Cimarron Facility Closure

Responses to NRC Questions

Prepared for

Cimarron Corporation

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EXECUTIVE SUMMARY

In a meeting on March 1, 1990 at the NRC offices in Rockville, Maryland, the NRC requested additional information related to the Cimarron Site Investigation Report. Additional information was requested on nine specific areas. The Cimarron Corporation has collected additional information to respond to the NRC requests. The additional information, which includes field and laboratory data, calculations, and computer simulations, is included in the main body of this report.

The additional data collected indicate that the proposed facility closure is viable. Specifically, the additional studies completed by the Cimarron Corporation on the nine areas have demonstrated the following:

- Fracture Flow:

  Fracture flow was determined not to be an important component to ground-water flow at the Cimarron Facility. Fractures are not numerous, the intergranular permeability of the sandstones is large, and no influence of jointing can be seen in the shape of the piezometric surface.

- Unsaturated Ground-Water Flow:

  Shallow mudstones act as aquitards and influence the direction of movement of infiltrating water in the unsaturated zone. The mudstones slope to the west in the vicinity of the Option 2 landfill. The Cimarron Corporation is revising the design of the landfill to control and limit seepage into the landfill.

- Ground-Water Flow Directions:

  The Option 2 landfill is located on the spine of a north-south trending ridge. Shallow ground-water flow is similar to surface-water flow, and consequently, ground water in the vicinity of the Option 2 landfill may flow either to the east or to the west. Cimarron Corporation has conducted additional analyses of ground-water flow and potential for contaminant transport from the landfill to include the movement in either direction.

- Erosional Stability:

  The erosional stability of the proposed landfill has been modeled under long-term and extreme conditions. Calculations using the NRC draft guidance document, and simulations using the GLEAMS computer code, have been used to demonstrate stability. The calculations using NRC draft guidance show that the cell will not be subject to severe erosion during the PMP so long as the slope of the cell cover is less than about 6 percent if the cover is grassed, and less than about 1 percent if the cover is fallow. Erosion control practices followed in the area would protect the cell from erosion at slopes steeper that one percent while it is under cultivation.

  The GLEAMS analyses showed the average annual erosion from the cover to be about 5 tons/acre (0.03 inches) for fallow conditions and a 4 percent slope. Calculations for a specified occurrence of the PMP indicated an increase of about 60 tons/acre (0.33 inches) for the year during which the PMP occurred.

- Data Files:

  Copies of data files used by the Cimarron Corporation and its consult[illegible] have been included with this submittal to facilitate independent review by the staff.

- Uranium Mobility:

  Additional information explaining the mechanisms by which uranium migrates downgradient from the former waste management areas (now cleaned and closed) has been collected, and computer modeling of the chemical behavior of uranium in this environment has been completed. Uranium is more mobile downgradient of the former waste management areas because the waste management activities had altered the natural chemistry of the ground water. Because only soil contaminated with uranium that has been sorbed on the soil matrix is to be placed in the Option 2 burial ground, alteration of the ground water downgradient of the burial ground will not occur.

  The effects of the former waste management practices on the quality of ground water, and consequently, the mobility of uranium, downgradient from the former waste management areas decrease with distance from the former waste management areas because natural chemical reactions gradually mitigate the process-related impacts on ground-water quality.

- Future Land and Water Use:

  Population information and current water use data have been collected. Little population increase is projected. The data indicate that changes in current land and water use are unlikely.

- Pathways Analyses:

  Analyses have been made of the impacts radionuclides moving along exposure pathways may have on human health and the environment. These analyses indicate that the impacts both on human health and the environment are negligible.

- Volume Estimates:

  Cimarron Corporation has collected additional radiological data to refine the estimate of the volume of soil to be left at the facility under the provisions of Option 2 of the Branch Technical Position Paper. The data indicate that 3,500 cubic yards of soil will be left under 4 feet of clean soil. Approximately 15,000 cubic feet of soil will be relocated from the yard area to the designated Option 2 material disposal area.

1. PURPOSE OF STUDY

1.1. Introduction

This study responds to questions that NRC raised during their review of Cimarron's September 9, 1989 submittal and further outlined in a meeting with the NRC on March 1, 1990 at the NRC offices in Rockville, Maryland. At the March 1 meeting, the NRC commented on the Cimarron Site Investigation Report (September, 9, 1989) completed by James L. Grant & Associates (JLGA). The NRC requested additional information on several aspects of the report including:

1) documentation on the importance or lack of importance of jointing to groundwater flow in the site area,

2) information on the orientation of mudstone units in the unsaturated zone found in the vicinity of the Option 2 concentration soil disposal cell to determine if these mudstones might channel water into or out of the disposal cell,

3) a review of the direction of ground-water flow in the vicinity of the Option 2 landfill to determine the amount of ground-water flow in each direction from the Option 2 landfill,

4) information on the erosional stability of the Option 2 landfill cover,

5) copies of data files used by Kerr-McGee and its consultants to analyze uranium transport from the Option 2 landfill,

6) information explaining the mechanism(s) by which uranium has entered the ground-water system around former waste management areas, and a demonstration that these mechanisms and existing conditions will not promote large-scale mobilization and migration of uranium from the Option 2 landfill,

7) information used to make projections concerning future ground-water and land use, and

8) an analysis of all reasonable exposure pathways along which materials leaching from the landfill site might reach the public.

9) a revised estimate of the volume of soils to be placed in the Option 2 landfill.

1.2. Previous Investigation

On September 12, 1989, JLGA submitted a Site Investigation Report for the Cimarron Facility to Cimarron Corporation. This report was then formally transmitted to the NRC. The purpose of this investigation was to determine the impacts that facility production activities had on the local hydrologic system, and how these impacts might influence future exposure potential. Also investigated were the geotechnical properties of the native materials surrounding the proposed Option 2 landfill site.

Data from that report, and additional data collected to address the above-referenced NRC questions, are presented in the following sections.

1.3. Current Investigation

1.3.1. Stratigraphy

A detailed stratigraphic analysis of the shallow soils and rocks around the Option 2 landfill excavation was completed by JLGA. Thirty-four detailed stratigraphic sections were measured within the excavation. From these stratigraphic sections, several stratigraphic cross-sections were constructed. Figure 1 shows the locations of measured sections and locations of stratigraphic cross-sections. Figure 2 shows stratigraphic correlations for the east and west walls of the excavation.

Rocks found in the Option 2 landfill excavation at the Cimarron Facility comprise a portion of the Permian Garber Sandstone. The Garber sandstone either crops out or is found underlying a thin veneer of soil throughout the Cimarron facility. Rock types found in the proposed landfill area are dominantly sandstones and mudstones, and are covered by a thin layer of soil. The mudstones exposed in the Option 2 landfill, although important to the hydrology in the immediate vicinity, are relatively minor inclusions of limited extent within a predominantly sandstone unit. The rocks exposed in the Option 2 excavation, including the mudstones, were included in the Site Investigation Report within the unit identified as Sandstone A.

The mudstones are less permeable than the sandstones, and the mudstone surface slopes from west to east around the Option 2 landfill. The mudstones locally limit the downward flow water, causing it to be diverted laterally through the sandstones along the top of the mudstones.

1.3.1.1. Soil

The Garber Sandstone at the facility is capped by a veneer of soil which ranges in thickness from 6 to 36 inches. This soil is reddish-brown in color and dominated by silt, very fine sand, and clay-size material. The soils overlying the upper mudstone contain a large percentage of clay-size material, while those overlying the upper sandstone contain a large percentage of sand- and silt-size grains.

1.3.1.2. Mudstones

Two distinct mudstone layers are exposed in the Option 2 excavation area. These are described as Mudstone 1 and Mudstone 2. The mudstones are dark reddish-brown in color and generally massive, although some zones are thinly laminated. Laminations, if present, generally occur in the upper portions of an individual mudstone unit. Mudstone 1 shows no trend in grain size.

Mudstone 2 becomes finer-grained upward, grading from silty mudstone at the base into clay-dominated mudstone at the top. Mudstone 1 occurs in the southern part of the excavation directly above Sandstone 1 (Figure 2). Mudstone 2 is found throughout the excavation below Sandstone 1 and above Sandstone 2.

Light-green to bluish-gray "reduction" zones were found within all mudstone units. These reduction zones are present at every mudstone-sandstone contact and are also found at scattered intervals throughout individual mudstone units. These features are generally planar and range in thickness from less than 0.10 to over 6 inches. These light-green to bluish-gray zones are believed to reflect the reduction of ferric oxides to ferrous oxides.

The mudstones present in the excavation area, particularly Mudstone 2, typically retard water moving vertically, causing transient saturated or near-saturated conditions to develop, and local horizontal flow to occur in the sandstone. Where the mudstone surface in the area slopes toward the excavation, the flow in the sandstone may produce seeps in the excavation. A purpose of this investigation was to determine the extent and slope of the mudstones near the Option 2 burial area and to evaluate the possibility that seepage along the top of the mudstones would enter the excavation.

1.3.1.3. Sandstones

Sandstones identified in the Option 2 excavation are reddish-brown, fine- to very fine-grained quartz arenites. Individual sandstone units grade upward from fine-grained sand to very fine-grained sand to silt-size material. Sediment is dominated by well sorted, subrounded to rounded, subspherical, quartz grains. Feldspar, muscovite and mafic minerals are present, but are rare. The sum of these three constituents comprises less than about 10 percent of the rock. Particles are only lightly cemented by calcite or hematite. The combination of near-spherical grains and light cementation makes the sandstone units porous, permeable, and friable. Sedimentary structures include both large- and medium-scale, trough cross-bedding and small-scale, ripple-drift cross-stratification. Bedding may also be massive to thinly bedded in some areas. Large-scale trough cross beds are common and generally occur near the base of a given unit, with the scale of the cross-bedding becoming smaller upward within the unit. Near the top of individual sedimentation units, bedding generally becomes massive to thinly bedded. Small-scale ripple-drift cross-stratification is also present near the top of some sandstone units.

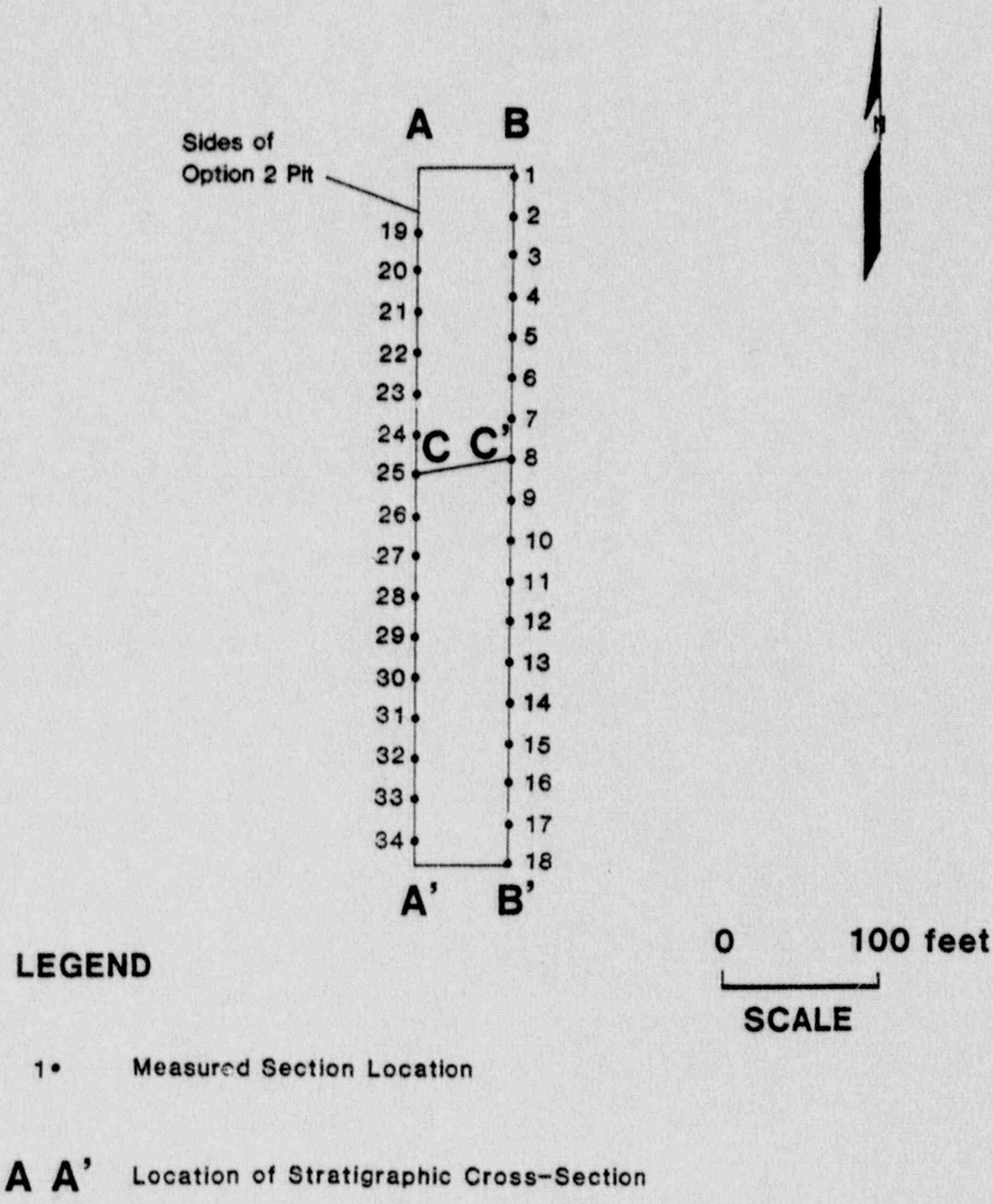

Figure 1: Locations of measured stratigraphic sections and stratigraphic cross-sections within waste landfill excavation.

2. PERCHED WATER

2.1. Data and Observations

The area surrounding the proposed Option 2 landfill area was investigated to determine whether the mudstones in the unsaturated zone might direct infiltrating water into the excavation. This investigation was aided by a substantial rainfall which occurred in the area immediately before the investigation was scheduled. This allowed direct observation of water movement in the unsaturated zone at the Option 2 pit walls.

Seepage was observed at the interface between sandstone units and underlying mudstone units on the western wall of the excavation (Figure 3). The western wall of the proposed Option 2 landfill is the most affected by seepage. Water also was observed seeping from the sandstones on the bluff facing the Cimarron River. As in the Option 2 landfill, seepage is confined to the contacts between sandstones and mudstones.

Rocks found in the vicinity of the Cimarron Facility were deposited in Permian time by a west-flowing fluvial-deltaic system. Because of the depositional environment, the upper surface of a given mudstone unit is uneven. This is shown by stratigraphic cross-sections A-A' and B-B' (Figure 2 - stratigraphy sections). The irregularity of the surface of the upper mudstone makes a detailed depiction of the upper mudstone impossible without a very large number of borings or additional test pits. However, cross-sections completed across the Option 2 pit excavation show that, in the immediate vicinity of the excavation, the upper sandstone and mudstone units dip toward the east. Figure 6 is a representative east-west stratigraphic cross-section showing this relationship.

On a larger scale, stratigraphic cross-sections constructed for the Site Investigation Report for the Cimarron Facility by JLGA show that sedimentary units dip gently to the northwest (Figures 5.1 and 5.2 from the aforementioned report). It is likely that the apparent eastward dip within the Option 2 excavation is an artifact of the slope of the mudstone surface, and is not related to the overall dip of the strata. Because the Option 2 landfill is located near the spine of a ridge, the extent of the shallow mudstones that are the subject of this study is limited by the ridge slopes to the east and west.

Immediately preceding the investigation of the excavation, the area received 4.7 inches of rainfall. This rain fell on March 11. In the week prior to this rainfall, the area received 1.1 inches of rainfall. Only a small volume of water was flowing out of the rock exposed on the walls of the excavation on the morning of March 12. By the end of the day however, more seepage was occurring on the western wall of the excavation. On March 13, seepage was still occurring on the western wall.

The reason for this seepage along the western wall is twofold. First, terracing resulted in water being ponded directly west of the landfill excavation at an elevation approximately equal to the elevation of the top of the excavation (Figure 2, A and B). Figure 5 shows that a larger influx of water occurs on the western wall than on the eastern wall. Second, the surface of the upper mudstone unit locally dips toward the northeast.

2.2. Conclusions

The following conclusions result from the study of the rocks in the landfill excavation:

1) The surface of the upper mudstone unit, which is a low-permeability layer and directs seepage into the excavation, is very irregular. It is not possible to map this surface accurately with the number of data points available, nor is it necessary given the observation of seeps after a significant rainfall.

2) Transient saturated or near-saturated conditions occur at the bottom of sandstones. The local northerly slope of the surface of the mudstone directs this water into the landfill excavation.

3) Seepage into the excavation is accelerated by terracing for erosion control and the associated ponding of water near the excavation.

4) Minor changes in land slopes around the Option 2 landfill can improve drainage, and prevent ponding around the landfill caused by the existing terraces. Erosional stability calculations presented in a later section of this report show that these changes can be accomplished without significant increases in succeptability to erosion.

5) With proper drainage around the Option 2 landfill, seepage along the mudstones into the landfill will be small. This seepage into the fill material can be eliminated by constructing an interceptor drain along the west side of the landfill to capture and divert the seepage around the landfill.

Figure 3: Photograph of contact between sandstone and underlying mudstone. Water emerges from wall at contact between sandstone and mudstone and collects at the base of the excavation. Photograph of western wall of landfill excavation; photo taken 13 March 1990.

A:

B:

Figure 4: Photographs of ponded water directly west of landfill excavation. A: Photograph looking northwest from landfill excavation showing large volumes of ponded water at approximately same elevation as top of excavation. Ponding of water is caused by terracing of farmland. B: Photograph of landfill excavation looking north. Photograph shows ponding of water on west side of excavation and resultant seepage. Note presence of water on western floor and absence of water on eastern floor.

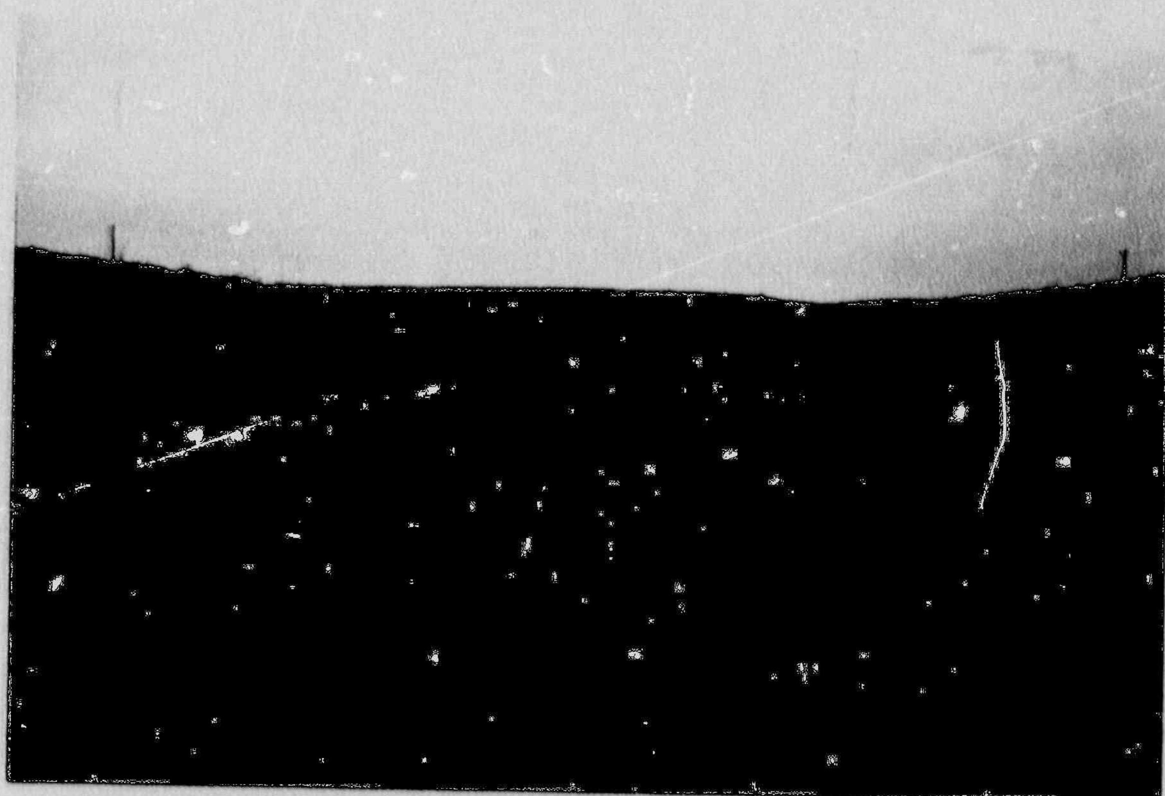

Figure 5: Photograph taken inside excavation looking north. Photograph shows seepage occurring on western wall, which forms a small stream. Note lack of stream or other evidence of seepage on eastern wall.

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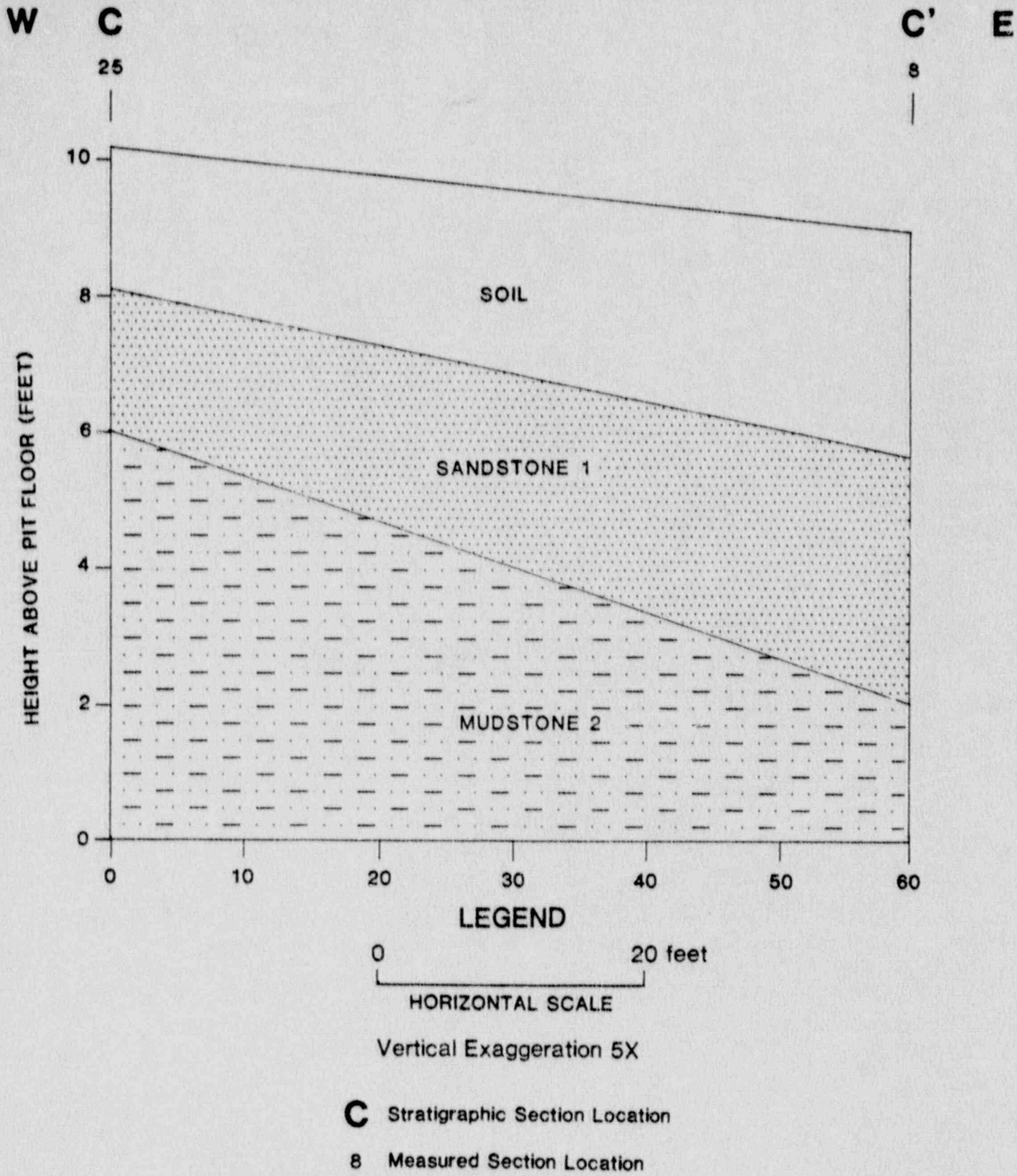


Figure 6: Representative stratigraphic cross-section perpendicular to long dimension of excavation showing that local dip of sedimentary units has a component to the east. Location of cross-section is shown in figure 1.

3. JOINTING

Jointing at the Cimarron Facility was investigated by conducting scanline surveys in the Option 2 excavation and by making observations and measurements of jointing at outcrops on the facility property. The scanline surveys consisted of stretching a tape measure along the length of the excavation. The orientation and location of joints that intersected the plane of the tape were measured, and observations such as seepage, roughness, vertical trace length, and infilling minerals were recorded.

In addition, measurements of joint orientation and the same physical observations identified above were made at all outcrops at the facility. Figure 7 is a facility map which shows the locations of the outcrops from which joint observations were made.

The findings can be summarized as follows. Joints in the sandstone bedrock at the surface and near surface at the facility are widely spaced, averaging up to about 8 to 10 feet at some outcrops. The joints generally have a limited vertical persistence, with vertical trace lengths ranging from about 0.5 to 5 feet observed. In the Option 2 excavation, joints with vertical trace lengths of 0.5 to 1.5 feet with an apparent horizontal spacing of around 5 feet were most common. The sandstones also exhibit considerable sub-horizontal parting along cross-beds. No measurements were made of these partings because they are discontinuous, minor sedimentologic features.

No joints were observed to penetrate contacts between the sandstones and mudstones or siltstones at either the Option 2 excavation or at outcrops along the escarpment.

The joints in sandstone are generally open, with slightly curved to irregular joint surfaces. Less than about 1 % of the observed joints had any infilling minerals. The most common infilling mineral observed is calcite. Moss and lichens grow on some of the open, exposed joint faces at the outcrops. The joint surfaces were generally slightly to moderately rough.

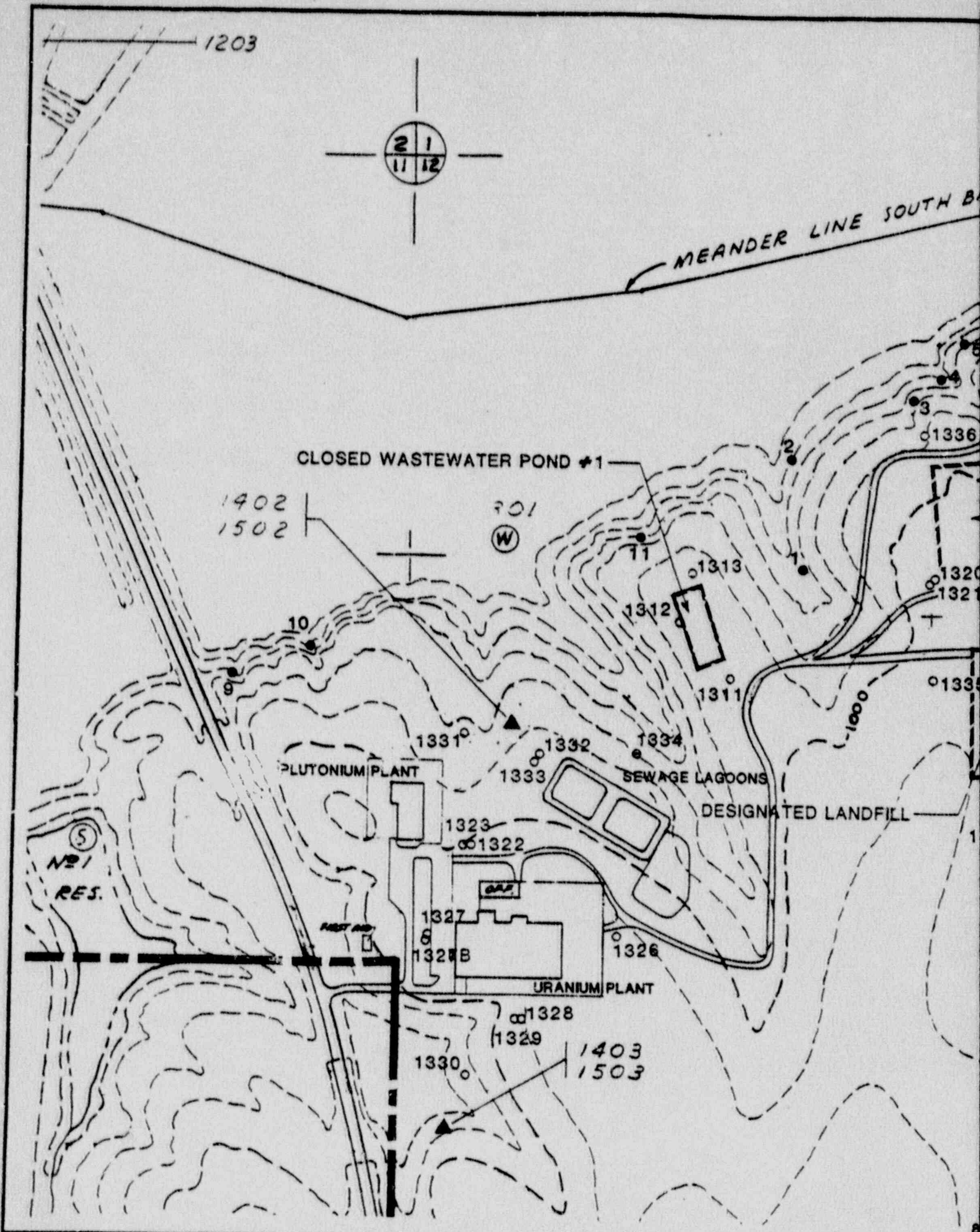
Some staining of joints at the outcrops was observed, but only on joints that are deeply weathered. No fresh joint surfaces were found. Direct seepage of ground water from joints was not observed despite conducting the field investigation immediately after unusually heavy precipitation. The seepage observed occurred primarily through the sandstone matrix and seepage faces were common at the contact between the uppermost sandstone and mudstone layers. No water was observed exiting the individual joints.

The mudstone or siltstone units in general exhibit virtually no jointing. These units are, however, extremely fissile and part readily into small fragments. Only a few joints in the mudstones were observed at the Option 2 excavation. The joints that were observed in the mudstones were closed; however, upon splitting a hand sample, the joint planes appear coated with manganese oxide. Joint planes are curved to slightly irregular in the mudstones. No joints in mudstones were observed at outcrops. This situation is probably due to the extensive weathering exhibited at the outcrops.

Figure 8 is a rose diagram showing frequency of joint strike directions. A total of 138 measurements were made around the facility, with the majority of the measurements (88) made in the Option 2 excavation. The majority of joints strike in the range N 60 E to N 75 E, and a subordinate conjugate population strikes N 45 W. Orientation measurements at outcrops and the Option 2 excavation were consistent and no systematic variation in orientation was observed across the facility area.

Figure 9 is a stereogram showing the distribution of poles or normals to the joint planes. The poles were plotted on a Schmidt equal-area stereonet. Figure 10 is a contoured stereogram that more clearly shows the distribution of the poles. Both principal populations are steeply dipping about the vertical plane.

Jointing of the surface and near surface bedrock is minimal and joints are not anticipated to have a significant effect on ground-water flow for the following reasons. The joint pattern has affected the pattern of weathering and erosion, but has no apparent effect upon the shape of the piezometric surface nor the direction of ground-water movement (see Figure 11). Fractures are not numerous enough given the inter-granular permeability of the sandstones in the area to have a great impact on ground water movement. Further, the wide spacing, limited vertical trace length, and termination at lithologic contacts will limit any influence of jointing on the hydrologic system, particularly in comparison with the inter-granular permeability of the sandstone units.


1203
2
1
11
12
MEANDER LINE SOUTH B
CLOSED WASTEWATER POND #1
1402
1502
701
W
11
1313
1312
1311
10
9
2
3
4
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1336
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1321
1335
1000
1331
1332
1333
1334
PLUTONIUM PLANT
SEWAGE LAGOONS
DESIGNATED LANDFILL
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1322
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No 1
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1327B
1326
URANIUM PLANT
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1403
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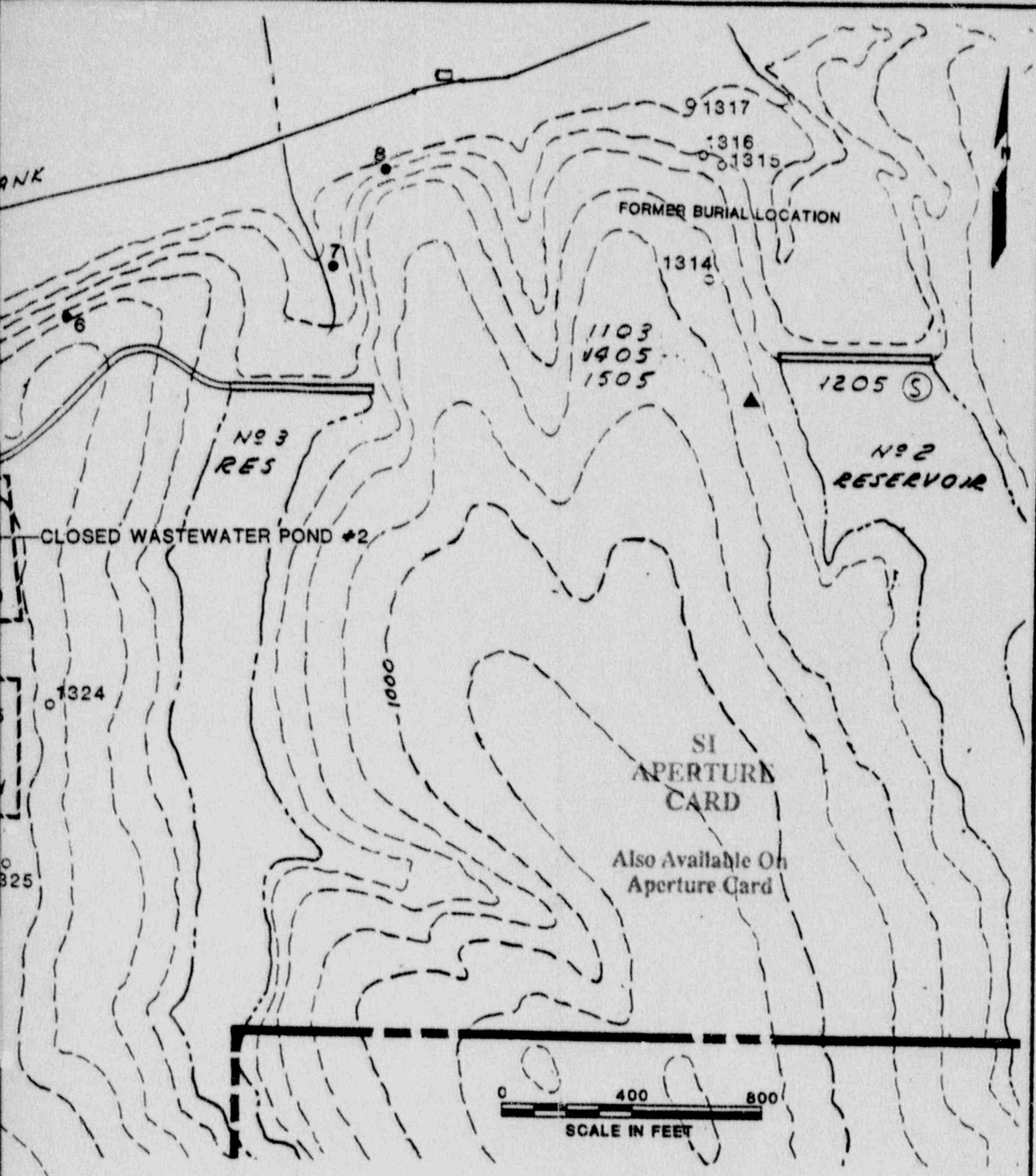

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FIGURE 7

CIMARRON FACILITY SITE MAP

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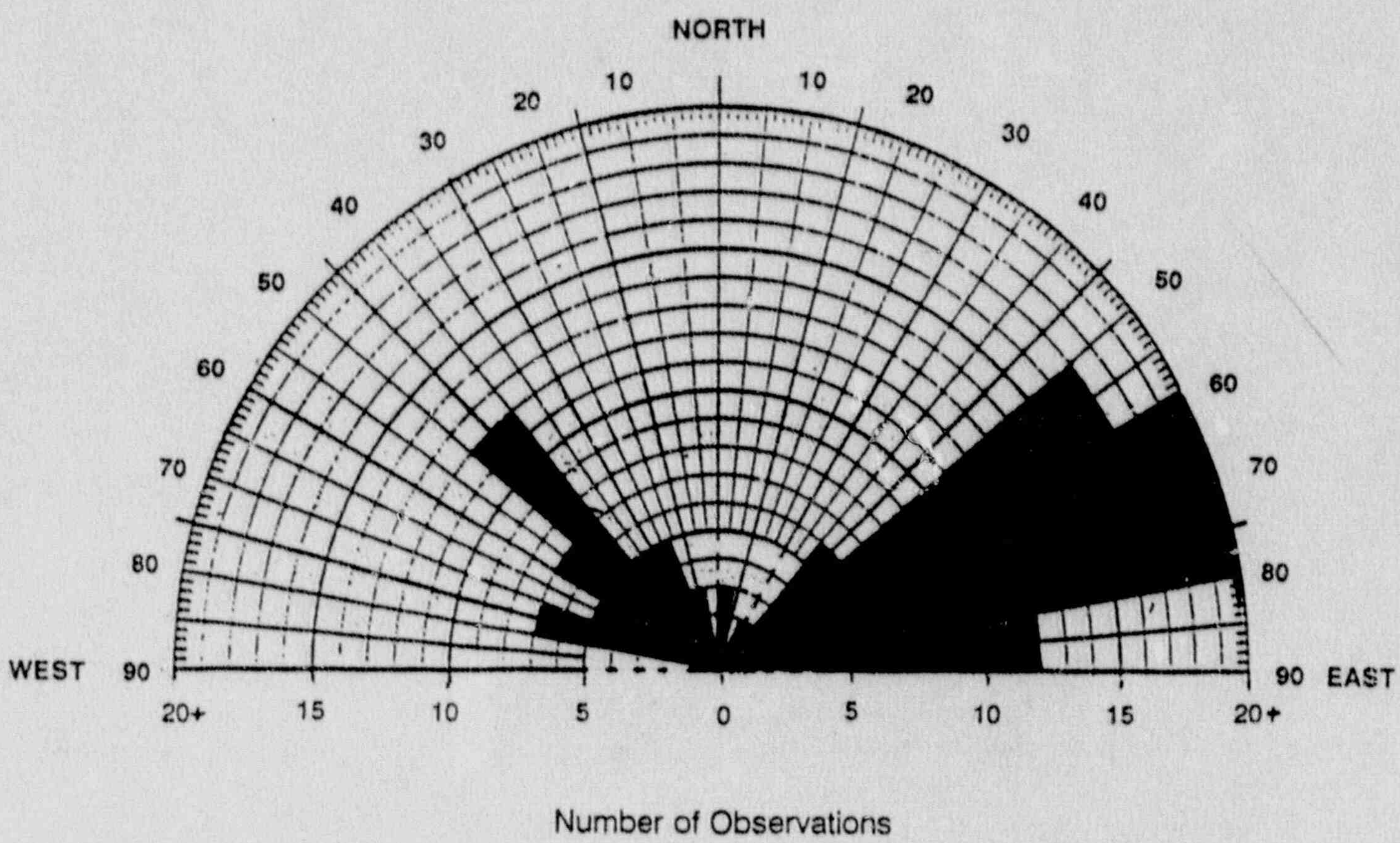


Figure 8 Rose Diagram

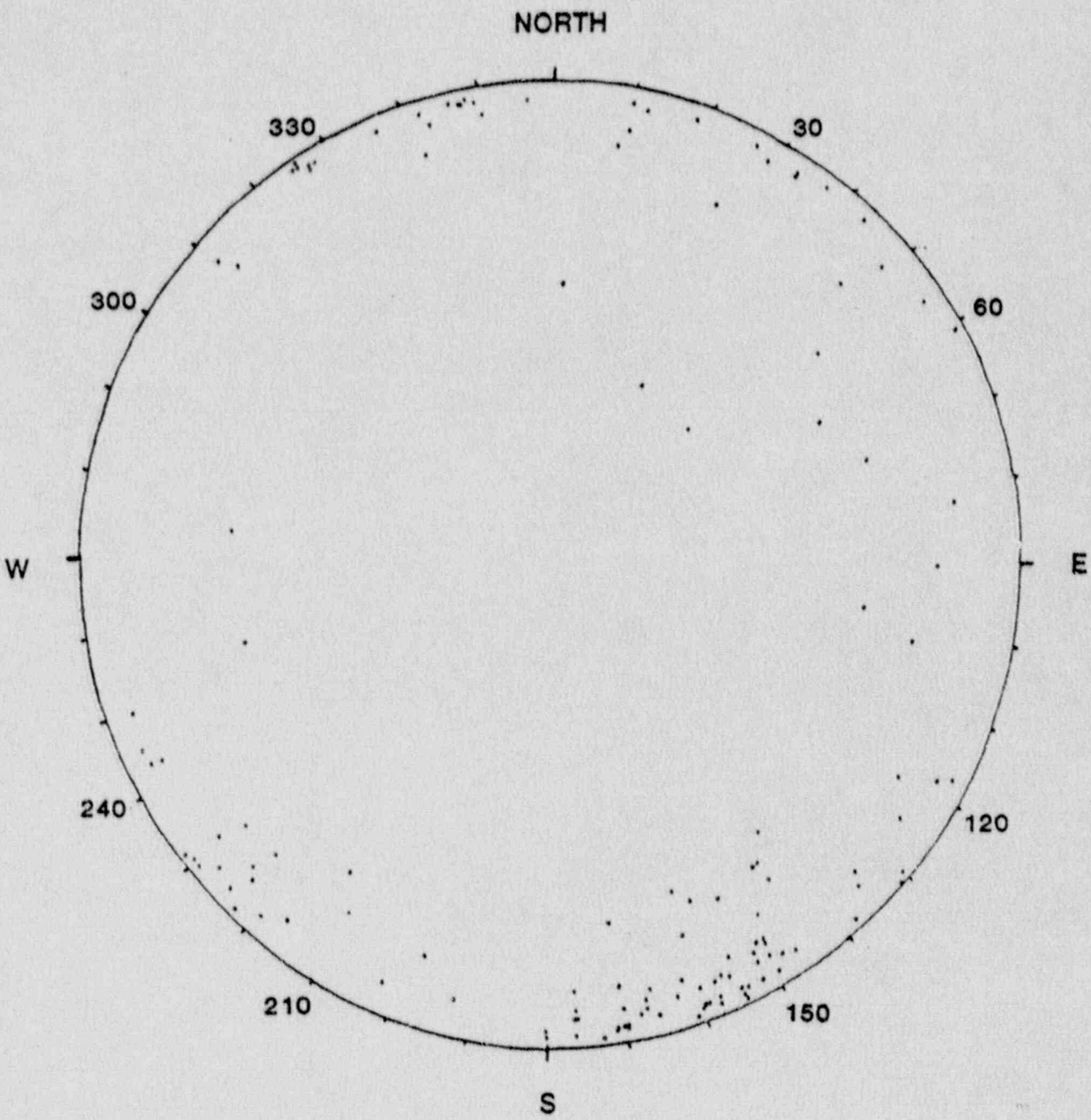
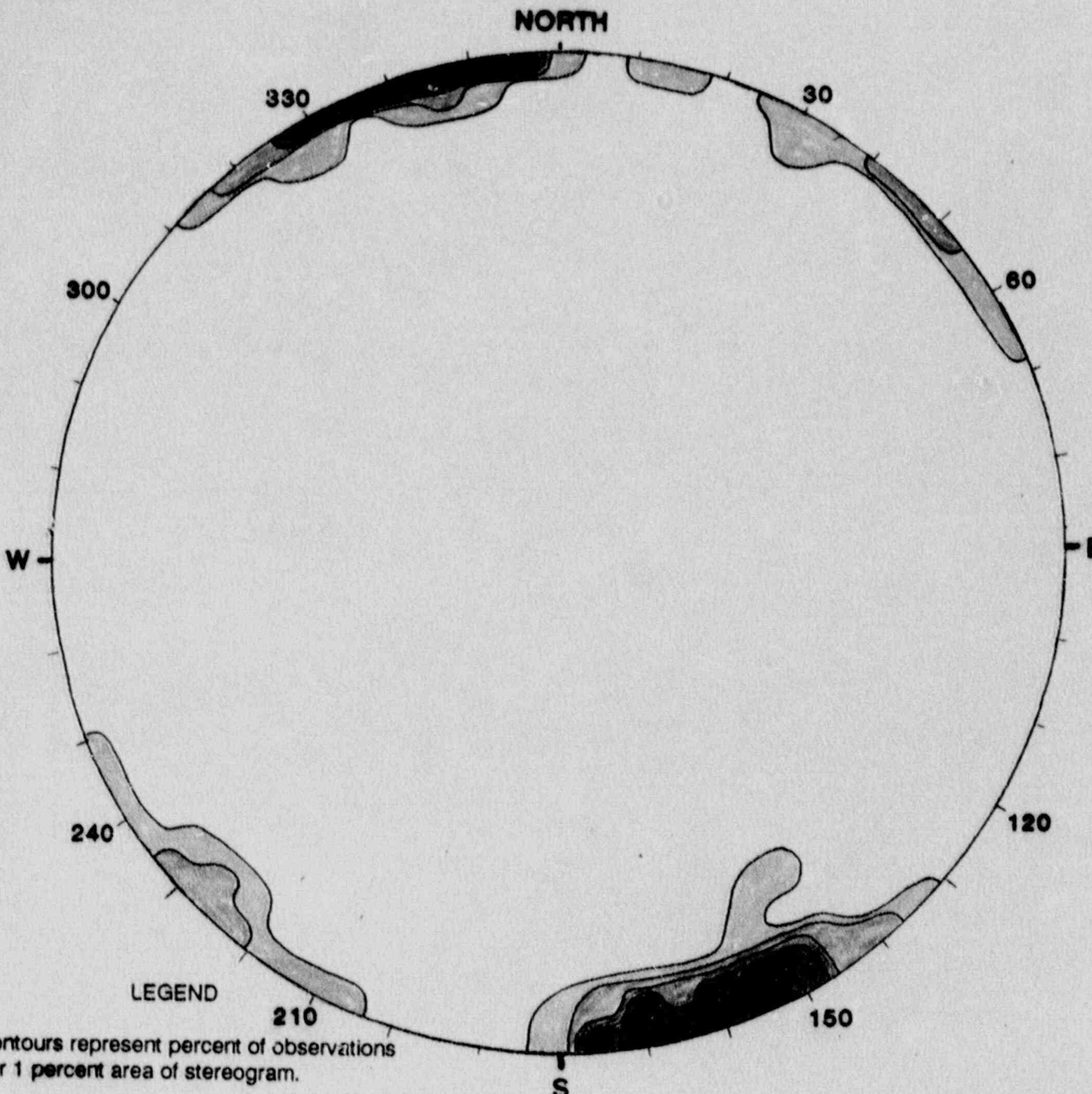


Figure 9 Stereogram



LEGEND

Contours represent percent of observations per 1 percent area of stereogram.

white	0-3 %
light	3-6 %
light	6-9 %
medium	9-12 %
dark	12-15 %
dark	> 15 %

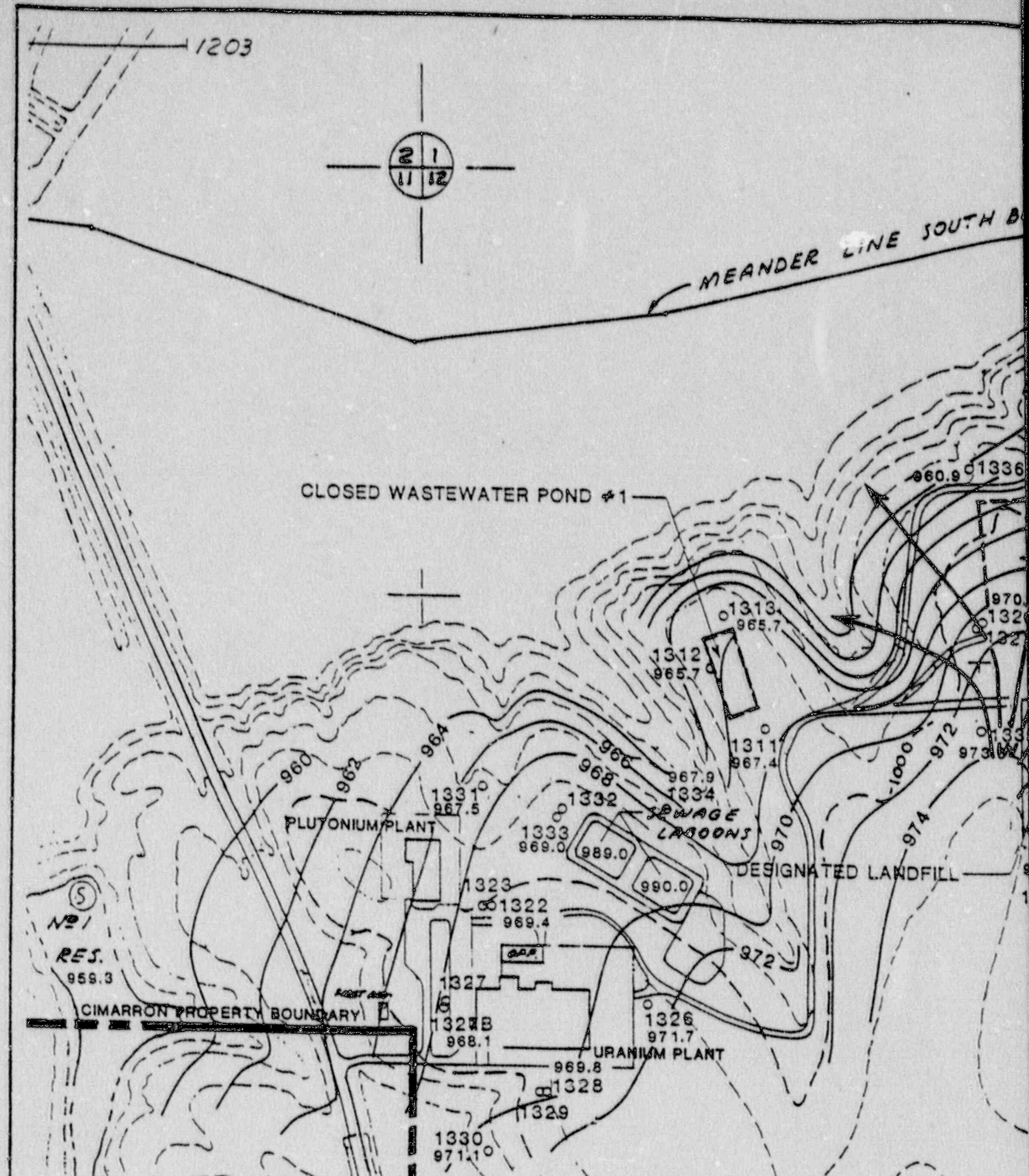
Figure 10 Contoured Stereogram

4. GROUND-WATER FLOW DIRECTIONS

Shallow ground-water flow directions in the immediate vicinity of the Option 2 burial area were reviewed to determine the fraction of ground water flowing beneath the Option 2 site that subsequently flows easterly toward Reservoir 3, and the fraction of ground water that flows north or northwest toward the Cimarron River alluvium. The Option 2 site is located along the spine of a ridge. Shallow ground-water flow is influenced by topography, and so the position of the excavation relative to the spine of the ridge may be a determining factor in the direction of ground-water flow away from the excavation.

The location and dimensions of the current Option 2 excavation were measured in the field to verify the location shown in the SIR. These measurements confirmed that the excavation is located within the indicated boundaries. Figure 11 depicts the potentiometric surface of the shallow ground water. Flow lines drawn normal to the potentiometric surface contours are shown on this figure. Figure 11 indicates that ground water flows from the southwest toward the northeast beneath the excavation.

Because the excavation is over the topographic divide, and very near the ground-water divide, even a small difference in the position of the ground-water divide could obscure the actual direction of flow. For this reason, Cimarron has concluded that, although the flow of the ground water in the immediate area probably is toward Reservoir 3, the direction of flow is somewhat uncertain. To accommodate this uncertainty, Cimarron will evaluate transport of contaminants both toward the Cimarron River alluvium and toward Reservoir 3. Pathways analyses described elsewhere examine both migration directions.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960
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964
966
968
967.9
1334
1331
967.5
1332
1333
969.0
PLUTONIUM PLANT
SEWAGE LAGOONS
989.0
990.0
DESIGNATED LANDFILL
970
972
1000
974
1323
1322
969.4
972
No 1
RES.
959.3
1327
CIMARRON PROPERTY BOUNDARY
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URANIUM PLANT
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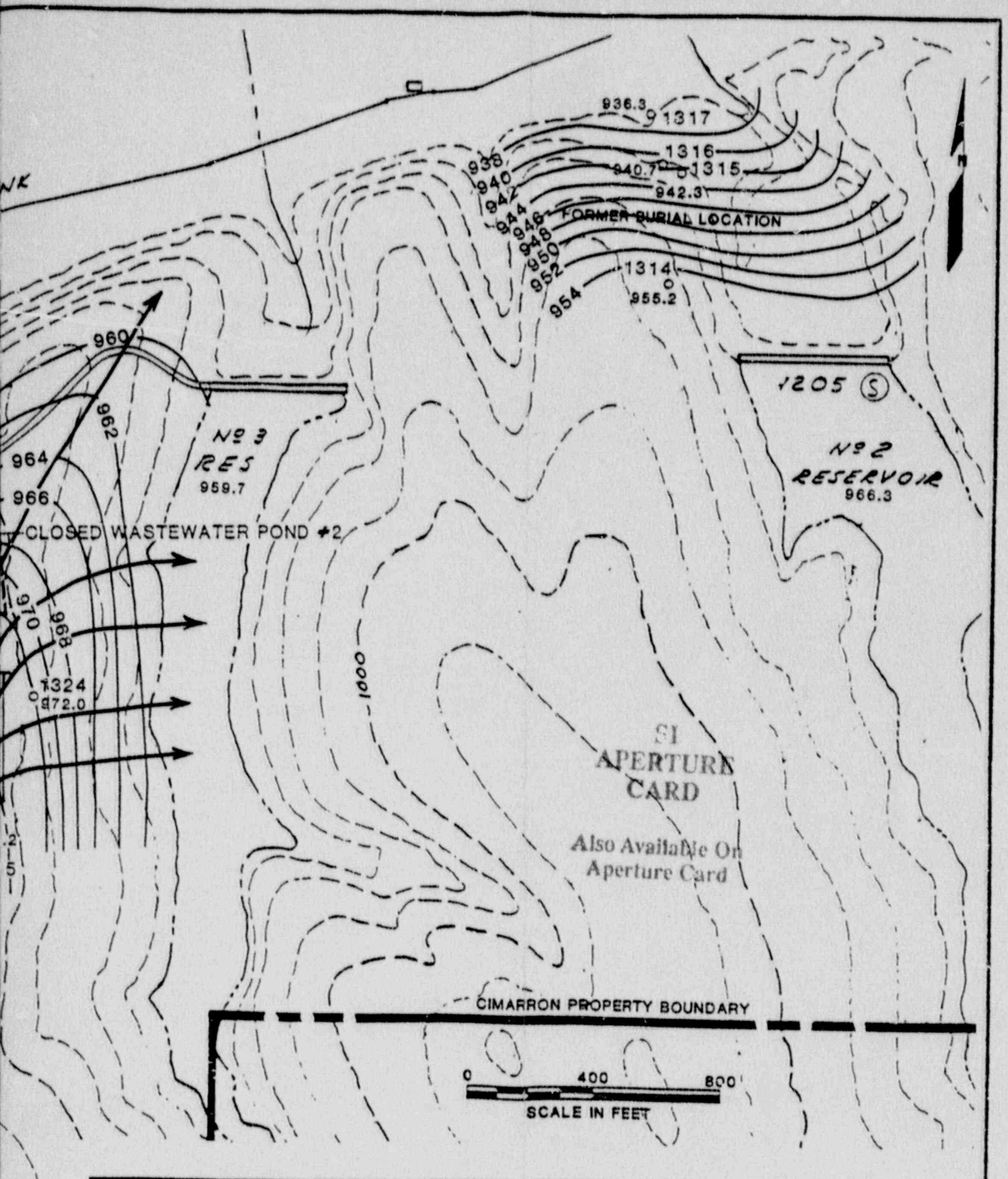

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FIGURE 11
POTENTIOMETRIC SURFACE OF THE SHALLOW GROUND WATER

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5. EROSION

5.1. Introduction

Evaluation of potential erosion of the Option 2 landfill cover and the area surrounding the cell was undertaken to determine whether the landfill cover will resist erosion to the extent that the material within the cell will be isolated from the environment for at least 200 years, and to the extent practicable, for 1,000 years.

Information was obtained from the Soil Conservation Service in Oklahoma City regarding typical erosion rates for the soils and vegetative covers found in the region.

The evaluation was completed using two well-established methods for evaluating long-term erosion. A tractive force method was used to evaluate erosion during the probable maximum storm. This method provides an assessment of the stability of a soil structure during very large precipitation events. The GLEAMS model was used to evaluate annual erosion of the landfill cover over a 100-year period. The GLEAMS model allows erosion to be calculated for average and extreme events, and allows an assessment of the resistance of an earth structure to the cumulative effects of erosion over a period of time.

5.2. Physical Considerations

5.2.1. Topographic Setting

The proposed Option 2 landfill is located on the spine of a ridge (see Figure 7). Drainage in the vicinity of the cell is mostly to the east and west toward the sides of the ridge. Ground slopes in these directions are about four percent. The ridge also slopes to the north toward the nose of the ridge at a slope of about one percent.

The Option 2 cell is aligned with the topography of the ridge. The cell excavation now is about 535 feet long (in a north-south direction), and about 61 feet wide (in an east-west direction). The finished cell will be about 535 feet long and 180 feet wide. For purposes of the erosional stability analyses, the width of the cover was assumed to be 200 feet. This allows the cover to extend about ten feet beyond the cell excavation on either side.

5.2.1.1. Drainage

The stabilized final shape of the landfill cover will conform generally with the shape of the original ground surface, except for minor modifications of the cover shape and the shape of the adjacent ground surface to prevent water flow from adjacent areas over the landfill cover. The spine of the cover will be aligned with the spine of the pre-existing ridge in a north-south direction. Rainfall on the cover will drain to the east and the west from the spine. The landfill location was chosen to assure that flow from off-site areas onto the landfill will not occur.

5.2.2. Soil Properties

Properties of site surficial soils have been determined by various investigators. These properties were used in the evaluations presented in a following section of this report.

5.2.2.1. JLGA Investigation

Laboratory tests of shallow soils from the Option 2 landfill area were performed by JLGA[1]. These tests showed the soil to be a silty clay or clayey silt. The D_{75} of the soils ranged from about 0.1 to 0.2 mm (about 0.004 to 0.008 inches). The soils belong to the Unified Soil Classification type CL. The plasticity index of the soils is about 10.

The maximum dry density of the soils as determined by ASTM 698 ranges from about 118 to 121 pounds per cubic foot. The average bulk density at 85 percent compaction is about 1.62, and the void ratio is about 0.64.

5.2.2.2. Engineering Enterprises

Engineering Enterprises[2], in an earlier study for Kerr-McGee, determined that the soils in the landfill area are in the Soil Conservation Service Zaneis type. This soil type was used, in conjunction with a soils data base[3], in the GLEAMS simulations. Soil properties for a clay loam, taken from the GLEAMS manual, also were used in these simulations.

5.2.2.3. Soil Thickness

Soils in the vicinity of the Option 2 landfill are relatively thin, ranging in thickness from one foot to about eight feet. The soils exposed in the Option 2 landfill excavation range in thickness from about 6 to 36 inches. Soils on the adjacent slopes usually are thinner. The soils are underlain by sandstones and mudstones which, while not very hard, are sufficiently indurated to form an erosional bottom, and prevent significant headcutting near the landfill.

5.3. Evaluation of Erosion

This section describes the evaluation of potential erosion of the landfill cover and the surrounding area.

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[1] James L. Grant & Associates, Inc., 1989, *Site Investigation Report for the Cimarron Corporation Facility, Logan County, Oklahoma.*

[2] Engineering Enterprises, unknown date, Report in Kerr-McGee Hydrology Section files.

[3] Arnold, J. G., J. R. Williams, A. D. Nicks, and N. B. Sammons, 1989, *SWRRB, A Basin Scale Simulation Model for Soil and Water Resources Management.* (to be published by the Texas A&M University Press).

5.3.1. NRC Draft Technical Position Paper

The tractive force method described in the NRC Draft Technical Position Paper[4] and Nelson, et.al.[5] was used to calculate the maximum slope at which the landfill cover soils would not be subject to erosion during the Probable Maximum Precipitation (PMP) event. Soil properties necessary for this evaluation were taken from the JLGA study, and are summarized above. PMP amounts were taken from Design of Small Dams.[6] Allowable shear stress values were taken from Temple, et.al.[7], and from Chow.[8]

The landfill cover was assumed to be 200 feet wide, and drainage from the cover equally diverted to the east and the west from the spine.

Potential erosion of the cell cover was evaluated assuming no vegetation on the cover. The allowable tractive force on the soil was evaluated using Table 3.3 in Temple, et. al. assuming a CL soil. The allowable tractive force was calculated to be 0.037 pounds/square foot. The 6-hour PMP was determined to be 31 inches, and the maximum intensity during the most intense 2.5 minute period was estimated to be 23.56 inches per hour. A maximum allowable slope of one-half percent was computed.

The above calculation of maximum allowable slope includes a conservative flow concentration factor of three. This factor, while probably appropriate for remote facilities in the west, is not consistent with the assumption, also used in these calculations, that the land is cultivated. Based upon current site agricultural use, erosion protection practices such as terracing would be followed while the land is cultivated. This practice is followed in the area today. If cultivation stops, the land would revert rapidly to meadow, prairie, or woodland, and potential erosion would be much less than during cultivation.

The maximum allowable slope, computed with application of the above factors and a unit concentration factor, is about 1.2 percent.

The allowable tractive force calculated above is low relative to values given in other references. Chow gives a value of 0.075 pounds/square foot for clay loam. Use of this value gives a maximum allowable slope of about 1 percent for a runoff concentration factor of 3, and 2.7 percent for a unit concentration factor. The effects of a projected wheat cover (the current crop cultivated) were evaluated by using the maximum permissible velocity from Chow for a poor grass cover. The maximum permissible velocity was converted to an allowable stress of about 0.25

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[4] U. S. Nuclear Regulatory Commission, 1989, *DRAFT STAFF TECHNICAL POSITION, DESIGN OF EROSION PROTECTION COVERS FOR STABILIZATION OF URANIUM MILL TAILINGS SITES*, Unpublished Draft document from NRC files.

[5] Nelson, J. D., S. R. Abt, R. L. Volpe, D. van Zyl, N. E. Hinkle, W. P. Staub, 1986, Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments, U. S. Nuclear Regulatory Commission, NUREG/CR-4620.

[6] Bureau of Reclamation, 1973, *Design of Small Dams*, U. S. Department of the Interior.

[7] Temple, D. M., K. M. Robinson, R. M. Ahring, and A. G. Davis, 1987, *Stability Design of Grass-Lined Open Channels*. U. S. Department of Agricultrue, Agruculture Handbook 667.

[8] Chow, V. T., 1959, *Open-Channel Hydraulics*, McGraw-Hill, New York.

pounds/square foot. This gave a maximum allowable slope of almost 6 percent for a runoff concentration factor of 3.

In summary, the analyses show that the landfill cover in a fallow condition is resistant to erosion during the PMP so long as the slope of the cover is less than about 1 percent. Erosion control practices currently followed in the area would protect the cover from severe erosion while it was under cultivation. A grass (or small grain) stand will prevent erosion of the cover constructed with even greater slopes. Absent cultivation, the cover would revert to a grass or forest condition.

5.3.2. GLEAMS

The GLEAMS model[9] was used to calculate average erosion of the Option 2 landfill cover. Climatic data from nearby Oklahoma City were used.[10] Required soil data were taken from the JLGA report and the SCS soil data base for Zaneis soil.[11] The SCS data base includes statistical parameters which allows synthetic sequences of daily rainfall to be computed.

Erosion of the landfill cover over a 100-year period was calculated using a cover slope of four percent, conforming to the average slope of the top of the ridge. The cover was assumed to be tilled, and planted in winter wheat (small grain cover).

After calculating cover erosion for a 100-year climatic sequence, the rainfall sequence within a wet year was modified to include a 48-hour PMP. The rainfall was inserted during a wet period in a wet year. The 48-hour PMP was separated into two 24-hour events to conform to the GLEAMS input. Rainfall during the first day of the two-day event was 2.33 inches, and during the second day was 37.2 inches. These values were determined from Design of Small Dams.[12]

The unmodified annual precipitation for the year in which the PMP was inserted was 56.2 inches. The modified rainfall was 95.7 inches. Annual precipitation in the Oklahoma City area is about 30 inches.

The GLEAMS analyses indicated a total soil loss over the 100-year period of 497 tons per acre. Using a soil unit weight of 102 pounds per cubic foot, this equates to about 2.7 inches per century, or about 27 inches over a 1000-year period.

The GLEAMS analysis for the modified rainfall record including the 48-hour PMP indicated that the erosion during that storm to be 60.4 tons per acre. This equates to about 0.33 inches of soil. Although the amount of erosion resulting from a PMP depends upon the timing of the storm, these analyses indicate that the occurrence of a PMP would have little effect on the landfill cover.

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9 Davis, Frank M., Ralph A. Leonard, and Walter G. Knisel, 1990, *GLEAMS User Manual, Version 1.8.55*, USDA-ARS Southeast Watershed Research Laboratory, Lab Note SEWRL-030190FMD.

10 Arnold, J. G., ibid.

11 Arnold, J. G., et.al. op cit.

12 U. S. Bureau of Reclamation, op. cit.

5.4. Summary

Erosion calculations using tractive force procedures presented in the NRC Staff Technical Position Paper, and using the GLEAMS model, indicate that the landfill cover will be safe from erosion even under the scenario of continued cultivation of small grain crops.

The tractive force method indicated that the cover will resist erosion even during the PMP if slopes are maintained below about 1 percent during cultivation, and 6 percent if allowed to revert to grass or forest. Analyses using the GLEAMS model indicate that erosion during a 200-year period will be about 5.4 inches. Calculated erosion during a PMP event was about 0.33 inches.

The above results are consistent with Cimarron Corporation's plans to shape the cell cover to generally conform to the existing topography. The results indicate that such a cover will be protected from erosion even during large storms.

6. COMPUTER SIMULATIONS

The attached floppy disk, in IBM-PC high-density (1.2 megabyte) format, contains the data files used by JLGA to calculate the migration of uranium along unsaturated and saturated flow pathlines from the landfill area. Two types of files are included. Files with the extension DAT are the actual data files used in the analyses. Files with the extension ANN are the same data files, annotated within the file to explain the information in the file. The annotated files are included to clarify the meaning of the data should the versions of TRANSS used by JLGA and the NRC be slightly different.

Copies of the GLEAMS input and output files also are included. These file names follow the above conventions, except that no annotated files are included, and the climatic file extensions are DA1, DA2, and PMP, representing the first and second 50-year series, and the modified record containing the PMP.

7. EXISTING GROUND-WATER CONTAMINATION

This section addresses the mobility of uranium in the ground water at the Cimarron facility. The chemistry of the ground water is examined, particularly as it relates to uranium solubility. The ground water in areas where higher levels or uranium are observed is compared with background ground water. The ground water downgradient of the waste management areas has been demonstrated to be altered by the waste materials which were managed within the areas. Since the proposed Option 2 burial includes only soils upon which uranium is sorbed, similar ground-water alteration is not likely as a result of the burial.

7.1. Cimarron Ground-Water Geochemistry

7.1.1. Site Ground-Water Quality

7.1.1.1. Data Sources

Ground-water samples were collected on March 5, 1990 from ten of the monitoring wells at the Cimarron facility. The groundwater samples were analyzed by the Kerr-McGee Technical Center. The results of these analyses are presented in Table 1. The ten wells were selected to provide ground-water quality data upgradient and downgradient of previously used, but then cleaned and closed, site waste management areas. Upgradient ground-water quality data are representative of background groundwater quality at the site. Ground-water quality downgradient of the site waste management areas reflects groundwater affected by past leakage from the closed waste management areas. Solid wastes were excavated prior to closure of the waste management areas, so that continuing leakage of waste constituents would not occur.

7.1.1.2. Data Analysis and Interpretation

Constituent concentrations shown in Table 1 are presented in milligrams per liter (mg/L). Table 2 presents the same data expressed in milliequivalents per liter (meq/L). Data provided in Table 2 were used to calculate the ion balance and for plotting Stiff and Piper diagrams. Stiff diagrams provide for a rapid visual comparison of groundwater composition. Hydrochemical facies classification, based on Piper diagrams, was used to determine the dominant constituents in the ground water at the site and to detect chemical trends that might be present in the site groundwater.

7.1.1.2.1. Major Ions

Groundwater present in the shallow water-bearing stratum beneath the site exhibits a relatively homogenous chemical composition generally dominated by calcium and bicarbonate ions. Minor constituent concentrations are dominated by fluoride and nitrate. The background water chemistry, represented as average concentrations from upgradient wells 1314, 1325, 1326, and 1335, is shown in Table 3.

Ion balance calculations were made to determine the completeness of the groundwater analyses. Results of the ion balance calculations are presented in Table 2. Groundwater samples are electrically neutral, so the total charges on cations and anions reported in an analysis should be equal. The total positive and negative charges are obtained by summing the equivalent concentrations of cations and anions. The ion balance error is normally expressed by the difference as a percentage of the sum and should be less than about 7.5 percent error[13]. The ion balances for seven of the ten wells are within the acceptable error range. Wells 1312, 1316, and 1336 exceed the acceptable ion balance error.

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[13] Lloyd, J. W., and J. A. Heathcote, 1985. *Natural Inorganic Hydrochemistry in Relation to Groundwater - An Introduction*. Clarendon Press, Oxford, 296 pp.

Site groundwater from the monitoring wells was grouped into dominant cation and anion types on the basis of the relative concentrations of major ions present. To facilitate this comparison, a Piper diagram was plotted for the groundwater results from the site wells. This diagram (Figure 12) shows that the hydrochemical type of the groundwater in the shallow aquifer is similar over the site. Figure 12 indicates that the site groundwater plots within the calcium dominant field. Table 2 indicates that calcium generally is the most dominant cation. Site groundwaters generally plot within the bicarbonate dominant anion field. Table 2 indicates that bicarbonate generally is the most dominant anion in groundwater at the site.

Stiff diagrams prepared for the site groundwater quality data are presented as Figures 13 through 17. These diagrams indicate that groundwaters at the site are similar, but exhibit a range in concentration of the major ions.

7.1.1.2.2. Radionuclides

The groundwater samples were analyzed for total uranium. Background concentrations of uranium at the site are generally at or less than the detection limit (0.005 mg/L). Concentrations of uranium ranged from not detected to 6.25 mg/L. Wells 1312, 1315, 1316, 1317, 1331, and 1336 exhibit uranium concentrations greater than the detection limit. Uranium concentrations greater than background generally are found downgradient of former waste management areas. Uranium concentrations in the site groundwater are shown in Table 1.

7.1.2. Areal Distribution of Selected Constituents

The areal distribution of selected groundwater constituents is shown by Figures 18 through 24. These figures were developed using the water quality data from the March, 1990 sampling event. Groundwater near or downgradient of former waste management areas and the uranium plant generally show salt concentrations above background, reflecting groundwater affected by the previously-managed waste materials. The waste materials at the waste management areas have been removed and the units closed.

Upgradient to downgradient groundwater quality comparisons are best made by examining data from the series of wells at the former waste burial location near the No. 2 Reservoir. This series of wells provides an upgradient well (1314), and wells (1315, 1316, and 1317) downgradient of the former burial location. Concentrations of most of the major ions increase downgradient, with the highest concentrations in well 1317. For example, calcium concentrations increase from 74 mg/l in well 1314 to 117 mg/l in wells 1315 and 1316. Bicarbonate concentrations increase from 402 mg/l in well 1314 to 496 mg/l in well 1315, and 618 in well 1316. The concentration of bicarbonate in well 1317 is 1290 mg/l, and the concentration of calcium is 223 mg/l. These concentrations are about two times higher than in the wells upgradient of this well. However, it is likely that this well is completed in the Cimarron River alluvium, and the well water is influenced by seepage from the river. Similar increases in concentration are observed in other ions.

Uranium concentrations also increase in a downgradient direction; however, in the case of the uranium, the highest uranium concentrations are observed near the former burial area. Salt concentrations are higher further downgradient, even excepting the well that appears to be completed in the alluvium. This is a consequence of the removal of the source from the former burial ground. The separation of the plumes indicates that the salts are moving more rapidly in the ground water than is the uranium. The presence of the salts increases the mobility of the uranium by complexing and by competition for exchange sites. The chromographic separation of the uranium and the salts will lead to decreasing mobility of the uranium as it moves downgradient from the former source, and the salts that increase its mobility separate from the uranium plume.

7.2. Geochemical Modeling

7.2.1. Introduction

Geochemical modeling was conducted to determine the uranium solution-mineral equilibria relationships in the ground water of the shallow water-bearing stratum at the Cimarron facility and to determine the apparent discrepancy between the solubility predicted by the soil distribution coefficients and uranium present in the ground water at certain locations downgradient of former waste management areas.

7.2.2. Model Used

Geochemical modeling of the shallow water-bearing stratum groundwater chemistry is based on calculations using the computer programs WATEQ4F and MINTEQA2[14,15,16]. WATEQ4F and MINTEQA2 compute major and trace element aqueous speciation and mineral saturation for low temperature natural waters. The WATEQ and MINTEQ family of aqueous speciation programs and thermodynamic database have been extensively used and evaluated by numerous research and government agencies.

7.2.3. Validation

WATEQ4F and MINTEQA2 were validated according to the guidelines presented by the U. S. Nuclear Regulatory Commission[17]. Validation was accomplished by executing the problem sets

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[14] Ball, J. W., and D. K. Nordstrom, 1987, WATEQ4F - a personal computer FORTRAN translation of the geochemical model WATEQ2 with revised database. U. S. Geological Survey Open-File Report 87-50, 108 pp.

[15] Brown, D. S., and J. D. Allison, 1987, *MINTEQA1, an equilibrium metal speciation model: user's manual.* U. S. Environmental Protection Agency, EPA/600/3-87/012, 92 pp.

[16] Brown, D. S., and J. D. Allison, 1988, *User's Manual for PRODEF/MINTEQA2, Version A2.00; Problem definition program for MINTEQ (PRODEF); Metal speciation equilibrium model for Surface and Groundwater (MINTEQ).* U. S. Environmental Protection Agency, Athens, Georgia, 22 pp.

[17] U. S. Nuclear Regulatory Commission, 1983, *Final technical position of documentation of computer codes for high-level waste management.* NUREG-0856-F, 13 pp.

furnished by the U. S. Geological Survey and EPA on an IBM PC and comparing the results of these analyses with the results presented in these reports. Thermodynamic data provided with the model have been critically evaluated by numerous university, government, and private researchers, and was not validated separately for this project.

7.2.4. Data Sources

Solute concentrations necessary for input into WATEQ4F and MINTEQA2 were obtained from groundwater quality data collected on March 5, 1990 for several monitoring wells at the Cimarron facility. Data include laboratory analyses of major cations and anions and some minor ions. pH was measured in the field. Model input comprised major and minor ion concentrations that were above the detection limit, pH, and estimates of groundwater temperature and redox conditions. Temperature and Eh were not measured for these groundwater samples. An estimate of the temperature, $16^{\circ}C$, was made using the average annual air temperature at the site. Eh conditions were assumed to be oxidizing in the shallow water table aquifer. A conservative Eh value of 600 millivolts was estimated for the site groundwater. This value is representative of typical oxidizing conditions in shallow groundwater aquifers.

7.2.5. Geochemical Modeling Results

Geochemical modeling was performed to determine possible mineral-water reactions that might control the solubility of uranium in the site groundwater. Ideally, a geochemical model should accomplish the following: (1) calculate the aqueous speciation, pH, and redox potential, (2) specify the kinds and amounts of minerals that precipitate or dissolve in the course of reactions, and (3) determine the equilibrium relationships between the groundwater, aquifer minerals, and waste constituents.

7.2.5.1. Mineral Equilibrium Calculations

Equilibrium calculations were performed for 8 of the 10 groundwater samples collected during March, 1989. Output from WATEQ4F is included as Appendix A, and includes calculation of the aqueous speciation of the major and minor ions, pH, ionic strength, TDS, cation-anion balance, activity coefficients, and the saturation indices (SI) of mineral phases. Table 4 presents the calculated saturation indices.

WATEQ4F calculates mineral SI for an aqueous solution using the chemical analysis and the thermodynamic stability data for both minerals and aqueous species. The SI is defined as log(IAP/Kt), where IAP is the ion activity product for the input chemical analysis, and Kt is the mineral equilibrium constant at the input temperature of the solution. A solution that is theoretically saturated with respect to a particular mineral phase will have a SI = 0; SI is negative for undersaturation and positive for supersaturation. Therefore, an SI equal to zero indicates that the groundwater is in equilibrium with a particular mineral phase.

Silicate (Quartz) Minerals: SI for quartz (SiO_2) mineral phases, alpha quartz , chalcedony , cristobalite , and amorphous silica average 0.828, 0.309, 0.393, and -0.200, respectively. In the site ground-water samples analyzed, amorphous silica is undersaturated, which suggests that silica is not in equilibrium with the groundwater. Quartz, one of the major aquifer host minerals, appears to have little control on silica concentrations in groundwater. Highly-ordered alpha quartz is oversaturated, a condition often observed for crystalline phases that in low temperature systems do not precipitate directly from ground water, but rather forms initially as amorphous silica.

The most important controls of aqueous silica in groundwater at the site probably are the clay minerals that are present in the aquifer matrix. Polzer[18] reported that groundwater in equilibrium with amorphous silica contains between 100 to 140 mg/L and groundwater in equilibrium with quartz contains about 6 to 12 mg/L silica. Groundwater in equilibrium with clay minerals, feldspars, mica, and other silicate phases contain intermediate concentrations of silica. The intermediate silica concentrations observed at the site and the presence of abundant clay minerals agree with Polzer's observations.

Carbonate Minerals: SI for the carbonate mineral phases, aragonite, calcite, and dolomite average -0.091, 0.059, and -0.146, respectively. The SI for calcite indicates that the site groundwater is in equilibrium with calcite. Calcite is the most abundant carbonate mineral phase present in the aquifer matrix, typically occurring as matrix cement. Dolomite is undersaturated in the site groundwater.

Figure 25 is a carbonate mineral stability diagram for the system Ca-Mg-CO_2-H_2O at 25^{0}C. Figure 25 plots the activity of (Ca+2/Mg+2) against the log of the partial pressure of CO2. Activities for site groundwaters are shown on this figure and indicate that the site groundwater is in equilibrium with calcite. The abundant calcite observed in the aquifer matrix and the equilibrium concentrations of calcite suggest that the primary control of calcium in solution is the dissolution and precipitation of calcite.

Aluminosilicate Minerals: Aluminosilicate minerals such as clay minerals comprise a large portion of the aquifer matrix. The stability of clay minerals in Cimarron groundwater was evaluated using cation ratio activity diagrams. Figures 25 through 29 are mineral stability diagrams showing the groundwater samples from Cimarron, and are indicative of the ratio of cation activity versus the activity of H_4SiO_4. Quartz and amorphous silica saturation lines also are shown on these figures. The mineral stability diagrams for the site indicate that the groundwater is in equilibrium with kaolinite.

Other Mineral Phases: Elevated fluoride concentrations present in some of the site wells near old waste management areas are related to the past waste management activities. SI for fluoride average -0.362 indicating that fluoride is undersaturated in the site groundwater. Figure 30 is a graph of the log of the ion activity product of fluoride versus calcite. This figure also indicates that fluoride is undersaturated in the site ground water, and that as fluoride migrates, it will react with matrix materials (e.g., calcium) and precipitate. The precipitation of fluoride as CaF_2 also makes other cations like uranium that are otherwise complexed with fluoride susceptible to sorption on the clays as the fluoride is stripped from the soluble ligand. The presence of the predominant calcium and clay minerals at the site provides an environment for the rapid attenuation of constituents such as uranium as they flow downgradient from the introduction

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[18] Plozer, W. L., 1967, "Geochemical control of solubility of aqueous silica:" in S. D. Faust and J. V. Hunter (editors), *Principles and Applications of Water Chemistry*, John Wiley and Sons, Inc., pp 505-519.

location. The effectiveness of these minerals in retaining uranium is reflected in the low natural background uranium concentrations.

7.2.5.2. Comparison of Geochemical Modeling Results with Kd Results

In order to compare the concentration of uranium in site groundwater with the uranium solubility predicted by the distribution coefficient results, groundwater from wells 1325, an upgradient well, and well 1315, a well downgradient of a former cleaned and closed waste management area, was modeled using MINTEQA2 to determine the solubility and speciation of uranium in site groundwater. Well 1325 is an upgradient well with no detectable uranium. Well 1315 is a well which has 6.25 mg/L uranium in solution.

The results of the modeling indicate that naturally soluble uranium in the site groundwater occurs primarily as the uranyl dicarbonate (UDC) and uranyl tricarbonate (UTC) complexes and aqueous uranyl carbonate. MINTEQA2 calculates that about 72 percent of the uranium is complexed as UDC, 25 percent as UTC, and the remaining 4 percent as aqueous uranyl carbonate.

The site geochemical modeling suggests a higher uranium solubility than otherwise reflected in the laboratory Kd tests. The Kd tests indicate that the uranium is less-soluble than predicted, and therefore is bound tightly to the soil. In order to explain this apparent discrepancy, it was assumed that the groundwater composition might have been altered during the Kd tests. The most likely source of change is degassing of CO_2 from the groundwater sample. PCO_2 pressures calculated using WATEQ4F indicate that the site groundwater has a PCO_2 of about 10^{-2} atmospheres. This value is typical of natural groundwaters. Simulation of CO_2 degassing was made by fixing the partial pressure of CO_2 at $10^{-3.5}$ atmospheres for groundwater from well 1315. This partial pressure of CO_2 is equal to that of the atmosphere and would represent degassing of groundwater supersaturated with CO_2, hence equilibration with atmospheric CO_2.

The results of the carbon dioxide degassing simulation indicates that about 85 percent of the uranium in solution would be precipitated as the mineral schoepite ($UO_3{*}2H_2O$). MINTEQA2 calculates that the uranium remaining (15%) in solution would be complexed as 56% $(UO_2)_3(OH)_5^{+1}$, 29% as aqueous UO_2CO_3, 8% as $UO_2(CO_3)_2^{-2}$, and 6% as UO_2OH^{+1}.

The results of these calculations supports the suggestion that losses of CO_2 would be reflected in laboratory Kd values higher than field values. However, a comparison of the concentration of uranium remaining in solution indicates that the loss of CO2 influences uranium concentrations by a factor of less than 10. Thus, changes in carbon dioxide in the laboratory cannot account alone for the discrepancy in uranium solubility suggested by the Kd results.

Since an overall increase in salts, generally fluoride and nitrate, is observed downgradient of the former waste disposal facilities, as shown on Figures 18 through 24, and an increase in total dissolved solids concentrations also is observed downgradient of these facilities, the apparent discrepancy between the solubility predicted by the geochemical modeling and the Kd results can also be accounted for by the effects of complexing of the uranium by other ions. Uranium complexes of fluoride, nitrate, and sulfate may be more soluble than uranium carbonate salts, and the complexes often are not sorbed as strongly. Increased competition between uranium and other cations for a limited number of sorption sites will increase the concentration of uranium in solution relative to the uranium sorbed on the soils. As anions are stripped from the ligands to react with matric materials, eg, F^- with Ca^{++}, the uranium ion becomes susceptible to formation of more insoluble species and eventually sorbs on clays where it is tightly bound. That such behavior is indicated is also reflected in the history of waste management at the site, where strong solutions of uranium in fluoride and nitrate form were stored or disposed. The competition for exchange sites and the complexing of the uranium by other ions will diminish in importance downgradient of the former waste management areas as dilution and chemical reactions cause the modified ground water to become more akin to the native ground water than to the leachate.

Neither of these solubility-enhancing factors should be operative in the potential leaching of soils placed in the Option 2 landfill, since these soils do not contain the high concentrations of salts or complexing ligands that were present in the original wastes.

TABLE 1: SITE GROUNDWATER QUALITY DATA (expressed in milligrams per liter (mg/L))

Well Number	Units	1312	1314	1315	1316	1317	1325	1326	1331	1335	1336
Sampling Date		Mar-90	Mar-90	Mar-90	Mar-90	Mar-90	Mar-90	Mar-90	Mar-90	Mar-90	Mar-90
Specific Conductance	umho/cm	9000	900	800	800	1750	900	550	750	550	14000
TDS	mg/L	1020	309	638	608	1550	331	376	634	377	2320
pH	std units	6.95	7.03	7.05	7.01	7.07	7.09	6.97	6.95	7.00	6.99
Calcium	mg/L	40.1	73.9	117	117	223	64.8	73	124	74.6	110
Magnesium	mg/L	12.4	23.7	47.1	41.4	108	22.8	26.8	42.3	29.2	114
Sodium	mg/L	140	16.4	40.1	40.6	213	22.1	23.4	64.5	19.6	123
Potassium	mg/L	13.5	1.2	< 1.0	< 1.0	3.2	< 1.0	1.2	< 1.0	< 1.0	15.2
Bicarbonate	mg/L	1140	402	496	618	1290	336	364	663	363	1090
Carbonate	mg/L	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Chloride	mg/L	30	16	67	68	130	7.9	12	17	6.9	49
Sulfate	mg/L	45	8.6	100	39	190	10	23	70	12	97
Silicon	mg/L	3.8	12	11	14	20	14	19	9.1	11	4.5
Fluoride	mg/L	46	0.7	1.5	1.4	3.1	1	0.61	1.2	1.1	57
Nitrate as N	mg/L	930	2.2	9.5	10	1.1	14	16	13	21	1700
Ammonia as N	mg/L	1500	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	2100
Phosphate	mg/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aluminum	mg/L	0.061	0.072	0.12	0.076	0.073	0.074	0.060	0.065	0.062	0.066
Iron	mg/L	0.053	0.061	0.031	0.015	0.026	< 0.006	0.062	0.028	0.013	0.009
Uranium	mg/L	0.045	< 0.005	6.25	0.38	0.087	< 0.005	0.005	0.16	< 0.005	0.060
Boron	mg/L	0.13	0.11	0.16	0.13	0.46	0.12	0.14	0.11	0.11	0.065

TABLE 2: SITE GROUNDWATER QUALITY DATA (expressed in milliequivalents per liter (meq/L))

Well Number	Units	1312	1314	1315	1316	1317	1325	1326	1331	1335	1336
Sampling Date		Mar-90	Mar-90	Mar-90	Mar-90	Mar-90	Mar-90	Mar-90	Mar-90	Mar-90	Mar-90
Calcium	meq/L	2.00	3.69	5.84	5.84	11.13	3.23	3.64	6.19	3.72	5.49
Magnesium	meq/L	1.02	1.95	3.87	3.41	8.88	1.8[illegible]	2.20	3.48	2.40	9.38
Sodium	meq/L	6.09	0.71	1.74	1.77	9.27	0.96	1.02	2.37	0.85	5.35
Potassium	meq/L	0.35	0.03	0.00	0.00	0.08	0.00	0.03	0.00	0.00	0.39
Bicarbonate	meq/L	18.68	6.59	8.13	10.13	21.14	5.51	5.97	10.87	5.95	17.87
Carbonate	meq/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chloride	meq/L	0.85	0.45	1.89	1.92	3.67	0.22	0.34	0.48	0.19	1.38
Sulfate	meq/L	0.94	0.18	2.08	0.81	3.96	0.21	0.48	1.46	0.25	2.02
Fluoride	meq/L	2.42	0.04	0.08	0.07	0.16	0.05	0.03	0.06	0.06	3.00
Nitrate as N	meq/L	15.00	0.04	0.15	0.16	0.02	0.23	0.26	0.21	0.34	27.42
Phosphate	meq/L	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aluminum	meq/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Iron	meq/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Cations	meq/L	9.47	6.39	11.47	11.02	29.37	6.08	6.91	12.05	6.98	20.61
Total Anions	meq/L	37.09	7.29	12.33	13.09	28.95	6.22	7.07	13.08	6.79	51.69
Total Anions-NO3	meq/L	22.09	7.26	12.18	12.93	28.93	5.99	6.82	12.87	6.45	24.27
Ion Balance	%	60.02	6.57	3.62	8.61	0.72	1.12	1.19	4.10	1.41	42.98
Ion Balance-NO3	%	41.49	6.33	2.99	7.99	0.75	0.73	0.67	3.29	3.90	8.14

TABLE 3: AVERAGE BACKGROUND AND SITE GROUNDWATER QUALITY DATA (mg/L)

Well Number	Units	BKG AVERAGE	SITE AVERAGE
Specific Conductance	umho/cm	725	3000
TDS	mg/L	348	876
pH	std units	7.02	7.01
Calcium	mg/L	71.6	101.7
Magnesium	mg/L	25.6	46.8
Sodium	mg/L	20.4	69.3
Potassium	mg/L	1.2	3.4
Bicarbonate	mg/L	366	676
Carbonate	mg/L	0.00	0.00
Chloride	mg/L	10.7	40.4
Sulfate	mg/L	13.4	59.5
Silicon	mg/L	14.0	11.8
Fluoride	mg/L	0.9	11.4
Nitrate as N	mg/L	13	271
Ammonia as N	mg/L	0	360
Phosphate	mg/L	0.00	0.00
Aluminum	mg/L	0.069	0.074
Iron	mg/L	0.045	0.030
Uranium	mg/L	0.000	0.699
Boron	mg/L	0.120	0.154

TABLE 4: Saturation Indicies Calculated For Site Groundwater Using WATEQ4F

Well Number	1314	1315	1316	1317	1325	1326	1331	1335	MEAN
Adularia	-0.012	------	------	0.787	------	0.501	------	------	0.475
Albite	-1.329	-0.901	-0.829	0.158	-0.953	-0.661	-1.358	-1.521	-0.924
Allophane (a)	0.237	0.340	0.216	0.098	0.264	0.273	0.107	0.144	0.210
Aragonite	-0.261	-0.031	0.034	0.551	-0.327	-0.377	0.017	-0.337	-0.091
Calcite	-0.110	0.119	0.185	0.702	-0.177	-0.227	0.167	-0.187	0.059
Chalcedony	0.266	0.224	0.329	0.486	0.328	0.463	0.153	0.222	0.309
Cristobalite	0.350	0.309	0.413	0.570	0.412	0.548	0.237	0.306	0.393
Dolomite	-0.553	0.008	0.081	1.256	-0.646	-0.727	0.031	-0.620	-0.146
Fluorite	-0.857	-0.123	-0.163	0.603	-0.595	-0.995	-0.286	-0.480	-0.262
Gypsum	-2.024	-1.496	-1.892	-1.159	-2.599	-2.215	-1.631	-2.490	-2.013
Halloysite	-0.223	0.007	-0.198	-0.368	-0.100	0.135	-0.685	-0.524	-0.245
Illite	2.495	------	------	2.995	------	3.090	------	------	2.860
Jarosite K	-0.240	------	------	1.253	------	0.640	------	------	0.551
Magnesite	-0.931	-0.600	-0.592	0.066	-0.957	-0.908	-0.624	-0.921	-0.693
Montmorillonite Ca	3.990	4.232	4.120	4.182	4.220	4.651	3.300	3.571	4.034
Phillipsite	-0.731	------	------	0.412	------	-0.140	------	------	-0.153
Quartz	0.785	0.744	0.848	1.006	0.847	0.983	0.672	0.741	0.828
SiO2(a,L)	-0.243	-0.285	-0.180	-0.023	-0.181	-0.046	-0.356	-0.287	-0.200
SiO2(a,M)	-0.564	-0.605	-0.500	-0.343	-0.502	-0.366	-0.676	-0.607	-0.520

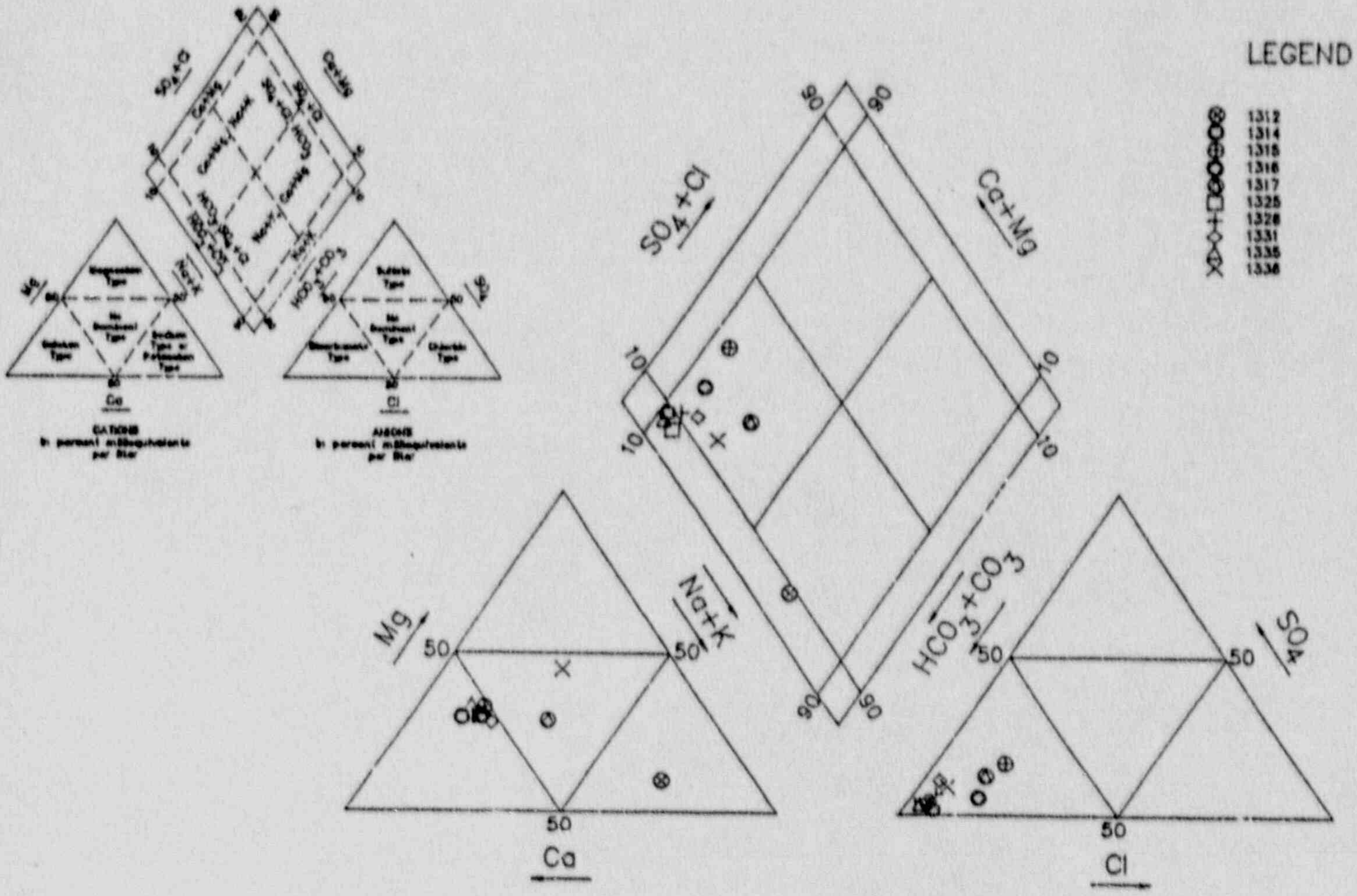

Figure 12 Piper Diagram of Site Ground Water

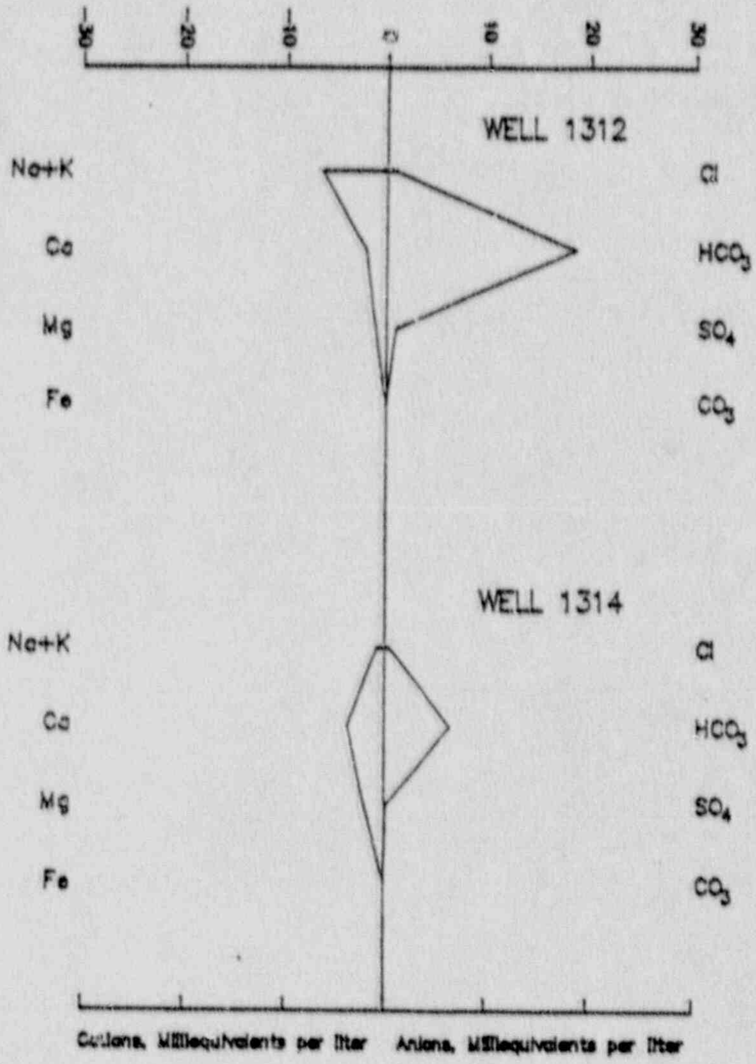

Figure 13 Stiff Diagram of Wells 1312 and 1314

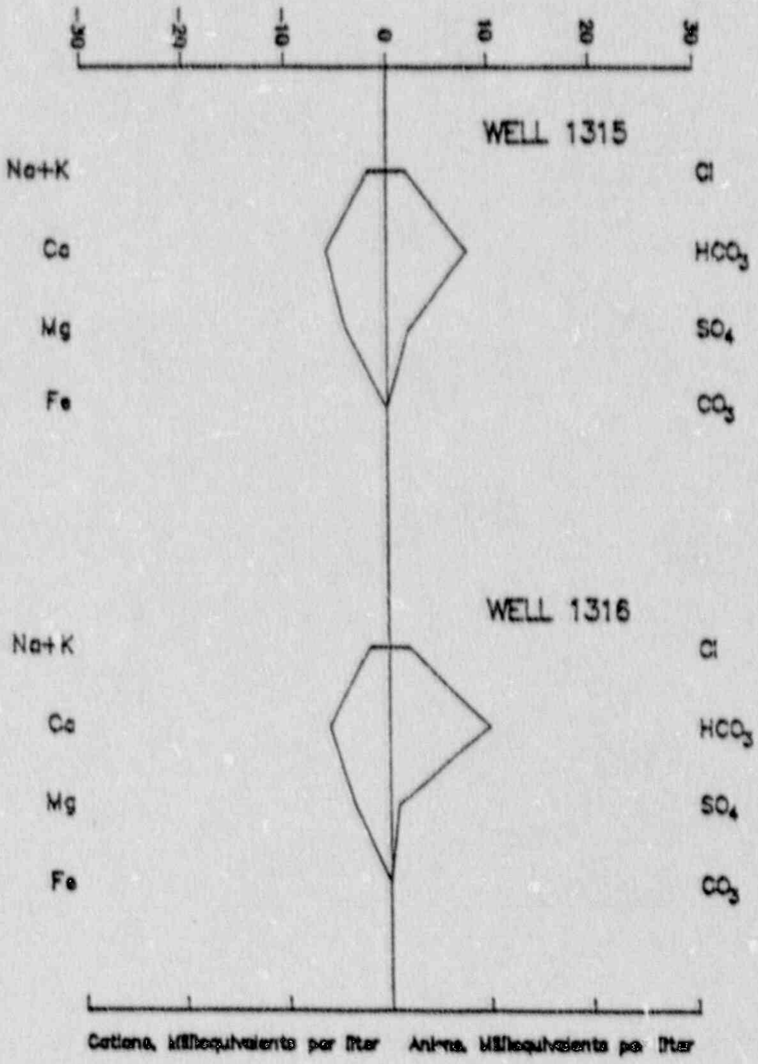

Figure 14 Stiff Diagram of Wells 1315 and 1316

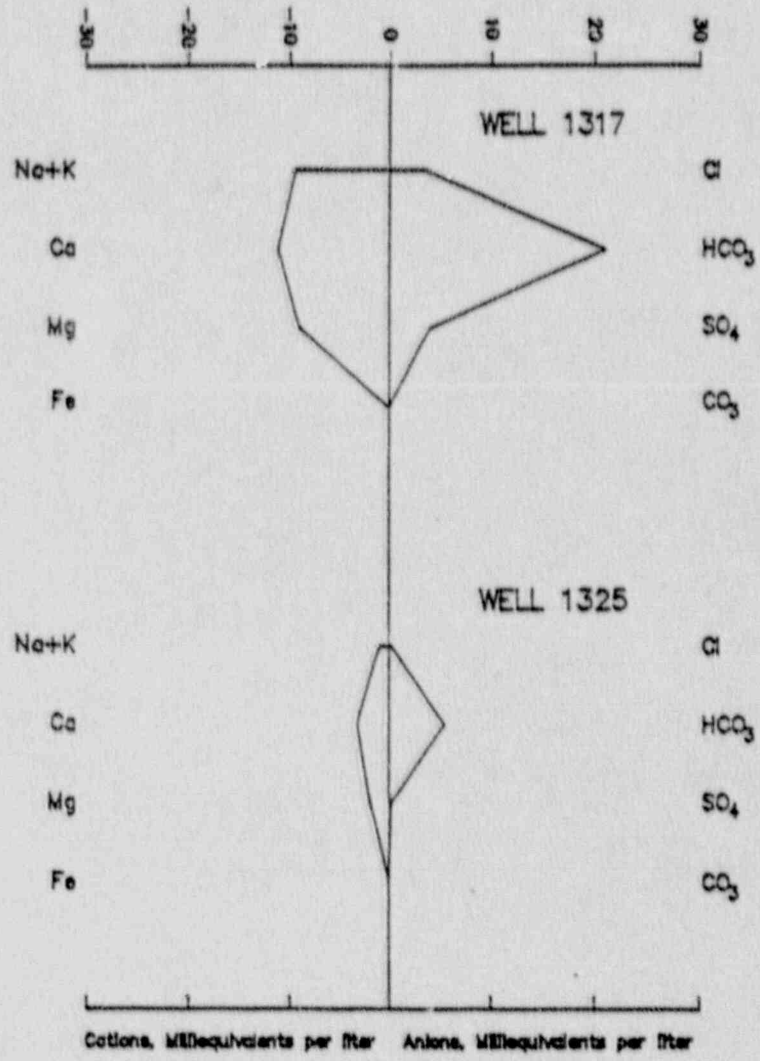

Figure 15 Stiff Diagram of Wells 1317 and 1325

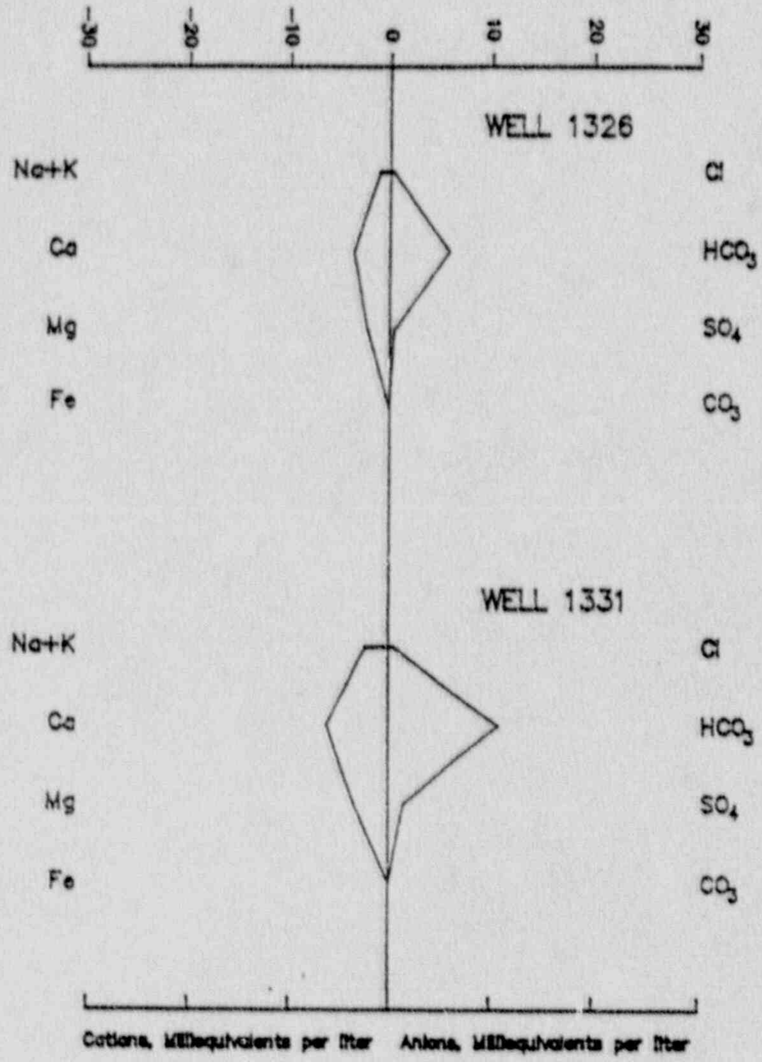

Figure 16 Stiff Diagram of Wells 1326 and 1331

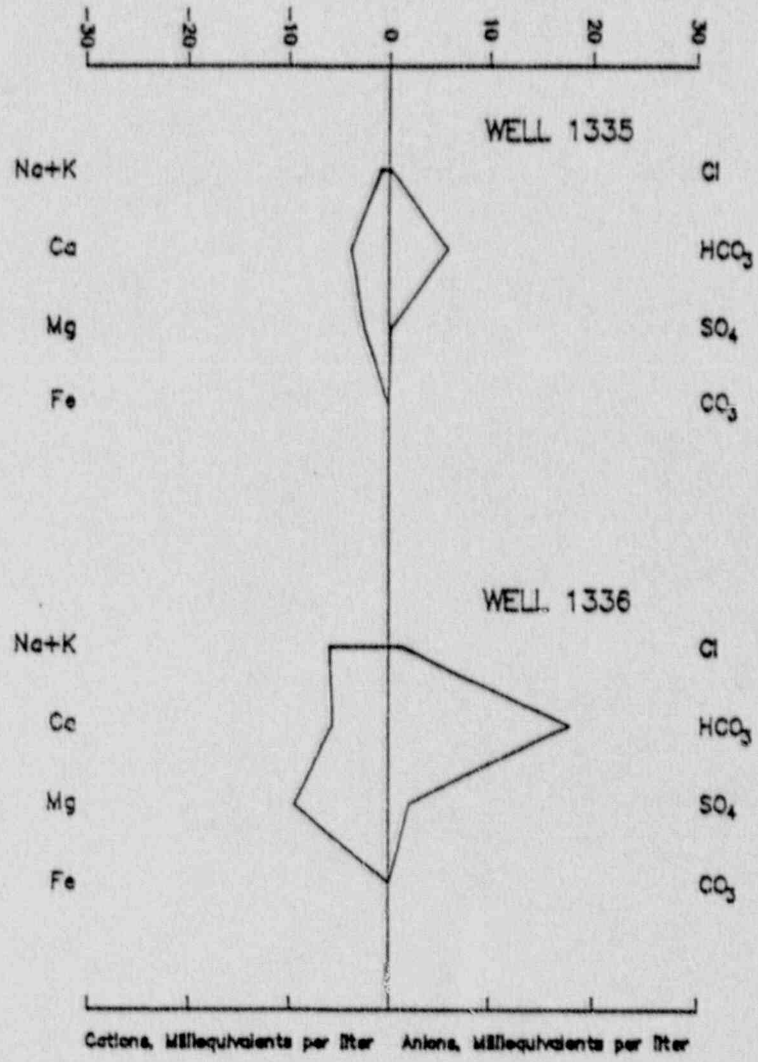

Figure 17 Stiff Diagram of Wells 1335 and 1336

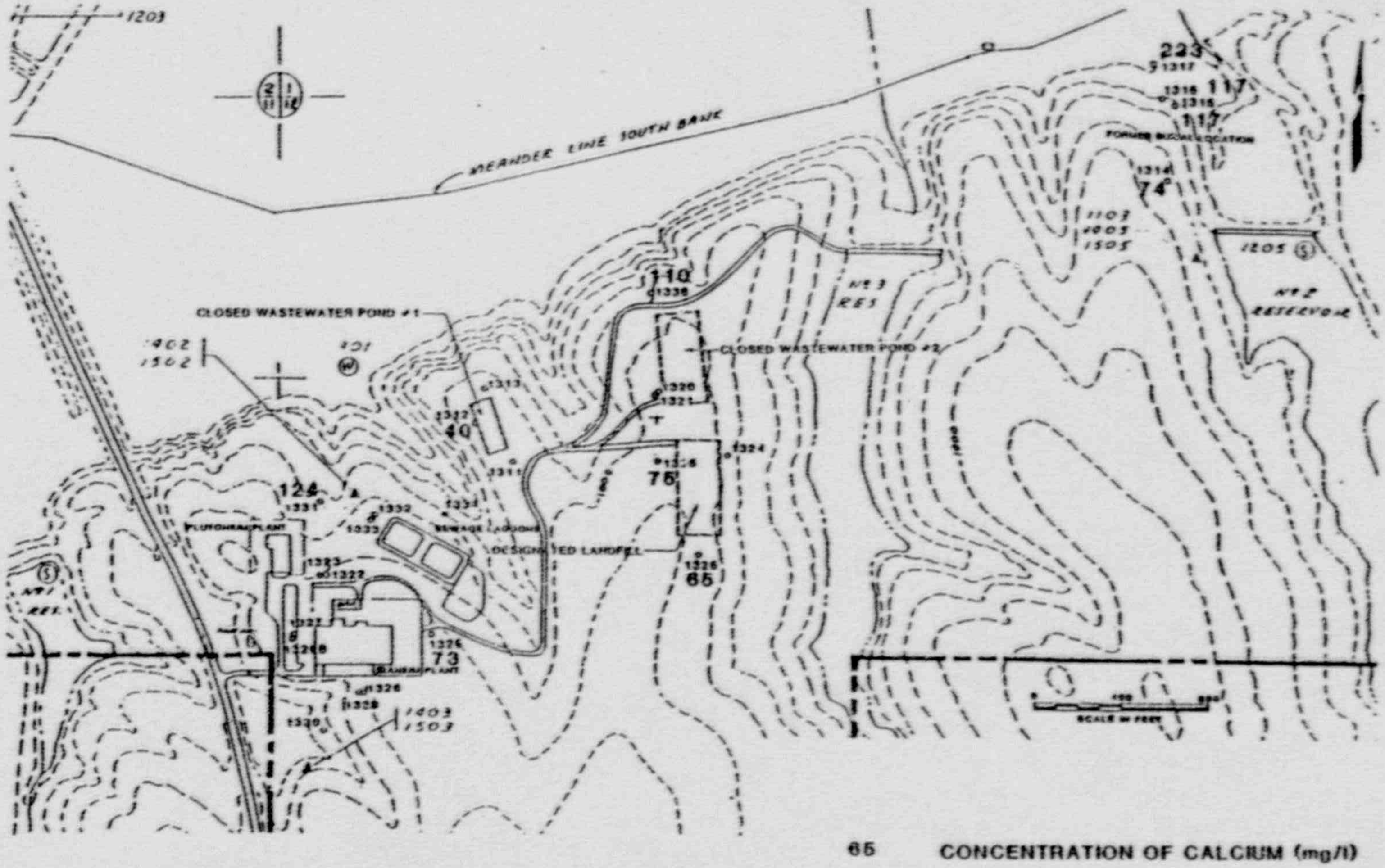

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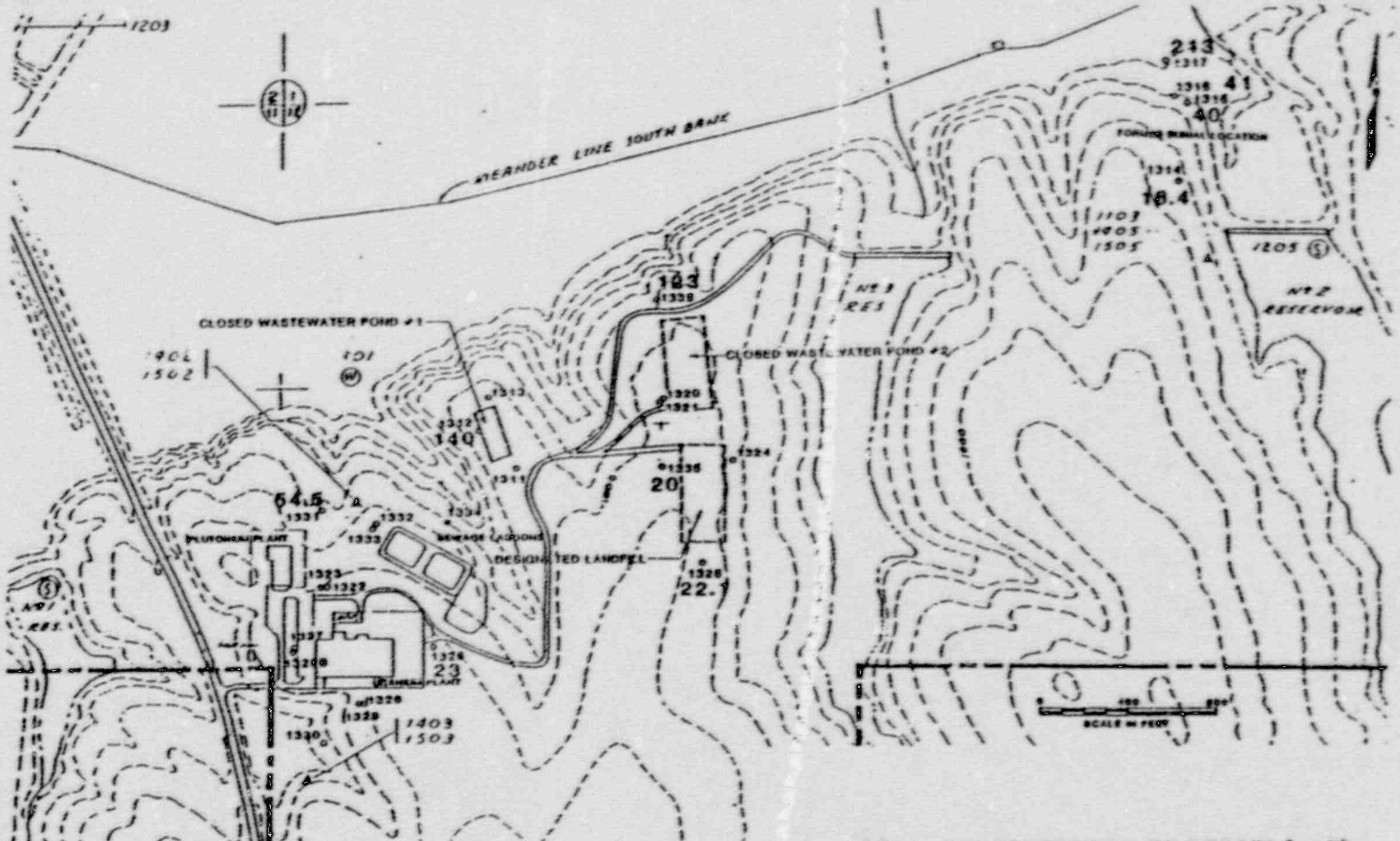
Figure 18

Areal Distribution of Calcium



20 CONCENTRATION OF SODIUM (mg/l)

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Figure 20

Areal Distribution of Sodium

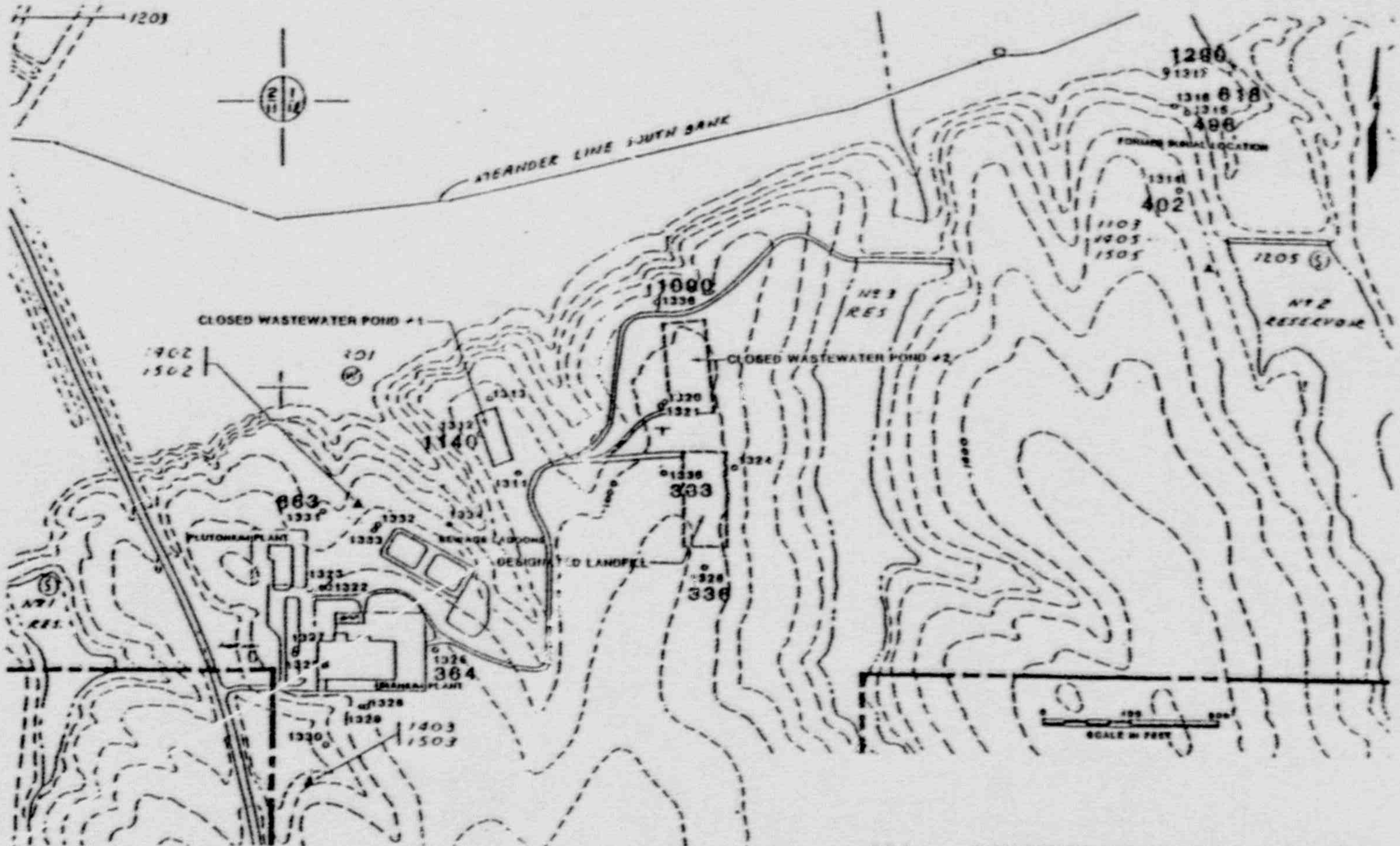

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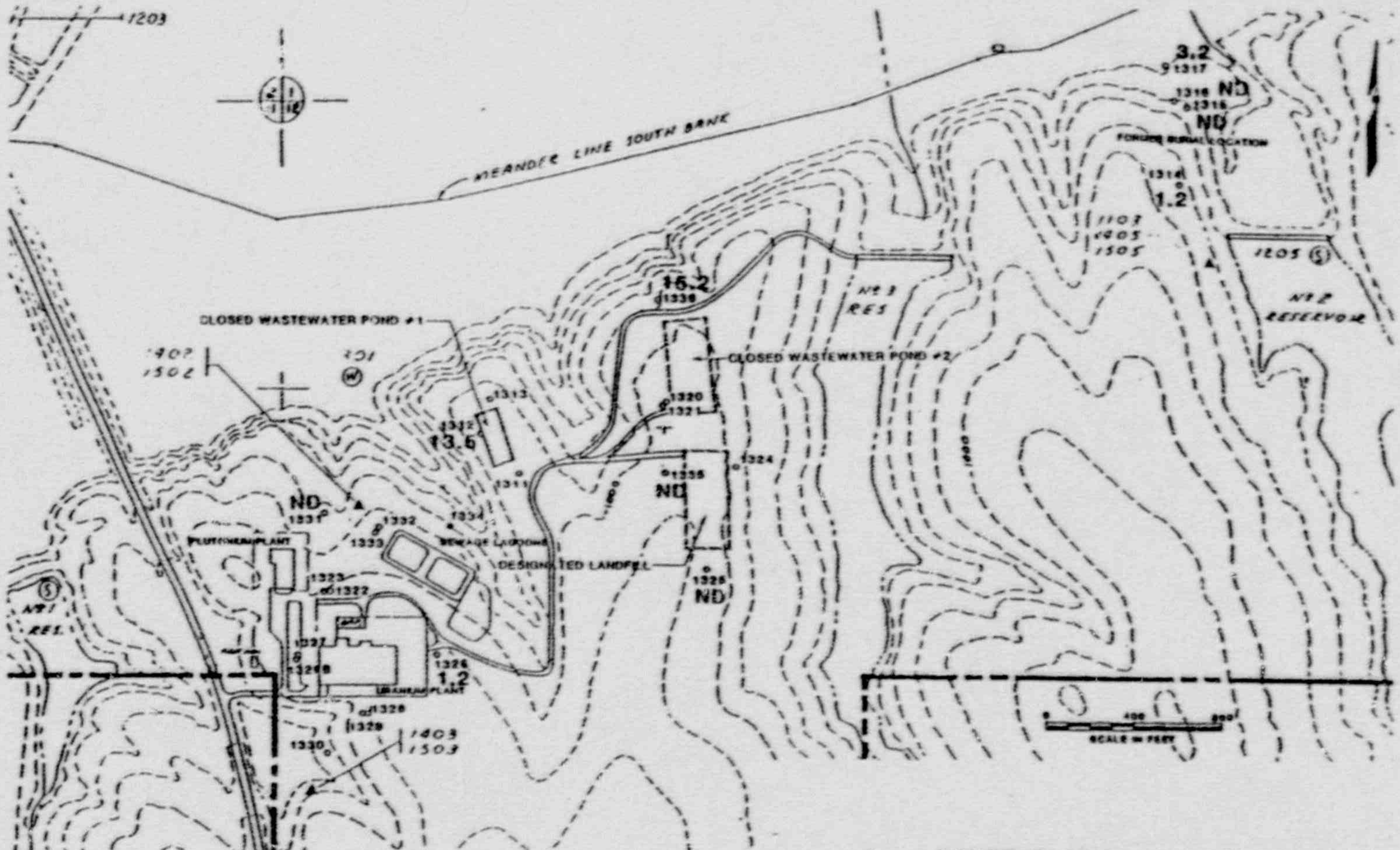
Figure 19

Areal Distribution of Bicarbonate



1.2 CONCENTRATION OF POTASSIUM (mg/l)

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Figure 21

Areal Distribution of Potassium

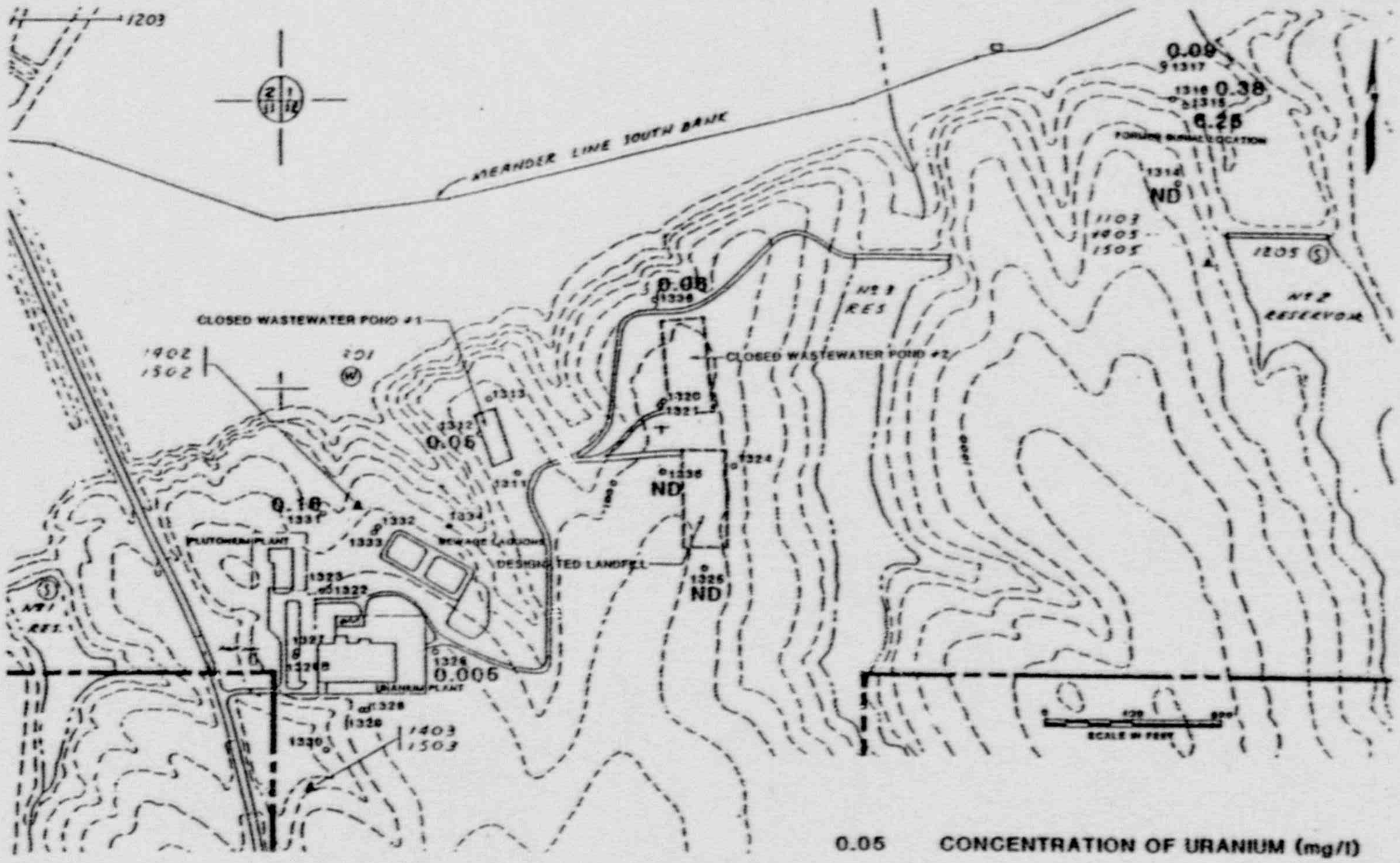

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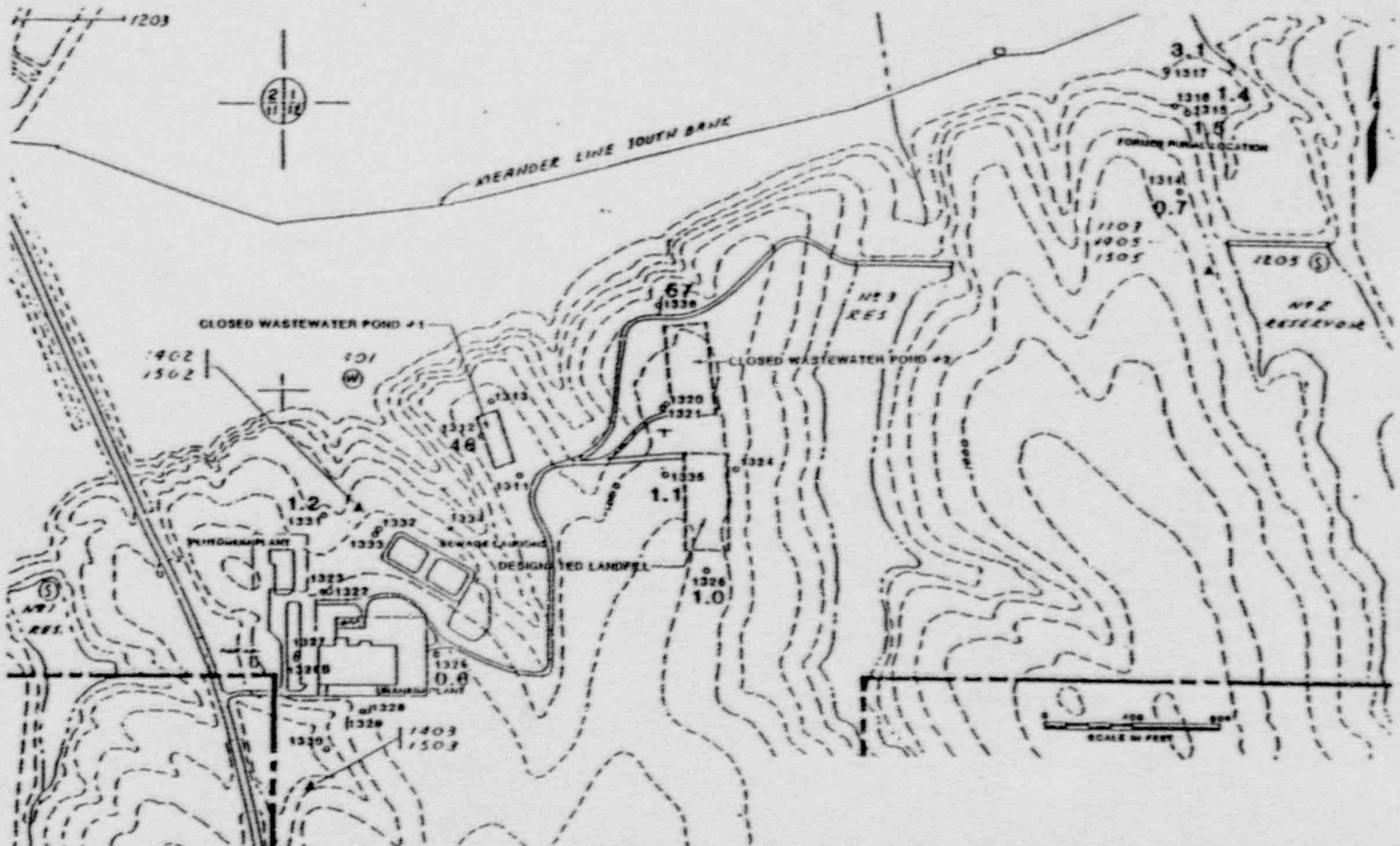
Figure 22

Areal Distribution of Uranium



1.1 CONCENTRATION OF FLUORIDE (mg/l)

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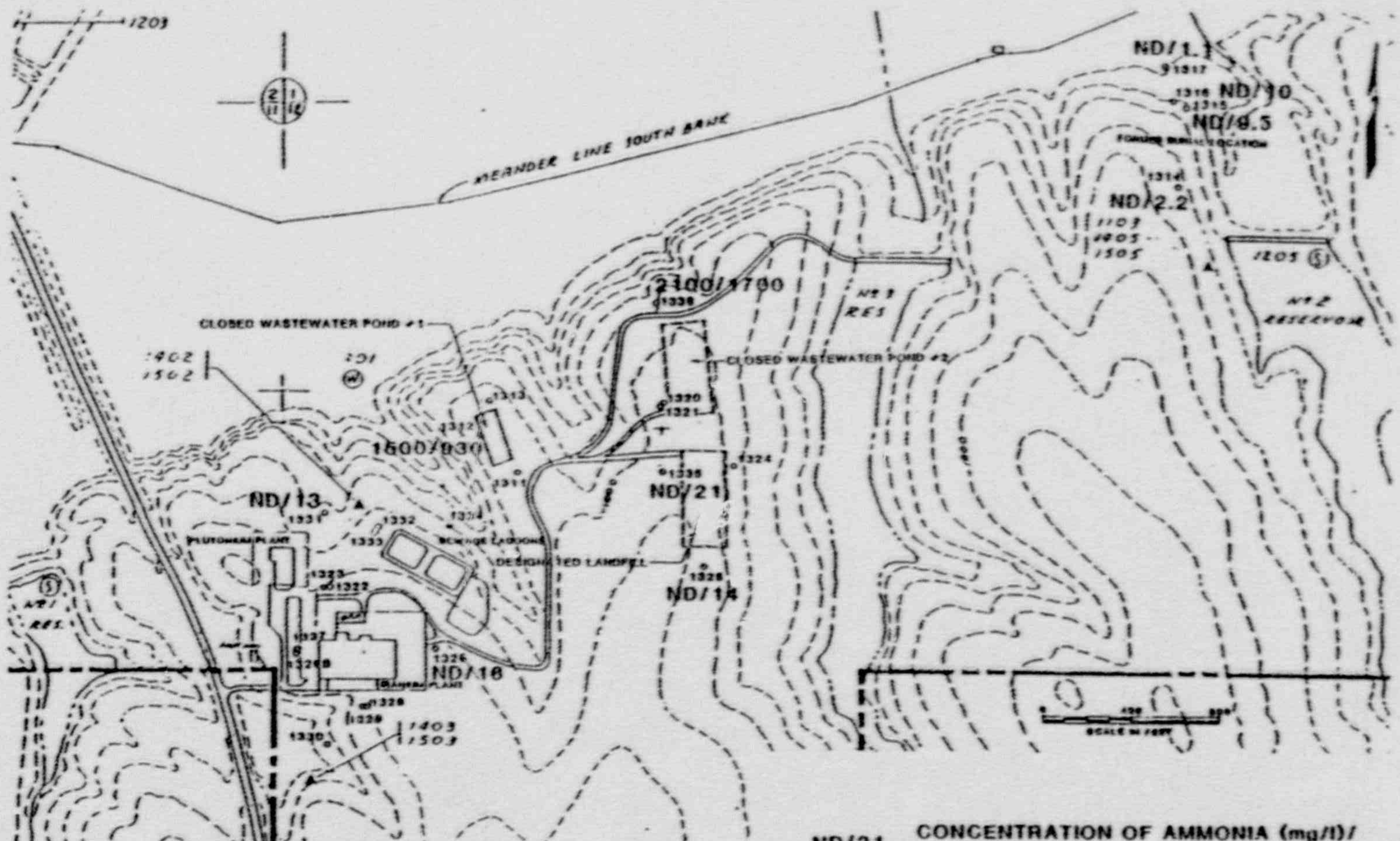
Figure 23

Areal Distribution of Fluoride



ND/21 CONCENTRATION OF AMMONIA (mg/l)/
CONCENTRATION OF NITRATE (mg/l)

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Figure 24

Areal Distribution of Ammonia and Nitrate

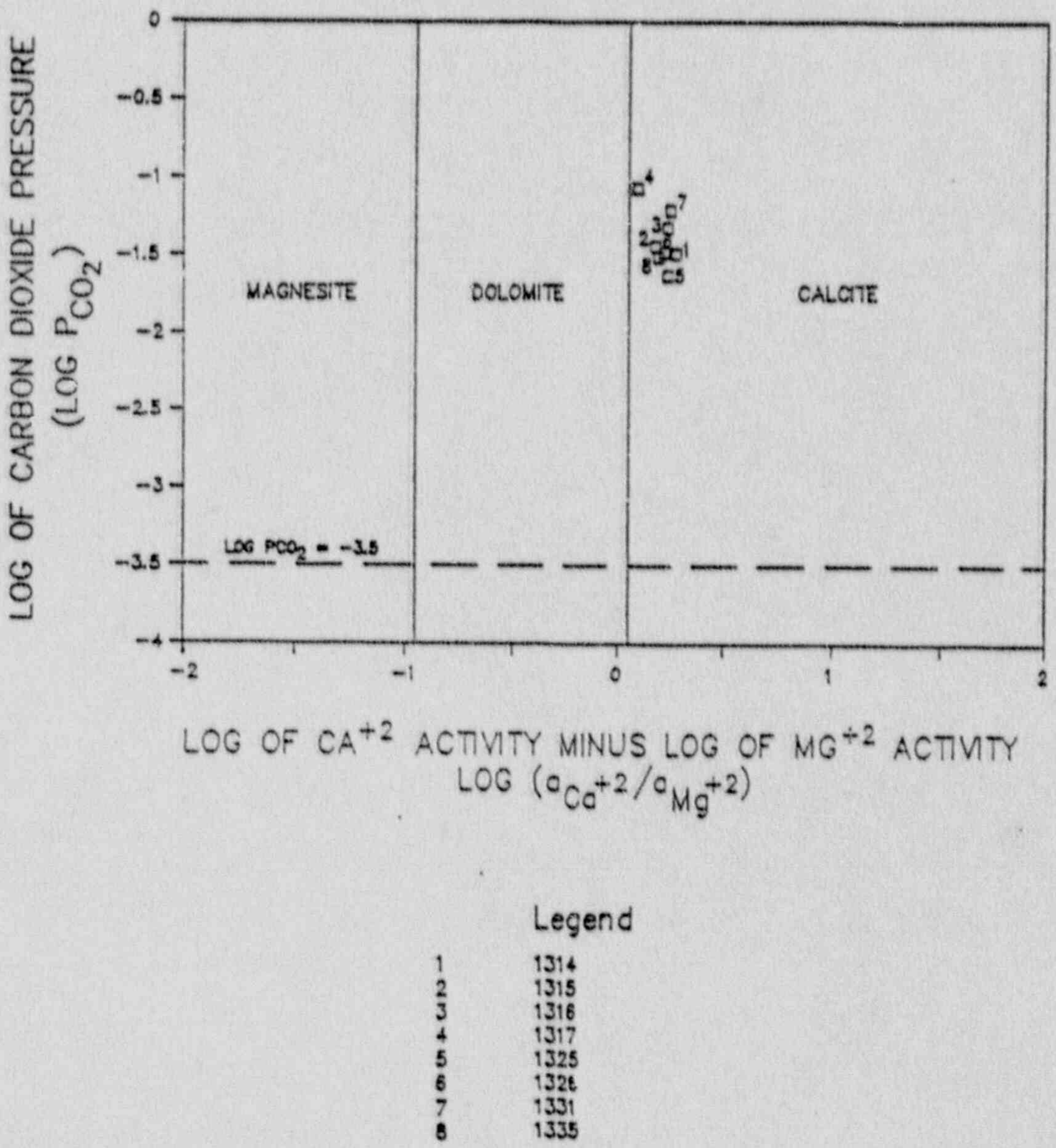

Figure 25 Carbonate Mineral Stability Diagram

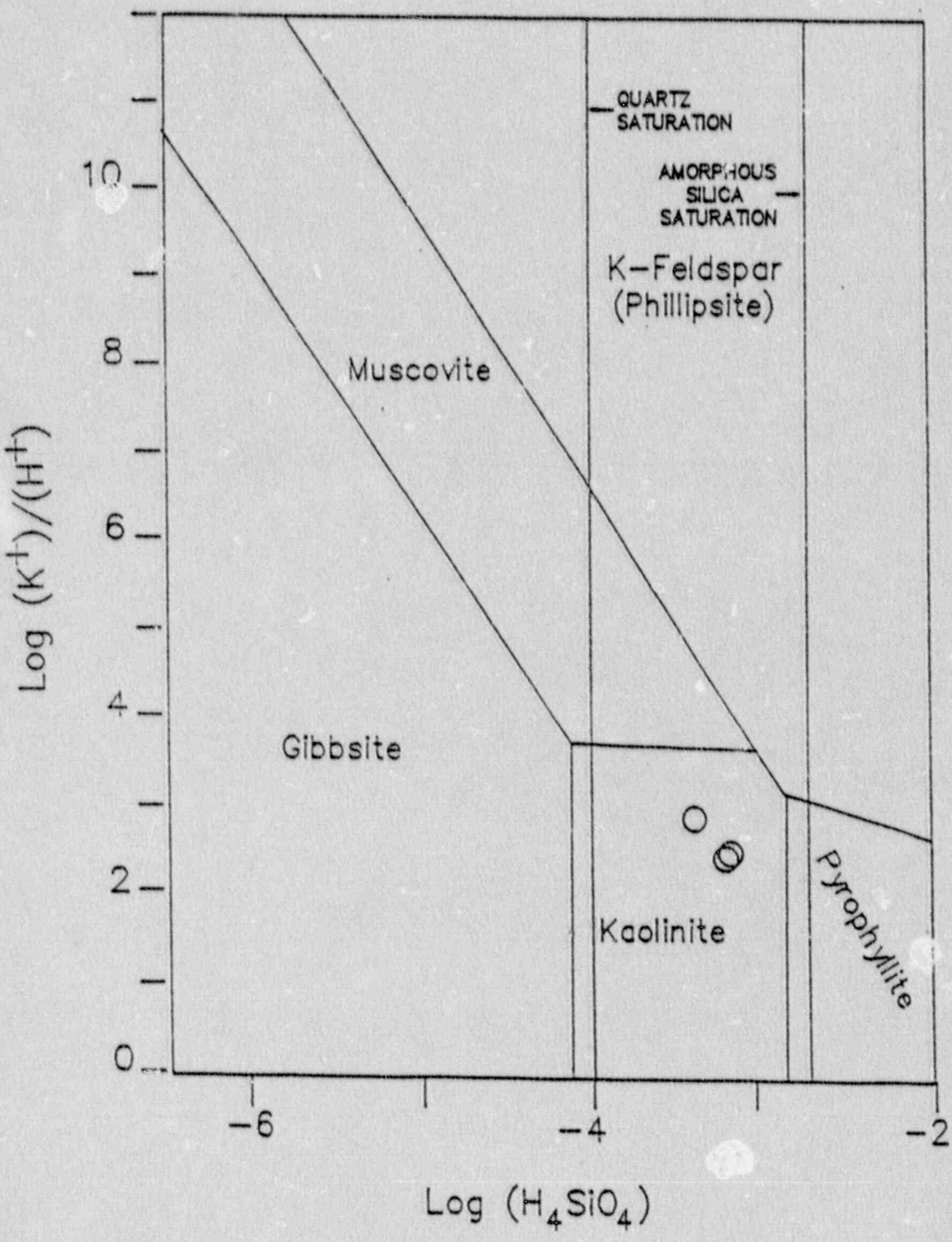

Figure 26 Silicate Mineral Stability Diagram for Activity of K^+/H^+ and H_4SiO_4

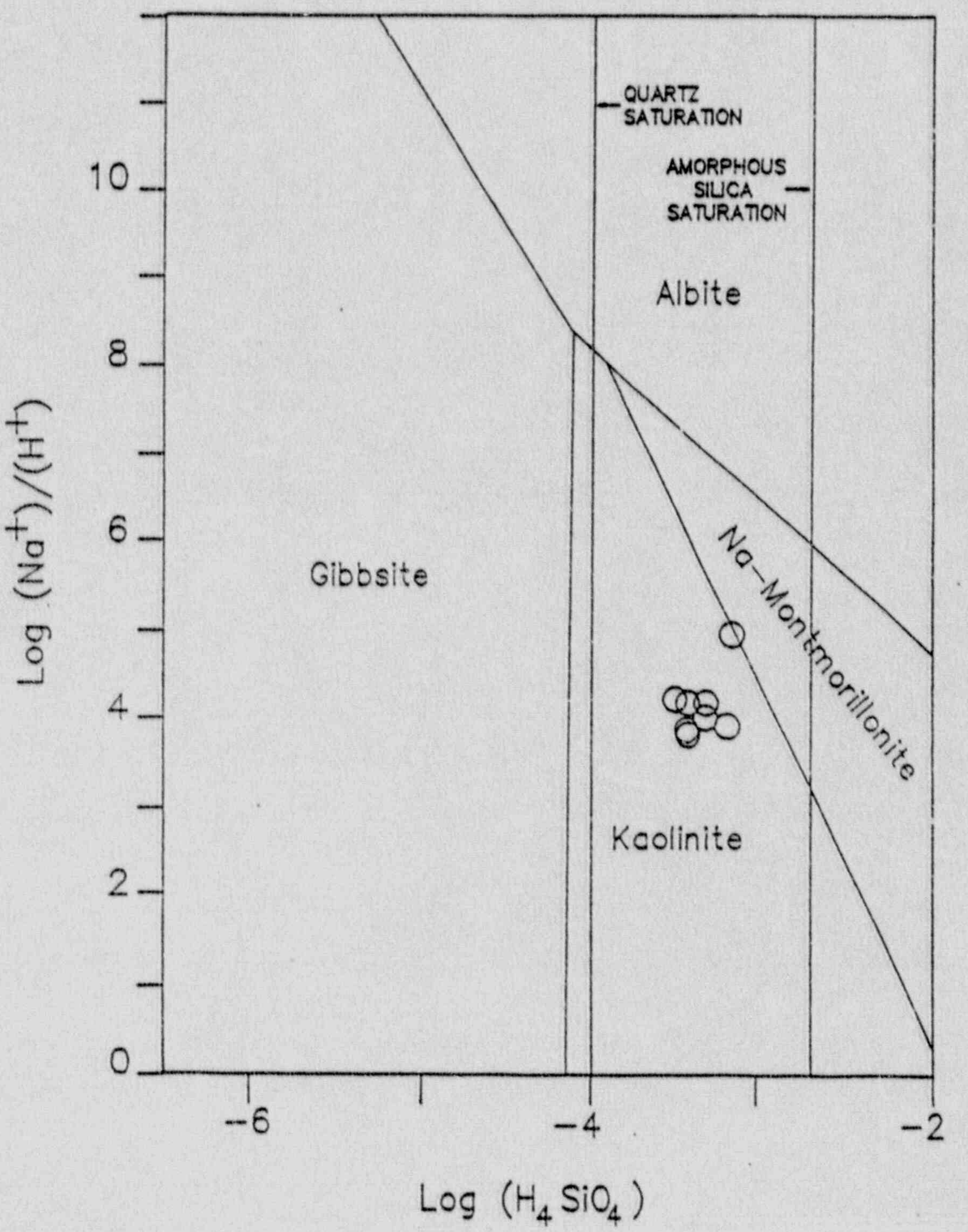

Figure 27 Silicate Mineral Stability Diagram for Activity of Na^{+}/H^{+} and H_4SiO_4

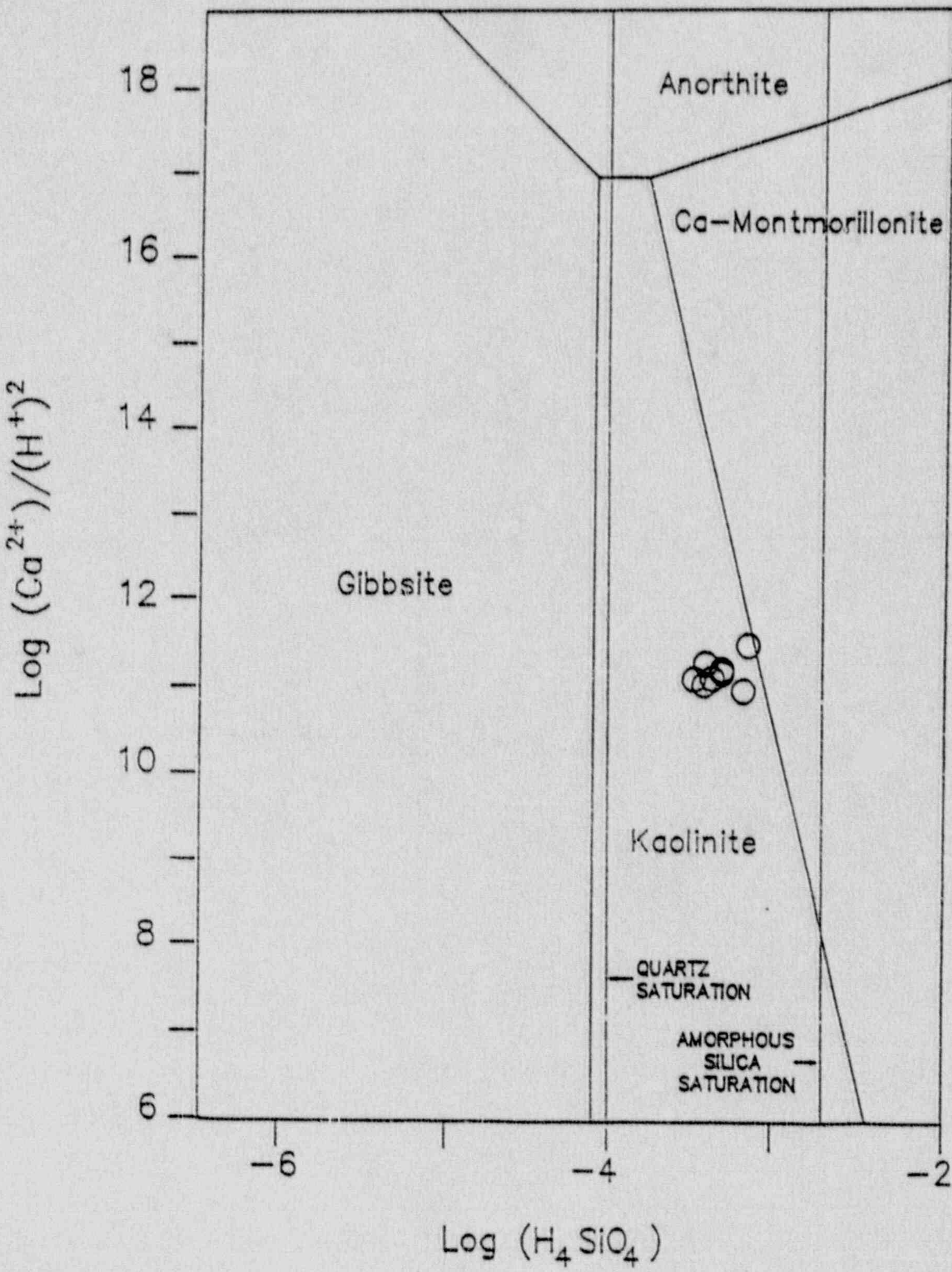

Figure 28 Silicate Mineral Stability Diagram for Activity of $Ca^{+}/(H^{+})^{2}$ and H_4SiO_4

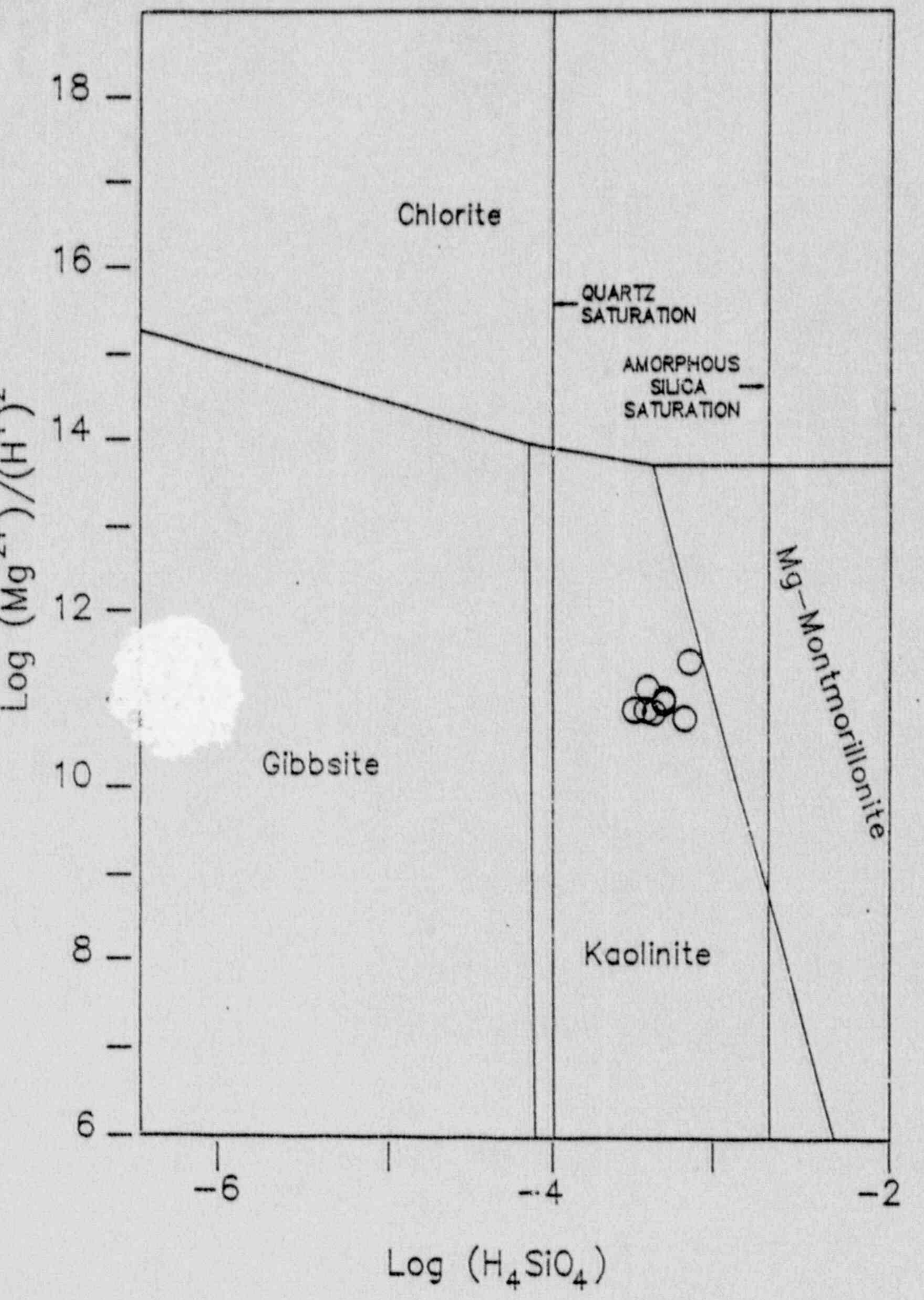

Figure 29 Silicate Mineral Stability Diagram for Activity of $Mg^+/(H^+)^2$ and H_4SiO_4

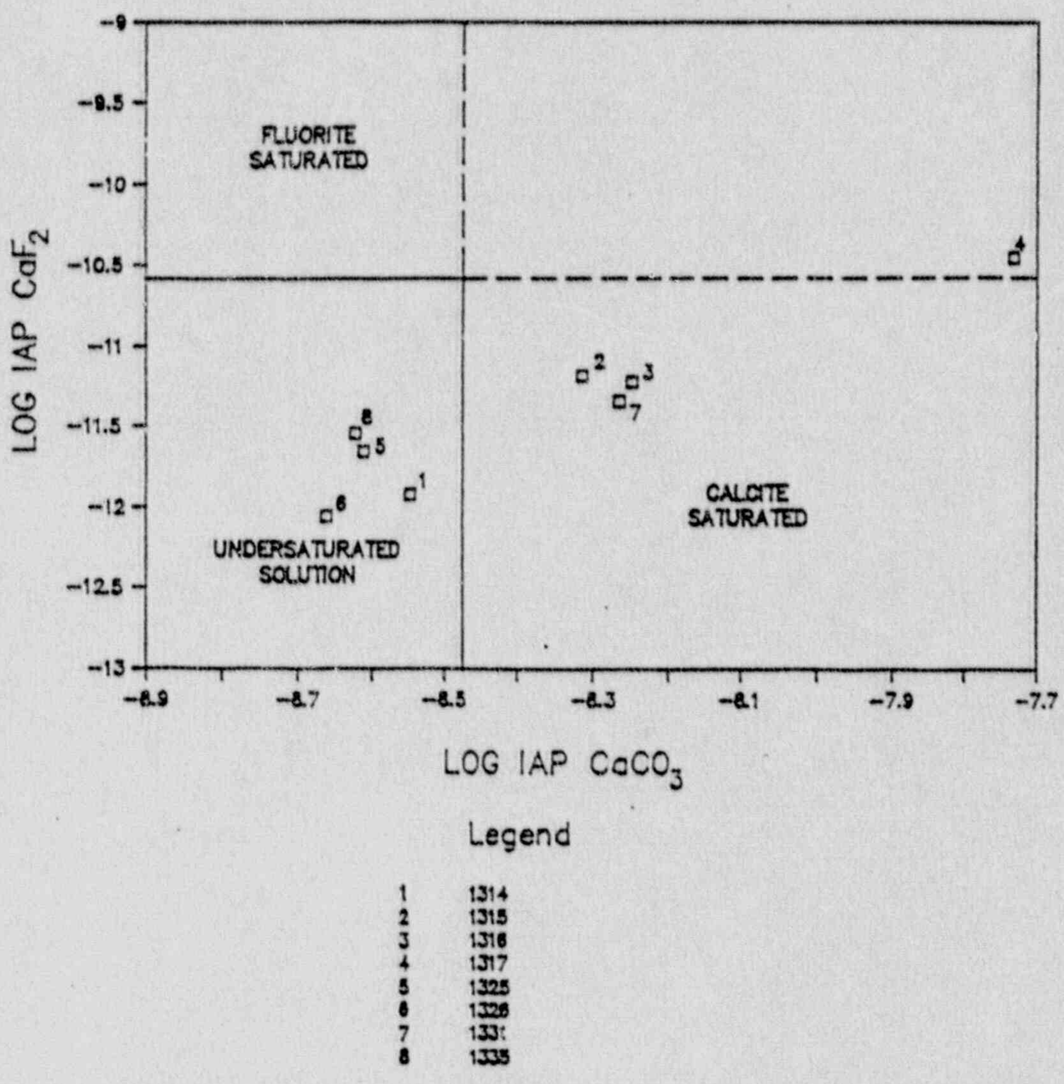

Figure 30 Ion Ac... y Product Diagram for Fluorite and Calcite

8. GROUND-WATER PATHWAY MODEL

Cimarron Corporation has evaluated the potential for radiological exposure to the general public from future use of ground water and from surface activities at the Cimarron Facility. Potential pathways evaluated for exposure to the public were ingestion of drinking water from a ground-water source, ingestion of drinking water from a surface water source, ingestion of agricultural products grown in contaminated soil, inhalation of airborne soils and direct external exposure to penetrating radiation.

Exposure scenarios, parameter values and assumptions used in the pathway evaluation were based on the methods contained in NUREG/CR-5512.[19] Exposure potential calculations are based on average predicted concentrations of uranium in contaminated soil and water of 70 pCi/g and 10 pCi/l, respectively. The soil concentration of 70 pCi/g total uranium is the predicted average concentration for soil to be left on-site under the provisions of Option 2 NRC Branch Technical Position. The water concentration of 10 pCi/l total uranium was determined to be a localized concentration of uranium in ground water reflective of past localized impacts from waste management. (See Site Investigation Report for the Cimarron Corporation Facility, James L. Grant and Associates, Inc., September 12, 1989, page 3-10).

The assumptions and calculations to determine the potential doses received by individuals potentially exposed to the uranium contained in media left at the Cimarron Facility is attached. The committed effective dose equivalent from each exposure pathway is summarized in Table 5. The calculation details are presented in Appendix B. The total committed effective dose equivalent is 5 mrem, from a one-year intake from all pathway sources combined. This dose is well within the Nuclear Regulatory Commission reference level of 100 mrem/year to the general public contained in the proposed changes to 10 CFR 20. We believe that this exposure potential is not significant, and in fact is conservative, based upon the probable future land use for agricultural or pasture utilization. Any nearby future residents would be connected to the existing rural water supply sources for potable water.

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[19] U. S. Nuclear Regulatory Commission, *Residual Radioactive Contamination form Decommissioning - Technical Basis for Translating Contamination Levels to Annual Dose.*

Table 5 Summary of Pathway Evaluation - Cimarron Facility

PATHWAY	DOSE* (mrem)
Direct External To Penetrating Radiation	0.29
Inhalation of Airborne Materials	2.44
Ingestion of Agricultural Food Products	0.90
Ingestion of Drinking Water	1.36
Ingestion of Surface Water (Res. No. 3)	0.005
TOTAL COMMITTED EFFECTIVE DOSE EQUIVALENT	5.00

* Dose means committed effective dose equivalent from one year intake.

9. FUTURE LAND AND WATER USE

Cimarron Corporation completed a survey to locate and describe all wells south of the Cimarron river and within a three mile radius of the Cimarron facility. This survey was conducted by searching the data files of the USGS in Oklahoma City, the Water Resources Division of the Association of Central Oklahoma Governments (ACOG), and the Oklahoma Water Resources Board. The wells located during this search are presented in Table 6. This table presents information, where available, about the depth, screened interval, and reported use of each well.

Lands around the Cimarron Facility are used for farming and grazing. The predominant crop is winter wheat. Irrigation is not common; most wells provide a domestic water supply for individual houses. A rural public water company supplies potable water to most homes and farms in the area. This water company obtains its water from wells completed in terrace deposits north of the Cimarron River.

Cimarron Corporation understands that land and water use in the area in the foreseeable future will be the same as is found today. The site area is sufficiently far from Oklahoma City, the nearest major metropolitan area, that significant development is not anticipated. Table 7 presents 1980 populations of Logan County and the cities of Cresent and Guthrie, along with projected populations for these governmental units for the years 1990 and 2000. Little growth is projected for the county or for the cities. The projected growth rate of the county is decreasing with time. Projected growth from 1980 to 1990 represents a 16 percent increase over the 1980 population, while growth from 1990 to 2000 is only 7 percent of the 1990 population.

The above population estimates indicate that the site area will remain rural. Because population and land use are not projected to change much in the future, the patterns of well construction and ground water use indicated by Table 6 are considered representative of future conditions and uses. Table 6 shows that the Garber-Wellington is used primarily for domestic supplies in the area (only one irrigation well is completed in the Garber-Wellington). Most of the Garber-Wellington wells are deep; three of the four domestic wells are deeper than 90 feet, and the most shallow well is 68 feet deep. The Garber-Wellington wells typically are screened from near ground surface to the bottom of the well. No shallow wells, wells completed only in the shallow water-bearing zone located at the site, were found in the area survey.

Table 6 Area Wells Near the Cimarron Facility

Well Owner	Location Sec/Twn/Rng	Elevation (ft,msl)	Formation	Well Purpose	Date Installed	Total Depth (ft)	Casing Depth (ft bgs)	Filter Pack (ft bgs)	Perforations (ft bgs)	Water Level (ft bgs)	Flow Rate (gpm)
STOLTS	SW NE NE 8-16N-3W	990	NA	DOMESTIC	1984	150	4.5"- 150	10 - 150	80 - 90 120 - 160	50	NA
ELLIS	SE SE NE 18-16N-3W	NA	NA	DOMESTIC	1987	190	6" - 10 4.5" - 190	10 - 190	50 - 190	70	20
NA	SW SE SE 10-16N-4W	970	PGW	TEST	1974	62	NA	NA	NA	42	NA
OWRB	SE SE SE SE 14-16N-4W	985	QT	TEST	NA	45	NA	NA	NA	NA	NA
OWRB	SW SE SE SE	1005	QT	TEST	NA	32	NA	NA	NA	NA	NA
NA	NE NE NE 14-16N-4W	1074	PGW	DOMESTIC	1974	91	NA	NA	NA	55	NA
NA	NE NE NW 14-16N-4W	1010	PGW	DOMESTIC	1970	68	NA	NA	NA	40	NA
ELLIS	SE SW SW 14-16N-4W	NA	NA	DOMESTIC	1987	160	4.5" - 160	65 - 160	110 - 120 130 - 160	90	15
BUXTON	NW NW NE NE 16-16N-4W	950	PGW	IRRIGATION	NA	163	NA	NA	NA	20	NA
BUXTON	NW NE SE 16-16N-4W	NA	NA	INDUSTRIAL	1979	163	9" - 30 6.75" - 163	NONE	NONE	20	PLUGGED (SALTY)
NA	SW N[illegible] NW 23-16N-4W	NA	NA	NA	NA	11	NA	NA	NA	NA	NA
MARTIN	NE NE NW 18-16N-3W	1040	PH	IRRIGATION	1974	NA	NA	NA	NA	NA	NA
MARTIN	NW SW NW 18-16N-3W	1010	PH	IRRIGATION	1974	NA	NA	NA	NA	NA	NA
MARTIN	SE NE SW 18-16N-3W	1063	PW	IRRIGATION	NA	NA	NA	NA	NA	NA	NA
MARTIN	SE SW SE 18-16N-3W	1040	PH	IRRIGATION	1989	190	8" - 18 6" - 190	18 - 190	50 - 190	40	80
MARTIN	NE SE NE 18-16N-3W	1063	PGW	DOMESTIC	1974	NA	NA	NA	NA	75	NA

Table 6 Area Wells Near the Cimarron Facility
(Continued)

Well Owner	Location Sec/Twn/Rng	Elevation (ft,msl)	Formation	Well Purpose	Date Installed	Total Depth (ft)	Casing Depth (ft bgs)	Filter Pack (ft bgs)	Perforations (ft bgs)	Water Level (ft bgs)	
MARTIN	SE SE SW 18-16N-3W	1040	PH	IRRIGATION	NA	NA	NA	NA	NA	NA	NA
MARTIN	SE SW SW 18-16N-3W	1030	PH	IRRIGATION	NA	NA	NA	NA	NA	NA	NA
POPE	SE NE NE 18-16N-3W	1060	PGW	DOMESTIC	NA	157	NA	NA	NA	NA	35
HARMONY	SE SE NE 18-16N-3W	1060	PGW	DOMESTIC	1970	150	NA	NA	NA	NA	50
DATIN	SW SW SW 7-16N-3W	NA	NA	DOMESTIC	1989	100	5" - 14 4" - 100	12 - 100	80 - 100	25	20
WILLIAMS	SE SW NE 7-16N-3W	NA	NA	DOMESTIC	1984	165	6" - 11 4" - 165	60 - 165	120 - 135 145 - 160	50	15
FABUION	NE NW NE 8-16N-3W	NA	NA	DOMESTIC	1980	170	6" - 10 4.5" - 170	60 - 170	80 - 90 120 - 160	40	20

Notes: NA - not available
PH - Permian Herrington
PGW - Permian Garber-Wellington
QT - Quaternary Terrace

Table 7 Area Population Projections for the Site Area

Area	1980 Census	1990 Projection	Percent Increase	2000 Projection	Percent Increase
Logan County	26,881	31,200	16	33350	7
Cresent	1,651	1,700	3	1,800	6
Guthrie	11,384	12,100	6	13,200	9

Source: U. S. Department of Commerce, *Population Projections for Oklahoma, 1980 - 2010,* November, 1988.

10. REVISED SOIL VOLUME ESTIMATE

Cimarron Corporation includes herein a revised volume estimate for the soil to be left at the Cimarron Facility under the provisions of Option 2 of the Branch Technical Position. The estimate is based on Cimarron Corporation's collection of an additional 100 soil samples from 50 locations within the uranium plant yard area. Analysis of the sampling data indicates that 3,500 cubic yards of soil will be left within the perimeter of the uranium plant yard area under four feet of clean soil. The balance of the Option 2 level soil (consisting of approximately 15,000 cubic yards of Option 2 material closer than 4 feet to the surface) will be relocated from the yard area to the designated Option 2 material disposal area.

The sample locations used to calculate the volume estimate are identified in Figure 31. Two samples were collected at each location, from the 0-1 foot and 1-2 foot depth intervals. Figures 32 and 33 show locations which exceeded a uranium concentration of 20 pCi/g for the two depth intervals described above. In addition to this soil, contaminated soil is presently being removed from beneath the uranium plant floor. Approximately 1/6 of the potentially contaminated floor area has been evaluated and the above Option 2 concentration soil removed. The projected volume of affected soil under the floor is 3,300 cubic yards. Experience gained in this decommissioning activity was used to estimate the quantity of soil requiring removal and the quantity which will remain in-situ under the provisions of Option 2 of the Branch Technical Position beneath the floor area. This soil is included in the 3,500 cubic yard estimate for soil which will be left within the perimeter of the yard area.

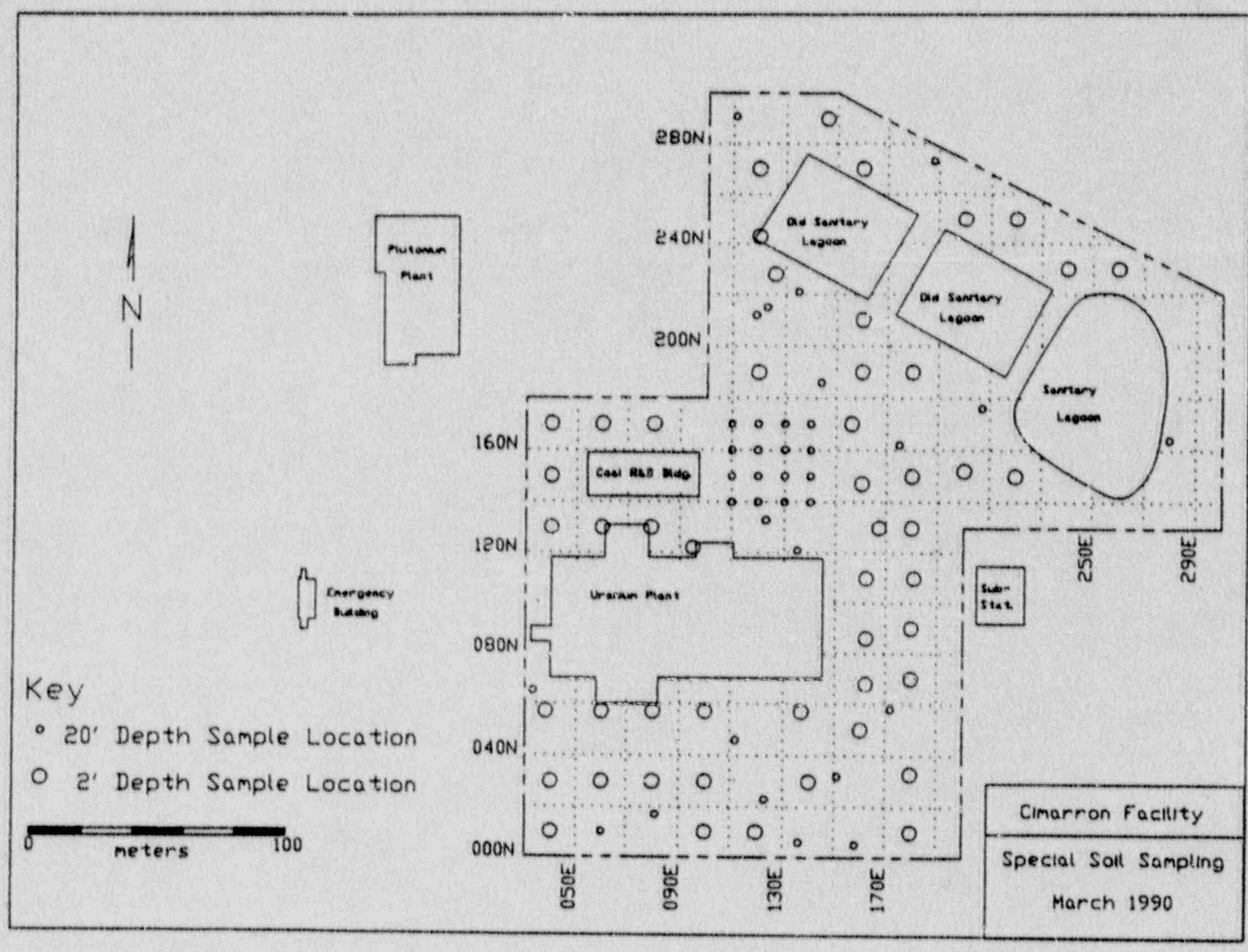

Figure 31 Special Soil Sampling - March 1990

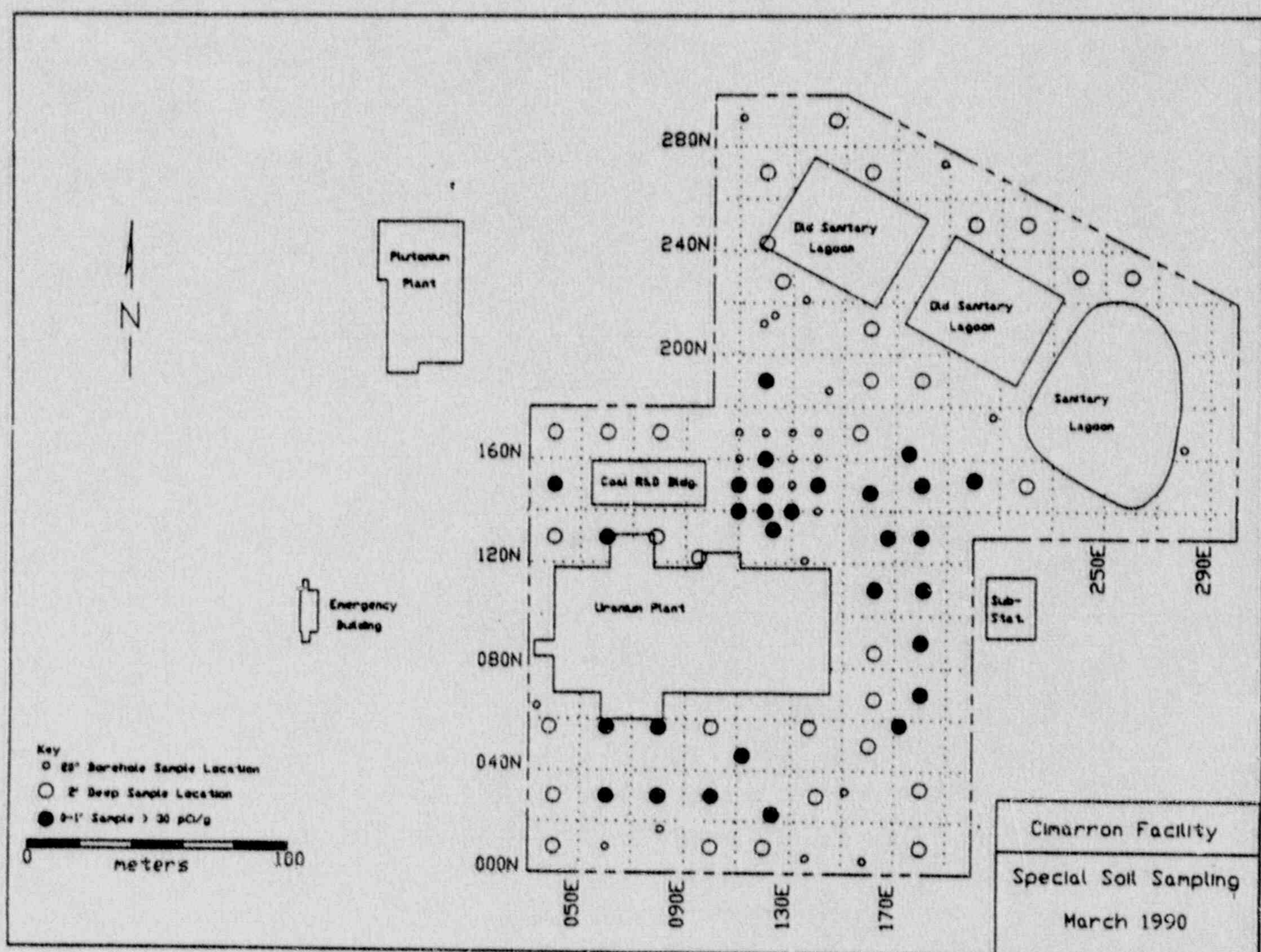

Figure 32 Locations Where Uranium Concentration > 20 pCi/g: 0 - 1 Foot Depth

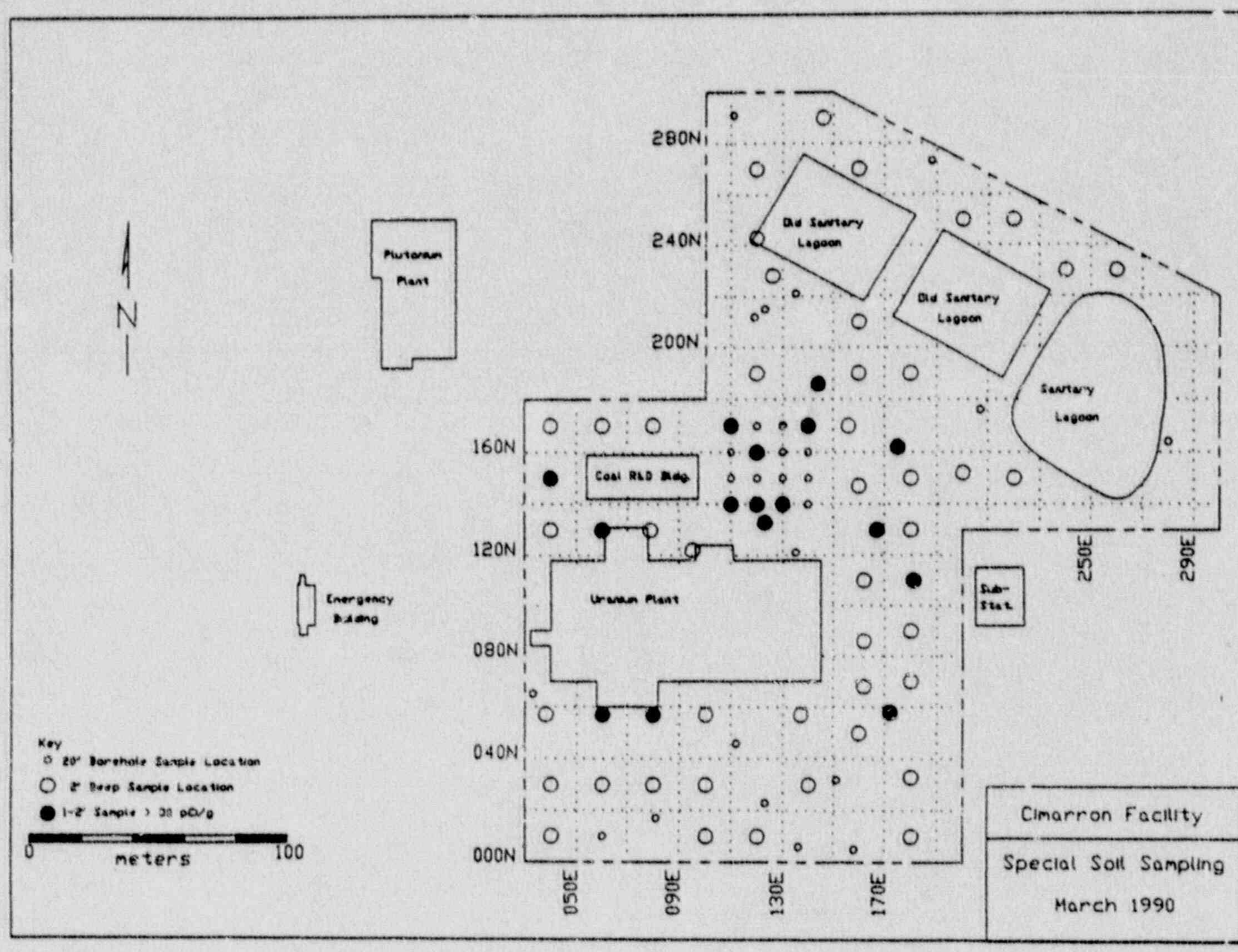

Figure 33 Locations Where Uranium Concentration > 20 pCi/g: 1 - 2 Foot Depth

APPENDIX A

WATEQ4F OUTPUT

```
1 CIMARRON WELL 1314                                               1314 X5
   900   309 030590      0       0       0    1200
                      TEMP      =         16.000000
                      PH        =          7.030000
                      EHM       =           .600000
                      DOC       =           .000000
                      DOX       =           .000000
                      CORALK    =          0
                      FLG       =        MG/L
                      DENS      =          1.000000
                      PRNT      =          0
                      PUNCH     =          1
                      EHOPT     =          0
                      EMPOX     =          0
                      ITDS      =        309.000000
                      COND      =        900.000000
                      SIGMDO    =           .000000
                      SIGMEH    =           .000000
                      SIGMPH    =           .000000

     Species     Index No       Input Concentration
     ----------------------------------------------
     Ca          :    0   :        73.90000000
     Mg          :    1   :        23.70000000
     Na          :    2   :        16.40000000
     K           :    3   :         1.20000000
     Cl          :    4   :        16.00000000
     SO4         :    5   :         8.60000000
     HCO3        :    6   :       402.00000000
     Fe total    :   16   :          .06100000
     H2S aq      :   13   :          .00000000
     CO3         :   17   :          .00000000
     SiO2 tot    :   34   :        26.00000000
     NH4         :   38   :          .00000000
     B tot       :   86   :          .11000000
     PO4         :   44   :          .00000000
     Al          :   50   :          .07200000
     F           :   61   :          .70000000
     NO3         :   84   :         9.70000000
```

1CIM-RRON WELL 1314 1314 X5

900 309 030590 0 0 0 1200

ITER	S1-AnalCO3	S2-AnalSO4	S3-AnalF	S4-AnalPO4	S5-AnalCL	S6-AnalH2S	S7-AnalFULV	S8-AnalHUM
1	1.437354E-04	1.983911E-05	1.782144E-06	0.000000E+00	4.920957E-17	0.000000E+00	0.000000E+00	0.000000E+00
2	1.175631E-06	2.354357E-07	-6.066525E-09	0.000000E+00	-1.749388E-19	0.000000E+00	0.000000E+00	0.000000E+00
3	-1.949897E-08	-5.025339E-09	-1.495219E-10	0.000000E+00	-7.729176E-21	0.000000E+00	0.000000E+00	0.000000E+00

1 CIMARRON WELL 1314 1314 X5 Date = 3/27/90 15:05

900 309 030590 0 0 0 1200

DOX = .0000 DOC = .0 INPUT TDS = 309.0

Anal Cond = 900.0 Calc Cond = 626.3

Anal EPMCAT = 6.3953 Anal EPMAN = 7.4163 Percent difference in input cation/anion balance = -14.7842

Calc EPMCAT = 6.2112 Calc EPMAN = 7.2408 Percent difference in calc cation/anion balance = -15.3087

Total Ionic Strength (T.I.S.) from input data = .00982

Effective Ionic Strength (E.I.S.) from speciation = .00947

				Sato						Calc					
Input	Sigma	Fe3/Fe2	Sigma	H2O2/O2	Sigma	NO3/NO2	Sigma	NO3/NH4	Sigma	H2O2/O2	Sigma	SO4/S=	Sigma	As5/As3	Sigma
Eh															
.600	.000	.600	.000	9.900	.000	.000	.000	9.900	.000	9.900	.000	9.900	.000	9.900	.000
pE															
10.457	.000	10.457	.000	100.000	.000	100.000	.000	100.000	.000	100.000	.000	100.000	.000	100.000	.000

T	pH	TDS ppm	Effective Ionic Str	pO2 Atm	pCO2 Atm	pCH4 Atm	CO2 Tot	Uncom CO2	ppm Uncom CO2	Ncrb Alk	aH2O
16.06	[illegible] 030	578.4	.00947	5.16E-17	3.19E-02	7.76-118	.00799	6.45E-03	2.84E+02	7.41E-07	.9998

I	Species		Anal ppm	Calc ppm	Anal Molal	Calc Molal	Activity	Act Coeff	-Log Act
0	Ca	2	73.900	69.948	1.845E-03	1.746E-03	1.189E-03	.6808	2.925
28	CaOH	1		.000093		1.630E-09	1.476E-09	.9056	8.831
31	CaSO4 aq	0		1.509		1.109E-05	1.111E-05	1.0022	4.954
81	CaHSO4	1		.000000		5.542E-12	5.018E-12	.9056	11.299
29	CaHCO3	1		8.383		8.297E-05	7.514E-05	.9056	4.124
30	CaCO3 aq	0		.411		4.110E-06	4.119E-06	1.0022	5.385
100	CaF	1		.018		2.983E-07	2.701E-07	.9056	6.568
1	Mg	2	23.700	22.416	9.754E-04	9.227E-04	6.319E-04	.6849	3.199
18	MgOH	1		.000219		5.292E-09	4.793E-09	.9056	8.319
22	MgSO4 aq	0		.621		5.164E-06	5.176E-06	1.0022	5.286
21	MgHCO3	1		3.851		4.516E-05	4.089E-05	.9056	4.388
20	MgCO3 aq	0		.106		1.258E-06	1.261E-06	1.0022	5.899
19	MgF	1		.050		1.149E-06	1.040E-06	.9056	5.983
2	Na	[illegible]	16.400	16.345	7.138E-04	7.115E-04	6.450E-04	.9065	3.190
43	NaSO4	-1		.020		1.668E-07	1.511E-07	.9056	6.821
42	NaHCO3aq	0		.178		2.118E-06	2.123E-06	1.0022	5.673
41	NaCO3	-1		.001645		1.984E-08	1.797E-08	.9056	7.746
297	NaF aq	0		.000101		2.397E-09	2.402E-09	1.0022	8.619

3	K	1	1.200	1.200	3.071E-05	3.070E-05	2.775E-05	.9040	4.557
45	KSO4	-1		.001227		9.081E-09	8.223E-09	.9056	8.085
63	H	1		.000103		1.019E-07	9.333E-08	.9163	7.030
26	OH	-1		.000988		5.812E-08	5.263E-08	.9056	7.279
17	CO3	-2		.211		3.523E-06	2.400E-06	.6812	5.620
6	HCO3	-1	402.000	392.885	6.592E-03	6.443E-03	5.854E-03	.9085	2.233
85	H2CO3 aq	0		86.972		1.403E-03	1.407E-03	1.0024	2.852
5	SO4	-2	8.600	7.022	8.958E-05	7.315E-05	4.957E-05	.6777	4.305
62	HSO4	-1		.000038		3.877E-10	3.511E-10	.9056	9.455
61	F	-1	.700	.668	3.687E-05	3.517E-05	3.185E-05	.9056	4.497
125	HF aq	0		.000073		3.649E-09	3.657E-09	1.0022	8.437
126	HF2	-1		.000000		4.618E-13	4.182E-13	.9056	12.379
296	H2F2 aq	0		.000000		5.166E-17	5.178E-17	1.0022	16.286
4	Cl	-1	16.000	15.998	4.516E-04	4.516E-04	4.082E-04	.9040	3.389
34	SiO2 tot	0	26.000		4.330E-04				
23	H4SiO4aq	0		41.551		4.326E-04	4.335E-04	1.0022	3.363
24	H3SiO4	-1		.036		3.740E-07	3.387E-07	.9056	6.470
25	H2SiO4	-2		.000000		3.601E-12	2.421E-12	.6724	11.616
124	SiF6	-2		.000000		1.816E-28	1.221E-28	.6724	27.913
86	B tot	0	.110		1.018E-05				

3	K	1	1.200	1.200	3.071E-05	3.070E-05	2.775E-05	.9040	4.557
45	KSO4	-1		.001227		9.[illegible]-09	8.223E-09	.9056	8.085
63	H	1		.000103		1.[illegible]E-07	9.333E-08	.9163	7.030
26	OH	-1		.000988		5.812E-08	5.263E-08	.9056	7.279
17	CO3	-2		.211		3.523E-06	2.400E-06	.6812	5.620
6	HCO3	-1	402.000	392.885	6.592E-03	6.443E-03	5.854E-03	.9085	2.233
85	H2CO3 aq	0		86.972		1.403E-03	1.407E-03	1.0024	2.852
5	SO4	-2	8.600	7.022	8.958E-05	7.315E-05	4.957E-05	.6777	4.305
62	HSO4	-1		.000038		3.877E-10	3.511E-10	.9056	9.455
61	F	-1	.700	.668	3.687E-05	3.517E-05	3.185E-05	.9056	4.497
125	HF aq	0		.000073		3.649E-09	3.657E-09	1.0022	8.437
126	HF2	-1		.000000		4.618E-13	4.182E-13	.9056	12.379
296	H2F2 aq	0		.000000		5.166E-17	5.178E-17	1.0022	16.286
4	Cl	-1	16.000	15.998	4.516E-04	4.516E-04	4.082E-04	.9040	3.389
34	SiO2 tot	0	26.000		4.330E-04				
23	H4SiO4aq	0		41.551		4.326E-04	4.335E-04	1.0022	3.363
24	H3SiO4	-1		.036		3.740E-07	3.387E-07	.9056	6.470
25	H2SiO4	-2		.000000		3.601E-12	2.421E-12	.6724	11.616
124	SiF6	-2		.000000		1.816E-28	1.221E-28	.6724	27.913
86	B tot	0	.110		1.018E-05				

I	Species		Anal ppm	Calc ppm	Anal Molal	Calc Molal	Activity	Act Coeff	-Log Act
35	H3BO3 aq	0		.625		1.012E-05	1.014E-05	1.0022	4.994
36	H2BO3	-1		.003510		5.775E-08	5.230E-08	.9056	7.282
101	BF(OH)3	-1		.000010		1.289E-10	1.167E-10	.9056	9.933
102	BF2(OH)2	-1		.000000		4.193E-14	3.797E-14	.9056	13.421
103	BF3OH	-1		.000000		1.634E-19	1.480E-19	.9056	18.830
104	BF4	-1		.000000		2.021E-24	1.830E-24	.9056	23.737
84	NO3	1	9.700	9.699	1.565E-04	1.565E-04	1.417E-04	.9056	3.848
50	Al	3	.072000	.000001	2.670E-06	4.264E-11	1.746E-11	.4095	10.758
51	AlOH	2		.000067		1.523E-09	1.024E-09	.6724	8.990
52	Al(OH)2	1		.011		1.758E-07	1.592E-07	.9056	6.798
181	Al(OH)3	0		.167		2.142E-06	2.147E-06	1.0022	5.668
53	Al(OH)4	-1		.024		2.510E-07	2.273E-07	.9056	6.643
54	AlF	2		.000389		8.462E-09	5.690E-09	.6724	8.245
55	AlF2	1		.002497		3.846E-08	3.483E-08	.9056	7.458
56	AlF3 aq	0		.004337		5.168E-08	5.179E-08	1.0022	7.286
57	AlF4	-1		.000107		1.041E-09	9.426E-10	.9056	9.026
58	AlSO4	1		.000000		8.940E-13	8.096E-13	.9056	12.092
59	Al(SO4)2	-1		.000000		3.395E-15	3.074E-15	.9056	14.512
203	AlHSO4	2		.000000		2.629E-20	1.768E-20	.6724	19.753
16	Fe total	2	.061		1.093E-06				
7	Fe	2		.000000		3.378E-12	2.272E-12	.6724	11.644
10	FeOH	1		.000000		4.248E-15	3.847E-15	.9056	14.415
79	Fe(OH)2	0		.000000		1.561E-19	1.565E-19	1.0022	18.806
11	Fe(OH)3	-1		.000000		6.279E-23	5.686E-23	.9056	22.245
33	FeSO4 aq	0		.000000		1.686E-14	1.690E-14	1.0022	13.772
122	FeHSO4	1		.000000		1.059E-20	9.589E-21	.9056	20.018
8	Fe	3		.000000		8.737E-15	3.578E-15	.4095	14.446
9	FeOH	2		.000016		2.131E-10	1.433E-10	.6724	9.844
76	Fe(OH)2	1		.087		9.694E-07	8.778E-07	.9056	6.057
77	Fe(OH)3	0		.012		1.102E-07	1.105E-07	1.0022	6.957
78	Fe(OH)4	-1		.001618		1.307E-08	1.184E-08	.9056	7.927
179	Fe2(OH)2	4		.000000		3.966E-18	8.109E-19	.2045	18.091
180	Fe3(OH)4	5		.000000		1.703E-21	1.426E-22	.0837	21.846
14	FeSO4	1		.000000		1.327E-15	1.201E-15	.9056	14.920
188	Fe(SO4)2	-1		.000000		2.005E-18	1.816E-18	.9056	17.741
123	FeHSO4	2		.000000		5.641E-22	3.793E-22	.6724	21.421
15	FeCl	2		.000000		4.887E-17	3.287E-17	.6724	16.483

27	FeCl2	1	.000000	8.882E-20	8.043E-20	.9056	19.095
32	FeCl3 aq	0	.000000	3.276E-24	3.283E-24	1.0022	23.484
105	FeF	2	.000000	2.330E-13	1.567E-13	.6724	12.805
106	FeF2	1	.000000	1.965E-13	1.779E-13	.9056	12.750
107	FeF3 aq	0	.000000	8.683E-15	8.702E-15	1.0022	14.060

1

CIMARRON WELL 1314 1314 X5

Mole ratios from analytical molality - Log activity ratios

Cl/Ca	=	2.4477E-01	Log Ca	/H2	=	11.1351
Cl/Mg	=	4.6296E-01	Log Mg	/H2	=	10.8607
Cl/Na	=	6.3264E-01	Log Na	/H1	=	3.8395
Cl/K	=	1.4706E+01	Log K	/H1	=	2.4733
Cl/Al	=	1.6912E+02	Log Al	/H3	=	10.3321
Cl/Fe	=	0.0000E+00	Log Fe	/H2	=	2.4163
Cl/SO4	=	5.0410E+00	Log Ca/Mg		=	.2745
CL/HCO3	=	6.8501E-02	LOG NA/K		=	1.3662
Ca/Mg	=	1.8914E+00	Log Ca/K2		=	6.1886
Na/K	=	2.3245E+01	Log Diss Fe/H2		=	14.0600

	Phase	Log AP/KT	Sigma(A)	Sigma(T)	Log AP/MinKT	Log AP/MaxKT	Log AP	Log KT	Log MinKT	Log MaxKT
39	Adularia	-.012					-21.288	-21.276		
40	Albite	-1.329					-19.922	-18.593		
140	AlOH3 (a)	-.687			.002		-32.594	-31.907	-32.596	
471	AlOHSO4	-4.803			-4.643	-4.963	-8.033	-3.230	-3.390	-3.070
472	Al4(OH)10SO4	.263					22.963	22.700		
157	Allophane(a)	.237					6.347	6.110		
158	Allophane(F)	1.062					6.347	5.286		
338	Alum k	-18.591					-23.925	-5.335		
50	Alunite	-3.098					-89.113	-86.014		
42	Analcime	-3.443					-16.559	-13.116		
17	Anhydrite	-2.679					-7.230	-4.551		
113	Annite	30.851					-56.219	-87.070		
41	Anorthite	-2.959					-22.937	-19.978		
21	Aragonite	-.261		.020			-8.545	-8.284		
150	Artinite	-7.666					2.590	10.256		
48	Beidellite	4.245					-42.404	-46.649		
52	Boehmite	1.093			1.606		-32.594	-33.688	-34.201	
19	Brucite	-6.534					-17.757	-11.223		
12	Calcite	-.110		.020	-.044		-8.545	-8.435	-8.501	
97	Chalcedony	.266					-3.363	-3.628		
49	Chlorite 14A	-6.958		6.000	-1.683	-15.682	64.878	71.836	66.561	80.560
125	Chlorite 7A	-10.416		6.000			64.878	75.294		
20	Chrysotile	-7.567					-59.996	-52.429		
29	Clinoenstite	-4.309			-3.943	-4.603	-21.120	-16.810	-17.176	-16.516
56	Clinoptilolt						-25.044			
99	Cristobalite	.350					-3.363	-3.712		
154	Diaspore	2.878					-32.594	-35.472		
28	Diopside	-5.377					-41.965	-36.587		
11	Dolomite	-.553					-17.364	-16.811		
340	Epsomite	-5.300					-7.505	-2.204		
55	Erionite						-21.604			
112	Ferrihydrite	1.752			5.086	1.647	6.643	4.891	1.557	4.996
419	Fe3(OH)8	-4.519			-1.409	-8.402	15.703	20.222	17.112	24.105
181	FeOH)2.7Cl.3	6.558					3.518	-3.040		
401	Fe2(SO4)3	-46.736			-42.506		-41.807	4.929	.699	
62	Fluorite	-.857					-11.919	-11.062		
27	Forsterite	-11.071					-38.876	-27.805		

51	Gibbsite (c)	1.042	.200	1.325	.372	10.332	9.290	9.007	9.950
110	Goethite	5.813	.800			6.643	.830		
111	Greenalite	-20.287				.523	20.810		
18	Gypsum	-2.624				-7.230	-4.606		
64	Halite	-8.141				-6.580	1.561		
47	Halloysite	-.223				-34.072	-33.849		
108	Hematite	16.591				13.287	-3.304		
117	Huntite	-5.622				-35.002	-29.380		
38	Hydrmagnesit	-16.854				-53.034	-36.180		
45	Illite	2.495				-39.019	-41.515		
204	Jarosite Na	-2.585	1.000			-12.960	-10.375		
205	Jarosite K	-.240	1.100		-2.540	-14.326	-14.086		-11.786
337	Jarosite H	-5.958				-16.799	-10.842		
46	Kaolinite	3.970		4.849	2.869	-34.072	-38.042	-38.921	-36.941
43	Kmica	9.323	1.300	10.721	7.644	23.381	14.058	12.660	15.737
128	Laumontite	2.201				-29.663	-31.864		
147	Leonhardite	12.485				-59.326	-71.811		
98	Magadiite	-6.767				-21.067	-14.300		
109	Maghemite	6.901				13.287	6.386		
10	Magnesite	-.931		-.681	-1.181	-8.819	-7.888	-8.138	-7.638

	Phase	Log AP/KT	Sigma(A)	Sigma(T)	Log AP/MinKT	Log AP/MaxKT	Log AP	Log KT	Log MinKT	Log MaxKT
107	Magnetite	10.815			11.185	7.957	15.703	4.888	4.518	7.746
339	Melanterite	-13.414					-15.949	-2.535		
63	Montmoril Ca	3.990					-42.369	-46.359		
115	Montmoril BF	4.317					-30.596	-34.913		
116	Montmoril AB	3.435					-26.253	-29.688		
57	Mordenite						-23.362			
66	Mirabilite	-9.139					-10.687	-1.547		
58	Nahcolite	-4.790					-5.423	-.633		
60	Natron	-10.331					-12.002	-1.670		
149	Nesquehonite	-3.331			-3.819	-4.406	-8.819	-5.489	-5.001	-4.414
54	Phillipsite	-.731					-20.605	-19.874		
44	Phlogopite	-32.972		3.000			11.293	44.265		
141	Prehnite	-3.233					-15.165	-11.932		
53	Pyrophyllite	7.516			10.812	5.682	-40.798	-48.314	-51.610	-46.480
101	Quartz	.785					-3.363	-4.148		
36	Sepiolite(c)	-4.344					11.632	15.976		
153	Sepiolite(a)	-7.028					11.632	18.660		
9	Siderite	-6.835			-5.281		-17.263	-10.428	-11.982	
100	SiO2 (a,L)	-.243					-3.363	-3.119		
395	SiO2 (a,H)	-.564					-3.363	-2.799		
37	Talc	-3.326		2.000	-1.158	-5.074	19.130	22.456	20.288	24.204
65	Thenardite	-10.520					-10.686	-.166		
61	Thermonatr	-12.190					-12.001	.189		
31	Tremolite	-9.167					-150.651	-141.484		
59	Trona	-17.040					-17.424	-.384		
155	Wairkite	-2.358					-29.663	-27.304		

800 638 030590 0 0 0 1200

TEMP	=	16.000000
PH	=	7.050000
EHM	=	.600000
DOC	=	.000000
DOX	=	.000000
CORALK	=	0
FLG	=	MG/L
DENS	=	1.000000
PRNT	=	0
PUNCH	=	1
EHOPT	=	0
EMPOX	=	0
ITDS	=	638.000000
COND	=	800.000000
SIGMDO	=	.000000
SIGMEH	=	.000000
SIGMPH	=	.000000

Species	Index No	Input Concentration
Ca	0	117.00000000
Mg	1	47.10000000
Na	2	40.10000000
K	3	.00000000
Cl	4	67.00000000
SO4	5	100.00000000
HCO3	6	496.00000000
Fe total	16	.03100000
H2S aq	13	.00000000
CO3	17	.00000000
SiO2 tot	34	23.60000000
NH4	38	.00000000
B tot	86	.16000000
PO4	44	.00000000
Al	50	.12000000
F	61	1.50000000
NO3	84	42.00000000

1CIMARRON WELL 1315 1315 X5

800 638 030590 0 0 0 1200

ITER	S1-AnalCO3	S2-AnalSO4	S3-AnalF	S4-AnalPO4	S5-AnalCL	S6-AnalH2S	S7-AnalFULV	S8-AnalHUM
1	2.600098E-04	2.976585E-04	7.704396E-06	0.000000E+00	1.020591E-16	0.000000E+00	0.000000E+00	0.000000E+00
2	7.899581E-06	1.165011E-05	-1.001669E-07	0.000000E+00	-1.050744E-18	0.000000E+00	0.000000E+00	0.000000E+00
3	-9.002885E-08	-3.375838E-07	7.343272E-10	0.000000E+00	9.147956E-20	0.000000E+00	0.000000E+00	0.000000E+00

1 CIMARRON WELL 1315 1315 X5 Date = 3/27/90 15:18

800 638 030590 0 0 0 1200

DOX = .0000 DOC = .0 INPUT TDS = 638.0

Anal Cond = 800.0 Calc Cond = 1144.5

Anal EPMCAT = 11.4825 Anal EPMAN = 12.8691 Percent difference in input cation/anion balance = -11.3881

Calc EPMCAT = 10.7295 Calc EPMAN = 12.1273 Percent difference in calc cation/anion balance = -12.2311

Total Ionic Strength (T.I.S.) from input data = .01809

Effective Ionic Strength (E.I.S.) from speciation = .01661

				Sato						Calc					
Input	Sigma	Fe3/Fe2	Sigma	H202/02	Sigma	N03/N02	Sigma	N03/NH4	Sigma	H202/02	Sigma	S04/S=	Sigma	As5/As3	Sigma
Eh															
.600	.000	.600	.000	9.900	.000	.000	.000	9.900	.000	9.900	.000	9.900	.000	9.900	.000
pE															
10.457	.000	10.457	.000	100.000	.000	100.000	.000	100.000	.000	100.000	.000	100.000	.000	100.000	.000

T	pH	TDS ppm	Effective Ionic Str	p02 Atm	pC02 Atm	pCH4 Atm	C02 Tot	Uncom C02	ppm Uncom C02	Ncrb Alk	aH20
16.00	7.050	934.6	.01661	6.20E-?7	3.63E-02	6.11-118	.00971	7.88E-03	3.47E+02	9.06E-07	.9997

I	Species		Anal ppm	Calc ppm	Anal Molal	Calc Molal	Activity	Act Coeff	-Log Act
0	Ca	2	117.000	105.202	2.922E-03	2.628E-03	1.617E-03	.6153	2.791
28	CaOH	1		.000136		2.385E-09	2.102E-09	.8815	8.677
31	CaS04 aq	0		20.213		1.486E-04	1.492E-04	1?.0038	3.826
81	CaHS04	1		.000010		7.299E-11	6.434E-11	.8815	10.192
29	CaHC03	1		13.9?5		1.380E-04	1.216E-04	.8815	3.915
30	CaC03 aq	0		.695		6.955E-06	6.982E-06	1.0038	5.156
100	CaF	1		.049		8.315E-07	7.329E-07	.8815	6.135
1	Mg	2	47.100	42.497	1.939E-03	1.750E-03	1.087E-03	.6213	2.964
18	MgOH	1		.000404		9.794E-09	8.633E-09	.8815	8.064
22	MgS04 aq	0		10.530		8.757E-05	8.791E-05	1.0038	4.056
21	MgHC03	1		8.099		9.502E-05	8.376E-05	.8815	4.077
20	MgC03 aq	0		.227		2.693E-06	2.703E-06	1.0038	5.568
19	MgF	1		.175		4.051E-06	3.571E-06	.8815	5.447
2	Na	1	40.100	39.864	1.746E-03	1.736E-03	1.533E-03	.8829	2.815
43	NaS04	-1		.478		4.021E-06	3.544E-06	.8815	5.450
42	NaHC03aq	0		.502		?.983E-06	6.005E-06	1.0038	5.221
41	NaC03	-1		.005005		6.037E-08	5.321E-08	.8815	7.274
297	NaF aq	0		.000476		1.135E-08	1.139E-08	1.0038	7.944

63	H	1		.000100		9.929E-08	8.913E-08	.8976	7.050
26	OH	-1		.001062		6.251E-08	5.510E-08	.8815	7.259
17	CO3	-2		.291		4.860E-06	2.992E-06	.6155	5.524
6	HCO3	-1	496.000	479.546	8.136E-03	7.867E-03	6.969E-03	.8858	2.157
85	H2CO3 aq	0		98.662		1.592E-03	1.599E-03	1.0043	2.796
5	SO4	-2	100.000	76.936	1.042E-03	8.017E-04	4.894E-04	.6105	3.310
62	HSO4	-1		.000364		3.755E-09	3.310E-09	.8815	8.480
61	F	-1	1.500	1.368	7.903E-05	7.209E-05	6.355E-05	.8815	4.197
125	HF aq	0		.000139		6.942E-09	6.969E-09	1.0038	8.157
126	HF2	-1		.000000		1.804E-12	1.590E-12	.8815	11.799
296	H2F2 aq	0		.000000		1.873E-16	1.880E-16	1.0038	15.726
4	Cl	-1	67.000	66.992	1.892E-03	1.892E-03	1.662E-03	.8788	2.779
34	SiO2 tot	0	23.600		3.931E-04				
23	H4SiO4aq	0		37.713		3.928E-04	3.943E-04	1.0038	3.404
24	H3SiO4	-1		.035		3.659E-07	3.226E-07	.8815	6.491
25	H2SiO4	-2		.000000		3.999E-12	2.414E-12	.6037	11.617
124	SiF6	-2		.000000		9.663E-27	5.834E-27	.6037	26.234
86	B tot	0	.160		1.481E-05				
35	H3BO3 aq	0		.909		1.472E-05	1.478E-05	1.0038	4.830
36	H2BO3	-1		.005499		9.050E-08	7.978E-08	.8815	7.098

I	Species		Anal ppm	Calc ppm	Anal Molal	Calc Molal	Activity	Act Coeff	-Log Act
101	BF(OH)3	-1		.000031		3.849E-10	3.393E-10	.8815	9.469
102	BF2(OH)2	-1		.000000		2.386E-13	2.103E-13	.8815	12.677
103	BF3OH	-1		.000000		1.772E-18	1.562E-18	.8815	17.806
104	BF4	-1		.000000		4.178E-23	3.683E-23	.8815	22.434
84	NO3	-1	42.000	41.995	6.780E-04	6.780E-04	5.976E-04	.8815	3.224
50	Al	3	.120000	.000002	4.452E-06	6.782E-11	2.179E-11	.3213	10.662
51	AlOH	2		.000097		2.217E-09	1.339E-09	.6037	8.877
52	Al(OH)2	1		.015		2.470E-07	2.178E-07	.8815	6.662
181	Al(OH)3	0		.239		3.063E-06	3.075E-06	1.0038	5.512
53	Al(OH)4	-1		.037		3.866E-07	3.408E-07	.8815	6.467
54	AlF	2		.001078		2.347E-08	1.417E-08	.6037	7.849
55	AlF2	1		.013		1.963E-07	1.731E-07	.8815	6.762
56	AlF3 aq	0		.043		5.115E-07	5.135E-07	1.0038	6.289
57	AlF4	-1		.002176		2.116E-08	1.865E-08	.8815	7.729
58	AlSO4	1		.000001		1.132E-11	9.975E-12	.8815	11.001
59	Al(SO4)2	-1		.000000		4.241E-13	3.739E-13	.8815	12.427
203	AlHSO4	2		.000000		3.446E-19	2.080E-19	.6037	18.682
16	Fe total	2	.031		5.556E-07				
7	Fe	2		.000000		1.694E-12	1.023E-12	.6037	11.990
10	FeOH	1		.000000		2.057E-15	1.813E-15	.8815	14.742
79	Fe(OH)2	0		.000000		7.692E-20	7.721E-20	1.0038	19.112
11	Fe(OH)3	-1		.000000		3.332E-23	2.937E-23	.8815	22.532
33	FeSO4 aq	0		.000000		7.482E-14	7.511E-14	1.0038	13.124
122	FeHSO4	1		.000000		4.617E-20	4.069E-20	.8815	19.390
8	Fe	3		.000000		5.012E-15	1.610E-15	.3213	14.793
9	FeOH	2		.000008		1.119E-10	6.753E-11	.6037	10.170
76	Fe(OH)2	1		.044		4.914E-07	4.331E-07	.8815	6.363
77	Fe(OH)3	0		.006070		5.686E-08	5.708E-08	1.0038	7.244
78	Fe(OH)4	-1		.000899		7.263E-09	6.402E-09	.8815	8.194
179	Fe2(OH)2	4		.000000		1.355E-18	1.800E-19	.1328	18.745
180	Fe3(OH)4	5		.000000		3.655E-22	1.560E-23	.0427	22.807
14	FeSO4	1		.000000		6.056E-15	5.338E-15	.8815	14.273
108	Fe(SO4)2	-1		.000000		9.036E-17	7.965E-17	.8815	16.099
123	FeHSO4	2		.000000		2.666E-21	1.610E-21	.6037	20.793
15	FeCl	2		.000000		9.978E-17	6.024E-17	.6037	16.220
27	FeCl2	1		.000000		6.810E-19	6.003E-19	.8815	18.222
32	FeCl3 aq	0		.000000		9.940E-23	9.978E-23	1.0038	22.001

105	FeF	2	.000000	2.331E-13	1.407E-13	.6037	12.852
106	FeF2	1	.000000	3.617E-13	3.189E-13	.8815	12.496
107	FeF3 aq	0	.000000	3.100E-14	3.112E-14	1.0038	13.507

1

CIMARRON WELL 1315 1315 X5

Mole ratios from analytical molality - Log activity ratios

Cl/Ca	=	6.4739E-01	Log Ca	/H2	=	11.3086
Cl/Mg	=	9.7549E-01	Log Mg	/H2	=	11.1363
Cl/Na	=	1.0835E+00	Log Na	/H1	=	4.2354
Cl/K	=	0.0000E+00	Log K	/H1	=	.0000
Cl/Al	=	4.2492E+02	Log Al	/H3	=	10.4883
Cl/Fe	=	0.0000E+00	Log Fe	/H2	=	2.1097
Cl/SO4	=	1.8154E+00	Log Ca/Mg		=	.1723
CL/HCO3	=	2.3248E-01	LOG NA/K		=	.0000
Ca/Mg	=	1.5068E+00	Log Ca/K2		=	.0000
Na/K	=	0.0000E+00	Log Diss Fe/H2		=	14.1000

	Phase	Log AP/KT	Sigma(A)	Sigma(T)	Log AP/MinKT	Log AP/MaxKT	Log AP	Log KT	Log MinKT	Log MaxKT
40	Albite	-.901					-19.493	-18.593		
140	AlOH3 (a)	-.531			.158		-32.438	-31.907	-32.596	
471	AlOHSO4	-3.692			-3.532	-3.852	-6.922	-3.230	-3.390	-3.070
472	Al4(OH)10SO4	1.841					24.541	22.700		
157	Allophane(a)	.340					6.484	6.144		
158	Allophane(F)	1.168					6.484	5.316		
42	Analcime	-2.973					-16.090	-13.116		
17	Anhydrite	-1.551					-6.102	-4.551		
41	Anorthite	-2.555					-22.534	-19.978		
21	Aragonite	-.031		.020			-8.315	-8.284		
150	Artinite	-7.263					2.992	10.256		
48	Beidellite	4.506					-42.143	-46.649		
52	Boehmite	1.249			1.762		-32.438	-33.680	-34.201	
19	Brucite	-6.258					-17.481	-11.223		
12	Calcite	.119		.020	.186		-8.315	-8.435	-8.501	
97	Chalcedony	.224					-3.404	-3.628		
49	Chlorite 14A	-5.392		6.000	-.117	-14.116	66.445	71.836	66.561	80.560
125	Chlorite 7A	-8.850		6.000			66.445	75.294		
20	Chrysotile	-6.823					-59.252	-52.429		
29	Clinoenstite	-4.075			-3.709	-4.369	-20.885	-16.810	-17.176	-16.516
56	Clinoptilolt						-24.894			
99	Cristobalite	.309					-3.404	-3.712		
154	Diaspore	3.034					-32.438	-35.472		
28	Diopside	-5.011					-41.598	-36.587		
11	Dolomite	.008					-16.803	-16.811		
340	Epsomite	-4.071					-6.275	-2.204		
55	Erionite						-21.196			
112	Ferrihyurite	1.465			4.799	1.360	6.356	4.891	1.557	4.996
419	Fe3(OH)8	-5.400			-2.290	-9.283	14.822	20.222	17.112	24.105
181	FeOH)2.7Cl.3	6.448					3.408	-3.040		
401	Fe2(SO4)3	-44.446			-40.216		-39.517	4.929	.699	
62	Fluorite	-.123					-11.185	-11.062		
27	Forsterite	-10.561					-38.366	-27.805		
51	Gibbsite (c)	1.198		.200	1.481	.528	10.488	9.290	9.007	9.960
110	Goethite	5.526		.800			6.357	.830		
111	Greenalite	-21.290					-.480	20.810		
18	Gypsum	-1.496					-6.102	-4.606		

64 Halite	-7.155					-5.594	1.561		
47 Halloysite	.007					-33.842	-33.849		
108 Hematite	16.018					12.713	-3.304		
117 Huntite	-4.399					-33.779	-29.380		
38 Hydrmagnesit	-15.253					-51.433	-36.180		
204 Jarosite Na	-1.141		1.000			-11.515	-10.375		
337 Jarosite H	-4.909					-15.751	-10.842		
46 Kaolinite	4.200			5.079	3.099	-33.842	-38.042	-38.921	-36.941
128 Laumontite	2.522					-29.342	-31.864		
147 Leonhardite	13.127					-58.684	-71.811		
109 Maghemite	6.327					12.713	6.386		
10 Magnesite	-.600			-.350	-.850	-8.488	-7.888	-8.138	-7.638
107 Magnetite	9.935			10.305	7.077	14.823	4.888	4.518	7.746
339 Melanterite	-12.766					-15.302	-2.535		
63 Montmoril Ca	4.232					-42.127	-46.359		
115 Montmoril BF	4.719					-30.194	-34.913		
116 Montmoril AB	3.837					-25.851	-29.688		
57 Mordenite						-23.192			
66 Mirabilite	-7.394					-8.941	-1.547		
58 Nahcolite	-4.339					-4.971	-.633		

	Phase	Log AP/KT	Sigma(A)	Sigma(T)	Log AP/MinKT	Log AP/MaxKT	Log AP	Log KT	Log MinKT	Log MaxKT
60	Natron	-9.485					-11.155	-1.670		
149	Nesquehonite	-2.999			-3.487	-4.074	-8.488	-5.489	-5.001	-4.414
141	Prehnite	-2.697					-14.629	-11.932		
53	Pyrophyllite	7.664			10.960	5.830	-40.650	-48.314	-51.610	-46.480
101	Quartz	.744					-3.404	-4.148		
36	Sepiolite(c)	-3.916					12.060	15.976		
153	Sepiolite(a)	-6.600					12.060	18.660		
9	Siderite	-7.086			-5.532		-17.514	-10.428	-11.982	
100	SiO2 (a,L)	-.285					-3.404	-3.119		
395	SiO2 (a,M)	-.605					-3.404	-2.799		
37	Talc	-2.664		2.000	-.496	-4.412	19.793	22.456	20.288	24.204
65	Thenardite	-8.774					-8.940	-.166		
61	Thermonatr	-11.342					-11.153	.189		
31	Tremolite	-7.771					-149.256	-141.484		
59	Trona	-15.741					-16.125	-.384		
155	Wairkite	-2.037					-29.342	-27.304		

1 CIMARRON WELL 1316 1316 X5

800 608 030590 0 0 0 1200

TEMP	=	16.000000
PH	=	7.010000
EHM	=	.600000
DOC	=	.000000
DOX	=	.000000
CORALK	=	0
FLG	=	MG/L
DENS	=	1.000000
PRNT	=	0
PUNCH	=	1
EHOPT	=	0
EMPOX	=	0
ITDS	=	608.000000
COND	=	800.000000
SIGMDO	=	.000000
SIGMEH	=	.000000
SIGMPH	=	.000000

Species		Index No		Input Concentration
Ca	:	0	:	117.00000000
Mg	:	1	:	41.40000000
Na	:	2	:	40.60000000
K	:	3	:	.00000000
Cl	:	4	:	68.00000000
SO4	:	5	:	39.00000000
HCO3	:	6	:	618.00000000
Fe total	:	16	:	.01500000
H2S aq	:	13	:	.00000000
CO3	:	17	:	.00000000
SiO2 tot	:	34	:	30.00000000
NH4	:	38	:	.00000000
B tot	:	86	:	.13000000
PO4	:	44	:	.00000000
Al	:	50	:	.07600000
F	:	61	:	1.40000000
NO3	:	84	:	44.20000000

1CIMARRON WELL 1316 1316 X5

800 608 030590 0 0 0 1200

ITER	S1-AnalCO3	S2-AnalSO4	S3-AnalF	S4-AnalPO4	S5-AnalCL	S6-AnalH2S	S7-AnalFULV	S8-AnalHUM
1	3.163032E-04	1.155478E-04	6.200895E-06	0.000000E+00	6.070219E-17	0.000000E+00	0.000000E+00	0.000000E+00
2	5.743779E-06	2.809523E-06	-6.738792E-08	0.000000E+00	-3.979996E-19	0.000000E+00	0.000000E+00	0.000000E+00
3	-1.089680E-07	-8.500965E-08	-1.532777E-10	0.000000E+00	5.421011E-20	0.000000E+00	0.000000E+00	0.000000E+00

1 CIMARRON WELL 1316 1316 X5 Date = 3/27/90 15:18

800 608 030590 0 0 0 1200

DOX = .0000 DOC = .0 INPUT TDS = 608.0

Anal Cond = 800.0 Calc Cond = 1129.5

Anal EPMCAT = 11.0302 Anal EPMAN = 13.6585 Percent difference in input cation/anion balance = -21.2921

Calc EPMCAT = 10.5238 Calc EPMAN = 13.1591 Percent difference in calc cation/anion balance = -22.2545

Total Ionic Strength (T.I.S.) from input data = .01739

Effective Ionic Strength (E.I.S.) from speciation = .01640

				Sato						Calc					
Input	Sigma	Fe3/Fe2	Sigma	H2O2/O2	Sigma	NO3/NO2	Sigma	NO3/NH4	Sigma	H2O2/O2	Sigma	SO4/S=	Sigma	As5/As3	Sigma
Eh															
.600	.000	.600	.000	9.900	.000	.000	.000	9.900	.000	9.900	.000	9.900	.000	9.900	.000
pE															
10.457	.000	10.457	.000	100.000	.000	100.000	.000	100.000	.000	100.000	.000	100.000	.000	100.000	.000

T	pH	TDS ppm	Effective Ionic Str	pO2 Atm	pCO2 Atm	pCH4 Atm	CO2 Tot	Uncom CO2	ppm Uncom CO2	Ncrb Alk	aH2O
16.00	7.010	999.8	.01640	4.29E-17	4.97E-02	1.75-117	.01230	9.83E-03	4.32E+02	7.67E-07	.9996

I	Species		Anal ppm	Calc ppm	Anal Molal	Calc Molal	Activity	Act Coeff	-Log Act
0	Ca	2	117.000	107.197	2.922E-03	2.678E-03	1.652E-03	.6168	2.782
28	CaOH	1		.000127		2.220E-09	1.958E-09	.8821	8.708
31	CaSO4 aq	0		8.116		5.968E-05	5.991E-05	1.0038	4.223
81	CaHSO4	1		.000004		3.211E-11	2.833E-11	.8821	10.548
29	CaHCO3	1		17.758		1.759E-04	1.551E-04	.8821	3.809
30	CaCO3 aq	0		.809		8.090E-06	8.120E-06	1.0038	5.090
100	CaF	1		.047		8.024E-07	7.077E-07	.8821	6.150
1	Mg	2	41.400	37.921	1.705E-03	1.562E-03	9.725E-04	.6228	3.012
18	MgOH	1		.000330		7.984E-09	7.043E-09	.8821	8.152
22	MgSO4 aq	0		3.702		3.079E-05	3.091E-05	1.0038	4.510
21	MgHCO3	1		9.038		1.060E-04	9.353E-05	.8821	4.029
20	MgCO3 aq	0		.231		2.743E-06	2.753E-06	1.0038	5.560
19	MgF	1		.148		3.423E-06	3.019E-06	.8821	5.520
2	Na	1	40.600	40.381	1.768E-03	1.759E-03	1.554E-03	.8834	2.809
43	NaSO4	-1		.190		1.601E-06	1.412E-06	.8821	5.850
42	NaHCO3aq	0		.635		7.571E-06	7.600E-06	1.0038	5.119
41	NaCO3	-1		.005772		6.963E-08	6.142E-08	.8821	7.212
297	NaF aq	0		.000456		1.087E-08	1.091E-08	1.0038	7.962

63	H	1		.000110		1.088E-07	9.772E-08	.8981	7.010
26	OH	-1		.000968		5.697E-08	5.025E-08	.8821	7.299
17	CO3	-2		.331		5.520E-06	3.406E-06	.6171	5.468
6	HCO3	-1	618.000	598.215	1.014E-02	9.815E-03	8.699E-03	.8863	2.061
85	H2CO3 aq	0		135.042		2.180E-03	2.189E-03	1.0042	2.660
5	SO4	-2	39.000	30.159	4.064E-04	3.143E-04	1.924E-04	.6120	3.716
62	HSO4	-1		.000157		1.617E-09	1.427E-09	.8821	8.846
61	F	-1	1.400	1.292	7.376E-05	6.810E-05	6.007E-05	.8821	4.221
125	HF aq	0		.000144		7.196E-09	7.223E-09	1.0038	8.141
126	HF2	-1		.000000		1.766E-12	1.558E-12	.8821	11.808
296	H2F2 aq	0		.000000		2.012E-16	2.020E-16	1.0038	15.695
4	Cl	-1	68.000	67.990	1.920E-03	1.920E-03	1.688E-03	.8794	2.773
34	SiO2 tot	0	30.000		4.998E-04				
23	H4SiO4aq	0		47.942		4.994E-04	5.013E-04	1.0038	3.300
24	H3SiO4	-1		.040		4.240E-07	3.740E-07	.8821	6.427
25	H2SiO4	-2		.000000		4.218E-12	2.555E-12	.6053	11.593
124	SiF6	-2		.000000		1.263E-26	7.647E-27	.6053	26.117
86	B tot	0	.130		1.204E-05				
35	H3BO3 aq	0		.739		1.197E-05	1.201E-05	1.0038	4.920
36	H2BO3	-1		.004074		6.706E-08	5.915E-08	.8821	7.228

I	Species		Anal ppm	Calc ppm	Anal Molal	Calc Molal	Activity	Act Coeff	-Log Act
101	BF(OH)3	-1		.000024		2.956E-10	2.607E-10	.8821	9.584
102	BF2(OH)2	-1		.000000		1.899E-13	1.675E-13	.8821	12.776
103	BF3OH	-1		.000000		1.462E-18	1.290E-18	.8821	17.889
104	BF4	-1		.000000		3.572E-23	3.151E-23	.8821	22.502
84	NO3	-1	44.200	44.193	7.136E-04	7.136E-04	6.294E-04	.8821	3.201
50	Al	3	.076000	.000001	2.820E-06	5.519E-11	1.784E-11	.3232	10.749
51	AlOH	2		.000077		1.653E-09	9.993E-10	.6053	9.000
52	Al(OH)2	1		.010		1.681E-07	1.483E-07	.8821	6.829
181	Al(OH)3	0		.148		1.902E-06	1.909E-06	1.0038	5.719
53	Al(OH)4	-1		.021		2.188E-07	1.930E-07	.8821	6.715
54	AlF	2		.000832		1.811E-08	1.096E-08	.6053	7.960
55	AlF2	1		.009313		1.435E-07	1.266E-07	.8821	6.898
56	AlF3 aq	0		.030		3.536E-07	3.550E-07	1.0038	6.450
57	AlF4	-1		.001421		1.382E-08	1.219E-08	.8821	7.914
58	AlSO4	1		.000000		3.638E-12	3.209E-12	.8821	11.494
59	Al(SO4)2	-1		.000000		5.361E-14	4.728E-14	.8821	13.325
203	AlHSO4	2		.000000		1.212E-19	7.339E-20	.6053	19.134
16	Fe total	2	.015		2.689E-07				
7	Fe	2		.000000		9.945E-13	6.020E-13	.6053	12.220
10	FeOH	1		.000000		1.104E-15	9.734E-16	.8821	15.012
79	Fe(OH)2	0		.000000		3.767E-20	3.781E-20	1.0038	19.422
11	Fe(OH)3	-1		.000000		1.487E-23	1.312E-23	.8821	22.882
33	FeSO4 aq	0		.000000		1.731E-14	1.738E-14	1.0038	13.760
122	FeHSO4	1		.000000		1.171E-20	1.033E-20	.8821	19.986
8	Fe	3		.000000		2.933E-15	9.481E-16	.3232	15.023
9	FeOH	2		.000004		5.990E-11	3.626E-11	.6053	10.441
76	Fe(OH)2	1		.022		2.404E-07	2.121E-07	.8821	6.673
77	Fe(OH)3	0		.002711		2.539E-08	2.549E-08	1.0038	7.594
78	Fe(OH)4	-1		.000366		2.956E-09	2.607E-09	.8821	8.584
179	Fe2(OH)2	4		.000000		3.866E-19	5.190E-20	.1343	19.285
180	Fe3(OH)4	5		.000000		5.080E-23	2.204E-24	.0434	23.657
14	FeSO4	1		.000000		1.400E-15	1.235E-15	.8821	14.908
108	Fe(SO4)2	-1		.000000		8.215E-18	7.246E-18	.8821	17.140
123	FeHSO4	2		.000000		6.748E-22	4.085E-22	.6053	21.389
15	FeCl	2		.000000		5.951E-17	3.602E-17	.6053	16.443
27	FeCl2	1		.000000		4.133E-19	3.646E-19	.8821	18.438
32	FeCl3 aq	0		.000000		6.133E-23	6.156E-23	1.0038	22.211

105	FeF	2	.000000	1.294E-13	7.832E-14	.6053	13.106
106	FeF2	1	.000000	1.902E-13	1.677E-13	.8821	12.775
107	FeF3 aq	0	.000000	1.541E-14	1.547E-14	1.0038	13.810

1

CIMARRON WELL 1316 1316 X5

Mole ratios from analytical molality - Log activity ratios

Cl/Ca	=	6.5705E-01	Log Ca	/H2	=	11.2379
Cl/Mg	=	1.1264E+00	Log Mg	/H2	=	11.0079
Cl/Na	=	1.0861E+00	Log Na	/H1	=	4.2013
Cl/K	=	0.0000E+00	Log K	/H1	=	.0000
Cl/Al	=	6.8094E+02	Log Al	/H3	=	10.2813
Cl/Fe	=	0.0000E+00	Log Fe	/H2	=	1.7996
Cl/SO4	=	4.7243E+00	Log Ca/Mg		=	.2300
CL/HCO3	=	1.8937E-01	LOG NA/K		=	.0000
Ca/Mg	=	1.7143E+00	Log Ca/K2		=	.0000
Na/K	=	0.0000E+00	Log Diss Fe/H2		=	14.0200

	Phase	Log AP/KT	Sigma(A)	Sigma(T)	Log AP/MinKT	Log AP/MaxKT	Log AP	Log KT	Log MinKT	Log MaxKT
40	Albite	-.829					-19.422	-18.593		
140	AlOH3 (a)	-.738			-.049		-32.645	-31.907	-32.596	
471	AlOHSO4	-4.225			-4.065	-4.385	-7.455	-3.230	-3.390	-3.070
472	Al4(OH)10SO4	.688					23.388	22.700		
157	Allophane(a)	.216					6.293	6.077		
158	Allophane(F)	1.038					6.293	5.255		
42	Analcime	-3.006					-16.122	-13.116		
17	Anhydrite	-1.947					-6.498	-4.551		
41	Anorthite	-2.832					-22.810	-19.978		
21	Aragonite	.034		.020			-8.250	-8.284		
150	Artinite	-7.269					2.987	10.256		
48	Beidellite	4.385					-42.264	-46.649		
52	Boehmite	1.042			1.555		-32.645	-33.688	-34.201	
19	Brucite	-6.386					-17.610	-11.223		
12	Calcite	.185		.020	.251		-8.250	-8.435	-8.501	
97	Chalcedony	.329					-3.300	-3.628		
49	Chlorite 14A	-6.135		6.000	-.860	-14.859	65.701	71.836	66.561	80.560
125	Chlorite 7A	-9.593		6.000			65.701	75.294		
20	Chrysotile	-6.999					-59.429	-52.429		
29	Clinoenstite	-4.099			-3.733	-4.393	-20.909	-16.810	-17.176	-16.516
56	Clinoptilolt						-24.617			
99	Cristobalite	.413					-3.300	-3.712		
154	Diaspore	2.827					-32.645	-35.472		
28	Diopside	-5.001					-41.589	-36.587		
11	Dolomite	.081					-16.730	-16.811		
340	Epsomite	-4.525					-6.729	-2.204		
55	Erionite						-21.072			
112	Ferrihydrite	1.115			4.449	1.010	6.006	4.891	1.557	4.996
419	Fe3(OH)8	-6.410			-3.300	-10.293	13.812	20.222	17.112	24.105
181	FeOH)2.7Cl.3	6.112					3.072	-3.040		
401	Fe2(SO4)3	-46.123			-41.893		-41.194	4.929	.699	
62	Fluorite	-.163					-11.225	-11.062		
27	Forsterite	-10.714					-38.519	-27.805		
51	Gibbsite (c)	.991		.200	1.274	.321	10.281	9.290	9.007	9.960
110	Goethite	5.176		.800			6.007	.830		
111	Greenalite	-22.011					-1.201	20.810		
18	Gypsum	-1.892					-6.498	-4.606		

64 Halite	-7.142				-5.581	- 1.561		
47 Halloysite	-.198				-34.048	-33.849		
108 Hematite	15.318				12.013	-3.304		
117 Huntite	-4.309				-33.689	-29.380		
38 Hydrmagnesit	-15.350				-51.530	-36.180		
204 Jarosite Na	-2.876	1.000			-13.251	-10.375		
337 Jarosite H	-6.611				-17.452	-10.842		
46 Kaolinite	3.995		4.874	2.894	-34.048	-38.042	-38.921	-36.941
128 Laumontite	2.454				-29.410	-31.864		
147 Leonhardite	12.992				-58.819	-71.811		
109 Maghemite	5.627				12.013	6.386		
10 Magnesite	-.592		-.342	-.842	-8.480	-7.888	-8.138	-7.638
107 Magnetite	8.924		9.294	6.066	13.813	4.888	4.518	7.746
339 Melanterite	-13.402				-15.937	-2.535		
63 Montmoril Ca	4.120				-42.238	-46.359		
115 Montmoril BF	4.677				-30.236	-34.913		
116 Montmoril AB	3.747				-25.941	-29.688		
57 Mordenite					-22.967			
66 Mirabilite	-7.788				-9.335	-1.547		
58 Nahcolite	-4.236				-4.869	-.633		

	Phase	Log AP/KT	Sigma(A)	Sigma(T)	Log AP/MinKT	Log AP/MaxKT	Log AP	Log KT	Log MinKT	Log MaxKT
60	Natron	-9.417					-11.087	-1.670		
149	Nesquehonite	-2.991			-3.479	-4.066	-8.480	-5.489	-5.001	-4.414
141	Prehnite	-2.940					-14.872	-11.932		
53	Pyrophyllite	7.667			10.963	5.833	-40.647	-48.314	-51.610	-46.480
101	Quartz	.848					-3.300	-4.148		
36	Sepiolite(c)	-3.860					12.116	15.976		
153	Sepiolite(a)	-6.544					12.116	18.660		
9	Siderite	-7.260			-5.706		-17.688	-10.428	-11.982	
100	SiO2 (a,L)	-.180					-3.300	-3.119		
395	SiO2 (a,M)	-.500					-3.300	-2.799		
37	Talc	-2.632		2.000	-.464	-4.380	19.825	22.456	20.288	24.204
65	Thenardite	-9.167					-9.333	-.166		
61	Thermonatr	-11.274					-11.085	.189		
31	Tremolite	-7.721					-149.205	-141.484		
59	Trona	-15.570					-15.955	-.384		
155	Wairkite	-2.105					-29.409	-27.304		

```
1 CIMARRON WELL 1317                                        1317 X5
  1750  1550 030590       0        0        0     1200
                    TEMP        =           16.000000
                    PH          =            7.070000
                    EHM         =             .600000
                    DOC         =             .000000
                    DOX         =             .000000
                    CORALK      =         0
                    FLG         =        MG/L
                    DENS        =            1.000000
                    PRNT        =         0
                    PUNCH       =         1
                    EHOPT       =         0
                    EMPOX       =         0
                    ITDS        =         1550.000000
                    COND        =         1750.000000
                    SIGMDO      =             .000000
                    SIGMEH      =             .000000
                    SIGMPH      =             .000000

       Species     Index No      Input Concentration
       ----------------------------------------------
       Ca          :    0   :        223.00000000
       Mg          :    1   :        108.00000000
       Na          :    2   :        213.00000000
       K           :    3   :          3.20000000
       Cl          :    4   :        130.00000000
       SO4         :    5   :        190.00000000
       HCO3        :    6   :       1290.00000000
       Fe total    :   16   :           .02600000
       H2S aq      :   13   :           .00000000
       CO3         :   17   :           .00000000
       SiO2 tot    :   34   :         42.80000000
       NH4         :   38   :           .00000000
       B tot       :   86   :           .46000000
       PO4         :   44   :           .00000000
       Al          :   50   :           .07300000
       F           :   61   :          3.10000000
       NO3         :   84   :          5.00000000
1CIMARRON WELL 1317                                         1317 X5
```

1750 1550 030590 0 0 0 1200

ITER	S1-AnalCO3	S2-AnalSO4	S3-AnalF	S4-AnalPO4	S5-AnalCL	S6-AnalH2S	S7-AnalFULV	S8-AnalHUM
1	1.132026E-03	7.641778E-04	2.350792E-05	0.000000E+00	1.684384E-16	0.000000E+00	0.000000E+00	0.000000E+00
2	5.298169E-05	4.534441E-05	6.348727E-07	0.000000E+00	-2.363010E-18	0.000000E+00	0.000000E+00	0.000000E+00
3	1.183898E-07	-9.524211E-07	-6.259324E-09	0.000000E+00	-4.637505E-20	0.000000E+00	0.000000E+00	0.000000E+00

1 CIMARRON WELL 1317 1317 X5 Date = 3/27/90 15:18

1750 1550 030590 0 0 0 1200

DOX = .0000 DOC = .0 INPUT TDS = 1550.0

Anal Cond = 1750.0 Calc Cond = 2469.1

Anal EPMCAT = 29.4332 Anal EPMAN = 29.0722 Percent difference in input cation/anion balance = 1.2339

Calc EPMCAT = 27.1526 Calc EPMAN = 26.7953 Percent difference in calc cation/anion balance = 1.3244

Total Ionic Strength (T.I.S.) from input data = .04127

Effective Ionic Strength (E.I.S.) from speciation = .03680

Input	Sigma	Fe3/Fe2	Sigma	Sato H202/02	Sigma	N03/N02	Sigma	N03/NH4	Sigma	Calc H202/02	Sigma	S04/S=	Sigma	As5/As3	Sigma
Eh															
.600	.000	.600	.000	9.900	.000	.000	.000	9.900	.000	9.900	.000	9.900	.000	9.900	.000
pE															
10.457	.000	10.457	.000	100.000	.000	100.000	.000	100.000	.000	100.000	.000	100.000	.000	100.000	.000

T	pH	TDS ppm	Effective Ionic Str	pO2 Atm	pCO2 Atm	pCH4 Atm	CO2 Tot	Uncom CO2	ppm Uncom CO2	Ncrb Alk	aH2O
16.00	7.070	2208.7	.03680	7.44E-17	8.49E-02	9.85-118	.02482	2.01E-02	8.83E+02	1.24E-06	.9992

I	Species		Anal ppm	Calc ppm	Anal Molal	Calc Molal	Activity	Act Coeff	-Log Act
0	Ca	2	223.000	187.790	5.576E-03	4.697E-03	2.425E-03	.5163	2.615
28	CaOH	1		.000223		3.924E-09	3.300E-09	.8409	8.482
31	CaSO4 aq	0		43.719		3.219E-04	3.247E-04	1.0085	3.489
81	CaHSO4	1		.000022		1.590E-10	1.337E-10	.8409	9.874
29	CaHCO3	1		53.305		5.286E-04	4.445E-04	.8409	3.352
30	CaCO3 aq	0		2.645		2.649E-05	2.672E-05	1.0085	4.573
100	CaF	1		.145		2.464E-06	2.072E-06	.8409	5.684
1	Mg	2	108.000	91.059	4.452E-03	3.755E-03	1.975E-03	.5260	2.704
18	MgOH	1		.000805		1.952E-08	1.641E-08	.8409	7.785
22	MgSO4 aq	0		27.586		2.297E-04	2.317E-04	1.0085	3.635
21	MgHCO3	1		37.523		4.408E-04	3.707E-04	.8409	3.431
20	MgCO3 aq	0		1.045		1.242E-05	1.253E-05	1.0085	4.902
19	MgF	1		.628		1.454E-05	1.223E-05	.8409	4.913
2	Na	1	213.000	210.537	9.285E-03	9.180E-03	7.738E-03	.8429	2.111
43	NaSO4	-1		3.667		3.088E-05	2.596E-05	.8409	4.586
42	NaHCO3aq	0		6.139		7.326E-05	7.388E-05	1.0085	4.131
41	NaCO3	-1		.067		8.152E-07	6.855E-07	.8409	6.164
297	NaF aq	0		.004501		1.075E-07	1.084E-07	1.0085	6.965

3	K	1	3.200	3.186	8.202E-05	8.167E-05	6.818E-05	.8348	4.166
45	KSO4	-1		.046		3.441E-07	2.894E-07	.8409	6.539
63	H	1		.000099		9.807E-08	8.511E-08	.8679	7.070
26	OH	-1		.001163		6.858E-08	5.767E-08	.8409	7.239
17	CO3	-2		.886		1.480E-05	7.632E-06	.5156	5.117
6	HCO3	-1	1290.000	1219.497	2.119E-02	2.004E-02	1.698E-02	.8474	1.770
85	H2CO3 aq	0		228.048		3.686E-03	3.721E-03	1.0094	2.429
5	SO4	-2	190.000	134.097	1.982E-03	1.399E-03	7.100E-04	.5074	3.149
62	HSO4	-1		.000528		5.454E-09	4.586E-09	.8409	8.339
61	F	-1	3.100	2.699	1.635E-04	1.424E-04	1.198E-04	.8409	3.922
125	HF aq	0		.000248		1.244E-08	1.254E-08	1.0085	7.902
126	HF2	-1		.000000		6.413E-12	5.393E-12	.8409	11.268
296	H2F2 aq	0		.000000		6.039E-16	6.090E-16	1.0085	15.215
4	Cl	-1	130.000	129.967	3.675E-03	3.675E-03	3.068E-03	.8348	2.513
34	SiO2 tot	0	42.800		7.139E-04				
23	H4SiO4aq	0		68.378		7.132E-04	7.192E-04	1.0085	3.143
24	H3SiO4	-1		.070		7.327E-07	6.161E-07	.8409	6.210
25	H2SiO4	-2		.000000		9.657E-12	4.829E-12	.5001	11.316
124	SiF6	-2		.000000		7.946E-25	3.973E-25	.5001	24.401
86	B tot	0	.460		4.264E-05				

I	Species		Anal ppm	Calc ppm	Anal Molal	Calc Molal	Activity	Act Coeff	-Log Act
35	H3BO3 aq	0		2.612		4.235E-05	4.271E-05	1.0085	4.369
36	H2BO3	-1		.017		2.871E-07	2.414E-07	.8409	6.617
101	BF(OH)3	-1		.000177		2.198E-09	1.848E-09	.8409	8.733
102	BF2(OH)2	-1		.000000		2.453E-12	2.063E-12	.8409	11.685
103	BF3OH	-1		.000000		3.281E-17	2.759E-17	.8409	16.559
104	BF4	-1		.000000		1.393E-21	1.171E-21	.8409	20.931
84	NO3	-1	5.000	4.999	8.082E-05	8.082E-05	6.796E-05	.8409	4.168
50	Al	3	.073000	.000000	2.712E-06	3.215E-11	6.760E-12	.2103	11.170
51	AlOH	2		.000038		8.692E-10	4.346E-10	.5001	9.362
52	Al(OH)2	1		.005354		8.800E-08	7.400E-08	.8409	7.131
181	Al(OH)3	0		.084		1.084E-06	1.094E-06	1.0085	5.961
53	Al(OH)4	-1		.014		1.509E-07	1.269E-07	.8409	6.897
54	AlF	2		.000760		1.657E-08	8.285E-09	.5001	8.082
55	AlF2	1		.015		2.268E-07	1.907E-07	.8409	6.720
56	AlF3 aq	0		.089		1.057E-06	1.066E-06	1.0085	5.972
57	AlF4	-1		.008915		8.679E-08	7.298E-08	.8409	7.137
58	AlSO4	1		.000000		5.339E-12	4.489E-12	.8409	11.348
59	Al(SO4)2	-1		.000000		2.902E-13	2.441E-13	.8409	12.612
203	AlHSO4	2		.000000		1.788E-19	8.941E-20	.5001	19.049
16	Fe total	2	.026		4.666E-07				
7	Fe	2		.000000		1.495E-12	7.474E-13	.5001	12.126
10	FeOH	1		.000000		1.649E-15	1.387E-15	.8409	14.858
79	Fe(OH)2	0		.000000		6.130E-20	6.182E-20	1.0085	19.209
11	Fe(OH)3	-1		.000000		2.927E-23	2.461E-23	.8409	22.609
33	FeSO4 aq	0		.000000		7.897E-14	7.964E-14	1.0085	13.099
122	FeHSO4	1		.000000		4.900E-20	4.121E-20	.8409	19.385
8	Fe	3		.000000		5.597E-15	1.177E-15	.2103	14.929
9	FeOH	2		.000008		1.033E-10	5.166E-11	.5001	10.287
76	Fe(OH)2	1		.037		4.124E-07	3.468E-07	.8409	6.460
77	Fe(OH)3	0		.005056		4.743E-08	4.783E-08	1.0085	7.320
78	Fe(OH)4	-1		.000825		6.677E-09	5.615E-09	.8409	8.251
179	Fe2(OH)2	4		.000000		1.683E-18	1.052E-19	.0625	18.978
180	Fe3(OH)4	5		.000000		5.552E-22	7.301E-24	.0131	23.137
14	FeSO4	1		.000000		6.731E-15	5.660E-15	.8409	14.247
108	Fe(SO4)2	-1		.000000		1.457E-16	1.225E-16	.8409	15.912
123	FeHSO4	2		.000000		3.260E-21	1.630E-21	.5001	20.788
15	FeCl	2		.000000		1.625E-16	8.126E-17	.5001	16.090

27	FeCl2	1	.000000	1.777E-18	1.494E-18	.8409	17.826
32	FeCl3 aq	0	.000000	4.546E-22	4.585E-22	1.0085	21.339
105	FeF	2	.000000	3.877E-13	1.939E-13	.5001	12.712
106	FeF2	1	.000000	9.844E-13	8.278E-13	.8409	12.082
107	FeF3 aq	0	.000000	1.510E-13	1.522E-13	1.0085	12.817

1

CIMARRON WELL 1317 1317 X5

Mole ratios from analytical molality - Log activity ratios

Cl/Ca	=	6.5904E-01	Log Ca	/H2	=	11.5247
Cl/Mg	=	8.2544E-01	Log Mg	/H2	=	11.4356
Cl/Na	=	3.9577E-01	Log Na	/H1	=	4.9587
Cl/K	=	4.4806E+01	Log K	/H1	=	2.9037
Cl/Al	=	1.3553E+03	Log Al	/H3	=	10.0400
Cl/Fe	=	0.0000E+00	Log Fe	/H2	=	2.0135
Cl/SO4	=	1.8539E+00	Log Ca/Mg		=	.0891
CL/HCO3	=	1.7344E-01	LOG NA/K		=	2.0550
Ca/Mg	=	1.2525E+00	Log Ca/K2		=	5.7173
Na/K	=	1.1321E+02	Log Diss Fe/H2		=	14.1400

	Phase	Log AP/KT	Sigma(A)	Sigma(T)	Log AP/MinKT	Log AP/MaxKT	Log AP	Log KT	Log MinKT	Log MaxKT
39	Adularia	.787					-20.489	-21.276		
40	Albite	.158					-18.434	-18.593		
140	AlOH3 (a)	-.980			-.291		-32.887	-31.907	-32.596	
471	AlOHSO4	-4.019			-3.859	-4.179	-7.249	-3.230	-3.390	-3.070
472	Al4(OH)10SO4	.168					22.868	22.700		
157	Allophane(a)	.098					6.276	6.178		
158	Allophane(F)	.929					6.276	5.346		
338	Alum k	-16.303					-21.638	-5.335		
50	Alunite	-1.394					-87.408	-86.014		
42	Analcime	-2.176					-15.292	-13.116		
17	Anhydrite	-1.213					-5.764	-4.551		
113	Annite	30.202					-56.868	-87.070		
41	Anorthite	-2.714					-22.692	-19.978		
21	Aragonite	.551		.020			-7.733	-8.284		
150	Artinite	-6.466					3.790	10.256		
48	Beidellite	4.486					-42.163	-46.649		
52	Boehmite	.801			1.314		-32.887	-33.688	-34.201	
19	Brucite	-5.959					-17.183	-11.223		
12	Calcite	.702		.020	.768		-7.733	-8.435	-8.501	
97	Chalcedony	.486					-3.142	-3.628		
49	Chlorite 14A	-4.010		6.000	1.265	-12.734	67.826	71.336	66.561	80.560
125	Chlorite 7A	-7.468		6.000			67.826	75.294		
20	Chrysotile	-5.403					-57.832	-52.429		
29	Clinoenstite	-3.514			-3.148	-3.808	-20.325	-16.810	-17.176	-16.516
56	Clinoptilolt						-23.663			
99	Cristobalite	.570					-3.142	-3.712		
154	Diaspore	2.586					-32.887	-35.472		
28	Diopside	-3.973					-40.560	-36.587		
11	Dolomite	1.256					-15.554	-16.811		
340	Epsomite	-3.651					-5.856	-2.204		
55	Erionite						-20.007			
112	Ferrihydrite	1.389			4.723	1.284	6.280	4.891	1.557	4.996
419	Fe3(OH)8	-5.650			-2.540	-9.533	14.572	20.222	17.112	24.105
181	FeOH)2.7Cl.3	6.445					3.405	-3.040		
401	Fe2(SO4)3	-44.233			-40.003		-39.305	4.929	.699	
62	Fluorite	.603					-10.459	-11.062		
27	Forsterite	-9.702					-37.507	-27.805		

51	Gibbsite (c)	.749	.200	1.032	.079	10.039	9.290	9.007	9.960
110	Goethite	5.450	.800			6.280	.830		
111	Greenalite	-21.056				-.246	20.810		
18	Gypsum	-1.159				-5.765	-4.606		
64	Halite	-6.186				-4.624	1.561		
47	Halloysite	-.368				-34.217	-33.849		
108	Hematite	15.865				12.560	-3.304		
117	Huntite	-1.818				-31.198	-29.380		
38	Hydrmagnesit	-12.291				-48.471	-36.180		
45	Illite	2.995				-38.519	-41.515		
204	Jarosite Na	-.404	1.000			-10.779	-10.375		
205	Jarosite K	1.253	1.100		-1.047	-12.834	-14.086		-11.786
337	Jarosite H	-4.896				-15.738	-10.842		
46	Kaolinite	3.875		4.704	2.724	-34.217	-38.042	-38.921	-36.941
43	Kmica	9.537	1.300	10.935	7.858	[illegible].594	14.058	12.660	15.737
128	Laumontite	2.885				-28.978	-31.864		
147	Leonhardite	13.855				-57.956	-71.811		
98	Magadiite	-4.795				-19.095	-14.300		
109	Maghemite	6.174				12.560	6.386		
10	Magnesite	.066		.316	-.184	-7.822	-7.888	-8.138	-7.638

Phase	Log AP/KT	Sigma(A)	Sigma(T)	Log AP/MinKT	Log AP/MaxKT	Log AP	Log KT	Log MinKT	Log MaxKT
107 Magnetite	9.685			10.055	6.827	14.574	4.888	4.518	7.746
339 Melanterite	-12.742					-15.278	-2.535		
63 Montmoril Ca	4.182					-42.177	-46.359		
115 Montmoril BF	5.700					-29.213	-34.913		
116 Montmoril AB	4.878					-24.810	-29.688		
57 Mordenite						-22.092			
66 Mirabilite	-5.828					-7.375	-1.547		
58 Nahcolite	-3.249					-3.881	-.633		
60 Natron	-7.673					-9.344	-1.670		
149 Nesquehonite	-2.334			-2.822	-3.409	-7.823	-5.489	-5.001	-4.414
54 Phillipsite	.412					-19.462	-19.874		
44 Phlogopite	-30.449		3.000			13.816	44.265		
141 Prehnite	-2.378					-14.310	-11.932		
53 Pyrophyllite	7.813			11.109	5.979	-40.501	-48.314	-51.610	-46.480
101 Quartz	1.006					-3.142	-4.148		
36 Sepiolite(c)	-2.535					13.442	15.976		
153 Sepiolite(a)	-5.218					13.442	18.660		
9 Siderite	-6.815			-5.261		-17.244	-10.428	-11.982	
100 SiO2 (a,L)	-.023					-3.142	-3.119		
395 SiO2 (a,M)	-.343					-3.142	-2.799		
37 Talc	-.721		2.000	1.447	-2.469	21.736	22.456	20.288	24.204
65 Thenardite	-7.205					-7.371	-.166		
61 Thermonatr	-9.529					-9.340	.189		
31 Tremolite	-3.753					-145.237	-141.484		
59 Trona	-12.838					-13.222	-.384		
155 Wairkite	-1.673					-28.978	-27.304		

1 CIMARRON WELL 1325 1325 X5

```
 900   331 030590      0        0        0    1200
                   TEMP      =          16.000000
                   PH        =           7.090000
                   EHM       =            .600000
                   DOC       =            .000000
                   DOX       =            .000000
                   CORALK    =          0
                   FLG       =         MG/L
                   DENS      =           1.000000
                   PRNT      =          0
                   PUNCH     =          1
                   EHOPT     =          0
                   EMPOX     =          0
                   ITDS      =         331.000000
                   COND      =         900.000000
                   SIGMDO    =            .000000
                   SIGKSH    =            .000000
                   SIGMPH    =            .000000
```

Species		Index No		Input Concentration
Ca	:	0	:	64.80000000
Mg	:	1	:	22.80000000
Na	:	2	:	22.10000000
K	:	3	:	.00000000
Cl	:	4	:	7.90000000
SO4	:	5	:	10.00000000
HCO3	:	6	:	336.00000000
Fe total	:	16	:	.00000000
H2S aq	:	13	:	.00000000
CO3	:	17	:	.00000000
SiO2 tot	:	34	:	30.00000000
NH4	:	38	:	.00000000
B tot	:	86	:	.12000000
PO4	:	44	:	.00000000
Al	:	50	:	.07400000
F	:	61	:	1.00000000
NO3	:	84	:	62.00000000

1CIMARRON WELL 1325 1325 X5

900 331 030590 0 0 0 1200

ITER	S1-AnalCO3	S2-AnalSO4	S3-AnalF	S4-AnalPO4	S5-AnalCL	S6-AnalH2S	S7-AnalFULV	S8-AnalHUM
1	1.130032E-04	2.151833E-05	2.545421E-06	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
2	8.504473E-07	2.334069E-07	-1.692635E-08	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
3	-1.518221E-08	-5.351426E-09	-8.045736E-11	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00

1 CIMARRON WELL 1325 1325 X5 Date = 3/27/90 15:31

900 331 030590 0 0 0 1200

DOX = .0000 DOC = .0 INPUT TDS = 331.0

Anal Cond = 900.0 Calc Cond = 610.4

Anal EPMCAT = 6.0821 Anal EPMAN = 6.9942 Percent difference in input cation/anion balance = -13.9494

Calc EPMCAT = 5.9258 Calc EPMAN = 6.8453 Percent difference in calc cation/anion balance = -14.4005

Total Ionic Strength (T.I.S.) from input data = .00921

Effective Ionic Strength (E.I.S.) from speciation = .00891

Input	Sigma	Fe3/Fe2	Sigma	Sato H2O2/O2	Sigma	NO3/NO2	Sigma	NO3/NH4	Sigma	Calc H2O2/O2	Sigma	SO4/S=	Sigma	As5/As3	Sigma
Eh															
.600	.000	9.900	.000	9.900	.000	.000	.000	9.900	.000	9.900	.000	9.900	.000	9.900	.000
pE															
10.457	.000	100.000	.000	100.000	.000	100.000	.000	100.000	.000	100.000	.000	100.000	.000	100.000	.000

T	pH	TDS ppm	Effective Ionic Str	pO2 Atm	pCO2 Atm	pCH4 Atm	CO2 Tot	Uncom CO2	ppm Uncom CO2	Ncrb Alk	aH2O
16.00	7.090	556.8	.00891	8.96E-17	2.33E-02	1.88-118	.00653	5.40E-03	2.38E+02	9.20E-07	.9998

I	Species		Anal ppm	Calc ppm	Anal Molal	Calc Molal	Activity	Act Coeff	-Log Act
0	Ca	2	64.800	61.691	1.618E-03	1.540E-03	1.059E-03	.6876	2.975
28	CaOH	1		.000095		1.663E-09	1.510E-09	.9079	8.821
31	CaSO4 aq	0		1.599		1.175E-05	1.178E-05	1.0021	4.929
81	CaHSO4	1		.000000		5.101E-12	4.632E-12	.9079	11.334
29	CaHCO3	1		6.247		6.183E-05	5.614E-05	.9079	4.251
30	CaCO3 aq	0		.353		3.526E-06	3.533E-06	1.0021	5.452
100	CaF	1		.022		3.796E-07	3.447E-07	.9079	6.463
1	Mg	2	22.800	21.688	9.383E-04	8.926E-04	6.173E-04	.6915	3.210
18	MgOH	1		.000244		5.920E-09	5.375E-09	.9079	8.270
22	MgSO4 aq	0		.722		6.002E-06	6.015E-06	1.0021	5.221
21	MgHCO3	1		3.147		3.691E-05	3.351E-05	.9079	4.475
20	MgCO3 aq	0		.100		1.183E-06	1.186E-06	1.0021	5.926
19	MgF	1		.069		1.603E-06	1.456E-06	.9079	5.837
2	Na	1	22.100	22.036	9.618E-04	9.591E-04	8.717E-04	.9089	3.060
43	NaSO4	-1		.032		2.676E-07	2.429E-07	.9079	6.614
42	NaHCO3aq	0		.202		2.402E-06	2.407E-06	1.0021	5.619
41	NaCO3	-1		.002136		2.576E-08	2.339E-08	.9079	7.631
297	NaF aq	0		.000195		4.642E-09	4.651E-09	1.0021	8.332

63	H	1		.000089		8.853E-08	8.128E-08	.9182	7.090
26	OH	-1		.001131		6.655E-08	6.042E-08	.9079	7.219
17	CO3	-2		.201		3.360E-06	2.311E-06	.6880	5.636
6	HCO3	-1	336.000	328.762	5.510E-03	5.391E-03	4.910E-03	.9107	2.309
85	H2CO3 aq	0		63.554		1.025E-03	1.028E-03	1.0023	2.988
5	SO4	-2	10.000	8.269	1.042E-04	8.613E-05	5.898E-05	.6847	4.229
62	HSO4	-1		.000039		4.007E-10	3.638E-10	.9079	9.439
61	F	-1	1.000	.954	5.267E-05	5.025E-05	4.562E-05	.9079	4.341
125	HF aq	0		.000091		4.554E-09	4.563E-09	1.0021	8.341
126	HF2	-1		.000000		8.232E-13	7.474E-13	.9079	12.126
296	H2F2 aq	0		.000000		8.044E-17	8.061E-17	1.0021	16.094
4	Cl	-1	7.900	7.899	2.230E-04	2.230E-04	2.021E-04	.9065	3.694
34	SiO2 tot	0	30.000		4.996E-04				
23	H4SiO4aq	0		47.939		4.991E-04	5.001E-04	1.0021	3.301
24	H3SiO4	-1		.047		4.941E-07	4.486E-07	.9079	6.348
25	H2SiO4	-2		.000000		5.418E-12	3.682E-12	.6796	11.434
124	SiF6	-2		.000000		1.031E-27	7.006E-28	.6796	27.155
86	B tot	0	.120		1.111E-05				
35	H3BO3 aq	0		.682		1.103E-05	1.106E-05	1.0021	4.956
36	H2BO3	-1		.004381		7.208E-08	6.544E-08	.9079	7.184

I	Species		Anal ppm	Calc ppm	Anal Molal	Calc Molal	Activity	Act Coeff	-Log Act
101	BF(OH)3	-1		.000016		2.007E-10	1.822E-10	.9079	9.739
102	BF2(OH)2	-1		.000000		8.146E-14	7.396E-14	.9079	13.131
103	BF3OH	-1		.000000		3.961E-19	3.597E-19	.9079	18.444
104	BF4	-1		.000000		6.113E-24	5.550E-24	.9079	23.256
84	NO3	-1	62.000	61.995	1.000E-03	1.000E-03	9.084E-04	.9079	3.042
50	Al	3	.074000	.000000	2.744E-06	2.749E-11	1.152E-11	.4193	10.938
51	AlOH	2		.000050		1.142E-09	7.763E-10	.6796	9.110
52	Al(OH)2	1		.009299		1.525E-07	1.385E-07	.9079	6.859
181	Al(OH)3	0		.167		2.140E-06	2.145E-06	1.0021	5.669
53	Al(OH)4	-1		.027		2.871E-07	2.607E-07	.9079	6.584
54	AlF	2		.000364		7.917E-09	5.380E-09	.6796	8.269
55	AlF2	1		.003374		5.196E-08	4.718E-08	.9079	7.326
56	AlF3 aq	0		.008417		1.003E-07	1.005E-07	1.0021	6.998
57	AlF4	-1		.000297		2.886E-09	2.620E-09	.9079	8.582
58	AlSO4	1		.000000		7.001E-13	6.357E-13	.9079	12.197
59	Al(SO4)2	-1		.000000		3.163E-15	2.872E-15	.9079	14.542
203	AlHSO4	2		.000000		1.779E-20	1.209E-20	.6796	19.918

1

Mole ratios from analytical molality - Log activity ratios

Cl/Ca	=	1.3782E-01	Log Ca	/H2	=	11.2049
Cl/Mg	=	2.3761E-01	Log Mg	/H2	=	10.9705
Cl/Na	=	2.3180E-01	Log Na	/H1	=	4.0304
Cl/K	=	0.0000E+00	Log K	/H1	=	.0000
Cl/Al	=	8.1247E+01	Log Al	/H3	=	10.3316
Cl/Fe	=	0.0000E+00	Log Fe	/H2	=	.0000
Cl/SO4	=	2.1405E+00	Log Ca/Mg		=	.2344
CL/HCO3	=	4.0466E-02	LOG NA/K		=	.0000
Ca/Mg	=	1.7240E+00	Log Ca/K2		=	.0000
Na/K	=	0.0000E+00	Log Diss Fe/H2		=	14.1800

	Phase	Log AP/KT	Sigma(A)	Sigma(T)	Log AP/MinKT	Log AP/MaxKT	Log AP	Log KT	Log MinKT	Log MaxKT
40	Albite	-.953					-19.546	-18.593		
140	AlOH3 (a)	-.687			.002		-32.595	-31.907	-32.596	
471	AlOHSO4	-4.848			-4.688	-5.008	-8.078	-3.230	-3.390	-3.070
472	Al4(OH)10SO4	.216					22.916	22.700		
157	Allophane(a)	.264					6.476	6.211		
158	Allophane(F)	1.099					6.476	5.377		
42	Analcime	-3.129					-16.245	-13.116		
17	Anhydrite	-2.653					-7.204	-4.551		
41	Anorthite	-2.766					-22.744	-19.978		
21	Aragonite	-.327		.020			-8.611	-8.284		
150	Artinite	-7.663					2.593	10.256		
48	Beidellite	4.490					-42.159	-46.649		
52	Boehmite	1.093			1.606		-32.595	-33.688	-34.201	
19	Brucite	-6.424					-17.647	-11.223		
12	Calcite	-.177		.020	-.110		-8.611	-8.435	-8.501	
97	Chalcedony	.328					-3.301	-3.628		
49	Chlorite 14A	-6.224		6.000	-.949	-14.948	65.612	71.836	66.561	80.560
125	Chlorite 7A	-9.682		6.000			65.612	75.294		
20	Chrysotile	-7.113					-59.543	-52.429		
29	Clinoenstite	-4.138			-3.772	-4.432	-20.948	-16.810	-17.176	-16.516
56	Clinoptilolt						-24.618			
99	Cristobalite	.412					-3.301	-3.712		
154	Diaspore	2.878					-32.595	-35.472		
28	Diopside	-5.074					-41.661	-36.587		
11	Dolomite	-.646					-17.457	-16.811		
340	Epsomite	-5.235					-7.439	-2.204		
55	Erionite						-21.196			
62	Fluorite	-.595					-11.657	-11.062		
27	Forsterite	-10.790					-38.595	-27.805		
51	Gibbsite (c)	1.041		.200	1.324	.371	10.331	9.290	9.007	9.960
18	Gypsum	-2.599					-7.205	-4.606		
64	Halite	-8.315					-6.754	1.561		
47	Halloysite	-.100					-33.949	-33.849		
117	Huntite	-5.768					-35.148	-29.380		
38	Hydrmagnesit	-16.850					-53.030	-36.180		
46	Kaolinite	4.093			4.972	2.992	-33.949	-38.042	-38.921	-36.941
128	Laumontite	2.518					-29.346	-31.864		

147 Leonhardite	13.119				-58.692	-71.811		
10 Magnesite	-.957		-.707	-1.207	-8.846	-7.888	-8.138	-7.638
63 Montmoril Ca	4.228				-42.131	-46.359		
57 Mordenite					-22.967			
66 Mirabilite	-8.802				-10.349	-1.547		
58 Nahcolite	-4.736				-5.369	-.633		
60 Natron	-10.086				-11.756	-1.670		
149 Nesquehonite	-3.357		-3.845	-4.432	-8.846	-5.489	-5.001	-4.414
141 Prehnite	-2.908				-14.840	-11.932		
53 Pyrophyllite	7.763		11.059	5.929	-40.551	-48.314	-51.610	-46.480
101 Quartz	.847				-3.301	-4.148		
36 Sepiolite(c)	-3.938				12.038	15.976		
153 Sepiolite(a)	-6.622				12.038	18.660		
100 SiO2 (a,L)	-.181				-3.301	-3.119		
395 SiO2 (a,M)	-.502				-3.301	-2.799		
37 Talc	-2.748	2.000	-.580	-4.496	19.708	22.456	20.288	24.204
65 Thenardite	-10.183				-10.349	-.166		
61 Thermonatr	-11.944				-11.755	.189		
31 Tremolite	-7.982				-149.467	-141.484		
59 Trona	-16.740				-17.124	-.384		

1 CIMARRON WELL 1325 1325 X5

Phase	Log AP/KT	Sigma(A)	Sigma(T)	Log AP/MinKT	Log AP/MaxKT	Log AP	Log KT	Log MinKT	Log MaxKT
155 Wairkite	-2.041					-29.346	-27.304		

1 CIMARRON WELL 1326 1326 X5

550 376 030590 0 0 0 1200

TEMP	=	16.000000
PH	=	6.970000
EHM	=	.600000
DOC	=	.000000
DOX	=	.000000
CORALK	=	0
FLG	=	MG/L
DENS	=	1.000000
PRNT	=	0
PUNCH	=	1
EHOPT	=	0
EMPOX	=	0
ITDS	=	376.000000
COND	=	550.000000
SIGMDO	=	.000000
SIGMEH	=	.000000
SIGMPH	=	.000000

Species	Index No	Input Concentration
Ca	0	73.00000000
Mg	1	26.80000000
Na	2	23.40000000
K	3	1.20000000
Cl	4	12.00000000
SO4	5	23.00000000
HCO3	6	364.00000000
Fe total	16	.06200000
H2S aq	13	.00000000
CO3	17	.00000000
SiO2 tot	34	41.00000000
NH4	38	.00000000
B tot	86	.14000000
PO4	44	.00000000

AL	:	50	:	.06900000
F	:	61	:	.61000000
NO3	:	84	:	71.00000000

1CIMARRON WELL 1326 1326 XS

550 376 030590 0 0 0 1200

ITER	S1-AnalCO3	S2-AnalSO4	S3-AnalF	S4-AnalPO4	S5-AnalCL	S6-AnalH2S	S7-AnalFULV	S8-AnalHUM
1	1.321760E-04	5.331827E-05	1.697558E-06	0.000000E+00	5.056278E-17	0.000000E+00	0.000000E+00	0.000000E+00
2	1.459824E-06	8.235522E-07	-3.569407E-09	0.000000E+00	-2.157816E-19	0.000000E+00	0.000000E+00	0.000000E+00
3	-3.006452E-08	-2.388330E-08	-2.996999E-10	0.000000E+00	9.582060E-21	0.000000E+00	0.000000E+00	0.000000E+00

550 376 030590 0 0 0 1200

DOX = .0000 DOC = .0 INPUT TDS = 376.0

Anal Cond = 550.0 Calc Cond = 699.5

Anal EPMCAT = 6.9103 Anal EPMAN = 7.9652 Percent difference in input cation/anion balance = -14.1822

Calc EPMCAT = 6.6826 Calc EPMAN = 7.7458 Percent difference in calc cation/anion balance = -14.7372

Total Ionic Strength (T.I.S.) from input data = .01061

Effective Ionic Strength (E.I.S.) from speciation = .01017

Input	Sigma	Fe3/Fe2	Sigma	Sato H2O2/O2	Sigma	NO3/NO2	Sigma	NO3/NH4	Sigma	Calc H2O2/O2	Sigma	SO4/S=	Sigma	As5/As3	Sigma
Eh															
.600	.000	.600	.000	9.900	.000	.000	.000	9.900	.000	9.900	.000	9.900	.000	9.900	.000
pE															
10.457	.000	10.457	.000	100.000	.000	100.000	.000	100.000	.000	100.000	.000	100.000	.000	100.000	.000

T	pH	TDS ppm	Effective Ionic Str	pO2 Atm	pCO2 Atm	pCH4 Atm	CO2 Tot	Uncom CO2	ppm Uncom CO2	Ncrb Alk	aH2O
16.00	6.970	636.3	.01017	2.97E-17	3.30E-02	2.43-117	.00742	5.84E-03	2.57E+02	8.41E-07	.9998

I	Species		Anal ppm	Calc ppm	Anal Molal	Calc Molal	Activity	Act Coeff	-Log Act
0	Ca	2	73.000	68.793	1.823E-03	1.718E-03	1.156E-03	.6728	2.937
28	CaOH	1		.000079		1.385E-09	1.250E-09	.9027	8.903
31	CaSO4 aq	0		3.868		2.843E-05	2.850E-05	1.0023	4.545
81	CaHSO4	1		.000002		1.637E-11	1.477E-11	.9027	10.830
29	CaHCO3	1		7.377		7.303E-05	6.592E-05	.9027	4.181
30	CaCO3 aq	0		.314		3.140E-06	3.147E-06	1.0023	5.502
100	CaF	1		.015		2.516E-07	2.271E-07	.9027	6.644
1	Mg	2	26.800	25.267	1.103E-03	1.040E-03	7.042E-04	.6771	3.152
18	MgOH	1		.000213		5.153E-09	4.652E-09	.9027	8.332
22	MgSO4 aq	0		1.826		1.518E-05	1.522E-05	1.0023	4.818
21	MgHCO3	1		3.886		4.557E-05	4.114E-05	.9027	4.386
20	MgCO3 aq	0		.093		1.102E-06	1.104E-06	1.0023	5.957
19	MgF	1		.048		1.111E-06	1.003E-06	.9027	5.999
2	Na	1	23.400	23.320	1.018E-03	1.015E-03	9.174E-04	.9037	3.037
43	NaSO4	-1		.075		6.280E-07	5.670E-07	.9027	6.246
42	NaHCO3aq	0		.228		2.719E-06	2.726E-06	1.0023	5.565
41	NaCO3	-1		.001846		2.225E-08	2.009E-08	.9027	7.697
297	NaF aq	0		.000124		2.949E-09	2.956E-09	1.0023	8.529

3	K	1	1.200	1.199	3.071E-05	3.068E-05	2.765E-05	.9011	4.558
45	KSO4	-1		.003234		2.394E-08	2.161E-08	.9027	7.665
63	H	1		.000118		1.172E-07	1.072E-07	.9140	6.970
26	OH	-1		.000863		5.077E-08	4.583E-08	.9027	7.339
17	CO3	-2		.168		2.803E-06	1.887E-06	.6732	5.724
6	HCO3	-1	364.000	355.648	5.969E-03	5.833E-03	5.284E-03	.9058	2.277
85	H2CO3 aq	0		90.111		1.454E-03	1.458E-03	1.0026	2.836
5	SO4	-2	23.000	18.748	2.396E-04	1.953E-04	1.308E-04	.6696	3.883
62	HSO4	-1		.000114		1.178E-09	1.063E-09	.9027	8.973
61	F	-1	.610	.579	3.213E-05	3.052E-05	2.755E-05	.9027	4.560
125	HF aq	0		.000072		3.624E-09	3.632E-09	1.0023	8.440
126	HF2	-1		.000000		3.979E-13	3.592E-13	.9027	12.445
296	H2F2 aq	0		.000000		5.095E-17	5.107E-17	1.0023	16.292
4	Cl	-1	12.000	11.999	3.387E-04	3.387E-04	3.052E-04	.9011	3.515
34	SiO2 tot	0	41.000		6.828E-04				
23	H4SiO4aq	0		65.529		6.823E-04	6.839E-04	1.0023	3.165
24	H3SiO4	-1		.049		5.155E-07	4.653E-07	.9027	6.332
25	H2SiO4	-2		.000000		4.363E-12	2.897E-12	.6641	11.538
124	SiF6	-2		.000000		2.112E-28	1.402E-28	.6641	27.853
86	B tot	0	.140		1.296E-05				

I	Species		Anal ppm	Calc ppm	Anal Molal	Calc Molal	Activity	Act Coeff	-Log Act
35	H3BO3 aq	0		.797		1.289E-05	1.292E-05	1.0023	4.889
36	H2BO3	-1		.003907		6.428E-08	5.803E-08	.9027	7.236
101	BF(OH)3	-1		.000012		1.425E-10	1.286E-10	.9027	9.891
102	BF2(OH)2	-1		.000000		4.603E-14	4.155E-14	.9027	13.381
103	BF3OH	-1		.000000		1.782E-19	1.608E-19	.9027	18.794
104	BF4	-1		.000000		2.189E-24	1.976E-24	.9027	23.704
84	NO3	-1	71.000	70.992	1.146E-03	1.146E-03	1.034E-03	.9027	2.985
50	Al	3	.069000	.000002	2.559E-06	6.358E-11	2.531E-11	.3981	10.597
51	AlOH	2		.000086		1.948E-09	1.293E-09	.6641	8.888
52	Al(OH)2	1		.012		1.939E-07	1.750E-07	.9027	6.757
181	Al(OH)3	0		.160		2.051E-06	2.056E-06	1.0023	5.687
53	Al(OH)4	-1		.020		2.100E-07	1.896E-07	.9027	6.722
54	AlF	2		.000494		1.074E-08	7.135E-09	.6641	8.147
55	AlF2	1		.002717		4.185E-08	3.777E-08	.9027	7.423
56	AlF3 aq	0		.004068		4.847E-08	4.859E-08	1.0023	7.313
57	AlF4	-1		.000087		8.474E-10	7.650E-10	.9027	9.116
58	AlSO4	1		.000000		3.430E-12	3.096E-12	.9027	11.509
59	Al(SO4)2	-1		.000000		3.436E-14	3.101E-14	.9027	13.508
203	AlHSO4	2		.000000		1.169E-19	7.763E-20	.6641	19.110
16	Fe total	2	.062		1.111E-06				
7	Fe	2		.000000		4.645E-12	3.084E-12	.6641	11.511
10	FeOH	1		.000000		5.039E-15	4.549E-15	.9027	14.342
79	Fe(OH)2	0		.000000		1.608E-19	1.612E-19	1.0023	18.793
11	Fe(OH)3	-1		.000000		5.650E-23	5.100E-23	.9027	22.292
33	FeSO4 aq	0		.000000		6.039E-14	6.054E-14	1.0023	13.218
122	FeHSO4	1		.000000		4.368E-20	3.943E-20	.9027	19.404
8	Fe	3		.000000		1.220E-14	4.857E-15	.3981	14.314
9	FeOH	2		.000019		2.552E-10	1.695E-10	.6641	9.771
76	Fe(OH)2	1		.090		1.002E-06	9.041E-07	.9027	6.044
77	Fe(OH)3	0		.011		9.688E-08	9.911E-08	1.0023	7.004
78	Fe(OH)4	-1		.001268		1.024E-08	9.247E-09	.9027	8.034
179	Fe2(OH)2	4		.000000		5.829E-18	1.134E-18	.1945	17.945
180	Fe3(OH)4	5		.000000		2.651E-21	2.053E-22	.0774	21.688
14	FeSO4	1		.000000		4.766E-15	4.303E-15	.9027	14.366
108	Fe(SO4)2	-1		.000000		1.901E-17	1.716E-17	.9027	16.766
123	FeHSO4	2		.000000		2.349E-21	1.560E-21	.6641	20.807
15	FeCl	2		.000000		5.024E-17	3.336E-17	.6641	16.477

27	FeCl2	1	.000000	6.761E-20	6.103E-20	.9027	19.214
32	FeCl3 aq	0	.000000	1.858E-24	1.863E-24	1.0023	23.730
105	FeF	2	.000000	2.771E-13	1.840E-13	.6641	12.735
106	FeF2	1	.000000	2.002E-13	1.807E-13	.9027	12.743
107	FeF3 aq	0	.000000	7.629E-15	7.646E-15	1.0023	14.117

1

Mole ratios from analytical molality - Log activity ratios

Cl/Ca	=	1.8584E-01	Log Ca	/H2	=	11.0028
Cl/Mg	=	3.0705E-01	Log Mg	/H2	=	10.7877
Cl/Na	=	3.3254E-01	Log Na	/H1	=	3.9326
Cl/K	=	1.1029E+01	Log K	/H1	=	2.4117
Cl/Al	=	1.3236E+02	Log Al	/H3	=	10.3133
Cl/Fe	=	0.0000E+00	Log Fe	/H2	=	2.4292
Cl/SO4	=	1.4137E+00	Log Ca/Mg		=	.2151
CL/HCO3	=	5.6739E-02	LOG NA/K		=	1.5209
Ca/Mg	=	1.6523E+00	Log Ca/K2		=	6.1794
Na/K	=	3.3166E+01	Log Diss Fe/H2		=	13.9400

	Phase	Log AP/KT	Sigma(A)	Sigma(T)	Log AP/MinKT	Log AP/MaxKT	Log AP	Log KT	Log MinKT	Log MaxKT
39	Adularia	.501					-20.775	-21.276		
40	Albite	-.661					-19.254	-18.593		
140	AlOH3 (a)	-.706			-.017		-32.613	-31.907	-32.596	
471	AlOHSO4	-4.280			-4.120	-4.440	-7.510	-3.230	-3.390	-3.070
472	Al4(OH)10SO4	.729					23.429	22.700		
157	Allophane(a)	.273					6.283	6.010		
158	Allophane(F)	1.088					6.283	5.194		
338	Alum k	-17.588					-22.923	-5.335		
50	Alunite	-2.134					-88.148	-86.014		
42	Analcime	-2.973					-16.089	-13.116		
17	Anhydrite	-2.270					-6.821	-4.551		
113	Annite	31.763					-55.307	-87.070		
41	Anorthite	-2.733					-22.711	-19.978		
21	Aragonite	-.377		.020			-8.661	-8.284		
150	Artinite	-7.915					2.341	10.256		
48	Beidellite	4.917					-41.732	-46.649		
52	Boehmite	1.075			1.588		-32.613	-33.688	-34.201	
19	Brucite	-6.606					-17.830	-11.223		
12	Calcite	-.227		.020	-.160		-8.661	-8.435	-8.501	
97	Chalcedony	.463					-3.165	-3.628		
49	Chlorite 14A	-6.767		6.000	-1.492	-15.491	65.070	71.836	66.561	80.560
125	Chlorite 7A	-10.225		6.000			65.070	75.294		
20	Chrysotile	-7.390					-59.819	-52.429		
29	Clinoenstite	-4.184			-3.818	-4.478	-20.995	-16.810	-17.176	-16.516
56	Clinoptilolt						-24.059			
99	Cristobalite	.548					-3.165	-3.712		
154	Diaspore	2.859					-32.613	-35.472		
28	Diopside	-5.187					-41.774	-36.587		
11	Dolomite	-.727					-17.538	-16.811		
340	Epsomite	-4.832					-7.036	-2.204		
55	Erionite						-20.837			
112	Ferrihydrite	1.705			5.039	1.600	6.596	4.891	1.557	4.996
419	Fe3(OH)8	-4.601			-1.491	-8.484	15.621	20.222	17.112	24.105
181	FeOH)2.7Cl.3	6.491					3.451	-3.040		
401	Fe2(SO4)3	-45.206			-40.976		-40.278	4.929	.699	
62	Fluorite	-.995					-12.057	-11.062		
27	Forsterite	-11.019					-38.824	-27.805		

51	Gibbsite (c)	1.023	.200	1.306	.353	10.313	9.290	9.007	9.960
110	Goethite	5.766	.800			6.596	.830		
111	Greenalite	-19.853				.957	20.810		
18	Gypsum	-2.215				-6.821	-4.606		
64	Halite	-8.114				-6.553	1.561		
47	Halloysite	.135				-33.714	-33.849		
108	Hematite	16.497				13.193	-3.304		
117	Huntite	-5.911				-35.291	-29.380		
38	Hydrmagnesit	-17.157				-53.337	-36.180		
45	Illite	3.090				-38.425	-41.515		
204	Jarosite Na	-1.551	1.000			-11.926	-10.375		
205	Jarosite K	.640	1.100		-1.660	-13.447	-14.086		-11.786
337	Jarosite H	-5.017				-15.858	-10.842		
46	Kaolinite	4.328		5.207	3.227	-33.714	-38.042	-38.921	-36.941
43	Kmica	9.799	1.300	11.197	8.120	23.857	14.058	12.660	15.737
128	Laumontite	2.823				-29.041	-31.864		
147	Leonhardite	13.729				-58.082	-71.811		
98	Magadiite	-5.443				-19.743	-14.300		
109	Maghemite	6.807				13.193	6.386		
10	Magnesite	-.988		-.738	-1.238	-8.877	-7.888	-8.138	-7.638

	Phase	Log AP/KT	Sigma(A)	Sigma(T)	Log AP/MinKT	Log AP/MaxKT	Log AP	Log KT	Log MinKT	Log MaxKT
107	Magnetite	10.733			11.103	7.875	15.622	4.888	4.518	7.746
339	Melanterite	-12.860					-15.395	-2.535		
63	Montmoril Ca	4.651					-41.708	-46.359		
115	Montmoril BF	5.138					-29.775	-34.913		
116	Montmoril AB	4.219					-25.469	-29.638		
57	Mordenite						-22.476			
66	Mirabilite	-8.412					-9.959	-1.547		
58	Nahcolite	-4.682					-5.315	-.633		
60	Natron	-10.130					-11.800	-1.670		
149	Nesquehonite	-3.388			-3.876	-4.463	-8.877	-5.489	-5.001	-4.414
54	Phillipsite	-.140					-20.014	-19.874		
44	Phlogopite	-32.677		3.000			11.588	44.265		
141	Prehnite	-2.941					-14.873	-11.932		
53	Pyrophyllite	8.271			11.567	6.437	-40.043	-48.314	-51.610	-46.480
101	Quartz	.983					-3.165	-4.148		
36	Sepiolite(c)	-3.896					12.080	15.976		
153	Sepiolite(a)	-6.580					12.080	18.660		
9	Siderite	-6.807			-5.253		-17.235	-10.428	-11.982	
100	SiO2 (a,L)	-.046					-3.165	-3.119		
395	SiO2 (a,M)	-.366					-3.165	-2.799		
37	Talc	-2.753		2.000	-.585	-4.501	19.704	22.456	20.288	24.204
65	Thenardite	-9.792					-9.958	-.166		
61	Thermonatr	-11.988					-11.799	.189		
31	Tremolite	-8.213					-149.697	-141.484		
59	Trona	-16.730					-17.114	-.384		
155	Wairkite	-1.736					-29.041	-27.304		

1 CIMARRON WELL 1331 1331 X5

750 634 030590 0 0 0 1200

TEMP	=	16.000000
PH	=	6.950000
EHM	=	.600000
DOC	=	.000000
DOX	=	.000000
CORALK	=	0
FLG	=	MG/L
DENS	=	1.000000
PRNT	=	0
PUNCH	=	1
EHOPT	=	0
EMPOX	=	0
ITDS	=	634.000000
COND	=	750.000000
SIGMDO	=	.000000
SIGMEH	=	.000000
SIGMPH	=	.000000

Species	Index No	Input Concentration
Ca	0	124.00000000
Mg	1	42.30000000
Na	2	54.50000000
K	3	.00000000
Cl	4	17.00000000
SO4	5	70.00000000
HCO3	6	663.00000000
Fe total	16	.02800000
H2S aq	13	.00000000
CO3	17	.00000000
SiO2 tot	34	20.00000000
NH4	38	.00000000
B tot	86	.11000000
PO4	44	.00000000
Al	50	.06500000
F	61	1.20000000
NO3	84	57.50000000

1CIMARRON WELL 1331 1331 X5

750 634 030590 0 0 0 1200

ITER	S1-AnalCO3	S2-AnalSO4	S3-AnalF	S4-AnalPO4	S5-AnalCL	S6-AnalH2S	S7-AnalFULV	S8-AnalHUM
1	3.424160E-04	2.082696E-04	5.263650E-06	0.000000E+00	3.777828E-17	0.000000E+00	0.000000E+00	0.000000E+00
2	8.469586E-06	6.835506E-06	-2.466872E-08	0.000000E+00	-3.243342E-19	0.000000E+00	0.000000E+00	0.000000E+00
3	-1.178189E-07	-1.948879E-07	-1.125302E-09	0.000000E+00	1.752299E-20	0.000000E+00	0.000000E+00	0.000000E+00

1 CIMARRON WELL 1331 1331 X5 Date = 3/27/90 15:31

750 634 030590 0 0 0 1200

DOX = .0000 DOC = .0 INPUT TDS = 634.0

Anal Cond = 750.0 Calc Cond = 1155.2

Anal EPMCAT = 12.0590 Anal EPMAN = 13.8077 Percent difference in input cation/anion balance = -13.5210

Calc EPMCAT = 11.3783 Calc EPMAN = 13.1331 Percent difference in calc cation/anion balance = -14.3183

Total Ionic Strength (T.I.S.) from input data = .01851

Effective Ionic Strength (E.I.S.) from speciation = .01717

				Sato						Calc					
Input	Sigma	Fe3/Fe2	Sigma	H2O2/O2	Sigma	NO3/NO2	Sigma	NO3/NH4	Sigma	H2O2/O2	Sigma	SO4/S=	Sigma	As5/As3	Sigma
Eh															
.600	.000	.600	.000	9.900	.000	.000	.000	9.900	.000	9.900	.000	9.900	.000	9.900	.000
pE															
10.457	.000	10.457	.000	100.000	.000	100.000	.000	100.000	.000	100.000	.000	100.000	.000	100.000	.000

T	pH	TDS ppm	Effective Ionic Str	pO2 Atm	pCO2 Atm	pCH4 Atm	CO2 Tot	Uncom CO2	ppm Uncom CO2	Ncrb Alk	aH2O
16.00	6.950	1049.7	.01717	2.47E-17	6.10E-02	6.48-117	.01354	1.05E-02	4.64E+02	5.10E-07	.9996

I	Species		Anal ppm	Calc ppm	Anal Molal	Calc Molal	Activity	Act Coeff	-Log Act
0	Ca	2	124.000	111.494	3.097E-03	2.785E-03	1.702E-03	.6112	2.769
28	CaOH	1		.000114		1.998E-09	1.758E-09	.8799	8.755
31	CaSO4 aq	0		14.821		1.090E-04	1.094E-04	1.0040	3.961
81	CaHSO4	1		.000009		6.751E-11	5.941E-11	.8799	10.226
29	CaHCO3	1		19.632		1.944E-04	1.711E-04	.8799	3.767
30	CaCO3 aq	0		.777		7.770E-06	7.801E-06	1.0040	5.108
100	CaF	1		.042		7.091E-07	6.239E-07	.8799	6.205
1	Mg	2	42.300	38.090	1.742E-03	1.569E-03	9.684E-04	.6173	3.014
18	MgOH	1		.000286		6.942E-09	6.108E-09	.8799	8.214
22	MgSO4 aq	0		6.532		5.433E-05	5.454E-05	1.0040	4.263
21	MgHCO3	1		9.653		1.133E-04	9.966E-05	.8799	4.001
20	MgCO3 aq	0		.214		2.545E-06	2.555E-06	1.0040	5.593
19	MgF	1		.126		2.922E-06	2.571E-06	.8799	5.590
2	Na	1	54.500	54.152	2.373E-03	2.358E-03	2.079E-03	.8813	2.682
43	NaSO4	-1		.452		3.805E-06	3.348E-06	.8799	5.475
42	NaHCO3aq	0		.909		1.084E-05	1.088E-05	1.0040	4.963
41	NaCO3	-1		.007215		8.703E-08	7.658E-08	.8799	7.116
297	NaF aq	0		.000522		1.244E-08	1.249E-08	1.0040	7.903

63	H	1		.000126		1.252E-07	1.122E-07	.8965	6.950
26	OH	-1		.000845		4.974E-08	4.377E-08	.8799	7.359
17	CO3	-2		.311		5.192E-06	3.174E-06	.6114	5.498
6	HCO3	-1	663.000	641.539	1.088E-02	1.053E-02	9.309E-03	.8843	2.031
85	H2CO3 aq	0		165.865		2.677E-03	2.689E-03	1.0044	2.570
5	SO4	-2	70.000	53.952	7.295E-04	5.623E-04	3.409E-04	.6062	3.467
62	HSO4	-1		.000320		3.299E-09	2.903E-09	.8799	8.537
61	F	-1	1.200	1.108	6.323E-05	5.839E-05	5.138E-05	.8799	4.289
125	HF aq	0		.000141		7.065E-09	7.093E-09	1.0040	8.149
126	HF2	-1		.000000		1.487E-12	1.308E-12	.8799	11.883
296	H2F2 aq	0		.000000		1.940E-16	1.948E-16	1.0040	15.710
4	Cl	-1	17.000	16.997	4.800E-04	4.800E-04	4.210E-04	.8771	3.376
34	SiO2 tot	0	20.000		3.332E-04				
23	H4SiO4aq	0		31.964		3.330E-04	3.343E-04	1.0040	3.476
24	H3SiO4	-1		.023		2.469E-07	2.172E-07	.8799	6.663
25	H2SiO4	-2		.000000		2.155E-12	1.292E-12	.5994	11.889
124	SiF6	-2		.000000		5.787E-27	3.469E-27	.5994	26.460
86	B tot	0	.110		1.019E-05				
35	H3BO3 aq	0		.626		1.014E-05	1.018F-05	1.0040	4.992
36	H2BO3	-1		.003012		4.959E-08	4.363E-08	.8799	7.360

I	Species		Anal ppm	Calc ppm	Anal Molal	Calc Molal	Activity	Act Coeff	-Log Act
101	BF(OH)3	-1		.000017		2.146E-10	1.889E-10	.8799	9.724
102	BF2(OH)2	-1		.000000		1.354E-13	1.192E-13	.8799	12.924
103	BF3OH	-1		.000000		1.024E-18	9.010E-19	.8799	18.045
104	BF4	-1		.000000		2.457E-23	2.162E-23	.8799	22.665
84	NO3	-1	57.500	57.490	9.283E-04	9.283E-04	8.168E-04	.8799	3.088
50	Al	3	.065000	.000002	2.412E-06	7.309E-11	2.311E-11	.3162	10.636
51	AlOH	2		.000083		1.881E-09	1.128E-09	.5994	8.948
52	Al(OH)2	1		.010		1.656E-07	1.457E-07	.8799	6.837
181	Al(OH)3	0		.127		1.628E-06	1.634E-06	1.0040	5.787
53	Al(OH)4	-1		.016		1.635E-07	1.439E-07	.8799	6.842
54	AlF	2		.000931		2.027E-08	1.215E-08	.5994	7.915
55	AlF2	1		.008848		1.363E-07	1.200E-07	.8799	6.921
56	AlF3 aq	0		.024		2.866E-07	2.878E-07	1.0040	6.541
57	AlF4	-1		.000988		9.602E-09	8.449E-09	.8799	8.073
58	AlSO4	1		.000001		8.374E-12	7.369E-12	.8799	11.133
59	Al(SO4)2	-1		.000000		2.186E-13	1.924E-13	.8799	12.716
203	AlHSO4	2		.000000		3.227E-19	1.935E-19	.5994	18.713
16	Fe total	2	.028		5.019E-07				
7	Fe	2		.000000		2.503E-12	1.500E-12	.5994	11.824
10	FeOH	1		.000000		2.401E-15	2.113E-15	.8799	14.675
79	Fe(OH)2	0		.000000		7.120E-20	7.148E-20	1.0040	19.146
11	Fe(OH)3	-1		.000000		2.455E-23	2.160E-23	.8799	22.666
33	FeSO4 aq	0		.000000		7.646E-14	7.677E-14	1.0040	13.115
122	FeHSO4	1		.000000		5.951E-20	5.236E-20	.8799	19.281
8	Fe	3		.000000		7.474E-15	2.363E-15	.3162	14.627
9	FeOH	2		.000010		1.313E-10	7.871E-11	.5994	10.104
76	Fe(OH)2	1		.041		4.557E-07	4.010E-07	.8799	6.397
77	Fe(OH)3	0		.004462		4.181E-08	4.197E-08	1.0040	7.377
78	Fe(OH)4	-1		.000526		4.250E-09	3.739E-09	.8799	8.427
179	Fe2(OH)2	4		.000000		1.894E-18	2.445E-19	.1291	18.612
180	Fe3(OH)4	5		.000000		4.808E-22	1.963E-23	.0408	22.707
14	FeSO4	1		.000000		6.201E-15	5.456E-15	.8799	14.263
108	Fe(SO4)2	-1		.000000		6.445E-17	5.671E-17	.8799	16.246
123	FeHSO4	2		.000000		3.456E-21	2.071E-21	.5994	20.684
15	FeCl	2		.000000		3.735E-17	2.239E-17	.5994	16.650
27	FeCl2	1		.000000		6.422E-20	5.651E-20	.8799	19.248
32	FeCl3 aq	0		.000000		2.370E-24	2.379E-24	1.0040	23.624

105	FeF	2	.000000	2.785E-13	1.670E-13	.5994	12.777
106	FeF2	1	.000000	3.475E-13	3.058E-13	.8799	12.515
107	FeF3 aq	0	.000000	2.403E-14	2.413E-14	1.0040	13.617

1

CIMARRON WELL 1331 1331 X5

Mole ratios from analytical molality - Log activity ratios

Cl/Ca	=	1.5499E-01	Log Ca	/H2	=	11.1310
Cl/Mg	=	2.7560E-01	Log Mg	/H2	=	10.8861
Cl/Na	=	2.0227E-01	Log Na	/H1	=	4.2678
Cl/K	=	0.0000E+00	Log K	/H1	=	.0000
Cl/Al	=	1.9904E+02	Log Al	/H3	=	10.2138
Cl/Fe	=	0.0000E+00	Log Fe	/H2	=	2.0762
Cl/SO4	=	6.5803E-01	Log Ca/Mg		=	.2450
CL/HCO3	=	4.4130E-02	LOG NA/K		=	.0000
Ca/Mg	=	1.7782E+00	Log Ca/K2		=	.0000
Na/K	=	0.0000E+00	Log Diss Fe/H2		=	13.9000

	Phase	Log AP/KT	Sigma(A)	Sigma(T)	Log AP/MinKT	Log AP/MaxKT	Log AP	Log KT	Log MinKT	Log MaxKT
40	Albite	-1.358					-19.951	-18.593		
140	AlOH3 (a)	-.805			-.116		-32.713	-31.907	-32.596	
471	AlOHSO4	-3.924			-3.764	-4.084	-7.154	-3.230	-3.390	-3.070
472	Al4(OH)10SO4	.786					23.486	22.700		
157	Allophane(a)	.107					6.083	5.976		
158	Allophane(F)	.919					6.083	5.164		
42	Analcime	-3.359					-16.475	-13.116		
17	Anhydrite	-1.685					-6.236	-4.551		
41	Anorthite	-3.425					-23.403	-19.978		
21	Aragonite	.017		.020			-8.267	-8.284		
150	Artinite	-7.393					2.863	10.256		
48	Beidellite	3.564					-43.084	-46.649		
52	Boehmite	.975			1.488		-32.713	-33.688	-34.201	
19	Brucite	-6.508					-17.732	-11.223		
12	Calcite	.167		.020	.234		-8.267	-8.435	-8.501	
97	Chalcedony	.153					-3.476	-3.628		
49	Chlorite 14A	-7.407		6.000	-2.132	-16.131	64.429	71.836	66.561	80.560
125	Chlorite 7A	-10.865		6.000			64.429	75.294		
20	Chrysotile	-7.717					-60.146	-52.429		
29	Clinoenstite	-4.397			-4.031	-4.691	-21.207	-16.810	-17.176	-16.516
56	Clinoptilolt						-25.561			
99	Cristobalite	.237					-3.476	-3.712		
154	Diaspore	2.760					-32.713	-35.472		
28	Diopside	-5.582					-42.169	-36.587		
11	Dolomite	.031					-16.780	-16.811		
340	Epsomite	-4.278					-6.482	-2.204		
55	Erionite						-21.689			
112	Ferrihydrite	1.332			4.666	1.227	6.223	4.891	1.557	4.996
419	Fe3(OH)8	-5.700			-2.590	-9.583	14.522	20.222	17.112	24.105
181	FeOH)2.7Cl.3	6.165					3.125	-3.040		
401	Fe2(SO4)3	-44.584			-40.354		-39.655	4.929	.699	
62	Fluorite	-.286					-11.347	-11.062		
27	Forsterite	-11.133					-38.939	-27.805		
51	Gibbsite (c)	.923		.200	1.206	.253	10.213	9.290	9.007	9.960
110	Goethite	5.393		.800			6.223	.830		
111	Greenalite	-21.533					-.723	20.810		
18	Gypsum	-1.631					-6.237	-4.606		

64 Halite	-7.619				-6.058	1.561		
47 Halloysite	-.685				-34.535	-33.849		
108 Hematite	15.751				12.446	-3.304		
117 Huntite	-4.424				-33.804	-29.380		
38 Hydrmagnesit	-15.602				-51.782	-36.180		
204 Jarosite Na	-1.423	1.000			-11.798	-10.375		
337 Jarosite H	-5.224				-16.066	-10.842		
46 Kaolinite	3.508		4.387	2.407	-34.535	-38.042	-38.921	-36.941
128 Laumontite	1.508				-30.355	-31.864		
147 Leonhardite	11.100				-60.710	-71.811		
109 Maghemite	6.060				12.446	6.386		
10 Magnesite	-.624		-.374	-.874	-8.512	-7.888	-8.138	-7.638
107 Magnetite	9.634		10.004	6.776	14.522	4.888	4.518	7.746
339 Melanterite	-12.757				-15.292	-2.535		
63 Montmoril Ca	3.300				-43.059	-46.359		
115 Montmoril BF	3.980				-30.933	-34.913		
116 Montmoril AB	3.080				-26.608	-29.688		
57 Mordenite					-23.823			
66 Mirabilite	-7.286				-8.834	-1.547		
58 Nahcolite	-4.080				-4.713	-.633		

	Phase	Log AP/KT	Sigma(A)	Sigma(T)	Log AP/MinKT	Log AP/MaxKT	Log AP	Log KT	Log MinKT	Log MaxKT
60	Natron	-9.194					-10.865	-1.670		
149	Nesquehonite	-3.024			-3.512	-4.099	-8.513	-5.489	-5.001	-4.414
141	Prehnite	-3.816					-15.748	-11.932		
53	Pyrophyllite	6.828			10.124	4.994	-41.486	-48.314	-51.610	-46.480
101	Quartz	.672					-3.476	-4.148		
36	Sepiolite(c)	-4.632					11.345	15.976		
153	Sepiolite(a)	-7.315					11.345	18.660		
9	Siderite	-6.894			-5.340		-17.322	-10.428	-11.982	
100	SiO2 (a,L)	-.356					-3.476	-3.119		
395	SiO2 (a,M)	-.676					-3.476	-2.799		
37	Talc	-3.701		2.000	-1.533	-5.449	18.755	22.456	20.288	24.204
65	Thenardite	-8.666					-8.832	-.166		
61	Thermonatr	-11.052					-10.863	.189		
31	Tremolite	-9.951					-151.435	-141.484		
59	Trona	-15.192					-15.577	-.384		
155	Wairkite	-3.051					-30.355	-27.304		

```
550  377 030590      0     0     0   1200
            TEMP    =    16.000000
            PH      =     7.000000
            EHM     =      .600000
            DOC     =      .000000
            DOX     =      .000000
            CORALK  =    0
            FLG     =    MG/L
            DENS    =     1.000000
            PRNT    =    0
            PUNCH   =    1
            EHOPT   =    0
            EMPOX   =    0
            ITDS    =   377.000000
            COND    =   550.000000
            SIGMDO  =      .000000
            SIGMEH  =      .000000
            SIGMPH  =      .000000
```

Species		Index No		Input Concentration
Ca	:	0	:	74.60000000
Mg	:	1	:	29.20000000
Na	:	2	:	19.60000000
K	:	3	:	.00000000
Cl	:	4	:	6.90000000
SO4	:	5	:	12.00000000
HCO3	:	6	:	363.00000000
Fe total	:	16	:	.01300000
H2S aq	:	13	:	.00000000
CO3	:	17	:	.00000000
SiO2 tot	:	34	:	23.50000000
NH4	:	38	:	.00000000
B tot	:	86	:	.11000000
PO4	:	44	:	.00000000
Al	:	50	:	.06200000
F	:	61	:	1.10000000
NO3	:	84	:	93.00000000

1CIMARRON WELL 1335 1335 X5

550 377 030590 0 0 0 1200

ITER	S1-AnalCO3	S2-AnalSO4	S3-AnalF	S4-AnalPO4	S5-AnalCL	S6-AnalH2S	S7-AnalFULV	S8-AnalHUM
1	1.388118E-04	2.916738E-05	3.658992E-06	0.000000E+00	5.265474E-18	0.000000E+00	0.000000E+00	0.000000E+00
2	1.209915E-06	3.594084E-07	-4.346303E-08	0.000000E+00	-1.053497E-20	0.000000E+00	0.000000E+00	0.000000E+00
3	-2.481303E-08	-9.609331E-09	2.654692E-10	0.000000E+00	-9.886463E-21	0.000000E+00	0.000000E+00	0.000000E+00

1 CIMARRON WELL 1335 1335 X5 Date = 3/27/90 15:31

550 377 030590 0 0 0 1200

DOX = .0000 DOC = .0 INPUT TDS = 377.0

Anal Cond = 550.0 Calc Cond = 698.9

Anal EPMCAT = 6.9890 Anal EPMAN = 7.9564 Percent difference in input cation/anion balance = -12.9452

Calc EPMCAT = 6.7958 Calc EPMAN = 7.7692 Percent difference in calc cation/anion balance = -13.3667

Total Ionic Strength (T.I.S.) from input data = .01067

Effective Ionic Strength (E.I.S.) from speciation = .01030

				Sato						Calc					
Input	Sigma	Fe3/Fe2	Sigma	H202/02	Sigma	NO3/NO2	Sigma	NO3/NH4	Sigma	H202/02	Sigma	SO4/S=	Sigma	As5/As3	Sigma
Eh															
.600	.000	.600	.000	9.900	.000	.000	.000	9.900	.000	9.900	.000	9.900	.000	9.900	.000
pE															
10.457	.000	10.457	.000	100.000	.000	100.000	.000	100.000	.000	100.000	.000	100.000	.000	100.000	.000

T	pH	TDS ppm	Effective Ionic Str	pO2 Atm	pCO2 Atm	pCH4 Atm	CO2 Tot	Uncom CO2	ppm Uncom CO2	Ncrb Alk	aH2O
16.00	7.000	623.1	.01030	3.91E-17	3.07E-02	1.30-117	.00730	5.82E-03	2.56E+02	6.09E-07	.9998

I	Species		Anal ppm	Calc ppm	Anal Molal	Calc Molal	Activity	Act Coeff	-Log Act
0	Ca	2	74.600	70.838	1.862E-03	1.769E-03	1.188E-03	.6714	2.925
28	CaOH	1		.000087		1.525E-09	1.376E-09	.9022	8.861
31	CaSO4 aq	0		2.052		1.508E-05	1.512E-05	1.0024	4.820
81	CaHSO4	1		.000001		8.109E-12	7.316E-12	.9022	11.136
29	CaHCO3	1		7.551		7.475E-05	6.744E-05	.9022	4.171
30	CaCO3 aq	0		.344		3.442E-06	3.450E-06	1.0024	5.462
100	CaF	1		.027		4.620E-07	4.168E-07	.9022	6.380
[illegible]	Mg	2	29.200	27.698	1.202E-03	1.140E-03	7.704E-04	.6758	3.113
18	MgOH	1		.000250		6.044E-09	5.453E-09	.9022	8.263
22	MgSO4 aq	0		1.031		8.575E-06	8.596E-06	1.0024	5.066
21	MgHCO3	1		4.234		4.966E-05	4.480E-05	.9022	4.349
20	MgCO3 aq	0		.108		1.286E-06	1.289E-06	1.0024	5.890
19	MgF	1		.094		2.171E-06	1.959E-06	.9022	5.708
2	Na	1	19.600	19.539	8.531E-04	8.505E-04	7.682E-04	.9033	3.115
43	NaSO4	-1		.032		2.717E-07	2.451E-07	.9022	6.611
42	NaHCO3aq	0		.190		2.267E-06	2.272E-06	1.0024	5.644
41	NaCO3	-1		.001650		1.989E-08	1.795E-08	.9022	7.746
297	NaF aq	0		.000185		4.410E-09	4.420E-09	1.0024	8.355

63	H	1		.000110		1.095E-07	1.000E-07	.9137	7.000
26	OH	-1		.000925		5.444E-08	4.911E-08	.9022	7.309
17	CO3	-2		.180		2.996E-06	2.013E-06	.6718	5.696
6	HCO3	-1	363.000	354.259	5.953E-03	5.810E-03	5.260E-03	.9053	2.279
85	H2CO3 aq	0		83.722		1.351E-03	1.354E-03	1.0026	2.868
5	SO4	-2	12.000	9.701	1.250E-04	1.011E-04	6.753E-05	.6681	4.171
62	HSO4	-1		.000055		5.680E-10	5.124E-10	.9022	9.290
61	F	-1	1.100	1.035	5.794E-05	5.453E-05	4.920E-05	.9022	4.308
125	HF aq	0		.000121		6.039E-09	6.054E-09	1.0024	8.218
126	HF2	-1		.000000		1.185E-12	1.069E-12	.9022	11.971
296	H2F2 aq	0		.000000		1.415E-16	1.419E-16	1.0024	15.848
4	Cl	-1	6.900	6.899	1.947E-04	1.947E-04	1.754E-04	.9006	3.756
34	SiO2 tot	0	23.500		3.914E-04				
23	H4SiO4aq	0		37.558		3.910E-04	3.920E-04	1.0024	3.407
24	H3SiO4	-1		.030		3.168E-07	2.858E-07	.9022	6.544
25	H2SiO4	-2		.000000		2.877E-12	1.907E-12	.6626	11.720
124	SiF6	-2		.000000		2.985E-27	1.978E-27	.6626	26.704
86	B tot	0	.110		1.018E-05				
35	H3BO3 aq	0		.626		1.013E-05	1.015E-05	1.0024	4.993
36	H2BO3	-1		.003290		5.413E-08	4.884E-08	.9022	7.311

I	Species		Anal ppm	Calc ppm	Anal Molal	Calc Molal	Activity	Act Coeff	-Log Act
101	BF(OH)3	-1		.000016		2.000E-10	1.804E-10	.9022	9.744
102	BF2(OH)2	-1		.000000		1.077E-13	9.715E-14	.9022	13.013
103	BF3OH	-1		.000000		6.946E-19	6.267E-19	.9022	18.203
104	BF4	-1		.000000		1.422E-23	1.283E-23	.9022	22.892
84	NO3	-1	93.000	92.991	1.501E-03	1.501E-03	1.354E-03	.9022	2.868
50	Al	3	.062000	.000001	2.299E-06	4.243E-11	1.681E-11	.3961	10.775
51	AlOH	2		.000061		1.389E-09	9.202E-10	.6626	9.036
52	Al(OH)2	1		.009015		1.479E-07	1.334E-07	.9022	6.875
181	Al(OH)3	0		.131		1.676E-06	1.680E-06	1.0024	5.775
53	Al(OH)4	-1		.017		1.839E-07	1.659E-07	.9022	6.780
54	AlF	2		.000587		1.277E-08	8.461E-09	.6626	8.073
55	AlF2	1		.005757		8.867E-08	8.000E-08	.9022	7.097
56	AlF3 aq	0		.015		1.833E-07	1.838E-07	1.0024	6.736
57	AlF4	-1		.000589		5.727E-09	5.167E-09	.9022	8.287
58	AlSO4	1		.000000		1.176E-12	1.061E-12	.9022	11.974
59	Al(SO4)2	-1		.000000		6.085E-15	5.490E-15	.9022	14.260
203	AlHSO4	2		.000000		3.748E-20	2.484E-20	.6626	19.605
16	Fe total	2	.013		2.329E-07				
7	Fe	2		.000000		8.431E-13	5.587E-13	.6626	12.253
10	FeOH	1		.000000		9.786E-16	8.829E-16	.9022	15.054
79	Fe(OH)2	0		.000000		3.344E-20	3.352E-20	1.0024	19.475
11	Fe(OH)3	-1		.000000		1.260E-23	1.137E-23	.9022	22.944
33	FeSO4 aq	0		.000000		5.648E-15	5.662E-15	1.0024	14.247
122	FeHSO4	1		.000000		3.815E-21	3.442E-21	.9022	20.463
8	Fe	3		.000000		2.221E-15	8.798E-16	.3961	15.056
9	FeOH	2		.000004		4.963E-11	3.289E-11	.6626	10.483
76	Fe(OH)2	1		.019		2.084E-07	1.880E-07	.9022	6.726
77	Fe(OH)3	0		.002353		2.203E-08	2.209E-08	1.0024	7.656
78	Fe(OH)4	-1		.000303		2.447E-09	2.208E-09	.9022	8.656
179	Fe2(OH)2	4		.000000		2.215E-19	4.271E-20	.1928	19.369
180	Fe3(OH)4	5		.000000		2.106E-23	1.608E-24	.0764	23.794
14	FeSO4	1		.000000		4.460E-16	4.024E-16	.9022	15.395
108	Fe(SO4)2	-1		.000000		9.184E-19	8.286E-19	.9022	18.082
123	FeHSO4	2		.000000		2.055E-22	1.362E-22	.6626	21.866
15	FeCl	2		.000000		5.240E-18	3.472E-18	.6626	17.459
27	FeCl2	1		.000000		4.046E-21	3.651E-21	.9022	20.438
32	FeCl3 aq	0		.000000		6.388E-26	6.403E-26	1.0024	25.194

105	FeF	2	.000000	8.984E-14	5.953E-14	.6626	13.225
106	FeF2	1	.000000	1.157E-13	1.044E-13	.9022	12.981
107	FeF3 aq	0	.000000	7.871E-15	7.889E-1[illegible]	1.0024	14.103

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CIMARRON WELL 1335 1335 X5

Mole ratios from analytical molality - Log activity ratios

Cl/Ca	=	1.0456E-01	Log Ca	/H2	=	11.0746
Cl/Mg	=	1.6204E-01	Log Mg	/H2	=	10.8867
Cl/Na	=	2.2828E-01	Log Na	/H1	=	3.8855
Cl/K	=	0.0000E+00	Log K	/H1	=	.0000
Cl/Al	=	8.4697E+01	Log Al	/H3	=	10.2255
Cl/Fe	=	0.0000E+00	Log Fe	/H2	=	1.7472
Cl/SO4	=	1.5580E+00	Log Ca/Mg		=	.1879
CL/HCO3	=	3.2715E-02	LOG NA/K		=	.0000
Ca/Mg	=	1.5497E+00	Log Ca/K2		=	.0000
Na/K	=	0.0000E+00	Log Diss Fe/H2		=	14.0000

	Phase	Log AP/KT	Sigma(A)	Sigma(T)	Log AP/MinKT	Log AP/MaxKT	Log AP	Log KT	Log MinKT	Log MaxKT
40	Albite	-1.521					-20.114	-18.593		
140	AlOH3 (a)	-.794			-.105		-32.701	-31.907	-32.596	
471	AlOHSO4	-4.715			-4.555	-4.875	-7.945	-3.230	-3.390	-3.070
472	Al4(OH)10SO4	.030					22.730	22.700		
157	Allophane(a)	.144					6.204	6.060		
158	Allophane(F)	.964					6.204	5.240		
42	Analcime	-3.591					-16.708	-13.116		
17	Anhydrite	-2.545					-7.096	-4.551		
41	Anorthite	-3.320					-23.298	-19.978		
21	Aragonite	-.337		.020			-8.622	-8.284		
150	Artinite	-7.803					2.453	10.256		
48	Beidellite	3.840					-42.809	-46.649		
52	Boehmite	.987			1.500		-32.701	-33.688	-34.201	
19	Brucite	-6.507					-17.73[illegible]	-11.223		
12	Calcite	-.187		.020	-.121		-8.622	-8.435	-8.501	
97	Chalcedony	.222					-3.407	-3.6[illegible]8		
49	Chlorite 14A	-7.172		6.000	-1.897	-15.896	64.664	71.836	66.561	80.560
125	Chlorite 7A	-10.630		6.000			64.664	75.294		
20	Chrysotile	-7.576					-60.006	-52.429		
29	Clinoenstite	-4.327			-3.961	-4.621	-21.137	-16.810	-17.176	-16.[illegible]16
56	Clinoptilolt						-25.370			
99	Cristobalite	.306					-3.407	-3.712		
154	Diaspore	2.772					-32.701	-35.472		
28	Diopside	-5.499					-42.087	-36.587		
11	Dolomite	-.620					-17.431	-16.811		
340	Epsomite	-5.080					-7.284	-2.204		
55	Erionite						-21.818			
112	Ferrihydrite	1.053			4.387	.948	5.944	4.891	1.557	4.996
419	Fe3(OH)8	-6.587			-3.477	-10.470	13.635	20.222	17.112	24.105
181	FeOH)2.7Cl.3	5.757					2.717	-3.040		
401	Fe2(SO4)3	-47.552			-43.322		-42.623	4.929	.699	
62	Fluorite	-.480					-11.541	-11.062		
27	Forsterite	-11.063					-38.868	-27.805		
51	Gibbsite (c)	.935		.200	1.218	.265	10.225	9.290	9.007	9.960
110	Goethite	5.114		.800			5.944	.830		
111	Greenalite	-22.382					-1.572	20.810		
18	Gypsum	-2.490					-7.096	-4.606		

64 Halite	-8.432				-6.871	1.561		
47 Halloysite	-.524				-34.373	-33.849		
108 Hematite	15.193				11.889	-3.304		
117 Huntite	-5.670				-35.050	-29.380		
38 Hydrmagnesit	-16.789				-52.969	-36.180		
204 Jarosite Na	-4.248	1.000			-14.623	-10.375		
337 Jarosite H	-7.667				-18.509	-10.842		
46 Kaolinite	3.669		4.548	2.568	-34.373	-38.042	-38.921	-36.941
128 Laumontite	1.752				-30.112	-31.864		
147 Leonhardite	11.587				-60.223	-71.811		
109 Maghemite	5.503				11.889	6.386		
10 Magnesite	-.921		-.671	-1.171	-8.810	-7.888	-8.138	-7.638
107 Magnetite	8.747		9.117	5.889	13.636	4.888	4.518	7.746
339 Melanterite	-13.889				-16.424	-2.535		
63 Montmoril Ca	3.571				-42.788	-46.359		
115 Montmoril BF	3.862				-31.051	-34.913		
116 Montmoril AB	2.924				-26.764	-29.688		
57 Mordenite					-23.667			
66 Mirabilite	-8.853				-10.401	-1.547		
58 Nahcolite	-4.761				-5.394	-.633		

Phase	Log AP/KT	Sigma(A)	Sigma(T)	Log AP/MinKT	Log AP/MaxKT	Log AP	Log KT	Log MinKT	Log MaxKT
60 Natron	-10.256					-11.926	-1.670		
149 Nesquehonite	-3.321			-3.809	-4.396	-8.810	-5.489	-5.001	-4.414
141 Prehnite	-3.698					-15.630	-11.932		
53 Pyrophyllite	7.128			10.424	5.294	-41.186	-48.314	-51.610	-46.480
101 Quartz	.741					-3.407	-4.148		
36 Sepiolite(c)	-4.423					11.553	15.976		
153 Sepiolite(a)	-7.107					11.553	18.660		
9 Siderite	-7.521			-5.967		-17.949	-10.428	-11.982	
100 SiO2 (a,L)	-.287					-3.407	-3.119		
395 SiO2 (a,M)	-.607					-3.407	-2.799		
37 Talc	-3.423		2.000	-1.255	-5.171	19.034	22.456	20.288	24.204
65 Thenardite	-10.234					-10.400	-.166		
61 Thermonatr	-12.114					-11.925	.189		
31 Tremolite	-9.508					-150.992	-141.484		
59 Trona	-16.935					-17.319	-.384		
155 Wairkite	-2.807					-30.112	-27.304		

APPENDIX B

EXPOSURE PATHWAY CALCULATIONS

Exposure Pathway Analysis

Cimarron Facility - Uranium Plant Operations

Reference: NUREG/CR-5512 "Residual Radioactive Contamination From Decommissioning - Technical Basis for Translating Contamination Levels to Annual Dose" Draft Report for Comment, January 1990

Exposure Pathways Considered for Radioactivity in Soil:

1. Direct External Exposure to Penetrating Radiation
2. Inhalation of Airborne Materials
3. Ingestion of Agricultural Food Products Grown in Contaminated Soil
4. Ingestion of Drinking Water from a Groundwater Source
5. Ingestion of Drinking Water from a Surface Water Source

Concentrations of Uranium in Soil and Water:

Total Uranium in Soil:	70	pCi/g
Total Uranium in Water:	10	pCi/l

Estimated Isotopic Content:

	U-238	U-235	U-234
Soil, pCi/g	11.28	2.20	56.20
Water, pCi/l	1.61	0.31	8.03

External Exposure to Penetrating Radiation

Rip = (Cip)(Up)(Dip)

Where: Rip = the radiation dose equivalent from radionuclide i via exposure pathway p, in mrem per year of exposure

Cip = concentration of radionuclide i in the media of exposure in pathway p, in pCi/g for soil

Up = usage parameter associated with exposure pathway p, in hours per year

Dip = dose rate equivalent factor for radionuclide i and exposure pathway p

Input Parameters:

Radionuclide	Cip (pCi/g)	Up (h/yr)	Dip (mrem/yr / pCi/g)
U-238	11.28	1800	2.6E-08
U-235	2.20	1800	7.2E-05
U-234	56.20	1800	5.7E-08

External Exposure Calculation:

Rip = 0.29 mrem

Inhalation

$H_{inh,i} = (V)(t)(C_d)(C_{w,i})(DF_{inh,i})$

Where: Hinh,i = the committed effective dose equivalent from one year intake of radionuclide i by inhalation, in mrem

V = the ventilation rate of the individual, in m3/h (0.97 m3/h assumed - from ICRP 1975)

t = the duration of exposure for the individual, in h/yr

Cd = concentration of respirable dust in air, in g/m3

Cw,i = the concentration of radionuclide i in the contaminated material, in pCi/g

DFinh,i = the committed effective dose from inhalation of radionuclide i, in mrem/pCi

Input Parameters:

Radionuclide	Cw,i (pCi/g)	DFinh,i (mrem/pCi)
U-238	11.28	1.1E-01
U-235	2.20	1.2E-01
U-234	56.20	1.3E-01

V = 0.97 m3/h

t =	100 h Gardening	Cd =	5E-04	g/m3 Gardening Dust
	1700 h Outdoors		1E-05	g/m3 Yardwork Dust
	4380 h Indoors		5E-05	EPA Standard (Indoors)

Inhalation Calculation:

Hinh,i = 2.44 mrem

-Drinking Water Ingestion

Hdw,i = (Qdw)(Cdw,i)(DFing,i)

Where: Hdw,i = the committed effective dose equivalent from a one year intake of radionuclide i by ingestion of drinking water, in mrem

Qdw = the quantity of drinking water ingested during a year, in liters (730 l/yr)

Cdw,i = the concentration of radionuclide i in the drinking water, in pCi/l

DFing,i = the committed effective dose equivalent factor from ingestion of radionuclide i, in mrem/pCi per year of intake

Maximum Organ Dose Rate Conversion Factors for Ingestion of Drinking Water:

U-238:	1.7E-04 mrem/pCi
U-235:	2.0E-04 mrem/pCi
U-234:	1.9E-04 mrem/pCi

Drinking Water Ingestion Calculation:

Hdw,i = 1.36 mrem

Agricultural Pathways - Air Deposition

(Direct deposition onto leaves and translocation to the edible parts of the plant)

Airborne Concentrations of Radionuclides:

U-238: 5.64E-03 pCi/m3
U-235: 1.10E-03 pCi/m3
U-234: 2.81E-02 pCi/m3

Agricultural Food Product Ingestion Committed Effective Dose Rate Conversion Factors for Exposure to Residual Radioactive Materials (Air Deposition):

U-238: 3.2E-01 mrem per pCi/m3
U-235: 3.6E-01 mrem per pCi/m3
U-234: 3.5E-01 mrem per pCi/m3

Air Deposition Calculation:

Had,i = 0.01 mrem

Agricultural Pathways - Soil Uptake

(Long-term accumulation in the soil and consequent root uptake)

Soil Concentrations of Radionuclides:

U-238:	11.28	pCi/g
U-235:	2.20	pCi/g
U-234:	56.20	pCi/g

Agricultural Food Product Ingestion Committed Effective Dose Rate Conversion Factors for Exposure to Residual Radioactive Materials (Soil Uptake)

U-238:	1.1E-02	mrem per pCi/g
U-235:	1.3E-02	mrem per pCi/g
U-234:	1.3E-02	mrem per pCi/g

Soil Uptake Calculation:

Hsup,i = 0.88 mrem

Total From Agricultural Products:

0.01 mrem + 0.88 mrem = 0.90 mrem

Surface Water Ingestion

Concentration of uranium water entering Res. #3: 7.2 pCi/l

Dilution factor provided by reservoir: 206

Individual consumption of drinking water: 730 l/yr

Total Intake (One year): 26 pCi/yr (As total uranium)

Isotopic Mix

U-238:	4.1 pCi
U-235:	0.8 pCi
U-234:	20.5 pCi

Maximum Organ Dose Rate Conversion Factors for Ingestion of Drinking Water:

U-238:	1.7E-04 mrem/pCi
U-235:	2.0E-04 mrem/pCi
U-234:	1.9E-04 mrem/pCi

Ingestion Dose form Surface Water:

$H_{sw,i}$ = 0.005 mrem

Summary of Pathway Evaluation - Cimarron Facility

Pathway	Dose (H50), mrem
Direct External Exposure to Penetrating Radiation	0.29
Inhalation of Airborne Materials	2.44
Ingestion of Agricultural Food Products	0.90
Ingestion of Drinking Water	1.36
Ingestion of Surface Water	0.005
TOTAL COMMITTED EFFECTIVE DOSE EQUIVALENT	5.00

Note: H(50) means the committed effective dose equivalent from one-year intake.