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Environmental Protection Technology Series

DISPOSAL OF FLUE GAS CLEANING WASTES: EPA SHAWNEE FIELD EVALUATION
Initial Report

Industrial Environmental Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Research Triangle Park, North Carolina 27711

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DISPOSAL OF FLUE GAS CLEANING WASTES:

EPA SHAWNEE FIELD EVALUATION--INITIAL REPORT

by

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ABSTRACT

This report describes the progress made during the initial phase (September 1974 - July 1975) of a field evaluation program, conducted by the Environmental Protection Agency, to assess techniques for the disposal of power plant flue gas desulfurization (FGD) wastes. The site chosen for the evaluation was the Tennessee Valley Authority Shawnee Power Station at Paducah, Kentucky. Two 10-MW prototype flue gas scrubber systems, one using lime and the other limestone, produced wastes that were stored in five disposal ponds on the plant site. Two of the ponds contain untreated wastes; each of the remaining ponds contains wastes chemically treated by one of three commercial contractors. Test samples of treated and untreated wastes, ground water, surface water, leachate, and soil cores are being analyzed in order to evaluate the environmental acceptability of current disposal technology. Based on this program, engineering estimates of total costs (capital and operating) for FGD waste treatment and disposal have been made.

This report was submitted in fulfillment of Contract No. 68-02-1010 by The Aerospace Corporation under the sponsorship of the Environmental Protection Agency.

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ACKNOWLEDGMENTS

This report, prepared by The Aerospace Corporation, is the result of a continuing cooperative effort of many individuals and organizations, all of whom have made valuable contributions to this program. The authors wish to thank the following: Frank W. Princiotta of EPA, for his guidance as the originial Shawnee Project Officer; John Williams, the current EPA Shawnee Project Officer; and Julian W. Jones, the EPA FGD Waste Disposal Program Project Officer, whose personal involvement and management of this program have been significant factors in the development of the data produced.

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CONVERSION TABLE

A list of conversion factors for British units used in this report is as follows:

British	Metric
1 acre	4047 m^2
1 Btu/lb	2.235 J/g
1 foot	0.3048 meters
1 ft^3/min	28.316 liters/min
1 inch	2.54 cm
1 gallon	3.785 liters
1 pound	0.454 kg
1 mile	1.609 km
1 ton (short)	0.9072 metric tons
1 ton/ft^2	9765 kg/m^2

SECTION I

CONCLUSIONS

This evaluation program has been underway for less than a year, and monitoring of treated sludge disposal for only a few months. Although it is too early in the program to draw conclusions, several significant results are evident from the information obtained to date. These results are as follows:

- The leachates from ponds containing treated sludge show significantly lower concentrations of major soluble species and trace metals than do leachates from ponds containing untreated sludge.
- The concentrations of major constituents in the leachates from ponds containing untreated sludge are increasing to levels approaching those in the input liquor.
- The ground waters being monitored for all ponds show no effect from either treated or untreated sludge disposal.
- The estimated total disposal cost for treated sludge of the Shawnee type, including capital and operating costs, is in the range of 0.9 to 1.4 mills/kW-hr. This estimate is based on a 50% average annual power plant load factor over a 30-yr service life. For a 65% average annual load factor, these costs are reduced approximately 7%.

SECTION II

RECOMMENDATIONS

At this point in the field evaluation program, no results have been obtained that would indicate the need for any major change in the program as currently planned. Further time is required to determine the long-term effects of the disposal of both treated and untreated sludge. Therefore, it is recommended that the program be continued as planned in order to produce sufficient field monitoring data and the associated analyses necessary for an evaluation of sludge disposal technology. Assessments of current data indicate that two to three years of monitoring may be sufficient for correlation with laboratory-accelerated test results such that knowledgable estimates of long-term effects can be made.

Two techniques not now in the program have the potential for reducing sludge disposal costs: the use of oxidized sulfite sludges and the removal of fly ash from the stack gases prior to scrubbing. Therefore, it is recommended that ponds be installed and monitored to evaluate the following techniques:

- Use of oxidized sulfite sludge that has been dewatered and compacted. During compaction, use would be made of low-moisture-content fly ash as available.
- Use of sludge from a scrubber located downstream of electrostatic precipitators. This sludge would be compacted, covered with earth, contoured, and landscaped. Low-moisture-content fly ash would be used during the compaction process.

It is further recommended that an assessment be made of the effect of these techniques on scrubber system make-up water requirements and total operating costs.

SECTION III

INTRODUCTION

As the installation of power plant nonregenerable flue gas desulfurization (FGD) systems and their resultant quantities of scrubber wastes continue to increase, the need for evaluation of waste disposal technology has become apparent. This need is based on the potential impact on water quality posed by sludge disposal and the nonstructural quality of sludge in a landfill because of the high water retention property of the sludge. Although several approaches to environmentally sound disposal are offered commercially or are being attempted by some power companies, the major sources of verification of the environmental acceptability of the disposal approaches are laboratory data or unpublished results of limited field demonstrations. The Environmental Protection Agency (EPA) Industrial Environmental Research Laboratory has, therefore, initiated a power plant site field evaluation of the disposal and monitoring of untreated and treated sludges for the purpose of verifying several disposal techniques and scrubbing operations, soil interactions, and field operation procedures on the environmental quality of the disposal site. The program began in September 1974.

The Tennessee Valley Authority (TVA) Shawnee Power Station at Paducah, Kentucky, was chosen as the site for the evaluation. Two different scrubber systems operating in parallel upstream of fly ash collection are being operated at this station as an EPA/TVA test facility, with the Bechtel Corporation as the scrubber test director. Each scrubber system is capable of independently treating up to 10 MW (equivalent) of flue gas from one boiler. Sludges from these scrubbers (i.e., a UOP Turbulent Contact Absorber and a Chemico venturi followed by a spray tower, using limestone and lime, respectively, as the SO_2 absorbent) are being used in the disposal demonstration. These sludges are undergoing analysis in several laboratories under EPA sponsorship. This program will provide a broader data base for the evaluation of flue gas SO_2 control by combining evaluations of scrubber performance and sludge disposal at the same site, while analyses are conducted of the same materials in directly related laboratory programs.

The initial plans for this program provide for five disposal sites, each occupying approximately 0.1 acre. All have been filled to a depth of approximately 3 feet, two sites with untreated sludge and three with chemically treated sludge. Potential expansion of the program includes adding several sites that will contain sludge conditioned by oxidation to gypsum, and possibly a site that will contain untreated sludge and be covered to simulate a retired pond throughout as much of the program as possible. The disposal sites are being monitored for leachate quality, ground water quality, soil chemistry changes, and treated sludge chemical and physical qualities.

The program has been underway since September 1974 and, although insufficient data and analyses are available to arrive at final conclusions, the findings and trends observed at this interim point are reported in the following sections. The evaluation program is scheduled to be completed by July 1976, and a final report issued by December 1976.

The objectives of this program are as follows:

- Evaluate current disposal techniques under representative field operating conditions.
- Evaluate the environmental acceptability of current disposal technology through periodic sampling, analysis, and assessment of water, soil, and sludge cores.
- Develop engineering cost estimates for alternative disposal methods on an operational basis.

SECTION IV

SUMMARY

The sludge disposal field evaluation program at the Shawnee Steam Plant is being conducted in order to assess the ponding of untreated sludge and the landfilling of chemically treated sludge simulating two different disposal situations. Two of the five ponds used in the program contain untreated sludge. Of the three treated sludge ponds, one represents an impoundment behind a dam, and two represent low spots (undrained) within a landfill. Sludges from two 10-MW (equivalent) scrubbers are used in the evaluations. A summary of the sludge types used in the program are shown in Table 1. All sludges used contained approximately 40% fly ash on a dry weight basis. The ponds are approximately 0.1 acre in size and 6 feet deep, and are filled to a depth of approximately 3 feet. The surfaces of the three treated ponds are sloped to create a wet section consisting of a combination of liquor and rainwater, and a potential dry section (depending on weather conditions) for the observation of physical conditions of dry material.

The ponds were filled between 7 October 1974 and 23 April 1975. Data taken until 1 July 1975 are discussed in this document; therefore, it will serve as a status report since the effects of time on program results have not been realized. It is expected that these disposal ponds will be monitored for at least another 18 months, thereby providing a much-broader data base for evaluation.

All ponds are monitored for leachate, for supernate and ground water quality, and for the characteristics of the soil and

Table 1. SHAWNEE POND DATA

Pond Designation	Scrubber Type	Sludge Absorbent/Source	Solids Content, wt%	Treatment Contractor
A	Venturi/Spray Tower	Lime/Filter Cake	46	Untreated
B	Turbulent Contact Absorber	Limestone/Clarifier Underflow	38	Dravo
C	Venturi/Spray Tower	Lime/Centrifuge Cake	55	IU Conversion Systems
D	Turbulent Contact Absorber	Limestone/Clarifier Underflow	38	Untreated
E	Turbulent Contact Absorber	Limestone/Clarifier Underflow	38	Chemfix

fixed sludge cores. Even though the monitoring period to date has been relatively short, the data obtained have provided some significant results, correlations with laboratory data, and possibly some trends. These are summarized briefly in the following paragraphs.

4.1 UNTREATED SLUDGE

In the ponds containing untreated sludge, the data obtained from leachate samples to date show that the concentrations of the major soluble species, i.e., calcium, sulfate, and chloride (and, of course, total dissolved solids), progressively increase with time. The data also indicate that the concentration levels are approaching those measured in the input liquor. Simultaneously, the concentrations of these same constituents in the pond supernate vary with time. Neither the sludge nor the scrubber system liquor is replenished, therefore, the supernate should become increasingly diluted with rainfall as the program progresses. Some fluctuation in this trend can be expected as a result of evaporation during dry periods. The detection of heavy metals in the leachate and supernate of the untreated ponds shows trends similar to the major species, however, concentration projections are not as easily made because of the relatively small magnitude of the values. Continued monitoring is expected to clarify this situation. Thus far, ground water quality shows no effect from the constituents of the untreated ponds. A sample plot of water analysis from Pond A is given in Figure 1, and a presentation of all data for the untreated ponds is given in Paragraph 8.2.3 and Appendix C.2.

4.2 TREATED SLUDGE

The data from the ponds containing treated sludge, although sampled over a shorter period of time, show trends similar to those of the untreated sludge, except the reductions of concentrations owing to chemical fixation are evident in the leachate analyses. Indications are that these concentrations either start at or quickly build up to approximately 50% of the respective concentrations in the liquor of

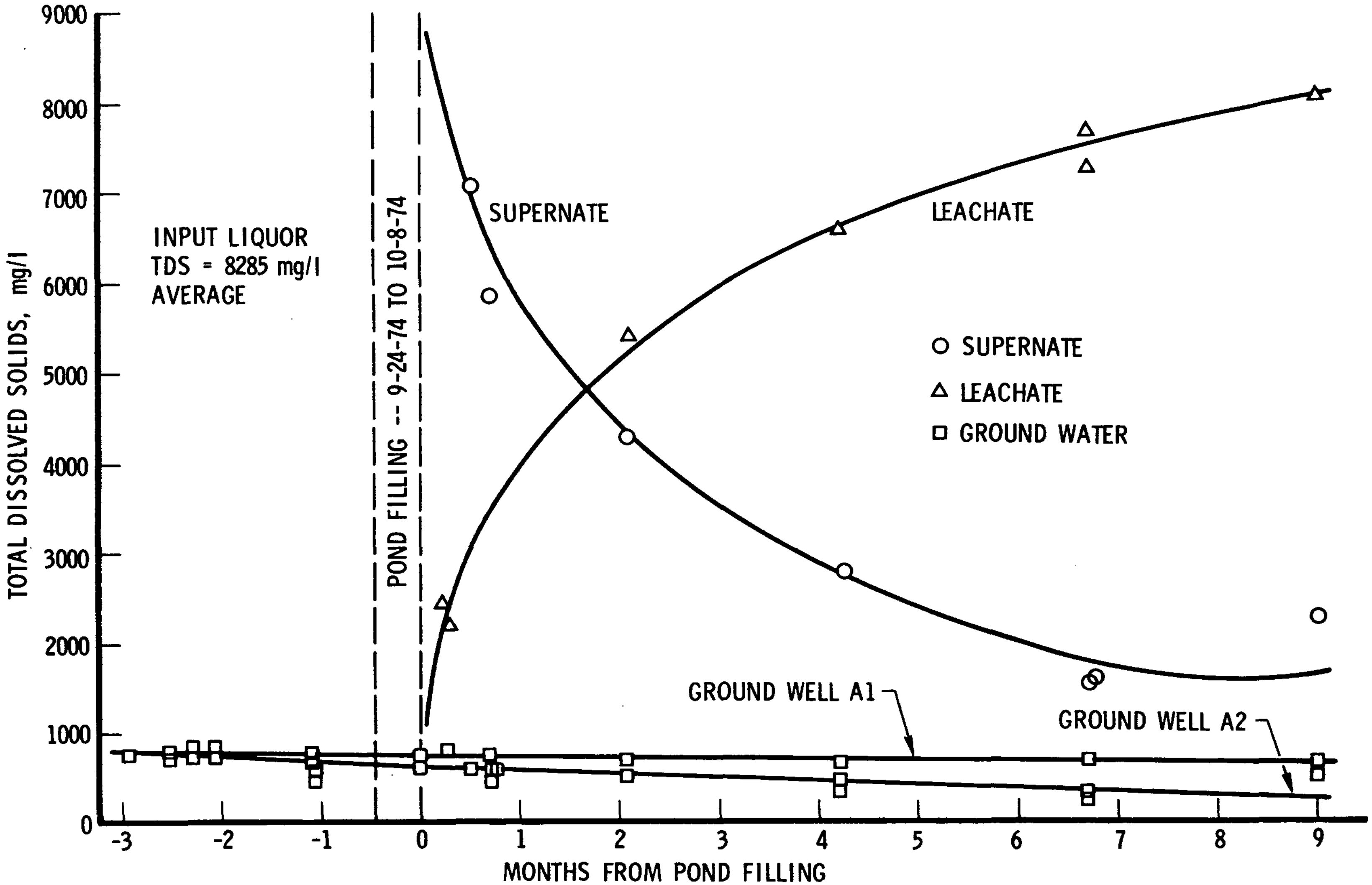


Figure 1. Sample plot of total dissolved solids in supernate, leachate, and ground water wells of Pond A

the untreated input sludge. These data correlate with a large body of data from analyses of laboratory-prepared samples, and if these correlations continue, the field evaluations should show a reduction of concentrations to relatively insignificant values after the effects of fixation have stabilized. (These correlations will be contained in an Aerospace report prepared for EPA entitled "Disposal of By-Products from Non-Regenerable Flue Gas Desulfurization Systems," to be released early in 1976.) The time-dependent results of these evaluations will be determined as this program progresses. As with the untreated sludges, the supernates of the treated ponds are showing the effects of change resulting from rainfall, evaporation, and seepage; thus far, ground waters are unaffected. A sample analysis of Pond E is given in Figure 2, and all data for the treated ponds are presented in Paragraph 8.2.4 and Appendix C.2.

Results of physical analyses of laboratory-prepared samples indicate that sludges treated for solubility control attain unconfined compressive strengths of 4.5 ton/ft^2 or better, and permeability coefficients are improved generally by one to two orders of magnitude to the range of 10^{-5} to 10^{-6} cm/sec, and in some cases to 10^{-7}. Sampling is being continued at Shawnee to confirm the laboratory results and to assess compressive strength and permeability of field-treated sludges with respect to time. Moreover, an attempt will be made to assess percentage of additive in relation to strength and permeability, as possible.

4.3 SOIL

As noted, the ground waters show no evidence of altered quality resulting from the filling of any of the five ponds. This result is in agreement with expectations based upon the very low permeabilities of the clay soils from the floor of the ponds. Analyses conducted by TVA show a typical permeability in the range of 10^{-8} cm/sec for these soils. Thus, in one year, the sludge leachate constituents would be expected to permeate to a depth of less than 0.5 inch. Laboratory

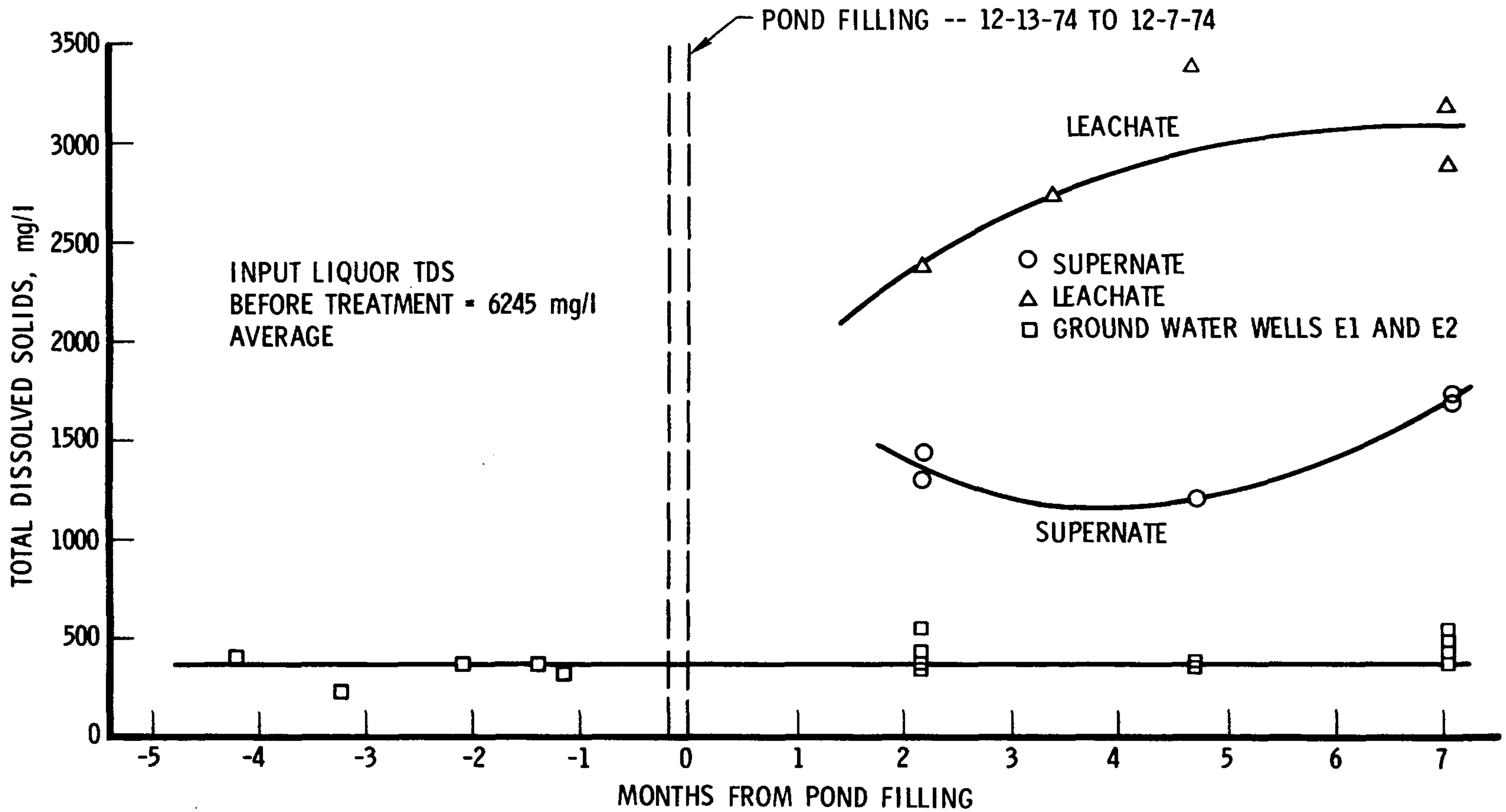


Figure 2. Sample plot of total dissolved solids in supernate, leachate, and ground water wells of Pond E

analyses using an ion microprobe mass analyzer are underway at The Aerospace Corporation to detect the progress of the constituents in successive soil cores in order to verify long-range analytical predictions over a relatively short time period, i.e., within the time span of the evaluation program. Details of the analyses are described in Section 8.2.5.2. Measurements have been completed on pond floor core samples taken prior to filling the ponds in order to provide background data for future tests. Results are shown in Appendix C.7.

4.4 TOTAL DISPOSAL COSTS

Engineering cost estimates have been prepared for the total costs associated with the disposal of treated Shawnee-type sludge from a 1000-MW power station producing sludge at a rate of 125 ton/hr on a dry basis. The costing was done for disposal at distances of 0.5 and 5.0 miles from the power plant. It was assumed that the service life of the equipment involved was 10, 15, or 30 years, as appropriate. Power plant average annual load factors of 50% and 65% were also assumed over a 30-yr service life.

The results of the cost analysis, using fixation contractor inputs adjusted by The Aerospace Corporation to provide a common base for capital and operating cost factors, are shown below.

Total Disposal Costs, 1975 Dollars

Per Ton of Sludge (Dry Basis)	Per Ton of Coal (Eastern)	Mills per kW-hr
$7.30 - 11.40	$2.07 - 3.24	0.9 - 1.4

These costs were determined for an average annual operating load factor of 50% over a 30-yr lifetime. Locating the disposal site 0.5 mile from the power plant rather than the 5 miles used as a baseline above and increasing the annual operating load factor from 50 to 65% reduce the disposal costs by approximately 9 and 7%, respectively.

The sludge includes fly ash, which is collected along with the SO_2 waste. The estimates represent the total disposal cost and do not reflect any credit for separate disposal of fly ash.

Total disposal costs are presented in Paragraph 9.4 for the three processes used under different conditions, as functions of solids content in the sludge and of the percent of additive. In all cases evaluated to date in this program, the higher the solids content the lower the amount of fixation additive needed. As the cost of the chemical additives is one of the major elements in the disposal cost, an Aerospace analysis was made to determine the major parameter associated with reducing additives, i.e., dewatering. This analysis determined that a net saving in processing costs can be achieved by dewatering, as the increased cost of dewatering is more than offset by the corresponding reduction in additive and processing costs. In addition, a reduction in sludge volume as a result of dewatering could further reduce overall disposal costs. In this regard, comparative economics achieved by separating the fly ash prior to treatment and adding it to a clarifier underflow or to a filter or centrifuge cake will be evaluated.

4.5 POTENTIAL PROGRAM EXPANSION

Since the inception of this program, technological developments and assessments by various organizations, including EPA research laboratories, power companies, and commercial waste handlers, have indicated an increased potential for sludge ponding without fixation. This process involves methods by which the sludge is dewatered and placed in a pond where underflow and supernate are collected and recirculated to the scrubber. The dewatered sludge would be compacted after placement. Techniques suggested include the following: (1) oxidation and dewatering of sulfite sludges with and without fly ash, and (2) scrubbing downstream from electrostatic precipitators and dewatering of the sludge. Compacting with available low-moisture-content fly ash would occur at the disposal site. These methods have not been validated from an environmental standpoint, but the Shawnee disposal evaluation site could accommodate chemical and structural evaluations of these types of disposal to determine whether they would be feasible. Monitoring and evaluation techniques now being conducted for the current program could be used. Additionally, evaluations of the effects of increased water recirculation to the scrubber, i.e., tightening the loop, should be made as well as economic studies. A further advancement of disposal technology would include the retiring of one of these ponds after filling. It would be capped with a clay cover, contoured, and landscaped; the monitoring and evaluating of well water samples would be continued; and the structural quality of the site would be evaluated.

SECTION V

ORGANIZATION AND MANAGEMENT

This program is managed by the EPA Industrial Environmental Research Laboratory, Research Triangle Park, North Carolina. The functional relationships of the other organizations participating in the program are shown in Figure 3.

The Aerospace Corporation is responsible for program coordination, writing and maintaining the program plans, selected analyses, evaluation and assessment of all analytical results including costing, and reporting of program activities and analyses.

The Tennessee Valley Authority (TVA) is responsible for all construction, filling of untreated ponds, supplying sludges to fixation processors at the site, maintenance, sampling and analyses, sample distribution, climatological and hydraulic data collection, photographic documentation (still and motion picture), and contracting with sludge fixation processors. TVA also provides analytical data, climatological and hydraulic data, and photographic documentation to The Aerospace Corporation for assessment and inclusion in formal reporting to EPA.

The sludge fixation processors are Chemfix, Inc., Pittsburgh, Pennsylvania; Dravo Corporation, Pittsburgh, Pennsylvania; and IU Conversion Systems, Inc., Philadelphia, Pennsylvania.

The Bechtel Corporation provides the technical interface relating the scrubber test facility to the disposal demonstration.

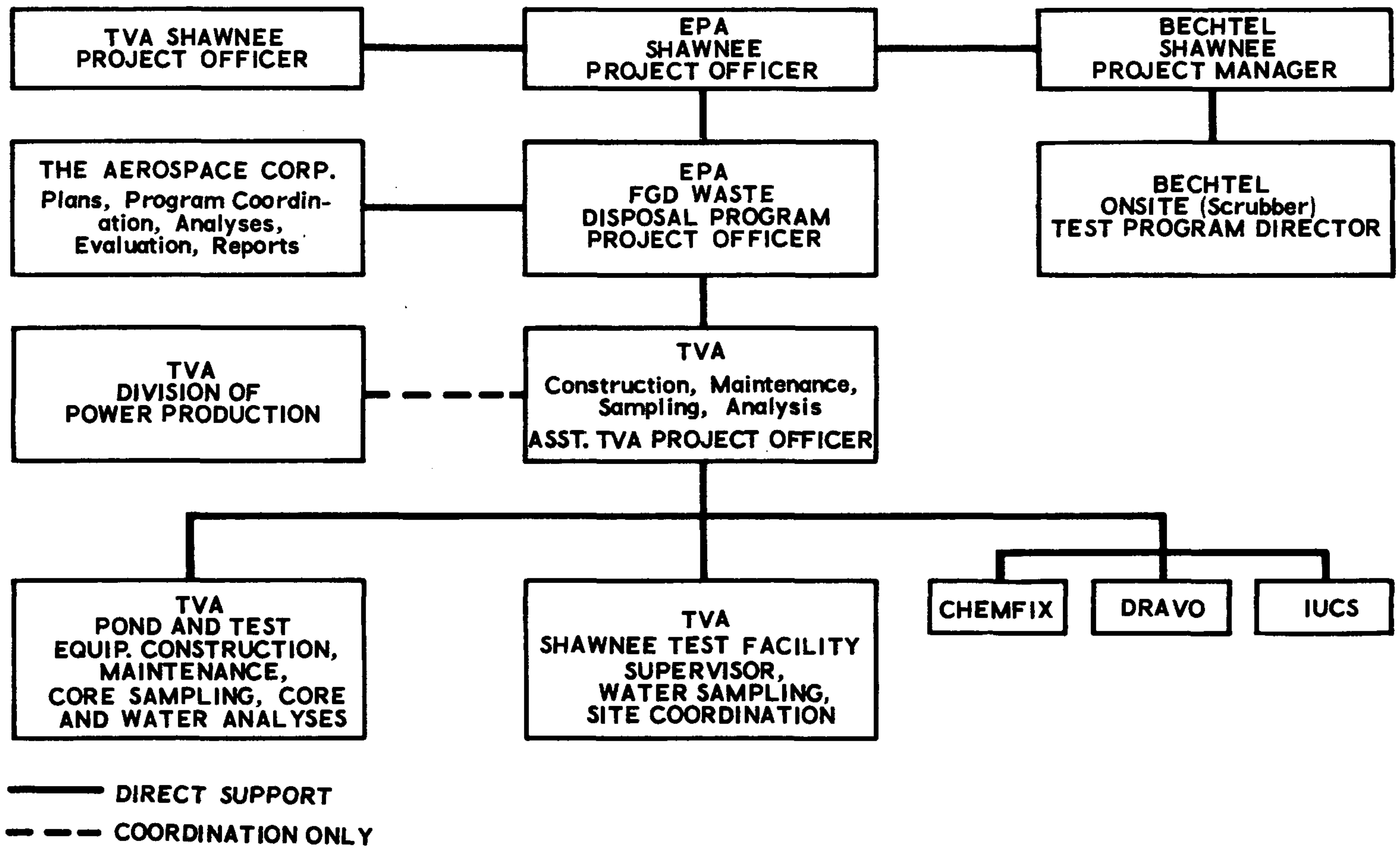


Figure 3. EPA Shawnee disposal field evaluation, functional organization

SECTION VI

SITE AND FACILITY DESCRIPTION

6.1 GENERAL

The site on which the disposal evaluation is being conducted is located approximately 0.5 miles from the TVA Shawnee Steam Plant near Paducah, Kentucky (see Figure 4). The Shawnee plant has ten generating units capable of producing a total of 1,750,000 kW of electric power. At its typical level of operation, Shawnee consumes 4,500,000 ton/yr of bituminous coal from the coal fields of western Kentucky and Illinois.[1] This coal has an average sulfur content of approximately 3.5%.

6.2 TEST FACILITIES

Two prototype wet lime/limestone scrubbers, each capable of treating approximately 30,000 ft^3/min (at 300°F) of flue gas, are currently operating in parallel on Shawnee boiler no. 10 (see Figure 5).[2] Gas is withdrawn from the boiler ahead of the power plant particulate removal equipment so that entrained fly ash is introduced into the scrubber. The two scrubbers, each of which treats an equivalent of 10 MW of boiler capacity, produce an effluent slurry containing sulfite, sulfate, chloride, and trace metals. The effluent is pumped to a thickener area from which sludge can be removed from a clarifier, centrifuge, or filter for placement in one of five disposal areas. Both treated and untreated sludges are being tested in the evaluation program.

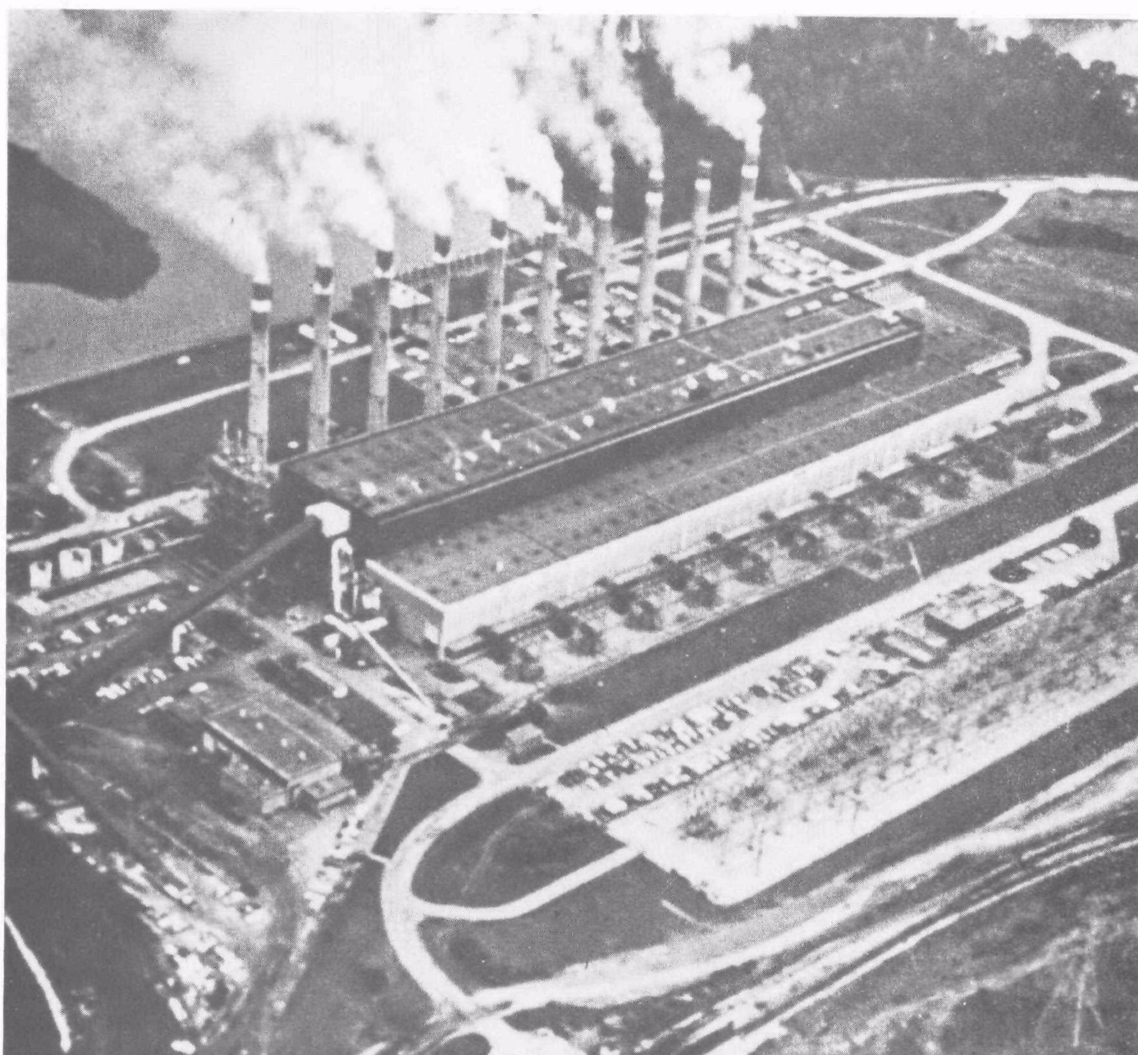


Figure 4. Shawnee steam plant

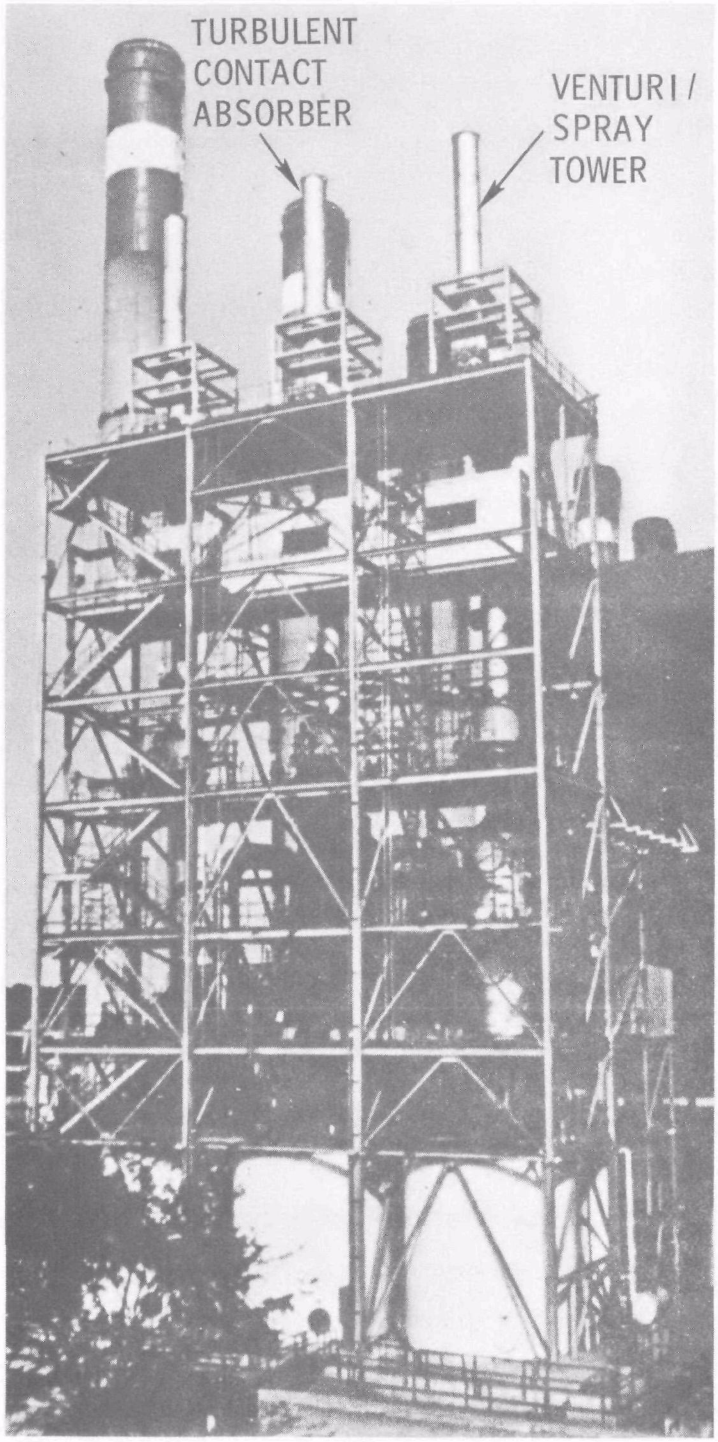


Figure 5. Prototype scrubber installation at Shawnee boiler no. 10

6.3 PONDS

The five disposal areas identified as Ponds A, B, C, D, and E are shown in relation to the power facility in Figure 6. Pond A measures 85 by 105 feet, and the other ponds measure 37 by 133 feet. All ponds are 6 feet deep, have 2:1 side slopes, and have bottom surfaces generally in the horizontal plane. All berms are contoured to drain away from each pond. Sludge is placed in the pond to a depth of approximately 3 feet. A wooden pier has been constructed at one end of each pond to serve as a support for a leachate well and to provide a sampling station for obtaining leachate well water. Pond A is filled with untreated lime sludge filter cake, and Pond D with untreated limestone sludge clarifier underflow. Ponds B, C, and E are filled with chemically fixed material by the Dravo Corporation, IU Conversion Systems, Inc., and Chemfix, Inc., respectively. Pond well nomenclature and dimensions are shown in Figure 7.

6.3.1 Ground Water Well Construction

A ground water well has been constructed at each pond on the berm approximately opposite the leachate well to measure the quality of ground water. The well is located downstream from the pond, relative to the direction of ground water flow. The well shaft extends 3 feet below the water table. A 4-in.-diameter plastic pipe, anchored in concrete and packed with clay to prevent seepage down the shaft, has been installed to extend below the ground water level. This pipe is covered with a force-fit plastic dust cap.

A second ground water well has been constructed approximately 100 feet from each pond in the ground water upstream direction for background water quality measurements. These wells are similar to those constructed on the berms. As an exception, the background well for Pond B serves also as the background well for Pond D.

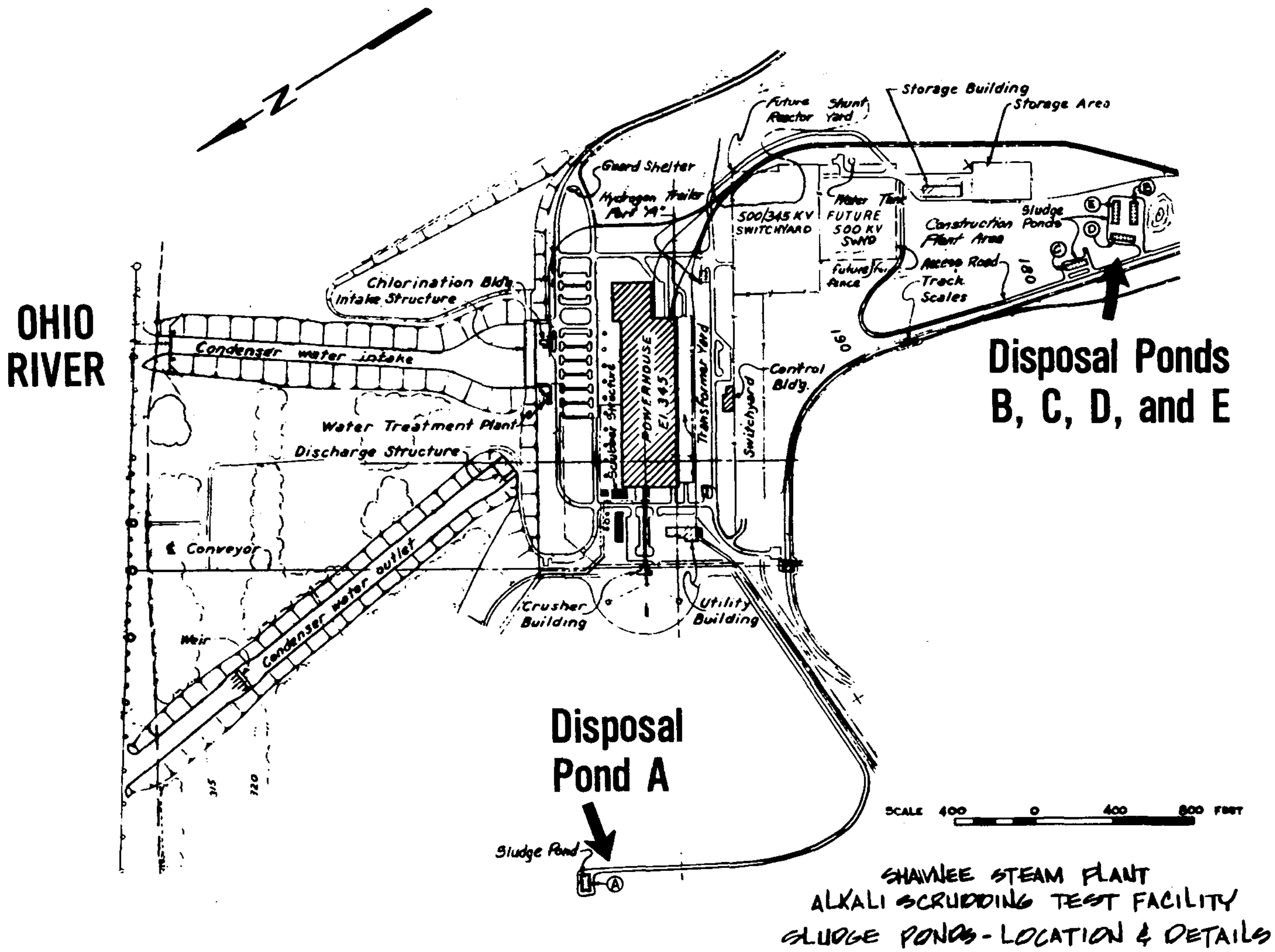
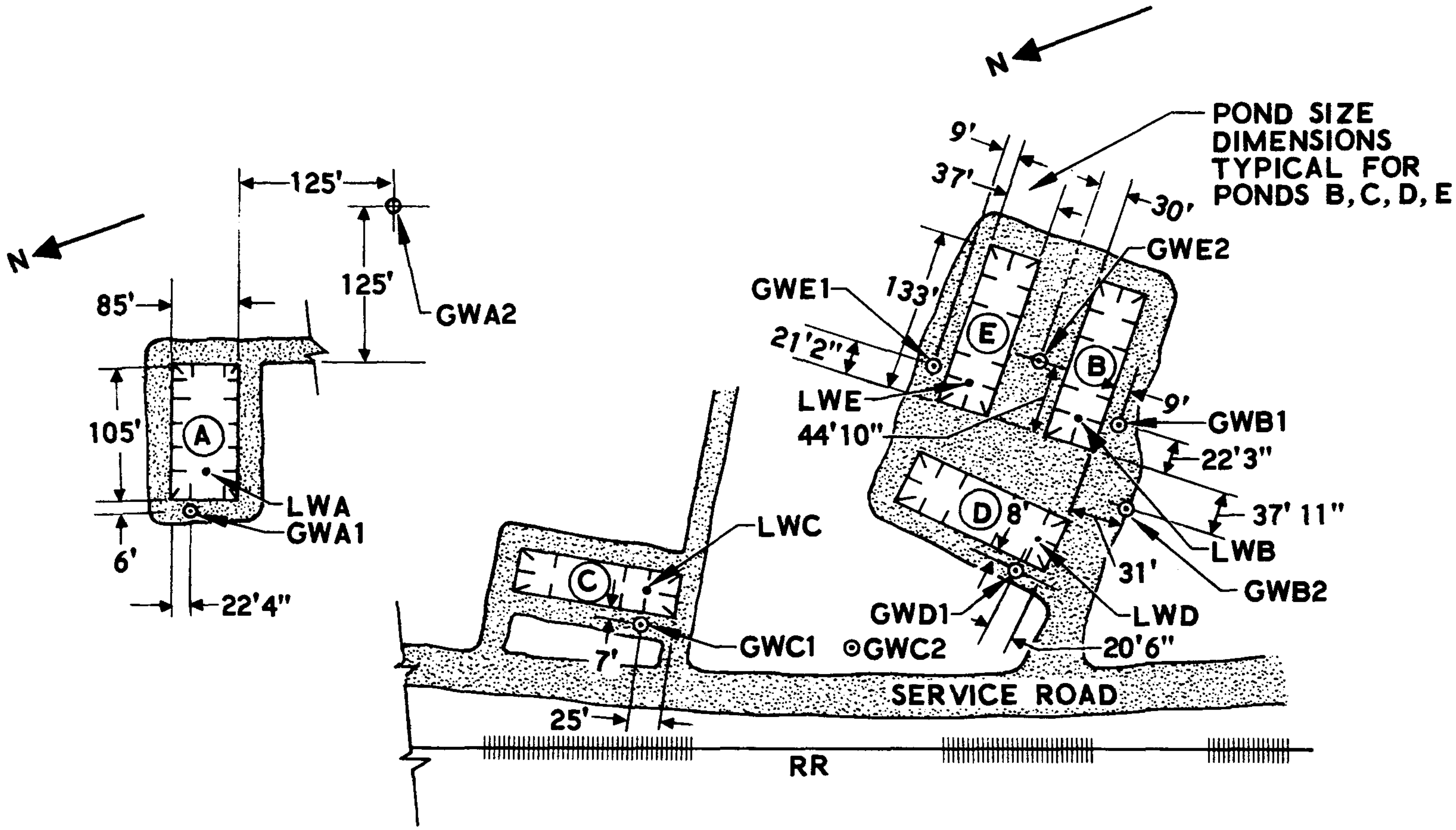


Figure 6. Shawnee steam plant alkali scrubbing test facility, sludge ponds location, and details (courtesy of TVA)



LEGEND:
⊙ DENOTES GROUNDWATER WELLS (GW)
· DENOTES LEACHATE WELLS (LW)

Figure 7. Disposal pond well nomenclature

6.3.2 Leachate Well Construction

A leachate well has been constructed on the flat bottom of each pond near a corner or one side and adjacent to the pier. The purpose of these wells is to provide water samples that can be analyzed to determine the quality of the water that seeps through the sludge (either untreated or treated) and enters the soil of the pond bottom.

The well is constructed using a 4-in.-diameter plastic pipe implanted as shown in Figure 8. This configuration is arranged to prevent solid material from blocking the entrance to the pipe. The pipe extends approximately 5 feet above the base of the pond. It is anchored to the pier and is covered with a force-fit plastic cap to prevent entry of foreign matter (including rainwater) into the well. The installation is such that surface water cannot freely flow between the sludge and the pipe, or through the upper end.

6.4 CLIMATOLOGICAL AND HYDRAULIC DATA STATION

A data-taking station, containing both recording and nonrecording instrumentation, has been installed for the purpose of determining weather conditions at the site that may affect the disposal evaluations. Initially, this station was located in the vicinity of Pond A; however, since February 1975, it has been located in the vicinity of Pond D.

Measurements made at this station include the following:

a. Air and water temperature
b. Precipitation
c. Evaporation
d. Wind movement
e. Relative humidity
f. Solar radiation

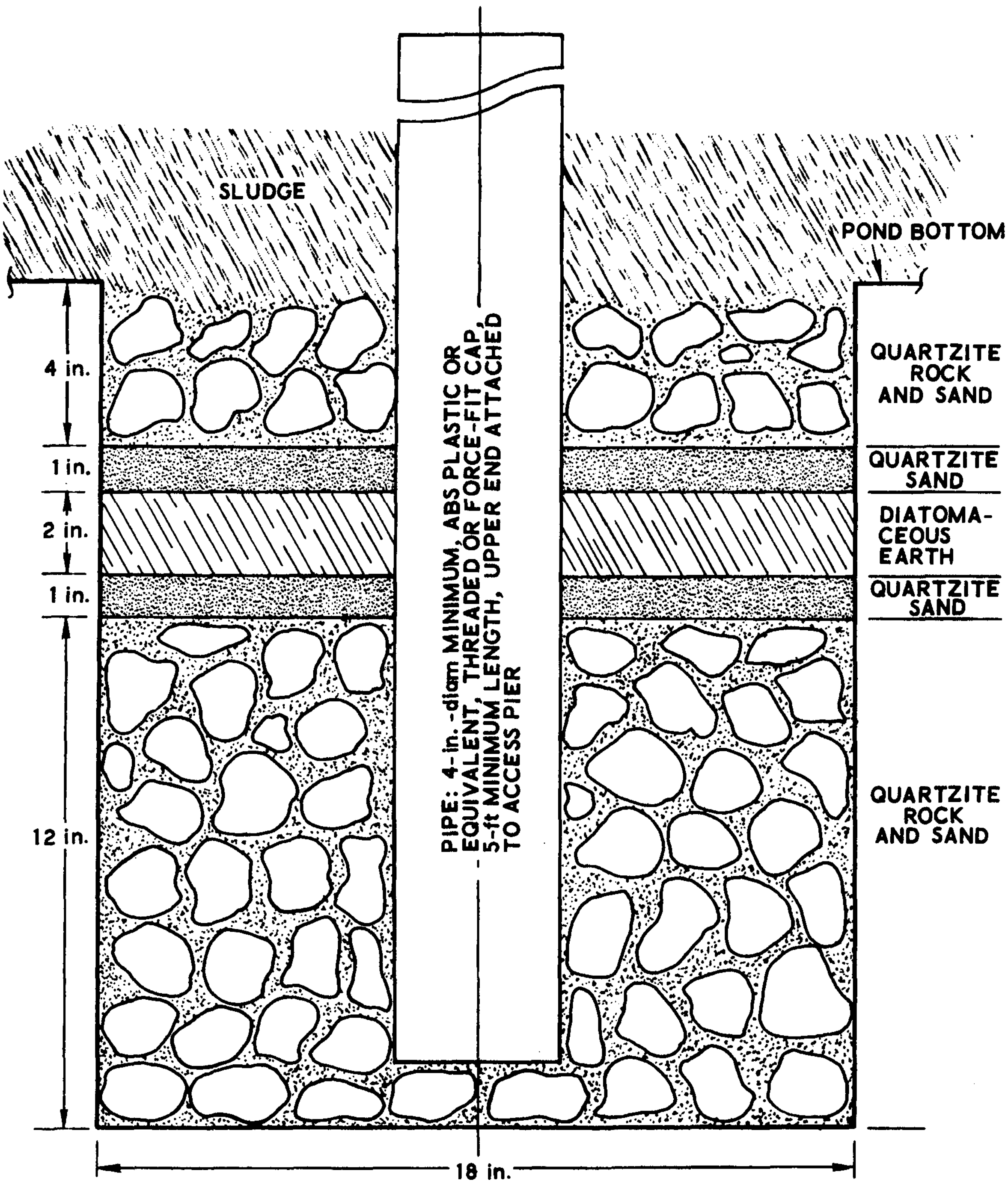


Figure 8. Leachate collection well

SECTION VII

OPERATIONS AND SCHEDULES

Operations began on this field evaluation program in September 1974 with the completion of construction of the five disposal ponds, A through E, previously described in Paragraph 6.3. Pond filling for all ponds, for both treated and untreated sludges, was completed by mid-April 1975. Analyses are being conducted on soils, input sludge, treated sludge, ground water, leachate, and supernate.

7.1 POND FILLING AND FIXATION

The five disposal ponds were filled with sludges representing a cross section of scrubber effluent conditions. The two ponds filled with untreated sludge were selected to evaluate both lime and limestone scrubbing waste disposal as well as a variation in the degree of sludge dewatering as shown previously in Table 1. The operations associated with the ponding of untreated sludges were as follows.

7.1.1 Untreated Ponds

7.1.1.1 Pond A

Pond A was filled between 24 September and 8 October 1974 with untreated sludge from the venturi/spray tower scrubber in which lime was used as the absorbent. The sludge had been dewatered by filtering and had a solids content of 46 wt% when it was placed in the pond. Ash constituted approximately 43 wt% of the solids. A rotary drum mixing truck was used to haul the sludge to the pond in order to maintain a homogenous mix during loading and transport. Dispersal of the sludge in the pond was achieved by dumping the sludge at various locations in the pond from which it was allowed to settle and seek its natural level. The condition of the sludge in Pond A one month after filling is shown in Figure 9. Rain water accumulated on the pond over the next few weeks, as shown in Figure 10.

7.1.1.2 Pond D

Pond D was filled twice, i.e., from 11 to 20 October 1974 and from 13 January to 5 February 1975. The material used in the first filling was subsequently transferred to Pond E; during the transfer the material was chemically treated by Chemfix. The sludge used for both fillings was clarifier underflow from the Turbulent Contact Absorber, with limestone as the absorbent and a solids content of 38 wt%. Likewise, on both occasions, ash represented approximately 38 wt% of the solids. For both fillings a rotary drum mixing truck was used to transport the sludge to the pond, and dispersal was as described for Pond A. The condition of Pond D two months after the second filling is shown in Figure 11.

7.1.2 Treated Ponds

The materials used in the evaluation of chemical fixation also represented various disposal operating conditions. Pond B was filled using clarifier underflow chemically treated by Dravo and placed in the pond under conditions approximating disposal behind a dam. Pond C was filled using sludge that had been dewatered by centrifuging, fixed by IUCS, and stored in the pond under conditions representing a landfill. Pond E was filled with clarifier underflow chemically treated by Chemfix and placed in the pond under conditions representing a landfill. Processor recommendations on additive quantities for each of these processes are contained in Sections 7.1.2.1 through 7.1.2.3 and in the cost discussion in Section IX. Liquor on the surface and rainwater were allowed to remain in these ponds to represent a low spot in a landfill from which water foes not readily drain.

Figure 9. Pond A one month after filling

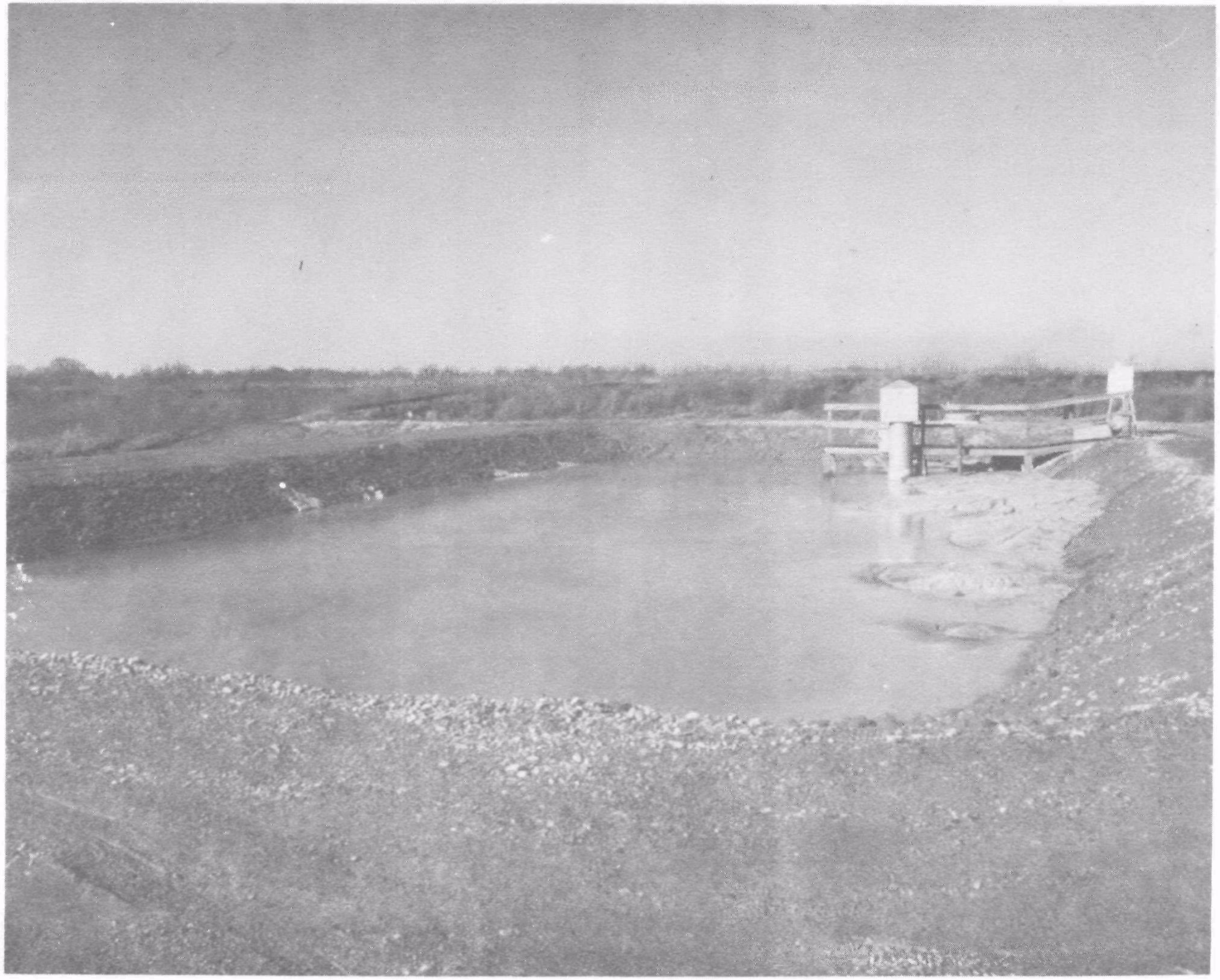


Figure 10. Pond A two months after filling

Figure 11. Pond D two months after second filling

The operations associated with the filling of each of these three ponds were as follows.

7.1.2.1 Pond B (Dravo)

Pond B was filled from 7 to 15 April 1975. The effluent delivered to Dravo was limestone/clarifier underflow from the Turbulent Contact Absorber. The sludge was 38 wt% solids and the solids contained 40 wt% ash. Dravo received the effluent from the clarifier, used a rotary drum mix truck for transportation, and added the Dravo proprietary additive (Calcilox®) to each truck load from 55-gal drums through the use of a fork lift. The amount of Calcilox® added represented approximately 11 wt% of the dry solids being treated. In the Dravo process, treated sludge is slurry transported to either an interim pond or a permanent impoundment. The sludge settles to approximately 45 wt% solids and stabilizes at a rate that is controlled by Calcilox® content. Interim stabilization to permit excavation and compaction as a landfill usually requires about ten days. If the sludge is pumped directly to final disposal behind a dam, less Calcilox® is required because rapid stabilization is unnecessary.

Delivery to the disposal site can be made by pipeline or by other transport modes. Because of the small scale and temporary nature of this project, the treated sludge was dumped directly into Pond B and allowed to settle and cure under the supernate and subsequent rainwater. Under normal field conditions the supernate would be returned to the scrubber loop. Views of Pond B six days and two months after filling are shown in Figures 12 and 13, respectively. Solids can be seen in the foreground in Figure 12.

The purpose of this process is to treat sludges of various solids content. It produces a material that resembles cemented soil in consistency for use as a material for landfill, either by mechanical compaction or by stabilization behind a dam. (Dravo has recommended Reference 3 for further information on their process.) Pond B at Shawnee simulates the latter condition, except

Figure 12. Pond B six days after filling

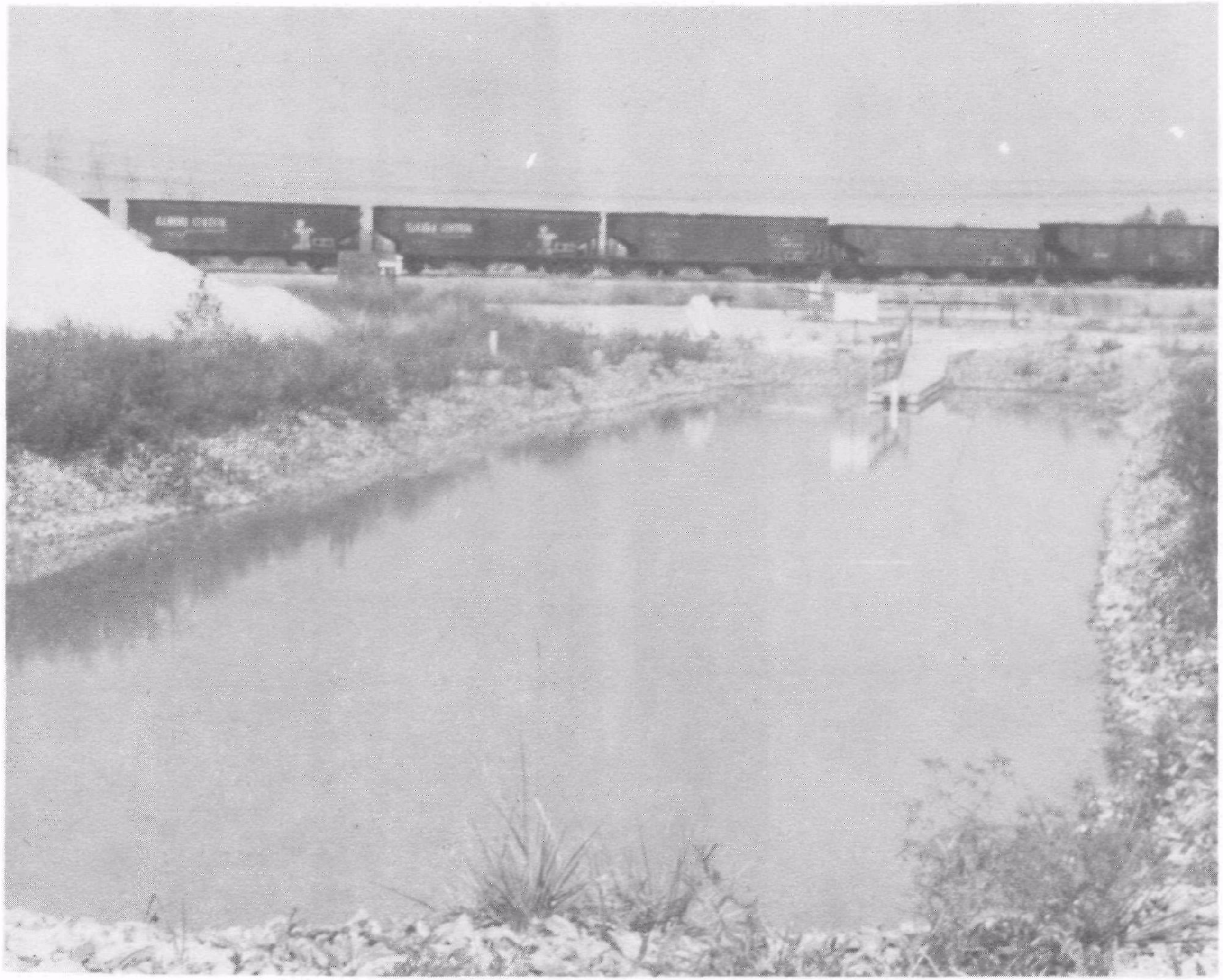


Figure 13. Pond B three months after filling

there is no recirculation of the supernate in the Shawnee evaluation. In this evaluation, Calcilox® with some lime (approximately 0.1%) for pH adjustment was prepackaged for 10 to 11 wt% additive based on an expected sludge solids content of 35 wt% that was diluted further by pump seal water. Based on the experience gained at Shawnee and their laboratory data, Dravo recommended a 7.5 wt% additive level for a full-scale operation using Shawnee-type sludge, with an assumed average of 38 wt% solids.

7.1.2.2 Pond C (IU Conversion Systems)

Pond C was filled from 31 March to 23 April 1975. The sludge delivered to IUCS was from the venturi/spray tower scrubber (using lime as the absorbent) and was clarifier underflow dewatered by centrifuge. The average solids content was 55 wt%, and the ash comprised 45 wt% of the solids. The centrifuged sludge was conveyed to an IUCS-operated rotary drum mixer truck and transported to the pond site where additive was mixed with the sludge prior to discharge into the pond.

The IUCS process produces a material identified as Poz-O-Tec®, which has applications as landfill, artificial aggregate, and road base courses (see References 4 through 8). In this evaluation, IUCS used a lime additive premixed with fly ash. The quantity of lime is dependent on the moisture content of the sludge and the reactivity of the fly ash already contained in the sludge. In some cases, dewatering of the sludge is necessary for the desired reactions to take place using economical amounts of the additives. In the Shawnee field evaluation, the sludge solids content ranged from 47.5 to 59 wt%, and the average additive quantity used was approximately 4.8 wt% lime of the dry solids being treated plus approximately an equal amount of fly ash. Delivery of the treated sludge to the disposal site by truck is generally the transport mode recommended by IUCS for a full-scale disposal operation under conditions similar to those of the Shawnee evaluation.

A significant benefit claimed for this method of fixation is low permeability. In this evaluation, the sludge was dispersed by manual raking, and some degree of compaction was achieved by this process. Dispersal and compacting methods appropriate to handling large quantities would be required in a full-scale operation. Figures 14 and 15 show Pond C three days and three months after filling, respectively.

IUCS reported that a lime additive of 1 to 4 wt% (dry) would be used operationally for Shawnee-type sludges and that the addition of dry fly ash is not mandatory, nor is it planned for full-scale operations, when a substantial quantity of fly ash is present in the sludge as is the case at Shawnee.

7.1.2.3 Pond E (Chemfix)

Pond E was filled between 3 and 7 December 1974 using the sludge stored in Pond D as input material. This sludge was clarifier underflow from the Turbulent Contact Absorber in which limestone was used as the absorbent. The solids content was 38 wt%, and ash constituted 38 wt% of the solids. The sludge stored in Pond D was thoroughly mixed before it was pumped from the pond into a Chemifix processing trailer and then pumped into Pond E (see Figure 16). The Chemfix process used the reaction of sodium silicate and portland cement with the sludge to stabilize it. After the material had cured, it was contoured with a back hoe so that it would more evenly cover the pond surface and so that an evaluation could be made of a fixed material that had been fractured and moved by heavy equipment (see Figures 17 and 18).

The Chemfix process is designed to handle sludge fixation over a broad range of percent solids and produces a material having a soil-like appearance. Furthermore, it is not designed to prevent the percolation of water but rather to bind the constituents chemically in order to accomplish pollution control, while also providing structurally stable properties (see References 9 through 13).

Figure 14. Pond C three days after filling

Figure 15. Pond C three months after filling

Figure 16. Pond E during filling, before contouring

Figure 17. Pond E five months after filling and contouring

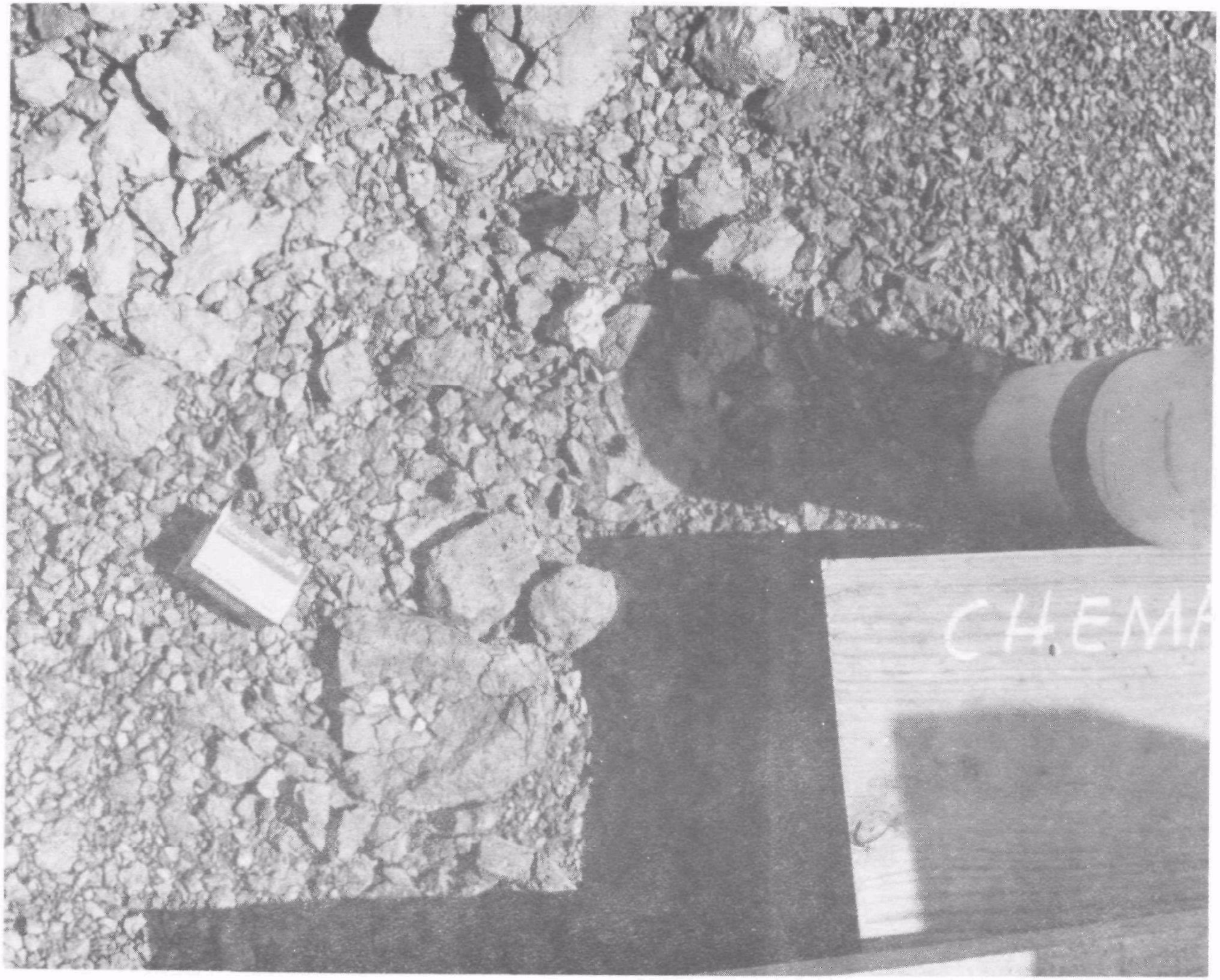


Figure 18. Pond E five months after filling and contouring (close-up)

In accordance with the specification provided Chemfix for the Shawnee evaluation, they treated clarifier underflow. In their process, the amount of additives is significantly affected by the moisture content of the sludge and the degree of drainage of the landfill. For the Shawnee evaluation, with 38 to 40 wt% sludge solids and the treated sludge in an undrained landfill, Chemfix reported that the additives required were 46 wt% of the solids content. Chemfix also reported the following: (1) If the water in the pond above the treated material were removed, the additive required to achieve an equivalent condition would be reduced to 38.8 wt%. (2) Dewatering of the sludge to 50 wt% solids would reduce additive requirements to approximately 15 wt% of the dry solids content. (3) Dewatering to 55 wt% solids would further reduce the additive requirements to about 9 wt% of the dry solids content.

7.2 SCHEDULES

A general program schedule and separate schedules for the activities at each pond are shown in Tables 2 through 7. The activities that have been completed are indicated by solid triangles.

Table 2. GENERAL SCHEDULE, EPA/TVA SHAWNEE SLUDGE DISPOSAL FIELD DEMONSTRATION

TASKS	AGENCIES/ CONTRACTOR	CY 74				CY 75												CY 76											
		1 S	2 O	3 N	4 D	5 J	6 F	7 M	8 A	9 M	10 J	11 J	12 A	13 S	14 O	15 N	16 D	17 J	18 F	19 M	20 A	21 M	22 J	23 J	24 A	25 S	26 O	27 N	28 D
PONDS FILLED																													
POND A	TVA		7 ▲																										
POND B	DRAVO (D)								15 ▲																				
POND C	IUCS (I)								23 ▲																				
POND D	TVA		20 ▲				5 ▲																						
POND E	CHEMFIX (C)				7 ▲																								
PROGRAM REVIEW MEETINGS	EPA/TVA/ AEROSPACE/ BECHTEL		2 ▲			21 ▲			6 ▲			29 ▲		24 ▲			△			△			△						
FIXATION REVIEW MEETINGS (1 day for each fixation contractor)	EPA/TVA/ AEROSPACE/ BECHTEL/ FIXATION CONTRACTORS		C 25 ▲	I 6 ▲	DC 34 ▲▲				D,I 9 ▲		C, D, I 18, 19, 20 ▲			D 19 ▲		I 20 △				△									
CLIMATOLOGICAL/ HYDRAULIC DATA	TVA	◄	—	—	—	—	—	—	—	COLLECTION AND ANALYSIS	—	—	—	—	—	—	—	—	—	—	—	—	►						
REPORTING																													
PHOTOGRAPHIC DOCUMENTATION	TVA	◄	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	►						
REPORTS																													
INTERIM																													
DRAFT	AEROSPACE																▲												
DISTRIBUTE	AEROSPACE																			▲									
FINAL																													
DRAFT	AEROSPACE																								△				
DISTRIBUTE	AEROSPACE																											△	

▲ TASK COMPLETED
△ TASK TO BE ACCOMPLISHED

Table 3. POND A, LIME SLUDGE FILTER CAKE–UNTREATED, FILL CONTRACTOR: TVA

TASKS	CONTRACTOR		CY 74				CY 75												CY 76											
			1 S	2 O	3 N	4 D	5 J	6 F	7 M	8 A	9 M	10 J	11 J	12 A	13 S	14 O	15 N	16 D	17 J	18 F	19 M	20 A	21 M	22 J	23 J	24 A	25 S	26 O	27 N	
1. POND CONSTRUCTION																														
AVAILABLE FOR FILLING	TVA		3 ▲																											
FILLING	TVA		23 ▲	7 ▲																										
2. SOIL CORING																														
SOIL CHARACTERIZATION																														
SAMPLE	TVA	▲																												
ANALYZE	TVA	▲																												
SOIL LEACHATE ANALYSIS																														
SAMPLE	TVA	▲			7 ▲	7 ▲						15 ▲						△						△						
ANALYZE	AEROSPACE	△			△	△						△						△						△						
3. INPUT SLUDGE ANALYSIS																														
SAMPLE AND STORE FILTER CAKE DAILY	TVA		23 ▲	7 ▲																										
SAMPLE FILTRATE DAILY	TVA		23 ▲	7 ▲																										
ANALYZE	TVA		23 ▲ 28 △	3 △ 7 ▲																										
ANALYZE COMPOSITE SAMPLE	AEROSPACE			7 ▲																										
4. GROUND WATER WELLS																														
CONSTRUCTION (2 wells)	TVA	▲																												
SAMPLE	TVA		23 ▲	7 ▲ 14 ▲ 21 ▲			▲		▲		▲		▲		▲		△		△		△		△		△					
ANALYZE	TVA		▲	▲ ▲ ▲			▲		▲		▲		▲		△		△		△		△		△		△					
ANALYZE	AEROSPACE			▲							▲						△						△							
5. LEACHATE WELL																														
CONSTRUCTION	TVA	▲																												
SAMPLE	TVA			▲			▲		▲		▲		▲		▲		△		△		△		△		△					
ANALYZE	TVA			▲			▲		▲		▲		▲		△		△		△		△		△		△					
ANALYZE	AEROSPACE			▲							▲						△						△							
6. SUPERNATE																														
SAMPLE	TVA			7 ▲			▲		▲		▲		▲		▲		△		△		△		△		△					
ANALYZE	TVA			▲			▲		▲		▲		▲		△		△		△		△		△		△					
ANALYZE	AEROSPACE			▲							▲						△						△							

▲ TASK COMPLETED
△ TASK TO BE ACCOMPLISHED
Note: Activity dates do not reflect shipping time

Table 4. POND B, LIMESTONE SLUDGE CLARIFIER UNDERFLOW–TREATED, FIXATION CONTRACTOR: DRAVO

TASKS	CONTRACTOR	CY 74				CY 75												CY 76											
		1 S	2 O	3 N	4 D	5 J	6 F	7 M	8 A	9 M	10 J	11 J	12 A	13 S	14 O	15 N	16 D	17 J	18 F	19 M	20 A	21 M	22 J	23 J	24 A	25 S	26 O	27 N	28 D
1. POND CONSTRUCTION																													
AVAILABLE FOR FILLING	TVA		▲																										
FILLING	DRAVO								7 15 ▲ ▲																				
2. SOIL CORING																													
SOIL CHARACTERIZATION																													
SAMPLE	TVA		▲																										
ANALYZE	TVA		▲																										
SOIL LEACHATE ANALYSIS																													
SAMPLE	TVA		▲				▲			15 ▲	15 ▲					△						△							
ANALYZE	AEROSPACE			△			△			△	△					△						△							
3. INPUT SLUDGE ANALYSIS																													
SAMPLE CLARIFIER UNDERFLOW DAILY	TVA								7 15 ▲▲																				
ANALYZE SEPARATED LIQUOR	TVA								7 10 15 ▲▲▲																				
ANALYZE COMPOSITE % SOLIDS	AEROSPACE								15 ▲																				
ANALYZE COMPOSITE LIQUOR	AEROSPACE								▲																				
ANALYZE COMPOSITE DRY SOLIDS	AEROSPACE								▲																				
4. GROUND WATER WELLS																													
CONSTRUCTION (2 wells)	TVA		▲																										
SAMPLE	TVA								7 15 22 28 ▲▲▲▲		▲		▲		△		△		△		△		△						
ANALYZE	TVA								▲▲▲▲		▲		△		△		△		△		△		△						
ANALYZE	AEROSPACE								28 ▲						△						△								
5. LEACHATE WELL																													
CONSTRUCTION	TVA		▲																										
SAMPLE	TVA						11 ▲		15 ▲		▲		▲		△		△		△		△		△						
ANALYZE	TVA						▲		▲		▲		△		△		△		△		△		△						
ANALYZE	AEROSPACE						▲		▲						△						△								
6. SUPERNATE																													
SAMPLE	TVA								▲		▲		▲		△		△		△		△		△						
ANALYZE	TVA								▲		▲		△		△		△		△		△		△						
ANALYZE	AEROSPACE								▲						△						△								
7. TREATED SLUDGE																													
INPUT MATERIAL																													
SAMPLE DAILY	TVA								7 15 ▲▲																				
RETAIN FOR CONTINGENCY ANALYSIS	AEROSPACE								▲																				
CORES																													
SAMPLE	TVA									15 ▲	15 ▲					△						△							
ANALYZE	AEROSPACE									▲	△					△						△							

▲ TASK COMPLETED
△ TASK TO BE ACCOMPLISHED
Note: Activity dates do not reflect shipping time

Table 5. POND C, LIME SLUDGE CENTRIFUGE CAKE–TREATED, FIXATION CONTRACTOR: IUCS

TASKS	CONTRACTOR	CY 74				CY 75												CY 76											
		1 S	2 O	3 N	4 D	5 J	6 F	7 M	8 A	9 M	10 J	11 J	12 A	13 S	14 O	15 N	16 D	17 J	18 F	19 M	20 A	21 M	22 J	23 J	24 A	25 S	26 O	27 N	28 D
1. POND CONSTRUCTION																													
AVAILABLE FOR FILLING	TVA		▲																										
FILLING	IUCS								1 ▲ 23 ▲																				
2. SOIL CORING																													
SOIL CHARACTERIZATION																													
SAMPLE	TVA		▲																										
ANALYZE	TVA		▲																										
SOIL LEACHATE ANALYSIS																													
SAMPLE	TVA							▲		23 ▲	23 ▲						△						△						
ANALYZE	AEROSPACE							▲		△	△						△						△						
3. INPUT UNTREATED SLUDGE ANALYSIS																													
SAMPLE CAKE DAILY	TVA								1 ▲ 23 ▲																				
ANALYZE SEPARATED LIQUOR	TVA								1 ▲ 8 ▲ ▲ ▲ 23																				
ANALYZE COMPOSITE % SOLIDS	AEROSPACE								23 ▲ 15																				
ANALYZE COMPOSITE LIQUOR	AEROSPACE								▲																				
ANALYZE COMPOSITE DRY SOLIDS	AEROSPACE								▲																				
4. GROUND WATER WELLS																													
CONSTRUCTION (2 wells)	TVA		▲																										
SAMPLE	TVA								1 ▲ 23 ▲ 30 ▲	7 ▲		▲		▲		△		△		△		△		△					
ANALYZE	TVA								▲ ▲ ▲	▲		▲		△		△		△		△		△		△					
ANALYZE	AEROSPACE									▲						△						△							
5. LEACHATE WELL																													
CONSTRUCTION	TVA		▲																										
SAMPLE	TVA						11 ▲		23 ▲			▲		▲		△		△		△		△		△					
ANALYZE	TVA						▲		▲			▲		△		△		△		△		△		△					
ANALYZE	AEROSPACE						▲		▲							△						△							
6. SUPERNATE																													
SAMPLE	TVA								▲			▲		▲		△		△		△		△		△					
ANALYZE	TVA								▲			▲		△		△		△		△		△		△					
ANALYZE	AEROSPACE								▲							△						△							
7. TREATED SLUDGE																													
INPUT MATERIAL																													
SAMPLE DAILY	TVA								1 ▲ 23 ▲																				
RETAIN FOR CONTINGENCY ANALYSIS	AEROSPACE								▲																				
CORES																													
SAMPLE	TVA									23 ▲	23 ▲						△						△						
ANALYZE	AEROSPACE									▲	▲						△						△						

▲ TASK COMPLETED
△ TASK TO BE ACCOMPLISHED
Note: Activity dates do not reflect shipping time

Table 6. POND D, LIMESTONE CLARIFIER UNDERFLOW—UNTREATED, FIXATION CONTRACTOR: TVA

TASKS	CONTRACTOR		CY 74				CY 75												CY 76											
			1 S	2 O	3 N	4 D	5 J	6 F	7 M	8 A	9 M	10 J	11 J	12 A	13 S	14 O	15 N	16 D	17 J	18 F	19 M	20 A	21 M	22 J	23 J	24 A	25 S	26 O	27 N	28 D
1. POND CONSTRUCTION.																														
AVAILABLE FOR FILLING	TVA			▲		▲																								
FILLING	TVA			▲ 11, ▲ 20 (1st FILLING)			▲ 13 (2nd FILLING)	▲ 5																						
SLUDGE REMOVAL	CHEMFIX					▲ 3, ▲ 7																								
2. SOIL CORING																														
SOIL CHARACTERIZATION																														
SAMPLE	TVA		▲																											
ANALYZE	TVA		▲																											
SOIL LEACHATE ANALYSIS																														
SAMPLE (soil only)	TVA	▲				▲			▲ 5	▲ 5								△						△						
ANALYZE	AEROSPACE	△				△			△	△								△						△						
3. INPUT SLUDGE ANALYSIS																														
SAMPLE AND STORE CLARIFIER UNDERFLOW DAILY	TVA			▲ 11, ▲ 20 (1st FILLING)			▲ 13 (2nd FILLING)	▲ 5																						
ANALYZE SEPARATED LIQUOR FROM UNDERFLOW	TVA			▲ 11, ▲ 14, ▲ 17, ▲ 21			▲ 13, ▲ 24, ▲ 31	▲ 5																						
ANALYZE COMPOSITE SAMPLE	AEROSPACE				▲			▲																						
4. GROUND WATER WELL																														
CONSTRUCTION	TVA		▲																											
SAMPLE	TVA			▲ 11, △ 20, ▲ 28 (1st FILLING)	▲ 4		▲ 13 (2nd FILLING)	▲ 5, ▲ 11, ▲ 17			▲		▲		▲		△		△		△		△		△					
ANALYZE	TVA			▲, △, ▲	▲		▲	▲, ▲, ▲			▲		▲		△		△		△		△		△		△					
ANALYZE	AEROSPACE				▲			▲			▲						△						△							
5. LEACHATE WELL																														
CONSTRUCTION	TVA		▲																											
SAMPLE	TVA			▲ 20 (1st FILLING)				▲ 5 (2nd FILLING)			▲		▲		▲		△		△		△		△		△					
ANALYZE	TVA			▲				▲			▲		▲		△		△		△		△		△		△					
ANALYZE	AEROSPACE			▲				▲			▲						△						△							
6. SUPERNATE																														
SAMPLE	TVA			▲ 20 (1st FILLING)				▲ 5 (2nd FILLING)			▲		▲		▲		△		△		△		△		△					
ANALYZE	TVA			▲				▲			▲		▲		△		△		△		△		△		△					
ANALYZE	AEROSPACE			▲				▲			▲						△						△							

▲ TASK COMPLETED
△ TASK TO BE ACCOMPLISHED
Note: Activity dates do not reflect shipping time

Table 7. POND E, LIMESTONE CLARIFIER UNDERFLOW–TREATED, FIXATION CONTRACTOR: CHEMFIX

TASKS	CONTRACTOR	CY 74				CY 75												CY 76											
		1 S	2 O	3 N	4 D	5 J	6 F	7 M	8 A	9 M	10 J	11 J	12 A	13 S	14 O	15 N	16 D	17 J	18 F	19 M	20 A	21 M	22 J	23 J	24 A	25 S	26 O	27 N	28 D
1. POND CONSTRUCTION																													
AVAILABLE FOR FILLING	TVA		▲																										
FILLING	CHEMFIX				3 7 ▲▲																								
2. SOIL CORING																													
SOIL CHARACTERIZATION																													
SAMPLE	TVA		▲																										
ANALYZE	TVA		▲																										
SOIL LEACHATE ANALYSIS																													
SAMPLE	TVA		▲			7 ▲	7 ▲									△						△							
ANALYZE	AEROSPACE		▲			△	△									△						△							
3. INPUT UNTREATED SLUDGE[a]																													
SAMPLE POND D SLUDGE DURING FIXATION (6 samples minimum)	TVA				3 7 ▲▲																								
ANALYZE SEPARATED LIQUOR	TVA				3 5 6 7 ▲▲▲▲																								
ANALYZE COMPOSITE % SOLIDS	AEROSPACE				7 ▲																								
ANALYZE COMPOSITE LIQUOR	AEROSPACE				▲																								
ANALYZE COMPOSITE DRY SOLIDS	AEROSPACE				▲																								
4. GROUND WATER WELLS																													
CONSTRUCTION	TVA		▲																										
SAMPLE	TVA				3 7 14 21 ◬◬◬◬		▲		▲		▲		▲		△		△		△		△		△						
ANALYZE	TVA				◬◬◬◬		▲		▲		▲		△		△		△		△		△		△						
ANALYZE	AEROSPACE				◬				▲						△						△								
5. LEACHATE WELL																													
CONSTRUCTION	TVA		▲																										
SAMPLE	TVA				7 ◬		▲		▲		▲		▲		△		△		△		△		△						
ANALYZE	TVA				◬		▲		▲		▲		△		△		△		△		△		△						
ANALYZE	AEROSPACE				◬				▲						△						△								
6. SUPERNATE																													
SAMPLE	TVA				7 ◬		▲		▲		▲		▲		△		△		△		△		△						
ANALYZE	TVA				◬		▲		▲		▲		△		△		△		△		△		△						
ANALYZE	AEROSPACE				◬				▲						△						△								
7. TREATED SLUDGE																													
INPUT TREATED SLUDGE[b]																													
SAMPLE PERIODICALLY (minimum of 6 samples)	TVA				3 7 ▲▲																								
RETAIN FOR CONTINGENCY ANALYSIS	AEROSPACE				▲ 7																								
CORES																													
SAMPLE	TVA					7 ▲	7 ▲									△						△							
ANALYZE	AEROSPACE					▲	△									△						△							

▲ TASK COMPLETED
△ TASK TO BE ACCOMPLISHED
◬ INSUFFICIENT SAMPLE AVAILABLE

Note: Activity dates do not reflect shipping time
a. Input to Chemfix trailer
b. Chemfix trailer input to Pond E

SECTION VIII

SAMPLING AND ANALYSIS

In order to make a quantitative assessment of the water pollution potential arising from the storing of scrubber wastes in ponds, periodic monitoring and analysis of pond liquors, soil, and ground water are necessary. These analyses must be conducted frequently to provide sufficient data within the time frame of the program to evaluate the environmental acceptability of the disposal method. The program schedule requires bimonthly sampling of ground water from two wells associated with each pond: one to provide background data, and the other to monitor the quality of the water table beneath the disposal site. A leachate well in the base of each pond is used to monitor sludge liquor major constituents (e.g., calcium, sulfate, sulfite, chloride, and total dissolved solids) as well as pH and trace elements previously identified in Shawnee liquors and considered potentially objectionable in public water supplies. Pond supernate liquor is also monitored for the same items. In addition, the soil from the bottom of each pond is monitored semiannually for some of these constituents to determine the rates of their permeation into the soil. All parameters for which water analyses are performed are given in Tables 8 and 9. As this report is being prepared, the monitoring program is in its initial stages, especially regarding the ponds containing chemically fixed sludge. Therefore, the resulting data are limited, and conclusions drawn from these data are necessarily tentative, but definite trends appear to be developing.

Table 8. WATER ANALYSIS PARAMETERS[a]

Arsenic	Sulfate
Boron	Sulfite[b]
Calcium	Conductance, mmho/cm
Lead	Total Dissolved Solids (TDS)
Magnesium	Total Suspended Solids (TSS)
Mercury	pH
Selenium	Chemical O_2 Demand (COD)
Total Alkalinity	Sodium[c]
Chloride	

[a]Concentration: mg/l unless otherwise indicated

[b]Applies to analyses of pond input liquors only

[c]Applies to analyses of waters associated with fixed sludge disposal sites where sodium is one of the additive constituents

Table 9. CHEMICAL CHARACTERIZATION PARAMETERS[a]

Aluminum	Silver
Antimony	Sodium
Arsenic	Tin
Beryllium	Vanadium
Boron	Zinc
Cadmium	Total Carbonate
Calcium	Chloride
Total Chromium	Fluoride
Cobalt	Sulfite
Copper	Sulfate
Iron	Phosphate
Lead	Total Nitrogen
Magnesium	Chemical O_2 Demand (COD)
Manganese	Total Dissolved Solids (TDS)
Mercury	Total Suspended Solids (TSS)
Molybdenum	Total Alkalinity
Nickel	Conductance, mmho/cm
Potassium	Turbidity, Jackson units
Selenium	pH
Silicon	

[a]Concentration: mg/l unless otherwise indicated

8.1 SAMPLING

8.1.1 Pond Input Materials

During the filling of Pond A and during both fillings of Pond D, TVA collected and stored duplicate one-liter samples of input untreated sludges once a day. One-liter bottles were completely filled and capped in order to protect the samples from CO_2 and O_2, thus preventing changes in pH and state of oxidation.

For Ponds B and C, TVA collected daily duplicate samples as described for Ponds A and D except that these samples were taken from untreated sludge supplied to Dravo and IUCS. However, for Pond E, since the Chemfix operation was a relatively short-term procedure (i.e., a total of 4 hours), the collection of input untreated sludge transferred from Pond D was made so that six duplicate samples were taken.

One complete set of daily samples of input untreated materials was retained by TVA. The other daily samples were shipped to The Aerospace Corporation by TVA.

TVA collected daily one-liter samples of treated materials as they were put into the respective ponds. These samples were not mixed. In the case of the Chemfix operation at Pond E, six samples were taken. All input treated samples were shipped to The Aerospace Corporation by TVA.

During the fillings of Ponds A, B, C, and E, and during both fillings of Pond D, TVA analyzed the liquid portion of the input untreated material. After separation of the solids by filtration through 0.45-μm pore diameter Millipore filters, this liquor analysis included the measurement of sulfite, sulfate, chloride, pH, and conductance. A minimum of four samples was analyzed; these samples were collected approximately at the beginning of, one-third of, two-thirds of, and the end of the fillings of the ponds. Analyses were conducted immediately after sampling. Unused samples were retained by TVA as contingency samples.

Each set of daily input sludge samples was mixed, and Aerospace analyzed the composite for the percentage of total solids. Aerospace also filtered this composite through 0.45-μm Millipore filters and performed water analyses in accordance with the test parameter list given in Table 8, for the liquid portion of these samples. The dried solids were analyzed for calcium sulfite, calcium sulfate, calcium hydroxide, calcium carbonate, and fly ash.

8.1.2 Pond Supernate

For Pond A, sludge liquor and natural precipitation were allowed to remain in the pond, and any overflow was controlled by a weir such that a maximum depth of 2 feet of surface water could accumulate. For Pond D, surface water requirements were the same as for Pond A except that a minimum water depth of 4 inches was maintained over at least 85% of the pond surface at all times. Overflow was controlled by pumping off excess water. For Pond B, the curing water used in this operation was allowed to remain in the pond. Natural precipitation was allowed to build up and was controlled by pumping to keep the water level below the pier in order to provide access to the leachate well. For Ponds C and E, natural precipitation was controlled in the same way as for Pond B. All water removed from these ponds was disposed of such that it would not drain or seep back to the evaluation site.

8.1.3 Leachate

Sampling of leachate wells for each pond was performed by TVA at two-month intervals after pond filling had been completed. Additionally, a control sample was taken prior to filling. TVA and Aerospace each received samples from all samplings, and the fixation contractors each received a sample if available from each sampling taken from their respective ponds.

Leachate samples were analyzed by TVA and Aerospace for the parameters given in Table 8. TVA analyzed all samples, while Aerospace analyzed the initial sample (taken after filling), and one approximately every six months thereafter. As an exception, Aerospace will analyze the sample taken in January 1976 for the parameters given in Table 9.

8.2 RESULTS OF ANALYSES

Analyses of supernate, leachate, and ground water were performed independently by TVA and The Aerospace Corporation. The raw data are presented in Appendix C, and overall results of the analyses are discussed below, followed by a discussion of the results for the individual ponds. Likewise, the results to date of analyses on soils and climatological and hydraulic data are also presented.

8.2.1 Supernate and Leachate

The quality of supernate and leachate associated with each of the ponds was monitored by conducting analyses for the parameters in Table 8. TVA performed analyses on each of the samples taken at approximately two-month intervals, while Aerospace analyzed samples at six-month intervals. The combined data from both laboratories have been arranged according to pond and well sources, and tabulated chronologically by sampling dates in Appendix C.2 of this report. The pH of initial samples of leachate and supernate from the three ponds containing chemically fixed sludge ranged from 6 to 12, and the pH of all other samples ranged between 6 and 9. The total suspended solids ranged widely because the samples contained varying amounts of soil sediments that were accumulated during sample collection. Chemical oxygen demand was usually below 100 ppm, which is normal for water containing only inorganic constituents. For solutions of strong electrolytes, conductance measurements closely paralleled the measurements of total dissolved solids (TDS); only the results of the latter measurements will be discussed here in detail. Sulfite measurements were only conducted by The Aerospace Corporation. As the sulfite found usually amounted to a few parts per million or a few tenths of a part per million, the total alkalinity measured primarily the carbonate content of the water. This alkalinity appeared to vary among the samples in a random manner, although the samples with higher pH values showed higher total alkalinities. Discussions relating to the remaining parameters of Table 8 will be grouped according to the water types and the ponds.

8.2.2 Ground Water

The ground water in the vicinity of each pond was monitored by means of two wells. One well, immediately adjacent to each pond, was labeled well number one (W1); the other, some distance away in the upstream direction, was labeled well number two (W2). Each well was sampled for some time prior to the filling of the pond in order to obtain data representative of the water quality before introduction of sludge to the pond. Because the ponds and wells were constructed at different times and because the fillings of several ponds coincided with a particularly dry weather season, background water quality data are not uniformly available for all wells. Although the sampling of well number one for Pond A (GWA1) was begun as early as February 1974, no other well was monitored prior to July 1974; therefore, only those data obtained subsequent to 1 July 1974 are being reported. The six GWA1 samples taken between 1 July 1974 and the beginning of Pond A filling on 24 September 1974 are adequate to establish the background quality.

The ground water samples from each of the five ponds showed nearly identical composition with regard to the so-called minor constituents: magnesium, boron, lead, arsenic, selenium, and mercury. Thus far, in no case has there been a trend or even a fluctuation that could be attributable to the filling of the pond with sludge. Although a different range of concentrations was observed for each of the six elements, in several the ground water from all five ponds showed the same characteristic ranges. For four of the five ponds, the magnesium concentrations ranged from 3 to 24 ppm. For Pond A, the magnesium content ranged from 4 to 74 ppm. For all five ponds, the boron concentrations ranged from 2.5 ppm to below the detection limit of 0.1 ppm. For all ponds, the lead concentrations ranged from 0.5 ppm to below the detection limit of 0.01 ppm (see Appendix C.2). Except for several samples from GWD1 taken before Pond D was filled, the arsenic concentrations for all ground water samples was below the detection limit of 0.005 ppm. The selenium concentrations for all ponds ranged from 0.015 ppm to below the detection limit of 0.002 ppm. The mercury concentration ranged from 0.05 ppm to below the detection limit, which varied from 0.0002 to 0.00005 ppm, depending on the volume of sample available.

The ranges of concentrations of major constituents (calcium, sulfate, and chloride) and the ranges of TDS in the ground water samples are similar for all five ponds. The discussion of these results will accompany the presentation of results for leachate and supernate, which have been grouped according to pond.

8.2.3 Untreated Sludge

8.2.3.1 Pond A

Pond A was filled with lime sludge filter cake during the period of 23 September 1974 to 7 October 1974. Ground water, leachate, and supernate were monitored at approximately two-month intervals thereafter. Ground water results were compared with those data taken prior to pond filling. The results for the three major constituents and for TDS are plotted in Figures 19 through 22. Calcium, sulfate, and chloride concentrations in the ground water samples ranged between 10 and 280 ppm, and the TDS values ranged between 250 and 880 ppm, with no patterns that can be correlated with the time of pond filling. In contrast, these same constituents of the leachate and pond supernate showed significant changes after the pond was filled. The concentrations in the supernate decreased and those in the leachate increased with time. Although after six months the concentrations had not leveled off in either case, from the shapes of the curves it appears that the leachate values will level off at approximately the initial values of the supernate (i.e., 2000 to 3000 ppm for calcium and sulfate, 3000 to 5000 ppm for chloride, and 8000 to 10,000 ppm for TDS), while the

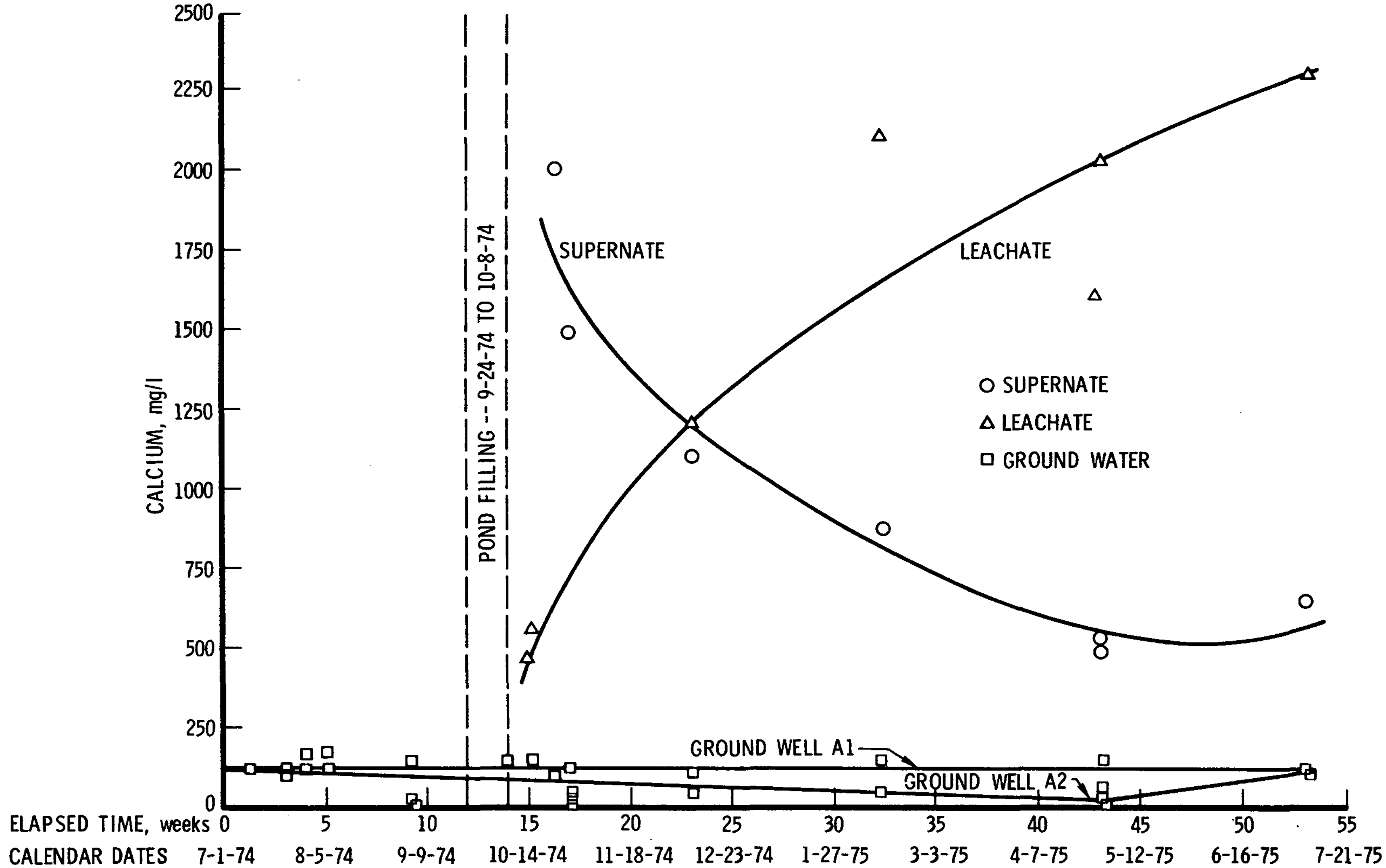


Figure 19. Calcium in Pond A supernate, leachate, and ground water wells

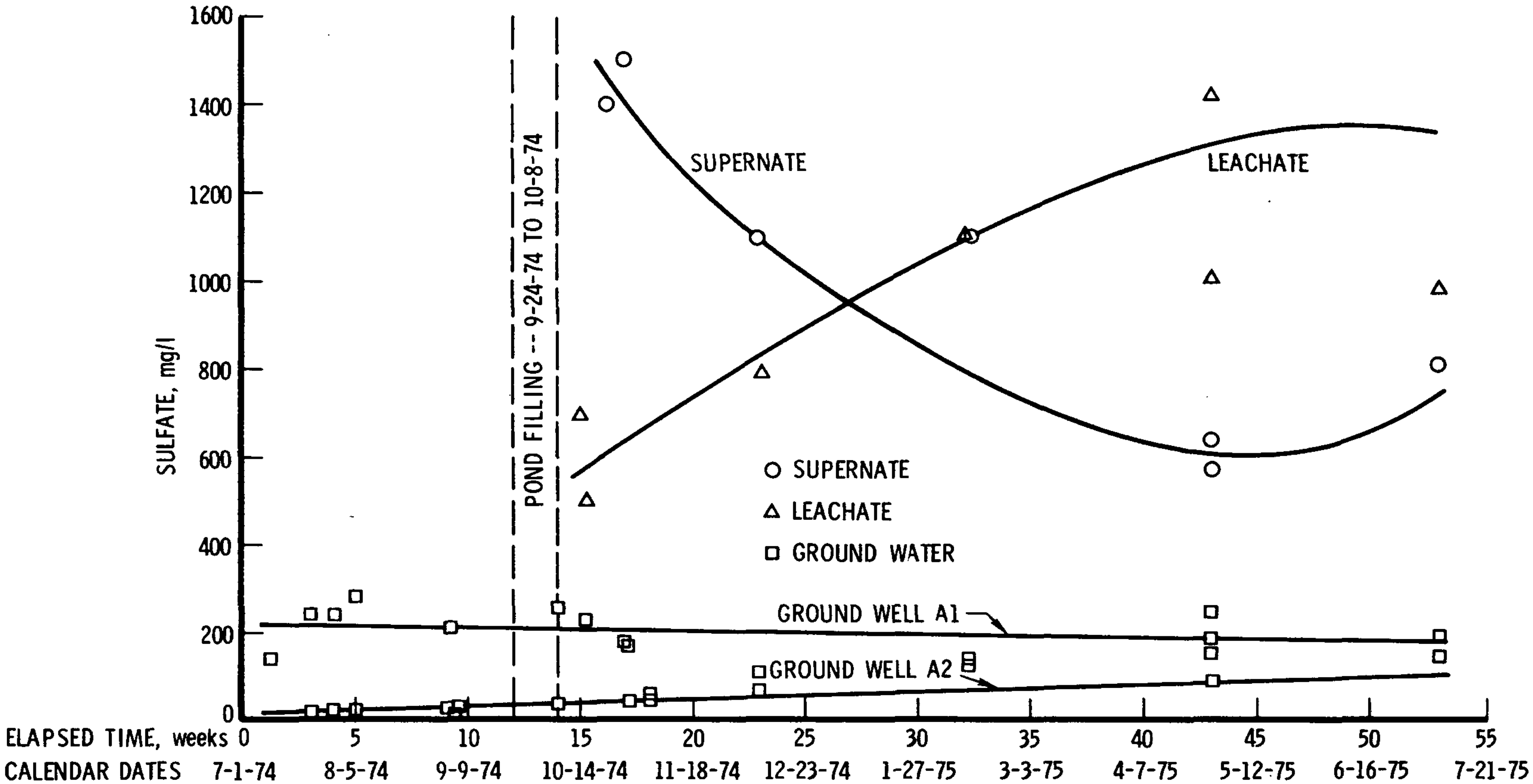


Figure 20. Sulfate in Pond A supernate, leachate, and ground water wells

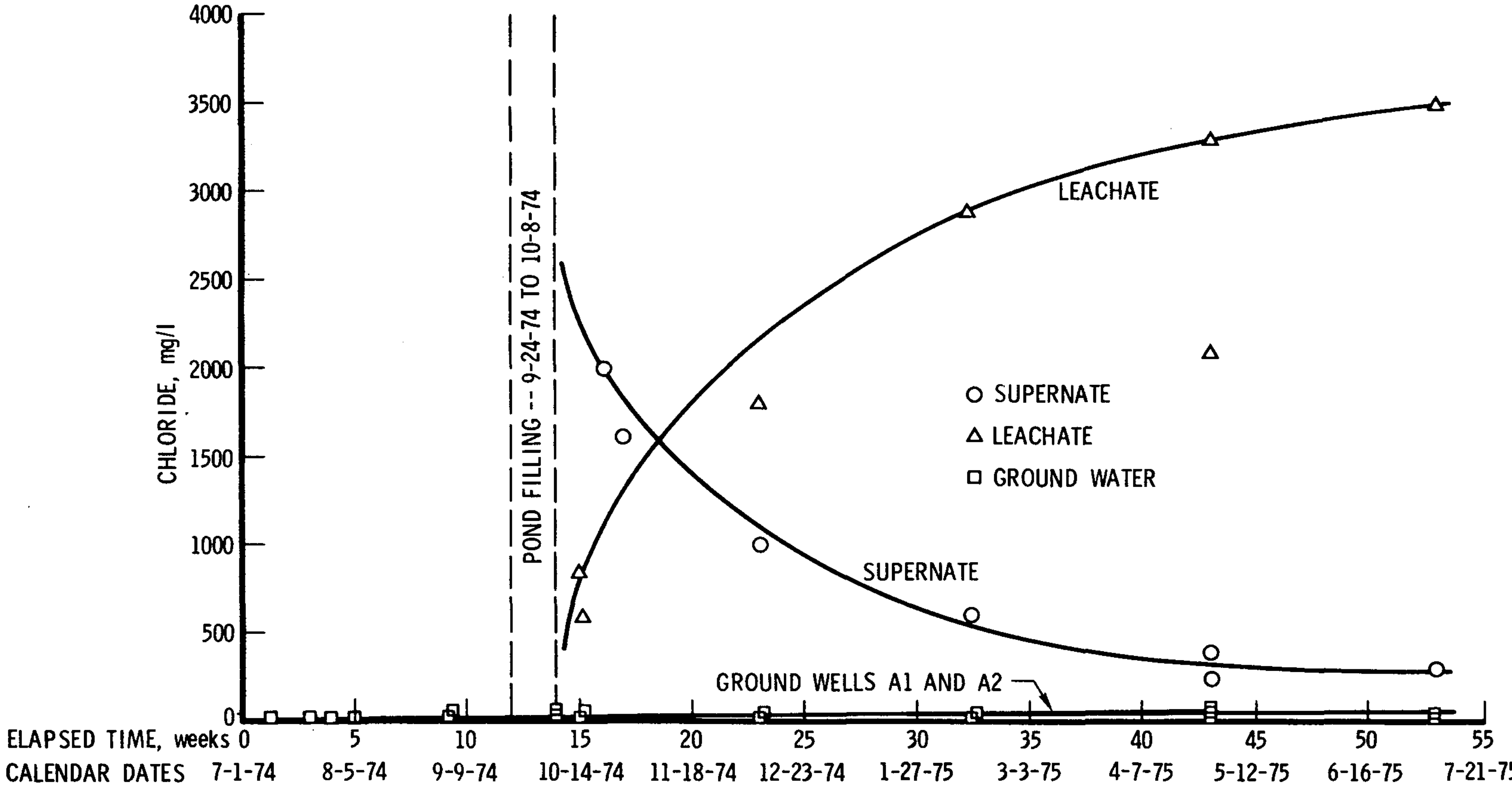


Figure 21. Chloride in Pond A supernate, leachate, and ground water wells

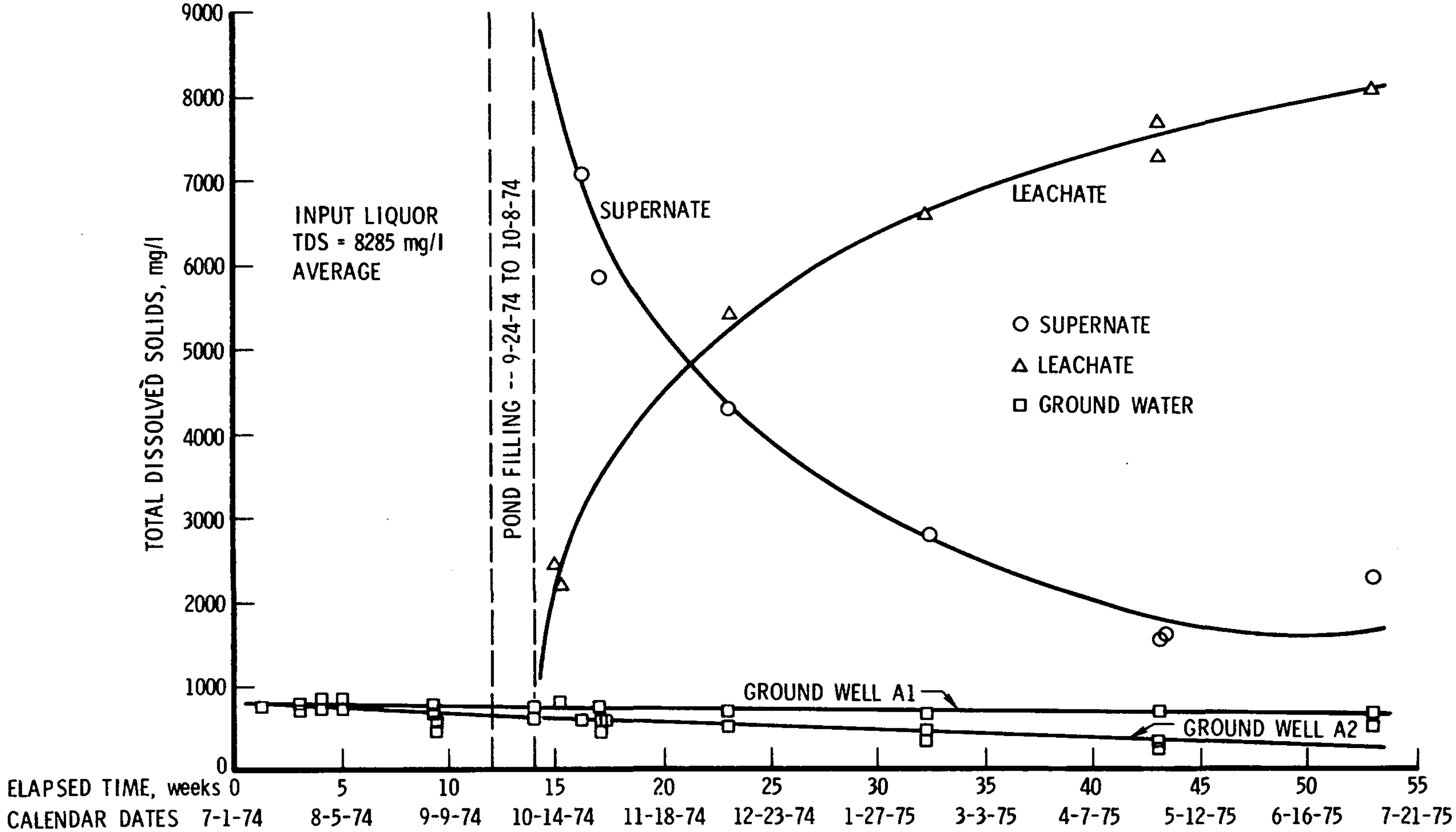


Figure 22. Total dissolved solids in Pond A supernate, leachate, and ground water wells

supernate values may decrease to the levels of the ground water. Slight upturns in the curves for pond supernate at the midsummer sampling are probably the net result of water loss by evaporation.

Somewhat similar patterns are observed for the six minor constituents in the leachate and supernate, as shown by the results plotted in Figure 23. However, because the levels of the concentrations of four of the elements are near the limits of detection, only for magnesium and boron are the trends easily distinguished.

8.2.3.2 Pond D

Pond D was the second pond to be filled with untreated sludge and was actually filled twice. It was initially filled from 11 to 20 October 1974 with clarifier underflow limestone sludge from the Turbulent Contact Absorber. Most of this sludge was removed from 3 to 7 December 1974 for treatment and transfer to Pond E. Pond D was refilled with clarifier underflow limestone sludge from 13 January to 5 February 1975. The double filling schedule of Pond D has been included in the plots shown in Figures 24 through 28. The monitored data for the three major constituents and TDS of the ground water, leachate, and supernate are shown in Figures 24 through 27, and the minor constituents of the leachate and supernate are shown in Figure 28. No ground water well for background water quality data was constructed specifically for Pond D. However, both Ponds E and B are in close proximity to Pond D. Prior to November 1974, background water data were obtained from well GWE2. In November 1974, well GWB2 was constructed, and subsequent background water data have been obtained from it. The ground water from both wells, as well as that from GWD1, showed uniform composition over the entire period of monitoring. The concentrations of the three major constituents ranged between 10 and 300 ppm, and the TDS ranged from 200 to 700 ppm.

In contrast, the compositions of the supernate and leachate from Pond D changed during the monitoring period with a pattern that can be related to the two fillings of the pond. The major constituents and the TDS of the supernate decreased with time between the first

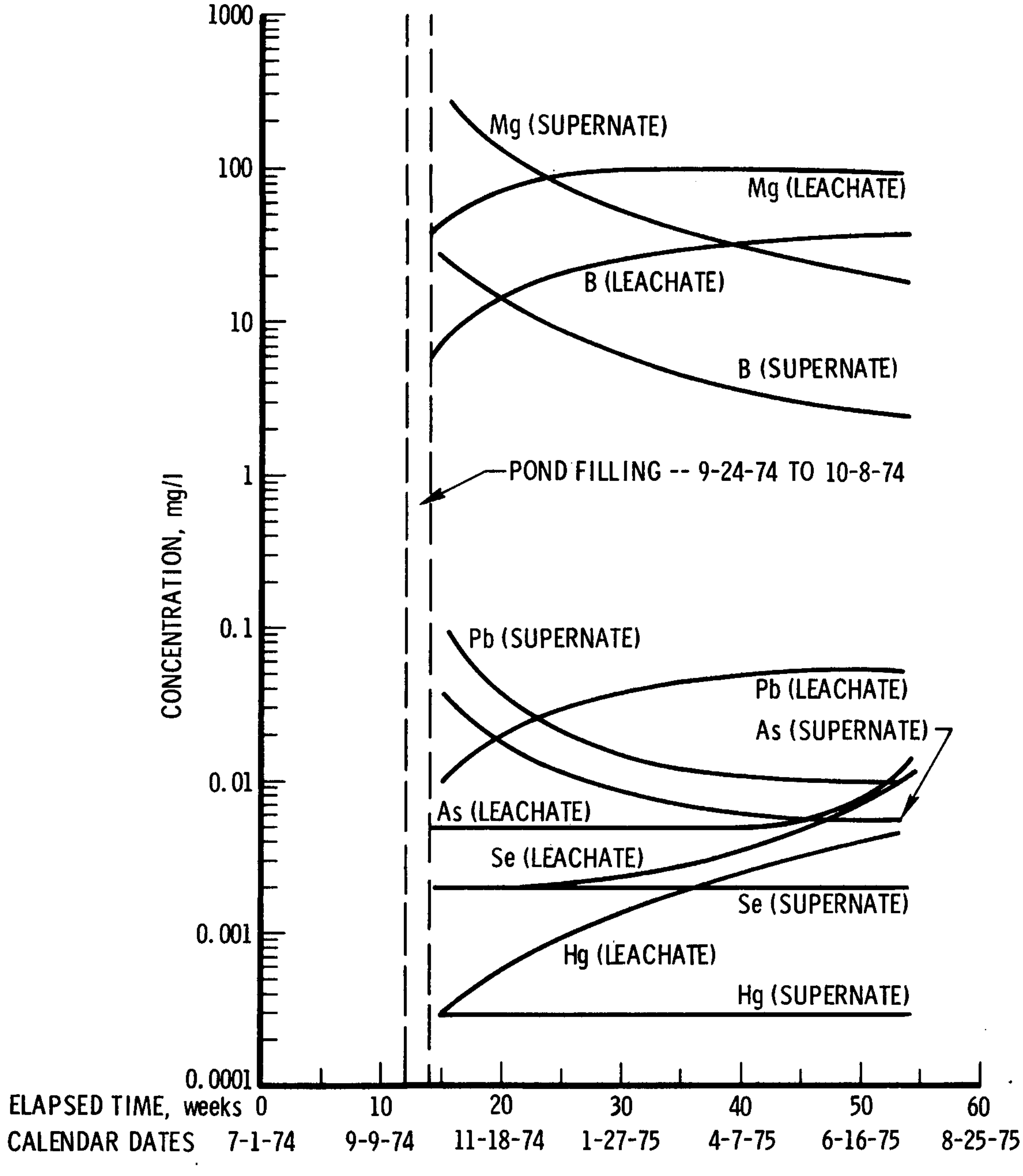


Figure 23. Minor constituents of Pond A supernate and leachate well (For the purpose of clarity, the data points have been deleted. The data are tabulated in Appendix C. 2.)

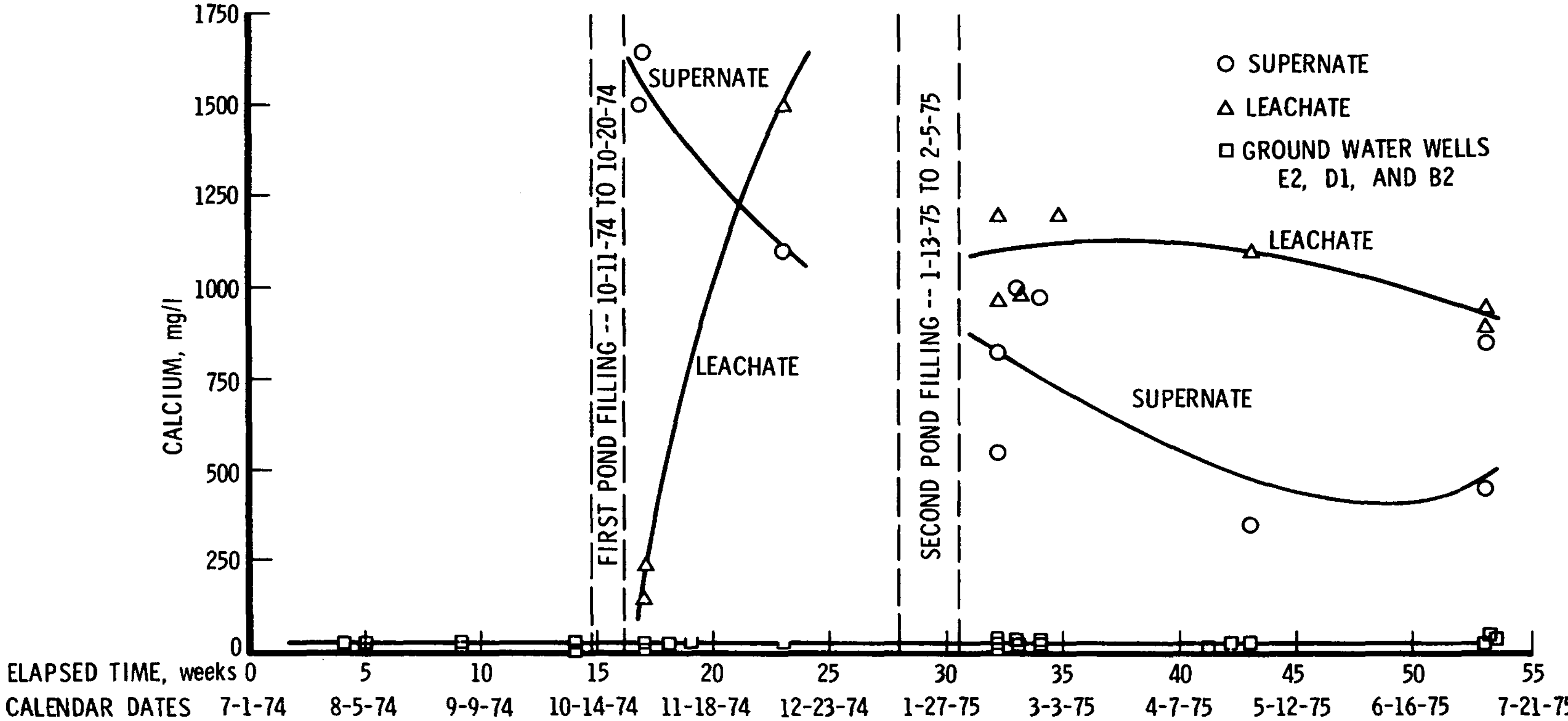


Figure 24. Calcium in Pond D supernate, leachate, and ground water wells

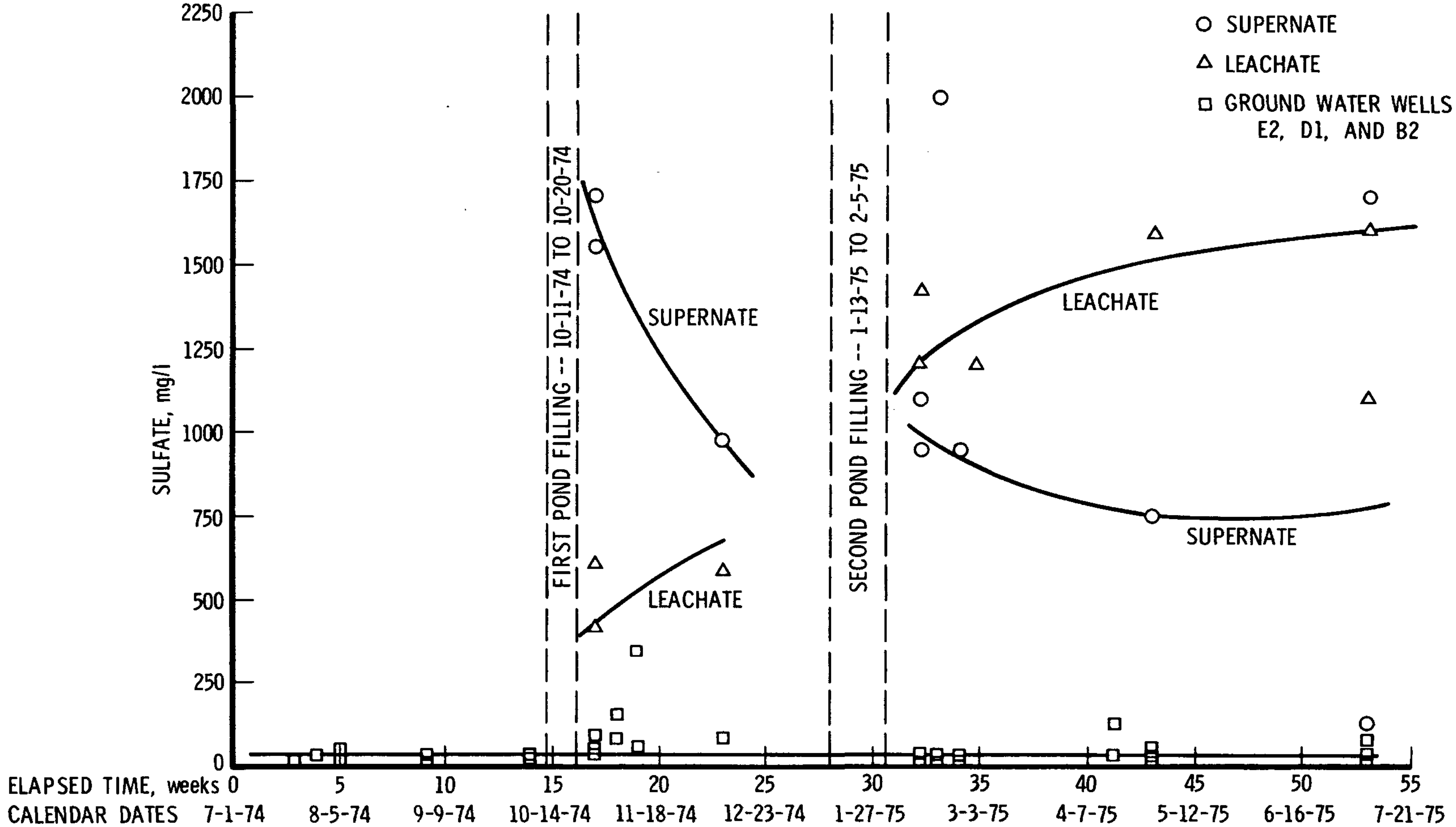


Figure 25. Sulfate in Pond D supernate, leachate, and ground water wells

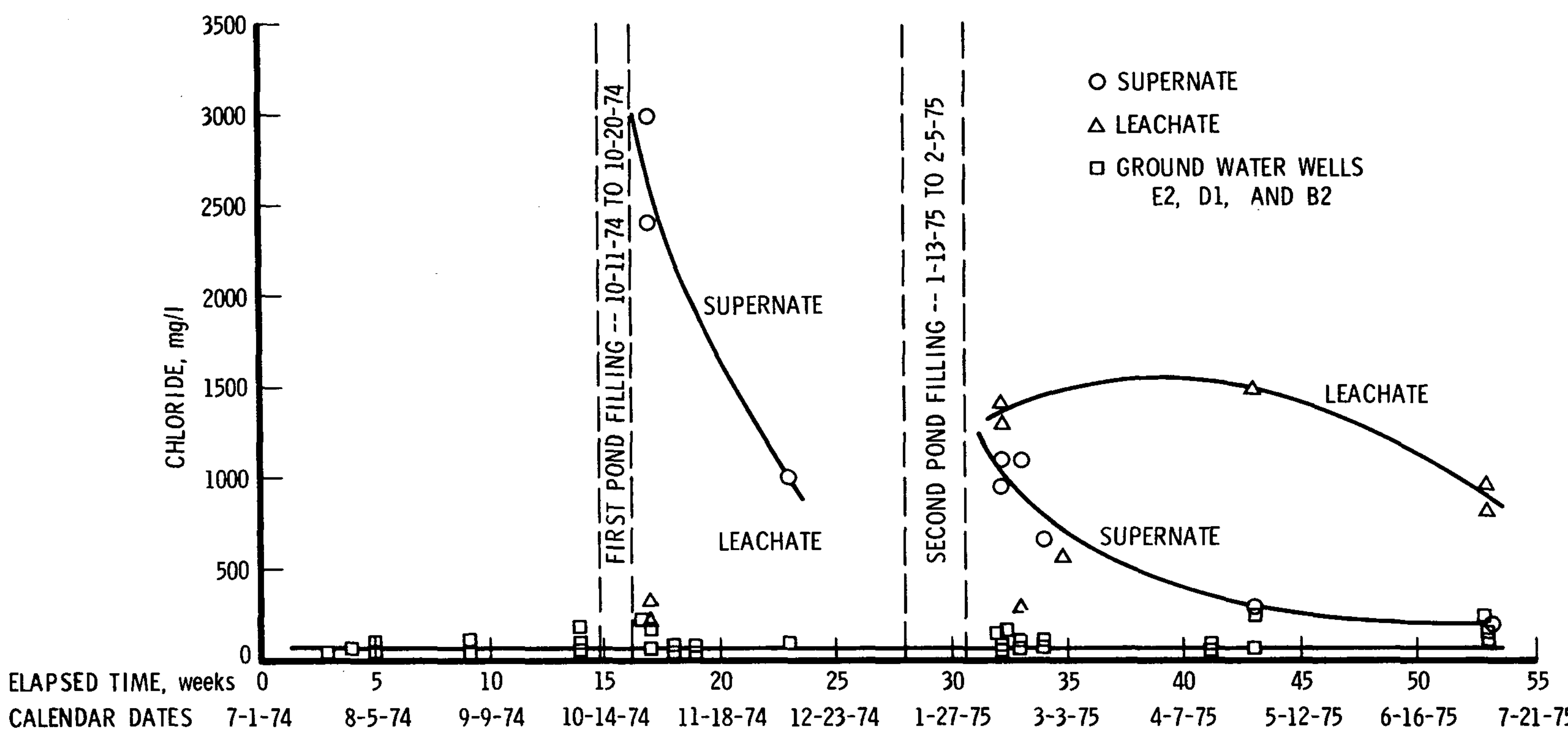


Figure 26. Chloride in Pond D supernate, leachate, and ground water wells

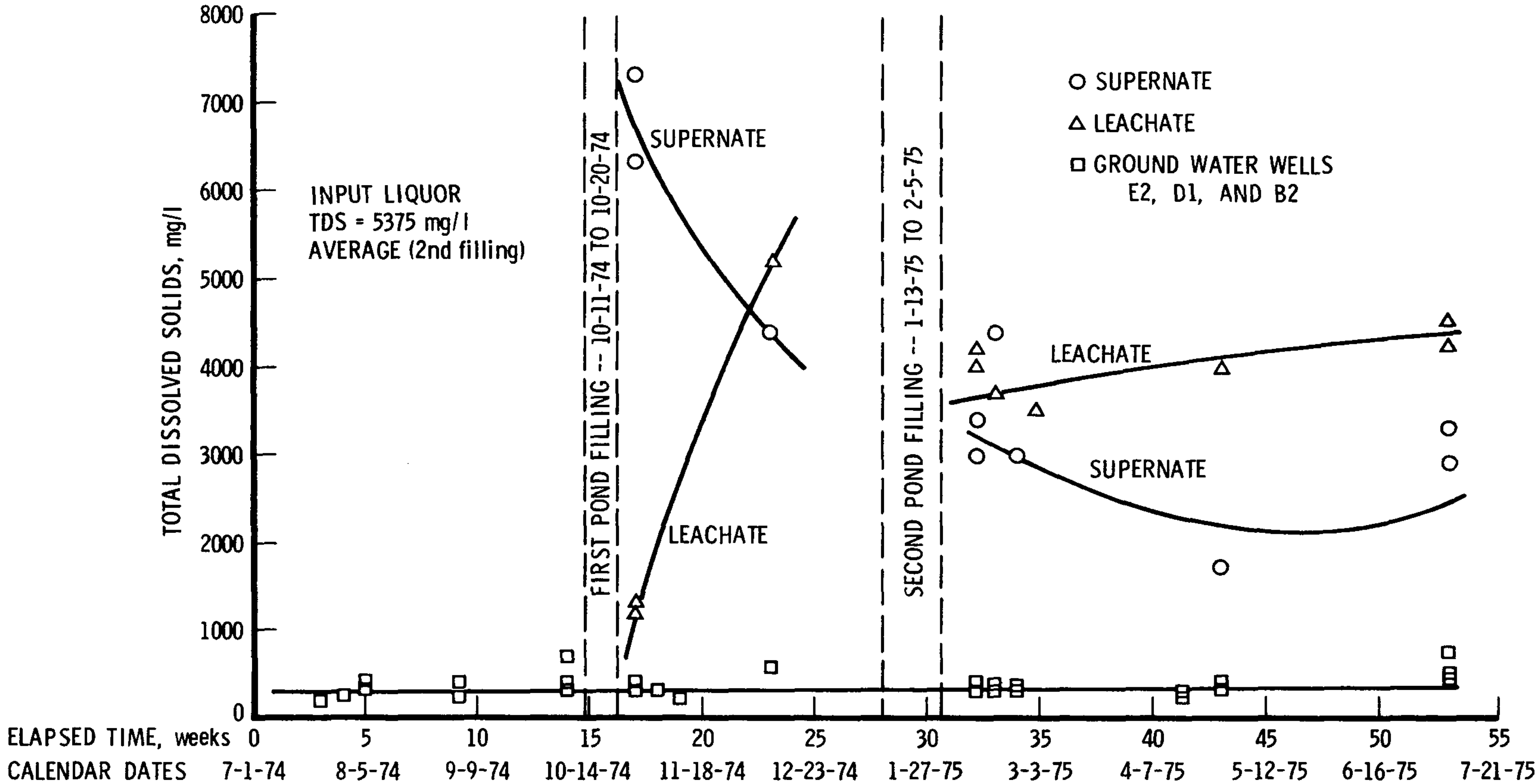


Figure 27. Total dissolved solids in Pond D supernate, leachate, and ground water wells

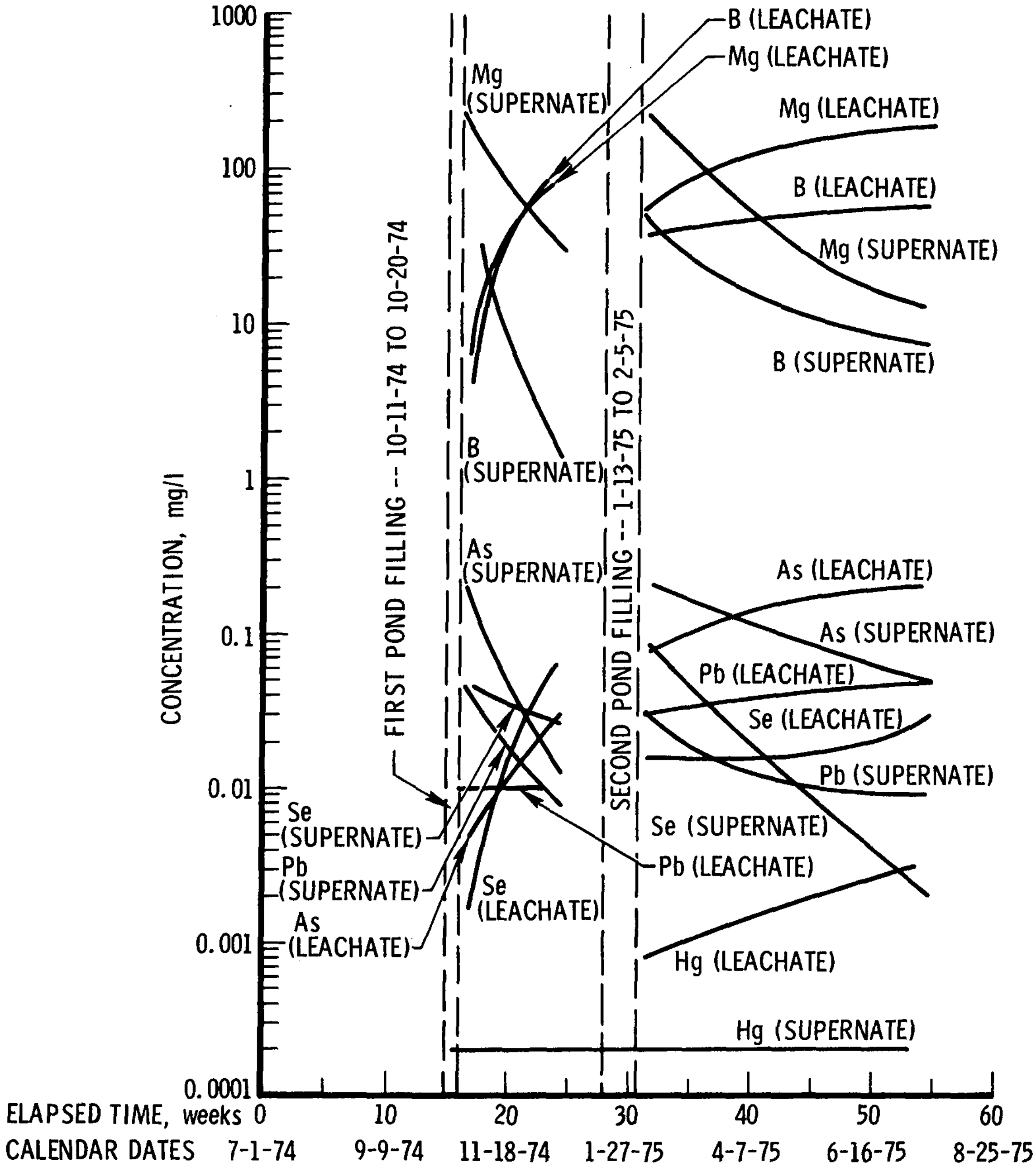


Figure 28. Minor constituents of Pond D supernate and leachate well (For the purpose of clarity, the data points have been deleted. The data are tabulated in Appendix C.2.)

and second fillings and continued to decrease at a reduced rate from approximately the same level following the second filling. In the leachate, the concentrations of the major constituents increased with time between the two fillings of Pond D and then increased slightly or remained approximately constant following the second filling of the pond. The TDS remained at a level of approximately 4000 ppm after the second pond filling, or approximately equal to the input liquor TDS. Similar patterns for the minor constituents of the leachate and supernate are apparent from the plots of Figure 28. However, the concentration of mercury is below or near the limit of detection so that a pattern cannot be distinguished.

8.2.4 Treated Sludge

For all three ponds containing the treated sludges, the concentrations of the minor constituents in the leachates and supernate were generally too low to establish trends with time. Therefore, these results have not been plotted as were the data for Ponds A and D in Figures 23 and 28; however, all the data are included in Appendix C.2. The leachate wells of Ponds B and C were sampled once prior to the filling of these ponds on 11 February 1975.

8.2.4.1 Pond B

Pond B was filled with limestone sludge chemically fixed by Dravo during the period of 7 to 15 April 1975. Ground water well GWB2 has been monitored since November 1974, and GWB1 has been monitored since the pond was filled. Since data are only available for a three-month period following the filling of Pond B, only tentative conclusions can be drawn with regard to the change in water composition with time. The ground water composition was unchanged during the post-filling period. The concentrations of the major constituents ranged between 10 and 200 ppm, and the TDS ranged between 200 and 600 ppm. As shown in the curves in Figures 29 through 32 and the tables in Appendix C.2, these constituents of the supernate decreased significantly in concentration during the post-filling period

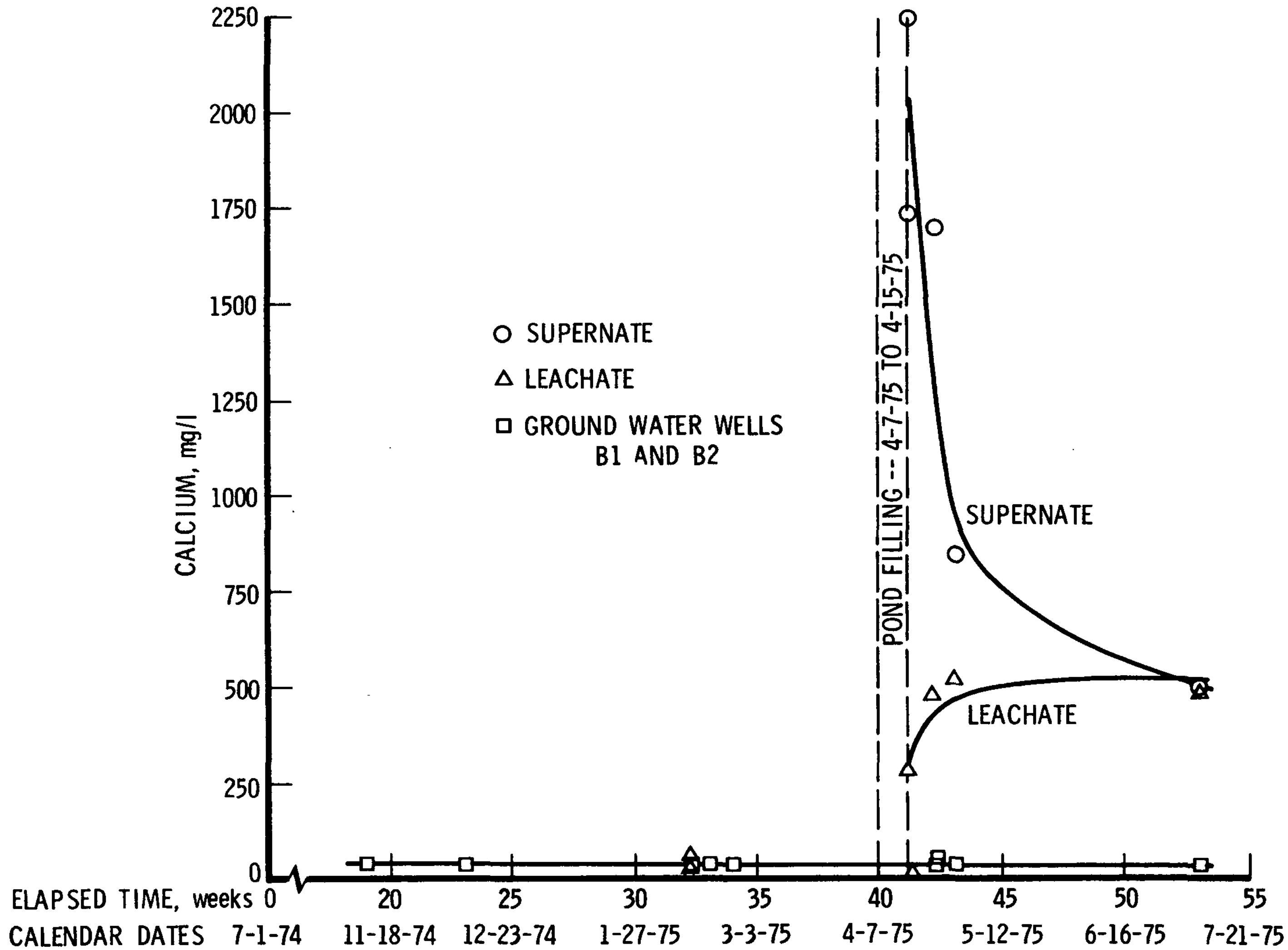


Figure 29. Calcium in Pond B supernate, leachate, and ground water wells

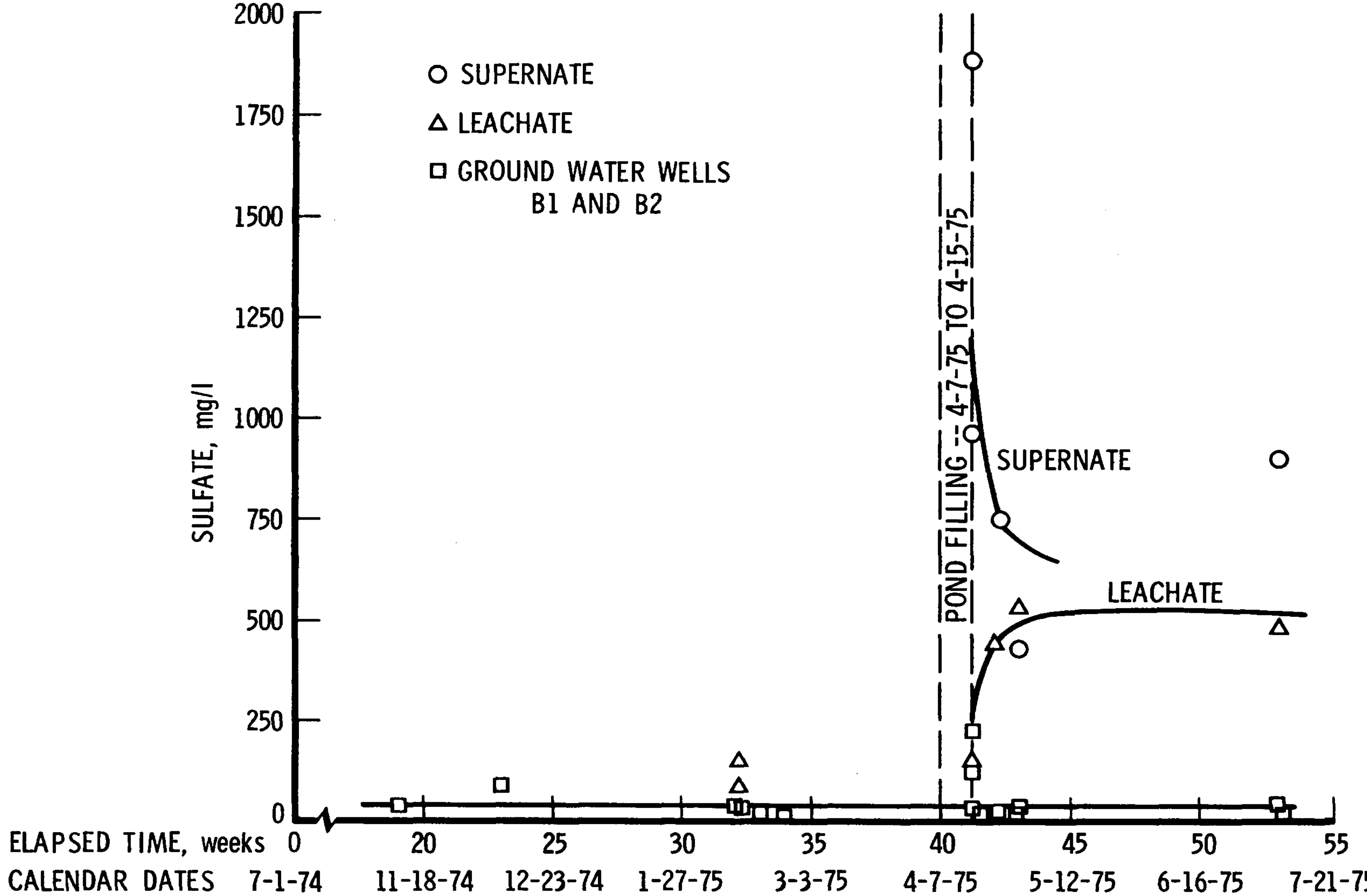


Figure 30. Sulfate in Pond B supernate, leachate, and ground water wells

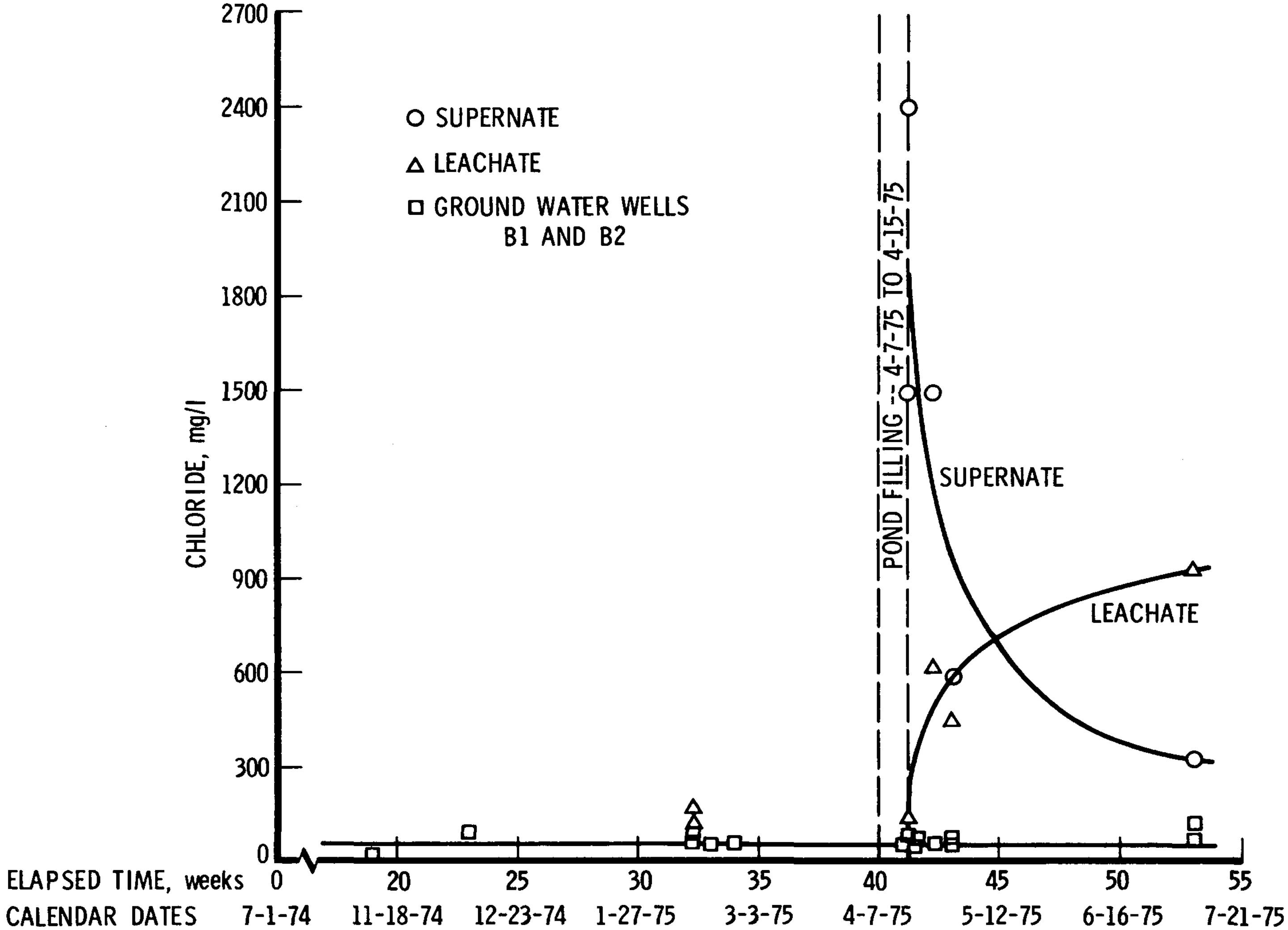


Figure 31. Chloride in Pond B supernate, leachate, and ground water wells

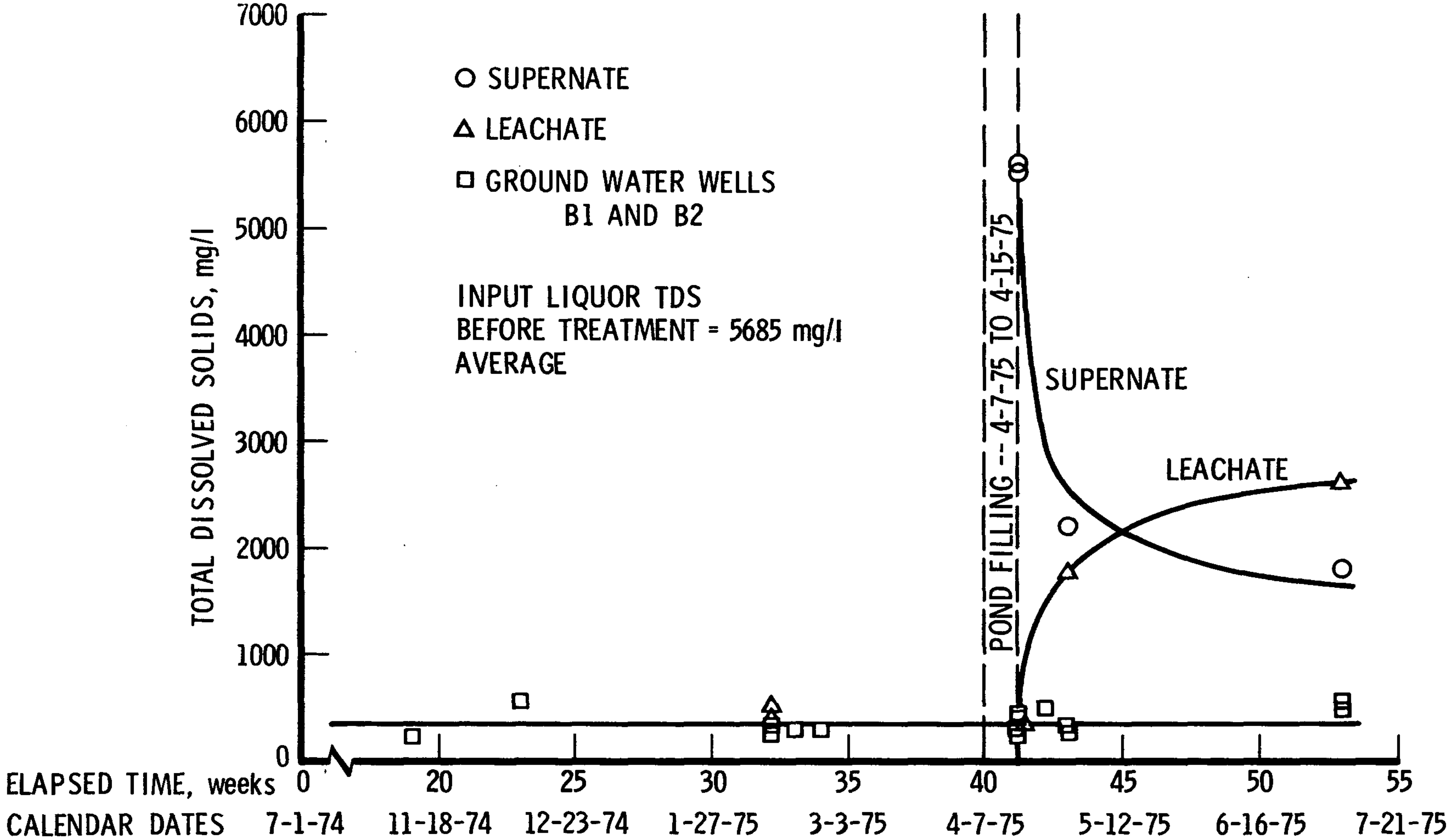


Figure 32. Total dissolved solids in Pond B supernate, leachate, and ground water wells

as a result of dilution by rainfall. As was the case for the ponds containing untreated sludge, the major constituents of the Pond B leachate are increasing with time. However, it is difficult to compare the current rates of increase, as they cannot easily be established from the few data points currently available. In the leachate of Pond B, the levels of the concentrations of the major constituents and the TDS currently are appreciably lower than those obtained for the input liquor prior to fixation. Additional data for Pond B must be obtained before the significance of these data can be ascertained.

8.2.4.2 Pond C

Pond C was filled with lime sludge that had been chemically treated by IUCS during the period of 1 to 23 April 1975. Monitoring data are therefore available only for a three-month period after pond filling. The ground water wells, however, had been monitored since July 1974. No significant changes in the ground water quality were observed in the samples taken after pond filling. Data for the major constituents and for TDS have been plotted in Figures 33 through 36 and are shown in Appendix C.2. The concentration levels were similar to those observed for the ground water of the other ponds. In the pond supernate, the concentrations of the major constituents and TDS were lower than in the input liquor as a result of rainfall dilution. In the Pond C leachate, the TDS in the early samples was approximately half that of the input liquor and then steadily dropped off with time. Additional Pond C monitoring data must be examined before conclusions can be reached with regard to the significance of these data.

8.2.4.3 Pond E

During the period of 3 to 7 December 1974, the sludge from Pond D was chemically fixed by Chemfix and transferred to Pond E. The ground water composition was unchanged during the entire monitoring period. The concentrations of the three major constituents in the ground water ranged between 10 and 120 ppm, and the TDS ranged between 200 and 600 ppm. Curves of water analysis data

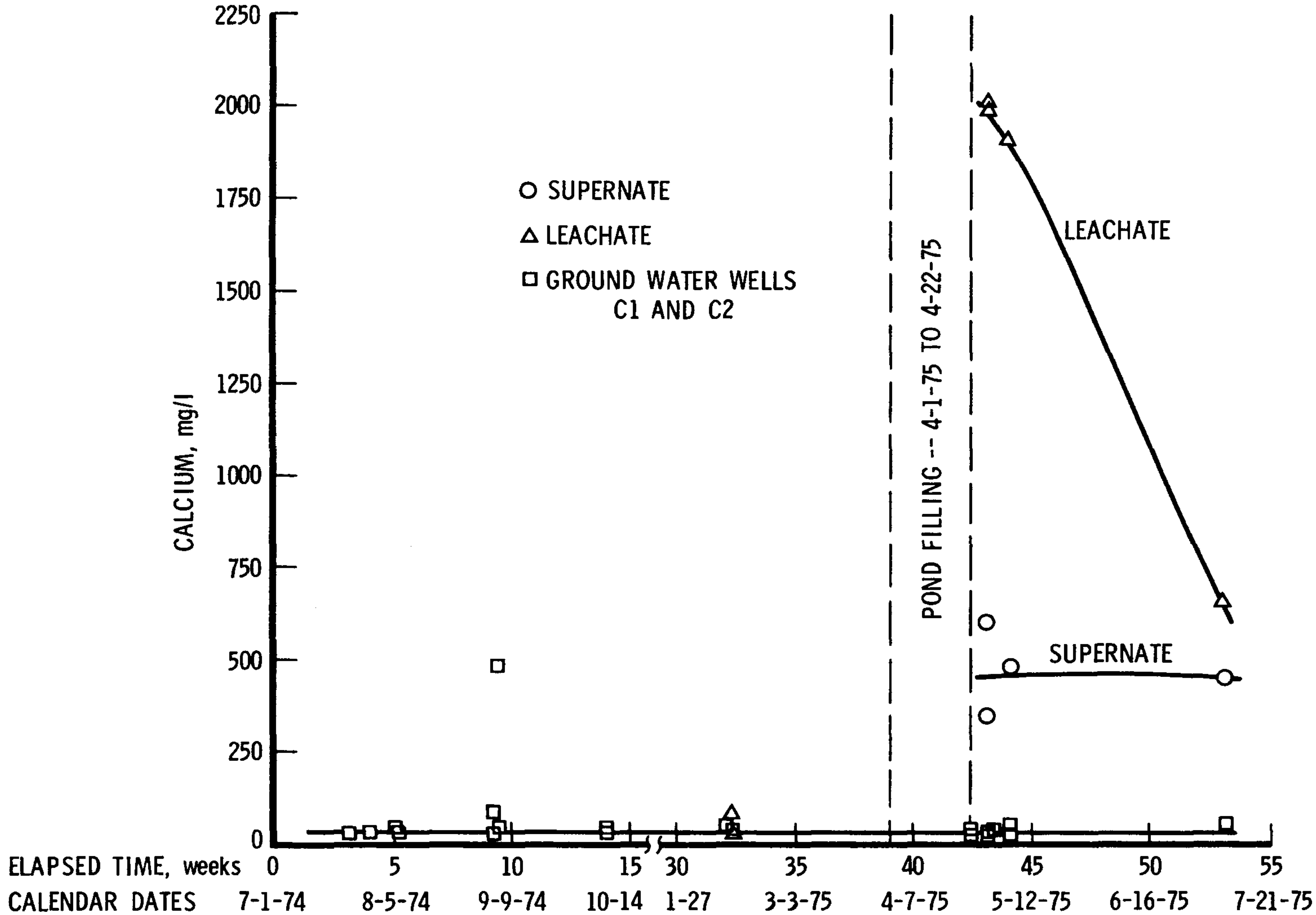


Figure 33. Calcium in Pond C supernate, leachate, and ground water wells

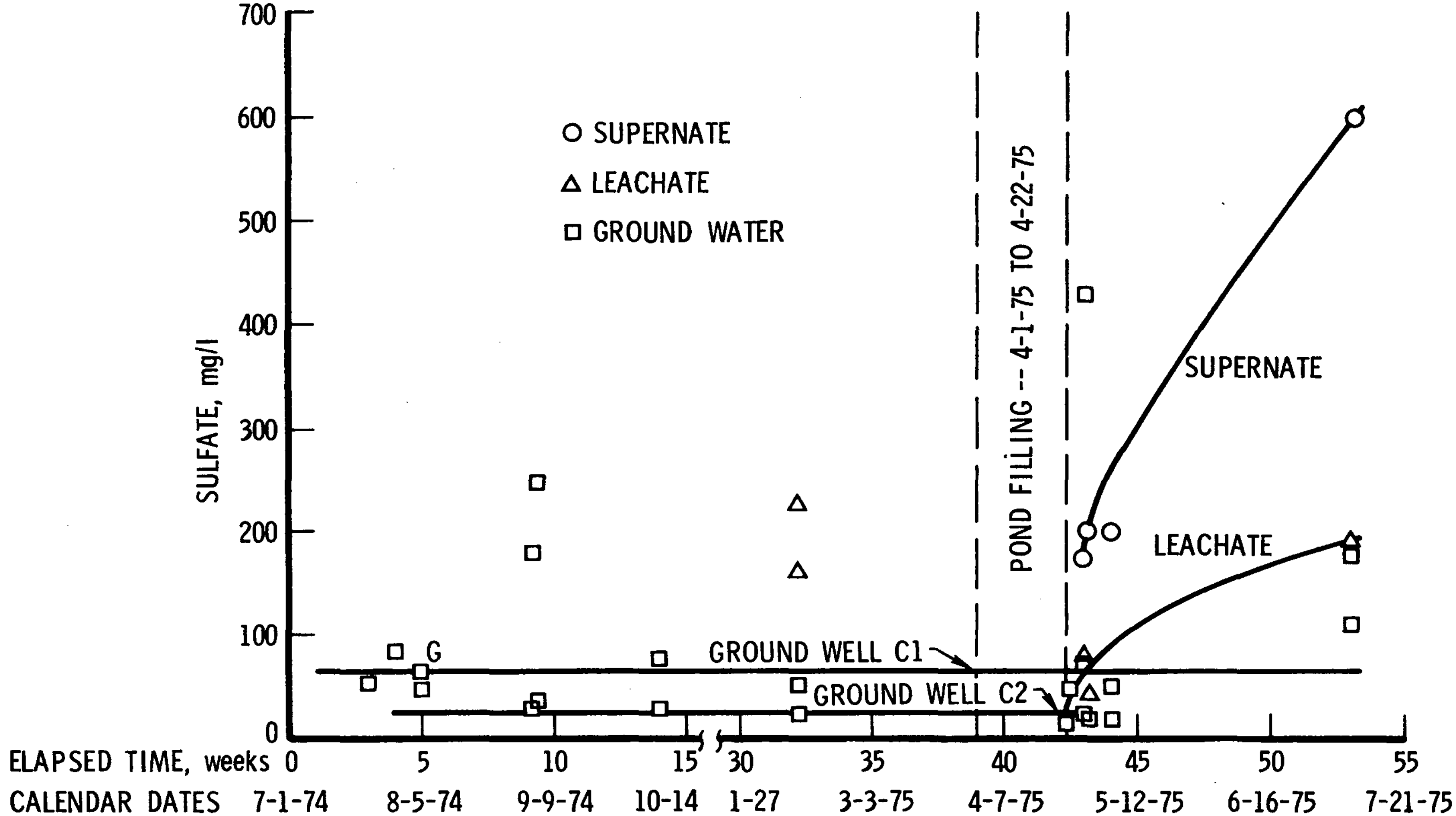


Figure 34. Sulfate in Pond C supernate, leachate, and ground water wells

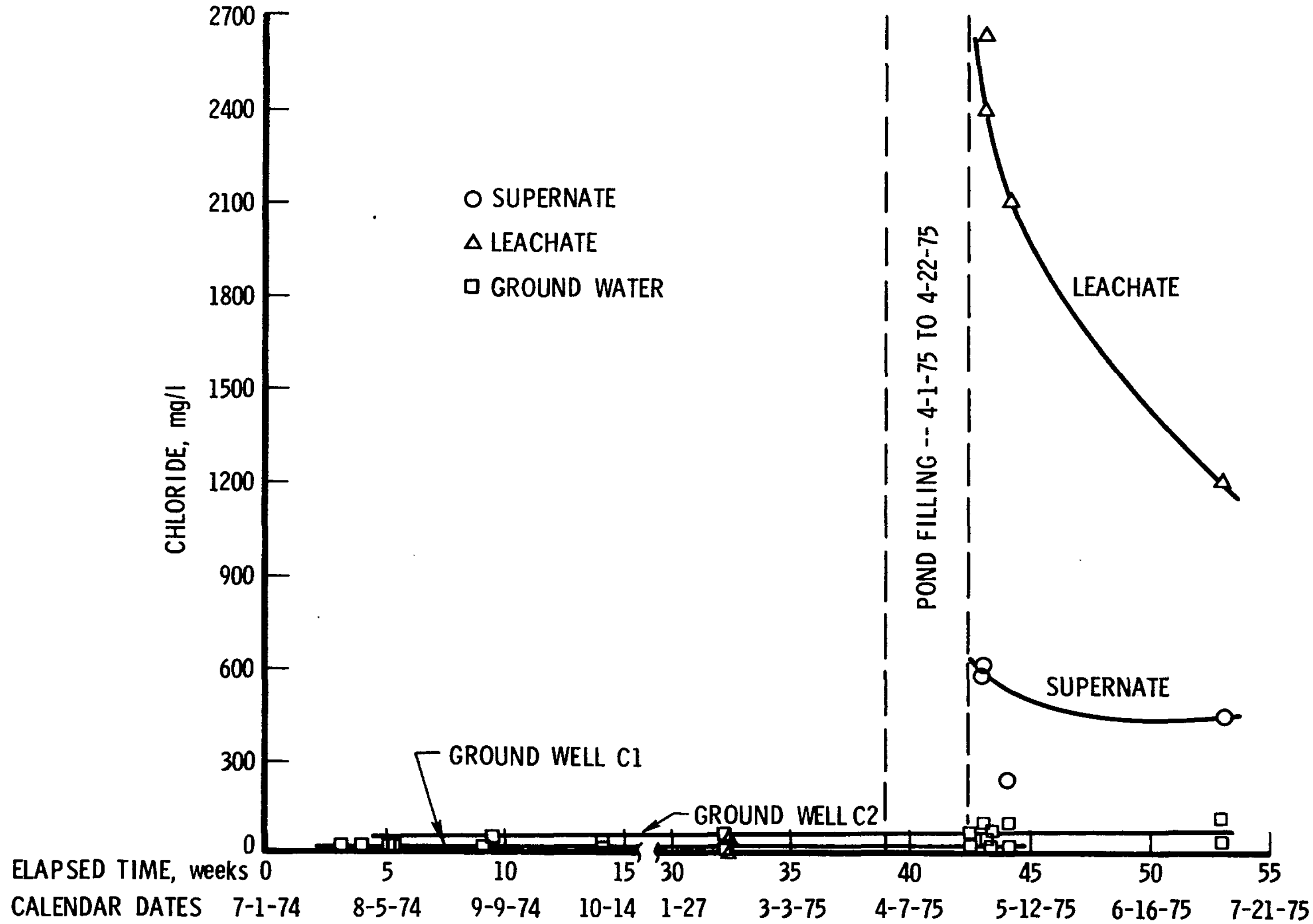


Figure 35. Chloride in Pond C supernate, leachate, and ground water wells

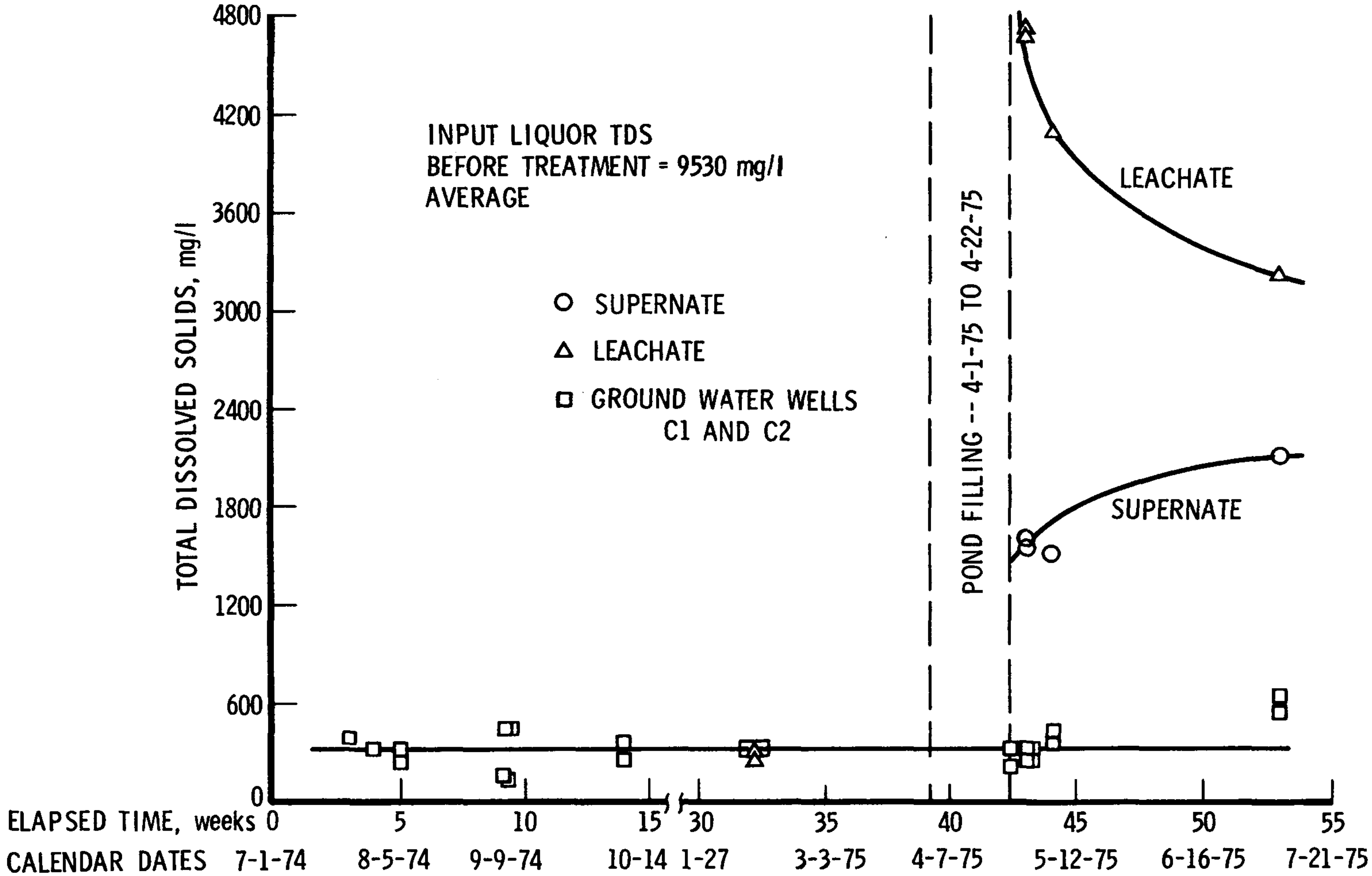


Figure 36. Total dissolved solids in Pond C supernate, leachate, and ground water wells

are shown in Figures 37 through 40, and tables of all data points are given in Appendix C.2. In the leachate, calcium and chloride concentrations decreased while sulfate and TDS concentrations increased with time to a value approximately half that in the input liquor; then they appeared to begin dropping off. In the supernate, concentrations generally reflected the effect of rainfall dilution. It will be necessary to obtain additional data from monitoring Pond E before definitive trends can be established. However, presently available data for the concentrations of the major constituents and TDS are appreciably lower than those from the input (untreated) sludge.

8.2.4.4 Physical Properties of Treated Sludge

Tests are being conducted at The Aerospace Corporation to determine coefficients of permeability, unconfined compressive strength, and triaxial shear strength of treated sludges from samples obtained from each of the treated ponds at the time of treatment and from pond core samples taken approximately every six months. These tests are in progress and will be reported as the data are available and verified.

A significant output of this effort will be the assessment of the time-related properties of the field samples as compared to analyses of laboratory-prepared samples that indicate the following: unconfined compressive strength equal to greater than 4.5 ton/ft^2, and coefficients of permeability of 10^{-5} to 10^{-7} cm/sec.

8.2.5 Soil Characterization

8.2.5.1 Physical Properties

The soil cores taken from the pond bottoms prior to filling and in the vicinity of the ponds when the ground water wells were dug were analyzed by TVA to determine their physical characteristics. The top soils are primarily lean clay, with some underlying layers of sand. The lean clay that forms the bottom and walls of each pond has a specific gravity of 2.6 to 2.7, a permeability of $\sim 2 \times 10^{-8}$ cm/sec, and a natural moisture content ranging from 14 to 22 wt%.

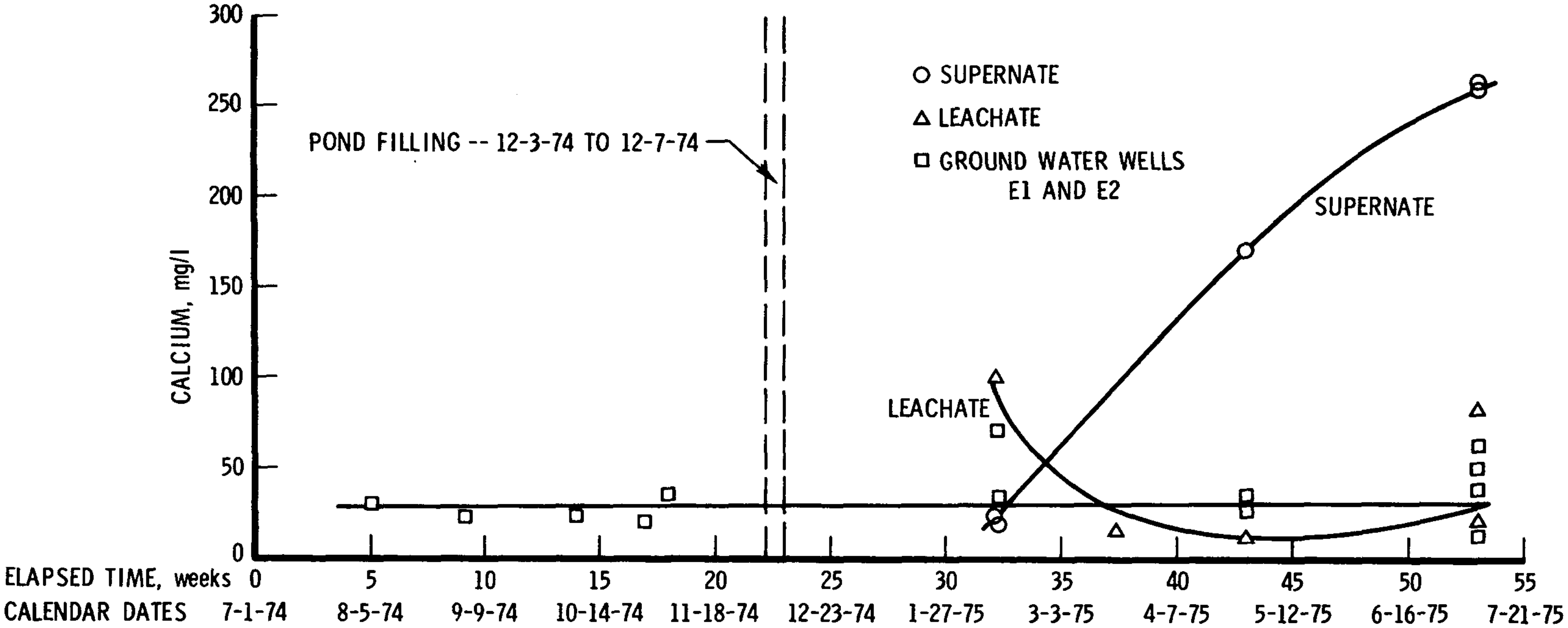


Figure 37. Calcium in Pond E supernate, leachate, and ground water wells

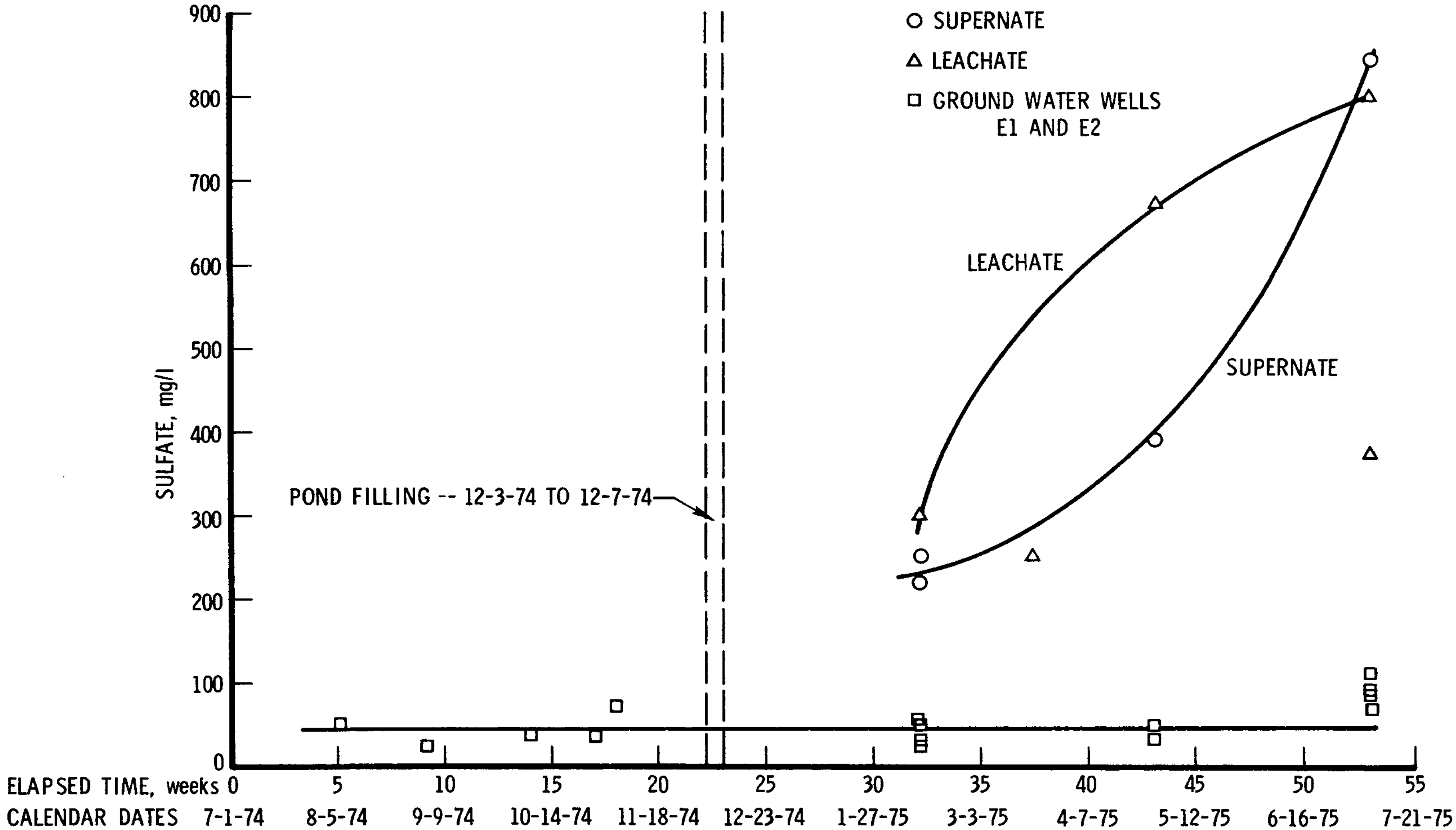


Figure 38. Sulfate in Pond E supernate, leachate, and ground water wells

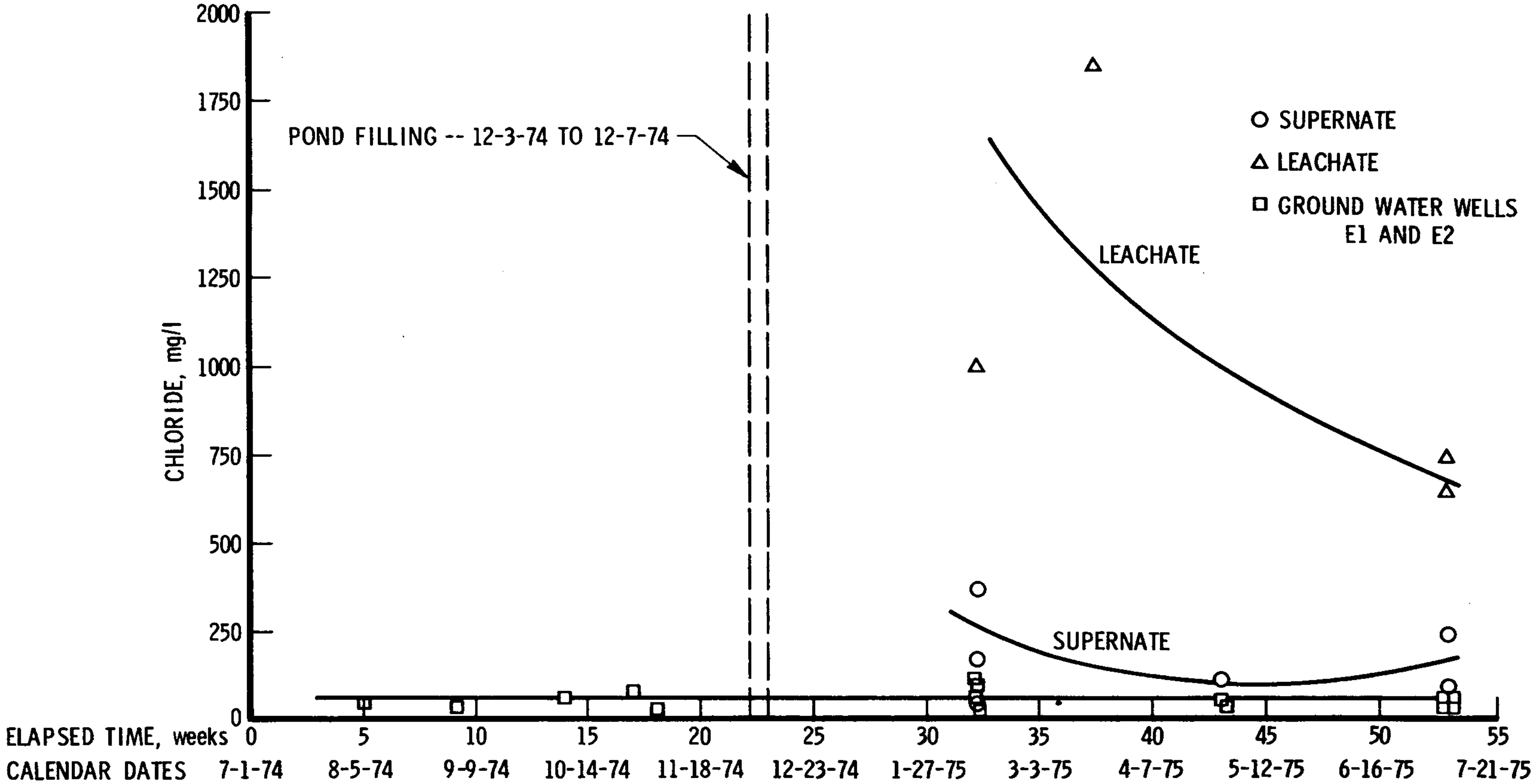


Figure 39. Chloride in Pond E supernate, leachate, and ground water wells

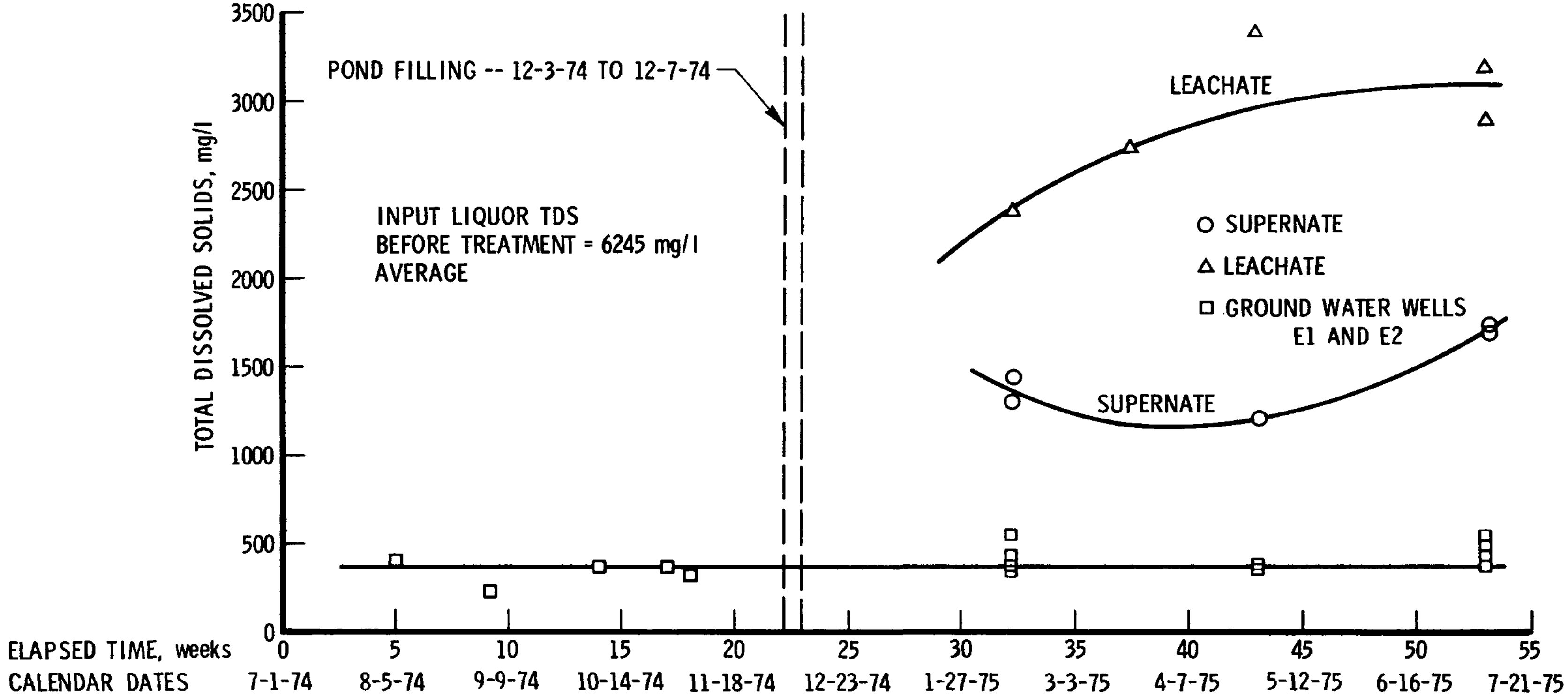


Figure 40. Total dissolved solids in Pond E supernate, leachate, and ground water wells

Less than 5% of the soil has a grain size greater than about 0.1 mm. It is expected that permeation of sludge liquor constituents will be exceedingly slow (i.e., less than 1 cm/yr) through the clay bed that forms the bottom and walls of the ponds. The results of the TVA analyses for the soils associated with each pond are tabulated in Appendix C.6.

8.2.5.2 Chemical Characterization

Using soil cores removed from the floor of each pond prior to filling, The Aerospace Corporation has begun an analysis of the chemical characterization of pond soils to serve as background for subsequent sludge permeation analyses. An elemental analysis of the soils is being conducted using the ion microprobe mass analyzer (IMMA). The IMMA represents the newest and most powerful instrument for microanalysis of solids.[14]

Briefly, the instrument uses a focused beam of charged ions impinging on the sample at high energy to create secondary ions from the sample material. These ions are mass analyzed to obtain characteristic elemental composition of the sample. For heterogeneous samples such as soil, the composition will vary with sample location; therefore, an average (or median) composition must be obtained. A limitation of the IMMA is that the analytical response and sensitivity vary with element and with the sample matrix. Therefore, an individual calibration for each element in the soil matrix must be obtained so that the ion current obtained directly from the IMMA can be correlated to concentration units.

Periodic IMMA analyses will be made at the sludge interfaces of soil cores taken from the bottom of sludge ponds, and increases in the relative amounts of specific elements present in the soil will be determined. These elements will be analyzed at different distances from the interface so as to obtain depth profiles of these elements that will establish the depth penetration and the attenuation of each element in the soil.

Results for the first set of five pond soil cores have been included in Appendix C.7 of this report. Analyses were made for seven elements: boron, magnesium, calcium, arsenic, selenium, sulfur, and chlorine.

Samples were cut from the tops of the soil cores. The samples were oriented with a cross-sectional surface exposed for elemental analysis with the IMMA. For each sample, analyses were made at three positions, each approximately 0.1 mm away from the top surface of the soil core. Because of the heterogeneous nature of the clay soil, the probe was allowed to traverse a linear distance of 0.4 mm, and the integrated average current was recorded for each ion. The median values for these integrated ion currents for each of the seven elements are shown in Appendix C.7, together with the standard deviations. These values of ion currents are proportional to concentrations when compared with calibration standards. For all elements, the data for the Pond A sample are significantly lower than the corresponding data for the four other samples. This difference may be due to the dilution of the clay soil at the Pond A site with an inert ingredient such as sand. The median current values for the samples from Ponds B, C, D, and E have been combined to obtain elemental analytical data that are representative of the clay soil on the bottoms of these four ponds.

Additional soil cores that were taken prior to the filling of Ponds B, C, and E have not yet been analyzed. With these additional samples, somewhat better determinations of the confidence limits of the data can be made. However, the combined results for Ponds B, C, D, and E shown in Appendix C.7 should form an adequate basis for comparison with analysis of soil samples taken after the ponds were filled with sludge.

8.2.6 Climatological and Hydraulic Data

In order to correlate pond water storage observations with local climatological conditions, a program of periodic monitoring of weather conditions, e.g., total wind movement, rainfall, evaporation, and maximum and minimum temperatures, was established, and measurements were taken daily at the pond site beginning early in 1974. On a weekly basis, the depths of water in the ponds, leachate wells, and ground water wells were monitored beginning early in 1974 for GWA1 and early in 1975 for the other ground water wells and for supernate levels of Ponds A and D. Starting in mid 1975, supernate and sludge levels for the other ponds were monitored, as were the water levels and bottom elevations of all the leachate wells. These weekly data have been compiled and are included in Appendix C.4.

Correlations between weekly precipitation and pond water levels are demonstrated by the graphs of Figures 41 through 46. Qualitative correlations of pond performance with weather effects will be made during the coming year. In Figures 41 through 43, the depths of water in leachate wells and supernates of Ponds A, B, and D have been plotted. Superimposed on the more gradual seasonal variation in water levels, caused by imbalances of evaporation losses from the ponds and rainfall replenishments, is a weekly fluctuation that in almost every case can be associated with high (or low) precipitation for that week. It should be noted that water level measurements, although usually taken on Monday of each week, sometimes were taken as late as Wednesday. Since rainfall data are cumulative for each week, in some instances the rain might precede the water level measurements and in others conversely, which would account for occasional lags in the correlation. Similar curves have been plotted in Figures 44 and 45 for Ponds C and E. However, comparable data for pond supernate are not available for these two ponds because of little or no supernate in the area of the leachate wells. In Figure 46, it is apparent that the depths of water in the ground water wells associated with Pond A also vary in step with the weekly precipitation. The seasonal variation of water levels in these wells is distinctly different from that of the remaining ground water wells. A possible explanation is a perched water table in the adjoining ash storage dump.

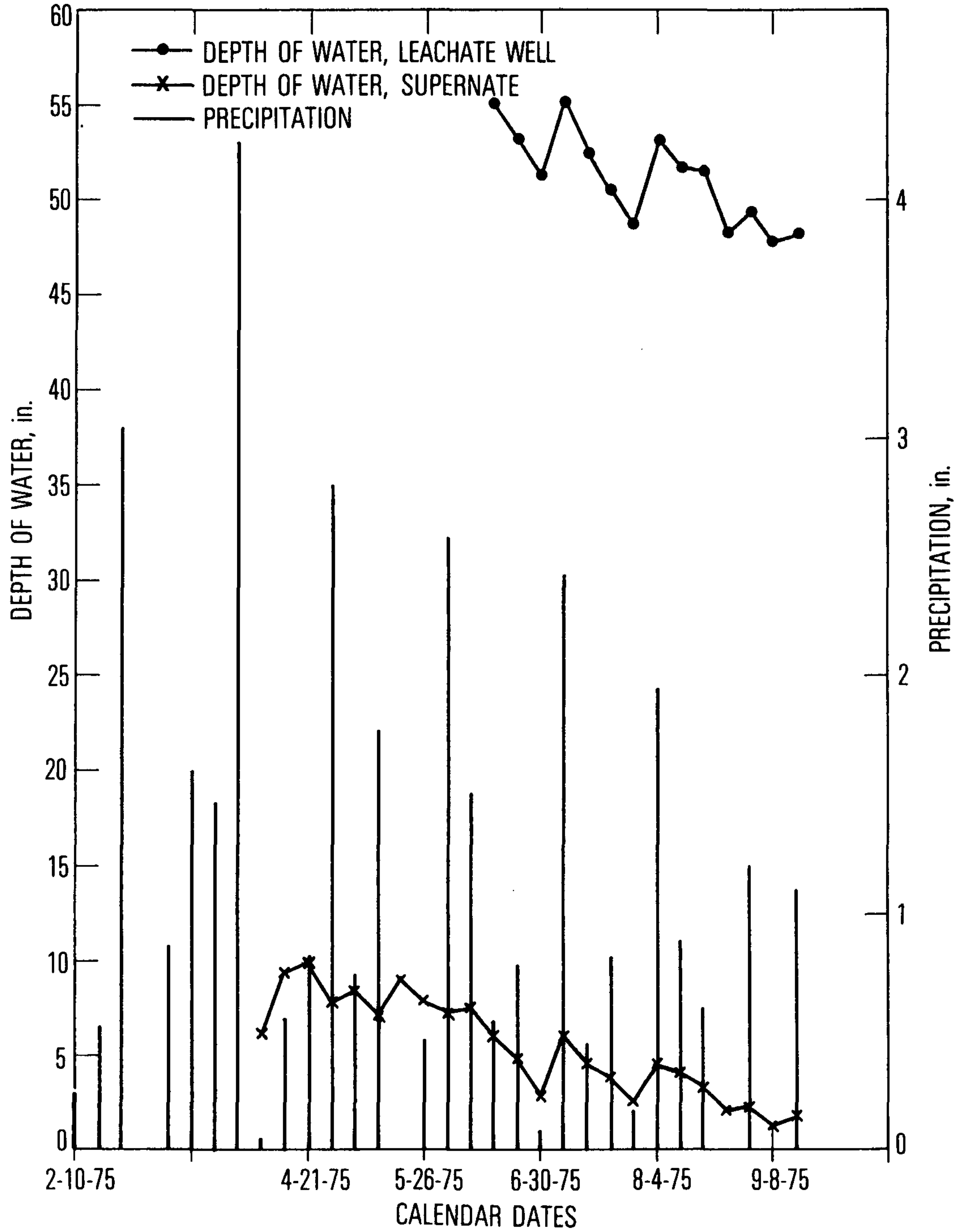


Figure 41. Weekly precipitation and water levels for Pond A supernate and leachate well

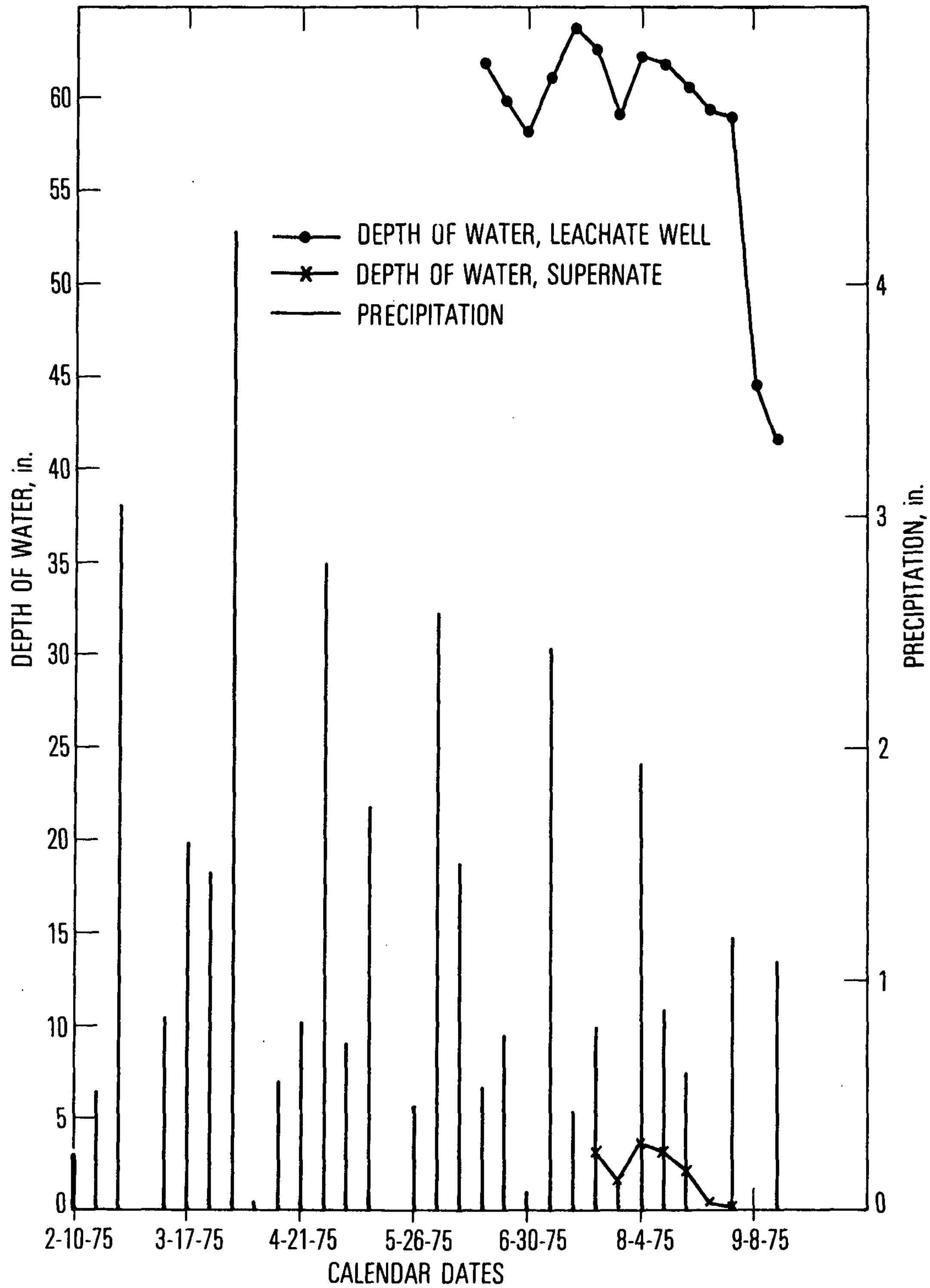


Figure 42. Weekly precipitation and water levels for Pond B supernate and leachate well

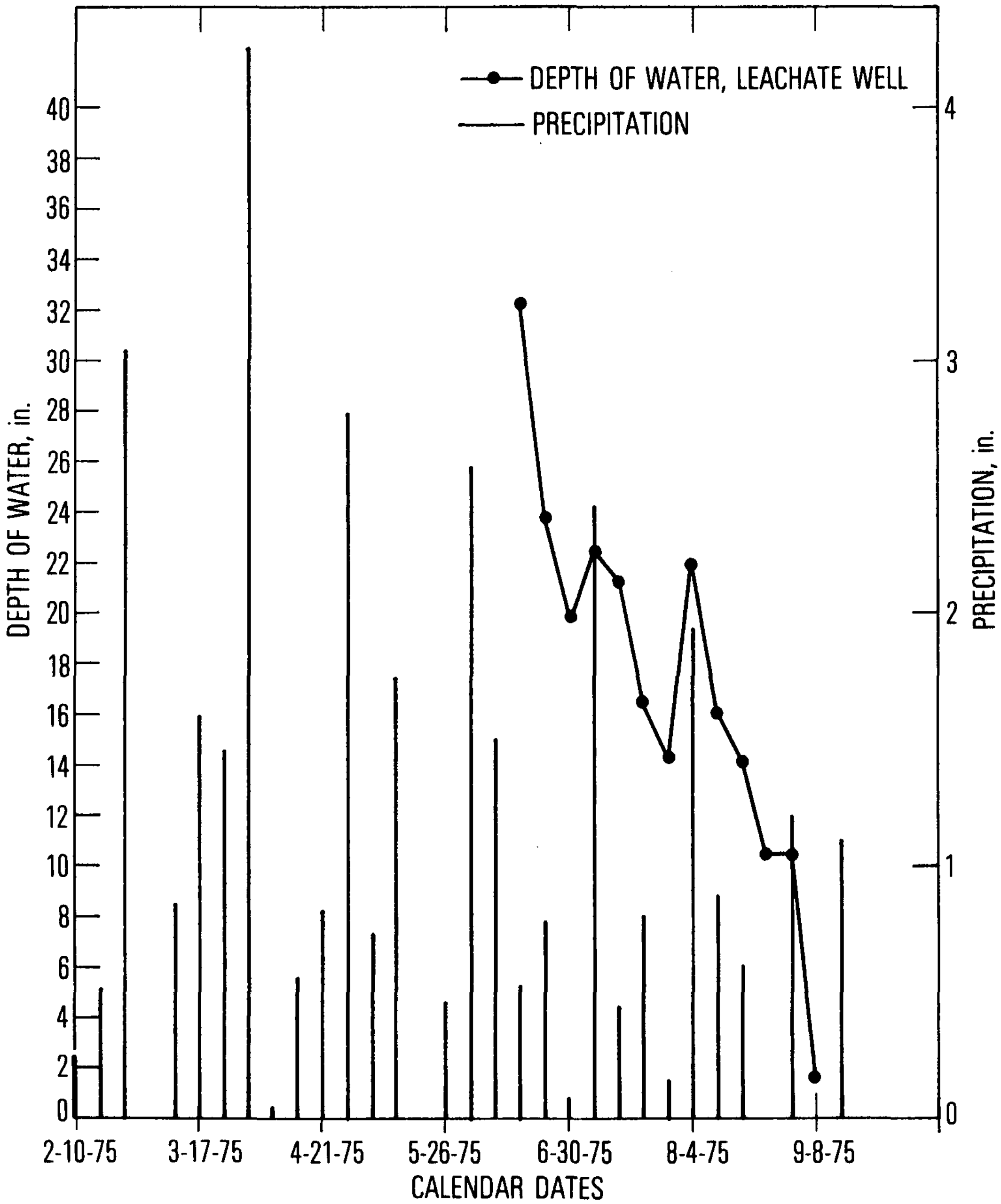


Figure 43. Weekly precipitation and water levels for Pond C supernate and leachate well

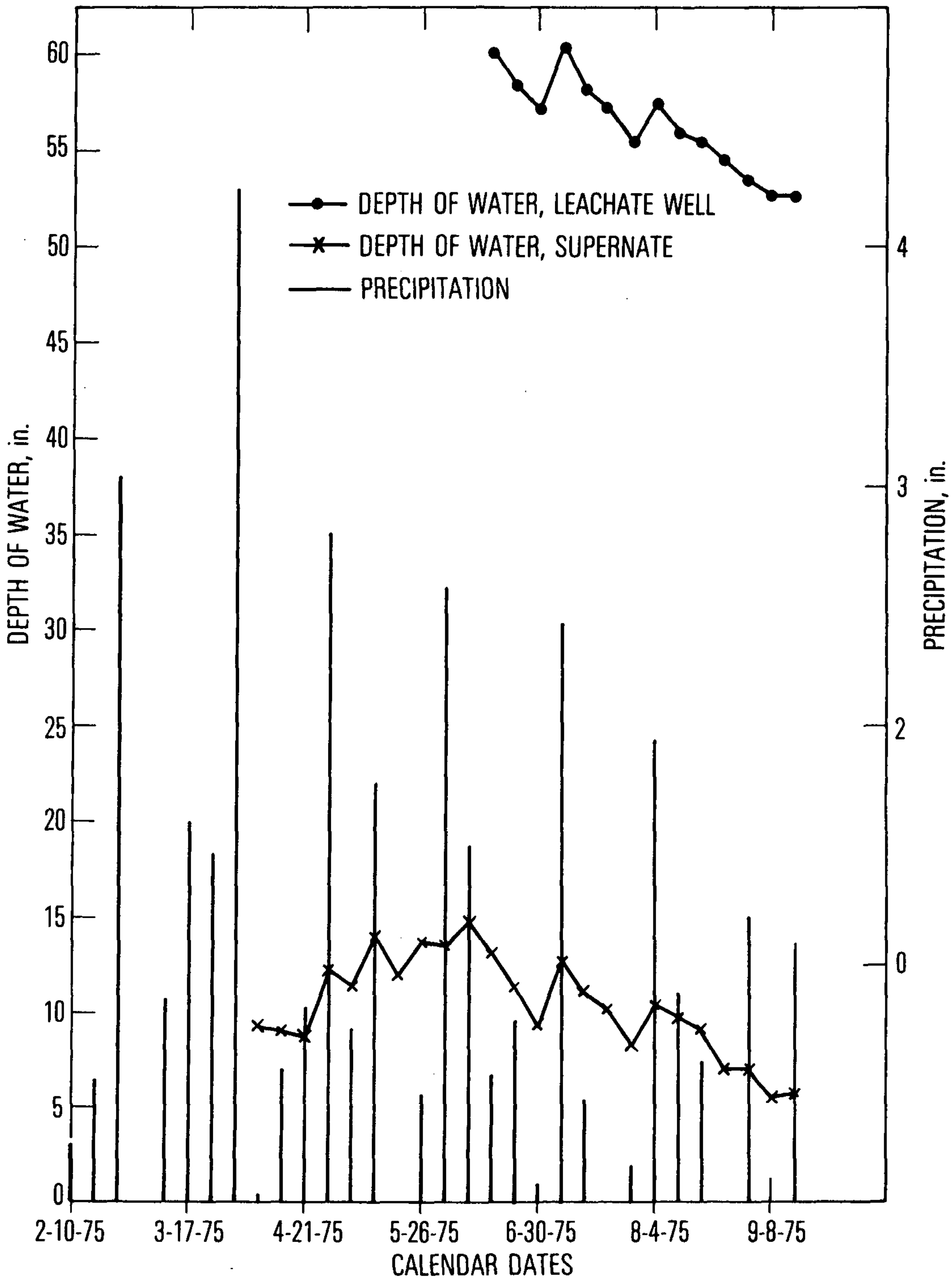


Figure 44. Weekly precipitation and water levels for Pond D supernate and leachate well

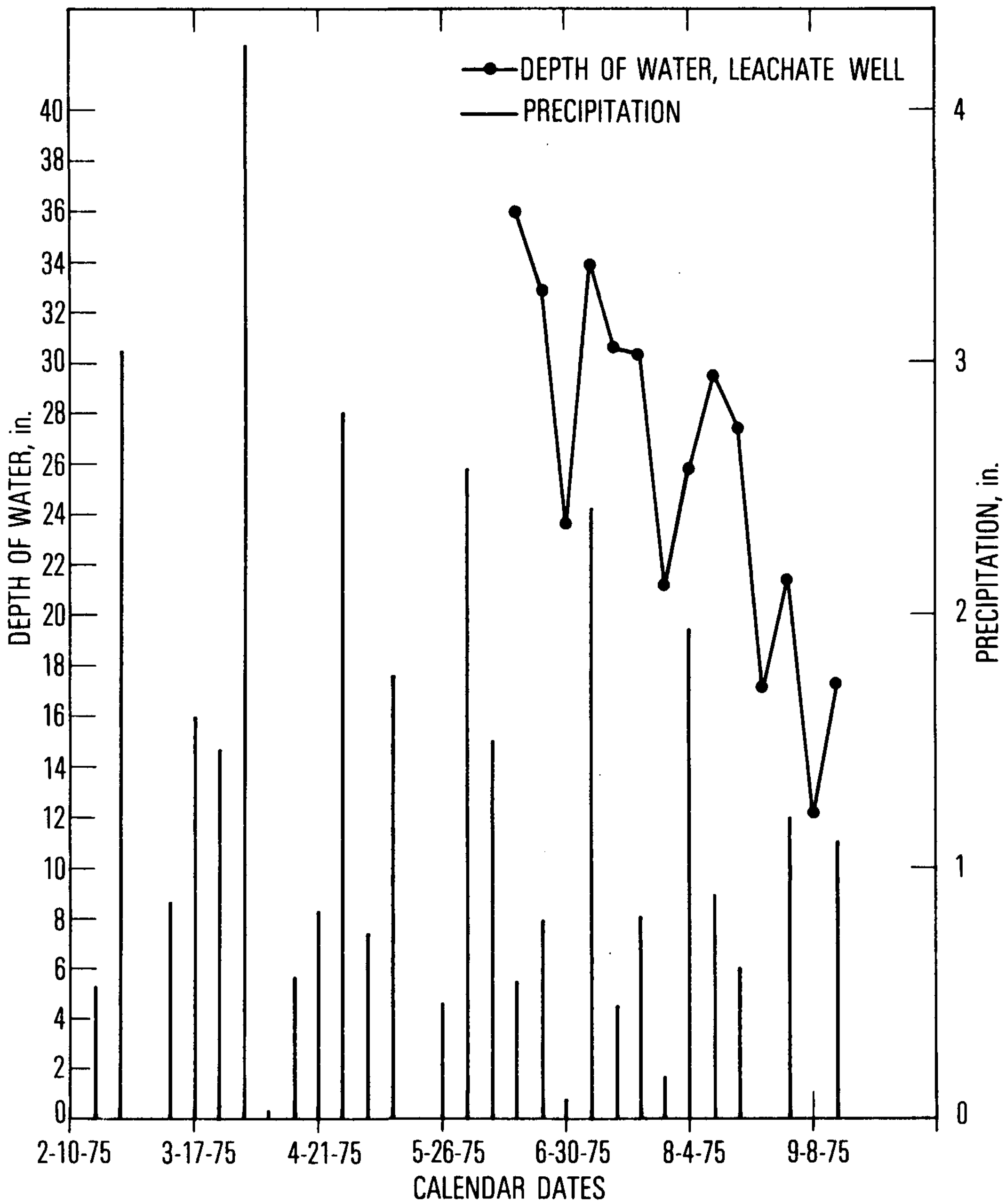


Figure 45. Weekly precipitation and water levels for Pond E supernate and leachate well

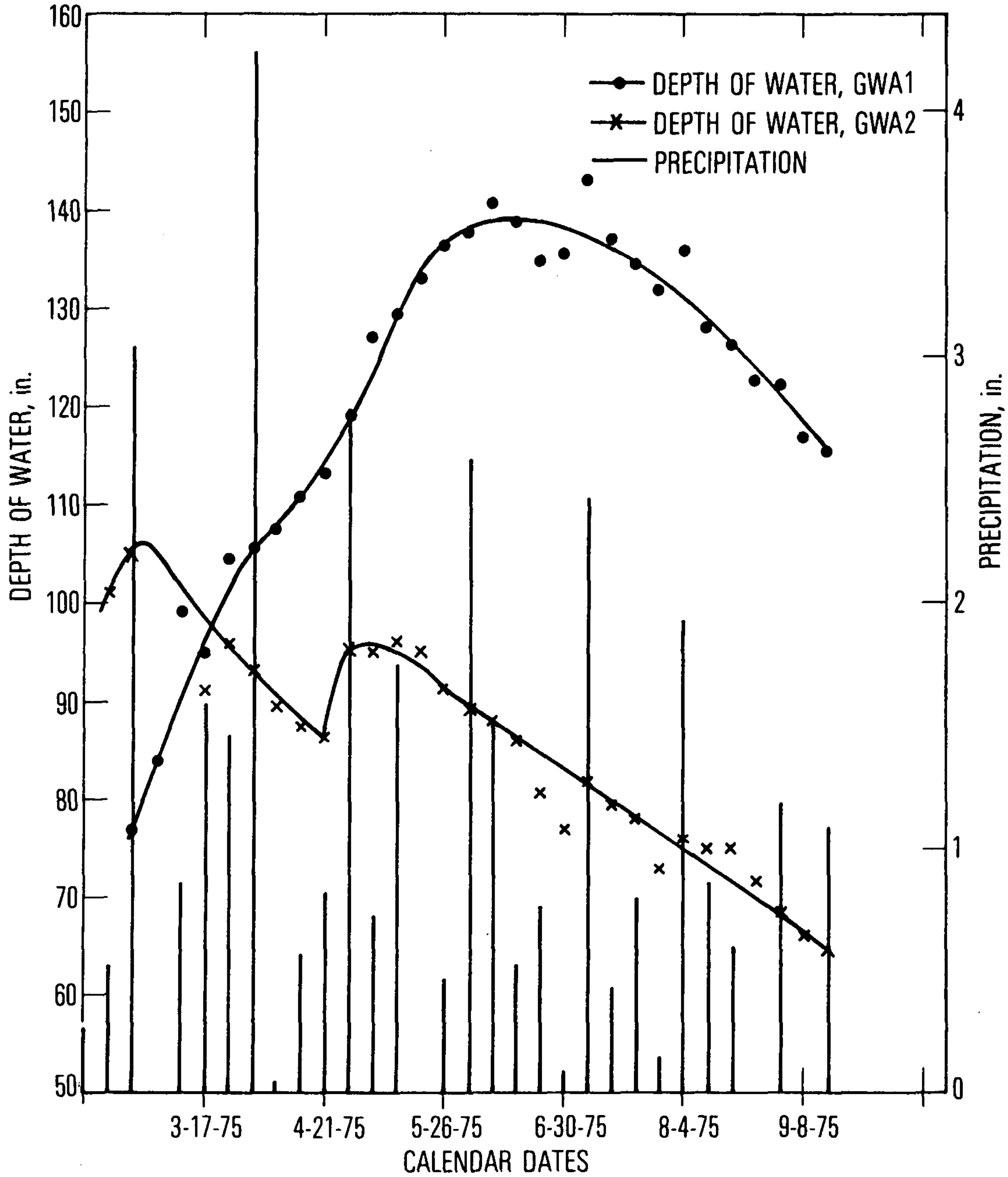


Figure 46. Weekly precipitation and ground water well levels for Pond A

In Figures 47 through 50, the depths of water in the ground water wells of Ponds B, C, D, and E are compared with the weekly stages of the Ohio River at Shawnee. Although for these wells weekly variations in water levels that correspond to the weekly precipitation are apparent, the purpose of these four graphs is to call attention to the seasonal variation in the water table that correlates with the level of the nearby river.

Mention should be made of the data obtained from monitoring the well bottom elevations. For all wells, the spread of these data is no greater than 1 foot. Therefore, over the monitoring period there is no evidence of any substantial silting of the wells. Well water depths appearing in this report have been obtained from the differences between weekly water level measurements and the averages of the weekly well bottom measurements.

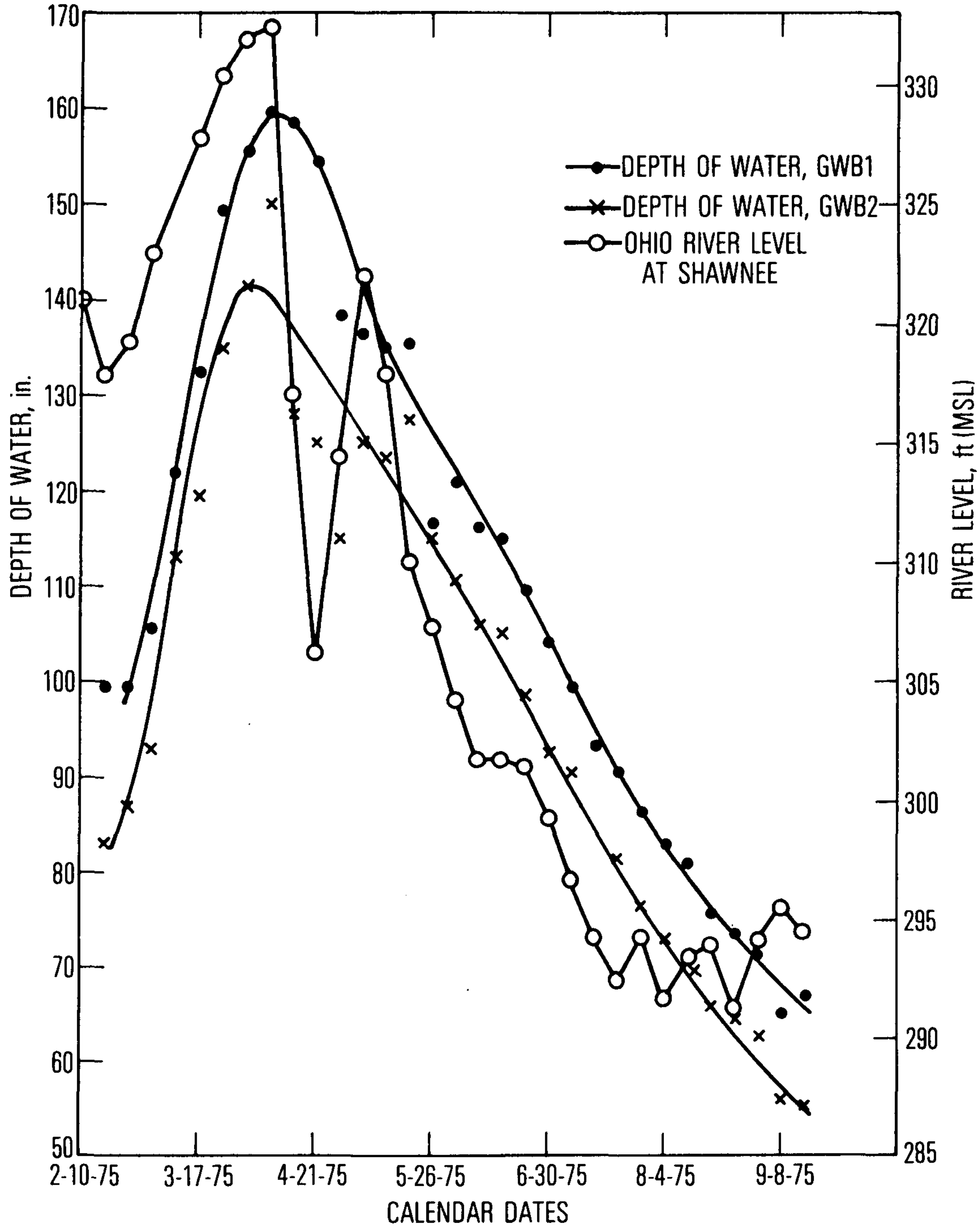


Figure 47. Weekly river stages and ground water well levels for Pond B

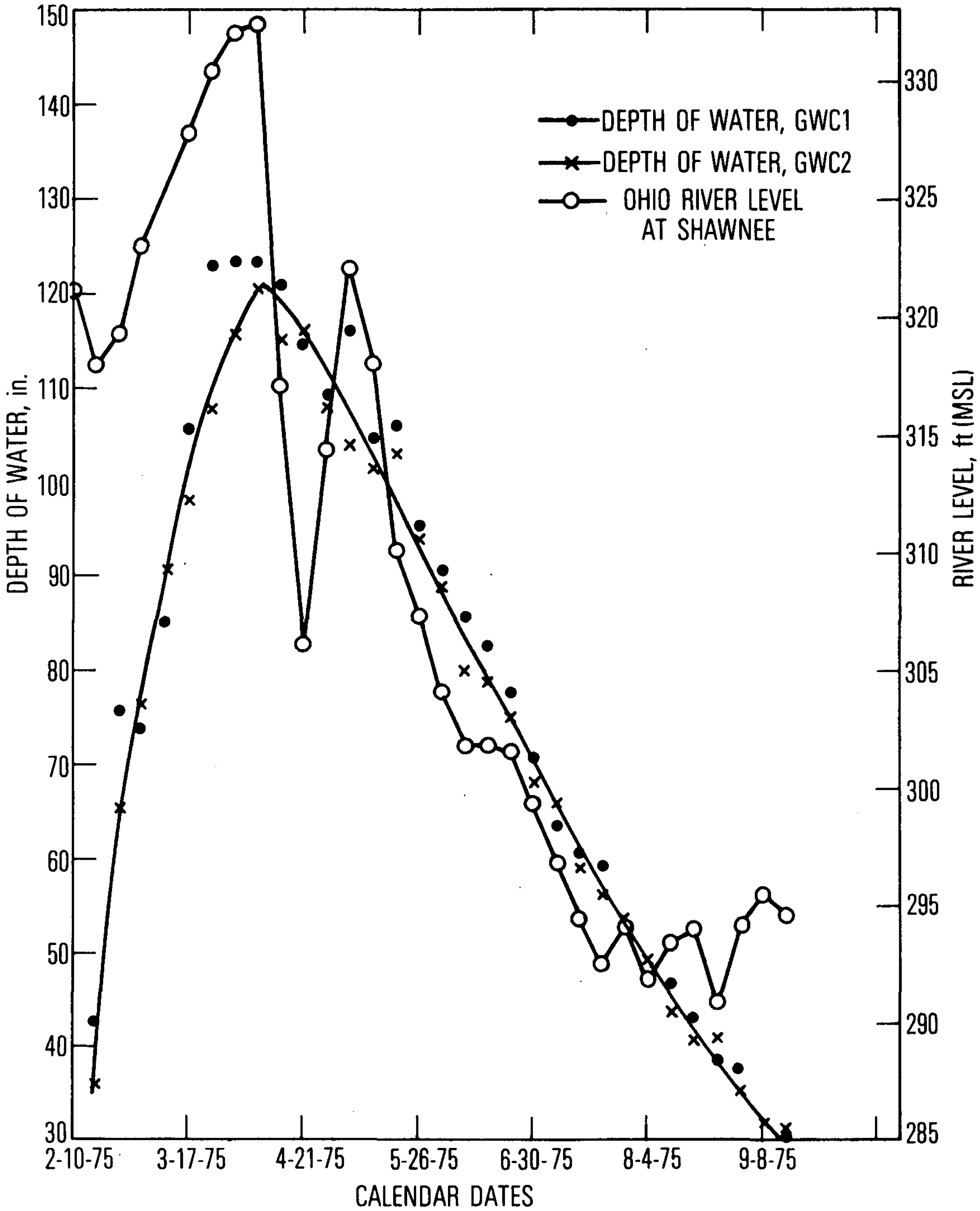


Figure 48. Weekly river stages and ground water well levels for Pond C

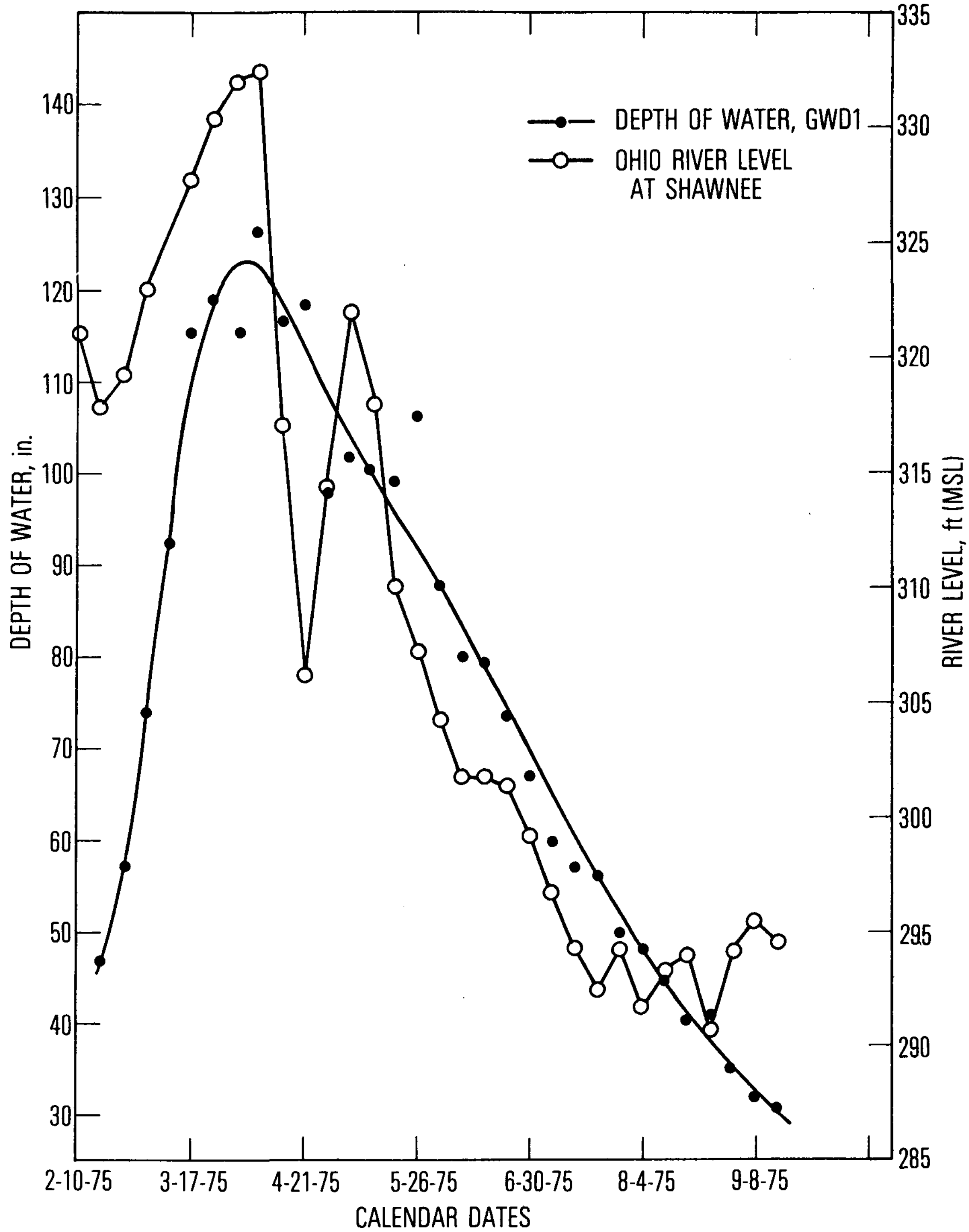


Figure 49. Weekly river stages and ground water well levels for Pond D

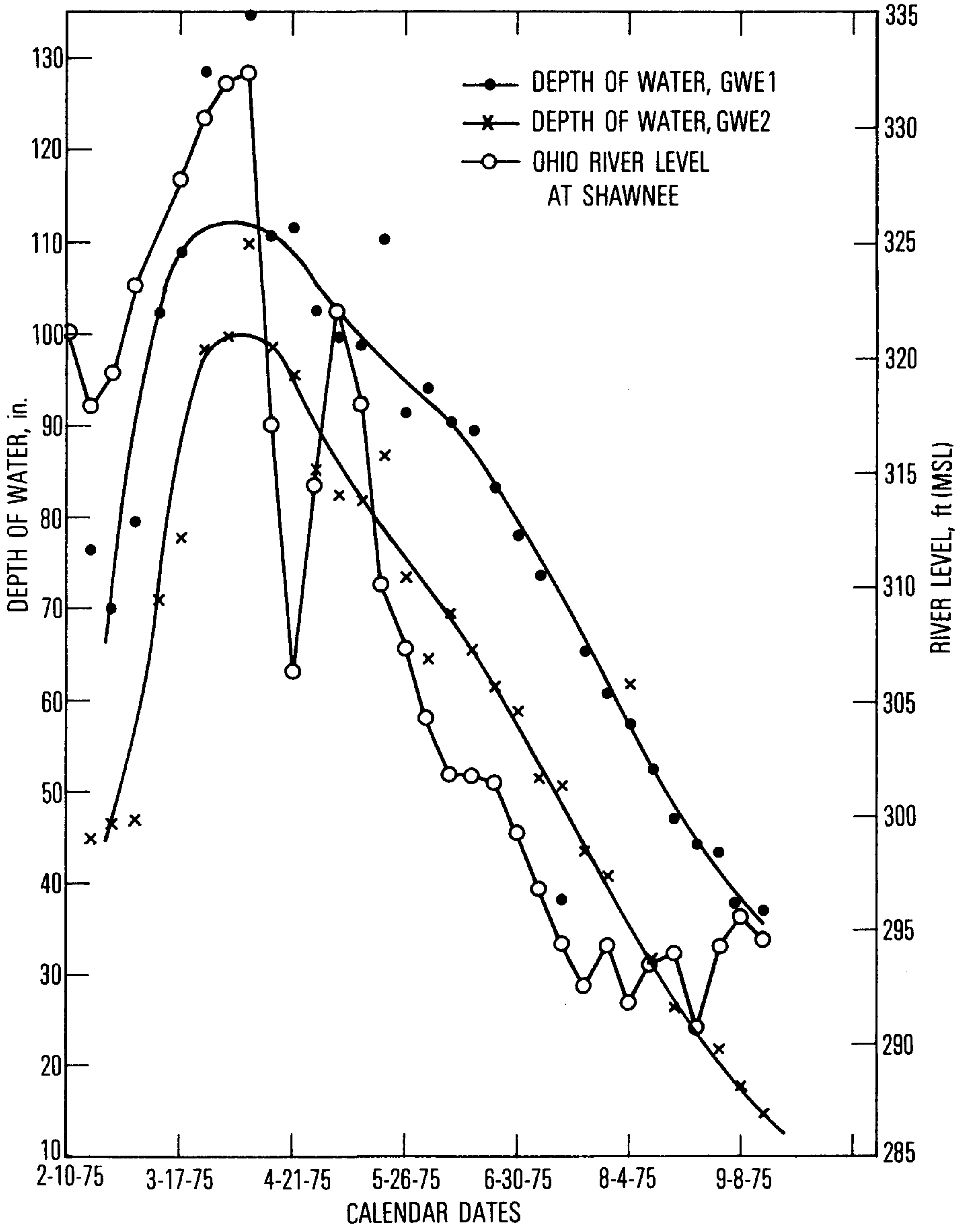


Figure 50. Weekly river stages and ground water well levels for Pond E

SECTION IX

TOTAL DISPOSAL COSTS

In order to assess the economics of the cross section of disposal modes being evaluated (i.e., simulations of dam and landfill), including variations in effluent conditions such as ash and solids content, engineering estimates were requested from each of the three fixation contractors for the cost of full-scale operations. The Shawnee field evaluation experience provided a basis to relate processing variables to the costs of an operation treating 125 ton/hr (dry basis) of sludge, including fly ash, from a 1000-MW power plant. Typically the solids in the sludges supplied to the processors were comprised of approximately 45 wt% fly ash, and 45 to 50 wt% calcium sulfite and calcium sulfate (in a 3 to 1 ratio), with the remainder being unreacted limestone or precipitated calcium carbonate.

Capital and operating costs for the full-scale projections were presented by the fixation contractors, including items such as capital investment, additives, labor, processing, and transportation, with disposal of the fixed material at sites both 0.5 and 5.0 miles from the power plant.[15-17] Other pertinent cost elements were identified and total costs in terms of dollars per ton of dry sludge disposed were provided. Those costs were evaluated and adjusted by The Aerospace Corporation to produce estimates of total disposal costs on a common basis as much as possible. Steps taken were as follows: (1) the same method of determining capital charges was used, (2) land and dewatering costs were added as appropriate, (3) transport and site preparation costs were adjusted as appropriate, and (4) all costs were adjusted for average annual load factors of 50 and 65%. Total disposal costs (Aerospace estimates) in 1975 dollars based on Shawnee test conditions scaled up for a 1000-MW power plant are described for a 30-yr plant life and a 50% average annual load factor. The effects on total disposal costs for operating at a 65% average annual load factor were also evaluated and are summarized. Corresponding costs, adjusted by Aerospace, for fixation conditions proposed by the processors are also provided; the latter generally relate to reduction in the additive requirements resulting from the application of their process to projected full-scale operations as compared to the Shawnee test conditions.

Since the cost data presented in this report are based on the conditions described above and may not be universally applicable, they are not intended to be a ranking of the disposal costs for the three processes being evaluated. As a result of this evaluation, however, the data developed by Aerospace provides a range within which the total cost of sludge fixation and disposal as represented by these three processes may be expected.

9.1 GENERAL ASSESSMENT

Ground rules for fixation contractor costs projections were specified in general rather than specific terms to allow originality by the contractors in defining variables and to minimize artificial restrictions that might have resulted from the small-scale field evaluations. As a result, full-scale cost projections were not necessarily based on a direct scale-up of the Shawnee sludge treatment conditions. The significant factors affecting the cost differences are shown in Table 10. Flow diagrams of the various fixation processes for an operational plant, based on the Shawnee evaluational ground rules, are shown in Figures 51 through 53. The Aerospace-derived cost for full-scale treatment and disposal are shown in

Table 10. SIGNIFICANT FACTORS AFFECTING FULL-SCALE COST PROJECTIONS, AND CONDITIONS ASSESSED BY AEROSPACE BASED ON PROCESSOR DATA

Process	Shawnee Operations	Disposal Conditions Costed by Processors	Conditions Assessed by Aerospace Based on Processor Information
Chemfix (Figure 54)	38 to 40 wt% sludge solids	40 wt% solids (50 wt% also reported)	35 to 55 wt% solids, drained disposal site 40 wt% solids, disposal site under water
Dravo (Figure 55)	32 to 38 wt% sludge solids	38 wt% solids, disposal site behind dam Dam-site return ratio = 20	32 to 38 wt% solids, dam return ratios of 10 and 20 35 wt% solids, dam return ratio of 15
IUCS (Figure 56)	47.5 to 59 wt% sludge solids (weighted average = 55%)	55 wt% solids	55 wt% solids (average), varied percent additive

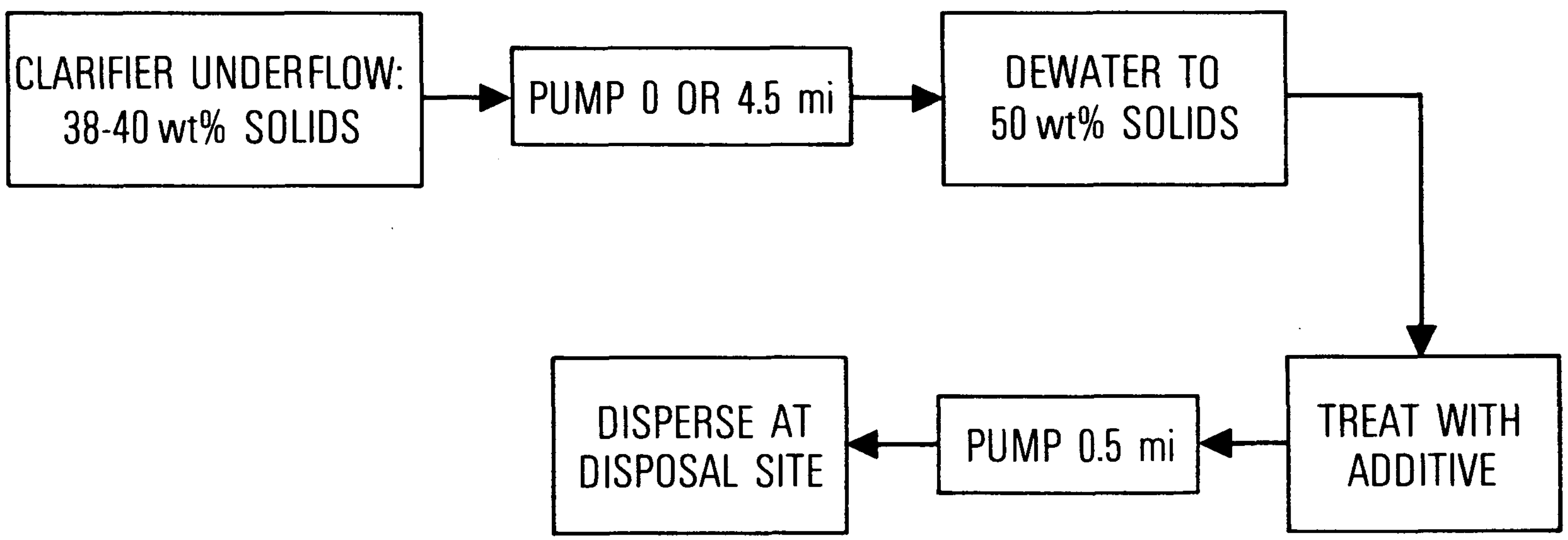


Figure 51. Flow sheet for an operational plant used as a baseline for costing the Chemfix process

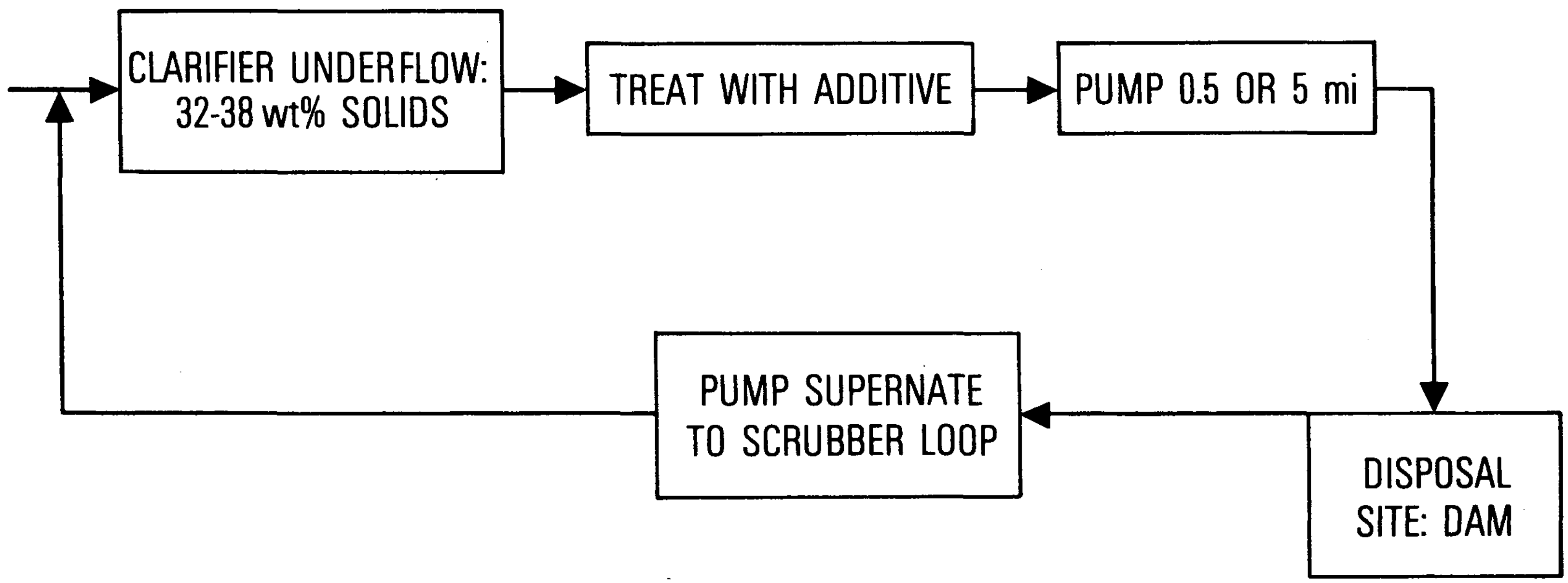


Figure 52. Flow sheet for an operational plant used as a baseline for costing the Dravo process

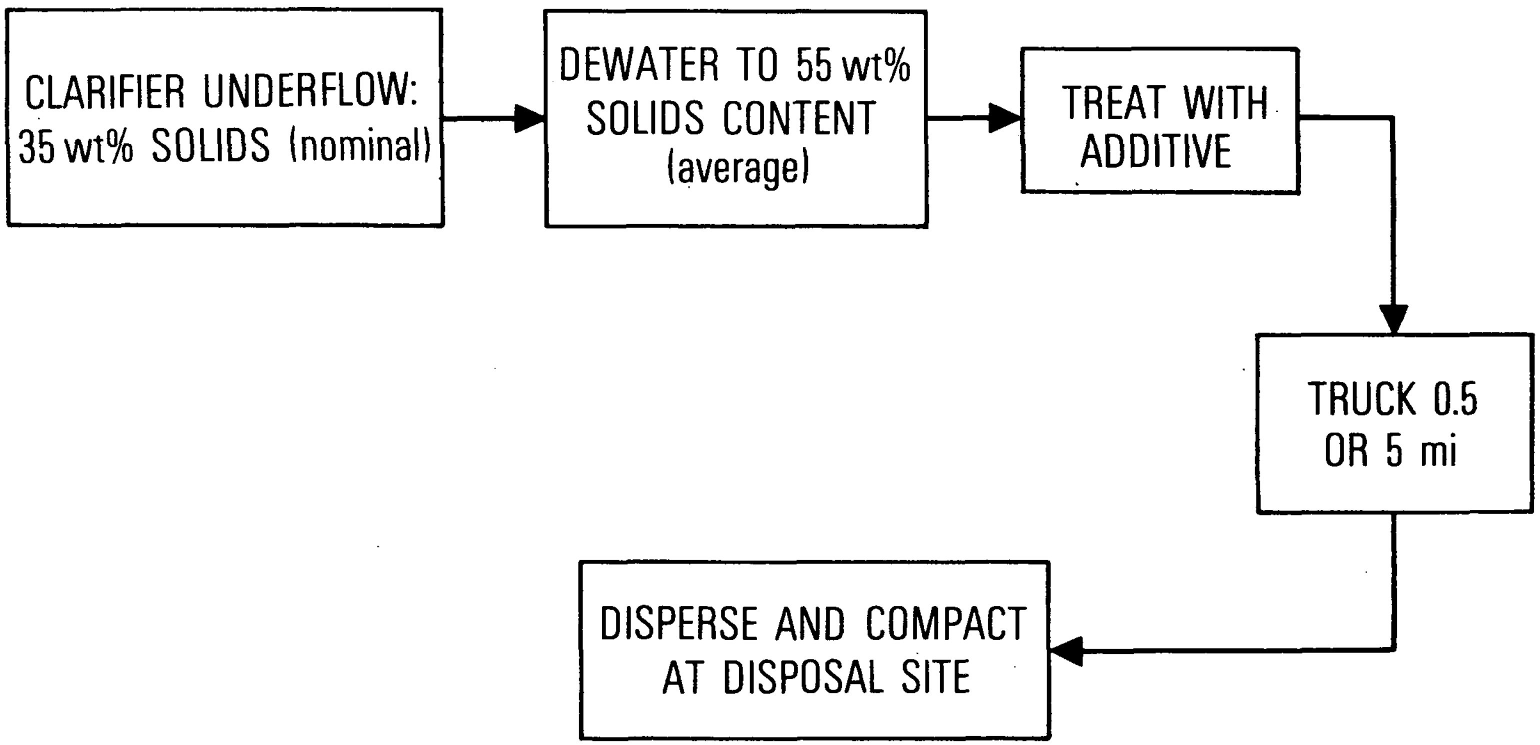


Figure 53. Flow sheet for an operational plant used as a baseline for costing the IUCS process

Figures 54 through 56 for Shawnee-type conditions, procesor-proposed conditions, and other conditions assessed by Aerospace based on processor-furnished data.

Total disposal costs are summarized in Section 9.4. These are presented in 1975 dollars per ton of dry sludge and are converted to dollars per ton of coal burned and mills per kilowatt hour of electricity.

9.2 CAPITAL EQUIPMENT AND LAND

A number of different capitalization factors and basic operating assumptions were made by the processors. These included lifetimes of equipment in the range of 10 to 30 years and average annual operating load factors of 70 to 100%. In the Aerospace analysis, equipment and replacement costs were adjusted as appropriate for 30 years, assuming average 50 and 65% annual load factors; the latter is a value projected for improved power plant designs and operation whereas the 50% load factor represents approximately current conditions in the power industry. The capital equipment cost of the fixation equipment was determined on a 100% load factor basis to account for the capacity to process maximum loads, but the sludge tonnage used in the calculations of annualized costs were based on 30-yr averages at the 50 and 65% annual load factors.

In all cases, the capital charges were annualized to include depreciation, insurance, cost of capital, replacements, and taxes. With a 50-50 debt-equity funding, and straight line depreciation for 30 years, the average annual charge on capital investment is 18%.

As disposal site land costs were not requested, they were not included in processor cost estimates. However, Aerospace adjusted the estimates by adding these land costs. Assumed were land acquisition costs of an average of $1000/acre and requirements of 500 and 650 acres, based on an arbitrary depth of 30 feet, for the 50 and 65% annual power plant load factors, respectively. Based upon these assumptions, a charge of $0.13/ton of dry sludge was

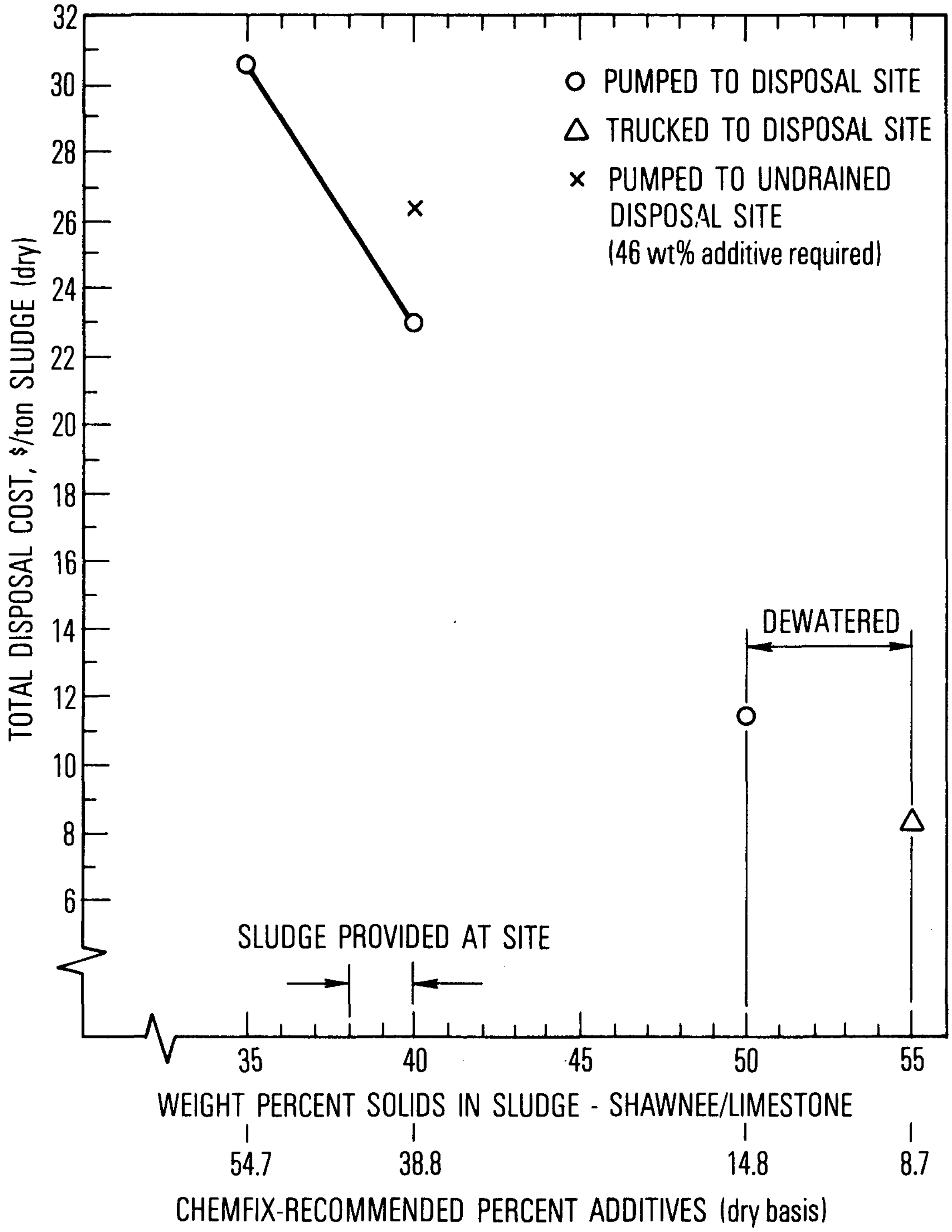


Figure 54. Aerospace estimate of total disposal costs for Chemfix process. 1975 dollars, 1000-MW plant, 30-yr plant life, 50% average annual load factor, 5 miles to disposal site.

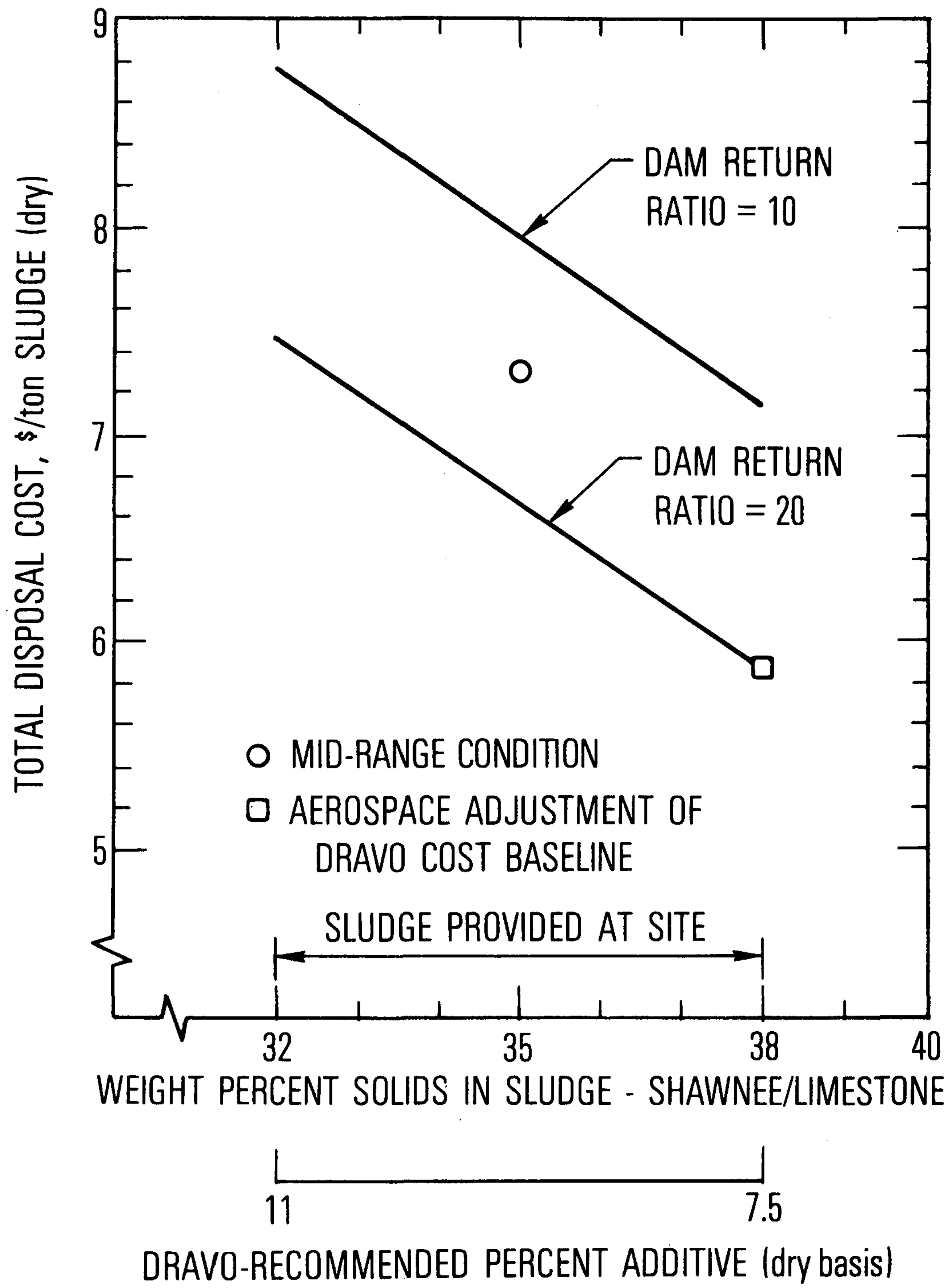


Figure 55. Aerospace estimate of total disposal costs for Dravo process. 1975 dollars, 1000-MW plant, 30-yr plant life, 50% average annual load factor, 5 miles to disposal site. Dam return ratio = storage volume to embankment volume.

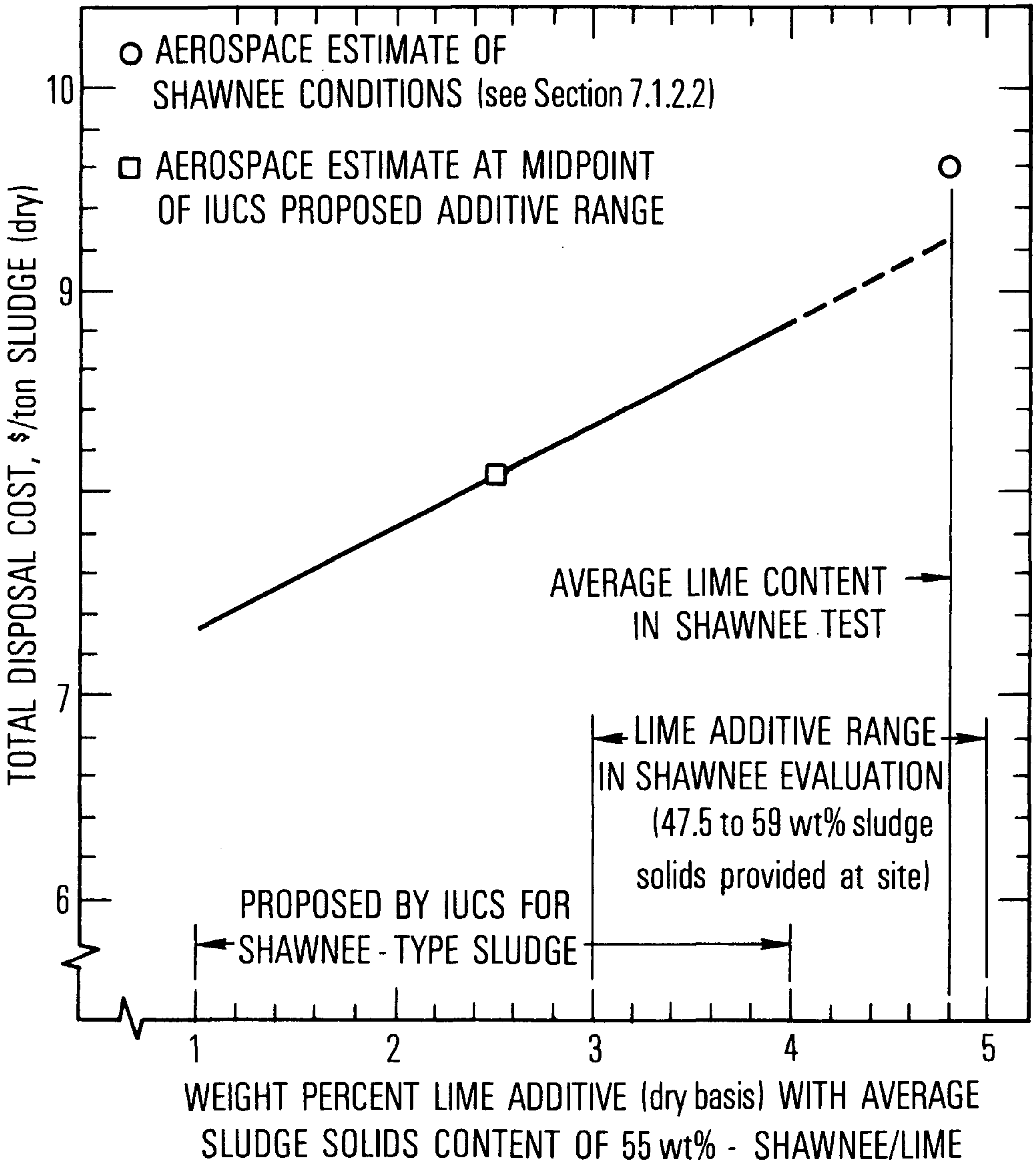


Figure 56. Aerospace estimate of total disposal costs for IUCS process. 1975 dollars, 1000-MW plant, 30-yr plant life, 50% average annual load factor, 5 miles to disposal site.

estimated. The economic effect of land requirements (acre-feet) can be approximated by prorating on a straight line basis and modifying the total cost accordingly.

The cost of dewatering the clarifier underflow, if recommended by the processors to achieve a more favorable condition for additive content or fixed sludge physical properties, was not included in their estimates. The benefits derived from reducing water content in the sludges are shown in Figures 54 and 55, and are due primarily to a reduction in the amount of additives required.

Aerospace estimates for dewatering equipment capital costs were based on information in Reference 18. The annualized capital costs for dewatering clarifier underflow to 50 to 55 wt% solids using vacuum drum filters is \$0.66 and \$0.50/ton (dry) for the 50 and 65% annual operating factors, respectively. [A charge of \$0.12/ton (dry) was estimated for labor and power, and was included in the costs presented in Figures 54 and 56.]

9.3 OPERATING COSTS

The various factors considered in the Aerospace analysis and adjustment of processor operating costs are discussed below.

The additive represents a significant fraction of the annual operating costs. Considering the large quantities required for a 1000-MW plant, the cost per ton of additive is unaffected by the operating load factor. Therefore, no corrections were applied to the unit cost of the additive when operating costs were computed for the 50 and 65% annual operating load factors.

In one case (see Figure 56 for IUCS), the cost of transporting fly ash to the disposal operation was included for completeness (see Section 7.1.2.2), although this procedure is not recommended by the processor. With a cost of \$8.00/ton of dry fly ash as delivered,[19] it was estimated that the disposal cost would be increased \$0.38/ton of sludge (dry).

Labor, maintenance, materials, spare parts, and power costs were examined. The Aerospace-adjusted costs, based on processor contractor inputs, were in the range of $1.00 to $1.50/ton of sludge (dry), exclusive of additive costs.

An annual cost for disposal site maintenance and monitoring totaling $35,000 was added to the estimates. This total represents $0.06/ton (dry) and $0.05/ton (dry) for the 50 and 65% annual operating load factors, respectively.

One-way rates for truck hauling of $0.12/ton-mile were used in the Aerospace evaluation.[20-26] Since "wet" tons are being transported, the corresponding rate when converted to "dry" tons is $0.24 (assuming the wet sludge has 50 wt% solids). Therefore, a 10-mile round trip would cost $1.20/ton (dry). Handling costs are included separately as processing and placement costs as appropriate.

Placement and compacting rates of $0.30/ton (wet) were included,[27,28] or estimates submitted by processors were adjusted to that figure as appropriate. On a dry basis, the rate becomes $0.60/ton (dry) for a sludge with 50 wt% solids.

9.4 TOTAL DISPOSAL COSTS

Total full-scale disposal costs estimated by The Aerospace Corporation for each of the processes with the power plant operating at an average annual load factor of 50% for 30 years and the disposal site 5 miles from the power plant are presented in Figures 54 through 56. Values are given for two distinct cases, one based on Shawnee field disposal treatment conditions and the others on conditions proposed by the processors for full-scale operations.

The total cost for disposal of the sludge is in the range of $7.30 to $11.40/ton of sludge (dry) in 1975 dollars. This cost is based on an assessment of the options presented in Figures 54 through 56. Operating costs are in the range of 65 to 85% of the total disposal costs; this variation is largely a function of the use of different quantities of additives by each of the three processors. The remaining 15 to 35% represents annual capital charges. If it is assumed that a coal with a thermal content of 12,000 Btu/lb is burned at a rate of 0.88 lb/kW-hr, the total disposal costs are \$2.07 to \$3.24/ton of coal burned and 0.9 to 1.4 mills/kW-hr. If a 65% annual plant load factor is assumed, the above 50% load factor disposal cost reduction is in the range of 4 to 11%. Total disposal costs are reduced by 5 to 13% if the sludge disposal site is 0.5 mile rather than 5 miles from the power plant. Historical background related to these results is given in References 29 and 30.

9.5 OTHER COST CONSIDERATIONS

The engineering estimates provided are considered to be representative of the cost of disposal by chemical fixation. Factors that could affect disposal costs but are highly site-dependent were not analyzed. These include access roads and rights-of-way whose costs may be offset by the residual value of the land.

Credit for the cost of fly ash disposal was not applied in this study. Consideration will be given to that factor in follow-on assessments of the cost impact of sludge treatment over current pollution control costs.

Another approach that may have merit in reducing disposal costs is the removal of fly ash prior to scrubbing and, in some cases, reintroducing it after the sludge is mechanically dewatered. An appreciable increase in the percent solids would result, thereby reducing the following: (1) fixation additive requirements, (2) the total mass of material to be treated and handled, and (3) the acre-feet of disposal site required. Cost trade-off studies to evaluate these effects will be made.

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APPENDIX A

SHAWNEE FIELD SAMPLING PROCEDURES

APPENDIX A

SHAWNEE FIELD SAMPLING PROCEDURES

A.1 GROUND WATER AND LEACHATE WELLS

The sampler is a cylindrical brass tube, 18 in. long by 3-3/8 in. in outside diameter (Foerst Specialities Company, Chicago). The bottom is sealed and has a spring-loaded valve for transferring the sample. The sampler top is sealed with a loose-fitting rubber stopper that allows the sampler to fill but falls into sealed position when released. The device is lowered and raised by means of a plastic rope held by the operator.

To sample, the device is lowered slowly slightly below water level and allowed to fill. It is withdrawn and the samples are drained through the spring-loaded bottom valve into appropriate bottles. Filling the sampler is repeated as required to fill all sample bottles. Samples are taken from standing water in the wells. After the sampling of each leachate well is completed, any remaining water is removed from the well. The sampler is washed carefully with deionized water after taking each sample to avoid cross-contamination.

A.2 TRUCK SAMPLES FOR SLUDGE FIXATION

These samples are collected directly in one-liter wide-mouth plastic bottles. A holder for the bottles was fabricated from expanded metal and conduit, and is dipped into the top of the filled concrete truck after the contents are mixed. Duplicate daily samples of unfixed sludge are taken from a single filled truck.

A.3 FIXED SLUDGE TO PONDS

When additives are mixed with sludge in the truck (Dravo, IUCS), a fixed sample is taken midway during the discharge of the truck contents into the storage pond. A single one-liter wide-mouth plastic bottle is filled and capped.

A.4 POND SUPERNATE

Pond supernate is sampled by skimming into a one-liter wide-mouth bottle. The sample is usually taken in the vicinity of the pond leachate well.

A.5 GROUND WATER WELL DEPTH

Well depths are measured using a graduated cord (Soiltest, Inc., Model DR 772 depth finder). The water surface is detected by shorted electrical leads on contact. The operator observes this as a meter deflection.

A.6 SLUDGE DEPTHS, SUPERNATE DEPTHS

Sludge depths in untreated ponds (A and D) are measured by sounding with a graduated stick. They are also measured by reference to a yardstick taped to the leachate well. The sludge-water and the water-air interface distances from the top of the leachate well casing are reported.

A.7 WEATHER STATION DATA

This information is taken as specified in "Weather Bureau Observing Hand Book No. 2, Substation Observations," Government Printing Office, Washington, D. C.

APPENDIX B

DESCRIPTION OF CHEMICAL ANALYSIS TECHNIQUES

APPENDIX B

DESCRIPTION OF CHEMICAL ANALYSIS TECHNIQUES

B.1 INTRODUCTION

This appendix describes the analytical techniques used by Aerospace to determine the concentration of constituents in the pond water and flue gas desulfurization (FGD) sludges. (The analytical techniques used by TVA are contained in References B-1 and B-2.) The constituents present in the liquor are divided into the following: major chemical species (i.e., calcium, sulfate, and chloride), trace metal species, and additional chemical species. Other water quality tests are also described.

Consideration was given to the constituent's range of concentration and to the corresponding costs of the analyses to obtain data having high precision and high accuracy.* Although the basis for selecting the proper analytical technique was to minimize any interference from other species, the presence of chemical species interfering with a particular analysis was fully acknowledged. Only when the interference was considered significant were corrections applied.

*Precision is defined as the relationship between a measured value and the statistical mean of measured values, and accuracy is the relationship between the true value and the measured value.

B.2 MAJOR CHEMICAL SPECIES

B.2.1 Calcium Determination

The method selected from among several has an accuracy of 40% and was one in which calcium oxalate was precipitated and filtered from the solution, the filter cake was redissolved in HCl, and the solution was titrated against $KMnO_4$ to a characteristic purple end point. Correction was then made for excess permanganate at the characteristic end point.

Alternative techniques using a specific ion electrode and atomic absorption spectrophotometry were eliminated because they had lower accuracies resulting from interferences, primarily from the sulfate ions.

B.2.2 Sulfate Determination

Standard nephelometry techniques were used for this task. A barium sulfate precipitate was formed by the reaction of the sulfate ion with a barium chloranilate reagent. The resulting turbidity was determined by a spectrophotometer and compared to a curve from standard sulfate solutions. Although multiple dilutions are necessary to bring the concentration to a range of optimum reliability, the resulting error is less than 10%.

B.2.3 Chloride Determination

A specific ion electrode was used to determine the concentration of chloride ions. Comparisons were made with results of titrations with silver nitrate. This method has a precision of about 1% and an accuracy of about 5%.

B.3 TRACE METAL SPECIES

Since most trace metal species are highly sensitive to atomic absorption spectrophotometry, this technique was used for the following elements: aluminum, antimony, beryllium, cadmium, chromium, copper, cobalt, iron, manganese, molybdenum, nickel, lead, silicon, silver, tin, vanadium, and zinc. Results were verified by analyzing standards of the National Bureau of Standards and by comparative analyses of elements present in relatively high concentrations through the use of gravimetric or volumetric methods. Precision and accuracy are dependent upon the means of activation, the specific element, its relative concentration, and the extent of interference by other elements and matrix effects. The precision and accuracy of the measurements of concentrations of all elements that exceed water quality reuse criteria ranged between 5 and 20%. However, the precision, with furnace activation, of trace metals occurring at very low levels is probably no better than 50%.

Mercury was also determined using this technique; however, the mercury was reduced to the elemental state with stannous chloride, and the absorption of the resulting mercury vapor was measured. This method has a precision of about 20% and an accuracy of about 20%.

Arsenic was determined by the Gutzeit method, which reacts arsine with mercurous bromide to produce Hg_3As; the unknown was compared colorimetrically against standards. For this application this technique has a precision of about 25% and an accuracy of about 25%.

A fluorimetric technique that has a sensitivity down to micrograms per liter was used to determine selenium. It has a precision of about 10% and is accurate to 60%.

B.4 ADDITIONAL CHEMICAL SPECIES

B.4.1 Sodium Determination

Atomic absorption spectrophotometry or flame photometry was used to determine sodium ion concentrations, depending on whether the concentrations were relatively low or high. Errors are typically less than 10%.

B.4.2 Sulfite Determination

Total sulfite was determined using a specific ion electrode, and no significant interferences were observed. The oxidation of the sulfite ion to sulfate in the scrubber liquor was found to be a very rapid reaction. Liquor protected from the atmosphere typically reveals concentrations of several hundred milligrams per liter of the sulfite ion; however, a brief atmospheric exposure causes oxidation and reduces these concentrations by one or more orders of magnitude. The reported sulfite measurements were for samples analyzed immediately upon arrival in the laboratory. No specific action was taken to inhibit oxidation other than to ensure that the samples were transported from the power plant scrubber to the analytical laboratory in sealed containers. The exposure to air during sampling, filtering, and measuring, however, resulted in the sulfite values reported. It is presumed that these concentrations would probably more closely represent the oxidation state of liquors in the event of their potential discharge.

B.4.3 Phosphate Determination

The phosphate analysis was determined by spectrophotometry methods, using ammonium molybdate to form the molybdenum blue complex. Total range of phosphate content varied from 0.5 mg/l in an acid liquor (pH = 4.3) to 0.01 mg/l in a base liquor (pH = 10.4).

B.4.4 Nitrogen Determination

Total nitrogen was determined by the Kjeldahl method, which reduces all nitrogen to ammonia with sodium thiosulfate. The ammonia was then distilled and the amount determined by titration. This method has a precision of about 10%, and accuracy at the levels of the concentrations determined is about 25%. It is assumed that most nitrogen in the scrubber system will exist as the nitrate and nitrite ions; the latter will oxidize under conditions similar to sulfite oxidation.

B.4.5 Fluroide Determination

The fluoride ion was determined by the specific ion electrode using a Beckman Model 4500 digital pH meter. There were no significant interferences in the scrubber liquors. This method has a precision of about 5%; an accuracy of 20% is attainable at the low levels measured.

B.4.6 Boron Determination

Boron was determined spectrophotometrically with the Hack DR2 using the Carmine method.

B.4.7 Magnesium Determination

Magnesium was determined by atomic absorption spectrophotometry in the same manner as were the trace metals.

B.5 OTHER WATER QUALITY TESTS

B.5.1 Chemical Oxygen Demand

Chemical oxygen demand was determined by reacting the organics and sulfites present with potassium dichromate and measuring the reduced chromium by spectrophotometry. While a precision of 25% is attainable, accuracy depends on the same history (i.e., degree of exposure to atmospheric oxygen) and is about 100% for routine analysis.

B.5.2 Total Alkalinity

Total alkalinity was determined by titrating a 25-ml sample with standard acid to a pH of 4.0. The Beckman Model 4500 digital pH meter was used as the indicating instrument. Total alkalinity is expressed as milligrams per liter calcium carbonate, but is actually a determination of the buffering capacity of the liquor owing to a number of weak acid species (i.e., carbonate, sulfite, borate, arsenite, selenite, and silicate). Precision is about 5%, and accuracy is estimated to be 25%.

B.5.3 Total Dissolved Solids Determination

The total dissolved solids were determined gravimetrically by evaporating a 25-ml sample overnight in a tared weighing bottle under vacuum at 120° F. Since two of the major constituents (calcium and sodium sulfates) form stable hydrated salts and are very hygroscopic in the anhydrous state, prolonged drying and minimal exposure of the dried residue were mandatory. The precision is about 2%, and the accuracy is about 5%.

B.5.4 Total Conductance Determination

This measurement, which was made with a General Radio Impedance Bridge Type 1650A, gave an estimate of the total ionic strength of the liquor. Precision is about 1%, and accuracy is estimated to be about 2%.

B.5.5 pH Determination

This parameter was measured with a Beckman Model 4500 digital pH meter to a precision of 0.002 pH units and an accuracy of 0.005 pH units.

B.5.6 Turbidity Determination

Turbidity measurements were made by nephelometry in which light absorption was compared to standards that were prepared using a formazine mixture; this is a mixture of hydrazine sulfate and hexamethylene tetramine in a water solution.

B.6 ANALYTICAL METHODS APPLICABLE TO SLUDGE SOLIDS

Sludge solids were analyzed for calcium, sulfate, sulfite, and carbonate in addition to total solids and inert material (fly ash).

Calcium was determined by a volumetric method following an oxalate separation. The sample, commonly 1/4 grams, was dissolved in hydrochloric and nitric acids, diluted and filtered, and calcium oxalate precipitated by ammonium oxalate from a slightly alkaline solution. The precipitate was filtered off, redissolved in sulfuric acid, and titrated with standard potassium permanganate.

Sulfate was determined gravimetrically using a 1/4-gram sample that was dissolved in hydrochloric acid. The solution was filtered, and barium chloride added to the hot filtrate to precipitate barium sulfate. This was filtered off through a tared Gooch crucible with a glass filter pad. It was then dried and ignited at 800°C cooled, and weighed.

Sulfite was determined volumetrically. A 2-gram sample was placed in a three-necked flask fitted with a dropping funnel for adding sulfuric acid, an entrance tube for nitrogen used to sweep out the evolved gases, and an exit tube dipping into an absorbent solution of N/10 sodium hydroxide. After evolving SO_2 and collecting it as sodium sulfite, the excess sodium hydroxide was neutralized and the sulfite titrated with standard iodine.

Carbonate was determined by a gravimetric method, after evolution as CO_2, along with SO_2, by acidifying a 2-gram sample in a tared flask. The flask was warmed gently to expel all gases, cooled, and weighed. The weight decrease represents CO_2 + SO_2 and must be corrected for the SO_2 content as determined volumetrically.

APPENDIX C

DATA RECORDS

APPENDIX C

DATA RECORDS

This appendix contains the following information regarding data taken during this program:

APPENDIX C

C.1 SAMPLE DESIGNATIONS

Sample Designation to be used for all Shawnee Disposal Demonstration Test Samples

Digit No.	1	2	3	4	5	6	7	8	9
	Sample Date					Sample Type Index		Pond Index	Aux. Sample Index
	Month		Day		Year				

Pond Index	Sample Type Index[a]	
A	Ground Water -- Well No. 1	GW_1
B	Ground Water -- Well No. 2	GW_2
C	Leachate Well	LW_
D	Pond Supernate	PS_
E	Untreated Input Sludge	IS_U
	Treated Input Sludge	IS_T
	Composited Input Sludge	IS_C
	Soil Core -- Pond Bottom	SC_P
	Soil Core -- Well No. 1	SC_1
	Soil Core -- Well No. 2	SC_2
	Fixed Sludge Core -- Section No. 1	FC_1

[a] Insert appropriate pond index, i.e., A, B, C, D or E, in space indicated by underscore. See examples next page.

Matrix of Sample Type and Pond Indices

Pond	Ground Water		Leachate	Pond	Input Sludge			Soil Core			Fixed Sludge Core[a]		
	Well #1	Well #2	Well	Supernate	Untreated	Treated	Composite	Well #1	Well #2	Pond	Section #1	Section #2	Section #3
A	GWA1	GWA2	LWA	PSA	ISAU	ISAT	ISAC	SCA1	SCA2	SCAP	--	--	--
B	GWB1	GWB2	LWB	PSB	ISBU	ISBT	ISBC	SCB1	SCB2	SCBP	FCB1	FCB2	FCB3
C	GWC1	GWC2	LWC	PSC	ISCU	ISCT	ISCC	SCC1	SCC2	SCCP	FCC1	FCC2	FCC3
D	GWD1	--	LWD	PSD	ISDU	ISDT	ISDC	SCD1	--	SCDP	--	--	--
E	GWE1	GWE2	LWE	PSE	ISEU	ISET	ISEC	SCE1	SCE2	SCEP	FCE1	FCE2	FCE3

Example No. 1 ⟶ 12094GWA2

Sample from second ground water well of Pond A taken 12/9/74.

Example No. 2 ⟶ 02275FCE3

Third section of fixed sludge core from Pond E taken 2/27/75

[a] If a vertical core sample is taken in sections, the sections shall be numbered sequentially starting with the uppermost sample.

APPENDIX C

C.2 SHAWNEE INPUT SLUDGE AND WATER ANALYSIS RECORDS

APPENDIX C

C.2 SHAWNEE INPUT SLUDGE AND WATER ANALYSIS RECORDS

Aerospace analyses are indicated by a sequential number. Sequential numbers of TVA analyses are prefixed by the letter N. All of the analytical data obtained are included in these records and on the pertinent plots. Blank spaces denote that no analyses were made, usually because of insufficient amounts of sample from the test wells, or occasionally from losses in handling. Additionally, sulfite analyses were required of Aerospace only, and analyses for sodium were required only for leachates from Pond E.

Shawnee Disposal Demonstration Water Analysis Record

(All concentrations in mg/l)

Pond Designation A

Sample Type GROUND WATER

Test Organization

Sequential Number	N-519	N-622	N-633	N-685	N-740	25
Designation Sample	07094 GWA1	07224 GWA1	07294 GWA1	08054 GWA1	09034 GWA1	09044 GWA1
Date Collected	7-9-74	7-22-74	7-29-74	8-5-74	9-3-74	9-4-74
Time Collected						
pH	6.9	6.9	6.8	6.8	6.9	8.18
Total Alkalinity	390	410	410	430	370	179
Chloride	31	34	34	36	35	84
Chemical O_2 Demand						40
Conductivity	1.1	0.39	1.1			0.91
Dissolved Solids	730	770	880	840	790	620
Suspended Solids	10	40	35	230		
Sulfate	140	240	240	280	210	8
Arsenic	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Boron	0.220	0.290	0.350	0.370		0.4
Calcium	120	130	180	190	160	40
Lead	0.240	0.058	0.095	0.068		0.05
Magnesium	6.8	42	47	56	48	72
Mercury	<0.0002	0.0010	0.047	0.0013	<0.0002	0.0008
Selenium	<0.002	<0.002	<0.002	<0.002	<0.002	0.004
Sulfite						0.4
Sodium						

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation A
Sample Type Ground Water
Test Organization ____________

Sequential Number	N-844	N-911	N-976	38	N-1129	N-209
Designation Sample	10074 GWA1	10154 GWA1	10284 GWA1	10284 GWA1	12094 GWA1	02115 GWA1
Date Collected	10-7-74	10-15-74	10-28-74	10-28-74	12-9-74	2-11-75
Time Collected						
pH	7.2	7.0	7.0	7.94	6.5	6.7
Total Alkalinity	380	410	390		440	380
Chloride	37	36	30	86	45	25
Chemical O_2 Demand					16	66
Conductivity		1.2	1.2	0.86	1.1	1.0
Dissolved Solids	820	830	770	588	700	670
Suspended Solids	83	150	49	130		
Sulfate	260	230	180	175	110	140
Arsenic	<0.005	<0.005	<0.005	<0.004	<0.005	<0.005
Boron	0.320	0.380	0.250	0.40	0.480	0.380
Calcium	160	160	120	40	110	150
Lead	<0.010	<0.010	<0.010	0.053	<0.010	0.040
Magnesium	49	44	41	34.2	32	36
Mercury	0.0003	0.0019	0.0002	<0.00005	0.0004	0.0035
Selenium	<0.002	<0.002	<0.002	0.0020	<0.002	<0.002
Sulfite				<0.1		
Sodium						

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation A
Sample Type GROUND WATER
Test Organization

Sequential Number	104	N-074	N-285			
Designation Sample	04286 GWA1	04285 GWA1	07075 GWA1			
Date Collected	4-28-75	4-28-75	7-7-75			
Time Collected						
pH	6.93	6.9	6.5			
Total Alkalinity	286	210	300			
Chloride	86	94	36			
Chemical O_2 Demand	95	19	34			
Conductivity	0.91	0.93	0.98			
Dissolved Solids	440	700	650			
Suspended Solids		81	420			
Sulfate	250	150	150			
Arsenic	<0.005	<0.005	0.005			
Boron	0.3	0.490	0.460			
Calcium	68	160	110			
Lead	0.07	0.040	0.045			
Magnesium	33	36	36			
Mercury	0.0005	0.0028	0.0170			
Selenium	0.015	<0.002	<0.002			
Sulfite	0.5					
Sodium						

Shawnee Disposal Demonstration Water Analysis Record

(All concentrations in mg/l)

Pond Designation A

Sample Type GROUND WATER

Test Organization ______

Sequential Number	N-623	N-634	N-686	N-741	26	N-845
Designation Sample	07224 GWA2	07294 GWA2	08054 GWA2	09034 GWA2	09044 GWA2	10074 GWA2
Date Collected	7-22-74	7-29-74	8-5-74	9-3-74	9-4-74	10-7-74
Time Collected						
pH	7.3	7.1	7.2	7.2	8.71	7.3
Total Alkalinity	670	640	590	570	389	490
Chloride	27	26	26	27	64	26
Chemical O_2 Demand					20	
Conductivity	1.1	0.87			0.77	
Dissolved Solids	790	750	720	680	488	610
Suspended Solids	100	39	31			62
Sulfate	22	32	28	21	22	42
Arsenic	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Boron	0.140	0.160	0.160	0.120	0.4	0.120
Calcium	100	120	120	100	<15	94
Lead	0.085	0.052	0.089	0.014	0.04	<0.010
Magnesium	65	66	63	54	74	51
Mercury	<0.0002	0.190	0.0015	<0.0002	0.0005	<0.0002
Selenium	<0.002	<0.002	<0.002	<0.002	0.005	<0.002
Sulfite					0.9	
Sodium						

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation A
Sample Type GROUND WATER
Test Organization ____________

Sequential Number	N-915	N-977	41	N-1130	N-210	132
Designation Sample	10224 GWA2	10284 GWA2	10284 GWA2	12094 GWA2	02115 GWA2	04285 GWA2
Date Collected	10-22-74	10-28-74	10-28-74	12-9-74	2-11-75	4-28-75
Time Collected						
pH	7.7	7.7	8.72	8.0	7.4	7.40
Total Alkalinity	400	480	330	400	74	55
Chloride	24	22	73	30	18	43
Chemical O_2 Demand			40	16	21	5
Conductivity	0.99	0.97	0.69	0.85	0.50	0.37
Dissolved Solids	610	580	440	550	330	248
Suspended Solids	43	110		18		
Sulfate	40	46	51	64	130	175
Arsenic	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Boron	0.100	<0.100	0.2	0.230	0.260	<0.1
Calcium	100	63	<15	59	40	28
Lead	<0.010	<0.010	0.03	<0.010	0.028	0.02
Magnesium	52	46	70	38	18	13.4
Mercury	0.0004	<0.0002		<0.0002	0.0004	0.0004
Selenium	<0.002	<0.002	0.002	<0.002	<0.002	0.004
Sulfite			0.9			0.2
Sodium						

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation A
Sample Type GROUND WATER
Test Organization

Sequential Number	N-075	N-286				
Designation Sample	04285 GWA2	07075 GWA2				
Date Collected	4-28-75	7-7-75				
Time Collected						
pH	7.4	7.1				
Total Alkalinity	58	100				
Chloride	16	20				
Chemical O_2 Demand	8	47				
Conductivity	0.42	0.44				
Dissolved Solids	320	530				
Suspended Solids	89	19000				
Sulfate	88	190				
Arsenic	<0.005	<0.005				
Boron	0.340	0.330				
Calcium	32	110				
Lead	0.016	0.200				
Magnesium	12	4.2				
Mercury	0.0011	0.0015				
Selenium	<0.002	<0.002				
Sulfite						
Sodium						

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation A
Sample Type LEACHATE
Test Organization

Sequential Number	N-912	37	N-1131	N-211	133	N-073
Designation Sample	10154 LWA	10144 LWA	12094 LWA	02115 LWA	04285 LWA	04285 LWA
Date Collected	10-15-74	10-14-74	12-9-74	2-11-75	4-28-75	4-28-75
Time Collected						
pH	6.6	7.83	6.8	7.6	7.71	7.6
Total Alkalinity	490	49	310	150	67	61
Chloride	590	840	1800	2900	2100	3300
Chemical O_2 Demand		110	90	100		150
Conductivity	3.1	3.3	6.3	9.5	9.8	9.8
Dissolved Solids	2200	2460	5400	6600	7292	7700
Suspended Solids	210	870	170			31
Sulfate	500	700	790	1100	1425	1000
Arsenic	<0.005		<0.005	<0.005	<0.005	<0.005
Boron	6.8	10.2	2.2	28	25	31
Calcium	560	465	1200	2100	2040	1600
Lead	<0.010	0.027	<0.010	0.048	0.44	0.032
Magnesium	47	49.3	120	98	14.8	72
Mercury	0.0003		0.0012	0.0010	0.0003	0.0018
Selenium	<0.002		<0.002	<0.002	0.008	0.012
Sulfite		8.6				
Sodium						

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation A
Sample Type LEACHATE
Test Organization

Sequential Number	N-287					
Designation Sample	07075 LWA					
Date Collected	7-7-75					
Time Collected						
pH	7.5					
Total Alkalinity	62					
Chloride	3500					
Chemical O_2 Demand	1400					
Conductivity	10.0					
Dissolved Solids	8100					
Suspended Solids	100					
Sulfate	980					
Arsenic	0.020					
Boron	42					
Calcium	2300					
Lead	0.062					
Magnesium	82					
Mercury	0.0067					
Selenium	0.013					
Sulfite						
Sodium						

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation A

Sample Type SUPERNATE

Test Organization ______

Sequential Number	N-916	40	N-1132	N-212	134	N-076
Designation Sample	10224 PSA	10284 PSA	12094 PSA	02125 PSA	04285 PSA	04285 PSA
Date Collected	10-22-74	10-28-74	12-9-74	2-12-75	4-28-75	4-28-75
Time Collected						
pH	8.1	7.71	8.2	8.5	7.68	8.0
Total Alkalinity	100	59	60	49	43	43
Chloride	2000	1600	980	630	390	250
Chemical O_2 Demand			60	24	50	14
Conductivity	8.0	7.8	4.6	3.2	1.8	1.8
Dissolved Solids	7100	5850	4300	2800	1540	1600
Suspended Solids	18	10	27	6		7
Sulfate	1400	1500	1100	1100	650	570
Arsenic	0.030		0.015	<0.005	<0.005	<0.005
Boron	16	22.8	2.2	8.8	1.9	
Calcium	2000	1480	1100	880	540	480
Lead	<0.010	0.093	<0.010	<0.010	0.10	0.016
Magnesium	140	<0.01	71	48	4.6	20
Mercury	0.0005		<0.0002	0.0003	0.0002	<0.0002
Selenium	<0.002		<0.002	<0.002	0.007	<0.002
Sulfite		1.3			0.20	
Sodium						

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation A
Sample Type SUPERNATE
Test Organization

Sequential Number	N-284					
Designation Sample	07075 PSA					
Date Collected	7-7-75					
Time Collected						
pH						
Total Alkalinity						
Chloride	300					
Chemical O_2 Demand	20					
Conductivity	2.5					
Dissolved Solids	2300					
Suspended Solids	14					
Sulfate	810					
Arsenic	0.006					
Boron	5.3					
Calcium	640					
Lead	<0.010					
Magnesium	21					
Mercury	0.0017					
Selenium	0.002					
Sulfite						
Sodium						

Shawnee Disposal Demonstration Input Sludge Analysis Record
(All liquor concentrations in mg/l)
(All solids analyses in wt %)

Pond Designation A
Sample Type INPUT MATERIAL*
Test Organization ________

Sequential Number		52				
Sample Designation	09234ISAU	ISAC	10054ISAU			
Sample Date	9-23-74		10-5-74			
Liquor Analysis:						
pH	8.80	8.35	7.95			
Total Alkalinity		61				
Chloride	3604	4600	4833			
Chemical O_2 Demand						
Conductivity	10.0	12	12.4			
Dissolved Solids	7110	8560	9460			
Suspended Solids						
Sulfate	974	1525	1488			
Arsenic		0.024				
Boron		44.0				
Calcium	1980	2100	2675			
Lead		0.49				
Magnesium	313	290	212			
Mercury		<0.0001				
Selenium		0.005				
Sulfite	64	4.3	32			
Sodium	56		79			
Solids Analysis:						
Total Solids	15.7		24.3			
Calcium Sulfite	46.5		38.6			
Calcium Sulfate	11.8		14.1			
Calcium hydroxide						
Calcium carbonate	3.4		3.9			
Fly Ash	42.5		46.9			

*The data presented reflect the analyses conducted as of July 1975. The complete analysis will be included in the next report.

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation B
Sample Type GROUND WATER
Test Organization ____________

Sequential Number	96	N-061	N-065	N-078	N-289	
Designation Sample	04155 GWB1	04155 GWB1	04225 GWB1	04285 GWB1	07085 GWB1	
Date Collected	4-15-75	4-15-75	4-22-75	4-28-75	7-8-75	
Time Collected						
pH	7.63	6.9	6.9	6.9	6.9	
Total Alkalinity	217	240	240	240	240	
Chloride	95	68	64	66	82	
Chemical O_2 Demand	75		40	210	1400	
Conductivity	0.62	0.61		0.72	0.69	
Dissolved Solids	400	420	490	300	510	
Suspended Solids		120	19	23	1000	
Sulfate	225	24	28	23	24	
Arsenic	<0.005	<0.005	<0.005	<0.005	<0.005	
Boron	0.9	0.130	0.140	0.130	0.140	
Calcium	40	31	43			
Lead	0.03	0.180	0.056			
Magnesium	15.8	15	16			
Mercury	0.0007	0.0059	0.0007	0.0008	0.0005	
Selenium	0.006	<0.002	<0.002	<0.002	<0.002	
Sulfite	.52					
Sodium						

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation B
Sample Type GROUND WATER
Test Organization ____________

Sequential Number	N-1026	N-1134	N-223	79	N-253	N-257
Designation Sample	1114 GWB2	12094GWB2	02115 GWB2	02115 GWB2	02175 GWB2	02245 GWB2
Date Collected	11-11-74	12-9-74	2-11-75	2-11-75	2-17-75	2-24-75
Time Collected						
pH	7.4	6.9	6.8	7.54	6.7	6.7
Total Alkalinity	90	58	170	171	170	160
Chloride	14	86	52	80	50	53
Chemical O_2 Demand			15	35	18	9
Conductivity	0.37	0.71	0.57	0.53	0.57	0.60
Dissolved Solids	220	580	340	320	330	330
Suspended Solids	110	11000				61
Sulfate	47	85	20	18	18	14
Arsenic	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Boron	<0.100	0.450	0.450	1.2	<0.100	<0.100
Calcium	35	35	34	40	31	32
Lead	0.120	<0.010	0.015	0.05	0.110	0.078
Magnesium	8.7	8.9	8.7	12	9.0	17
Mercury	<0.0002		<0.0002	<0.0001	0.0005	0.0008
Selenium	<0.002	<0.002	<0.002	0.009	<0.002	<0.002
Sulfite				0.3		
Sodium						

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation B
Sample Type GROUND WATER
Test Organization

Sequential Number	95	W-062	N-066	W-079	W-290	
Designation Sample	04155 GWB2	04155 GWB2	04225 GWB2	04285 GWB2	07085 GWB2	
Date Collected	4-15-75	4-15-75	4-22-75	4-28-75	7-8-75	
Time Collected						
pH	7.58	6.7		6.7	6.9	
Total Alkalinity	158	160		160	170	
Chloride	73	52		53	120	
Chemical O_2 Demand	15	8	14	7	10	
Conductivity	0.44	0.54		0.53	0.71	
Dissolved Solids	320	300		310	470	
Suspended Solids		47		12	2300	
Sulfate	125	19		15	34	
Arsenic	<0.005	<0.005	<0.005	<0.005	<0.005	
Boron	0.8	0.420	0.130	0.100	0.250	
Calcium	12		29	29	42	
Lead	0.09		0.046	0.030	<0.010	
Magnesium	13.6		11	11	16	
Mercury	0.0004	0.0022	0.0005	0.0013	<0.0002	
Selenium	0.007	0.003	0.004	0.003	<0.002	
Sulfite	0.27					
Sodium						

Shawnee Disposal Demonstration Water Analysis Record

(All concentrations in mg/l)

Pond Designation B

Sample Type LEACHATE

Test Organization

Sequential Number	N-214	72	97	N-063	N-067	N-077
Designation Sample	02115 LWB	02115 LWB	04155 LWB	04155 LWB	04225 LWB	04285 LWB
Date Collected	2-11-75	2-11-75	4-15-75	4-15-75	4-22-75	4-28-75
Time Collected						
pH	8.3	5.32	6.73		6.0	6.9
Total Alkalinity	350	0	28		8	22
Chloride	110	170	140		620	460
Chemical O_2 Demand	48	75	0	14	92	42
Conductivity	1.2	0.88	0.30			
Dissolved Solids	440	500	320			1800
Suspended Solids						18
Sulfate	.85	150	150		440	530
Arsenic	0.007	0.014	<0.005	0.005	0.010	0.050
Boron	0.96	<0.1	1.0	<0.100	50	
Calcium	64	<20	28	290	470	530
Lead	0.058	0.04	0.02	0.090	0.024	0.028
Magnesium	6.8	8	8.0	44	36	35
Mercury	<0.0002	0.001	0.0004	0.0016	<0.0002	0.0038
Selenium	<0.002	0.017	0.008	0.010	0.062	0.130
Sulfite		0.17	0.10			
Sodium						

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation B
Sample Type LEACHATE
Test Organization

Sequential Number	N-291					
Designation Sample	07075 LWB					
Date Collected	7-7-75					
Time Collected						
pH	10.1					
Total Alkalinity	250					
Chloride	940					
Chemical O_2 Demand	1200					
Conductivity	3.4					
Dissolved Solids	2600					
Suspended Solids	12000					
Sulfate	490					
Arsenic	0.040					
Boron	3.2					
Calcium	2300					
Lead	0.049					
Magnesium	57					
Mercury	0.0007					
Selenium	0.200					
Sulfite						
Sodium						

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation B
Sample Type SUPERNATE
Test Organization ____________

Sequential Number	98	N-064	N-068	N-080	N-288	
Designation Sample	04155 PSB	04155 PSB	04225 PSB	04285 PSB	07085 PSB	
Date Collected	4-15-75	4-15-75	4-22-75	4-28-75	7-8-75	
Time Collected						
pH	12.15	11.5	9.6	8.7	8.4	
Total Alkalinity	1294	1300	190	79	30	
Chloride	2400	1500	1500	600	320	
Chemical O_2 Demand		60	110	25	25	
Conductivity	7.9	8.6		2.6	2.2	
Dissolved Solids	5560	5600		2200	1800	
Suspended Solids		160		8	4	
Sulfate	1875	960	750	430	900	
Arsenic	<0.004	<0.005	<0.005	<0.005	0.010	
Boron	86	63000	60	24	10	
Calcium	1740	2300	1700	840	510	
Lead	0.39	<0.010	0.020	0.040	<0.010	
Magnesium	<0.01	0.2	0.9	4.2	2.8	
Mercury	<0.0001	0.0002	<0.0002	<0.0002	0.0003	
Selenium	<0.089	0.090	0.021	<0.002	0.005	
Sulfite	70					
Sodium	34					

Shawnee Disposal Demonstration Input Sludge Analysis Record
(All liquor concentrations in mg/l)
(All solids analyses in wt %)

Pond Designation B
Sample Type INPUT MATERIAL*
Test Organization ______

Sequential Number						
Sample Designation	04135 ISBU	04155 ISBU				
Sample Date	4-13-75	4-15-75				
Liquor Analysis:						
pH	7.00	7.15				
Total Alkalinity						
Chloride	2552	2198				
Chemical O_2 Demand						
Conductivity	6.0	4.85				
Dissolved Solids	6610	5670				
Suspended Solids						
Sulfate	1955	1519				
Arsenic						
Boron						
Calcium	1525	1210				
Lead						
Magnesium	345	429				
Mercury						
Selenium						
Sulfite	80	160				
Sodium	45	31				
Solids Analysis:						
Total Solids	39.7	41.4				
Calcium Sulfite	30.7	32.9				
Calcium Sulfate	19.6	17.5				
Calcium hydroxide						
Calcium carbonate	19.3	22.4				
Fly Ash	35.5	34.0				

*The data presented reflect the analyses conducted as of July 1975. The complete analysis will be included in the next report.

Shawnee Disposal Demonstration Water Analysis Record

(All concentrations in mg/l)

Pond Designation C

Sample Type GROUND WATER

Test Organization ______

Sequential Number	N-624	N-635	N-687	N-742	27	N-846
Designation Sample	07224 GWC1	07294 GWC1	08054 GWC1	09034 GWC1	09044 GWC1	10074 GWC1
Date Collected	7-22-74	7-29-74	8-5-74	9-3-74	9-4-74	10-7-74
Time Collected						
pH	7.7	7.4	7.4	7.5	8.08	7.0
Total Alkalinity	130	120	130	96	106	47
Chloride	10	9	10	7	61	13
Chemical O_2 Demand					7	
Conductivity	.40	.46			.59	
Dissolved Solids	380	330	330	450	460	370
Suspended Solids	720	81	26			1000
Sulfate	56	85	67	180	250	78
Arsenic	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Boron	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
Calcium	29	34	34	83	480	38
Lead	0.120	0.040	0.032	<0.010	0.05	<0.010
Magnesium	6.1	5.9	5.7	12	18	7.3
Mercury		0.029	0.0003	<0.0002	0.0007	<0.0002
Selenium	<0.002	<0.002	<0.002	<0.002	0.004	<0.002
Sulfite					0.2	
Sodium						

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation C

Sample Type GROUND WATER

Test Organization ____________

Sequential Number	N-1112	W-218	W-069	122	W-082	O-093
Designation Sample	12094-GWX1	02115 GWX1	04235 GWX1	04285 GWX1	04285 GWX1	05065 GWX1
Date Collected	12-9-74	2-11-75	4-23-75	4-28-75	4-28-75	5-5-75
Time Collected						
pH		6.6	7.6	7.37	7.6	6.7
Total Alkalinity		130	82	93	88	110
Chloride		14	11	55	11	12
Chemical O_2 Demand		12	7	48	5	5
Conductivity		.45	.34	.33	.53	.45
Dissolved Solids		330	240	280	300	420
Suspended Solids			12		13	28
Sulfate		55	50	75	430	18
Arsenic	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Boron	.200	<0.1	.110	<0.1	<0.100	<0.100
Calcium		33	15	12	19	22
Lead		0.015	0.020	0.020	0.022	0.022
Magnesium		48	2.7	4.1	3.1	4.6
Mercury		0.0004	0.0011	0.0003	0.0002	0.0052
Selenium	<0.002	<0.002	<0.002	0.012	<0.002	<0.005
Sulfite				0.19		
Sodium						

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation C
Sample Type GROUND WATER
Test Organization ______

Sequential Number	N-293	N-688	N-743	28	N-847	N-1113
Designation Sample	07085GWC1	08054GWC2	09034GWC2	09044GWC2	10074 GWC2	12094 GWC2
Date Collected	7-8-75	8-5-74	9-3-74	9-4-74	10-7-74	12-9-74
Time Collected						
pH	7.0	7.3	7.3	7.88	7.3	
Total Alkalinity	120	68	80	83	99	
Chloride	40	14	15	41	26	
Chemical O_2 Demand	5					
Conductivity	.44			.29		
Dissolved Solids	650	230	170	154	260	
Suspended Solids	3000	210			120	
Sulfate	180	48	30	37	30	
Arsenic	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Boron	<0.1	<0.1	<0.1	0.4	<0.1	<0.1
Calcium	40	31	23	36	26	
Lead	0.150	0.024		0.03	<0.010	
Magnesium	9.3	8.6	8.4	13	8.4	
Mercury	0.0009	0.0002	<0.0002	0.0006	<0.0002	
Selenium	<0.002	<0.002	<0.002	0.005	<0.002	<0.002
Sulfite				<0.1		
Sodium						

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation C

Sample Type GROUND WATER

Test Organization

Sequential Number	N-219	N-070	106	N-083	N-094	N-294
Designation Sample	02115 GWC2	04235-GWC2	04285 GWC2	04285 GWC2	05055 GWC2	07085 GWC2
Date Collected	2-11-75	4-23-75	4-28-75	4-28-75	5-5-75	7-8-75
Time Collected						
pH	7.2	7.2	7.35	7.2	7.1	7.0
Total Alkalinity	140	150	149	150	160	130
Chloride	63	85	99	66	100	110
Chemical O_2 Demand	13	9	75	9	18	12
Conductivity	.61	.54	.53	.57	.65	.85
Dissolved Solids	320	320	340	330	400	540
Suspended Solids		48		20	87	3800
Sulfate	22	17	25	23	52	110
Arsenic	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Boron	<0.1	.170	<0.1	0.200	.250	2.5
Calcium	38	36	32	36	44	
Lead	0.044	0.022	0.05	0.020	0.058	
Magnesium	9.4	12	13.4	15	13	
Mercury	0.0002	0.0003	0.0003	0.0008	0.0028	0.0009
Selenium	<0.002	<0.002	0.010	<0.002	<0.002	<0.002
Sulfite			0.28			
Sodium						

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation C
Sample Type LEACHATE
Test Organization

Sequential Number	N-217	80	128	N-081	N-071	N-092
Designation Sample	0215 LWC	0215 LWC	04285 LWC	04285 LWC	04295 LWC	05055 LWC
Date Collected	2-11-75	2-11-75	4-28-75	4-28-75	4-29-75	5-5-75
Time Collected						
pH	7.1	7.46	10.61	10.4	11.8	11.9
Total Alkalinity	56	56	50	99	600	720
Chloride	5	42	2562	2400	2100	2100
Chemical O_2 Demand	17	20		140	140	130
Conductivity	0.50	0.43	7.5	7.5	8.5	8.4
Dissolved Solids	340	260	4720	4700	4600	4100
Suspended Solids				73	36	30
Sulfate	160	225	75	750	44	23
Arsenic	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Boron	0.17	<0.1	<0.1	0.190	0.130	<0.100
Calcium	86	20	1980	2000	2000	1900
Lead	<0.010	0.04	0.36	0.052	0.110	0.120
Magnesium	15	14	3.8	5.4	0.4	0.1
Mercury	<0.0002	0.0003	<0.0001	<0.0002	<0.0002	0.0010
Selenium	<0.002	0.009	0.011	0.011	0.011	0.010
Sulfite			4.5			
Sodium						

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation C
Sample Type LEACHATE
Test Organization

Sequential Number	N-295					
Designation Sample	0075 LWC					
Date Collected	7-7-75					
Time Collected						
pH	11.4					
Total Alkalinity	300					
Chloride	1200					
Chemical O_2 Demand	1300					
Conductivity	5.6					
Dissolved Solids	3200					
Suspended Solids	2800					
Sulfate	190					
Arsenic	<0.005					
Boron	0.370					
Calcium	650					
Lead	0.220					
Magnesium	8.3					
Mercury	0.0250					
Selenium	0.008					
Sulfite						
Sodium						

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation C

Sample Type SUPERNATE

Test Organization

Sequential Number	121	N-072	N-095	N-292		
Designation Sample	04285 PSC	04285 PSC	05055 PSC	07085 PSC		
Date Collected	4-28-75	4-28-75	5-5-75	7-8-75		
Time Collected						
pH	11.43	11.2	10.3	8.3		
Total Alkalinity	173	170	31	21		
Chloride	610	560	240	440		
Chemical O_2 Demand	49	20	17	18		
Conductivity	2.4	2.4	2.3	2.7		
Dissolved Solids	1560	1600	1500	2100		
Suspended Solids		9	31	5		
Sulfate	175	200	200	600		
Arsenic	<0.005	0.008	<0.005	0.007		
Boron	0.1	0.340	0.260	1.5		
Calcium	340	590	480	450		
Lead	0.14	0.016	0.036	<0.010		
Magnesium	3.68	0.2	0.4	3.0		
Mercury	0.0003	<0.0002	<0.0002	<0.0002		
Selenium	0.004	0.003	0.002	<0.002		
Sulfite	0.85					
Sodium						

Shawnee Disposal Demonstration Input Sludge Analysis Record
(All liquor concentrations in mg/l)
(All solids analyses in wt %)

Pond Designation C

Sample Type INPUT MATERIAL* (Clarifier underflow to centrifuge)

Test Organization ____________

Sequential Number						
Sample Designation	04065ISCU	04235ISCU				
Sample Date	4-6-75	4-23-75				
Liquor Analysis:						
pH	8.35	7.75				
Total Alkalinity						
Chloride	2871	5566				
Chemical O_2 Demand						
Conductivity	6.4	10.0				
Dissolved Solids	6980	11,010				
Suspended Solids						
Sulfate	1672	1578				
Arsenic						
Boron						
Calcium	1995	3275				
Lead						
Magnesium	165	309				
Mercury						
Selenium						
Sulfite	72	88				
Sodium	54	65				
Solids Analysis: Total Solids	25.1	22.2				
Calcium Sulfite	40.8	38.5				
Calcium Sulfate	12.5	15.4				
Calcium hydroxide						
Calcium carbonate	3.6	3.8				
Fly Ash	46.1	46.5				

*The data presented reflect the analyses conducted as of July 1975. The complete analysis will be included in the next report.

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation D
Sample Type GROUND WATER
Test Organization ______

Sequential Number	N-626	N-637	N-689	N-744	N-848	36
Designation Sample	07224-GWD1	07294 GWD1	08054 GWD1	09034GWD1	10074 GWD1	10074GWD1
Date Collected	7-22-74	7-29-74	8-5-74	9-3-74	10-7-74	10-7-74
Time Collected						
pH	7.1	6.8	6.7	7.0	6.8	7.70
Total Alkalinity	72	110	140	140	60	76
Chloride	20	50	72	110	89	170
Chemical O_2 Demand						25
Conductivity	.22	.42				.38
Dissolved Solids	210	260	330	410	330	696
Suspended Solids	2100	100	15		64	
Sulfate	16	22	14	12	40	29
Arsenic	0.015	0.008	0.006	<0.005	<0.005	<0.004
Boron		<0.100	<0.100	<0.100	<0.100	<0.100
Calcium		27	30	29	18	10
Lead		0.079	0.049		<0.010	0.05
Magnesium		11	11	13	6.8	7.4
Mercury	<0.0002	0.0010	<0.0002	<0.0002	<0.0002	0.001
Selenium	<0.002	<0.002	<0.002	<0.002	<0.002	0.002
Sulfite						.23
Sodium						

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation D
Sample Type GROUND WATER
Test Organization

Sequential Number	42	N-978	N-983	N-1025	N-1133	N-222
Designation Sample	10284 GW01	10284 GW01	11044 GW01	11114 GW01	12094 GW01	02115 GW01
Date Collected	10-28-74	10-28-74	11-4-74	11-11-74	12-9-74	2-11-75
Time Collected						
pH	7.48	6.9	7.3	7.8		6.9
Total Alkalinity		52	100	52		140
Chloride	210	170	17	12		150
Chemical O_2 Demand						14
Conductivity	.66	.67	.67	.60		.70
Dissolved Solids	324	420	510			420
Suspended Solids	1010	6600	2200			
Sulfate	29	85	160	340		24
Arsenic	<0.004	<0.005	<0.005	<0.005	<0.005	<0.005
Boron	0.20	<0.100	0.250	<0.100	<0.100	2.00
Calcium	20	17				66
Lead	<0.013	<0.010				0.016
Magnesium	11.2	7.3				9.1
Mercury	0.0013	<0.0002				<0.0002
Selenium	0.0080	<0.002	<0.002	<0.002	<0.002	<0.002
Sulfite	<0.1					
Sodium						

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation D
Sample Type GROUND WATER
Test Organization ____

Sequential Number	78	N-252	N-256	N-086	150	N-297
Designation Sample	02115GW01	02175GW01	02245GW01	04285GW01	07075GW01	07085GW01
Date Collected	2-11-75	2-17-75	2-24-75	4-28-75	7-7-75	7-8-75
Time Collected						
pH	7.49	6.7	6.7	6.9	7.07	6.9
Total Alkalinity	138	150	140	150	138	140
Chloride	135	100	100	240	230	160
Chemical O_2 Demand	40	24	16	14	40	22
Conductivity	0.64	0.66	0.68	0.69	0.79	0.89
Dissolved Solids	372	380	380	410	480	740
Suspended Solids			190	12		720
Sulfate	10	7	9	38	11	74
Arsenic	<0.005	<0.005	<0.005	<0.005	<0.004	<0.005
Boron	1.0	<0.100	0.130	0.160	0.2	0.22
Calcium	28	38	37		30	53
Lead	0.04	0.032	0.090		0.1	0.26
Magnesium	17	8.9	16		15.2	22
Mercury	0.0003	0.0002	0.0020	0.0005	<0.00005	0.0011
Selenium	0.005	<0.002	<0.002	<0.002	<0.0005	<0.002
Sulfite	0.6				0.4	
Sodium						

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation D
Sample Type LEACHATE
Test Organization

Sequential Number	45	N-980	N-1135	N-220	77	N-254
Designation Sample	10284 LWD	10284 LWD	12094 LWD	02115 LWD	02115 LWD	02175 LWD
Date Collected	10-28-74	10-28-74	12-9-74	2-11-75	2-11-75	2-17-75
Time Collected						
pH	7.62	7.6	8.8	9.0	8.96	9.1
Total Alkalinity		40	200	160	53	140
Chloride	285	210	6900	1400	1300	310
Chemical O_2 Demand	75		60	13		15
Conductivity	1.6	1.7	6.5	5.0	5.0	4.3
Dissolved Solids	1210	1300	5200	4200	3960	3700
Suspended Solids	790	180	220			
Sulfate	425	590	580	1200	1425	
Arsenic	<0.004	0.005	0.020	0.088	0.03	0.110
Boron	7.80	4.4	89	58	52.0	48
Calcium	150	240	1500	1200	960	990
Lead	<0.013	<0.010	<0.010	0.015	0.26	0.037
Magnesium	8.05	29	76	66	63	58
Mercury	<0.00005	<0.0002	<0.0002	0.0007	<0.00005	0.0035
Selenium	<.0066	<0.002	<0.048	<0.002	0.016	0.100
Sulfite	1.3				6.1	
Sodium						

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation D
Sample Type LEACHATE
Test Organization

Sequential Number	N-258	N-085	151	N-298		
Designation Sample	02285 LWD	04285 LWD	07075 LWD	07075 LWD		
Date Collected	2-28-75	4-28-75	7-7-75	7-7-75		
Time Collected						
pH	9.0	8.7	8.08	8.3		
Total Alkalinity	120	120	130	110		
Chloride	560	1500	940	810		
Chemical O_2 Demand		27	95	20		
Conductivity	3.2	4.4	4.27	4.6		
Dissolved Solids	3500	4000	4240	4500		
Suspended Solids	34	20		1400		
Sulfate	1200	1600	1600	1100		
Arsenic	0.070	0.160	0.21	0.008		
Boron	39	47	58	55		
Calcium	1200	1100	900	940		
Lead	0.028	0.030	0.05	0.18		
Magnesium	84	140	18	180		
Mercury	0.0013	0.0008	0.0002	0.0075		
Selenium	0.016	0.008	0.055	0.048		
Sulfite			0.4			
Sodium						

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation D

Sample Type SUPERNATE

Test Organization

Sequential Number	44	N-981	N-1136	N-221	76	N-255
Designation Sample	10284 PSD	10284 PSD	12094 PSD	02115 PSD	02115 PSD	02175 PSD
Date Collected	10-28-74	10-28-74	12-9-74	2-11-75	2-11-75	2-17-75
Time Collected						
pH	8.70	8.9	9.2	8.5	8.27	8.3
Total Alkalinity		270	310	97	68	120
Chloride	3000	2400	1000	950	1100	1100
Chemical O_2 Demand			170	11		19
Conductivity	5.6	9.0	5.2	4.0	3.6	5.6
Dissolved Solids	6340	7300	4400	3400	3020	4400
Suspended Solids	30	98	1700	2900		
Sulfate	1550	1700	980	1100	950	2000
Arsenic	0.005	0.180	0.020	0.240	0.28	0.300
Boron	98	110	42	49	44	64
Calcium	1640	1500	1100	830	560	1000
Lead	0.040	<0.010	<0.010	0.027	0.21	<0.010
Magnesium	<0.101	190	40	170	152	200
Mercury	<0.00005	<0.0002	<0.0002	<0.0002	<0.00005	<0.0002
Selenium	0.0409	0.040	0.028	0.075	0.062	0.080
Sulfite	2.8				1.5	
Sodium						

Shawnee Disposal Demonstration Water Analysis Record

(All concentrations in mg/l)

Pond Designation D

Sample Type SUPERNATE

Test Organization

Sequential Number	N-259	N-087	152	N-296		
Designation Sample	02245 PSD	04285 PSD	07075 PSD	07085 PSD		
Date Collected	2-24-75	4-28-75	7-7-75	7-8-75		
Time Collected						
pH	8.1	8.0	7.48	8.4		
Total Alkalinity	170	35	45	40		
Chloride	670	260	205	200		
Chemical O_2 Demand	14	16	95	31		
Conductivity	3.7	1.9	2.44	2.7		
Dissolved Solids	3000	1700	3320	2900		
Suspended Solids	.90	8		7		
Sulfate	950	750	1700	130		
Arsenic	0.120	0.005	0.09	0.035		
Boron	35	11	8	10		
Calcium	970	360	460	850		
Lead	0.012	<0.010	0.05	<0.010		
Magnesium	180	34	15.5	17		
Mercury	<0.0002	<0.0002	<0.00005	0.0016		
Selenium	0.060	0.018	0.002	<0.002		
Sulfite			36			
Sodium						

Shawnee Disposal Demonstration Input Sludge Analysis Record
(All liquor concentrations in mg/l)
(All solids analyses in wt %)

Pond Designation D
Sample Type INPUT MATERIAL*
Test Organization

Sequential Number						
Sample Designation	10034 TSDU	10214 TSDU	01155 TSDU	91 TSDC	02055 TSDU	
Sample Date	10-3-74	10-21-74	1-15-75	~	2-5-75	
Liquor Analysis:						
pH	9.05	8.80	7.80	8.21	7.15	
Total Alkalinity						
Chloride	2694	2765	1560	1450	1843	
Chemical O_2 Demand						
Conductivity	4.9	5.2	3.05	5.7	5.35	
Dissolved Solids	6400	6845	3010	5852	3700	
Suspended Solids						
Sulfate	1491	1700	2253	2500	2484	
Arsenic				.24		
Boron				90		
Calcium	1780	1920	917	1100	1330	
Lead				.26		
Magnesium	253	262	395	255	332	
Mercury				<0.0001		
Selenium				0.040		
Sulfite	48	72	24	16	24	
Sodium	56	58	41		42	
Solids Analysis:						
Total Solids	36.5	37.2	33.3			
Calcium Sulfite	30.4	33.1	30.9			
Calcium Sulfate	14.5	17.7	16.6			
Calcium hydroxide						
Calcium carbonate	21.8	19.7	16.9			
Fly Ash	37.9	34.7	38.3			

*The data presented reflect the analyses conducted as of July 1975. The complete analysis will be included in the next report.

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation E
Sample Type GROUND WATER
Test Organization

Sequential Number	N-207	75	N-089	153	W-300	
Designation Sample	0211S GWE1	0211S GWE1	0428S GWE1	0707S GWE1	0708S GWE1	
Date Collected	2-11-75	2-11-75	4-28-75	7-7-75	7-8-75	
Time Collected						
pH	6.8	7.34	7.0	7.25	7.0	
Total Alkalinity	220	223	220	217	230	
Chloride	55	115	36	71	55	
Chemical O_2 Demand	25	50	10	0	9	
Conductivity	0.68	0.64	0.63	0.55	0.66	
Dissolved Solids	420	416	390	440	560	
Suspended Solids			90		4600	
Sulfate	36	28	37	70	86	
Arsenic	<0.005	<0.005	<0.005	<0.004	0.005	
Boron	0.24	<0.1	<0.100	0.2	0.14	
Calcium	32	32	26	13	49	
Lead	0.025	0.04	0.022	0.05	0.51	
Magnesium	9.4	15.0	9.8	11.7	19.0	
Mercury	<0.0002	0.0003	0.004	0.0004	0.0013	
Selenium	<0.002	0.005	0.002	<0.0005	0.003	
Sulfite		0.3		0.64		
Sodium						

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation E
Sample Type GROUND WATER
Test Organization

Sequential Number	N-690	N-745	N-849	N-979	43	N-986
Designation Sample	08054 GWE2	09034 GWE2	10074 GWE2	10284 GWE2	10284 GWE2	11044 GWE2
Date Collected	8-5-74	9-3-74	10-7-74	10-28-74	10-28-74	11-4-74
Time Collected						
pH	7.0	7.2	7.2		8.36	7.0
Total Alkalinity	110	94	170		181	100
Chloride	50	28	66		84	29
Chemical O_2 Demand					50	
Conductivity					0.61	0.49
Dissolved Solids	400	220	370		384	320
Suspended Solids	5400		180			190
Sulfate	48	26	40		37	69
Arsenic	0.023	<0.005	<0.005	<0.005	<0.005	<0.005
Boron	<0.100	<0.100	<0.100	<0.100	0.3	<0.100
Calcium	31	22	23		20	35
Lead	0.095	0.016	<0.010		0.03	<0.010
Magnesium	24.0	5.6	8.3		15.0	8.8
Mercury	<0.0002	<0.0002	<0.0002			<0.0002
Selenium	<0.002	<0.002	<0.002	<0.002	0.004	<0.002
Sulfite					0.3	
Sodium						

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation E
Sample Type GROUND WATER
Test Organization

Sequential Number	N-208	74	N-090	154	N-301	
Designation Sample	02115 GWE2	02115 GWE2	04285 GWE2	07075 GWE2	07085 GWE2	
Date Collected	2-11-75	4-28-75	7-7-75	7-8-75		
Time Collected						
pH	6.9	7.63	6.8	6.89	6.8	
Total Alkalinity	230		160	176	150	
Chloride	63	125	46	64	52	
Chemical O_2 Demand	860		31	15	120	
Conductivity	1.0	0.64	0.59	0.50	0.60	
Dissolved Solids	460	544	350	400	480	
Suspended Solids			25		7500	
Sulfate	52	56	50	110	89	
Arsenic	<0.005	<0.005	<0.005	<0.004	<0.005	
Boron	0.50	0.6	0.150	0.20	0.18	
Calcium	72	20	34	37	62	
Lead	0.890	0.09	<0.010	0.050	0.25	
Magnesium	12.0	12.0	8.5	7.5	16	
Mercury	0.0005		0.0002	<0.00005	<0.0002	
Selenium	<0.002	0.003	<0.002	0.001	<0.002	
Sulfite		0.7		0.44		
Sodium						

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation E
Sample Type LEACHATE
Test Organization

Sequential Number	N-206	92	N-088	155	N-302	
Designation Sample	02115 LWE2	03195 LWE2	04285 LWE2	07075 LWE2	07075 LWE2	
Date Collected	2-11-75	3-19-75	4-28-75	7-7-75	7-7-75	
Time Collected						
pH	7.9	8.82	11.1	10.96	11.2	
Total Alkalinity	120	162	490	568	700	
Chloride	1000	1850		740	650	
Chemical O_2 Demand	56	90	320	245	180	
Conductivity	4.0	3.9		4.16	4.6	
Dissolved Solids	2400	2720	3400	3200	2900	
Suspended Solids			14		9300	
Sulfate	300	250	670	800	370	
Arsenic	0.027	0.01	0.140	0.08	0.110	
Boron	0.68	1.6	0.140	0.6	<0.100	
Calcium	98	<15	13	<20	83	
Lead	0.048	0.13	0.020	<0.05	0.055	
Magnesium	5.1	30	0.5	0.5	23	
Mercury	0.0005	<0.0005	0.0013	0.0003	0.0033	
Selenium	<0.002	0.0120	0.046	0.043	<0.002	
Sulfite		0.2		0.3		
Sodium		970		970		

Shawnee Disposal Demonstration Water Analysis Record
(All concentrations in mg/l)

Pond Designation E

Sample Type SUPERNATE

Test Organization

Sequential Number	73	N-205	N-091	156	N-299	
Designation Sample	02115 PSE	02115 PSE	04285 PSE	07075 PSE	07085 PSE	
Date Collected	2-11-75	2-11-75	4-28-75	7-7-75	7-8-75	
Time Collected						
pH	11.79	11.9	10.2	6.95	7.5	
Total Alkalinity	536	410	34	28	27	
Chloride	365	170	110	245	100	
Chemical O_2 Demand	20	6	9	80	7	
Conductivity	2.9	2.8	1.6	1.66	2.0	
Dissolved Solids	1440	1300	1200	1720	1700	
Suspended Solids		6	12		19	
Sulfate	250	220	390	1000	840	
Arsenic	<0.004	<0.005	<0.005	<0.004	0.010	
Boron	0.4	0.11	0.33	0.7	0.66	
Calcium	24	19	170	260	260	
Lead	0.05	<0.010	0.036	0.05	0.011	
Magnesium	30	0.3	1.0	3.3	3.7	
Mercury	<0.00005	0.0008	<0.0002	0.0001	<0.0002	
Selenium	0.0013	<0.002	0.003	0.019	<0.002	
Sulfite	28			.18		
Sodium				190		

Shawnee Disposal Demonstration Input Sludge Analysis Record
(All liquor concentrations in mg/l)
(All solids analyses in wt %)

Pond Designation E
Sample Type INPUT MATERIAL*
Test Organization

Sequential Number	65					
Sample Designation	ISEC					
Sample Date						
Liquor Analysis:						
pH	9.43					
Total Alkalinity						
Chloride	2450					
Chemical O_2 Demand						
Conductivity						
Dissolved Solids	5960					
Suspended Solids						
Sulfate	1175					
Arsenic						
Boron						
Calcium						
Lead						
Magnesium						
Mercury						
Selenium						
Sulfite						
Solids Analysis:						
Total Solids						
Calcium Sulfite						
Calcium Sulfate						
Calcium hydroxide						
Calcium carbonate						
Fly Ash						

*The data presented reflect the analyses conducted as of July 1975. The complete analysis will be included in the next report.

APPENDIX C

C.3 PRECIPITATION DATA

Week		Precip-itation (Inches)	Net Increase in Moisture (Precipitation minus 0.7X Evaporation) (Inches)
Sequen-tial No.	Date		
1	3-11-74	1.18	.34
2	3-18	0.45	- .05
3	3-25	1.08	
4	4-1	0.59	
5	4-8	1.49	.30
6	4-15	0.28	- .80
7	4-22	1.28	.28
8	4-29	0.03	- .31
9	5-6	0.66	- .26
10	5-13	0.98	- .17
11	5-20	1.16	- .13
12	5-27	0.73	- .17
13	6-3	0.28	- .89
14	6-10	1.83	.69
15	6-17	0.60	- .73
16	6-24	1.15	- .39
17	7-1	0.00	-1.59
18	7-8	0.31	-1.23
19	7-15	0.18	-1.13
20	7-22	0.01	-1.66
21	7-29	1.07	- .41
22	8-5	0.08	-1.28
23	8-12	1.64	.55
24	8-19	1.25	.08

Week		Precip-itation (Inches)	Net Increase in Moisture * (Precipitation minus 0.7X Evaporation) (Inches)
Sequen-tial No.	Date		
25	8-26	0.47	-.65
26	9-2	3.28	2.70
27	9-9	0.25	-.61
28	9-16	0.64	.01
29	9-23	0.07	
30	9-30	0.67	.06
31	10-7	0.00	-.93
32	10-14	0.00	
33	10-21	0.96	.37
34	10-28	0.00	
35	11-4	2.27	1.79
36	11-11	0.98	
37	11-18	0.04	
38	11-25	1.39	.99
39	12-2	0.42	
40	12-9	0.52	
41	12-16	0.64	
42	12-23	0.15	
43	12-30	1.75	
44	1-6-75	1.18	
45	1-13	1.73	
46	1-20	0.41	
47	1-27	0.13	
48	2-3	1.65	

*Evaporation data are not available after week number 38 because of equipment difficulties at the evaluation site. Alternative data sources are being sought to complete this information.

Week		Precipitation (Inches)	Net Increase in Moisture* (Precipitation minus 0.7X Evaporation) (Inches)
Sequential No.	Date 75		
49	2-10	0.24	
50	2-17	0.51	
51	2-24	3.04	
52	3-3	0.00	
53	3-10	0.85	
54	3-17	1.59	
55	3-24	1.46	
56	3-31	4.23	
57	4-7	0.03	
58	4-14	0.56	
59	4-21	0.82	
60	4-28	2.79	
61	5-5	0.73	
62	5-12	1.75	
63	5-19	0.00	
64	5-26	0.46	
65	6-2	2.58	
66	6-9	1.50	
67	6-16	0.53	
68	6-23	0.77	
69	6-30	0.08	
70	7-7	2.42	
71	7-14	0.43	
72	7-23	0.80	

*Evaporation data are not available after week number 38 because of equipment difficulties at the evaluation site. Alternative data sources are being sought to complete this information.

Week		Precip-itation (Inches)	Net Increase in Moisture* (Precipitation minus – 0.7x Evaporation) (Inches)
Sequen-tial No.	Date		
73	7-29	0.15	
74	8-4	1.94	
75	8-11	0.88	
76	8-18	0.60	
77	8-25	0.00	
78	9-1	1.19	
79	9-8	0.00	
80	9-15	1.09	

*Evaporation data are not available after week number 38 because of equipment difficulties at the evaluation site. Alternative data sources are being sought to complete this information.

APPENDIX C

C.4 HYDROLOGICAL RECORDS

Shawnee Disposal Demonstration Hydrological Data Weekly Record

Date	Depth of Water (Inches)								
	Ground Water Wells								
	A1	A2	B1	B2	C1	C2	D1	E1	E2
2-17-75	84.82	101.24	99.52	83.02	42.96	36.09	46.82	76.84	44.93
2-24-75	76.82	105.74	99.52	87.02	75.96	65.59	57.32	70.09	46.43
3-3-75	84.32	–	105.52	93.02	73.96	76.59	74.32	79.84	46.93
3-10-75	99.32	–	122.27	113.02	85.21	90.59	92.32	102.34	70.93
3-17-75	95.07	91.24	132.40	119.52	105.96	98.09	115.32	108.84	77.805
3-25-75	104.82	95.99	149.52	135.02	122.96	107.84	119.32	128.84	98.43
4-1-75	105.57	93.24	155.27	141.52	123.46	115.84	115.32	142.84	99.68
4-8-75	107.57	89.49	159.52	150.02	123.46	120.59	126.32	136.84	109.93
4-15-75	110.82	87.49	158.52	128.02	120.96	115.09	116.32	110.84	98.43
4-22-75	113.07	86.49	154.52	125.02	114.46	116.09	118.32	111.84	95.43
4-29-75	118.95	95.24	138.52	115.02	108.96	108.34	98.82	102.84	84.43
5-6-75	127.20	95.24	136.52	115.02	116.09	104.09	101.82	99.59	82.555
5-13-75	129.38	95.99	135.27	123.40	104.46	101.59	100.195	98.84	81.93
5-21-75	133.07	95.37	135.52	127.52	105.96	103.09	99.32	110.34	86.93
5-28-75	136.70	91.49	116.52	115.02	95.46	94.09	106.32	91.59	73.43
6-3-75	137.82	89.24	121.02	110.52	90.46	88.84	87.82	94.09	64.43
6-11-75	140.82	88.24	116.27	106.02	85.96	80.09	80.32	90.59	69.43
6-16-75	138.82	86.24	115.02	105.02	82.46	78.84	79.82	89.84	65.43
6-25-75	134.82	80.74	109.52	98.52	77.96	75.09	73.82	83.34	61.93
7-2-75	135.57	77.24	104.02	92.77	70.96	68.34	67.32	78.09	58.93
7-8-75	143.07	82.24	99.52	90.52	63.46	66.09	60.07	73.84	51.68
7-14-75	137.32	79.74	93.52	147.52	60.46	59.09	57.32	38.34	50.93
7-23-75	134.45	78.12	90.77	81.77	59.46	56.34	56.32	65.34	43.68
7-29-75	132.32	73.24	81.52	76.77	53.71	53.84	50.07	60.84	40.93

Shawnee Disposal Demonstration Hydrological Data Weekly Record

Date	Depth of Water (Inches)								
	Ground Water Wells								
	A1	A2	B1	B2	C1	C2	D1	E1	E2
8-4-75	135.82"	75.74"	83.27"	73.02"	48.96"	49.09"	48.32"	57.34"	61.93"
8-11-75	128.07"	75.24"	81.02"	70.52"	46.96"	43.59"	44.57"	52.84"	31.68"
8-18-75	126.07"	75.24"	75.77"	66.02"	42.96"	40.59"	40.32"	47.34"	26.43"
8-25-75	122.82"	71.74"	73.77"	64.52"	38.46"	40.84"	41.07"	44.84"	24.93"
9-1-75	122.07"	68.99"	71.77"	62.77"	37.46"	35.09"	35.32"	43.59"	21.93"
9-8-75	116.82"	66.24"	65.27"	56.02"	31.46"	31.59"	32.32"	37.84"	17.93"
9-15-75	115.32"	64.74"	67.02"	55.52"	30.46"	31.34"	30.82"	37.09"	14.68"

Shawnee Disposal Demonstration Hydrological Data Weekly Record

Week		Depth of Water (Inches)				
		Leachate Wells				
Sequential No.	Date	A	B	C	D	E
	2-17-75					
	2-24-75					
	3-3-75					
	3-10-75					
	3-17-75					
	3-25-75					
	4-1-75					
	4-8-75					
	4-15-75					
	4-22-75					
	4-29-75					
	5-6-75					
	5-13-75					
	5-21-75					
	5-28-75					
	6-3-75					
	6-11-75					
	6-16-75	55.0"	61.83"	32.02"	60.13"	35.79"
	6-25-75	53.25"	59.83"	23.77"	58.38"	32.79"
	7-2-75	51.25"	58.08"	19.77"	57.13"	23.54"
	7-8-75	55.25"	61.08"	22.77"	60.38"	34.04"
	7-14-75	52.25"	63.83"	21.27"	48.13"	30.54"
	7-23-75	50.5"	62.58"	16.52"	57.13"	30.29"
	7-29-75	48.75"	59.08"	14.27"	55.38"	21.04"

Shawnee Disposal Demonstration Hydrological Data Weekly Record

Week		Depth of Water (Inches)				
		Leachate Wells				
Sequential No.	Date	A	B	C	D	E
	8-4-75	53.25"	62.33"	22.02'	57.38"	25.79"
	8-11-75	51.75"	61.83'	16.02"	55.88"	29.54"
	8-18-75	51.625"	60.58"	14.27'	55.38"	27.29"
	8-25-75	48.25"	59.33"	10.52"	54.38"	17.04"
	9-1-75	49.5"	58.955"	10.52"	53.38"	21.54"
	9-8-75	47.75"	24.58"	1.77"	52.63"	12.04"
	9-15-75	48.25"	41.58"	–	52.63"	17.29"

APPENDIX C

C.5 POND WATER/SOLIDS LEVEL RECORDS

Shawnee Disposal Demonstration Pond Water/Solids Level
Weekly Record

Week		Supernate Water Level (Inches)*					Solids Level (Inches)*				
		Pond					Pond				
Sequential No.	Date	A	B	C	D	E	A	B	C	D	E
	2-17-75			**		**					
	2-24-75										
	3-3-75										
	3-10-75										
	3-17-75										
	3-25-75										
	4-1-75										
	4-8-75	35.5			26.3		41.8			34.9	
	4-15-75	32.3			26.5		42.6			35.5	
	4-22-75	31.8			26.8		41.9			35.8	
	4-29-75	33.9			23.3		46.0			35.5	
	5-6-75	33.1			24.1		46.4			35.8	
	5-13-75	34.5			21.5		46.9			35.8	
	5-21-75	32.6			23.6		43.4			35.9	
	5-28-75	33.8			21.9		41.5			35.8	
	6-3-75	34.3			22.0		41.5			35.5	
	6-11-75	34.0			20.8		41.8			35.5	
	6-16-75	35.5			22.5		41.5			36.0	
	6-25-75	36.8			24.3		42.8			35.5	
	7-2-75	38.8			26.3		41.8			35.5	
	7-8-75	35.5			22.8		41.5			35.8	
	7-14-75	37.0			24.5		41.5			35.8	
	7-23-75	37.8	17.8	31.5	25.5	21.3	41.6	21.0	26.3	35.5	15.3
	7-29-75	39.0	19.3	33.3	27.3	24.0	41.5	21.0	26.3	35.8	14.8
	8-4-75	37.0	17.3	30.5	25.1	20.0	41.5	21.0	26.3	35.5	15.0
	8-11-75	37.5	17.8	30.8	25.8	19.8	41.8	21.0	26.1	35.5	15.0
	8-18-75	38.3	18.8	32.0	26.5	21.8	41.8	21.0	26.1	35.5	15.0
	8-25-75	39.5	20.5	34.5	28.5	24.8	41.8	21.0	26.3	35.5	15.3
	9-1-75	39.3	20.8	34.0	28.5	24.5	41.8	21.0	26.3	35.5	15.0
	9-8-75	40.3	23.0*	36.5*	30.0	26.5*	41.8	21.0	26.1	35.5	15.0
	9-15-75	39.8	23.0*	36.0*	29.8	26.0*	41.8	21.0	26.3	35.5	15.0

*Measurements taken from top of leachate well casing.

**There was insufficient supernate at the point of measurement in Ponds C and E to obtain a valid water level reading.

APPENDIX C

C.6 SOIL CHARACTERIZATION RECORDS

Shawnee Disposal Demonstration Soil Characterization Record

Pond Designation A

Sample Type Soil Core

Test Organization TVA

Sequential Number	1	2	3				1
Sample Designation	12133SCA1	12133SCA1	12133SCA1				SCAP
Sample Date	12-13-73	12-13-73	12-13-73				
Sample Depth (from surface)	2.5'	5.1'	~ 9'				
Permeability Coefficient (cm/sec)							2.3×10^{-8}
Natural Moisture Content (wt%)	15.7	21.1	22.6				20.0
Liquid Limit (wt%)	32.4	32.7	27.9				38.5
Plasticity Index	13.1	13.6	6.2				18.0
Plastic Limit (wt%)	19.3						
Specific Gravity	2.69						
Mechanical Analysis							
1) Sand (%)	2						2
2) Silt (%)	74						73
3) Clay (%)	24						25
Soil Classification	Lean Clay	Lean Clay	Silty Clay				Lean Clay

Shawnee Disposal Demonstration Soil Characterization Record

Pond Designation B

Sample Type SOIL CORE

Test Organization TVA

Sequential Number	1	2	3	4	5	6	7
Sample Designation	11054SCB1	11054SCB1	11054SCB1	11054SCB1	11054SCB1	11054SCB1	11054SCB1
Sample Date	11-5-74	11-5-74	11-5-74	11-5-74	11-5-74	11-5-74	11-5-74
Sample Depth (from surface)	3.3'	5.4'	7.7'	11.6'	15.0'	~20'	~27.5'
Permeability Coefficient (cm/sec)							
Natural Moisture Content (wt%)	18.6	18.7	15.9	18.2	20.5	16.3	14.6
Liquid Limit (wt%)	31.8	42.0	30.4	29.1	34.4	24.8	25.4
Plasticity Index	10.5	21.9	8.8	9.9	14.5	11.2	13.4
Plastic Limit (wt%)			21.6		19.9		
Specific Gravity							
Mechanical Analysis							
1) Sand (%)			2		3		
2) Silt (%)			78				
3) Clay (%)			20				
Soil Classification	LEAN CLAY	L.C.	L.C.	L.C.	L.C.	SANDY LEAN CLAY	SANDY LEAN CLAY

Shawnee Disposal Demonstration Soil Characterization Record

Pond Designation B

Sample Type SOIL CORE

Test Organization TVA

Sequential Number	8	9	10				
Sample Designation	11054SCB1	11054SCB1	11054SCB1				
Sample Date	11-5-74	11-5-74	11-5-74				
Sample Depth (from surface)	~32.5'	~37.5'	~43.5'				
Permeability Coefficient (cm/sec)							
Natural Moisture Content (wt%)	14.1	16.4	14.4				
Liquid Limit (wt%)	29.2	32.7	33.9				
Plasticity Index	16.6	17.5	19.8				
Plastic Limit (wt%)	12.6						
Specific Gravity							
Mechanical Analysis							
GRAVEL	26						
1) Sand (%)	32						
2) Silt (%)	26						
3) Clay (%)	16						
Soil Classification	GRAVELLY CLAYEY SAND	SANDY LEAN CLAY	GRAVELLY CLAYEY SAND				

Shawnee Disposal Demonstration Soil Characterization Record

Pond Designation C

Sample Type Soil Core

Test Organization TVA

Sequential Number	1	2	3	4	5	6	1
Sample Designation	12123SCC1	12123SCC1	12123SCC1	12123SCC1	12123SCC1	12123 SCC1	SCCP
Sample Date	12-12-73	12-12-73	12-12-73	12-12-73	12-12-73	12-12-73	
Sample Depth (from surface)	7.2'	10.2'	14.3'	~17'	~22.5	~30'	
Permeability Coefficient (cm/sec)							1.9×10^{-8}
Natural Moisture Content (wt%)	22.0	21.8	22.1	19.7	14.9	14.6	21.6
Liquid Limit (wt%)	31.0	32.9	33.3	32.4	20.9	22.7	34.0
Plasticity Index	10.6	14.4	15.6	14.4	11.1	12.0	14.6
Plastic Limit (wt%)						10.7	
Specific Gravity							
Mechanical Analysis							
Gravel						11	
1) Sand (%)						43	3
2) Silt (%)						30	73
3) Clay (%)						16	24
Soil Classification	LEAN CLAY	LC	LC	LC	SANDY LEAN CLAY	CLAYEY SAND	LEAN CLAY

Shawnee Disposal Demonstration Soil Characterization Record

Pond Designation D

Sample Type SOIL CORE

Test Organization TVA

Sequential Number	1	2	3	4	5	6	7
Sample Designation	12123 SCD1	12123 SCD1	12123 SCD1	12123 SCD1	12123 SCD1	12123 SCD1	12123 SCD1
Sample Date	12-12-73	12-12-73	12-12-73	12-12-73	12-12-73	12-12-73	12-12-73
Sample Depth (from surface)	7.3'	10.3'	13.3'	~ 17'	~22.5'	~27.5'	~ 35'
Permeability Coefficient (cm/sec)							
Natural Moisture Content (wt%)	18.3	16.0	16.8	13.7	12.3	10.5	19.7
Liquid Limit (wt%)	35.3	30.0	32.2	33.7	36.3	22.5	–
Plasticity Index	15.5	11.0	13.6	17.8	20.4	10.2	
Plastic Limit (wt%)							
Specific Gravity							
Mechanical Analysis GRAVEL							4
1) Sand (%)							71
2) Silt (%)							14
3) Clay (%)							11
Soil Classification	LEAN CLAY	LC	LC	LC	LC	GRAVELLY CLAYEY SAND	SILTY SAND

Shawnee Disposal Demonstration Soil Characterization Record

Pond Designation D

Sample Type Soil Core

Test Organization TVA

Sequential Number	1						
Sample Designation	SCDP						
Sample Date							
Sample Depth (from surface)							
Permeability Coefficient (cm/sec)	"TRACE"						
Natural Moisture Content (wt%)	20.6						
Liquid Limit (wt%)	29.4						
Plasticity Index	8.8						
Plastic Limit (wt%)							
Specific Gravity							
Mechanical Analysis							
1) Sand (%)	1						
2) Silt (%)	75						
3) Clay (%)	24						
Soil Classification	LEAN CLAY						

Shawnee Disposal Demonstration Soil Characterization Record

Pond Designation E

Sample Type Soil Core

Test Organization TVA

Sequential Number	1	2	3	4	5	6	7
Sample Designation	11064 SCE1	11064 SCE1	11064 SCE1	11064 SCE1	11064 SCE1	11064 SCE1	11064 SCE1
Sample Date	11-6-74	11-6-74	11-6-74	11-6-74	11-6-74	11-6-74	11-6-74
Sample Depth (from surface)	3.1'	6.9'	10.4'	13.1'	16.1'	~18'	~22.5'
Permeability Coefficient (cm/sec)							
Natural Moisture Content (wt%)	20.3	19.7	19.7	19.7	21.7	20.1	17.9
Liquid Limit (wt%)	40.2	32.6	32.4	33.2	36.2	36.2	38.8
Plasticity Index	20.2	11.6	12.8	15.4	18.6	19.9	23.6
Plastic Limit (wt%)	20.0						
Specific Gravity	2.64						
Mechanical Analysis							
1) Sand (%)	7						
2) Silt (%)	66						
3) Clay (%)	27						
Soil Classification	LEAN CLAY	LC	LC	LC	LC	LC	LC

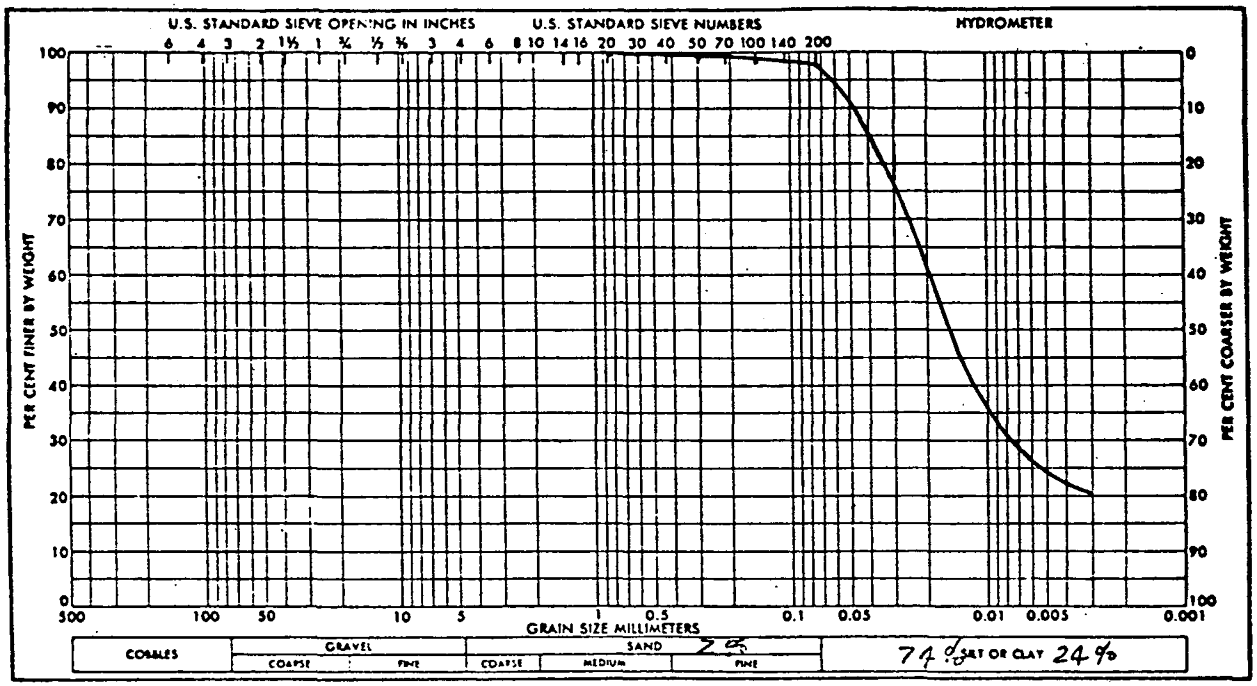
Shawnee Disposal Demonstration Soil Characterization Record

Pond Designation E

Sample Type SOIL CORE

Test Organization TVA

Sequential Number	8	9	10				
Sample Designation	11064SCE1	11064 SCE1	11064 SCE1				
Sample Date	11-6-74	11-6-74	11-6-74				
Sample Depth (from surface)	~27.5'	~32.5'	~37.5'				
Permeability Coefficient (cm/sec)							
Natural Moisture Content (wt%)	16.3	14.7	19.2				
Liquid Limit (wt%)	24.7	30.3	34.1				
Plasticity Index	11.4	17.8	18.2				
Plastic Limit (wt%)			15.9				
Specific Gravity							
Mechanical Analysis							
1) Sand (%)			12				
2) Silt (%)			58				
3) Clay (%)			24				
Soil Classification	LC	CLAYEY SAND	LEAN CLAY				

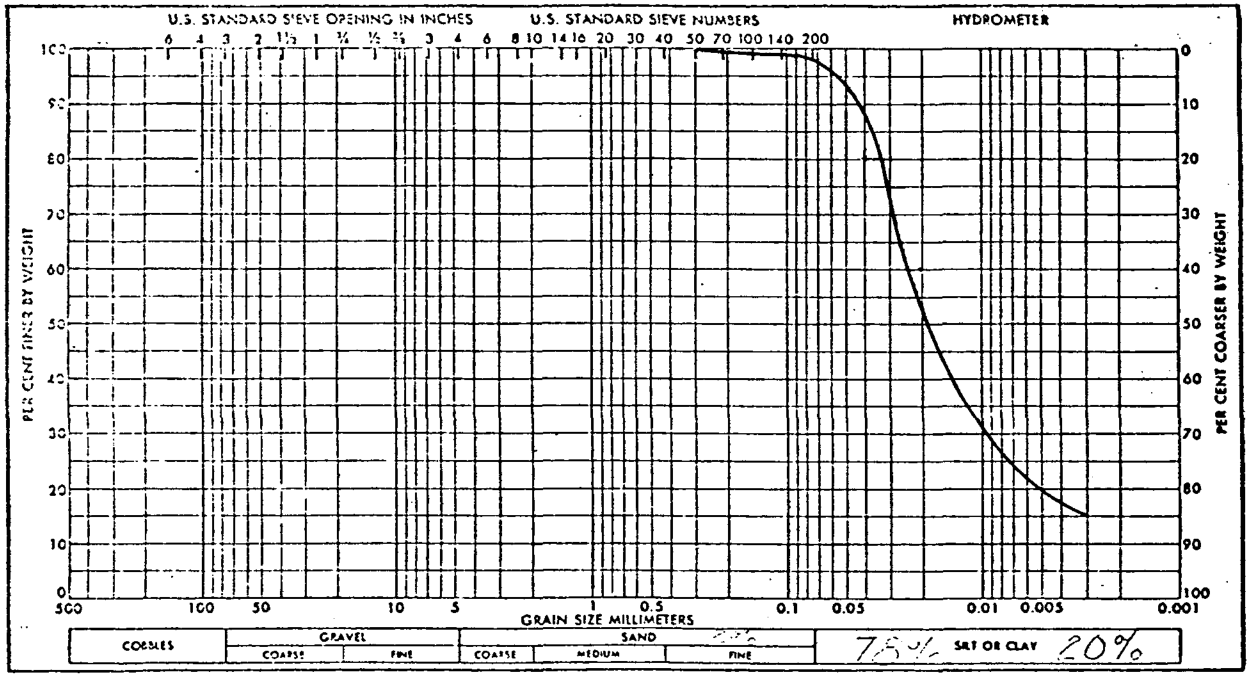


Soil Symbol	CL	Liquid Limit, %	32.4
Moisture Content, %	15.7	Plastic Limit, %	19.3
Specific Gravity	2.69	Plasticity Index, %	13.1
		Shrinkage Limit, %	

Remarks:

Project SHAWNEE S.P.	
Feature POND "A"	
Boring No. US-1	Sample No. 1
Station	Offset
Date 12-21-73	Elevation

GRAIN SIZE ANALYSIS

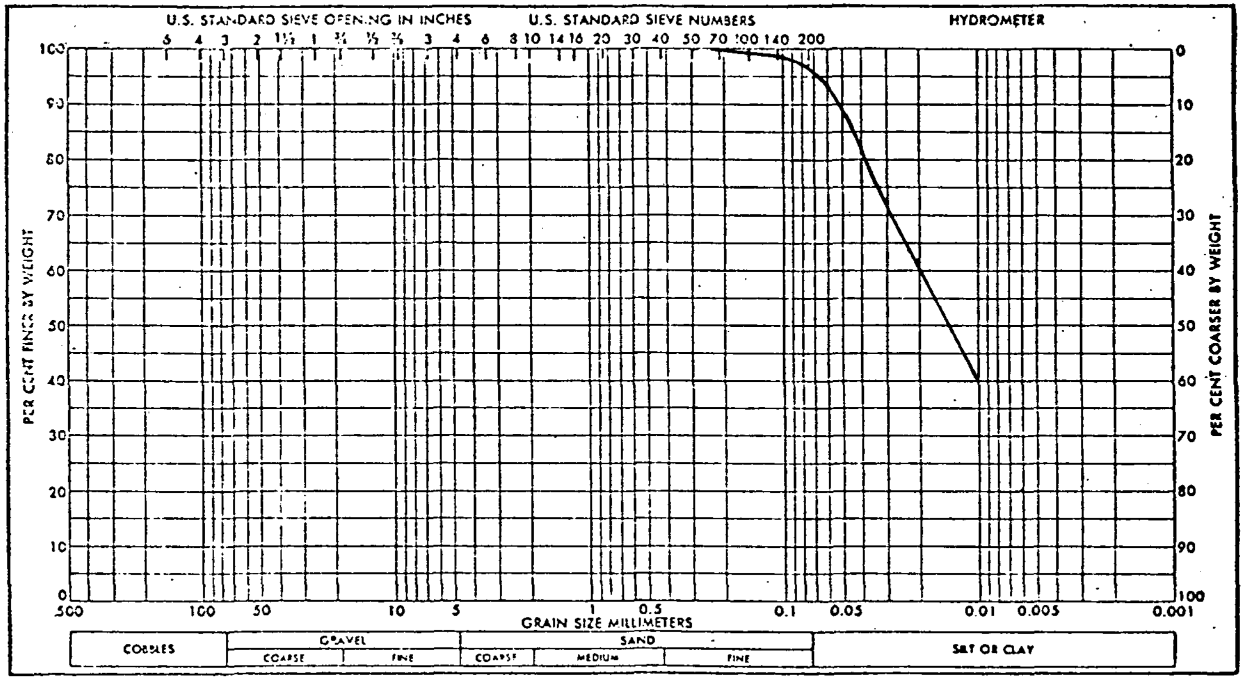


Soil Symbol	[illegible]	Liquid Limit, %	33.4
Moisture Content, %	45.0	Plastic Limit, %	24.6
Specific Gravity		Plasticity Index, %	8.8
		Shrinkage Limit, %	

Remarks: Depth 7'

Project [illegible]	
Feature	
Boring No. [illegible]	Sample No. [illegible]
Station [illegible]	Offset
Date 12-3-70	Elevation

GRAIN SIZE ANALYSIS

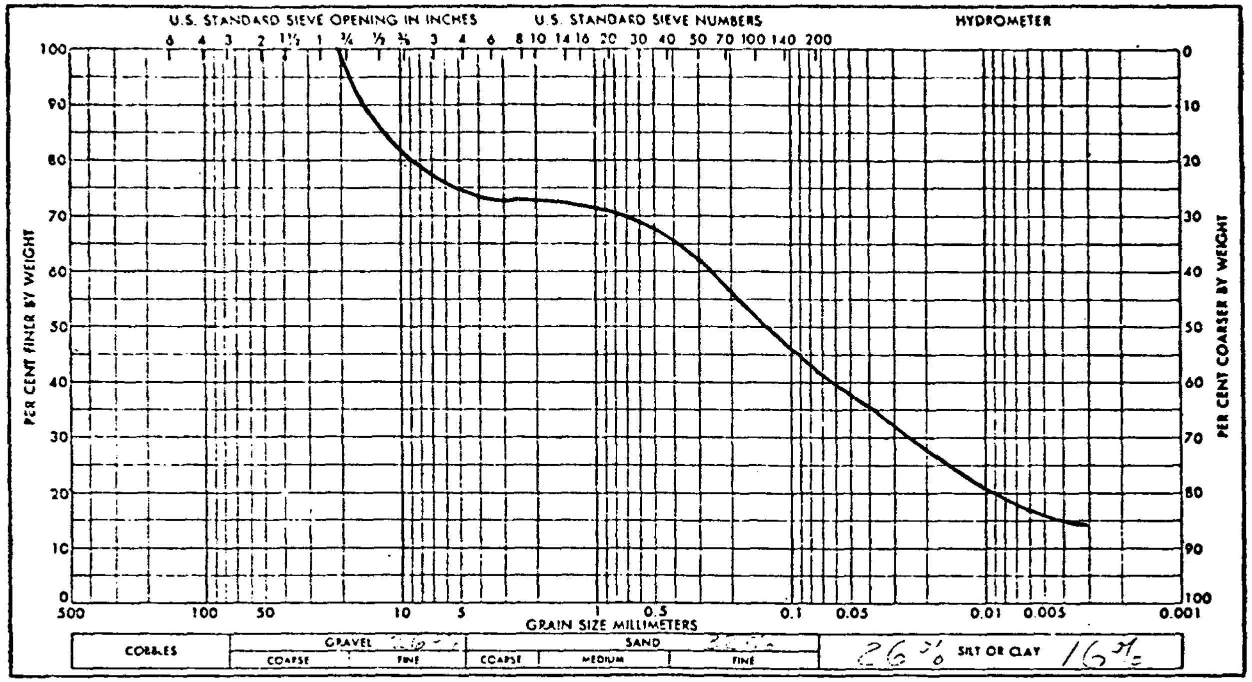


Soil Symbol	[illegible]	Liquid Limit, %	[illegible]
Moisture Content, %	[illegible]	Plastic Limit, %	[illegible]
Specific Gravity		Plasticity Index, %	[illegible]
		Shrinkage Limit, %	

Remarks: Depth 14'

Project: [illegible]	
Feature	
Boring No. [illegible]	Sample No. [illegible]
Station Pond B	Offset
Date [illegible]	Elevation

GRAIN SIZE ANALYSIS



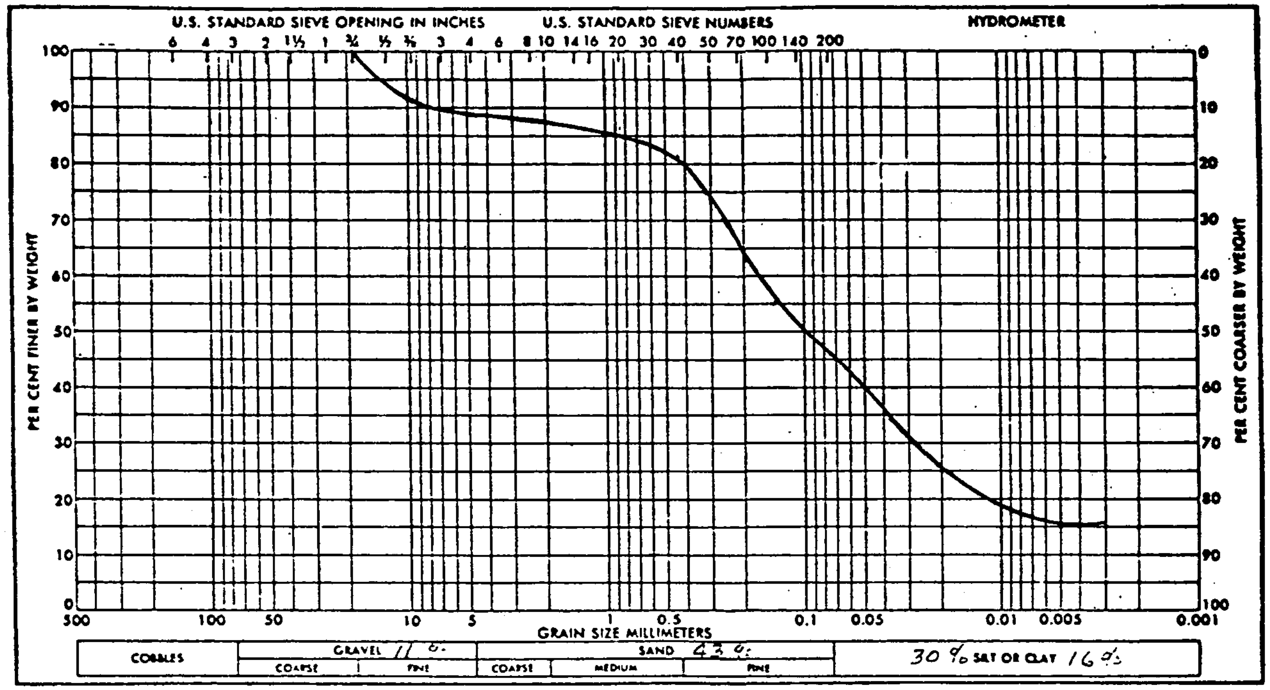
Soil Symbol	[illegible]	Liquid Limit, %	[illegible]
Moisture Content, %	[illegible]	Plastic Limit, %	[illegible]
Specific Gravity		Plasticity Index, %	[illegible]
		Shrinkage Limit, %	

Remarks: [illegible] chert

Depth 22.5'

Project Shawnee S.P.	
Feature	
Boring No. W[illegible]-4	Sample No. [illegible]
Station Pond B	Offset
Date 12-3-74	Elevation

GRAIN SIZE ANALYSIS

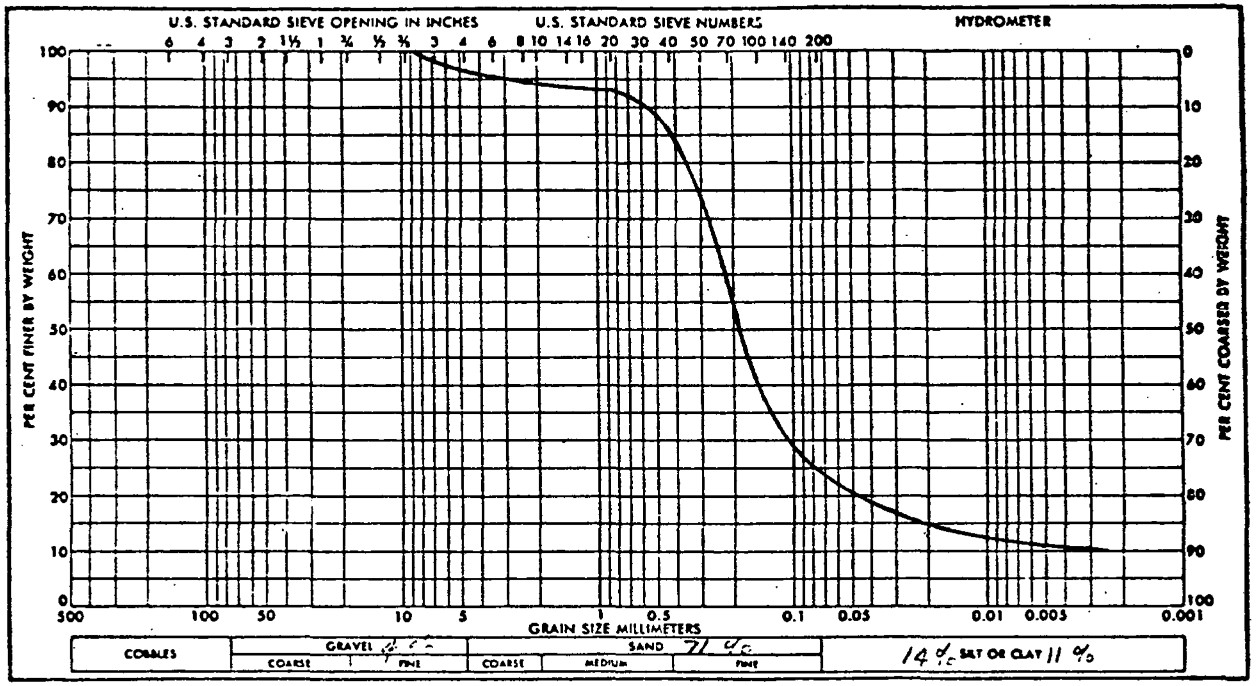


Soil Symbol	SC	Liquid Limit, %	22.7
Moisture Content, %	14.6	Plastic Limit, %	10.7
Specific Gravity		Plasticity Index, %	12.0
		Shrinkage Limit, %	

Remarks:

Project SHAWNEE S.P.	
Feature POND "C"	
Boring No. US-2	Sample No. 6A
Station	Offset
Date 1-3-74	Elevation

GRAIN SIZE ANALYSIS

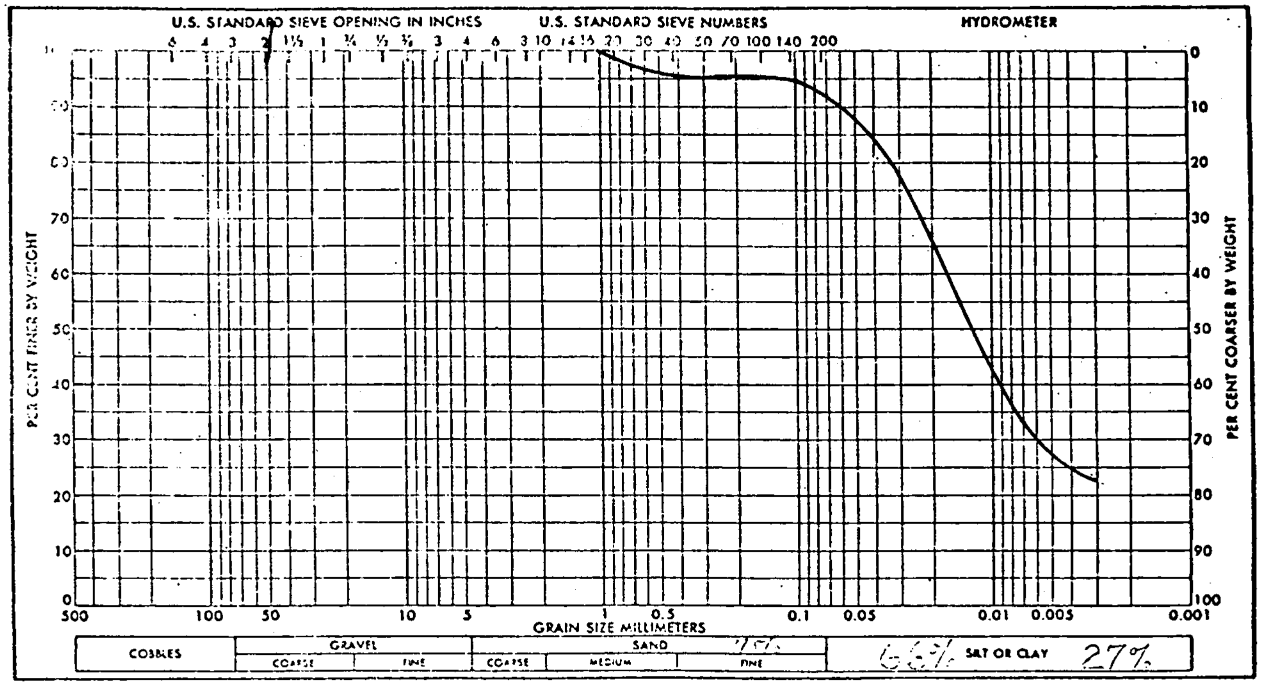


Soil Symbol	SM	Liquid Limit, %	N.P.
Moisture Content, %	19.7	Plastic Limit, %	N.P.
Specific Gravity		Plasticity Index, %	N.P.
		Shrinkage Limit, %	

Remarks:

Project SHAVINEE S.P.	
Feature POND "C" "D"	
Boring No. US-3	Sample No. 7A
Station	Offset
Date 1-3-74	Elevation

GRAIN SIZE ANALYSIS



Soil Symbol	CL	Liquid Limit, %	[illegible]
Moisture Content, %	[illegible]	Plastic Limit, %	[illegible]
Specific Gravity	2.60	Plasticity Index, %	[illegible]
		Shrinkage Limit, %	

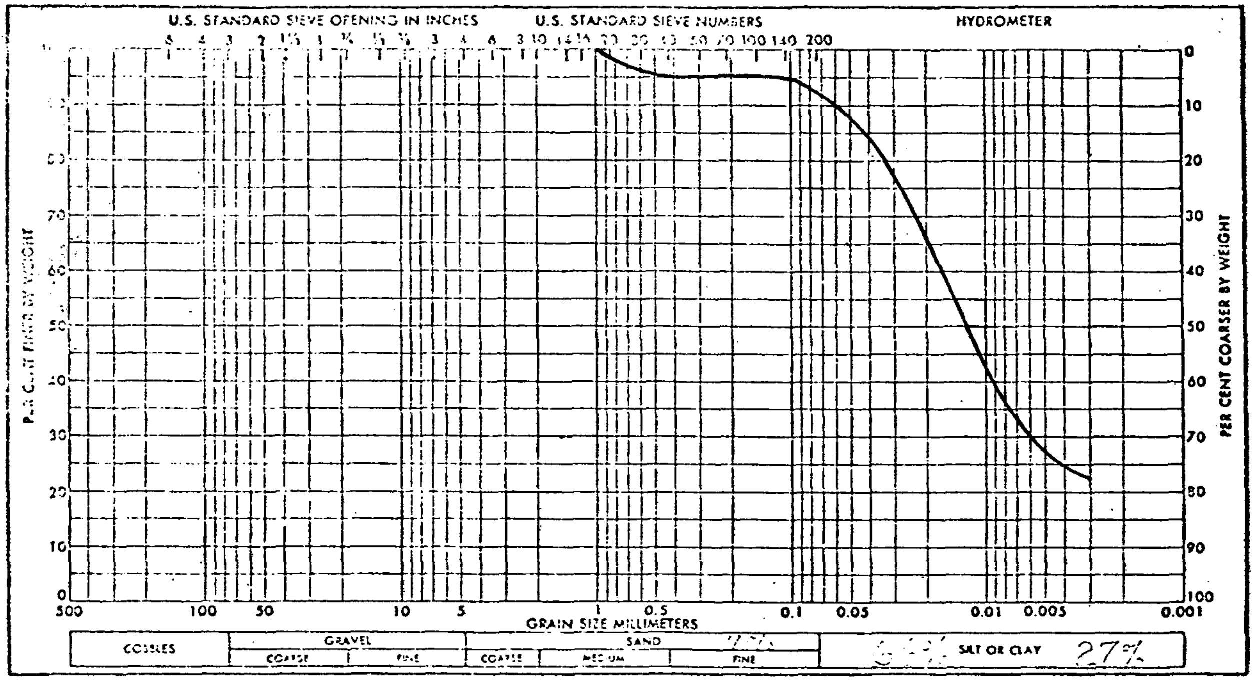
Remarks: Depth 2.5'

Project Shawnee S.P.

Feature

Boring No. [illegible]	Sample No. 1
Station Pond E	Offset
Date 12-3-74	Elevation

GRAIN SIZE ANALYSIS

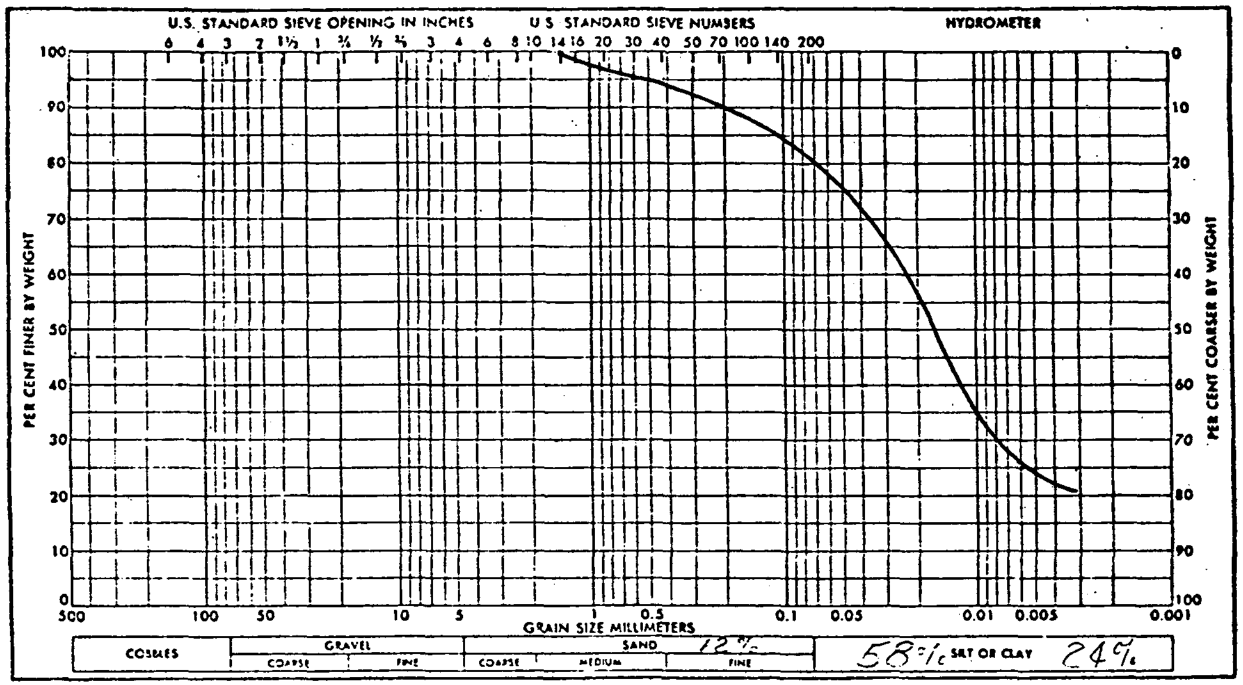


Soil Symbol	[illegible]	Liquid Limit, %	[illegible]
Moisture Content, %	[illegible]	Plastic Limit, %	20.[illegible]
Specific Gravity	[illegible]	Plasticity Index, %	[illegible]
		Shrinkage Limit, %	

Remarks: Depth 2.5'

Project [illegible]	
Feature	
Boring No. [illegible]	Sample No. 1
Station [illegible]	Offset
Date 12-[illegible]-74	Elevation

GRAIN SIZE ANALYSIS



Soil Symbol	CL	Liquid Limit, %	34.1
Moisture Content, %	19.2	Plastic Limit, %	15.9
Specific Gravity		Plasticity Index, %	18.2
		Shrinkage Limit, %	

Remarks: Depth 37.5'

Project Shawnee S.P.

Feature

Boring No. WW-6 Sample No. 5-A

Station Pond E Offset

Date 12-3-74 Elevation

GRAIN SIZE ANALYSIS

APPENDIX C

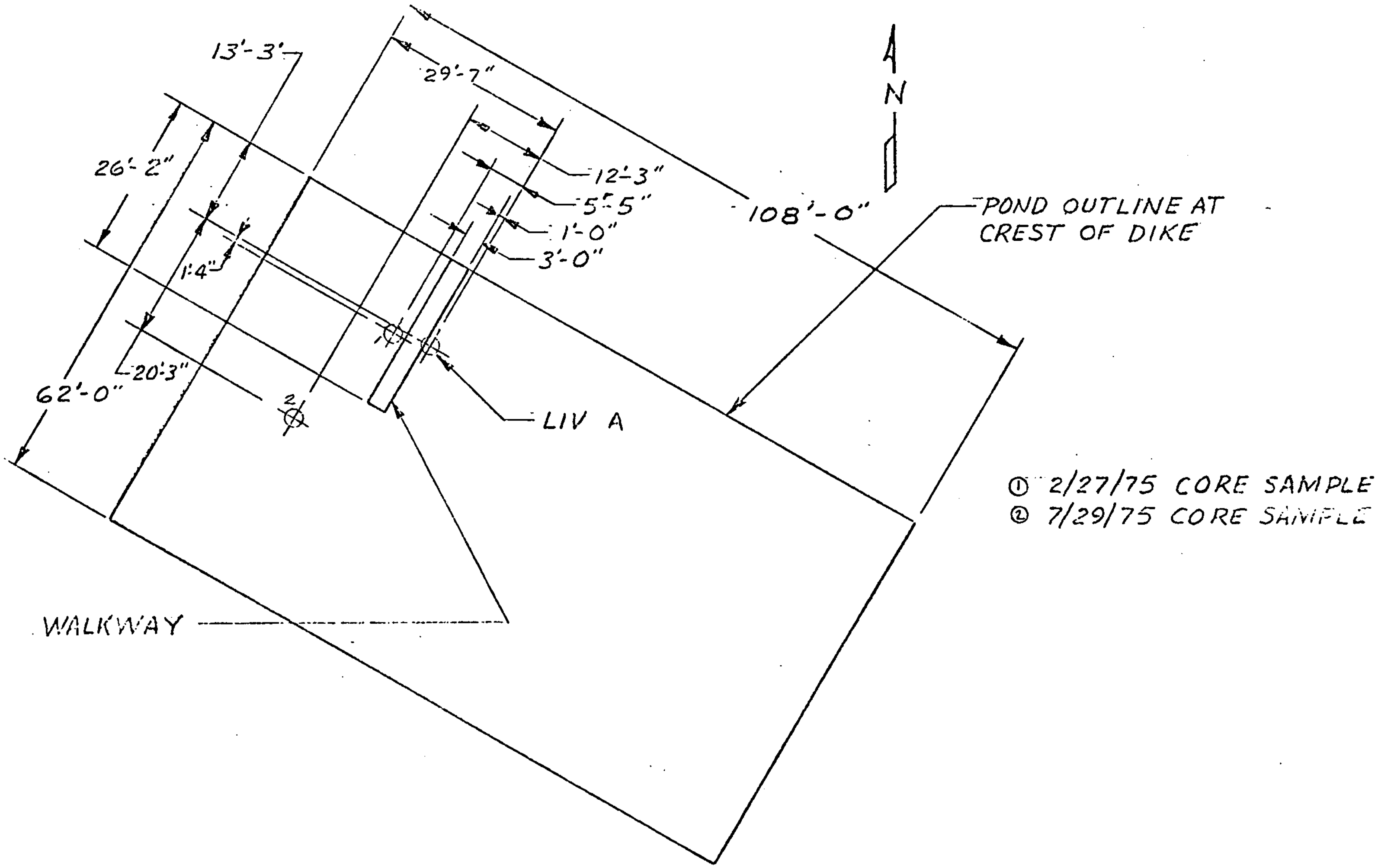
C.7 ION MICROPROBE MASS ANALYZER RESULTS

Median Values of Integrated Ion Currents (nanoamps) Measured by IMMA with Associated Standard Deviations for Pond Soil Samples Taken Before Introduction of Sludge

Pond		$^{11}B^+$	$^{24}Mg^+$	$^{40}Ca^+$	$^{75}As^+$	$^{80}Se^+$	$^{34}S^-$	$^{35}Cl^-$
A	Median	0.150	90	79	0.049	0.132	0.077	9.1
	Std. Dev.	(0.15)	(96)	(67)	(0.122)	(0.115)	(0.066)	(16.5)
B	Median	1.73	498	426	0.52	0.65	0.102	48
	Std. Dev.	(0.45)	(87)	(55)	(0.32)	(0.55)	(0.31)	(75)
C	Median	0.54	336	321	0.307	0.52	0.168	29.7
	Std. Dev.	(0.080)	(85)	(42)	(0.046)	(0.43)	(0.065)	(6.3)
D	Median	0.69	650	314	0.228	2.16	0.135	28.0
	Std. Dev.	(0.30)	(245)	(89)	(0.065)	(0.41)	(0.128)	(19)
E	Median	1.54	510	357	0.68	1.16	0.066	56.4
	Std. Dev.	(0.69)	(119)	(67)	(0.29)	(0.98)	(0.025)	(8.3)
B, C, D, and E	Median	1.11	504	339	0.41	0.91	0.118	38.8
	Std. Dev.	(0.58)	(154)	(55)	(0.22)	(0.80)	(0.050)	(13.9)

APPENDIX C

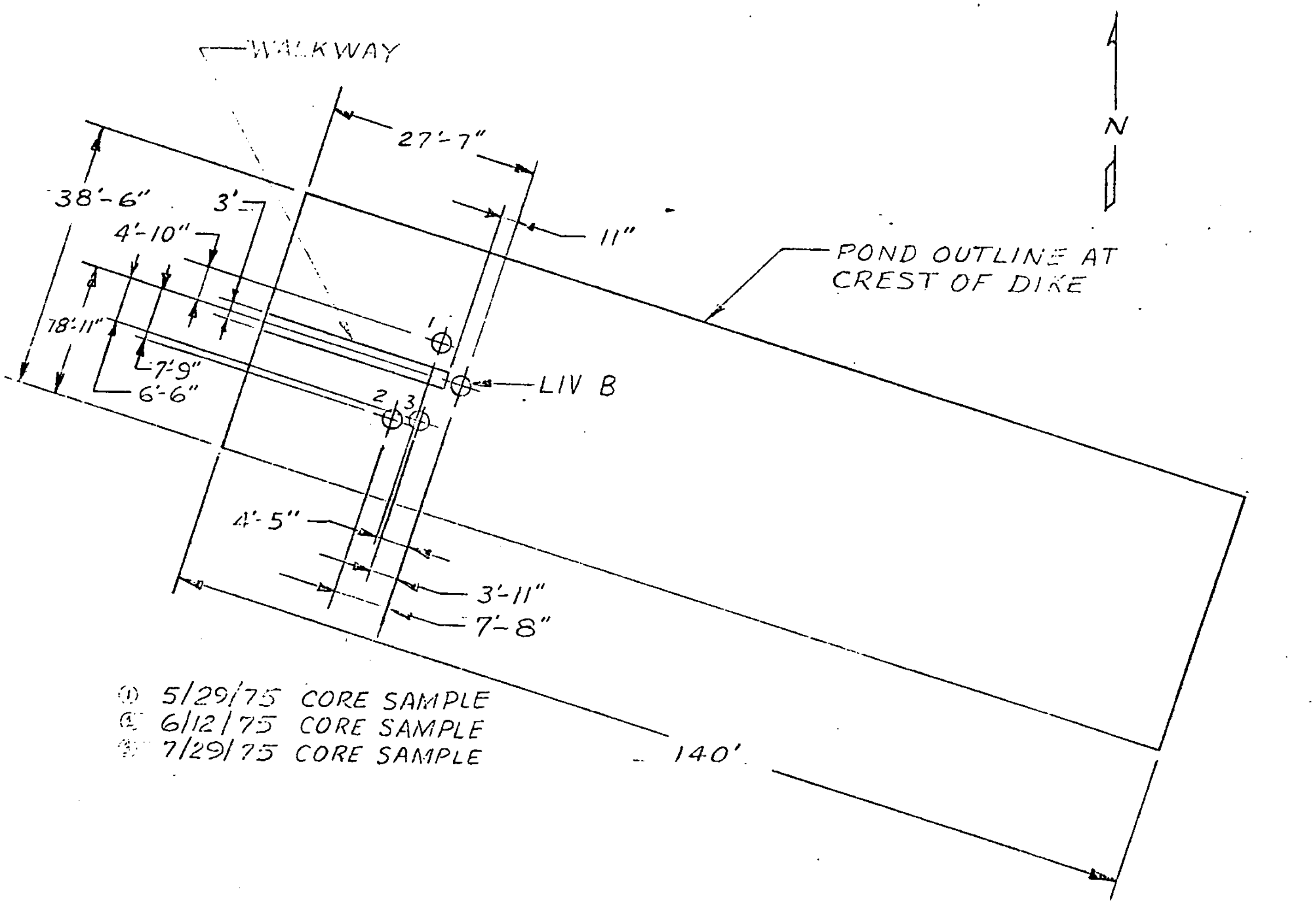
C.8 SHAWNEE POND CORE SAMPLE LOCATIONS



SLUDGE POND A

SHAWNEE STEAM PLANT
WET SCRUBBER PROJECT
BLP 8/8/75

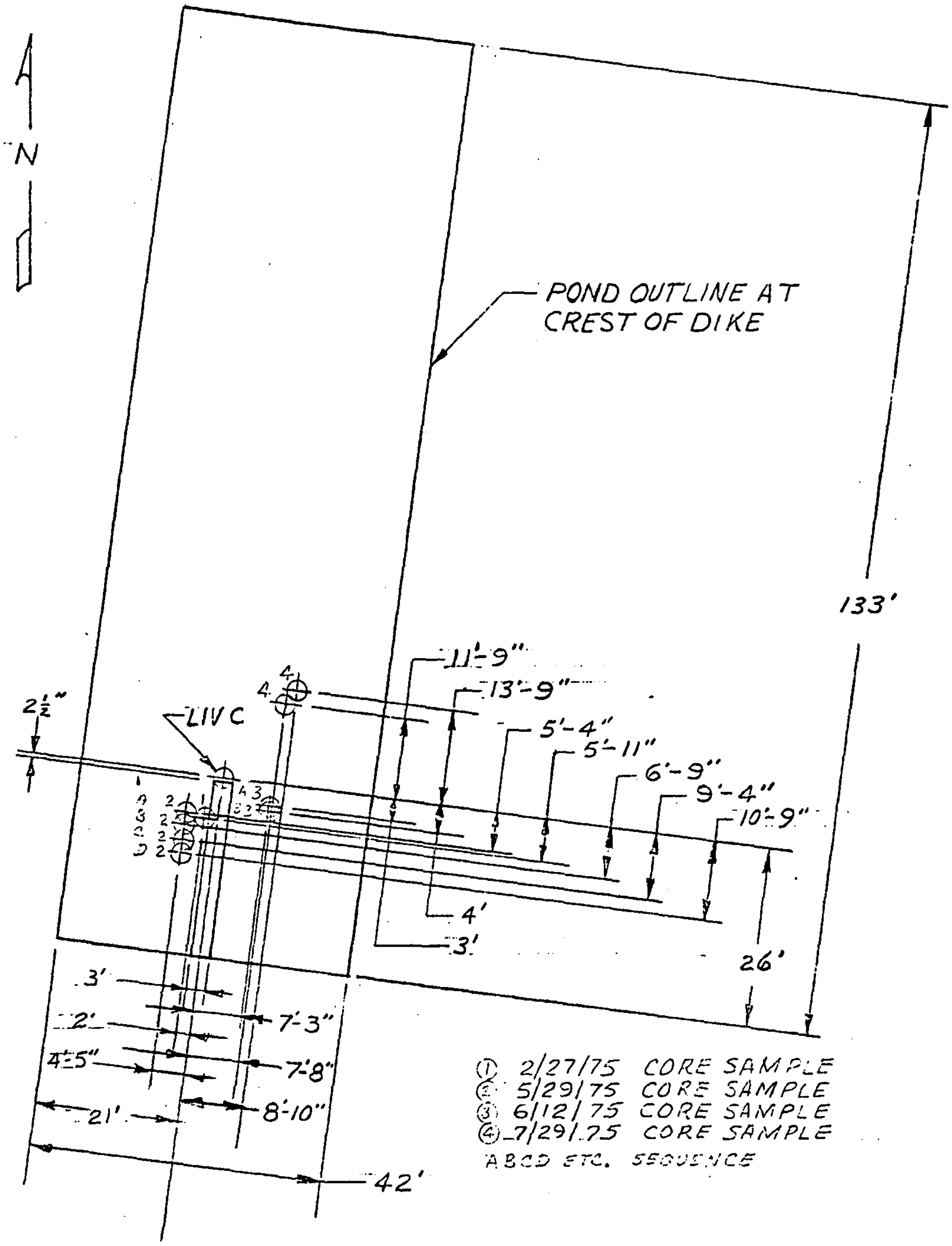
Courtesy of TVA



SLUDGE POND B

SHAWNEE STEAM PLANT
WET SCRUBBER PROJECT
BLP 8/8/75

Courtesy of TVA

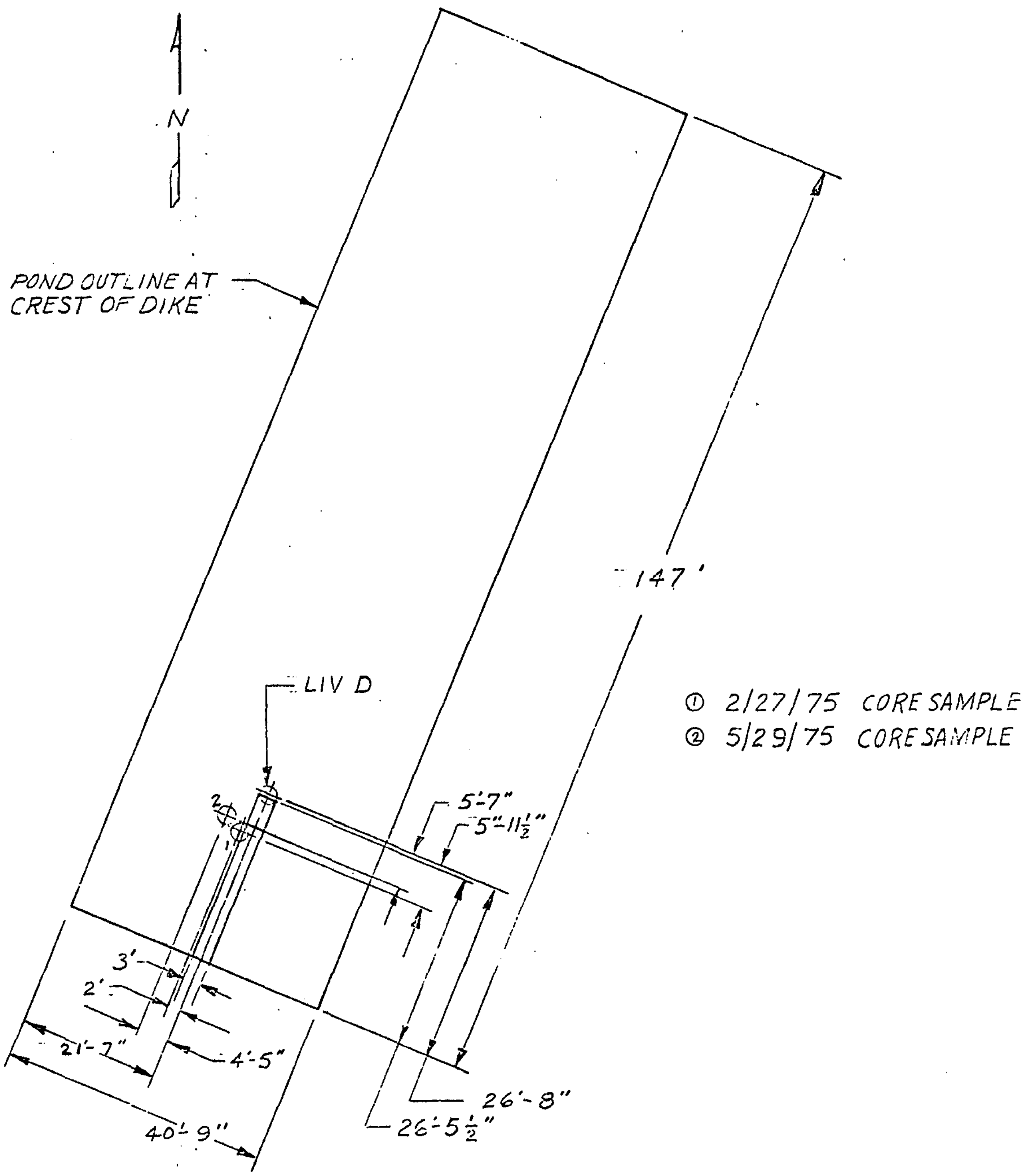


SLUDGE POND C

SHAWNEE STEAM PLANT
WET SCRUBBER PROJECT

BLP 8/7/75

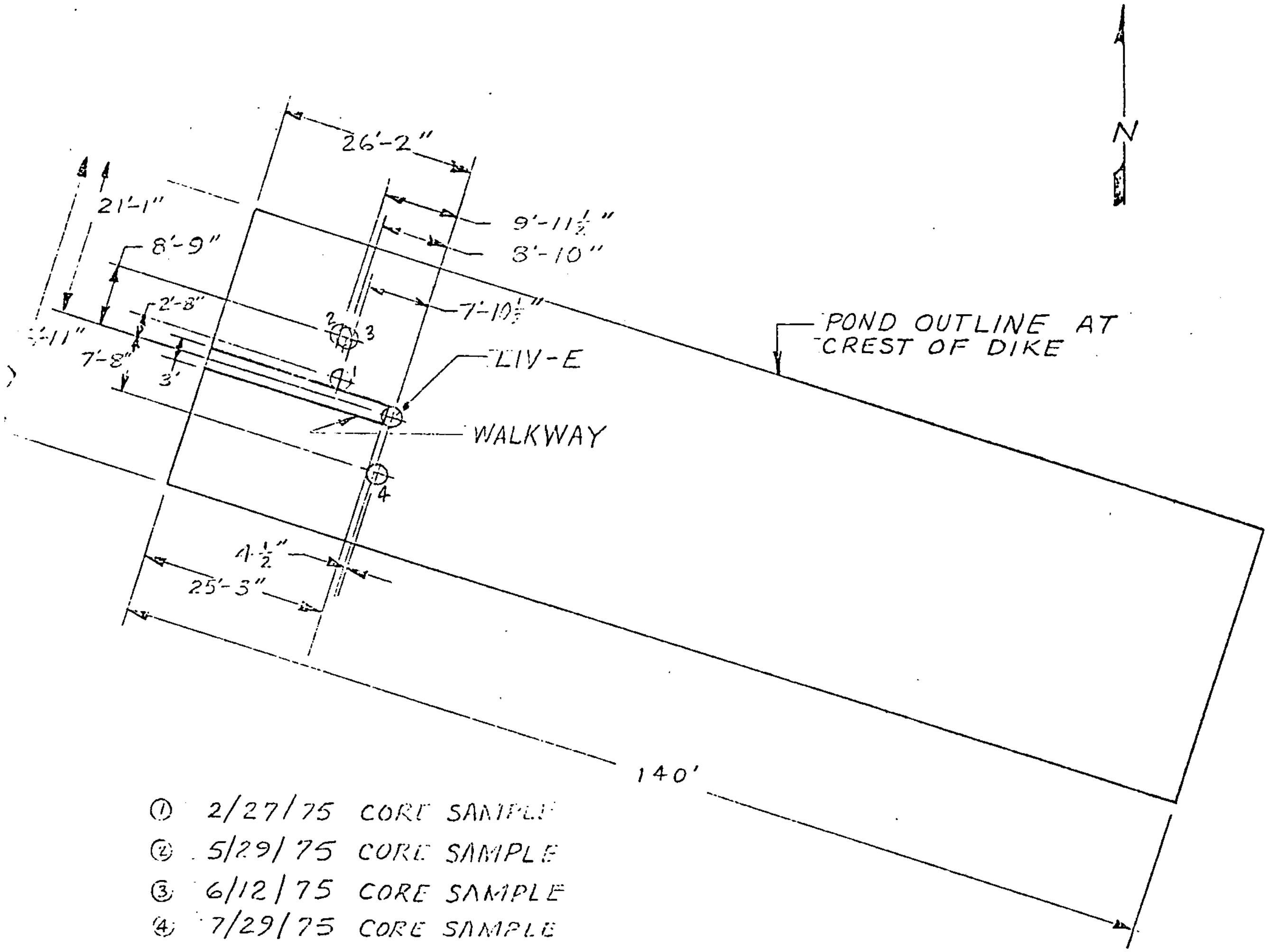
Courtesy of TVA



SLUDGE POND D

SHAWNEE STEAM PLANT
WET SCRUBBER PROJECT
BLP 8/7/75

Courtesy of TVA



SLUDGE POND E

SHAWNEE STEAM PLANT
WET SCRUBBER PROJECT
BLP 8/7/75
Courtesy of TVA

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

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EPA-600/2-76-070		

4. TITLE AND SUBTITLE	5. REPORT DATE
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	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) R. B. Fling, W. M. Graven, F. D. Hess, P. P. Leo, R. C. Rossi, and J. Rossoff	8. PERFORMING ORGANIZATION REPORT NO. ATR-76 (7297-01)-1
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT NO.
The Aerospace Corporation Environment and Energy Conservation Division P.O. Box 92957 Los Angeles, California 90009	EHB-528; ROAP ABA-001 11. CONTRACT/GRANT NO. 68-02-1010
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EPA, Office of Research and Development Industrial Environmental Research Laboratory Research Triangle Park, NC 27711	Initial; 9/74-7/75 14. SPONSORING AGENCY CODE EPA-ORD

15. SUPPLEMENTARY NOTES Project officer for this report is J.W. Jones, Mail Drop 61, Ext 2915.

16. ABSTRACT The report describes progress made during the initial phase of a field evaluation program, conducted by EPA, to assess techniques for the disposal of power plant flue gas desulfurization (FGD) wastes. The site chosen for the evaluation was TVA's Shawnee Power Station, Paducah, Kentucky. Two 10-MW prototype flue gas scrubber systems--one using lime, the other limestone--produced wastes that were stored in five disposal ponds on the plant site. Two of the ponds contain untreated waste; each remaining pond contains waste chemically treated by one of three commercial contractors. Test samples of treated and untreated wastes, ground water, surface water, leachate, and soil cores are being analyzed in order to evaluate the environmental acceptability of current disposal technology. Based on this program, engineering estimates of total costs (capital and operating) for FGD waste treatment and disposal have been made.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
Pollution	Field Tests	Stationary Sources	13B	14B
Flue Gases	Calcium Oxides		21B	07B
Desulfurization	Limestone		07A,07D	08G
Waste Treatment	Ponds			08H
Waste Disposal	Evaluation			14A
Electric Power Plants	Engineering Costs			05A
			10B	

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	Unclassified	

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