EXXON COAL and MINERALS COMPANY

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SAFETY, HEALTH & ENVIRONMENT

LINDA Z. KRUPNIK
Manager

December 18, 1998

Docket No. 40-8102
License No. SUA-1139

U. S. Nuclear Regulatory Commission
Division of Waste Management, M.S. 5 E2
ATTN: Joseph J. Holonich, Chief
High Level Waste and Uranium
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Mail Stop T7J9
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Dear Sir:

Exxon Corporation, c/o Exxon Coal and Minerals Company, possesses the Highland uranium tailings basin in Converse County, Wyoming under License No. SUA-1139. This submittal requests a license amendment changing the Highland tailings basin Ground Water Protection Limits (GPLs) for nickel (Ni), radium-226+228 (Ra-226+228) and natural uranium (UNAT) to the Alternate Concentration Limits (ACLs) found below.

In 1989 NRC approved the tailings basin reclamation plan and ECMC completed most of the reclamation. However, a small area of the basin has been only partially reclaimed due to operation of an evaporation pond associated with the ground water Corrective Action Program (CAP) and continued tailings consolidation. Continuation of the ground water recovery operation prevents completion of the final reclamation of the tailings basin.

ECMC submitted the CAP to the NRC Uranium Recovery Field Office on August 15, 1989, in response to a July 3, 1989, letter from the NRC. The CAP consisted of pumping five wells to remove Potentially Hazardous Constituents (PHCs) from the uppermost aquifer. The evaporation pond receives this well production.

NRC approved the CAP on August 18, 1989, with License Amendment 32 to License SUA-1139. ECMC began recovering ground water in accordance with the CAP in November of 1989. In 1990 NRC approved discontinuing pumping from one of the five wells due to very limited production. The system has recovered 16.6 million gallons through October 1998, and the aquifer has fallen substantially. Two of the four remaining recovery wells are now incapable of producing a significant volume of water due to the low ground water levels.

With License Amendment No. 44 issued November 16, 1994, the NRC approved suspension of CAP operations from December 15 through April 15 to avoid winter operations. The system now produces too little water to prevent pipeline freezing. In approving the annual shutdown, NRC concluded turning off the wells during the winter would not pose a threat to the environment or to the health and welfare of the public.

Most of the PHCs have fallen to concentrations below the GPLs in the license. Ni and Ra 226+228 at one Point of Compliance (POC) well and UNAT at two POC wells still exceed the GPLs. However, the existing concentrations are not a hazard to the environment or the public. The Ni, Ra 226+228 and UNAT concentrations are not improving and are not expected to improve with continued operation of the CAP. Therefore, ECMC requests approval of the ACLs in the table found below. The monitoring data from the past four years including 1998 meet these ACLs.

ECMC has determined appropriate Health and Environmental Limits (HELs) at the Potential Points of Exposure (POEs) and extrapolated these to the POC wells through site specific attenuation factors. Derived Health and Environmental Limits (DHELs) were calculated for the POCs using the HELs and the attenuation factors. The proposed ACLs are at or below the DHEL concentrations as indicated in the table.

The CAP was approved by the NRC as being the method by which the PHC concentrations could be reduced to As Low As Reasonably Achievable (ALARA). With no improvement in the Ni, Ra 226+228 and UNAT concentrations occurring at the POCs, the ALARA concentrations have been demonstrated since there are no further reasonable corrections actions available.

Setting an ACL requires determining an ALARA concentration for each PHC for which an ACL is sought. In this ACL application, the ALARA concentrations reported are based on the mean concentrations at the POCs plus 1.96 times the standard deviation of the data for each PHC. The proposed ACLs equal the ALARA concentrations.

POC WELL	PHC	GPL	DHEL	ALARA	PROPOSED ACL	HIGHEST MEASUREMENT SINCE 1994
125	UNAT (pCi/l)	0.43	NA	59	59	28.9
175	Ni (mg/l)	0.02	1.8	1.8	1.8	1.7
175	Ra 226 & 228 (pCi/l)	5.0	27	24	24	13.4
177	UNAT (pCi/l)	0.43	1290	71	71	57.5

NA means not applicable. There is no POE associated with Well 125.

The proposed ACLs do not pose a substantial present or potential hazard to human health or the environment. With NRC approval of the ACLs, the ground water monitoring results will meet the NRC limits. ECMC proposes decommissioning the CAP upon approval of the ACLs. The remaining tailings basin reclamation could be completed when the CAP evaporation pond is dry and tailings consolidation meets the license requirement. The wells would be reclaimed after a successful two-year post-corrective action-monitoring period.

The attached report, "Supporting Information for Alternate Concentration Limit Application", provides detailed information on the Highland tailings basin, ground water levels and quality, the CAP and the ACLs.

The NRC provided comments on a 1995 ACL application. The NRC comments and the ECMC responses that are all incorporated into the supporting document are summarized below:

- Provide human health and wildlife hazard assessments for exposure to surface water from Highland Reservoir, the creek that runs through the tailings basin and the North Fork of Box Creek.

  These are primarily addressed in Section 2.3.2.3 (Possible Points of Exposure) of the Hazard Assessment. The measured concentrations of Ra 226+228, selenium and UNAT in Highland Reservoir are not the results of tailings basin seepage. The reservoir is regulated under the Highland Mining Permit from the Wyoming Department of Environmental Quality.

  There is no hydrologic connection between the tailings basin seepage and the other surface water areas. No creek runs through the tailings basin. The unnamed tributary to the North Fork of Box Creek that once existed west of the tailings basin dam is filled with mine overburden, tailings and the tailings basin conpacted earthen dam. The unnamed tributary still exists east of the tailings basin dam, but ground water from the uppermost aquifer does not reach it now, nor will it reach it in the future. The same is true for the North Fork of Box Creek.

- Provide and Justify Point of Exposure Locations

  These are primarily addressed in Section 2.3.2.3 (Possible Points of Exposure) of the Hazard Assessment.

- Provide Point of Compliance Justifications

  ECMC did not propose the POCs locations. On December 29, 1988, the NRC selected four wells to be POCs (Amendment No. 27) from all the wells for which data were presented by ECMC. These four POC wells lie to the north, south, east and west of the center of the ponded water once held within the tailings basin. This pond created the seepage mound below the basin that has now largely dissipated. The four wells are within the area ECMC has proposed to be deeded to the state or federal government for perpetual monitoring.

- Provide Basis for Projected Attenuation Rates in Ground Water

  This subject is primarily discussed in Section 2.3.6.1 (Basis for Attenuation Factors) of the Hazard Assessment. By the early 1990s the advance of the PHCs had essentially ceased as predicted in a 1982 study by Exxon Production Research Company. Therefore, simple ratios created by dividing the concentrations of the PHCs at the POEs by the concentrations at the corresponding POCs provide suitable attenuation factors.

- Designate Site Area for Perpetual Monitoring

  This is found on Figure 1.2. The site area is labeled "Proposed Perpetual Monitoring Area."

- Revisit Proposed Well 125 ACL Value Since Proposal Is Lower Than ALARA Value

  The proposed ACL value now equals the ALARA value (see Table E-1 in the Executive Summary).

- Revisit Location of Chloride Seepage Front

  This subject is introduced on page 1-17 in Section 1.3.2 (Hydrologic Setting) of the General Information. The subject is dealt with in detail in Section 3 of Appendix 3 (Highland Tailings Basin Ground Water Study).

The NRC letter of March 13, 1997, asked ECMC to include a new corrective action assessment in the ACL application. This review is provided in Appendix 7 of the Supporting Information.

If you have any questions regarding this application, please contact David Range of my staff at (713) 978-5438.

Yours truly,

LZK:DMR\dmr

Enclosure (5 copies)

cc: D. M. Range w/o Enclosure

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Executive Summary

Exxon Corporation, c/o Exxon Coal and Minerals Company (ECMC), possesses the Highland uranium tailings basin in Converse County, Wyoming under License No. SUA-1139. The tailings basin was originally licensed under the National Environmental Policy Act (NEPA). The Atomic Energy Commission prepared the Final Environmental Statement (FES). The FES acknowledged that seepage would occur from the tailings basin with some decline in ground water quality occurring around the basin. The license was issued with no requirement for ground water mitigation.

The Highland tailings basin was constructed in 1972 by building a dam across a natural valley underlain by interbedded sandstones, siltstones, mudstones and shales. The natural valley is usually referred to as the unnamed tributary to the North Fork of Box Creek. The uppermost aquifer is referred to as the Tailings Dam Sandstone (TDSS). It has not been developed locally as a ground water source. Prior to mining it was a recharge source to the ephemeral North Fork of Box Creek south of Highland. Early in the operations seepage from the tailings basin surfaced in the unnamed tributary downstream of the dam, but the seepage stopped within three years of the permanent 1984 shutdown of the Highland mill.

The Tailings Dam Shale (TDSh) that has been described as the most laterally continuous formation in the Highland vicinity underlies the TDSS. This formation prevents significant impacts to aquifers further down in the geologic profile, confining Potentially Hazardous Constituents (PHCs) to the TDSS. A detailed 1982 study by Exxon Production Research Company (EPR) thoroughly evaluated the hydrologic and geochemical properties of the TDSS and the TDSh.

The current TDSS piezometric surface indicates tailings seepage does not reach surface water such as the North Fork of Box Creek nor its unnamed tributary. Currently, seepage only has potential to affect ground water and Highland Reservoir since the seepage movement is now towards the west. Ground and surface water inflows formed this reservoir within two connecting ECMC open pit uranium mines. The tailings seepage through the TDSS is only a minor source of ground water to Highland Reservoir. This component will decline over time; entirely ceasing by the time the reservoir is full.

ECMC had a steady state ground water model based on Visual MODFLOW© prepared for when the reservoir is full and ground water levels have stabilized. Based on this model, the seepage in the TDSS will be towards the east after the reservoir is full, but will not reach surface water such as the creek and its unnamed tributary. The supporting data for these conclusions are included in the introduction and in Appendix 3

In License Amendment No. 27 the NRC selected four Point of Compliance (POC) wells around the tailings basin completed in the TDSS. The conformity of Potentially Hazardous Constituents (PHCs) against Ground Water Protection Limits (GPLs) mandated by NRC regulations is determined at the four POC wells. The NRC selected POC wells that are north, south, east and west of the tailings basin since seepage had, over the lifetime of the operation and most of the time since then, moved in all directions. As discussed above, the principle direction is now west. The GPLs were set by the NRC based on the Table 5C values in Appendix A to 10 CFR Part 40 and background.

Under the Uranium Mill Tailings Radiation Control Act, ECMC has operated a ground water Corrective Action Program (CAP) at the tailings basin since 1989 that was approved by the NRC as being capable of achieving As Low As Reasonably Achievable (ALARA) concentrations. In 1994 the NRC approved suspension of CAP operations from December 15 through April 15 to avoid trying to operate the system during the winter since the system now produces too little water to prevent the CAP pipeline from freezing.

In approving the winter shutdown (License Amendment No. 44), NRC concluded that turning off the wells during the winter would not pose a threat to the environment or to the health and welfare of the public.

NRC proposed the basic concept for the current CAP after an exhaustive examination of possible remedies was completed for ECMC and reviewed by NRC. The detailed CAP was submitted by ECMC and approved by the NRC as being the method by which the PHC concentrations could be reduced to As Low As Reasonably Achievable (ALARA).

Most of the PHCs in the ground water now meet the GPLs at the POC wells. However, nickel (Ni) at one POC well, radium 226 plus 228 (Ra 226 + 228) at the same POC well and natural uranium (UNAT) at two other POC wells still exceed the GPLs. One of the two wells with elevated UNAT is now dry and will remain dry for many decades until Highland Reservoir is nearly full. The other well with elevated UNAT will eventually be dry and remain so permanently. The Ni, Ra 226 + 228, and UNAT concentrations are not generally improving and are not expected to improve with continued operation of the CAP. Therefore, ECMC is proposing the Alternate Concentration Limits (ACLs) in Table E-1 found on the next page.

ECMC has determined appropriate Health and Environmental Limits (HELs) at appropriate Potential Points of Exposure (POEs) in developing the ACLs. The HELs are existing or proposed EPA Maximum Contaminant Levels (MCLs) for public drinking water supplies. The POEs are proposed and justified in this document. ECMC completed a comprehensive risk assessment for the HELs proposed that is included in Appendix 6 although EPA has already asserted these concentrations are appropriate limits for public use. ECMC extrapolated these HELs to the POCs from the POEs through site specific attenuation factors. This extrapolation resulted in the calculation of the Derived Health and Environmental Limits (DHELs) provided in Table E-1 using the HELs and the attenuation factors. The proposed ACLs are at or below the DHEL concentrations. There is one exception. There is no possible point of exposure east of POC Well 125 since the aquifer is dry in this direction and there is no surface discharge of the ground water. Therefore, an exposure-based limit such as an HEL or DHEL is not appropriate for this location and only an ALARA value applies.

As stated above, a substantial improvement in water quality has occurred since the CAP was implemented with most PHCs now meeting the GPLs. ECMC has completed of the ground water. Therefore, an exposure-based limit such as an HEL or DHEL is not appropriate for this location and only an ALARA value applies.

As stated above, a substantial improvement in water quality has occurred since the CAP was implemented with most PHCs now meeting the GPLs. ECMC has completed a new evaluation of corrective action plan alternatives that could further mitigate the PHCs that still exceed the GPLs. This evaluation is included in Appendix 7. The evaluation demonstrates that the costs of additional mitigation greatly outweigh the benefits. With no further improvement occurring in the past several years at the POC wells where the GPLs are still exceeded and the new evaluation of mitigation alternatives, the ALARA concentrations have been demonstrated.

The ALARA concentrations in Table E-1 are based on the mean concentration for each PHC plus two standard deviations. For insitu uranium mining the compliance intervals for monitor wells around the production wells are based on the mean plus five standard deviations, so the proposal here is stricter. The proposed ACLs equal the lower value in each case of comparing the DHELs and the ALARA concentrations. In all cases the ALARA concentration equaled or was below the DHEL.

The POC well monitoring data from the past four years meet the proposed ACLs.

Table E-1 PROPOSED ALTERNATE CONCENTRATION LIMITS

POC WELL	PHC	GPL	DHEL	ALARA	ACL	HIGHEST MEASUREMENT SINCE 1994
125	UNAT (pCi/l)	0.43	NA	59	59	28.9
175	Ni (mg/l)	0.02	1.8	1.8	1.8	1.7
175	Ra 226 & 228 (pCi/l)	5.0	27	24	24	13.4
177	UNAT (pCi/l)	0.43	1290	71	71	57.5

NA means not applicable. There is no POE associated with Well 125.

There is no POE relative to POC Well 125. The proposed ACL is the ALARA value. The monitoring data suggest the UNAT and the non-potentially hazardous constituents at this well are declining. There is no present or anticipated future potential health or environmental risk associated with this well nor with any ground water east of the tailings basin.

The Ra 226+228 ACL at Well 175 is less than the Maximum Concentration Limits (MCLs) that have been proposed by the EPA for public drinking water supplies. The

ECMC proposes that the POC Well 125 UNAT ACL apply east of the tailings basin, the POC Well 175 ACLs for Ni and Ra 226+228 apply in all directions from the tailings basin and the POC Well 177 UNAT ACL apply in all directions but east of the tailings basin.

With approval of the ACLs the ground water quality at the POC wells will meet the NRC license limits. Because there has been no significant change in water quality in several years, ECMC proposes that concurrent with approval of the ACLs that permission be given to: 1) Terminate the ground water corrective action, 2) Decommission the corrective action system, 3) Complete reclamation of the tailings basin when the tailings settlement has reached the ground settlement milestone specified in the license and 4) Terminate ground water monitoring and decommission the monitor wells after a two year monitoring period following termination of the corrective action, assuming the monitoring results continue to meet the new GPLs incorporating the ACLs proposed.

The ground water data at the POCs will be considered to meet the ACLs as long as the ACLs are not exceeded. In the event an ACL is exceeded, ECMC will conduct an investigation to determine if the ground water has indeed failed to meet the ACLs. Since the ALARA values are based on the mean of the monitoring data plus two standard deviations, there is a 5% probability of an exceedance for any single result with no actual change in the ground water quality. Also, field and laboratory errors could cause a recorded exceedance. Investigation will help avoid false positive values interfering with the post-corrective action monitoring success.

If an investigation reveals a cause for an exceedance other than the actual ground water quality, normal monitoring will continue. The results of the investigation documenting that the actual ground water quality is not the cause of exceedance will be provided verbally to the NRC within three working days and in writing within 30 days. The same notification process will be followed if the examination described above cannot rule out that the actual ground water quality is the cause. ECMC will then review with NRC what steps should be taken to correct the deviation from the ACL.

ECMC expects that the future data will continue to meet the proposed ACL values based on past results. Without approval of the ACLs, the final reclamation of the tailings basin could be significantly delayed.

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1. GENERAL INFORMATION

1.0 REPORT FORMAT

When figures or sections of previous reports are referenced, a reference is provided in parenthesis. If none is given, the reader may assume the figure or section is in this report.

1.1 INTRODUCTION

This submittal supports Exxon's application for Alternate Concentration Limits (ACLs) for the Point of Compliance (POC) monitor wells at the Highland Reclamation Project tailings basin. The NRC selected the POC wells after the agency made a detailed review of the Exxon data.

Exxon Corporation, c/o Exxon Coal and Minerals Company, possesses the Highland uranium tailings basin in Converse County, Wyoming under License No. SUA-1139. Figure 1.1 on the next page shows the location of Highland within the Powder River Basin of Wyoming.

Exxon, then known as Standard Oil Company of New Jersey and operating as Humble Oil and Refining Company, began conventional milling at Highland in October 1972. Atomic Energy Commission License No. SUA-1139 issued October 5, 1972 authorized this activity. Exxon owned and operated the uranium mines at Highland that provided the ore for the mill. Small volumes of ore were toll milled for two other companies. The first Final Environmental Statement (FES) issued by the Atomic Energy Commission for a uranium mine and mill was for Highland. This FES addressed the expected ground water impacts due to tailings disposal. The operations were approved with the understanding that ground water impacts would occur. No ground water remediation was proposed and none was required by the licensing agency. Site characteristics, milling processes, tailings disposal options and ore characteristics are among the topics discussed in the FES. Additional details on Highland operations are provided in the "Supplemental Environmental Report" by Exxon Company, U.S.A., August 1977.

Milling operations ended in 1984. By 1989 all but twenty acres of the tailings basin had been reclaimed. This twenty acres (the wick area) near the center of the basin is fully stabilized but only partially reclaimed for two reasons. First, a portion of this area contains an evaporation pond for recovered ground water. The evaporation pond is a necessary consequence of the ground water Corrective Action Program (CAP) discussed in this report. The presence of the evaporation pond prevents completion of the remaining tailings basin reclamation. Second, tailings under this area continue to consolidate. Exxon is committed by Condition 40 of the license and Exxon's letter of July 27, 1989, to wait until tailings consolidation is ninety percent complete before completing the wick area reclamation. Consolidation has noticeably slowed in the past five years; indicating consolidation is nearly complete.

In 1986 the NRC sampled and analyzed the tailings basin liquid for organic, inorganic and radioactive constituents (NRC, September 19, 1986). The analyses found sufficient concentrations of some inorganic elements and radionuclides to be considered Potentially Hazardous Constituents (PHCs). No organic compounds were detected in significant concentrations. These 1986 results are the best available analytical description of the source of the impacts on ground water.

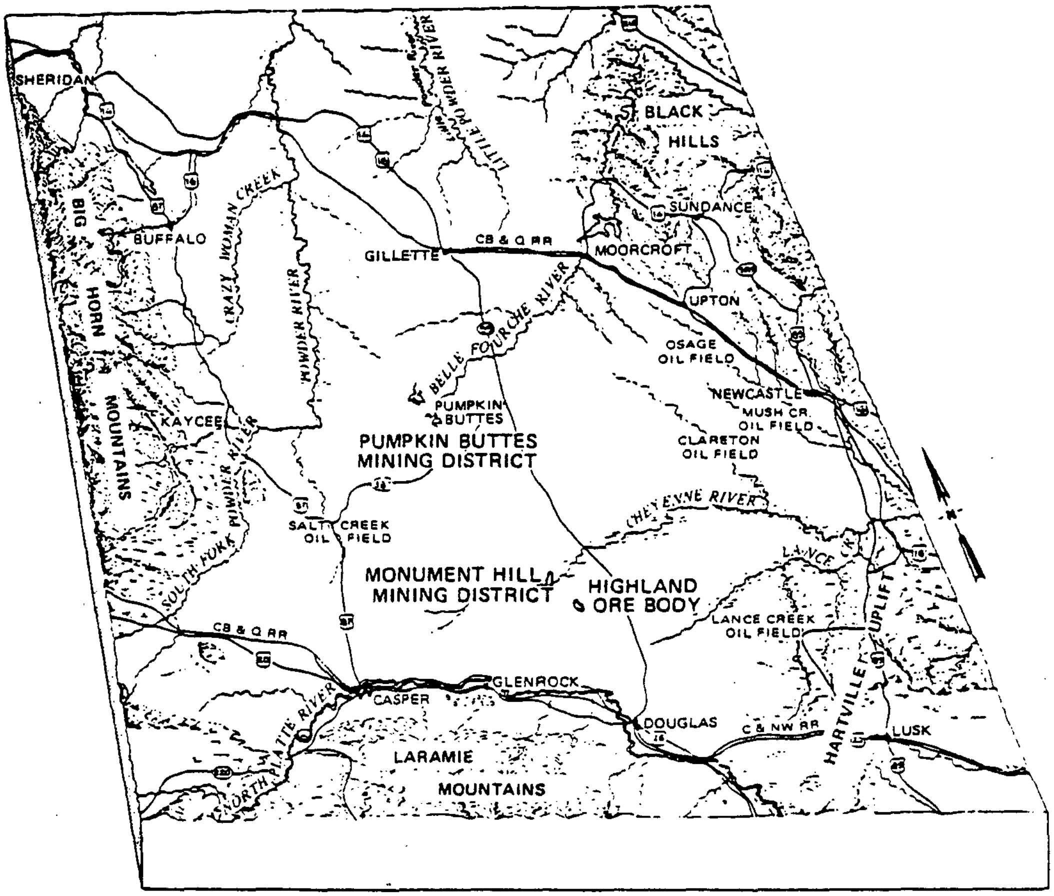


FIGURE 1.1

RELIEF MAP OF POWDER RIVER BASIN, WYOMING AND ADJACENT MOUNTAINS
(FROM WYOMING GEOLOGICAL ASSOC. GUIDEBOOK, 1958)

In 1988 (Exxon, January 29, 1988), per NRC instructions (Amendment No. 13), Exxon reported completion of a formal leak detection program that confirmed the basin seeped liquid into the uppermost aquifer as predicted in the FES and as seen in earlier monitoring data. Later in 1988 (Exxon, December 29, 1988) Exxon reported completion of a PHC detection monitoring program at the request of the NRC (Amendment No. 23) that measured PHCs at the existing wells and new wells approved by the amendment. This program involved monitoring at the background wells and other monitor wells either in the upper most aquifer or in mine backfill areas near the tailings basin. The concentrations of inorganic elements and radionuclides found in the NRC samples in 1986 and others commonly associated with uranium tailings were measured. The monitoring results allowed elimination of beryllium, fluoride, mercury, molybdenum, silver and vanadium from further monitoring as these were not detected at the monitor wells or were only found at insignificant concentrations. These elements are not considered PHCs at Highland.

After NRC reviewed the compliance monitoring data, the agency amended the license in 1988 (Amendment No. 27) to include Ground Water Protection Limits (GPLs) for the PHCs detected at significant concentrations. The GPLs were to be met at four monitor wells that were selected by NRC to be Point of Compliance Wells. These are wells 125, 175, 176 and 177. These four wells are north, south, east and west of the tailing basin. These were sensible choices since the pond had created a seepage mound with liquid flowing outwards in all four directions.

Exxon had found concentrations at most of the POCs in excess of most of the GPLs. In Amendment No. 27 the NRC placed a requirement in the license to develop a corrective action program due to exceedance of the GPLs at the POCs. For this application it is important to emphasize that <u>the POCs were selected by the NRC and were not proposed by Exxon.</u> Exxon had no objection to the NRC choices.

Exxon submitted a corrective action program in 1989 (Exxon 1989). The program included reducing future infiltration by surface reclamation and allowing natural processes to mitigate the ground water impacts to achieve the NRC mandated GPLs. This was the plan envisioned in the FES. WWL 1989 showed no practicable technology could achieve the license standards sooner than could be achieved by natural processes. Exxon proposed ACLs (Exxon 1989) that were protective of human health and the environment at the potential Points of Exposure (POEs) and were As Low As Reasonably Achievable (ALARA).

NRC denied approval of the proposed ACLs and instructed Exxon to prepare another corrective action program (NRC, July 3, 1989). NRC stated, "Selective pumping of wells with elevated levels of hazardous constituents will reduce hazardous constituent concentrations in the aquifer." NRC also stated, "with reasonable efforts, considerable improvement in the future ground-water quality can be accomplished at the site. Due to this, we are unable to approve your request for alternate concentration limits at this time." NRC further stated, "Following operation of your corrective action program and based upon the monitoring gained during its operation, an alternate concentration limit proposal would be appropriate."

In response to the NRC recommendation, Exxon proposed the current Corrective Action Program (CAP) that includes pumping from wells in the area of the highest concentrations of PHCs and disposing of the water in an evaporation pond (Exxon August 15, 1989). NRC approved this Program and deferred approving ACLs pending a demonstration through pumping of what the ALARA concentrations would be (License Amendment No. 32). NRC stated: "On a separate but related matter, you are correct in stating that the monitoring results obtained from this program may supply sufficient data for the issue of alternative concentration limits to be revisited. Please understand that it is the responsibility of Exxon to demonstrate that concentrations of hazardous constituents have been reduced to levels as low as reasonably achievable. With this consideration in mind, adequate collection of water quality, water level and pumping rate data is essential to provide a basis for your determination that levels as low as reasonably achievable will have been achieved."

Most of the PHCs now meet the current NRC GPLs. PHC concentrations have improved at both POC wells that are part of the CAP pumping and those that are not. Of ten PHCs specified in the license, seven are now in compliance with the GPLs. The UNAT concentrations remain above the limit at one of the four POC wells and are not declining. Also, the Ni concentration is above the limit at one well and is not declining. The Ra 226 + 228 concentration at one well is above the limit and is not declining. POC Well 177 is now dry. The UNAT concentration still exceeded the GPL before the well went dry. The concentrations at these wells are not declining after nine years of seepage recovery.

There is no potential for human or ecosystem exposure to the three PHCs that remain above the GPLs because these are confined to Exxon property close to the tailings basin. The nearest home is nearly two miles away. There are no nearby livestock or other agricultural wells within a one-mile radius. The remote Highland location makes the ground water unattractive to development. Sections 2 and 4 of this report describe the rationale, which results in the conclusion that there are no health or environmental consequences of the current situation.

Exxon, therefore, is seeking approval of ACLs for UNAT, Ni and Ra 226 + 228 to enable ground water pumping to end and to remove this impediment to completing final reclamation of the tailings basin.

1.2 Facility Description

In 1968, Exxon discovered a significant uranium deposit in Converse County, 35 miles north of Douglas, Wyoming, which became known as the Highland property. Uranium was removed from the deposit through surface, underground, and in-situ mining. Overburden removal at the surface mine was initiated in September, 1970, and the first ore was milled in October, 1972. The surface mine was operated until 1984 when major reclamation activities commenced. Underground mining began in 1973 with the sinking of the Buffalo Shaft and in 1976 lateral development at two levels began. The track drift, located at a depth of 600 feet, was used for ore haulage and water control while active mining occurred at a depth of 550 feet. Actual ore production started in 1977 and continued until 1982. In-situ mining occurred in a pilot mine that was initiated in 1972, expanded in 1979, and terminated in 1981. Ground water restoration was completed in 1986.

The surface mine is of most importance with respect to Exxon's submittal. It is likely that the underground mine has an impact on water levels in the area, but these effects are not considered important with regard to water quality. The dewatering associated with the underground mine does have an impact on the length of time necessary for ground water levels to recover. The effects of the in-situ mine on water quality and water levels are believed to be minimal since the injection and production wells were sealed from the Tailings Dam Sandstone (TDSS) aquifer. Other mines in the area such as the TVA Golden Eagle underground mine development, west of Highland, also contributed to the drawdown of the water level.

The surface mine was a typical truck/shovel operation in which overburden was removed to reach the ore zones. As mining moved downdip, overburden and waste rock which contained some low-grade uranium and other associated elements was placed back in previously mined out pits. A total of four pits were developed. At the end of operations, the two final pits were left open to become Highland Reservoir. The layout of the surface facilities at the Highland site is shown on Figure 1.2. This figure also shows the current restricted area boundary and the proposed perpetual monitoring area boundary.

The Highland mill used a conventional acid leach-solvent extraction process to remove uranium from the ore. Production of yellowcake commenced in October 1972 when ore was processed at a rate of about 2,200 tons per day. In 1974, the milling capacity was increased to 3,000 tons per day. Half of the mill was decommissioned and reclamation of the mill site commenced in 1984. The other half of the mill is now part of the Power Resource, Inc. Highland Uranium Operations.

The mill tailings were deposited in an above grade impoundment formed by damming an unnamed tributary to the North Fork of Box Creek. It should be noted that many reports and descriptions of the site indicated that the North Fork of Box Creek was dammed to form the tailings basin. Actually the dam was built on an unnamed ephemeral tributary of the creek. The North Fork of Box Creek runs south of the Highland Property. Before the mine was developed, the unnamed tributary ran through what is now the tailings basin area. However, construction of the tailings basin and two mine overburden piles have filled the tributary west of the tailings dam. The layout of the tailings basin, backfilled mine area and lake relative to the North Fork of Box Creek is shown on Figure 1.2 at the end of this section. The figure provides the topography of the Highland site showing the site features and monitor well locations. It also shows the outline of the current restricted area and the outline of the land Exxon has proposed for transfer to government ownership when the license is terminated.

Tailings were deposited in the tailings basin from October 1972, until June 1984. Since 1984, reclamation has been nearly completed in accordance with the NRC approved construction specifications.

Many of the monitor wells are described in an Exxon Production Research Company report (EPRCO, 1982). The others are described in either the "Phase 2 Final Report Exxon Highland Tailings Basin Seepage Analysis" (WWL, March, 1988), or an Exxon license amendment application (Exxon December 29, 1988).

Ground water monitoring is carried out in accordance with Conditions 22, 33, and 38 of license SUA-1139. The monitoring procedures are documented. The Environmental Protection Agency (EPA) "Procedures Manual for Ground Water Monitoring at Solid Waste Disposal Facilities" was used in preparing the Highland procedures. Sample pH is measured at Highland. An EPA certified private laboratory performs the other water quality parameters reported to the NRC.

1.3 Extent of Ground Water Contamination

1.3.1 Geologic Setting

The Highland site is located in the Powder River basin of northeastern Wyoming. This basin has an area of about 12,000 square miles and is bounded on the west by the Big Horn Mountains and the Casper Arch, on the south by the Laramie Mountains and the Hartville Uplift, and on the east by the Black Hills. To the north the basin gradually terminates as it enters into Montana. Mining districts, primarily coal and uranium, are abundant in the basin.

The basin topography consists of moderate relief covered with sagebrush with rolling hills occurring between flat-topped highlands and wide gentle drainages. Elevations generally range from 4,500 to 5,500 feet except in the central part of the basin near Pumpkin Buttes where elevations rise to 6,000 feet. At the site, surface elevations range from about 5,100 feet in the drainages to the east of the tailings basin to as much as 5,400 feet at some of the higher hills to the west.

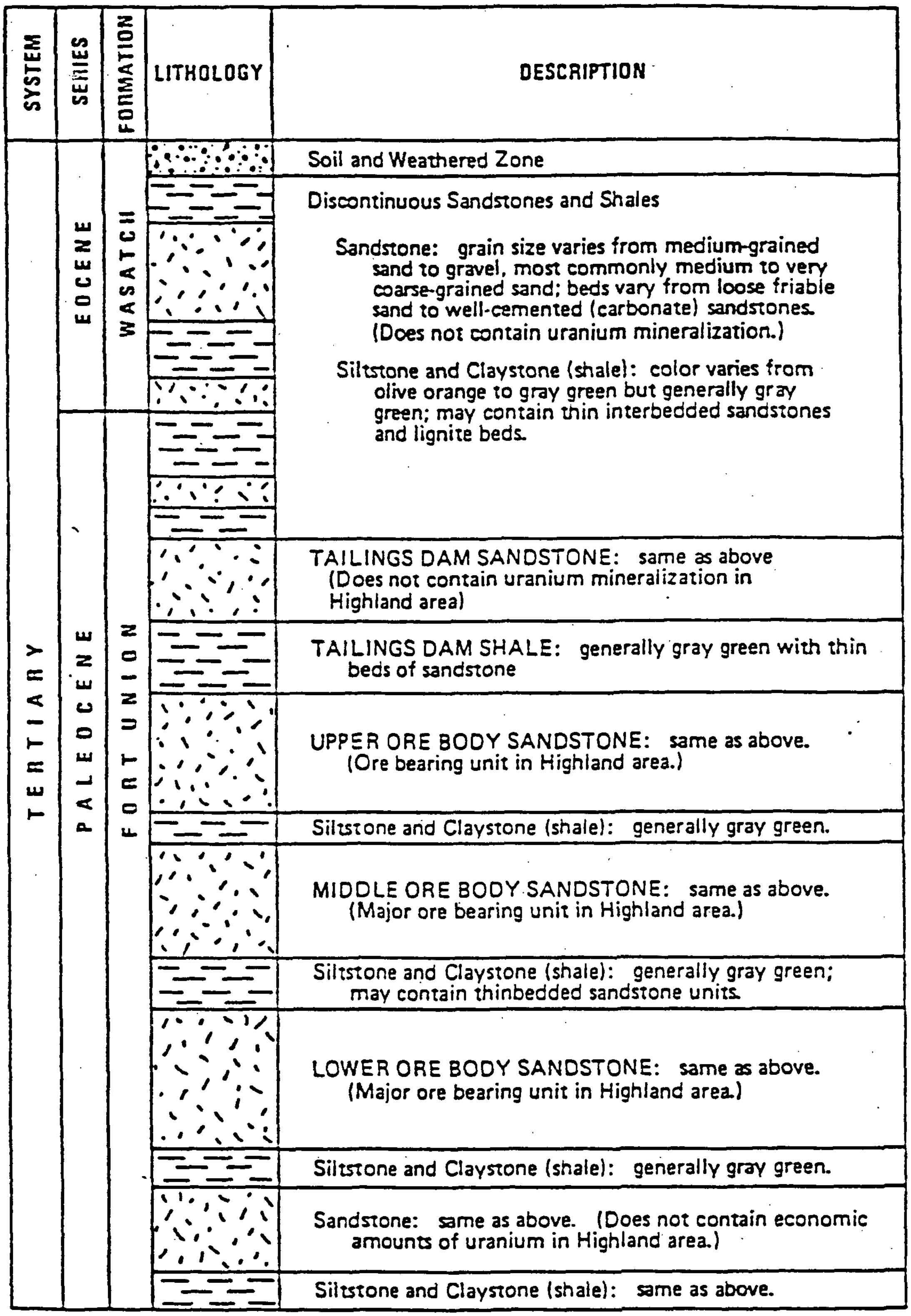
The northern end and western portions of the Powder River basin are drained by the Powder River that flows to the north into Montana. In the southern part of the basin, the principal drainage is the Cheyenne River that flows in an easterly direction. The primary drainage in the Highland vicinity is Box Creek (the North Fork of Box Creek flows along the southern boundary of the site) which is a tributary to Lance Creek which is in turn a tributary to the Cheyenne River. At the site, the North Fork of Box Creek is ephemeral in nature. That is, it normally does not contain surface water except in a few isolated pockets and it only runs during major precipitation events or during rapid snow melt.

The Power River Basin is an asymmetric syncline with its axis displaced several miles west of the center of the basin. The Highland ore deposit lies approximately parallel to the axis of the syncline and about two miles east of it. On the east side of the basin dips are generally on the order of three degrees or less but are much steeper on the southwest and west sides near the margins of the basin. Faulting is generally localized and small-scale and has been mapped primarily in the mineralized areas near Pumpkin Buttes, Monument Hill and Box Creek.

The local geology consists of interbedded fine-to-coarse grained sandstone, siltstone, and clay stone (EPRCO, 1982). A generalized stratigraphic column for the Highland area is shown on Figure 1.3. The primary hydrogeologic units at the site, in order of increasing depth, are the Fowler Sand, the Tailings Dam Sandstone (TDSS), the Tailings Dam Shale (TDSh), and the Highland Ore Sands (50SS, 40SS, and 30SS). The TDSS and the TDSh are the units of interest and the discussion in the remainder of this section is directed at these units.

1.3.1.1 Tailings Dam Sandstone. The TDSS is the unit of primary interest since it is the uppermost aquifer in the vicinity. The TDSS outcrops in the area to the east of the Tailings Dam in the channel eroded by the unnamed ephemeral tributary to the North Fork of Box Creek (which was dammed to form the tailings basin). It is believed that erosion had exposed the TDSS in the tailings basin upstream of and beneath the dam. The exposed area was covered with tailings but it is presumed that it provided a relatively direct pathway for tailings fluid to migrate into the TDSS. This condition was known and considered when the tailings basin was permitted by the AEC and was constructed.

Because the TDSS unit is of most importance with regard to ground water impacts, a structure map for the top of the TDSS was prepared and is presented as Figure 1.4. The top of the



Soil and Weathered Zone

Discontinuous Sandstones and Shales

Sandstone: grain size varies from medium-grained sand to gravel, most commonly medium to very coarse-grained sand; beds vary from loose friable sand to well-cemented (carbonate) sandstones. (Does not contain uranium mineralization.)

Siltstone and Claystone (shale): color varies from olive orange to gray green but generally gray green; may contain thin interbedded sandstones and lignite beds.

TAILINGS DAM SANDSTONE: same as above (Does not contain uranium mineralization in Highland area)

TAILINGS DAM SHALE: generally gray green with thin beds of sandstone

UPPER ORE BODY SANDSTONE: same as above. (Ore bearing unit in Highland area.)

Siltstone and Claystone (shale): generally gray green.

MIDDLE ORE BODY SANDSTONE: same as above. (Major ore bearing unit in Highland area.)

Siltstone and Claystone (shale): generally gray green; may contain thinbedded sandstone units.

LOWER ORE BODY SANDSTONE: same as above. (Major ore bearing unit in Highland area.)

Siltstone and Claystone (shale): generally gray green.

Sandstone: same as above. (Does not contain economic amounts of uranium in Highland area.)

Siltstone and Claystone (shale): same as above.

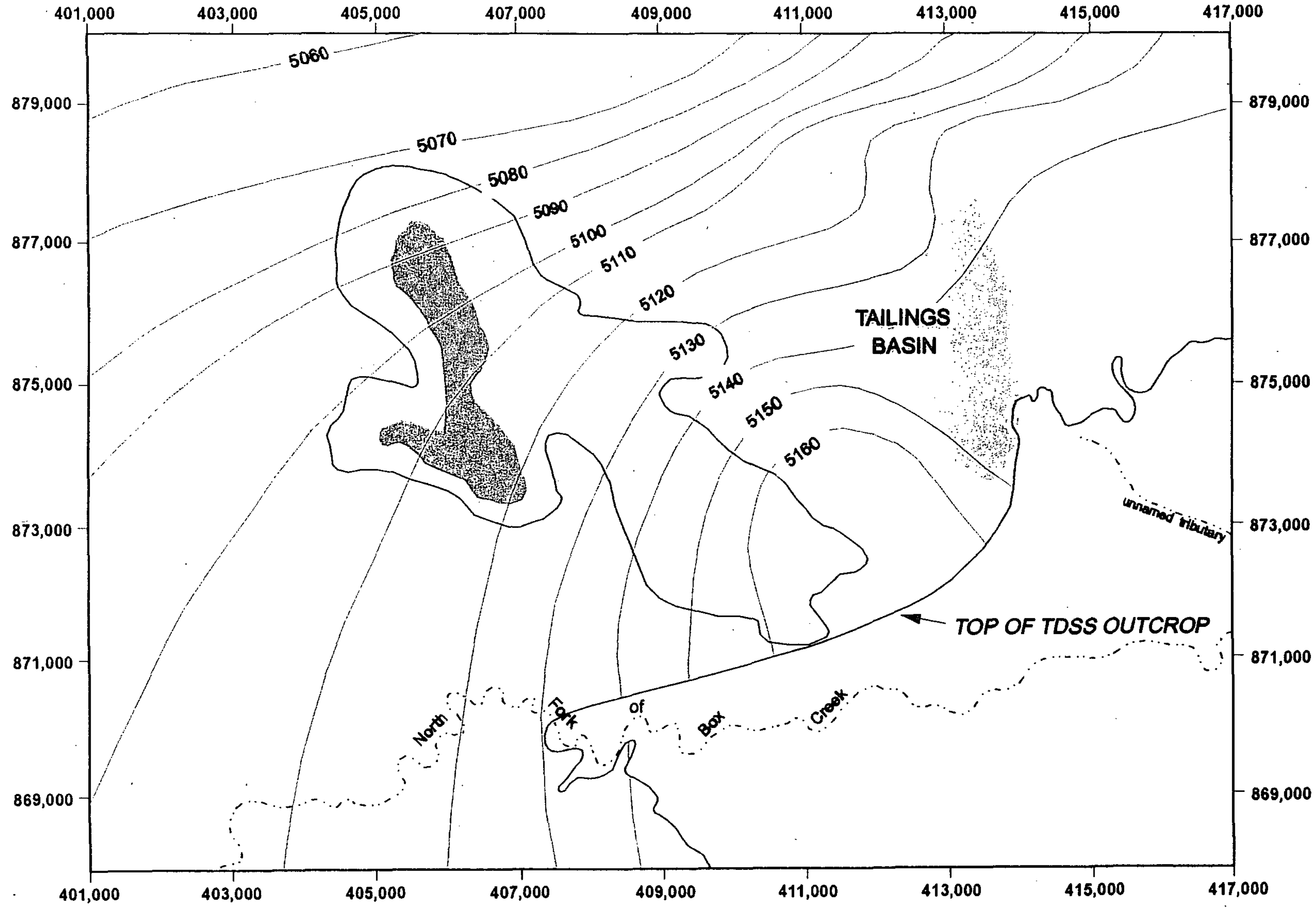
Adapted from EPRCo, 1982

WATER, WASTE AND LAND, INC.

FIGURE 1.3
GENERALIZED STRATIGRAPHIC COLUMN, HIGHLAND AREA

DATE: APRIL 1989

PROJECT: 005



TOP OF TAILINGS DAM SANDSTONE STRUCTURE MAP

Figure 1.4

TDSS structural map is useful for locating areas in which confined conditions exist. In addition, this map can be coupled with a similar map for the TDSh to accurately estimate volumes of rock through which seepage water might move.

The structural map for the top of the TDSS was developed using data from wells in the vicinity of the tailings basin. Geologic cross-sections provided in the EPRCO (1982) report were also utilized to fill in areas missing data. The EPRCO cross-sections were derived from a geologic model developed from a large number of drill holes. The EPRCO cross-sections provided the only source of data for some of the areas where drill hole data were sparse. Also, logs for a few holes to the south and west of the lake and backfill areas were located and utilized in preparation of the structure map in this document. These logs were especially useful in defining the geology south of the North Fork of Box Creek.

1.3.1.2 Tailings Dam Shale. The TDSh is of interest for two reasons. First, this unit, which has been described as the most laterally extensive rock stratum encountered at the Highland site (EPRCO, 1982), exhibits low permeability and retards seepage from the TDSS into the underlying sandstone units. In addition, studies performed by EPRCO (1982) indicate that the shales in the area are geochemically superior to the sandstones with regard to both neutralizing and attenuating capacities. Second, the TDSh forms the lower boundary of the TDSS so that accurate estimates of the TDSS rock volume and water storage volume require that the surface configuration of the TDSh be known relatively well. The surface structure of the TDSh also provides insight into flow boundaries during various periods of water level fluctuation at the site.

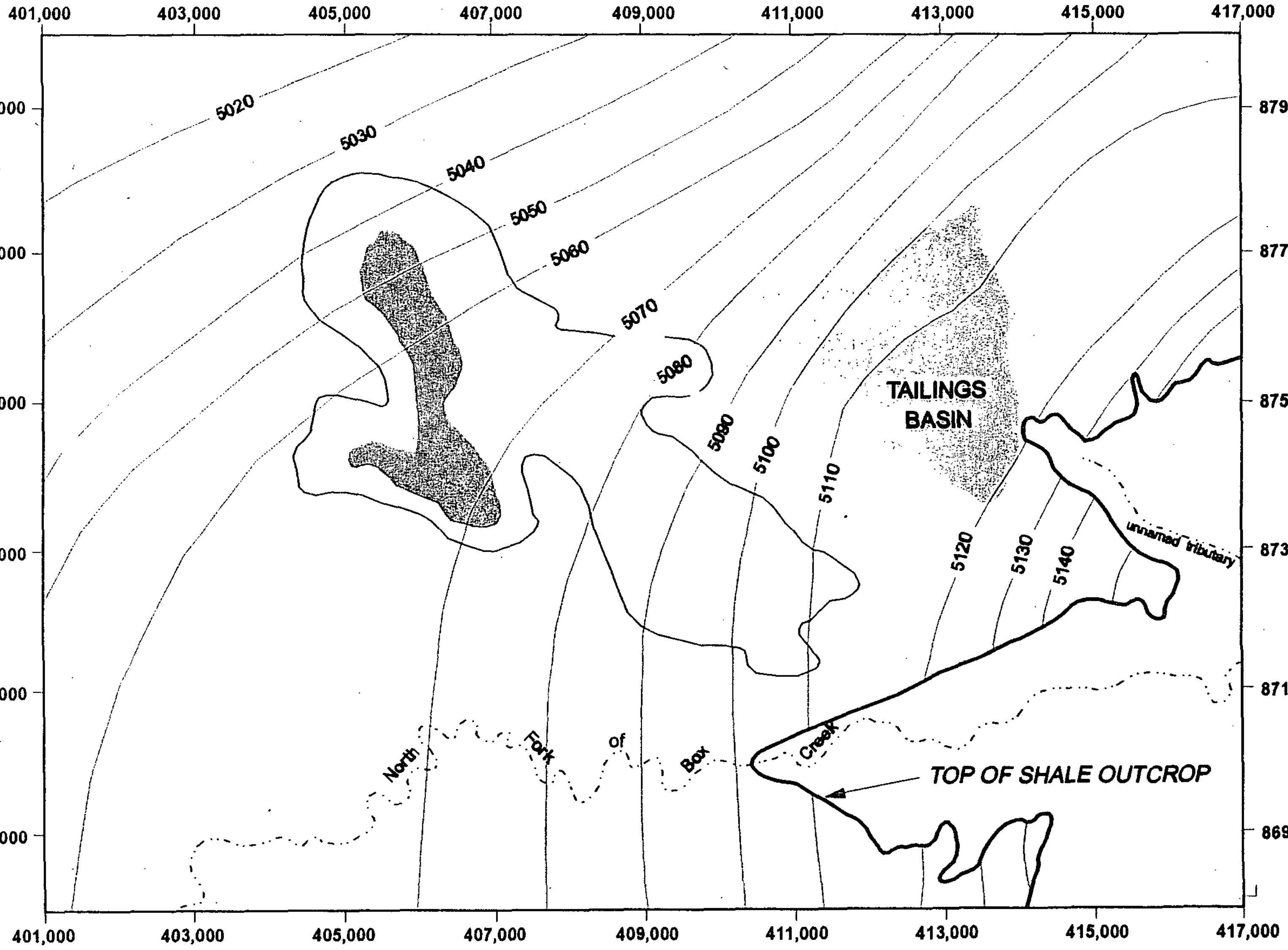
A map depicting the structure of the surface of the TDSh is presented on Figure 1.5. This map was prepared in the same manner as the top of TDSS structure map. The map is consistent with other interpretations and the regional interpretation of the geology of the site.

An important aspect of the TDSh structure is the elevation at which the ephemeral streams cut through the TDSS. As Figure 1.5 shows, the estimated elevation of the discharge point in the unnamed tributary to the east of the tailings basin is about 5,116 feet. This elevation was deduced from geotechnical borings installed during initial construction of the dam. At the location where the North Fork of Box Creek has eroded through the TDSS down to the shale, the elevation is estimated to be 5,102 feet. Thus, the major discharge from the TDSS to surface water would be at the North Fork of Box Creek site to the south of the mine and the tailings basin. Mine backfill lies between the discharge point and the tailings basin.

1.3.2 Hydrologic Setting

The climate of the Highland site is semi-arid and cool. Annual precipitation averages about 12 inches while the average lake evaporation rate is about 44 inches per year. Average summer temperatures are in the high 60s to low 70s while average winter temperatures are in the mid 20s. Extreme temperatures may exceed 100° F in the summer and may fall to -40° F or lower in the winter.

Surface water in the area is sparse and before mining commenced was generally limited to the ephemeral streams which drain the area. As described previously, the final mine pits were left



TOP OF TAILINGS DAM SHALE STRUCTURE MAP

Figure 1.5

open and have become a lake, which is the most prominent surface water feature in the vicinity of the tailings basin.

The direction of regional ground water flow is to the northeast or, generally, up dip. The principal recharge area for the aquifers of interest is thought to be the outcrop areas in the vicinity of Blizzard Heights several miles west of the site. Prior to the initiation of operations, it is likely that flow in the TDSS was essentially in an easterly direction with discharge occurring in the outcrop area in the North Fork of Box Creek to the south of the lake. Near the discharge area, it is likely that unconfined conditions existed with confined conditions occurring to the north and west (downdip).

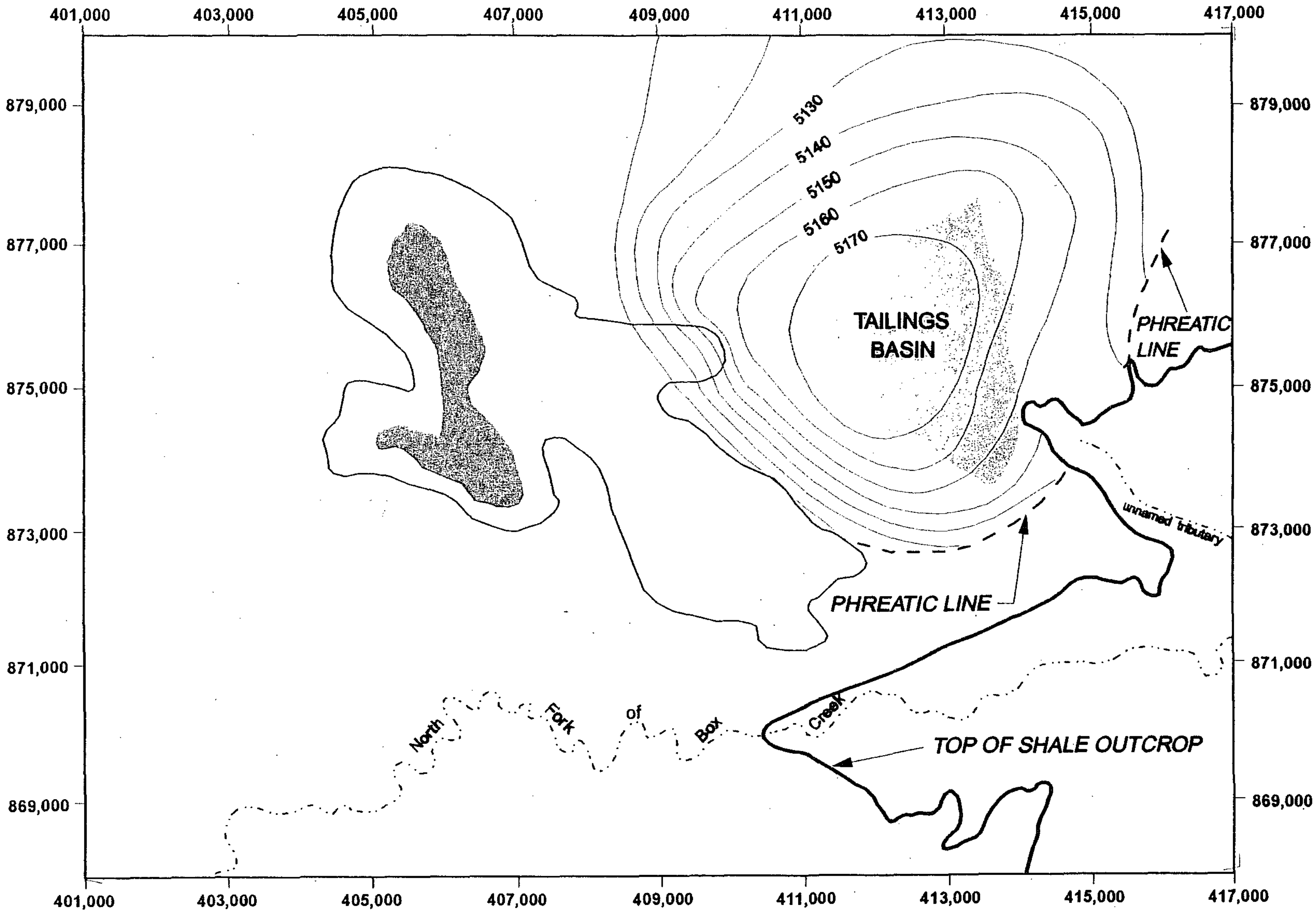
As the top of TDSh structure map presented on Figure 1.5 indicates, the outcrop elevation east of the tailings dam is several feet higher than that in the North Fork of Box Creek. Therefore, it is likely that the North Fork of Box Creek outcrop serves as the primary discharge area for the TDSS flow system at an elevation of 5,102 feet.

It is postulated that the outcrop area in the vicinity of the tailings dam served as a local discharge and recharge area prior to construction of the dam. It is probable that during times of large infiltration, such as during the spring snow melt, that it served as a discharge area as water levels in the immediate area increased in response to the infiltration. During dry times, it likely served as a local recharge area during those brief periods when flow occurred in the stream and ground water flowed back toward the primary discharge area in the North Fork of Box Creek. Under these conditions, the water table in between the two outcrop areas would be expected to be relatively flat with most of the ground water beneath the tailings basin being relatively stagnant.

During operation, seepage from the tailings basin resulted in the development of a ground water mound under and around the tailings basin. As the mound grew, it eventually reached an elevation that caused seepage to occur into the alluvial deposits located downstream of the dam. It should be noted that the center of the foundation of the dam was keyed into the TDSh to minimize seepage losses through the TDSS beneath the dam to increase dam stability. The wings of the dam were not keyed into the shale, which explains why seepage was found emanating from springs located downstream of the dam early in the operating life. In about 1975, a sump system was constructed to capture the seepage water and pump it back to the tailings basin.

As the ground water mound grew beneath the tailings basin, mining activities in the mine pits to the southwest of the basin resulted in substantial drawdown and formation of a ground water sink. Since the base of the pits extended down into the Ore Sands, the pit also served to dewater the TDSS. Figure 1.6 presents a piezometric surface map for April 1982 when the mound appears to have reached its maximum elevation. The combined effects of the mound and the sink caused by the pits are apparent. Given the small discharges measured to the east of the dam, it seems likely that most of the seepage from the tailings basin flowed toward the pit during active operations.

The permeability of the TDSS has been estimated at various locations in the vicinity. Several tests were conducted by EPRCO as part of their 1982 seepage study. A local consultant (Hydro-Engineering, 1987) reported results of well testing performed in the TDSS. In addition,



PIEZOMETRIC SURFACE MAP - APRIL 1982

Figure 1.6

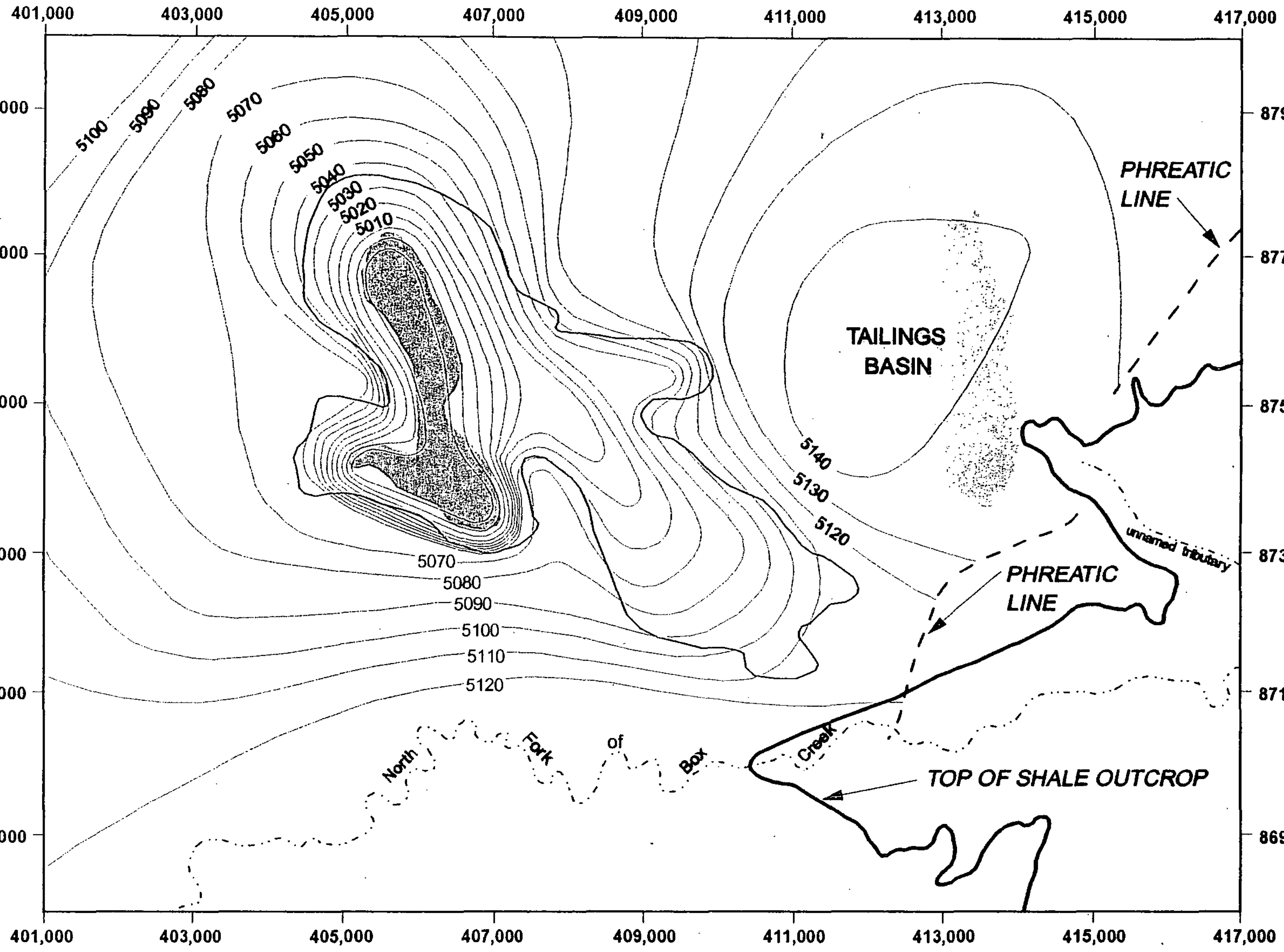
all of the wells installed in 1988 were slug tested in 1989 and analyzed as described by WWL (WWL, 1989). A summary of permeability testing results for the site is presented in Table 1.1.

A piezometric surface map for late 1988 is presented on Figure 1.7. The overwhelming effects of the ground water sink caused by the unsaturated backfill and lake to the south and west of the tailings basin are obvious.

TABLE 1.1

SUMMARY OF PERMEABILITY ESTIMATES

Well ID#	Formation	Aquifer Thickness (ft)	Permeability (cm/sec)	Test Type
WWL, 1989				
173	Backfill		9.8×10^{-6}	Slug
174	TDSS	44	4.0×10^{-4}	Slug
175	TDSS	46	1.5×10^{-4}	Slug
176	TDSS	35	1.2×10^{-3}	Slug
177	TDSS	35	1.1×10^{-3}	Slug
178	TDSS	53	1.1×10^{-3}	Slug
179	TDSS	44	4.4×10^{-4}	Slug
180	Backfill		6.3×10^{-4}	Slug
181	TDSS	40	3.6×10^{-3}	Slug
182	TDSS	22	3.6×10^{-3}	Slug
183	TDSS	29	1.5×10^{-3}	Slug
Hydro-Engineering, 1987				
112	TDSS	45	3.1×10^{-3}	Drawdown
114	TDSS	45	2.8×10^{-5}	Drawdown
131	TDSS	13	4.2×10^{-5}	Drawdown
132	TDSS	30	1.2×10^{-3}	Drawdown
133	TDSS	21	2.2×10^{-3}	Recovery
133	TDSS	24	4.9×10^{-3}	Drawdown
150	TDSS	40	1.1×10^{-5}	Drawdown
EPRCO, 1982				
112	TDSS	49	7.9×10^{-3}	Drawdown
112	TDSS	49	7.4×10^{-3}	Recovery
117	TDSS	46	2.2×10^{-3}	Drawdown
120	TDSS	51	1.2×10^{-3}	Drawdown



PIEZOMETRIC SURFACE MAP - DECEMBER 1988

Figure 1.7

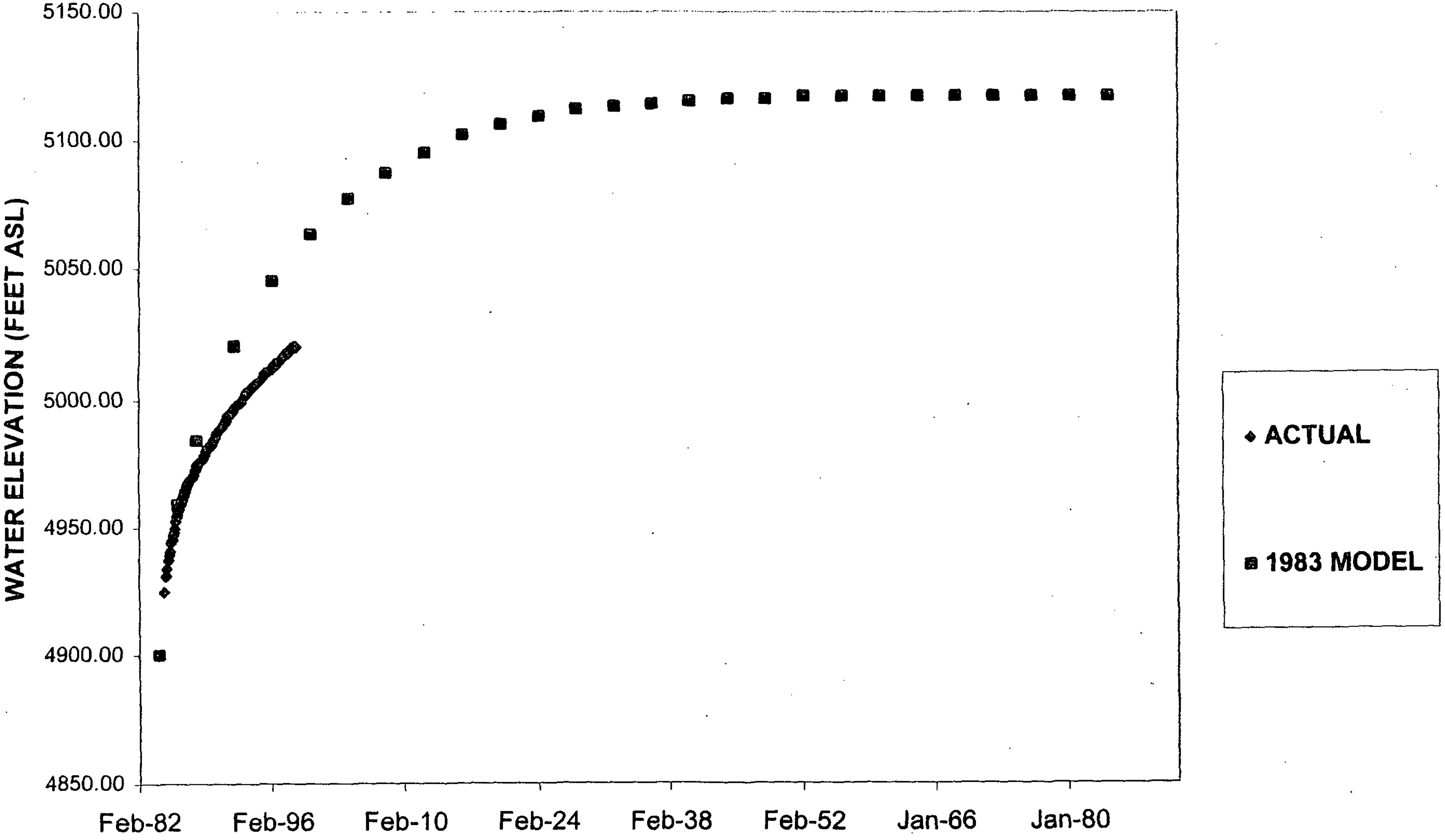
Comparison of Figures 1.6 and 1.7 indicates that water levels in the immediate vicinity of the tailings basin had declined in excess of 30 feet in some of the wells by 1988. Plots of water levels as a function of time for all available data were presented in the December 1988 submittal to the NRC and demonstrated the relatively rapid rate at which the mound was declining. Since discharge to the sump system to the east of the dam ceased in July 1987 it is concluded that inflow into the backfill area is largely responsible for dissipation of the mound.

Based on the previous discussion, it is obvious that the backfilled mine pits and reclamation lake are the prominent features with regard to ground water flow in the TDSS. It should be noted that inflow to the lake and backfill also occurs from the Ore Sands thereby reducing the time necessary for the lake to fill. In addition, some surface water runoff reaches the lake to accelerate its filling. Nonetheless, the results of an EPRCO study (EPRCO 1983) indicate that it will take 100 years or more after cessation of operations for the lake to recover to its ultimate level. Until it is completely recovered, the seepage mound will continue to dissipate by flowing into the backfill area. Figure 1.8 depicts the predicted and measured water levels in the lake as a function of time. While it appears that the 1983 predicted and measured levels match relatively well, there is evidence that the actual levels are lagging the predicted levels. It is believed that the inflows from the TDSS are reduced over what was predicted by the 1983 EPRCO lake model. Because the EPRCO lake model was based on an analytical ground water inflow equation, it is unlikely that the time computed for the lake to fill included time necessary to resaturate the TDSS. This would tend to increase the amount of time required for the lake to fill. The steady state Visual MODFLOW model of Highland summarized in Figure 12 of Appendix 3 indicates the reservoir will fill to a slightly higher ultimate elevation than EPRCO predicted in 1983.

As the previous discussion indicates, the ground water flow regime in the vicinity of the tailings basin is transient in nature but these conditions are expected to remain for a significant time into the future. While the declining water levels beneath the basin are judged to be beneficial in terms of removing contaminated water to the treatment area (backfilled pit), they do create some problems with regard to the mobility of certain constituents, particularly the class of elements called metalloids (Cr, Se, As, Mo, UNAT). The mobility of these materials tends to be very dependent on oxidation potential which will be maintained at a high level during conditions associated with a falling water table. Only one of the metalloids, UNAT, remains in excess of the GPLs at two POC wells (Well 125 and Well 177 that went dry in 1996).

After the lake has been filled to capacity and the TDSS to the east of the lake is resaturated to the ultimate lake elevation, it is anticipated that conditions similar to those that existed prior to the initiation of operations will be re-established. The major difference is that recharge which is thought to have occurred in the area to the east of the tailings dam will no longer occur because the TDSS outcrop has been buried by reclamation of the dam. Therefore, it is expected that ground water beneath the tailings basin will be stagnant. These steady state conditions are ideal for the establishment of reducing conditions beneath the tailings basin which should eventually immobilize most of the hazardous constituents of interest.

FIGURE 1.8
HIGHLAND RESERVOIR WATER ELEVATION



Figures 1.7 and Figure 1 of Appendix 3 show the piezometric surface within the TDSS in December of 1988 and the third quarter of 1996, respectively. The maximum saturated thickness at a ground water recovery well is now about 21 feet at Well 175. The saturated thicknesses at the other recovery wells 117, 177 and 178 are currently about 6, 0 and 7 feet, respectively. Figure 1.9 shows the change in the TDSS saturated thickness between 1988 and 1994.

On Figure 4 of Appendix 3 a line is shown that indicates the approximate location of the chloride ion front in 1988 discussed below. Two interpretations are given that are discussed in Section 3 of the Appendix. The water production rates at the recovery wells are discussed in Section 3 of the main body of this report.

The chloride ion front has been identified as the best indicator of tailings seepage (See WWL, 1989, Section 2.2.5 "Conservative/Indicator Constituents"). Some change in the location of the chloride front has occurred since 1988 (see Figure 6 in Appendix 3). In nearly all directions the front has retreated.

The principal ground water flow direction for the seepage water is now towards the mine backfill area as shown on Figure 1 of Appendix 3. The mine backfill exhibits high porosity and high geochemical attenuation potential but low permeability. These three properties exist because the backfill is a random mixture of sandstones and shales. The dilution from the high porosity and geochemical attenuation from the sandstone, shale mixture within the backfill results in only modest impacts on the backfill water quality from seepage. The backfill itself contains low grade uranium mineralization that contributes radionuclides to the backfill waters. For this reason the backfill waters generally exhibit uranium and radium concentrations exceeding those around the tailings basin. Due to low mine backfill permeability, the area is not considered a viable source of usable quantities of ground water. Also, Exxon found it very difficult to complete wells in the mine backfill. The holes drilled tended to collapse before and during placement of the screened well casing, making well completion very frustrating. The unsaturated portion of the hole generally would stay open but the saturated portion collapsed.

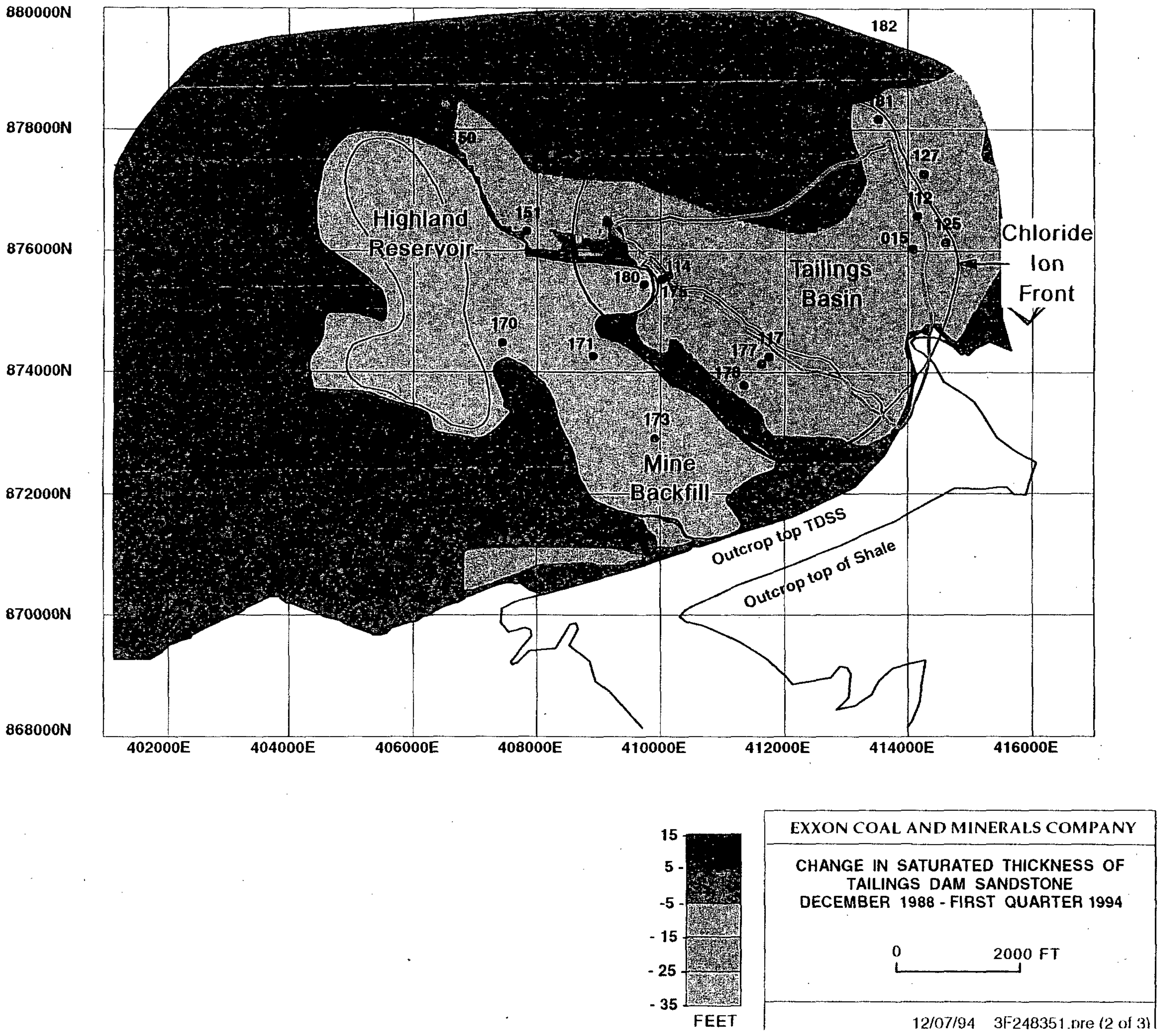
The TDSS contained an estimated 1.7 billion gallons of contaminated water in 1988 within the chloride front. Of this, 280 million gallons was in the most contaminated area between the tailings basin and the mine backfill (called the finger area). See Section 4 of Appendix 3 for details of this discussion.

In the first half of 1996 the total contaminated water and finger area volumes had declined to approximately 1 billion gallons and 132 million gallons, respectively. These volumes are based on the TDSS estimated porosity of 34% (EPRCO, 1982). Less than a third of the water in the saturated portion of the TDSS can be drained by gravity to a well. That is, the estimated specific yield is about one third of the porosity (WWL, 1989).

Based on a specific yield of 0.1, the total and finger area water volumes capable of draining from the TDSS were 0.6 billion and 80 million in 1989 versus 294 million and 39 million in 1996. This indicates that between April 1989 and September 1996, 0.3 billion gallons total and 41 million gallons in the finger area drained from the chloride front, primarily to the mine backfill and recovery wells, without extending the front.

These volume reductions are equivalent to flows of 80 gallons per minute in total and 11 gallons per minute from the finger area. From Figure 1.6 the ground water flowed radially from the tailings basin through the TDSS in 1982. This flow pattern has been largely supplanted by a

Figure 1.9



EXXON COAL AND MINERALS COMPANY

CHANGE IN SATURATED THICKNESS OF
TAILINGS DAM SANDSTONE
DECEMBER 1988 - FIRST QUARTER 1994

12/07/94 3F248351.pre (2 of 3)

western flow from the tailing basin towards the mine backfill and Highland Reservoir by 1996 as shown in Figure 1 of Appendix 3. The ground water recovery system captured 14 million of the 41 million gallons that left the finger area between 1988 and mid-1996. The other 27 million gallons primarily entered the mine backfill.

In summary, the significant tailings seepage is confined to the TDSS in an area that contained a recoverable volume of 0.6 billion gallons of water in 1989 and 0.3 billion in 1996. The most contaminated water is in the finger area. This area has been the focus of the ground water protection program. The finger area of the TDSS contained a recoverable volume of about 80 million gallons in 1988. This declined to 39 million gallons by 1996 with the CAP responsible for about 34% of the reduction. The other 66% drained to the mine backfill where the water is unavailable to future use and where natural attenuation has improved the overall water quality.

1.4 Current Ground Water Protection Limits

On February 8, 1989, the NRC issued Amendment No. 27 to SUA-1139 revising License Condition 33 and instructing Exxon to implement a compliance monitoring program and to submit a corrective action program. The program was to return ground water concentrations of listed PHCs to GPLs set by the NRC in the license amendment. The GPLs (License condition No. 33B) equal the background concentrations at Well 182 (see Exxon December 29, 1988, submittal) or the EPA established Maximum Concentration Limits (MCLs) for public water supplies listed in Table 5C of Appendix A, whichever is higher.

1.5 Compliance with Current Ground Water Protection Limits

Attachments 3A, 3B, 3C, 3E AND 3F of the Exxon August 12, 1998, letter of the semiannual environmental monitoring results contain the water quality data from 1988 through the second quarter of 1998 for the TDSS POC wells, the TDSS Monitor Wells, the TDSS Background Monitor Wells, and the Mine Backfill Wells, respectively. From an inspection of the POC data in Attachment 3A it is obvious the cadmium, chromium, lead, selenium, gross alpha and thorium-230 concentrations are lower than the current GPLs. Virtually all the results since 1993 for these parameters are below the limits. The same can be said of the other TDSS monitor wells with the exception of selenium at Well 112. This is a localized condition unique to this well and not a result of selenium from the tailings basin (see selenium section of Appendix 5).

The fact that some of the nickel, radium and uranium measurements at some of the POC wells exceed the GPLs does not by itself prove non-compliance. EPA has developed statistical tools for judging compliance that are found in the February, 1989 Interim Final Guidance document titled "Statistical Analysis Of Ground-Water Monitoring Data At RCRA Facilities - Interim Final Guidance" (EPA, 1989). Section 4.2.2 and 6 of the guidance document ("Coefficient - of - Variation Test" and "Comparisons with MCLs or ACLs", respectively) are the most relevant part of the EPA document for comparing Highland POC data to the GPLs.

In the guidance document, EPA recommends a determination be made of whether the data for a particular PHC at a POC well follows a normal or lognormal distribution. If so, a Confidence Interval can be calculated at a confidence level of 98% from the appropriate mean, the standard deviation, and the size of the sample population. If the data does not follow a normal or lognormal distribution, the guidance document provides a non-parametric statistical method for establishing the Confidence Limits. EPA judges a PHC to be in non-compliance at a POC if the lower bound of the Confidence Limit exceeds the GPL.

The table below summarizes the Appendix 2 statistical analyses of the POC nickel, radium and natural uranium concentrations.

TABLE 1.2 SUMMARY OF GPL COMPLIANCE BY STATISTICAL ANALYSIS (FOR POC WELLS - NICKEL, RADIUM AND URANIUM)

Well	PAC	Ground Water Protection Limit	Time Period	Data Statistical Distribution	Mean/ Medium	Confidence Interval	Compliance Yes / No
125	Ni	0.02	88 - 98	Log-normal	<0.02	<0.02, <0.02	Yes
	Ra 226 + 228	5	88 - 98	Normal	2.15	1.33, 2.97	Yes
	UNAT	0.43	88 - 98	Normal	30.2	23.5, 36.8	No
175	Ni	0.02	88 - 98	Normal	1.22	1.06, 1.38	No
	Ni	0.02	91 - 98*	Normal	1.42	1.29, 1.56	No
	Ra 226 + 228	5	88 - 98	Normal	8.70	5.85, 11.55	No
	Ra 226 + 228	5	91 - 98*	Normal	10.48	6.40, 14.55	No
	UNAT	0.43	88 - 98	Non-Parametric	0.30	<0.20, 0.90	Yes
176	Ni	0.02	88 - 98	Log-normal	<0.02	<0.02, 0.02	Yes
	Ra 226+228	5	88 - 98	Normal	3.92	2.94, 4.89	Yes
	UNAT	0.43	88 - 98	Log-normal	0.26	<0.20, 0.50	Yes
177	Ni	0.02	88 - 96	Log-normal	0.03	<0.02, 0.06	Yes
	Ra 226 + 228	5	88 - 96	Log-normal	4.73	2.98, 7.49	Yes
	UNAT	0.43	88 - 96	Normal	45.0	37.7, 52.2	No
	UNAT	0.43	93 - 96*	Normal	59.4	54.6, 64.1	No

NOTES: Nickel (Ni) in mg/l, Radium 226+228 (Ra 226+228) in pCi/l, uranium (UNAT) in pCi/l.
*Additional statistical analysis performed since concentrations were increasing in earlier years.

By these statistical analyses the uranium concentrations exceed the GPL at POC Wells 125 and 177 (before it went dry). The nickel concentration exceeds the GPL at POC Well 175. The radium 226+228 concentrations exceed the GPL at POC Well 175. POC Well 176 meets all the GPLs. Well 177 has been dry since 1996 so the data analyzed is for 1988-1996.

2. HAZARD ASSESSMENT

2.1 Source and Contamination Characterization

The Highland Mill began operating in October of 1972. Operations ended in June of 1984. Tailings fluid recycling to the mill to remove uranium continued until September 1984. In addition to the milling operation, Exxon operated a solid resin ion exchange system to recover uranium from the tailing fluid from 1977 through the end of ore milling.

Some 10.5 million tons of uranium ore were processed, containing an average U_3O_8 concentration of 0.1%. The mill achieved uranium recoveries of about 94%. The ore was relatively simple without significant concentrations of the vanadium or molybdenum typical of many other uranium ores.

The mill employed a conventional dry crusher and wet rod mill to separate the individual grains of sand, silt and clay particles. The resulting ore slurry was leached in wood stave tanks for six to eight hours with sulfuric acid and sodium chlorate at a pH of between 1 and 1.5.

The solubilized uranium was separated from the barren ore solids (tailings) through conventional countercurrent decantation using a series of thickeners. The uranium liquor was processed by liquid ion exchange (solvent extraction) to yield a rich eluate ready for uranium precipitation and drying. The ion exchange was highly specific for uranium. Other elements solubilized by leaching were discharged with the tailing.

The tailings were pumped at about 35% solids by weight to the tailings basin. The tailings slurry pH was between 2.5 and 3.5. The tailings basin was constructed by placing an earthen dam with a compacted clay core across a natural valley to create an impoundment. As approved by the AEC and the NRC and as discussed in the 1973 Final Environmental Statement (FES), the tailings basin was not lined, and seepage occurred into the foundation rock strata as expected. As acknowledged in the FES, this reduced the quality of water near the basin in an area with little potential for ground water development.

Exxon Production Research Company (EPRCO) examined the geology and ground water hydrology of the tailings basin. The results of this examination were reported in the 1982 study entitled "Highland Uranium Tailings Impoundment Seepage Study" (EPRCO, 1982).

The strata in contact with the tailings include the Fowler Formation (or Fowler Sand) and the Tailings Dam Sandstone (TDSS). The Fowler Formation lies above the TDSS and consists of a series of discontinuous sandstones interbedded with mudstones, claystones and shales. It underlies most of the tailings basin. It dips to the west like the other formations at Highland and was sliced through by the open pit mine which prevented any movement through the Fowler Formation in the down dip direction to the southwest, west or northwest.

The TDSS underlies the Fowler Formation and is only in direct contact with the tailings in a small area at the east end of the tailings basin. The TDSS is in turn underlain by the Tailings Dam Shale (TDSh) which is a thick aquitard. The 1982 EPRCO study reported the TDSh has excellent attenuation properties for the Potentially Hazardous Constituents (PHCs). Thus, the Fowler Formation and the TDSS constituted the uppermost aquifer during operations.

When milling began the tailings basin seepage rate initially increased into the underlying strata as the basin filled but then stabilized and eventually began to decline. It is surmised that the clay fraction of the tailings and gypsum precipitation reduced the permeability of the Tailings Dam Sandstone (TDSS) over time, thereby slowing the seepage. The reduced permeability of the tailings as they consolidated under their own weight also gradually reduced the seepage into the underlying foundation strata.

After milling operations ceased in 1984, the Fowler Formation drained, so the TDSS is now considered the upper most aquifer. The Fowler Formation will not resaturate in the future around the tailings basin because the formations elevation is above the pre-mining and expected post mining ground water levels.

In August 1986, the NRC sampled the Highland tailings liquid and EPA analyzed it for organic and inorganic constituents. The results served as the principal basis for deciding which PHCs to measure in the TDSS monitor wells during the hazardous and non-hazardous constituent detection program required under License Amendment No. 23, issued on June 15, 1988. The EPA found no organic constituents in the tailings fluid.

The detection program collected data on the parameters listed in the following table.

TABLE 2.1 - AMENDMENT No. 23 PARAMETERS

Potentially Hazardous - Non-Radioactive

Arsenic
Beryllium
Cadmium
Chromium
Lead
Mercury
Molybdenum
Nickel
Selenium
Silver
Vanadium

Potentially Hazardous - Radioactive

Gross Alpha
Radium-226
Radium-228
Thorium-230
Uranium

Non-Hazardous - Non-Radioactive

Fluoride
Nitrate
PH
Sulfate
Total Dissolved Solids

After Exxon submitted the detection program results to the NRC on December 29, 1988, the agency removed beryllium, fluorine, mercury, molybdenum, silver and vanadium from the requirements for future monitoring in Amendment No. 27 since these elements were not detected at the monitor wells in significant concentrations.

Tailings basin surface reclamation is nearly complete in accordance with Condition 40 of License SUA-1139 and 10 CFR Part 40, Appendix A. Reclamation reports submitted to the NRC include "Construction Quality Assurance Testing for Reclamation of the Uranium Tailings Basin at the Highland Reclamation Project" by WWL, April, 1991 and " Response To NRC

Inspection Report No. 40 - 8102/91-01" by WWL, November, 1993. Current waste management includes ground water recovery in keeping with the Corrective Action Program (CAP), ground water monitoring, monthly surface inspections and quarterly surface settlement surveys. The CAP is a principal impediment to final completion of the remaining tailings basin reclamation.

2.2 Rate and Direction of Transport Assessment

Th 1982 EPRCO report contained the results of an extensive contaminant modeling study. Figures 56 through 61 and Figure 63 of that study summarize the modeling results.

The EPRCO study concluded some tailings liquid constituents would migrate at essentially the same rate from the tailings basin as the water itself. These constituents, such as chloride, would only be attenuated by dilution through mixing with naturally occurring ground water containing lower concentrations of dissolved constituents.

Conversely, EPRCO concluded the Fowler Formation and the TDSS would substantially retard the advance of most Potentially Hazardous Constituents (POCs) through chemical and physical processes. Figure 56 (EPRCO, 1982) shows the EPRCO prediction of the farthest reach of the low pH front through 1992. Figure 61 (EPRCO, 1982) shows the maximum predicted advance by 1995 with the front retreating thereafter when the TDSS began resaturating as Highland Reservoir filled. The retreat has been delayed by the slower than predicted rise of the reservoir water level. This will allow the TDSS more time to drain to the mine backfill area before resaturation of the TDSS begins. This is beneficial because the mine backfill immobilizes PHCs.

Table 3A through 3C and 3E through 3F in Appendix 1 show the 1988 through mid 1998 water quality in the TDSS, the mine backfill and Highland Reservoir. These results are compared to the EPRCO predictions in Appendix 5. In summary, the 1988-1998 data are in general agreement with the EPRCO predictions. The PHCs are confined to the area close to the tailings basin in the area between the tailings basin and the mine backfill. Table 3D is not included in Appendix 1 since it provides data from the ore sands aquifer below the TDSh that is not part of the uppermost aquifer. Table 3D is provided in the semiannual reports of environmental data sent to the NRC.

Some PHCs were at higher concentrations at the POC wells in the 1980's than now. These include cadmium, chromium, lead and thorium-230. These PHCs have virtually disappeared at the monitor wells since 1989 and now agree with the EPRCO prediction of very limited movement through the TDSS.

Section 2 and Figure 1 of Appendix 3 provide the current rate and direction of ground water flow in the TDSS.

2.3 Exposure Assessment

2.3.1 Resource Classification and Water Use

During the Exxon mining operations there was no development of the TDSS ground water within a one mile radius of the tailings basin other than the Exxon uranium mining related dewatering wells and pits (see Exxon's May 3, 1988 update of 1986 land use survey).

Ground water enters Highland Reservoir at approximately 300 gallons per minute. Potentially, Highland Reservoir could provide water in the future for livestock, wildlife, and agriculture consumption.

The only use of ground water developed by man other than that related to uranium mining within a two mile radius has been for livestock and wildlife watering. Livestock grazing served by any single water source is limited to less than six months per year. Such locations are outside the area impacted by tailings basin seepage. The closest is a spring about a mile north-northeast of the tailings basin. The spring is not fed by the TDSS.

The aquifers in the region are either too unproductive or too deep for economic use for irrigation except when uranium mining operations have made surplus mine water available (not tailings water).

Table 2.2 on the next page compares the 1997 TDSS background well, POC well and the Highland Reservoir water quality to the Wyoming Department of Environmental Quality, Water Quality Division, Underground Water Suitability Standards (Wyoming Standards) for domestic, agricultural, aquatic and livestock use.

TABLE 2.2 DEQ WQD Water Classifications

WELL NUMBER	DEQ WQD USE CLASS* pH	Non-Haz	Pot-Haz	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
DEQ WQD Standards																					
Domestic (D)				6.5-9.0	500	250	250	NL	10	0.05	0.01	0.05	NL	0.05	0.01	15	NL	NL	5	NL	3385
Agriculture (A)				4.5-9.0	2000	200	100	NL	NL	0.1	0.01	0.1	0.2	5	0.02	15	NL	NL	5	NL	3385
Fish/Aquatic (F/A)				6.5-9.0	2000	NL	NL	NL	NL	0.05	0.015**	0.05	0.4	0.15	0.05	15	NL	NL	5	NL	948**
Livestock (L)				6.5-8.5	5000	3000	2000	NL	NL	0.2	0.05	0.05	NL	0.10	0.05	15	NL	NL	5	NL	3385
Industrial (I)				No numerical standards.																	
Background Wells 1997 Averages																					
134	D	F/A	D	7.9	1025	559	9.7	190	0.17	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.40	< 1.00	< 1.40	< 0.20	1.03
172	D	F/A	D	8.0	662	339	2.5	126	< 0.11	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	1.95	< 1.00	< 2.95	< 0.20	< 0.75
174	D	D	D	8.2	297	100	8.9	67.7	< 0.10	< 0.003	< 0.010	< 0.050	< 0.020	< 0.05	< 0.003	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	< 0.27
182	D	D	D	8.4	390	180	5.6	107	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	< 0.45
Compliance Wells 1997 Averages																					
125	D	D	L	7.4	1820	944	77.2	126	< 0.14	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.002	< 1.0	0.20	< 1.00	< 1.20	< 0.20	21.65
175	A	I	I	6.4	6793	4255	304	294	< 0.11	< 0.001	< 0.010	< 0.050	1.27	< 0.05	< 0.001	< 1.0	1.05	< 6.25	< 7.30	< 0.20	< 0.31
176	D	L	D	7.3	3558	1909	241	214	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.95	< 2.70	< 3.65	< 0.20	< 0.20
177	D	L	D(1996 data)	7.3	4254	2383	263	256	3.97	< 0.002	< 0.010	< 0.050	< 0.025	< 0.05	< 0.001	< 2.1	0.90	< 1.00	< 1.90	< 0.20	53.90
Highland Reservoir 1995 Averages																					
167	D	F/A	I***	8.2	858	469	30.0	116.0	< 0.10	0.004	< 0.010	< 0.050	< 0.020	< 0.050	0.125	5.9	3.8	< 1.00	< 4.8	< 0.20	1985

NOTES:

NL = No Limit Set by Wyoming Department of Environmental Quality, Water Quality Division (WQD)

NM = Not Measured

* Classifications in pH, non-hazardous and potentially hazardous columns are based on the highest classification that the water quality data fits. The highest classification is domestic followed by agriculture, fish/aquatic and livestock.

** Fish/aquatic standards vary depending on water hardness. As Highland waters are very hard, the standards for hard water are shown.

*** Highland reservoir exceeds the WQD selenium standards for all recognized uses other than industrial and the uranium standard for fish and other aquatic life due to naturally occurring mineralization in the reservoir walls.

Water at the four TDSS background wells met the Wyoming Standards for livestock and for fish/aquatic use in 1997. Half met the domestic use standards.

The 1997 water quality results from the POC wells also came close to meeting the Wyoming Standards for livestock use. All the data from POC Wells 125 and 176 met the standards. Well 177 was dry but in 1996 met the livestock standards. This leaves POC well 175, which exceeded the Wyoming livestock standard for pH, Total Dissolved Solids (TDS), sulfate and Ra 226+228.

POC Well 175 produces water slightly below the WQD livestock pH standard. Once the water is exposed to the atmosphere, as in the evaporation pond, the pH increases to well within the pH standard. The water at Well 175 exceeds the Wyoming livestock standards for TDS and sulfate. At Well 180 in the mine backfill just a short distance west (and down dip) of Well 175 in the direction of Highland Reservoir, the water met the WQD TDS and sulfate livestock standards until the well went dry in 1994. Highland Reservoir also meets these standards. The Ra 226 and Ra 228 concentrations at Well 175 meet the EPA proposed public drinking water supply standards. Well 175 is within the area that will be deeded to the state or federal government for perpetual monitoring.

In summary, with respect to the past and current uses of ground water by non-uranium mine users within a mile of the tailings basin, uses which have been limited to livestock water, the tailings impacts have not made the water at POC wells 125, 176 and 177 unsuitable. Well 175 exceeds the TDS, sulfate and radium 226 + 228 standards. However, this location is within the area to be deeded to government ownership and will be unavailable to public or private use. West of Well 175 lies the mine backfill, which is an impractical source of ground water given the low well productivity and the difficulty in completing a well. West of the backfill lies Highland Reservoir which meets all the Wyoming livestock standards except for selenium. The selenium is not caused by the tailings seepage as the POC wells are free of this element. While the selenium in the reservoir exceeds the state standard it is not harmful to cattle. The 1978 Water Quality Criteria document of California states: "In water, 0.4 to 0.5 mg/l of selenium is believed to be non-toxic to cattle."

2.3.2 Evaluation of Health and Environmental Hazards

This section assesses the potential health and environmental hazards associated with seepage from the tailings basin. It is concluded that the potential for human exposure is remote and that the seepage does not represent a substantial present or future threat to human health, to the environment or to structures. This conclusion is based on site-specific conditions and does not rely on any changes in the water quality standards.

Even though human exposure to seepage is considered very unlikely, pathways of remotely possible exposure are considered. Safe concentrations of hazardous constituents are identified based on toxicology data and exposures conservatively projected. Standards based on environmental and other considerations are also discussed. Based on these considerations and application of the NRC ACL logic ("Technical Position of Alternate Concentration Limits for Uranium Mills", January 1996), health and environmental limits (HELs) are proposed for Highland, see Table 2.6.

Points of possible exposure are identified based on the flow regime at the site. While several possible exposure points are identified, the most likely point of exposures is the mine reclamation lake (Highland Reservoir). The observations drawn here are based on the hydrological characteristics of the Highland site and observation of the terrain, meteorology and culture gained during the extensive hydrology, water quality and mitigation studies.

2.3.2.1 Potentially Exposed Populations

Three populations have the unlikely possibility of exposure to tailings seepage at Highland. These are the human population, the environmental population (flora and fauna) and the population of physical structures placed by humans. Each is discussed below in terms of present and future exposure and associated risks to life and property.

2.3.2.1.1 Human Exposure

Current human exposure is non-existent since the Highland site is remote with no nearby habitations. There is no permanent human population at the site and the nearest residence is a ranch located two miles northwest (up gradient). The nearest population centers, with a combined population of about 8,000, are located 25 miles southeast and southwest. Neither of these population centers uses ground or surface water that could be affected by seepage moving from the tailings. There is no current impact to ground water or surface water quality that reaches the limits of the Highland site. Because of the large distances separating existing populations from the waste disposal area, there is no potential for current impacts.

There is little potential that the current very low population density in the vicinity of the site will change in the near or even the distant future. Consideration of the physical conditions and geographic location of the area make this the most plausible prediction . It is notable that during the twenty-six years since uranium mining began no residences were established near Highland.

The reclamation lake and more productive deep aquifers below the TDSh provide the most accessible water sources should water supplies ever be developed near Highland. The deeper aquifers are used at present for potable and industrial water by insitu uranium mining at Highland. It can be concluded that ground water obtained from the TDSS is an unlikely water supply option compared to the reclamation lake and the deeper aquifers.

Future land use at the site is not predicted to change from the current uses except that the reclamation lake has the potential for limited recreational use. It is unlikely that potable water will be provided for a recreational use area. Most likely is either the development of a limited use recreation area with no water development as part of the plan, or no formal development of the area. In either of these cases water used at the site for the occasional recreation use would either be brought in or come from the lake. Under all recreation use scenarios, the potential for human exposure to ground water impacted by seepage is essentially zero.

Although development of ground water through wells completed in the backfill is theoretically possible, such uses are improbable give the low permeability of the backfill material. Even if tailings seepage were precluded from entering the backfill, the current quality water would be encountered. This quality exists because rock containing low grade uranium bearing materials was used to backfill the pits. The quality is unrelated to tailings seepage.

The TDSS contains insufficient quantities of water to be used for irrigation water, primarily because of the formations limited transmissivity. Given the close proximity of the lake and better quality water in sandstones under the TDSS, it is considered unlikely that wells will be completed in the TDSS to obtain a supply of livestock water.

2.3.2.1.2 Potential Environmental Exposure

The current environmental exposure is low. Ground water, impacted by tailings seepage or not, is not readily accessible to wildlife. Contaminants from seepage in the ground water are slowly moving to the mine backfill. The attenuation of the PHCs by the mine backfill, the limited quantities of seepage that will reach the lake relative to inflow from other sources and the lack of perennial streams in the area indicate that potential exposures to aquatic biota are negligible. Endangered or threatened species other than golden eagles are not known to exist in the area. It is not expected that seepage from the tailings basin area would have an adverse effect on such species should they exist. The ground water is sufficiently deep in the geologic/soil profile that it will not reach the root zone of plants.

Future conditions in terms of potential environmental exposure are not expected to be significantly different from current conditions. Highland Reservoir is the only surface water body that may be impacted by tailings seepage now or in the future. The reservoir water quality meets all Wyoming standards for domestic, livestock, agriculture and aquatic use for PHCs except uranium (for aquatic use) and selenium (see Table 2.2). The uranium and selenium concentration at the reservoir are not caused by tailings seepage. This is discussed at Section 2.3.2.5.4. Based on meeting the Wyoming standards for most PHCs and the source of the uranium and selenium concentrations, the tailings seepage is not posing a significant risk to humans, livestock, wildlife or other biota that might consume water from Highland Reservoir.

2.3.2.1.3 Physical Structures

There are no physical structures at or near the site that could be exposed to ground water constituents derived from the tailings basin area. No such structures are anticipated in the future.

2.3.2.2 Health and Environmental Levels

The NRC Staff Technical Position "Alternate Concentration Limits for Title II Uranium Mills" requires quantification of the permissible levels of PHCs in terms of health effects and environmental protection. In the following sections, possible although highly unlikely human exposure pathways for the site are described, appropriate standards for water at the site are identified, and health and environmental limits (HELs) are recommended for the Points of Exposure (POEs).

2.3.2.2.1 Human Exposure Pathways

The least unlikely human exposure pathway to ground water is the drinking water route. Dermal exposure could occur through recreational activities or use of lake water or ground water for domestic purposes such as bathing and washing clothes. Such exposures to the seepage water are very unlikely and the levels of hazardous constituents in the ground water are not high enough to cause adverse effects through dermal exposure. According to the EPA, dermal uptake of radionuclides and metals is generally not an important route of uptake (EPA RAGS, 1989).

Exposure via plant uptake is improbable since ground water is well below the root zone and the limited productivity of the TDSS and mine backfill preclude practical use of the water for large scale irrigation. Although livestock exposure could occur were wells developed, the concentrations of hazardous constituents are not high enough to enter the human food chain through this mechanism. The water at the POC wells generally meets Wyoming livestock standards. As stated previously, the most likely source of livestock water is the reclamation lake since it is readily available and negates the need to expend the money to drill a well. However, as discussed earlier, the PHCs in the lake that exceed the GPLs are due to the characteristics of the lake and are not due to seepage from the Highland tailings basin.

2.3.2.2.2 Health Effects

Human health effects due to exposure to the PHCs that occur in the tailings seepage were evaluated for long term, or chronic exposures. (Such exposures now and in the future are highly unlikely considering the remote Highland location.) Short term exposure, while very unlikely, is more likely than long term exposure. Since it is improbable that residences will be established in the areas of highest contamination, the most logical type of exposure to expect is the one time or infrequent use of ground water as a source of drinking water. Although it seems more likely that water from the lake would be used because of convenience, it is remotely possible that someone might occasionally remove water from a well impacted by seepage for drinking. Continued use would not be expected for all the reasons given earlier and because the water tastes brackish.

The toxicology data of the constituents for which ACLs are being sought are examined in Table 2.4 and summarized in Table 2.5. A human health risk assessment is found in Appendix 6.

2.3.2.2.3 Health and Environmental Standards

All the POC wells meet Wyoming livestock standards with the exception of pH, TDS, sulfate and Ra226+228 at Well 175. This well is within the area to be deeded to the state or federal government for perpetual monitoring. The selected Health and Environmental Limits (HELs) for the Highland site are summarized in Table 2.5 and are based on health criteria.

2.3.2.3 Possible Points of Exposure

The possible Points of Exposure that must be examined include the following:

Ground water
Surface Water East of Tailings Dam
Surface Water South of Mine Site
Highland Reservoir

These are examined below.

2.3.2.3.1 Ground Water

On December 29, 1988, **the NRC selected** four POC wells (Amendment No. 27) from all the wells for which data were presented by Exxon . These four POC wells lie to the north, south, east and west of the center of the ponded water once held within the tailings basin. This pond created the seepage mound below the basin that has now largely dissipated. All four wells are within the area Exxon has proposed to be deeded to the state or federal government for perpetual monitoring.

The next table lists the POC wells and the proposed POE wells.

Table 2.3 Proposed POEs

POC Well	POE
125	None
175	Highland Reservoir
176	Well 179
177	Well 178

The TDSS is dry a short distance east of 125 so there is no ground or surface water POE on the east side of the tailings basin. The POE wells proposed are the closest downgradient wells with respect to POC wells 175, 176 and 177. Each proposed POE is close to the boundary of the area that Exxon has proposed be deeded to the state or federal government for perpetual monitoring.

2.3.2.3.2 Surface Water East of Tailings Dam

Prior to mining and milling, an unnamed tributary of the North Fork of Box Creek ran from west to east through the area that is now the tailings basin. It was this tributary that was dammed to create the tailings basin. West of the basin the drainage has been filled with mine overburden. In the area between the overburden and the tailings dam the tributary has been filled with tailings. The drainage still exists east of the tailings dam. Therefore, this unnamed tributary no longer runs through the area west of the tailings basin dam.

During milling operations tailings seepage came to the surface downstream (east) of the dam. Three sample points were monitored with the data reported in the semi-annual reports to the NRC. The three points were #12 - Lower Tailings Dam Seepage Return Pump, #13 - Outside Fence 100 Feet below #12, and #14 - End of Seepage Flow.

The seepage to the surface ended within three years after mill operations closed. Therefore, there is no exposure to seepage components in surface waters east of the dam. NRC approved discontinuing further monitoring of surface water east of the dam with Amendment No. 28 to the license. This amendment, along with Amendment No. 27, established the current ground water monitoring program. Section 5 of Appendix 3, "Highland Tailings Basin Ground Water Study" indicates seepage will not return to the unnamed tributary in the future. See Subsection 5.4 and Figure 12 of the study.

2.3.2.3.3 Surface Water South of Tailings Basin

South of Highland lies the North Fork of Box Creek. This is an ephemeral drainage - water only runs during heavy storms and heavy snow melt. Surface water may exist at various times of the year in a man-made reservoir. This is Reservoir 2A, created by the mine operation. It was monitored with the results reported to the NRC in semi-annual reports until license Amendment No. 14 when the NRC authorized discontinuing monitoring.

An examination of Figure 1 of the 1998 EPRCO report in Appendix 3 shows that the current ground water flow direction from the tailings basin does not reach the North Fork of Box Creek. Ground water flow moves from the creek towards the mine backfill and Highland Reservoir. Therefore, tailings seepage has no impact on the creek.

When Highland Reservoir is full, the 1998 EPRCO report in Appendix 3 (see Subsection 5.4 and Figure 12 of report) concludes "in general, once water levels stabilize, ground water will flow from west to east, with perturbations to this flow regime in the vicinity of the Highland Reservoir and mine backfill. The rate of flow is greatest to the northwest of the Reservoir (approximately .15 ft/day), and slowest to the northeast of the Reservoir (approximately .05 ft./day). In the vicinity of the tailings basin, the ground water flows from northwest to the southeast at a rate of about .03 ft/day, but changes to an easterly flow direction at the eastern edge of the tailing basin. In addition to this change in flow direction, the water table dips below the TDSS and lies within the TDSh in the southeast portion of the tailings basin. <u>As a result, it appears that the portion of the unnamed tributary of the North Fork of the Box Creek that lies to the east of the tailings dam, and the North Fork of the Box Creek that lies to the south of the tailings basin, will not intercept ground water migrating from beneath the basin."</u> (Underlining added.)

2.3.2.3.4 Highland Reservoir

Tailings seepage currently moves towards Highland Reservoir. The seepage passes through mine backfill before reaching the surface water. This situation will reverse when the reservoir is full.

Highland Reservoir is now monitored for the same constituents as are monitored to meet NRC license requirements. The Total Dissolved Solids, sulfate and chloride concentrations are far below those seen at the POC and POE wells. This clearly indicates the tailings seepage is only a minor portion of the water in the reservoir.

The reservoir uranium concentration is orders of magnitude higher than at any POC or POE well. Given the low component of seepage in the water and the much lower uranium concentration at the wells, an explanation other than seepage is needed for this uranium concentration. The explanation is obvious. The bottom and sides of the reservoir include unmined uranium mineralization. These provide the source of the uranium in the surface water. The uranium is not the result of tailings basin seepage. Therefore, the GPL is not applicable as the limit only applies to PHCs derived from byproduct material whereas the uranium in Highland Reservoir derives from unmined mineralization. The uranium concentration in the reservoir meets the Wyoming potable, livestock and irrigation standards. Therefore, this is not a significant risk factor.

Ra 226 is measured in the Reservoir. The concentrations are higher than the POC or POE wells. The explanation is the same as for uranium, so the Ra 226 results are not the result of tailings seepage. A few measurements have been made of the Ra228 concentration. These were less than the detection limit. The Ra 226 + 228 GPL is not applicable to Highland Reservoir for the reasons given above. However, the data is close to the GPL. The average Ra 226 + 228 concentration since 1996 where Ra228 measurement began is <5.4 pCi/l (4.4 pCi/l Ra 226 plus <1.0 pCi/l Ra 228). It is worth emphasizing that Ra 228 causes Well 175 to exceed the Ra 226 + 228 limit while Ra 226 has sometimes caused Highland Reservoir to exceed the limit. The isotopic "fingerprinting" indicates the Ra 226 and Ra 228 sources for Well 175 and Highland Reservoir are different.

Nickel measurements are made but none has been detected in Highland Reservoir.

Selenium is found above the GPL. Selenium is below the detection limit at the POC and POE wells and is far below the GPL. Once again, the explanation for the selenium in the reservoir is unmined mineralization and not tailings seepage. The GPL is, therefore, not applicable to

Highland Reservoir. The water quality of Highland Reservoir is under review with the Wyoming Department of Environmental Quality.

In summary, there is no exposure to any PHC above a GPL in Highland Reservoir that derives from tailings basin seepage. Any exposure that exists derives from naturally occurring materials at the reservoir.

TABLE 2.4

HAZARDOUS CONSTITUENT HEALTH EFFECTS DISCUSSION

Constituent	Health Effects
Nickel (Ni)	EPA promulgated a maximum contaminant level of 0.1 mg/l under the Safe Drinking Water Act on July 17, 1992. This standard applies to public water supplies. The standard is set to be below, with an adequate margin of safety, the concentration below which no adverse health affects are observed. Nickel is not considered a carcinogen via ingestion. [57 FR 31776-31849]. Wyoming has established agricultural (irrigation) and fish/aquatic standards for nickel of 0.2 and 0.4 mg/l, respectively.
Radium (RA226/228)	In 1991 EPA proposed radium 226 and radium 228 Maximum Contaminant Limits (MCLs) for public water supplies of 20 pCi/l (56 FR33050-33127). These limits were based on EPA policy for regulating carcinogens in drinking water to a lifetime individual risk target of 1 in 10,000 to 1 in 1,000,000. Therefore, this standard is protective of human health and the environment to a lifetime risk level not exceeding 1 in 10,000.
Uranium (UNAT)	In 1991 EPA proposed a uranium Maximum Contaminant Limit (MCL) for public water supplies of 20 mg/l (30 pCi/l) (56 FR 33050-33127). This limit was based on EPA policy for regulating carcinogens in drinking water to a lifetime individual risk target of 1 in 10,000 to 1 in 1,000,000. Therefore, this standard is protective of human health and the environment to a lifetime risk level not exceeding 1 in 10,000.

TABLE 2.5

MAXIMUM CONTAMINANT LIMITS (MCLs)

Constituent	MCL
Inorganics (units are mg/l)	
Nickel (Ni)	0.1
Radionuclides (units are pCi/l)	
Radium (Ra226) (Proposed)	20
Radium (Ra228) (Proposed)	20
Radium (Ra226+228) (Derived)	20*
Uranium (UNAT) (Proposed)	30

*Using 20 pCi/l for Ra226 + 228 is the most conservative approach whereas 40 pCi/l would be the least conservative. Using 20 pCi/l provides assurance that neither Ra226 nor Ra228 will exceed the respective MCL.

2.3.3 Practical Possibility of Using Ground Water

Obviously no human exposure would occur unless someone chose to develop a well in the TDSS or chose to use an existing TDSS well in the area impacted by tailings seepage. After the tailings area is transferred to government ownership, the areas near Wells 178, 179, 181 and 183 could potentially be developed. Three of these four TDSS wells lie within the 1998 seepage front (based on chloride concentration) but outside of the zone proposed for government ownership. Well 183 is outside the 1996 seepage front. Of these, only the ground water at Well 178 does not meet the current GPLs due to UNAT. UNAT at Well 178 is covered in the risk assessment (Appendix 6).

The current productivity of Well 178 of about 115 gallons per day is not adequate to supply the needs of a single home. Section 1.0 of Chapter III of the Wyoming Department of Environmental Quality Rules and Regulations require a sewage treatment capacity of at least 350 gallons per day for a single family residence. This does not allow for other water uses that do not discharge to the sewer such as landscape watering. The Well 178 limited productivity is declining further as the water level falls in the TDSS.

Under extraordinary circumstances a water well with a production rate as low as Well 178 might be employed, even with the current water quality. However, much better and much more productive aquifers can be reached less than 100 feet deeper. Therefore, the short term availability of a very limited supply of water at Well 178 that does not meet the GPL is not a potential hazard. When Highland reservoir is full, the water level at this well will return with a saturated thickness of about 13 feet so the well will then be productive. However, the return of the better quality groundwater from the northwest should eventually return the water quality of Well 178 to near baseline conditions.

Someone might attempt in the future to complete a well in the mine backfill. However, wells completed in the mine backfill produce very little water. Typically, no more than 200 gallons can be produced before these wells run dry. Therefore, the mine backfill is not an aquifer. The mine backfill material is unconsolidated. This makes completing a well difficult, as the drilled holes can collapse before the well casing can be placed in the hole, as happened with Well 173 (see Exxon, December 29, 1988, license amendment application). Highland Reservoir and wells located entirely off the mine backfill and drilled into deeper strata would be much more logical sources of water.

2.3.4 Proposed Health and Environment Limits (HELs)

Health and Environmental Limits (HELs) for the ACL application are proposed in the table below:

Table 2.6 Health and Environmental Limits

CONSTITUENT (mg/l)	HEL	CONSTITUENT (pCi/l)	HEL
Nickel	0.1	Radium 226 + 228	20
		Natural Uranium	30

These values are taken from the MCLs on Table 2.5.

2.3.5 Documentation of Attenuation Factors

The proposed Highland attenuation factors are based on data obtained from on site measurements and monitoring records of the water quality at the POC and POE wells. This comparison between wells provides stronger evidence of attenuation than calculations based on laboratory data for seepage interacting with TDSS material. This comparison is also very site specific.

POEs have been discussed by Exxon and the NRC before but have not been officially recognized specifically for Highland. Exxon proposes a POE of Highland Reservoir for Well 175. The reservoir is less than 4000 feet from the Well 175 and is close to the edge of the area proposed for transfer to government ownership for long term monitoring. The reservoir is in the current approximate down gradient direction from Well 175. No POE exists east of Well 125 as the TDSS is unsaturated in this direction a short distance from Well 125. Therefore, no POE is proposed for Well 125. This in effect means health and environmental limits are not applicable to Well 125. Well 178 is 450 feet southeast of Well 177 and is close to the edge of the area proposed for transfer to government ownership.

The PHC concentrations at the above POEs are compared to the concentrations at the respective POC wells in Table 2.7 on the next page. From this comparison attenuation factors can be derived as presented in the table. These are simple ratios of the POC concentrations divided by the POE concentrations to yield attenuation factors. In cases where the ratio is less than one, no attenuation is claimed between the POC and the POE.

Table 2.7 Attenuation Factors

DIRECTION	PHC	POE Average.	POC Average	Attenuation Factor
West		Highland Res.	Well 175	
	(mg/l)	(1997)	(1997)	
	Nickel	<0.02	1.27	64
	(pCi/L)			
	Radium 226+228	<5.45	<7.30	1.34
South		Well 178 (1996)	Well 177(1996)	
	Uranium	1.25	53.9	43

2.3.6 Derived Health and Environment Limits (DHELs)

Applying the above described attenuation factors to the HELs yields a set of Derived Health and Environment Limits (DHELs) that should not be exceeded at the POCs. These are presented in Table 2.8 on the next page. Water quality at the POCs at the DHEL concentrations would not result in a substantial present or potential hazard to human health or the environment at the POEs. No DHEL applies east of the tailings basin (east of Well 125) because there is no POE in that direction (see Section 2.3.2.3.1).

2.3.6.1 Basis for Attenuation Factors

Attenuation factors have been calculated for uranium south of the tailings basin and for nickel and Ra 226 + 228 west of the basin. The calculated values are based on simple ratios of the current concentrations at the POCs and the POEs. These ratios essentially assume no significant changes over time in the relative POC and POE concentrations before Highland Reservoir is full. All groundwater concentrations should begin to fall around the tailings basin after that time as better quality water moves into the area and reducing conditions are restored.

There is a rational basis for forecasting no significant change in ground water quality around the tailings basin before the reservoir is full and the ground water quality begins to improve. EPRCO completed a model of the tailings basin in 1982 (EPRCO 1982) that has been a relatively good predictor of current concentrations. Conclusions can be drawn from that report, supported by the monitoring data.

First, the EPRCO Seepage Study model (EPRCO, 1982) indicated solute movements would nearly cease in the southerly direction by 1992. Therefore, the latest uranium concentrations at Wells 177 and 178 represent long term concentrations. This is supported by the current ground water flow direction (Figure 1 of Appendix 3) and predicted long term flow direction (Figure 12 of Appendix 3) and years of monitoring Wells 177 and 178.

Second, the 1982 EPRCO study indicates finite limits to the movement of the PHCs. The study found radium is nearly immobile with a Relative Velocity (defined term in study) of 0.011 versus 1.0 for sulfate and calcium. Highland Reservoir will be full and the ground water flow will be reversed before tailing basin Ra 228, the principal tailings basin radium isotope in solution, can reach Highland Reservoir. While Ni is not attenuated by the TDSS in an acidic environment (other than by simple dilution), Ni solubility is pH dependent. Thus, it only travels as far as the low pH front. The EPRCO Seepage study found a relative velocity of the pH front of 0.5. Figure 57 of the EPRCO Seepage Study indicates the pH front would be nearly stagnant by 1992. This is born out by the monitoring date. The pH has not declined below 5.9 at Well 175 by 1998 although the pH front had reached the well by 1988 as predicted by EPRCO. The pH front was just beginning to impact Well 180 when it went dry in 1994. This well is only 300 feet west of Well 175. The reservoir is another 1700 feet further away

The model predicts a declining rate of advance for the pH front as the volume of low pH liquid declines behind the seepage front and the perimeter of the front grows. The mass of alkaline TDSS and mine backfill between Well 175 and Highland Reservoir is too great for the remaining seepage volume to overcome. A simple acknowledgement of the much larger volume of seepage from 1972 to date that barely pushed the pH front to Well 180 versus the much smaller remaining volume plus the long distance to Highland Reservoir makes this point very strongly. Tailings seepage is only a modest contributor to the Highland Reservoir inflow, a fact attested to by the reservoir TDS and S04 concentrations versus the concentrations at TDSS wells around the tailings basin.

Highland Reservoir currently contains 2.6 billion gallons of pH 8 water versus 294 million gallons within the entire TDSS chloride front in 1996 capable of draining to the reservoir (Appendix 3). Most of the 294 million gallons has a neutral pH and no measurable Ni. Therefore, the remaining low pH liquid within the pH front has insufficient mass to significantly affect the reservoir, thereby preventing the appearance of Ni in the lake.

While the Ni concentration in Highland Reservoir will not change, neither will that of Well 175 in the near future. The pH front has reached this Well, the Ni concentration matches that of both the tailings fluid and the EPRCO prediction for the Ni concentration behind the pH front. The concentration will only begin to decline when Highland Reservoir is full and alkaline water begins to move back towards Well 175.

EPRCO found a Relative Velocity for uranium in the TDSS of 0.068. Therefore, its rate of movement is only 7% of the rate for the conservative ion front. With the southerly seepage movement nearly stopped, the uranium front movement in that direction is essentially zero.

Table 2.8 DERIVED HEALTH AND ENVIRONMENTAL LIMITS FOR POINTS OF COMPLIANCE

			Well 175		Well 177	
Constituent	NRC LIMIT	HEL	Atten. Factor	DHEL	Atten. Factor	DHEL
(mg/l)						
Nickel	0.02	0.1	64	6.4	----	----
(pCi/l)						
Radium 226+228	5	20	1.34	27	----	----
Nat. Uranium	0.43	30	----	----	43	1290

3. CORRECTIVE ACTION ASSESSMENT

3.1 Previous Corrective Action

Before Criterion 5 of Appendix A to 10 CFR Part 40 became effective in 1987, the only requirement to control tailings seepage at Highland was to return seepage to the basin that came to the surface. The facility had been designed and licensed with seepage and some degradation of the uppermost acquifer expected. Nevertheless, Exxon took steps before 1987 to reduce that seepage.

During the 1970s, Exxon operated a tailings water evaporation system that reduced the tailings liquid volume by upwards of 100 million gallons. This reduced the hydrostatic head in the tailings basin and slowed seepage. From the later 1970s to 1984 when mill operations ceased, Exxon recycled tailings liquid to the mill. This reduced fresh-water use by about 500 million gallons, reduced sulfuric acid use and recovered about ten thousand pounds of uranium. Using less fresh water reduced the hydrostatic head in the tailings basin and reduced seepage. Less sulfuric acid use meant less sulfate entering ground water and there was less migration of the low pH front into the uppermost aquifer. The uranium recovery reduced potential uranium migration into the uppermost aquifer.

From the mid 1970s until mill operation ceased, Exxon operated a uranium recovery system at the tailings basin that reduced the mass of uranium available to seepage by over 150 thousand pounds. From 1984 until 1988 Exxon operated a spray system and evaporation lagoons to rapidly dry out the tailings basin in preparation for reclamation. The spray system and lagoons rapidly reduced the hydrostatic head in the tailings basin and reduced seepage. This impact can be seen in the graphs of the static water elevations at the monitor wells (see Appendix 4). Many water levels peaked around 1984 and then began a rapid decline.

3.2 Source Decommissioning and Reclamation

Following closure of the Highland mill in 1984 interim stabilization began. As the liquid level was reduced in the tailings basin, tailings recontouring was performed. Once tailings were at the necessary subgrade elevation for reclamation, a thin lift of clayey fill was placed to prevent wind migration of tailings. By 1989 the pond had evaporated and most of the tailings were covered with soil. Recovery of wind blown tailings was completed that year. During the spring, summer and early fall of 1989, the tailings reclamation work proceeded. Dam and tailings recontouring were completed. All the tailings were covered with a low permeability radon barrier consisting of compacted clayey soil. Once the radon barrier was placed, topsoil was placed and planted with winter wheat. Only a 20-acre area was not topsoiled. This was the area in the middle of the basin where settlement continued and the seepage mitigation pond is located. This area has a two-foot layer of radon barrier. In 1990 the topsoiled areas were planted with permanent vegetation.

The radon barrier exercises effective control over infiltration of rainfall and snow melt into the tailings. The vegetation further reduces infiltration by evapotranspiration. Between the radon barrier and the vegetation, the water infiltration has been reduced to about three gallons per minute for the entire tailings basin - equivalent to about one half inch per year. Once tailings settlement is 90% complete and tailings seepage recovery ends, the reclamation of the 20-acre area in the tailings can be completed.

The reclaimed basin, with the low permeability clayey cover, is the Base Case for seepage mitigation. Benefits of the Base Case (source decommissioning and reclamation) include no longer recharging the tailings from an active mill operation, reduced seepage from eliminating the surface impoundment and minimization of long term seepage by restricting recharge.

3.3 Corrective Action Program

License Amendment No. 27 for the Highland mill and tailings basin, dated February 8, 1989, required implementation of a Corrective Action Program (CAP) to meet the GPLs at the POCs around the Highland tailings basin. Exxon submitted a CAP for NRC approval on May 1, 1989. The program included reducing future infiltration by surface reclamation and allowing natural processes to mitigate the ground water impacts to achieve the GPLs. WWL 1989 showed no practicable technology could achieve the license standards sooner than could be achieved by natural processes. Exxon proposed ACLs (Exxon 1989) that were protective of human health and the environment at the potential POEs. After reviewing this submittal, the NRC asked Exxon to submit a revised CAP involving selective pumping of wells with elevated levels of PHCs to improve future ground water quality.

On August 15, 1989 Exxon submitted a revised CAP to the NRC. The objective of this CAP was to remove PHCs from ground water in order to reduce concentrations to levels As Low As Reasonably Achievable (ALARA).

The CAP proposed and approved by NRC on August 18, 1989 in License Amendment No. 32, consisted of pumping five existing wells completed in the TDSS in the area of highest PHC concentrations. This is called the finger area and lies south and west of the tailings basin. The CAP included disposal of the recovered water in an evaporation pond built on top of the radon barrier. The specific wells to be pumped included Wells 114, 117, 175, 177 and 178.

3.4 Results of Correction Action Program

Exxon began operating the NRC approved CAP in November of 1989. Annual progress reports have been submitted each January since then. The system originally included an evaporation pond and five recovery wells south and west of the tailings. NRC approved discontinuing pumping from Well 114 in 1990 since the well was unproductive. The system has recovered 15.0 million gallons through 1997. This recovered ground water contained about 300 metric tons of dissolved solids including 54 kilograms of non-radioactive, potentially hazardous constituents and 1.3 millicurie of radioactive constituents. About seventy percent of the radioactive material has been uranium of which about 1.2 kilograms has been recovered.

The PHCs are being precipitated with the non-hazardous dissolved solids that are deposited at the bottom of the evaporation pond. For example, the water pumped to the evaporation pond through September 1996 contained about 21 kilograms of salts (primarily sodium and calcium sulfates), 3 grams of the non-radioactive PHCs, 0.08 grams of uranium and 25 nanocuries of other radionuclides per square meter of evaporation pond surface. The uranium and radium 226 concentrations in the total dissolved solids in the water are about three and one picocurie per gram of solid (pCi/g) , respectively. The evaporites, containing these concentrations of uranium and radium 226, will be buried under at least 1.5 feet of radon barrier and a half foot of topsoil when the reclamation of the evaporation pond area is completed. The evaporites will make no distinguishable contribution to the tailings basin radon flux.

The ground water volumes recovered from the recovery wells along with the June 1998 average recovery rates are presented in Table 3.1. The TDSS saturated thicknesses at the recovery wells in 1998 are also provided.

Table 3.1 TDSS Ground Water Recovery

Well	1998 Gallons (Thousands)	Total Gallons (Thousands)	June 1998 Gallons per		Saturated Thickness Feet-1998
			Day	Minute	
114	0	2	0	0	21
117	52	3483	300	0.2	6
175	1144	9168	4050	3.2	18
177	0	1519	0	0	0
178	28	625	160	0.1	7
Total	1224	15797	4900	3.4	

Ground water recovery was suspended in 1990 at Well 114 due to poor productivity.

Graphs of the water levels at the TDSS wells in Appendix 4 show steep declines in water levels near the tailings basin since mill operations ended in 1984. The decline has tapered off at many of the wells in the past several years. Ground water recovery rates have declined as the ground water levels have fallen. The water production from Wells 117 and 175 was restricted until 1994 to maintain steady pumping rates. Production is now at the maximum capacity of the wells to make up for the loss of productive capacity at Wells 177 and 178. However, Well 117 now has very little productivity. The water quality data is provided in Appendix 1 from 1988 to the present. These show the decline in most of the PHCs.

3.5 Feasibility of Alternative Correction Actions from WWL, May 1989

As required by Appendix A of 10 CFR Part 40, Exxon submitted a CAP in 1989 (Exxon, 1989). The Program included reducing future seepage from the tailings basin by surface reclamation and allowing natural processes to mitigate the ground water impacts to achieve the NRC Ground Water Protection Limits (GPLs). This is the Base Case and is essentially the same plan as in the Highland Environmental Impact Statement. WWL 1989 included a detailed review of potential corrective actions. This review, summarized in Section 4.0, Table 4.1, Table 4.2, and Appendix B (all from WWL, 1989) concluded that no practicable technology could achieve the license limits sooner than could be achieved by surface reclamation and natural processes. Exxon proposed Alternative Concentration Limits (ACLs) that were protective of human health and the environment that were As Low As Reasonably Achievable (ALARA) using practicable technology.

The possible corrective actions included a slurry trench to confine the remaining liquid beneath the tailings basin, a water purge to flush the seepage more quickly into the mine backfill and various combinations of pumping out and disposing of seepage, reinjecting treated seepage and injecting clean water from various sources - - with and without chemical reductant and acid neutralizers. In a letter dated July 3, 1989, NRC denied approval of the proposed ACLs and time." NRC stated, "Following operation of your corrective action program and based upon the monitoring gained during its operation, an alternate concentration limit proposal would be appropriate."

In response to the NRC recommendation, Exxon proposed pumping from wells in the area of the highest PHC concentrations and disposing of the water in an evaporation pond. NRC approved this plan and deferred approving ACLs pending a demonstration through pumping of what the ALARA concentrations would be. This is the plan Exxon has been executing since 1989.

3.6 Updated and Expanded Review of Alternative Corrective Actions

The review of the potential corrective action plans is updated and expanded in Appendix 7. This updated review demonstrates the high costs and low benefits of additional mitigation.

3.7 Correction Action Cost Estimates (from WWL, May 1989)

Table 4.3 and Appendix B (WWL, 1989) include cost estimates of the corrective action alternatives. The cost estimates range from hundreds of thousands to millions of dollars without providing significant benefits to human health or the environment over completing surface reclamation and natural mitigation. Besides financial costs, all the options had potential human costs due to potential industrial accidents performing the work and potential highway accidents in getting to the remote Highland site. Appendix 7 yields essentially the same conclusions.

3.8 Actual Correction Action Costs

The estimated financial cost of operating the current CAP was reported in the latest reclamation surety estimate submitted to NRC by Exxon on August 3, 1998. The cost is about fifty thousand dollars per year over the cost of ground water monitoring. To date there have been no accidents or injuries associated with the CAP.

3.9 Expected Corrective Action Benefits (from WWL May, 1989)

Section 4.0 - Corrective Action Alternatives (WWL, 1989) addressed alternatives and benefits. It concluded natural mitigation after completing the surface reclamation to reduce future infiltration into the tailings was the best approach. The following quotation summarizes the view of WWL in 1989.

> "The rejected alternatives suffered from a common problem. In the short term they could not achieve the current NRC standards [NRC ground water protection limits]. Pumping out the seepage would reduce the chance that seepage might be used by anyone but this chance is already negligible [due to demographics, palatability, economics and better alternative supplies]. In the very long term, none of the alternatives proved superior to letting the seepage flow into the [mine] backfill area where geochemical attenuation of the hazardous constituents will occur, while allowing the ground water to return to its pre-mining levels, creating a reducing environment. To improve this natural mitigation during the next 100 years would require continuous injection of higher quality water for 100 years [consuming a very large volume of good water]."

Appendix 7 indicates the substantially higher costs of additional mitigation measurements, such as more pumping, a reactive barrier or ground water injection and disposal, would yield very little benefit.

3.10 Actual Benefits of Corrective Action Program

This program has removed 15.8 million gallons of water from the uppermost aquifer through 1997. The water pumping has removed about 338 metric tons of dissolved solids from the TDSS including 54 kilograms of non-radioactive, potentially hazardous constituents and 1.3 millicurie of radioactive constituents. About seventy percent of the radioactive material has been uranium of which about 1.2 kilogram has been recovered. During the operation of the CAP the volume of liquid that can be drained from within the chloride front has declined by over 50%. The volume in the finger area where the PHC concentration was highest in 1989 has also declined by 50%.

More importantly, there has been a substantial reduction in the number of GPLs exceeded at the POC wells. The table below compares the PHCs exceeded by each POE well in 1988 versus the 1998 results.

Table 3.2 GPL Exceedances

	Well 125		**Well 175**		**Well 176**		**Well 177**	
	1988	1998	1988	1998	1988	1998	1988	1996
Arsenic	--	--	--	--	--	--	--	--
Cadmium	--	--	--	--	--	--	X	--
Chromium	--	--	X	--	--	--	--	--
Gross Alpha	--	--	--	--	--	--	--	--
Lead	X	--	X	--	--	--	--	--
Nickel	X	--	X	X	X	--	X	--
Radium 226 + 228	--	--	X	X	X	--	X	--
Selenium	X	--	--	--	--	--	--	--
Thorium-230	X	--	X	--	X	--	X	--
Uranium	X	X	X	--	X	--	X	X
TOTAL	**5**	**1**	**6**	**2**	**4**	**0**	**5**	**1**

In summary, there were twenty GPLs being exceeded (counting each GPL exceeded at each well) versus only four in the most recent data.

3.11 As Low As Reasonably Achievable by Recovery System Demonstration

In eight years of operation the CAP has removed 15.8 million gallons from the area south and west of the tailings basin. This is about twenty percent of the 80 million gallons in that area in 1989 (at 0.1 specific yield) capable of draining. There is about 40 million gallons there now. Natural mitigation since 1989 has removed three times more ground water than the ground water pumping efforts in the CAP.

Natural mitigation occurs when the ground water moves down gradient into the mine backfill. In the backfill geochemical reactions cause the pH to increase and cause both the total dissolved solids and the potentially hazardous constituent concentrations to decline as predicted in the

1982 EPRCO study. This process has occurred over the life of the tailings basin. The concentrations of the potentially hazardous constituents will eventually reflect the water quality at Well 171 in the mine backfill. This well has not been significantly impacted by ground water from the tailings basin as the non-hazardous constituent concentrations and pH are about the same as the TDSS background wells. The only potentially hazardous constituents regularly found above the NRC ground water protection limits at Well 171 is uranium. These concentrations are due to the low grade uranium mineralization in the mine backfill and not tailings seepage. This claim is proven as the uranium concentrations at Wells 114 and 175 close to the tailings basin (and with the lowest pH values and highest TDS and nickel values) are lower than at Well 171.

3.12 Expected Timing for Natural Mitigation to Meet License Limits

Section 2.3.2 - Ground Water Quality Predictions (WWL, 1989) estimated baseline conditions would return to the TDSS after the TDSS under the tailings had drained (20 to 50 years) and Highland Reservoir had filled (100 years). Between the time that the TDSS is drained and the reservoir is full, the TDSS at the tailings basin will be unsaturated. Therefore, no ground water will exist for development.

Highland Reservoir must fill to an elevation of at least 5090 feet above sea level for any area under or immediately around the tailings basin in the TDSS to resaturate. After this occurs it may take a hundred years or more for background conditions to be restored at the POC wells. The water level in the TDSS under the tailings basin will be between 5105 and 5124 feet above sea level when the reservoir is full. At the higher elevation the saturated thickness at POC Wells 125, 175, 176 and 177 would be zero, 41, 37 and 7 feet, respectively (Figure 12 of Appendix 3). Thus, one of the four POC wells will remain dry after the tailings basin seepage has dissipated and the reservoir has filled. This means there will be no groundwater development potential for the TDSS to the east of the tailings basin. Only uranium exceeds the GPL south of the basin and the risk assessment (Appendix 6) indicates no significant risk at the proposed POE.

Of Wells 175 and 176, only the water at Well 175 does not meet all the current NRC limits. This well is within the smallest possible area that under federal law must be deeded to the State of Wyoming or the U.S. Department of Energy for perpetual monitoring. Highland Reservoir is the only reasonable Point of Exposure (POE) for this POC well.

The reservoir water quality meets the GPLs except for uranium and selenium. A comparison of the uranium and selenium concentrations versus the POC wells proves the reservoir concentrations are not a result of the tailings basin. The reservoir concentrations of uranium and selenium are much higher than at Wells 114 and 175 in the TDSS at the west end of the tailings basin and also much higher than the concentrations at the mine backfill wells.

Once the reservoir is full, the ground water movement in the TDSS will be from the reservoir towards the surface discharge (elevation of 5100 feet) in the North Fort of Box Creek south of the mine backfill. The ground water under the tailings basin will be nearly stagnant.

4. PROPOSED ALTERNATE CONCENTRATION LIMITS (ACLs)

4.1 Proposed ACLs

The cadmium, chromium, lead, selenium, gross alpha and thorium-230 concentrations at the Point of Compliance (POC) wells meet the current Ground Water Protection Limits (GPLs). Therefore, no ACLs are proposed for these Potentially Hazardous Constituents (PHCs). POC Well 176 meets all the GPLs, so no ACLs are proposed based on this well. The GPLs were set by the NRC based on the Table 5C values in Appendix A to 10 CFR Part 40 and background quality as measured in 1988 at Well 182. ECMC did not agree with the use of only one well to establish background. However, the GPLs that could have been established based on a wider set of background wells would not of significantly changed the GPLs in the license, so ECMC did not appeal the values.

ACLs based on the other three POC wells are proposed in Table 4.1 for nickel (Ni), radium 226 + 228 (Ra 226 + 228) and natural uranium (UNAT). The proposed ACLs are based on the Derived Health and Environmental Limits (DHELs) (see Table 2.4) and ALARA values (see Table 1.2) for the POC wells. Each proposed ACL equals either the appropriate DHEL or ALARA concentration, whichever is lower. The concentrations at the POCs already meet the proposed ACLs as shown in the table below.

Table 4.1 Proposed Alternate Concentration Limits (ACLs)

Well	PHC	GPL	DHEL	ALARA	ACL	HIGHEST MEASUREMENT SINCE 1994
125	UNAT (pCi/l)	0.43	NA	59	59	28.9
175	Ni (mg/l)	0.02	1.8	1.8	1.8	1.7
175	Ra 226 & 228	5.0	27	24	24	13.4
177	UNAT (pCi/l)	0.43	1290	71	71	57.5

NA means Not Applicable because there is no Point of Exposure east of the tailings basin.

The Well 125 uranium ACL is well below the Wyoming Chapter III ground water standards for potable, agricultural, livestock and aquatic use. East of the tailings basin the TDSS lies above the predicted long-term ground water elevation, so the TDSS at Well 125 will not be an aquifer in the future. The ACL does not pose a substantial present or potential hazard to human health or the environment.

The Well 175 nickel ACL, in conjunction with the demonstrated attenuation factors, protects Highland Reservoir from detectable concentrations of nickel (0.02 mg/l) and from exceeding the EPA MCL of 0.1 mg/l (40 CFR 141.62). The ACL protects the mine backfill nickel concentrations (Wells 170, 171 and 173) from exceeding the 0.1 mg/l drinking water MCL promulgated July 17, 1992. The mine backfill is not capable of producing a significant amount of water from a well. Well 175 itself is within the minimum required area that must be deeded to the state or federal government with the byproduct material disposal area. Eventually, natural processes will return the ground water at this location to near background conditions after the existing ground water has drained into the mine backfill and Highland Reservoir has filled to the final elevation. The ACL does not pose a substantial present or potential hazard to human health or the environment.

The Well 175 radium 226 + 228 ACL protects Highland Reservoir from exceeding the EPA proposed drinking water MCLs of 20 pCi/l for radium 226 and radium 228 (56 FR 33050-33127). The ACL protects the mine backfill radium 226 + 228 concentrations (Wells 170, 171 and 173) from exceeding the EPA proposed MCLs. EPA MCLs are intended to protect small and very large public water systems so provide a wide margin of safety at this very rural site.

The Well 177 uranium ACL protects ground water further south of the tailings basin at Well 178 from exceeding the proposed MCL. Well 177 is dry. Ground water meeting the ACL at this location does not pose a substantial present or potential hazard to human health or the environment. Well 177 is no longer capable of producing water due to the lack of saturated thickness in the TDSS south of the tailings basin. The bottom of the TDSS in this area lies below the predicted long-term ground water elevation (Figure 4 of Appendix 3), so the TDSS at Wells 177 and 178 will be an aquifer after Highland Reservoir fills. The ACL will then be protective of the POE (Well 178).

4.2 Proposed Implementation Measures

PHCs for which ACLs are not being sought(chromium, thorium-230, etc.) have been in compliance with the GPLs for a significant period of time (see Appendix 1). In the case of the ACLs proposed, the monitoring results have been in compliance with the proposed ACLs for a significant period of time (see Table 4.1 above or Appendix 1). Therefore, ECMC proposes that ground water recovery as required by License Condition Numbers 33A and 33C be terminated. ECMC also proposes that the ground water corrective action system be decommissioned and reclaimed in accordance with Section 5 of this report. The tailings basin reclamation could then be completed as soon as the ground settlement achieves the milestone in the license. ECMC further proposes that ground water monitoring continue for two years beyond the granting of the ACL license amendment. Assuming the ground water monitoring results stay within the ACL limits, the proposal is to then terminate ground water monitoring and decommission the monitoring wells.

The ground water data at the POCs will be considered to meet the ACLs as long as the ACLs are not exceeded. In the event an ACL is exceeded (an event with a 5% probability with no real change in the ground water since the ACLs equal the ALARA values that are based on the mean values plus two standard deviations), ECMC will conduct an investigation to determine if the ground water has indeed failed to meet an ACL.

Investigations will be performed following the procedure summarized below. NRC recommends this procedure when insitu uranium mine monitor well data exceeds an Upper Control Limit.

1) The data will be examined to determine if a procedural error in the field, in the laboratory, or during data management has occurred. This examination will include, but not be limited to the following:

- Review of field notes to ascertain a potential error in sampling location or procedure.
- Verification that the laboratory work has met quality assurance requirements.
- Review of the data management work to determine if a transcription or other data handling error has occurred.

2) If a procedural error is uncovered and can be corrected (as, for example, a mistake in transcription), no further verification action will be taken, and routine monitoring will resume in accordance with the site-specific monitoring program.

3) If a lapse in laboratory quality assurance is suspected that can be corrected by reanalysis within the maximum allowed holding times of the sample portion that remains with the laboratory, the reanalysis will be performed.

4) If insufficient sample remains in the laboratory for reanalysis, if the holding time requirements cannot be met, if a lapse in field sampling procedure is suspected to have occurred, or more generally, if confirmation of the result is desired, resampling may be necessary. The decision whether or not to resample immediately or wait until the next regularly scheduled sampling will depend on the nature and level of exceedance, hydrologic conditions, and the water quality at other locations. The decision when to resample will be made in consultation with the NRC.

If the investigation described above reveals a cause for the exceedance other than the actual ground water quality, normal monitoring will continue. The results of the investigation documenting that the actual ground water quality is not the cause of exceedance will be provided verbally to the NRC within three working days and in writing within 30 days. The same notification process will be followed if the investigation described above cannot substantially rule out that the actual ground water quality is the cause. ECMC will then review with NRC what steps should be taken to correct the deviation from the ACL.

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5. DECOMMISSIONING CORRECTIVE ACTION SYSTEM

Assuming NRC approves Exxon's full request, the corrective action of continuous ground water recovery will be terminated. Once the evaporation pond is dry and tailings settlement in this area has achieved 90% consolidation, the evaporation pond will be reclaimed and the reclamation of the tailings basin will be completed in accordance with the approved reclamation plan (Condition 40 of the license). The reclamation will stabilize the evaporites in the bottom of the evaporation pond between the existing two feet of radon barrier under the evaporation pond and the additional one and a half feet of radon barrier and one half foot of topsoil to be placed as well as additional soil needed to make up for settlement. The radium-226 concentration in the evaporites is about 1 pCi/g. Therefore, the evaporites will make no significant contribution to radon emissions from the basin.

Once two successful years of post-corrective action monitoring have been collected, the monitoring and ground water recovery wells will be plugged and reclaimed according to Exxon's license commitment (Section 2.5 of Exxon Application for Amendment dated November 10, 1989).

Following a brief reclamation stabilization period, the site should be ready for termination of the specific license and transfer to government ownership under general license provisions.

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6. REFERENCES

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Wyoming Department Of Environmental Quality; Chapter VIII Quality Standards For Wyoming Ground Waters; Table I.

U. S. Environmental Protection Agency, 1989, Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A)

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APPENDIX 1

WATER QUALITY DATA

TABLES 3A, 3B, 3C, 3E, EF, WATER QUALITY TABLES

3A	TDSS COMPLIANCE WELLS
3B	TDSS MONITOR WELLS
3C	TDSS BACKGROUND MONITOR WELLS
3E	MINE BACKFILL MONITOR WELLS
3F	HIGHLAND RESERVOIR

APPENDIX 5.DOC

ATTACHMENT 3A TDSS COMPLIANCE MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
125	TDM XXVI	02/29/88	7.4	3614	1650	190			< 0.001				1.20	< 0.001		0.70			0.70	0.70
		05/31/88	7.5	3784	2300	195			< 0.001				1.00	0.007		3.50			0.50	18.00
		08/30/88	7.3	3298	1790	208			< 0.001				1.30	0.049		0.20			0.90	63.00
		09/15/88	7.3	3567	1810	211		3.38	< 0.001	0.007	0.060	0.080	0.09	0.038	3.5	0.80	1.20	2.00	0.40	59.00
		09/29/88	7.4	3565	1670	211		2.85	< 0.001	0.009	< 0.010	< 0.020	< 0.05	0.331	1.6	0.30	3.40	3.70	0.50	59.00
		10/15/88	7.6	3117	1380	211	283	2.67	< 0.001	0.008	< 0.010	< 0.020	< 0.05	0.049	3.0	0.70	3.10	3.80	0.80	58.00
		11/28/88	7.6	3108	1780	308			< 0.001				1.10	0.049		1.90			1.20	38.00
	Average 1988		7.5	3436	1769	219	283	2.97	< 0.001	0.008	< 0.003	< 0.040	< 0.68	0.075	2.7	1.16	2.57	3.17	0.71	42.20
		02/23/89	7.5	3141	1480	209	317	1.77	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.038	1.9	1.50	1.70	3.20	0.50	29.00
		05/22/89	7.6	2747	1710	215	369	0.46	0.002	0.012	< 0.010	< 0.020	< 0.05	< 0.001	1.2	0.30	1.20	1.50	0.40	26.00
		07/18/89	7.5	2414	1840	180	249	1.24	< 0.001	0.003	< 0.010	< 0.020	< 0.05	0.038	1.6	1.00	0.70	1.70	0.70	34.00
		10/19/89	7.4	2672	1570	230	340	0.65												
	Average 1989		7.5	2744	1650	208	318	1.03	< 0.002	< 0.006	< 0.010	< 0.020	< 0.05	< 0.026	1.4	0.93	1.20	2.13	0.53	29.70
		01/22/90	7.3	2871	1380	145	232	< 0.01	< 0.001	0.010	< 0.010	< 0.020	< 0.05	0.008	1.5	0.90	2.60	3.50	0.70	22.00
		05/02/90	7.7	2228	1140	125	152	0.29												
		08/23/90	7.5	2506	1500	145	227	0.43	0.001	0.004	< 0.010	< 0.020	< 0.05	< 0.001	2.5	0.40	1.50	1.90	0.20	32.00
		10/18/90	7.5	2667	1300	140	228	0.28												
	Average 1990		7.4	2568	1330	139	210	< 0.25	< 0.001	0.007	< 0.010	< 0.020	< 0.05	< 0.005	2.0	0.65	2.55	3.20	0.45	27.00

ATTACHMENT 3A TDSS COMPLIANCE MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
125	TDM XXVI	01/10/91	7.2	2568	1531	117	235	0.04	< 0.001	< 0.010	< 0.050	< 0.050	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	30.70
		04/18/91	7.4	2526	1390	110	225	0.50												
		07/03/91	7.4	2405	1249	109	214	0.04	0.002	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.70	< 1.00	< 1.70	< 0.20	40.30
		10/10/91	7.4	2370	1279	106	194	0.16												
	Average 1991		7.3	2467	1362	110	217	0.19	< 0.002	< 0.010	< 0.050	< 0.035	< 0.05	< 0.001	< 1.0	< 0.45	< 1.00	< 1.45	< 0.20	35.50
		01/08/92	7.3	2308	1351	87.7	186	< 0.10	0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	2.20	< 2.40	< 0.20	31.10
		04/23/92	7.3	2325	1220	96.3	200	< 0.10												
		07/23/92	7.2	2336	1230	89.7	213	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	22.30
		10/23/92	7.5	2328	1295	93.4	191	< 0.10												
	Average 1992		7.3	2324	1274	91.8	197	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.60	< 1.80	< 0.20	26.70
		01/11/93	7.3	2235	1234	91.9	183	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.80	1.90	2.70	< 0.20	7.45
		04/26/93	7.2	2032	1117	96.3	167	0.10												
		07/10/93	7.0	2291	1155	92.3	173	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	2.1	1.30	6.30	7.60	< 0.20	22.34
		10/25/93	7.4	2002	1090	85.8	158	0.13												
	Average 1993		7.2	2140	1149	91.6	170	< 0.11	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.6	1.05	4.10	5.15	< 0.20	14.90
		01/12/94	7.1	2029	1098	85.2	157	< 0.10	0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	6.3	.60	3.70	4.30	< 0.20	20.90
		04/25/94	7.3	2005	1101	85.9	145	< 0.10												
		07/08/94	7.8	2117	1124	88.4	146	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	2.0	1.50	< 1.00	< 2.50	< 0.20	37.20
		10/24/94	7.4	2078	1148	89.5	154	< 0.10												
	Average 1994		7.4	2057	1118	87.2	150	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	4.2	1.05	2.35	< 3.40	< 0.20	29.05
		01/26/95	7.4	2124	1183	88.6	145	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.002	< 1.0	0.30	< 1.00	< 1.30	< 0.20	27.00
		05/04/95	7.8	2198	1161	92.0	155	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	3.2	0.50	1.60	2.10	< 0.20	23.00
		07/24/95	7.1	2079	1080	92.0	144	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	1.3	0.80	2.60	3.40	< 0.20	30.00
		11/20/95	7.2	1930	1023	72.9	142	0.38												
	Average 1995		7.4	2083	1112	86.4	146	< 0.17	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.002	< 1.9	0.53	< 1.70	< 2.30	< 0.20	26.67
		01/26/96	7.5	2006	1014	69.2	143	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.20	< 1.00	< 1.20	< 0.20	28.50
		04/15/96	7.7	1891	1022	73.1	135	0.29												
		07/09/96	7.8	1909	1034	69.0	140	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.30	< 1.00	< 1.30	0.40	28.90
		11/11/96	7.4	1880	1084	80.0	126	< 0.10												
	Average 1996		7.6	1922	1039	72.8	136	< 0.15	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.25	< 1.00	< 1.25	< 0.30	28.70
		01/27/97	7.3	1850	989	71.0	130	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	23.70
		04/21/97	7.4	1860	922	75.0	127	0.22												
		07/01/97	7.6	1820	950	80.4	129	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	19.60
		10/06/97	7.3	1750	916	82.6	119	< 0.10												
	Average 1997		7.4	1820	944	77.2	126	< 0.14	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	21.65
		01/06/98	7.3	1730	998	65.2	127	< 0.10	< 0.001	< 0.005	< 0.050	< 0.020	< 0.05	0.002	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	24.20
		04/10/98	7.4	1630	872	70.0	115	< 0.10												
		07/01/98	7.5	1670	821	47.5	124	< 0.10	0.001	< 0.005	< 0.050	< 0.020	< 0.05	0.002	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	19.50

ATTACHMENT 3A TDSS COMPLIANCE MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
175	TDM XLI	08/17/88	6.2	5685	2920	455		0.12	< 0.001	0.009	0.520	0.720	0.12	< 0.001	3.1	2.10	2.60	4.70	1.00	0.20
		09/01/88	6.2	5420	2940	449		0.92	0.001	0.010	0.580	0.730	0.16	< 0.001	8.1	1.10	10.00	11.10	0.30	2.10
		09/14/88	6.2	5298	3420	331		0.03	< 0.001	0.010	< 0.010	0.810	< 0.05	0.003	3.6	1.50	5.80	7.30	0.40	0.30
		09/28/88	6.4	4929	3270	376	291	0.12	< 0.001	0.012	0.550	0.830	0.08	< 0.001	8.2	1.00	9.40	10.40	0.60	0.70
	Average 1988		6.2	5333	3138	403	291	0.30	< 0.001	0.010	< 0.415	0.772	< 0.11	< 0.002	5.8	1.43	6.95	8.38	0.58	0.83
		01/12/89	6.5	5810	3950	410	279	0.35	< 0.001	0.012	0.200	0.900	< 0.05	0.007	7.1	2.10	6.20	8.30	1.00	0.80
		04/25/89	6.4	5766	3600	480	299	0.24	< 0.001	0.014	0.770	0.720	< 0.05	< 0.001	2.3	0.60	1.50	2.10	0.90	< 0.20
		07/14/89	6.4	5393	3000	410	284	0.07	< 0.001	0.011	0.400	0.730	< 0.05	0.001	1.6	1.30	0.80	2.10	0.90	0.30
		10/20/89	6.4	5542	3980	420	360	0.04												
		12/12/89	6.4	5526	2200	420	314	0.13	< 0.001	0.014	2.030	1.130	< 0.05	< 0.001	4.9	1.60	3.30	4.90	1.00	0.40
	Average 1989		6.4	5607	3346	428	307	0.17	< 0.001	0.013	0.850	0.870	< 0.05	< 0.003	4.0	1.40	2.95	4.35	0.95	< 0.42
		01/16/90	6.1	3924	2480	430	324	< 0.01	< 0.001	0.014	1.970	1.190	< 0.05	0.001	1.5	1.30	1.60	2.90	1.50	0.90
		05/03/90	6.2	6080	3360	400	308	< 0.01												
		08/22/90	6.2	5864	3140	395	316	0.49	0.001	0.013	0.490	0.990	< 0.05	0.001	6.0	1.10	1.90	3.00	0.10	< 0.20
		10/19/90	6.2	7056	3850	384	274	0.43												
	Average 1990		6.2	5731	3208	402	306	< 0.24	< 0.001	0.014	1.230	1.090	< 0.05	0.001	3.8	1.20	1.75	2.95	0.80	< 0.55

ATTACHMENT 3A TDSS COMPLIANCE MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
175	TDM XLI	01/13/91	6.4	6722	4092	356	374	< 0.01	< 0.001	< 0.010	< 0.050	1.090	< 0.05	< 0.001	4.4	2.00	5.40	7.40	< 0.20	< 0.20
		04/21/91	6.1	7145	4139	369	315	< 0.01												
		07/03/91	6.1	6235	4091	346	394	< 0.01	< 0.001	< 0.010	< 0.050	1.300	< 0.05	< 0.001	< 1.0	0.90	4.60	5.40	< 0.20	1.80
		10/14/91	6.1	4097	2240	364	315	< 0.01												
	Average 1991		6.2	6049	3641	359	350	< 0.01	< 0.001	< 0.010	< 0.050	1.145	< 0.05	< 0.001	< 2.7	1.45	5.00	6.40	< 0.20	< 1.00
		01/08/92	6.4	7365	4463	303	310	< 0.10	< 0.001	< 0.010	< 0.050	1.39	< 0.05	< 0.001	1.0	1.30	6.10	7.40	< 0.20	< 0.20
		04/23/92	6.1	7312	4208	368	309	< 0.10												
		07/10/92	6.0	6758	4531	339	354	< 0.10	< 0.001	< 0.010	< 0.050	1.40	< 0.05	< 0.001	1.9	1.80	6.50	8.30	< 0.20	2.71
		10/27/92	6.2	7305	4505	322	286	< 0.10												
	Average 1992		6.2	7185	4427	333	315	< 0.10	< 0.001	< 0.010	< 0.050	1.40	< 0.05	< 0.001	1.5	1.55	6.30	7.85	< 0.20	< 1.46
		01/20/93	6.1	7426	4640	340	313	< 0.10	< 0.001	< 0.010	< 0.050	1.22	< 0.05	< 0.001	3.6	3.20	7.70	10.90	< 0.20	< 0.20
		04/27/93	5.9	6291	4198	373	321	< 0.10												
		07/13/93	5.9	7399	4507	363	355	< 0.10	< 0.001	< 0.010	< 0.050	1.32	< 0.05	< 0.001	2.2	1.70	4.30	6.00	< 0.20	1.35
		10/27/93	5.7	7486	4299	304	314	< 0.10												
	Average 1993		5.9	7151	4411	345	326	< 0.10	< 0.001	< 0.010	< 0.050	1.26	< 0.05	< 0.001	2.9	2.45	6.00	8.45	< 0.20	< 0.78
		01/12/94	6.0	6467	4103	300	362	< 0.10	< 0.001	< 0.010	< 0.050	1.98	< 0.05	< 0.001	18.4	2.20	10.70	12.90	< 0.20	0.68
		04/25/94	6.3	7553	4707	344	342	< 0.10												
		07/08/94	6.2	7595	4739	335	324	< 0.10	< 0.001	< 0.010	< 0.050	1.34	< 0.05	< 0.001	4.8	2.20	29.00	31.20	< 0.20	0.70
		10/25/94	6.3	6656	4681	300	357	0.91												
	Average 1994		6.2	7068	4558	320	346	< 0.31	< 0.001	< 0.010	< 0.050	1.66	< 0.05	< 0.001	11.6	2.20	19.85	22.05	< 0.20	0.69
		01/30/95	6.4	7290	4875	304	330	< 0.10	< 0.001	< 0.010	< 0.050	1.53	< 0.05	< 0.001	18.7	3.20	10.20	13.40	< 0.20	0.40
		05/04/95	6.5	7179	4394	340	326	< 0.10	< 0.001	< 0.010	< 0.050	1.51	< 0.05	< 0.001	16.6	3.00	10.00	13.00	< 0.20	< 0.20
		07/21/95	6.1	7683	4720	323	350	< 0.10	< 0.001	< 0.010	< 0.050	1.57	< 0.05	< 0.001	6.7	2.20	8.80	11.00	< 0.20	< 0.20
		11/21/95	6.1	7013	3698	294	320	0.12												
	Average 1995		6.3	7291	4422	315	332	< 0.11	< 0.001	< 0.010	< 0.050	1.54	< 0.05	< 0.001	14.0	2.80	9.67	12.46	< 0.20	< 0.27
		01/26/96	6.8	7367	4335	271	329	< 0.10	< 0.001	< 0.010	< 0.050	1.44	< 0.05	< 0.001	6.7	1.80	6.70	8.50	< 0.20	< 0.20
		05/01/96	6.5	7255	4445	325	345	< 0.10												
		07/11/96	6.5	7298	4610	308	335	< 0.10	< 0.001	< 0.010	< 0.050	1.70	< 0.05	< 0.001	2.7	1.60	< 1.00	< 2.60	1.50	< 0.20
		11/12/96	6.0	7270	4204	338	295	< 0.10												
	Average 1996		6.5	7298	4399	311	326	< 0.10	< 0.001	< 0.010	< 0.050	1.57	< 0.05	< 0.001	4.7	1.70	< 3.85	< 5.55	< 0.85	< 0.20
		01/31/97	6.4	6530	4200	325	289	< 0.10	< 0.001	< 0.010	< 0.050	1.19	< 0.05	0.001	< 1.0	0.90	< 1.00	< 1.90	< 0.20	< 0.20
		04/26/97	6.6	6640	4100	303	295	< 0.10												
		07/11/97	6.6	7000	4350	304	303	< 0.10	< 0.001	< 0.010	< 0.050	1.34	< 0.05	< 0.001	< 1.0	1.20	11.50	12.70	< 0.20	0.41
		10/07/97	6.0	7000	4370	283	290	< 0.10												
	Average 1997		6.4	6793	4255	304	294	< 0.10	< 0.001	< 0.010	< 0.050	1.27	< 0.05	< 0.001	< 1.0	1.05	< 6.25	< 7.30	< 0.20	< 0.31
		01/01/98	6.1	6930	4000	281	283	< 0.10	< 0.001	< 0.005	< 0.050	1.57	< 0.05	0.004	4.7	2.50	10.50	13.00	< 0.20	7.40
		04/20/98	6.2	6370	3500	296	295	< 0.10												
		07/07/98	5.9	6550	3967	270	299	< 0.22	0.001	< 0.005	< 0.050	1.25	< 0.05	0.004	4.4	1.50	11.50	13.00	< 0.20	0.30

ATTACHMENT 3A TDSS COMPLIANCE MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
176	TDM XLII	08/23/88	8.0	2546	950	175		0.44	< 0.001	0.003	< 0.010	0.050	< 0.05	< 0.001	4.1	1.30	2.40	3.70	1.10	0.05
		09/07/88	8.4	2345	1270	180		0.36	< 0.001	0.005	< 0.010	< 0.020	< 0.05	< 0.001	3.6	0.90	3.90	4.80	0.50	0.05
		09/21/88	8.2	2524	1410	185		0.13	< 0.001	0.007	< 0.010	0.040	< 0.05	< 0.001	3.1	1.10	3.60	4.70	0.60	1.20
		10/05/88	8.4	2390	1500	172	193	0.25	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	6.3	2.10	4.80	6.90	0.90	1.30
	Average 1988		8.2	2451	1282	178	193	0.30	< 0.001	< 0.005	< 0.010	< 0.032	< 0.05	< 0.001	4.3	1.35	3.68	5.03	0.78	0.65
		01/18/89	8.0	2641	1580	182	197	0.39	< 0.001	0.006	< 0.010	0.140	< 0.05	0.004	5.6	1.90	5.00	6.90	0.50	1.70
		04/26/89	8.2	2491	1880	215	195	< 0.01	< 0.001	0.007	< 0.010	< 0.020	< 0.05	< 0.001	3.0	0.90	2.00	2.90	0.20	< 0.20
		07/17/89	8.1	2546	1540	250	198	0.17	< 0.001	0.006	< 0.010	< 0.020	< 0.05	0.001	1.4	1.10	0.90	2.00	0.60	0.80
		10/23/89	8.3	2645	1570	205	204	0.09												
	Average 1989		8.2	2581	1642	213	198	< 0.16	< 0.001	0.006	< 0.010	< 0.060	< 0.05	< 0.002	3.3	1.30	2.63	3.93	0.43	< 0.90
		01/17/90	8.0	2066	1650	190	205	< 0.01	< 0.001	0.012	< 0.010	0.030	< 0.05	0.001	1.6	1.30	2.00	2.30	0.20	0.30
		04/24/90	7.6	2706	1100	375	238	0.08												
		08/24/90	8.1	2576	1500	172	206	0.03	< 0.001	0.008	0.030	< 0.020	< 0.05	< 0.001	2.2	0.60	2.30	2.90	0.20	< 0.20
		10/18/90	8.0	2796	1350	198	201	< 0.01												
	Average 1990		7.9	2536	1400	234	212	< 0.04	< 0.001	0.010	< 0.020	< 0.025	< 0.05	< 0.001	1.9	0.95	2.15	2.60	0.20	< 0.25

ATTACHMENT 3A TDSS COMPLIANCE MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
176	TDM XLII	01/11/91	7.8	2693	1631	178	210	0.01	< 0.001	< 0.010	< 0.050	< 0.050	< 0.05	< 0.001	1.8	0.20	< 1.00	< 1.20	1.40	< 0.20
		04/18/91	7.3	2732	1548	182	160	< 0.01												
		07/03/91	7.0	2742	1483	187	207	< 0.01	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.30	< 1.00	< 1.30	< 0.20	2.40
		10/10/91	7.5	2884	1538	181	194	< 0.01												
	Average 1991		7.4	2763	1625	182	193	< 0.01	< 0.001	< 0.010	< 0.050	< 0.035	< 0.05	< 0.001	< 1.4	0.25	< 1.00	< 1.25	< 0.80	< 1.30
		01/09/92	6.9	2835	1509	181	194	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.80	3.30	4.10	< 0.20	< 0.20
		04/22/92	7.6	2754	1551	175	207	< 0.10												
		07/09/92	7.4	2663	1445	164	261	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.60	3.50	4.10	< 0.20	0.68
		10/26/92	7.6	2703	1479	170	221	< 0.10												
	Average 1992		7.4	2739	1496	172	221	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.70	3.40	4.10	< 0.20	< 0.44
		01/20/93	7.6	2508	1466	176	176	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	1.6	1.3	< 1.0	< 2.3	< 0.20	< 0.20
		04/28/93	7.3	2331	1335	173	180	< 0.10												
		07/12/93	7.0	2810	1450	251	228	10.50	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	4.2	3.6	< 1.0	< 4.6	< 0.20	1.35
		10/26/93	7.0	2559	1412	175	195	< 0.10												
	Average 1993		7.2	2552	1416	194	195	< 2.70	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	2.9	2.5	< 1.0	< 3.5	< 0.20	< 0.78
		01/13/94	7.1	2420	1396	170	187	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	6.1	0.80	3.40	4.20	< 0.20	0.68
		04/24/94	7.1	2822	1685	185	209	< 0.10												
		07/17/94	7.5	3172	1747	204	208	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	12.8	1.20	7.60	8.80	< 0.20	< 0.20
		10/25/94	7.1	3242	1801	211	227	< 0.10												
	Average 1994		7.2	2914	1657	192	208	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	9.4	1.00	5.50	6.50	< 0.20	< 0.44
		01/26/95	7.0	3212	1728	208	221	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.001	8.1	1.50	4.30	5.80	< 0.20	< 0.20
		04/24/95	7.1	3312	1742	235	223	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	1.6	0.70	4.30	5.00	< 0.20	0.70
		07/21/95	7.1	3221	1737	231	220	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	4.2	1.70	3.20	4.90	< 0.20	0.20
		11/20/95	7.2	3445	1724	217	235	< 0.10												
	Average 1995		7.1	3298	1733	223	225	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	4.6	1.30	3.93	5.23	< 0.20	< 0.37
		01/24/96	7.6	3506	1892	232	230	0.19	0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	2.4	1.50	< 1.00	< 2.50	< 0.20	< 0.20
		04/24/96	6.5	3484	1892	238	234	< 0.10												
		07/11/96	7.5	3507	1970	225	241	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	1.3	1.30	< 1.00	< 2.30	< 0.20	2.00
		11/11/96	7.2	3540	1952	247	213	< 0.10												
	Average 1996		7.2	3509	1927	236	230	< 0.13	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	1.6	1.40	< 1.00	2.40	< 0.20	<1.10
		01/27/97	7.3	3510	2055	264	212	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.90	< 1.00	< 1.90	< 0.20	<0.20
		04/26/97	7.3	3620	1903	248	214	< 0.10												
		07/07/97	7.5	3530	1807	231	221	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	1.00	4.40	5.40	< 0.20**	<0.20
		10/09/97	7.1	3570	1870	222	209	< 0.10												
	Average 1997		7.3	3558	1909	241	214	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.95	< 2.70	< 3.65	< 0.20	<0.20
		01/05/98	7.0	3230	1850	242	221	< 0.10	< 0.001	< 0.005	< 0.050	< 0.020	< 0.05	0.005	< 1.0	1.60	3.60	5.20	< 0.20	0.20
		04/20/98	7.3	3590	1900	234	226	< 0.10												
		07/02/98	7.2	3720	1830	213	222	< 0.10	< 0.001	< 0.005	< 0.050	< 0.020	< 0.05	0.004	< 1.0	0.90	3.70	4.60	< 0.20	0.30

ATTACHMENT 3A TDSS COMPLIANCE MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
177	TDM XLIII	08/22/88	6.1	4974	2080	325		< 0.01	< 0.001	0.010	< 0.010	0.110	< 0.05	< 0.001	3.0	1.60	2.00	3.60	1.20	43.00
		09/07/88	6.1	4450	2250	308		0.40	< 0.001	0.016	< 0.010	0.120	< 0.05	< 0.001	3.6	0.80	4.30	5.10	0.50	69.00
		09/21/88	6.3	4526	2510	290		0.12	< 0.001	0.013	< 0.010	0.150	< 0.05	0.001	2.9	1.00	6.50	7.50	0.50	62.00
		10/18/88	6.3	5349	2470	338	283	0.15	< 0.001	0.011	< 0.010	0.140	< 0.05	< 0.001	2.8	1.20	6.90	8.10	1.00	41.00
	Average 1988		6.2	4825	2328	315	283	< 0.17	< 0.001	0.012	< 0.010	0.130	< 0.05	< 0.001	3.1	1.15	4.92	6.07	0.80	53.75
		01/11/89	6.5	4167	2800	282	283	0.75	< 0.001	0.011	< 0.010	< 0.020	< 0.05	0.002	4.6	1.80	5.70	7.50	0.70	64.00
		04/24/89	6.4	4037	3050	460	277	0.25	< 0.001	0.011	< 0.010	< 0.020	< 0.05	< 0.001	4.0	1.60	2.40	4.00	1.80	20.00
		07/13/89	6.4	4636	2690	320	273	0.14	< 0.001	0.008	< 0.010	< 0.020	< 0.05	0.003	2.0	1.80	1.20	3.00	1.40	64.00
		10/20/89	6.4	4432	2650	310	350	0.18												
		12/18/89	6.4	4355	2290	310	280	0.44	< 0.001	0.015	0.040	0.090	< 0.05	< 0.001	3.0	1.40	1.60	3.00	1.10	47.00
	Average 1989		6.4	4325	2696	336	293	0.35	< 0.001	0.011	< 0.018	< 0.038	< 0.05	< 0.002	3.4	1.65	2.72	4.37	1.25	48.80
		01/18/90	6.3	3105	2400	290	274	< 0.01	< 0.001	0.015	< 0.010	0.060	< 0.05	0.001	2.1	1.40	1.60	3.00	0.60	36.00
		05/30/90	5.9	5022	2880	320	317	2.36												
		08/24/90	6.6	3783	2170	275	293	0.13	< 0.001	0.009	0.040	0.070	< 0.05	< 0.001	6.1	1.60	2.10	3.70	0.20	25.00
		10/19/90	6.5	4624	2500	265	277	0.14												
	Average 1990		6.3	4134	2488	288	290	< 0.66	< 0.001	0.012	< 0.025	0.065	< 0.05	< 0.001	4.1	1.50	1.85	3.35	0.40	30.50

ATTACHMENT 3A TDSS COMPLIANCE MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
177	TDM XLIII	01/13/91	6.2	4809	2903	264	322	0.04	< 0.001	< 0.010	0.060	0.200	< 0.05	< 0.001	0.9	0.70	< 1.00	< 1.70	< 0.20	22.50
		04/21/91	6.6	4638	2446	258	248	0.04												
		07/03/91	6.4	4647	2476	257	269	< 0.01	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	1.0	1.20	1.80	3.00	< 0.20	34.10
		10/14/91	6.4	4654	2413	292	271	0.39												
	Average 1991		6.4	4687	2560	268	278	< 0.12	< 0.001	< 0.010	< 0.055	< 0.110	< 0.05	< 0.001	1.0	0.95	< 1.40	< 2.35	< 0.20	28.30
		01/14/92	6.4	4596	2552	261	254	1.40	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	1.4	2.10	1.70	3.80	< 0.20	35.20
		04/23/92	6.0	4120	2311	282	260	0.90												
		07/10/92	6.4	4611	2495	248	338	0.20	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.80	6.20	7.00	< 0.20	31.80
		10/27/92	6.5	3919	2273	241	269	1.09												
	Average 1992		6.3	4311	2408	258	280	0.90	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.2	1.45	3.95	5.40	< 0.20	33.50
		01/20/93	6.4	4497	2481	247	252	1.79	< 0.001	< 0.010	< 0.050	0.030	< 0.05	< 0.001	4.3	4.10	5.10	9.20	< 0.20	39.90
		04/27/93	6.3	4132	2354	237	247	3.90												
		07/15/93	6.2	4200	2529	204	255	0.67	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	1.9	1.40	4.30	5.70	< 0.20	41.30
		10/27/93	6.1	3744	2180	209	220	1.89												
	Average 1993		6.3	4143	2386	224	244	2.06	< 0.001	< 0.010	< 0.050	< 0.025	< 0.05	< 0.001	3.1	2.75	4.70	7.45	< 0.20	40.60
		01/12/94	6.3	3834	2161	230	222	20.50	< 0.001	< 0.010	< 0.050	0.320	< 0.05	< 0.001	6.1	1.40	3.00	4.40	< 0.20	54.20
		04/25/94	7.3	3583	2153	231	260	< 0.10												
		07/24/94	7.2	4351	2648	237	232	4.00	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.005	108.0	91.40	10.60	102.00	< 0.20	38.59
		10/27/94	7.2	4341	2503	239	275	35.0												
	Average 1994		7.0	4027	2366	234	247	14.90	< 0.001	< 0.010	< 0.050	< 0.170	< 0.05	< 0.003	57.0	46.4	6.80	53.20	< 0.20	46.40
		01/30/95	6.9	4404	2421	253	223	26.6	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.002	9.0	1.50	4.90	6.40	< 0.20	44.40
		05/04/95	7.2	4407	2500	298	241	30.6	< 0.001	< 0.010	< 0.050	0.020	< 0.05	< 0.001	6.2	1.30	7.20	8.50	< 0.20	57.50
		07/24/95	6.8	3712	2054	235	200	14.9	< 0.001	< 0.010	< 0.050	0.020	< 0.05	0.001	4.3	1.00	3.10	4.10	< 0.20	55.90
		11/22/95	6.9	4012	2165	212	234	9.98												
	Average 1995		7.0	4134	2285	250	224	20.5	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.002	6.5	1.27	5.07	6.33	< 0.20	52.60
		01/26/96	7.0	4179	2348	272	250	4.87	0.002	< 0.010	< 0.050	0.030	< 0.05	< 0.001	3.2	0.90	< 1.00	< 1.90	< 0.20	51.00
		05/01/96	7.6	4284	2331	276	256	4.01												
		07/10/96	7.4	4299	2470	240	262	3.03	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.90	< 1.00	< 1.90	< 0.20	56.80
		10/12/96	DRY WELL																	
	Average 1996		7.3	4254	2383	263	256	3.97	< 0.002	< 0.010	< 0.050	< 0.025	< 0.05	< 0.001	< 2.1	0.90	< 1.00	< 1.90	< 0.20	53.90
		01/27/97	DRY WELL																	
		04/26/97	WATER LEVEL TOO LOW TO SAMPLE																	
		07/07/97	DRY WELL																	
		10/09/97	DRY WELL																	
	Average 1997		DRY WELL																	
		01/06/98	DRY WELL																	
		04/06/98	DRY WELL																	
		07/07/98	DRY WELL																	

ATTACHMENT 3B TDSS MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
015	TDM WELL D	01/27/88	6.9	3474	1420	265			< 0.001				0.80	0.002		1.70			0.70	69.00
		04/30/88	6.9	4273	1900	290			< 0.001				1.00	0.001		2.60			0.80	87.00
		07/20/88	6.9	4221	1660	380			< 0.001				0.00	0.007		1.70			2.50	186.00
		08/30/88	6.9	3423	1950	273		0.83	< 0.001	0.007	0.030	0.040	0.09	0.002	1.5	0.90	2.60	3.50	0.40	52.00
		09/14/88	6.8	3811	1850	308		0.64	< 0.001	0.009	< 0.010	0.060	0.09	0.001	1.7	1.20	2.20	3.40	0.60	51.00
		09/28/88	6.9	3819	1810	300	263	0.38	0.001	0.007	< 0.010	0.040	0.08	0.001	1.6	1.50	2.00	3.50	0.90	44.00
		10/25/88	6.9	4201	2300	360	245	0.72	< 0.001	0.007	< 0.010	< 0.020	< 0.05	0.008	3.1	1.50	2.00	3.50	2.40	51.00
	Average 1988		6.9	3889	1599	311	254	0.64	< 0.001	0.008	< 0.020	< 0.040	< 0.30	0.003	2.0	1.60	2.20	3.50	1.20	77.00
		01/27/89	7.4	3230	1990	346	257	0.33	< 0.001	0.007	< 0.010	0.060	< 0.05	0.001	4.3	1.80	3.20	5.00	0.70	88.00
		04/28/89	7.2	3923	2180	280	268	0.29	< 0.001	0.006	0.010	< 0.020	< 0.05	< 0.001	2.8	1.40	1.20	2.60	1.40	27.00
		07/18/89	7.4	3062	1830	270	260	0.48	< 0.001	< 0.005	< 0.010	0.040	< 0.05	0.001	1.6	1.20	0.90	2.10	0.80	42.00
		10/19/89	7.4	3296	1700	265	310	0.2												
	Average 1989		7.4	3378	1925	290	274	0.34	< 0.001	< 0.006	< 0.010	< 0.040	< 0.05	< 0.001	2.9	1.50	1.77	2.45	0.97	52.00
		01/19/90	7.0	1724	1500	290	271	< 0.01	< 0.001	0.013	< 0.010	< 0.020	< 0.05	0.001	1.7	1.30	2.00	3.30	0.30	69.00
		05/01/90	7.2	3540	1780	255	243	0.08												
		08/23/90	Not Enough Water to Sample																	
		11/08/90	7.1	3610	1660	275	278	0.10												
	Average 1990		7.1	2958	1647	273	264	< 0.05	< 0.001	0.013	< 0.010	< 0.020	< 0.05	0.001	1.7	1.30	2.00	3.30	0.30	69.00

ATTACHMENT 3B   TDSS MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
015	TDM WELL D	01/10/91	7.1	4059	2225	261	264	< 0.01	< 0.001	< 0.010	< 0.050	< 0.050	< 0.05	< 0.001	3.1	1.50	10.40	11.90	< 0.20	162.80
		04/18/91	7.0	3972	2009	256	264	0.10												
		06/30/91	Not Enough Water to Sample																	
		10/07/91	Well Dry																	
	Average 1991		7.0	4016	2117	258	264	< 0.06	< 0.001	< 0.010	< 0.050	< 0.050	< 0.05	< 0.001	3.1	1.50	10.40	11.90	< 0.20	162.80
		01/08/92	Well Dry																	
		04/09/92	Well Dry																	
		07/24/92	Well Dry																	
		10/12/92	Well Dry																	
	Average 1992																			
		01/11/93	Well Dry																	
		04/10/93	Well Dry																	
		07/15/93	Well Dry																	
		10/26/93	Well Dry																	
	Average 1993																			
		01/12/94	Well Dry																	
		04/16/94	Well Dry																	
		07/07/94	Well Dry																	
		10/12/94	Well Dry																	
	Average 1994																			
		01/23/95	Well Dry																	
		04/03/95	Well Dry																	
		07/21/95	Well Dry																	
		11/20/95	Well Dry																	
	Average 1995																			
		01/15/96	Well Dry																	
		04/15/96	Well Dry																	
		07/09/96	Well Dry																	
		11/11/96	Well Dry																	
	Average 1996																			
		01/03/97	Well Dry																	
		04/11/97	Well Dry																	
		07/01/97	Well Dry																	
		10/06/97	Well Dry																	
Average 1997																				
		01/06/98	Well Dry																	
		04/04/98	Well Dry																	
		07/07/98	Well Dry																	

ATTACHMENT 3B TDSS MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
112	TDM VII	01/30/88	7.1	3479	1340	206			< 0.001	0.004	< 0.010		< 0.05	0.100		0.90			0.70	0.10
		04/30/88	7.1	3432	1840	220			0.001	0.007	< 0.010		< 0.05	< 0.001		1.20			2.10	29.00
		07/18/88	7.0	3715	1500	215			< 0.001	0.012	0.030		< 0.05	0.195		0.80			1.00	15.00
		08/31/88	7.3	3487	1750	242		0.28	< 0.001	0.006	0.020	< 0.020	< 0.05	0.139	2.5	0.70	4.10	4.80	0.30	33.00
		09/15/88	7.1	3748	1910	202		1.16	0.005	0.008	< 0.010	0.030	0.06	0.096	2.2	1.30	5.60	6.90	0.30	20.00
		09/29/88	7.2	3977	1780	211	252	1.11	0.001	0.008	< 0.010	0.040	< 0.05	0.181	4.0	1.40	3.50	4.90	0.70	17.00
		10/14/88	7.2	4392	1770	220		1.22	< 0.001	0.008	< 0.010	< 0.020	< 0.05	0.172	6.2	0.60	4.60	1.00	1.00	11.00
	Average 1988		7.1	3747	1699	217	252	0.94	< 0.002	0.008	< 0.014	< 0.028	< 0.05	< 0.126	3.7	0.99	4.45	5.53	0.87	18.00
		01/26/89	7.2	3208	1990	319	245	18.90	< 0.001	0.007	< 0.010	0.030	< 0.05	0.097	1.9	1.50	4.00	5.50	0.60	18.00
		04/27/89	7.5	3192	1810	260	250	12.20	< 0.001	0.007	< 0.010	< 0.020	< 0.05	< 0.001	2.3	0.90	2.00		0.30	4.90
		07/18/89	7.3	3045	1830	260	244	13.30	< 0.001	0.010	< 0.010	0.060	< 0.05	0.260	1.7	1.40	0.80			6.50
		10/19/89	7.0	3108	1900	230	309	12.00												
	Average 1989		7.3	3138	1883	267	262	14.00	< 0.001	0.008	< 0.010	< 0.037	< 0.05	< 0.119	1.3	1.27	2.27	5.50	0.45	9.80
		01/19/90	7.0	2350	1630	220	259	11.80	< 0.001	0.012	< 0.010	< 0.020	< 0.05	0.177	1.4	1.20	3.30	4.50	0.10	11.00
		05/01/90	7.2	3528	1730	225	227	11.80												
		08/23/90	7.3	3203	1520	202	263	4.47	0.001	0.009	< 0.010	< 0.020	< 0.05	0.169	2.8	0.70	1.60	2.30	0.20	10.00
		10/19/90	7.0	3578	1680	216	253	3.09												
	Average 1990		7.1	3185	1640	216	250	7.79	< 0.001	0.011	< 0.010	< 0.020	< 0.05	0.173	2.1	0.95	2.45	3.40	0.15	10.50

ATTACHMENT 3B TDSS MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
112	TDM VII	01/11/91	7.1	3673	2043	207	249	11.50	< 0.001	< 0.010	< 0.050	< 0.050	< 0.05	0.148	1.0	0.60	4.20	4.80	< 0.20	10.00
		04/18/91	7.2	3874	2094	193	253	19.80												
		07/04/91	7.1	3671	2028	201	262	12.20	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.164	< 1.0	0.30	1.60	1.90	< 0.20	25.30
		10/10/91	7.3	3845	2039	204	246	6.80												
	Average 1991		7.1	3766	2051	201	253	12.58	< 0.001	< 0.010	< 0.050	< 0.035	< 0.05	0.156	< 1.0	0.45	2.90	3.35	< 0.20	17.65
		01/08/92	7.4	3485	1942	184	244	5.97	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.110	1.0	1.00	< 1.00	< 2.00	< 0.20	9.48
		04/23/92	7.1	3412	1923	193	280	4.90												
		07/09/92	8.0	3447	2038	175	309	8.40	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.106	< 1.0	0.30	2.00	2.30	< 0.20	11.50
		10/27/92	7.5	3758	2004	179	281	7.73												
	Average 1992		7.5	3525	1977	183	278	6.75	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.108	< 1.0	0.65	< 1.50	< 2.15	< 0.20	10.49
		01/11/93	8.0	3718	2008	176	279	10.9	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.058	2.7	2.50	12.60	15.10	< 0.20	< 0.20
		04/26/93	7.0	3697	1984	173	246	6.9												
		07/15/93	6.8	3824	2026	191	292	29.7	0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.105	7.3	6.90	3.00	9.90	< 0.20	8.12
		10/27/93	7.2	3462	1938	172	258	8.8												
	Average 1993		7.3	3675	1989	178	269	14.1	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.082	5.0	4.75	7.80	12.50	< 0.20	< 4.16
		01/14/94	7.0	3534	2037	177	243	6.2	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.102	12.1	1.60	6.90	8.50	< 0.20	10.20
		04/25/94	7.0	3569	1995	173	246	16.0												
		07/08/94	7.6	3793	1997	170	254	6.0	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.196	3.1	1.60	3.30	4.90	< 0.20	17.60
		10/27/94	7.5	3656	2106	175	264	8.03												
	Average 1994		7.3	3638	2034	174	252	9.16	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.149	7.6	1.60	5.10	6.70	< 0.20	13.90
		01/30/95	7.1	3766	2111	179	264	6.86	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.126	6.9	1.90	3.20	5.10	< 0.20	10.80
		05/04/95	7.4	3830	2072	201	239	6.80												
		07/21/95	7.0	3820	1974	193	242	6.71	0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.100	10.6	0.90	5.00	5.90	< 0.20	12.30
		11/22/95	7.0	3793	1986	170	253	8.85												
	Average 1995		7.1	3802	2036	186	250	7.30	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.113	8.8	1.40	4.10	5.50	< 0.20	11.55
		01/26/96	7.4	3887	1950	167	265	4.24	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.061	3.3	1.30	2.30	3.60	< 0.20	11.30
		04/30/96	7.5	3867	2042	181	274	4.02												
		07/09/96	7.4	3854	2047	180	266	3.03	0.005	< 0.010	< 0.050	< 0.020	< 0.05	0.052	1.2	0.90	< 1.00	< 1.90	0.50	15.90
		11/12/96	7.1	3830	2075	190	252	3.49												
	Average 1996		7.4	3860	2029	180	264	3.69	< 0.003	< 0.010	< 0.050	< 0.020	< 0.05	0.056	2.2	1.10	< 1.65	< 2.75	< 0.35	13.60
		02/04/97	7.2	3790	2080	215	263	3.65	0.002	< 0.010	< 0.050	< 0.020	< 0.05	0.062	2.4	< 0.20	2.40	< 2.60	< 0.20	12.90
		04/21/97	7.6	3790	1773	165	252	4.20												
		07/01/97	7.2	3770	1923	196	252	3.96	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.066	< 1.0	1.00	3.00	4.00	< 0.20	17.60
		10/09/97	7.1	3810	2040	182	250	4.21												
	Average 1997		7.3	3790	1954	190	254	4.00	< 0.002	< 0.010	< 0.050	< 0.020	< 0.05	0.064	< 1.7	< 0.60	2.70	< 3.30	< 0.20	15.25
		01/01/98	7.2	3830	2000	199	253	4.11	0.002	< 0.005	< 0.050	< 0.020	< 0.05	0.069	< 1.0	2.20	< 1.00	< 3.20	< 0.20	13.80
		04/04/98	7.4	3810	1850	183	324	3.48												
		07/01/98	7.0	3880	1910	170	250	3.66	0.003	< 0.005	< 0.050	< 0.020	< 0.05	0.074	< 1.0	0.90	< 1.00	< 1.90	< 0.20	13.40

ATTACHMENT 3B TDSS MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
114	TDM 1X	01/30/88	6.5	6616	3700	360			< 0.001	0.013	< 0.100		< 0.05	0.007		1.50			0.60	< 0.10
		04/30/88	6.3	7203	5400	400			< 0.001	0.013	0.010		< 0.05	0.003		1.40			1.30	< 0.70
		07/14/88	6.1	5899	2140	275			< 0.001	0.016	0.020		0.09	0.014		1.30			1.50	0.20
		08/25/88	6.1	6310	4420	387		0.03	< 0.001	0.008	0.610	0.710	0.08	< 0.001	3.4	0.70	5.40	6.10	0.50	0.10
		09/15/88	6.0	7240	5300	388		< 0.01	< 0.001	0.011	0.620	0.820	0.10	0.008	0.7	0.90	6.80	7.70	0.70	< 0.05
		09/29/88	6.0	7216	5140	376		0.12	< 0.001	0.012	0.600	0.020	0.11	< 0.001	12.5	0.80	6.80	7.60	0.40	1.00
		10/14/88	6.1	6802	5010	359	339	0.37	< 0.001	0.020	0.120	< 0.020	< 0.05	< 0.001	10.1	1.30	8.80	10.10	0.80	< 0.05
	Average 1988		6.2	6755	4444	364	339	< 0.14	< 0.001	0.013	< 0.297	< 0.390	< 0.08	< 0.005	6.7	1.13	6.95	7.88	0.83	< 0.17
		01/26/89	6.3	5394	4420	391	302	0.17	< 0.001	0.010	0.200	0.510	< 0.05	0.004	3.2	1.50	4.00	5.50	0.70	1.10
		04/26/89	6.4	5342	7050	390	328	< 0.01	< 0.001	0.010	0.790	0.690	< 0.05	0.002						
		07/14/89	6.3	6797	4300	400	313	0.28	< 0.001	0.010	0.470	0.410	< 0.05	0.002	1.4	1.10	0.90	2.00	0.80	< 0.20
		10/23/89	6.2	6676	3980	390	390	0.17												
		12/12/89	6.1	5861	2350	400	313	0.01	< 0.001	0.014	2.080	1.170	< 0.05	< 0.001	2.9	1.00	3.60	4.60	1.80	< 0.20
	Average 1989		6.3	6014	4420	394	329	< 0.13	< 0.001	0.011	0.865	0.700	< 0.05	< 0.003	2.5	1.20	2.83	4.03	1.10	< 0.50
		01/16/90	5.8	3347	3260	420	328	< 0.01	< 0.001	0.013	1.880	1.200	< 0.05	< 0.001	2.6	1.40	3.60	5.00	0.80	< 0.20
		05/03/90	6.2	6086	3940	600	286	< 0.01												
		08/24/90	6.3	5634	3100	400	318	0.50	0.001	0.012	0.500	0.970	< 0.05	0.002	4.3	1.80	1.60	3.40	0.30	< 0.20
		10/19/90	6.3	6306	3600	380	279	0.13												
	Average 1990		6.2	5343	3475	450	303	< 0.16	< 0.001	0.012	1.190	1.089	< 0.05	< 0.002	3.4	1.60	2.60	4.20	0.55	< 0.20

ATTACHMENT 3B TDSS MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
114	TDM IX	01/13/91	5.7	7232	4757	320	368	< 0.01	< 0.001	< 0.010	< 0.050	1.170	< 0.05	< 0.001	5.3	3.20	7.40	10.60	< 0.20	< 0.20
		04/18/91	6.1	6673	4017	343	338	< 0.01												
		07/04/91	6.1	5187	3209	303	336	< 0.01	< 0.001	< 0.010	< 0.050	0.700	< 0.05	< 0.001	< 1.0	0.70	< 1.00	< 1.70	< 0.20	< 0.20
		10/14/91	6.2	6582	4059	232	304	< 0.01												
	Average 1991		6.0	6419	4011	300	337	< 0.01	< 0.001	< 0.010	< 0.050	0.935	< 0.05	< 0.001	< 3.2	1.95	< 4.20	< 6.15	< 0.20	< 0.20
		01/08/92	6.0	6436	3823	239	307	< 0.10	< 0.001	< 0.010	< 0.050	1.28	< 0.05	< 0.001	2.0	2.00	6.60	8.60	< 0.20	0.68
		04/23/92	6.1	5795	3596	344	301	< 0.10												
		07/24/92	6.3	5971	4100	337	303	0.30	0.001	< 0.010	< 0.050	1.21	< 0.05	< 0.001	1.8	1.70	4.90	6.60	< 0.20	0.68
		10/27/92	6.3	6711	3424	348	293	< 0.10												
	Average 1992		6.2	6228	3736	317	301	< 0.15	< 0.001	< 0.010	< 0.050	1.24	< 0.05	< 0.001	1.9	1.85	5.75	7.60	< 0.20	0.68
		01/11/93	6.0	6934	4305	329	333	< 0.10	< 0.001	< 0.01	< 0.050	1.49	< 0.05	< 0.001	4.6	4.20	8.10	12.30	< 0.20	< 0.20
		04/27/93	5.7	6369	3877	295	260	0.10												
		07/13/93	5.7	6207	4113	336	341	0.62	< 0.001	< 0.01	< 0.050	1.41	< 0.05	0.004	9.3	8.10	9.60	17.70	< 0.20	0.68
		10/27/93	5.5	7133	3968	334	296	0.10												
	Average 1993		5.7	6661	4066	324	308	< 0.23	< 0.001	< 0.01	< 0.050	1.45	< 0.05	< 0.003	7.0	6.15	8.85	15.00	< 0.20	< 0.44
		01/12/94	5.9	6147	4004	263	377	0.21	< 0.001	< 0.01	< 0.050	1.36	< 0.05	0.002	23.4	3.70	13.00	16.70	< 0.20	0.68
		04/24/94	6.1	7617	4806	347	337	< 0.10												
		07/08/94	6.6	7668	4881	344	324	< 0.10	< 0.001	< 0.01	< 0.050	0.40	< 0.05	0.001	14.0	2.80	29.00	31.80	< 0.20	1.40
		10/12/94	6.5	7309	4493	323	370	1.17												
	Average 1994		6.3	7185	4546	319	352	< 0.40	< 0.001	< 0.01	< 0.050	0.88	< 0.05	0.002	18.7	3.25	21.00	24.25	< 0.20	1.04
		01/30/95	6.4	7786	5220	327	335	< 0.10	< 0.001	< 0.01	< 0.050	0.49	< 0.05	< 0.001	28.0	10.00	11.90	21.90	< 0.20	2.00
		05/04/95	6.4	7692	4783	327	310	0.12												
		07/24/95	6.0	7760	4819	339	307	< 0.10	< 0.001	< 0.01	< 0.050	0.65	< 0.05	0.001	2.2	3.00	4.20	7.20	< 0.20	<0.20
		11/21/95	5.9	7347	4305	299	295	0.14												
	Average 1995		6.2	7646	4782	323	312	< 0.12	< 0.001	< 0.01	< 0.050	0.57	< 0.05	< 0.001	15.1	6.50	8.05	14.55	< 0.20	<1.10
		01/26/96	6.2	7037	4285	295	330	< 0.10	0.001	< 0.01	< 0.050	1.41	< 0.05	< 0.001	11.4	5.70	5.20	10.90	< 0.20	<0.20
		04/30/96	6.3	7577	4350	328	350	0.10												
		07/09/96	6.2	7537	4820	317	330	< 0.10	0.001	< 0.01	< 0.050	0.40	< 0.05	< 0.001	3.0	2.10	9.80	11.90	1.7	0.50
		11/12/96	6.0	7600	4769	337	292	0.22												
	Average 1996		6.2	7438	4556	319	326	< 0.13	0.001	< 0.01	< 0.050	0.90	< 0.05	< 0.001	7.2	3.90	7.50	11.40	< 0.95	<0.35
		02/04/97	6.2	7510	4835	350	325	< 0.10	0.007	< 0.01	< 0.050	1.62	< 0.05	< 0.002	< 1.0	0.70	4.50	5.20	< 0.20	<0.20
		04/26/97	6.3	7570	4475	289	308	< 0.10												
		07/08/97	6.3	7270	4385	297	293	< 0.10	< 0.001	< 0.01	< 0.050	1.23	< 0.05	< 0.001	3.7	1.40	4.60	6.00	< 0.20	0.68
		10/07/97	5.9	7410	4550	325	292	< 0.10												
	Average 1997		6.2	7440	4561	315	305	< 0.10	< 0.004	< 0.01	< 0.050	1.43	< 0.05	< 0.002	< 2.4	1.05	4.55	5.60	< 0.20	<0.44
		01/05/98	5.9	6880	4200	332	307	< 0.10	< 0.001	< 0.01	< 0.050	1.05	< 0.05	0.004	< 1.0	2.70	3.60	6.30	< 0.20	0.20
		04/10/98	5.9	6630	4300	332	298	0.66												
		07/02/98	6.2	6970	4380	290	307	< 0.10	< 0.001	< 0.01	< 0.050	0.26	< 0.05	0.003	< 1.0	0.40	3.50	3.90	< 0.20	0.30

ATTACHMENT 3B TDSS MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
117	TDM XII	01/30/88	6.3	4514	2250	270			< 0.001	0.013	< 0.010		< 0.05	0.004		1.60			0.66	0.20
		04/30/88	6.4	4933	2670	300			0.003	0.014	< 0.010		< 0.05	0.004		2.10			1.40	57.00
		07/18/88	6.2	5044	1970	265			< 0.001	0.017	0.030		0.09	0.007		3.00			1.20	44.00
		08/25/88	6.2	4414	2320	299		0.15	0.001	0.008	< 0.010	0.070	0.08	< 0.001	4.3	1.50	6.50	8.00	1.00	55.00
		09/09/88	6.2	5064	2350	308		0.20	0.001	0.012	< 0.010	0.090	0.10	0.001	3.5	1.20	2.70	3.90	0.50	60.00
		09/23/88	6.2	4243	2740	308		0.11	< 0.001	0.011	0.020	0.020	0.06	< 0.001	5.1	1.30	6.70	8.00	0.40	51.00
		04/26/89	6.4	3676	2510	305	277	< 0.01	0.002	0.016	< 0.010	< 0.020	< 0.05	< 0.001	3.3	1.10	1.80	2.70	1.20	24.00
		07/13/89	6.3	4214	2650	350	267	0.30	< 0.001	0.008	< 0.010	0.080	< 0.05	0.003	1.7	1.20	0.60	1.80	0.90	14.00
		10/20/89	6.4	3941	2560	295	340	0.16												
		12/18/89	6.4	3277	2150	350	282	0.24	< 0.001	0.013	0.040	0.090	< 0.05	< 0.001	3.2	1.40	1.90	3.30	1.40	46.00
	Average 1989		6.4	3577	2468	325	292	< 0.18	< 0.002	0.012	< 0.020	< 0.063	< 0.05	< 0.002	2.7	1.23	1.43	2.60	1.17	28.00
		01/18/90	6.2	2812	2120	310	273	< 0.01	< 0.001	0.012	< 0.010	< 0.020	< 0.05	0.001	2.9	1.20	3.30	4.50	1.70	22.00
		05/03/90	6.3	4344	2260	255	256	< 0.01												
		08/22/90	6.5	3698	1750	228	269	0.08	< 0.001	0.009	< 0.010	0.070	< 0.05	< 0.001	2.9	0.80	1.30	2.10	0.20	19.00
		10/19/90	6.4	4339	2380	260	267	0.08												
	Average 1990		6.4	3798	2128	263	266	< 0.05	< 0.001	0.010	< 0.010	< 0.045	< 0.05	< 0.001	2.9	1.00	2.30	3.30	0.95	20.50

ATTACHMENT 3B TDSS MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
117	TDM XII	01/13/91	6.6	4384	2449	245	264	0.37	< 0.001	< 0.010	< 0.050	< 0.050	< 0.05	< 0.001	3.1	0.60	4.70	5.30	< 0.20	45.10
		04/21/91	6.3	4631	2531	249	271	1.20												
		07/04/91	6.5	4455	2364	246	244	0.10	< 0.001	0.010	< 0.050	< 0.020	< 0.05	0.010	< 1.0	0.40	< 1.00	< 1.40	< 0.20	52.80
		10/14/91	6.5	4549	2448	276	235	0.45												
	Average 1991		6.4	4505	2448	254	254	0.53	< 0.001	< 0.010	< 0.050	< 0.035	< 0.05	< 0.005	< 2.0	0.50	< 2.85	< 3.35	< 0.20	48.95
		01/14/92	6.6	4258	2390	249	238	0.48	< 0.001	< 0.010	< 0.050	0.040	< 0.05	< 0.001	1.0	1.00	6.80	7.80	< 0.20	60.30
		04/23/92	6.6	4068	2169	255	266	1.64												
		07/24/92	6.3	4253	2413	240	302	1.00	< 0.001	< 0.010	< 0.050	0.030	< 0.05	< 0.001	< 1.0	0.80	3.20	4.00	< 0.20	46.70
		10/27/92	6.9	4120	2406	235	277	2.40												
	Average 1992		6.6	4175	2344	245	271	1.38	< 0.001	< 0.010	< 0.050	0.035	< 0.05	< 0.001	< 1.0	0.90	5.00	5.90	< 0.20	53.50
		01/11/93	6.4	4555	2435	259	254	6.48	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	2.3	2.00	5.20	7.20	< 0.20	13.50
		04/22/93	6.2	4176	2342	251	225	6.40												
		07/14/93	6.2	4644	2449	257	249	4.31	< 0.001	< 0.010	< 0.050	0.080	< 0.05	< 0.001	3.9	3.30	5.00	8.30	< 0.20	52.81
		10/27/93	6.2	3900	2143	222	246	3.40												
	Average 1993		6.3	4319	2342	247	244	5.15	< 0.001	< 0.010	< 0.050	< 0.050	< 0.05	< 0.001	1.6	2.65	5.10	7.75	< 0.20	33.16
		01/12/94	6.4	4221	2271	242	222	2.96	< 0.001	< 0.010	< 0.050	0.020	< 0.05	0.004	5.0	3.80	< 1.00	< 4.80	< 0.20	47.40
		04/25/94	6.6	4232	2379	261	236	4.60												
		07/07/94	6.5	4572	2694	269	217	6.43	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.010	8.3	5.20	1.50	6.70	< 0.20	21.00
		10/24/94	7.0	4448	2553	259	266	4.08												
	Average 1994		6.6	4368	2474	258	235	4.52	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.007	6.6	4.50	< 1.25	< 5.75	< 0.20	34.20
		01/26/95	6.7	4518	2415	287	220	3.61	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	5.3	1.20	2.10	3.30	< 0.20	53.60
		05/04/95	7.3	4560	2603	318	234	4.10												
		07/24/95	6.4	4279	2248	271	230	4.04	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	7.9	1.40	2.80	4.20	< 0.20	39.30
		11/21/95	6.4	4188	2167	278	232	4.41												
	Average 1995		6.7	4386	2358	288	229	4.04	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	6.6	1.30	2.45	3.75	< 0.20	46.45
		01/26/96	6.9	4566	2325	253	270	< 0.10	0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	3.2	1.20	3.80	5.00	< 0.20	80.70
		04/30/96	6.7	5910	3700	310	305	< 0.10												
		07/10/96	7.0	4606	2386	301	250	0.20	< 0.001	< 0.010	< 0.050	0.070	< 0.05	< 0.001	2.3	1.50	12.20	13.70	0.80	58.90
		11/12/96	6.6	4650	2439	313	218	7.85												
	Average 1996		6.8	4933	2713	294	261	< 2.06	< 0.001	< 0.010	< 0.050	< 0.045	< 0.05	< 0.001	2.8	1.40	8.00	9.35	< 0.50	69.80
		01/31/97	7.4	4530	2500	303	240	1.53	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.002	< 1.0	0.60	5.00	5.60	< 0.20	62.30
		04/26/97	7.0	4540	2050	280	225	2.08												
		07/01/97	6.7	4620	2153	289	229	10.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.90	4.60	5.50	< 0.20	30.50
		10/06/97	6.5	4710	2470	278	218	10.40												
	Average 1997		6.9	4600	2293	289	228	6.03	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.002	< 1.0	0.75	4.80	5.55	< 0.20	46.40
		01/01/98	6.5	4610	2200	349	221	7.96	< 0.001	< 0.005	< 0.050	< 0.020	< 0.05	0.006	< 1.0	1.50	< 1.00	< 2.50	< 0.20	43.30
		04/06/98	6.5	4560	2250	310	230	2.29												
		07/01/98	6.5	4730	2150	264	228	4.78	0.001	< 0.005	< 0.050	< 0.020	< 0.05	0.006	< 1.0	0.70	2.10	2.80	2.10	45.20

ATTACHMENT 3B TDSS MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
120	TDM XXI	01/30/88	7.0	3736	1460	260		< 0.01	0.002	0.008	< 0.010		< 0.05	0.004		1.40			0.50	0.20
		04/30/88	7.0	2844	1850	280			< 0.001	0.009	< 0.010		< 0.05	0.002		1.10			2.50	78.00
		07/13/88	7.2	2890	1660	235			< 0.001	0.015			0.09	0.002		1.40			1.10	< 0.50
		08/25/88	6.9	3286	1610	273		0.44	0.002	0.007	0.040	< 0.020	0.08	< 0.001	3.3	0.40	3.90	4.30	0.60	60.00
		09/09/88	6.9	4090	2050	273		0.44	0.003	0.010	< 0.010	0.070	0.09	0.001	4.1	0.70	2.90	3.60	0.60	42.00
		09/23/88	7.0	2766	1670	277		0.15	0.002	0.010	< 0.010	< 0.020	0.06	< 0.001	3.2	0.80	3.70	4.50	0.50	57.00
		10/13/88	7.0	3584	1610	280	168	0.68	< 0.001	0.010	< 0.010	< 0.020	< 0.05	0.003	5.2	0.70	6.10	6.80	0.50	48.00
	Average 1988		7.0	3314	1701	268	168	< 0.34	< 0.002	0.010	< 0.010	< 0.040	< 0.07	< 0.002	4.0	0.93	4.15	4.80	0.90	<40.81
		01/27/89	7.2	2586	1700	346	168	0.29	0.002	0.007	< 0.010	0.030	< 0.05	< 0.001	3.1	1.30	3.70	5.00	0.40	41.00
		04/25/89	7.2	2978	1980	290	164	< 0.01	0.002	0.007	0.060	0.030	< 0.05	< 0.001	3.4	0.60	2.70	3.30	0.90	24.00
		07/17/89	7.2	3033	1460	270	160	0.07	0.003	0.004	< 0.010	0.040	< 0.05	< 0.001	1.4	0.90	0.60	1.50	0.50	16.00
		10/19/89	7.2	3187	1900	240	165	< 0.01												
	Average 1989		7.2	2946	1760	287	164	< 0.10	0.002	0.006	< 0.040	0.033	< 0.05	< 0.001	2.6	0.93	2.33	3.27	0.60	27.00
		01/16/90	6.9	2171	1600	240	158	< 0.01	0.001	0.011	< 0.010	< 0.020	< 0.05	0.001	2.7	1.00	2.30	3.30	1.50	21.00
		04/24/90	7.4	2182	1740	310	196	< 0.01												
		08/23/90	7.1	3397	1410	265	184	0.20	0.005	0.005	0.040	0.030	< 0.05	< 0.001	4.3	1.10	1.20	2.30	0.50	28.00
		10/18/90	7.2	3697	1850	395	202	0.19												
	Average 1990		7.2	2862	1650	302	205	< 0.11	0.003	0.008	< 0.025	< 0.025	< 0.05	< 0.001	3.5	1.05	1.75	2.80	1.00	24.50

ATTACHMENT 3B TDSS MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
120	TDM XXI	01/11/91	6.5	3957	2019	285	205	< 0.01	0.008	< 0.010	< 0.050	< 0.050	< 0.05	< 0.001	1.1	0.90	2.40	3.30	< 0.20	49.40
		04/18/91	7.1	4174	2046	259	224	0.05												
		07/04/91	7.1	4036	1984	265	212	< 0.01	0.005	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.50	< 1.00	< 1.50	< 0.20	42.80
		10/10/91	7.0	4197	2063	263	196	< 0.01												
	Average 1991		6.9	4091	2028	268	209	< 0.02	0.007	< 0.010	< 0.050	< 0.035	< 0.05	< 0.001	< 1.1	0.70	< 1.70	< 2.40	< 0.20	46.10
		01/08/92	7.2	4248	2068	257	193	< 0.10	0.008	< 0.010	< 0.050	0.040	< 0.05	< 0.001	< 1.0	0.50	5.10	5.60	< 0.20	32.50
		04/22/92	7.0	4001	2050	261	201	< 0.10												
		07/09/92	7.3	3866	2185	261	222	0.30	0.007	< 0.010	< 0.050	< 0.020	0.08	0.002	< 1.0	0.30	2.70	3.00	< 0.20	21.00
		10/26/92	7.2	4346	2120	298	221	< 0.10												
	Average 1992		7.2	4115	2106	269	209	< 0.15	0.008	< 0.010	< 0.050	< 0.030	< 0.07	< 0.002	< 1.0	0.40	3.90	4.30	< 0.20	26.75
		01/11/93	7.0	4282	2083	284	218	< 0.10	0.006	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	1.8	1.30	4.40	5.70	< 0.20	50.10
		04/26/93	7.2	4069	2120	275	196	0.10												
		07/10/93	6.7	4454	2102	284	228	< 0.10	0.004	< 0.010	< 0.050	< 0.020	< 0.05	0.002	21.5	20.50	8.20	28.70	< 1.00	64.99
		10/25/93	6.8	3885	1951	265	178	0.16												
	Average 1993		6.9	4173	2064	277	160	< 0.12	0.005	< 0.010	< 0.050	< 0.020	< 0.05	0.002	11.7	10.90	6.30	17.20	< 0.20	57.55
		01/13/94	6.9	4017	2050	247	173	0.16	0.002	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	8.6	1.50	4.60	6.10	< 0.20	38.60
		04/24/94	6.8	4090	2175	281	228	< 0.10												
		07/05/94	7.4	4355	2354	264	265	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	3.0	2.20	4.40	6.60	< 0.20	21.00
		10/24/94	7.8	4253	2252	294	221	< 0.10												
	Average 1994		7.2	4179	2208	272	222	< 0.12	< 0.002	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	5.8	1.85	4.50	6.35	< 0.20	29.80
		01/26/95	7.4	4554	2365	304	205	< 0.10	0.003	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	8.7	2.80	3.80	6.60	< 0.20	44.30
		04/24/95	7.2	4255	2112	370	188	< 0.10												
		07/21/95	6.7	4596	2134	316	184	< 0.10	0.004	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	1.3	1.40	5.30	6.70	< 0.20	52.20
		11/20/95	7.0	4168	2095	293	177	< 0.10												
	Average 1995		7.1	4393	2176	321	188	< 0.10	0.004	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	5.0	2.10	4.55	6.65	< 0.20	48.25
		01/24/96	7.3	4623	2163	278	191	< 0.10	0.002	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	5.1	1.90	1.60	3.50	< 0.20	13.40
		04/30/96	7.3	4648	2312	329	175	< 0.10												
		07/11/96	7.3	4722	2418	340	193	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	1.3	1.30	7.10	8.40	0.50	1.20
		11/12/96	6.9	4690	2421	370	170	< 0.10												
	Average 1996		7.2	4671	2329	329	182	< 0.10	< 0.002	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	3.2	1.60	4.35	5.95	< 0.35	7.30
		03/11/97	6.9	4730	2298	363	190	< 0.10	0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.90	< 1.00	< 1.90	< 0.20	2.70
		04/21/97	7.0	3840	1995	75	189	< 0.10												
		07/01/97	7.0	4880	2287	364	189	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.60	3.60	4.20	< 0.20	0.54
		10/09/97	7.2	4940	2300	410	184	< 0.10												
	Average 1997		7.0	4598	2220	303	188	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.75	< 2.30	< 3.1	< 0.20	1.62
		01/05/98	6.7	5050	2220	416	206	< 0.10	< 0.001	< 0.005	< 0.050	< 0.020	< 0.05	0.007	< 1.0	2.40	< 1.00	< 3.40	< 0.20	0.20
		04/10/98	6.8	5080	2350	421	204	< 0.10												
		07/01/98	6.7	5300	2310	371	222	< 0.10	0.002	< 0.005	< 0.050	< 0.020	< 0.05	0.006	< 1.0	0.60	< 1.00	< 1.60	1.60	1.20

ATTACHMENT 3B TDSS MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
127	TDM XXVIII	02/29/88	7.7	982	933	12			< 0.001				0.90	0.018		0.80			1.10	0.50
		05/31/88	7.6	931	348	14			< 0.001				1.00	0.017		1.50			0.10	33.00
		08/31/88	7.7	909	410	13		< 0.01	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.001	1.1	0.70	1.70	2.40	0.40	49.00
		09/15/88	7.7	911	394	22		< 0.01	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.001	4.1	1.10	1.10	2.20	0.50	57.00
		09/29/88	7.8	1051	390	11		0.28	< 0.001	0.003	< 0.010	< 0.020	< 0.05	0.001	1.3	0.80	3.60	4.40	0.50	60.00
		10/18/88	7.8	818	394	12	82	0.26	< 0.001	0.003	< 0.010	< 0.020	< 0.05	0.002	1.5	0.90	2.80	3.70	0.60	31.00
		11/28/88	7.5	875	221	16			< 0.001				1.00	0.016		1.70			1.10	32.00
	Average 1988		7.7	937	441	14	82	< 0.14	< 0.001	< 0.003	< 0.010	< 0.020	< 0.44	0.005	2.0	1.07	2.30	3.18	0.61	37.50
		02/23/89	8.2	969	400	15	128	0.29	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.001	1.7	1.80	1.90	3.70	0.50	33.00
		05/10/89	7.9	920	490	14	112	0.19	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	2.1	1.50	1.80	3.30	0.50	25.00
		07/18/89	7.9	873	530	16	83	0.45	< 0.001	< 0.002	< 0.010	< 0.020		0.001	1.2	0.90	0.70	1.60	0.60	42.00
		10/19/89	7.9	879	440	15	91	0.35												
	Average 1989		8.0	910	465	15	104	0.32	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	1.7	1.40	1.47	2.87	0.53	33.00
		01/19/90	7.7	747	390	17	84	< 0.01	< 0.001	0.004	< 0.010	< 0.020	< 0.05	0.002	1.5	0.70	1.50	2.20	0.70	56.00
		05/01/90	8.0	852	410	55	79	< 0.01												
		08/23/90	7.8	759	298	30	86	0.65	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.001	2.1	0.60	1.30	1.90	0.20	26.00
		10/19/90	7.7	861	340	16	89	0.56												
	Average 1990		7.8	805	360	30	84	< 0.31	< 0.001	< 0.003	< 0.010	< 0.020	< 0.05	< 0.002	1.8	0.65	1.40	2.05	0.45	41.00

ATTACHMENT 3B TDSS MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
127	TDM XXVIII	01/11/91	7.0	863	451	9.4	94.4	0.02	< 0.001	< 0.010	< 0.050	< 0.050	< 0.05	< 0.001	2.3	1.60	3.70	5.30	< 0.20	34.50
		04/21/91	7.5	820	418	9.8	94.9	0.06												
		07/04/91	7.7	925	447	10.2	85.0	< 0.01	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.30	< 1.00	< 1.30	< 0.20	32.10
		10/14/91	7.2	857	423	4.7	82.9	0.05												
	Average 1991		7.3	866	435	8.5	89.3	< 0.04	< 0.001	< 0.010	< 0.050	< 0.035	< 0.05	< 0.001	< 1.7	0.95	< 2.35	< 3.30	< 0.20	33.30
		01/08/92	7.6	863	424	10.2	85.1	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	34.50
		04/22/92	7.3	889	416	9.6	92.6	< 0.10												
		07/23/92	7.4	901	435	10.8	93.9	< 0.10	0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	29.80
		10/26/92	7.4	899	452	14.8	96.1	< 0.10												
	Average 1992		7.4	888	432	11.3	91.9	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	32.15
		01/11/93	7.5	859	410	13.0	86.0	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	46.51
		04/26/93	7.4	831	396	12.5	72.0	< 0.10												
		07/10/93	7.0	839	433	11.5	76.0	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.50	3.80	4.30	< 0.20	26.40
		10/25/93	7.1	838	384	9.6	76.7	0.16												
	Average 1993		7.3	842	406	11.7	77.7	< 0.12	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.35	< 2.40	< 2.75	< 0.20	36.46
		01/22/94	7.3	842	378	8.8	72.9	0.17	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.80	< 1.00	< 1.80	< 0.20	27.10
		04/25/94	7.6	843	372	11.1	71.6	< 0.10												
		07/06/94	7.8	880	388	10.4	70.4	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.50	< 1.00	< 1.50	< 0.20	56.20
		10/24/94	7.6	765	381	15.6	73.0	< 0.10												
	Average 1994		7.6	832	380	11.5	72.0	< 0.12	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.65	< 1.00	< 1.65	< 0.20	41.65
		01/26/95	7.2	828	364	24.6	67.0	0.19	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.007	< 1.0	0.40	< 1.00	< 1.40	< 0.20	39.90
		05/04/95	7.6	847	339	33.0	67.0	< 0.10												
		07/21/95	7.5	787	333	41.0	69.0	0.15	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.007	< 1.0	0.80	2.60	3.40	< 0.20	42.50
		11/20/95	7.7	813	308	44.2	70.2	0.28												
	Average 1995		7.5	819	336	35.7	68.3	< 0.18	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.007	< 1.0	0.60	< 1.80	< 2.40	< 0.20	41.20
		01/24/96	7.8	843	310	44.0	69.5	0.19	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	41.10
		04/15/96	8.0	814	339	51.0	69.4	0.28												
		07/09/96	8.0	837	348	47.0	71.0	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.6	< 0.20	< 1.00	< 1.20	< 0.20	40.80
		11/11/96	7.6	827	356	55.0	64.6	< 0.10												
	Average 1996		7.9	830	338	49.2	68.5	< 0.17	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.001	< 1.3	< 0.20	< 1.00	< 1.20	< 0.20	40.95
		01/03/97	7.7	839	369	55.1	67.0	0.13	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.006	< 1.0	< 0.20	< 1.00	< 1.20	1.00	33.20
		04/21/97	7.7	882	345	47.7	69.0	0.11												
		07/08/97	7.8	859	332	52.8	69.7	0.11	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.006	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	30.50
		10/06/97	7.4	895	358	59.7	63.1	< 0.10												
	Average 1997		7.7	869	351	53.8	67.2	< 0.12	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.006	< 1.0	< 0.20	< 1.00	< 1.20	< 0.60	31.85
		01/06/98	7.4	902	389	62.8	72.1	< 0.10	< 0.001	< 0.005	< 0.050	< 0.020	< 0.05	0.007	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	47.70
		04/10/98	7.5	938	364	63.5	68.0	< 0.10												
		07/07/98	7.5	959	376	44.0	73.0	0.31	0.001	< 0.005	< 0.050	< 0.020	< 0.05	0.008	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	39.30

ATTACHMENT 3B TDSS MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
178	TDM XLIV	08/17/88	6.6	4028	1460	315		< 0.01	< 0.001	0.006	< 0.010	< 0.020	< 0.05	0.001	4.2	1.90	2.10	4.00	1.20	57.00
		09/01/88	6.6	4160	2050	334		0.36	0.002	0.006	0.050	< 0.020	0.12	0.001	5.0	1.10	6.70	7.80	0.20	36.00
		09/14/88	6.7	3999	2250	312		0.36	0.001	0.009	0.050	0.110	0.06	0.001	3.0	1.50	4.10	5.60	0.40	35.00
		09/22/88	6.7	3968	1470	326	284	0.05	0.001	0.012	0.040	0.080	0.10	0.001	3.6	1.30	4.40	5.70	0.40	37.00
	Average 1988		6.6	4039	1808	322	284	< 0.019	< 0.002	0.008	< 0.038	< 0.060	< 0.08	0.001	4.0	1.45	4.33	5.78	0.55	41.25
		01/11/89	6.9	3980	2900	300	271	0.31	< 0.001	0.009	< 0.010	< 0.020	< 0.05	< 0.001	2.1	1.90	3.70	5.60	0.90	31.00
		04/24/89	6.9	3227	2500	420	267	0.05	0.002	0.007	< 0.010	< 0.020	< 0.05	< 0.001	2.0	1.70	1.70	3.40	1.70	26.00
		07/13/89	7.0	4392	2800	330	273	0.08	< 0.001	0.009	0.030	0.030	< 0.05	< 0.001	1.6	1.10	0.60	1.70	1.30	75.00
		10/20/89	6.8	3923	2370	310	340	0.16												
		12/16/89	6.9	4029	1940	320	286	0.17	< 0.001	0.016	0.060	0.070	< 0.05	< 0.001	3.2	1.30	1.90	3.20	0.70	2.30
	Average 1989		6.9	3910	2502	336	287	0.15	< 0.002	0.010	< 0.030	< 0.035	< 0.05	< 0.001	2.2	1.50	1.98	3.48	1.15	33.58
		01/18/90	6.5	2324	1990	320	324	< 0.01	< 0.001	0.015	< 0.010	0.030	< 0.05	0.001	1.7	1.40	1.50	2.90	0.40	2.60
		05/03/90	6.9	4078	2070	320	273	< 0.01												
		08/24/90	6.8	3690	2100	290	305	0.05	< 0.001	0.014	0.050	0.050	< 0.05	< 0.001	5.2	1.30	1.60	2.90	0.20	2.60
		10/19/90	6.5	4340	2200	255	291	0.05												
	Average 1990		6.7	3608	2090	296	298	< 0.06	< 0.001	0.014	< 0.030	0.040	< 0.05	< 0.001	3.4	1.35	1.55	2.90	0.30	2.60

ATTACHMENT 3B TDSS MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
178	TDM XLIV	01/10/91	7.0	4534	2427	281	299	< 0.01	< 0.001	< 0.010	< 0.050	< 0.050	< 0.05	< 0.001	4.3	2.70	1.40	4.10	< 0.20	0.60
		04/21/91	6.7	4830	2421	269	283	0.01												
		07/19/91	6.6	4322	2223	271	297	< 0.01	< 0.001	< 0.010	< 0.050	< 0.020	0.05	< 0.001	1.3	1.80	< 1.00	< 2.80	< 0.20	1.80
		10/14/91	6.6	4414	2299	295	276	0.06												
	Average 1991		6.7	4525	2343	279	289	< 0.02	< 0.001	< 0.010	< 0.050	< 0.035	< 0.05	< 0.001	2.8	2.25	< 1.20	< 3.45	< 0.20	1.20
		01/14/92	6.7	4528	2258	235	271	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	25.0	24.70	5.00	29.70	< 0.20	3.39
		04/23/92	6.6	4157	2160	213	306	< 0.10												
		07/10/92	6.6	4662	2396	249	364	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.90	4.80	5.70	< 0.20	1.35
		10/27/92	6.8	3924	2093	239	277	< 0.10												
	Average 1992		6.7	4318	2227	234	304	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 13.0	12.80	4.90	17.70	< 0.20	2.37
		01/20/93	6.6	4501	2383	239	264	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.003	21.8	20.4	6.3	26.7	< 0.20	6.80
		04/27/93	6.5	4052	2299	234	253	< 0.10												
		07/23/93	6.4	4083	2250	262	257	< 0.10	< 0.001	< 0.010	< 0.050	0.030	< 0.05	< 0.001	15.8	14.8	8.3	23.1	< 0.20	< 0.20
		10/27/93	6.3	4074	2217	215	256	< 0.10												
	Average 1993		6.5	4178	2287	238	258	< 0.10	< 0.001	< 0.010	< 0.050	< 0.025	< 0.05	< 0.002	18.8	17.6	7.3	24.9	< 0.20	< 3.50
		01/12/94	6.4	4136	2180	224	245	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	22.4	1.30	6.80	8.10	< 0.20	2.71
		04/25/94	7.2	3630	2210	232	293	< 0.10												
		07/08/94	7.0	4722	2463	244	306	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	3.0	1.50	3.00	4.50	< 0.20	1.40
		10/27/94	7.1	4729	2717	248	305	< 0.10												
	Average 1994		6.9	4304	2392	237	287	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	12.7	1.40	4.90	6.30	< 0.20	2.06
		01/30/95	7.4	4656	2572	242	266	0.57	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	16.4	2.00	9.80	11.80	< 0.20	2.50
		05/04/95	7.1	4786	2531	272	262	0.10												
		07/24/95	6.5	4426	2409	278	260	< 0.10	0.003	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	1.9	1.20	1.40	2.60	< 0.20	0.70
		12/21/95	6.6	4488	2410	249	277	0.20												
	Average 1995		6.9	4589	2480	260	266	< 0.25	< 0.002	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	9.2	1.60	5.60	7.20	< 0.20	1.60
		01/26/96	6.9	4751	2910	279	272	0.24	0.002	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	1.9	0.80	2.90	3.70	< 0.20	1.70
		05/01/96	7.4	4754	2423	268	257	< 0.10												
		07/11/96	7.1	4735	2615	240	280	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.70	< 1.00	< 1.70	0.50	0.80
		11/12/96	6.6	4710	2569	286	238	< 0.10												
	Average 1996		7.0	4738	2629	268	262	< 0.14	< 0.002	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.5	0.75	< 1.95	< 2.35	< 0.35	1.25
		01/31/97	6.8	4590	2570	240	250	0.14	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.80	< 1.00	< 1.80	< 0.20	< 0.20
		04/26/97	7.0	4710	2276	265	245	0.39												
		07/01/97	6.6	4630	2470	271	246	0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.90	8.40	9.30	< 0.20	1.35
		10/06/97	6.7	439	140	19.7	13.3	< 0.10												
	Average 1997		6.8	4643*	2439*	259*	247*	0.21*	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.85	< 4.70	< 5.55	< 0.20	< 0.78
		01/01/98	6.6	4640	2300	233	237	< 0.10	< 0.001	< 0.005	< 0.050	< 0.020	< 0.05	0.005	< 1.0	0.90	4.90	5.80	< 0.20	1.10
		04/06/98	6.6	4640	2450	277	254	< 0.10												
		07/01/98	6.7	4760	2430	234	265	0.31	< 0.001	< 0.005	< 0.050	0.18	< 0.05	0.004	< 1.0	1.20	3.00	4.20	< 0.20	1.20

* Does not include October 1997 data as the laboratory data does not match field measurements nor historical results.

ATTACHMENT 3B TDSS MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
179	TDM XLV	08/22/88	7.5	1022	336	81		0.31	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	3.2	0.80	2.20	3.00	1.40	0.60
		09/06/88	9.0	1148	490	110		0.28	< 0.001	0.003	< 0.010	< 0.020	< 0.05	0.001	2.4	0.80	3.40	4.20	0.20	0.05
		09/20/88	8.8	1169	494	82		0.40	0.001	0.005	< 0.010	< 0.020	< 0.05	< 0.001	2.4	1.00	2.70	3.70	0.20	0.50
		10/05/88	8.7	976	542	85	172	0.37	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	2.9	1.80	4.10	5.90	0.50	< 0.05
	Average 1988		8.5	1079	465	90	172	0.34	< 0.001	< 0.003	< 0.010	< 0.020	< 0.05	< 0.001	2.7	1.10	3.10	4.20	0.58	< 0.30
		01/18/89	8.1	1028	510	77	160	0.28	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	1.3	1.20	2.90	4.10	0.30	0.90
		04/27/89	8.3	1012	600	230	156	0.06	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	2.1	1.20	2.70	3.90	0.80	< 0.20
		07/17/89	8.2	1015	430	80	149	0.06	0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.003	1.9	0.90	0.50	1.40	1.20	< 0.20
		10/23/89	8.3	958	500	82	175	0.07												
	Average 1989		8.2	1003	510	117	160	0.12	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.002	1.8	1.10	2.00	3.10	0.77	< 0.43
		01/17/90	7.9	652	458	115	159	< 0.01	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.001	1.3	1.00	1.40	2.40	0.20	0.70
		05/02/90	8.3	1036	520	85	157	< 0.01												
		08/24/90	7.8	1002	490	80	167	< 0.01	< 0.001	0.006	< 0.010	< 0.020	< 0.05	0.001	2.4	0.60	1.60	2.20	0.20	< 0.20
		10/18/90	8.5	968	425	72	163	< 0.01												
	Average 1990		8.1	914	473	88	162	< 0.01	< 0.001	< 0.004	< 0.010	< 0.020	< 0.05	0.001	1.8	0.80	1.50	2.30	0.20	< 0.45

ATTACHMENT 3B TDSS MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
179	TDM XLV	01/11/91	7.5	1016	568	69.2	167	< 0.01	< 0.001	< 0.010	< 0.050	< 0.050	< 0.05	< 0.001	6.5	0.70	7.90	8.60	< 0.20	< 0.20
		04/18/91	7.8	1027	522	70.8	171	0.01												
		07/19/91	7.5	1010	527	71.0	167	< 0.01	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	3.30	< 3.50	< 0.20	0.60
		10/10/91	8.5	1049	552	78.8	167	< 0.01												
	Average 1991		7.8	1026	542	72.4	168	< 0.01	< 0.001	< 0.010	< 0.050	< 0.035	< 0.05	< 0.001	< 3.8	< 0.45	5.60	< 6.05	< 0.20	< 0.40
		01/09/92	7.8	1066	503	70.8	167	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	2.0	1.70	< 1.00	< 2.70	< 0.20	6.09
		04/22/92	7.9	1123	557	70.2	203	< 0.10												
		07/24/92	7.6	1144	574	78.9	210	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.60	< 1.00	< 1.60	< 0.20	1.35
		10/26/92	7.9	1108	561	77.6	161	< 0.10												
	Average 1992		7.8	1110	549	74.4	185	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.5	1.15	< 1.00	< 2.15	< 0.20	3.72
		01/20/93	8.1	1150	592	84.5	174	0.32	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.60	5.90	6.50	< 0.20	< 0.20
		04/28/93	7.9	1117	568	98.5	162	< 0.10												
		07/12/93	7.5	1232	650	89.0	176	0.73	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	1.6	1.40	< 1.00	< 2.40	< 0.20	2.71
		10/26/93	7.2	1256	623	90.5	173	0.10												
	Average 1993		7.7	1189	608	90.6	171	< 0.32	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.001	< 1.3	1.00	< 3.45	< 4.45	< 0.20	< 1.46
		01/13/94	7.8	1287	674	94.7	169	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	4.6	0.80	2.40	3.20	< 0.20	0.68
		04/24/94	7.2	1190	665	94.0	193	< 0.10												
		07/10/94	7.2	1434	768	103	196	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.80	< 1.00	< 1.80	< 0.20	1.40
		10/25/94	6.8	1400	753	110	188	< 0.10												
	Average 1994		7.2	1328	715	100	186	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 2.8	0.80	< 1.70	< 2.50	< 0.20	1.04
		01/26/95	6.5	1552	859	117	197	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	4.0	1.00	1.90	2.90	< 0.20	0.50
		04/24/95	7.2	1606	883	127	208	< 0.10												
		07/21/95	7.5	1527	837	128	201	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.60	2.80	3.40	< 0.20	< 0.20
		11/20/95	7.5	1668	877	124	210	< 0.10												
	Average 1995		7.2	1588	864	124	204	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 2.5	0.80	2.35	3.15	< 0.20	< 0.35
		01/24/96	7.8	1680	928	135	207	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	1.6	0.60	< 1.00	< 1.60	< 0.20	< 0.20
		04/24/96	6.9	1705	920	135	210	< 0.10												
		07/11/96	7.8	1753	984	133	227	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.40	< 1.00	< 1.40	< 0.20	< 0.20
		11/11/96	7.4	1820	1034	147	202	< 0.10												
	Average 1996		7.5	1740	967	138	212	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.3	0.50	< 1.00	< 1.50	< 0.20	< 0.20
		01/27/97	7.6	1820	935	130	216	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	< 0.20
		04/26/97	7.7	1910	936	156	209	< 0.10												
		07/07/97	7.8	1880	1012	146	221	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	< 0.20
		10/06/97	7.5	1910	1010	144	222	< 0.10												
	Average 1997		7.7	1880	973	144	217	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	< 0.20
		01/05/98	7.7	2100	1050	163	223	< 0.10	< 0.001	< 0.005	< 0.050	< 0.020	< 0.05	0.002	< 1.0	0.60	< 1.00	< 1.60	< 0.20	< 0.20
		04/10/98	7.5	1950	1050	142	234	< 0.10												
		07/02/98	7.5	2040	1040	132	229	< 0.10	< 0.001	< 0.005	< 0.050	< 0.020	< 0.05	0.002	< 1.0	0.50	1.90	2.40	< 0.20	< 0.20

ATTACHMENT 3B   TDSS MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
181	TDM XLVII	08/22/88	7.6	769	274	55		< 0.01	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	3.2	1.30	2.30	3.60	1.10	5.50
		09/06/88	8.7	692	280	55		< 0.01	0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.001	1.9	1.20	1.90	3.10	0.20	5.00
		09/20/88	8.6	738	282	49		< 0.01	0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	1.1	1.00	1.60	2.60	0.30	0.05
		10/04/88	8.5	719	302	51	145	0.15	< 0.001	0.003	< 0.010	< 0.020	< 0.05	< 0.001	1.7	2.40	3.10	5.50	0.40	< 0.05
	Average 1988		8.4	730	285	52	145	< 0.04	< 0.001	< 0.003	< 0.010	< 0.020	< 0.05	< 0.001	2.0	1.48	2.20	3.68	0.50	< 2.65
		01/11/89	8.1	683	350	56	146	0.30	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.001	1.5	1.10	2.90	3.00	0.60	2.60
		04/27/89	7.9	754	400	220	148	< 0.01	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	1.1	1.70	2.50	4.20	0.70	0.30
		07/14/89	7.8	842	460	70	151	0.06	0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.003	2.0	1.30	1.20	2.50	1.10	< 0.20
		10/23/89	8.0	835	460	78	177	0.18												
	Average 1989		8.0	778	418	106	156	< 0.14	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.002	1.5	1.40	2.20	3.60	0.80	< 1.03
		01/17/90	7.6	809	460	115	172	< 0.01	< 0.001	0.003	< 0.010	< 0.020	< 0.05	0.001	1.1	0.90	1.60	2.50	0.20	23.00
		04/24/90	7.7	1072	450	95	237	< 0.01												
		08/22/90	7.7	1269	520	84	213	0.19	< 0.001	0.005	< 0.010	< 0.020	< 0.05	< 0.001	3.7	1.00	2.80	3.80	0.20	0.70
		10/18/90	7.9	1303	560	98	210	0.14												
	Average 1990		7.7	1113	498	98	210	< 0.09	< 0.001	0.004	< 0.010	< 0.020	< 0.05	< 0.001	2.4	0.95	2.20	3.15	0.20	11.90

ATTACHMENT 3B TDSS MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
181	TDM XLVII	01/11/91	7.4	1344	770	89	218	0.02	< 0.001	< 0.010	< 0.050	< 0.050	< 0.05	< 0.001	2.3	2.00	< 1.00	< 3.00	< 0.20	< 0.20
		04/18/91	7.5	1394	745	85.3	226	0.02												
		07/03/91	7.1	1459	881	90.9	233	0.02	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.90	< 1.00	< 1.90	< 0.20	1.80
		10/14/91	8.1	1571	814	115	241	0.05												
	Average 1991		7.3	1422	803	95	230	0.03	< 0.001	< 0.010	< 0.050	< 0.035	< 0.05	< 0.001	< 1.7	1.45	< 1.00	< 2.45	< 0.20	< 1.00
		01/09/92	7.8	1758	902	108	252	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.007	< 1.0	0.60	< 1.00	< 1.60	< 0.20	1.35
		04/23/92	7.5	1978	1078	117	299	< 0.10												
		07/09/92	7.8	2035	1130	105	330	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	1.1	1.00	< 1.00	< 2.00	< 0.20	0.68
		10/26/92	7.6	2007	1127	104	307	< 0.10												
	Average 1992		7.7	1944	1059	108	297	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.004	< 1.1	0.80	< 1.00	< 1.80	< 0.20	1.02
		01/20/93	7.3	2149	1214	114	252	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.20	5.20	5.40	< 0.20	< 0.20
		04/26/93	7.5	2156	1118	122	264	< 0.10												
		07/12/93	7.1	2167	1211	132	319	0.97	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	1.5	1.20	2.60	3.80	< 0.20	1.35
		10/25/93	7.1	2074	1183	111	266	0.27												
	Average 1993		7.3	2137	1182	120	275	< 0.36	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.3	0.70	3.90	4.60	< 0.20	< 0.78
		01/13/94	7.2	2083	1187	110	271	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	5.3	1.20	2.60	3.80	< 0.20	0.68
		04/24/94	7.1	2022	1143	123	288	< 0.10												
		07/06/94	7.3	2392	1269	123	293	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.50	< 1.00	< 1.50	< 0.20	< 0.20
		10/25/94	7.2	2202	1219	117	270	< 0.10												
	Average 1994		7.2	2175	1204	118	280	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 3.2	0.85	< 1.80	< 2.65	< 0.20	< 0.44
		01/26/95	7.0	2376	1391	124	278	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.80	< 1.00	< 1.80	< 0.20	0.20
		04/24/95	7.2	2342	1261	123	281	< 0.10												
		07/21/95	7.4	2230	1282	123	286	< 0.10	0.003	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	2. 0	1.20	2.00	3.20	0.60	< 0.20
		11/20/95	7.5	2225	1187	103	286	< 0.10												
	Average 1995		7.3	2293	1280	118	283	< 0.10	< 0.002	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.5	1.00	< 1.50	< 2.50	< 0.40	< 0.20
		01/24/96	7.8	2193	1266	112	276	0.20	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	2.0	0.50	< 1.00	< 1.50	< 0.20	< 0.20
		04/15/96	7.9	2210	1246	111	282	0.14												
		07/10/96	8.0	2192	1275	104	292	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.60	< 1.00	< 1.60	< 0.20	< 0.20
		11/11/96	7.4	2080	1204	102	255	< 0.10												
	Average 1996		7.8	2169	1248	107	276	< 0.14	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.5	0.55	< 1.00	< 1.55	< 0.20	< 0.20
		01/27/97	7.7	2010	1069	85.3	258	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	1.00	< 1.00	< 2.00	< 0.20	0.70
		04/26/97	7.7	2000	1099	91.0	296	< 0.10												
		07/07/97	7.7	1950	994	74.8	257	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.70	3.10	3.80	< 0.20	< 0.20
		10/09/97	7.5	1960	1100	80.0	256	< 0.10												
	Average 1997		7.7	1980	1066	82.8	267	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.85	< 2.05	< 2.90	< 0.20	< 0.45
		01/05/98	7.4	1890	1080	78.2	251	< 0.10	< 0.001	< 0.005	< 0.050	< 0.020	< 0.05	0.002	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	< 0.20
		04/10/98	7.5	1850	1050	72.5	258	< 0.10												
		07/02/98	7.4	1860	964	55.0	252	< 0.10	< 0.001	< 0.005	< 0.050	< 0.020	< 0.05	0.001	< 1.0	0.50	< 1.00	< 1.50	< 0.20	< 0.20

ATTACHMENT 3B TDSS MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
183	TDM XLIX	08/22/88	8.2	880	310	72		0.00	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	3.3	1.20	2.00	3.20	0.40	4.50
		09/06/88	8.6	890	390	70		0.39	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.002	1.6	0.70	2.00	2.70	0.30	5.50
		09/20/88	8.5	965	400	71		0.48	0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.001	1.5	1.00	2.40	3.40	0.30	4.10
		10/05/88	8.1	843	380	75	159	0.27	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	2.6	2.10	4.00	6.10	0.70	0.87
	Average 1988		8.4	894	370	72	159	0.28	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.002	2.2	1.25	2.60	3.85	0.43	3.77
		01/18/89	8.0	1018	460	103	156	0.32	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.003	1.4	1.00	2.80	3.80	0.60	0.70
		04/27/89	8.3	1060	670	120	171	0.27	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	2.9	1.00	1.90	2.90	0.90	< 0.20
		07/17/89	7.9	1128	510	80	169	0.18	< 0.001	< 0.002	< 0.010	< 0.020		0.002						
		10/23/89	8.4	1064	642	86	184	0.13												
	Average 1989		8.2	1068	570	97	170	0.22	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.002	2.2	1.00	2.35	3.35	0.75	< 0.45
		01/17/90	8.4	997	500	90	183	< 0.01	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.001	2.6	0.70	1.60	2.30	1.90	0.70
		05/02/90	8.2	1202	620	75	173	< 0.01												
		08/24/90	7.9	1376	476	96	195	0.16	< 0.001	0.004	< 0.010	< 0.020	< 0.05	< 0.001	2.6	0.70	1.50	2.20	0.10	0.20
		10/18/90	7.6	1410	625	90	195	0.11												
	Average 1990		8.0	1246	555	88	186	< 0.08	< 0.001	< 0.003	< 0.010	< 0.020	< 0.05	< 0.001	2.6	0.70	1.55	2.25	1.00	0.45

ATTACHMENT 3B TDSS MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
183	TDM XLIX	01/11/91	7.3	1406	847	88.7	195	< 0.01	< 0.001	< 0.010	< 0.050	< 0.050	< 0.05	< 0.001	2.9	1.80	1.30	3.10	< 0.20	< 0.20
		04/18/91	7.6	1405	734	85	218	0.03												
		07/19/91	7.4	1373	710	80.6	204	< 0.01	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.60	< 1.00	< 1.60	< 0.20	1.80
		10/10/91	7.6	1398	746	89.4	190	< 0.01												
	Average 1991		7.4	1396	759	85.9	202	< 0.02	< 0.001	< 0.010	< 0.050	< 0.035	< 0.05	< 0.001	< 2.0	1.20	< 1.15	< 2.35	< 0.20	< 1.00
		01/09/92	7.5	1340	712	72.0	183	0.70	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.50	< 1.00	< 1.50	< 0.20	< 0.20
		04/22/92	7.6	1290	650	64.2	183	< 0.10												
		07/23/92	7.6	1202	625	64.9	221	0.50	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.60	< 1.00	< 1.60	< 0.20	0.68
		10/26/92	7.7	1061	566	65.7	179	< 0.10												
	Average 1992		7.6	1223	638	66.7	191	< 0.35	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.55	< 1.00	< 1.55	< 0.20	< 0.44
		01/20/93	7.8	1052	542	61.5	166	9.96	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.70	< 1.00	< 1.70	< 0.20	< 0.20
		04/28/93	7.6	861	520	63.0	146	< 0.10												
		07/12/93	7.3	1025	528	69.2	160	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	1.3	1.10	< 1.00	< 2.10	< 0.20	1.35
		10/26/93	6.9	1008	486	59.3	142	1.82												
	Average 1993		7.4	986	519	63.3	154	< 3.00	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.2	0.90	< 1.00	< 1.90	< 0.20	< 0.78
		01/13/94	7.4	1007	521	56.8	132	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.50	< 1.00	< 1.50	< 0.20	2.71
		04/24/94	7.7	1001	508	57.3	141	< 0.10												
		07/10/94	7.5	1045	492	61.5	148	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.60	< 1.00	< 1.60	< 0.20	1.40
		10/25/94	7.5	1021	526	68.8	165	0.13												
	Average 1994		7.5	1018	512	61.1	146	< 0.11	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.55	< 1.00	< 1.55	< 0.20	2.06
		01/26/95	7.0	1042	526	68.0	153	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	6.5	0.90	3.60	4.50	< 0.20	0.70
		04/24/95	7.5	1041	529	70.0	166	< 0.10												
		07/21/95	7.5	1082	544	75.0	169	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	1.5	0.90	< 1.00	< 1.90	< 0.20	< 0.20
		11/20/95	7.7	1124	537	71.9	176	0.11												
	Average 1995		7.4	1072	534	71.2	166	< 0.11	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	4.0	0.90	< 2.30	< 3.20	< 0.20	< 0.45
		01/24/96	8.0	1150	645	88.0	169	0.17	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	2.3	0.40	< 1.00	< 1.40	< 0.20	< 0.20
		04/24/96	7.6	1123	583	80.5	169	< 0.10												
		07/10/96	8.1	1191	639	80.0	183	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.30	< 1.00	< 1.30	< 0.20	< 0.20
		11/11/96	7.7	1220	642	87.0	170	< 0.10												
	Average 1996		7.9	1171	627	83.8	173	< 0.12	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.7	0.35	< 1.00	< 1.35	< 0.20	< 0.20
		01/27/97	7.7	1250	605	80.0	174	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	< 0.20
		04/26/97	7.8	1300	604	93.0	169	< 0.10												
		07/07/97	8.0	1280	613	81.0	184	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.70	2.90	3.60	< 0.20	< 0.20
		10/09/97	7.6	1330	666	88.5	190	< 0.10												
	Average 1997		7.8	1290	622	85.6	179	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.45	< 1.95	< 2.40	< 0.20	< 0.20
		01/01/98	7.6	1350	764	109	184	< 0.10	< 0.001	< 0.005	< 0.050	< 0.020	< 0.05	0.002	< 1.0	1.00	< 1.00	< 2.00	< 0.20	< 0.20
		04/10/98	7.7	1380	713	92.5	197	< 0.10												
		07/02/98	7.7	1420	688	81.1	191	0.14	< 0.001	< 0.005	< 0.050	< 0.020	< 0.05	<0.001	< 1.0	0.70	< 1.00	< 1.70	< 0.20	< 0.20

ATTACHMENT 3C TDSS BACKGROUND MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
134	RM-4	01/07/88	8.1	975	446	12			< 0.001	< 0.002	< 0.010		< 0.05	0.053		0.60			0.40	1.70
		03/31/88	7.8	975	400	15			< 0.001	< 0.002	< 0.010		< 0.05	0.013		0.80			1.00	3.40
		06/25/88	7.6	943	410	19			< 0.001	< 0.002	< 0.010		< 0.05	0.005		0.80			0.60	0.10
		09/19/88	8.1	1014	460	13	177	0.55	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.001		1.20	2.90	4.10	1.30	10.00
		10/26/88	8.0	975	532	12	178	0.69	< 0.001	0.005	< 0.010	< 0.020	< 0.05	0.002	2.4	1.20	2.90	4.10	0.70	9.60
		11/09/88	7.9	985	540	13	184	1.02	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.013	2.8	0.60	2.80	3.40	1.30	4.60
		11/23/88	7.7	1025	555	17	184	0.05	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.001	2.6	0.90	2.70	3.60	1.40	2.40
		12/08/88	7.8	1043	600	27			< 0.001	< 0.010	< 0.010		< 0.05	0.001		1.20			0.80	2.00
	Average 1988		7.9	992	492	16	181	.58	< 0.001	< 0.004	< 0.010	< 0.020	< 0.05	0.011	2.6	0.90	2.80	3.80	0.90	3.10
		03/27/89	8.0	956	510	33	195	< 0.01	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	2.1	0.90	1.50	2.40	0.80	2.10
		06/12/89	7.9	927	540	30	229	0.29	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.004	0.5	1.10	0.80	1.90	2.00	3.40
		09/19/89	7.9	968	560	42	181	< 0.01	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	5.3	0.50	0.80	1.30	2.10	2.60
		12/20/89	7.7	1000	500	96	199	0.31												
	Average 1989		7.9	963	528	50	201	< 0.16	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.002	2.6	0.83	1.03	1.86	1.63	2.70
		03/26/90	7.7	928	600	20	205	1.22	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.001	3.8	1.60	1.50	3.10	1.10	< 0.20
		06/26/90	8.0	1027	488	17	191	0.49												
		09/07/90	8.3	1019	420	14	196	0.98	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.004	3.6	0.80	2.00	2.80	0.50	0.30
		12/01/90	7.5	987	434	11	200	0.14												
	Average 1990		7.9	990	486	16	198	0.71	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.002	3.7	1.20	1.75	2.95	0.80	< 0.25

ATTACHMENT 3C TDSS BACKGROUND MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
134	RM-4	03/02/91	7.7	1019	578	8.7	180	0.06	< 0.001	< 0.010	< 0.050	< 0.050	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	< 0.20
		06/10/91	7.8	970	572	6.8	187	0.04	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.60	1.40	2.00	< 0.20	0.30
		09/08/91	7.8	1033	591	3.9	196	1.20	0.020	< 0.010	< 0.050	< 0.020	< 0.05	0.074	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	1.40
		12/12/91	8.1	993	565	11.0	171	0.32												
	Average 1991		7.8	1004	574	7.6	184	0.40	< 0.007	< 0.010	< 0.050	< 0.030	< 0.05	< 0.025	< 1.0	< 0.33	< 1.13	< 1.50	< 0.20	< 0.63
		03/28/92	7.5	1053	589	9.4	204	< 0.10	0.002	< 0.010	< 0.050	0.020	< 0.05	< 0.001	< 1.0	0.20	< 1.00	< 1.20	< 0.20	18.96
		06/10/92	7.8	1014	554	8.0	211	< 0.10												
		09/21/92	7.8	992	515	7.5	203	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.70	1.50	2.20	< 0.20	1.35
		12/03/92	7.8	849	567	6.5	184	< 0.10												
	Average 1992		7.7	977	556	7.8	200	< 0.10	< 0.002	< 0.010	< 0.050	<0.020	< 0.05	< 0.001	< 1.0	0.45	< 1.25	< 1.70	< 0.20	10.16
		03/03/93	7.8	964	522	8.9	189	< 0.01	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.20	3.90	4.10	< 0.20	4.74
		06/05/93	7.7	983	583	7.3	224	< 0.10												
		09/16/93	7.2	991	529	7.0	190	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	3.0	1.40	1.10	2.50	< 0.20	< 0.20
		12/02/93	7.5	977	516	7.6	181	< 0.10												
	Average 1993		7.6	978	538	7.7	196	< 0.10	< 0.001	< 0.010	< 0.050	<0.020	< 0.05	< 0.001	< 2.0	0.80	2.50	3.30	< 0.20	< 2.47
		03/28/94	7.2	998	527	9.0	192	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	1.9	1.70	< 1.00	< 2.70	< 0.20	20.30
		06/29/94	7.9	980	563	8.76	153	< 0.10												
		09/29/94	8.1	960	569	8.4	192	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	1.3	1.10	< 1.00	< 2.10	< 0.20	0.70
		12/14/94	7.2	981	551	10.1	191	0.23												
	Average 1994		7.6	980	552	9.0	182	< 0.14	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	1.6	1.40	< 1.00	< 2.40	< 0.20	10.50
		03/21/95	7.4	1002	517	8.2	162	0.11	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	5.5	1.00	2.90	3.90	< 0.20	0.70
		06/26/95	7.6	997	574	9.1	197	< 0.10												
		09/07/95	7.6	979	537	7.9	188	0.18	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	2.90	< 3.10	0.70	0.70
		12/01/95	7.5	971	563	10.2	179	0.22												
	Average 1995		7.5	987	548	8.8	182	0.15	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 3.3	< 0.60	2.90	< 3.50	< 0.45	0.70
		03/12/96	7.8	970	550	7.6	180	0.18	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.80	< 1.00	< 1.80	< 0.20	< 0.20
		06/29/96	8.2	1015	593	9.1	194	0.35												
		09/30/96	8.2	1000	527	8.9	185	0.61	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	0.60
		12/26/96	7.9	1020	535	9.3	185	0.24												
	Average 1996		8.0	1001	551	8.7	186	0.34	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.60	1.00	< 1.50	< 0.20	< 0.40
		03/21/97	8.0	1020	550	8.4	189	0.13	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.60	< 1.00	< 1.60	< 0.20	1.35
		06/13/97	8.0	1020	535	9.0	190	0.19												
		09/29/97	7.9	1050	544	10.0	192	0.18	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	0.70
		12/29/97	7.8	1050	609	11.4	190	<0.10												
	Average 1997		7.9	1025	559	9.7	190	0.17	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.40	< 1.00	< 1.40	< 0.20	1.03
		03/05/98	7.7	1010	550	10.5	194	<0.10	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	0.002	< 1.0	0.80	< 1.00	< 1.80	< 0.20	0.60
		06/26/98	7.6	1100	567	9.7	191	<0.10												

ATTACHMENT 3C TDSS BACKGROUND MONITOR WELLS CONTINUED

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
172	SM - EM-5	07/29/88	7.8	719	186	16			< 0.001					0.001		5.20				21.00
		11/26/88	7.8	456	270	19	106	0.10	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001		3.10				0.70
	Average 1988		7.8	588	228	18	106	0.10	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001		4.15				10.85
		04/26/89	7.8	418	248	30	103	0.11	< 0.001	0.003	< 0.010	< 0.020	< 0.05	0.002	2.0	1.40	1.90	3.30	0.30	1.70
		06/12/89	7.8	485	220	34	132	0.20	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.004	3.0	1.70	0.40	2.10	1.60	0.40
		09/26/89	7.7	450	228	40	97	< 0.10	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.002	3.1	1.50	0.50	2.00	1.40	0.30
		12/20/89	7.5	627	205	15	123	0.13												
	Average 1989		7.7	495	225	30	114	< 0.14	< 0.001	< 0.003	< 0.010	< 0.020	< 0.05	0.003	2.7	1.53	0.93	2.46	1.10	1.34
		04/23/90	7.4	530	302	14	112	0.26	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.001	2.3	2.20	3.10	5.30	0.50	3.10
		06/26/90	7.8	595	340	13	115	0.57												
		09/07/90	7.9	520	308	20	115	0.94	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.002	3.2	1.90	2.10	4.00	0.20	0.50
		12/01/90	7.7	653	254	16	122	0.25												
	Average 1990		7.7	574	301	16	116	0.50	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.002	2.8	2.05	2.60	4.65	0.35	1.80

ATTACHMENT 3C TDSS BACKGROUND MONITOR WELLS CONTINUED

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
172	SM - EM-5	03/02/91	7.5	574	310	10.4	116	0.01	< 0.001	< 0.01	< 0.050	< 0.050	< 0.05	< 0.001	3.0	3.00	< 1.00	< 4.00	< 0.20	< 0.20
		06/10/91	7.4	531	273	8.6	114	0.02	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	1.1	1.40	< 1.00	< 2.40	< 0.20	< 0.20
		09/08/91	7.7	565	301	4.8	116	1.20	0.014	< 0.01	< 0.050	< 0.020	< 0.05	0.034	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	2.00
		12/12/91	8.0	551	305	11.7	107	< 0.01												
	Average 1991		7.6	555	297	8.9	113	< 0.31	< 0.005	< 0.01	< 0.050	< 0.030	< 0.05	< 0.012	1.7	< 1.50	< 1.00	< 2.50	< 0.20	< 0.20
		03/28/92	7.4	510	272	10.4	110	< 0.10	0.002	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	2.9	3.00	< 1.00	< 4.00	< 0.20	18.3
		06/10/92	8.5	549	254	9.3	124	< 0.10												
		09/21/92	8.2	520	275	9.8	107	< 0.10	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	1.8	1.60	< 1.00	< 2.60	< 0.20	1.35
		12/03/92	7.6	358	272	7.3	111	< 0.10												
	Average 1992		7.9	484	268	9.2	113	< 0.10	< 0.002	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	2.4	2.30	< 1.00	< 3.30	< 0.20	9.82
		03/03/93	7.5	491	250	9.0	111	< 0.01	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	1.8	1.60	5.50	7.10	< 0.20	6.77
		06/05/93	7.8	504	265	10.2	113	< 0.10												
		09/16/93	7.0	528	278	8:3	104	< 0.10	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	8.3	3.40	3.30	6.70	< 0.20	< 0.20
		12/02/93	7.6	515	263	11.0	103	< 0.10												
	Average 1993		7.5	510	264	9.6	108	< 0.10	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	5.0	2.50	4.40	6.90	< 0.20	< 3.48
		03/28/94	7.7	532	276	9.7	110	< 0.10	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	4.7	2.60	1.30	3.90	< 0.20	23.00
		06/29/94	8.0	587	292	10.1	100	< 0.10												
		09/29/94	7.4	588	291	9.5	123	< 0.10	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	2.4	2.20	< 1.00	< 3.20	< 0.20	0.70
		12/14/94	6.5	552	291	11.6	121	0.11												
	Average 1994		7.4	565	288	10.2	114	< 0.11	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	3.6	2.40	< 1.20	< 3.55	< 0.20	11.85
		03/21/95	7.4	597	274	10.6	103	2.89	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	2.2	2.20	1.20	3.40	< 0.20	0.50
		06/26/95	7.8	613	316	11.5	123	< 0.10												
		09/07/95	7.7	591	306	10.1	124	< 0.10	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	4.4	2.10	3.20	5.30	0.50	0.70
		12/01/95	7.8	579	324	11.9	116	0.14												
	Average 1995		7.7	595	305	11.0	116	< 0.81	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	3.3	2.15	2.20	4.35	< 0.35	0.60
		03/12/96	7.7	596	316	10.5	116	< 0.10	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	2.9	2.00	< 1.00	< 3.00	< 0.20	< 0.20
		06/29/96	8.2	626	338	10.2	126	0.13												
		09/30/96	8.2	620	319	10.7	123	< 0.10	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	1.50	< 1.00	< 2.50	< 0.20	0.80
		12/26/96	8.3	607	306	10.9	119	0.42												
	Average 1996		8.1	612	320	10.6	121	< 0.19	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 2.0	1.75	< 1.00	< 2.75	< 0.20	< 0.50
		03/21/97	8.0	643	329	11.5	125	< 0.10	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	2.00	< 1.00	< 3.00	< 0.20	< 0.20
		06/13/97	8.1	607	314	11.8	123	< 0.10												
		09/29/97	8.0	695	342	12.7	128	0.14	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	1.90	< 1.00	< 2.90	< 0.20	1.30
		12/30/97	7.9	704	372	14.0	128	<0.10												
	Average 1997		8.0	662	339	12.5	126	< 0.11	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	1.95	< 1.00	< 2.95	< 0.20	< 0.75
		03/05/98	7.9	729	362	14.3	130	< 0.10	0.001	< 0.01	< 0.050	< 0.020	< 0.05	0.001	4.2	2.40	< 1.00	< 3.40	< 0.20	0.50
		06/26/98	7.8	705	376	12.1	125	< 0.10												

ATTACHMENT 3C TDSS BACKGROUND MONITOR WELLS CONTINUED

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
174	TDMXL	08/17/88	10.8	292	46	5		0.05	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.001	3.0	0.80	1.90	2.70	0.90	1.60
		09/01/88	9.4	326	106	10		0.49	0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.161	0.9	0.80	1.20	2.00	0.30	1.40
		09/14/88	9.3	327	170	10		0.22	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	1.0	1.20	1.50	2.70	0.50	2.10
		09/28/88	9.2	312	54	6	74	0.20	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	1.5	0.70	3.40	4.10	0.50	1.30
	Average 1988		9.7	314	94	8	74	0.24	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.041	1.6	0.88	2.00	2.88	0.55	1.60
		02/27/89	8.5	340	96	14	93	0.10	0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.005	1.7	1.40	1.70	3.10	0.40	< 0.20
		04/26/89	8.1	292	134	30	71	< 0.01	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	2.9	1.00	1.50	2.50	0.90	< 0.20
		07/18/89	7.9	291	95	18	67	0.03	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.006	1.5	0.50	0.60	1.10	0.60	0.20
		10/20/89	8.5	301	110	13	80	0.08												
	Average 1989		8.2	306	109	19	78	< 0.06	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.004	2.0	0.97	1.27	2.23	0.63	< 0.20
		01/22/90	7.9	298	88	26	74	0.04	< 0.001	< 0.002	0.240	< 0.020	< 0.05	0.001	1.4	1.20	1.60	2.80	0.20	< 0.20
		04/23/90	8.0	320	65	12	81	< 0.01												
		08/24/90	8.2	294	110	12	74	< 0.01	0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	2.7	0.70	1.80	2.50	0.20	< 0.20
		10/23/90	8.2	316	85	12	72	< 0.01												
	Average 1990		8.1	307	87	16	75	< 0.02	< 0.001	< 0.002	< 0.125	< 0.020	< 0.05	< 0.001	2.0	0.95	1.70	2.65	0.20	< 0.95

ATTACHMENT 3C TDSS BACKGROUND MONITOR WELLS CONTINUED

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
174	TDMXL	01/13/91	7.3	287	126	5.6	82.4	< 0.01	< 0.001	< 0.010	< 0.050	< 0.050	< 0.05	< 0.001	< 1.0	0.20	< 1.00	< 1.20	< 0.20	< 0.20
		04/28/91	7.8	249	104	5.5	84.8	< 0.01												
		07/19/91	8.0	297	110	6.3	73.5	< 0.01	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.70	< 1.00	< 1.70	< 0.20	1.80
		10/14/91	8.1	312	102	7.6	78.0	< 0.01												
	Average 1991		7.8	278	113	5.8	80.2	< 0.01	< 0.001	< 0.010	< 0.050	< 0.035	< 0.05	< 0.001	< 1.0	0.45	< 1.00	< 1.45	< 0.20	< 1.00
		01/14/92	8.2	317	100	5.5	73.3	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	1.60	< 1.80	< 0.20	< 0.20
		04/23/92	8.1	324	105	4.3	76.1	< 0.10												
		07/10/92	8.2	350	114	15.2	89.8	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	5.42
		10/27/92	7.5	299	128	7.5	79.4	< 0.10												
	Average 1992		8.0	322	112	8.1	79.6	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.30	< 1.50	< 0.20	< 2.81
		01/21/93	7.8	291	103	6.0	70.0	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.80	2.20	3.00	< 0.20	< 0.20
		04/28/93	7.6	290	101	6.1	74.6	< 0.10												
		07/13/93	7.4	311	103	7.3	74.4	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.60	< 1.00	< 1.60	< 0.20	0.20
		10/26/93	7.0	300	102	4.1	70.8	< 0.10												
	Average 1993		7.5	298	102	5.9	72.5	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.70	< 1.60	< 2.30	< 0.20	< 0.20
		01/14/94	7.2	279	96.0	3.8	63.5	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	4.9	0.30	3.00	3.30	< 0.20	0.68
		04/24/94	6.6	284	86.0	6.7	65.1	< 0.10												
		07/10/94	7.1	294	99.5	11.8	66.4	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.30	< 1.00	< 1.30	< 0.20	0.70
		10/27/94	7.0	281	98.9	3.9	76.9	< 0.10												
	Average 1994		7.0	284	95.1	6.6	68.0	< 0.10	< 0,001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	3.0	0.30	< 2.00	< 2.30	< 0.20	0.69
		01/30/95	7.5	298	102	< 1,0	67.2	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.40	< 1.00	< 1.40	< 0.20	0.20
		05/04/95	7.4	301	103	8.1	70.0	< 0.10												
		07/25/95	8.0	331	103	6.4	72.5	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.60	2.40	3.20	< 0.20	10.20
		11/21/95	7.9	309	99.6	5.3	69.0	< 0.10												
	Average 1995		7.7	310	102	5.2	69.7	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.50	< 1.70	< 2.30	< 0.20	5.20
		01/26/96	7.9	313	94	4.8	68.0	0.15	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	1.10	< 1.30	< 0.20	< 0.20
		05/01/96	8.3	299	103	6.4	71.0	< 0.10												
		07/11/96	8.3	311	104	6.4	70.9	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.30	< 1.00	< 1.30	< 0.20	< 0.20
		11/11/96	7.8	288	103	7.1	67.3	< 0.10												
	Average 1996		8.1	303	101	6.2	69.7	< 0.12	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.25	< 1.05	< 1.30	< 0.20	< 0.20
		02/04/97	8.1	282	104	6.5	64.9	< 0.10	0.005	< 0.010	< 0.050	< 0.020	< 0.05	0.005	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	< 0.20
		04/26/97	8.4	315	98.0	6.7	65.2	< 0.10												
		07/09/97	8.2	289	100	6.5	71.0	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	0.34
		10/09/97	7.9	300	98.0	15.7	69.6	< 0.10												
	Average 1997		8.2	297	100	8.9	67.7	< 0.10	< 0.003	< 0.010	< 0.050	< 0.020	< 0.05	< 0.003	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	< 0.27
		01/05/98	7.9	360	108	5.2	70.3	< 0.10	< 0.001	< 0.005	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	0.70	< 0.20
		04/06/98	8.0	312	108	8.1	70.3	< 0.10												
		07/07/98	8.0	299	99.0	4.8	70.0	< 0.10	< 0.001	< 0.005	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	< 0.20

ATTACHMENT 3C TDSS BACKGROUND MONITOR WELLS CONTINUED

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
182	TOM XLVIII	08/22/88	9.7	373	240	9		0.39	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	2.8	1.10	2.50	3.60	0.90	0.05
		09/06/88	9.9	385	182	10		0.30	0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.003	0.9	0.90	1.50	2.40	0.20	1.10
		09/20/88	9.6	403	104	11		0.26	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	0.8	1.10	1.80	2.90	0.40	0.50
		10/04/88	9.6	379	110	13	104	0.05	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	1.0	1.80	2.10	3.90	0.70	< 0.05
	Average 1988		9.7	385	159	11	104	0.25	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	1.4	1.23	1.98	3.20	0.55	< 0.42
		01/18/89	9.3	341	162	14	106	0.43	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.002	0.9	0.70	1.30	2.00	0.60	0.60
		04/27/89	9.2	337	195	14	108	< 0.01	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	3.0	0.30	2.10	2.40	1.10	< 0.20
		07/14/89	8.9	350	165	18	100	0.04	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.002	1.4	1.20	0.90	2.10	0.30	0.70
		10/23/89	9.5	351	182	12	117	1.07												
	Average 1989		9.2	345	176	14	108	< 0.39	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.002	1.8	0.73	1.43	2.17	0.67	< 0.50
		01/15/90	8.9	351	149	12	107	< 0.01	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.001	0.6	0.40	1.60	2.00	0.20	0.90
		04/24/90	8.6	324	100	43	119	< 0.01												
		08/23/90	8.6	389	134	25	110	0.22	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	2.3	0.60	1.70	2.30	0.20	0.30
		10/18/90	8.6	361	157	11	107	0.18												
	Average 1990		8.7	356	135	23	111	< 0.10	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	1.4	0.50	1.65	2.15	0.20	0.60

ATTACHMENT 3C TDSS BACKGROUND MONITOR WELLS CONTINUED

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
182	TDM XLVIII	01/11/91	7.7	392	209	4.9	126	< 0.01	< 0.001	< 0.010	< 0.050	< 0.050	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	< 0.20
		04/18/91	8.1	352	188	5.6	116	0.01												
		07/03/91	7.5	388	197	4.6	114	< 0.01	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	2.0	1.50	< 1.00	< 2.50	< 0.20	1.80
		10/10/91	8.1	394	197	4.1	109	< 0.01												
	Average 1991		7.8	377	198	5.0	119	< 0.01	< 0.001	< 0.010	< 0.050	< 0.035	< 0.05	< 0.001	< 1.5	< 0.85	< 1.00	< 1.85	< 0.20	< 1.00
		01/09/92	8.5	390	191	5.6	111	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	< 0.20
		04/23/92	7.3	430	182	5.3	114	< 0.10												
		07/23/92	8.2	444	221	4.1	138	0.20	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.001	< 1.0	0.20	< 1.00	< 1.20	< 0.20	0.20
		10/26/92	8.0	392	203	6.6	113	< 0.10												
	Average 1992		8.0	414	199	5.4	119	< 0.13	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	< 0.20
		01/21/93	8.2	380	197	6.5	104	< 0.10	0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	< 0.20
		04/28/93	8.1	397	189	5.0	104	< 0.10												
		07/12/93	7.9	400	191	5.3	111	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	1.4	1.00	< 1.00	< 2.00	< 0.20	1.35
		10/25/93	7.7	409	184	4.4	112	< 0.10												
	Average 1993		8.0	397	190	4.3	108	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.2	< 0.60	< 1.00	< 1.60	< 0.20	< 0.78
		01/13/94	7.5	382	184	3.2	95.2	< 0.10	0.002	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.60	< 1.00	< 1.60	< 0.20	0.68
		04/24/94	7.1	384	156	6.4	104.0	< 0.10												
		07/06/94	8.3	425	198	5.1	110.0	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.20	< 1.00	< 1.20	< 0.20	0.70
		10/25/94	7.2	395	190	4.6	106	< 0.10												
	Average 1994		7.5	396	182	4.8	104	< 0.10	< 0.002	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.40	< 1.00	< 1.40	< 0.20	0.69
		01/26/95	7.2	406	199	4.0	102	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.30	< 1.00	< 1.30	< 0.20	1.60
		04/24/95	7.6	388	198	6.9	110	<0.10												
		07/21/95	8.2	434	193	6.4	111	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.70	< 1.00	< 1.70	0.50	< 1.00
		11/20/95	8.5	402	206	4.3	112	< 0.10												
	Average 1995		7.9	408	199	5.4	109	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.50	< 1.00	< 1.50	< 0.35	< 1.30
		01/24/96	8.7	411	198	4.7	104	< 0.10	0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	1.3	< 0.20	< 1.00	< 1.20	< 0.20	< 0.20
		04/24/96	7.8	400	194	5.1	107	< 0.10												
		07/10/96	8.6	415	209	4.7	112	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	< 0.20
		11/11/96	8.3	391	196	6.4	103	< 0.10												
	Average 1996		8.4	404	199	5.2	107	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.2	0.20	< 1.00	< 1.20	< 0.20	< 0.20
		01/27/97	8.5	397	189	5.5	103	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	0.70
		04/26/97	8.5	380	150	5.9	103	< 0.10												
		07/07/97	8.3	378	196	5.7	113	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	< 0.20
		10/06/97	8.1	406	185	5.2	107	< 0.10												
	Average 1997		8.4	390	180	5.6	107	< 0.10	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	< 0.45
		01/05/98	8.2	432	211	4.9	108	< 0.10	< 0.001	< 0.005	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.90	< 1.00	< 1.90	< 0.20	< 0.20
		04/06/98	8.3	402	207	5.5	112	< 0.10												
		07/02/98	8.2	421	191	3.4	112	< 0.10	< 0.001	< 0.005	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	< 0.20

ATTACHMENT 3E MINE BACKFILL MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
171	TDM XXXVIII	05/31/88	7.5	750	428	46			< 0.001					0.011		2.20				14.20
		12/09/88	7.5	749	400	55	82		< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001		0.90				15.00
	Average 1988		7.5	750	414	50	82		< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.006		1.55				14.60
		03/20/89	7.3	727	400	44	97	< 0.01	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	1.7	0.60	1.80	2.40	0.20	2.80
		06/13/89	7.5	736	400	52	118	0.02	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.003	1.2	1.00	0.50	1.50	0.70	1.60
		09/27/89	7.6	689	400	40	78	0.13	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	2.7	0.90	0.60	1.50	0.80	1.10
		12/21/89	7.1	805	310	38	90	0.10												
	Average 1989		7.4	739	378	43	96	< 0.06	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.002	1.9	0.80	1.00	1.80	0.60	1.80
		05/01/90	7.4	806	340	30	90	< 0.01	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	1.7	0.90	4.80	5.70	0.60	0.40
		06/27/90	7.4	848	396	60	98	0.62												
		09/07/90	8.2	743	324	23	95	0.90	0.003	< 0.002	< 0.010	< 0.020	< 0.05	0.003	4.1	1.00	2.20	3.20	0.40	4.30
		12/01/90	7.7	810	350	30	94	0.11												
	Average 1990		7.7	802	352	36	94	< 0.41	< 0.002	< 0.002	< 0.010	< 0.020	< 0.05	< 0.002	2.9	0.95	3.50	4.45	0.50	2.35

ATTACHMENT 3E MINE BACKFILL MONITOR WELLS

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
171	TDM XXXVIII	03/02/91	6.9	771	471	23	96.9	< 0.01	< 0.001	< 0.01	< 0.050	< 0.050	< 0.05	< 0.001	< 1.0	< 0.20	1.50	< 1.70	< 0.20	1.80
		06/10/91	7.3	640	387	27.7	83.9	1.12			< 0.050									
		09/08/91	7.4	786	458	19.0	96.5	1.20	0.015	< 0.01	< 0.050	< 0.020	< 0.05	0.028	< 1.0	< 0.20	< 1.00	< 1.12	< 0.20	4.10
		12/21/91	7.1	551	472	27.4	83.6	< 0.01												
	Average	1991	7.2	687	447	24.3	90.2	< 0.58	< 0.008	< 0.01	< 0.050	< 0.035	< 0.05	< 0.015	< 1.0	< 0.20	< 1.25	< 1.45	< 0.20	2.95
		03/28/92	7.3	738	461	24.7	111	< 0.10	0.002	< 0.01	< 0.050	0.020	< 0.05	< 0.001	1.7	1.50	< 1.00	< 2.50	< 0.20	14.22
		06/10/92	8.0	743	418	28.5	95.5	< 0.10												
		09/21/92	8.0	819	432	25.6	111	1.10	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	1.3	1.20	< 1.00	< 2.20	< 0.20	4.74
		12/03/92	7.0	614	457	21.8	90.0	< 0.10												
	Average	1992	7.6	728	442	25.2	101.9	< 0.35	< 0.002	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	1.5	1.35	< 1.00	< 2.35	< 0.20	9.48
		03/03/93	6.9	710	429	26.6	90.8	< 0.01	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.70	1.30	2.00	< 0.20	6.09
		06/05/93	7.0	772	461	34.0	86.8	< 0.10												
		09/16/93	6.4	699	410	26.5	77.0	0.27	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	7.7	4.30	2.30	6.60	< 0.20	5.20
		12/02/93	7.1	723	428	24.2	84.4	< 0.10												
	Average	1993	6.8	726	432	27.8	84.8	< 0.12	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 4.4	2.50	1.80	4.30	< 0.20	5.64
		03/28/94	6.5	734	406	37.4	83.5	< 0.10	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.60	< 1.00	< 1.60	< 0.20	104.00
		06/29/94	7.4	747	434	28.3	80.1	1.10												
		09/29/94	7.3	805	479	21.1	101.0	< 0.10	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	2.7	2.50	< 1.00	< 3.50	< 0.20	2.70
		12/14/94	6.0	741	453	33.3	93.0	0.61												
	Average	1994	6.8	757	443	30.0	89.4	< 0.48	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.9	1.55	< 1.00	< 2.55	< 0.20	53.35
		03/21/95	6.7	800	439	37.0	79.0	0.19	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	3.3	0.40	1.80	2.20	< 0.20	6.90
		06/26/95	7.5	792	483	30.6	94.2	< 0.10												
		09/07/95	7.5	768	463	27.9	97.0	0.27	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	1.9	1.10	< 1.00	< 2.10	< 0.20	2.60
		12/01/95	7.5	971	563	10.2	179.0	0.22												
	Average	1995	7.3	833	487	26.4	112.3	< 0.20	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	2.6	0.75	< 1.40	< 2.15	< 0.20	4.75
		03/12/96	7.2	813	486	34.2	92.1	< 0.10	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	2.0	1.05	2.50	3.50	< 0.20	2.30
		06/29/96	7.9	847	528	38.0	101	0.17												
		09/30/96	7.7	837	487	36.0	99.0	< 0.10	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.60	< 1.00	< 1.60	< 0.20	4.00
		02/04/97	7.7	813	436	35.0	97.0	< 0.10												
	Average	1996	7.6	828	484	35.8	97.3	< 0.12	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.5	0.82	< 1.75	< 2.55	< 0.20	3.15
		03/21/97	7.4	887	513	41.2	102	< 0.10	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	1.3	1.20	< 1.00	< 2.20	< 0.20	3.39
		06/12/97	7.5	868	496	39.9	103	0.32												
		09/29/97	7.6	982	546	51.6	105	0.26	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	4.70
		12/30/97	7.4	918	588	55.5	101	< 0.10												
	Average	1997	7.5	912	536	47.0	103	< 0.20	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.2	< 0.70	< 1.00	< 1.70	< 0.20	4.05
		03/03/98	7.5	940	541	45.5	102	< 0.10	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	0.002	6.7	4.70	< 1.00	< 5.70	< 0.20	3.80
		06/26/98	7.3	913	553	46.0	96.1	< 0.10												

ATTACHMENT 3E MINE BACKFILL MONITOR WELLS CONTINUED

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
173	TDM XXXIX	08/24/88	7.0	637	264	70		< 0.01	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.003		0.80	2.40	2.20	0.70	6.00
		09/09/88	7.4	739	200	69		0.09	0.002	< 0.002	< 0.010	< 0.020	< 0.05	0.001	1.0	0.50	0.60	1.10	0.60	5.10
		09/23/88	8.0	629	474	60		0.06	0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001		0.60	3.20	3.80	0.60	6.40
		10/13/88	7.6	510	290	63	71	0.05	< 0.001	0.003	< 0.010	< 0.020	< 0.05	< 0.001	2.4	1.20	3.40	4.60	0.50	6.30
	Average 1988		7.5	628	307	66	71	< 0.06	< 0.002	< 0.003	< 0.010	< 0.020	< 0.05	< 0.002	1.7	0.80	2.40	3.20	0.60	5.95
		01/12/89	7.8	604	275	98	74	0.24	0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.003	2.8	0.90	3.00	3.90	0.20	4.40
		04/24/89	7.8	626	400	125	71	0.03	0.002	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	2.8	1.00	1.80	2.80	0.60	0.70
		07/13/89	7.4	602	290	85	69	0.13	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.004	1.7	1.00	0.80	1.80	0.80	0.20
		10/23/89	7.8	635	300	74	79	0.10												
	Average 1989		7.7	617	316	96	73	0.12	< 0.002	< 0.002	< 0.010	< 0.020	< 0.05	< 0.003	2.4	0.97	1.90	2.87	0.53	1.77
		01/15/90	7.5	563	262	76	74	< 0.01	0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.001	0.7	0.40	1.90	2.30	0.20	< 0.10
		04/23/90	7.5	604	232	90	79	< 0.01												
		08/23/90	8.1	652	220	78	77	0.09	0.003	< 0.002	< 0.010	< 0.020	< 0.05	0.001	3.7	1.00	0.20	1.20	0.20	2.00
		10/19/90	7.8	653	238	72	76	0.09												
	Average 1990		7.7	618	238	79	76	< 0.05	0.002	< 0.002	< 0.010	< 0.020	< 0.05	0.001	2.2	0.70	1.05	1.80	0.20	< 1.05

ATTACHMENT 3E MINE BACKFILL MONITOR WELLS CONTINUED

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
173	TDM XXXIX	01/13/91	6.9	626	359	66.4	86.2	< 0.01	< 0.001	< 0.01	< 0.050	< 0.050	< 0.05	< 0.001	1.1	0.90	< 1.0	< 1.90	< 0.20	3.10
		04/21/91	7.1	605	323	66.3	67.8	< 0.01												
		07/19/91	7.8	626	332	64.7	78.2	0.04	0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.50	< 1.0	< 1.50	< 0.20	7.80
		10/14/91	8.3	655	335	77.3	84.0	0.03												
	Average 1991		7.5	619	338	65.8	77.4	< 0.20	< 0.001	< 0.01	< 0.050	< 0.035	< 0.05	< 0.001	< 1.1	0.70	< 1.0	< 1.70	< 0.20	5.45
		01/14/92	8.3	654	299	62.9	77.2	< 0.10	0.002	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.60	1.20	1.80	< 0.20	3.39
		04/22/92	7.8	662	323	68.8	78.0	< 0.10												
		07/10/92	8.4	672	289	68.9	97.5	< 0.10	0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	1.70	< 1.90	< 0.20	1.35
		10/27/92	7.5	627	287	75.2	74.0	< 0.10												
	Average 1992		8.0	654	299	68.9	81.7	< 0.10	0.002	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.40	1.45	< 1.85	< 0.20	2.37
		01/20/93	7.3	645	315	70.2	72.0	< 0.10	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	2.3	1.90	< 1.00	< 2.90	< 0.20	< 0.20
		04/28/93	7.4	673	332	78.4	71.8	< 0.10												
		07/13/93	7.2	658	337	75.8	70.6	0.79	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.80	2.70	3.50	< 0.20	6.09
		10/27/93	7.0	634	302	71.8	69.4	0.10												
	Average 1993		7.2	653	322	74.1	72.6	< 0.27	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.7	1.35	< 1.85	< 3.20	< 0.20	< 3.15
		01/22/94	7.1	649	311	72.6	71.5	< 0.10	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	2.1	0.50	1.10	1.60	< 0.20	< 0.20
		04/25/94	6.2	751	368	67.4	83.6	< 0.10												
		07/10/94	6.6	662	318	78.0	69.7	< 0.10	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	2.1	0.40	11.40	11.80	< 0.20	8.10
		10/27/94	7.1	641	321	79.8	87.0	< 0.10												
	Average 1994		6.8	676	330	74.4	78.0	< 0.10	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	2.1	0.45	6.25	6.70	< 0.20	4.15
		01/30/95	7.5	706	335	81.7	77.0	< 0.10	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.90	< 1.00	< 1.90	< 0.20	4.10
		05/04/95	7.2	659	324	87.0	77.1	< 0.10												
		07/25/95	7.6	740	320	86.0	79.0	< 0.10	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	1.00	< 1.00	< 2.00	< 0.20	3.90
		11/21/95	7.7	700	310	81.5	80.1	0.12												
	Average 1995		7.5	701	322	84.1	78.3	< 0.11	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	0.95	< 1.00	< 1.95	< 0.20	4.00
		01/26/96	7.6	706	300	80.0	77.0	< 0.10	0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	1.2	0.60	1.70	2.30	< 0.20	3.30
		05/01/96	8.2	713	343	88.4	79.0	< 0.14												
		07/09/96	8.0	707	332	90.0	81.0	< 0.10	0.005	< 0.01	< 0.050	< 0.020	< 0.05	0.002	< 1.0	0.50	< 1.00	< 1.50	< 0.20	3.00
		11/13/96	7.5	695	337	98.5	76.9	< 0.10												
	Average 1996		7.8	705	328	89.2	78.4	< 0.11	0.003	< 0.01	< 0.050	< 0.020	< 0.05	< 0.002	< 1.1	0.55	< 1.35	< 1.90	< 0.20	3.15
		02/04/97	8.0	679	315	93.0	74.0	< 0.10	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	0.001	< 1.0	< 0.20	< 1.00	< 1.20	< 0.20	2.70
		04/26/97	8.1	745	325	100	77.0	< 0.10												
		07/08/97	8.0	727	361	99.1	85.1	< 0.10	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	2.70	< 2.70	< 0.20	2.71
		10/09/97	7.6	777	368	100	81.6	< 0.10												
	Average 1997		7.9	732	342	98.0	79.4	< 0.10	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	< 1.85	< 1.95	< 0.20	2.71
		01/05/98	7.6	932	384	106	80.3	< 0.10	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	0.002	1.4	0.60	1.40	2.00	< 0.20	6.00
		04/04/98	7.7	736	354	102	81.7	< 0.10												
		07/06/98	7.6	777	393	83.0	84.3	< 0.10	< 0.001	< 0.01	< 0.050	< 0.020	< 0.05	< 0.001	< 1.0	< 0.20	<1.00	<1.20	< 0.20	3.20

ATTACHMENT 3E MINE BACKFILL MONITOR WELLS CONTINUED

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
180	TDM XLVI	08/23/88	7.3	2212	930	155		0.25	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	3.5	3.90	2.40	6.30	0.90	632.00
		09/07/88	7.1	2298	1250	180		0.09	0.001	0.007	< 0.010	< 0.020	< 0.05	0.002	16.4	2.00	8.10	10.10	0.40	620.00
		09/21/88	6.9	2717	1610	242		0.11	0.002	0.003	< 0.010	< 0.020	< 0.05	0.003	10.4	1.50	5.20	6.70	0.50	528.00
		10/05/88	7.4	1688	238	185	171	0.01	< 0.001	0.009	< 0.010	< 0.020	< 0.05	0.001	7.5	3.60	7.60	10.20	1.00	574.00
	Average 1988		7.2	2228	1007	190	171	0.12	< 0.002	< 0.005	< 0.010	< 0.020	< 0.05	< 0.002	7.0	2.75	5.80	8.55	0.70	588.00
		01/12/89	7.4	2189	1100	173	162	0.44	0.001	< 0.002	< 0.010	< 0.020	< 0.05	0.002	10.8	5.90	5.00	10.90	2.60	528.00
		04/25/89	7.4	1797	1400	175	150	< 0.01	< 0.001	< 0.002	< 0.010	< 0.020	< 0.05	< 0.001	4.3	3.20	2.90	6.10	4.00	166.00
		08/29/89	6.8	2697	1320	215	197	0.01	0.001	0.006	0.010	0.020	0.05	0.001	6.1	5.70	1.50	7.20	0.80	385.00
		10/20/89	6.9	2299	1380	215	190	0.08												
	Average 1989		7.1	2246	1300	194	175	< 0.14	< 0.001	< 0.005	< 0.010	< 0.020	< 0.05	< 0.002	7.1	4.90	3.10	8.00	2.50	360.00
		01/16/90	7.1	1606	1100	175	163	< 0.01	< 0.001	0.004	< 0.010	< 0.020	< 0.05	0.002	2.1	1.70	1.70	3.40	0.30	499.00
		04/24/90	6.9	2400	1160	255	269	< 0.01												
		08/23/90	7.0	2327	920	200	179	0.03	0.001	0.007	< 0.010	< 0.020	< 0.05	0.009	4.2	4.90	2.30	7.20	0.40	459.00
		10/19/90	7.1	2311	1110	158	177	0.28												
	Average 1990		7.0	2161	1072	197	197	< 0.08	< 0.001	0.006	< 0.010	< 0.020	< 0.05	0.006	3.2	3.30	2.00	5.30	0.35	479.00

ATTACHMENT 3E MINE BACKFILL MONITOR WELLS CONTINUED

WELL NUMBER	WELL NAME	DATE	pH (S.U.)	TDS (mg/l)	SO4 (mg/l)	Cl (mg/l)	Na (mg/l)	NO3 (mg/l)	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Grs Alpha (pCi/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Ra226+228 (pCi/l)	Th230 (pCi/l)	UNAT (pCi/l)
180	TDM XLVI	01/13/91	7.3	3254	1766	274	233	0.09	< 0.001	< 0.010	< 0.050	0.050	< 0.05	0.008	13.4	11.20	< 1.00	< 12.20	< 0.20	319.20
		04/18/91	6.7	3466	1791	276	236	0.13												
		07/19/91	6.6	2973	1451	243	223	0.04	< 0.001	< 0.010	< 0.050	< 0.020	< 0.05	0.009	7.0	6.70	< 1.00	< 7.70	< 0.20	519.00
		10/14/91	6.6	3081	1484	263	208	1.90												
	Average	1991	6.9	3231	1669	264	231	< 0.08	< 0.001	< 0.010	< 0.050	< 0.035	< 0.05	0.009	10.2	8.95	< 1.00	< 9.95	< 0.20	419.10
		01/14/92	6.6	3405	1739	267	206	< 0.10	< 0.001	< 0.010	< 0.050	0.040	< 0.05	< 0.001	6.0	5.70	< 1.00	< 6.70	< 0.20	276.00
		04/22/92	6.9	3450	1708	272	262	< 0.10												
		07/10/92	6.8	2852	1472	210	247	< 0.10	< 0.001	< 0.010	< 0.050	0.020	< 0.05	0.025	5.9	5.60	< 1.00	< 6.60	< 0.20	510.00
		10/27/92	6.8	3095	1593	232	244	< 0.10												
	Average	1992	6.8	3200	1628	245	240	< 0.10	< 0.001	< 0.010	< 0.050	0.030	< 0.05	< 0.013	6.0	5.65	< 1.00	< 6.65	< 0.20	393.00
		01/21/93	7.0	2645	1420	203	178	< 0.10	< 0.001	< 0.010	< 0.050	0.020	< 0.05	0.027	5.1	4.90	3.80	8.70	< 0.20	846.00
		04/27/93	6.5	2499	1351	203	188	0.60												
		07/13/93	6.4	3167	1635	228	238	1.67	< 0.001	< 0.010	< 0.050	0.120	< 0.05	0.090	9.3	8.90	2.90	11.80	< 0.20	363.55
		10/27/93	6.1	3594	2013	265	271	< 0.10												
	Average	1993	6.5	2976	1605	225	219	< 0.62	< 0.001	< 0.010	< 0.050	0.070	< 0.05	0.058	7.2	6.90	3.35	10.25	< 0.20	604.78
		01/22/94		Water level too low to sample																
		04/24/94		DRY																
		07/07/94		DRY																
		10/12/94		DRY																
	Average	1994																		
		01/26/95		DRY																
		04/03/95		DRY																
		07/21/95		DRY																
		10/20/95		DRY																
	Average	1995																		
		01/15/96		DRY																
		04/15/96		DRY																
		07/10/96		DRY																
		11/11/96		DRY																
	Average	1996																		
		01/27/97		DRY																
		04/11/97		DRY																
		07/07/97		DRY																
		10/07/97		DRY																
	Average	1997																		
		01/06/98		DRY																
		04/06/98		DRY																
		07/07/98		DRY																

APPENDIX 2

STATISTICAL DETERMINATION OF POINT OF COMPLIANCE WELL NICKEL, RADIUM AND URANIUM COMPLIANCE WITH CURRENT GROUND WATER PROTECTION LIMITS AND PROPOSED ALARA CONCENTRATIONS

This appendix presents the determination of the compliance status of the Point of Compliance (POC) Well nickel (Ni), Radium 226 + 228 (RA 226 + 228) and natural uranium (UNAT) data with the Ground Water Protection Limits (GPLs) and the proposed As Low As Reasonably Achievable (ALARA) concentrations based on the Corrective Action Plan. The compliance determinations are based on statistical tools found in the EPA February, 1989 Interim Final Guidance document titled "Statistical Analysis Of Ground-Water Monitoring Data At RCRA Facilities" (EPA, 1989). This document is very relevant given the fact the NRC ground water regulations for uranium tailing basins were extracted from the RCRA regulations. Sections 4.2.2 and 6 of the guidance document were used. The ALARA concentrations proposed are upper limits based on a statistical method used in establishing insitu uranium mining Upper Control Limits for monitor wells.

Graphs of the Ni and Ra 226 + 228 concentrations for Well 175 and the UNAT concentrations for Wells 125 and 177 versus time are found at the end of this Appendix. In a visual sense these help make the case for the proposed ALARA concentrations.

EPA, 1989 presents methods for statistically evaluating the compliance status of normal, lognormal and non-parametric distributions of POC well data against fixed compliance limits such as MCLs (EPA drinking water Maximum Concentration Limits), ACLs or other fixed limits (Section 6 of EPA, 1989).

Following the EPA guidance for determining compliance against a Ground Water Protection Limit requires making a decision on whether the measured concentrations for a PHC at a POC follow a normal, lognormal or non-parametric statistical distribution (Section 4.2.2 of EPA, 1989). EPA, 1989 presents a simple method for making this statistical distribution determination. The EPA method was used on the data as presented in Table A2.1. If a normal statistical distribution was indicated, a normal distribution was assumed for the subsequent calculations. If a normal distribution was not found, the method was applied to the natural log-rhythms of the data. If normality was indicated, the data follow a lognormal distribution. Otherwise, a non-parametric distribution is indicated.

Normal mean, lognormal mean, and non-parametric median values and confidence limits were calculated from the concentration data using the EPA methods. These calculated values, along with the EPA method determination of whether the data for a PHC at a POC well followed a normal, lognormal or non-parametric distribution, are provided in Table A2-2. The table also lists the current GPLs and determinations from the calculated values of whether each PHC at each POC is in compliance with the appropriate GPL.

EPA, 1989 does not provide guidance on the statistical method for determining ALARA concentrations from monitoring data following operation of a corrective action program since ALARA is not a RCRA concept. However, the NRC has shown a preference for limits that do not require a statistical test to enforce. This has been institutionalized for ACL applications by setting ALARA based limits that are sufficiently high that there is only a small probability that any measurement would exceed the measurement if the water quality does not deteriorate. Such an upper limit must also be lower than the site-specific POC limits based on health and environmental limits at the POEs.

A 95% confidence interval is used in expressing precision for radionuclide measurements. This confidence limit equals the mean plus 1.96 standard deviations. If a limit were set at the upper confidence limit (mean plus 1.96 standard deviations), there would only be a 5% chance of a false positive. That is, only 5% of future measurements should exceed the limit. The chance of two consecutive measurements exceeding the limit would be very small unless the water quality significantly deteriorated.

ECMC proposes to set the ALARA values at the 95% Upper Confidence Limit. If a sample result exceeds the limit, ECMC would examine the measurement using the NRC recommended procedure for insitu uranium mining Upper Control Limit data.

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TABLE A2.1

Determination of Statistical Distribution

			Normal Distribution			Log Normal Distribution		
Well	PHC	Time Period	Mean	Std. Dev	CV	LN Mean	LN Std Dev	CV
125	Ni	88 - 98	<0.02	<0.02	1.1	-4.5	0.52	0.12
	Ra 226 + 228	88 - 98	2.15	1.65	0.77	0.21	0.34	1.57
	UNAT	88 - 98	30.2	14.6	0.48	3.23	0.81	0.25
175	Ni	91 - 98	1.42	0.21	0.15	0.34	0.14	0.42
	Ra 226 + 228	91 - 98	10.48	6.55	0.62	2.16	0.68	0.32
	UNAT	88 - 98	0.84	1.47	1.77	-1.07	1.13	1.05
176	Ni	88 - 96	0.02	0.03	1.4	-4.3	0.71	0.17
	Ra 226+228	88 - 96	3.92	2.01	0.51	1.20	0.64	0.53
	UNAT	88 - 96	0.56	0.68	1.21	-1.33	1.27	0.95
177	Ni	88 - 96	0.06	0.08	1.3	-3.53	1.26	0.36
	Ra 226 + 228	88 - 96	8.98	20.41	2.27	1.55	0.88	0.57
	UNAT	93 - 96	54.9	5.7	0.1	4.08	0.10	0.02

NOTES:

- Coefficient-of-Variation (CV) = absolute value $\left[\frac{\text{Mean}}{\text{Standard Deviation (Std. Dev.)}}\right]$
  from Section 4.2.2 of EPA at February 1989 Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities - Interim Final Guidance.
  A CV of one or less indicates a normal distribution can be assumed for the data set.

- A normal distribution is assumed if the normal CV is less than l. Otherwise, a lognormal distribution is assumed if the lognormal CV is less than l. Otherwise, a non-parametric distribution is assumed.

TABLE A2.2

		Ground Water			Normal Distribution		Log Normal Distribution		Non-Parametric Distribution		Compliance
Well	PHC	Protection Limit	Time Period	Distribution	Mean	Confidence Interval	Mean	Confidence Interval	Median	Confidence Interval	Yes / No
125	Ni	0.02	88 - 96	Lognormal	<0.02	<0.02, 0.02	<0.02	<0.02, <0.02	*<0.02*	*<0.02, <0.02*	Yes
	Ra 226 + 228	5	88 - 96	Normal	2.2	1.3, 3.0	1.2	1.0, 1.5	1.9	0.6, 3.5	Yes
	UNAT	0.43	88 - 96	Normal	30.2	23.5, 36.8	25.1	7.6, 36.5	28.5	20.9, 37.2	No
175	Ni	0.02	88 - 98	Normal	1.22	1.06, 1.38	1.17	1.02, 1.35	1.25	0.83, 1.51	No
	Ni	0.02	91 - 98*	Normal	1.42	1.29, 1.55	1.41	1.28, 1.55	1.39	1.25, 1.57	No
	Ra 226 + 228	5	88 - 98	Normal	8.7	5.8, 11.6	7.0	5.0, 9.8	8.3	3.0, 12.9	No
	Ra 226 + 228	5	92 - 98*	Normal	11.02	6.41, 15.62	9.05	5.57, 14.71	10.90	6.00, 13.00	No
	UNAT	0.43	88 - 98	Non-Parametric	0.84	0.13, 1.54	0.34	0.20, 0.59	0.30	<0.20, 0.90	Yes
176	Ni	0.02	88 - 98	Lognormal	0.02	<0.02, 0.03	<0.02	<0.02, 0.02	<0.02	<0.02, 0.03	Yes
	Ra 226+228	5	88 - 98	Normal	3.9	2.9, 4.9	3.3	2.4, 4.5	4.1	1.8, 5.4	Yes
	UNAT	0.43	88 - 98	Lognormal	0.56	0.23, 0.90	0.26	<0.20, 0.50	0.13	<0.20, 1.30	Yes
177	Ni	0.02	88 - 96	Lognormal	0.06	0.02, 0.10	<0.02	<0.02, 0.06	<0.02	<0.02, 0.12	Yes
	Ra 226 + 228	5	88 - 96	Lognormal	9.0	<1.2, 19.7	4.1	2.5, 7.5	4.1	3.0, 7.5	Yes
	UNAT	0.43	88 - 96	Normal	45.0	37.7, 52.2	43.0	35.8, 51.0	43.0	34.1, 57.5	No
	UNAT	0.43	93 - 96*	Normal	59.4	53.9, 64.9	57.5	53.9, 64.9	57.5	54.2, 64.0	No

Well	PHC	Proposed ACL	Time Period	Distribution	NORMAL MEAN	STANDARD DEVIATION	MEAN+1.96 X STANDARD DEVIATION	HIGHEST MEASUREMENT SINCE 1994	COMPLIANCE
125	UNAT	71**	88 - 98	Normal	30.2	14.6	59	28.9	YES
175	Ni	1.8	91 - 98	Normal	1.42	0.21	1.8	1.7	YES
	Ra 226 & 228	24	91 - 98	Normal	11.02	6.79	24	13.4	YES
177	UNAT	71	93 - 96	Normal	59.4	5.7	71	57.5	YES

NOTES: Ni (mg/l), Ra 226+228 (pCi/l), UNAT (pCi/l)
* To determine the ALARA concentrations for Wells 175 and 177, only the more recent results were used since earlier the concentration had been increasing.
** Used Well 177 ALARA concentration.

PB89-151047

STATISTICAL ANALYSIS OF GROUND-WATER MONITORING DATA AT RCRA FACILITIES - INTERIM FINAL GUIDANCE

(U.S.) Environmental Protection Agency
Washington, DC

Feb 89

U.S. DEPARTMENT OF COMMERCE
National Technical Information Service
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SECTION 6

COMPARISONS WITH MCLs OR ACLs

This section includes statistical procedures appropriate when the monitoring aims at determining whether ground-water concentrations of hazardous constituents are below or above fixed concentration limits. In this situation the maximum concentration limit (MCL) or alternate concentration limit (ACL) is a specified concentration limit rather than being determined by the background well concentrations. Thus the applicable statistical procedures are those that compare the compliance well concentrations estimated from sampling with the prespecified fixed limits. Methods for comparing compliance well concentrations to a (variable) background concentration were presented in Section 5.

The methods applicable to the type of comparisons described in this section include confidence intervals and tolerance intervals. A special section deals with cases where the observations exhibit very small or no variability.

6.1 SUMMARY CHART FOR COMPARISON WITH MCLs OR ACLs

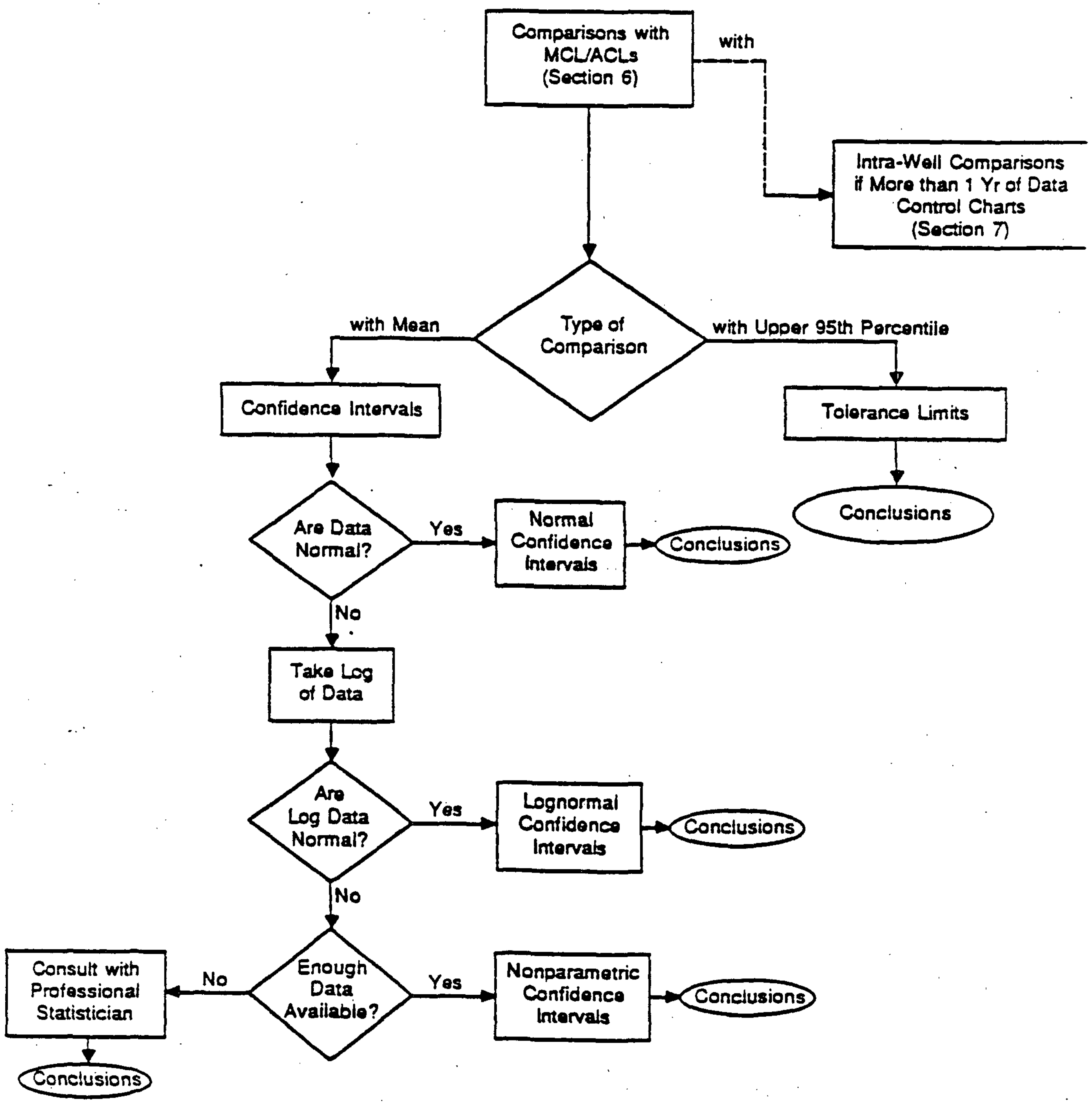
Figure 6-1 is a flow chart to aid the user in selecting and applying a statistical method when the permit specifies an MCL or ACL.

As with each type of comparison, a determination is made first to see if there are enough data for intra-well comparisons. If so, these should be done in parallel with the other comparisons.

Here, whether the compliance limit is a maximum concentration limit (MCL) or an alternate concentration limit (ACL), the recommended procedure to compare the mean compliance well concentration against the compliance limit is the construction of a confidence interval. This approach is presented in Section 6.2.1. Section 6.2.2 adds a special case of limited variance in the data. If the permit requires that a compliance limit is not to be exceeded more than a specified fraction of the time, then the construction of tolerance limits is the recommended procedure, discussed in Section 6.2.3.

6.2 STATISTICAL PROCEDURES

This section presents the statistical procedures appropriate for comparison of ground-water monitoring data to a constant compliance limit, a fixed standard. The interpretation of the fixed compliance limit (MCL or ACL) is that the mean concentration should not exceed this fixed limit. An alternate interpretation may be specified. The permit could specify a compliance limit as a concentration not to be exceeded by more than a small, specified



Comparisons with MCL/ACLs

Figure 6-1. Comparisons with MCLs/ACLs.

proportion of the observations. A tolerance interval approach for such a situation is also presented.

6.2.1 Confidence Intervals

When a regulated unit is in compliance monitoring with a fixed compliance limit (either an MCL or an ACL), confidence intervals are the recommended procedure pursuant to §264.97(h)(5) in the Subpart F regulations. The unit will remain in compliance monitoring unless there is statistically significant evidence that the mean concentration at one or more of the downgradient wells exceeds the compliance limit. A confidence interval for the mean concentration is constructed from the sample data for each compliance well individually. These confidence intervals are compared with the compliance limit. If the entire confidence interval exceeds the compliance limit, this is statistically significant evidence that the mean concentration exceeds the compliance limit.

Confidence intervals can generally be constructed for any specified distribution. General methods can be found in texts on statistical inference some of which are referenced in Appendix C. A confidence limit based on the normal distribution is presented first, followed by a modification for the log-normal distribution. A nonparametric confidence interval is also presented.

6.2.1.1 Confidence Interval Based on the Normal Distribution

PURPOSE

The confidence interval for the mean concentration is constructed from the compliance well data. Once the interval has been constructed, it can be compared with the MCL or ACL by inspection to determine whether the mean concentration significantly exceeds the MCL or ACL.

PROCEDURE

Step 1. Calculate the mean, $\overline{X}$, and standard deviation, S, of the sample concentration values. Do this separately for each compliance well.

Step 2. For each well calculate the confidence interval as

$$\overline{X} \pm t_{(0.99,\ n-1)} S/\sqrt{n}$$

where $t_{(0.99,\ n-1)}$ is obtained from the t-table (Table 6, Appendix B). Generally, there will be at least four observations at each sampling period, so t will usually have at least 3 degrees of freedom.

Step 3. Compare the intervals calculated in Step 2 to the compliance limit (the MCL or ACL, as appropriate). If the compliance limit is contained in the interval or is above the upper limit, the unit remains in compliance.

If any well confidence interval's lower limit exceeds the compliance limit, this is statistically significant evidence of contamination.

REMARK

The 99th percentile of the t-distribution is used in constructing the confidence interval. This is consistent with an alpha (probability of Type I error) of 0.01, since the decision on compliance is made by comparing the lower confidence limit to the MCL or ACL. Although the interval as constructed with both upper and lower limits is a 98% confidence interval, the use of it is one-sided, which is consistent with the 1% alpha level of individual well comparisons.

EXAMPLE

Table 6-1 lists hypothetical concentrations of Aldicarb in three compliance wells. For illustration purposes, the MCL for Aldicarb has been set at 7 ppb. There is no evidence of nonnormality, so the confidence interval based on the normal distribution is used.

TABLE 6-1. EXAMPLE DATA FOR NORMAL CONFIDENCE INTERVAL--ALDICARB CONCENTRATIONS IN COMPLIANCE WELLS (ppb)

Sampling date	Well 1	Well 2	Well 3
Jan. 1	19.9	23.7	5.6
Feb. 1	29.6	21.9	3.3
Mar. 1	18.7	26.9	2.3
Apr. 1	24.2	26.1	6.9
$\bar{X}$ =	23.1	24.6	4.5
S =	4.9	2.3	2.1

MCL = 7 ppb

Step 1. Calculate the mean and standard deviation of the concentrations for each compliance well. These statistics are shown in the table above.

Step 2. Obtain the 99th percentile of the t-distribution with (4-1) = 3 degrees of freedom from Table 6, Appendix B as 4.541. Then calculate the confidence interval for each well's mean concentration.

Well 1: $23.1 \pm 4.541(4.9)/\sqrt{4} = (12.0, 34.2)$

Well 2: $24.6 \pm 4.541(2.3)/\sqrt{4} = (19.4, 29.8)$

Well 3: $4.5 \pm 4.541(2.1)/\sqrt{4} = (-0.3, 9.3)$

where the usual convention of expressing the upper and lower limits of the confidence interval in parentheses separated by a comma has been followed.

Step 3. Compare each confidence interval to the MCL of 7 ppb. When this is done, the confidence interval for Well 1 lies entirely above the MCL of 7, indicating that the mean concentration of Aldicarb in Well 1 significantly exceeds the MCL. Similarly, the confidence interval for Well 2 lies entirely above the MCL of 7. This is significant evidence that the mean concentration in Well 2 exceeds the MCL. However, the confidence interval for Well 3 is mostly below the MCL. Thus, there is no statistically significant evidence that the mean concentration in Well 3 exceeds the MCL.

INTERPRETATION

The confidence interval is an interval constructed so that it should contain the true or population mean with specified confidence (98% in this case). If this interval does not contain the compliance limit, then the mean concentration must differ from the compliance limit. If the lower end of the interval is above the compliance limit, then the mean concentration must be significantly greater than the compliance limit, indicating noncompliance.

6.2.1.2 Confidence Interval for Log-Normal Data

PURPOSE

The purpose of a confidence interval for the mean concentration of log-normal data is to determine whether there is statistically significant evidence that the mean concentration exceeds a fixed compliance limit. The interval gives a range that includes the true mean concentration with confidence 98%. The lower limit will be below the true mean with confidence 99%, corresponding to an alpha of 1%.

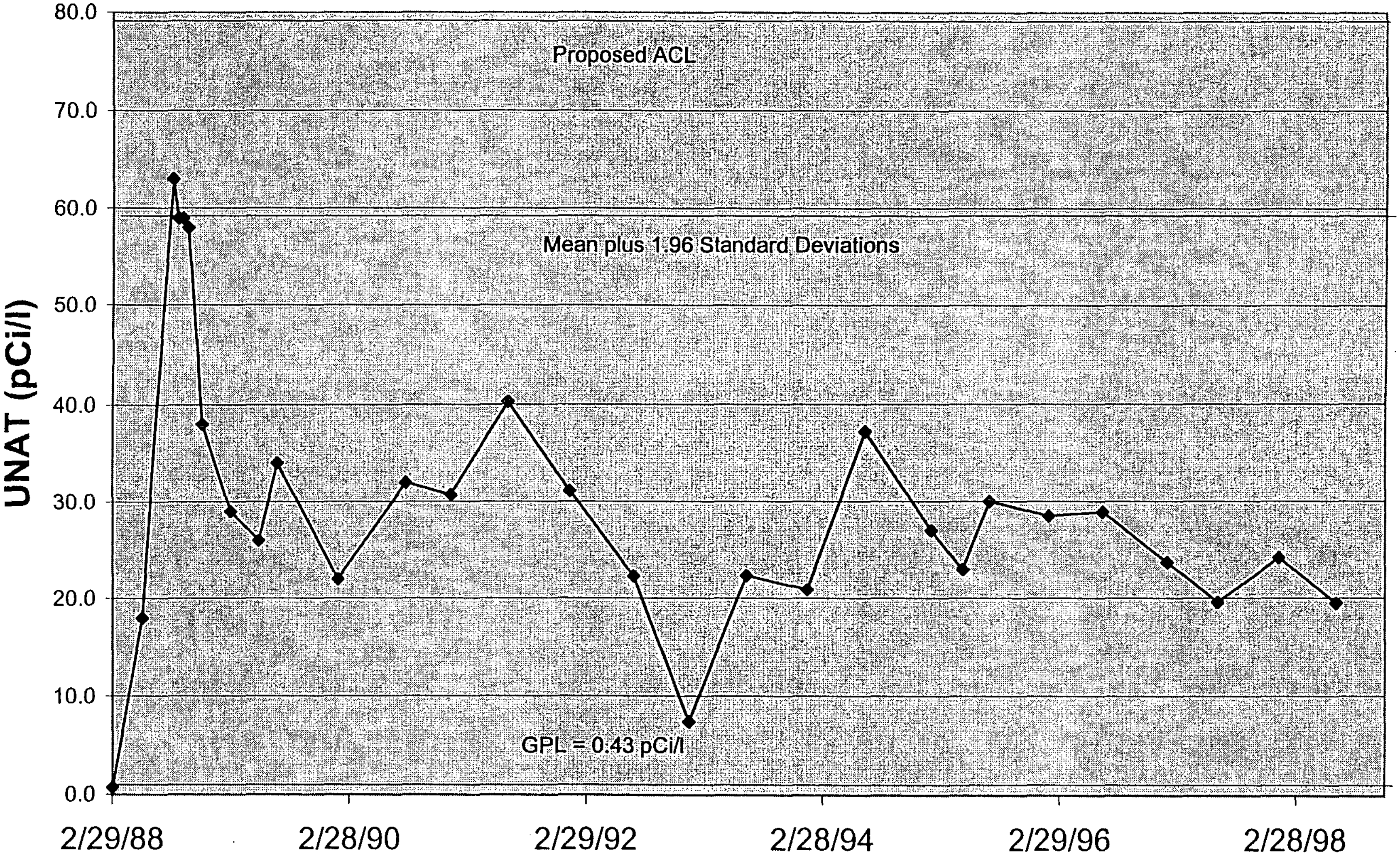
PROCEDURE

This procedure is used to construct a confidence interval for the mean concentration from the compliance well data when the data are log-normal (that is, when the logarithms of the data are normally distributed). Once the interval has been constructed, it can be compared with the MCL or ACL by inspection to determine whether the mean concentration significantly exceeds the MCL or ACL. Throughout the following procedures and examples, natural logarithms (ln) are used.

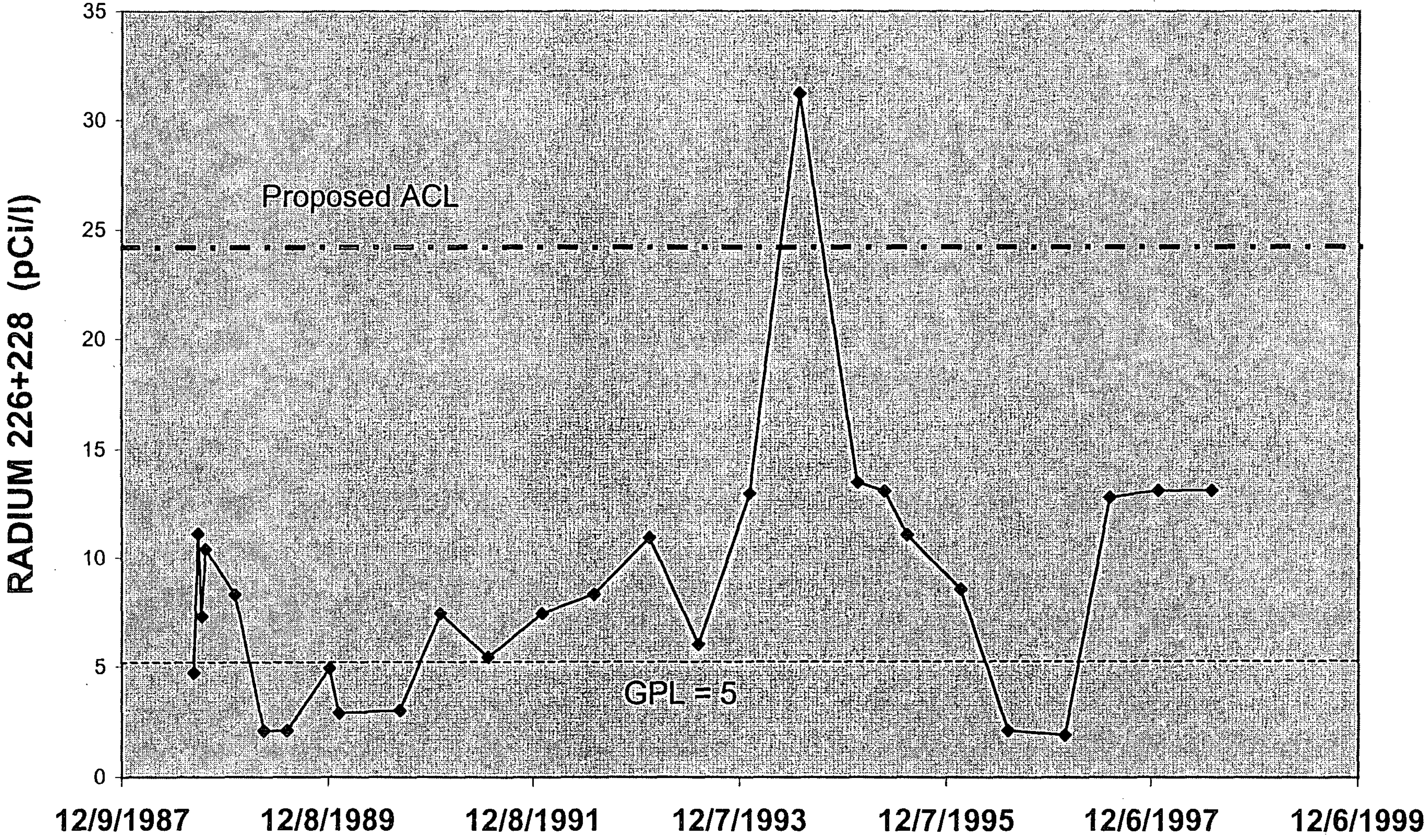
Step 1. Take the natural logarithm of each data point (concentration measurement). Also, take the natural logarithm of the compliance limit.

Step 2. Calculate the sample mean and standard deviation of the log-transformed data from each compliance well. (This is Step 1 of the previous section, working now with logarithms.)

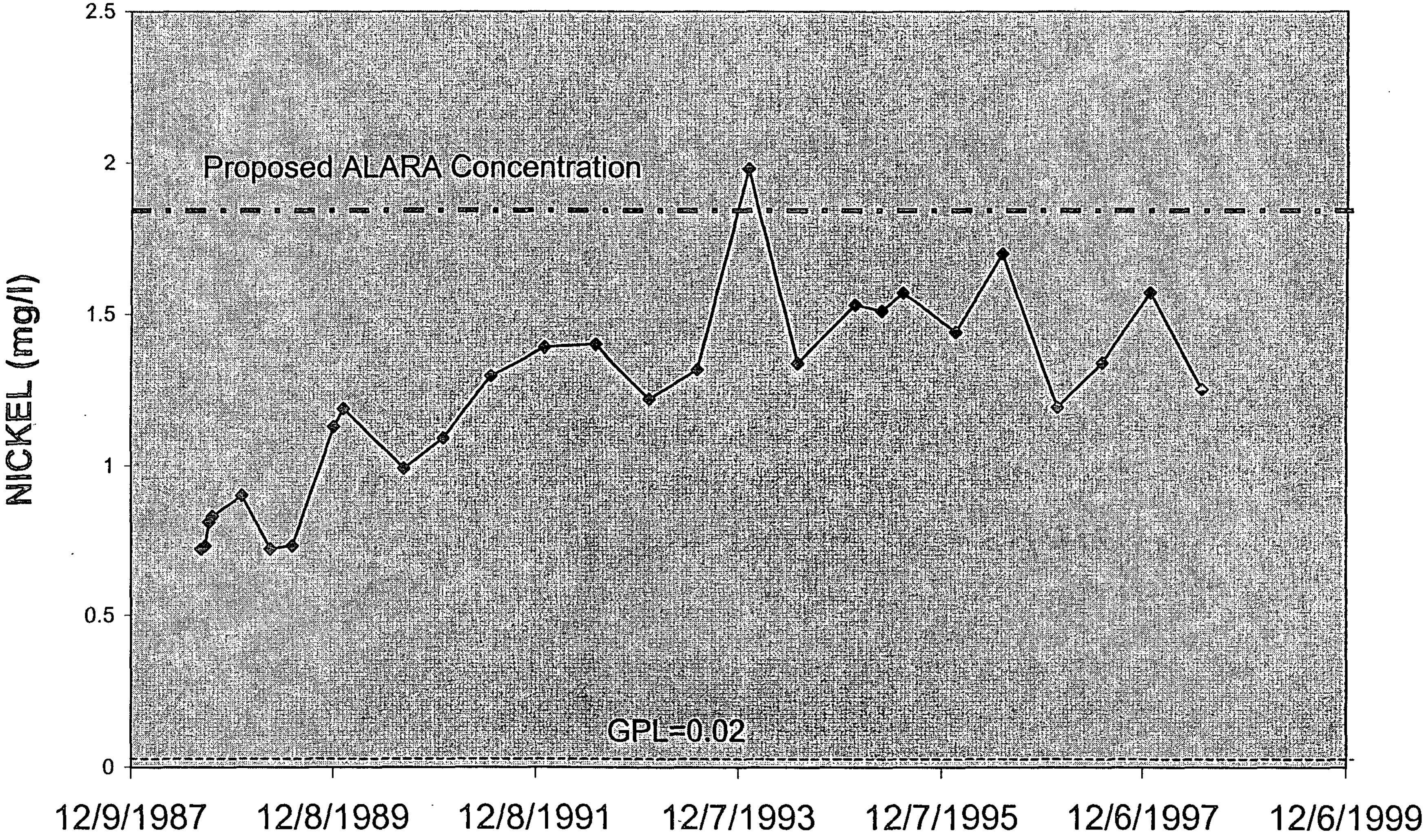
WELL 125 - NATURAL URANIUM



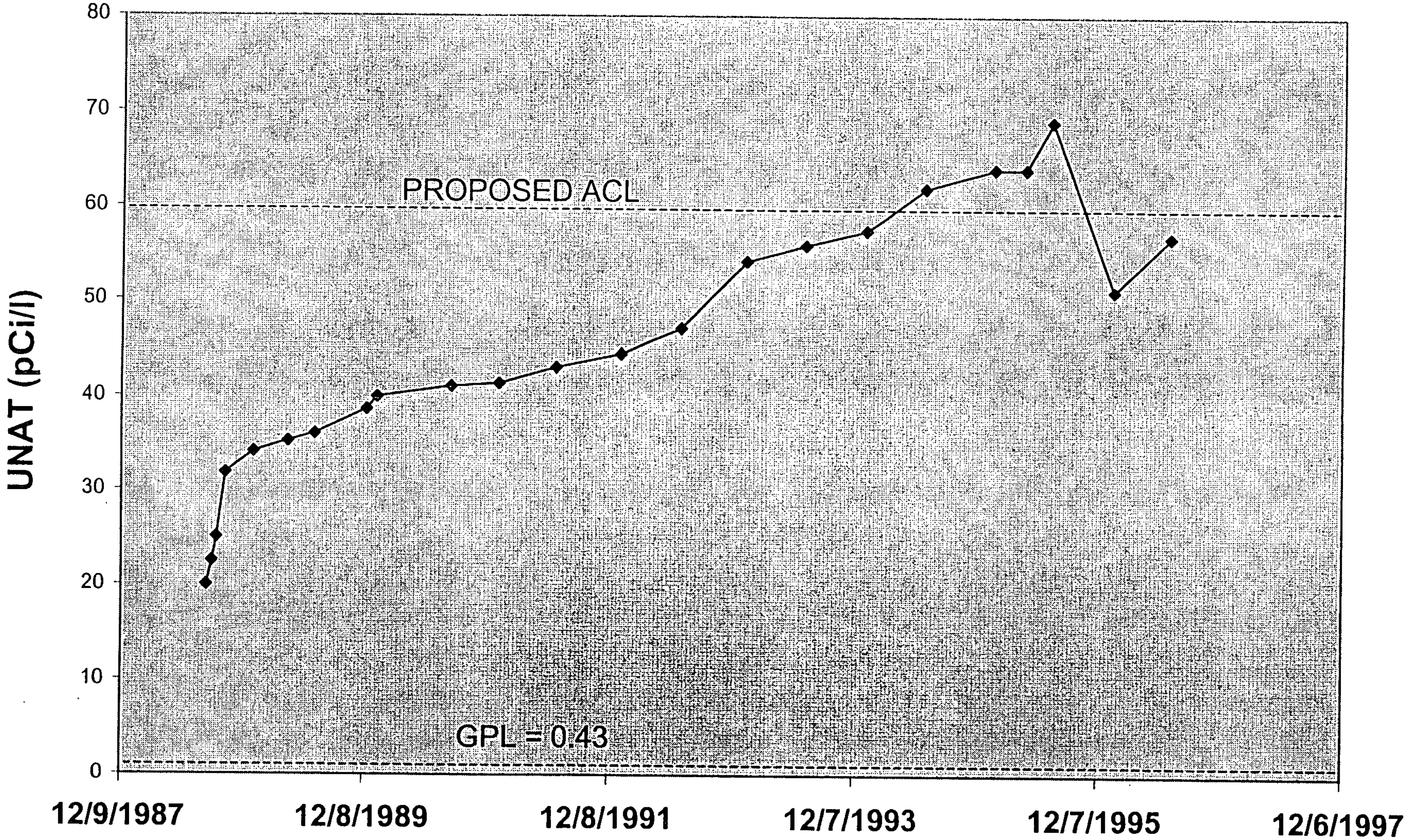
WELL 175 - RADIUM 226+228



WELL 175 - NICKEL



WELL 177 - URANIUM



HIGHLAND TAILINGS BASIN GROUNDWATER STUDY

FINAL REPORT

August, 1998

Prepared For:

Exxon Production Research Company
and
Exxon Coal and Minerals Company
Houston, Texas

Original Draft Prepared By:

Rebecca L. Carovillano
Consultant to EPR

TECHNICAL PRODUCT (TP) RISK SCREENING FORM

TP HIGHLAND TAILINGS BASIN GROUNDWATER STUDY

USER(S) EXXON COAL AND MINERALS CO.

RISK ASSESSMENT DECISION

__x__ This TP does not require EPR Risk Study. ***Indicate below decision rationale and any assumptions about the TP and its use, such as limits on operating conditions, mitigators/preventers in place, training/experience of operating personnel, critical safety systems and safeguards in place, use of hazardous materials, and emergency response plans.***

______ EPR Risk Study is necessary. Previous Risk Study results are adequate and are attached.

______ EPR Risk Study is necessary. Previous Risk Study results have been modified to be adequate and are attached.

______ A new EPR Risk Study should be carried out using about _____ individuals and should take approximately _____ days. The following units should be represented or consulted:

____________________ ____________________ ____________________

____________________ ____________________ ____________________

Comments or Rationale Supporting this Decision and Assumptions About Use:

This TP will be primarily used as a supporting document by ECMC in their application to the Nuclear Regulatory Commission (NRC) for a waiver on certain groundwater quality requirements that must otherwise be met before remediation activities at the site can be stopped. ECMC has been conducting remediation activities at the site for several years, and is of the opinion that continued remediation at the site would be of marginal benefit.

Most of the work presented here was done by an outside contractor to EPR but it has been reviewed for technical accuracy by EPR staff. The results of the TP are within reasonable ranges of what one would expect given conditions at the site.

The TP is based on computer modeling of groundwater flow and analysis of contaminant transport in groundwater. If the modeling/analysis approach or results turn out to be wrong, the most serious consequence is early termination of groundwater remediation which might lead to contaminants migrating off-site with groundwater.

Given the remote location of the site, this consequence does not pose a serious risk to human health or to the environment. If some of the contaminated groundwater discharges into one of the nearby creeks, ~~there~~ dilution in the surface waters would mitigate the downstream consequence.

Responsible R&E Staff CK Owens for AEA — 10/6/98
C. K. Owens for A. E. Adenekan — **Date**

Intermediate R.A. Trained Staff JP Smith — 10.7.98
J. P. Smith — **Date**

Section Supervisor ________________ — 10/07/98
N. K. Springer — **Date**

This page is to accompany the TP when delivered.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

LIST OF ABBREVIATIONS

ACLs	alternative concentration limits
ft	feet
gpm	gallons per minute
mg/l	milligrams per liter
msl	mean sea level
n	porosity
NRC	Nuclear Regulatory Commission
S_s	specific storage
S_y	specific yield
TDS	total dissolved solids
TDSS	Tailings Dam Sandstone
TDSh	Tailings Dam Shale
TVA	Tennessee Valley Authority
WWL	Water,Waste and Land

SUMMARY

The piezometric surface map was updated using ground water elevation data measured in wells in September, 1996 and using average 1996 ground water elevations calculated for other site monitoring wells. It was necessary to use the average 1996 data to have sufficient data to map the ground water surface. The piezometric surface map indicates that the ground water mound that used to exist beneath the tailings basin has dissipated to the point where it is significantly reduced in height. Ground water flows from the northeastern edge of the tailings basin towards the west-northwest before it is affected by the flow regime of the Highland Reservoir and begins to flow southwest. Ground water flows from the southeastern edge of the tailings basin towards the west-southwest before it too is affected by the Highland Reservoir and begins to flow to the northwest. Ground water beneath the tailings basin migrates west to the Highland Reservoir. There is no significant ground water flow from the tailings basin to the east or to the south, and therefore neither the North Fork of Box Creek, nor its unnamed tributary east of the tailings dam lies in the path of ground water migrating from the basin area. There is a ground water depression around the Highland Reservoir.

The 1988 location of the chloride front as shown in Figure 2.4 of WWL, 1989 was verified. Because it appeared that the placement of the 1988 seepage front boundary was not consistent relative to a well-defined chloride concentration, an analysis was performed using the average 1988 chloride and TDS measurements. Based upon this analysis, a TDS concentration of 1000 mg/l and a corresponding chloride concentration of 90 mg/l was used to define the placement of the chloride seepage front. As a result, the 1988 location of the chloride seepage front was revised slightly (only the northern edge of the boundary was impacted).

Because this analysis indicated that the location of the 1988 chloride seepage boundary within the finger area was accurate, the contaminated liquid volume within the finger area was not revised from the estimate of 280 million gallons provided by Exxon, 1994. The change in location of the northern boundary did impact the estimates of the total liquid volume within the chloride seepage front. Based upon the revised location of the 1988 chloride seepage front, the total liquid volume was estimated to be 1.7 billion gallons (which is lower than the original estimate of 2.0 billion gallons provided by Exxon, 1994). Using the revised location of the seepage boundary, the total volume capable of draining from the TDSS was estimated to be 0.5 billion gallons.

The chloride seepage front criterion of 90 mg/l that was defined using the 1988 data was applied to estimate the 1996 location of the chloride seepage front. Only one well that had been within the 1988 boundary was found to lie outside of the 1996 boundary. While the chloride concentrations in several of the wells located within the front declined considerably from 1988 to 1996, the configuration of the interpreted chloride front remained essentially unchanged from the modified 1988 configuration.

For the third quarter of 1996, the total volume of liquid contained within the chloride front was estimated to be 1 billion gallons. Approximately 132 million gallons were contained within the finger area that was also within the chloride front. Approximately 294 million gallons of this liquid were capable of draining from the area defined by the entire chloride front, and 39 million gallons were capable of draining from the portion of the chloride front that overlaps the finger area.

A computer model was developed using Visual MODFLOW in order to estimate the long-term stable elevation of the water surface in the Highland Reservoir once ground water levels stabilize, and to show the stable configuration of the piezometric surface in the vicinity of the site. Hydraulic properties, boundary conditions, and recharge rates that were deemed to be appropriate based upon the modeling efforts of previous investigators as well as a transient calibration performed for this project were used to simulate the long-term configuration of the piezometric surface and Highland Reservoir. The long-term stable level of the Highland Reservoir was estimated to be approximately 5125 ft above msl.

In general, once water levels stabilize, ground water will flow from west to east, with perturbations to this flow regime in the vicinity of the Highland Reservoir and mine backfill. The rate of flow is greatest to the northwest of the Reservoir (approximately .15 ft/day), and slowest to the northeast of the Reservoir (approximately .05 ft/day). In the vicinity of the tailings basin, the ground water flows from northwest to southeast at a rate of about .03 ft/day, but changes to an easterly flow direction at the eastern edge of the tailings basin. In addition to this change in flow direction, the water table dips below the TDSS and lies within the TDSh in the southeast portion of the tailings basin. As a result, it appears that the portion of the unnamed tributary of the North Fork of Box Creek that lies east of the tailings dam, and the North Fork of Box Creek that lies to the south of the tailings basin, will not intercept ground water migrating from beneath the basin.

Sensitivity analyses were performed in order to determine the degree of uncertainty in the model results based upon uncertainty in the model input parameters. It appears that the model results are most sensitive to order-of-magnitude changes in the hydraulic conductivities assigned to model layers 1 through 4, and to two order-of-magnitude changes to the specific storage in layers 4 through 9. The model results were found to vary by as much as 15% when these parameters were changed in this manner. Model results were less sensitive to the boundary conditions assigned and to recharge rates.

Section 1

Introduction

Four tasks were performed at the request of Exxon Coal and Minerals Company in order to assist them in pursuing alternative concentration limits (ACLs) for the Highland Uranium Mine site. These tasks are as follows:

Task 1. Updating the piezometric surface map using the most recent ground water elevation data, and estimating the ground water flow rates and flow paths within the Tailings Dam Sandstone (TDSS) and the mine backfill.

Task 2. Verifying the 1988 location of the chloride seepage front and estimating the location of the chloride seepage front using 1996 chloride measurements.

Task 3. Calculating the 1988 and 1996 liquid volumes (in the saturated zone) in the TDSS within the chloride seepage front and within the portion of the chloride seepage front that overlies the "finger area"[1].

Task 4. Modeling the piezometric surface at a time in the future when water levels are stable, and estimating the ground water flow paths and rates at that time.

This report documents the methodology used to perform each task, and the findings for each. Task 1 is described in Section 2, Task 2 in Section 3, Task 3 in Section 4, and Task 4 in Section 5. Section 6 provides a summary of findings, and Section 7 includes a list of references.

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[1] The area that is being referred to as the "finger area" is that area southwest of the tailings impoundment between the impoundment and the Mine Backfill Area.

Section 2

Task 1: 1996 Ground Water Flow Rate and Direction

2.1 Introduction

The purpose of this task was to estimate the ground water flow directions and rates in the TDSS and mine backfill using the most recent ground water elevation data available. At the time that this task was performed, the most recent data collected were from September, 1996.

2.2 1996 Ground Water Elevations, Flow Directions and Flow Rates

Inspection of the data provided in Table 1 indicates that for September 1996, ground water elevations were available for a total of six wells and the Highland Reservoir. Because the ground water elevation data for September 1996 are so few and are widely distributed across the site, average 1996 ground water elevations were calculated for the other wells listed in Table 1, and were used to construct a contour map of the piezometric surface.

The configuration of the piezometric surface for the TDSS and mine backfill using the data from Table 1 is shown in Figure 1. Several features are evident from the figure. The ground water mound that used to exist beneath the tailings basin has dissipated to the point where it is significantly reduced in height (now less than 5130 feet (ft) above mean sea level (msl)). This mound was interpreted to be at elevations greater than 5140 ft above msl in 1988 (Water, Waste and Land (WWL), 1989) and greater than 5130 ft above msl in 1994 (Exxon, 1994).

Ground water flows from the northeastern edge of the tailings basin towards the west-northwest before it is affected by the flow regime of the Highland Reservoir (discussed in the following paragraph) and begins to flow southwest towards the Reservoir. Ground water flows from the southeastern edge of the tailings basin towards the west-southwest before it too is affected by the Highland Reservoir and begins to flow to the northwest. Ground water beneath the tailings basin migrates west to the Highland Reservoir. There is no significant ground water flow from the tailings basin to the south, and therefore the North Fork of Box Creek does not lie in the path of ground water migration from the basin.

The hydraulic gradient around the Reservoir varies considerably. The magnitude of the gradient is greatest from the south as evident by the closeness of the contour spacing in Figure 1, while the magnitude of the gradient from the north/northwest is less, as evident by the wider contour spacing. However, when the ground water flow velocities are calculated for the south and for the northwest using average hydraulic conductivities at nearby wells (Exxon Production Research Company, 1982), and an average site-wide porosity of 34 percent, the ground water velocity immediately around the reservoir varies by less than 0.01 ft/day, with an average value of about 0.46 ft/day.

Table 1. 1996 Ground Water Elevation Data for Wells Screened in TDSS and Mine Backfill

	1996 Ground Water Elevations (ft above msl)						
Well Number	Jan	Mar	Apr	Jun	Jul	Sep	Average
015	DRY		DRY		DRY	**DRY[1]**	-
112	5127.30		5126.75		5126.90		**5126.98[2]**
114	5110.27		5109.59		5109.99		**5109.95[2]**
117	5126.05		5125.20		5125.90		**5125.72[2]**
120	5121.07		5120.42		5120.62		**5120.70[2]**
125	5126.50		5126.25		5126.40		**5126.38[2]**
127	5127.83		5127.40		5127.55		**5127.59[2]**
131		5121.90				**5126.40**	
132		5080.00				**5079.85**	
133		5078.90				**5079.40**	
134		5124.45		5125.40		**5124.20**	
170				5019.40			**5019.40[2]**
171		5042.00		5042.30		**5042.80**	
172		5086.39		5086.39		**5086.59**	
173	5064.44		5064.09		5064.29		**5064.27[2]**
174	5084.34		5083.99		5084.34		**5084.22[2]**
175	5107.89		5103.89		5103.99		**5105.26[3]**
177	5121.96		5121.04		5120.34		**5121.11[3]**
178	5118.14		5115.54		5117.64		**5117.11[2]**
179	5121.44		5120.69		5120.84		**5120.99[2]**
180	DRY		DRY		DRY	**DRY[1]**	-
181	5125.10		5124.20		5124.60		**5124.63[2]**
182	5121.88		5120.98		5121.18		**5121.35[2]**
183	5112.62		5111.87		5112.12		**5112.20[2]**
Highland Res.		5012.30		5013.94		**5013.94**	

Notes:

Measurements used to construct the contour map of the piezometric surface are shown above in bold.

1. The ground water elevation lies beneath the bottom of the screen, which is at an elevation of 5134.8 and 5085.9 feet above mean sea level (msl), for wells 015 and 180, respectively.

2. The average 1996 value differed from the value projected for September, 1996 (using a straight line projection from the nearest water level measurement) by less than one foot.
3. The average 1996 value differed from the value projected for September, 1996 (using a straight line projection) by approximately 1.5 feet.

Section 3

Task 2: Verification and Location of Chloride Seepage Front

3.1 Introduction

The purpose of this task was to verify the 1988 location of the chloride seepage front and to estimate the location of the chloride seepage front using 1996 chloride measurements. Data used to perform this task were obtained from Exxon's database of chemical measurements for the site.

3.2 Verification of the Chloride Seepage Front in 1988

Chloride concentrations measured in 1988 were obtained from Exxon's chemical database and compared to those used to estimate the location of the "seepage front" as shown in Figure 2.4 of WWL, 1989. It appears that four concentrations were reported for each well and are annotated on the figure: one was collected in approximately August of 1988, two were collected in September of 1988 and the fourth was collected in either late September or October of 1988. Three wells (Numbers 134, 015 and 125) had at least one other chloride concentration measured at another time, which was not used to determine the placement of the seepage front. For each of the three wells, this additional concentration was greater than any of the four measurements used in Figure 2.4 (WWL, 1989), but they would not have affected the placement of the seepage front. In addition, the fourth measurement for well number 117 was not reported on Figure 2.4 (WWL, 1989) and may not have been used to determine the location of the seepage front. This omission would also not have affected the location of the 1988 chloride seepage front.

In general, the placement of the 1988 seepage front is questionable since it is not evident from Figure 2.4 (WWL, 1989) what chloride concentration was used to define the seepage front boundary. Section 2.2.5 of WWL, 1989 describes a background chloride concentration of 20 milligrams per liter (mg/l). It is evident however, that 20 mg/l was *not* used to define the seepage front, as shown by the placement of well 173 (with an average 1988 chloride concentration of 66 mg/l) outside of the boundary. In contrast, wells 181, 179 and 183, which have chloride concentrations that are approximately equal to or less than well 173, are placed inside the seepage front. A different document ("Supporting Information for ACL Application," Exxon, 1994) refers to a chloride seepage front concentration of 110 mg/l. Again, it appears that this concentration was not used to consistently define the location of the seepage front boundary due to the placement of wells 181, 179 and 183 (all with concentrations less than 110 mg/l) inside the boundary. In conclusion, it appears that the placement of the 1988 seepage front boundary was not consistent relative to a well defined chloride concentration.

In order to better identify the region where the ground water quality may have been impacted by mining activities (and thus should be included within the chloride seepage front boundary), plots were constructed that show the average 1988 chloride concentration versus total dissolved solids (TDS), and average 1988 chloride concentration versus pH for all of the monitoring wells. TDS and pH were used since they tend to be reliable indicators of overall ground water quality.
Figure 2 is a graph of average 1988 chloride concentrations versus pH. This figure indicates that there is no consistent relationship between ground water pH and chloride concentration, especially at low chloride concentrations. For example, five wells with chloride concentrations of less than 50 mg/l had pH measurements that ranged from about 7.7 to 9.7. Four of these five wells are considered to be background wells and are therefore outside the influence of any mine-related activities on ground water quality. Consequently, it was determined that pH could not be used reliably to assist in locating the chloride seepage front.

A graph of average 1988 chloride concentration versus TDS, shown in Figure 3, exhibits a linear trend (chloride concentration increases as TDS increases). The wells also appear to plot into two clusters: cluster 1 includes those wells that have TDS concentrations of around 1000 mg/l or less, and cluster 2 includes those wells that have a TDS concentration of 2000 mg/l and above (there are no wells between the two clusters). An inspection of Figure 3 suggests that wells 174, 182, 172, 134 and 127 lie outside of the seepage front due to their low chloride concentrations (< 25 mg/l). Four of these wells (174, 182, 172 and 134) are considered to be background monitoring wells. Well Number 134, despite its low chloride concentration, has a TDS concentration of approximately 1000 mg/l, which is considerably higher than the TDS concentration of the other background wells. If a TDS concentration of 1000 mg/l is used for an upper limit for water outside the chloride seepage front, then wells 173, 181, 183 and 171(shown on Figure 3 with triangle symbols) would also lie outside of the seepage front. All of these wells also have chloride concentrations of less than 90 mg/l, which is still quite low relative to the State of Wyoming drinking water criteria of 250 mg/l. Only one well (well 179) in cluster 1 has a TDS concentration of just greater than 1000 mg/l and a chloride concentration equal to 90 mg/l, and this is the only well in the cluster interpreted to lie within the seepage front. All of the wells in cluster 2 lie within the seepage front.

Based upon this analysis it was determined that wells 174, 182, 172, 127, 134, 181, 171, 173 and 183 should lie outside of the 1988 chloride seepage front, while all of the other wells should lie within the front. This conclusion does impact the previous interpretation of the 1988 seepage boundary location in the vicinity of wells 181, 183 and 179, north of the tailings basin.

The 1988 interpretation of the chloride seepage front has also been modified in the area southwest of the tailings basin. The previous interpretation had the seepage front in this area coinciding with the southwestern boundary of the finger area, nearly midway between wells 178 and 173. However, well 178 had an average chloride concentration of 322 mg/l (for 1988 data) while well 173 had an average concentration of 65 mg/l. While it may not be entirely correct to use a strict linear interpolation to locate the 90 mg/l chloride contour, it would appear to be more correct than the arbitrary manner in which the front was originally placed. Linear interpolation was also used for the pair of data at wells 180 and 173.

Based on the foregoing discussion, the revised interpretation for the location of the 1988 chloride seepage front is shown in Figure 4.

3.3 Location of the 1996 Chloride Seepage Front

A similar analysis was performed using the chloride and TDS concentrations measured in 1996. Figure 5 is a plot of average 1996 chloride versus TDS concentrations in the wells. The wells no longer plot in two distinct clusters -- there are three wells with TDS concentrations of between 1000 and 2000 mg/l. If the chloride seepage front criterion of 90 mg/l that was defined using the 1988 data is applied to the 1996 data, wells 174, 182, 172, 134, 171, 127, 173, 183 and 125 would lie outside of the seepage front (all of these wells are shown with either diamond or triangle symbols on the figure). With the exception of well 125, these are the same wells that were outside of the seepage front in 1988. The chloride concentration in well 125 declined considerably since 1988 (from 219 to 71 mg/l) such that in 1996 the well no longer lies within the seepage front.

The chloride seepage front location in 1996 is shown in Figure 6. The configuration of the northern portion of the boundary is essentially the same as that in 1988. The configuration to the southwest of the tailings basin is also nearly the same as it was in 1988. Chloride concentration in well 173 - the only data point that can be used to fix the location of the seepage front in this area - increased from an average of 65 mg/l in 1988 to 84 mg/l in 1996.

Due to lack of data in the area west of the tailings basin, in the area directly northwest of wells 180, 175 and 114, the 1988 interpretation of the chloride seepage front has not been modified in this area. Nevertheless, the 1996 interpretation in slightly different, with the front placed closer to the tailings basin. This is not based on any data specifically, only that the front appears smoother as presented.

Section 4

Task 3: Liquid Volumes Within the TDSS Chloride Front and Finger Area

4.1 Introduction

The purpose of this task was to calculate the 1988 and 1996 liquid volumes (in the saturated zone) in the TDSS within the chloride seepage front, and within that portion of the chloride seepage front which lies within the finger area.

The liquid volumes within the TDSS 1988 chloride seepage front and finger area are discussed in WWL, 1989 and were later revised by Exxon using MINEX software (Exxon, 1994). Exxon also estimated the liquid volumes within the TDSS 1994 chloride seepage front and finger area (Exxon, 1994). For the purpose of this task, only Exxon's revised 1988 volumes and 1994 volumes will be referred to (Exxon, 1994).

4.2 1988 Liquid Volumes Within that Portion of the Chloride Front that:
(a) Lies Within the TDSS
(b) Lies Within the Finger Area

The previous estimate for the volume of liquid inside the entire chloride front within the TDSS has now been changed based upon the revision to the location of the chloride front as shown in Figure 4. The change in estimate arises from the modification to the chloride front north of the tailings basin but <u>not</u> due to the modification to the front southwest of the basin. This is because the extension of the front to the southwest is into the mine backfill, not into the TDSS. Exxon (1994) estimated that the total liquid volume inside the chloride front in 1998 was 2.0 billion gallons and that 0.6 billion gallons of this was drainable (again based on a specific yield of 0.1). Using the revised chloride front shown in Figure 4, these volumes are now estimated to be 1.7 billion gallons and 0.5 billion gallons, respectively.

Because the analysis performed in Task 2 corroborated the previous location (Exxon, 1994) of the 1988 chloride seepage front within the finger area, the estimate of the corresponding liquid volume remains unchanged from the earlier estimate of 280 million gallons (Exxon, 1994). Using a specific yield value of 0.1, it was estimated that 80 million gallons of this volume could be drained from the TDSS within the finger area (Exxon, 1994).

4.3 1996 Liquid Volumes Within that Portion of the Chloride Front that:
(a) Lies Within the TDSS
(b) Lies Within the Finger Area

Liquid volumes within the TDSS 1996 chloride seepage front and finger area were calculated using the TDSh structure contour map to estimate the saturated thickness of the TDSS[2]. For the third quarter of 1996, the total liquid volume inside the chloride front was estimated to be 1 billion gallons. It was also estimated that approximately 132 million gallons were contained within that portion of the chloride front which overlapped the finger area. These estimates do not include water in the unsaturated zone and are based on an estimated site-wide TDSS porosity of 34 percent.

A specific yield of 0.1 was used to estimate the volume of liquid capable of draining from the TDSS, and from the finger area. The resulting estimated volumes were 294 million gallons capable of draining from inside the entire chloride front, and 39 million gallons from the area inside the chloride front that overlaps the finger area.

The 1994 estimates reported in Exxon (1994) were:

- 1.5 billion gallons of liquid contained in the TDSS within the area enclosed by entire chloride front.
- 140 million gallons of liquid contained in the TDSS within the portion of the chloride front which overlaps the finger area
- 400 million gallons of liquid capable of draining from the TDSS in the area within the chloride front
- 40 million gallons of liquid capable of draining from the TDSS in the portion inside the chloride front that overlaps the finger area.

These volumes were also based on a TDSS porosity of 34% and a specific yield of 0.1.

The decline in volume of contaminated water from 1988 to 1996 is due primarily to the fact that the saturated thickness of the TDSS in the region defined by the chloride seepage front is declining as the ground water mound beneath the tailings basin continues to dissipate.

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[2] None of the reports made available to EPR contain any description of the MINEX software based method used by Exxon to estimate the 1988 and 1994 liquid volumes. To check that the method used in the current study produces results that are comparable to those based on the MINEX software, the former was used to estimate 1988 liquid volumes. The results were very close to the previous MINEX based results.

Section 5

Task 4: Ground Water Model of the Piezometric Surface

5.1 Introduction

A computer model was developed in order to estimate the long-term average or steady state elevation of the water surface in the Highland Reservoir once ground water levels stabilize, and to show the stable configuration of the piezometric surface in the vicinity of the site. Visual MODFLOW (Waterloo Hydrogeologic) was used to develop the model and solve the ground water flow equation. Visual MODFLOW is based on MODFLOW, a finite difference model developed by the United States Geological Survey, but includes significant pre- and post-processing capabilities. The sections below discuss the configuration of the model, calibration results, the simulated long-term stable Reservoir elevation, and sensitivity analyses performed.

5.2 Model Configuration

The model domain, shown in Figure 7, is 30,000 feet by 30,000 feet. The Highland Reservoir lies approximately in the center of the model domain. The model grid consists of 96 columns and 80 rows, with a finite difference node located at the center of each block formed by the intersection of a row and column.

Vertically, the model consists of nine layers (layer 1 is the most shallow, layer 9 is the deepest). Layers 1 and 2 represent the Fowler and TDSS formations. Layer 3 represents the TDSh, and layers 4 through 9 represent the upper, middle and lower Ore Body Sandstones, and the two aquitards that lie between the upper and middle sands, and the middle and lower sands. In the vicinity of the Highland Reservoir, mine backfill is represented by specific node blocks in layers 1 through 8. This is also true of the Highland Reservoir itself, which is defined by specific nodes in layers 1 through 9. Average hydraulic properties were initially assigned to each model layer based upon tests performed in the vicinity of the site. These were later refined as part of the transient calibration and are discussed in the following section.

5.3 Transient Calibration

A transient calibration was performed in order to refine the hydraulic properties assigned to the various model layers. The calibration "target" was the average annual water level measured in site monitoring wells in 1996.

5.3.1 Initial and Boundary Conditions

The initial condition for the transient calibration consisted of average 1988 ground water levels across the site. The same ground water elevations were used as the initial condition for each model layer. The year 1988 was selected as the starting point for the transient calibration (as opposed to an earlier year) in order to maximize the amount of well data available to compare with the model results.

A constant head boundary condition was used on the western and eastern edges of the model for most of the model layers. In layers 1 and 2, the western boundary condition was fixed at an elevation of 5200 ft above msl. This value was obtained by projecting the average hydraulic gradient at the western edge of piezometric surface maps from 1988 (WWL, 1989) and 1994 (Exxon, 1994) back to the western boundary of the model. The western boundary of layer 3 was fixed at an elevation of 5175 ft above msl. In layers 4 through 9, the western boundary was fixed at a constant head that increased with time, as shown below in Table 2.

Table 2. Values of Time-Varying Western Boundary Condition Assigned to Layers 4 Through 9.

Years	Value of Constant Head Boundary (ft above msl)
1988-1990	5025
1990-1992	5050
1992-1994	5075
1994-1996	5100
1996 and beyond	5125

These values were based on measurements of ground water elevations in the Ore Body Sands in the vicinity of the western boundary of the model. Water levels in the sands were greatly impacted in the early 1980s by underground operations associated with a Tennessee Valley Authority (TVA) mine. Since the mid-1980s, underground operations have ceased at the TVA mine. Recent ground water measurements (January 1997) at wells near the western boundary indicate that water levels in the Ore Body Sands have risen approximately 100 ft.

To the east, the TDSS and TDSh outcrop. In the field, the outcrop of the top of the TDSh shows no evidence of ground water seepage. As a result, it can be assumed that the piezometric surface in the TDSS west of the outcrop drops beneath the top of the TDSh before the outcrop occurs. Therefore, a no-flow boundary condition was defined for model layer 1 at the TDSh outcrop. In layers 2 and 3, the eastern boundary does not lie along the eastern edge of the model domain, but instead follows the line of the TDSh outcrop as shown in Figure 8. Ground water elevations along this eastern boundary were set equal to the elevations of the top of layers 2 and 3. All of the nodes to the east of the TDSh outcrop in layers 1 through 3 were defined to be inactive.

The eastern boundary in layers 4 through 9 was located along the eastern edge of the model domain since there was no information regarding outcrops of the Ore Body Sands in this region. Ground water elevations along the eastern boundary in layers 4 through 9 were set equal to an elevation of approximately one foot above the bottom of layer 4.

It should be noted that along the western and eastern boundaries, the head difference above and below layer 3 indicates that the TDSh is believed to be laterally extensive across the model domain and is an effective aquitard. In contrast, the value of the constant head boundary condition is the same in layers 4 through 9 because the Ore Body Sands are believed to be in hydraulic communication across the model domain and the aquitard units between the Ore Body Sands are not laterally extensive.

5.3.2 Recharge

Three different recharge zones were defined for the model domain, as shown in Figure 9. The first (not explicitly shown in the Figure) was applied to the entire model domain, except those regions shown in color on the Figure. This recharge zone was set at a constant rate of 0.5 inches per year, and represents the amount of rainfall available to infiltrate to ground water after evapotranspiration.

The second recharge zone is shown in green, and lies within the tailings basin outline. Here, the ground water from the extraction wells (discussed below) is discharged into an evaporation pit. The size of the pit is approximately 1.5 acres (the size of two grid blocks in this portion of the model domain), and the amount of recharge assigned to the zone varied from 4.7 inches/year to negative 24 inches/year (a loss of water from the evaporation pit) depending upon the amount of discharge from the wells.

Finally, the Reservoir surface, which is shown in blue in Figure 9, was defined as the third recharge zone. For the time period simulated for the transient calibration, it was held constant at a rate of 42.5 inches/year. It was estimated using the water balance shown in Table 3, which is based upon work performed by Exxon Production Research Company (Exxon Production Research Company, 1983). The estimate of 42.5 inches/year indicates that during this time frame, ground water inflow greatly exceeded ground water outflow and evaporation.

Table 3. Water Balance Used to Estimate Net Recharge at the Reservoir Surface

	Acre-feet/month						
Years since 1996	Ground Water Inflow	Direct Rainfall	Runoff	Evaporation	Ground Water Outflow	Lake Area (acres)	Net Recharge (in/year)
0	45.7	8.4	4.8	30	0	98	42.5
5	45.7	9.3	4.7	33.1	0	112	34.2
10	45.7	10.3	4.7	36.9	0	123	27.9
15	45.7	11.3	4.6	40.2	0	134	23
20	45.7	11.9	4.6	42.3	0	140	20.5
25	45.7	12.4	4.5	44.1	0	146	18.3
30	45.7	12.9	4.5	45.8	0	152	16.4
35	45.7	13.3	4.5	47.4	0	157	14.8
40	45.7	13.7	4.5	48.9	0	162	13.3
45	44.5	14.1	4.4	50.3	0	166	11
50	42.8	14.5	4.4	51.6	0	171	8.5
60	40.6	15	4.4	53.4	2.2	176	3.6
70	39.7	15.2	4.4	54.2	3.2	178	1.5
80	39.3	15.3	4.4	54.5	3.6	179	.7
90	39.1	15.3	4.4	54.7	3.8	180	.2
100	39.1	15.4	4.4	54.7	3.9	180	.2
110	39	15.4	4.4	54.8	3.9	180	.1
120	39	15.4	4.4	54.8	3.9	180	.1

5.3.3 Ground Water Extraction Wells

As many as five wells have been extracting ground water from the finger zone since 1989. The average annual pumping rate for each of the wells was used in the model to simulate pumping conditions. The average annual pumping rates in gallons per minute (gpm) for the wells are shown in Table 4 and the location of the wells are shown in Figure 10.

Table 4. Average Annual Ground Water Extraction Rates (in gpm) Used in Model Calibration

Well Number	1989	1990	1991	1992	1993	1994	1995	1996
114	.004	0.0	0.0	0.0	0.0	0.0	0.0	0.0
117	1.117	1.117	1.117	1.117	1.117	.494	.332	.104
175	1.839	1.839	1.839	1.839	1.839	2.854	1.602	1.594
177	.572	.572	.572	.572	.572	.023	.002	.001
178	.511	.511	.511	.511	.511	.239	.150	.089

5.3.4 Transient Calibration Results

The configuration of the piezometric surface for the TDSS and mine backfill using the calibrated model output is shown in Figure 11. In general, the calibrated model output agrees well with the average 1996 piezometric surface. In the vicinity of the tailings basin, the modeled piezometric surface is approximately one to four feet lower than the average 1996 piezometric surface. Close to the Highland Reservoir, the modeled piezometric surface matches the 1996 surface very closely. The modeled piezometric surface differs from the 1996 piezometric surface in the southeast portion of the mine backfill, and south of the Reservoir. In general, however, the modeled ground water flow velocities agree well with average 1996 conditions. The final hydraulic properties assigned to each model layer are summarized below in Table 5.

Table 5. Hydraulic Properties Assigned to Calibrated Model Layers

Layer	Predominant Formation Represented by Layer	Range of Hydraulic Properties Used for Predominant Formation
1	Fowler Formation	$K_{x,y,z}$=.002-.015 cm/sec S_s=.00073-.073 1/ft; S_y=.15, n=.3
2	Tailings Dam Sandstone	$K_{x,y,z}$=.002-.015 cm/sec S_s=.00073-.073 1/ft; S_y=.15, n=.3
3	Tailings Dam Shale	$K_{x,y,z}$=1X10^{-7} -8X10^{-7} cm/sec S_s=.00022 1/ft; S_y=.04, n=.14
4	Upper Ore Body Sandstone	$K_{x,y,z}$=.01 cm/sec S_s=.00073 1/ft; S_y=.15, n=.3
5	Upper Aquitard	$K_{x,y,z}$=.008 cm/sec S_s=.00073 1/ft; S_y=.15, n=.3
6	Middle Ore Body Sandstone	$K_{x,y,z}$=.008 cm/sec S_s=.00073 1/ft; S_y=.15, n=.3
7	Lower Aquitard	$K_{x,y,z}$=.008 cm/sec S_s=.00073 1/ft; S_y=.15, n=.3
8,9	Lower Ore Body Sandstone	$K_{x,y,z}$=.008 cm/sec S_s=.00073 1/ft; S_y=.15, n=.3
1-8	Mine Backfill	$K_{x,y,z}$=1X10^{-6} cm/sec S_s=.00075 1/ft; S_y=.15, n=.35
1-9	Highland Reservoir	$K_{x,y,z}$=100 cm/sec S_s=.99, S_y=.99, n=.99

5.4 Long-term Simulations

The hydraulic properties, initial condition, and boundary conditions discussed in section 5.3 were used to simulate the long-term configuration of the piezometric surface and Highland Reservoir. For the purpose of the long-term simulations, it was assumed that no ground water extraction occurs within the model domain after 1996, and there was no corresponding recharge of the extracted ground water via the evaporation pond. The recharge rate assigned to the Reservoir surface declined to a rate of 0.2 inches/year, based on the assumption that as the Reservoir begins to fill more slowly, ground water outflow increases, and the greater surface area of the Reservoir allows for increased evaporation (refer to Table 4).

The long-term configuration of the piezometric surface in the TDSS and mine backfill is shown in Figure 12. The long-term stable level of the Highland Reservoir is estimated to be approximately 5125 ft above msl. In general, ground water flows from west to east, with perturbations to this flow regime in the vicinity of the Highland Reservoir and mine backfill. The rate of flow is greatest to the northwest of the Reservoir (approximately .15 ft/day), and slowest to the northeast of the Reservoir (approximately .05 ft/day). Ground water flow velocities were estimated using an average hydraulic conductivity for the site (.002 cm/sec), and an average site-wide porosity of 34 percent.

In the vicinity of the tailings basin, ground water flows from the northwest to the southeast at a rate of about .03 ft/day, but changes to an easterly flow direction at the eastern edge of the tailings basin. Beneath the northwest portion of the tailings basin, ground water flows from northwest to southeast. In the southeast portion of the tailings basin, the water table actually lies within the TDSh and the direction of ground water flow starts to change to more of an easterly direction. As a result, it appears that the portion of the unnamed tributary of the North Fork of Box Creek that lies east of the tailings dam, and the North Fork of Box Creek that lies to the south of the tailings basin, will not intercept ground water migrating from beneath the basin. Ground water flow velocities were estimated using an average hydraulic conductivity for the site (.002 cm/sec), and an average site-wide porosity of 34 percent.

5.4.1 Sensitivity Analyses

Sensitivity analyses were performed in order to determine the degree of uncertainty in the model results based upon uncertainty in the model input parameters. All sensitivity analyses, except those performed on the value of specific storage, were performed as steady state simulations in order to greatly reduce the computational effort required.

Hydraulic Conductivity

The values of the hydraulic conductivities assigned to the model layers were increased and then decreased by an order of magnitude in order to evaluate the sensitivity of the final Reservoir elevation to the values used. In general, an order of magnitude change in hydraulic conductivity in any of the layers resulted in a change in the long-term stable Reservoir elevation of about 15% or less. For most of the layers, the change in Reservoir elevation was less than 10% (a 10% change is approximately 15 feet). The Reservoir elevation was most sensitive to the hydraulic conductivity assigned to model layers 1 and 4.

Recharge

The values assigned to the two recharge zones (the areal recharge zone and the zone assigned to the Reservoir surface) used in the steady state simulation were changed to determine the sensitivity of the long-term stable Reservoir elevation to the values used. For the first sensitivity analysis, the recharge assigned to the entire model domain was increased from 0.5 inches/year to 1.5 inches/year. This change had a negligible impact (approximately 3%) on the long-term stable Reservoir elevation. For the second sensitivity analysis, the net recharge to the Reservoir surface was changed in a rather extreme manner from 0.2 inches/year to -50 inches/year. While the estimates of net recharge to the Reservoir provided in Table 3 are not as low as -50 inches/year, this value is similar to estimates of pan evaporation rates in the area and therefore is considered to be reasonable. This change in the net recharge to the Reservoir also had a negligible impact (it resulted in a decline of less than 3%) on the long-term stable Reservoir elevation.

Boundary Conditions

The boundary conditions were modified in order to evaluate the sensitivity of the final Reservoir elevation to the values assigned. In layers 1 through 3, the western boundary condition was decreased by 20 ft. This resulted in a negligible (approximately 3%) decline in the long-term stable Reservoir elevation. A 20 ft increase in the western boundary condition for layers 1 through 3 also resulted in an increase in Reservoir elevation of about 3%.

For layers 4 through 9, the western boundary condition was increased from 5125 to 5150 ft above msl. This resulted in an almost 7% increase in the long-term stable

Reservoir elevation. A corresponding decrease in the boundary condition for layers 4 through 9 was not made, since current water level measurements are at or below 5125 feet above msl, and while it is believed that the ground water system in these layers may continue to rebound slightly, water levels are not expected to decline.

To the east, the boundary condition in layers 2 and 3 was lowered by 10 feet in order to evaluate the impact on the long-term stable Reservoir elevation. The resulting Reservoir elevation was essentially the same (a less than 2% decline) as the original elevation. In layers 4 through 9, the eastern boundary conditions were increased by 20 feet. This resulted in a less than 2% increase in the long-term stable Reservoir elevation simulated by the model.

Specific Storage

Out of necessity, the sensitivity analyses performed on specific storage were performed as transient simulations. The computational effort required was significant and limited the number of analyses that could be performed to two. The first sensitivity analysis performed was on the value of specific storage and specific yield used in layers 1 and 2. Here, the specific storage was increased by two orders of magnitude, and specific yield was increased 33%. The result was a less than 7% decrease in the long-term stable Reservoir elevation.

The second sensitivity analysis was on the value of specific storage used in the model layers that correspond to the Ore Body Sands and the aquitards between the sands (layers 4 through 9). Again, the specific storage was increased by two orders of magnitude (the specific yield was also increased by 33%). The resulting Reservoir elevation was approximately 13% lower. While the model results are certainly more sensitive to the value of specific storage used in layers 4 through 9 as opposed to layers 1 and 2, the change can still be considered to be rather minimal when compared to the overall rise in water level in the Reservoir.

Section 6

Findings

The piezometric surface map was updated using ground water elevation data measured in wells in September, 1996 and using average 1996 ground water elevations calculated for other site monitoring wells. It was necessary to use the average 1996 data to have sufficient data to map the ground water surface. The piezometric surface map indicates that the ground water mound that used to exist beneath the tailings basin has dissipated to the point where it is significantly reduced in height. Ground water flows from the northeastern edge of the tailings basin towards the west-northwest before it is affected by the flow regime of the Highland Reservoir and begins to flow southwest. Ground water flows from the southeastern edge of the tailings basin towards the west-southwest before it too is affected by the Highland Reservoir and begins to flow to the northwest. Ground water beneath the tailings basin migrates west to the Highland Reservoir. There is no significant ground water flow from the tailings basin to the east or to the south, and therefore neither the North Fork of Box Creek, nor its unnamed tributary east of the tailings dam lies in the path of ground water migrating from the basin area. There is a ground water depression around the Highland Reservoir.

The 1988 location of the chloride front as shown in Figure 2.4 of WWL, 1989 was verified. Because it appeared that the placement of the 1988 seepage front boundary was not consistent relative to a well-defined chloride concentration, an analysis was performed using the average 1988 chloride and TDS measurements. Based upon this analysis, a TDS concentration of 1000 mg/l and a corresponding chloride concentration of 90 mg/l was used to define the placement of the chloride seepage front. As a result, the 1988 location of the chloride seepage front was revised slightly (only the northern edge of the boundary was impacted).

Because this analysis indicated that the location of the 1988 chloride seepage boundary within the finger area was accurate, the contaminated liquid volume within the finger area was not revised from the estimate of 280 million gallons provided by Exxon, 1994. The change in location of the northern boundary did impact the estimates of the total liquid volume within the chloride seepage front. Based upon the revised location of the 1988 chloride seepage front, the total liquid volume was estimated to be 1.7 billion gallons (which is lower than the original estimate of 2.0 billion gallons provided by Exxon, 1994). Using the revised location of the seepage boundary, the total volume capable of draining from the TDSS was estimated to be 0.5 billion gallons.

The chloride seepage front criterion of 90 mg/l that was defined using the 1988 data was applied to estimate the 1996 location of the chloride seepage front. Only one well that had been within the 1988 boundary was found to lie outside of the 1996 boundary. While the chloride concentrations in several of the wells located within the front declined considerably from 1988 to 1996, the configuration of the interpreted chloride front remained essentially unchanged from the modified 1988 configuration.

For the third quarter of 1996, the total volume of liquid contained within the chloride front was estimated to be 1 billion gallons. Approximately 132 million gallons were contained within the finger area that was also within the chloride front. Approximately 294 million gallons of this liquid were capable of draining from the area defined by the entire chloride front, and 39 million gallons were capable of draining from the portion of the chloride front that overlaps the finger area.

A computer model was developed using Visual MODFLOW in order to estimate the long-term stable elevation of the water surface in the Highland Reservoir once ground water levels stabilize, and to show the stable configuration of the piezometric surface in the vicinity of the site. Hydraulic properties, boundary conditions, and recharge rates that were deemed to be appropriate based upon the modeling efforts of previous investigators as well as a transient calibration performed for this project were used to simulate the long-term configuration of the piezometric surface and Highland Reservoir. The long-term stable level of the Highland Reservoir was estimated to be approximately 5125 ft above msl.

In general, once water levels stabilize, ground water will flow from west to east, with perturbations to this flow regime in the vicinity of the Highland Reservoir and mine backfill. The rate of flow is greatest to the northwest of the Reservoir (approximately .15 ft/day), and slowest to the northeast of the Reservoir (approximately .05 ft/day). In the vicinity of the tailings basin, the ground water flows from northwest to southeast at a rate of about .03 ft/day, but changes to an easterly flow direction at the eastern edge of the tailings basin. In addition to this change in flow direction, the water table dips below the TDSS and lies within the TDSh in the southeast portion of the tailings basin. As a result, it appears that the portion of the unnamed tributary of the North Fork of Box Creek that lies east of the tailings dam, and the North Fork of Box Creek that lies to the south of the tailings basin, will not intercept ground water migrating from beneath the basin.

Sensitivity analyses were performed in order to determine the degree of uncertainty in the model results based upon uncertainty in the model input parameters. It appears that the model results are most sensitive to order-of-magnitude changes in the hydraulic conductivities assigned to model layers 1 through 4, and to two order-of-magnitude changes to the specific storage in layers 4 through 9. The model results were found to vary by as much as 15% when these parameters were changed in this manner. Model results were less sensitive to the boundary conditions assigned and to recharge rates.

Section 7

References

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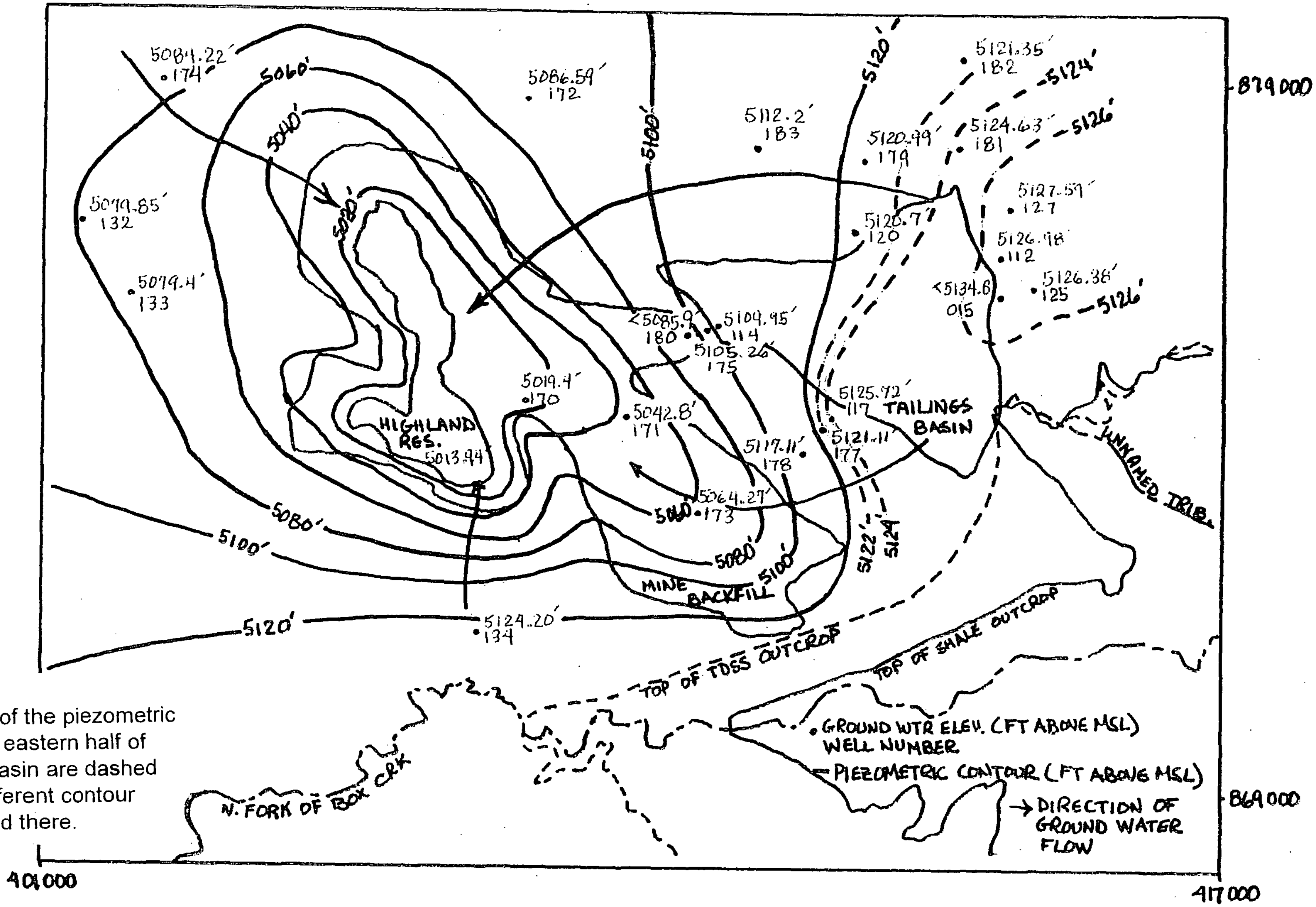
Water, Waste and Land, Inc., 1989. Supporting Information to License Amendment Response.

Waterloo Hydrogeologic. User's Manual for Visual MODFLOW.

FIGURES



Note:
The contours of the piezometric surface in the eastern half of the Tailings Basin are dashed because a different contour interval is used there.

Figure 1. Piezometric Surface of TDSS and Mine Backfill using September 1996 and Average 1996 Ground Water Elevations

Figure 2. Average 1988 Chloride Concentrations versus pH

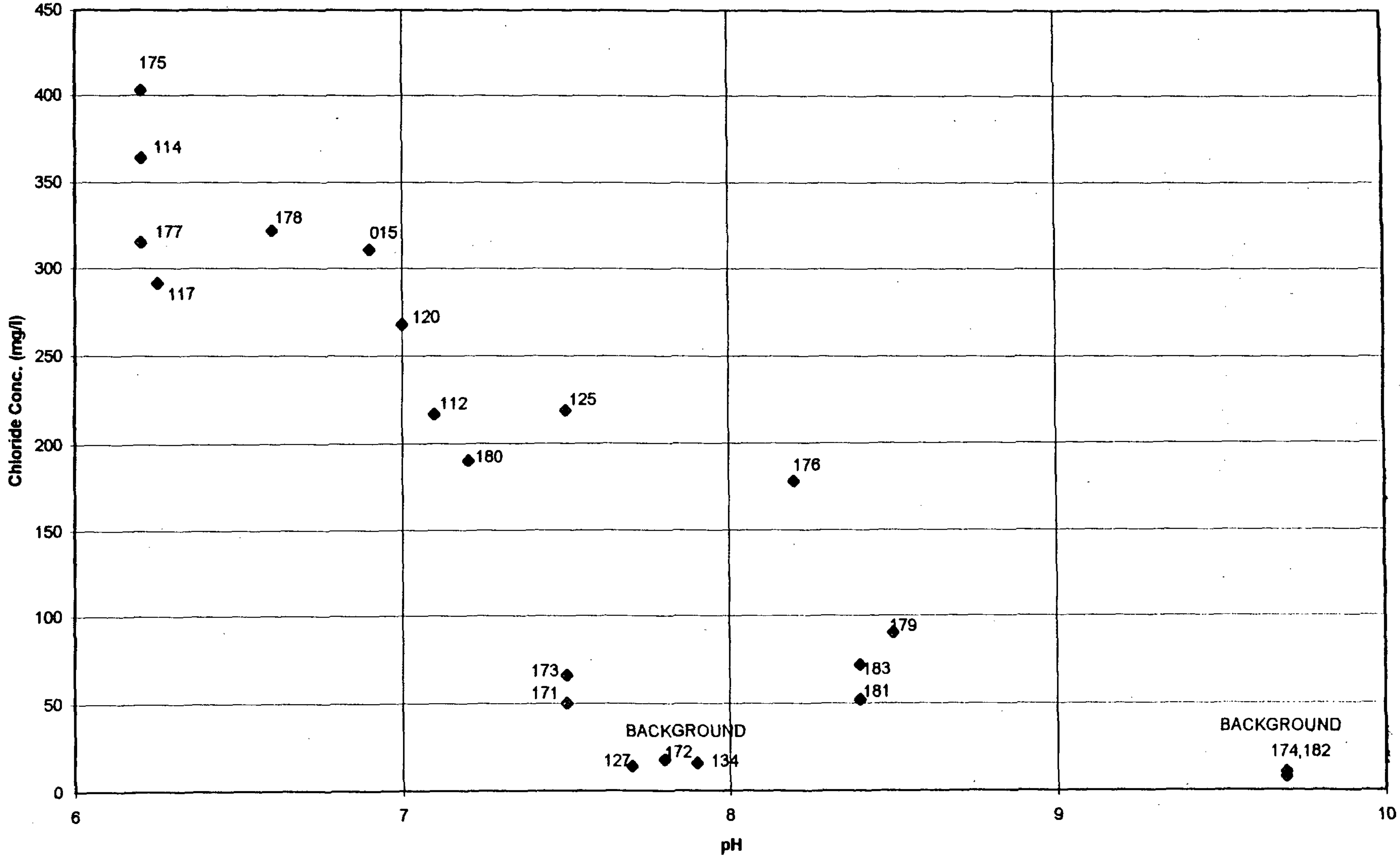
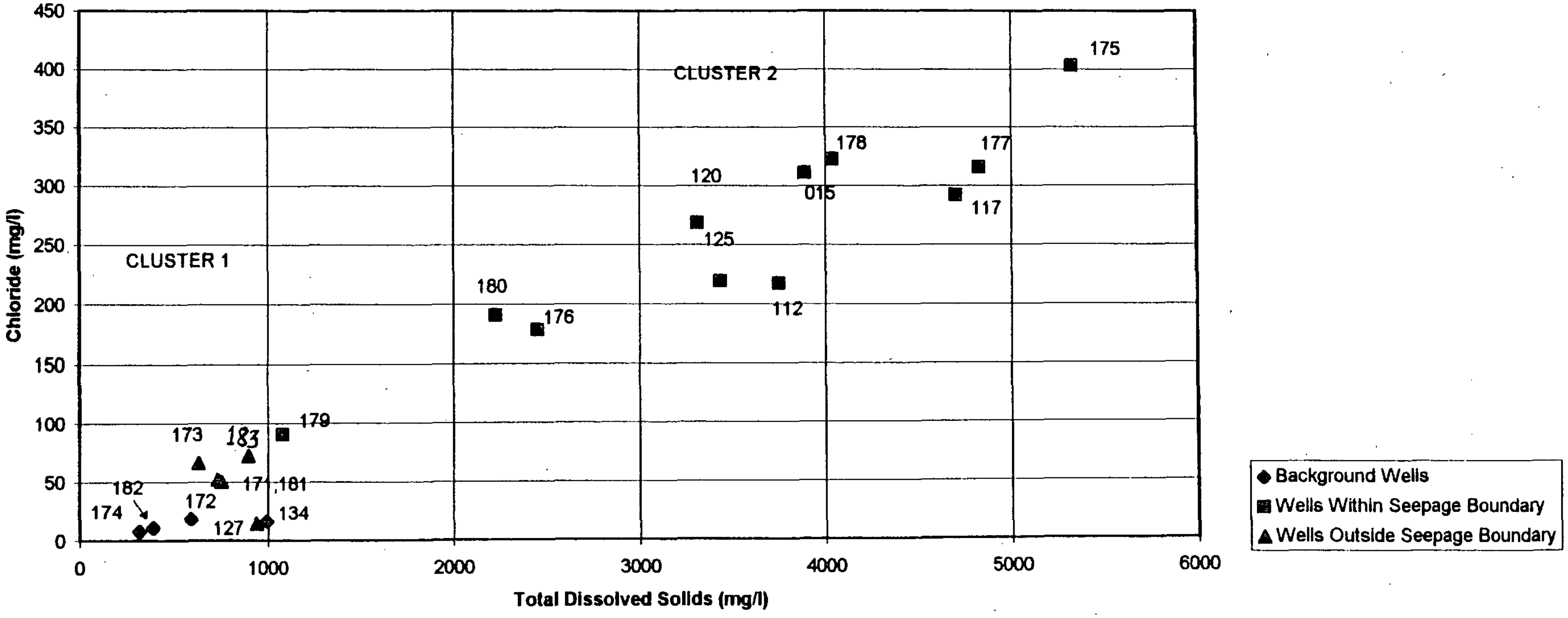


Figure 3. Average 1988 Chloride versus TDS Concentrations



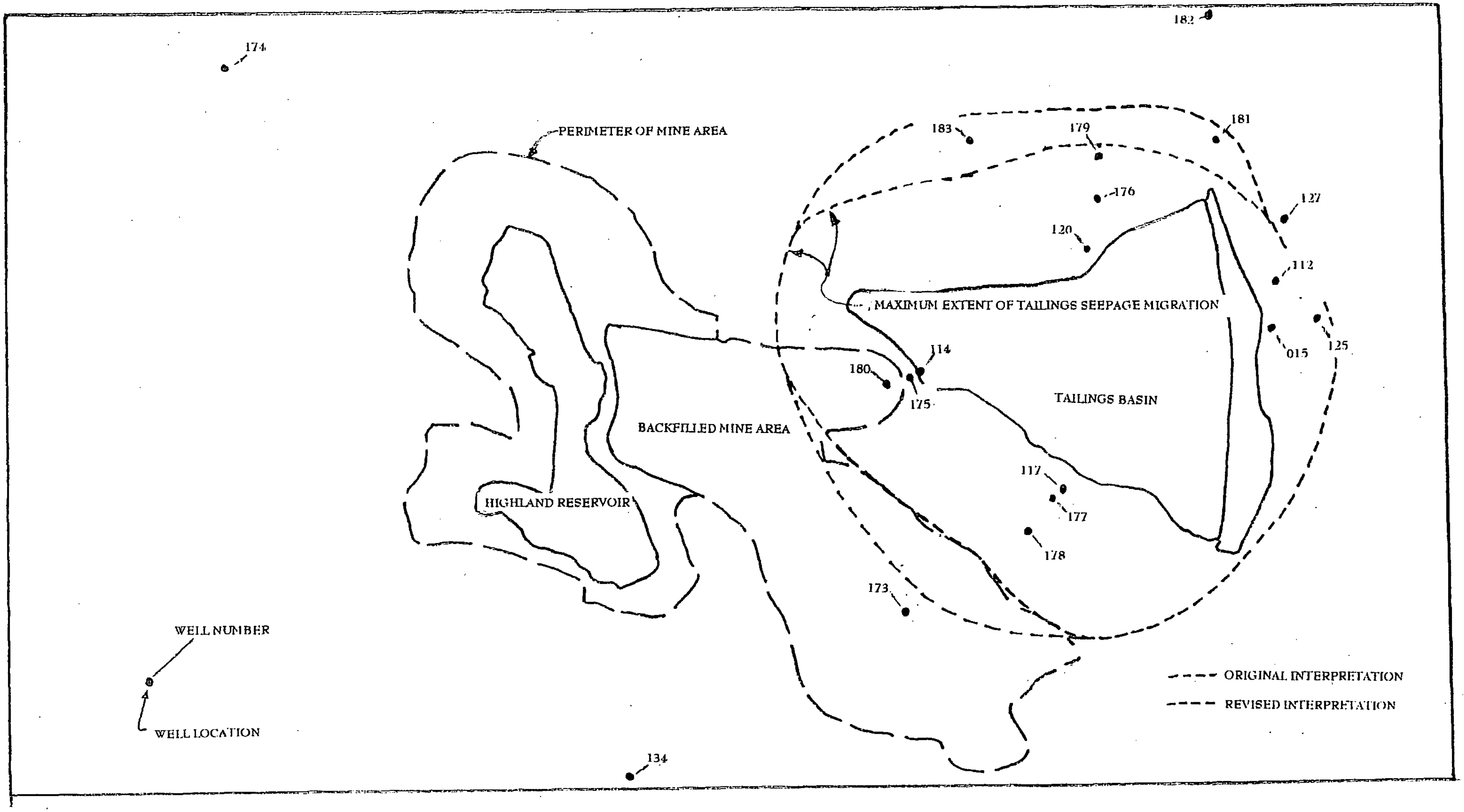
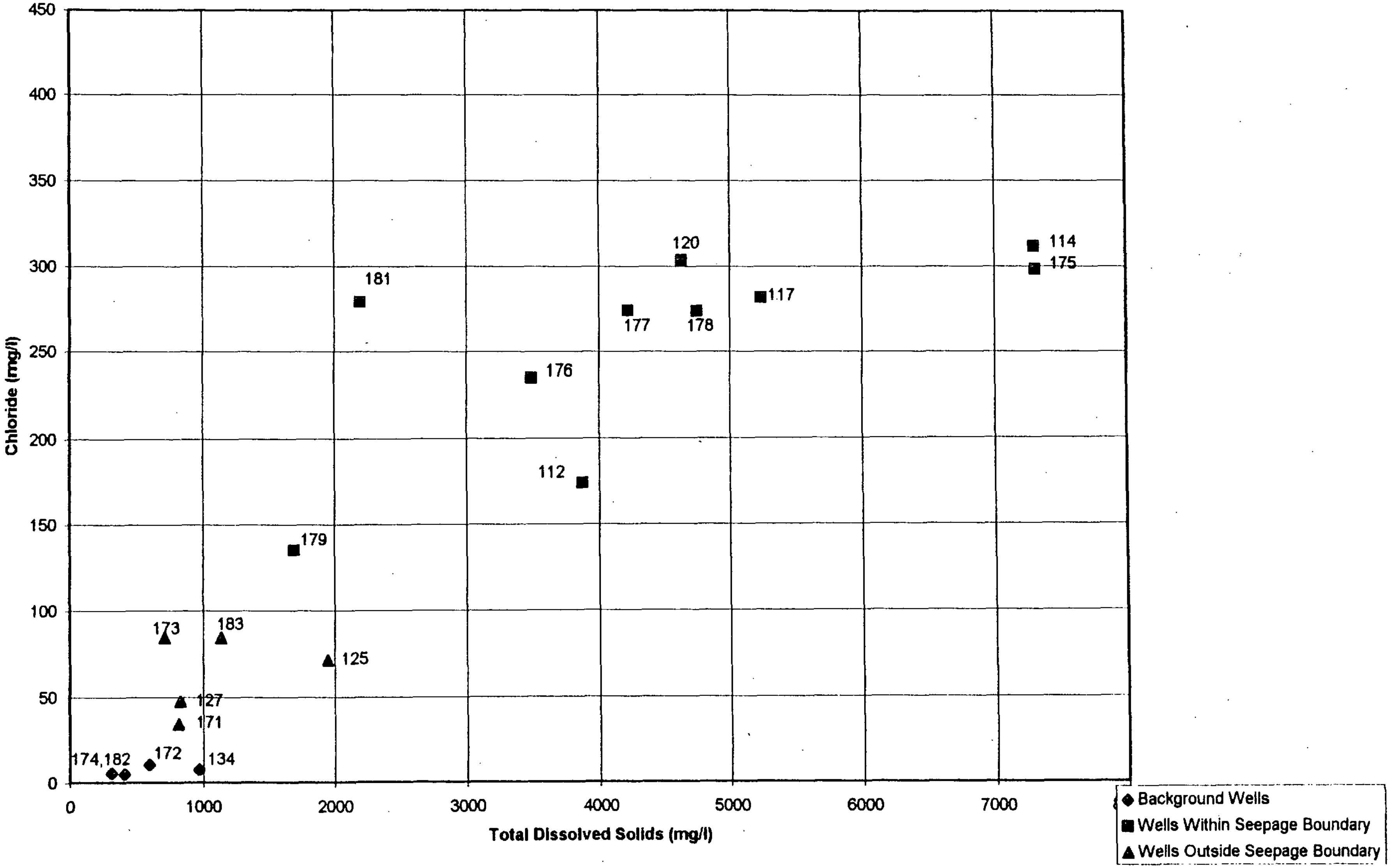
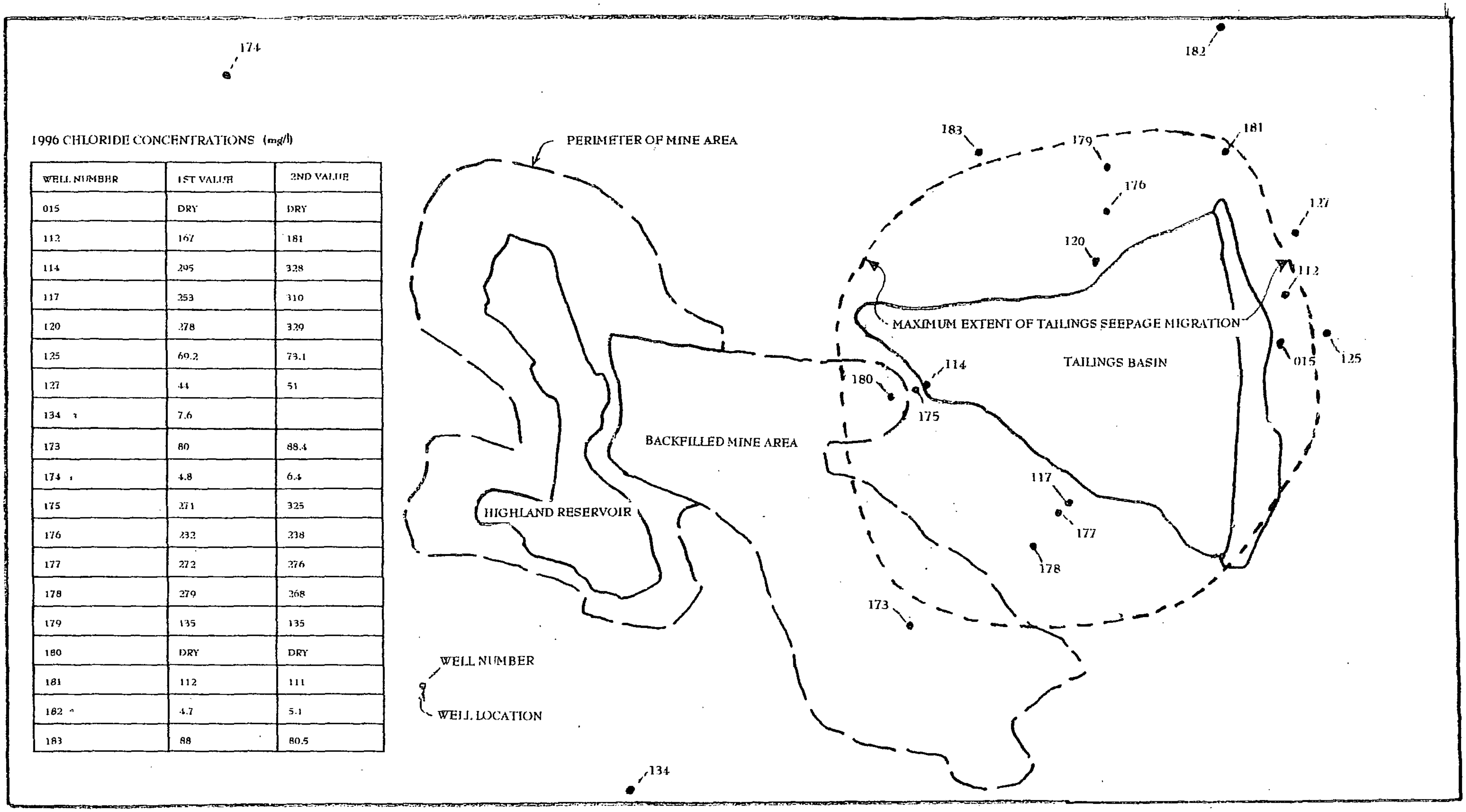


Figure 4. Revised Location of the 1988 Chloride Seepage Front

Figure 5. Average 1996 Chloride versus TDS Concentrations

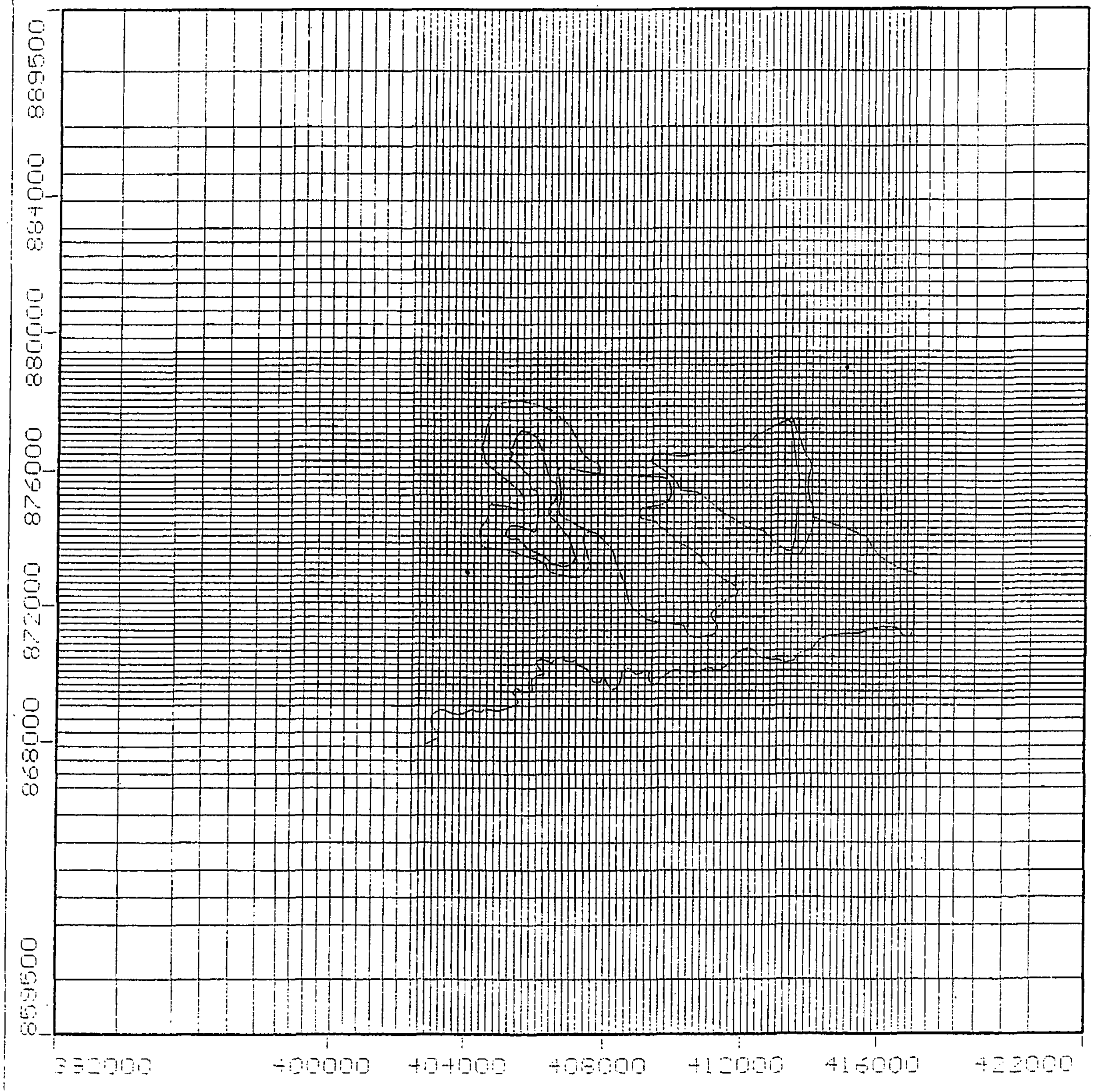




1996 CHLORIDE CONCENTRATIONS (mg/l)

WELL NUMBER	1ST VALUE	2ND VALUE
015	DRY	DRY
112	167	181
114	295	328
117	253	310
120	278	329
125	69.2	73.1
127	44	51
134	7.6	
173	80	88.4
174	4.8	6.4
175	271	325
176	232	238
177	272	276
178	279	268
179	135	135
180	DRY	DRY
181	112	111
182	4.7	5.1
183	88	80.5

Figure 6. Location of the 1996 Chloride Seepage Front



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Modeller: RLC
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Figure 7. Extent of Ground Water Model Domain

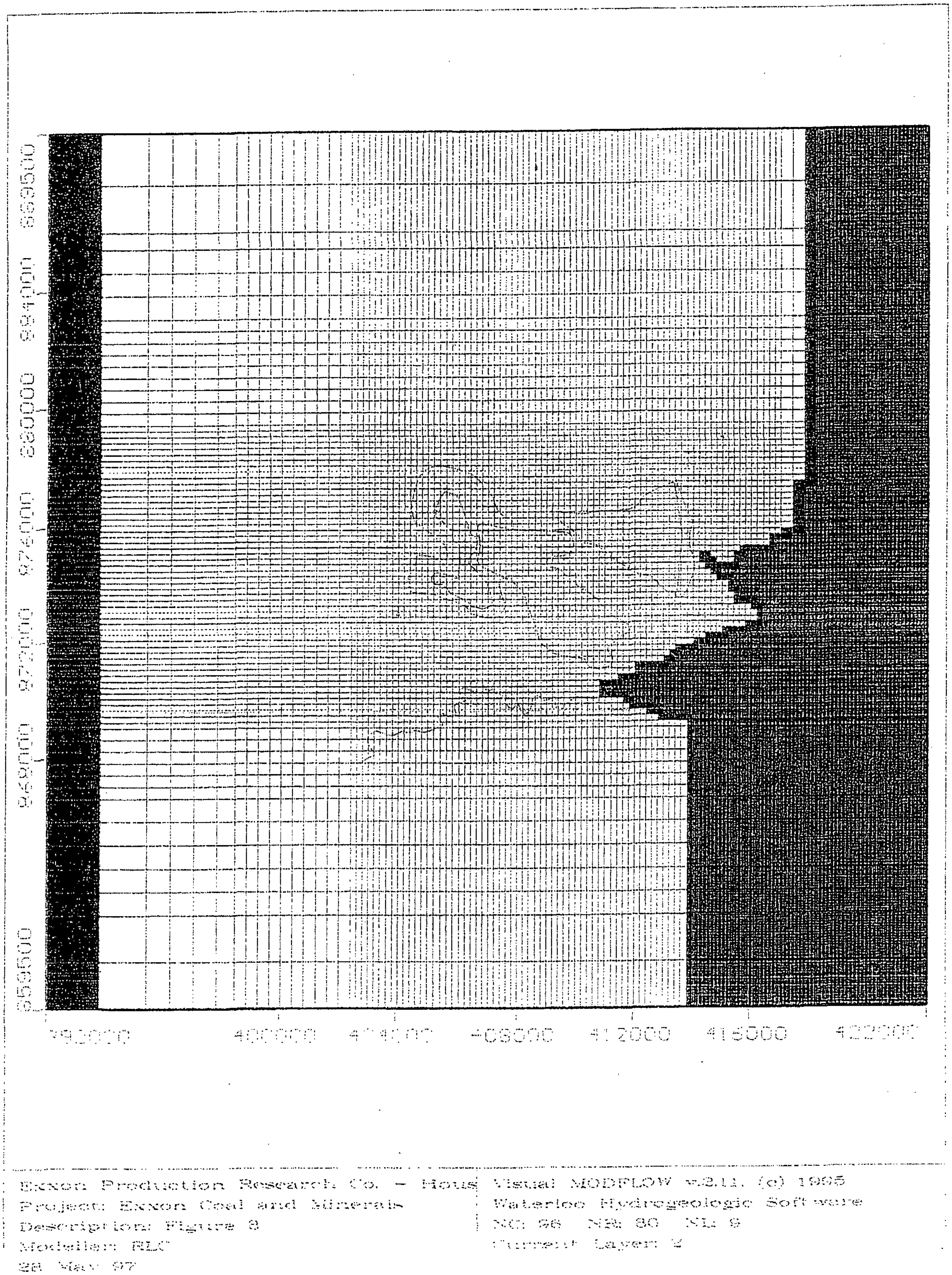

Figure 8. Location of the Eastern Boundary (Shown in Red) in Layers 2 and 3 (Inactive Nodes are Shown in Grey)

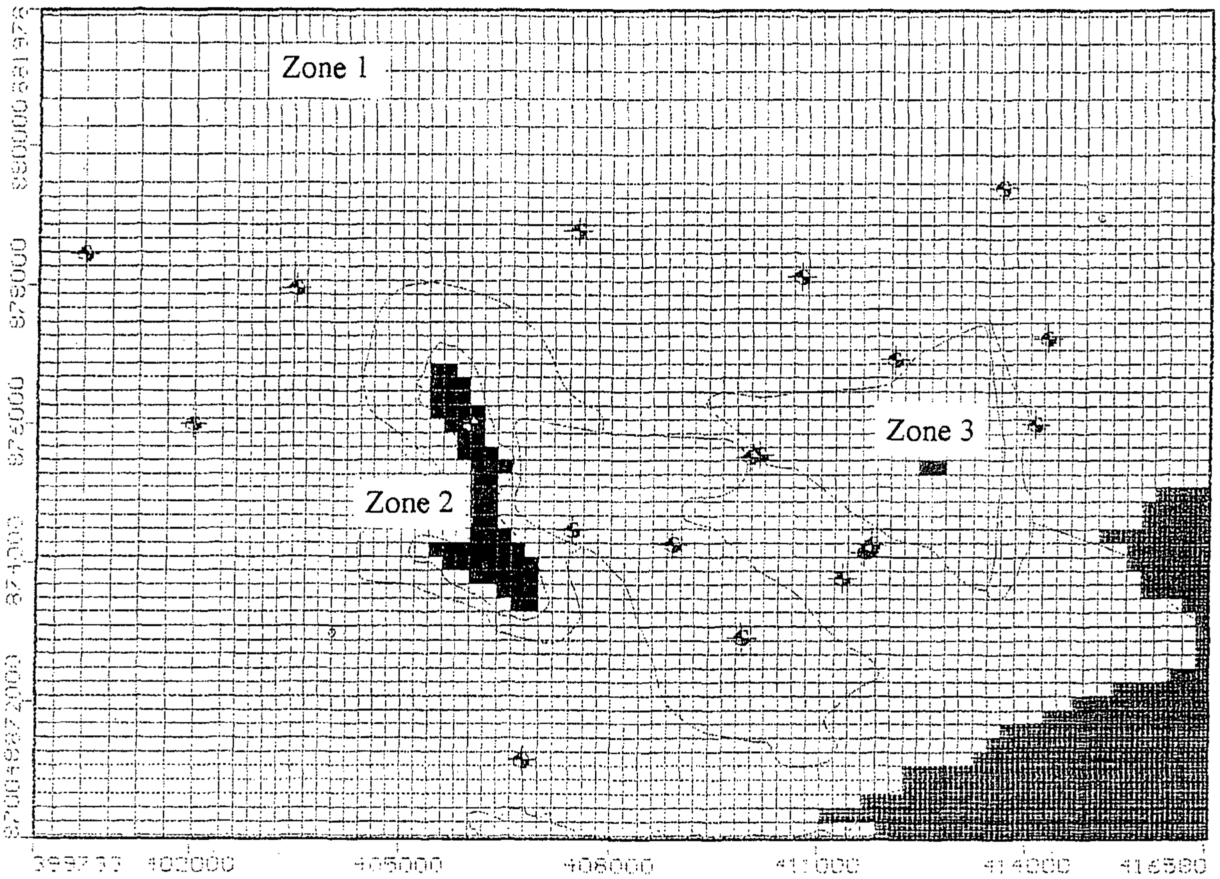

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Figure 9. Model Recharge Zones

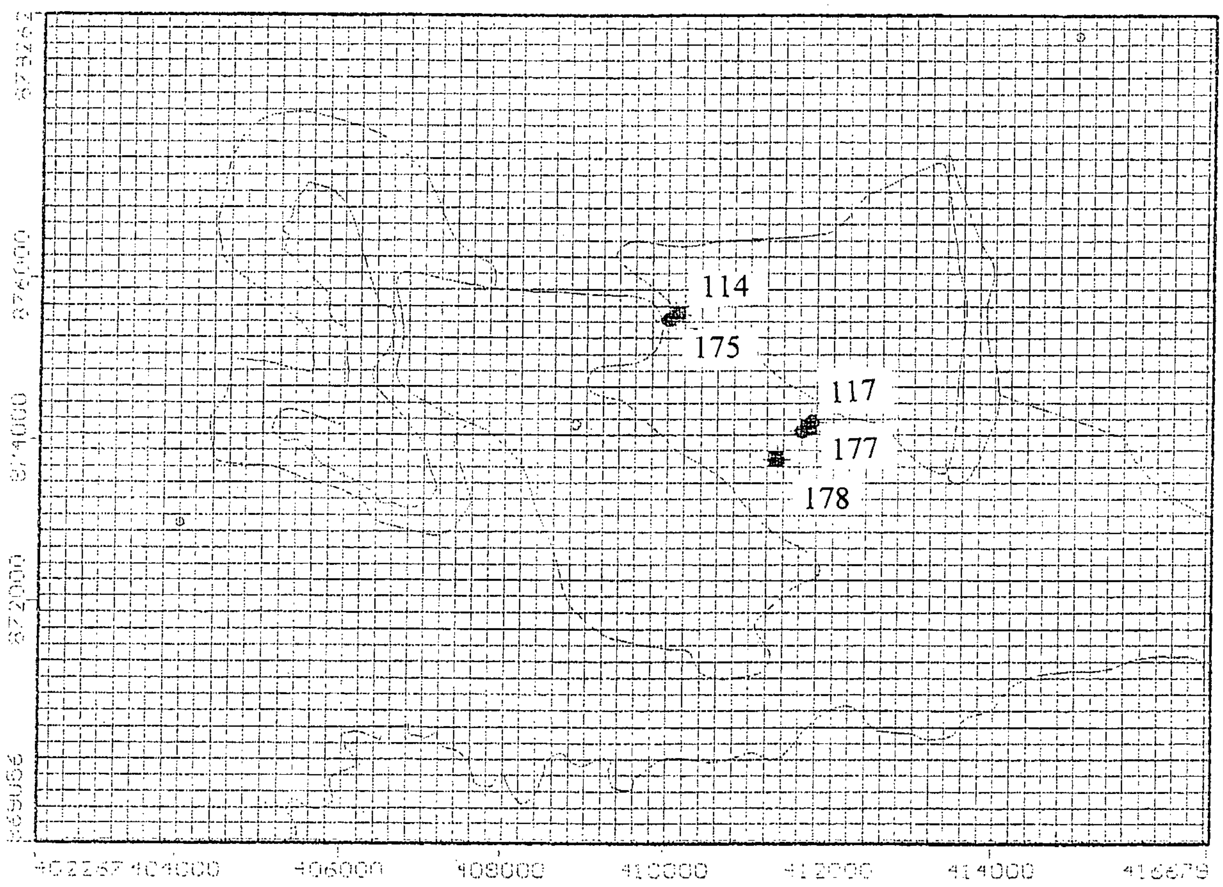

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Figure 10. Location of Ground Water Extraction Wells

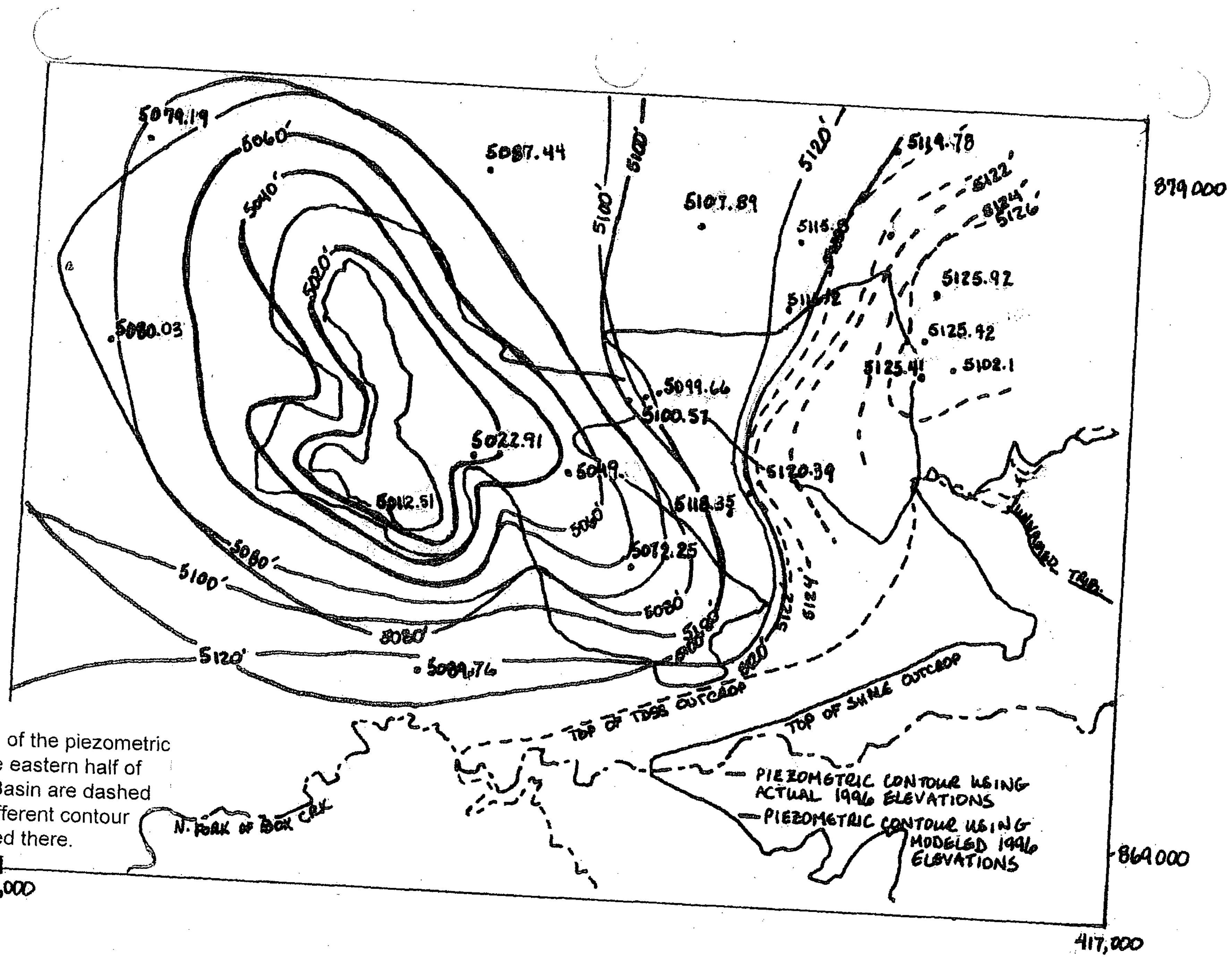

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Figure 11. Results of Transient Calibration

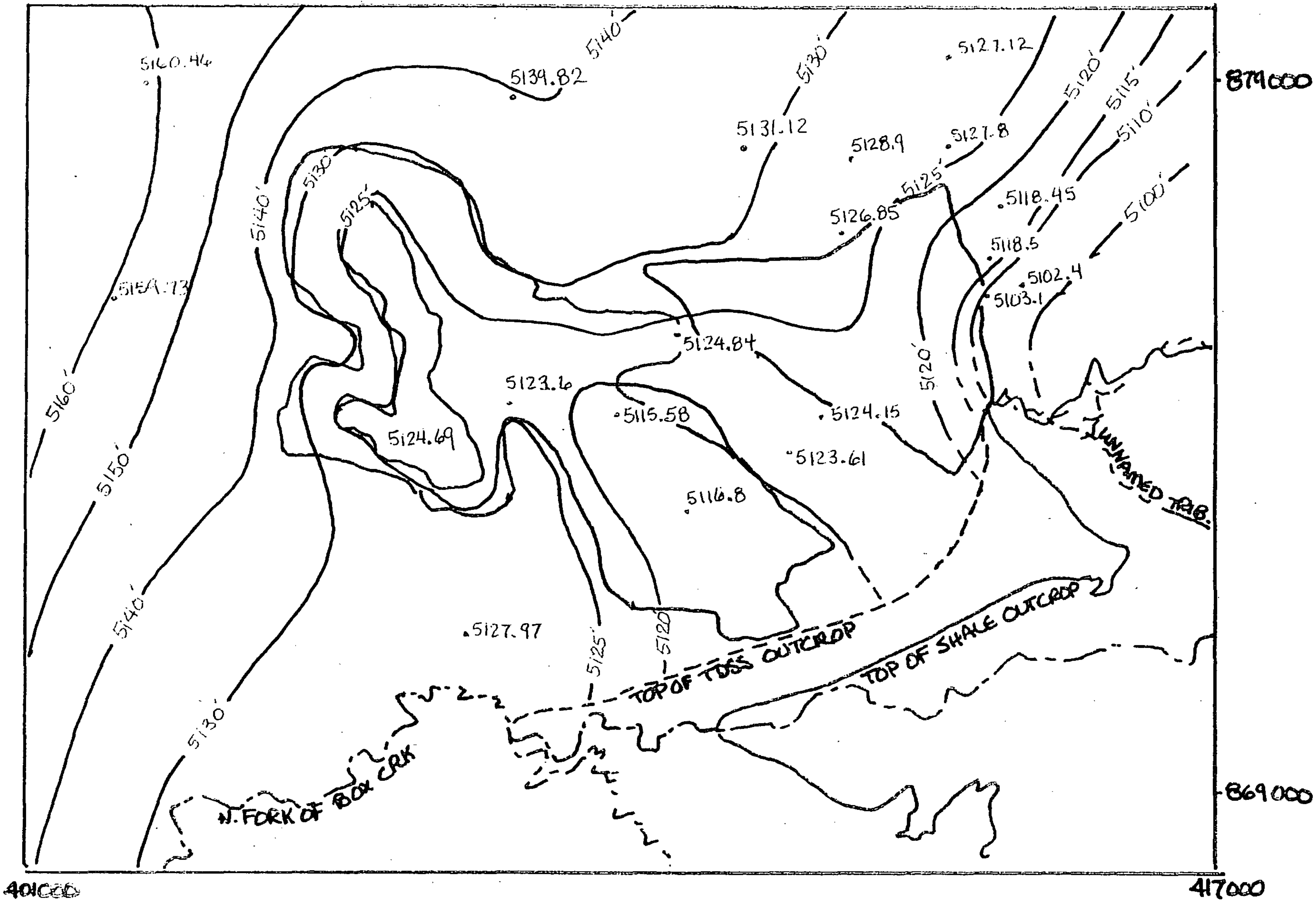

Figure 12. Long-Term Configuration of the Piezometric Surface in the TDSS and Mine Backfill

MODELING ADDENDUM

September, 1997

Prepared For:

Exxon Production Research Company
and
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Houston, Texas

Prepared By:

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LIST OF TABLES AND FIGURES

LIST OF ABBREVIATIONS

ACL	alternative concentration limits
ft	feet
gpm	gallons per minute
mg/l	milligrams per liter
msl	mean sea level
n	porosity
NRC	Nuclear Regulatory Commission
S_s	specific storage
S_y	specific yield
TDS	total dissolved solids
TDSS	Tailings Dam Sandstone
TDSh	Tailings Dam Shale
TVA	Tennessee Valley Authority
USGS	United States Geological Survey

Section 1. Introduction

This Addendum was prepared to document the modeling effort performed on behalf of Exxon Production Research Company and Exxon Coal and Minerals Company for the Highland Reservoir project. A computer model was developed in order to predict the ultimate elevation of the water surface in the Highland Reservoir once ground water levels stabilize, and to show the stable configuration of the piezometric surface in the vicinity of the Site. Visual MODFLOW (Waterloo Hydrogeologic) was used to develop the model and solve the ground water flow equation. Visual MODFLOW is based on MODFLOW, a finite difference code developed by the United States Geological Survey (USGS), but includes significant pre- and post-processing capabilities.

The Modeling Addendum contains four sections. Section 2 documents the configuration of the model; Section 3 describes the results of the transient calibration, and Section 4 describes the long-term simulations performed.

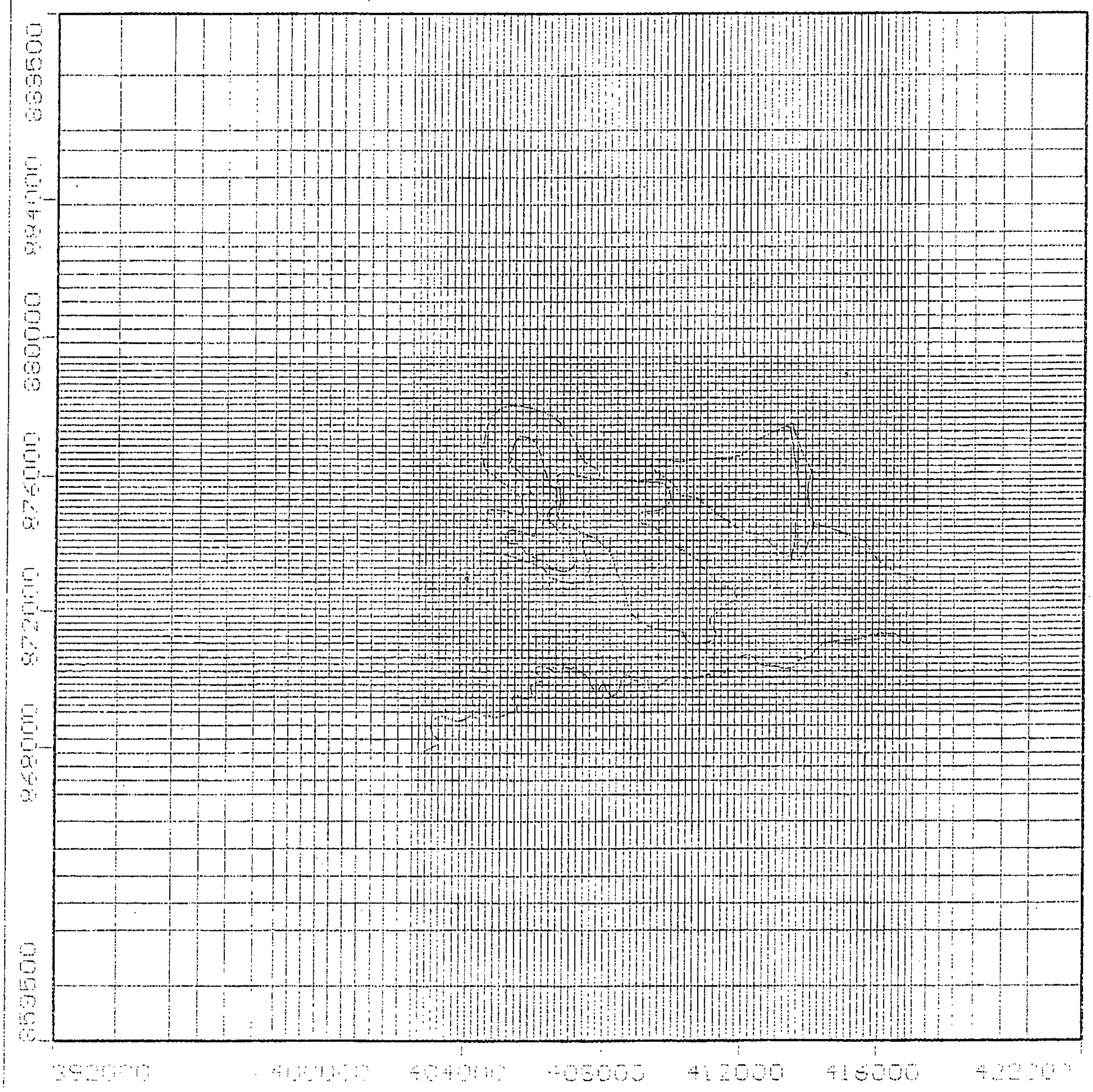
Section 2. Model Configuration

The model domain, shown in Figure 1, is 30,000 feet by 30,000 feet. The Highland Reservoir lies approximately in the center of the model domain. The model grid consists of 96 columns and 80 rows, with a finite difference node located at the center of each block formed by the intersection of a row and column. The largest grid blocks (located at the outermost edges of the domain) have approximate dimensions of 1800 by 1600 feet, while the smallest grid blocks (located near the Highland Reservoir) measure approximately 200 by 200 feet.

Vertically, the model consists of nine layers (layer 1 is the most shallow, layer 9 is the deepest). Layers 1 and 2 represent the Fowler and Tailings Dam Sandstone (TDSS) formations. Layer 3 represents the Tailings Dam Shale (TDSh), and layers 4 through 9 represent the upper, middle and lower Ore Body Sandstones, and the two aquitards that lie between the upper and middle sands, and the middle and lower sands.

Elevations for the top of layer 2 (top of TDSS) and the top of layer 3 (top of TDSh) were read from ASCII files that were digitized from Figures 1.3 and 1.4 in Water, Waste and Land, 1989. The elevations for the top of layer 1 (the ground surface) were hand-entered into ASCII file format from the two USGS topographic quadrangles that cover the model domain (Whipple Hollow and Bobby Draw). Elevations for the remainder of the model layers were created by subtracting constant thicknesses from the elevations for the top of the TDSh. The values for the thicknesses of the various layers beneath the TDSh were obtained from a generalized geologic cross section of the Site (Figure 12 in "Surface Mine Reclamation Lake Study for Highland Uranium Operations," EPR.81ES.83). For all model layers, the ASCII file elevations were interpolated onto the model grid using a utility included in the Visual MODFLOW software.

Average hydraulic properties were initially assigned to each model layer based upon tests performed in the vicinity of the Site. These tests and the resulting hydraulic data are documented in various Exxon reports (including "Highland Uranium Tailings Impoundment Seepage Study," EPR.5ES.82) and are not repeated here. The hydraulic properties were refined as part of the transient calibration and are discussed in the following section, as are the values used for the initial and boundary conditions, recharge rates and ground water extraction rates..



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Current Layer: 1

Figure 1. Extent of Ground Water Model Domain

Section 3. Transient Calibration

A transient calibration was performed in order to refine the hydraulic properties assigned to the various model layers. The calibration "targets" were the average annual water levels measured in Site monitoring wells from 1989 to 1996.

3.1 Initial and Boundary Conditions

The initial condition for the transient calibration consisted of average 1988 ground water levels across the Site. The piezometric surface for December, 1988 (Figure 1.6 of Water, Waste and Land, 1989) was digitized into ASCII file format. The ASCII data were read into the model and the model was run for one iteration (not enough to change the heads significantly). The resulting heads for the entire model grid were saved to a file that was later used for the initial heads for each of the transient simulations.

The same ground water elevations were used as the initial condition for each model layer. The year 1988 was selected as the starting point for the transient calibration (as opposed to an earlier year) in order to maximize the amount of well data available to compare with the model results (refer to Table 1, below).

Table 1. Number of Wells Having Water Level Measurements Prior to and Including 1988

Year	Number of Wells Having Water Level Measurements
1982	7 (no measurements in Reservoir)
1984	8 (measurements in Reservoir began)
1986	15 (seven additional wells installed)
1988	27 (12 additional wells installed)

A constant head boundary condition was used on the western and eastern edges of the model for most of the model layers. In layers 1 and 2, the western boundary condition was fixed at an elevation of 5200 ft above msl. This value was obtained by projecting the average hydraulic gradient at the western edge of piezometric surface maps from 1988 (WWL, 1989) and 1994 (Exxon, 1994) back to the western boundary of the model. The western boundary of layer 3 was fixed at an elevation of 5175 ft above msl. In layers 4 through 9, the western boundary was fixed at a constant head that increased with time, as shown below in Table 2.

Table 2. Values of Time-Varying Western Boundary Condition Assigned to Layers 4 through 9

Years	Value of Constant Head Boundary (ft above msl)
1988-1990	5025
1990-1992	5050
1992-1994	5075
1994-1996	5100
1996 and beyond	5125

These values were based on measurements of ground water elevations in the Ore Body Sands in the vicinity of the western boundary of the model. Water levels in the sands were greatly impacted in the early 1980s by underground operations associated with a Tennessee Valley Authority (TVA) mine. Since the mid-1980s, underground operations have ceased at the TVA mine. Recent ground water measurements (January 1997) at wells near the western boundary indicate that water levels in the Ore Body Sands have risen approximately 100 ft. (Range, 1997). These water levels are shown below in Table 3.

Table 3. January 1997 Water Level Measurements in Ore Body Sand Wells

Well Name	Easting (ft)	Northing (ft)	Ground Water Elevation (ft above msl)
CM-2	391235	886600	5088.9
CM-20	387525	880922	5106.5
CM-29	386323	882772	5109.3
EM-5	387110	879105	5122.8
EM-18	381042	880380	5135.2
FM-36	373049	877817	5170.0
FM-44	376936	879339	5153.7

To the east, the TDSS and TDSh outcrop. In the field, the outcrop of the top of the TDSh shows no evidence of ground water seepage. As a result, it can be assumed that the piezometric surface in the TDSS west of the outcrop drops beneath the top of the TDSh before the outcrop occurs. As a result, no eastern boundary condition was defined for model layer 1. In layers 2 and 3, the eastern boundary does not lie along the eastern edge of the model domain, but instead follows the line of the TDSh outcrop as shown in Figure 2. Ground water elevations along this eastern boundary were set equal to the elevations of the top of layers 2 and 3. All of the nodes to the east of the TDSh outcrop in layers 1 through 3 were defined to be inactive.

The eastern boundary in layers 4 through 9 was located along the eastern edge of the model domain since there was no information regarding outcrops of the Ore Body Sands in this region. Ground water elevations along the eastern boundary in layers 4 through 9 were set equal to an elevation of approximately one foot above the bottom of layer 4.

It should be noted that along the western and eastern boundaries, the head difference above and below layer 3 indicates that the TDSh is believed to be laterally extensive across the model domain and is an effective aquitard. In contrast, the value of the constant head boundary condition is the same in layers 4 through 9 because the Ore Body Sands are believed to be in hydraulic communication across the model domain and the aquitard units between the Ore Body Sands are not laterally extensive.

3.2 Recharge

Three different recharge zones were defined for the model domain, as shown in Figure 3. The first (not explicitly shown in the Figure) was applied to the entire model domain, except those regions shown in color on the Figure. This recharge zone was set at a constant rate of 0.5 inches per year, and represents the amount of rainfall available to infiltrate to ground water after evapotranspiration.

The second recharge zone is shown in green, and lies within the tailings basin outline. Here, the ground water from the extraction wells (discussed below) is discharged into an evaporation pit. The size of the pit is approximately 1.5 acres (the size of two grid blocks in this portion of the model domain), and the amount of recharge assigned to the zone varied from 4.7 inches/year to negative 24 inches/year (a loss of water from the evaporation pit) depending upon the amount of discharge from the wells. Appendix A includes the spreadsheet printout containing the calculations of recharge for the evaporation pit.

Finally, the Reservoir surface, which is shown in blue in Figure 3, was defined as the third recharge zone. For the time period simulated for the transient calibration, it was held constant at a rate of 42.5 inches/year. It was estimated using the water balance shown in Appendix A, which is based upon work performed by Exxon Production Research Company (EPR, 1983). The estimate of 42.5 inches/year indicates that during this time frame, ground water inflow greatly exceeded ground water outflow and evaporation.

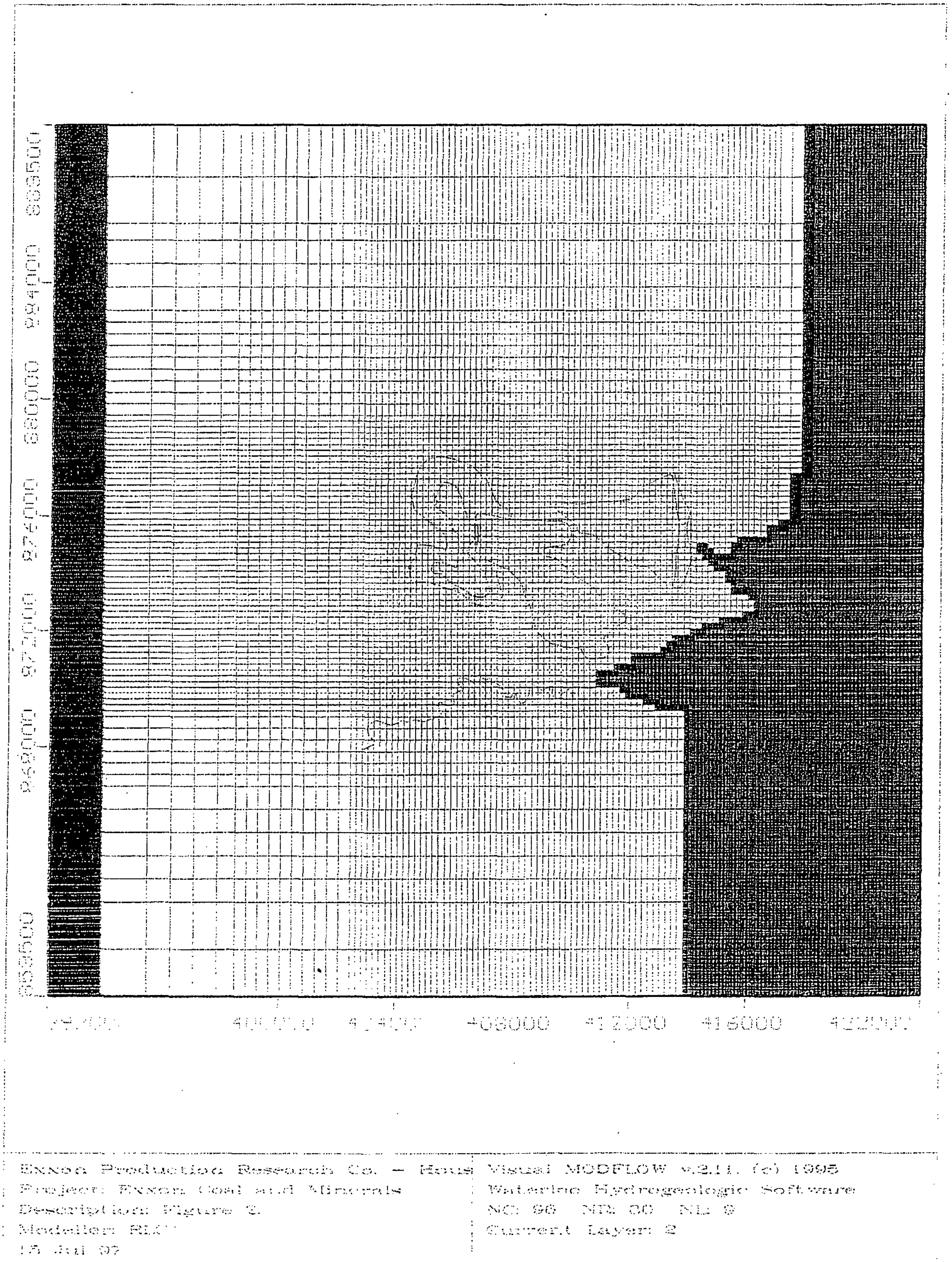

Figure 2. Location of the Eastern Boundary (Shown in Red) in Layers 2 and 3 (Inactive Nodes are Shown in Grey)

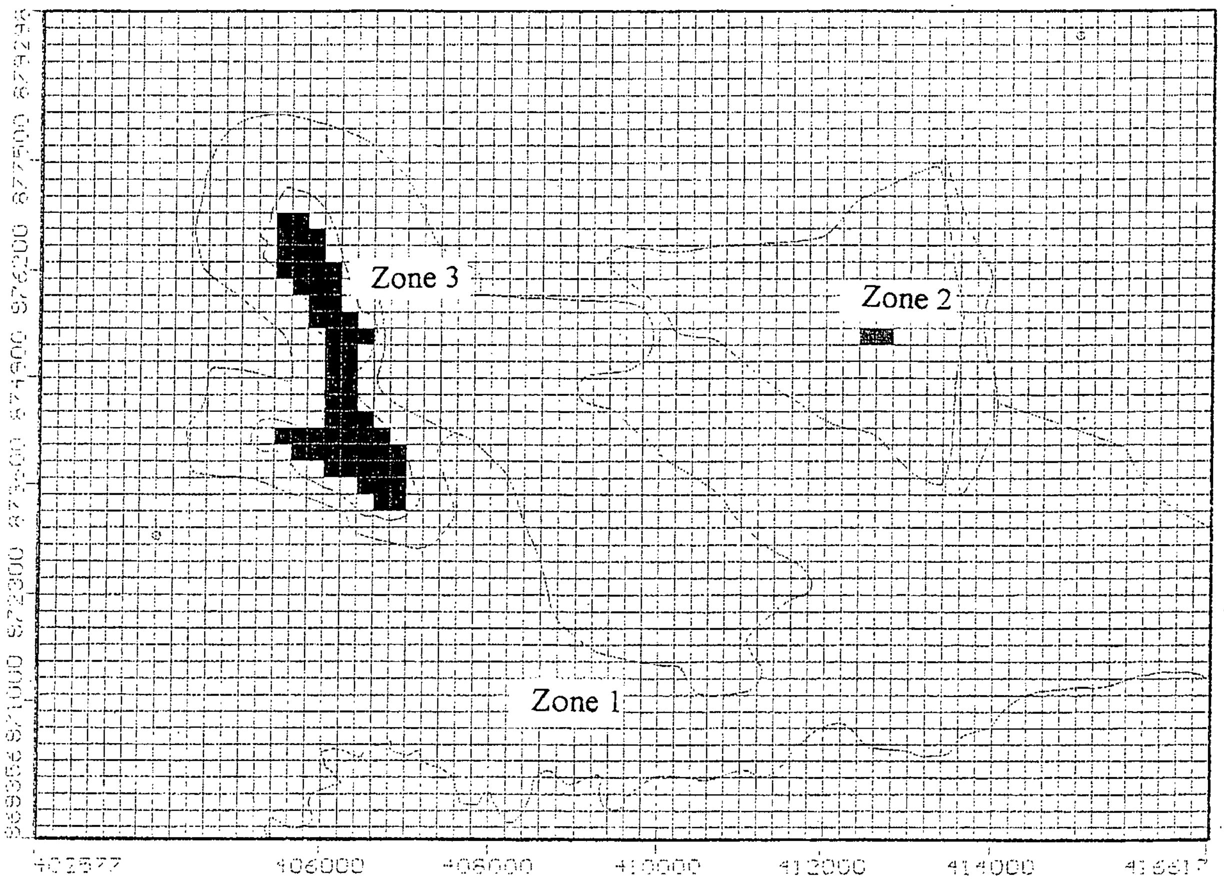

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Figure 3. Model Recharge Zones

3.3 Ground Water Extraction Wells

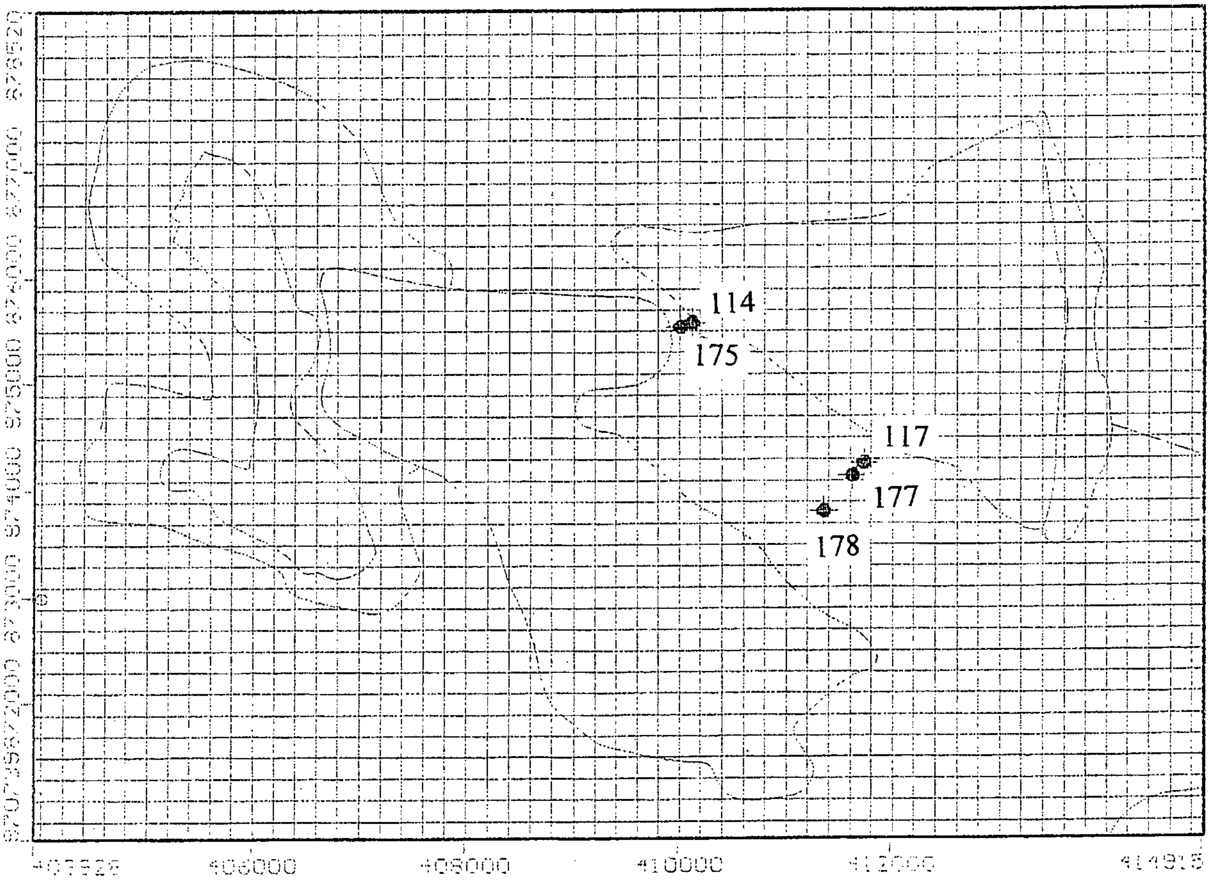
As many as five wells have been extracting ground water from the finger zone since 1989. The average annual pumping rate for each of the wells was used in the model to simulate pumping conditions. The average annual pumping rates in gallons per minute (gpm) for the wells are shown below in Table 4 and the location of the wells is shown in Figure 4.

Table 4. Average Annual Ground Water Extraction Rates (in gpm) Used in Model Calibration

Well Number	1989	1990	1991	1992	1993	1994	1995	1996
114	.004	0.0	0.0	0.0	0.0	0.0	0.0	0.0
117	1.117	1.117	1.117	1.117	1.117	.494	.332	.104
175	1.839	1.839	1.839	1.839	1.839	2.854	1.602	1.594
177	.572	.572	.572	.572	.572	.023	.002	.001
178	.511	.511	.511	.511	.511	.239	.150	.089

3.4 Transient Calibration Results

The results of the transient calibration on a well by well basis are shown in Appendix B. The hydraulic properties assigned to each model layer are summarized below in Table 5. The distribution of hydraulic conductivities and storage properties for each model layer are shown in Figures 5a through 5i. Figure 6 is a map of the simulated and measured piezometric surfaces in the TDSS and mine backfill for average 1996 conditions.



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Current Layer: 1

Figure 4. Location of Ground Water Extraction Wells

Table 5. Hydraulic Properties Assigned to Calibrated Model Layers

Layer	Predominant Formation Representing Layer	Range of Hydraulic Properties Used for Predominant Formation
1	Fowler Formation	$K_{x,y,z}$=.002-.015 cm/sec S_s=.00073-.073 1/ft; S_y=.15, n=.3
2	Tailings Dam Sandstone	$K_{x,y,z}$=.002-.015 cm/sec S_s=.00073-.073 1/ft; S_y=.15, n=.3
3	Tailings Dam Shale	$K_{x,y,z}$=1X10^{-7} -8X10^{-7} cm/sec S_s=.00022 1/ft; S_y=.04, n=.14
4	Upper Ore Body Sandstone	$K_{x,y,z}$=.08 cm/sec S_s=.00073 1/ft; S_y=.15, n=.3
5	Upper Aquitard	$K_{x,y,z}$=.008 cm/sec S_s=.00073 1/ft; S_y=.15, n=.3
6	Middle Ore Body Sandstone	$K_{x,y,z}$=.008 cm/sec S_s=.00073 1/ft; S_y=.15, n=.3
7	Lower Aquitard	$K_{x,y,z}$=.008 cm/sec S_s=.00073 1/ft; S_y=.15, n=.3
8,9	Lower Ore Body Sandstone	$K_{x,y,z}$=.008 cm/sec S_s=.00073 1/ft; S_y=.15, n=.3
1-8	Mine Backfill	$K_{x,y,z}$=4X10^{-7} cm/sec S_s=.00075 1/ft; S_y=.15, n=.35
1-9	Highland Reservoir	$K_{x,y,z}$=100 cm/sec S_s=.99, S_y=.99, n=.99

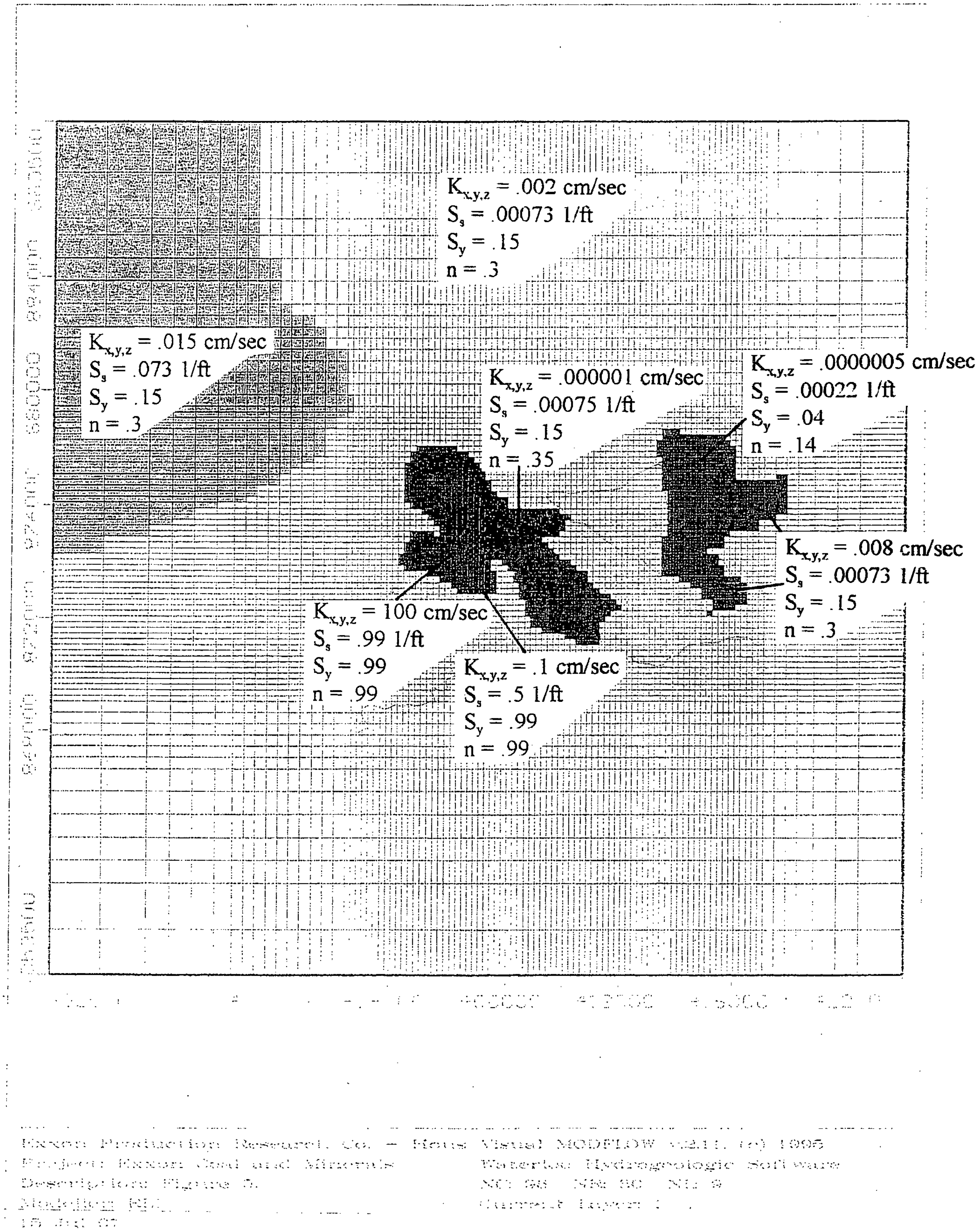

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Figure 5a. Hydraulic Conductivities and Storage Properties Assigned to Layer 1

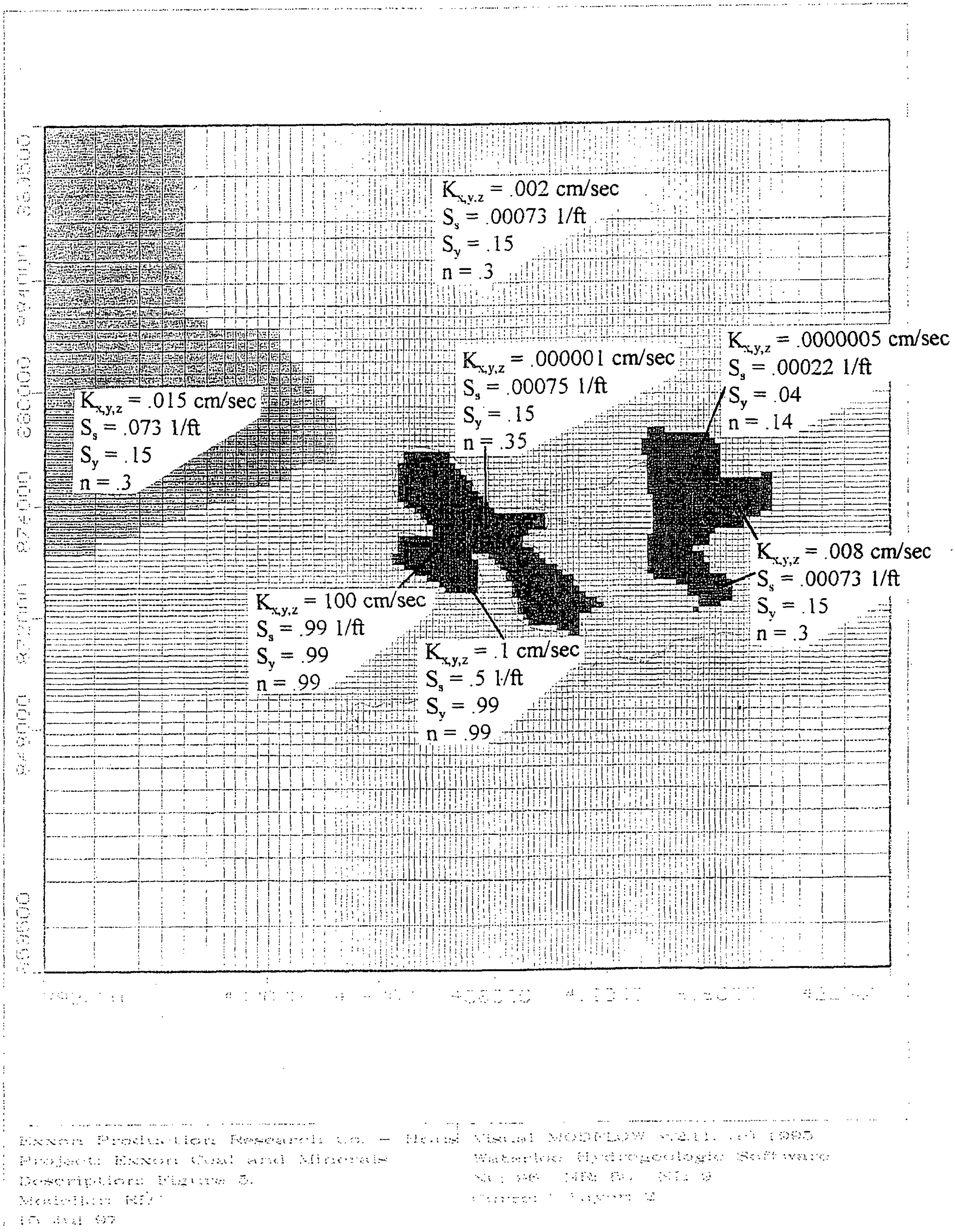

Figure 5b. Hydraulic Conductivities and Storage Properties Assigned to Layer 2

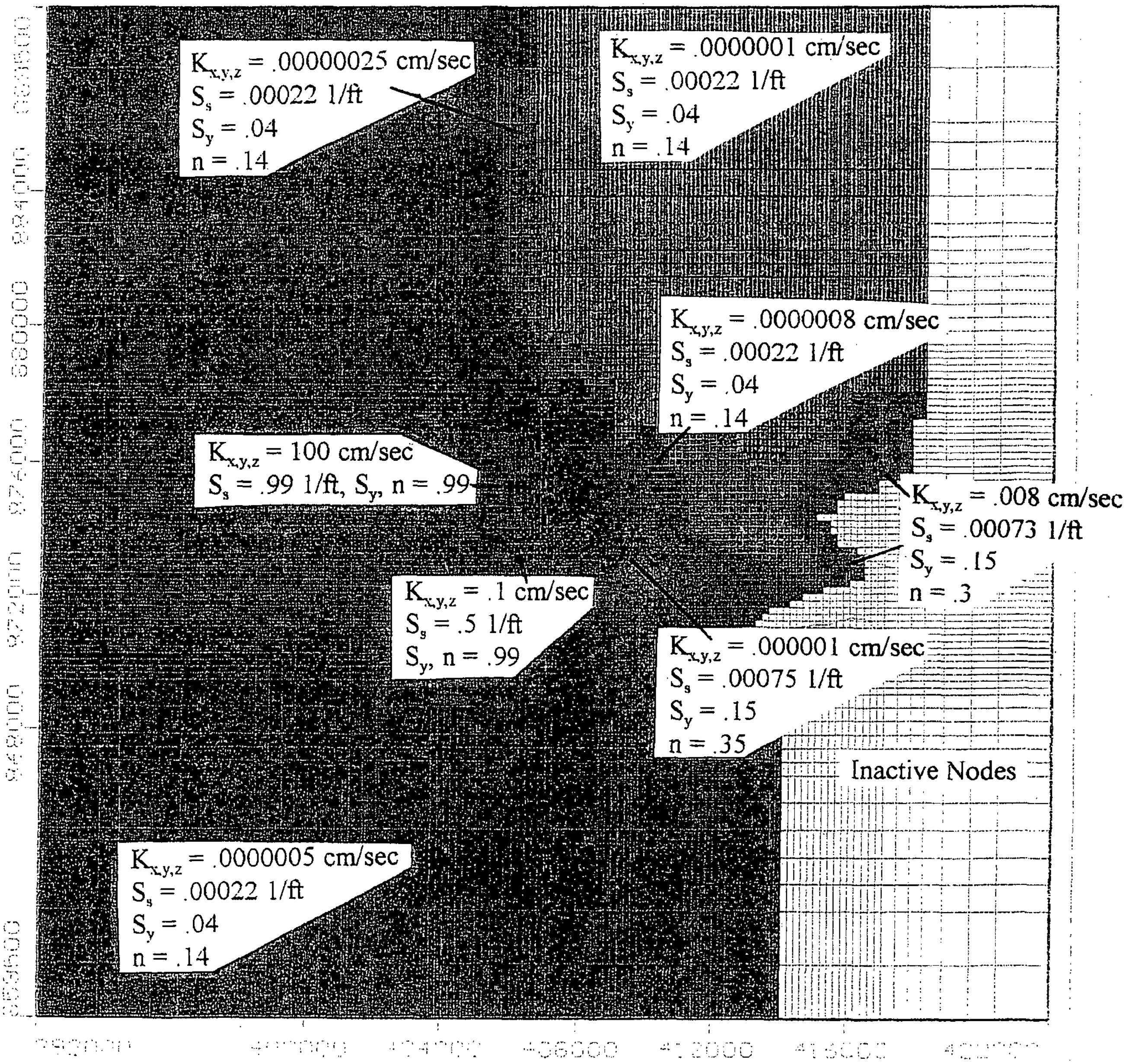

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Figure 5c. Hydraulic Conductivities and Storage Properties Assigned to Layer 3

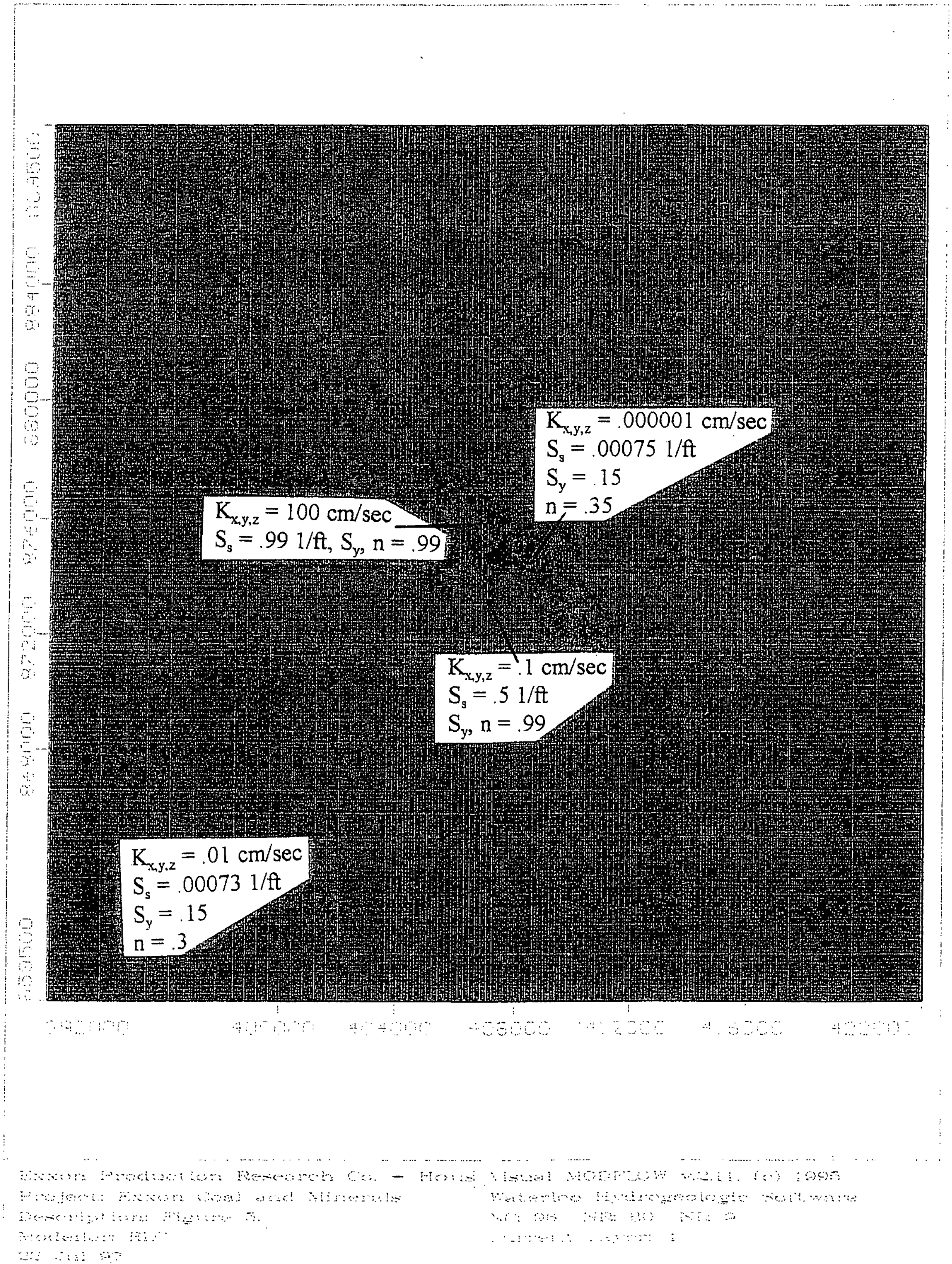

Figure 5d. Hydraulic Conductivities and Storage Properties Assigned to Layer 4

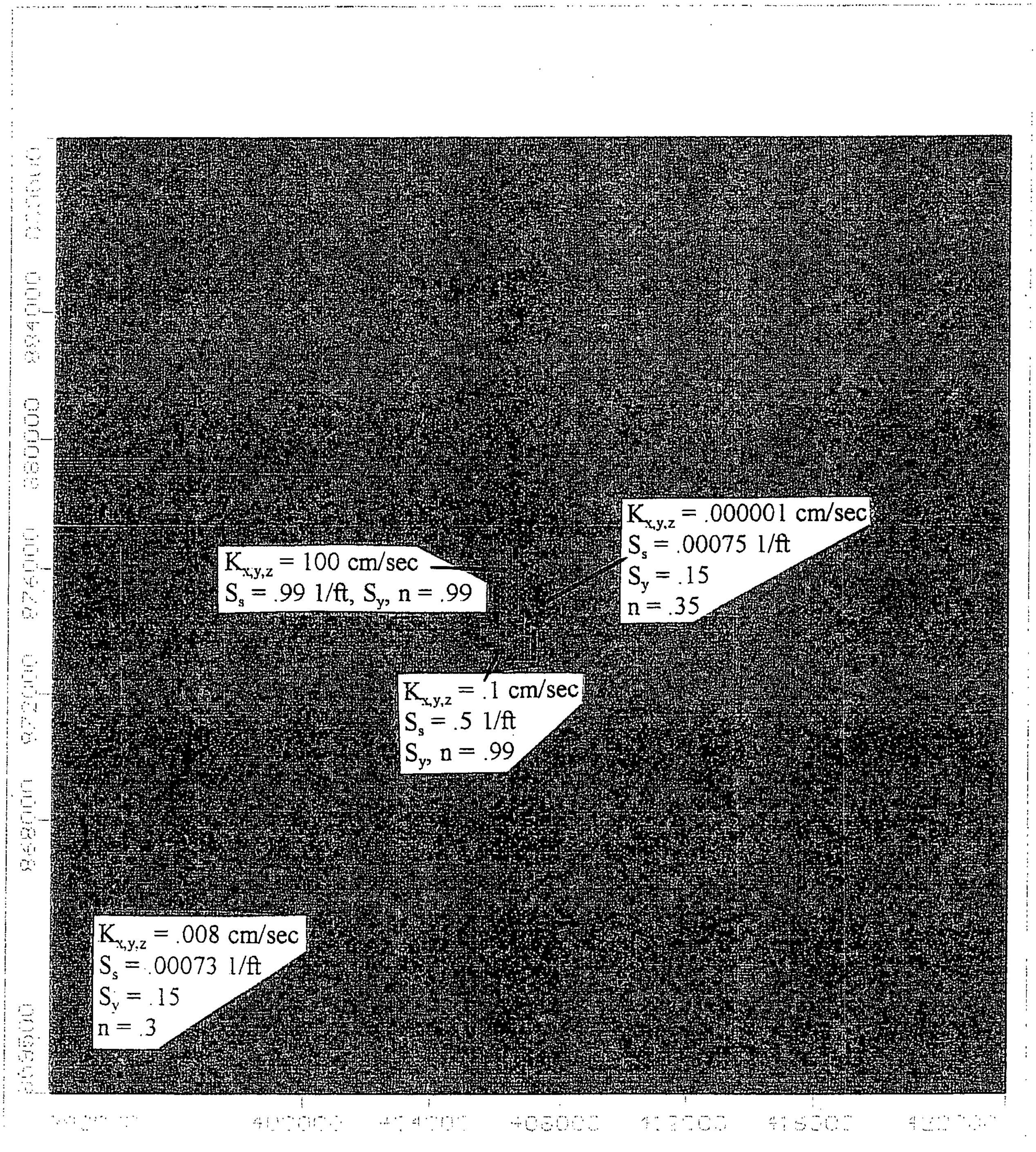

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Figure 5e. Hydraulic Conductivities and Storage Properties Assigned to Layer 5

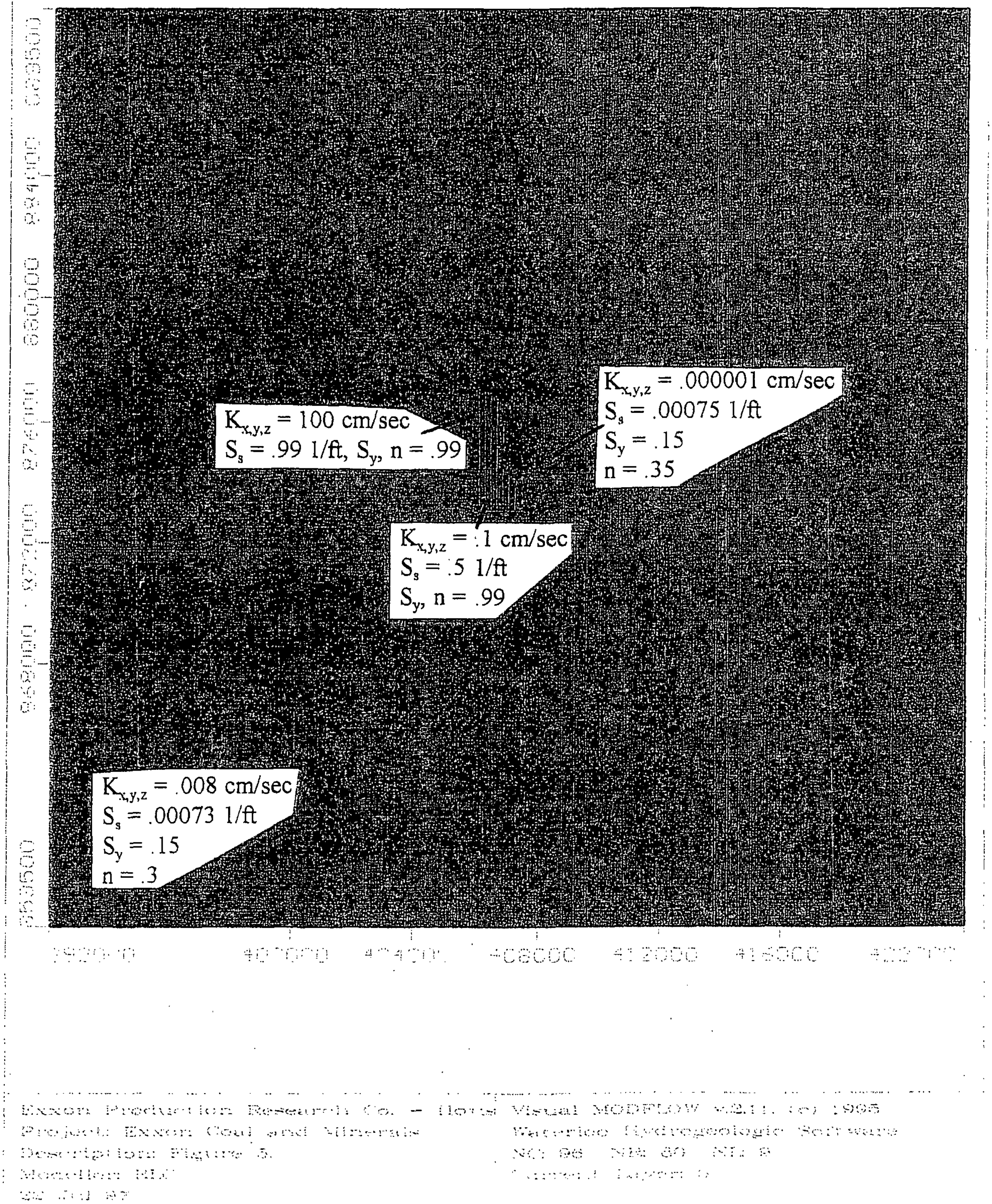


Figure 5f. Hydraulic Conductivities and Storage Properties Assigned to Layer 6

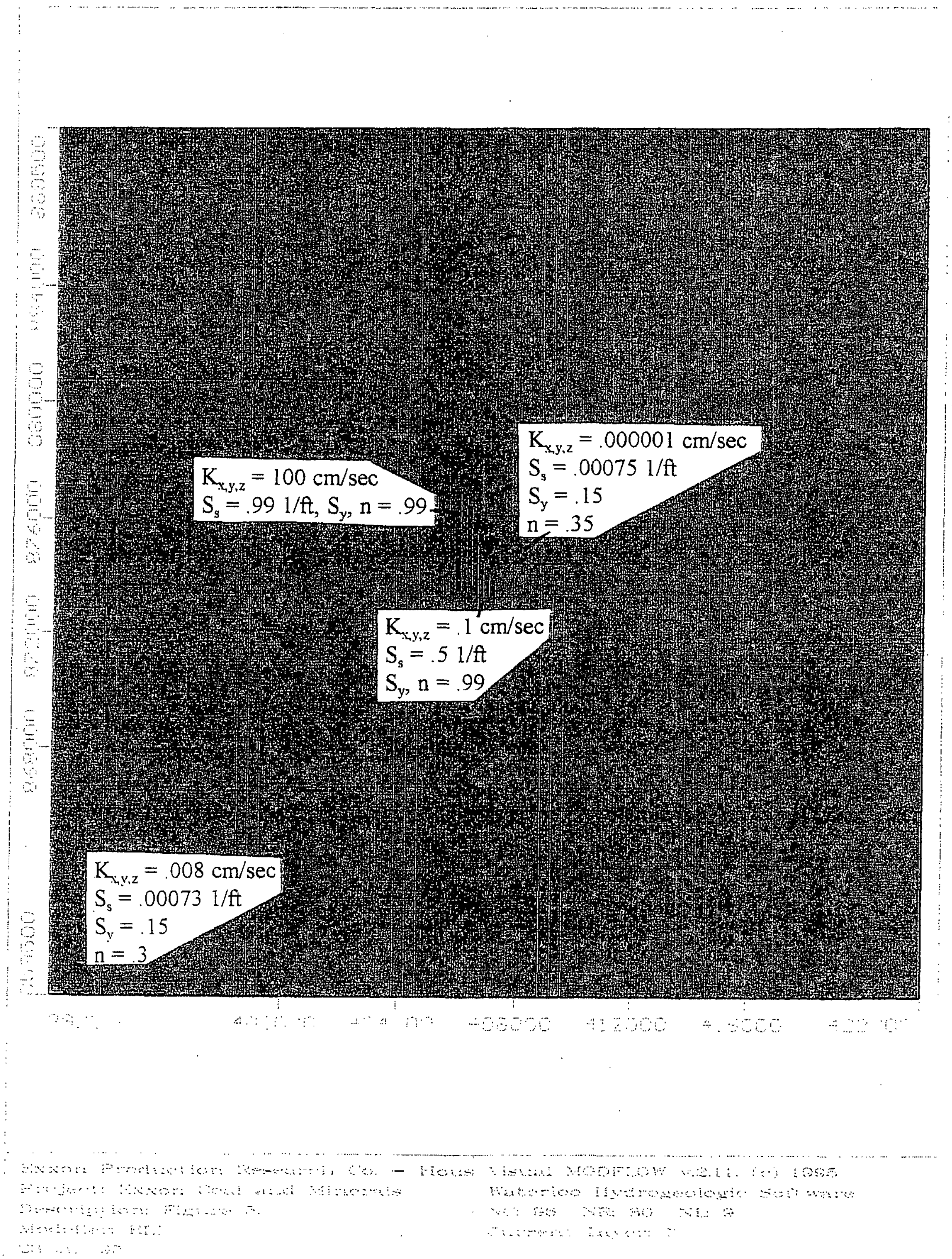


Figure 5g. Hydraulic Conductivities and Storage Properties Assigned to Layer 7

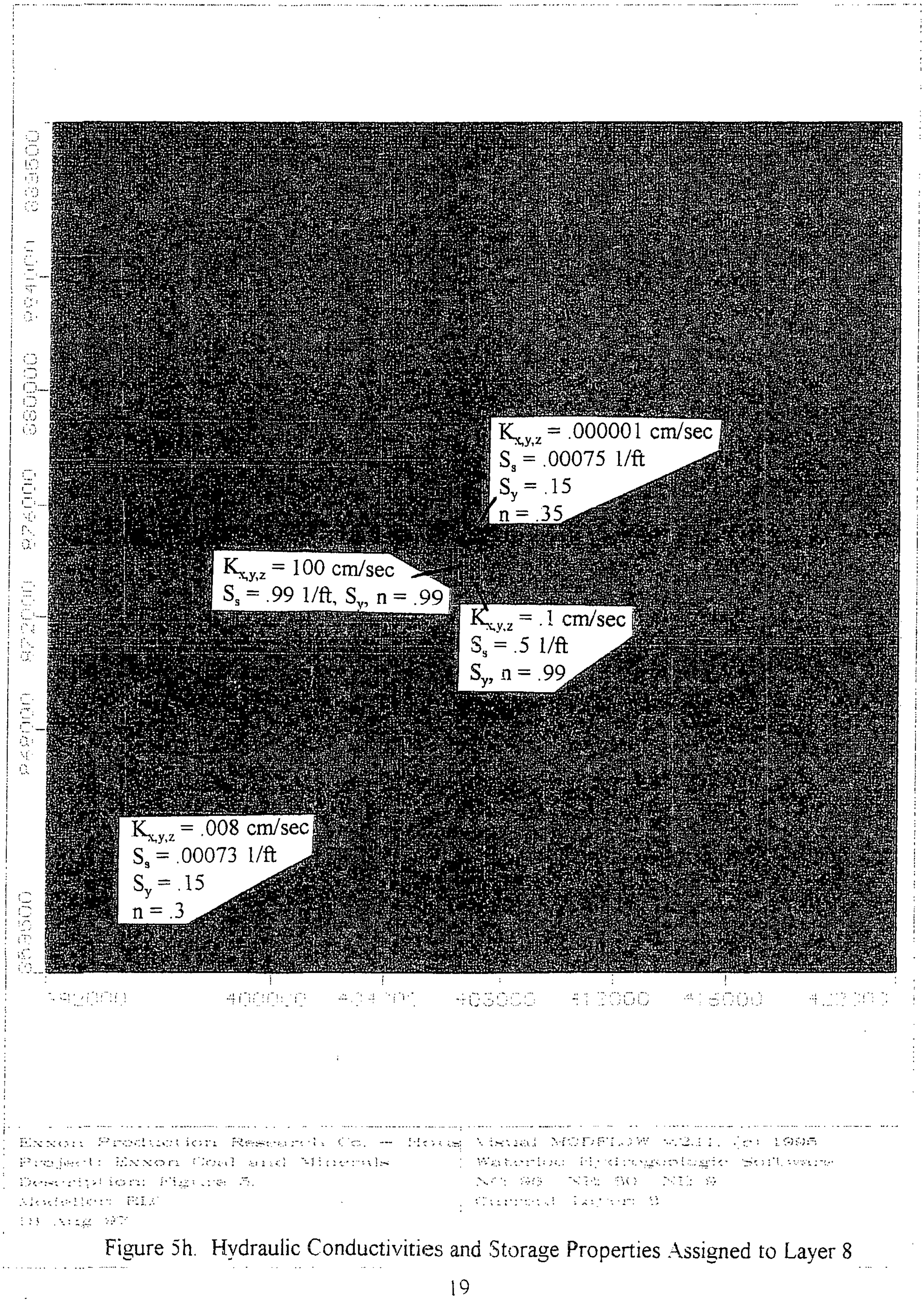


Figure 5h. Hydraulic Conductivities and Storage Properties Assigned to Layer 8

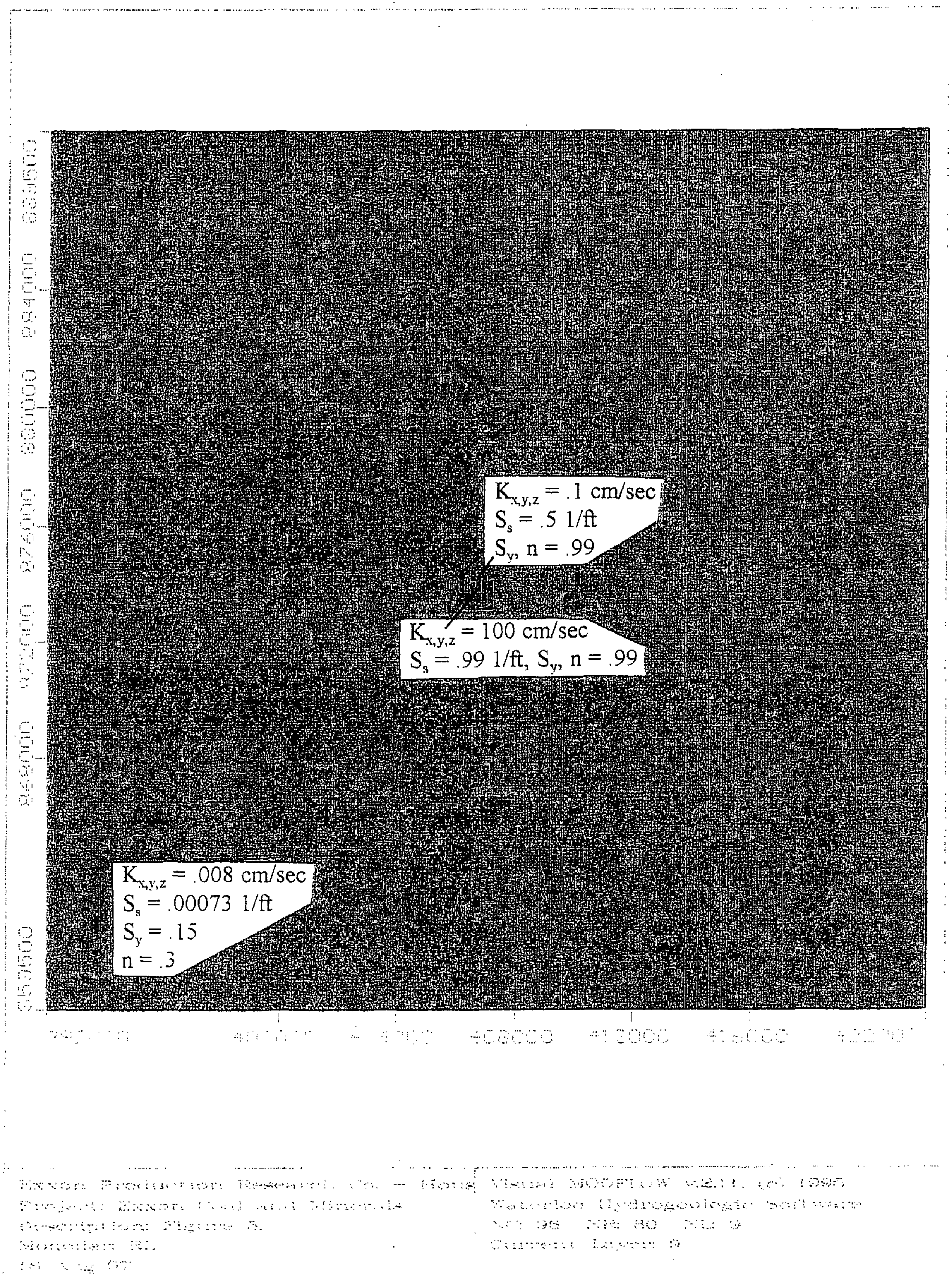


Figure 5i. Hydraulic Conductivities and Storage Properties Assigned to Layer 9

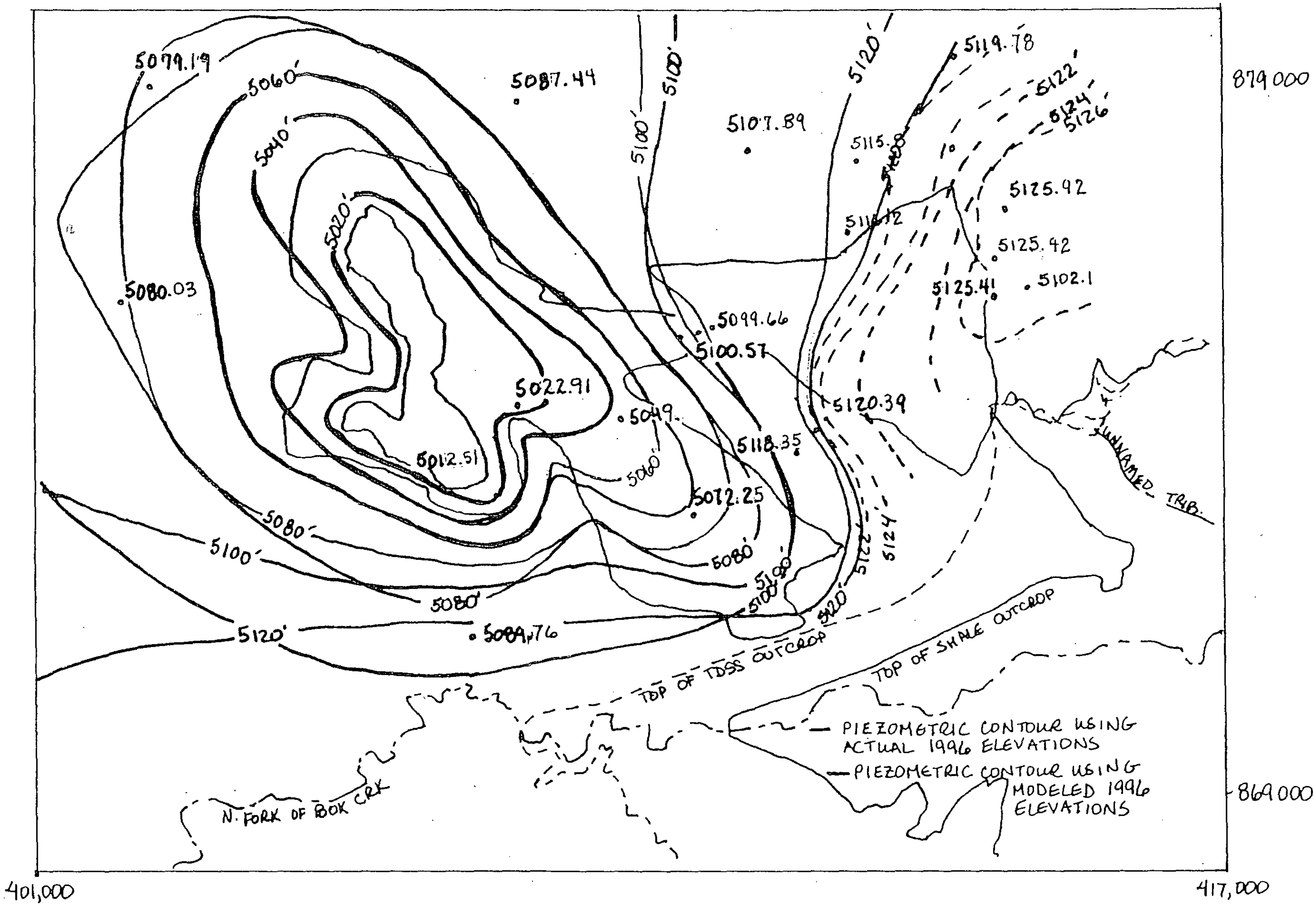


Figure 6. Results of Transient Calibration

Section 4. Long-Term Simulations

The hydraulic properties, initial condition, and boundary conditions discussed in Section 3 were used to simulate the long-term configuration of the piezometric surface and Highland Reservoir. For the purpose of the long-term simulations, it was assumed that no ground water extraction occurs within the model domain after 1996, and there was no corresponding recharge of the extracted ground water via the evaporation pond. The recharge rate assigned to the Reservoir surface declined to a rate of 0.2 inches/year, based on the assumption that as the Reservoir begins to fill more slowly, ground water outflow exceeds inflow, and the greater surface area of the Reservoir allows for increased evaporation. Refer to Appendix A for the water balance spreadsheet that estimates the net recharge to the Reservoir surface.

The long-term configuration of the piezometric surface in the TDSS and mine backfill is shown in Figure 7. The ultimate level of the Highland Reservoir is predicted to be approximately 5125 ft above msl. In general, ground water flows from west to east, with perturbations to this flow regime in the vicinity of the Highland Reservoir and mine backfill. The rate of flow is greatest to the northwest of the Reservoir (approximately .15 ft/day), and slowest to the northeast of the Reservoir (approximately .05 ft/day). Ground water flow velocities were estimated using an average hydraulic conductivity for the site (.002 cm/sec), and an average site-wide porosity of 34 percent.

In the vicinity of the tailings basin, ground water flows from the northwest to the southeast at a rate of about .03 ft/day, but changes to an easterly flow direction at the eastern edge of the tailings basin. Beneath the northwest portion of the tailings basin, ground water flows from northwest to southeast before the water table drops below the top of the TDSh. Within the TDSh, ground water starts to flow in more of an easterly direction beneath the southeast portion of the tailings basin. As a result, it appears that the portion of the North Fork of the Box Creek that lies to the south and east of the tailings basin will not intercept ground water migrating from beneath the basin. Ground water flow velocities were estimated using an average hydraulic conductivity for the site (.002 cm/sec), and an average site-wide porosity of 34 percent.

4.1 Sensitivity Analyses

Sensitivity analyses were performed in order to determine the degree of uncertainty in the model results based upon uncertainty in the model input parameters. All sensitivity analyses, except those performed on the value of specific storage, were performed as steady state simulations in order to greatly reduce the computational effort required.

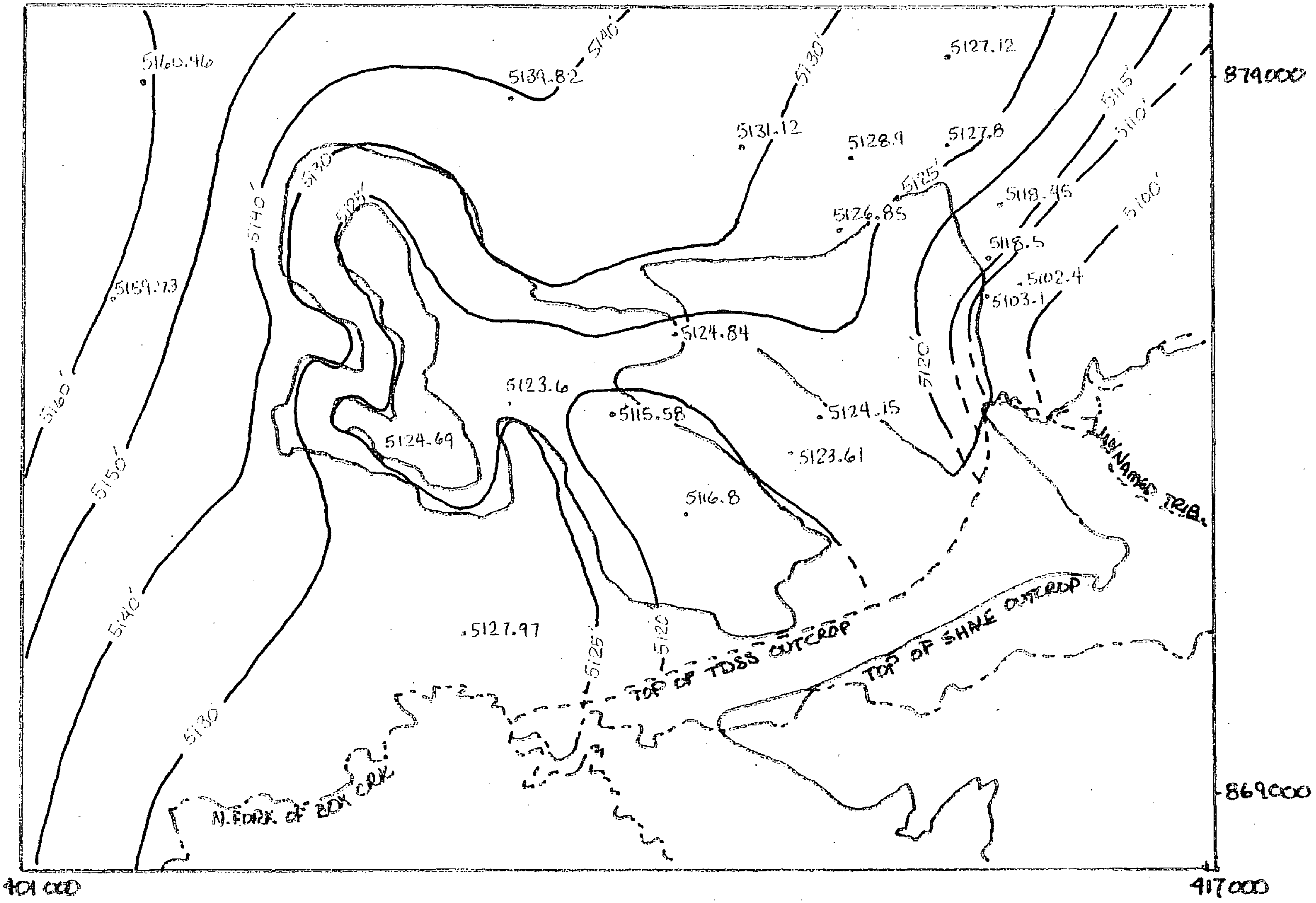


Figure 7. Long-Term Configuration of the Piezometric Surface in the TDSS and Mine Backfill

Hydraulic Conductivity

The values of the hydraulic conductivities assigned to the model layers were increased and then decreased by an order of magnitude in order to evaluate the sensitivity of the final Reservoir elevation to the values used. In general, an order of magnitude change in hydraulic conductivity in any of the layers resulted in a change in ultimate Reservoir elevation of about 15% or less. For most of the layers, the change in Reservoir elevation was less than 10% (a 10% change is approximately 15 feet). The Reservoir elevation was most sensitive to the hydraulic conductivity assigned to model layers 1 and 4.

Recharge

The values assigned to the two recharge zones (the areal recharge zone and the zone assigned to the Reservoir surface) used in the steady state simulation were changed to determine the sensitivity of the ultimate Reservoir elevation to the values used. For the first sensitivity analysis, the recharge assigned to the entire model domain was increased from 0.5 inches/year to 1.5 inches/year. This change had a negligible impact (approximately 3%) on the ultimate Reservoir elevation. For the second sensitivity analysis, the Reservoir evaporation rate was increased from 0.2 inches/year to -50 inches/year. This also had a negligible impact (it resulted in a decline of less than 3%) on the ultimate Reservoir elevation.

Boundary Conditions

The boundary conditions were modified in order to evaluate the sensitivity of the final Reservoir elevation to the values assigned. In layers 1 through 3, the western boundary condition was decreased by 20 ft. This resulted in a negligible (approximately 3%) decline in the ultimate Reservoir elevation. A 20 ft increase in the western boundary condition for layers 1 through 3 also resulted in an increase in Reservoir elevation of about 3%.

For layers 4 through 9, the western boundary condition was increased from 5125 to 5150 ft above msl. This resulted in an almost 7% increase in the ultimate Reservoir elevation. A corresponding decrease in the boundary condition for layers 4 through 9 was not made, since current water level measurements are at or below 5125 feet above msl, and while it is believed that the ground water system in these layers may continue to rebound slightly, water levels are not expected to decline.

To the east, the boundary condition in layers 2 and 3 was lowered by 10 feet in order to evaluate the impact on the ultimate Reservoir elevation. The resulting Reservoir elevation was essentially the same (a less than 2% decline) as the original elevation. In layers 4 through 9, the eastern boundary conditions were increased by 20 feet. This resulted in a less than 2% increase in the ultimate Reservoir elevation simulated by the model.

Specific Storage

Out of necessity, the sensitivity analyses performed on specific storage were performed as transient simulations. The computational effort required was significant and limited the number of analyses that could be performed to two. The first sensitivity analysis performed was on the value of specific storage and specific yield used in layers 1 and 2. Here, the specific storage was increased by two orders of magnitude, and specific yield was increased 33%. The result was a less than 7% decrease in the ultimate Reservoir elevation.

The second sensitivity analysis was on the value of specific storage used in the model layers that correspond to the Ore Body Sands and the aquitards between the sands (layers 4 through 9). Again, the specific storage was increased by two orders of magnitude (the specific yield was also increased by 33%). The resulting Reservoir elevation was approximately 13% lower. While the model results are certainly more sensitive to the value of specific storage used in layers 4 through 9 as opposed to layers 1 and 2, the change can still be considered to be rather minimal when compared to the overall rise in water level in the Reservoir.

Section 5. References

Exxon, 1994. Supporting Information for ACL Application.

Exxon Production Research Company (G. G. Peters, G. B. Dreher, D. E. Hamilton, R. J. Mitro, T. J. Cannon), "Highland Uranium Tailings Impoundment Seepage Study," EPR.5ES.82, February 10, 1982.

Exxon Production Research Company (N. K. Springer and R. J. Mitro), "Surface Mine Reclamation Lake Study for Highland Uranium Operations (Updated)," EPR.81ES.83, April 26, 1983.

Range, David; Exxon Coal and Minerals, Company. 1997. Personal communication to R. Carovillano: Water levels in Ore Body Sand wells near Highland Reservoir.

Water, Waste and Land, Inc., 1989. Supporting Information to License Amendment Response.

Waterloo Hydrogeologic. User's Manual for Visual MODFLOW.

APPENDIX A

CALCULATION SPREADSHEETS

Calculation of net recharge from evaporation pond

Well	1989	1990	1991	1992	1993	1994	1995	1996
114	0.004	0	0	0	0	0	0	0
117	1.117	1.117	1.117	1.117	1.117	0.494	0.332	0.104
175	1.839	1.839	1.839	1.839	1.839	2.854	1.602	1.594
177	0.572	0.572	0.572	0.572	0.572	0.023	0.002	0.001
178	0.511	0.511	0.511	0.511	0.511	0.239	0.15	0.089
Total (gpm)	4.043	4.039	4.039	4.039	4.039	3.61	2.086	1.788
Total (ft3/yr)	284091	283809.9	283809.9	283809.9	283809.9	253665.2	146577.8	125638.1
Evap Pond Area (ft2)	65340	65340	65340	65340	65340	65340	65340	65340
Baseline Recharge (in/yr)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Evap Pond Rechg (in/yr)	52.17	52.12	52.12	52.12	52.12	46.59	26.92	23.07
Pan Evap. (in/yr)	-48.00	-48.00	-48.00	-48.00	-48.00	-48.00	-48.00	-48.00
Sum (in/yr)	4.67	4.62	4.62	4.62	4.62	-0.91	-20.58	-24.43
Amt in model	4.7	4.6	4.6	4.6	4.6	-1	-21	-24

Calculation of net recharge at Reservoir surface.

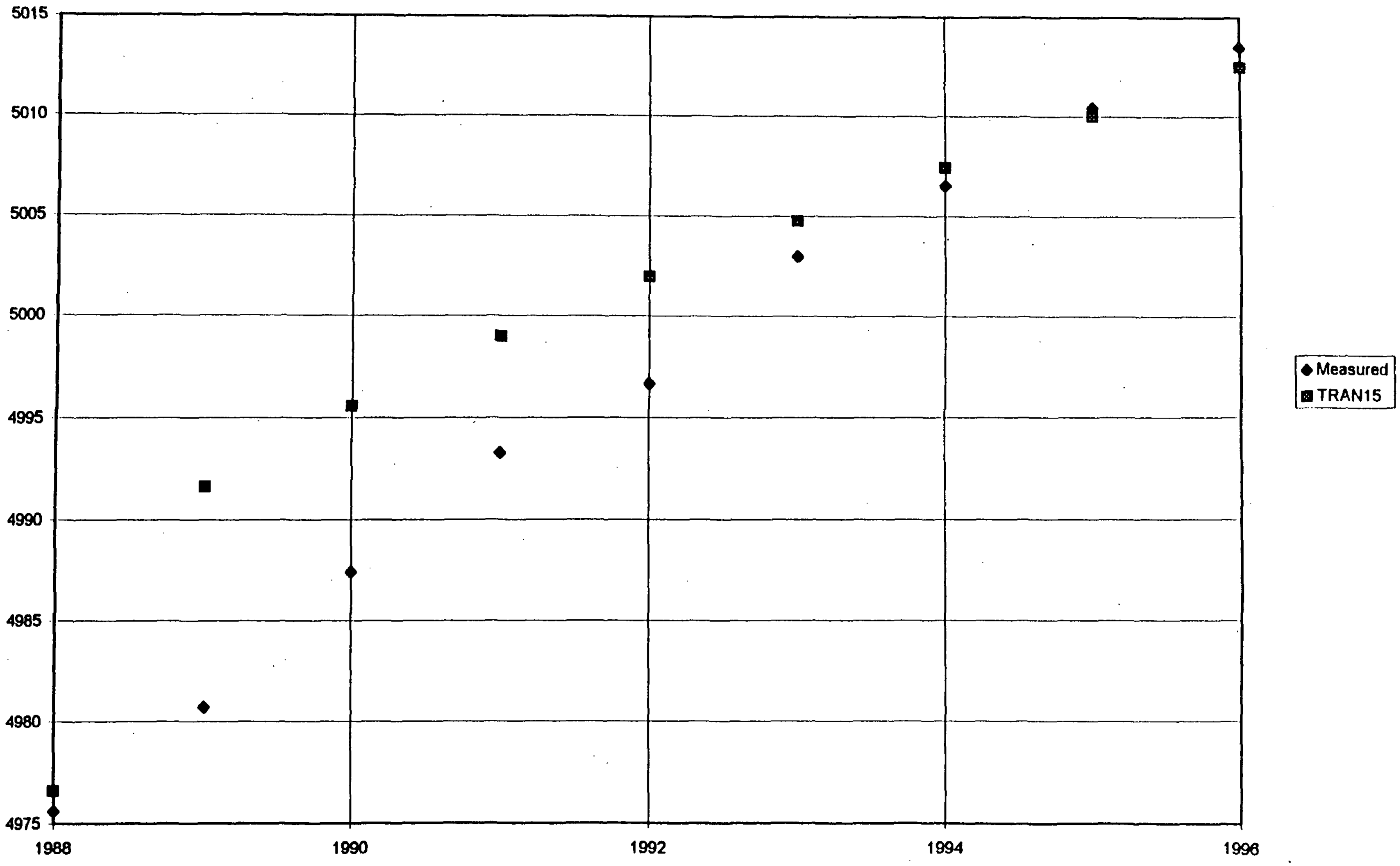
	ac-ft/month							
Years since 1996	Ground Water Inflow	Direct Rainfall	Runoff	Evap	Ground Water Outflow	Lake Area(ac)	Net water ac-ft/month	in/yr
0	45.7	8.4	4.8	30	0	98	28.9	42.47
5	45.7	9.3	4.7	33.1	0	112	26.6	34.20
10	45.7	10.3	4.7	36.9	0	123	23.8	27.86
15	45.7	11.3	4.6	40.2	0	134	21.4	23.00
20	45.7	11.9	4.6	42.3	0	140	19.9	20.47
25	45.7	12.4	4.5	44.1	0	146	18.5	18.25
30	45.7	12.9	4.5	45.8	0	152	17.3	16.39
35	45.7	13.3	4.5	47.4	0	157	16.1	14.77
40	45.7	13.7	4.5	48.9	0	162	15	13.33
45	44.5	14.1	4.4	50.3	0	166	12.7	11.02
50	42.8	14.5	4.4	51.6	0	171	10.1	8.51
60	40.6	15	4.4	53.4	2.2	176	4.4	3.60
70	39.7	15.2	4.4	54.2	3.2	178	1.9	1.54
80	39.3	15.3	4.4	54.5	3.6	179	0.9	0.72
90	39.1	15.3	4.4	54.7	3.8	180	0.3	0.24
100	39.1	15.4	4.4	54.7	3.9	180	0.3	0.24
110	39	15.4	4.4	54.8	3.9	180	0.1	0.08
120	39	15.4	4.4	54.8	3.9	180	0.1	0.08

EXXEVAP.XLS

APPENDIX B

TRANSIENT CALIBRATION RESULTS

RESERVOIR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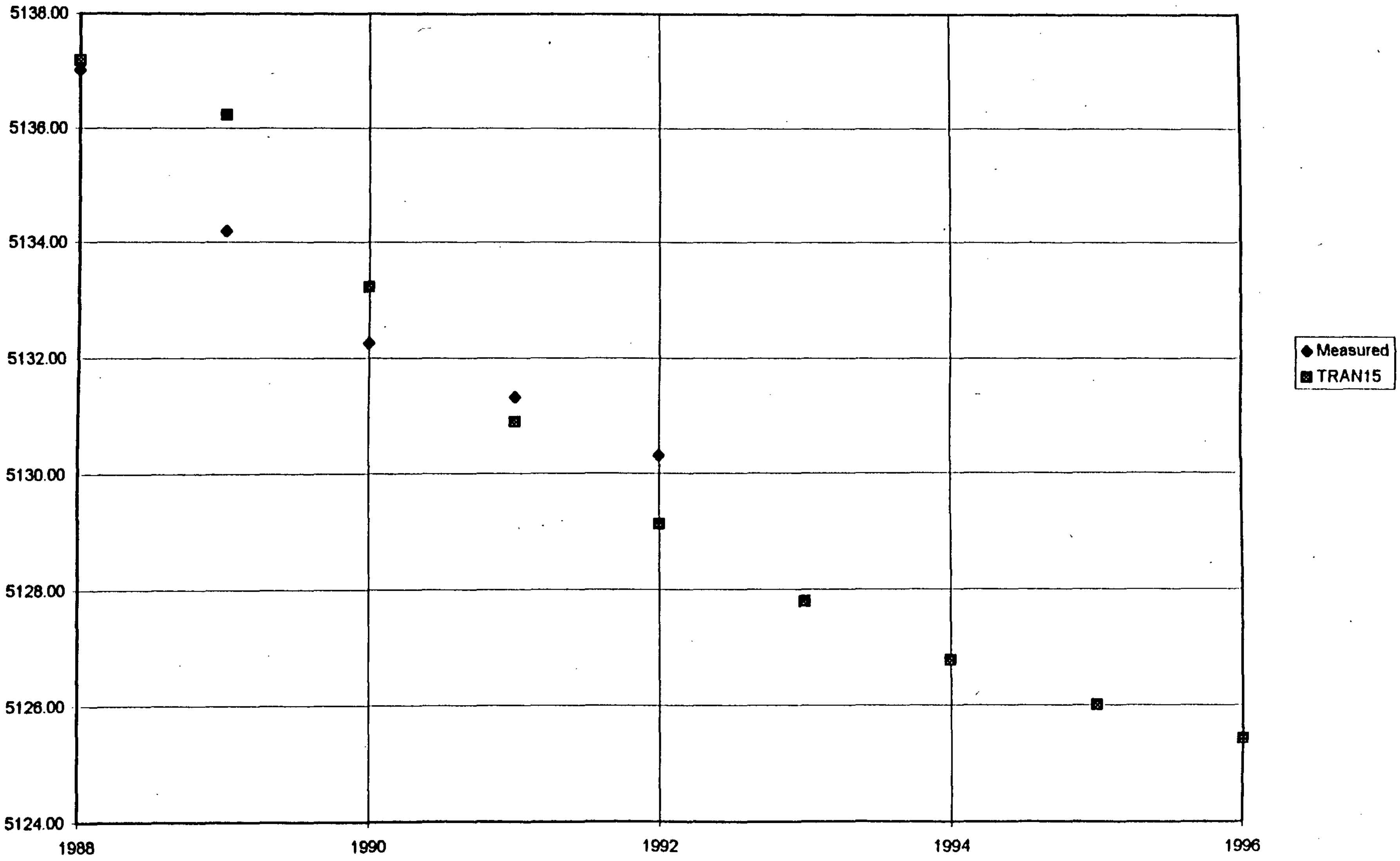
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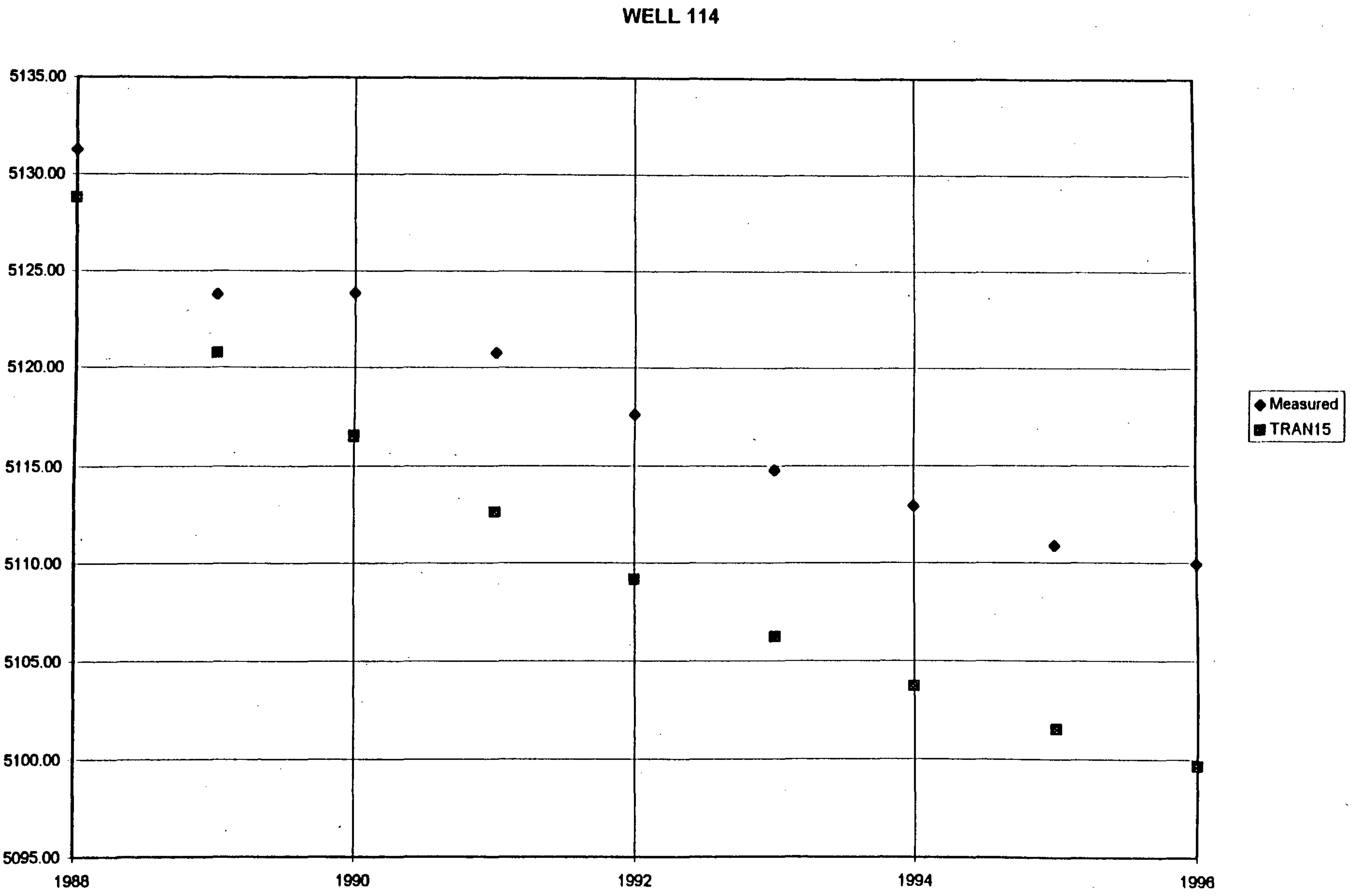
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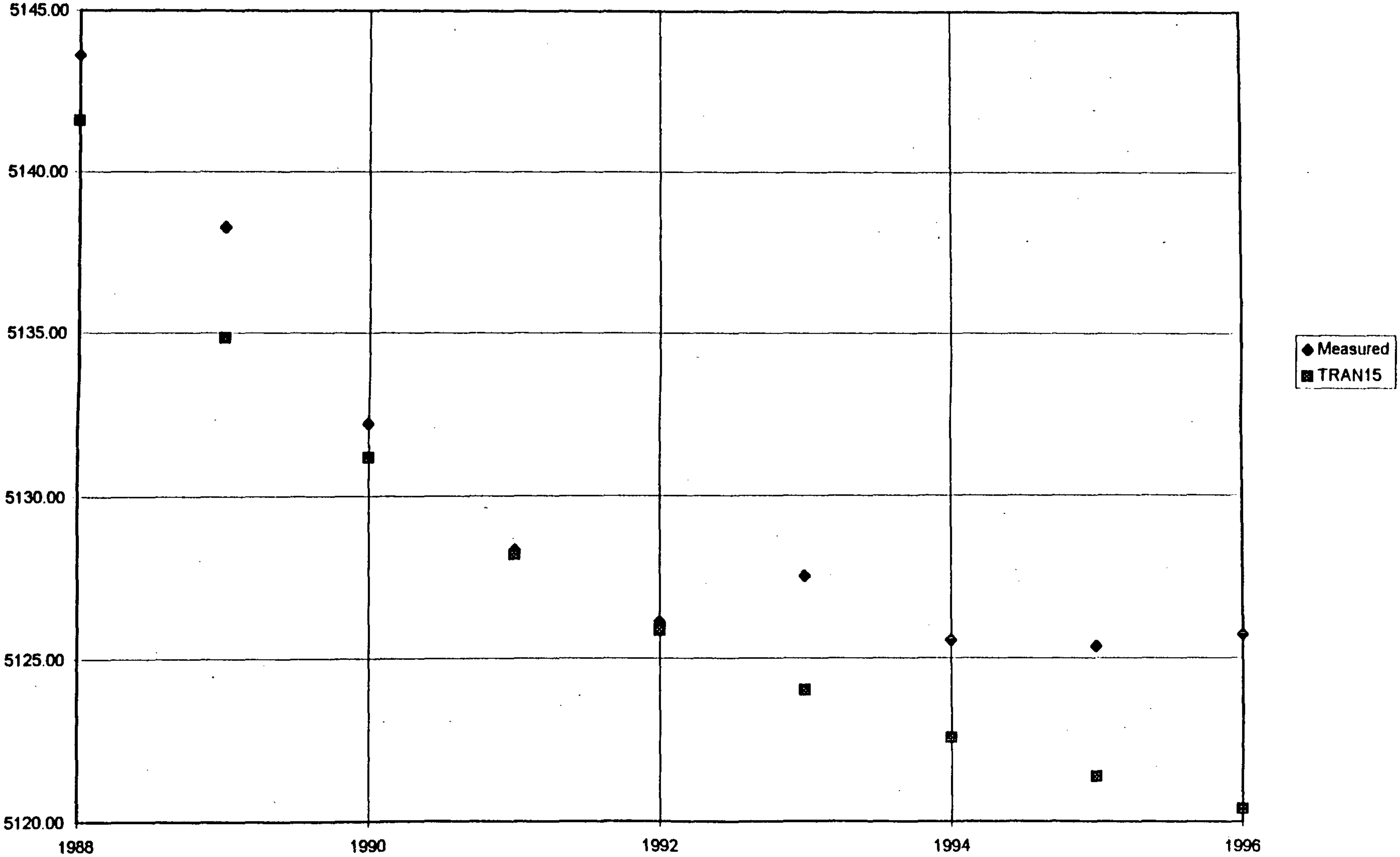

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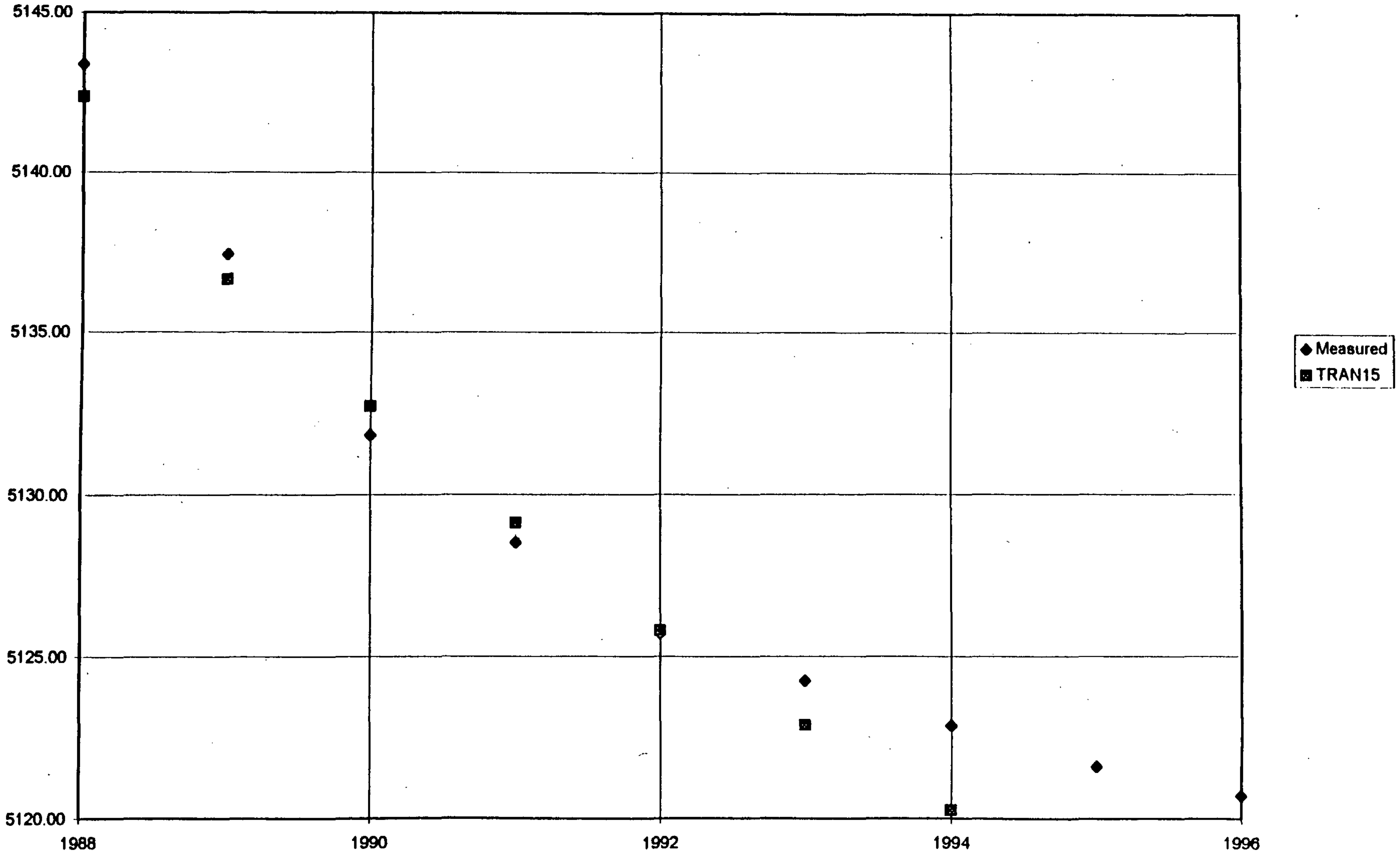
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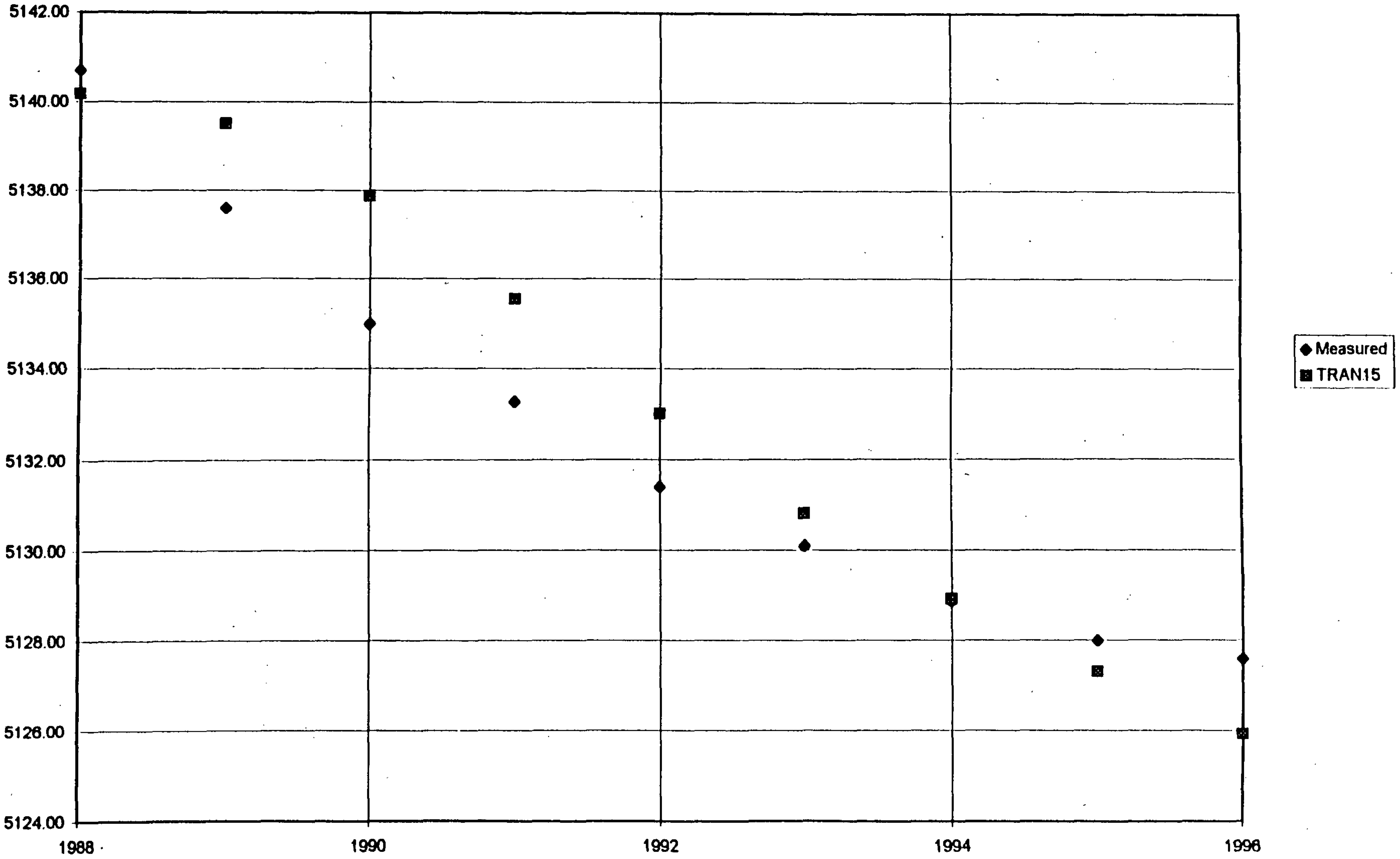

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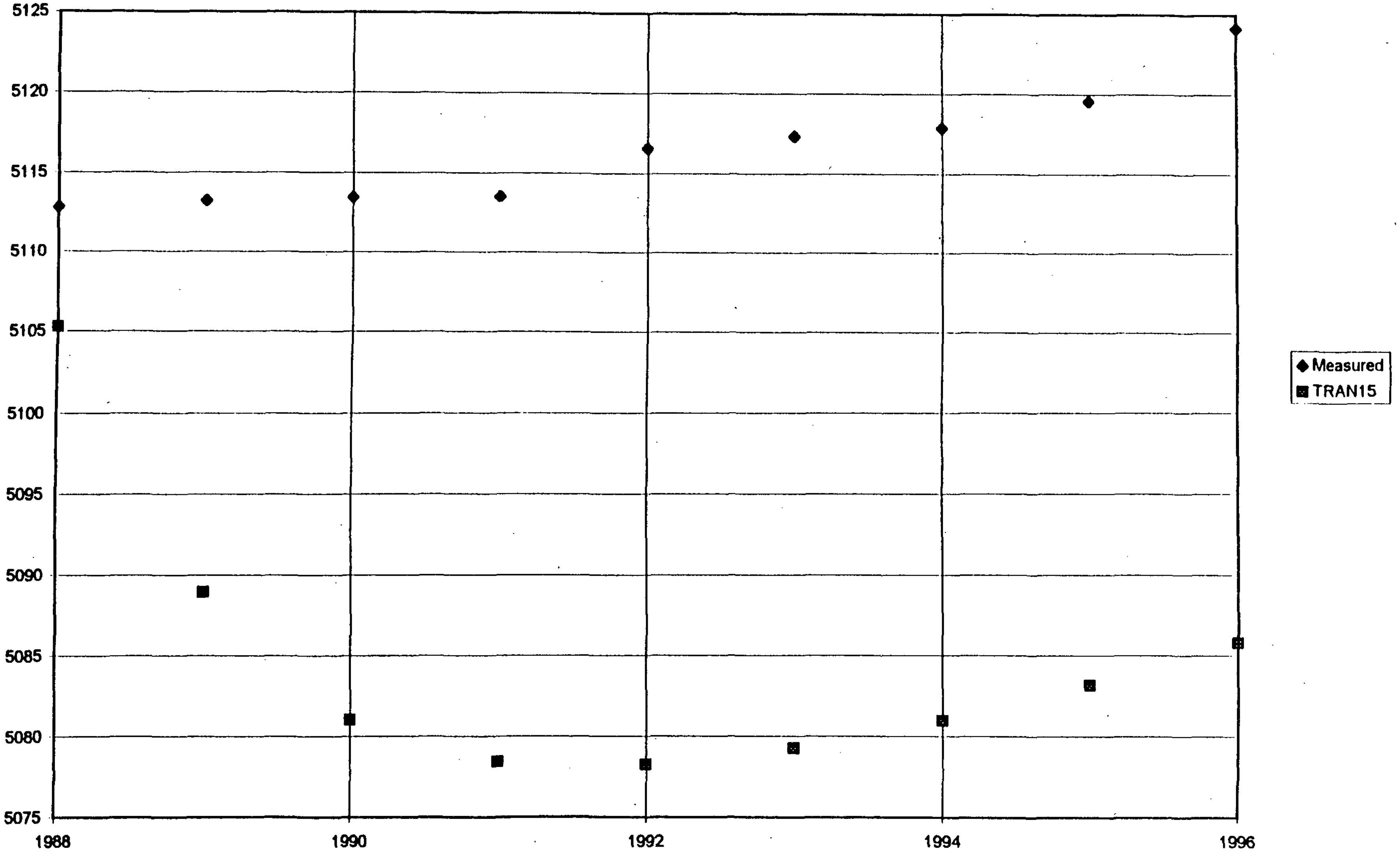
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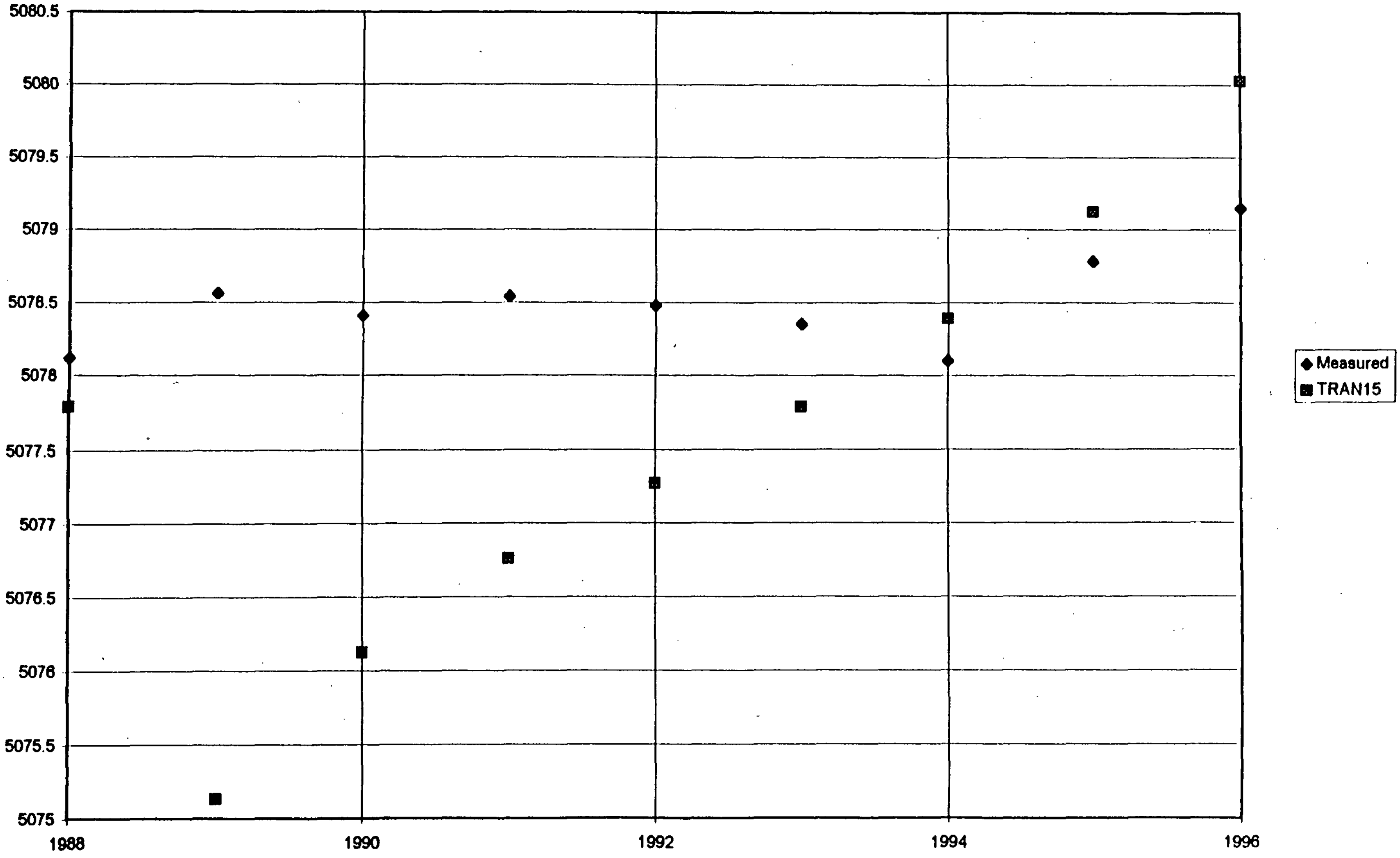
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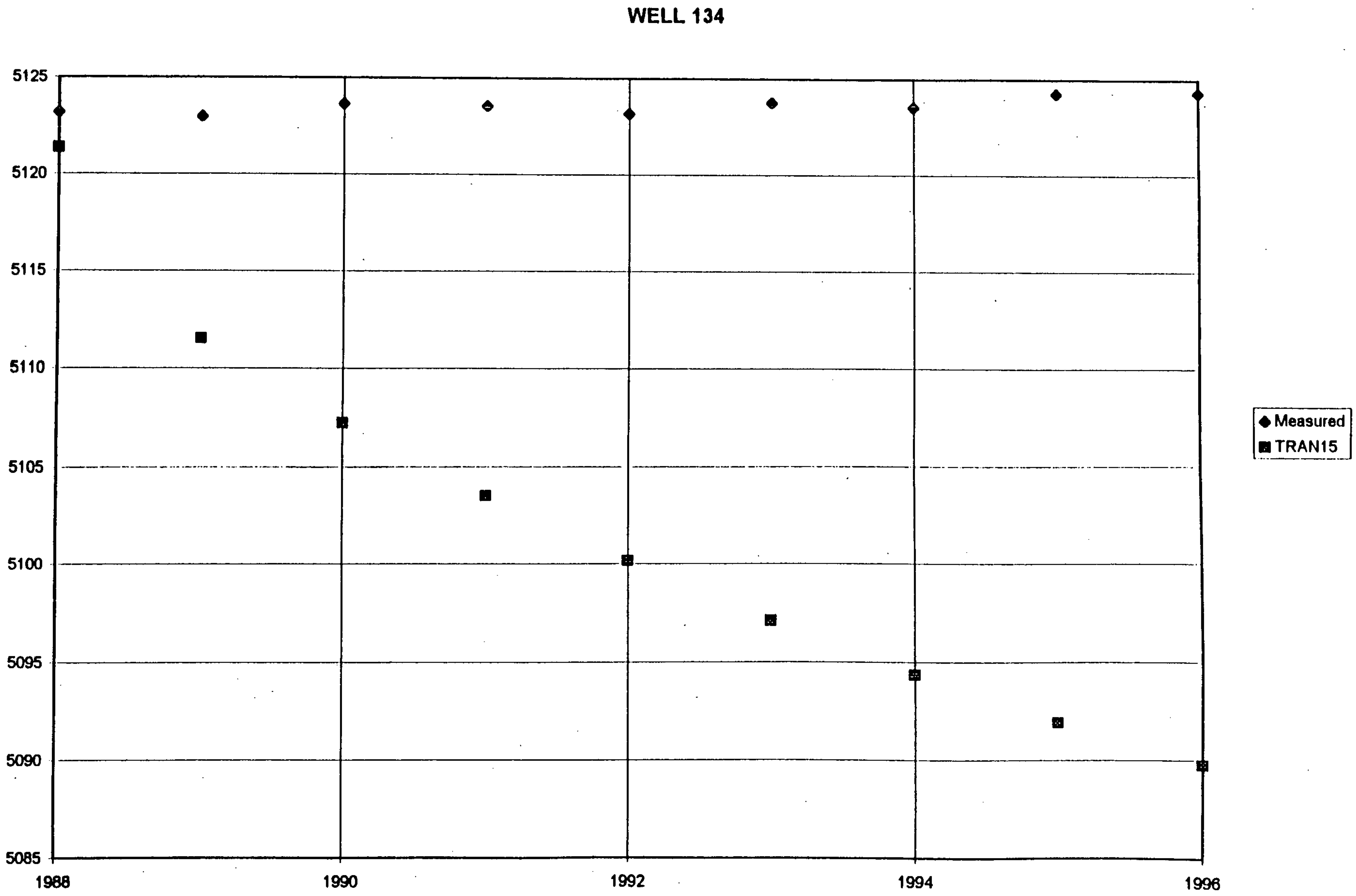
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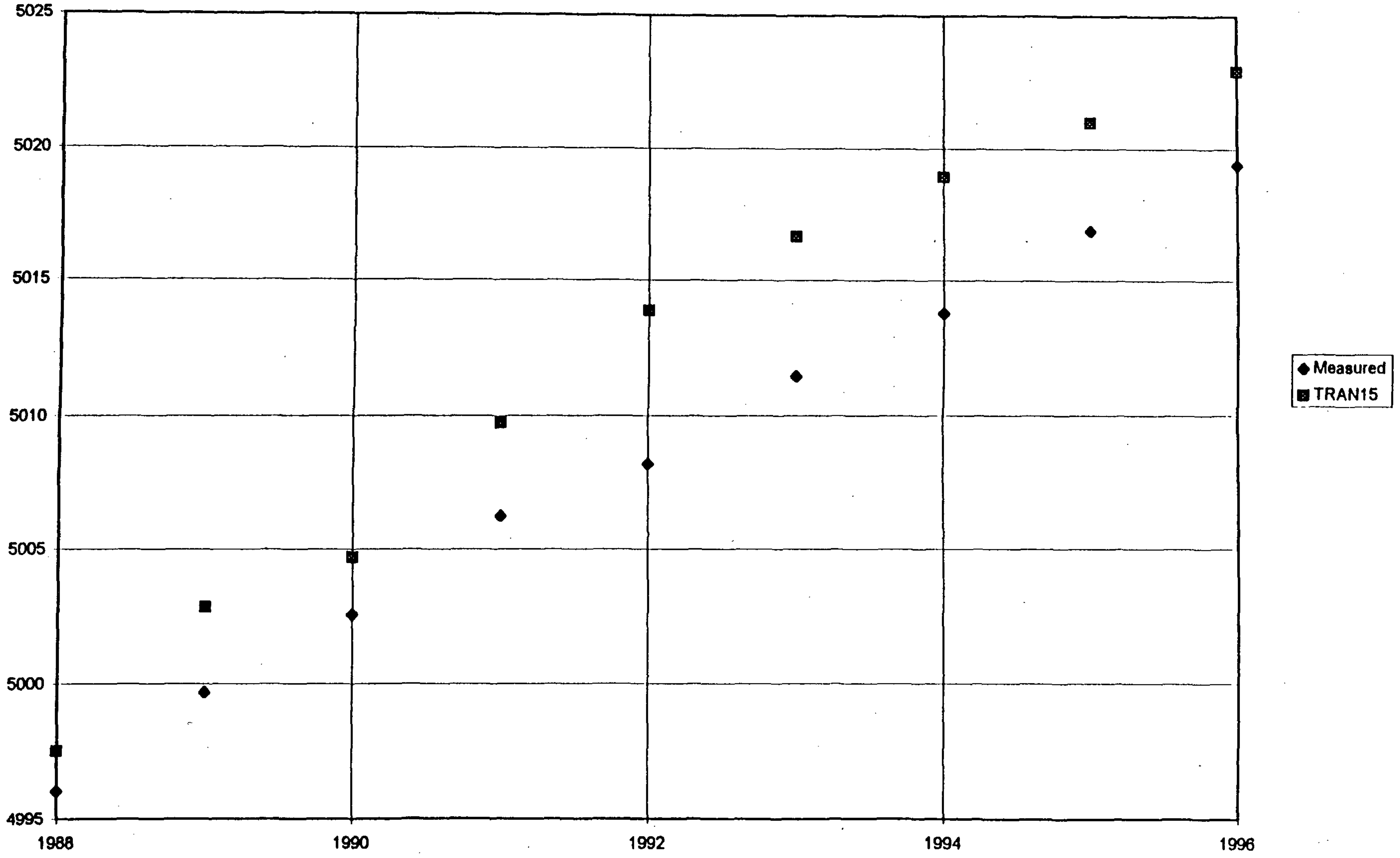
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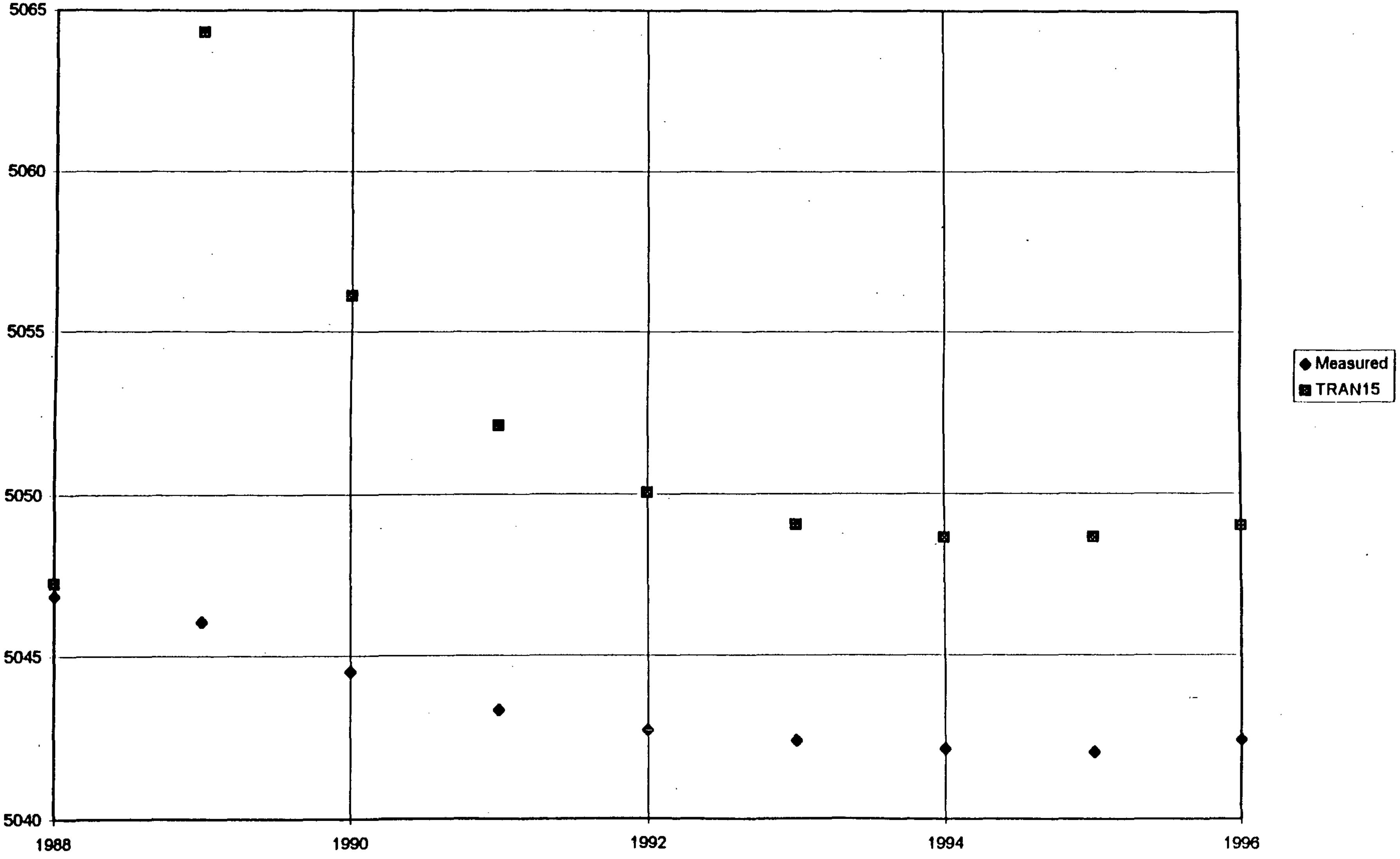

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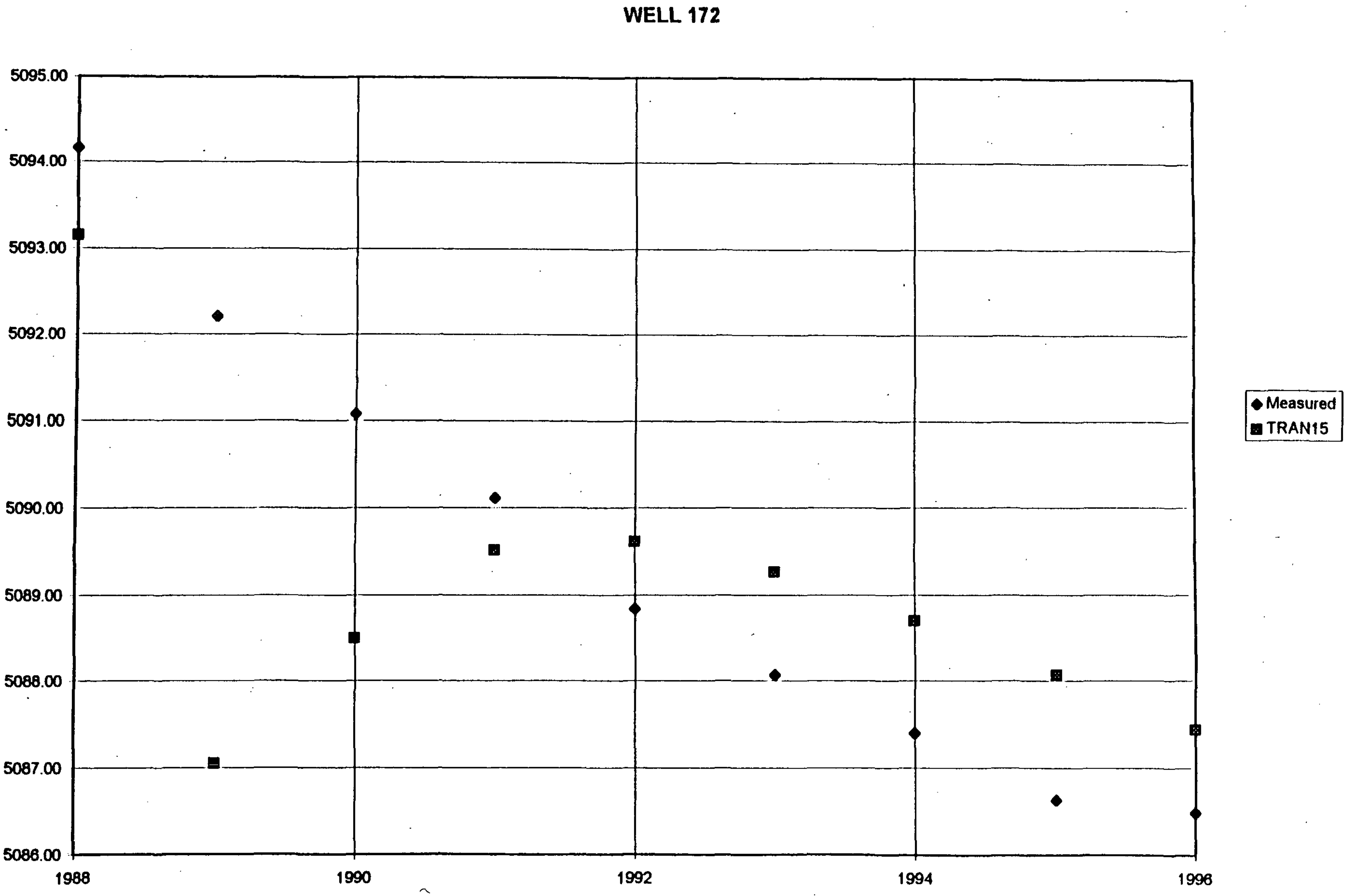
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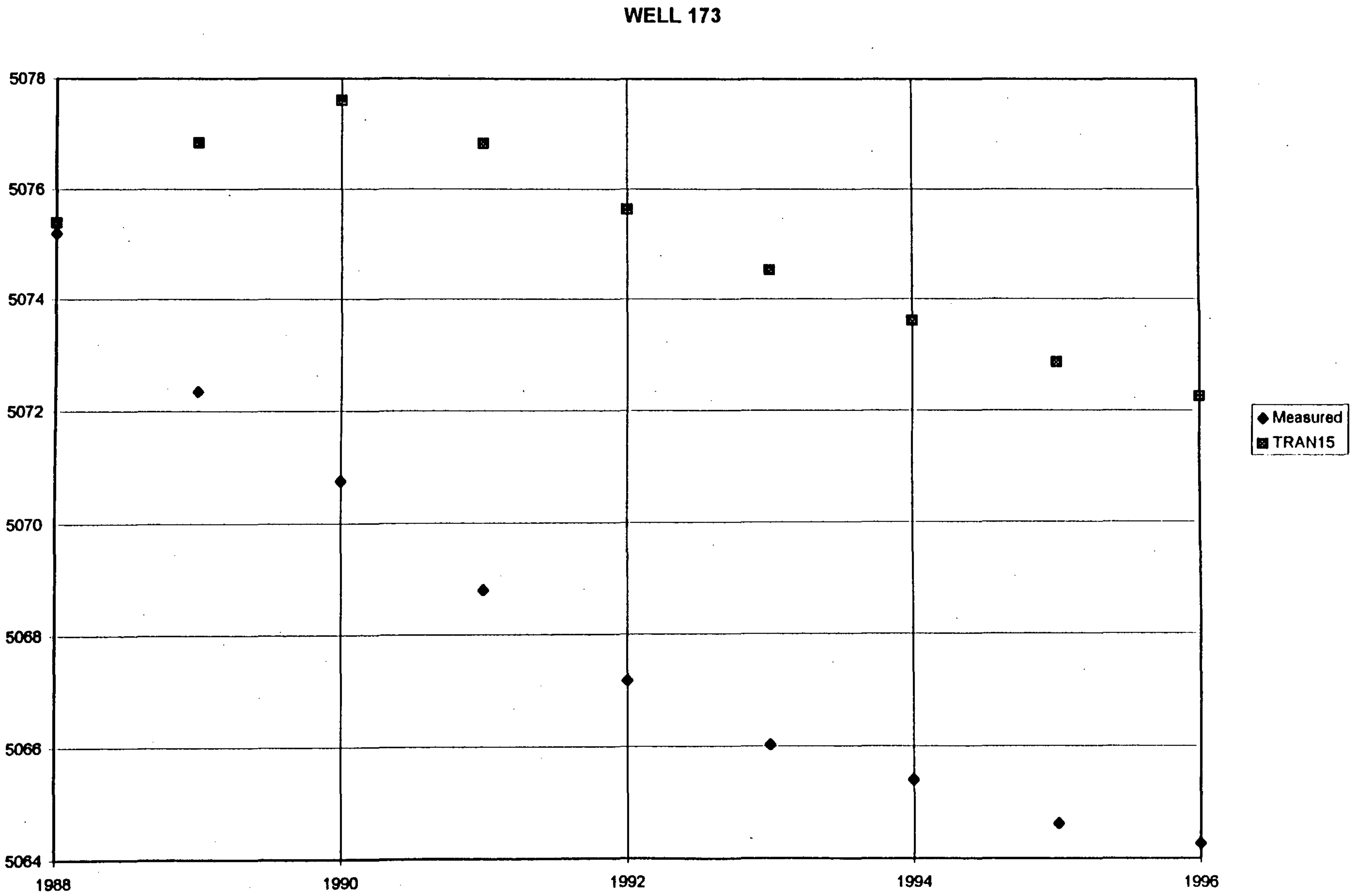WELL 173
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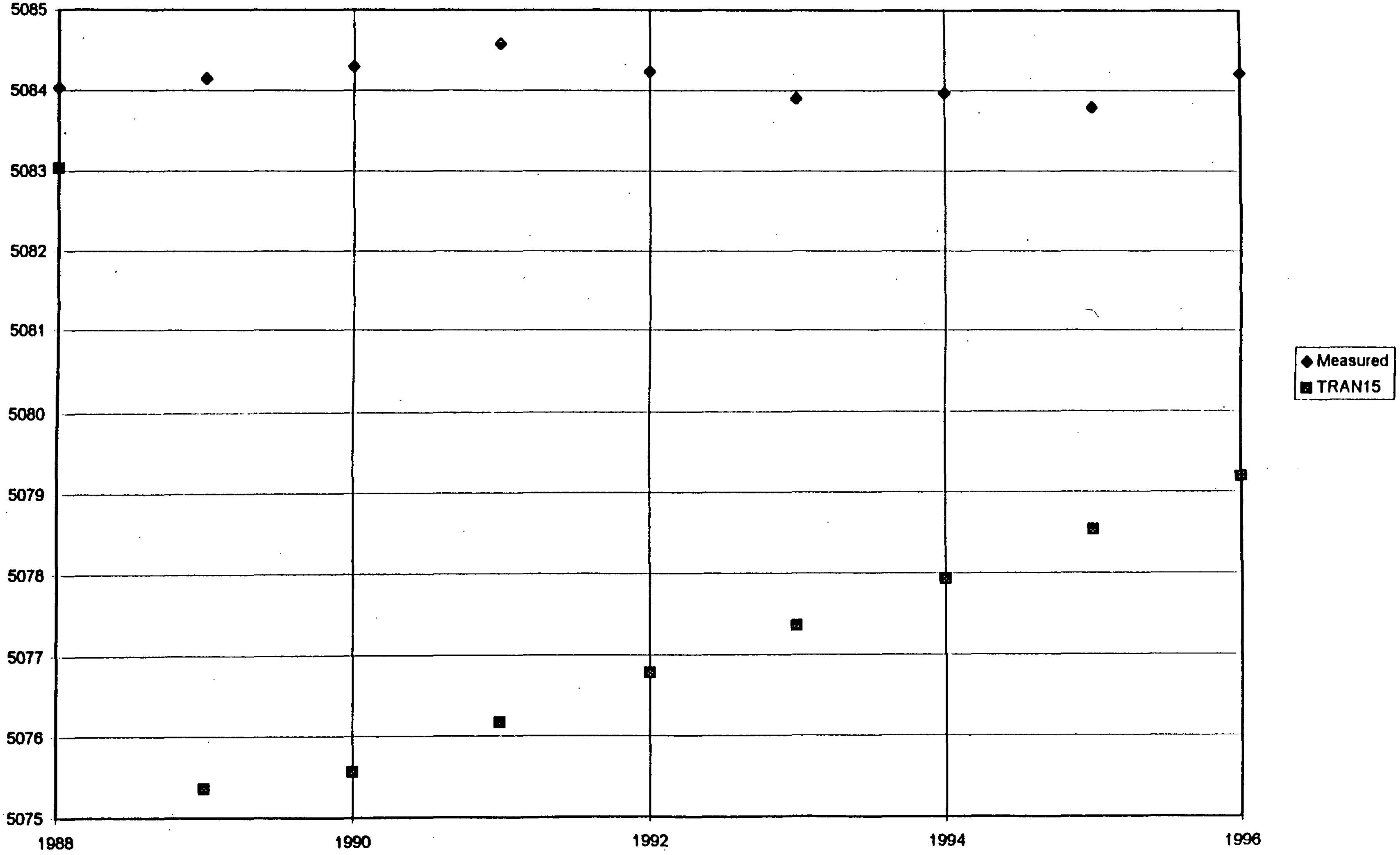

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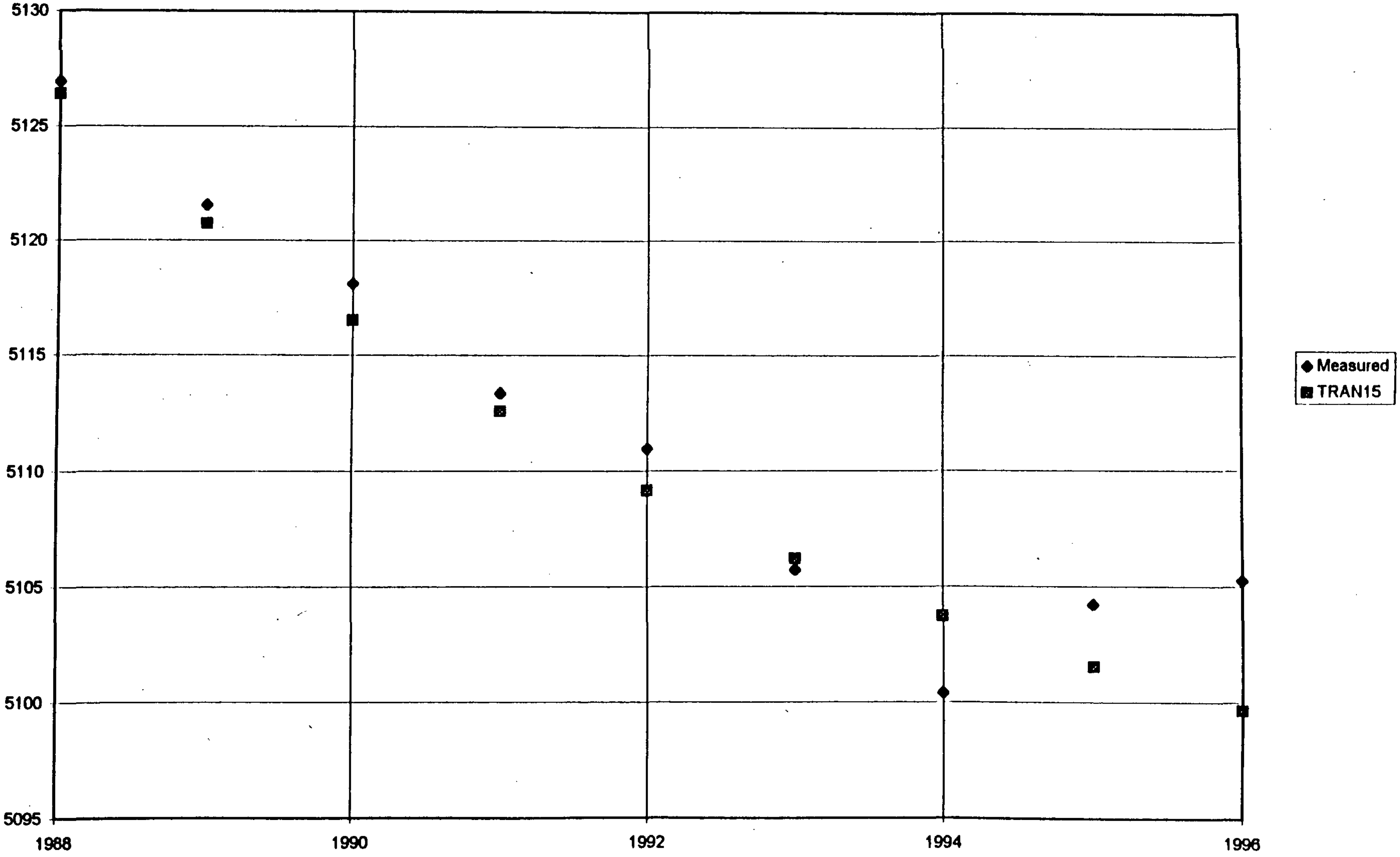

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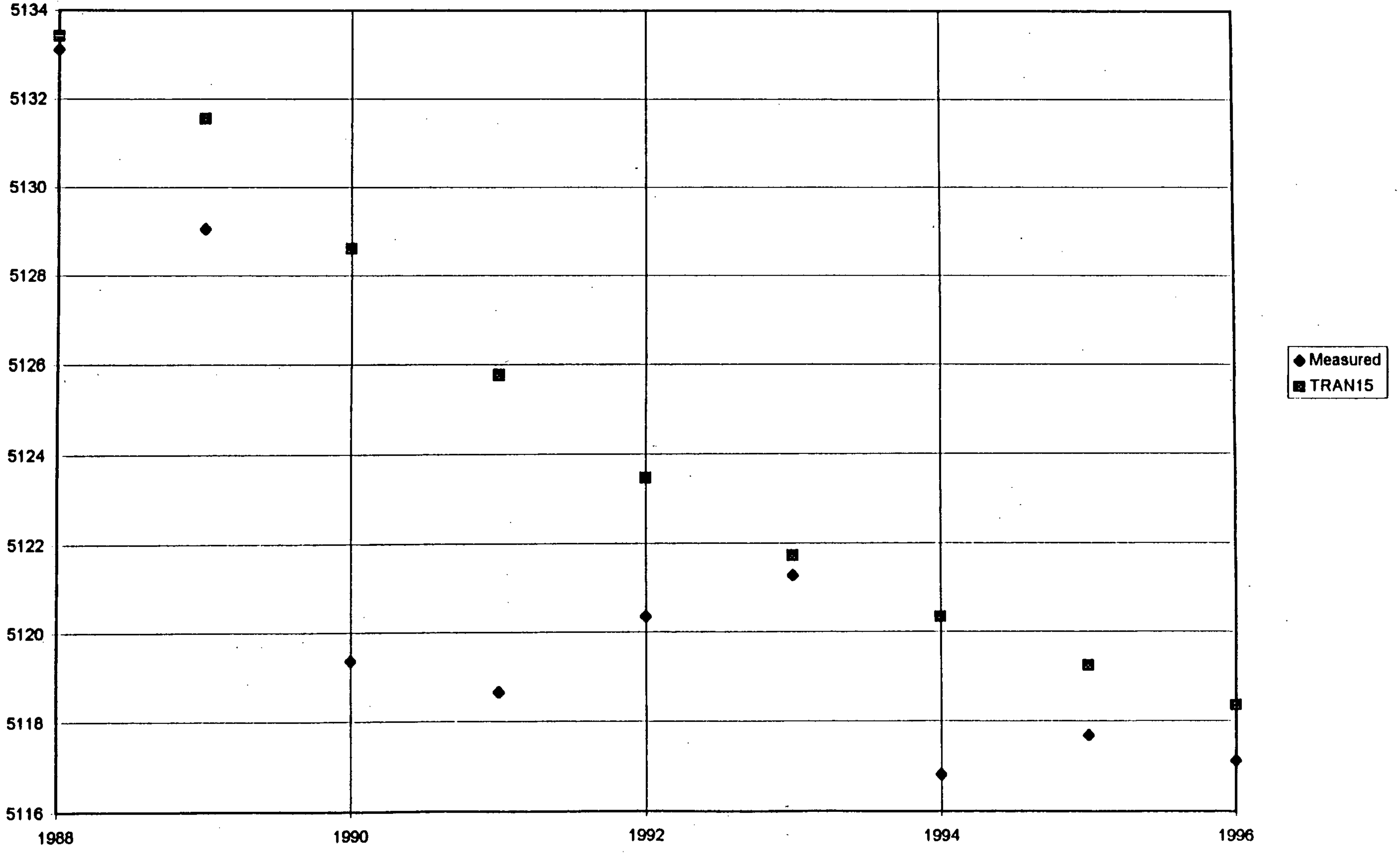
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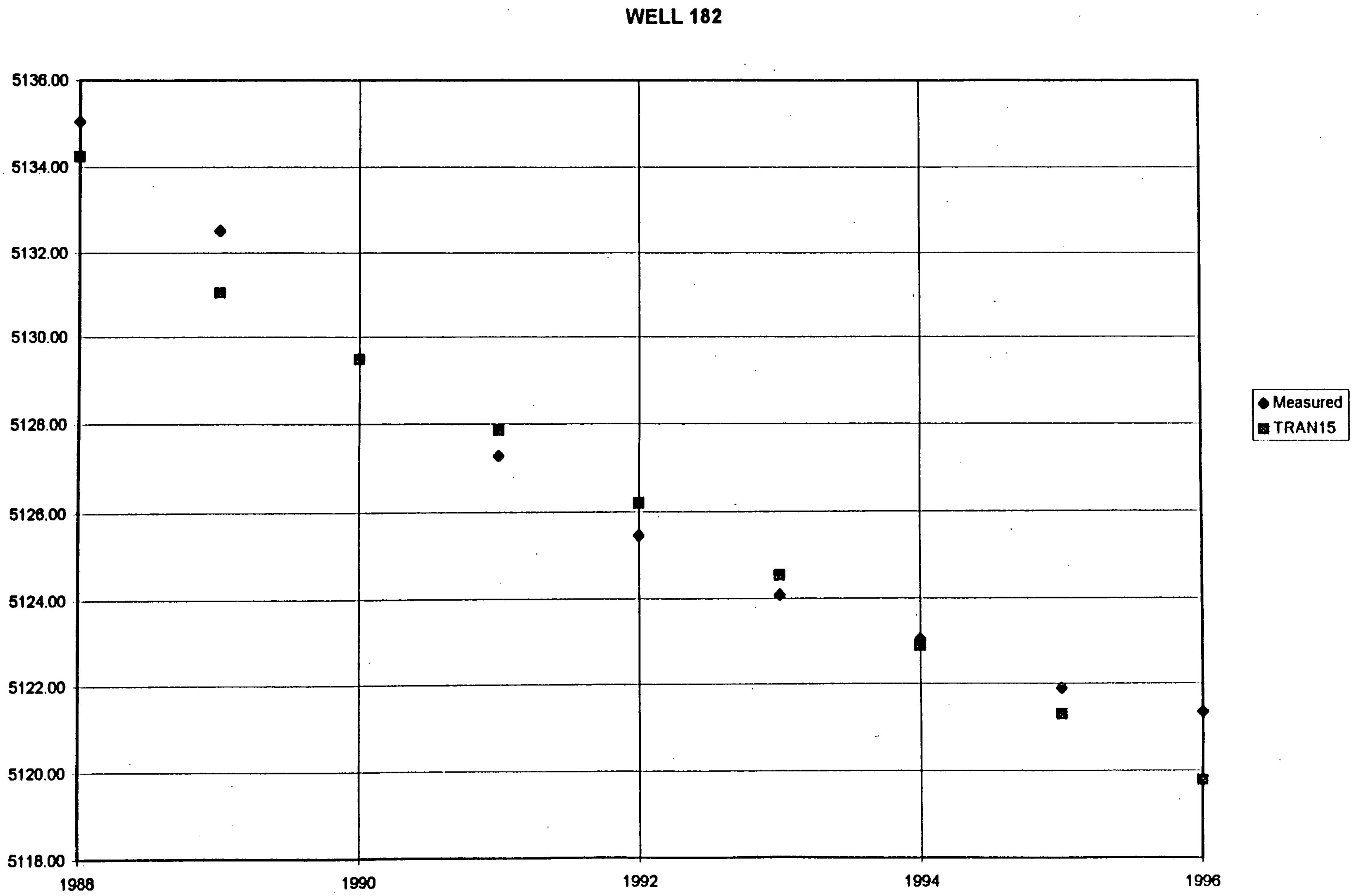
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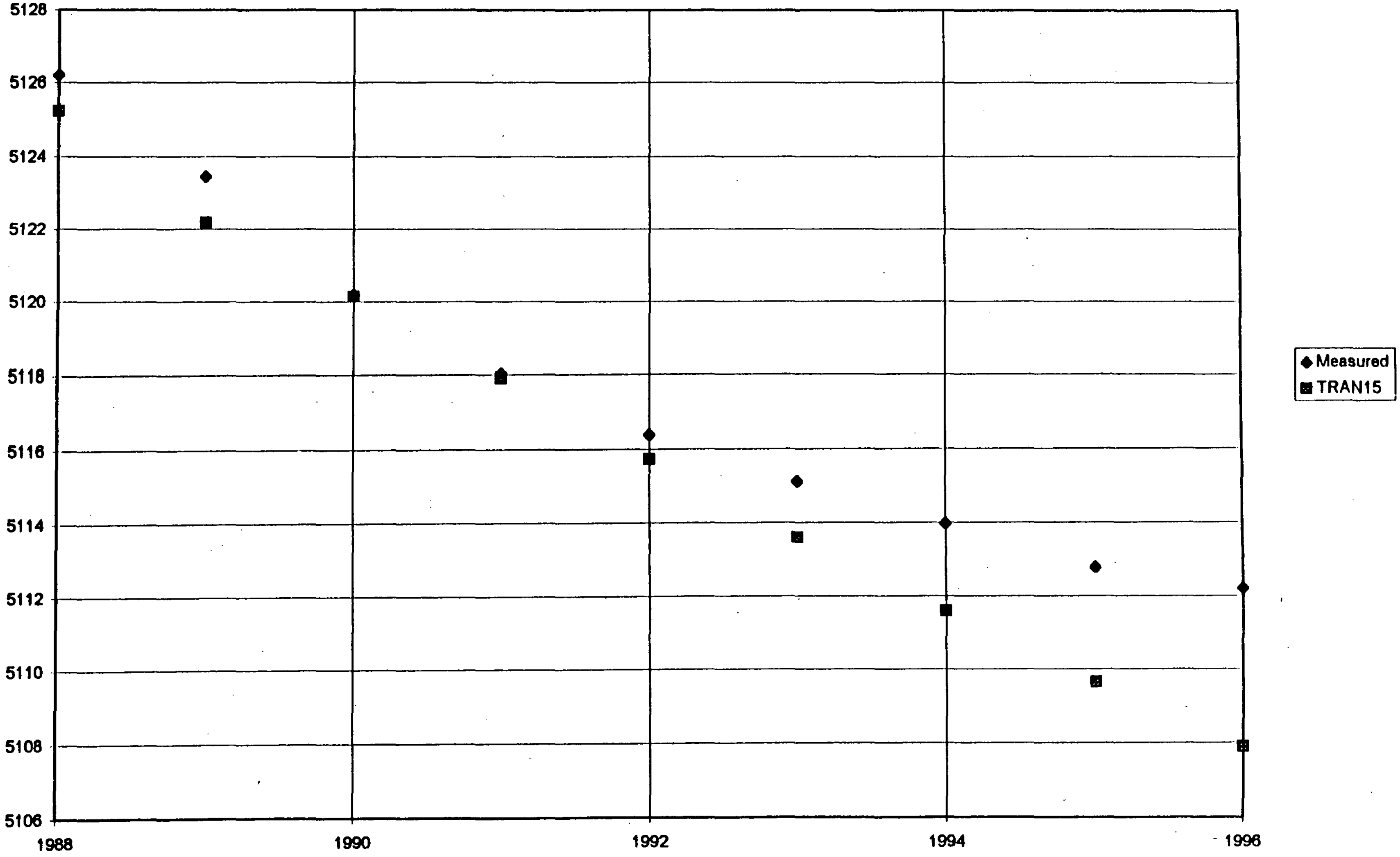
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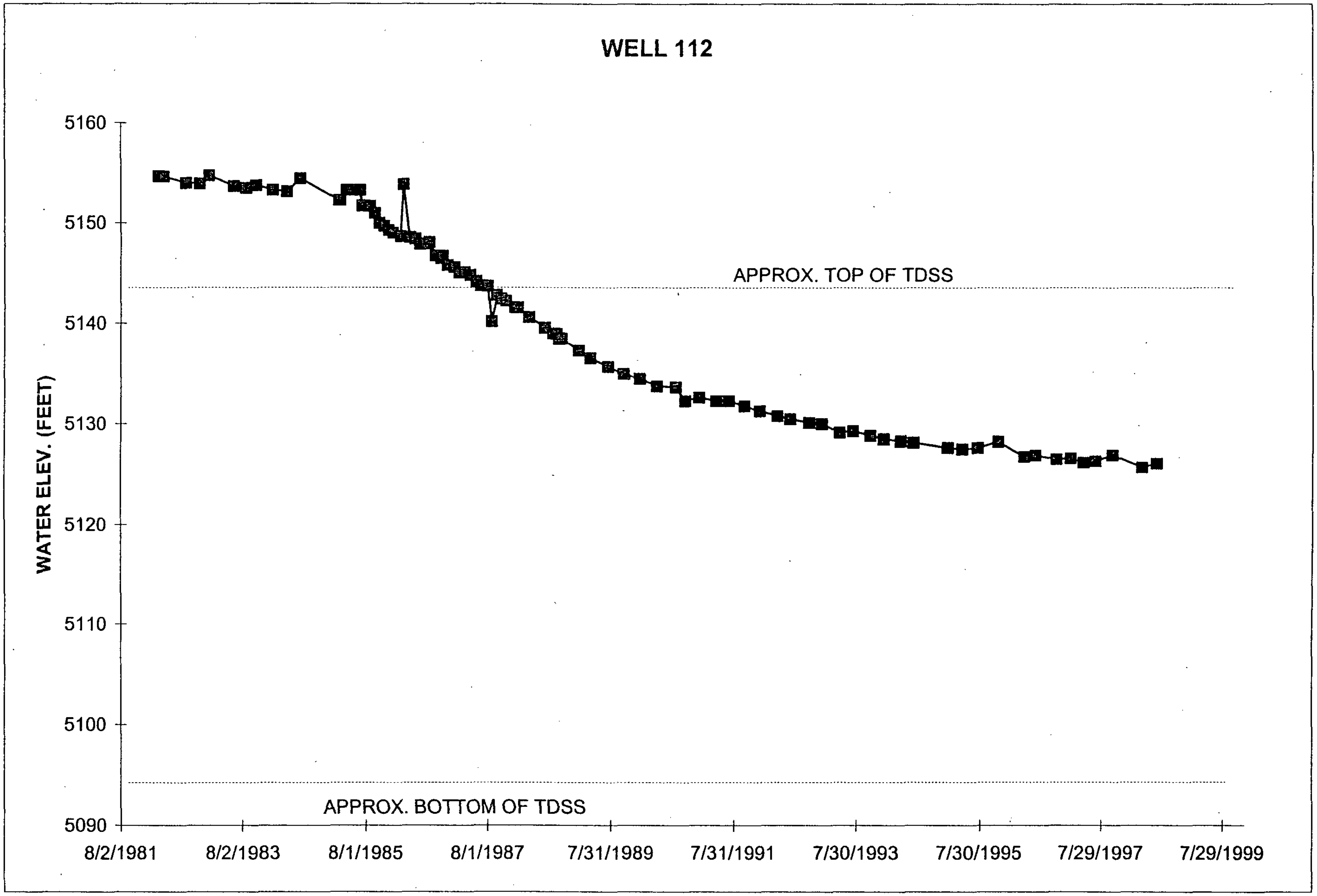

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5150
5140
5130
5120
5110
5100
5090
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APPROX. BOTTOM OF TDSS
8/2/1981
8/2/1983
8/1/1985
8/1/1987
7/31/1989
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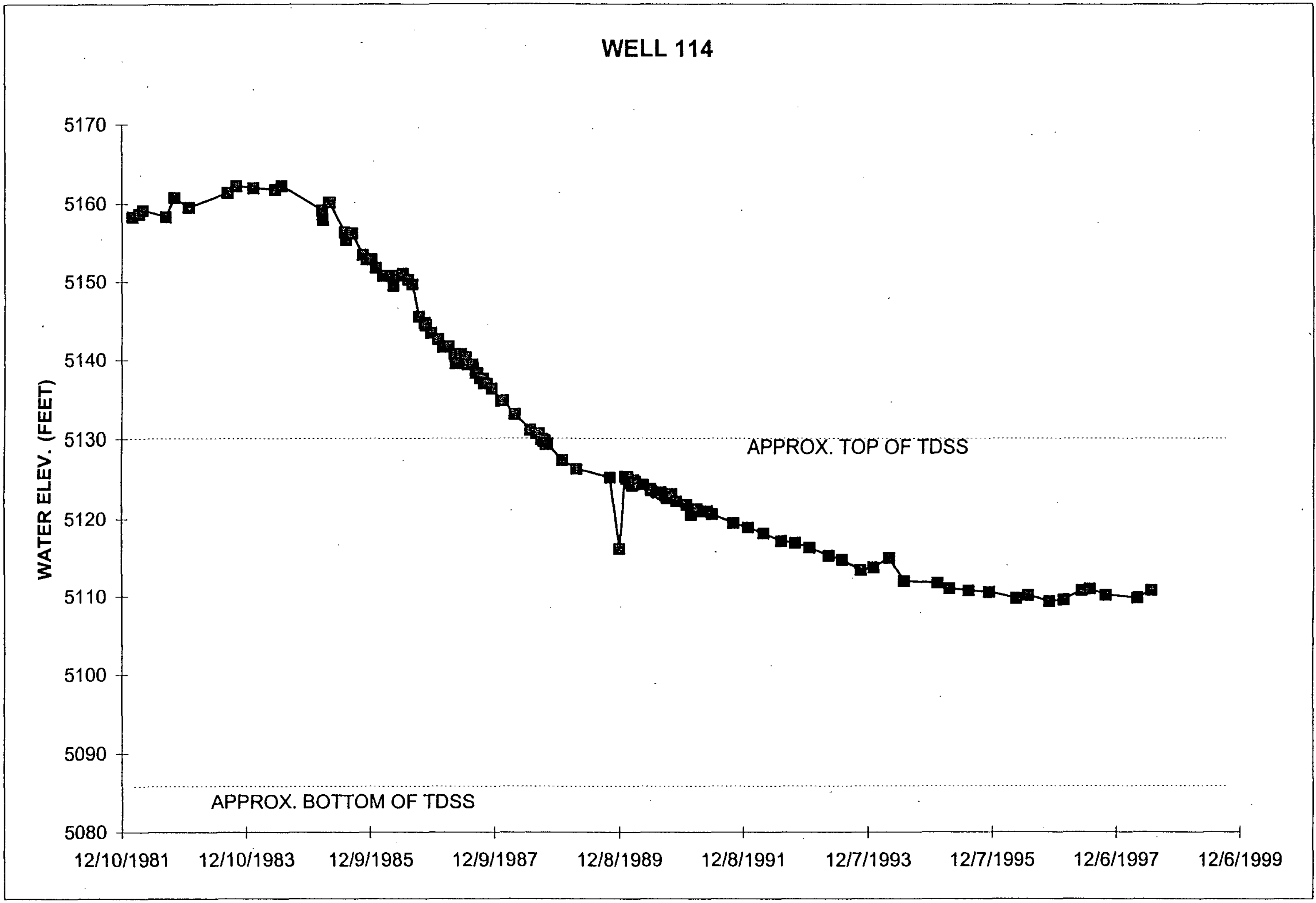
7/29/1999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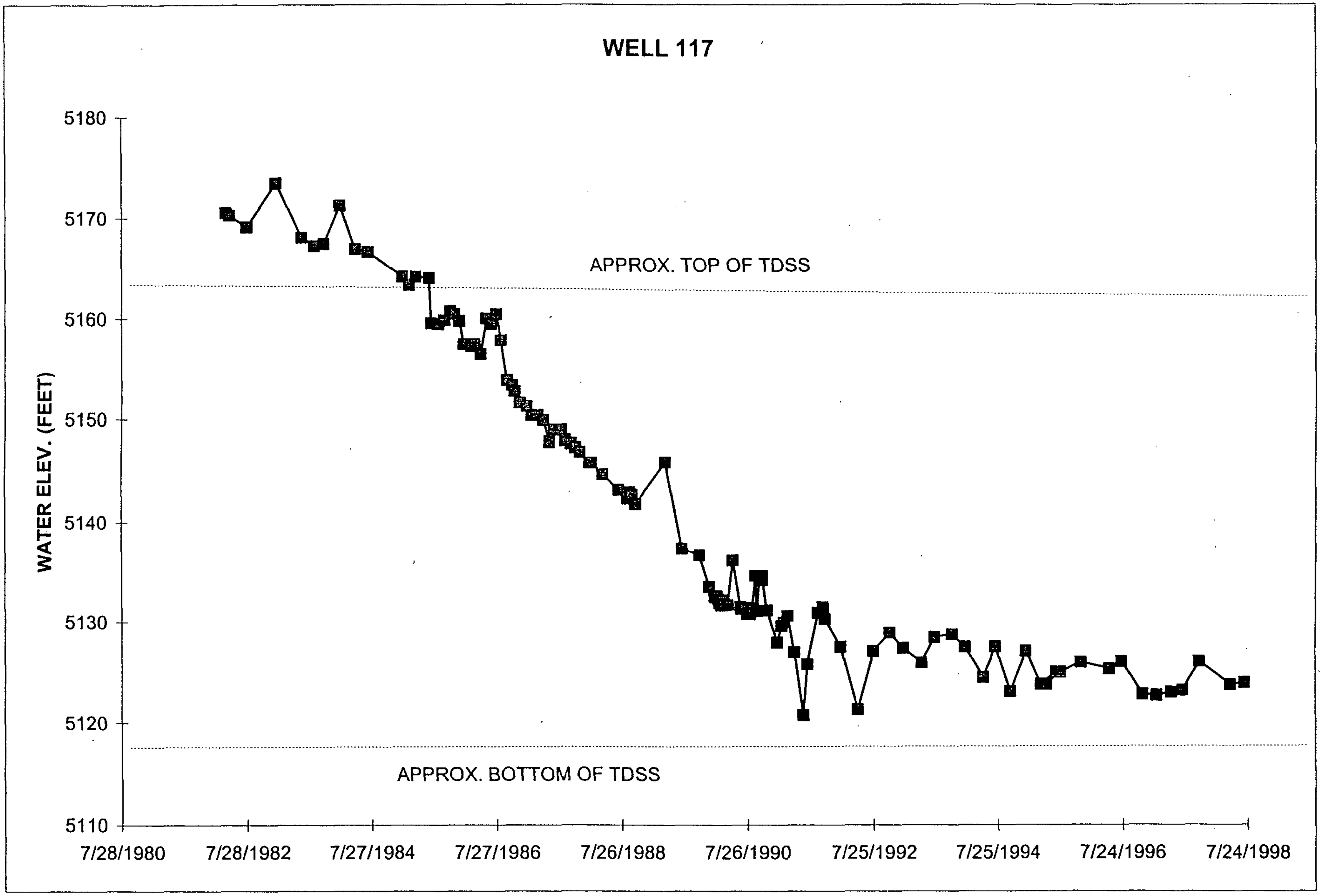WELL 117
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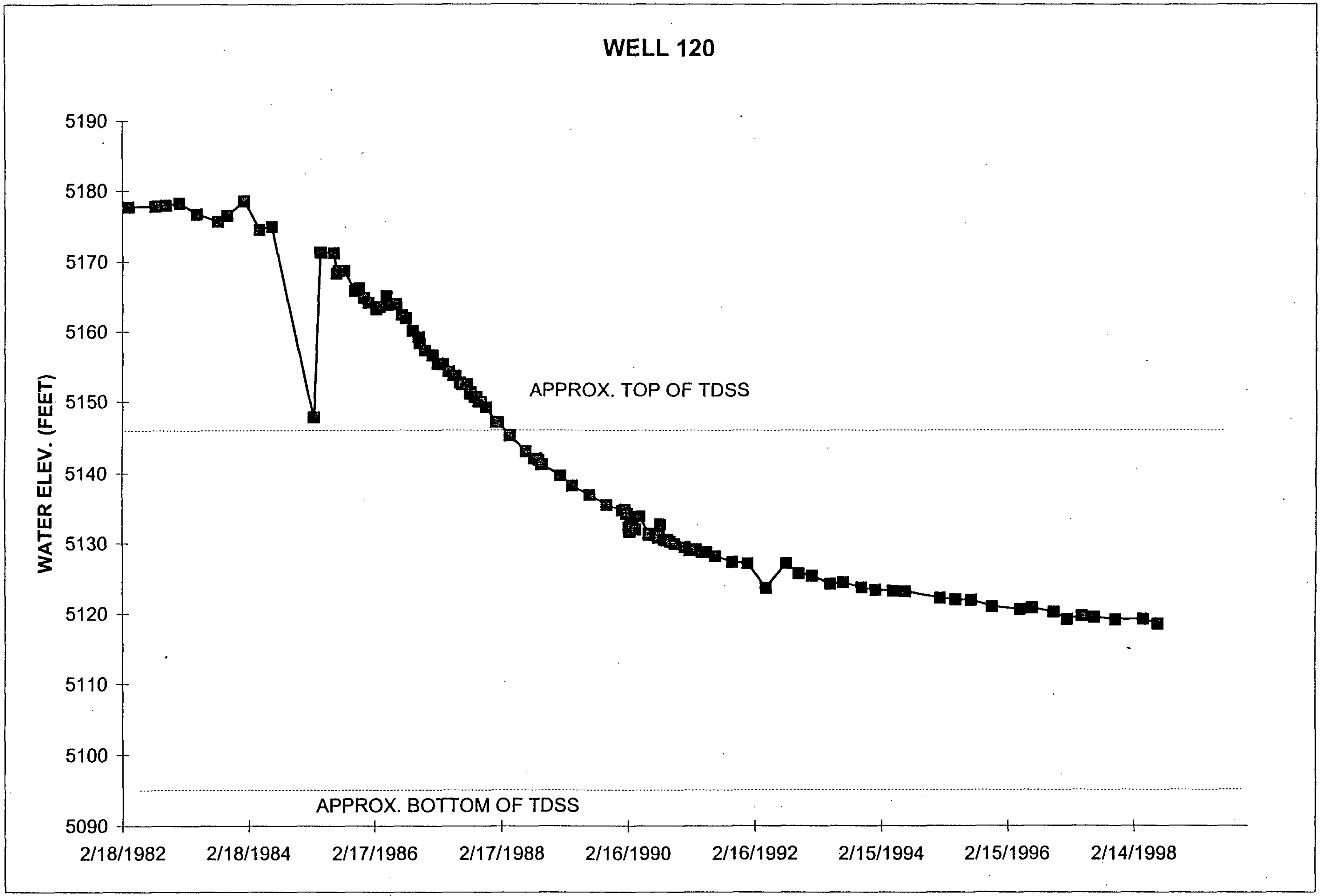

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APPROX. BOTTOM OF TDSS
2/18/1982
2/18/1984
2/17/1986
2/17/1988
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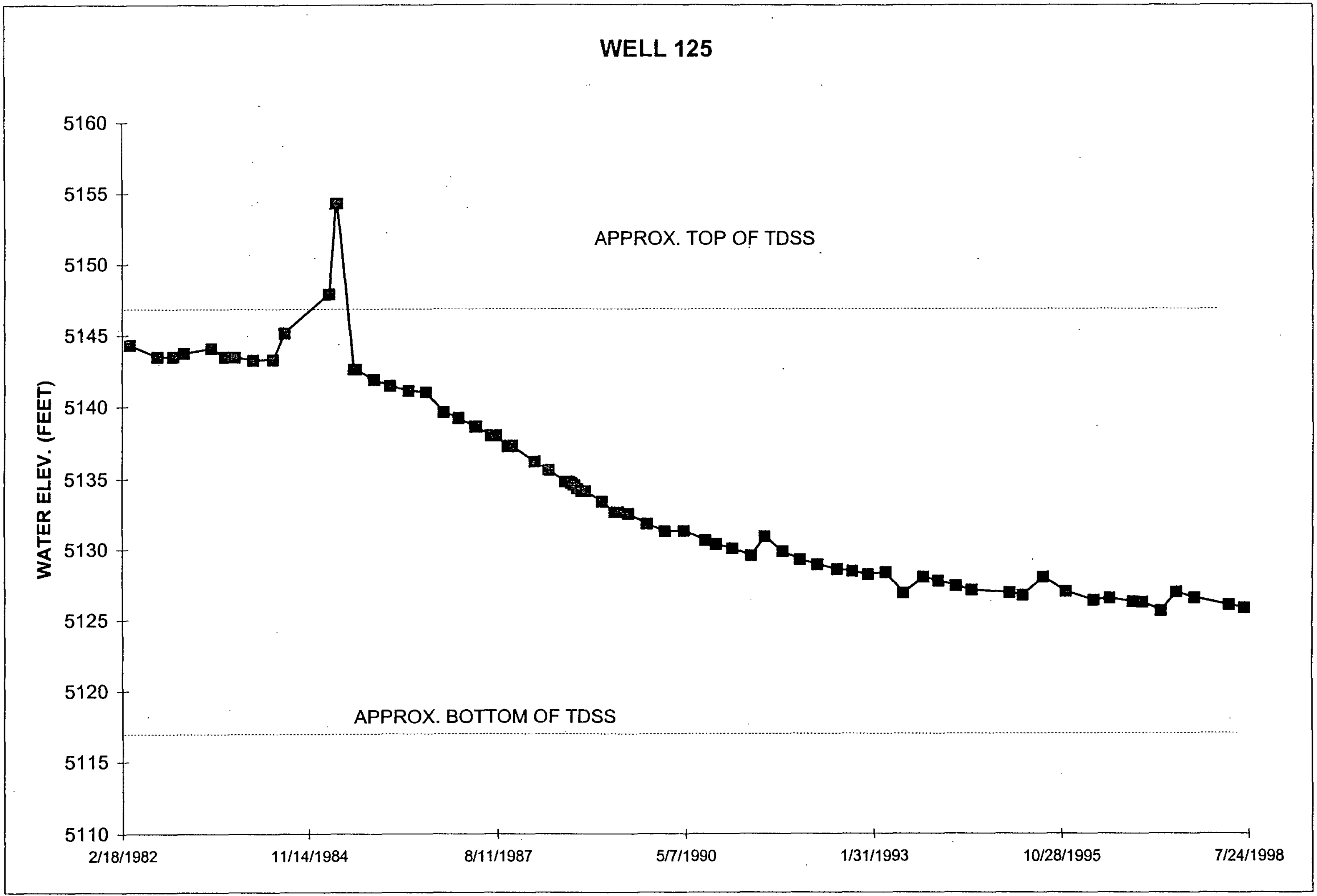
2/16/1992
2/15/1994
2/15/1996
2/14/1998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5130
5125
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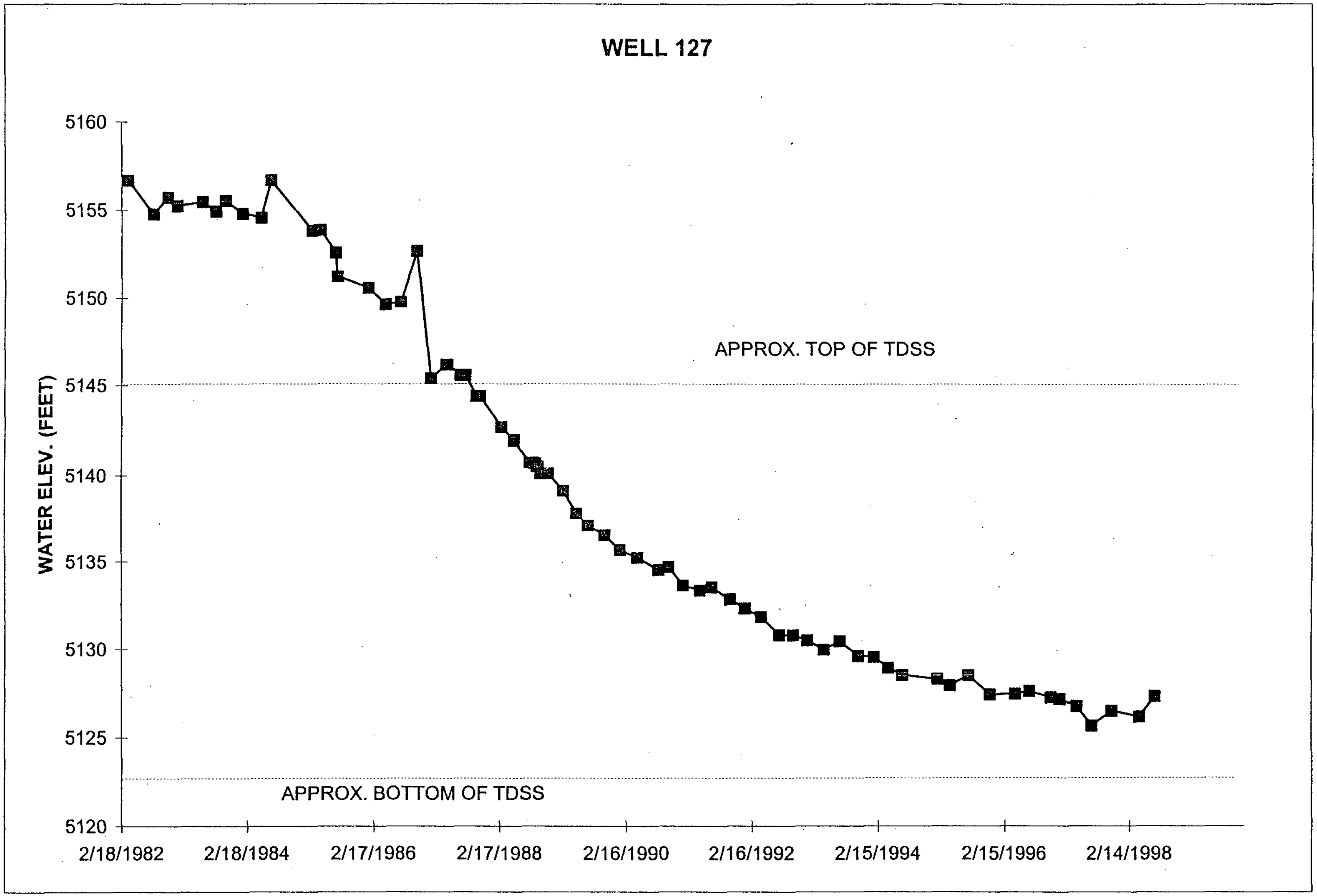
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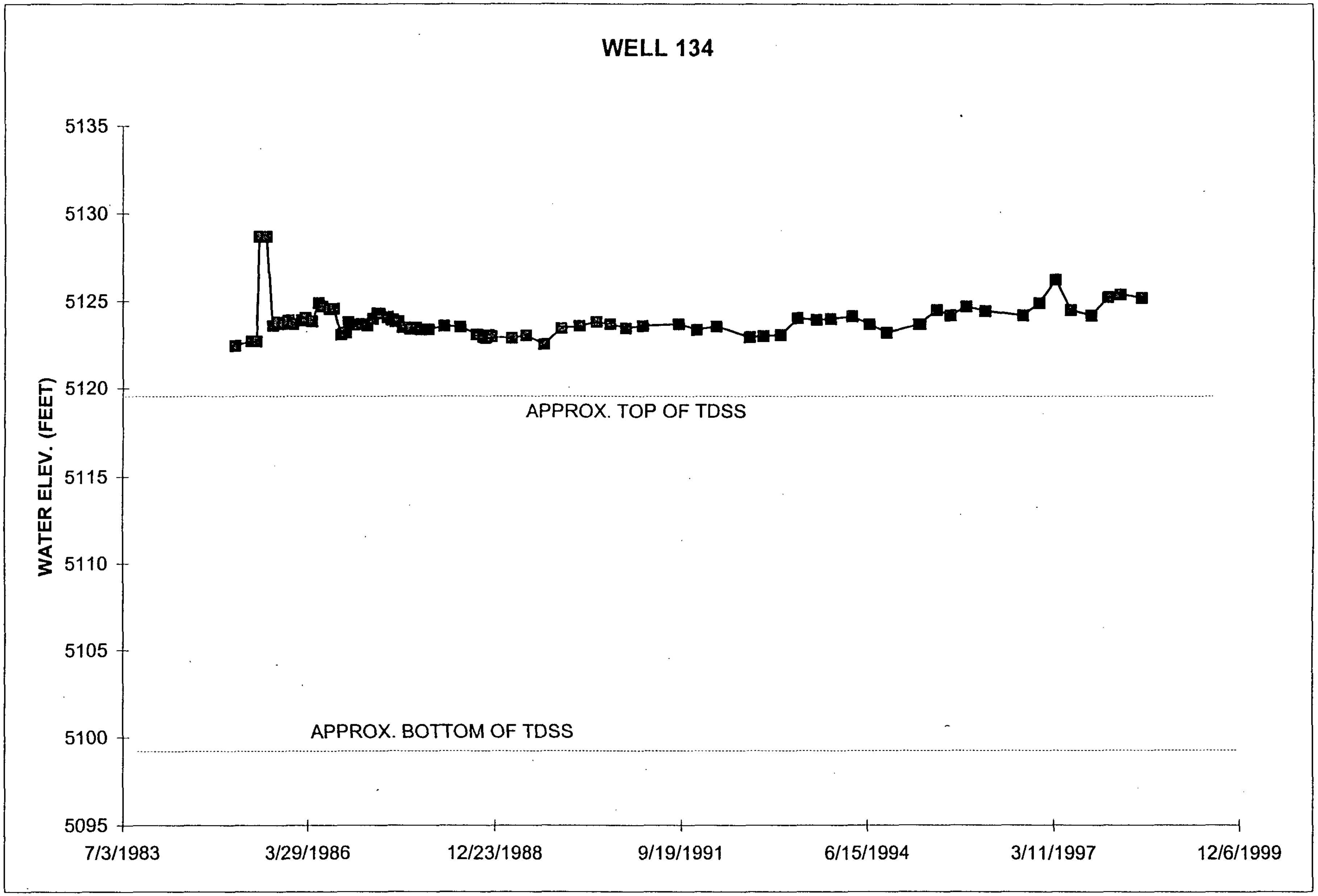
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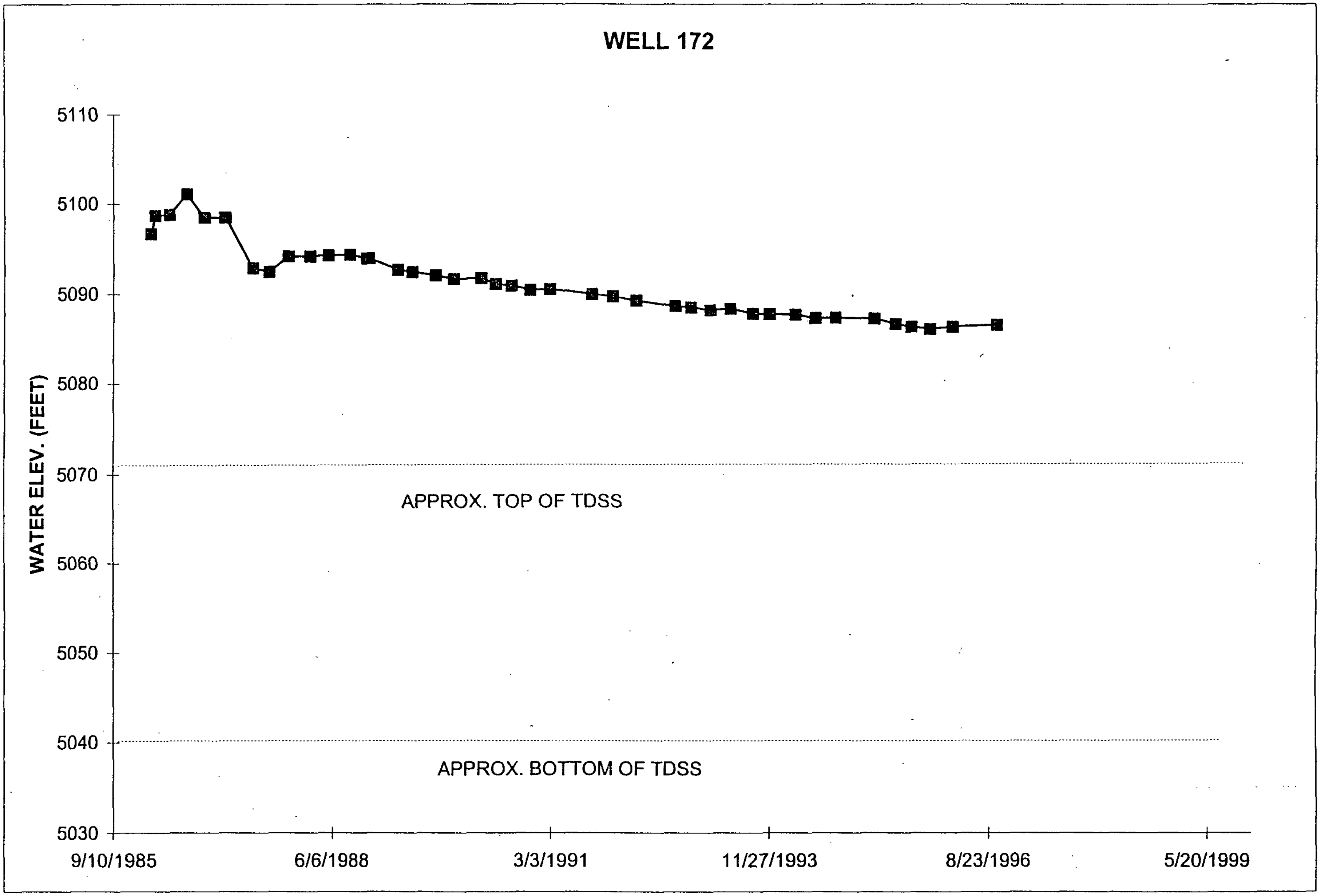
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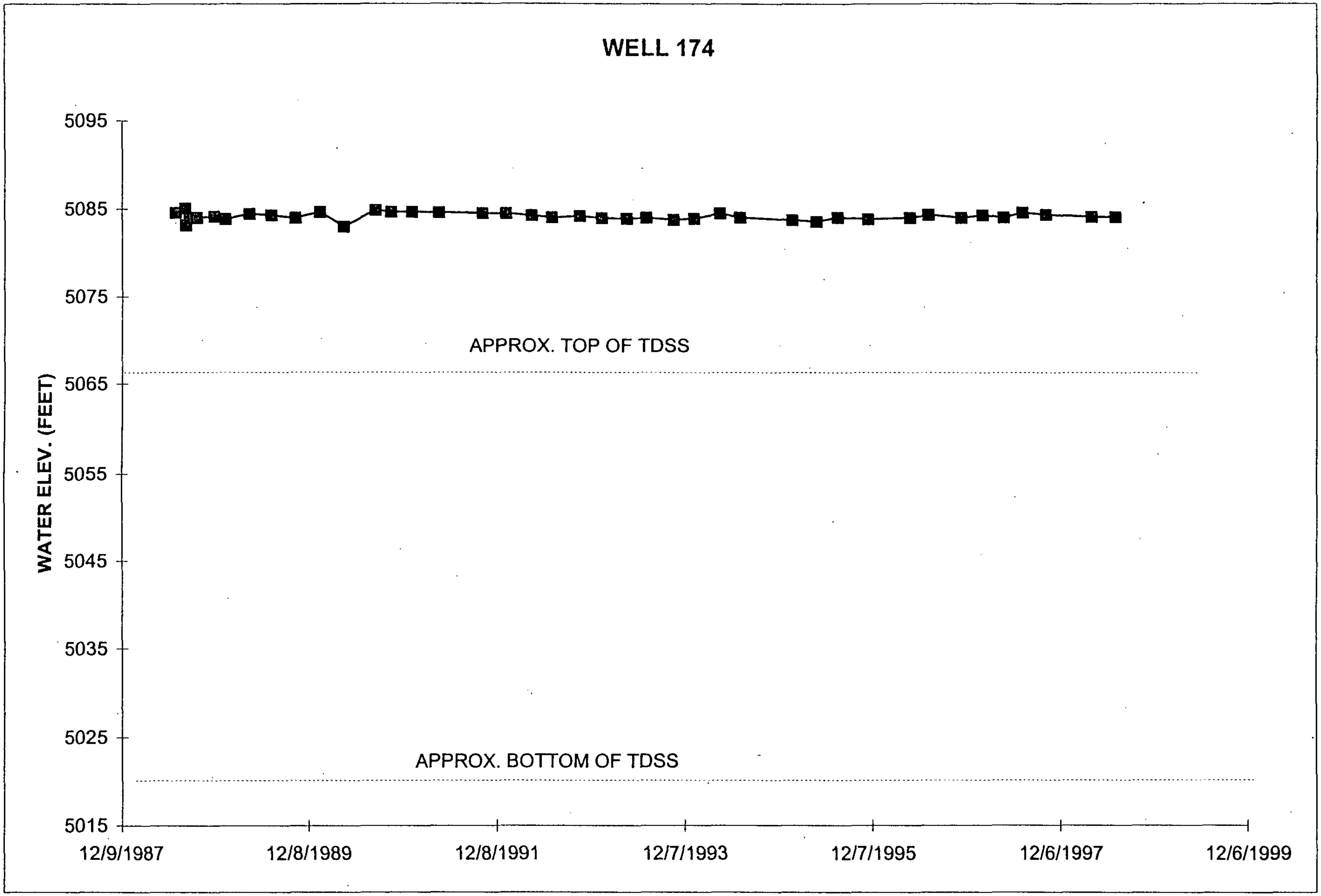
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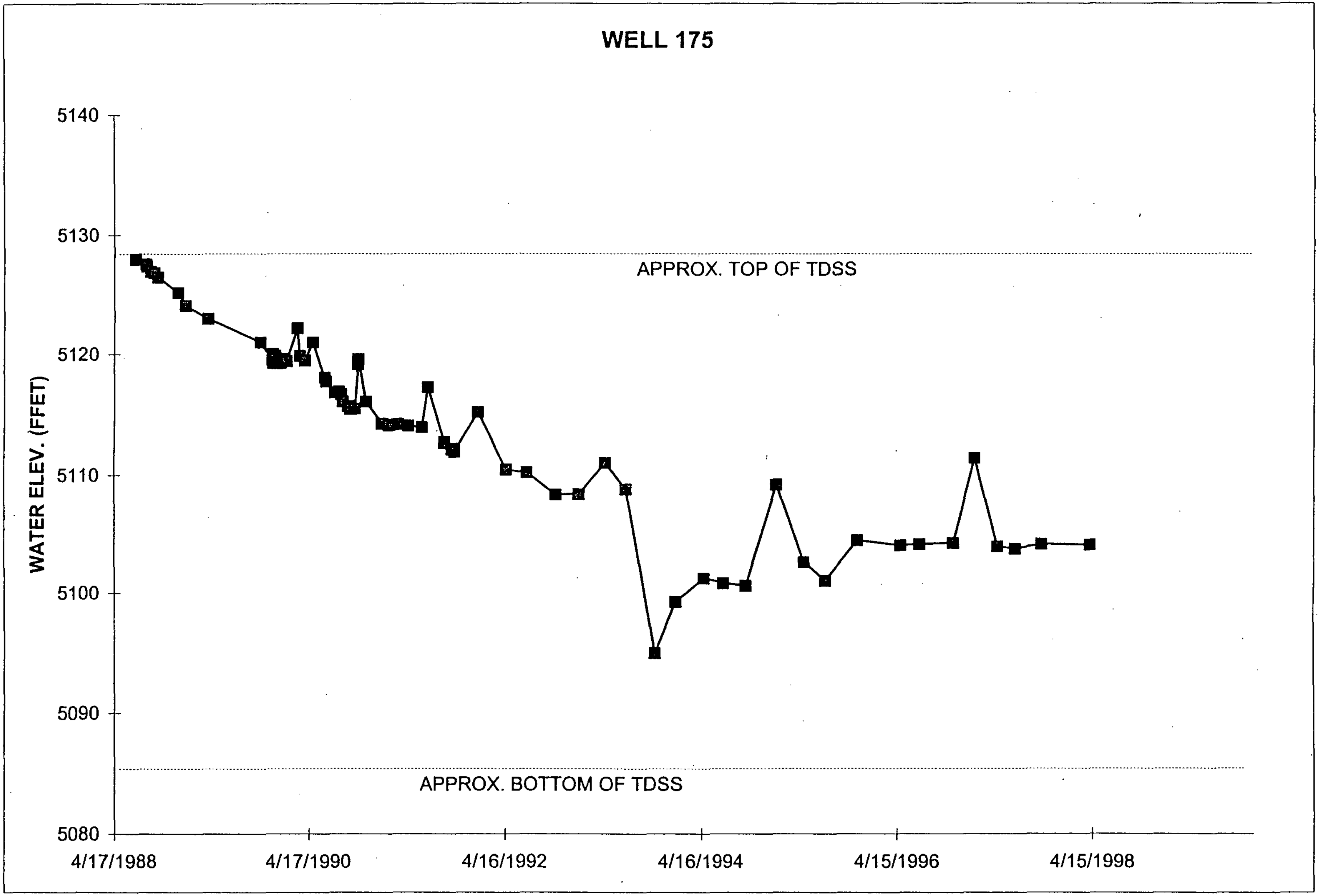
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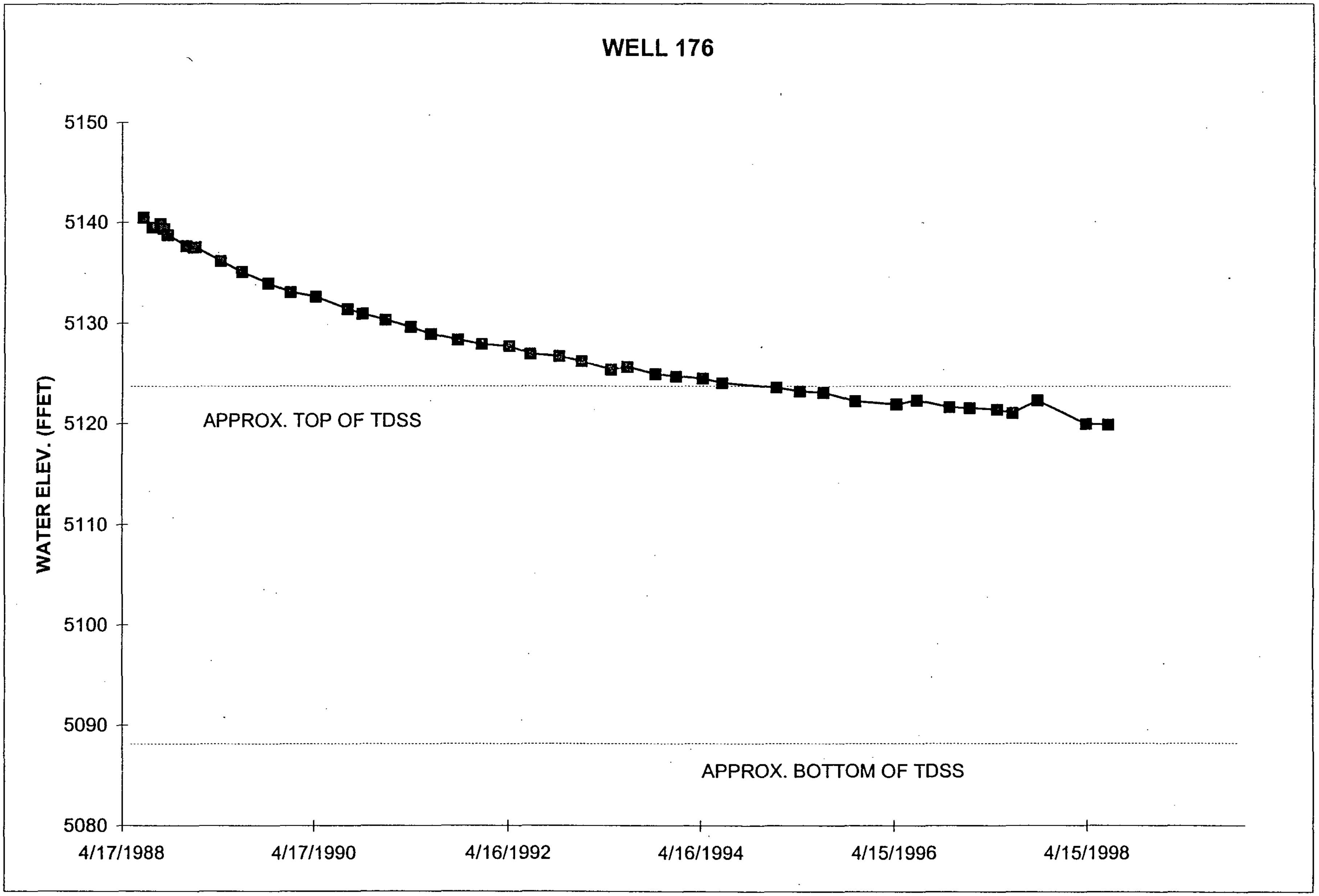
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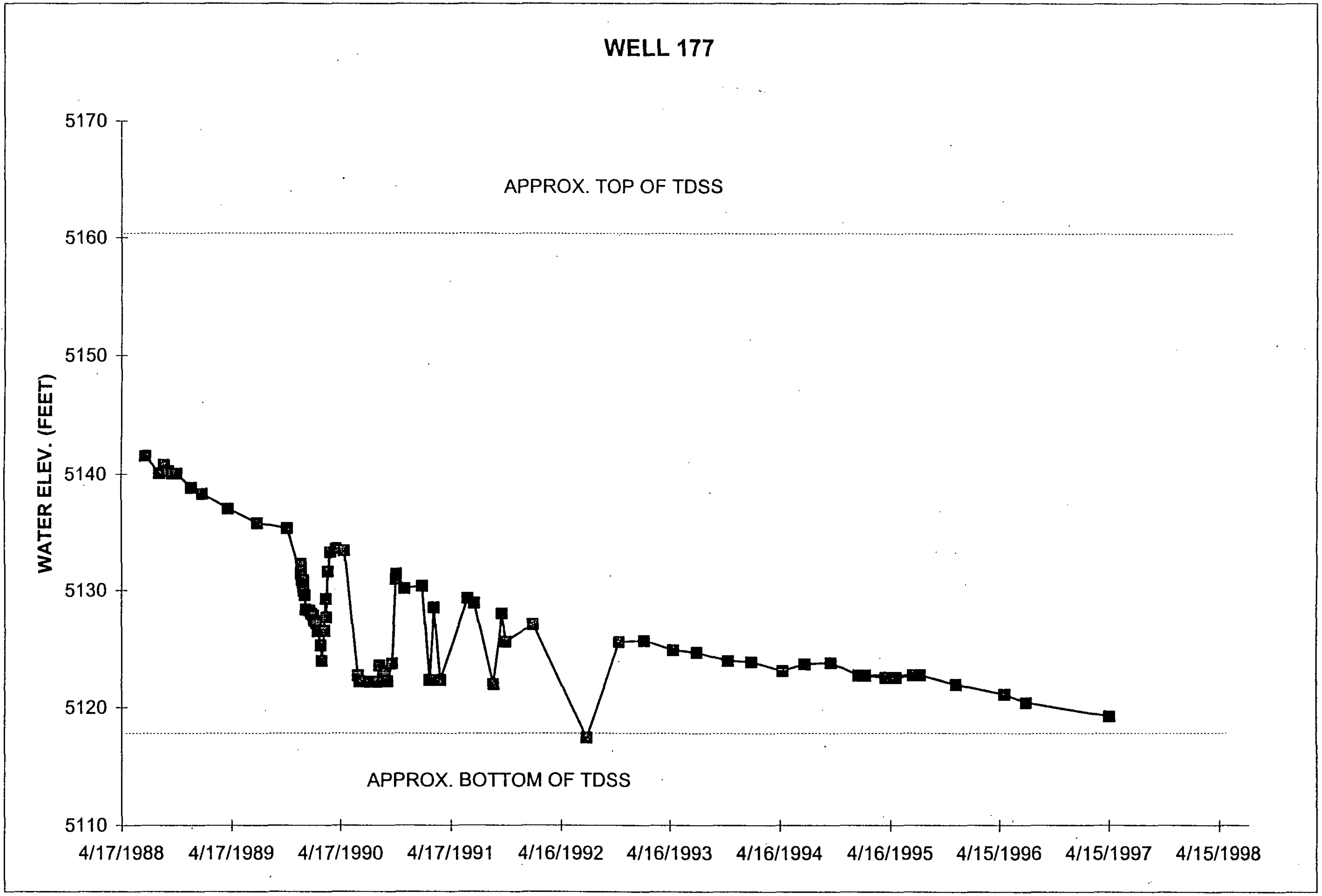
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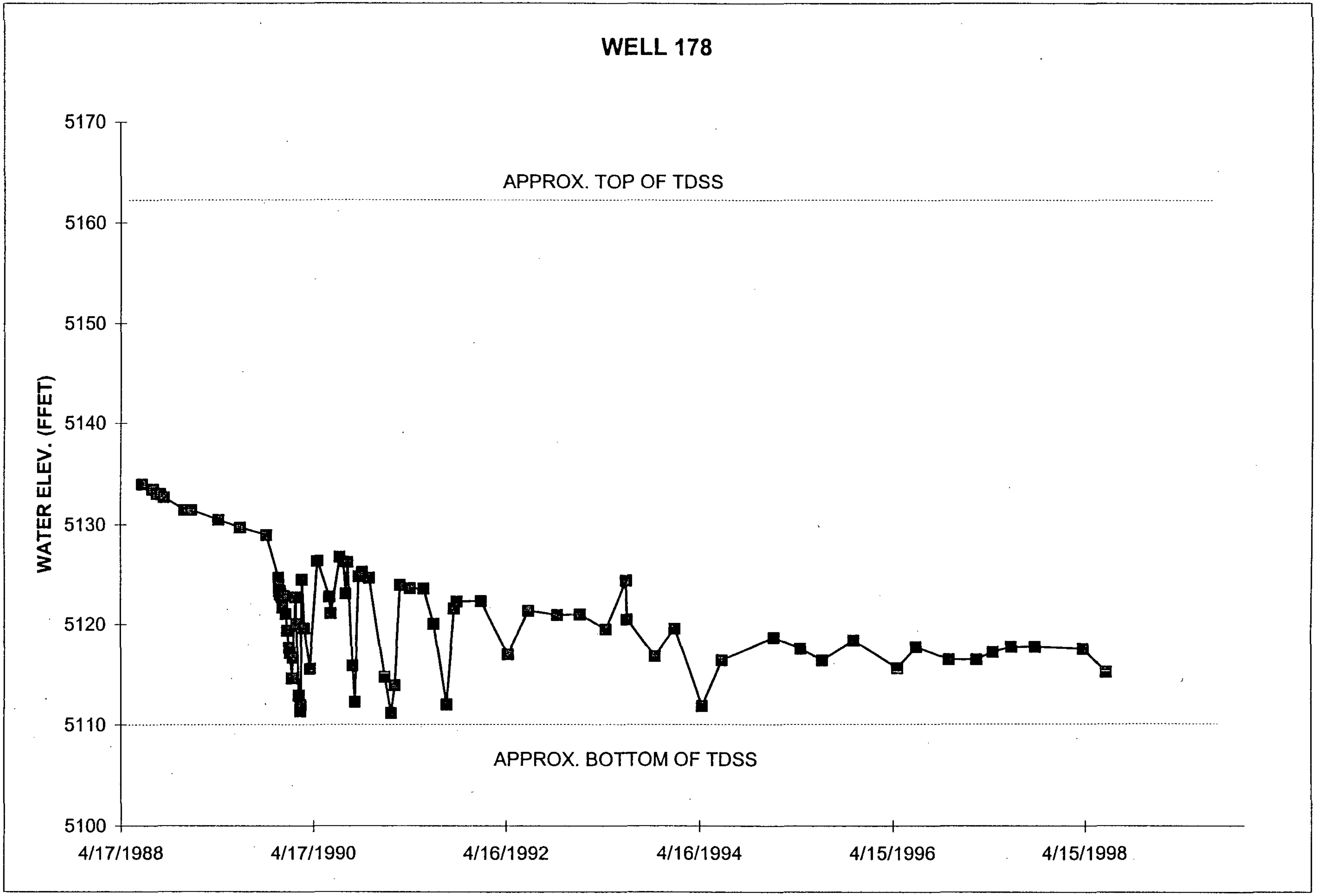
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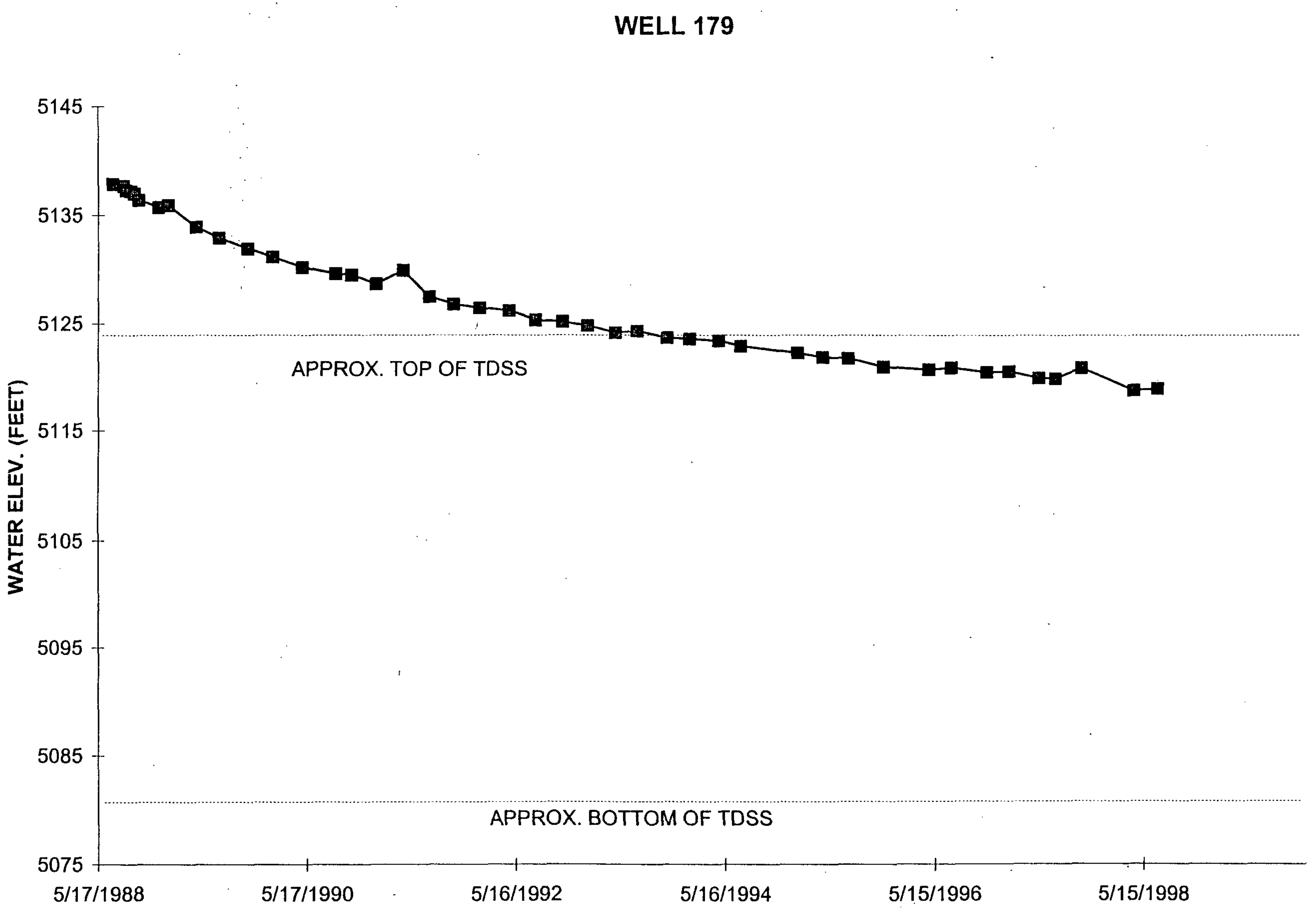
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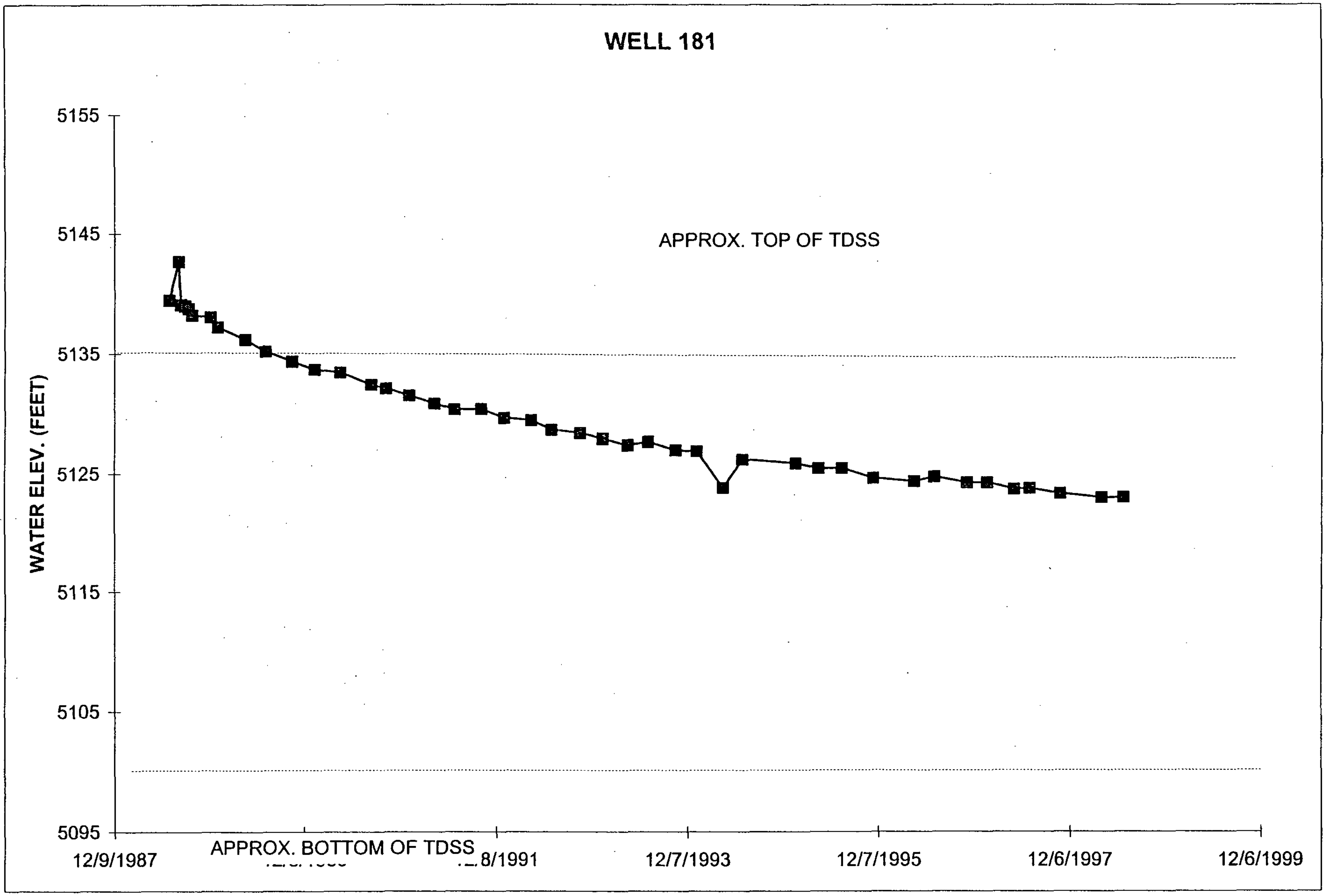
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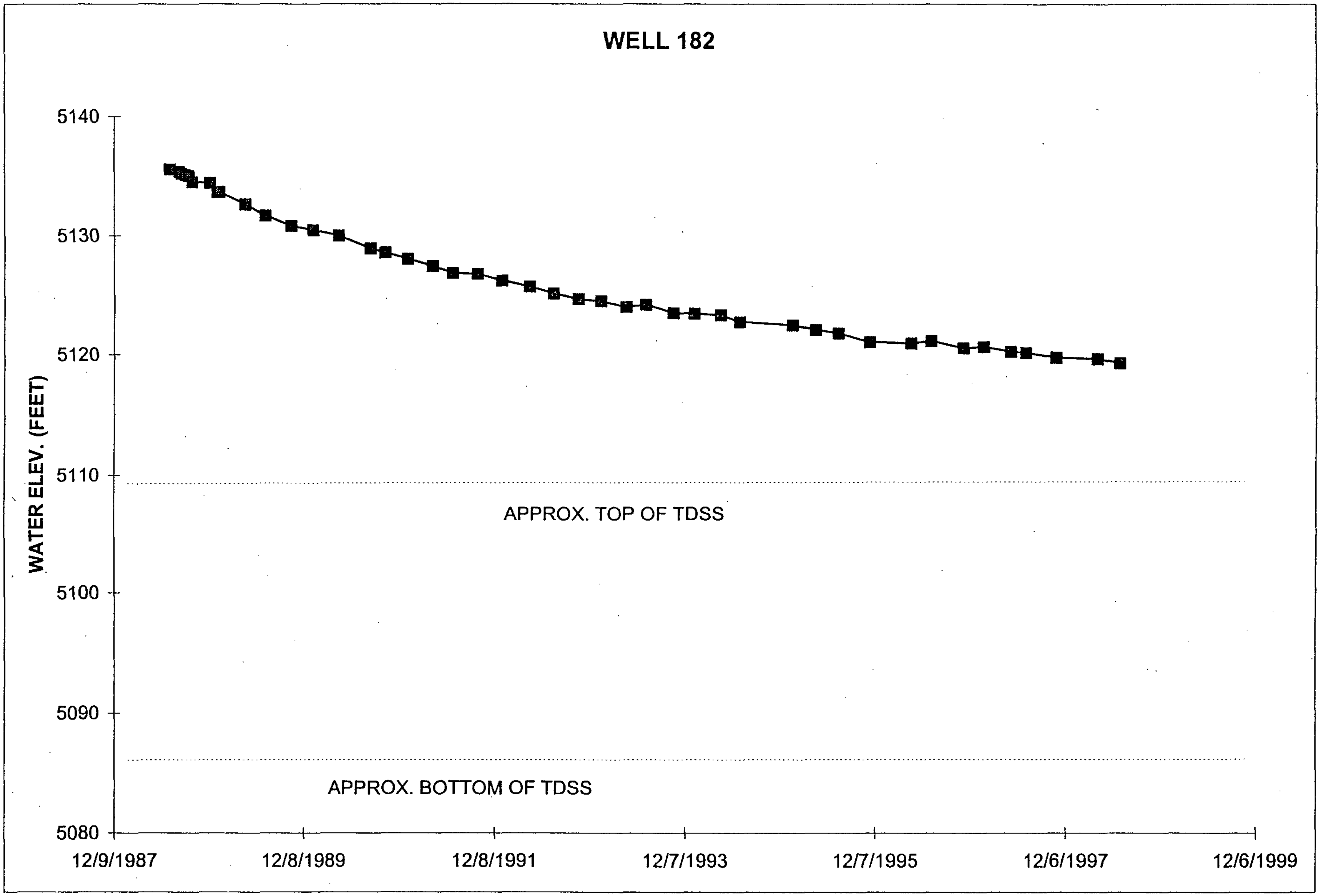
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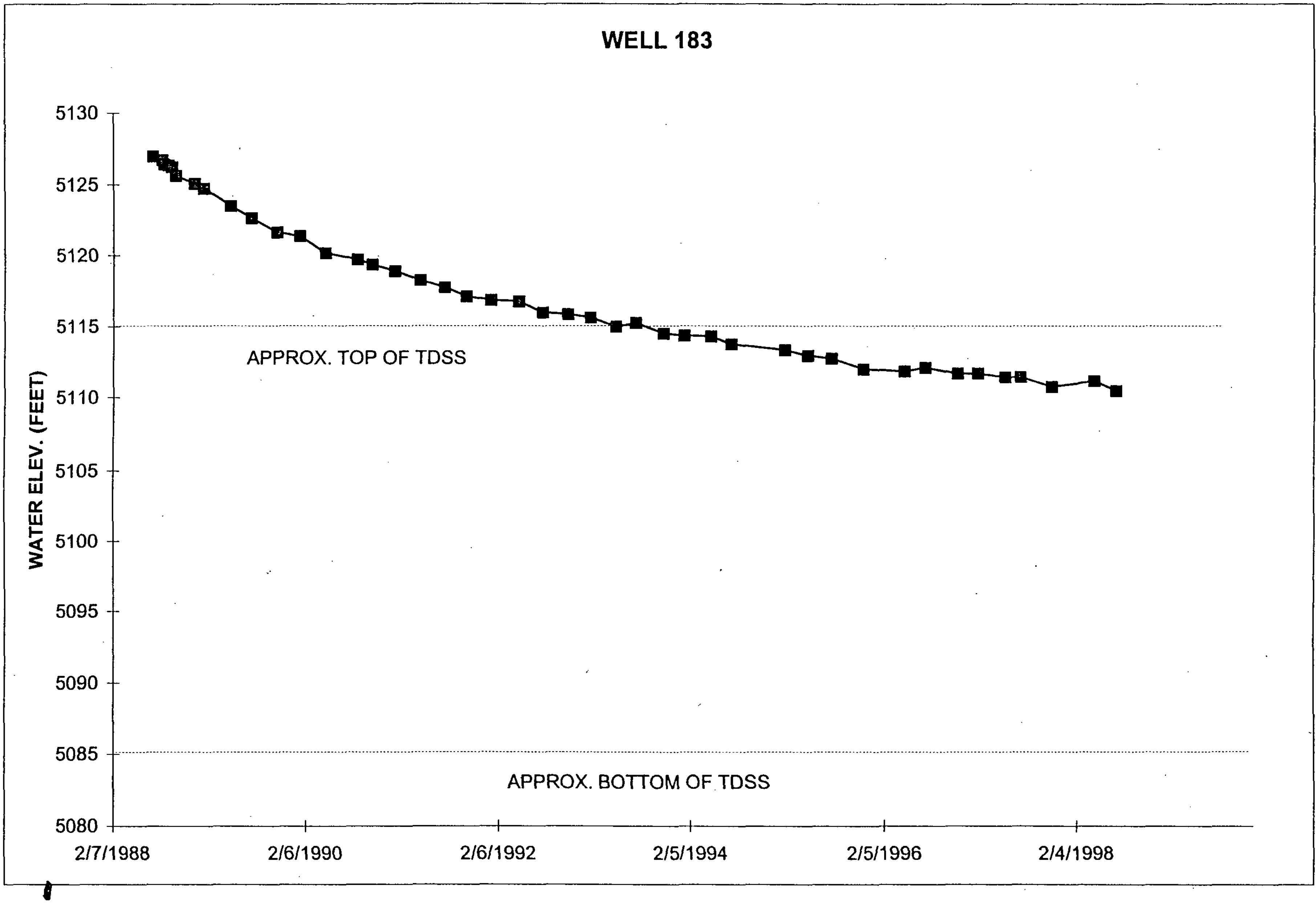
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APPROX. BOTTOM OF TDSS
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2/6/1992
2/5/1994
2/5/1996
2/4/1998

APPENDIX 5

COMPARISON OF EPRCO PREDICTIONS WITH ACTUAL WATER QUALITY RESULTS

WHAT EPRCO DID

EPRCO developed geologic, hydrologic and solute transport models for the tailings basin area. The geologic model was based on drill hole data and core samples. The hydrologic model was based on the geologic model and hydrologic tests of monitor wells and core samples. The solute transport model was based on the first two models and geochemical testing including column leach tests of tailings liquid through geologic media, titration tests of tailings liquid, and contact tests between geologic media and tailings liquid.

In preparing the solute transport model, Distribution Coefficients and Relative Velocities for the various solutes were developed (Table 20 of EPRCO, 1982). The Relative Velocities compare the solute front velocity to the fluid velocity. According to the EPRCO report, the solute front was considered to be the point at which the solute concentration was half of the tailings fluid concentration. Solution pH was handled slightly differently as the pH front was considered to be at the point at which the pH had dropped to 5, a pH value that is about midway between the tailings fluid pH and background.

EPRCO prepared Figures 56 through 60 (Table 20 of EPRCO, 1982) that showed the expected horizontal distribution of solutes in the TDSS at relative solute velocities from a ratio of 1.0 to 0.1 of the fluid velocity.

COMPARISON OF DATA TO EPRCO MODEL PREDICTIONS

In general it appears EPRCO slightly overpredicted the movement of Potentially Hazardous Constituents (PHCs) in most directions. PHC movement through the TDSS has only exceeded EPRCO predictions to the west. In this direction the mine backfill strongly attenuates the effects. Comparisons for specific constituents with the EPRCO model results follow.

Cadmium:

The cadmium Relative Velocity was predicted to be 1.0, and the tailings fluid cadmium concentration was about 0.08 mg/l, resulting in a predicted seepage front concentration of 0.04 mg/l versus the GPL of 0.01. The NRC sample of tailings fluid in 1986 contained 0.12 mg/l for a seepage front concentration of 0.06 mg/l, versus the GPL of 0.01. By the time the NRC collected samples, the tailings liquid had experienced a good deal of evaporation without the introduction of new tailings fluid, so the solute concentrations were probably well above those typical during most of the life of the tailings basin. The EPRCO model apparently over predicted the extent of cadmium movement as none of the TDSS wells reached 0.04 mg/l and measurements are now below the GPL, whereas EPRCO predicted the solute front for a Relative Velocity of 1.0 would be well outside the perimeter of the tailings basin by 1992 (See Figure 56 of EPRCO, 1982).

Chloride:

Although not measured in laboratory tests, EPRCO expected a chloride Relative Velocity of 1.0. The tailings fluid chloride concentration was about 220 mg/l for a seepage front concentration of 110 mg/l. There is no GPL. The chloride front is beyond the EPRCO model prediction for 1992 to the west, south and north, but is about where the EPRCO model predicted it would be to the east. The chloride front does appear to be shrinking.

Chromium:

The chromium Relative Velocity was predicted to be 0.01, and the tailings fluid chromium concentration was about 0.03 mg/l, resulting in a predicted seepage front concentration of 0.015 mg/l versus the GPL of 0.05 mg/l. The NRC sample of tailings fluid in 1986 contained 2.4 mg/l, which corresponds to a seepage front concentration of 1.2 mg/l versus the GPL of 0.05. The EPRCO model under predicted the chromium movement to the west as it existed in 1989-1991 and perhaps slightly over predicted it to the south in 1989-1991. The monitoring data matches the EPRCO model prediction in the other directions. However, this is somewhat academic as the chromium concentrations have fallen to below the GPL at all the monitor wells. EPRCO speculated that the discharge of tailings in the west end of the tailings basin in the middle 1970s caused solute concentrations in this direction in excess of the model predictions which were based on seepage only occurring from the main pool of liquid in the tailings basin. It can be speculated that this western discharge caused the elevated chromium values found in Wells 114 and 175 in 1988-1990. The strong attenuation of chromium implied by the chromium Distribution Coefficient and Relative Velocity could explain why it disappeared from solution a few years after the tailings pool had evaporated.

Nickel:

The nickel Relative Velocity was predicted to be 1.0 in an acidic environment, but nickel is pH sensitive - not moving faster than the pH front. The tailings fluid nickel concentration was about 1.1 mg/l resulting in a predicted seepage front concentration of 0.55 mg/l versus the GPL of 0.02 mg/l. The NRC sample of tailings fluid in 1986 contained 3.5 mg/l for a seepage front concentration of 1.8 mg/l versus the GPL of 0.02. The nickel front is about where the EPRCO model predicted. The EPRCO pH prediction shows progressively smaller outward increments of movement over time. This perhaps reflects the finate quantity of low pH fluid from the tailings basin meeting a growing perimeter of alkaline rock as the front spreads. This would indicate the front would finally stop moving with all the low pH fluid neutralized.

pH:

The pH (hydrogen cation) Relative Velocity was predicted to be 0.5 in the TDSS, and the tailings fluid pH was about 2.4 with a seepage front value of 5. There is no GPL. The pH front was only predicted to reach wells to the southeast of the tailings basin and to the edges of the basin to the east and north. The pH measurements have declined below background in these directions and to the west. The EPRCO model appears to have over predicted the total decline in pH that would occur in that the lowest pH observed has been 5.7 at well 114. The pH is generally consistent with the other parameters in that the movement to the west of the lowered pH zone has been slightly more pronounced than the model predicted.

Radium-226:

The radium-226 Relative Velocity was predicted to be 0.01, and the tailings fluid radium-226 concentration was about 70 pCi/l, resulting in a predicted seepage front concentration of 35 pCi/l. There is no specific GPL for radium-226, but the radium-226+228 GPL is 5 pCi/l. Some individual wells have occasionally exhibited radium-226 results above 5 pCi/l. Given that the wells at the western end of the tailings basin have not generally had elevated concentrations, contrary to the norm for other solutes, and the very low predicted Relative Velocity of radium, it definitely appears that the occasional elevated radium-226 results at other wells are localized due to specific geochemical circumstances near specific wells rather than the result of tailings seepage. EPRCO did not model radium-228, which is the principle radium radionuclide found at Wells 114 and 175 at the west end of the tailings basin.

Selenium:

The selenium Relative Velocity was predicted to be 0.016, and the tailings fluid selenium concentration was about 0.126 mg/l, resulting in a predicted seepage front concentration of 0.063 mg/l versus the GPL of 0.05. The NRC sample of tailings fluid in 1986 contained 0.77 mg/l for a seepage front concentration of 0.38 mg/l versus the GPL of 0.05. Only well 112 regularly exceeds the detection limit of 0.001 mg/l. The concentration at well 112 is usually above 0.1 mg/l. Given that the wells at the western end of the tailings basin have not had elevated concentrations, contrary to the norm for other solutes, and the very low predicted Relative Velocity of selenium, it definitely appears that the elevated selenium results at Well 112 are a localized event due to specific geochemical circumstances near the well rather than the result of tailings seepage.

Sodium:

The sodium Relative Velocity was predicted to be 1.0, and the tailings fluid sodium concentration was about 260 mg/l, resulting in a predicted seepage front concentration of 130 mg/l. There is no GPL for sodium. The NRC sample of tailings fluid in 1986 contained 630 mg/l for a seepage front concentration of 320 mg/l. The EPRCO model somewhat under predicted the extent of sodium movement in all directions. This would indicate the EPRCO hydrologic model somewhat under predicted the fluid velocity in all directions.

Sulfate:

The sulfate Relative Velocity was predicted to be 1.0, and the tailings fluid sulfate concentration was about 7580 mg/l, resulting in a predicted seepage front concentration of 3790 mg/l. There is no GPL. The EPRCO model over predicted the extent of sulfate movement in all direction except to the west where the model under predicted the movement. The discharge of tailings in the west end of the basin during much of the 1970s probably explains this under prediction to the west by the model.

Thorium-230:

The thorium-230 Relative Velocity was predicted to be 0.094, and the tailings fluid thorium-230 concentration was about 31,000 pCi/l, resulting in a predicted seepage front concentration of 15,500 pCi/l versus the GPL of 0.55 pCi/l. The EPRCO model correctly predicted virtually no movement of this solute from the tailings basin.

Natural Uranium:

Uranium-238 accounts for about half of the radioactivity in natural uranium. The uranium-238 Relative Velocity was predicted to be 0.104. The tailings fluid natural uranium concentration was about 5,000 pCi/l, resulting in a predicted seepage front concentration of 2,500 pCi/l versus the GPL of 0.43 pCi/l. The EPRCO model predicted the uranium seepage front would only emerge out of the basin to the south edge. No measurements have approached 2,500 pCi/l at the TDSS monitor wells, but the highest concentrations have been at wells 117 and 177 in the southerly direction.

Summary:

The conditions within the TDSS surrounding the tailings basin are much like those EPRCO predicted fifteen years ago would exist at this tiime. Discrepancies from the model are relatively minor.

From the sodium data it appears the EPRCO hydrologic model slightly under predicted the seepage fluid velocity. For most solutes the model under predicted movement to the west. EPRCO discussed this in the report and concluded it was a result of tailings disposal in the western end of the basin that created a secondary source of seepage into the Fowler formation and the TDSS apart from the main pool of tailings liquid. The impact of this secondary source of seepage is limited to the monitor wells at the west end of the tailings basin and has had no significant impact on the mine backfill or Highland Reservoir water quality due to the strong attenuation of the mixture of sands and shales in the backfill.

The EPRCO model tended to over predict movement of PHCs in all directions but to the west. Given the predominant current western flow of ground water from the tailings area towards the mine backfill, significant further movement of solutes in any other direction is not expected in the future. The TDSS in the tailings area will probably be totally drained before the Highland Reservoir water level is high enough to begin resaturating the TDSS.

APPENDIX 6

A COMPREHENSIVE RISK ASSESSMENT
FOR THE
HEALTH AND ENVIRONMENTAL LIMITS
AT THE PROPOSED POINTS OF EXPOSURE
FOR
NICKEL, RADIUM, AND URANIUM
AT THE
HIGHLAND RECLAMATION PROJECT

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EXECUTIVE SUMMARY

This assessment of risk was prepared in support of an application for alternate concentration limits. Ground water monitoring indicates that the concentrations of nickel, radium, and uranium exceed background concentrations at some Point of Compliance (POC) locations.

To determine the risk associated with water use at the Points of Exposure (POEs) with the ALARA concentrations to nickel, radium, and uranium at the POC, a residential use scenario was assumed to exist. Although there is no current use of the affected water resource and none is expected, this conservative approach was utilized. The typical 70-kg individual over a 70-year life span was assumed to consume 2 liters of water per day and eat vegetables irrigated with the predicted water quality.

Carcinogenic risks were determined for nickel, radium, and uranium. Additionally, noncarcinogenic hazard quotients were determined for these constituents. All of the hazard quotients were found to be less than unity; consequently, the toxic effects of the assessed constituents were found to be acceptable.

The carcinogenic risks for individual constituents were assessed. The risk associated with radium and uranium were found to be within an acceptable range, being less than E-4. The risk associated with nickel was found to be on the order of E-3 as was the total risk associated with all of the assessed constituents.

To determine the incremental increase in risk due to the reclaimed mill tailings, the risk associated with consumption of water having background concentrations of nickel, radium, and uranium was calculated. The assessment of total risk associated with the background conditions indicated nickel risks on the order of E-3, while radium and uranium were on the order of E-5. The addition of the measured concentrations of nickel, radium, and uranium at the POEs were minimal and did not change the risk order of magnitude.

The exposure assessment indicated that there is no exposed population and it is reasonable to assume that there will be no future exposed population. However to support the calculation of risk, a hypothetical population was assumed to exist. The scenario demonstrated that the total risk associated with the utilization of background water concentrations was essentially the same as the risk associated with the measured water quality at the POEs.

1.0 HUMAN HEALTH EVALUATION

1.1 Introduction

This document evaluates the potential risks to human health associated with water use at the POE locations east and west of the Highland tailings basin. The risk assessment is based on the United States Environmental Protection Agency's (EPA) Risk Assessment Guidance for Superfund, Vol. 1 Human Health Evaluation Manual (Part A and B) 1989 (RAGS). Other sources of information used in this risk assessment are the EPA Integrated Risk Information System (IRIS), the Health Effects Assessment Summary Tables (HEAST), and the Federal Guidance Report Number 11: Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion, Table 2.2.

The NRC selected four wells as POCs. These are on the north, east, south and west sides of the tailings basin. One ACL is sought for the east side. Three are sought for the west side. None is sought for the north side since the north POC is in compliance with the NRC set Groundwater Protection Limits (GPLs) established in the license. The south POC well is now dry but is expected to be resaturated in the future, so one ACL is sought for this currently dry well.

For the east and south sides, only uranium ACLs are needed. For the west side nickel and radium 226 + 228 ACLs are sought. This risk assessment is by POE with assessments performed for each POE associated with a POC well for which an ACL is needed.

East of the east POC well the uppermost aquifer is dry and will not be resaturated in the future. Therefore no POE will exist east of the POC well.

West of the west POC well lies Highland Reservoir. One well (Well 180) exists between the west POC well, Well 175 and Highland Reservoir, but this one well is dry. Highland Reservoir is an obvious POE. It serves as the POE for all concentrations other than uranium and selenium. Since the reservoir lies in a mined-out uranium open pit mine, it contains uranium and selenium concentrations much higher than those found in the tailings basin monitor wells.

1.2 Selection of Hazardous Constituents for Risk Evaluation

Information collected from monitoring of the corrective action program (CAP) was utilized to determine the parameters for risk evaluation. The monitoring data indicate that nickel, radium 226+228 (radium), and uranium will require alternate concentration limits and an evaluation of risk at the POE locations.

The monitoring information indicates that although other potentially hazardous constituents are present in the water found in the upper most acquifier, the concentrations are below the license-established limits. Evaluation of past concentrations, current concentrations and the EPRCO 1973 Seepage Study indicate that they will remain below the license-established limits in the future.

1.3 Toxicity Information for Noncarcinogenic and Carcinogenic Effects

The toxicity information used in this risk assessment, to evaluate noncarcinogenic dose-response effects, was acquired from IRIS and HEAST. The Reference Dose (RfD) was the primary parameter utilized for noncarcinogenic effects through ingestion routes of exposure. Exposures were assumed to be chronic exposures, lasting between seven years and a 70-year lifetime. Nickel has a RfD, but the radioisotopes do not have RfD values. The RfD for nickel is given in Table 1.3.1 and was utilized as a measure of the health efforts associated with nickel. The primary health effect associated with radium and uranium is from radioisotope exposure and the resulting potential for cancer.

The EPA assumes that there is essentially no level of exposure to a carcinogenic chemical that does not pose a finite possibility, no matter how small, of generating a carcinogenic response. In evaluating carcinogenic effects, no threshold value can be assumed. The EPA uses a two-part evaluation in which the substance is first assigned a weight-of-evidence classification, (defined by the EPA as a plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a 70-year lifetime). Following this a slope factor is calculated. This value is multiplied by the chronic daily intake of the chemical to produce an estimate of probability of an individual developing cancer due to exposure to that chemical.

Exposure to radioisotopes requires that the slope factor be multiplied by the chronic daily intake, which has been modified by the dose conversion factor (DCF). These calculations were carried out for nickel, radium, and uranium. Slope factors and weight-of-evidence classifications for these constituents are included in Table 1.3.1.

Table 1.3.1 Toxicity Values for Hazardous Constituents.

Hazardous Constituent	Uranium -238	Radium-226	Radium-228	Nickel
Oral Slope Factor	2.8E-11 (risk/pCi)	1.2E-10 (risk/pCi)	1E-10 (risk/pCi)	8.4E-1 (mg/kg-day)1
Weight of evidence	Carcinogen per EPA	Carcinogen per EPA	Carcinogen per EPA	Carcinogen per EPA
Chronic Oral RfD (mg/kg-day)	None	None	None	0.02
Uncertainty Factor	None	None	None	300
Reference	HEAST, 1992	HEAST, 1992	HEAST, 1992	IRIS, 1996
Target Organ System	Skeletal system	Skeletal system	Skeletal system	Whole Body, Major organs

There are inherent uncertainties in the toxicity data used to assess risk in this, and any other evaluation. For instance, using dose-response information from effects observed at high doses to predict the health effects that may occur following exposure to the low levels of hazardous constituents concentrations introduces uncertainties. Similarly, using animal studies to predict human response and the use of short-term studies to predict the effects of 70-year life-time exposure add to the uncertainties.

Experimental studies of animal populations coupled with studies of healthy human populations are used to predict the response likely to be observed in a population consisting of individuals with a wide range of sensitivities.

Uncertainty factors which may overestimate potential risk, and are used to calculate risk, are presented along with toxicity values in Table 1.3.1. These values give an indication of the confidence in experimental data used to determine the associated RfD. The greater the uncertainly factor, the greater the uncertainly associated with the experimental data.

1.4 Dose Conversions Factors and Exposure Pathways

Dose Conversions Factors (DCF) are utilized to more accurately determine the radiation dosage due to the presence of the radionuclide in a given matrix. These DCFs are not utilized in the determination of risk of developing cancer, but instead are used to determine the effective dose intake associated with the concentration of radionuclide in the matrix, the frequency of dosage, and the duration of dosage.

This assessment considered risk to future populations at each POE for which an ACL is sought. Ground water with the nickel, radium, and uranium concentrations predicted to be present at these points were assumed to the utilized by humans. The exposure matrix assumed that water at the POEs would be a drinking water source and would nourish consumable food products. Intake of hazardous constituents as a result of exposure to contaminated soils was not considered, as there are no contaminated soils at the site. Similarly, dermal exposure was not considered a probable exposure pathway and not included in the assessment.

1.5 Ground Water Concentrations

The POE concentrations of nickel, radium, and uranium were used in this risk assessment. The POE locations are established at the down-gradient edge of the land mass that will accompany an amendment application for a General license. Consequently, this land mass is the minimal amount of land that is necessary to assure long-term control of the reclaimed byproduct materials. Information on the concentration of nickel, radium and uranium are shown in Table 1.5.1.

Table 1.5.1 Potentially Hazardous Constituents
Concentration at POE Locations

Potentially Hazardous Constituent	**POE**	**1994-1998 POE Max. Conc.**	**NRC Established Limit**	**NRC Recognized Background***
Nickel	Highland Reservoir	0.02 mg/l	0.02 mg/l	0.02 mg/l
Radium 226+228	Highland Reservoir	6.8 pCi/l	5 pCi/l	3.2 pCi/l
Uranium 238	Well 178	1.4 pCi/l	0.43 pCi/l	0.43 pCi/l
	Well 125	37.2pCi/l	0.43 pCi/l	0.43 pCi/l

*Four samplings of Well 182 in 1988.

The values for nickel, radium, and uranium shown in Table 1.5.1 indicate that risk was assessed for concentrations that represent the entire range of hazardous constituents that have occurred The risk for nickel was assessed for the background concentration of 0.02 mg/l as well as the actual maximum concentration of 0.02 mg/l to demonstrate the minimal incremental increases in risk associated with this concentration of nickel. Similarly, the background concentrations of radium and uranium as well as the POE maximum measured concentrations were assessed for risk.

1.6 Future Land Use

Although no exposed populations currently exist at the Highland site and none are predicted to be in the area in the future, residential land use was considered in the risk assessment. Lesser exposure scenarios would have resulted in no exposed populations. Although this is the likely scenario, it is inconsistent with the ACL guidance document. Exposure pathways considered for future populations include ingestion of contaminated ground water. Additionally, consumption of produce using contaminated ground water for irrigation, assuming that water will be ingested from vegetable and fruits grown at residences. Table 1.6.1 summarized the potential for exposure to future residents across all routes of exposure.

Table 1.6.1 Potentially Exposed Populations and Exposure Routes

Potentially Exposed Population	Exposure Route, Medium, and Exposure Point	Pathway Selected for Evaluation	Reason for Selection or Exclusion
Residential	Ingestion of contaminated ground water	Yes	Wells developed in the upper most acquifier - the TDSS
Residential	Ingestion of home-grown vegetables and fruits	Yes	The site and the surrounding area are in a rural location, iNRCeasing the potential for home gardening. The wells developed in the TDSS could potentially irrigate gardens
NA	Dermal absorption through bathing	No	According to the EPA, dermal uptake of radionuclides and metals is generally not an important route of uptake (EPA RAGS, 1989).
NA	Inhalation of contaminated dust	No	The soil at the Highland site meets NRC limits for unrestricted use.
NA	Dermal contact with contaminated soil	No	The soil at the Highland site meets NRC limits for unrestricted use.
NA	Inhalation of airborne (vapor phase) chemicals	No	There are no volatile hazardous constituents at the Highland site.
NA	Ingestion of contaminated soils	No	The soil at the Highland site meets NRC limits for unrestricted use.

1.7 Quantification of Potential Risk

The quantification of risk utilized standard EPA equations and the methodology as discussed in RAGS, 1989. Included in this subsection are explanations of the calculations, which were performed for each pathway. The equations that were utilized are shown below.

Intake of nickel by ingestion of ground water was calculated by using the following equation:

$$\text{Intake (mg/kg-day)} = \frac{CW \times IR \times EF \times ED}{BW \times AT}$$

Where:

CW = Nickel Concentration in Ground water (mg/l)
IR = Ingestion Rate (liters/day)
EF = Exposure Frequency (days/year)
ED = Exposure Duration (years)
BW = Body Weight (kg)
AT = Averaging Time (days)

Intake of nickel due to ingestion of home-grown produce irrigated with POE ground water was calculated by using the following equation:

$$\text{Intake (mg/kg-day)} = \frac{CF \times IR \times FI \times EF \times ED}{BW \times AT}$$

Where:

CF = Nickel Concentration in Food (mg/kg)
IR = Ingestion Rate (kg/meal)
FI = Fraction Ingested from POE Source (unitless)
EF = Exposure Frequency (days/year)
ED = Exposure Duration (years)
BW = Body Weight (kg)
AT = Averaging Time (days)

For calculation of intake of the radioisotopes, averaging time (AT) and body weight (BW) were deleted and the resulting intake was multiplied by the dose conversion factor (DCF). This conversion provided a more accurate estimation of radiation dosage due to the consumption of POE ground water and ingestion of POE irrigated home-grown produce. The units of intake are therefore discussed in terms of effective dose and expressed as fractions of radiation equivalent man (rem).

1.8 Risk Characterization

The carcinogenic and noncarcinogenic risks associated with exposure to nickel, radium, and uranium under the residential future land use scenario serve as the characterization for this assessment. Although there is no current indication that the ground water will be utilized under a residential scenario, this type of use was assumed to take place. This use scenario incorporates the most conservative exposure values (i.e., length of residence, duration of exposure, etc.)

If exposure to nickel, radium, and uranium under this land use scenario demonstrates no increase in risk of developing cancer and non-cancer illnesses, then it will be the case for all other land use scenarios.

A lifetime exposure of 70 years was assumed. Due to this, children and adults were not assessed separately, because the 70-year lifetime encompassed both childhood and adulthood. The exposure pathways under the residential land use scenario include the ingestion of POE ground water and the ingestion of home-grown produce irrigated with POE ground water. The intake of potentially carcinogenic chemicals by residents is summarized in Table 1.8.1.

Table 1.8.1 Potentially Carcinogenic Intake by Residents

Potentially Hazardous Constituents	Intake by Ingestion of Ground Water			Intake by Ingestion of Home Grown Products		
	Highland Resv.	Well 178	Well 125	Highland Resv.	Well 178	Well 125
Nickel (mg/kg-day)	5.5E-4	----	----	2.8E-5	----	----
Radium-226 and Radium-228 (mrem)	5.5E+2	----	----	2.5E+1	----	----
Uranium (mrem)	----	1.7	45	----	8.3 E-2	2.2

The potential risk for residents to develop cancer, from the predicted nickel concentrations in the ground water, is provided by the product of the slope factor and the intake, and expressed in (mg/kg-day). The potential risk to residents to develop cancer from radium and uranium is determined by the product of the estimated ingested activity (in pCi; not utilizing the DCF) and the slope factor (risk/pCi). The potential risk for residents to develop cancer due to exposure to site contaminants is summarized in Table 1.8.2.

Table 1.8.2 Potentially Carcinogenic Risks to Residents

Pathway	Potentially Hazardous Constituents	Residents Risk (Unitless)		
		East (Well 125)	South (Well 178)	West (Highland Resv.)
Ingestion of Ground Water	Uranium -228	5.3E-5	4.9E-7	----
	Radium-226 and Radium-228	---		4.2E-5
	Nickel	---		4.6E-4
Ingestion of Home Grown Produce	Uranium-228	1.0E-5	1.0E-7	----
	Radium-226 and Radium-228	---		2.1E-6
	Nickel	---		2.3E-5

The potential risk for residents to develop a non-cancer illness due to chronic exposure to nickel is summarized in Table 1.8.3. Radium and uranium are not considered in this portion of the assessment, because they are detailed in Table 1.8.2.

Table 1.8.3 Noncarcinogenic Hazard Quotients for Residents

Pathway	Potentially Hazardous Constituents	Both Residents (Highland Reservoir) and Background HQ(Unitless)
Ingestion of Ground Water	Nickel	2.8E-2
Ingestion of Home Grown Produce	Nickel	1.4E-3
TOTAL	Nickel	2.9E-2

An overall assessment of the risk of developing cancer or a non-cancer illness due to exposure to nickel, radium, and uranium was conducted. The assessment utilized the residential land use scenario and combined risks and HQs across all pathways. Summing the risks and HQs over all pathways produces a very conservative representation of the risks.

In order for the estimated cancer risk to fall within EPA guidelines for acceptable risk, the risk from an individual chemical should be less than 1E-6, and the combined cancer risk across all pathways from all chemicals should be less than 1E-4. This differs from the ACL guidance, which allows a 1E-4 risk for any individual constituent.

According to the same EPA guidelines, the risk for contracting a non-cancer illness (described by the HQ) from an individual chemical, and combined for all chemicals across all pathways, should be less than one. The HQs for individual chemicals and the sum of HQs for all chemicals across all pathways should be less than one. For the individual and combined hazard quotients to be acceptable, they must be less than one.

The total risk for residents to develop cancer across an individual pathway is summarized in Table 1.8.4.

Table 1.8.4 Total Risk of Developing Cancer for Residents

Pathway	RESIDENTS Risk (Unitless)			
	EAST	**SOUTH**	**WEST**	**Background**
Ingestion of Ground Water	5.3E-5	4.9E-7	5.1E-4	4.8E-4
Ingestion of Home-Grown Produce	1.0E-5	1.0E-7	2.6E-5	2.4E-5
Total Risk of Developing Cancer	6.3E-5	5.9E-7	5.3E-4	5.0E-4

The HQ is obtained by dividing the intake of nickel (units of mg/kg-day) by the RfD for nickel (units of mg/kg-day). A summary of chronic HQs across each exposure pathway is given in Table 1.8.5.

Table 1.8.5 Total Hazard Quotient for Residents

Pathway	Both Highland Reservoir and Background HQ(Unitless)
	West Flow Path
Ingestion of Contaminated Ground Water	2.8E-2
Ingestion of Home-Grown Produce	1.4E-3
Total Hazard Quotient	2.9E-2

The overall risk for individuals residing at the POE locations to develop cancer is 5.3E-4 in the Western flow path, 5.9 E-7 in the Southern flow path and 6.3E-5 in the Eastern flow path. The use of water at the background concentrations results in an overall risk to develop cancer of 5.2E-4.

The overall risk for individuals residing at the western POE for nickel to develop a non-cancer illness is 0.03. Because these values are well below the EPA risk levels, non-cancer illness was not assessed for utilization of water at the background concentration.

The calculations indicate that all hazard quotients are well below recommended levels. Therefore, they are not a contributor to the overall risk. The driving factor for risk is the predicted development of cancer due to the presence of nickel in the background water as well as in the water predicted to reside in the Western POE flow path.

1.9 Uncertainties in the Characterization of Risk

There are uncertainties inherent in calculating the risk of developing cancer and non-cancer illnesses due to exposure to nickel, radium, and uranium. Included are the site-specific uncertainly factors associated with characterizing the physical setting, and determining the fate and transport, as well as toxicity.

The physical setting of the reclaimed tailings are located in a remote section of central Wyoming. The land use is limited to cattle grazing. There is no reason to believe that the land use will change; however, the ACL guidance document requires that a residential land use be assumed for the risk assessment.

The exposure pathways (ingestion of POE groundwater and ingestion of home-grown produce irrigated by POE water) were chosen for evaluation based upon the ACL guidance document. Again, there is little or no chance of this taking place, within the foreseeable future.

No risk assessment modeling information was used in performing this risk assessment. Rather, the concentrations of nickel, radium and uranium measured at a background location as well as the concentrations of these constituents measured at the POE locations were utilized in the risk assessment.

Significant site data gaps occur when site specific data is unavailable or unknown. This specifically occurs when estimating the exposure to future populations. This risk assessment follows the guidance of RAGS when determining these unknown values. For example, when estimating what the exposure to a future resident will be, there are no current resident upon which to base the estimates of exposure parameters; therefore, the EPA recommended values have been used to estimate exposure to residents. When several options are available, the most conservative value was utilized.

Similarly, conservative values for the ingestion of home-grown produce, 250 mg/meal, for one meal per day have been used for the intake calculation. Using the most conservation values leads to a potential over estimation of risk.

A certain amount of uncertainly exists with the slope values and references doses that were used in the calculation of risk. These values were obtained from EPA sources. These references acknowledge the uncertainly associated with the lack of human or animal data and the extrapolation that is necessary. These uncertainty factors probably overestimate the calculated risk.

2.0 Conclusions

The EPS RAGS methodology was implemented in this risk assessment. The objective of this assessment was to assess the degree of risk associated with future residential land use at the POE locations. The assessment assumed that the maximum predicted concentrations would be realized at the POE locations. The exposure routes included ingestion of POE ground water and ingestion of home-grown vegetables irrigated with POE ground water.

Under a residential land use scenario, the overall risk across all pathways for residents to develop cancer was evaluated at the POE locations. The risk exceeds 1E-4 limit for cumulative pathways. Exceeding this value is primarily a function of nickel. However, it is important to note that the risk associated with use of background ground water also exceeds the 1E-4 limit. The uranium and nickel GPLs are based on Highland background data. The radium limit is the EPA MCL for drinking water.

The concentrations of uranium and radium in the ground water at the POEs will cause a minimal increase in the risk of cancer to future residents, primarily from the ingestion of ground water. Risks of developing cancer from ingesting ground water containing uranium are 5.3E-5 and 4.9E-7 in the Eastern flow path and the Southern flow path, respectively. Corresponding radium value is 4.2E-5 for the West flow path. All of these risks are within acceptable ACL guidance levels. The predicted risk values for uranium in home-grown produce are 1.0E-5 and 1.0E-7 for the Eastern and Southern flow paths, respectively.

The predicted risk value for radium in home-grown produce is 2.1E-6 for the West flow path. Again, these values are within the range specified in the ACL guidance. No pathways or risk levels exceed a 1E-6 level for developing a non-cancer illness.

The exposure estimates for the exposure pathways were determined by using the most conservative values recommended by the EPA. They represent the worst-case scenario and likely overestimate the actual exposure.

The reviewer should note that the EPA has issued, based upon recent data, a maximum concentration limit for nickel in drinking water of 0.1 mg/l with an oral reference dose (RFD) of 2E-2 mg/kg/day. The model predicted levels of nickel at the POEs would represent about one-fifth of this limit. The carcinogenic risk based scenario is based upon data collected in relation to airborne particulate inhalation of "nickel refinery dust and specific nickel compounds - nickel carbonyl and nickel subsulfide". The application of this risk to soluble nickel in ground water is certainly conservative.

APPENDIX 7

Updated and Expanded Review
Of Potential Corrective Action Programs
(ALARA DEMONSTRATION)

The Corrective Action Program (CAP) was instituted to improve the quality of water in the TDSS around the tailings basin and to prevent unacceptable impacts at Points of Exposure (POEs). The TDSS is not a significant aquifer at Highland. Deeper, thicker, much more productive aquifers exist and were developed for potable and process water for the Highland uranium operations. No livestock or other uses of TDSS water were in place within a mile of the tailings basin before mining began. These same deeper aquifers exist around the tailings basin.

Well 175, the most productive well in the TDSS once had a maximum sustainable yield of 3 gallons per minute. This has been declining as the aquifer continues to drain. Wells in the deeper aquifer had sustained yields that are ten times greater.

In order to put an upper value on the lengths society will go to gain useable water, desalinization projects were reviewed. Santa Barbara, California contracted to have a plant to deal with drought emergencies. The contracted cost of water was $1,100 per acre-foot in 1995 (www.ci.santa-barbara.ca.us/wresourc/bfsupply.htm#Desal), equal to $3,400 per million gallons. A proposal for Pinellas County, Florida estimated $1300 to $2200 per million gallons (www.enviroworld.com/March97/030597.html#anchor786456). These put an upper limit on water resources of less than $5000 per million gallons. The finger area south of the tailings basin contained about 39 million gallons of producible water in 1996 that the CAP seeks to replace with more useable water. At $5000 per million gallons that water would have a perceived value up to $0.2 million, assuming the source was next to a city in great need of a water supply.

Following the CAP has resulted in pumping and evaporating about 16 million gallons of liquid from the uppermost aquifer during the nearly nine years of operation. If the CAP is shut down at this time, there is sufficient attenuation capacity between the point of compliance (POC) wells and the point of exposures (POEs) to attenuate the Potentially Hazardous Constituents (PHCs) and continue to maintain the levels of PHCs at acceptable risk levels at the POEs. (See Hazard Assessment section of this document.)

The CAP has substantially reduced the mass of potentially hazardous constituents in the uppermost aquifer. A graph of the annual cost per 1,000 gallons of ground water recovered associated with the CAP program is attached as Figure 1. The annual cost have increased sharply during the last four years due to low well yields caused by decreasing head. To date ECMC has spent $0.6 million on a water supply worth a maximum of $0.2 million.

Several options were considered to try to further reduce the concentrations of potentially hazardous constituents to levels that would be as low as reasonably achievable taking into consideration the cost of the options versus the expected change in constituent concentration at the POEs.

OPTION 0. End Current Corrective Action Program

This includes what has already been accomplished as discussed in the Corrective Action Assessment in the main body of this report. Some 16 million gallons has been pumped from the uppermost aquifer at a cost of $0.6 million dollars or about $34 thousand/million gallons over a period of nine years. During that time, most of the PHC concentrations have fallen below the GPLs. Operating this program now costs about $50 thousand per year.

OPTION 1. Continue Current Corrective Action Program

The impact of continuing the current CAP until all of the recoverable solution has been removed from the tailings was estimated. This option leaves no useable water in the uppermost aquifer - it will be dry.

The cost versus benefit was determined using the following information:

a) Recoverable volume in the uppermost aquifer in the area of elevated potentially hazardous constituents is 13 million gallons. (Estimated volume equals 34% of the 39 million gallons in the finger area by 1996 less 1.6 million gallons recovered in 1997-1998. Between 1989 and 1996 the finger area drainable liquid volume declined from 80 million gallons to 39 million gallons. The mitigation system recovered 34% of the reduction. The other 66% drained to the mine backfill.).

b) Rate of recovery is 1.1 million gallons per year, based upon the most recent dewatering rates, gradually declining to less than 0.2 millions gallons per year in about twenty years. (See Figure 6)

c) Total cost would be at least one million dollars over a 20-year period. The present mitigation system costs about $50 thousand per year to operate. The total treatment cost for the finger area water would rise to $1.6 million versus the $0.2 million maximum worth of the water.

d) The minimum cost estimate would be $77 thousand /million gallons of solution recovered and evaporated.

e) POE Well 125 would be essentially dry in 20 years. (See Figure 7.) It will probably go dry or nearly dry over this time frame whether pumping continues or not. Well 177 is already dry. The 1998 EPRCO study in Appendix 3 indicates the TDSS at this well will be permanently dry when steady state conditions are reached. The study did not predict the timing for this state to occur.

f) The concentration of Ni and Ra 226 + 228 in Highland Reservoir would not change. Ni and Ra 228 are already not detectable. Ra 226 has average 4 pCi/l since 1990 versus 0.8 at Well 175. The higher Ra 226 concentration in the reservoir is probably the result of natural mineralization around the lake perimeter.

g) The nickel and Ra 226 + 228 concentrations at Well 175 would not change but the well would be nearly dry. This is based on having removed the entire drainable volume of the TDSS in the finger area by that time. This will occur in nearly the same time frame with or without pumping given that drainage to the mine backfill accounted for two-thirds of the reduced drainable liquid volume in the finger area over the past decade.

There are uncertainties associated with this option. Well 175 yields most of the water produced. Pump maintenance at this well is increasing each year with iron scaling becoming progressively worse. This may reduce the annual volume that can be practically taken from the well.

OPTION 2. Treated Water, Ground Water Sweep

Pumping and reinjection of treated uppermost aquifer water was also considered as a ground water corrective action plan. This plan could utilize an expanded system of wells as described in Ground Water Remedial Action Alternative Number 12.1 in Appendix B (WWL, 1989). This option leaves 37 million gallons of water in the aquifer that could be used at a cost of $73 thousand per million gallons.

The cost versus benefit was determined using the following assumptions:

a) The volume of recoverable solution that would be treated would be 37 million gallons over a period of five years. This is the entire drainable volume within the finger area in 1996, less the 1997-1998 water production and assuming no seepage escaping to the mine backfill since 1996 and throughout the five years - clearly an unrealistic assumption.

b) The rate of recovery is estimated at 7.4 million gallons per year.

c) The cost of the system including wells, operation and maintenance would be about $2.7M or $73,000/million gallons of solution treated. The total treatment cost including the current corrective action plan would rise to $3.3 million versus the $0.2 million maximum value of the water.

d) The water quality in Highland Reservoir would not change. The Ni, Ra 226 + 288 and U concentrations at wells 125, 175 and 177 would decline by about one third. This is based on replacing the entire drainable volume of the TDSS in the finger area with clean water that would mix with the two-thirds of the formation water that will not drain (difference between the specific yield of 0.1 and the porosity of 0.3 - (EPRCO, 1982)).

The uncertainties associated with this option are the same as those in Option 1. The dilution effects from injection of treated solution would be temporary and localized. Permanent change would require system operation until Highland Reservoir has filled, which is expected to take up to 100 years.

OPTION 3. Fresh Water, Ground Water Sweep

Fresh water injection was considered as an another possible corrective action technique. This plan would utilize an expanded system of wells as described in Ground Water Remedial Action Alternative Number 12.2 and Water Treatment Alternative Number 2.2 in Appendix B (WWL, 1989). However, a fresh water source other than Highland Reservoir would be needed due to the U and Se concentrations caused by naturally occurring mineralization. This option leaves 37 million gallons of water in the aquifer that could be used at a cost of $105,000 per million gallons.

The cost versus benefits was determined using the following assumptions:

a) The volume of recoverable solution that would be disposed and replaced with fresh water would be about 37 millions gallons over a period of five years. This is the same volume as the last option.

b) The rate of recovery and reinjection would be about 7.4 million gallons per year.

c) The cost of the system including wells, evaporation pond, operations and maintenance would be about $3.9 M or $105,000/million gallons of solution disposed. The total treatment cost including the current corrective action plan would rise to $4.5 million versus the $0.2 million maximum value of the water.

d) The water quality in Highland Reservoir would not change. The Ni, Ra 226 and 228 and U concentrations at well 125, 175 and 177 would decline by about one third, just as in the last option.

The uncertainties associated with the option are the same as those of Option 1. The dilution effects from injection of fresh water would be temporary and localized. Permanent change would require system operation until Highland Reservoir has filled, which is expected to take up to 100 years.

The downside of this alternative is that the fresh water injected would be degraded in a formation that is not used as a water source in this area. It also may cause PHCs to move in a slug rather than diluting them. Areas that have been dewatered may be resaturated with fluid that does not meet the GPLs.

OPTION 4. Install Reactive Barrier

A reactive barrier was evaluated. One of these structures could be built to minimize the movement of pH sensitive solutes along the Western flow path. The location of this barrier would be approximately 100 feet up-gradient from the POC well. The West flow path barrier would be about 175 feet deep by 5000 feet long and 8 feet wide. The bottom 25 feet would be filled with 37,000 cubic yards of limestone having a particle size of 0.25 inches.

The estimated cost of the reactive barriers is 14 million dollars. Additionally, the pump and evaporate option, discussed as Option 1, would be utilized at a cost of one million dollars. This option leaves no useable water in the uppermost aquifer - it will be dry.

The cost versus benefit was determined using the following assumptions:

a) The volume of low pH solution that would be contacted by the barriers is 13 million gallons. This is the 1996 drainable volume estimated by the EPRCO study in Appendix 3 less the volume pumped out during 1997-1998.

b) The total cost would be 15 million dollars.

c) Combined with the Option 1 cost, the cost for the reactive barrier would be about $400,000/million gallons of solution. The total treatment cost including the current corrective action plan would rise to $15.6 million versus the $0.2 million maximum value of the water.

d) The concentration of Ni and Ra 226 + 228 in Highland Reservoir would not change. Ni and Ra 228 are already not detectable. Ra 226 has averaged 4 pCi/l since 1990 versus 0.8 pCi/l at Well 175. The higher Ra 226 concentration in the reservoir is probably the result of natural mineralization around the lake perimeter. The Ni and Ra 226 & 228 concentrations at Well 175 (before it went dry) would probably decline to near background since Ni solubility is pH sensitive and radium would tend to co-precipitate with gypsum as the low pH fluid was neutralized and gypsum was created. A similar barrier was not evaluated across the eastern flow. First, only U exceeds the GPLs at this well and it is not sensitive to this type of barrier. Uranium is soluble at low, neutral and high pH values. Uranium can only be precipitated in a bicarbonate/carbonate environment by reducing agents in the absence of oxygen. Second, the present flow gradient between the tailings basin and Well 125 is towards the tailings basins, so the barrier would not impact the well (see Figure 1 of Appendix 3).

Figure 2 through 5 demonstrate on graphs the cost versus benefits expressed as Ni, Ra 226 + 228 and U concentrations comparing the CAP results from the past nine years and the alternative options.

After considering the practicable corrective actions, ECMC believes that the current concentrations of PHCs at the POCs are As Low As Reasonably Achievable considering the value of TDSS ground water at the tailings basin and high cost to benefit ratio of the alternatives to ending ground water mitigation.

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FIGURE 1
MITIGATION ANNUAL OPERATING COSTS

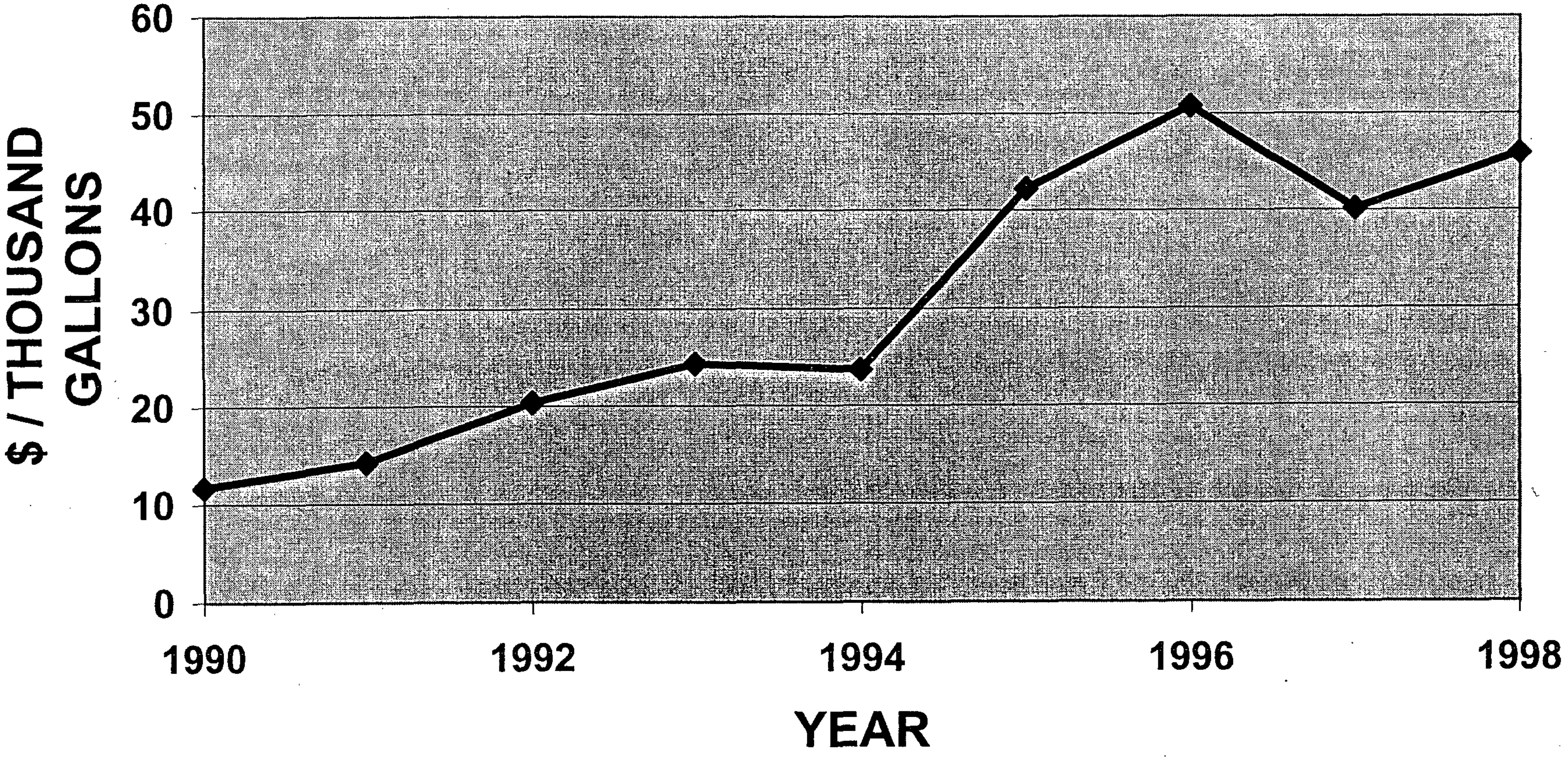


FIGURE 2

Well 125 U Concentration vs Cost

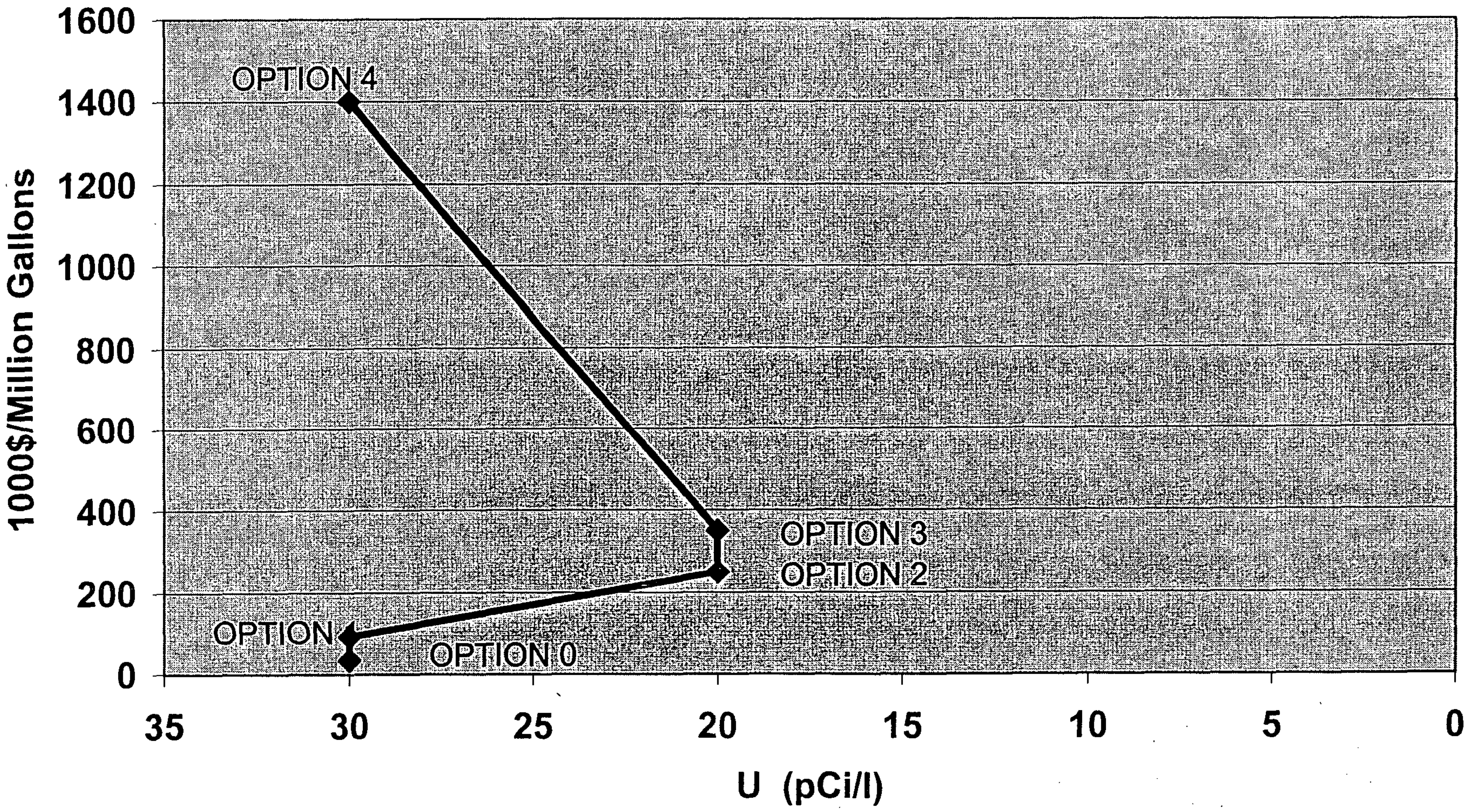


FIGURE 3

Well 175 Ni Concentration vs Cost

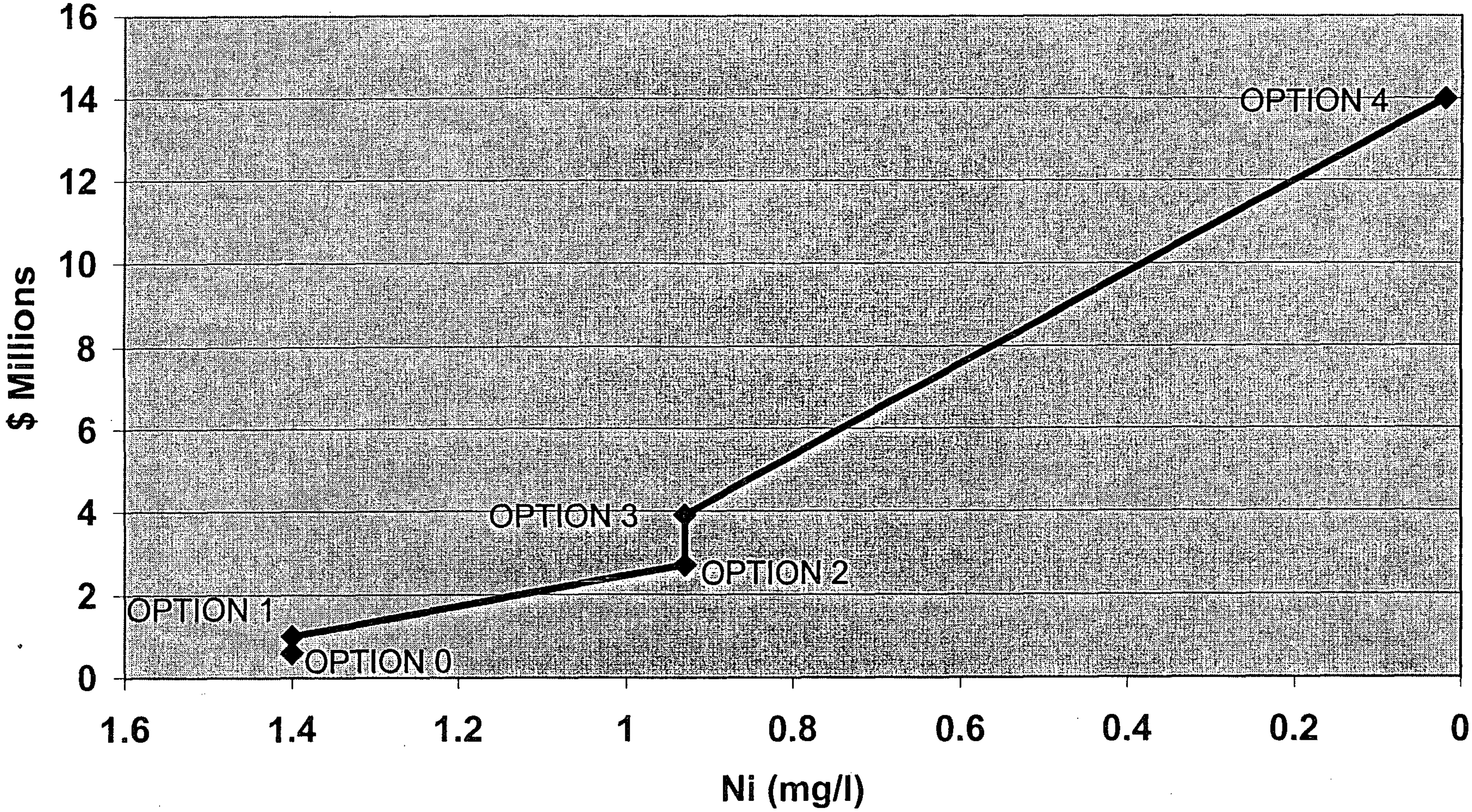


FIGURE 4

Well 175 Ra-226+228 vs Cost

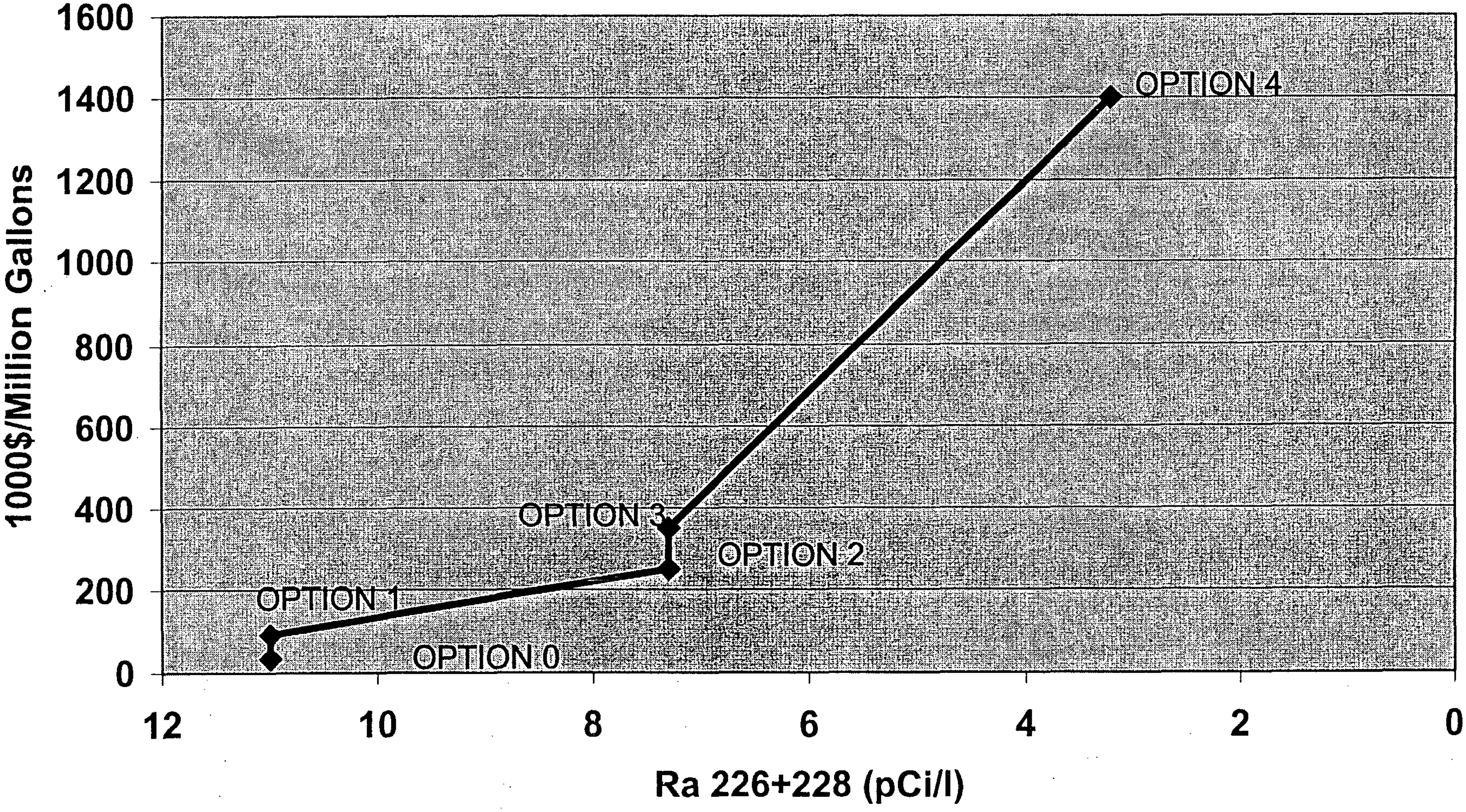
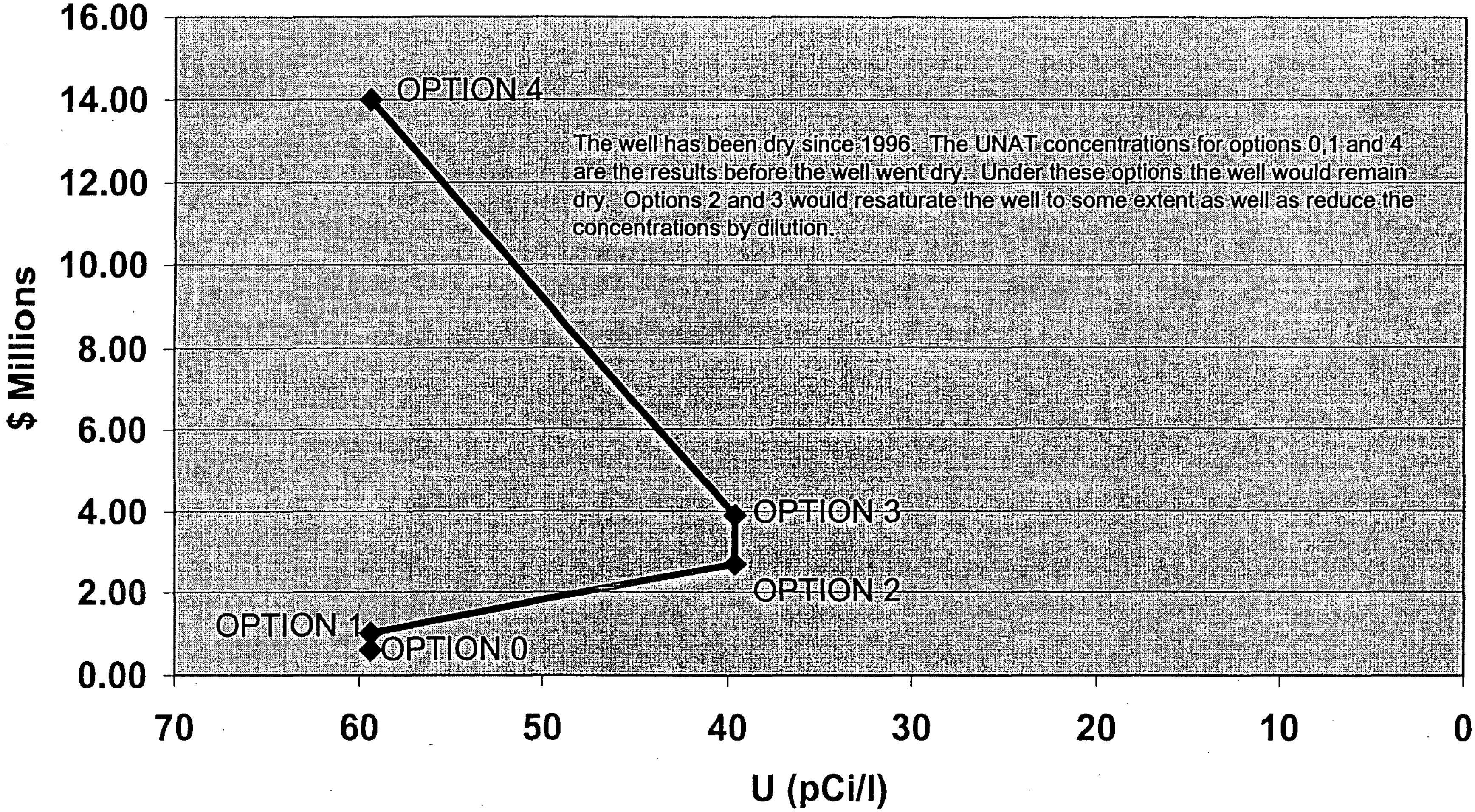


FIGURE 5

Well 177 U Concentration vs Cost



The well has been dry since 1996. The UNAT concentrations for options 0,1 and 4 are the results before the well went dry. Under these options the well would remain dry. Options 2 and 3 would resaturate the well to some extent as well as reduce the concentrations by dilution.

FIGURE 6
ACTUAL AND PROJECTED PUMPING RATE
(Continue Current Corrective Action Program)

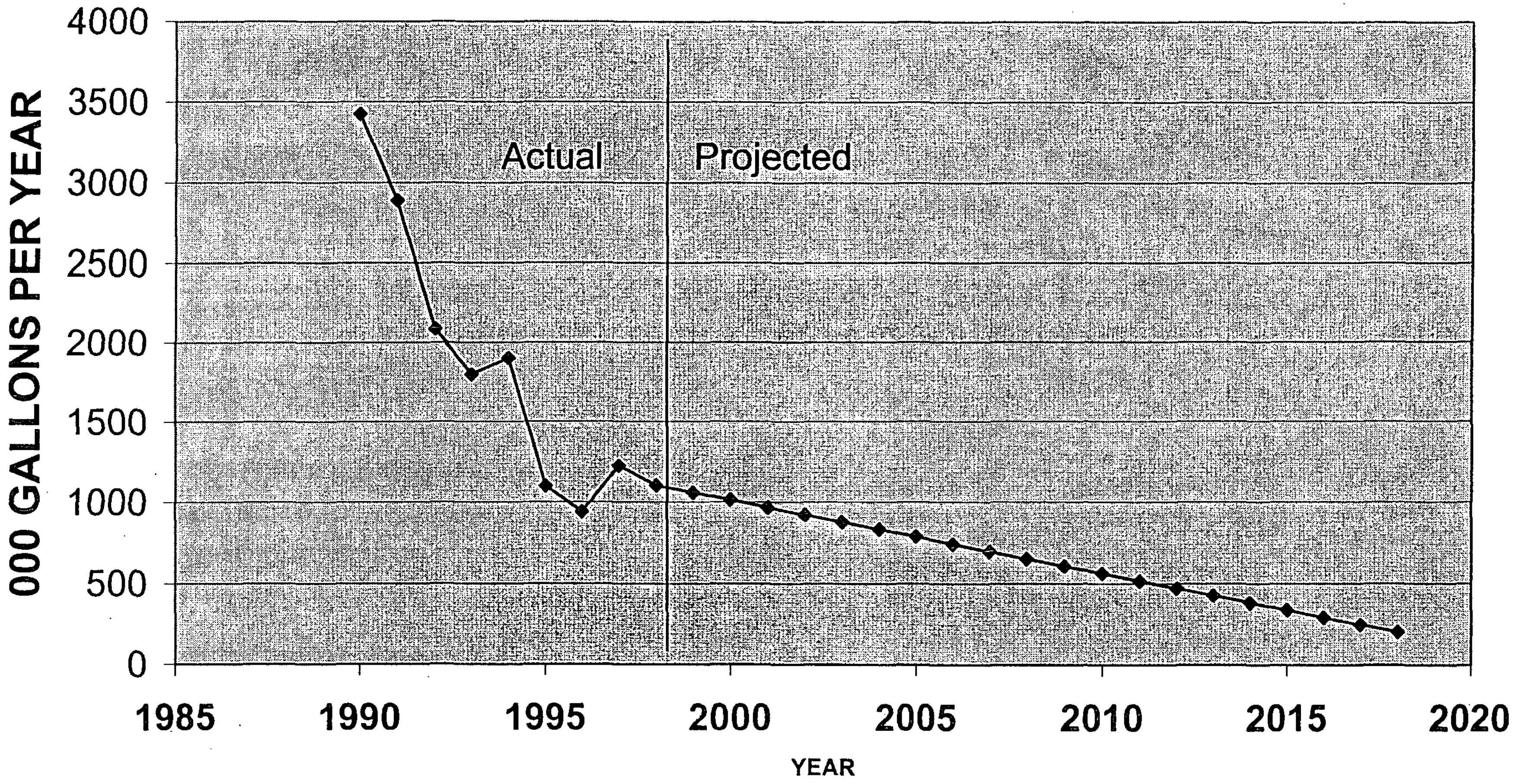


FIGURE 7
WELL 125