Evaluation of Chiyoda Thoroughbred 121 FGD Process and Gypsum Stacking

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Evaluation of Chiyoda Thoroughbred 121 FGD Process and Gypsum Stacking
Volume 3 Addendum

CS-1579, Volume 3 Addendum
Research Project 536-4

Final Report, March 1981

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ABSTRACT

As a continuing part of the field evaluation of the Chiyoda Thoroughbred 121 (CT-121) flue gas desulfurization (FGD) gypsum stack at the Scholz Electric Generating Station of Gulf Power Company in Sneads, Florida, the stack and disposal area were monitored after shutdown of the FGD system for a one-year period beginning June 1979. The objectives of the study were to establish whether long-term changes occur in the geotechnical properties of stacked CT-121 FGD gypsum and to evaluate any changes in groundwater quality. Results are presented for geotechnical laboratory testing and visual inspections of CT-121 FGD gypsum from the stack. These test results indicate no measurable long-term change in shear strength or permeability. Visual inspection of the stack found no significant change in the overall appearance or stability, further confirming the feasibility of utilizing stacking for permanent disposal of CT-121 FGD gypsum. Water quality results obtained after the one-year monitoring period are also presented. With the exception of two downstream monitoring wells, water quality in the aquifers near the disposal area has either remained unchanged or has improved slightly since shutdown of the FGD system.

EPRI PERSPECTIVE

PROJECT DESCRIPTION

This volume is an addendum to Volume 3 of EPRI Final Report CS-1579. All four volumes including this report, RP536-4, describe flue gas desulfurization (FGD) research efforts performed with Southern Company Services, Inc., since 1978. Volume 1 details the results of an eight-month evaluation of a 23-MW Chiyoda Thoroughbred 121 (CT-121) scrubbing system at Gulf Power Company's Scholz Electric Generating Station near Sneads, Florida. Volume 2 contains the appendixes that support the system evaluation efforts defined in Volume 1. Volume 3 summarizes the results of RP536-3, which evaluated the feasibility of disposing of FGD gypsum by-product by stacking rather than by ponding or landfilling. This addendum summarizes results of tests to determine whether any long-term changes occurred in the geotechnical properties of stacked CT-121 FGD gypsum after the stack "aged" one year.

Stacking the gypsum by-product offers the utility industry a disposal option that is consistent with the trend toward scrubbing systems which produce gypsum rather than sludge. Proper design, operation, and construction of a gypsum stack can eliminate the need for a thickener, thereby reducing the capital investment and size of a scrubbing system. The CT-121 evaluation (RP536-4) offered an opportunity to test a waste disposal method that has been practiced for years by the phosphate fertilizer industry. Therefore, RP536-3 was pursued in parallel with the evaluation of the CT-121 scrubber--a gypsum-producing process.

PROJECT OBJECTIVE

The objective was to determine the technical and environmental feasibility of stacking FGD gypsum by-product using existing phosphate fertilizer industry stacking techniques.

PROJECT RESULTS

The completed stack, approximately one-half acre (2000 m^2) and 12 feet (4 m) high, was generally constructed and operated using the design concepts and operation practices utilized by the phosphate fertilizer industry. The construction of a prototype FGD gypsum stack at the Scholz Electric Generating Station of the Gulf Power Company confirmed the feasibility of utilizing stacking for disposal of an FGD gypsum by-product.

The gypsum stack evaluation showed that the addition of fly ash to the gypsum by-product produced a mixture that does not stack as well as pure gypsum--that is, the settled gypsum-fly ash mixture has a lower solids content, lower density, and lower permeability. Thus fly ash contamination is a factor that a utility must consider when designing a gypsum stack.

Tests performed on the gypsum stack after it aged one year indicated no measurable long-term change in shear strength or permeability. Visual inspection of the stack found no significant change in overall appearance or stability. This confirms the long-term feasibility of utilizing stacking for permanent disposal of CT-121 FGD gypsum.

This report is for utilities that (1) are considering a lime or limestone scrubber producing an oxidized by-product (gypsum), (2) do not have an established market for the gypsum, and (3) have limited space for disposal.

No follow-on effort is presently planned; however, if a utility decides to incorporate a gypsum stack into a full-scale scrubbing system, EPRI would seriously consider the possibility of characterizing it.

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SUMMARY

The field performance of the Chiyoda Thoroughbred 121 (CT-121) flue gas desulfurization (FGD) gypsum stack at the Scholz Electric Generating Station of Gulf Power Company in Sneads, Florida, was monitored for a one-year period after the FGD system shutdown beginning in June 1979. After the one-year retirement period, the stack was sampled to obtain undisturbed samples for geotechnical laboratory testing of the gypsum, and monitoring wells were sampled to further evaluate the impact of leachate from the disposal area on groundwater quality. The purpose of the evaluations was to establish whether long-term changes occur in the geotechnical properties of stacked CT-121 FGD gypsum, to confirm the long-term stability and weathering resistance of the stack, and to evaluate changes in groundwater quality.

The results from laboratory tests on undisturbed samples of CT-121 FGD gypsum indicated no change in the sheer strength or permeability of the stacked gypsum after the one-year retirement period. Visual inspections indicated no significant change in the overall appearance or stability of the stack, further confirming the feasibility of utilizing stacking for permanent disposal of CT-121 FGD gypsum.

Water quality measurements obtained from the aquifers underlying the stack after the one-year retirement period indicated that all U.S. Environmental Protection Agency primary drinking water standards are satisfied at the observation wells and piezometers surrounding the disposal area. With the exception of two monitoring locations, water quality in the aquifers has remained unchanged or has improved slightly since abandonment of the gypsum stack.

Section 1

INTRODUCTION

PROJECT BACKGROUND

An objective of the Chiyoda Thoroughbred 121 (CT-121) flue gas desulfurization (FGD) process evaluation was to assess the feasibility of utilizing stacking for permanent disposal of FGD gypsum. Although stacking methods of waste disposal have been successfully utilized by the phosphate industry for disposal of gypsum, no significant information or experience has previously existed on the stacking characteristics of FGD gypsum. The evaluation of the CT-121 system as installed at the Scholz Electric Generating Station (Scholz) of Gulf Power Company in Sneads, Florida, was sponsored by The Southern Company* and the Electric Power Research Institute (EPRI), and included: the overall process evaluation by Radian Corporation, presented in Volumes 1 and 2, and the evaluation of CT-121 FGD gypsum stacking by Ardaman & Associates, Inc., presented in Volume 3.

As presented in Volume 3, two methods were used to assess the stacking characteristics of CT-121 FGD gypsum. First, detailed geotechnical laboratory testing was conducted on CT-121 FGD gypsum from the Chiyoda pilot plant in Japan and from the 20 MW scrubber at Plant Scholz. Tests were performed to assess the physical and chemical properties, sedimentation-consolidation behavior, permeability characteristics, and shear strength characteristics of CT-121 FGD gypsum relevant to stacking methods of waste disposal. Test data from this investigation was compared with similar data from numerous phosphate gypsums. The laboratory comparison indicated that CT-121 FGD gypsum has settling, dewatering, and structural characteristics similar to and, in some instances, more favorable than phosphate gypsum, making stacking methods of waste disposal a viable option for disposing of CT-121 FGD gypsum.

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* The Southern Company is an electric utility holding company in the Southeast and is the parent firm of Alabama Power Company, Georgia Power Company, Gulf Power Company, Mississippi Power Company, and Southern Company Services, Inc.

Secondly, a prototype FGD gypsum stack was constructed and operated at Plant Scholz for a nine-month test period beginning in October 1978. This coincided with the period of operation of the CT-121 FGD system. The completed stack was approximately one-half acre (2023 m^2) and 12-feet (3.7 m) high. Successful operation of the stack indicated that CT-121 FGD gypsum can be stacked with a dragline using the upstream method of construction as typically accomplished in the phosphate industry.

The CT-121 scrubber was shut down on June 26, 1979. At that time, the stack was also abandoned, except for the month of July when process water from the settling pond was pumped to the stack to maintain seepage through the stack. This was done to further observe the effects of steady-state seepage on slope stability. During the one-year retirement period following abandonment of the stack, groundwater from monitoring wells around the disposal area was sampled at six-month intervals, and undisturbed gypsum samples were obtained from the stack at the end of the one-year period. Upon completion of these tests, the gypsum will probably be sold locally for use as a soil amendment.

PROJECT SCOPE

The results obtained from the Plant Scholz stacking study were presented in Volume 3 and addressed four major items: (1) an engineering evaluation of the geotechnical properties of CT-121 FGD gypsum, (2) a presentation of general guidelines and methods used in the phosphate industry for designing, constructing, and operating gypsum stacks, (3) a summary of the site-specific geotechnical conditions, stacking operations, stack performance, and impact of leachate on groundwater quality at Plant Scholz, and (4) an overall appraisal of the feasibility of utilizing stacking for disposal of FGD gypsum.

The results of geotechnical laboratory testing performed on CT-121 FGD gypsum from the stack and observations of the long-term stability and weathering resistance of the stack are discussed in Section 2. Additional groundwater monitoring results obtained approximately one year after abandonment of the disposal facility are presented in Section 3. Finally, conclusions developed from the results of testing are summarized in Section 4.

Section 2

AGING AND WEATHERING CHARACTERISTICS OF CT-121 FGD WASTE GYPSUM

INTRODUCTION

This section presents the results of geotechnical laboratory testing performed on undisturbed samples of CT-121 FGD gypsum obtained from the Plant Scholz stack after a one-year retirement period. The purpose of performing the tests was to determine whether long-term changes occur in the geotechnical properties (e.g., shear strength, permeability, density, or chemical composition) of stacked CT-121 FGD gypsum. Visual inspections were also performed to confirm the long-term stability and weathering resistance of the stack.

EFFECTS OF AGING AND WEATHERING ON ENGINEERING PROPERTIES

Samples of CT-121 FGD gypsum were obtained from the stack on September 24, 1980. Undisturbed shelby tube samples were obtained from the center of the stack within sedimented gypsum and from the west dike within cast gypsum. Moisture content and dry density measurements on each sample are summarized in Table 2-1.

Table 2-1

MOISTURE CONTENT AND DRY DENSITY OF CT-121 FGD GYPSUM FROM PLANT SCHOLZ GYPSUM STACK

Sample	Depth (Feet)	Moisture Content (%) (Min., Max., Avg.)	Average Dry Density (lb/ft^3, kN/m^3)
Sedimented Gypsum	1.5 - 4.0	10.6, 29.5, 19.3	64.1 (10.1)
Sedimented Gypsum	4.0 - 6.5	9.5, 41.6, 23.7	57.7 (9.1)
Cast Gypsum	1.5 - 4.0	7.8, 8.1, 8.0	75.9 (11.9)
Cast Gypsum	4.0 - 6.5	8.8, 9.1, 9.0	77.3 (12.3)

As shown, the dry density of sedimented gypsum varied from 57.7 to 64.1 lb/ft^3 (61 to 65 percent solids) with an average moisture content of 23.7 to 19.3 percent, respectively. These dry densities are lower than expected from the results of laboratory sedimentation tests, which indicated a minimum dry density of 75 to 77 lb/ft^3 (71 to 72 percent solids) after initial settling and sedimentation, and are also lower than densities previously measured on other undisturbed samples from the gypsum stack (e.g., Figure 2-8 in Volume 3). The lower dry density may result, at least in part, from the presence of layers of fly ash and coal dust within the samples. Fly ash was simultaneously collected with gypsum during particulate tests which allowed venturi liquor containing fly ash to enter the Jet-Bubbling Reactor (JBR). The resulting gypsum-fly ash slurry within the JBR was piped to the stacking area as normally accomplished with gypsum alone. The coal dust was a light brown slightly clayey silt with a liquid limit of 58 percent and a plastic limit of 35 percent and was found to accumulate within the stack near the spillway. Fly ash and coal dust both sediment to a lower dry density than CT-121 FGD gypsum.

The cast gypsum dry densities of 75.9 to 77.3 lb/ft^3 (11.9 to 12.3 kN/m^3) are similar to values previously obtained from the stack (e.g., Figure 2-8 in Volume 3). The low moisture content for the cast gypsum samples results because the stack contains no ponded water, and the dikes have drained and dried. Overall, no significant change in gypsum dry density or moisture content occurred during the one-year period, other than those expected from normal draining and drying of the stack.

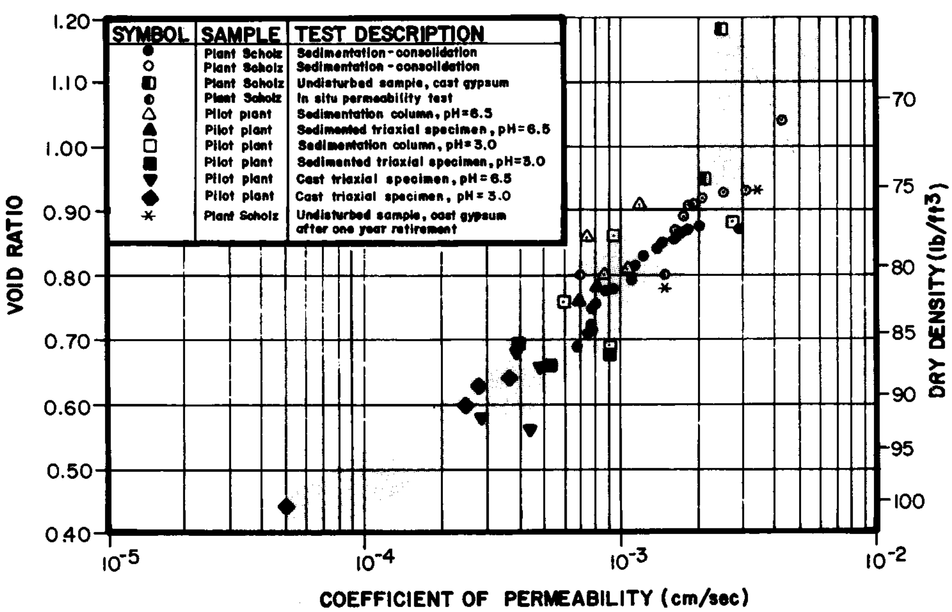

Figure 2-1. Void Ratio Versus Coefficient of Permeability

Coefficients of permeability measured on undisturbed samples of cast gypsum indicated values of 3.8×10^{-3} and 1.4×10^{-3} cm/sec for dry densities of 75.5 and 81.2 lb/ft^3 (11.9 and 12.7 kN/m^3), respectively. These values are in agreement with permeability values discussed in Section 2 of Volume 3 and presented here in Figure 2-1. As shown, similar coefficients of permeability of 1×10^{-3} to 4×10^{-3} cm/sec were measured on sedimented and cast gypsum samples for similar dry densities of 75 to 82 lb/ft^3 (11.8 to 12.9 kN/m^3), indicating no significant change in the permeability of the stacked gypsum with time.

The results from one drained (CIDC) triaxial test on an undisturbed sample of sedimented gypsum from the stack is compared with the results from a laboratory sedimented sample in Figure 2-2. As shown, both samples display similar stress-strain behavior with zero cohesion and effective friction angles of 40.1° to 40.9°, indicating no change in the strength properties of the stacked gypsum with time. Further, no cementation was observed in the undisturbed samples obtained from the stack. Based upon laboratory triaxial strength tests, visual observation of laboratory test samples, and observations of the condition of the gypsum within the stack, no cementation has been found to develop in CT-121 FGD gypsum.

LONG-TERM STACK PERFORMANCE

Photographs of the gypsum stack after the one-year retirement period are shown in Figure 2-3. Photograph 2-3A shows the entire stack and Photographs 2-3B and 2-3C show the north and west slopes, respectively. No significant change in the appearance or stability of the stack has occurred.

As with phosphate gypsum stacks, the cast CT-121 FGD gypsum dikes and slopes developed a thin, hard drying crust. Photographs of the drying crust are shown in Figure 2-4. The crust appears as clusters of short vertical columns of hard gypsum crystals. The crust develops within several months and apparently results from the dissolution of gypsum crystals by rainfall and subsequent recrystallization and drying. Slopes of the stack, therefore, are resistant to rainfall and wind erosion. The drying crust is also sufficiently hard and possesses sufficient strength to maintain vertical faces at the toe of slope of the gypsum stack as shown in Photographs 2-3B and 2-3C. Vegetation was observed to continue to develop on top of the stack and on the stack slopes during the one-year retirement period. Reclamation of the stack with a grass cover may be possible with or without a topsoil dressing.

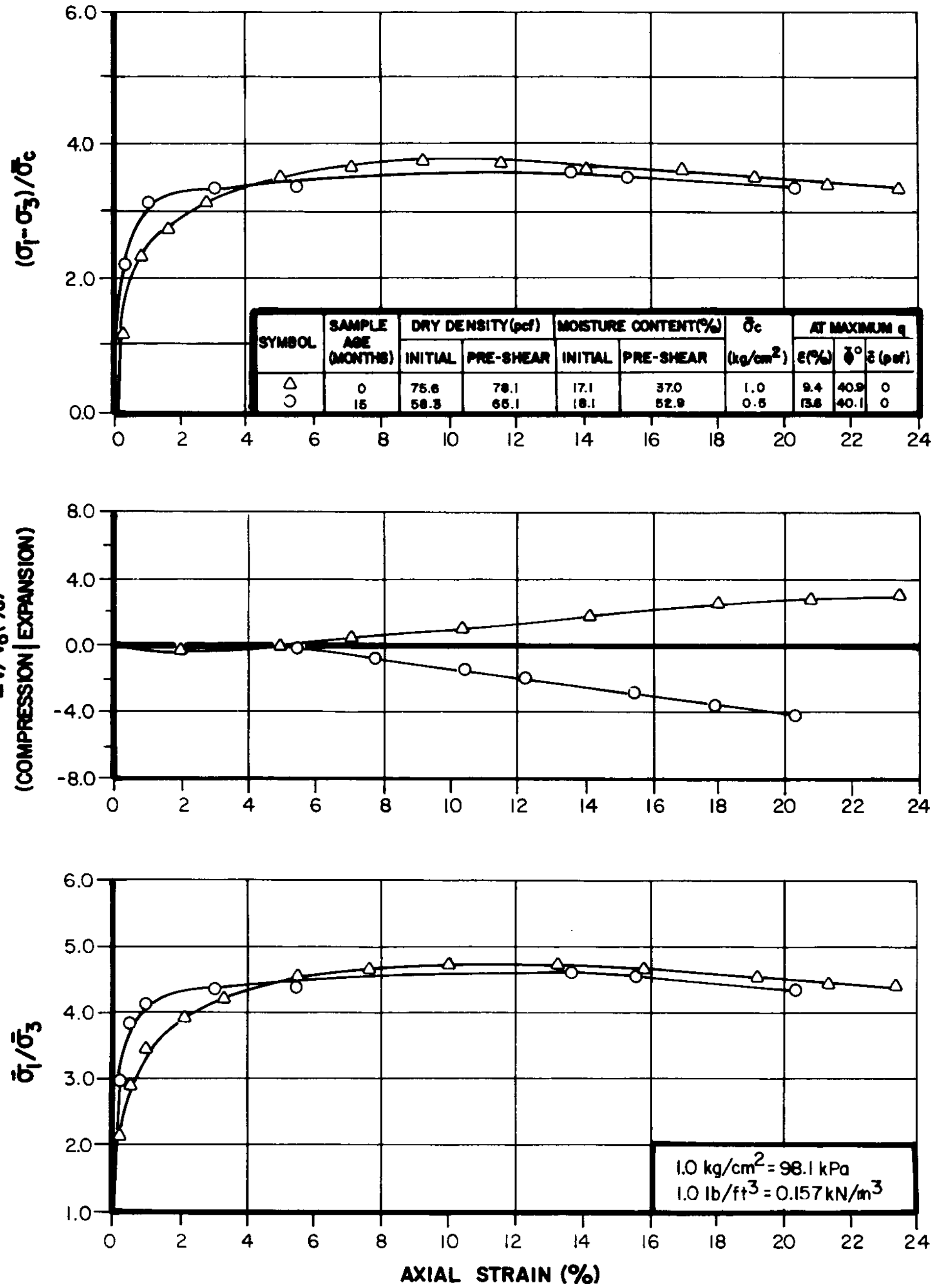

Figure 2-2. Drained Stress-Strain Curves For Recent And Aged Sedimented Gypsum

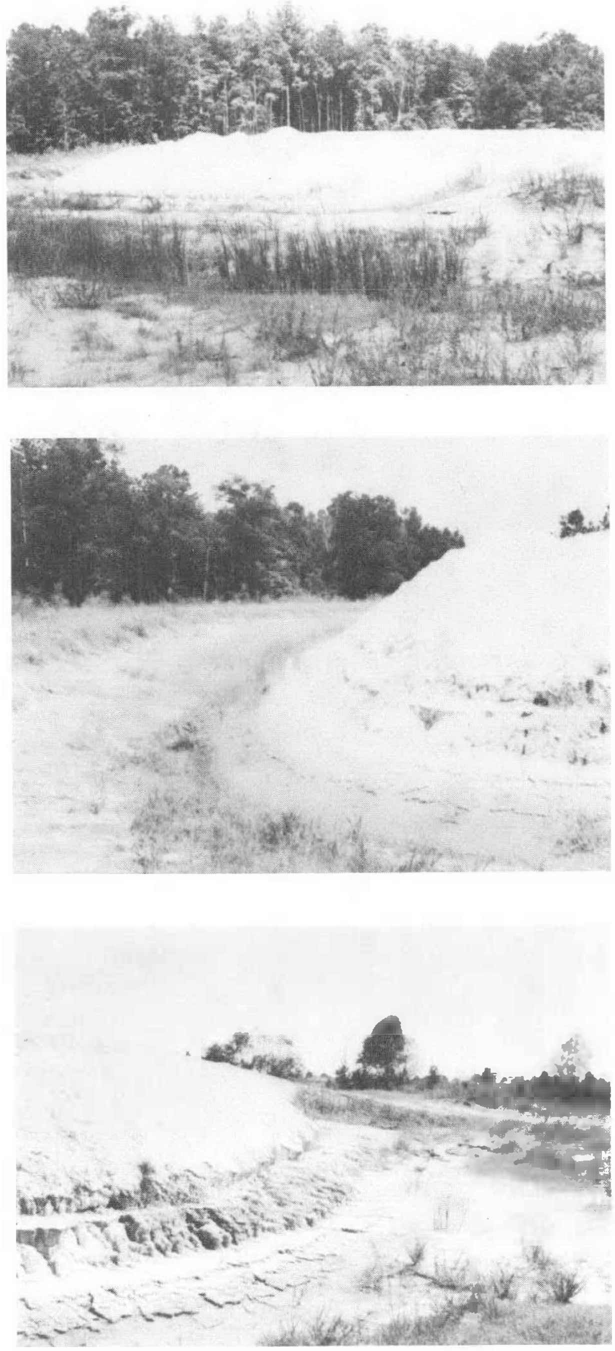

Figure 2-3. Photographs of Gypsum Stack After One Year Retirement Period

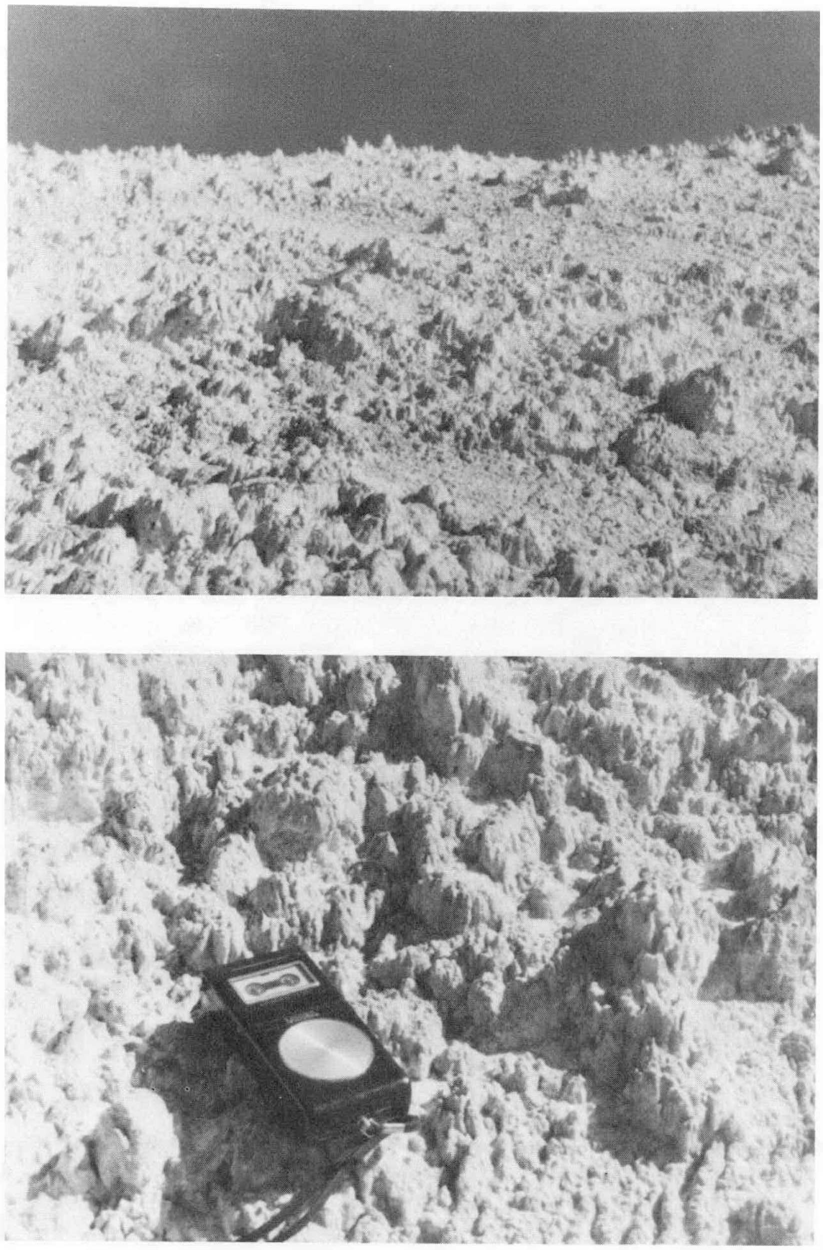

Figure 2-4. Photographs of Drying Crust on Slopes of Gypsum Stack

Section 3

GROUNDWATER MONITORING

INTRODUCTION

Thirteen observation wells and piezometers were installed around the gypsum disposal area to monitor changes in groundwater quality during operation and after retirement of the gypsum stack. Water quality samples were obtained approximately monthly from each observation well and piezometer during the nine-month active life of the stack, and at six-month intervals for one year after retirement of the stack. Results from water quality sampling conducted during the active life of the facility and after six months of retirement were presented in Volume 3. Additional water quality monitoring results obtained after one year of retirement are presented here. The locations and subsurface strata monitored by the observation wells and piezometers are shown in Figure 3-1.

PROCESS WATER CHEMICAL COMPOSITION

The process water within the disposal area was monitored on a monthly basis during the active life of the gypsum stack. Results from these analyses were presented in Volume 3 and are summarized in Table 3-1. The process water is a neutralized gypsum-saturated liquor and, therefore, contains high concentrations of calcium and sulfate ions. The process water is also high in chloride, magnesium, nitrate and sodium ions. The trace elements of concern are arsenic, chromium, nickel, silver and selenium.

Table 3-1

PROCESS WATER CHEMICAL COMPOSITION

Parameter	Average Test Period Value	Parameter	Average Test Period Value
pH	7.4	TDS	8900 mg/l
Ca	740 mg/l	As	0.15 mg/l
Mg	780 mg/l	Cr	0.22 mg/l
Na	90 mg/l	Ni	0.94 mg/l
Cl	890 mg/l	Ag	0.07 mg/l
SO_4	3050 mg/l	Se	0.20 mg/l
NO_3	530 mg/l		

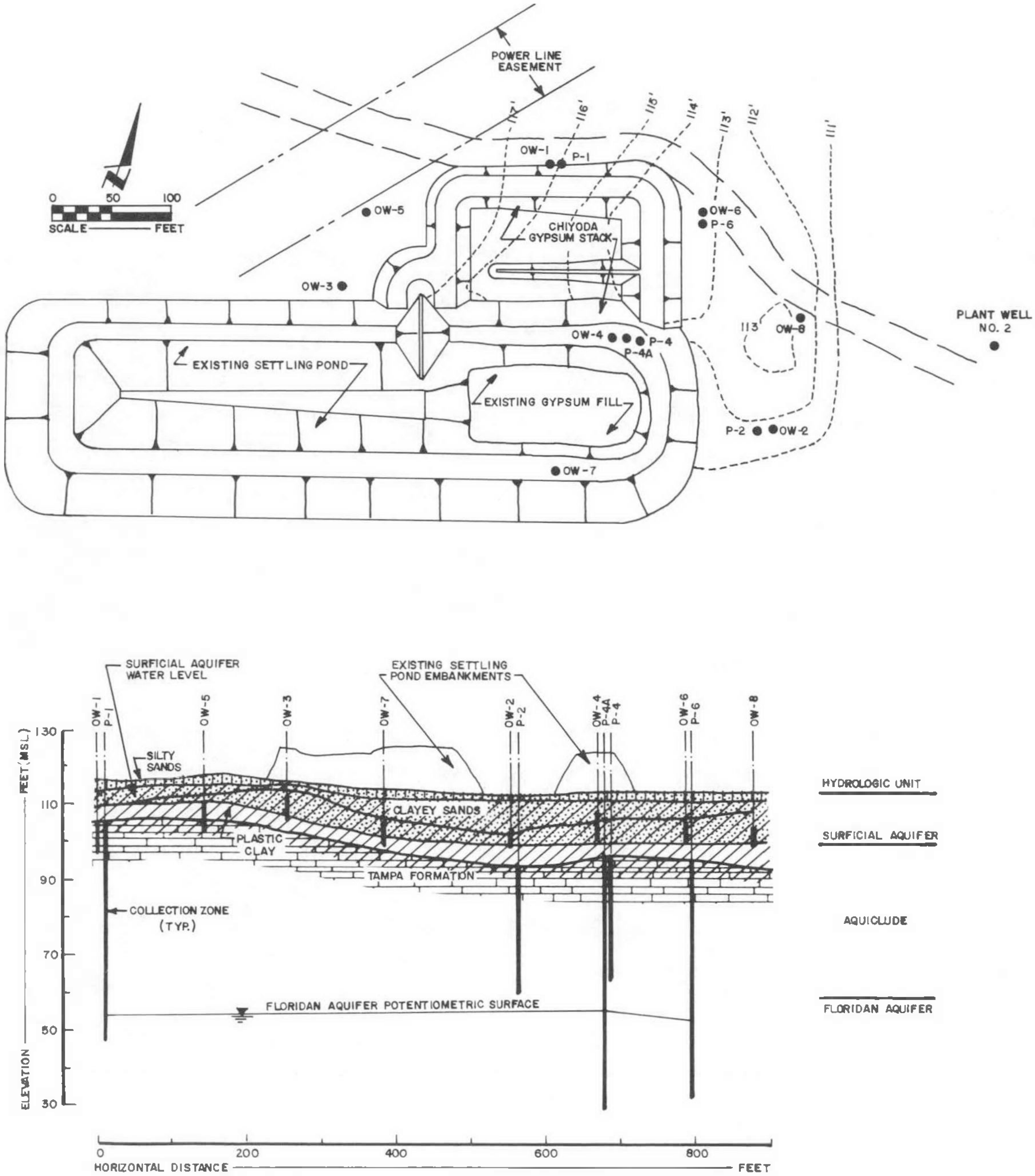

Figure 3-1. Groundwater Monitoring Location Plan And Profile

WATER QUALITY ONE YEAR AFTER STACK RETIREMENT

Analytical results for groundwater samples collected on May 28, 1980 are shown in Tables 3-2 and 3-3. Chemical analyses were performed by Radian Corporation. The analyses included major species, pH, total dissolved solids and conductivity (Table 3-2), and trace elements determined by inductively coupled argon plasma emission spectroscopy (Table 3-3). Based upon the results obtained from these analyses, several trends are apparent in the water quality within aquifers near the disposal area:

- No consistent increase in trace elements has occurred in either the surficial or Floridan aquifers as a result of operation of the disposal area. Levels of arsenic, chromium and selenium, the trace elements of concern within the CT-121 FGD process liquor, are within the EPA interim primary drinking water standards at all monitoring locations.*

- Water quality within deeper units of the Floridan aquifer has not changed from background conditions as monitored at Plant Well No. 2.

- Water quality within the upper unit of the Floridan aquifer immediately below the gypsum stack, which was affected by leachate during the active of the stack, has improved slightly or has not changed since the November 1979 sampling at piezometers P-4A and P-6.

- Water quality within the surficial aquifer at observation wells OW-4, OW-5, OW-6 and OW-8, and within the aquiclude separating the surficial and Floridan aquifers at observation well OW-1 and piezometer P-2 has either improved slightly or remained essentially unchanged since the November 1979 sampling.

- Water quality has further deteriorated at two monitoring locations. Most measured parameters for the major species increased at observation well OW-2 within the surficial aquifer and at piezometer P-4 within the aquiclude separating the surficial and Floridan aquifers.

*Observation wells OW-3 and OW-7 indicated local groundwater contamination of the surficial aquifer from the CT-101 FGD gypsum and dual alkali sludge stored in the existing settling pond. These wells should not be considered when evaluating changes in groundwater quality, since their background concentration levels were above normal for the aquifers underlying the stack. The antimony (Sb) concentration of 0.024 mg/l reported for piezometer P-4A is also suspect since all other monitoring locations still indicate a background value of <0.003 mg/l while the process liquor was reported to have a concentration of 0.011 mg/l.

Table 3-2

AQUIFER WATER QUALITY ONE YEAR AFTER STACK RETIREMENT

Sample	T(°C)	pH	Conductivity ($mhos/cm^2$)	Concentration (mg/l)							
				TDS	Ca	Mg	Na	Cl	NO_3	SO_4	CO_3
OW-1	27.0	8.1	2.05×10^{-4}	353	46	30	8.1	11	<0.6	29	278
OW-2	27.0	4.0	1.05×10^{-3}	2340	171	334	42	70	111	649	158
OW-3	26.0	6.6	5.70×10^{-4}	1100	139	58	75	48	2.9	543	243
OW-4	27.0	7.5	1.62×10^{-4}	332	45	27	5.7	24	<0.6	55	176
OW-5	27.0	8.05	1.04×10^{-4}	142	24	14	5.1	3.5	4.5	5.3	139
OW-6	26.5	8.00	3.05×10^{-4}	561	125	17	3.9	539	---	227	134
OW-7	26.5	4.25	1.95×10^{-3}	4050	93	33	--	372	---	1653	25
OW-8	27.0	6.45	3.20×10^{-5}	71.4	3.0	1.8	6.6	3.7	3.7	6.3	1.8
P-2	27.5	6.95	1.15×10^{-4}	224	27	13	4.4	10	5.6	11	143
P-4	26.5	6.10	4.65×10^{-4}	896	72	62	28	278	60	72	25
P-4A	27.0	7.90	8.10×10^{-4}	1930	242	229	17	136	117	728	196
P-6	27.0	7.70	5.20×10^{-4}	1040	127	87	15	43	8.1	384	288
Plant Well No. 2	---	7.80	---	271	25	14	22	46	4.8	1.9	148

Table 3-3

AQUIFER WATER QUALITY ONE YEAR AFTER STACK RETIREMENT

	Concentration (mg/l)																
Sample	K	Al	Ag	B	Ba	Cd	Cr	Cu	Fe	Ni	V	Zn	As	Sb	Hg	Pb	Se
OW-1	5.3	0.27	<0.002	<0.009	0.056	<0.008	0.003	<0.001	<0.008	0.01	0.01	0.01	<0.003	<0.003	<0.001	<0.005	<0.008
OW-2	26	17	0.008	12	0.056	<0.008	0.021	0.026	0.43	0.02	0.03	0.13	<0.003	<0.003	<0.001	0.013	<0.008
OW-3	8.0	0.36	<0.002	0.27	0.070	<0.008	0.007	0.004	0.91	<0.003	0.02	0.02	<0.003	<0.003	0.002	<0.005	<0.008
OW-4	4.5	0.34	<0.002	0.11	0.058	<0.008	0.002	0.004	<0.008	0.004	0.02	0.01	<0.003	<0.003	<0.001	<0.005	<0.008
OW-5	2.7	0.13	<0.002	<0.009	0.046	<0.008	<0.001	<0.001	<0.008	<0.003	0.02	0.003	<0.003	<0.003	<0.001	<0.005	<0.008
OW-6	3.9	<0.05	0.005	<0.009	<0.001	<0.008	0.007	0.012	<0.008	0.003	0.02	0.01	<0.003	<0.003	<0.001	<0.005	<0.008
OW-7	5.7	15	0.011	1.1	<0.001	0.02	<0.001	0.037	106	0.01	0.01	0.15	<0.003	<0.003	<0.001	0.019	<0.008
OW-8	0.49	0.06	<0.002	<0.009	0.020	<0.008	<0.001	<0.001	0.04	0.01	<0.003	0.02	<0.003	<0.003	<0.001	<0.005	<0.008
P-2	2.6	0.20	<0.002	0.10	0.040	<0.008	0.003	0.002	<0.008	0.01	<0.003	0.01	<0.003	<0.003	<0.001	<0.005	<0.008
P-4	9.6	0.43	<0.002	0.54	0.375	<0.008	0.008	<0.001	0.02	0.01	0.01	0.02	<0.003	<0.003	<0.001	<0.005	<0.008
P-4A	22	1.1	0.023	7.3	0.078	<0.008	0.032	0.023	0.08	0.03	0.05	0.04	<0.003	0.024	<0.001	<0.005	<0.008
P-6	11	0.63	0.003	0.69	0.078	<0.008	0.011	0.004	<0.008	0.01	0.01	0.03	<0.003	<0.003	<0.001	<0.005	<0.008
Plant Well No. 2	3.0	0.15	<0.002	<0.009	0.049	<0.008	<0.001	<0.001	0.02	0.01	<0.003	0.01	<0.003	<0.003	<0.001	<0.005	<0.008

Floridan Aquifer Water Quality

Water quality versus time within the Floridan aquifer at Plant Well No. 2 is summarized in Figure 3-2. Plant Well No. 2 is approximately 250 feet east of the disposal area with a collection zone approximately 135 to 165 feet below ground surface. Concentrations for all measured constituents show no increasing trend with time and satisfy all EPA interim criteria for drinking water standards (Table 3-4). As mentioned in Volume 3, these criteria are not used as a means of regulating leachate from gypsum stacks; however, they are included in this report in order to provide a basis for comparison.

Water quality versus time within the Floridan aquifer immediately below the gypsum stack in piezometer P-4A is summarized in Figure 3-3. As shown, the measured concentrations have generally remained unchanged since the November 1979 sampling. Further away from the disposal area at piezometer P-6, the measured concentrations indicate a slight reduction in most constituents since retirement of the gypsum stack. The measured concentrations at piezometers P-4A and P-6 do not exceed the EPA primary drinking water standards established for health criteria, but do exceed secondary standards established for aesthetic and taste characteristics (e.g., total dissolved solids, nitrate and sulfate).

Surficial Aquifer Water Quality

Water quality within the surficial aquifer at observation wells OW-4, OW-5, OW-6 and OW-8 has improved slightly or has not changed since the November 1979 sampling. Water quality versus time at observation well OW-6 immediately adjacent to the disposal area, which indicated increasing concentrations of all measured constituents with time during the active life of the stack, is summarized in Figure 3-4. As shown, most of the major species have decreased slightly, indicating no further contamination of the surficial aquifer at this location. The water quality at observation wells OW-4, OW-5 and OW-8 satisfies all EPA drinking water standards. The water quality at observation well OW-6 also satisfies the primary drinking water standards and only slightly exceeds the secondary standards for total dissolved solids and chloride.

The only location in the surficial aquifer indicating an increase in most measured parameters since November 1979 is observation well OW-2. This observation well, located approximately 175 feet downstream of the gypsum stack in the direction of groundwater flow, has consistently indicated increases in major species since construction of the disposal area (Table 3-5).

Table 3-4

EPA DRINKING WATER STANDARDS[++]

Constituent	Interim Primary Drinking Water Standards** Maximum Permissible Concentration (mg/l)
Arsenic (As)	0.05
Barium (Ba)	1.0
Cadmium (Cd)	0.01
Chromium (Cr)	0.05
Selenium (Se)	0.01
Antimony (Sb)	0.01
Lead (Pb)	0.05
Mercury (Hg)	0.002
Silver (Ag)	0.05
Fluoride (F)	1.4 - 2.4[+]
	Secondary Drinking Water Standards Recommended Concentration Limit* (mg/l)
Total dissolved solids	500
Chloride (Cl)	250
Sulfate (SO_4)	250
Nitrate (NO_3)***	45
Iron (Fe)	0.3
Manganese (Mn)	0.05
Copper (Cu)	1.0
Zinc (Zn)	5.0
Hydrogen sulfide (H_2S)	0.05

Source: Adapted from Groundwater, 1979, p. 386.

* Recommended concentration limits for these constituents were mainly to provide acceptable aesthetic and taste characteristics.

** Maximum Permissible limits are set according to health criteria.

*** Limit for NO_3 expressed as N is 10 mg/l.

\+ Limit depends on air temperature of the region; fluoride is toxic at about 5-10 mg/l if water is consumed over a long period of time.

++ Currently, these standards are not applied as a means of regulating leachate from gypsum stacks, and are used here only to provide a basis for comparison.

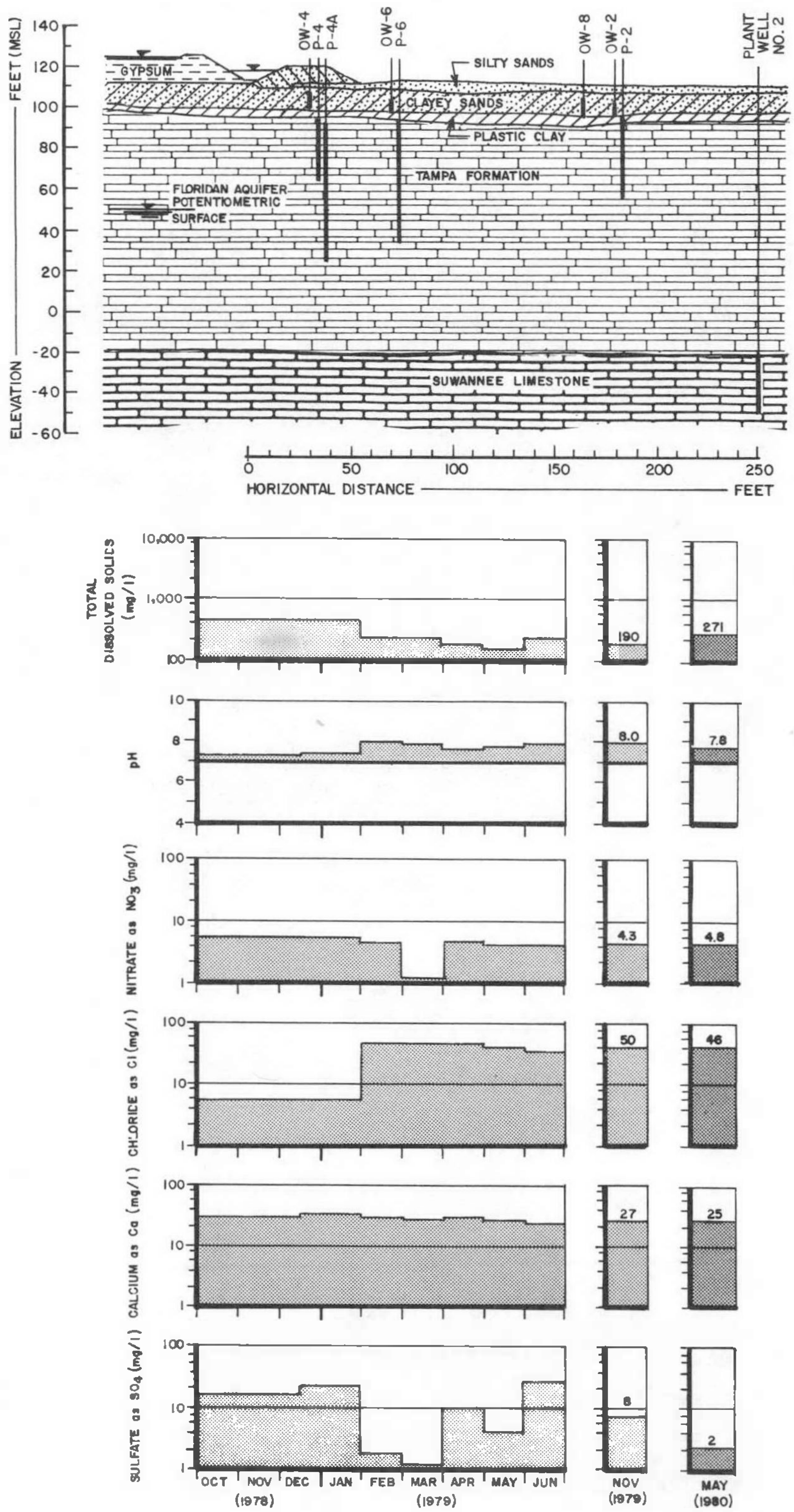

Figure 3-2. Floridan Aquifer Water Quality at Plant Well No. 2

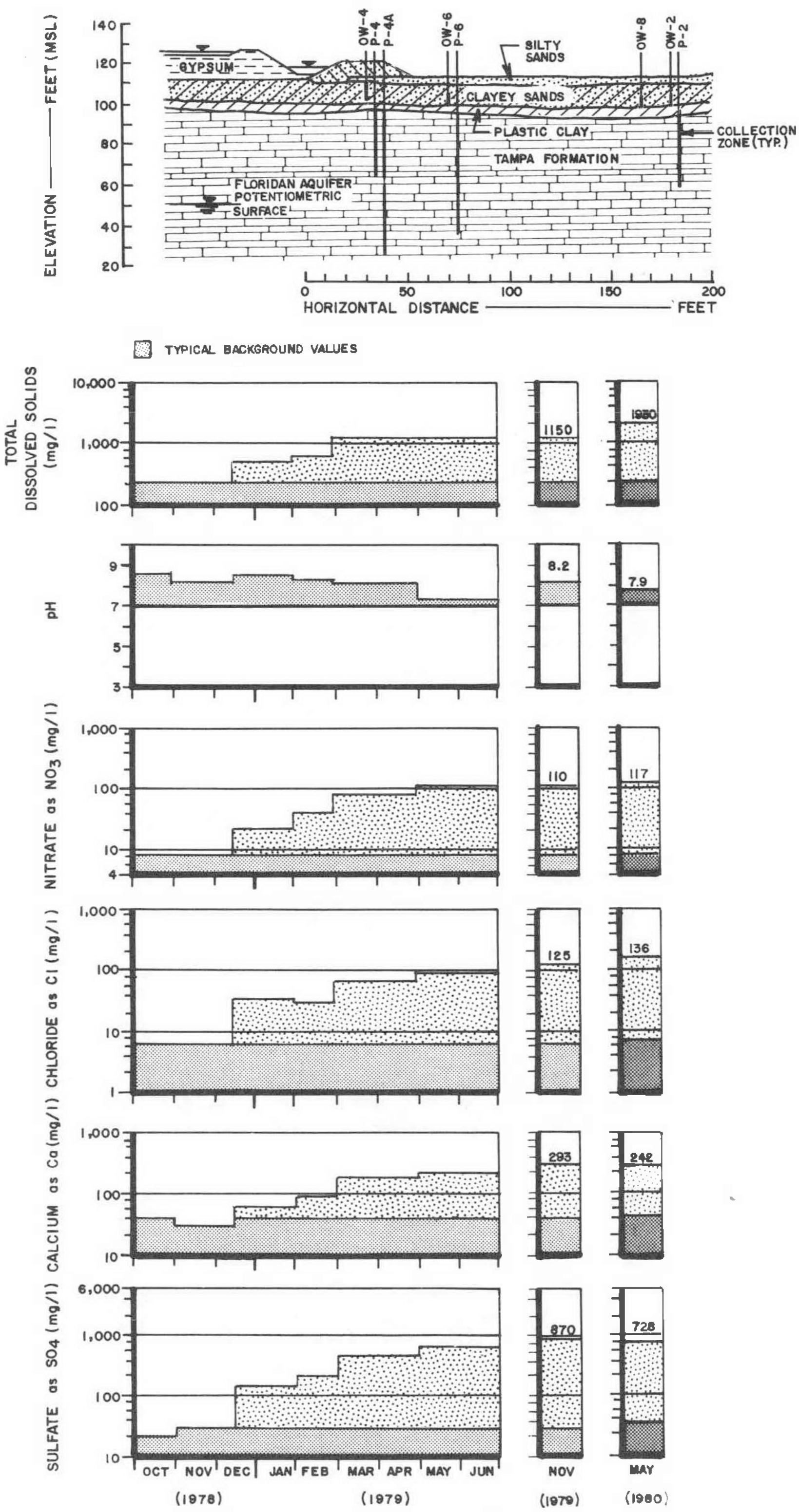

Figure 3-3. Floridan Aquifer Water Quality at Piezometer P-4A

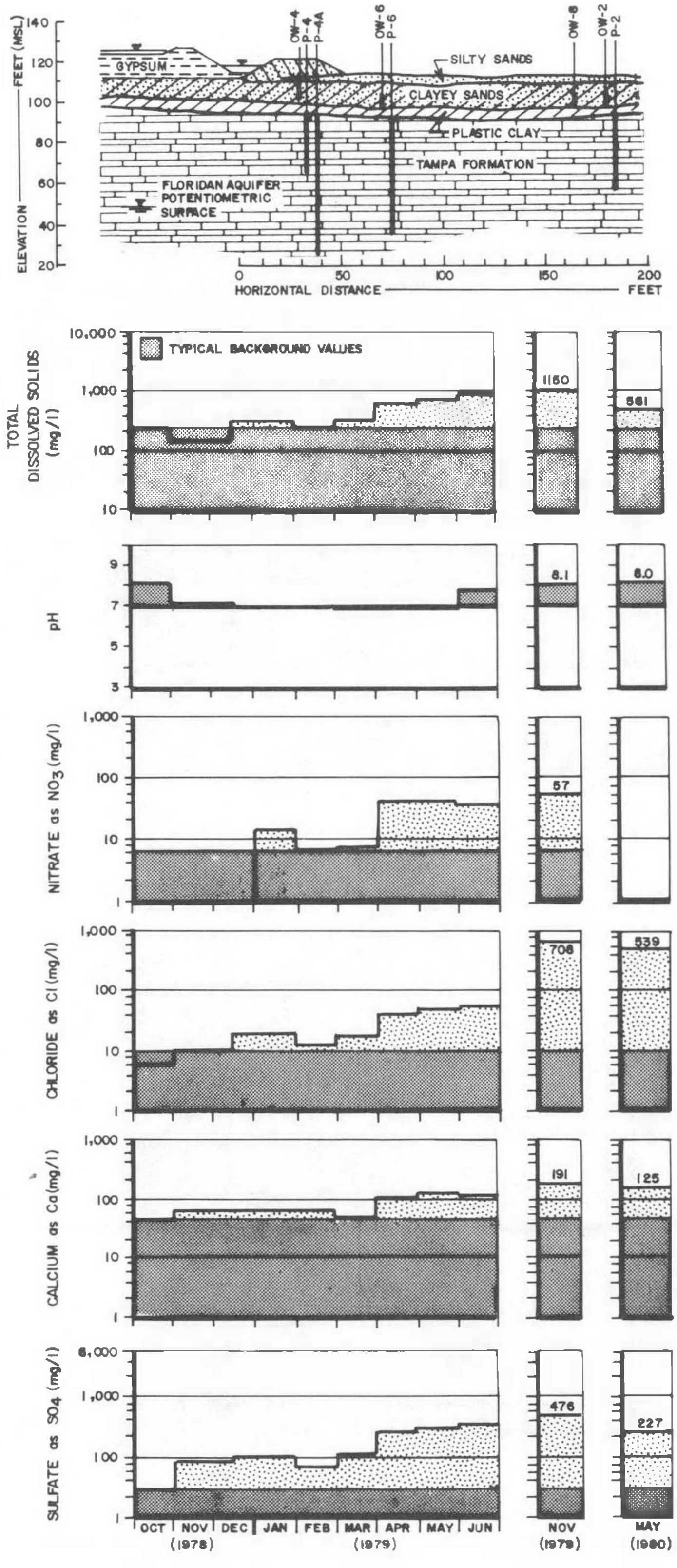

Figure 3-4. Surficial Aquifer Water Quality At Observation Well OW-6

Table 3-5

WATER QUALITY AT OBSERVATION WELL OW-2

Parameter	Concentration (mg/l) 10-04-78	6-26-79	11-29-79	5-28-80
pH	7.2	4.7	4.6	4.0
Ca	4.7	52	94	171
Mg	1.5	45	63	334
Na	22	35	40	42
Cl	11	106	193	70
SO_4	13	149	270	649
NO_3	--	96	120	111
TDS	61	570	933	2340

The water quality at observation well OW-2 does not exceed interim primary drinking water standards, although pH and the concentrations of all major species exceed secondary standards. The consistent decrease in pH from 7.2 to 4.0 may indicate that leachate is reaching observation well OW-2 from other adjacent disposal areas (such as the ash pond or existing settling pond) since the CT-121 FGD process liquor was neutralized, resulting in an average pH of 7.4 (Table 3-1).

Aquiclude Water Quality

Water quality within the aquiclude separating the surficial and Floridan aquifers has not changed at observation well OW-1 or piezometer P-2 due to operation of the disposal area. The water quality at these monitoring locations satisfies all EPA interim drinking water standards. Piezometer P-4, however, which previously indicated no contamination, is now indicating increased concentrations of most major species. The water quality at piezometer P-4 satisfies the EPA interim primary drinking water standards, although the levels of total dissolved solids, chloride and nitrate are slightly above the secondary drinking water standards.

REFERENCES

1. United States Department of Health, Education, and Welfare. "Public Health Service Drinking Water Standards". United States Public Health Service Publication 956, 1962.

2. United States Environmental Protection Agency. "Water Programs: National interim primary drinking water regulations". Federal Register, 40, No. 248, 1975.

3. Freeze, R.A. & J.A. Cherry. Groundwater. New Jersey: Prentice-Hall, Inc., 1979.

Section 4

SUMMARY AND CONCLUSIONS

EFFECTS OF AGING AND WEATHERING ON ENGINEERING PROPERTIES

The field performance of the prototype CT-121 FGD gypsum stack at Plant Scholz has been evaluated for a one-year retirement period using laboratory testing and visual inspections to determine whether long-term changes occur in the geotechnical properties of stacked CT-121 FGD gypsum. The results from laboratory tests on undisturbed gypsum samples indicated no measurable change in the shear strength or permeability of gypsum within the stack. No significant change in the gypsum dry density or moisture content occurred, other than that expected due to normal draining and drying. Laboratory strength tests and observations of the condition of gypsum within the stack indicated no cementation.

No significant change occurred in the appearance or stability of the stack during the one-year retirement period. The hard drying crust which formed on the slopes of the stack before abandonment was also intact and remained resistant to rainfall and wind erosion. Overall, no significant changes occurred in the engineering properties of the stacked gypsum. These results further confirm the feasibility of utilizing stacking for permanent disposal of CT-121 FGD gypsum.

WATER QUALITY ONE YEAR AFTER STACK RETIREMENT

Water quality measurements obtained from the aquifers underlying the stack indicate that all EPA primary drinking water standards were satisfied at the observation wells and piezometers surrounding the disposal area. At observation wells OW-2 and OW-6 and piezometers P-4, P-4A and P-6, however, the secondary drinking water standards were often exceeded (e.g., total dissolved solids, chloride, nitrate and sulfate). With the exception of observation well OW-2 and piezometer P-4, water quality in the aquifers near the disposal area has remained essentially unchanged or has improved slightly.