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Jim Ruby, Executive Secretary
Environmental Quality Council

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of)
)
STRATA ENERGY, INC.,) Docket No. 40-9091-MLA
)
(Ross In Situ Recovery Uranium Project))

(Materials License Application)

DECLARATION OF ROBERT E. MORAN ON BEHALF OF THE NATURAL RESOURCES DEFENSE COUNCIL & POWDER RIVER BASIN RESOURCE COUNCIL

I, Robert E. Moran, declare that the following statements are true and correct to the best of my knowledge:

Introduction

1. I am a hydrogeologist/geochemist with more than 39 years of domestic and international experience in conducting and managing water quality, geochemical, and hydrogeologic work for private investors, industrial clients, tribal and citizens groups, NGO's, law firms, and governmental agencies at all levels. Much of this technical expertise involves the quality and geochemistry of natural and contaminated waters and sediments as related to mining, nuclear fuel cycle sites, industrial development, geothermal resources, hazardous wastes, and water supply development.

2. I have significant experience in the application of remote sensing to natural resource issues, development of resource policy, and litigation support. I have often taught courses to technical and general audiences, and have given expert testimony on numerous occasions. I have worked in numerous countries including Australia, Greece, Mali, Senegal, Guinea, Gambia, Ghana, South Africa, Iraqi Kurdistan, Oman, Pakistan, Kazakhstan, Kyrgyzstan,

Mongolia, Romania, Russia (Buryatia), Papua New Guinea, Argentina, Bolivia, Chile, Colombia, Guatemala, Honduras, Mexico, Peru, El Salvador, Belgium, Canada, Great Britain, and the United States. My CV is attached.

3. Much of my experience has involved uranium mining, processing, and related environmental impacts.

4. The Powder River Basin Resource Council has contracted my services to supply comments on the Strata Energy Ross In-Situ Recovery[1] NRC License Application.

5. In addition to my professional experience, the opinions and comments that follow are based on review of relevant portions of the application and documents listed in the References Cited section as well as a site visit to the proposed Ross Project area on June 7, 2011.

Summary of Comments

6. It is my opinion that Strata Energy misuses the term "Baseline." Baseline water quality results are, of course, a very important part of any uranium mining and milling license application because the baseline is what one measures impacts from and what one strives to restore to. The application fails to define pre-operational groundwater and surface water baseline water quality and aquifer water levels. As a consequence, it is likely the company will be able to avoid future liability for inadequate restoration.

7. It is my opinion that the application fails to adequately present the true extent of historical exploration drilling, borehole abandonment details, R&D testing, changes to groundwater water quality, and interconnections of geologic strata. These are cumulative impacts that should be disclosed and analyzed.

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[1] In-situ recovery ("ISR") is also commonly referred to as in-situ leaching ("ISL"). For the purposes of this declaration, the two phrases are used interchangeably.

8. The Ross permit area is only one small part of Strata Energy's proposed Lance Project. However, the application does not fully discuss the scope of the larger planned Lance Project and in doing so disregards cumulative impacts. For instance, the application states that "it is likely that the proposed Ross CPP will serve as the central processing location for future Strata satellite facilities and, potentially, satellite facilities owned and/or operated by other uranium recovery companies or water treatment entities; however, for purposes of the current license application, Strata intends for the Ross CPP to service only ISR operations within the proposed Ross license boundary." ER pg. 1-20. Therefore, any reasonably foreseeable future cumulative impacts associated with using the Ross CPP facility for future Strata or other operator sites and the related cumulative impacts related to water and other resources from the ISL mining associated with those future Strata or other operator sites are not disclosed or analyzed in the application.

9. Although it is not tabulated anywhere in the application, by my count, Strata Energy's Technical Report (TR) plus Appendices consists of more than 3577 pages. The Environmental Report (ER) consists of 1206 pages over three volumes. This is a very long application and unfortunately it is disjointed, confusingly-organized and repetitive, with discussions artificially split between numerous sections, so that a coherent picture is lacking. In my professional opinion, the organization of the report makes it difficult to fully assess Strata's proposed operations and their corresponding impacts.

10. It is my opinion that the ultimate conclusions in the application are not technically independent of Strata's financial interests. The license application (composed of the ER & TR) is written in a way that represents the positions, interests, and business needs of the company, rather than being written to provide an independent technical approach with full

disclosure of unfavorable arguments and conclusions. I believe it is therefore important for the NRC and the public to serve as independent reviewers and fully scrutinize the application with independent data and conclusions.

11. In some places of the application, it is unclear who is the author of individual opinions and conclusions. It is therefore not clear whether the opinions are of individuals with sufficient credentials and expertise to issue the opinions. As a professional in my field, I believe it is crucial that all conclusions related to water resources be drawn by individuals with sufficient expertise and experience. Where opinions or conclusions are of a professional nature, the person making them should be clearly identified.

12. It is my opinion that the application also fails to address several subsidiary tasks and permits that should be evaluated prior to award of the NRC license (for instance, the wetlands determination).

13. In summary, I believe there are several main questions that need to be answered in a NRC license application, the answers to which are not included in Strata's application. Specifically, Strata needs to 1) statistically define pre-operational baseline water quality, both on-site and in the potentially-impacted perimeter; and 2) fully disclose and analyze impacts related to the amount of water that will be consumed by operations per year and over the lifetime of the Lance project; 3) fully disclose and analyze impacts related to the sources and causes of water and hydrogeologic interactions of water-bearing units in the long-term; 4) fully disclose and analyze impacts related to the aquifer restoration criteria; and 5) fully disclose and analyze impacts related to the cumulative impacts that will result from past, present, and reasonably foreseeable future actions. Without answering these questions it is my professional opinion that the NRC will not be able to determine whether approving the

Strata project will adequately protect public health, safety, and the environment pursuant to NRC obligations.

Specific Comments

[Note: all page numbers cited refer to the number on the printed page, not the counter on the electronic files.]

The Application Fails to Adequately Characterize Site Disturbance from Past Exploration and Test Activities—Historic and Recent

14. The Application states in numerous places that thousands of exploration boreholes were drilled on the Ross site and throughout the Lance area during the 1970s and other time periods and that a pilot plant conducted test leaching / extraction activities from 1978 to 1979 (ER, pg. 3-10).

15. It is required in ISL License Applications to include detailed tabulations on all historic boreholes, including locations, dates of drilling, depth drilled and abandonment details. NUREG 1569, pg. 2-5 states that the site characterization related to water should include a map of abandoned wells and "The locations of abandoned wells and drill holes, including the depth, type of use, condition of closing, plugging procedure used, and date of completion for each well or drill hole within the site area and within 0.4 km [.25 mi] of the well field boundary." While there is some discussion in the application disclosing exploration boreholes, the application is deficient in meeting the requirements to fully disclose the wells, their status, and their impacts.

16. Importantly, the application is deficient because it never discloses the precise number of boreholes drilled in pre-Strata times. There are various numbers presented in different parts

of the Application. For example, within a 0.5 mi. radius of the Ross site, the following numbers are given:

- ER, pg. 3-47 reports 1,115 surveyed drillholes and 962 unsurveyed drill holes. (It is unclear whether this includes both Strata and pre-Strata drillholes);
- TR Addendum 2.6-B, Table1 reports 1,483 Nubeth holes within the Permit Area and 199 Nubeth holes within the 0.5 mile "buffer" and 1,952 total holes within the Permit Area and 270 within the 0.5 mi. "buffer." (It is once again unclear whether these numbers include pre-Strata drillholes).

17. Meanwhile, Peninsula Energy's (Australian parent of Strata) website reports 5,036 drillholes constructed within the Lance project, which includes the Ross Project.[2] This is clearly more holes than were considered in Strata's license application.

18. In addition to confusion about the number of boreholes, several locations in the Application confusingly summarize the fate of the boreholes [i.e. TR Addendum 2.6-B, Table 1; and TR Addendum 2.6-E] and raise more questions than they answer.[3] Importantly, nowhere in the application is there a complete description of the status of the boreholes and information necessary for a regulator to determine that there were properly plugged and abandoned and thus will not create pathways for water contamination. TR Addendum 2.6-E, pg. 1, states that "Details on the Nubeth boreholes are tabulated in Appendix A of this Addendum. Documentation on the abandonment practices of the majority of the boreholes was not available." Appendix A is not included in any of the Application documents, as was confirmed after talking with the project manager for WWC, the main consultants to Strata. Two possibilities for this important data are (1) that it was included in previous drafts and

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[2] http://www.pel.net.au/projects/lance_project__wyoming_usa.phtml
[3] For clarity these two addenda should have been combined—as is the case throughout the Application.

subsequently removed for some reason; or (2) the information simply no longer exists and Strata does not have the information to demonstrate that the boreholes were properly abandoned. Either way, Strata should be required to come back and discuss the location and status of the boreholes.

19. Strata's application downplays the significance of the boreholes without sufficient support. At ER, pg. 4-63, Strata states without sufficient basis that "Given the relatively small borehole diameter used for exploration and delineation, little water would be capable of migrating through one or more of these conduits." Such a statement is clearly without support and fails to consider the presence of thousands of potential pathways (open or ineffectively plugged boreholes) leaking over decades.

20. In my experience, the plugging and sealing materials used to abandoned boreholes and wells (bentonite, cement, gels) all begin to deteriorate many years after emplacement. It is also common that wells and boreholes are incorrectly or imperfectly abandoned in the first place (URS, 2006). In the present situation, we don't know the details, but we do know that at least hundreds and probably thousands of these Ross-Lance area boreholes have remained open for several decades, allowing mixing of waters between water-bearing units. Until these wells are located and shown to be sealed properly, they will continue to serve as a conduit for fluid migration and inter-mixing of the aquifers.

21. Given the operation of the ISL test plant in 1978-79, it seems inevitable that Nubeth leach solutions mobilized high concentrations of cations, anions, metals / metalloids and even some organic compounds between the ore zones and the proximate strata, both vertically and horizontally.

22. The significance of this is that the various geologic strata in the Ross / Lance region have been perforated by at least 5000 boreholes through the activities of Nubeth and Strata. It is unclear whether other companies also drilled in the area in pre-Strata times, possibly prior to the 1970s. Many of the historic boreholes have never been located by Strata and of those that have been located, many have not been correctly plugged and abandoned. Hence, the open boreholes provide potential pathways for the movement of ground water and solution fluids between the various water-bearing strata and the inter-fingering finer-grained sediments, both vertically and laterally. It is clear that original baseline ground water quality (pre-Nubeth operations) would have been negatively-impacted by the pilot ISL testing and the presence of the open boreholes, and that many of these impacts are present today. Thus there is much less certainty that Ross site ground waters and leach solutions can be as completely contained as is alleged throughout the Application.

The Ross water-bearing units are hydrogeologically interconnected with potential pathways for fluid migration

23. The Ross area sediments are composed of interfingering fluvial-deltaic sediments (Buswell, 1982), commonly referred to as facies rather than traditional geologic formations. (Fisher, et. al., 1969; Galloway, 1982). Such interfingering environments are the typical hosts for sedimentary uranium deposits. In many such settings, the water-bearing units are hydraulically interconnected, as has been demonstrated by long-term aquifer testing combined with water quality solute and isotope testing. (i.e. Galloway, 1982; Henry et. al., 1982; Moran, 1976).

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24. The Ross Application repeatedly alleges that the site aquifers are hydraulically isolated from each other, meaning that vertical leakage and fluid migration will not occur, because of the presence of fine-grained sediments above and below these aquifers. Unfortunately, Strata fails to demonstrate such hydraulic isolation. Rather, the evidence presented in the Application demonstrates the reverse.

25. First, TR pages 2-151 and 152 report that three water supply wells (for oilfield water flood uses) on the Ross site have pumped continuously from the uranium ore zone (the OZ unit) since 1980 -- for more than 30 years. Thus we have the equivalent of a 30 year-aquifer test performed at relatively low pumping rates. TR pg 2-157 estimates the total yield from the three oilfield wells to be 30 gpm.

26. Interestingly, Strata estimates (based on computer simulations) that water levels in the OZ unit have declined roughly 150 feet in the area of the oilfield water supply wells as a result of the 30 years of pumping.[4] Similarly, Strata estimates that water levels in the SM unit have declined roughly 10 feet during this 30 year period. The most obvious explanation for these declines is that the confining strata between the OZ and SM units allow vertical leakage of ground water under such long-term pumping conditions. It is totally unreasonable to conclude that such water level declines would result from compression of the intervening sediments.

27. Several other lines of evidence indicate that these water-bearing units are hydraulically connected. 1) the lithology of the SM unit is discontinuous (TR, pg. 2-152) and it is likely that the detailed lithologies of several of the other units are also discontinuous; and 2) Strata

[4] Two of the oilfield water supply wells pumping from the OZ (ore zone) aquifer were originally Nubeth R & D wells. They had maximum estimated drawdowns of 176 feet and 158 feet (ER p. 4-64).

states that "....the SM unit does not behave as a single aquifer and vertical gradients are present." (TR pg. 2-152).

28. In my experience, almost all aquifers leak if pumped for extended periods of time (i.e. years) at high rates (i.e. Freeze and Cherry, 1979; Kruseman and DeRidder, 1979; Todd, 1976). On pg. 320, Freeze and Cherry state: "Even when production wells are screened only in a single aquifer, it is quite usual for the aquifer to receive a significant inflow from adjacent beds."
29. Strata conducted seven pumping tests, six of 24 hour duration and one of 72 hour duration (TR, Addendum 2.7-F), all having low pumping rates (between 2.3 and 14.9 gpm). Such testing is adequate for calculating theoretical hydraulic parameters, but these durations are far too short and the pumping rates far too low for evaluating whether leakage occurs between the water-bearing units. More importantly, if Strata actually wanted to answer the question of whether aquifers are hydrologically connected and can result in fluid leakage and migration, they should have collected water quality measurements and samples (*in-situ* field and laboratory solute and isotope samples) throughout the duration of the aquifer testing. (Moran, 1976; Mazor, 1991). Interpretation of such data allows one to identify leakage of flow and chemical constituents from one unit to another. No such combined pump testing / water quality evaluations were performed or presented in the Application.
30. The Application is unclear regarding the total volumes of ground water that will be extracted during the various operational and recovery periods (see later discussions). Nevertheless, it is clear that Strata plans to extract hundreds of gallons per minute of local ground water during the Ross Project, which will undoubtedly result in leakage between the water-bearing units.

31. Nevertheless, throughout the Application, Strata contends that no leakage occurs or will occur. Despite such promises, Strata appears to want to take both sides of the argument. On ER, p. 4-61 they state in somewhat tortured language: "Water quality impacts to the vertically adjacent SM and DM aquifers, though isolated from the ore zone by natural conditions, could potentially occur through a compromise of the confining intervals. The geologic modeling and hydrologic testing conducted to date indicate no natural conduits are available for vertical migration of uranium recovery fluids. However, an improperly abandoned borehole or an improperly sealed well could introduce injected lixiviant into a vertically adjacent non-exempt aquifer." As was described previously, thousands of exploration boreholes and wells have been drilled in the Ross area. Many were undoubtedly drilled through multiple zones interconnecting the various water-bearing units. Clearly, many of these boreholes / wells have never been located or correctly plugged and abandoned. These open boreholes provide more direct pathways between the water-bearing units, in addition to the other leakage routes.

Changes to Water Quality from Baseline Conditions Have Already Resulted from Exploration Drilling, ISL Test Operations and Associated Construction

32. My applied experience with exploration / well drilling and associated ground water quality monitoring, plus numerous technical studies I have reviewed clearly indicate that such activities alter the original, baseline ground water quality conditions. Exploration drilling alters the baseline chemical conditions via the following actions: 1) introduces oxygen and other atmospheric gases formerly lacking, or at low concentrations; 2) drilling grinds up and fractures the subsurface rock / sediments, increasing the surface area available for chemical reactions; 3) introduces numerous forms of bacteria which can change the rates of chemical

reactions in the borehole (i.e. iron-reducing / sulfate-reducing / nitrifying, etc.; 4) changes down-hole Eh-pH conditions; 5) alters the pressure conditions in these subsurface zones; and 6) creates interconnections of subsurface water bearing zones formerly separated.

33. All of the above factors alter the chemical reactions occurring in the borehole, both on the walls of the borehole and out to a radius of many feet outside the borehole. These changes generally increase the concentrations of dissolved and total (particulate) chemical constituents in the local ground waters.

34. I have reviewed over the years numerous literature sources that describe and support the sorts of biogeochemical changes to ground waters described above: Abitz (2003), Abitz and Darling (2010), Chapelle (1994), Freeze & Cherry (1979), Gotkowitz, et. al. (2004), Hem (1989), Leybourne et. al. (2009, 2010), Moran (1976), Ripley and others (1996), Rose, Hawkes & Webb (1979), Sass (2011).

35. At TR, pg. 4-7, Strata states that Non-AEA-regulated liquid wastes will include TENORM wastes (technologically enhanced naturally occurring radioactive materials). "TENORM liquid waste includes drilling fluid and 'native' groundwater generated during construction and development of monitor, recovery and injection wells…" However, as described above, the drilling of thousands of exploration boreholes plus the leaching and recovery activities related to the Nubeth pilot operations, have already altered the previously undisturbed, baseline ground water quality conditions. Thus, portions of the Ross site ground waters no longer have the chemical characteristics of "native" ground water; thus, they should not be considered as representative of baseline or TENORM.

The Application Fails to Adequately Define and Characterize Baseline Conditions

36. The word baseline is used hundreds of times throughout the Ross Application. Nevertheless, baseline conditions for water resources at the proposed Ross site are never adequately defined or characterized. It is clear that Strata prefers to be held to two general definitions of baseline conditions: 1) those conditions existing when field activities occurred in support of the Application preparation (roughly 2009-2010); and 2) conditions that will be defined after NRC license approval, construction and further monitoring.

37. For the reasons discussed below, the Ross Application discussions of "baseline" largely confuse and confound the categories of historic and recent baseline, and site-specific and regional baseline.

38. Strata's approach contradicts NRC guidance (NUREG-1569), which requires that pre-mining baseline conditions be defined before licensing (NRC, 2003, pg. 2-24). As discussed in the previous section, the Application makes clear that this site has already been significantly disturbed through the drilling of thousands of exploration boreholes and wells, construction and operation of a pilot ISL operation during 1978 and 1979, which involved injection of lixiviant into the ore zone, pumping of production and recovery of the various solutions, and related construction. All such historical (pre-Strata) baseline water quality and water level data should be provided as part of the NRC Application, including sampling locations that should be clearly shown on appropriate maps and data that should be summarized in tables and where appropriate (such as with water quality data) statistically summarized.

39. Importantly, the application is deficient because no detailed data (pre-Strata) are included or statistically summarized in either the TR or the TR Addenda.[5] Incidentally, the addendums to the TR contain information that could be used to describe and interpret pre-mining baseline water quality but it is not presented as doing that. TR Addenum 1.2-A contains correspondence between the State of Wyoming and NRC regulators and the Nubeth Venture partners regarding the Sundance Project (Nubeth). TR Addenum 1.2-A, pg. 12—16, is a Memo (June 9, 1983) to Docket File No. 40-8663 from Ted Johnson, Project Manager, Uranium Recovery Field Office. This memo discusses the existence of baseline data for several wells, and that in a 1980 Nubeth report reviewed by NRC, additional restoration was needed "...because levels of arsenic, molybdenum, selenium, vanadium, and uranium exceeded baseline values." Hence, detailed pre-Strata baseline water quality data – both before and after the Nubeth project - obviously do exist, but have not been analyzed in the Ross Application.

40. In my experience with and interacting with numerous federal, state and international agencies on mining and other resource-related issues, baseline conditions represent conditions that act as a "yardstick" or criterion against which future conditions can be compared. Baseline water

[5] On TR pg. 2-171 and 172, the Application claims that data from 9 Nubeth wells are "summarized in TR Table 2.7-52. This table simply confirms that these 9 Nubeth wells were sampled from 4/1978 through 10/1981 (or 4/1980). No water quality data are presented. A following table, TR Table 2.7-53 reveals that the well waters were mostly of a sodium sulfate type, with one being dominantly sodium bicarbonate type. This table also presents concentrations for each well of Gross Alpha, Radium-226, and uranium; single values only for each well. No other Nubeth ground water quality data are presented here. Moreover, TR Table 2.7-23 identifies 80 wells (registered and unregistered) within 2 miles of the proposed project that have historically made use of local ground waters. However, on TR pg. 2-156, the application states that 14 monitor and industrial wells were permitted for the Nubeth operations. It seems likely that many of these wells and the neighboring private wells (those shown on TR Fig. 2.7-23) were previously sampled as part of the 1978-79 Nubeth efforts, but these historical data are not included in the Application---but should be.

The Nubeth test operations occurred in 1978-79, which was at the height of environmental reporting following the passage of the Clean Water Act in 1972. It is clear that the Nubeth partnership would have collected and maintained significant quantities of environmental data [water quality, water quantity (hydrogeology, pump tests, water levels) facility soil chemistry, etc.] as well as exploration data and reports. Detailed pre-Strata data are not presented in the Ross Application.

conditions are usually interpreted as conditions existing prior to the beginning of any significant industrial activities. If the NRC were to disregard the pre-Strata (Nubeth) baseline data, it would be equivalent to approving continued degradation of the earlier site water quality and to some extent quantity conditions. Therefore, the NRC should consider baseline for the purposes of determining restoration targets as pre-Nubeth conditions.

41. Moreover, it is likely that many of the recent wells (clusters) have water quality impacted by previous exploration and test activities and inadequate abandonment procedures. Hence, many of the conclusions presented in the Application are largely irrelevant without discussion of this past activity.

42. In addition to failing to consider pre-Strata water conditions, the Application also fails to properly characterize current water conditions. The Application claims that Baseline Groundwater Quality data are summarized in TR Addendum 2.7-I, but this table contains only data from Strata-collected samples (from industrial, stock and domestic wells) in 2009 and 2010. None of these Strata data are summarized in a meaningful statistical manner (i.e. showing for each constituent, by well: (n)—number of values; minimum, maximum, median, mean). Clearly, where the site (n) equals only two or three, the mean or median is essentially meaningless, statistically. The TR presents a table inadequately labeled "Table 2.7-29. Cluster Well Water Quality." It fails to tell the reader which wells were sampled, on what dates, and identify whether they were Strata wells or pre-Strata wells. The table also fails to identify the number (n) of samples used to construct the concentration ranges presented. One can only assume that the data summarized in Table 2.7-29 are the same Strata well data presented in TR Addendum 2.7-I, but it is unclear from the document.

43. In addition, only dissolved concentrations (filtered samples) are presented in Addendum 2.7-I for the majority of the minor constituents (except for iron and manganese). This totally misrepresents the water being used for domestic, stock and industrial purposes as humans don't consume water filtered through a 0.45- micrometer membrane filter. It simply presents a body of data having artificially low concentrations when compared to water actually used and consumed.

44. The application is also not clear in identifying how previously monitored wells will continue to be tested and monitored throughout the life of the project. TR Figure 2.7-14, TR, pg. 2-156, is titled "Regional Baseline Groundwater Monitoring Network." On the contrary, this map covers predominantly the *site-specific portions* of the proposed Ross project. The Application is not clear as to precisely which wells be monitored, both the on-site Strata wells and the buffer zone wells (within 2-miles of the project boundary). In order to be meaningful, future monitoring should include many of the wells previously monitored during both historic and Strata Application monitoring. Otherwise, Strata will be using different wells to determine post-mining water quality than they used to determine pre-mining water quality.

45. In my opinion, in order to have a technically sufficient application, Strata must collect and analyze unfiltered samples, as a minimum, for baseline ground water evaluation. These provide a more accurate and properly conservative characterization of the ground waters, because waters used in rural areas (human and livestock consumption from wells, other agricultural uses, irrigation, and fisheries) are not filtered. Furthermore, contaminants carried in particulate form are ingested by humans and other organisms when consuming unfiltered waters. These particles / colloids are dissolved by the extreme biochemical conditions found

in the guts of such organisms, mobilizing the contaminants into the blood and other tissues. In addition, many trace constituents are mobile in ground waters as colloidal particles (McCarthy, 1989; Ramsey, 2000, Slowey et. al., 2007, Crancon et. al, 2010), which would be removed by filtration, generating unreasonably-low concentrations.

46. The application is also deficient because a baseline spring and seep survey is not presented in the application. TR pg. 2-134 states that springs were identified near Oshoto Reservoir and several others were noted on the USGS quadrangle map, but these were more than 0.5 miles from the project area so their locations were not verified. The Application further states springs occur about 7 miles to the north of the site where the Lance and Fox Hills Formations outcrop. Thus these springs are potentially in direct hydrologic connection to the Ross ore zone. It is imperative that a detailed spring and seep survey within at least a 2-mile distance form the project boundary be performed which would: locate and map all spring locations, measure spring discharge, and collect and analyze samples from all springs. These activities should be performed at least quarterly for a year prior to permit approval.

47. Further, the application is deficient because soil contamination (radiation and metals / metalloids) from past mining and exploration data are not incorporated into determining baseline.

48. Strata has also inadequately defined the existing conditions of the soils and shallow ground waters within the proposed plant area. The Application presents no historical data (pre-Strata) on detailed soils or shallow ground water chemistry. On TR pg. 2-167 the application describes water quality samples taken from piezometers installed by Strata, but fail to mention the presence of actual monitoring wells in the plant area. Ground water (shallow) quality data from the plant area piezometers are presented in TR Table 2.7-43. These data are

not compared to the water quality data from the shallow aquifers. More importantly, Strata states that the total dissolved solids (TDS) in piezometer SA43-18-2 was between 4190 and 7280 mg/L (TR p.2-167) and also had high gross alpha concentrations. *These results (and others, such as elevated specific conductance (SC), chloride, sulfate, uranium, selenium, radium, etc.) suggest that these shallow ground waters below the plant area are already contaminated from past operations or recent activities. Such data should not be considered as representative of baseline conditions.*

49. Strata also needs to include water testing results from areas below and near proposed evaporation ponds that may leak and contaminate shallow aquifers.

50. The Application presents inconsistent approaches to defining the present use of local ground waters and thus determining baseline water quality. TR p. 2-156 says Strata evaluated ground water use in the project area and surrounding 2-mile (3.2 km) area. However, on TR p. 2-168, it says: ...operable water supply wells were identified within a 2 km (1.2 mi) area.

51. TR Addend. 2.9-A, p. 26, states that Strata followed NRC Regulatory Guide 4.14 to monitor wells. Regulatory Guide 4.14. is available at http://pbadupws.nrc.gov/docs/ML0037/ML003739941.pdf. It is a 1980 document related to surface uranium mills and largely irrelevant to in-situ uranium mining and milling. In contrast, NUREG 1569 (US NRC, 2003), which is directly related to in-situ mining and clearly relevant to Strata's application, at pg. 2-4 states:

> "The staff should also review tables showing, for each of the 22½-degree sectors centered on each of the 16 compass points (i.e., north, north-northeast, etc.), the distances {to a distance of 3.3 km [2 mi]} from the center of the site to the nearest resident and to the nearest site boundary.
>
> The staff review should include the location, nature, and amounts of present and projected surface-and ground-water use (e.g., water supplies, irrigation, reservoirs, recreation, and transportation) within 3.3 km [2 mi] of the site boundary {0.8 km [0.5 mi]

for research and development operations} and the present and projected population associated with each use point.

The reviewer should determine whether the application provides sufficient information on the use of the lands and waters within a 3.3 km [2 mi] distance from the site boundary surrounding the proposed facilities {0.8 km [0.5 mi] for research and development operations} to assess the likely consequences of any impacts of in situ leach operations on adjacent properties.

The staff should determine that the application contains the location of residences, ground-water supply wells, surface-water reservoirs, and the estimated use of water in the lands surrounding the site of the proposed facility. Data sources should be referenced. This information should be evaluated to determine whether it is sufficient to delineate the likely impact(s) of the facility, under both normal operating conditions and accidents, on the ground water, surface water, and population (both human and animal) near the site. The reviewer should determine that within 3.3 km [2 mi] from the site boundary, the nature and extent of present and projected water and land use and any other trends or changes in population or industrial patterns have been reported. Any other nuclear fuel cycle facilities located or proposed within an 80-km [50-mi] radius of the site should be identified."

52. At pg. 2-5, NUREG -1569 further states: "A 3.3-km [2-mi] distance from the site boundary is an acceptable area for which land and water use data should be collected."

53. Given these NRC guidelines, Strata should have evaluated and sampled all wells within a distance of at least 2 miles from the site boundary, and should have included pre-Strata baseline data for all wells within such an area. The Application fails to present *detailed* water quality data for all **functioning private wells within the 2-mile buffer zone** (i.e. as shown on TR Fig. 2.7-26). These summaries should include **both recent Strata and pre-Strata data** including: detailed water quality, water levels and well yields. Where adequate data are available, the Application should present detailed maps portraying changes in the local water levels through time, using both historic and recent data.

54. Because the closest private well is only 0.12 mi. (TR, pg. 2-170) outside the Ross Project boundary, it is imperative that the long-term trends in detailed water quality and water level measurements for these private wells be available to the public and regulators. Clearly it is possible that the water quality of some of these wells may already have been impacted by the previous (pre-Strata and Strata) drilling and test activities.

55. Without detailed baseline data (based on both historic and recent Strata data) on ground water quality and well water levels, there will be no reliable criteria for determining whether changes have occurred in the future during and after the various Strata operations. Also, there would be no reliable method for stating what Strata actions caused such changes in the future. This missing critical information makes it impossible for the NRC to determine whether the public health and safety will be protected during the project.

56. In my opinion, without all of this information, Strata has been unable to adequately define the presence of high-quality ground waters within the Ross Project boundary and therefore does not have appropriate baseline measurements, both within the project boundary and outside, that can be approved in a license application.

Project Water Use: The Ross Project will Use Significant Volumes of Ground Water and Will Impact Water Levels and Availability

57. Despite assurances to the contrary stated in the application, the proposed Ross ISL project can, and likely will have negative impacts on ground waters surrounding the site. Potential impacts are mentioned in the ER, Section 4.4 and in the TR, Section 7.2. Potential declines in water levels in surrounding wells are summarized in ER Table 4.4-2. Such declines may or may not occur in these and other wells. There is a great deal of potential error in the use of

such computer models and their assumptions. In my experience, such predictions made in environmental permit documents are generally far too optimistic (see later discussion).

58. The Ross Application fails to clearly answer the following question: How much water will be used by all proposed Ross operations in the long-term? The Application presents differing volumes in different portions of the Application. These variations likely result from the great uncertainty in many of the operational details (see subsequent discussion) to be selected. Nevertheless, these differences should be clarified and rectified prior to NRC permit approval.

ER Table 4.4-3 presents *estimates of consumptive use* of water during all phases (ER, p. 4-73) as follows:

Operations: 62 gpm

Concurrent Operation & Aquifer Restoration: 227 gpm

Aquifer Restoration: 190 gpm

Calculating the consumptive water usage for longer periods of time we obtain:

Max. Amount Consumed (gpm)

Operations: 62 gpm = 89,280 gpd = 32,587,200 gpy. Assuming 10 yrs. = **325,872,000 gals.**

Concurrent Operation & Aquifer Restoration: 227 gpm = 326,880 gpd = 119,311,200 gpy. Assuming 10 yrs. = **1.19 billion gals.**

Aquifer Restoration: 190 gpm = 273,600 gpd = 99,864,000 gpy; assume 10 yrs. = **approx. 998 million gals.**

59. However, another perspective on the volumes of water to be used is presented in the TR, pg. 3-1 and 3-2. Here it reports that the Production Area (wellfields and CPP) will have a maximum recovery flow of 7,500 gpm. The ER further states that the maximum restoration

flow is 1,100 gpm. And then a third perspective on the volumes of water to be used is presented in the estimated project Water Balance, shown in ER Figs. 4.13-1 thru 4.13-3 and TR Figs. 3.1-11 thru 3.1-13. Some details on these water balance figures are unclear, but again they assume a maximum source flow of 7,500 gpm during the Operations phase.[6]

60. Essentially all of these volumes of water will come from pumping local ground water sources. The Ross-Oshoto area is extremely dry, with average annual precipitation being about 12 in. per yr. (TR, p. 4-23). Therefore, most rural residents most likely rely upon ground water for domestic and livestock purposes. ISL projects will be able to pump tremendous volumes of ground water rapidly, but with such low precipitation, recharging the aquifers and recovery of local water levels may require much longer periods of time than are predicted in the Application, especially if numerous other ISL projects are approved. Hence, it is imperative that the public and regulators have reliable, *conservative* information for the predictions of water level declines around the perimeter of the proposed project.[7] Similar information on cumulative volumes pumped and cumulative predicted water level declines with cumulative predicted aquifer recharge rates should also be presented assuming that several additional phases of ISL uranium development occur within the regions surrounding the Ross Project (i.e. the neighboring Lance areas). Such cumulative simulations would provide a more conservative picture of the actual stresses likely to occur in the region.

61. Long-term ISL operations are likely to lower water levels in the shallow aquifers (both confined and unconfined), causing surface springs and seeps to go dry. Unfortunately, I see no evidence that Strata preformed a detailed seep and spring survey throughout the region.

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[6] Strangely, Strata has presented these Water Balance figures within TR Section 4.2 Liquid Waste, more specifically in a subsection entitled "Permeate Disposal Water Balance" (TR, p. 4-19). A more transparent approach would have presented these water balances within a "Water Use" section.

[7] While Strata's Application discusses some potential declines in water levels in surrounding wells in ER Table 4.4-2, this information is nowhere near sufficient for a full cumulative impacts analysis.

Hence, there would be no way to relate potential future impacts to any ISL operations activities, or any other activities. Such surveys are routinely performed as part of environmental impact assessments, and when correctly performed, identify (and map) the locations of such springs / seeps, measure flow volumes throughout the various seasons and collect spring water quality samples, identifying the detailed water quality characteristics throughout the various seasons.

62. Apparently the NRC does not regulate the total volumes of ground water an ISL project can use, throughout the operation of the project. If correct, the Ross Project could pump unlimited volumes of ground water from the local aquifers. Even if the NRC does not limit ground water consumption, the application should disclose the total consumptive amount in the environmental report because it will need to be analyzed by the NRC through its National Environmental Policy Act analysis. Consumptive amounts should be estimated for both operational periods and restoration, as needed to restore water to pre-mining quality as required by the NRC's primary restoration standards.

63. In my opinion, Strata's application unreasonably relies upon assumptions and computer model simulations to project impacts. There is a great deal of potential error in the use of such computer models and their assumptions. In my experience, such predictions made in environmental permit documents are generally far too optimistic and do not reveal the whole story. For instance, ER, p. 4-63, states that Strata's ground water model predicts that, as a result of Ross Project operations, maximum water level declines in the SM aquifer within the permit boundary would be 5 to 15 ft. However, the reader is left wanting to know what the declines in this and other local aquifers out to a radius of 2 miles from the project boundary will be, as required to be disclosed in the application.

Potential Impacts to Ground Water Quality

64. The TR, p. 7-36, 37, and section 7.2, and the ER, Section 4.4, describe possible impacts to private wells outside the project boundary---potential impacts to well yields, declines in water levels, and degradation of water quality. As discussed in other sections of this report, there will be no way to reliably demonstrate that such impacts have occurred without reliable baseline data on ground water quality and related water levels---using both historic and recent data. It is naïve to rely simply on the predictions coming from company-developed computer simulations.

65. I have reviewed decades of technical literature relating to uranium mining, both traditional and ISL, which make it clear that sediments containing uranium also contain elevated concentrations of numerous chemical constituents (i.e. Gabelman, 1977; Deutsch, et. al. 1984). Once leach solutions react with the ore-bearing and surrounding rock and sediments, the pregnant solutions mobilize elevated concentrations of numerous trace elements, anions, cations, and organic compounds. Selected constituents of concern in leach solutions because of potential toxicity to humans, livestock, fish, wildlife and agriculture are: uranium, molybdenum, vanadium, selenium, arsenic, copper, lead, radium, thorium, strontium, lithium, and others. (i.e. Mudd, 1998; Hall, 2009). Many of these constituents form chemical complexes that are mobile in both acidic and alkaline environments (Hem, 1989). As such pregnant leach solutions can readily contaminate surface and ground waters, soils, and vegetation if released into the environment. Strata should not make the same mistake as the NRC's Generic Environmental Impact Statement in presenting partial chemical composition data for pregnant leach solutions, (NRC (2009), pg. 2-16), as this implies that only a few

constituents are present at elevated concentrations. Instead, Strata needs to analyze all constituents that will be mobilized or released through the ISL process.

66. In reviewing the application, it is my opinion that Strata has not proposed anything differently that will limit the mobilization of trace elements. Strata is proposing to utilize the same technology that has resulted in contamination concerns at previous ISL mining sites. Even after ISL mining sites have completed restoration, these trace elements continue to be mobilized and are therefore present in greater levels than pre-mining conditions.

67. Since Strata is not proposing to do anything differently than previous ISL sites, it is likely that ISL mining at the Ross site will mobilize heavy metals and other toxic constituents. This will result in elevated levels of these constituents from baseline pre-mining conditions and will subsequently result in impacts to groundwater chemistry and quality. These impacts are un-mitigated in Strata's application.

68. In reviewing the literature and history of ISL mining, there is significant evidence that liners from evaporation ponds used to store waste from ISL projects will leak and cause possible contamination of shallow aquifers. It is my opinion that these possible impacts are not fully considered in the application.

69. There may also be water quality problems from liquid waste disposal. Much of the liquid waste will be disposed of via deep well injection (ER, pg. 4-66, 67) into (up to) 5 wells completed in the Deadwood and Flathead Formations. Strata has assumed that because these formations are deep and already contain high-TDS waters that no significant impacts can occur. However, numerous other regional energy-industrial projects—especially oil and gas projects disposing brines-- are also disposing their liquid wastes into these formations. The

Application fails to present any evidence that such cumulative, long-term disposal of large volumes of wastes into these formations will not result in long-term negative impacts.

Aquifer Restoration and Cleanup Criteria

70. The Application describes great uncertainty as to the actual, detailed procedures that will be employed for aquifer restoration and fails to adequately define the specific aquifer restoration criteria / standards. For example, ER, pg. 4-67—69 states: "Strata proposes to conduct aquifer restoration concurrently with operations where possible as the potential exists for the two phases to interfere with one another." Therefore, the exact timing of restoration activities is unknown. On TR, pg. 1-12, Strata states that the actual procedures for aquifer restoration are unknown and merely describes several possible methods. Without up-front review of restoration methods or criteria, it is impossible to know whether restoration will be successful and whether the NRC's primary restoration standard of returning water to pre-mining conditions will be achieved. In my opinion, the application is greatly deficient in this area and needs to be revised to contain a robust discussion about restoration techniques and success probabilities.

71. The Application does not clearly define the specific chemical constituents that will be sampled during aquifer restoration monitoring. More importantly, it fails to clearly define the specific chemical constituents / field measurements that will be used as aquifer restoration criteria, and their specific numerical limits. Any reasonable list of aquifer restoration criteria should be detailed and extensive.

72. Importantly, the technical and regulatory literature amply documents the numerous *failures to restore aquifer water quality at other ISL sites to pre-mining conditions*. Thus, because Strata is proposing to use the same mining and milling methods as other ISL sites, it is

reasonable to assume that portions of the ground water surrounding the leached zones will have degraded water quality and may be unfit for future uses.

73. Information from the Nubeth project shows that it may be difficult, if not impossible, to adequately restore the local aquifers. It is instructive to note that Nubeth testing ended in 1979, but aquifer restoration was not deemed to be completed until several years later in April 1983 when the Wyoming DEQ gave their approval. Final NRC decommissioning continued for three more years, from 1983 through 1986 (TR pg. 1-3). TR Addenum 1.2-A contains correspondence between the State of Wyoming and NRC regulators and the Nubeth Venture partners regarding the Sundance Project. TR Addenum 1.2-A, pg. 12—16, is a Memo (June 9, 1983) to Docket File No. 40-8663 from Ted Johnson, Project Manager, Uranium Recovery Field Office. This memo discusses the existence of baseline data for several wells, and that in a 1980 Nubeth report reviewed by NRC, additional restoration was needed "...because levels of arsenic, molybdenum, selenium, vanadium, and uranium exceeded baseline values."[8] As stated previously, the Nubeth tests and subsequent restoration activities occurred following Congress's passage of the Clean Water Act so it seems likely that much more extensive ground water quality and quantity data are available for the pre-Strata years at this site than is disclosed in the application.

74. Information from the Nubeth project also shows that there may be operational problems with conducting ISL mining at this location, which could translate to restoration problems down the road. TR, pg. 3-13 states: "While injectivity (sic) issues plagued the Nubeth R&D site....." This could indicate that the Nubeth operators over-pressured and hydro-fracked the

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[8] Water quality in the aquifer / ore zone leached during the Nubeth testing in 1978-79 was never adequately restored for domestic, livestock or agricultural uses due to elevated gross alpha concentrations (TR, pg. 2-172). It is unclear whether the "restored" aquifer had elevated concentrations of other chemical constituents because the Strata Application (TR Table 2.7-54) presents only selected data on gross alpha, radium-226, and uranium. All other details on aquifer water quality are lacking.

field. According to information in the application, the Nubeth tests had limited success due to "...fines and organic material buildup in the wellfields..." (TR pg. 1-3). No additional details are given, but clearly the operators were not successful in developing a viable program---not entirely due to the drop in world uranium prices.

75. Throughout the Application, Strata repeatedly makes optimistic statements about assured aquifer restoration. However, attempts at aquifer restoration at other in-situ operations fail to support such optimism. Indeed, the historical reality from other operating or closed ISL sites demonstrates an inability to restore to pre-operational or baseline water quality conditions for all constituents. (Otton, 2009; Hall, 2009).

Future Uses of Ground Water – Failure to Consider Cumulative Impacts

76. Strata's application carves up the potential impacts into pieces, preventing the public and regulators from realistically looking at long-term, cumulative impacts. Here it seems short-sighted to evaluate only the potential impacts from long-term pumping of Ross Project ground waters. The long-term scenario presented by Strata clearly involves the possibility of developing several additional ISL projects adjacent to the Ross Project. All would require use of tremendous volumes of ground water for both operations and recovery.

77. The truly conservative approach – which should be required for this application – would require ground water simulations to be conducted combining the anticipated pumping from the operation of the Ross Project (assuming ground water extraction occurred at maximum anticipated rates) with those assuming the operation of several other nearby ISL operations. Numerous possible worst-case scenarios would be developed. Thus, water planners / regulators would receive much more useful information for deciding what volumes of local / regional ground water can be sustainably pumped, long-term.

78. In addition, it is only intelligent that those tasked with making long-term decisions regarding local ground water use foresee that uses of these waters may change drastically in the distant future---not simply 10 or 20 years in the future. Such uses may be quite different than the present predominant livestock and agricultural uses, and conceivably require high water quality. If local ground water quality is degraded by ISL operations, such alternative future uses may be precluded. Or, these ground waters might require treatment at public expense to allow these other future uses.

Problems with Water Monitoring Programs

79. On TR pg. 5-78 the application states that the monitoring programs will follow the details presented in TR Table 5.7-1. TR pg. 5-79 states that: "Existing private wells within two kilometers of the proposed project area boundary are to be sampled on a quarterly basis with the landowner's consent. Samples will be analyzed for the parameters listed in Table 5.7-2." This table also indicates that operational environmental monitoring for *ground water monitoring wells* will be limited to: dissolved uranium, Ra-226, Th-230, Pb-210, Po-210, gross alpha and gross beta. Similar monitoring of existing water supply wells will be limited to: dissolved and suspended uranium, Ra-226, Th-230, Pb-210, Po-210, gross alpha and gross beta. In my opinion, both suites are far too limited to provide a detailed understanding of possible impacts to ground water quality. TR Table 5.7-2 is much more extensive, but still largely neglects to include data from unfiltered (total) samples for most constituents. TR, 5-83 states that Table 5.7-2 constituents will be monitored for the first two quarterly sampling periods, and then the list may be reduced.

80. Monitoring samples need to be analyzed for a broad range of inorganic and organic compounds. Such analyses should include, as a minimum: field and lab pH, specific conductance, water temperature, together with total determinations (and in some cases dissolved determinations) of: aluminum, antimony, arsenic, barium, cadmium, copper, chromium, cobalt, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, zinc, calcium, magnesium, sodium and potassium, sulfate, nitrate, ammonia, boron, phosphorus, fluoride, chloride, and natural radioactive constituents (uranium, thorium, potassium-40, gross alpha and beta, in general), cyanide and related breakdown compounds (metal-cyanide complexes, cyanate, thiocyanate, organic carbon, oils and greases, together with a comprehensive scan for organic compounds.

81. No excursion parameters are discussed in the application. TR, pg.3-19 states that *excursion parameters* are presented in Sect. 5.7.8.1 However, *no detailed list of excursion parameters was found in that section.*

82. The application is missing field sample collection and handling details for ground and surface water quality, including bottles, preservatives, filtration, handling, etc. TR, pg. 2-289 says all ground water samples were collected according to SOP 9, in Addendum 2.9A [Radiological Sampling and Analysis Plan (RS&AP), Aug. 6, 2010]. This SOP is not actually mentioned in the Radiological Sampling Plan, nor is it listed in the Table of Contents, but follows the RS&AP. When one finally locates SOP 9, pg. 3 states: "Section 3.9 of the Sampling and Analysis Plan defines sampling locations and radiochemical analysis requirements for the preoperational baseline program." Thus, with no guidance as to page, the reader is sent back to the SAP---which presents almost no useful details on actual field sample collection and handling details. Section 4.3 of the RS&AP (p. 34) then states:

"Specific field sampling procedures for the program elements presented in this SAP are described in the SOPs which are provided in Appendix A." But there is no Appendix A. So, one returns to SOP 9, pg. 6: Sample Collection: Field measurements taken while purging well. However, that document also does not disclose the field sampling methodology. While the company claims that its procedures produced stable readings, from what I was able to review in the application, I do not think that is likely.

The Application Fails to Present Detailed Chemical Composition Data for Expected Process Fluids, Liquid Wastes, Pregnant Leach Solutions, Other Chemicals, and Ores

83. The Application needs to present *detailed* chemical composition data for barren and pregnant leach solutions. Application information presented at TR, p. 3-10 and Table 3.1-1 is insufficiently detailed to be meaningful. Thus, the actual detailed impacts that will result from leaching and mobilization of chemical constituents are not known.

84. The Application fails to provide details on the chemical composition of the liquid wastes to be injected. TR, Table 4.2-5 fails to present detailed chemistry of the brines. It seems likely that such details have been developed, as part of Feasibility Report testing that would have been performed to inform potential investors or as part of its state Underground Injection Control permit application.

85. Detailed chemical composition data for representative ores should also be included in the Application, so that one will be able to determine whether the proposed ground water monitoring will adequately sample for all relevant chemical constituents.

86. A detailed tabulation of all process chemicals, hazardous materials, fuels and explosives to be utilized during the life of the Ross Project should be compiled. The table(s) should

identify chemicals by common chemical names, and where appropriate commercial names; quantities / volumes for each to be used per year should also be included.

87. Full chemical composition data should be released, partly to allow regulators and the public to evaluate impacts that might result from potential spills of these liquids.

Other Uncertainties about Actual Project Operational Details

88. The Ross Project Application often presents large ranges of uncertainty when describing numerous proposed operational details. For example, TR, pg. 3-1 and 3-2 state that two mine units will be operated with estimates of modules between 15 and 25, each module estimated to contain approximately 40 recovery wells (TR, p. 3-11). However, elsewhere in the application, the total number of recovery / injection wells is estimated to be between 1400 and 2200.

89. Strata also expresses uncertainty regarding well placement and uranium ore zones. ER at 1-16.

90. Strata also estimates that they will produce 750,000 lbs of uranium per year but they are requesting a license application to produce 3 million lbs per year. ER, pg. 1-4.

91. TR, pg. 1-14 states that the final Facilities Engineering Report will be prepared later, presumably following NRC license approval. A "Site Operation Plan" detailing wellfield operations "that relate to protecting against and responding to any potential excursion from the recovery zone" will also be prepared "after issuance of the requested NRC license." ER, pg. 1-15.

92. Evaporation from lined retention ponds is calculated to be only about 1.5 gpm per acre of pond, thus evaporation ponds will not actually provide viable alternatives for disposing of permeate. TR, pg. 4-19. Nevertheless, they are proposed in the Application.

93. "By treating part of the injection stream, Strata hopes to help maintain the water quality of the injection solution." TR, pg. 3-15. In order to receive an ISL license application, Strata should demonstrate that the water quality will be maintained, not just hope that it will be the case.

94. Despite the normal large degrees of error / uncertainty associated with various ground water models, the following comments regarding the Ross model simulations demonstrate that there is even more uncertainty than normal. 1) At ER, pg. 4-64-65 Strata states that many of the modeling results may not come to pass because of numerous uncertainties. Modeling simulations ".....do not include injection of lixiviant or RO permeate, only an average bleed (1.25%) from recovery wells....." 2). At TR, pg. 3-15 and 16 Strata states that the Application has used a "one size fits all simulation." Such uncertainty regarding project operational details should warn both the public and regulators that Strata's pronouncements about the extent of expected impacts are also subject to a great range of error and uncertainty.

Prerequisites to NRC License Approval

95. The Application implies that Strata will perform numerous tasks and obtain subsidiary permits following issuance of the NRC license to Strata. These tasks / permits should be completed / obtained prior to NRC licensing of the Ross Project in order for the NRC to determine that the project will not cause harm to public safety or the environment. For instance, a wetlands determination permit (U.S. Army Corps of Engineers) approval should be evaluated prior to awarding an NRC license so the NRC will be able to determine that those impacts are appropriately avoided or mitigated.

Financial Assurance

96. The NRC and the general public know several general facts about the usefulness of most company-generated financial assurance estimates:

a) Financial assurance estimates generally are based on overly-optimistic assumptions about future water quality, thereby under-estimating costs. Kuipers (2000) conducted a survey of bonding practices at metal mines throughout the western U.S. and found that the bond amounts available were hundreds of millions of dollars below that necessary to conduct actual clean-ups. Many of the "problem" sites have been foreign-owned entities.

b) Aquifer restoration at most, if not all previously-licensed and operated ISL sites has failed to actually return ground water quality to baseline conditions [Hall (2009); Otton and Hall (2009)]. Nevertheless, since restoring to baseline conditions is the primary restoration goal, ISL facilities should be bonded for the amount it would take to do that restoration. ISL facilities are not often bonded for that amount.

c) Predictions of future aquifer restoration success made by the project proponents seldom use truly conservative assumptions. Calculations of financial assurance amounts made by representatives of the party that stands to profit from project licensing represent an extreme conflict of interest.

d) The technical literature is filled with documentation that quantitative predictions of future water quality at specific sites cannot be done reliably [Sarewitz, et. al. (2000); Moran (2000); Pilkey & Pilkey-Jarvis (2007); Kuipers & Maest (2006)], and the general failure to restore aquifers back to pre-operational baseline concentrations supports this. At an academic level, this approach must be totally rejected because it assumes one can make accurate and precise *deterministic* predictions.

97. For these reasons, the financial assurance calculations should be made by some independent party, not paid or directed by the project proponents. These calculations should also consider the actual reclamation and restoration costs incurred, long-term, from a statistical sampling of the previously-licensed ISL sites. Furthermore, these financial assurance amounts and mechanisms should be made public prior to award of any licenses.

98. To ensure protection of the general public, such financial assurance vehicles should be made with the parent corporation, not simply the local operating entity.

NRC Capabilities to Reliably Oversee Strata Activities and Importance of Agency Oversight because of Flawed Assumptions and Conclusions in the Application

99. The application (ER p. 4-55) implies that NRC oversight activities of ISL sites are detailed and efficient. However, I have heard from the NRC regional office in Texas that there are only 2 NRC staff available to inspect and oversee all ISL projects in the entire western U.S. This detail should be verified. In my opinion, the ability of the NRC to enforce its own regulations and license conditions is limited.

100. Nevertheless, the NRC's oversight role in this license proceeding is critical. Given the inherent conflict of interest in having the Application preparation directed, partially-prepared, and paid for by the project proponent, some independent party needs to take a more assertive oversight role, including in oversight of actual monitoring methods in the field. This is especially evident in the biased decisions made throughout these Application documents regarding aquifer isolation and baseline water quality and quantity decisions, as discussed below.

101. The Application frequently intends to show that existing water quality is already impacted; i.e. plant-area piezometers, leakage from SM unit wells, etc. Rather than explain data using science, the application focuses on arguments to minimize liability (i.e. it focuses on comparing water quality to various regulatory standards).

102. Unfavorable conclusions are often presented in disjointed fashion throughout several sections. Hence it is difficult to determine the actual impacts [i.e. role of "baseline" water quality for NUBETH wells (TR, p.2-169, 2-171, etc.); impact of improperly abandoned boreholes, etc.].

103. The Application states that no impact to nearby aquifers is expected, but the application discloses already seen impacts in SM wells. 30 yrs of oilfield well pumping at about 30 gpm (total) has dropped water levels in SM unit wells about 10 ft. Hence, leakage has occurred between the aquifers. Pumping from the OZ unit would actually have started in the late '70s. Thus, Strata has purposely avoided mentioning that the various geologic units surrounding the uranium ore zone leak.

104. In my opinion, the application contains numerous overly-optimistic discussions and explanations. For instance, ER, p. 4-67 refers to potential impacts to the surficial aquifer (SA) during restoration, but then states: "Water management within the central plant area will continue in a similar fashion during aquifer restoration, with utilization of the lined retention ponds for temporary storage of permeate and brine pending injection. Again, engineered controls utilized during operations will prevent impacts to the system."

Confusing Organization

105. The Ross Application is an enormous set of documents composed of the Technical Report (TR) plus Addenda (6 volumes) of more than 3577 pages and the Environmental Report (ER) composed of 3 volumes comprising 1206 pages.

106. Discussions of many of the topics are divided between several unrelated sections throughout the ER and TR so that the reader fails to receive a coherent picture of the topic. The data are not adequately summarized in tables and /or maps. The reader must wade through numerous sections of both the ER and TR and their Addenda, checking dozens of separate tables and maps, many of which could easily have been combined in order to realize that Strata has avoided answering the basic questions.

107. The Tables of Contents for both the TR and ER are insufficiently detailed to allow easy access to the important topics. The Addenda Tables of Contents have no page numbers for most portions. Many important addenda are "sequestered" in other addenda sections that are unrelated to the topic at hand and their presence is not listed in the Table of Contents. For example, what methods were employed for sampling and handling ground waters for naturally-occurring water quality constituents? Sampling methods are not mentioned in the Tables of Contents for either the ER or TR. The ER text makes no reference to such details, but, finally, in an unrelated section of the TR entitled Background Radiological Characteristics, (TR, pg. 2-289) one reads: "All groundwater sampling was completed in accordance with procedures outlined in SOP 9, provided in Addendum 2.9-A." This addendum is entitled: Radiological Sampling and Analysis Plan (SAP), with no mention of non-radiological constituents. This SAP contains no mention of SOP 9. On pg. 34 of the SAP (TR Addendum 2.9-A), it states: "Specific field sampling procedures for the program

elements presented in this SAP are described in the SOPs which are provided in Appendix A." No Appendix A is present! Finally, by paging through the entire Addendum 2.9-A one finds SOP 9 sitting unannounced at the back.

108. Often the titles of sections, addenda, tables and figures are unclear as to what is actually being described or portrayed. A typical example is TR Addendum 2.6-B, entitled: "Exploration / Delineation Drillhole Tabulation." As with so many other examples, the title is unclear about whether this is a compilation of pre-Strata or Strata-constructed boreholes.

109. These are only a few examples of the recurring disorganization and confusion that exist throughout the Application and which make comprehension of the main points unnecessarily cumbersome.

Summary

110. An official baseline data set for all site aquifers should be developed and presented publicly before NRC permit approval is given. These data should include (as a minimum) all pre-Strata and Strata data for ground waters, surface waters and surficial soils within a 2-mile area of the project boundary. All data should be statistically summarized by monitoring site, aquifer, etc. so that the reader can determine the number of determinations (n), and the minimum and maximum concentrations for these sites, median and mean concentrations (where appropriate). Such baseline data should similarly include the water quality and water level data (historic and recent) for all private wells within a 2-mile radius of the project boundary.

111. A complete sampling database of surface and ground waters, water levels, pump tests, soils, etc. should be compiled and made public prior to NRC license approval. These should include all historic and recent data. [ER, pg. 1-2 states: "The development of these wellfield

modules and the accumulation of a complete sampling database will begin when Strata is issued an NRC license……"]

112. Strata also needs to develop and identity aquifer restoration criteria / cleanup criteria / excursion criteria. Specific numeric criteria for these categories should be defined and made public prior to NRC license approval. If Strata does not intend to restore to pre-mining conditions and instead rely on Alternative Concentration Limits, those limits also should be defined and made public prior to NRC license approval.

113. Strata needs to present a detailed summary (in tabular form) of all exploration borehole data, both pre-Strata and Strata, showing all relevant completion, depth, and detailed abandonment information where available. The summary should clearly identify boreholes not located or not plugged and abandoned. TR, p. 3-20, 21 states: many exploration / delineation holes are still not located and correctly abandoned. This task should be completed prior to license approval to ensure that there will not be pathways for groundwater contamination.

114. Details regarding Financial Assurance should be made public prior to NRC license approval and should be based on the primary restoration goal of returning waters to pre-mining conditions.

I declare under penalty of perjury that the foregoing is true and correct, to the best of my knowledge, information, and belief.

Dated: 24 Oct. 2011

Robert E. Moran

Signature

LQD SEP 28 2012 RECEIVED

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EDUCATION

University of Texas, Austin: Ph.D., Geological Sciences, 1974
San Francisco State College: B.A., Zoology, 1966

PROFESSIONAL HISTORY

Michael-Moran Associates, LLC, Partner, 2003 to present
Moran and Associates, President, 1983 to 1992; 1996 to 2003
Woodward-Clyde Consultants, Senior Consulting Geochemist, 1992 to 1996
Gibbs and Hill, Inc., Senior Hydrogeologist, 1981 to 1983
Envirologic Systems, Inc., Senior Hydrogeologist/Geochemist, 1980 to 1981
Tetra Tech Intl./ Sultanate of Oman, Senior Hydrogeologist, 1979 to 1980
Science Applications, Inc., Geochemist/Hydrologist, 1978 to 1979
U.S. Geological Survey, Water Resources Division, Hydrologist/Geochemist, 1972 to 1978
Texas Bureau of Economic Geology, Research Scientist Assistant, 1970 to 1971

REPRESENTATIVE EXPERIENCE

Dr. Moran has more than thirty-nine years of domestic and international experience in conducting and managing water quality, geochemical and hydrogeologic work for private investors, industrial clients, tribal and citizens groups, non-governmental organizations, law firms, and governmental agencies at all levels. His experience includes the following representative project assignments:

- Pro Patrimonio (the National Trust of Romania); Brussels, Belgium. Presentation to members of European Union Parliament regarding environmental aspects associated with the proposed Rosia Montana Mine, Romania.
- Trustees for Alaska. Prepared expert report on hydrogeologic and water quality impacts from exploration activities at the Pebble Mine site. Opinions prepared for litigation in Alaska Superior Court on behalf of *Nunamta Aulukestai, et. al. v. State of Alaska, et. al.* (Pebble Limited Partners); deposition and trial testimony.
- Bank Information Center and Earthworks, Washington, D.C. Report on hydrogeologic and geochemical impacts at the proposed Weda Bay, Indonesia, cobalt-nickel mine; delivered to Multilateral Investment Guarantee Agency.
- IKV Pax Christi (Netherlands), Bogota, Colombia. Prepare mining-environmental best practices report for presentation to Colombian Ministry of Environmental Affairs.
- Oglala Sioux Tribe, Western Mining Action Project, Gonzalez Law Firm, South Dakota. Review of Powertech License Application and provide expert opinions: Dewey-Burdock In Situ Uranium Project.
- Comisión de Gestión Integral de Aguas de Bolivia (Commission for the Integrated Management of Bolivian Waters) and Federación Regional Única de los Trabajadores Campesinos del Altiplano Sud (Regional Farmers Federation of the Southern Altiplano), Bolivia. Review of present mining activities and documents related to the San Cristobal Mine. Activities funded by the Municipality of Colcha K (Potosí, Bolivia), the Centro de Estudios de la Universidad de San Simón, Cochabamba, and Global Green Grants Fund.
- Shute, Mihaly & Weinberger / San Diego State University Research Foundation. Review of hydrogeologic / environmental impacts associated with quarry construction near a university wildlife refuge.
- Sarah Vogel Law Firm, North Dakota. Litigation support and evaluation of environmental impacts resulting from a release of oilfield waters onto livestock lands and waters.

- IKV Pax Christi (Netherlands), Tolima, Colombia. Technical review of proposed La Colosa gold project (Anglo Gold Ashanti); interaction with regulators, civil society and company; prepare recommendations & report.
- Thompson Divide Coalition, Western Colorado. Technical assistance to a consortium of environmental groups in designing and conducting a baseline water sampling program in anticipation of gas drilling activities. Preparation of summary report.
- Global Green Grants / Nature's Own, Papua New Guinea.
  Prepare technical / policy papers on marine disposal of mining wastes.
- SAVIA, School of Ecological Thought / Comision Pastoral Paz y Ecologia, Guatemala. Presentations on ecological aspects of resource legislation to Guatemalan government ministries, high-level officials, and educational institutions. Conduct water quality training classes; assist with development of laboratory capabilities.
- Astrella & Rice, Colorado, U.S.A. Technical assistance in preparing litigation arguments for citizen lawsuit involving alleged drinking water contamination by oil and gas activities.
- Office of the Prime Minister, Iraqi Kurdistan. Development of information infrastructure and management training for numerous ministries in Northern Iraq; done in partnership with faculty of American University, Washington, D.C. Headed an audit team for the Regional Statistics Organization.
- Southwest Research and Information Center / Buryat Regional Organization on Baikal / Mongolia Nature Protection Coalition; Buryatia, Siberia, Russia and northern Mongolia. Technical information exchanges with local NGOs, government officials and mining company staffs.
- Rulison Citizens Group / Public Counsel of the Rockies. Colorado. Development of technical arguments and potential litigation support intended to define environmental issues related to gas development near the Rulison underground nuclear test site. Hearing testimony.
- The Nature Conservancy, Trout Unlimited, Alaska Conservation Foundation, Trustees for Alaska and Renewable Resources Coalition, Alaska. Presentations to public interest groups and development of technical issues and papers relating to construction of the Pebble copper-molybdenum-gold mine, proposed for operation above the largest sockeye salmon fishery in the world.
- Wild Salmon Center, Alaska. Technical evaluation of hydrogeological, and chemical issues that may impact fisheries near the proposed Pebble Mine.
- Miller, Axline & Sawyer / Meyers, Nave, Riback, Silver & Wilson / City of Grass Valley, California. Technical and litigation support in a suit alleging contamination by Newmont Mining Corporation; deposition testimony.
- Latin American Water Tribunal. San Salvador, El Salvador. Prepare presentations and conduct workshops on water and water quality. Funding: Heinrich Boll Foundation.
- Alburnus Maior, Rosia Montana, Romania. Evaluation of EIA and preparation of summary report on a proposed gold mine in Transylvania. Funded by the Staples Trust, U.K. and the Open Society Foundation, Romania.
- Asociacion de Desarrollo Social Santa Marta (ADES), El Salvador. Evaluate EIA and related documents, El Dorado Mine; technical presentation at national forum; prepare review report. Funded by DIAKONIA, Swedish Ecumenical Action.
- Alburnus Maior, Romania. Review documents and prepare comments related to development of proposed Rosia Montana Mine for a Romanian NGO.
- La Lumiere, Senegal and WACAM, Ghana. Conducted water quality training sessions for NGO and government staffs, as related to mining and other development activities. Funded by Oxfam America.
- ESRI (Environmental Systems Research Institute). Provide technical assistance to several Iraqi Ministries to define information management needs, deploy map- based systems (GIS), and establish a Middle East-based Center of Excellence to support these ministries.
- Colectivo Madre Selva, Guatemala. Evaluation of Marlin Mine site, review of EIA and preparation of report; attendance at national and indigenous mining forums; conducted water quality training; review of CAO / IFC documents. Funded partly by Misereor, Catholic Bishops' Development Organization, Germany.

- International Union for Conservation of Nature and Natural Resources (IUCN, Switzerland). Review of the Mining and Metals Supplement of the Global Reporting Initiative (GRI).
- World Bank, Extractive Industry Review. Member of Advisory Group assisting WB in evaluating extractive industry practices; London, Lisbon.
- Nishnawbe Aski and other Ontario First Nation bands---Ontario, Canada. Review of environmental documents relating to Montcalm Mine, a proposed copper-nickel facility. Activities paid for by Falconbridge Limited.
- Kazakh Institute of Physics and Technology / ISTC---Almaty, Kazakhstan. Technical oversight of environmental program, evaluating migration of radionuc-lides at the Semipalatinsk Nuclear Test site.
- Greenpeace Argentina / Mineral Policy Center---Esquel, Argentina. Review of EIA (water, environ. issues) and conditions at proposed mine in Patagonia.
- Oxfam America / Sahel Development Foundation ---Syama Mine, Southern Mali. Review of environmental conditions and documents related to an IFC-funded gold mine (2003); conduct technical workshops and policy meetings with Mali government and press (2004).
- Kivalina Relocation Planning Committee---Alaska. Litigation support to Center on Race, Poverty & the Environment regarding water quality issues, Red Dog Mine. Deposition testimony.
- Asociation de Organismos No Gubernamentales—Santa Rosa de Copan, Honduras. Independent review of water / environmental issues at San Andres mine; funded by Dan Church Aid (Danish government and NGOs) and Christian Aid (English NGO).
- Oxfam America / Friends of the Earth Int'l. / Global Green Grants---Quellaveco, Peru. Independent review of mining, water and environmental issues at request of Asociacion Civil "Labor", Lima.
- Oxfam America / Mineral Policy Center / Environmental Mining Council of B. C.: Tambogrande, Peru. Independent review of mining water and environmental issues. Includes numerous public presentations to citizens and governmental groups, including members of the Peruvian Congress.
- New Mexico Environment Department---New Mexico. Review of cost estimates for water treatment systems for closure plans / bonding calculations, Chino and Tyrone Mines.
- International Institute for Environment and Development—London, U.K. Consultant to MMSD project on sustainable development / mining issues.
- Technical Chamber of Greece---Thrace, Greece. Technical assistance to an advisory arm of the Greek government and citizens groups regarding gold mining / environmental issues.
- Malerah-Wahlabul Native Title Claimants / Friends of the Earth—Sydney, Australia. Review of water quality issues related to cyanide leach gold operations on aboriginal lands, and testimony at Land and Environment Court.
- Loeb Aron &Co.---London, U.K. Preparation of report evaluating the Baia Mare, Romania waste spill for an investment banking firm.
- Centro de Investigacion y Planificacion del Medio Ambiental (CIPMA) / World Resources Institute / International Development Research Centre---Chile. Evaluation of environmental costs associated with copper mining in Chile.
- Carl Duisberg Gesellschaft / Univ. of Witwatersrand / United Nations---South Africa. Teaching cyanide technology and environmental technology assessment issues.
- Dogrib Nation / Pape and Salter---Yellowknife, Canada. Geochemical consulting and testimony regarding the proposed Diavik diamond mine.
- Soros Foundation Kyrgyzstan---Bishkek, Kyrgyzstan. Water quality instruction to regulators and NGOs regarding mining, sampling, laboratory procedures, and general environmental issues. Review laboratory.
- General Chemical / Sierra Club---Piceance Basin, Colorado. Review of water quality, treatment, legal and policy issues regarding the proposed Yankee Gulch soda ash mine; hearing testimony.

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- Sierra Club Legal Defense Fund / Okanogan Highlands Alliance----Crown Jewel Mine, Washington. Litigation support on water quality, geochemistry, treatment issues to groups opposing proposed gold operation; test case on federal mining law; deposition testimony.
- National Wildlife Federation---Carlota Mine, Arizona. Litigation support for challenge of EPA regarding water quality/ treatment issues at copper mine.

Review of TMDL issues related to Pinto Creek for NWF and local citizens.
- International Rivers Network---Review of proposed dam project and associated mine water quality issues at the San Roque site, Philippines.
- Mineral Policy Center---Preparation of technical documents on the environmental behavior, analysis and toxicity of cyanides.
- Holnam Industries---Penrose, Colorado. Ground water quality/ geochemistry study for cement operation.
- World Resources Institute---mining water quality/ geochemistry assistance on Venezuelan forestry / mining environmental regulations, and on environmental economics of copper mining practices, Chile.
- U.S. EPA / American Geological Services---French Gulch, Colo. Geochemical / treatment /remediation support at an abandoned mine site; negotiated Superfund issues.
- Stoel Rives---Richmond Hill Mine, So. Dakota. Review water quality treatment and geochemistry issues at a closed gold mine site with discharge violations.
- Nacho Nyak Dun First Nation/ Pape and Salter—Yukon, Canada. Evaluation of proposed heap-leach gold mining facilities and practices for native group and barristers.
- Molycorp/ Unocal—Questa, New Mexico. Review of water quality/ geochemical / aquatic biology issues at a molybdenum mine/ mill site.
- Homestake Mining---Lead, South Dakota, U.S.A. Review of water quality and geochemical problems and waste rock storage and tailings stability issues.
- U.S. Bureau of Land Management / Summo Minerals—Lisbon Valley, Utah. Review of water quality and geochemistry, and assistance in preparation of an EIS at a proposed copper mining and recovery site.
- Southern Peru Copper Corp. –Toquepala, Peru. Design and oversight of water quality, geochemistry, and remediation issues at an open-pit copper mine, mill, and waste facilities.
- Cortez Mining/ Placer Dome / U.S. Bureau of Land Management - Pipeline Project, Nevada. Review of water quality and geochemistry and preparation of EIS-related reports at this proposed open pit gold site.
- Kennecott Utah Copper. Interacted with the law firm of Bogle and Gates to assist an active metal mining company in defending against a CERCLA listing. Activities involved interpreting water quality/geochemical and other environmental data within the Hazardous Ranking System (HRS) context.
- Asarco - Leadville, Colorado. Oversight of water quality and geochemical activities at a historic metal mining and processing site where the client is involved in CERCLA negotiations. Interaction with State and EPA representatives and legal staff.
- Cambior Minerals - Metates Mine, Mexico. Water quality and geochemistry evaluation of a new gold property.
- Fraser Stryker and the Lindsey Chemical Co. - Nebraska. Technical support to legal staff involved in negotiations regarding a Superfund industrial processing site.
- W.R. Grace - Motorwheel Site, Michigan. Technical assistance to Grace legal staff involved in CERCLA negotiations at a hazardous waste site.

- Zortman Mining Co./U.S. Bureau of Land Management. Technical and management responsibilities for water resources and geochemistry tasks in preparation of revised EIS at a gold-cyanide leach site with existing acid drainage problems.
- Echo Bay Mining, Lamefoot Mine, Republic, Washington. Responsible for geochemistry and water quality aspects of a supplemental EIS at a new gold mine site. Development of monitoring, testing and remedial recommendations to the BLM.
- Angelina Farms, Louisiana. Technical support to legal staff of oil production companies accused of contaminating groundwaters with brines.
- Chino Mines, New Mexico. Technical evaluation of water quality and geochemical issues associated with leaching operations at an operating copper facility.
- Amax Gold/Haile Mining, South Carolina. Water quality consulting at a gold mining site with existing acid drainage problems.
- Shea and Gardner / Rockwell--Rocky Flats Plant, Colorado. Reviewed and evaluated geochemical studies; proposed future activities in preparation of potential litigation.
- Saunders, Snyder, Ross and Dickson/American Water Development, Inc. - San Luis Valley, Colorado. Coordinated water quality and geochemistry activities in support of water rights litigation. Oversaw water quality sampling, evaluated water quality and remote sensing data, assisted attorneys in technical strategy development and opponents' depositions; supplied deposition testimony.
- Arnold and Porter/Keystone Ski Corporation - Keystone, Colorado. Designed water quality and geochemical sampling program for ski area expansion in a previously mined area. Evaluated data and proposed remediation activities.
- Advanced Sciences, Inc./EG&G - Rocky Flats Plant, Colorado. Evaluated existing water quality and geochemical sampling programs; prepared document on non-facility related sources of chemical constituents and background.
- City of Brighton - Brighton, Colorado. Evaluated existing surface and groundwater quality data and suggested remedial activities to deal with excessive manganese and dissolved organic concentrations. Provided testimony to City Council.
- Chadwick & Associates, Inc./Newmont Mining - Telluride, Red Mountain, Colorado. Provided diverse water quality and geochemical consulting relating to remediation of acid mine drainage problems.
- Intergraph Corp. - Reston, Virginia. Assisted in technical development and marketing of a new environmental data management/GIS product.
- U.S. Forest Service - Salmon, Idaho. Acted as a geochemical/water quality consultant at the Beartrack mine site, a proposed cyanide-leach gold project.
- Earth Satellite Corporation/Navajo Nation/Patton, Boggs, and Blow - Window Rock, Arizona. Conducted a preliminary reconnaissance of water resources on the joint-use area of the Navajo/Hopi reservations using satellite imagery.
- Mission-Viejo/Morrison and Forester - Denver Basin, Colorado. Acted as a geochemical consultant in a groundwater rights dispute.
- Bunker Hill Corporation/Dames and Moore - Kellogg, Idaho. Reviewed field and laboratory water quality procedures at a CERCLA metal-mining and processing facility. Audited proposed laboratory.
- Saunders, Snyder, Ross, and Dickson/Adolph Coors Company - Golden, Colorado. Water quality consultant; reviewed data from Central City/Blackhawk, CERCLA site, and determined potential impact to the Coors water treatment plant. Provided testimony at stream classification hearings, Colorado Water Quality Control Commission.

- Colorado Water Resources and Power Authority - San Luis Valley, Colorado. Conducted water quality/geochemical and Landsat evaluations of deep groundwater to aid in development decisions.
- Armstrong, Teasdale, Kramer, Vaughan, and Schlafly / Anschutz Corp.-- Fredricktown, Missouri. Supervised technical activities of a CERCLA / SARA-related lawsuit; acted as a technical liaison with attorneys and regulators; managed consultants; authored reports; deposition testimony.
- Holland and Hart/White and Jankowski/Weller, Friedrich, Ward and Andrew/Breckenridge Ski Corporation - Breckenridge, Colorado. Technical supervision of water quality-related issues in a private lawsuit against Breckenridge Ski Corporation. Managed sampling and data interpretation; interacted with attorneys on strategy and assisted at depositions; authored reports; expert witness.
- Dames and Moore/Hecla Mining Corporation - Leadville, Colorado. Acted as hydrogeological/geochemistry consultant to Hecla on a natural resources damage suit; interacted with attorneys at Davis, Graham and Stubbs.
- Dames and Moore/Davis, Graham and Stubbs - Eagle Mine, Colorado. Supervised water quality/hydrogeology activities in preparation of a legal defense of Gulf and Western Corporation versus the State of Colorado in a natural resources damage suit; supervised and participated in all sampling; QA activities and report preparation; interacted with attorneys and regulators; assisted at depositions; deposition testimony; testified before Colorado Water Quality Control Commission on appropriateness of proposed metals standards.
- Jacobs Engineering - Albuquerque, New Mexico. Prepared policy documents on water quality/geochemistry procedures associated with the Uranium Mill Tailings Remedial Actions Project (UMTRA).
- University of Wisconsin. Designed a proposed groundwater exploration program for Gambia, West Africa, in conjunction with Earth Satellite Corporation.
- Harza Engineering Company/University of Michigan - Senegal, Guinea, and Gambia, West Africa. Evaluated potential impacts of new dam construction within the Gambia River basin. Reviewed local hydrogeology, mining production and exploration data; interacted with local officials.
- Engineering-Science, Inc. Faisalabad, Pakistan. Assisted in design of a well field for a groundwater supply in the central Punjab where high salinity and TDS were major problems; negotiated with local officials; prepared reports for Asian Development Bank.
- Holme Roberts and Owen - Canon City, Colorado. Reviewed and interpreted existing hydrogeology and water quality data at the Cotter uranium mill and tailings; proposed future activities; interpreted background concepts, prepared position papers for attorneys in negotiations with State of Colorado.
- Earth Satellite Corporation - Sultanate of Oman. Conducted an interpretive study of regional groundwater potential in Oman, with the staff of Earth Satellite Corporation. Activities included interpretation of existing geology and Landsat imagery combined with conventional low altitude flight and ground reconnaissance. Prepared reports for government of Oman.
- Anschutz Mining Corporation - Fredericktown, Missouri. Managed water resource-related activities for environmental baseline studies at a proposed cobalt/ nickel mine. Designed sampling programs, oversaw sampling, data interpretation, and report preparation.
- Kemmerer Coal Company - Frontier, Wyoming. Managed and conducted hydrogeologic and water quality studies at a proposed open-pit coal mine. Supervised well installation, aquifer testing, sampling, report preparation; interacted with state regulators.
- Anaconda Copper Company - Rico, Colorado. Conducted an investigation of hydrology, water chemistry, and aquatic biology at a complex ore mining district.

- Union Carbide Corporation - Uravan, Colorado. Managed and conducted a water quality monitoring program for a proposed uranium tailings disposal area and effluent evaporation basin. Assisted in design of geochemical testing program to evaluate potential leachate quality.
- Anschutz, Mining Corporation - Laredo, Texas. Managed and conducted an investigation of groundwater hydrology and soils geochemistry and associated hazardous wastes at a metal ore handling and reagent storage facility. Designed sampling protocol; prepared reports; negotiated with state regulators; interacted with attorneys at Baker, Botts.
- Snowmass Coal Company - Carbondale, Colorado. Managed and conducted hydrogeology investigation of an underground coal mine with steeply dipping seams.
- Marline Uranium Corporation/Union Carbide Corporation - Danville, Virginia. Managed water resources portion of a baseline investigation at a proposed hard-rock uranium mine site. Oversaw well installation monitoring programs and dewatering investigations.
- Southern Pacific Petroleum - Means, Kentucky. Conducted baseline hydrogeological/geochemical investigations at a proposed oil shale mine and retort facility.
- Central Arizona Association of Governments - Globe/Miami, Arizona. Conducted study to determine hydrogeologic/geochemical impact of long-term copper mining and processing facility. Designed monitoring programs; interacted with federal, state, local and tribal officials; prepared numerous reports.
- United Nuclear - Homestake Partners - Milan, New Mexico. Conducted hydrogeological/geochemical evaluation of an existing monitoring program for a uranium milling and waste-disposal facility.
- Sultanate of Oman/Tetra Tech International - Muscat, Oman. Member of Water Resources Council Staff, Sultanate of Oman, based in Muscat, Oman. The Water Resources Council was an interministerial body intended to coordinate all water-related activities within the Sultanate. Duties involved planning and design of surface and groundwater projects (both exploration and utilization) for the Omani government; development of water resources policy for the government; hydrogeological field work on both exploration and resource characterization projects - aquifer testing, borehole geophysics, water quality sampling, hydrogeologic mapping; review of work performed (or planned) by other consultants to the government, published reports on water resources of Oman.
- EG&G - Idaho National Engineering Laboratory, Idaho Falls, Idaho. Managed a hydrologic investigation of transuranic nuclide migration in groundwater. Contributed geochemical expertise to evaluation of waste isolation and transport modeling.
- Kerr-McGee Corporation - Grants, New Mexico. Conducted investigation into geochemistry of selenium associated with uranium mining/ milling.

While with the U.S. Geological Survey Water Resources Division, Dr. Moran was responsible for the design, management, and implementation of the following hydrogeological / geochemical studies:

- Metal-Mine Drainage - Colorado. Study of extent and magnitude of mining and mine drainage on the quality of Colorado streams.
- Selenium in Groundwater - Golden, Colorado. Hydrogeological/geochemical investigation of selenium and associated constituents at the margins of Rocky Flats nuclear plant.
- Geothermal Resources - Colorado. Reconnaissance investigation of potential geothermal resources throughout Colorado.
- Underground Coal Mine Water Quality - Colorado. Evaluation of existing and potential water quality problems from underground coal mines.
- In Situ Uranium Leaching - Grover, Colorado. Study of geochemical and hydrologic processes associated with in situ uranium mining and reinjection of waste products.

- Alluvial Metal Transport - Telluride, Colorado. Investigation of metal movement from tailings ponds into alluvium.
- Southwest Colorado Groundwater - Colorado. Study to determine availability and quality of groundwater in southwestern Colorado.
- Oil Shale Waters - Piceance Basin Colorado. Evaluation of disposal of saline groundwater discharged to the surface during oil shale development.
- Grace Coal Site - Axial Basin, Colorado. Hydrogeological /water quality study of proposed open-pit coal site.

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Sep 28, 2012

Jim Ruby, Executive Secretary
Environmental Quality Council

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
STRATA ENERGY, INC.,	)	Docket No. 40-9091-MLA
	)	
(Ross In Situ Recovery Uranium Project)	)	
(Materials License Application)		

DECLARATION OF DR. RONALD L. SASS ON BEHALF OF THE NATURAL RESOURCES DEFENSE COUNCIL & POWDER RIVER BASIN RESOURCES COUNCIL

INTRODUCTION

I, Dr. Ronald L. Sass, declare that the following statements are true and correct to the best of my knowledge.

1. My name is Ronald L. Sass. I am the Harry C. and Olga Keith Wiess Professor Emeritus of Natural Sciences in the Departments of Chemistry and Ecology and Evolutionary Biology at Rice University in Houston, Texas. I am also a Fellow in Energy and Climate Change of the James A. Baker Institute of Public Policy. My business address is 1834 Norfolk Street, Houston, Texas 77098.
2. I received a B.A. degree in chemistry and mathematics from Augustana College in Rock Island Illinois and a Ph.D. in Physical Chemistry from the University of Southern California. Upon receiving my Ph.D., I was awarded a post-doctoral fellowship at the Brookhaven National Laboratory in New York before accepting a position of Assistant Professor at Rice University in 1958. Since that time I have been a member of the faculty of the Chemistry, Biology, and Ecology and Evolutionary Biology Departments. . I was

chair of the Biology and then the Ecology and Evolutionary Biology Department at Rice University from 1981 to 2005 when I took Emeritus status. I conducted research as Co-Director of the Wetland Center for Biogeochemical Research at Rice University from 1988 to 2006. I have had additional experiences as a Guggenheim Fellow of theoretical chemistry at Cambridge University and as a National Research Fellow with NASA in Virginia, Alaska, and Canada.

3. My career at Rice University covered a span of over fifty years, conducting an active research program, teaching and serving the local, national and international scientific communities.

4. My research has covered a variety of subjects working with many undergraduates, graduate students and post-doctoral fellows. I have published over 165 papers in reviewed journals and have acted as editor and author in several books. I have taught a variety of graduate and undergraduate courses in chemistry (general chemistry, physical chemistry, quantum chemistry, x-ray diffraction), biology (introductory biology, general physiology, biophysical chemistry) and ecology (earth systems, environmental science, climate change dynamics, and environmental literature). My service work includes being a member of most of the faculty committees at Rice, Co-Director of the Center for Education (teacher training), Master of Hanszen Residential College. Nationally, I have been Chair of the Chemistry Examination for the SAT's, Chair of the international rice research team of the International Global Atmospheric Chemistry program, a member of the American Chemical Society, American Crystallographic Society and the American Geophysical Union. As a charter member and an author for the Intergovernmental Panel on Climate Change I shared in the 2007 Nobel Peace Prize awarded to the IPPC. I

currently serve as a member of the Board of Trustees of the Galveston Bay Foundation and the Nature Conservancy. As a Fellow of the Baker Institute I participate in workshops, symposia and conferences on questions of science policy. I have recently published several policy papers through the Baker Institute including several on surface and ground water issues in Texas.

5. While earning my B.A. degree at Augustana College I worked full time as a chemist for the Corp of Engineers developing nuclear chemical analytical methods and inventing an all-weather grease for the US Army. My graduate school research was in X-ray diffraction studies of the structures of certain chemical compounds. At Brookhaven National Laboratories, I had direct access to the thermal neutron flux generated by the large research nuclear reactor at the site. I conducted thermal neutron scattering experiments to determine nuclear spin orientations of anti-ferromagnetic materials and characterize the crystal and molecular structure of hydrogen bonding materials. During my fifty years at Rice University I conducted experiments in x-ray crystallography, Fourier transfer filtering analysis of electron micrographic images, physiology of cardiac and skeletal muscle, and calcification studies on a variety of mollusk species. The final twenty years of my active research career was the Co-Director of the Wetlands Research Laboratory at Rice and active in research in the role of a biogeochemist studying the processes characterizing wetland-generated methane as a greenhouse gas and the general properties of greenhouse gases. I have published over 150 scientific articles in standard refereed journals on the various research topics enumerated above. I am now a Professor Emeritus of Chemistry and Ecology and Evolutionary Biology at Rice University in

Houston, Texas, but still an active Fellow of the James A. Baker Institute for Public Policy and a faculty member of the School of Continuing Education at Rice University.

CONCERNS ABOUT THE DESCRIPTION GIVEN OF THE URANIUM ORE BODY AND RELATED BASELINE DATA.

6. This statement is offered in support of the contentions offered by the Natural Resources Defense Council in response to inadequacies in the Strata Energy Ross In Situ Recovery NRC License Application. These contentions are:

   Contention 1: The application fails to adequately characterize baseline (i.e., original or pre-mining) groundwater quality.

   Contention 2: The application fails to analyze the environmental impacts that will occur if Strata cannot restore groundwater to primary or secondary limits.

   Contention 3: The application fails to include adequate hydrogeological information to demonstrate Strata's ability to contain fluid migration.

   Contention 4: The application fails to adequately document negative impacts on groundwater quantity.

   Contention 5: The applications fails to adequately assess cumulative impacts of the proposed action in conjunction with other industrial activities in the area, and fails to evaluate adverse environmental effects resulting from an insufficient decommissioning bond and the disposal of 11e(2) byproduct material. It also improperly tiers to NRC's flawed GEIS for ISL uranium mining.

7. In addition to my professional experience, particularly work performed on the evaluation of similar mining operations similar mining operations in the state of Texas, the comments that follow are based on a review of the Strata Energy Liscense Application to the NRC. My comments will address but are not limited to the issues presented in Contentions 1, 2 and 3.

Failure of Strata to provide clarity on the current state of the underground ore zone

8. The uranium ore body is inadequately described both in terms of spatial extent as well as distribution of ore concentration. What description that is presented in the application is

repetitive, fragmented, unorganized and difficult to interpret. The general geology of the entire state of Wyoming is apparently presented, rather than a concentration on the geology in the vicinity of the project.

9. First, it is unclear just how many exploratory drill holes are being used by Strata, when and by whom they were drilled, what is their current status (capped or not, surveyed, logged, cored, etc.) and which are being used for detailed analysis. This report seems to address these questions, but fails to provide adequate clarity on several important factors. The information that is provided in the application simply fails to provide the public and even the regulator with information on the subsurface that would be necessary to assess any potential impacts of industrial scale ISL mining.

10. Starting on page 2-88 in section 2.6.2.2 of the Technical Report, Strata states the following:

> From 1971 to 1975, thousands of exploration holes were drilled to delineate roll front uranium deposit boundaries and provide information for the economic evaluation of uranium deposits. From 1975 to 1977, exploration efforts emphasized the development of a mineable ore deposit in the Oshoto area. In 1978, Nuclear Dynamics formed a joint venture with Bethlehem Steel called the Nubeth Joint Venture. That year Nubeth developed and briefly operated a pilot ISR plant within the proposed project area. All exploration efforts in the Oshoto area ended in 1979 upon completion of an initial test of the leach chemistry ...

11. It is now 2011. Because the majority of these "thousands" of exploratory holes were drilled over thirty-six years ago, serious questions are raised concerning the validity of any current baseline data obtained and reported by Strata Energy. Those holes that were capped were done so with only a surface concrete plug. Thus, since the time the wells were drilled, they have served as a conduit among the four aquifers through which groundwater, including dissolved substances, could move freely from one aquifer to

another. This movement would place in question the repeated contentions that the aquifers are isolated from each other. In addition, during that time an indeterminate number of the exploratory holes may have been open to the surface and were subject to the introduction of surface water including contaminants such as oxygen that could have interacted with the aquifer chemistry, particularly the uranium ore which becomes soluble in an oxidizing environment.

12. Continuing to quote from the Application,

> In 2007 and 2008, Strata initiated mineral acquisition in the Lance District and acquired a portion of the Nubeth drill hole database. Strata subsequently began confirmation drilling and exploration drilling for the Ross ISR Project in September 2008. Strata continued with exploration and development drilling in 2009 and also acquired the complete historic Nubeth database that same year. As of June 18, 2010, there were 1,115 surveyed drill holes and 962 unsurveyed drill holes within a 1/2-mile radius of the proposed Ross Project area. Core samples were collected from 14 of the surveyed holes (Page 2-89).

13. From the complete exploration database acquired by Strata Energy from Nubeth, of the 2,077 drill holes there were at least 962 drill holes that were not surveyed. Thus, not only do these drill holes represent pathways for the transport of groundwater between aquifers but also potential pathways for the introduction of contaminants into the various aquifers, including oxygen and other chemicals that could render soluble the uranium ore in the OZ aquifer.

14. In addition the Application states that:

> A total of 371 geophysical logs that were of sufficient resolution and considered most representative of the stratigraphy were selected for the preparation of six geologic cross sections that are used to illustrate the subsurface stratigraphy of the proposed project area (2-90).

15. These geophysical logs are used to construct a fence diagram that depicts the three dimensional stratography of the mine project area. This diagram is useful in picturing the stratography of the mine area, but fails to provide an adequate diagram of the distribution of the actual ore bodies. The geophysical logs are not well explained (what actual parameters are logged), but it appears that there is at least a gamma ray log or some nuclear measuring device that could at least approximate relative ore concentrations. Such data is critical in being able to engineer the placement of monitoring as well as injection and recovery wells. It is also important in planning the returning the mining site to baseline conditions after mining is complete. In sum, Strata has failed to adequately detail the underground ore zone, a necessary prerequisite to defining appropriate and accurate baseline and in ultimately restoring that water, if industrial mining were to take place.

Insufficiency of newly drilled exploratory wells.

16. The Application states that

> Figure 2.6-7 depicts the stratigraphic nomenclature that is used within the proposed project area. This figure illustrates the geophysical log and corresponding lithology obtained from exploration drill hole number RMR008, the location of which is shown on Figure 2.6-4. This particular drill hole was chosen as the "type log" for the proposed project area due to the clarity of the geophysical logs and the associated stratigraphic descriptions from land surface to the top of the Pierre Shale (Page 2-89).

17. Figure 2.6-4 is a low-resolution map of the area surrounding the project area. It shows drill hole number RMR008 but does not relate it to any information about the ore body. Figure 2.6-7 shows the well log from RMR008 with the various strata identified. It shows that the gamma radioactivity occurs in the OZ (ore zone) at five different levels. It also shows that the Pierre Shale conformably (having the same stratification direction)

underlies the Fox Hills Formation, which is divisible into upper and lower units and that the Upper Fox Hills strata comprise the lower mineralized horizon having four uranium roll fronts labeled **A** through **D**). One can also read that the Fox Hills formation is overlayed by the Lance Formation. The boundary between these formations is conformable. Mineralization also occurs in the lower Lance formation having roll front uranium deposit **E**.

18. However, no data are given stating the ore concentration at any five deposits. What we see is that the ore body is quite complex at this single location, but no indication is given as to the relative or absolute amount of ore present in any of the five deposits. We are also given no information as to how these data relate to any other location in the ore body. Such information is important in assessing the connectivity of the various ore bodies and possible pathways for movement of the soluble reaction products during the ore recovery operation so that injection and recovery wells can be properly placed. It is also important information to inform one where to place monitoring wells.
19. It is stated in the technical report that core samples were collected from 14 of the surveyed drill holes (Page 2-89). I have found no other mention of these core samples (other than drill hole RMR008 above), no concentration data and no chemical analyses of the core segments. The fence diagram shown in Figure 2.6-8 does not exhibit any features of the ore body itself, only the thickness of the four major zones (SA, SM, OZ and DM) along three transects (A-A'. B-B' and D-D') without any data pertaining to the ore body itself.
20. Additional evidence of a lack of complete information about the ore body by Strata can be found on page 1-5 of the technical report. It is stated there that "Due to the variability

of the depositional environment and hence controls on groundwater movement, the roll fronts in the proposed project area are complex with constantly increasing resource estimates. At this time, resources within the proposed project area exceed 5.5 million pounds of uranium and based on current roll front projections are likely to increase as more exploration drilling results become available."

21. Thus, the small number of core samples collected and the absence of reported concentration data or chemical analysis of core samples in the application do not allow either Strata or the NRC to gain a sufficiently detailed concept of the ore body to carry out the various components of the mining operaton. Furthermore, the lack of quantitative data does not support an analysis of connectivity within the ore body area nor does it seem possible for Strata to intelligently place monitoring wells or even estimate the extent of the resource.

Failure to address the history of problems encountered with Nubeth mining operations.

22. As pointed out above, the majority of the exploratory wells were completed by Nubeth prior to 1975. Nubeth attempted uranium recovery mining operations from August 1978 through April 1979. It is revealed in the Strata Technical Report of this application (Page 1-3) that "The overall success of the R&D site was limited based on injection problems which eventually led to the premature shutdown of the test. These problems were attributed to fines and organic material buildup in the wellfields and although filtering equipment was used, it was insufficient." This statement would indicate that there are additional problems associated with the geology and/or chemistry of the ore body that should have been investigated by Strata before they filed an application for a license, much less before the NRC grants any such license.

23. From 1975 to 1979 Nubeth carried out limited mining operations. And then the company undertook restoration activities until 1983. These activities would have caused considerable changes in the OZ aquifer which then could have been transmitted to the other aquifers through connections formed by the numerous exploratory wells. Thus, given the amount of perturbation that the project site has undergone, from the limited information presented in the application it is my opinion that it is essentially impossible to obtain a meaningful natural baseline value for the chemical components of the four aquifers without substantially more work in establishing an accurate and appropriate reflection of the baseline water quality. As one example, a more rigorous baseline measurement can be attempted by obtaining OZ aquifer chemical analyses from new baseline wells drilled at different distances from the 1970s wells to check for their accumulated impacts on the groundwater chemistry. Before the NRC grants any license for industrial mining, it should require Strata's engineers to propose a more appropriate methodology for obtaining these necessary data. Without requiring such information and a thorough public and technical review, the damage to the aquifer could be substantial.

The information in the application suggests that the aquifers may not be isolated from one another.

24. Strata did drill six clusters of baseline monitoring wells as located in figure 2.7-14 . Each of the six clusters of four wells contained a dedicated well that was screened for one of the four aquifers, SA. SM. OZ and DM. Water samples for chemical analysis were obtained from each of the wells quarterly during 2010. The analyses are presented in Tables 2.7- 28 to 2.7-42. The data are discussed in section 2.7.3.5 of the technical report. On the basis of these chemical analyses, the aquifers are given the probable classification

(Table 2.7-30) of Class II or III for aquifer SA, Class III for aquifer SM, Class IV for aquifer OZ and Class III for aquifer DM. The aquifers are given these rather poor classifications for a variety of reasons including high values of TDS. The predominant cation is sodium. Bicarbonate and carbonate are high in all aquifers with high sulfate in SA, SM and OZ and high chloride in DM (See table 2.7-29).

25. One feature of these data is striking, namely the similar chemical composition of the various aquifers and especially the high concentrations of sodium carbonate and bicarbonate. This may suggest a high groundwater interchange among the aquifers via the long existing exploratory bore holes, especially connecting aquifers SA, SM and OZ. I say this because the lixiviant used by Nubeth during mining operations was sodium carbonate as a complexing agent for the uranium (page 1-2). Although the lixiviant was injected into the OZ aquifer, the presence of thousands of exploratory bore holes could easily have carried it to the other aquifers resulting in a high level of contamination of the various aquifers during the mining and recovery operations. If the natural movement of the groundwater is slow, it is not unreasonable to expect much of that contamination to still be in the region.

26. On the other hand, the radium 226 levels in the OZ aquifer are not particularly elevated. The highest value is 12.01 pCi/L with a range of 0.71 – 12.01 pCi/L. This is rather surprising given the amount of disturbance that the aquifer has experienced. With a significant contamination with oxygen, one might have expected a high amount of radium would have been liberated from the ore. Either that did not happen or the radium has been carried away by some process. One suggestion is that the groundwater flow within an aquifer and/or the inter-aquifer transfer is high. This might very well be true

judging by the high variability among the four different chemical analyses during the year in each well indicating a relatively fast replacement of the groundwater at the well site. In any event, it is absolutely crucial that any analysis in an application to perform industrial scale ISL mining get to the bottom of such matters so that the environmental impacts can be understood. Thus far, the Strata application fails to provide such analysis.

SUMMARY STATEMENT

27. In summary, I have a number of serious reservations about this application. I believe that Strata Energy does not demonstrate that they have sufficient data about the detailed geometry of the ore body to continue to develop this mine. I am also of the opinion that Strata Energy, because of this lack of detailed data about the ore body, has not demonstrated that they have chosen the optimum locations of the base-line wells with respect to the distribution of ore concentration densities within the ore zone, and thus do not accurately reflect what might be an accurate and appropriate baseline. I also am of the opinion that the description of the ore body that is presented in this application is not adequate to properly locate optimum placement of injection and recovery wells as well as monitoring wells. If a license is granted without these substantial technical inadequacies being addressed, as well as those problems identified by Dr. Abitz and Dr. Moran, the environmental harms could be significant.

Pursuant to 28 U.S.C. § 1746, I declare that the foregoing is true and correct to the best of my knowledge, information and belief, and that this declaration was executed in Houston, Texas on October 25, 2011.

Signature ______________________

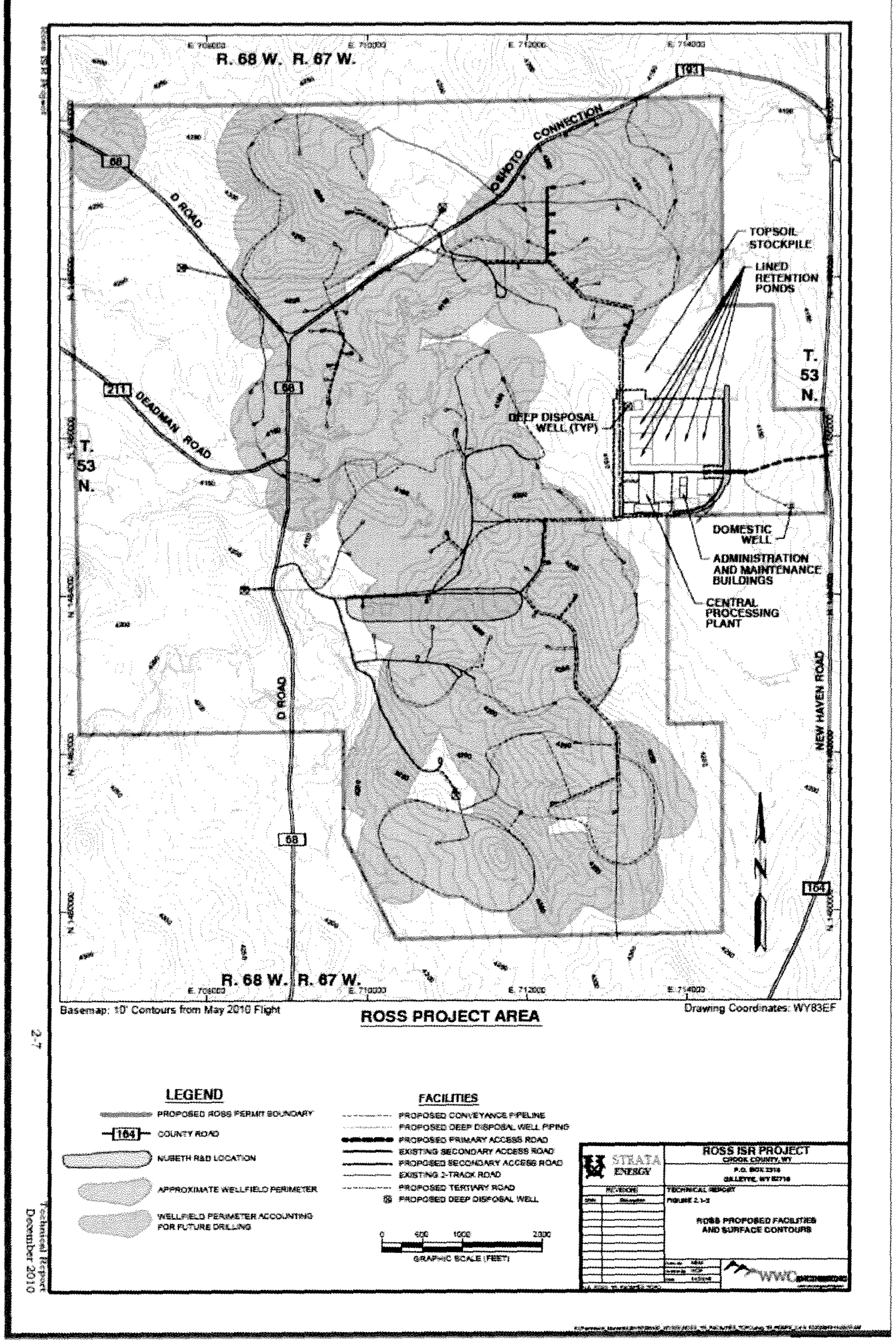

Figure 2.1-3

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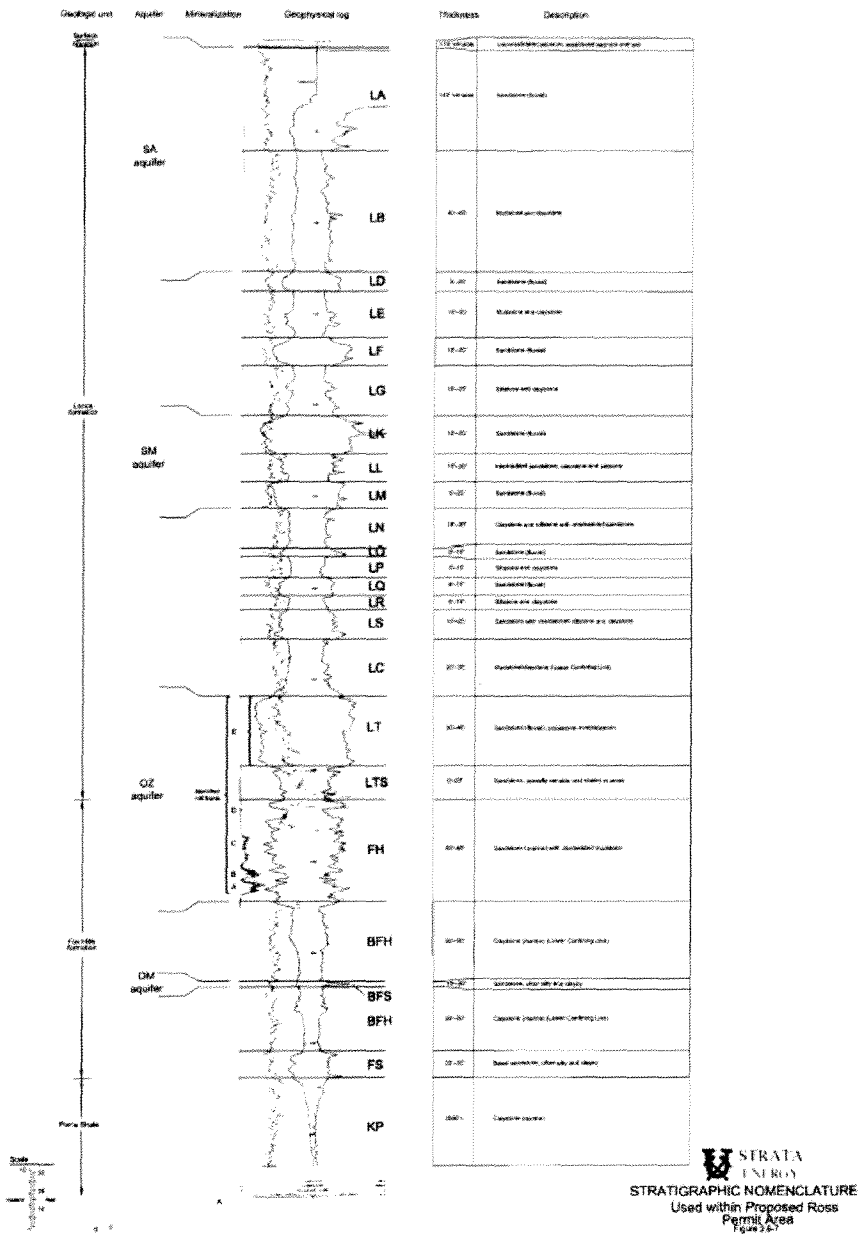
Geologic unit
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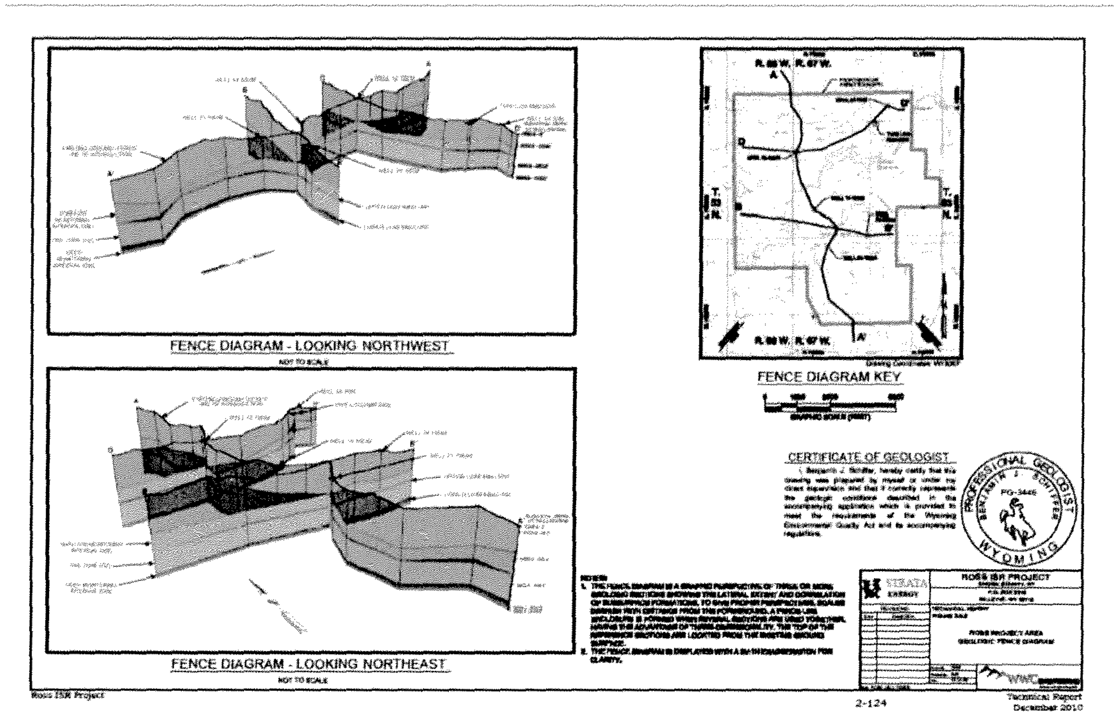
STRATA ENERGY
STRATIGRAPHIC NOMENCLATURE
Used within Proposed Ross Permit Area
Figure 2.6-7

Figure 2.6-7


FENCE DIAGRAM - LOOKING NORTHWEST
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CERTIFICATE OF GEOLOGIST
FENCE DIAGRAM - LOOKING NORTHEAST
NOT TO SCALE
ROSS ISR PROJECT
WYOMING
Ross ISR Project
2-124
Technical Report
December 2010

Figure 2.6-8

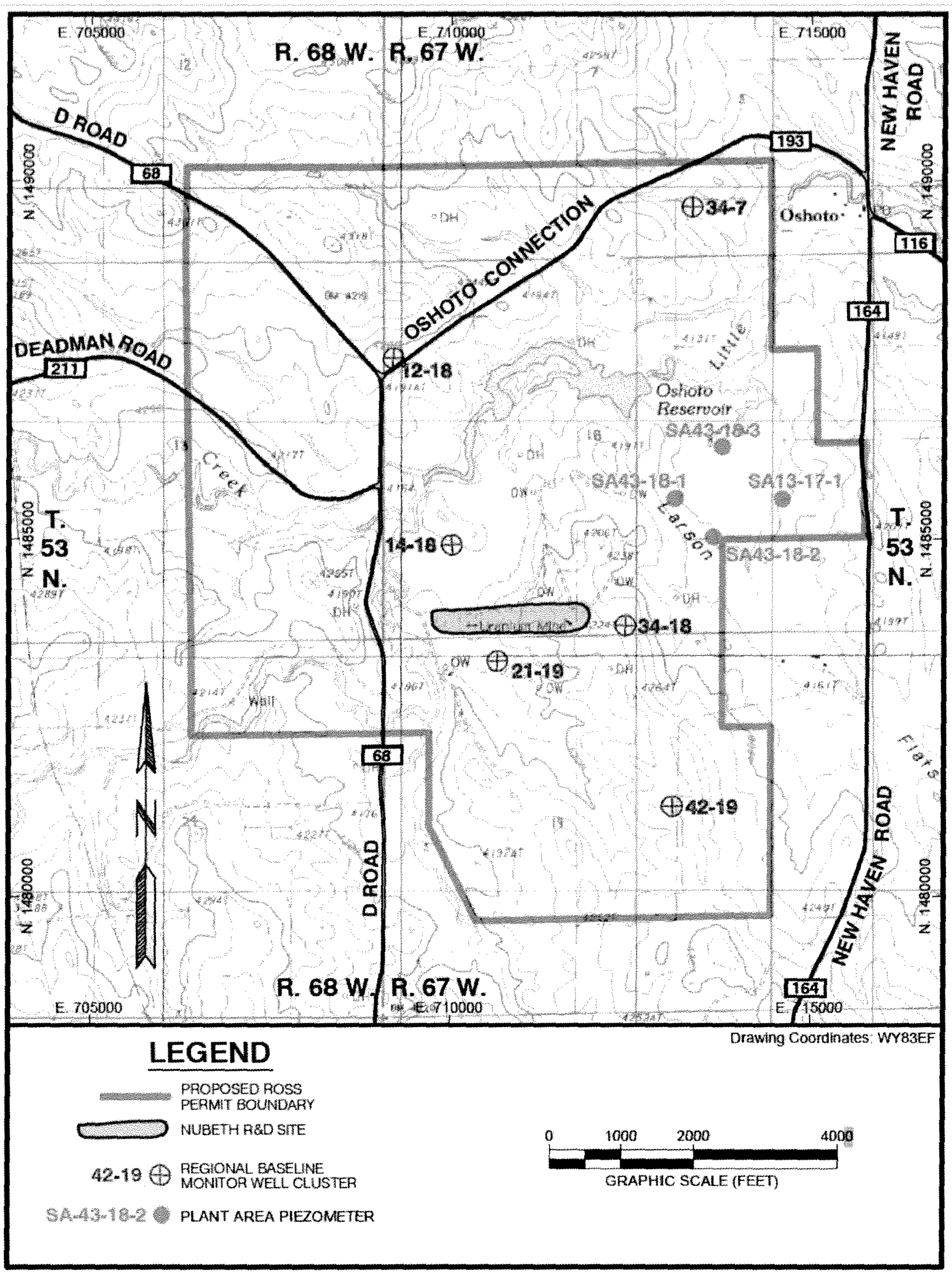

Figure 2.7-14. Regional Baseline Groundwater Monitoring Network

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EDUCATION:
University of Southern California, Ph.D. (Chemistry), 1957.
Augustana College, Rock Island, B.A. (Chemistry), 1954.

CURRENT POSITION
Harry C and Olga K. Wiess Professor Emeritus of Natural Sciences, Rice University 2003-date
Consultant and Expert Witness on Environmental Matter, 2006-date
Fellow, James A. Baker Institute for Public Policy, 2003-present

EXPERIENCE:
Chair of Ecology and Evolutionary Biology, *Rice University* 1990-2003
Professor of Biology, Chemistry, and Education, *Rice University*, 1993-2003.
Visiting Professor, Nanjing Agricultural University, Nanjing, China, 2000.
Adjunct Professor, *University of New Hampshire*, 1999-present
Acting Chair of the Department of Education, *Rice University*, 1995-96.
Visiting Research Scientist, *NASA*, Langley, VA 1988-1989.
Chairman of Biology Department, *Rice University*, 1981-1987.
Adjunct Professor of Medicine, *Baylor College of Medicine*, 1977-present.
Professor of Biology and Chemistry, *Rice University*, 1975-1993.
Adjunct Professor of Biophysics, *Baylor College of Medicine*, 1974-1977.
Adjunct Professor of Biochemistry, *Baylor College of Medicine*, 1969-present.
Master, Hanszen College, *Rice University*, 1964 and 1966-1968.
Professor of Chemistry, *Rice University*, 1966-1975.
Visiting Professor of Theoretical Chemistry, *Cambridge University*, England, 1965.
Associate Professor of Chemistry, *Rice University*, 1962-1966.
Assistant Professor of Chemistry, *Rice University*, 1958-1962.
Research Fellow, *Atomic Energy Commission*, *Brookhaven National Laboratory*, Long Island, New York, 1957-1958.
Predoctoral Fellow, *National Science Foundation*, University of Southern California, 1954-1957.
Chemist, *United States Army, Rock Island Arsenal*, 1951-1954.

PROFESSIONAL ACTIVITIES

RESEARCH: Work is conducted in the Wetland Center for Biogeochemical Research at Rice University. Since 1988 this group has been studying the generation of biogenic atmospheric trace gases and the biological processes in waterlogged plant-soil environments leading to their formation. These gases, principally methane and nitrous oxide are important contributors to global climate change and major components of the chemical system responsible for stratospheric ozone depletion. Our work originally focused on projects sponsored by the National Aeronautics and Space Administration in the tundra and boreal forest wetlands of Northern Canada and Alaska. Our current interests are in process studies of methane production and possible mitigation strategies for methane gas emissions from rice paddies and natural wetlands, the source of nearly half of all methane gas emitted annually to the global atmosphere.

Under the sponsorship of the US Department of Agriculture and the Ministry of Agriculture of the People's Republic of China. I traveled extensively in China to develop a cooperative effort between our laboratory and scientists in China for the study of gas emissions from Chinese and Indian rice paddies. This work began in May 1993 and has culminated in a joint research program with the National Agricultural University at Nanjing the Chinese Academy of Science Atmospheric Sciences Laboratory and the University of New Hampshire.

Most recently I have initiated a study of science policy issues related to global, regional, and local climate change. The first project is to consider various facets of the urban heat island effect in Houston, Texas. This work is sponsored jointly in the Rice University Center for the Study of the Environment and Culture and the James Baker Institute of Public Policy.

INTERNATIONAL ACTIVITIES

Convenor, *International Global Atmospheric Chemistry Program* Committee on Trace Gas Exchange in Rice Paddies (RICE). Committee members are scientific experts on atmospheric chemistry from the United States, Germany, Australia, Philippines, China, India, Thailand, and Japan. This committee is a part of the program in International Global Atmospheric Chemistry (IGAC) of the International Geosphere Biosphere Program (IGBP). The IGBP is part of the International Committee of Scientific Unions with the United States represented by the National Academy of Science. As part of this committees activities I am an editor for a book published by the Japanese National Institute of Agro-Environmental Sciences, which is the "Proceedings of CH_4 and N_2O Workshop" held in March,1992 at Tsukuba, Japan.

Member AGU Committee on Global Environmental Change. The purpose of this committee is to foster global environmental change science, to assure a home in AGU for all involved disciplines and individuales and, to provide scientific background for policy decisions. Global environmental change is meant to include large-scale chemical, biological, geological, and physical perturbations of the Earth's atmosphere, oceans, land surfaces, and hydrologic cycle, with special attention to time scales of decades to centuries and to human-caused perturbations.

Consultant Embrapa Meio Ambiente (Embrapa Environment). Government of Brazil. Conduct workshops, train scientists, and set up experimental system to measure tracegas emissions from Brazilian irrigated rice fields.

Consultant Advisor on Graduate Programs, The Joint Graduate School of Energy and Environment King Mongkut' s University of Technology, Bangkok, Thailand

Member, Scientific Organization Committee, Workshop on GHG Emissions from Rice Fields in Asia, Chinese Academy of Science Soil Science Institute, Nanjing, China,

Consultant *Environmental Protection Agency* on Global Climate Change Issues in Agriculture. Activities I have participated in for the EPA have included workshops on various aspects of trace gas emissions, contributions to publications on atmospheric trace gases and mitigation of these gases from agricultural sources. I also serve as part of the oversight committee to monitor the EPA's program in the Philippines on the effects of increased carbon dioxide and ultraviolet radiation on agricultural crops in Asia.

Consultant *United Nations Development Program.* As a member of the External Advisory Committee to the International Rice Research Institute, I monitor the inter-regional research program on methane emission from rice fields in China, India, Indonesia, Philippines, and Thailand.

Lead Author *Organisation for Economic Co-operation and Development.* Co-authored the IPPC Guidelines on National Greenhouse Gas Inventories: Methane Emissions from Rice Cultivation (Reference Manualand Workbook). Also represented the OECD as an expert at the Twelfth Session of the IPCC in Mexico City, 1996.

Member, *National Science Teachers Association* Facilities Task Force. This committee addresses various questions of school science laboratory design and safety. It also keeps track of various regulations relating to laboratory use by students and helps teachers to be aware of them. The committee also publishes recommended designs for laboratory renovation and construction.

EDUCATIONAL ACTIVITIES

Co-director, Rice University Center for Education, 1988-date
The Center for Education at Rice University was established in 1988 as the administrative umbrella for a number of projects in school improvement in pre-kindergarten through twelfth grade.

The mission of the Center is to improve the education of children at all grade levels by identifying, fostering, and coordinating individual projects to improve teaching and learning in pre-college environments in ways that cut across their usual isolation from each other.

Over the past several years, the Center Directors have developed several successful and ongoing programs in science, mathematics, writing, Asian and multicultural studies, early children's literacy, and in the relationships between Latino students, their families, and schools.

These programs operate primarily in Houston and in some surrounding districts.

OTHER EDUCATIONAL ACTIVITIES

Minority Honors Pre-Med Academy Co-Director, 1988-1998.
College Board, Science Advisory Committee, Member 1989-1994.
Educational Testing Service, Chemistry Achievement Test Committee, 1988-1994
Academy of Science and Technology, Conroe, TX. Member Academy Advisory Council, 1988-1992.
National Center for Atmospheric Research, Education Effort Committee, 1988-date
Baylor College of Medicine, "Minority Research Apprentice Programs", Advisor, 1985-1987
Houston High School for the Health Professions, Science Curriculum Consultant, 1985-date
Fund for Improvement of Post-secondary Education, Consultant for the Life Sciences Program , 1984,1985
National Science Foundation Program to Train Master Teachers in Secondary Science Education, Mentor, 1983-1988
Conroe Texas Independent School District, Consultant, 1984-date.
Houston Mathematics and Science Improvement Consortium, Director, 1984,1985.

HONORS:

Rice University Gold Medal, 2007
Award Certificate from IPPC for the Nobel Peace Prize, 2007
The Texas Hall of Fame for Science, Mathematics and Technology, 2002
Meritorious Service Award, 2001, Association of Rice Alumni
Piper Professor for 1999, Piper Foundation, San Antonio, Texas
Citation for Excellence in Refereeing by the editors of the American Geophysical Union journals. 1998.
National Research Council Senior Research Fellow (NASA), 1988.
The Rice University Honor Certificate for Teaching, 1985.
The George R. Brown Prize for Superior Teaching, 1981.
The Rice University Student Association Mentor Recognition Award, 1976.
The Rice University Award of Highest Merit, 1972.
The George R. Brown Prize for Excellence in Teaching, 1967, 1969, 1970.
Salgo-Noren Distinguished Professor Award, 1966.
Guggenheim Foundation Fellowship (Cambridge University), 1965.
Senior Class Teaching Award, 1964.
Atomic Energy Commission Postdoctoral Fellowship, 1957-1958.
Sigma Xi, 1957.
Phi Lambda Upsilon, 1955.
National Science Foundation Predoctoral Fellowship, 1954-1957.
Phi Beta Kappa, 1954.

PROFESSIONAL SOCIETIES:

American Geophysical Union
National Science Teachers Association

RECENT PRESENTATIONS,WORKSHOPS AND OTHER ACTIVITIES (1993-date):

"Process study of methane emission from rice paddies, " Jiangsu Academy of Agricultural Sciences, Nanjing, China, May 17, 1993

"A four year study of methane emission and production in Texas rice fields", Agro Environmental Protection Institute, Ministry of Agriculture, Tianjin, China, May 21, 1993.

Invited keynote address, International Symposium on Climate Change, Natural Disasters and Agricultural Strategies, Beijing Agricultural University, Beijing, China, May 26, 1993.

"Rice Cultivation and Trace Gas Exchange" (invited), Global Atmospheric Biospheric Chemistry: The first IGAC Scientific Conference, Eilat, Israel, April 18-22, 1993, with H. U. Neue.

"Options for Reducing Methane Emissions from Rice Cultivation" (invited), White House Conference on Global Climate Change, Washington D.C. June 10-11, 1993.

STELLA Model Demonstrations, Update (invited), Spring Meeting of the Cooperative University-Based Program in Earth System Science Education, Langley Research Center, Hampton, VA, June 22-23, 1993.

Methane Emission from Rice Paddy: IGAC Foci (keynote address), All Asian Workshop-Cum-Training Course on Methane Emission Studies, National Physical Laboratory, New Delhi, India, September 20-24, 1993.

"Methane Emission: Five Year Study at Rice University" (Invited), All Asian Workshop-Cum-Training Course on Methane Emission Studies, National Physical Laboratory, New Delhi, India, September 20-24, 1993.

IGAC Approach to Measurement Procedures (Invited), Federation of Asian Scientific Academies and Societies Seminar on Global Environment Chemistry, New Delhi, India, Sept. 27-Oct. 1, 1993.

"Tracegas Exchange with the Biosphere-I " (Invited), Federation of Asian Scientific Academies and Societies Seminar on Global Environment Chemistry, New Delhi, India, Sept. 27-Oct. 1, 1993.

"Methane Emission: Five Year Study at Rice University " (Invited), Regional Research Laboratory, Bhubaneswar, India, October 2, 1993.

"Methane Emission from Rice Fields in the United States" (Invited) International Symposium on Climate Change and Rie, International Rice Research Institute, Los Baños, Philippines, March 14-16, 1994.

Member, External Advisory Committee, United Nations Development Program, Interregional Research Program on Methane Emission from Rice Fields, Los Baños, Philippines, March 17-18, 1994.

Rice Cultivation and Trace Gas Exchange, CH_4 and N_2O Workshop, National Institute for Agro-Ecological Sciences, Tsukuba, Japan, March 23-25, 1994.

International Global Atmospheric Chemistry-Global Change & Terrestrial Ecosystems Task Team; Inaugural Meeting, Oxford UK, 8-9 December, 1994.

"A Multi-year Study of Methane Emissions from Texas Rice Fields, " Engineering Faculty, Tulane University, New Orleans, LA, March 10, 1995

"Methane Emission from Rice Paddies; A Process Study " (invited), International Symposium on Soil-Source and Sink of Greenhouse Gases, Institute of Soil Sciences (CAS), Nanjing, China, September 14-30, 1995.

Opportunities for Mitigation of CH4 Emissions from Agricultural Sources (invited IPCC Symposium), American Society of Agronomy Annual Meeting, St. Louis, MO, October 29-Nov 3, 1995.

Convenor, The NASA Workshop on Regional Assessment of Tracegas Emissions from Rice Fields of China, Rice University, November 7-9, 1995.

Member, External Advisory Committee, United Nations Development Program, Interregional Research Program on Methane Emission from Rice Fields, Bangkok, Thailand, November 19-25, 1995.

"The China Experience." Lecture Series, Rice University Homecoming December 1-3, 1995.

"Climate and Change." Rice University Summit of the Minds, February 3, 1996

"Global Change," Toward the 21st Century, Topics in Contemporary Science, Rice University, April 8, 1996.

"Who Will Feed Asia?" Rice University Alumni College, April 26-28, 1996.

Participant, IPCC/OECD Meeting of Experts on Emission Factors for Methane from Wetland Rice Cultivation, Bangkok, Thailand, April 30-May 2, 1996.

"Agricultural Practices and Other Factors Influencing Methane Emissions from Rice Fields" (Invited), IPCC/OECD Meeting of Experts on Emission Factors for Methane from Wetland Rice Cultivation, Bangkok, Thailand, April 30-May 2, 1996.

International Geosphere Biosphere Program Wetlands Workshop on Classification, University of California at Santa Barbara, May 16-20, 1996.

Convenor, The NASA Workshop on Regional Assessment of Tracegas Emissions from Rice Fields of China, Beijing, China, June 5-7, 1996.

Participant, Intergovernmental Panel on Climate Change Working Group I, Sixth Session, Mexico City , Mexico, September 10, 1996.

"Global Change: Are We Warming Up?", Rice University Families Weekend, October 4-5, 1996.

"Wetlands and Global Climate Change," Wetland Biogeopchemistry Institute, Louisiana State University, Baton Rouge, October 17, 1996.

"Mechanisms of Methane Emission from Flooded Agricultural Systems: A Modeling Study. Tulane University, New Orleans, April 4, 1997.

Rice Environmental Conference 1997, February 1, 1997 Panel Participant: The Scope of Technology in Environmental Protection

IGAC Science Advisory Council Meeting, Toronto, Ont., Canada, May 16-19, 1997.

IPCC Scientific Steering Committee, Expert Group on Methods for the Assessment of Country Greenhouse Gas Inventory Quality, National Institute of Public Health and the Environment, Bilthoven, Netherlands, November 5-7, 1997.

"Mechanisms of Methane Emission from Flooded Rice Fields: A Modelling Study. " Max-Planck-Institut für Terrestrische Mikrobiologie, Marburg, Germany, November 10, 1997

"Mechanisms of Methane Emission from Flooded Rice Fields: A Modelling Study. " UFZ-Centre for Environmental Research, Department of Soil Sciences, Bad Lauchstaedt, Germany, November 13, 1997.

TRAGNET Working Group to Synthesize Trace Gas Research in Managed and Natural Ecosystems. National Center for Ecological Analysis and Synthesis, Santa Barbara, California, December 2-6, 1997.

"A semi-empirical model of methane emission from irrigated rice fields." (Invited) Workshop of the Interregional Research Program on Methane Emission from Rice Fields in Beijing China, August 10-15, 1998 sponsored by the United Nations Development Programme Global Environmental Facility and the International Rice Research Institute.

"Exchange of methane and other trace gases from rice fields: a model system for wetland emission modeling." (Invited) The Ninth Symposium of the IAMAS Commission on Atmospheric Chemistry & Global Pollution (CACGP) and Fifth Scientific Conference on the International Global Atmospheric Chemistry Project (IGAC), Seattle, Washington, 19-25 August 1998.

"A semi-empirical model of methane emission from irrigated rice fields." The Ninth Symposium of the IAMAS Commission on Atmospheric Chemistry & Global Pollution (CACGP) and Fifth Scientific Conference on the International Global Atmospheric Chemistry Project (IGAC), Seattle, Washington, 19-25 August 1998.

"Methane emissions from rice fields: Effect of rice cultivars and plant height." The Ninth Symposium of the IAMAS Commission on Atmospheric Chemistry & Global Pollution (CACGP) and Fifth Scientific Conference on the International Global Atmospheric Chemistry Project (IGAC), Seattle, Washington, 19-25 August 1998.

"Global Warming and Climate Change." The Association of Rice Alumni, Alumni College, November 7, 1998. Washington, D.C.

"Agricultural Sources of Methane and Nitrous Oxide: Methane from Rice Agriculture" Invited background paper. IPCC/OECD workshop, "Good Practice in Inventory Preparation: Agricultural Sources of Methane and Nitrous Oxide." Wageningen Agricultural University (The Netherlands). February 24-26, 1999.

"Modeling Methane Emissions from Chinese Rice Paddies." Agro-Meteorological Research Center of Chinese Academy of Meteorological Sciences, Beijing, China. May 24, 1999.

"Regional and Country Level Assessment of Methane from Rice Paddies." Institute of Remote Sensing, Chinese Academy of Sciences, Beijing China, May 25, 1999.

"Factors Affecting Methane Emissions from Rice Paddies: Modeling and Remote Sensing." Institute of Natural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Beijing, China, May 26, 1999.

"A GIS Based System for Estimating Methane Emissions from Rice Paddies." Chinese Ecological Research Network, Chinese Academy of Sciences, Beijing, China, May 27, 1999.

"Modeling Methane Emissions from Chinese Rice Paddies." Nanjing Agricultural University, Nanjing, China, May 31, 1999.

"A GIS Based System for Estimating Methane Emissions from Rice Paddies." Chinese Ecological Research Network, Institute of Agricultural Modernization and Remote Sensing, Changsha, China, June 7, 1999.

"Modeling Methane Emissions from Chinese Rice Paddies." Guangxi Academy of Agricultural Science, Nanning, China, June 9, 1999.

"A GIS Based System for Estimating Methane Emissions from Rice Paddies." Chinese Ecological Research Network Tropical Forest Station at Xi-shuang-ban-na, China, June 14, 1999.

"Monitoramento e mitigação da emissão de metano pela cultura do arroz." Invited talk to the First Brazilian Irrigated Rice Congress and the XXIII Irrigated Rice Cultivation Meeting, Pelotas, RS, Brazil, August 4, 1999.

"Modeling and Remote Sensing of Methane Emissions from Rice Paddies". Nanjing Meteorological Institute, Nanjing, China, March 25, 2000

"Global Ecosystem Dynamics", A short course, Nanjing Agricultural University, Nanjing, China, March 19-24, 2000

Session convenor: Biogeochemistry of C and N in Soils I. American Geophysical Union Spring Meeting, May 30-June 3, 2000, Washington, D. C., with S. Frolking

Session convenor: Biogeochemistry of C and N in Soils II Posters, American Geophysical Union Spring Meeting, May 30-June 3, 2000, Washington, D. C., with S. Frolking

"A Process Model of Methane Production, Oxidation and Transport in Paddy Rice Ecosystems" Invited talk, American Geophysical Union Spring Meeting, May 30-June 3, 2000, Washington, D. C., with Li, C. Zhang, Y. , Huang, Y., and Butterbach-Bahl, K

"Spatial Variability in Methane Emissions from Rice Fields", Department of Earth, Oceans, and Space, University of New Hampshire, August 16, 2000

"Spatial Variability in Methane Emissions from Rice Fields", Departments of Ecology & Evolutionary Biology and Earth Systems, University of California at Irvine, Nov. 3, 2000

"Seasonal and Spatial Variability of Methyl Halide Emissions from Rice Paddies near Houston, Texas" Fall Meeting of American Geophysical Union, December 15-19, 2000, San Francisco, California. With Redeker, K. , Andrews, J., Fisher F. and Cicerone, R. J.

"Spatial and temporal variability in methane emissions from rice paddies: Implications for assessing regional methane budgets", Workshop on GHG Emissions from Rice Fields in Asia, Chinese Academy of Science Soil Science Laboratory, Nanjing, China, Feb. 26, 2001.

"Spatial Variability in Methane Emissions from Rice Fields", Nanjing Agricultural University, Nanjing, China, March 1, 2001.

"Spatial Variability in Methane Emissions from Rice Fields", Chinese Academy of Science, Atmospheric Science Laboratory, Beijing, China, March 8, 2001.

"Spatial Variability in Methane Emissions from Rice Fields", The Joint Graduate School of Energy and Environment King Mongkut' s University of Technology, Bangkok, Thailand, September 26, 2001.

"Remote Sensing of Methane Emissions from Rice Fields", The Thailand Research Fund, Program on Greenhouse Gas Emissions Assessment. Bangkok, Thailand, September 28, 2001

"Five lectures on Ecology and Global Change" Presented during an ecotourism trip on the Peruvian Amazon River. Sponsored by the Rice Alumni Association, October 20-28, 2001

"Can you see China from Texas", Rice's Best: Winners of Rice University's Teaching Awards 1999-2000, Rice School of Continuing Studies, November 19, 2001

"Global Measurement Standardization of Methane Emissions from Irrigated Rice Cultivation", Embrapa Meio Ambiente (Embrapa Environment), Jaguaruna, SP, Brazil, January 29, 2002.

"An Extensive Survey of Gaseous Emissions from Rice Paddy Agriculture", with Redeker, K R, Meinardi, S, :Blake, D, and Cicerone, R. American Geophysical Union, Spring meeting, Washington, DC., May 28-31, 2002

NACP Methane Workshop, Breakout session on process studies in atmospheric methane emissions, University of New Hampshire, September 10-12, 2002.

"Mitigation of Methane Emissions from Rice Fields", Non-CO2 Network Project on Agricultural Greenhouse Gas Mitigation, Environmental Protection Agency, Washington, DC, December 2-3, 2002.

"Human Response to the Subject of Global Warming" Conference on climate change at the Shell Center for Sustainability, Baker Institute, Houston, TX Sept. 14, 2004.

"Texas Coastal Marshes and Potential impact of Gulf of Mexico Oil Spills", U.S. Offshore Oil Exploration: Managing Risks to Move Forward, Baker Institute, Huston, TX, Feb. 11, 2011

"Gulf pf Mexico Currents and Fate of Spilled Oil", International Association of Drilling Contractors, Port of Spain, Trinidad, May 12-13, 2011

PUBLICATIONS:

Books:

CH_4 and N_2O Global Emissions and Controls from Rice Fields and Other Agricultural and Industrial Sources, NIAES Japan, 1994, Editors K. Minami, A. Mosier and R. L. Sass.

Journal Articles and Book Chapters:

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
STRATA ENERGY, INC.,	)	Docket No. 40-9091-MLA
	)	
(Ross In Situ Recovery Uranium Project)	)	

(Materials License Application)

DECLARATION OF DR. RICHARD ABITZ ON BEHALF OF THE NATURAL RESOURCES DEFENSE COUNCIL & POWDER RIVER BASIN RESOURCES COUNCIL

I. INTRODUCTION

I, Dr. Richard Abitz, declare that the following statements are true and correct to the best of my knowledge.

1. I am a geologist and geochemist with more than 22 years of domestic and international experience in conducting and managing environmental work associated with the restoration of groundwater and soil contaminated by uranium and other radionuclides.

2. I have significant experience in the application of geochemical principles, experimental methods, and computer models to problems involving the solubility and mobility of hazardous and radioactive elements in the environment, evaluation of environmental and human risk associated with exposure to hazardous and radionuclide contaminants in air, soil and water media, remediation techniques for waters and soil contaminated by hazardous and radioactive wastes, and the design and treatment of mixed and radioactive waste streams. My CV and related experience with Geochemical Consulting Services, LLC and other employers is attached.

3. Much of my experience has been focused on the mobility of uranium in the environment, including the restoration of soil and groundwater contaminated with uranium at the DOE

Fernald Superfund Site and uranium mining, processing, and related environmental impacts in New Mexico, Texas, Colorado, Texas, and Nebraska.

4. The Natural Resources Defense Council has contracted my services to supply comments on the Strata Energy Ross In Situ Recovery[1] Nuclear Regulatory Commission (NRC) License Application.

5. In addition to my professional experience, the opinions and comments that follow are based on review of relevant portions of the application and documents listed in the References Cited section.

6. This review of the Strata Energy License Application (herein after the application) focuses on two technical areas: 1) fluid migration between aquifer horizons in the Fox Hills and overlying Lance Formations and 2) baseline water quality for the four aquifer horizons discussed in the application.

Fluid Migration

Aquifer Horizons at the Project Site

7. The application discusses four aquifer horizons (in descending order): shallow aquifer (SA), shallow monitoring zone (SM), ore zone aquifer (OZ) and deep monitoring zone (DM). The Lance Formation is exposed on the surface of the permit area and contains the SA, SM and top of the OZ horizons. Underlying the Lance Formation is the Fox Hills Formation, which contains the remainder of the OZ and the DM horizons. Further, the application states that there are two confining units: one between the SM and OZ and the other between the OZ and DM. The confining units are purported to isolate the SM, OZ, and DM aquifers in the project

[1] In-situ recovery ("ISR") is also commonly referred to as in-situ leaching ("ISL"). For the purposes of this declaration, the two phrases are used interchangeably.

area. The aquifers noted above are shown in Figure 1 (taken from the Ross In Situ Recovery NRC License Application, TR Addendum 2.7-H, Fig. 4.1-2, pg. 39).

Well Clusters and Boreholes in the Permit Area

8. Six well clusters (Well Cluster (WC) 12-18, WC 14-18, WC 21-19, WC 42-19, WC 34-18 and WC 34-7) have been placed across the project area to sample the groundwater in the aquifer horizons. Approximately 2,000 exploratory boreholes pierce the aquifer horizons in the permit area. Per Table 1 in Technical Report Addendum 2.6-B, as of October 2010 there were 1,483 Nubeth boreholes (unknown location for 858/1,483) and 467 Strata holes. The located boreholes and well clusters are shown in Figure 2 (Strata and Nubeth borehole location are from the Ross In Situ Recovery NRC License Application, TR Addendum 2.6-B, pp 2-52; WC locations are taken from TR Addendum 2.7-F, pg. 20, pg. 22, pg. 24, pg. 27, pg. 29 and pg. 32; map data for Applicant's Proposed Permit Boundary was taken from the Ross In Situ Recovery NRC License Application, Environmental Report, pg. 1-52).

Insufficient Data to Support the Hypothesis of Confining Layers

9. Speculation on the isolation of the SM, OZ, and DM aquifers by two confining units is tied to the interpretation of 371 geophysical logs and short-duration pump tests (24 hours at the 6 well clusters and a 72 hour test at WC 12-18). It is speculative because there are insufficient data and detail in the application to support the hydraulic isolation hypothesis.

10. The 371 geophysical logs are fair to poor with respect to seeing the trace of the resistivity, spontaneous potential and gamma activity. Where the trace is too faint or invisible, it is not possible to trace the confining unit between the boreholes (e.g., Addendum 2.6-C, Figure 2, borings SP-246V and SP-248V for confining layer between SM and OZ). Many of the visible traces on the geophysical logs show no difference between aquifer horizons and confining units

(e.g., Addendum 2.6-C, Figure 3, borings SP-154V and SP-634R for confining layer between SM and OZ). Therefore, the presence of the confining layer across the project site has not been demonstrated with the geophysical logs in Addendum 2.6-C.

11. Because the vertical and horizontal heterogeneity in the sediments (discussed below) creates variation in the vertical and horizontal hydraulic conductivity, a detailed hydrological analysis must be presented to demonstrate that a 24 hour pump test on the OZ water horizon would be of sufficient duration to transmit a change in pressure to the overlying SM and underlying DM horizons. No such analysis is presented to defend a pump-test interval of 24 hours. The need for a detailed hydrological analysis is supported by information in the application that indicates the OZ and SM units are hydraulically connected (Section 2 of the Technical Report p. 2-152):

> ".....the SM unit's hydrostatic pressure heads have likely declined over the last three decades as result of pumping the local oil field water source wells completed in the underlying OZ interval. "

There are numerous notations in the application on the vertical and horizontal heterogeneity of the stratigraphy, which is discussed as discontinuity of mudstone and claystone horizons. Here are some examples:

> As for the aquifer test cited by Buswell, the groundwater hydrologist (P.A. Manera) who conducted and analyzed the test stated in his report (Manera 1978) that the changing permeability and lateral discontinuity in the stratigraphy was the more probable reason for some observation wells to be hydrologically isolated …

Technical Report, Section 2, p. 2-87.

> "The lowest sand package of the Lance Formation is comprised of narrow, rejoining fluvial channel deposits. Channel sandstones form sharp upper and lower contacts and display abrupt boundaries with laterally equivalent interchannel sediments. The sandstone deposits in the lowest section are divided into thick bedded sandstones and thin, interbedded sandstone, siltstone, and shale. Thick-bedded sandstones are gray to light gray, fine- to very fine-grained, and often have clasts of carbonaceous fragments and coalified woody materials. Interbedded sediments have dark brown

> and gray organic-rich shales, black lignitic shales, and dark gray, very fine-grained sandstones and siltstones. Basal Lance distributaries formed a complex rejoining channel pattern that probably resulted from rapid and repeated channel diversions. Sandstones form a net of north-south oriented sand bodies within this section. These sand bodies are typically narrow and straight, rejoining channels trending roughly north-south that extend out of the Oshoto area.

Technical Report, Section 2, pp. 2-95 & 2-96.

> When strike-oriented sand channels were encountered, groundwater was diverted primarily northward.

Technical Report, Section 2, pp. 2-99

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

Technical Report, Section 2, pp. 2-100.

12. The above citations from the application make clear that the depositional environment is dynamic and the grain size of the sediments is highly variable horizontally and vertically. Therefore, it is not logical to expect a continuous mudstone or claystone to extend across the entire project area, and the data are absent to support such a hypothesis.

13. Additionally, there are hundreds of pathways between the OZ and other water horizons due to the nearly 2,000 exploration boreholes drilled in the project area, as shown in Figure 2. Information on the abandonment of exploration boreholes provides compelling evidence that there are numerous flow pathways between the aquifers:

> Typical abandonment involved setting a cement plug 5-10 feet below ground surface (probably several bags of neat cement) …

Technical Report, Section 2, pp. 2-104.

14. Clearly, there was no effort to plug and abandon the boreholes from the bottom up and pathways between the water horizons exist now; and they existed back in 1978 when Nubeth performed their pilot scale ISL operation within the present permit boundary (Figure 1).

Fluid Migration between Water Horizons

15. There is indirect evidence for the migration of fluid between the OZ and SM water horizons. Groundwater quality data for the OZ horizon shows the concentration of sufate (600 mg/L) to be about twice that observed in the overlying SM horizon (most less than 300 mg/L). Well cluster WC 21-19 is immediately south of the Nubeth pilot ISL area (Figure 1), and the water quality in SM horizon shows the highest values for sulfate (335-396 mg/L), carbonate (99-218), sodium (426-451 mg/L) and uranium (0.003-0.004 mg/L), relative to the 5 other WC wells in the SM horizon. Given the common use of sodium bicarbonate in the lixiviant injected into uranium ore zones, it is possible that the injection of lixiviant into the Nubeth pilot ISL field, over the time frame of approximately one year (Technical Report, Section 2, pp. 2-89 & 2-90), pushed contaminated fluids from the OZ horizon into the overlying SM horizon. Detailed information on lixiviant composition and injection volume and pressure during operation must be supplied in the application to assess the potential for cross contamination of aquifers in the vicinity of the Nubeth pilot ISL field.

Baseline Water Quality

Invalid and Insufficient Data to Develop Baseline Water Quality in the Ore Zone

16. The six cluster wells that tap the OZ water horizon are an insufficient number of wells to provide a representative sample of the groundwater quality in the Ross permit area. Reported data are also invalid because the wells were constructed with rotary mud drilling and developed with air purge methods, which oxidizes the ore zone and releases uranium and radium.

Additionally, historical water quality data from the Nubeth pilot ISL site are not provided to allow a comparison of baseline water quality prior to the operation of the pilot ISL field to the data collected from the six cluster wells.

Improper Location of Wells to Develop Representative Water Quality Parameters

17. The six cluster wells are an insufficient number of wells to characterize the baseline water quality of the water horizons in the Ross permit area. *See* Figure 2. Although the application states additional baseline well clusters will be installed, all the proposed well clusters are in ore zones (Technical Report, Figure 5.7-9; p. 5-106). This biases water quality samples to high values and does not account for the collection of representative samples from the surrounding aquifer that will be part of the aquifer exemption permit.

18. A statistically valid approach for establishing baseline water quality in the mine area is to locate baseline wells with a systematic grid or by random selection (Gilbert, 1987; Matzke et al., 2007). For a systematic grid, a 400-by-400 foot grid (160,000 ft^2 or about 4-acre cells) should be placed over the proposed mine area to ensure that a minimum of one well is placed in every 4 acres (NRC, 2003; p. 5-39). Given the proposed mine area illustrated on Figure 2.1-3 in Section 2 of the Technical Report (as shown on Figure 2), approximately two-thirds of the Ross permit area is covered by proposed well fields. The Ross permit area covers about 1,866 acres, and two-thirds of this is 1,250 acres. Therefore, if the recommendation is to place one baseline well in every four acres, there should be approximately 312 wells located on a systematic grid that covers the proposed mine field. Figure 3 illustrates the systematic placement of 312 wells on a 400 by 400 ft grid across the proposed mine fields (map data for Applicant's Proposed Permit Boundary, Applicant's Estimated Wellfield Perimeter, and Applicant's Estimated

Nubeth Pilot ISL Area are taken from the Ross In Situ Recovery NRC License Application, Environmental Report, pg. 1-49 and pg. 1-52)

19. Alternatively, baseline wells could be located on a 1,000 by 1,000 ft grid across the proposed mine field area (about 50 wells) and the collected baseline data processed through appropriate statistical methods to determine if 50 locations is a sufficient sample size to represent the water quality in the four water horizons across the Ross permit area. If 50 locations are insufficient to statistically establish a representative sample size, additional wells can be systematically located on a smaller grid until the sample size is shown to be statistically significant or 312 wells have been established across the Ross permit area.

Oxidation of the Ore Zone Elevates Uranium and Radium in OZ Water Samples

20. The application fails to account for the oxidation of the ore zone by the present inappropriate drilling and development methods used for construction of baseline wells. Rotary drilling with mud and development of the wells with air purging adds contamination and oxygen to the aquifer (Laaksoharju, 2008; Abitz and Darling, 2010). This is documented in the application:

> All baseline monitoring wells were constructed using conventional mud rotary drilling techniques........Following filter pack placement, air-lift development was conducted until turbidity readings stabilized.

Technical Report, Section 2, p. 2-146.

21. Fluids used with mud-rotary drilling and air-lift development of a well placed in a reduced uranium ore zone introduce oxygen into the formation, and oxidation of the ore releases uranium and radium to the aquifer. Water quality data from the USNRC License Application for the Goliad Texas ISR Project (UEC, 2007) indicates anthropogenic oxidation of the ore zone. Monitoring data collected at the Goliad Project after the drilling oxidation event shows that the anthropogenic oxidation of the ore zone, documented by the first round of sampling,

was reversed when the aquifer was left undisturbed for 18 months (as shown by second and third rounds of sampling). That is, uranium values decrease as the aquifer returns to a reduced environment. However, radium is not redox sensitive, so once the radium is mobilized by improper drilling techniques that oxidize the ore zone, it will not return to an immobile form and it is no longer possible to establish a baseline value for radium (Abitz and Darling, 2010). Baseline monitoring wells must be developed using reducing fluids during the drilling process and the well must be developed using surge-block and bailing techniques.

Sample Bias from Invalid Screen Lengths in the OZ Water Horizon

22. The screens placed through part of the OZ water horizon only sample water that is in contact with the ore zone, rather than the entire column of water in the OZ sand interval (Table 1). Therefore, reported uranium and radium-226 values are biased high and cannot be used for baseline water quality. It is possible that all wells would meet the EPA MCL's for uranium and radium-226 if the water quality sample was collected from the entire thickness of the OZ sand horizon. Despite the bias in the sampling, upgradient wells OZ 21-19 and OZ 42-19 meet the EPA MCL's for uranium and radium-226. This may be due to the migration of undisturbed water from the southwest into the cone of depression that surrounds Industrial well 18xx19, near OZ 21-19 (Figure 1).

Table 1.

OZ Well	OZ well screen length[1]	OZ sand thickness[2]	Uranium (mg/L)[3]	Radium-226 (pCi/L)[3]
12-18	110 feet	200 feet	0.033-0.070	5.00-12.0
14-18	30 feet	180 feet	0.085-0.109	2.31-4.90
21-19	35 feet	160 feet	0.005-0.024	0.71-0.93
42-19	90 feet	180 feet	0.009-0.011	1.36-1.46
34-18	105 feet	180 feet	0.041-0.062	5.97-9.68
34-7	60 feet	150 feet	0.028-0.044	0.94-2.35

[1]data from Addendum 2.7 F, Table 1
[2]data from Addendum 2.6 C, Figure 7 (12-18), Figure 9 (14-18), Figure 11 (21-19), Figure 24 (42-19), Figure 16 (34-18), Figure 17 (34-7).
[3]data from Technical Report, Section 2, Table 2.7-37

Evidence for Existing Mining Contamination of Groundwater in OZ Water Horizon

23. Because the OZ water horizon has been impacted by previous ISL mining during the Nubeth pilot ISL operation, it is also possible that the water quality data reported for the 2010 quarterly samples of the OZ water horizon (Addendum 2.7 J) has been affected by past contamination of the aquifer. The three highest uranium and radium-226 results for the 6 OZ wells are from wells that are adjacent to and downgradient from the Nubeth pilot ISL site. Well OZ 34-18 is located on the eastern boundary of the Nubeth pilot ISL site, and OZ 14-18 and OZ 12-18 are north and downgradient from the site (Figure 1; U and Ra-226 values are in Table 1). As cited on page 2 of this Declaration, strike-oriented sand channels transport the groundwater northward, and Wells OZ-14-18 and OZ 12-18 may lie in one of these sand channels directly downgradient of the Nubeth ISL site. The groundwater model presented in the application should address the potential impact of 30 years of transport of groundwater with the pilot ISL restoration values (Table 2) along highly permeable, north trending sand channels to the 14-18 and 12-18 locations.

WDEQ Groundwater Class for OZ Water Horizon

24. Based on the invalid water quality results for uranium and radium-226 in OZ wells, the application indicates that the OZ water is suitable only for industrial use (Technical Report, Section 2, p. 2-166). Because representative water samples were not collected from the OZ aquifer, the WDEQ groundwater class cannot be determined at this time. Moreover, in the event that valid representative samples are collected in the future, the presence of uranium or radium-226 at a level slightly above an EPA MCL does not preclude the use of the water for stock or domestic purposes.

25. The city of Gillette, WY has a well field north of Moorcraft and this water is piped to Gillette where it is blended with water from the Ft. Union, Fox Hills and Lance Formations for domestic use (ER Addendum 1.6 A). Therefore, it is possible to use the OZ aquifer for future stock and domestic use if it is blended with another source to dilute an ion concentration that exceeds an EPA MCL. Presently, on the eastern end of the Ross permit area, it is noted that:

> ...[T]he aquifers are much shallower and several stock/domestic wells located in this area are likely completed within the OZ aquifer.

Technical Report, Addendum 2.7 H, p. ES-3.

26. This establishes WDEQ groundwater class of use for the OZ aquifer as stock and domestic.

Missing Water Quality Data

27. Several other sources of water quality data are cited in the application, but the data could not be located for review and comparison to the results in Addendum 2.7-J. In Addendum 2.7-F, p. 15, it is noted that during the pumping test, the discharge was monitored for TDS, TSS, pH, radium and uranium. Likewise, the application referenced water quality studies by the BLM (2010), Ogle and Calle (2006) and Rankle and Lowry (1990), yet the study results were not found in the application.

Failure to Restore Water Quality at Nubeth Pilot ISL Site

28. The Nubeth monitoring wells are shown on Figure 2.5-1 in Addendum 2.7 H. 1978 pre-mining and 1981 restoration data reported for the monitoring wells are summarized in Table 2. There are no original well logs and analytical results to evaluate whether the pre-mining data represent unbiased samples collected from the OZ water horizon. It is very probably that the samples represent a high bias due to anthropogenic oxidation of the ore horizon and screening only in the ore zone, as discussed above for the six regional well clusters. Restoration was carried out

for two years and, although the duration of the pilot ISL operation was short, most of the wells were not returned to the pre-mining, high-biased value.

Table 2.

Nubeth Well	1978 pre-mining U (mg/L)	1981 restoration U (mg/L)	1978 pre-mining Ra-226 (pCi/L)	1981 restoration Ra-226 (pCi/L)
3X	0.071	0.240	73	22
4X	0.080	0.220	16	26
5X	0.100	0.035	0.3	0.5
6X	0.075	0.095	0.6	0.1
7X	0.008	ND	0.5	0.6
11X	0.079	0.082	1.4	1
12X	0.073	0.076	2.3	1.6
19X	0.300	0.480	97	31
20X	0.006	0.068	0.6	20

1978 pre-mining data from Technical Report, Section 2, Table 2.7-53
1981 restoration data from Technical Report, Section 2, Table 2.7-54

Failure to Describe Technology Capable of Restoring Water Quality After Mining

The two year period for restoration of the Nubeth pilot ISL operation is 4 times as great as the proposed 6 month restoration proposed for the Ross project (Addendum 2.7 H, p. 75). Given the failure to restore to pre-mining conditions after two years for a short pilot ISL operation (6 months), it is inappropriate to propose a 6 month restoration period for a full-scale mining operation of 2-3 years per wellfield. The application provides no technical basis for why it could suggest such an abbreviated time frame.

29. Moreover, the application does not discuss new technology that is capable of greater efficiency and performance relative to the standard ISL restoration techniques of groundwater sweep, treatment of contaminated water with reverse osmosis, and permeate injection (Technical Report, Section 1, p. 1-12; Section 6, p. 6-5). Hall (2009) and Staub et al (1986). These documents are available on line for you to download) have shown that the standard techniques applied to ISL mines in Texas and Wyoming have never returned the post-mining water quality to baseline values for all constituents. Regulatory restoration is achieved at ISL sites only after

alternate concentration limits for restoration are granted to the operator by the NRC or agreement State Agency.

/s/ Dr. Richard Abitz (electronic signature approved)

Dated: October 23, 2011

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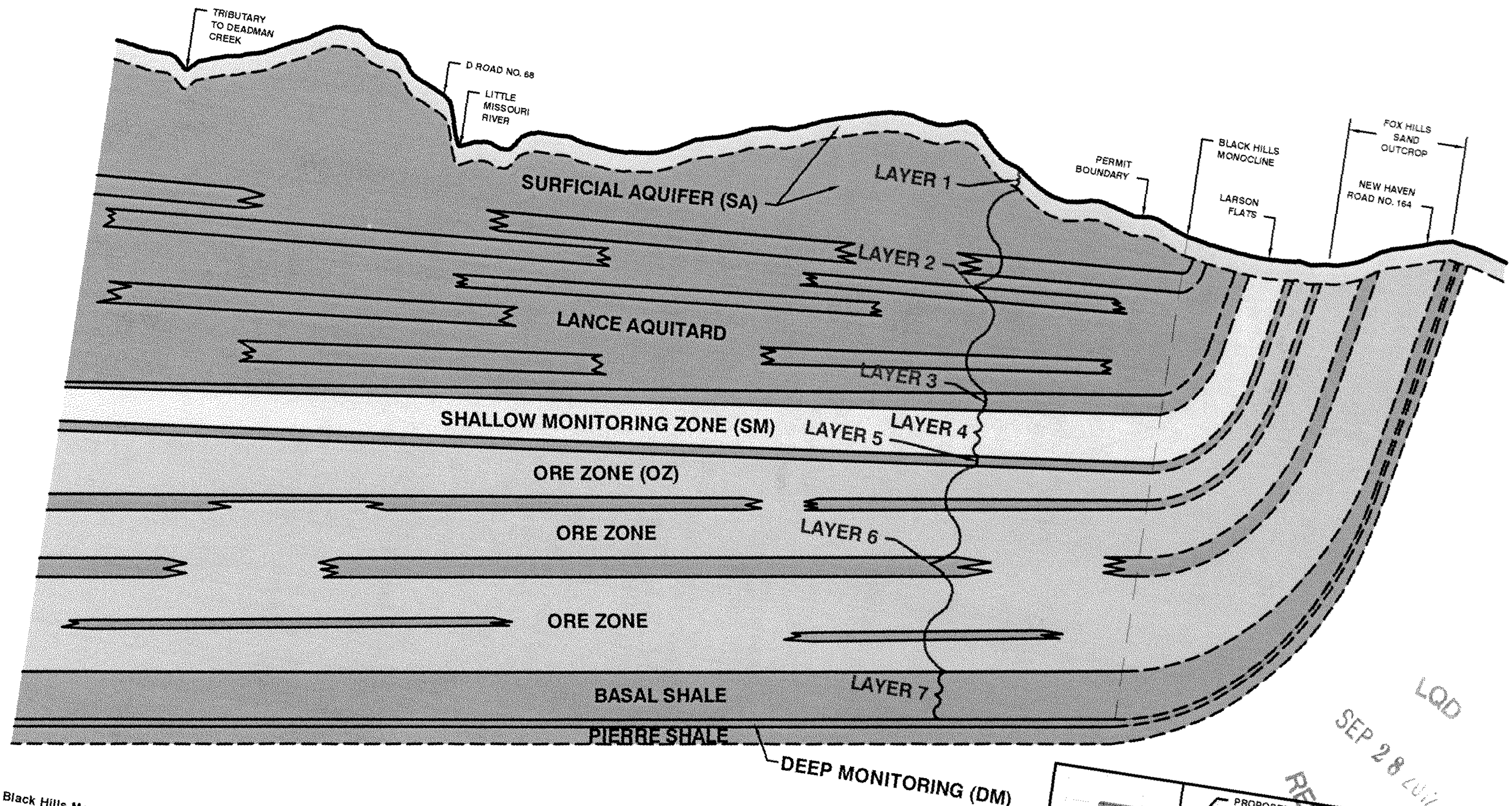
Figure 1



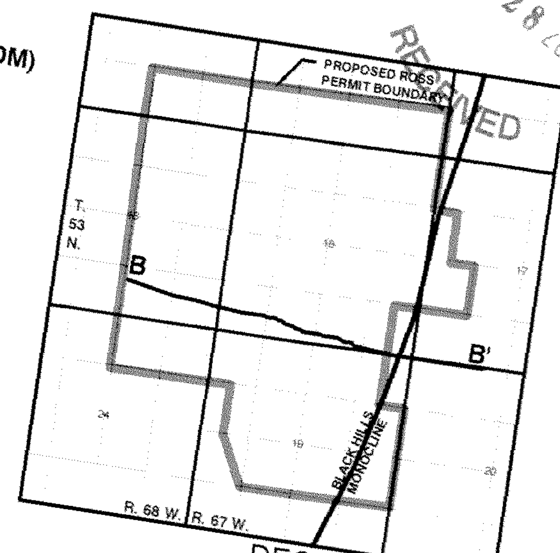
Black Hills Monocline adapted from Sutherland, W.M., 2008, Geologic Map of the Devils Tower 30' X 60' Quadrangle, Crook County, Wyoming, Butte and Lawrence Counties, South Dakota, and Carter County Montana: Wyoming State Geological Survey Map Series 81, Scale 1:100,000.

Fox Hills sand outcrop adapted from Halberg, L.L., Et. Al., Geologic Map of the Sundance 30' X 60' Quadrangle, Crook and Weston Counties, Wyoming and Lawrence and Pennington Counties, South Dakota: Wyoming State Geological Survey Map Series 78, Scale 1:100,000.

CONCEPTUAL CROSS SECTION B-B'

NOT TO SCALE

Figure 4.1-2.



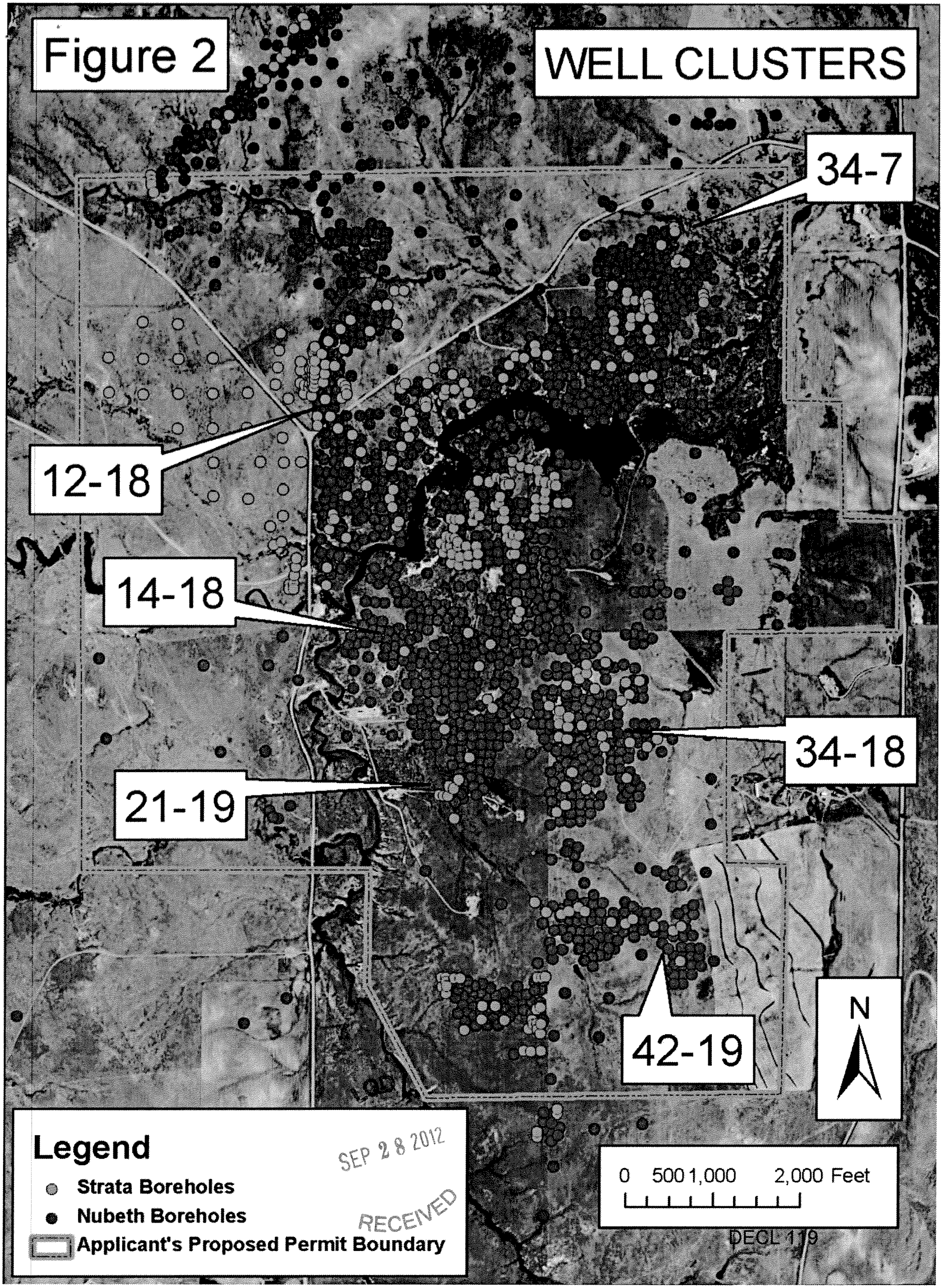


Figure 2
WELL CLUSTERS
34-7
12-18
14-18
34-18
21-19
42-19
N
0 500 1,000 2,000 Feet
Legend
Strata Boreholes
Nubeth Boreholes
Applicant's Proposed Permit Boundary

DECL 119

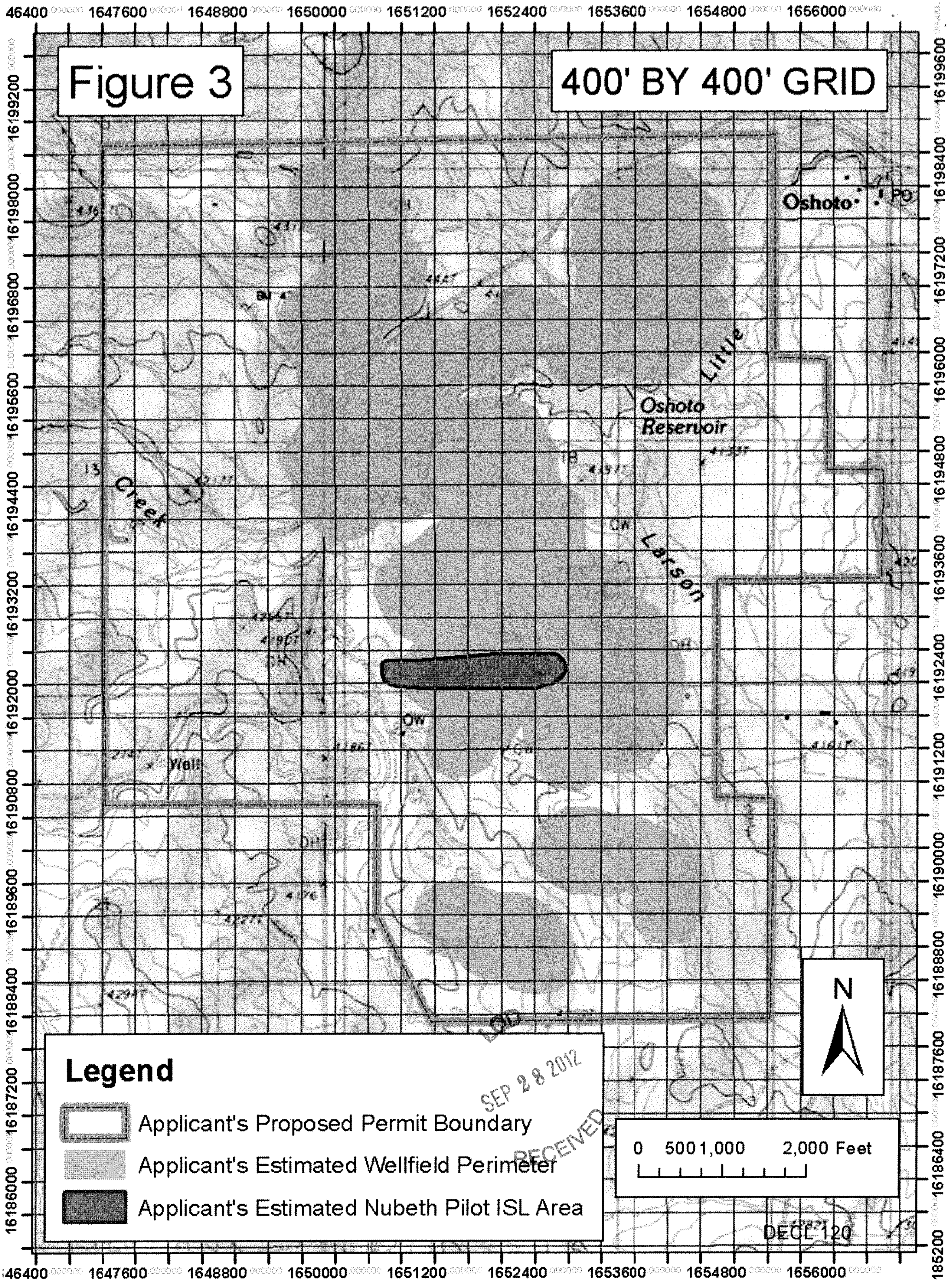


Figure 3
400' BY 400' GRID
Oshoto
Oshoto Reservoir
Little
Larson
Creek
Well
Legend
Applicant's Proposed Permit Boundary
Applicant's Estimated Wellfield Perimeter
Applicant's Estimated Nubeth Pilot ISL Area
0 500 1,000 2,000 Feet
N
RECEIVED SEP 28 2012 LQD
DECL 120

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Richard J. Abitz

Professional Qualifications

Dr. Abitz is a geochemist with over twenty-two years of experience in the environmental services sector of private and government organizations. His broad experience encompasses project and personnel management, analysis of chemical and radiological data, modeling of soil/water systems and radioactive waste streams with experimental methods and geochemical computer codes, risk assessment, and development of remedial work plans for CERCLA and RCRA sites. His technical expertise includes the application of geochemical principles, experimental methods, and computer models to problems involving the solubility and mobility of hazardous and radioactive elements in the environment, evaluation of environmental and human risk associated with exposure to contaminants in air, soil and water media, real-time mapping of radionuclide distribution in soil, remediation techniques for waters and soil contaminated by hazardous and radioactive wastes, and the treatment of mixed and radioactive waste streams.

At the DOE Savannah River Site (SRS), Dr. Abitz currently serves with the Savannah River National Laboratory as a program manager for the development of technologies to support the *in situ* decommissioning of highly contaminated nuclear facilities and the remediation of soil and groundwater contaminated by hazardous metals and radionuclides. In this capacity, he has been invited to international conferences in the United Kingdom and Japan to present technical information on the decommissioning of nuclear facilities and remediation of groundwater and soil contaminated with uranium and other radionuclides.

As the owner and principal geochemist of Geochemical Consulting Services, LLC, Dr. Abitz has supported numerous technical reviews for groundwater restoration at UMTRA sites and permit applications for uranium *in situ* leach mining. He served as an EPA subcontractor supporting the Bluewater Valley Downstream Alliance as a geochemical expert on groundwater remediation at the Homestake uranium tailings site north of Milan, NM. For the Navajo Nation (New Mexico), Sioux Nation (Nebraska), Coloradoans Against Resource Destruction, and the Goliad County Groundwater Conservation District (Texas), he served as a technical expert and has evaluated the impact of proposed *in situ* uranium leach mining on the community groundwater supply. He presently supports the National Resources Defense Council, Inc (NRDC) on the technical review of the Strata Energy permit application to the Nuclear Regulatory Agency for the Ross ISR Project in Crook County, Wyoming.

At the Fernald, Ohio superfund site, Dr. Abitz managed the Environmental Services Group and was responsible for the business and technical scope associated with preparing remediation work plans, collecting soil, water and air samples, data validation, data analysis and modeling, *in situ* measurements for ^{226}Ra, ^{232}Th, and ^{238}U activity using sodium iodide and high-purity germanium detectors, developing an estimate of the Curie inventory for the on-site disposal cell (OSDF), and preparation of the residual risk assessment and soil certification reports. He also served the Fernald site as a senior consultant to the DOE Technology Development Program and managed active research projects at several universities. These projects included laboratory studies on the mobilization and removal of contaminants from soil/water systems, such as passive removal of uranium from groundwater using inorganic and organic media.

Dr Abitz also has experience with environmental media contaminated with uranium and other radionuclides at Los Alamos National Laboratory (LANL), the Idaho National Engineering Laboratory (INEL), the Idaho Chemical Processing Plant (ICPP), and the Waste Isolation Pilot Plant (WIPP).

Richard J. Abitz

Education and Training

B.A., Geology, Humboldt State University, Arcata, California; 1981
M.S., Geology, University of New Mexico, Albuquerque; 1984
Ph.D., Geology, University of New Mexico, Albuquerque; 1989
Environmental Risk Assessment Communication and Application Workshop, INEL Oversight Program, Boise, Idaho; 1992
OSHA HAZWOP Training, 29 CFR 1910.120 (40 hours, IT Corporation, 1994)
Practical Models Supporting Remediation of Chlorinated Solvents, Aiken, SC 2010

Experience and Background

2009 - present

Program Manager, Savannah River National Laboratory, Aiken, SC

- Dr. Abitz leads the DOE EM-44 site-wide program to investigate and develop technologies for the *in situ* decommissioning of highly contaminated nuclear facilities. He also supports EM-32 technology development for the remediation of contaminated groundwater and soil across the DOE complex. His knowledge in these areas has been extended into international nuclear clean-up programs in the United Kingdom and Japan, where he interfaces and collaborates with international scientists and engineers on innovative technologies for the safe and effective decommissioning of highly contaminated nuclear facilities and the removal or immobilization of radionuclides in the environment.

2006 - present

Principal Geochemist/Owner, Geochemical Consulting Services, Blue Ash, Ohio

Geochemical Expert on ISL Uranium Mining for the Navajo & Sioux Nations, Coloradoans Against Resource Destruction (CARD), the Goliad County Groundwater Conservation District (GCGCD), and the National Resources Defense Council, Inc.(NRDC)

- Dr. Abitz provides legal testimony, technical review, geochemical modeling, and geological analysis for work associated with the proposed *in situ* uranium leach mines in the vicinity of Church Rock and Crownpoint, New Mexico (Navajo Nation), the expansion of the Crow Butte mine in Nebraska (Sioux Nation), the Centennial Project in Weld County, Colorado (CARD), the Goliad Project near Goliad, Texas (GCGCD), and the Ross Project in Crook County, Wyoming (NRDC).

Technical Support to the Savannah River Site

- Dr. Abitz supported the contract transition team for Savannah River Nuclear Solutions (SRNS). He reviewed RCRA and CERCLA groundwater remedial systems (electrical resistivity heating with soil vapor extraction, chemical reactive barrier, and tritium phytoremediation), project controls and management systems used to status the remediation work, and regulatory milestones to assess the status of the Area Closure Projects and SRNS readiness to perform the work scope. He also supported SRNS in the preparation of the ARRA baseline estimate for the Solid Waste Management and Area Closure Projects.

NESHAP Report for the Fernald Preserve, Cincinnati, Ohio

- For the Fernald Annual Sitewide Environmental Report, Dr. Abitz prepares the chapters on air emissions (particulate with uranium, thorium and radium isotopes, and radon), population dose, and the NESHAP annual report.

Risk Assessment for the Fernald Closure Project (FCP), Cincinnati, Ohio

- Tasked with the responsibility to develop and author the Interim Residual Risk Assessment for the Fernald site, Dr. Abitz evaluated the risk to visitors and workers exposed to residual contaminants in air, soil and surface-water pathways. Risk scenarios showed the incremental lifetime cancer risk to the receptors was below the recommended EPA maximum of 0.0001.

2003 – 2006 ***Manager of the Environmental Services Group and Senior Consultant, Fluor Fernald, Inc., Cincinnati Ohio***

- As the manager for the Environmental Services Group (ESG), Dr. Abitz oversaw the work of over 50 scientists and technicians. Personnel in the ESG performed water, soil and air sampling and monitoring; analytical services for radionuclides, metals and organic compounds; data verification, validation, reduction and reporting; and *in situ* soil activity measurements for ^{226}Ra, ^{232}Th, and ^{238}U via the site's real-time instrument measurement program (RTIMP).

- As the site geochemist, he prepared an estimate of the curie inventory for the OSDF to provide a baseline value to DOE legacy management. The scope of this task was to develop the estimate using information from the Ohio Field Office Recycled Uranium Project Report, OU3 and OU5 RI/FS documents, the Fernald Dosimetry Reconstruction Project, remedial operation records, historic records, active monitoring data, interviews with technical personnel who supervised plant operations from the early 1960's through production shut down in 1989, and analytical results on soil placed in the OSDF.

- Dr. Abitz also served as senior consultant to the FCP on the long-term remediation strategy for the Great Miami aquifer. In this capacity, he coordinated laboratory and microscopy studies on the form of uranium present on aquifer sediments. The laboratory and microscopy studies examined the amount of uranium that is fixed to the sediments via chemical adsorption and overgrowth rims versus the mobile fraction that is readily desorbed from the aquifer matrix. These key studies identified and addressed the kinetics of uranium reactions to determine the time constraints associated with achieving the EPA's drinking water standard for uranium.

Environmental Science Manager/Project Manager/Senior Consultant, Fluor Fernald,

1998 - 2003 ***Inc., Cincinnati, Ohio.***

- In his role as environmental science manager, Dr. Abitz directed the RTIMP, which provided *in situ* soil activity measurements for ^{226}Ra, ^{232}Th, and ^{238}U in live time. This program supports excavation and D&D work by scanning soil to confirm U contamination is below the waste acceptance criteria for Fernald's on-site disposal facility (OSDF). Prior to the release of remediated land, the RTIMP performs *in situ* activity measurements to demonstrate that the soil is below the final remediation levels established for ^{226}Ra, ^{232}Th, and ^{238}U.

- As a project manager, Dr. Abitz managed a remediation budget of six million dollars for Title I/II design work for D&D of structures and removal of all contaminated soil and subgrade structures within the former Production Area. Dr. Abitz lead a team of engineers and scientists who integrated the remedial design with regulatory issues, sampling and analysis plans, waste management operations, demolition and construction activities, health and safety issues, radiological controls, and quality assurance protocols.

- Dr. Abitz served as a senior consultant to the DOE Technology Development Program, where he performed technical oversight of several university studies dealing with the mobilization of uranium and its removal from groundwater. He was active with laboratory investigations that examine the distribution of uranium phases in soil and aquifer sediment, the leaching behavior of the uranium phases, the treatment of contaminated soil with phosphate, and the geochemical properties of aggregate materials used to construct liners in the OSDF. The research established important baseline information on the distribution of uranium in the aquifer and in OSDF construction materials, while treatment studies evaluated the effectiveness of phosphate in reducing the solubility and mobility of uranium in the disposal cell.

- As a participant in research that evaluated the natural attenuation of uranium using a combination of passive inorganic and organic systems, Dr. Abitz was involved with work groups from industry, academia and DOE laboratories. The inorganic systems that were investigated include rip-rap channels constructed with rock containing iron oxyhydroxide phases (e.g., goethite and hematite) or phosphate minerals (e.g., apatite) and flow-through cells using zero-valent iron. Organic systems that showed potential promise include sulfate-reducing bacteria, microbial mats, lichen, and phytoextraction. A combination of these systems may prove to be practical and cost effective in the treatment of low leachate volumes.

President/Owner, Geochemical Consulting Services, Albuquerque, New Mexico.
Dr. Abitz served as a geochemical consultant to the Fernald Environmental Management
1997 - 1998 Program (FEMP) and the WIPP Project.

- Dr. Abitz performed confidential work for the Navajo Nation on the proposed *in* *situ* uranium leach mines in the vicinity of Church Rock and Crownpoint, New Mexico.

- At FEMP, he evaluated the efficiency of selected alternatives for soil and groundwater remediation, including soil washing and *in situ* uranium leaching methods. This effort involved supervising the technical team, assisting in the negotiation of clean-up levels with DOE and EPA, developing soil-treatment protocols, and interacting with public-interest groups.

- At the WIPP site, Dr. Abitz provided the operating contractor with expertise in the area of brine geochemistry. He was responsible for oversight of laboratory analyses and QA/QC, data analysis, and geochemical interpretation of the composition and origin of fluids in the vicinity of underground operations. Dr. Abitz also evaluated the solubility of transuranic elements in sodium-chloride brine and in brine containing organic-complexing agents such as citric acid, oxalic acid, and EDTA.

Project Manager/Senior Staff Consultant, IT Corporation, Albuquerque, New Mexico. Dr. Abitz served as project scientist/manager on geochemical tasks associated with the WIPP Project, Norton AFB Groundwater Study, FEMP Operable Units 5 and 3 RI/FS, and

1994 - 1997 Navajo EPA. Specific activities include:

- Conducted a rerun of the chemical compatibility analysis of TRU waste forms and container materials for Appendix C1 of the WIPP RCRA Part B permit. The chemical compatibility analysis was carried out with all defense generated, contact-handled (CH) and remote-handled (RH) transuranic-mixed waste streams reported in the 1995 WIPP Transuranic Waste Baseline Inventory Report (WTWBIR). Chemicals reported by the generator sites were classified into reaction groups as defined by the U.S. Environmental Protection Agency (EPA) document "A Method for Determining the Compatibility of Hazardous Wastes." The list of potential chemical incompatibilities reported by the program was hand checked using the EPA document as a reference to assure proper functioning of the program. All potential chemical incompatibilities were then evaluated on a case-by-case basis to identify which of the reactions could occur, given the nature of the waste, its chemical constituents, and final waste form.

- Assisted in evaluating the geochemical performance of backfill configurations proposed in the WIPP Compliance Certification Application. Modeled the interaction of Salado Formation brine with MgO placed in the backfill to estimate the quantity of MgO required to buffer the pH of the indigenous brine between 8 and 9. This pH range is desirable for minimizing the solubility of plutonium and neptunium contained within the waste forms, and lowers the solubility of uranium and americium relative to lower pH values found in Salado Formation brine.

- Project scientist responsible for developing the background groundwater report for Norton AFB This report established background radionuclide concentrations in local and regional groundwater and provided a robust scientific model to explain the presence of elevated levels of naturally-occurring uranium. The task required coordination of scientific and support staff to produce a principal milestone document that was delivered to the client one week ahead of schedule.

- Project manager and scientist on the FEMP OU5 FS task to evaluate aqueous reactions of metal and radionuclide complexes in proposed injection zones of the Great Miami Aquifer. Responsible for oversight of technical tasks, budget, schedule, and final technical report.

- Project scientist tasked with supporting the Navajo EPA on the evaluation of groundwater contamination from the mill tailings at the UNC Church Rock, New Mexico site. Radionuclide, sulfate and nitrate concentrations were evaluated to discriminate between contamination originating from the mill tailings and natural salts present in the valley alluvium.

- Project manager and scientist on the FEMP OU3 RI/FS task to evaluate the release of radionuclides and metals from the proposed on-site disposal facility. Responsible for oversight of technical tasks, budget, schedule, and final technical report.

1989 - 1994 ***Senior Geochemist, IT Corporation, Albuquerque, New Mexico*** Dr. Abitz evaluated the radiochemistry of transuranic elements in sodium-chloride brine for the WIPP Project and served as the project geochemist for four operable units on the FEMP RI/FS. He was also active setting up the LANL RMMA concept and provided radiochemistry support to INEL in developing a No Migration Variance Petition (NMVP) for the INEL calcine facility.

- Developed solubility database for the WIPP EATF. Evaluated the solubility of thorium, uranium, neptunium, plutonium, and americium in sodium-chloride brine and in the presence of organic complexing agents, such as EDTA and citric acid. Prepared solubility charts of the radionuclides over the pH range of 2 to 12.

- Authored white paper on geochemistry of FEMP site for OU 5 RI/FS. This paper discusses leaching, dissolution, and desorption processes that release uranium and its progeny from surface sources, adsorption and aqueous complexation of the solubilized uranium and progeny with subsurface soils and groundwater, and predicts secondary uranium phases that may form in the soils.

- Conducted site-surveys and interviewed LANL personnel on radiation practices associated with the handling, packaging, labeling, storage, transport, and disposal of transuranic materials. Information was used to develop LANL RMMA concept, where each RMMA is held accountable for all radiaoactive materials that enter and exit the area.

- Developed waste analysis plans for transuranic and low-level mixed wastes present at LANL. This activity was conducted to complete RCRA Part B permits and ensure regulatory compliance to DOE orders for all LANL facilities that generate, store, or dispose of mixed waste.

- Managed and had technical oversight on geochemical program associated with FEMP RI/FS. Program tasks include the characterization of soil mineralogy by polarized light microscopy and x-ray diffraction studies, design and implementation of laboratory tests to characterize the composition of leachate derived from cemented and vitrified waste samples, evaluation of contaminant adsorption ratios, data validation, and tracking of labor and material costs.

- Designed laboratory experiments for FEMP RI/FS to measure adsorption ratios of radionuclides and metals and implemented ANSI/ANS-16.1 leach tests to evaluate the performance of cemented waste forms. Results were used to evaluate the most effective alternative for immobilizing radionuclides and metals from a near surface disposal cell.

- Led INEL waste characterization program on calcined solid waste. Responsible for evaluating radiochemistry data on uranium fission products and transuranic elements in aqueous and calcined waste forms. Provided assistance in the development of EPA approved sampling and analytical plans to support a draft no migration variance petition for the radioactive calcined waste stored at the ICPP.

Professional Affiliations

Geological Society of America
International Association of Geochemistry and Cosmochemistry

Presentations & Publications

Abitz, R.J., Farfan, E., and Coleman, R., 2011, Gamma-Ray Mapping and Waste Segregation, invited presentation to the Japan/USDOE October 26 & 27 workshop on clean-up of the Fukushima Nuclear Power Stations, Tokyo, Japan.

Szilagyi, A., P. Kirk, R. Abitz, and J. Gladden, 2011, The Office of Deactivation and Decommissioning Research and Development Program for Fiscal Year 2011, Paper 11533, Waste Management Symposia, Phoenix, AZ.

Abitz, R.J., 2010, Decommissioning Highly Contaminated Nuclear Facilities at the Department of Energy Sites, *Proceedings of the United Kingdom Decommissioning and Waste Management Conference*, Penrith, Cumbria, UK.

Abitz, R. J. and B. Darling, 2010, Anthropogenic Induced Redox Disequilibrium in Uranium Ore Zones, *Geological Society of America Abstracts w/Programs*, Vol. 42.

Abitz, R.J., 2010, Technical Basis for Approval of Decon Gel as an Acceptable Component of WIPP Waste Streams, *Proceedings of the American Nuclear Society Meeting on Decommissioning, Decontamination and Reutilization*, Idaho Falls, ID.

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Buck, E.C., N.L. Dietz, and R.J. Abitz, 1995, "The Nature of Uranium Phases at Fernald" ***American Chemical Society Book of Abstracts for Emerging Technologies in Hazardous Waste Management VII,*** Vol. I.

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Beard, J.S., R.J. Abitz, and G.E. Lofgren, 1993, "Experimental Melting of Crustal

Xenoliths from Kilbourne Hole, New Mexico and Implications for Magma Contamination and Genesis," ***Contributions to Mineralogy and Petrology,*** Vol. 115, pp. 88-102.

Abitz, R. J., and M. Furhmann, 1993, "Adsorption of Radionuclides and Metals Below a Mixed-Waste Disposal Cell: Implications for Risk-Assessment Calculations," ***Geological Society of America Abstracts w/Programs***, Vol. 25, No. 6, p. A-185.

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Deal, D. E., R. J. Abitz, J. Myers, D. S. Belski, M. L. Martin, D. J. Milligan, R. W. Sobocinski, and P. James-Lipponer, 1993, "Brine Sampling and Evaluation Program, 1991 Report," ***DOE-WIPP 93-026***, U.S. Department of Energy, WIPP Project Office, Carlsbad, New Mexico.

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Abitz, R. J., R. W. Sobocinski, and J. Myers, 1991, "Assessing Inorganic Contaminant Release to Groundwater with the EQ3/6 Geochemical Code," ***IT Technology Exchange Symposium Proceedings***, Vol. II, Paper 11-2, Phoenix, Arizona.

Deal, D. E., R. J. Abitz, J. Myers, J. B. Case, D. S. Belski, M. L. Martin, and W. M. Roggenthen, 1991 "Brine Sampling and Evaluation Program, 1990 Report," ***DOE-WIPP 91-036***, U.S. Department of Energy, WIPP Project Office, Carlsbad, New Mexico.

Deal, D. E., R. J. Abitz, D. S. Belski, J. B. Clark, M. E. Crawley, and M. L. Martin, 1991 "Brine Sampling and Evaluation Program, 1989 Report," ***DOE-WIPP 91-009***, U.S. Department of Energy, WIPP Project Office, Carlsbad, New Mexico.

Abitz, R. J., J. Myers, P. E. Drez, and D. E. Deal, 1990, "Geochemistry of Salado Formation Brines Recovered from the Waste Isolation Pilot Plant (WIPP) Repository," ***Waste Management '90***, Vol. 2, pp. 881-891, Tucson, Arizona.

Abitz, R. J., J. Myers, P. E. Drez, and D. E. Deal, 1989, "Geochemistry of Salado Formation Brines Recovered from the Waste Isolation Pilot Plant (WIPP) Repository Horizon," ***Geological Society of America Abstracts w/Programs***, Vol. 21, p. A317.

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Elston, W. E., and R. J. Abitz, 1989, "Regional Setting and Temporal Evolution of the Mogollon-Datil Volcanic Field, Southwestern New Mexico," ***New Mexico Bureau of Mines and Mineral Resources***, Bulletin 131, p. 82.

Deal, D. E., R. J. Abitz, D. S. Belski, J. B. Case, M. E. Crawley, R. M. Deshler, P. E. Drez, C. A. Givens, R. B. King, B. A. Lauctes, J. Myers, S. Niou, J. M. Pietz, W. M. Roggenthen, J. R. Tyburski, and M. G. Wallace, 1989 "Brine Sampling and Evaluation Program, 1988 Report," ***DOE-WIPP 89-015***, U.S. Department of Energy, WIPP Project Office, Carlsbad, New Mexico.

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