a box culvert will provide for ease of installation, and low maintenance considering the design life of the facility.

NUREG-1569 states that the probable maximum flood (PMF) should be used as the design flood for diversion channel designs. It is presumed that NUREG-1569 has based this from guidance presented in NUREG-1623 (NRC 2002), which states that the PMF should be used as the design flood in diversion channel and erosion protection design for uranium mill tailings storage facilities. Generally, design requirements for hydraulic structures are based on the design life of the facility. NUREG-1623 was written based on assumptions of a uranium tailings storage facility, where design life may equal or exceed 1,000 years. In the case of ISR facilities, design lives are commonly in the range of 10 to 20 years. A diversion channel at an ISR facility designed for

the PMF would be both impractical and uneconomical considering the relatively short design life. Therefore, Strata has determined that a reduced design flood will be sufficient for design of the diversion channel and erosion protection. A 100-year, 24-hour design storm was selected. A 100 year storm event has an annual exceedance probability of 1%, which means that the design storm has a 1% chance of occurring, or a 99% chance of not occurring in any given year. Over the design life of the facility, which is expected to be up to 25 years if the facility is retained to process uranium loaded resins from other generators, there is approximately a 22% chance that the design flood for the diversion channel will be exceeded. In addition, several conservative assumptions were made during the design of the diversion structure. The peak flow was calculated without taking into account runoff that will be impounded by multiple small reservoirs that are located upstream of the CPP area. Also, the diversion channel will have 1 foot of freeboard while passing the design flow. Assumptions used in the design of the diversion channel will be discussed in Addendum 3.1-A.

In the unlikely event that recovery, injection, and/or monitor wells must be located within flood plains, engineered controls and instrumentation detailed in Section 3.1.4 will act to prevent leakage to the environment or contamination to the wells from a flood event. The well seals detailed on Figure 3.1-7 and 3.1-8 will prevent inflow of flood waters down the well casing while the fiberglass structure and bottom containment feature will limit exposure of the well to the environment. Erosion control measures such as rip-rap, grading, contouring and water bars will be utilized where appropriate in order to reduce sediment mobilization and reduce velocities. All measures will use the best management practices in accordance with WDEQ/LQD Rules and Regulations, Chapter 3 or those stated in 10 CFR Part 40.

Table 3.1-1. Typical Lixiviant Concentrations

Parameter	Range
Na	< 400 to 6,000
Ca	<20 to 500
Mg	<3 to 100
K	<15 to 300
CO_3	<0.5 to 2,500
HCO_3	<400 to 5,000
Cl	<100 to 5,000
SO_4	<400 to 5,000
U_3O_8	<1 to 700
V_2O_5	<1 to 400
TDS	<1,000 to 12,000
Ra-226	<300 to 2,000
pH	<6 to 8

* All values are in mg/L except pH, which is expressed as standard units, and Ra-226, which is expressed in pCi/l.

E. 708000 E. 710000 E. 712000 E. 714000

R. 68 W. R. 67 W.

SEE FIGURE 3.1-14 FOR TYPICAL WELLFIELD AREA LAYOUT

193

CONNECTION

OSHOTO

Oshoto

68

D ROAD

MINE UNIT 1

LINED RETENTION PONDS

T. 53 N.

Oshoto Reservoir

211

DEADMAN ROAD

68

DEEP DISPOSAL WELL (TYP)

T. 53 N.

MINE UNIT 2

DOMESTIC WELL

ADMINISTRATION AND MAINTENANCE BUILDINGS

CENTRAL PROCESSING PLANT

←Uranium Mine

D ROAD

NEW HAVEN ROAD

68

164

N. 1490000 N. 1488000 N. 1486000 N. 1484000 N. 1482000 N. 1480000

R. 68 W. R. 67 W.

E. 708000 E. 710000 E. 712000 E. 714000

Drawing Coordinates: WY83EF

ROSS PROJECT AREA

LEGEND

- PROPOSED ROSS PERMIT BOUNDARY
- MINE UNIT 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

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

REVISIONS

Date	Description

TECHNICAL REPORT
FIGURE 3.1-1

APPROXIMATE WELLFIELD PERIMETER AND PROPOSED FACILITIES

Drawn By: MBM
Checked By: WCF
Date: 12/27/10

FILE: ROSS_ER_FACILITIES

WWC ENGINEERING
www.wwcengineering.com

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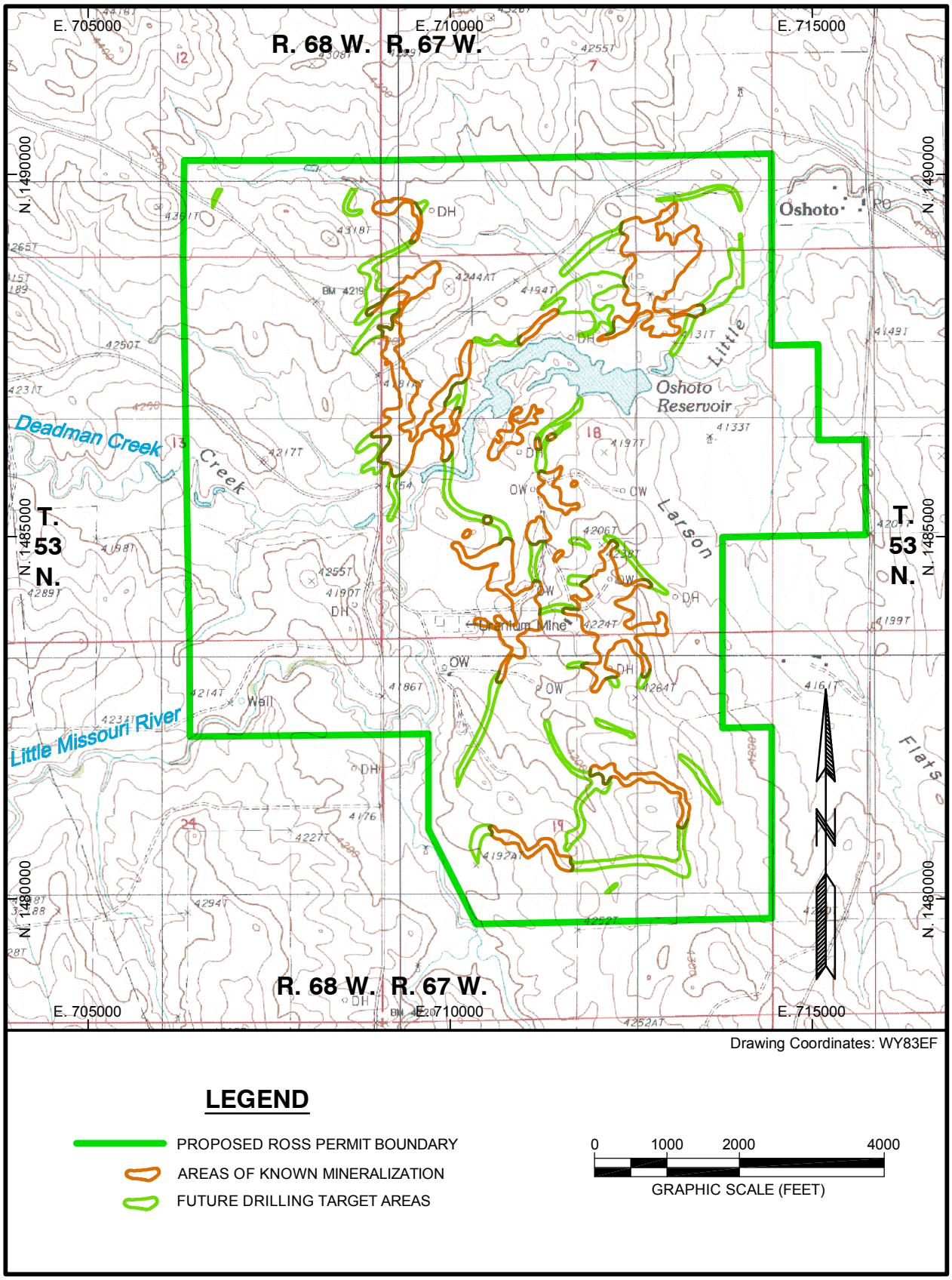

Figure 3.1-2. Current Areas of Economic Mineralization

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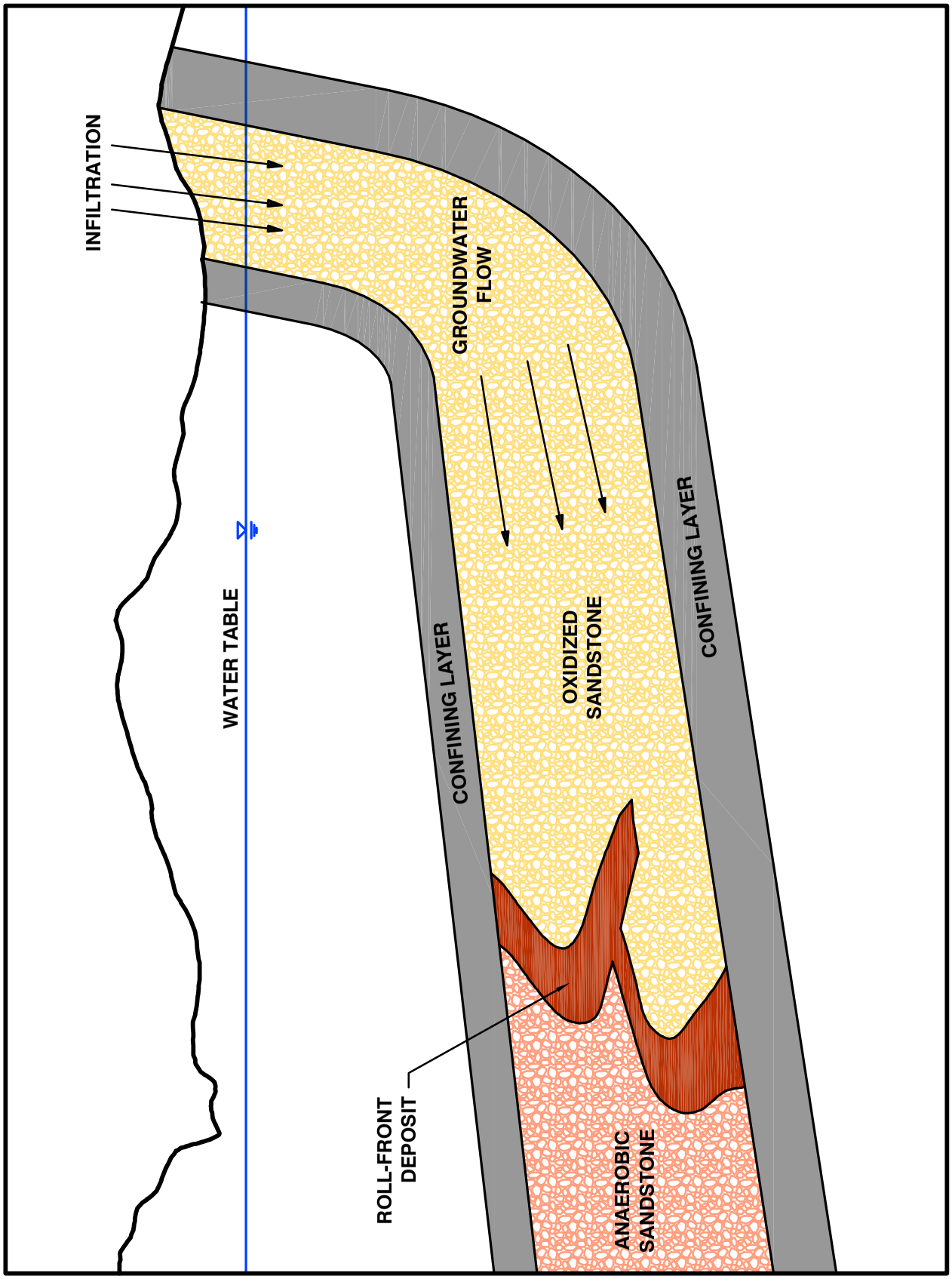

Figure 3.1-3. Typical Uranium Roll Front, Lance District

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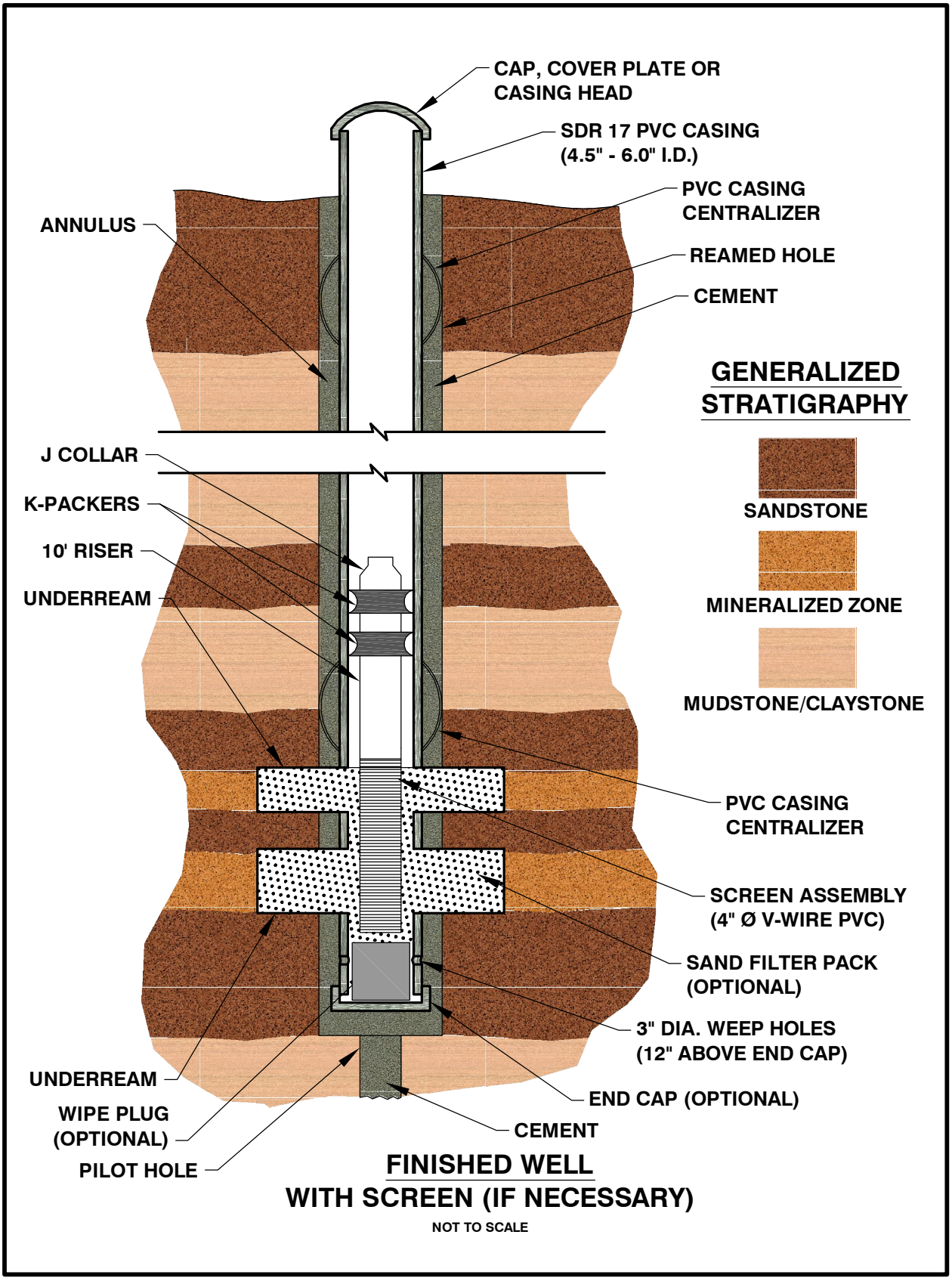

Figure 3.1-4. Proposed Well Installation - Method 1

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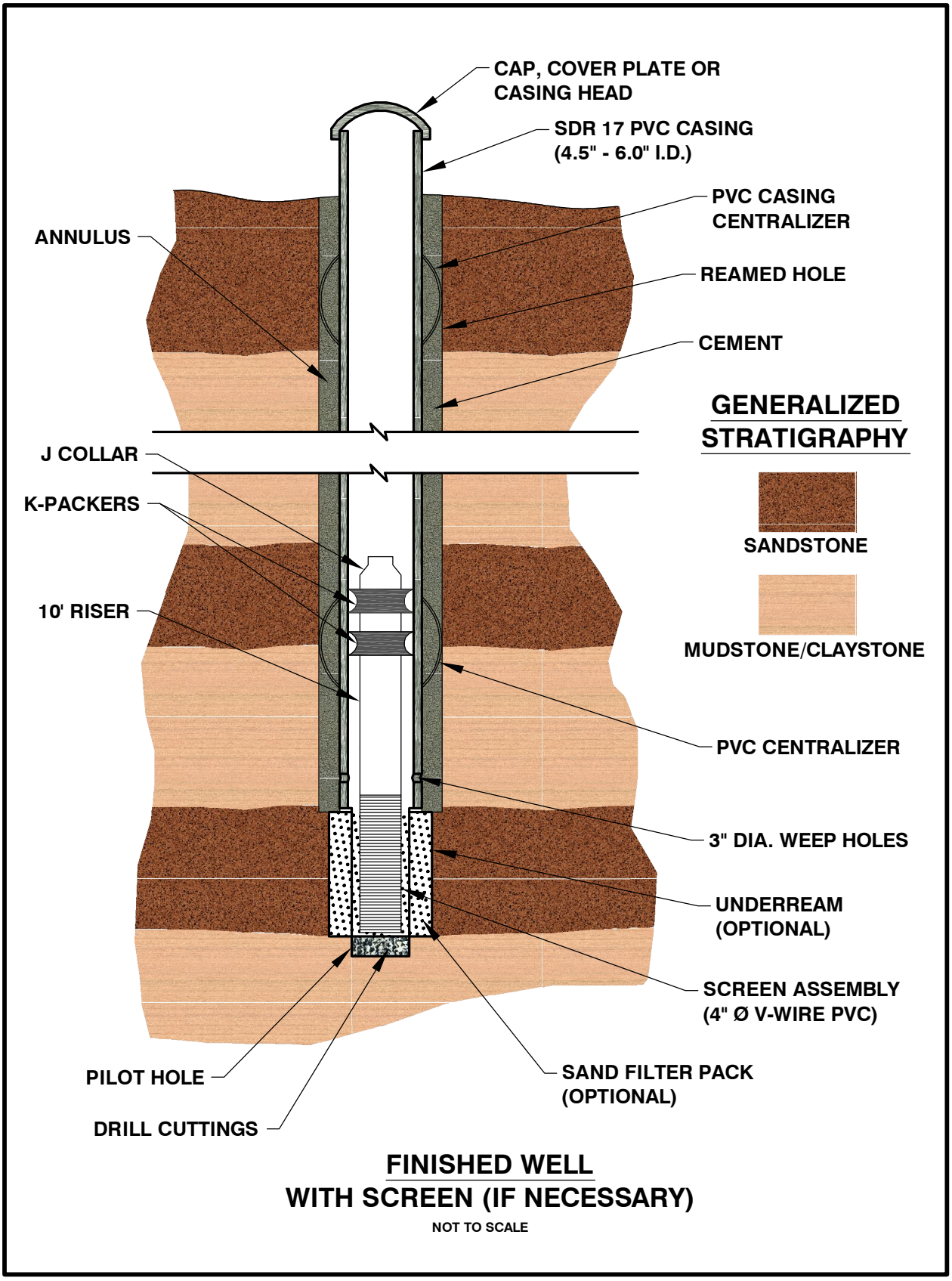

Figure 3.1-5. Proposed Well Installation - Method 2

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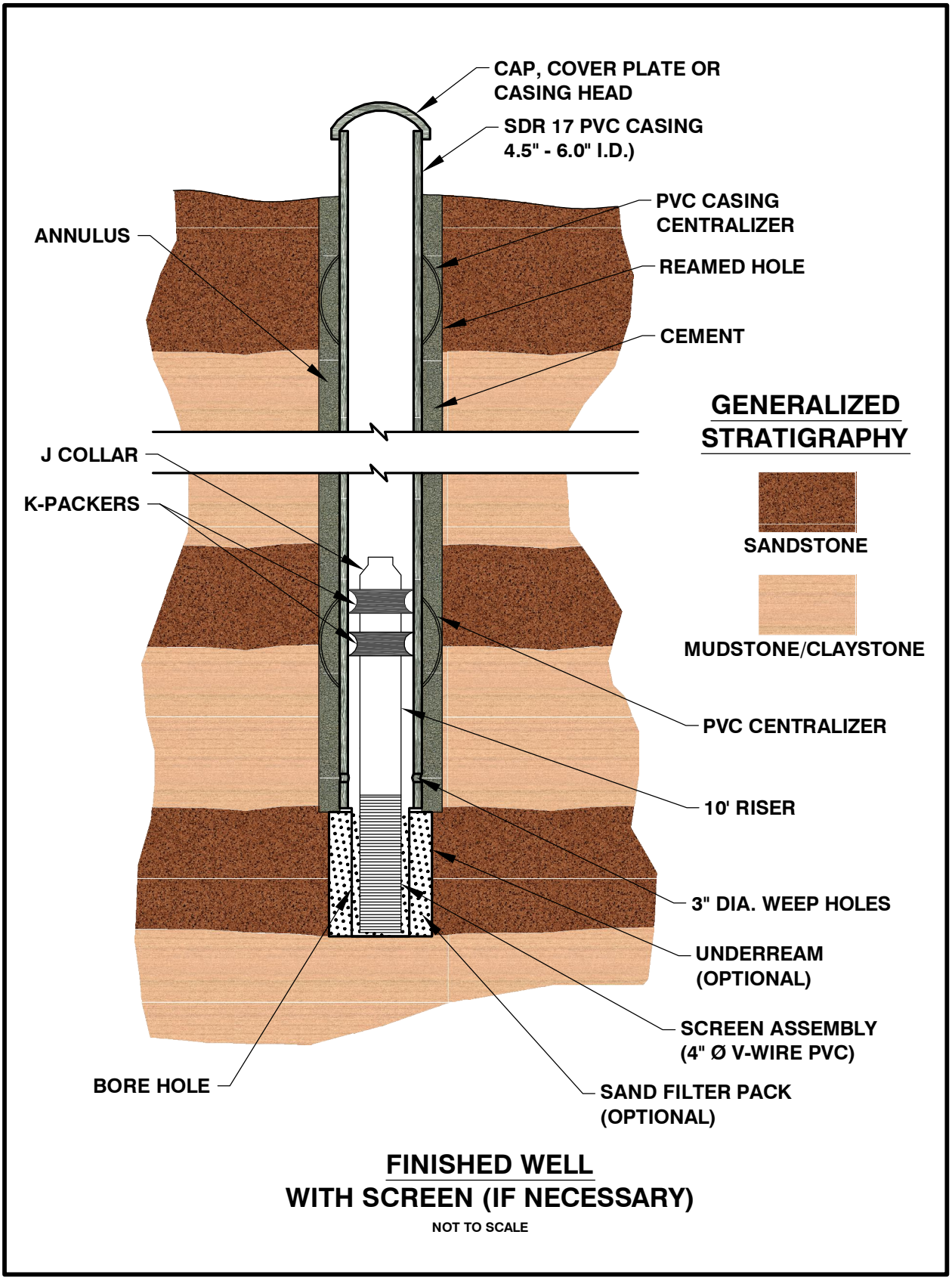

Figure 3.1-6. Proposed Well Installation - Method 3

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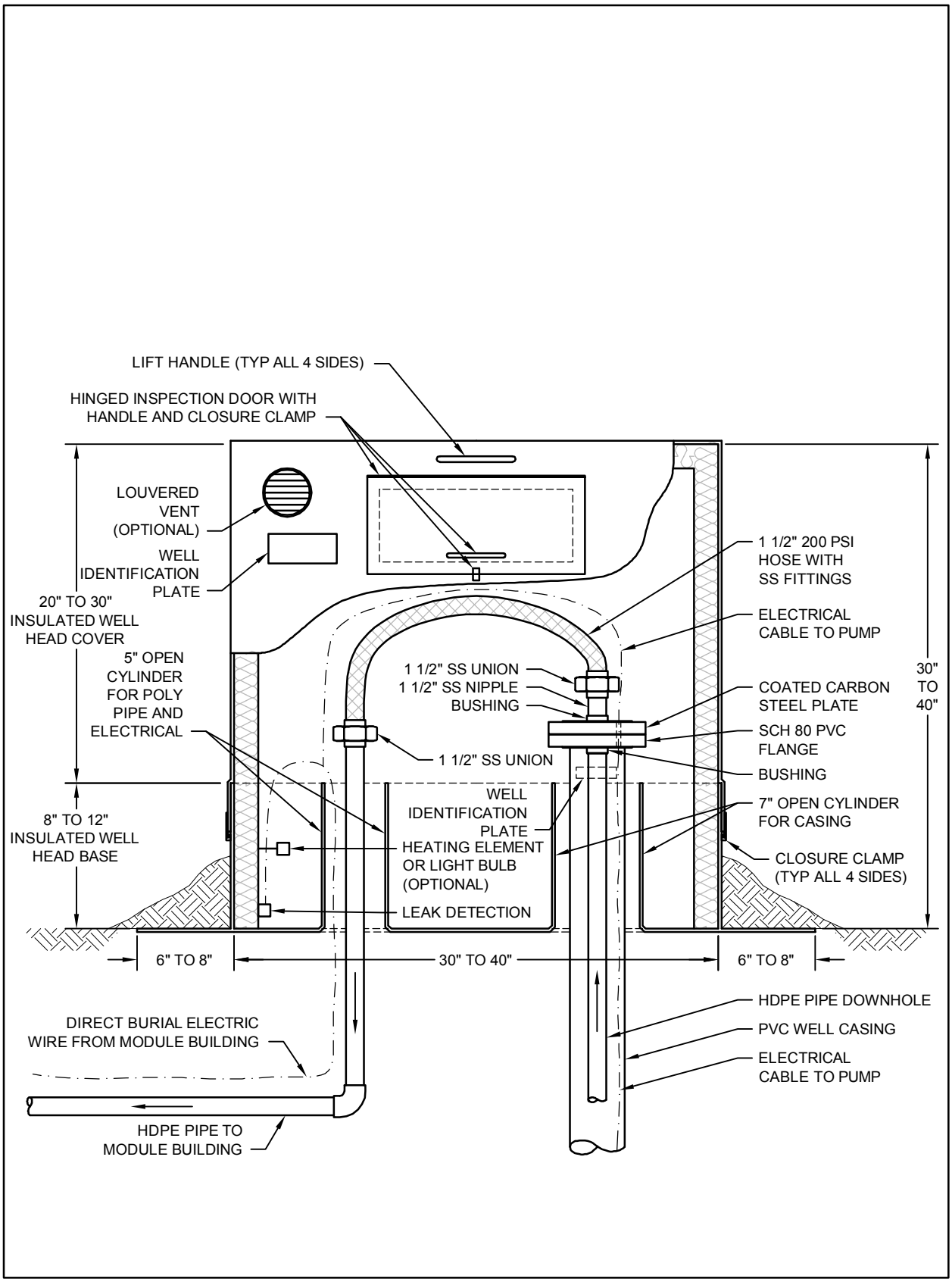

Figure 3.1-7. Typical Recovery Wellhead

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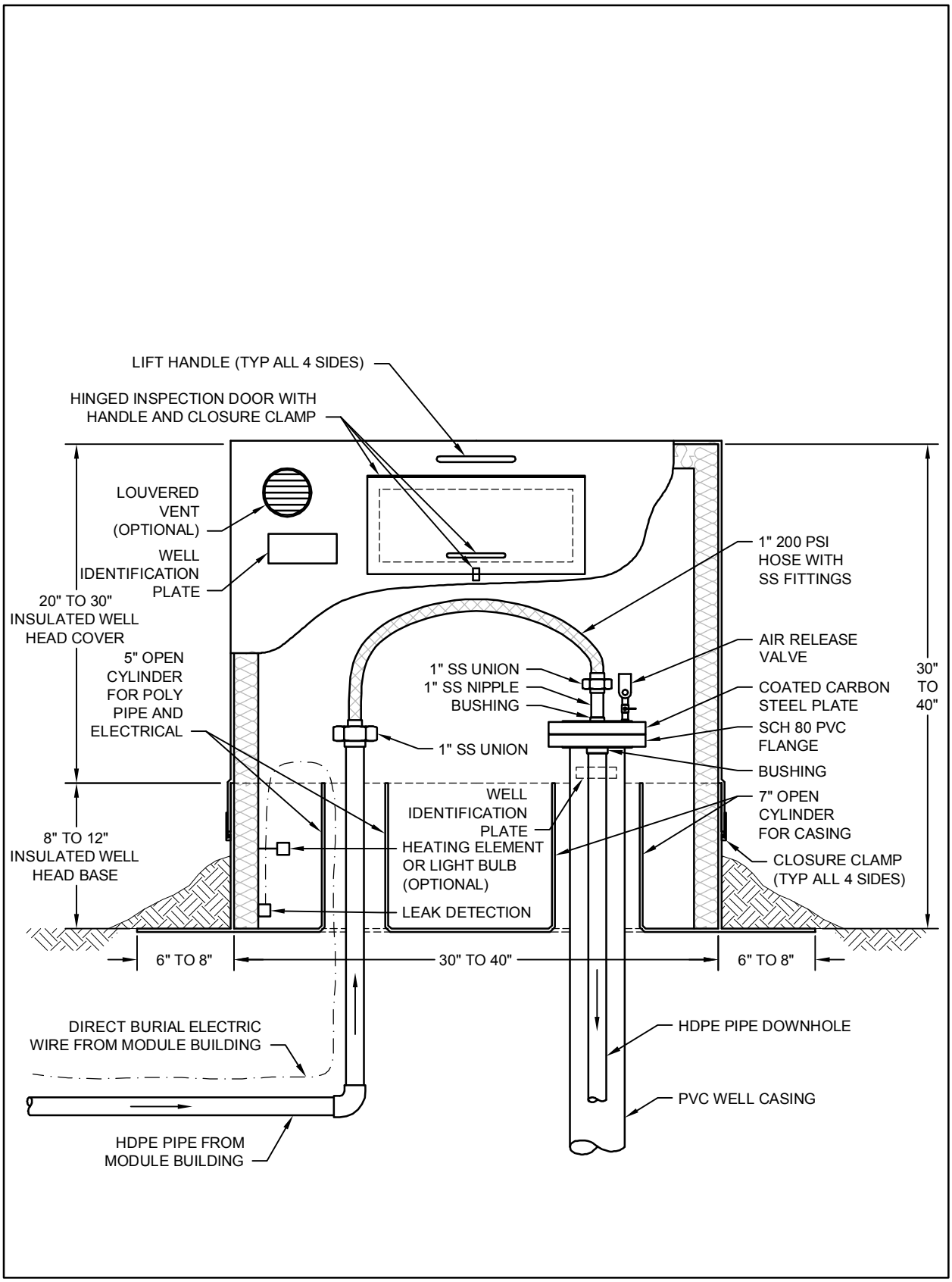

Figure 3.1-8. Typical Injection Wellhead

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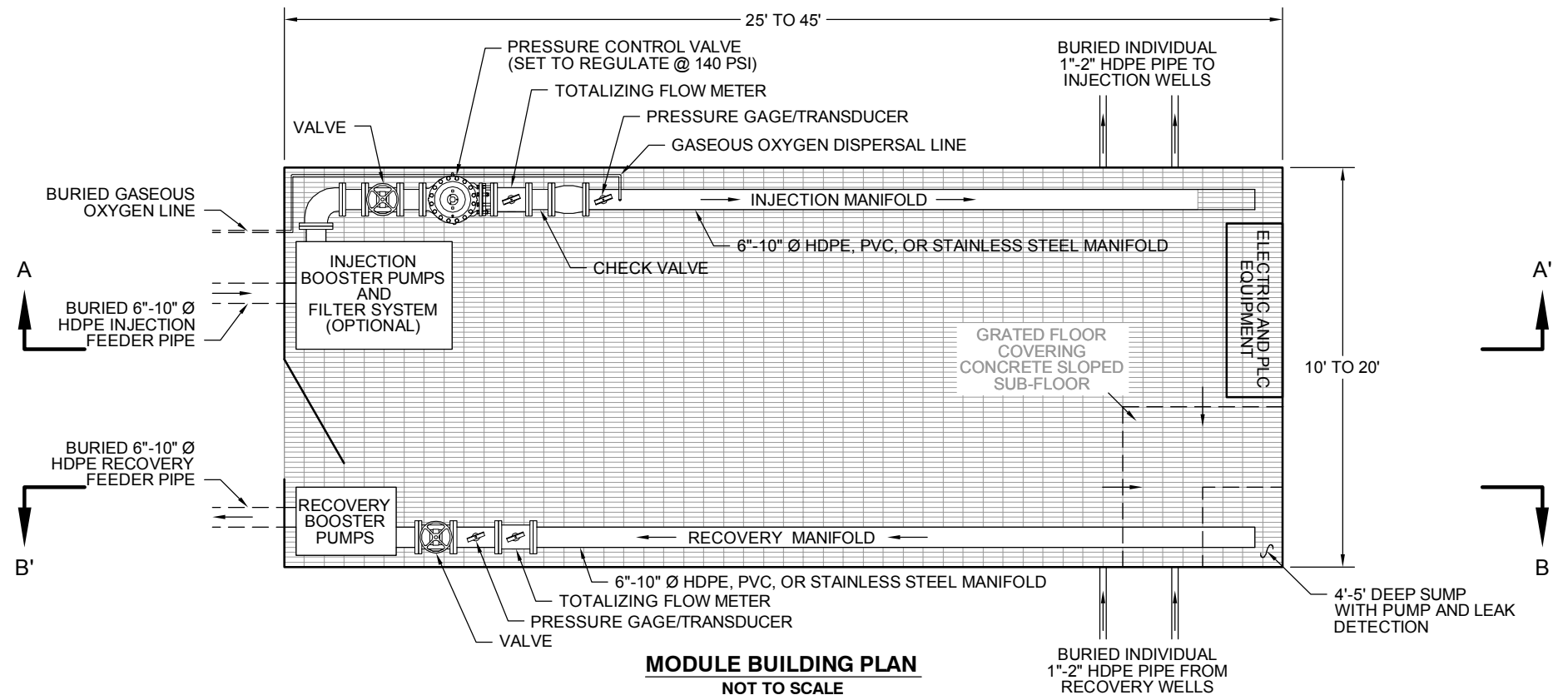
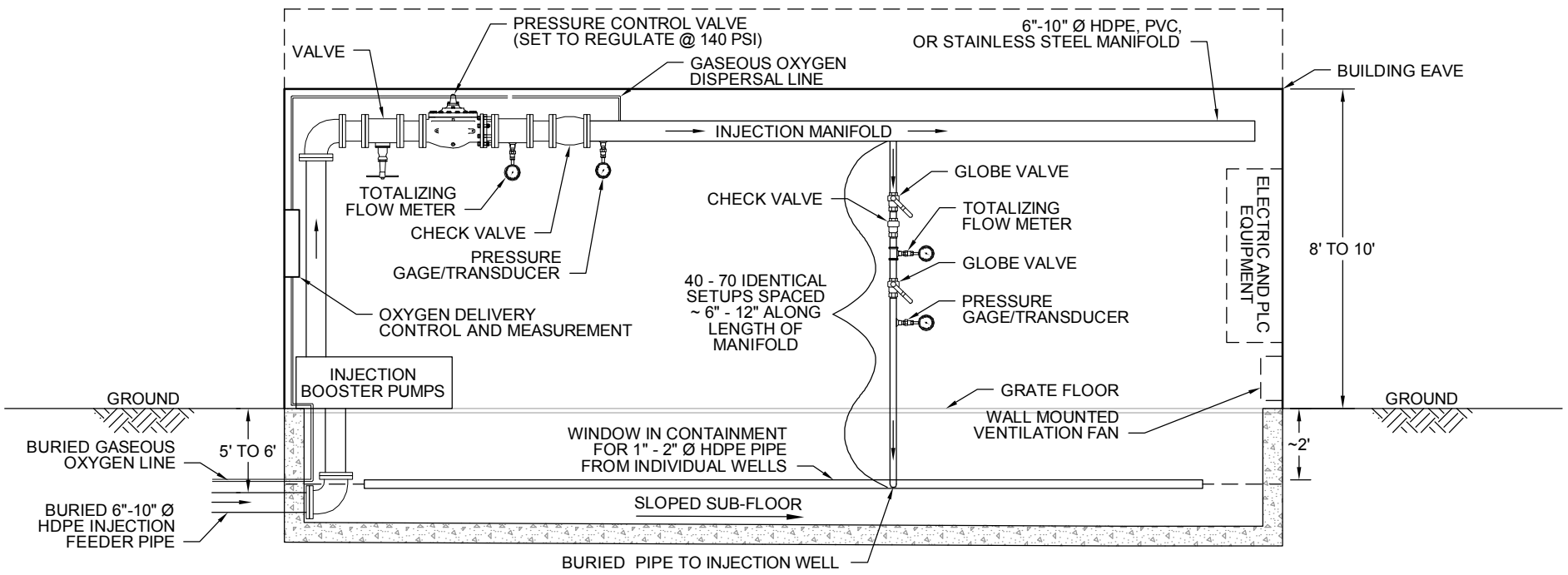
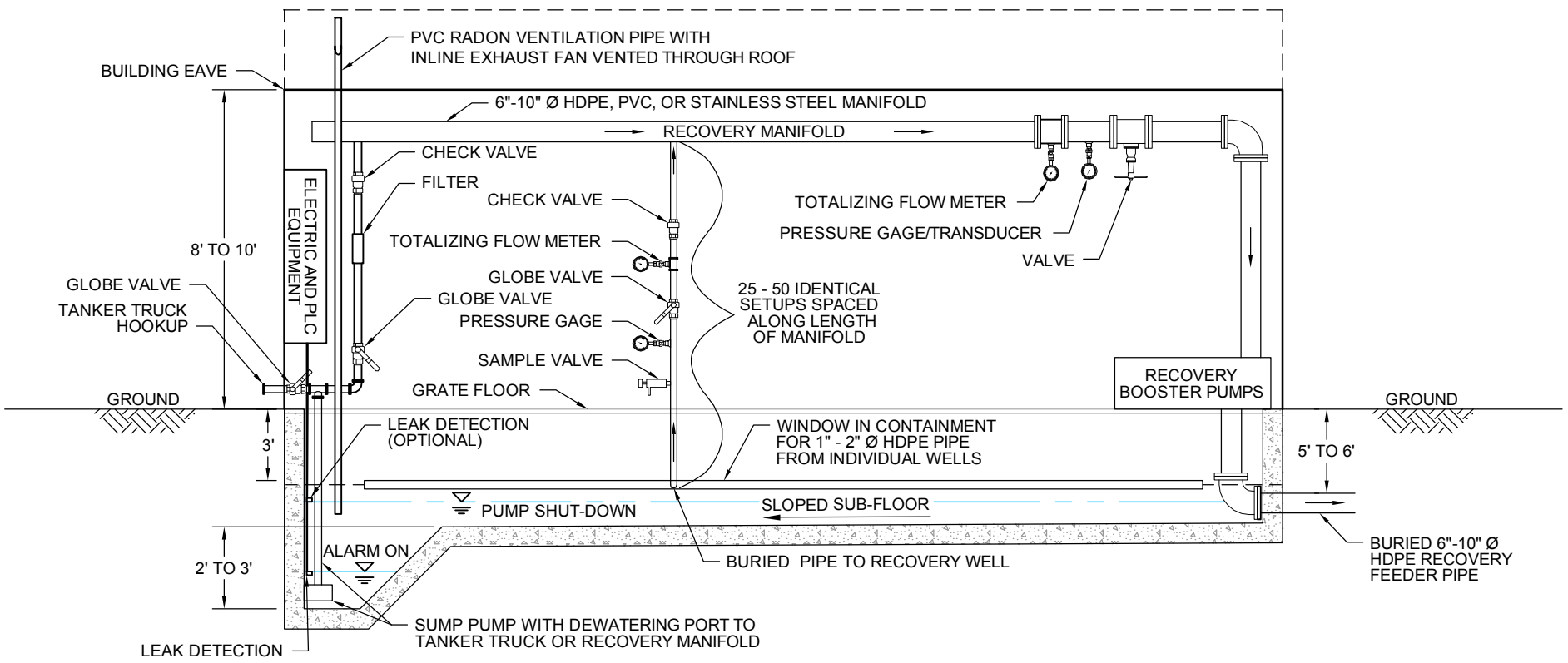


MODULE BUILDING PLAN
NOT TO SCALE



MODULE BUILDING INJECTION SIDE ELEVATION A-A'
NOT TO SCALE



MODULE BUILDING RECOVERY SIDE ELEVATION B-B'
NOT TO SCALE

Notes:
1. Totalizing flow meters will be instantaneous with the total flow reported via PLC algorithm to the SCADA System.
2. Flow and pressure analog instrument signals will be recorded via the PLC.

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FIGURE 3.1-9

WELLFIELD MODULE BUILDING DETAILS

Drawn By: RAM
Checked By: BJS
Date: 11/29/10
FILE: ROSS_TR_FAC_MODBLDG

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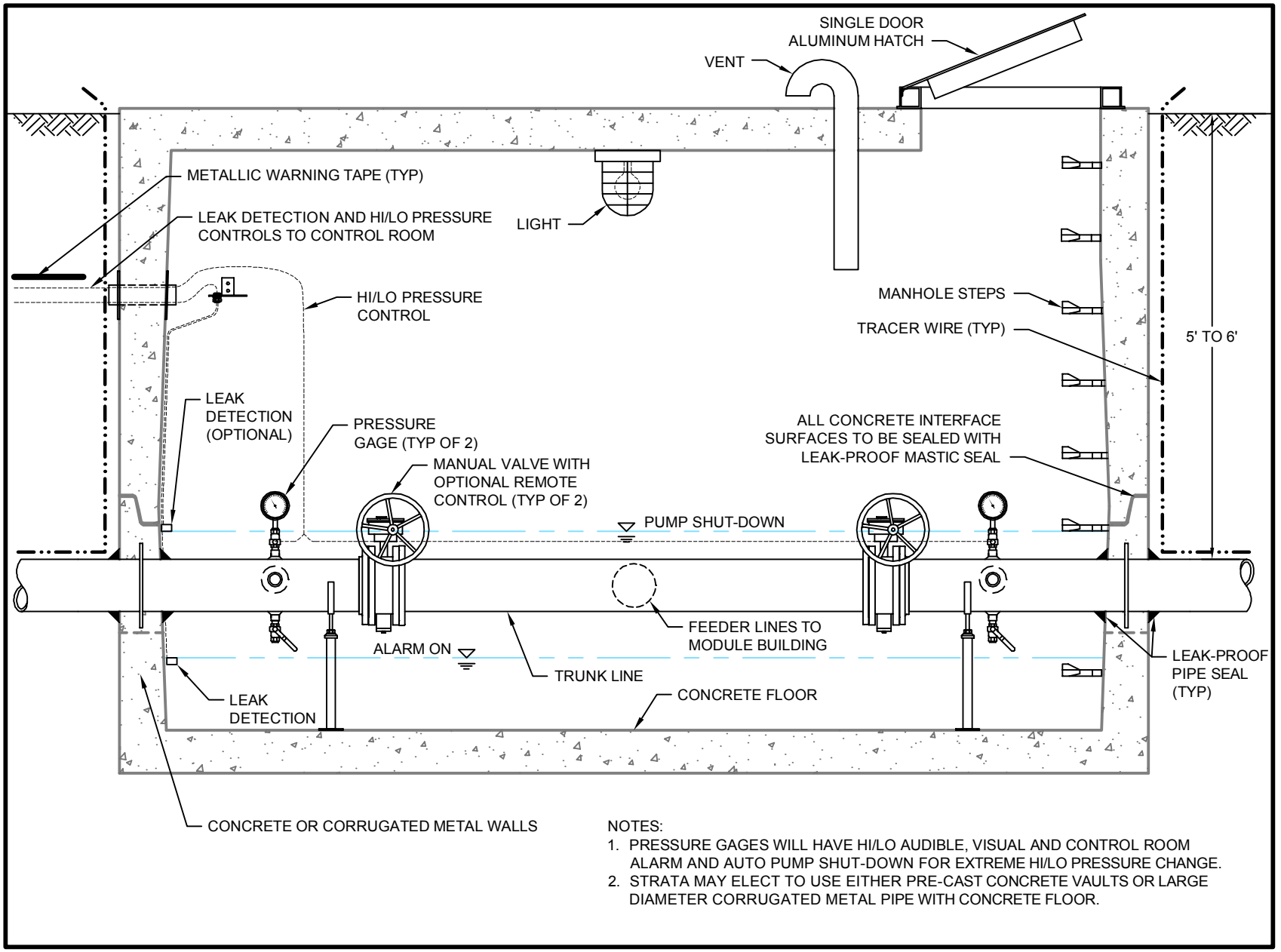

Figure 3.1-10. Typical Valve Manhole

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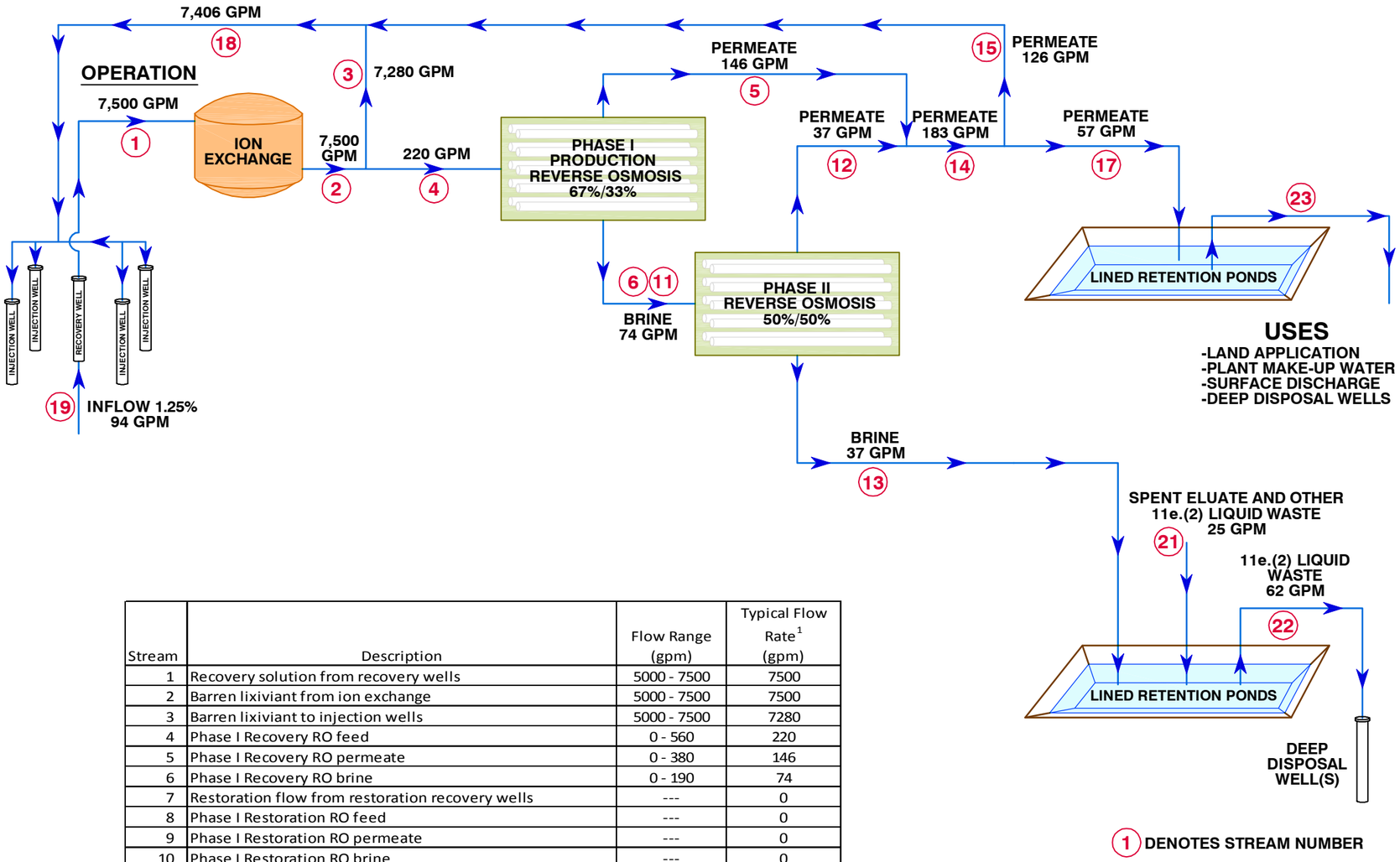

Stream	Description	Flow Range (gpm)	Typical Flow Rate[1] (gpm)
1	Recovery solution from recovery wells	5000 - 7500	7500
2	Barren lixiviant from ion exchange	5000 - 7500	7500
3	Barren lixiviant to injection wells	5000 - 7500	7280
4	Phase I Recovery RO feed	0 - 560	220
5	Phase I Recovery RO permeate	0 - 380	146
6	Phase I Recovery RO brine	0 - 190	74
7	Restoration flow from restoration recovery wells	---	0
8	Phase I Restoration RO feed	---	0
9	Phase I Restoration RO permeate	---	0
10	Phase I Restoration RO brine	---	0
11	Phase II RO feed	0 - 190	74
12	Phase II RO permeate	0 - 95	37
13	Phase II RO brine	0 - 95	37
14	Total permeate	0 - 475	183
15	Permeate to injection stream	0 - 475	126
16	Permeate to restoration injection stream	---	0
17	Permeate to lined retention ponds	0 - 80	57
18	Total flow to injection stream	4900 - 7460	7406
19	Recharge to wellfield (0.5% to 2% production bleed)	25 - 150	94
20	Recharge to restoration wellfield	---	0
21	Spent eluate and other 11e.(2) liquid waste	10 - 40	25
22	Brine and other 11e.(2) liquid waste to disposal	25 - 140	62
23	Permeate to beneficial uses and disposal	0 - 80	57

[1] Typical flow rate at 7,500 gpm recovery flow, 1.25% bleed

(1) DENOTES STREAM NUMBER

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FIGURE 3.1-11

TYPICAL WATER BALANCE DURING OPERATION ONLY

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FILE: ROSS_TR_FAC_WATER_BALANCE

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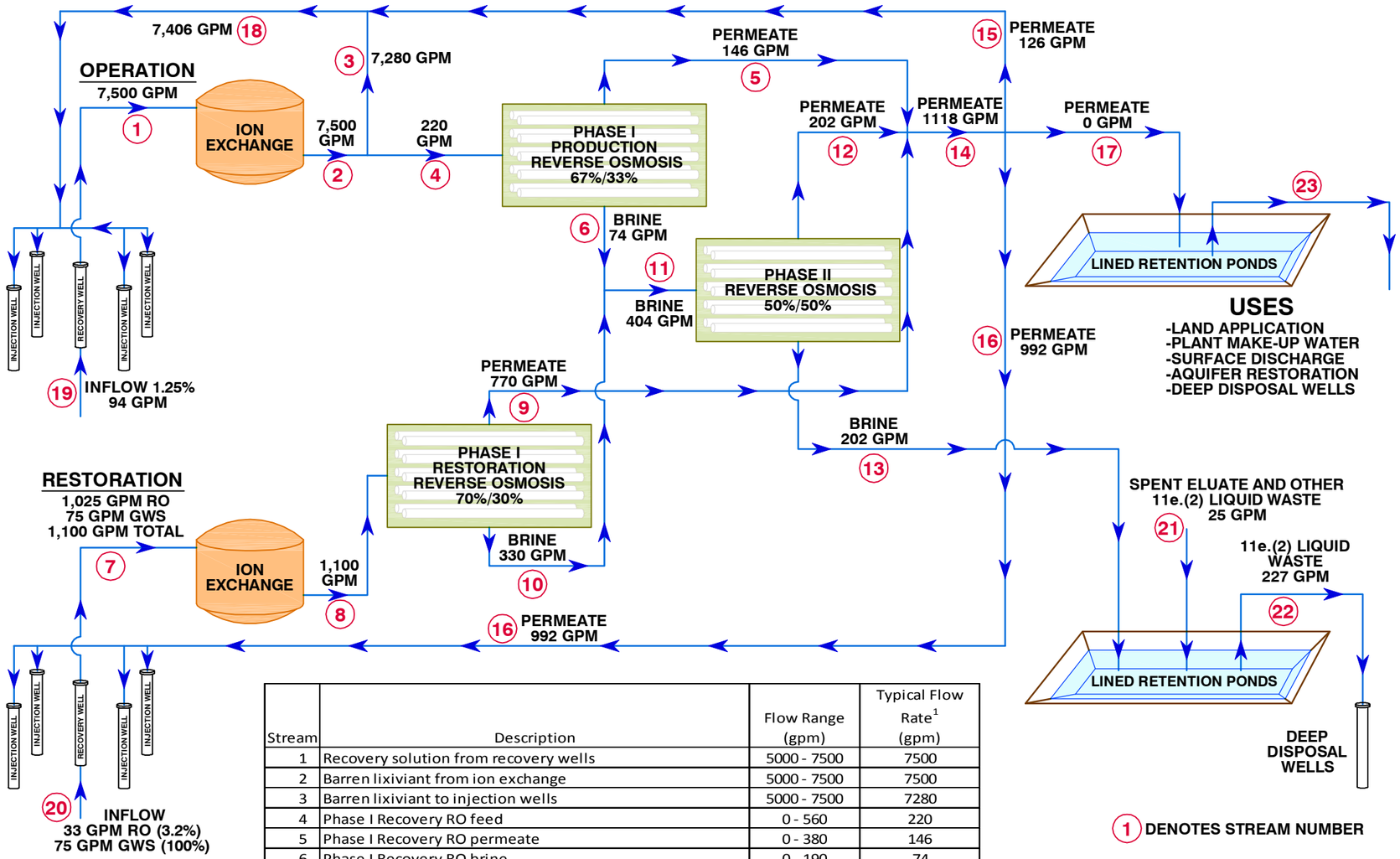

Stream	Description	Flow Range (gpm)	Typical Flow Rate[1] (gpm)
1	Recovery solution from recovery wells	5000 - 7500	7500
2	Barren lixiviant from ion exchange	5000 - 7500	7500
3	Barren lixiviant to injection wells	5000 - 7500	7280
4	Phase I Recovery RO feed	0 - 560	220
5	Phase I Recovery RO permeate	0 - 380	146
6	Phase I Recovery RO brine	0 - 190	74
7	Restoration flow from restoration recovery wells	300 - 1100	1100
8	Phase I Restoration RO feed	300 - 1100	1100
9	Phase I Restoration RO permeate	210 - 770	770
10	Phase I Restoration RO brine	90 - 330	330
11	Phase II RO feed	90 - 520	404
12	Phase II RO permeate	45 - 260	202
13	Phase II RO brine	45 - 260	202
14	Total permeate	255 - 1410	1118
15	Permeate to injection stream	0 - 470	126
16	Permeate to restoration injection stream	0 - 1000	992
17	Permeate to lined retention ponds	0 - 320	0
18	Total flow to injection stream	4900 - 7460	7406
19	Recharge to wellfield (0.5% to 2% production bleed)	25 - 150	94
20	Recharge to restoration wellfield	80 - 300	108
21	Spent eluate and other 11e.(2) liquid waste	10 - 40	25
22	Brine and other 11e.(2) liquid waste to disposal	90 - 300	227
23	Permeate to beneficial uses and disposal	0 - 320	0

[1] Typical flow rate at 7,500 gpm recovery flow, 1.25% bleed, 0.5 PVD groundwater sweep and 7.0 PVD RO

1 DENOTES STREAM NUMBER

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FIGURE 3.1-12

TYPICAL WATER BALANCE DURING CONCURRENT OPERATION AND AQUIFER RESTORATION

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FILE: ROSS_TR_FAC_WATER_BALANCE

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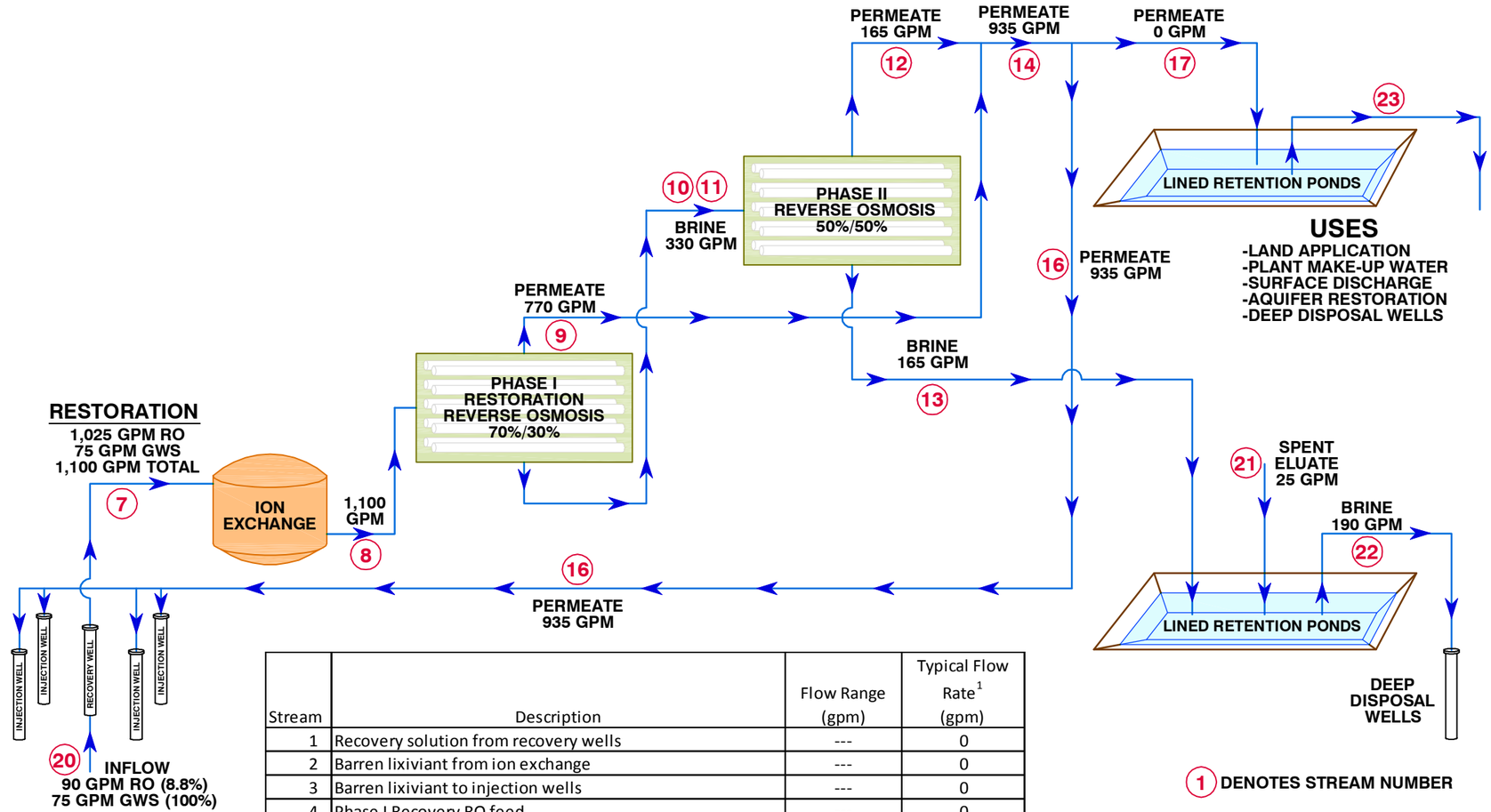

Stream	Description	Flow Range (gpm)	Typical Flow Rate[1] (gpm)
1	Recovery solution from recovery wells	---	0
2	Barren lixiviant from ion exchange	---	0
3	Barren lixiviant to injection wells	---	0
4	Phase I Recovery RO feed	---	0
5	Phase I Recovery RO permeate	---	0
6	Phase I Recovery RO brine	---	0
7	Restoration flow from restoration recovery wells	550 - 1100	1100
8	Phase I Restoration RO feed	550 - 1100	1100
9	Phase I Restoration RO permeate	385 - 770	770
10	Phase I Restoration RO brine	165 - 330	330
11	Phase II RO feed	165 - 330	330
12	Phase II RO permeate	80 - 165	165
13	Phase II RO brine	80 - 165	165
14	Total permeate	465 - 935	935
15	Permeate to injection stream	---	0
16	Permeate to restoration injection stream	465 - 935	935
17	Permeate to lined retention ponds	0 - 50	0
18	Total flow to injection stream	---	0
19	Recharge to wellfield (0.5% to 2% production bleed)	---	0
20	Recharge to restoration wellfield	80 - 170	165
21	Spent eluate and other 11e.(2) liquid waste	10 - 40	25
22	Brine and other 11e.(2) liquid waste to disposal	90 - 210	190
23	Permeate to beneficial uses and disposal	0 - 50	0

[1] Typical flow rate at 1,100 gpm restoration flow, 0.5 PVD groundwater sweep and 7.0 PVD RO

1 DENOTES STREAM NUMBER

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FIGURE 3.1-13

TYPICAL WATER BALANCE DURING AQUIFER RESTORATION ONLY

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FILE: ROSS_TR_FAC_WATER_BALANCE

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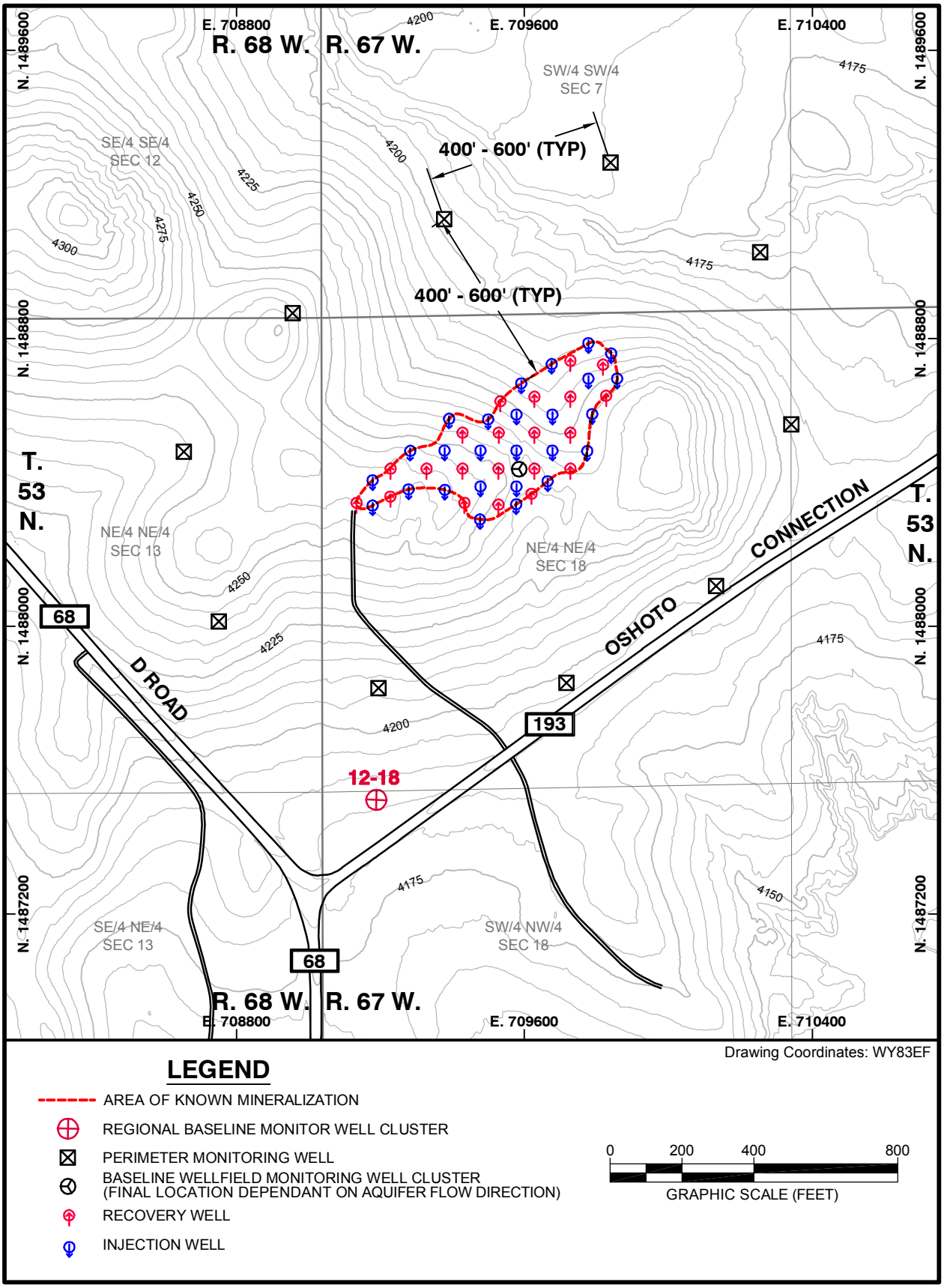

Figure 3.1-14. Typical Wellfield Area - Proposed Baseline and Perimeter Monitoring Wells

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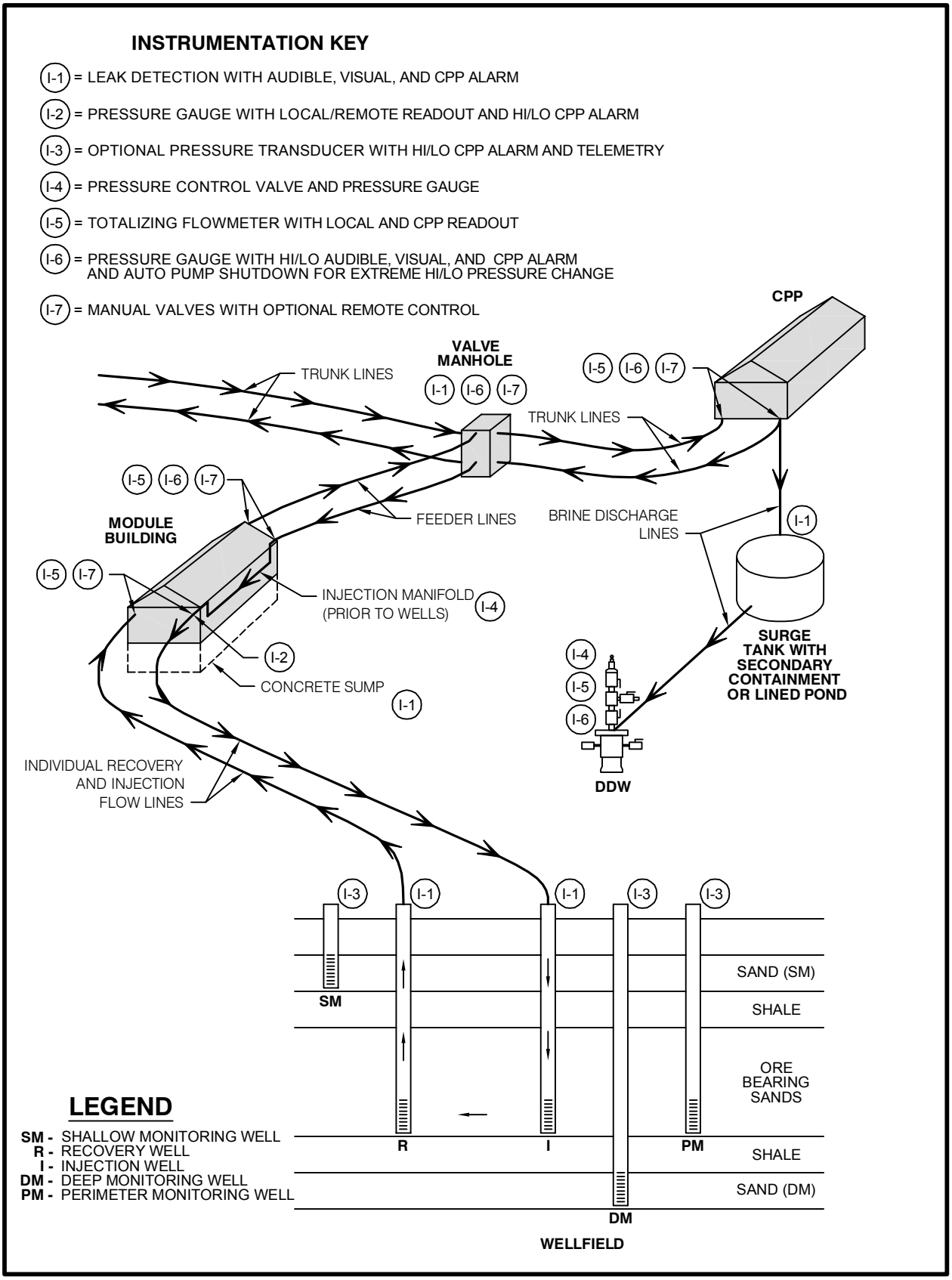

Figure 3.1-15. Typical Wellfield to CPP Instrumentation

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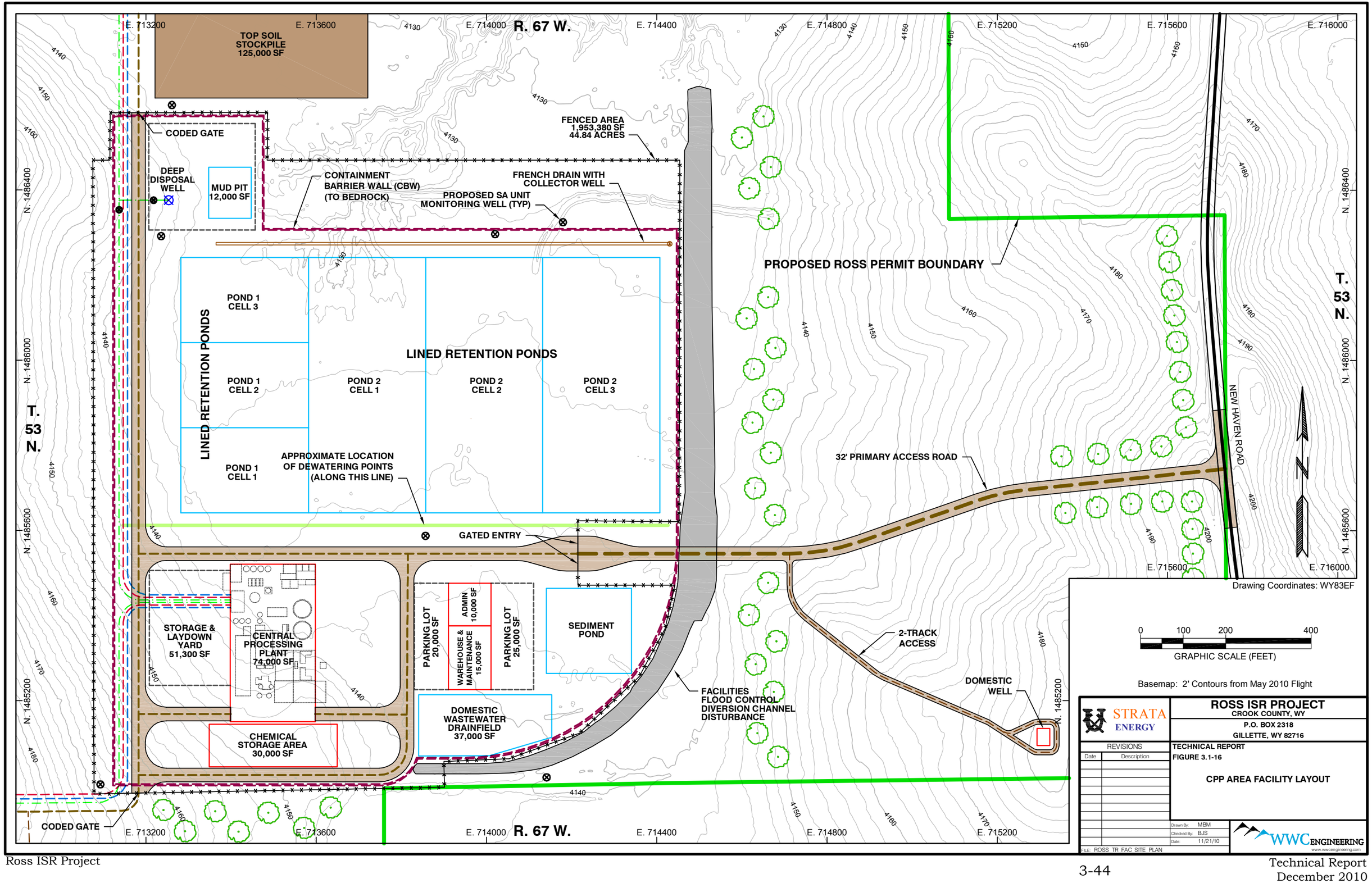

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FIGURE 3.1-16

CPP AREA FACILITY LAYOUT

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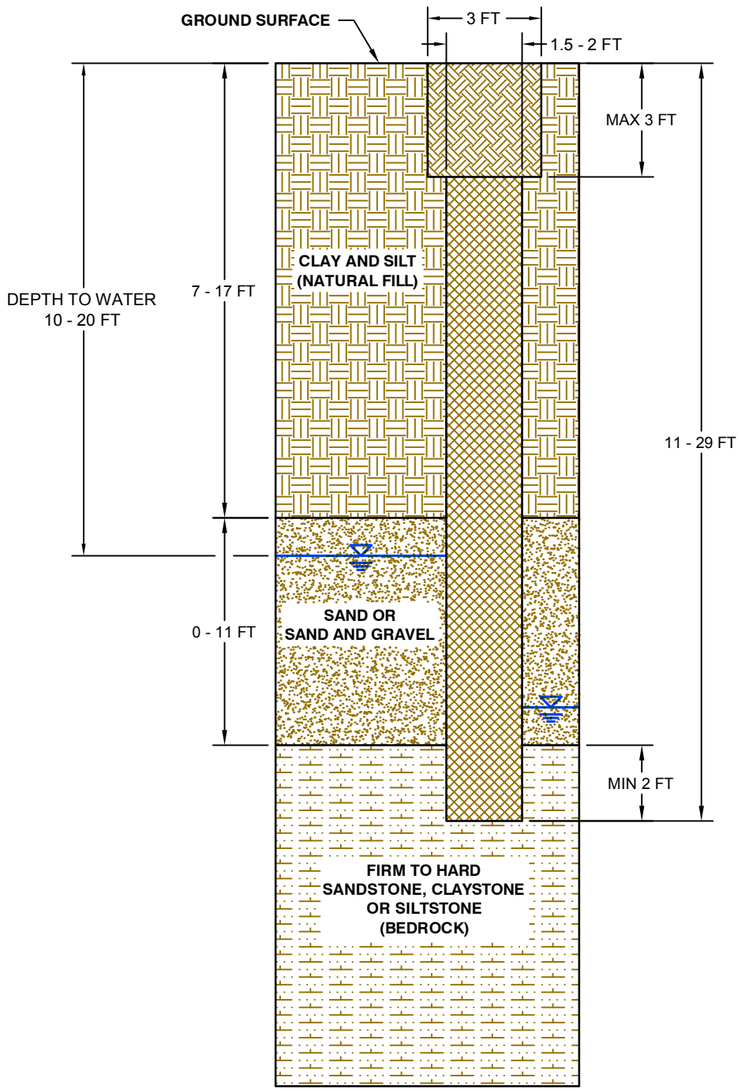

SCHEMATIC CROSS SECTION

SCALE: 1" = 4'

BELLE AYR MINE CBW INSTALLATION (2004)

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FIGURE 3.1-17

CONTAINMENT BARRIER WALL

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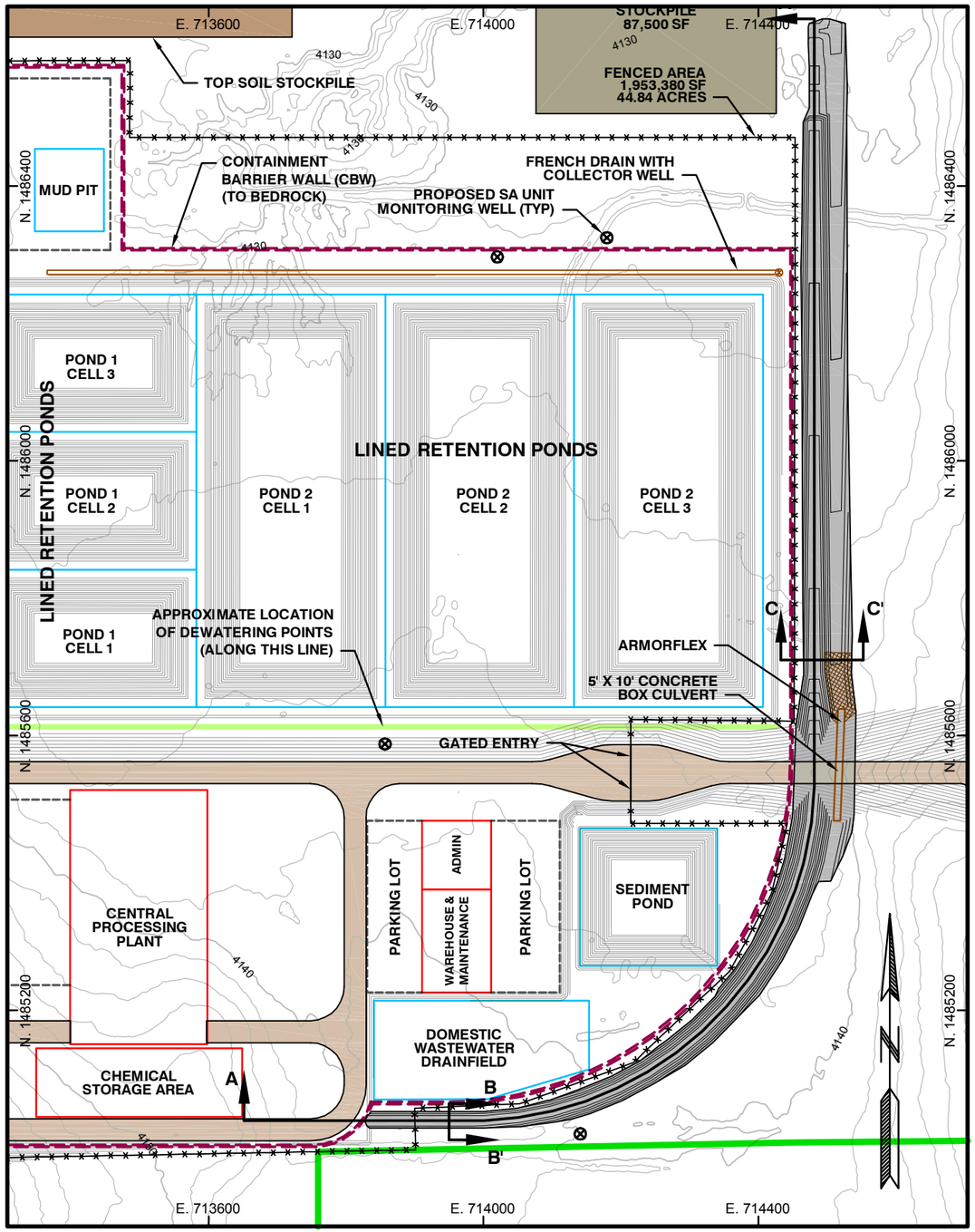


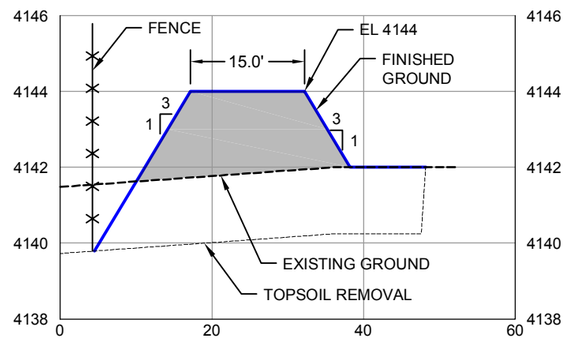
Basemap: 2' Contours from May 2010 Flight

Drawing Coordinates: WY83EF

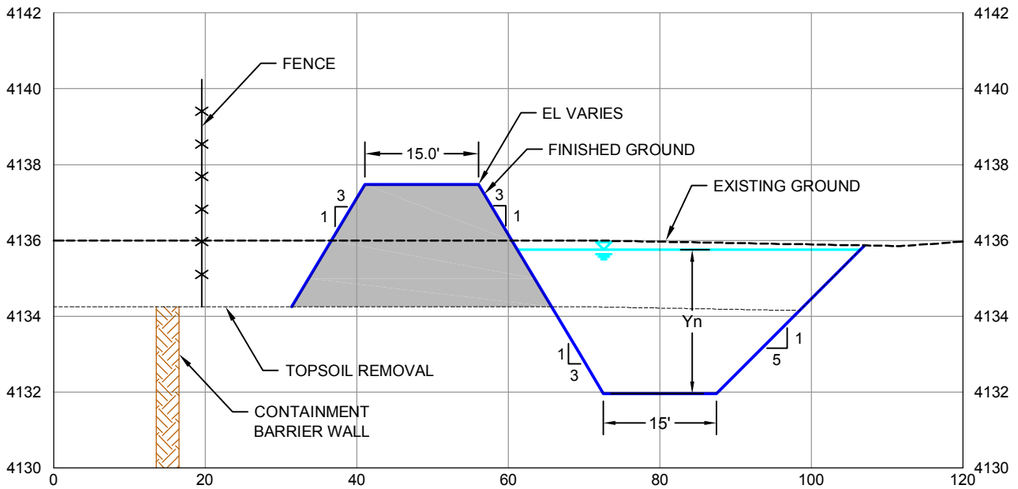
SITE PLAN

0 100 200 400

GRAPHIC SCALE (FEET)



SECTION B-B'
BERM WITHOUT DIVERSION
EXAGGERATION 5H:1V (FT)



SECTION C-C'
BERM WITH DIVERISON
EXAGGERATION 5H:1V (FT)

DIVERSION CROSS SECTION

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$

10-yr, 24-hr				100-yr, 24-hr			
Q =	331.30 cfs	A =	66.82 ft^2	Q =	681.10 cfs	A =	112.79 ft
n =	0.03	WP =	36.66 ft	n =	0.03	WP =	46.03 ft
S =	0.0045 ft/ft	R =	1.82 ft	S =	0.0045 ft/ft	R =	2.45 ft
b =	15 ft	V =	4.96 fps	b =	15 ft	V =	6.04 fps
		Yn =	2.62 ft			Yn =	3.76 ft

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FIGURE 3.1-18 **SHEET 1 OF 2**

FLOOD CONTROL
DIVERSION CHANNEL

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Date: 12/18/10

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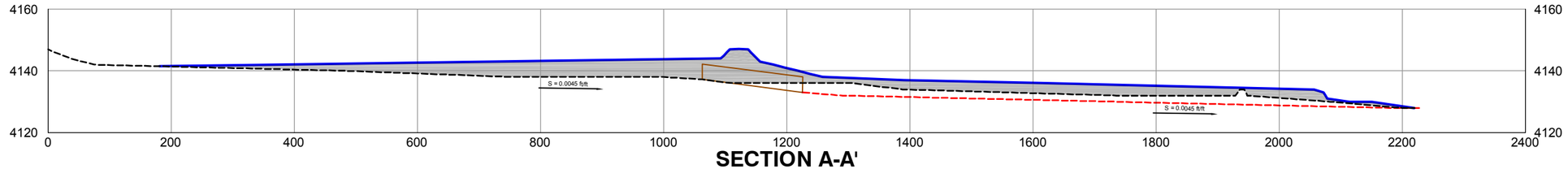
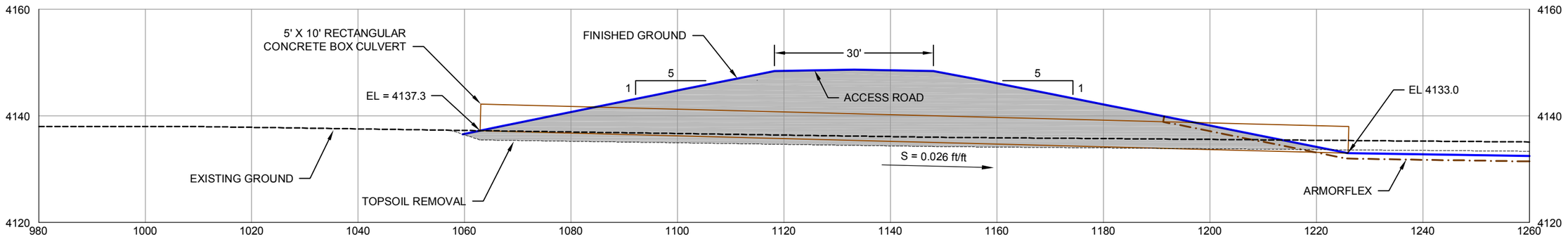


SECTION A-A'
DIVERSION PROFILE
EXAGGERATION 5H:1V (FT)

HYDROLOGIC DESIGN STORM CALCULATIONS

DRAINAGE BASIN PARAMETERS			10-YR, 24-HR STORM			100-YR, 24-HR STORM		
DRAINAGE AREA (sq-mi)	CURVE NO. (CN)	WATERSHED LAG TIME (hrs)	10-YR, 24-HR PRECIP. (in)	PEAK INFLOW (cfs)	RUNOFF VOLUME (ac-ft)	100-YR, 24-HR PRECIP. (in)	PEAK INFLOW (cfs)	RUNOFF VOLUME (ac-ft)
1.65	78	1.26	2.8	311.3	87.0	4.2	681.1	180.2

NOTE: RUNOFF VOLUMES AND PEAK INFLOWS WERE COMPUTED BY THE HEC-HMS COMPUTER PROGRAM USING THE SCS TYPE II RAINFALL DISTRIBUTION.



CULVERT ROAD CROSSING

CULVERT ROAD CROSSING

DISCHARGE GOVERNED BY FULL PIPE FLOW CONDITIONS

$$Q = \frac{A\,(2gH)^{1/2}}{(1+K_e+K_cL)^{1/2}}$$

$Q_{100,24}$ = 681.1 cfs

g =	32.2 ft/s^2	K_e =	1.0
L =	163 ft	K_c =	0.00199
A =	50 ft^2	T_w =	3.76 ft
H =	6.7 ft		

NOTE: METHOD ACCORDING TO BARFIELD, WARNER AND HAAN, 1981.

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FIGURE 3.1-18 **SHEET 2 OF 2**

FLOOD CONTROL
DIVERSION CHANNEL

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3.2 Recovery Plant, Processing, and Chemical Storage Facilities

Recovery of uranium from the pregnant lixiviant at the Ross ISR Project will be accomplished at the CPP. Processes used at the CPP to recover uranium will include the following circuits (described in detail in the following sections):

- Resin loading (IX circuit)
- Resin elution
- Uranium Precipitation
- Uranium Product washing, drying and packaging
- Vanadium recovery, precipitation, and packaging

The IX circuit at the CPP will be capable of processing up to 7,500 gpm of pregnant lixiviant. The elution, precipitation, and drying and packaging circuits will be designed to process approximately 3 million pounds per year of U_3O_8. In addition, it has been determined that vanadium will also be produced from the Ross ISR Project; however the relationship of vanadium production to uranium production appears to be quite variable, so a range of production is likely. Given available information, it appears that a likely range of 0.1 To 2.0 lbs of vanadium as V_2O_5 will be produced for each pound of uranium as U_3O_8.

All primary operating equipment and materials required to support the uranium recovery operations will be housed in or near the CPP building. The CPP building will also include equipment for a restoration circuit with the capacity to treat groundwater from wellfield modules that are in restoration. The conceptual general arrangement of the components of the CPP is illustrated in Figure 3.2-1. It is important to note that detailed engineering for the plant has not yet been completed, and therefore plant designs have yet to be finalized. However, the design concept behind the plant along with the monitoring, operation concept, chemistry, and equipment is not expected to be altered.

The following sections provide a description of each processing system and the equipment and materials used. A complete process flow diagram which shows process flows and equipment is shown in Figure 3.2-2. Table 3.2-1 shows a preliminary mass balance for uranium recovery at the CPP. In accordance with 10 CFR Section 2.390(a)(4), the plant designs are considered proprietary and confidential. Therefore, the drawings and specifications

included in Section 3.2 of this TR are not for release to the public. This includes Figures 3.2-1 through 3.2-7.

3.2.1 Ion Exchange Circuit

Recovery of uranium from the pregnant lixiviant will be accomplished through a pressurized down-flow IX process. Pregnant lixiviant from the wellfield modules will flow through the IX resin and the uranium complexes will be exchanged with chloride, bicarbonate, or sulfate ions on the resin surface as shown in the following chemical reaction where R is the IX resin:

$$2RCl + UO_2(CO_3)_2^{2-} \rightarrow R_2UO_2(CO_3)_2 + 2Cl^-$$

$$2RHCO_3 + UO_2(CO_3)_2^{2-} \rightarrow R_2UO_2(CO_3)_2 + 2HCO_3^-$$

$$4RCl + UO_2(CO_3)_3^{4-} \rightarrow R_4UO_2(CO_3)_3 + 4Cl^-$$

$$R_2SO_4 + UO_2(CO_3)_2^{2-} \rightarrow R_2UO_2(CO_3)_2 + SO_4^{2-}$$

Each resin loading circuit will consist of two pressurized vessels operating in series; each designed to contain a 500 ft^3 batch of anionic IX resin. The IX circuit will capture both the uranium and the vanadium products from the lixiviant. These vessels are expected to be configured in seven parallel trains for two-stage down flow loading.

Prior to passing through the IX columns, the pregnant lixiviant will pass through a de-sanding system consisting of sand or other media filter type, centrifugal separators, or settling type clarifiers. The choice of a de-sanding system will depend on the character and amount of any suspended solids in the pregnant lixiviant. It is most likely that a sand filter will be chosen as the preferred filter type based on current information. Periodically the sand filters will require cleaning. This will be accomplished by backwashing accumulated solids from the filter. Barren lixiviant is pumped upward to fluidize the bed of sand and carry away solids while not removing any sand. The backwash slurry is pumped into a holding/settling tank where the solution will be allowed to settle and the barren lixiviant will be sent back to the de-sanding system for recovery. The settled solids are dewatered in a mobile or stationary filter press. The filter press filtrate is barren lixiviant and will be refortified and returned to the wellfield as lixiviant; the filter cake becomes waste and must be disposed of as 11e.(2) byproduct material. This dewatering step minimizes the volume of 11e.(2) waste produced. The sand filter media will become 11e.(2) waste at the end of project operations.

The IX columns, which are shown in detail on Figure 3.2-3, will also act as media filters and trap particulates in the pregnant lixiviant. During times when the suspended solid concentration in the pregnant lixiviant is very low, the IX columns alone may serve as adequate primary media filters to trap particulates and could be operated as the primary filter when the de-sanding system is offline for cleaning and regeneration. The de-sanding system will be operated as necessary to minimize fouling and plugging in the IX columns. The solids captured by the primary or secondary filtering methodologies will be stored for proper disposal as 11e.(2) byproduct material. The captured suspended solids will be stored in the 11e.(2) material storage area where it will be collected and shipped to an approved facility. The solids which will be removed from the lixiviant prior to reinjection are expected to include radium, uranium and vanadium attached to clay, silt and sand particles. Information on size distribution of these suspended solids is unavailable at this time, but will be required for proper sizing of the appropriate de-sanding system. All solid effluents will be managed as discussed in Section 4.2 of this TR.

The barren lixiviant exiting the second IX loading stage will be monitored and will normally contain less than 2 ppm of uranium. Booster pumps will be located upstream and downstream of the IX trains and a guard column will be located downstream of the IX trains just downstream of the RO unit. IX "guard" columns are used to ensure that all possible uranium is removed from bleed and restoration streams before further treatment. A guard column may be similar in construction to a normal IX recovery column or may be built with a deeper bed, but will use the same resin. The specific flow rate (gpm/ft^2) or flux for flow through a guard column is designed to be much lower than what is normally used in a uranium recovery column in order to ensure maximum removal of uranium from the feed stream. A typical guard column will reduce uranium concentrations from 2 ppm to non-detectable levels. The rate that the resin loads with uranium is low due to the low flow rates and feed concentrations. Generally, the resin in a guard column will need elution no more often than once every six months or once a year.

Carbon dioxide is to be added in the CPP, upstream of the resin vessels. The carbon dioxide controls the pH of the pregnant lixiviant to optimize the IX loading capacity of the uranium and the vanadium.

An example of a commercial resin is Dowex 21K XLT resin. This is a resin in widespread, successful use in ISR facilities in the U.S. and elsewhere.

It is conventional to use a standard resin that has been tested and thoroughly accepted throughout the industry.

The uranium enriched (or pregnant) lixiviant is expected to arrive in the CPP at ground temperature of about 50 to 60 degrees with a pressure ranging from 80 to 110 psi, dependent upon distance from the wellfield, final plant design, and selected manufacturer's equipment specifications.

The lixiviant flows through the two columns and the uranium loads on the resin. As resin in the first stage IX vessel becomes loaded, or saturated, and is extracting very little additional uranium from the lixiviant, the vessel is isolated from the normal process flow. The 500 ft^3 batch of loaded resin is removed from the first stage vessel and replaced with stripped, or barren, resin. It is expected that a resin column will likely be loaded in a few days.

Resin manufacturers indicate that the anion resin of choice for uranium extraction also has a slightly lower affinity for vanadium. Therefore, during the loading phase the resin will attract both uranium and vanadium. During the latter stages of loading the resin will tend to have more affinity for the uranium, but the operation will focus upon optimizing the capture of uranium and vanadium from the lixiviant.

3.2.1.1 Ion Exchange Circuit Equipment

Materials of construction and general specifications for the major IX circuit equipment are listed below. Further specifications and dimensions will be addressed during detailed engineering.

- IX Vessels and IX Guard Columns

The IX vessels are pressure vessels constructed of mild steel with an epoxy internal coating. Internal distribution headers are constructed of 316SS steel. The IX vessels will operate in pressure down-flow mode.

- Booster Pumps

Booster pumps are standard pumps of steel construction.

3.2.2 Elution Circuit

The elution circuit will separate both the uranium complexes and the vanadium complexes from the resin as well as regenerate the resin capacity by replacing chloride and bicarbonate ions on the resin exchange sites. The primary chemical reaction involved in elution is shown below. Similar reactions

also occur for the displacement of uranyl dicarbonate (UDC) and for bicarbonate loading.

$$R_4[UO_2(CO_3)_3] + 4NaCl \rightarrow 4RCl + Na_4[UO_2(CO_3)_3]$$

The elution of vanadium is believed to behave in a fashion similar to the uranium elution and is expected to strip from the resin under the same conditions as the uranium.

As can be seen in Figure 3.2-4, prior to elution, the loaded resin will be transferred to vibrating screens to wash sand, silt, broken resin, scale, and other trash from the resin before it is placed in the elution columns. All solids recovered during this secondary filtration step will be collected, stored, and disposed as 11e.(2) byproduct material. Resin is then gravity fed to the elution vessels where uranium is recovered and the resin is regenerated.

In addition to the resin from the CPP, resins from other uranium-loaded resin generators may also be eluted at the facility. As mentioned previously, the CPP will have the capacity to elute 3 million pounds of uranium per year. The IX resin will be pumped from the resin truck to the resin screens and then into the eluate tank, mimicking the same process that is used for the CPP resin. After elution, the regenerated resin is pumped back into the truck for transfer back to the IX generators site. The elution will be conducted in batch mode for the resin being eluted.

The eluate solution, which will contain approximately 10% sodium chloride and 2% sodium carbonate, will be added to the elution vessels, stripping the resin of uranium and vanadium and regenerating the resin for further use. In some cases, it is necessary to add an additional regeneration stage by employing a rinse of hydrochloric acid. If chloride buildup in the lixiviant becomes a problem, a sodium bicarbonate rinse may be included in the elution process. Eluted resin, or barren resin, is then rinsed with fresh water and returned to IX vessels for further loading. The rinse water is then used to make up additional fresh eluate. The elution process will consist of four stages: three (3) eluant stages will contact one 500 ft^3 batch of resin with three bed volumes of eluant each and one (1) rinse stage will contact the batch with four bed volumes of fresh water. Uranium complexes (as uranyl carbonate) and vanadium are then contained in the rich eluate solution. The pH of the solution will be approximately neutral.

3.2.2.1 Elution Circuit Equipment

Materials of construction and general specifications for the major elution circuit equipment are listed below. Further specifications and dimensions will be addressed during detailed engineering.

- Elution Vessels

The Elution vessels are constructed of mild steel with an epoxy internal coating. The Elution vessels will operate in up flow mode and are vented.

- Eluant Tanks

The Eluant tanks are constructed of mild steel with 316SS steel agitators. They are enclosed, agitated, and vented.

- Vibrating Resin Screen

The vibrating resin screen is constructed of 304SS and uses a mesh style vibration screen to separate water from the loaded resin before it is fed to the elution vessel.

3.2.3 Precipitation Circuit

The purpose of the precipitation circuit is to break the uranium complexes and precipitate the uranium. This process will produce uranium peroxide slurry. Multiple precipitation tanks plumbed in series with mechanical agitators will accomplish the steps needed to form the slurry. Precipitation chemicals include sulfuric acid, caustic soda or ammonia, and hydrogen peroxide. Anhydrous ammonia is the least expensive reagent choice for pH control in the precipitation circuit. It is well proven in practice, is easy to control and may have a beneficial effect on product quality. However, use of anhydrous ammonia will require additional permits for control of potential air emissions and issues with Homeland Security. Caustic soda solution can be temporarily substituted for anhydrous ammonia with a few, inexpensive additions to the plant (3 small metering pumps), and will produce an acceptable product, at a slightly higher reagent cost. This process can also be seen on Figures 3.2-4 and 3.2-5.

When a sufficient volume of rich eluate is collected, sulfuric acid will be added to break down the uranyl carbonate and to bring the pH down to the range of 2-3. The drop in pH will cause the uranyl carbonate to break down, which will liberate carbon dioxide and free uranyl ions. In the next stage,

sodium hydroxide (caustic soda) is added to raise the pH to the range of 4-5. The chemical reaction for this process is:

$$Na_4[UO_2(CO_3)_3] + 3H_2SO_4 \rightarrow UO_2SO_4 + 2Na_2SO_4 + 3CO_2\uparrow + 3H_2O$$

After pH adjustment, hydrogen peroxide is added (0.36 lb H_2O_2/lb U_3O_8) in a continuous circuit to form an insoluble uranyl peroxide (UO_4) compound; this precipitation takes up to 8 hours. After precipitation, sodium hydroxide is added to raise the pH to approximately 7. The uranium precipitate slurry is then pumped to the first yellowcake thickener, where most of the solution is separated from the uranium oxide solids. The thickener overflow solution is pumped through a sock filter and becomes the feed to the vanadium recovery circuit.

A second stage of precipitation is designed to remove impurities entrained in the first precipitate. The first yellowcake thickener underflow is fed to the re-dissolve tank, where the solids are contacted with sulfuric acid. The uranium is then re-precipitated in a series of precipitation tanks. The uranium precipitate slurry is pumped from the last precipitation tank to the second yellowcake thickener, where most of the solution is separated from the uranium oxide solids. The thickener overflow solution is pumped through a sock filter and becomes the feed to the vanadium recovery circuit. The solids from the sock filters are collected and sent to 11e.(2) storage and disposal. This process can be seen in Figure 3.2-5 and 3.2-6.

The precipitation reaction for the sulfuric acid acidified pregnant eluate is:

$$UO_2SO_4 + H_2O_2 + 2H_2O \rightarrow UO_4{\cdot}2H_2O \text{ (precipitates)} + H_2SO_4$$

The reaction for pH adjustment with caustic soda is:

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + H_2O$$

Hydrogen peroxide precipitation of uranium has been chosen for this project due to selectivity of the process for precipitating a clean uranium product in the presence of other metals, particularly vanadium in this case. Hydrogen peroxide precipitation is used in most operating and proposed uranium ISR operations in the United States. This precipitation process has a long history for being highly selective for uranium in most solutions (Merritt 1971) including vanadium-rich solutions (Caropreso and Badger 1974, Shabbir and Tame 1974). Cahill and Burkhart (1990) report that hydrogen peroxide

precipitation maintained a high-quality, fast filtering uranium product with a feed with a molar ratio of vanadium to uranium of 1:2, which is very close to the molar ratio at the Ross ISR Project. This assumption is still being verified.

The filtration characteristics of the uranium precipitate are very sensitive to operating conditions and good filtration (fast filtering open cakes) is critical to the production of a high value yellowcake. The best operating conditions for the production of yellowcake at the proposed project area will have to be determined by experience when the plant is running. And as conditions will inevitably change over the life of the plant those conditions will require adjustment.

If the amount of vanadium in a batch of yellowcake exceeds quality standards, the precipitated yellowcake can be re-dissolved, releasing most of the trapped vanadium and precipitated again, making a cleaner yellowcake product. This fresh precipitate will be thickened again and sent to the filter press as described below. Equipment for this possibility is included in the current flow sheet design and will be used as necessary.

After extraction of the uranium, the spent eluate solution will go to the vanadium recovery circuit or, in the case of no vanadium recovery, will be routed to the lined retention ponds.

3.2.3.1 Precipitation Circuit Equipment

Materials of construction and general specifications for the major Uranium Precipitation equipment are listed below. Further specifications and dimensions will be addressed during detailed engineering.

- Precipitation Tanks

These tanks are covered, agitated, and vented fiber reinforced plastic (FRP) tanks with mid-tank agitator suspension.

- Thickener

The yellowcake thickeners are constructed of SS with a rubber lining and has a centrally driven drive head and rubber coated raking arms.

- Thickener Overflow Treatment

The yellowcake thickener overflow is fed to a surge tank composed of a mild SS that is polyethylene-lined and a wire basket filter down line.

3.2.4 Drying and Packaging

After precipitation, the uranium precipitate, or yellowcake slurry, is removed for washing, filtering, drying, and product packaging in a controlled area. The yellowcake from the thickener underflow is washed in a filter press to remove excess chlorides and other soluble contaminants. The filter cake is re-slurried with clean water, and then transferred by a slurry pump and piping to the yellowcake dryer. After drying, the yellowcake is packaged into 55-gallon drums for storage before transport to a conversion facility. The yellowcake dryer and storage areas will be located in a separate room in the CPP to reduce the possibility of airborne contamination to the rest of the plant. This process is shown in Figure 3.2-6.

The yellowcake will be dried in a low temperature (<300° F) vacuum dryer, which is completely enclosed during the drying cycle. By operating at low temperatures (<300° F), no measurable quantities of respirable uranium solids are produced, further reducing environmental and occupational risks. This drying technology requires a high purity feed stock because operating temperatures are not sufficient to volatilize contaminants.

The dryers at the CPP will be batch type and will typically take 16 hours to process a batch. Each dryer is sized to produce yellowcake containing at least 750,000 lb/yr of U_3O_8 by processing one batch per day. The dryer volume chosen will be twice that of the batch of yellowcake slurry that will be fed to the dryer. For example, production of 800,000 lb/yr of U_3O_8 will require drying of approximately 2310 lb/day of uranium peroxide ($UO_4 \cdot 2H_2O$) product. At a typical feed slurry mix of 35% solids by weight, this will occupy 98 cubic feet. The vacuum paddle dryer volume required will therefore be 196 cubic feet. Vacuum paddle dryers are available in a wide range of sizes, with units that can produce 2,000,000 lb/yr of U_3O_8.

The off-gases generated during the drying cycle will be filtered and scrubbed to remove entrained particulates. The water sealed vacuum pump will also provide ventilation while the dryer is being loaded and unloaded into drums by operators.

The packaging equipment is located directly below the dryer and includes a discharge chute, rotary airlock valve, ventilated drum hood and drum conveyor. A drum is placed beneath the dryer discharge chute; the ventilation hood is then secured over the drum opening to prevent escape of yellowcake

into the surrounding environment. After the drum is in place and securely covered, the rotary airlock valve is activated to start the loading process. A viewport in the hood allows the operator to determine when the drum is full. The loaded drum is then weighed and labeled before it is moved to the side to cool and de-gas before it is sealed and stored for shipment (see Figure 5.7-3). Standard operating procedures for loading yellowcake drums will be instituted to ensure that yellowcake is sufficiently cool before loading and that no particulates are released during loading.

3.2.4.1 Uranium Drying and Packaging Equipment

Materials of construction and general specifications for the major Uranium Drying and Packaging equipment are listed below. Further specifications and dimensions will be addressed during detailed engineering.

- Vacuum Dryer

The industry standard type of dryer for yellowcake produced in both ISR and modern conventional uranium recovery plants is a vacuum paddle dryer. This is an indirectly heated dryer consisting of a cylindrical shell with the axis horizontal and a heating jacket. A paddle system, based on a horizontal shaft, agitates the contents of the dryer. A vacuum is drawn on the dryer to cause the water in the product to evaporate at lower temperatures than atmospheric pressure. These dryers are widely used in the pharmaceutical industry.

Vacuum dryers are heated by circulating hot oil (or steam) through an outer shell which encloses the interior of the dryer. The heating oil is heated in an oil heater fueled by natural gas, fuel oil or electricity. Safety features include an expansion and overflow tank to contain the oil and expansion loops in the piping as necessary to account for thermal expansion. Combustion exhaust for a natural gas or fuel oil fired heater will exhaust through a stack on the roof.

In uranium production, vacuum dryers have several advantages, primarily in control of the process and also in controlling yellowcake dust emissions. The vapor and air are drawn from the drying chamber and then flow through a filter system, then into a condenser and liquid ring vacuum pump. Any yellowcake dust that might pass through the filters will be collected in the condenser or seal water for the vacuum pump and then will return to the process. Compared to conventional high temperature drying by multi-hearth systems, this dryer has significantly lower airborne particulate emissions.

- Filter Press

The yellowcake filter press consists of a head and follower that contain in between a pack of vertical rectangular plates. Each plate is dressed with filter cloth on both sides and, once pressed together, they form a series of chambers that depend on the number of plates. The entire pack of plates is supported by side or overhead beams.

- Yellowcake Dryer Feed System

Feed to the yellowcake dryer will be via an enclosed shaftless screw conveyor in order to prevent particulate matter from escaping.

3.2.5 Restoration Circuit

A groundwater restoration circuit will be used at the Ross ISR Project to treat groundwater from wellfield modules that are in the RO with permeate injection stage of restoration. The restoration circuit will utilize an IX guard column to remove uranium and RO to further reduce the total dissolved solids of the makeup water to be reinjected. The restoration circuit will be designed to handle a maximum flow rate of 1,100 gpm. Restoration equipment will be housed in the CPP building. Restoration will begin approximately 6 to 12 months after operation has been finished on the modules and will be done concurrently with operation of other modules.

The RO system will consist of two units in series. The first unit will operate so as to return approximately 70% of the flow as high quality permeate and 30% of the flow as a concentrated brine solution. The concentrated brine is then pumped to a second RO unit which will produce approximately 50% permeate and 50% brine. Permeate from the RO system will then be recycled back to the wellfield.

3.2.5.1 Restoration Circuit Equipment

Materials of construction and general specifications for the major restoration equipment are listed below. Further specifications and dimensions will be addressed during detailed engineering.

- Reverse Osmosis System

The reverse osmosis unit and related pumps will be of stainless steel construction.

- RO Guard Column

The RO vessels will be constructed of mild steel with an epoxy internal coating. Internal distribution headers are constructed of 316SS steel. The guard vessel will operate in pressure down-flow mode.

3.2.6 Bleed Treatment Circuit

The bleed treatment circuit system configuration and components will be very similar to the restoration circuit described above. A bleed flow averaging approximately 1.25% will be removed from the barren lixiviant stream. During typical operation, the bleed will enter a holding tank and will then be routed through a two-stage RO system. A portion of the permeate from the RO will be added back to the barren lixiviant stream such that the net production bleed is maintained at approximately 1.25%. The remainder of the permeate will be routed to modules in restoration or a lined retention pond for disposal or recycling. Production bleed may or may not be routed through the RO system depending on the barren lixiviant water quality as well as liquid disposal capacity.

3.2.7 Vanadium Removal Circuit

3.2.7.1 Vanadium Precipitation

The uranium-depleted supernate solution overflows the uranium thickener number 2 and is then pumped to the vanadium precipitation circuit. The vanadium bearing solution is placed into a feed surge tank from where it is pumped to a vanadium precipitation conversion tank, where steam, plant air and ammonia are added in vigorous agitation to convert the vanadium to the pentavalent (+5) state, which is a form better suited to precipitation, prior to placement into one of four agitated precipitation tanks. These tanks typically will work in batch mode with two tanks working at a time.

Ammonium sulfate is added to the vigorously agitated precipitation tanks to effect the precipitation of the ammonium metavanadate (NH_4VO_3) through the formation of crystals. The crystal formation is expected to be sufficient such that the slurry from the last precipitation tank will be pumped to a vanadium belt filter for separation of liquid and solids.

The precipitate slurry is pumped to a horizontal vacuum belt filter which removes the solution from the precipitated ammonium metavanadate. The solid

ammonium metavanadate is also washed on the filter. The filter cake is transferred into a rotary vacuum dryer to remove moisture content prior to packaging. The filtrate from the belt filter contains primarily sodium sulfate and is transferred to the disposal surge tank. The vanadium recovery circuit is shown in Figure 3.2-7.

All solids leaving the vanadium precipitation circuit are dried and packaged as products. Filtrate, wash water and ammonia scrubber solutions related to vanadium removal will be treated by RO and/or sent to the deep disposal well.

3.2.7.2 Ammonium Metavanadate Drying and Packaging

The ammonium metavanadate filter cake from the horizontal belt filter is transferred to a batch vacuum paddle dryer, similar to the units used to dry the uranium yellowcake. This type of dryer has been chosen due to the inherent control of dust and potential ammonia fumes from the drying process. The off-gas from this dryer is first filtered to remove particulates and then it flows to a condenser that removes most of the water vapor. The ammonia will also be absorbed in the water in the condenser. The vacuum will be generated by a liquid ring vacuum pump, which will provide a secondary trap for entrained particulates and ammonia vapors.

The vanadium precipitation tanks and the vacuum dryer vacuum pump are vented to a wet off-gas scrubber to recover the ammonia and ammonium sulfate from the gas before it exhausts to the atmosphere. The captured ammonia and ammonium sulfate is pumped back to the vanadium precipitation system to be used as make-up.

3.2.7.3 Vanadium Circuit Equipment

Equipment used in the vanadium circuit are expected to include but are not limited to: precipitation tanks, a belt filter or filter press and a vacuum paddle dryer (as described in Section 3.2.4.1). Materials of construction will be selected in compliance with chemical compatibilities within the system.

3.2.8 Chemical Storage Facilities

Chemical storage facilities at the Ross ISR Project will store both hazardous and non-hazardous chemicals for use in the uranium recovery process. The ISR process requires chemical storage and feeding systems to

store and use chemicals at various stages in the extraction, processing, and waste treatment processes. Chemical storage and feeding systems will include some or all of the following: sulfuric and/or hydrochloric acid, sodium hydroxide, hydrogen peroxide, carbon dioxide, oxygen, sodium chloride, sodium carbonate, barium chloride, anhydrous ammonia, and non-process related chemicals such as gasoline, diesel and propane. Each chemical storage and feeding system will be designed to safely store and accurately deliver process chemicals to the intended delivery points in the process. All chemical storage tanks will be clearly labeled to identify the contents. Design criteria for chemical storage and feeding systems include applicable regulations of the International Building Code (IBC), National Fire Protection Association (NFPA), Compressed Gas Association (CGA), Occupational Safety and Health Administration (OSHA), Resource Conservation and Recovery Act (RCRA), and the Department of Homeland Security (DHS). Designing, constructing, and maintaining chemical storage facilities in accordance with applicable regulations will help ensure the safety of Strata employees and members of the public, both in regard to the specific chemicals and in regard to the potential release of radioactive materials if the chemicals were not stored properly.

Process chemicals will be located either in the CPP or in the chemical storage area. The chemical storage area will be located adjacent to the CPP as shown on Figure 3.1-16. The chemical storage area will be divided into two areas, one of which will be enclosed in a building and one outside. Chemicals stored outside within the chemical storage area will include oxygen (if stored at the CPP), ammonia, and carbon dioxide. Figure 3.2-8 shows the layout of the proposed chemical storage area.

Areas within the CPP and chemical storage area will be provided with secondary containment which will consist of concrete berms as part of the floor of each area. Berms will divide areas to ensure that there is no mixing of incompatible fluids in the event of a leak or spill. Details of the secondary containment are included in Sections 3.2.9 and 7.5.

Several of the chemicals handled in the uranium recovery process will be highly corrosive. Concrete floors, secondary containment, and sumps in areas where corrosive fluids could be spilled will be coated with corrosion resistant materials as recommended by the manufacturer. Pre-leach tanks, leaching tanks and thickeners will be of plain carbon steel construction lined with chlorobutyl or bromobutyl rubber and capable of operating at 175 F in a highly

acidic environment. Elastomeric linings will also be used to resist abrasion from the slurries in these tanks. All slurry piping will use materials that are abrasion and corrosion resistant and solution piping will be appropriately corrosion resistant. Tanks that carry solutions only will be constructed from FRP using resins and liners appropriate to the conditions as recommended by the manufacturers.

3.2.8.1 Process Related Chemicals

3.2.8.1.1 Oxygen

Oxygen will be added to the injection stream either upstream of the injection manifolds within the module buildings or at each well head. Oxygen will be stored as a cryogenic liquid either near the wellfield module buildings or in the chemical storage area adjacent to the CPP. Oxygen will be stored in storage vessels designed, fabricated, tested, and inspected in accordance with the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code. Oxygen storage vessels will be equipped with safety relief devices and will be located at least 25 feet from buildings or as required by applicable NFPA and OSHA standards. Oxygen will be delivered and stored as a cryogenic liquid and then conveyed to the injection point (either upstream of the injection manifold within the module building or at each well head) as a gas through stainless steel piping. Oxygen storage and delivery systems will be designed and fabricated in accordance with NFPA 55 and OSHA standards for the installation of bulk oxygen systems on industrial premises (29 CFR 1910.104).

The hazards associated with oxygen storage include combustion and explosion. To reduce the risk of an accident which could potentially affect other processes or storage facilities and radiological safety, oxygen will be stored a sufficient distance from other infrastructure and storage areas. Facilities used to store oxygen at the project will conform to standards detailed in the NFPA NFPA-55 publication (NFPA 2010). Typically, oxygen storage and dispensing systems will be leased from the bulk oxygen vendor.

Conveyance systems for oxygen will be clean of oil and grease because these substances will burn violently if ignited in the presence of oxygen. The proper pressure relief devices, component isolation and barriers will also be employed. Cleaning of equipment used for delivering and storage of oxygen will be done in accordance with the Compressed Gas Associations CGA G4.1. The design and installation of oxygen piping system will be done according to the

requirements of CGA G4.4. Strata will develop procedures that implement emergency response instructions for a spill or fire involving oxygen systems.

3.2.8.1.2 Carbon Dioxide

Carbon dioxide may be used in the ISR process at two locations. Carbon dioxide may be used as a source of carbonate to fortify the barren lixiviant as it leaves the CPP. Carbon dioxide may also be used upstream of the IX vessels to control the lixiviant pH and increase the resin loading capacity. The carbon dioxide storage and feeding system will be a vendor-supplied packaged system including cryogenic tank, vaporizer, pressure gauges, and pressure relief devices. Carbon dioxide will be stored adjacent to the CPP in the chemical storage area. Carbon dioxide presents few potential hazards in its use. The main hazard is through asphyxiation if it is allowed to accumulate in a confined area. To reduce this risk of a harmful accident, carbon dioxide will be stored in the chemical storage area adjacent to the CPP in large tanks. Floor-level ventilation and carbon dioxide monitoring at low point(s) within the CPP will be provided to protect workers from accidental leaks of carbon dioxide.

3.2.8.1.3 Anhydrous Ammonia

Anhydrous ammonia will be used at the CPP as part of the vanadium recovery circuit and, potentially, to adjust the pH of the eluate solution in the precipitation tanks. In the uranium precipitation circuit a base is required to neutralize the acid that forms as a direct result of the yellowcake precipitation reaction. In practice either ammonia or sodium hydroxide is used to accomplish this. Ammonia is more difficult to permit and requires additional safety measures, while sodium hydroxide is typically more expensive and used on a temporary basis until the ammonia permitting is approved. The anhydrous ammonia system will include a storage tank, piping, instrumentation, and safety control devices. All components of the anhydrous ammonia system will be designed in accordance with the American National Standards Institute (ANSI) K61.1 (ANSI 1999) and 29 CFR 1910.111, “Storage and Handling of Anhydrous Ammonia.” Ammonia will be stored as a cryogenic liquid outside of the CPP in the chemical storage area. The storage tank will be designed, fabricated, tested, and inspected in accordance with the ASME Boiler and Pressure Vessel Code. The storage tank will include a safety relief valve, a liquid level gaging device, and a clear label identifying the contents as anhydrous ammonia. All piping and fittings will be made of materials suitable

for anhydrous ammonia service and complying with the applicable ANSI/ASME or ASTM standards. An excess flow valve will automatically close if the flow in the supply piping exceeds a specified value.

According to NUREG/CR-6733, ammonia is the chemical most frequently involved in accidents reported under the EPA Risk Management Program (RMP). The maximum quantity of ammonia stored at the site will be 2,500 gallons. The primary hazard associated with ammonia occurs with a piping leak where the ammonia can evaporate and can damage the human respiratory tract. An additional hazard associated with ammonia is that it reacts vigorously with sulfuric acid, which will also be present in the precipitation circuit.

To minimize the probability and consequence of an ammonia accident, ammonia system design and operating procedures will be consistent with ANSI recommendations. Supply piping in the ammonia system will be fitted with an excess flow valve that automatically closes if the flow rate exceeds the specified value. This valve shall be located as close to the storage tank as possible. All non-refrigerated ammonia piping will conform to the applicable sections of the American National Standards Institute/American Society of Mechanical Engineers (ANSI/ASME) standard code for pressure piping. Positive pressure, self-contained, full face respirators will be readily available in the immediate vicinity of ammonia piping and process operations. The piping will be placed to minimize impact from vehicles or other objects that might cause ruptures.

The quantity of ammonia that will be stored at the site will exceed the threshold quantity (TQ) of toxic and flammable substances as set forth in 40 CFR 68.130; therefore, the EPA will require implementation of a RMP for the ammonia system. The goal of an RMP is to prevent accidental releases of hazardous chemicals that can cause serious harm to the public and the environment. The RMP will include items such as accident consequence analysis, standard operating procedures, emergency response procedures, documented management system, and accident prevention plans.

In addition, the project will store an amount of ammonia in excess of the screening TQ as stated in Appendix A of 6 CFR Part 27, Chemical Facility Anti-terrorism Standards; Final Rule, by the Department of Homeland Security (DHS). Therefore, Strata will submit a “Top-Screen” analysis in order for the DHS to evaluate the chemical security risks associated with the Ross ISR Project.

In addition to the listed regulatory programs, the Process Safety Management (PSM) of Highly Hazardous Chemicals standard contained in 29 CFR 1910.119 applies to anhydrous ammonia for TQs in excess of 10,000 pounds. In the State of Wyoming, industrial safety at ISR facilities is regulated by the Wyoming State Mine Inspector and OSHA's PSM standard does not apply. However, Strata will comply with the PSM standard during development of the ammonia system design and operating procedures.

3.2.8.1.4 Hydrogen Peroxide

Hydrogen peroxide will be added as a 50% H_2O_2 solution to the precipitation tanks, as part of the precipitation process for uranium peroxide. Hydrogen peroxide may also be added to the barren lixiviant as an alternative or supplement to the gaseous oxygen addition. The hydrogen peroxide system will include a storage tank and delivery pump. The hydrogen peroxide storage tank will be located in the chemical storage area outside the CPP and will be isolated from the storage areas for acids and reducing agents. The site will have storage facilities for 2,500 gallons (25,000 pounds) of 50% H_2O_2. If Strata chooses to use hydrogen peroxide as an oxidizer in the lixiviant, the storage volume may need to be increased. The hydrogen peroxide storage tank will be located adjacent to the CPP building in the chemical storage area in a concrete secondary containment basin designed to contain at least 110% of the tank volume.

Hydrogen peroxide is a strong oxidizer, can be very reactive and is easily decomposable. Its hazardous decomposition products include oxygen and hydrogen gas, heat, and steam. Decomposition can be caused by mechanical shock, incompatible materials including alkalis, light, ignition sources, excess heat, combustible materials, strong oxidants, rust, dust and a pH above 4.0. When sealed in strong containers, decomposition of hydrogen peroxide can cause excessive pressure to build up which may cause the container to burst explosively.

The use of hydrogen peroxide at concentrations higher than 52% is subject to the PSM standard contained in 29 CFR 1910.119 for TQs in excess of 7,500 pounds and TPQs contained in 40 CFR Part 355, Emergency Response Plans for TQs in excess of 1,000 pounds.

3.2.8.1.5 Sodium Carbonate

Sodium carbonate (soda ash) will be used to make up fresh elution brine and will be stored in tanks as a saturated solution in equilibrium with a bed of crystals in the storage tank. Sodium carbonate solution must be kept above 100°F (38°C) to prevent precipitation in the tank and piping. This will be accomplished by heating the water added to the tank, and continuously circulating liquid from the tank through a heat exchanger. An electric heater will be used to heat a thermal fluid to heat the exchanger. Dry sodium carbonate will be delivered by truck and will be blown into the storage tanks using air pressure. Sodium carbonate has a low risk of affecting radiological safety at the proposed project.

3.2.8.1.6 Sodium Chloride

Sodium chloride will be used to make up fresh elution brine and will be stored in tanks as a saturated solution (approximately 26% by weight) in equilibrium with a bed of crystals in each storage tank. Dry sodium chloride will be delivered by truck and will be blown into the storage tanks using air pressure. Sodium chloride has a low risk of affecting radiological safety at the proposed project.

3.2.8.1.7 Sulfuric and Hydrochloric Acid

Sulfuric acid will be used in the precipitation circuit of the CPP to break down the uranium carbonate complexes. The hazards associated with the use and storage of sulfuric acid include corrosiveness, toxicity to tissue, and reactivity with other chemicals which will be used at the project such as ammonia, sodium carbonate, and water. The acid storage tanks will be isolated from the above listed chemicals to reduce the risk of reactions.

The acid storage and feeding system will include one or more storage tanks and delivery pumps. The storage tank will be located adjacent to the CPP building in the chemical storage area. The chemical storage area will include a lined concrete secondary containment basin designed to contain at least 110% of the largest tank volume. This secondary containment basin for acid storage will be separate from the containment basins for other chemical systems. The acid feed pump(s) will be located inside the building, near the storage tank(s).

Sulfuric acid will be purchased and stored as standard commercial grade concentrated acid (approximately 93% H_2SO_4 by weight). The concentrated acid

will be added directly to the pregnant eluate tanks under pH control. The storage tank will be made either of carbon steel or ultra-high-molecular-weight, cross linked polyethylene. The piping and pumps will be carbon steel. Note that if hydrochloric acid is used, piping and pump material will be chosen based on compatibility. The freezing point of 93% sulfuric acid is listed as -28.9 C (-20 F), therefore freeze protection of the storage tank and outside piping (insulation and heat tracing) will be used.

The quantity of sulfuric acid stored at the site will be in excess of the TPQs listed in 40 CFR Part 355, Emergency Response Plans for TQs in excess of 1,000 pounds. This is also the EPA reportable limit under CERCLA. Therefore, Strata will develop and implement an emergency response plan and emergency notification procedures in the event of a release.

The storage quantity of sulfuric acid at the proposed project area will also constitute coverage under the DHS Chemical Facility Anti-terrorism Standards. A "Top Screen" analysis for sulfuric acid will be submitted to DHS by Strata.

3.2.8.1.8 Sodium Hydroxide

The sodium hydroxide system will include a storage tank and delivery pump. The storage tank will be located adjacent to the CPP building in the chemical storage area in a concrete secondary containment basin designed to contain at least 110% of the tank volume. This secondary containment basin will be separate from the containment basins for other chemical systems. The sodium hydroxide feed pump will be located inside the building, near the storage tank. Sodium hydroxide will be purchased as aqueous caustic soda, and will be pumped directly into the storage tank from the supplier's tanker trucks.

3.2.8.1.9 Barium Chloride

A barium chloride storage and feeding system will be designed to dissolve solid barium chloride in water to make up the solution for feeding into permeate if needed for radium precipitation. If needed, the barium chloride storage and feeding system will include a storage tank, agitator, and chemical metering pump. This system will be located in a metal building located adjacent to the lined retention ponds. If the feed solution is added to the ponds,

the discharge pipe will release the solution along with permeate below the pond surface to minimize radon release.

3.2.8.2 Non-Process Related Chemicals

Non-process related chemicals that will be stored at or near the proposed CPP include gasoline, diesel and propane. Due to the flammable and/or combustible properties of these materials, all bulk quantities will be stored outside of the CPP in a designated hydrocarbon storage area. All liquid storage tanks will be located above ground within secondary containment structures designed to accommodate at least 110% of the volume of the largest tank in the containment structure. If the aboveground hydrocarbon storage capacity exceeds 1,320 gallons, Strata will prepare a Spill Prevention, Control, and Countermeasure (SPCC) plan in accordance with EPA requirements in 40 CFR Part 112.

3.2.9 Occupational and Environmental Safety Considerations

3.2.9.1 Control of Emission of Hazardous Materials

Throughout the CPP the release of hazardous compounds to the atmosphere will be mitigated by staged filtration, as well as water scrubbing equipment installed in all ventilation circuits. Where particle control is needed such as in drying and packaging circuits, bag house air filters will be used to ensure that no product is lost to the atmosphere. In acid producing systems, the ventilation systems will contain mist eliminating and recycling systems that feed into secondary particle filtration with discharge monitoring to further ensure containment. Radon and possible other gaseous daughter products that can be liberated in the IX and elution transfer process will be captured by ventilation systems and discharged outside of the CPP.

3.2.9.2 CPP Liquid Containment

The CPP will employ three levels of containment for liquid process fluids and effluents: process tanks, secondary containment berms, and an impermeable liner below the building foundation.

The primary form of containment throughout the processing building is each individual process tank or vessel. Secondary containment will consist of concrete curbing. There are two philosophies used for curbing within the CPP, total containment in the event of tank failure and containment of leaks or spills

during operations. Curbing to contain a failed tank will be used in areas that pose a major health risk or potential product recovery; these areas will have curbing to contain at least 110% of the volume of the largest tank. Curbing for spill containment only will be employed in areas where it is unnecessary or impractical to contain the total volume of fluid in that area but where it is still desirable to contain spills, one such area is near the yellowcake thickeners. The use of sloped floors within designated areas throughout the CPP will direct any spilled/leaked fluid to an appropriate sump to be disposed of or returned to the process. Table 3.2-2 shows the dimensions and capacities of process vessels, chemical storage tanks, and secondary containment.

The CPP building foundation will incorporate a stem wall extending at least 12" above finished floor at the base of the building's perimeter. This wall feature will serve as an additional level of containment for the entire building and will be able to contain the entire volume of process and chemical liquid in the CPP. The volume of the Concrete surfaces at risk of coming in contact with process fluids or chemical reagents will be sealed with appropriate chemical resistant epoxy coatings. Areas expected to see heavy traffic volume, such as the truck bay, will have a chemical and wear resistant floor coating system. Working in concert with the curbing, the reinforced concrete slab will be sized to minimize (or eliminate) the number of construction or contraction joints necessary and thus will minimize potential leak sites.

An impermeable liner will be installed under the foundation slab. An example of an appropriate barrier is a single layer of 60 mil HDPE liner as is commonly used to line tailings impoundment ponds in conventional milling operations.

The adjacent chemical storage building and area will employ curbing to contain at least 110% of the volume of the storage tank. Secondary containment in this area will be necessary to keep spills from entering the surrounding environment and to prevent the mixing of chemicals with deleterious effects. The chemical storage area will also include a 60 mil HDPE liner beneath the pad foundation.

Table 3.2-1. Preliminary Uranium Recovery Mass Balance

Area	**IX**												
Description	Pregnant Lixiviant	Single IX Train Feed	Single IX Train Stage 1 Discharge	Single IX Train Stage 2 Discharge	Barren Lixiviant From Ix (All Trains)	Well Field Bleed	Total Permeate	Total Brine	Barren Lixiviant To WellField	O_2 Total	CO_2 Total	$NaHCO_3$ to Barren Lixivian	Loaded Resin
Continuous or Batch	C	C	C	C	C	C	C	C	C	C	C	C	B
Flow Rate (gpm or as noted)	7,500	1,072	1,072	1,072	7,500	94	57	37	7,406	22,253 (1)	9,802 (1)	10	-
Batch Size (ft^3/batch)	-	-	-	-	-	-	-	-	-	-	-	-	500
Batches per Day	-	-	-	-	-	-	-	-	-	-	-	-	1.4
Uranium Conc. (ppm or as noted)	25	25	2.0	0.5	0.5	0.005	0.00	0.05	-	-	-	-	3 (2)
U_3O_8 Mass Flow Rate (st/hr)	0.046	0.007	0.001	0.000	0.001	0.000	-	-	-	-	-	-	-
U_3O_8 Mass Flow Rate (st/yr)	397	57	4.5	1.1	7.9	0	-	-	-	-	-	-	382

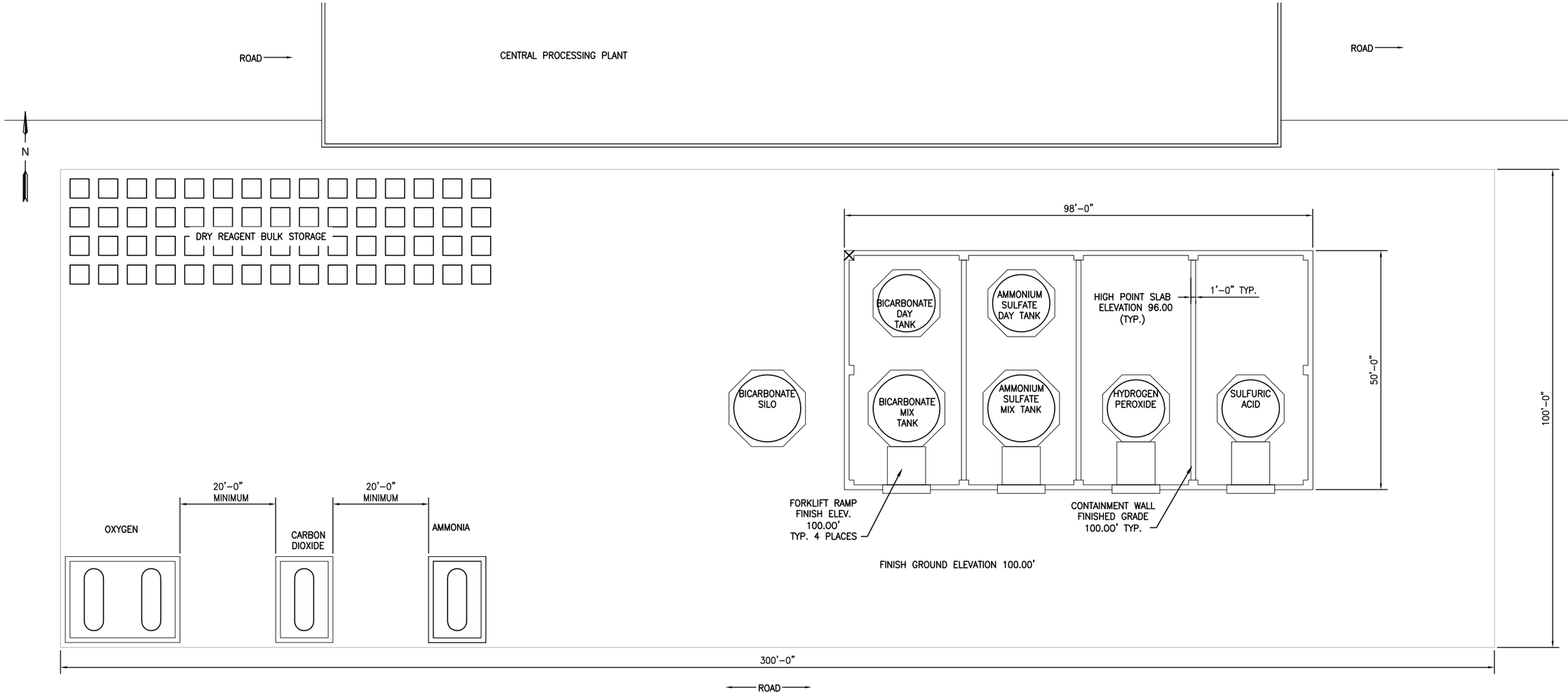
Area	**ELUTION**								**Precipitation**			**Drying and Package**	
Description	Loaded IX Resin Slurry	Resin Prior to First Elution	Pregnant Eluant	NaCl Addition to Fresh Eluant	Na_2CO_3 Addition to Fresh Eluant	Sulfuric Acid to Pregnant Eluant	Acidified Pregnant Eluant	Pregnant Eluant to Precipitation Circuit	TOTAL 50% H_2O_2 to Precip	Total 50% NaOH to Precip	Yellowcake Slurry to Yellowcake Thickener	Feed to Filter Press	Yellowcake Product
Continuous or Batch	B	B	B	B	B	B	B	C	C	C	C	B	B
Flow Rate (gpm or as noted)	-	-	-	-	-	-	-	12	0.06	0.03	11.6	-	-
Batch Size (ft^3/batch)	2,250	500	1,500	413	73	58	1,558	-	-	-	-	-	-
Batches per Day	1.4	1.4	1.4	1.4	1.4	1.4	1.4	-	-	-	-	-	-
Uranium Conc. (ppm or as noted)	-	3 (2)	-	-	-	-	-	15,246	-	-	-	-	-
U_3O_8 Mass Flow Rate (st/hr)	-	-	-	-	-	-	-	0.04	-	-	13,747	-	-
U_3O_8 Mass Flow Rate (st/yr)	382	382	377	-	-	-	-	377	-	-	375	375	375

Notes: (1) lbs/day
(2) lbs/ft^3

Table 3.2-2. CPP Primary and Secondary Containment Capacities

	Largest Tank					Secondary Containment Area				
	Diameter (ft)	Height (ft)	Cone Height (ft)	Volume (ft^3)	110% of Volume (ft^3)	Long Side (ft)	Short Side (ft)	Curb Height (ft)	Containment Volume [1] (ft^3)	Volume Sufficient for Total Containment of Largest Tank
Process Area										
Thickener	40	8	9	26,179	28,796	100	60	0.5	4,934	No
Waste Water (Brine) Storage	24	24	0	10,857	11,943	33	30	0.5	463	No
Uranium Precipitation	10	12	0	942	1,037	55	43	0.5	1,655	Yes
Vanadium Precipitation	6	8	0	226	249	53	34	0.5	1,292	Yes
Resin Cond. /Water Tank	12	18	0	2,036	2,239	112	49	0.5	4,335	Yes
Eluate Tanks	12	21	0	2,375	2,613	86	49	0.5	2,704	Yes
Backwash Tanks	12	15	0	1,696	1,866	35	21	0.5	377	No
De-Sanding Area	12	15	0	1,696	1,866	48	24	0.5	590	No
IX Vessel[2]	12	8	0	1,350	1,485	196	48	0.5	7,792	Yes
RO Area[2][3]	12	8	0	1,389	1,528	60	26	0.5	1,541	Yes
						24	22	0.5		Yes
Brine Generation	14	14.75	0	2,271	2,498	74	26	0.5	886	No
Building Foundation[4]	-					52,946		1.2	63,535	Yes
Chemical Storage Area										
Sulfuric Acid	12	12	0	1,357	1,493	22	22	3.5	1,628	Yes
Hydrogen Peroxide	12	12	0	1,357	1,493	22	22	3.5	1,628	Yes
Ammonium Sulphate Mix	14	15	0	2,232	2,455	28	28	3.5	2,667	Yes
Bicarbonate Mix	14	15	0	2,232	2,455	28	28	3.5	2,667	Yes
Ammonia	10	4	1	419	-	-	-	-	-	-

Notes:
[1] Containment volumes include sloped floors to bottom of sump and volume loss due to tank bases as appropriate.
[2] Tank volume based on pressure vessel with a 2:1 ellipsoidal head; Height listed refers to straightwall of vessel.
[3] RO containment area is not rectangular therefore multiple areas are added to calculate volume (see Figure 5.7-4).
[4] Area calculated as building footprint less the yellowcake and vanadium drying, packaging, and storage rooms.



CHEMICAL STORAGE AREA PLAN

SCALE: 3/32" = 1'–0"

RELEASED FOR PERMITTING ONLY NOT FOR CONSTRUCTION

3/32"=1'–0"

Figure 3.2-8 Preliminary Chemical Storage Area Layout

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LYNTEK INCORPORATED

ROSS ISR PROJECT
PLANT DESIGN

GENERAL ARRANGEMENT
CHEMCAL STORAGE AREA LAYOUT

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3.3 Instrumentation and Control

3.3.1 Instrumentation and Control

Process control at the CPP will be conducted from a central control facility wherein plant operations can be remotely monitored and controlled 24 hours a day. In addition, other control capabilities will exist throughout the wellfield and the CPP so that local control can be exercised by field operations personnel.

The Master Control System (MCS) will reside at the CPP and consist of a pair of redundant PLC's capable of monitoring and controlling the CPP as well as some functions in the module building. Each module building will also have its own PLC and HMI touch screen that communicates with the CPP and will allow for continuous operation even if communication to the CPP is lost.

Operators can interface with the control system in several ways. The PC based Central Operator Station (COS), located in the main control room of the CPP is one such way. Customized screens representing the various areas and systems display information in an easy to understand fashion and allow for intuitive control and process manipulation. The COS will also be loaded with a historical data software package used for tracking and trending critical values and event timing. Alarms and faults for both the CPP and Module buildings will be displayed on the COS as well as on the Module buildings HMIs.

Limited, local control is achieved using panel mounted HMI touch screens. Manual hand switches will also be utilized where needed.

3.3.2 Wellfield

Wellfield instrumentation and control are discussed in Section 3.1.

3.3.3 CPP

Flow rates and line pressures will be monitored throughout the CPP to manage and guide plant operations. These flow rates and line pressures will be monitored at locations such as:

- Feed to the IX columns;
- Feed to the RO guard column;
- Feed to the RO Unit #1;

- Barren lixiviant feed to filter;
- Barren lixiviant to injection pumps;
- Barren lixiviant to module buildings;
- RO Unit #1 brine;
- RO Unit #1 permeate;
- Feed to the RO Unit #2;
- RO Unit #2 brine;
- RO Unit #2 permeate;
- Plant brine to brine storage tank;
- Brine storage tank to lined retention pond high pressure injection pump;
- Antiscalant feed to deep well injection brine;
- Brine high pressure injection pump to deep disposal well;
- Restoration feed to guard column;
- Restoration fluids to restoration reverse osmosis unit;
- Restoration RO Unit brine;
- Restoration RO Unit permeate to injection wells and storage pond;
- Restoration injection fluids;
- Permeate supply to plant from lined retention ponds;
- Permeate discharge to lined retention ponds;
- All chemicals added to the processing system (which will also include metering devices);
- Carbon dioxide
- Flocculent
- Gaseous NH3
- Water
- Sodium chloride
- Hydrogen peroxide
- Sulfuric acid
- Sodium carbonate
- Sodium bicarbonate
- Ammonia

- Ammonium sulfate
- Steam
- Plant air
- Antiscalant

In addition, level controls will be used in tanks such as:

- Sand filters
- Eluant tanks
- Precipitation tanks
- Resin transfer tanks
- Bleed fluid tank
- Uranium thickener
- Uranium thickener overflow tank
- Vanadium precipitation feed surge tank
- Vanadium precipitation conversion tank
- Vanadium precipitation tanks

The system will also have pressure indicating transmitters on all pressurized tanks such as IX vessels and pH metering and control in the eluant system. The differential pressure across the IX and elution vessels will be monitored closely and used to trigger alarms and automatic shutdown sequences should the values exceed the safe limit. Low differential pressure will indicate a leak or malfunction. Level, pH, temperature, and flow will also be monitored throughout the site and used to automate to the desired level.

The system will be controlled by the MCS with alarms and automatic shutoff capability built into the control system at appropriate limits for each individual monitoring and control point. All pumps and motors will have individual Hand-Off-Auto hand switches and will be monitored and controllable through the MCS system.

The overall control system will be designed so that appropriate redundancy exists for safe plant operation. Critical pumps will have backup pumps designed into the system such that if a failure occurs, the pumping operation can be easily controlled. Redundancy will also occur from installing

multiple monitoring points for each process. If a monitoring point fails, other monitoring points can be used to provide an indication of plant conditions while a monitoring point is checked for replacement or repair. Typical monitoring equipment is provided in Table 3.3-1 and preliminary monitoring point locations are shown in Figure 3.3-1. In accordance with 10 CFR Section 2.390(a)(4), the plant designs are considered proprietary and confidential. Therefore, the drawings and specifications included in Section 3.3 of this TR are not for release to the public. This includes Figure 3.3-1.

Instrumentation and logging of the yellowcake dryer will include all parameters that are important to the efficient operation of the dryer and its safety features. Monitored parameters will include: oil temperature in and out; off-gas temperature and pressure; and dryer pressure. Alarms and automatic shutoff switches will activate whenever these parameters are out of normal operating ranges. Hourly records of all important parameters will be collected and stored on site for a minimum of three years in accordance with 10 CFR, Part 40, Appendix A, Criterion 8.

Table 3.3-1. Typical CPP Monitoring Equipment

Monitoring Equipment	Description
Variable Frequency Drive	Controls speed on selected pump motors to regulate flow rate
Pressure Transmitter	Monitors pressure in pipelines, pressure vessels, tanks, dryer, etc.; 4-20mA signal output to PLC
Flow Meter	Magnetic or Ultrasonic type flow meters with instantaneous signal output to PLC
Level Indicator	Ultrasonic, Radar, Guided Wave, Capacitance or Vibrating Fork; 4-20 mA signal output to PLC
Level Switch	Float type switch
pH Meter	Measures pH to aid in monitoring, controlling and troubleshooting CPP processes
Programmable Logic Controller (PLC)	Totalizes flow rates, records pressure, flow, level, pH and communicates with control room in CPP
Human Machine Interface (HMI)	Allows operators to interface with control system and view status and alarm information
Central Operator Station (COS)	PC based operator interface and data management

3.4 References

AASHTO (American Association of State Highway and Transportation Officials), 2002, Roadside Design Guide

ANSI (American National Standards Institute), 1999, Safety Requirements for the Storage and Handling of Anhydrous Ammonia, Pamphlet K-61.1, 1989.

Buswell, M.D., 1982, Subsurface Geology of the Oshoto Uranium Deposit, Crook County, Wyoming: MS Thesis, South Dakota School of Mines and Technology.

Caropreso, F.E., and Badger, W.P., 1974, Hydrogen Peroxide Precipitation of Uranium at the Atlas Minerals Uranium Mill, American Institute of Mining, Metallurgical, and Petroleum Engineers, Transactions v.256.

Cahill A.E., and Burkhart, L.E., 1990, Continuous Precipitation of Uranium with Hydrogen Peroxide, Metallurgical Transactions B, Vol. 21B, October 1990, pp 819-826.

Mayo, A.L., 2010, Ambient Well-bore Mixing, Aquifer Cross-contamination, Pumping Stress, and Water Quality from Long-screened Well: What is Sampled and What is Not? Hydrogeology J 18: 823-837.

Merritt, R.C., 1971, The Extractive Metallurgy of Uranium, Colorado School of Mines and Technology, Golden, CO.

NFPA (National Fire Protection Association), 2010, NFPA 55: Compressed Gases and Cryogenic Fluids Code. Available from the website on the Internet as of December 2010: <http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=55>

NRC (U.S. Nuclear Regulatory Commission), 2009, NUREG-1910, Generic Environmental Impact Statement for *In-Situ* Leach Uranium Milling Facilities. Final Report, May 2009.

_____, 2002, NUREG-1623, Design of Erosion Protection for Long-Term Stabilization, August 2002.

Shabbir, M., and Tame, J.E., 1974, Hydrogen Peroxide Precipitation of Uranium, U.S. Bureau of Mines, Report of Investigations RI-7931.

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4.0 EFFLUENT CONTROL SYSTEMS

This section describes the proposed effluent control systems for the Ross ISR Project. Effluents will be typical of Wyoming ISR projects and will include gaseous emissions, airborne particulates, and solid and liquid waste. The effluent control systems proposed at the Ross ISR Project include existing technologies that have demonstrated success at controlling effluents using specific procedures, training, and engineering controls to reduce effluent production and minimize the potential for accidental releases. The proposed monitoring and control systems have been located to optimize their intended function and are appropriate for the types of effluents generated during ISR construction, operation, aquifer restoration and decommissioning. These procedures include recycling/reusing materials through segregation of waste, careful control of all materials delivered to or transported from the proposed project area in accordance with US DOT requirements, extensive employee training in hazard recognition and prevention of accidental releases, use of signage, detailed Standard Operating Procedures and Spill Prevention/Response Plans, and use of engineering controls for all types of effluent. SOPs and spill prevention plans will address contingencies for all reasonably expected system failures and include appropriate personnel to be notified, measures to efficiently detect and mitigate a release to the environment and confirmation that the SOPs comply with notification requirements.

4.1 Gaseous Emissions and Airborne Particulates

Both radioactive and non-radioactive airborne effluents are anticipated in the proposed project area. The primary radioactive effluent will be radon gas. Potential radiological air particulate effluents also include dried yellowcake. Non-radioactive airborne effluents will include gases emitted from the operation of internal combustion engines and airborne particulates released from unpaved roads, earth disturbing activities, and wind erosion. Minor non-radioactive airborne effluents might also include: small releases of salt and soda ash during reagent delivery, dust from cementing operations, welding fumes, particulates from grinding steel, as well as carbon dioxide, oxygen and water vapor vented from ISR facilities. Fumes from chemicals used in the laboratory will be minor but present as well.

4.1.1 Non-Radioactive Emissions and Control Measures

Emissions from internal combustion engines will be the primary source of gaseous effluent. Small releases are anticipated from the following: drilling rigs, drilling support equipment (backhoes, water trucks, pipe trucks, cement units), wellfield utility trucks (MIT units, workover units, swabbing units), light vehicles associated with wellfield operations and construction along with vehicles to transport staff to/from the site. These emissions will likely include CO, CO_2, SO_2, NO_x and PM_{10} and total hydrocarbon (THC). A preliminary emissions inventory is presented in Addendum 4.6-A of the ER and summarized in Table 4.6-1 of the ER.

Fugitive dust will be generated during all project phases from activities such as the mechanical disturbance of and soil materials by heavy equipment, from transport vehicles traveling on access roads, and from wind blowing over disturbed areas and stockpiles. As discussed in Section 5.6 of the ER, Strata will mitigate fugitive dust emissions during all project phases with the use of speed limits, strategically placed water loadout facilities near access roads, chemical dust suppressants such as magnesium chloride, selection of road surface materials which will minimize dust, and prompt revegetation of disturbed areas.

The potential for non-radioactive emissions will also exist in the vanadium precipitation, drying and packaging circuits. Vanadium metavanadate dust and ammonia fumes will be generated within the vacuum

dryer. The design of the vanadium dryer is similar to that of the uranium dryer. Emissions from the vacuum dryers are easily contained because the dryers operate under a vacuum and process material does not come into contact with the heating system. Off gas from the dryer will be treated with filtration, and then routed to a condenser to remove the water vapor and ammonia. Vanadium precipitation tanks will be vented to a wet scrubber which will remove the ammonia and ammonium sulfate. Ammonia and ammonium sulfate is then recycled back to the vanadium precipitation system.

4.1.2 Radioactive Gaseous Emissions and Control Measures

Radon gas will be the primary source of radioactive gaseous effluent at the Ross ISR Project. Radon is a radioactive, colorless and odorless gas that occurs naturally as the decay product of radium. Radon is present in the lixiviant solution that is extracted from the wellfields and piped to the CPP for processing. Radon gas may potentially be released in the CPP as a result of solution spills, filter changes, IX resin transfer operations, and maintenance activities. Routine monitoring of radon progeny within the CPP (see section 5.7.3.2) will identify exposure levels and initiate corrective actions, if necessary, to ensure exposures of workers are maintained as low as reasonably achievable (ALARA). These measurements will form the basis of worker dose assessment from radon progeny and assignment of this component of internal dose (exposure in working level hours, along with breathing zone sampling results) is described in Section 5.7.4. Additionally, these radon sources contribute to the overall facility source term and consequent off-site public dose as demonstrated by the MILDOS analysis described in Section 7.3.

Areas within the CPP where radon exposure will be of concern include the desanding system, IX vessels, resin transfer area, and in fluid collection sumps. Pressurized down-flow IX vessels with vents in the top of each vessel will be used which will minimize radon releases. The desanding system, resin shaker screens, and sumps will have exhaust hoods and redundant exhaust fans. Vents from these systems will be connected to a manifold and discharged through vents on the plant roof (see additional discussion below). Vents will be located away from plant ventilation intakes and will be located on the leeward side of the CPP. Exhaust fans for these systems will create a negative flow, ensuring that air will not enter the process areas from the vessels or systems. Redundant fans will be of identical size and capacity and will operate only when primary fans are down for repair or maintenance. Radon exposure risks

to personnel in the CPP will be further reduced by the general plant area HVAC system. The general plant area ventilation system will circulate air within the CPP by exhausting air outside the building, forcing fresh in. The general plant area HVAC system will be designed to provide a minimum of 6 air changes per hour, which will require fans sized to generate an intake flow rate of 300,000 cubic-feet per minute (cfm). Air sampling for radon progeny will be conducted regularly in the plant as described in Section 5.7.3.

All exhaust points will be ducted through a common system to a wet scrubber then discharged to the atmosphere. This discharge will be downstream from the filtration device (wet scrubber) and terminated above the facilities roof per local and federal codes. The general air within the facility will be gravity ventilated up through a ridge vent. This used air will not come in contact to any critical process air and needs no filtration. All vented equipment will be ducted to a filtration unit prior to discharge.

A fan performance monitoring station will be located at the exhaust fan point of discharge after the filtration equipment (wet scrubber). Typically there is one exhaust fan per filtration unit and a single exhaust termination (stack/flue/pipe) located above the facility roof per local and federal codes. There will be two exhaust fans, one serving the negative pressure system area and one serving the main plant system scrubber or bag house (see Section 5.7, Figure 5.7-1). The area under positive pressure will be served by single supply fan. Each restroom will be served by an 80 CFM exhaust fan. These fans will be ducted up to and through the roof per building code.

Minor amounts of radon gas may be released outside of the CPP from the wellheads, module buildings, and lined retention ponds. At the wellheads and lined retention ponds, radon will be released directly to the atmosphere where it will rapidly disperse. Wellhead enclosures may be vented to reduce radon buildup which could otherwise expose wellfield personnel during inspection and maintenance activities. If vents are not installed on wellhead enclosures, SOPs will be used for accessing wellheads to ensure exposures to personnel are minimal. Module buildings will have ventilation systems consisting of a roof- or wall-mounted fan as well as a separate radon ventilation system with an intake located in the module building sump and exhaust point on the building roof.

The CPP and module buildings will also be ventilated passively by opening doors during processes when radon may be released. Ventilation of this type will be suitable most months of the year.

Radon that is discharged from the Ross facilities will quickly disperse into the atmosphere. Although radon monitoring devices are not proposed as part of the process equipment ventilation system or the general area ventilation system, the pre-operational baseline environmental monitoring program will be continued during operations as described in Section 5.7.7. This will ensure radon and progeny released to unrestricted areas will be measured and maintained below the limits specified in 10 CFR 20, Appendix B, table 2 and ALARA.

Additionally, environmental releases and their potential impact to the public have been modeled using the MILDOS-Area computer model. Results of this model are presented in Section 7.3 of this report. The basis of the MILDOS code, including its ability to be representative of site conditions, is inherent in the approved code documentation as developed by Argonne National laboratory (ANL 1997); use of the code is in accordance with NRC's guidance as presented in Regulatory Guide 3.59 (NRC 1987) and NUREG-1569, Appendix D (NRC 2003)

4.1.3 Radioactive Particulate Emissions and Control Measures

Potential radioactive particulate emissions will consist primarily of airborne yellowcake in the uranium drying and packaging circuit. Yellowcake drying will be done in a low temperature, vacuum-paddle dryer. This dryer will operate at a temperature of 300°F or less. Dryers of this type minimize generation of particulates and are very efficient at controlling particulate emissions because they are externally heated (no flame in contact with yellowcake) and the drying chamber is under vacuum. Accordingly, these dryers emit no airborne particulates to the environment. (See references supporting this in sections 5.7.1.1.2 and 7.3.1) Vented off-gas from the drying procedure will be filtered through a baghouse filter, and then cooled and scrubbed to remove smaller entrained particles and water vapor. Entrained particles in the baghouse fabric and scrubber water are returned to the process. The vacuum pump at the end of the off gas train discharges into the dryer room. Additional information on the dryer off gas treatment system is described in Section 5.7.1.1.2 of this report.

Upon drying, yellowcake will be packaged on a batch basis. A port in the bottom of the drying chamber will discharge yellowcake into 55-gallon drums. The yellowcake feed port will be fitted with a rotary air lock valve. The valve will

create a sealed and pressurized system to guard against particulate contamination of the surrounding area (See Figure 5.7-3).

A seal rupture on the dryer system could potentially release yellowcake particulates into the drying room atmosphere. Seals will be inspected at least once per shift with results recorded. If a seal rupture were to occur, a change in the applicable process parameters would be immediately identified in the off-gas system monitoring equipment (immediate pressure drop, air flow reduction, etc), which is monitored in the control room and checked at least once per shift. While the likelihood of an unnoticed seal rupture is low, the potential ramifications of this situation are covered in Section 7.5 of this report.

4.2 Liquid Waste

4.2.1 Sources of Liquid Waste

The proposed Ross ISR Project will generate several types of liquid waste during construction, operation, and restoration activities. Liquid waste at the Ross ISR Facility can be divided into two general categories: AEA-regulated wastes, and non-AEA-regulated wastes. AEA-regulated wastes include wastes meeting the definition of 11e.(2) byproduct material as defined by 10 CFR Part 40.4: "The tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content." AEA-regulated liquid wastes include brine and excess permeate from the treatment of production bleed and aquifer restoration water, decontamination waste water, spent eluate and other process liquids, and "affected" groundwater generated during well enhancement and maintenance activities. Non-AEA-regulated liquid wastes will include TENORM (technologically enhanced naturally occurring radioactive materials); storm water runoff; Hazardous waste such as petroleum products and chemicals; and domestic sewage. TENORM liquid waste includes drilling fluid and "native" groundwater generated during construction and development of monitor, recovery and injection wells, and groundwater generated during sample collection, and aquifer testing of wells.

As discussed in Section 3.1.5, uranium recovery will follow a "phased" mode, consisting of the operation only phase, the concurrent operation and aquifer restoration phase, and the aquifer restoration only phase. Figures 3.1-11 through 3.1-13 present the anticipated water balance during each phase.

4.2.1.1 AEA-Regulated Liquid Wastes

4.2.1.1.1 Brine

At the proposed Ross ISR Project, brine will be generated from RO treatment of the production bleed and treatment of groundwater from aquifer restoration. Two stages of RO will be used in treating both the production bleed and restoration water. From the second phase RO brine will be discharged into the lined retention ponds for storage and eventually disposal in the deep disposal wells. Methods used to dispose of brine as well as brine generation and disposal rates are discussed below in Section 4.2.3.

4.2.1.1.2 Excess Permeate

Permeate will also be generated from the treatment of both the process bleed and groundwater from aquifer restoration. Most of the permeate produced during the operation only phase, concurrent operation and aquifer restoration, and the aquifer restoration only phase will be recycled back into the wellfields to reduce salt buildup in the recovery solution, or as part of aquifer restoration activities. Permeate that is recycled to the wellfield is not considered a waste product. Excess permeate which is not recycled back to operation or restoration activities will be discharged to the lined retention ponds. From the ponds, excess permeate may be used as plant makeup water, surface discharged, discharged to land application systems, or injected with brine in the deep disposal wells. Permeate will be high quality water and will generally be put to beneficial use. Excess permeate generation, disposal, and use rates are discussed in Section 4.2.3.

4.2.1.1.3 Other 11e.(2) Liquid Waste

Other 11e.(2) liquid waste includes spent eluate, liquid from process drains in the CPP, contaminated reagents, resin transfer wash water, filter backwash water, plant wash down water, decontamination water (e.g., employee showers), and fluids generated from work over and enhancement operations on injection and recovery wells. Liquid wastes generated in the CPP will be discharged into the lined retention ponds through the wastewater collection system, while water collected from swabbing or other work over activities on injection and recovery wells will be collected in dedicated tanks and transported to the lined retention ponds. Any water captured from leaking pipelines or equipment will also be transported to lined retention ponds in dedicated portable tanks or tanker trucks.

Other 11e.(2) liquid wastes will be combined with brine and disposed primarily through deep well injection, with lesser amounts evaporated in the lined retention ponds prior to disposal. The quantity of other 11e.(2) liquid waste will depend mostly on the production rates of the uranium elution and precipitation circuits as spent eluate is the largest contributor. This waste stream will range in flow from 10 to 40 gpm depending on the production rates of the uranium elution and precipitation circuits.

Based on information gathered during installation of the regional baseline monitor wells for the proposed Ross ISR Project, a typical injection,

recovery, or monitor well is expected to use between 3,000 and 30,000 gallons of water during drilling and well development and average around 6,000 gallons. Volumes generated during work over and enhancement operations are expected to be similar.

4.2.1.2 Non-AEA-Regulated Liquid Wastes

4.2.1.2.1 TENORM

TENORM liquid waste includes drilling fluids and drill cuttings from monitor wells and from the construction and development of recovery and injection wells prior to using the wells for ISR uranium recovery. TENORM drilling fluids will be stored and disposed of on-site in mud pits, which will be constructed adjacent to the drilling pad. TENORM groundwater produced during baseline activities was discharged under a temporary WYPDES permit as discussed below. It is expected that other TENORM groundwater generated during the operation and decommissioning phases will be discharged in a similar manner as long as the well is not completed in an interval which could have been affected by uranium recovery operations.

During hydrologic baseline activities, TENORM groundwater was discharged during sample collection and aquifer testing. The "native" groundwater had not been exposed to any uranium recovery processes or chemicals. The groundwater recovered during these activities was discharged to the surface in a non-erosive manner. This discharge was authorized under temporary WYPDES permit WYG720229. In accordance with the permit, the discharge was monitored for flow, TDS, TSS, pH, radium, and uranium, and the results reported to WDEQ/WQD. These discharges occurred during water quality sampling at each of the 6 baseline well clusters and throughout July of 2010 during aquifer tests conducted at each of the baseline well clusters.

As discussed above, a typical injection, recovery, or monitor well is expected to use between 3,000 and 30,000 gallons of water during drilling and well development and average around 6,000 gallons. In addition, installation of each well is expected to yield approximately 5 to 15 cubic yards of drill cuttings.

4.2.1.2.2 Storm Water Runoff

Storm water management will be controlled under a WYPDES permit issued by the WDEQ/WQD. Regulations under the federal Clean Water Act and

Chapter 2 of the Wyoming Water Quality Rules and Regulations require operators of construction sites that disturb an acre or more to obtain coverage under a storm water permit. As part of the permit, a storm water pollution prevention plan (SWPPP) will be prepared describing best management practices (BMPs) used to keep pollutants out of surface waters and storm drains. Periodic review of BMPs will ensure that storm water runoff is not a potential source of pollution.

Facility drainage will be designed to route storm water runoff away from or around the CPP, parking areas, and other associated structures. As discussed in Section 3.1, storm water runoff from the paved area around the CPP will be collected in a storm drain system and routed to a sediment pond for disposal.

4.2.1.2.3 Waste Petroleum Products and Chemicals

Small quantities of used oil will be generated from equipment and vehicles used at the project. The waste petroleum products will be temporarily stored on site before being transported to a nearby recycling or disposal facility. These wastes will not have been affiliated with the processing or generation of 11e.(2) byproduct material and will not be classified as AEA-regulated waste.

The used petroleum storage tank will be sealed and located in the maintenance shop. The storage tank will be cylindrical and constructed of steel with a locking cap and venting system. Secondary containment will consist of a concrete curb, designed to contain 110% of the tank volume. Spills of waste petroleum will be contained, mitigated, cleaned up, and reported in accordance with WDEQ requirements.

Strata anticipates that the proposed Ross ISR Project will be classified as a conditionally exempt small quantity generator (CESQG) by WDEQ/SHWD. As such, the project will be required to generate less than 220 pounds (100 kg) of hazardous waste in any calendar month and store less than 2,200 pounds (1,000 kg) of hazardous waste at any one time. If the facility does not meet the requirements for a CESQG, it would lose its CESQG status and be fully regulated as either a small-quantity generator (more than 100 but less than 1,000 kg hazardous waste per calendar month) or a large quantity generator (more than 1,000 kg per calendar month) (NRC 2010).

4.2.1.2.4 Domestic Sewage

Domestic sewage generation will vary throughout the phases of the project based on the number of workers on site. The maximum anticipated number of workers will occur during the construction phase when approximately 200 workers will be on site. Based on a peak waste generation rate of 30 gallons per day (gpd) per industrial employee (Chapter 11, Wyoming Water Quality Rules and Regulations), the peak daily domestic wastewater generation rate is expected to be up to about 6,000 gpd during construction. The average daily wastewater generation rate during operation will likely be up to about 800 gpd, based on the EPA (2002) domestic wastewater generation rate of 13 gpd for industrial building employees.

Domestic waste will be disposed in an on-site wastewater treatment or disposal system. The system will be designed according to WDEQ/WQD standards and will likely include one or more septic tanks for primary treatment. Septic tank effluent will either be disposed in a gravity or pressure-dosed drainfield, or Strata might decide to design and permit an enhanced treatment system. A wastewater treatment system would potentially include a recirculating geotextile or sand filter and disinfection followed by surface discharge of highly treated effluent. Based on the anticipated peak daily flow rate greater than 2,000 gpd, it is anticipated that a drainfield would be permitted as a Class V UIC facility through WDEQ/WQD. As such, WDEQ/WQD would likely require the installation of monitor wells around the drainfield with requirements for quarterly or semiannual monitoring. WDEQ/WQD would establish monitor well contaminant limits for common domestic wastewater contaminants such as chloride, nitrate, ammonia, and bacteria. A wastewater treatment system would also require point-of-compliance sampling. Typically, treated effluent would be discharged under a WYPDES permit with effluent limits established by WDEQ/WQD as protective of the receiving stream. Alternately, treated effluent could be put to beneficial use in constructed wetlands.

Due to the significantly higher number of construction workers relative to operating personnel, Strata will consider constructing an on-site wastewater disposal system for operating personnel and temporary holding tanks pumped by a wastewater disposal contractor for construction and decommissioning. This would reduce the amount of on-site effluent disposal.

4.2.2 Lined Retention Pond Design

Two ponds are planned as part of the waste storage infrastructure at the proposed project area. Each pond will include three cells and will be built utilizing common containment berms. Interconnected piping within the ponds will allow the transfer of liquids between cells. Ponds will include double liners and leak detection systems as described in Section 4.2.2.1.

Lined retention ponds will be designed to meet the requirements of both NRC Regulatory Guide 3.11 for embankment retention systems and Wyoming Water Quality Rules and Regulations, Chapter 11, for lined wastewater storage ponds. The proposed pond designs will not be covered under the National Dam Safety Program because the proposed impoundments do not meet the criteria listed in NRC Regulatory Guide 3.11. The primary purpose of retention ponds is to manage permeate and brine inflows to optimize disposal techniques and provide for waste storage in the event of upset conditions. Sheet 1 of Figure 4.2-1 shows the location and layout of the proposed ponds.

Pond cells will be rectangular, with maximum internal slopes of 3 horizontal to 1 vertical. Ponds will be 15 feet deep with 3 feet of freeboard and a maximum hydraulic depth of 12 feet. Wherever possible, ponds will be almost entirely incised to minimize embankment fill and minimize the volume of water that could be released during a catastrophic embankment failure. Final pond designs will be prepared following a geotechnical analysis of foundation and borrow soil conditions. Designs will be prepared and submitted to WDEQ and NRC by a licensed professional engineer registered in the State of Wyoming. Typical pond design details are shown on Sheet 2 of Figure 4.2-1. Final pond designs will be included in a separate facilities design report, Addendum 3.1-A, submitted at a later date following further evaluation through geotechnical drilling programs. Final designs for the ponds will include a quality control program for installation, tests to demonstrate liner resistance to chemicals and any other pertinent analysis required to establish that the structures meet all necessary regulatory requirements.

As discussed in Sections 3.1 and 2.7 of this report, preliminary evaluations of the surficial aquifer at the CPP site indicate that shallow groundwater is present at depths ranging from 8-12 feet below grade. Current proposed pond depths extend up to 14 feet below grade. In order to mitigate the effects of the surficial aquifer on the ponds, Strata is proposing to install a containment barrier wall (CBW) around the perimeter of the CPP area as

discussed in Section 3.1.8.2. The area inside the CBW will be dewatered by a series of wells located within the CBW boundary. Due to the presence of consistent low permeability bedrock below the site, it is expected that maintenance dewatering efforts will be minimal once the water table is initially lowered. Water generated during dewatering of the CPP area will most likely meet surface discharge standards and will therefore be discharged under a temporary WYPDES permit.

Under normal operating conditions, the water levels in the pond cells will be maintained such that the total volume of liquid in any one cell of the pond can be transferred to the other two cells to allow for leak repair. Two water levels will be considered in the pond designs, as indicated on Figure 4.2-1: (1) high water level (HWL), which is the highest water level that will be obtained in any pond while maintaining a minimum of three feet of freeboard, and (2) normal water level (NWL). The NWL is the maximum level that will provide sufficient storage in the event that brine or permeate from a leaking pond cell needs to be transferred to other cells within a pond. The capacity at the NWL is termed the operating capacity and the capacity between the HWL and NWL is termed the auxiliary capacity (see Figure 4.2-1, Sheet 2). Table 4.2-1 shows the anticipated operating capacity, auxiliary capacity, and total capacity for the ponds. The minimum freeboard depth of 3 feet will be sufficient to capture direct precipitation resulting from the 100-year, 24-hour storm and protect the embankment from wave runup. In the Oshoto region, the 100-year, 24-hour precipitation total is about 4.2 inches as discussed in Section 3.1 of the ER. The contributing drainage area of each pond is nearly equal to the HWL area so therefore the 100-year, 24-hour precipitation event is expected to result in a net water level increase of less than 0.5 foot in each pond.

Prevention of overfilling due to abnormal operation, malfunctions in level equipment or human error will be minimized through frequent inspections, maintenance of freeboard and redundant monitoring equipment.

Potential impacts to avian wildlife from liquid waste in the sediment and lined retention ponds will be reduced by using avian specific deterrents such as bird proofing (netting) and/or aversion techniques (sound/visual hazing systems or stretch wire). Best available control technologies (BACT), as determined at the time of construction, will be used.

4.2.2.1 Pond Liner and Leak Detection Systems

The retention ponds liners and leak detection systems will meet the requirements of Regulatory Guide 3.11. Each pond will be equipped with an impermeable high density polyethylene (HDPE) or polypropylene (PP) primary liner with a minimum thickness of 36 mils (0.036 inch). HDPE and PP liners are generally very resistant to chemicals and alkaline and acid agents, with the exception of oxidizing acids, and salt solutions (Renken et al 2005). Site preparation and liner installation will be in accordance with manufacturer's specifications.

The leak detection system will consist of a permeable drainage layer and a collection piping system. The permeable drainage layer will be located directly under the primary liner. This layer will provide support for the overlying liner, and will also transmit any leakage to collection pipes. The drainage layer will be constructed of suitable transport media (i.e. sand). Geocomposite fabric will be used on the side slopes to allow movement of the leakage to the collection pipes. The pond bottom will be sloped from the center outward. The perforated pipes will be installed along the same slope as the pond floors and will drain to riser pipes located in the embankment. The presence of liquid in these riser pipes will signal an audible and visual alarm in the CPP control room to be followed by sampling for water quality to confirm a leak is the cause of the moisture. Water quality analysis will include electrical conductivity and other major ions required to evaluate and mitigate a liner integrity issue. A cross section of the ponds leak detection system is shown in Sheet 2 of Figure 4.2-1.

Beneath the leak detection system will be a secondary geosynthetic liner, with a minimum thickness of 36 mils (0.036 inch). The liner will be installed on top of the underlying foundation material and will function to contain potential leakage. Geotechnical investigations of the underlying foundation material it may indicate that conditions favor installation of natural clay liner instead of the geosynthetic liner. This determination will be made after falling head permeability tests are conducted on bulk soil samples of the foundation material. If the permeability of foundation material is a minimum of two orders of magnitude less than either the graded sand or geocomposite drainage materials that make up the leak detection system, the permeability contrast ensures that any leakage through the primary synthetic liner will be detected before saturation of the foundation materials could occur. If the foundation materials do not have the required permeability, bentonite may be mixed with

the foundation material to decrease its permeability. Use of a natural clay or soil-bentonite secondary liner is preferred over the use of synthetic materials due to the self-healing properties of these liners and the proximity of the proposed project to bentonite supplies.

The use of sand and geocomposite drainage material beneath the primary synthetic liner eliminates the need for air vents beneath the liner since gases produced under the liner would be vented through the sand and geocomposite drainage material.

Routine pond inspections and monitoring will be conducted as stated in Section 5.3.2 and consistent with the requirements detailed in Regulatory Guide 3.11. Inspection sheets and monitoring results will be maintained on-site and submitted in annual reports to NRC and WDEQ/LQD. In the event of a confirmed loss of liner integrity a verbal notification to NRC will occur within 48 hours to be followed by a written report to the NRC within 30 days detailing suspected cause of the leak, estimated amount of leaked material, chemical nature of leaked material and mitigation efforts undertaken to repair and re-capture any effluent leaked into the native materials within the CBW. In addition, the report will provide methods to prevent a similar event in the future.

4.2.3 AEA-Regulated Liquid Waste Disposal Plan

The AEA-regulated liquid waste at the Ross ISR Project will be managed through discharge to the lined retention ponds. Ponds will allow for surge and storage capacity, and provide additional disposal capacity through evaporation in summer months. Regulated flow of liquid waste will be routed from the ponds to the different disposal options that are discussed below.

4.2.3.1 Excess Permeate Disposal and Use

Excess permeate generated during uranium recovery and aquifer restoration activities at the proposed project will be used beneficially through surface discharge, recycling for use as plant make-up water, land application, or disposed of with brine in the Class I deep disposal well. As discussed previously, most permeate generated during RO treatment of the production bleed and aquifer restoration streams will be recycled back to the wellfield. Times when excess permeate is present, such as during the operation only phase, it will be discharged into lined retention ponds, where it will be used or

disposed of by one of four methods discussed above. Aside from beneficially use and disposal it is also expected that evaporation of excess permeate from lined retention ponds will be an additional abstraction. Evaporation estimates are discussed in Sections 4.2.3.1.5 and 4.2.2.3.2.

Permeate from the RO systems will be a high quality effluent, Table 4.2-2 summarizes the anticipated permeate water quality. Methods used to obtain the estimated water quality are discussed in Section 6.1.

4.2.3.1.1 Surface Discharge

The Federal Water Pollution Control Act of 1972, as amended by the Clean Water Act of 1977 and the Water Quality Act of 1987, provides the EPA with the authority to regulate the discharge of pollutants to waters of the U.S. through the National Pollutant Discharge Elimination System (NPDES) Program. Since 1975, the WDEQ/WQD has had primacy of NPDES permits in Wyoming through the WYPDES Permitting Program.

Strata is considering obtaining a WYPDES permit to discharge excess permeate to tributaries of the Little Missouri River, where the water will be used beneficially for livestock and wildlife. Within the proposed project area, the Little Missouri River and its tributaries are classified by WDEQ/WQD as 3B, meaning they are protected for industrial, agricultural, wildlife, recreation, non-fish aquatic life, and scenic value (WDEQ 2001). Class 3B streams are not protected for drinking water, game fish, non-game fish, or fish consumption.

Generally, two types of effluent limits will be applied in the WYPDES permit, including technology-based effluent limits subject to the requirements of 40 CFR 440, and water-quality based effluent limits protecting the class of use of the receiving stream. The anticipated WYPDES effluent limits are shown in Table 4.2-3 and are based on a recent permit renewal for Cogema Mining Inc.'s Christensen Ranch ISR. It should be noted that both the technology and water-quality based limits will be more stringent than limits specified in 10 CFR Part 20 Appendix B for Ra-226, which will be the only radionuclide present in the permeate.

Excess permeate will likely meet all WYPDES effluent limits through RO treatment alone, with the possible exception of Ra-226. If necessary, Ra-226 removal could be accomplished through barium chloride precipitation or a zeolite-based radium treatment system such as that available from Water Remediation Technology, LLC. In the latter case the treatment provider would

dispose of the radium-loaded treatment media in an NRC-approved disposal facility.

4.2.3.1.2 Plant Make-Up Water

Excess permeate may be used for various processes in the CPP, including elution and precipitation. The required flow rate for plant make up water will range from 10 to 40 gpm depending on the production rate of the uranium elution and precipitation circuits.

4.2.3.1.3 Land Application

Strata is considering the use of land application systems in order to utilize excess permeate for growing crops. Land application through direct sprinkler or a subsurface drip irrigation (SDI) system would allow Strata to provide a beneficial use to landowners (forage production) within the proposed project area and also provide straw for use in reclamation activities. Excess permeate would be disposed of in one or more center pivot irrigation or in subsurface drip irrigation systems permitted as land application systems through WDEQ/WQD. Land application is defined by WDEQ/WQD as "the spraying or spreading of wastewater onto the land surface or the injection of wastewater below the land surface" (WDEQ 1997). Chapter 16 of WDEQ Rules and Regulations along with the Groundwater Program's *Compliance Monitoring and Siting Requirements for Drip Irrigation Systems Permitted Under the Underground Injection Control (UIC) Program, June 2007* formulate the requirements for permitting this type of facility.

Considering the high ion rejection rates for the RO units, permeate will have low divalent cations (calcium and magnesium) and might pose an infiltration risk to clay soils. Therefore, a land application system would likely include the application of soil or water amendments such as gypsum (calcium sulfate dihydrate). Prior to land application, the permeate might also be treated for Ra-226 reduction using the methods described above for treatment prior to WYPDES discharge.

Excess permeate will be applied at an agronomic rate high enough to ensure adequate soil salt leaching but low enough to prevent runoff into stream channels. In the case of a center pivot system, water would only be applied during the growing season, which is typically May through September. If an SDI system were used, disposal of water may occur year round. Irrigated crops

will be selected for compatibility with the irrigation water and will likely include alfalfa, wheat, or native grass hay.

SDI systems have been used successfully in the Powder River Basin to beneficially utilize water co-produced during CBNG development. Typical SDI systems use rows of emitter pipes, buried at depths from 3 to 5 ft in zones designed to maximize plant uptake and system efficiency. The emitters are designed to release water at a rate compatible with the site soils. The system typically allows the introduction of fertilizers, soils amendments or other additives to prevent scaling or root intrusion. The CBNG co-produced water typically has much higher concentrations of salts than the permeate that will be generated at the proposed project. Soil and water amendments combined with application of a leaching fraction (applying more water to the soil than is required for evaporation and plant transpiration), allow the saltier water to enhance crop production as the leaching fraction prevents concentration of salts in the root zone. These systems are permitted by WDEQ/WQD under V (5F2) classification and require rigorous site characterization.

Strata has conducted a preliminary study on the suitability of soils for land application in the proposed project area. The study indicated that suitable soils exist, considering the high quality permeate that would be used. Further evaluation would be required to acquire the necessary permits. Prior to pursuing land application as a use option, Strata will provide the following for NRC and WDEQ/WQD approval:

- An irrigation plan including application system designs and flow rates,
- A site description,
- Area of review evaluation,
- Water balance demonstration,
- Geologic description,
- Hydrogeologic description,
- Water quality evaluation including a demonstration that potential doses conform to 10 CFR part 20 requirements,
- Baseline soil conditions including textural and chemical analysis for the affected areas,
- Crop description including fate of crops produced,
- Water treatment and soil amendment plans,

- Monitoring program focusing on potential impacts to irrigated soil crops, and a
- Decommissioning plan.

Strata will also work closely with the WDEQ/LQD division to ensure compliance with the Permit to Mine.

4.2.3.1.4 Class I Deep Disposal Wells

The final method of excess permeate disposal is injection, along with brine, in Class I deep disposal wells. Where possible, Strata will employ one of the other methods to maximize beneficial uses of the relatively high quality permeate. Class I deep disposal wells are discussed below in Section 4.2.3.2.1.

4.2.3.1.5 Permeate Disposal Water Balance

The three main phases of operation which will dictate excess permeate generation at the proposed project include: operation only, concurrent operation and aquifer restoration, and aquifer restoration only. The following section discusses the expected permeate flow rates and water balance for each phase. Table 4.2-4 summarizes the typical permeate generation and excess permeate disposal rates.

Due to the limited surface area of the lined retention ponds that are planned for excess permeate storage, evaporation is not included as a significant permeate disposal option. However, it should be noted that excess permeate is estimated to evaporate at an average annual rate of 1.5 gpm per surface acre as discussed below.

Operation Only

The operation only phase will occur during wellfield startup, when operating modules are in production prior to any aquifer restoration activities. Figure 3.1-11 shows the anticipated permeate generation rates during this phase. During this time, the maximum flow rates based on expected operating conditions will be 7,500 gpm from the wellfields and a 1.25% average production bleed or 94 gpm. The anticipated amount of excess production bleed which will be removed from the barren lixiviant stream and treated by RO is 220 gpm. The treatment of the excess production bleed will produce 183 gpm of permeate from two stages of RO. Of this, 126 gpm will be recycled back to

the injection stream and the remaining portion of excess permeate will be 57 gpm.

Excess permeate during this phase will be discharged to the lined retention ponds (see Figure 4.2-1). Although both Pond #1 and Pond #2 may hold either permeate or brine, it is likely that Pond #1 will be used to store permeate during this phase. Each Pond #1 cell will have an operating capacity of around 5.5 ac-ft for a total operating capacity of 16.5 ac-ft.

Of the 57 gpm of excess permeate that will be discharged to Pond #1, it is anticipated that approximately 25 gpm will be recycled back to the plant for use as make up water. This leaves a balance of 32 gpm, which will be surface discharged, used in land application systems, or disposed of in the deep disposal wells. In the absence of other methods, Strata will commit to maintain sufficient capacity in the deep disposal wells to handle all excess permeate generated from this phase of recovery. At a flow rate of 32 gpm, excess permeate will accumulate at a rate of 4.4 ac-ft per month if no disposal options were available, such as in an upset condition. The storage capacity in Pond #1 would allow for up to 3.8 months of excess permeate storage at this rate.

Concurrent Operation and Aquifer Restoration

A flow schematic of the concurrent operation and aquifer restoration phase is shown on Figure 3.1-12. The anticipated operation flow rates during this phase will be the same as discussed previously in the operation only phase. At this point in operation, aquifer restoration of some of the modules will have begun. The anticipated maximum aquifer restoration flow rates will consist of 1,025 gpm of restoration water from RO treatment and reinjection, and 75 gpm from groundwater sweep for a total of 1,100 gpm. Similar to the production bleed, groundwater recovered from restoration activities will be treated with two stages of RO. The final flow rate of excess permeate resulting from the treatment of the production bleed and restoration groundwater will be 1,118 gpm. Of this permeate, 126 gpm will be injected into the recovery solution and 992 gpm will be injected to wellfield modules undergoing the RO treatment with permeate injection phase of restoration. Due to the permeate demand for injection into the recovery and restoration streams, no excess permeate will be produced during this phase. An exception to this will be during the beginning of concurrent operation and aquifer restoration phase when the first several modules in restoration will be in groundwater sweep and

no modules will be in the RO treatment and permeate reinjection phase. Groundwater sweep is expected to occur over a 1 to 4 month period with flow rates of 37.5 to 150 gpm per wellfield module. Assuming an average of two months are needed to complete the groundwater sweep phase, the flow of excess permeate to the lined retention ponds would be approximately 184.5 gpm. It is of importance to note that concurrent operation and groundwater sweep will only occur for a short period of time. In addition, the recovery and aquifer restoration flow rates used in this water balance represent near maximum conditions and therefore are conservatively high due to the variability in individual well flow rates. In order to manage the excess permeate during this time, disposal options may also include groundwater transfer between wellfields in restoration and operation, which is discussed in more detail in Section 6.1. In addition, extra storage capacity available in Pond #2 may be used to store excess permeate.

Because no excess permeate is available during most of the concurrent operation and aquifer restoration phase, the required plant make up flow of 25 gpm will come from permeate in storage or if needed, the production and aquifer restoration bleed and/or RO reject rates will be adjusted to produce the required permeate.

Aquifer Restoration Only

The aquifer restoration only phase will begin when uranium recovery has been completed in all modules. The typical water balance for this phase is shown on Figure 3.1-13. Similar to the concurrent operation and aquifer restoration phase, all permeate generated will be injected into wellfield modules undergoing restoration.

4.2.3.2 Brine Disposal

Most of the brine generated by the Ross ISR Project will be disposed of in Class I deep disposal wells. Deep well disposal was selected as the preferred method of brine disposal due to minimal potential impacts to human health and the environment and reduced cost compared to other brine disposal alternatives such as evaporation ponds or off-site brine transport. In addition to deep well injection, the effects of evaporation in lined retention ponds have been considered in the brine water balance. These disposal options are discussed in more detail below.

The anticipated brine water quality is presented in Table 4.2-5. The brine water quality was estimated using the anticipated water quality at the end of uranium recovery, the typical RO salt rejection rates, and the quality and quantity of brine originating from other sources such as the elution bleed from the CPP.

4.2.3.2.1 Class I Deep Disposal Wells

Strata submitted a Class I UIC permit application to WDEQ on June 23, 2010. Strata's permit application includes up to 5 Class I deep disposal wells. The application is included as Addendum 4.2-A of this document. Correspondence received throughout the deep disposal well permit process is included in Addendum 4.2-B. Class I deep disposal wells inject hazardous and nonhazardous wastes into deep, isolated rock formations that are below the lowermost underground source of drinking water (USDW). The receiving formations will be the Cambrian-age, Deadwood and Flathead Formations, both of which are at least 500 feet below the lowermost potential USDW, the Madison Formation. Estimated depths for the target formations range from 8,160 feet below ground surface to 8,560 feet below ground surface. The receiving Cambrian sandstones are confined above by the Ice Box Shale member of the Winnepeg Group which is overlain by the Red River Formation. The Red River Formation also separates the Deadwood and Flathead Formations from the Madison Formation. Granitic and metamorphic rocks of the Precambrian basement provide the lower confining interval for the Deadwood and Flathead Formations.

Based on the anticipated porosity, thickness, lateral extent, and permeability of the receiving formations, the capacity of each Class I deep disposal well is expected to range from 35 to 80 gpm.

Figure 4.2-2 is a typical deep disposal well construction schematic. Deep disposal wells will be constructed according to WDEQ/WQD Class I disposal well construction standards, including surface casing from the ground surface to a distance of at least 100 feet below the base of the lowermost potential USDW. Strata will also perform regular monitoring and perform internal and external MITs in accordance with WDEQ and the conditions of the UIC permit.

Each well location will consist of a 250' by 250' pad and one or more storage ponds or tanks. Surface equipment for the deep disposal wells will include storage tanks, pumps, filtration systems, instrumentation and control

systems, and equipment for injection of treatment chemicals. Well pads will be either asphalt pavement or gravel and will be retained through the life of the disposal well in order to conduct maintenance. Access roads to the sites will be constructed on existing roads where possible and will have widths up to 14 feet. The supply pipelines to the wells will be 6 to 10-inch HDPE. Pressures and flow rates for the piping and the disposal well will be constantly monitored at the CPP.

Instrumentation details for the deep disposal wells are provided in Addendum 4.2-A, and consist of the necessary measures to ensure safe operation of the disposal system. At a minimum, these would include a flow totalizer, flow rate, pressure regulator, pressure indicator, pressure switch, annular tank level indicator and injection pressure chart recorder. Water quality, quantity and rates will be provided to the WDEQ/WQD UIC program as required by the permit.

4.2.3.2.2 Evaporation in Lined Retention Ponds

The secondary method of brine disposal at the proposed Ross ISR Project is evaporation in lined retention ponds. Evaporation will provide additional disposal capacity during normal operations, particularly during summer months. The following is a brief description of the water disposal capacity of the lined retention ponds.

Evaporation was estimated according to methods described in Pochop et al. (1985), which presents evaporation estimates for first-order pan stations in Wyoming. Although the Ross MET station included a Class A evaporation pan, only four months of data was collected. Data collection of pan evaporation rates will continue after application submittal which will provide a better estimate of site specific rates in the future. According to Pochop et al., the mean gross annual lake evaporation rate at the two nearest first-order pan stations varies from 39.1 inches in Sheridan to 42.4 inches in Casper. Pan evaporation rates were measured using relatively clean water, similar to the permeate at the proposed project. The proposed project area gross annual lake evaporation rate is assumed to be the average of these two values or 40.8 inches. The average annual precipitation for the region is approximately 12 inches per year as stated in Section 2.5.1.1.3. The net annual evaporation would be calculated as 40.8 inches, less 12 inches, or 28.8 inches per year. Thus, for each surface

acre of permeate in the lined retention ponds, the net annual evaporation will be approximately 1.5 gpm.

Pochop et al. also studied the impact on evaporation of higher TDS water from various sources, including brine generated from a uranium mining facility with a TDS of 54,100 mg/L. They found that the uranium brine decreased the evaporation rate by 3% as compared to tap water. The gross annual evaporation rate for brine is estimated at 97% of 40.8 inches or 39.6 inches. Subtracting the average annual precipitation of 12 inches gives 27.6 inches per year. Therefore, for each surface acre of brine in the lined retention ponds, the net annual evaporation will be approximately 1.4 gpm.

4.2.3.2.3 Brine Disposal Water Balance

The following section discusses the expected flow rates and water balance of brine for each phase of operation. Table 4.2-6 summarizes the typical brine production and disposal rates.

Operation Only

Brine sources from the operation only phase will include reject from treatment of the production bleed stream as well as other 11e.(2) liquid waste from the CPP and wellfield operations. The anticipated brine rate from these two sources is 62 gpm, which will most likely be stored in Pond #2.

Most of the brine will be disposed of in the deep disposal wells during this phase. Deep disposal well capacity has been estimated at 50 gpm per well on average, based on the injectivity of the target formation in surrounding areas. A maximum of two deep disposal wells will be needed during this phase in order to dispose of the anticipated brine flow rate.

In order to plan for an upset condition, where one or more wells may be down for repair or maintenance, Strata will maintain pond levels to provide for one full month of brine storage, allowing sufficient time for repairs to be conducted. One month of brine storage is equal to approximately 8.2 ac-ft. Considering the operating capacity of Pond #2 is 63.4 ac-ft, this will leave 55.2 ac-ft available for storage during this phase. Evaporation is also expected to decrease the volume of brine disposed of in the deep disposal wells. The surface area of the pond at 55.2 ac-ft is equal to 7.4 acres. As previously discussed in Section 4.2.3.2.2, the expected brine evaporation rate is 1.4 gpm per surface acre. The average annual evaporation rate from Pond #2 would be

approximately 10.4 gpm, reducing the overall flow rate to the deep disposal wells to approximately 51.6 gpm.

Concurrent Operation and Aquifer Restoration

The concurrent operation and restoration phase will produce the largest brine streams expected during ISR operations. Three brine sources will contribute to the waste stream including brine from excess production bleed treatment, brine from RO treatment of aquifer restoration water, and other 11e.(2) liquid waste generated from the recovery processes in the CPP and wellfield maintenance activities. The anticipated brine flow rate will be 227 gpm. It is likely that all five deep disposal wells will be necessary during this period. As in the operation only phase, Pond #2 will be operated such that a month of storage is available at all times in case the deep disposal wells are down. A month of storage at the anticipated brine storage rate is equal to 30.1 ac-ft. This will leave 33.3 ac-ft of available capacity in Pond #2.

If surface area of Pond#2 at a capacity of 33.3 ac-ft is 6.3 acres. This surface area would provide a total of 8.8 gpm of average annual evaporation. Including evaporation, the brine feed rate to the disposal wells will be approximately 218.2 gpm.

Restoration Only

The typical restoration only flow rate of brine is 190 gpm. This flow rate is comprised of 165 gpm from the treatment of aquifer restoration water and an estimated 25 gpm from other 11e.(2) liquid waste. It is anticipated that sufficient deep disposal well capacity will have already been developed and be available from previous phases of uranium recovery operations. Brine levels in ponds will be managed so that at least one month of brine storage is available. In order to provide at least one month of surge capacity, Pond #2 will be operated so that there is at least 25.2 ac-ft available at all times. Considering that the surface area of the pond at this capacity would be 6.6 acres, the annual brine evaporation rate would be 9.3 gpm, reducing the overall feed to the deep disposal wells to 180.7 gpm.

Table 4.2-1. Lined Retention Pond Capacities

Pond	Operating Capacity (ac-ft)	Auxiliary Capacity (ac-ft)	Total Capacity (ac-ft)
Pond #1	16.5	8.0	24.5
Pond #2	63.4	31.6	95.0

Table 4.2-2. Anticipated Permeate Water Quality

Parameter	Unit	Typical Value	Minimum Value	Maximum Value
EC	µS/cm	300	180	400
TDS	mg/L	200	100	250
pH	s.u.	8	6	6.5
Alkalinity as $CaCO_3$	mg/L	100	50	200
Sulfate	mg/L	15	10	20
Bicarbonate	mg/L	150	50	200
Chloride	mg/L	15	5	25
Calcium	mg/L	0	0	1
Sodium	mg/L	50	20	100
Manganese	mg/L	0	0	0.1
Selenium	mg/L	0	0	0.1
Arsenic	mg/L	0	0	0.1
Uranium	mg/L	0	0	0.1
Radium	pCi/L	30	5	100

Table 4.2-3. Anticipated WYPDES Effluent Limits

Parameter and Units	Monthly Average	Daily Maximum
Chemical oxygen demand (COD), mg/L	100	200
Oil and grease, mg/L	---	10
Total suspended solids (TSS), mg/L	20	30
pH	---	6.5-9.0
Radium 226, total, pCi/L	10	12
Radium 226, dissolved, pCi/L	3	10
Selenium, total, mg/L	---	0.005
Uranium, total as U, mg/L	2	4
Zinc, total, mg/L	0.5	1
Zinc, dissolved, mg/L	---	0.023

Source: WYPDES permit WY0033642 (Cogema Christensen Ranch) August 2008 renewal

Table 4.2-4. Anticipated Excess Permeate Generation and Disposal Rates

	Operational Phase			
		Concurrent Operation and Restoration		
Waste Stream or Abstraction	**Operation Only**	**Sweep Only**	**Sweep and Ro with Injection**	**Restoration Only**
Excess Permeate (GPM)	57	184.5	0	0
Plant Make Up (GPM)	25	25	-	-
Excess Permeate to Disposal or Use (GPM)	32	159.5	-	-

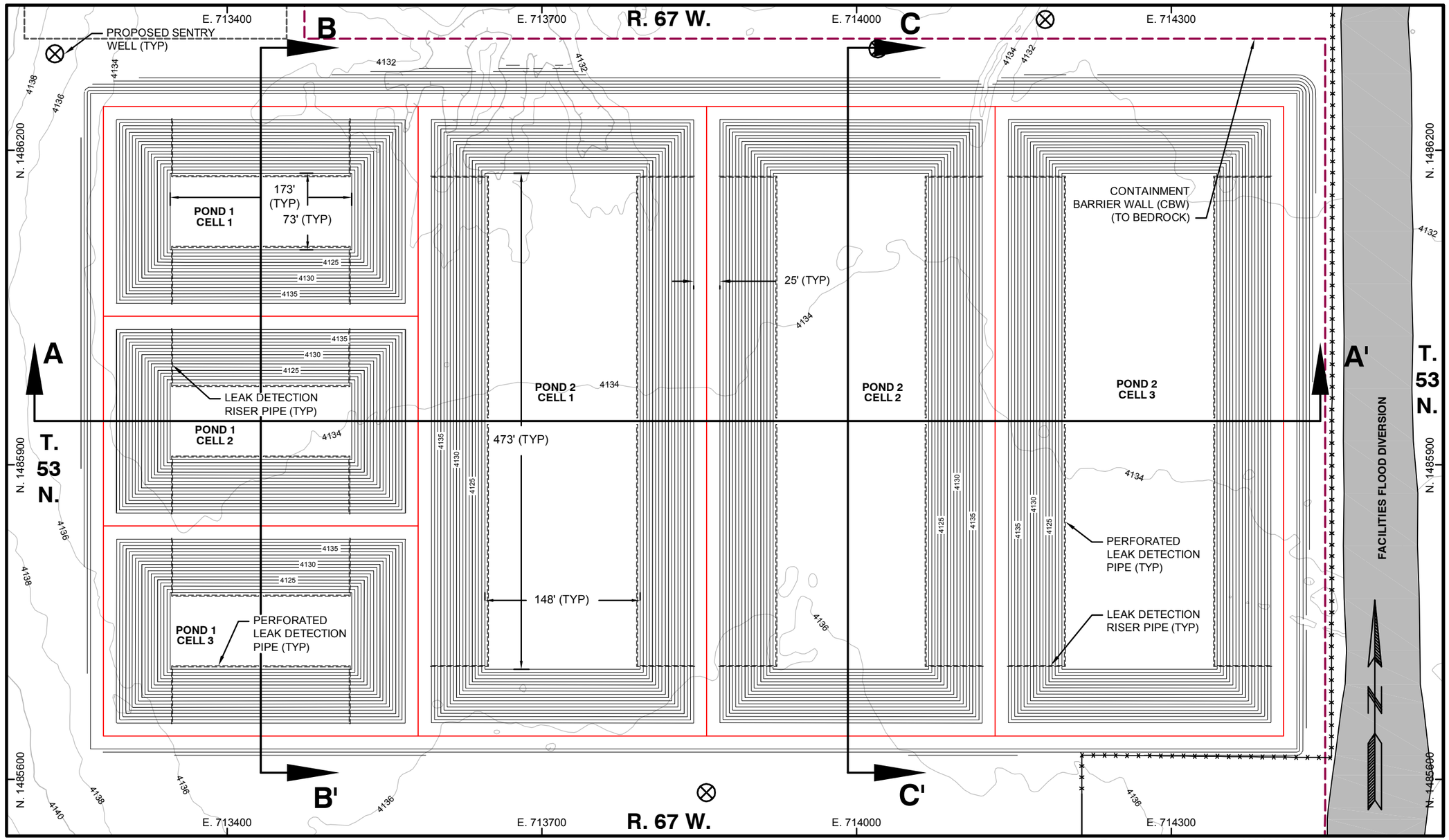
Table 4.2-5. Anticipated Brine Water Quality

Parameter	Unit	Typical Value	Minimum Value	Maximum Value	Actual Range from Operating ISRs[1]
EC	S/cm	50,000	35,000	70,000	ND
TDS	mg/L	35,000	20,000	60,000	4,000 - 92,000
pH	s.u.	8	5	9	3 - 9
Alkalinity as $CaCO_3$	mg/L	10,000	7,000	20,000	0 - 4,500
Sulfate	mg/L	8,000	6,000	10,000	ND
Bicarbonate	mg/L	14,000	7,000	20,000	700 - 4,500
Chloride	mg/L	5,000	3,000	15,000	10,000 - 15,000
Calcium	mg/L	1,500	300	2,000	3,000 - 5,000
Sodium	mg/L	10,000	6,000	20,000	10,000 - 15,000
Manganese	mg/L	4	0	10	ND
Selenium	mg/L	8	0	20	ND
Arsenic	mg/L	1	0	3	ND
Uranium	mg/L	10	0	100	0 - 130
Radium	pCi/L	500	200	10,000	10 - 4,000

[1] Sources: NRC 2009, Power Resources 2003, and Ross DDW Application (Addendum 4.2-A).

Table 4.2-6. Anticipated Brine Production and Disposal Rates

Waste Stream or Abstraction	Operational Phase		
	Operation Only	Concurrent Operation and Restoration	Restoration Only
Brine (GPM)	37	202	165
Other 11e.(2) Waste (GPM)	25	25	25
Evaporation (GPM)	10.4	8.8	9.3
Brine to Deep Well Disposal (GPM)	51.6	218.2	180.7



Basemap: 2' Contours from May 2010 Flight

Drawing Coordinates: WY83EF

PLAN VIEW

0 50 100 200

GRAPHIC SCALE (FEET)

STRATA ENERGY

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

REVISIONS

Date	Description

TECHNICAL REPORT
FIGURE 4.2-1 **SHEET 1 OF 2**

LINED RETENTION POND LAYOUT AND DESIGN DETAILS

Drawn By: DCJ
Checked By: BJS
Date: 12/22/10

FILE: ROSS_TR_FAC_PONDS

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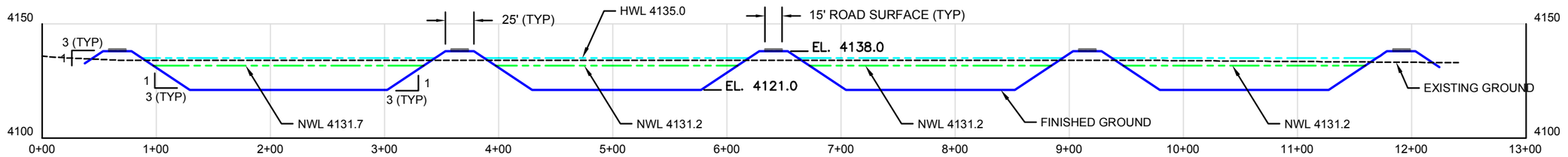
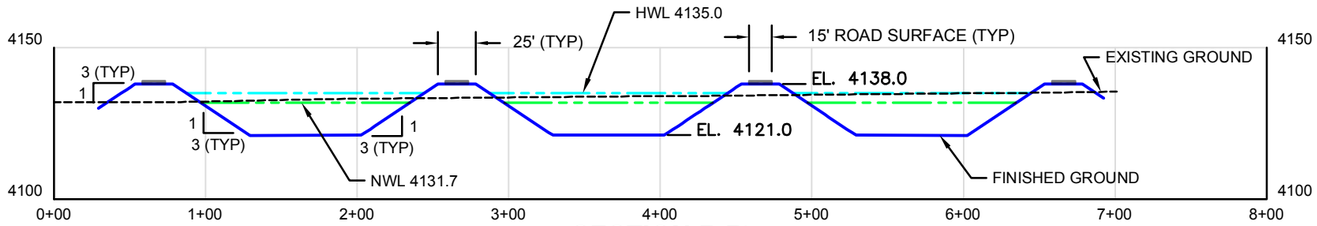
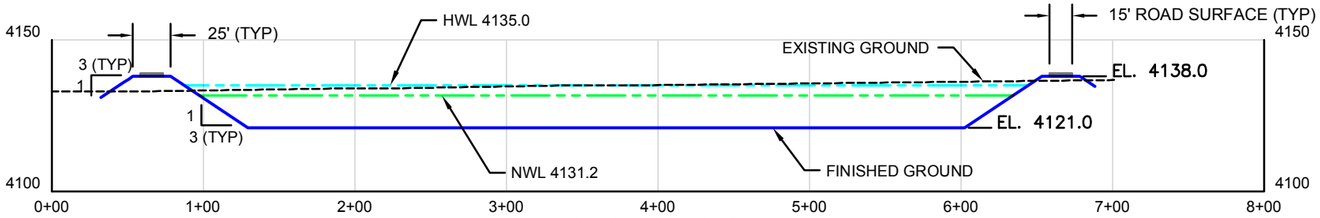


SECTION A-A'
EXAGGERATION 2H:1V (FT)



SECTION B-B'
EXAGGERATION 2H:1V (FT)



SECTION C-C'
EXAGGERATION 2H:1V (FT)

POND 1 - CELLS 1-3
AREA CAPACITY TABLE

Elevation (ft)	Area (ac)	Avg. Area (ac)	Capacity Incr.	Capacity Accum.
4121	0.87			0.00
		0.93	0.93	
4122	0.99			0.93
		1.04	1.04	
4123	1.08			1.97
		1.14	1.14	
4124	1.20			3.11
		1.26	1.26	
4125	1.32			4.37
		1.38	1.38	
4126	1.44			5.75
		1.50	1.50	
4127	1.56			7.25
		1.64	1.64	
4128	1.71			8.89
		1.77	1.77	
4129	1.83			10.66
		1.91	1.91	
4130	1.98			12.57
		2.06	2.06	
4131	2.13			14.63
		2.21	2.21	
4132	2.28			16.84
		2.37	2.37	
4133	2.46			19.21
		2.54	2.54	
4134	2.61			21.75
		2.70	2.70	
4135	2.79			24.45
		2.87	2.87	
4136	2.94			27.32
		3.03	3.03	
4137	3.12			30.35
		3.23	3.23	
4138	3.33			33.58

TOTAL CAPACITY 24.5 ac-ft
OPERATING CAPACITY 16.5 ac-ft
AUXILLARY CAPACITY 8.0 ac-ft
FREEBOARD STORAGE 9.1 ac-ft

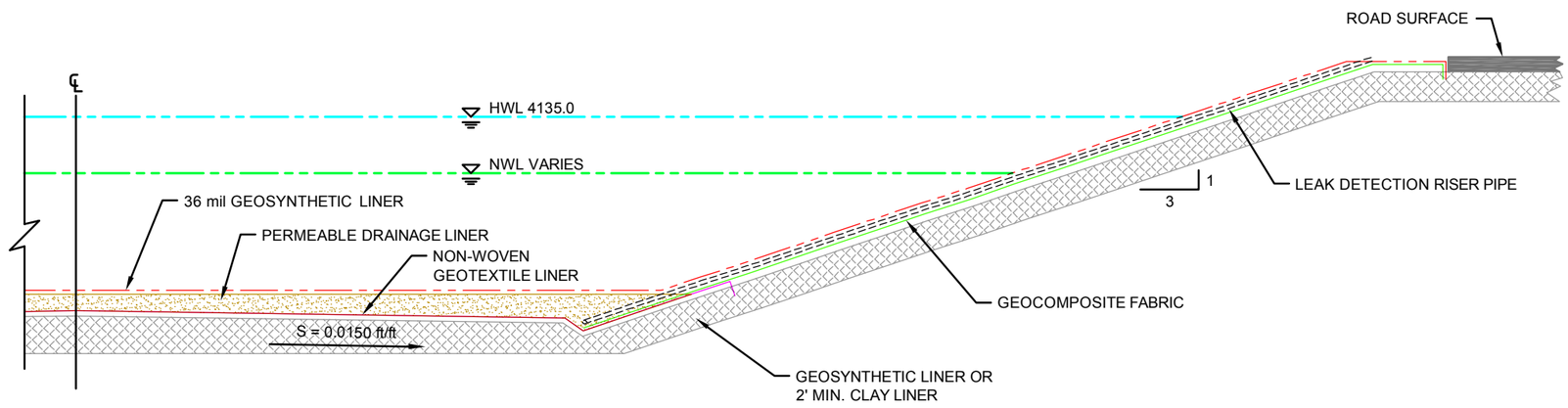
NOTE: WATER WILL BE PUMP EVACUATED

POND 2 - CELLS 1-3
AREA CAPACITY TABLE

Elevation (ft)	Area (ac)	Avg. Area (ac)	Capacity Incr.	Capacity Accum.
4121	4.83			0.00
		4.95	4.95	
4122	5.07			4.95
		5.21	5.21	
4123	5.34			10.16
		5.48	5.48	
4124	5.61			15.64
		5.75	5.75	
4125	5.88			21.39
		6.03	6.03	
4126	6.18			27.42
		6.32	6.32	
4127	6.45			33.74
		6.60	6.60	
4128	6.75			40.34
		6.89	6.89	
4129	7.02			47.23
		7.17	7.17	
4130	7.32			54.40
		7.49	7.49	
4131	7.65			61.89
		7.80	7.80	
4132	7.95			69.69
		8.10	8.10	
4133	8.25			77.79
		8.42	8.42	
4134	8.58			86.21
		8.75	8.75	
4135	8.91			94.96
		9.08	9.08	
4136	9.24			104.04
		9.41	9.41	
4137	9.57			113.45
		9.74	9.74	
4138	9.90			123.19

TOTAL CAPACITY 95.0 ac-ft
OPERATING CAPACITY 63.4 ac-ft
AUXILLARY CAPACITY 31.6 ac-ft
FREEBOARD STORAGE 28.2 ac-ft

NOTE: WATER WILL BE PUMP EVACUATED



CONTAINMENT DETAIL
NOT TO SCALE

STRATA ENERGY

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

REVISIONS

Date	Description

TECHNICAL REPORT
FIGURE 4.2-1 **SHEET 2 OF 2**

LINED RETENTION POND LAYOUT AND DESIGN DETAILS

Drawn By: DCJ
Checked By: BJS
Date: 12/22/10
FILE: ROSS_TR_FAC_PONDS

WWC ENGINEERING
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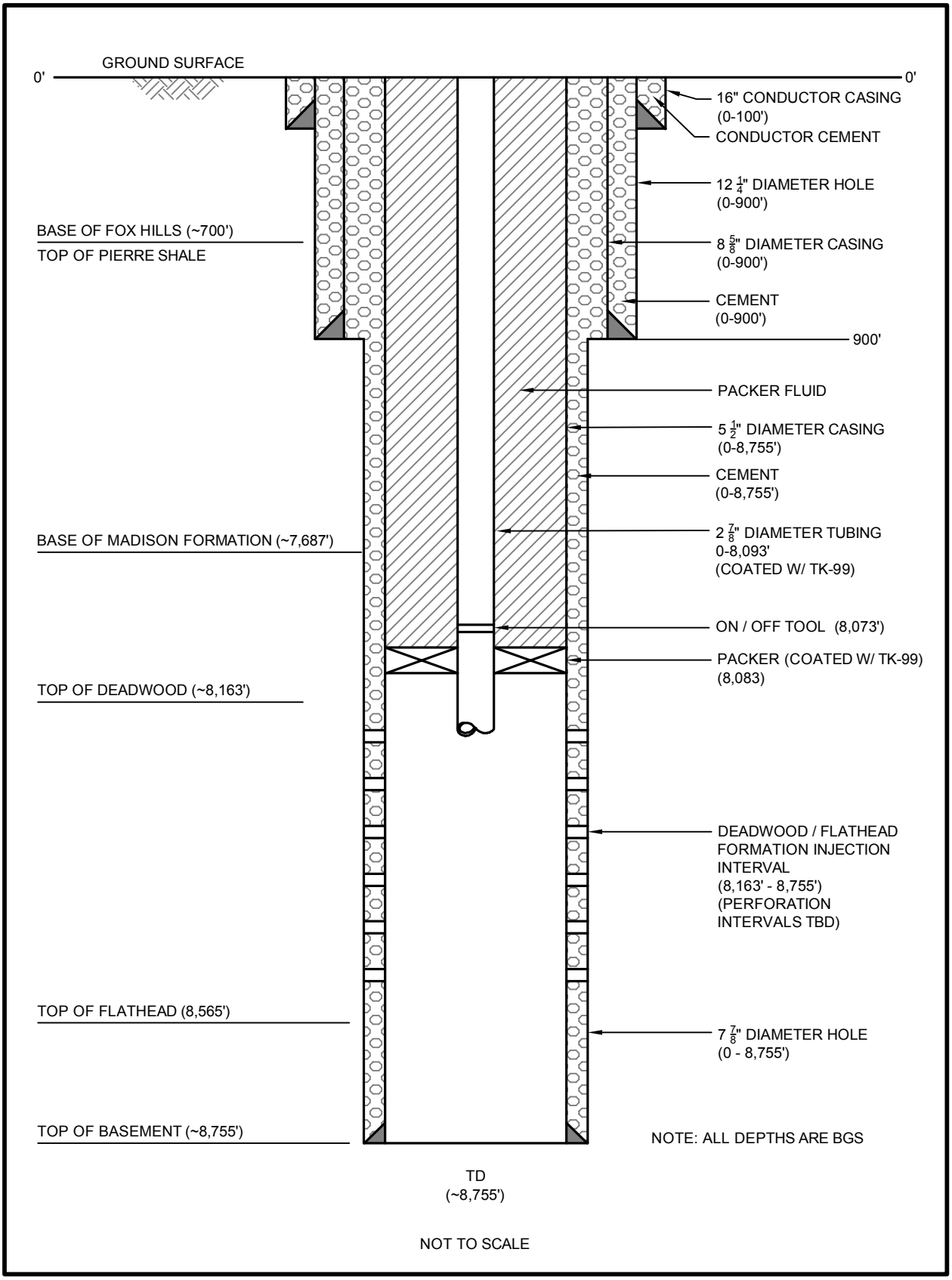

Figure 4.2-2. Proposed Deep Disposal Well Construction Schematic

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4.3 Solid Waste and Contaminated Equipment

Solid waste at the proposed project is divided into two general categories: AEA-regulated solid waste and non-AEA-regulated solid waste. AEA-regulated solid waste includes 11e.(2) byproduct material in the form of process solids (e.g., filter media, resins), contaminated soil, equipment and parts, debris, and personal protective equipment (PPE) that cannot be decontaminated for unrestricted use including but not limited to pipe, fittings, and hardware (NMA 2007). Non-AEA-regulated solid wastes include construction debris, office trash, and decontaminated materials and equipment, solid hazardous waste, and septic system solid waste.

4.3.1 AEA-Regulated Solid Waste

4.3.1.1 Solid 11e.(2) Byproduct Material

Solid 11e.(2) byproduct material includes radioactive and non-radioactive waste generated during source material recovery operations. Solid 11e.(2) byproduct material will be generated during all phases of the Ross ISR Project except during construction. Byproduct material generated during operation and aquifer restoration will include:

- Filtrate and spent filter media from production and restoration circuits,
- General sludge, scale, etc. from maintenance operations,
- Affected soil collected from spill areas,
- Spent/damaged ion exchange resin,
- Vanadium circuit effluents, and
- Well solids from injection/production well work over operations.
- Contaminated PPE

Strata estimates that approximately 100 yd^3 per year of 11e.(2) byproduct material will be generated from the above. During operation and aquifer restoration, 11e.(2) byproduct material will be stored inside the CPP in the 11e.(2) Storage and Preparation Area. The location of this area is depicted on Figure 3.2-1. The storage area contains space for at least two 20 yd^3 roll-off containers, with adequate additional space for 55-gallon drums and loading

operations. The 11e.(2) Storage and Preparation Area will be locked and posted as restricted.

Byproduct material will be placed inside of 55-gallon, lined drums within the 11e.(2) Storage and Preparation Area. When the drums are full, they will be sealed and moved into a 20-cubic yard roll-off container. Roll-off containers will ultimately be shipped to a licensed disposal facility. Adequate storage will be provided for at least two roll-off containers in the CPP. One or more additional 11e.(2) Storage Areas may be designated outside of the CPP. These areas will be fenced, locked and posted with signs indicating restricted access. Large items such as contaminated equipment that cannot be stored in a roll-off container will be stored in one of the designated 11e.(2) Storage Areas and covered/sealed in a manner that will prevent the spread of contamination in the 11e.(2) storage area.

During decommissioning, solid 11e.(2) byproduct material will be generated from the following sources:

- Wellfield decommissioning, including:
  - Injection, recovery, and restoration fluid trunklines,
  - Individual well pipelines,
  - Downhole well piping (drop pipe),
  - Manholes and sumps,
  - Valves, pumps, instrumentation and control equipment, and
  - Impacted soils.
- Affected concrete floors, sumps, and berms in the CPP,
- Equipment and piping in the CPP,
- Pond sludge, pond liners, and leak detection systems, and
- Disposal well piping and equipment.

Up to 5,000 yd^3 of material and equipment will be generated during decommissioning. Contaminated material volumes will be minimized by disassembling equipment where possible and using physical reduction techniques such as chipping or grinding.

Materials such as piping, valves, instrumentation or other equipment that is 11e.(2) byproduct material, can be reclassified as a non-hazardous material and released for unrestricted use if decontaminated. Decontamination

will be accomplished by completing a preliminary radiological survey to determine the location of the contamination, performing additional evaluation and testing as needed to verify the contamination extent, decontaminating through pressure washing, acid rinse, or another appropriate method, and performing a final radiological survey to verify decontamination success. Procedures for decontaminating structures and equipment are discussed in Section 6.3. Any equipment not meeting the decontamination standards shall continue to be handled as 11e.(2) byproduct material.

20-cubic yard roll-off containers containing 11e.(2) byproduct material will be transported by a contract shipping company to a disposal facility licensed by NRC or an agreement state. Strata will develop an agreement with an off-site disposal facility prior to initiating any activity that will generate 11e.(2) byproduct material. Strata will notify NRC within 7 days if the 11e.(2) byproduct material disposal agreement is terminated and will submit a new agreement for NRC approval within 90 days of expiration or termination. Potential disposal facilities include:

- Pathfinder Mine Corporation, Shirley Basin Facility, Shirley Basin, Wyoming
- Denison Mines Corporation, White Mesa Uranium Mill, Blanding, Utah
- EnergySolutions LLC, Clive Disposal Site, Clive, Utah
- Waste Control Specialists LLC, Byproduct Material Disposal Facility, Andrews, Texas

Based on the anticipated 11e.(2) byproduct material generation rate of 100 cubic yards per year during production and aquifer restoration, about 5 shipments of 11e.(2) byproduct material are anticipated during these project phases. During decommissioning, which is estimated to last 12-18 months, up to 200 shipments are expected.

4.3.2 Non-AEA-Regulated Solid Waste

4.3.2.1 Solid Waste

Solid waste includes solid material and equipment that are not generated by source material recovery or which have been successfully decontaminated and will include hazardous and non-hazardous waste. The proposed Ross ISR project is expected to produce approximately 1,000 yd^3 of non-contaminated

solid waste per year during construction and operation. During decommissioning, up to 2,000 yd^3 will be produced.

Non-hazardous materials may include construction debris, office trash, and decontaminated material and equipment. Non-hazardous materials will be stored in commercial trash containers located near the CPP and will be disposed by a contracted waste disposal operator to a municipal landfill permitted by WDEQ Solid and Hazardous Waste Division (WDEQ/SHWD). The nearest non-hazardous solid waste disposal facilities are municipal landfills located in Moorcroft (approximately 23 road miles south) and Sundance (approximately 38 road miles southeast).

4.3.3 Hazardous Solid Waste

Hazardous solid waste may include oily rags, oil-contaminated soil, used batteries, expired laboratory reagents, fluorescent lightbulbs, solvents, cleaners, and degreasers. As discussed in Section 4.2.1.3, the proposed Ross ISR Project is expected to be classified as a Conditionally Exempt Small Quantity Generator of hazardous waste. Hazardous solid waste will be stored in secure containers within the maintenance building. Hazardous solid waste will be transported according to DOT regulations to an approved disposal facility licensed by WDEQ/SHWD or to a suitable facility in a nearby state.

4.3.4 Domestic Solid Waste

Septic system solid waste will be stored in septic tanks near the CPP and administration building. Every 1 to 5 years, the septic tank(s) will require sludge removal. This will be performed by a waste disposal contractor, who will pump the solids from the septic tanks into a tanker truck and transport the sludge to a nearby municipal wastewater treatment system for disposal.

4.4 References

ANL (Argonne National Laboratory), Faillace, E.R., LePoire, D.J., Chen, S.Y., Yuan, Y., 1997, MILDOS-AREA: An Update with Incorporation of In Situ Leach Uranium Recovery Technologies, May, 1997.

EPA (U.S. Environmental Protection Agency), 2002, Onsite Wastewater Treatment Systems Manual, EPA/625/R-00/008, February 2002.

NMA, 2007, Generic Environmental Report in Support of the Nuclear Regulatory Commission's Generic Environmental Impact Statement for In Situ Uranium Recovery Facilities, prepared for the National Mining Association by Thompson & Simmons, PLLC, Tetra Tech, Inc., and Katie Sweeney, National Mining Association, November 30, 2007.

NRC, 2010, Environmental Impact Statement for the Moore Ranch ISR Project in Campbell County, Wyoming: Supplement to the Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities - Final Report (NUREG-1910, Supplement 1), August 2010.

_____, 2009, NUREG-1910, Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities, Final Report, May 2009.

_____, 2003, NUREG-1569, Standard Review Plan for In-situ Leach Uranium Extraction License Applications, June 2003.

_____, 1987, Regulatory Guide 3.59, Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations, March 1987.

Pochop, L., K. Warnaka, J. Borrelli and V. Hasfurther, 1985, Design Information for Evaporation Ponds in Wyoming, Wyoming Water Resource Center Publication WWRC-85-21.

Power Resources, Inc., 2003, Smith Ranch – Highlands Uranium Project, Source Materials License Application, March 12, 2003, NRC ADAMS Accession No. ML030730592.

Renken, K., Mchaina, D.M. and Yanful, E.K., 2005. Geosynthetics Research and Applications in the Mining and Mineral Processing Environment. North American Geosynthetics Society (NAGS)-Geosynthetic Institute (GSI) Conference, Las Vegas, Nevada. December 14-16, 2005.

Wyoming Department of Environmental Quality, 2001; source: WDEQ, Wyoming Surface Water Classification List, 2001.

Wyoming Department of Environmental Quality 1997; source: Wyoming Water Quality Rules and Regulations, Chapter 21, Standards for Reuse of Treated Wastewater, October 1997.

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5.0 OPERATIONS

Strata Energy, Inc. (Strata) is committed to ensuring that the proposed Ross ISR Project will comply with all applicable laws, regulations, and requirements of the NRC and other regulatory agencies. The responsibilities described below have been designed to ensure compliance and further implement Strata's policy for providing a safe working environment with cost effective incorporation of the philosophy of maintaining radiation exposures as low as is reasonably achievable (ALARA).

5.1 Corporate Organization and Administrative Procedures

Strata will maintain a performance-based approach to the management of environment and employee health and safety, including radiation safety. The responsibility of management personnel will be to provide for development, review, approval, implementation, and adherence to operating procedures, radiation safety programs, environmental and groundwater monitoring programs, quality assurance programs, routine and non-routine maintenance activities, changes to any of these programs or activities, and all necessary training associated with the above. Strata's management structure is shown in Figure 5.1-1. The structure is applicable to site construction and site management. Figure 5.1-1 represents the management levels that play a key part in the Radiation Protection Program (RPP). These individuals may also be members on the Safety and Environmental Review Panel (SERP) described under Section 5.2.4

5.1.1 Board of Directors

The Board of Directors has the ultimate responsibility and authority for setting corporate policy and related procedural guidance but delegates ultimate responsibility and authority for occupational (including radiation) safety, environmental protection, and compliance with all NRC regulations and license conditions and all state and local regulations/permit conditions to Strata management as described below.

5.1.2 Chief Operating Officer

The Chief Operating Officer (COO) is responsible for interpreting and acting upon the Board of Director's policy and procedural decisions. The COO is authorized by the Board of Directors to have the responsibility and authority for the radiation safety and environmental compliance programs at all Strata facilities. The COO is directly responsible for ensuring that Strata personnel comply with corporate industrial safety, radiation safety, and environmental protection programs. The COO is also responsible for company compliance with all regulatory license conditions/stipulations, regulations and reporting requirements. The COO has the responsibility and authority to terminate immediately any activity that is determined to be a threat to employees, public health, the environment, or a violation of state or federal regulations. The COO has the authority to assign corporate resources (e.g., capital equipment,

personnel, budget) to ensure corporate environmental, health, and safety goals and directives are met.

5.1.3 General Manager

The General Manager is responsible for all uranium production activities at the various project sites. In addition to production activities, The General Manager is also responsible for implementing any industrial and radiation safety and environmental protection programs associated with operations. The General Manager is authorized to immediately implement any action to correct or prevent hazards. The General Manager has the responsibility and the authority to suspend, postpone or modify, immediately if necessary, any activity that is determined to be a threat to employees, public health, the environment, or potentially a violation of state or federal regulations. The General Manager reports directly to the COO.

5.1.4 ISR Facility Manager

The Facility Manager is responsible for all uranium production activity at the proposed Ross ISR Project. All site operations, maintenance, construction, environmental health and safety, and support groups report directly to the Facility Manager. The Facility Manager is authorized to immediately implement any action to correct or prevent hazards. The Facility Manager has the responsibility and the authority to suspend, postpone or modify, immediately if necessary, any activity that is determined to be a threat to employees, public health, the environment, or potentially a violation of state or federal regulations. The Facility Manager cannot unilaterally override a decision for suspension, postponement or modification if that decision is made by the COO, the General Manager, and/or the Manager of Health, Safety and Environmental Affairs. The Facility Manager reports directly to the General Manager.

5.1.5 Manager of Health, Safety, and Environmental Affairs

The Manager of Health, Safety, and Environmental Affairs is responsible for all radiation protection, health and safety, and environmental programs as stated in the RPP and for ensuring that Strata complies with all applicable regulatory requirements. The Manager of Health, Safety, and Environmental Affairs reports directly to the Facility Manager and supervises the Radiation Safety Officer (RSO) to ensure that the radiation safety and environmental monitoring and protection programs are conducted in a manner consistent

with regulatory requirements. This position assists in the development and review of radiological and environmental sampling and analysis procedures and is responsible for routine auditing of the programs. The Manager of Health, Safety, and Environmental Affairs has no production-related responsibilities. The Manager of Health, Safety, and Environmental Affairs also has the responsibility to advise the COO on matters involving radiation safety and to implement changes and/or corrective actions involving radiation safety authorized by the COO.

5.1.6 Radiation Safety Officer

The RSO is responsible for the development, administration, and enforcement of all radiation safety programs. The RSO is authorized to conduct inspections and to immediately order any change necessary to preclude or eliminate radiation safety hazards and/or maintain regulatory compliance. The RSO is responsible for the implementation of all on-site environmental programs, including emergency procedures, training programs for both the staff and the Radiation Safety Technician, and sampling and inspection procedures. The RSO inspects facilities to verify compliance with all applicable requirements in the areas of radiological health and safety. The RSO works closely with all supervisory personnel to review and approve new equipment and changes in processes and procedures that may affect radiological safety and to ensure that established programs are maintained. The RSO is also responsible for the collection and interpretation of employee exposure related monitoring, including data from radiological safety. The RSO makes recommendations to improve any and all radiological safety related controls as well as provide quality assurance/quality control for all health and environmental radiological monitoring programs. The RSO cannot be overruled by other members of the management team on any decision regarding radiation safety. The RSO has no production related responsibilities and reports directly to the Manager of Health, Safety, and Environmental Affairs.

5.1.7 Radiation Safety Technician

The Radiation Safety Technician(s) (RST) will assist the RSO with the implementation of the radiological and industrial safety programs. The RST is responsible for the orderly collection and interpretation of all monitoring data, to include data from radiological safety and environmental programs. The RST

reports directly to the RSO and must satisfy training requirements prescribed by the RSO.

5.1.8 Site Department Supervisors

The proposed Ross ISR Project department supervisors will include the Operations Superintendent, Construction Superintendent, and Chief Geologist. These positions are responsible for the direct supervision of site activities including construction, operation, and maintenance of the proposed Ross ISR Project CPP, wellfields, and water disposal facilities. The department supervisors will be responsible for enforcing compliance with all aspects of the RPP and Standard Operating Procedures (SOPs) to control exposure to ionizing radiation and radioactive materials in accordance with the Strata ALARA Program. Department supervisors will perform and document an annual review of each SOP within his or her area of responsibility to ensure continued accuracy and relevance. These individuals report directly to the Facility Manager.

5.1.9 ALARA Program Responsibilities

The purpose of the ALARA (As Low As Reasonably Achievable) program is to keep exposures to all radioactive materials and other hazardous material as low as possible and to personnel, contractors, visitors, and the public. The ALARA program will take into account the state of technology and the economics of improvements in relation to benefits to health and safety, and other societal and socioeconomic considerations, and in relation to the utilization of atomic energy in the public interest.

In order for an ALARA program to correctly function, all individuals including management, supervisors, health physics staff, and workers, must take part in and share responsibility for keeping all exposures as low as reasonable achievable. This policy addresses this need and describes the responsibilities of each level in the organization.

5.1.9.1 Management Responsibilities within the ALARA Program

Consistent with Regulatory Guide 8.31 (NRC 2002a), Strata senior management is responsible for the development, implementation, and enforcement of rules, policies, and procedures as directed by regulatory agencies and company policies. These responsibilities include the following:

1. The development of a strong commitment to and continuing support for the development and implementation of the RPP and ALARA program;

2. Providing information and policy statements to employees, contractors, and visitors;

3. An annual management audit program that reviews procedural and operational methods to maintain radiation exposures ALARA;

4. A continuing evaluation of the RPP, its staff and support; and

5. Providing sufficient training and briefings in radiation safety, including ALARA concepts, for all employees and, when appropriate, contractors and visitors.

5.1.9.2 Radiation Safety Officer Responsibilities within the ALARA Program

The RSO has the primary responsibility for ensuring the technical adequacy and accuracy of the RPP. The RSO is also responsible for the implementation of proper radiation protection measures, and the overall surveillance and maintenance of the ALARA program. The RSO is assigned the following:

1. The responsibility for the development and administration of the ALARA program;

2. Enforcement of the regulations and administrative policies that affect any aspect of the RPP;

3. Responsibility to review and approve plans for new equipment, process changes or operating procedures to ensure that the plans do not adversely affect the radiological aspects of the RPP;

4. Assist in conducting the annual ALARA audit as discussed in Section 5.3.3, to determine the effectiveness of the program and make any suitable recommendations or changes as may be dictated by the ALARA philosophy;

5. Maintain equipment and surveillance programs to monitor the relative success of the ALARA program;

6. Conduct (or designate a qualified individual to conduct) daily inspections of pertinent facility areas to observe that general radiation control practices, hygiene, and housekeeping practices are in line with the ALARA principle;

7. Conduct training and/or provide training requirements for the RST.

5.1.9.3 Supervisor Responsibility within the ALARA Program

Supervisors are responsible for implementing the ALARA program. Each supervisor shall be trained and instructed in the general radiation safety practices and procedures. Their responsibilities include:

1. Adequate training to implement the general philosophy behind the ALARA program;

2. Provide direction and guidance to subordinates in ways to adhere to the ALARA program;

3. Enforcement of rules and policies as directed by the RPP, which implement the requirements of regulatory agencies and company management; and

4. Seek additional help from management and the RSO should radiological problems be deemed by the supervisor to be outside his or her sphere of training.

5.1.9.4 Worker Responsibility within the ALARA Program

The success of the ALARA program and the RPP are reliant on the cooperation and adherence to those policies by the workers themselves. Therefore, worker responsibilities at the proposed Ross ISR Project include:

1. Adherence to all rules, notices, and operating procedures as established by management and the RSO through the RPP;

2. Making suggestions for improvements to the RPP and ALARA program; and

3. Reporting to the immediate supervisor equipment malfunctions or violations of standard practices or procedures that could result in increased radiological hazard to any individual.

5.1.10 Administrative Procedures for Spill or Release

In the event of a spill or release it is the responsibility of the Facility manager or designee to report the incident in accordance with 10 CFR Part 20, Subpart M and 10 CFR 40.60.

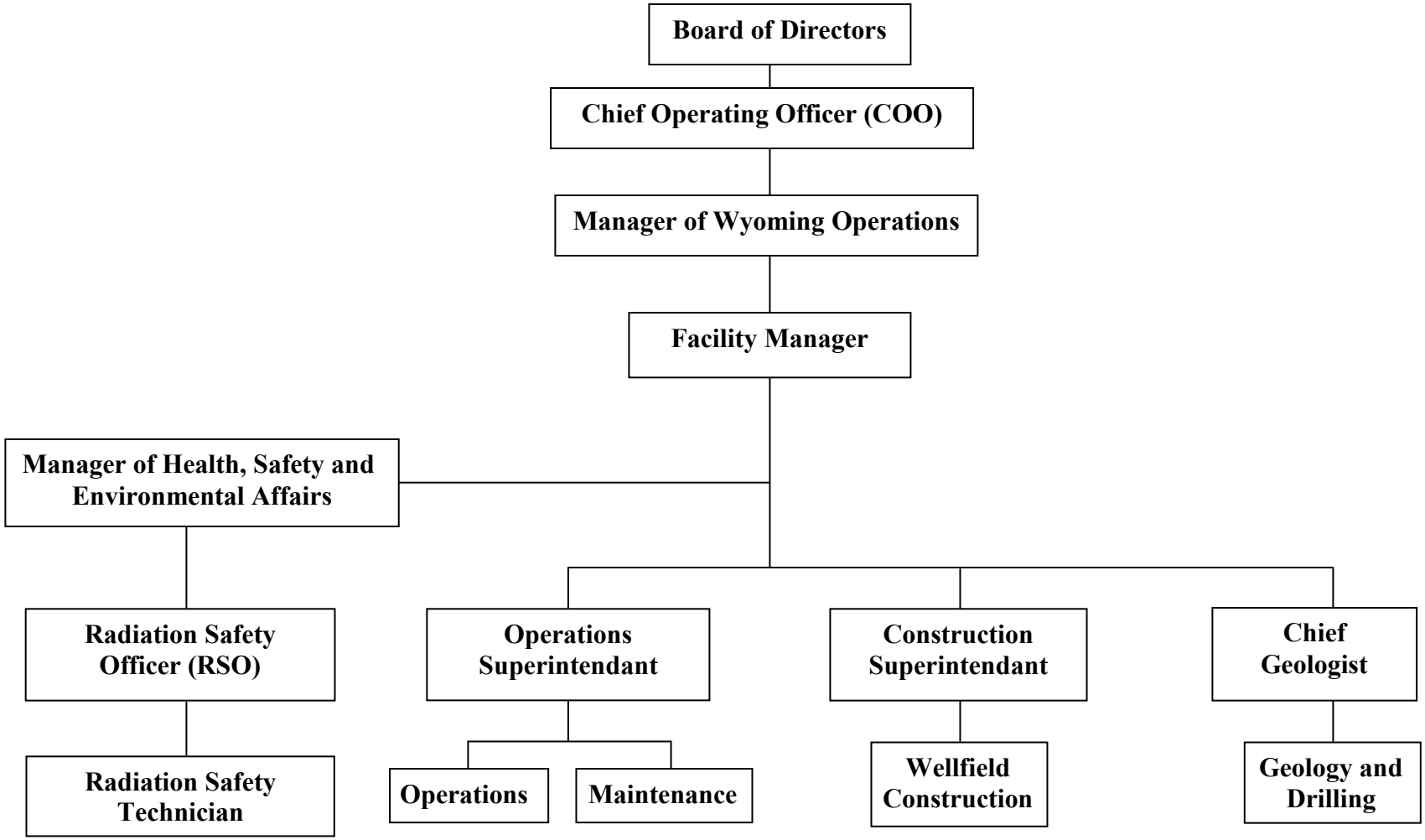

Figure 5.1-1. Ross ISR Organizational Chart

5.2 Management Control Program

This section describes the management control program put in place within the Strata organization to ensure activities will be conducted in a manner to protect the health and safety of employees, the public, and the environment.

5.2.1 Operating Procedures

Management controls will be implemented throughout Strata by written procedures or instructions consistent with the corporate policies and standards and regulatory requirements. All routine activities involving handling, processing, or storing of radioactive material will be documented by written SOPs. The SOPs will include all pertinent radiation safety practices. The Radiation Protection Program (RPP) will consist of written operating procedures for all process activities including those activities involving radioactive materials. Written operating procedures will also be established for record keeping, document control, quality assurance, environmental and health physics monitoring, emergency procedures, and industrial safety.

A current copy of each procedure will be kept in the area where it is used and accessible to all employees. All operating procedures will be reviewed and approved in writing by the RSO (or qualified designee in the absence of the RSO) prior to being implemented. In addition, review and approval of SOPs will be required by the Safety and Environmental Review Panel (SERP) to ensure proper safety principles and practices are included and to ensure that the SOPs follow the ALARA program. All proposed changes to an operating procedure will also be reviewed and approved by the RSO (or designee) and SERP. The RSO will also perform a documented annual review of the operating procedures to ensure they follow currently established radiation protection practices. SOPs which will be implemented at the proposed Ross ISR Project include but are not limited to the following:

- Operation Activities Involving Radioactive Materials
- Non-Operational Activities Involving Radioactive Materials
- Handling of Radioactive Materials
- Processing of Radioactive Materials
- Storing of Radioactive Materials

- Work Within Restricted Areas
- Transportation Security and Radiological Surveying
- Diversion Channel Inspection and Maintenance
- Retention Pond Inspections and Maintenance
- Statistical Assessment of Baseline Water Quality Data
- Determination of Upper Control Limits
- Excursion Verification, Reporting, and Mitigation
- External Radiation Monitoring Plan
- Radiation Safety Practices
- Radon Monitoring
- Radiological Monitoring During Soil Remediation
- Air Particulate Monitoring
- Bioassay Program
- Quality Control Requirements for Environmental Bioassay Program
- Respirator Use and Availability Program
- Radiological Sampling, Equipment Maintenance, and Calibration
- Laboratory Quality Control
- Accident Training for Local Emergency Officials
- Well Installation, Completion, and Development
- Borehole Plugging and Abandonment
- Well Plugging and Abandonment
- Monitoring for Radon In Air
- Environmental Gamma Monitoring
- Air Particulate Sampling
- Surface Soil and Soil Profile Sampling
- Sediment Sampling
- Food Crop and Vegetation Sampling
- Direct Gamma Field Survey
- Surface Water Sampling
- Ground Water and Domestic Well Sampling
- Animal Tissue Sampling

- Decontamination of Sampling Equipment
- Sample Management
- Data Management
- Emergency Emission Control System Procedures
- Gamma Exposure Rate Surveys
- Special Contamination Surveys During Maintenance Activities
- Hazardous/Radioactive Accident Emergency Response
- Spill Response and Remediation
- Receiving and Unloading Hazardous Chemicals
- Storage and Handling of Hazardous Chemicals
- Loading, Surveying, and Packaging of Yellowcake

5.2.2 Radiation Work Permits

Any activities for which no operating procedure exists where there is the potential for significant exposure to radioactive materials will require radiation work permits (RWPs). The RWP will describe the following:

- The scope of the task to be performed.
- The precautions necessary to maintain radiation exposures ALARA.
- The supplemental radiological monitoring and sampling to be conducted for the task.
- The specific training that will be required.
- The personal protective equipment that will be required.

The RSO must review and approve, by signature, the RWP before initiation of the work. The RSO may designate a person of the radiation safety staff who has received the proper training to approve RWPs in the RSO's absence.

5.2.3 Record Keeping and Retention

Records will be maintained as hard copy originals or stored electronically in accordance with the requirements of 10 CFR 20 Subpart L and 10 CFR 40.61 (d) and (e). Records will be readily available for regulatory inspection and may be transferred to the NRC after license termination. Records will also be

provided to a new owner or new licensee in the event that the property or license is transferred.

The following significant information will be permanently maintained and retained until license termination:

- Records of the receipt, transfer, and disposal of any source or byproduct material processed or produced at the facility.
- Records of on-site radioactive waste disposal such as by deep well injection, discharge, or burial under 10 CFR 20.2002 and 20.2007.
- Records required by 10 CFR 20.2103(b)(4).
- Records required by 10 CFR Part 40, Appendix A, Criteria 8 and 8A.
- Records containing information important to decommissioning and reclamation, including:
    - Descriptions of any spills, excursions, contamination events or unusual occurrences, including the dates, locations, areas, or facilities affected; assessments of hazards; corrective and cleanup actions taken; assessment of cleanup effectiveness, and the location of any remaining contamination; nuclides involved; quantities, forms and concentrations, and descriptions of hazardous constituents; descriptions of inaccessible areas that cannot be cleaned up; and sketches, diagrams, or drawings marked to show areas of contamination and places where measurements were made.
    - Information related to site characterization such as: residual soil contamination levels, on-site locations used for burials of radioactive materials, hydrology and geology characteristics that could contribute to contamination and locations of surface impoundments and wellfield aquifer anomalies.
    - As-built drawings or photographs of structures, equipment, restricted and secured areas, wellfields, areas where radioactive materials are stored, and any modifications showing the locations of these structures and systems through time.
    - Drawings of areas of possible inaccessible contamination, including features such as buried pipes or pipelines.
    - Pre-operational background radiation levels at and near the site.

Duplicates of all significant records will be maintained in the corporate office or other off-site location. The RSO will be responsible for ensuring that the required records are maintained and controlled with adequate safeguards against tampering and loss.

5.2.4 Safety and Environmental Review Panel

An SERP will be established to evaluate proposed changes in the facility or process, changes in procedures, and new tests or activities with respect to whether they first require a license amendment.

The SERP will consist of a minimum of three members. One member will have expertise and management authority and will be responsible for managerial and financial approval for changes. One member will have expertise in operations and/or construction and will have responsibility for implementing any operational changes. One member will be the RSO, or equal, with responsibility of ensuring that the changes conform to radiation safety and environmental requirements. Additional members may be included on the SERP when aspects of the change, experiment, or test, are beyond the expertise of the other members. The additional members may serve temporarily and may be consultants or attorneys.

5.2.4.1 SERP Procedures and Responsibilities

The SERP will function in accordance with a written operating procedure. The procedure will ensure that approvals of changes in the facility, license, operating procedures, or conduct of tests and experiments are properly documented and reported, and if the proposed changes will require a license amendment. The changes will not require a license amendment pursuant to 10 CFR, Part 40.44 as long as the changes do not:

- Create a possibility of an accident unlike what is evaluated in the license application.
- Create a possibility for a malfunction or a structure, system, or control with a different result than previously evaluated in the license application.
- Result in a departure from the method of evaluation described in the license application used in establishing the final Safety Evaluation Report (SER) or the ER or TR or other analyses and evaluations for license amendments.

The changes may be derived from operational, economic, or regulatory requirements. The SERP will review the following to determine if the proposed change will impact any NRC licensing conditions, the ability to meet NRC, state, and local requirements, financial surety, and environmental and safety procedures:

- The operating criteria and critical equipment if the proposed change impacts the operations or significantly changes the processes used at the facility.
- The operating procedures for the proposed change with respect to existing operation procedures.
- The emergency response plan to determine the compatibility with the proposed change.
- The monitoring and recordkeeping requirements of the proposed change to ensure compliance with existing programs.
- The need for additional training and key personnel training records to verify the training needs of the proposed change.
- The environmental and safety requirements to ensure the proposed change will not deviate from existing programs.

If implementing the proposed change results in an increase of the surety, the surety must be updated through a license amendment or the annual surety update before the proposed change takes place.

5.2.4.2 SERP Record Keeping and Reporting

Detailed records of the evaluations made by the SERP will be kept until license termination. The records will be maintained by the RSO and copies distributed to the Mine Manager and the Manager of Health, Safety, and Environmental Affairs. The records kept will include a description of the proposed change, test, or experiment, the names and titles of each SERP member, the conclusions and recommendations of the SERP including required actions, deadlines, and assignment of responsibility. An annual report summarizing all SERP actions will be submitted to the NRC. This report will include replacement pages to the license application which will have a change indicator adjacent to the revised language and an indication of the date and change number.

5.2.5 Reporting

Strata will report all spills, lined retention pond leaks, excursions of recovery solutions, or process chemicals to the NRC Headquarters Project Manager by telephone or electronic mail within 48 hours of the event. This notification will be followed by submittal of a written report to the NRC Headquarters Project Manager detailing the conditions leading to the spill or incident/event, corrective actions taken, and results achieved within 30 days of the notification.

Strata will submit an annual report to the NRC that includes the ALARA audit report, land use survey, monitoring data, corrective action program report, one of the semiannual effluent and environmental monitoring reports, and the SERP information.

5.2.6 Radioactive Materials Postings

All entrances to the facility will be conspicuously posted with the words "ANY AREA WITHIN THIS FACILITY MAY CONTAIN RADIOACTIVE MATERIAL," in order to be exempted from the requirements of 10 CFR 20.1902(e) for areas within the facility.

5.2.7 Historic and Cultural Resources Inventory

Strata will administer a historic and cultural resources inventory before engaging in any development activity not previously assessed by NRC or any cooperating agency. Any disturbances to be associated with such development will be addressed in compliance with the National Historic Preservation Act (NHPA), the Archeological Resources Protection Act, and the guidelines discussed in Section 3.8 of the ER. Strata will cease immediately any work resulting in the discovery of previously unknown cultural artifacts to ensure that no unapproved disturbance occurs. Strata will notify appropriate authorities per any license conditions and will not go forward without appropriate approvals from NRC or other agencies as appropriate. Any such artifacts will be inventoried and evaluated, and no further disturbance will occur until authorization to proceed has been received. Strata recognizes that the NHPA environment is not static, but rather is ongoing up to and through final license termination.

5.3 Management Audit and Inspection Program

Inspections and audits will be performed periodically at the proposed Ross ISR Project to ensure compliance with radiological health, operational, and environmental standards. The following section describes the managerial responsibilities, frequencies, scope, and action measures of the inspection and audit program.

5.3.1 Radiation Health Inspections

5.3.1.1 Daily Inspections

A daily walk through inspection will be conducted by the RSO or RST of all work and storage areas. The purpose of the inspection is to determine if proper radiation safety procedures and good housekeeping practices are being used in order to minimize contamination. Specifically, the inspection will focus on the effluent control systems, security features, instrumentation and alarm systems, and radiation monitoring devices. Problems, poor practices, or deviations from SOPs and ALARA principles noted during inspections will be documented, including a description and/or drawing, date and signature by the inspection personnel. These issues will be reviewed by the Manager of Health, Safety, and Environmental Affairs to determine what corrective action measures will be implemented.

5.3.1.2 Weekly Inspections

The RSO along with the Production Supervisor will conduct weekly inspections of all facility areas to observe general radiation control practices and to review required changes in procedures or equipment.

Similar to daily inspections, issues identified during the weekly inspections will be documented, including a description and/or drawing of the problem, the date, and the inspector's signature. Records of the inspection issues will be retained for a minimum of one year. The inspection issues will then be reviewed and discussed by the Manager of Health, Safety, and Environmental Affairs and the Department Supervisor who has the authority to mitigate the problem.

5.3.1.3 Monthly Inspections

A minimum of once monthly, the RSO will review the results of the daily and weekly inspections, including a review of all monitoring and exposure data for the month. The RSO will then provide the Mine Manager and Department Supervisors a written report which details the month's significant worker protection activities that contains a summary of the most recent personnel exposure data, including bioassays and time weighted calculations, and a summary of all pertinent radiation survey records. The report will specifically address the trends and any deviations from the radiation and ALARA programs, including a review of the adequacy of the implementation of license conditions regarding radiation protection and ALARA. In addition, the summary reports will also describe unresolved problems and the proposed corrective action. Monthly reports will be maintained and readily available for at least five years from the date of the report.

5.3.2 Lined Retention Pond Inspections

Lined retention ponds at the proposed Ross ISR Project will be inspected in accordance with NRC Regulatory Guide 3.11. Engineering data related to the design, construction, and operation of the lined retention ponds will be kept on-site and available for reference and inclusion in inspection reports. The following section describes the routine inspections for the lined permeate and brine ponds.

5.3.2.1 Daily Inspections

A daily inspection of each lined retention pond will be conducted by a trained employee who is knowledgeable of the pond construction and safety features. The inspection will be documented on and conducted in accordance with a standard checklist. Inspection records will be kept on site and retained until termination of the project. Daily inspections will include the following:

- Water levels will be recorded and examined to ensure that minimum freeboard is maintained.
- The condition of pond inlet and outlet structures, associated piping, and instrumentation will be inspected to ensure proper operation.
- The embankments will be visually inspected for signs of erosion, cracking, slumping, or evidence of seepage.

- The liner will be visually inspected for damage or practices that may result in damage to the liner.
- The pond area will be visually surveyed for the presence of animals.
- The pond leak detection riser pipe will be examined for signs of leakage.

5.3.2.2 Monthly Inspections

Monthly inspection of each lined retention pond will be conducted by a trained employee who is knowledgeable of the pond construction and safety features. The inspection will be documented on and conducted in accordance with a standard checklist. Inspection personnel will be responsible for reviewing inspection issues with the Production Supervisor and the Manager of Health, Safety, and Environmental Affairs. Inspection records will be kept on site and retained until termination of the project. Monthly inspections will include the following:

- Runoff diversion channels and berms will be inspected for erosion and flow obstructions.
- The perimeter fence and associated signage will be inspected to ensure adequate protection and warning from unauthorized entry.

5.3.2.3 Quarterly Inspections

A quarterly inspection of each lined retention pond will be conducted by a trained employee who is knowledgeable of the pond construction and safety features. The inspection will be documented on and conducted in accordance with a standard checklist. The results of the inspection will be reviewed by the Production Supervisor and the Manager of Health, Safety, and Environmental Affairs. Inspection records will be kept on site and retained until termination of the project. Quarterly inspections will include the following:

- The embankment top, side slopes, and toe will be visually inspected for settlement, surface cracks, erosion, and changes in alignment. If unusual conditions or depressions are observed, the area will be surveyed to assess the extent of the problem.
- Downstream embankment toes and slopes will be examined for evidence of seepage.

- Instrumentation and safety equipment will be tested to ensure proper operation. Recent readings of the instrumentation will be reviewed to detect unusual performance or distress of the embankment.
- Groundwater samples will be collected from pond monitoring wells as well as wells within 2 kilometers of the ponds that are used for drinking water.
- Surface water samples will be obtained from each pond as well as nearby surface impoundments that may be affected by pond failures.
- A detailed examination of the liner system will be conducted to determine if degradation is occurring.

5.3.2.4 Annual Technical Evaluation

A technical evaluation of the ponds will be done annually to evaluate the hydraulic and hydrologic capacities of the ponds and diversion ditches and the structural stability of the embankments. Inspections will be conducted by either a trained employee or an independent expert. Information obtained from the annual technical evaluation will be compiled along with previous inspection and water quality data for an annual report. The report will be kept on-site until the termination of the project. The technical evaluation report will be reviewed by the Production Supervisor, Manager of Health, Safety, and Environmental Affairs, and Facility Manager. The annual technical evaluation will include the following:

- A survey of the embankment will be completed and compared to as-constructed dimensions of the ponds. The survey will be evaluated to ensure embankment settlement is within acceptable limits.
- An assessment of the hydraulic and hydrologic capacities will be evaluated to determine if existing pond infrastructure is adequate to guard against pond failure.
- Quarterly water quality data will be evaluated for indication that the seepage control measures are not functioning properly.
- Daily, monthly, and quarterly inspection data will be reviewed to ensure that issues have been addressed.

5.3.3 Module Building, Wellhead, and Valve Vault Inspections

Strata will implement a continuous wellfield monitoring program based on roving wellfield personnel. Wellfield personnel will be trained, and intimately familiar with the functions and normal operating characteristics of equipment in these areas. Inspections of the module buildings, wellheads, and valve vaults will be conducted on a weekly basis. Inspections of module buildings will coincide with flow and pressure record collection. Inspections will involve visual surveys of pipes, valves, pumps, manifolds, ventilation equipment, and leak detection equipment. In addition, operational testing of ventilation system equipment will be performed in accordance with R.G. 3.56 (NRC 1986a), and operational tests of leak detection equipment will be performed in accordance with manufacturer specifications. The inspection will be documented on and conducted in accordance with a standard checklist. Inspection records will be kept on site and retained until termination of the project.

5.3.4 Diversion Structure Inspection

A visual inspection of the condition of the diversion structure and box culvert will be conducted monthly as well as immediately following large storm events. Personnel competent in the evaluation of these structures will conduct the inspections on a standard checklist. Personnel will visually inspect the embankment top, side slopes, and toe for settlement, surface cracks, erosion, and changes in alignment. The box culvert will be inspected for structural integrity, obstructions, and scouring. Erosion protection will be inspected for scouring, and the condition of anchoring. If unusual conditions are observed, the area will be surveyed to assess the extent of the problem. Inspection records will be kept on site and retained until termination of the project.

5.3.5 Containment Barrier Wall Inspection

Visual inspection of the CBW itself is limited due to the lack of surface expression of the wall itself, however, instrumentation installed to demonstrate the effectiveness of the structure will be inspected on a monthly basis. Key features proposed for the monthly inspection include the french drain/collector well system, monitoring wells on both sides of the CBW and the dewatering well points. Inspections could include the following; manual water levels to confirm pressure transducer readings, testing of the pumping system installed in the collector well, testing of the dewatering well point system and a check of

the monitoring wells surface condition. While not expected to be routinely utilized, testing of the dewatering systems will ensure that in an upset condition, the infrastructure will be in an operational state necessary to mitigate any impacts from the upset. Monitoring frequency may be increased during periods of heavy precipitation or seasonally to confirm the necessary contrast in water levels across the CBW. In the event of a hi alarm in the collector well, an immediate inspection will occur to verify functionality of the pumping system. Records will be kept on site and retained until termination of the project.

5.3.6 Annual ALARA Audit

Strata will conduct annual audits of the RPP and ALARA program. The purpose of the audit will be to evaluate the effectiveness of RPP and ALARA program, to ensure that all regulations, policies, and license conditions are being followed, and to explore methods to further reduce employee and public exposure to radiological contaminants. The audit will be conducted by a team of members who are knowledgeable of the RPP with at least one member who is experienced in the operational aspects of the radiation protection practices at the facility. The RSO will accompany the audit team to provide information when needed but will not be allowed to participate in the audit conclusions. Strata may also elect to use qualified personnel from another uranium facility or an independent radiation protection consultant to conduct the audit. Based on the findings of the audit, an audit report will be compiled and kept on record at the facility until project termination. The Manager of Health, Safety, and Environmental Affairs, Facility Manager, and RSO will review the audit conclusions and recommendations and ensure that the proper corrective actions are implemented.

The annual ALARA audit report will summarize the following items:

- Employee exposure records (external and time weighted calculations);
- Bioassay results;
- Inspection log entries and summary reports of daily, weekly, and monthly inspections;
- Documented training program activities;
- Radiation safety meeting reports;
- Radiological survey and sampling data;

- Reports on overexposure of workers submitted to the NRC, Occupational Safety and Health Administration (OSHA), or State of Wyoming;
- Operating procedures that were reviewed during this time period.
- The report will specifically discuss the following:
- Trends in personnel exposures for identifiable categories of workers and types of operational activities;
- Whether equipment for exposure control is being properly used, maintained, and inspected;
- Recommendations on ways to further reduce personnel exposure from uranium and its daughters.

5.4 Qualifications for Persons Conducting the Radiation Safety Program

Strata will establish the following minimum qualifications for personnel conducting the radiation safety program.

5.4.1 Radiation Safety Officer Qualifications

The minimum qualifications for the RSO are as follows:

- Education: A bachelor's degree in the physical sciences, industrial hygiene, or engineering from an accredited college or university or an equivalent combination of training and relevant experience in a uranium recovery facility radiation protection. Two years of relevant experience are generally considered equivalent to one year of academic study.
- Health Physics Experience: At least one year of work experience relevant to uranium recovery operations in applied health physics, radiation protection, industrial hygiene or similar work. This experience should involve actually working with radiation detection and measurement equipment, not strictly administrative or "desk" work.
- Specialized Training: At least 4 weeks of specialized classroom training in health physics specifically applicable to uranium recovery. In addition, the RSO should attend refresher training on uranium recovery facility health physics every two years.
- Specialized Knowledge: A thorough knowledge of the proper application and use of all health physics equipment used in the uranium recovery facility, the chemical and analytical procedures used for radiological sampling and monitoring, methodologies used to calculate personnel exposure to uranium and its daughters, and a thorough understanding of the uranium recovery process and equipment used in the facility and how the hazards are generated and controlled during the uranium recovery process.

5.4.2 Radiation Safety Technician

The RST should demonstrate a working knowledge of the proper operation of the health physics instruments used at the uranium recovery facility, surveying and sampling techniques, and personnel dosimetry requirements. The RST will have at least one of the following combinations of education, training, and experience.

Option 1:

- Education: An associate degree or two or more years of study in the physical sciences, engineering, or a health-related field.
- Training: At least a total of four weeks of generalized training (up to two weeks may be on-the-job training) in radiation health protection applicable to uranium recovery facilities.
- Experience: One year of work experience using sampling and analytical laboratory procedures that involve health physics, industrial hygiene, or industrial safety measures to be applied in a uranium recovery facility.

Option 2:

- Education: A high school diploma.
- Training: A total of at least three months of specialized training (up to one month may be on-the-job training) in radiation health protection related to uranium recovery facilities.
- Experience: Two years of relevant work experience in applied radiation protection.

5.5 Radiation Safety Training

Radiation safety training at the proposed Ross ISR Project will be designed to inform employees of the inherent risks of exposure to radiation as well as the fundamentals of protection against exposure to uranium and its progeny. The radiation safety training program will be administered according to guidance provided in NRC Regulatory Guide 8.31, NRC Regulatory Guide 8.29 and NRC Regulatory Guide 8.13 (NRC 2002a, NRC 1996 and NRC 1999, respectively). Specific details of the radiation safety policy will be addressed in the Radiation Safety Manual. All employees will be provided access to and made familiar with instructions outlining radiation safety and emergency procedures. The radiation safety training program content will be under the management of the RSO. The RSO will be responsible for updating training material according to changes in regulatory requirements, license amendments, plant operational experience, and the ALARA concept.

5.5.1 Initial Training

New employees at the facility will receive training on the following topics:

1. Fundamentals of Health Protection
   - The radiological and toxic hazards of exposure to uranium and its progeny,
   - How uranium and its daughters enter the body (inhalation, ingestion, and skin penetration),
   - Why the concept of ALARA is important with respect to minimizing exposure to uranium and its progeny.
   - Relative risks associated with exposure to ionizing radiation and potential risks from working specifically with materials containing uranium and its progeny.

2. Personal Hygiene at ISR Facilities
   - The use of protective clothing and other PPE,
   - The correct use of respiratory protective equipment,
   - Eating, drinking, and smoking in only in designated areas,
   - Using proper methods for decontamination and self survey.

3. Facility Provided Protection
   - Ventilation systems and effluent controls,
   - Cleanliness of the work place,

- Features designed for radiation safety for process equipment,
- Standard operating procedures,
- Security and access control to designated areas,
- Electronic data gathering and storage,
- Automated processes.

4. Health Protection Measurements
   - Measurement of airborne radioactive materials,
   - Bioassay to detect uranium,
   - Surveys to detect contamination of personnel and equipment,
   - Personnel dosimetry.

5. Radiation Protection Regulations
   - Regulatory authority of NRC, MSHA, and the State of Wyoming,
   - Employee rights according to 10 CFR Part 19,
   - Radiation protection requirements in 10 CFR Part 20.

6. Emergency Procedures

In addition to the above topics, female employees and all supervisors of female employees will be given training which addresses prenatal radiation exposure. The training will be based upon NRC Regulatory Guide 8.13, and may be given as instruction in a classroom setting or as an informational pamphlet. This training will consist of the following:

- Risks associated with prenatal radiation exposure and employee rights
- Regulations concerning exposure limits and dose monitoring provisions for pregnant women,
- Strata's policy for pregnancy declaration.

A written or oral test with questions directly related to the radiation safety training will be administered to each employee. The instructor will review the test with each employee and discuss any incorrect answers so that the employee understands the correct answer. Workers who do not pass the test with 70% of the answers correct will be retested after receiving additional training.

If the employee is a supervisor, they will be given special instruction pertaining to their supervisory responsibilities in the area of worker radiation protection. Radiation safety issues or concerns that arise during operations will be addressed during regularly scheduled weekly safety meetings.

Additionally, employees will also be given general training and specific instructions on the health and safety aspects and non - radiological hazards based on the jobs they will perform. This training will comply with the OSHA training requirements specified in 29 CFR 1910 and training guidelines described in OSHA 2254 (OSHA 1998). Additionally, on-the-job training will be provided to address job/task specific hazards.

Records of the training program syllabus, dates of administration, attendance lists and records of exam results will be maintained in employee records.

5.5.2 Refresher Training

Each employee will receive a radiation safety training refresher course annually. The training will include a brief review of topics covered in the initial training as well as relevant information that has become available with regard to safety issues that have arisen, changes in regulations and license conditions, and employee exposure trends.

5.5.3 Contractor Training

Contractors doing work at the proposed Ross ISR Project will receive appropriate radiation safety training. Contractors who work on contaminated equipment, in contaminated and/or radiation areas will receive the same training that is required of ISR employees as described in Section 5.5.1. Contractors who have previously received full training from prior work experience at the facility or have evidence of recent and relevant radiation safety training elsewhere may only need to receive job-specific radiation safety training at the discretion of the RSO.

5.5.4 Visitor Training

Visitors to the proposed Ross ISR Project will receive hazard recognition and avoidance training for areas of the facility they will be visiting. All visitors that have not received training described in Section 5.5.1 will be escorted by someone properly trained and knowledgeable about the hazards at the site.

5.5.5 RSO Training

The RSO will receive a minimum of 40 hours of refresher training (total) in health physics and related subjects at least once every two years. This training need not be all at the same time but can involve multiple training events over the two year period.

5.5.6 Training Documentation and Records

After completion of training, employees and contractors will be required to sign a statement that they have received radiation safety training. The statement will outline the extent of the training and the dates when the training was received. The statement will also be signed by the instructor. These statements, as well as records of training program syllabus, dates of administration, attendance lists, and records of exam results will be maintained until license termination.

5.6 Security

As required in 10 CFR Part 20, Subpart I, Strata will secure from unauthorized removal or access all licensed material that is stored in controlled or unrestricted areas as part of the security program. Security measures will include the following passive and active controls:

- Areas where licensed material is located or stored such as wellfields, lined retention ponds, and the CPP will be fenced.
- Gates or doors for access to areas where licensed material is located or stored will have appropriate signage and be locked when facility personnel are not within the area to prevent unauthorized access.
- The main access gate to the project will be locked with coded and remote activated entry. The gate will be equipped with an intercom and video surveillance so that plant or administrative personnel can identify contractors and other site visitors. During normal working hours the gate will be controlled by personnel in the administration building. During night shifts the gate will be controlled by personnel in the Central Control Room. Contractors and visitors will be required to sign in and will be given applicable safety training as described in Section 5.5.4.
- Staff will be on-site 24-hours per day, 7-days a week to monitor unauthorized access.
- Daily inspections of access controls and signage will be conducted by facility operators.

Also as required in 10 CFR Part 20, Subpart I, Strata will control and maintain constant surveillance of any licensed material that is in a controlled or unrestricted area and that is not in storage. This includes transportation of loaded ion exchange resin from future satellite facilities or other resin generators to the CPP. The following passive and active controls will be used at the proposed Ross ISR Project to maintain control and surveillance of licensed material:

- Transportation security risks will be documented and SOPs concerning these risks will be strictly followed.
- All access to containers and vehicles where license material is located when not in storage will be locked, if possible, and under surveillance.

Transporting shipments of licensed material off-site will be done by appropriately licensed and qualified transporters in accordance with packaging and shipping requirements in U.S. DOT Hazardous Materials Regulations and may qualify for requirements of 49 CFR Part 172, Subpart I.

5.7 Radiation Safety Controls and Monitoring

Processes at the proposed Ross ISR Project include work with radioactive materials and will produce gaseous, liquid, and solid radioactive effluents as described in Chapter 4.0 of this report. Strata is committed to the control of these materials and effluents in order to protect occupational and public health at the proposed Ross ISR Project. The methods used for control and monitoring of radioactive materials and effluents are described in the following section. In accordance with 10 CFR Section 2.390(a)(4), the plant designs are considered proprietary and confidential. Therefore, the drawings and specifications included in Section 5.7 of this TR are not for release to the public. This includes Figures 5.7-1 through 5.7-6.

5.7.1 Effluent Control Techniques

5.7.1.1 Gaseous and Airborne Particulate Radiological Effluents

5.7.1.1.1 Gaseous Effluents - Radon

Under routine operations, the only gaseous radioactive effluent at the proposed Ross ISR Project will be Rn-222 gas from the production and restoration solutions. Processing of uranium to produce yellowcake will be performed in a vacuum dryer. As described in detail in Section 7.3 and summarized below, no particulate radiological emissions to the environment are expected from the dryer and the associated off gas treatment system (see Section 5.7.1.1.2).

Rn-222 dissolved in the pregnant lixiviant will come from the wellfield into the Ross processing facility. The production flow will be directed to the CPP for recovery of uranium. The uranium will be separated by passing the recovery solution through pressurized down flow IX units. The vents from the individual vessels and the resin transfer area (elevated shakers, i.e., resin screens to remove fines and degraded resin and interface with elution system) will be connected to a manifold that will be exhausted outside the plant building through the elevated shaker stack. Areas where radon and progeny exposure will be of concern in the CPP include the vents from the desanding system, IX vessels, the resin transfer area, and in fluid collection sumps. IX vessels will be operated in a pressurized manner with vents in the top of each vessel. The desanding system, resin shaker screens, and sumps will have exhaust hoods and redundant exhaust fans. Vents from these systems will be

connected to a manifold and discharged on the plant roof. Discharge points will be located away from plant ventilation intakes and will be located on the leeward side of the CPP. Exhaust fans for these systems will create a negative flow ensuring that air will not enter the process areas from the vessels or systems. Redundant fans will be of identical size and capacity and will operate only when primary fans are down for repair or maintenance. Radon exposure risks to personnel in the CPP will be further reduced by the general plant area HVAC system which is discussed in Section 4.1. Air sampling for radon progeny will be conducted regularly in the plant as described in Section 5.7.3. The general HVAC arrangement is depicted in Figure 5.7-1

Airflow through any openings in the vessels will be from the process area into the vessel and then into the ventilation systems, maintaining negative flow into the vessel and controlling any releases. (Note that the lixiviant circuit through IX will be a closed system; atmospheric pressures will initially be encountered during resin transfer at the shaker screens. This is where radon is expected to be released from the lixiviant circuit. Tank ventilation and local exhaust systems of this type have been successfully utilized at other ISR facilities and have proven to be an effective method for radon management and minimizing employee exposure (Brown 1982, 2007, 2008, NRC 2009, NMA 2007).

Venting to the atmosphere outside of the plant building minimizes personnel exposure to radon and its progeny which is a primary radiological and occupational health risk at modern ISRs. Rn-222 may be released in the plant building during solution spills, filter changes, IX resin transfer operations and maintenance activities. The plant building will be equipped with general area exhaust fans to remove any radon that may be released in the building before any significant ingrowth of progeny can occur. Personnel exposure to Rn-222 and progeny is expected to be minimal based on experience at similar facilities.

During plant start up, these potential in plant radon sources will be monitored and ventilation adjustments made as necessary, including provisions for additional local exhaust systems if necessary (see Sections 4.1, 5.7.3 and Figure 5.7-1). The general HVAC system in the plant will further reduce employee exposure by removing radon from plant air, which will be exhausted as described previously. This system will be connected via ductwork and manifolds to the eluant and precipitation tanks.

5.7.1.1.2 Particulate Effluents Yellowcake

The vacuum dryers will be steel vessels heated externally and fitted with rotating plows to stir the yellowcake. The chamber will have a top port for loading the wet yellowcake and a bottom port for unloading the dried product. A third port will be provided for venting through the bag house during the drying procedure. The bag house and vapor filtration unit will be mounted directly above the drying chamber so that any dry solids collected on the bag filter surfaces can be batch discharged back to the drying chamber. The bag house will be heated to prevent condensation of water vapor during the drying cycle. It will be kept under negative pressure by the vacuum system (vacuum pump – see below).

The condenser (scrubber) will be located downstream of the bag house and will be water cooled. It will be used to remove the water vapor from the non-condensable gases emanating from the drying chamber following particulate filtration by the baghouse. The gases are moved through the condenser by the vacuum system. These gases become entrained in the condenser fluids which are recycled back to the process. Dust passing through the bag filters is wetted and entrained in the condensing moisture within this unit. Only the vacuum pump discharges and this is to the yellowcake dryer room. The vacuum pump is a rotary water sealed unit that provides a negative pressure on the entire system during the drying cycle. It is also used to provide ventilation during transfer of the dry powder from the drying chamber to 55 gallon drums. The water seal of the rotary vacuum pump captures any small amount of residual entrained particulate matter remaining in the gas streams. This particulate matter is recycled back to the process. The impact of this point of discharge to the concentrations of radionuclides in dryer room air will be routinely monitored via filter collection and analysis as described in Section 5.7.3.1 to ensure radionuclide concentrations are maintained ALARA in accordance with recommendations contained in R.G. 8.30 (NRC 2002b). Figure 5.7-2 presents the flow sheet for the yellowcake product area including the dryer and it's off gas treatment system. Figure 5.7-3 demonstrates the arrangement for yellowcake packaging including drum loading.

As stated in NUREG-1910, Section 4.2.11.2.1, " …radon gas is emitted from ISL wellfields and processing facilities during operations and is the only radiological airborne effluent for those facilities that use vacuum dryer technology." The off-gas treatment system and associated emission controls for

the vacuum dryer system as described above and in Section 4.1 and are ALARA by design relative to potential for particulate emissions to the environment and therefore compliant with the requirements of 10 CFR 40, Appendix A, Criterion 8. NRC recognizes in NUREG-1910 (NRC 2009) that the emission of radionuclide particulates from this technology is essentially zero (see Section 7.3.1).

A seal rupture on the dryer system could potentially release yellowcake particulate into the air in the drying room. Seals will be inspected regularly for integrity. If a seal rupture were to occur, a change in the appropriate process parameters (sudden pressure drop, reduction in air flow, etc) would be immediately identified which is monitored in the control room and the off gas treatment system is inspected at least once per shift. The dryer off gas system will be instrumented sufficiently to operate automatically and to shut down if malfunctions such as this vacuum system failure were to occur. The system will alarm if there is an indication that the emission control system is not performing within operating specifications. While the likelihood of an unnoticed seal rupture is low, the potential ramifications of this situation are addressed in Section 7.5, Effects of Accidents.

If the system is alarmed due to off normal conditions in the emission control system, the operator will follow SOPs contained in the plant operations manual to recover from the alarm condition, and the dryer will not be unloaded or reloaded until the emission control system is returned to normal service.

Ventilation and effluent control equipment will be inspected for proper operation as recommended in R.G. 3.56 (NRC 1986a) via routine equipment inspections and as discussed in Section 5.3. To ensure that the emission control systems are performing within specified operating conditions, instrumentation will be installed that signals an audible alarm if the air pressure (i.e., vacuum level) falls below specified levels, and the operation of this system is routinely monitored during dryer operations. The operator will perform and document inspections of the differential pressure or vacuum every operating shift. Additionally, the air pressure differential gauges for other emission control equipment is observed and documented at least once per shift during dryer operations.

Estimating and Reporting Effluent Releases per 10 CFR 40.65 and to Demonstrate Compliance with Public Dose Limits at 10 CFR 20.1301

Calculations performed in accordance with existing NRC guidance will be used to estimate source terms and calculate off-site dose to the public. For example, Regulatory Guide 3.59, Section 2.6 provides methods acceptable to NRC for estimating the radon source term during ISR operations. Additionally, NUREG-1569, Appendix D, provides the MILDOS-AREA methodology acceptable to the NRC, which includes expressions for calculating the annual Rn-222 source terms from various aspects of ISR operations which is then used by MILDOS to calculate off-site public dose and demonstrate compliance with the 100 mrem/yr public dose limit of 10 CFR 20.1301.

The MILDOS-AREA computer code calculates the radiological dose commitments received by individuals and the general population within an 80-km radius of an operating uranium recovery facility. In addition, air and ground concentrations of radionuclides, as a result of deposition of radon progeny on soil and vegetation, are estimated for individual locations, as well as for a generalized population grid. Extra-regional population doses resulting from transport of radon and its progeny can also be estimated.

The transport of radiological emissions from point and different area sources is predicted with a sector-averaged Gaussian plume dispersion model. Mechanisms such as radioactive decay, plume depletion by deposition, ingrowth of decay products, and resuspension of deposited radionuclides are included in the transport model. Alterations in operation throughout the facility's lifetime can be accounted for in the input stream. The exposure pathways considered are inhalation; external exposure from groundshine and cloud immersion; and ingestion of vegetables, meat, and milk. Dose commitments are calculated primarily on the basis of the recommendations of the International Commission on Radiological Protection (ICRP). Only airborne releases of radioactive materials are considered in MILDOS-AREA; releases to surface water and to groundwater are not addressed in MILDOS-AREA. MILDOS-AREA is a multi-purpose code that can be used to evaluate population doses for NEPA assessments, maximum individual doses for predictive 40 CFR 190 compliance evaluations, or maximum offsite air concentrations for predictive evaluations of 10 CFR 20 compliance.

It should be noted that the MILDOS code considers the fact that the radon concentrations in the pregnant lixiviant are orders of magnitude higher

than considerations of just the equilibrium values from the Ra-226 concentrations in the ore. The applicable input parameters to MILDOS include radon emanating power, size/thickness of ore zone, radon fraction in lixiviant, etc. Furthermore, in growth of radon progeny in the environment between the emission source (plant, wellfield, etc.) and point of interest (location of member of public including application of applicable exposure scenarios through direct inhalation, ingestion, ground shine, etc.) is included in the MILDOS calculation of offsite doses from the ISR radon source term.

Throughout the 30 years of ISR operational experience in the US there is no evidence of public exposure from radon releases (including effect of progeny) in excess of public exposure criteria. For example, NUREG-1910, Table 4.2-2 presents a number of dose estimates to offsite receptors from radon releases from ISR facilities, all of which are≤ 40 mrem/yr. Further, Section 4.2.11.2.1 states "all doses reported are well within the 10 CFR 20 annual radiation dose limit for the public of 1 mSv (100 mrem/yr)."

The requirements for providing a semi annual report to NRC in 10 CFR 40.65 of the quantity of each of the principal radionuclides released to unrestricted areas can be met through modeling methods as described above (and confirmed via environmental monitoring as described in Section 2.9) since 40.65 does not specifically require "measurement." The MILDOS–AREA computer code as described above will be used, in conjunction with the process parameters applicable to the previous 6 months of facility operation, to estimate the semi annual radon source term. It will be conservatively assumed that the radon progeny are in equilibrium with the radon parent when released in estimating the total quantities of radionuclides emitted during the previous six-month period.

Furthermore, the disperse and diffuse nature of potential radon releases from multiple locations at ISRs makes traditional (i.e., "isokinetic") source term measurements impractical (from some sources at ISRs, there is no discrete "stack" per se). However, the operational environmental monitoring program for the proposed Ross ISR Project will provide for continuous radon monitoring at site boundary locations and analysis of soil samples including for radon progeny (e.g., Pb-210) as described in Section 2.9 and 5.7.7. This will validate modeling results with regards to potential for radon progeny in the environment and demonstrate compliance to criteria for releases of radioactive material in effluents to unrestricted areas per 10 CFR 20, Appendix B, table 2.

5.7.1.2 Liquid Effluent

The production bleed and water from restoration are the primary sources of liquid waste as previously discussed in Section 4.2. Water from these processes will be routed to a reverse osmosis system (RO) for treatment. A portion of the resulting permeate from the RO will be routed back to the production and restoration injection streams and the remainder will be recycled in the plant, used beneficially, or disposed of. Brine will be routed to lined retention ponds and subsequently disposed of in Class I deep disposal wells. Figures 3.1-11 through 3.1-13 depict process liquid waste streams.

Other liquid waste streams at the proposed project will include CPP wash down water, spent eluate, decontamination waste water, filter backwash water, fluids generated from work over operations on injection and recovery wells, and contaminated reagents.

5.7.1.2.1 Liquid Effluent Accidents

5.7.1.2.1.1 Responsibilities

The RSO will be charged with the responsibility to develop and oversee implementation of appropriate procedures to address spills of byproduct material. Personnel representing the engineering and operations functions will assist the RSO in this effort. Basic responsibilities of plant management and the RSO in this regard will include:

- Identification of potential spill sources including lessons learned from review of past incidents of spills.
- Assignment of resources and manpower.
- Responsibility for materials management and inventory.
- Establishment of spill reporting procedures and visual inspection programs.
- Establishment of employee emergency response training programs.
- Responsibility for program implementation and subsequent review and updating.
- Review of new construction and process changes that may require updating of spill prevention and control programs.

5.7.1.2.1.2 Failure of Process Tanks

Leaks from failures of process tanks will be contained within the CPP building. Where it is feasible, process area within the CPP building will have secondary containment consisting of concrete curbs. Secondary containment basins will drain to sumps which will allow the transfer of the spilled solutions to appropriate tankage, pondage or directly to the deep well injection system. In addition an overall plant containment berm will be incorporated into the building foundation which will contain spills during a catastrophic event or spills from areas where it is not feasible to include secondary containment berms. Plant secondary containment design features are shown on Figure 5.7-4. Details concerning the secondary containment capacity in the plant are discussed in Sections 3.2 and 7.5 of this report.

5.7.1.2.1.3 Surface Releases between the Wellfield and CPP

The most common form of surface releases from in-situ recovery operations occurs from breaks, leaks, or separations within the piping system that transfer recovery fluids between the CPP and the wellfield. These leaks will generally be limited to small releases due to engineering and instrumentation controls at the proposed Ross ISR Project. Instrumentation and controls will include leak detection sensors in module buildings, valve manholes, and wellheads, as well as pressure monitoring instrumentation on pipelines which will trigger alarms and automatic shutdown in the case of an upset condition.

In general, piping within the wellfield will be constructed of PVC or HDPE pipe with butt welded joints, or equivalent. All pipelines will be hydrostatically tested according to manufacturer's specifications and industry standards prior to final burial. In the event of leakage from the fitting, the defective component will be replaced. Prior to backfilling, a final inspection of all pipe and appurtenances will be conducted.

In order to prevent spills of mining solutions, the following precautions will be taken.

- Piping and associated fittings will only be constructed of materials that are chemically compatible, able to withstand the expected operating pressures, and compatible with ambient conditions.
- Wellfield pipelines and manifolds will be pressure checked before being placed into operation and after significant repairs.

- Regular inspections of operating wellfields will be conducted as outlined in Section 5.3.3. The entire plant also will be inspected at least daily when operating as discussed in Section 5.3.1.
- Automated monitoring will be installed in so any significant deviations in operating parameters will signal alarms and automatic shutdown.

Each operating module building will be inspected at least once per week by the operations staff with the results documented. The inspector will look for the following:

- Leaks of lixiviant in the module building;
- Failing pipes and fittings;
- Conditions that may lead to a release of lixiviant;
- Proper capping of wellheads and pipes that are not in use;
- Exposed scale that could become airborne; and
- Exposed piping that is supposed to be buried.

Any condition discovered during the inspection that may lead to the spread of contamination will be repaired in a timely manner or made safe. Results of the inspection will be made available to the RSO and will be maintained for the life of the license.

At least once per year, the Manager of Health, Safety, and Environmental Affairs will convene the SERP to review the cause of recent spills. The SERP will consist of at least three individuals with experience in operations. After reviewing the causes of recent spills, the SERP will send a report to the facility manager detailing reasonable recommendations on how to prevent and minimize the size of future spills.

5.7.2 External Radiation Exposure Monitoring Program

This section describes Strata's approach for assessing the external exposure or deep dose equivalent (DDE) of personnel working at the proposed Ross ISR Project. The approach includes general area surveys with hand held instrumentation and the use of fixed location TLDs/OSDs to determine radiological conditions throughout plant areas as well as personnel dosimetry involving assignment of thermo-luminescent or optically stimulated dosimeters (TLD/OSD) to personnel who work at the plant. Additionally, visitors and other

occasional personnel will not be permitted access to any area which the dose rate exceeds 2 mrem/hr without being provided personnel dosimetry. Figure 5.7-5 displays the plant general arrangement with the radiological survey plan while monitoring locations for external radiation within the greater facility will be provided once final facility designs have been prepared.

5.7.2.1 General Area Gamma Surveys

Gamma surveys of the process area will be performed at least once a month to maintain a record of external exposure rate data and allow quick identification of changed conditions and help maintain that personnel exposures are kept ALARA. All surveys of this nature will be completed by a radiation safety technician meeting the training and experience requirements described in Section 5.4.2. These surveys will be performed using hand held instrumentation. Comprehensive surveys will be conducted initially at start up to verify assumptions regarding where external exposure rates will be highest. Survey locations and frequencies may be adjusted should process conditions change in the future affecting the external exposure profile of the plant and wellfields. Additionally, fixed location, area TLDs (or OSDs) will be emplaced at locations at which initial surveys indicate highest potential for gamma exposure as well as in non process areas such as offices, change rooms and lunchroom. These dosimeters will be exchanged on a quarterly basis or more frequently based on survey results at the discretion of the RSO.

Surveys will be performed at worker occupied process areas of potentially elevated gamma levels where radium may concentrate or precipitate and in areas where uranium concentrates are processed and/or stored. These areas will include wellfield module buildings within which precipitates from dried leaks could form, loaded IX and elution tanks, resin transfer system, RO unit, yellowcake precipitation, thickening, drying/packaging and storage areas, and other areas where 11e.(2) byproduct material is accumulated and stored. Figure 5.7-5 depicts areas of potential external exposure within the CPP where at a minimum, regular gamma surveys will be performed. Additionally, since elevated gamma levels can be an indication of surface contamination, areas where elevated gamma levels are identified during routine surveys that are not typically elevated, will also be assessed for surface contamination (see Section 5.7.6)

Designated “Radiation Areas” will be areas with external radiation levels at which an employee could receive an exposure greater than 5 millirems (0.05 millisievert) in one hour at 30 centimeters from the source and will be posted as such. These circumstances are considered unlikely at an ISR operation, except in areas where concentrations of radium precipitates accumulate and/or large quantities of final product concentrate is stored awaiting shipment (these will be controlled areas with limited personnel access). Should such exposure rates be encountered, an evaluation will be performed to determine the probable process circumstances that result in this condition and if practical opportunities exist to reduce exposure levels ALARA. In these circumstances, survey frequencies may need to be increased, sources (e.g., drums in storage) may need to be repositioned and/or stay times reduced as practical based on results of the ALARA analysis. Additionally, ad–hoc surveys will be performed during maintenance of systems which may contain concentrations of radium precipitates (e.g., tank clean outs.)

External gamma surveys will be performed with survey equipment that meets the following minimum specifications:

- Range - Lowest range not to exceed 100 micro Roentgens per hour (uR/hr) fullscale with the highest range to read at least 50 mill Roentgens per hour (mR per hour) full scale.
- Battery operated and portable.

An example of satisfactory instrumentation that meets these requirements is the Ludlum Model 19 micro R meter. Gamma survey instruments will be calibrated at the manufacturer's suggested interval or semi–annually (whichever is more frequent) and will be operated in accordance with the manufacturer's recommendations. Verification of instrument consistency of operation will be performed using check sources prior to each use. Variations from reference readings greater than 20 percent will require the instrument to be removed from service and re-calibrated. Calibration records of gamma survey equipment will be retained on-site.

Gamma exposure rate surveys will be performed in accordance with standard operating procedures as defined in the project Radiation Safety Manual. These SOPs will be developed and surveys performed in accordance with NRC guidance (NRC 2000, NRC 2002a).

5.7.2.2 General Area Beta Surveys

Regulatory Guide 8.30 recommends that, in addition to gamma surveys, beta surveys of specific operations that involve direct handling of large quantities of aged yellowcake be performed to ensure that extremity and skin exposures are not unduly high. Beta exposure rate surveys will be performed at the specific operations that involve direct handling of large quantities of aged yellowcake. This would include in plant areas associated with precipitation, dewatering (filter press) and drying/packaging. These surveys will be performed near the surface of the material (e.g., within 10 cm) so as to be representative of beta exposure rates to workers' hands and skin during the handling of the material. Any beta exposure rate evaluations for these operations that are performed in lieu of instrument surveys will use the information provided in Regulatory Guide 8.30 Figures 1 and 2.

However, it is noted that modern ISRs typically involve a "process life cycle" for uranium measured in hours or a few days. (time from extraction of the uranium *in-situ* through final packaging in steel drums). Accordingly, no aged yellowcake is expected that could have experienced significant in growth of beta emitting daughters (i.e., Pa-234, Th-234). (Small amounts of precipitates which could contain aged yellowcake as scale in pipes and/or tanks are not accessible to workers except potentially for very brief periods during maintenance activities, and workers would not be "handling" such scale for exposure periods longer than a few minutes at a time).

Nonetheless, during the initial operational period, beta surveys will be performed as described here to verify the experiences at other operating ISRs and/or assess the needs for routine beta monitoring moving forward. See discussion on beta emitters below and also in Section 5.7.3.1.

Beta contamination surveys will similarly be performed in these same plant areas initially and whenever a procedural and/or equipment change may increase risk of beta contamination (i.e. when performing maintenance on tanks/pipes that may accumulate materials over time) and could present a potential for in growth of beta emitting progeny (see commitment for use of radiation work permits below). These surveys will be performed with a Ludlum 43-1-1 alpha–beta phoswich scintillation probe or equivalent. This probe has an active window area of 83 cm^2, rated efficiencies of 30% alpha (Pu^{239}) and 30% beta (Sr^{90}/Y^{90}) and typical backgrounds of 3 counts per minute (cpm) alpha and <300 cpm beta.

However, it should be recognized that there is no aspect of the ISR process that would separate beta emitters Th-234 or Pa-234 from their alpha emitting uranium parents and therefore, there cannot be "beta contamination" associated with spills or maintenance activities in the absence of detectable alpha. In the event that there was a spill on a complex matrix (carpet, wood, etc) alpha surveys may not indicate the presence of contamination due to self absorption effects; however it is unlikely that a spill would occur on this type of surface in an ISR plant since only in office areas would there be carpeted and/or wood floors. Special care will be taken to survey for beta emitters in the unlikely event that a spill occurs on such a complex material. (Maximum beta possible would be when Th-234/Pa-234 are at equilibrium with the uranium at approximately 4 months post mining). Strata will typically transport offsite all yellowcake as soon as a full shipment is accumulated. Accordingly no aged yellowcake is stored on site.

It is therefore highly unlikely that under conditions of routine operations or as a result of spills or maintenance activities, beta exposure rates to which workers could be exposed could result in shallow dose equivalents to the skin or the skin of extremities ≥10% of the limits at 10 CFR 20.1201 (a)(2) requiring individual beta monitoring per 10 CFR 20.1502 (10% of 50 Rem/yr = 5 Rem /yr). For any maintenance work and/or spill clean up activities (typically not covered by existing standard operating procedures) a radiation work permit would be prepared which will define specific radiological monitoring and controls for the task. These will include beta exposure rate monitoring if it is suspected that the material in question may be aged yellowcake.

However, if these circumstances were to be identified, an ALARA analysis will be performed to evaluate needs for additional surveys and controls, including provisions for personnel beta monitoring (e.g., ring and/or wrist badges).

It is of interest to note that Cameco Resources Corporation has performed extensive beta surveys at both the Smith Ranch and Crow Butte ISRs in 2010 throughout their plants. These surveys were performed with GM detectors in the open vs. closed shield modes and indicated no difference at any location surveyed (including proximate to products in yellowcake areas) between measured exposure rates in the open (beta plus gamma) vs. closed (gamma only) configurations. That is, the beta exposure rates were zero. (Brown 2010a).

5.7.2.3 Personnel Dosimetry

NRC regulations require exposure monitoring for adults likely to receive, in 1 year from sources external to the body, a dose in excess of 10 percent of the limits which are defined in 10 CFR 20.1201. Ten percent of the dose limit would correspond to a deep dose equivalent (DDE) of 0.5 Rem.

Regular plant workers will be provided personal monitoring devices (TLDs or OSLs). Strata will determine routine monitoring requirements in accordance with the NRC guidance R.G. 8.30 (NRC 2002b), R.G. 8.34 (NRC 1992a) and R.G. 8.36 (NRC 1992b). Nonetheless, Strata believes that it is unlikely that any employee working at the proposed Ross ISR Project will accrue a dose approaching 10 percent of the regulatory limit and therefore require monitoring per 10 CFR 20.1502(a)(1) (i.e., 10 percent of 5 Rem or 500 mrem/yr).

Although monitoring of external exposure may not be required by applicable regulatory requirements, Strata will issue dosimeters to all process employees and will exchange and have them analyzed on a quarterly basis (more frequently if dictated by exposure conditions at the discretion of the RSO). Dosimeters will be provided by a vendor that is accredited by the National Voluntary Laboratory Accreditation Program (NVLAP) of the National Institute of Standards and Technology. The dosimeters will have a range of 1 mR to 1000 R. Results from personnel dosimetry will be used to assess individual DDE for use in determining total effective dose equivalent (TEDE). Results from the external dosimetry program will be entered into each employee's personal exposure record and integrated into the overall dose assessment program as described in Section 5.7.4, Exposure Calculations.

At modern ISRs, current data indicates annual doses very rarely exceed 500 mrem/yr TEDE (Brown 2010a). In general, at any uranium recovery facility, personal exposures are typically much less than 1 rem/yr (IAEA 1976).

5.7.3 In-Plant Airborne Radiological Monitoring

5.7.3.1 Airborne Uranium Particle Monitoring

Very low levels of uranium particulates are expected in a modern ISR plant due the nature of low temperature vacuum drying equipment. The main potential source of particulate uranium particulate is at the location of the yellowcake packaging equipment. This area of the plant will be closed off

(ventilation system isolated) and posted as an airborne radioactivity area. Additionally, surveys for airborne uranium will be performed to:

- Demonstrate compliance with the occupational dose limits for workers, specified in 10 CFR 20.1201, and DAC/ALI values specified in 10 CFR 20, Appendix B, Table 1.
- Determine if an area needs to be posted in accordance with NRC regulations found in 10 CFR 20.1902(d).
- Determine whether additional precautionary measures are required to comply with 10 CFR 20.1701 and 20.1702.
- Determine whether occupational exposures to radioactive materials are being maintained ALARA.

Air sampling efforts will be concentrated near precipitation tanks, filter press equipment and in the drying/packaging area to ensure airborne levels are below the regulatory limits found in 10 CFR 20.1201. Locations of air sampling stations are shown in Figure 5.7-5. Initially, weekly area air sampling will be conducted. Based on results, frequency may be adjusted (more or less frequent) at the discretion of the RSO.

Airborne particulate samples will be collected monthly in accordance with NRC Regulatory Guide 8.25. The regulated air sampler (e.g., Staplex TFIA Series High Volume Air Sampler or equivalent) will be calibrated according to manufacturer specifications. Samples will be collected on glass fiber filters. Documentation of calibrations and readings with be kept by the RSO on-site until the license is terminated. Calibrations and readings will be documented on a form compliant with NRC Regulatory Guide 8.7, Instructions for Recording and Reporting Occupational Radiation Exposure, Revision 1.

Breathing zone sampling will be implemented as determined appropriate by the RSO during use of a radiation work permit, in the drying/packaging area or when any worker is performing a special high-exposure task and may be exposed to more than 12 derived air concentration (DAC) hours in any one week. Breathing zone samplers (e.g., Staplex model PST-2X Personal Air Sampler or equivalent) will be placed in the vicinity of the user's upper torso. Breathing zone samplers will be calibrated according to the manufacturer's qualifications or semi-annually (whichever is more frequent). Calibrations and sampling records will be recorded and maintained by the RSO and also kept in a format compliant with NRC Regulatory Guide 8.7.

Breathing zone samplers will also be used during changes in operations or during conditions that may increase airborne radioactive particulates. Some examples of times when breathing zone samplers may be used include but are not limited to: opening of pipes that contain yellowcake slurry, yellowcake or eluant spills, changing filters contaminated with pregnant eluant or slurries, or when manually handling yellowcake products. Additional needs for breathing zone sampling will be determined by the RSO during the preparation of radiation work permits.

When available, breathing zone sampling results will typically be the primary air sampling data used to establish intake of radionuclides by workers for purposes of establishing compliance with Annual Limits on Intake (ALIs) (10 CFR 20, Appendix B, Table 1) and to estimate DAC hours of exposure and therefore for calculating dose, (see Section 5.7.4). However, general area air sampling data will also be used when necessary, if breathing zone sampling data is not available or at the discretion of the RSO, if it is believed to be more representative of intake by the worker. General area air sampling results will be used to estimate intakes whenever results exceed 10% of the DAC in areas that have been occupied by workers. Time-weighted exposure assessments will be performed in these cases to estimate DAC - hours of exposure (see Section 5.7.4). Breathing zone sampling data will be used to estimate DAC - hours and intakes for jobs and tasks that required workers to wear them (see above), but these calculations may be supplemented with general area sampling data if appropriate. These decisions will be based on representativeness and statistical confidence of air sampling results, length of exposure periods and other factors at the discretion of the RSO.

The volume of air sampled and the method for analysis for high volume area and for breathing zone samples will allow for a lower limit of detection of at least 1×10^{-11} microcuries per milliliter (µCi/mL) as required by NRC Regulatory Guide 8.30. Samples will generally be analyzed within 2 days of sampling, however a minimum delay of 4 to 8-hours will be instituted to allow for the decay of radon progeny. In the event immediate action is required using the 4 to 8-hour delay, the filter will be recounted after 24 hours to verify the long-lived alpha concentration. The counting system used for filters will be a Ludlum Model 2929 alpha/beta sample counting system or equivalent.

Gross alpha counting of filters will be performed because it can be assumed to be exclusively U-nat (see Section 5.7.3.1.1 for discussion of the

potential for radionuclide mixtures in air). Studies of ISR lixiviant show a very small portion of uranium daughter products are mobilized in the ISR process (Brown 2007). Furthermore, the IX process is selective for uranium, therefore Th-230 and Ra-226 and other progeny will not be located downstream of the IX process other than in 11e.(2) wastes. However, it is recognized that in 11e.(2) material storage areas, or during maintenance activities in which exposure to 11e.(2) materials is possible, contamination control and air sampling will need to consider the possibility of the presence of Ra-226 as well as U-nat.

Ingrowth of long lived daughters such as Th-234 and Pa-234 (both beta emitters) would take approximately 4 months to reach equilibrium and thus are not associated with fresh product. Finally, 10 CFR 20.1204(g) acknowledges that nuclides in a mixture can be ignored if any individual nuclides are less than 10% of the mixture, and all nuclides ignored total less than 30% of the mixture. Because of the inherent process properties described above, it is not necessary that any other decay products need be included in filter counting for long lived alpha emitters in air. To verify this, filters from initial studies at the plant will be composited and sent for analysis of U-nat, Th-230 and Ra-226. Radiochemical analysis of the plant yellowcake product can also be used to accomplish this.

Lower limits of detection (LLDs) will be established to ensure the ability to detect <10% of applicable DAC. For U-nat in air, initially assuming solubility class W (ICRP 19 & 30 which is equivalent to ICRP 66/71 Type M), this LLD will be <3 E-11 µCi/ml. Additionally, during initial plant operation, a sample of yellowcake product will be radiologically characterized (Unat, Th-230, Ra-226) to verify its composition is essentially exclusively uranium (see Section 5.7.3.1.1).

The following equipment will be used to obtain air samples.

- High volume air sampler (15 to 30 cfm) such as a Staplex TFIA Series High Volume Air Sampler or equivalent
- Hi-Q low volume samplers (0 to 100 lpm) or equivalent; and
- Breathing zone (lapel) sampler (0 to 5 lpm) such as a Staplex model PST-2X Personal Air Sampler or equivalent

For uranium in air, the volume of air sampled and air filter counting times will be established to ensure achievement of this LLD and calculated as follows:

$$\mu Ci/ml\ Uranium = \frac{(cpm_S - cpm_B)(4.5E\text{-}7\ \mu Ci/dpm)}{(E)(V)}$$

Where:
- cpm_S = Sample count rate
- cpm_B = Background count rate
- dpm = Disintegrations per minute
- E = Instrument efficiency (cpm/dpm)
- V = Sample volume (ml)

Different terminology has been used over the years regarding statistical requirements to ensure that air sampling procedures can detect airborne levels of a radionuclide at 10% of the DAC in 10 CFR 20, Appendix B. Although the terminology has varied (e.g., LLD; Minimum Detectable Activity, (MDA); Minimum Detectable Concentration (MDC), the basic statistics have remained the same. Strata's technical approach as described here outlines the methods to be used for the calculation of the MDC to ensure that the air sampling process is adequate to measure airborne levels of natural uranium below 10% of the DAC for natural uranium.

Regulatory Guide 8.30, Section 2.2, states: "The quantity of air sampled and the method of analysis should allow a LLD of at least…10% of the Appendix B to 10 CFR Part 20 concentration for natural uranium." Regulatory Guide 8.25 and NUREG-1400 expand on the statistical processes used to determine the detection limits and MDC. The application of these processes and methods recommended in these two documents will validate that sampling procedures are adequate to detect 10% of the DAC.

Regulatory Guide 8.25, Section 6.3, provides information regarding lapel sampling and calculation of the MDA. It states: "The 10 CFR 20 monitoring criteria (i.e., 10 percent of the limit) do not establish required levels of detection sensitivity (lower level of detection, minimum detectable concentration, etc.). For example, lapel samplers may not be able to detect uranium concentrations of 10 percent of the DAC, but lapel samplers are still acceptable for measuring the uranium intake of workers. The monitoring criteria should not be considered requirements on the sensitivity of a particular measurement because when the results of multiple measurements are summed, the sum will have greater statistical power than the individual measurements."

The MDA is discussed further in relation to the MDC in NUREG-1400 which is an implementing document for Regulatory Guide 8.25. It provides the next derivation of the MDA formula, the formula for the MDC. The opening

statement to Section 6.3.4 states: “Suppose a licensee wants to set a performance goal for an air-sampling program of being able to detect 0.1 x DAC.” NUREG-1400 then goes on to explain the formula for the MDC as will be used by Strata.

While the LLD or “Detection Limit (L_D)”, as is more commonly used in NUREG-1575, is related to and is incorporated into the MDC, it is not necessary to compare it to each individual measurement. As a side note, the LLD calculation appears to be incorrect in Regulatory Guide 8.30; this is not a critical issue since it is not necessary to calculate the LLD/L_D prior to calculating the MDC. Thus, the MDC for each measurement is required to be less than 3E-11 uCi/ml, which is 10% of the DAC; this ensures that the LLD/L_D for multiple measurements is also less than 3E-11 uCi/ml.

5.7.3.1.1 Potential for Mixtures of Radionuclide Particulates in Air

It is important to recognize the radiological environment of a modern ISR as related to the potential radionuclides of concern that could become airborne. Studies performed in the late 1970s and early 1980s of radionuclide mobilization from several ISRs and subsequent measurements at operating ISRs indicate a relatively small portion of the uranium daughter products in the ore body are actually mobilized by the lixiviant (Brown 2007).

In addition to the fact that very little of these uranium daughter products are mobilized *in-situ*, the (IX) resin used in ISR facilities is specific for removal of uranium. Thorium compounds are not removed by the IX resin and are therefore not expected in the process downstream of the IX columns (e.g., elution, precipitation, and drying circuits). Accordingly, the “nuclide mix” that can potentially become airborne in the precipitation, drying and packaging areas of a modern ISR facility is expected to be almost exclusively U-nat. Ingrowth of the first few short lived daughter products (Th-234, Pa-234) takes approximately 4 months to reach equilibrium, and therefore is not expected to be associated with the relatively fresh product present in an operating ISR CPP.

Additionally, it should be noted that in accordance with 10 CFR 20.1204(g), nuclides can be ignored in a mixture in air if the following conditions are met; 1) total activity in the mixture is used to determine compliance with 20.1201 and 20.1502(b), 2) any nuclides ignored are <10% of the mixture, and 3) the sum of all nuclides ignored are <30% of the mixture. For modern ISRs, these conditions are expected to be met.

In order to establish that natural uranium isotopes are the exclusive alpha emitting radionuclides of concern in air, composite samples (long sampling times to maximize collected material) from several representative air particulate monitoring locations will be collected and radiologically characterized. These sample locations will adequately characterize various points in the process (e.g., lixiviant, precipitation, and drying/packaging areas). Samples will be analyzed for U-nat, Th-230, and Ra-226. Results will be compared with the mixture exclusion conditions defined in 10 CFR 20.1204(g) to ensure that the appropriate DAC limits from 10 CFR, 20 Appendix B, Table 1 are used. If a mixture is present greater than the 10 CFR 20.1204(g) exclusion, a "sum of fractions rule" will be applied to establish the appropriate DAC. Additionally, yellowcake product will also be characterized to verify the radiological composition of fresh yellowcake is essentially exclusively uranium.

5.7.3.2 Airborne Rn-222 Progeny Monitoring

Rn-222 will be sampled by measuring its progeny as they are easier to measure and are the basis for the assignment of worker dose. Initial sampling will occur in many locations in the CPP as depicted on Figure 5.7-5.

Measurements of Rn-222 progeny will be taken on a monthly basis in areas where Rn-222 progeny routinely exceed 10% of the regulatory limit or 0.03 working levels (WL) above background. Other locations that are routinely below the 0.03 WL will be sampled quarterly. During the first few months of CPP operation, monthly sampling will occur.

If at any time the levels of Rn-222 progeny exceed 0.08 WL, the circumstances will immediately be investigated or mitigated. Samples will then be taken weekly at this location until 4 consecutive samples show levels below 0.08 WL. Additional samples will be taken in areas where there is an upset condition, maintenance, or operational change that could result in the release of radon and/or as may be required by an RWP. Radon progeny samples will also be required before an RWP can be issued for work in confined spaces likely to contain radon and progeny.

When collecting a sample, the date, time, and status of major equipment and processes in the area will be recorded. The LLD for Rn-222 daughter measurements will be no greater than 0.03 WL (10% of the DAC) and shall be calculated using guidance found in Appendix B of NRC Regulatory Guide 8.30. Measured values less than the LLD, including negative values, will be recorded

on data sheets. The LLD is set high enough to provide a high degree of confidence that 95 percent of the measured values above the LLD are accurate and do not represent false positive values. Filter paper samples will be analyzed using standard alpha counting equipment (e.g. Ludlum Model 2929 alpha/beta sample counting system or equivalent).

The modified Kusnetz method will be used for measuring Rn-222 working levels. This is the standard, generally accepted method for determining radon decay product concentrations in air (Kusnetz 1956 and Thomas 1972).

One WL is that concentration of radon decay products in one liter of air that will result in the emission of 1.3 x 105 MeV of alpha energy when all of the decay products present, decay to Pb-210. The Kusnetz method involves collecting an air sample for, nominally, five minutes on a high efficiency glass filter. Alpha counts on the filter will be determined by counting with an alpha scaler for one to five minutes after a decay time of 40 to 90 minutes. Filter paper samples will be analyzed using standard alpha counting equipment (e.g. Ludlum Model 2929 alpha/beta sample counting system or equivalent).

The total alpha disintegration rate is divided by the volume of air sampled and an empirical factor (Kusnetz factor) that relates alpha activity per liter to WL for a specified decay period. An additional correction factor will be applied to the counting efficiency to account for any self absorption by the filter.

Air samplers will be calibrated as per manufacturer recommendations or at least semiannually with a mass flow meter or other primary calibration standard. A record shall be kept of all calibrations and radon progeny surveys by the RSO until license termination and in a form compliant with NRC Regulatory Guide 8.7, Instructions for Recording and Reporting Occupational Radiation Exposure, Revision 1.

Radon Progeny in Air will be determined via the modified Kusnetz method as follows:

$$WL = \frac{\text{Sample cpm - background cpm}}{(SAF)(Eff)\ (Vol)\ (TF)}$$

Where:

cpm = Counts per minute (sample – background)
Eff = Instrument counting efficiency
SAF = Filter paper self absorption factor

Vol = Total air volume pumped through filter (flow rate in liters per minute x sample time in minutes)

TF = Time factor ("Kusnetz" factor from table at 40 – 90 minutes after sampling)

5.7.3.3 Respiratory Protection Criteria

A Respiratory Protection Program will be implemented in accordance with 10 CFR 20, Subpart H. Although it is not anticipated that respirators will be required to control intake or necessary to reduce exposure to airborne radionuclides below 10 CFR 20 limits during routine operations at the Ross ISR plant, workers in the yellowcake drying and packaging areas may be required to wear respirators as standard PPE in the unlikely event that process upsets and spills occur. In other circumstances, respirators will only be used in the event that exposures cannot be maintained ALARA with engineering and/or administrative controls. The RSO will determine when respirators are needed, per NRC Regulatory Guide 8.31. All respirators used on the site will be certified by the National Institute for Occupational Safety and Health (NIOSH) and will be used in accordance with 10 CFR 20.1703.

5.7.4 Exposure Calculations

Radiation doses to personnel will be calculated using methodology described in NRC Regulatory Guides 8.30 and 8.34. Estimates of the Total Effective Dose Equivalent (TEDE) at the proposed project area will be based on external gamma ray measurements via TLDs or OSDs as described in Section 5.7.2, results from air samples that are representative of the air breathed by workers as described in Section 5.7.3, and results of bioassay measurements described in Section 5.7.5. Radiation doses estimated from elevated uranium in urine samples will be integrated with the dose estimates described in this section. The referenced methods and requirements will be applicable to routine operations, maintenance activities and incident response. It should be noted that historically, occupational doses at US ISRs have been quite low, with most radiation workers <200 mem/yr TEDE. As would be expected, the highest exposures are typically associated with yellowcake workers because they work in close proximity to uranium concentrates (external exposure measured via TLDs) and are potentially exposed to uranium dusts in the drying and packaging operations (internal exposure measured via air sampling and

urinalysis). However, even for these workers, annual doses very rarely exceed 500 mrem/yr TEDE (Brown 2010b).

Although breathing zone air samples are considered more representative of the air breathed by workers than area air samples, both will be used as dictated by airborne conditions and job activities as described in Section 5.7.3. General area air sampling results will be used to estimate intakes whenever results exceed 10% of the DAC in areas that have been occupied by workers. Time-weighted exposure assessments will be performed in these cases to estimate DAC - hours of exposure and intake. Breathing zone sampling data will be used to estimate DAC - hours and intakes for jobs and tasks that required workers to wear them, but these calculations may be supplemented with general area sampling data if appropriate. These decisions will be based on representativeness and statistical confidence of air sampling results, length of exposure periods and other factors at the discretion of the RSO. The methods used to calculate radiation doses and to obtain representative air samples are applicable to all operations and activities (routine, maintenance, and ad hoc). Determination of the worker's TEDE and CEDE will be based on assigned external and internal exposure as described in this section.

Potential for external exposure is the direct result of proximity to gamma emitting radionuclides. This will be measured via TLDs or OSDs as described in Section 5.7.4.3.

Potential for internal dose will be primarily from inhaled uranium and radon progeny with only rare, unusual potential contributions from ingestion, wounds, or absorption through the skin. All reporting and record keeping of the worker doses will conform to Regulatory Guide 8.7, which requires record retention through license termination. Historical radiation exposures will be used to assess long-term trends. The SERP will assess exposure trends during annual ALARA reviews (see Sections 5.2.4 and 5.3.3).

The CEDE is the estimated internal radiation dose accrued over 50 years from intakes during the year of interest and is calculated from the intake of uranium and from radon and its progeny which are inhaled. Exposure calculations will be consistent with Regulatory Guide 8.30, Section 3 and Regulatory Guide 8.34, Section 3.

5.7.4.1 Calculations for Intake of Uranium

The intake of Uranium is calculated as shown.

$$I_u = b\sum_{i=1}^{n} \frac{X_i \times t_i}{PF}$$

where:

- I_u = Uranium intake, µg, mg, or µCi
- t_i = Time that the worker is exposed to concentrations X_i (Occupancy time in hours)
- X_i = Average concentration of uranium in breathing zone, µg/m^3, mg/m^3, or µCi/m^3, adjusted for sampler efficiencies
- b = Breathing rate, 1.2 m^3/hr
- PF = Respirator protection factor, if applicable
- n = Number of exposure periods during the week or quarter

Uranium will be present at the facility exclusively in relatively soluble forms, i.e., uranyl carbonates (various forms), uranyl trioxide (UO_3), uranyl peroxide (UO_4) and their hydrates. The lixiviant uses oxygen and carbonate to dissolve and mobilize the uranium minerals *in-situ*. Accordingly, the uranium goes into solution as a carbonate. However, when acid is added to the precipitation cell the carbonate complexes are destroyed and disassociate to form uranyl ions. When hydrogen peroxide is added to the precipitation vessel, the uranium is oxidized further to form uranyl peroxide (UO_4*nH_2O). When dried by the vacuum drier at relatively low temperature, a combination of UO_4, UO_3 and their hydrates are expected to result.

Although specific studies and references on solubility (e.g., in vitro solubility studies in simulated lung fluids, historical animal studies, etc.) for UO_4 are sparse (a few specific references are provided below), numerous references appear in the literature over 30+ years regarding general solubility characteristics of industrial uranium compounds (representative list also provided below). The UO_4 and UO_3 products will be ICRP 19 class D or W (most or moderately soluble)(ICRP 1972a, ICRP 1972b), which is equivalent to ICRP Publication 66 and 71 Type F or M (fast or medium dissolution)(ICRP 1994a, ICRP 1995). Additional evidence is presented in ICRP Publication 19 (ICRP 1972a), ICRP 30 (ICRP 1972b), and ICRP 66 (ICRP 1994a). It is also of note that ICRP 54, which assigns Class W to UO_3 indicates "…there is evidence from animal studies that industrial uranium trioxide may behave more like a class D material" (ICRP 1989). The issue of assumed solubility class is critical in

establishing the appropriate DAC for defining air-monitoring parameters for worker airborne exposure control and dose assessment.

The following references provide support for a Class D or W designation for UO_4:

- Regulatory Guide 8.30 (NRC 2002b) calls out UO_4 specifically: "Yellowcake dried at low temperature, which is predominantly composed of ammonium diuranate, or in the new processes uranyl peroxide, both are more soluble in body fluids than yellowcake dried at higher temperature and a relatively large fraction is rapidly transferred to kidney tissues" (see Section 7.5.5. Bioassay for additional discussion on expected solubility of Ross ISR uranium products and associated solubility class).
- Kathren and Burklin states "…the more soluble compounds of uranium such as…. and UO_4 are more quickly absorbed into the blood and therefore exhibit toxic effects in moderate doses" (Kathren and Burklin 2008).
- Results in Metzger et al. (1997) indicated airborne U in wet process area = 97% with dissolution $T_{1/2}$ = 0.3 day; airborne U in drum load out area = 97% with dissolution $T_{1/2}$ = 0.25 day. NRC staff makes reference to this study in context of a "split DAC." However, the results of this study indicated airborne U in both the wet process and drum load out areas of 97% dissolution with half times <0.5 day. These results are clearly indicative of a Task group on Lung Dynamics (TGLD) Class D or ICRP 66 Class F compound. Many of the historical studies on yellowcake solubility present results suggesting "di" (2) or "tri" (3) phased dissolution patterns indicative of mixtures of uranium compounds of differing solubility classes (U_30_8 plus UO_3, e.g.). However, based on reported results, the study referenced here is clearly a single-phase dissolution pattern, i.e. single solubility class, single DAC and it is Class D. (Since the secondary "W" component is reported at only 3%, use of the <10% exclusion rule similar to that allowable for mixtures of radionculides in air at 10 CFR 20.1204(g) would seem to be appropriate).
- ICRP Publication 78 (ICRP 1997) defines UO_3 and UO_4 as "less soluble compounds" with an inhalation Type M classification. While this is the most recent ICRP document that provides a solubility class for UO_3 and UO_4 it is important to note the following statement made in the document: "For the purposes of this report, compounds for which clearance was given as Classes D, W, or Y in the Publication 30 system, are assigned to absorption Types F, M, and S respectively."

- National Radiation Protection Board (NRPB) -W22 (NRPB 2002) provides a summary of solubility information from several United Kingdom and French sources on different uranium compounds. The results indicate both UO_3 and UO_4 should be assigned absorption type F ("equivalent" to ICRP 19/30 solubility class D) per ICRP 71 criteria. This document by the National Radiation Protection Board (NRPB) of the United Kingdom was funded in part by the European commission to examine and question current standards for "monitoring occupational intakes of natural uranium compounds encountered in the nuclear fuel cycle."
- Tairova et al. (2010) presents the results of dissolution studies in simulated lung fluid for uranium products from many Cameco facilities including the Crow Butte and Smith Ranch ISRs. Both ISR products were determined to be very soluble, All ISR samples appear to exhibit solubility characteristics that meet the definition of absorption Type F as defined in ICRP 71 (i.e. the most soluble category). ICRP 71 considers Type F as "generally equivalent" to solubility Class D from the older ICRP 19/30. ICRP 19/30 is the basis of 10 CFR 20 dosimetry (Uranium Derived Air Concentrations {DACs} and Annual Limits on Intake {ALIs} in 10 CFR 20, Appendix B, Table 1).

Based on examples from the literature as cited above, particularly the results of solubility studies for ISR products (Irigaray, Crow Butte and Smith Ranch), modern ISR products are highly soluble and should be considered ICRP 19/30 solubility Class D (equivalent to ICRP 66/71 absorption Type F). This is expected, given the peroxide precipitation process and low temperature drying typical in modern ISRs producing UO_3 and UO_4 that retain water of hydration due to the low temperature of modern vacuum dryers. However, at startup, Strata will consider the Ross ISR product ICRP 19/30 solubility Class W until its molecular composition has been characterized to demonstrate similarities with the other ISR products for which definitive solubility data has been reported (see Metzger et al. 1997 and Tairova et al. 2010)

5.7.4.2 Calculation Intake from Radon Progeny

The intake of radon progeny will be based on representative measurements of the airborne concentrations of radon progeny expressed in working levels (WLs). Time of exposure and/or time studies will be combined with measured airborne concentrations to calculate exposure in working level months (WLM). The radon progeny intake will be calculated as follows:

$$I_r = \frac{1}{170} \sum_{i=1}^{n} \frac{W_i \times t_i}{PF}$$

where:

I_r = Radon progeny intake, working-level months
t_i = Time that the worker is exposed to concentrations W_i (Occupancy time in hours)
W_i = Average number of working level concentrations in or near the worker's breathing zone during the time (t_i)
170 = Number of hours in a working month
PF = Respirator protection factor, if applicable
n = Number of exposure periods during the year

Time of exposure will be the actual time the worker is exposed to radon progeny or the time of exposure determined by Time of Work studies of specific job functions and/or activities. Either situation can apply depending on circumstances.

5.7.4.3 Radiation Dose Calculations

For uranium intakes

$$CEDE_u = (I_u)(5000)/ALI$$

where:

$CEDE_u$ = Committed effective dose equivalent in mrem from uranium
I_u = Uranium intake in µCi
5000 = Radiation dose in mrem from the intake of 1 ALI
ALI = Annual limit of intake for uranium presented in 10 CFR 20, Appendix B, Table 2 (assume class W solubility for U-nat DAC/ALI until operational data verify class D)

For radon and progeny intakes

$$CEDE_r = (I_r)(5000)/ALI$$

where:

CEDEr = Committed effective dose equivalent in mrem from radon and progeny
I_r = Radon intake in working level months
5000 = Radiation dose in mrem from the intake of 1 ALI, 5000 mrem assumed equivalent to 4 WLM/ yr

ALI = Annual limit of intake for radon and radon progeny in working level months

For external exposure

The external whole body radiation dose is measured with TLDs or OSLs (see Section 5.7.2) reported and recorded as mrem/year.

The total radiation dose is the sum of the internal and external radiation doses:

$$TEDE = CEDE_u + CEDE_r + DDE$$

Where:

TEDE	=	Total effective dose equivalent in mrem = total radiation dose
$CEDE_u$	=	Committed effective dose equivalent in mrem from uranium
$CEDE_r$	=	Committed effective dose equivalent in mrem from radon and progeny
DDE	=	The external deep dose equivalent

5.7.4.4 Limits and Control of Intake of Soluble Uranium

Intake of soluble uranium will be limited to 10 mg per week per 10 CFR 20.1201(e). Accordingly, at an assumed specific activity of 0.67 uCi/gram for U-nat (10 CFR 20, Appendix B, footnote 3), the weekly soluble intake limit is 6.7E-03 uCi. Initially, solubility class W will be used to establish the appropriate ALI of 0.8 uCi and DAC of 3.0E-10 uCi/ml for U-nat (10 CFR 20, App B, Table 1). Assuming a 40 hour work week and average breathing rate of 20 liters/min, the average concentration at the soluble weekly intake limit is approximately equal to 50% of the DAC. Compliance to this requirement will be documented by recording of worker airborne exposure in DAC–hours, whenever long lived particulate concentrations in the air are determined to be ≥10% DAC, and an action level of 25% DAC will be established requiring RSO investigation and potential corrective actions. Assignments of positive airborne exposures will be reviewed weekly. Accordingly, any exposures to soluble uranium >5% of the 10 mg/week limit will in fact be recorded (as DAC–hours), and controlling exposure to 25% of DAC ensures both that the 10 mg/week limit is not exceeded and ALARA.

5.7.4.5 Notification of Overexposures

Notification to NRC and reporting of overexposures of workers will be in accordance with 10 CFR 20.2202, 20.2203 and 20.2205.

5.7.4.6 Prenatal Exposure Calculation

The dose to an embryo/fetus during the entire pregnancy from occupational exposure of a declared pregnant woman is limited to 0.5 Rem (500 mrem). Efforts will be made to avoid substantial variation above a uniform monthly exposure rate to a declared pregnant woman during the gestation period. The dose to the embryo/fetus is calculated as the sum of (1) the deep-dose equivalent to the declared pregnant woman and (2) the dose to the embryo/fetus from radionuclides in the embryo/fetus and radionuclides in the declared pregnant woman (10 CFR 20.1208).

Calculations and guidance for prenatal and fetal radiation exposure will be consistent with Regulatory Guide 8.36, Radiation Dose to the Embryo Fetus, and Regulatory Guide 8.13, Instructions Concerning Prenatal Radiation Exposure.

5.7.4.7 Action Levels Tied to Worker Exposure Calculations

Dose calculations to workers will be performed in accordance with the guidance contained in Regulatory Guide 8.30, Section 3 – Intake and Exposure Calculations and Regulatory Guide 8.34, Section 3 - Calculation of CEDE from Inhalation. The primary method of assigning occupational dose to workers will be via the use of the stochastic inhalation ALIs and/or DACs per methods 1 and 2 respectively as described in Regulatory Guide 8.30, Section 3 (ratio of calculated intake to ALI x 5 Rem, or ratio of DAC-hours of exposure to 2000 DAC-hrs/yr x 5 Rem). However, confirmed bioassay results may need to be used in cases where the estimated dose could approach or exceed annual limits and/or it is determined by the RSO that the confirmed bioassay results may provide greater accuracy or be more representative of actual intake than relying exclusively on air sampling results and related calculations. The methods and assumptions described in Regulatory Guide 8.9 (NRC 1993b), NUREG-0874 (NRC 1986b), and/or HPS N 13.22 – 1995 (HPS 1995), will be used to estimate and assign internal dose using bioassay results. Details regarding the bioassay program are presented in the next section.

Action levels will be established for both airborne concentration surveys and for bioassay, the two methods that will be used to assess intake and therefore internal dose. At measured concentrations of 10% of the DAC, the DAC-hrs of exposure will be estimated and assigned to employees. At an internal administrative limit of 25% of the DAC, the RSO will initiate an investigation to determine if corrective actions are necessary. Regarding action levels based on bioassay results, the action levels and recommended actions specified in Tables 1 and 2 of Regulatory Guide 8.22 will be used. It is noted that Table 2 would only be applied in the event of suspicion of a very large intake. The conditions for utilizing Table 2 can be found in Regulatory Guide 8.22. There will not be routine in vivo lung counting performed on workers at the Ross site. See Section 5.7.4.5, Bioassay for justification of use of bioassay action levels and actions per Tables 1 and 2 of Regulatory Guide 8.22.

5.7.5 Bioassay Program

Strata will implement a bioassay (urinalysis) program at the proposed project area. The primary purpose of the program will be to detect uranium intake by employees who are potentially exposed to uranium concentrates during work in yellowcake areas.

This section presents Strata's approach and methods for conduct of a bioassay program at the proposed Ross ISR Project in accordance with NRC Regulatory Guide 8.22 (NRC 1988), NUREG-0874, (NRC 1986b) and other national standards that define acceptable methods for uranium bioassay sampling and analysis in urine (see HPS 1995). The program will have provisions for pre-employment samples to establish baselines, exit samples upon termination, and routine sample collection and analysis to verify adequacy of air sampling and engineering controls, as well as special sampling based on air sampling results, RWP requirements or incidents potentially involving intake.

5.7.5.1 Regulatory and Technical Basis of Bioassay Program

Bioassay (urinalysis) programs at uranium facilities must be appropriate for the specific characteristics of the uranium products to which employees are potentially exposed. Product-specific solubility characteristics can have metabolic implications for bioassay that impact appropriate action levels and

the interpretation and dose implications of results (Cook and Holt 1974, Eidson and Mewhinney 1980, Brown and Blauer 1980, NRC 1988).

The proposed Ross ISR Project will dry yellowcake using vacuum dryers operated at approximately 250°F. This is considered "low - fired yellowcake" since it is produced at temperatures below 400°F (NRC 1988). Accordingly, Strata will implement a bioassay program in accordance with NRC guidance for low fired yellowcake. The uranium concentrates and final product associated with this project will be solubility class D and/or W, as described in NRC models (NRC 1986b). Refer to Section 5.7.4.1 on the expected solubility characteristics of the Ross ISR yellowcake products.

The bioassay program will be conducted in accordance with Regulatory Guide 8.22 and NUREG-0874. NUREG-0874 provides the technical basis for Regulatory Guide 8.22. In fact, frequencies of sampling based on solubility characteristics, associated action levels and recommended actions specified in Tables 1 and 2 of Regulatory Guide 8.22 are taken directly from NUREG-0874 (Section 6 compares action levels and bioassay frequencies of Regulatory Guide 8.22 vs. NUREG-0874). Any proposals for deviations in the Ross ISR bioassay program from the technical positions in Regulatory Guide 8.22 will be justified based on data derived from NUREG-0874 (or appropriate updates – see below).

Although there is some uncertainty at present regarding the applicability of TGLD solubility class D vs. class W for modern yellowcake products, the solubility characteristics of the less soluble class W can be well within the range of dissolution half times defined by NUREG-0874 for "low temperature drying" (see NUREG-0874, Table 1-3). Additionally, data from the technical literature indicates that the UO_3, UO_4 and associated hydrates produced in modern ISRs are "low fired" and therefore relatively soluble (see Section 5.7.4).

These products meet the definition of "low fired yellowcake" as used in Regulatory Guide 8.22 that is defined explicitly in NUREG-0874. This definition is reproduced below:

Low Temperature Drying	**Fractional Composition**	**Dissolution Half Time (days)**	**Inhalation (Solubility) Class**
Short Lived Component	0.61	0.8	D
Medium Lived Component	0.39	39	W

The implication here is that a uranium product can have up to 39% of the "medium component" with dissolution half time up to 39 days (i.e., a significant "Class W" component) and still be considered "low fired yellowcake" and therefore "soluble" for purposes of application of Regulatory Guide 8.22.

Accordingly, the use of NRC Regulatory Guide 8.22, Table 1 to establish action levels and required actions, based on a 30-day routine urinalysis sampling frequency is justified. Additionally, use of Figure 2 of Regulatory Guide 8.22 to estimate uranium concentration in urine following a single acute intake of low-fired yellowcake is similarly appropriate which the Ross yellowcake product almost certainly will be.

It is also of note as the data in the recent literature suggests, given (1) the considerable solubility demonstrated by these peroxide precipitated, low temperature products in vitro and (2) their molecular composition as primarily uranyl peroxides and associated hydrates, that in vivo lung counting as a bioassay technique is unlikely to provide useful information. This conclusion has been previously reported by the NRPB (NRPB 2002).

Specifically regarding bioassay implications for UO_4, the report recommends that no lung monitoring measurement should be used after an acute or chronic inhalation

Accordingly, urinalysis has been used for >30 years in uranium mills and ISRs as an appropriate bioassay method for detecting exposures to low fired, relatively soluble uranium products. A monthly sampling frequency will be used for workers potentially exposed to low fired yellowcake, as recommended in Regulatory Guide 8.22 and NUREG-0874. However, ad hoc samples, in addition to routine monthly samples, may need to be collected in response to potentially elevated airborne concentrations, as may be required by radiation work permits and whenever respiratory protection devices are found to be internally contaminated following use in response to positive nasal and/or mouth swabs, etc. In such cases, it will be assumed that the exposure/intake occurred at a specific time related to the activities causing the potential intake, and Figure 2 of Regulatory Guide 8.22 will be used to establish action levels.

Although Regulatory Guide 8.22 requires routine bioassays for yellowcake workers at suspected inhalation exposures of≥E -10 uCi/L (1/3 the class W DAC), all workers potentially exposed to dry yellowcake will be included in the routine bioassay program that includes monthly urinalysis. The

action levels and associated recommended actions specified in Regulatory Guide 8.22, Table 1 and 2 will be used. It will be our intention to have employees deposit and submit their monthly urine samples following 1 - 2 days off from work, or as practical, to allow for clearance and elimination of uranium that does not become systemic and absorbed by the kidneys. Standard practice for routine urinalysis programs is to assume the exposure/intake occurred on the day or days immediately following the previous sample collection. Accordingly, the action levels and actions of Regulatory Guide 8.22, Table 1 are appropriate based on a monthly sampling frequency.

We note that footnote b of Table 1 of Regulatory Guide 8.22 defers to NUREG-0874, Section 6, for considerations of in vivo lung counting to detect intakes of more insoluble, high fired materials. In vivo lung counting quantifies pulmonary deposition of natural uranium (or other constituents of concern). The NUREG recommends that in vivo capabilities should be available "to guard against the unlikely, but possible, contingency that large intakes of class W or Y transportability might go undetected." In vivo capabilities as follow-up to confirmed urinalysis results in excess of action levels as specified in RG 8.22, Table 1, will be assessed as necessary. However, as discussed above, Ross ISR yellowcake products will exhibit transportability characteristics typical of soluble, low-fired yellowcake (UO_3/UO_4 class D/W) and the contingency alluded to in NUREG-0874 is not applicable to soluble modern ISR yellowcake products.

This perspective is supported by a recent report by the NRPB, funded in part by the European Commission, to examine and question current standards for "monitoring occupational intakes of natural uranium compounds encountered in the nuclear fuel cycle." The report assessed the solubility and metabolic characteristics of a number of uranium compounds including UO_4 (NRPB 2002). Specific recommendations regarding bioassay implications for UO_4 were provided. The report recommends that no lung monitoring measurement should be used after an acute or chronic inhalation, a thirty day urine monitoring interval should be used after chronic inhalation and a one to ninety day urine monitoring period should be used after an acute inhalation.

It must be recognized that there are only a few in vivo lung counting facilities in the U.S. (none within 1,000 miles of northeast Wyoming) with the appropriate equipment, software and experience to measure pulmonary deposition of U-nat at the required detection limits (e.g., 9 nCi total

pulmonary), and these few facilities have been historically used for this purpose in response to suspected "significant" intakes as based on confirmed urinalysis results. Note that at facilities with very insoluble uranium products, e.g., high-fired oxides at fuel fabrication and/or nuclear weapon plants, fecal sampling is also used as "trigger" for in vivo analysis. However, for all but the most insoluble materials, fecal sampling is not necessary, practical nor appropriate.

The basic dosimetry model and guidance in NUREG-0874 will be used to assess the dosimetric impacts of uranium intake as modified by more recent elimination/retention functions (e.g., ICRP 1989 and ICRP 1994b) and guidance in Regulatory Guide 8.9 and 8.34. The dosimetry model used by NUREG-0874 is the historical TGLD –ICRP 19 metabolic model (see NUREG-0874, Figure 1) which assumes:

- 67% of uranium entering blood is excreted via urine in the first day without appreciable uptake to tissues
- kidney uptake is 11% subsequently excreted
- systemic uptake is 22% which is subsequently released to the blood, from which 67% is excreted per day
- 11% absorbed by the kidney, and
- 22% reabsorbed back to tissues.

Some minor updates to this dosimetry model have been published subsequent to NUREG-0874 (e.g., ICRP 1989 and ICRP 1994b).

5.7.5.2 Program Elements

The bioassay program will consist of the following elements:

- Prior to assignment to the facility, all new employees will be required to submit a baseline urinalysis sample. Upon termination, an exit bioassay will also be required from all employees.
- During operations, employees who have the potential for exposure to uranium concentrates and/or dried yellowcake will submit bioassay samples on a monthly basis or more frequently as determined by the project RSO. Samples will be analyzed for uranium content by a contract analytical laboratory meeting performance requirements specified in ANSI/HPS (1987).
- Special samples will be required in response to incidents or other circumstances indicative of a higher potential for intake. These

circumstances would include contamination detected on face, eating/drinking with contaminated hands, respirator determined to be internally contaminated following use, process upsets and/or spills creating the potential for elevated airborne uranium levels, and/or employee exposures to airborne concentrations in excess of 25% DAC (see Section 5.7.3).

- Action levels for urinalysis will be established as specified in NRC Regulatory Guide 8.22, Table 1.
- Elements of the quality assurance requirements for the bioassay program will also be based upon NRC guidelines, e.g., NRC Regulatory Guide 8.22. These include the following:
  - Blank and spiked samples will be submitted to the laboratory with employee samples as part of the Quality Assurance program. The minimum measurement sensitivity for the analytical laboratory will be 5 ug uranium /liter.
  - Each batch of samples submitted to the analytical laboratory will be accompanied by two control blanks and two spiked control samples. These samples will be from persons that have not been occupationally exposed. The two spiked control samples will be spiked to a uranium concentration of 10 to 20 ug/l and 40 to 60 ug/l, respectively. Alternatively, synthetic "spiked" samples may be used. The results of analysis for these samples are required to be within ±30% of the spiked value for actual employee results to be considered valid.
  - The analytical laboratory will spike 10% to 30% of all samples received with known concentrations of uranium and the recovery fraction will be determined. Results will be reported to Strata and analytical data/lab reports will be maintained on-site.

5.7.5.3 Action Levels and Corrective Actions Based on Urinalysis Results

Action levels and associated follow up and corrective actions to be taken in response to elevated uranium results in a uranalysis sample will follow Table 1 of Regulatory Guide 8.22. It is currently assumed that the yellowcake products produced at the proposed Ross ISR Project will be relatively soluble "low fired yellowcake." Accordingly, for any two consecutive samples confirmed to be in excess of 35 ug/liter, or any single specimen confirmed to be in excess of 130 ug/liter, the affected employee will have urine samples collected daily. Follow-up and dose assessment will be performed, and the employee may be

referred for an in vivo lung count to ascertain if he/she may have been exposed to at the discretion of the RSO based on circumstances of exposure, solubility characteristics of Ross ISR yellowcake and R.G. 8.22/NUREG-0874 recommendations.

5.7.5.4 Dose Assessment and Record Keeping

All bioassay results, including negative (i.e., < action level of 15 ug/l) results, will be retained in employee personnel files. For results confirmed in excess of action levels, an internal dose assessment will be performed including information obtained from follow-up actions and investigations including follow up bioassay results, if applicable. Estimates of the CEDE associated with the exposure will be made using guidance and data from NRC (1986b, 1988 and 1992a) as well as ICRP (1972b). Records of all dose assessments will be maintained through license termination in accordance with recommendations in Regulatory Guide 8.7 and in formats necessary to demonstrate compliance with 10 CFR 20.2102, 20.2103, 20.2106, and 20.2110.

5.7.6 Contamination Control Program

Contamination surveys will be conducted at the Ross ISR facility to ensure exposure of workers is maintained ALARA and to minimize potential for release of radioactive material to unrestricted (public access) areas. This section describes policies and methods that will be applied for the conduct of contamination surveys in restricted areas (process areas as well as general plant areas), for assessment of contamination of skin and clothing of workers, and for the release of equipment to unrestricted areas. Contamination assessments will also be conducted in unrestricted areas to ensure program effectiveness. The contamination control program and action levels described in this section are based on the guidelines contained in Regulatory Guide 8.30, (NRC 2002b).

5.7.6.1 Surveys for Surface Contamination in Restricted (Plant) Areas

Surveys will be conducted for surface contamination throughout all plant areas on at least a weekly basis. Surveys will be conducted using hand held instrumentation (e.g., portable rate meters with pancake type GM or large area scintillation detectors) to assess both fixed and removable contamination as well as smear type surveys of surfaces to assess removable contamination as described below. Figure 5.7-6 depicts typical surface contamination sampling

locations at which both hand held instrument surveys and swipe (smear) tests will be performed.

5.7.6.1.1 Process Area

In the IX and elution areas, uranium and progeny concentrations in solutions are low and there is minimal potential for dust, and therefore little expectation of significant surface contamination. In the precipitation circuit, dewatering, and the yellowcake drying and packaging areas, surface contamination can occur because of the concentrated nature of the yellowcake. The International Atomic Energy Agency (IAEA 1976) recommends a limit for alpha contamination on such areas as walls, floors and benches of 10^{-3} $\mu Ci/cm^2$ (220,000 dpm/100 cm^2), which is equivalent to about 2 mg/cm^2 of U-nat. Based on experience, the IAEA has concluded that if surface contamination levels are kept below this value, the contribution to airborne radioactivity from surface contamination would be well below applicable limits.

NRC Regulatory Guide 8.30 considers surface contamination levels in process areas of $<10^{-3}$ $\mu Ci/cm^2$ acceptable to meet the ALARA concept in uranium recovery facilities, since these levels are low enough to ensure little contribution to airborne radioactivity, yet are practical to achieve. This amount of yellowcake surface contamination is typically visible. Accordingly, whenever yellowcake is visible on surfaces outside of intended process vessels, it will be cleaned up as soon as possible.

In yellowcake areas, daily visual inspections will be made by the RSO or RST (see Section 5.3.1) for locating yellowcake contamination on surfaces. Visible yellowcake will be cleaned up promptly, especially where contamination could be disturbed and resuspended from walkways, railings, other high traffic areas, tools and similar surfaces. Objectives will be that trained radiation workers will clean up spills before the yellowcake dries so that resuspension during cleanup will be minimized.

5.7.6.1.2 General Plant and Unrestricted Areas

In areas where work with uranium is not performed, such as eating rooms, change rooms, control rooms and offices, a lower level of surface contamination is possible. These areas will be spot-checked weekly by the RSO or RST for removable surface contamination using filter paper smear tests. The areas will be immediately cleaned by trained radiation workers if surface

contamination levels exceed the values of NRC Regulatory Guide 8.30, Table 2. However, to help maintain doses ALARA any detectable activity above background in these areas will be cleaned and removed as soon as possible.

5.7.6.1.3 Special Surveys During Maintenance Activities

When maintenance is performed on systems and/or components that may result in exposure to and/or contact with internal surfaces of pipes, drain lines, duct work, etc., special contamination surveys will be conducted as specified in SOPs and RWPs. Whenever maintenance work needs to be performed and radiation safety controls specific for the work are not addressed in standing SOPs, an RWP will need to be prepared and approved prior to initiation of the job as described in Section 5.2.2. RWPs will specify additional survey, personal protective equipment, documentation and related requirements to ensure the work can be performed safely and in accordance with ALARA principles.

5.7.6.2 Surveying Skin and Personal Clothing

Strata will designate and post the plant processing area as restricted and limit access to only those individuals who have received appropriate training and/or are escorted by an experienced employee. The restricted area is shown in Figure 5.7-4 indicating the locations of frisking stations. Signage will read, "ANY AREA WITHIN THIS FACILITY MAY CONTAIN RADIOACTIVE MATERIAL." Before leaving the restricted area, all individuals must perform and document an alpha survey. Individuals who have been in the wellfields, byproduct storage area, near the deep well or storage ponds will perform and document an alpha survey immediately upon returning to the plant before entering office areas, before eating, or before leaving the mine site.. The personnel monitoring system will consist of a Ludlum Model 43 series alpha detector (Background ≤3 cpm; efficiency 17-35% rated for Pu-239) coupled to a Model 177 alarming rate meter or equivalent. The alarm will be set by the RSO after determining the efficiency of the system so that contamination above the limit will be detected. A typical alarm setting for this type of equipment is 20 cpm. The goal is no personal contamination above background levels. All workers shall receive training regarding how to properly perform and document alpha surveys. The RSO or RST shall post by each alpha survey meter the written instructions for use of the system and the allowable limits in cpm.

All exit doors without a permanent or temporary scanning station will be designated and labeled as emergency exits only. A temporary scanning station may be set up for a limited period using an alpha detector/meter system approved by the RSO. Unannounced quarterly spot surveys of personnel will be performed by the RSO or RST as recommended by NRC Regulatory Guide 8.30, Section 2.6. The spot surveys will take place in a non-restricted area and will include personnel who work in wellfield and process areas. Spot checks will ensure that employees perform self survey before leaving the restricted areas.

5.7.6.2.1 Response to Identification of Personnel Contamination in Excess of Background

Upon determination by any employee that contamination on his/her person, clothing or other personal effects exceeds background, the affected area(s) will be washed with water and soap and resurveyed. A second washing using modest abrasive methods may be required (soft brush or cloth). If the contamination remains above background, the RSO or RST will be contacted. More aggressive methods, e.g., use of detergents may be used, but abrasion of the skin should be avoided. If the ALARA objective of background cannot be achieved without more extensive and potentially abrasive methods, the methods and release limits specified in Regulatory Guide 8.30, Section 2.6 would be used and all detected activity would be assumed to be removable. If these limits cannot be achieved without abrasion of the skin or other potentially harmful impact to the employee, the RSO may need to refer the employee for medical intervention.

Since any beta–gamma contamination at an ISR (or uranium mill) must be associated with alpha emitting nuclides, no special monitoring or survey for beta–gamma emitters are required. The lack of detectable alpha contamination assures no beta–gamma contamination. For example, the immediate short-lived beta-gamma emitting progeny Pa-234 and Th-234 take approximately 4 months to reach equilibrium and little would be associated with fresh product. The fact that the radionuclide composition of material in an ISR plant would be almost exclusively natural uranium and/or radium 226 is discussed in Section 5.7.3.1.1. The very small amount of in growth of other progeny during the brief life cycle of the material through the plant will be associated with its alpha emitting parents, i.e. the natural uranium isotopes and radium 226, all alpha emitters. These beta – gamma emitting progeny must be associated with their uranium parent; Ra-226 emits alpha particles at >94% yield. However, surveys

performed with a pancake GM probe (e.g., Ludlum Model 44 – 9 as described in Section 5.7.6.1) will detect any significant beta contamination present. Since release limits for beta/gamma emitters are identical to alpha ("uranium and daughter products" at 1000/5000 dpm per 100 cm^2), use of these limits for total activity are protective (e.g., Regulatory Guide 1.86 and FC 83-23 as referenced in Regulatory Guide 8.30 – see discussion in Section 5.7.6.3). Additionally, since the personnel "release objective" is background (or very close to it, e.g., Regulatory Guide 8.30, Section 2.6 limits), the quantification of potential contribution from other the small amounts of other uranium series nuclides is neither dosimetrically significant nor relevant.

Although the objective of personnel decontamination is to achieve background levels in accordance with Regulatory Guides 8.10 (NRC 1977) and 8.31 (NRC 2002a), should background not be achievable without potential damage to the skin of the affected employee, the approach and limits described in Regulatory Guide 8.30, Section 2.6 will be applied. No requirement is specified therein to establish the nuclide mix of the≤1000 dpm/100 cm^2 limit (5000 dpm/100 cm^2 for soles of shoes) nor is there any technical basis for doing so since there is no need at levels approaching background to perform a "dose assessment."

Should contamination be detected in the facial areas and/or a respirator found to be internally contaminated following use, nose and mouth swabs using q-tips or equivalent will be performed. If any contamination is found on the swab, or other evidence suggests that the worker may have received an internal exposure, a bioassay sample will be will be collected as discussed in Section 5.7.5, Bioassay Program. Results of the bioassay analysis will be integrated with the workers exposure assessment as described in Section 5.7.4, Exposure Calculations.

5.7.6.3 Surveys for Release of Equipment to Unrestricted Areas

5.7.6.3.1 Methods and Procedures

The RSO or RST will survey potentially contaminated items before they are released from the facility. Items which cannot be representatively surveyed due to geometry or any other reason may not be released for unrestricted use. A Ludlum Model 2224 counter and Model 44-9 pancake GM probe, or equivalent, will be used for release surveys. Survey equipment shall be calibrated per manufacturer specifications at least annually. Instruments used

to assess surface contamination shall be checked for proper response daily when the plant is operating. Operational tests will be conducted on all survey instruments to ensure they are in working order. All instrument documentation will be maintained on-site.

Equipment and surfaces shall not be painted over or plated for the purpose of meeting release criteria. However, if painting over an area with contamination that cannot reasonably be removed is determined by the RSO to be ALARA, it may be allowed as long as the contamination on the article or surface is characterized and documented. The item or area must be visibly labeled as contaminated. The radioactivity of pipes, drain lines, pumps, or duct work where access can be difficult, will be determined by making measurements at a trap or similar access point. Adequate records will be maintained to ensure that the article or surface is not inadvertently released for unrestricted use.

Strata will ship yellowcake to other facilities for further processing. Prior to the release of packages containing yellowcake from the ISR facility, the packages shall be washed and thoroughly surveyed to ensure compliance with DOT release standards found in 49 CFR 173.433(a) and (b).

Figure 5.7-5 depicts the survey locations for yellowcake product and 11e.(2) byproduct material trucks and associated decontamination stations.

5.7.6.3.2 Contamination Limits to Be Applied for Release of Equipment and Materials From Restricted Areas

It is important and fundamental to recognize the radiological environment of a modern ISR as related to potential radionuclides of concern for which contamination surveys must be performed, and unrestricted release limits established. Studies performed in the late 1970s and early 1980s of radionuclide mobilization from several ISRs and subsequent measurements at operating ISRs, indicate a relatively small portion of the uranium daughter products in the ore body are actually mobilized by the lixiviant. (Brown 2007 and Brown 2008).

The vast majority of secular equilibrium radionuclides remain in the host formation. The majority of the mobilized Ra-226 (approximately 80-90%), which was estimated to be 5-15 percent of the calculated equilibrium radium concentrations in the host formation, followed the calcium chemistry in the ISR process and resulted in radium carbonates/sulfates in the calcite byproduct

waste streams (e.g., as 11e.(2) byproduct material). It is only this material in which Ra-226 concentrations would be expected to be elevated relative to equilibrium with uranium but not without some uranium but only very small amounts of the short-lived daughter products (e.g., Pa 234, Th 234).

Accordingly, the existing, NRC guidance for unrestricted release of equipment and clearance limits for "U-nat, U-235, U-238 and associated decay products" are applicable and appropriate for ISR plants as described in NRC Regulatory Guide 8.30, Section B, which indicates, "The contents of this guide conform with NRC's current licensing practice." We are unaware of any revisions of RG 8.30, subsequently issued NRC regulatory guides and/or NRC rules and regulations that supersede the continued use of RG 8.30 as issued in 2002.

Recommended surface contamination limits are defined in RG 8.30 in its Table 2 entitled *Surface Contamination Levels for Uranium and Daughters on Equipment to be Released for Unrestricted Use, on Clothing and on Non Operating Areas of UR Facilities*. A footnote to RG 8.30 Table 2 indicates the stated contamination levels are taken from Regulatory Guide 1.86, *Termination of Operating Licenses for Nuclear Reactors* and from *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct Source or Special Nuclear Material* (NRC 1987). It is also of interest to note that NRC's Policy and Guidance Directive FC 83-23, (NRC 1983) uses the 1982 version of *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct Source or Special Nuclear Material*, as its ENCLOSURE 2 with the identical radionuclide categories and contamination limits as the 1987 version as well as with Regulatory Guide 1.86.

The 1987 document is essentially identical to the 1982 version referenced in FC 83-23. Accordingly, FC 83-23 and both the 1982 and 1987 versions of *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct Source or Special Nuclear Material* use identical radionuclide categories and quantitative limits, although the 1987 document also specifies dose rate guidance (mrad/hr for beta gamma emitters). Therefore the radionuclide categories, limits, and intended application of FC 83-23, of *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses*

for Byproduct Source or Special Nuclear Material (1982 and 1987), Regulatory Guide 8.30 and Regulatory Guide 1.86, are all consistent.

Although Ra-226 concentrations can be elevated relative to equilibrium with uranium in certain process precipitates, historical application by multiple Federal agencies is clear that the category of "U-nat, U-235, U-238 and associated decay products" (as originally used in Regulatory Guide 1.86 and in NRC 1987), incorporated by reference into RG 8.30, is appropriate for the radiological environment of ISRs. Analysis performed to assess the dosimetric/risk based consequences of the application of these limits by NRC indicate they are protective and provide an appropriate standard of care (see NRC 1997). Accordingly, the applicable recommendations provided in RG 8.30 incorporating the guidance contained in NRC (1987) will be integrated into the contamination assessment and control elements of the Ross ISR radiation protection program. Upon official published revision of the current NRC regulatory guides and standards of practice for release criteria to unrestricted areas applicable to source material facilities, Strata will revise appropriate procedures accordingly.

5.7.6.4 Survey Methods and Instrumentation

The RSO, or individuals properly trained and authorized by the RSO, will perform contamination surveys of plant areas and of items removed from the restricted areas as described above. Guidance for instrument selection and survey methodology is provided in NRC (1992a) and NRC (2000).

Survey equipment will be calibrated annually or at the manufacturer's recommended schedule, whichever is more frequent. Verification of instrument operation will be performed using check sources prior to each use or at least daily. Variations from reference readings greater than 20% will require the instrument to be immediately removed from service and re calibrated.

Surface activity will be measured with an appropriate alpha survey meter, e.g., Ludlum Model 2241 scaler or a Ludlum Model 177 Ratemeter with a Model 43-65 or Model 43-5 alpha scintillation probe, or equivalent. Additionally, a portable pancake GM survey meter (e.g., Ludlum Model 44-9) with a beta/gamma probe and/or a Ludlum Model 3 survey meter with a Ludlum 44 series GM probe or equivalent will also be used for items and in areas potentially contaminated with 11e.(2) byproduct material.

Survey equipment will be calibrated annually or at the manufacturer's recommended frequency, whichever is more frequent. Surface contamination instruments will be checked daily when in use. Alpha survey meters for personnel surveys will be response checked before each use.

5.7.6.5 Routine Daily Inspections and Qualifications of Personnel Performing Contamination Surveys

In general, the RSO or radiation safety staff will perform all of the daily walkthrough inspections of the plant. However, this can prove problematic on weekends because the RSO and radiation safety staff is typically on site during regular working hours. To address weekend inspection, it has been industry practice to train selected individuals (usually the plant operators) to perform the weekend daily walkthrough inspections and to perform contamination surveys. In order to accomplish this, in addition to their training as radiation workers in accordance with guidance in RG 8.31, Section 2.5 *Radiation Safety Training,* these individuals will receive specific training for inspections for radiological safety and in the performance of contamination surveys of areas and for release of material and equipment from the restricted area. This training includes specific procedural requirements contained in Standard Operating Procedures and related documentation of inspections. A checklist will be prepared by the RSO or assistant RSO, which provides a "tool" that the designated worker uses to maintain consistency and continuity of this function. Training is documented in the individual's training records. The records of this training and the results of daily walkthrough inspections have been inspected by NRC at current licensees and found to be acceptable.

5.7.7 Airborne Effluent and Environmental Monitoring Program

5.7.7.1 Operational Environmental Monitoring Program

This section presents the methods that will be used for the proposed Ross ISR Project airborne effluent and environmental monitoring program during operations. The program as described herein presents information on which media will be sampled, radionuclides analyzed, sampling locations and frequency and reporting requirements. This operational environmental monitoring program is a continuation of the pre-operational program described in Section 2.9 and will include similar media, sampling locations, methods and

procedures referenced therein. Groundwater and surface water radiological sampling is discussed in Section 5.7.8.

This operational environmental monitoring program will be conducted in accordance with the recommendations of NRC Regulatory Guides 4.14, (NRC 1980), 4.15 (NRC 1979) and 8.37 (NRC 1993a).

Field sample collection and/or measurement techniques will be conducted in accordance with accepted scientific protocols, e.g., field survey and sampling methods described in NUREG/CR-5849 (NRC 1992c), and/or NUREG-1575 (NRC 2000), as applicable. For sampling and analysis of water, guidance from the EPA-625-/6-74-003a (EPA 1974), will also be used. These field methods were incorporated into the SOPs that were used and are cross-referenced to the applicable program elements in Table 2.9-1 of Section 2.9. These SOPs are contained in Addendum 2.9-A.

The operational environmental monitoring program will include the measurement of naturally occurring radionuclides as described in NRC Regulatory Guide 4.14, Table 2 and as summarized in Table 5.7-1 below.

5.7.7.1.1 Ambient Monitoring

The operational airborne radiation monitoring program will utilize the air particulate sites established for the pre-operational baseline monitoring program, discussed in Section 2.9.2.3. Baseline monitoring and MILDOS-AREA modeling confirmed that the monitoring locations, depicted in Figure 2.9-24, are consistent with Regulatory Guide 8.30. Additionally, the monitoring stations meet the recommendations of Regulatory Guide 4.14, which states that:

> "Air particulate samples should be collected at (1) a minimum of three locations at or near the site boundary, (2) the residence or occupiable structure within 10 kilometers of the site with the highest predicted airborne radionuclide concentration, (3) at least one residence or occupiable structure where predicted doses exceed 5 percent of the standards in 40 CFR Part 190, and (4) a remote location representing background conditions."

Strata will utilize F&J Specialty Products Models DF-40L-BL-AC and LV-1D samplers. Filters will be collected from each air-sampling unit on a weekly basis (or more often as required by dust loading) and analyzed for uranium, Ra-226, Th-230 and Pb-210.

Strata will co-locate radon detectors and thermoluminescent dosimeters (TLDs) with the air particulate samplers as well as other areas of interest including the nearest residences, CPP, lined retention ponds, and wellfields. Strata will utilize Landauer high sensitivity environmental radon Trak-Etch detectors and environmental low level TLDs. The results will be used to assess quarterly radon concentrations and gamma exposure rates at each of the sites.

5.7.7.1.2 Soils and Sediment Monitoring

During operations, Strata will conduct soil and sediment sampling on an annual basis. Soil samples will be collected at the five air particulate stations, while sediment samples will be collected at the surface water monitoring stations and Oshoto Reservoir as discussed in Section 2.7.1. All samples will be collected to a depth of 60 inches for consistency with the baseline soil sampling surveys described in Section 2.6.5. Following the recommendations of Regulatory Guide 4.14, the samples will be analyzed for uranium, Ra-226, Pb-210 and gross alpha. In addition, sediment samples will be analyzed for Th-230. Sediment collected during a runoff event in the pump samplers, installed at the surface water monitoring stations between April and October, will be analyzed for radiological constituents.

5.7.7.1.3 Vegetation, Food, and Fish Monitoring

Monitoring for vegetation, food and fish will be based on the results of the MILDOS-AREA model and final NRC approval of the operational monitoring program. As stated in Regulatory Guide 4.14, "where a significant pathway to man is identified in individual licensing cases, vegetation, food and fish samples should collected." In the event that monitoring is required, sample collection will be conducted similar to the pre-operational baseline monitoring described in Section 2.9 and will meet the recommendations of Regulatory Guide 4.14.

5.7.7.2 Estimation of Radionuclide Effluents and Reporting

As stated in NUREG-1910 "…radon gas is emitted from ISL wellfields and processing facilities during operations and is the only radiological airborne effluent for those facilities that use vacuum dryer technology." The off gas treatment system and associated emission controls for the vacuum dryer system are described in Section 4.1 and 5.7.1 and are ALARA by design relative to potential for particulate emissions and therefore compliant with the

requirements of 10 CFR 40, Appendix A, Criterion 8. NRC recognizes in NUREG-1910 that the emission of radionuclide particulates from this technology is essentially zero.

Regarding estimation of radon emissions, calculations performed in accordance with existing NRC guidance will be used to estimate source terms and calculate potential off site dose to the public. For example, Regulatory Guide 3.59, Section 2.6 provides methods acceptable to NRC for estimating the radon source term during ISR operations. Additionally, NUREG-1569, Appendix D, provides the MILDOS–AREA methodology acceptable to the NRC, which includes expressions for calculating the annual Rn-222 source terms from various aspects of ISR operations, which is then used by MILDOS to calculate offsite public dose and demonstrate compliance with dose limits of 10 CFR 20.1301.

It should be noted that the MILDOS code considers the fact that the radon concentrations in the pregnant lixiviant are orders of magnitude higher than consideration of the equilibrium values from the Ra-226 concentrations in the ore. The applicable input parameters include radon emanating power, size and thickness of ore zone, radon fraction in lixiviant, etc. Furthermore, the growth of radon progeny in the environment between the emission source (plant, wellfield, etc.) and point of interest (location of member of public including application of applicable exposure scenarios - direct inhalation, ingestion, ground shine, etc.) is included in the MILDOS calculation of offsite doses from the ISR radon source term.

Effluent Reports

Semi annual reports will be submitted to the NRC in accordance with 10 CFR 40.65, which will summarize the results of the ongoing environmental monitoring program. These reports will provide an estimate of the quantity of each of the principal radionuclides released to unrestricted areas in liquid and gaseous effluents during the previous 6 months, injection rates, recovery rates, methods and basis for these estimates, and any other data specified by license condition to be included in these reports.

The requirements for providing a semi annual report to NRC at 10 CFR 40.65 of the quantity of each of the principal radionuclides released to unrestricted areas can be met through modeling (e.g., MILDOS-AREA as described above and in Section 5.7.1.1.2 and confirmed by environmental

monitoring as described further described in Section 2.9) since 10 CFR 40.65 does not specifically require "measurement" of effluent at the source. The MILDOS–AREA computer code as previously described will be used, in conjunction with the process parameters applicable to the previous 6 months of facility operation, to estimate the semi annual radon source term. It will be conservatively assumed that the radon progeny are in equilibrium with the radon parent when released in estimating the total quantities of radionuclides emitted during the previous six-month period.

Furthermore, the disperse and diffuse nature of potential radon releases from multiple locations at ISRs makes empirical measurement impractical and unnecessary. Throughout the 30 years of ISR operational experience in the US there is no evidence of public exposure from radon releases in excess of public exposure criteria. For example, NUREG-1910, Table 4.2-2 presents numerous dose estimates to offsite receptors solely from radon releases from ISR facilities, all of which are≤40 mrem/yr. Further, S ection 4.2.11.2.1 states "all doses reported are well within the 10 CFR 20 annual radiation dose limit for the public of 1 mSv (100 mrem/yr)." See also the discussion on effluent reporting at 5.7.1.1.2.

5.7.8 Groundwater/Surface Water Monitoring Programs

During operations at the proposed Ross ISR Project, a detailed water sampling program will be conducted to identify any potential impacts to water resources of the area. The operational water monitoring program includes evaluation of groundwater on a regional basis, groundwater within the permit or licensed area, and surface water on both a regional and site specific basis. A summary of the proposed groundwater and surface water monitoring programs is given in Table 5.7-1.

5.7.8.1 Wellfield Baseline Groundwater and Construction Phase Surface Water Monitoring

A groundwater and surface water monitoring program will be instituted after license approval in order to gather the required data to prepare a comprehensive wellfield package for submittal to WDEQ/LQD and NRC, and to assess the impacts of construction activities for the Ross ISR infrastructure. Submission and approval of a wellfield package will likely be a license/permit condition and will be required in order to commence uranium recovery operations.

The wellfield baseline groundwater monitoring program will evolve significantly from the pre-application submittal baseline program with the construction of additional monitoring wells. This monitoring program will also include the pre-application submittal sampling sites. Domestic, stock, and industrial use wells will be sampled on a quarterly basis. The surface water monitoring stations will be maintained from April through October along with quarterly sampling of the Oshoto Reservoir.

Construction Phase Monitoring – Surface Water

The Oshoto Reservoir will continue to be monitored for water quality on a quarterly basis. Because the focus of the construction-phase surface water monitoring program is to assess construction impacts, additional reservoirs may be sampled near concentrated construction areas. In addition, three surface water monitoring stations, which are located on Deadman Creek upstream of the proposed wellfields (SW-3), on the Little Missouri River upstream of proposed wellfields (SW-2), and downstream of proposed wellfields on the Little Missouri River (SW-1) will be utilized for the life of the project. The stations are equipped with pressure transducers, a data-logging system, and runoff event activated sampling mechanisms. Figure 5.7-7 depicts the proposed wellfield baseline and life of mine reservoir and stream monitoring locations.

Wellfield Baseline Monitoring – Private Wells

Existing private wells within two kilometers of the proposed project area boundary are to be sampled on a quarterly basis with the landowner's consent. Samples will be analyzed for the parameters listed in Table 5.7-2. Baseline data acquisition efforts have indicated that under some circumstances private water wells are not always available for sampling for a number of reasons, including dry or abandoned, non-functioning, winterized, and/or not accessible. In the event that a private well is not sampled during a given quarter, it will be revisited quarterly until such time as a sample can be obtained. Pre-submittal reviews of Wyoming State Engineer's Office records along with anecdotal evidence from landowners are typically the best methods to identify groundwater resources and their level of current use. As with pre-license data, landowners will continue to receive water quality results and be apprised if a significant deviation is apparent in the data. Figure 5.7-8 depicts private wells proposed for wellfield baseline and life of mine monitoring. If, during the course of groundwater model development for specific mine units, impacts to adjacent

groundwater rights are predicted, Strata may request that data logging pressure transducers be installed in the well(s) in order to monitor any potential abstractions during operations.

Wellfield Baseline Monitoring - Wellfield

The wellfield baseline monitoring program is designed to define the primary restoration goals, determine upper control limits for horizontal excursions of lixiviant into the ore zone aquifer outside of the wellfield, and potential vertical excursions into the overlying or underlying water-bearing intervals. This program will be based on information obtained from baseline geologic and hydrologic information, groundwater model simulations, wellfield aquifer testing, and wellfield groundwater baseline sampling, which is described in detail below.

Strata understands that a license is necessary to conduct construction activities as detailed in 10 CFR Part 51. However, in order to facilitate project development, Strata will likely submit an exemption request in order to conduct site exploration to establish the necessary monitoring network to develop additional background information related to the site suitability. In order to support the request to conduct additional pre-construction activities (beyond the limited work to develop the pre-license baseline data), Strata has initiated a geologic evaluation using GemCom Gems of the first mine unit in order to provide more detailed resolution of the key upper and lower confining intervals as well as intervening shales that might play a role in fluid movement through the mineralized portions of the sandstones. The improved geologic resolution will be integrated with the current groundwater model to aid in predicting the capability of the proposed monitoring network to provide strong detection and mitigation efforts. These data would be provided to the NRC and DEQ to support Strata's request along with an analysis to demonstrate the need and small environmental consequences.

In order to determine operational groundwater monitoring objectives, a wellfield data package containing results of aquifer tests, potentiometric surface maps, water quality results, and groundwater modeling predictions will be assembled for LQD and NRC review. Based on the results of the pre-license monitoring efforts, the following program is proposed.

In accordance with LQD Chapter 11, one baseline well cluster will be installed for every four wellfield acres. The proposed Ross ISR Project wellfield

baseline program will include approximately 24 baseline clusters, with a range of 15 to 30 possible clusters based on final wellfield acreage. Each cluster will include three wells targeting: 1) a 10-30 foot thick sandy interval in the Fox Hills Formation (designated as the DM unit) below the ore zone, 2) the ore zone (100-180 foot thick sand interval) completed in the lower Lance/Upper Fox Hills formations (designated as the OZ interval), and 3) a shallow Lance sandstone that is the first water-bearing unit above all mineralized zones (designated as the SM unit). SM and DM interval/unit wells will utilize a fully penetrating completion while the OZ wells will target specific roll front horizons. Beyond the six existing clusters utilized for pre-license monitoring, no additional surficial aquifer (SA) wells are proposed for the wellfield areas, although additional SA monitoring is proposed within the CPP area, as discussed in Section 5.7.8.2. The existing network of SA wells and piezometers monitor both areas upgradient and downgradient from proposed wellfields. Similarly, the proposed DM and SM well locations target areas downgradient from recovery activities. Figure 5.7-9 depicts existing and proposed monitor well clusters.

As in the existing cluster wells, baseline wells in the proposed recovery areas will be equipped with dedicated submersible pumps and sounding tubes for manual water level measurement. Wells will most likely also be equipped with pressure transducers which will relay water levels to the PLC in each module building. The wells which will be used to monitor the ore zone will be recovery wells that will be used during recovery operations. A pressure transducer or sounding tube will not be used on these wells. By using the pressure transducers to monitor aquifer pressure in real time, sample quality can be maximized as the yield can be adjusted to prevent well pump-off. Further, with the instrumentation in place, hydraulic properties can be measured during sampling. Well responses measured during sampling have proven to be highly effective for determining suitable pumping rates prior to aquifer testing. Given the low storage coefficient measured during aquifer test analyses (Addendum 2.7-F), head changes appear to be very good indicators of stress to the ore zone aquifer system. Field parameters to be monitored beyond yield and water level are listed in Table 5.7-2.

In addition to the wellfield area baseline well clusters that are located in proposed recovery areas, perimeter monitor wells are proposed to characterize baseline conditions and to act as sentries for detection of lateral movement of

lixiviants outside of the mineralized areas during operations. A typical layout of the proposed perimeter monitor well rings is shown on Figure 3.1-14. The perimeter monitor wells will fully penetrate the lower Lance and Upper Fox Hills mineralized sandstones of the OZ interval. One of the aquifer tests detailed in the supplemental report on the pre-license aquifer pump tests (Addendum 2.7-F) utilized a fully penetrating well as an observation well (12-18OZ) and a partially penetrating well with a more discreet, production-type completion as the pump well (OW1B57-1). Results indicate that the response time in the fully penetrating well was very similar to the response time when the fully penetrating well was pumped and the partially penetrating well was monitored during another aquifer test conducted at the same cluster. The nearly instant response in the fully penetrating well indicates that even with vertical geological heterogeneity, local wellfield imbalances would be observed as a head change in the perimeter monitor well. Figure 5.7-10 depicts a typical relationship between a perimeter monitor well and the adjacent wellfield. Like wellfield baseline wells, perimeter monitor wells would likely be equipped with dedicated submersible pumps, data logging pressure transducers and a sounding tube for manual water level measurement. Given the data collected during pre-submittal baseline efforts, water level deviations within monitoring wells are good indicators of stress within the aquifer system.

The regional groundwater model developed for the proposed Ross ISR Project indicates that a spacing of 400 to 600 feet between the production wellfields and perimeter monitor well ring is sufficient to detect an excursion. Spacing between the monitor wells is also proposed to be 400 to 600 feet. Addendum 2.7-H details the results of the groundwater model simulations during operation and during an excursion. Briefly, simulations of excursions from a wellfield were modeled, points recording the modeled heads were located at 200 feet, 400 feet, and 600 feet from the active wellfield in both the downgradient and upgradient directions. The local wellfield imbalance was simulated for 30 days and resulted in nearly an 18 and 14-foot increase in water level 400 feet upgradient and downgradient from the wellfield, respectively. Similarly, nearly a 10 and 12-foot head change was apparent 600 feet both upgradient and downgradient from the wellfield respectively. Results of the simulation run for the upgradient and downgradient scenarios are presented on Figures 5.7-11 and 5.7-12. *Most importantly, the simulations indicate that a head change or hydraulic anomaly would rapidly become*

apparent in the perimeter wells, well before any geochemical influences would be detected.

The groundwater model developed in support of the wellfield data packages will be utilized to confirm or adjust the spacing and offset distances of the perimeter monitor well ring. Strata proposes to present the wellfield package groundwater model results as a work plan, to both the NRC and LQD prior to the monitor well installation. The wellfield data package will include model simulations demonstrating that the monitoring networks are sufficient to detect a hydraulic anomaly resulting from a local wellfield imbalance. In addition, initial model simulations clearly indicate the effects of an unbalanced wellfield. Thus, upon submittal the wellfield package will be hydraulically balanced.

Aquifer tests will be conducted following installation of the perimeter, deep, shallow and ore zone wellfield baseline wells. The tests will serve three purposes: one, to demonstrate that the overlying and underlying aquifers are hydrologically isolated from the mineralized sandstone; two, that the perimeter monitor wells are in communication with the ore zone and spaced to effectively detect an operational wellfield imbalance, and; three, to further improve and calibrate the groundwater model developed in support of the wellfield package. Wellfield aquifer testing will only be completed after nearby exploration and delineation boreholes which are within the area of influence (AOI) of the tests, have been abandoned with cement from bottom to top, as well as after MITs have been completed on the all existing wells that will be used during operations.

Water quality data acquisition during wellfield baseline characterization will include at least four samples, with a minimum of 2 weeks between sampling events, for all perimeter, deep monitor (DM), OZ baseline wells and shallow monitoring (SM) wells. In addition, the SA well network will continue to be sampled on a quarterly basis through the wellfield data acquisition phase and be available for more frequent monitoring in the event of an upset condition, such as a significant spill or pipeline leak. The first and second sample events will include analyses for all WDEQ/LQD Guideline 8, Appendix 1, parts III and IV (WDEQ/LQD 2005), and NRC NUREG-1569, Table 2.7.3-1 parameters as shown in Table 5.7-2. The third and fourth sampling events may be analyzed for a reduced list of parameters as defined by the results of the previous sample events and pre-permit baseline efforts. Results from the

samples are averaged arithmetically to obtain an average baseline value, as well as a maximum value for determination of upper control limits (UCLs) for excursion detection.

5.7.8.2 Operational Ground and Surface Water Monitoring

Operational Monitoring – Surface Water

Operational surface water monitoring will focus on those surface water features that could be impacted either due to a spill or pipeline leak or from surface discharges. Given the depths of the ISR operations (over 400 feet below ground level) and lack of hydrologic connection between the OZ interval and surface water features in the area, no direct impacts to surface water (quantity-of quality-wise) are anticipated during normal ISR operation. Operational sampling of surface water will be performed at the same sites that pre-operational surface water monitoring was conducted. A detailed description of the pre-operational surface water monitoring program is included in Section 2.7.1.7. Operational monitoring sites will consist of the three surface water monitoring stations (SW-1, SW-2 and SW-3), which will be operated from April through October and will measure flow and collect samples during runoff events, and the 11 reservoirs within or near the proposed project area. Sampling at reservoir sites will be conducted on a quarterly basis. Surface water samples will be analyzed for dissolved and suspended uranium, Th-230, Ra-226, Po-210, Pb-210, gross alpha, and gross beta unless sufficient cause can be demonstrated to measure a parameter less frequently. Figure 5.7-7 depicts locations of the operational surface water monitoring sites. If a leak at the surface or from a pipeline occurs, inspections and reporting as stated in Section 7.5.1.6 will be conducted, and an investigation of the impact on the surface hydrologic features will occur.

Strata will permit all discharges to surface water through the WDEQ WYPDES program. Monitoring will be completed in accordance with permit requirements and samples will be analyzed for constituents identified in the permit. WYPDES permits will include a temporary WYPDES permit for well testing and construction water, one or more stormwater WYPDES permits, and, potentially, a WYPDES permit to discharge permeate during operation and aquifer restoration.

Operational Monitoring – CPP Area

The surficial aquifer, also known as the SA monitoring unit, is monitored in the wellfield areas by the SA cluster wells, and in the CPP area by the SA monitoring wells and piezometers. Monitoring efforts on the SA unit will be to demonstrate water level contrasts across the containment barrier wall (CBW) and measure and record the extent of surficial contamination from potential spills resulting from piping, tank, and pond failures as well as other accidents relating to the handling of the various solutions used in the CPP. Because of a relatively higher potential for contamination of the SA unit in the CPP area, the majority of the SA monitoring wells and piezometers will be located in this immediate area. Figure 5.7-13 depicts the locations of the proposed SA wells in the CPP area.

As discussed in Section 3.1.8.2, due to a relatively high groundwater table in the CPP area, a continuous containment barrier wall (CBW) will be constructed around the perimeter of the CPP. Monitoring wells will be completed in the SA unit to monitor water levels both inside and outside the CBW. It will be necessary to dewater the area within the CBW prior to construction, and a groundwater control system will be used to manage groundwater levels within the CBW over the life of the project.

The SA unit monitoring wells depicted on Figure 5.7-13 will monitor both the hydraulic gradient and groundwater quality across the CBW. Water level differentials within and adjacent to the CBW will serve to demonstrate the ability of the CBW to isolate the CPP area from the background groundwater flow regime of the SA unit, and to indicate adjustments that may be necessary in the dewatering system. In the event of a large spill at the CPP, samples collected at the monitor wells outside of the CBW will allow Strata to determine if contaminated groundwater was contained within the CBW.

In the vicinity of the CPP, groundwater levels within the SA unit monitoring wells will be monitored continuously with dedicated data logging pressure transducers (note: wellfield baseline SA wells will be monitored manually). In conjunction with the monitoring wells, the dewatering french drain/collector well will also be monitored. Samples will be collected monthly at three down-gradient monitoring wells and at least one up-gradient monitor well. Analytes are presented in Table 5.7-2.

Operational Monitoring – Private Wells

Stock, domestic, and industrial use wells within a 2-km radius of the proposed project boundary will be monitored quarterly through the operational life of the facility. Results will be tabulated and provided to the NRC, LQD and well owners on an annual basis. Drawdown simulation with the regional groundwater model indicates that only a small percentage of the existing private wells may be impacted by ISR operations. With the well owner's cooperation, Strata may elect to geophysical log and instrument the wells where impacts may occur with recording pressure transducers to aid in the monitoring program. These results would also be provided to the WDEQ and NRC. Figure 5.7-8 depicts the private wells proposed for life-of-mine monitoring.

Operational Monitoring - Wellfield

Operational monitoring consists of sampling the perimeter, DM and SM monitor wells on a biweekly basis and analyzing each sample for the excursion indicators. License SUA-1534, Condition 11.2, and LQD Chapter 11 currently require that monitor wells be sampled no more than 14 days apart except in the event of certain situations. These situations include inclement weather, mechanical failure, holiday scheduling, or other factors that may result in placing an employee at risk or potentially damaging the surrounding environment. In these situations the cause and the duration of any delays will be documented. No event will delay scheduled sampling for more than 5 days.

In addition to sampling for excursion indicators, Strata may utilize recording pressure transducers to obtain continuous water level measurements. The water levels would either be downloaded from the data logging equipment at each well, or transmitted via a telemetry or similar communication system to the CPP control room. Water levels in the adjacent aquifers would be integrated with the reservoir/mining software platform. The real-time integration of hydraulic, or hydrostatic pressure conditions, particularly in the perimeter monitor wells, would allow for an early warning (prior to excursion) of an impending lateral migration due to local wellfield imbalance. The software platform would include real time flows from the injection and recovery wells such that an operator could readily identify why and where the local imbalance was occurring. These data would lead to instant recommendations on imbalance rectification through decreased injection rates, increased production rates, or potentially changing an injector into a recovery

well with the addition of submersible pump and removal of the injection stinger. Based on the results of continuous water level monitoring in the overlying and underlying aquifers, a migration of lixiviants would first be indicated by an upward deviation in the water levels. Again, this abstraction would be apparent quickly as there are little stresses on these systems and hence mitigated in a timely manner. It is anticipated that through strong drilling controls (i.e., preventing over-penetration into the DM interval), thorough cementing programs, mechanical integrity testing, and cementing/plugging of all exploration and delineation holes, that vertical migration of fluids will not occur. Unlike the ore zone aquifer, little instrumentation in the form of wells is available in the SM and DM units to mitigate a vertical migration. Mitigation instead becomes an investigation into well integrity, geologic integrity and, more often than not, the presence of unknown boreholes or poorly abandoned wells.

The following procedure will be utilized for detecting and controlling excursions at the proposed Ross ISR Project:

1) During recovery or restoration phase, routine monitoring is proposed every 10 to 14 days for each perimeter, deep and shallow monitor well within the active wellfield. Monitoring is proposed to consist of measurement of a manual water level to maintain accurate pressure transducer readings, downloading from the pressure transducer/datalogging system, and sampling of the well for excursion indicator parameters (optimally utilizing a low-flow system).

2) Following routine monitoring, water level data will be entered into the reservoir engineering/GW model platform for verification of anomalous conditions. Modeling indicates that an increase in the water level during periods of local wellfield imbalance will occur almost instantaneously. Water samples will be analyzed by the lab for indicator parameters. If two or more parameters exceed the UCL's set forth in the wellfield permit, then the well must be re-sampled in 24 hours.

3) If the resample and subsequent water level data collected by the pressure transducer confirm initial suspicion, then the well is placed on excursion status with verbal notification to the LQD and NRC within 24 hours.

4) Based on reservoir engineering/GW model analysis, a recovery plan will be implemented to mitigate the excursion. Typically, an excursion is the result of a recovery well going off-line, over-injection or a combination of the two. Hence, mitigation will likely

entail repair of the recovery well and turning down the injection rate at the wells proximal to the excursion well.

5) Follow-up sampling for water quality is proposed to occur on a weekly basis with additional information derived from the dedicated pressure transducer/datalogging system on hydraulic conditions following implementation of mitigation measures. If after 30 days, UCL's are still in exceedance, the well on excursion status will be sampled for a full Guideline 8 parameter suite.

Impacts to financial assurance estimates from a lateral excursion will be significantly aided through the use of a groundwater model or aquifer management software platform. The regional groundwater model utilized for pre-license characterization appears to accurately predict where an excursion might take place and more importantly, the magnitude of the excursion in terms of volume of aquifer impacted. Based on the pore volume impacted, the financial assurance estimates would be increased and included within both the quarterly NRC reporting as well as in the annual reports for NRC and WDEQ/LQD.

Financial assurance estimates in the unlikely event of a vertical excursion would again utilize a modeling platform along with aquifer specific hydraulic and physical characteristics to determine the magnitude of the incident. In situ measurements of hydraulic conductivity will be provided for both the SM and DM systems to aid in surety updates.

Excursion Monitoring and Upper Control Limits

After baseline water quality is established for the monitor wells for a particular production unit, UCLs are set for chemical constituents that would be indicative of a migration of lixiviant from the wellfield and provide an "early warning" of a potential excursion. Consistent with the ISR-GEIS, the constituents proposed for indicators of lixiviant migration and for which UCLs are set are chloride, conductivity, and total alkalinity. Chloride was chosen due to its low natural levels in the native groundwater and because chloride is introduced into the lixiviant from the IX process (uranium is exchanged for chloride on the IX resin). Chloride is also a very mobile constituent in groundwater and will show up very quickly in the case of a lixiviant migration to a monitor well. Conductivity was chosen because it is an excellent general indicator of overall groundwater quality. Total alkalinity concentrations should be affected during an excursion as bicarbonate is the major constituent added

to the lixiviant during recovery operations. Water levels are obtained and recorded prior to each well sampling. Rising water levels are indicative of an imbalance in the wellfield, which could result in an excursion. Although water levels are not proposed as an official excursion indicator, modeling indicates that such changes may provide a much earlier indication of an excursion than a geochemical anomaly measured in a monitoring well.

WDEQ/LQD Guideline 4 (WDEQ/LQD 1994) indicates UCLs are set at 20% above the maximum baseline concentration of the excursion indicator. The UCL will be less than the lowest concentration that typically occurs in the lixiviant while the wellfield is in operation and greater than the baseline concentration for its respective excursion indicator. For excursion indicators with a low baseline average, the UCL may be determined by adding 15 mg/L to the baseline average if the resulting value is greater than the baseline mean plus 5 standard deviations for the indicator.

Chloride, total alkalinity and conductivity appear to be strong indicators of dissolution during ISR operations. Therefore, these constituents as UCLs are proposed for excursion determination for the mineralized sandstones of the OZ aquifer as well as the shallow sandstones of the SM system. However, elevated natural/background chloride concentrations in the DM aquifer negate the use of chloride as downward movement of lixiviants into the DM aquifer would likely result in a decrease in chloride concentrations. In lieu of chloride, Strata proposes that sulfate will be used along with conductivity and alkalinity as a metric for determining that a vertical excursion downward has occurred. Water quality testing indicates concentrations of sulfate in the DM aquifer are typically less than 150 mg/L while ambient sulfate levels in the OZ aquifer range between 300 mg/L to more than 900 mg/L and are anticipated to increase during ISR operations by at least 150 mg/L. In addition, Section 6.1.6 compares water quality analogs at various operating ISR facilities, and increases of sulfate commonly occur during operations, which should be beneficial to detecting a downward vertical movement at the proposed Ross ISR Project. Upper control limits for the excursion indicator parameters have not been calculated at this time due to the limited number of wells installed during the regional baseline program. Following completion of the necessary monitoring well network in order to develop the Mine Unit 1 wellfield package, sufficient data on the ore zone aquifer, DM, SM and laterally adjacent aquifers

will be available to calculate UCLs. The Mine Unit 1 monitoring well network will not be installed without both NRC and LQD approval.

As discussed previously, the proposed Ross ISR Project may use an early warning system of pressure transducers to detect hydraulic anomalies in the form of hydrostatic pressure increases (beyond those caused by changes in barometric pressure) in the perimeter monitoring wells. Due to the high confining pressures in the OZ unit (Section 2.7.3.2), pressure transients propagate very quickly through the aquifer. Additionally, modeling indicates that local wellfield imbalances would be detected in perimeter monitoring wells spaced 400 to 600 feet from the wellfield as well as offset from one another by 400 to 600 feet within days, considerably before any geochemical evolution would be noted. Not only would the detection of a hydraulic anomaly potentially prevent a chemical excursion, the operational control of wellfields with pressure head data, both inside the wellfields as well as adjacent to the wellfields, would result in improvements in recovery efficiency, particularly in maintaining wellfield balance and minimizing interference. Strata may utilize internal ore zone trend wells to monitor wellfield head data and to provide a comprehensive hydraulic assessment to further aid recovery efficiency. Beyond the public perception and regulatory challenges posed by excursions, they are a significant distraction to the effectiveness of solution extraction and therefore an economic concern. The enriched lixiviants only produce uranium when they are focused within an ore body, hence there is reagent waste, electrical costs and manpower considerations any time recovery fluids migrate beyond the mineralized target.

Excursion Verification and Corrective Action

Through the use of continuous water level measurements, operational data capture and integration with a suitable reservoir engineering software platform, Strata plans to minimize the potential for local wellfield imbalances to impact adjacent non-exempt aquifers. However, in the unlikely event that water level data indicate this potential the following procedures would be initiated in accordance with NRC and LQD regulations.

During routine sampling, if two of the three UCL values for excursion indicators are exceeded in a monitor well, or if one UCL value is exceeded by 20%, the well will be re-sampled within 48 hours and analyzed for the excursion indicators. If the second sample does not exceed the UCLs, a third

sample will be taken within 48 hours. If neither the second nor third sample results exceeded the UCLs, the first analysis is considered in error.

If the second or third sample verifies an exceedance, the well in question will be placed on excursion status. Upon verification of the excursion, the NRC Project Manager will be notified by telephone or email within 24 hours and notified in writing within 7 days. A written report describing the excursion event, corrective actions, and corrective action results will be submitted to the NRC within 60 days of the excursion confirmation. If wells are still on excursion status when the report is submitted, the report will also contain a schedule for submittal of future reports describing the excursion event, corrective actions taken, and results obtained. In the case of a vertical excursion to an overlying or underlying aquifer, the report will contain a projected date when characterization of the extent of the vertical excursion would be completed.

If an excursion is verified, the following methods of corrective action will be instituted depending upon the circumstances:

- A preliminary investigation is completed to determine the probable cause;
- Adjustment of production and/or injection rates in the vicinity of the monitor well to increase the net over-recovery, thus inducing a hydraulic gradient toward the production zone; and
- Pumping of individual wells to enhance solution recovery.
- Injection into the wellfield area adjacent to the monitor well may be suspended. Recovery operations would continue, thus increasing the overall bleed rate and the recovery of wellfield solutions.

In addition to the above corrective actions, the monitor well on excursion status would be sampled weekly. An excursion would be considered concluded when the concentrations of excursion indicators do not exceed the criteria defining an excursion for three consecutive samples.

If an excursion is not corrected within 60 days of confirmation, injection of lixiviant into the wellfield will be terminated until the excursion is controlled, or the reclamation surety will be increased an amount that is agreeable to the NRC, which would cover the expected full cost of correcting and cleaning up the excursion. The surety increase would remain in force until the excursion is

controlled. The written 60-day report would explain and justify the course of corrective action that be followed.

5.7.8.3 Lined Retention Pond Leak Detection Monitoring

The lined retention ponds will be equipped with leak detection system consisting of perforated subsurface pipes along the pond floor. Perforated pipes will drain to riser standpipes that can be accessed from the pond embankments. The presence and depth of water in the riser pipes will be checked as part of the daily inspections conducted for the ponds. These inspections are detailed in Section 5.3.2. Condensate will often be present in the leak detection systems; therefore, ponds will only be sampled if more than 6 inches of water is detected in the piping. The fluid from the riser pipe will be tested and compared to the water quality of the contents of the ponds. Strata will use common constituents such as conductivity and chloride to determine if the leakage is from the pond. If the sample is verified, the NRC will be notified within 48 hours and the contents of the pond will be transferred to the other two pond cells or into the deep disposal well. The liner will then be thoroughly inspected and leak tested to determine the source of the leak. After the leak has been repaired and the pond is back in operation, any fluid detected in the riser pipes will be sampled at least once every 7 days for at least 14 days. NRC will be provided a written report that explains the details of the leak investigation and mitigation, and the analytical results from the samples. This leak detection and mitigation report will be sent to NRC within 30 days of the initial notification of the leak.

Water levels in the CPP area SA monitoring network and collector well would also be monitored to determine if any of the leaked substance reached the isolated environment underlying the facility. Capture of any leaked fluids would be conducted through the french drain/collector well system and dewatering well points.

5.7.9 Quality Assurance Program

Strata will establish a quality assurance (QA) program at the facility consistent with the recommendations contained in NRC Regulatory Guide 4.14 Sections 3 and 6 and Regulatory Guide 4.15 (NRC 1979). The purpose of the program is to ensure that all radiological and non-radiological measurements that support the environmental monitoring program are reasonable, valid and

of a defined quality. These programs are needed to identify deficiencies in the sampling and measurement processes and report them to those responsible for these operations so that licensees may take corrective action, and to obtain some measure of confidence in the results of the monitoring programs to assure the regulatory agencies and the public that the results are valid. Strata will provide a quality assurance program to the NRC during the license application review period.

The QA program will contain the following:

- Formal delineation of organization structure and management responsibilities, responsibility for both review/approval of written procedures and monitoring data/reports is provided;
- Minimum qualifications and training programs for individuals performing radiological monitoring and those individuals associated with the QA program;
- Written procedures for QA activities, these procedures include activities involving sample analysis, calibration of instrumentation, calculation techniques, data evaluation, and data reporting;
- Quality control (QC) in the laboratory, procedures cover statistical data evaluation, instrument calibration, duplicate sample programs and spike sample programs, outside laboratory QA/QC programs are included; and
- Provisions for periodic management audits to verify that the QA program is effectively implemented, to verify compliance with applicable rules, regulations, and license requirements, and to protect employees by maintaining effluent releases and exposures ALARA.
- Quality assurance and control procedures to ensure validity of measurements made as part of the worker radiation protection program to include considerations of:
  - External Radiation Exposure Monitoring Program
  - Airborne Radiation Monitoring Program
  - Bioassay Program
  - Contamination Control Program

QA procedures as described in RG 4.14, Sections 5 through 7, will be defined to ensure the quality of samples, that lower limits of detection consistent with requirements have been established, for sample and

measurement precision and accuracy, and for recording and reporting of results.

QA recommendations contained in RG 4.14 and RG 8.22 will be incorporated in the environmental monitoring and bioassay programs, respectively. In general, the QC requirements for a specific activity will be incorporated into the SOP for that activity.

The QA program will be audited periodically. The audits will be conducted by individuals qualified in radiochemistry and monitoring techniques. However, the auditors will not have direct responsibilities in the areas being audited. An example of an appropriate auditor is an outside consultant. The results of the audits will be documented and provided to the NRC and made available to members of management with authority to enact any changes needed (i.e., RSO, Mine Manager, etc.). Authorities of personnel responsible for implementation of the QA program and how the QA function is integrated with Radiation Safety are presented in Section 5.1. Additional detail on the QA program, including the management control, audit and inspection programs are provided in Section 5.2 and 5.3. Minimum qualifications of personnel are defined in Section 5.4.

Table 5.7-1. Summary of the Major Elements of the Operational Environmental Monitoring Program

Program Element	Location	Radionuclides Analyzed	Sampling Frequency	Number of Sampling Locations
Groundwater – Monitor Wells	Up-gradient and down-gradient from CPP	Dissolved uranium, Ra-226, Th-230, PB-210, Po-210, gross alpha, gross beta	Monthly first year, quarterly thereafter	3 or more down-gradient; at least up-gradient control sample
Groundwater – Existing Water Supply Wells	Private wells within 3.3 km (2 mi) of project area similar to pre-operational baseline monitoring (Section 2.7.3 and Figure 2.7-33)	Dissolved and suspended uranium, Ra-226, Th-230, Pb-210, Po-210, gross alpha, gross beta	Quarterly	29
Surface Water	Surface waters passing through project area and reservoirs subject to runoff similar to pre-operational baseline monitoring (Section 2.7.3 and Figure 2.7-7)	Dissolved and suspended uranium, Ra-226, Th-230, Pb-210, Po-210, gross alpha, gross beta	Quarterly (as available)	3 surface water monitoring stations and 11 reservoirs within project area
Particulates in Air[1]	Locations with the highest predicted concentrations, nearest residences and control location similar to pre-operational baseline monitoring (Section 2.9 and Figure 2.9-24)	Total uranium, Th-230, Ra-226, Pb-210	Continuous-Composites of weekly filters analyzed quarterly	5 or more
Radon in Air	Particulate in air locations and other areas of interest similar to pre-operational baseline monitoring (Section 2.9, Figure 2.9-26)	Rn-222	Continuous via Track-Etch units – quarterly exchange and analysis of units	5 or more
Soil	Particulate in air locations and other locations with the highest predicted concentrations similar to pre-operational baseline monitoring (Section 2.9, Figure 2.9-27)	Total uranium, Ra-226, Pb -210, gross alpha	Annually	5 or more
Sediment	Surface waters passing through project area and reservoirs subject to runoff similar to pre-operational baseline monitoring (Section 2.7.3 and Figure 2.7-7)	Total uranium, Ra-226, Pb -210, gross alpha	Annually (as available)	3 surface water monitoring stations and 11 reservoirs within project area
Direct Radiation	Particulate in air locations and other areas of interest similar to pre-operational baseline monitoring (Section 2.9, Figure 2.9-26)	Continuous via TLD	Quarterly	5 or more

Table 5.7-1. Summary of the Major Elements of the Operational Environmental Monitoring Program (Continued)

Program Element	Location	Radionuclides Analyzed	Sampling Frequency	Number of Sampling Locations
Vegetation (2)	Animal grazing areas and other locations with the highest predicted concentrations similar to pre-operational baseline monitoring (Section 2.9, Figure 2.9-26)	Ra-226 and Pb-210	Three times during grazing season	Grazing vegetation representing 3 different sectors that have the highest predicted concentrations of radionuclides
Animal Tissue	Livestock (cattle) raised within 3 km of the site and fish from Oshoto Reservoir similar to pre-operational baseline monitoring (Section 2.9, Figure 2.9-26)	Ra-226 and Pb-210	Once during site decommissioning and prior to license termination	3 samples of beef 1 fish sample (composite to meet laboratory MDL)

(1) Location of air particulate samplers used during the preoperational baseline monitoring will be re-evaluated for operational monitoring based on results of the pre-operational meteorological monitoring program (Section 2.5) and the results of the MILDOS-AREA analysis (Section 7.3) to insure at least 3 locations are selected representing 3 different sectors that have the highest predicted concentrations of radionuclides

(2) In accordance with the provisions of NRC Regulatory Guide 4.14, Footnote (o) to Table 2: "*vegetation and forage sampling need be carried out only if dose calculations indicate that the ingestion pathway from grazing animals is a potentially significant exposure pathway...*" defined as a pathway which would expose an individual to a dose in excess of 5% of the applicable radiation protection standard. This pathway was evaluated by MILDOS-AREA and is discussed further in Section 7.3.

Table 5.7-2. Wellfield Baseline Aqueous Sampling Parameter List

Parameter	Units
Field	
Field conductivity	umhos/cm
Field pH	s.u.
Field turbidity	NTUs
Depth to water	Ft
Temperature	Deg C
ORP	Millivolts
Dissolved oxygen	mg/L
General	
Alkalinity (as CaCO3)	mg/L
Ammonia	mg/L
Fluoride	mg/L
Laboratory conductivity	umhos/cm
Laboratory pH	s.u.
Nitrate/nitrite	mg/L
Total dissolved solids	mg/L
Major Ions	
Calcium	mg/L
Magnesium	mg/L
Potassium	mg/L
Sodium	mg/L
Bicarbonate	mg/L
Carbonate	mg/L
Chloride	mg/L
Sulfate	mg/L
Metals	
Aluminum, dissolved	mg/L
Arsenic, dissolved	mg/L
Barium, dissolved	mg/L
Boron, dissolved	mg/L
Cadmium, dissolved	mg/L
Chromium, dissolved	mg/L
Copper, dissolved	mg/L
Iron, dissolved	mg/L
Iron, total	mg/L
Lead, dissolved	mg/L
Manganese, total	mg/L
Mercury	mg/L
Molybdenum, dissolved	mg/L
Nickel, dissolved	mg/L
Selenium, dissolved	mg/L
Silver, dissolved	mg/L
Uranium, dissolved	mg/L
Uranium, suspended	mg/L
Vanadium, dissolved	mg/L
Zinc, dissolved	mg/L
Radiological	
Lead 210, dissolved	pCi/L
Lead 210, suspended	pCi/L
Polonium 210, dissolved	pCi/L
Polonium 210, suspended	pCi/L
Ra-226, dissolved	pCi/L
Ra-226, suspended	pCi/L
Ra-228, dissolved	pCi/L
Radon-222	pCi/L
Th-230, dissolved	pCi/L
Th-230, suspended	pCi/L
Gross alpha	pCi/L
Gross beta	pCi/L

Source: WDEQ (1994), NRC (2003)

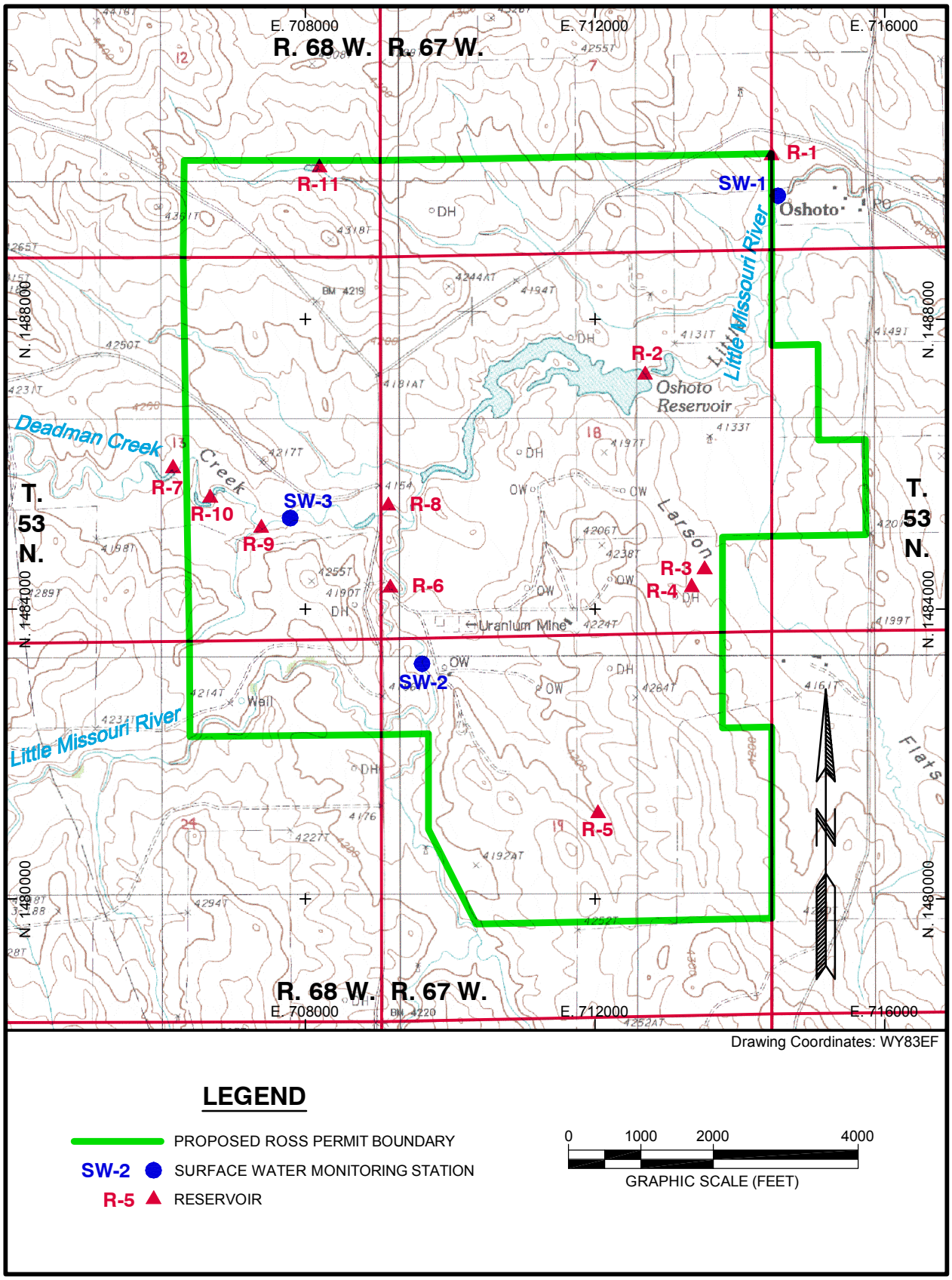

Figure 5.7-7. Proposed Life of Mine Reservoir and Stream Monitoring Locations

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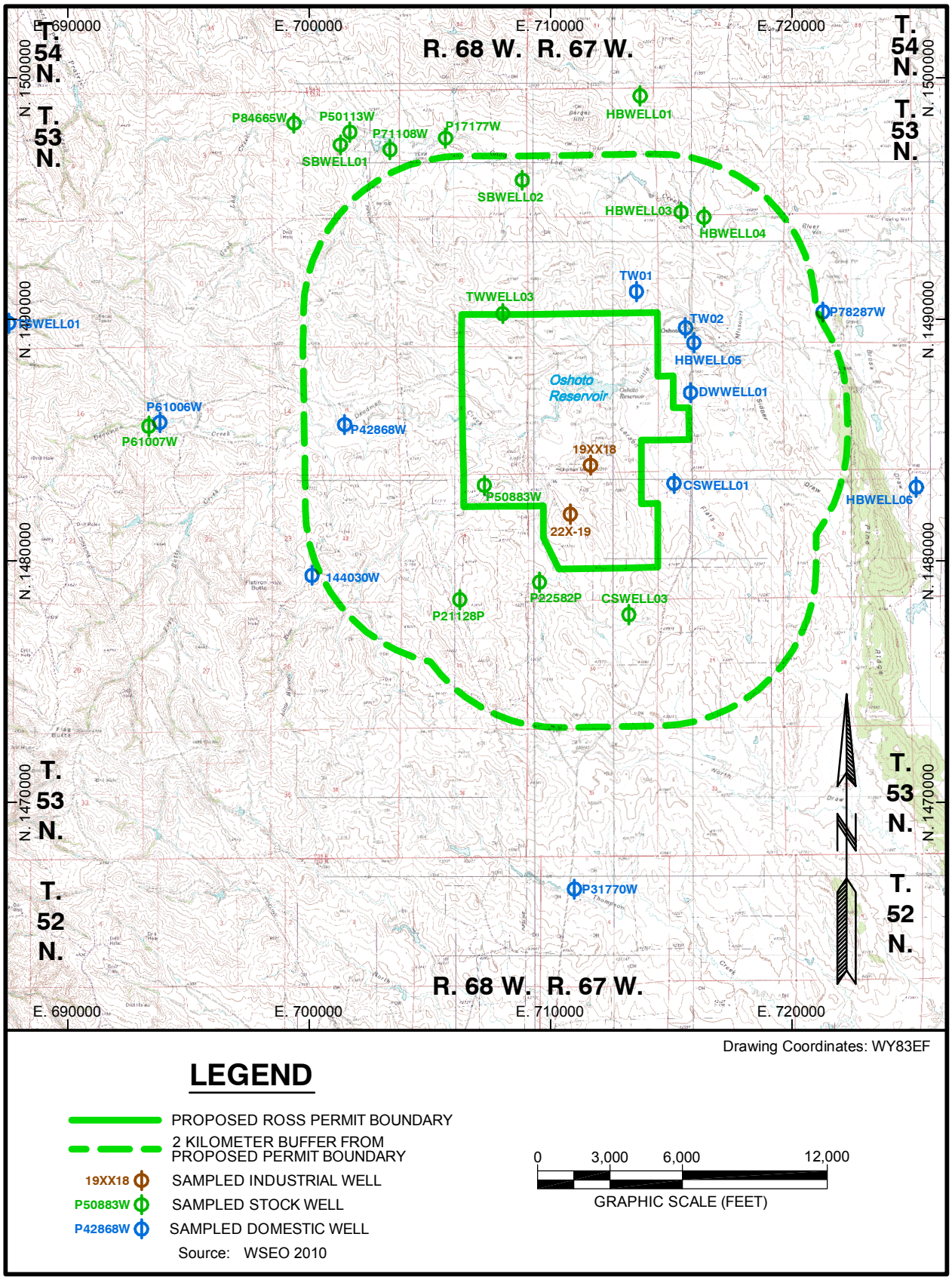

Figure 5.7-8. Sampled Water Supply Wells

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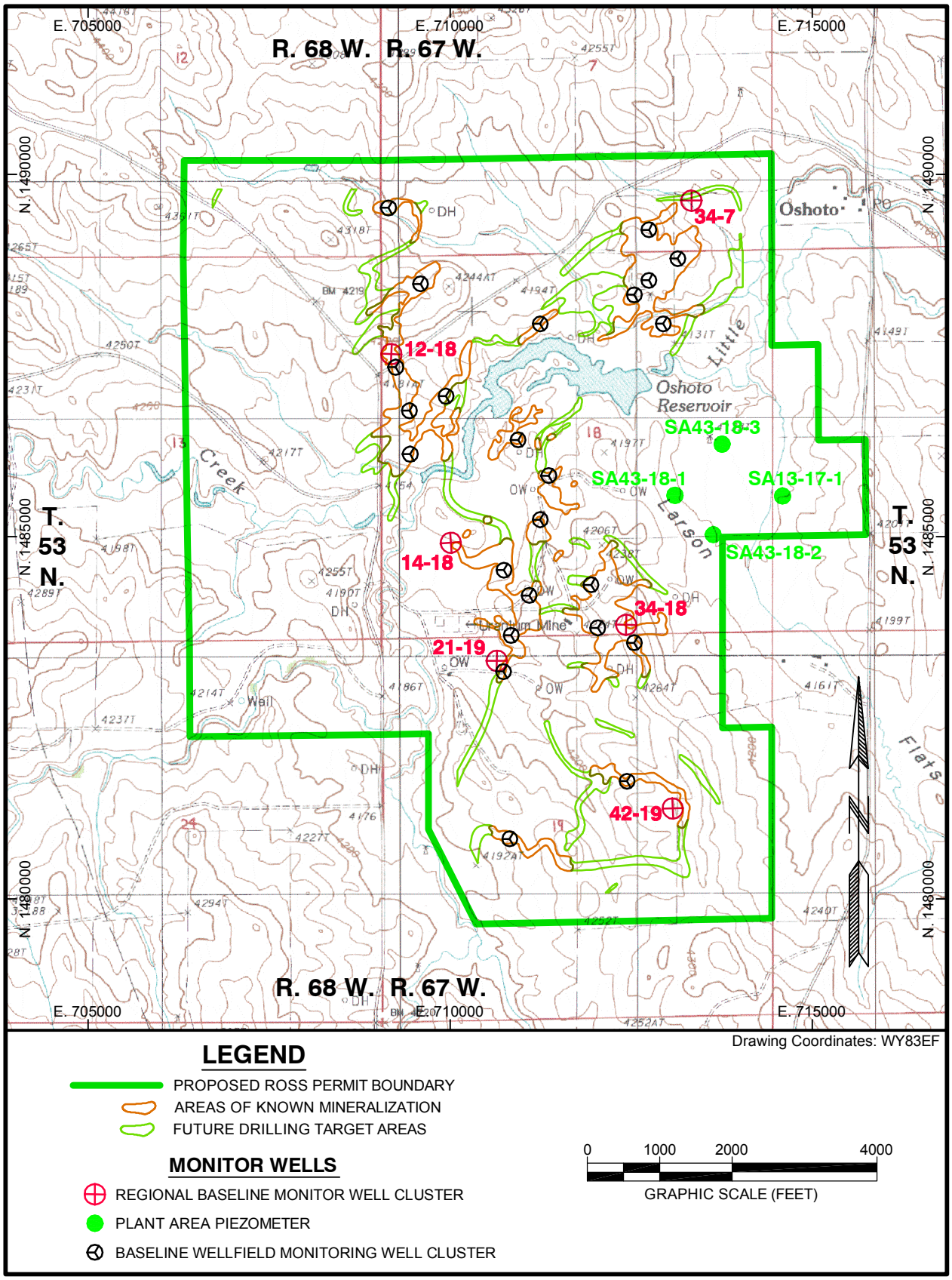

Figure 5.7-9. Proposed and Existing Wellfield Monitor Wells

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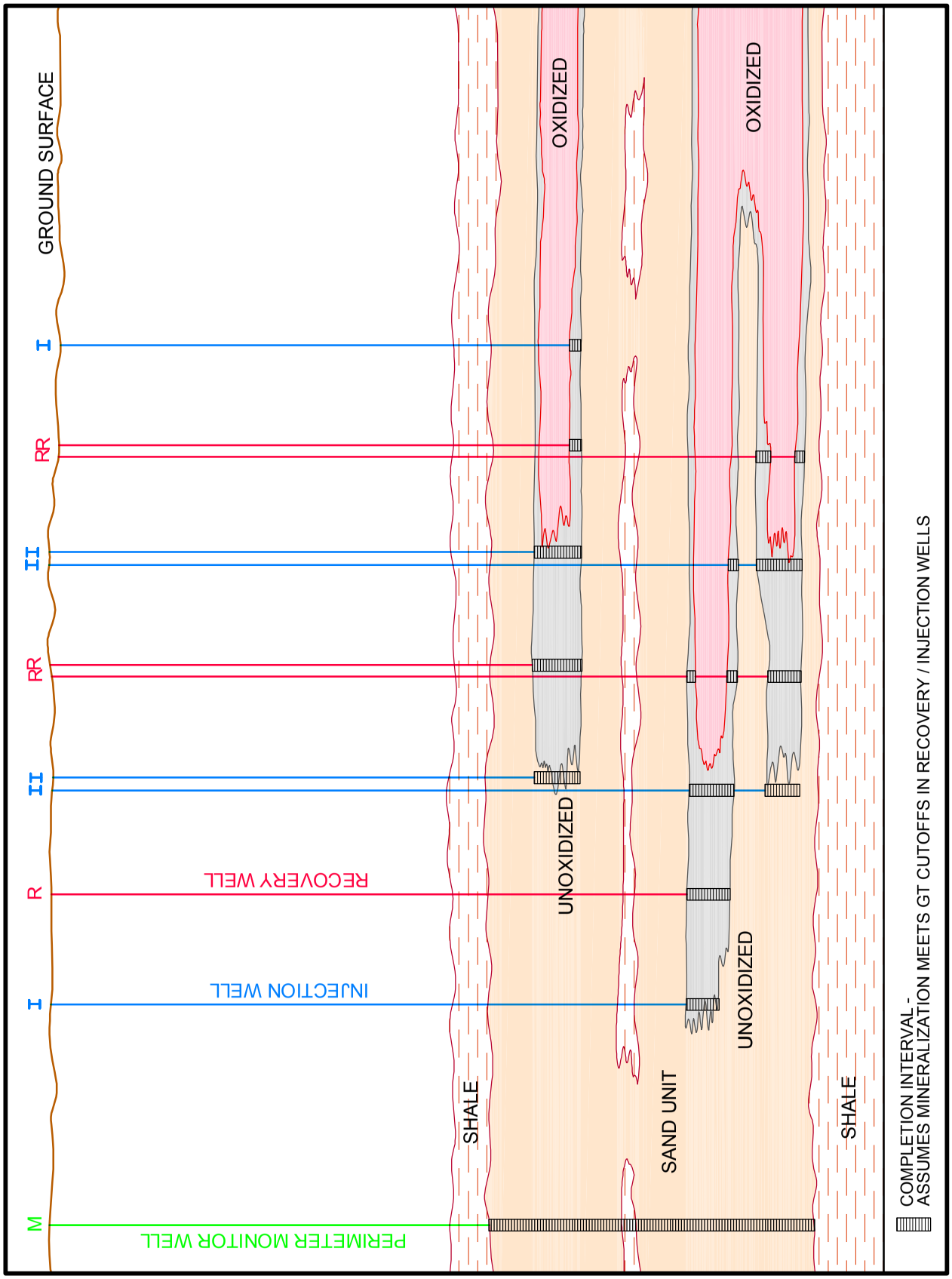

Figure 5.7-10. Typical Perimeter Monitor Well to Wellfield Relationship

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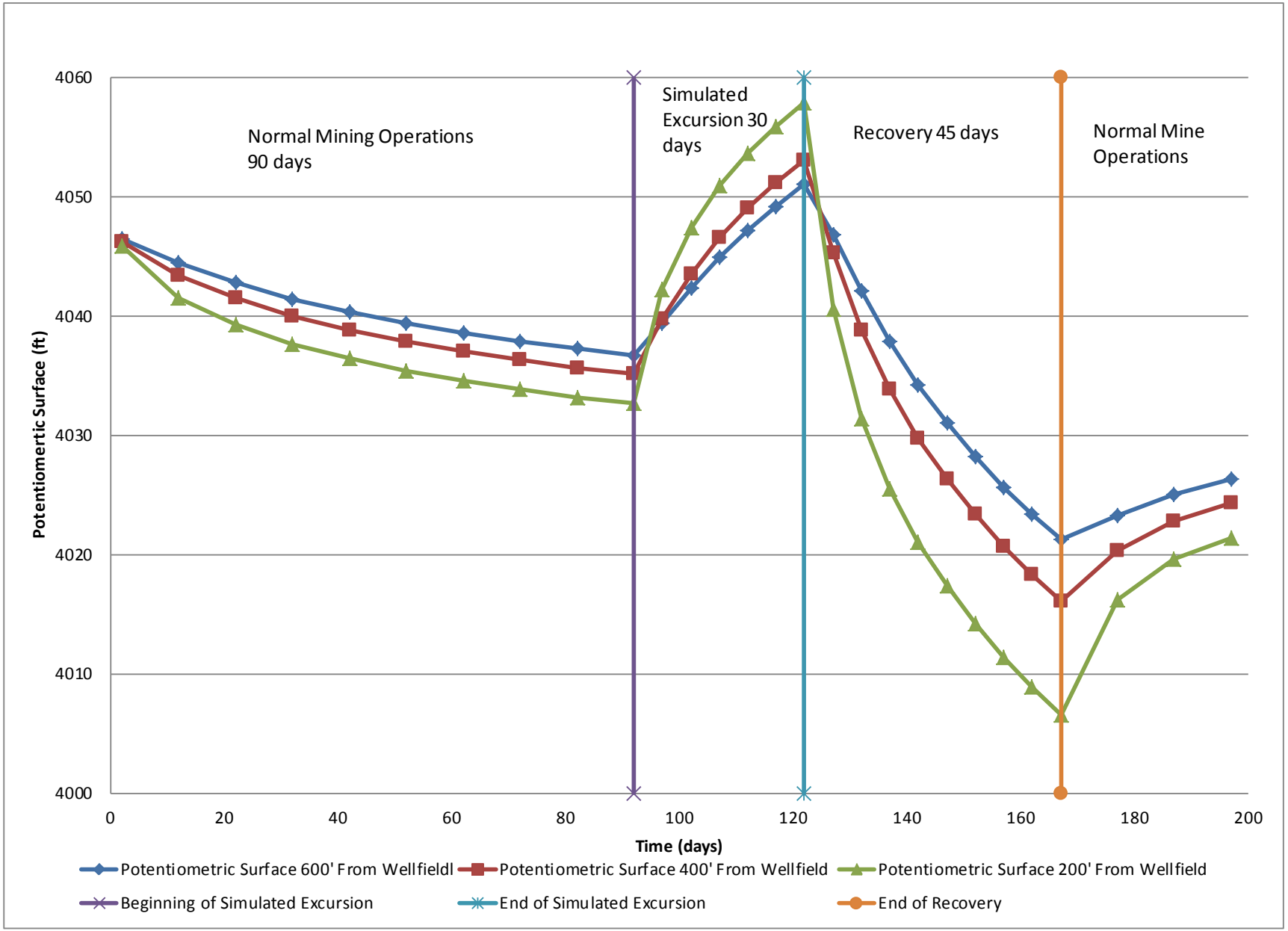


Figure 5.7-11. Upgradient Head Response to NW Wellfield during Simulation Excursion

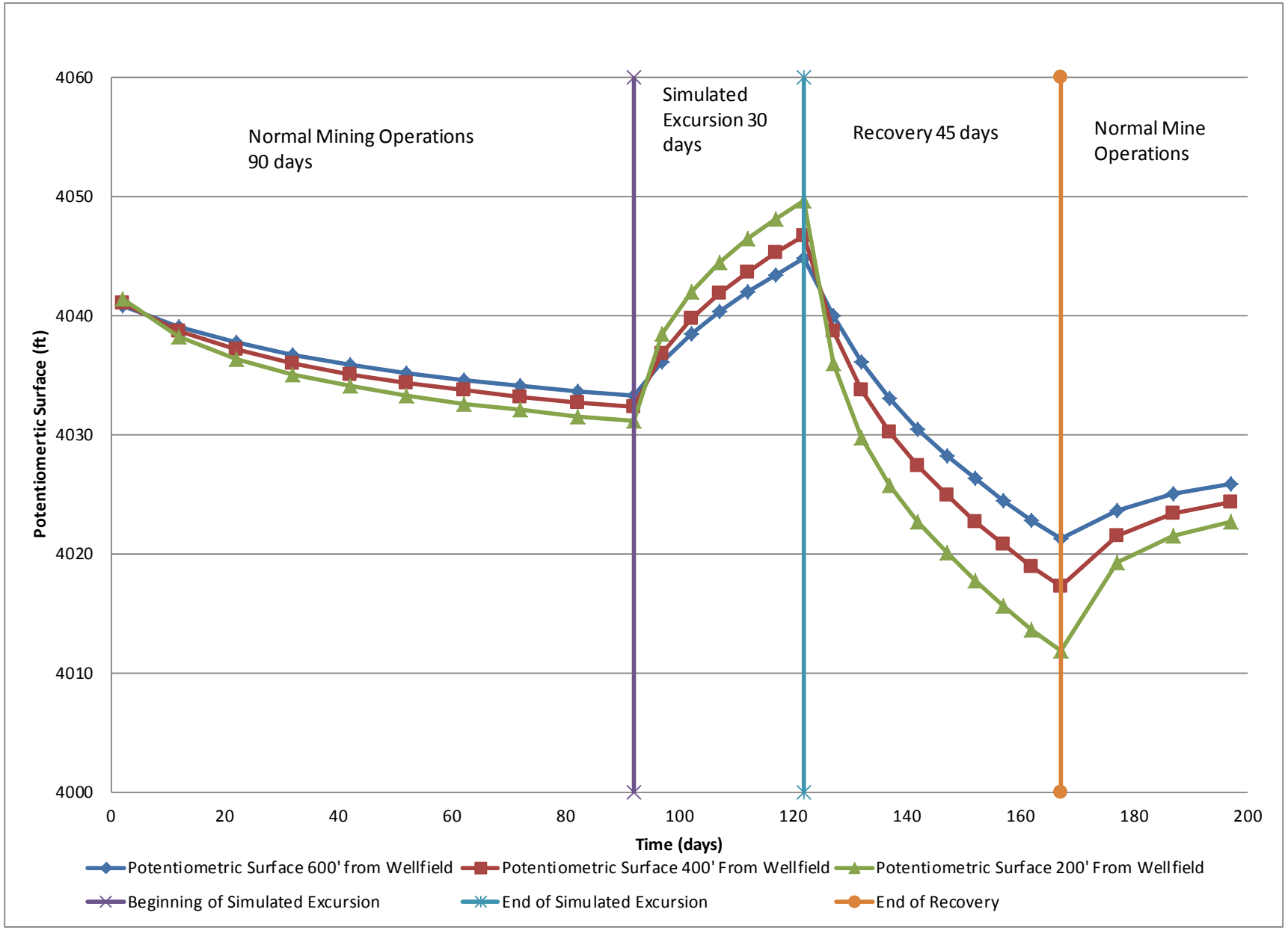
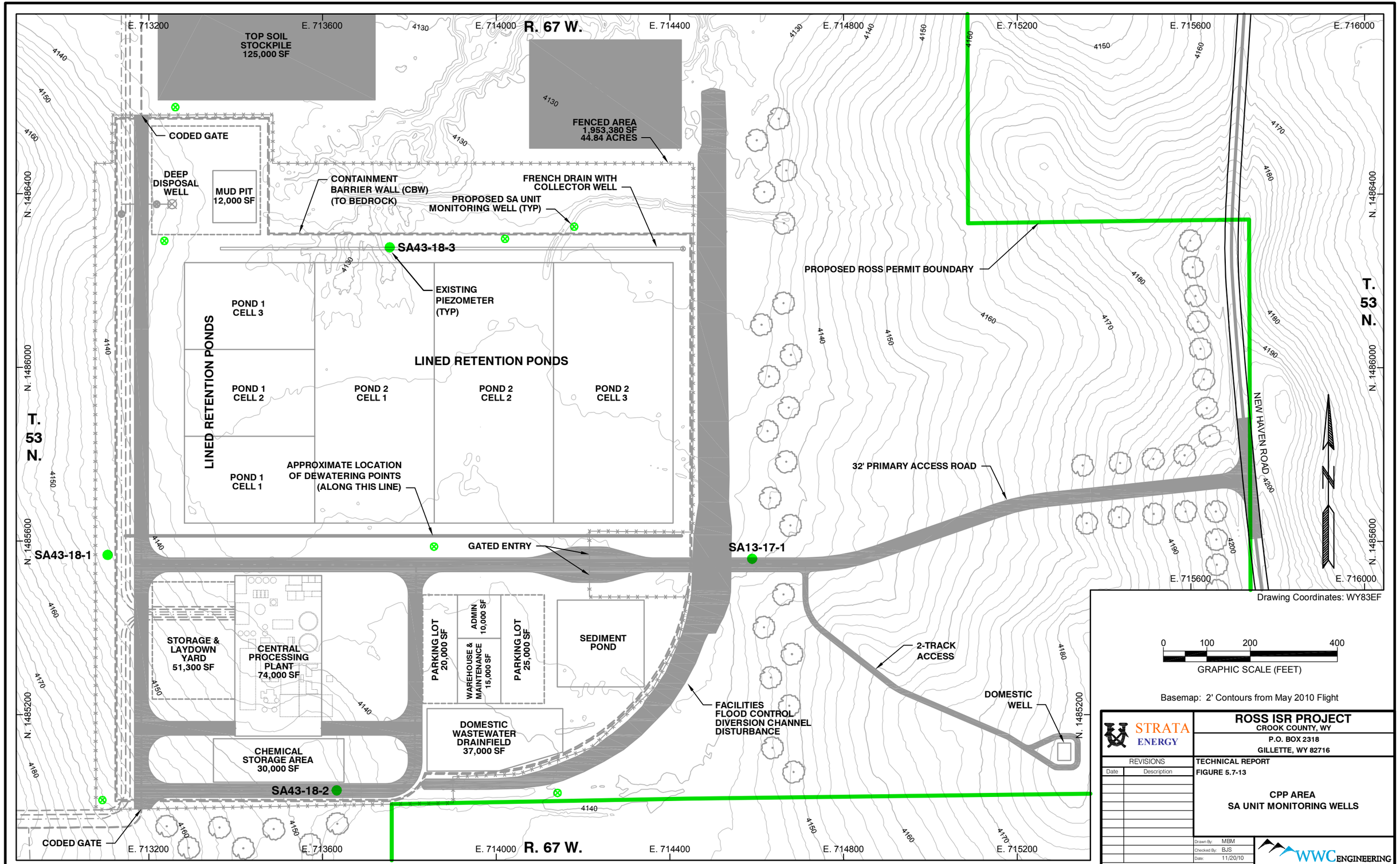


Figure 5.7-12. Downgradient Head Response to SW Wellfield during Simulation Excursion



STRATA ENERGY

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

REVISIONS

Date	Description

TECHNICAL REPORT
FIGURE 5.7-13

CPP AREA
SA UNIT MONITORING WELLS

Drawn By: MBM
Checked By: BJS
Date: 11/20/10
FILE: ROSS_TR_FAC_SITE_PLAN

WWC ENGINEERING
www.wwcengineering.com

K:\Peninsula_Minerals\09142\DWGS_WY83E\ROSS_TR_MON_SITE.dwg, TR_FIGURE_5.7-13, 12/27/2010 10:46:26 AM

5.8 References

ANSI/HPS (American National Standards Institute/Health Physics Society), 1987, Performance Criteria for Radio-bioassay.

Brown, S., 2010a, Personal Communication, P Goranson, Cameco to S Brown, October 2010.

_____, 2010b, Personal Communication, Lee Snowhite, Cameco to Steve Brown, SENES August 2010.

_____, 2008, The New Generation of Uranium In Situ Recovery Facilities: Design Improvements Should Reduce Radiological Impacts Relative to First Generation Uranium Solution Mining Plants. Proceedings of the 2008 Waste Management Symposium, Phoenix. ASME Press, New York, NY, ISBN # 978160560422.

_____, 2007, Radiological Aspects of In Situ Uranium Recovery. American Society of Mechanical Engineers, Proceedings of 11th International Conference on Environmental Management, Bruges, Belgium; ASME Press, New York, NY, ISBN 0-7918-3818-8.

_____, 1982, Radiological Aspects of Uranium Solution Mining, In: Uranium, 1, 1982, p37-52, Elsevier Scientific Publishing Co.

Brown, S. and Blauer, M., 1980, Physical and Chemical Parameters Affecting the Dissolution Characteristics of Yellowcake in Simulated Lung Fluids. Abstracts of the 25th Annual Meeting of the Health Physics Society, Seattle, Paper # 177, Pergamon Press.

Cook, N. and Holt, B., 1974, The Solubility of Some Uranium Compounds in Simulated Lung Fluid, Health Physics 27, 69-77.

Eidson, F. and Mewhinney, J., 1980, In Vitro Solubility of Yellow Cake Samples from Four Uranium Mills and Implications for Bioassay Interpretation, Health Physics 39, 893-902.

EPA (U.S. Environmental Protection Agency), 1974, EPA-625-/6-74-003a, Manual for Chemical Analysis of Water and Wastes.

HPS (Health Physics Society), 1995, Bioassay Programs for Uranium, HPS N 13.22 – 1995.

IAEA (International Atomic Energy Agency), 1976, Safety Series No. 43, Manual on Radiological Safety in Uranium and Thorium Mines and Mills.

ICRP (International Commission on Radiation Protection), 1997, Publication 78, Individual Monitoring for Internal Exposure of Workers.

_____, 1995, Publication 71, Age-dependent Doses to Members of the Public from Intake of Radionuclides – Part 4 Inhalation Dose Coefficients.

_____, 1994a, Publication 66, Human Respiratory Tract Model for Radiological Protection.

_____, 1994b, Publication 68, Dose Coefficients for Intakes of Radionuclides by Workers.

_____, 1989, Publication 54, *Individual Monitoring for Intakes of Radionuclides by Workers*.

_____, 1972a, Publication 19, The Metabolism of Compounds of Plutonium and other Actinides, Task Group on Lung Dynamics.

_____, 1972b, Publication 30, *Limits for Intakes of Radionuclides* by Workers.

Kathren R.L. and Burklin R.K., 2008, Proposed Standards for Acute Exposure to Low Enriched Uranium for Compliance with 10 CFR 70.61, Operational Radiation Safety, V. 95.2, Page S123, August 2008.

Kusnetz, H.L., 1956, Radon Daughters in Mine Atmospheres: A Field Method for Determining Concentrations. American Industrial Hygiene Association 17:85.

Metzger, R., Wichers, D., Vaselin, J., Velasquez, P., 1997, Solubility Characteristics of Airborne Uranium from an In-Situ Uranium Processing Plant, Health Physics 72.3, p 418, March 1997.

NMA (National Mining Association), 2007, Generic Environmental Report in Support of the Nuclear Regulatory Commission's Generic Environmental Impact Statement for In Situ Uranium Recovery Facilities, prepared for the National Mining Association by Thompson & Simmons, PLLC, Tetra Tech, Inc., and Katie Sweeney, National Mining Association, November 30, 2007.

NRPB (National Radiation Protection Board), 2002, Industrial Uranium Compounds: Exposure Limit, Assessment of Intake and Toxicity after Inhalation, W22.

NRC (U.S. Nuclear Regulatory Commission), 2009, NUREG-1910, Generic Environmental Impact Statement for *In-Situ* Leach Uranium Milling Facilities. Final Report, May 2009.

_____, 2003, NUREG-1569, Standard Review Plan for In-situ Leach Uranium Extraction License Applications, June 2003.

_____, 2002a, Regulatory Guide 8.31, Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable, May 2002.

_____, 2002b, Regulatory Guide 8.30, Health Physics Surveys in Uranium Recovery Facilities, May 2002.

_____, 2000, NUREG-1575, Revision 1, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM).

_____, 1999, Regulatory Guide 8.13, Instruction Concerning Prenatal Radiation Exposure, June 1999.

_____, 1997, NUREG BR-0241, NMSS Handbook for Decommissioning Fuel Cycle and Material Licenses.

_____, 1996, Regulatory Guide 8.29, Instruction Concerning Risks from Occupational Radiation Exposure, February 1996.

_____, 1993a, Regulatory Guide 8.37, ALARA Levels For Effluents from Materials Facilities, July 1993.

_____, 1993b, Regulatory Guide 8.9, Acceptable Concepts, Models, Equations and Assumptions for a Bioassay Program, July 1993.

_____, 1992a, Regulatory Guide 8.34 Monitoring Criteria and Methods to Calculate Occupational Doses, August 1992.

_____, 1992b, Regulatory Guide 8.36, Radiation Dose to the Embryo/Fetus, July 1992.

_____, 1992c, NUREG/CR-5849, Manual for Conducting Radiological Surveys in Support of License Termination.

_____, 1988, Regulatory Guide 8.22, Bioassay at Uranium Mills, August 1988.

_____, 1987, Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of License for Byproduct, Source, or Special Nuclear Material, Washington, DC, August 1987.

_____, 1986a, Regulatory Guide 3.56, General Guidance For Designing, Testing, Operating, and Maintaining Emission Control Devices at Uranium Mills, May 1986.

_____, 1986b, NUREG-0874, Internal Dosimetry Model for Application to Bioassay at Uranium Mills.

_____, 1983, Policy and Guidance Directive FC 83-23, Termination of Byproduct Source and Special Nuclear Material.

_____, 1980, Regulatory Guide 4.14, Revision 1, Radiological Effluent and Environmental Monitoring at Uranium Mills, April 1980.

_____, 1979, Regulatory Guide 4.15, Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination) – Effluent Streams and the Environment, February 1979.

_____, 1977, Regulatory Guide 8.10, Operating Philosophy for Maintaining Occupational Radiation Doses As Low As is Reasonably Achievable, May

OSHA (Occupational Health and Safety Administration), 1998, Training Requirements in OSHA Standards and Training Guidelines, OSHA 2254, U.S. Department of Labor

Tairova, G., Boucher, M., Toews, K., Ioffe, M., Takala, J., Murchie, M., and Ozberk, E., 2010, Solubility Of Radionuclides In Simulated Lung Fluid, Cameco Corporation. Proceedings of URANIUM 2010, The Third International Conference on Uranium, Saskatoon, Saskatchewan, Canada, August 2010.

Thomas, J.W., 1972, Measurement of Radon Daughters in Air, Health Physics 23,783.

WDEQ (Wyoming Department of Environmental Quality), 1994, Guideline No. 4, In-Situ Mining, updated March 2000.

_____, 2005, Guideline No. 8, Hydrology Coal and Non-Coal, updated March 2005.

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6.0 GROUNDWATER RESTORATION, SURFACE RECLAMATION, AND FACILITY DECOMMISSIONING PLAN

Throughout the project life, a variety of restoration and reclamation activities will be implemented in order to return the affected areas to their pre-production use. This Chapter describes the general procedures and methods during restoration, reclamation, and decommissioning & decontamination (D&D) activities. The radiological verification survey program will serve as a basis for determining compliance with NRC concentration limits during post-reclamation and decommissioning radiological surveys. Appropriate financial assurance will be maintained with NRC and WDEQ to cover the cost of restoration, reclamation and D&D. Detailed description of groundwater restoration, and site decommissioning activities are included in the Restoration Action Plan (RAP), which is included as Addendum 6.1-A. The RAP establishes pre-license financial assurance methods and estimates as required by the NRC pursuant to its interpretation of Criterion 9 in the Hydro Resources Inc. (HRI) case. The RAP also uses an NRC approved format and methodology according to the RAP submitted by HRI.

Furthermore, this chapter considers regulatory compliance and therefore uses NUREG-1575, (NRC 2000), NUREG-1569, (NRC 2003), NUREG/CR-5512 (NRC 1992), 10 CFR Part 40, and 64 CFR 17690 as guidelines.

6.1 Groundwater Restoration

The primary goals of the groundwater restoration program are to:

1. Restore the groundwater consistent with Criterion 5(B)(5).
2. Complete groundwater restoration contemporaneously with ISR uranium recovery in accordance with 10 CFR 40.42.
3. Provide sufficient restoration capacity to restore each wellfield module in a phased approach as production in depleted wellfields ceases.
4. Minimize consumptive use of groundwater.
5. Apply state-of-the-art technology based on successes and lessons learned from operations, initial Strata restoration efforts and analog facilities.

This section presents the target restoration goals and Strata's specific plan to achieve these goals. The proposed groundwater restoration process is presented, beginning at the end of production, continuing through active restoration and post-restoration stability monitoring, and concluding with NRC and WDEQ/LQD approval of successful restoration for each Mine Unit. The groundwater restoration schedule is tied to production schedules and wastewater disposal capacity. Groundwater restoration analogs demonstrate that the ore body conditions and restoration methods will be similar to those at other ISR facilities that have successfully met target restoration goals and received regulatory approval for groundwater restoration. For more detailed information, refer to the RAP included as Addendum 6.1-A.

6.1.1 Groundwater Target Restoration Goal

Groundwater shall be restored consistent with the groundwater protection standards contained in 10 CFR 40, Appendix A, Criterion 5(B)(5) on a parameter-by-parameter basis using Best Practicable Technology (BPT). If the restoration activities are unable to achieve the background or maximum contaminant levels (whichever is greater) in Criterion 5(B)(5), Strata will submit a license amendment application request for NRC approval of alternate concentration limits (ACLs).

Criterion 5(B)(5) requires that each parameter be restored to one of the following levels:

1. Baseline concentration or,

2. The respective value given in Table 5C, 10 CFR 40, Appendix A, if the constituent is listed in the table and if the background level of the constituent is below the value listed, or
3. An ACL established by NRC after demonstration that BPT has been applied and that further activities would not be technically or economically feasible to further treat the water.

The primary goal of the groundwater restoration program will be to restore the groundwater in the production zone consistent with pre-operational water quality in each wellfield module (Criteria #1 above). However, Strata recognizes that ISR operations fundamentally alter groundwater chemistry, and for some parameters, especially redox-sensitive parameters such as uranium, selenium, and manganese, restoration activities likely may not return groundwater quality to the exact water quality that existed at every location prior to ISR operations. In such cases, Strata will restore groundwater to the Table 5C standards (Criteria #2 above) or to an ACL established by the Commission (Criteria #3 above). In any case, groundwater in the production zone will be restored to the pre-operational WDEQ class of use.

Table 6.1-1 compares the Table 5C restoration criteria with current EPA maximum contaminant levels (MCLs), WDEQ class of use standards, and typical pre-operational water quality. The typical pre-operational water quality is representative of the regional baseline monitor wells and will not exactly match the pre-operational water quality in each Mine Unit. This will be determined as part of the baseline monitoring for individual Mine Units.

Table 6.1-1 shows that the pre-operational ore zone water quality will likely exceed the EPA MCLs for uranium and gross alpha and the WDEQ class of use standards for a variety of parameters. Notably, gross alpha typically exceeds the class I (domestic), class II (agriculture), and class III (livestock) WDEQ/WQD class of use standards. Based on this comparison and comparable baseline water quality in other Wyoming ISRs (see Section 6.1.6), the ore zone within the wellfield areas will likely be classified as IV (industrial use only) by WDEQ (see, for example, COGEMA 2008a). In addition, the presence of the commercially producible uranium and vanadium qualify the aquifer for exemption from the SDWA and thus suitable for injection through a Class III system (WDEQ/LQD 2005).

6.1.1.1 Groundwater Target Restoration Values

Target restoration values (TRVs) representative of baseline water quality will be established for the entire first Mine Unit after sampling representative production zone recovery wells. Strata will measure baseline water quality by collecting multiple water samples from representative recovery wells as described in Section 5.7.8.1 following license issuance. Baseline water quality will be established for each Mine Unit by combining the analytical results from sampled recovery wells within the Mine Unit and calculating an arithmetic average.

Outliers, which are anomalously high or low values relative to the other values, will be removed by quality control checks including visual screening and statistical analysis. The statistical analysis method for outlier screening will be selected based on the sample size and distribution and may include the tolerance-limit formula, as described in WDEQ/LQD Guideline 4, Attachment 1.

The TRVs will be calculated as a function of the "average" baseline water quality and the variability in each parameter according to statistical methods approved by NRC and WDEQ/LQD. Statistical methods used to calculate TRVs will be in accordance with ASTM D6312-98(2008) (ASTM 2005).

6.1.2 Groundwater Restoration Methods

Strata's proposed groundwater restoration program stems from the successes and lessons learned from current and proposed ISRs. The basic procedures are described in the ISR GEIS and have been proven effective at the analog facilities described in Section 6.1.6. To ensure successful groundwater restoration, Strata proposes a number groundwater restoration improvements that may not have been implemented at one or more of the analog facilities. These include:

- Construction of adequate restoration infrastructure such as pipelines, RO units, ponds, and deep disposal wells prior to or closely following the commencement of ISR uranium recovery to ensure a seamless transition from production to restoration;
- Utilization of RO units during the production only phase to limit the potential for continuously increasing the concentrations of dissolved solids in the lixiviant along with ensuring equipment viability and personnel familiarity with the systems;

- Use of an adequately sized restoration plant with RO capacity sized at 15% of the production capacity to ensure that restoration keeps pace with production;
- Maintaining hydraulic control (bleed) between production and restoration such that there are no inactive wellfield modules; and
- Employing the same groundwater model/reservoir engineering software platform used during the production phase to guide restoration hydraulics and performance.

The proposed groundwater restoration program includes six processes:

1. Groundwater Sweep (targeted or selective)
2. Groundwater Transfer
3. Reverse Osmosis Treatment with Permeate Injection
4. Groundwater Recirculation
5. Stability Monitoring.

The sequence of activities will be determined by Strata based on operating experience, restoration treatment system capacity, and brine disposal capacity. Not all phases of groundwater restoration will be used if deemed unnecessary by Strata. A description of each groundwater restoration method is presented below.

6.1.2.1 Groundwater Sweep

During groundwater sweep, water will be pumped from the recovery and injection wells in the affected module(s) to the CPP without reinjection into the modules undergoing groundwater sweep. As described in the ISR GEIS, groundwater sweep causes uncontaminated, native groundwater to flow into the ore body, thereby flushing the contaminants from areas that have been affected by the lixiviant flowing through the peripheries of wellfield area during uranium recovery. In addition, groundwater sweep will help recover lixiviant from areas of low permeability within the production zone.

The water produced from wellfield modules undergoing groundwater sweep will be processed in the CPP by IX and RO. Typically, groundwater sweep will be the first phase of restoration, but Strata may use selective or targeted groundwater sweep on all or a portion of a wellfield module at any time during restoration.

The primary drawback of groundwater sweep is consumptive use of groundwater, since permeate cannot be reinjected into a module actively undergoing groundwater sweep. WDEQ/LQD has determined that groundwater sweep with direct disposal of produced water is not considered BPT due to excessive consumption of groundwater and resultant impacts to groundwater resources (LCI 2009). Strata proposes the following strategy to minimize consumptive use of groundwater during groundwater sweep:

- Groundwater sweep may be used selectively (e.g., around the perimeter of the module) rather than throughout the entire module to maximize benefits while minimizing consumptive use of groundwater. Strata would likely utilize the same site-specific production reservoir engineering platform to aid in identification of areas to target based on potential portions of the aquifer that may have seen local imbalances during the operation phase and or areas where local, low horizontal hydraulic conductivity was measured during the model calibration. To some extent, the operational reservoir management platform would help predict where potential 'hot spots' might be in the wellfield area.
- Water produced during groundwater sweep will be treated by RO to minimize brine, thereby avoiding any occurrence of groundwater sweep with direct disposal of produced water.
- Whenever possible, permeate generated from one module undergoing groundwater sweep will be reinjected into another module undergoing RO treatment with permeate reinjection.
- Much of the permeate discharged into the lined permeate ponds will be recycled to the CPP for make-up water.
- The total volume of water planned for groundwater sweep is much lower than that planned for RO treatment with permeate injection.

Groundwater modeling experience within the project area has shown that some portions of a wellfield are easier to restore than others due to localized aquifer hydraulic properties and wellfield geometry. Strata anticipates that by updating the groundwater model presented in Addendum 2.7-H with site-specific data used to develop the proposed wellfield packages, restoration activities can be modeled. Results of the restoration modeling will indicate where groundwater sweep activities are likely be the most effective. The use of the groundwater model to help direct selective sweep operations has the potential to significantly decrease the consumptive use of water during the sweep portion of the groundwater restoration process while at the same time

significantly increasing the effectiveness of the restoration process. In addition, by utilizing data collected during the operational phase of a particular wellfield, restoration methodology and options could be utilized to better focus specific processes where they might be most effective.

6.1.2.2 Groundwater Transfer

Groundwater transfer involves moving groundwater between one wellfield module entering restoration and another wellfield module entering production, or moving water between two areas within a single wellfield module that are in different stages of restoration (ISR GEIS). Strata may elect to use groundwater transfer before groundwater sweep or during any of the other stages of restoration to help homogenize groundwater quality within or between modules along with stabilizing the groundwater quantity within a localized portion of the wellfield. Prior to injection, the water recovered during groundwater transfer may be passed through IX columns and/or filters for additional uranium and vanadium recovery.

6.1.2.3 Groundwater RO Treatment with Permeate Injection

During this phase of groundwater restoration, water will be pumped from one or more wellfield modules to the CPP for treatment. Treatment will include uranium and vanadium removal in IX columns and RO treatment to reduce dissolved constituents. Treatment equipment is described in Section 3.2.5 and consists of IX guard columns and phased RO units. Two stages of RO treatment will typically be used to maximize permeate and minimize brine production. Additional treatment may include filtration to prevent fouling RO membranes, injection of anti-scalent, pH control, minimizing the amount of oxygen introduced into the system and de-carbonation. Permeate will be reinjected into the production zone, while brine will be disposed in the lined retention ponds and deep disposal wells. This phase of groundwater restoration will occur immediately following groundwater sweep or in conjunction with groundwater sweep in another module.

The influx of natural groundwater will be kept to a minimum by maximizing the quantity of permeate reinjected into modules undergoing RO treatment with permeate injection. This will also be accomplished through two separate phases of RO treatment, which will significantly reduce the amount of

brine as compared to single-pass treatment. This will help reduce the amount of groundwater consumptive use during RO treatment with permeate injection.

6.1.2.4 Groundwater Recirculation

After completing the RO treatment with permeate injection phase, the groundwater recirculation phase will commence. In this phase, water from the production zone will be pumped from recovery wells and recirculated into injection wells in the same module. This recirculation will homogenize the groundwater and help reduce the risk of "hot spots," or areas of unusually high concentrations of dissolved constituents. The only treatment that will occur during recirculation will be filtration, uranium/vanadium removal, and/or reductant addition along with minimizing the amount of oxygen introduced into the injection stream.

6.1.2.5 Groundwater Stability Monitoring

Following active groundwater restoration, Strata will initiate the stability monitoring phase to ensure that chemical species of concern do not increase in concentration subsequent to restoration. The following sections describe the proposed stability monitoring phase, including monitoring, evaluating stability based on monitoring results, corrective actions to address constituents with increasing trends, hot spots or excursions, and reporting.

Wells to be Monitored

During baseline characterization of each Mine Unit, Strata will sample recovery and monitor wells to assess baseline water quality within the production zone and underlying and overlying aquifers. Strata will evaluate the results of the pre-ISR water quality and recommend specific recovery wells to be sampled during stability monitoring. These recommendations will be included in the wellfield baseline packages submitted to NRC and WDEQ/LQD prior to initiating construction of each Mine Unit.

Monitor wells (perimeter wells and wells completed in the underlying and overlying aquifers) will also be sampled during the post-restoration stability monitoring period at the frequency discussed below.

Sampling Frequency and Duration

Strata proposes to perform at least eight rounds of stability monitoring over a 12-month period. This includes an initial sample event at the end of active groundwater restoration, followed by monthly sampling for six months then either monthly or quarterly for another six months pending the level of stability observed in the groundwater quality. The proposed sampling frequency exceeds the minimum stability monitoring duration of 6 months specified in WDEQ/LQD Guideline 4. The extended duration and reduced sampling frequency (quarterly instead of monthly) are proposed to better analyze long-term trends in water quality. Long-term stabilization of the ore zone aquifer following R&D operations is addressed in Section 6.1.6.1 along with a graph of the life of well water quality (Figure 6.1-2) for the original recovery well at the R&D site.

Strata proposes to reduce the frequency of excursion monitoring from biweekly to quarterly during the stability monitoring phase. The reduced monitor well sample frequency is justified on the basis that active groundwater restoration will be complete and no fluids will be injected into the affected wellfield module. In addition, Strata hopes to utilize the reservoir engineering platform developed during operation and restoration to demonstrate the lack of wellfield interference.

Monitored Constituents

Stability monitoring will include an evaluation of physical/field water quality parameters and laboratory measurements of chemical constituents as shown in Table 6.1-2. The parameter list has been prepared for consistency with NUREG-1569, Table 2.7.3-1, and WDEQ/LQD Guideline 8, Appendix 1.

Monitor well samples will be analyzed for all excursion parameters and the static water level will be recorded at each monitoring well during stability phase activities.

Restoration Success Criteria

Stability monitoring results will be evaluated using various methods to determine whether there are any significant trends in chemical species of concern. The methods may include trend analysis, statistical variance calculations (e.g., t-test), or other common environmental statistical methods. The specific method will depend on the variability in pre-operational water

quality. The data will be examined on a parameter by parameter basis over the entire duration of stability monitoring.

Hot Spots

Criteria used to determine whether further action is required include:

1. If a constituent exhibits a statistically significant increasing trend, or
2. If a hot spot is discovered during stabilization monitoring.

Hot spots, or wells with elevated concentrations of dissolved constituents, will be identified using statistical analysis. A hot spot will generally be defined as a well with a constituent concentration greater than two standard deviations above the mean concentration for that parameter in the affected wellfield module.

Hot spots and constituents with increasing trends could potentially impact groundwater outside of the exempted portion of the aquifer. If Strata identifies either of these occurrences during stability monitoring, additional evaluation will be conducted to determine the potential impact on the water quality outside of the exempted aquifer. This analysis could include extended stability monitoring or flow and transport modeling. If the evaluation reveals that groundwater outside of the exempted aquifer could potentially be affected, Strata may return to a previous stage of active restoration to resolve the issue. The active restoration process and duration will depend on the parameter and concentration.

Excursions

The following methods of corrective action for an excursion occurring during the restoration stability monitoring period will be instituted (not necessarily in the order given), dependent upon circumstances pursuant to the Criterion 5(b)(5) as implemented by the Commission. Section 5.7.8 describes the excursion response procedure in more detail.

- A preliminary investigation will be completed to determine the probable cause and the area affected.
- Affected wells will be analyzed for the full suite of parameters in Table 6.1-2.

- An assessment will be performed to determine what actions, if any, need to be taken to protect the groundwater outside the exempted aquifer. If sufficient data to make such a determination are not available, additional wells may be installed to fill in data gaps.
- If the excursion may result in degradation of groundwater outside of the exempted aquifer, a pump back or pump and treat plan will be initiated as soon as possible to recover the excursion. The stability monitoring period will continue but will not be considered successful until the excursion is recovered or it can be demonstrated that the remnant of the excursion will not degrade the water quality outside the exempted aquifer.
- If the excursion will not result in degradation of groundwater outside the exempted aquifer, then the stability monitoring period may continue. However, at the end of the successful stability monitoring period the wells affected by an excursion will be analyzed for the parameters listed in Table 6.1-2 to verify the previous assessment that groundwater outside the exempted aquifer will not be degraded.

Reporting

During the groundwater restoration process, Strata will perform daily, weekly, and monthly analyses as described in Section 6.1.3 to track restoration progress. These analyses will be summarized, along with the restoration methods, and discussed in the Semiannual Radiological Effluent and Environmental Monitoring Report submitted to NRC. The analyses will also be submitted to WDEQ/LQD on a quarterly basis or as required by the WDEQ/LQD Permit to Mine. This information will also be included in the final report on restoration. The final restoration report will include the results of all stabilization monitoring, statistical trend and hot spot analyses, and the results of any flow and transport modeling to assess potential impacts outside of the exempted aquifer. The final restoration report will be submitted to NRC and WDEQ/LQD for regulatory approval. Following NRC and WDEQ/LQD approval, plugging and abandonment of wells and final reclamation will be performed as described in Section 6.2.

6.1.3 Active Groundwater Restoration Monitoring

During all phases of active groundwater restoration, specific recovery wells in the affected modules will be monitored monthly (consistent with WDEQ/LQD Guideline 4) to track restoration progress and provide early

warning of any potential hot spots. The monitored constituents will include a portion of the constituents listed in Table 6.1-2. These may include pH, EC, total alkalinity, chloride, and other parameters appropriate to the specific stage of active restoration. If hot spots are identified, appropriate corrective measures will be taken. These may include adjusting the flows in the area, changing wells from injection to recovery or vice-versa, targeting the affected area with additional groundwater sweep or RO treatment with permeate injection.

The transition from active restoration to stability monitoring will be determined by Strata based on the active restoration monitoring results and the volume requirements. When Strata is confident that the groundwater restoration goal has been achieved using BPT, active groundwater restoration will cease and stability monitoring will commence.

During active restoration, the recovery stream at each module building will also be sampled daily to measure the restoration progress for each module as a whole. The constituent list will be similar to that for individual recovery wells.

During active restoration all potentially affected monitor wells will be sampled biweekly and monitored for water level and UCL parameters.

6.1.4 Restoration Volumes and Flow Rates

This section describes the method used to estimate a typical restoration pore volume displacement (PVD). The PVD calculation includes site-specific measurements of ore zone thickness and porosity and an estimate of horizontal flare supported by groundwater modeling. The anticipated restoration flow rates are compared to production rates to demonstrate that the restoration plant has been designed to keep pace with production. The number of PVDs anticipated for successful groundwater restoration is presented. The PVD estimates required for groundwater restoration are supported by the restoration analogs presented in Section 6.1.6.

6.1.4.1 Pore Volume Displacement Estimate

Restoration progress is often measured on the basis of the number of PVDs processed during each phase of groundwater restoration. A pore volume is a term used by the ISR industry to define an indirect measurement of a unit volume of aquifer affected by ISR operation or restoration (ISR GEIS). This report distinguishes between the in situ pore volume (PV) and the pore volume

displacement (PVD), which is used to describe the volume of water displaced during ISR uranium recovery and aquifer restoration. Site specific calculations of the PVDs utilized in the following analysis are provided in the RAP.

6.1.4.2 Restoration Pore Volume Displacements

The total number of PVDs of groundwater sweep and RO treatment with permeate injection necessary to achieve the restoration goals was estimated based on the number of production PVDs. A typical wellfield module is expected to require 50 to 60 PVDs of production to complete economical uranium recovery. The minimum restoration volume is estimated as 15% of the production PVDs, or 8.5 PVDs of groundwater sweep plus RO treatment with permeate injection. Strata proposes to add one additional PVD of recirculation, bringing the total to 9.5 PVDs. The minimum number of restoration PVDs is consistent with other ISRs that have successfully achieved groundwater restoration goals (Section 6.1.6). PVD estimates for each phase of groundwater restoration are presented in Table 6.1-3. The number of PVDs required to restore stacked roll front systems is not expected to change as described in Section 6.1.7.

6.1.4.3 Restoration Flow Rates

The restoration capacity has been designed specifically to keep pace with production. The CPP will have the capacity to process up to 7,500 gpm of lixiviant from producing wellfield modules. Based on a typical PVD of 11.2 million gallons, it would take about 60 days (2 months) to process 57 PVDs if only one typical wellfield module were operated at a time (57 x 11.2 million gallons/7,500 gpm = 60 days). As discussed in Section 6.1.5 below, the actual production duration of each module will be longer since the production rate will be spread over multiple wellfield modules that will be operated simultaneously. In practice, each module will be in production approximately 21 months and uranium recovery will be completed in about six modules per year. This equates to 2 months per wellfield module.

The restoration portion of the CPP will have the capacity to process up to 1,100 gpm of water from wellfield modules undergoing active groundwater restoration. A typical wellfield module would therefore require 60 days or 2 months to process the 8.5 PVDs at this restoration rate (8.5 x 11.2 million gallons/1,100 gpm = 60 days). The actual duration of restoration for each

module is estimated at 8 months since multiple wellfield modules will undergo groundwater sweep and RO treatment with permeate injection simultaneously. By sizing the restoration capacity equal to 15% of the production capacity, restoration will keep pace with production. Table 6.1-4 presents the anticipated flow range for each phase of groundwater restoration.

6.1.4.4 Restoration Fluid Disposal

Figures 3.1-11 through 3.1-13 depict the anticipated quantities of permeate and brine generated during each of the three operational phases: production only, concurrent production and restoration, and restoration only. During the two phases involving groundwater restoration, all permeate generated during both groundwater sweep and RO treatment with permeate injection will typically be reinjected into wellfield modules in the latter stage of groundwater restoration. The only exception is during groundwater sweep of the first two wellfield modules, when excess permeate will be generated. Section 4.2 describes the disposal of permeate and waste fluids generated during groundwater restoration, discusses waste fluid disposal capacity at various stages of production, and presents mitigation strategies to be implemented in the event that the operation of one or more disposal systems is interrupted.

Estimated permeate water quality is presented in Table 6.1-5. Hydranautics RO software was used to estimate permeate water quality based on the anticipated post-production water quality constituents (see Section 6.1.6 below). The estimated permeate water quality is based on specific ion rejection rates ranging from 94% to over 99%.

Table 6.1-6 presents the estimated concentrations of various constituents in the brine that will be discharged into the evaporation ponds and injected into the deep disposal wells. The site-specific estimate accounts for the anticipated water quality at the end of production, typical RO salt rejection rates, and the quantity and quality of brine originating from other sources, including the elution bleed from the CPP. This table also includes a comparison with actual concentrations of deep disposal fluids from other operating ISRs, including the Smith Ranch-Highland facility and Christensen Ranch/Irigaray Projects. The concentration of TDS and other dissolved constituents anticipated in the proposed project area is generally within the observed range at other facilities. The primary reason that some constituents are higher in the anticipated brine water quality compared to other facilities is

that Strata is proposing a two-stage RO system, which will reduce the amount of wastewater but also concentrate the salts in the brine stream compared to a single-stage RO system. The two-stage RO system decreases the amount of consumptive use of water by returning more permeate to the exempted aquifer.

6.1.5 Groundwater Restoration Schedule

Strata will adhere to the timelines in decommissioning regulations of 10 CFR 40.42. When groundwater restoration begins in a given wellfield module, NRC and LQD will be notified and a plan submitted for regulatory review and approval. If, at that time, groundwater restoration is estimated to take longer than 24 months, Strata will provide an explanation and request approval for an alternate schedule through a license amendment as allowed under 10 CFR 40.42(i).

6.1.5.1 Transition from Production to Restoration

Strata will monitor uranium concentrations in the recovery wells and trunk lines from producing wellfield modules to determine when a wellfield module will be taken out of production and started in restoration. The criteria used to determine when this will occur may include, but will not be limited to:

- An adequate recovery of uranium
- Uranium recovery grade below 10 mg/l
- Available production plant capacity.

The NRC and WDEQ/LQD will be informed when a transition from production to restoration occurs in a wellfield module. In addition to the typical transition criteria listed above, the following four conditions would trigger NRC notification of decommissioning (restoration) activities:

- The license has expired
- The licensee has decided to permanently cease principal activities (defined as the last date of lixiviant injection)
- No principal activities have been conducted for 24 months under the license
- No principal activities have been conducted in a specific wellfield.

The proposed production plant has been designed with a capacity of 7,500 gpm to permit simultaneous production in multiple wellfield modules.

The large plant capacity will allow modules to remain in production for a relatively long period of time, resulting in greater uranium recovery and, potentially, easier groundwater restoration as result.

6.1.5.2 Groundwater Restoration Schedule for Individual Modules

Following an anticipated typical production period of 21 months, Strata will alert NRC and WDEQ/LQD to the transition from production to restoration for the affected module. During the interim period between production and active groundwater restoration, which is estimated to average 9 months and last up to 12 months, a hydrologic bleed sufficient to control ISR solutions will be maintained. The wellfield module will then enter active groundwater restoration.

Typically the first phase of groundwater restoration will be groundwater sweep, but this may occur at any time during active groundwater restoration. Groundwater sweep is anticipated to take approximately 1 to 4 months and average 2 months. During all phases of active groundwater restoration (excluding stabilization monitoring), including any pauses between, for example, groundwater sweep and RO treatment with permeate injection, a hydrologic bleed will be maintained to control production and restoration solutions.

RO treatment with permeate injection will typically require 4 months to complete. This will be followed immediately by approximately 1 month of recirculation. The stability monitoring period lasting 12 months will follow. Figure 6.1-1 depicts the anticipated restoration schedule for a typical wellfield module.

The estimated time to complete each step of active groundwater restoration is based on the number of PVDs required, restoration plant capacity, and hydrologic limitations. Strata assumes that average production flow rate in a typical wellfield module will be 715 gpm. By comparison, the typical flow rates in individual wellfield modules during groundwater sweep and RO treatment with permeate injection are anticipated to be 75 gpm and 515 gpm, respectively. The reduced active restoration flow rates compared to production should be feasible even with a moderate reduction in production zone permeability throughout the life of ISR operations.

6.1.5.3 Cumulative Groundwater Restoration Schedule

It is anticipated that two wellfield modules will undergo groundwater sweep simultaneously and two will undergo RO treatment with permeate injection simultaneously. Due to the relatively longer period of stability monitoring, up to six or eight modules may be in the stability monitoring phase at one time. Figure 1.9-1 depicts the anticipated project schedule, including groundwater restoration, for the proposed Ross ISR Project.

6.1.6 Restoration Analogs

Restoration activities at Wyoming and Nebraska ISRs have proven that the groundwater can be restored to baseline water quality or ACLs approved by NRC and WDEQ/LQD following commercial ISR uranium recovery activities. Similarities between the ore zone hydrogeologic and chemical conditions at the proposed Ross ISR Project and Irigaray, Christensen Ranch, Smith Ranch-Highland Uranium Project, and Crow Butte indicate that aquifer restoration in the proposed project area is achievable using the methods and volumes proposed in this license application. Following is a comparison of the anticipated restoration conditions and methods at the Ross ISR Project with other licensed ISRs who have successfully restored groundwater in one or more Mine Units. Restoration analogs are presented for geologic/hydrogeologic properties, pre-operational and post-production water quality, and restoration methods.

6.1.6.1 Geologic and Hydrogeologic Properties Analogs

Although depositionally and formationally different, roll front deposits in the western interior that have undergone successful recovery and restoration have a number of common attributes, key of which is a permeable host rock, typically consisting of slightly dipping sandstones deposited in fluvial or marginal marine environments. The distal margins of these sandstones grade laterally into organic-rich siltstones claystones and mudstones deposited in low-energy back swamp or lagoonal environments. Typical uranium roll front deposits are formed epigenetically by groundwater solutions that move from upland recharge areas toward lowland discharge areas. Along the groundwater flow path, the chemical facies changes from oxidizing in the recharge areas to reducing in the discharge area.

To varying degrees, the geologic and hydrogeologic properties noted above are common between the proposed Ross ISR Project and the Irigaray, Christensen Ranch, Smith Ranch-Highland, and Crow Butte sites, all of which have undergone successful restoration. The physical proprieties listed in Table 6.1-7 compare favorably between the five sites. Further, the Ross site has a high degree of hydraulic confining head in the ore-bearing aquifer, which demonstrates the isolation of the ore zone from overlying and underlying water-bearing intervals, a key factor in successful recovery and restoration.

An additional analog that demonstrates that the Ross site can be successfully restored is the successful restoration of the Nubeth R&D facility by groundwater sweep. In the period from April through September, 1979, some 4.2 pore volumes were displaced at the facility, resulting in restoration below the upper control limits for critical parameters. Figure 6.1-2 indicates that restoration is achievable at the proposed Ross ISR Project.

6.1.6.2 Water Quality Analogs

The production zone within the proposed project area has similar baseline water quality as that in the analog facilities. Based on similar ISR methods, the post-production water quality is also expected to be similar in the proposed project area.

Pre-Operational Water Quality

Table 6.1-8 compares the pre-operational water quality in the proposed project area with pre-operational water quality at other operating ISRs. In terms of major ion chemistry, sodium dominates the cations in the proposed project area, much the same as all analog sites except Smith Ranch-Highland, where sodium and calcium dominate the cations. Calcium and magnesium, which form precipitates and scale much more readily than sodium, are typically lower at Ross than any other facility. This supports the conclusion that the ore body within the proposed project area is amenable to sustained pumping during production and restoration operations.

Anion dominance in the proposed project area is divided between sulfate and bicarbonate. The relative contribution of bicarbonate is generally higher than that at the analog sites. During production, the bicarbonate concentration will be similar to that at the analog sites due to the common use of a bicarbonate lixiviant. In terms of scale potential, the relatively high bicarbonate

concentration at the proposed project area is offset by the relatively low calcium concentration.

The TDS concentration is typically higher at Ross than at the analog sites, ranging from about 1 to 1.5 times the TDS at Crow Butte to several times higher than that at Smith Ranch-Highland. Although higher ionic strength generally leads to greater opportunity for precipitation and scale formation, the increase in salts compared to other facilities is primarily due to highly soluble sodium bicarbonate. Strata anticipates that restoration may in fact be easier at the Ross ISR Project since it should generally be easier to restore groundwater to higher background concentrations for major ions than the lower concentrations found at the analog facilities.

The pre-operational water quality analogs are depicted graphically in Figure 6.1-3, which compares the average concentrations of TDS and major ions at the proposed project area with the analog facilities. This figure demonstrates that the TDS, sodium, and bicarbonate levels at the proposed project area are higher than the other facilities but similar to Crow Butte, that the sulfate levels are similar to most of the analog facilities, and that calcium is lower in the proposed project area.

Water Quality at the End of Production

In order to estimate the water quality at the end of production/beginning of restoration, the post-production water quality was compared to pre-operational water quality at each of the analog sites, and the minimum, maximum, and average change in each constituent was calculated. These factors were then applied to the typical pre-operational water quality in the proposed project area to estimate the range of anticipated post-production water quality. The anticipated post-production water quality is therefore based on the observed changes in water quality at other facilities using the same or similar ISR methods.

Table 6.1-9 presents the anticipated water quality at the end of production in comparison with typical values derived from the ISR GEIS. This table shows that all constituents are expected to be within the typical range presented in the ISR GEIS.

Table 6.1-10 compares the anticipated post-production water quality with the average or typical range of post-production water quality at the analog sites. This table shows that the TDS is expected to be slightly higher at Ross

than at some other facilities due to the higher pre-operational TDS, but that all constituents generally are expected to fall into the range of values observed at other ISRs.

6.1.6.3 Restoration Method Analogs

The restoration methods and PVDs proposed for the Ross ISR Project are supported by successful restoration at other ISR facilities. Following is a description of the methods used to restore groundwater at the Irigaray, Christensen Ranch, Smith Ranch-Highland, and Crow Butte facilities. Each facility description includes a list of changes or improvements that were made to help ensure that future groundwater restoration activities at these facilities could be carried out using fewer PVDs. The proposed restoration methods for the Ross ISR Project include all of the process improvements noted for the analog facilities.

Irigaray and Christensen Ranch

At Irigaray, wellfield restoration operations were initiated in 1990 and completed in 2002. Groundwater within the production zone was successfully restored and received regulatory approval from WDEQ/LQD in 2005 and NRC 2006. Groundwater restoration volumes included an average of 2.3 PVDs of groundwater sweep, 10.4 PVDs of RO treatment with permeate injection, and 0.9 PVD of recirculation (13.7 PVDs total) (COGEMA 2004, 2008b).

At Christensen Ranch, aquifer restoration was initiated in 1997 and completed by 2006. The wellfield restoration report was submitted to WDEQ/LQD and NRC for approval in 2008. Groundwater restoration volumes included an average of 2.4 PVDs of groundwater sweep, 9.4 PVDs of RO treatment with permeate injection, and 0.8 PVD of recirculation (12.6 PVDs total) (COGEMA 2008b).

An evaluation of the Irigaray and Christensen Ranch restoration programs was completed by LCI (2010). The evaluation noted that there were several areas in which improvements could be made:

- Production and restoration were not conducted sequentially, and were hindered with extended periods of shut-in and standby, with delays of up to several years in some cases;

- During early production at Irigaray, the lixiviant used ammonium bicarbonate with hydrogen peroxide, which resulted in extensive additional restoration efforts;
- Groundwater sweep, the initial phase of restoration, was often largely ineffective and in some cases may have exacerbated the impacts to water quality; and
- RO was continued in some wellfields after it was apparent that little improvement in water quality was occurring.

Recognizing that improvements in groundwater restoration schedule and methods could reduce the number of PVDs required for restoration of future wellfield modules, COGEMA proposed the following restoration methods in the 2008 license renewal application for Irigaray and Christensen Ranch (COGEMA 2008a):

- Groundwater sweep: 1 PVD
- RO treatment/permeate injection: 5 PVD
- Recirculation: 1 PVD
- Total: 7 PVD

Smith Ranch-Highland

Groundwater restoration at the Smith Ranch-Highland Project Mine Unit B was initiated in 1997 and completed in 2004. Groundwater restoration included an average of 2.9 PVDs of groundwater sweep, 13.5 PVDs of RO treatment with permeate injection, and 0.9 PVD of recirculation, for a total of 17.3 PVDs. Restoration of this mine unit was approved by WDEQ/LQD in 2008 and is currently undergoing review by NRC (Cameco 2009a).

Cameco (2009a) noted that there were four reasons for the large number of PVDs treated during restoration that would not be encountered in future restoration operations at Smith Ranch-Highland:

- Repeat treatment of wellfield modules with RO treatment/permeate reinjection due to a TDS boost caused by a reductant;
- Changes in reductant procedures;
- Additional RO treatment/permeate injection was used to add nutrients during bioremediation; and
- Delay in the construction of restoration infrastructure.

Crow Butte

Groundwater restoration for Mine Unit 1 began in 1994 and was completed in 1999. Restoration included 0.9 PVD of groundwater transfer, 0.1 PVD of groundwater sweep, 6.0 PVDs of RO treatment with permeate injection, and 2.9 PVDs of recirculation accompanied by uranium removal (CBR 2000). Sodium sulfide reductant was also added to reduce uranium and other trace elements. Successful groundwater restoration was approved by the Nebraska Department of Environmental Quality and NRC. NRC approval occurred in February 2003 (CBR 2009).

The Mine Unit 1 Restoration Report (CBR 2000) noted several changes made during the restoration process to improve efficiency, including:

- The addition of new, larger capacity RO units during restoration;
- The installation of new restoration pipelines to increase flow capacity and provide more versatile flow arrangements; and
- The addition of reductant (sodium sulfide) beginning in 1996.

The restoration report noted that the improvements implemented during restoration of Mine Unit 1 should significantly reduce the number of PVDs for the restoration of future Mine Units.

In the 2009 amended license application for the North Trend Expansion Area (CBR 2009), Crow Butte Resources proposed the following restoration PVDs:

- IX treatment without RO: 3 PVDs
- RO treatment/permeate injection: 6 PVDs
- Recirculation: 2 PVDs
- Total: 11 PVDs

6.1.6.4 Comparison of Proposed Restoration Methods with Analog Sites

The proposed restoration methods and volumes are supported by the analog sites. The 9.5 PVDs of active groundwater restoration at the proposed project area is higher than the 7 PVDs proposed for future restoration activities at Irigaray and Christensen Ranch. Although the total restoration PVDs is higher for future Crow Butte mine units than Ross, the number of PVDs of RO

treatment with permeate injection, which is the most important step in groundwater restoration, is higher in the proposed project area.

The proposed Ross ISR Project has the advantage of learning from the improvements that were made during groundwater restoration at the analog facilities. Specific improvements that are described in greater detail elsewhere in this section include:

- Construction of adequate restoration infrastructure such as pipelines, RO units, ponds, and deep disposal wells prior to or closely following the commencement of ISR uranium recovery to ensure a seamless transition from production to restoration;
- Utilization of RO units during the production only phase to limit the potential for continuously increasing the concentrations of dissolved solids in the lixiviant along with ensuring equipment viability and personnel familiarity with the systems;
- Use of an adequately sized restoration plant with RO capacity sized at 15% of the production capacity to ensure that restoration keeps pace with production;
- Maintaining hydraulic control (bleed) between production and restoration such that there are no inactive wellfield modules;
- Employing the same groundwater model/reservoir engineering software platform used during the production phase to guide restoration hydraulics and performance;
- Testing reductants on a small area before widespread application; and
- Primary focus and significant restoration PVDs dedicated to RO treatment with permeate injection, which is primarily responsible for lowering the TDS and concentrations of other dissolved constituents.

The restoration analogs provide a technical basis for Strata's ability to meet the standards in 10 CFR 40, Appendix A, Criterion 5(B)(5).

6.1.7 Restoring Stacked Roll Fronts

Section 3.1 discusses Strata's proposed strategy for ISR uranium recovery, groundwater restoration, and excursion monitoring in stacked roll front deposits. To summarize, Strata proposes to complete recovery and injection wells in multiple zones in which recoverable uranium is present if the zones are in the same sand unit. If the stacked roll fronts occur in separate

sand units, separate recovery and injection wells would be installed to address the ore in each sand. In this situation there would be multiple wells at each location. The stacked roll fronts would be produced and restored together, and the restoration processes and PVDs would be unchanged in the case of restoring stacked roll fronts.

6.1.8 Potential Environmental Impacts from Groundwater Restoration

Potential environmental impacts from groundwater restoration are discussed in Chapter 4.0 of the ER.

There are two primary categories of potential environmental impacts from the proposed groundwater restoration activities. The first is potential surface and groundwater quality impacts and the second is potential water consumption impacts. Other potential environmental impacts such as noise, air quality, and traffic impacts are not specific to groundwater restoration and are described in detail in Chapter 4.0 of the ER.

Potential water quality impacts include those potentially occurring to surface water and groundwater. Surface water quality impacts could occur in the event of a leak, spill, or equipment failure that would result in release of a process fluid to surface water. Instrumentation and controls designed to limit the likelihood of a surface water release and the magnitude of any release are described in Section 3.1. Potential accident scenarios and mitigation measures are described in Section 7.5 of this report and Section 4.4 and 5.4 of the ER. Potential surface water quality impacts are not limited to groundwater restoration, but are similar to those expected during construction, production, and decommissioning.

Potential groundwater quality impacts are also similar to those expected during production and are discussed in Section 4.4 of the ER. Potential groundwater quality impacts during groundwater restoration include horizontal and vertical excursions of recovery solutions, potential water quality impacts to the adjacent non-exempted aquifer from hot spots or constituents exhibiting increasing trends during stability monitoring, or potential shallow groundwater quality impacts to spills and leaks. Generally there is less potential for groundwater quality impacts during restoration compared to production since, a) the injection and recovery flow rates are lower in restoration compared to production, b) the duration that each wellfield module is in groundwater restoration is typically much lower than the production duration, and c) the

production zone water quality will improve throughout active restoration. The purpose of groundwater restoration is to restore groundwater to target restoration values that minimize or eliminate the potential for adverse impacts on adjacent groundwater outside of the EPA/WDEQ exempted production area. The primary restoration *goal* is always background water quality or an MCL whichever is higher. If this cannot be met, in order to receive NRC and LQD approval of restoration success, Strata will demonstrate that BPT has been applied (i.e., it would not be technically or economically feasible to further reduce the constituent concentration) and that the constituent is not a threat to surrounding water users or potential water users outside the exemption area. Typically this would involve hydrologic or geochemical modeling to assess the fate of constituents.

The primary potential impact of groundwater restoration is groundwater consumption. This potential impact will be minimized by committing to the use of two stages of RO, reinjection of permeate generated during groundwater sweep into modules undergoing RO treatment with permeate injection, and minimizing the amount of groundwater sweep employed. The primary potential impact will be drawdown in the ore zone aquifer in areas surrounding the exemption area. This potential impact is addressed in Section 4.4 of the ER.

Table 6.1-1. Comparison of Typical Pre-Recovery Water Quality with Various Standards

Parameter	Units	Typical Pre-Recovery	EPA MCL	Table 5C	WDEQ/WQD Class of Use Standards		
					Class I	Class II	Class III
Arsenic	mg/L	< 0.005	0.01	0.05	0.05	0.1	0.2
Barium	mg/L	< 0.5	2.0	1.0	2.0	---	---
Cadmium	mg/L	< 0.002	0.005	0.01	0.005	0.01	0.05
Chromium	mg/L	< 0.01	0.1	0.05	0.1	0.1	0.05
Lead	mg/L	< 0.02	---	0.05	0.015	5	0.1
Mercury	mg/L	< 0.001	0.002	0.002	0.002	---	0.00005
Selenium	mg/L	< 0.005	0.05	0.01	0.05	0.02	0.05
Silver	mg/L	< 0.003	---	0.05	0.1	---	---
Uranium	mg/L	0.045	0.03	---	---	---	---
Vanadium	mg/L	0.01	---	---	---	0.1	0.1
TDS	mg/L	1,600	---	---	500	2,000	5,000
Chloride	mg/L	6	250[s]	---	250	100	2,000
Iron	mg/L	0.33	0.3[s]	---	0.3	5.0	---
Manganese	mg/L	0.01	0.05[s]	---	0.05	0.2	---
Sulfate	mg/L	630	250[s]	---	250	200	3,000
Ra 226 + Ra 228	pCi/L	4	5	5	5	5	5
Gross alpha	pCi/L	98	15	15	15	15	15

Note: [s] denotes secondary standard (non-enforceable guidelines for cosmetic or aesthetic effects)

Table 6.1-2. Post-Restoration Stability Monitoring Parameters

Physical and Field Water Quality Parameters		
Static water level	Electrical conductivity, field	Temperature
pH, field		
General Water Quality Parameters		
pH, lab	Ammonia	Alkalinity
Electrical conductivity, lab	Nitrate-nitrite	
Total dissolved solids		
Major Ions		
Calcium		Bicarbonate
Magnesium		Carbonate
Potassium		Chloride
Sodium		Sulfate
Radiological		
Gross alpha		Radium 226, dissolved
Gross beta		Radium 228, dissolved
Trace and Minor Elements		
Arsenic, dissolved	Fluoride	Molybdenum, dissolved
Barium, dissolved	Iron, dissolved	Nickel, dissolved
Boron, dissolved	Iron, total	Selenium, dissolved
Cadmium, dissolved	Lead, dissolved	Uranium, dissolved
Chromium, dissolved	Manganese, total	Vanadium, dissolved
Copper, dissolved	Mercury, dissolved	Zinc, dissolved

Table 6.1-3. Anticipated Restoration Pore Volumes

Groundwater Restoration Phase	Proposed PVs
Groundwater Sweep	0.5
RO Treatment with Permeate Injection	8.0
Recirculation	1.0
Total	9.5

Table 6.1-4. Anticipated Restoration Flow Rates

Groundwater Restoration Phase	Individual Wellfield Modules		Cumulative Flow Rates	
	Flow Range (gpm)	Typical Flow Rate (gpm)	Flow Range (gpm)	Typical Flow Rate (gpm)
Groundwater Sweep	30 - 150	75	75 - 300	75
RO Treatment with Permeate Injection	300 - 600	515	550 - 1,100	1,025
Recirculation	150 - 600	300	300 - 1,200	600
Total to Restoration RO Units (see note)				1,100

Note: Recirculation water will not be treated by RO.

Table 6.1-5. Anticipated Restoration Permeate Water Quality

Parameter	Unit	Typical Value	Minimum Value	Maximum Value
EC	S/cm	300	180	400
TDS	mg/L	200	100	250
pH	s.u.	8	6	6.5
Alkalinity as $CaCO_3$	mg/L	100	50	200
Sulfate	mg/L	15	10	20
Bicarbonate	mg/L	150	50	200
Chloride	mg/L	15	5	25
Calcium	mg/L	0	0	1
Sodium	mg/L	50	20	100
Manganese	mg/L	0	0	0.1
Selenium	mg/L	0	0	0.1
Arsenic	mg/L	0	0	0.1
Uranium	mg/L	0	0	0.1
Radium	pCi/L	30	5	100

Table 6.1-6. Anticipated Brine Water Quality

Parameter	Unit	Typical Value	Minimum Value	Maximum Value	Actual Range from Operating ISRs[1]
EC	S/cm	50,000	35,000	70,000	ND
TDS	mg/L	35,000	20,000	60,000	4,000 - 92,000
pH	s.u.	8	5	9	3 - 9
Alkalinity as $CaCO_3$	mg/L	10,000	7,000	20,000	0 - 4,500
Sulfate	mg/L	8,000	6,000	10,000	ND
Bicarbonate	mg/L	14,000	7,000	20,000	700 - 4,500
Chloride	mg/L	5,000	3,000	15,000	10,000 - 15,000
Calcium	mg/L	1,500	300	2,000	3,000 - 5,000
Sodium	mg/L	10,000	6,000	20,000	10,000 - 15,000
Manganese	mg/L	4	0	10	ND
Selenium	mg/L	8	0	20	ND
Arsenic	mg/L	1	0	3	ND
Uranium	mg/L	10	0	100	0 - 130
Radium	pCi/L	500	200	10,000	10 - 4,000

[1] Sources: NRC 2009, Power Resources 2003, and Ross DDW Application (Addendum 4.2-A).
ND - no data

Table 6.1-7. Geologic and Hydrogeologic Analogs

Parameter	Unit	Proposed Ross ISR Project	Irigaray	Christensen Ranch	Smith Ranch - Highland	Crow Butte
Data Source	---	(1)	(2)	(3)	(4)(5)	(6)(7)
Ore thickness	ft	5-30	15-25	15-25	10	39
Depth to ore zone	ft	410-700	100-300	250-500	450-1,000	400-800
Porosity	%	24-47	23-29	26-29	27	29
Hydraulic gradient	ft/ft	0.005-0.007	0.005	0.004-0.010	0.0009	ND
Transmissivity	ft^2/d	80-102	40-136	33-138	120-180	363
Hydraulic conductivity	ft/d	4.5-7.6	0.4-1.4	0.3-1.6	1.3-2.0	9.3
Hydraulic conductivity	md	2,170-7,000	179-676	155-773	600-950	4,500
Storativity		6.1E-05 - 1.5E-04	2.7E04	4.5E-05 - 1.3E-03	4.0E-05 - 2.0E-04	9.7E-05
Groundwater velocity	ft/d	<0.003	0.019-0.03	0.009-0.043	ND	ND

Data Sources:

(1) Regional baseline monitor wells, refer to TR Addendum 2.7-F.
(2) "Irigaray Wellfield Restoration Report," COGEMA 2004.
(3) "Christensen Ranch Wellfield Restoration Report," COGEMA 2008a.
(4) "Smith Ranch-Highland Uranium Project Source Material License Application," Power Resources 2003.
(5) "Highland Uranium Project Mine Unit 9 Hydrologic Test Report," Cameco 2008.
(6) Crow Butte North Trend License Amendment Revised Section 2.7, CBR 2009.
(7) Crow Butte North Trend License Amendment Technical Report, CBR 2007

ND - no data

Table 6.1-8. Pre-Recovery Water Quality Analogs

Parameter	Unit	Ross ISR Project	Irigaray	Christensen Ranch	Smith Ranch - Highland	Crow Butte
Data Source	---	(1)	(2)	(3)	(4)	(5)
Water Type	---	Na-SO_4/HCO_3	Na-SO_4	Na-SO_4	Na/Ca-HCO_3/SO_4	Na-SO_4/HCO_3/Cl
TDS	mg/L	1,340-2,020	270-1,050	400-1,200	250-480	1,100-1,300
Sulfate	mg/L	480-900	130-630	230-680	80-220	310-380
Bicarbonate	mg/L	480-610	5-150	130-210	160-230	400-470
Chloride	mg/L	4-10	5-15	9-12	3-16	190-220
Calcium	mg/L	4-7	1-35	10-50	40-70	20-40
Magnesium	mg/L	1-2	0-9	1-11	8-13	1-10
Sodium	mg/L	440-620	90-280	150-280	40-90	380-430
Manganese	mg/L	0-0.06	0.05-0.19	0.01-0.05	0-0.2	0-0.01
Selenium	mg/L	0-0.008	0.001-0.4	0.003-0.03	0-0.01	0-0.004
Arsenic	mg/L	0-0.005	0.001-0.1	0.002-0.01	0-0.007	0-0.002
Uranium	mg/L	0-0.1	0.0003-19	0.03-0.4	0.004-0.62	0.05-0.2
Radium	pCi/L	0.9-10	0-250	80-430	3-1,035	80-240

Data Sources:

(1) Regional baseline monitor wells, refer to TR Section 2.7.3.
(2) "Irigaray Wellfield Restoration Report," COGEMA 2004.
(3) "Christensen Ranch Wellfield Restoration Report," COGEMA 2008a.
(4) "Mine Unit B Ground Water Restoration Report, Smith Ranch – Highland Uranium Project," Cameco 2009a.
(5) Crow Butte North Trend License Amendment attachments, Cameco 2009b.

Table 6.1-9. Anticipated Water Quality at the End of Production

Parameter	Unit	Typical Value	Minimum Value	Maximum Value	ISR GEIS Range[1]
EC	S/cm	6,000	4,000	7,000	---
TDS	mg/L	4,000	2,500	5,000	≤1,650 - 12,000
pH	s.u.	7.5	6	8.5	≤6.5 - 10.5
Alkalinity as $CaCO_3$	mg/L	1,500	1,000	2,000	---
Sulfate	mg/L	1,100	900	1,500	≤400 - 5,000
Bicarbonate	mg/L	2,000	1,000	2,500	≤400 - 5,000
Chloride	mg/L	300	100	500	≤200 - 5,000
Calcium	mg/L	200	50	300	≤20 - 500
Magnesium	mg/L	40	10	100	≤3 - 100
Sodium	mg/L	1,000	500	1,500	≤400 - 6,000
Manganese	mg/L	0.5	0	1	---
Selenium	mg/L	1.0	0	3	---
Arsenic	mg/L	0.1	0	0.5	---
Uranium	mg/L	5	5	20	≤0.01 - 500
Radium	pCi/L	600	100	1,500	------

[1] ISR GEIS Table 2.4-1, NRC 2009

Table 6.1-10. Post-Production Water Quality Analogs

Parameter	Unit	Ross ISR Project	Irigaray	Christensen Ranch	Smith Ranch - Highland	Crow Butte
Data Source	---	(1)	(2)	(3)	(4)	(5)
TDS	mg/L	2,500-5,000	2,451	3,000-3,800	1,672	3,100-3,900
Sulfate	mg/L	900-1,500	639	780-1,100	402	960-1,290
Bicarbonate	mg/L	1,000-2,500	1,343	1,400-2,300	824	900-1,210
Chloride	mg/L	100-500	277	120-180	232	450-620
Calcium	mg/L	50-300	199	260-330	349	80-100
Magnesium	mg/L	10-100	46	50-70	66	20-30
Sodium	mg/L	500-1,500	627	600-900	83	940-1,180
Manganese	mg/L	0-1	1.2	0.5-1	0.9	0-0.2
Selenium	mg/L	0-3	0.25	0.5-6	0.8	0.01-0.15
Arsenic	mg/L	0-0.5	<0.6	0-0.12	0.008	0.01-0.03
Uranium	mg/L	0-20	7.4	11-18	22	5-55
Radium	pCi/L	0-1,500	201	260-530	1,478	120-1,560

Data Sources:

(1) Regional baseline monitor wells, refer to TR Section 2.7.3.
(2) "Irigaray Wellfield Restoration Report," COGEMA 2004.
(3) "Christensen Ranch Wellfield Restoration Report," COGEMA 2008a.
(4) "Mine Unit B Ground Water Restoration Report, Smith Ranch – Highland Uranium Project," Cameco 2009a.
(5) Crow Butte Mine Unit 1 Restoration Report, CBR 2000.

Figure 6.1-1. Typical Wellfield Module Production and Restoration Schedule

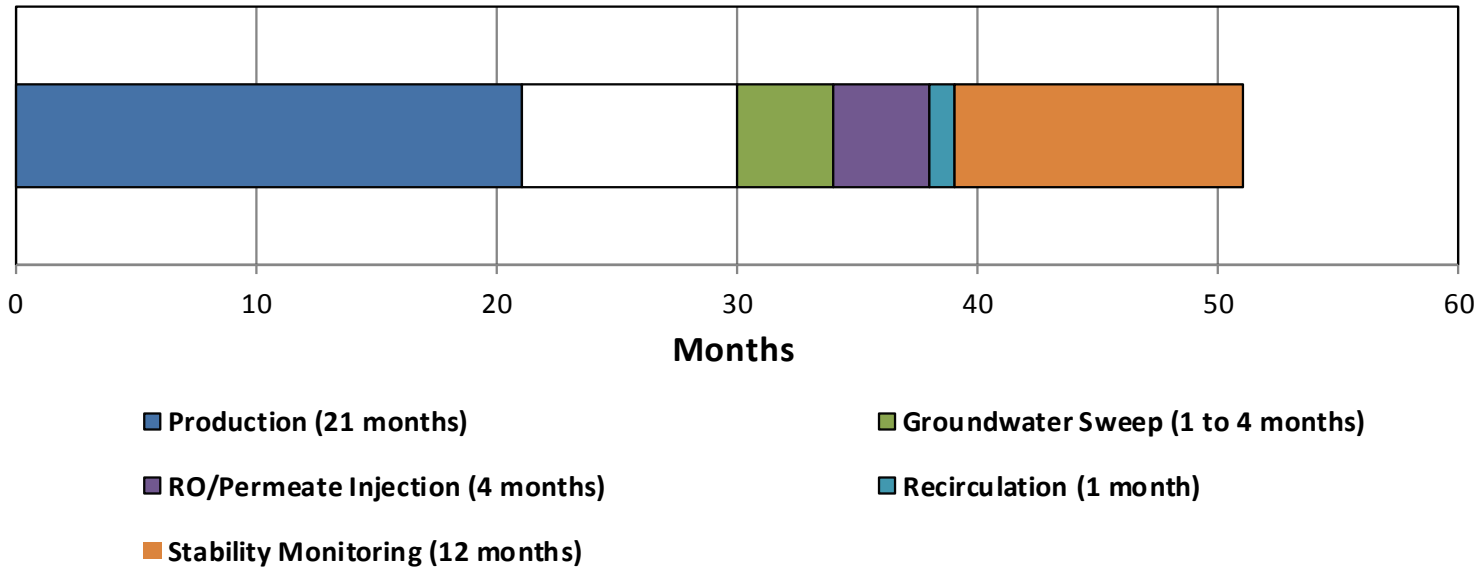


Figure 6.1-2. Nubeth R&D Site Well 19XX Restoration Results

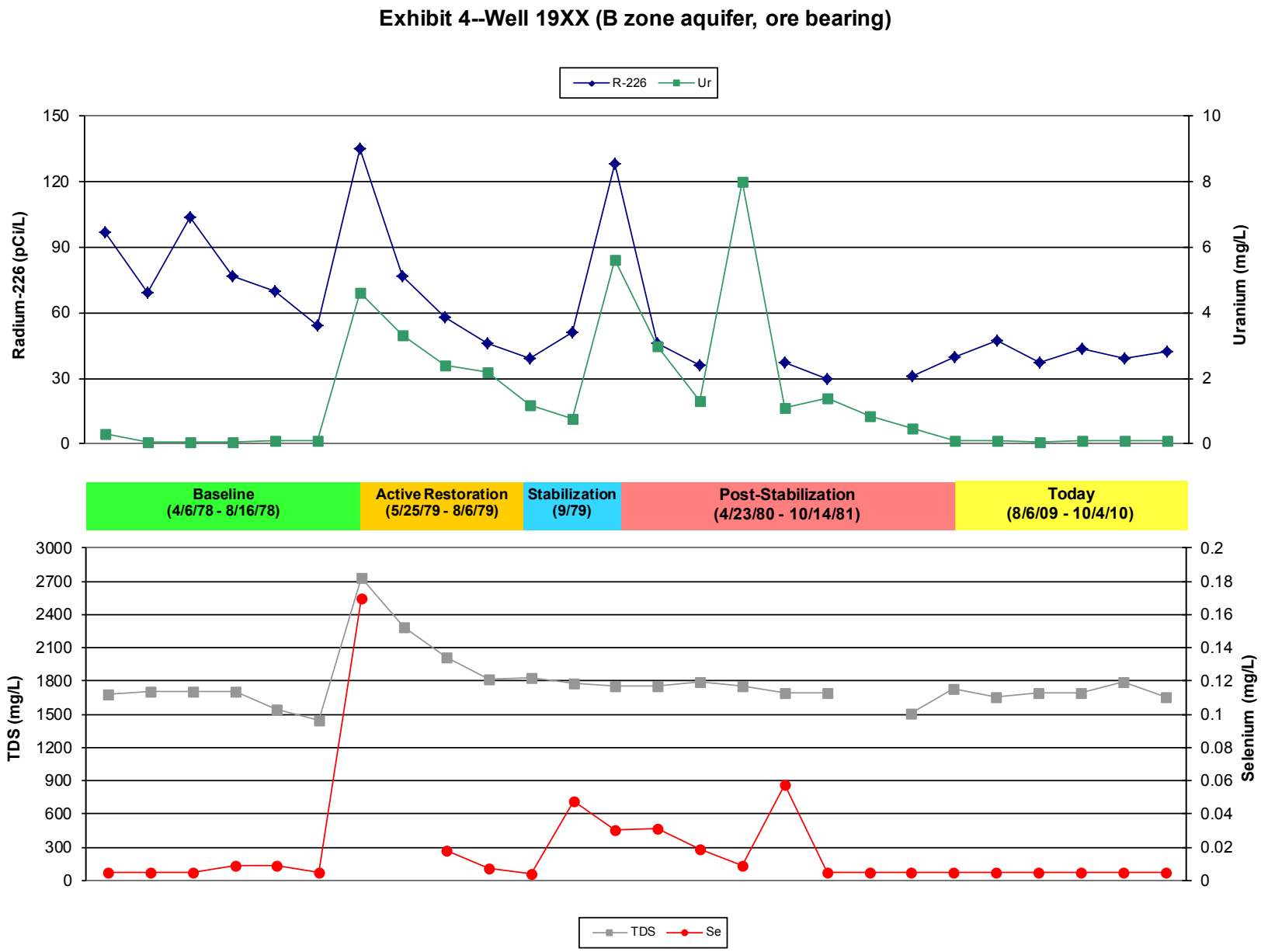
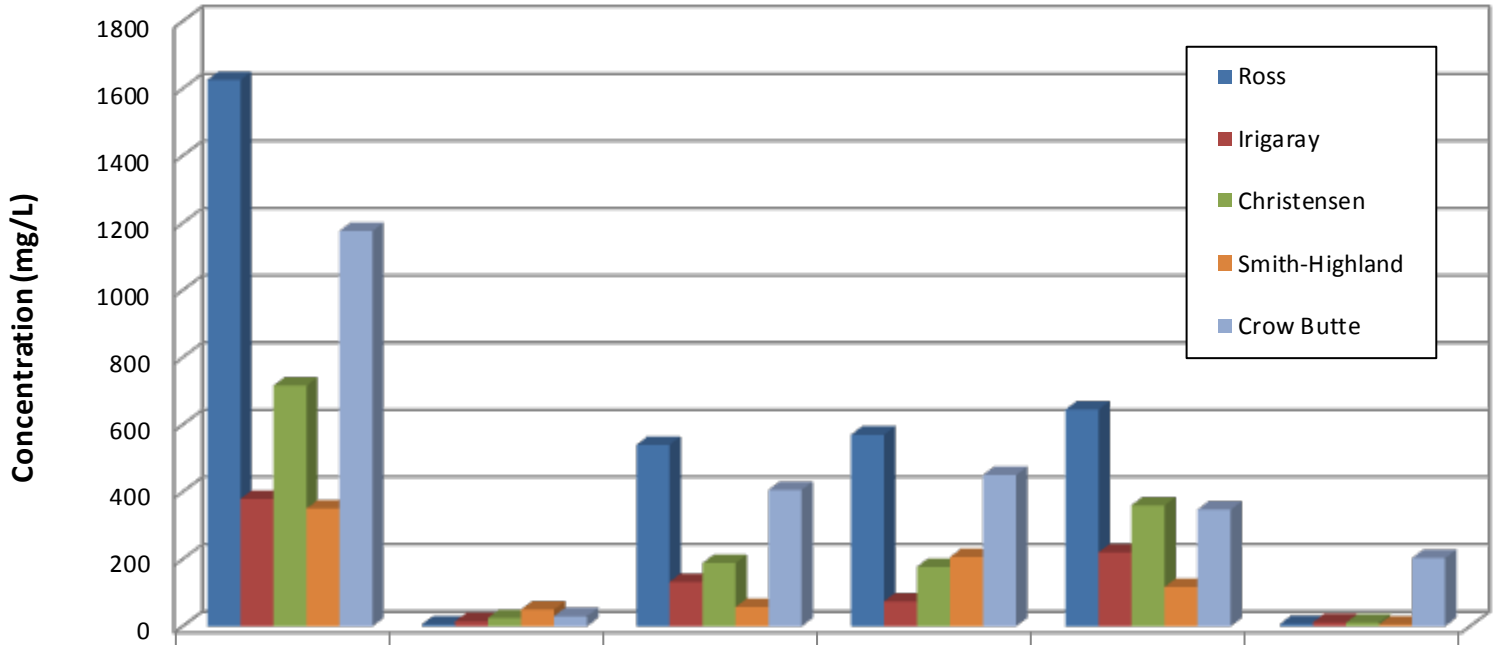


Figure 6.1-3. Comparison of Typical Pre-Recovery Water Quality with Analog Facilities



	TDS	Ca	Na	HCO3	SO4	Cl
Ross	1626	6	540	570	645	7
Irigaray	379	15	132	74	220	12
Christensen	716	25	188	177	360	11
Smith-Highland	350	50	57	206	117	5
Crow Butte	1176	30	406	450	347	203

6.2 Reclamation of Disturbed Land

This section describes general procedures for the surface reclamation plan at the proposed Ross ISR Project. At the completion of the project, all of the disturbed lands will be returned to their pre-production conditions. In the case that the landowner wishes to preserve structures such as roads or buildings, approval of the alternative use from the appropriate agencies will be obtained. The surface reclamation plan goals will be to return the land to equal or better condition than existed prior to uranium recovery and thus making it available for "unrestricted use."

At the proposed Ross ISR project area, the reclaimed land will be capable of supporting livestock grazing, dry land farming and wildlife habitat. Structures and equipment will be decontaminated or deposited at an NRC approved waste facility site. Details regarding disposal of structures and equipment are discussed in Section 6.3. Baseline soils, vegetation, and radiological data will be used to guide the reclamation activities. Prior to final decommissioning and surface reclamation of any area, Strata will submit a detailed decommissioning and reclamation plan to the NRC at least 12 months prior to the commencement of the activities.

Surface reclamation activities will include the following:

- Plug and abandon all wells as described in Addendum 2.6-E.
- Determine the proper soil cleanup criteria as described in Section 6.4.
- Perform a pre-reclamation radiological survey of all facilities, process related equipment and soils to determine the extent of contamination as described in Section 6.3.
- Clean up contaminated areas.
- Perform final soil radiological survey.
- Contour all disturbed areas.
- Establish vegetation and temporary erosion control on all disturbed areas.

6.2.1 Surface Disturbance

The primary surface disturbance areas at the proposed project site include the CPP and support buildings, waste disposal facilities, wellfield module buildings, pipeline corridors, and access roads. Less intensive surface

disturbance will also occur in wellfield areas and adjacent to perimeter monitor wells.

Surface disturbance associated with the CPP, lined retention ponds, deep disposal well infrastructure, and access roads will remain for the life of the project. Disturbances occurring from wellfield and pipeline installation will be reclaimed and reseeded as soon as construction is completed. Vegetation within these areas will likely be established within 2 years. Final reclamation of these areas will occur after groundwater restoration and well abandonment have been approved. The schedule of surface reclamation for the wellfield modules will vary based upon the development sequence.

The estimated surface disturbance at the proposed Ross Project is presented in Table 6.2-1. This includes the primary disturbance associated with the facilities discussed above as well as the disturbance from all wellfield modules and infrastructure.

6.2.2 Topsoil Handling and Replacement

Topsoil will be salvaged prior to surface disturbance activities from building sites, storage areas, pond sites, and access roads in accordance with WDEQ/LQD guidelines and conditions of the WDEQ/LQD permit to mine for this project. Areas to be stripped will be staked and typical earth moving equipment, such as rubber-tired scrapers, will be used for stripping and stockpiling. The depth that topsoil will be stripped to will vary throughout the proposed project area, but is expected to be nearly 2 feet. Soil survey results presented in Section 2.6, calculated the average topsoil salvage depth as 1.74 feet.

All topsoil within the proposed CPP area will be stockpiled adjacent to the plant area, while topsoil associated with other construction activities will be stockpiled in areas to minimize wind and water erosion. Typically this includes locations on the leeward side of hills. Strata will avoid locating stockpiles in drainage channels or other locations that could lead to a loss of material. All stockpile slopes will be 3H:1V or flatter and clearly marked. Strata will seed all stockpiles with an appropriate perennial seed mix to prevent erosion.

During excavation of mud pits associated with well construction, exploration drilling, and delineation drilling activities, topsoil will be separated from the subsoil with a backhoe. The topsoil will be removed and placed in a separate location, while the subsoil is removed and deposited next to the mud

pit. When the use of the mud pit is complete, usually within 30 days, the subsoil is redeposited in the mud pit followed by the replacement of topsoil.

Pipeline ditch construction follows a similar procedure. The topsoil and subsoil will be stored separately with the topsoil being placed on top of the subsoil after the ditch has been backfilled. The topsoil may also be bladed to the side to allow for laying of the pipeline and then bladed back after construction is complete.

During decommissioning, topsoil will be redistributed on disturbed areas to a depth approximately equal to pre-construction conditions. As needed, the subsoil will be ripped to minimize compaction prior to revegetation. As described in Section 5.3, Strata has been employing various methods of soil reclamation according to landowner preference during regional baseline monitoring and exploratory drilling. These methods have included ripping compacted soil with the teeth of a grader, loosening compacted soil with a disc, or simply replacing topsoil and re-seeding. These techniques will continue to be refined and coordinated with WDEQ/LQD and the affected landowners.

6.2.3 Revegetation Methods

Revegetation practices will be conducted in accordance with WDEQ/LQD requirements. During operations, the topsoil stockpiles, and as much as practical of the disturbed wellfield and pond areas, will be seeded to establish vegetative cover to minimize wind and water erosion. After re-spreading of topsoil the area will be seeded with a permanent seed mix. The mix may contain a nurse crop (sterile wheat or oats) to establish a standing vegetative cover along with the permanent seed mix. Mulch may also be used to cover the seed. The seed mix will be chosen to be compatible with the post-production land use. The landowner and WDEQ/LQD will be consulted when selecting the seed mix. Seeding will be conducted by drill or broadcast methods depending upon the type of seed being planted.

The extended reference area concept, as outlined in WDEQ/LQD Guideline No. 2, will be used to evaluate the success of final revegetation and productivity. The extended reference area is comprised of undisturbed portions of pertinent vegetation types within the project area and allows for a statistical comparison with the reclaimed area. The area that the extended reference area has to encompass must be at least half the size of the reclaimed area that is being assessed, or at least 25 acres in size. WDEQ/LQD will be consulted when

choosing the extended reference area to ensure that the area adequately represents the reclaimed area being assessed. The success of the final revegetation and final bond release will be determined by WDEQ/LQD.

6.2.4 Access Road Reclamation

All primary, secondary, tertiary, and temporary access roads constructed for access to the facilities and wellfield will be removed and reclaimed unless exempted from reclamation by the request of landowners/lessees, in which case the landowners/lessees will assume responsibility for their long term maintenance and ultimate reclamation.

Prior to reclamation, any contamination resulting from ISR facility construction or operation will be cleaned to appropriate NRC standards and the contaminated material disposed at a licensed disposal facility. All contaminated soil or gravel that is determined to be 11e.(2) byproduct material will be disposed at a licensed 11e.(2) byproduct material disposal facility, while petroleum-contaminated soil will be disposed at a WDEQ/SHWD licensed facility. Removal of roads will be accomplished by removing excess imported road surfacing material and ripping the road surface and shallow subsoil to loosen the subsoil. Culverts will be removed and pre-construction drainages re-established. The area will be graded to a contour consistent with the surrounding landscape. Topsoil will be re-spread in a uniform manner and the area revegetated.

6.2.5 Waste Storage, Treatment, and Disposal Facility Reclamation

The Class I deep disposal wells will be abandoned and decommissioned in accordance with the requirements of the WDEQ/WQD UIC permit. Well abandonment procedures are included in Addendum 4.2-A. Surface facilities associated with the Class I deep disposal wells will be decommissioned and reclaimed in accordance with methods presented in Sections 6.3 and 6.2.1 through 6.2.4.

Wastes and equipment associated with lined retention ponds such as accumulated sludge, the pond liners, and leak detection piping and materials will be surveyed for radiological contamination and disposed of or released for unrestricted use. The soil beneath the pond will be surveyed for radiological contamination, and any areas that exceed limits for unrestricted use will be excavated and disposed of at an NRC approved facility.

6.2.6 Containment Barrier Wall Reclamation

At the end of operations at the proposed Ross ISR Facility, the containment barrier wall (CBW) surrounding the CPP will be reclaimed to the extent necessary to restore the natural flux of shallow aquifer groundwater beneath the CPP and in the immediate vicinity outside the CBW. The reclamation of this wall will be accomplished by creating a series of breaches, also known as finger drains, along the up-gradient and down-gradient reaches of the CBW. A "one-pass" trencher, very similar to that used to construct the CBW, will be utilized to install the finger drains. Each finger drain will consist of a 1.5 ft wide by 25 ft long trench that is cut through the CBW at a right angle and to a depth that is 2 ft below the lowest historical groundwater level. During the "one-pass" operation, gravel will be placed in the trench from the bottom to a point 2 ft above the highest recorded groundwater level such that a highly permeable flow path is created through the CBW. The remaining trench will be backfilled with topsoil and seeded.

This method of CBW reclamation was selected as a means of effectively restoring the groundwater system in the CPP area, while minimizing surface and environmental disturbance.

Selected monitoring wells that were used to characterize the shallow aquifer at the site before installation of the CBW will be retained, and water levels will be monitored following CBW reclamation to verify that the natural flow of shallow ground water through the CBWs and beneath the CPP has been restored. Measured groundwater levels that show no appreciable gradient across the CBWs will verify that the CBW reclamation and groundwater system restoration are complete.

6.2.7 Surface Restoration and Contouring

There will be very few construction activities that will require any major contouring during reclamation due to the nature of ISR recovery. The central plant area and primary access road are the only areas that will require significant contouring during decommissioning. During decommissioning, the excess fill from the central plant area that was either used to construct the primary access road or stored in a stockpile will be hauled the short distance to the central plant area, redistributed, and compacted in place. All disturbed areas will be re-contoured as necessary to blend in with the natural terrain and consistent with the pre-construction topography. Any affected drainage

channels will also be restored to pre-construction conditions during decommissioning. A survey of the preconstruction topography was conducted in July of 2010 using Light Detecting and Ranging technology. A preconstruction topographical map of the permit area is included in Section 2.1.

Table 6.2-1. Disturbance within the Ross Project Area

Facility	Acres of Anticipated Disturbance	
	During Year Preceding Operating	Over Life of Proposed Action
Central Plant Area	55	55
Wellfield Modules	30	160
Access Roads	12	30
Deep Disposal Wells	3	5
Pipelines	5	15
Utilities	5	15
Total	110	280

6.3 Procedures for Removal and Disposal of Structures and Equipment

Prior to process plant decommissioning, procedures for removing and disposing of structures and equipment will be established. These include the establishment of surface contamination limits, preliminary radiological surveys of process building surfaces, equipment and piping systems, strategic cleanup and removal of process building materials and equipment, sorting materials according to contamination levels and salvageability, and preparing materials for transport and offsite use or disposal, which are discussed below.

6.3.1 Establishment of Soil Contamination Limits

Soil contamination release limits will be modeled using the RESRAD computer model or an equivalent to assure compliance with 10 CFR Part 40, Appendix A, Criterion 6.

6.3.2 Preliminary Radiological Surveys and Contamination Control

Radiological surveys will be conducted prior to process plant decommissioning to characterize the levels of contamination on structures and equipment and to identify any potential hazards. The surveys will be used to develop a program to control residual contamination on structures and equipment. Measurements of radioactivity on the interior surfaces of pipes, drain lines, and duct work will be determined by making measurements at all traps and other appropriate access points. Areas showing evidence of possible contamination will be evaluated further. The contamination control program used during recovery operations, as discussed in Section 5.7.6, will be appropriate for use during decommissioning of structures.

6.3.3 Removal of Process Building and Equipment

Based on the preliminary radiological surveys, all equipment will be removed to a new location within the proposed project area for further use or storage, removed to another licensed facility for either use or permanent disposal, or decontaminated to meet unrestricted use criteria for release. Particular attention will be given to equipment and structures in which radiological materials could accumulate, including piping, traps, junctions, filters, and access points. Materials that can be decontaminated may include piping, valving, instrumentation, and various other types of equipment. The

process buildings will most likely be decontaminated, dismantled, and released for use at another location.

Decontamination of salvageable building materials, equipment, pipe, and other materials to be released for unrestricted use will be accomplished by completing a preliminary radiological survey to determine the location and extent of the contamination and to identify any hazards. The preliminary review will be in the form of an alpha survey. The primary step will be to remove loose contamination from the object by use of high pressure washing. If required, secondary decontamination will consist of washing with dilute acid or equivalent compatible solution. Upon completion of decontamination processes a final alpha, and as needed beta surveys will be performed. The release limits for alpha and beta-gamma radiation from NRC Regulatory Guide 1.86 are as follows:

- Removable alpha contamination of 1,000 dpm/100 cm^2
- Average total alpha contamination of 5,000 dpm/100 cm^2 over an area no greater than 1 m^2
- Maximum total alpha contamination of 15,000 dpm/100 cm^2 over an area no greater than 100 cm^2
- Removable beta-gamma contamination of 1,000 dpm/100 cm^2
- Average total beta-gamma contamination of 5,000 dpm/100 cm^2 over an area no greater than 1 m^2
- Maximum total beta-gamma contamination of 15,000 dpm/100 cm^2 over an area no greater than 100 cm^2

The ALARA principle will apply to the decontamination of surfaces to reduce surface contamination to levels as low as practical. Equipment that cannot be decontaminated to these standards will be sent to an NRC licensed facility for disposal as 11e.(2) byproduct material.

Processing and water treatment equipment, including tanks, filters, IX columns, pipes, and pumps, will be prepared, including decontamination if necessary, for use at another location or dismantled and disposed of in accordance with applicable regulation. Materials contaminated with other industrial constituents will be disposed of at an appropriately licensed facility. Decontaminated and non-contaminated materials will be removed for salvage or disposed of at an appropriately licensed solid waste facility.

Structures will be decontaminated, if necessary, and moved to a new location and salvaged or disposed at an appropriately licensed solid waste facility. Concrete flooring, foundations, and foundation materials will be decontaminated, if necessary, broken up, and disposed of at an appropriately licensed facility.

Records of equipment decontamination, distribution, disposal, and related decommissioning activities will be maintained in accordance with the specifications of Section 5.7. Any necessary decontamination activities will be conducted in accordance with the operating procedures for the project.

6.3.4 Decommissioning of Non-11e.(2) Hazardous Constituents

Strata will decommission all equipment and facilities associated with non-radiological hazardous constituents from both operation and decommissioning activities.

Storage tanks and conveyance piping associated with process chemicals that are hazardous will be cleaned to remove any residual chemicals. The tanks will then be transferred for use at other Strata facilities, sold to another operator, or disposed of at an approved off-site landfill. Tanks and piping will be cleaned by qualified individuals who are trained in the risks of the chemicals and in a manner that is protective of the environment. Proper personal protective equipment will be required during these activities.

Appropriate storage facilities for hazardous chemicals, domestic waste, and other non-radiological wastes generated during decommissioning will be located on-site. Storage of these constituents will be done in accordance with OSHA, EPA, and WDEQ requirements.

6.4 Methodologies for Conducting Post-Reclamation and Decommissioning Radiological Surveys

This section presents methodologies for establishing site specific radiological decommissioning criteria and conducting post-reclamation and decommissioning radiological surveys, including the radiological verification survey program that will serve as a basis for determining compliance with NRC concentration limits. These limits are specified in 10 CFR Part 40, Appendix A, Criterion 6(6). Survey methods provided in NUREG–1575 "Multi-Agency Radiation Survey and Site Investigation Manual" (NRC 2000), along with the applicable site conditions, will be used to define sampling techniques. Determination of background concentrations of Ra-226 and other naturally occurring uranium series radionuclides will be based upon the pre–operational baseline sampling and analysis program described in Section 2.9 and the results of ongoing operational environmental monitoring programs described in Section 5.7.7.

Regulatory Background

On April 12, 1999, the NRC issued a Final Rule (64 FR 17506) that requires the use of the existing soil radium standard (10 CFR 40, Appendix A Criterion 6(6)) to derive a dose criterion for the cleanup of byproduct material. The amendment to Criterion 6(6) of 10 CFR Part 40, Appendix A was effective on June 11, 1999. This "benchmark approach" requires that NRC licensees model the site-specific dose from the existing radium standard and then use that dose to determine the allowable quantity of other radionuclides that would result in a similar dose to the average member of the critical group. These determinations must then be submitted to NRC with the site reclamation plan or included in license applications. Concurrent with publication of the Final Rule, NRC published draft guidance (64 FR 17690) for performing the benchmark dose modeling required to implement the final rule. Final guidance was published as Appendix E to NUREG-1569 which discusses acceptable models and input parameters. Guidance, from the RESRAD Users Manuals (ANL 2001), the Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil (ANL 1993) and site-specific parameters were used in the modeling as discussed in the following sections.

Critical Group

The resident rancher was identified as the critical group for the proposed Ross ISR Project based on historical and current land use practices. Strata considered several other groups including the resident farmer, home-based businesses and light industry and mining. The resident farmer was considered unrealistic as no prime farmland was identified with the proposed project area (Environmental Report, Section 3.3.5) and home-based businesses were also unlikely due to the rural and remote location of the proposed project. Light industry and mining were potential scenarios, although less restrictive than a rancher living on the land and consuming locally grown food.

Records indicate that the area has historically been used for lower density livestock production of cattle, horses and sheep. Therefore, is expected that the resident rancher would receive a higher dose of residual contamination as this individual would spend significant time outdoors and likely consume livestock and produce locally grown.

6.4.1 Cleanup Criteria

RESRAD Version 6.3 computer code was used to model the proposed project area and calculate the annual dose from the current radium cleanup standard. The radium benchmark dose was calculated as the greater of two potential doses:

- The peak potential dose as a result of 5 pCi/g Ra-226 contamination in surface soil (0-15 cm)
- The peak potential dose as a result of 15 pCi/g Ra-226 contamination averaged over 15 cm thick layers more than 15 cm below the surface.

The results of the radium benchmark dose were then applied to create the cleanup criteria for natural uranium contamination. This allows the calculation of a standard for natural uranium in soil which is derived from the concept of the radium benchmark dose approach of 10 CFR 40, Appendix A, Criterion 6(6). This approach is designed to meet NRC issued Final Rule (64 FR 17506) that requires the use of the existing soil radium standard (see 10 CFR 40, Appendix A Criterion 6(6); 5pi/gram at 0-15 cm, 15 pCi/gram > 15 cm subsurface) to derive a dose criterion for the cleanup of byproduct material.

The following sections present the results of the radium benchmark dose and cleanup criteria for natural uranium in soil. The model for the critical

group assumed that the resident rancher would be located on the proposed project area directly over a 10,000-m^2 contamination zone, near a surface water body (i.e., Oshoto Reservoir) from which livestock drink. No contamination above background was assumed for drinking water. Additional specifics inputted into the RESRAD model, including assumptions, are provided in Addendum 6.4-A.

6.4.1.1 Determination of Radium Benchmark Dose

RESRAD calculations were performed over a 1000 year period for two scenarios to determine the radium benchmark dose. The first scenario modeled surface contamination (5 pCi/g Ra-226 over the first 15 cm of surface soil), while the second scenario modeled subsurface contamination (15 pCi/g Ra-226 over 15 cm subsurface soils with 15 cm clean cover).

The maximum Total Effective Dose Equivalent (TEDE) for each scenario is summarized in Table 6.4-1 and depicted in Figure 6.4-1. The results indicate that the maximum dose of surface contamination will occur at year zero, while the maximum dose of subsurface contamination will occur approximately 25 years following decommissioning. As previously stated, the radium benchmark dose is the greater of the two scenarios (33.4 mrem TEDE). The TEDE includes dose contribution from external deep dose equivalent associated with ground shine and internal dose from inhalation and ingestion of plants, animals and soil.

Since the TEDE is the sum of multiple pathways the contribution of each pathway was evaluated. Table 6.4-2 summarizes the contribution of each pathway for the maximum dose of the two scenarios. In both cases, the ground shine pathway (external exposure) is the dominant pathway, although it is not maximized in the subsurface scenario until the clean cover soil begins to erode away. Contributions from each pathway over the 1000-year period are presented in Figure 6.4-2 and 6.4-3 for the surface and subsurface scenarios, respectively.

A sensitivity analysis was also performed for several parameters that were considered particularly important to major dose pathways for the surface scenario. The sensitive parameters were identified as the area of the contaminated zone, mass loading for inhalation, wind speed, contaminated fraction of plant diet and fraction of time spent outdoors.

The results of the sensitivity analysis are presented in Table 6.4-3. The results indicate that changes to sensitive parameters have negligible impact to the maximum dose; however, two parameters, contaminated fraction of plant food and fraction of time spent outdoors, resulted in a dose change of more than 1 mrem/yr. The table shows that increases to the fraction of plant diet correspond with increased doses (less than 5 mrem/yr across the range). Similarly, as the fraction of time spent outdoors increased from 0.33 to 0.75 the dose increased almost 20 mrem/yr. This result was expected given that the dose is primarily due to ground shine. Although the dose does increase with exposure time, the results remain well below the 10 CFR Part 20 exposure limit of 100 mrem/yr. Additional details of the sensitivity analysis are presented in Addendum 6.4-A.

6.4.1.2 Determination of a Natural Uranium Soil Standard and Considerations for Thorium

The RESRAD model was then used to determine the concentration of natural uranium in soil above background that would result in a maximum radium benchmark dose of 33.4 mrem/yr. The method involved modeling the dose from a preset concentration of natural uranium in soil. This dose was then compared to the radium benchmark dose and scaled to arrive at the maximum allowable natural uranium concentration in soil.

For ease of calculations, a preset concentration of 100 pCi/g natural uranium was used for modeling the dose. The isotopic composition of natural uranium was assumed to be 48.9 percent U-234, 48.9 percent U-238 and 2.2 percent U-235. All other input parameters were the same as those used in the Ra-226 benchmark modeling.

The model was set up to calculate doses for each of the three inhalation classes of uranium (Class Y, W, and D). The results of the model, summarized in Addendum 6.4-A, indicated negligible differences between the classes and therefore results for the W solubility class are described in this section. A discussion of yellowcake solubility is presented in Section 5.7.4.

Based on the natural uranium concentration in soil of 100 pCi/g, the model calculated a maximum dose of 6.98 mrem/yr. This dose was then scaled to the radium benchmark dose, using the following equation, to calculate the uranium soil standard.

$$\frac{[U]_1}{D_1} = \frac{[U]_2}{D_2}$$

Where: [U] = Concentration of natural uranium in soil (pCi/g)
D = Dose received as a result of [U]
Scenario 1= A default consideration of 100 pCi/g of natural uranium in soil and its resultant dose
Scenario 2= The uranium concentration that results from the radium benchmark dose

The use of this ratio provided a uranium soil standard limit of 479 pCi/g to meet the radium benchmark dose criteria.

The results of the calculated uranium standard in conjunction with the radium soil standards will be used at the Ross ISR Project to determine the need for reclamation in soils. The cleanup criteria will be based on the unity (sum of fractions) rule for Ra-226 and natural uranium contaminations when both constituents are present. In general, reclamation will meet the clean-up criteria if:

$$\left(\frac{\text{Soil Uranium Concentration}}{\text{Soil Uranium Limit}}\right) + \left(\frac{\text{Soil Radium Concentration}}{\text{Soil Radium Limit}}\right) < 1$$

It is not expected that elevated levels of Th-230 will be encountered during radiological monitoring associated with soil remediation activities. However, Th-230 will be radiochemically analyzed in representative soil samples. If elevated levels are indicated, scaling ratios and a sum of fractions rule similar to that described above for radium and uranium will be used to develop a clean-up criteria for Th-230 such that, combined with Ra-226, would result in a radium concentration (residual plus decay of thorium) that would be present in 1,000 years that meets the radium clean-up criteria and/or the radium benchmark dose.

In regards to other nuclides of interest, there is no evidence that there are elevated levels of natural Th-232 in the environs at the Ross ISR Project and this nuclide and its decay chain are not associated with the natural uranium series. The longer-lived radon progeny Pb-210 (half life 22 years) is also not expected to be elevated during the reclamation period since as Ra-226

decays into Rn-222, much of the radon gas escapes the surface soil prior to decay into its progeny.

6.4.2 Radiological Monitoring During Soil Remediation Activities

Strata will use hand-held radiological survey instrumentation and GPS-based gamma surveys to guide soil remediation efforts. Soil excavations will be monitored by field personnel to ensure contaminated material is removed in order to meet the cleanup criteria. Support will be provided by GPS-based gamma surveys periodically to more accurately assess the progress of excavation. Strata will prepare SOPs for inclusion in the project Radiation Safety Manual to define specific soil remediation methodologies.

6.4.3 Soil Remediation Verification and Sampling Plan

Remediation of soils are expected to be restricted to a few areas where there are known (or suspected and verified through survey) spills. Final GPS-based gamma surveys will be conducted in potentially contaminated areas by dividing the area into 100 m^2 grid blocks. In addition, soil samples will be collected from grid blocks with gamma count rates previously correlated with Ra-226 concentrations, exceeding the action level (e.g., 5 pCi/g Ra-226). The samples will be five-point composites. Radium concentrations estimated via gamma survey will be collaborated by radiochemical analysis of representative samples.

6.4.4 Quality Assurance

Verification soil samples will be sent to a commercial laboratory for analysis of Ra-226 and natural uranium. The commercial laboratory will be required to have a well-defined quality assurance program that addresses the laboratory's organization and management, personal qualifications, physical facilities, equipment and instrumentation, reference materials, measurement traceability and calibration, analytical method validation, SOPs, sample receipt, handing, storage, records, and appropriate licenses. Strata will maintain a laboratory QA file that will include, at a minimum, the laboratory's Quality Assurance Manual (QAM) and audit reports. The commercial laboratory's QA program will need to comply with the Ross Project QA Manual.

6.4.5 Health Physics and Radiation Safety during Decommissioning

The health physics and radiation safety program for decommissioning will ensure that occupational radiation exposure levels will be kept as low as reasonably achievable. The Radiation Safety Officer and/or Radiation Safety Technician or designee will be on site during any decommissioning activities where a potential radiation exposure hazard exists. In general, the radiation safety program discussed in Section 5.7 and the Ross Project Radiation Safety Manual will be used as the basis for development of the decommissioning health physics program. Health physics surveys conducted during decommissioning will be guided by applicable sections of Regulatory Guide 8.30 and other applicable regulatory guides and standards (see Section 5.7)

6.4.6 Records and Reporting Procedures

At the conclusion of site decommissioning and surface reclamation, a report containing all applicable documentation will be submitted to the NRC. Records of all contaminated materials transported to a licensed disposal site will be maintained for a period of five years or as otherwise required by applicable regulations at the time of decommissioning.

Table 6.4-1. Maximum Dose (TEDE) from Surface and Subsurface Ra-226 Contaminations

Scenario	Max Dose (mrem)	Time Max Dose Occurs (years after decommissioning)
Surface Contamination	33.4	0
Subsurface Contamination	22.9	25.4

Table 6.4-2. Maximum Dose (TEDE) by Pathway for Surface and Subsurface Contamination Scenarios

	Surface Contamination		Subsurface Contamination	
Pathway	**Dose (mrem)**	**Total Dose (%)**	**Dose (mrem)**	**Total Dose (%)**
Ground	30.83	92.3	14.19	62.1
Inhalation	0.003782	0	0.001525	0
Plant	1.946	5.8	7.437	32.5
Meat	0.4144	1.3	0.9501	4.2
Soil	0.1942	0.6	0.2824	1.2
Total	**33.39**	**100**	**22.86**	**100**

Table 6.4-3. Sensitivity Analysis

Parameter	RESRAD Input	Maximum Dose (mrem/yr)
Area	20000 m^2	33.12
	10000 m^2	33.03
	5000 m^2	32.83
Contaminated Fraction of Plant Food	0.5	35.01
	0.25	33.03
	0.125	31.93
Fraction of Time Spent Outdoors	0.75	44.35
	0.50	33.03
	0.33	25.41
Mass Loading for Inhalation	0.0005	33.03
	0.0001	33.03
	0.00002	33.02
Wind Speed	6.7 m/s	33.03
	4.5 m/s	33.03
	3 m/s	33.03

Figure 6.4-1. Total Annual Dose for Surface and Subsurface Scenarios

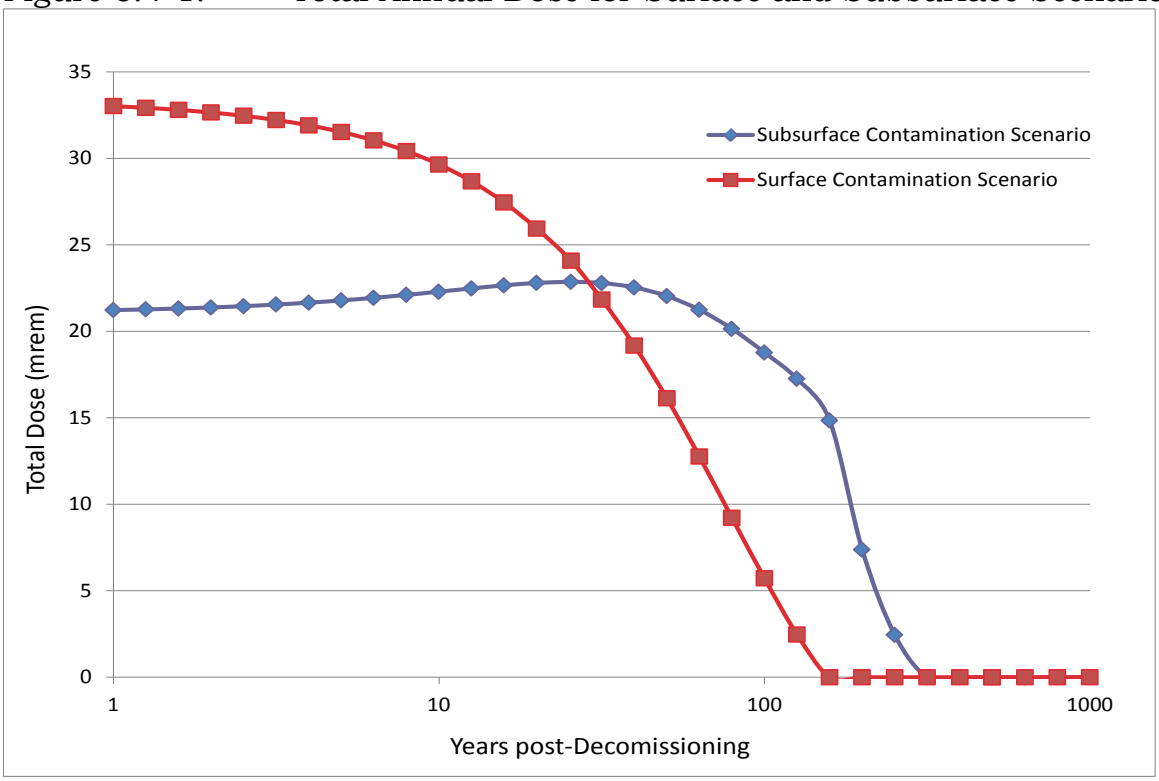


Figure 6.4-2 Surface Contamination Scenario Dose by Pathway

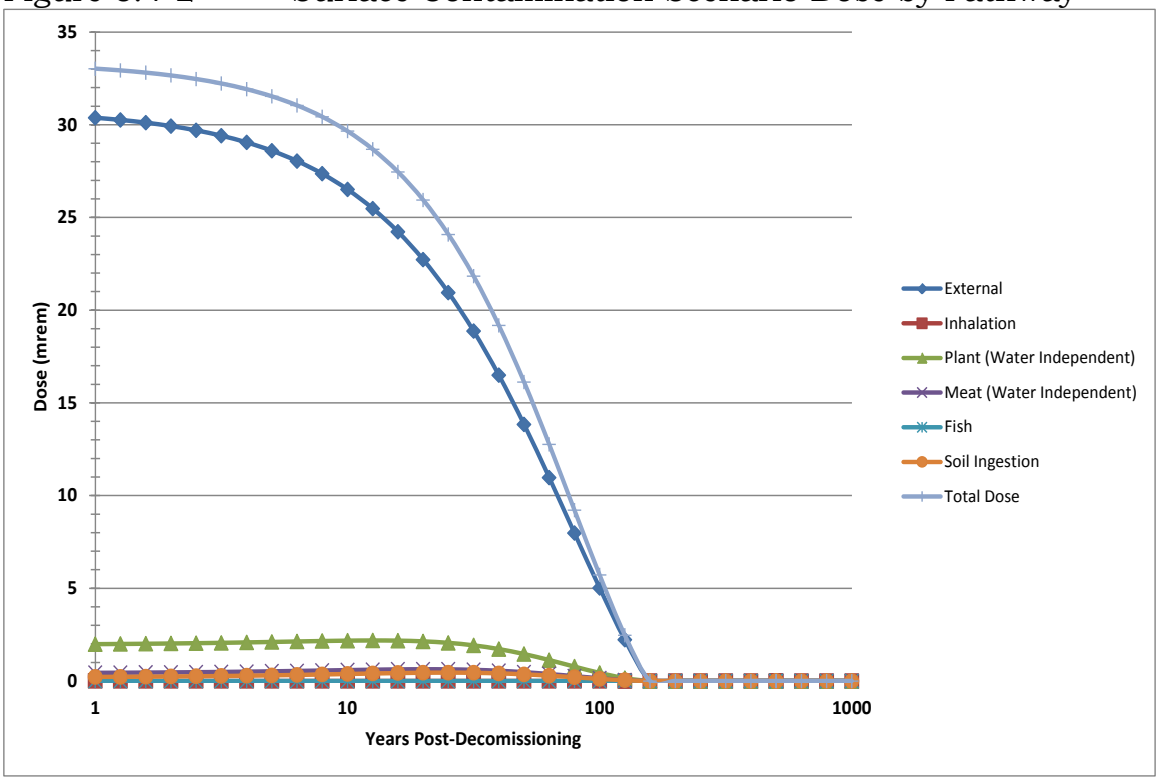
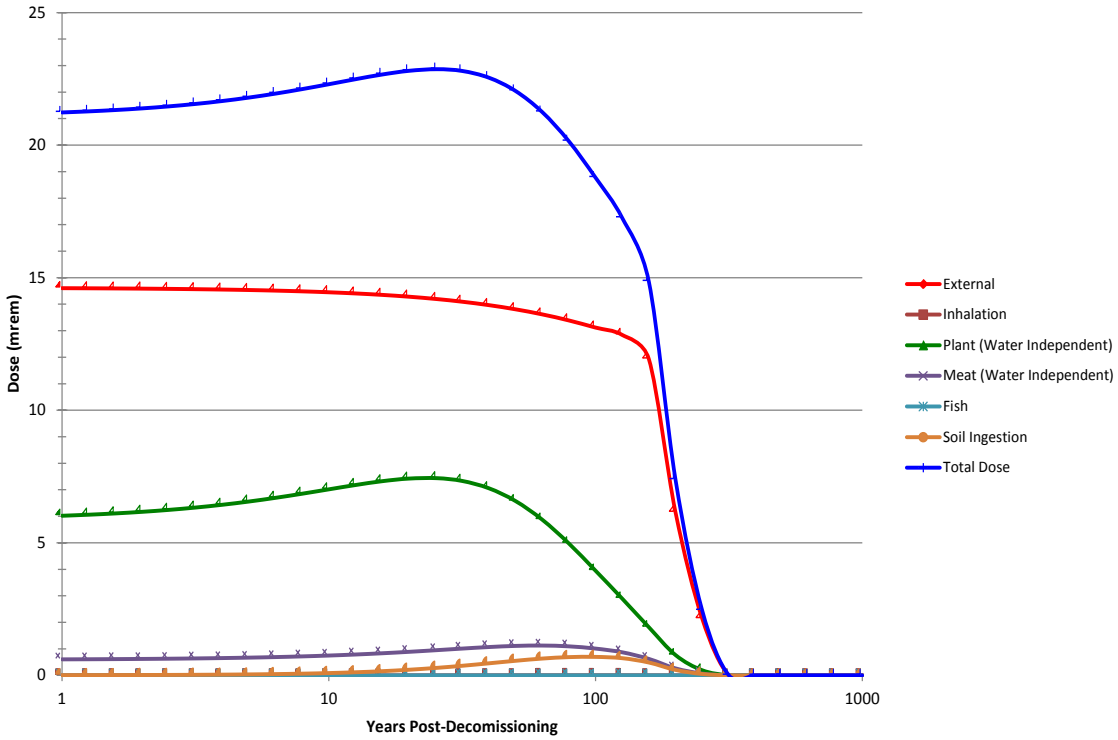


Figure 6.4-3 Subsurface Contamination Scenario Dose by Pathway



6.5 Financial Assurance

Based on Strata's proposed RAP in Addendum 6.1-A, appropriate financial assurance arrangements with the NRC and WDEQ/LQD will be established to cover the costs of groundwater restoration decontamination and decommissioning of process buildings and the equipment, and surface reclamation at the site so that it can be released for unrestricted use. The financial assurance funding mechanism is currently unknown at this time however, Strata will provide a mechanism for the approved financial assurance estimate in accordance with the conditions as set forth in 10 CFR Part 40, Appendix A, Criterion 9, prior to beginning active uranium recovery operations.

The financial assurance for the proposed Ross ISR Project only includes reclamation for a portion of the first Mine Unit and the facilities area. Costs of reclamation and restoration of additional Mine Units will be added as they come online and will be submitted to the NRC 90 days prior to beginning associated construction. Costs estimates for well monitoring are based on procedures set forth in Section 6.1.2.6 of this report. Strata will provide the NRC with copies of financial assurance related correspondence, the State of Wyoming's review, and the final approved financial assurance arrangement.

An updated Annual Financial Assurance Estimate Revision will be submitted to the NRC and WDEQ/LQD each year adjusting the value of the mechanism to reflect existing operations and any additional module buildings planned for construction or operation in the first Mine Unit in the following year pursuant to Criterion 9. Any surface spills requiring cleanup will also be included in the updated revision. After review and approval of the Annual Financial Assurance Estimate Revision by the NRC and WDEQ/LQD, Strata will update the mechanism to reflect the revised amount. Strata will extend the financial assurance device an additional year if NRC has not approved a proposed revision 30 days prior to the mechanism expiration date, if any. Within three months of commission approval, Strata will update the financial assurance amount to reflect additional costs, if any, that result from the approved RAP for the proposed Ross ISR Project.

6.6 References

ANL (Argonne National Laboratory), 2001, Yu, C., Zielen, A.J., Cheng, J.J., LePoire, D.J., Gnanapragasam, E., Kamboj, S., Amish, J., Wallo, A. III, Williams, W. A., and Peterson, H., 2001, User's Manual for RESRAD Version 6.

_____, 1993, Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil.

ASTM, (American Society for Testing and Materials), 2005, D6312-98, Standard Guide for Developing Appropriate Statistical Approaches for Ground-Water Detection Monitoring Programs, 2005.

Cameco Resources, 2009a, Smith Ranch-Highland Operation Mine Unit B Ground Water Submittal, including Restoration Report, Correspondence, Stability Report, and Final Approval – WDEQ, June 26, 2009, NRC ADAMS Accession No. ML091831100.

_____, 2009b, Crow Butte North Trend License Amendment Attachments, , November 20, 2009, NRC ADAMS Accession No. ML093520688.

_____, 2008, Highland Uranium Project Mine Unit 9 Hydrologic Test Report, Cameco Resources and Hydro-Engineering, LLC, January 2008, NRC ADAMS Accession No. ML081350710.

CBR (Crow Butte Resources, Inc.), 2009, North Trend Expansion Area Technical Report, Revised February 27, 2009, NRC ADAMS Accession No. ML090750428.

_____, 2007, North Trend Expansion Area Technical Report, Vol. I, NRC ADAMS Accession Nos. ML071760344, ML071760347 and ML071760349.

_____, 2000, Mine Unit 1 Restoration Report, Crow Butte Uranium Project, January 10, 2000, NRC ADAMS Accession No. ML003677938.

COGEMA Mining, Inc., 2008a, Wellfield Restoration Report, Christensen Ranch Project, Wyoming, prepared by COGEMA Mining, Inc. and Petrotek Engineering Corporation, March 5, 2008, NRC ADAMS Accession Nos. ML081060131, ML08106132 and ML081060140.

_____, 2008b, Irigaray and Christensen Ranch Projects U.S. NRC License Renewal Application, Source Material License SUA-1341, May 2008, NRC ADAMS Accession No. ML081890414.

_____, 2004, Irigaray Wellfield Restoration Report, Response to LQD/DEQ January 10, 2005 Comments, prepared by COGEMA Mining, Inc., Petrotek Engineering Corporation and Resource Technologies Group, May 4, 2005, NRC ADAMS Accession No. ML053270037.

LCI (Lost Creek, Inc.), 2010, Responses to NRC RAIs, Lost Creek Project, April 2010, NRC ADAMS Accession No. ML102100241.

_____, 2009, 3rd Round WDEQ/LQD Comment Responses, October 22, 2009, NRC ADAMS Accession No. ML100610158.

NRC (U.S. Nuclear Regulatory Commission), 2009, NUREG-1910, Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities, Final Report, May 2009.

_____, 2003, NUREG-1569, Standard Review Plan for In situ Leach Uranium Extraction License Applications, June 2003.

_____, 2000, NUREG-1575, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), August 2000.

_____, 1992, NUREG/CR-5512, Residual Radioactive Contamination from Decommissioning, October 1992.

Power Resources, 2003, Smith Ranch-Highland Uranium Project, Source Material License Application, March 12, 2003, NRC ADAMS Accession No. ML030730592.

WDEQ/LQD (Wyoming Department of Environmental Quality – Land Quality Division), Chapter 11, Noncoal In Situ Mining, May 2005

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7.0 POTENTIAL ENVIRONMENTAL IMPACTS

This chapter provides a description of the environmental conditions and how they will be affected by ISR operations. The potential impacts to environmental resources during the construction, operation, aquifer restoration, and decommissioning phases are analyzed in detail including radiological and non-radiological effects as well as the potential for accidents due to chemical spills, fires and explosions, transportation of materials, and natural disasters. The economic and social effects of construction and operation are also evaluated.

7.1 Potential Impacts during Construction for the Proposed Action

The following section summarizes the environmental impacts of the proposed project from construction. A more detailed discussion of the environmental impacts is included in Chapter 4.0 of the ER.

7.1.1 Potential Land Use Impacts during Construction

Existing land uses include livestock grazing on rangeland, dry land crop production, oil production, recreation, wildlife habitat, and transportation/utilities. The Proposed Action includes construction of 15 to 25 sequentially developed ISR wellfield modules and a CPP for uranium and vanadium processing. Of the approximately 1,721 acres within the proposed project area, approximately 280 acres are anticipated to be disturbed over the life of the project. Much of the proposed project area will remain undisturbed due to the relatively minor nature of surface disturbance associated with the ISR process. Nevertheless, construction of the proposed Ross ISR Project has the potential to impact land use in the proposed project area through the following mechanisms:

(1) Changing and disturbing existing land uses,
(2) restricting access or establishing right-of-way access,
(3) affecting mineral rights,
(4) restricting livestock grazing areas,
(5) restricting recreational activities, and
(6) altering historical and cultural resources.

7.1.1.1 Changing and Disturbing Existing Land Uses

Surface disturbance will occur as result of construction of the CPP and other facilities within the central plant area (offices, lined retention ponds, surface runoff control features and similar) along with wellfield modules, access roads, deep disposal wells, pipelines, and utilities. Potential changes or disturbances in land use resulting from the construction of these facilities are discussed below. Due to the relatively minor nature of disturbance created by construction of an ISR uranium recovery facility, there are only a few areas such as lined retention ponds disturbed to the extent to which subsoil and geologic markers are removed, causing topographic changes that need backfilling and recontouring during decommissioning. Potential impacts resulting from surface disturbance will be small due to the relatively small

disturbance area and due to restoring and re-seeding of much of the disturbed area during the same construction season. Potential future land use impacts resulting from surface disturbance will be negligible, since the entire project area will be returned to pre-operational use and release for unrestricted use following project D&D.

Central Plant Area

The central plant area will include the CPP building, storage facilities, office/warehouse facilities, lined retention ponds, and other piping and equipment. Construction of the central plant area is estimated to disturb approximately 55 acres, including the facilities flood control diversion channel and the primary topsoil stockpile for the central plant area.

The land on which the CPP is located is currently used for dry land crop production and pasture for livestock. These land uses will be temporarily changed to industrial throughout the construction, operation, aquifer restoration, and decommissioning phases. Following decommissioning and release of the proposed project area for unrestricted use, the land uses can revert to dry land crop production and pasture.

Wellfield Modules

Each wellfield module will consist of injection and recovery wells connected to a common module building and associated monitor wells. Construction of the 15 to 25 wellfield modules planned within the proposed project area is estimated to disturb up to 160 acres with up to 30 acres disturbed during the year preceding operation. Surface disturbing activities associated with wellfield module construction will include topsoil stripping, constructing temporary well pads, constructing temporary access roads, excavating mud pits, trenching for pipelines and buried electrical utilities, and excavating foundations for module buildings.

The wellfield modules will be constructed predominantly on land currently used for livestock grazing. This land use will temporarily change however, temporary well pads, mud pits, well pad access roads, and pipelines will be restored and re-seeded at the end of construction. Therefore, disruption to livestock grazing will be temporary except for fenced wellfield areas and the relatively small area surrounding and including each module building.

Other land uses within areas potentially disturbed by wellfield module construction include industrial use (oil production), communication and power lines, transportation, recreation, reservoirs, and wildlife habitat. Strata will work with the operating oil company to ensure that there are no interruptions in oil production activities. Communication, power lines, and county roads will be avoided during wellfield module construction. There will be no changes in these land uses with the exception of brief traffic interruptions resulting from pipeline and utility crossings of existing county and private roads.

Access Roads

Access roads constructed under the Proposed Action will include the primary access road between the New Haven Road and the central plant area, secondary access roads within the central plant area and between the central plant area and the wellfield module buildings, and tertiary access roads used to access monitor wells. The maximum estimated surface disturbance associated with access road construction, excluding access roads within the central plant area, is 30 acres with up to 12 acres disturbed during the year preceding operation.

Surface disturbing activities associated with access road construction include topsoil stripping and stockpiling, excavation, backfill, compaction, and grading. Significant cut and fill are planned only for the primary access road in order to provide a relatively level grade and wide driving lanes for heavy trucks. Secondary access roads will generally follow the existing topography, and tertiary roads will be unconstructed, two-track roads.

Access roads will predominantly be constructed on land currently used for livestock grazing. Potential changes in this land use will be small and temporary. While up to 30 acres are estimated to be disturbed during access road construction, only about half of this area will be surfaced with gravel. Surface disturbance will be minimized by locating access roads, pipelines, and utilities in common corridors and by utilizing existing roads wherever possible.

Deep Disposal Wells

Strata will construct up to five deep disposal wells as part of the Proposed Action. One of the deep disposal wells will be located in the central plant area and the remaining wells will be located throughout the proposed project area. The maximum estimated surface disturbance associated with

deep disposal well construction is 5 acres with up to 3 acres disturbed during the year preceding operation. Surface disturbing activities associated with deep disposal well construction include topsoil stripping, well pad grading, and mud pit excavation.

Of the four deep disposal wells proposed outside of the central plant area, all are proposed on land currently used for livestock grazing on rangeland. One well, proposed in the NWNE Section 13, T53N, R67W, is on land identified in as cropland and pasture. This land in not currently being used for crop or hay production, but it has been used for this purpose in the past and could be again in the future. Throughout the life of the proposed Ross ISR Project, areas used for deep disposal wells will change from the existing land uses (grazing and, potentially, crop land) to industrial use. However, the impact will be small, since the deep disposal wells occupy a very small portion (less than 0.3%) of the proposed project area and are very similar to oil production facilities currently present in the area.

Pipelines

Pipelines will include trunk lines carrying barren lixiviant and recovery solutions between the CPP and module buildings, feeder lines carrying these solutions between the module buildings and injection/recovery wells, and deep disposal well pipelines. The disturbance area associated with feeder lines, trunk lines, and deep disposal well pipelines adjacent to newly constructed access roads has been included in other estimated disturbance areas. The total estimated disturbance area resulting from trunk line and deep disposal well pipelines that are not in an access corridor is 15 acres. The amount anticipated during the year preceding operation is 5 acres.

Surface disturbing activities associated with pipeline construction will include topsoil stripping, trenching, backfill, topsoil replacement, and re-seeding. Pipeline corridors will be restored and re-seeded immediately, and changes in land use will be accordingly brief. Potential changes in land use are similar to those described previously for wellfield module construction surface disturbance will be minimized by locating pipelines in common corridors with access roads and utilities wherever possible.

Utilities

Utilities that are anticipated to be installed under the Proposed Action include a buried gas pipeline supplying natural gas to the central plant area, overhead electrical lines supplying electrical power from a nearby transmission line to the CPP and from the CPP to the module buildings, and buried electrical lines providing power within the central plant area and within wellfield modules. The total estimated disturbance resulting from utility construction is 15 acres, with up to 5 acres disturbed during the year preceding operation. Potential changes and disruptions to existing land uses will be temporary, since areas disturbed during utility installation will be restored and re-seeded during construction.

7.1.1.2 Access Restrictions and Establishment of Right-of-Way

The primary land use within the proposed project area is livestock grazing on rangeland. This land use will be impacted during construction through the exclusion of livestock from disturbed areas and fenced areas. Much of the disturbed area will be restored, re-seeded and made accessible. Strata estimates that about one-half of the disturbed area (CPP area and active wellfield modules) will be fenced to exclude livestock during construction. Access for dry land crop production, wildlife habitat, and recreation will be similarly impacted during construction.

No public right-of-way will be established during construction of the proposed Ross ISR Project. All access roads will be private access roads for Strata employees and contractors and will be reclaimed during decommissioning unless they are transferred to the affected landowner.

7.1.1.3 Mineral Rights

The only known minerals in the project area other than those proposed to be developed by Strata in the Ross ISR Project are conventional oil and gas. There are three producing oil wells, two water injection wells and three water supply wells used for enhanced oil recovery within the proposed project area. The existing oil wells and water injection wells will not be impacted by the Proposed Action due to the large difference in target completion intervals between oil production and ISR injection and recovery wells. Water supply wells used for enhanced oil recovery are completed in the ore zone may be

affected. Strata will work with the oil production company to provide an alternate supply of water or alternate method for enhanced oil recovery.

7.1.1.4 Livestock Grazing and Agricultural Restrictions

Approximately 95% of the land use within the proposed project area is attributed to livestock grazing and dry land crop production. No further restrictions will be made on these land uses beyond the access restrictions discussed in Section 4.1.1.1.2. Livestock and agricultural land use will be temporarily restricted from disturbed areas until they are restored and re-seeded. Long term access restrictions will occur for the fenced central plant area and the fenced wellfield areas.

Of the 40 BLM-administered surface acres, only 1.3 acres (3%) are anticipated to be disturbed under the Proposed Action. Grazing permits on State of Wyoming surface will potentially be impacted by construction of fenced wellfield areas. The total fenced wellfield area is estimated to be up to 50 acres at any one time. Surface use agreements will be established between Strata and surface owners/lessees to provide mitigation or compensation for temporary loss of areas currently used for livestock grazing or crop production.

7.1.1.5 Restrictions on Recreational Activities

Recreational activities, including hunting, will be minimally impacted under the Proposed Action. Hunting and recreation are not major land use activities in the proposed project area therefore, these activities will be minimally impacted due to access restrictions. To protect workers, hunting will be restricted from the proposed project area during the life of project. Big game hunting is currently limited in the proposed project area due to the small percentage of publicly owned lands (approximately 20.6%) and limited access. There is no public access to BLM lands and limited recreation opportunity on State of Wyoming lands therefore, the impact on these land uses due to the restricted access areas will be small.

7.1.1.6 Altering Historic and Cultural Resources

Potential impacts to historic and cultural resources will be kept small by avoiding construction in sites identified by the Class III inventory as potentially eligible for listing on the NRHP, by consultation with the appropriate SHPO and Tribal Historic Preservation Office, by negotiating a memorandum of agreement

with the Wyoming Archeologist to ensure the preservation or data recovery from any historical, cultural, and archeological sites that may be present within the proposed project area, by implementing a phased identification of previously unidentified historic and cultural resources during all phases of the Proposed Action, and by implementing a stop-work provision if any previously undiscovered cultural resources are encountered during construction.

7.1.2 Potential Socioeconomic Impacts during Construction

Socioeconomic impacts during construction of the Ross ISR Project are described in Section 4.10.1.1 of the ER. The workforce necessary for construction of the CPP and other buildings, access roads, lined retention ponds, and general civil/site work is projected to be 115 employees, and the duration of construction is projected at 6 to 12 months. For wellfield construction, the maximum workforce is estimated at up to 85 workers, and the duration of construction is projected at 3 to 5 years. Thus the impacts from employment for the Ross ISR Project will be approximately the same as the projections in the ISR GEIS for a typical ISR project. The workforce who constructs the initial wellfield modules will overlap with the operational workforce employed for ongoing wellfield construction.

As described in Section 3.10 of the ER, unemployment has risen throughout the region since 2007. As described in Section 4.10.1.1 of the ER, it is expected that the local labor force should be sufficient in number and have the skill set to accommodate the employee needs of the Ross ISR Project without the need to import labor from outside the region. Thus, labor impacts from the construction of the Ross ISR Project would be small.

Assuming the number of persons per household in Wyoming is about 2.5 (U.S. Census Bureau 2008), the number of people associated with the anticipated maximum workforce could be as many as 500 (i.e., 200 workers times 2.5 persons/household). Because there is sufficient local labor in Campbell and Crook counties for construction of the Ross ISR Project, the population of the area and the demand for housing are not expected to increase significantly as a result of the Ross ISR Project. With little or no increase in population, it follows that the demand for public services (schools, police, fire, emergency services) would not be expected to increase significantly with the construction of the Ross ISR facility. Since the proposed project area is in a sparsely populated portion of Crook County, there may be a need for additional

standby emergency services not immediately available in the proposed project area. Strata plans to develop contingency plans and/or additional training for specialized service employees, such as EMTs, and equipment, such as ambulances and fire-fighting equipment. Infrastructure (streets, waste management, utilities) for the families of the Ross ISR construction workforce would not be significantly impacted since the labor from the Ross ISR Project can be supplied primarily from the local labor force.

The equipment inside the plant, including the IX columns, uranium and vanadium processing equipment, water treatment RO systems, and associated pumps, motors and control systems, will be largely manufactured off site and assembled by local contract labor. Therefore the influx of workers is expected to result in a small impact in Crook and Campbell counties. Because of the short duration of plant construction (about 6 months) and the small size of the workforce compared to the available labor pool in these two counties (see Section 4.10.1.1 of the ER), any potential impacts of worker influx will be mitigated by preferentially sourcing the labor force from the within the surrounding region.

Construction impacts to regional income for the Ross ISR facility in the Nebraska-South Dakota-Wyoming Uranium Milling Region will also likely be small. This construction is likely to draw upon the labor force within the region before going outside the region (and state). It would benefit the region to have the labor force drawn from within the region and reduce the unemployment rates of Crook and Campbell counties. Still, any impacts will be moderated by the short duration of construction.

The construction phase of the proposed project would be expected to last for approximately 3 to 5 years. Given the general current global recession and the downward pressure on natural gas prices (suppressing exploration and development of CBNG projects), lower demand for electricity and therefore coal production, the recent rise in local unemployment rates (to around 6%), and the small number of workers expected during the construction phase, the impact of the proposed action on employment would be small and beneficial in the short term if the project were to begin under currently prevailing economic conditions.

It is expected that construction workers would be paid the regional rates typical of Campbell County, where a higher percentage of jobs are in the relatively higher-paying energy industry. Impacts of construction of the Ross

ISR Project on local income would be relatively short-term, lasting about 3 to 5 years, and would be small, consisting primarily of temporarily providing jobs to 200 workers, many or most of whom are currently unemployed.

Because most of the construction work force is expected to be found within the existing workforce in Crook and Campbell counties, the construction phase would cause only a small impact on the availability of housing.

There would be increased purchases of local goods and services during construction which would contribute to county and state tax revenues. Taxes derived from the value of construction equipment and use tax on purchases for the proposed project area would contribute to the Crook County tax base. As described in Section 4.10.1.1.5 of the ER, tax revenues would accrue to Crook County during construction based on the value of construction equipment on the site. Typically, this equipment would be registered at the County Assessor's Office, and a discount applied to the market value (42%), then 11.5% of the adjusted value would be taxed at the local tax rate. This income would help offset any increased needs for public services, such as ambulance service and fire control. To the extent that project contractors and subcontractors register equipment as required by Wyoming Statute, the greater the benefit to the county and the more capable the county would be to manage growth through increased services.

Because of the structure of the taxing system, taxes might not accrue to the localities proportionate to the population/public service impacts experienced by those entities. This would be the case, for example, for workers that choose to live in Campbell County. Tax revenue might accrue mainly in Crook County and to the state. Similarly, small towns experiencing increased population/public service demand might not receive a proportionate level of tax increase as sales tax accrues in the larger population centers. However, the construction period is relatively short and the construction workforce is expected to reside within the existing workforce currently living in these two counties. Therefore, the construction phase of the proposed project area would have a small impact on local finances.

It is assumed that most of the construction workers would come from Campbell and Crook counties, primarily from the communities of Gillette, Moorcroft and possibly Sundance. The families will continue to live in these communities during the short (3- to 5-year) construction period. Therefore, the

construction workforce and their families will have a small impact on the local infrastructure, schools, and public services.

Increases in population and changes in population characteristics cause changes in the demand for health and human services. However, in this case the construction period is relatively short and the construction work force is expected to be found within the existing workforce currently living in these two counties. Therefore, the impact on health and social services during the construction phase of the proposed project area would be small.

7.1.3 Potential Historic, Scenic and Cultural Resource Impacts during Construction

7.1.3.1 Historic and Cultural Resources Impacts

Class I and III cultural resource surveys were conducted on the proposed project area and the results are included in Addendum 3.8-A of the ER. Cultural resource sites considered significant under Criterion D were identified as well as sites that were not considered significant because they are small in areal extent, lack features, and exhibit poor integrity. Paleontological materials (vertebrate remains) were also found during the cultural resource inventories. It was the opinion of the archeologist that none of the fossil bone appeared to be exposed in-situ, and that the fossil bone has weathered out of the Lance Formation long ago and lacked contextual integrity.

The Proposed Action has the potential to disturb cultural resource sites, including some of the potentially eligible sites, and to temporarily limit access to cultural resource sites. Section 4.3.8.1 of the ISR GEIS notes that most of the potential for adverse effects to potentially NRHP-eligible historic properties, traditional cultural properties, and paleontological material, both direct and indirect, would likely occur during land-disturbing activities. Mitigation measures as discussed in Section 5.8 of the ER will be implemented to minimize potential impacts to cultural resources. If previously unidentified cultural resources are discovered during any phase of the proposed project, work in the immediate area of the discovery will cease until a qualified archeologist evaluates the site and consults with SHPO. Potential impacts during aquifer restoration would be similar to those during operation which would primarily result from surface disturbing activities associated with maintenance and repair of existing facilities.

No Native American heritage, special interest, or sacred sites have been formally identified and recorded to date directly associated with the proposed project area. However, Devils Tower (located approximately 11 miles from the site) is a sacred area for several Plains Tribes (Hanson and Chirinos 1991). Since the entire proposed project area will be reclaimed and restored to pre-existing land uses during decommissioning, any potential indirect impacts to cultural resources will be temporary.

7.1.3.2 Scenic Resources Impacts

The Proposed Action will result in temporary, small impacts to the visual and scenic resources of the area that would be consistent with the visual resource classification of the area by the BLM. The BLM has classified the project area as a Class II and the management objective of VRM Class III is to partially retain the existing character of the landscape. The level of change to the characteristic landscape can be moderate. Under the Proposed Action, the character of the existing landscape would be retained, but would be modified with noticeable but minor additional industrial facilities, utilities, and roads. The Devils Tower National Monument is the only Class II VRM area in Crook County. The proposed project area is not visible from the visitor's center or hiking trails around the monument.

Visual impacts to the proposed project area during construction would generally be short term and would result from ground clearing, grading, wellfield development, vehicular and pedestrian traffic, construction of facilities, and installation of underground and overhead utilities. During construction heavy equipment may be visible from portions of New Haven Road and D Road. Construction within rural areas may give the area a more industrial feel, therefore decreasing the visual appeal. Construction activities will be short term, and following completion of facility installation, temporary disturbance areas will be reclaimed.

A typical truck-mounted drill rig may be about 30-40 feet tall and will be the most visible piece of equipment used in wellfield construction. Strata anticipates that up to 12 drill rigs may be operated at one time during wellfield construction. For nighttime operation, the drill rigs would be lighted, increasing the potential visual impacts.

The wellfield modules will be phased into construction and operation, with 2 to 6 modules typically under construction at one time and up to 10

modules in operation at once. The maximum area disturbed by wellfield module construction is expected to be 40 acres at any one time. The shapes of the uranium deposits are typically irregular, and the network of pipes, wells, and power lines would not be regular in appearance, thereby reducing the visual contrast and associated impacts.

Dust generated from construction equipment may impact visual resources. Dust particles will be mobilized during grading and topsoil removal and by and vehicles traveling on gravel roads. Large particles are also created by wind blowing over the surface of bare land and stockpiles; this will be reduced by promptly restoring and reseeding disturbed soil, wetting disturbed areas, and enforcing speed limits.

7.1.4 Potential Air Quality Impacts during Construction

Section 4.6.1.1 of the ER discusses potential air quality impacts during construction. The greatest potential for air quality impacts will be fugitive dust from the trucks transporting supplies to the facility and equipment (cranes, bulldozers, graders, excavators, trenchers, loaders, etc.) used to construct facilities, wellfields and roads. Large particles will also be released by wind blowing over disturbed areas and stockpiles. Emissions during construction will be short-term and reduced through BMPs described in Section 5.6 of the ER (e.g., speed limit controls, strategically placing water loadout facilities, prompt revegetation, and use of chemical dust inhibitors such as magnesium chloride). Fugitive dust has the potential to impact visual resources as described in Section 4.9 of the ER.

Another source of potential air quality impacts during construction is combustion emissions. During construction of the wellfield, diesel emissions will be emitted from drill rigs, diesel-powered water trucks and other equipment. Additional equipment will be used to construct the CPP, lined ponds, access roads, and associated facilities. Employee vehicles and trucks transporting equipment to the site will also emit fuel combustion products.

Table 4.6-1 of the ER summarizes the estimated emissions during construction of the Ross ISR Project. Construction of the Ross facilities will not cause exceedances of particulate standards.

7.1.5 Potential Geology and Soils Impacts during Construction

7.1.5.1 Potential Geology Impacts during Construction

Potential impacts on geology and soils are described in Section 4.3 of the ER. NUREG-1748 notes that geological resources are more likely to exert an impact than be impacted by ISR construction and operation. Two geologic hazards present in Wyoming are volcanoes and earthquakes.

The proposed project area is located 250 miles east Yellowstone National Park. Yellowstone is centered on an active volcano system that has resulted in three immense explosive volcanic eruptions in the past 2.1 million years (USGS 2010). According to the USGS (2005), a large volcanic eruption at Yellowstone could bury vast areas of the U.S. with volcanic debris. It could also create lava flows, the impact of which would be limited to areas within and adjacent to the park, but far from the proposed project area. USGS (2005) notes that the probability of a large, caldera-forming eruption within the next few thousand years is "exceedingly low."

A geologic hazard related to Yellowstone is seismic activity. Section 2.6.7 describes the seismic hazard of the proposed project area. That section describes how there are no active faults with surface expression in or near the proposed project area and how only two magnitude 3.0 or greater earthquakes have been recorded in or near Crook County. The section also describes how a magnitude 6.25 floating earthquake placed 15 km (9.3 mi) from the proposed project area would generate horizontal accelerations of approximately 0.15g, which is a Level VI earthquake. The 2,500-year probabilistic map presented in Section 2.6.7 shows that the peak ground acceleration with a 2% probability of exceedance in 50-years is 0.06 to 0.08g, which equates to a Level V earthquake. Level V or VI earthquakes are felt by almost everyone around but do not cause significant damage. Since structures at the Ross ISR Project will be designed according to the 2,500-year probabilistic map, the risk of significant earthquake damage to the proposed facilities is small.

7.1.5.2 Potential Soil Impacts during Construction

ISR uranium recovery does not disturb soil to the extent of conventional open-pit mining, but a portion of the soils within the proposed project area will be impacted by the proposed action. Activities resulting in soil manipulation include clearing vegetation, topsoil stripping, excavation, backfill, and

reclamation. In general, soil impacts within the proposed project area will be dependent on the area, type and length of disturbance. The anticipated disturbance associated with construction of the Ross ISR Project is summarized in Section 4.1, Table 4.1-1 of the ER. The total estimated disturbance area is approximately 280 acres over the life of the project.

Most soil disturbance will occur during construction and decommissioning. Construction of the CPP and associated facilities, access roads, and wellfield will result in short and long term soil disturbance. Areas such as utility corridors and well pads will be reclaimed soon after construction, while other areas such as roads and the plant area will be disturbed throughout the life of the project. Potential soil impacts vary by severity and may include soil loss, compaction, salinity, loss of soil productivity, and soil contamination.

The two greatest sources of potential soil loss are wind and water erosion. As described in Section 2.6, the soils within the proposed project area have a moderate to severe potential to be affected by wind erosion, while water erosion hazards range from negligible to moderate. Only one soil type, making up less than 3% of the proposed project area, has a severe potential for wind erosion. Potential soil loss impacts resulting from wind erosion of disturbed soils will be small to moderate. Mitigation measures are described in Section 5.3 of the ER and include removing vegetation only where necessary, minimizing disturbance in highly erosive areas and performing reclamation in a timely manner.

Potential water erosion impacts within the proposed project area will be small to moderate. Although precipitation in the area is generally low and streams upstream of Oshoto Reservoir are ephemeral, surface disturbing activities will expose soil and temporarily increase the potential for water erosion. To minimize the potential for water erosion, Strata will contour and revegetate disturbed areas, implement storm water control measures, and provide sediment control structures. Roads and utilities will also be located in areas not susceptible to flooding, or configured to minimize disturbance in surface water drainages (i.e., roads and pipelines will cross drainages perpendicular to the flow direction).

Soils within the proposed project area have the potential to be compacted, particularly during construction and decommissioning, when heavy equipment operation will be at the highest level. Soil compaction could result in

a decrease in infiltration capacity, thereby increasing runoff. To decrease the potential for compaction, Strata will use existing roads where possible and rip compacted soils during reclamation as described in Section 5.3 of the ER.

Saline soils can be susceptible to soil loss if disturbed due to difficulty in establishing vegetation during reclamation. The baseline surveys described in Section 2.6 indicate that the soils in the proposed project area are generally not saline, and therefore the soil loss risk is low. Revegetation of any saline soils would be expedited by irrigating the soils with permeate, if land application is used for permeate disposal. Soil salinity impacts and baseline soil salinity at the surface and root zone would be addressed in a site-specific land application plan submitted for regulatory approval prior to land application.

Soil productivity may be affected during topsoil removal, stockpiling and redistribution. Excavation activities change the structure and microbial activity of the topsoil, resulting in a loss or dilution (by mixing) of organic matter. Similarly, soils may be mixed or compacted during excavation and stockpiling resulting in the breakdown of soil structure and loss of pore space. These activities not only impact the soil, but may create conditions not conducive to vegetation. To minimize soil productivity impacts Strata will utilize BMPs throughout the life of the project as described in Section 5.3 of the ER.

During construction, potential soil impacts could occur from introduction of drilling fluids or drilling muds to soils near the production, injection, and monitor wells. The volume of drilling fluids and muds will be small, and these will be contained within mud pits constructed at each well. The potential for soil contamination impact resulting from drilling fluids or mud is therefore small.

During all project phases, potential soil impacts could occur from leaking fuel or oil from vehicles. The volume of fluids and lubricants would be small and result in only localized impacts. Oil-contaminated soil would be disposed as described in Section 4.13 of the ER. The release of any spill or leak would result in immediate cleanup response.

7.1.6 Potential Impacts to Water Resources during Construction

Section 2.7 of this report describes the water resources of the proposed project area. Surface water and groundwater within the proposed project area are used for livestock and industrial use. Potential impacts to water resources from the Ross ISR Project are described in Section 4.4 of the ER.

7.1.6.1 Potential Impacts to Surface Water during Construction

The Ross ISR Project has been designed to minimize impacts to surface water features. Roads and utility corridors will be constructed away from drainages where possible. Where it is necessary to cross drainages, crossings will be perpendicular to the channel and culverts designed to pass a 10-year flood event will be used for road crossings. A runoff diversion channel will be constructed around the central plant area to reduce the risk of flooding or surface water contamination during events up to and including the 100-year event. ISR wells will not be constructed in stream channels, but it might be necessary to install some wells within the 100-year floodplain. BMPs will be implemented to minimize sediment transport due to surface disturbance (e.g., silt fence, sediment logs, hay bale check dams, etc.) and to protect the wellfields from flooding (e.g., cement seals around well casings and watertight well caps). Figure 4.4-1 in the ER depicts the proposed facilities in comparison with surface water features. Mitigation measures for potential surface water impacts are presented in Section 5.4.1 of the ER.

During construction, surface water impacts could potentially occur from site-disturbing activities such as wellfield, road, and facility installation. Potential impacts include degrading water quality during the infrequent runoff events (all streams in the area are ephemeral), erosion and encroaching on wetlands. While only a very small portion of the 280 acres to be disturbed contains surface water features, any disturbance has potential to degrade water quality through accelerated erosion unless proper mitigation measures are in place.

Construction activities that require clearing, topsoil removal and grading have the greatest potential for increased sedimentation due the removal of vegetation. To reduce the potential for eroded sediment to reach a stream, Strata will employ sediment control measures, storm water control measures, and timely revegetation procedures.

Accidental spills and leaks (e.g., leaking mud pits) may occur during wellfield construction. Any impacts to water quality associated with leaks, spills, or equipment failures will be dependent upon several considerations including: timing of runoff events with respect to the spill, quantity and quality of material spilled, proximity of a spill relative to surface water, and remediation. Potential impacts from accidental spills and leaks will be small due to the small volume, infrequent runoff events, rapid cleanup response,

location of most wellfield areas away from surface water features, and containment controls such as mud pits.

Strata will obtain a temporary water discharge permit (WYPDES) to discharge water produced from well development and water used for pipeline integrity testing. Additionally, Strata will implement a storm water pollution prevention plan (SWPPP) to address storm water runoff during construction. The plan, permitted by the WDEQ/WQD, will describe Strata's BMPs used to keep pollutants out of surface waters.

Accelerated erosion may result from soil disturbance and exposure of soils to wind and water erosion. The soil survey results (Section 2.6.6) indicate that soils within the proposed project area are generally only moderately susceptible to wind and water erosion.

The proposed project area includes 65 acres of potential wetlands, as discussed in Section 2.7.3 and ER Section 3.4.3. The majority of the wetlands are situated along the Little Missouri River and adjacent to Oshoto Reservoir. The proposed action has the potential to impact up to 2 acres of wetlands. Impacts to wetlands will be mitigated, as required by USACE, by enhancing existing wetlands or constructing new wetlands.

7.1.6.2 Potential Impacts to Groundwater during Construction

The groundwater quality and quantity within the proposed project area could potentially be impacted during each phase of the Ross ISR Project. Impacts to groundwater could potentially occur to the non-exempt aquifer surrounding the ore zone (OZ), the overlying (SM) and underlying (DM) aquifers, or the surficial aquifer. Potential impacts to groundwater during construction of the Ross ISR Project are described in Section 4.4.2.1 and 4.4.2.2 of the ER. Groundwater mitigation measures are detailed in Section 5.4.2.

Shallow surficial aquifers are susceptible to impact from spills or leaks from construction equipment or from drilling fluids. Strata will reduce the potential for a spill or leak by implementing BMPs, including spill prevention, spill control and remediation. The potential for groundwater to be impacted by drilling fluids and muds is minimal due to the small volume of materials used for well construction and due to the use of mud pits to contain drilling fluids.

As described in Section 4.4.2.1 of the ER, use of water from Oshoto Reservoir and construction of the CBW could have a small effect on the water level in the surficial aquifer, but the effects will be small, seasonal, and localized.

Water quality of the aquifers below the surficial aquifer will not be impacted during construction. Water levels in these aquifers will be subject to slight impacts from pumping during well completion and development, aquifer testing, and possibly the use of water from these wells for dust control, earthwork compaction and pipeline pressure testing during construction. These effects will be small and localized to the vicinity immediately surrounding the wells.

Ongoing well installation and delineation drilling programs have the potential to impact groundwater quality through mixing of industrial water quality aquifers with aquifers of other classes of use by over-penetration, improperly abandoned boreholes, or lack of well integrity. In order to mitigate these impacts, Strata will continue to use the extensive amount of geologic data collected throughout the Nubeth R&D project and the current Ross project development combined with the geologic model to determine total depths and prevent over penetration. Strata will continue to comply with WDEQ/LQD guidelines for hole abandonment by cementing or employing heavily mixed bentonite grout installed from the total depth to the surface to further limit the potential for groundwater migration within any proposed area perimeter monitor (sentry) well ring. Strata also employs on-site geologic/engineering oversight during any drilling project for all phases of well drilling, installation and abandonment. On-site geological/engineering supervision would continue during the construction phase. Wells installed for further hydrologic studies, baseline characterization and production infrastructure will pass mechanical integrity testing (MIT) prior to utilization.

7.1.7 Potential Ecological Impacts during Construction

Potential ecological impacts of the Ross ISR Project are discussed in Section 4.5 of the ER. The type of disturbance associated with ISR mining will not result in large expanses of habitat being dramatically transformed from its original character as in other surface mining operations. Additionally, all disturbed areas will be reclaimed following either the completion of construction or restoration. Impacts would also be partially mitigated by the

low proportion (10%) of the total proposed project area expected to be impacted by construction of wellfield modules, processing facilities, and associated infrastructure. Once those structures are completed, regular disturbance would be reduced to only that needed to operate and maintain the operations. Traffic will persist during operation and aquatic restoration, but should occur at a reduced and predictable level. Limited habitat disturbance also results in fewer displaced animals from existing territories into other, potentially occupied, areas, which reduces competition and stress on animals in both locations. A detailed description of potential threats to vegetation, terrestrial wildlife, fisheries, and threatened and endangered species associated with the proposed project area is contained in Section 3.5.5 of the ER.

Direct impacts to vegetation would be short-term loss (modification of structure, species composition, and areal extent of cover types). Indirect impacts would include the short-term and long-term increased potential for non-native species invasion, establishment, and expansion; exposure of soils to accelerated erosion; shifts in species composition or changes in vegetative density; reduction of wildlife habitat; reduction in livestock forage; and changes in visual aesthetics. An estimated 89 ha (221 acres) of the proposed project area would be affected by the surface disturbance under current development plans. Potential impacts to vegetation would be highest during the construction phase when significant surface disturbance will occur. No threatened or endangered vegetation species were observed within the proposed project area; therefore, no impacts are anticipated. Mitigation measures designed to prevent or reduce impacts to vegetation are discussed in Section 5.5 of the ER.

As with other energy extraction industries, ISR operations can have direct and indirect impacts on local wildlife populations. These impacts are both short-term (until successful reclamation is achieved) and long-term (persisting beyond successful completion of reclamation). Indirect impacts typically affect more than a single individual and often persist longer than direct impacts. Direct, project-related impacts of ISR operations may be experienced by all wildlife species to varying degrees. Individuals may be injured or killed due to collisions with drilling and/or heavy construction equipment and related traffic. Topsoil stripping required for construction of drill pads, access roads, plant facilities, and other infrastructure may also result in injury and mortality to some wildlife species, particularly small and young burrowing species such as rodents and herptiles that have limited

mobility to escape the equipment. The likelihood for impacts resulting in injury or mortality is greatest during the initial construction phase of each aspect of the proposed project, when traffic is heaviest and machinery is actively disturbing new areas. Disturbance would also be greatest during construction of facilities and supporting infrastructure, which would require more equipment and cover a larger area.

Due to the type of disturbance (relatively small areas disturbed and the sequential nature of the disturbance), impacts to vegetation, big game, other mammals, upland game birds, raptors, nongame and migratory birds, reptiles, amphibians, fish, and threatened or endangered species related to the construction phase would be limited.

7.1.8 Potential Noise Impacts during Construction

Due to the remote location of the proposed project area and small number of noise receptors, noise impacts are expected to be small. There are 11 residences within the surrounding 2-mile radius of the proposed project area. Four of the residences are located within 0.3 mile of the proposed project area and would be impacted the most by increased noise. The nearest residence to the proposed project boundary is about 690 feet away, and the nearest residence to the proposed CPP is about 2,500 feet away. A background noise survey completed at the Strata field office, which is also one of the four nearest residences, indicated that the average noise level is about 38 dBA. Peak noise levels reached 80 to 90 dBA, due to heavy truck traffic on the nearby New Haven Road.

Potential noise impacts will be greatest during construction. Peak commuter traffic coupled with the highest anticipated level of material and equipment shipments will cause the greatest increase in traffic on affected county roads. Heavy equipment operation within the proposed project area will also peak during construction of the CPP, wellfield, and associated infrastructure.

Most of the potential noise impacts to nearby receptors (residences) will be caused by increased traffic on the New Haven Road and D Road. Traffic traveling between I-90 and the primary access road will only pass one of the four closest residences. Potential impacts were therefore assessed at this residence, which is designated as N-1 on Figure 3.7-2 of the ER. A noise survey

was conducted and the maximum recorded noise level near this residence was 73.4 dBA when a bentonite truck passed by on the New Haven Road.

An estimate of the relative noise impacts to the N-1 residence was made using the noise data collected during the 7-day study at the Strata field office. The average daily duration of noise level above the 55 dBA nuisance level at the Strata field office was 62 minutes per day. The Strata field office is only 50 feet away from the New Haven Road, so it is particularly susceptible to traffic noise. By comparison, the N-1 residence is 600 feet from the New Haven Road. In order to assess baseline nuisance noise levels at this residence, the noise study data were corrected to a distance of 600 feet from the New Haven Road.

Noise from point sources diminishes by about 6 dBA for each doubling of distances. The noise level at the N-1 residence would typically be about 22 dBA less than the noise level at the Strata field office for a noise source on the New Haven Road (based on a relative distance of 12 times further to the N-1 residence than the Strata field office). Based on the 7-day noise study results, the frequency of noise levels exceeding 77 dBA at the Strata field office averaged 34 occurrences per day. Therefore, it is estimated that the N-1 residence currently experiences nuisance noise levels exceeding 55 dBA about 30 times per day. The N-1 residence might experience an increase of about 80% in the frequency of nuisance noise levels related to traffic on the New Haven Road. The other nearby residences will experience significantly lower traffic noise impacts, since they are not on the primary site access route.

Traffic-related noise impacts will be minimized by funding additional speed limit signs on the New Haven Road and D Road and developing a speed limit policy for Strata employees and contractors traveling on county roads.

Noise originating from construction equipment will be apparent locally over the short term where construction activities are occurring. Heavy trucks, drilling rigs, and other equipment used to develop the CPP, wellfield, and associated infrastructure will generate noise within the proposed project area. Table 4.7-1 of the ER identifies typical noise levels 50, 690, and 2,500 feet away from construction equipment. This table shows that noise levels may exceed nuisance levels (greater than 55 dBA) if heavy equipment is operated very near the proposed project boundary. No nuisance noise levels at nearby receptors are anticipated due to construction activities within the central plant area. Furthermore, the actual distance from construction equipment to the residences will generally be much greater than the minimum distances shown

depending on the location of the construction activities within the proposed project area.

Exposures at and above the National Institute for Occupational Safety and Health (NIOSH) recommended exposure limit for workplace noise of 85 dBA is considered hazardous. Hearing protection will be required for workers in areas that may exceed 85 dBA.

Elevated noise levels associated with construction activities could affect wildlife behavior. Noise due to construction can cause wildlife to avoid the proposed project area and potentially disrupt their breeding habits.

Mitigation measures for construction-related noise impacts are discussed in Chapter 5 of the ER and may include nighttime drilling restrictions within a specified distance of residences, “first move forward” driving policies to limit backup alarms, and speed limit enforcement on access roads within the proposed project area.

7.2 Potential Impacts during Operation and Decommissioning for the Proposed Action

The following section summarizes the environmental impacts of the proposed project from operation and decommissioning. A more detailed discussion of the environmental impacts is included in Chapter 4.0 of the ER.

7.2.1 Potential Land Use Impacts during Operation and Decommissioning

Potential impacts to land use during operation are expected to be less than construction since many of the short-term disturbance areas will be reclaimed. During the operation phase of the project, the primary impacts to land use will occur in conjunction with the expansion of wellfield modules.

Potential land use impacts specific to operation and aquifer restoration involve permeate disposal. Strata may use land application and WYPDES discharge to dispose permeate. If land application were used for permeate disposal, the affected land would temporarily be restricted from livestock or crop production. If Strata discharges permeate to the Little Missouri River or a tributary under a WYPDES permit, existing low-water channel crossings could be impacted. Both land application and WYPDES discharge require permitting through WDEQ/WQD. In either case effluent limits would be established to protect the receiving soil or stream. Operational monitoring would ensure that the permeate meets all applicable effluent limits. Therefore, potential impacts to existing and future land use resulting from permeate disposal would be small.

Potential land use impacts during aquifer restoration will be similar to those during operation. Relatively small portions of the proposed project area will temporarily be used for industrial purposes rather than the predominant pre-operational land used of livestock grazing and dry land crop production. Access will be restricted in fenced areas and if land application is used for permeate disposal, additional access restrictions would occur. If WYPDES discharge is used for permeate disposal, low-water channel crossings could be impacted.

Surface disturbance activities would temporarily increase during decommissioning compared to operation and aquifer restoration. 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. Land will be returned to the approximate surface topography and drainage patterns prior to disturbance. All roads will be removed and reclaimed unless exempted from reclamation by the request of landowners/lessees.

Revegetation practices will be conducted in accordance with WDEQ/LQD requirements and, for the small areas disturbed on BLM surface, in accordance with BLM requirements. Topsoil stockpiles, and as much as practical of the disturbed wellfield areas, will be seeded to establish vegetative cover to minimize wind and water erosion. After spreading topsoil the area will be seeded with a permanent seed mix compatible with the prior land use. The landowner or surface lessee and WDEQ/LQD will be consulted when selecting the seed mix.

Following decommissioning, all land in the proposed project area will be released for unrestricted (i.e., any) use.

7.2.2 Potential Socioeconomic Impacts during Operation and Decommissioning

7.2.2.1 Potential Operational Impacts

Socioeconomic impacts during operation and decommissioning of the proposed Ross ISR Project are described in Section 4.10.1.2 of the ER. The workforce necessary for operation of the CPP is projected to be 60 employees, and the duration of operation is projected at about 4 to 8 years, depending upon market conditions and the timing as to when additional reserves can be brought on line. During uranium recovery operations, revenues will be generated from federal, state, and local taxes on the facility and the uranium and vanadium produced and from sales and use taxes on goods and services purchased by the owners and employees of the plant.

Employees with a different technical expertise would be required during the operations phase, including management, health and safety, plant operations, regulatory and environmental, accounting and laboratory personnel. These people will probably be imported from outside the region. It is estimated that up to 20% of the operations personnel, or about 10 to 12 people, will come from outside the area, and the remainder will be hired from the local labor force.

As described in Section 3.10 of the ER, unemployment has risen throughout the region since 2007. As described in Section 4.10.1.2 of the ER, it is expected that the local labor force should be sufficient in number and have the skill set to accommodate the employee needs of the proposed Ross ISR Project with minimal need to import labor from outside the region. Thus, labor impacts from the construction of the Ross ISR Project would be small.

With sufficient local labor in Campbell and Crook counties for operation and decommissioning of the Ross ISR Project, the population of the area and the demand for housing are not expected to increase significantly as a result of the Ross ISR Project. It follows that the demand for public services (schools, police, fire, emergency services) would not be expected to increase significantly with during operation and decommissioning of the Ross ISR facility. Since the proposed project area is in a sparsely populated portion of Crook County, there may be a need for additional standby emergency services not immediately available in the proposed project area. Strata plans to develop contingency plans and/or additional training for specialized service employees, such as EMTs, and equipment, such as ambulances and fire-fighting equipment.

Tax revenue would continue to accrue to Crook County during operations. A personal property tax would be applied to the assessed value of all equipment and property used. In addition, a state mineral severance tax would be applied to the mined uranium and vanadium, some of which would be returned to Crook County. The State also receives a royalty on minerals produced from State-owned lands. The county imposes an ad valorem (based on value) tax on production. Crook and Campbell counties would both benefit from the increased sales tax revenue. Wyoming has a 4% sales and use tax to which local governments may add up to a 1% general purpose option, a 1% specific purpose option (capital facilities tax), and up to a 1% optional tax for economic development purposes. The counties also have the option to impose up to a 4% excise tax on all sleeping accommodations for guests staying less than 30 days (lodging tax). Crook County at this time has imposed the 1% general purpose optional sales tax, a 1% capital facilities tax, and a 2% lodging tax. Campbell County has imposed a 1% general purpose optional tax and a 2% lodging tax.

The State's share of sales tax revenue (69%) is distributed to the General Fund. The counties keep the remaining 31% as well as the optional sales taxes. The State severance tax rate on U_3O_8 is 4% of the sales value times an industry

factor (currently 42%). The current royalty rate is 2.5% on yellowcake sales at less than $20/lb, 2.75% on yellowcake sales at more than $20/lb but less than $26/lb, and 3% for yellowcake sales at $30/lb or more (Kemp 2010).

About 18% of the proposed project area of 1,721 acres is owned by the State of Wyoming. Yellowcake production from the State lands is subject to the 3% royalty plus the 4% severance tax. During the early years of production, about half of the yellowcake will be produced from State lands. Assuming a yellowcake price of $45 per pound and an annual production rate of 750,000 pounds per year, the total annual state royalty would be about $1.01 million and the severance tax would be about $530,000, for a total of $1.54 million. Considering the projected FY 2010 revenues to the State of $631,600,000 and estimating that 23.3% will come from mineral taxes, the projected impact to the State from production at the Ross ISR Project will be small (refer to Section 3.10.3.3 of the ER). However, the property tax on yellowcake production at the Ross ISR Project would be about $880,000 per year (assuming $45 per pound times 750,000 pounds per year times an industry factor of 42% times a 62.545 mill levy, see Table 3.10-11 of the ER). Compared to total FY 2008 property taxes levied in Crook County of $10,067,332 (see Table 3.10-11 of the ER), this represents an increase of about 9%, which could be considered a significant, positive impact. Considering that vanadium may also be sold for about $12 per pound, and assuming it is produced at a rate of 0.6 pound per pound of yellowcake, the tax revenues from production would increase by about 10% to 20%.

The workforce is expected to be reduced by one-half to two-thirds during aquifer restoration and operations (see Section 4.10.1.3 of the ER), so the small socioeconomic impacts of the project will be further reduced. After the end of the operations phase, revenues from production and severance taxes and any State royalties will decline and eventually cease. Thus the positive impacts from these revenues will cease to exist.

7.2.2.2 Potential Decommissioning Impacts

During decommissioning, a similar workforce as that required for construction will be required. As described in Section 4.3.10.4 of the ISR GEIS, up to about 200 workers with similar skills to those required for construction are needed at a typical ISR facility. Strata anticipates that around 90 workers will be required during this project phase. Decommissioning of the central

plant area, access roads, and associated infrastructure is expected to last for 12 to 18 months. However, due to phased development, decommissioning of individual wellfield modules is anticipated after regulatory approval of successful aquifer restoration. Therefore, the overall decommissioning phase may overlap significantly with aquifer restoration and last 4 to 7 years.

Decommissioning, whether done by a contractor or using operations staff after operations cease, will have similar socioeconomic impacts to those during construction.

7.2.3 Potential Historic, Scenic and Cultural Resource Impacts during Operation and Decommissioning

7.2.3.1 Historic and Cultural Resources Impacts

Direct and indirect adverse effects on historic and cultural resources are possible during the operation phase of the proposed project. Potential impacts during operation would result primarily from maintenance and repair of existing facilities. Potential impacts identified before construction are expected to continue during operation. Overall, impacts during operations would be expected to be less than those during construction. Implementing mitigation measures will minimize impacts to cultural resources during the operations phase of the proposed project.

Surface disturbing activities will temporarily increase during decommissioning, therefore the potential to impact potentially NRHP-eligible historic properties, traditional cultural properties, and paleontological materials will increase accordingly. Most of the decommissioning activities would focus on previously disturbed areas, and therefore most of the historic, cultural, and paleontological resources would be known from investigations conducted prior to construction. Strata will implement a stop-work provision should previously unidentified resources be encountered during decommissioning.

7.2.3.2 Scenic Resources Impacts

Potential impacts to the visual resources during ISR uranium recovery operations are discussed in more detail in Section 4.9 of the ER. During operations, impacts may result from the presence of wellhead covers, module buildings, facility buildings, lined retention ponds, access roads, buried utilities, and power lines. Potential impacts could also result from wellfield

activities such as monitor well sampling, module building inspections and MITs. Some of the facilities and wellfield activities will be visible from the county roads within and near the proposed project area including the New Haven Road and D Road.

Wellhead covers will be approximately 30 to 40 inches high would present only a slight contrast with the existing landscape. Feeder pipelines and electrical lines between the wells and module buildings will be buried and disturbed areas restored and reseeded. Module buildings will be small metal buildings approximately 10 to 14 feet tall and 15 to 25 of them will be constructed throughout the proposed project area. Electrical distribution lines (typically overhead) will connect module buildings to existing electric distribution lines and will be approximately 20 to 40 feet high.

The CPP will be the largest structure, at approximately 200 feet wide by 370 feet long by 50 feet tall. The total plant area will occupy a space of approximately 45 acres. These facilities will be prominent in the foreground and middle ground views and will be silhouetted in the background view from certain locations. Based on the viewshed analysis (Figure 3.9-3 of the ER), 4 or less of the 11 residences located within 2 miles of the proposed project area will be able to see the top of the highest buildings.

Trucks traveling to, from and within the proposed project area have the potential to impact visual and scenic resources during operation. Strata anticipates that two MIT units will operate on a regular basis. As recovery wells decrease their production rates a swabbing rig may be used to stimulate the wells. For testing and well stimulation a light duty truck is needed.

Operations will occur in an area where oil development operations occur today. The CPP and other structures will be noticeable from certain vantages; however, they will not be the only prominent industrial features in the area. Solid geometric features such as storage tanks, pump jacks, maintenance buildings, power lines, and meter houses are prominent in the immediate foreground and often are noticeable in the foreground views by the casual observer.

Visual resource impacts during decommissioning will be similar to those during construction and primarily attributed to heavy equipment operations and material and equipment transport. Areas of disturbance will be restored and reseeded to the pre-construction condition. At the end of decommissioning,

all structures and facilities will be removed or reclaimed, and no alterations to visual and scenic resources will be left.

7.2.4 Potential Air Quality Impacts during Operation and Decommissioning

7.2.4.1 Non-Radiological Emissions

As discussed in Section 4.6.1.2 of the ER, smaller amounts of fugitive dust will be generated during operation than during construction. Wellfield construction activities will be staggered and the amount of equipment and disturbance at any one time will be significantly less than during the construction phase. Vehicle combustion emissions will also be less during operations due to less worker traffic and fewer shipments of supplies to the site. Sources of fugitive dust during operation will include trucks transporting yellowcake, vanadium, and waste materials from the site; trucks delivering chemicals and supplies to the site; wellfield construction, work over, and operation activities; and employee and contract worker vehicles traveling to and from the proposed project area on local county roads. Vehicles will utilize the primary access road from the New Haven Road and, in some cases, secondary access roads within the proposed project area. These roads will be maintained and speeds within the proposed project area will be limited to ensure that fugitive emissions are minimal. Mitigation measures are discussed in Section 5.6 of the ER.

Vehicle combustion emissions during the operation phase will include traffic related to operations and maintenance, equipment used to construct wellfield modules, employee and contractor traffic to and from the site, and truck traffic delivering supplies to the site and products and waste from the site. Vehicle combustion emissions will be lower during operation than construction due to the smaller number of workers and material shipments.

Non-radiological emissions present during operation include release of gaseous effluents such as oxygen and CO_2 from the wellfield and CPP. The primary sources of non-radiological gaseous effluents will include CO_2 released from uranyl tricarbonate breakdown in the precipitation circuit, CO_2 and oxygen released during elution, and combustion emissions, including CO_2, from the natural gas-fired vacuum dryer(s). A summary of the emissions inventory for the proposed Ross ISR Project during operations is presented in Table 4.6-1 of the ER. A summary of the anticipated annual CO_2 production

and release from processes in the CPP are presented in Table 4.6-2 of the ER. A complete greenhouse gas inventory is provided in Addendum 4.6-A of the ER.

During the operation phase there is potential for small amounts of other non-radiological gaseous emissions, although the potential for environmental impacts from these sources is small. Potential sources of minor quantities of non-radiological gaseous emissions include venting of excess vapor pressure in pipelines and small amounts of chemical vapor released from the CPP ventilation system. Emissions from pipeline venting will produce minimal environmental impacts since the emissions are rapidly dispersed in the atmosphere.

Potential impacts to air quality during the decommissioning phase will be similar to the construction phase of the project. Fugitive emissions will be generated from heavy equipment used to remove contaminated soil and grade the proposed project area, trucks transporting equipment off-site, and trucks transporting waste off-site. Combustion emissions will also be produced by these trucks as well as vehicles transporting workers to and from the site. Table 4.6-1 of the ER provides a preliminary emission inventory during decommissioning.

7.2.4.2 Radiological Emissions

Radiological gaseous emissions anticipated during operation of the CPP and wellfield are described in Sections 4.1 and 5.7.1. An estimate of the gaseous radiological emissions during operation is provided in Section 7.3. The primary source of radiological gaseous emissions will be venting of Rn-222 gas from occasional wellfield venting for sampling events, small unavoidable leaks in wellfield and IX equipment, resin transfer operations, and maintenance of wellfield and IX equipment. Since pressurized downflow IX columns will be used and the wellfield will be operated under pressure, the majority of radon released to the recovery solution will stay in solution and will not be released.

Rn-222 dissolved in the pregnant lixiviant will be transported from the wellfield to the CPP for recovery of uranium. The uranium will be separated by passing the recovery solution through pressurized downflow IX units. The vents from the individual vessels and the resin transfer area (elevated shakers) will be connected to a manifold that will be exhausted outside the plant building through the elevated shaker stack. The lixiviant circuit through the IX will be a closed system; atmospheric conditions will initially be encountered during

resin transfer at the shaker screens. The CPP will be vented to the atmosphere outside the building, where any gas will quickly disperse in the air. Small amounts of Rn-222 may be released in the plant building during solution spills, filter changes, IX resin transfer operations and maintenance activities. Therefore, the building will be equipped with ventilation systems designed to prevent indoor radon concentrations. CPP area ventilation systems are described in more detail in Section 4.1.

Minor amounts of radon gas may be released outside of the CPP from the well heads, module buildings, and lined retention ponds. These releases will quickly disperse into the atmosphere.

Strata will utilize batch vacuum dryers to contain airborne uranium particles during the drying process. Section 4.2.11.2.1 of the ISR GEIS states that "radon gas is emitted from ISL wellfields and processing facilities during operations and is the only radiological airborne effluent for those facilities that use vacuum dryer technology." The vacuum dryers at the Ross ISR Project will be steel vessels heated externally and fitted with rotating plows to stir the yellowcake. The vessels will be equipped with ports to load wet yellowcake, unload dry powder, and vent through a bag house. The bag house will be heated to prevent condensation and will be kept under negative pressure. A condenser will be located downstream of the bag house to cool water and remove water vapor from the non-condensable gases emanating from the dryers. All particulate matter from the drying system will be recycled back to the process.

7.2.5 Potential Geology and Soils Impacts during Operation and Decommissioning

7.2.5.1 Potential Geology Impacts

During operation and aquifer restoration, there will be a very low risk of hydraulic fracturing during operation of injection wells, including Class III injection wells in the ore zone and Class I deep disposal wells. Potential impacts will be avoided by maintaining the injection pressure at a level that does not exceed the fracture pressure of the receiving formation (OZ aquifer for Class III wells and Deadwood/Flathead Formations for Class I wells). As noted in Section 7.1.5, the ISR operation poses no other significant risks of geological impacts, but earthquakes and volcanoes have the potential to impact the operation should they occur. The Ross site is in an area of low seismic risk,

and the probability of a major volcanic eruption at Yellowstone during the relatively short life of the project is relatively small (see Section 7.1.5).

During decommissioning, potential soil impacts will be similar to those occurring during construction. The risk of compacting soil will temporarily increase due to increased heavy equipment operation. Heavy equipment operation also increases the risk of soil contamination from fuel or oil leaks. These will be mitigated by ripping compacted soils prior to topsoil replacement and reseeding and by immediately cleaning up any oil or fuel-contaminated soil.

The only recognized potential geologic impact from decommissioning is physical impacts to the surficial aquifer within the central plant area. For example, if the containment barrier wall were allowed to persist after decommissioning, hydrogeologic impacts could occur within the surficial aquifer.

7.2.5.2 Potential Soils Impacts

Potential impacts to soils during operation and decommissioning will be similar to those during construction (see Section 7.1.5) although of smaller magnitude. Topsoil stripped from areas for construction of long-term facilities, such as the CPP, access roads, and evaporation ponds, will be stockpiled until these facilities are removed. These stockpiles will be located and configured to minimize the potential for wind and water erosion and will be vegetated to minimize wind erosion.

During operation and aquifer restoration, potential soil impacts could occur from vehicle compaction and contamination from spills or leaks. During decommissioning, potential soil impacts will be similar to those occurring during construction. During operation and aquifer restoration, potential soil impacts could occur from leaking pipelines or spills of process fluids or chemicals. Pipeline and wellfield leak detection systems are described in TR Section 3.1.7. Wellfield leak detection monitoring and control will include continuous measurement of flows and pressures for injection and recovery trunk lines and feeder lines, inclusion of leak detection sensors in valve manholes, and inclusion of leak detection sensors in well head sumps.

Potential soil impacts resulting from spills from process vessels or chemical storage tanks will be small due to the secondary containment provided in the CPP and chemical storage areas.

7.2.6 Potential Impacts to Water Resources during Operation and Decommissioning

7.2.6.1 Potential Impacts to Surface Water during Operation and Decommissioning

During operation and aquifer restoration there will be less surface disturbing activities, and therefore the risk of water quality impacts from sediment transport will be lower than during construction. As new wellfield modules are constructed during operation, BMPs will continue to be implemented to minimize potential sediment transport and related surface water impacts. Surface water quality could potentially be impacted during operation by leaks, spill or equipment failure that would result in release of a process fluid. Strata will minimize the possibility of a leak by installing leak detection controls and alarms and by providing secondary containment for module buildings, process vessels, and chemical storage tanks.

The ISR operation will continually extract more groundwater than is injected to maintain a cone of depression. Extraction of groundwater can theoretically result in a depletion of flow in streams and springs that are hydraulically connected to the ore bearing zone. However, since the ore zone is relatively deep and confined, its connection with surface water is located at a considerable distance from the proposed project area. Further information is provided in the groundwater model report in Addendum 2.7-H.

During operation and aquifer restoration, surface waters could potentially be impacted by surface discharge of permeate, land application of permeate, erosion, accidental leaks and spills, and storm water runoff. Strata may apply for a WYPDES permit to discharge permeate to tributaries of the Little Missouri River, where the water will be used beneficially for livestock and wildlife. Effluent will be required to meet requirements of 40 CFR 440 and effluent limits established by WDEQ/WQD designed to protect the class of use of the receiving streams. As shown in Table 4.13.2 of the ER, quality of the permeate should be excellent. Strata will locate and construct outfalls in a manner that reduces the potential for erosion. If land application is used for permeate disposal, there is the potential that water could flow overland to nearby drainages and potentially impact surface water quality. Proper management of water application rates and contingencies for reducing or stopping the irrigation system in the event of surface runoff would be addressed in a site-specific land application plan submitted to NRC and

WDEQ/LQD for regulatory approval prior to constructing a land application system.

After being reduced following initial construction of the facilities, sediment yield and storm water runoff have the potential to increase during decommissioning due to disturbances associated with equipment and structure removal and site reclamation activities. In general, impacts will be similar to construction although likely to be less since reclamation and decommissioning of the wellfields will be ongoing throughout the life of the project, reducing the area of disturbance during the final decommissioning activities.

7.2.6.2 Potential Impacts to Groundwater Quality during Operation and Decommissioning

During ISR operations the surficial aquifer has the potential to be impacted by leaks and spills. Lixiviant will be continuously injected and recovered from the wellfield modules during operation. The solutions will be transported through various pipelines to module buildings and pumped to the CPP for processing. Since the pipelines will be buried the solution has potential to seep undetected into the shallow aquifer. To reduce the risk of pipelines failing, Strata will hydrostatically test all pipelines prior to use and install leak detection devices in manholes along the pipeline. Strata will also monitor the operating characteristics of production and injection pipelines and shut down affected pumps if a leak is detected.

The CPP area has the greatest potential for a spill since it is where the majority of chemicals will be stored and where process vessels will be located, and where liquid 11e.(2) waste will be stored. Strata will implement spill control, containment, and remediation measures in the CPP area. These include providing secondary containment for process vessels and chemical storage tanks, providing a liner beneath the plant foundation, providing two liners with leak detection systems for ponds, providing a sediment pond to capture storm water runoff, and providing a bentonite slurry cutoff trench to prevent the migration of contaminants from the plant area. Appropriate inspections of containment systems will be conducted as described in Section 5.3.

During operations the groundwater quality in the exempted aquifer will be impacted as part of the ISR process. The uranium and vanadium in the ore zone will be oxidized and dissolved by introducing lixiviant into the OZ aquifer

using Class III injection wells. In addition to the uranium and vanadium, other constituents will be mobilized, including anions, cations, and trace metals. Impacts to the exempted aquifer water quality will be short term, since aquifer restoration will take place immediately following uranium production from any given wellfield.

Prior to operation, Strata will provide a wellfield package to the WDEQ/LQD and EPA with demonstration of wellfield integrity and exemptibility. Baseline water quality shows the OZ aquifer groundwater is of the Class IV type of use (industrial use only) based on WDEQ/WQD Chapter 8, Table 1 criteria. Exceedances of water quality standards for other uses were measured for TDS, sulfate, Ra-226 & 228 and gross alpha. Exceedances of EPA primary drinking water standards were measured for uranium, Ra-226 & 228 and gross alpha. Given these exceedances, water from this aquifer is not suitable for human or livestock/wildlife consumption. While the OZ aquifer was never requested for exemption as a source of drinking water during the R&D phase, the presence of commercially producible uranium/vanadium mineralization, confinement of the OZ and apparent poor water quality should allow WDEQ/LQD to support exempting portions of the aquifer within the perimeter monitor well ring(s) as either Class IV or V groundwater. Following a decision by WDEQ/LQD on the exemption status, WDEQ/LQD will request an aquifer exemption from EPA. Strata will not inject water into a non-exempted aquifer.

During operations there will be a net consumption of groundwater in the ore zone which could theoretically affect water levels in the SM and DM aquifers. The potential for significant impacts to the amount of water available in the SM and DM aquifers resulting from the Proposed Action are remote given the natural confinement and measures discussed in ER Section 4.4.2.3.3. However, in the unlikely event of a vertical excursion of lixiviant-fortified groundwater to the SM or DM aquifers, mitigation measures may require withdrawal and treatment of impacted groundwater. These withdrawals would be minimal given that in all likelihood the excursion conduit would be due to anthropogenic activities (e.g., well failure or unplugged borehole) and would result in a limited extent of impact (see ER Section 4.4.2.3.4).

Potential impacts to water levels in the SM and OZ aquifers were evaluated with the use of a regional groundwater flow model. These impacts are described in ER Section 4.4.2.3.4, and the model report is provided in

Addendum 2.7-H). Conservative modeling demonstrates that potential drawdown in the SM aquifer from operation of the Ross ISR Project would be less than 12.5% of available head. The modeling also was used to show that potential impacts to nearby stock, domestic and industrial use wells will be small. Only one well, the Kiehl Water Well #2, may see limited drawdown due to operation and restoration activities (see ER Section 4.4.2.3.4).

Water withdrawals from the OZ aquifer during operation and aquifer restoration have the potential to decrease the available head in three industrial water supply wells located within the proposed permit area. The three wells currently operated by Merit Energy utilize water from the OZ aquifer to stimulate oil production from wells completed in the underlying Minnelusa Formation. ER Table 4.4-2 summarizes the locations of wells within and adjacent to the Ross ISR Project that may experience drawdown. ER Figure 4.4-4 depicts the maximum estimated drawdowns at the end of uranium recovery operations and aquifer restoration along with the locations of the wells. Six wells completed in the OZ aquifer adjacent to the Ross ISR Project are also predicted to experience drawdown during the operation and aquifer restoration phases. The most significant estimated drawdown occurs in Wesley TW02 located in the SWSW Section 8, Township 53 North, Range 67 West, with 33.3 feet of drawdown or 42.4% of the available head. This well is located along the Little Missouri River floodplain adjacent to the no-flow boundary of the groundwater model; the presence of the no-flow boundary may conservatively bias the estimated drawdown. As explained in ER Section 4.4.2.3.4, the moderate reduction in available head should not materially decrease the yield from existing wells in the area.

The overlying aquifer (SM), underlying aquifer (DM), and non-exempt ore zone (OZ) aquifer outside of the exemption area could be impacted by an excursion of lixiviant during production. The most common types of excursions are due to a wellfield imbalance or well integrity failure. Potential impacts will be minimized by wellfield balance during operation, maintaining adequate bleed, properly installing and testing wells, and rapidly detecting and correcting excursions.

Strata will minimize the potential for excursions by hydrostatically testing all wells during installation and during periodic MITs and by installing controls and alarms for well failure detection. Recovery and injection wells will be installed with identical completion methods to allow the function to be

changed. Strata will maintain a bleed from the beginning of production through the end of active restoration, as discussed in Section 5.4 of the ER. The bleed will maintain an inward hydraulic gradient for each wellfield module. Strata will install perimeter monitor wells and monitor wells in the overlying and underlying aquifers to detect excursions. Pressure transducers will be provided for rapid excursion detection and response.

Strata proposes to utilize up to five Class I deep disposal wells within the proposed project area. A Class I UIC permit application for the injection wells was submitted to WDEQ/WQD on June 15, 2010, and a round of responses was completed in November 2010 (Addenda 4.2-A and 4.2-B in this TR). The wells will target the Cambrian-age Deadwood and Flathead Formations. These zones were selected based on their position in the stratigraphic column, permeability and porosity thickness, confinement and expected poor water quality. Water quality calculations indicate that the interval contains waters with average TDS concentrations over 10,000 mg/L. The potential environmental impacts from injection into the deep disposal wells are negligible since the intervals are confined and located thousands of feet below the deepest USDW.

Potential groundwater quality impacts during aquifer restoration will begin with whatever impacts prevail at the end of operations in a particular wellfield and will be reduced as the aquifer water quality approaches baseline or restoration criteria. Strata's groundwater restoration program includes five processes: (1) targeted/selective groundwater sweep, (2) groundwater transfer, (3) reverse osmosis with permeate injection, (4) groundwater recirculation, and (5) stability monitoring. These processes are discussed in more detail in Section 5.4 of the ER and in Section 6.1.2 of this TR.

The primary potential impact of groundwater restoration is groundwater consumption. This potential impact will be minimized by committing to the use of two stages of RO, reinjection of permeate generated during groundwater sweep into modules undergoing RO treatment with permeate injection, and minimizing the amount of groundwater sweep employed. The primary potential impact will be drawdown in the ore zone aquifer in areas surrounding the exemption area.

Generally there is less potential for groundwater quality impacts during restoration compared to production since a) the injection and recovery flow rates are lower in restoration compared to production, b) the duration that

each wellfield module is in groundwater restoration is typically much shorter than the production duration, and c) the production zone water quality will improve throughout active restoration.

The potential impacts to groundwater during decommissioning are similar to the construction impacts. Accidental spills and leaks will be minimized by implementing BMPs.

7.2.7 Potential Ecological Impacts during Operation and Decommissioning

Potential ecological impacts of the Ross ISR Project are discussed in Section 4.5 of the ER. Similar to the construction phase, the operation and decommissioning phases may directly and indirectly impact terrestrial ecology within the proposed project area. Access to areas may be limited by fencing, and some construction will continue as new wellfield modules are developed.

During operation the soils within the proposed project area may become temporarily contaminated or altered due to unanticipated operational leaks and spills. Any spill/leak impacts would be minimized by an in place spill response plan implemented by Strata.

During the operation phase noise and vehicular activity will be reduced, particularly within the proposed project area. The majority of vehicular activity will be primarily confined to the New Haven Road, the access road, and the area associated with the CPP facility. The decreased vehicular traffic should decrease the risk of vehicular collisions and reduce noise, which would reduce disruptions to wildlife populations.

Post-construction phase well module construction would be staged (sequential) so impacts to vegetation and wildlife within the proposed project area would likely be similar to the construction phase.

Potential impacts from decommissioning would be similar to or less than those discussed for the construction phase. Overall, the decommissioning phase will be short in duration. Decommissioning will include revegetation and recontouring, which will restore habitat disturbed during the construction, operation, and aquifer restoration phases.

Due to the type of disturbance (relatively small areas disturbed and the sequential nature of the disturbance), impacts to vegetation, big game, other mammals, upland game birds, raptors, nongame and migratory birds, reptiles,

amphibians, fish, and threatened or endangered species related to the operations and decommissioning phases would be limited.

7.2.8 Potential Noise Impacts during Operation and Decommissioning

Noise sources specifically resulting from operation include the CPP operations, vehicle traffic related to employee travel to and from the proposed project area, material transportation and wellfield equipment, especially MITs and work over operations.

Operational noise at the CPP would be generated by pumps and other processing equipment. The majority of this noise would be abated by closed buildings and would not significantly impact nearby receptors. Similarly, wellfield equipment would be contained within module buildings and well pumps would be submerged.

The major noise source during operation will be attributed to vehicles traveling to and from the proposed project area. It is estimated that there could be an increase of 108% to 114% in total daily traffic along affected portions of the New Haven Road and D Road and an increase of 133% to 178% in truck traffic. Traffic-related noise impacts will be less than those experienced during construction due to a smaller workforce and less frequent material shipments.

Potential noise impacts during aquifer restoration will be similar to those during operation, but smaller due to a smaller anticipated workforce and less shipments. Noise levels during decommissioning will also be similar to those during construction. Most potential impacts to nearby receptors will occur as result of increased traffic on the New Haven Road. Most decommissioning activities will be centered around the central plant area. Heavy equipment operation within the central plant area will not likely result in nuisance noise levels at nearby residences.

Noise levels during decommissioning will be similar to those during construction. Most potential impacts to nearby receptors will occur as result of increased traffic on the New Haven Road. Most decommissioning activities will be centered around the central plant area, which is approximately 2,500 feet from the nearest residence. The previous analysis demonstrated that heavy equipment operation within the central plant area will not likely result in nuisance noise levels at nearby residences.

In the wellfield, equipment used during plugging and abandonment of recovery, injection, and monitor wells would produce the greatest source of temporary noise. Cement mixers, compressors, and pumps would be operated for short durations.

7.3 Radiological Effects

7.3.1 Introduction

Strata is proposing to develop a uranium in-situ recovery facility with a maximum production flow of approximately 7,500 gallons per minute (gpm) and a restoration flow of approximately 1,100 gpm. An assessment of the potential radiological effects of the Ross ISR facility must consider the types of effluents and emissions, the potential exposure pathways present, and an evaluation of potential consequences of radiological emissions.

The Ross ISR Project will use fixed bed pressurized down flow IX columns to separate uranium from the pregnant production fluid and restoration solutions. The uranium contained in the eluant from the production IX columns will be precipitated and subsequently vacuum dried. In addition to IX treatment, the production bleed and groundwater from restoration will be treated by reverse osmosis to remove the dissolved solids.

Three types of liquid effluents are expected from the Ross CPP during operation: permeate and brine from the production and restoration RO systems and spent eluant from plant processes. Liquid waste will be discharged into lined ponds, and then routed to beneficial uses or to disposal. Permeate will be of high quality and will meet the criteria for several discharge options including use as plant make up water for the elution and precipitation circuits, surface discharge, and land application. Radium treatment may be required for surface discharge and land application. Excess permeate will likely be disposed in deep disposal wells. Brine and spent eluant will be discharged to lined ponds and then routed to the deep disposal wells. Lined ponds will have double geosynthetic liners and leak detection.

Evaporation from ponds at the Ross ISR is expected to occur at an annual rate of 1.4 gpm per surface acre for brine, and 1.5 gpm per surface acre for permeate. Evaporation effects will depend on the amount of liquid in storage and the time of year. Detailed discussion of the liquid disposal plan for the Ross ISR Project is located in Section 4.2.

Since the drying and packaging operation is conducted using modern vacuum dryers operating at low temperatures (250 – 350° F), the only expected routine radiological emission from the facility will be Rn-222 gas (see below). Rn-222, a decay product of Ra-226, is dissolved in the lixiviant as it travels

through the ore bearing aquifer to a production well where it is brought to the surface. The concentration of Rn-222 in the production solution and estimated releases are calculated using the methods found in NUREG 1569, Appendix D. The details of and assumptions used in these calculations are found in Section 7.3.4.4. Modern vacuum dryers have virtually no particulate release. Sections 3.2 and 4.1, describe the design and operation of the vacuum dryers and associated off-gas treatment systems. NRC has concluded the following:

(A) NUREG 1910, Section 2.4.2.3, Precipitation, Drying and Packaging:

Newer ISR facilities usually use vacuum yellowcake dryers. In a vacuum dryer (Figure 2.4-5), the heating system is isolated from the yellowcake so that no radioactive materials are entrained in the heating system or its exhaust. The drying chamber that contains the yellowcake slurry is under vacuum. Therefore, any potential leak would cause air to flow into the chamber, and the drying can take place at relatively low temperature {e.g., 149°C [250°F]}. Moisture in the yellowcake is the only source of vapor. Emissions from the drying chamber are normally treated in two ways. First, vapor passes through a bag filter to remove yellowcake particulates with an efficiency exceeding 99 percent. Any captured particulates are returned to the drying chamber. Then, any water vapor exiting the drying chamber is cooled and condensed. This process is designed to capture virtually all escaping particles (NRC 2001).

(B) NUREG 1910, Section 4.2.11.2.1 - Radiological Impacts to Public and Occupational Health and Safety From Normal Operations:

Radionuclides can be released to the environment during ISL facility operation. As discussed in Section 2.7.1, radon gas is emitted from ISL wellfields and processing facilities during operations and is the only radiological airborne effluent for those facilities that use vacuum dryer technology.

(C) NUREG/CR -6733, Section 2.2.3, Precipitation and Drying:

Newer plants usually employ vacuum yellowcake dryers. In a vacuum dryer, the heating system is isolated from the yellowcake so that no radioactive materials are entrained in the heating system or its exhaust. The drying chamber that contains the yellowcake slurry is under vacuum. Therefore, any potential leak would cause air to flow into the chamber, and the drying can take place at relatively low temperature [e.g., 149°C (250°F)]. Moisture in the

yellowcake is the only source of vapor. Emissions from the drying chamber are normally treated in two ways. First, vapor is passed through a bag filter to remove yellowcake particulates with efficiency in excess of 99 percent. Any captured particulates are returned to the drying chamber. Then, any water vapor exiting the drying chamber is cooled and condensed. This process captures virtually all escaping particles.

MILDOS-AREA (ANL 1997) was used to model radiological impacts on human and environmental receptors (e.g. air and soil) using site specific Rn-222 release estimates (Regulatory Guide 3.59 and NUREG 1569), local meteorological and population data, and other parameters (see Section 7.3.4). The estimated radiological impacts resulting from routine site activities are compared to applicable public dose limits as well as to naturally occurring background levels.

7.3.2 Exposure Pathways - General

Figure 7.3-1 presents a conceptual model depicting exposure pathways from potential effluent sources at the Ross ISR Project, including the predominant pathways for planned and unplanned releases. Atmospheric Rn-222 is expected to be the predominant radiological source term for impacts on human and environmental media. Impacts of Rn-222 releases (including impacts of progeny) are possible in all quadrants surrounding the facility, the magnitude of which is driven predominantly by wind direction and atmospheric stability. As a noble gas, Rn-222 itself has very little radiological impact on human health or the environment. Rn-222 has a relatively short half-life (3.2 days) and its decay products are short lived, alpha emitting, particulate radionuclides. These decay products have the potential for radiological impacts to human health and the environment. As Figure 7.3-1 demonstrates, all exposure pathways, with the exception of skin absorption, are potentially relevant depending on the environmental media impacted and importance of a specific pathway at a given site/locale. All of the pathways related to air emissions of Rn-222, including effects of its progeny, are evaluated by MILDOS-AREA.

7.3.3 Exposures from Water Pathways

The recovery solutions in the ore zone will be controlled and adequately monitored to ensure that migration does not occur. The overlying and

underlying aquifers will also be monitored. This will ensure that there is no migration to surface waters or adjacent non-exempt aquifers. A discussion of control of recovery fluids is located in Section 3.1.

The IX, precipitation, drying and packaging facilities will be located on concrete pads with berms and sumps to prevent any liquids from entering the environment. Solutions used to wash down equipment drain to a sump and will be either pumped back into the processing circuit or to the brine ponds. The berms and sumps will be of sufficient size to contain the contents of the largest tank in the event of a rupture. The measures discussed above will greatly limit the possibility of contamination of water bodies at the Ross ISR Project. Containment structures and safety controls are discussed in more detail in Section 3.2 of this report. In addition, Strata proposes to install a CBW to hydraulically isolate the CPP area, as described in Section 3.1. Contaminates that may reach the soil from process spills, tank spills, pipe leaks, pond leaks, and other possible accidents can be contained and mitigated.

The primary method of waste disposal at the facility will be by deep well injection. The deep well(s) will be completed at a depth more than 8,000 feet and will be isolated geologically from underground sources of drinking water. The well(s) will be constructed under a permit from WDEQ and all requirements of the Underground Injection Control (UIC) program for Class I wells will be met.

No routine liquid environmental discharges, other than waste disposal via deep well injection, are planned and as such, no definable water related pathways for routine operations exist.

7.3.4 Exposures from Air Pathways

Dose estimates from air pathways were made using MILDOS-AREA, the Argonne National Laboratory (ANL) computer code recommended by NRC in NUREG 1569, Section 7.3.1.2.2, for assessing radiological impact to the public from air emissions at ISRs.

The MILDOS-AREA computer code calculates the radiological dose commitments received by individuals and the general population within an 80-km radius of an operating uranium recovery facility. In addition, air and ground concentrations of radionuclides are estimated for individual locations, as well as for a generalized population grid. Extra regional population doses resulting from transport of radon and export of agricultural produce can also

be estimated. The transport of radiological emissions from point and different area sources is predicted with a sector-averaged Gaussian plume dispersion model. Mechanisms such as radioactive decay, plume depletion by deposition, ingrowth of decay products, and resuspension of deposited radionuclides are included in the MILDOS-AREA transport model.

Alterations in operation throughout the facility's lifetime can be accounted for in the input stream. The exposure pathways considered were inhalation; external exposure from ground shine and cloud immersion; and ingestion of vegetables and meat. Dose commitments were calculated primarily on the basis of the recommendations of the ICRP. Only airborne releases of radioactive materials were considered in MILDOS-AREA; releases to surface water and to groundwater were not addressed.

The Ross ISR Project will use modern vacuum dryer technology, therefore particulate emission will be considered negligible and the only airborne emissions from this facility will be radon gas, per guidance in NUREG 1569 (see previous discussion in Section 7.3.1). Radon-222 will have the potential to be released into the atmosphere through a vent system in the CPP and from the wellfields. As shown in Figure 7.3-1, atmospheric releases of radon-222 can result in radiation exposure via three pathways; inhalation, ingestion, and external exposure.

7.3.4.1 MILDOS History and Methodologies

The MILDOS-AREA computer code has gone through many changes over the years. In 1981 MILDOS (NUREG/CR-2011) was developed from version IV of the ANL computer program UDAD (Uranium Dispersion and Dosimetry). Version IX of UDAD is documented as NUREG/CR-0553. The models and assumptions on which the MILDOS program was based are described in the U.S. Nuclear Regulatory Commission Draft Regulatory Guide RH 802-4 and portions of the UDAD document. Models were included in MILDOS to consider both point sources (stacks, vents) and area sources (ore pads, tailing areas). Releases of particulates explicitly considered are limited to the radionuclides U-238, Th-230, Ra-226, and Pb-210. Other radionuclides are implicitly accounted for under the secular equilibrium assumption. Gaseous releases were limited to consideration of Rn-222 plus ingrowth of decay products. The dose to exposed individuals is calculated for comparison with requirements of both 40 CFR Part 190 and 10 CFR Part 20.

The version of MILDOS developed in 1981 allowed the user to define a maximum of 20 source terms, 10 time steps, and 48 individual receptor locations. Ingestion dose conversion factors were based on International Commission on Radiation Protection (ICRP) Publication 2 and 10 A's ingestion models. Inhalation dose conversion factors were calculated by the UDAD computer code in accordance with the Task Group on Lung Dynamics (TGLM) lung model of the ICRP (ICRP 1966 and 1972a), and the external dose conversion factors were taken directly from NUREG-0172 (NRC 1977).

In 1989, ANL developed the MILDOS-AREA code (ANL/ES-161) by modifying the MILDOS code developed in 1981. The changes were intended to provide enhanced capability to compute doses from large-area sources and to incorporate changes in methods for dosimetry calculations (ICRP 1979). This version of MILDOS-AREA allowed the user to define a maximum of 10 sources (point or area), 48 individual receptors, and 10 time steps. The number of sources was reduced from 20 allowed in the MILDOS code because in the revised code a large-area source is considered as a single source rather than as two or more virtual-point sources. MILDOS-AREA considers the same radionuclides as MILDOS.

While the MILDOS code could only be used on a mainframe computer, MILDOS-AREA was designed for use on an IBM or IBM-compatible personal computer. MILDOS-AREA was easier to use; more flexible in handling the large amount of printer output; and although slower in execution, usually exhibited a better net turnaround time than MILDOS. A validation study of MILDOS-AREA was conducted with measured Rn-222 concentration and flux data from the Monticello, Utah uranium mill tailings impoundment. The results of that study demonstrated that use of MILDOS-AREA can result in generally good agreement between model-generated and measured Rn-222 concentrations.

The MILDOS-AREA computer code was further updated by ANL in 1997. The 1989 version of MILDOS-AREA computer code incorporated dose conversion factors derived by the ICRP recommendations of 1978. The annual average air concentrations were compared with the maximum permissible concentrations (MPCs) in the Nuclear Regulatory Commission's Standards for Protection Against Radiation (10 CFR Part 20). On January 1, 1994, a revision to 10 CFR Part 20 (revised Part 20) went into effect. The revised Part 20 updated its dosimetry to the ICRP 1978 recommendations. The dose limit to the general public also changed. The changes led to a revision of the calculated

allowable concentrations (ALC) for unrestricted areas, with MPC being replaced by the term "effluent concentrations." In addition, a new method of recovering uranium gained popularity in the late 1980s, and the majority of operating licensees started using the in-situ leach (ISL) method.

The 1997 MILDOS-AREA update had two principal objectives. The first objective was to update the code's data structures and terminology to meet the needs of the revised Part 20; the second objective was to create an example problem for in-situ leach facilities. These two objectives resulted in the creation of a patch program that updated the 1989 version to the 1997 version of MILDOS-AREA.

In 1998, ANL again updated MILDOS-AREA. In previous versions, up to the 1997 update, code lacked user-friendly features. To run the code, a user had to first separately develop an input file, which is an ASCII file containing all of the pertinent values that are required by the code. The code was then executed to produce the output file, which contains results of the calculations. The latest version of MILDOS-AREA code includes a user-friendly software interface. This graphical user interface (GUI) is simple and easy to use and allows MILDOS-AREA to run under the Windows operating system. The interface contains sufficient information so that the user clearly understands where to input each parameter needed for the calculations. The GUI follows standard Windows 3.x and Windows 95 structures. The GUI allows the creation, retrieval, and editing of MILDOS-AREA input files. In the various editing windows, the GUI provides information to clearly indicate where each parameter value should be input and what units should be used for each parameter. The GUI allows the results of the MILDOS-AREA calculations (the output file) to be viewed, the results file to be saved, the information from the results to be moved into other software applications, and the results files from previous runs to be retrieved.

The GUI is implemented with standard Windows 3.x and Windows 95 usage of menus, windows, buttons, and other Windows functions. All user actions in the GUI are accessible through keystrokes and keystroke combinations, as well as a pointing device (mouse). The GUI contains an online help system that uses Windows-standard protocols and includes information from the user's manual and other basic operating information. The 1998 GUI version of MILDOS-AREA computer code runs on a baseline PC, configured

with a 486/66 MHz CPU, with 8 MB RAM, that uses the Windows 3.x or Windows 95 operating system.

Nature of Problems Solved by MILDOS-AREA

The MILDOS-AREA computer code calculates the radiological dose commitments received by individuals and the general population within an 80-km radius of an operating uranium recovery facility. In addition, air and ground concentrations of radionuclides are estimated for individual locations, as well as for a generalized population grid. Extra-regional population doses resulting from transport of radon and export of agricultural produce are also estimated.

The transport of radiological emissions from point and different area sources is predicted with a sector-averaged Gaussian plume dispersion model. Mechanisms such as radioactive decay, plume depletion by deposition, ingrowth of decay products, and resuspension of deposited radionuclides are included in the transport model. Alterations in operation throughout the facility's lifetime can be accounted for in the input stream.

Exposure Pathways and Dose Conversion Factors Considered by MILDOS

The pathways considered for individual and population impacts are:

- Inhalation,
- external exposure from ground concentrations,
- external exposure from cloud immersion,
- ingestion of vegetables,
- ingestion of meat, and
- ingestion of milk.

Doses are calculated by use of dose conversion factors. Those in MILDOS-AREA are ultimately based on recommendations of the ICRP. These factors are fixed internally in the code, and are not part of the input options.

Source Description

Radionuclide releases are defined for each source for particulates and radon gas. The U-238 decay chain is assumed to be the only significant source of radiation for uranium milling operations. The contribution from the U-235

chain is less than 5% of that from the U-238 chain. Particulate releases are defined to include the radionuclides U-238, Th-230, Ra-226, and Pb-210. The gaseous releases are defined for Rn-222, with ingrowth of short-lived decay products also considered. For Rn-222, these decay products include Po-218, Pb-214, Bi-214, Pb-210, and Po-210. The dosimetry model accounts for releases and ingrowth of other radionuclides by assuming secular equilibrium.

The time history of release for each source is defined for the life of the mill and post-operational period. Typically, a uranium mill will operate for a period of years, during which there will be radon and particulate releases from the ore storage pile, the mill itself, and the tailings disposal area or for ISR projects, from the wellfields and the CPP during construction, operation and aquifer restoration.

Atmospheric Transport and Diffusion

Emissions of radioactive materials from different sources are modeled with a sector-averaged Gaussian plume dispersion model, which utilizes user-provided wind frequency data. Mechanisms such as deposition of particulates, resuspension, radioactive decay, and ingrowth of decay-products radionuclides are included in the transport model. The model computes annual average air concentrations of radionuclides and then uses the results to compute impacts to humans through various pathways. Ground surface concentrations are estimated from depositional buildup and ingrowth of radioactive decay products. The surface concentrations are modified by radioactive decay, weathering, and other environmental processes. The MILDOS-AREA code allows the user to vary the emission sources as a step function of time by adjusting the emission rates, which includes shutting them off completely. Thus, the results of a computer run can be made to reflect changing processes throughout the facility's operational life.

7.3.4.2 Site Specific Inputs

The MILDOS-AREA program was provided with a stability array (STAR) file of onsite meteorological data. The wind speed data provided was collected as part of the baseline monitoring program and represents over 80% of the 12 month collection period. The meteorological data that was provided to MILDOS is described in Section 2.5.1.

Additionally, the population data provided in Table 3.10-2 of the ER was inputted into the MILDOS-AREA program for the calculation of population doses within 80 km.

The amount of meat and vegetables produced annually per km^2 were calculated based on data for Campbell County provided in Tables 3.1-3 and 3.1-4 of the ER, respectively. Based on the values given for this county for tons of hay produced per acre (average) and annual meat production, it is estimated that on average this site can expect to produce 2.71E5 kg hay/km^2 and 2370 kg meat/km^2. The milk pathway was considered not relevant for the Ross project. The area in this county and specifically near the proposed project area is used for lower density beef cattle ranching and not for dairy farming. It is unlikely that local residents would get any portion of their dairy diet from cows living in the immediate area.

Fourteen potentially exposed members of the public were identified for the model. These included the four nearest residents (Strong, Wood, Wesley, and Burch), the Oshoto Field Office, five rancher scenarios, two oilfield worker scenarios, a courier, and a vendor. All of these members were assumed to spend at least 50 hours per year at the Ross ISR project. Other members of the public were considered, including a commuter driving past the site, a hunter and a fisherman; however, these members were not modeled since time on the proposed project area was estimated as 25 hours or less per year for each. The locations and annual hours spent in the proposed project area by members of the public are listed in Table 7.3-1. Note that all scenarios make the conservative assumption that all work will be carried out by the same person (for example, that the same courier delivers all packages to the CPP throughout the year).

7.3.4.3 Potential Sources of Radiological Effluent

The Ross ISR project has the potential to produce radiological effluent in the form of Rn-222 that is dissolved in the production and restoration fluid and is present as a result of the uranium decay series. It is assumed there will be no particulate emissions during routine operations of this facility as the facility will use modern, low temperature vacuum driers, the particulate release of which is considered to be zero by the NRC as provided in NUREG 1910 (NRC 2009). This will be the case for the Ross ISR since the dryer off gas system captures essentially all particulates and exhausts into the dryer room (see

Sections 4.1 and 5.7.1). The Rn-222 releases result from the following sources during the lifespan of the Ross ISR project:

- New Wells: The drilling process removes soil/drill cuttings which contain Rn-222. This soil is stored in mud pits until the wells are decommissioned. Rn-222 is released during the mud pit storage.
- Production Wells: Rn-222 may be released via leaks/venting in the well heads or the module buildings.
- CPP: The pressurized, closed system for the production fluids is opened at the point of ion-exchange column transfer and point of conveyance discharge points (MILDOS-AREA defines this as "purge water") to the lined retention ponds near the CPP.
- Aquifer Restoration Wells: Circulating water and discharged water from the restoration process also contains Rn-222 which may be released during the process.

MILDOS-AREA parameters used to characterize and estimated atmospheric releases are provided in Table 7.3-2. For purposes of this analysis, it has been assumed that the Ross ISR project will have two Mine Units that will be operated concurrently over the span of 51 months. The proposed project schedule for the Ross ISR Project is shown in Figure 1.9-1.

In any areas of overlap, it was assumed that the part of the process that is active and produces the highest source term represents 100% of all wellfield operations (most conservative). For example, the operation phase of the project has larger source term than the new wellfield construction phase. Accordingly, during the time period of 13-43 months, it is assumed that the entirety of the wellfield is in operation even though in fact the source term will be smaller as portions of the Mine Units will be in construction or aquifer restoration.

7.3.4.4 Source Term Estimates

The source term estimates for Rn-222 releases were calculated for each of the sources described in the previous section. For modeling purposes the two Mine Units were assigned point locations based on the centroid of each unit. The locations and areas of the Mine Units are presented in Table 7.3-3. Source terms were calculated using equations provided in NUREG 1569, Appendix D and the ISR specific patch to the MILDOS-AREA code. A summary of calculated source terms for the Ross ISR Project is provided in Table 7.3-4.

New Wells

The primary source of Rn-222 during the construction process was identified as the mud pits. Construction source terms were calculated at the centroid of both Mine Units using the following equation:

$$Rn_{nw} = (10^{-12})(E)(L)([Ra])(T)(M)(N)$$

where:

Rn_{nw}	=Rn-222 release rate from new wellfield (Ci/yr)
10^{-12}	=unit conversion factor (Ci/pCi)
[Ra]	=concentration of Ra-226 in ore (pCi/g)
E	=emanating power (Assumed 0.25)
L	=decay constant of Rn-222 (0.181/day)
T	=storage time in mud pits (days)
M	=average mass of ore material in mud pits (g)
N	=number of mud pits generated per year

This calculation provided a source term of 0.0213 Ci/yr Rn-222 released into the atmosphere for each Mine Unit resulting in a total of 0.0426 Ci/yr released as a result of new wellfield construction.

Production Wells

The total operation source term is the sum of three terms that represent Rn-222 releases as a result of occasional venting and leaking of wellheads and pipes at module buildings, purge water release and unloading IX columns. The Rn-222 release associated with leaking and venting of wellheads was calculated with the following equations:

$$Rn_v = (3.65^{-10})(v)(C_{Rn})(V)$$

where:

Rn_v	= Rn-222 release from venting (Ci/yr)
v	= rate of radon venting from piping and valves during circulation (day^{-1})
V	= volume of water in circulation (L)

where:

$$C_{Rn} = \frac{(10^6)([Ra])(A)(D)(\rho)(E)(L)(f)}{(L + v)\,V + F_p + F_i}$$

where:

C_{Rn}	= Rn-222 concentration in the process water (pCi/L)
[Ra]	= concentration of Ra-226 in the ore (pCi/g)
A	= active area of ore zone (m^2)

D = average thickness of the ore zone (m)
ρ = density of ore material (g/cm^3)
E = emanating power (assumed 0.25)
L = decay constant of Rn-222 (0.181/d)
M = average mass of ore material in mud pits (g)
N = number of mud pits generated per year
F_p = purge rate of treated water (L/day)
F_i = water discharge rate, resin unloading of IX columns (L/day)
V,v = as previously defined

The wellfield operation source terms were calculated for both Mine Units resulting in a source term of 122 Ci/yr at Mine Unit 1 and 123 Ci/yr at Mine Unit 2.

CPP

The contribution of Rn-222 from unloading IX columns and water discharge to lined retention ponds were modeled as the CPP source term. The following equation was used to calculate the contribution to the CPP source term from water discharge to lined retention ponds:

$$Rn_w = (3.65^{-10})(C_{Rn})(F_p)$$

where
Rn_w = Rn-222 release rate from water discharge to lined retention ponds (Ci/yr)
F_p = purge rate of treated water (L/day)

While the following equation was used to calculate the contribution to the CPP source term as a result of IX column unloading:

$$Rn_x = (3.65^{-10})(C_{Rn})(F_i)$$

where:
Rn_x =annual Rn-222 discharge from unloading IX column contents
F_i =water discharge rate from resin unloading of IX columns (L/day)

The Rn-222 source term as a result of water discharge to lined retention ponds was 70.2 Ci/yr, while the source term as a result of IX column unloading was 1.0 Ci/yr for a total source term at the CPP of 71.2 Ci/yr.

Aquifer Restoration

During aquifer restoration, radon will continue to be vented through surface well heads and released via water discharge to lined retention ponds. However, there will no longer be a component from IX column unloading. The equations used for source term production at both production Mine Units and CPP were applied for aquifer restoration resulting in a source term of 70.2 Ci/yr for the CPP and 122 and 123 Ci/yr for Mine Units 1 and 2, respectively.

7.3.5 Exposures from External Radiation

Exposures from external radiation (from cloud and ground shine) were included in the calculations performed by MILDOS-AREA to estimate Total Effective Dose Equivalent (TEDE). These calculations resulted in estimates of dose equivalent from external pathways to be < 2 % of the TEDE since the dose to members of the public is > 98 % from inhalation of radon progeny.

7.3.6. Annual Exposure to Humans

In order to demonstrate compliance with the annual dose limit (100 mrem/yr) found in 10 CFR 20.1301, the MILDOS-AREA model was used to calculate the maximum TEDE that members of the public could receive as a result of the Ross ISR Project. The results, presented in Table 7.3-5, indicate that the TEDE to each of the fourteen members of the public is less than 1 mrem/yr. Overall, the highest TEDE is estimated at the Wesley residence. Figure 7.3-2 depicts the locations of each member of the public as well as the annual estimated TEDE.

Doses to local residents were based on an exposure of 8,400 hours per year, while the TEDE calculated to the other members of the public were scaled per the number of hours of exposure per year as summarized in Table 7.3-1. In addition, it was recognized that only groundshine and inhalation pathways could be directly scaled since the ingestion pathways were not relevant for all receptor types modeled. Contributions from each pathway for the Wesley residence are presented in Table 7.3-6.

The annual dose to the members of the public throughout the life of the project were calculated based on the proposed schedule shown in Figure 1.9-1, the annual doses presented in Table 7.3-5 and assumptions shown in Table 7.3-7. The annual dose over the life of the project to the 14 members of the public chosen for modeling are presented in Figure 7.3-3.

Since the doses presented in Table 7.3-5 were calculated for adult members of the public, Strata also evaluated TEDE to an infants, child and teenagers at the four residences and the Oshoto field office. In all likelihood it is reasonable to assume the oilfield worker, vendor and courier will be an adult. The results, presented in Table 7.3-8, indicate that the dose does not change for the various age groups.

In the event that any potential public exposure scenario of importance was overlooked in the process of selecting receptors, an isodose map (Figure 7.3-4) was prepared to show the annual doses to any person standing at various locations across the proposed project area. The isopleths were generated by placing receptors every 250 meters on a 4 km grid centered on the CPP for a total of 287 receptors. The source terms were calculated as described previously; however, because these receptors represented workers (2000 hours/yr residency time was assumed) and not residents, all vegetation and meat ingestion pathways were set to zero. The largest annual dose to any receptor was 1.6 mrem/yr near the CPP. Since it is not likely that any person could reside there for any significant fraction of 2000 hrs/yr and this dose is less than 10% of the annual dose limit for members of the public, the design of the plant and the current wellfields and the operational strategies to be employed by Strata are considered to be ALARA.

7.3.7 Population Dose

Annual population dose was also estimated by MILDOS-AREA. The "Collective TEDE" is expressed by the MILDOS-AREA code in "Person-Rem". The TEDE to the population within 80 km was estimated to be 0.361 Person-Rem. Based on the annual natural background dose for this population, using an average annual background exposure to a resident of Wyoming of 257 mrem/yr (ER Table 3.11-3) and the size of the regional population within 80 km (ER Table 3.10-2), the annual population dose would be approximately 10,500 Person Rem.

7.3.8 Exposure to Flora and Fauna

Because of their relative mobility, some native animals, including small mammals and birds, may have contact with potential Rn-222 releases and associated progeny. Within the proposed project area it is possible that individual animals might have contact with higher concentrations of

radionuclides than any member of the public because of potential proximity to releases, environmental transport and bioaccumulation factors. However, the mobility of biota makes it unlikely that any individual animal would receive a constant concentration for the entire year. There are no current dosimetric standards for protection of biota. However, it has been assumed by the ICRP that if humans were protected, then biota in the same exposure environment would also be protected

US Department of Energy (DOE) Order 5400.5 proposed a limit of one rad per day (rad/day) for aquatic organisms (DOE 1993). Title 10 CFR Part 834, Subpart F proposes limits of one rad/day for terrestrial plants and 0.1 rad/day for terrestrial animals. Those proposed values are expected to be far higher than the doses that would be calculated to any non-human receptor. Therefore, it is reasonable to expect no significant impact from exposure of biota from releases from the facility.

Table 7.3-1. Potentially Exposed Members of the Public

Member of Public	Location[1] N/S (km)	Location[1] E/W (km)	Location[1] Z (m)	Activities	Annual Hours	Calculation of Total Hours of Exposure
Wood	0.32925	0.76825	4.8768	Resident	8400	50 wk/yr x 7 d/wk x 24 h/d
Strong	-0.46095	0.4829	0.6096	Resident	8400	50 wk/yr x 7 d/wk x 24 h/d
Oshoto Field Office	0.9192	0.6585	4.572	Potential Residence	8400	50 wk/yr x 7 d/wk x 24 h/d
Wesley	1.2704	0.1317	-10.668	Resident	8400	50 wk/yr x 7 d/w x 24 h/d
Burch	0.32925	-3.8551	47.244	Resident	8400	50 wk/yr x 7 d/w x 24 h/d
Rancher 1	0.06585	-0.32655	9.7536	Horse Pasture Grazing	50	10 h/d x 5d/y
Rancher 2	0.06585	0.4829	3.6576	Hay Production	100	10 h/d x 10 d/y
Rancher 3	-0.2195	0.06585	3.048	Cattle Grazing	50	10 h/d x 5d/y
Rancher 4	0.3512	0.06585	-6.096	Cattle Grazing/Hay Production	100	10 h/d x 10 d/y
Rancher 5	0.3512	0.4829	0.6096	Hay Production	100	10 h/d x 10 d/y
Oilfield Worker 1	0.06585	-0.32655	9.7536	Operation and maintenance	175	Op: 0.5 h/d x 5 d/w x 50 w/y Maint: 10 h/d x 5 d/y
Oilfield Worker 2	-0.2195	0.439	1.524	Operation and maintenance	175	Op: 0.5 h/d x 5 d/w x 50 w/y Maint: 10 h/d x 5 d/y
Courier	0.02195	0.15365	-2.4384	Package Delivery	90	20 min/d x 5 d/w x 52 w/y
Vendor	0	-0.06585	0	Equipment Delivery	260	1 h/d x 5 d/w x 52 w/y

[1] Locations are listed as kilometers from the CPP and meters above or below the elevation of the CPP

Table 7.3-2. MILDOS-AREA Input Parameters

Parameter	Abbreviation	Value	Unit	Source
Average Ore Grade		0.05%	% U_3O_8	Application
Ore Ra-226 concentration	[Ra]	143	pCi/g	2860 pCi/g per % U_3O_8 Reg Guide 3.59, U.S. NRC 1987
Mined Area	A	4.05E+5	m^2	Application
Average lixiviant flow		5,075	gpm	Application
Average restoration flow		950	gpm	Application
Operating days a year		365	days	Estimate based on planned activities
Ore formation thickness	D	2.7	meters	Application
Ore formation porosity		34	%	Application
Ore formation rock density	ρ	2.1	g/cm^3	Application
Average residence time for lixiviant		11	days	Estimate based on planned activities
Average residence time for restoration solutions		32	days	Estimate based on planned activities
Average mass of ore material in mud pits	M	225,000	g	Estimate based on planned activities
Number of mud pits generated per year	N	733	number of pits	Estimate based on planned activities
Storage time in mud pits	T	20	days	Estimate based on planned activities
Rn-222 emanating power	E	0.25	-	NUREG 1569
Resin porosity		0.35	% U_3O_8	Application
IX column volume		14,160	pCi/g	Application
Number of resin transfers per day		1.5	transfers/day	Estimate based on planned activities
Purge water release	F_p	550,000	L/day	Estimate based on planned activities
Radon venting	v	0.01	day^{-1}	NUREG 1569
Decay constant	L	0.181	day^{-1}	NUREG 1569

Table 7.3-3. Mine Unit Locations Relative to the CPP

	Mine Unit 1	**Mine Unit 2**
X Location (km)	-0.72165	-0.58995
Y Location (km)	0.5707	-0.3073
Z Location (elevation) (m)	5.79	25.9
Area of the Well field (m^2)	218,100	219,600

Table 7.3-4. Estimated Rn-222 Releases (Ci/yr) from the Ross ISR Facility

Location	Construction	Operation	Aquifer Restoration
Mine Unit 1	0.0213	122	122
Mine Unit 2	0.0213	123	123
CPP	N/A	71.2	70.2
TOTAL	0.0426	316.2	315.2

Table 7.3-5. Estimated Annual Dose to Members of the Public

Member of the Public	Maximum TEDE (mrem/yr)		
	Construction	Construction	Construction
Wood residence	0.000045	0.470	0.468
Strong residence	0.000053	0.735	0.731
Wesley residence	0.000070	0.779	0.775
Burch residence	0.000013	0.090	0.089
Oshoto field office	0.000048	0.542	0.540
Rancher #1	0.000002	0.017	0.018
Rancher #2	0.000001	0.011	0.011
Rancher #3	0.000001	0.020	0.020
Rancher #4	0.000001	0.041	0.041
Rancher #5	0.000001	0.010	0.010
Oilfield worker #1	0.000005	0.049	0.049
Oilfield worker #2	0.000001	0.020	0.020
Courier	0.000001	0.049	0.049
Vendor	0.000004	0.548	0.542

Table 7.3-6. Contributions to the TEDE from Individual Exposure Pathways for the Wesley Residence

	Pathway					
	Inhalation	**Ground**	**Cloud**	**Ingestion (produce)**	**Ingestion (meat)**	**Ingestion (dairy)**
Dose (mrem/yr)	0.76800	.00120	.01150	.00005	.00001	0
Contribution to Total Dose (%)	98.4	0.2	1.5	0	0	0

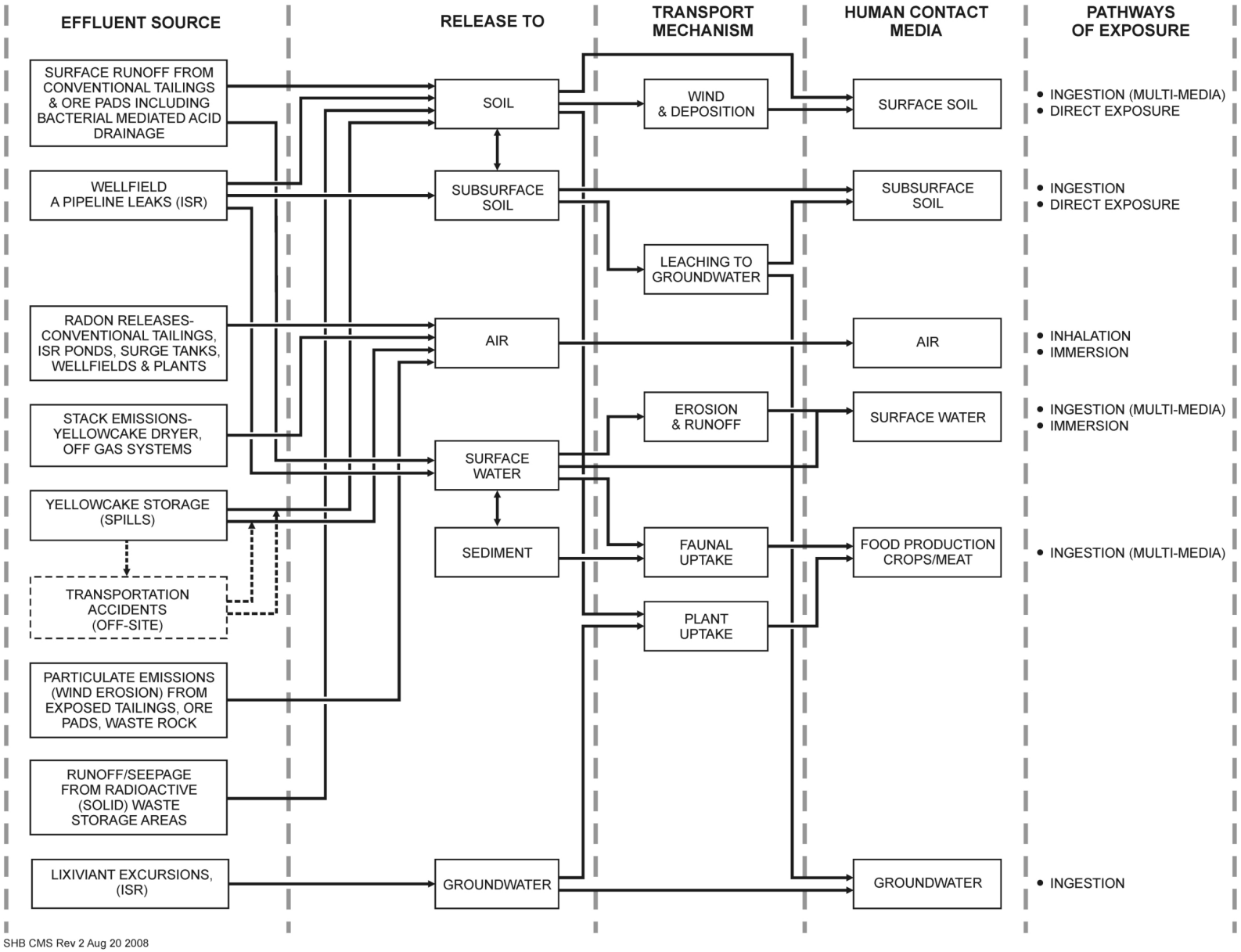
Table 7.3-7. Annual Dose Computation by Year

Year	Source Term Contributing to Annual Dose
1	12 months construction
2	1 month construction, 11 months operation
3	12 months operation
4	12 months operation
5	1 month operation, 11 months aquifer restoration
6	12 months aquifer restoration
7	12 months aquifer restoration

Table 7.3-8. Estimated Annual Dose to Various Residence Age Groups

		Maximum TEDE (mrem/yr)		
Residence	**Age Group**	**Construction**	**Operation**	**Aquifer Restoration**
Wood	Infant	0.000045	0.470	0.468
	Child	0.000045	0.470	0.468
	Teenager	0.000045	0.470	0.468
	Adult	0.000045	0.470	0.468
Strong	Infant	0.000053	0.735	0.731
	Child	0.000053	0.735	0.731
	Teenager	0.000053	0.735	0.731
	Adult	0.000053	0.735	0.731
Oshoto field office	Infant	0.000048	0.542	0.540
	Child	0.000048	0.542	0.540
	Teenager	0.000048	0.542	0.540
	Adult	0.000048	0.542	0.540
Wesley	Infant	0.000070	0.779	0.775
	Child	0.000070	0.779	0.775
	Teenager	0.000070	0.779	0.775
	Adult	0.000070	0.779	0.775
Burch	Infant	0.000013	0.090	0.090
	Child	0.000013	0.090	0.090
	Teenager	0.000013	0.090	0.090
	Adult	0.000013	0.090	0.090

Figure 7.3-1. Conceptual Model Depicting Typical Radiological Exposure Pathways for ISRs



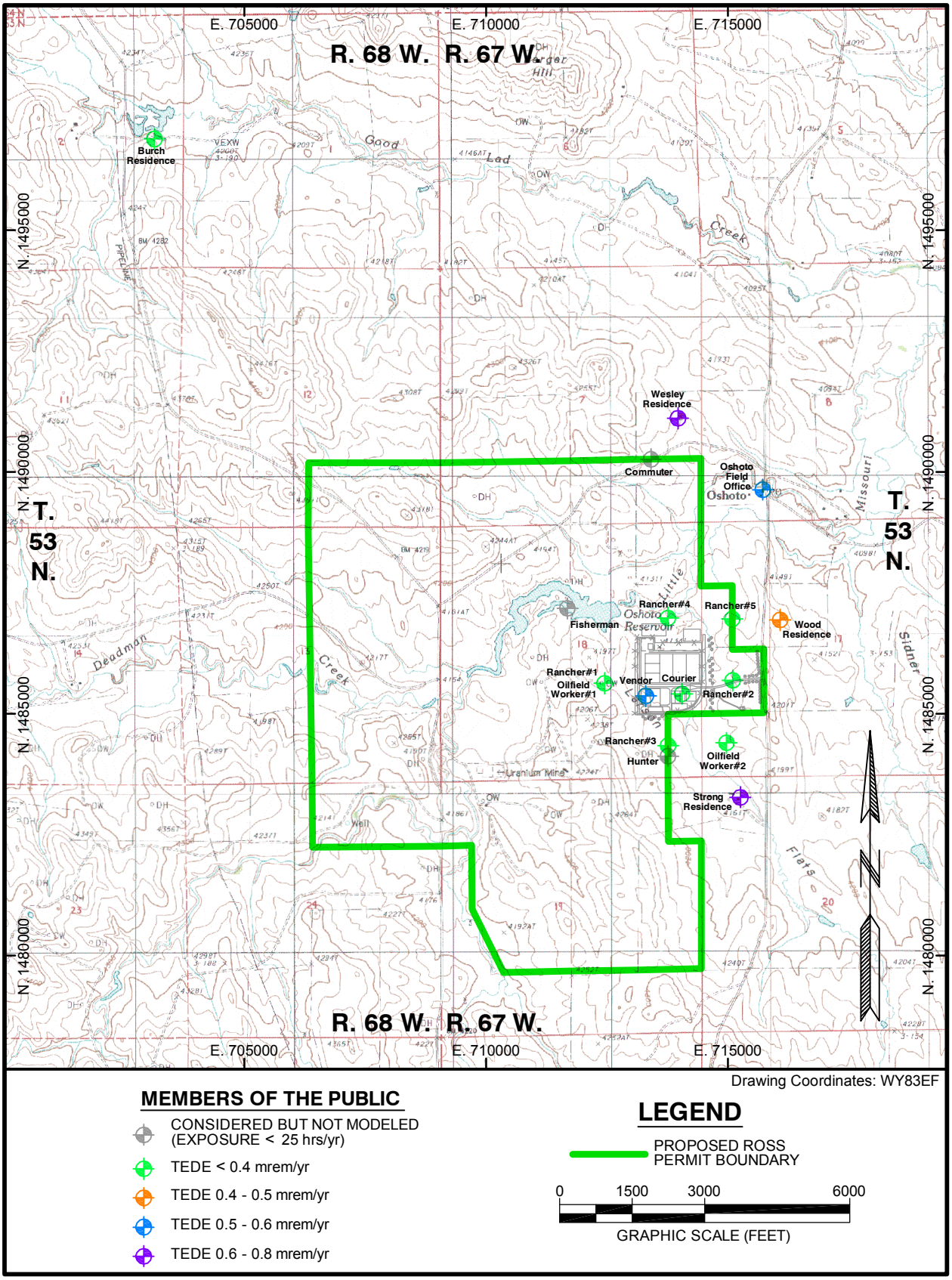


Figure 7.3-2. Maximum TEDE to Members of the Public

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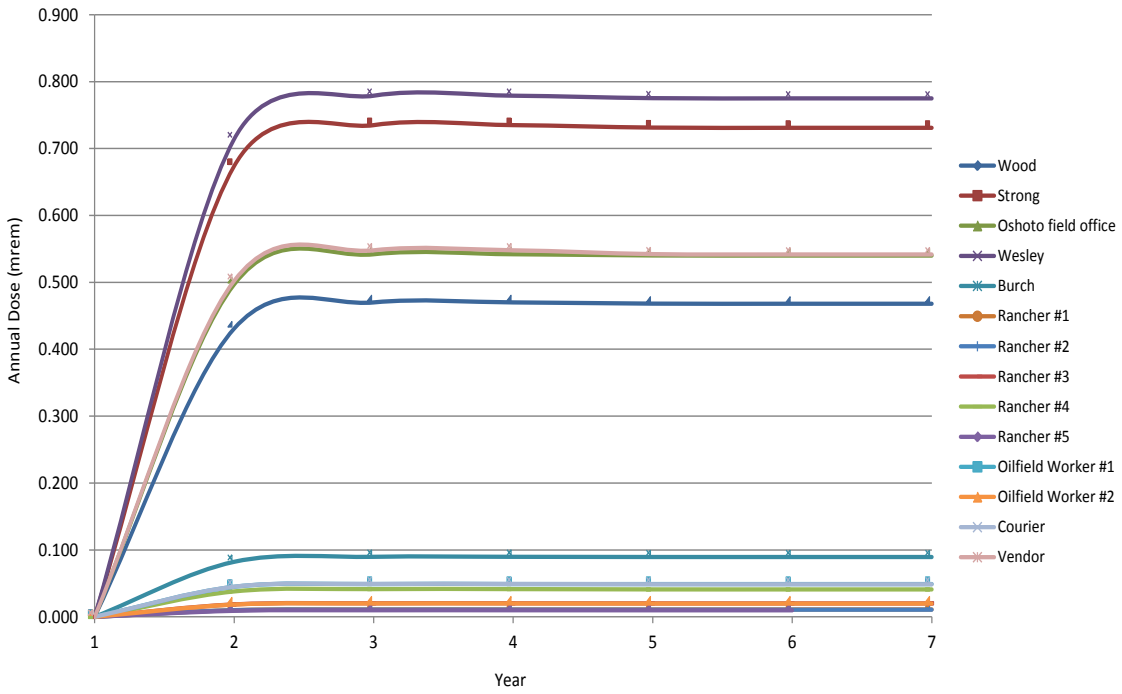
Figure 7.3-3. Annual Dose to Members of the Public throughout the Project



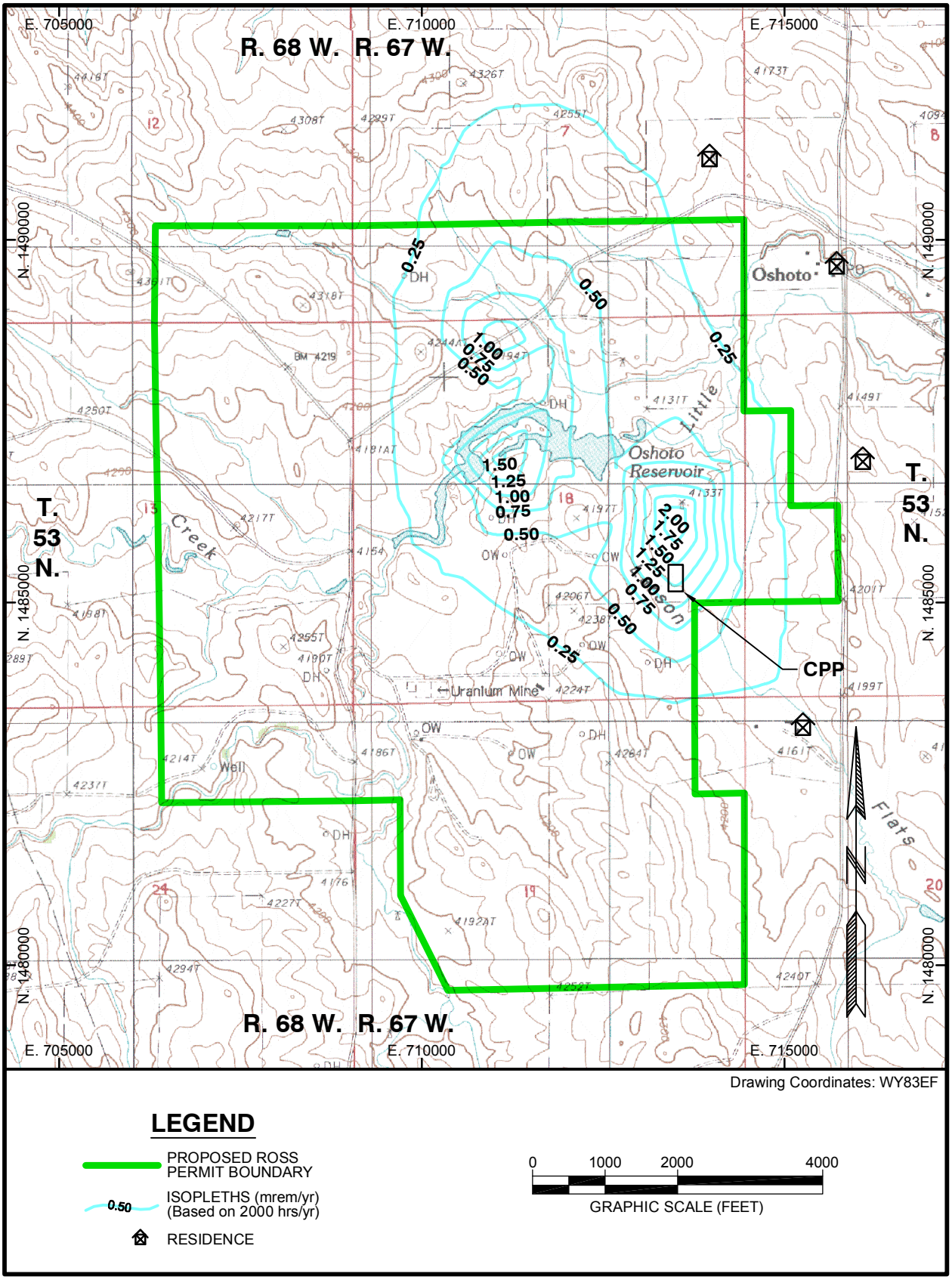


Figure 7.3-4. Isograph

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7.4. Non Radiological Effects

During the life of the project, the greatest potential for non-radiological impacts can primarily be attributed to fugitive dust, combustion emissions, gaseous emissions, and liquid emissions.

7.4.1 Potential Exposure from Air Pathways

7.4.1.1 Fugitive Dust

Sections 7.1.4.2, and 7.2.4.1 discuss potential air quality impacts due to fugitive dust during construction, operation, and decommissioning. As previously discussed fugitive dust will increase over baseline levels during the life of the project due to increased traffic over the local road system. Some sources of fugitive dust generated will include trucks transporting supplies, chemicals and waste materials to and from the site; building and wellfield construction, work over, and operation activities; and employee and contract worker vehicles traveling to and from the proposed project area. All access roads used by vehicles traveling to and from the project area will be maintained to ensure that fugitive emissions are minimal. Mitigation measures are discussed in Section 5.6 of the ER and include speed limit control, use of dust control water loadout facilities, occasional rerouting of traffic to reduce volumes, use of chemical dust suppression chemicals, and proper selection of road surface materials.

7.4.1.2 Engine Emissions

Potential air quality impacts due to combustion emissions during construction, operation, and decommissioning are also discussed in Sections 7.1.4.2 and 7.2.4.1. During construction, diesel emissions will be emitted from drill rigs, diesel-powered water trucks and other heavy equipment. Employee vehicles and trucks transporting equipment to the site will also emit fuel combustion products.

Vehicle combustion emissions will be less during operations due to less worker traffic and fewer shipments of chemicals and supplies to the site. Vehicle combustion emissions will include onsite traffic related to operations and maintenance, heavy equipment used to construct additional wellfield modules, employee and contractor traffic to and from the site, and heavy truck traffic delivering supplies to the site and products and waste from the site. A

summary of the emissions inventory for the proposed Ross ISR Project during all project phases is presented in Table 4.6-1 of the ER.

7.4.1.3 Gaseous Emissions

Non-radiological emissions present during operation include release of gaseous effluents such as oxygen and carbon dioxide from the wellfield and CPP. The primary sources of non-radiological gaseous effluents will include CO_2 released from uranyl tricarbonate breakdown in the precipitation circuit, CO_2 and oxygen released during elution, and combustion emissions, including CO_2, from the natural gas-fired vacuum dryer(s). A summary of the anticipated annual CO_2 production and release from processes in the CPP is presented in Table 4.6-2 of the ER. A complete greenhouse gas inventory is provided in Addendum 4.6-A of the ER.

Other non-radiological gaseous emissions sources may include venting of excess vapor pressure in pipelines and small amounts of chemical vapor released from the CPP ventilation system. These sources are expected to have minimal environmental impacts.

7.4.2 Potential Exposures from Water Pathways

During operation Strata may utilize surface discharge as a disposal method for permeate, as discussed in Section 4.2 of this TR. Surface discharge of permeate would be performed under a WYPDES permit, which would be issued by WDEQ/WQD and would contain effluent limits based on 40 CFR 440 and Wyoming Water Quality Rules and Regulations that are designed to protect public health and the environment. There would be no potential public health impacts resulting from permeate discharge due to the high effluent quality and small discharge rate (typically 50 gpm or less).

There are several public water supplies located near the project which include Pine Haven (17 miles), Hulett, (19 miles), Moorcroft (22 miles), and Gillette (10-12 miles). All supply wells for these systems are located in the Madison Formation with the exception of Moorcroft, which currently utilizes the Lance-Fox Hills Formation. A construction project scheduled for 2010 will provide a transmission line to a recently drilled Madison Formation well approximately 10 miles East of Moorcroft (Wyoming State Loan and Investments Board 2007). More details of the public water supply systems near the project area are described in Section 4.12 of the ER.

The potential to impact area public water supplies as result of the proposed action is extremely remote. All public water supplies within 20 miles (32 km) are completed in the Madison Formation, which is stratigraphically far below the Lance-Fox Hills Formation targeted for ISR uranium recovery in the proposed project area (see Figure 2.6-3, Regional Stratigraphic Column, for the general location of the Madison in comparison to the Lance/Fox Hills Formation). As described in the deep disposal well application (Addendum 4.2-A), the depth to the top of the Madison Formation is anticipated to be approximately 7,000 feet. By comparison, the depth to the ore zone is about 250 to 650 feet within the proposed project area (see Section 2.6.2.2.4). Furthermore, the minimum distance from the proposed project area to a public water supply well is at least 10 miles.

Rural residents of the area surrounding the proposed project area have private wells that provide drinking water for household use and livestock watering. A description of the domestic water supply wells near the proposed project area is included with the description of the baseline groundwater quality monitoring program in Section 2.7.3.3.1. Water quality impacts from normal operation of the proposed Ross ISR Project will be confined to the portions of the ore zone within the aquifer exemption boundary, and therefore there will be no impacts to nearby drinking water wells from normal operations

7.5 Effects of Accidents

Accidents involving human safety associated with the ISR uranium recovery technology typically have far less severe consequences than accidents associated with underground and open pit mining methods. ISR provides a higher level of safety for employees and neighboring communities when compared to conventional mining methods or other energy related industries. Accidents that may occur would generally be considered minor when compared to other industries. Radiological accidents that might occur would typically manifest themselves slowly and are therefore easily detected and mitigated. The remote location of the Ross ISR Project and the low level of radioactivity associated with the process combine to decrease the potential hazard of an accident to the general public.

The NRC has previously evaluated the effects of accidents at conventional uranium milling facilities in NUREG-0706 and specifically at ISR uranium facilities in NUREG/CR-6733. These analyses demonstrate that, for most credible potential accidents, consequences are minor so long as effective emergency procedures and properly trained personnel are used. The Ross ISR Project facilities are consistent with the operating assumptions, site features, and designs examined in the NRC analyses in NUREG/CR-6733.

Strata will develop emergency management procedures to implement the recommendations contained in the NRC analyses. As part of the emergency management procedures, a response program with emergency response SOPs will be developed. Training programs discussed in Chapter 5.0 will ensure that Strata personnel are adequately trained to respond to all potential emergencies. Accident occurrence will generally require notification and reporting to various agencies. SOPs contained in the emergency response program will specify under what conditions emergency notification and reporting will be required, and to which agencies. Assessments of potential accident scenarios, as well as preventative and mitigation measures are discussed in the following sections.

7.5.1 Liquid Waste and Process Fluid Accidents

7.5.1.1 Process Vessel or Tank Failure

Process fluids will be contained in process vessels and pipes during operation. Instrumentation, controls, and alarms will monitor the flows and levels of tanks to maintain proper levels. The central processing plant will

employ three levels of containment for liquid process fluids and effluents: process tanks, secondary containment berms, and an impermeable liner below the building foundation.

The primary form of containment throughout the processing building is each individual process tank or vessel. Secondary containment will consist of concrete curbing. There are two philosophies used for curbing within the plant, total containment in the event of tank failure and containment of leaks or spills during operations. Curbing to contain a failed tank will be used in areas that pose a major health risk or potential product recovery; these areas will have curbing to contain at least 110% of the volume of the largest tank. Curbing for spill containment only will be employed in areas where it is unnecessary or impractical to contain the total volume of fluid in that area but where it is still desirable to contain spills, one such area is near the yellowcake thickeners. The use of sloped floors within designated areas throughout the plant will direct any spilled/leaked fluid to an appropriate sump to be disposed of or returned to the process. Table 3.2-2 shows the dimensions and capacities of process vessels, chemical storage tanks, and secondary containment. A layout of the secondary containment curbs within the CPP is shown in Figure 5.7-4.

The secondary containment berms were designed to contain at least the largest process vessel within each area. In some instances, secondary containment berms will also contain accidents involving multiple tank failures which could occur as a result of one vessel falling into another or in the event of a natural disaster. It is possible that in the event of a natural disaster where multiple tanks are damaged, that the total volume of fluid released would not be confined in the secondary containment. In this scenario, spilled liquid would also be contained by the central processing plants building foundation, which incorporates a stem wall which extends 12-inches above the finished floor. This stem wall will contain the entire volume of process and storage tanks which are located in the CPP. All containment basins will be sloped to drain into the sumps which are located throughout the CPP. In the unlikely event that the capacities of the secondary containment, CPP foundation containment, and sumps were exceeded, such as would be the case if pregnant lixiviant trunklines could not be shut down, the soil adjacent to the CPP would adsorb and slow migration of the spilled liquid. Further assurance that radiological contaminants or hazardous chemicals will not reach exposure pathways such as shallow groundwater will be provided by the geosynthetic liner which will be

installed under the CPP foundation as well as Strata's ability to recover contaminates in the subsurface with the containment barrier wall dewatering system. The geosynthetic liner and containment barrier wall are discussed in Chapter 3.0 of this report.

As discussed in Section 3.3, piping and process tanks within the CPP will be equipped with instrumentation which will monitor pressure at key points. Events such as leaks or spills which cause operating parameters to move outside of predetermined ranges will trigger alarms, and the pump system will immediately shut down, limiting any release.

NUREG/CR-6733 evaluated the potential dose to onsite workers and the public from a spill of pregnant lixiviant and IX resin as a result of a damaged IX vessel. Based on several assumptions, the predicted dose was 1.3 rem in a 30-minute period. It should be noted in this analysis that any change to the radon concentration or the exposure time will have a linear effect on the dose estimate. For example if the room size doubles or the exposure time is cut in half, the dose will be half as much. The analysis also operated under the conservative assumption that all of the radon contained in the pregnant lixiviant is immediately released into the facility, which would depend on the solubility of radon at atmospheric pressure. Aside from the assumption stated above, radiological risk of an accident of this type will further be mitigated by the presence of general area ventilation in the CPP and the response to spills by personnel following spill response procedures and utilizing personal protective equipment.

NUREG/CR-6733 also evaluated the potential impact of the failure of a yellowcake thickener releasing yellowcake into and outside the plant. This accident scenario is discussed in Section 7.5.2, Yellowcake Precipitation and Dryer Accidents.

7.5.1.2 Chemical Spills and Accidents

NUREG/CR-6733 noted that the scope of the NRC mission includes hazardous chemicals to the extent that mishaps with these chemicals could affect releases of radioactive materials. Industrial safety aspects associated with the use of hazardous chemicals at the Ross ISR Project are regulated by the Wyoming State Mine Inspector. ISR facilities utilize chemicals during the extraction process and during restoration of groundwater quality. Bulk chemicals will be stored on-site in areas at a distance from the processing

facilities that will pose no significant hazard to the public or workers' health and safety. Industrial safety aspects associated with the use of chemicals will be regulated by EPA and WDEQ in addition to the State Mine Inspector.

Chemicals which will be stored and used at the proposed Ross ISR project will include some or all of the following: sulfuric and/or hydrochloric acid, sodium hydroxide, hydrogen peroxide, carbon dioxide, oxygen, sodium chloride, sodium carbonate, barium chloride, anhydrous ammonia, and non-process related chemicals such as gasoline, diesel and propane. Chemicals will be stored either in the CPP or in the chemical storage area. The chemical storage area will be located adjacent to the CPP as shown on Figure 3.1-16. The chemical storage area will be divided into two areas, one of which will be enclosed in a building and one outside. Chemicals stored outside within the chemical storage area will include oxygen (if stored at the CPP), ammonia, and carbon dioxide. The storage area is shown on Figure 3.2-8. In order to mitigate the potential release of hazardous chemicals into the environment, the chemical storage area will be provided with secondary containment similar to that in the CPP. Berms will divide areas to ensure that there is no mixing of incompatible fluids. The capacities of the secondary containment along with the chemical storage tank volumes are listed in Table 3.2-2. Sumps will be provided within containment berms so that spilled chemicals can be collected and pumped to temporary storage areas or to disposal.

Oxygen

The hazards associated with oxygen storage include combustion and explosion. Oxygen will be delivered to the site by truck and stored in a cryogenic tank in liquid form. Many materials that may not be combustible in atmospheric conditions may burn in an oxygen rich environment. Credible accident scenarios which exist when bulk oxygen is stored and used may include explosions and fires as a result of impacts to oxygen storage or conveyance equipment, improper design of storage and conveyance equipment, and incorrect operation and cleaning of oxygen systems. To reduce the risk of an accident which could potentially affect other processes or storage facilities and radiological safety, oxygen will be stored away from other plant infrastructure and storage areas. Where above ground oxygen storage or conveyance facilities exist, barriers will be used to prevent impacts from mobile equipment. All oxygen conveyance pipelines which are installed will be properly surveyed and marked with proper tracer wire to make them locatable by field

personnel during excavation activities. The design and installation of the oxygen storage facility will be performed by a qualified oxygen supplier and will meet industry standards contained in Compressed Gas Association (CGA) CGA G-4.4 for material specifications and compatibility, velocity, fitting and valve specifications, and system instrumentation and control. Cleaning of equipment for oxygen storage and conveyance systems will follow the standards specified in CGA G-4.1.

Strata will develop emergency response procedures for oxygen accidents. All employees who may be exposed to hazards associated with oxygen will be properly trained with regards to the hazards, accident prevention and mitigation, and emergency response procedures.

Carbon Dioxide

Carbon dioxide may be used in several processes at the Ross project. Carbon dioxide presents few potential hazards in its use. The main hazard is through asphyxiation if it is allowed to accumulate in a confined area. To reduce the risk of a harmful accident, carbon dioxide will be stored adjacent to the CPP building in the chemical storage area. Floor level ventilation and carbon dioxide monitoring at low points within the CPP will be performed to protect workers from undetected leaks of carbon dioxide.

Anhydrous Ammonia

NUREG/CR-6733 states that ammonia is the chemical most frequently involved in accidents reported under the EPA Risk Management Planning (RMP). Ammonia at the proposed project area will be in liquid form, and will be stored outside of the CPP in the chemical storage area and piped in for use. The primary hazard associated with ammonia is inhalation if a piping leak occurred and the ammonia evaporates.

NUREG/CR-6733 specifies that the concentration of ammonia that is immediately dangerous to life and health (IDLH) is 300 parts per million (ppm). NUREG/CR-6733 identifies an ammonia leak as a significant risk factor within a plant because generally, ventilation rates would not be adequate to dilute ammonia fumes to below the IDLH in the event of a leak. An ammonia header pipe break would constitute a significant hazard. An additional hazard associated with ammonia is that it reacts vigorously with sulfuric acid, which will also be present in the precipitation circuit.

To minimize the probability and consequence of an ammonia accident, ammonia system design and operating procedures will be consistent with the American National Standards Institute (ANSI) pamphlet on safety requirements for the storage and handling of anhydrous ammonia. Recommendations in the pamphlet include:

- Providing an excess flow valve as close to the storage tank as possible which will automatically close of the flow rate exceeds a specified value,
- All nonrefrigerated piping for ammonia should conform to applicable sections of the ANSI/ASME standard code for pressure piping,
- Provide positive pressure, self-contained, full face respirators will be readily available in the immediate vicinity of ammonia piping and process operations.

Ammonia piping and storage facilities will be placed to minimize impact from vehicles or other objects that might cause ruptures. Underground conveyance piping for ammonia will also be accurately surveyed and provided with tracer wiring to prevent impact accidents form excavation equipment.

Quantities of ammonia stored at the site will constitute coverage under various regulations including the following:

- Quantities of ammonia will exceed threshold quantities (TQ) in 40 CFR 68.130, therefore EPA will require implementation of an RMP,
- Quantities of ammonia will exceed screening TQ as stated in 10 CFR Part 27 Chemical Facility Anti-Terrorism Standards; Final Rule, by the DHS. Therefore Strata will submit a "Top Screen" analysis to the DHS,
- Threshold Planning Quantities (TPQ) contained in 40 CFR Part 355, Emergency Response Plans for TQs in excess of 500 lbs, and
- Reportable quantity for spills under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) from 40 CFR 302.4.

The regulations listed above will require extensive accident analysis, and the development of standard operating procedures, emergency response procedures, a documented management system, and accident prevention plans.

Hydrogen Peroxide

Hydrogen peroxide is a strong oxidizer, can be very reactive, and is easily decomposable. Its hazardous decomposition products include oxygen and hydrogen gas, heat, and steam. Decomposition can be caused by mechanical shock, incompatible materials including alkalis, light, ignition sources, excess heat, combustible materials, strong oxidants, rust, dust, and a pH above 4.0. When sealed in strong containers, the decomposition of hydrogen peroxide can cause excessive pressure to build up which may then cause the container to burst explosively. In addition, solutions and vapors of hydrogen peroxide are irritants to body tissue, which can cause blistering of the skin and respiratory tract burns in the case of inhalation.

The hydrogen peroxide storage tank will be located in the chemical storage area and will be isolated from the storage areas for acids and reducing agents which will be used at the facility. The site will have storage facilities for 2,500 gallons (25,000 pounds) of 50% H_2O_2.

NUREG/CR-6733 evaluates an accident scenario involving a piping system leak, which could result in a vapor concentration which exceeds the IDLH value of 75 ppm within minutes. In addition, a leak within a confined space has the potential to create lethal conditions in an even shorter time. In order to minimize the risks associated with a hydrogen peroxide accident, Strata will follow design and operating practices published in accepted standards and codes which are recommended by NUREG/CR-6733. These may include the use of explosion proof ventilation equipment, local ventilation equipment, and recommendations for materials of construction.

Sodium Carbonate and Sodium Chloride

Sodium carbonate (soda ash) and sodium chloride (salt) generally present low risks of affecting radiological safety at ISR facilities. Sodium carbonate and sodium chloride are primarily inhalation hazards. Dry storage and handling will be designed to industry standards to control the discharge of dry material. This will generally be accomplished with adequate area ventilation in these areas.

Sulfuric Acid

Sulfuric acid is extremely irritating, corrosive, and toxic to tissue, resulting in rapid destruction of the tissue and causing severe burns. Other

than direct skin contact, sulfuric acid fume inhalation during a spill may also be of concern to employees at the Ross CPP. The concentration of sulfuric acid fumes that are IDLH is 15 mg/m^3. According to a risk analysis conducted in NUREG/CR-6733 with a 93% sulfuric acid solution, sulfuric acid did not pose a significant inhalation hazard as long as normal air dilution is occurring from the building ventilation system. Additionally, sulfuric acid reacts vigorously with other chemicals which will be used at the project such as ammonia, sodium carbonate, and water. To minimize the potential for chemical reactions in the unlikely event of simultaneous tank leaks, the sulfuric acid storage tank(s) will be located away from other chemical storage tanks and away from process vessels at the chemical storage area, and the acid will be piped to an inside smaller storage tank for daily use.

The use of sulfuric acid is subject to Threshold Planning Quantities (TPQs) contained in 40 CFR Part 355, Emergency Response Plans for threshold quantities (TQs) in excess of 1,000 pounds. This is also the EPA reportable limit under CERCLA. As discussed in Section 3.2, the storage quantity of sulfuric acid at the Ross project will exceed the TPQ. Based on the design capacity, the CPP will be subject to Emergency Response Plan requirements which will qualify for coverage under the DHS Chemical Facility Anti-Terrorism Standards. A "Top Screen" analysis for sulfuric acid will be submitted to DHS by Strata.

7.5.1.3 Wellfield Spill/Pipeline Failure

A failure in a wellfield pipeline, module building, valve vault, or at a well head has the potential to release pregnant or barren lixiviant into the environment and contaminate the ground in the area of the failure. As discussed in Section 3.1, the operating parameters of injection and recovery lines from the modular buildings to the wellfields will be continuously monitored from the CPP. In the event that a significant piping failure causes a leak of injection or recovery fluids, the corresponding variation in flow or pressure will signal alarms in the module building and CPP. Automatic controls will stop operating equipment (primary pumps), and the operators will manually control equipment and valves to isolate and contain the leaking section of pipe.

All piping will be rated for a maximum operating pressure greater than the proposed maximum for injection or recovery. All piping will also be

hydrostatically tested for leakage prior to operation. Construction specifications for buried pipelines will include pipe bedding to provide support and prevent rocks in trench backfill from damaging the pipes. Thrust blocking will also be provided at pipe bends and valves, and transient analysis will be performed to ensure that pipes are protected from rapid pressure changes resulting, for example, from the sudden closing of a valve or starting of a pump.

The possibility exists for production or injection fluid to be released through failure of the fittings on the wellhead or by failure in the casing of the well. Individual flow line pressures will be monitored in the module building in order to give an indication of potential leaks in these areas. In addition, wells will undergo routine MITs, which will identify casing failures. Well head enclosure will have small containment basins and leak detection so that leaks can be recognized early. Regular inspections of module buildings and wellheads will further reduce the risk of spills from these facilities.

In the event of a piping leak in the module buildings, alarms in the buildings floor sump will trigger audible and visual signals in the building and in the CPP. Operators will be immediately dispatched to the module building for inspection, shutdown and repair.

Periodic inspections of these facilities will be done by Strata personnel as outlined in Section 5.3. Following the repair of a leak the affected soil will be surveyed for contamination and the area of the spill will be documented. If contamination is detected, the soil is sampled and analyzed for the appropriate radionuclides. Contamination will be removed in accordance with NRC and/or state requirements. Spill response procedures are discussed below in Section 7.5.1.6.

7.5.1.4 Lixiviant Excursion

Horizontal and vertical excursions of barren lixiviant from production aquifers pose a potential risk of groundwater contamination to adjacent aquifers. In ISR operations, preventing any excursion from occurring is essential. Different systems will be employed during operation to help prevent, limit the extents of, and recover lixiviant excursions.

Systems proposed to limit the potential for excursions include development of balanced wellfields, instrumentation within and adjacent to wellfields to constantly monitor water levels, integration of water level data with operational injection and recovery data in a suitable reservoir management

software platform along with the necessary operational oversight. Components of these systems will utilize dedicated pressure transducers that monitor within the wellfield ore zone, in adjacent aquifers above/below the ore zone as well as in the perimeter monitor wells. Beyond monitoring and integration of flow and level metrics from the active wellfields, samples will be recovered from the wells completed in adjacent aquifers every two weeks. A more detailed description of the operational monitoring and controls can be found in Section 5.7.8.

If an excursion is detected, the recovery and injection wells will have the ability to respond and have been demonstrated through modeling to be capable of responding (see Addendum 2.7-H for groundwater model results). By reducing the imbalance caused by over-injection combined with the necessary maintenance of recovery well(s) a local wellfield imbalance can be rectified in the time required. In addition, injection wells will include the necessary electrical infrastructure to be 'changed over' to recovery wells, further enhancing Strata's ability to quickly and efficiently recall the lixiviant. Although the potential for lixiviant excursions do exist, with all these systems in operation an undetected excursion will be highly unlikely.

Preventing vertical excursions given the extensive nature of the natural geologic confining intervals requires two primary measures, abandoning all of the exploration and delineation holes with cement along with constructing wells that limit the potential for annular migration. Strata has already initiated an extensive exploration hole finding and sealing program in addition to verifying the integrity of the cementing program for the well installation procedures. MITs will be conducted prior to operations, if a well is reentered with a drilling bit or tool and every five years with the necessary reporting to the WDEQ/LQD and NRC. To further limit the potential for vertical excursions, Strata has initiated and will continue to limit over-penetration into the DM aquifer. Monitoring wells installed in the aquifers above and below the ore zone interval will be placed in downgradient locations to further improve the potential of detecting these rare events.

7.5.1.5 Lined Retention Pond Accidents

Liquid waste spills or leaks could occur if one of the ponds were to overtop or if the liner failed. The potential for pollution from the lined ponds will be minimized through careful construction and inspection of the pond liners during construction, routine inspection and testing of the leak detection

equipment, and control of pond water levels. The ponds, liners, and leak detection systems will be constructed in accordance with Regulatory Guide 3.11 and WDEQ/WQD requirements. The liners will also be leak tested as part of the construction performance testing.

Normally the water levels in the lined ponds will be maintained at or below the NWL, which includes not only freeboard for runoff and wave runup, but also freeboard to pump the contents of a damaged pond cell into the remaining cells within that pond in the even of a liner failure. The water level will always be maintained at or below the HWL, which includes freeboard for direct precipitation resulting from the 100-year, 24-hour storm and wave runup. Pond levels will be recorded daily as part of inspections which are outlined in Section 5.3. If pond levels rise beyond the NWL, plant operations or the deep disposal well feed rate will be modified to bring the levels back to the specified level.

Leak detection piping will drain to riser standpipes which will be monitored daily for the presence of fluid. If the water level in the riser pipes is above a predetermined level, samples will be taken to determine if the water is of similar quality to the contents of the ponds. Strata will focus on common constituents such as conductivity and chloride to determine if the fluid is leaking from the pond. If the sample is verified, the contents of the pond will be transferred to the other two pond cells or into the deep disposal well. The liner will then be thoroughly inspected and leak tested to determine the source of the leak.

In addition to the measures discussed above, any leak from the lined retention ponds will be captured within the CBW as discussed in Section 3.1 of this report. The CBW and dewatering system will allow Strata to recall fluids that could potentially reach shallow groundwater from an accident.

In the event of a leak from a lined pond cell, the NRC will be notified by telephone within 48 hours of verification. A written report including analytical data and descriptions of the correction actions and results of those actions will be submitted to the NRC within 30 days of initial leak notification.

7.5.1.6 Waste and Process Solution Spill Response and Remediation

Strata will implement an emergency response plan and SOPs to be used in the case of a spill of waste and process fluids at the proposed project. The

RSO or HPT will be notified immediately so that a prompt inspection of the spill can be made. The spill inspection will include the following:

- A drawing of the affected area and equipment so that the location can be referenced during decommissioning
- A determination of the amount of fluid spilled
- An analysis to assess the radiological risks immediately present at the site
- Determination of safety precautions that need to be taken immediately, if any
- A preliminary determination of the cause of the spill
- A determination as to whether or not reporting is required pursuant to the regulations listed in 10 CFR 20.2202 (immediate notification within 24 hrs), 20.2203 (written report within 30 days), and 10 CFR 40.60 (24 hr immediate notification vs. written report within 30 days).

The RSO and HPT will be assisted as necessary by personnel with knowledge of the incident and the site supervisor. After the initial inspection, The RSO or HPT will prepare a report which includes the following information:

- The date, location, and description of the affected facilities and equipment
- The corrective and cleanup actions taken
- An assessment of the effectiveness of cleanup
- The location and a description of residual contamination
- A description of areas that where inaccessible during cleanup

At least once per year, the Manager of Health, Safety, and Environmental Affairs will convene a Spill Committee to review the cause of recent spills. The Spill Committee will consist of at least three individuals with experience in operations. After reviewing the causes of recent spills, the Committee will send a report to mine management detailing reasonable recommendations on how to prevent and minimize the size of future spills.

7.5.2 Yellowcake Precipitation and Dryer Accidents

Yellowcake Thickener Failure

NUREG/CR-6733 evaluates the potential impact of the failure of a yellowcake thickener which results in the release of approximately 20% of the thickener volume outside of the plant. This accident scenario is based on an event at the Irigary ISR Facility in 1994. The only substantial radiological hazard in this situation is the inhalation of yellowcake powder if the yellowcake slurry was allowed to dry. NUREG/CR-6733 used fate and transport modeling considering wind speeds from several regions and concluded that the dose to the public would likely be under the limits specified in 10 CFR Part 20. However, modeling also concluded that the dose to an unprotected worker could exceed the limit of 5 rem specified in 10 CFR Part 20.

Although this is a credible accident scenario, NUREG/CR-6733 used several conservative assumptions, which make the dose estimate unlikely. These include the assumption that no cleanup activities would be conducted and that the yellowcake slurry would be allowed to dry and become airborne, a lung clearance class Y for uranium was used (relatively insoluble), which assumes that the material will be retained in the respiratory tract for years, and that no protective equipment such as respirators were used by personnel. The following discussion analyzes the conservatisms inherent in the NUREG/CR-6733 analysis for this accident scenario and compares and contrasts these assumptions to the process specifics and circumstances at the Ross ISR facility should such an accident occur.

With regard to this accident scenario, NUREG/CR-6733 Section 4.2.1 assumes insoluble uranium, the worst-case assumption. If the material involved in the accident were more soluble, the dose to a worker on site would be reduced by the ratio of the more soluble annual average DAC to the insoluble DAC. The dose to a member of the public would be reduced by the ratio of the annual average effluent release limit for the more soluble uranium to the effluent limit for insoluble uranium. This is quantified below.

The products of interest are uranyl peroxide (UO_4) and or uranyl trioxide (UO_3) and/or their hydrates (not "U_3O_8") as a direct result of the elution and precipitation chemistry to be used and since even when drying is conducted, the Ross ISR product will be dried with a low temperature vacuum dryer. These products are historically considered much more soluble than U_3O_8. A detailed

discussion of the relative solubility of these and related industrial uranium products as described in the literature over the last 30+ years is provided in Sections 5.7.4.1 and 5.7.5.1.

When eventually dried by a modern vacuum drier at relatively low temperature, very little, if any actual "U_3O_8" will be produced. Again, hydrates of UO_3 and UO_4 are expected. Products shipped from uranium recovery facilities vary in color from yellow to orange yellow to dark green (or even brown or black) depending on the water of hydration and oxygen content of the material. These variations are caused by differing methods of drying (rotary vacuum versus calcining) and different methods of precipitation, (hydrogen peroxide, ammonia etc.). It has been demonstrated that these color variations represent differences in chemical composition and therefore relative solubility (see Merritt 1971, Brown and Blauer 1980, Eidson and Mewhinney 1980). In general, the darker the color, the lower the uranium valence (+ IV, e.g. UO_2 thru + VI, UO_3) and the more "insoluble" is the product. Additional assumptions stated in the thickener failure and spill scenario of NUREG CR - 6733 also would tend to "maximize" dose to both workers and public relative to more realistic and credible emergency response circumstances at the Ross ISR. This comparison is summarized in Table 7.5-1.

NUREG/CR-6733 Figure 4.2, reproduced as Figure 7.5-1, indicates all doses to members of the public are well below any applicable standards, and would be further reduced to about 1 mrem/year if just solubility alone were considered and less if other factors presented in Table 1 were taken into account.

With regard to potential on-site (occupational) doses, the analysis in NUREG/CR-6733 for an accident involving thickener failure shows a potential dose at the center of the spill, to someone standing in the spill for four hours after the spill had dried, could exceed 5 rem. The assumption is that the spill consists of insoluble Class Y U_3O_8. Reducing the dose estimate based on solubility considerations alone (ratio of DACs - see Table 7.5-1) results in a worker dose projection of about 500 mrem, not taking into account respiratory protection and/or other credible emergency response mitigating actions as presented in Table 7.5-1. On page 4-22 of NUREG/CR-6733 it is stated that, "It is reasonable to assume that cleanup personnel would be outfitted with protective equipment including respirators." It is also likely that any spill would be cleaned up before it dried. The implication is that the dose is minimal while

the spill is wet. Maintaining the spill "wet" during cleanup is an expected method of collection will ensure dust control and minimize exposure potential. Air sampling during the cleanup process will provide documentation of actual exposure and indications if ad –hoc bioassay sampling is appropriate (see Section 5.7.5).

Seal Rupture in Dryer Off Gas Treatment System

A seal rupture on the dryer off gas treatment system could potentially release yellowcake particulates into the air in the drying room. Seals will be inspected at least once per shift for integrity. If a seal rupture were to occur, a change in the applicable process parameters would be immediately identified in the off gas system monitoring equipment (immediate pressure drop, air flow reduction, etc), which is continuously monitored in the control room when the dryer is operational. While the likelihood of an unnoticed seal rupture is low, the potential ramifications of this situation could involve release of yellowcake into the dryer room.

Workers in the dryer room will be required to wear respiratory protection equipment and breathing zone monitors when the dryer is in operation. Although routine uranium air concentrations in the area under normal operating conditions are expected to be low (<10% DAC), these precautions will be specified in standard operating procedures in the event a process upset results in a potential elevated exposure condition.

Process parameters for the off gas system are monitored continuously and the time during which workers could be exposed (from event initiation until identification and immediate evacuation of the dryer room) would be expected to be limited. Additionally, since workers are only in the dryer room for short-term specific tasks when the unit is running (e.g., packaging operations), time of exposure would be expected to be relatively short.

Accordingly, given the expected expedient identification of the event's occurrence, immediate evacuation, personnel protective equipment and monitoring used as standard protocol when workers are in the dryer room, the radiological impact to workers (intake) will be well documented and is not expected to result in exposures in excess of the limits at 10 CFR 20.1201.

7.5.3 Fires and Explosions

The fire and explosion hazard within the proposed project area will be minimal however measures will be taken to reduce the risk. During operations, precautions will be taken to ensure that chemicals do not inadvertently come into contact with each other. The oxygen storage facility readily supports combustion, fire and explosion and will therefore, be located a safe distance from the CPP or module buildings. From production and restoration solutions, radon gas is produced and could potentially be released into the building. A dedicated air handler equipped with High Efficiency Particulate Air (HEPA) filters will ventilate the dryer and packaging room and will provide an additional level of control for particulate emissions, which also reduces the opportunity for buildup of explosive gases in the building. All employees will be trained on the proper procedures and evacuation plans should a fire or explosion occur.

Throughout Crook County there remains potential for future wildfires, however the potential is low. Crook County has a community wildfire protection plan and was developed by Crook County Fire Department (Crook County 2005). According to this plan, the proposed project area is not located in a high risk area. Strata is currently investigating strategically placing water loadout facilities near the processing facilities and wellfields as part of a dust suppression program, however they could also be used in the event of a fire. In addition, wellfield personnel will be trained in fire prevention and emergency notification procedures to further reduce the risk of a fire.

7.5.4 Transportation Accidents

Throughout the project several types of materials may be transported to or from the proposed Ross ISR project including:

- Shipments of 11e.(2) byproduct material from the site to a licensed disposal facility
- Shipment of yellowcake from the Ross ISR CPP to a uranium conversion facility
- Shipment of process chemicals and fuel from suppliers to the site
- Shipments of uranium-loaded IX resin to the site
- Shipment of vanadium to a processing facility

To minimize transportation accidents, extensive emergency response programs will be in place along with environmental emergency response contractors for spill cleanup. Strata will provide ongoing training for local emergency personnel including firemen, police and emergency medical technicians (EMT) in the hazards and emergency response procedures to ensure safe working practices in the presence of spilled materials.

All material shipments will be made by appropriately licensed transporters in accordance with DOT hazardous material regulations and requirements. The Federal Hazardous Materials Transportation Law (Federal Hazmat Law), 49 U.S.C. § 5101 et seq., is the basic statute regulating hazardous materials transportation in the United States. Section 5101 states that the purpose of the Federal hazmat law is to "protect against the risks to life, property, and the environment that are inherent in the transportation of hazardous material in intrastate, interstate, and foreign commerce." Section 5103 provides that the Secretary of Transportation shall:

- Designate material (including an explosive, radioactive material, infectious substance, flammable or combustible liquid, solid or gas, toxic, oxidizing, or corrosive material, and compressed gas) or a group or class of material as hazardous when the Secretary determines that transporting the material in commerce in a particular amount and form may pose an unreasonable risk to health and safety or property.
- Issue regulations for the safe transportation, including security, of hazardous material in intrastate, interstate, and foreign commerce.

Federal regulations applying to safe transportation of materials classed as hazardous are found at 49 CFR Parts 171-180. These hazardous materials regulations (HMR) cover the following areas:

- Hazardous materials classification (Parts 171 and 173);
- Hazard communication (Part 172, Subparts A-G);
- Packaging requirements (Parts 173, 178, 179, and 180);
- Operational rules (Parts 171, 173, 174, 175, 176 and 177);
- Training and Security (Part 172, Subparts H and I); and
- Registration (Part 171; see also Part 107, Subpart G).

A specific mitigation measure will be implemented for shipment of yellowcake, uranium-loaded IX resin from an ISR satellite owned and/or

operated by Strata, or 11e.(2) byproduct material. Spill of a radioactive material as a result of a transportation-related incident will invoke activities found in the HMR regulations found at 49 CFR Part 171, Subpart B – Incident Reporting, BOE Approvals and Authorization. Among other things, these regulations require immediate notice of certain incidents, detailed incident reports, submission of examination reports, and assistance with investigations and special studies. Should an accident occur that results of a release of any of these materials to the environment, Strata will perform a post-cleanup radiological survey of the affected area to ensure that there are no long-term hazards associated with the spilled material or spill response and cleanup operations.

7.5.4.1 Shipment of 11e.(2) Byproduct Material

Solid 11e.(2) byproduct material or unusable contaminated equipment generated during operations and decommissioning will be transported to a licensed disposal site. Before operations begin, Strata will have an agreement in place with a licensed disposal facility to accept solid 11e.(2) byproduct material. As discussed in Section 4.2.1.2 of the ER, Strata has considered shipment of byproduct material to four disposal sites. These include one facility in Wyoming, two in Utah, and one in Texas. The distance of these facilities from the Ross Project ranges from 235 to 1,000 miles. Shipments will be handled as low-specific-activity (LSA) material and will generally be made in sealed roll off containers in accordance with the applicable DOT hazardous materials shipping provisions. Shipments of 11e.(2) byproduct material are expected to average about 5 per year during operation and then increase to between 100 and 200 per year during decommissioning.

The risk of an accident involving the transporting of 11e.(2) byproduct material will be kept to a minimum by the use of proper packaging and exclusive use shipments. Similar to transportation of yellowcake, Strata will contract with a transport company that provides training and emergency response procedures specific to the transport of 11e.(2) byproduct material. In addition, the solid material would be easily collected and contained in the event of an accident.

7.5.4.2 Shipment of Yellowcake

Transportation of dried yellowcake will be made in exclusive-use transportation vehicles to a licensed conversion facility, which transforms the yellowcake to uranium hexafluoride. The only currently permitted conversion facility is in Metropolis, Illinois, which is approximately 1,260 mile from the project area. The proposed annual yellowcake production rate for the proposed Ross ISR project is 3 million pounds. Based on weight limits for legal transport, each shipment will contain approximately 40,000 pounds of yellowcake, resulting in a total of about 75 shipments per year. Yellowcake is shipped in 55 gallon steel drums; each containing a maximum of 950 lbs.

Strata will contract with a transport company that specializes in shipment of yellowcake. The transport company will have extensive emergency response programs including spill response equipment on board, drivers will be trained in radiological emergency response, there will be constant monitoring of truck location and operating parameters, and standing contracts will be in place with environmental emergency response contractors for spill cleanup. Shipments will be handled as LSA material for yellowcake. In addition, Strata will commit to training local emergency response personnel in the specific hazards and spill control procedures associated with yellowcake, and Strata will commit to performing a radiological survey of the affected area following spill cleanup if a yellowcake spill should occur.

NUREG-0706 states that the probability of a truck accident is in the range of 1.6 to 2.6 x 10^{-6}/mile. Based on the average of these two values, the likelihood of a truck shipping yellowcake being involved in an accident of any type during a one-year period is approximately 20%. This probability was obtained by multiplying the probability of an accident per vehicle-mile (2.1 x 10^{-6}/mile) by the maximum number of shipments per year (75) and the distance per shipment (1,260 miles). It is important to note that a minority of accidents will result in release of yellowcake. According to a report prepared for the Federal Motor Carrier Safety Administration (2001), the likelihood that an enroute accident will result in a release, based on 12 categories of hazardous material transportation, is about 31%. Further, as described in Section 4.2.2.2 of the ISR GEIS, 30% or less of the shipment contents were released in previously reported accidents involving yellowcake release. Therefore, while there is an estimated 20% probability that an accident involving yellowcake shipment will occur in any one year, there is only about a 31% probability that

the accident will result in a release of yellowcake, and then the volume of yellowcake released will likely be 30% or less of the quantity shipped. Based on a 40,000-pound typical load, this would result in a release of 12,000 pounds or less of yellowcake.

The NUREG-0706 analysis also considered the amount of material which may be released during a traffic accident. Yellowcake release during a potential traffic accident was calculated considering the degree of loss of package containment for a range of accident severities and information on the likelihood that an accident of a particular severity class would occur when an accident happens. Two models for package response to accident conditions were considered. Model 1 assumed complete loss of package contents for any accident severe enough to breach packages, whereas Model 2 used results from package tests indicating only partial release of contents for accidents sufficient to breach packages. The resulting population dose estimates for these estimated releases from a single accident in an area containing 61 people per km^2 (158 people per mi^2) (i.e., rural residential population living on a given area of land) were 200 person-rem (2 person-Sv) for Model 1 and 14 person-rem (0.14 person-Sv) for Model 2 (NRC 1980). Further analysis of this yellowcake accidents in the ISR GEIS weighted the above doses by accident probabilities and converted them to latent cancer fatalities. The ISR GEIS estimated that 0.01 (complete loss of package contents) and 0.0008 (partial release) cancer deaths per year would result from yellowcake accidents.

In the unlikely event that an accident involving spilled yellowcake during transportation does occur, all yellowcake and contaminated soil would be removed, processed through a uranium mill, or disposed of in an NRC licensed disposal facility. The cleanup would be directed by qualified personnel from the state radiological emergency assistance team. Should the accident be outside the state personnel's capability, the NRC will be requested to provide assistance (NRC 1980). In addition, Strata will commit to providing a radiological survey of the affected area following spill cleanup if a yellowcake spill should occur.

7.5.4.3 Shipment of Process Chemicals or Fuel

It is estimated that approximately 4 bulk chemical, fuel, and supply deliveries will be made per working day throughout the operational life of the project. Process chemicals range from nonreactive solids with very low

environmental risk if released (e.g., sodium chloride) to liquids with significant environmental risk if released (e.g., sulfuric acid) to toxic gases such as anhydrous ammonia. The environmental risk associated with these chemicals in the event of a spill ranges from low to high, with sulfuric acid and anhydrous ammonia being the most hazardous. Significant environmental and health risks could result if a truck carrying anhydrous ammonia or sulfuric acid was involved in an accident. Since ammonia is transported as a compressed, liquefied gas, an accident could release a large volume of ammonia vapor which could pose a hazard if it were to occur in a populated area or near surface water supporting aquatic life. The anhydrous ammonia will be likely be transported to the proposed project area from Casper, Wyoming, 180 miles southwest of the proposed project area. Alternate shipping locations include Billings, Montana, 280 miles northwest, and Rapid City, South Dakota, 135 miles east. Each shipment will contain 2,500 gallons. Based on the estimated annual usage of about 70,000 gallons of anhydrous ammonia, the frequency of shipments is approximately 28 trucks per year. Using the accident rate of 4.3×10^{-6} accidents/mile from Section 7.1.5.3 of NUREG-0706, the chance of a traffic accident involving these trucks is approximately 2% per year, using the 180-mile distance to Casper. NUREG-0706 also provides a probability of an injury to a member of the general public resulting from an average shipment of anhydrous ammonia as 4.8×10^{-7}/mile. Based on this probability, the average annual probability of an injury to a member of the general public resulting from an ammonia transportation accident is 0.2%. Risks involving other process chemicals would generally be equal to or less than the risk in transporting ammonia.

Transportation accidents involving fuel (diesel, gasoline, and propane) shipment also present potential environmental impacts. During operation it is estimated that approximately 1 shipment of fuel will be transported to the site each day. Fuel will be transported from a nearby town such as Moorcroft, Gillette or Sundance, which will minimize the trip distance and keep the probability of an accident very low.

7.5.4.4 Shipment of Loaded Resin to the Ross ISR CPP Facility

The uranium recovery circuit at the CPP will be designed to process up to 3 million pounds per year of U_3O_8. The Ross ISR Project wellfield is estimated to produce 750,000 pounds per year of U_3O_8; therefore the CPP will be capable of processing additional uranium-loaded IX resin from satellite ISR facilities,

including those owned and/or operated by Strata and those owned and/or operated by other ISR licensees, and from other water treatment entities generating uranium-loaded IX resins that are the same or substantially similar to those generated at ISR facilities. Uranium-loaded IX resin would be transported to the Ross ISR Project in tanker trailers with 500 cubic-foot capacity. Based on a typical concentration of 50 g/L U_3O_8 (ISR GEIS Section 4.2.2.2), each truckload of uranium-loaded IX resin will contain approximately 1,500 pounds U_3O_8. Based on a maximum processing rate of 2.25 million pounds of U_3O_8 equivalent derived from uranium-loaded IX resin, up to 4 shipments would be made to the facility each day.

A transportation accident resulting in release of uranium-loaded IX resin would have a lower risk than the relatively low risk from an accident involving yellowcake described previously. As described in Section 4.2.2.2 of the ISR GEIS, IX resin contains a much lower concentration of uranium than yellowcake and the uranium is chemically bound to the IX resin and is therefore less likely to spread and easier to remediate in the event of a spill. Further, although there would be more frequent shipments of uranium-loaded IX resin than yellowcake, the distance traveled would typically be less, so the total distance traveled would likely be less. If an accident occurred with loaded resin the impacted soils would be salvaged and shipped to a licensed 11e.(2) byproduct material disposal site, the topsoil and vegetation would be replaced, and Strata would perform a post-reclamation radiological survey to verify that no long-term hazards would be present.

Transportation of loaded resin from satellite facilities not operated by Strata will be the responsible of the satellite facility, and covered under its source and byproduct material license. Strata will assume responsibility of the loaded resin when the shipment has reached the site. An unlikely but credible accident could occur if the truck was involved in a collision which ruptured the tanker trailer. The risk of an accident within the CPP area is low due to the short distance which would be traveled and the low speed limit of roads within the CPP area. In addition, if an accident did occur, cleanup and remediation efforts are expected to be very prompt considering the proximity to trained personnel.

7.5.4.5 Shipment of Vanadium

Vanadium Shipment

Vanadium will be shipped in sealed transport vehicles to prevent uncontrolled release into the atmosphere. AMV is considered a hazardous material by the USDOT (40 CFR Part 172.101). As such, vanadium will be shipped by an appropriately licensed transporter to a processing facility.

It is estimated that the quantity of vanadium produced from the Ross ISR Project may be up to 60% of the yellowcake quantity. This would be up to 1.8 million pounds per year. Since the weight limits for legal transport are 40,000 pounds, up to 45 shipments would be required annually. The location of the vanadium processing facility has not been finalized, but based on the reduced shipment frequency and the lack of radiological hazard compared to yellowcake shipment, the potential risk associated with vanadium shipment will be smaller than that associated with yellowcake shipment.

7.5.5 Natural Disaster Risks

The risks for widespread release of radioactive materials due to natural disasters are not high, although the potential for an earthquake or tornado does exist. NUREG/CR-6733 evaluated the potential risks of an ISL facility from an earthquake and tornado strike. The NRC determined that the primary hazard from a tornado or earthquake would be from the dispersal of yellowcake or the failure of chemical storage facilities.

Between 1950 and 2003, 28 tornadoes were reported in Crook County with a mean annual frequency of 0.61. All but 2 of the 28 tornadoes to touch down were classified as F0 or F1 which have wind speeds from 40 to 112 mph. The other 2 tornadoes were classified as having F2 intensity winds, between 113 and 157 mph or stronger, and described as significant tornadoes. The Fujita Scale is the official classification system for tornado damage. The scale rates the intensity of the tornado, and measures both the path length and the path width (Curtis and Grimes 2004). According to the Fujita Scale, considerable damage can result from an F2 tornado which includes roofs torn off of framed houses, mobile homes demolished, large trees uprooted, and projectile risks from light objects. According to the Wyoming Climate Atlas, the probability of a tornado in the eastern third of the state is approximately 1 in 10,000 years to 1 in 1,000,000 years (Curtis and Grimes 2004).

NUREG-0706 estimates the probability of a tornado occurring based on milling regions in the western United States. The proposed project is located within the Great Plains region where the probability of occurrence of a tornado is 4.8×10^{-4} per year, which is slightly higher than what the Wyoming Climate Atlas predicts. Tornados within this region are characterized by a tornado intensity category of I. A typical tornado in this category has a wind speed of 360 mph, of which 300 mph is rotational and 60 mph is translational. Structures at the Ross ISR Project will not be designed to withstand these kinds of events, however as shown above the probability of a tornado is low.

NUREG-0706 assessed the dose associated with a tornado occurring at a milling facility. The assessment assumed that approximately 25,000 lbs of yellowcake is lifted and dispersed by the tornado and that all yellowcake was in respirable form. It was also assumed that the tornado released all of the yellowcake at the site boundary and the yellowcake was then dispersed by the trailing winds. The assessment yielded a maximum dose at 2.5 miles from the yellowcake packaging area of 8.3×10^{-7} rems for the 50-year dose commitment to an individual's lung. NUREG/CR-6733 reviewed the assessment and concluded that even if the amount of yellowcake available for dispersion was increased by a factor of four, the dose commitment would still be low. After reviewing the assessment, NUREG/CR-6733 also concluded that generally the tornado risk at ISR facilities are low and that no design or operational changes are required to mitigate this risk.

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 one earthquake with a magnitude greater than 2.5 (Richter Magnitude Scale) or intensity greater than III (Modified Mercalli Intensity Scale) has been recorded in Crook County and only five 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.

There are no capable faults (i.e. active faults) with surface expression mapped within or near the proposed project area, according to the USGS Quaternary Fault and Fold Database (USGS 2009). The closest capable faults to the site are located in central Wyoming, 270 km (168 miles) to the west-southwest. Section 2.6.2.2 describes how faults previously mapped in the area by Buswell (1982) were the result of limited survey data. For more information on seismology see Section 2.6.6.

According to NUREG/CR-6733 the primary hazard associated with an earthquake at an ISR facility is from the rupture of hazardous chemical tanks and mixing of incompatible fluids. The recommendations for mitigation of this hazard include locating storage tanks which contain incompatible fluids a sufficient distance away from each other. As discussed in Section 7.5.1.1 of this report, storage tanks will include separate containment berms which will reduce the risk of mixing of incompatible chemicals in the event of a spill. In addition, tanks will be strategically located such that there is a low risk of a chemical reaction during an accident that results in the rupture of a tank. SOPs, training, and personal protective equipment will be available to personnel for response and mitigation of hazardous chemical spills.

Table 7.5-1. Comparison of Thickener Failure Accident Scenario Assumptions in NUREG/CR-6733 vs. Ross ISR Emergency Response Assumptions

NUREG / CR-6733 Assumptions	**Ross ISR Most Credible Case**	**Impact on Worker Dose[1]**	**Impact on Public Dose[1]**
Product is insoluble U_3O_8, ICRP 19 Class Y / ICRP 66 Class S[2]	Product is relatively soluble U04 and/or U03 hydrates - ICRP 19 Class D or W / ICRP 66 Class F or M	DAC (Y) = 2E-11; DAC (W) = 3E-10 Therefore Class W dose = 15% of Class Y dose	Effluent concentration (Y) = 9 E-14; (W) = 9 E-13 Therefore Class W dose = 10% of Class Y dose
Design features (berms. sumps) at thickener inadequate to contain entire thickener contents; 20% escapes building	Since at the Ross ISR, the building foundation stem wall will be designed to contain >100% of the tank contents, any environmental release will be through the plant HVAC / off gas treatment systems and therefore mitigated to some additional degree via plate out, water scrubbing, filtration, etc.	N/A	Loss would only be through HVAC / off gas treatment systems which will reduce source term considerably
Takes no credit for "immediate" emergency response actions, assumes entire volume dries and is available for dispersion	Plant alarms and/or observation would alert staff to occurrence of event quickly; clean up actions would be initiated before majority of volume can dry including wetting / wash down techniques to move spilled material to bermed areas and sumps and other wet collection methods	Much less source term available (lower release fraction) for dispersion and therefore less dose	Much less source term available (lower release fraction) for dispersion and therefore less dose
Takes no credit for use of PPE by clean up workers	Workers involved in clean up of spilled material would be wearing respirators in accordance with an approved respiratory protection program per, e.g., 10 CFR 20, Subpart H	Dose assignment can be reduced by appropriate protection factor for device(s) used	N/A

Table 7.5-1. Comparison of Thickener Failure Accident Scenario Assumptions in NUREG/CR-6733 vs. Ross ISR Emergency Response Assumptions (Continued)

NUREG / CR-6733 Assumptions	**Ross ISR Most Credible Case**	**Impact on Worker Dose[1]**	**Impact on Public Dose[1]**
Takes no credit for emergency response planning, procedures and associated training	Response to spill would be conducted in accordance with previously developed and approved emergency response protocols. Minimizes time to respond; equipment needed readily available; enhances efficiency of worker performance to affect clean up due to in place emergency response procedures, exercises and training.	In place and exercised emergency response procedures, readily available equipment and trained workers will reduce worker dose	In place and exercised emergency response procedures, readily available equipment and trained workers will reduce source term and therefore offsite dose to public

(1) Derived air concentrations (DAC) for workers and effluent concentrations released to unrestricted areas from 10 CFR 20, App B, Tables 1 and 2 respectively; units in uCi/ml. Although the products of interest are likely to be TGLD Class D (see discussion in Sections 5.7.4.1 and 5.7.5.1), Class W is conservatively assumed.

(2) (ICRP 1972b); (ICRP 1994).

Figure 7.5-1. Figure 4.2 from NUREG/CR-6733
Source: NRC (2001)

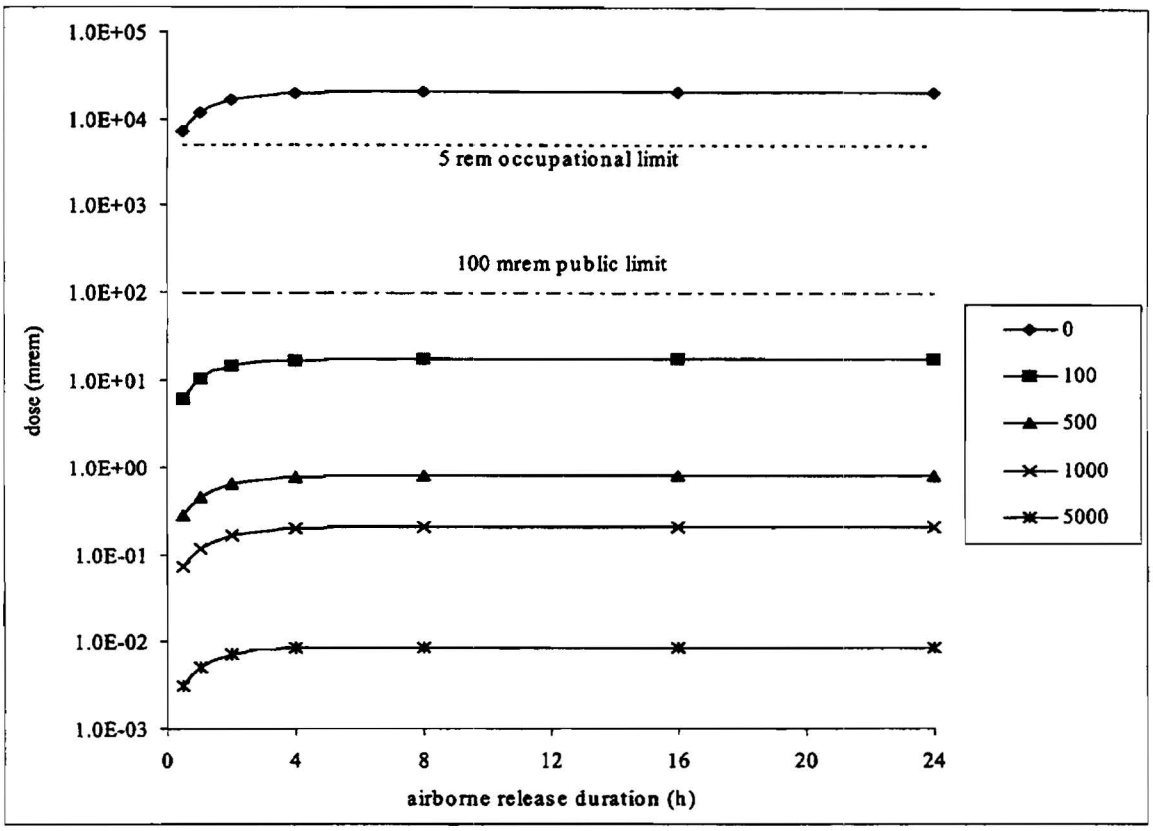

Figure 4-2. A plot of the downwind doses at various x-distances (meters) (y = 0, z = 1 m) from a U_3O_8 spill, based on different airborne release durations (length of time that the U_3O_8 spill receives no mitigating action after drying to a point when airborne release is possible). These dose estimates assume that no remedial or personnel protection actions are implemented.

7.6 Economic and Social Effects of Construction and Operations

The socioeconomics effects of site preparation, construction, and operations are discussed in Section 4.10 of the ER, and summarized in Sections 7.1 and 7.2 above. The costs and benefits for these phases are discussed in Chapter 9.0 of this report. Economic and social costs for the proposed Ross ISR Project include impacts on housing and social services, land restrictions for area landowners, aesthetic and noise impacts, and health and environmental impacts. Economic and social benefits include monetary benefits in the form of tax revenue and employment opportunities for area residents.

7.7 References

ANL (Argonne National Laboratory), 1997, Faillace, E.D., LePoire, D.J., Chen, S.Y., Yuan, Y., MILDOS-AREA: An Update with Incorporation of In Situ Leach Uranium Recovery Technology, May 1997.

Buswell M.D., 1982, Subsurface Geology of the Oshoto Uranium Deposit Crook County, Wyoming (Master's thesis), South Dakota School of Mines and Technology, Rapid City, SD.

Brown, S. and Blauer, M., 1980, Physical and Chemical Parameters Affecting the Dissolution of Yellowcake in Simulated Lung Fluids, Abstracts of the 25th Annual Meeting of Health Physics Society, Paper #177, Seattle, WA.

Crook County, 2005, Crook County Community Wildfire Protection Plan, October 2005.

Curtis, J. and K. Grimes, 2004, Wyoming Climate Atlas. Available from website on the Internet as of March 2010: <http://www.wrds.uwyo.edu/wrds/wsc/climateatlas/>

DOE (U.S. Department of Energy), 1993, Radiation Protection of the Public and the Environment Order No. DOE 5400.5 Available from website on the Internet as of December 2010: <https://www.directives.doe.gov/directives/current-directives/5400.5-BOrder-c2/view?searchterm=None>

Eidson, A.F. and Mewhinney, J.A., 1980, In Vitro Solubility of Yellowcake Samples from Four Uranium Mills and the Implications for Bioassay Interpretations, Health Physics, V. 39, pg. 893-902.

Federal Motor Carrier Safety Administration, 2001, Comparative Risks of Hazardous Materials and Non-hazardous Materials Truck Shipment Accidents/Incidents, Final Report, prepared for the Federal Motor Carrier Safety Administration by Battelle, March 2001.

Hanson, J.R. and S. Chirinos, 1991, Ethnographic Overview and Assessment of Devils Tower National Monument, University of Texas, Arlington.

ICRP (International Commission on Radiation Protection), 1994, Publication 66, Human Respiratory Tract Model for Radiological Protection.

_____, 1979, Publication 35, General Principles of Monitoring for Radiation Protection of Workers.

_____, 1972a, Publication 30, Limits for Intakes of Radionuclides by Workers.

_____, 1972b, Publication 19, The Metabolism of Compounds of Plutonium and other Actinides, Task Group on Lung Dynamics.

_____, 1966, Publication 8, Evaluating Risks from Radiation.

Kemp, Harold D., 2010, Assistant Director, Mineral Leasing and Royalty Compliance Division, Wyoming Office of State Lands and Investments, personal communication with Doyl Fritz, WWC Engineering, April 9, 2010.

Merritt, R.C., 1971, The Extractive Metallurgy of Uranium, Colorado School of Mines, Golden, CO.

NRC (U.S. Nuclear Regulatory Commission), 2009, NUREG-1910, Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities, Final Report, May 2009.

_____, 2003, NUREG-1569, Standard Review Plan for In Situ Leach Uranium Extraction License Applications - Final Report. Available from the website on the Internet as of September 2010: <http://www.epa.gov/rpdweb00/docs/neshaps/subpart-w/historical-rulemakings/nrc_isl.pdf>

_____, 2001, NUREG/CR-6733, A Baseline Risk-Informed, Performance-Based Approach for In Situ Leach Uranium Extraction Licenses, September 2001.

_____, 1980, NUREG-0706, Final Generic Environmental Impact Statement on Uranium Milling Project M-25, Summary and Text.

_____, 1977, NUREG-0172, Age-specific Radiation Dose Commitment Factors for a One-Year Chronic Intake.

U.S. Census Bureau (USCB), 2008, State & County QuickFacts – Wyoming. Available from the website on the Internet as of October 2010: <http://quickfacts.census.gov/qfd/states/56000.html>

USGS (U.S. Geological Survey), 2010, Protocols for Geologic Hazards Response by the Yellowstone Volcano Observatory, USGS Circular 1351, prepared jointly by the USGS, the University of Utah, and Yellowstone National Park, June 2010, available from website on the Internet as of October 2010: http://pubs.usgs.gov/circ/1351/

_____, 2009, Quaternary Fault and Fold Database, updated in October 2009. Available from website on the Internet as of September 2010: <http://earthquake.usgs.gov/hazards/qfaults/>

_____, 2005, Stream Explosions, Earthquakes, and Volcanic Eruptions - What's in Yellowstone's Future?, USGS Fact Sheet 2005-3024, prepared jointly by the USGS, the University of Utah, and Yellowstone National Park, available from website on the Internet

Wyoming State Loan & Investment Board, 2007, minutes from December 13, 2007 board meeting approving an application for a Drinking Water State Revolving Fund Loan to the Town of Moorcroft for its Madison Pipeline Level III project. Available on website on the Internet as of September 2010: http://slf-web.state.wy.us/webboard/1207/slib/1207.aspx.

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8.0 ALTERNATIVES

8.1 Description of Alternatives

As required by NRC regulations at 10 CFR Part 51 adopted by the NRC pursuant to NEPA, and as required by NUREG-1569 this chapter provides a listing of alternatives to the Proposed Action, including but not limited to: (1) the No Action Alternative; (2) the Proposed Action; and (3) Reasonable Alternatives considered but not carried forward for detailed analysis. These alternatives are considered below.

8.1.1 No Action Alternative

10 CFR Part 51 as adopted by the NRC under NEPA requires that Strata assess the "No Action" alternative. Under the No Action Alternative, Strata would not receive a combined source and 11e.(2) byproduct material license to construct, operate, and decommission the proposed Ross ISR Project. Under this alternative, Strata would not construct and operate the proposed CPP and associated facilities and wellfield and there will be none of the potential impacts identified and analyzed as part of the Proposed Action. Moreover, none of the approximately 5.5 million pounds of uranium proposed to be recovered over the 4 to 8-year production lifecycle of the Ross ISR wellfield will be realized in the commercial nuclear fuel cycle. Furthermore, none of the uranium-loaded IX resin would be processed from satellite facilities owned and/or operated by Strata or other ISR licensees or from other water treatment entities. Currently, the U.S. nuclear power generating industry is the world's largest producer of nuclear power, generating approximately 800 billion kWh of electricity in 2009, or over 20% of the total U.S. output (WNA 2010a). The U.S. imports approximately 86% percent of its uranium from foreign sources such as Canada, Australia, Russia, and Kazakhstan. In 2009, domestic uranium recovery companies produced 3.7 million pounds of yellowcake uranium (EIA 2010). By comparison, U.S. nuclear fuel reactors consumed 50.8 million pounds of yellowcake equivalent in 2009 (WNA 2010b). Thus, domestic nuclear power generating companies were required to import or receive from government-based programs (i.e., down-blending of U.S. and Russian-based highly-enriched uranium) approximately 93 percent of their required uranium. As a result of the No Action Alternative, the domestic nuclear power generating capacity will be deprived of enough uranium to supply approximately 1.5

nuclear power reactors per year, based on 750,000 pounds of annual production from the Ross ISR Project wellfield and an average requirement of about 500,000 pounds of yellowcake equivalent per year for the 104 U.S. nuclear reactors operated in 2009 (EIA 2010). Accordingly, these power reactors will be required to import sufficient uranium to fill this requirement and the U.S. will continue to be as dependent on foreign sources of uranium for the foreseeable future.

Under the No Action Alternative, baseline conditions will be influenced by natural processes and by any other industrial, commercial, or residential development in the area. Groundwater in the ore-bearing aquifer will remain unsuitable for drinking because of high naturally occurring levels of radionuclides, constituents in the uranium decay series, total dissolved solids, and sulfate, as described in Section 2.7.3 and elsewhere in this TR.

8.1.2 Proposed Action

As described in Section 3.1 of this TR, the Proposed Action involves Strata utilizing ISR processes and methodologies to recover uranium from an identified ore body that is amenable to such processes and methodologies in the proposed project area. ISR involves the circulation of native groundwater fortified with oxidizing and complexing agents (i.e., oxygen, hydrogen peroxide, carbon dioxide, and/or sodium bicarbonate) to create a recovery solution, which is pumped into the ore recovery zone using injection wells. As uranium is dissolved into the recovery solution, the solution is pumped to the surface using recovery wells and is passed through pressurized, down-flow IX columns where the uranium attaches to synthetic IX resins. After the uranium attaches to these resins, it is stripped using the elution process with the stripped resins returning to the IX columns for further use unless they are exhausted. The eluted uranium will be precipitated, washed, filtered, pressed and dried into the final product—yellowcake. The Proposed Action also includes a separate vanadium recovery, processing, and packaging circuit.

As part of the ISR process, groundwater pumped to the surface to recover uranium is re-fortified with the above-mentioned reagents and re-circulated through the recovery zone in a continuous process until the economically recoverable uranium resources in a given wellfield module are removed. After uranium recovery is complete in a given wellfield module, groundwater in that module is restored. Groundwater will be restored to the groundwater protection

standards presented in 10 CFR 40, Appendix A, Criterion 5(B)(5) on a parameter-by-parameter basis using Best Practicable Technology (BPT). If the restoration activities are unable to achieve the background or maximum contaminant levels (whichever is greater) in Criterion 5(B)(5), Strata will submit a license amendment application request for NRC approval of ACLs, but only after demonstrating that there are no specific hazards and the restored constituent concentrations are as low as reasonably achievable (ALARA). All surface facilities specifically associated with any given wellfield module will be subject to D&D requirements such that, ultimately, there will be no visual evidence of site use and the entire disturbance area can be released for "unrestricted use." Successful groundwater restoration and D&D was demonstrated within the proposed project area by the Nubeth R&D facility. A detailed description of the Proposed Action, including the methods by which well design and layout will be completed, is presented in Chapter 3 of this TR and Chapter 1 of the ER.

8.1.3 Reasonable Alternatives Considered but Not Carried Forward for Detailed Analysis

8.1.3.1 Wellfield Layout

Typically, an ISR production unit consists of an ISR-amenable ore body located within a sandstone unit bounded by upper and lower hydrologic and geologic barriers. In the simplest scenario, there would be a single production zone and a monitor well ring radially bounding that production zone with monitor wells within the ore zone aquifer and in aquifers above and below the upper and lower hydrological barriers. Proper wellfield balance (including a "bleed") is the means of ensuring control of recovery solutions within a production unit. In more complex systems, there may be more than one production unit stacked vertically within a sandstone unit, and there may be more than one sandstone unit, with multiple production zones stacked vertically (e.g., LCI 2008). However, generally the geologic and hydrologic parameters will be consistent with the concept of some greater or lesser confining structures above and below production zones.

Within the proposed project area, there exist stacked uranium roll-front deposits that can be recovered using two potential wellfield layout plans. In the first option, uranium recovery and aquifer restoration would occur in the same injection and recovery wells. This would be accomplished by recovering the

deepest roll front, recompleting the wells by plugging back, underreaming, and then recovering the next upper roll front. This would be repeated for any other shallower stacked fronts. After recovering the shallowest roll front, each zone would be restored individually with another sequence of well recompletion necessary between each restoration. This method would be difficult and time-consuming to manage, and any cost savings associated with re-use of recovery and injection wells would be consumed by added recompletion and integrity testing costs. Furthermore, there is significant risk that drilling out cement plugs in the PVC well casing would result in integrity failure, which would require replacement wells to be installed. Due to the added time and well integrity risks associated with sequentially recovering and restoring stacked roll fronts in the same wells, this option was not considered for further analysis.

In the Proposed Action, uranium will be recovered in stacked roll fronts and the aquifer will be restored according to whether or not the stacked roll fronts occur in the same sand unit. Stacked roll fronts in the same sand unit without confinement between the stacked roll fronts will be recovered by opening multiple zones in the same injection and recovery wells. If the mineralized zones which meet the GT (grade-thickness) cutoff are in separate sand units, a well would be installed to target the ore zone in each sand. In other words, where this situation exists there will be twin wells at each location with one group of recovery and injection wells on top of the other. The stacked roll fronts would be recovered and restored together. Additional information and a figure showing the proposed method of ISR uranium recovery in stacked roll fronts is included in Section 5.7.8.

8.1.3.2 Conventional Uranium Mining/Milling, Including Heap Leaching

As stated in the Generic Environmental Report for ISR facilities (GER) (NMA 2007), conventional methods of uranium mining/milling (including heap leaching) are alternatives or adjuncts to the ISR method of uranium recovery. These alternatives are considered but not carried forward for detailed analysis in this report because they were assessed in the 1980 GEIS for conventional uranium mining/milling. Conventional uranium mining, milling, and heap leaching are summarized below; the Final GEIS on Uranium Milling (NUREG-0706) should be consulted for additional detail (NRC 1980).

Open-pit and underground uranium mining alternatives to ISR operations at the proposed Ross ISR project site were considered but eliminated based on economics, health, safety, and environmental impacts. As a general matter, conventional uranium recovery methods are not suitable for the recovery of lower grade ores due to the significant capital costs associated with the construction and operation of a conventional mine and mill. Low-grade uranium ores produce a relatively small quantity of uranium per unit of rock moved. The higher capital and operating expenditures for open pit and underground mining operations are not justified when pursuing recovery of lower grade ores like those at the proposed Ross project site. Further discussion of conventional uranium mining methods is provided below.

Open-pit uranium mining involves the removal of all overburden above the identified ore body and then the ore itself to recover the uranium. The overburden is generally stockpiled and then used to fill in the pit after mining is completed. The ore is transported to a mill for processing, which involves grinding the ore, leaching the uranium from the ground ore, and concentrating and drying the recovered uranium into yellowcake. The tailings (ore from which the uranium has been removed) from the milling process require safe disposal in a properly designed and licensed facility. As stated in the GER, the maximum depth of open-pit mining in the United States is usually about 550 ft (NMA 2007), which places the Ross ISR Project ore zone at or near the maximum limit for surface mining. Open-pit mining at the Ross site would require dewatering of several aquifers (see Section 2.7.3), and the considerable amount of water produced would likely require treatment prior to discharge. Surface water features such as the Little Missouri River and Oshoto Reservoir would also require extensive management during open pit mining.

The milling process can be completed using one of two potential business models. The first model involves recovering the identified uranium ore and transporting the ore to a conventional uranium milling facility for processing pursuant to a contractual arrangement with a uranium recovery company currently operating such a facility (i.e., toll milling). From an economic perspective, this alternative was eliminated due to the lack of potential financial benefit to Strata. This alternative could also result in significant transportation impacts, since there are no conventional uranium mills within 50 miles (80 km) of the proposed project area. The second model involves the recovery of the uranium ore and the construction and operation of a uranium

milling facility by Strata. The construction and operation of a conventional uranium milling facility involves significant capital expenditures for the construction of a mill plant, uranium mill tailings impoundments and other associated facilities and structures. Further, the overall footprint of the mine and mill site would be substantially larger than that of an ISR site and would result in significant surface disturbance. For example, NRC determined that the Moore Ranch ISR Project was estimated to disturb a total of 150 acres, compared to 741 acres that would be disturbed during construction of a conventional milling operation (NRC 2010).

Wastes generated by a conventional mining and milling operation would be substantial and would result in permanent, irretrievable impacts to the local topography. In addition, conventional mining and milling results in higher potential risks for personal injury and from potential radiological exposures than those posed by ISR operations and would require substantially more effort to complete surface reclamation and site closure. Further, the area where the conventional mill and associated mill tailings impoundments would be located would not be able to be released for unrestricted use like an ISR site. For these reasons, Strata eliminated the alternative of open-pit mining and conventional milling.

Underground uranium mining involves sinking shafts in the vicinity of the identified ore body, driving crosscuts and drifts to the ore body at different levels, removing the ore and transporting the recovered ore to a uranium milling facility for processing. As with open-pit mining, the uranium ore is transported to a conventional uranium milling facility owned and/or operated by another company pursuant to a contractual arrangement for toll milling, or Strata could construct and operate a uranium milling facility at the Ross site.

The potential risks and impacts associated with underground mining are somewhat similar to those described above for open-pit mining. Less overburden is removed, so waste stockpiles are smaller. Surface disturbance is generally less for underground mining than for surface mining. At the Ross site, where the ore zone and overburden both contain highly confined aquifers, dewatering would be required in order to operate an underground mine. The water would likely need to be treated prior to discharge. There are health and safety risks associated with underground mining and potential exposure of miners to radon daughters if the mine is not properly ventilated in accordance

with Mine Safety and Health Administration (MSHA) regulations. There are also potential exposures to members of the public from radon and its daughters if the mine is not operated according to Clean Air Act (CAA) regulations (e.g., 40 CFR Part 61, Subpart B). For these reasons, Strata eliminated the underground mining and conventional milling alternative.

As an alternative to conventional milling, low-grade ore that is recovered by open-pit or underground mining operations can undergo further processing to remove and concentrate the uranium by heap leaching. This process is described in the GER (NMA 2007). Heap leaching occurs at or very near the mine site. The low-grade ore is crushed to a fine size and mounded above grade on a prepared pad. The heap leaching pads must be constructed to the same standards as tailings impoundments per 10 CFR Part 40, Appendix A, including the requirement for a double liner. A sprinkler or drip system distributes leach solution over the mound. For ores with low lime content (less than 12 percent), an acid solution is used, while alkaline solutions are used when the lime content is above 12 percent, which is the case for the Ross site. The leach solution trickles through the ore and mobilizes uranium, as well as other metals, into solution.

The solution is collected at the base of the mound by a manifold and processed to extract the uranium. The uranium recovery from heap leaching is expected to range from 50 to 80 percent, resulting in a final tailings material of around 0.01 percent U_3O_8 content. Once heap leaching is complete, the depleted materials are 11e.(2) byproduct material that must be placed in a tailings impoundment unless NRC grants an exemption for disposal in place. Heap leaching was used mostly on an experimental basis in the 1970s and 1980s, but generally is not in use in the United States today, although it may be in the future. While the impacts from heap leaching may be less than those from conventional milling, the impacts from the associated open-pit or underground mining would still be substantial. For these reasons, this alternative is not carried forward for detailed analysis.

8.1.3.3 Alternate Location of Central Processing Plant

Prior to preparation of this license application, Strata considered two potential locations for the CPP in the proposed project area. The first site, referred to as the south site, is located southeast of the Oshoto Reservoir, primarily in NE¼SE¼ Section 18, T53N, R67W (see Figure 3.1-1). The second

site, referred to as the north site, is located north of the Oshoto Reservoir in S½SW¼ Section 27, T53N, R67W. The following is a list of factors which led Strata to select the south site for construction of the CPP.

The south site is situated on relatively flat topography, which would minimize the amount of earthwork and surface disturbance required to prepare the site for construction of the CPP, associated buildings and parking/staging area. The surface is entirely private, and baseline instrumentation is currently adequate for all baseline environmental studies. There is little mineralization beneath the south site, and what there is could be accessible without major modification of the wellfield and monitor well layout. Preliminary geotechnical studies at the south site indicate that subsoil materials are relatively impermeable and have adequate strength for the proposed structures. Preliminary estimates of the radionuclide release rates from the entire project including the south CPP site indicated that the average annual radiation dose to the nearest receptor was less than 6% of the annual limit. The owner of the south site is also the owner of the Oshoto Reservoir, so a surface use agreement, lease, or purchase of this area would afford Strata control over this impoundment.

The north site has more varied topography, so leveling the site for construction of the CPP and related facilities would require more earthwork and surface disturbance. The site is screened from view relatively from all directions except the south. There is mineralization beneath the site, which might require reconfiguration of the wellfield and monitor well layout. This site is also closer to the proposed license boundary than the south site, which could, following completion of all baseline modeling and impact analyses, require that the site boundary be relocated further to the north, which would in turn require a new round of baseline studies.

In addition to the two optional Ross sites for the CPP, as described above, Strata considered construction of the CPP within the Barber Amendment Area, some 15 miles south of the Ross ISR Project area. Strata has identified significant uranium resources within the Lance District (see Figure 1.4-2). The proposed Ross ISR Project is intended to be just the first of several ISR project sites to be developed in the area. If these other sites are developed, it is likely that they will serve as ancillary or satellite facilities to the proposed Ross project site, with all satellite facilities using the same CPP. The Barber

Amendment Area is currently being evaluated by Strata as an ISR satellite to the proposed Ross ISR Project. Since the Ross site has been identified as the first area for ISR development, and has been evaluated based on the extensive geologic, hydrologic, and ISR uranium recovery characteristics regarding the site and surrounding environment, it is logical that this would be the site for the CPP. Delaying construction of the CPP until another project is ready to permit and license within the Lance District would require that Strata enter into a contract for toll milling until the CPP is permitted and constructed. The Ross ISR site has the additional advantage of having data from a successfully operated R&D project (Nubeth) licensed through both the NRC and WDEQ/LQD, with authorized decommissioning that proved the feasibility of aquifer restoration and D&D. These factors made the Ross ISR Project a strong candidate site for full commercial production. Consideration of the alternative CPP location was not analyzed in detail because a site has not been selected and it is likely that the environmental effects of constructing and operating the CPP at a different location within the Lance District would be essentially the same as for the Proposed Action.

8.1.3.4 Alternate Lixiviants

Alternate lixiviant chemistry was also considered for the operations phase of the proposed action, including acid leach solutions and ammonia-based lixiviants. As discussed in the final SEIS for the Moore Ranch ISR Project (NRC 2010), acid-based lixiviants such as sulfuric acid dissolve heavy metals and other solids associated with uranium in the host rock and create chemical compounds that require additional remediation and have greater environmental impacts.

At a small-scale research facility in Wyoming, test patterns were developed using acid-based lixiviants. During operations, two significant problems developed. The mineral gypsum precipitated on the well screens and in the aquifer, which plugged the wells and reduced the efficiency of the wellfield restoration. Aquifer restoration had limited success because of the gradual dissolution of the precipitated gypsum, which resulted in increased salinity and sulfate levels in the affected groundwater (NRC 2010). As described in Section 1.2, an R&D ISR project at the Ross Site was operated in 1978 and 1979 and restoration was approved by the regulatory agencies by 1986. That project is considered to have demonstrated the feasibility of uranium recovery

and groundwater restoration using a sodium-bicarbonate based lixiviant on the ore zone at the Ross site. Because it is technically more difficult to restore uranium recovery sites when acid is the lixiviant and this technology has not been proven feasible at the Ross Site, the use of an acid-based lixiviant was eliminated from further consideration by Strata.

Ammonia-based lixiviants have been used at ISR operations in Wyoming. However, operational experience has shown that ammonia tends to adsorb onto clay minerals in the subsurface and then slowly desorbs from the clay during restoration, therefore requiring that a much larger volume of groundwater be removed and processed during aquifer restoration (NRC 2010). An example of this is early production at the Irigaray ISR operation in Johnson County. According to the Irigaray Wellfield Restoration Report (Cogema 2005), ammonium bicarbonate was used as the lixiviant in Mine Units 1 through 5, but not in Mine Units 6 through 9. Traces of the ammonium bicarbonate lixiviant remained in the aquifer upon completion of extensive aquifer restoration. Because of the greater consumptive use of groundwater to meet aquifer restoration requirements, the use of an ammonia-based lixiviant was eliminated from detailed analysis.

8.1.3.5 Alternate Waste Management

Plans for management of liquid waste from the operation and aquifer restoration are described in Section 4.2 of this TR. Figures 3.1-11 through 3.1-13 show the project water balance in schematic and tabular forms. Most permeate generated during RO treatment of the production bleed and restoration flows will be recycled back to wellfield modules and used in operation or aquifer restoration and will therefore not be considered waste. The balance of the permeate will be discharged into lined retention ponds, after which it will be recycled back to the wellfield or disposed by surface discharge, for plant make-up water, Class I deep disposal wells, or land application (refer to Sections 4.2.2.1 in this TR and 4.13 in the ER for more detail).

Deep well disposal was selected as the preferred method of brine disposal due to its minimal impact to human health and the environment. Although there will be lined retention ponds to store permeate, brine and other 11e.(2) liquids such as spent eluate, reliance solely upon evaporation for wastewater disposal was rejected as the primary alternative because of the large area that would be required to build the ponds and the increased environmental risk

associated with storing large quantities of brine and other 11e.(2) liquids in surface impoundments. As shown in Figure 3.1-12, an average of 227 gpm of these fluids are estimated to require disposal during concurrent operation and aquifer restoration. This may range between 90 and 300 gpm. The average net evaporation rate for brine ponds at uranium recovery operations (for this study the brine contained about 55,000 mg/L TDS) in northeastern Wyoming is about 30 inches per year (Pochop et al. 1985). The water surface necessary to evaporate 227 gpm would average about 146 acres. Considering the requirement (e.g., ISR GEIS, NRC 2009, pg. 2-37) to maintain reserve capacity to transfer the entire contents of any one pond into the other ponds in the event of a leak, and the need to allow for fluctuations in brine and eluate production rates as well as seasonal and annual variations in precipitation and evaporation rates, the actual footprint occupied by evaporation ponds could easily total 200 acres or more if evaporation were to be the only method of water disposal. Since the Proposed Action would disturb only about 280 acres as planned, the evaporation pond alternative would require significantly more surface disturbance, and this disturbance would last throughout the construction, operation, aquifer restoration and decommissioning phases of the project.

As an alternative to evaporation ponds, Strata also evaluated the potential to use enhanced evaporation technology to eliminate the liquid waste stream. For this option the brine would be boiled away using natural gas as the heat source because a natural gas pipeline is very near to the property and natural gas would provide a smaller carbon footprint than coal. For a waste liquid flow of 227 gpm and a gas cost of $3.50 per million BTU, it is estimated that the cost of the natural gas alone could total about $6 million per year. For a yellowcake production rate of 750,000 pounds per year, this natural gas cost would add $8 per pound to the cost of production. There would also be significant capital and operating costs of the evaporation system.

For any evaporation technology, the dried solids that remain after evaporation of the liquid would require disposal as 11e.(2) byproduct material. A brine rate of 227 gpm with a dissolved-solids content of 35,000 mg/L TDS (reference Table 4.2-5 in this TR) represents a salt load of about 17,000 tons per year that would require disposal in a licensed facility. This is equivalent to about 500,000 cubic feet of 11e.(2) byproduct material, which for a disposal cost of $10 to $20 per cubic foot would result in an additional annual operating

cost of $5 to $10 million per year, or $7 to $13 per pound of yellowcake produced.

On the basis of costs, environmental impacts, possible carbon footprint, and 11e.(2) byproduct material disposal issues, brine disposal by evaporation alone was not carried forward for further consideration.

8.1.3.6 Uranium Processing Alternatives

8.1.3.6.1 Single Stage RO

The Proposed Action includes two phases of RO for treatment of the production bleed and restoration solutions as described in Section 3.2.5 and 3.2.6 of this TR and as shown on Figures 3.1-11 through 3.1-13 of this TR. The brine generated from the Phase 1 production and restoration RO systems will be passed through the Phase 2 (recovery) RO system. Brine from the Phase 2 RO system will be discharged to lined retention ponds for deep well disposal, while all permeate will be recycled to the wellfield or discharged to lined retention ponds designated for permeate storage and subsequently recycled back to the wellfield or plant or disposed by land application, surface discharge, or deep well injection.

An alternative considered by Strata was to use only one phase of RO treatment. Permeate from this single-stage RO would be handled just like the permeate described above, but the brine would be discharged directly to the lined retention ponds rather than being passed through a second phase of RO treatment. The two-stage RO treatment creates about one-half the amount of brine as a single-stage treatment and allows much more of the process wastewater to be converted to permeate. Most of this permeate will be put to beneficial use through (1) injection into wellfields undergoing operations or aquifer restoration, (2) plant makeup water, (3) land application, or (4) surface discharge, all of which are beneficial uses. Reducing the amount of brine through the use of two-stage RO treatment reduces the size of lined retention ponds necessary for storage of the brine and reduces the amount of water disposed of by evaporation and deep well injection, both of which are non-beneficial consumptive uses of water. Because of the advantages of two-stage RO treatment in reducing brine volume and providing more permeate for beneficial uses, the single phase of RO treatment was not further considered by Strata.

8.1.3.6.2 No RO Treatment of Groundwater Sweep Recovery Solution

Section 6.1.2.1 of this TR describes the groundwater sweep process that will be employed by Strata to restore groundwater quality in the ore zone after uranium recovery is completed. During groundwater sweep, water is pumped from recovery wells to the CPP for uranium removal and/or RO treatment with none of the RO permeate being reinjected into the modules undergoing groundwater sweep. As described in the ISR GEIS (pg. 2-28), groundwater sweep causes uncontaminated, native groundwater to flow into the ore body, flushing contaminants from areas that have been affected by injection of lixiviant during uranium recovery. Groundwater sweep also helps recover lixiviant from areas of low permeability within the production zone. Typically, groundwater sweep is the first phase of restoration, but Strata may decide to use groundwater sweep on all or a portion of a wellfield module at any time during restoration.

A drawback of groundwater sweep without reinjection is the additional consumptive use of groundwater. If permeate is not reinjected into a module actively undergoing groundwater sweep, and if there is not an active wellfield module where the permeate can be injected as part of the uranium recovery process, then the permeate from the groundwater sweep adds to the waste disposal stream. WDEQ/LQD has determined that groundwater sweep with direct disposal of produced water is not considered BPT due to excessive consumption of groundwater and resultant impacts to groundwater resources (LCI 2009). Strata proposes the following strategy to minimize consumptive use of groundwater during groundwater sweep:

- Water produced during groundwater sweep will be treated by two phases of RO to minimize brine, thereby avoiding any occurrence of groundwater sweep with direct disposal of produced water.
- Whenever possible, permeate generated from one module undergoing groundwater sweep will be reinjected into another module undergoing RO treatment with permeate reinjection.
- Much of the permeate discharged into the lined retention ponds will be recycled to the CPP for make-up water.
- Groundwater sweep may be used selectively (e.g., around the perimeter of the module) rather than throughout the entire module to maximize benefits while minimizing consumptive use of groundwater.

- The total volume of water planned for groundwater sweep is much lower than that planned for RO treatment with permeate injection.

Groundwater modeling within the project area has shown that some portions of a wellfield will likely be easier to restore than others due to localized aquifer hydraulic properties and wellfield geometry. Strata anticipates that by updating the groundwater model presented in TR Addendum 2.7-H with site specific data used to develop the wellfield packages, aquifer restoration activities can be modeled. Results of the aquifer restoration modeling will indicate where groundwater sweep activities are likely be the most effective. The use of the groundwater model to help direct selective sweep operations has the potential to significantly decrease the consumptive use of water during the sweep portion of the groundwater restoration process while at the same time significantly increasing the effectiveness of the restoration process.

Because WDEQ/LQD does not consider groundwater sweep without permeate injection to be BPT due to excessive groundwater consumption, Strata eliminated this option from further consideration.

8.1.3.7 Alternate Size of CPP

As described in Section 1.8, the IX circuit of the CPP at the Ross ISR Project will be designed to handle a flow rate up to 7,500 gpm and produce 750,000 pounds of uranium annually over a 4 to 8 year period. The CPP will have the capacity to process up to 3 million pounds of U_3O_8 per year from the current Ross ISR operations as well as future ISR facilities operated by Strata and other uranium-loaded resin generators as discussed previously. This could potentially extend the life of the proposed CPP an additional 20 years.

The capacity of the CPP is larger than would be justified by the proven reserves at the Ross ISR Project alone. Strata considered other sizes for the CPP and IX circuit before selecting the preferred alternative. The primary consideration 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.

Strata's license application includes a request for authorization to receive and process uranium-loaded resins from satellite ISR facilities, including those owned and/or operated by Strata or those owned and/or operated by other ISR licensees, and from other water treatment entities generating uranium-loaded

IX resins that are substantially similar to those generated at the Ross ISR facilities. In support of 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 per year of yellowcake to include the receipt and processing of the aforementioned uranium-loaded IX resins.

Because NRC requires financial assurance to support permissible licensed operations for each license, Strata proposes that, for purposes of receiving and processing uranium-loaded IX resins from the aforementioned entities, NRC Staff issue a license condition permitting the receipt and processing of such resins so long as the processing of such resins does not require any 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 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 Ross CPP.

Having excess capacity in the CPP 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.

Having excess capacity in the CPP will increase safety in the plant since there will be less incentive to push pipelines, valves and other process equipment to their maximum limits.

Basing the analysis of potential environmental consequences on a larger CPP should provide a conservative analysis and help to streamline future license amendments.

Several factors, including hydraulic characteristics of the ore body as determined from aquifer tests and modeling and the relatively low grade of the ore, support the theory that more water movement through the wellfield and CPP will enable more complete removal of the uranium from the ore zone. Having excess plant capacity will provide Strata with the flexibility to increase throughput to achieve operational goals without being constrained by system capacity.

The potential environmental impacts of the CPP are essentially the same irrespective of capacity. There is little difference in the plant footprint for a plant capable of handling 1 or 3 million pounds of U_3O_8 per year; only the size of the lined retention ponds is directly proportional to liquid throughput capacity.

For these reasons, Strata has selected the plant capacity described for the Proposed Action and alternate sizes were not carried forward for detailed analysis.

8.1.3.8 Arsenic and Selenium Recovery

Strata commissioned a cursory review by Lyntek Incorporated of the technology and economic viability of capturing arsenic and selenium along with uranium and vanadium from the Ross ISR Project. Standard practice within the industry is to remove the selenium and the arsenic from the recovered water with an RO unit during aquifer restoration operations. The arsenic and selenium are retained in the brine and disposed in the deep disposal wells or with the evaporation residue along with the other 11e.(2) byproduct material. Strata considered selectively capturing the selenium and arsenic during uranium recovery operations rather than during aquifer restoration.

Potentially economical technologies for recovery/treatment of arsenic and selenium are to co-precipitate these metals with iron or to adsorb the metals onto an iron substrate, such as iron-impregnated resin. Historically, the cleanest, cheapest and easiest method employs the use of IX resins, which also allows the opportunity to generate a clean product that might be saleable.

For the analysis, it was assumed that a separate IX system would be used to capture selenium and arsenic at a flow rate up to 7,500 gpm, or the maximum flow rate anticipated for the pressurized, down-flow IX columns used to capture uranium and vanadium. Vendors indicated a cost for an IX resin specific for arsenic and selenium would be about $350/cu ft. The selenium and arsenic system would require approximately a total of 3,000 cu ft or 3 columns each with a 1,000-cu ft capacity. It was assumed that the system would be installed within the CPP and operated by the same plant operators. Therefore, the incremental capital and operating costs for those services were ignored for this conceptual analysis.

Capital costs for the columns, resin, pumps, piping and strip circuit were estimated at roughly $2.4 million. Operating costs were estimated at $0.001 per gallon of water treated, for a total of $10,800 per day or $3.9 million per year.

According to the USGS Minerals Yearbook dated November 2010, the annual average New York dealer price for selenium was $23.07 per pound in 2009 and was 26% lower than the annual average price in 2008. The price remained about $20 per pound for the first 7 months of 2009, down from the year-end 2008 price of $23 per pound. An optimistic value of $30 per pound was used for this cursory analysis. The USGS Minerals Yearbook indicates a recent price for arsenic of around $1,000 per ton, or $0.50 per pound, which is negligible compared to the price of selenium. Therefore, the evaluation was performed to see if there would be any value in producing selenium and whether the costs of removing selenium from the process water stream would be economical for the 7,500-gpm flow rate. Two different selenium concentrations were considered for this cursory evaluation, a low level of 0.03 mg/L and a high level of 0.28 mg/L based upon the leachate characteristics determined by laboratory leach tests with core sample from the ore zone. The evaluation considered only the basic processing costs with an assumption of 100% selenium recovery, and ignored the costs of packaging produced material. Using the higher concentration for selenium of 0.28 mg/L, it was estimated that the value of selenium produced would be about $760 per day, compared with an operating cost to produce this selenium of $10,800 per day.

Even though this evaluation was cursory in nature, the results show that the disparity between production costs and sales price of selenium would be large, and this clearly this would not be an economically viable operation. As stated in the assumptions, arsenic has a lower economic value than selenium, so it can be assumed that the arsenic will have even poorer economics and would also not be feasible as a revenue generation concept.

With an operating cost on the order of $10,800 per day, or $3.9 million per year, the operating costs alone would add roughly $5.25 to the production cost of the yellowcake at the Ross ISR Project. The small quantities of selenium and arsenic produced can best be disposed of with the RO brine in the deep disposal wells. For these reasons the recovery and sale of selenium and arsenic

as a byproduct of uranium recovery was not carried forward for further analysis.

8.2 Comparison of the Predicted Environmental Impacts

As discussed above, Strata has identified and developed the Proposed Action as the best approach to recovering uranium resources from the proposed Ross ISR Project. Table 8.2-1 presents a chart of predicted potential impacts associated with the No Action Alternative (Section 8.1.1) compared to the Proposed Action (Section 8.1.2), and alternatives considered but eliminated from further analysis in this ER, including: alternate wellfield layout (Section 8.1.3.1), conventional mining/milling, including heap leaching (Section 8.1.3.2), alternate CPP locations (Section 8.1.3.3), alternate lixiviants (Section 8.1.3.4), alternate waste management (Section 8.1.3.5), uranium processing alternatives (Section 8.1.3.6), alternate CPP size (Section 8.1.3.7) and arsenic and selenium recovery (8.1.3.8). Chapter 4 of the ER provides a more detailed discussion of potential environmental impacts of the Proposed Action and No Action Alternative.

Table 8.2-1. Comparison of Potential Environmental Impacts for Various Alternatives

Potential Impact	Alternative	Potential Impacts
Potential Land Surface Impacts	Proposed Action	Surface disturbance on about 280 acres, or about 16% of proposed project area. Disturbance will range from short term for construction of well pads and utility corridors that will be reclaimed after construction to long term for roads, buildings, parking areas, and ponds that will remain until final D&D. All disturbance will be reclaimed to be suitable for pre-construction uses after aquifer restoration and D&D.
	No Action	None
	Alternative Wellfield Layout	Not analyzed in detail, but surface disturbance would be similar in severity and of longer duration than Proposed Action.
	Conventional Mining/Milling including Heap Leaching	Open-pit mining could disturb up to five times as much area for pit, ramps, and material stockpiling and would create permanent topographic changes. Conventional milling requires crushing of ore and disposal of tailings, creating long-term or permanent 11e.(2) byproduct material disposal area.
	Alternate CPP Location	Same as Proposed Action
	Use of Alternate Lixiviants	Same as Proposed Action
	Alternate Waste Management	Disposal in evaporation ponds would require considerably more long-term surface disturbance due to evaporative surface required. Residue left after evaporation would be 11e.(2) byproduct material that would require disposal in an appropriately licensed facility.
	Uranium Processing Alternatives	Use of single-stage rather than two-stage RO treatment of bleed and restoration solutions would create twice as much brine as Proposed Action, requiring larger storage ponds - much larger ponds if evaporation is selected for waste water disposal. Reducing RO treatment of water recovered during aquifer restoration would increase surface area required for water storage and may increase the duration of the project due to longer time to achieve aquifer restoration.
	Alternate Size of CPP	Same as Proposed Action
	Arsenic and Selenium Recovery	Same as Proposed Action

Table 8.2-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Land Use Impacts	Proposed Action	Restricted access on up to 1,721.3 acres for 8-12 years (construction through decommissioning) which will have small impacts on livestock grazing and hunting.
	No Action	None
	Alternative Wellfield Layout	Not analyzed in detail, but land use restrictions would be similar in severity and of longer duration than Proposed Action.
	Conventional Mining/Milling including Heap Leaching	Area used for pit, ramps, haul roads, overburden stockpiles and topsoil stockpiles would be unavailable for any other uses for the duration of the operation, including decommissioning. Tailings piles would be a permanent restricted-use area.
	Alternate CPP Location	Same as Proposed Action
	Use of Alternate Lixiviants	Same as Proposed Action
	Alternate Waste Management	Larger area required for water retention ponds would be unavailable for any other uses during project duration.
	Uranium Processing Alternatives	Same as Proposed Action
	Alternate Size of CPP	Same as Proposed Action
	Arsenic and Selenium Recovery	Same as Proposed Action

Table 8.2-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Transportation Impacts	Proposed Action	Approximately 30 acres will be disturbed for life of project to construct access roads. Traffic will increase on local public roads, peaking during construction. Chemicals being hauled to the site and products being hauled away, including small quantities of 11e.(2) byproduct material, pose small risk of spill during project life. Some roads might remain after decommissioning if they support the post-decommissioning land use and are desired by the surface owner.
	No Action	None
	Alternative Wellfield Layout	Same as Proposed Action
	Conventional Mining/Milling including Heap Leaching	Open-pit mine would most likely require relocation of local roads to accommodate pits, overburden stockpiles, and tailings impoundments. Conventional mining methods would require more employees with accompanying traffic on local roads.
	Alternate CPP Location	Same as Proposed Action
	Use of Alternate Lixiviants	Same as Proposed Action, possibly for longer duration since aquifer restoration could require more time.
	Alternate Waste Management	Same as Proposed Action
	Uranium Processing Alternatives	Use of single-stage RO treatment would require more area used for ponds than Proposed Action.
	Alternate Size of CPP	A smaller CPP would require fewer people and less materials to construct. If uranium-loaded IX resin were not processed, there would be no shipments of resin and fewer shipments of chemicals and yellowcake.
	Arsenic and Selenium Recovery	Similar to proposed action, with slightly more equipment, chemical, and product shipments.

Table 8.2-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Geology and Soils Impacts	Proposed Action	No significant impacts on geology. About 280 acres will be stripped of topsoil for construction of facilities. Topsoil will be stockpiled and protected from erosion until it is replaced during reclamation. After topsoil is replaced and revegetated, the land will support the pre-construction uses of livestock grazing and limited hunting.
	No Action	None
	Alternative Wellfield Layout	Same as Proposed Action
	Conventional Mining/Milling including Heap Leaching	Open-pit mining would be much more radical in terms of impacts on geology and soils. All the materials from the surface through the ore zone would be removed. Overburden would be stockpiled during mining and replaced in the pit after mining as a relatively homogeneous mixture of the original, stratified overburden.
	Alternate CPP Location	Same as Proposed Action
	Use of Alternate Lixiviants	Same as Proposed Action, although project duration could be extended if alternative lixiviants require more time for aquifer restoration.
	Alternate Waste Management	More area for retention/evaporation ponds would require more topsoil removal and stockpiling, which would last for the life of the operation.
	Uranium Processing Alternatives	Use of single-stage RO treatment would require more area used for ponds (hence, topsoil removal) than Proposed Action.
	Alternate Size of CPP	Similar to Proposed Action. There would be slightly less soil disturbance for a smaller CPP.
	Arsenic and Selenium Recovery	Same as Proposed Action

Table 8.2-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Surface Water Impacts	Proposed Action	Small risk of increased sediment load to ephemeral stream channels due to surface disturbance. Small risk of spill of chemicals or fuels during project life. Small potential for impacting surface water if excess permeate is managed through WYPDES discharge or land application. Risks minimized by applying BMPs.
	No Action	None
	Alternative Wellfield Layout	Same as Proposed Action
	Conventional Mining/Milling including Heap Leaching	Open-pit mining would alter the surface drainage network, including requirement to divert surface water around the pit and stockpile area and restore all affected streams after mining. Larger disturbed area would present larger risk of sediment contributions to surface waters. Large amount of groundwater to be treated and discharged for either open-pit or underground mine would impact drainages which normally see only ephemeral flow events.
	Alternate CPP Location	Similar to Proposed Action, depending on CPP proximity to surface water.
	Use of Alternate Lixiviants	Increased potential risk to surface water associated with potential spill of acid or ammonia-based lixiviant compared to sodium-bicarbonate based lixiviant.
	Alternate Waste Management	Larger ponds would pose greater risk of spill to surface waters and disturb more acreage, presenting more risk of increased sediment load to streams.
	Uranium Processing Alternatives	Larger ponds would pose greater risk of spill to surface waters and disturb more acreage, presenting more risk of increased sediment load to streams. Little or no excess permeate would be generated if groundwater sweep solutions were not treated by RO. Potential surface water impacts from WYPDES discharge or land application of permeate would therefore be avoided.
	Alternate Size of CPP	Same as Proposed Action
	Arsenic and Selenium Recovery	Same as Proposed Action

Table 8.2-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Groundwater Impacts	Proposed Action	Small risk that adjacent aquifers could be contaminated by excursion of recovery solution and would require cleanup. Small risk that shallow groundwater could be contaminated by leaks or spills. Small net withdrawal of water from the ore zone aquifer during operation to contain fluids. Some of the water withdrawn will be evaporated in ponds or disposed by deep well injection and thus represents a consumptive use. Water consumed will be replaced by natural recharge over time.
	No Action	None
	Alternative Wellfield Layout	Repeated recompletion of wells and potential well integrity problems would add to duration of operation and aquifer restoration.
	Conventional Mining/Milling including Heap Leaching	Open-pit and underground mining would drastically alter the hydrogeology of the area. All discrete aquifers from the surface to the bottom of the ore zone would be exposed in the pit, requiring water management, dewatering, treatment and disposal, and possibly creating safety hazards from highwall failures or cave-ins. Changes to aquifers would be permanent. Groundwater removed to allow conventional mining would have to be discharged, affecting streamflow patterns.
	Alternate CPP Location	Similar to Proposed Action, depending on CPP proximity to shallow groundwater.
	Use of Alternate Lixiviants	Same as Proposed Action, possibly with longer duration due to extended time for aquifer restoration.
	Alternate Waste Management	Same as Proposed Action
	Uranium Processing Alternatives	Use of single-stage RO or not treating groundwater sweep recovery solutions with RO would increase net amount of groundwater withdrawn from ore zone aquifer.
	Alternate Size of CPP	Same as Proposed Action
	Arsenic and Selenium Recovery	Similar to Proposed Action, except that aquifer restoration could require less time if selenium is recovered during operations.

Table 8.2-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Ecological Impacts	Proposed Action	No threatened or endangered species will be impacted. No critical game habitat will be impacted. Small, temporary loss of habitat for some species will occur for life of project. BMPs will limit waterfowl and other wildlife access to lined retention ponds.
	No Action	None
	Alternative Wellfield Layout	Same as Proposed Action
	Conventional Mining/Milling including Heap Leaching	Much more surface disturbance, which will represent loss of habitat for life of project. Large quantities of water to be treated and discharged or stored in ponds would alter habitat for life of project.
	Alternate CPP Location	Same as Proposed Action
	Use of Alternate Lixiviants	Similar to Proposed Action, possibly for longer duration if aquifer restoration occurs more slowly.
	Alternate Waste Management	More terrestrial habitat lost due to need for larger impoundments.
	Uranium Processing Alternatives	Same as Proposed Action
	Alternate Size of CPP	Same as Proposed Action
	Arsenic and Selenium Recovery	Same as Proposed Action

Table 8.2-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Air Quality Impacts	Proposed Action	Slight increases in fugitive dust will occur, mostly during construction. Fugitive dust will increase over baseline levels for life of project due to increased traffic over local road system. No violation of air quality standards will result. Combustion and greenhouse gas emissions are estimated and will be relatively low. Greenhouse gas emissions will be offset by the power generated from the recovered uranium.
	No Action	None
	Alternative Wellfield Layout	Same as Proposed Action
	Conventional Mining/Milling including Heap Leaching	Open-pit mining would expose much more disturbed surface to potential wind and water erosion and fugitive dust. Earthmoving equipment would increase emissions of greenhouse gases. Tailings piles and ponds and heap leach pads would increase risk of airborne contaminants, including radioactive materials.
	Alternate CPP Location	Same as Proposed Action
	Use of Alternate Lixiviants	Similar to Proposed Action, possibly for longer duration if alternative lixiviants require more time for aquifer restoration.
	Alternate Waste Management	More surface disturbance caused by need to construct larger ponds would increase emissions of fugitive dust.
	Uranium Processing Alternatives	Same as Proposed Action
	Alternate Size of CPP	Similar to Proposed Action. While there would be slightly fewer combustion emissions and greenhouse gas emissions if uranium-loaded IX resin were not received and processed, there would also be less carbon-offsetting power generated by the recovered uranium.
	Arsenic and Selenium Recovery	Similar to Proposed Action. Combustion emissions would be slightly higher due to increased material shipments.

Table 8.2-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Noise Impacts	Proposed Action	Noise will increase over ambient levels, which are 35 to 45 dBA, over life of project, mostly from construction equipment and vehicles. Nearest residence could experience short-term noise above the 55-dBA "annoyance" threshold if construction occurs near the license boundary at its shortest distance from the residence.
	No Action	None
	Alternative Wellfield Layout	Similar to Proposed Action. Slight reduction in noise levels due to the installation of fewer injection and recovery wells would be offset by added noise due to recompletion and additional MIT.
	Conventional Mining/Milling including Heap Leaching	Open-pit mining would entail use of much more heavy equipment, a primary source of noise.
	Alternate CPP Location	Similar to Proposed Action, although local effects could vary depending upon location with respect to existing roads and residences.
	Use of Alternate Lixiviants	Similar to Proposed Action, possibly for longer duration if alternative lixiviants require more time for aquifer restoration.
	Alternate Waste Management	The need to construct larger ponds would increase severity and/or duration of noise from earthmoving equipment.
	Uranium Processing Alternatives	Same as Proposed Action
	Alternate Size of CPP	Similar to Proposed Action, with slightly fewer material shipments for a smaller CPP.
	Arsenic and Selenium Recovery	Similar to Proposed Action, with slightly more material shipments.

Table 8.2-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Historical and Cultural Impacts	Proposed Action	Impacts will be small, since sites eligible for NRHP will be avoided, a phased process will be used to identify previously undiscovered cultural resources and a stop-work provision will be provided if any cultural resources are discovered during construction.
	No Action	None
	Alternative Wellfield Layout	Same as Proposed Action
	Conventional Mining/Milling including Heap Leaching	Same as Proposed Action, except that increased surface disturbance increases the risk that historical or cultural resources will be impacted if they are not noticed during construction.
	Alternate CPP Location	Similar to Proposed Action, although potential impacts could vary according to location with respect to historical and cultural resources.
	Use of Alternate Lixiviants	Same as Proposed Action
	Alternate Waste Management	Similar to Proposed Action, except that additional surface disturbance caused by larger ponds increases risk that unknown historical or cultural resources will be impacted.
	Uranium Processing Alternatives	Same as Proposed Action
	Alternate Size of CPP	Same as Proposed Action
	Arsenic and Selenium Recovery	Same as Proposed Action

Table 8.2-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Visual/Scenic Impacts	Proposed Action	Slight visual impacts will occur from new structures and construction equipment but will maintain consistency with BLM visual resource classification of the area.
	No Action	None
	Alternative Wellfield Layout	Same as Proposed Action
	Conventional Mining/Milling including Heap Leaching	Open-pit mine would create a significant visual impact, with large stockpiles and a large tailings impoundment that would be present for the life of the operation.
	Alternate CPP Location	Similar to Proposed Action. Potential impacts would depend on location relative to residences and roads.
	Use of Alternate Lixiviants	Same as Proposed Action, possibly for longer duration if alternative lixiviants prolonged the aquifer restoration phase.
	Alternate Waste Management	More and larger impoundments than required under the Proposed Action would have localized visual impacts.
	Uranium Processing Alternatives	Same as Proposed Action
	Alternate Size of CPP	Similar to Proposed Action. Potential impacts would be slightly less with smaller central plant area.
	Arsenic and Selenium Recovery	Same as Proposed Action

Table 8.2-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Socioeconomic Impacts	Proposed Action	Most of the workforce is projected to come from the local area so there will be minimal impact on housing and local services. Project could employ up to 14% of the currently unemployed workforce in Campbell and Crook counties during construction, with employment declining during operation and decommissioning. Project would have slight, positive benefit to the State on severance tax, royalty, and sales and use tax collections and moderate benefits to Crook County on property and production taxes. Remoteness of the site might indicate slight need for increased emergency services (fire and ambulance service).
	No Action	None
	Alternative Wellfield Layout	Same as Proposed Action
	Conventional Mining/Milling including Heap Leaching	Conventional mining and milling would require more employees than ISR recovery, and underground mining would likely require more employees than open-pit mining for the same amount of yellowcake produced per year. Local labor force might still be able to supply most of the employees, but would not be experienced in underground mining. Revenues to the State, which are based on production, would be similar to Proposed Action, but Crook County revenues from property taxes would be more due to additional equipment required for conventional mining.
	Alternate CPP Location	Same as Proposed Action
	Use of Alternate Lixiviants	Same as Proposed Action, possibly for longer duration if alternative lixiviants prolong aquifer restoration. The aquifer restoration phase has no revenues from mineral production and would require fewer employees than the operation phase, so impacts of extended aquifer restoration would be slight.
	Alternate Waste Management	Same as Proposed Action, possibly with extended construction period due to need to construct more and/or larger impoundments.
	Uranium Processing Alternatives	Same as Proposed Action
	Alternate Size of CPP	Fewer employees would be required to construct and operate a smaller CPP, and less tax revenue would be generated.
	Arsenic and Selenium Recovery	Similar to Proposed Action with slightly more revenue to Crook County due to higher property and production taxes.

Table 8.2-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Nonradiological Health Impacts	Proposed Action	Slight risk of public exposure through chemical leaks and spills will be mitigated by employing BMPs.
	No Action	None
	Alternative Wellfield Layout	Same as Proposed Action
	Conventional Mining/Milling including Heap Leaching	Open-pit and underground mining have risk of more accidents and more severe accidents than ISR recovery operations. Safety hazards from conventional mining at the Ross site would be compounded by the depth of the ore zone (average nearly 500 feet) and weakly cemented, saturated sands in the ore zone and shallower aquifers, which would create risk of highwall and roof failures.
	Alternate CPP Location	Same as Proposed Action
	Use of Alternate Lixiviants	Similar to Proposed Action; acid or ammonia-based lixiviant would introduce additional nonradiological health risks.
	Alternate Waste Management	Same as Proposed Action
	Uranium Processing Alternatives	Same as Proposed Action
	Alternate Size of CPP	Similar to Proposed Action, since the same types of chemicals would be stored and used.
	Arsenic and Selenium Recovery	Similar to Proposed Action; arsenic and selenium processing would introduce additional nonradiological health risks.

Table 8.2-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Radiological Health Impacts	Proposed Action	Modeling shows no impact to the public.
	No Action	None
	Alternative Wellfield Layout	None
	Conventional Mining/Milling including Heap Leaching	Conventional mining, particularly underground, presents more risk of exposure to radiation than ISR recovery. Tailings from conventional milling or heap leaching would constitute 11e.(2) byproduct material that would be a permanent feature of the landscape.
	Alternate CPP Location	Same as Proposed Action
	Use of Alternate Lixiviants	Same as Proposed Action
	Alternate Waste Management	Same as Proposed Action
	Uranium Processing Alternatives	Same as Proposed Action
	Alternate Size of CPP	Similar to Proposed Action; potential impacts could be reduced slightly with smaller CPP and lined retention ponds.
	Arsenic and Selenium Recovery	Same as Proposed Action

Table 8.2-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Waste Management Impacts	Proposed Action	Slight risk of exposure to public by transporting wastes to approved disposal site. Risk will be minimized by employing BMPs.
	No Action	None
	Alternative Wellfield Layout	Same as Proposed Action
	Conventional Mining/Milling including Heap Leaching	Conventional mining and milling creates considerably more waste than ISR, including tailings, which would be 11e.(2) byproduct material, and residue (salts and minerals) left over from treatment of the large amount of water that would be produced to allow access by open pits or underground tunnels.
	Alternate CPP Location	Same as Proposed Action
	Use of Alternate Lixiviants	Same as Proposed Action
	Alternate Waste Management	Use of evaporation to dispose of liquid wastes would leave a residue of solids that would require disposal in a licensed facility as 11e.(2) byproduct material. If that facility were off site, there would be additional impacts from hauling the material to the disposal site. If that facility were created on site, it would be a permanent impact on the site.
	Uranium Processing Alternatives	Same as Proposed Action
	Alternate Size of CPP	Similar to Proposed Action; potential impacts would be slightly reduced if a smaller CPP were constructed.
	Arsenic and Selenium Recovery	Similar to Proposed Action; slightly more waste could be generated during selenium and/or arsenic processing.

Table 8.2-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Mineral Resource Recovery Impacts	Proposed Action	Applicant will coordinate with oil producer on the property to assure that the operation does not interfere with oil recovery. No other minerals will be impacted.
	No Action	None
	Alternative Wellfield Layout	Same as Proposed Action
	Conventional Mining/Milling including Heap Leaching	Any existing oil wells would represent a conflict with development of an open-pit mine and would have to be plugged and abandoned.
	Alternate CPP Location	Similar to Proposed Action; potential impacts would depend on proximity to mineral resource development.
	Use of Alternate Lixiviants	Same as Proposed Action
	Alternate Waste Management	Same as Proposed Action
	Uranium Processing Alternatives	Same as Proposed Action
	Alternate Size of CPP	Same as Proposed Action
	Arsenic and Selenium Recovery	Same as Proposed Action

8.3 References

COGEMA, 2005, Response to DEQ/LQD January 10, 2005 Comments, Irigaray Wellfield Restoration Report, prepared by COGEMA Mining, Inc., Petrotek Engineering Corporation, and Resource Technologies Group, May 4, 2005, ADAMS Accession No. ML053270037.

EIA (U.S. Department of Energy, Energy Information Administration), 2010, Domestic Uranium Production Report, Data for 2009, report date July 15, 2010. Available on the Internet as of August 2010: <http://www.eia.gov/cneaf/nuclear/dupr/dupr.html>.

LCI (Lost Creek ISR, LLC), 2009, 3rd Round WDEQ/LQD Comment Responses to Lost Creek ISR Mine permit application. NRC ADAMS Accession No. ML100610158.

_____, 2008, Environmental Report for the Lost Creek Project, Volume 1 of 3, revised March 2008. NRC ADAMS Accession number ML081060567.

NMA (National Mining Association), 2007, Generic Environmental Report in Support of the Nuclear Regulatory Commission's Generic Environmental Impact Statement for In Situ Uranium Recovery Facilities, prepared for the National Mining Association by Thompson & Simmons, PLLC, Tetra Tech, Inc., and Katie Sweeney, National Mining Association, November 30, 2007.

NRC, 2010, Environmental Impact Statement for the Moore Ranch ISR Project in Campbell County, Wyoming: Supplement to the Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities - Final Report (NUREG-1910, Supplement 1).

_____, 1980, Final Generic Environmental Impact Statement on Uranium Milling, Project M-25, NUREG-0706, September 1980.

Pochop, L, J. Borelli, and V. Hasfurther, 1985, Design Characteristics for Evaporation Ponds in Wyoming, WWRC 84-08, revised August 1985.

WNA (World Nuclear Association), 2010a, Supply of Uranium, updated August 2010. Available from website on the Internet as of October 2010: <http://www.world-nuclear.org/info/inf23.html>

_____, 2010b, World Nuclear Power Reactors and Uranium Requirements, updated August 2010. Available from website on the Internet as of October 2010: <http://www.world-nuclear.org/info/reactors.html>

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9.0 COST-BENEFIT ANALYSIS

9.1 General

Demand for uranium to fuel nuclear power plants is set to grow rapidly as the nuclear industry expands. The world's appetite for energy is expanding at a fast pace, driven largely by modernization of the developing nations. At the same time as total energy demand is growing, there is a growing impetus to reduce the burning of carbon-based fuels.

Currently, nuclear energy provides 6% of the world's total energy supply, including 15% of the world's electricity. Some countries rely heavily on the nuclear industry; in the United States, nearly 20% of the electricity is produced from nuclear power and in France it is 78% (U.S. Energy Information Administration 2010a).

There are now over 430 reactors operating worldwide and 56 more are presently under construction. Plants now in the planning stages number 136 units in 26 countries – mainly in China and India. China, to reduce its reliance on coal, is expected to further expand its nuclear industry and could see more than 100 nuclear power plants. The country has plans to stockpile uranium to avert supply shortages. In North America, existing nuclear reactors are being expanded (although at a slower rate due to the recession and permitting delays) and licenses are being extended. The U.S. stimulus plan has dedicated funding to provide loan guarantees for new plants.

New generation reactors are more efficient than older units, and that will moderate the growth in demand. Nevertheless, over the coming years, usage of uranium as a fuel for nuclear power plants is forecast to grow at a fast pace. At present, annual global usage of uranium is around 150 million pounds.

For the first half of 2010, U.S. uranium concentrate production totaled 1,931,186 pounds U_3O_8. This amount is 4% higher than the 1,862,796 pounds produced during the first half of 2009 (EIA 2010b). During the second quarter 2010, U.S. uranium concentrate was produced at four U.S. uranium concentrate processing facilities. Of these, three (Alta Mesa, Crow Butte and Smith Ranch-Highland) are ISR facilities and the fourth (White Mesa) is a conventional mill.

The general need for production of uranium is assumed in the operation of nuclear power reactors. In reactor licensing evaluations, the benefits of the

energy produced are weighed against environmental costs, including a prorated share of the environmental costs of the uranium fuel cycle. The incremental impacts of typical mining and milling operations required for the fuel cycle are justified in terms of the benefits of energy generation to the society in general. However, the specific site-related benefits and costs of an individual fuel-cycle facility such as the Ross ISR Project must be reasonable as compared to that typical operation.

Strata has evaluated the costs and the benefits associated with uranium production in order to formulate the Ross ISR Project. Historically, a company operated a pilot project and considered mining uranium within the proposed project area, but the price of uranium declined to where the costs outweighed the benefits at that time. More recently, due to the increased demand for uranium, associated price increase, and improved and tested technologies, Strata believes the benefits now outweigh the costs. Although the specific amount of yellowcake produced will depend on the market price and the cost of production, Strata anticipates producing about 750,000 pounds of uranium per year. If market conditions remain positive, preliminary plans are to produce about 0.6 pound of vanadium for each pound of yellowcake produced. Early analyses suggest that the vanadium can be produced with relatively little additional capital investment and operating costs. Based on current information and projections, the anticipated life of the Project is 8 to 12 years. Current demand/supply projections indicate that the price should remain sufficiently high to support the Ross ISR Project over that time frame. With appropriate regulatory approval, the CPP could process loaded resins from other ISR sites in the region, even after the ISR operation in the original license area is complete.

9.2 Potential Economic Benefits

Monetary benefits will accrue to the community from the presence of the Ross ISR Project, such as local expenditures of operating funds and the federal, state and local taxes paid by the owner of the project. Against these monetary benefits are any potential monetary costs to the communities involved, such as would occur if the project required new or expanded schools and other community services.

It is not possible to precisely quantify all the economic benefits and costs of the project for any one community because many of the benefits, such as tax

revenues, depend upon prevailing market prices which are subject to change due to unpredictable economic and political factors. This section discusses the potential economic impacts of the proposed action and compares these impacts to the No Action alternative.

Since the operation of the Nubeth pilot project in the 1970's, ISR production methods have been improved to minimize costs. The primary mining method for uranium is now ISR rather than conventional surface or underground mining. ISR has lower operating costs and also reduces exposure of radioactive materials to the atmosphere. While some alternatives to the project have been considered, including facility locations and plant capacity, the overall capital costs and the operating costs per unit of production do not differ substantially with the choice of alternatives.

9.2.1 Tax Revenues

Section 4.10 of the ER summarizes the tax revenues from the Ross ISR Project. Future tax revenues are dependent on uranium prices which cannot be forecast with any accuracy; however, these taxes are also somewhat dependent on the number of pounds of uranium produced by Strata. To the extent that uranium prices remain approximately at current levels (spot market price was $46.50 per pound U_3O_8 in mid-October 2010 when this benefit-cost analysis was done and had risen to about $60 per pound by mid-December 2010), the Ross ISR Project can produce significant tax revenues for Crook County and the State of Wyoming. In order to provide an estimate of the tax revenues that might be generated by the Ross ISR Project, the following assumptions were made:

- Production: 750,000 pounds U_3O_8 for a period of 10 years
- Sale price: $45 per pound for purposes of illustration;
- 18% of total production will be from State lands and therefore subject to State mineral royalty payments
- All mineral production will be in Crook County, and the mill levy will remain constant at 62.545 mills
- The production facilities and property will have an assessed valuation of $50 million

Table 9.2-1 summarizes the major tax revenue stream for the Ross ISR Project based on the assumptions listed above. Severance taxes and royalties

will accrue to the State and will be distributed among the State and local agencies in accordance with established procedures, while the gross products and property taxes will be assessed and collected by Crook County.

The severance and gross products taxes and State royalties are sensitive to the price of U_3O_8 and are likely to vary over the life of the project. These taxes will end when production ends. Property taxes should remain relatively constant over the mine life and will continue after production is completed throughout the wellfield restoration until the facilities are removed and the area is reclaimed.

It is possible that vanadium will also be produced at the Ross ISR Project. Preliminary analyses suggest that 0.6 pound of V_2O_5 could be produced for every pound of U_3O_8 produced with relatively little additional investment in capital or operating costs. The current price of vanadium is about $12.00 to $13.00 per pound (Global Infomine 2010). Assuming the vanadium production is taxed similarly to yellowcake, and that prevailing prices hold steady, the possible benefits from severance taxes, royalties and gross products taxes shown in Table 9.2-1 could be understated by as much as 10% to 20%).

Income taxes are not considered in this analysis because there is no state income tax in Wyoming, income taxes are difficult to estimate because they are based on operating profits which are variable and hard to predict, and they accrue to the federal government and do not represent a direct benefit to the local or regional economy.

9.2.2 Employment

9.2.2.1 Construction Employment

As described in Section 4.10 of the ER, the Ross ISR Project is expected to employ about 225 people during construction, and the duration of construction is expected to last from 6 months (for the CPP) to 36 months (for the initial, fully operational wellfield modules). These employees are expected to come from the local labor force, since the total number of jobs is small relative to the number of unemployed workers in the local labor force and the required skill set fits well with skills and experience of the local labor force (light construction and wellfield installation).

Salaries for the construction workers are expected to be about $50,000 per year, which is higher than the current average per capita income in Crook County but is representative of prevailing wages in the mining sector (see ER Section 4.10). This will be beneficial by reducing the local unemployment rate for the duration of construction, and some of the workers will likely stay on through the operational phase. Assuming an average of around 125 workers during a 2-year construction period, and a per-capita wage of $50,000, the total annual payroll during construction would be about $6,250,000. This represents "new" money injected into the local economy. Payroll taxes would amount to around $500,000 per year.

This level of employment is significant to the local economies. As described in Section 4.10, there were 1,321 unemployed people in Campbell County and 150 in Crook County in October 2010, representing unemployment rates of 4.7% and 4.2%, respectively. The peak employment of 225 persons during construction could reduce the local unemployment rate to about 3.7%.

9.2.2.2 Operating Employment

As stated in ER Section 4.10.1.2, about 50 to 60 employees would be required to operate the Ross ISR facility. It is estimated that about 80% of these will come from the local labor force, with many staying on after construction of the facility is completed. Assuming the same per capita income as the construction work force, the total payroll during the 10- to 20-year operating life of the facility would be about $2.5 to $3 million, with payroll taxes amounting to around $200,000 to $250,000 per year.

The employment level would be reduced by two-thirds after mining is completed and the only remaining activities are wellfield restoration and surface reclamation. Payroll and payroll taxes would decrease accordingly. If market conditions are favorable and additional reserves are identified, the life of the facility as well as the tax and payroll benefits could be extended.

9.3 Potential Benefits of the No-Action Alternative

Under the no-action alternative, the production and property taxes identified above would not be realized by the State and local governments. The uranium ore would remain in the ground and thus could be developed at a later date, but consideration of that alternative is not within the scope of this analysis.

The employment, and associated personal income and payroll taxes identified in the previous section, would not occur under the No-Action alternative. It is possible that other jobs will be created in the region, but that speculation is not within the scope of this report. The lands on which the Ross ISR Project would be created have historically been used for rangeland agriculture, limited hunting, and limited oil and gas development. No other potential uses for this property have been identified to date, so it is considered likely that these historic uses will continue to prevail of the Ross ISR Project is not constructed.

9.4 Potential External Costs of the Project

9.4.1 Housing

As explained in ER Section 4.10, the available housing resources in Crook and Campbell counties are expected to be adequate to support the needs of the Ross ISR Project during facility construction and operation. Considering the recent economic recession and the decline in housing cost and demand, and the fact that the workforce will primarily come from the local labor force, the Ross ISR Project is not expected to create a housing crunch.

9.4.2 Noise and Congestion

Strata projects an increase in the noise and congestion in the immediate area of the Ross CPP and wellfield during construction of the facility. This will include heavy truck and equipment traffic and access to the jobsite by construction workers. These impacts will be most noticeable to residents in the immediate vicinity of the facility and will be temporary. As described in Section 3.10 the of the ER, project vicinity is sparsely populated and the nearest residence is about 1 mile away from the proposed CPP. As described in Section 3.7 of the ER, ambient noise levels in the proposed project area are low, consisting mostly of wind and trucks, primarily hauling bentonite along the local county roads. During construction, truck traffic on these roads will increase but will be similar in intensity to historic noise sources. During operation, little noise will emanate from the CPP, which will be enclosed. Noise during operation will be associated primarily with the well drilling activities and ongoing installation of utility lines to and from the wellfield.

Dust from construction activities will be controlled using standard dust suppression techniques used in the construction industry.

9.4.3 Local Services

Strata plans to actively recruit and train local residents for positions at the mine. As stated in ER Section 4.10, it is expected that the majority of construction and operating positions at the Ross ISR Project will be filled with local hires. As a result of using the local workforce, the impact on local services, including schools and medical facilities, should be small. In many cases these services (e.g., schools) are underutilized due to population trends in the area. As noted in ER Section 3.10.3.6, due to the remoteness of the site, Strata will maintain on staff personnel and equipment necessary to provide emergency services to deal with environmental, safety and health emergencies during construction and operation, including during restoration and reclamation of the site. Thus, these services will not represent a cost to local governments.

9.4.4 Potential Aesthetic Costs

Section 3.9 of the ER describes the existing visual resources of the proposed project area and surrounding area. Landscapes within the visual resource study area are characterized by a gently rolling topography and large, open expanses of upland grassland, pasture/hayland, and sagebrush shrubland. Intermittent streams are fed by ephemeral drainages which seasonally drain the adjacent uplands. Water features include the Little Missouri River and some minor tributaries, the Oshoto Reservoir and several small stock reservoirs. There are also areas of altered landscape within the study area, including 10 nearby residences, oil production facilities (oil well pump jacks, pipeline and utility rights of way, aboveground tanks, and access roads), transportation facilities (public and private roads, road signage, power and utility transportation lines), agricultural activities (fences, livestock, stock tanks, and cultivated fields), and environmental monitoring installations. The visible surface structures proposed for the Ross ISR Project include pre-engineered steel buildings housing the CPP, office/lab facilities and a warehouse; chemical storage vessels; wellhead covers, several small module buildings, and electrical distribution lines. The project will use existing and new roads to access each wellfield module. Because of the relatively flat to rolling topography, construction of roads, buildings and drill pads will require only minor amounts of earthwork, with little or no cuts or fills. Project development would alter the physical setting and visual quality of portions of

the landscape, which would affect the overall landscape to some degree, as viewed from sensitive viewing areas. The proposed facilities would introduce new elements into the landscape and would alter the existing form, line, color, and texture, which characterize the existing landscape. The project would primarily affect rangelands.

In foreground-middleground views, the CPP, module buildings, wellhead covers, and water storage ponds would be the most obvious features of development. Access roads would be visible as light-tan exposed soils in geometrically-shaped areas with straight, linear edges that provide some textural and color contrasts with the surrounding rangeland. The CPP buildings, module buildings, and wellhead covers would be painted to resemble the colors of the surrounding soil and vegetation cover. These facilities would be visible from local county roads, but would be subordinate to the rural landscape. During construction of the wellfield modules and during operations as depleted wells are replaced with new wells in unmined areas, the most visible structures from any distance away will be the masts on the drill rigs. From beginning of construction through completion of the operational phase there could be as many as 12 drill rigs operating simultaneously. Due to the rolling topography, these may or may not be visible from a distance depending upon whether the rig or the viewer is in an area of high or low relief.

The electric distribution line poles would be an estimated 20 feet tall, and would be located throughout the proposed project area to provide power to module buildings and deep disposal wells. The distribution lines are similar in appearance to those typical of the rural landscape, but would occur at a higher density than on adjacent lands. The lines would be obvious to viewers at the viewing areas, but would not change the rural character of the existing landscape.

Following completion of each well, the mud pits would be regraded and the land around the well will be graded to conform to existing topography and seeded to approved species. Wellhead covers would be difficult to discern in the landscape from any sensitive viewing area. The form and textural contrast would be very weak because the relatively low profile (3 to 4 feet high) and small size of the facilities would disappear into the surrounding textures of soil and vegetation. Generally, color contrasts are most likely to be visible in foreground-middleground distance zone; however, the wellhead covers would be painted an earthtone color that would harmonize with the surrounding

vegetation and soil colors. Therefore, contrast of line, form, texture, and color would be low. The facilities would not be noticeable to the casual observer. Wellhead covers would be visually subordinate to the landscape in foreground-middleground distance zone.

Any decreases in aesthetics at the proposed project area, such as increased noise, will be minimal due to the remoteness of the area, the nature of ISR operations, improved technologies, and required reclamation. In addition, the activities at the Ross ISR Project, such as well installation, are similar to the activities associated with other extractive industries in the region (e.g., oil and gas drilling).

9.4.5 Land Access Restrictions

Property owners of land located within the wellfield and plant boundaries will lose access and free use of these areas during mining and reclamation. The areas impacted are all used for agricultural purposes and the owners will lose the ability to use the areas for production purposes. Offsetting these land use restrictions are the surface lease, damage payments and production royalties to the landowners.

Interference with other uses of the proposed project area will be limited due to the lack of development in the area and the reclamation requirements. For example, due to limited development of groundwater in the area to date, minimal impact to other water users outside the proposed project area is anticipated. As another example, hunting will be restricted at the proposed project area during production and reclamation to reduce safety concerns; but in the long term, hunting access may be improved due to road construction. To ensure that future users of the proposed project area are aware of the presence of abandoned wells, a deed notice of the mine unit locations will be required.

9.4.6 Most Affected Population

The expected impacts from the proposed Ross ISR Project would represent a totally new land use within what is currently a basically rural area with some limited recreation and oil and gas development. This represents a change for the few residents of the area, and the impacts of change, like those of noise, are based in part on the perception and attitude of the individual being affected. For the most part, the financial impact from operation of the Ross ISR Project would be positive for Crook County and the residents who

would be directly or indirectly employed by the operation. With this project Strata could provide much-needed and well-compensated employment opportunities for the local population. Strata would adopt a policy of purchasing goods and services locally to the extent possible, in order to maximize the positive economic impact on a county facing economic challenges. Production tax collections and particularly the increase in local property taxes paid on the facilities and the production of uranium would have a significant economic impact on local government-provided services.

Offsetting these positive impacts to the local population are increases in noise, congestion, and aesthetic impacts for residents in and adjacent to the proposed Ross ISR Project. Residents with property in the proposed project area are land owners that would have financial arrangements with Strata and will benefit economically from the presence of the facility. Residents of nearby ranches will receive no direct financial benefits from the project.

9.4.7 Health and Environmental Costs

Strata proposes the Ross ISR Project will provide the societal benefits described in ER Section 7.2 while knowing that health and environmental costs will be minimized by ISR operations. The health and environmental costs that were evaluated include:

- disturbance of soil and vegetation,
- disturbance to wildlife and wildlife habitat,
- disturbance to hydrogeology,
- use of groundwater,
- depletion of uranium and vanadium minerals,
- production of waste,
- potential exposure to radioactive material, and
- impact on aesthetics.

The soil, vegetation, hydrology, wildlife, and wildlife habitat will be temporarily disturbed during the Project. These natural resources were characterized during studies of the baseline conditions at the proposed project area, which are summarized in various parts of Section 2 of this report. Potential impacts to these resources are described in Section 4 of the ER. The resources will be reclaimed to support the approved post-project land uses of

livestock, wildlife grazing, and oil and gas production, which are the same as the pre-project land uses, in accordance with applicable standards and regulations. Reclamation activities are described in more detail in Section 6 of this report and the accompanying Restoration Action Plan presented in Addendum 6.1-A. Because ISR operations are conducted in a series of wellfield modules, which are installed, produced, and reclaimed sequentially, only portions of the proposed project area will be disturbed at a given time.

Inherent to the proposed action, the uranium and vanadium will be depleted. However, the uranium mineral will provide a source of fuel for producing nuclear energy. Currently, the nation and the public are strongly supporting alternative sources of energy, including nuclear energy, to reduce dependence on foreign petroleum supplies and to reduce carbon emissions. The proposed action will remove uranium, in a safe and controlled manner, from the geological formation in which it naturally occurs. By doing so, the radioactivity of the host rock associated with uranium will be reduced. This will improve the health of humans and the environment that may otherwise be exposed to the ores.

Metallurgical use, primarily as an alloying agent for iron and steel, accounted for about 94% of the domestic vanadium consumption in 2009. Of the other uses for vanadium, the major nonmetallurgical use was in catalysts for the production of maleic anhydride and sulfuric acid. Net import reliance was 100% of vanadium consumption in the U.S. from 2005 through 2009 (USGS 2010).

Groundwater will serve as a tool to recover uranium. Groundwater will be pumped from the production wells in the ore zone; oxidized by the addition of lixiviant (a bicarbonate based solution); re-introduced to the ore zone through the injection wells; recovered from the production wells; treated at the CPP for removal of uranium; and circulated through this system again and again. Ultimately, the majority of the water will be treated to remove dissolved constituents and returned to the aquifer containing the ore zone. A fraction of the groundwater will be consumed as waste. This fraction of consumed groundwater will be minimized by concentrating the waste through multiple wastewater treatments. The vanadium will be recovered along with the uranium and, if commercially feasible, recovered in a separate circuit for sale. The current price of vanadium is about $12.00 to $13.00/lb (Global Infomine 2010), so the additional capital and operating costs necessary to remove

vanadium from the water during the ISR project must be relatively small in order to prove commercially viable.

Various types of wastes will be produced from the Project. These wastes may be categorized as domestic sewage, non-radiological wastes, and radiological wastes. Materials will be decontaminated or treated to reduce the volume of waste. Radiological waste will be removed from the proposed project area and disposed at an NRC-licensed facility or will be disposed of in a UIC Class I well or evaporation pond, depending on the type of waste, in accordance with current NRC regulations. All other wastes will also be disposed of according to applicable local, state, and federal regulations.

Exposures to radioactive materials were estimated using results from the radiation survey and the MILDOS model. Estimated public exposure to radioactive materials is negligible due to the remote location of the proposed project area, the nature of ISR operations, and the ore processing technologies. Occupational exposure will be reduced or eliminated by providing the proper training, guidance, and PPE to safely handle, store, decontaminate, and/or dispose waste materials.

9.5 Potential Internal Costs of the Project

Internal costs impact Strata and cover the construction, operation, and reclamation phases of the Project. The primary internal costs will include:

- capital costs associated with obtaining claims and regulatory approvals, including permits, and environmental studies;
- capital costs of facility construction;
- operation and maintenance costs;
- costs of groundwater restoration;
- costs of facility decommissioning, including radiological decontamination; and
- costs of surface reclamation.

The estimated internal costs are provided in Table 9.5-1.

The estimated decommissioning costs for the Ross ISR Project will be included in the annual surety update submitted to WDEQ and the NRC for approval prior to construction activities. Each year, the cost estimate will be

reviewed by the regulatory authorities based on total remaining reclamation and restoration work, and adjustments will be made as necessary.

9.6 Benefit Cost Summary

The benefit-cost summary for a fuel-cycle facility such as the Ross ISR Project involves comparing the societal benefit of a constant U3O8 supply, which will be used to provide energy, against possible local environmental costs, for some of which there may be no directly related compensation. For this project, there are basically three of these potentially uncompensated environmental costs:

- groundwater impact,
- radiological impact, and
- disturbance of the land.

The groundwater impact is considered to be temporary in nature, as restoration activities will restore the groundwater to pre-mining use suitability. The successful restoration of groundwater during the Nubeth R&D project demonstrated that the restoration process can meet this criterion successfully.

The radiological impacts of the proposed project are small, with all radioactive wastes being transported and disposed of off-site. Radiological impacts to air and water are also expected to be small.

The disturbance of the land for an ISR facility is quite small, both in terms of total area disturbed and magnitude of topographic changes, especially when compared with conventional surface mining techniques. All of the disturbed land will be reclaimed after the project is decommissioned and will become available and suitable for pre-mining uses.

In addition to the specific, tangible benefits, the Ross ISR Project will also provide more diverse benefits. Regional recreation may be enhanced following the reclamation of the disturbed area, because of improved access and the reclamation of the disturbed area to support wildlife and livestock grazing. Due to the remoteness and small population of the area in which the project is located, the baseline studies and monitoring associated with the project have greatly increased the information available on natural resources. Required monitoring during the project will continue to provide scientific data about this area.

The Ross ISR Project will support a domestic source of energy and environment-friendly practices. The uranium production will assist to supply a reliable, economical, domestic source of uranium while applying new technologies to minimize disturbance. The project will also help offset the deficit in annual domestic uranium production and help meet increasing energy demands. Uranium production varies as a function of market conditions, which are affected by political and economic factors. After a decade of falling worldwide production of uranium prior to 1993, production has generally risen and now meets 76% of the demand for uranium for power generation. An increasing portion of uranium, now 36%, is produced by ISR (World Nuclear Association 2010). The U.S. produced about 2.9% of the world's uranium in 2009. Today's reactor fuel requirements are met from primary supply (direct mine output - 78% in 2009) and secondary sources: commercial stockpiles, nuclear weapons stockpiles, recycled plutonium and uranium from reprocessing used fuel, and some from re-enrichment of depleted uranium tails (left over from original enrichment). The Ross ISR Project, once in full-scale production, will add 750,000 pounds of U_3O_8 per year to the market. With appropriate regulatory approval, the processing facilities could also take loaded resins from other ISR sites in the region, even after the ISR operation is complete in the proposed project area.

9.7 Summary

In considering the energy value of the U_3O_8 produced to U.S. energy needs, the economic benefit to Crook County, the minimal radiological impacts, minimal disturbance of land, and technical feasibility of mitigating all other impacts, it is believed that the overall benefit cost balance for the proposed Ross ISR Project is favorable, and that issuing a license for the proposed project is the appropriate regulatory action.

Table 9.2-1. Major Tax Revenues from the Ross ISR Project

	Tax Revenues	
Description	**Average Per Year**	**Over 10 Years Production**
Severance taxes	$500,000	$5,000,000
State royalties	$180,000	$1,800,000
Gross products taxes	$900,000	$9,000,000
Property taxes	$350,000	$3,500,000
Total	$1,930,000	$19,300,000

Table 9.5-1. Estimated Internal Project Costs

Item	Present Worth (1,000 $US)
Obtain right to mine (claims, surface access and permits	13,000
Facility construction	40,000
Operation and maintenance	74,000
Groundwater restoration[2]	5,100
Decommissioning (including decontamination)[2]	3,500
Surface reclamation[2]	1,100
Total	136,700

[1] Due to sequential development of modules, some of the facility construction costs are distributed throughout the life of the project rather than concentrated at the beginning

[2] Includes plant area facilities and portion of Mine Unit 1, complete restoration, reclamation and decontamination costs as estimated in Addendum 6.1-A (RAP)

9.8 References

Global Infomine, October 2010, Historic Commodity Prices, available from website on the Internet on October 11, 2010 <http://infomine.com/commodities/vanadium.asp>.

U.S. Energy Information Administration, 2010a, Independent Statistics and Analysis, International Energy Statistics, Annual Energy Review. Available from website on the Internet as of October 11, 2010: <http://www.eia.gov/emeu/aer/nuclear.html>.

_____, 2010b, Independent Statistics and Analysis, Domestic Uranium Production Report-Quarterly. Available from website on the Internet as of October 11, 2010: <http://www.eia.doe.gov/cneaf/nuclear/dupr/qupd.html>.

USGS, 2010, Vanadium statistics and information. Available from website on the Internet as of October 2010: <http://minerals.usgs.gov/minerals/pubs/commodity/vanadium>.

World Nuclear Association, Updated August 2010, Supply of Uranium, available from website on the Internet October 11, 2010: <http://www.world-nuclear.org/info/inf23.html>.

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10.0 ENVIRONMENTAL APPROVALS AND CONSULTATIONS

Several licenses, permits, and other approvals of construction and operation are required by federal, state, local, and regional authorities. This section outlines the necessary permits and licenses required to construct and operate the proposed Ross ISR Project. Table 10.0-1 summarizes the proposed, pending and approved permits/licenses necessary.

Table 10.0-1. Summary of Proposed, Pending, and Approved Permits for Ross ISR Project

Regulatory Agency	Permit or License	Status
Federal		
NRC	11e.(2) source and byproduct material license	Application submitted herein, including license application, an Environmental Report (ER), and a Technical Report (TR)
EPA	UIC Class I Permit (deep disposal wells)	See WDEQ/WQD permits; Wyoming has primacy for the UIC program
	Aquifer Exemption Permit for Class I wells	
	UIC Class III Permit (injection and recovery wells)	
BLM	Plan of Operations	Being prepared
	BLM Right of Way (Roads)	Being prepared
	Notice of Intent to Explore	Being prepared
State		
WY State Land & Farm Loan Office	Uranium Minerals Mining Lease	Approved #0-40979
WDEQ/AQD	Air Quality Permit (Fugitive Dust)	Being prepared
WDEQ/LQD	Permit to Mine	Application submitted January 2011 to WDEQ District 3, Sheridan, Wyoming; TFN # 5 6/110.
	UIC Class III Permit (injection and recovery wells)	Being prepared
	Mineral Exploration Permit/Drilling Notification	384DN
WDEQ/WQD	UIC Class I Permit (deep disposal wells)	Application submitted June 23, 2010 to UIC Program in Cheyenne, Wyoming; TFN # WYS-011-00031.
	Aquifer Exemption Permit for Class I wells	Being prepared
	Aquifer Exemption Permit for Class III (injection and recovery) wells	Being prepared
	Permit to Construct Domestic Septic System	Being prepared
	Stormwater WYPDES Permit (industrial/mining)	Being prepared
	Stormwater WYPDES Permit (construction)	Being prepared
	Temporary WYPDES Permit (discharge during well testing)	Approved #WYG720229
WSEO	Permit to Appropriate Groundwater for ISR wells	Being prepared
	Permit to Appropriate Groundwater for Monitoring Wells	Approved Permit #'s: 191679-191702; 192703-192705
County		
Crook County	County Development Permits	Being prepared

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11.0 LIST OF PREPARERS..... 11-1

11.0 LIST OF PREPARERS

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GLOSSARY

11e.(2) byproduct material: The tailings or wastes produced by extracting or concentrating uranium or thorium from any ore processed primarily for its source material content. Also byproduct material.

Barber Amendment Area: An area, approximately 15 miles south of the proposed project within the Lance District, that is currently being evaluated by Strata as an ISR Satellite to the Ross ISR Project. Wellfields and an IX Plant would provide loaded resins to the Ross CPP. Mineralization occurs in similar Lance Formation sandstones, confined by thick shales as those present at the proposed project area.

Bleed: A solution drawn to adjust production or to restore groundwater by removing more fluids from the production zone than are injected, causing fresh groundwater to flow into the production area and minimizing the potential movement of lixiviant out of the wellfield.

Brine: Water with concentrated dissolved solids generated from the production and restoration reverse osmosis units.

Buffer area: Area extending a specified distance outside the proposed project area for analyzing baseline conditions and potential impacts. The distance from the proposed project area varies by resource.

Byproduct material: See 11e.(2) byproduct material.

Central plant area: The fenced area that will include the central processing plant, storage facilities, office/warehouse facilities, lined ponds, and other piping and equipment. The central plant area is proposed in portions of the NESE and SENE of Section 18, Township 53 North, Range 67 West.

Containment barrier wall: A highly impermeable, *in-situ* mixture of soil and bentonite that will form a continuous contaminant containment barrier around the central plant area. Also soil-bentonite slurry wall.

Deadwood/Flathead Formations: The Cambrian aged sandstones targeted at the Ross ISR Project for disposal of liquid waste. The Deadwood/Flathead formations are below the Madison Formation (lowermost USDW) and hydraulically isolated by the Englewood Shale Formation.

Deep monitoring zone (DM): The first water-bearing interval that lies stratigraphically below the uranium ore-bearing sands in the Upper Fox Hills Formation, and the target completion interval for the deep monitor wells. Also described as “BFS” horizon in the Lower Fox Hills Formation.

Ephemeral stream: A stream which flows only in direct response to a single precipitation event in the immediate watershed or in response to a single snow melt event, and which has a channel bottom that is always above the prevailing water table.

Excursion: The exceedance of upper control limits for two or more excursion indicators in a monitor well.

Facilities flood control diversion channel: A constructed earthen channel designed to route all surface water flow, up to and including the 100-year, 24-hour storm event, around the facilities in the central plant area.

Feeder line: A buried pipeline conveying lixiviant from a trunk line to an individual module building or recovery solution from an individual module building to a trunk line.

Flare: The undetected spread of recovery solutions between the wellfield and perimeter monitoring wells of the production zone. Flare is also a proportionality factor that estimates the amount of aquifer water outside of the pore volume that has been affected by lixiviant flow during the recovery phase. The flare is usually expressed as a horizontal and vertical hydraulic conductivity of an aquifer material.

Hydraulic anomaly: A water level deviation from historic trends as measured in perimeter, deep or shallow monitor wells indicating a local wellfield imbalance or a compromised confining unit. A precursor to a potential excursion where no geochemical abstractions have been measured.

Individual flow line: A buried pipeline conveying lixiviant or recovery solution from a module building to an individual injection well or recovery solution from an individual recovery well to a module building.

Injection well: A well or conduit through which lixiviant is introduced into the subsurface.

Intermittent stream: A stream or part of a stream where the channel bottom is below the local water table for some part of the year, but is not a perennial stream.

ISR GEIS: Generic Environmental Impact Statement for *In-Situ* Leach Uranium Milling Facilities, NUREG-1910.

ISR Satellite: An ISR/resin operation that transports its loaded resin to a CPP operated by the same company/licensee. As such, the ISR/resin operation is a "satellite" of the CPP.

Lance District: Uranium ore-bearing area along the west side of Crook County in northeastern Wyoming. The proposed project area encompasses approximately 2.7 square miles within the Lance District, which includes approximately 56 square miles of total surface area. Geologic conditions supporting uranium mineralization and hydrogeologic continuity are consistent throughout the 56 square miles.

Lined retention pond: A retention pond with a leak detection system used to temporarily store either permeate or brine and other wastewater, including spent eluate, liquid from process drains in the central processing plant, fluids generated from work over operations on injection and recovery wells, contaminated reagents, resin transfer wash water, filter backwash water, plant wash down water, and decontamination water.

Lixiviant: A leachate solution composed of native groundwater and chemicals (such as sodium carbonate/bicarbonate, ammonia, or sulfuric acid) added by the ISR facility operator. In the ISR process, the lixiviant is pumped underground for the purpose of mobilizing (dissolving) uranium from a uranium ore body.

Lower confining unit: A low-permeability, stratigraphic horizon below the ore zone composed of dark gray to black shale, claystone and mudstone. Also described as the "BFH" horizon in the Lower Fox Hills Formation.

Madison Formation: Mississippian limestone confined aquifer used by regional municipalities in public drinking water supplies.

Mine unit: A collection of wellfield modules permitted simultaneously through WDEQ/LQD.

Module: A module building and associated injection and recovery wells, individual flow lines, and feeder lines. Strata anticipates that 15 to 25 modules will be developed within the proposed Ross ISR Project.

Module building: A building containing manifolds, pumps, flow control valves, and sample points for controlling and monitoring lixiviant flowing to injection wells and recovery solutions from recovery wells within a wellfield module. Typically referred to as a header house at ISR facilities.

Monitor well: A well constructed or utilized to measure static water levels and/or to obtain liquid, solid, or gaseous analytical samples or other physical data that would be used for controlling the operation or to indicate potential circumstances that could affect the environment.

Nubeth: A joint venture formed between Nuclear Dynamics Inc., and Bethlehem Steel Corporation.

Ore zone (OZ): The targeted uranium ore-bearing sands in the Upper Fox Hills/Lower Lance formations, and the target completion interval for the ore zone and perimeter monitor wells. Also described as "FH" and "LT" stratigraphic horizons in the Upper Fox Hills and Lower Lance formations.

Perennial stream: A stream or part of a stream that flows continually during all of the calendar year as the result of a groundwater discharge or surface runoff.

Permeate: Nearly pure water generated from the production and restoration reverse osmosis units.

Permit boundary: The boundary of the proposed project area.

Pierre Shale: A geologic formation or series in the Upper Cretaceous which occurs east of the Rocky Mountains in the Great Plains, from North Dakota to New Mexico. A known regional confining interval between Late Cretaceous sediments and older sediments of the Early Cretaceous/Paleozoic Era.

Pore volume: A term used to define an indirect measurement of a unit volume of aquifer affected by ISR recovery or restoration. This report distinguished between the *in situ* pore volume and the pore volume displacement (see below).

Pore volume displacement: The unit volume of aquifer displaced during ISR uranium recovery and aquifer restoration. Pore volume displacement is calculated as completion thickness x area x porosity x flare, where the thickness is the average completion thickness for recovery and injection wells, area is the surficial area of injection and recovery well patterns, porosity is the collective open spaces of the formation, and flare is defined above.

Primary access road: An access road to provide access to the central plant area from the New Haven Road (County Road 164). The primary access road will include significant cut and fill and gravel surfacing and will be constructed for long-term use.

Production zone: See ore zone.

Proposed Action: The Proposed Action involves construction, operation, aquifer restoration, and decommissioning of an ISR uranium recovery facility in the proposed project area.

Proposed project area: The area proposed for construction, operation, aquifer restoration, and decommissioning of an ISR uranium recovery facility. For the Ross ISR Project, the proposed project area encompasses 1,721.3 acres in portions of Sections 7, 17, 18, and 19, Township 53 North, Range 67 West, and portions of Sections 12, 13, and 24, Township 53 North, Range 68 West.

Recovery solution: Any material which flows or moves, whether semi-solid, liquid, sludge, gas or other form of state, used to dissolve, leach, gasify or extract a mineral.

Recovery well: A well or conduit through which a recovery fluid, mineral, or product is produced from the subsurface. If a well is used for both injection and recovery, it is considered an injection well until the operator has adequately demonstrated that the well has been converted to use(s) other than injection.

Secondary access road: A road constructed within the proposed project area that provides access to wellfield module buildings and deep disposal wells with limited cut and fill construction. Also a graveled access road within the central plant area. These roads are used for long-term traffic and may be surfaced with small sized aggregate or other appropriate material.

Shallow monitoring zone (SM): The first water-bearing interval that lies stratigraphically above the targeted uranium ore-bearing sands in the Upper Fox Hills/Lower Lance formations, and the target completion interval for the shallow monitor wells. Also described as "LM", "LL", and "LK" stratigraphic horizons in the Lance Formation.

Soil-bentonite slurry wall: See containment barrier wall.

Staging and storage area: Areas used to store non-radioactive equipment (cement, bentonite, piping, vehicles, trailers, etc.) during short-term construction activity (typically less than 6 months).

Study area: Area including the proposed project area and a buffer area extending a specified distance outside the proposed project area for analyzing baseline conditions and potential impacts. The distance from the proposed project area varies by resource.

Surficial aquifer (SA): Water-bearing fluvial sandstones of the upper-most Lance Formation and recent alluvium/colluvium. Also described as "LB" and "LA" stratigraphic horizons in the Upper Lance Formation.

Temporary access road: A road used within the proposed project area for temporary access to drilling sites, wellfields in development, or ancillary areas assisting wellfield development. Temporary access roads are temporary in nature (generally in use 2-6 months) and consist of designated two-track trails where the land surface is not typically modified to accommodate the road.

Tertiary access road: A road used within the proposed project area for access to monitor wells, injection wells, and recovery wells. Tertiary access roads are used for limited travel and consist of designated two-track trails where the land

surface is not modified to accommodate the road. They are used until they are no longer needed to access the desired location within the wellfield.

Trunk line: A buried pipeline conveying lixiviant from the central processing plant to feeder lines or recovery solution from a feeder line to the central processing plant.

Upper confining unit: A low-permeability, stratigraphic horizon above the ore zone composed of mudstone and claystone. Also described as the "LC" horizon in the Lance Formation.

Wellfield: The area of an ISR operation that encompasses the array of injection, recovery (or production) and monitoring wells and interconnected piping employed in the ISR recovery process.

Wellfield area: The surface area overlying the injection and recovery zones. This area may be all or a portion of the entire area proposed for the injection and production of recovery fluid throughout the life of the mine.

Wellfield pattern area: The surface area overlying the injection and recovery wells and interconnected piping (excludes wellfield area between injection/recovery wells and perimeter monitor well ring).