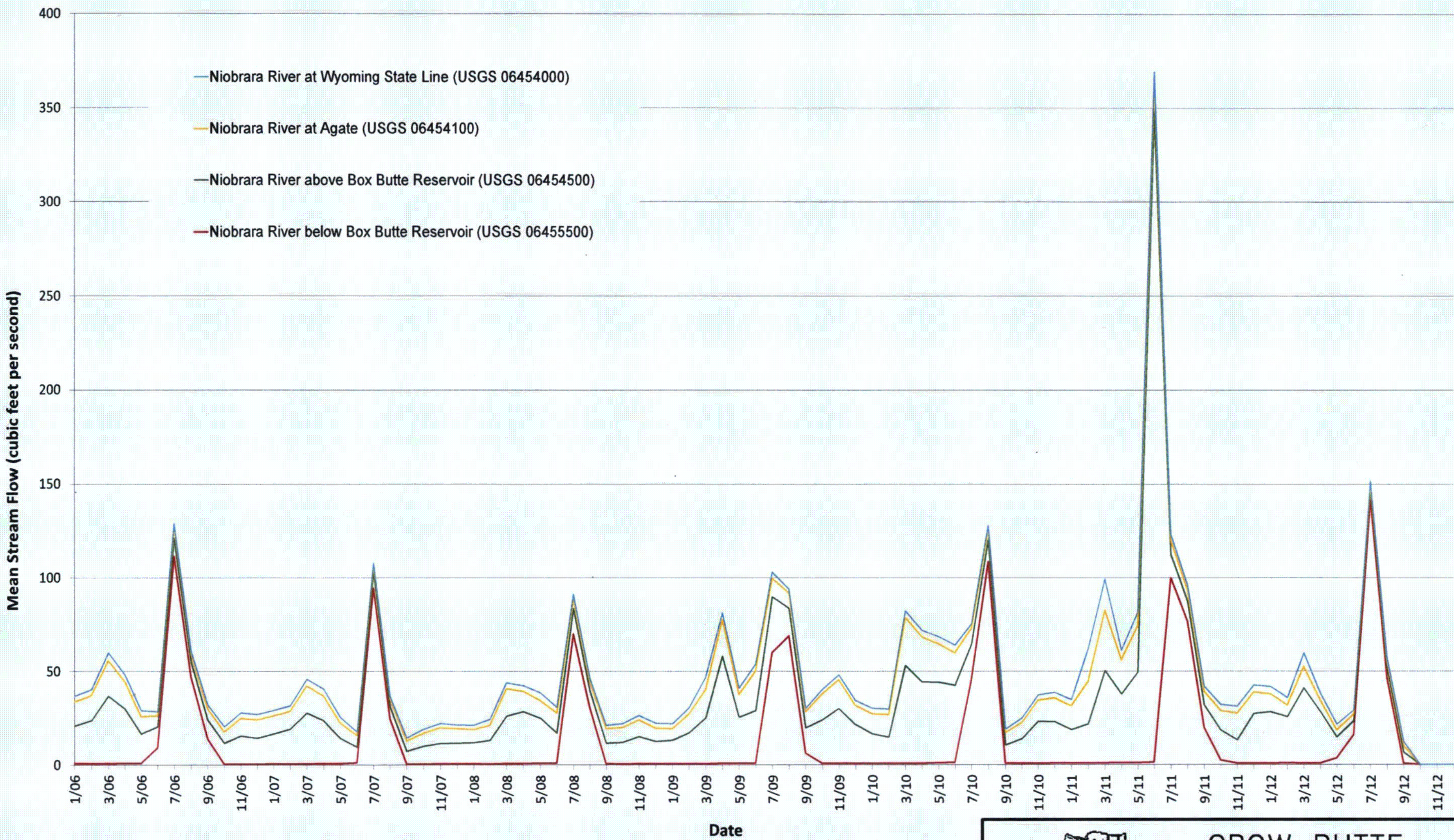


Source: Williams.2013; Table F.1-3

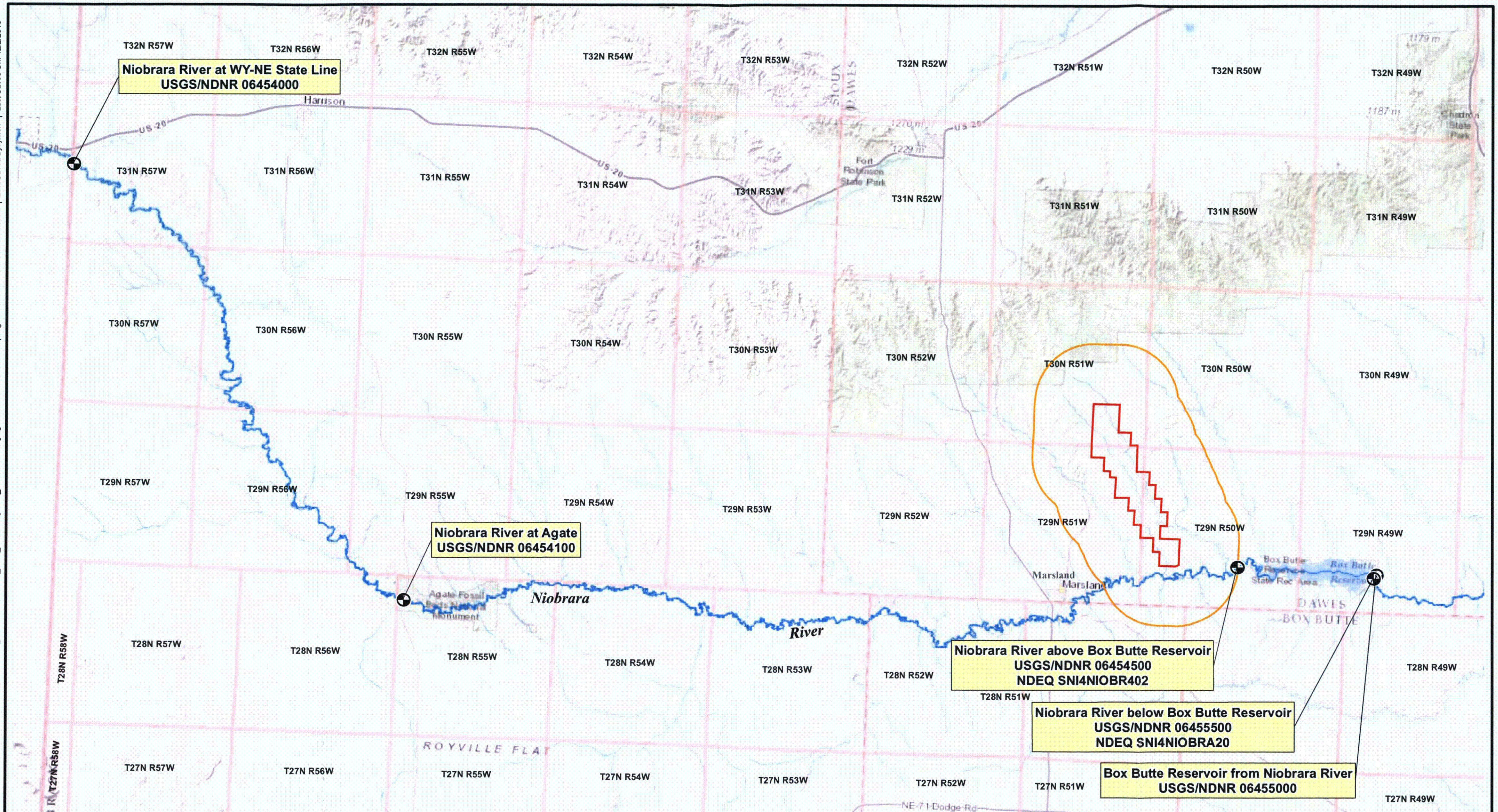
CROW BUTTE RESOURCES, INC.

FIGURE 2.9-7
UPPER NIOBRARA RIVER AVERAGE FLOWS AT USGS/NDNR STREAM GAGING STATIONS

PROJECT: CO001636	MAPPED BY: JC	CHECKED BY: JEC

ARCADIS
630 Plaza Drive, Ste. 100
Highlands Ranch, CO 80129
P: 720-344-3500 F: 720-344-3535
www.arcadis-us.com

K:\CBR_Projects\CO001636_Marsland\3_IMAGES\Illustrator\UIC_Fig_F 1-5 Upper Niobrara River Average Flows at USGS_NDNR Stream Gaging Stations4.ai @ 09/04/2013



LEGEND

- USGS/NDNR Stream Gaging Station and NDEQ Sampling Location
- Niobrara River
- Proposed Marsland Expansion Area
- Area of Review (AOR)

PROJECTION: NAD 1983, STATE PLANE
NEBRASKA NORTH FIPS 2600
SOURCE: TOPOGRAPHIC MAP, SERVICED BY
ESRI ARCGIS ONLINE

N

0 2 4
Miles

CROW BUTTE RESOURCES, INC.

FIGURE 2.9-8
USGS/NDNR STREAM GAGING STATIONS AND NDEQ SAMPLING LOCATIONS FOR NIOBRARA RIVER

PROJECT: CO001636 MAPPED BY: JC

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Path: C:\Users\jchen\Documents_PROJECTS\KCBR_Projects\CO001636_Marsland\2_GIS\ArcMaps\0004_NRC_TR\TR Figure 2_9-8 USGS GagingStations and NDEQ Sampling Locations for Niobrara River.mxd | Last Saved By: jchen | Last Saved On: 12/2/2013

3 DESCRIPTION OF PROPOSED FACILITY

Production of uranium by ISR mining techniques involves a mining step and a uranium recovery step. Mining is accomplished by installing a series of injection wells through which the leach solution is pumped into the ore body. Corresponding production wells and pumps promote flow through the ore body and allow for the collection of uranium-rich leach solution. Uranium is removed from the leach solution by IX, and then from the IX resin by elution. The leach solution can then be reused for mining purposes. The elution liquid containing the uranium (the "pregnant" eluent) is then processed by precipitation, dewatering, and drying to produce a transportable form of uranium called yellowcake.

The MEA is being developed by CBR in conjunction with the CPF licensed under NRC Source Material License SUA-1534. The MEA will be developed by constructing independent mine units and mining support facilities while employing existing processing equipment for uranium recovery. Transfer of recovered leach solutions from the area is prohibitive because of the distance over which a relatively large stream would have to be pumped. Therefore, a satellite facility will be constructed in the MEA to provide chemical makeup of leach solutions, recovery of uranium by IX, and restoration capabilities. The IX processes at the satellite facility recover the uranium from the leach solution in a form (loaded IX resin) that is relatively safe and simple to transport by tanker truck to the CPF, which will serve as feed to the CPF for elution and further processing of recovered uranium. Regenerated resin is then transported back to the satellite facility for reuse in the IX circuit.

3.1 Solution Mining Process and Equipment

3.1.1 Orebody

In the CPF license area, uranium is recovered by ISR from the basal sandstone of the Chadron Formation at a depth that varies from 400 feet to 900 feet. The overall width of the mineralized area varies from 1,000 feet to 5,000 feet. The orebody ranges in grade from less than 0.05 to more than 0.5 percent U_3O, with an average grade estimated at 0.27 percent U_3O_8.

In the MEA license area, uranium will also be recovered via ISR from the basal sandstone of the Chadron Formation. The depth to the ore body within the basal sandstone of the Chadron Formation in the MEA ranges from approximately 800 to 1,250 feet bgs (**Figures 2.6-3a** through **2.6-3n**). The width of the ore body varies from approximately 1,000 to 4,000 feet. The ore grade as U_3O_8 ranges from 0.11 to .33 percent with an average ore grade of 0.22 percent.

Typical stratigraphic intervals to be mined by the ISR method are shown in the geologic cross-sections contained in Section 2.6. For ISR wellfields, the production zone is the geological sandstone unit where the leaching solutions are injected and recovered.

3.1.2 Well Construction and Integrity Testing

Three well construction methods and appropriate casing materials are used for the construction and installation of production and injection wells.

3.1.2.1 Well Materials of Construction

The well casing material will be PVC, which is 5-inch Standard Dimension Ratio-17 (SDR-17) or equivalent. However, should a larger pump size be required, 6-inch SDR-17 or greater casing will be used. The PVC casing joints are 20 feet long, and the bottom joint can be made either 10 or 20 feet long depending on the casing depth. With SDR-17 PVC casing, each joint has a watertight O-ring seal and is held together with a high-strength nylon spline.

Deleted: PVC well casing is

CertainTeed Certa-Lok well casing or like material will be used for well construction at Marsland. Based on manufacturer's information, there is no one recommended maximum depth for a particular size and class of PVC well casing. As explained by the manufacturer, proper design criteria allow a wide range of applications for a particular size and class of PVC casing. For example, it is possible to use thinner-walled casing at significant depths as long as design criteria address hydraulic collapsing pressures and heat. Conversely, thicker-walled casing may fail at shallow depths if collapsing pressures and heat are not designed for accordingly. To ensure that hydraulic collapse pressures are not exceeded during well construction, wells will be constructed using pressure grouting and weighted displacement fluid.

Pressure grouting through the inside of the casing essentially eliminates hydraulic collapsing pressures by retaining pressure on the cement and displacement fluid with a closed well head valve. Weighted displacement fluid consisting of water, bentonite-based drilling mud, and/or a weighting agent (such as barite) may also be used to displace cement. Weighted displacement fluid helps maintain the hydraulic collapse pressure in case of a leaky well head and reduces the pumping pressures required to push the annular column of cement to the surface.

The net external hydraulic collapsing pressure at the bottom of the casing can be calculated to ensure the weight of the displacement fluid provides sufficient offsetting internal pressure. External collapsing pressure at the bottom of the casing is calculated using the following equation:

$Pd = Pe - Pi$

where:

Pd = Pressure differential

Pe = Pressure external

Pi = Pressure internal

Pressure (psi) may be calculated using the following equation:

Pressure (psi) = H x W x 0.052

Where:

H = Height of fluid column (ft.)

W = Weight of fluid (lbs./gallon)

It is important to note that, once the cement has begun to cure and reaches a semi-rigid state, the collapse pressure forces are eliminated. The cured cement provides lateral support and holds the casing firmly in place. It seals the borehole against water infiltration from the surface and

undesirable aquifers. Note also that all wells must successfully pass a Mechanical Integrity Test (MIT) prior to being placed into service.

CBR has widely used both PVC and stainless steel well screens in the injection, production, and monitoring wells at the Crow Butte Operation since 1991. Both screen types have demonstrated good reliability with minimal maintenance required when operating within anticipated chemical and pressure environments required for mining. **Table 3.1.5** of the application shows the typical lixiviant concentrations anticipated for mining wells at Marsland. These concentrations are similar to those observed at Crow Butte. **Table 3.1-6** shows additional lixiviant concentrations of constituents measured at injection points for four mine units at the current CBR operations; these concentrations are expected to be similar for the MEA operations.

Stainless steel well screens used at Crow Butte are made out of type 304 and type 316L stainless steel. PVC screens are constructed from white PVC Type 1, Grade 1 material as described in ASTM F480 and ASTM D1784, Class 12454B. Both stainless steel and PVC screens provide excellent resistance to corrosion and corrosion-stress cracking and pitting.

The PVC well casing used at Crow Butte also shows excellent corrosion resistance and durability, meeting the ASTM F480 specifications for plastic pipe. Since 1991, more than 5,000 wells have been placed into production at Crow Butte. Down-hole video surveys do show some calcite and sodium bicarbonate scale buildup on the casing walls that can be removed with the well jetting procedure discussed below. After removal, no evidence remains to indicate that corrosion or destructive forces have degraded the casing.

Down-hole video surveys of wells with declining flow rates have shown well screen fouling and plugging due to sand, calcite, and bicarbonate scale. Wells identified with this type of fouling are rehabilitated using a drill rig to jet and flush the scale, generally restoring the well back to original flow rates. Post-rehabilitation down-hole video surveys have shown that the jet-and-flush process removes most foreign material, alleviating fouling and plugging.

SS screens are more durable than PVC screens, are rated for greater depths than PVC screens, are easier to install, and can achieve better flow. The SS screens are significantly more expensive than the PVC screens. Currently, CBR primarily uses SS screens, but would maintain the option to use PVC screens as necessary at the satellite facility based on site conditions and purpose of the borehole. For example, PVC well screens are currently used in both shallow observation monitor wells and commercial production monitor wells. This practice will continue to be an option for Marsland. PVC screens are used for these types of wells primarily because these types of monitor wells typically have much longer screen intervals than other types of wells. This results in employee safety issues due to the handling of the heavy SS screens. In addition, flow rate using PVC screens is less of a concern for these monitoring wells, as the amount of flow is limited by the formation, not the screen. The PVC well screen consists of a perforated 3-inch PVC pipe. PVC rods run longitudinally along the sides of the pipe. Keystone-shaped PVC wire is helically wrapped around the outsides of the pipe and ribs and solvent-welded to the pipe. Spacing between consecutive wraps of the wire varies depending upon the screen ordered. Slot sizes from 0.010 to 0.020 inch have been used successfully at Crow Butte. In most cases, a slot size of 0.020 inch is sufficient to prevent sand from entering the screens. All Class III wells will be screened and naturally developed. CBR does not intend to introduce a sized gravel pack for wells at Marsland at this time.

Deleted: In addition, flow rate using PVC screens is less of a concern for these types of wells.

The SS well screen consists of longitudinal ribs of SS with a SS "V" shaped wire wrapped helically around the interior ribbing. The wire is welded to the circular rib array for support. As with PVC screens, slot sizes of 0.010 to 0.020 inch have been used historically at Crow Butte.

3.1.2.2 Well Construction Methods

Pilot holes for monitor, production, and injection wells will be drilled through the target completion interval with a small rotary drilling unit using native mud and a small amount of commercial drilling fluid additive for viscosity control. The hole will be logged, reamed, casing set, and cemented to isolate the completion interval from all other aquifers. Three well construction methods are described. Any of these methods is appropriate for monitor wells and have been approved by the NDEQ under the current Crow Butte Class III UIC Permit and recently issued Class III UIC Permit for the NTEA satellite facility. All wells will be constructed in accordance with the provisions of this section. Of the three methods, CBR primarily uses Method 1, shown on **Figure 3.1-1,** on a routine basis. Method 2, shown on **Figure 3.1-2,** may be used by the CBR geologic staff when there is a need to study the geology of an area and to determine the best placement of the screens without having to attach screens to the casing string. Method 3, shown on **Figure 3.1-3,** is not routinely used, but this method is maintained as an option so that the method (including minor modifications) can be used if warranted for specific geological formations. All of these methods are appropriate for constructing monitor wells and have been approved by the NDEQ under the UIC Permit.

Method 1

For this method, the well is drilled to depth in the Pierre Shale and then logged. Based upon the e-log, geologic staff will pick a casing depth, and will then begin to review the local area wells for the best location (depth) to select the screened interval. The well is cased through the mining zone and cemented in place. Cement flows down the inside of the casing, exits out the bottom, and flows back up the annulus to the surface. Cement may be pushed out of the bottom of the casing by using rubber cement plug that is pushed to the bottom and stays in the bottom of the well, or cement may be displaced using fresh water. If the cement is displaced with water, a rig will need to drill the excess cement out of the casing prior to under-reaming and setting screens. If the cement is displaced using a cement plug, then nothing further is required prior to under-reaming. The under-reaming process begins with a rig tripping (inserting in borehole) a specialized drill bit into the depths to be screened. Blades on the bit open outward to cut away and remove the casing and cement grout from the area to be screened. When the interval to be screened has been cut away, the drill rig removes the drill pipe, and the hole is logged to make certain that the cut is accurate. If the cut-check depths are determined to be satisfactory, the rig is used to place the screen assembly at the selected depth and then develop the well.

Method 1 is the primary method used for all injection and production wells. A slight variation of this method is used for monitor wells. Monitor wells are cased to the top of the mining zone and cemented using water displacement. Allowing for time for the cement to set up (harden), the excess cement is drilled out of the casing and the well is logged to determine where to place the well screens.

Method 1 is similar to Method 2, except that a plug and weep holes are not used.

Method 2

Method 2 uses a screen telescoped down inside the cemented casing. A hole is drilled and geophysically logged to locate the desired screen interval. The hole is then reamed if necessary only to the top of the desired screen interval. Next, a string of casing with a plug at the lower end and weep holes just above the plug is set into the hole. Cement is then pumped down the casing and out the weep holes. It returns to the surface through the annulus. After the cement has cured, the residual cement in the casing and plug are drilled out, with the drilling continuing through the desired zone. The screen with a K-packer and/or shale traps is then telescoped through the casing and set in the desired interval. The packer and/or shale traps serve to hold the screen in the desired position while acting as a fluid seal. Well development is again accomplished by airlifting or pumping. Minor variations from these procedures may be used as conditions require.

Method 2 is an improvement over Method 3 due to drilling only to the top of the mining zone. At that point, the well is cased and cemented. Because the drill hole does not penetrate through the mining zone, no cement basket must be used. A cement plug and weep holes are used to place the cement.

Method 3

This method involves setting an integral casing/screen string. The method consists of drilling a hole to the Pierre Shale; geophysically logging the hole to define the desired screen interval; and reaming the hole, if necessary, to the desired depth and diameter. Next, a string of casing with the desired length of screen attached to the lower end is placed into the hole. A cement basket is attached to the blank casing just above the screen to prevent plugging of the screen interval during cementing. The cement is pumped down the inside of the casing to a plug set just below the cement basket. The cement passes out through weepholes in the casing and is directed by the cement basket back to the surface through the annulus between the casing and the drill hole. After the cement has cured sufficiently, the residual cement and plug are drilled out, and the well is developed by airlifting or pumping.

For all three well completion methods, casing centralizers, located at a maximum spacing of 100 feet, are run on the casing to ensure that it is centered in the drill hole and that an effective cement seal is provided. The purpose of the cement is to stabilize and strengthen the casing and plug the annulus of the hole to prevent vertical migration of solutions. The volume of cement used in each well is determined by estimating the volume required to fill the annulus and ensure that cement returns to the surface. In almost all cement jobs, returns to the surface are observed. In rare cases, however, the drilling may result in a larger annulus volume than anticipated, and cement may not return all the way to the surface. In these cases, the upper portion of the annulus will be cemented from the surface to backfill as much of the well annulus as possible and stabilize the wellhead. This procedure is performed by placing a tremie hose from the surface as far down into the annulus as possible. Cement is pumped into the annulus until return to the surface is observed.

Current CBR Class III permits allow a 100-foot maximum spacing for casing centralizers. Historically, Crow Butte has placed centralizers every 60 feet except when a centralizer is scheduled to fall within the potential zone to be screened. In those instances, that centralizer is moved upward on the casing string and out of the screened zone so that it does not interfere with the under-reaming and screening process. Centralizers placed at this spacing still ensure that

there is sufficient annular space for the correct placement of the sealing grout and is supported by a successful MIT rate of 98 percent at the current CBR facility.

Screening

The exact size of the screen slot is determined by analyzing the formation samples brought to the surface during the drilling process, and is selected at the discretion of the Crow Butte geologic staff. The location and amount of drill screen to be set in a well are based upon the geologic and economic factors. Well screens are placed at a selected depth using the drilling rig. The screens are secured in place using a rubber K-packer and blank assembly that is attached to the top of the screens. The K-packer suspends the screens in the open portion of the well until well development creates a natural gravel pack surrounding the screen.

For injection and production wells, the screen interval is determined by the geologic staff based on the location of sands and ore grade material. The zones to be mined are correlated and selected by reviewing geophysical logs, which also confirms that the screened intervals between wells are hydrologically connected. Typically, an interval of approximately 18 feet is screened; however, individual intervals may range from 6 feet to 35 feet in length.

For monitor wells, a slightly different process is followed for placement of the screens. When the monitor well is drilled, the total thickness of the production zone is calculated. The number of screens to be placed in the well must cover the production zone, and the screen-to-blank ratio must exceed 50 percent. Care should be taken to ensure that those zones impacted by nearby wells are covered by screens, and not left blank. A well completion report is documented for each well and maintained at the site for review. All wells are constructed by a licensed/certified water well contractor, as defined by the Nebraska Health and Human Services System, Water Well Standards and Licensing Act, Article 46.

3.1.2.3 Cement/Grout Specifications

All cement will be ASTM International (ASTM) Type I, II or American Petroleum Institute (API) Class B or G and will meet the following criteria:

- The cement will have a density of no less than 11.5 lbs/gal.
- A bentonite grout shall be mixed as close as possible to a concentration of 1.5 lb. bentonite per gallon of water (1 quart polymer per 100 gallons of water may be premixed to prevent the clays from hydrating prematurely) and shall have a density of 9.2 lbs./gal or higher.

3.1.2.4 Logging Procedures and Other Tests

Appropriate geophysical logs and other tests are conducted during the drilling and construction of new Class III wells. These are determined based on the intended function, depth, construction, and other characteristics of the well; availability of similar data in the area of the drilling site; and the need for additional information that may arise from time to time as the construction of the well progresses.

Logging Equipment

CBR currently owns three operational logging units. All were built by Century Geophysical Corporation in Tulsa, Oklahoma. These units are capable of logging drill holes to a depth of approximately 2,000 feet.

These trucks are capable of using a wide variety of tools. All of these tools (or probes, as used by CBR) measure Single Point Resistance (RES), SP, Natural Gamma (GAM[NAT]), and Deviation. Some of the probes used by CBR are also capable of measuring temperature, 16-inch normal resistance, and 64-inch normal resistance (**Table 3.1-1**). Deviation with these units is measured using a slant angle and azimuth technique. Standardized procedures are used by trained personnel to carry out the logging tasks.

Borehole Geophysical Logs

As of November 1, 2011, there have been 1,653 exploration/development holes and 22 monitor and observation wells drilled within the MEA boundary. A sample portion of a borehole geophysical log (M-1251) is shown on **Figure 2.6-5**. Detailed analysis of a carefully chosen suite of borehole geophysics provides a method for interpreting lithology, stratigraphy, and depositional environment; and for deriving porosity values, permeability index, and water salinity. The log curves used for interpretation and parameter derivation measure RES, SP, GAM(NAT), and Deviation.

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Log interpretation and parameter evaluation involves analysis of the measured log curve values and responses. The measured curve and resultant analysis are influenced by drilling processes, properties of the formation, and limitations of the logging tools themselves. Common hydrogeologic objectives of borehole geophysical logging include: (1) definition and correlation of aquifer or other lithologic units; (2) estimation of aquifer properties such as porosity and permeability; and (3) assessment of physical properties of formation water including conductivity, TDS, and total hardness. These objectives must be considered in the design, selection, and implementation of an effective logging program.

There are three basic parameters derived or interpreted from borehole geophysical logs: lithology, resistivity, and porosity. From these basic parameters, there are numerous variations that can provide information regarding lithologic identification, correlation, facies evaluation, delineation of permeable and porous zones, and identification of pore fluids. The type of measurements used to determine this information are:

- SP
- GAM(NAT)
- resistivity/induction

The following represent the general log suite at each borehole location:

Gamma ray (GR) tools measure naturally occurring GR radiation emitted spontaneously from the formation by uranium, thorium, and the potassium 40 isotope. Natural gamma logs are powerful tools in identification and correlation of lithology, identification of potential migration pathways, and evaluation of water quality with respect to radionuclides, such as uranium salts. GR logs usually show the clay content in sedimentary rocks because heavy radioactive elements (potassium, thorium, and uranium-radium) tend to concentrate in clays. While clays and clayey

sands are higher in radioactivity, clean sands (no clay content) and carbonates usually exhibit low levels of radioactivity. The GR curve can differentiate among sands, clays, and the gradation between the two. As radioactive elements tend to concentrate in shales and clays, high GR readings reflect high shale or clay content in sedimentary units. Very low levels of radioactive elements or isotopes are present in clean formations (sands, gypsum, and anhydrite) unless contaminants are present such as dissolved potassium or uranium salts, volcanic ash, or granite wash.

The tool records counts per second (CPS), which should be converted to API units. Natural gamma logs should always be calibrated in API units. The API unit is a unit of counting rate used for scaling GR logs and neutron logs (Schlumberger 2010). The API unit of radioactivity is used for natural GR logs and is based on an artificially radioactive concrete block located at the University of Houston, Texas. This unit was chosen because it was considered to carry twice the radioactivity of typical shale. The United States Department of Energy (DOE) maintains facilities for the calibration of geophysical probes used in creating gamma logs, with one being located in Casper, Wyoming. CBR employs the test pits monthly at the DOE Casper facility to calibrate the geophysical probes.

Deleted: GR logs

Deleted: neutron logs

The Spontaneous Potential (SP) log is a measurement of the electrical potential (voltage) that occurs in a boring when fluids of different salinities are in contact. The electrical potential is produced by the interaction of formation water, conductive drilling fluids, and certain ion-selective sediments (clay). Because clays have a very low permeability and sands have a high permeability, the SP can be a valuable lithology indicator. In general, clay-free permeable beds of moderate to low resistivity are sharply defined by the SP curve. High resistivity beds distort the SP currents, flattening the slope of the SP curve at bed boundaries. This causes poor bed boundary definition. The SP curve is also distorted (depressed or elevated) by permeable zones that contain clay, hydrocarbons, gas, or contaminants.

Single point resistance (RES) tools measure the resistance to current flow between a tool electrode and a ground electrode (conventional single point resistance), or between an electrode in the tool and the shell of the tool (differential single point resistance). Response of the log curve is attributed to lithologic units of varying resistance. Resistance increases in freshwater-filled sands or gravels and decreases in shales, clays, silts, and brine-filled sands. Curve values are recorded in ohms. Point resistance tools have a relatively small radius of investigation and poor thin bed resolution compared to resistivity tools. These logs are mainly used for correlation of beds.

Borehole Deviation Logging

Deleted: The Neutron-Neutron (N-N) tool is a direct measurement of variations in the hydrogen content of the formation. An N-N probe takes a direct measurement of the variations in the hydrogen content profile. The neutron probe contains a source of high-energy neutrons (commonly americium-beryllium) with thermal neutron detectors at a fixed distance away from the source. The tool records CPS, which should be converted to API units. A high count indicates a low porosity, while a low count indicates a high porosity. Neutron logs are influenced by changes in the hole diameter.¶

Deviation of boreholes is measured using a slant angle and azimuth technique. CBR uses a Century Geophysical Corporation Tool Borehole deviation log tool 9057 or equivalent to record the attitude (dip angle and dip direction) of rock layers in the borehole. Borehole deviation and pad 1 azimuth are recorded in real time, via a deviation package contained within the tool, which contains the X-Y inclinometers and the X-Y-Z magnetometers. From these sensors, the Compu-Log computes and records slant angle (angle of the tool) and slant angle bearing (tool direction) as the tool proceeds along the borehole path. This device is aligned to correct for spatial indications with pad 1 azimuth. The deviation calibration is performed by recording two CPS rotating logs, and then using the dipmeter calibration to produce a special deviation calibration file (Century Geophysical Corporation 2009).

3.1.2.5 Field Observations and Core Samples Analysis

At CBR, subsurface formation lithology mapping and interpretation for boreholes during the drilling and construction of Class III wells are primarily based on field observations and geophysical logging. Field observations documented during drilling include depth, drilling rate, size of cuttings, and changes in lithology. Drill cuttings or core samples may be analyzed for physical and chemical parameters as needed in support of geophysical measurements. For example, core samples were recently collected in the MEA for four lithostratigraphic units. Sample analyses included XRD and sieve analysis (i.e., grain size distribution). Of particular importance for this sampling program was a better understanding of the hydraulic characterization of the upper and lower confining units for the basal sandstone of the Chadron Formation. This information was required for the Aquifer Exemption Petition.

Core samples may be collected as needed, but coring is typically not needed during the drilling and construction of Class III wells. The types of tests conducted on core samples are based on the intended need (e.g., porosity, relative permeability, and lithology).

Groundwater Measurements

Groundwater sampling and water level measurements are two tests typically conducted for new wells. Results of the groundwater sampling and analysis are used to evaluate water quality baseline values for future restoration to groundwater standards, and water level measurements provide for a more detailed understanding of the hydraulic gradient within the MEA. Groundwater monitoring for new wells is discussed below.

3.1.2.6 Well Development

Following well construction (and before baseline water quality samples are taken for restoration and monitoring wells), the wells must be developed to restore the natural hydraulic conductivity and geochemical equilibrium of the aquifer. All wells are initially developed immediately after construction using airlifting or other accepted development techniques. This process is necessary to allow representative samples of groundwater to be collected. Well development removes water and drilling fluids from the casing, formation, and borehole walls along the screened interval. The primary goal for well development is to allow formation water to enter the well screen.

Initially, well development is generally performed by airlifting and cleanup with a drill rig. The well is developed until the water produced is clear. This can be determined visually or with a turbidimeter. During the final stages of initial development, water samples will be collected in a transparent or translucent container and visually examined for turbidity (i.e., cloudiness and visual suspended solids). Development is continued until clear, sediment-free formation water is produced.

When the water begins to clear, the development flow will be temporarily stopped and/or the flow rate will be varied. Sampling and examination for turbidity will continue. When varying the development rate no longer causes the sample to become turbid, the initial development will be deemed complete.

Before obtaining baseline samples from monitor or restoration wells, the well must be further developed to ensure that representative formation water is available for sampling. Final development is performed by pumping the well or swabbing for an adequate period to ensure that

stable formation water is present. pH and conductivity are monitored during this process to ensure that development activities have been effective. The field parameters must be stable at representative formation values before baseline sampling will begin.

Following well installation, all well development water will be captured in water trucks specifically labeled and dedicated for such purpose and equipped with signage indicating that these trucks may only discharge their contents for injection into the DDW. Alternatively, these fluids may be transported to the CPF evaporation ponds, but only if there are fluid separation equipment issues at the MEA satellite facility. Section 3.1.6 (Wellfield and Process Waste) discusses process wastewaters generated by the wellfield and satellite facility in further detail. Section 4.2.1.1 discusses handling and disposal of well drilling fluids and well development water.

3.1.2.7 Well Integrity Testing

All wells (i.e., injection, production, and monitor) are field tested using pressure-packer tests to demonstrate the mechanical integrity of the well casing. Every well will be tested after well construction is completed before it can be placed into service; after any work-over with a drill rig or servicing with equipment or procedures that could damage the well casing; at least once every 5 years; and whenever there is any question of casing integrity. To ensure the accuracy of the integrity tests, periodic comparisons are made between the field pressure gauges and a calibrated test gauge. The mechanical integrity test procedure has been approved by the NDEQ and is currently contained in the SHEQMS Volume III, Operating Manual. These same procedures will be used at the MEA.

The following general mechanical integrity test procedure is employed:

- The well is tested after well development and prior to the well being placed into service. The test consists of placement of two packers within the casing. The bottom packer is set just above the well screen, and the upper packer is set at the wellhead. The packers are inflated with nitrogen, and the casing is pressurized with water to 125 percent of the maximum operating pressure (i.e., 125 pounds per square inch [psi]).
- The well is then "closed in" and the pressure is monitored for a minimum of 20 minutes.
- If more than 10 percent of the pressure is lost during this time period, the well has failed the integrity test. When possible, a well that fails the integrity testing will be repaired and the testing repeated. If the casing leakage cannot be repaired or corrected, the well is plugged and reclaimed as described in Section 6.

CBR submits all mechanical integrity testing records to the NDEQ for review after the initial construction of a mine unit or wellfield. Test results are also maintained on site for regulatory review.

3.1.3 Wellfield Design and Operation

The proposed MEA mine timeline and MU map are shown on **Figure 1.7-4** and **Figure 1.7-5**, respectively. The preliminary map and mine timeline are based on current knowledge of the area. As the MEA is developed, the mine timeline and a mine unit map will be further developed. The MEA will be subdivided into an appropriate number of mine units. Each mine unit will contain a number of wellhouses where injection and recovery solutions from the satellite facility building

are distributed to the individual wells. The injection and production manifold piping from the satellite process facility to the wellhouses will be either PVC or HDPE with butt welded joints or an equivalent. In the wellhouse, injection pressure will be monitored on the injection trunk lines. Oxidizer will be added to the injection stream, and all injection lines off of the injection manifold will be equipped with totalizing flowmeters, which will be monitored in the satellite control room. The MEA mine units will be designed in a manner consistent with the existing CBR mine units.

The wellfield injection/production pattern employed is based on a hexagonal seven-spot pattern, which is modified as needed to fit the characteristics of the ore body. The standard production cell for the seven-spot pattern contains six injection wells surrounding a centrally located recovery well.

The cell dimensions vary depending on the formation and the characteristics of the ore body. The injection wells in a normal pattern are expected to be between 65 feet and 150 feet apart. A typical wellfield layout is shown on **Figure 3.1-4**. The wellfield is a repeated seven-spot design, with the spacing between production wells ranging from 65 to 150 feet. Other wellfield designs include alternating single line drives.

All wells are completed so they can be used as either injection or recovery wells, so that wellfield flow patterns can be changed as needed to improve uranium recovery and restore the groundwater in the most efficient manner. During operations, leaching solution enters the formations through the injection wells and flows to the recovery wells. Within the monitor well ring, prior to stability monitoring, more water is produced than injected to create an overall hydraulic cone of depression in the production zone. Under this pressure gradient, the natural groundwater movement from the surrounding area is toward the wellfield, providing additional control of the leaching solution movement. The difference between the amount of water produced and injected is the wellfield "bleed." The minimum overproduction or bleed rates will be a nominal 0.5 percent of the total wellfield production rate, and the maximum bleed rate typically approaches 2.0 percent. Bleed is adjusted as necessary to ensure that the perimeter ore zone monitor wells are influenced by the cone of depression until stability monitoring described in Section 6.1.5 begins.

Monitor wells will be placed in the basal sandstone of the Chadron Formation and in the overlying Brule Formation and Arikaree Group aquifers. All monitor wells will be completed by one of the three methods discussed above and developed prior to leach solution injection. The development process for monitor wells includes establishing baseline water quality before the initiation of mining operations.

Deleted: Arikaree and Brule aquifers.

Deleted: first significant water-bearing Brule sand above the basal sandstone of the Chadron Formation.

Injection of solutions for mining will be at a rate of 6,000 gpm with a 0.5 to 2.0 percent production bleed stream. Production solutions returning from the wells to the production manifold will be monitored with a totalizing flowmeter. All pipelines and trunklines will be pressure checked for leaks and buried prior to production operations.

A water balance for the proposed satellite facility is presented in **Appendix T**. The primary liquid waste generated at the satellite facility will be the production bleed which, at a maximum scenario, is estimated at 1.2 percent of the production flow. At 6,000 gpm (4,500 gpm process flow and 1,500 gpm restoration flow), the maximum volume of liquid waste in year 2024 would

be approximately 31 gpm. CBR proposes to handle the liquid waste using DDW injection. Detailed discussions of to the MEA water balance calculation and evaluation are presented in Section 3.1.7

Regional information, previous CBR license and permit submittals, and historical operational practices indicate that the minimum pressure that could initiate hydraulic fracture is 0.63 psi per foot of well depth. This value has historically and successfully been applied to CBR operations. Calculations for MEA result in a value of 0.53 psi. As such, the injection pressure is limited to less than 0.63 psi per foot of well depth. Injection pressures also will be limited to the pressure at which the well was integrity tested.

As discussed in Section 2.7, a regional pumping test has been conducted to assess the hydraulic characteristics of the basal sandstone of the Chadron Formation and overlying confining units. Pumping tests will also be performed for each MU not covered by the regional pump test to demonstrate hydraulic containment above the production zone, demonstrate communication between the production zone mining and exterior monitor wells, and to further evaluate the hydrologic properties of the basal sandstone of the Chadron Formation.

A full and detailed analysis of the potential impacts of the mining operations at Marsland on surrounding water users will be provided in an Industrial Groundwater Use Permit application. A similar permit application was submitted by Ferret Exploration of Nebraska (predecessor to Crow Butte Resources) in 1991, and that application provides a reasonable analogy between the current licensed area and satellite facility. The application states that water levels in the City of Crawford (approximately 3 miles [4.8 km] northwest of the mining area) could potentially be impacted by approximately 20 feet by consumptive withdrawal of water from the basal sandstone of the Chadron Formation during mining and restoration operations (based on a 20-year operational period).

A similar order of magnitude impact (drawdown) exists for the MEA operations. No impact to other users of groundwater is expected because there is no documented existing use of the basal sandstone of the Chadron Formation in the proposed MEA.

Because the basal sandstone of the Chadron Formation (production zone) is a deep confined aquifer, no surface water impacts are expected. Based on available information, all water supply wells within the MEA and AOR are completed in the relatively shallow Arikaree and/or Brule Formation, with no domestic or agricultural use of groundwater from the basal sandstone of the Chadron Formation.

Further, the geologic and hydrologic data presented in Sections 2.6 and 2.7, respectively, demonstrate that (1) uranium mineralization is limited to the basal sandstone of the Chadron Formation, and (2) this formation is isolated from underlying and overlying sands. Hence, the mining operations are expected to impact water quality only in the basal sandstone of the Chadron Formation, and restoration operations will be conducted in the basal sandstone of the Chadron Formation following completion of mining.

Based on a bleed of 0.5 to 2.0 percent (0.5 to 1.5 percent have been successfully applied in the current licensed area), the potential impact from consumptive use of groundwater is expected to be minimal. In this regard, the vast majority (e.g., on the order of 98 percent) of groundwater

used in the mining process will be treated and re-injected (**Figure 3.1-5**). Potential impacts on groundwater quality due to consumptive use outside the license area are expected to be negligible.

The data were evaluated using a Theis semi-steady state analytical solution, which includes the following assumptions:

- The aquifer is confined and has apparent infinite extent.
- The aquifer is homogeneous and isotropic, and of uniform effective thickness over the area influenced by pumping.
- The piezometric surface is horizontal prior to pumping.
- The well is pumped at a constant rate.
- No recharge to the aquifer occurs.
- The pumping well is fully penetrating.
- Well diameter is small, so well storage is negligible.

Based on a drawdown response observed during the MEA pumping test at the most distant observation well locations, the ROI during the pumping test was estimated to be in excess of approximately 8,800 feet. More than 0.8 foot of drawdown was achieved during testing in all observation wells completed in the basal sandstone of the Chadron Formation, with a maximum drawdown of 23.40 feet observed in the test pumping well during the test. During the test (pumping and recovery periods), no discernable drawdown or recovery responses attributed to the test were observed in overlying Brue Formation observation wells, which supports the conclusion that adequate confinement exists between the overlying Brule Formation and the basal sandstone of the Chadron Formation. Detailed discussions of the MEA pumping test are provided in Section 2.7.2.2 and in **Appendix F**.

As discussed in Section 5.7 of this application, an extensive water sampling program will be conducted prior to, during, and following mining operations at the satellite facility to identify any potential impacts to water resources in the area.

The groundwater monitoring program is designed to establish baseline water quality prior to mining, detect excursions of lixiviant either horizontally or vertically outside of the production zone, and determine when the production zone aquifer has been adequately restored following mining. The program will include sampling of monitoring wells and private wells within and surrounding the license area to establish pre-mining baseline water quality. Water quality sampling will continue throughout the operational phase of mining for detection of excursions. Water quality sampling will also be conducted during restoration, including stabilization monitoring at the end of restoration activities, to determine when baseline or otherwise acceptable water quality has been achieved.

During operation, the primary purpose of the wellfield monitoring program will be to detect and correct conditions that could lead to an excursion of lixiviant or detect such an excursion, should one occur. The techniques employed to achieve this objective include monitoring of production and injection rates and volumes, wellhead pressure, water levels, and water quality.

Monitoring of production (extraction) and injection rates and volumes will enable an accurate assessment of water balance for the wellfield. A bleed system will be employed that will result in less leach solution being injected than the total volume of fluids (leach solution and native groundwater) being extracted. A bleed of 0.5 to 2.0 percent will be maintained during production. Maintenance of the bleed will cause an inflow of groundwater into the production area and prevent loss of leach solution.

Injection pressures are monitored in the wellhouse at the manifold with an audible and visible alarm monitored 24 hours per day, 7 days per week in the control room. The alarms are set at 90 to 95 psi to prevent pressure in excess of 100 psi at the wellhouse manifold, below the 125 psi integrity test pressure demonstrated in each injection well. Due to line losses, pressures at the wellheads remain below that which is monitored at wellhouse manifold.

Each new production well (extraction and injection) will be pressure-tested to confirm the integrity of the casing prior to being used for mining operations. Wells that fail pressure testing will be repaired or abandoned and replaced as necessary.

Water levels will be routinely measured in the production zone and overlying aquifer. Sudden changes in water levels within the production zone may indicate that the wellfield flow system is out of balance. Flow rates would be adjusted to correct this situation. Increases in water levels in the overlying aquifer may indicate fluid migration from the production zone. Adjustments to well flow rates or complete shutdown of individual wells may be required to correct this situation. Increases in water levels in the overlying aquifer may also indicate casing failure in a production, injection, or monitor well. Isolation and shutdown of individual wells can identify the well causing the water level increases.

To ensure the leach solutions are contained within the designated area of the aquifer being mined, the production zone and overlying aquifer monitor wells will be sampled once every 2 weeks as discussed in Section 5.7.

Cameco also conducted an analysis, presented in **Appendix AA**, of the potential hydrologic impacts to local irrigation wells resulting from a hypothetical shallow casing leak in the overlying aquifer (Aqui-Ver 2013a). After pumping well 732 continuously for 5 months at 800 gpm, at the end of the irrigation season approximately 0.1 to 0.7 feet of drawdown (low and high transmissivity, respectively) is predicted in the nearest shallow monitor wells (AOW-9/BOW-9).

The 30-year capture zone of well 732 was computed using reverse particle-tracking techniques. Based on the results of this analysis, MEA wellfields are not located within the capture zone of irrigation well 732. A shallow casing leak within the MEA wellfields should not impact irrigation well 732 at any time in the future given similar operating conditions. Given the location of other irrigation and domestic wells outside the license boundary, and the area and configuration of the worse-case capture zone for well 732, it is also reasonable to conclude there are no other private irrigation or domestic wells outside the license boundary that could be impacted by a release of MEA regulated material to the shallow aquifer.

Cameco controls all existing private wells inside the license boundary. Cameco will prohibit the use of a private well by the lessor(s) once well field construction begins in that vicinity. For existing private wells inside the license boundary and near active wellfields, biweekly monitoring

will be performed on all wells being actively used by Cameco (e.g. well 720 at the drillers pond). This will ensure that any impact of the private wells inside the license boundary on hypothetical shallow casing leaks will be quickly identified.

3.1.4 Assessment of Flooding and Erosion Potential

The potential for flooding or erosion that could impact the proposed *in-situ* Marsland mining processing facilities and mine units has been assessed through two separate studies. The complete report of the hydrologic and erosion study, including tables and figures, is provided in **Appendix K-1** (ARCADIS 2012). The complete report of the hydrologic and flood study, including tables and figures, is provided in **Appendix K-2** (ARCADIS 2013). The studies addressed guidance in NUREG-1569 for an NRC licensee to assess the potential effects of erosion or surface water flooding on a proposed uranium *in-situ* facility. The ultimate objective of the studies was to determine whether the potential for erosion or flooding may require special design features or mitigation measures to be implemented.

The studies focused on catchment and watershed delineation, hydrologic characteristics, determination of areas most prone to flooding and erosion due to rainfall runoff, and determination of flood flow characteristics. The analysis presented in **Appendix K-1** identifies proposed wells and facilities in areas of moderate to high risk of erosion that may require mitigation measures. The analysis presented in **Appendix K-2** provides estimates of storm-related discharge rates and velocities within the MEA. Seven primary tasks comprise the comprehensive hydrologic and erosion analysis:

- Data collection and analysis: rainfall, digital elevation data, soil and land use data
- Watershed delineation: dividing the project area basin into watersheds for detailed hydrologic analysisHydrologic and erosion analysis: determining the flood routing characteristics of watersheds and generating the erosion risk map using hydrologic, land use, and soil data
- Erosion risk assessment: identifying MEA wells and other site facilities in locations of high erosion potential that may require erosion mitigation;
- Flood assessment: determining estimated storm-specific discharge rates within MEA watersheds
- Flood assessment: determining estimated storm-specific flood velocities within MEA watersheds.

3.1.4.1 Data Collection

Similar data collection processes were followed for the studies presented in **Appendix K-1** and **Appendix K-2**. The data necessary to complete the studies included digital terrain data or a digital elevation model (DEM), existing floodplain maps, land use and land cover data (LULC), National Hydrography Dataset (USGS NHD) published stream network data, soil data, and rainfall data.

The terrain data were downloaded from the USGS National Elevation Dataset (NED) at a resolution of 30 m. DEM data were used throughout the model domain to describe watershed

topography and streams within the hydrologic model. The project area is in the watershed HUC12 101500020607 (Belmont Cemetery-Niobrara River Basin).

Floodplain maps in the form of Federal Emergency Management Agency (FEMA) Digital Flood Insurance Rate Maps (DFIRM) were downloaded from the FEMA Map Service Center (FEMA 2011). Land use data for the study area were the National Land Cover Data (NLCD) 2006, which were downloaded from the USGS seamless online Data Warehouse.

Supplementary data used to prepare and recondition the DEM include the USGS National Hydrography Dataset (NHD) published stream network, NHD Flowline (Simley and Carswell 2009) and the NRCS published 12-digit hydrologic unit code (HUC12) watershed delineation (NRCS 2009).

Soil data were downloaded from the NRCS geospatial data gateway, Soil Survey Geographic Database (SSURGO). Regional soil characteristics, most importantly the infiltration rate, were represented by the Soil Conservation Service (SCS) Curve Number Method. Meteorological data, including precipitation, evaporation, and runoff values, were collected from the National Ocean and Atmospheric Administration (NOAA), NWS, and NCDC.

3.1.4.2 Analysis Procedures

A detailed description of procedures used for watershed delineation and basin characteristics, hydrologic and soil erosion analysis, and modeling is presented in **Appendix K-1.** Procedures for analysis of flood characteristics are presented in **Appendix K-2.**

A GIS-based erosion model (Revised Universal Soil Loss Equation [RUSLE]) was used to investigate potential erosion in the project area. The model provides a fine spatial resolution of the model results. The RUSLE model is relatively simple and is one of the most practical methods to estimate soil erosion potential and the effects of different management practices. It was selected due to its wide acceptance, including for construction site management at the federal level in NPDES Phase II permitting (Wachal and Banks 2007, EPA 2000).

The RUSLE is the modified version of U.S. Department of Agriculture's Universal Soil Loss Equation (USLE), which has been used to measure soil loss from agriculture lands with relatively uniform slopes. The RUSLE modified certain factors in USLE to more accurately account for more complex terrain. The output of the RUSLE model is an annual rate of erosion and sedimentation in tons per acre per year, as opposed to erosion resulting from specific storm events. A detailed description of RUSLE is presented in **Appendix K-1.**

For the flood analysis, software developed by the U.S. Army Corps of Engineers Hydrologic Engineering Center was used to delineate watershed boundaries and, approximate rainfall-runoff volumes. Detailed descriptions of models and modeling procedures used are presented in **Appendix K-2**. HEC-GeoRAS software was used to construct a hydraulic model to calculate flow velocity through the study area. Peak runoff calculated from the HEC-GeoHMS modeling was applied as the peak flow in the HEC-GeoRAS modeling.

3.1.4.3 Erosion Risk Analysis

Mine units and other MEA facility locations were compared to the RUSLE map to evaluate erosion risk potential for each location. Proposed mine units, the satellite building, and the areas adjacent to the satellite building for potential placement of the access road and DDW were all evaluated. **Table 3.1-2** lists the risk of erosion for each mine unit. Maps displaying the average annual erosion potential as estimated by the RUSLE model in relation to the MUs and satellite facility locations are provided in **Appendix K-1**.

MU-A and MU-1 have low or very low erosion risk throughout the unit, while MU-C, MU-D, MU-E, and MU-F have very low erosion risk throughout the unit. MU-5 has multiple locations of moderate erosion risk. MU-2, MU-3, MU-4, and MU-B have locations of moderate and high erosion risk. Although MU-2, MU-3, MU-4, and MU-B have areas of high erosion risk, only 2 to 7 percent of the area within the units is at a moderate to high risk. Placement of well locations around areas of moderate and high potential erosion should be feasible in these units, particularly in MU-3, were only 2 percent of the land is at an increased risk of erosion. In comparison, 11 percent of MU-5 has a moderate risk of erosion. Though the overall risk of MU-5 is lower than in other units, it may be more difficult to place wells without additional mitigation measures due to the widespread risk of erosion in the unit.

If wells cannot be placed outside of areas within the wellfields deemed to have moderate to high risks, mitigation measures (e.g., berms) can be implemented to minimize the potential for flooding and erosion. The mitigation measures can be defined during final engineering and prior to any construction. Model results indicate that the risk of erosion is low or very low at the satellite facility, satellite facility access road, and DDW. Therefore, the probable need for erosion mitigation in this area is low.

As part of the concentrated flow analysis, drainage lines (i.e., channels, gulleys, or areas of concentrated flow) and DFIRM floodplain extents were compared to MU locations. Although drainage lines are the primary contributor to increased erosion risk as part of the RUSLE analysis, the model was unable to accurately define erosion rates in these areas of concentrated flow during flood events. Thus, published FEMA DFIRM 100-year floodplain extents were compared to MUs in the area. MU locations within the 100-year floodplain should be considered at risk to flooding, as well as erosion caused by flood events. Further analysis, mitigation measures, or modification of well locations should be considered for those wells near concentrated flow routes or in the 100-year floodplain during the final engineering phase and prior to well installation and construction activities.

Figures 22 through **27** of **Appendix K-1** display the drainage lines and floodplain extents relative to the MU and satellite facility locations. Drainage line 21 (NRCS HUC number 149152245) runs generally north-to-south and crosses mining units MU-2, MU-3, MU-4, and MU-5. Well locations in these mining units will be positioned outside of the floodplain or will include flood protection measures in the final engineering plans. Drainage line 24 (NRCS HUC number 149157281) crosses the proposed access road to the satellite facility. However, the proposed access road and satellite facility are not within the 100-year floodplain. The access road will be constructed with consideration given to the location of the drainage and potential for concentrated runoff and erosion to occur. Drainage line 21 is predicted to accumulate notably more surface runoff than other drainages and therefore has a higher potential for flooding and erosion. Further analysis, mitigation measures, or modification of well locations will be considered for those wells

near concentrated flow routes during the final engineering phase and prior to well installation and construction activities.

3.1.4.4 Flood Risk Analysis

The hydrologic and flood study presented in **Appendix K-2** divides the MEA into two study areas based on drainage characteristics: Hydrologic Project South and Hydrologic Project East. Hydrologic Project South contains the majority of sub-basins and drainages where project facilities and activities would occur (e.g., wellfields, satellite facility). Drainage lines 21 and 24, described above in Section 1.3.2.16, are both located within Hydrologic Project South. Peak discharge rates and flood velocities were calculated for storms with return intervals of 10, 25, 50, and 100 years and are provided in **Appendix K-2**. Model results for the 100-year storm event are described below.

Peak discharge rates for the main drainages where they exit the MEA license boundary are summarized in **Tables 3.1-3 and 3.1-4**. The peak discharge for Hydrologic Project South during a 100-year storm is estimated to be 1,455 (cfs, whereas the peak discharge for Hydrologic Project East during the same storm is estimated to be 2,659 cfs. These discharge values are almost double the rates expected for storms with a 10-year recurrence interval.

In order to determine the potential risk of project facilities and infrastructure due to flooding, the velocity of flood waters within MEA drainages during a 100-year storm were calculated using the HEC-RAS model. For the western tributary within Hydrologic Project South (drainage line 24 of **Appendix K-2**), the maximum flow velocity is estimated to be 5.8 ft/s. For the main stem drainage within Hydrologic Project South (drainage line 21 of **Appendix K-2**), the maximum flow velocity is estimated to be 6.3 ft/s upstream of the confluence with the western tributary and 6.5 ft/s downstream of the confluence. The maximum flow velocity for the main stem drainage within Hydrologic Project East is estimated to be 8.9 ft/s.

Although not within FEMA-designated flood zones, portions of the MEA may be subject to concentrated water flow during storm runoff and may also be at risk of damage. FEMA-designated flood zones supersede any estimated flood widths presented in **Appendix K-2**. For locations within or adjacent to the drainages assessed in this study, but beyond the FEMA flood zones, model results can be used as described below to estimate areas potentially affected under these circumstances, in addition to peak discharge rates and flood velocity. For example, the location where the access road to the proposed satellite facility crosses drainage line 24 (**Appendix K-2**) is outside of a FEMA-designated flood zone. However, model results indicate that runoff velocity within that drainage during a 100-year storm is estimated to be between 2.8 and 3.3 ft/s. Model results also indicate that the total width of flowing water at the access road crossing during a 100-year storm would be between approximately 140 and 220 feet.

3.1.4.5 Flood Risk Planning

CBR will use the results of the two hydrologic and erosion studies to support current and future planning and additional project design and layout. Once more detailed engineering commences, the results of these studies will be used to assess the potential for erosion and flooding that may require implementation of special design features or mitigation measures (e.g., berms around areas of MUs, strategically located drainage channels, culverts on roadways). Additional hydrologic and erosion analysis may be required during specific phases of site grading and

Deleted: to be implemented
Deleted: MUs
Deleted: mine units

engineering design to supplement the current studies. For example, specific phases requiring additional analysis may include the final design of MU (locations of buildings, wells, and piping), DDWs, or the satellite facility building and associated structures.

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Deleted: DDWs
Deleted: deep disposal wells

3.1.4.6 Surface Water Management and Erosion Control

In general, CBR will carry out tasks including the following in regard to surface water management and erosion control.

CBR will use ditches, diversions, culverts and other best management practices (BMPs) to control surface water flow within the license boundary.

An erosion and sediment control plan will be developed and implemented during construction, operation and reclamation activities in order to reduce soil losses within the license area and to protect surface and subsurface assets.

Using the results of erosion and flood analyses, CBR will construct facilities outside of these flood-prone boundaries in order to avoid potential impacts to facilities from flooding and potential impacts to major ephemeral drainages, and the Niobrara River in the event of any potential spills or leaks. When possible CBR will locate surface structures/wells outside of the 100-year flood zone boundaries. Any facilities that will have to be built within the 100-year flood zone boundaries will be protected from flood damage by the use of control measures such as diversion/collection ditches, channels, storm drains, slope drains, and/or berms.

Pipelines will be buried below the frost line, and pipeline valve stations will be located outside of the 100-year flood zone in order to avoid damage due to potential surface flooding.

Efforts will be made to avoid placement of production, injection and monitor wells in potential flood prone areas (using results of erosion and flood risk analyses), but if it is necessary to place such wells in these areas, surface water control measures (e.g., diversion or erosion control structures) will be used. Wellheads in these areas can be built so that the casing extends above grade and is mounted on a concrete pad. In addition, an above ground protective housing can be used to protect the well casing in the event of flooding. CBR currently uses an anchored metal or plastic protective housing (similar to a 55-gallon drum with the ends cut out), which affords protection in the event of flooding. As applicable, well heads will be sealed in order to withstand brief periods of submergence.

Deleted: housing
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CBR will carry out all construction tasks in compliance with applicable NPDES stormwater general permit requirements.

Sections 4.2.1.14 and 7.2.6 describe mitigation measures used to protect surface water from potential spills and leaks. Section 7.2.5.3 describes mitigation measures used to protect groundwater from potential spills and leaks.

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3.1.4.7 Erosion Control during Construction and Decommissioning

The events that carry the greatest potential for erosion and sedimentation will be the construction and decommissioning phases of the MEA project. Land management and farming techniques will be used by CBR in order to minimize the erosion of disturbed, reclaimed, and native areas.

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Mitigation measures are discussed in Section 7.2.2. CBR will typically prepare and seed ground areas that are disturbed as soon as possible in order to minimize the potential for erosion. As discussed above, erosion controls (runoff control diversion structures, storm drains, slope drains, channels, mulch, cover crops, rip-rap, sediment fences, and other controls) will be used in order to reduce overland flow velocity, reduce runoff volume, and minimize the transport of sediment into drainages. Construction of the mine units will be sequenced so that only part of the site is affected at one time. This sequencing provides a timeline that coordinates the timing of land-disturbing activities and the installation of erosion and sediment control measures (EPA 2013). This will assist with the erosion and sediment control because it helps to ensure that management practices are installed where necessary and when appropriate (EPA 2013).

The need to control sediment will be most critical during wellfield construction and immediately after redistributing topsoil. Sediment control features that may be required include silt fences, sediment basins, sediment traps, vegetation buffers, and other features. CBR will use existing roads when possible and limit the various access road widths, which will minimize the surface disturbance to soil and vegetation. Traffic will be limited to established roadways to the extent possible.

Erosion and sediment controls will be developed prior to commencement of construction, at a time when site disturbance activities are clearly defined.

3.1.5 Process Description

Uranium solution mining is a process that takes place underground, or *in-situ*, by injecting lixiviant (leach) solutions into the ore body and then recovering these solutions when they are rich in uranium. The chemistry of solution mining involves an oxidation step to convert the uranium in the solid state to a form that is easily dissolved by the leach solution. H_2O_2 or gaseous O_2 is typically used as the oxidant because both revert to naturally occurring substances. Carbonate species are also added to the lixiviant solution in the injection stream to promote the dissolution of uranium as a uranyl carbonate complex.

The reactions representing these steps at a neutral or slightly alkaline pH are:

Oxidation:

$$UO_{2\,(solid)} + H_2O_{2\,(in\ solution)} \longrightarrow UO_{3\,(at\ solid\ surface)} + H_2O$$

$$UO_{2\,(solid)} + \tfrac{1}{2}\,O_{2\,(in\ solution)} \longrightarrow UO_{3\,(at\ solid\ surface)}$$

Dissolution:

$$UO_3 + 2\,HCO_3^{-1} \longrightarrow UO_2(CO_3)_2^{-2} + H_2O$$

$$UO_3 + CO_3^{-2} + 2HCO_3^{-1} \longrightarrow UO_2(CO_3)_3^{-4} + H_2O$$

The principal uranyl carbonate ions formed as shown above are uranyl dicarbonate, $UO_2(CO_3)_2^{-2}$, (UDC), and uranyl tricarbonate $UO_2(CO_3)_3^{-4}$ (UTC). The relative abundance of each is a function of pH and total carbonate strength.

Solutions resulting from the leaching of uranium underground will be recovered through the production wells and piped to the satellite facility for extraction. The uranium recovery process employs the following steps:

1. Loading of uranium complexes onto an IX resin
2. Reconstitution of the leach solution by addition of CO_2 and/or $NaHCO_3$ and an oxidizer
3. Elution of uranium complexes from the resin
4. Precipitation of uranium.

The first two steps will be performed at the satellite facility. Steps 3 and 4 will be performed at the CPF. The process flow sheet for the above steps is shown on **Figure 3.1-6**. The left side of this figure depicts the uranium extraction process that is completed at the satellite facility. The right side of the figure shows the uranium recovery steps that will be performed at the CPF. Once the IX resin at the satellite facility is loaded to capacity with uranium complexes, the resin will be transferred to the CPF for the completion of uranium recovery.

3.1.5.1 Uranium Extraction

The recovery of uranium from the leach solution in the satellite facility will take place in the IX columns. The uranium-bearing leach solution enters the pressurized downflow IX column and passes through the resin bed. The uranium complexes in solution are loaded onto the IX resin in the column. This loading process is represented by the following chemical reaction:

$$2\ R\ HCO_3 + UO_2(CO_3)_2^{-2} \longrightarrow R_2UO_2(CO_3)_2 + 2HCO_3^{-1}$$

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

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

As shown in the reaction, loading of the uranium complex results in simultaneous displacement of chloride, bicarbonate, or sulfate ions.

The now barren leach solution passes from the IX columns to be reinjected into the formation. The solution is refortified with sodium and carbonate chemicals, as required, and pumped to the wellfield for reinjection into the formation. The expected lixiviant concentration and composition are shown in **Table 3.1-5.** **Table 3.1-6** lists non-radiological and radiological parameters for the lixiviant injection streams at the current operations MU-3, MU-4, MU-5, and MU-6. These are based on one sample per MU for sampling on MU-3 (July 23, 1999), MU-4 (October 31, 2003), MU-5 (August 14, 2007), and MU-6 (October 27, 2010). These measurements are considered representative of the lixiviant injections streams at the current operations, and are expected to be similar at the MEA project.

3.1.5.2 Resin Transport and Elution

Once the majority of the IX sites on the resin in an IX column are filled with uranium, the column will be taken out of service. The resin loaded with uranium will be transferred to a tanker truck for transport to the CPF for elution and final processing. Once the resin has been stripped of the uranium by elution, it will be returned to the satellite facility for reuse in the IX circuit.

At the CPF, the loaded resin will be stripped of uranium by an elution process based on the following chemical reaction:

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

After the uranium has been stripped, the resin is rinsed with a solution containing $NaHCO_3$. This rinse removes the high-chloride eluent physically entrained in the resin and partially converts the resin to bicarbonate form. In this way, chloride ion buildup in the leach solution can be controlled.

3.1.5.3 Precipitation

When a sufficient volume of pregnant eluent is held in storage, it is acidified to destroy the uranyl carbonate complex ion. The solution is agitated to assist in removal of the resulting CO_2 The decarbonization can be represented as follows:

$$UO_2(CO_3)_3^{-4} + 6H^+ \longrightarrow UO_2^{++} + 3\,CO_2 + 3H_2O$$

Sodium hydroxide (NaOH) is then added to raise the pH to a level conducive for precipitating pure crystals.

H_2O_2 is then added to the solution to precipitate the uranium according to the following reaction:

$$UO_2^{++} + H_2O_2 + 2H_2O \longrightarrow UO_4 \bullet 2H_2O + 2H^+$$

The precipitated uranyl peroxide slurry is pH adjusted, allowed to settle, and the clear solution decanted. The decant solution is recirculated back to the barren makeup tank, sent to fresh salt brine makeup, or sent to waste. The thickened uranyl peroxide is further dewatered and washed. The solids discharge is either sent to the vacuum dryer for drying before shipping or is sent to storage for shipment as slurry to a licensed recovery or converting facility.

The production aquifer at the MEA (the basal sandstone of the Chadron Formation) is the same formation currently mined at the nearby CBR property. The baseline water quality of the MEA is comparable to the water quality of the current mining operation at the CBR property. The baseline water quality at both sites exhibit elevated sodium concentrations compared to the overlying aquifers. A concern during ISR mining is that clays in the formation will interact with the lixiviant and cause a reduction in permeability.

As discussed in Section 2.6.1, The XRD clay analysis from the core taken at the MEA showed that the five predominant clays in the samples were kaolinite, chlorite, illite, mixed-layered illite/smectite, and montmorillonite. kaolinite, chlorite, and illite are less likely to be ion-exchanging clays. The smectite and montomorillonite clays known to have ion-exchanging properties have potassium and sodium signatures in the XRD analysis. The lack of a calcium or magnesium signature in the clays explains why a relatively small amount of calcium is liberated during the mining process.

The operating history at CBR has shown that the formation clays in the basal sandstone of the Chadron Formation are minimally reactive to the proposed lixiviant. A significant increase in the sodium concentrations during the mining process does not lead to a large increase in calcium concentrations in the mining solution. Careful monitoring of the pH during the mining process minimizes the chances of scale restricting the permeability at the injection well screens.

3.1.6 Wellfield and Process Wastes

All well development water will be captured in water trucks specifically labeled and dedicated for such purpose, and equipped with signage indicating that these trucks may only discharge their contents for injection into the DDW. Alternatively, these fluids may be transported to the CPF evaporation ponds, but only if there are fluid separation equipment issues at the MEA satellite facility. The operation of the satellite facility will result in a production bleed stream that is continuously withdrawn from the recovered lixiviant stream at an expected rate of 0.5 to 2.0 percent of the total volume of recovered lixiviant. The production bleed stream is taken following the recovery of uranium by IX and has the same chemical characteristics as the lixiviant. The production bleed waste stream will be managed by using a DDW, which will be constructed and operational at the satellite facility prior to commencement of production.

The other source of wastewater resulting from uranium mining activities in the MEA is the eluent bleed stream at the CPF. This existing source of wastewater at the CPF is currently produced at a rate of approximately 5 to 10 gpm. It is likely that the eluent bleed stream will increase by a maximum of 10 percent due to processing of IX resin from the satellite facility. The eluent bleed waste stream will be managed by reuse in the processing facility DDW injection at the CPF.

All byproduct material produced as a result of the operation of the satellite facility will be disposed of at a licensed facility approved for disposal of 11e.(2) byproduct material, similar to provisions made for the byproduct material currently produced. All solid waste will be disposed of in an approved landfill in accordance with current practice. There will be no onsite disposal of these materials.

3.1.7 MEA Water Balance

From 2015 to 2022, the majority of the wastewater produced at the MEA satellite facility will be the production bleed. Starting in 2022, the wastewater flows will rise sharply as the bleed from the RO process must be addressed. Other liquid wastewater generated will consist of process liquids (e.g., affected well development water, laundry water and plant washdown water). These waste streams will account for an intermittent discharge with an maximum average of 1 to 2 gpm. The disposal water balance discussed below is of such a magnitude that these small quantities of wastewaters will be small enough to be easily managed in the proposed disposal system. The well development water will be collected using a dedicated vacuum truck and delivered to the well work-over fluid tank located in the satellite building (**Figure 55.7-2**). The other liquid wastes (i.e., laundry and plant washwater originating in restricted areas) described above will flow to plant sumps and be transferred to a wastewater tank located within the satellite building. All of the above waste streams will be disposed of through the DDWs.

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Liquid waste will be generated from process bleed and groundwater restoration water (approximately 96 percent), plant cleanup water (miscellaneous non-hazardous water; approximately 2 percent), and water originating from fresh water well(s) (approximately 2 percent). The detailed MEA water balance for production and restoration for the life of the project is shown in **Appendix T**. The project required disposal water balance is presented **Table 3.1-7** and depicted graphically in **Figure 3.1-7**. These water balances illustrate the anticipated water management and disposal capacity needed for production bleed and restoration activities. These schedules are based on installation of two wells prior to commencing operation, with the

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assumption that each well will have an injection capacity of approximately 45 gpm. The 45 gpm injection capacity assumption is based upon the Crow Butte well with lower flow. Both of the DDWs at the existing plant are drilled into the same formations proposed for the MEA.

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Deleted: at the existing plant.

Two DDWs will accommodate all wastewater generated from startup in 2015 through the end of 2020. In 2021, groundwater restoration will result in increased wastewater volumes, which will require additional disposal capacity. Considering the capacity of the two DDWs, the need to install additional deep disposal well(s) and/or new surge/evaporation ponds will be evaluated to supply long-term wastewater disposal. CBR has submitted an area permit application for multiple Class I nonhazardous waste injection wells at the MEA site.

Operating procedures at the MEA site that will minimize the amount of water requiring disposal via DDW include: designing wellfields to maximize the ability to continuously minimize the amount of production bleed through continuous and effective wellfield balancing; minimizing the consumptive use of process water by injecting all of the ISR fluids except for the small production and restoration bleed streams necessary to maintain an inward hydraulic gradient in each wellfield configuration; and if necessary, using two stages of RO to treat restoration fluids and reduce the total required wastewater disposal capacity.

As shown in **Appendix T**, only five mine units will be in production mode at any one given time. Total production flow over the life of the project will be variable, ranging from 1,100 to 5,400 gpm. The production bleed (1.2 percent) and the RO bleed, over the life of operations, will vary from approximately 25 to 65 gpm and 80 to 250 gpm, respectively. Permeate flows will vary from 500 to 750 gpm, with 750 gpm being the estimated average flow from 2022 to 2037. The amount of brine sent to DDW will range from approximately 167 to 250 gpm beginning in year 2022 and continuing until 2037.

Figure 3.1-8 depicts the water balance at MEA during the third quarter of 2024 when maximum production and restoration flows will occur (5,400 gpm and 1,800 gpm, respectively). As illustrated in **Figures 3.1-8** up to an additional 315 gpm (65 gpm production bleed plus 250 gpm RO bleed) of disposal capacity is needed to accommodate groundwater restoration. DDWs are expected to provide all of the disposal capacity needed at each expansion area. As has been demonstrated at the CPF, DDW injection rates may vary from the assumed 45 gpm per well at the MEA site

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Until the capacity of the first two DDWs is known, the exact needs for additional water disposal wells beyond 2020 are not understood. Additional disposal options required for use during production and restoration activities will be dependent on the volume of wastewater generated, the efficiency of production and restoration activities including the RO process, and the actual injection capacity of DDWs, e.g., surge/evaporation ponds and/or land application.

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For the years 2015 through 2020 , two DDWs will be used. Each DDW can act as a backup for the other if maintenance is required. At the same time, plant operations can be curtailed as needed to ensure that an inward hydraulic gradient is maintained. A third option would be trucking water to the CPF evaporation ponds.

In the event of an extended total facility shutdown (e.g., lengthy power failures), the ability to maintain hydraulic containment of the wellfields has been assessed. This analysis demonstrated

that hydraulic containment of the ISR wellfields could be provided using one or two wells (powered by portable generator) located near the downgradient edge of the mine unit wellfield, operating at a total pumping rate of 30 gpm. Groundwater extracted from the ISR wellfields would be either disposed of in an onsite DDW equipped with a portable generator, or trucked to the main CPF facility for disposal in the evaporation ponds.

In order to evaluate the ability to maintain hydraulic containment during an extended total facility shutdown, the following basic analyses were performed (Aqui-Ver 2013b):

- The maximum velocity of groundwater under non-pumping conditions was calculated for the MEA ISR wellfields.
- A hypothetical pumping well was placed within an ISR wellfield, and the zone of hydraulic containment (capture zone) was computed using an analytical groundwater flow model and particle tracking techniques. The well location and pumping rate were adjusted until an optimal capture zone was achieved.

Groundwater Velocity of the Basal Sandstone of the Chadron Formation

Under non-pumping conditions (e.g. facility shut down, pre-development), the velocity of groundwater within the basal sandstone of the Chadron Formation (production aquifer) can be computed from Darcy's Law and a knowledge of aquifer properties and hydrologic data collected as part of the regional aquifer pumping test conducted at the MEA in May 2011 (Aqui-Ver 2011), as follows:

V = KI/ne

where V is the groundwater velocity, K is the hydraulic conductivity of the production aquifer, I is the baseline or pre-development hydraulic gradient, and ne is the aquifer effective porosity.

As a conservative measure, the maximum groundwater velocity was computed by using the maximum observed values for hydraulic conductivity (61.7 ft/day) and hydraulic gradient (0.00048) identified from baseline sampling and aquifer testing at the MEA. Using these aquifer properties and an estimated effective aquifer porosity of 0.2, the resulting maximum groundwater velocity of the production aquifer is approximately 0.15 ft/day (55 ft/year). It was concluded from this calculation that mining solutions from ISR operations would only migrate a very small distance over any reasonable period of time representing temporary facility shutdown.

ISR Wellfield Hydraulic Containment Analysis

Additional analyses were performed to demonstrate that hydraulic containment can be maintained in the event of an extended facility shut-down. Because groundwater velocity is a maximum of 0.15 ft/day, hydraulic containment would essentially be provided without active remediation unless monitor wells were already on excursion status. Therefore, for purposes of this analysis, we have assumed a worst-case scenario in which downgradient monitor wells are on excursion status when the facility experiences a hypothetical temporary shut-down.

To accomplish this task, an analytical groundwater flow model (ESI 1999) was used to simulate groundwater flow in the production aquifer at the MEA. Particle-tracking techniques were used to illustrate the zone of hydraulic containment (capture zone) produced by a hypothetical pumping

well(s) placed within an ISR wellfield. MU-5 at the MEA was used for illustrative purposes in this analysis.

The monitor well ring is assumed to be located 300 feet from the edge of the ISR wellfield pattern area (production zone), identical to the design used at the main Crow Butte ISR facility. Input parameters for the groundwater flow model were assigned in order to produce a conservatively small capture zone and provide a margin of safety, as follows:

- Aquifer Transmissivity (T) - 2469 ft^2/day (maximum observed from aquifer pumping test) (Aqui-Ver 2011)
- Regional Hydraulic Gradient (I) – 0.00048 (maximum observed from baseline monitoring) (Aqui-Ver 2011)
- Effective Porosity – 0.2
- Pumping Rate – 30 gpm

The zone of hydraulic containment was computed using reverse particle-tracking techniques after 30-days of pumping (zone will expand over time). **Figure** 3.1-9 illustrates the zone of hydraulic containment produced by a single well placed near the downgradient edge of the MU-5 wellfield. The zone of hydraulic containment includes the entire ISR wellfield plus an adequate buffer zone. Although an adequate zone of containment is provided using a single well operating with a sufficiently large pump at 30 gpm, a similar zone of containment can be provided using two wells operating at 15 gpm each (30 gpm total) located in the same general location and separated by approximately 300 feet (east-west) along the downgradient edge of the mine unit.

The 30 gpm pumping rate is conservatively estimated based on maximum values of aquifer transmissivity and hydraulic gradient observed at the site. Under more realistic conditions (e.g. using average values for aquifer properties), the pumping rate needed to maintain hydraulic containment is significantly lower (10 gpm).

These results are generally applicable to all MEA mine units. If multiple mine units are in operation at the time of the hypothetical shut-down, additional wells would be needed (e.g. one or two wells at a total rate of 30 gpm per mine unit) to maintain complete containment of multiple mine units.

Historically, power outages at the CPF site last less than 24 hours. The longest time without power at the CPF was approximately 40 hours due to a winter storm. Potential adverse impacts associated with power outages are not anticipated.

CBR will ensure that adequate DDW disposal capacity is available at each mine unit under normal operating conditions during production, production and restoration, and restoration phases described in this document. Such capacity demonstration will be phased, initially to address years 2015 through 2020 (with two DDWs), with additional demonstrations as needed in order to address future increases in production and restoration flows. Capacity demonstrations will be addressed in written procedures for NRC written verification prior to preoperational inspection (for years 2015 through 2020) and prior to construction of future mine unit expansions beginning in 2021.

Cumulative impacts associated with the potential impacts on groundwater due to the concurrent operations of the CPF, MEA, NTEA, and TCEA projects are discussed in Sections 7.2.5 and 7.2.5.2.

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3.2 Central Processing Facility, Satellite Facility, Wellfield, and Chemical Storage Facilities – Equipment Used and Material Processed

The uranium recovery process described in the preceding section will be accomplished in two steps. The uranium recovery from the leach solution by IX will be performed at the satellite facility. The subsequent processing of the loaded IX resin to remove the uranium (elution), the precipitation of uranium, and the dewatering and packaging of solid uranium (yellowcake) will be performed at the existing CPF. Depending upon the mining timelines for the existing CPF wellfields and the MEA, it is possible that the belt filter and dryer capacity at the CPF may need to be increased.

3.2.1 Marsland Satellite Facility Equipment

Only the equipment proposed for the satellite facility is described in this section. The equipment and processes in the CPF are covered under the existing NRC Source Materials License Number SUA-1534. A general arrangement of equipment for the satellite facility is shown on **Figure 55.7-2**. The satellite facility equipment will be housed in a building approximately 130 feet long by 100 feet wide. The satellite facility equipment includes the following systems:

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- Ion exchange
- Filtration
- Resin transfer
- Chemical addition.

The satellite facility will be located within section 12, T29N, R51W. The DDW will be located nearby (**Figure 1.7-5**). **Figure** 5.7-2 shows the plan view of the satellite facility.

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The satellite facility will house the IX columns, water treatment equipment, resin transfer facilities, pumps for injection of lixiviant, wastewater tanks, and an employee lunch room/break area. Bulk soda ash, CO_2 and O_2 in compressed form, and/or H_2O_2 will be stored adjacent to the satellite facility or in the wellfield. $NaHCO_3$ and/or gaseous CO_2 are added to the lixiviant as the fluid leaves the satellite facility for the wellfield. Gaseous O_2 is added to the injection line for each injection well at the wellhouses.

The IX system consists of eight fixed-bed IX columns. The IX columns will be operated as three sets of two columns in series with two columns available for restoration. The IX system is designed to process recovered leach solution at a maximum rate of 6,000 gpm. Once a set of columns is loaded with uranium, the resin is transferred to a truck for transport to the CPF. The downflow columns are pressurized, sealed systems, so there is no overflow of water; O_2 stays in solution; and radon emissions are contained. Radon releases from the pressurized downflow columns occur only when the individual columns are disconnected from the circuit and opened to remove the resin for elution. One disadvantage of the downflow column is that there must be

good pressure control. Exposure pathways associated with downflow columns to be used at MEA are discussed in Section 7.3.1.

After the IX process, the barren leach solution recovered from the wellfield is replenished with an oxidant and leaching chemicals (i.e., $NaHCO_3$ and/or CO_2). The injection filtration system consists of optional backwashable filters, with an option of installing polishing filters downstream. The lixiviant injection pumps are centrifugal type.

The areas in the proposed satellite facility where fumes or gases could be generated are discussed in Section 7.3. The potential sources are minimal in the satellite facility because the mining solutions contained in the process equipment are maintained under a positive pressure. Building ventilation in the process equipment area will be accomplished by the use of an exhaust system that draws in fresh air and sweeps the satellite facility air to the atmosphere.

3.2.2 Chemical Storage Facilities

Chemical storage facilities at the satellite facility will include both hazardous and non-hazardous material storage areas. Bulk hazardous materials, which have the potential to impact radiological safety, will be stored outside and segregated from areas where licensed materials are processed and stored. Other non-hazardous bulk process chemicals (e.g., $NaCO_3$) that do not have the potential to impact radiological safety may be stored within the satellite facilities.

3.2.2.1 Process-Related Chemicals

Process-related chemicals stored in bulk at the satellite facility will include carbon dioxide (CO_2), oxygen (O_2), and hydrogen peroxide (H_2O_2). Sodium sulfide (Na_2S) may also be stored for use as a reductant during groundwater restoration.

CO_2

CO_2 is stored adjacent to the satellite facility, where it will be added to the lixiviant prior to leaving the satellite facility.

O_2

O_2 is also typically stored at the satellite facility, or within wellfield areas, where it is centrally located for addition to the injection stream in each wellhouse. Because O_2 readily supports combustion, fire and explosion are the principal hazards that must be controlled. The O_2 storage facility will be located a safe distance from the satellite facility and other chemical storage areas for isolation. The storage facility will be designed to meet industry standards in NFPA-50 (NFPA 1996).

O_2 service pipelines and components must be clean of oil and grease because gaseous O_2 will cause these substances to burn with explosive violence if ignited. All components intended for use with the O_2 distribution system will be properly cleaned using recommended methods in CGA G-4.1 (CGA 2000). The design and installation of O_2 distribution systems is based on CGA-4.4 (CGA 1993).

Na_2S

Hazardous materials typically used during groundwater restoration activities include the addition of a chemical reductant (i.e., Na_2S or hydrogen sulfide [H_2S] gas). To minimize potential impacts to radiological safety, these materials are stored outside of process areas. Na_2S is currently used as the chemical reductant during groundwater restoration at the current license area. The material consists of a dry flaked product and is typically purchased on pallets of 55-pound bags or super sacks of 1,000 pounds. The bulk inventory is stored outside of process areas in a cool, dry, clean environment to prevent contact with any acid, oxidizer, or other material that may react with the product. H_2S gas has never been used at the CPF. In the event that CBR determines that use of H_2S as a chemical reductant is necessary, proper safety precautions will be taken to minimize potential impacts to radiological and chemical safety.

As part of the SHEQMS, a risk assessment was completed to identify potential hazards and risks associated with chemical storage facilities (and other processes) and to mitigate those risks to acceptable levels. The risk assessment process identified hydrochloric acid as the most hazardous chemical with the greatest potential for impacts to chemical and radiological safety. The hydrochloric acid storage and distribution system is located only at the CPF and will not be used at the satellite facility.

None of the hazardous chemicals used at the CPF are covered under the EPA Risk Management Program (RMP) regulations. The RMP regulations require certain actions by covered facilities to prevent accidental releases of hazardous chemicals and minimize potential impacts to the public and environment. These actions include measures such as accidental release modeling, documentation of safety information, hazard reviews, operating procedures, safety training, and emergency response preparedness.

3.2.2.2 Non-Process Related Chemicals

Non-process related chemicals that will be stored at the satellite facility include petroleum (gasoline, diesel) and propane. Due to the flammable and/or combustible properties of these materials, all bulk quantities will be stored outside of process areas at the satellite facility. All gasoline and diesel storage tanks are located above ground and within secondary containment structures to meet regulatory requirements

3.3 Satellite Facility Instrumentation and Control

The instrumentation and controls at the MEA will be configured similar to those at the existing Crow Butte plant. Other than newer equipment, the interaction among the operators, computers, instrumentation, alarm systems, and process equipment will not change. The configuration employed at the existing Crow Butte plant has effectively minimized upsets and provides balanced operation.

The wellhouse will be located remotely from the satellite facility building. A distribution system will be used to control the flow to and from each well in the wellfield. Wellfield instrumentation will measure total production and injection flow and indicate the pressure being applied to the injection trunklines. A wellhouse will be equipped with wet alarms to monitor the presence of liquids in the wellhouse sumps. The system is monitored 24 hours per day, 7 days per week by control room operators. The operators rely on visual and audible alarms from a variety of

systems to control mine operations. Power failures, pressure exceedances and flow disruption are some of the conditions for which alarm systems will be monitored.

Instrumentation will monitor the total flow into the satellite facility, the total injection flow leaving the facility, and the total waste flow leaving the facility. Instrumentation on the facility injection manifold will record an alarm in the event of any pressure loss that might indicate a leak or rupture in the injection system. The instruments used for flow measurement will include, but are not limited to, turbine meters, ultrasonic meters, variable area meters, electromagnetic flow meters, differential pressure meters, positive displacement meters, and piezoelectric and vortex flow meters.

The injection pumps are equipped with pressure reducing valves so that they are incapable of producing pressures high enough to exceed design pressure of the injection lines, the 125 psi integrity test, the maximum pressure demonstrated in each injection well, or the 100 psi maximum injection pressure measured at the wellhouse manifold. Pressure gauges, pressure shutdown switches, and pressure transducers will be used to monitor and control the trunkline pressures. During power failures, overpressuring of wells is not possible, as all pump systems are shut down.

The basic control system at the satellite facility and associated wellfield will be built around a Sequential Control and Data Acquisition (SCDA) network. At the heart of this network is a series of programmable logic controllers. This system allows for extensive monitoring and control of all waste flows, wellfield flows, and facility recovery operations.

The SCDA system will be interconnected throughout the facility via a Local Area Network (LAN) to computer display screens. The software used to display facility processes and collect data incorporates a series of menus which allows the facility operators to monitor and control a variety of systems and parameters. Critical processes, pressures, and wellfield flows will have alarmed set-points that alert operators when any are out of tolerance. The injection manifold in each wellhouse is alarmed at 90 to 95 psi, to ensure that the pressure remains below the 100 psi maximum injection pressure measured at the wellhouse manifold. As noted in the application, due to line losses, the actual pressure at the wellhead is lower than the pressure monitored in the wellhouse manifold.

In addition, each wellhouse will contain its own processor, which will allow it to operate independent of the main computer. Pressure switches will be fitted to each injection manifold in the wellhouse to alert the facility and wellfield operators of increasing manifold pressures. All critical equipment will be equipped with uninterruptible 30-minute power supply systems in the event of a power failure.

Through this system, not only will the facility operators be able to monitor and control every aspect of the operation in real-time, but management will be able to review historical data to develop trend analysis for production operations. This will not only ensure an efficient operation, but will allow Crow Butte personnel to anticipate problem areas and to remain in compliance with appropriate regulatory requirements.

In the process areas, tank levels are measured in chemical storage tanks as well as process tanks.

Detailed information on the instrumentation and controls will be developed as part of the final design activities prior to construction. This information will be made available to the NRC for review prior to any construction activities. The final design, including installation and use of devices to monitor injection pressure, flow rate, and volume, must be submitted for approved by the NDEQ and written verification by the NRC.

Handheld radiation detection instruments and portable samplers will be used to monitor radiological conditions at the satellite facility. Specifications for this equipment are included in the SHEQMS Volume IV, Health Physics Manual, and are discussed in further detail in Section 5. The locations of monitoring points, monitoring procedures, and monitoring frequencies for in-plant radiation safety are also discussed in Section 5.

The types of health physics instrumentation that would be used at the proposed MEA include the following:

Air Sampling Equipment

- Eberline RAS-1 or Aircon 2 samplers (0-100 lpm) or equivalent

  Calibrated semiannually or after repair on site with a primary standard instrument or a properly calibrated secondary standard instrument
- BDX II or SKC lapel samplers (0-5 lpm) or equivalent

  Calibrated daily before each use on site with a primary standard instrument or a properly calibrated secondary standard instrument.

External Radiation Equipment

- Ludlum Model 19 Gamma Meter (μR/hr) or equivalent
- Ludlum Model 3 Gamma Meter with Ludlum Model 44-38 G-M detector (mR/hr) or equivalent
- Ludlum Model 2221 Ratemeter/Scaler with a Ludlum Model 44-10 NaI detector (CPM) or equivalent

  Calibrated annually or after repair manufacturer or qualified accredited vendor.

Surface Contamination Equipment

- Ludlum Model 2241 scaler or a Ludlum Model 12 Ratemeter with a Model 43-65 or Model 43-5 alpha scintillation probe or equivalent (Total Alpha)
- Ludlum Model 177 Ratemeter with a Ludlum Model 43-5 alpha scintillation probe or equivalent (Personnel Contamination)
- Ludlum Model 2000 Scaler or Model 2200 Scaler with an Eberline SAC-R5 or Ludlum Model 43-10 alpha scintillation sample counter or equivalent (Removable Alpha, Radon Daughters, Airborne Radioactivity)

Instruments will be calibrated annually or at a frequency recommended by the manufacturer, whichever is more frequent. Repairs will be by the manufacturer by or by a qualified accredited vendor, and the instrument will be calibrated following such repair. The calibration vendor shall provide the as-found calibration condition of each instrument. If more than 10 percent of the

instruments are out of calibration when received by the calibration vendor, more frequent calibration will be considered.

New radiation survey instruments will be acquired for use at the MEA. The number of instruments purchased will be sufficient so that backup instruments are available in the event of failure of one, or if one instrument has been sent to the vendor for calibration or repair.

The manufacturer or a qualified accredited vendor shall calibrate portable survey instruments, counter/scalers, mass flow meters and/or dry cell calibrators, and calibration sources. Calibration will be performed as recommended in ANSI N323 and ANSI N323A. The ANSI standard requires that radiation detection instruments are performance tested annually to verify that they continue to meet operational and design requirements. Instruments must be tested for range, sensitivity, linearity, detection limit, and response to overload. The specific calibration requirements for various types of instruments are discussed in the SHEQMS Volume IV Health Physics Manual.

RG 8.30 specifies requirements for routine maintenance and calibration of radiological survey instruments. RG 8.30 references the standards contained in ANSI N323-1978, Radiation Protection Instrumentation Test and Calibration. ANSI is in the process of a major revision of this Standard that will result in three separate Standards applicable to radiological instrumentation. The first revision, ANSI-N323A-1997, Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments, was incorporated in this Chapter. When conflicts arise between NRC RG 8.30 and the ANSI Standard, the RG recommendations will be followed.

Calibration vendors will provide a certificate of calibration for all instruments. These calibration certificates will be maintained by the Radiation Safety Officer (RSO) on file for that instrument. Records of repair completed by the calibration vendor will also be maintained in the instrument file.

Documentation of calibration of air samplers performed on site will be maintained by the RSO in the sampler file.

Records of instrument checks, including the daily checks and initial checks, will be maintained in a format determined by the RSO. These records will be readily available and in a format that will allow the RSO to review the records for potential problems (e.g., background drift in a continuous direction, battery check that does not respond, ratemeter that does not zero and alpha background rates greater than 0.5 CPM).

All records of instrument calibration and checks will be retained until NRC License termination. The RSO will be responsible for record retention.

Details about calibration, functional tests, procedures, and recordkeeping/retention are discussed in the SHEQMS Volume IV Health Physics Manual.

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Table 3.1-1 Background Information for Logging Probes Used at the Marsland Expansion Area

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Table 3.1-2 Summary of Risk of Erosion for Proposed Marsland Expansion Area Mine Units

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Table 3.1-3 The Peak Flow for Hydrologic Project South

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Table 3.1-4 The Peak Flow for Hydrologic Project East

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Table 3.1-5 Typical Lixiviant Concentrations

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Table 3.1-6 Lixiviant Parameters Measured in the Injection Stream at Crow Butte MU-3, MU-4, MU-55 and MU-6

Parameter	Concentration	Mine Unit Results				Reporting Limit
		MU-3	MU-4	MU-5	MU-6	
Major Ions, Suspended						
Alkalinity, Total as $CaCO_3$	mg/L	1,180	1,680	1,200	1,740	1.0
Bicarbonate as HCO_3	mg/L	1,440	2,050	1,540	2,120	1.0
Carbonate	mg/L	<1.0	<1.0	<1.0	<5.0	1.0 – 5.0
Calcium	mg/L	95	77.4	75.0	73 [a]	1.0 – 2.0
Chloride	mg/L	681	603	581	714 [a]	1.0 – 4.0
Fluoride	mg/L	0.47	0.6	0.6	0.5	0.1
Magnesium	mg/L	25	22.9	22.0	23.0	1.0
Nitrogen, Total Ammonia as N	mg/L	<0.05	<0.05	<0.05	<0.05	0.05
Nitrite, as N	mg/L	<0.10	<0.1	<0.10	ND	0.10
Nitrite + Nitrate as Nitrogen	mg/L	0.49	0.46	0.5	0.4	0.05 – 0.1
Potassium	mg/L	40	35.3	34.0	32	1.0
Silica		21.5	21.0	22.2	24.1	1.0
Sodium	mg/L	1,240	1,310	1,220	1,460 [a]	1.0 – 3.0
Sulfate	mg/L	740	901	915	708 [a]	1.0 - 20
Physical Properties						
Conductivity @ 25° C	µmhos/cm	6,020	6,260	5,260	5,930	1.0
pH, Field	s.u.	7.81	8.19	7.67	7.99	0.1
Total Dissolved Solids, TDS @ 180 °C	mg/L	3,680	4,080	3,330	4,110 [a]	2.0 - 16
Metals, Dissolved						
Aluminum	mg/L	<0.1	<0.1	<0.1	<0.1	0.10
Arsenic	mg/L	0.062	0.057 [a]	0.046	0.049	0.001- 0.002
Barium	mg/L	<0.10	<0.1	<0.1	<0.1	0.10
Boron	mg/L	1.0	1.10	1.2	1.3	0.10
Cadmium	mg/L	<0.005	<0.005	<0.005	<0.005	0.005
Chromium	mg/L	<0.05	<0.05	<0.05	<0.05	0.05
Copper	mg/L	0.06	0.04	0.02	0.02	0.01
Iron	mg/L	<0.05	<0.05	<0.03	<0.03	0.03 - 0.05
Lead	mg/L	<0.05	<0.05	0.001	<0.001	<0.001 0.03 - 0.05
Manganese	mg/L	0.07	0.05	0.04	0.03	0.01
Mercury	mg/L	<0.001	<0.001	<0.001	<0.001	0.001
Molybdenum	mg/L	0.40	0.5	1.4	0.4	0.10
Nickel	mg/L	<0.05	<,0.05	<0.05	<0.05	0.05
Selenium	mg/L	0.065	0.073 [a]	0.096	0.128	0.001- 0.005
Vanadium	mg/L	1.10	2.2	1.3	0.8	0.01
Zinc	mg/L	0.10	0.02		0.01	0.01
Radionuclides						
Uranium	mg/L	2.10	3.70 [a]	0.636	0.951	0.0003
Uranium, Activity	µC i/mL	ND	ND	ND	6.4E-07	2.0E-10
Ra-226	pCi/L	991	ND	969	1,150	0.2
Radium Error Estimate ±	--	9.4	--	34.7	7.0	--
Radium 226 MDC	pCi/L	ND	ND	ND	0.18	--
Quality Assurance Data	--	--	--	--	--	**Target Range**
Anion	meq	58.26	ND	ND	ND	--
Cation	meq	61.80	ND	ND	ND	--
WYDEQ A/C Balance	%	2.95	ND	ND	ND	-5 - + 5
Calc. TDS	mg/L	3,565	ND	ND	ND	--

mg/L = milligrams per liter s.u = standard unit µCi/mL = microCuries per milliter meq = milliequivalent pCi/L= picoCuries per liter µmhos/cm =µ mhos/cm = micromhos per centimeter < = less than MDC = minimum detectable concentration ND = No data
[a] Reporting Limit increased due to sample matrix WYDEQ = Wyoming Department of Environmental Quality

Table 3.1-7 Disposal Water Balance (Marsland Expansion Area), Crow Butte Resources, Inc., Crawford, NE

Year	2015				2016				2017				2018				2019			
Elapsed Time (Quarters)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Prod Flow	1100	1700	2100	2100	2100	2700	3400	3600	3500	3900	4500	4700	4500	4800	5300	5400	5100	5300	5300	5300
Prod Bleed 1.2%	13	20	25	25	25	32	41	43	42	47	54	56	54	58	64	65	61	64	64	64
MU1 IX Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU1 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU2 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU3 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU4 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU5 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU6 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU7 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU8 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU9 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU10 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU11 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total disposal capacity needed (gpm)	13	20	25	25	25	32	41	43	42	47	54	56	54	58	64	65	61	64	64	64
Cumulative	13	34	59	84	109	142	182	226	268	314	368	425	479	536	600	665	726	790	853	917
Production bleed capacity needed (gpm)	13	20	25	25	25	32	41	43	42	47	54	56	54	58	64	65	61	64	64	64
Restoration capacity needed (gpm)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total disposal capacity needed (gpm)	**13**	**20**	**25**	**25**	**25**	**32**	**41**	**43**	**42**	**47**	**54**	**56**	**54**	**58**	**64**	**65**	**61**	**64**	**64**	**64**
Disposal Option(s)	DDW1	DDW1	DDW1	DDW1	DDW1	DDW1	DDW1	DDW1	DDW1	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)

Notes:

(1) Additional deep disposal wells will be installed as needed

Assumed start date = 1Q 2015

gpm - gallons per minute

hr - hours

DD1 - Deep Disposal Well 1

DD2 - Deep Disposal Well 2

Assumed sustainable DDW injection rates = 45 gpm

Table 3.1-7 Disposal Water Balance (Marsland Expansion Area), Crow Butte Resources, Inc., Crawford, NE

Year	2020				2021				2022				2023.				2024			
Elapsed Time (Quarters)	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Prod Flow	4500	4500	4200	4100	4100	4600	4500	4300	4300	4800	4800	4500	4500	5000	5100	4800	4800	5300	5400	5100
Prod Bleed 1.2%	54	54	50	49	49	55	54	52	52	58	58	54	54	60	61	58	58	64	65	61
MU1 IX Bleed	0	16	16	16	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU1 RO Bleed	0	0	0	0	167	167	167	167	167	167	167	167	167	0	0	0	0	0	0	0
MU2 RO Bleed	0	0	0	0	0	0	0	0	83	83	83	83	83	167	167	167	167	167	167	167
MU3 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	83	83	83	83	83	83	83
MU4 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU5 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU6 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU7 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU8 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU9 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU10 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU11 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total disposal capacity needed (gpm)	54	70	66	65	220	222	221	218	302	308	308	304	304	310	311	308	308	314	315	311
Cumulative	971	1041	1107	1172	1392	1614	1835	2053	2355	2662	2970	3274	3578	3888	4199	4507	4814	5128	5443	5754
Production bleed capacity needed (gpm)	54	54	50	49	49	55	54	52	52	58	58	54	54	60	61	58	58	64	65	61
Restoration capacity needed (gpm)	0	16	16	16	170.667	167	166.667	166.667	250	250	250	250	250	250	250	250	250	250	250	250
Total disposal capacity needed (gpm)	**54**	**70**	**66**	**65**	**220**	**222**	**221**	**218**	**302**	**308**	**308**	**304**	**304**	**310**	**311**	**308**	**308**	**314**	**315**	**311**
Disposal Option(s)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)

Notes:

(1) Additional deep disposal wells will be installed as needed

Assumed start date = 1Q 2015

gpm - gallons per minute

hr - hours

DD1 - Deep Disposal Well 1

DD2 - Deep Disposal Well 2

Assumed sustainable DDW injection rates = 45 gpm

Table 3.1-7 Disposal Water Balance (Marsland Expansion Area), Crow Butte Resources, Inc., Crawford, NE

Year	2025				2026				2027				2028				2029			
Elapsed Time (Quarters)	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Prod Flow	5300	5300	5200	4700	4300	3700	3900	3600	3400	3700	3900	3500	3200	2900	2600	2400	2200	1800	1600	1500
Prod Bleed 1.2%	64	64	62	56	52	44	47	43	41	44	47	42	38	35	31	29				
MU1 IX Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU1 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU2 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU3 RO Bleed	167	167	167	167	167	167	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU4 RO Bleed	83	83	83	83	83	83	167	167	167	167	167	167	0	0	0	0	0	0	0	0
MU5 RO Bleed	0	0	0	0	0	0	83	83	83	83	83	83	167	167	167	167	167	167	0	0
MU6 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	83	83	83	83	83	83	167	167
MU7 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	83	83
MU8 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU9 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU10 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU11 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total disposal capacity needed (gpm)	314	314	312	306	302	294	297	293	291	294	297	292	288	285	281	279	250	250	250	250
Cumulative	6067	6381	6693	7000	7301	7596	7893	8186	8477	8771	9068	9360	9648	9933	10214	10493	10743	10993	11243	11493
Production bleed capacity needed (gpm)	64	64	62	56	52	44	47	43	41	44	47	42	38	35	31	29	0	0	0	0
Restoration capacity needed (gpm)	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
Total disposal capacity needed (gpm)	**314**	**314**	**312**	**306**	**302**	**294**	**297**	**293**	**291**	**294**	**297**	**292**	**288**	**285**	**281**	**279**	**250**	**250**	**250**	**250**
Disposal Option(s)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)

Notes:

(1) Additional deep disposal wells will be installed as needed

Assumed start date = 1Q 2015

gpm - gallons per minute

hr - hours

DD1 - Deep Disposal Well 1

DD2 - Deep Disposal Well 2

Assumed sustainable DDW injection rates = 45 gpm

Table 3.1-7 Disposal Water Balance (Marsland Expansion Area), Crow Butte Resources, Inc., Crawford, NE

Year	2030				2031				2032				2033				2034			
Elapsed Time (Quarters)	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Prod Flow	1400	1300	1200	900	800	700	600	500	400	200	200	200	200	200	200	0	0	0	0	0
Prod Bleed 1.2%																				
MU1 IX Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU1 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU2 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU3 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU4 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU5 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU6 RO Bleed	167	167	167	167	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU7 RO Bleed	83	83	83	83	167	167	167	167	167	167	0	0	0	0	0	0	0	0	0	0
MU8 RO Bleed	0	0	0	0	83	83	83	83	83	83	167	167	167	167	167	167	0	0	0	0
MU9 RO Bleed	0	0	0	0	0	0	0	0	0	0	83	83	83	83	83	83	167	167	167	167
MU10 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	83	83	83	83
MU11 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total disposal capacity needed (gpm)	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
Cumulative	11743	11993	12243	12493	12743	12993	13243	13493	13743	13993	14243	14493	14743	14993	15243	15493	15743	15993	16243	16493
Production bleed capacity needed (gpm)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Restoration capacity needed (gpm)	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
Total disposal capacity needed (gpm)	**250**	**250**	**250**	**250**	**250**	**250**	**250**	**250**	**250**	**250**	**250**	**250**	**250**	**250**	**250**	**250**	**250**	**250**	**250**	**250**
Disposal Option(s)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)

Notes:

(1) Additional deep disposal wells will be installed as needed

Assumed start date = 1Q 2015

gpm - gallons per minute

hr - hours

DD1 - Deep Disposal Well 1

DD2 - Deep Disposal Well 2

Assumed sustainable DDW injection rates = 45 gpm

Table 3.1-7 Disposal Water Balance (Marsland Expansion Area), Crow Butte Resources, Inc., Crawford, NE

Year	2035				2036				2037				2038				2039	
Elapsed Time (Quarters)	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98
Prod Flow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Prod Bleed 1.2%																		
MU1 IX Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU1 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU2 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU3 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU4 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU5 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU6 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU7 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU8 RO Bleed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU9 RO Bleed	167	167	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU10 RO Bleed	83	83	167	167	167	167	167	167	0	0	0	0	0	0	0	0	0	0
MU11 RO Bleed	0	0	83	83	83	83	83	83	250	250	250	250	0	0	0	0	0	0
Total disposal capacity needed (gpm)	250	250	250	250	250	250	250	250	250	250	250	250	0	0	0	0	0	0
Cumulative	16743	16993	17243	17493	17743	17993	18243	18493	18743	18993	19243	19493	19493	19493	19493	19493	19493	19493
Production bleed capacity needed (gpm)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Restoration capacity needed (gpm)	250	250	250	250	250	250	250	250	250	250	250	250	0	0	0	0	0	0
Total disposal capacity needed (gpm)	**250**	**250**	**250**	**250**	**250**	**250**	**250**	**250**	**250**	**250**	**250**	**250**	**0**	**0**	**0**	**0**	**0**	**0**
Disposal Option(s)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	DDW1, DDW2(1)	--	--	--	--	--	--

Notes:

(1) Additional deep disposal wells will be installed as needed

Assumed start date = 1Q 2015

gpm - gallons per minute

hr - hours

DD1 - Deep Disposal Well 1

DD2 - Deep Disposal Well 2

Assumed sustainable DDW injection rates = 45 gpm

Figure 3.1-1 Typical Mineralized Zone Completion for Injection/Production Wells – Method No. 1

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Figure 3.1-2 Typical Liner Completion for Monitor or Injection/Production Wells – Method No. 2

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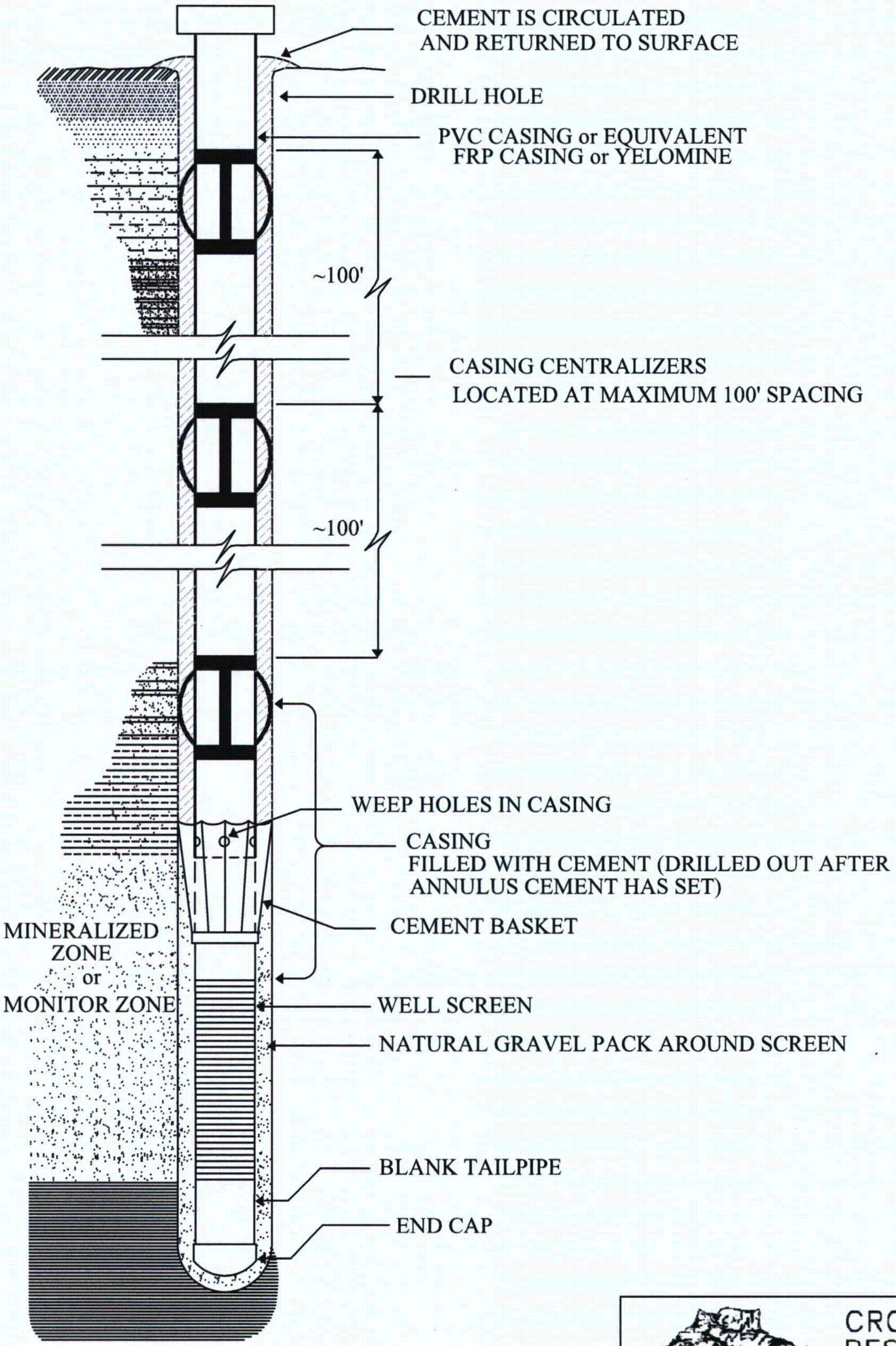

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FIGURE 3.1-3

TYPICAL CEMENT BASKET COMPLETION FOR MONITOR OR INJECTION/PRODUCTION WELLS

METHOD NO.3

PROJECT: CO001396.02 MAPPED BY: JC CHECKED BY: JEC

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PATH: C:\Users\jch...uments_PROJECTS\KCBR_Projects\CO001636_Marsland\1_ACAD\WellCompletionMethods.dwg LAYOUT: U... DATE/TIME: 10/21/2011 11:46 AM

Figure 3.1-4 Typical Wellfield Layout

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Figure 3.1-5 Water Balance for Marsland Facility

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Figure 3.1-6 Marsland Expansion Area Satellite Facility and Current CBR Production Facility Process Flow Diagram

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Figure 3.1-7 Disposal Water Balance Marsland Expansion Area

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Figure 3.1-8 Marsland Water Balance and Process Flow Diagram

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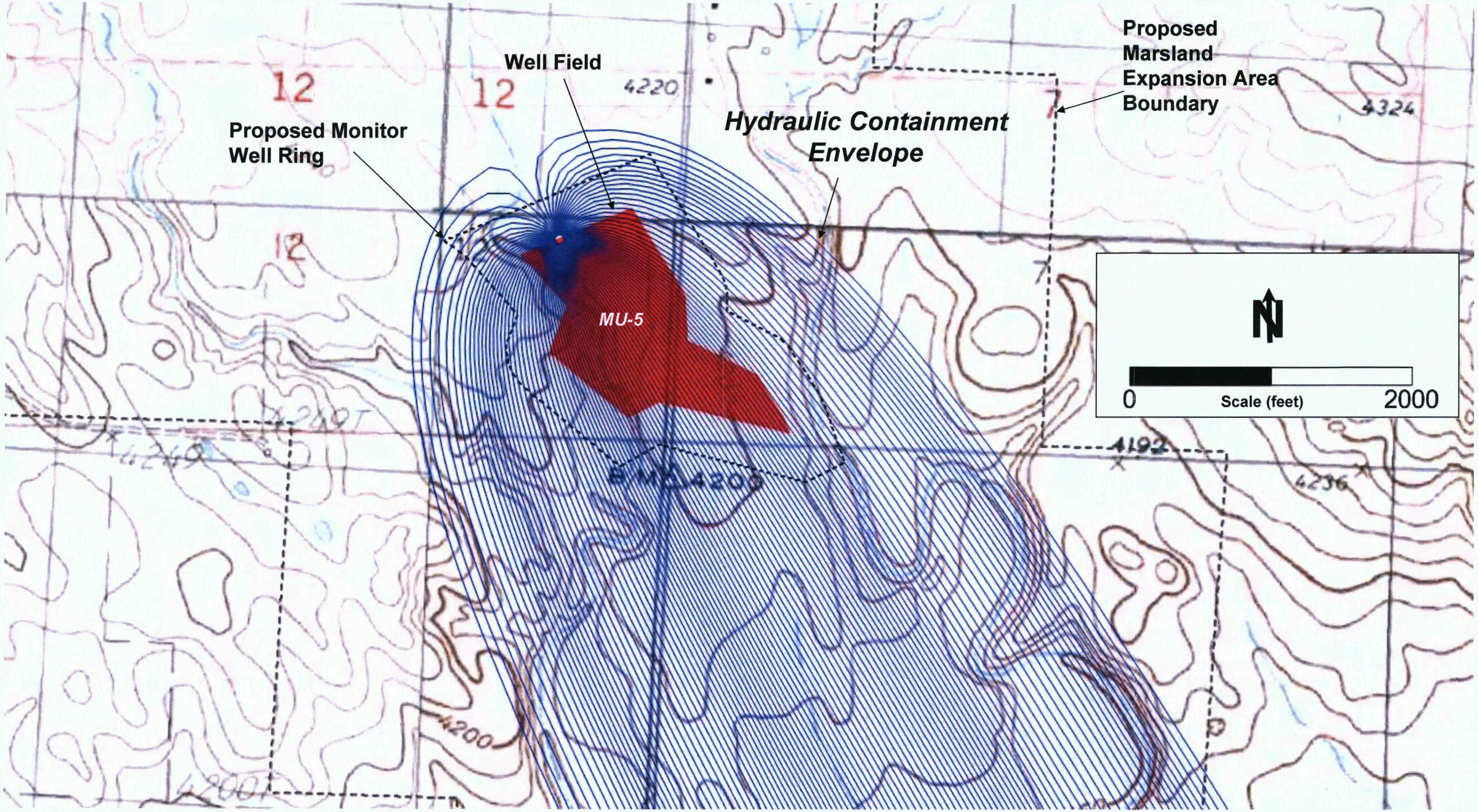

Source: AQUI-VER, INC., 5/30/2013

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FIGURE 3.1-9
MARSLAND HYDRAULIC CONTAINMENT ANALYSES

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