COGEMA
Mining, Inc.

Responses to NRC Comments

License Renewal Application for Source Material License SUA-1341

September 3, 1997

January 24, 1997 - ACCEPTANCE REVIEW FOR THE RENEWAL OF LICENSE SUA-1341 - NRC REQUEST FOR ADDITIONAL INFORMATION:

Request 1. Omitted Information: A discussion of the economic and social effects of the changes to construction and operation activities that are proposed or contemplated in the renewal was not provided. The recommended format for such a discussion is outlined in Section 7.6 of Regulatory Guide 3.46 "Standard Format and Content of License Applications, Including Environmental Reports, for In-Situ Uranium Solution Mining" (F&CG).

Response: A new category entitled "7.6 Economic and Social Effects of Construction and Operation" has been added to Chapter 7.0 of the January 5, 1996 license renewal application (LRA). Section 7.6.1 specifically discusses the benefit-cost summary for the projects. Revised pages 7-35 and 7-36 include the new information, and are included for your review. If acceptable, these pages should replace the current page 7-35 in the LRA document. The revised LRA pages are in Attachment 1, and include revised Table of Contents pages to reflect the addition of Section 7.6.

Request 2. Omitted information: A references section was not provided. Requirements for references are outlined in Chapter 11 of the F&CG.

Response: A references section has been added to the LRA, as Section 11.0. References for each chapter are listed with the page number on which they appear. The new Section 11.0 is attached for insertion into the LRA document in Attachment 1.

January 24, 1997 - DETAILED TECHNICAL REVIEW FOR THE RENEWAL OF LICENSE SUA-1341 - NRC COMMENTS:

Request 1. **COMMENT:** Lack of technical basis for changes in monitoring well density for vertical excursion monitoring.

DISCUSSION: Sections 3.3.1.2 and 5.8.2.2 propose new criteria for the number and spacing of monitor wells in the overlying and underlying aquifers at the Irigaray and Christensen Ranch Sites. No technical basis is provided by which the Nuclear Regulatory Commission (NRC) can evaluate the proposed criteria.

The NRC is particularly concerned with the proposed criterion of "..one well per each 3.5 acres of installed pattern area" for monitor wells in the overlying and underlying aquifers. This concern results from documentation that vertical excursions at the Irigaray site have been persistent and difficult to retrieve, as noted in Section 3.3.1.2 of the renewal application, and the fact that past densities for monitoring wells in the overlying and underlying zones at Irigaray usually were one well per 1 or 2 acres of wellfield. NRC requires assurance that new wellfields will have adequate well coverage to provide early detection and timely restoration of vertical excursions.

The proposed criterion is subject to a variety of interpretations. For example, one well for each 3.5 acres could be an average value, allowing a high well density in one pattern area to compensate for low well density in another. Conversely, the criterion could mean that any circular area of 3.5 acres within the wellfield should contain at least one monitor well. Furthermore, this criterion does not consider the direction of groundwater flow and could allow monitor wells to be upgradient from a potential excursion.

ACTION NEEDED: COGEMA should consider the intent of Staff Technical Position Paper WM-8102 "Groundwater Monitoring at

In-Situ Uranium Solution Mines," Part III, Section D, in any decision to change the density or frequency of the monitoring wells, and should include a discussion presenting the technical basis for this decision in supplemental material for the renewal application. COGEMA should also provide a criterion that allows for flexibility in determining monitor well locations and spacing for each new mine unit.

Response: **DISCUSSION:** The NRC states that the proposed shallow and deep monitor well spacing for Irigaray and Christensen is new. The proposed density and frequency is different for any new wellfields at Irigaray, but it is the same density and frequency that NRC approved for Christensen nine years ago with the issuance of Amendment No. 10 to SUA-1341, dated August, 1988. The one set of shallow and deep monitor wells every 3.5 acres was, in fact, a higher density of installation than that evaluated in the Environmental Assessment prepared by NRC in consideration of the major amendment to incorporate Christensen Ranch operations into the license (May, 1988). In this document, only one set of shallow and deep monitor wells were thought by NRC to be necessary for each production (mine) unit. The document states on Page 51 and 52: "Operational data at the Christensen Ranch Research and Development Operation, as well as at the neighboring Irigaray facility, indicate that monitoring on a production unit basis with one set of centrally-located overlying and underlying monitor wells as well as lateral monitoring wells at the margins of the production units are adequate. Therefore, the licensee will be required to monitor a deep and shallow monitor well in addition to production unit monitor wells." Based on the size of mine units planned in 1988, this equates to one overlying and one underlying monitor well for every 20 acres of wellfield pattern area.

For Irigaray, the one overlying (shallow) and one underlying (deep) monitor well for every 3.5 acres of wellfield pattern is a different density than currently approved. The current license specifies two shallow and deep wells per mine unit. When NRC first issued

the operational license for Irigaray in 1978, the overlying (shallow) and underlying (deep) monitor wells for the first seven wellfields were installed using the criteria set forth in the license application. This criteria stated (page M4-10, Section 4.5.3 Shallow and Deep Monitor Wells, January, 1976 and revised in April, 1978): "Shallow and deep monitor wells may be drilled to monitor possible migration to sands above and below the Upper Irigaray Sandstone. If electric log data from drill holes indicates that no sand exists within 30 feet above or below the Upper Irigaray Sandstone then no shallow or deep monitor well will be cased." The NRC's Environmental Impact Statement for the Irigaray Project, NUREG-0481, September, 1978, went on to say in Section 8.2.3.3, Shallow and Deep Monitor Wells: "These wells will be installed to permit monitoring of the aquifer or dry formation immediately above or below the confining mudstone or shale that overlies or underlies the mineralized formation. These wells should be placed within the well field area, and a minimum of one shallow and one deep monitor well for each 2 ha (5 acres) of well field is recommended."

Accordingly, in 1978 through 1979 at Irigaray, one shallow and one deep monitor well were installed in each wellfield. Shortly thereafter the shallow zone excursions were detected, and many more shallow wells were installed to investigate the extent of the problem. Thus, the installation of the many shallow monitor wells was unrelated to the original monitoring plan, which proved successful in detecting the first excursions.

NRC's concern that shallow excursions at Irigaray are persistent and difficult to retrieve, and past monitoring densities are higher than proposed, would be valid if the shallow excursions were caused by poor geologic confinement inherent throughout the property. However, the cause of the Irigaray shallow zone excursions in 1979 and 1980 was confirmed to be improperly abandoned exploration drill holes and damaged injection well casings, both correctable problems. The shallow zone excursions that have persisted since that time are felt to be caused by

residual contamination from the original excursions, and not from on-going sources. Because the original excursions contributed injection solutions at multiple intervals above the ore zone, cleaning these zones has been difficult at best, especially since the original conduits for the sources were eliminated in 1979 and 1980 by cementing the exploration holes and damaged wells.

Excursions caused by un-sealed exploration holes and damaged injection well casings are not expected to occur at any of the operations in the future. This is because of the program for testing the mechanical integrity of our wells prior to injection, and COGEMA's practice of sealing all exploration holes within a prospective wellfield area, prior to wellfield installation, with cement from bottom to surface.

TECHNICAL JUSTIFICATION AND PROPOSED ACTION: Pursuant to NRC's suggestion, Staff Technical Position Paper WM-8102, Part III, Section D, was reviewed. The only density criteria provided in this reference for monitoring above and below the ore zone is, "Premining aquifer test(s) results and other data should be used to determine the extent of monitoring required in aquifers above and below the ore-zone aquifer. For example, if an aquifer test(s) shows no evidence that an adjacent aquifer is susceptible to excursion from the ore-zone aquifer, the need for extensive monitoring of that adjacent aquifer during mining is decreased..." Figure 3 of the same document shows upper and lower monitor wells spaced 200 feet apart, or at a frequency of one well for every 0.9 acres. However, no technical justification is provided in WM-8102 for upper and lower monitor well spacing or density.

COGEMA's justifications for the one well for every 3.5 acres of wellfield are not purely technical. We are not aware of any other licensee that has a firm technical basis on the spacing of their shallow and deep monitoring wells. Although NRC does not like the justification that our monitoring standard is the same as allowed at other mines, the facts are that both Power Resources and Rio Algom have licensed spacings of one shallow/deep well

for every 3 acres of wellfield, with Rio Algom having an additional requirement that no well can be further than 1000 feet apart in the same zone. Crow Butte Resources in Nebraska is required to have one shallow well for every 4 acres of wellfield (there are no deep monitors required due to lack of sands below the shale underlying the production zone). Pathfinder Mines Corporation's North Butte license requires one shallow well for every 4 acres of wellfield (deep monitors are not required), whereas the requirements for the Ruth Project are one shallow and deep monitor pair for every 4 acres of wellfield. Even the recently licensed HRI project in New Mexico is allowed by NRC to have one shallow monitor well for every 4 acres of wellfield, and deep monitor wells are not required.

Some reasons to support one shallow and deep monitor well pair every 3.5 acres are as follows:

1. The likelihood of an excursion occurring in either the overlying or underlying aquifers at Christensen and Irigaray is small. The overlying aquifer is protected from the production zone by 60 to 100 feet of confining layer (aquitard) which exhibits extremely low permeabilities ranging from 1.3 E-7 to 9.5 E-9 cm/sec, or three to five orders of magnitude lower permeability than the production zone. In most areas, the underlying aquifer is protected by 60 to 70 feet of aquitard exhibiting permeabilities on the same order of magnitude as the upper aquitard. Additionally, the strong vertical anisotropy (ranging from 6:1 to 30:1, horizontal permeability:vertical permeability) limits the potential for vertical excursions of lixiviant.

2. The current spacing of one well for every 3.5 acres of wellfield provides an overlying and underlying monitor well every 390 feet within the wellfield perimeter. This is very similar to the most stringent spacing of the ore zone monitor wells completed around the wellfields.

3. The cost for the installation of an average monitor well is approximately $6,000 depending upon depth (about $12.00 per foot, not including the pump). Some deep monitor wells can cost up to $9,600 at Christensen. With this type of cost, an arbitrary density and spacing at a higher frequency than currently approved does not make economic sense, as there is no technical basis for the higher frequency.

4. A high frequency of deep monitor wells that are installed through the production zone may create conduits for excursions to the lower aquifer. As it will be almost impossible to have an excursion of lixiviant downward into a lower aquifer during operations, where a natural connection does not exist, the possibility of a created excursion will be greatly enhanced just by the penetration of cased wells through the production zone into the lower aquifer. The number of deep monitor wells should be limited just for this reason.

Based on the above discussion and supporting reasons, COGEMA proposes the following action for the LRA:

1. The recommended spacing for shallow and deep monitor wells will remain one pair for every 3.5 acres of wellfield.

2. To provide flexibility, it is recommended that deep monitor wells not be installed if there is no appropriate aquifer to monitor below 50 feet of the top of the confining shale underlying the production zone. An appropriate aquifer would, at a minimum, be a continuous sandstone with at least 10 feet of thickness and a permeability that will allow the production of enough water for sampling purposes.

3. Shallow monitor wells will be installed in the first continuous aquifer overlying the production zone aquitard that would, as a minimum, have 10 feet of thickness and

a permeability that will allow the production of enough water for sampling purposes.

4. Page 3-10 of the LRA has been revised to incorporate the above language. A copy of revised 3-10 is attached.

Request 2. **COMMENT:** Lack of technical basis for changes in ore zone baseline and restoration monitoring well density.

DISCUSSION: Section 5.8.2.2 proposes a change in ore zone baseline and restoration sampling from one well per acre to one well per four acres. No technical basis is provided by which NRC Staff can evaluate the adequacy of such a standard.

Considering that this renewal application is for a performance-based license, NRC Staff requires assurance that baseline sampling standards at future mine units will be adequate to meet the performance objectives outlined in Staff Technical Position Paper WM-8102 "Groundwater Monitoring at In-Situ Uranium Solution Mines," Part IV(A). Specifically, sufficient baseline information should be collected to support evaluation of anomalous conditions that may occur during or after mining. Assertions that the proposed sampling methods are consistent with Wyoming Department of Environmental Quality requirements, or that such standards are used at other mine sites, are not sufficient justification.

ACTION NEEDED: COGEMA should submit a technical justification that the proposed sampling program will provide an adequate statistical population for baseline and restoration sampling at mine unit locations within the Irigaray and Christensen Ranch license boundaries.

Response: **DISCUSSION:** COGEMA's request for changing the ore zone baseline and restoration sampling from one well per acre to one well per four acres is based on the large amount of water quality data collected to date at both projects. We feel that we have

adequate data from specific mining areas to show that the water quality at both properties is well defined, and reducing the amount of water quality data obtained from each mining area is justified.

To demonstrate that baseline data from one well per four acres is statistically representative of baseline data from one well per one acre, COGEMA analyzed the baseline water quality data from the ore zone within the most recent wellfield, Christensen Mine Unit 6. Mine Unit 6 is 41 acres in size, and has 42 ore zone baseline wells. Each well was sampled four times (with the exception of 6AS47-1, where only three samples were obtained) and analyzed for the DEQ Guideline 8 (chemical constituents include all cations, anions, trace metals and radiometrics), providing a total of 167 data points for each chemical constituent. Using the Student's *t* distribution, COGEMA tested the hypothesis that the population mean for total dissolved solids (TDS) from the 42 baseline water quality wells (mean of 167 data points) is equal to a sample mean for TDS from 11 baseline water quality wells (one well per four acres, and 44 data points).

First, the Unit 6 wellfield was divided into 11 areas, each with three to four baseline water quality wells, in order to account for spatial variability. Nine of the areas contained four baseline wells, and the remaining two areas had three baseline wells each. For the purposes of this demonstration, one well from each area was randomly chosen (using random numbers one through four) and the mean TDS data from the 11 random wells were compared to the population mean for TDS. This test was repeated five times and each time the sample mean was found to be equal to, or alternatively not significantly different than, the population mean. In other words, the 44 TDS data points from 11 baseline wells were found to be statistically representative of the 167 TDS data points from the 42 baseline wells. Therefore, it is concluded that one baseline well for four acres provides the same representative water quality data as does one baseline well per one acre. The supporting statistical data are provided in Attachment 2.

PROPOSED ACTION: Based on the above statistical analysis, COGEMA requests that the spacing for ore zone baseline water quality wells remains at the recommended one well per four acres of pattern area. This is also consistent with the NRC requirements for other licensees.

May 5, 1997 - NRC REQUEST FOR ADDITIONAL INFORMATION IDENTIFIED DURING DETAILED REVIEW OF COGEMA MINING, INC. LICENSE RENEWAL APPLICATION FOR SOURCE MATERIAL LICENSE SUA-1341:

Request 1. COMMENT: Estimates of the Number of Pore Volume Displacements Required to Meet Restoration Targets are not Supported by COGEMA's Actual Restoration Experience at Irigaray and Christensen Ranch

DISCUSSION: The proposed restoration program indicates that COGEMA is confident that restoration can be achieved at all mine units by pumping a total of 7 pore volume displacements (PVDs) during the combined groundwater sweep, permeate injection, and recirculation phases of restoration. NRC staff is concerned that the number may be unrealistically optimistic.

Restoration activities conducted at Irigaray Mine Units 1-3 and the Willow Creek Research and Development (R&D) site required 16 PVDs and 13 PVDs, respectively, and were only marginally successful (i.e., primary restoration targets were not met for all constituents). Based on the results at the Willow Creek R & D site, which is more representative of current operations, 13 PVDs represents a more reasonable approximation of the effort required to achieve restoration goals.

In the LRA, COGEMA proposes a different apportionment of PVDs than was used in the Willow Creek R&D project: future restoration plans are to pump fewer pore volumes for groundwater sweep and more for reverse osmosis (RO)/permeate injection. However, the basic techniques will be the same as those used at the Willow Creek R&D Site. The anticipated improvement in performance from 13 PVDs to 7 PVDs is not supported by either field observation or technical investigation information presented in the LRA.

NRC staff acknowledges that the Aquifer Restoration and Wellfield Decommissioning Plan approved by NRC on March 29, 1996, for Irigaray Mine Units 4 through 9, contains the seven PVD estimate as well as the same apportionment of PVDs as is proposed in the LRA. However, the restoration plan provided in the LRA should reflect current knowledge of site characteristics and actual restoration operating history.

ACTION NEEDED: COGEMA should provide an analysis of PVD groundwater restoration requirements that is consistent with historical site operating data.

Response: **DISCUSSION:** To date, historical restoration activities for License SUA-1341 have included the Irigaray 517 test site, the Irigaray E-Wellfield, the Christensen Willow Creek R&D, and the Irigaray Units 1-3. All of these areas were operated as Research and Development tests, with Irigaray Units 1-3 being expanded into commercial operations in 1978. At Christensen, the Willow Creek R&D site was encompassed by Mine Unit 5. All restorations were conducted by previous operators, during a time spanning 1980 through 1993. Summaries of each restoration project are provided in Attachment 3.

More recently, within the past two years, COGEMA has completed the restoration of four commercial wellfields in Texas. None of these wellfields were Research and Development tests; all were operated to completeness as commercial wellfields. The restoration summaries of these wellfields are provided in Attachment 3, as well as a summary table of both Wyoming and Texas restorations in terms of PVDs and results achieved.

NRC points out that for this license renewal, COGEMA should tailor our restoration program for the future to what was done historically in Wyoming. If you look closely at the Willow Creek R&D summary in Attachment 3, you will see that the two five-spot patterns were restored with 8.4 PVDs of groundwater sweep, 3.3 PVDs of reverse osmosis treatment and permeate

reinjection, 1.0 PVD of circulation with a reductant, and 0.4 PVD of recirculation. This was a very small wellfield (two patterns), with a very small pore volume. Because of the size, it was possible to remove 8.4 PVDs of groundwater without affecting water levels within the wellfield, and thus, the ability to recovery groundwater. And, in 1986 when the restoration was completed, disposing of the small amount of groundwater was not a problem as it was treated for uranium and radium removal and surface discharged. Today, our surface discharge permits have selenium standards that were not present in 1986 which seriously affect our ability to surface discharge large amounts of groundwater during restoration. With other limitations on wastewater disposal, including very limited capacity deep wells, limited spacing for evaporation ponds, and restrictions on surface irrigation, COGEMA has changed the restoration plan to limit the large amounts of consumptive removal of groundwater during restoration (groundwater sweep) and to concentrate on in-place treatment of the affected groundwater (reverse osmosis phase).

We believe that the 8.4 PVDs of groundwater sweep at the Willow Creek R&D was excessive, but was very simple and economical to do at the time. This is no longer the case; the 8.4 PVDs of groundwater sweep will not be achievable in the commercial restoration scenario due to the consumptive removal of massive amounts of groundwater, without equal disposal capacity. A more effective restoration at the Willow Creek R&D would have been to limit the number of PVDs of groundwater sweep to what is absolutely necessary to retrieve wellfield solutions to within the boundary of the wellfield, and then to increase the number of in-place treatment PVDs. COGEMA has very successfully incorporated this technique into our restoration projects in Texas over the past two years, and this success is more applicable to a future restoration plan than the Willow Creek R&D results.

COGEMA's approach in Texas was to cease the ongoing groundwater sweep efforts in the four wellfields in question and

to switch to the in-place treatment with both freshwater injection (well water from another geologic horizon), and permeate from the reverse osmosis treatment. The amount of groundwater sweep completed in each wellfield averaged about 4.5 PVDs, but this water had been slowly extracted over a period of many years. After COGEMA stepped up the restoration pace with in-place treatment in 1995 and 1996, the wellfields were successfully restored with an additional 3.8 PVDs (average) of cleanwater sweep (freshwater injection combined with reverse osmosis treatment). We believe that the approach of limiting the groundwater sweep and increasing the in-place treatment of the groundwater will also be successful for the Wyoming wellfields. Our plan for Wyoming incorporates more PVDs of in-place cleanwater treatment than has been necessary in Texas, but some of our groundwater in Wyoming is cleaner at baseline than what is normally found in Texas.

PROPOSED ACTION: Based on our recent restoration experiences in Texas, COGEMA wishes to leave our proposed restoration program in Wyoming at the one PVD of groundwater sweep and five PVDs of in-place treatment, with one final PVD of recirculation. We believe that restoration is performance based, and that if we have not met our goals with the approved program, that we will continue restoration until we do, or have justification for otherwise.

NRC must realize, however, that a return of all chemical constituents to background is not an economically reasonable or technically practicable goal for all wellfield restorations. NRC's comment that the Irigaray Units 1-3 and Willow Creek R&D restorations "were only marginally successful (i.e., primary restoration targets were not met for all constituents)" , is somewhat disturbing. The restoration summary in Attachment 3 shows that an average of approximately 70% of all chemical constituents will be returned to baseline during restoration, with 27% returned to baseline use classifications (drinking water), and 3% that do not meet either baseline or use classification (in

Wyoming this is typically radium-226 due to Wyoming's treatability standard for radium-226). We have continually demonstrated these percentages at the majority of our restoration operations, in both Wyoming and Texas.

In Wyoming, a change to the Land Quality Division, DEQ, Rules and Regulations for in situ mining has recently been proposed to the Environmental Quality Council. Specifically, the requirement for restoring to baseline has been expanded to account for situations where this is not economically reasonable nor technically practicable. The new language in Land Quality Division Rules and Regulations, Chapter 11, Section 3(a)(iv) states (new language is underlined):

"(A) The information necessary to demonstrate that the operation will return all affected groundwater, including affected groundwater within the production zone, receiving strata, and any other areas, to a condition such that its quality of use is equal to or better than, and consistent with, the uses for which the water was suitable prior to the operation by employing the best practicable technology. Such a demonstration shall be made by showing that through the employment of the best practicable technology, as defined in W.S. §35-11-103(f)(I):

<u>(I) All affected groundwater will be returned to as close to pre-mining conditions and quality as practicable. At a minimum, the groundwater will be returned to a quality of use equal to and consistent with uses for which the water was suitable prior to the commencement of operations.</u>

<u>(II) In making a determination of whether a demonstration has been made by the operator to reach the best achievable condition and quality, the Administrator shall, at a minimum, take the following factors into consideration:</u>

(a) The character and degree of injury to or interference with the health and well being of the people, animals, wildlife, aquatic life and plant life affected;

(b) The social and economic value of the source of pollution;

(c) The priority of location in the area involved;

(d) The technical practicability and economic reasonableness of reducing or eliminating the source of pollution;

(e) The effect upon the environment;

(f) The potential impacts to other waters of the state; and

(g) Restoration on a parameter by parameter basis."

Previous language in the rules and regulations simply required that "(I) The condition and quality of all affected groundwater will be returned to background or better, or: (II) The requirements of Section 3.(a)(v)(A)(I) cannot be achieved. In this event the condition and quality of all affected groundwater will at a minimum be returned to a quality of use equal to and consistent with uses for which the water was suitable prior to the commencement of the operation." The DEQ recognized that restoration to baseline is not always achievable, and that additional restoration criteria were necessary in the regulations. What DEQ has incorporated into their regulations is essentially NRC's ALARA concept. We hope that NRC also recognizes that geochemical changes do occur during mining that are not always totally reversible, and uses their own ALARA philosophy during their evaluation of restoration success.

In summary, COGEMA wishes to leave our restoration program as written in the LRA. Restoration has begun at Christensen within Mine Units 2 and 3. These restoration areas are being operated just as they were mined. We feel that wellfield management is extremely important during mining, and restoration, and that these mine units will be the best demonstration of COGEMA's ability to restore within the realm of our proposed program.

Request 2. **COMMENT:** The Tolerance-Limit Formula That was Used to Determine the Range of Target Restoration Values Appears to be Improperly Applied

DISCUSSION: On pages 6-1 and 6-4 of the LRA, it is stated that a concentration range of acceptable baseline restoration targets for the Irigaray and Christensen Ranch sites will be calculated "..using the same tolerance-limit method previously provided in section 5.8 under upper control limit calculations."

The tolerance-limit formula is a statistical method that is tailored specifically for one type of comparison - the comparison of a single sample (e.g., a monitor well water sample) to a previously determined average (e.g., baseline mean) in order to determine whether the single sample is a likely member of the same "population" used to determine the average. As such it is good for identifying baseline outliers or lixiviant excursions that are not considered to be part of the baseline population. Thus, for upper control limits (UCLs), the tolerance-limit formula is correctly applied to the case where individual monitor well samples are compared to a baseline average.

As described in the LRA, the tolerance-limit formula has been/will also be used to establish a range for primary restoration goals. If COGEMA examines each well in a mine unit to determine restoration on a well by well basis, then the criteria are met for the use of the formula - comparing single well samples to the

previously determined baseline average. However, it appears in the LRA, that COGEMA intends to compare a well field average (i.e., a composite of several samples) to the baseline average for purposes of establishing target restoration. If this is the case, then the tolerance-limit formula is not properly applied for restoration targets.

In the renewal application the standard deviation for one set of baseline samples is used to determine the acceptable range for restoration targets. However, the correct use of the tolerance-limit method for this purpose requires using the standard deviation of a set of many wellfield averages. Normally, obtaining such a set of averages would require several wellfield sample populations from which several averages and their associated standard deviations are calculated. In the absence of several sample populations, the standard deviation from the previously determined average (e.g. baseline mean) can be divided by the square root of the number of samples in the new average (e.g., post-restoration average). This gives a corrected standard deviation which can then be used in the tolerance limit formula to determine a confidence interval around the baseline mean.

It is not apparent from the LRA that COGEMA applied this correction to the standard deviation used to establish the range of target restoration values. As a result, the range of target restoration values would be significantly wider than if it was calculated as described above.

ACTION NEEDED: COGEMA should clarify whether the intention is to base target restoration values on a wellfield average or on individual well data. If a wellfield average will be used, COGEMA should provide sample calculations to show how the standard deviation for wellfield averages is determined and how the tolerance-limit formula is used to determine restoration targets. These calculations should be accompanied by any statistical data used. Alternatively, COGEMA may propose a different means for establishing a range for target restoration values. REFERENCE:

COGEMA Mining, Inc., 1995, "Aquifer Restoration and Wellfield Decommissioning Plan: Irigaray Mine Units 4 through 9," dated March 1995.

Response: The tolerance-limit formula is simply used to provide a range for the baseline data. The baseline data presented for each wellfield consists of four samples (taken at a minimum of two weeks apart) from each well analyzed for 35 different parameters. A mean and standard deviation is calculated for each parameter using the four sampling periods from each well, providing say, 168 data points for each individual chemical constituent if you have 42 baseline water quality wells. The standard deviation is then used in the tolerance-limit formula to provide the confidence intervals for each parameter.

At the end of restoration, several samples will be obtained. Table 6.2, page 6-14 of the LRA, shows that four samples from each baseline well will be obtained during the post-restoration period. These will be analyzed for the same 35 parameters, thus providing 168 data points for each chemical constituent, for example, if you have 42 baseline wells. It is planned to compare the average of these 168 data points, on a parameter by parameter basis, to the mean of the baseline data, on a parameter by parameter basis, to verify that the restored mean value for any given parameter falls within the original baseline mean range for that parameter as set with the tolerance-limits.

We believe that this method will be statistically valid, thus no changes in the LRA have been made at this time.

Request 3. **COMMENT:** Geologic and Hydrologic Site Characterization Data Were Not Updated in the License Renewal Application (LRA)

DISCUSSION: The site geology and hydrology described in sections 2.6.2 and 2.7.1 of the LRA, respectively are based on

data collected prior to 1987. Reference is made in Section 2.7 to more recent wellfield data packages; however, no discussion is provided that relates this new data to the site characterization data developed for the original license application. Given that hundreds of new wells have been logged during mining operations, updated characterizations of the site geology and hydrology should be included in the LRA. This information will be used by NRC to assess the accuracy of the geologic and hydrologic conceptual models that have been used to represent site conditions during past and future operations.

Updated information should include descriptions of stratigraphy obtained from well logs with a focus on the continuity of the confining layers that bound the ore zone. For example, earlier review of wellfield data from Mine Unit 5 at Christensen Ranch (NRC, 1995) revealed that the upper confining layer pinches out in certain areas. COGEMA has agreed not to produce from these areas until additional monitor wells have been installed. Although Mine Unit 5 at Christensen deviates from the conceptual model developed in the original license application, no modifications to this model have been provided in the LRA.

As another example, section 2.7 of the LRA provides no discussion of any changes in local groundwater wells, water usage, or water quality.

ACTION NEEDED: COGEMA should provide updated characterizations of the site geology and hydrology and a description of any changes that have resulted to the site conceptual models in sections 2.6.2 and 2.7.1 of the LRA. If appropriate, the stratigraphic cross-section in figure 2.7 should be updated. Section 2.7 should also be updated to include a discussion of current and projected local groundwater usage and water quality, to focus on changes that have occurred or are likely to occur during the period that will be covered by the renewed license. REFERENCE: NRC, 1995, Letter from J. Holonich (NRC) to COGEMA Mining, Inc., "Review of Request to

Operate Christensen Ranch Mine Unit 5: License Amendment No. 38 to Source Material License SUA-1341," dated March 1995.

Response: Regulatory Guide 3.46, "Standard Format and Content of License Applications, Including Environmental Reports, For In Situ Uranium Solution Mining", page vii, Section entitled "Presentation of Information", states that information previously submitted to the Commission may be incorporated into the application by reference. COGEMA elected to use this reference allowance for all of the hydrologic and geologic data collected since the last renewal, or original application (in the case of Christensen), due to the volume and technical detail of the material. In addition to all of the Mine Unit baseline packages, special hydrologic testing, etc., there is the original geologic and hydrologic studies performed in 1987 that were extensive. In Appendix D5 of the Christensen Ranch amendment application, there are 31 geologic cross-sections, four lower aquitard isopach maps, four structure contour maps of the lower aquitard, four isopach maps of the K Sandstone, eight structure contour maps of the K Sandstone, four upper aquitard isopach maps and four structure contour maps of the upper aquitards. These maps cover the entire Christensen Ranch license area. The geology and hydrology of the area has not changed since the submittal in 1988, and data collected in the years following has not yielded any surprises or conditions that are different than those originally documented.

In their comment, NRC states that wellfield data from Mine Unit 5 at Christensen Ranch (NRC, 1995) revealed that the upper confining layer pinches out in certain areas. We believe that NRC has misunderstood the concern in Unit 5. The upper confining layer did not pinch out. In the western portion of Unit 5, the K Sandstone is essentially one thick sand unit; in the northeastern portion of Mine Unit 5, the breaks between the individual members of the K Sandstone are more defined (shale thickens and develops) and shales separate the K4 (lowest sand member), the K3 and the K2. The K2 and K3 sands are mineralized in the area; the K4, where present, is not. Figure 2.7 of the LRA shows theat

the K sand is very thick in the Jack area (western portion of Mine Unit 5) and is divided in the North Prong area of Christensen (eastern portion of Mine Unit 5, and also Mine Units 6 and 7).

As a result of having a limited-mineralized "sand" member (K4) below the lowest sand member to be mined (K3), DEQ asked that COGEMA place a deep trend well in the K4 past a point where the separating shales develop to assure that mining solutions from the K3 did not migrate into the K4 and go undetected (caused by the lack of a shale break between the K3 and K4 in the western portion of the wellfield). NRC later requested a second deep trend well (Amendment No. 38), and additional hydrologic data if COGEMA planned to mine the K4. All of the K sand members are part of the production zone. Confining layers above the K sand and below the K sand have substantial integrity, and this was never the concern.

There is one minor change in geologic nomenclature that NRC should be aware of. In 1990, Total Minerals Corporation became the operator of Christensen. In the North Prong area, they changed the nomenclature of the subdivisions of the K sand from the K1, K2 and K3 to the K2, K3 and K4, and assigned a very localized sandstone lense the name of K1. This is only in the North Prong area. Accordingly, COGEMA has made this minor revision to Figure 2.7 of the LRA, and has incorporated language to page 2-32 of the document to clarify this.

For the hydrology portion of the LRA, COGEMA has added language to page 2-35 that provides more support for the fact that groundwater conditions have not changed, and recent data simply confirm the characteristics identified in the original applications. This includes language on updated groundwater usage.

All revised LRA pages may be found in Attachment 1.

Request 4. **COMMENT:** Inspections of Evaporation Ponds are Not Addressed

DISCUSSION: Section 5, Operations, does not discuss the inspection program for evaporation ponds as required by current license condition 35 or Regulatory Guide 3.11, Rev. 2 (NRC, 1977). As this is a specific condition for this license, it should be addressed in the LRA.

ACTION NEEDED: COGEMA should incorporate a discussion of the inspections of evaporation ponds in Section 5, consistent with License Condition 35 and Regulatory Guide 3.11, Rev. 2. REFERENCE: NRC, 1977, Regulatory Guide 3.11, Revision 2: "Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills," dated December, 1997.

Response: The evaporation pond monitoring program is discussed in Section 5.8.3 of the LRA, page 5-106. NRC perhaps overlooked this particular section. To make it clear that COGEMA intends to continue this program, a paragraph as been added to this section that states the program will continue for future operations. Revised page 5-106 is included in Attachment 1.

Request 5. **COMMENT:** Plans Presented in the LRA for Review and Evaluation of New Wellfields do not Require Confirmation of Hydrologic Parameters

DISCUSSION: Section 5 of the LRA does not require that wellfield tests to ensure horizontal connection of monitor wells within the ore zone, and vertical isolation of monitor wells above and below the ore zone will be considered by the Safety and Environmental Review Panel (SERP) when evaluating the opening of new wellfields.

Subsequent to COGEMA's submittal of the LRA, a performance-based license condition for establishing wellfields was approved by an NRC letter dated December 24, 1996. This approval specifies wellfield evaluation procedures to be used by the SERP. These procedures are incorporated into COGEMA Standard Operating Procedure (SOP) PBL-2 and include requirements for the SERP to consider the results of tests to ensure horizontal connection and vertical isolation. The LRA contains provisions for all of the previously approved components of wellfield evaluation except for the confirmation of hydrologic parameters.

ACTION NEEDED: For consistency, the requirements for the confirmation of hydrologic parameters should be incorporated into section 5 of the LRA.

Response: The procedures for approving a new mine unit are included in the LRA in Section 5.10.1. This section does state that a SERP review will be performed for new mine units. COGEMA has expanded on the SERP review in Section 5.10.1 by adding an additional paragraph describing how the SERP review of new mine units will be performed. This includes an elaboration of the confirmation of hydrologic properties. It also requires that the SERP follow SOP No. PBL-2, "Performance-Based License Condition: Review and Evaluation of New Wellfields," for their detailed evaluation of a new mine unit. Revised LRA Pages 5-110 and 5-111 are included in Attachment 1.

Request 6. **COMMENT:** Units not provided in Monitor Well Control Limit Tables.

DISCUSSION: Units are not provided for monitor well upper control limits in Tables 5.26 and 5.27 of the LRA. NRC staff will assume that units for conductivity are micromhos per centimeter;

units for alkalinity are milligrams per liter (mg/L) as total carbonate (HCO^{3-} + CO_3^{2-}); and units for chloride are mg/L.

ACTION NEEDED: COGEMA should provide confirmation of units used in the renewal application.

Response: The following units were intended for Tables 5.26 and 5.27:

1.) Units for conductivity are micromhos per centimeter (μmho/cm).

2.) Units for alkalinity are milligrams per liter (mg/l) as total carbonate (HCO^{3-} + CO_3^{2-}).

3.) Units for chloride are mg/l.

Revised copies of Tables 5.26 and 5.27 are enclosed with the appropriate units included.

Request 7. **COMMENT:** Rationale for Changes to Gamma Survey Monitor Locations is not Provided.

DISCUSSION: Page 5-15. Proposed Gamma Survey Program, paragraph 1 of the LRA indicates that monitoring location changes will "provide more accurate monitoring of plant radiological conditions than those currently specified." However, no technical justification for these changes has been provided. Changing the location of monitor locations may invalidate comparisons of monitoring results with past measurements for the purpose of trend analysis. Also figure 5.2 and 5.3 should show both the old and the new monitor locations so that the effect of the changes can be determined. Furthermore, no criteria are provided for selecting the monitor locations [see Regulatory Guide 3.46,

section 5.72 (NRC, 1982)]. This comment also applies to monitoring location changes proposed for the in-plant airborne uranium and radon daughter monitoring programs.

ACTION NEEDED: COGEMA should provide the technical bases for proposed changes to gamma radiation survey locations and the in-plant airborne uranium and radon daughter monitoring programs.

Response: Gamma Monitoring Program

COGEMA desires to revise the proposed gamma survey program described in the LRA for Irigaray and Christensen Ranch to remove specified survey locations from the program. License-specified gamma survey locations are not typical for other uranium in-situ mining licensees and are not required in the applicable guidance. USNRC Regulatory Guide 3.46, *"Standard Format and Content of License Applications, Including Environmental Reports, For In Situ Uranium Solution Mining"* (June 1982), Section 5.7.2, requires that the "...criteria for determining survey locations" be provided. USNRC Regulatory Guide 8.30, *"Health Physics Surveys in Uranium Mills"* (June 1983), Section 1.4, provides recommendations for performance of surveys for external radiation. These recommendations include surveying locations which allow:

1. determination of radiation area boundaries; and

2. determination of the need for monitoring external exposure in accordance with 10 CFR 20.1502(a).

COGEMA has implemented this recommendation in the appropriate Standard Operating Procedure (HP-2, *"Gamma Exposure Rate Survey"*).

COGEMA does not believe that gamma survey locations should be specified in the source materials license. Rather, survey locations

should be determined by the radiation protection staff based upon historical survey data obtained since 1987 at Irigaray and 1989 at Christensen Ranch and knowledge of process operations. License-specified locations do not take changing operational and radiological conditions into account. In fact, strict adherence to surveying specified locations could result in the failure to detect changing conditions. Following are some examples where specified locations do not address actual operating conditions.

1. Surveying a specific Christensen Ranch ion exchange column (as is currently required in the locations shown in Figure 5.2). If the column is surveyed immediately following transferring the resin to the Irigaray plant for elution, the results would indicate low gamma exposure rates. At the same time, the resin in another ion exchange column could be loaded, resulting in an elevated gamma exposure rate.

2. A similar operational scenario would apply to individual sock filters in relation to the last filter changeout. Specific locations are identified in Figure 5.2 for Christensen Ranch which do not take into account the operational status of the individual filters.

3. Elution columns at Irigaray are normally empty. However, elevated gamma exposure rates are noted when the columns are in use for elution of Christensen Ranch ion exchange resin. The specified locations shown in Figure 5.3 of the LRA do not address the fact that any particular elution column could be in use at a point in time.

While trend analysis is important in any radiation protection program, it is not useful if the data is obtained from locations which do not accurately represent plant radiological exposure conditions.

COGEMA proposes to perform gamma surveys in areas which are accessible to personnel and which could potentially exceed the

criteria for designation and posting as a radiation area in accordance with 10 CFR 20.1902(a). COGEMA also uses the results of gamma surveys to determine areas which exceed the administrative action level of 2.0 mRem per hour, requiring increased survey frequency. Gamma survey results from worker occupied areas are also used to determine the need for monitoring external exposure.

Revised copies of LRA pages 5-15 and 5-19 reflecting this change are attached. Additionally, Figures 5-2 and 5-3, pages 5-17 and 5-18, have been revised to delete all gamma monitoring locations.

In-Plant Airborne Uranium Monitoring Program:

The total number of air particulate sample points at each mine site remains the same. The only change in the proposed program was to move an air particulate location at the Irigaray main plant from the vanadium separation circuit area to the center of the building. Since the vanadium circuit has not been installed, it was COGEMA's opinion that the new location would provide a more representative sample of the main plant air particulate concentrations.

In-Plant Radon Daughter Monitoring Program:

Irigaray: Four radon daughter concentration sample locations were eliminated at the Irigaray main plant in the proposed program because there are very few radon sources at the facility since it is now in restoration. A sample location in the office area was added since it is frequently occupied by employees and visitors. With the exception of the restoration building, two wellfield buildings were eliminated since there is no longer filtration or venting of the groundwater in these buildings which could release radon.

Christensen Ranch: Two radon daughter concentration sample locations were eliminated at the Christensen Ranch plant

in the proposed program because the building is not large and experience has shown that the only area with elevated radon daughter concentrations is in the soda ash mix area. Injection solution is mixed with soda ash in covered tanks which are not air-tight. If the ventilation system to these tanks is not functioning as designed, the tanks can become a source of radon. Therefore, the sample location adjacent to these tanks is retained in the proposed program. An additional sample location in the control room was added since it is frequently occupied by employees and visitors.

Request 8. **COMMENT:** Justification for Relocation of Airborne Effluent Sampling Location IR-1 and Removal of Location IR-4 is Not Provided.

DISCUSSION: Page 5-63. Proposed Airborne Effluent and Environmental Monitoring Program second bullet of the LRA relocates sample point IR-1 from 10 feet to 50 feet from the plant building. It is stated that the new location is in accordance with the guidance in Regulatory Guide 4.14. However, no further information of justification for the change is provided. Furthermore, the third bullet indicates sampling will be discontinued at location IR-4 without providing rationale for this change.

Changes to these monitoring locations may result in difficulty assessing trends in airborne effluent. Changes to monitoring programs are appropriate when improved long term monitoring performance clearly outweighs the short term disadvantage of degraded ability to analyze trends.

ACTION NEEDED: COGEMA should provide the rationale for moving monitoring location IR-1 (e.g., there is a particular aspect

of Regulatory Guide 4.14 that necessitates the change), and an explanation for discontinuing monitoring at location IR-4.

Response: Station IR-1: As noted in the LRA, Station IR-1 is located approximately 10 feet downwind of the plant building at Irigaray. USNRC Regulatory Guide 8.25, *"Air Sampling In The Workplace"*, discusses determining the proper location of air samplers. Section 2.2 discusses consideration of air flow patterns when selecting the location of fixed samplers. COGEMA believes that the close proximity of Station IR-1 to the plant building influences the representativeness of results for this station due to the impact of the building on air flow patterns. While COGEMA recognizes the importance of trend analysis, in this case the sampler is not in an appropriate location for monitoring releases from the building. COGEMA believes that the proposed location will provide more representative data over the long term.

An additional factor in relocation of IR-1 is the impact on COGEMA's soil and vegetation monitoring programs. COGEMA samples soil and vegetation at air monitoring locations to determine potential deposition of radioactive material. The area where IR-1 is currently located is gravel covered fill adjacent to the building. The proposed location is more representative of native soil and vegetation and will improve the data collected in these monitoring programs.

Station IR-4: This station is located at the 517 R&D site, and was sited there to monitor emissions from the R&D operations. In October, 1987, a license amendment was received which approved the restoration and decommissioning plan for the 517 site. The radiological monitoring program which was approved for this area did not include air particulate monitoring. The only required monitoring in the plan was gamma surveys and radon monitoring.

Restoration has been completed and all process equipment removed from the site. For this reason, no air particulate

monitoring is necessary at the site. The evaporation ponds remain, so gamma and radon monitoring have continued.

Request 9. **COMMENT:** Data from Locations of Highest Exposure are not Presented in Personnel Gamma Exposure Survey

DISCUSSION: Page 5-15. Historical Program Results subsection for gamma surveys, table 5.1 of the LRA presents average annual exposure rates for each year of operation. These values appear to have been averaged over a number of sampling locations to obtain general facility values. From a worker protection standpoint, it is more meaningful to present the information from each monitoring station, or at least from those stations where gamma exposures were found to be highest.

ACTION NEEDED: COGEMA should provide the average annual gamma exposure rate data for the monitoring stations with the highest annual average gamma exposure to support assessments of exposure significance.

Response: The values contained in Table 5.1, External Gamma Radiation Survey Results, are annual averages of the results of monthly gamma surveys performed at Irigaray from 1987 to 1994 and at Christensen Ranch from 1989 to 1994. The plant survey points which are included in these averages are indicative of the general external gamma radiation fields to which COGEMA process workers are exposed. COGEMA calculated these averages based upon the recommendations contained in Regulatory Guide 8.30, section 1.4, which recommends semiannual surveys "...throughout the mill at locations representative of where workers are exposed in order to":

1.) Determine radiation area boundaries; and

2.) Determine the need for monitoring external exposure in accordance with 10 CFR 20.1502(a).

COGEMA performed the analysis of the average annual general plant gamma exposure rates in order to determine whether there were any trends in general area exposure rates. As noted in the LRA, area gamma exposure rates have been relatively constant with the exception of elevated averages during the start-up of Christensen Ranch. COGEMA believes that determination of the average general gamma exposure rates is a useful tool for the purposes recommended in Regulatory Guide 8.30.

In addition to trend analysis, COGEMA attempted to correlate the average gamma exposure rates with the average annual exposures reported in the personnel dosimetry program (LRA, Table 5.2, External Radiation Exposure Monitoring Results). As noted, no correlation is apparent.

COGEMA utilizes an internal action level of 2 mRem per hour or higher to determine whether increased gamma survey frequencies are required for an area. A limit of 5.0 mRem per hour is used to designate radiation areas. Designated radiation areas are currently surveyed on a weekly basis and access to these areas is controlled. Radiation areas at Irigaray and Christensen Ranch are generally near process equipment such as filters, ion exchange columns, and the reverse osmosis units. This would be expected due to the collection of radon daughters and radium 226 in this equipment. Engineering actions (e.g., filter or column backwashing) are taken when gamma levels increase beyond normally expected values.

COGEMA does not believe that determination of the average gamma exposure rates for the monitoring stations with the highest levels will provide meaningful information. There are several reasons for this.

1.) The recorded weekly gamma exposure levels in the radiation areas is highly dependent upon the timing of the survey and the operational status of the equipment which is the source of exposure. If maintenance activities such as filter backwash or membrane cleaning have recently been performed, the gamma exposure rates will be relatively low. Conversely, exposure rates will be higher immediately prior to such maintenance activities.

2.) The areas in question are radiation areas to which access is controlled. Although exposure rates in these areas are higher than the general plant exposure rates, the percentage of time spent in these areas by operating personnel is limited compared to their time spent in the general plant areas.

3.) The results of the external exposure monitoring program (see LRA, Section 5.7.2.2) indicate very low and consistent personnel exposures. In fact, reported exposures from 1987 through 1994 listed in Table 5.2 of the LRA show that the average and maximum annual exposures to COGEMA personnel are below the level where individual monitoring for external exposure is required in 10 CFR 20.1502(a).

Request 10. COMMENT: Isokinetic Sampling Program for Dryer Stack Differs From the Methods Recommended in Regulatory Guide 4.14

DISCUSSION: Page 5-63 of the LRA, Proposed Airborne Effluent and Environmental Monitoring Program, fourth bullet proposes to change the isokinetic sampling frequency for the dryer stack to a semi-annual requirement. Additionally, the dryer stack sample would be analyzed for only natural uranium. NRC staff are unable to evaluate the validity of these changes. The proposed sampling is less frequent and more limited than that recommended by Regulatory Guide 4.14 (quarterly sampling and analysis for natural uranium (Unat), Th-230, Ra-226, Pb-210; and

semiannual flow measurement) and no rationale is provided for the less stringent program.

ACTION NEEDED: COGEMA should provide a justification for using the less stringent sampling program proposed in the LRA, or comply with Regulatory Guide 4.14.

Response: The isokinetic sampling and flow tests have historically been performed on a semiannual basis at Irigaray. COGEMA adopted this testing frequency because it is similar to that implemented at other uranium ISL Licensees. Note that the original COGEMA NRC and DEQ license application, as well as the current NRC License, do not address stack sampling.

Based upon the data collected during the past three years at Irigaray, COGEMA believes that continuing testing and sampling on a semiannual basis is adequate to monitor stack effluents. COGEMA has prepared a table summarizing the stack emission data from semiannual testing conducted since the dryer was placed in operation in November, 1994. This table follows the conclusion of this response.

The LRA erroneously excluded thorium-230, radium-226, and lead-210 from the list of analytes for isokinetic sampling. COGEMA has analyzed for these radionuclides in addition to natural uranium since 1994 and proposes to continue this analysis. Revisions of pages 5-63 and 5-65 (Table 5.23) reflecting this correction are provided in Attachment 1.

SUMMARY OF STACK EMISSION SURVEY RESULTS
Irigaray Dryer and Packaging Circuit

Date	*Total Particulate (lb./hr)*	*U3O8 Emissions (lb./hr)*	*Unat (µCi/ml)*	*Ra-226 (µCi/ml)*	*Th-230 (µCi/ml)*	*Pb-210 (µCi/ml)*
December 1994	0.074	0.0047	3.06 E-10	7.75 E-13	6.7 E-13	2.33 E-12
March 1995	0.149	0.0106	7.53 E-10	3.86 E-12	3.9 E-12	3.93 E-12
September 1995	0.167	0.005	3.37 E-10	9.17 E-13	1.5 E-12	8.7 E-13
March 1996	0.056	0.0041	2.92 E-10	1.51 E-13	1.13 E-12	1.13 E-12
September 1996	0.029	0.0035	2.04 E-10	1.52 E-12	1.68 E-13	1.10 E-12
May 1997	0.057	0.007	4.28 E-10	6.71 E-13	1.34 E-12	1.73 E-12

Request 11. COMMENT: Discrepancy in Calculation of Annual Radon Emission

DISCUSSION: Page 7-3(A)-4, Calculation of Annual Radon Emissions, Christensen Ranch, step 2 of the LRA indicates that the total radon release from start-up is calculated to be 44 Ci/yr. However, step 3 uses 22 Ci/yr. for start-up. As this apparent discrepancy affects safety and health aspects of operations, clarification is required.

ACTION NEEDED: COGEMA should clarify the reason for the difference in these values.

Response: Step 3 in the calculation estimates the radon emissions from restoration. The value of 22 Curies per year for start-up was inadvertently used and the correct value is 44 Curies per year. This error was found in the source term calculation for both Christensen Ranch and Irigaray. The correction changes the source term as follows:

Christensen Ranch	Previous Source Term:	712 Ci/yr.
	Corrected Source Term:	735 Ci/yr.
	Percent Change:	3.1 %
Irigaray	Previous Source Term:	781 Ci/yr.
	Corrected Source Term:	801 Ci/yr.
	Percent Change:	2.6 %

The results of the MILDOS simulation indicated a Total Effective Dose Equivalent (TEDE) of 0.59 mRem per year and 0.40 mRem per year to the nearest residents located at the Christensen and Irigaray ranches, respectively.

Since the TEDE at the most affected residences are such a small fraction of the limit of 100 mRem per year, a change of 2 to 3% in the source term will result in an insignificant increase.

A corrected copy of Attachment 7.3(A) is attached.

Request 12. COMMENT: Process for Estimating Agricultural Parameters is not Defined

DISCUSSION: Pages 7-3(A)-6 and 7-3(A)-14, Miscellaneous Data, of the LRA, provides values for agricultural parameters used in dose calculations. Most of these parameters are estimated, but there is no discussion of the estimation technique.

ACTION NEEDED: COGEMA should provide a description of techniques for estimating agricultural parameters or should reference a previously approved source for these parameters.

Response: The sources of the estimate used in the Miscellaneous Data section of Attachment 7.3(A) have been identified in the revised Attachment 7.3(A).

Request 13. **COMMENT:** Operations Plan Does not Address the Weekly Intake Toxicity Limit for Uranium

DISCUSSION: There is no provision in the LRA to ensure compliance with the requirement of 10 CFR 20.1201(e) that limits intake of uranium to 10 mg/wk.

ACTION NEEDED: A limit on weekly intake of uranium affects safety and health aspects of operations. Section 5 of the renewal application should describe how COGEMA will monitor compliance with this regulatory requirement.

Response: Section 5.7.4.1 of the LRA provides information on the methods used by COGEMA to determine internal exposure to natural uranium. This section discusses the MPC-Hour method (used prior to 1994), the DAC-Hour method (used after 1994), and the intake method to determine intake of soluble uranium in milligrams. The intake method is discussed in detail on page 5-29. COGEMA performs this calculation weekly to ensure compliance with 10 CFR 1201(e) in accordance with instructions currently contained in Standard Operating Procedure HP-5, *"Internal and External Occupational Dose Calculations"*. It is noted that the intake limit for soluble uranium of 10 milligrams per week is more restrictive than the DAC-Hour limit due to the chemical toxicity of uranium.

As noted in this section, COGEMA plans to institute the same the same internal uranium exposure methods which have been used to date.

Request 14. COMMENT: Unrecorded Exposures Should be Explained

DISCUSSION: Page 5-20, table 5.2, footnote 1 of the LRA states that for the maximum individual exposure values "...some higher reported exposures were not recorded following investigation." Information has not been provided concerning the levels of these higher exposures and the justification for not recording them.

ACTION NEEDED: COGEMA should provide documentation on the levels of these exposures and the justification for not recording them.

Response: There was one occasion where the detected external exposure for an employee was investigated and, based upon the results of that investigation, the recorded exposure was based upon the estimated dose. The situation involved an employee who had a reported dose during the third quarter of 1994 of 332 mRem, which was nearly one order of magnitude higher than his typical quarterly dose. The investigation determined that the employee in question improperly stored his TLD in his locker during off-shift hours. The locker was located next to the reverse osmosis unit at Christensen Ranch, which is a posted radiation area. A gamma survey conducted at the interior of the locker showed a dose rate of 0.6 mRem per hour.

The employee was assigned a dose for the third quarter of 1994 based upon the average of his previous quarterly doses. All lockers were subsequently removed from the Christensen Ranch restricted area. The results of the investigation and the action

taken were properly documented and are maintained in the In-House Investigation File at the site.

September 3, 1997 - COGEMA MINING, INC. - ADDITIONAL PROPOSED CHANGES TO THE JANUARY 5, 1996 LRA

Request 1. **PROPOSED CHANGE:** On July 31, 1997, NRC approved an increase in process plant flow rate for the Christensen Mine. Amendment No. 47 to SUA-1341 revises the annual average flow rate of 3600 gallons per minute (gpm) to a new annual average of 4000 gpm. As a result of the flow rate increase, pages in the LRA have been revised to change the 3600 gpm to 4000 gpm. The affected pages are as follows: 1-4, 1-6, 1-8, 3-1, 3-38, 3-40, 5-12, and 7-2. The revised pages are included with Attachment 1.

COGEMA requests that the NRC incorporate the revised pages into the LRA indicating the newly approved flow rate.

Request 2. **PROPOSED CHANGE:** A minor title change has been made in the Wyoming operations. The title of production manager has been changed to operations manager, consistent with our Texas operations. To recognize this change, several pages in the LRA have been revised including: 5-1, 5-2 (Figure 5.1), 5-5 and 5-6. The revised pages are provided in Attachment 1.

COGEMA requests that NRC incorporate the revisions into the LRA document.

Request 3. **PROPOSED CHANGE:** In April, 1997, COGEMA completed the construction of the restoration addition to the Christensen satellite process plant. Figure 3.11, page 3-37, of the LRA has been revised to show the "as-built" general arrangement layout of the restoration addition. Additionally, Figure 5.2 of the LRA was revised to show the as-built arrangement. These revised figures are provided in Attachment 1.

COGEMA requests that NRC incorporate the revisions into the LRA document.

Request 4. **PROPOSED CHANGE:** During COGEMA's last inspection by the NRC, it was noted that water levels from the regional groundwater windmills had not be obtained prior to sampling the wells. We explained to the NRC that it is impossible for us to obtain the water levels from the operating windmills. NRC then said that COGEMA should revise the application to delete the requirement to obtain the water levels prior to sampling. Accordingly, COGEMA has revised Table 5.25, page 5-77, of the LRA to delete the requirement for obtaining water levels in the regional groundwater wells. Revised page 5-77 is provided in Attachment 1.

COGEMA requests that NRC incorporate the revised Table 5.25 into the LRA document.

Request 5. **PROPOSED CHANGE:** Figures 3.1 and 5.5 of the LRA (in-pocket) have had minor revisions made to them as a result of comments from the Wyoming DEQ. The following revisions were made:

Figure 3.1:

- A reference to Figure 3.16, Detailed Mining and Restoration Schedule, was added;
- Projected future Christensen Mine Unit boundaries and the potential year for the initiation of mining has been added for each development area; and
- Potential Irigaray development areas, Mine Unit boundaries and development dates have been added.

Figure 5.5:

- Regional groundwater monitoring well locations were re-labeled to make them more visible. Some well names were also changed to make them consistent with reported environmental monitoring data.
- IR Willow No. 2, regional groundwater monitoring well for the Irigaray site, was added to the figure.

Copies of the revised Figures 3.1 and 5.5 are included with Attachment 1. We request that NRC approve the revisions and incorporate the revised maps into the LRA document.

Request 6. **OBSERVATION:** A new surety submittal has been submitted to the NRC by letter dated August 18, 1997. COGEMA is unsure whether NRC needs to incorporate this new estimate into the LRA, or not. The current estimate in the LRA is out of date and has undergone two revisions since the LRA submittal in January, 1996; however, it will continue to undergo annual update. NRC should advise COGEMA how they would like to handle the annual surety update.

ATTACHMENT 1

Revised Pages for January 1996 License Renewal Application

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6.2 Decommissioning and Reclamation Cost Estimate . . . . . End of Section 6.0
7.3(A) USNRC Attachment A . . . . . End of Section 7.0

TABLE 1.2
CHRISTENSEN RANCH LAND OWNERSHIP

SURFACE OWNERSHIP	MINERAL OWNERSHIP
Bureau of Land Management (BLM)	BLM
State of Wyoming	State of Wyoming
John O. Christensen	John O. Christensen, et al. and BLM

1.2.3 DESCRIPTIONS OF EXISTING FACILITIES

Roll-front uranium mineralization is present at the both the Irigaray and Christensen Ranch properties in the Wasatch formation. Remaining reserves on the entire Irigaray property controlled by COGEMA is approximately seven million pounds. Reserves remaining on the Christensen Ranch property are approximately thirteen million pounds in today's low value uranium market.

Previous mining operations at the Irigaray Site were conducted in twelve acres of wellfield (Production Units 1 through 5) in 1978 through 1981 by Westinghouse. Production Units 6 through 9 were operated by Malapai in 1987 through 1990, in addition to continued operations in Units 1 through 5. Restoration of Units 1 through 3 began in 1990 and stabilization monitoring ended at the beginning of 1994. Restoration in Units 4 and 5 began in 1992, was temporarily suspended in 1994, and resumed in April, 1995 in combination with restoration in Units 6 through 9. Restoration of all units is expected to be completed by 1998.

Operations at Christensen Ranch began in April, 1989 in Mine Unit 3. Operations were suspended in February, 1990 with the sale of the company. Operations in Mine Unit 3 resumed in 1992, as well as the startup of Mine Unit 2. Mine Unit 4 came on line in 1994, and Mine Unit 5 in 1995. Mine Unit 3 is now in standby status pending aquifer restoration.

Processing facilities include the central plant at Irigaray which is an average 2,400 gpm ion exchange plant in addition to the other circuits common to both Irigaray and Christensen processing such as the resin elution, precipitation and drying/packing circuits. The Christensen Ranch satellite extraction plant consists of an ion exchange circuit which will be operated at a flow rate of 4,000 gpm on an annual average, and ◂R1 a lixiviant makeup circuit. Water treatment processes such as reverse osmosis are used to clean well field bleed water for use in future restoration. Uranium-laden resin from the ion exchange columns will periodically be transferred to a tanker trailer and

- Incorporation of new background data collected since 1987, where appropriate.

Section 3.0, Mine Plan

- Combination of both Irigaray and Christensen Ranch revised and updated mine and development plans into one plan.

- Updated estimates of disturbance for each site.

- Updated reserve estimates and development schedule.

- Updated facilities location maps, mine unit and development area locations, and areas mined to date.

- Deletion of the plan for four satellite plants in each of four operational phases at Christensen Ranch; phase areas are now called geographical areas of the permit area.

- Incorporation of the 2,400 gpm annual average production flow rate for Irigaray (amended upwards in 1989).

- Incorporation of a 4,000 gpm annual average flow rate at the Christensen Ranch satellite (currently licensed for 2,500 gpm annual average), and increase in annual yellowcake production estimates, including a 2.5 million pound throughput. Includes the addition of process equipment to accommodate the flow increase (one sand filter, two ion exchange columns and a 40' extension to the plant building). ◂R1

- Updated discussion of the drying and packaging unit at Irigaray; includes the possibility of toll-drying other licensee's yellowcake product.

- Updated flow and material balance process sheets for Christensen Ranch and Irigaray.

- Updated equipment lists for both the Irigaray central plant and the Christensen satellite plant.

- Incorporation of a new generic low water crossing design in place of the previous low water crossing design for Willow Creek, or other significant drainages.

- Incorporation of topsoil volumes stockpiled.

Section 6.0, Restoration and Reclamation Plan

- Summaries of past groundwater restoration activities at Irigaray and Christensen Ranch.

- Revised restoration plan for Christensen Ranch and future well fields.

- Updated financial surety estimate included for 1995-1996 (previously submitted to USNRC and WDEQ).

Section 7.0, Environmental Effects

- Inclusion of results of new MILDOS computer modeling; worst case analysis includes Irigaray and Christensen Ranch both in full production (2400 and 3600 gpm each), with dryer operating at 2.5 million pounds/year. The average annual flow rate of 4,000 gpm was approved by NRC after the MILDOS was submitted. ◂R1

- Completely revised Section 7.3 - Radiological Effects, based on new 10 CFR 20, new MILDOS modeling and EPA guidance.

- Incorporation of a discussion of incidents, including excursion history since 1987, well field spills, the yellowcake thickener incident and repair of the permeate storage pond.

Section 8.0, Alternatives to Proposed Action

- Generally updated.

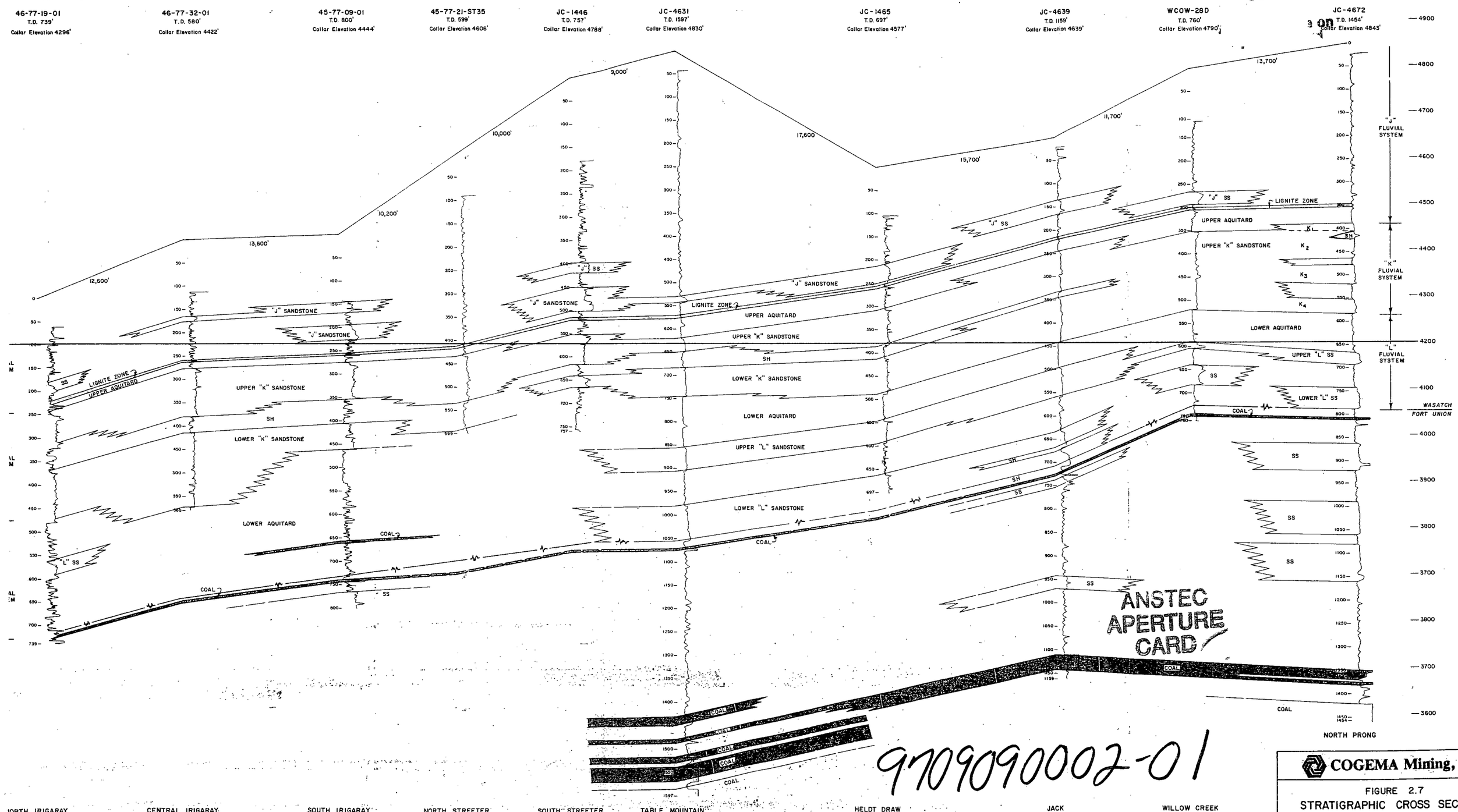
Section 9.0, Benefit-Cost Summary

- Generally updated.

Section 10.0, Environmental Approvals and Consultations

- Incorporation of a listing of current primary licenses and permits.

ANSTEC APERTURE CARD



ANSTEC APERTURE CARD

9709090002-01

COGEMA Mining, Inc.

FIGURE 2.7
STRATIGRAPHIC CROSS SECTION
IRIGARAY & CHRISTENSEN RANCH
PROJECT AREAS
JOHNSON & CAMPBELL COUNTIES, WYOMI

GEOLOGIST: L. M. Toucher | DRAWN BY: Lanouette | DATE: September

three major sandstone units which have been designated "K_1", "K_2", and "K_3" sandstones in descending order. Separation of these units, where it occurs, is caused by thin shaley lenses which are limited both vertically and laterally. It should be noted that in 1990, the current operator of the Christensen Ranch (Total Minerals Corporation), made a nomenclature change to the K sands in the eastern portion of the North Prong area. In this area, the geologic staff chose to re-designate the three major subdivisions of the K system as the K2, K3 and K4, and assign the name of K1 to a small lense of sandstone at the top of the sequence. This variation in nomenclature is present only in the North Prong area, and is not reflected on the original geologic cross-sections for North Prong provided in Appendix D5 of the Christensen Ranch amendment application. The average thickness of the "K" fluvial system in the Christensen Ranch permit area is approximately 177 feet. See Appendix D5 for detailed cross sections, isopach maps and structural contour maps of the base and top of the "K" fluvial system. ◄R1 ◄

The "J" fluvial system at Christensen Ranch is defined as those Wasatch sediments from the base of the upper aquitard to the ground surface. It is dominated by siltstone and mudstone sediments with thin sandstone units and thin lignitive coal seams. Although the "J" fluvial system has one sandstone lens known to contain uranium, it is not incorporated into the present mine plans. The "J" facies of primary concern is the carbonaceous mudstone/lignite zone which have been labeled the upper aquitard. The average thickness of the "J" fluvial system in the area is approximately 348 feet. Thickness of the upper aquitard varies from 60 to 100 feet in the area. There is no evidence of breaching of the upper aquitard within the project area. See Appendix D5 for detailed cross sections of the "J" fluvial system and isopach maps of the upper aquitard.

Roll-type uranium mineralization at the Irigaray site is present in fluvial channel sands in the "Upper" and "Lower" sandstone units of the Wasatch formation. The "Upper" unit, termed the Upper Irigaray Sandstone, is the largest and most economically important. At present, only the "Upper" unit will be mined. The channel sands trend to the north, which is also the direction of the regional dip and hydraulic gradient. The host environment of the upper unit consists of arkosic, fine to coarse grained, poorly sorted sands. The mineralization has been stratigraphically confined by persistent layers of shales, mudstones or claystones. The top of mineralization is on the average about 200 feet below the surface and the host averages near 100 feet in thickness. The calcite content of the host ranges 1 to 3 percent.

Mineralization occurs along the margins of the large tongue of sand altered by oxidizing groundwater flow. This tongue measures some three miles in width near the center of the Irigaray property and extends from the southern boundary for a strike length of ten miles. Uranium deposition as uraninite and coffinite occurred where the groundwater encountered reducing conditions. Uranium is localized at the interface (roll front) between the oxidized and reduced sandstone. The oxidized zone is difficult

to distinguish from the reduced zone; the sandstone on the oxidized side has a tan to yellowish green bleached color whereas the reduced portion is characterized by a gray color. Lack of strong red and brown coloration in oxidized material is due to the generally low pyrite content (less than 0.5 percent). In contrast to many uranium deposits of similar origin, no molybdenum mineralization has been found at the Irigaray site to date. Arsenic and selenium are present within and adjacent to the uranium mineralization. Barite, $BaSO_4$, is also found with the uranium mineralization.

In addition to the original hydrologic evaluations at the Irigaray property, the following hydrologic and water quality investigations have been performed, and submitted to the DEQ and NRC on or about the following dates:

Groundwater Properties of Production Units 6 through 9 - September, 1987
Groundwater Properties, 517 Test Site - November, 1987
Aquifer-Aquitard Characterization Production Units 2 and 3 - August, 1986
Aquifer-Aquitard Characterization Section 5 Test Site - March, 1987
Predicted Pumping Rates and Time for Restoration Sweep, Irigaray Units 1-9 - June, 1990
Production Unit 6 - April, 1988
Production Unit 7 - November, 1987
Production Unit 8 and 9 - January, 1988

All of the above studies previously submitted to the NRC and DEQ confirm and substantiate the baseline hydrologic conditions established and discussed in Appendix D6 of both the Irigaray and Christensen license applications. This includes groundwater hydrologic characteristics such as directional gradient, transmissivities, permeabilities, storage coefficients, and the strong vertical anisotropy of the host K sandstone. All of the hydrologic testing conducted since the original application support the following generalizations: ◂R1

- When stressed, the host K Sandstone and Upper Irigaray Sandstone responded as a single hydraulic unit with strong directional anisotropy.

- Monitoring of the overlying and underlying aquifers did not demonstrate any hydraulic connections to the K Sandstone. The lack of response attributable to the pumping of the K Sandstone indicates the presence of vertical isolation of the overlying and underlying aquifers.

- The confining layers separating the K Sandstone from other water-bearing strata act as continuous, low permeability barriers within each mine unit tested.

Groundwater quality data collected since the last license renewal has also been confirmed and substantiated to be essentially the same as that identified in Appendix D6 of the original applications. Groundwater generally tends to be classed as sodium-sulfate in the eastern half of Christensen Ranch, trending towards sodium bicarbonate in the western half of the licensed area. Irigaray groundwater is primarily sodium bicarbonate based. Although total dissolved solids concentrations in the western half of Christensen and all of Irigaray tend to average below drinking water standards, the water cannot be considered potable within the ore zones due to excessive concentrations of radium-226 and radon gas. Groundwater in the eastern half of Christensen demonstrates elevated levels of sodium-sulfate which cause the total dissolved solids concentrations to be greater than drinking water standards. In these

areas (Mine Units 5, 6, and 7), the water is classified by the State of Wyoming as Class IV, Industrial Use.

Groundwater usage in the vicinity of the Irigaray and Christensen Ranch license areas has not changed since the original issuance of the license. Groundwater usage is still limited to agricultural use (livestock), industrial use (uranium in situ mining, oil and gas development), and limited domestic use (Christensen Ranch house and Irigaray Ranch house). There are no new domestic or livestock developments in the area as the properties are located on the large Christensen and Irigaray ranches. For the future, there are no projected changes in the current groundwater usage.

2.7.2 SURFACE WATER

Surface water characteristics for the Irigaray project are described in Section D6 of the Irigaray permit application document. The descriptions are rather general, due to the relatively small size of the Irigaray project (less than 1,000 acres). Willow Creek, considered an intermittent stream, crosses the permit area to the north, and is the only surface water feature in the immediate vicinity of the permit area. Willow Creek flows northwesterly from the edge of the Irigaray permit area approximately two miles before its confluence with the Powder River. Water quality and available hydrologic characteristics for both Willow Creek and the Powder River are given in Section D6 of the Irigaray application document.

Regional and site specific surface water studies were conducted to develop quantitative and qualitative data and to assess the potential impact of the proposed mining operation on the surface water and drainage system within the Christensen Ranch permit area. The drainages basins within and adjacent to the area were mapped and described. They include 18 watersheds of the Willow Creek drainage basin which provide surface drainage for the majority of the area. Surface water bodies in the permit area and adjacent to it were characterized including Willow Creek, its primary tributaries and permanent stockponds. Drainage channel profiles were constructed for Willow Creek and its major tributaries.

Results indicate that drainages in the Christensen Ranch project area are ephemeral. Intermittent surface water occurs only in the extreme north west portion of the permit area. Flood frequency analyses were calculated from field data and indicate a range of flood events for the watershed.

Surface water quality was sampled along Willow Creek and its major tributaries. Appendix D6 of the Christensen permit application provides the surface water quality data. Drainage basin characteristics are also provided for review in Appendix D6, as well as sedimentology as related to the ongoing mining disturbance.

3.0 MINE PLAN

In the past, COGEMA Mining, Inc. has operated the Irigaray central processing facility and associated well fields plus a satellite ion exchange plant and well fields located at the Christensen site. All existing well fields at the Irigaray site have been mined out and are currently undergoing aquifer restoration. These well fields consist of Units 4 through 9, with the restoration in Units 1 through 3 having been completed in 1993. Mining continues at the Christensen satellite operation, in Mine Units 2, 4 and 5. Operations in Mine Unit 3 ceased in mid-1995 in preparation for aquifer restoration scheduled to commence in 1996.

Future operations at Irigaray will consist of the completion of restoration in the existing Irigaray well fields, plus the continuation of plant activities for the processing of the Christensen and Irigaray ion exchange resins (elution), uranium precipitation, yellowcake drying, packaging and shipping. Additionally, continued mining is eventually planned at the Irigaray site, within the current permit boundary plus areas to the north and south of the permit boundary. The existing Irigaray plant will be utilized for the processing, with the current 2400 gpm ion exchange circuit. The timing for resumption of mining at Irigaray is discussed in more detail later within this chapter.

Future operations at Christensen will consist of continued well field installation and operation. In the original plan for Christensen, four satellite plants were anticipated for installation and operation. It is now planned that the entire Christensen ore body will be mined through the use of the one existing satellite plant connected to the various well fields by injection and recovery trunklines. This system has worked well during operations in Mine Units 2 through 5. Booster pump stations are necessary periodically along the trunklines to help move the solutions over the distance to and from the satellite plant. The flow rate of the satellite plant will increase to an annual average of 3,600 gpm by January, 1996, <u>and has recently been approved by the NRC for an increase to an annual average of 4,000 gpm</u>. ◂R1

Mining operations at Christensen will continue with Mine Units 6 and 7, located in the North Prong geographical area of the Christensen permit boundary. After Mine Unit 7, well fields will progress to either the Heldt Draw or Table Mountain geographical areas for Mine Units 8 through 12. The development schedule is discussed in more detail later within this chapter.

The major components of both the Irigaray and Christensen Ranch in-situ mining operations are: 1) the orebody; 2) the well fields; 3) the lixiviant injection circuit; 4) the uranium extraction circuit; 4) uranium precipitation, drying and packaging (Irigaray only); 6) wastewater management systems; and 7) aquifer restoration and surface reclamation. The physical descriptions and operating characteristics of these components and processes are provided in detail in the following sections.

well spacing on the perimeters of the well pattern areas has become more sophisticated, and is now based on hydrologic parameters of the mining formation, including gradient and transmissivities, and the ability to retrieve excursions within a 60 day regulatory time frame.

Based upon detailed studies of the hydrologic characteristics of the mining aquifers at both the Irigaray and Christensen Ranch sites, perimeter ore zone monitor wells will be located as follows:

1. Downgradient from the well field, where the well field orientation with the groundwater flow direction forms an angle greater than 45 degrees: 300 feet from the well field edge, spaced 300 feet apart.

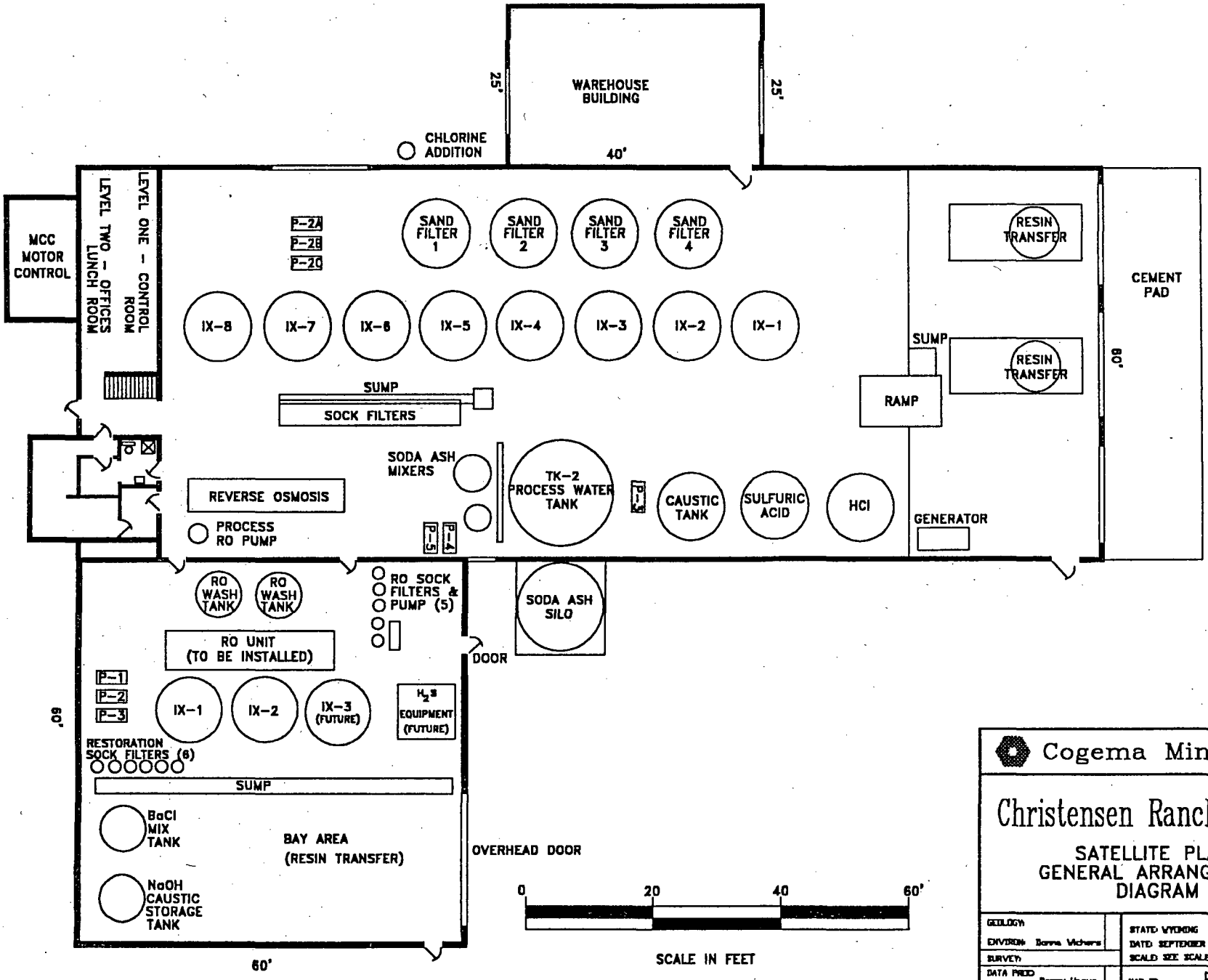
2. Upgradient from the well field, where the well field orientation with the groundwater flow direction forms an angle greater than 45 degrees: 500 feet from the well field edge, spaced 500 feet apart.

3. Sides of the well field, which form angles with the flow direction of less than 45 degrees: 500 feet from the well field edge, spaced 500 feet apart.

Perimeter ore zone monitor wells within the trend of the orebody will eventually be abandoned or incorporated into the well field pattern as mining progresses. Ore zone monitor wells will have a completion interval which encompasses the same completed intervals of the adjacent mine unit wells.

Monitor wells are also installed within the mine unit boundaries to monitor for potential excursions to the aquifers overlying and underlying the host ore aquifer. Shallow monitor wells are completed in the first continuous overlying aquifer above the ore aquifer that exhibits at least 10 feet of thickness and a permeability that will allow the production of enough water for sampling. At the Irigaray site, the shallow aquifer is designated as the "Unit 1 Sand"; at the Christensen Ranch site, the "J" sandstone unit of the stratigraphic column is typically the shallow monitor zone. Deep monitor wells are completed in the first continuous underlying aquifer that exhibits at least 10 feet of thickness and a permeability that will allow the production of enough water for sampling. These are termed the lower Irigaray sandstone and the "L" sandstone unit at the Christensen Ranch site. If there is no appropriate aquifer to monitor below 50 feet of the top of the confining shale underlying the production zone, deep monitor wells will not be installed. One shallow and one deep monitor well will be installed within the mine unit boundaries for each three and one-half (3.5) acres of installed pattern area, where appropriate monitory zone exists. ◄R1 ◄

In the past, due to problems with improperly sealed exploration drill holes and poor well casing integrity, shallow excursions occurred at the Irigaray site. As a result,


WAREHOUSE BUILDING
25'
25'
40'
CHLORINE ADDITION
MCC MOTOR CONTROL
LEVEL TWO - OFFICES LUNCH ROOM
LEVEL ONE - CONTROL ROOM
P-2A
P-2B
P-2C
SAND FILTER 1
SAND FILTER 2
SAND FILTER 3
SAND FILTER 4
IX-8
IX-7
IX-6
IX-5
IX-4
IX-3
IX-2
IX-1
RESIN TRANSFER
RESIN TRANSFER
CEMENT PAD
80'
SUMP
RAMP
SUMP
SOCK FILTERS
SODA ASH MIXERS
TK-2 PROCESS WATER TANK
P-1A
CAUSTIC TANK
SULFURIC ACID
HCl
GENERATOR
REVERSE OSMOSIS
PROCESS RO PUMP
P-1B
P-1C
RO WASH TANK
RO WASH TANK
RO SOCK FILTERS & PUMP (5)
SODA ASH SILO
RO UNIT (TO BE INSTALLED)
DOOR
P-1
P-2
P-3
IX-1
IX-2
IX-3 (FUTURE)
H_2S EQUIPMENT (FUTURE)
60'
RESTORATION SOCK FILTERS (6)
SUMP
BaCl MIX TANK
BAY AREA (RESIN TRANSFER)
NaOH CAUSTIC STORAGE TANK
OVERHEAD DOOR
60'
0
20
40
60'
SCALE IN FEET
Cogema Mining, Inc.
Christensen Ranch Project
SATELLITE PLANT
GENERAL ARRANGEMENT
DIAGRAM
GEOLOGY
ENVIRON: Barrie Vickers
SURVEY:
DATA PREP: Penny Hague
STATE: WYOMING
COUNTY: JOHNSON
DATE: SEPTEMBER 1993
SCALE: SEE SCALEBAR REVISED 8/15/97
MAP ID
FIGURE 3.11

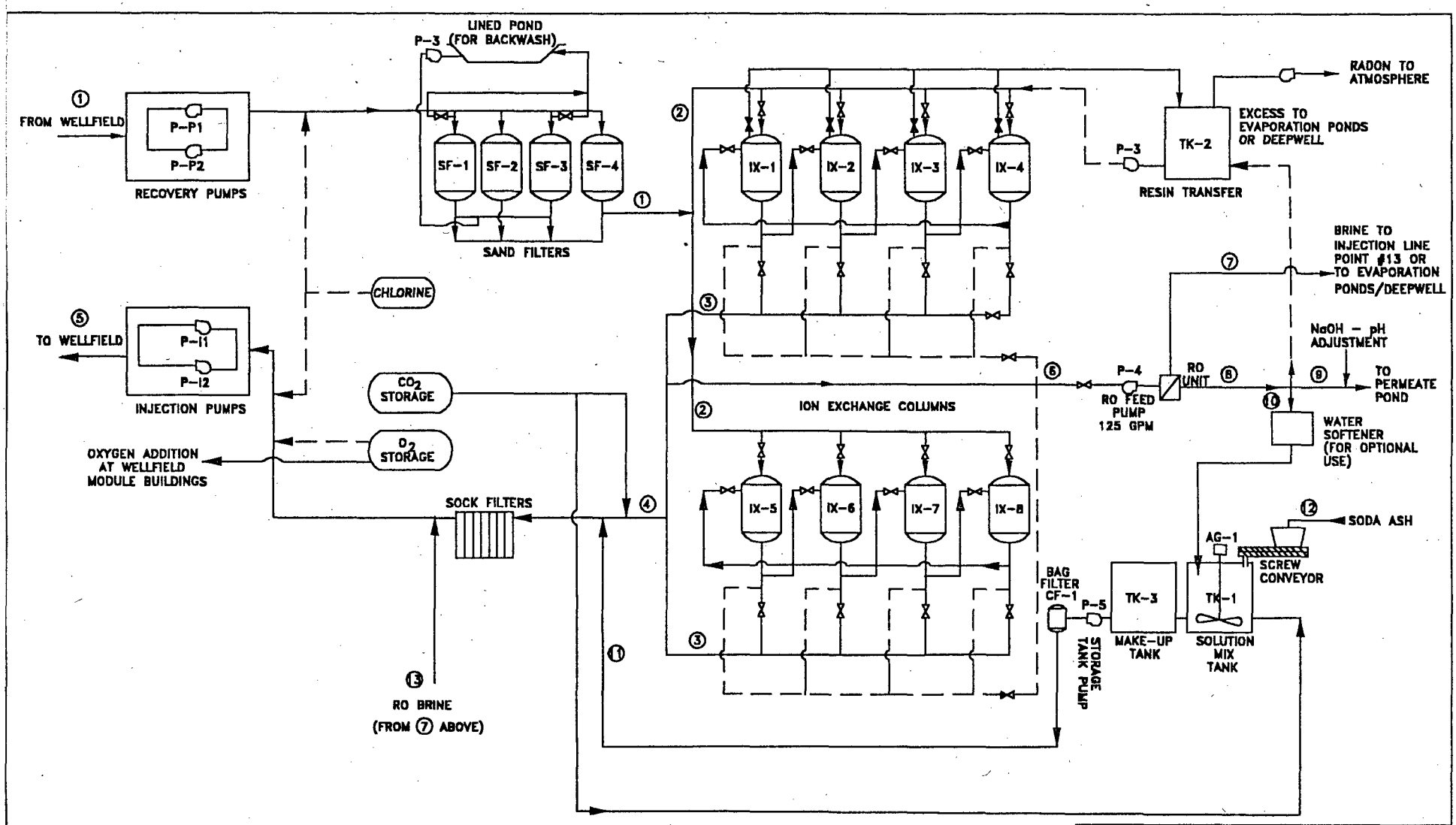
3.4.2.2 Ion Exchange/Lixiviant Makeup Circuit

The satellite plant contains four IX trains (sets of columns) with each train having two fixed-bed columns connected in series. The columns in each train have individual capacities of approximately 600 gpm, thus providing a maximum 4,800 gpm capacity of the system. The plant will be operated at an annual average flow rate of 4,000 gpm. The columns are designed to process well field solutions containing 100 parts per million (ppm) of uranium as U_3O_8 over a period of two days without incurring high uranium tailings losses into the injected well field solutions. Since the concentration of uranium in the well field will realistically average approximately 60 ppm, and the plant will be operated at an average 4,000 gpm, some conservatism is built into the design and the plant should be able to operate without transportation of resin for two or more days in the event that winter weather limits access to the site. ◄R1 ◄R1

A portion of the effluent from the IX circuit is withdrawn to ultimately provide the 1% bleed from the well field for lixiviant migration control and clean water for lixiviant makeup and resin transfer. Up to 125 gpm of barren effluent from the IX circuit is passed through a 125 gpm reverse osmosis (RO) unit. The concentrated salts or brine from the RO process (up to 62.5 gpm) will be recycled to the injection stream to the well field, thereby reducing the chemical requirements of the lixiviant makeup and the waste volumes requiring disposal. An alternative to recycling the brine from the RO unit is to send the brine to lined ponds for evaporation, or to the deep disposal well. Approximately 40 gpm of the clean product water or permeate will be sent to the permeate storage pond for use in aquifer restoration. This 40 gpm will constitute the 1% bleed from the well field for lixiviant migration control. The remaining 22.5 gpm of permeate will be used for lixiviant makeup and resin transfer. A radium-226 adsorption column may be included in the line which will feed permeate to the unlined storage pond, for further radium-226 removal, if necessary. ◄R1 ◄R1 ◄R1

The benefits of using RO treatment of the IX tails bleed are that pure water is discharged from the plant and problems with calcium buildup during lixiviant makeup are avoided. This results in a cleaner plant operation with reduced solids generation.

The lixiviant makeup system consists of chemical mixing tankage and an outside storage silo for solid soda ash. The 22.5 gpm of permeate discussed above is used to mix the lixiviant. The lixiviant makeup system is operated manually by filling the makeup tank with permeate and adding sodium bicarbonate from the external silo. The pH of the resulting solution is lowered by adding carbon dioxide gas and the resulting mixture is pumped to a day tank for metering into the injection stream. The pH instrumentation in the makeup tank is monitored during lixiviant makeup. The permeate is added to the makeup tank from a level-activated valve on the permeate discharge line. When the tank is full, the level control closes the valve and discharges the permeate to the outside storage pond. If CO_2 alone is used as the lixiviant, the lixiviant makeup system will be bypassed and the CO_2 gas will be added to the ◄R1



ITEM / LINE #	①	②	③	④	⑤	⑥	⑦ ⑬	⑧	⑨	⑩	⑪	⑫
Liquid TPH	1,000	500	500	969	990	31	16	16	10	6	6	–
S.G.	1.01	1.01	1.01	1.01	1.03	1.01	1.06	–	1.01	1.01	1.06	–
Flow Rate GP	4,000	2,000	2,000	3,875	3,960	125	62.5	62.5	40	22.5	22.5	–
U3O8 lbs/hr	100	50.0	1.0	1.8	2.0	0.1	0.1	–	–	–	–	–
V lbs/hr	1.50	0.75	0.1	0.2	0.2	0.0	0.0	–	–	–	–	–
HCO3 lbs/hr	4,000	2,000	1,960	3,797	4,277	123	123	2.5	1.6	0.9	388	387
Na lbs/hr	1,600	800	800	1,550	1,680	50	49	1.0	0.6	0.4	80	–
Cl lbs/hr	320	160	170	329	337	11	10	0.2	0.1	0.1	0.1	–
U3O8 ppm	50.0	50.0	1.0	1.0	1.0	1.0	2.0	–	–	–	–	–
V ppm	0.75	0.75	0.1	0.1	0.1	0.1	–	–	–	–	–	–
HCO3 ppm	2,000	2,000	1,960	1,960	2,160	1,960	3,920	78.4	78.4	78.4	28,165	–
Na ppm	800	800	800	800	848	800	1,568	32	32	32	7,980	–
Cl ppm	160	160	170	170	170	170	333	7	7	7	7	–

NOTE:
EVAPORATION PONDS ARE EQUIPPED WITH EVAPORATION ENHANCEMENT (SPRAY OR TRICKLE SYSTEMS)

Cogema Mining, Inc.

Christensen Ranch Project

PROCESS FLOW SHEET
SATELLITE PLANT

GEOLOGY:
PROCESS: W. Hall
ENVIRON: B. Vichers
SURVEY:
DATA PROC: P. Hague

STATE: WYOMING
DATE: 8/16/95
SCALE: None
COUNTY: JOHNSON
REVISED: 06/17/97
MAP ID:

FIGURE 3.12

5.0 OPERATIONS

COGEMA Mining, Inc. (COGEMA) is a subsidiary of COGEMA Resources, Inc., a wholly owned subsidiary of COGEMA, Inc. COGEMA, Inc. is a United States subsidiary of COGEMA, S.A.E. located in France. COGEMA maintains a United States headquarters in Mills, Wyoming where site licensing actions originate. All COGEMA operations, including the Irigaray Mine and Christensen Ranch satellite operations, are conducted in conformance with applicable laws, regulations and requirements of the various regulatory agencies. The responsibilities described below have been designed to both ensure compliance and further implement COGEMA's policy for providing a safe working environment with cost effective incorporation of the philosophy of maintaining radiation exposures as low as is reasonably achievable (ALARA).

5.1 CORPORATE ORGANIZATION AND ADMINISTRATIVE PROCEDURES

The COGEMA organizational chart, as it pertains to the responsibility for radiation safety and environmental protection at the Christensen Ranch satellite and Irigaray recovery facility is given as Figure 5.1. The personnel identified are responsible for the development, review, approval, implementation, and adherence to operating procedures, radiation safety programs, environmental and groundwater monitoring programs, as well as routine and non-routine maintenance activities. Specific responsibilities of the organization are provided below.

5.1.1 GENERAL MANAGER, ISL OPERATIONS

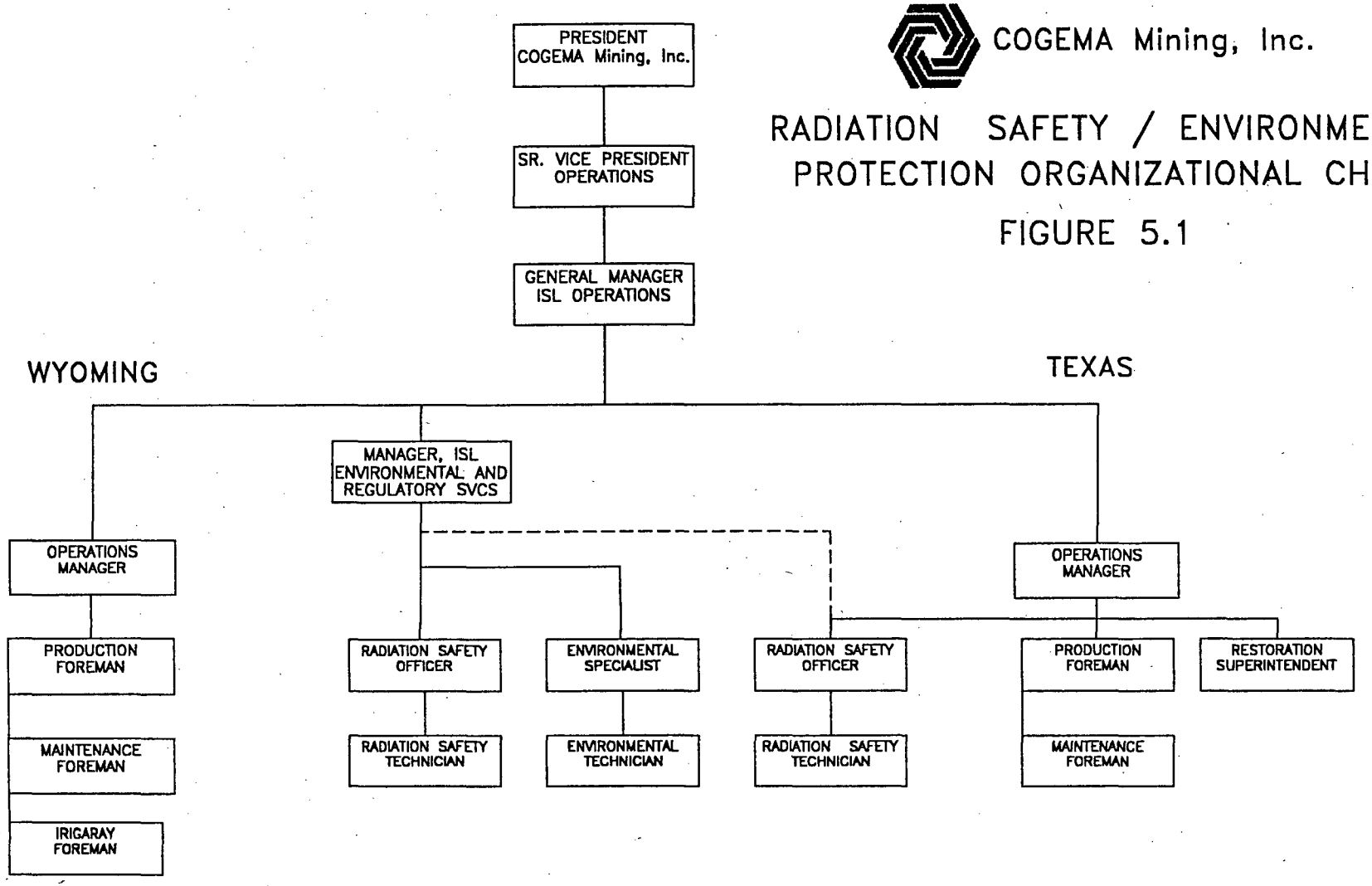
The General Manager, ISL Operations has the overall responsibility for each level of management and the radiation, safety and environmental programs for all of COGEMA's in-situ leach uranium operations, including the Texas operations and the Irigaray and Christensen Ranch projects. The General Manager has responsibility for the mine development, engineering and operational procedures. These responsibilities include the development, review and implementation of all production related operating procedures and the implementation of safety programs, associated quality assurance programs and routine and non-routine maintenance activities. The General Manager has the authority to terminate immediately any or all portion(s) of the project that have been determined to be a threat to health or property as indicated in reports from the Radiation Safety Officer or his designee.

The General Manager works closely with the Manager, ISL Environmental and Regulatory Services, the Radiation Safety Officer, and the Operations Manager to assure that all activities at each site are conducted in a safe, prudent and responsible manner in compliance with all applicable regulations. The General Manager reports to the Senior Vice President of Operations in COGEMA's Saskatoon office. ◂R1

COGEMA Mining, Inc.

RADIATION SAFETY / ENVIRONMENTAL PROTECTION ORGANIZATIONAL CHART

FIGURE 5.1



Revised 08/15/97

5.2.2 SAFETY AND ENVIRONMENTAL REVIEW PANEL (SERP)

COGEMA is applying for a Performance Based License (PBL) with this renewal application. If a PBL is issued as a result of this renewal application, COGEMA will form a Safety and Environmental Review Panel (SERP) comprised of a minimum of three individuals. The SERP will be responsible for reviewing changes, tests or experiments to determine whether an amendment to the license is required.

One member of the SERP shall have expertise in management and shall be responsible for managerial and financial approval changes; one member shall have expertise in operations and shall have responsibility for implementing any operational changes; and, one member shall be either the Manager, ISL Environmental and Regulatory Services or the Radiation Safety Officer, for the responsibility of assuring changes conform to radiation safety and environmental requirements. Additional members may be included in the SERP as appropriate, to address technical aspects such as health physics, hydrology, engineering or other technical disciplines.

Once the PBL is issued, COGEMA will prepare an SOP to outline the SERP's responsibilities in conducting safety and environmental evaluations of changes to the application, tests or experiments to determine whether an amendment to the license is required.

5.3 MANAGEMENT AUDIT AND INSPECTION PROGRAM

The following internal inspections, audits and reports are performed for the Irigaray recovery facility and Christensen Ranch satellite operations:

Weekly

The RSO or a qualified designee conduct a weekly inspection of the process area to observe general radiation safety control practices and make or review required changes in procedures and equipment. Any items of non-compliance or other problems are reviewed with the Operations Manager or General Manager. ◂R1

Monthly

The RSO provides a written summary of the month's radiological activities at the Christensen Ranch and Irigaray facilities. The report includes a review of all monitoring and exposure data for the month, a summary of worker protection activities, a summary of all pertinent radiation survey records, a discussion of any trends in the ALARA program, and a review of adequacy of the implementation of the USNRC license conditions. Recommendations are made for any corrective actions or improvements in the process or safety programs.

Annually

On an annual basis, an audit of the radiation protection and ALARA program is conducted and a written report of the results submitted to corporate management. The audit team consists of either the Manager, ISL Environmental and Regulatory Services and/or the outside radiation safety auditor identified in Section 5.1.6, the RSO and the Operations Manager or General Manager. The RSO may accompany the ◂R1 audit team, but may not participate in the conclusions.

The annual ALARA audit report summarizes the following data:

1. Employee exposure records
2. Bioassay results
3. Inspection log entries and summary reports of mine and process inspections
4. Documented training program activities
5. Applicable safety meeting reports
6. Radiological survey and sampling data
7. Reports on any overexposure of workers
8. Operating procedures that were reviewed during this time period

The ALARA audit report specifically discusses the following:

1. Trends in personnel exposures
2. Proper use, maintenance and inspection of equipment used for exposure control
3. Recommendations on ways to further reduce personnel exposures from uranium and its daughters

The ALARA audit report is reviewed by the General Manager with the ALARA audit team. Implementations of the recommendations to further reduce employee exposures, or improvements to the ALARA program, are discussed at that time.

An audit of the Quality Assurance/Quality Control (QA/QC) program is also conducted on an annual basis. The audit is performed by an individual qualified in analytical and monitoring techniques who does not have direct responsibilities in the areas being audited. The results of the QA/QC audit are documented and reported to the Manager, ISL Environmental and Regulatory Services, the RSO and the General Manager. The RSO has the primary responsibility for the implementation of the QA/QC programs at the Irigaray and Christensen Ranch facilities.

2. Release of yellowcake through the multi-hearth dryer exhaust system.

The production flow of 2400 gpm is directed to the process building for separation of the uranium. The uranium is separated by passing the recovery solution through pressurized fixed bed downflow ion exchange units. Since the recovered solution is pressurized at all times in the uranium recovery process virtually none of the contained radon is released to the environment. The only radon released to the environment is from the bleed stream that is used for process bleed and for chemical make-up. Radon is also released during the restoration phases of operation, but is significantly reduced due to the lower operational flow rates.

Venting of non-pressurized tanks to the atmosphere outside of the plant building minimizes personnel exposure. The plant buildings are equipped with exhaust fans to remove radon that is released in the plant building, and are used on an as needed basis. No significant personnel exposure to Rn-222 gas has been noted during operation of the Irigaray facility. Results of radon daughter monitoring in the process areas are contained in Section 5.7.3.

The primary source of airborne particulates at the Irigaray facility is the multihearth dryer. The exhaust system for the multi-hearth dryer is equipped with a high intensity Venturi scrubber system to remove contaminants prior to discharge to the atmosphere. This system is designed to remove approximately 90 to 95% of particulates. Further information on the scrubber system was previously discussed in Section 4 of this renewal document. The efficiency of the scrubber system is demonstrated by the uranium concentration measured in the stack effluents. Stack tests conducted in 1994 and 1995 showed that the particulate emissions from the dryer range from 24.7 to 55.7 percent of the standard allowable specified in COGEMA's Permit No. OP-254.

In the event that the yellowcake product is not dried and is stored in existing tanks and shipped as a slurry, the particulate emissions from the dryer are eliminated.

Christensen Ranch Gaseous and Airborne Particulate Control Techniques

The Christensen Ranch satellite facility produces one radioactive airborne effluent, Radon-222 gas, as a result of operations as previously discussed in Section 4. Radon-222 gas primarily remains in solution because the majority of the plant flow is in a pressurized system. A limited amount of radon gas is released as a result of the diversion process bleed stream into the lixiviant makeup circuit. These unpressurized tanks are vented directly to the atmosphere outside of the plant building to minimize personnel exposures. Another potential release of radon gas may occur during the resin transfer from a loaded IX column to the resin tanker trailer. During this process, the IX column is also vented to the atmosphere directly outside of the plant building.

were maintained of each investigation and the corrective action taken. If the results of a gamma survey identified areas where gamma radiation was in excess of levels that delineate a "radiation area", access to the area was restricted and the area was posted as required in 10 CFR §20.1902 (a).

External gamma surveys were performed with survey equipment which meets the following minimum specifications:

1. Range - Lowest range not to exceed 0.1 milliRoentgens per hour (μR/hr) full-scale with the highest range to read at least 5 milliRoentgens per hour (mR/hr) full scale;

2. Battery operated and portable;

Examples of satisfactory instrumentation which meets these requirements are the Eberline Instruments Corporation Model E-120 with a HP-270 probe or equivalent. Gamma survey instruments were calibrated every six months and were operated in accordance with the manufacturer's recommendations. Instrument checks were performed each day that an instrument was used.

Historical Program Results

Table 5.1 summarizes the results of external gamma surveys performed since the time of the last license renewal in 1987. The table provides the annual average values for monthly surveys performed at the Irigaray and Christensen Ranch facilities.

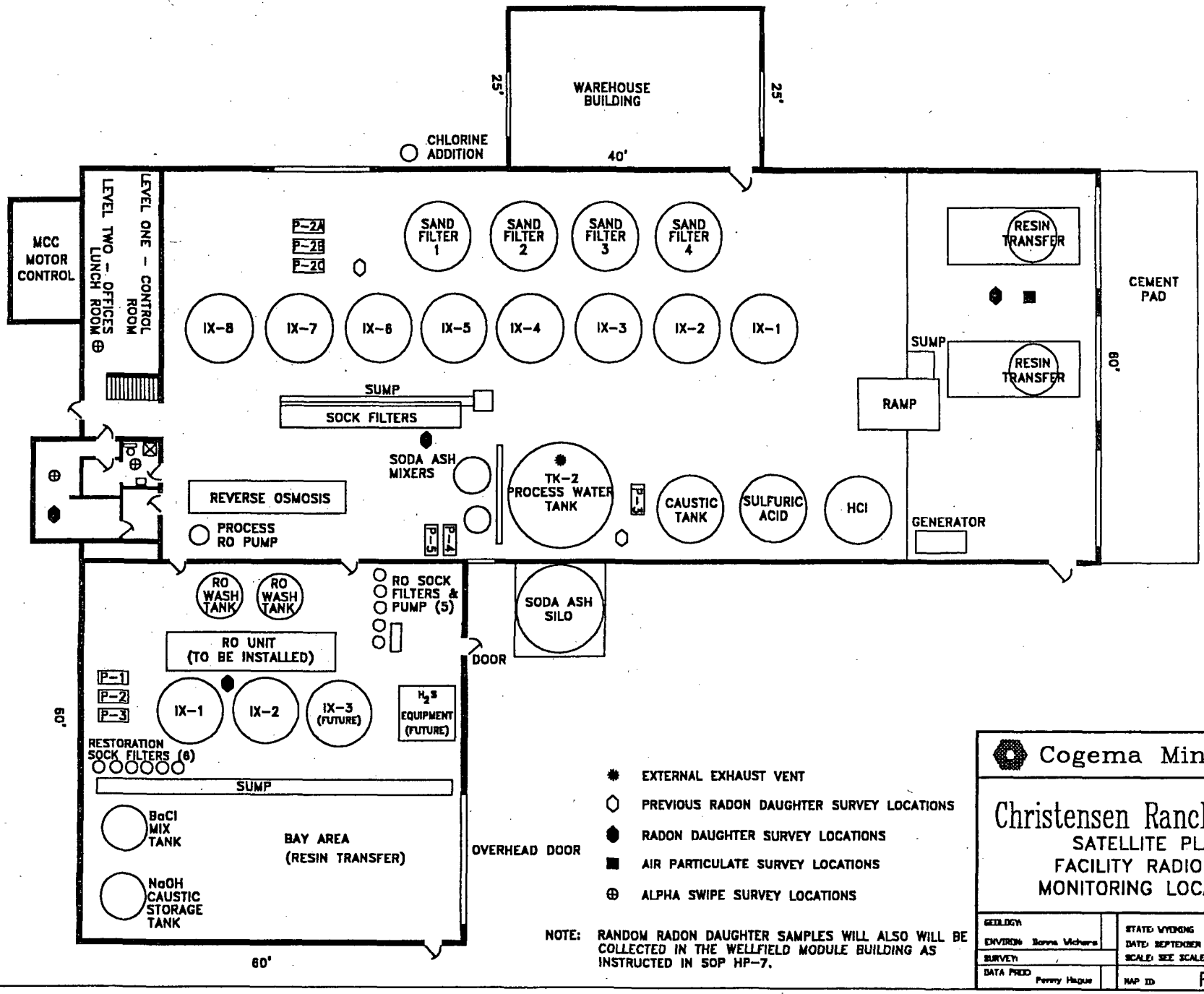
The historical data indicates that the average exposure rates have been relatively constant since 1987 with the exception of elevated readings in 1989 at Christensen Ranch during startup operations. Engineering controls instituted at Christensen Ranch since startup have resulted in reduced exposure rates. The data does not show any upwards trend over time. Additional details concerning those periods for which higher values were observed can be found in the semi-annual reports submitted to NRC.

COGEMA has attempted to correlate the gamma exposure rate survey data with the gamma exposure data contained in Section 5.7.2.2. No correlation is evident.

Proposed Gamma Survey Program

COGEMA proposes to institute the same gamma exposure monitoring program at Irigaray and Christensen Ranch that has been performed to date with the following changes.

- COGEMA proposes to perform gamma exposure rate surveys in areas which are accessible to personnel and which could potentially exceed the criteria for designation and posting as a radiation area. Based on operating experience, these areas will include, but not be limited to, the filteration equipment, reverse osmosis units and columns shown in Figures 5.2 and 5.3. ◂R1 ◂


WAREHOUSE BUILDING
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CHLORINE ADDITION
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SAND FILTER 1
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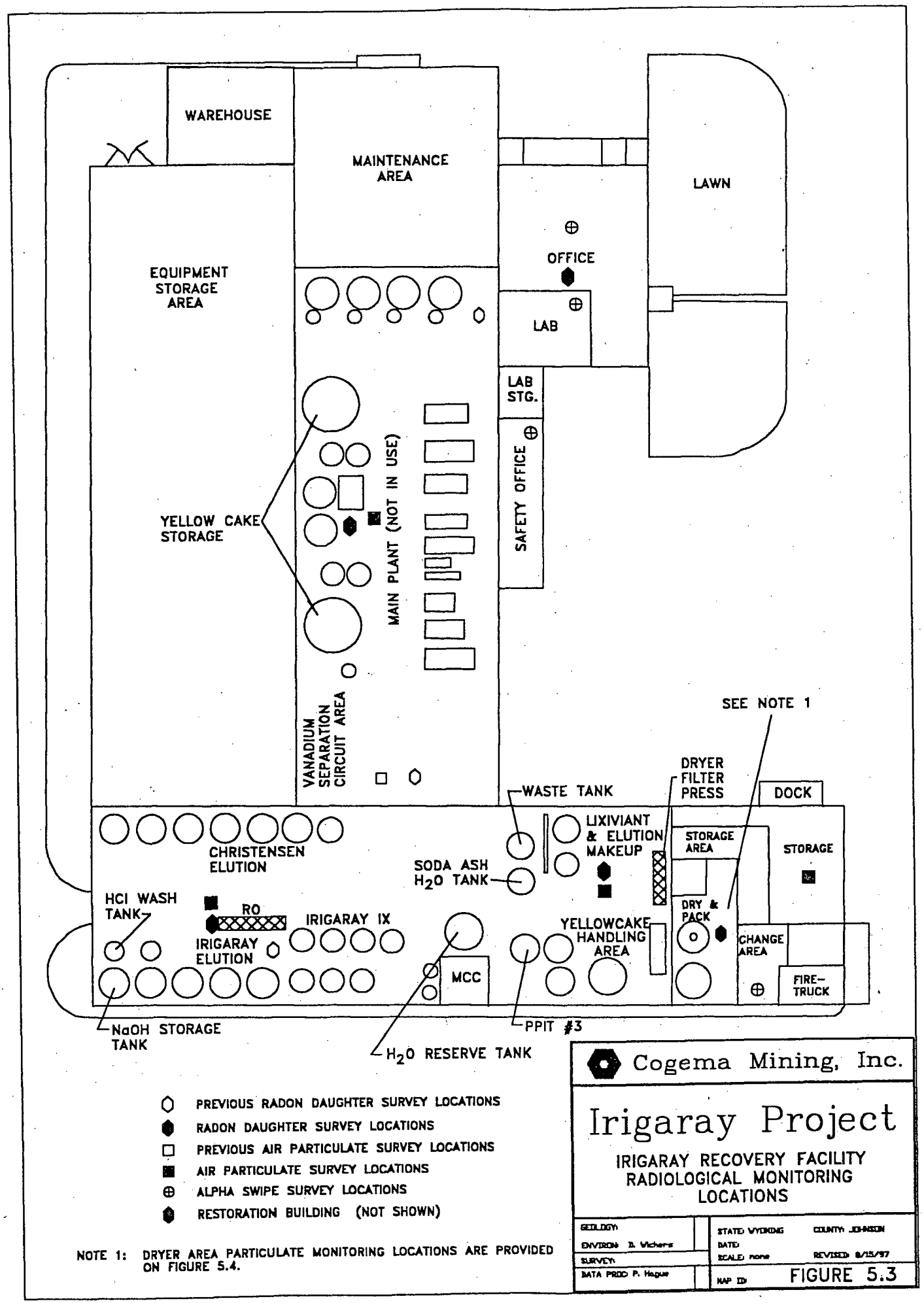
SAND FILTER 3
SAND FILTER 4
IX-8
IX-7
IX-6
IX-5
IX-4
IX-3
IX-2
IX-1
RESIN TRANSFER
RESIN TRANSFER
CEMENT PAD
60'
SUMP
RAMP
SUMP
SOCK FILTERS
SODA ASH MIXERS
TK-2 PROCESS WATER TANK
P-4
CAUSTIC TANK
SULFURIC ACID
HCl
GENERATOR
REVERSE OSMOSIS
PROCESS RO PUMP
P-5
P-4
RO WASH TANK
RO WASH TANK
RO SOCK FILTERS & PUMP (5)
SODA ASH SILO
RO UNIT (TO BE INSTALLED)
DOOR
P-1
P-2
P-3
IX-1
IX-2
IX-3 (FUTURE)
H_2S EQUIPMENT (FUTURE)
60'
RESTORATION SOCK FILTERS (6)
SUMP
BaCl MIX TANK
BAY AREA (RESIN TRANSFER)
OVERHEAD DOOR
NaOH CAUSTIC STORAGE TANK
60'
EXTERNAL EXHAUST VENT
PREVIOUS RADON DAUGHTER SURVEY LOCATIONS
RADON DAUGHTER SURVEY LOCATIONS
AIR PARTICULATE SURVEY LOCATIONS
ALPHA SWIPE SURVEY LOCATIONS
NOTE: RANDOM RADON DAUGHTER SAMPLES WILL ALSO WILL BE COLLECTED IN THE WELLFIELD MODULE BUILDING AS INSTRUCTED IN SOP HP-7.
Cogema Mining, Inc.
Christensen Ranch Project
SATELLITE PLANT
FACILITY RADIOLOGIC
MONITORING LOCATIONS
GEOLOGY:
ENVIRON: Bonna Wickers
SURVEY:
DATA PROD: Penny Hague
STATE: WYOMING COUNTY: JOHNSON
DATE: SEPTEMBER 1993
SCALE: SEE SCALEBAR REVISED 8/15/97
MAP ID:
FIGURE 5.2


WAREHOUSE
MAINTENANCE AREA
LAWN
OFFICE
EQUIPMENT STORAGE AREA
LAB
LAB STG.
SAFETY OFFICE
MAIN PLANT (NOT IN USE)
YELLOW CAKE STORAGE
VANADIUM SEPARATION CIRCUIT AREA
SEE NOTE 1
DRYER FILTER PRESS
DOCK
WASTE TANK
LIXIVIANT & ELUTION MAKEUP
STORAGE AREA
STORAGE
CHRISTENSEN ELUTION
SODA ASH H_2O TANK
HCl WASH TANK
RO
IRIGARAY IX
IRIGARAY ELUTION
YELLOWCAKE HANDLING AREA
DRY & PACK
CHANGE AREA
MCC
FIRE-TRUCK
NaOH STORAGE TANK
H_2O RESERVE TANK
PPIT #3
PREVIOUS RADON DAUGHTER SURVEY LOCATIONS
RADON DAUGHTER SURVEY LOCATIONS
PREVIOUS AIR PARTICULATE SURVEY LOCATIONS
AIR PARTICULATE SURVEY LOCATIONS
ALPHA SWIPE SURVEY LOCATIONS
RESTORATION BUILDING (NOT SHOWN)
NOTE 1: DRYER AREA PARTICULATE MONITORING LOCATIONS ARE PROVIDED ON FIGURE 5.4.
Cogema Mining, Inc.
Irigaray Project
IRIGARAY RECOVERY FACILITY RADIOLOGICAL MONITORING LOCATIONS
GEOLOGY:
ENVIRON: D. Vickers
SURVEY:
DATA PROC: P. Hague
STATE: WYOMING
COUNTY: JOHNSON
DATE:
SCALE: none
REVISED: 8/15/97
MAP ID:
FIGURE 5.3

Because these areas may vary depending upon operational activities, no permanent gamma monitoring locations have been specified. ◂R1

- The consistency and extent of the survey data available since 1987 indicates that the frequency of surveys can be changed to quarterly for routine surveys and monthly for areas over the 2.0 mRem/hr administrative limit without a reduction in radiological safety. COGEMA believes that this survey frequency schedule is frequent enough to detect changes in conditions. Additionally, these frequencies are more stringent than the schedule recommended in USNRC Regulatory Guide 8.30, "Health Physics Surveys in Uranium Mills". Changes which could affect gamma exposure radiological conditions would be reviewed by the Safety and Environmental Review Panel (SERP) under the proposed Performance Based License. The SERP would recommend any additional monitoring requirements.

Gamma exposure rate surveys will be performed in accordance with the instructions currently contained in Standard Operating Procedure HP-2, "Gamma Exposure Rate Survey". Gamma survey instruments will be checked each day of use in accordance with the instructions currently contained in Standard Operating Procedure HP-14, "Instrument Performance Checks".

5.7.2.2 Personnel Dosimetry

Program Description

Since 1987, all employees who were assigned full-time to the Irigaray and Christensen Ranch facilities were issued Thermoluminescent Dosimeters (TLD) for determination of external gamma exposure. TLDs have been provided by TMA Eberline which is accredited by NVLAP of the US Department of Commerce as required in 10 CFR § 20.1501. The TLDs were exchanged and read on a quarterly basis.

Historical Program Results

Table 5.2 contains a summary of the average and maximum annual exposure for all personnel at the Irigaray and Christensen Ranch facilities since 1987. As can be seen in Table 5.2, the average annual exposures at Irigaray and Christensen Ranch are well below 1% of the regulatory limits. The maximum annual individual exposures are well below 10% of the regulatory limit and indicate that exposures at Irigaray and Christensen Ranch are maintained ALARA.

Proposed Personnel Dosimetry Program

10 CFR §20.1502 (a)(1) requires exposure monitoring for "Adults likely to receive, in 1 year from sources external to the body, a dose in excess of 10 percent of the limits

Proposed Airborne Effluent and Environmental Monitoring Program

COGEMA proposes to continue to implement the Airborne Effluent and Environmental Monitoring Program described in this section with the following proposed changes.

- COGEMA proposes to change the restricted area at the Irigaray facility. The results of monitoring conducted at the facility and modeling indicate that the process portion of the plant building would be the appropriate restricted area boundary for the facility. Approximately two thirds of the fenced storage area adjacent to the plant building will also be maintained as a restricted area for storage purposes. Additionally, temporary restricted areas will be established for any areas which may contain radioactive material or exceed airborne effluent or external radiation limits.

- COGEMA proposes to relocate sample point IR-1 which is currently located approximately ten feet downwind from the plant building. The new proposed location is approximately 50 meters from the building. The proposed new location is in accordance with the guidance contained in NRC Regulatory Guide 4.14, "Radiological Effluent and Environmental Monitoring at Uranium Mills" and is depicted in Figure 5.5 (in pocket).

- COGEMA proposes to continue sampling at sample location IR-13 and discontinue sampling at location IR-4. Station IR-13 is in accordance with the guidance contained in NRC Regulatory Guide 4.14, "Radiological Effluent and Environmental Monitoring at Uranium Mills" and is depicted in Figure 5.5.

- Isokinetic sampling of the yellowcake dryer stack will be conducted on a semi-annual basis. The stack sample will be analyzed for Unat, thorium-230, radium-226 and lead-210. ◂R1

- A summary of the proposed airborne effluent and environmental monitoring program is provided in Tables 5-22 and 5-23.

5.8.2 GROUNDWATER AND SURFACE WATER MONITORING PROGRAM

Program Description

During past operations at the Irigaray and Christensen Ranch facilities, a detailed water sampling program was conducted to identify any potential impacts to water resources of the area. COGEMA's operational water monitoring program included the evaluation of groundwater on a regional basis, groundwater within individual well fields within the permit or licensed area and surface water on a regional and site specific basis. These programs are described in more detail following.

TAL .23
IRIGARAY ENVIRONMENTAL AIRBORNE EFFLUENT MONITORING PROGRAM

	SAMPLE COLLECTION					SAMPLE ANALYSIS	
MONITORED CONSTITUENT	NO.	LOCATION	TYPE	FREQUENCY	METHOD	FREQUENCY	PARAMETER
Air (Radon)	5	1. One directly upwind from restricted area boundary, IR-3	Continuous	Quarterly exchange of cups	Terradex Trac-Etch Type F1 Cups or equivalent	Quarterly	Rn-222
		2. One downwind from restricted area boundary, IR-1					
		3. North Access Road, IR-4 (517 Test Site)					
		4. Irigaray Ranch, IR-5					
		5. Ridge Road Southeast, IR-6					
Air (Particulate)	5	Same locations as for radon (above): Employee house trailer, IR-13, may be substituted for IR-4	Continuous during dryer operation	Weekly	Composite air filter sample	Quarterly	Uranium Ra-226 Th-230 Pb-210
	1	Yellowcake dryer stack	Isokinetic	Semi-Annually	40 CFR 60	Semi-Annually	Uranium Ra-226 Th-230 Pb-210

5.8.2.1 Regional Groundwater Monitoring

Historical Results

Approximately six (6) stock watering and domestic water wells are located within two kilometers of the Christensen Ranch mining area and one well is located near Irigaray. Baseline data from these wells were collected prior to mining for reference to operational sampling results. Grab samples of groundwater from these wells were collected on a quarterly frequency when the wells were operational, with the exception of Willow No. 2 at Irigaray, where there is only a semi-annual sampling requirement. Groundwater monitoring results were submitted in the semi-annual activity and monitoring reports submitted to NRC. A summary table of regional groundwater monitoring results for Irigaray and Christensen Ranch since 1987 can be found in Table 5.24. As can be seen from Table 5.24, no variances are seen which can be attributed to the mining operations.

Proposed Program

COGEMA proposes to institute the same regional groundwater monitoring program during future operations, with the exception that only five of the six Christensen ◂R1
Ranch regional wells will be sampled. This is because the Del Gulch Well No. 3 is an ◂R1
old windmill and normally inoperative. Table 5.25 summarizes the proposed regional groundwater sampling program.

5.8.2.2 Mine Unit Groundwater Monitoring

Historical Results

At both the Irigaray and Christensen Ranch sites, monitor wells are completed in a minimum of three different stratigraphic horizons for monitoring the containment of mining solutions in the wellfields during operations. At Irigaray, monitor wells are completed in the overlying aquifer (Unit 1 Sand), the underlying aquifer (deep zone), and in the ore zone (Upper Irigaray Sandstone). Additionally, ore zone trend wells were installed at Irigaray in 1978 and 1979 and are located between the wellfield and the monitor well ring. And, trend wells are located in the coal zone, a strata overlying the production zone. The coal zone was the original overlying monitor zone at Irigaray, but due to hydrologic connections to the ore zone, the coal zone was incorporated into the production zone in 1980. The original coal zone monitor wells have since been treated as overlying trend wells for the ore zone. Installed monitor well spacing and frequency existing at Irigaray is as follows:

TABLE 5.25
IRIGARAY AND CHRISTENSEN RANCH ENVIRONMENTAL GROUNDWATER AND SURFACE WATER MONITORING PROGRAMS

	SAMPLE COLLECTION			SAMPLE ANALYSIS		
CONSTITUENT	LOCATION	TYPE	FREQUENCY	METHOD	FREQUENCY	PARAMETER
Regional Groundwater	Christensen Ranch 1. Christensen Ranch House No. 3 2. Ellendale No. 4 3. Willow Corral No. 32 4. First Artesian No. 1 5. Middle Artesin No. 2 Irigaray 1. Willow No. 2	Grab	Quarterly	Pumped or bailed; downhole submersible pump or windmill	Quarterly	Uranium, Ra-226, Th-230, Pb-210, Po-210
Groundwater	Monitor Wells: Ore Zone Perimeter Upper Aquifer Lower Aquifer	BASELINE Grab	4 samples each spaced two weeks apart	Downhole submersible pump	4 samples each spaced two weeks apart	One sample - Assay Suite A[1] Three samples Assay Suite B[2] Water levels
	Monitor Wells: Ore Zone Perimeter Upper Aquifer Lower Aquifer	OPERATIONAL MONITORING Grab	Twice per month	Downhole submersible pump	Twice per month	Assay Suite C[3] Water levels
	Mine Unit Baseline Wells (For definition of restoration goals)	BASELINE Grab	4 samples each spaced two weeks apart	Downhole submersible pump	4 samples each spaced two weeks apart	Two samples - Assay Suite A[1] Two samples - Assay Suite B[2] Water levels

1. Assay Suite A = Ca, Mg, Na, K, CO_3, HCO_3, SO_4, Cl, NH_4 (as N), NO_2 + NO_3 (as N), F, Si, TDS, Conductivity, Total Alkalinity (as $CaCO_3$), pH, Al, As, Ba, Bo, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, V, Zn, U, Ra-226.
2. Assay Suite B = TDS, SO_4, Cl, Conductivity, Total Alkalinity, pH, As, Se, U, Ra-226
3. Assay Suite C = Excursion parameters: Cl, Conductivity, Total Alkalinity

TABLE 5.26

INDIVIDUAL MONITOR WELL UPPER CONTROL LIMITS and TREND WELL ACTION LIMITS IRIGARAY RANCH

Monitor Wells

Well No.	Location	Upper Control Limit			Well No.	Location	Upper Control Limit		
		Cl mg/l	Cond umho/cm	Alk mg/l $HCO_3 + CO_3$			Cl mg/l	Cond umho/cm	Alk mg/l $HCO_3 + CO_3$
Perimeter Ore Zone									
M2	Mine Unit 2	18.0	685	131.1	M26	Mine Unit 7	14.6	596	113.9
M4	Mine Unit 2	18.1	671	100.4	M27	Mine Unit 7	15.2	625	105.8
M7	Mine Unit 1	17.5	679	109.8	M28	Mine Unit 8	15.5	715	110.9
M10	Mine Unit 4	17.5	701	132.3	M29	Mine Unit 8	16.1	702	109.8
M17	Mine Unit 1	17.1	724	111.7	M30	Mine Unit 9	15.2	704	105.5
M18	Mine Unit 1	17.0	719	109.8	M31	Mine Unit 9	15.6	690	107.2
M19	Mine Unit 3	17.0	651	116.7	M32	Mine Unit 9	16.1	707	107.4
M23	Mine Unit 5	17.0	614	106.6	M33	Mine Unit 9	15.9	686	112.0
M24	Mine Unit 6	14.5	632	119.4	RS27	Mine Unit 5	16.9	646	101.2
M25	Mine Unit 6	15.5	692	111.9	16-151	Mine Unit 9	16.0	702	110.2
					T31	Mine Unit 1	21.8	779	106.1
Shallow Sand									
SSM2	Mine Unit 1	20.3	2075	128.4	SSM19	Mine Unit 8	13.7	1636	114.1
SSM3	Mine Unit 2	38.5	1451	219.1	SSM34	Mine Unit 9	13.2	1698	110.4
SSM4	Mine Unit 2	23.5	883	275.5	SSM35	Mine Unit 9	14.4	1688	132.7
SSM5	Mine Unit 3	21.5	825	254.9	SSM36	Mine Unit 9	13.7	1565	119.6
SSM6	Mine Unit 4	16.3	2445	122.2	SSM37	Mine Unit 7	14.3	1813	120.0
SSM7	Mine Unit 5	17.1	2604	119.4	SSM38	Mine Unit 7	16.2	2800	118.8
SSM8	Mine Unit 5	16.6	2389	112.2	SSM39	Mine Unit 7	14.5	2071	104.4
SSM9	Mine Unit 6	15.0	2008	117.8	SSM40	Mine Unit 8	13.6	1672	109.2
SSM10	Mine Unit 6	15.5	1955	177.4	SSM41	Mine Unit 4	24.9	2566	126.8
SSM11	Mine Unit 6	16.2	2784	122.9	SSM42	Mine Unit 3	23.3	1571	213.2
SSM18	Mine Unit 8	14.7	1849	119.4	SSM43	Mine Unit 1	25.6	1456	170.4

TABLE 5.26

INDIVIDUAL MONITOR WELL UPPER CONTROL LIMITS and TREND WELL ACTION LIMITS IRIGARAY RANCH

Monitor Wells - cont'd

Well No.	Location	Upper Control Limit			Well No.	Location	Upper Control Limit		
		Cl mg/l	Cond umho/cm	Alk mg/l $HCO_3 + CO_3$			Cl mg/l	Cond umho/cm	Alk mg/l $HCO_3 + CO_3$
Deep Sand									
DM1	Mine Unit 1	16.2	609	207.4	DM14	Mine Unit 8	15.5	619	109.5
DM2	Mine Unit 1	15.1	757	187.1	DM15	Mine Unit 9	15.1	618	110.6
DM3	Mine Unit 2	15.8	677	240.9	DM16	Mine Unit 9	15.7	646	111.0
DM4	Mine Unit 4	14.4	603	117.6	DM17	Mine Unit 5	15.0	618	108.2
DM5	Mine Unit 2	15.7	675	206.0	DM18	Mine Unit 4	14.5	598	105.6
DM9	Mine Unit 5	16.3	647	132.7	DM19	Mine Unit 3	31.7	1207	245.3
DM10	Mine Unit 6	16.4	606	107.5	DM20	Mine Unit 3	17.5	609	135.6
DM11	Mine Unit 7	15.0	607	104.7	DM21	Mine Unit 7	15.6	628	126.7
DM13	Mine Unit 8	15.1	624	113.5	DM22	Mine Unit 6	15.1	654	117.0

TABLE 5.26

INDIVIDUAL MONITOR WELL UPPER CONTROL LIMITS and TREND WELL ACTION LIMITS IRIGARAY RANCH

Trend Wells - cont'd

Well No.	Location	Action Limit			Well No.	Location	Action Limit		
		Cl mg/l	Cond umho/cm	Alk mg/l as $HCO_3 + CO_3$			Cl mg/l	Cond umho/cm	Alk mg/l as $HCO_3 + CO_3$
Perimeter Ore Zone									
E118	Mine Unit 2	85.2			T39	Mine Unit 7	20.6		
M1	Mine Unit 1	22.8			T40	Mine Unit 7	20.8		
M12	Mine Unit 6	23.6			T41	Mine Unit 7	20.4		
M14	Mine Unit 1	22.2			T42	Mine Unit 7	21.0		
M15	Mine Unit 5	27.2			T43	Mine Unit 7	20.8		
RS26	Mine Unit 4	23.0			T44	Mine Unit 7	21.4		
T3	Mine Unit 1	93.4			T45	Mine Unit 7	20.6		
T8	Mine Unit 1	90.2			T46	Mine Unit 7	21.2		
T12	Mine Unit 2	23.8			T47	Mine Unit 8	21.2		
T17	Mine Unit 4	27.0			T48	Mine Unit 8	22.4		
T18	Mine Unit 3	25.2			T49	Mine Unit 8	21.4		
T23	Mine Unit 5	24.2			T50	Mine Unit 8	21.0		
T24	Mine Unit 3	26.0			T51	Mine Unit 8	21.4		
T25	Mine Unit 2	27.4			T52	Mine Unit 9	21.4		
T27	Mine Unit 4	26.4			T53	Mine Unit 9	21.4		
T29	Mine Unit 5	20.2			T54	Mine Unit 9	21.4		
T32	Mine Unit 1	33.4			T55	Mine Unit 9	21.0		
T33	Mine Unit 1	22.8			T56	Mine Unit 9	22.2		
T34	Mine Unit 6	21.2			T57	Mine Unit 9	21.0		
T35	Mine Unit 5	27.0			T58	Mine Unit 9	21.4		
T36	Mine Unit 6	21.0			T59	Mine Unit 9	21.4		
T37	Mine Unit 6	21.0			T60	Mine Unit 9	22.0		
T38	Mine Unit 6	20.8			T61	Mine Unit 9	21.6		
					T62	Mine Unit 9	22.4		

TABLE 5.26

INDIVIDUAL MONITOR WELL UPPER CONTROL LIMITS and TREND WELL ACTION LIMITS IRIGARAY RANCH

Trend Wells - cont'd

Well No.	Location	Action Limit			Well No.	Location	Action Limit		
		Cl mg/l	Cond umho/cm	Alk mg/l as $HCO_3 + CO_3$			Cl mg/l	Cond umho/cm	Alk mg/l as $HCO_3 + CO_3$
Interior Coal Zone									
RS19	Mine Unit 3	56.0			SM15	Mine Unit 6	56.0		
RS34	Mine Unit 2	56.0			SM16	Mine Unit 6	56.0		
RS39	Mine Unit 3	56.0			SM17	Mine Unit 5	56.0		
RS84	Mine Unit 4	56.0			SM18	Mine Unit 7	56.0		
SM1	Mine Unit 1	56.0			SM19	Mine Unit 7	56.0		
SM2	Mine Unit 1	56.0			SM23	Mine Unit 8	56.0		
SM4	Mine Unit 4	56.0			SM24	Mine Unit 8	56.0		
SM7	Mine Unit 2	56.0			SM25	Mine Unit 8	56.0		
SM9	Mine Unit 5	56.0			SM26	Mine Unit 9	56.0		
SM10	Mine Unit 6	56.0			SM27	Mine Unit 9			
SM11	Mine Unit 7	56.0			SM28	Mine Unit 9	56.0		

Units 1 through 3: Operational Status Restored
Sampling Frequency Once every two months

Units 4 through 9: Operational Status In Restoration
Sampling Frequency Monthly

TABLE 5.27

INDIVIDUAL MONITOR WELL UPPER CONTROL LIMITS and TREND WELL ACTION LIMITS CHRISTENSEN RANCH

Monitor Wells

Well No.	Location	Upper Control Limit			Well No.	Location	Upper Control Limit		
		Cl mg/l	Cond umho/cm	Alk mg/l as $HCO_3 + CO_3$			Cl mg/l	Cond umho/cm	Alk mg/l as $HCO_3 + CO_3$
Perimeter Ore Zone									
MW17-2	Mine Unit 3	13.4	777	129.7	MW75	Mine Unit 2	13.6	823	121.3
MW18	Mine Unit 3	13.4	777	129.7	MW76	Mine Unit 2	13.6	823	121.3
MW19	Mine Unit 3	13.4	777	129.7	MW77	Mine Unit 2	13.6	823	121.3
MW20	Mine Unit 3	13.4	777	129.7	MW78	Mine Unit 2	13.6	823	121.3
MW23	Mine Unit 3	13.4	777	116.3	MW79	Mine Unit 2	13.6	823	121.3
MW24	Mine Unit 3	13.4	777	116.3	MW80	Mine Unit 2	13.6	823	121.3
MW25	Mine Unit 3	13.4	777	129.7	MW81	Mine Unit 2	13.6	823	121.3
MW26	Mine Unit 3	13.4	777	129.7	MW82	Mine Unit 2	13.6	823	121.3
MW27	Mine Unit 3	13.4	777	129.7	MW83	Mine Unit 2	13.6	823	121.3
MW28	Mine Unit 3	13.4	777	129.7	MW84	Mine Unit 2	13.6	823	121.3
MW29	Mine Unit 3	13.4	777	129.7	MW85	Mine Unit 2	13.6	823	121.3
MW30	Mine Unit 3	13.4	777	129.7	MW86	Mine Unit 2	13.6	823	121.3
MW31	Mine Unit 3	13.4	777	129.7	MW87	Mine Unit 2	13.6	823	121.3
MW32	Mine Unit 3	13.4	777	129.7	MW88	Mine Unit 2	13.6	823	121.3
MW35	Mine Unit 3	13.4	777	129.7	MW89	Mine Unit 2	13.6	823	121.3
MW36	Mine Unit 3	13.4	777	129.7	MW90	Mine Unit 2	13.6	823	121.3
MW37	Mine Unit 3	13.4	777	129.7	MW101	Mine Unit 2	11.6	778	124.6
MW38	Mine Unit 3	13.4	777	129.7	MW102	Mine Unit 2	11.6	778	124.6
MW39	Mine Unit 3	13.4	777	129.7	MW103	Mine Unit 2	11.6	778	124.6
MW40	Mine Unit 3	13.4	777	129.7	MW104	Mine Unit 2	11.6	778	124.6
MW41	Mine Unit 3	13.4	777	129.7	MW105	Mine Unit 2	11.6	778	124.6
MW42	Mine Unit 3	13.4	777	129.7	MW106	Mine Unit 2	11.6	778	124.6
MW43	Mine Unit 3	13.4	777	129.7	MW107	Mine Unit 2	11.6	778	124.6
MW44	Mine Unit 3	13.4	777	129.7	MW108	Mine Unit 2	11.6	778	124.6
MW45	Mine Unit 3	13.4	777	129.7	MW109	Mine Unit 2	11.6	778	124.6
MW62	Mine Unit 3	13.4	777	129.7	MW110	Mine Unit 2	11.6	778	124.6
MW63	Mine Unit 3	13.4	777	129.7	MW111	Mine Unit 2	11.6	778	124.6
MW64	Mine Unit 3	13.4	777	129.7	MW114	Mine Unit 2	13.4	777	129.7
MW73	Mine Unit 2	13.6	823	121.3	MW115	Mine Unit 2	13.4	777	129.7
MW74	Mine Unit 2	13.6	823	121.3	MW116	Mine Unit 2	13.4	777	129.7

TA[illegible] 5.27

INDIVIDUAL MONITOR WELL UPPER CONTROL LIMITS and TREND WELL ACTION LIMITS CHRISTENSEN RANCH

Monitor Well - cont'd

Well No.	Location	Upper Control Limit			Well No.	Location	Upper Control Limit		
		Cl mg/l	Cond umho/cm	Alk mg/l as $HCO_3 + CO_3$			Cl mg/l	Cond umho/cm	Alk mg/l as $HCO_3 + CO_3$
Perimeter Ore Zone (cont.)									
4MW-1	Mine Unit 4	11.1	825	116.9	5MW7	Mine Unit 5	22.7	1004	134.3
4MW-2	Mine Unit 4	11.1	825	116.9	5MW8	Mine Unit 5	23.0	1423	122.5
4MW-3	Mine Unit 4	11.1	825	116.9	5MW10	Mine Unit 5	22.7	1004	134.3
4MW-4	Mine Unit 4	11.1	825	116.9	5MW12	Mine Unit 5	22.8	1725	145.4
4MW-5	Mine Unit 4	11.1	825	116.9	5MW14	Mine Unit 5	22.7	1004	134.3
4MW-6	Mine Unit 4	11.1	825	116.9	5MW16	Mine Unit 5	22.7	1004	134.3
4MW-7	Mine Unit 4	11.1	825	116.9	5MW18	Mine Unit 5	22.7	1004	134.3
4MW-8	Mine Unit 4	11.1	825	116.9	5MW20	Mine Unit 5	22.7	1004	134.3
4MW-9	Mine Unit 4	11.1	825	116.9	5MW30A	Mine Unit 5	22.7	1004	134.3
4MW-10	Mine Unit 4	11.1	825	116.9	5MW31	Mine Unit 5	22.7	1004	134.3
4MW-11	Mine Unit 4	11.1	825	116.9	5MW32A	Mine Unit 5	22.7	1004	134.3
4MW-12	Mine Unit 4	11.1	825	116.9	5MW33	Mine Unit 5	22.7	1004	134.3
4MW-13	Mine Unit 4	11.1	825	116.9	5MW34	Mine Unit 5	22.7	1004	134.3
4MW-14	Mine Unit 4	11.1	825	116.9	5MW35A	Mine Unit 5	22.7	1004	134.3
4MW-15	Mine Unit 4	11.1	825	116.9	5MW36	Mine Unit 5	22.7	1004	134.3
4MW-16	Mine Unit 4	11.1	825	116.9	5MW37	Mine Unit 5	22.7	1004	134.3
4MW-17	Mine Unit 4	11.1	825	116.9	5MW38	Mine Unit 5	22.7	1004	134.3
4MW-18	Mine Unit 4	11.1	825	116.9	5MW39A	Mine Unit 5	22.7	1004	134.3
4MW-19	Mine Unit 4	11.1	825	116.9	5MW40	Mine Unit 5	22.7	1004	134.3
4MW-20	Mine Unit 4	11.1	825	116.9	5MW41A	Mine Unit 5	22.7	1004	134.3
4MW-21	Mine Unit 4	11.1	825	116.9	5MW42	Mine Unit 5	22.7	1004	134.3
4MW-22	Mine Unit 4	11.1	825	116.9	5MW43	Mine Unit 5	22.7	1004	134.3
4MW-23	Mine Unit 4	11.1	825	116.9	5MW44	Mine Unit 5	22.7	1004	134.3
4MW-24	Mine Unit 4	11.1	825	116.9	5MW46	Mine Unit 5	22.7	1004	134.3
4MW-25	Mine Unit 4	11.1	825	116.9	5MW47B	Mine Unit 5	22.7	1004	134.3
5MW1	Mine Unit 5	22.7	1004	134.3	5MW48	Mine Unit 5	22.7	1004	134.3
5MW2	Mine Unit 5	22.7	1004	134.3	5MW49	Mine Unit 5	22.7	1004	134.3
5MW3	Mine Unit 5	22.7	1004	134.3	5MW50	Mine Unit 5	22.7	1004	134.3
5MW4	Mine Unit 5	22.7	1004	134.3	5MW51	Mine Unit 5	22.7	1004	134.3
5MW5	Mine Unit 5	22.7	1004	134.3	5MW52	Mine Unit 5	22.7	1004	134.3
5MW6	Mine Unit 5	22.7	1004	134.3	5MW53	Mine Unit 5	22.7	1004	134.3

TABLE 5.27

INDIVIDUAL MONITOR WELL UPPER CONTROL LIMITS and TREND WELL ACTION LIMITS CHRISTENSEN RANCH

Monitor Well - cont'd

Well No.	Location	Upper Control Limit			Well No.	Location	Upper Control Limit		
		Cl mg/l	Cond umho/cm	Alk mg/l as $HCO_3 + CO_3$			Cl mg/l	Cond umho/cm	Alk mg/l as $HCO_3 + CO_3$
Perimeter Ore Zone (cont'd)									
5MW54	Mine Unit 5	22.7	1004	134.3	5MW62	Mine Unit 5	22.7	1004	134.3
5MW55	Mine Unit 5	22.7	1004	134.3	5MW63	Mine Unit 5	22.7	1004	134.3
5MW56	Mine Unit 5	22.7	1004	134.3	5MW64	Mine Unit 5	22.7	1004	134.3
5MW57	Mine Unit 5	22.7	1004	134.3	5MW65	Mine Unit 5	24.9	734	128.1
5MW58	Mine Unit 5	22.7	1004	134.3	5MW66	Mine Unit 5	22.7	1004	134.3
5MW59	Mine Unit 5	22.7	1004	134.3	5MW67	Mine Unit 5	22.7	1004	134.3
5MW60	Mine Unit 5	23.7	779	191.3	5MW69	Mine Unit 5	22.7	1004	134.3
5MW61	Mine Unit 5	22.7	1004	134.3					
Shallow Sand									
MW46S	Mine Unit 3	13.5	1087	184.4	MW98S	Mine Unit 2	63.4	21365	5861.3
MW48S	Mine Unit 3	22.2	1775	268.3	MW100S	Mine Unit 2	23.5	3560	304.0
MW50S	Mine Unit 3	22.2	1775	268.3	MW112S	Mine Unit 2	63.4	21365	5861.3
MW52S	Mine Unit 3	22.2	1775	268.3	MW117S	Mine Unit 2	13.6	768	144.5
MW54S	Mine Unit 3	22.2	1775	268.3	4SM-1	Mine Unit 4	8.8	1570	142.7
MW56S	Mine Unit 3	13.5	1087	184.4	4SM-4	Mine Unit 4	8.8	1570	142.7
MW58S	Mine Unit 3	13.5	1087	184.4	4SM-8	Mine Unit 4	8.8	1570	142.7
MW66S-2	Mine Unit 3	22.2	1775	129.7	4SRM-07	Mine Unit 4	19.4	1175	447.1
MW68S	Mine Unit 2	23.5	3560	304.0	5SM1	Mine Unit 5	22.1	2922	316.6
MW70S	Mine Unit 2	63.4	21365	5861.3	5SM2	Mine Unit 5	22.1	2922	316.6
MW72S	Mine Unit 2	63.4	21365	5861.3	5SM3	Mine Unit 5	22.1	2922	316.6
MW92S	Mine Unit 2	23.5	3560	304.0	5SM5	Mine Unit 5	22.1	2922	316.6
MW94S	Mine Unit 2	23.5	3560	304.0	5SM6	Mine Unit 5	22.1	2922	316.6
MW96S	Mine Unit 2	23.5	3560	304.0	5SM7	Mine Unit 5	22.1	2922	316.6

TABLE 5.27

INDIVIDUAL MONITOR WELL UPPER CONTROL LIMITS and TREND WELL ACTION LIMITS CHRISTENSEN RANCH

Monitor Well - cont'd

Well No.	Location	Upper Control Limit			Well No.	Location	Upper Control Limit		
		Cl mg/l	Cond umho/cm	Alk mg/l as $HCO_3 + CO_3$			Cl mg/l	Cond umho/cm	Alk mg/l as $HCO_3 + CO_3$
Deep Sand									
MW45D	Mine Unit 3	13.7	753	153.3	MW97D	Mine Unit 2	13.8	723	143.3
MW47D	Mine Unit 3	13.7	753	153.5	MW99D	Mine Unit 2	13.8	723	143.3
MW49D	Mine Unit 3	13.7	753	153.5	MW113D	Mine Unit 2	13.8	723	143.3
MW51D	Mine Unit 3	13.7	753	153.3	4DM-1	Mine Unit 4	14.1	712	189.2
MW53D	Mine Unit 3	13.7	753	153.3	4DM-4	Mine Unit 4	14.1	712	189.2
MW55D	Mine Unit 3	13.7	753	153.3	4DM-8	Mine Unit 4	14.1	712	189.2
MW57D	Mine Unit 3	13.7	753	153.3	4DRM-07	Mine Unit 4	14.1	712	189.2
MW65D	Mine Unit 3	13.7	753	129.7	5DM1A	Mine Unit 5	22.8	1017	420.9
MW67D	Mine Unit 2	12.9	789	134.0	5DM2	Mine Unit 5	22.8	1017	420.9
MW69D	Mine Unit 2	12.9	789	134.0	5DM3	Mine Unit 5	22.8	1017	420.9
MW71D	Mine Unit 2	12.9	789	134.0	5DM4	Mine Unit 5	22.8	1017	420.9
MW91D	Mine Unit 2	12.9	789	134.0	5DM5	Mine Unit 5	22.8	1017	420.9
MW93D	Mine Unit 2	12.9	789	134.0	5DM7	Mine Unit 5	22.8	1017	420.9
MW95D	Mine Unit 2	12.9	789	134.0	5DM8T	Mine Unit 5	22.7	1004	134.3
5DM9T	Mine Unit 5	NOT BASELINED							

TABLE 5.27

INDIVIDUAL MONITOR WELL UPPER CONTROL LIMITS and TREND WELL ACTION LIMITS CHRISTENSEN RANCH

Trend Wells - cont'd

Well No.	Location	Upper Control Limit			Well No.	Location	Upper Control Limit		
		Cl mg/l	Cond umho/cm	Alk mg/l as $HCO_3 + CO_3$			Cl mg/l	Cond umho/cm	Alk mg/l as $HCO_3 + CO_3$
Perimeter Ore Zone									
MW78T	Mine Unit 2	13.6	823	121.3	MW87T	Mine Unit 2	13.6	823	121.3
5TW-1	Mine Unit 5	NOT BASELINED							

Units 2, 4 and 5: Operational Status Active
Sampling Frequency Every 2 Weeks

Unit 3: Operational Status Standby
Sampling Frequency Every 2 Weeks

analytical list of chloride, conductivity and total alkalinity. An excursion was considered concluded when the concentrations of excursion indicators did not exceed the criteria defining an excursion for three consecutive one-week samples.

Proposed Excursion Verification and Monitoring Program

The proposed excursion verification and monitoring program for both the Irigaray and Christensen Ranch sites is the same as noted above for Christensen Ranch, except that upper control limits for all monitor wells at the Irigaray and Christensen Ranch sites will be calculated as follows:

Chloride -	baseline mean plus 15 mg/l, or baseline mean plus 5 standard deviations, whichever is greater	◂R1
Total Alkalinity -	baseline mean plus 5 standard deviations	
Conductivity -	baseline mean plus 5 standard deviations	

Group upper control limits for each stratigraphic unit within each mine unit will continue to be calculated as well. The method for removal of outliers from the water quality data base will also be the same as noted above.

5.8.2.4 Surface Water Monitoring

Program Description and Historic Results

The pre-operational water quality monitoring program assessed water quality and quantity for the Willow Creek drainage and tributaries within and immediately adjacent to the Irigaray and Christensen Ranch boundaries. During operations, COGEMA sampled four surface water locations at Irigaray and three at Christensen Ranch. Quarterly grab samples were taken from upstream (IR-14) and downstream (IR-9) Willow Creek monitoring stations at Irigaray. Additionally, a sample was collected quarterly at station IR-17, adjacent to the operating well fields. Annually, samples were also collected from the Powder River at the Irigaray Ranch, downstream from the confluence with Willow Creek (IR-5). At Christensen, samples were collected downstream from the well field operations (GS-01), upstream from the operations (CG-05) and adjacent to Mine Unit 3 (GS-03). Samples from all locations except IR-5 were obtained quarterly on a runoff event basis as Willow Creek is an ephemeral stream. IR-5 is obtained annually. Surface monitoring results are submitted in the semi-annual activity and monitoring reports submitted to the WDEQ and NRC. A summary of the past regional surface water monitoring results is given in Table 5.28.

Proposed Surface Water Monitoring Program

No changes to the current surface water monitoring program are recommended. A summary of the proposed program is given in Table 5.25.

5.8.3 EVAPORATION POND LEAK DETECTION MONITORING

The brine evaporation and restoration ponds at both Irigaray and Christensen Ranch are lined and equipped with a leak detection system. During operations, the leak detection standpipes are checked for evidence of leakage on a weekly frequency. Visual inspection of the pond embankments, fences and liners and the measurement of pond freeboard are performed on the same frequency. Anytime six (6) inches or more of fluid is detected in a leak detection system standpipe, a sample of the solution is obtained and analyzed for chloride, conductivity, pH and uranium. Should the analyses indicate that the pond is leaking (by comparison to chemical analyses of pond water), the following actions are taken:

- The WDEQ and USNRC are notified by telephone within 48 hours of leak verification.

- The level of the leaking pond is lowered by transferring its contents into an adjacent pond, or a pond within the pond system. While lowering the water level in the pond, inspections of the liner are made to determine the cause and location of the leakage. The area of investigation first centers around the pond area specific for the particular standpipe which contains fluid.

- Once the source of the leakage is found, the liner is repaired and water is reintroduced to the pond to check the adequacy of the repair. Water in the leak detection standpipes is monitored on a daily basis while refilling the pond.

- A written report is submitted to the WDEQ and USNRC within 30 days of correcting the leakage. The report includes analytical data and describes the cause of the leakage, corrective actions taken and the results of those actions.

Because the permeate storage ponds are unlined and will contain water which meets NPDES surface discharge criteria, leak detection systems are not installed. Water quality in the permeate storage ponds is sampled on a quarterly frequency and analyzed for uranium, radium-226 (dissolved), pH, TDS, chloride, conductivity and zinc. Water quality in the brine evaporation ponds is sampled on a quarterly basis and analyzed for uranium, radium-226, pH, TDS, chloride, conductivity, sulfate, ammonium (NH4), nitrate (NO3) and zinc. Results of the quarterly assays are reported to the WDEQ and NRC in the semi-annual reports.

<u>COGEMA will maintain the same evaporation pond leak detection monitoring program, as is currently in place, for future operations</u>. ◂R1

3. Potentiometric surface maps for the ore zone, the overlying aquifer and the underlying aquifer as developed from pre-mining water levels.

4. Monitor well upper control limits.

5. Location and completion details for monitor wells and ore zone baseline water quality wells.

6. Average mine unit baseline water quality and proposed restoration target values.

7. If a mine unit is in an area where no previous baseline hydrologic data is available, the results of a multi-well aquifer test will be submitted. The test will define the aquifer properties within the affected area including average and directional transmissivity, permeabilities, hydrologic boundary conditions, and vertical confinement of the mining zone. An analysis of whether an excursion can be retrieved from a monitor well within the 60-day regulatory timeframe will be conducted, if the aquifer properties are significantly different than others identified in previous mine units.

The SERP review procedure for new mine units will involve the evaluation of the following information to assure that: ◂R1

- The new mine unit is within the licensed area;
- Wells have been constructed pursuant to the application and applicable Standard Operating Procedures, including the spacing and density requirements for monitor wells;
- Mechanical integrity tests have been conducted for each operational well in the new mine unit;
- Baseline water quality has been properly established for all monitor and restoration wells;
- Upper Control Limits have been correctly established for monitor wells;
- Target Restoration Values have been established; and
- Hydrologic parameters have been confirmed.

The SERP will follow Standard Operating Procedure No. PBL-2, "Performance-Based License Condition: Revise and Evaluation of New Wellfields", for their detailed evaluation of the above information. ◂

5.10.2 NON-ROUTINE REPORTS

In the event that a report of a non-routine incident becomes necessary, COGEMA will follow specific reporting procedures for that incident as identified by the particular regulatory agency. In most cases, both the WDEQ and NRC are notified by telephone within 24 to 48 hours of verified monitor well excursions, pond leakage, significant spills, tank ruptures, or any other incidents that would trigger the reporting requirements provided in 10 CFR 20, Subpart M. Written reports will follow such telephone reports within the timeframes discussed in this application, or by other requirements imposed by the regulatory agency.

preparation and construction of the various components of the mining operation. It is probable that the irregular and often narrow well field disturbances may, in some cases, enhance wildlife habitat for certain species by creating an increased edge effect along the perimeter and by adding temporary diversity to the area. Domestic livestock grazing may be temporarily interrupted on the operating areas.

7.1.1 PROCESS FACILITIES AND POND CONSTRUCTION

The Irigaray/Christensen Ranch terrain will be disturbed temporarily where the ponds and plant facilities are placed, along sections of newly constructed access roads and where buried process lines are installed. Estimates and actual acreage of disturbance are provided for Irigaray and Christensen Ranch sites in Section 3.0. After groundwater restoration has been accomplished, the facilities will be decommissioned as described in Section 6.2 and the surface disturbances reclaimed according to the reclamation plan, Section 6.3.

7.1.2 WELL FIELD DISTURBANCES

Well field installations at the Irigaray site consist of 30 acres of production well fields, and a small area associated with the 517 R&D site (less than one acre of well field area). Within the current permit area, two to three additional mine units may be feasible; Production Unit Ten is planned for installation at the 517 site.

Well field installations at the Christensen Ranch site will cause the majority of the surface disturbance created during mining. Well field mine units will, however, be disturbed to a lesser degree than other installations and will be withdrawn from grazing for a shorter period of time than other facilities. The surface disturbance of well field mining units will be reclaimed and returned to grazing use sequentially once the groundwater restoration has been approved. Mine units will continue to be installed to achieve and maintain the plant recovery rate (annual average of 4,000 gpm at Christensen). When the initial mine unit is depleted (mined out), restoration will commence and will continue sequentially as areas are mined out. The mining sequence will continue through the completion of mining, with the mine units being rotated back to various stages of restoration, and surface reclamation returning them to livestock production. ◂R1

The total area disturbed by well fields at any given time will vary according to the mining schedule and the size of the mine units in operation. The amount of disturbance in a given well field will depend on surface relief and the degree of disturbance necessary for efficient installation and operation of the mine unit.

Each unit will be disturbed for three to six years before surface reclamation is conducted. This time includes approximately three years for mining, and up to three years for groundwater restoration and stability monitoring. After surface reclamation has been achieved, the areas will be returned to grazing use.

A spill prevention, control and countermeasure (SPCC) plan is in place for the Irigaray and Christensen Ranch sites. Although EPA only requires this plan for oil or raw petroleum fuel products, COGEMA has expanded our plan to include all stored chemicals. The plan is addressed in *Standard Operating Procedures SPCC-1, Inspection of Facilities, and SPCC-2, Spill Response.*

7.6 ECONOMIC AND SOCIAL EFFECTS OF CONSTRUCTION AND OPERATION ◂R1

7.6.1 BENEFIT-COST SUMMARY

The Irigaray facilities were constructed in Johnson County, Wyoming in 1978. The Christensen Ranch satellite plant and first wellfield were constructed in 1988 and 1989, with subsequent wellfields added in the years 1993 through present. As both facilities have been in existence for quite some time, the obvious benefits from the operations are those inherent in the value of the uranium recovered, and the resulting kilowatt-hours of electricity produced from the uranium. Impacts to the local community infrastructure have been small, and long absorbed since the initial construction of the Irigaray plant in 1978. This is due to the small labor force at the mine sites, and that the majority of the construction is performed by site personnel.

Other social and economic benefits from these operations are associated with taxes paid to the county and state, as well as employment opportunities for local employees, contractors and associated businesses. A summary of the local and state spending for the Irigaray and Christensen Ranch operations and associated sales tax paid during the past three years is as follows:

Year	Spending	Sales Tax
1996	$15,910,771	$493,123
1995	$14,129,993	$506,276
1994	$11,409,030	$293,918

Production and property taxes paid to Johnson and Campbell counties over the equivalent three year period of 1994 through 1996 amounted to $867,067. State mineral severance tax was paid for a five month period from October, 1996 through February, 1997. The mineral severance tax is only applicable when the spot price of uranium averages over $14.00 per pound for a minimum six month period. As the price of uranium increases over time, more severance tax will be paid on produced uranium. And lastly, Wyoming operations payroll, excluding benefits, for the past two and one-half year period (1995 through the first half of 1997) was $5,593,550.

The above economic benefits are very quantifiable. These benefits must be compared against environmental costs for which there is no directly related compensation. For

this project, the environmental costs are essentially three: potential groundwater impact, radiological impact and disturbance of the land surface. The radiological impacts of the on-going project will be small, and all radioactive wastes will eventually be removed off-site. The disturbance of the land surface is also a small, temporary impact, as all of the disturbed land will be reclaimed after the project is decommissioned and will become available for the pre-mining uses. Groundwater impacts could potentially occur if restoration operations were totally unsuccessful, but previous experience with groundwater restoration shows that the groundwater can and will, at a minimum, be returned to a quality of use equal to or better than, and consistent with, the uses for which the water was suitable prior to mining.

It is COGEMA's conclusion that the short-term and long-term environmental impacts and costs from the continued Christensen and Irigaray ISL projects are very small, as these impacts will be mitigated through the course of routine operations. Conversely, the benefits of continuing the operations are quite high, considering the energy value of the uranium produced and the economic benefits to the residents of the State of Wyoming in terms of salaries, revenues and services. Consequently, if the project is not renewed for continued operations, the State of Wyoming, Johnson and Campbell Counties, and local communities such as Buffalo, Wyoming, will suffer substantial economic losses. It is COGEMA's recommendation that the project has, and will continue to have, a substantive beneficial impact to the state and local community that far outweighs the minimal environmental impacts seen on a temporary basis, and that Source Material License SUA-1341 should be renewed to allow continued operation of the Irigaray and Christensen Ranch ISL projects.

ATTACHMENT 7.3(A)

USNRC ATTACHMENT A
TABLE 7.3(A)-1

SITE SPECIFIC INFORMATION
CHRISTENSEN RANCH

PARAMETER	VALUE
Average ore quality, U_3O_8, in ore body	0.094%
Ore Radon-222 activity, assuming equilibrium with U-238	265 pCi/g
Operating days per year (plant factor)	365 days
Dimensions of ore body	
Area per year to be mined	40 acres
Average thickness of body	12.0 feet (3.7 meters)
Average production flow rate	3600 gpm
Formation porosity	28%
Process recovery	95%
Leaching efficiency	60%
Rock density	1.91 g/cm^3
Restoration flow rate	500 gpm
Production cell parameters	
Residence time (Production)	8.7 days
Residence time (Restoration)	30 days
Type of cell pattern	Mixture of 5 spots
Average cell area	5,000 ft^2
Average cell flow rate	38 lpm
Annual Rn-222 emission from production	1471 Ci/yr
Annual Rn-222 emission from restoration	258 Ci/yr
Annual Rn-222 emission from start-up	44 Ci/yr
Source stack description (Radon)	plant vent
Stack height	23.0 ft (7.0 meters)
Stack diameter	0.25 ft (0.08meters)
Stack exit velocity	218 m/sec

TABLE 7.3(A)-2
SOURCE AND RECEPTOR COORDINATES
CHRISTENSEN RANCH

Source Name	X (km)	Y (km)	Z (km)	
MU 3	0.15	-0.08	1.00	
MU 4	0.65	-2.10	1.00	
MU 5A	2.13	-2.93	1.00	
MU 5B	1.79	-2.67	1.00	
Plant	0.00	0.00	7.01	
Receptor Name	**X (km)**	**Y (km)**	**Z (km)**	**Distance (km)**
AS-1	-3.66	-0.46	0.00	3.69
AS-5A	0.01	-0.05	0.00	0.06
AS-5B	-0.01	0.01	0.00	0.02
AS-6	3.51	-3.73	0.00	5.12
100m North	0.00	0.10	0.00	0.10
100m East	0.10	0.00	0.00	0.10
100m South	0.00	-0.10	0.00	0.10
100m West	-0.10	0.00	0.00	0.10
100m Upwind	0.07	-0.07	0.00	0.10
100m Downwind	-0.07	0.07	0.00	0.10
200m North	0.00	0.20	0.00	0.20
200m East	0.20	0.00	0.00	0.20
200m South	0.00	-0.20	0.00	0.20
200m West	-0.20	0.00	0.00	0.20
200m Upwind	0.14	-0.14	0.00	0.20
200m Downwind	-0.14	0.14	0.00	0.20
240 deg @ 725m	-0.72	-0.38	0.00	0.82
270 deg @ 5500m	-5.49	0.00	0.00	5.49
330 deg @ 5100m	-4.00	3.05	0.00	5.03
345 deg @ 2050m	-0.84	1.83	0.00	2.01
45 deg @ 3350m	2.36	2.29	0.00	3.29
80 deg @ 4725m	4.57	1.22	0.00	4.73

TABLE 7.3(A)-3

CALCULATION OF ANNUAL RADON EMISSIONS
CHRISTENSEN RANCH

1) To calculate Radon release from leaching assuming that U-238 is in equilibrium with all its decay products:

$$Ci/m^3 = 265\ pCi/g\ ore \times 1.91\ g/cm^3 \times 0.2 \times 0.72/0.28 \times 10^{-6}$$
$$= 2.60 \times 10^{-4}\ Ci/m^3$$

Where:
- 0.2 = Emanating Power
- 0.72 = 1 - Porosity
- 0.28 = Porosity

The yearly release is then:

$$2.60 \times 10^{-4}\ Ci/m^3 \times 13626\ lpm \times (0.79) \times 365\ d/yr \times 1.44 = 1471\ Ci/yr$$

Where:
- 13626 = liters per minute
- $\in = 1 - e^{-(\lambda t)}$
- $\in = 1 - e^{-(0.1812)(8.7\ days)}$
- $\in = 1 - 0.21$
- $\in = 0.79$
- 1.44 = constant

2) The Radon release from start-up is given by:

$$2.60 \times 10^{-4}\ Ci/m^3 \times 40\ acres \times 4074\ m^2/acre \times 3.7\ m \times 0.28 = 44\ Ci/yr$$

Where:
- 4074 = m^2/acre
- 3.7 = Thickness of orebody in meters
- 0.28 = Porosity

The total release of Radon from the start-up solution and production lixiviant solution is:

Start-up solution	44 Ci/yr
Production	1471 Ci/yr
	1515 Ci/yr

3) The Radon release from restoration is given by:

$$2.60 \times 10^{-4}\ Ci/m^3 \times 1893\ lpm \times 365\ d/yr \times (0.996) \times 1.44 = 258\ Ci/yr$$

258 Ci/yr + 44 (start-up) = 302 Ci/yr total release

Where:	3785	=	Restoration flow in liters per minute
	$\in$	=	$1 - e^{-(\lambda t)}$
	$\in$	=	$1 - e^{-(0.1812)(30\ days)}$
	$\in$	=	1 - 0.004
	$\in$	=	0.996
	1.44	=	constant

The total release from this 40 acre in-situ mining operation is then:

Production	1471 Ci/yr
Start-up	44 Ci/yr
Restoration (Includes Start-up)	302 Ci/yr
	1817 Ci/yr

4) Actual Radon Release to the Environment

4.1) Production

The average annual flow at Christensen Ranch will be 3600 gpm during production. During production the 3600 gpm of recovery solution will be processed using a pressurized fixed bed ion exchange process to remove the uranium. A worst case bleed stream of 125 gpm will be processed by reverse osmosis and approximately 60 gpm of this bleed will be sent to the evaporation pond and approximately 65 gpm will be sent to chemical make-up and will be reinjected into the formation. Radon losses to the environment will be minimal on the processing of the 3600 gpm since the recovered solution will be pressurized at all times above ground. The only Radon released to the environment should be from the 125 gpm bleed stream which will be at atmospheric conditions. This loss will be 3.5% of the Radon Source Term of 1515 Ci/yr or 53 Ci/yr.

Approximately 25% of the total Radon could be released during reinjection of the process solution. This Radon may be released in venting of the injection wells. The total source term for Radon from production Is 1515 Ci/yr (including start-up) and 25% of that will be 379 Ci/yr. The two mine units closest to the nearest resident are Mine Units 4 and 5 For example, the 25% could be derived from Mine Unit 4 operating at 1600 gpm, from which 168 Ci/yr of Radon will be released, and Mine Unit 5 operating at 2000 gpm, where 211 Ci/yr wil be released. After completion of mining in Mine Units 4 and 5 mining will be initiated in Mine Units 6 and 7 and will proceed as per the Mine Plan.

4.2) Restoration

The maximum restoration flow will be 500 gpm. Initially restoration will be conducted in Mine Unit 3 and the maximum dose to the nearest resident is expected to occur at this time. This assures ongoing production in Mine Units 4 and 5, with restoration in Mine Unit 3. The total Radon produced in restoration will be 302 Ci/yr and 25% of this total (76 Ci/yr) could be released in the wellfield and 75% (227 Ci/yr) could be released in the plant. It is not certain that 75% of the Radon will be released at the plant, but for purposes of this evaluation a 75% release will be conservatively estimated.

A summary of the actual Radon releases to the environment follows:

Process Building

Production Release	53 Ci/yr
Restoration Release	227 Ci/yr

Wellfields

Mine Unit #4	168 Ci/yr
Mine Unit #5	211 Ci/yr
Mine Unit #2 (Restoration)	76 Ci/yr
Total	735 Ci/yr

TABLE 7.3(A)-4

MISCELLANEOUS DATA
CHRISTENSEN RANCH

(1) Fraction of year during which cattle graze locally — Est. 33%

- The landowner has 300 cattle on a ranch of approximately 36,000 acres. The landowner conservatively estimates that the cattle would be within a 2 mile radius of the permit area no more than 4 months per year.

(2) Fraction of cattle feed obtained by grazing — Est. 90%

- The landowner advised that virtually all (90%) cattle feed is obtained by grazing.

(3) Fraction of stored cattle feed grown locally — Est. 90% of the remaining 10%

- The landowner advised that the hay used as stored cattle feed is at least 90% grown locally.

(4) Acreage required to graze 1 animal unit — 3.5 ha

(450 kg) for one month (AUM)

- The acreage required for one AUM was based on discussions with the Area Resource Management Section of the BLM office in Buffalo, Wyoming.

(5) Length of growing season — 4 mo/yr

- The length of the growing season is based on discussions with the landowner and personnel at the Fremont and Campbell County Soil Survey.

(6) Fraction of locally produced vegetables consumed locally — Est. 100%

- There are no commercial vegetable farms in the project area. Discussions with the landowner indicate that vegetables grown locally are consumed by the grower.

(7) Fraction of locally produced meat consumed locally Est. < 5%

- Discussions with the landowner indicate that almost all of the cattle are sent to markets outside of the local area.

(8) Fraction of locally produced milk consumed locally Est. 100%

- Discussions with the landowner indicate that there are no commercial milk producers in the area and that any milk produced is for local consumption.

The above estimates were based on personal communication with the landowner or the agency identified. Details of each estimate are found above.

TABLE 7.3(A)-5

SITE SPECIFIC INFORMATION
IRIGARAY

PARAMETER	VALUE
Average ore quality, U_3O_8, in ore body	0.12%
Ore Radon-222 activity, assuming equilibrium with U-238	338 pCi/g
Operating days per year (plant factor)	365 days
Dimensions of ore body	
Area per year to be mined	28 acres
Average thickness of body	12.0 feet (3.7 meters)
Average production flow rate	2400 gpm
Formation porosity	27%
Process recovery	95%
Leaching efficiency	60%
Rock density	1.93 g/cm^3
Restoration flow rate	500 gpm
Production cell parameters	
Residence time (Production)	8.4 days
Residence time (Restoration)	40 days
Type of cell pattern	Variable
Average cell area	5,000 ft^2
Average cell flow rate	38 lpm
Annual Rn-222 emission from production	1315 Ci/yr
Annual Rn-222 emission from restoration	351 Ci/yr
Annual Rn-222 emission from start-up	40 Ci/yr
Source stack description (Radon)	plant vent
Stack height	25.0 ft (7.6 meters)
Stack diameter	0.25 ft (0.08 meters)
Stack exit velocity	104 m/sec

TABLE 7.3(A)-6

SOURCE AND RECEPTOR COORDINATES
IRIGARAY

Source Name	X (km)	Y (km)	Z (km)	
MU 4-9	-6.44	7.85	1.00	
MU 10	-6.71	9.22	1.00	
MU 11-12	-7.24	9.91	1.00	
Plant	-7.11	9.22	7.62	
Thermal Dryer	-7.09	9.22	18.90	
Receptor Name	**X (km)**	**Y (km)**	**Z (km)**	**Distance (km)**
IR-1	-7.18	9.28	0.00	11.73
IR-3	-7.05	9.22	0.00	11.61
IR-4	-7.09	10.06	0.00	12.30
IR-5	-9.22	15.09	0.00	17.68
IR-6	-6.02	8.50	0.00	10.41
50m North of TD	-7.09	9.27	0.00	11.67
50m East of TD	-7.04	9.22	0.00	11.60
50m South of TD	-7.09	9.17	0.00	11.59
50m West of TD	-7.14	9.22	0.00	11.66
50m Upwind of TD	-7.05	9.19	0.00	11.58
50m Downwind of TD	-7.13	9.26	0.00	11.68
100m North of TD	-7.09	9.32	0.00	11.71
100m East of TD	-6.99	9.22	0.00	11.57
100m South of TD	-7.09	9.12	0.00	11.55
100m West of TD	-7.19	9.22	0.00	11.69
100m Upwind of TD	-7.02	9.15	0.00	11.53
100m Downwind of TD	-7.16	9.29	0.00	11.73
200m North of TD	-7.09	9.42	0.00	11.79
200m East of TD	-6.89	9.22	0.00	11.51
200m South of TD	-7.09	9.02	0.00	11.47
200m West of TD	-7.29	9.22	0.00	11.75
200m Upwind of TD	-6.95	9.08	0.00	11.43
200m Downwind of TD	-7.23	9.36	0.00	11.83
500m North of TD	-7.09	9.72	0.00	12.03
500m East of TD	-6.59	9.22	0.00	11.33
500m South of TD	-7.09	8.72	0.00	11.24

TABLE 7.3(A)-7

CALCULATION OF ANNUAL RADON EMISSIONS
IRIGARAY

1) To calculate Radon release from leaching assuming that U-238 is in equilibrium with all its decay products:

$$Ci/m^3 = 338\ pCi/g\ ore \times 1.93\ g/cm^3 \times 0.2 \times 0.73/0.27 \times 10^{-6}$$
$$= 3.53 \times 10^{-4}\ Ci/m^3$$

Where:
- 0.2 = Emanating Power
- 0.73 = 1 - Porosity
- 0.27 = Porosity

The yearly release is then:

$$3.53 \times 10^{-4}\ Ci/m^3 \times 9084\ lpm \times (0.78) \times 365\ d/yr \times 1.44 = 1315\ Ci/yr$$

Where:
- 9084 = liters per minute
- $\in = 1 - e^{-(\lambda t)}$
- $\in = 1 - e^{-(0.1812)(8.4\ days)}$
- $\in = 1 - 0.22$
- $\in = 0.78$
- 1.44 = constant

2) The Radon release from start-up is given by:

$$3.530 \times 10^{-4}\ Ci/m^3 \times 28\ acres \times 4074\ m^2/acre \times 3.66\ m \times 0.27 = 40\ Ci/yr$$

Where:
- 4074 = m^2/acre
- 3.66 = Thickness of orebody in meters
- 0.27 = Porosity

The total release of Radon from the start-up solution and production lixiviant solution is:

Start-up solution	40 Ci/yr
Production	1315 Ci/yr
	1355 Ci/yr

3) The Radon release from restoration is given by:

3.53×10^{-4} Ci/m^3 x 1893 lpm x 365 d/yr x 1.00 x 1.44 = 351 Ci/yr
351 Ci/yr + 40 Ci/yr (start-up) = 391 Ci/yr total release

Where:	1893	=	Restoration flow in liters per minute
	$\in$	=	$1 - e^{-(\lambda t)}$
	$\in$	=	$1 - e^{-(0.1812)(40\ days)}$
	$\in$	=	1.0
	1.44	=	constant

The total release from this 28 acre in-situ mining operation is then:

Production	1315 Ci/yr
Start-up	40 Ci/yr
Restoration (Includes Start-up)	391 Ci/yr
	1746 Ci/yr

4) Actual Radon Release to the Environment

4.1) Production

The production flow rate at the Irigaray Site will be 2400 gpm and the total source term for Radon will be 1355 Ci/yr. Approximately 25% of the total Radon will be released in the wellfield due to venting and the 25% will be equal to 339 Ci/yr. It is anticipated that the wellfield release will be equally distributed over Mine Unit 10 and a combination of Mine Units 11 and 12, in future development areas to the north of the current Irigarary plant site.

The production flow of 2400 gpm will report to the process building for separation of the uranium. The uranium will be separated by passing the recovery solution through pressurized fixed bed downflow ion exchange units. Since the recovered solution will be pressurized at all times in the uranium recovery process virtually none of the contained Radon will be released to the environment. The only Radon that will be released to the environment will be for the up to 125 gpm bleed stream (worst case) that is used for the process bleed and for chemical make-up. The up to 125 gpm bleed will be 5.2% of the production flow and therefore 5.2% of the production source term of 1355 Ci/yr could potentially be released to the environment. The actual Radon release from the plant would then be 70 Ci/yr.

4.2) Restoration

The maximum restoration flow will be 500 gpm. Initially restoration activities will be conducted in Mine Units 4 through 9. The total restoration source term for 500 gpm will be 391 Ci/yr and it is estimated that 25% (98 Ci/yr) of the source term will be released in the wellfield by venting and 75% (293 Ci/yr) of the source term will potentially be released at the process plant. It is not certain that 75% of the Radon will be released at the process plant, but for purposes of this evaluation a 75% release will be conservatively estimated.

A summary of the actual Radon releases to the environment follows:

Process Building

Production Release	70 Ci/yr
Restoration Release	293 Ci/yr

Wellfields

Mine Unit #10	170 Ci/yr
Mine Units #11,#12	170 Ci/yr
Mine Units #4-9 (Restoration)	98 Ci/yr
Total	801 Ci/yr

TABLE 7.3(A)-8

YELLOWCAKE DRYING AND PROCESSING EMISSIONS IRIGARAY

PARAMETER	VALUE
Processing Rates for dry/pack	285 lbs/hr
Estimated annual production	2,500,000 lbs/yr
Estimated production purity, % UO_3/UO_4 by weight[1]	95%
Airborne effluent concentrations	9900 uci U-238 per year[2] 26.8 uci Ra-226 per year 80.5 uci Pb-210 per year 23.1 uci Th-230 per year
Dry/pack stack height (above ground)	62 feet (18.9 m)
Stack diameter	1.33 feet (0.41 m)
Airflow	2322 SCFM (65.76 m^3/min)
Stack velocity	12.3 m/sec

1. COGEMA performed x-ray diffraction studies on the bulk product from the drying operation and the composition of the product was determined to be 83.7% $UO_4.2H_2O$ and 16.3% UO_3. Samples of the scrubber water were also analyzed and the uranium in the scrubber water was determined to be 99.5% UO_3. Therefore stack effluents will be considered to be primarily UO_3.

2. Airborne effluents are based on a stack emissions survey conducted at the Irigaray site in December 1994. U-natural, Ra-226, Th-230 and Pb-210 were measured on the stack samples collected. The average U_3O_8-natural released on three tests was 40.9 lbs/yr with a standard deviation of 18.2 lbs/yr. For modeling purposes the average plus two standard deviations was used and this value is 77.3 lbs/yr. The pounds U_3O_8/yr was converted to uCi/yr using the following calculation:

(77.3 lbs U_3O_8/yr)x(0.848 U/U_3O_8)x(454 g/lb)x(3.33×10^{-7} Ci/g)x(1×10^6 uCi/Ci) = 9910 uCi/yr

The values for Ra-226, Th-230 and Pb-210 were calculated using the respective effluent data.

TABLE 7.3(A)-9

MISCELLANEOUS DATA
IRIGARAY

(1) Fraction of year during which cattle graze locally — Est. 33%

- The landowner has 250 cattle and 1500 sheep. The landowner conservatively estimates that the cattle and/or sheep would be within a 2 mile radius of the permit area no more than 4 months per year.

(2) Fraction of cattle feed obtained by grazing — Est. 90%

- The landowner advised that virtually all (90%) cattle feed is obtained by grazing.

(3) Fraction of stored cattle feed grown locally — Est. 90% of the remaining 10%

- The landowner advised that the hay used as stored cattle feed is at least 90% grown locally.

(4) Acreage required to graze 1 animal unit (450 kg) for one month (AUM) — 3.5 ha

- The acreage required for one AUM was based on discussions with the Area Resource Management Section of the BLM office in Buffalo, Wyoming.

(5) Length of growing season — 4 mo/yr

- The length of the growing season is based on discussions with the landowner and personnel at the Fremont and Campbell County Soil Survey.

(6) Fraction of locally produced vegetables consumed locally — Est. 100%

- There are no commercial vegetable farms in the project area. Discussions with the landowner indicate that vegetables grown locally are consumed by the grower.

(7) Fraction of locally produced meat consumed locally Est. < 5%

- Discussions with the landowner indicate that almost all of the cattle are sent to markets outside of the local area.

(8) Fraction of locally produced milk consumed locally Est. 100%

- Discussions with the landowner indicate that there are no commercial milk producers in the area and that any milk produced is for local consumption.

The above estimates were based on personal communication with the landowner or the agency identified. Details of each estimate are found above.

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Section 7.0

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Section 8.0

No References

Section 9.0

No References

Section 10.0

No References

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"Irigaray and Christensen Ranch Environmental Monitoring Station Locations."

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ATTACHMENT 2

Christensen Ranch Mine Unit 6
Statistical Analysis of Baseline Data

MINE UNIT 6 BASELINE WATER QUALITY		
Sample I.D.	Well Number	TDS @ 180 C
1	6026-1	864
2	6026-1	836
3	6026-1	820
4	6026-1	872
5	6AA41-1	872
6	6AA41-1	840
7	6AA41-1	856
8	6AA41-1	864
9	6AC35-1	856
10	6AC35-1	840
11	6AC35-1	840
12	6AC35-1	844
13	6AD61-1	868
14	6AD61-1	848
15	6AD61-1	840
16	6AD61-1	864
17	6AE33-1	800
18	6AE33-1	804
19	6AE33-1	820
20	6AE33-1	808
21	6AE44-1	856
22	6AE44-1	856
23	6AE44-1	860
24	6AE44-1	824
25	6AG48-1	772
26	6AG48-1	804
27	6AG48-1	780
28	6AG48-1	820
29	6AG68-1	888
30	6AG68-1	856
31	6AG68-1	800
32	6AG68-1	830
33	6AJ37-1	828
34	6AJ37-1	784
35	6AJ37-1	792
36	6AJ37-1	764
37	6AL31-1	924
38	6AL31-1	896
39	6AL31-1	904
40	6AL31-1	908
41	6AL35-1	928
42	6AL35-1	916
43	6AL35-1	928
44	6AL35-1	924
45	6AL40-1	924
46	6AL40-1	908
47	6AL40-1	908
48	6AL40-1	924
49	6AM36-1	900
50	6AM36-1	916
51	6AM36-1	924

52	6AM36-1	930
53	6A033-2	1000
54	6A033-2	976
55	6A033-2	928
56	6A033-2	972
57	6AO42-1	920
58	6AO42-1	884
59	6AO42-1	912
60	6AO42-1	892
61	6AP37-1	884
62	6AP37-1	904
63	6AP37-1	896
64	6AP37-1	920
65	6AQ46-1	864
66	6AQ46-1	928
67	6AQ46-1	892
68	6AQ46-1	955
69	6AQ52-1	868
70	6AQ52-1	888
71	6AQ52-1	912
72	6AQ52-1	920
73	6AQ56-1	1000
74	6AQ56-1	1032
75	6AQ56-1	1010
76	6AQ56-1	880
77	6AS47-1	920
78	6AS47-1	904
79	6AS47-1	910
80	6AT51-1	880
81	6AT51-1	916
82	6AT51-1	868
83	6AT51-1	915
84	6AT58-1	916
85	6AT58-1	904
86	6AT58-1	840
87	6AT58-1	940
88	6M29-1	856
89	6M29-1	816
90	6M29-1	852
91	6M29-1	856
92	6M34-1	828
93	6M34-1	848
94	6M34-1	840
95	6M34-1	836
96	6P30-2	856
97	6P30-2	876
98	6P30-2	852
99	6P30-2	860
100	6R21-1	848
101	6R21-1	808
102	6R21-1	824
103	6R21-1	876
104	6T17-1	824
105	6T17-1	828

106	6T17-1	808
107	6T17-1	832
108	6T23-1	824
109	6T23-1	828
110	6T23-1	836
111	6T23-1	820
112	6T35-1	836
113	6T35-1	844
114	6T35-1	836
115	6T35-1	828
116	6U20-2	796
117	6U20-2	828
118	6U20-2	800
119	6U20-2	832
120	6V24-1	852
121	6V24-1	884
122	6V24-1	836
123	6V24-1	888
124	6W33-1	840
125	6W33-1	864
126	6W33-1	832
127	6W33-1	852
128	6X26-1	800
129	6X26-1	808
130	6X26-1	808
131	6X26-1	828
132	NPHW-1	812
133	NPHW-1	776
134	NPHW-1	804
135	NPHW-1	792
136	NPHW-15	924
137	NPHW-15	932
138	NPHW-15	920
139	NPHW-15	928
140	NPHW-2	804
141	NPHW-2	764
142	NPHW-2	784
143	NPHW-2	772
144	NPHW-3A	828
145	NPHW-3A	820
146	NPHW-3A	836
147	NPHW-3A	820
148	NPHW-5	860
149	NPHW-5	820
150	NPHW-5	872
151	NPHW-5	856
152	NPHW-7	836
153	NPHW-7	844
154	NPHW-7	856
155	NPHW-7	856
156	NPOW-2	888
157	NPOW-2	872
158	NPOW-2	880
159	NPOW-2	888

160	NPOW-3	844
161	NPOW-3	832
162	NPOW-3	832
163	NPOW-3	800
164	NPPW-1	824
165	NPPW-1	812
166	NPPW-1	800
167	NPPW-1	808
AVERAGE		**861**
STDEVP		**50.75**
STDEV		**50.90**
SUMSQ		**124256482**
SUM		**143802**
n=167		

Mine Unit 6 ups of Baseline Wells

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10	Group 11
1	M34-1	T35-1	T17-1	6W33-1	6AE33-1	6AG48-1	6AL31-1	NPHW-3	6AO42-1	6AQ52-1	6AD61-1
2	M29-1	NPHW-	6U20-2	NPHW-2	NPHW-1	NPPW-1	6AL35-1	NPOW-2	6AQ46-1	6AQ56-1	NPHW-7
3	6026-1	T23-1	6V24-1	6AA41-1	6AE44-1	6AJ37-1	6AM36-1	6AO33-2	6AS47-1	6AT58-1	6AG68-1
4	6P30-2	R21-2	6X26-1	6AC35-1	NPOW-3	NPHW-15	6AL40-1	6AP37-1	6AT51-1		

Random Sampling of Mine Unit 6 Baseline Wells

Random Sampling #1		Random Sampling #2		Random Sampling #3		Random Sampling #4		Random Sampling #5	
1	M34-1	3	6026-1	4	6P30-2	4	6P30-2	2	M29-1
3	T23-1	3	T23-1	2	NPHW-5	3	T23-1	1	T35-1
1	T17-1	1	T17-1	3	6V24-1	3	6V24-1	2	U20-1
4	6AC35-1	1	6W33-1	3	6AA41-1	2	NPHW-2	4	6AC35-1
1	6AE35-1	3	6AE44-1	1	6AE33-1	1	6AE33-1	2	NPHW-1
4	NPHW-15	1	6AG48-1	3	6AJ37-1	1	6AG48-1	2	NPPW-1
3	6AM36-1	1	6AL31-1	4	6AL40-1	1	6AL31-1	2	6AL35-1
1	NPHW-3	1	NPHW-3	2	NPOW-2	3	6AO33-2	4	6AP37-1
3	6AS47-1	1	6AO42-1	4	6AT51-1	2	6AQ46-1	3	6AS47-1
3	6AT58-1	3	6AT58-1	3	6AT58-1	2	6AQ56-1	1	6AQ52-1
4	6AG68-1	1	6AD61-1	1	6AD61-1	3	6AG68-1	2	NPHW-7

Random Sampl			Random Sampling #2			Random Sampling #3			Random Sampling #4			Random Sampling #5		
Well No.	TDS @ 180C		Well No.	TDS @ 180C		Well No.	TDS @ 180C		Well No.	TDS @ 180C		Well No.	TDS@180C	
M34-1	828		6O26-1	864		6P30-2	856		6P30-2	856		M29-1	856	
	848			836			876			876			816	
	840			820			852			852			852	
	836			872			860			860			856	
T23-1	824		T23-1	824		NPHW-5	860		T23-1	824		T35-1	836	
	828			828			820			828			844	
	836			836			872			836			836	
	820			820			856			820			828	
T17-1	824		T17-1	824		6V24-1	852		6V24-1	852		U20-1	796	
	828			828			884			884			828	
	808			808			836			836			800	
	832			832			888			888			832	
6AC35-1	856		6W33-1	840		6AA41-1	872		NPHW-2	804		6AC35-1	856	
	840			864			840			764			840	
	840			832			856			784			840	
	844			852			864			772			844	
6AE33-1	800		6AE44-1	856		6AE33-1	800		6AE33-1	800		NPHW-1	812	
	804			856			804			804			776	
	820			860			820			820			804	
	808			824			808			808			792	
NPHW-15	924		6AG48-1	772		6AJ37-1	828		6AG48-1	772		NPPW-1	824	
	932			804			784			804			812	
	920			780			792			780			800	
	928			820			764			820			808	
6AM36-1	900		6AL31-1	924		6AL40-1	924		6AL31-1	924		6AL35-1	928	
	916			896			908			896			916	
	924			904			908			904			928	
	930			908			924			908			924	
NPHW-3	828		NPHW-3	828		NPOW-2	888		6AO33-2	1000		6AP37-1	884	
	820			820			872			976			904	
	836			836			880			928			896	
	820			820			888			972			920	
6AS47-1	920		6AO42-1	920		6AT51-1	880		6AQ46-1	864		6AS47-1	920	
	904			884			916			928			904	
	910			912			868			892			910	
6AT58-1	916			892			915			955		6AQ52-1	868	
	904		6AT58-1	916		6AT58-1	916		6AQ56-1	868			888	
	840			904			904			888			912	
	940			840			840			912			920	
6AG68-1	888			940			940			920		NPHW-7	836	
	856		6AD61-1	868		6AD61-1	868		6AG68-1	888			844	
	800			848			848			856			856	
	830			840			840			800			856	
				864			864			830				
AVERAG	**859**		**AVERAGE**	**853**		**AVERAGE**	**862**		**AVERAGE**	**860**		**AVERAGE**	**856**	
STDEV	**45**		**STDEV**	**39**		**STDEV**	**40**		**STDEV**	**59**		**STDEV**	**44**	

STATISTICAL ANALYSIS
Mine Unit 6 Baseline Water Quality Data

STATISTICS:

Student's t Distribution: $t = \frac{\chi - \mu_o}{s / \sqrt{n}}$

where χ = sample mean
μ_o = population mean
s = sample standard deviation
n = sample size

Two tailed test: $\alpha = .05$, $t_{.025}$

Hypothesis: $\chi = \mu_o$

Reference: Mendenhall, William. Introduction to Probability and Statistics, 4th Edition; Wadsworth Publishing, Co., 1975.

DATA:

μ_o = 861 mg/l TDS @ 180° C

Random Sampling #1: $t = \frac{859 - 861}{45\sqrt{43}} = -0.29$

Reject hypothesis when $t > 1.96$ or $t < -1.96$ ($t_{\alpha/2} = .025$, d.f. = 42)
∴ Accept hypothesis

Random Sampling #2: $t = \frac{853 - 861}{39\sqrt{44}} = -1.36$

Reject hypothesis when $t > 1.96$ or $t < -1.96$ ($t_{\alpha/2} = .025$, d.f. = 43)
∴ Accept hypothesis

Random Sampling #3: $t = \frac{862 - 861}{40\sqrt{44}} = 0.17$

Reject hypothesis when $t > 1.96$ or $t < -1.96$ ($t_{\alpha/2} = .025$, d.f. = 43)
∴ Accept hypothesis

Random Sampling #4: $t = \frac{860 - 861}{59\sqrt{44}} = 0.11$

Reject hypothesis when $t > 1.96$ or $t < -1.96$ ($t_{\alpha/2} = .025$, d.f. = 43)
∴ Accept hypothesis

Random Sampling #5: $t = \frac{856 - 861}{44\sqrt{44}} = 0.75$

Reject hypothesis when $t > 1.96$ or $t < -1.96$ ($t_{\alpha/2} = .025$, d.f. = 42)
∴ Accept hypothesis

ATTACHMENT 3

Historical Restoration Summaries

IRIGARAY - 5I7

HISTORY

1. Three (3) large 5-spot patterns
2. Mined with ammonium bicarbonate: 1975-77
3. Tried combination of various treatment methods targeted at ammonium reversal.
4. Restoration: 1988

RESTORATION SUMMARY

PVD	Restoration Process
1.7	Mg lixiviant - exchange Mg with NH_4
1.8	TDS reduction - lime softening to remove HCO_3, Mg, Ca
0.5	Uranium reduction - high pH sweep to reduce uranium (precip. as insoluble calcium diurante), possibly radium
2.0	TDS reduction - R.O.
0.2	Final GWS
6.2	TOTAL

DETERMINATIONS

- 4.5 PVD of treatment for parameters other than NH_4
  - 45% R.O.
  - 40% Lime Softener
  - 11% High pH Flush
  - 4% GWS

- Parameters restored to essentially baseline - 63%:
  TDS, Na, SO_4, CO_3, NO_2, SiO_2, pH, Al, As, Ba, B, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Mo, Ni, V, Zn

- Parameters not restored to baseline, within WY Class I Drinking Water - 31%:
  Ca, Mg, HCO_3, Cl, F, Tot. Alk., U, Se, NO_3, Cond., K

- Exceeds Baseline, Class I Standards - 6%:
  NH_4, Ra-226

	Class I	Baseline	Restored	Mining
Ra-226 (pCi/l)	5.0	26.8	146.0	1370.0
NH_4 (mg/l)	0.5	<1.0	19.0	400.0
			50.0 (Target Value)	

IRIGARAY - E-Field

HISTORY

1. 12 patterns mined with sodium bicarbonate: 1980
2. Restoration 1: 1981
3. Restoration 2: 1984-85

RESTORATION SUMMARY

Restoration 1

PVD	Restoration Process
7.8	Clean water recycle utilizing ion exchange Anion exchange: Cl, SO_4, HCO_3, Uranium Cation exchange: Ca, Mg, Na, etc. High pH adjustment prior to injection Circulation

Class of use met on all parameters; baseline not met. Restoration not accepted by State of Wyoming. Said BPT was not used.

Restoration 2

PVD	Restoration Process
5.0	Reverse Osmosis Treatment
12.8	TOTAL

DETERMINATIONS

- Steady-state condition for conductivity approached after 3.5 PVD of R.O. treatment. Minimal change seen after next 1.5 PVD of Reverse Osmosis treatment.

- Parameters restored to baseline - 83%:
  Ca, Mg, Na, K, CO_3, SO_4, NO_3, TDS, pH, As, Ba, B, Cd, Cr, Cu, Fe, Pb, Hg, Mo, Ni, Se, V, Zn, NH_4, Ra-226

- Parameters not restored to baseline, within WY Class I Drinking Water - 17%:
  HCO_3, Cl, F, U, Mn

- Exceeds Baseline and Class of Use - 0%:
  None

CHRISTENSEN WILLOW CREEK R & D

HISTORY

1. Two (2) patterns mined with sodium bicarbonate: 1986
2. Restoration: 1987
3. Used as demonstration for Christensen License application

RESTORATION SUMMARY

PVD	Restoration Process
8.4	Groundwater Sweep
3.3	Reverse Osmosis
1.0	H_2S gas (reductant)
0.4	Recirculation
13.1	TOTAL

DETERMINATIONS

- Achieved an 83% reduction towards goal of 425 mg/l TDS after 8.4 PVD of GWS (2406 mg/l to 776 mg/l). However, left with reducing the 776 mg/l by 55% to reach 425 mg/l.

- Parameters restored to baseline - 65%:
  Ca, Mg, K, CO_3, NO_3, NO_2, F, SiO_2, pH, Al, Ba, B, Cd, Cr, Cu, Pb, Hg, Mo, Ni, V, Zn, NH_4

- Parameters not restored to baseline, within WY Class of Use (I) - 30%:
  HCO_3, Na, Cond., Tot. Alk., SO_4, As, Se, Fe, U, Mn

- Exceeds Baseline and Class of Use (I) - 5%:
  TDS, Ra-226

	Class I	Baseline	Restored
Ra-226 (pCi/l)	5.0	73.2	142 (average)
TDS (mg/l)	500.0	425.0	572 (last stability sample)

IRIGARAY UNITS 1 THROUGH 3

HISTORY

1. Operated on and off for four different episodes of mining, with downtime between episodes as long as 5 years, by four different operators: 1978-1990
2. 61 patterns mined with ammonium bicarbonate, sodium bicarbonate, CO_2, hydrogen peroxide, oxygen, pH ranges from 6.0 to 9.5.
3. Severe formation damage assumed by prolonged operations and calcite cementation.
4. First in situ mine in Wyoming licensed for commercial operations beginning in 1978.
5. Restoration: 1990-93

RESTORATION SUMMARY

PVD	Restoration Process
3.0	Groundwater Sweep
10.0	Reverse Osmosis
2.0	Reverse Osmosis with H_2S gas (reductant)
1.0	Recirculation
16.0	TOTAL

DETERMINATIONS

- Parameters restored to essentially baseline - 69%:
  Mg, K, SO_4, Cl, NO_2, NO_3, F, SiO_2, pH, Al, As, Ba, B, Cd, Cr, Cu, Fe, Pb, Hg, Mo, Ni, Se, V, Zn

- Parameters not restored to baseline, within Target Values or Class of Use -26%:
  Ca, Na, HCO_3, Cl, NH_4, Cond., Tot. Alk., U, Mn

- Parameters Exceeding Baseline and Class of Use - 5%:
  TDS, Ra-226

	Class I	Baseline	Restored
Ra-226 (pCi/l)	5.0	39.3	141
TDS (mg/l)	500.0	378.0	741

- Only an 8% reduction in TDS seen in the 3 PVD of GWS (2198 mg/l to 2054 mg/l) - baseline is 378 mg/l.
- Believe that initial affected area may have been larger than originally anticipated.
- PVDs No. 6, 9, 10, 11 and 12 (5 PVD) almost ineffective in reducing TDS levels
- Final circulation felt to be unnecessary.

TEXAS - EL MESQUITE E2 WELLFIELD

HISTORY

1. Mined with sodium bicarbonate.
2. Placed in restoration in 1986, completed in 1996.

RESTORATION SUMMARY

PVD	Restoration Process
2.4	GWS (1986 to 1992)
2.1	Reverse osmosis permeate injection (1992 to 1993)
1.1	GWS (1993 to 1995)
0.8	Reverse osmosis + freshwater sweep (May 1995 to December 1995)
6.4	TOTAL

DETERMINATIONS

- Parameters restored to essentially baseline - 54%:
  K, SO_4, CO_3, NO_3, SiO_2, pH, Cl, F, As, Cd, Fe, Pb, Hg, NH_4

- Parameters not restored to baseline, within Texas Drinking Water - 38%:
  Ca, Mg, Na, HCO_3, TDS, Tot. Alk., Mn, U, Mo

- Exceeds Baseline and Drinking Water Standards - 8%:
  Se, Ra-226

	TX DW	Baseline	Restored
Ra-226 (pCi/l)	5.0	22.6	44.0
Se (mg/l)	0.05	.003	.08

TEXAS - HOLIDAY H2 WELLFIELD

HISTORY

1. Mined with sodium bicarbonate.
2. Placed in restoration in 1986, completed in 1995.

RESTORATION SUMMARY

PVD	Restoration Process
3.0	GWS (1986 to 1992)
1.5	Reverse osmosis permeate injection (1992 to 1993)
1.0	GWS (1993 to 1995)
0.5	Reverse osmosis + freshwater sweep (March 1995 to May 1995)
6.0	TOTAL

DETERMINATIONS

- Parameters restored to essentially baseline - 65%:
  K, SO_4, CO_3, NO_3, SiO_2, pH, Cl, F, As, Cd, Fe, Pb, Mn, Hg, NH_4, Mo, Ra-226

- Parameters not restored to baseline, within Texas Drinking Water - 35%:
  Ca, Mg, Na, HCO_3, TDS, Cond., Tot. Alk., Se, U

- Exceeds Baseline and Drinking Water Standards - 0%:

TEXAS - WEST COLE WELLFIELD 1 (WF1)

HISTORY

1. Mined with sodium bicarbonate.
2. Placed in restoration in 1989, completed in 1996.

RESTORATION SUMMARY

PVD	Restoration Process
4.0	GWS
3.7	Reverse osmosis permeate injection
3.0	Reverse osmosis + freshwater injection
10.7	TOTAL

DETERMINATIONS

- Parameters restored to essentially baseline - 62%:
  K, SO_4, CO_3, NO_3, SiO_2, pH, Cl, F, As, Cd, Fe, Pb, Mn, Hg, NH_4, Ra-226

- Parameters not restored to baseline, within Texas Drinking Water - 38%:
  Ca, Mg, Na, HCO_3, TDS, Cond., Tot. Alk., Se, U, Mo

- Exceeds Baseline and Drinking Water Standards - 0%:

TEXAS - O'HERN GRID 3 WELLFIELD

HISTORY

1. Mined 1977 to 1986
2. Placed in restoration in 1989, completed in 1996.

RESTORATION SUMMARY

PVD	Restoration Process
6.3	GWS (1989 to 1995)
3.4	Reverse osmosis permeate injection (June 1995 to February 1996)
9.7	TOTAL

DETERMINATIONS

- All parameters were restored to essentially baseline.
- High high baseline values; one of first wellfields installed and operated.

RESTORATION SUMMARY - ALL WELLFIELDS

Wellfield	PVD GWS	PVD Cleanwater Sweep	PVD Reductant	PVD Recirculation	TOTAL PVD	% Parameters Meeting Baseline	% Parameters Meeting Drinking Water	% Parameters Exceeding Both
Wyoming 517	0.2	4.3	0	1.7	6.2	63	31	6
E-Field	0	12.8	0	Included	12.8	83	17	0
CR R&D	8.4	3.3	1.0	0.4	13.1	65	30	5
IR 1-3	3.0	10.0	2.0	1.0	16.0	69	26	5
Average	2.9	7.6	0.75	1.0	12.0	70	26	4
Texas E2	3.5	3.2	0	0	6.4	54	38	8
H2	4.0	2.0	0	0	6.0	65	35	0
WF1	4.0	6.7	0	0	10.7	62	38	0
G3	6.3	3.4	0	0	9.7	100	-	-
Average	4.5	3.8	0	0	8.2	70	28	2
OVERALL AVERAGE	**3.7***	**5.7***	**0.4**	**0.4**	**10.0**	**70**	**27**	**3**

*Feel that 5 PVD of cleanwater sweep is the most effective restoration technique, with 1 to 2 PVD of GWS = 6 to 7 PVD. Many of the PVD shown in the table were not effective at lowering water quality values. Can lower the PVD by better management of wellfields.