Safety Evaluation Report
Amendment 7 to License SUA-1601
Regarding License Condition 11.3(A) & (B)
Strata Energy, Inc. Ross ISR Project
Crook County, Wyoming

1.0 Introduction

By letter dated December 21, 2015 (Strata, 2015a), Strata Energy, Inc. (Strata) submitted a request to the U.S. Nuclear Regulatory Commission (NRC) to amend License Condition 11.3 (A) and (B) in its Materials License SUA-1601. The amendment request consists of modifying: (a) the minimum density requirement in a wellfield baseline monitoring program from one well per two acres to one well per four acres and (b) the distance to and spacing of wells on the perimeter monitoring well ring from the specified distance of 400 feet to a variable distance of 300 to 500 feet.

This safety evaluation report (SER) documents the NRC staff's review of this amendment request.

2.0 Background

License Condition 11.3(A) and (B) requires Strata to install and collect samples from wells in the ore zone and perimeter monitoring well ring for the excursion monitoring program to be conducted during operations (for details of the license condition, see Section 3.0).

<u>Density of the Ore Zone Baseline Wells</u>

In its initial license application (Strata, 2011), Strata requested a minimum density for a wellfield baseline monitoring of one well per four acres, in accordance with Wyoming Department of Environmental Quality (WDEQ) Land Quality Division (LQD) requirements. The minimum density of one well per four acres is consistent with guidance for large wellfields in the NRC's NUREG-1569, the Standard Review Plan for in Situ Leach Uranium Extraction License Application (SRP or NRC, 2003); however, the guidance states that the preferred density is one well per one acre. As documented in the SER for Strata's initial license application (NRC, 2014), the NRC staff reviewed the proposed density and determined that a minimum density of one well per two acres was appropriate for this proposed facility based on the existing data. As documented in the SER, the NRC staff's rationale for this density was based in part on (1) heterogeneity of the water quality in the proposed ore zone, and (2) heterogeneity and barrier to flow exhibited at the former Nubeth Research and Development (R&D) facility, the only prior in situ uranium recovery (ISR) operation in the Lance/Fox Hills Formation, which is the formation of interest at the Ross project. Furthermore, the NRC staff stated that the minimum density would establish continuity within the ore zone and thus identify any barriers to flow, which may result in preferred groundwater migration paths and included the license condition requiring a minimum density of one well per two acres.

Perimeter Monitoring Well Ring Distance and Spacing of Wells

Strata documented in the 2011 license application (Strata, 2011) that the distance to and spacing of the perimeter monitoring well ring between 400 and 600 feet were adequate for the timely detection and correction of an excursion.[1] The justification for the distances was based on results of various predictive simulations using Strata's numerical groundwater flow model provided in its application. In its application for this amendment, Strata proposed submitting a workplan to WDEQ and the NRC defining the exact distance to and spacing of a perimeter monitoring well ring for a specific wellfield as part of the wellfield's development.

By letter dated January 25, 2012 (NRC, 2012), the NRC staff issued a request for additional information (RAI) to complete the safety review of Strata's initial Ross license application. One RAI requested additional justification for the 600-foot distance. The NRC staff stated that Strata's rationale – based on modeling which demonstrated that water levels at 600 feet are affected similar to those at 400 feet – was insufficient justification for a 600-foot distance. Furthermore, the NRC staff noted that no rationale was included the initial application regarding impacts from the variations in water quality on the timing for an excursion, which is the most significant factor in determining whether an excursion has occurred; nor did Strata provide commitments regarding the placement of wells for staff to evaluate other than to state that the modeling results suggested that an acceptable range for the distance to the perimeter monitoring well ring would be 400 to 600 feet.

In response to the NRC staff's RAI, Strata revised the application to document that a distance to and spacing of 400 feet will be used for the perimeter monitoring well ring (Strata, 2012). As documented in its 2014 SER, the NRC staff evaluated Strata's 2011 application and determined that the distance and spacing for the perimeter monitoring well ring at 400 feet was appropriate based on the uncertainties in the heterogeneity of the Lance/Fox Hills Formation and for providing timely detection of a potential excursion compared to the 600-foot distance, which is the goal of the excursion monitoring program (NRC, 2003; 2014a). By License Condition 10.13, staff required that the wellfield data package demonstrate that the perimeter wells were in communication with the production wells and thus had reasonable assurance that the 400-foot distance was sufficient for its safety evaluation.

3.0 Regulatory Requirements, License Conditions and Applicable Guidance

3.1 Regulations

The applicable regulations to this amendment application are Section 40.44 of Title 10 of the Code of Federal Regulation (10 CFR 40.44) and section 10 CFR 40.32. Section 10 CFR 40.44 requires a licensee who submits an application for amendment of a license to file a Form 313, in accordance with 10 CFR 40.31, and specify the respects in which the licensee desires the license to be amended and the grounds for such amendment. Section 10 CFR 40.45 requires the NRC staff to apply applicable criteria set forth in 10 CFR 40.32 when considering an application to amend a license. The applicable criteria in 10 CFR 40.32 are the following:

[1] In this amendment application, Strata introduces the terminology of spacing and offset to refer to distances between the production area and perimeter monitoring well ring, and between the wells on the perimeter monitoring well ring, respectively. To avoid confusion, the NRC staff will continue to use the terminology "distance to and spacing of" in reference to the perimeter monitoring well ring.

- The application is for a purpose authorized by the Atomic Energy Act.
- The applicant is qualified by reason of training and experience to use the source material for the purpose requested in such a manner as to protect health and minimize danger to life and property.
- The applicant's proposed equipment, facilities and procedures are adequate to protect health and minimize danger to life or property.
- The issuance of the license will not be inimical to the common defense and security or to the health and safety of the public.

3.2 License Conditions

If the proposed amendment were to be found acceptable, the license conditions that would be modified as a result of this amendment request are License Conditions 9.2 and 11.3. License Condition 9.2 would be updated to reflect information provided as part of this license amendment request. License Condition 11.3 (A) and (B) would be modified as a result of Strata's license amendment request. The existing language for License Condition 11.3 in License SUA-1601 is as follows:

Establishment of Background Water Quality. Prior to injection of lixiviant in a wellfield, the licensee shall establish background water quality data for the ore zone, overlying and underlying aquifers. The background water quality sampling shall provide representative baseline data and establish groundwater protection standards and excursion monitoring upper control limits, as described in Section 5.7.8 of the approved license application and this license condition.

The data for each mine unit shall consist, at a minimum, of the following sampling and analyses:

A) Ore Zone. To establish a Commission-approved background concentration pursuant to Criterion 5B(5)(a) of 10 CFR Part 40 Appendix A, samples shall be collected from production and injection wells at a minimum density of one production or injection well per two acres of wellfield production area, or, if a wellfield production area is sufficiently isolated from the other wellfield production areas in the Wellfield, a minimum of two wells. Wells selected for the baseline data will be the same ones used to measure restoration success and stabilization.

B) Perimeter Monitoring Wells. Samples shall be collected from all perimeter monitoring wells that will be used for the excursion monitoring program. The perimeter wells will be installed for a wellfield in accordance with information presented in Section 3.1.6 of the approved license application. In no case will the perimeter monitoring wells be installed outside of the exempted aquifer as defined by the Class III UIC permit issued by the Wyoming Department of Environmental Quality.

C) Overlying and Underlying Aquifers. Samples shall be collected from all monitoring wells in the first overlying and first underlying aquifer at a minimum density of one well per 4 acres of wellfield.

D) Sampling and Analyses. Four samples shall be collected from each well to establish background levels. The sampling events shall be at least 14 days apart. The samples shall be analyzed for parameters listed in Table 5.7-2 of the approved license application, as revised by the May 27, 2015 submittal (ML15149A023). The third and fourth sample events can be analyzed for a reduced list of parameters; the parameters that can be deleted from analysis are those below the minimum analytical detection limits (MDL) during the first and second sampling events provided the MDLs meet the data quality objectives for the sampling.

E) Background Water Quality. For the perimeter ring monitoring wells (Section B) and monitoring wells in the overlying and underlying aquifers (Section C), the background levels shall be the mean values on a parameter-by-parameter, well-by-well, wellfield or sub-set of the wellfield basis, as deemed appropriate, in accordance with Section 5.7.8.1 of the approved license application. The UCLs for monitoring wells in the perimeter ring and overlying and underlying aquifers are established per LC 11.4. For the ore zone monitoring wells, the background levels shall be established on a parameter-by-parameter basis using either the wellfield, sub-set of the wellfield or well-specific mean value. The established background value for each parameter shall be based on the mean value plus a statistically valid factor to account for spatial variability in the data, in accordance with Section 6.1.1.1 of the approved license application.

3.3 Applicable Guidance

The applicable guidance for this review is the SRP (NRC, 2003).

In the case of the ore zone baseline well density, acceptance criterion 5.7.8.3(1) of the SRP states:

> *"An acceptable set of samples should include all well field perimeter monitor wells, all upper and lower aquifer monitor wells, and at least one production/injection well per acre in each well field. For large well fields, it may not be practical to sample one production/injection well per acre. Consequently, enough production/injection wells must be sampled to provide an adequate statistical population if fewer than one well per acre is used. As a general guideline, for normally and log-normally distributed populations, at least six samples are required to achieve 90 percent confidence that any random sample will lie within two standard deviations from the sample mean. In no case should the baseline sampling density for production/injection wells be less than one per 4 acres."*

In the case of distance and spacing to the perimeter wells, acceptance criterion 5.7.8.3(3) of the SRP states:

> *"Perimeter monitor wells should be placed close enough to the well field to provide timely detection, yet they should be far enough away from the well field to avoid numerous false alarms. Previously approved in situ leach excursion monitoring systems used monitor wells as far as 180 m [600 ft] and as near as 75*

m [250 ft] from the well field edge (NRC, 2001, Table 4-6). The licensee should be afforded some discretion in determining the appropriate distance of horizontal excursion monitor wells from the well field, but should provide justification for distances greater than about 150 m [500 ft]. For example, a rigorous modeling demonstration that a theoretical excursion can be controlled at the monitor well locations within 60 days of detection is an acceptable technical basis. The horizontal excursion monitor wells must be spaced close enough to one another so that the likelihood of missing an excursion plume is low. In determining the appropriate spacing between perimeter monitoring wells, the applicant must consider such factors as the distance of the monitoring wells from the edge of the well field, the minimum likely size of an excursion source zone, ground-water flow directions and velocities outside of the well field, and the potential for mixing and dispersion. Staff should consult NUREG/CR–6733 (NRC, 2001, Section 4.3.3) for an analysis and discussion of acceptable approaches for establishing the appropriate monitor well spacing."

The SRP provides general guidance on acceptable methods for compliance with the existing regulatory framework. However, as described in an NRC white paper on risk-informed, performance-based regulation (NRC, 1999), the applicant has the flexibility to propose other methods as long as it demonstrates how it will meet regulatory requirements (NRC, 2003).

4.0 Licensee's Application for an Amendment

A Form 313 accompanied Strata's amendment application.

The licensee's desire and grounds for the amendment application are discussed below. By letter dated December 21, 2015 (Strata, 2015a), Strata requested to amend License Condition 11.3 (A) and (B) regarding the minimum density of the ore zone baseline wells, and distances to and spacing of the perimeter wells, respectively.

4.1 Density of the Ore Zone Baseline Wells

Strata has proposed to revise License Condition 11.3(A) as follows [emphasis depicting the change added]:

A) <u>Ore Zone</u>. To establish a Commission-approved background concentration pursuant to Criterion 5B(5)(a) of 10 CFR Part 40 Appendix A, samples shall be collected from production and injection wells at a minimum density of one production or injection well per **four** acres of wellfield production area, or, if a wellfield production area is sufficiently isolated from the other wellfield production areas in the wellfield, a minimum of two wells. Wells selected for the baseline data will be the same ones used to measure restoration success and stabilization.

Strata's rationale in its amendment request to modify the density of the ore zone baseline wells from one well per two acres to one well per four acres includes the following:

- The baseline sampling results for Mine Unit 1 exhibit a variation in concentrations for most constituents that can be described by a normal distribution with few outliers; thus, the data indicate a lack of heterogeneity in water quality.
- A single hydraulic barrier within the wellfield was demonstrated during the pumping test; however the quality on either side of the barrier was statistically similar (i.e., homogeneous).

- Strata's review of the former Nubeth R&D data suggests that the "abnormal" water quality, which the NRC staff cited in its SER on Strata's initial license application, was only restricted to the first few sampling events and the later water quality data for the Nubeth project exhibited consistent quality. Strata attributed the "anomalies" of the early sampling events to incomplete well development or insufficient purging. Strata suggested that this "abnormal" quality would have been identified and removed as outliers in the statistical evaluation as required today in order to determine Commission-approved background levels.
- Strata presented three hypothetical cases of randomly selected 9-well subsets from the existing Mine Unit 1 data. The randomly selected subsets were intended to demonstrate an expected water quality if the wellfield baseline density of wells was one well per four acres rather than one well per two acres. Strata states that the background concentrations calculated from the three hypothetical datasets are consistent with those established for the entire dataset and thus the proposed changes in minimum density would not affect the established background levels.

4.2 Perimeter Monitoring Well Ring Distance and Spacing of Wells

Strata has proposed to revise License Condition 11.3(B) as follows [emphasis depicting the change added]:

> B) Perimeter Monitoring Wells. Samples shall be collected from all perimeter monitoring wells that will be used for the excursion monitoring program. The perimeter wells **will be installed no closer than 300 feet and no further than 500 feet from the wellfield with similar offset distances between perimeter monitor wells.** In no case will the perimeter monitoring wells be installed outside of the exempted aquifer as defined by the Class III UIC permit issued by the Wyoming Department of Environmental Quality.

Strata's rationale for modifying the distance to and spacing of wells on the perimeter monitoring well ring from the specified distance of 400 feet to a variable distance of 300 to 500 feet is to (a) alleviate logistical difficulties encountered in the field, and (b) be consistent with prior NRC precedent. The logistical difficulties consist of avoiding historical and cultural sites, water bodies, wetlands, and existing infrastructure such as roads and pipelines.

Strata presented a summary of data from existing NRC-licensed facilities to show that NRC had previously approved distances to and spacings of perimeter monitoring well ring wells from 300 to 500 feet. Strata also cites NUREG/CR-6733, *A Baseline Risk-Informed, Performance-Based Approach for In Situ Leach Uranium Extraction Licensees*, which states that the distance to and spacing of a typical perimeter monitoring well ring were between 300 and 500 feet.

Strata proposes to maintain a distance to the wells equal to the spacing between wells. As a result, the maximum angle from a production well to the two nearest perimeter monitoring well ring is 53 degrees, which is less than the maximum 75 degrees recommended in NUREG/CR-6733, and thus acceptable (NRC, 2001).

Finally, Strata asserts that a more homogeneous aquifer would more likely exhibit an excursion as modeled in NUREG/CR-6733. Strata states that the Mine Unit 1 data package demonstrates a high degree of homogeneity to the aquifer, which supports use of guidance in NUREG/CR-6733 for its evaluation.

On March 9, 2017, the NRC staff provided Strata draft license conditions with modified language different from that proposed by Strata because, based upon the NRC staff's review of the information provided in Strata's license amendment application, the NRC staff proposed to grant the Strata's requested amendment only in part (NRC, 2017a).[2] On March 29, 2017, Strata accepted the NRC staff's revision to the language of License Condition 11.3(A). With respect to License Condition 11.3(B), Strata revised its license amendment request to include additional information and commitments in support of its application, and proposed alternative modifications to the language of License Condition 11.3(B) (Strata, 2017a). On April 3, 2017, the NRC staff issued a request for supplemental information to clarify Strata's proposed commitments and proposed modification to License Condition 11.3B (NRC, 2017b). On April 5, 2017, Strata provided responses to NRC staff's request for supplemental information (Strata, 2017b). Details of the commitments and revised language for License Condition 11.3(B) and the NRC staff's review are discussed in Section 5.0.

5.0 The NRC Staff's Review

5.1 Density of the Ore Zone Baseline Wells

For approval of the initial Ross license application, the NRC staff required a minimum density of one well per two acres as a license condition. The NRC staff's rationale for this requirement was primarily based on the following factors: (1) the heterogeneity in the aquifer (groundwater quality and hydraulic properties); and (2) the limited data on ISR operations within the Lance/Fox Hills formations, where the site is located. The NRC staff's rationale is found in the SER for the license application (NRC, 2014 p. 40):

> "The noted exception is the analysis of the potential for preferred migration paths due to heterogeneities in the ore zone geology. Staff finds that the applicant did provide an adequate description of the heterogeneities in the ore zone. Staff agrees with the applicant's departure from Buswell's interpretation of the faults based on the evidence provided in the application. However, staff does not fully agree with the applicant's argument that the heterogeneities in the Ross Project ore zone geology are similar to heterogeneities in other ore zone geologies that have undergone ISR operations. The applicant's argument is exemplified by the introductory sentence in Section 6.1.6.1 of the Technical Report (Strata, 2011):
>
> > *Although depositionally and formationally different, roll front deposits in the western interior that have undergone successful recovery and restoration have a number of common attributes, key of which is a permeable host rock, typically consisting of slightly dipping sandstones deposited in fluvial or marginal marine environments.*
>
> As noted by the introductory sentence, the facts are that (1) the host formation at the Ross Project is unique compared to the host formations at other ISR facilities in Wyoming (Upper Cretaceous Lance/Fox Hills Formation versus the Tertiary Wasatch Formation); and (2), the depositional environments are different (marine to marginal marine fluvial environments versus terrestrial fluvial environments). In a broad sense, a sequence of interlayered mudstones, siltsones and sandstones with similar detrital material will have common traits regardless of the geologic

[2] For uranium recovery licensees, the NRC practice is for a licensee to agree with the proposed license condition if the condition was a request of the licensee.

> time or environments during which the original material was deposited. However, the applicant acknowledges that the lateral discontinuity of the stratigraphy has led to hydraulic isolation of observation wells in the ore zone host formation at the Ross Project. The hydraulic isolation refers to the lack of responses in water levels at several monitoring wells during the Nubeth R&D operations. In addition to hydraulic isolation, staff has inferred that changes in water quality can also be associated with the hydraulically isolated wells (for further discussion, see SER Sections 2.4.3 and 2.5.3). Therefore, staff will include a license condition, which would limit the minimum density of baseline wells for the ore zone aquifer to one well per 2 acres (see SER Section 5.7.8.4). Staff is reasonably assured that, with that license condition, preferred migration paths and variability in the baseline water quality due to the heterogeneities of the host formation will be identified such that the applicant will have the ability to confine its possession and use of source and byproduct material to locations and purposes identified in the approved application."

In imposing the minimum density of one well per two acres, the NRC staff anticipated that, with operational experience, the licensee could submit a licensee-initiated amendment request to change this minimum density requirement, provided that Strata's experience in the Lance Formation demonstrates that such a change is justified (NRC, 2013). The NRC staff's evaluation of this amendment application focuses on whether the data from Mine Unit 1, and to a limited extent Mine Unit 2, provided by Strata in support of its license amendment application, are sufficient justification for granting the request.

The NRC staff reviewed each of Strata's justifications for its license amendment request.

<u>Lack of Heterogeneity to the Water Quality</u>

The NRC staff disagrees with Strata's characterization that "most constituents" exhibited a normal distribution, thus reflecting homogeneity. To be precise, based on Table 1 to Attachment 12 of the Mine Unit 1 wellfield package (Strata, 2015b), six constituents (potassium, carbonate, sulfate, chloride radium-226 and gross alpha) exhibited a "lognormal" distribution, 13 constituents (alkalinity, ammonia, fluoride, silica, conductivity, pH, total dissolved solids, calcium, magnesium, sodium, bicarbonate, boron and uranium) exhibited a "normal" distribution, and the 16 remaining constituents exhibited a "undefined" distribution because the levels in this group were generally below the minimum analytical detection.

The fact that Mine Unit 1's baseline water quality exhibits heterogeneities is not, in and of itself, a reason to deny this request. If heterogeneities are identified, representative samples of those heterogeneous areas must be included in the background analysis if the proposed injection is to be performed within those areas. Based on Strata's Mine Unit 1 wellfield package, the hydraulic barrier is a thin distinct zone, and, based on the pumping test results, thinner than that depicted on Figure 1-3 of Strata's Mine Unit 1 wellfield package. Given the discrete nature of the hydraulic barrier zone, its anticipated low hydraulic conductivity, and its location along the margin of Mine Unit 1, it is unlikely that Strata will include production units within this zone as the flow rates would be extremely low. Such flow rates would not be operationally effective. Therefore, the NRC staff found that the dataset reported for Mine Unit 1 represents the quality of the aquifer that will be affected by the operations. If production were to occur in the lower conductivity zones, Strata would need to ensure the baseline data are "representative" of the ore zone.

Based on its review of the Mine Unit 1 wellfield package, the NRC staff agrees with Strata's conclusion that the hydraulic barriers attributed to facies changes in the strata are not on the local scale (i.e., every two acres) as was interpreted by staff on the NUBETH data, but rather on a wellfield scale (i.e., 30 acres). This scale of hydraulic barriers in the subsurface strata is consistent with the data for Mine Unit 2 (Strata, 2016a). While such discontinuities within a wellfield are not a common trait at most ISR facilities, hydraulic barriers within the ore zone are documented at the Lost Creek ISR facility in Sweetwater County, Wyoming (Lost Creek, 2008). For that facility, the hydraulic barriers are attributed to faulting in the subsurface strata. The NRC staff concluded that the hydraulic barriers at that facility are not detrimental to ISR operations provided that hydraulic control is maintained for each hydraulically isolated area and that suitable baseline data are obtained for all areas.

Given the discrete nature to the hydraulic barrier (or heterogeneity) and the scale of the heterogeneities, the NRC staff agrees that a minimum density of one well per four acres is sufficient for the baseline dataset if wells are included in all hydraulically isolated areas of a wellfield.

Hydraulic Barrier Separating a Homogenous Aquifer

As stated above, the fact that the aquifer exhibits heterogeneities or is homogeneous is not a factor in approving or denying this amendment request. However, the distribution of wells to measure the effectiveness of restoration activities should be representative of the aquifer that is impacted by operations. As discussed above, if production units were located within the hydraulically isolated areas in which the chemistry could be different, then background wells need to be located in those areas.

Strata has demonstrated that the distribution of wells are representative of the impacted area. By including a requirement that all impacted areas are represented, the NRC staff finds that the proposed minimum density is acceptable because it would yield representative background data.

NUBETH Data Analysis

The NRC staff did not evaluate this aspect of the request since Strata's analysis of the NUBETH data is not germane to the NRC staff's review. When the initial license was issued, the NUBETH data was the only dataset available to evaluate an ISR operation in the Lance Formation. The license condition under consideration was based, in part, on the scale of the NUBETH data. With the addition of data from Mine Unit 1 and Mine Unit 2, the "anomalies" within the ore zone appear to be at larger scales (i.e., one "anomaly" per 30-acre area).

Hypothetical Datasets

Strata's presentation of the hypothetical datasets demonstrates the NRC staff's concern about the possibility of deficient representative data for all hydraulically isolated areas. In Mine Unit 1, the only ore zone baseline well located in the southeastern isolated area is well MU1-OZ23. Of the three hypothetical cases, only one of Strata's hypothetical cases included data from well MU1-OZ23.

Without a baseline well within the isolated area, effectiveness of restoration in that area could not be reasonably established in the future. This issue is eliminated by requiring at least one well in each hydraulically isolated area. Therefore, the NRC staff will include a requirement in the license condition that any baseline program include at least one baseline well in each hydraulically isolated area.

Based on a review of the amendment request, the NRC staff finds that the proposed change in baseline well density from one well per two acres to one well per four acres is acceptable because the proposed density will provide adequate background characterization of a wellfield provided that all areas within a wellfield are included in the dataset. Therefore, the NRC staff proposes the following revised License Condition 11.3(A) [emphasis depicting the change added]:

> 11.3(A) Ore Zone. To establish a Commission-approved background concentration pursuant to Criterion 5B(5)(a) of 10 CFR Part 40 Appendix A, samples shall be collected from production and injection wells at a minimum density of one production or injection well per **four** acres of wellfield production area. If a portion of a wellfield production area is isolated by distance to other production areas within a wellfield or **isolated hydraulically, as determined by the pumping tests, a minimum of one well in each of the isolated areas will be required for the baseline data if the isolated area is less than four acres in area.** Wells selected for the baseline data will be the same ones used to measure restoration success and stabilization.

5.2 Perimeter Monitoring Well Ring Distance and Spacing of Wells

In the original license application for the Ross ISR project, Strata suggested a range of 400 to 600 feet for the distance to and spacing of the perimeter monitoring well ring (Strata, 2011). However, based on the NRC staff's evaluation of Strata's application, the NRC staff placed, and Strata agreed to, a condition in the license restricting the distance to and spacing of the wells in the perimeter monitoring well ring to 400 feet. Strata's current amendment application requests the flexibility to establish a distance to and spacing of wells in the range of 300 to 500 feet.

Strata's request to modify distances to and spacing of wells on the perimeter monitoring well ring is based largely on logistical problems encountered in the field rather than safety issues; however, logistical problems could, at times, hamper implementation of the safety systems. Therefore, the NRC staff has given this concern of logistical problems some weight in its analysis. While logistical issues similar to those described in the amendment application have been encountered at other ISR facilities at which such flexibilities have not been requested, the logistical issues are further complicated at the Ross site by the greater number of tribal cultural and archeological properties identified at the property.

In its application, Strata identifies distance requirements for other NRC-licensed facilities. While several of those facilities, largely the older licensed facilities, do have distance and spacing requirements between 300 and 500 feet, they did not have a "variable" distance requirement that allows them flexibility in establishing a distance requirement for any particular well. Rather, the older facilities have specific requirements for the distances and spacings for individual wells within a ring (i.e., 300 feet for the downgradient wells and 500 feet for the side and up-gradient wells) rather than complete flexibility. The NRC staff notes that Strata's request for a "variable distance" is not similar to the other facilities.

Nevertheless, the NRC staff finds that variable distances for an individual perimeter monitoring well ring may be acceptable provided those distances are bounded within an approved range taking into account a maximum angle between well spacings. However, if the NRC staff grants Strata's requested license amendment in full, Strata would be able to install all of its wells in a perimeter monitoring well ring at a 500-foot distance to and spacing of the wells. Initially, the NRC staff found Strata's requested variability for a distance of up to 500 feet unacceptable (prior to Strata's Commitment to a well-specific Upper Control Limit (UCL)). The NRC staff's initial conclusion was based on its assessment of the site-specific poor baseline water quality, resulting in higher thresholds for detection, and thus unacceptable timing for the detection of an excursion beyond the approved distance of 400 feet.

The conceptual model used by the NRC staff in its assessment of the license amendment request is that in a homogeneous setting, an excursion results from lixiviant flowing radially out from an injection well(s) with imbalanced flow rates. Such radial flow has divergent flow paths and thus the migration of constituents is characterized as radial advective, divergent transport. As a fluid migrates in this flow regime, its constituents are subjected to dispersion[3] and attenuation, which affects its flow relative to the "mean" groundwater flow rate through the aquifer. Dispersion is mixing that occurs from the variable flow rates within the aquifer due to the variability in pore openings. In general, dispersion will decrease the time that the initial concentrations and increase the time the later or higher concentrations are observed at some specified distance from the source area.

Typically, dispersion is a scale-dependent variable based on the distance a plume travels (i.e., the longer a plume travels, the greater the dispersion value). Dispersion is generally quantified in modeling by dispersivity, which is a property of the aquifer, multiplied by the mean groundwater flow velocity. Typically, the longitudinal dispersivity is assigned a value of one-tenth the total distance traveled and the transverse dispersivities are assigned one-tenth the value of the longitudinal dispersivity. For a continuing source, dispersion in non-uniform radial flow regime (which is modeled here) has been shown to be less than dispersion in a uniform one-dimensional flow regime (Gelhar & Collins, 1971).

Attenuation is the degree to which a constituent will sorb and desorb onto the aquifer matrix during its migration. In general, attenuation will delay the arrival time (retardation) of a constituent based solely on the mean groundwater flow. For the Ross facility as well as most NRC-licensed facilities, the parameters selected for excursion monitoring are more conservative (i.e., those parameters least affected by attenuation/retardation). However, one parameter, specific conductance, may be affected by some attenuation. Specific conductance is a measure of groundwater's ability to conduct electricity and has been shown to be proportional to the total dissolved solids (TDS) concentration in the groundwater. The TDS concentration consists largely of the major elements (e.g., calcium, sodium, bicarbonate, sulfate) dissolved in the groundwater. Each of the dissolved constituents may have its own attenuation factor, and the

[3] For this discussion, dispersion is not the molecular dispersion, which is based on chemical gradient, but the hydrodynamic dispersion, which is attributed to the distribution of flow velocities within the porous media due to its tortuosity (i.e., the variation in sand grain sizes within the media leads to differing flow lines and velocities).

attenuation factor for TDS would be a combined-weighted average. The attenuation factor for the major elements that make up the TDS concentration is generally low.

To evaluate the impact of a poor baseline groundwater quality (such as at the Ross facility) on the timing for an excursion detection, the NRC staff developed numeric groundwater models to simulate an excursion. Using those models, the NRC staff compared timeframes to achieve an excursion threshold for both sets of baseline/excursion threshold levels, while maintaining the other properties (e.g., hydraulic properties of the aquifer and a specified lixiviant quality) constant. Two different modelling software were used for this analysis. The first software consists of using MODFLOW-2000 (Harbaugh et al, 2000) to establish groundwater flow coupled with MODPATH (Pollock, 1994) to establish flow paths and MT3D (Zheng and Wang, 1999) to establish fate and transport. The second modeling software consists of using PHAST (Parkhurst et al, 2010), which is a fate and transport modeling based on the HST3D, a three-dimensional, finite-difference flow model (Kipp, 1987) and PHREEQC, a geochemical model (Parkhurst and Appelo, 2013).

The lixiviant quality was based on data reported by Strata (Strata, 2016b) with modifications by NRC staff (NRC, 2017c). The ISR facility with a better baseline ground-water quality for a comparative analysis was Nichols Ranch in Campbell and Johnson Counties, Wyoming (Uranerz, 2013). The groundwater quality at Nichols Ranch is similar to other facilities listed by Strata with approved perimeter monitoring well rings at 500 feet. Table 1 presents the parameters used in the NRC staff's comparative analysis.

Details of the model setup, input and output files are contained in NRC staff's calculation package (NRC, 2017c). In brief, the procedures for model setup are as follows:

- A static water level prior to operations was determined using a steady-state simulation and those results were used as initial conditions for the subsequent transient simulation.
- A transient simulation was used to simulate operations for a balanced wellfield for 365 days, followed by operations of an imbalanced wellfield for 365 days.
- The wellfield for the simulations consisted of a single 5-spot pattern, one production well in the center surrounded by 4 injection wells at a distance of approximately 100 feet. During the balanced operations, the production well withdrew water at 41.67 gallons per minute (gpm) whereas each injection well injected water at 10.3 gpm for a total of 41.25 gpm (the difference between production and injection representing an approximate 1 percent bleed). During the imbalanced operations, the production well ceased withdrawing water.[4] The start of the event was the discontinuing of the production well operations.
- For the fate and transport modeling, the injection wells were assigned the lixiviant chemistry and the aquifer assigned the baseline chemistry.
- Simulations for the MODFLOW/MODPATH/MT3D were performed for two dispersivity values, 40 feet and 4 feet, and various attenuations. The attenuation was based on the equilibrium-controlled linear sorption isotherm based on a distribution coefficient (K_d) relating the sorbed concentration to dissolved concentration. Four simulations were run using different K_d values of 0.0 (truly conservative constituent), 0.02, 0.05 and 0.1 cubic

[4] The PHAST model did not allow a 0.0 withdrawal rate. The withdrawal rate was set to a negligible value.

centimeters per gram (cm^3/g). In total 16 simulations were performed, eight simulations for Strata and eight for Nichols.

The MODFLOW/MODPATH/MT3D model-predicted constituent concentrations at an approximate distance of 300, 400 and 500 feet from the nearest injection well are summarized in Table 2. General observations based on the results are as follows:

- For both Ross and Nichols Ranch simulations, the larger dispersivity value resulted in shorter time to an UCL exceedance.
- For both Ross and Nichols Ranch simulations, slightly increasing the distribution coefficient values above no retardation (i.e., K_d=0 cm^3/gr) resulted in a significant (three times) increase in the time to an UCL exceedance.
- The time to an UCL exceedance at the Ross facility was approximately twice that for the Nichols Ranch facility under the same set of conditions for attenuation and dispersion.
- In general, the time to an UCL exceedance for the Nichols Ranch facility at a distance of 500 feet was approximately equal to the time to an UCL exceedance at the Ross facility at a distance of 400 feet under the same set of conditions for attenuation and dispersion.

The MODFLOW/MODPATH/MT3D analysis was set up with a generic constituent with values derived from the respective specific conductance levels. If the simulations were performed using alkalinity or chloride levels, the NRC staff anticipates similar results, but did not perform these simulations. The issue for any simulation is to determine the appropriate dispersivity or distribution coefficient for either of the three constituents, which the model does not perform. However, as can be seen by the simulations performed, even slight increases in the distribution coefficient above the no retardation level significantly affects the model-predicted migration of a constituent. Information on distribution coefficients for the major chemistry is not available as most studies on distribution coefficients focus on trace metals and man-made volatile organic compounds. Consequently, the NRC staff developed a simple PHAST advection-dispersion model.

The PHAST software has an advantage over the MODFLOW/MODPATH/MT3D software for this analysis because it is linked to the software PHREEQC. PHREEQC is a geochemical modeling software that evaluates constituent-based equilibrium reactions in addition to evaluating other processes normally attributed to sorption (i.e., surface complexation). For this analysis, the reaction of pH and alkalinity of the lixiviant with the aquifer matrix is the primary driver for the plume front migration. For a simple analysis, NRC staff's PHAST model included only reactions that are associated with equilibrium of the plume with calcite and existing partial pressure of carbon dioxide in the aquifer matrix; it did not include any sorption. The existing partial pressure of carbon dioxide was estimated from the aquifer baseline ground-water chemistry.

Results of the PHAST analysis are summarized in Table 3 and graphically shown on Figure 1. Based on the PHAST analysis, for all three constuents, the time to detect an excursion takes longer at the Ross facility at either 400 or 500 feet than it does at 500 feet at Nichols Ranch.

Based on the above, the NRC staff found that a distance greater than 400 feet to a perimeter well was not acceptable because of the increased time to detect an excursion. The 400-foot distance for the Ross facility had previously been approved by the NRC staff and is acceptable. A distance to the nearest production and perimeter well less than 400 feet is acceptable because it would provide timelier detection of an excursion than at 400 feet. Therefore, the NRC staff found that Strata's request to amend License Condition 11.3(B) to allow variability in the distance to a monitoring well on the perimeter monitoring well ring was acceptable within the range of 300 to 400 feet.

With regard to spacing between perimeter monitoring wells, because of the general lack of heterogeneities, the NRC staff has found acceptable spacings that result in a maximum angle formed by lines drawn from any production or injection well to the nearest two monitor wells of 75 degrees for a perimeter monitoring well ring (NRC, 2001). For a 400-foot distance to the perimeter ring, a 75-degree angle would equate to a spacing of 500 feet. For distances greater than 400 feet, a 500-foot spacing would result in an angle less than the maximum. For distances less than 400 feet, the spacing would be limited by the maximum angle requirement. Therefore, the NRC staff finds that the spacing of 300 to 500 feet is acceptable because the maximum angle previous found acceptable would be maintained.

As a result of the above assessment of Strata's license amendment request, the NRC staff informed Strata that it could approve Strata's request in part, as reflected in the following proposed modification to License Condition 11.3(B) (NRC, 2017a) [emphasis on changes added]:

> Samples shall be collected from all perimeter monitoring wells that will be used for the excursion monitoring program. The perimeter wells will be installed for a wellfield in accordance with information presented in Section 3.1.6 of the approved license application, **as amended by the submittal dated December 21, 2015 (ML16004A032), with the following stipulations: the distance between the nearest production unit and perimeter well will be between <u>300 and 400</u> feet and the spacing between perimeter wells will be between 300 and 500 feet provided that the maximum angle from the closest unit to the two nearest wells is less than 75 degrees.** In no case will the perimeter monitoring wells be installed outside of the exempted aquifer as defined by the Class III UIC permit issued by the Wyoming Department of Environmental Quality.

Strata did not agree to the above language because the maximum distance was limited to 400 feet, and not up to the requested 500 feet. The NRC staff explained that the limit of 400 feet was due to NRC staff's calculation that, at 500 feet, the delay in identifying an excursion was not acceptable. The NRC staff provided Strata its calculations (NRC, 2017c).

In response, Strata supplemented its license amendment request with the following commitment (Strata, 2017a):

> For a well located at distance greater than 400 feet, Strata will determine a "lower" well-specific UCL that would result in the detection of an excursion on the same timeframe as a well that would have been located at a distance of 400 feet using the standard UCL.

Strata also provided page changes to the approved license application that documents its commitment and procedures to be used. Strata proposed amending License Condition 11.3(B) as follows [emphases on changes from staff's proposed language added]:

> Samples shall be collected from all perimeter monitoring wells that will be used for the excursion monitoring program. The perimeter wells will be installed for a wellfield in accordance with information presented in Section 3.1.6 of the approved license application, as amended by the submittal dated December 21, 2015 (ML16004A032), with the following stipulations: the distance between the nearest production unit and perimeter well will be between 300 and **500** feet and the spacing between perimeter wells will be between 300 and 500 feet provided that the maximum angle from the closest unit to the two nearest wells is less than 75 degrees. **In the event a perimeter well exceeds the 400-foot spacing from the nearest production unit, the UCLs for that perimeter well will be calculated in accordance with commitments in [Strata's submittal dated March 29, 2017].** In no case will the perimeter monitoring wells be installed outside of the exempted aquifer as defined by the Class III UIC permit issued by the Wyoming Department of Environmental Quality.

After reviewing Strata's response, NRC staff requested supplemental information on: (1) Strata's justification and rationale for the standard 400-foot distance to be 400 feet +/- 5 percent, and (2) an example calculation of the methodology to determine a well-specific UCL (NRC, 2017b).

On April 5, 2017, Strata responded to NRC staff's supplemental information request (Strata, 2017b). In its response, Strata's rationale and justification for the 400 feet +/- 5 percent was the expected variability in a well's exact location based on the presence of physical features, precision of the survey equipment locating the wells in the field, vertical drift to the well during installation, and Strata's estimated short increase in time to detect an excursion at wells located at 400 and up to 420 feet (400 feet plus 5 percent (20 feet)). Strata calculated that the time between the detections at those two distances was between 8 and 15 days and proffered that such an increase is within the sampling period under the monitoring program (i.e., twice monthly and at least 10 days apart).

Strata provided in its response a five-step methodology and an example calculation for determining the well-specific specific conductance UCL for a well at a distance of 440 feet using Mine Unit 2 data (Strata, 2017b). In essence, Strata's methodology utilized four data points from NRC staff's modeling results (each datapoint was defined by time, distance and specific conductance), and, by linear interpolation from those points in both time and distance, calculated a well-specific specific conductance UCL. Using this method, Strata calculated a well-specific specific conductance UCL of 3,716 microSiemens per centimeter (uS/cm) for a well at 440 feet.

The NRC staff reviewed Strata's responses and, in principle, agrees with Strata that a lower well-specific UCL for wells at distances greater than 400 feet would address NRC staff's concern regarding timely detection of an excursion at wells beyond the approved 400 feet. Furthermore, the NRC staff finds acceptable Strata's proposed procedures to calculate a revised UCL, although NRC staff provides minor clarifications, as discussed below.

First, Strata elected to base their UCL calculations on the model output from NRC staff's calculations. This method is acceptable, but the NRC staff notes that the modeling effort was based on chemistry from Mine Unit 1. In its example, Strata applied the modeling output to calculate a UCL for Mine Unit 2. While the chemistry for the two mine units are slightly different, the NRC staff's review verified that the impacts from the chemistry differences have negligible effect on the calculations. For future mine units, Strata would need to verify that the model is appropriate for the chemistry at the mine unit being evaluated.

Second, Strata proposes to establish a range of distances (400 feet +/- 5 percent or, in other words, 380 to 420 feet) for which the “standard” 400-foot UCL applies. NRC staff agrees that some flexibility is reasonable as, proffered by Strata, attempting to install a well precisely 400 feet from a production area may result in some deviation, especially for a production area that is not fully completed when the perimeter monitoring well ring is installed, as is the case for most ISR facilities. In fact, the NRC staff acknowledged the variability in spacing of and distance to the perimeter monitoring well ring for Mine Unit 1 during its review of the wellfield package, noting however that the distances and spacings for most wells were largely less than 400 feet (NRC, 2015). Consequently, the NRC staff finds that the standard UCL calculation for wells within the 380 to 420 feet range is appropriate.

Third, NRC staff confirmed that Strata’s method to calculate a well-specific UCL (i.e., linear interpolation between data points) was appropriate. The NRC staff fitted the model-predicted specific conductance levels during the entire excursion event at both the 400- and 440-foot distance to a fifth-order polynomial equation for each respective distance. Then, using the polynomial equation for the 400-foot distance, the NRC staff determined the time to achieve the standard UCL. Next, using the time calculated above, the NRC staff estimated the specific conductance level at the 440-foot distance using its polynomial. The calculations are shown graphically on Figure 2. The NRC staff’s calculated well-specific specific conductance UCL at 440 feet is 3745 uS/cm, which is consistent with Strata’s calculated UCL of 3714 uS/cm.[5]

Therefore, with commitments documented in Strata’s page changes to the approved Ross license application, the NRC staff finds that Strata’s proposed methodology is acceptable because it would provide reasonable assurance of a timely detection of an excursion. Therefore, the NRC staff proposes the following revised License Condition 11.3(B):

> 11.3B <u>Perimeter Monitoring Wells</u>. Samples shall be collected from all perimeter monitoring wells that will be used for the excursion monitoring program. The perimeter wells will be installed for a wellfield in accordance with information presented in Section 3.1.6 of the approved license application, **as amended by the submittal dated December 21, 2015 (ML16004A032), with the following stipulations: the distance between the nearest production unit and perimeter well will be between 300 and 500 feet and the spacing between perimeter wells will be between 300 and 500 feet provided that the maximum angle from the closest unit to the two nearest wells is less than 75 degrees. In the event a perimeter well exceeds the 400-foot spacing from the nearest production unit, the UCLs for that perimeter well will be calculated in accordance with commitments in the submittals dated March 29, 2017 (ML17089A275) and April 5, 2017 (ML17095A893).** In no case will the perimeter monitoring wells be installed outside of the exempted aquifer as defined by the Class III UIC permit issued by the Wyoming Department of Environmental Quality.

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[5] The slight differences are attributed largely to NRC staff’s use of a refined model that used a modified chemistry resulting in a slightly higher baseline (30 uS/cm) and also incorporated nodes at distances of 400 and 440 feet from the injection well.

6.0 Environmental Review

The NRC staff prepared an Environmental Assessment (EA) on the amendment application in accordance with the requirements in 10 CFR Part 51, *Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions*. NRC's regulations in 10 CFR Part 51 implement Section 102(2) of the National Environmental Policy Act of 1969, as amended. The EA includes an evaluation of the potential environmental impacts of the requested license amendment and alternatives to the proposed action (NRC, 2017d).

7.0 Conclusions

The NRC staff reviewed Strata's license amendment application to modify requirements of several monitoring programs listed in License Condition 11(A) and (B). The NRC staff finds that changes to the monitoring programs affected by the amendment request, with the NRC staff's modification to the proposed license condition's language, remain effective in protecting human health and safety and the environment. As such, the NRC staff finds that the amendment request satisfies the applicable criteria in 10 CFR 40.32 for approval of an amendment:

- The application is for a purpose authorized by the Atomic Energy Act

  The amendment application affects the monitoring programs that ensure the source material remains under the possession and control of the licensee.

- The applicant is qualified by reason of training and experience to use the source material for the purpose requested in such a manner as to protect health and minimize danger to life and property

  The amendment application does not modify the personnel training or experience from that previously analyzed and approved for issuance of the license.

- The applicant's proposed equipment, facilities and procedures are adequate to protect health and minimize danger to life and property

  As documented in this SER, the NRC staff finds that the proposed modified programs are adequate to protect health and minimize danger to life and property.

- The issuance of the license will not be inimical to the common defense and security or to the health and safety of the public

  Issuance of the amendment, with the NRC staff's proposed license condition language, provides the same level of protection as was determined for the issuance of the initial license.

Therefore, the NRC staff recommends approval of the amendment application with the following license conditions:

9.2 The licensee shall conduct operations in accordance with the commitments, representations, and statements contained in the license application dated January 4, 2011 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML110120063), which is supplemented by submittals dated February 28, 2011 (ML110800187), March 30, 2012 (ML121030404), April 6, 2012

(ML121020343), August 10, 2012 (ML12227A369), January 18, 2013 (ML130370654), October 14, 2013 (ML13295A230), October 17, 2013 (ML13296A026), February 28, 2014 (ML14091A036), January 14, 2015 (ML15036A062), May 27, 2015 (ML15149A023), September 30, 2015 (ML15289A056), October 20, 2015 (ML15294A228), December 21, 2015 (ML16004A032), March 29, 2017 (ML17089A275) and April 5, 2017 (ML17095A893). The approved application and supplements, hereby, are incorporated by reference, except where superseded by specific conditions in this license. The licensee must maintain the approved, updated, license application on site.

Whenever the word “will” or “shall” is used in the above referenced documents, it shall denote a requirement. The use of “the Wellfield” in this license is synonymous with the use of mine unit as defined in the approved license application. The use of “verification” in this license with respect to a document submitted for NRC staff review means a written acknowledgement by the NRC staff that the specified submitted material is consistent with commitments in the approved license application, or requirements in a license condition or regulation. A verification will not require a license amendment.

[Applicable Amendment: 2, 3, 4, 7]

11.3 Establishment of Background Water Quality. Prior to injection of lixiviant in a wellfield, the licensee shall establish background water quality data for the ore zone, overlying and underlying aquifers. The background water quality sampling shall provide representative baseline data and establish groundwater protection standards and excursion monitoring upper control limits, as described in Section 5.7.8 of the approved license application and this license condition.

The data for each mine unit shall consist, at a minimum, of the following sampling and analyses:

A) Ore Zone. To establish a Commission-approved background concentration pursuant to Criterion 5B(5)(a) of 10 CFR Part 40 Appendix A, samples shall be collected from production and injection wells at a minimum density of one production or injection well per four acres of wellfield production area. If a portion of a wellfield production area is isolated by distance to other production areas within a wellfield or isolated hydraulically, as determined by the pumping tests, a minimum of one well in each of the isolated areas will be required for the baseline data if the isolated area is less than four acres in area. Wells selected for the baseline data will be the same ones used to measure restoration success and stabilization.

B) Perimeter Monitoring Wells. Samples shall be collected from all perimeter monitoring wells that will be used for the excursion monitoring program. The perimeter wells will be installed for a wellfield in accordance with information presented in Section 3.1.6 of the approved license application, as amended by the submittal dated December 21, 2015 (ML16004A032), with the following stipulations: the distance between the nearest production unit and perimeter well will be between 300 and 500 feet and the spacing between perimeter wells will be between 300 and 500 feet provided that the maximum angle from the closest unit to the two nearest wells is less than 75 degrees. In the event a perimeter well exceeds the 400-foot spacing from the nearest production unit, the UCLs for that perimeter well will be calculated in accordance with commitments in the submittals dated March 29, 2017 (ML17089A275) and April 5, 2017 (ML17095A893). In no case will the perimeter monitoring wells be installed outside of the exempted aquifer as defined by the Class III UIC permit issued by the Wyoming Department of Environmental Quality.

C) Overlying and Underlying Aquifers. Samples shall be collected from all monitoring wells in the first overlying and first underlying aquifer at a minimum density of one well per 4 acres of wellfield.

D) Sampling and Analyses. Four samples shall be collected from each well to establish background levels. The sampling events shall be at least 14 days apart. The samples shall be analyzed for parameters listed in Table 5.7-2 of the approved license application, as revised by the May 27, 2015 submittal (ML15149A023). The third and fourth sample events can be analyzed for a reduced list of parameters; the parameters that can be deleted from analysis are those below the minimum analytical detection limits (MDL) during the first and second sampling events provided the MDLs meet the data quality objectives for the sampling.

E) Background Water Quality. For the perimeter ring monitoring wells (Section B) and monitoring wells in the overlying and underlying aquifers (Section C), the background levels shall be the mean values on a parameter-by-parameter, well-by-well, wellfield or sub-set of the wellfield basis, as deemed appropriate, in accordance with Section 5.7.8.1 of the approved license application. The UCLs for monitoring wells in the perimeter ring and overlying and underlying aquifers are established per LC 11.4. For the ore zone monitoring wells, the background levels shall be established on a parameter-by-parameter basis using either the wellfield, sub-set of the wellfield or well-specific mean value. The established background value for each parameter shall be based on the mean value plus a statistically valid factor to account for spatial variability in the data, in accordance with Section 6.1.1.1 of the approved license application.

[Applicable Amendment: 2, 7]

8.0 References

10 CFR Part 40. *Code of Federal Regulations*, Title 10, Energy, Part 40, "Domestic Licensing of Source Material." Washington, D.C.

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NRC (U.S. Nuclear Regulatory Commission), 2017d. Staff email with proposed License Conditions. March 9, 2017. NRC ADAMS Accession No. ML17079A289.

NRC (U.S. Nuclear Regulatory Commission), 2017e. Staff email for supplemental information request for license condition 11.3B amendment. April 3, 2017. NRC ADAMS Accession No. ML17094A356.

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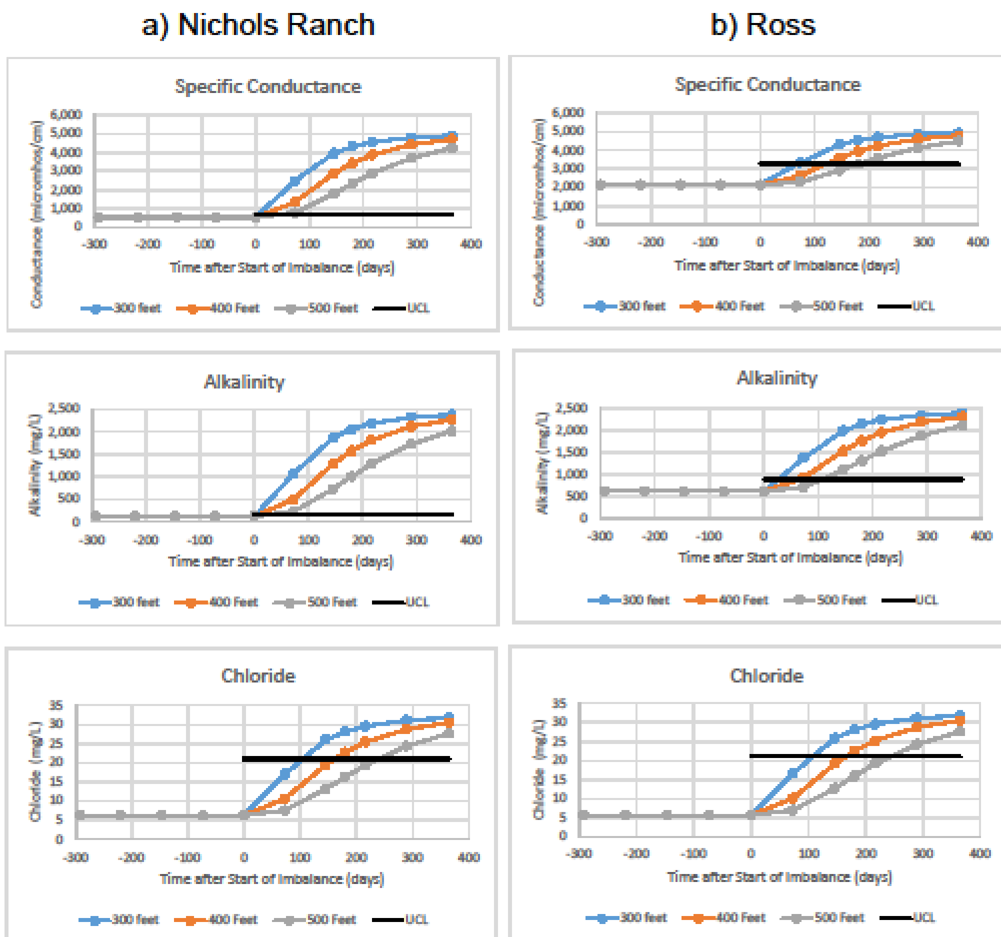

Figure 1. PHAST Model Output for the a) Nichols Ranch and b) Ross simulations
Source: NRC (2017c)

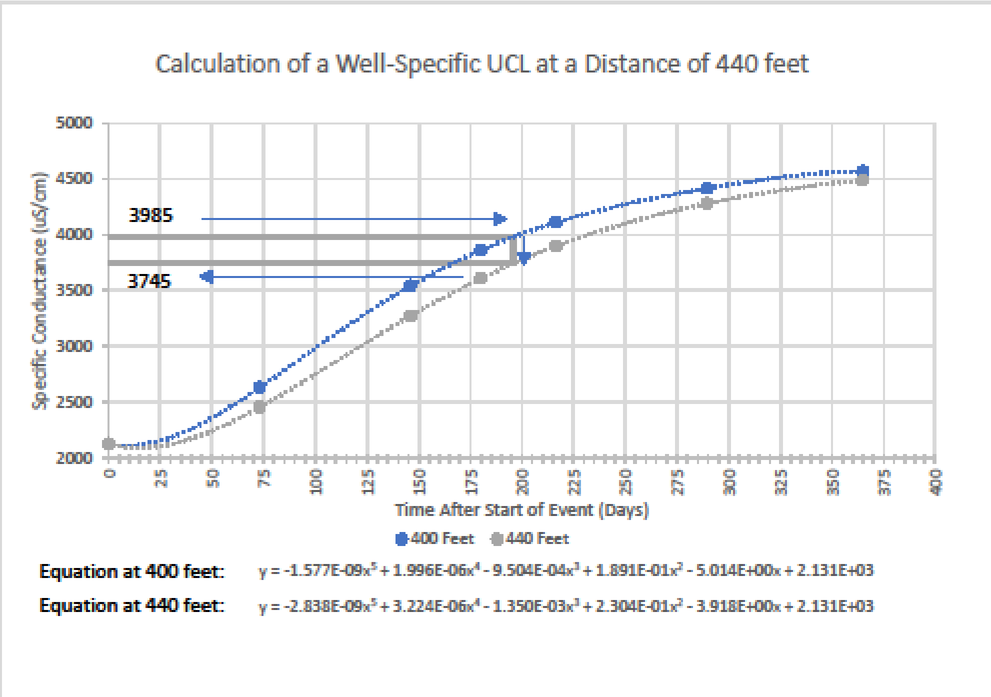

Figure 2. Method for Determining Well-Specific Specific Conductance UCL for a Well at 440 feet
At the standard specific conductance level of 3985 uS/cm draw a horizontal line to the intersection of the curve for specific conductance at 400 feet, then continue with a vertical line (constant time) to the intersection of the curve for specific conductance at 440 feet, then a horizontal line to determine well-specific level. Alternatively, use the equation for the curve fitted to the data for 400 feet to solve for the time to the standard UCL, then using that time, solve the equation for the curve fitted to the data for 440 feet to solve for the specific conductance.

Table 1. The Quality for Lixiviant and the Baseline and Excursion UCLs for Strata Energy's Ross Facility and Uranerz Energy's Nichols Ranch Facilty used in the NRC Staff's Models

Parameter	Units	Lixiviant	Ross		Nichols Ranch	
			Data	Phast Model	Data	Phast Model
ph	su	6.78	8.52	8.54	8.85	8.85
Pe		14.242 a		-4.823 e		-5.12 g
Temperature	degrees C	25	11.4	11.4		11.4
Alkalinity	mg/L	2930 b	625.4	625.4	128	128
Calcium	mg/L	68	7	7	8	8
Magnesium	mg/L	23	3.3	3.3	0.1	0.1 h
Sodium	mg/L	1300	545.4	545.4	117	117
Potassium	mg/L	14	6.9	6.9	3.5	3.5
Chloride	mg/L	32	5.7	5.7	6.3	6.3
Ammonia as N	mg/L	0.0001 c	0.4	0.4	0.05	0.05 h
Silica as SiO2	mg/L	1 c	8.3	8.3	9.5	9.5
Sulfate	mg/L	896	506.8	506.8	130	130
Bicarbonate	mg/L	b	684.6	684.6	145	145
Specific Conductance at 25C	uS/cm	5160 d	2225	2134 f	578	536
Excursion Parameter			UCL		UCL	
Specific Conductance at 25C	uS/cm		3269		731	
Alkalinity	mg/L		885		154	
Chloride	mg/L		21		21	

Notes:
a Equilibrium with O2 at 7.9 atmospheres
b As HCO3
c Assumed value
d Value from PHAST Analysis (see NRC, 2017c)
e Adjusted to equilibrium with calcite and CO2 partial pressure of 6.08x10-2 ATM to fit measured pH
f For the Phast model output, the specific conductance (SC) is reported at 11.4C; the SC was corrected to 25C by a factor of 1.35
g Adjusted to equilibrium with calcite and CO2 partial pressure of 1.58x10-4 ATM to fit measured pH
h Below the minimum analytical detection limit

Source: Lixiviant (Strata, 2016b; NRC, 2017c): Ross Data (Strata, 2015b): Nichols Ranch (Uranerz, 2013)

Table 2. Comparison of the MT3D-Predicted Times for a Excursion UCL Exceedance for Differing Distances to the Perimeter Monitoring Well Ring using the Strata Energy Ross and Uranerz Energy Nichols Ranch Baseline and USCLs, and various Distribution Coefficients and Longitudinal Dispersivities

Longitudinal Dispersivity = 40 feet

Distance to Perimeter Well (feet)	Time to UCL Exceedance from Start of Event (days)			
	Kd=0	Kd=0.02	Kd=0.05	Kd=0.1
Strata Energy Ross				
300	49.8	74.6	111	172.8
400	86.8	128.1	189.8	293.7
500	130.1	192.2	285.1	>365
Uranerz Energy Nichols Ranch				
300	23.5	35.5	51.8	76
400	48.2	68.9	97.4	145.3
500	76.8	108.8	155	233

Longitudinal Dispersivity = 4 feet

Distance to Perimeter Well (feet)	Time to UCL Exceedance from Start of Event (days)			
	Kd=0	Kd=0.02	Kd=0.05	Kd=0.1
Strata Energy Ross				
300	56.5	83.9	123.9	191
400	95.8	140.6	209.5	319.8
500	141.3	207.8	307.7	>365
Uranerz Energy Nichols Ranch				
300	35.8	52.7	76.8	116.8
400	66.3	95.4	138.2	209.8
500	102.1	147.1	213.9	326.3

NOTES:
Based on MODFLOW/MT3D Model setup (see NRC, 2017c)
Injection Concentration of 5160 (based on Specific Conductance levels (see Table 1))
For Strata Energy Ross, the baseline is 2225 and the UCL is 3269
For Uranerz Energy Nichols Ranch, the baseline is 578 and the UCL 731
Kd is distribution Coefficient (L/Kg)
UCL is Upper Control Limit

Table 3. Summary of PHAST Output

Location/Distance to Perimeter Monitoring Well Ring	Excursion Parameter	Time to UCL Exceedance (Days)		Excursion (Days)
		Multiple UCL	Single UCL	(Multipl/Single)
Nichols Ranch @ 500 feet	Specific Conductance	58.3	75	58.3/52
	Alkalinity	42	52	
Ross @ 400 feet	Specific Conductance	122	184.1	122/83.2
	Alkalinity	55.3	83.2	
Ross @ 500 feet	Specific Conductance	185.1	255.3	185.1/141.6
	Alkalinity	108	141.6	

Source: NRC (2017c)