TVA 489H (EN DES-2-78) **TENNESSEE VALLEY AUTHORITY** SHEET

SUBJECT ________ PROJECT ________

COMPUTED BY DATE CHECKED BY DATE

Things to add to closure plan:

1.) Interim cover (p.3)?

2.) Flowable fill specs. (p.6)

3.) Separate QA/QC contract. (p.23)

4.) Separate Painter contract - to coat towers. (p.6)

5.) Pages are out of order.

6.) Make corrections to specifications on final cover. (p.9)

CLOSURE/POST CLOSURE PLAN
DREDGED ASH DISPOSAL FACILITY
(RAIL LOOP AREA)
TENNESSEE VALLEY AUTHORITY
JOHNSONVILLE FOSSIL PLANT

AUGUST 1991

PRELIMINARY

PREPARED FOR

TENNESSEE VALLEY AUTHORITY

PREPARED BY

TRIBBLE & RICHARDSON INC

AND

LAW ENGINEERING INC.

CLOSURE/POST CLOSURE PLAN
DREDGED ASH DISPOSAL
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CLOSURE/POST CLOSURE PLAN
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TENNESSEE VALLEY AUTHORITY
(RAIL LOOP AREA)
JOHNSONVILLE FOSSIL PLANT

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I. INTRODUCTION

A. Facility Description

Johnsonville Fossil Plant (JOF) is located on the east shore of Kentucky Lake, approximately 12 miles west of the town of Waverly in Humphreys County, Tennessee. (See Figure I)The plant has 10 coal fired units with a total generating capacity of 1,485 megawatts. The first unit began operation in late 1951 and the last in 1959.

B. Operational History

The combustion of coal for the purpose of generating electricity results in the production of by-products that include fly ash and bottom ash. The JOF produces approximately 315,000 cubic yards of ash per year. The present coal ash disposal method at JOF is sluicing fly ash and bottom ash to the active ash pond, the "west pond" which is 91 acres in size and is located west of the generating facility. This pond requires periodic dredging to maintain compliance with the NPDES Permit free water volume requirement. The ash dredged from this pond has been hydraulically conveyed to settling ponds constructed in the rail loop area on the JOF. A new ash disposal area is currently being developed on a 35-acre tract of land owned by TVA adjacent to the JOF rail loop.

This Closure/Post Closure Plan is for an area of approximately 69 acres in the southern half of the railroad loop area.

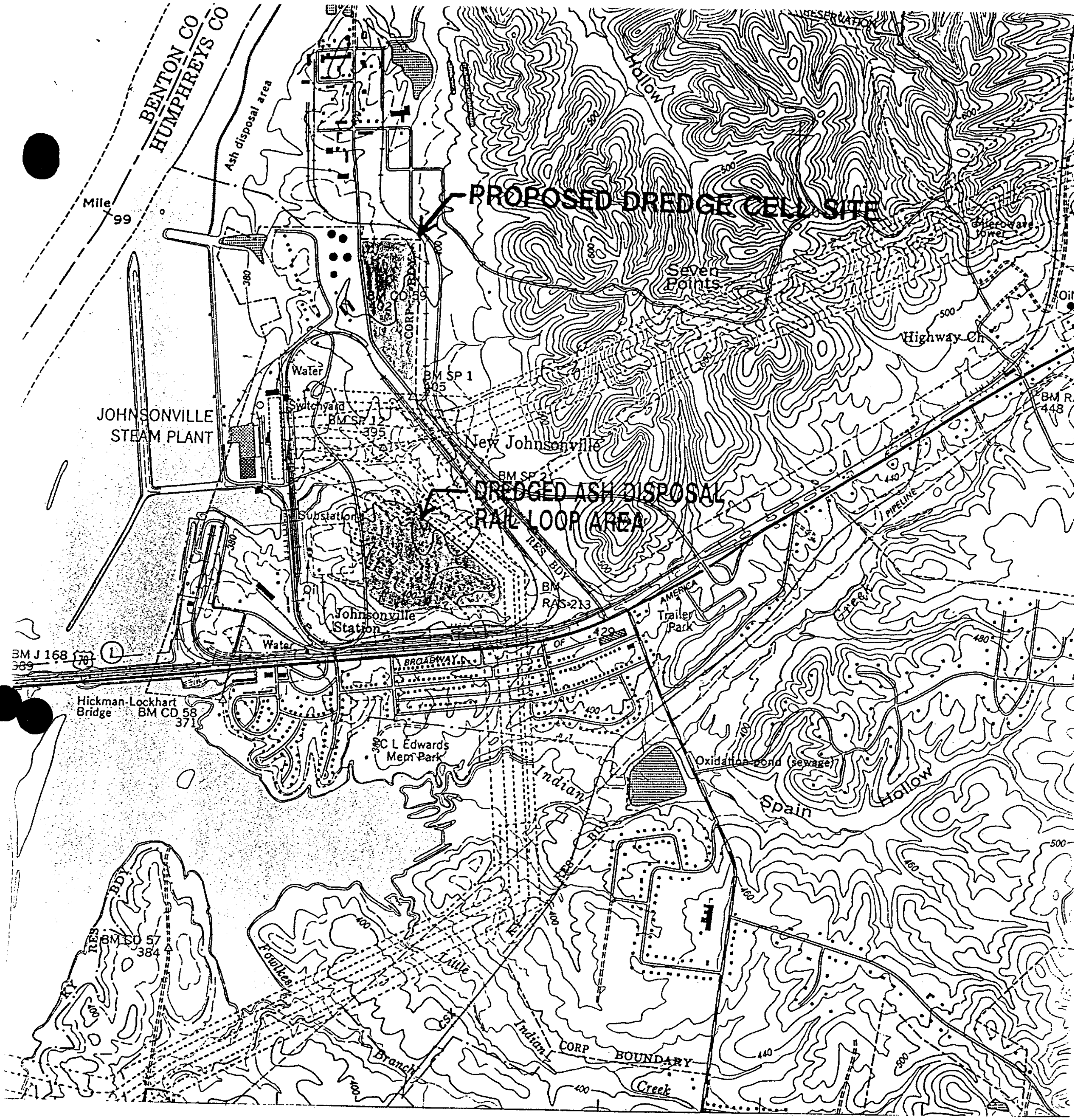
PROPOSED DREDGE CELL SITE
DREDGED ASH DISPOSAL
RAIL LOOP AREA
JOHNSONVILLE
STEAM PLANT
BENTON CO
HUMPHREYS CO
Ash disposal area
Mile
99
Seven
Points
Hollow
Highway Ch
Microwave
tower
New Johnsonville
Switchyard
Water
Substation
Johnsonville
Station
BM SP 1
305
BM SP 12
395
BM CD 59
402
BM RAS 213
RES BDY
BROADWAY
Trailer
Park
Oxidation pond (sewage)
Spain
Hollow
Indian
Creek
Little
Indian
Fowlkes
Branch
CORP BOUNDARY
C L Edwards
Mem Park
Hickman-Lockhart
Bridge
BM CD 58
371
BM J 168
389
BM CD 57
384
BM RA
448
PIPELINE
Oil
CSX

FIGURE 1

C. Expected Year of Closure

The dredged ash disposal facility in the railroad loop area will receive ash dredged from the active ash pond. Approximately 400,000 cubic yards of dredged material is removed from the active west ash pond during each dredging cycle. On a yearly basis, approximately 315,000 cubic yards of ash are produced at the JOF. It is estimated that approximately 1,000,000 cubic yards of volume is available for ash disposal in the railroad loop area. This estimate is based on July 31, 1990 aerial photography. TVA is currently developing a new dredged ash disposal facility adjacent to this site with an estimated volume of 830,000 cubic yards.

The projected date of closure for the railroad loop facility will be affected by TVA's implementation of construction of the new dredged ash disposal area. The actual closure date will be affected by both ash production and ash utilization. However, in accordance with the DSWM solid waste regulations (March 18, 1990) the dredged ash disposal facility (Rail Loop Area) must be closed by March 18, 1994.

D. Facility Contract

The names, addresses and telephone numbers of the TVA personnel that may be contacted during the post closure care period are listed as follows:

Plant Manager
Tennessee Valley Authority
Johnsonville Fossil Plant
P.O. Box 259 - Hwy 70
New Johnsonville, TN 37134
(615) 55-2501

As of the date of this report the plant manager is Mr. Charles Damman.

II. FACILITY CLOSURE

A. Partial Closure Steps

This section is for the purpose of explaining the steps that will need to be followed should the Railroad Loop Area (RLA) Dredged Ash Disposal facility be closed prior to the projected closure date discussed in Section I Subsection C, Expected Year of Closure. A basic premise for partial closure of the (RLA) disposal facility is that this facility, if closed before the projected closure date, will result in final grades that are less than the proposed final grades shown on the plans submitted as part of this Closure/Post-Closure Plan. If such a partial closure is implemented TVA will be required to submit revisions to the Closure/Post-Closure Plan (to include drawings and narrative). The specific items that may need to be modified are listed in Section II Subsection B Complete Closure Steps. Each item in Section II Subsection B Complete Closure Steps should be addressed even if the response would be that no change is necessary.

Also, it should be noted that two other possible scenarios regarding closure of the facility may occur.

(1) Closure occurs prior to the projected closure date but final grades are attained. This should not require a modification of Closure/Post-Closure Plan.

(2) Closure is to occur near March 18, 1994 (DSWM deadline for closure of existing facilities) and final grades are not attained. This may require a modification of the Closure/Post-Closure Plan. TVA

will coordinate with DSWM to review the status of the RLA disposal facility in order to determine if a modification is required.

B. Complete Closure Steps

1. Stack Operation

During normal operation, material dredged from the active west ash pond will be disposed of in the dredged ash disposal facility. The ash stacking procedure consists of:

(1) Dewatering the dredged ash if necessary to facilitate handling and stacking operations.

(2) Transporting the ash by pans, backhoe/loaders, front-end loaders and dump trucks to the stack.

(3) Spreading the ash with bulldozers to a maximum thickness of 12 inches.

(4) Compacting the ash with a vibratory roller compactor to achieve an in-place density of ninety percent (90%) of its maximum compaction density as determined by the STANDARD PROCTOR COMPACTION TEST (ASTM D-698).

(5) The ash will be graded to provide approximately a 1-percent minimum slope at the end of each working day to provide drainage sufficient to prevent ponding and excess surface infiltration. The disposal process is an essentially continuous incremental stacking procedure. No daily or intermediate earth cover will be required. The ash is physically

stable, nonputrescible, and is not an attractant for disease or animal vectors.

(6) The stack side-slopes will continue at 3:1 with intermediate benches for erosion control and surface water drainage.

(7) Dust is controlled by utilizing a water tank truck as required on the haul road and stack.

2. Drainage System

The surface water drainage system will be operated with the same concepts as have proven to be historically successful during the operation of other TVA ash stacking facilities.

The potential run-on from surrounding areas will continue to be intercepted in the existing diversion ditching network. These interception ditches direct the surface flow around the stack area to preclude this water from mixing with runoff from the ash stack. The handling of this extraneous water assists in stormwater management and erosion control within the stack area.

The run-off from the stack area will utilize the following method of controlling water. The run-off collection system will consist of maintaining a minimum one-percent (1%) slope on top of the stack and utilizing side slope benches to control run-off by directing the water downslope along circuitous ditches on approximately one-percent (1%) slopes. These slopes and circuitous path aid in controlling velocities and erosive forces while facilitating the deposition of ash that may accumulate in the run-off. The ditching from the ash stacking area flows to a settling pond for additional sediment control. Discharge from the stack settling pond is to an existing stilling pool on the site. This stilling pond is an NPDES permitted facility that provides surface water quality control and discharge of all ash dredge pond water used at the JOF (NPDES Permit No. TN0005444 DSN001).

Collection of any accumulated fly ash that settles in the ditches, settling pond or other areas will periodically be removed and placed on the stack for disposal. As the height of the stack is raised on the 3 to 1 side slopes the placement of cover material and establishment of vegetative cover will be accomplished as soon as possible. This helps control erosion and maintains an effective drainage system. Past operations have maintained good attention to detail in this regard. This attention to detail will continue in order to keep erodible ash under erosion control.

Several steel power line support towers are located within the rail loop area. Some of these towers are located in small depressions which do not allow adequate drainage. These depression are to be filled prior to closure to facilitate proper drainage. Flowable fill shall be used to bring the depression up to grade. Flowable Fill Specifications

3. <u>Leachate Collection</u>

The dredged ash stacking facility is scheduled be closed on or before March 18, 1994 (four years after the effective date of the new regulations). This facility currently does not have a leachate collection system. Monitoring and investigations conducted by TVA at other sites and previously furnished to DSWM conclude that during active ash stacking little or no leachate will be produced and site groundwater monitoring does not indicate evidence of leachate contamination.

Therefore, in accordance with the March 18, 1990 regulations (1200-1-7-.04)(1)(b)3. (page .04-1) leachate collection is not required for this facility since the facility currently does not have a leachate collection system and there is no indication of leachate contamination.

4. <u>Gas Collection</u>

Gas collection for ash disposal facilities is not applicable as so stated in DSWM Policy Memorandum SW-91-2. Ash produced from the combustion of coal is the only waste material which will be deposited in this facility. Ash is completely composed of the noncombustible mineral components incorporated in the coal during its formation. Ash is inert, noncombustible, nonputresible, and will not decompose to produce gases.

5. <u>Final Cover</u>

The footprint of the dredged ash stacking area is shown on the drawings submitted as part of this Closure/Post-Closure Plan. As has been discussed previously the disposal facility is an embankment constructed of ash. The continued use of the stack, until its closure, will result in an increase in the vertical dimensions but no increase in the footprint. The embankment of ash is proposed to be constructed to an approximate maximum final elevation of 465 msl. The closure of the dredged ash facility to this grade, as shown on the drawings, will allow the area of 3 to 1 side slopes to be maximized while minimizing the amount of relatively flat surface area that will be the final top of the stack. This final grading will facilitate controlling run-off of precipitation and further minimize the generation of leachate or accumulation of moisture within the stack.

TVA has conducted investigations of the Phase I dry fly ash stack at its Bull Run Fossil Plant. One such study that has been previously furnished to DSWM was an investigation related to the generation of leachate. In summary, it was determined that the modified WF model, developed from the studies of the Bull Run Phase I dry fly ash stack predicts that little or no leachate would be generated. This is due to the unique characteristics of fly ash to evaporate and store water. This study also explained why the use of the HELP model consistently overpredicts leachate generation.

Given the unique characteristics of ash and the results of the modeling studies conducted by TVA the final cap to be utilized on top of the ash will be as follows (from top layer downward):

- Soil suitable for support of vegetation twelve inches (12")
- Soil compacted to achieve a maximum hydraulic conductivity of 1×10^{-7} cm/sec twelve inches (12")

Appendix A is a printout of the HELP model that provides the justification for using this final cap. In summary, the printout is to be used to evaluate the cap design only in regards to the anticipated average annual percolation through the cap. The results indicate that for the 20 years modeled the average annual percolation through the cap is predicted to be 1.2447 inches/year. The proposed cap design will provide sufficient protection from the percolation of water into fly ash stack. This is further supported by the field experiments and analyses conducted by TVA that indicate (1) the fly ash exhibits strong capillary forces and an ability to store water (2) the moisture content of the stack during active stacking (no cap) is not saturated and (3) during active stacking (no cap), no leachate flux is predicted. Reference is also made to the report "Design, Construction and Maintenance of Cover

Systems for Hazardous Waste - An Engineering Guidance Document" prepared by the Army Engineer Waterways Experiment Station for EPA, May 1987. Reference is also made to Sheet 5 of 5 the plans submitted as part of this Closure/Post-Closure Plan for additional details regarding the final cap.

6. Vegetative Cover

The conditioning, fertilizing and seeding of the final cover in order to establish an adequate vegetative cover shall begin immediately upon placement of the final cover. The applicable seeding methods and types to be used for vegetation will be selected in consideration of seasonal and other factors. TVA specifications for seed mixture applications are included in Appendix B.

7. Groundwater Monitoring

(1) Compliance Monitoring Boundary

The compliance monitoring boundary of the RLA dredged ash stacking facility should be the area within the location of the existing monitoring wells.

These well designations are.

Upgradient Well	Well B9
Downgradient Wells	Well B5, B6, B7, B8

The location of these wells are shown on the drawings submitted as part of this Closure/Post-Closure Plan.

(2) Monitoring System for the Existing Facility

As mentioned above, the RLA dredged ash disposal area has a groundwater monitoring system in place which was installed to support permitting of the facility. Quarterly monitoring of these wells has been conducted since their installation. Quarterly monitoring data is included in Appendix F.

(3) Detection Monitoring Program

a. The operator must determine the concentration or value of the following parameters in groundwater samples in accordance with List I and List II as listed below.

List I

Indicator parameters used for characterizing and tracking the ground water chemistry and changes therein:

I. Ammonia
II. Calcium
III. Chloride
IV. Iron
V. Magnesium
VI. Manganese, dissolved
VII. Nitrate (as N)
VIII. Potassium
IX. Sodium
X. Sulfate
XI. Chemical Oxygen Demand (COD)
XII. Total Dissolved Solids (TDS)
XIII. Total Organic Carbon (TOC)
XIV. pH

List II

Parameters establishing the ground water quality:

I. Arsenic
II. Barium
III. Cadmium
IV. Chromium
V. Cyanide
VI. Lead
VII. Mercury
VIII. Selenium
IX. Silver

However, ammonia, total organic carbon and cyanide are not expected to be present in coal combustion by-products and therefore monitoring of these is unnecessary for this monitoring program. The operator has established background concentrations and analysis for all List I and List II parameters with the exception of ammonia, total organic carbon and cyanide. Refer to Appendix F for this data.

Beginning with the next routine sampling date following approval of this closure plan, the operator will begin sampling for the 20 groundwater contamination indicator parameters specified below at least once every six months.

Calcium	Arsenic
Chloride	Barium
Iron	Cadmium
Magnesium	Chromium
Manganese, dissolved	Lead
Nitrate (as N)	Mercury
Potassium	Selenium
Sodium	Silver
Sulfate	
Chemical Oxygen Demand (COD)	
Total Dissolved Solids (TSD)	
pH	

Monitoring for volatile organic compounds (VOC's)(listed in DSWM Solid Waste Regulations Appendix I) will not be necessary for this facility since these VOC's are not known or suspected to be constituents of coal fly ash. If any of these constituents were present in the coal, which is unlikely, the high temperatures of the combustion process (greater than 2,000° F) would be expected to decompose or drive off all volatile constituents. TVA has conducted tests of fly ash for the presence of VOC's and the results indicated the VOC's were "nondetectible". A summary of testing results is included in Appendix C of this Closure/Post-Closure Plan. Additional procedures to be followed for the Detection Monitoring Program are in TVA's Quality Assurance Procedure - Groundwater Sample Collection Techniques which is included in Appendix D.

b. Recordkeeping and Reporting:

Recordkeeping: Records of all groundwater sampling of Wells B5, B6, B7, B8, and B9 are kept at the facility. Information includes groundwater sampling activities conducted, the sample analysis results and the groundwater surface elevation.

Reporting: All results of ground water sampling and analysis results and groundwater surface elevations of Wells B5, B6, B7, B8, and B9 are submitted to the Tennessee Department of Solid Waste Management within fifteen days after completing the analysis.

c. Well Plugging:

Procedure: If it becomes necessary to abandon a monitoring well, the following plugging procedures shall be used to ensure the well will not become an avenue of aquifer contamination. Plugging can also serve to inhibit water loss from artisan aquifers and to eliminate the physical hazard of an open hole. Proper plugging materials and techniques will vary according to the original well construction and the geohydrology of the site.

The general procedure for plugging shallow monitoring wells completed in water table aquifers includes three steps.

i. Removal of obstructions in the well that could interfere with the plugging operation and thorough flushing of the well to purge residual drilling fluids and other fine detritus,

ii. Removal of the well casing (where practical) to ensure placement of an effective seal - as a minimum when the casing is not properly grouted, the upper 20 feet of casing must be removed,

iii. Sealing of the well with an impermeable filler such as neat cement.

<u>Sealant Materials</u>: Well sealants shall be chemically inert and impermeable. Neat portland cement (with or without bentonite clay additives) and bentonite clay are acceptable sealants. General purpose (Type 1) neat portland cement is acceptable. The cement slurry is to be mixed with five to six gallons of water for each 94 pound sack of cement. The water of the cement slurry should have a low sulfate content and a total dissolved solids content less than 2,000 parts per million. No aggregate materials are to be included in the slurry.

The neat cement slurry shall be piped to the point of application so that the well is filled upward from the bottom. Free falling of the slurry into the well is unacceptable.

Bentonite clay additives reduce shrinking (and cracking) of the cement while the slurry is setting. Three to five pounds of additive and 6-1/2 gallons of water are to be mixed with each 94 pound sack of cement (the clay and water are to be mixed together before cement is added to form the slurry).

TABLE 2

CAPACITIES OF WELL CASINGS			
Diameter of Hole	Gallons per Lineal Foot	Sacks Cement Per Lin. Foot	Cement Set Volume
2"	0.1632	0.0199	50.2
3"	0.3672	0.0311	32.1
4"	0.6528	0.0791	12.6
5"	1.0200	0.1240	8.0
6"	1.4688	0.1785	5.6
7"	1.9992	0.2430	4.1
8"	2.6112	0.3373	3.2
10"	4.0800	0.4958	2.0
12"	5.8752	0.7140	1.4

Recommended quantities of neat portland cement needed for plugging various diameter wells are shown in the above Table. Quantities are based on the set volume, which is somewhat less than the slurry volume.

(Taken from "Plugging Abandoned Wells" by Donald K. Keech, Ground Water Age, January 1973)

Bentonite clay can be used separately as a well sealant. The clay can be dropped into the well in the form of granules, chunks, pellets, or balls. Where the potentiometric head of an aquifer causes water to rise in the well high above the level of the plug, consideration must be given to the physical form of the bentonite to be used. Adding the bentonite in chunk or pellet form will prolong the effective period of wetting prior to hydration and allow proper placement of the plug. Bentonite clay can not be used as a sealant where organic contaminants are present in the groundwater unless the bentonite is treated and documentation is presented to show that it is capable of containing organic contaminants.

Shallow monitoring wells installed in unconsolidated sediments or consolidated rocks without fractures or dissolution voids are to be filled with a sealant. Backfilling of the screened or uncased section of the well (up to several feet below the casing) with clean, disinfected sand is permissible. Sand with a diameter of 0.025 inches or less (plaster sand or mortar sand) reduces cement penetration/loss. As a minimum, the upper 50 feet of deep monitoring wells shall be plugged with neat cement or bentonite clay.

Consolidated rocks with a high density of fractures or dissolution voids shall be filled completely with neat cement. Sand and clay fill materials are not suitable. The use of bridging materials, such as pea gravel or larger rocks (the diameter of the bridging material should be less than 1/3 of the diameter of the well) below the casing or the placement of a plug at the base of the casing, may be necessary to retain the neat portland cement slurry in the well.

Where several confined aquifers are present in an abandoned monitoring well, impermeable seals between water bearing sections are required. Flow from artisan wells can cause problems with the installation of neat portland cement. Packers or heavy plugs shall be required to inhibit water flow.

8. Closure Schedule

Upon determination that the closure of the facility is forthcoming a notification of TVA's intent to close the facility must be sent to DSWM sixty (60) days prior to the closure date.

After the final grade of ash has been reached, closure activities, to include final grading and vegetative cover must be complete as soon as possible but are not to exceed 180 days.

TVA must notify DSWM in writing of completion of closure of the RLA disposal facility. Such notification must include a certification by TVA that the RLA disposal facility has been closed in accordance with the approved Closure/Post-Closure care plan. Within 21 days of the receipt of such notice DSWM is supposed to inspect the facility to verify that closure has been completed and is in accordance with the approved plan. Within 10 days of such verification, DSWM is supposed to approve the closure in writing to TVA. Closure shall not be considered final and complete until such approval has been made by DSWM.

9. Notice in Deed to Property

TVA is required to ensure that within 90 days of completion of final closure of the facility and prior to sale or lease of the property on which the facility is located, there is recorded, in accordance with State law, a notation on the deed to the property or on some other instrument which is normally examined during title search that will in perpetuity notify any person conducting a title search that the land has been used as a disposal facility.

10. <u>Post-Closure Care Activities</u>

<u>Post-Closure Care Activities</u> - During the post-closure care period, the operator must, at a minimum, perform the following activities on closed portions of his facility:

1. Maintain the approved final contours and drainage system of the site such that precipitation run-on is minimized, erosion of the cover/cap is minimized, precipitation on the stack is controlled and directed off the stack, and ponding is eliminated.
2. Ensure that a healthy vegetative cover is established and maintained over the site.
3. Maintain the drainage facilities, sediment ponds, and other erosion/sedimentation control measures (if such are present at the disposal site), at least until the vegetative cover is established sufficiently enough to render such maintenance unnecessary.
4. Maintain and monitor the ground water monitoring system. The monitoring system and sampling and analysis program established in the previous sections shall be continued during the post-closure care period, unless the Closure/Post-Closure plan is modified to establish a different system or program. Monitoring data must be reported in writing to the DSWM within 30 days after the completion of the analysis.

III. QUALITY ASSURANCE/QUALITY CONTROL

A. General

The purpose of this plan is to establish standards that must be followed by the registered professional engineer or geologist in order to insure that the construction of the facility meets the specifications given in the design documents. The professional engineer or geologist shall use sound judgment when determining what additional procedures may be required in order to further assure the construction quality.

The Quality Assurance/Quality Control shall be performed by a party independent of all other construction contractors involved in construction for the dredged ash disposal site. The plan will be performed in addition to any Construction Quality Control Programs implemented by construction contractors.

Detailed in this plan are the minimum standards for soil selection, minimum testing programs, minimum construction standards, and the minimum documentation required to assure that the requirements of the plans and specifications are met.

Throughout this document, the word "clay" is used to mean material of low permeability. This may include soil classified as clay or mixtures of soil with additives as required to meet the specifications.

B. Cap

1. Construction specifications: The one foot of soil in the bottom half of the cap for the RLA dredged ash disposal facility, will meet the following requirements.

   - A saturated, vertically oriented hydraulic conductivity no greater than 1×10^{-7} cm/sec, after compaction within the density and moisture content range specified for construction as determined during laboratory testing.
   - A classification of CH or CL, as determined by the Unified Soil Classification System, ASTM standard D-2487-69, unless the DSWM approves another classification.
   - Any alternative soil proposed to DSWM will include documentation that the soil can be compacted to achieve the hydraulic

conductivity and engineering properties of the soil specified above.

2. Clay Source Verification: The clay source will be tested and verified by a registered professional engineer or geologist as meeting the standards specified. Random samples of the source material will be obtained every 3,000 cubic yards excavated and whenever the texture, color or location of the source of the soil changes significantly. Samples will be tested for the following such that a correlation to permeability may be made:

   a. Moisture-density relationship of the soil by the Standard Proctor Test, (ASTM D698);

   b. Grain size analysis (ASTM D422);

   c. Atterberg Limits (ASTM D4318).

   Random samples of the material placed will be obtained a minimum of once every 5 acres to verify the correlations which are made from the previously stated sample testing. Samples will be tested for hydraulic conductivity as specified by the EPA Method 9100 in Test Methods for Evaluating Solid Waste SW-846 or other method approved by the DSWM.

3. Cap Construction: The cap will be constructed as outlined below:

   a. Lift thickness of no more than 8 inches, loose lift (prior to compaction).

b. Each lift is thoroughly and uniformly compacted to that density and within that moisture content range determined necessary to achieve a hydraulic conductivity less than 1 x 10^{-7} cm/sec.

c. Soil <u>will not</u> be compacted at moisture contents <u>less</u> than optimum, nor to less than 95% of the maximum dry density, as determined by the Standard Proctor Test, ASTM D698.

d. The cap will be continuous and completely keyed together at all construction joints. Where required the previous lift or area of construction shall be scarified to facilitate bonding between lifts.

e. During construction, the clay will be protected from detrimental climatic effects by:

-Protect construction from extraneous surface water, sloped to facilitate drainage;

-Removing all ice and snow prior to placing a lift, and not using frozen soil in any part of cap;

-Recompacting any soil that has been subjected to a freeze and thaw cycle.

-Insuring that the cap is not subject to desiccation cracking by sprinkling the soil with water not less than twice per day, covering or tarping the soil, or other preventative measures;

-By removing soil which has experienced desication cracking before compacting the next lift or installing the next cap system component.

-By removing excessively wet soil or areas determined to be not acceptable by the registered professional engineer or geologist.

f. If the construction has areas determined to be not acceptable by the registered professional engineer or geologist remedial actions shall be taken. As a minimum, additional tests may be required to locate the extent of the unacceptable area. It shall be remedied based on the engineer's or geologist's sound judgment. Actions may include recompaction or removal and replacement of unsatisfactory material with new material, compaction and retesting.

Documentation of these procedures shall be provided by the engineer or geologist.

4. <u>Clay Construction Certification</u>: A registered professional engineer or geologist will verify that a compacted cap is constructed in accordance with these criteria by performing all of the following quality control tests.

a. Field density-moisture measurements of the cap immediately after compaction, as specified by ASTM D2922 (nuclear methods), for each 3000 cubic yards placed, with a minimum of 1 test per day of construction of lift of soil. The location of the soil samples will be rotated with each lift to maximize the coverage of the tests. Filed in-place density/moisture content tests will be conducted using a nuclear density gauge, sand cone or drive cylinder. If nuclear density methods are used sufficient numbers of the sand cone or drive cylinder test will be performed to correlate and verify the nuclear gauge results. The moisture content of the fill materials will be kept within a range which allows the earthwork contractor to achieve the required density and permeability. When, in the opinion of the certifying Engineer or Geologist the moisture content of the fill material is too high or too low, the material will be alternately dried or moistened to facilitate compaction to the specified density.

b. The undisturbed hydraulic conductivity of a soil sample will be conducted at a minimum once per 5 acres of the cap, by the EPA Method 9100 in Test methods for Evaluating Solid Waste SW-846 or by another method per DSWM approval. Permeability samples will be obtained by extracting a Shelby tube sample from the in-place compacted material and returning this sample to the laboratory for testing. The hole left by the Shelby tube will be carefully backfilled with bentonite, hand tamped and compacted into place.

c. Upon completion of the clay construction, elevations will be taken to verify construction.

d. Provide documentation of the quality control measures performed with field notes and certifications.

e. The soil to be utilized for establishing the vegetative cover shall have an organic composition capable of sustaining a healthy stand of vegetation. Once this soil has been applied and tamped the area shall be seeded as soon as practical in order to minimize soil erosion. The soil for vegetation shall not be compacted such that vegetative growth is hindered. The top surface of the soil for vegetation may need to be roughened to create a favorable environment for vegetation to grow in. The seeding and fertilization schedule can be found in Appendix D of this manual. The TVA specifications shown in Appendix D shall be modified to change the following: (1) reference to topsoil to read soil suitable for vegetative growth, (2) Section 580.3 shall be modified to provide 12" of soil suitable for vegetative growth to match the cap section detail shown on the plans (3) Section 580.4 - seedbeds to be roughened or scarified shall be done in such a manner that will not damage the portion of the cap that consists of the 12" of soil with a maximum hydraulic conductivity of 1×10^{-7} cm/sec.

C

E. <u>DOCUMENTATION</u>

1. <u>Daily Logs</u>

   a. The registered professional engineer or geologist performing Quality Assurance/Quality Control shall prepare a daily log giving the detailed descriptions of the construction operations.

b. The daily log shall include but not be limited to: construction operations and their locations, operations and locations of other QA/QC engineers or geologists, all tests performed and their designation and location, all the locations and designations of samples taken, locations and findings of core sampling, meteorological conditions, and general comments and observations.

c. A copy of the daily logs shall be kept on site and made available to TVA, the QA/QC personnel, and Construction Contractor.

Test Data

All field and laboratory test data shall be accompanied by test/sampling data, location, reasons for the location, personnel and any comments.

2. Approval Documentation

a. All corrective measures taken to bring unsuitable work into conformance with the design specifications must be documented. This document must describe what is at fault and the exact location and the designation(s) that shows the work to be unsuitable, the corrective measures agreed upon to bring it into conformance with design specifications, the dates that corrective work was accepted, and the test designation that shows the work to be acceptable. All work shall be documented as to quality and verified by the engineer or geologist.

b. The documentation will be organized and indexed to enable easy access and retrieval of original inspection and testing data sheets and reports. During the construction period, originals of the documents will be maintained by the engineer or geologist of and copies will be kept by the TVA. Once the construction quality assurance has been certified by an independent, registered engineer and has been accepted by the Owner, originals of the documentation will be maintained by TVA through the closure and post closure period of the site.

APPENDIX A

HELP MODEL PRINTOUT

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TVA JOHNSONVILLE ASH MONOFILL
NEW JOHNSONVILLE, TENNESSEE
7/18/91

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                              GOOD GRASS

                              LAYER  1
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                     VERTICAL PERCOLATION LAYER
 THICKNESS                              =      12.00 INCHES
 POROSITY                               =       0.4640 VOL/VOL
 FIELD CAPACITY                         =       0.3104 VOL/VOL
 WILTING POINT                          =       0.1875 VOL/VOL
 INITIAL SOIL WATER CONTENT             =       0.4588 VOL/VOL
 SATURATED HYDRAULIC CONDUCTIVITY       =       0.0002687999804 CM/SEC


                              LAYER  2
                              --------

                         BARRIER SOIL LINER
 THICKNESS                              =      12.00 INCHES
 POROSITY                               =       0.4300 VOL/VOL
 FIELD CAPACITY                         =       0.3663 VOL/VOL
 WILTING POINT                          =       0.2802 VOL/VOL
 INITIAL SOIL WATER CONTENT             =       0.4300 VOL/VOL
 SATURATED HYDRAULIC CONDUCTIVITY       =       0.0000001000000 CM/SEC


                              LAYER  3
                              --------

                     VERTICAL PERCOLATION LAYER
 THICKNESS                              =     480.00 INCHES
 POROSITY                               =       0.4400 VOL/VOL
 FIELD CAPACITY                         =       0.3300 VOL/VOL
 WILTING POINT                          =       0.0600 VOL/VOL
 INITIAL SOIL WATER CONTENT             =       0.1947 VOL/VOL
 SATURATED HYDRAULIC CONDUCTIVITY       =       0.0000299999992 CM/SEC
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LAYER 4

BARRIER SOIL LINER

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4300 VOL/VOL
FIELD CAPACITY	=	0.3663 VOL/VOL
WILTING POINT	=	0.2802 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4300 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.0000001000000 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	75.00
TOTAL AREA OF COVER	=	43560. SQ FT
EVAPORATIVE ZONE DEPTH	=	29.00 INCHES
UPPER LIMIT VEG. STORAGE	=	5.5680 INCHES
INITIAL VEG. STORAGE	=	5.5058 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR NASHVILLE TENNESSEE

MAXIMUM LEAF AREA INDEX	=	3.30
START OF GROWING SEASON (JULIAN DATE)	=	97
END OF GROWING SEASON (JULIAN DATE)	=	305

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
37.10	40.40	49.00	59.60	68.10	75.80
79.40	78.40	72.30	60.20	48.60	40.90

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MONTHLY TOTALS FOR YEAR 1

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
[illegible]CIPITATION (INCHES)	2.21	5.33	2.80	2.17	3.09	4.65
	3.48	3.80	4.06	2.28	3.14	9.03
[illegible]UNOFF (INCHES)	0.807	3.368	0.887	0.000	0.000	0.000
	0.000	0.048	0.159	0.000	0.000	7.074
[illegible]VAPOTRANSPIRATION	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

(INCHES)	2.338	5.010	2.284	2.690	1.376	1.196
PERCOLATION FROM	0.1966	0.1842	0.1920	0.1542	0.1050	0.0000
LAYER 2 (INCHES)	0.0000	0.0000	0.0305	0.1431	0.1209	0.2054
PERCOLATION FROM	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LAYER 4 (INCHES)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS

AVG. DAILY HEAD ON	10.34	11.22	9.78	6.11	2.39	0.00
LAYER 2 (INCHES)	0.00	0.00	0.55	4.29	2.21	11.46
STD. DEV. OF DAILY HEAD	0.96	0.79	1.66	0.22	1.71	0.00
ON LAYER 2 (INCHES)	0.00	0.00	0.98	1.18	0.39	1.38
AVG. DAILY HEAD ON	0.00	0.00	0.00	0.00	0.00	0.00
LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00
STD. DEV. OF DAILY HEAD	0.00	0.00	0.00	0.00	0.00	0.00
ON LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00

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ANNUAL TOTALS FOR YEAR 1

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	46.04	167125.	100.00
RUNOFF	12.343	44803.	26.81
EVAPOTRANSPIRATION	32.366	117487.	70.30
PERCOLATION FROM LAYER 2	1.3320	4835.	2.89
PERCOLATION FROM LAYER 4	0.0000	0.	0.00
CHANGE IN WATER STORAGE	1.332	4835.	2.89
SOIL WATER AT START OF YEAR	114.40	415271.	
SOIL WATER AT END OF YEAR	115.73	420106.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 2

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
ECIPITATION (INCHES)	1.59 2.74	2.17 5.61	6.64 1.84	5.80 3.83	5.22 2.57	4.44 3.29
RUNOFF (INCHES)	0.494 0.000	0.000 0.000	3.294 0.000	1.623 0.000	0.066 0.001	0.006 1.210
EVAPOTRANSPIRATION (INCHES)	1.669 2.278	2.034 5.925	3.022 2.460	4.685 1.976	5.134 1.721	5.616 1.234
PERCOLATION FROM LAYER 2 (INCHES)	0.1984 0.0000	0.1695 0.0429	0.1836 0.0000	0.1838 0.0809	0.1335 0.1398	0.0662 0.1910
PERCOLATION FROM LAYER 4 (INCHES)	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
AVG. DAILY HEAD ON LAYER 2 (INCHES)	10.53 0.00	9.34 0.37	8.90 0.00	9.57 3.02	4.08 4.43	1.12 9.79
STD. DEV. OF DAILY HEAD ON LAYER 2 (INCHES)	1.10 0.00	1.03 0.51	2.33 0.00	1.58 3.08	1.84 0.96	2.01 2.20
AVG. DAILY HEAD ON LAYER 4 (INCHES)	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
STD. DEV. OF DAILY HEAD ON LAYER 4 (INCHES)	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00

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ANNUAL TOTALS FOR YEAR 2

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	45.74	166036.	100.00
RUNOFF	6.696	24305.	14.64
EVAPOTRANSPIRATION	37.755	137049.	82.54
PERCOLATION FROM LAYER 2	1.3896	5044.	3.04
RCOLATION FROM LAYER 4	0.0000	0.	0.00
CHANGE IN WATER STORAGE	1.290	4682.	2.82
SOIL WATER AT START OF YEAR	115.73	420106.	
SOIL WATER AT END OF YEAR	117.02	424788.	

SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 3

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	2.82 7.43	7.01 3.79	4.35 4.07	6.00 2.91	2.46 1.61	3.01 4.00
RUNOFF (INCHES)	1.011 0.065	5.406 0.106	2.200 0.034	0.797 0.000	0.000 0.000	0.000 1.048
EVAPOTRANSPIRATION (INCHES)	1.503 6.236	1.984 2.818	2.547 3.976	3.966 2.958	5.095 1.577	3.370 1.396
PERCOLATION FROM LAYER 2 (INCHES)	0.2013 0.0210	0.1864 0.0136	0.1766 0.0587	0.1709 0.1665	0.1498 0.1522	0.0036 0.1553
PERCOLATION FROM LAYER 4 (INCHES)	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS

AVG. DAILY HEAD ON LAYER 2 (INCHES)	10.91 0.62	11.45 0.17	8.04 1.44	8.15 6.93	4.92 5.87	0.01 5.75
STD. DEV. OF DAILY HEAD ON LAYER 2 (INCHES)	0.67 1.49	0.68 0.53	2.01 2.01	2.16 1.87	2.59 0.83	0.08 3.01
AVG. DAILY HEAD ON LAYER 4 (INCHES)	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
STD. DEV. OF DAILY HEAD ON LAYER 4 (INCHES)	0.00 0.00	0.00 -0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00

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ANNUAL TOTALS FOR YEAR 3

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	49.46	179540	100.00

RUNOFF	10.666	38717.	21.56
EVAPOTRANSPIRATION	37.424	135850.	75.67
PERCOLATION FROM LAYER 2	1.4559	5285.	2.94
PERCOLATION FROM LAYER 4	0.0000	0.	0.00
CHANGE IN WATER STORAGE	1.370	4973.	2.77
SOIL WATER AT START OF YEAR	117.02	424788.	
SOIL WATER AT END OF YEAR	118.39	429761.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 4

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	1.67 1.77	2.32 3.04	1.89 0.36	7.46 1.93	4.21 3.91	1.47 4.18
RUNOFF (INCHES)	0.000 0.000	0.840 0.084	0.000 0.000	1.532 0.000	0.005 0.334	0.000 1.886
EVAPOTRANSPIRATION (INCHES)	1.281 1.770	1.887 2.924	2.698 0.176	5.175 0.933	5.557 1.872	2.288 1.598
PERCOLATION FROM LAYER 2 (INCHES)	0.1743 0.0000	0.1891 0.0326	0.1658 0.0000	0.1725 0.0000	0.1050 0.1764	0.0000 0.2011
PERCOLATION FROM LAYER 4 (INCHES)	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS

AVG. DAILY HEAD ON LAYER 2 (INCHES)	7.78 0.00	11.01 0.75	6.82 0.00	8.28 0.00	3.95 9.38	0.00 10.89
STD. DEV. OF DAILY HEAD ON LAYER 2 (INCHES)	1.43 0.00	0.82 1.51	0.86 0.00	1.91 0.00	3.81 3.01	0.00 0.70
AVG. DAILY HEAD ON LAYER 4 (INCHES)	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00

ON LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00

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ANNUAL TOTALS FOR YEAR 4

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	34.21	124182.	100.00
RUNOFF	4.681	16991.	13.68
EVAPOTRANSPIRATION	28.158	102215.	82.31
PERCOLATION FROM LAYER 2	1.2168	4417.	3.56
PERCOLATION FROM LAYER 4	0.0000	0.	0.00
CHANGE IN WATER STORAGE	1.371	4976.	4.01
SOIL WATER AT START OF YEAR	118.39	429761.	
SOIL WATER AT END OF YEAR	119.76	434738.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
NNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	3.29	4.34	5.92	4.37	1.63	3.70
	3.74	3.66	2.72	4.12	2.19	3.08
RUNOFF (INCHES)	1.368	2.209	3.712	0.000	0.000	0.001
	0.059	0.000	0.000	0.010	0.000	0.627
EVAPOTRANSPIRATION (INCHES)	1.699	2.357	2.383	4.954	2.564	4.394
	3.681	3.333	2.663	2.279	1.774	1.410
COLATION FROM LAYER 2 (INCHES)	0.1902	0.1847	0.1730	0.1705	0.0703	0.0236
	0.0000	0.0000	0.0000	0.0260	0.1572	0.1909
PERCOLATION FROM LAYER 4 (INCHES)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS

AVG. DAILY HEAD ON LAYER 2 (INCHES)	9.63	11.25	7.66	8.01	1.74	0.11
	0.00	0.00	0.00	1.04	6.47	9.79
D. DEV. OF DAILY HEAD ON LAYER 2 (INCHES)	1.37	0.56	2.26	1.53	2.05	0.21
	0.00	0.00	0.00	2.40	0.31	2.14
AVG. DAILY HEAD ON LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
STD. DEV. OF DAILY HEAD ON LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00

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ANNUAL TOTALS FOR YEAR 5

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	42.76	155219.	100.00
RUNOFF	7.987	28992.	18.68
EVAPOTRANSPIRATION	33.491	121571.	78.32
ERCOLATION FROM LAYER 2	1.1864	4307.	2.77
PERCOLATION FROM LAYER 4	0.0000	0.	0.00
CHANGE IN WATER STORAGE	1.283	4656.	3.00
SOIL WATER AT START OF YEAR	119.76	434738.	
SOIL WATER AT END OF YEAR	121.05	439394.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 6

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
RECIPITATION (INCHES)	5.76	1.42	4.87	7.90	4.37	4.98
	3.25	3.22	3.90	3.61	5.55	3.81

RUNOFF (INCHES)	2.491	1.997	1.213	4.118	0.000	0.000
	0.000	0.000	0.000	0.015	2.917	2.962
EVAPOTRANSPIRATION (INCHES)	1.358	1.673	3.035	4.908	5.529	4.315
	4.046	3.445	2.812	2.212	1.802	1.418
PERCOLATION FROM LAYER 2 (INCHES)	0.2056	0.1723	0.1825	0.1859	0.1462	0.0189
	0.0116	0.0180	0.0000	0.0028	0.1862	0.1986
PERCOLATION FROM LAYER 4 (INCHES)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS

AVG. DAILY HEAD ON LAYER 2 (INCHES)	11.37	9.64	8.82	9.80	4.57	0.38
	0.14	0.05	0.00	0.08	9.98	10.55
STD. DEV. OF DAILY HEAD ON LAYER 2 (INCHES)	0.44	2.13	1.83	1.96	2.43	0.94
	0.48	0.12	0.00	0.46	1.84	1.38
AVG. DAILY HEAD ON LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
STD. DEV. OF DAILY HEAD ON LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00

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ANNUAL TOTALS FOR YEAR 6

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	52.64	191083.	100.00
RUNOFF	15.713	57038.	29.85
EVAPOTRANSPIRATION	36.553	132688.	69.44
PERCOLATION FROM LAYER 2	1.3286	4823.	2.52
PERCOLATION FROM LAYER 4	0.0000	0.	0.00
CHANGE IN WATER STORAGE	0.374	1358.	0.71
SOIL WATER AT START OF YEAR	121.05	439394.	
SOIL WATER AT END OF YEAR	121.42	440752.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 7

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	8.58	5.20	2.96	7.02	7.94	1.93
	2.97	2.83	2.10	0.88	2.13	5.86
RUNOFF (INCHES)	6.615	3.192	0.000	2.121	1.683	0.000
	0.000	0.000	0.040	0.000	0.000	2.349
EVAPOTRANSPIRATION (INCHES)	0.954	1.814	2.990	4.759	7.250	3.664
	2.692	2.957	2.246	0.774	0.859	1.514
PERCOLATION FROM LAYER 2 (INCHES)	0.2047	0.1836	0.1743	0.1747	0.1731	0.0234
	0.0000	0.0000	0.0000	0.0000	0.0000	0.1822
PERCOLATION FROM LAYER 4 (INCHES)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS

AVG. DAILY HEAD ON LAYER 2 (INCHES)	11.32	11.13	7.81	8.54	7.65	0.50
	0.00	0.00	0.00	0.00	0.00	9.73
STD. DEV. OF DAILY HEAD ON LAYER 2 (INCHES)	1.26	0.76	2.05	1.61	2.68	1.24
	0.00	0.00	0.00	0.00	0.00	2.89
AVG. DAILY HEAD ON LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
STD. DEV. OF DAILY HEAD ON LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00

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ANNUAL TOTALS FOR YEAR 7

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	50.40	182952.	100.00
RUNOFF	16.000	58080.	31.75
EVAPOTRANSPIRATION	32.471	117871.	64.43
PERCOLATION FROM LAYER 2	1.1160	4051.	2.21
PERCOLATION FROM LAYER 4	0.0000	0.	0.00
CHANGE IN WATER STORAGE	1.928	7000.	3.83

SOIL WATER AT START OF YEAR	121.42	440752.	
SOIL WATER AT END OF YEAR	123.35	447752.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 8

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	1.51	2.68	4.69	1.12	3.80	3.72
	2.62	3.10	5.19	0.90	2.35	4.90
RUNOFF (INCHES)	0.243	0.691	1.063	0.000	0.000	0.000
	0.000	0.017	0.283	0.000	0.000	2.371
EVAPOTRANSPIRATION (INCHES)	1.550	2.322	2.490	2.571	5.212	3.628
	2.679	3.082	2.976	2.017	0.698	1.178
PERCOLATION FROM LAYER 2 (INCHES)	0.1992	0.1789	0.1639	0.1616	0.1120	0.0000
	0.0000	0.0321	0.0833	0.1363	0.1122	0.1732
PERCOLATION FROM LAYER 4 (INCHES)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS

AVG. DAILY HEAD ON LAYER 2 (INCHES)	10.67	9.73	6.66	6.92	3.21	0.00
	0.00	0.50	4.00	3.45	1.17	7.83
STD. DEV. OF DAILY HEAD ON LAYER 2 (INCHES)	0.81	1.55	1.56	1.91	2.18	0.00
	0.00	0.91	4.69	1.59	0.32	3.58
AVG. DAILY HEAD ON LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
STD. DEV. OF DAILY HEAD ON LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00

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ANNUAL TOTALS FOR YEAR 8

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	36.58	132785.	100.00
RUNOFF	4.668	16946.	12.76
EVAPOTRANSPIRATION	30.405	110370.	83.12
PERCOLATION FROM LAYER 2	1.3527	4910.	3.70
PERCOLATION FROM LAYER 4	0.0000	0.	0.00
CHANGE IN WATER STORAGE	1.506	5468.	4.12
SOIL WATER AT START OF YEAR	123.35	447752.	
SOIL WATER AT END OF YEAR	124.85	453220.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 9

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	2.41 2.21	4.51 3.38	4.16 0.00	4.65 3.30	1.99 1.58	4.32 1.97
RUNOFF (INCHES)	1.399 0.000	2.534 0.000	0.863 0.000	0.059 0.016	0.000 0.000	0.000 0.000
EVAPOTRANSPIRATION (INCHES)	1.720 1.714	1.987 3.805	3.418 0.037	3.435 0.424	4.738 1.921	4.361 1.647
PERCOLATION FROM LAYER 2 (INCHES)	0.2017 0.0000	0.1686 0.0337	0.1824 0.0000	0.1667 0.0049	0.1172 0.1591	0.0000 0.1775
PERCOLATION FROM LAYER 4 (INCHES)	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
AVG. DAILY HEAD ON LAYER 2 (INCHES)	10.90 0.00	9.23 0.29	8.73 0.00	7.63 0.18	3.93 6.68	0.00 8.23
STD. DEV. OF DAILY HEAD ON LAYER 2 (INCHES)	1.21 0.00	2.05 0.46	1.61 0.00	1.93 0.99	2.90 1.50	0.00 1.44

AVG. DAILY HEAD ON LAYER 4 (INCHES)	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
STD. DEV. OF DAILY HEAD ON LAYER 4 (INCHES)	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00

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ANNUAL TOTALS FOR YEAR 9

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	34.48	125162.	100.00
RUNOFF	4.871	17684.	14.13
EVAPOTRANSPIRATION	29.208	106027.	84.71
PERCOLATION FROM LAYER 2	1.2117	4398.	3.51
PERCOLATION FROM LAYER 4	0.0000	0.	0.00
CHANGE IN WATER STORAGE	0.400	1452.	1.16
SOIL WATER AT START OF YEAR	124.85	453220.	
SOIL WATER AT END OF YEAR	125.25	454672.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 10

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	3.85 3.26	5.50 6.29	5.55 4.27	2.83 1.77	1.55 1.15	2.27 1.03
RUNOFF (INCHES)	1.656 0.000	3.344 0.007	1.546 0.456	0.358 0.000	0.000 0.000	0.000 0.000
EVAPOTRANSPIRATION (INCHES)	1.628 2.011	2.088 6.103	3.326 3.478	2.889 2.829	4.074 1.592	2.268 0.886
PERCOLATION FROM LAYER 2 (INCHES)	0.1987 0.0000	0.1825 0.0822	0.1905 0.0463	0.1703 0.0413	0.1316 0.0000	0.0000 0.0000

LAYER 4 (INCHES)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS

AVG. DAILY HEAD ON LAYER 2 (INCHES)	10.62	10.97	9.69	7.99	4.42	0.00
	0.00	2.10	0.98	0.80	0.00	0.00
STD. DEV. OF DAILY HEAD ON LAYER 2 (INCHES)	1.22	1.10	1.58	2.00	2.45	0.00
	0.00	2.43	1.42	1.29	0.00	0.00
AVG. DAILY HEAD ON LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
STD. DEV. OF DAILY HEAD ON LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00

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ANNUAL TOTALS FOR YEAR 10

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	39.32	142732.	100.00
RUNOFF	7.367	26741.	18.74
EVAPOTRANSPIRATION	33.171	120409.	84.36
PERCOLATION FROM LAYER 2	1.0434	3787.	2.65
PERCOLATION FROM LAYER 4	0.0000	0.	0.00
CHANGE IN WATER STORAGE	-1.217	-4418.	-3.10
SOIL WATER AT START OF YEAR	125.25	454672.	
SOIL WATER AT END OF YEAR	124.04	450254.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 11

JAN/JUL FEB/AUG MAR/SEP APR/OCT MAY/NOV JUN/DEC

PRECIPITATION (INCHES)	6.41	4.87	3.89	8.85	1.64	2.76
	3.88	3.90	1.16	4.11	1.21	5.68
RUNOFF (INCHES)	2.081	3.713	1.223	3.625	0.000	0.000
	0.175	0.034	0.000	0.000	0.000	1.473
EVAPOTRANSPIRATION (INCHES)	1.143	1.548	3.073	4.370	4.340	2.759
	3.701	2.552	2.175	3.019	1.423	1.656
PERCOLATION FROM LAYER 2 (INCHES)	0.1069	0.1843	0.1917	0.1831	0.1164	0.0000
	0.0000	0.0131	0.0177	0.1057	0.1140	0.1638
PERCOLATION FROM LAYER 4 (INCHES)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS

AVG. DAILY HEAD ON LAYER 2 (INCHES)	5.26	11.18	9.77	9.57	4.04	0.00
	0.00	0.30	0.25	2.30	1.38	6.75
STD. DEV. OF DAILY HEAD ON LAYER 2 (INCHES)	5.19	0.81	1.95	1.94	2.86	0.00
	0.00	0.89	0.69	1.43	0.33	3.63
AVG. DAILY HEAD ON LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
STD. DEV. OF DAILY HEAD ON LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00

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ANNUAL TOTALS FOR YEAR 11

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	48.36	175547.	100.00
RUNOFF	12.326	44743.	25.49
EVAPOTRANSPIRATION	31.758	115283.	65.67
PERCOLATION FROM LAYER 2	1.1966	4344.	2.47
PERCOLATION FROM LAYER 4	0.0000	0.	0.00
CHANGE IN WATER STORAGE	4.276	15521.	8.84
SOIL WATER AT START OF YEAR	124.04	450254.	
SOIL WATER AT END OF YEAR	128.31	465774.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 12

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	2.51	4.88	2.22	2.06	2.29	3.60
	6.55	2.82	1.05	1.73	3.17	3.97
RUNOFF (INCHES)	0.783	3.590	0.000	0.000	0.000	0.001
	0.030	0.006	0.000	0.000	0.000	0.891
EVAPOTRANSPIRATION (INCHES)	1.527	2.146	2.095	2.461	3.267	4.185
	4.448	4.689	1.013	1.733	1.751	1.225
PERCOLATION FROM LAYER 2 (INCHES)	0.2002	0.1838	0.1615	0.1520	0.0809	0.0000
	0.0256	0.0454	0.0000	0.0000	0.0665	0.1894
PERCOLATION FROM LAYER 4 (INCHES)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS

AVG. DAILY HEAD ON LAYER 2 (INCHES)	10.78	10.29	6.38	5.83	1.98	0.00
	0.34	1.05	0.00	0.00	0.59	9.66
STD. DEV. OF DAILY HEAD ON LAYER 2 (INCHES)	1.37	1.66	0.48	0.55	1.99	0.00
	0.68	1.80	0.00	0.00	0.56	3.02
AVG. DAILY HEAD ON LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
STD. DEV. OF DAILY HEAD ON LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00

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ANNUAL TOTALS FOR YEAR 12

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	36.85	133766.	100.00
RUNOFF	5.300	19241.	14.38
EVAPOTRANSPIRATION	30.539	110857.	82.87
PERCOLATION FROM LAYER 2	1.1055	4013.	3.00

PERCOLATION FROM LAYER 4	0.0000	0.	0.00
CHANGE IN WATER STORAGE	1.010	3667.	2.74
SOIL WATER AT START OF YEAR	128.31	465774.	
SOIL WATER AT END OF YEAR	129.32	469442.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 13

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	9.47	9.72	1.63	3.42	5.25	6.33
	1.86	3.81	7.17	3.14	3.19	3.17
RUNOFF (INCHES)	7.876	7.865	0.000	0.775	0.710	0.059
	0.000	0.000	0.334	1.397	0.471	0.767
EVAPOTRANSPIRATION (INCHES)	1.546	2.123	2.309	2.377	4.613	6.658
	3.039	2.753	4.803	2.518	1.686	1.808
PERCOLATION FROM LAYER 2 (INCHES)	0.2060	0.1858	0.1690	0.1627	0.1656	0.0638
	0.0000	0.0000	0.1040	0.1901	0.1763	0.1928
PERCOLATION FROM LAYER 4 (INCHES)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS

AVG. DAILY HEAD ON LAYER 2 (INCHES)	11.43	11.39	7.18	7.12	6.83	1.44
	0.00	0.00	4.43	9.63	8.76	9.95
STD. DEV. OF DAILY HEAD ON LAYER 2 (INCHES)	0.69	0.75	1.41	1.37	2.57	1.66
	0.00	0.00	3.76	1.67	1.91	1.48
AVG. DAILY HEAD ON LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
STD. DEV. OF DAILY HEAD ON LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00

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ANNUAL TOTALS FOR YEAR 13

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	58.16	211121.	100.00
RUNOFF	20.254	73521.	34.82
EVAPOTRANSPIRATION	36.232	131524.	62.30
PERCOLATION FROM LAYER 2	1.6161	5867.	2.78
PERCOLATION FROM LAYER 4	0.0000	0.	0.00
CHANGE IN WATER STORAGE	1.674	6076.	2.88
SOIL WATER AT START OF YEAR	129.32	469442.	
SOIL WATER AT END OF YEAR	131.00	475517.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 14

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	3.92	8.07	2.24	6.21	6.99	3.17
	2.93	0.70	2.38	1.60	5.13	8.76
RUNOFF (INCHES)	2.768	5.588	0.004	2.215	1.618	0.000
	0.000	0.000	0.000	0.000	0.375	7.118
EVAPOTRANSPIRATION (INCHES)	1.604	1.628	3.114	3.770	6.973	3.664
	2.930	0.489	1.876	2.305	1.454	1.322
PERCOLATION FROM LAYER 2 (INCHES)	0.1981	0.1665	0.1869	0.1629	0.1749	0.0450
	0.0000	0.0000	0.0000	0.0000	0.1071	0.2064
PERCOLATION FROM LAYER 4 (INCHES)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS

AVG. DAILY HEAD ON	10.48	9.03	9.20	7.12	7.85	0.27
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

STD. DEV. OF DAILY HEAD ON LAYER 2 (INCHES)	1.44 0.00	1.76 0.00	1.36 0.00	1.85 0.00	2.64 5.32	0.37 0.72
AVG. DAILY HEAD ON LAYER 4 (INCHES)	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
D. DEV. OF DAILY HEAD ON LAYER 4 (INCHES)	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00

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ANNUAL TOTALS FOR YEAR 14

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	52.10	189123.	100.00
RUNOFF	19.686	71460.	37.78
EVAPOTRANSPIRATION	31.129	112997.	59.75
PERCOLATION FROM LAYER 2	1.2477	4529.	2.39
PERCOLATION FROM LAYER 4	0.0000	0.	0.00
CHANGE IN WATER STORAGE	1.285	4666.	2.47
SOIL WATER AT START OF YEAR	131.00	475517.	
SOIL WATER AT END OF YEAR	132.28	480183.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 15

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	7.91 7.26	3.52 7.07	3.40 3.72	5.97 3.32	4.54 1.28	5.35 6.02
RUNOFF (INCHES)	6.561 0.088	1.223 0.030	1.203 0.000	1.110 0.001	0.739 0.000	0.000 2.249
EVAPOTRANSPIRATION (INCHES)	1.265 6.731	2.002 6.344	3.213 4.656	4.441 2.194	5.835 1.484	5.468 1.385

LAYER 2 (INCHES)	0.0876	0.0675	0.0498	0.0558	0.0093	0.0673
PERCOLATION FROM LAYER 4 (INCHES)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS

AVG. DAILY HEAD ON LAYER 2 (INCHES)	11.37	9.71	8.10	8.41	5.93	0.86
	2.36	0.79	0.45	0.09	0.00	3.65
STD. DEV. OF DAILY HEAD ON LAYER 2 (INCHES)	0.73	1.85	1.72	1.97	2.89	0.95
	2.37	0.93	0.51	0.10	0.01	5.37
AVG. DAILY HEAD ON LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
STD. DEV. OF DAILY HEAD ON LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00

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ANNUAL TOTALS FOR YEAR 15

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	59.36	215477.	100.00
RUNOFF	13.205	47933.	22.25
EVAPOTRANSPIRATION	45.019	163418.	75.84
PERCOLATION FROM LAYER 2	1.2813	4651.	2.16
PERCOLATION FROM LAYER 4	0.0000	0.	0.00
CHANGE IN WATER STORAGE	1.137	4126.	1.91
SOIL WATER AT START OF YEAR	132.28	480183.	
SOIL WATER AT END OF YEAR	133.42	484308.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 16

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	2.85	3.26	7.00	5.76	2.52	4.51
	2.00	4.30	3.72	0.46	4.41	2.58
RUNOFF (INCHES)	1.251	0.536	3.163	2.094	0.021	0.000
	0.000	0.002	0.115	0.000	0.151	1.366
EVAPOTRANSPIRATION (INCHES)	1.589	2.331	3.613	4.577	2.516	6.522
	1.591	4.708	2.590	1.425	0.954	1.393
PERCOLATION FROM LAYER 2 (INCHES)	0.2022	0.1751	0.1909	0.1818	0.0846	0.0238
	0.0000	0.0000	0.0117	0.0380	0.0390	0.2056
PERCOLATION FROM LAYER 4 (INCHES)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS

AVG. DAILY HEAD ON LAYER 2 (INCHES)	10.98	9.30	9.72	9.33	2.38	0.35
	0.00	0.00	0.13	0.45	0.86	11.37
STD. DEV. OF DAILY HEAD ON LAYER 2 (INCHES)	0.72	1.31	1.60	1.78	2.45	0.69
	0.00	0.00	0.36	0.68	2.49	0.66
AVG. DAILY HEAD ON LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
STD. DEV. OF DAILY HEAD ON LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00

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ANNUAL TOTALS FOR YEAR 16

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	43.37	157433.	100.00
RUNOFF	8.699	31576.	20.06
EVAPOTRANSPIRATION	33.809	122727.	77.95
PERCOLATION FROM LAYER 2	1.1528	4185.	2.66
PERCOLATION FROM LAYER 4	0.0000	0.	0.00
CHANGE IN WATER STORAGE	0.862	3130.	1.99
SOIL WATER AT START OF YEAR	133.42	484308.	
SOIL WATER AT END OF YEAR	134.28	487438.	
SNOW WATER AT START OF YEAR	0.00	0.	

SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 17

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	2.77	3.45	3.67	3.33	3.56	1.56
	2.65	3.82	4.78	0.71	2.08	3.32
RUNOFF (INCHES)	0.656	1.713	1.297	0.261	0.026	0.000
	0.000	0.000	0.002	0.000	0.000	0.000
EVAPOTRANSPIRATION (INCHES)	1.488	1.547	3.286	3.474	4.873	1.753
	2.519	3.031	4.759	1.149	1.224	1.485
PERCOLATION FROM LAYER 2 (INCHES)	0.1928	0.1879	0.1844	0.1602	0.1240	0.0000
	0.0000	0.0000	0.0246	0.0000	0.0000	0.1380
PERCOLATION FROM LAYER 4 (INCHES)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS

AVG. DAILY HEAD ON LAYER 2 (INCHES)	9.96	11.66	8.91	6.83	4.36	0.00
	0.00	0.00	0.24	0.00	0.00	6.45
STD. DEV. OF DAILY HEAD ON LAYER 2 (INCHES)	1.48	0.38	2.27	1.91	3.11	0.00
	0.00	0.00	0.45	0.00	0.00	3.70
AVG. DAILY HEAD ON LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
STD. DEV. OF DAILY HEAD ON LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00

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ANNUAL TOTALS FOR YEAR 17

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	35.70	129591.	100.00
RUNOFF	3.954	14354.	11.08

EVAPOTRANSPIRATION	30.590	111040.	85.68
PERCOLATION FROM LAYER 2	1.0120	3674.	2.83
PERCOLATION FROM LAYER 4	0.0000	0.	0.00
CHANGE IN WATER STORAGE	1.156	4197.	3.24
SOIL WATER AT START OF YEAR	134.28	487438.	
SOIL WATER AT END OF YEAR	135.44	491636.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 18

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	2.81	2.66	6.77	3.76	1.79	0.25
	1.03	2.49	2.39	5.98	3.60	4.36
RUNOFF (INCHES)	1.093	0.098	3.033	1.120	0.000	0.000
	0.000	0.000	0.031	0.846	1.624	2.363
EVAPOTRANSPIRATION (INCHES)	1.836	2.129	3.751	2.160	4.749	0.250
	0.855	2.665	0.887	3.362	2.022	1.343
PERCOLATION FROM LAYER 2 (INCHES)	0.1969	0.1716	0.1934	0.1611	0.1246	0.0000
	0.0000	0.0000	0.0000	0.1414	0.1902	0.2020
PERCOLATION FROM LAYER 4 (INCHES)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS

AVG. DAILY HEAD ON LAYER 2 (INCHES)	10.39	9.60	10.01	6.94	4.57	0.00
	0.00	0.00	0.00	6.65	10.33	11.02
STD. DEV. OF DAILY HEAD ON LAYER 2 (INCHES)	0.85	0.90	1.92	1.64	3.30	0.00
	0.00	0.00	0.00	4.01	0.99	0.93
AVG. DAILY HEAD ON LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
STD. DEV. OF DAILY HEAD ON LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00

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ANNUAL TOTALS FOR YEAR 18

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	37.89	137541.	100.00
RUNOFF	10.208	37054.	26.94
EVAPOTRANSPIRATION	26.010	94416.	68.65
PERCOLATION FROM LAYER 2	1.3812	5014.	3.65
PERCOLATION FROM LAYER 4	0.0000	0.	0.00
CHANGE IN WATER STORAGE	1.672	6070.	4.41
SOIL WATER AT START OF YEAR	135.44	491636.	
SOIL WATER AT END OF YEAR	137.11	497706.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 19

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	2.49	3.90	3.12	5.68	3.83	3.04
	4.71	2.48	3.71	1.77	5.33	8.52
RUNOFF (INCHES)	1.610	0.882	0.964	1.051	0.672	0.000
	0.000	0.000	0.056	0.000	2.033	5.818
EVAPOTRANSPIRATION (INCHES)	1.645	1.967	3.058	4.118	5.515	3.040
	4.689	2.480	3.655	1.035	1.715	1.372
PERCOLATION FROM LAYER 2 (INCHES)	0.1958	0.1606	0.1939	0.1657	0.1400	0.0000
	0.0208	0.0000	0.0000	0.0000	0.1807	0.1916
PERCOLATION FROM LAYER 4 (INCHES)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS

AVG. DAILY HEAD ON LAYER 2 (INCHES)	10.23 0.18	8.26 0.00	10.01 0.00	7.49 0.00	5.78 9.86	0.00 9.85
STD. DEV. OF DAILY HEAD ON LAYER 2 (INCHES)	1.51 0.40	1.55 0.00	1.24 0.00	1.75 0.00	3.93 2.56	0.00 2.41
AVG. DAILY HEAD ON LAYER 4 (INCHES)	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
STD. DEV. OF DAILY HEAD ON LAYER 4 (INCHES)	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00

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ANNUAL TOTALS FOR YEAR 19

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	48.58	176345.	100.00
RUNOFF	13.086	47503.	26.94
EVAPOTRANSPIRATION	34.289	124468.	70.58
PERCOLATION FROM LAYER 2	1.2492	4535.	2.57
PERCOLATION FROM LAYER 4	0.0000	0.	0.00
CHANGE IN WATER STORAGE	1.205	4374.	2.48
SOIL WATER AT START OF YEAR	137.11	497706.	
SOIL WATER AT END OF YEAR	138.31	[illegible]	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	5.22 2.27	3.02 3.35	3.34 1.79	2.32 0.12	7.93 2.32	4.61 4.57
RUNOFF (INCHES)	3.549	0.504	0.170	0.044	3.133	0.000

EVAPOTRANSPIRATION (INCHES)	1.814	2.279	3.671	1.710	7.084	4.414
	2.734	2.890	2.035	0.334	1.583	1.422
PERCOLATION FROM LAYER 2 (INCHES)	0.2029	0.1738	0.1732	0.1513	0.1774	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.1391
PERCOLATION FROM LAYER 4 (INCHES)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS

AVG. DAILY HEAD ON LAYER 2 (INCHES)	11.06	9.14	7.67	5.78	8.10	0.00
	0.00	0.00	0.00	0.00	0.00	6.94
STD. DEV. OF DAILY HEAD ON LAYER 2 (INCHES)	0.84	0.86	1.65	0.53	3.10	0.00
	0.00	0.00	0.00	0.00	0.00	4.71
AVG. DAILY HEAD ON LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
STD. DEV. OF DAILY HEAD ON LAYER 4 (INCHES)	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00

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ANNUAL TOTALS FOR YEAR 20

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	40.86	148322.	100.00
RUNOFF	8.596	31203.	21.04
EVAPOTRANSPIRATION	31.970	116051.	78.24
PERCOLATION FROM LAYER 2	1.0177	3694.	2.49
PERCOLATION FROM LAYER 4	0.0000	0.	0.00
CHANGE IN WATER STORAGE	0.294	1068.	0.72
SOIL WATER AT START OF YEAR	138.31	502080.	
SOIL WATER AT END OF YEAR	138.61	503148.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.00	4.39	4.06	4.83	3.83	3.48
	3.43	3.67	3.02	2.42	2.89	4.61
STD. DEVIATIONS	2.41	2.07	1.65	2.16	2.02	1.49
	1.78	1.39	1.77	1.51	1.38	2.18
RUNOFF						
TOTALS	2.216	2.465	1.292	1.145	0.434	0.003
	0.021	0.017	0.076	0.114	0.395	2.138
STD. DEVIATIONS	2.252	2.083	1.201	1.207	0.828	0.013
	0.045	0.030	0.132	0.356	0.816	2.140
EVAPOTRANSPIRATION						
TOTALS	1.510	1.968	3.008	3.661	4.951	3.880
	3.135	3.600	2.578	1.708	1.524	1.394
STD. DEVIATIONS	0.224	0.271	0.462	1.091	1.306	1.585
	1.508	1.450	1.393	0.897	0.356	0.202
PERCOLATION FROM LAYER 2						
TOTALS	0.1939	0.1781	0.1803	0.1683	0.1294	0.0164
	0.0083	0.0191	0.0213	0.0566	0.1044	0.1686
STD. DEVIATIONS	0.0217	0.0082	0.0104	0.0103	0.0315	0.0237
	0.0205	0.0250	0.0314	0.0663	0.0719	0.0517
PERCOLATION FROM LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	44.64 (7.674)	162054.	100.00
RUNOFF	10.315 (4.942)	37444.	23.11
EVAPOTRANSPIRATION	33.117 (4.130)	120216.	74.18
PERCOLATION FROM LAYER 2	1.2447 (0.1536)	4518.	2.79

PERCOLATION FROM LAYER 4	0.0000	(0.0000)	0.	0.00
CHANGE IN WATER STORAGE	1.210	(0.994)	4394.	2.71

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	4.35	15790.5
RUNOFF	3.682	13367.4
PERCOLATION FROM LAYER 2	0.0069	25.0
HEAD ON LAYER 2	12.8	
PERCOLATION FROM LAYER 4	0.0000	0.0
HEAD ON LAYER 4	0.0	
SNOW WATER	2.02	7314.9

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4640
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1846

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	4.80	0.4000
2	5.16	0.4300
3	118.33	0.2465
4	10.32	0.4300
SNOW WATER	0.00	

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APPENDIX B

TVA VEGETATION SPECIFICATIONS

SECTION 580 - Seeding (Pay Item 580)

580.1 -- Description

This specification consists of furnishing and placing seed, commercial fertilizer, and agricultural limestone on roadway slopes, shoulders, borrow pits, channel banks, waste areas, lawns, meadows, beaches, open play areas, and other areas specified by the plans or the Engineer and in accordance with the methods outlined by these specifications.

580.2 -- Materials

1. Seeds

Seeds shall meet the requirements of applicable seed laws and shall be tested in accordance with the most current edition of the U.S. Department of Agriculture Handbook No. 30, Testing Agricultural and Vegetable Seed. Seeds shall be from the last preceding crop and comply with the requirements outlined below for purity and germination. Each variety of seed shall be furnished in separate, strong bags with each bag being fully tagged or labeled to show the variety, weight, purity, germination, and test data prescribed by law. All test results shall be fully certified by the vendor or by a recognized seed testing agency. TVA reserves the right to require that samples be furnished, and to inspect and test the seeds after delivery. Seeds found not to comply with specification requirements shall be subject to rejection.

When mixing or forming seed mixtures, the seeds shall be carefully and uniformly mixed. Seeds shall not be mixed until each variety of seed to be used in the mix has been inspected and/or tested separately and approved.

Seed Varieties	Purity, Minimum %	Germination, Minimum %
Korean Lespedeza (Lespedeza stipulacea), scarified	90	85
~~Sericea Lespedeza (Lespedeza cuneata), scarified~~	~~95~~	~~85~~
~~Interstate Sericea Lespedeza (Lespedeza cuneata, variety Interstate), scarified~~	~~95~~	~~85~~
White Clover (Trifolium repens)	95	85
Alsike Clover (Trifolium repens hybridum)	95	85

580.2 -- Materials (Continued)

Seed Varieties	Purity, Minimum %	Germination, Minimum %
Red Clover (Trifolium pratense)	85	95
Crownvetch (Coronilla varia), scarified	95	80
Foxtail Millet (Setaria italica)	80	98
Bermuda Grass (Cynodon dactylon), hulled	95	80
Annual Rye (Lolium multiflorum)	90	90
Perennial Rye (Lolium perenne)	90	90
Kentucky 31 Fescue (Festuca arundinacea, variety Ky 31)	95	85
Rebel Fescue (Festuca arundinacea, variety Rebel)	95	85
Hard Fescue (Festuca ovina, duriuscula)	95	85
Kentucky Bluegrass (Poa pratensis)	95	90
Creeping Red Fescue (Festuca rubra)	95	90
Centipede Grass (Eremochloa ophiuroides)	90	75
Weeping Lovegrass (Eragrostis curvula)	95	90
Switchgrass (Panicum virgatum)	80	75
Zoysia Grass (Zoysia japonica)	95	80
Little Bluestem Grass (Andropogon scoporius)	40	60
Bahia Grass (Paspalum notatum)	75	80
Buffalo Grass (Buchloe dactyloides)	85	50

580.2 -- Materials (Continued)

Seeding materials shall be free from seeds or bulbets of Wild Onion (Allium vineale), Canada Thistle (Cirsium arvense), and Johnson Grass (Sorghum halepense).

Seed species shall not contain more than six seeds per ounce of the seed of any of the following noxious weeds or the seeds of any other weed specifically listed as noxious:

Bindweed (Convolvulus arvensis)
Buckthorn (Plantago lanceolata)
Corncockle (Agrostemmo githago)
Dodder (Cuscuta species)
Oxeyedaisy (Chrysanthemum leucantheumum)
Quackgrass (Agropyron repens)
Sorrel (Rumex acetosella)

Seed species shall not contain an excess of 2 percent by weight of weed seeds, noxious or otherwise.

2. Seed or seed mixtures, rates, and seasons

Seeding mixtures, rates, and seasons shall be those specified herein. The types to be used for each area or project will be specified by the drawings or by memorandum. Mixtures or rates of application other than those specified shall be used only when specified by the plans or the Engineer. Seeding shall be planted during the season and between the dates specified. Temporary cover shall be planted when it is required during seasons not suitable for planting the seed specified by the plans.

a. Lawns

Type 1: Spring or fall seeding (Plant between March 15 and May 1, or between August 15 and October 15).

(1) Kentucky 31 Fescue . . . 120 pounds per acre
(2) Rebel Fescue . . . . 120 pounds per acre
(3) Creeping Red Fescue . . 80 pounds per acre |1

Type 2: Fall seeding (Plant between August 15 and October 15).

(1) Perennial Ryegrass . . . 120 pounds per acre
(2) Kentucky Bluegrass . . . 80 pounds per acre

Type 3: Spring seeding (Plant between March 15 and May 1).

Bermuda Grass . . . . 40 pounds per acre

580.2 -- Materials (Continued)

b. Meadows

Type 4: Spring seeding (Plant between March 15 and May 1).

Mixture:

(1) Kentucky 31 Fescue . . . 50 pounds per acre
Korean Lespedeza
(scarified) . . . . . . 10 pounds per acre
Alsike Clover . . . . . 10 pounds per acre
Total mixture . . . 70 pounds per acre

(2) Bermuda Grass
(hulled) . . . . 40 pounds per acre
Korean Lespedeza
(scarified) . . . . . . 10 pounds per acre
Total mixture . . . 50 pounds per acre

~~(3) Sericea Lespedeza~~
~~(scarified) . . . . . . 30 pounds per acre~~
~~Kentucky 31 Fescue . . . 30 pounds per acre~~
~~Total mixture . . . 60 pounds per acre~~

~~(4) Interstate Sericea Lespedeza~~
~~(scarified) . . . . . . 30 pounds per acre~~
~~Kentucky 31 Fescue . . . 30 pounds per acre~~
~~Total mixture . . . 60 pounds per acre~~ 1

(5) Crownvetch (inoculated
and scarified) . . . . 30 pounds per acre
Kentucky 31 Fescue . . . 30 pounds per acre
Total mixture . . . 60 pounds per acre

Type 5: Fall seeding (Plant between August 15 and October 15).

Mixture:

(1) Kentucky 31 Fescue . . . 50 pounds per acre
White Clover . . . . . . 15 pounds per acre
Total mixture . . . 65 pounds per acre

(2) Bluegrass . . . . 50 pounds per acre
White Clover . . . . . . 15 pounds per acre
Total mixture . . . 65 pounds per acre

580.2 -- Materials (Continued)

c. Channel Banks, Cuts, Fill Slopes, Waste Areas, and Other Disturbed Areas

Type 6: Spring seeding only (Plant between March 15 and May 15).

Mixture:

(1) Kentucky 31 Fescue . . . 60 pounds per acre

(2) Bermuda Grass (hulled) . 40 pounds per acre

(3) Creeping Red Fescue . . 80 pounds per acre
(Shaded slopes only)

(4) Weeping Lovegrass . . . 15 pounds per acre
Korean Lespedeza
(scarified) . . . . . . 10 pounds per acre
Total mixture . . . 25 pounds per acre

~~(5) Sericea Lespedeza (scarified) . . . . . . 30 pounds per acre~~
~~Kentucky 31 Fescue . . . 30 pounds per acre~~
~~Total mixture . . . 60 pounds per acre~~

~~(6) Interstate Sericea Lespedeza (scarified) . 30 pounds per acre~~
~~Rebel Fescue . . . . . . 30 pounds per acre~~
~~Total mixture . . . 60 pounds per acre~~ 1

(7) Crownvetch (scarified and inoculated) . . . . 30 pounds per acre
Kentucky 31 Fescue . . . 30 pounds per acre
Total mixture . . . 60 pounds per acre

(8) Bahia Grass . . . . . . 40 pounds per acre
Bermuda Grass . . . . . 20 pounds per acre
Switch Grass . . . . . . 10 pounds per acre
Total mixture . . . 70 pounds per acre

(9) Rebel Fescue . . . . . . 40 pounds per acre
Hard Fescue . . . . . . 10 pounds per acre
White Clover . . . . . . 5 pounds per acre
Total mixture . . . 55 pounds per acre 1

580.2 -- Materials (Continued)

c. Channel Banks, Cuts, Fill Slopes, Waste Areas, and Other Disturbed Areas (Continued)

Type 7: Summer seeding (Plant between May 15 and July 15).

Mixture:

(1) Bermuda Grass (hulled) . 40 pounds per acre
Korean Lespedeza (scarified) . . . . 10 pounds per acre
Total mixture . . . 50 pounds per acre

(2) Buffalo Grass . . . . . 40 pounds per acre
Korean Lespedeza (scarified) . . . . 10 pounds per acre
Total mixture . . . 50 pounds per acre

Type 8: Fall seeding (Plant between August 15 and October 15).

(1) Kentucky 31 Fescue . . . 60 pounds per acre
White Clover . . . . . . 15 pounds per acre
Total mixture . . . 75 pounds per acre

(2) Hard Fescue . . . . . . 10 pounds per acre
Rebel Fescue . . . . . . 40 pounds per acre
White Clover . . . . . . 5 pounds per acre
Total mixture . . . 55 pounds per acre

(3) Rebel Fescue . . . . . . 40 pounds per acre
Hard Fescue . . . . . . 10 pounds per acre
White Clover . . . . . . 5 pounds per acre
Total mixture . . . 55 pounds per acre 1

d. Highway Shoulders

The planting dates and seed mixtures for each type listed here are described above.

Type 6: Spring seeding [Mixture (1), (2), (3) or (9)]

Type 7: Summer seeding [Mixture (1) or (3)] 1

Type 8: Fall seeding [Mixture (2)]

580.2 -- Materials (Continued)

e. Temporary Cover

Type 9: Temporary winter seeding (Plant between October 15 and March 15).

Annual Ryegrass	80 pounds per acre
White Clover	10 pounds per acre
Total mixture . . .	90 pounds per acre

Type 10: Temporary summer seeding (Plant between May 1 and August 15).

Mixture:

(1)

Korean Lespedeza (scarified)	20 pounds per acre
Foxtail Millet	20 pounds per acre
Total mixture . . .	40 pounds per acre

(2)

Red Clover	20 pounds per acre
Weeping Lovegrass . . .	10 pounds per acre
Total mixture . . .	30 pounds per acre

3. Fertilizer

Fertilizers shall be those readily available commercially. The application of fertilizer shall be at a rate of 200 pounds Ureaform (38-0-0) per acre with either 400 pounds of 15-15-15 per acre or 600 pounds of 6-12-12, unless specified otherwise by the drawings or memorandum.

Ammonium nitrate (NH_4NO_3) may be used for supplemental fertilization when specified by the Engineer.

4. Agricultural Limestone

Limestone shall contain no less than 85 percent calcium carbonate by weight. It shall be crushed so that at least 85 percent will pass a No. 10 sieve. The application of limestone shall be at the rate of 2 tons per acre unless specified otherwise by the drawings or memorandum. Hydrated lime may be substituted at a rate of 1 ton per acre.

580.3 -- Topsoil

All lawn areas to be seeded shall have a 2-inch minimum depth of topsoil immediately below finish grade. Topsoil requirements for other areas, if any, will be determined by field inspection and shall comply with Section 581.3.

580.4 -- Soil Preparation

Areas to be seeded shall have approved cross sections and grades. Objects such as large roots, stones, stumps, coarse vegetation, debris, or any other items that might impede mechanical mowing shall be removed and disposed of satisfactorily.

Seedbeds shall be plowed, disked, harrowed, scarified, or cultivated to the approved depth. In areas where it is practical, this work shall be done with farm-type equipment. On steep slopes, preparation of seedbeds shall be done with the tools and methods specified by the Engineer. It is strongly recommended that scarifying and preparation of seedbeds on cut and fill slopes be accomplished with tools or equipment specially designed for this purpose. Small furrows or grooves formed in the slopes shall be horizontal or as nearly horizontal as practical. The work shall be performed only when the ground is in a workable and tillable condition as determined by good farming practices.

580.5. -- Special Hydroseeding Equipment

Equipment to be used for the hydraulic application of planting materials shall be a Finn Hydro-Seeder, Bowie Hydro Mulcher, Toro Environmental Control Unit, or an approved equal. The equipment shall have mixing tanks with built-in agitators having operating capacities sufficient to agitate, suspend, and homogeneously mix slurries of water and planting materials. Tanks shall have capacities of 1000 gallons or more, and shall be mounted on traveling units that can be either self-propelled or towed by a separate vehicle. The slurry distribution lines shall be large enough to prevent clogging or stoppage. Discharge lines shall be equipped with sets of different sized hydraulic spray nozzles capable of providing for even distribution of varying slurry mixtures on areas to be seeded. Slurry mixture rates are described in Section 580.6.

580.6 -- Seeding Methods

Seeds shall be sown with approved mechanical power-drawn drills or seeders, hand cyclone seeders, or with special hydroseeding equipment. Rates specified in Section 580.2 shall be maintained in a manner that will guarantee uniform coverage. Seeding operations shall not be performed when drought, high winds, and excessive moisture or other factors may defer satisfactory results.

On slopes where the use of drills or seeders is not practical and in other areas specified by plans or by memorandum, seeding shall be accomplished using hydroseeding equipment.

Drill seeding shall be performed in rows with spacing suitable for the type of seed or mixture used. Fertilizer may be drilled simultaneously if drills are equipped for this type of operation. Where fertilizer is not drilled, it may be applied during the cultivation operation described in Section 580.4. When fertilizer and seed are applied separately, the fertilizer shall be spread uniformly over the prepared seedbeds prior to final filling. Rates of application shall be those specified by the plans or the Engineer or those specified in this section. It shall be thoroughly mixed with soil for a depth of 1/2-inch.

580.6 -- Seeding Methods (Continued)

Care shall be taken to ensure that seed and fertilizer remain uniformly and thoroughly mixed in the seeding equipment. Additional mixing shall be performed if necessary to avoid segregation of the seed or seed and fertilizer.

Hydroseeding is the method of applying lime, fertilizer, seed, and mulch combined with water in a single operation. Using the equipment described in Section 580.5, mixing tanks shall be filled with water to the level indicated inside of the tanks. With the engines turned on and the agitators running, the following materials shall be added: (1) limestone at the specified rate of 1/5 per acre (finely ground); (2) fertilizer; (3) seed (Section 580.2); and (4) wood fiber mulch (Section 582.2), for each 1000 gallons of water. The resulting slurries shall be applied to seedbeds at a rate of 5000 gallons per acre.

When hydroseeding slopes are 2:1 or steeper, a vinyl or plastic mulch (Section 582.2) shall be added to the slurries at the rate specified by the manufacturer.

Discharge lines are activated by opening bypass valves with hand levers that allow the slurries to spray through the nozzles. Slurries shall be sprayed on the seedbeds as the spraying vehicles move slowly across the area. Care shall be taken to ensure that all areas are evenly covered. If wind or rough terrain causes skips to occur, additional applications shall be made before moving to other areas. To provide for the even distribution of a slurry, hydroseeding should be performed with the wind or preferably with no wind at all.

For steep slopes, even coverage is best obtained when an application is begun at the top and worked down a slope with successive overlapping passes. When a hydroseeder is located on top of a slope, the reverse is true.

Seed not sown by drills or hydroseeders shall be covered to a depth of approximately 1/4-inch by lightly harrowing or raking. Raking or harrowing shall follow contours as closely as practical.

Where mulching is to be done, the mulch shall be applied immediately after the seeding is completed to avoid the loss of soil moisture or possible erosion. Mulching shall comply with Section 182.

When specified by the Engineer, one or more applications of fertilizer shall be made after a stand of grass has been obtained and allowed to grow for a period of from 3 to 6 weeks. The grade and rate of application of the fertilizer will be specified by the Engineer. When ammonium nitrate or a similar soluble fertilizer is used alone, areas shall be thoroughly soaked as soon as an application is completed.

580.7 -- Maintenance

Seeded areas shall be maintained until a satisfactory cover of plant material is secured, unless stipulated otherwise. All areas shall be preserved, repaired, and protected as specified for this purpose. Areas having poor stands of plant material shall be seeded again and fertilized at the proper rates.

Watering shall be accomplished during the maintenance period to the extent necessary.

580.8 -- Method of Measurement

Seeded areas will be measured in square yard units and include the seeded areas along slopes.

580.9 -- Costs

Costs for Pay Item 580 shall include all materials, labor, tools, equipment, and incidentals necessary to complete the work for this item.

APPENDIX C

TVA VOC TESTING

The following table titled Analytical Summary results is a summery of testing of ash samples from TVA's Allen Fossil Plant in Memphis, Tennessee. The analysis of the samples was in accordance with TCLP testing requirements which included TCLP Extraction, TCLP 2HE Extraction, TCLP 2HE Extraction 8240 and TCLP Extraction 8270.

ANALYTICAL SUUMMARY RESULTS

PROJECT: PLANT ALLEN CTVA
WORK ORDER NO.: 1888

PARAMETER	POND #1	POND #2	POND #3	ASP-001	ASP-002	ASP-003	REPORTING LIMIT (ug/L)
Benzene	ND	ND	ND	ND	ND	ND	5
Carbon tetrachloride	ND	ND	ND	ND	ND	ND	5
Chlordane	ND	ND	ND	ND	ND	ND	0.5
Chlorobenzene	ND	ND	ND	ND	ND	ND	5
Chloroform	ND	ND	ND	ND	ND	ND	5
m-Cresol	ND	ND	ND	ND	ND	ND	20
o-Cresol	ND	ND	ND	ND	ND	ND	20
p-Cresol	ND	ND	ND	ND	ND	ND	20
1,4-Dichlorobenzene	ND	ND	ND	ND	ND	ND	20
1,2-Dichlorobenzene	ND	ND	ND	ND	ND	ND	20
1,1-Dichloroethylene	ND	ND	ND	ND	ND	ND	5
2,4-Dinitrotoluene	ND	ND	ND	ND	ND	ND	100
Hepachlor	ND	ND	ND	ND	ND	ND	0.05
Hexachlorobenzene	ND	ND	ND	ND	ND	ND	20
Hexachloroethane	ND	ND	ND	ND	ND	ND	20
Nitrobenzene	ND	ND	ND	ND	ND	ND	20
Pyridine	ND	ND	ND	ND	ND	ND	5
Pentachlorophenol	ND	ND	ND	ND	ND	ND	100
Trichloroethylene	ND	ND	ND	ND	ND	ND	5
Tetrachloroethylene	ND	ND	ND	ND	ND	ND	5
2,4,5-Trichlorophenol	ND	ND	ND	ND	ND	ND	100
2,4,6-Trichlorophenol	ND	ND	ND	ND	ND	ND	20
Vinyl chloride	ND	ND	ND	ND	ND	ND	10
Endrin	ND	ND	ND	ND	ND	ND	0.1
Lindane	ND	ND	ND	ND	ND	ND	0.05
Methoxychlor	ND	ND	ND	ND	ND	ND	0.5
Toxaphene	ND	ND	ND	ND	ND	ND	1
2,4-D	ND	ND	ND	ND	ND	ND	10
2,4,5-TP	ND	ND	ND	ND	ND	ND	1
Methyl ethyl ketone	ND	ND	ND	ND	ND	ND	100
Hexachlorobutadiene	ND	ND	ND	ND	ND	ND	20

ND = Not Detected

APPROVED BY: Richard L. Minell

05-29-90 09:55AM

APPENDIX D

TVA QUALITY ASSURANCE PROCEDURE

GROUNDWATER SAMPLE COLLECTION TECHNIQUES

Copy No. 20

TENNESSEE VALLEY AUTHORITY
SYSTEM ENGINEERING
DATA SYSTEMS

QUALITY ASSURANCE PROCEDURE

No. DS-41.6

Title: GROUNDWATER SAMPLE COLLECTION TECHNIQUES

Revision:	0
Date:	12/7/89
Prepared by:	D. L. Meinert 9-13-89
Recommended by: Manager, Field Engineering	A. H. Smalley 9-15-89
Technical Reviewer Data Systems	T. M. Wilson
Technical Reviewer Data Systems	K. H. Winters 9-18-89
Concurred by: QAC, Field Engineering	L. E. Scroggie 12/7/89
Approved by: Manager, Data Systems	R. T. Joyce 12/7/89
Concurred by: Manager, Engineering Lab.	E. E. Driver
Concurred by: Manager, Environ. Chemistry	C. W. Holley 9/22/89
Concurred by: Manager, Water Quality	R. D. Urban 10/6/89

1.0 OBJECTIVE

To prescribe specific, detailed instructions for Field Engineering (FENG) personnel involved in the collection of water samples in accordance with standard practices generally accepted by the U.S. Environmental Protection Agency (EPA), U.S. Geological Survey (USGS), and TVA.

2.0 SCOPE

The techniques described herein are limited to those to be used by FENG personnel for routine studies. They do not apply to special studies that may require special apparatus and/or handling or specially trained personnel. For example, the collection of groundwater samples at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites (i.e., "Superfund" sites), certain Resource Conservation and Recovery Act (RCRA) sites, and those activities which fall under the scope of the Superfund Amendments and Reauthorization Act (SARA) of 1986 are not within the scope of this procedure. This procedure applies to collection of routine groundwater samples in connection with TVA's regional water management program activities and assessment of groundwater quality in the vicinity of TVA power facilities.

3.0 REFERENCES

3.1 National Handbook of Recommended Methods for Water Data Acquisition, Chapter 2, "Groundwater" (January 1980), U.S. Geological Survey, Reston, VA, 1977.

3.2 Handbook--Groundwater, Environmental Protection Agency, EPA/625/6-87/016, Cincinnati, OH, 1987.

3.3 A Guide to Groundwater Sampling-Technical Bulletin No. 362, National Council of the Paper Industry for Air and Stream Improvement, Inc., New York, NY, 1982.

3.4 Practical Guide for Groundwater Sampling, Environmental Protection Agency, EPA/600/2-85/104, Ada, Oklahoma, 1985.

3.5 Macrodispersion Experiment Management Policies and Requirements (EPRI RP 2485-05), TVA Engineering Laboratory Report No. WR28-2-520-136, Chapters 4.2.6, "Field Tracer Sampling," and 4.2.7, "Field Monitoring and Sampling," 1987.

3.6 Fletcher G. Driscoll, Groundwater and Wells, Johnson Division, St. Paul, Minnesota, Second Ed., 1982.

ALH 92

3.7 40 CFR 136, "Guidelines Establishing Test Procedures for the Analysis of Pollution," Table II - Required Containers, Preservation Techniques, and Holding Times.

3.8 Methods for Chemical Analysis of Water and Wastes, Environmental Protection Agency, EPA-600/4-79-020, Cincinnati, OH, 1979.

3.9 Standard Methods for the Examination of Water and Wastewater, 16th Ed., American Public Health Association, Washington, D.C., 1985.

3.10 Handbook for Sampling and Sample Preservation of Water and Wastewater, Environmental Protection Agency, EPA-600/4-82-029, Cincinnati, OH, 1982.

3.11 Sampling Guidelines for Groundwater Quality, Electric Power Research Institute, EA-4952, Research Project 2485-1, Palo Alto, CA, 1987.

3.12 Groundwater Manual for the Electric Utility Industry, Electric Power Research Institute, CS-3901, Research Project 2301-1 (volumes 1, 2, and 3), Palo Alto, CA, 1985.

3.12.1 Volume 1: Geological Formations and Groundwater Aquifers.

3.12.2 Volume 2: Groundwater Related Problems.

3.12.3 Volume 3: Groundwater Investigations and Mitigation Techniques.

3.13 Resource Conservation and Recovery Act (RCRA) Groundwater Monitoring Technical Enforcement Guidance Document, Environmental Protection Agency, PB87-107751, OSWER-9950.1, Washington, D.C., 1986.

3.14 DS-41.1, "Collection and Handling of Samples."

3.15 DS-41.2, "Water Sample Collection Techniques."

3.16 DS-41.4, "Trace Organics Sample Collection Techniques."

3.17 DS-42.1, 42.3, 42.4, 42.7, 42.8, and 42.11, "Water Quality Field Analyses."

3.18 DS-43.1, 43.2, 43.3, 43.7, and 43.8, "Standardization of Field Instruments."

3.19 DS-5.20, "STORET - Water Quality Data Management."

4.0 ABBREVIATIONS AND DEFINITIONS

4.1 Definitions

4.1.1 Definitions of job titles and general responsibilities of managerial and supervisory personnel in FENG are given in section 4.1 of reference 3.14.

4.2 Abbreviations

4.2.1 DO--Dissolved oxygen

4.2.2 DMGT--Data Management, Data Systems

4.2.3 ECHE--Environmental Chemistry, Water Quality Department

4.2.4 EPA--United States Environmental Protection Agency

4.2.5 FENG--Field Engineering, Data Systems

4.2.6 MLS--Multilevel sampling well

4.2.7 NPDES--National Pollutant Discharge Elimination System

4.2.8 ORP-Oxidation-reduction potential

4.2.9 pH--Measure of hydrogen ion concentration

4.2.10 USGS--United States Geological Survey

4.2.11 WQ--Water Quality Department

4.2.12 WQU--Water Quality Unit (Chattanooga), DMGT

5.0 RESPONSIBILITIES

5.1 The projects engineers (eastern or western geographic areas) have overall responsibility for sample collection activities and are responsible for assuring that employees are qualified for their assignments and that all requirements are met. The projects engineers are responsible for approval of all work and budget estimates before field activities begin and are responsible for designating qualified senior project engineers.

5.2 The unit supervisors and senior project engineers are responsible for the technical adequacy of the particular functional work being performed. They are responsible for coordinating sampling schedles and technical workplans with the laboratory, Data Management, and the client organization. Unit supervisors and senior project engineers are responsible to ensure that data are collected and reported on schedule and in a valid manner according to the procedures of this manual.

The unit supervisors and senior project engineers are responsible for reviewing all data collected by FENG personnel for reasonableness and accuracy prior to the data being released to the client organization.

All quality control problems are reported to the appropriate unit supervisor or senior project engineer.

5.3 Survey leaders are responsible for the quality of the field work done by his or her party or crew. It is the responsibility of the field survey leader to notify his or her unit supervisor or senior project engineer of any deviations from procedures and workplans or problems or difficulties encountered in the field, particularly as they may affect the quality of the data being collected.

5.4 All FENG personnel assigned to a project or involved in sample collection are responsible for following all instructions in this procedure manual. This includes ensuring that manuals are up-to-date and that procedures are strictly followed. If errors in procedures are observed, the error must be brought to the immediate attention of the QAC. Notes in the procedures manuals or alteration, in the field, to procedures are prohibited. FENG personnel are responsible for working in a safe manner, for notifying unit supervisors and project engineers of any deviation from the workplan, and for submitting records to their unit supervisor.

5.5 The ECHE laboratory, Water Quality Department, performs bacteriological, chemical, and physical analyses.

5.6 The WQU is responsible for coding, keypunching, processing, reviewing, validating, retrieving, and reporting field and laboratory data related to ambient groundwater quality.

6.0 PROCEDURES/REQUIREMENTS

6.1 Workplans

6.1.1 A written workplan is usually prepared in advance of the sampling activities. This written workplan must be coordinated with the client organization and other service organizations. The workplan must receive concurrence by all affected organizations and will address, at a minimum, the purpose of the monitoring activities, the choice of water characteristics to be measured, the method or methods to be employed in collection of the samples, the locations and frequency of sampling, project deadlines and schedules, budget requirements, and collection of auxiliary data.

6.1.2 If special sample collection requirements, handling techniques, or analyses are required (other than the standard procedures contained in this manual), they will be spelled out in detail in the workplan or in supplemental procedures. All items which will affect the quality of the data to be collected must be addressed in the written workplan and/or referenced to the appropriate FENG procedures. The written workplan must be approved by the appropriate senior project engineer prior to any fieldwork.

6.2 Requirements and Instructions for Groundwater Sampling

6.2.1 "Collection and Handling of Samples" (reference 3.14) will be followed as appropriate. In addition, particular attention must be given to the following requirements.

6.2.2 The FENG survey leader will review the workplan in detail and consult with his or her unit supervisor and project engineer prior to the first survey to ensure that no misunderstanding exists about how, when, where, and what samples are to be collected.

6.2.3 Before starting a new work activity at a TVA facility (i.e., nuclear, steam, hydro, etc.), the FENG project engineer or unit supervisor will contact the facility manager or his/her designee (usually the Results Section supervisor at a steam plant) and inform them of the work to be performed and on what schedule it will be done. To ensure recognition of any situations which may require special safety awareness, the field survey leader will meet with the plant manager or his/her designee and complete a safety notification record which identifies safety procedures which need to be observed, unusual conditions to be aware of, and names of FENG personnel working at the TVA facility.

6.2.4 The survey leader will select and assemble the needed equipment (pumps, meters, Hydrolabs, filtration apparatus, tapes/plunkers, compressor, generators, titration equipment, pH/conductance/ORP standards, buckets, etc), sample containers, workplan, maps, well driller logs, and forms and field worksheets. The survey leader will ensure that all equipment and supplies are appropriately cleaned, in good working order and within their laboratory calibration interval as specified in DS-43.1, attachment 1 (reference 3.18). It is recommended that an equipment checklist be prepared on the initial field survey and that it be referred to and updated on each subsequent survey.

6.2.5 The survey leader will obtain a summary of the last four sets of field data for use to validate and compare information at the time it is being collected. A computer printout can be obtained from the WQU to facilitate this data validation process.

6.3 Groundwater Sample Collection Techniques

6.3.1 Quality Control of Sampling Operations

6.3.1.1 Every effort will be made to collect a representative and uncontaminated sample. After each sample is collected, it will be visually examined for any foreign material that is not representative. If any foreign material is observed, or suspected, the sample will be discarded and new sample recollected in a fresh sample container. Do not immerse anything--even a thermometer--in the sample. Always pour the sample directly into the specified containers one at a time. Transferral to another container will greatly increase the opportunity for contamination and cross contamination.

6.3.1.2 Many sample containers contain chemical preservatives. These preservatives may be a source of contamination to other samples, may be ineffective if diluted, or may be harmful if allowed to contact skin or eyes. Use care when handling sample containers with chemical preservatives. Fill sample containers individually, one at a time, to prevent cross contamination of preservatives: uncap the container, fill it directly from the sampler, and recap the container. Do not place flexible sample tubing inside the containers unless specifically instructed to do so. Do not lay caps on surfaces that might contaminate them. Do not overfill containers. If any of these potential sources of contamination occur, discard the affected portion of the sample, and collect another portion in a fresh container.

6.3.1.3 Sample collection methods for groundwater may include the use of a pneumatic bladder pump, submersible centrifugal pump, single or 10-channel peristaltic pump, check valve bailer, Kemmerer sampler, lysimeter, or perhaps a gas lift pump. The method used to collect a groundwater sample must be compatible with the water quality characteristics of interest. All of these methods, in one or more ways, alter the quality of the sample while it is being collected. In most instances, the pneumatic bladder pump or check valve bailer, when used properly, will collect the most representative (least altered) sample for a variety of constituents (particularly volatile organics and reduced/dissolved species). The use of gas lift devices for collection of groundwater quality samples is not recommended. Chapter 6 of reference 3.2 provides additional details.

6.3.1.4 When collecting groundwater samples, the sample should be obtained as close to the discharge at the source or wellhead as possible to reduce the potential for contamination, precipitation of solute, and loss of dissolved gasses. Treated (chlorinated or filtered) or stored groundwater samples, such as from some private or domestic wells are of limited value. Care must be taken to limit sample contact with air and agitation that would interfere with the field determination of pH, ORP, dissolved gasses, and alkalinity, or the laboratory determination of volatile organics and reduced species.

6.3.1.5 On occasion it may be desirable to determine concentrations of dissolved inorganic constituents (i.e., dissolved minerals or dissolved metals) in groundwater. In such cases, by definition, the sample is filtered through a 0.45μm average pore diameter cellulose ester membrane filter (Millipore Cat. No. HAWP04700 or equivalent), during (pressure filtration) or immediately after (vacuum filtration) sample collection. Techniques used to filter groundwater samples should be discussed in detail in the project's workplan. In most cases, the preferred method for filtration of groundwater is an "in-line" pressure filtration technique which eliminates sample contact with the atmosphere and utilizes the sampling pump's pressure for filtration. The field worksheets and request for laboratory analysis forms must clearly indicate when samples are filtered in the field. Samples for field analysis (temperature, DO, pH, conductance, ORP, alkalinity, etc.) and certain laboratory analyses (ferrous and manganous ions, sulfide, organics, turbidity, suspended solids, etc.) are never filtered. Additional details in regard to sample filtration procedures are given in section 6.2.2 of reference 3.15.

6.3.1.6 Samples collected for extremely low levels (i.e., less than one part per billion) of trace organics and/or trace elements may easily be contaminated by contact with foreign materials. Motor oil, gasoline, soft plastics, etc., may be potential sources of contamination for trace organic/pesticide sampling, while soil and dust, which is ubiquitous at fossil plants, may be potential sources of contamination for many trace elements. Reference 3.16 and section 6.3.3.5 below discuss routine precautions which are taken to minimize potential sources of contamination. The permanent installation of a groundwater sampling device in each monitoring well has many advantages. It will eliminate the possibility of the introduction of foreign material during the lowering of sampling equipment into the well and the potential for cross contamination between wells caused by the possible carryover of contaminants on the sampling equipment from one well to another. In those cases where special attention must be paid to extremely low levels of organics or trace elements, permanent installation of sampling equipment/pumps in each groundwater monitoring well is a necessity.

6.3.1.7 Unless otherwise specified in the project's workplan, duplicate groundwater samples will be collected at every 20th well (i.e., five percent of the samples). Further details in regard to collection of duplicate samples are given in section 6.15.3 of reference 3.14.

6.3.2 <u>Standardization of Field Equipment and Field Measurements</u>

6.3.2.1 FENG procedures for standardization of field instruments (reference 3.18) must be followed, as appropriate, with particular attention given to the following instruments which are commonly used by FENG in the collection of groundwater quality samples.

6.3.2.1.1 Field Instruments (reference 3.18) FENG Procedure

Hydrolabs	DS-43.2
YSI Conductivity Meters	DS-43.3
Orion pH Instruments	DS-43.7
Thermometers	DS-43.8

6.3.2.1.2 Field instruments will be standardized as specified in the above referenced procedures. At a minimum, instruments will be standardized before and after field measurements are made and whenever the accuracy of the instrument is questioned. Form TVA 30035, "Instrument Standardization, Field Standardization of Instruments," will be completed to document all field standardizations of instruments.

6.3.2.2 FENG procedures for water quality field analyses (reference 3.17) must be followed, as appropriate, with particular attention given to the following analyses which are commonly used by FENG in the collection of groundwater quality samples.

6.3.2.2.1 Water Quality Field Analyses (reference 3.17) FENG Procedure

Alkalinity and Acidity	DS-42.1
Conductance	DS-42.3
Dissolved Oxygen (DO)	DS-42.4
Oxidation-Reduction Potential (ORP)	DS-42.7
pH	DS-42.8
Temperature	DS-42.11

6.3.3 <u>Collection of Well Samples Using a Submersible Pump</u>

6.3.3.1 To obtain a representative sample of groundwater, it must be understood that the composition of the water within the well casing and in close proximity to the well is probably not representative of the overall groundwater quality at the sampling site. This is due to the possible presence of drilling contaminants near the well; introduction of foreign material from the surface, casing corrosion, and/or because environmental conditions such as the oxidation-reduction potential may differ drastically near the well from the conditions in the surrounding water-bearing materials. Consequently, each well must be flushed (purged) of standing (i.e., stagnant) water until it contains fresh water from the surrounding aquifer. The recommended length of time required to pump a well and the rate at which a well can be pumped before sampling are dependent on many factors including the physical characteristics of the well, the hydrogeological nature of the aquifer (i.e., hydraulic conductivity), the type of sampling equipment being used, and the water quality parameters of interest.

6.3.3.2 Prior to any sampling or pumping of a well, measure and record the distance to the water surface (Dws) with a tape and plunker or electric tape. Measure and record the depth of the well (Dw) with a tape and plunker. Depth measurements are usually referenced to the top of the well casing and not the outer protective casing. All data, measurements, observations, and computations are to be recorded on form TVA 30066A, "Groundwater Quality Data Field Worksheet (Chemical Data)," attachment 1. In addition, if the well to be sampled is a new well or has never been sampled, form TVA 30066B, "Groundwater Quality Data Field Worksheet (Physical Data)," attachment 2, which documents information about type of well, owner of well, location of well, well drillers log/information, etc., must also be completed.

6.3.3.3 Calculate the volume of water in the well as shown below:

Well Casing ID (inches)	Gallons Per Foot	Liters Per Foot
2.0	0.1632	0.6178
3.0	0.3672	1.390
4.0	0.6528	2.471

$$Vw \text{ (in gallons)} = (Dw - Dws) \times \text{gallons/ft}$$

or

$$Vw \text{ (in liters)} = (Dw - Dws) \times \text{liters/ft}$$

where:

Vw = Volume of well, in gallons or liters;
Dw = Depth of well, in feet; and
Dws = Depth to water surface, in feet.

6.3.3.4 If a submersible pump is not already permanently installed, such as might be the case at a private or domestic well, the preferred method of purging and sampling a well is to use a pneumatic bladder pump. However, in situations where large volumes of water must be purged from a well, resulting in long pumping times (i.e., greater than one hour), a centrifugal pump with a higher pumping capacity (1-4 gallons per minute) can usually be used instead of the lower capacity bladder pump (1-3 liters per minute). All such cases should be specifically addressed in each project's workplan. Domestic wells with a submersible pump already permanently installed can be sampled from a convenient tap or faucet after letting the water run for several minutes.

6.3.3.5 Prior to lowering the pump into the well, a large tarpaulin or heavy sheet of plastic should be spread on the ground to cover the work area. This "good housekeeping" practice will help minimize the potential for contamination caused by contact of the soil with the pump and/or pump tubing. Immediately prior to placing the pump into the well, rinse the outside of the pump and the first two feet of pump tubing with distilled water.

6.3.3.6 Carefully lower the pump to two feet below the water surface. The pump should not be lowered below the top of the well screen or to the bottom of the well unless specific instructions to do so are given in the workplan. Studies have shown that lowering the pump to the bottom of a well (below the well screen) may result in a poor flushing of the column of water above the pump if the transmissivity of the aquifer is high. In such cases the pump would be primarily removing inflowing water from the lower portion of the well casing and not effectively removing the water in the upper water column. Pumping from near the surface (and lowering the pump with the drop in the water surface) ensures that inflowing water moves up through the water column and that no stagnant water will remain in the well after purging. If the well's recharge rate is slow, the pumping rate will need to be reduced to minimize the drawdown of the water level in the well. At no time should the water level be drawn below the top of the well screen.

6.3.3.7 While purging the well, continuously monitor the time, pumping rate, and distance to water surface. The pumping rate should be adjusted to minimize the drawdown of the water surface in the well. Using a Hydrolab flow-through cell system to avoid groundwater-air contact, also monitor the groundwater's temperature, pH, DO, conductance, and ORP. Record all the stabilization test data on form TVA 30066A, "Groundwater Quality Data Field Worksheet," attachment 1, approximately every five minutes. At each well, while recording and monitoring the field stabilization test data (i.e., pumping rate, water surface, temperature, pH, DO, conductivity, and ORP), the survey leader will compare the data being collected with previously collected field data. A computer printout of the last four sets of field results, obtained from the WQU in Chattanooga, will facilitate this comparison and ensure, on the spot, that valid and comparable data are being obtained.

6.3.3.8 When at least two well volumes of water have been purged from the well and the Hydrolab readings (temperature, pH, DO, conductivity, and ORP) have stabilized, (i.e., do not change by more than 10 percent), samples may be collected. If the water quality readings have not stabilized after removal of two well volumes, remove a third well volume, then begin sampling. When filling the various sample bottles/containers, care must be taken to minimize sample aeration, and to gently fill each bottle. This will often necessitate the lowering of the pumping rate to less than one liter per minute to avoid the turbulence caused by the high velocity of the water as it is discharged from the pump tubing. Be sure to record the pumping rate, temperature, pH, DO, conductivity, ORP, etc., at the time of sample collection and record the distance to the water surface immediately upon completion of sampling.

6.3.3.9 If the well's recharge is slow, the pumping rate will need to be reduced to minimize the drawdown of the water surface level in the well. If a well becomes dry during the purging, it must be allowed to recover before sampling to avoid taking a nonrepresentative sample. It may be necessary to allow 24 hours or longer for recovery. If circumstances are encountered which are not addressed in this procedure or in the project's workplan, notify the FENG project engineer immediately for instructions.

6.3.3.10 After purging and sampling, water should be removed from the pump and tubing before sampling another well. A centrifugal pump should have the check valve removed so that water will drain back into the well when the pump is turned off. If using a bladder pump, remove the pump from the well, connect the air line to the sample line, and blow out any remaining water left in the sample line before proceeding to the next well.

6.3.4 <u>Collection of Samples Using a Bailer or Kemmerer Sampler</u>

6.3.4.1 Prior to sampling a well with a bailer or Kemmerer sampler, measure and record the distance to the water surface and the depth of the well as given in section 6.3.3.2.

6.3.4.2 Calculate the volume of water in the well as shown in 6.3.3.3.

6.3.4.3 Prior to sampling a well with a bailer or Kemmerer sampler, thoroughly flush the sampler with distilled water. Carefully lower the sampler to the water surface. Do not drop the sampler or let it free fall to the water surface, as this will cause aeration of the sample. Gently lower the sampler into the water. Trigger the Kemmerer sampler. Retrieve the bailer or sampler. Repeat this process until two well volumes of water have been removed or as specified in the project's workplan.

6.3.4.4 Collect the samples by carefully lowering the sampler to the well screen or the perforated section of the well casing or to the depth specified in the workplan. Care should be taken to avoid striking the bottom of the well with the sampler.

6.3.4.5 Fill the specified bottles/containers directly from the sampler. Slow and careful transfer is important to minimize sample aeration. Measure and record temperature, pH, DO, conductivity, ORP, and the distance to the water surface immediately after collection of the sample.

6.3.5 <u>Collection of Samples From Multilevel Sampling (MLS) Wells</u>

6.3.5.1 A typical MLS well, see attachment 3, will consist of several (often 20 to 30) small diameter, flexible sampling tubes. Each tube will have a filter, usually a nylon mesh, on the intake end of the tube with the intake ends of these tubes spaced at known distances below the ground surface. These flexible sampling tubes are housed and extend to the surface inside a PVC pipe as shown in attachment 3.

6.3.5.2 Groundwater samples will be collected from MLS wells using peristaltic 10-channel pumps (i.e., two 10-channel pumps for 20 flexible sampling tubes, three 10-channel pumps for 30 flexible sampling tubes, etc.). In all sample collections from MLS wells, the 10-channel peristaltic pumps will be used in parallel to purge all tubes and collect all samples simultaneously. Every effort will be made to collect representative and uncontaminated samples. An important consideration in obtaining a valid, representative sample is first the removal of the standing water which has been trapped in the multilevel flexible sample tubing since the last sample collection. However, to avoid stressing the aquifer and perhaps altering its natural movement, this purging of the trapped water in the tubing will be minimized. One of the reasons for using the small diameter flexible tubing is that it minimizes the amount of water which is purged. For example, one foot of 3/16-inch ID tubing contains approximately 5-1/2 mL of water. Therefore, the purging of two tubing volumes would result in the purging of approximately one liter of water from each sample tube (assuming 100-foot lengths of 3/16-inch ID tubing) prior to collection of the samples. Specific purging instructions for individual MLS wells will be detailed in each project's workplan.

6.3.5.3 To collect samples at MLS wells, connect the MLS flexible sampling tubes to the 10-channel peristaltic pump tubes by mating like numbered (colored) tubes number 1 through 30 (assuming there are 30 flexible sample tubes and that three 10-channel pumps are used).

6.3.5.4 Place waste containers beneath each sampling tube, turn on the 10-channel peristaltic pumps, and simultaneously purge all the sample tubes of stagnant water by pumping approximately two volumes of water from each sample tube. (One foot of 3/16-inch ID tubing contains approximately 5-1/2 mL of water.) Discard the purge water. Record on the field worksheets any tubes which do not produce water or produce only small quantities of water.

6.3.5.5 After purging the MLS sample tubes, place sample bottles/containers marked with sample identification numbers and in proper numerical order under each correspondingly numbered sample tube. Fill the bottles/containers to the required volume and repeat this step until all types of sample bottles (i.e., metals, minerals, nutrients, sulfide, etc.) have been collected.

6.3.5.6 During the collection of the MLS groundwater samples, it is important to keep track of the fluid volume in each of bottle/container, because each sampling tube will not discharge at the same rate. As a bottle or container reaches the proper volume of sample, the sample collector will clamp off the appropriate peristaltic pump tube while allowing the remaining bottles/containers to continue to fill. Finally, after the last bottle or container has filled and the pump tube has been clamped off, the 10-channel peristaltic pumps can be shut off.

6.3.5.7 Immediately after collection of MLS well samples, make field measurements for those water quality characteristics specified in the project's workplan (e.g., temperature, pH, DO, conductivity, ORP, alkalinity, etc.).

6.3.6 <u>Collection of Samples Using a Peristaltic Pump</u>

6.3.6.1 A peristaltic pump can be used to collect a sample from a shallow well (water surface less than 25 feet below ground surface), spring or seep.

6.3.6.2 Prior to sampling a shallow well, measure and record the distance to the water surface and the depth of the well as given section 6.3.3.2.

6.3.6.3 Calculate the volume of water in the well as shown in 6.3.3.3.

6.3.6.4 Lower the tygon or teflon tubing connected to the peristaltic pump into the water. Remove at least two volumes of water before collection of samples from a shallow well. No purging of water is necessary if collecting a sample from a spring or seep, since the water is naturally flowing.

6.3.6.4 Fill the specified containers, process the samples, and make the water quality field measurements as specified in the project's workplan. Measure (or estimate) and record the spring or seep discharge rate (or the pumping rate if sampling a shallow well) on form TVA 30066A, "Groundwater Quality Data Field Worksheet," attachment 1.

6.3.7 <u>Collection of Samples Using a Lysimeter</u> (Pressure-Vacuum Soil Water Sampler)

6.3.7.1 General Instructions--Lysimeter (pressure/vacuum soil water samplers) can generally be installed and used at any depth up to approximately 50 feet. The access tubes (i.e., pressure/vacuum tube and sample discharge tube) from the lysimeter can extend above the ground surface directly above the lysimeter, or if conditions require, the access tubes can be laid in a trench, terminating above the ground surface at some distance from the lysimeter. The ends of the access tubes should be installed so that they will be protected from damage by mechanical equipment, livestock, etc. The tube ends should be covered or plugged to prevent debris from entering the tubes and later contaminating the samples. The ground surface directly above the lysimeter should not be covered in any manner that would interfere with the normal percolation of soil moisture down to the depth of the lysimeter. Attachment 4 shows a typical lysimeter installation.

6.3.7.2 Access Tubes--The "pressure/vacuum" access tube and the "sample discharge" access tube are usually small diameter polyethylene tubes (e.g., 3/16" I.D.) that extend from the porous ceramic collection device to the ground surface. Typically the tubes are inserted through a cap or plug at the open end of the porous collection cup as shown in attachment 4. One end of the "sample discharge" tube extends nearly to the bottom of the porous ceramic collection cup with the other (discharge) end extending to the ground surface. The discharge end of this tube must be marked and identified as the tube from which the samples are collected. The "pressure/vacuum" access tube is installed slightly differently. One end of the "pressure/vacuum" tube is inserted only about an inch past the cap or plug with the other end also extending to the ground surface. The fit of the tubing through the cap or plug and the fit of the cap or plug at the open end of the porous collection cup must be tight and well seated so as to be able to maintain a pressure-vacuum seal.

6.3.7.3 Installing a Soil Water Sampler---Installation of a lysimeter can be performed in several ways. Methods for installation of a lysimeter must be specified in the project's workplan. Typically a 4-inch-diameter hole is cored using a T-handle bucket auger. The augered soil should be sifted through a 1/4-inch mesh screen to remove any larger rocks and pebbles. This sifted soil will provide a reasonably uniform backfill for filling in around the inplaced lysimeter. The following discussion details some of the more common methods for installation of a lysimeter. The primary concern in all the methods is that the porous ceramic cup of the lysimeter be in tight, intimate contact with the soil so that soil moisture can move readily from the soil through the pores of the ceramic cup where it can then be withdrawn through the sample discharge tube.

6.3.7.3.1 Native Soil Backfill Method--After the hole has been cored to the desired depth, insert the lysimeter and backfill the hole with native screened (sifted) soil, tamping continuously with a small-diameter rod to ensure good soil contact with the porous ceramic cup and to prevent surface water from channeling down the cored hole.

6.3.7.3.2 Soil Slurry Method- After the hole has been cored, mix a substantial quantity of the sifted soil from the bottom of the hole with water to make a slurry which has a consistency of cement mortar. This slurry is then poured into the bottom of the cored hole. Immediately after the slurry has been poured, push the lysimeter into the hole so that approximately the bottom third of the lysimeter is completely embedded in the soil slurry. Backfill the remaining voids around the lysimeter with sifted soil, tamping lightly with a small-diameter rod to ensure good soil contact with the lysimeter. Backfill the remainder of the hole, tamping firmly, to prevent surface water from running down the cored hole. The first set(s) of soil water samples collected after installing a lysimeter by this soil slurry method may need to be discarded to avoid differences in water chemistry between the water used to prepare the slurry and the natural soil water.

6.3.7.3.3 Sand and Soil Method--Core hole to the desired depth. Pour into the hole, to a depth of about two inches, crushed 200 mesh pure silica sand of almost talcum powder consistency (commercially available under trade names of Super-Sil and Silica Flour). Insert the lysimeter and pour in additional sand until at least the bottom third of the lysimeter is covered. Backfill the remainder of the hole with sifted native soil, tamping to ensure good soil contact with the lysimeter and to prevent surface water from channeling down between the lysimeter and the soil.

6.3.7.3.4 Bentonite-Sand-Soil Method--Core hole to the desired depth. Pour into the hole, to a depth of about two inches, a small quantity of wet bentonite clay. This will isolate the lysimeter from soil below. Next, pour in a small quantity of 200 mesh silica-sand and insert the lysimeter. Pour in additional sand until at least the bottom third of the lysimeter is covered. Backfill with sifted native soil to a level about two inches above the lysimeter, tamping lightly. Again add about two inches of wet bentonite clay as a plug to further isolate the lysimeter and guard against possible channeling of water down the hole. Finally, backfill the remainder of the hole slowly with sifted native soil, tamping continuously. Allow sufficient time for the wet bentonite clay to harden before using the lysimeter to collect soil water samples.

6.3.7.4 Collecting a Soil Water Sample--After the lysimeter has been installed, a pinch clamp is securely tightened on the sample discharge tube, and a vacuum is applied to the pressure/vacuum tube. A vacuum of approximately 60 centibars (18" of mercury) is applied. A pinch clamp is then securely tightened on the pressure/vacuum tube. The lysimeter is then left undisturbed for a predetermined period of time, determined by experience and/or trial and error.

6.3.7.4.1 The vacuum within the lysimeter causes the soil moisture to move from the soil through and into the porous ceramic cup. The rate at which the soil water will collect in the lysimeter depends on the capillary conductivity of the soil and the amount of vacuum that has been created within the lysimeter. In most soils of good conductivity, substantial soil water samples can be collected within a few hours. Under more difficult conditions it may require several days to collect an adequate volume of sample.

6.3.7.4.2 In general, vacuums of 50-85 centibars (15"-25" of mercury) are normally applied to the lysimeter. However, in very sandy soils it has been shown that high vacuums may result in a slow rate of sample collection. In coarse, sandy soils, the high vacuums may deplete the soil moisture in the immediate vicinity of the porous ceramic cup and, hence, reduce the capillary conductivity, which results in lower sample collection rates. In loam and gravelly clay loam, collection rates of 300-500 mL/day at 50 centibars (15" of mercury) are common. On waste water disposal sites, collection rates of up to 1500 mL/day have been observed.

6.3.7.4.3 To recover the soil water from the lysimeter, attach the pressure/vacuum access tube to the pressure port on a pump. Place the sample discharge tube into the sample bottle or container. Open both pinch clamps (one on the pressure/vacuum tube and one on the sample discharge tube) and gently apply pressure to develop enough pressure within the lysimeter to force the collected soil water out of the lysimeter and into the sample bottle or container.

6.3.7.4.4 Subsequent samples are collected by again creating a vacuum within the lysimeter and repeating the above steps, sections 6.3.7.4 through 6.3.7.4.3

7.0 <u>HANDLING OF SAMPLES</u>

7.1 <u>Sample Identification</u>--All sample bottles and sample containers shall be labeled with a permanent sample identification number. This sample identification number or tag number must be unique for each sample collected and must be cross referenced on all field sheets (forms TVA 30066A and 30066B), chain-of-custody forms (form TVA 11064), and laboratory analysis requests (form TVA 991). Prior to packaging and shipping of samples, all containers and bottles shall be inspected for tag numbers and cross checked against all field sheets, chain-of-custody forms, and laboratory analysis requests. Additional explanation of sample identification requirements are given in section 6.11, reference 3.14 .

7.2 <u>Packing and Shipping of Samples</u>--Sample containers should be closely protected against contamination while transporting them to the survey site, during sampling, field handling and analysis processes, and while transporting them back to the laboratory. Detailed instructions for packing and shipping the various kinds of samples are given in reference 3.7. These requirements are summarized in attachment 1 of reference 3.15. As soon as practicable, samples that are to be stored at 4°C must be packed on ice. To avoid breakage, care must be taken when packing bottles and containers in shipping chests. Copies of field sheets, sample custody records, and request for laboratory analyses must be sent to the laboratory with the samples. Check to make sure all paperwork has been accurately completed and sealed in a plastic bag to prevent water damage. All shipping containers shall be clearly addressed and shall be sealed and closed with strapping tape.

7.3 Holding Times--The time which elapses between sample collection and sample analysis is critical for many constituents (e.g., BOD, ortho-phosphorus, turbidity, nitrite, etc.). So that the laboratory can complete the analyses within the appropriate holding times, samples must be shipped or transported so as to arrive within the time limits given in attachment 1, reference 3.15. Any time samples are to be collected with holding times less than 48 hours, the laboratory must be notified in advance. All collections of samples should be coordinated with the laboratory.

7.4 Chain-of-Custody--The sample collector is responsible for the care and custody of the samples until they are properly dispatched to the receiving laboratory. The sample collector will ensure that each sample is under his/her control at all times. When samples are dispatched to the laboratory for analyses, the sample collector will retain a copy to the completed sample custody record(s) and request for laboratory analysis form(s), the originals of which accompany the samples. All samples shipped to the laboratory will be listed on the sample custody form, cross referenced with their unique sample tag (identification) number. The sample custody form will record the name and telephone number of the sample collector/shipper and the date of shipment. Shipping record receipts for shipments (UPS, Greyhound bus, etc.) will be retained by the sample collector/shipper as part of the permanent chain-of-custody documentation. Upon receipt, the laboratory will inspect for the shipping container for broken seals and will inspect the samples for breakage, missing samples, tampering, etc. The laboratory will verify all samples by cross referencing tag numbers between the sample custody record and the sample bottles received to ensure that all samples which were shipped have been received complete and intact. The laboratory will immediately notify the sample collector/shipper of any discrepancies.

7.5 Field Data Worksheets--Copies of all field data worksheets will be sent to the WQU in Chattanooga. Section 8.3 gives additional details.

8.0 RECORDKEEPING

8.1 Project Notebooks

8.1.1 A project field notebook and/or file shall be maintained by the FENG survey leader to record pertinent information and observations. The project field notebook accompanies the survey leader to the field. The survey leader shall record and/or file all physical measurements and field analyses performed in the project notebook/file. In addition, auxiliary data often prove very useful in the interpretation of the results. Thus, water surface elevations of nearby ash ponds, basins, lakes, streams, etc., gas bubbles in the sample line, rapid development of turbidity or color in the sample, equipment problems, clogged sampling ports at MLS wells, weather conditions, deviations from workplans or this procedure, or any number of other observations could prove very helpful and should be recorded. Project field notebooks, should there be a change in personnel, should include all information necessary to properly conduct the field survey. At a minimum this would include: the original project workplan with all revisions; sample identification (tag) numbers and descriptions of the well locations; copies of past survey field worksheets and groundwater level observations; computer printouts of prior field data; a survey equipment checklist; and all field instrument calibration records. Also included in the field notebook might be maps, sample collection and handling instructions, bus schedules, names and telephone number of project personnel, and any miscellaneous notes to aid in conducting the survey.

8.1.2 A project office notebook and/or file are maintained by the FENG project engineer. The project office notebooks remain in the office at all times and are available for reference by FENG, client, and other project organizations. In addition to containing the original project workplan and all revisions, it should contain information relating to the project such as memoranda, budget estimates, progress reports, data reports, correspondence with client organizations, etc.

8.2 Survey Reports--Following completion of each groundwater field survey, the FENG survey leader will prepare a brief (usually handwritten) report to the FENG project engineer which will be filed in the project office notebook. The report shall contain:

a. Copies of all field worksheets;
b. Survey dates and personnel participating in the survey;
c. A statement certifying that all samples were collected as specified in the workplan or, if such was not the case, a detailed listing of any omissions or deviations from the workplan;
d. Identification of equipment failures or malfunctions and recommendations for additional equipment needed to complete the survey more efficiently;
e. A brief discussion of observations made during the survey, any problems encountered, and recommendations for improving data quality;
f. All observations made (i.e., environmental, photographs, physical, etc.) that could in any way affect the interpretation of the data that were not specifically recorded on the field forms and which need to be brought to the project leader's attention; and
g. A detailed explanation of any overtime incurred.

8.3 Disposition of Forms

8.3.1 Forms TVA 30066A and B, Groundwater Quality Data Field Worksheets, attachments 1 and 2, are used any time physical and/or chemical groundwater measurements are made. The original is sent to and is filed by the WQU in Chattanooga. Copies are retained by FENG and the client organization(s).

8.3.2 Form TVA 11552, Groundwater Level Measurements (Field), attachment 5, is used any time groundwater elevations are observed or recorded on ash ponds, coal pile runoff ponds, metal cleaning waste ponds, rivers, lakes, etc. The original is sent and is filed by the WQU in Chattanooga. Copies are retained by FENG and the client organization(s).

8.3.3 Form TVA 991, Request for Analysis, is used for samples requiring laboratory analyses. It specifies which analyses are to be performed or which workplan is to be followed for sample analyses. The original is sent with the samples to the laboratory, one copy is retained by FENG, and one copy is sent to WQU. Reference 3.15 contains an example of form TVA 991.

8.3.4 Form TVA 11064, Sample Custody Record, is used any time samples are shipped or delivered to the laboratory to ensure that the proper number and types of samples, as specified in the project workplan, are in fact received by the laboratory. The original is sent with the samples to the laboratory, and one copy is retained by FENG. Reference 3.15 contains an example of form TVA 11064.

8.3.5 Retention periods and file locations for these forms are given in attachment 6.

LIST OF ATTACHMENTS

1. Groundwater Quality Data Field Worksheet (Chemical Data), form TVA 30066A.
2. Groundwater Quality Data Field Worksheet (Physical Data), form TVA 30066B.
3. Schematic Drawing of a Multilevel Sampling (MLS) well.
4. Typical Lysimeter Installation.
5. Groundwater Level Measurements (Field), form TVA 11552.
6. Records (Use, Distribution, and Retention).

Attachment I

Ground Water Quality Data Field Worksheet

(Chemical Data)

Collected By: ______ Project Name: ______

Collection Date: ______ Acct. No.: ______

Sample Tag No.: ______ Well ID: ______

Collection Method: Bladder Pump ______ Centrifugal Pump ______ Bailer ______ Kemmerer ______

Stabilization Test: Start Time: ______ End Time: ______

W.S. Elevation: ______ W.S. Elevation: ______

Description of RP: ______

Time (min)	Pump Rate	Water Surface (ft)	Temperature (°C)	pH	DO (mg/L)	Conductivity (μmhos/cm)	ORP (mV)

Sample Field Measuremments (at time of sample collection):

Time: ______

Temperature (°C) ______ Phenol Alkalinity (mg/l) ______

pH ______ Total Alkalinity (mg/l) ______

ORP (mV) ______ Conductivity (μmhos/cm) ______

DO (mg/l) ______ Odor ______

Total Acidity (mg/l) ______ Sample Color ______

Sample Turbidity: Clear ______ Slightly Turbid ______ Turbid ______ Highly Turbid ______

Remarks: ______

Volume of water in well casing: ______

Volume of purged well water: ______

Reviewed by ______ Date ______

Attachment 2

Ground Water Quality Data Field Worksheet
(Physical Data)

Project ______________________________

Well Name/Number ______________ Spring Name/Number ______________

Owner's Name ______________________________

Address ______________________________

Phone Number ______________

Well/Spring Information

Lat __________ Long __________ State __________

Location ______________________________

Well Depth (ft.) ______________________________

Depth of Well Screen (ft.) ______________________________

Approximate Water Surface Depth (ft.) ______________________________

Description of Reference Point Used to Make Depth Measurement ______________________________

____

Elevation of Reference Point (MSL-ft.) ______________________________

Water Use ______________________________

Volume of Water Use (GPD) ______________________________

Type Casing ______________________________

Casing Dimensions ID __________ (in) OD __________ (in) Length __________ (ft)

Does well have permanently installed pump? ________ If so, type of pump __________

capacity (gpm) __________, discharge flow rate (gpm) __________

Well Drillers Log Data

(Attach sketch and/or provide written detailed description)

Remarks: ______________________________

____

____

____

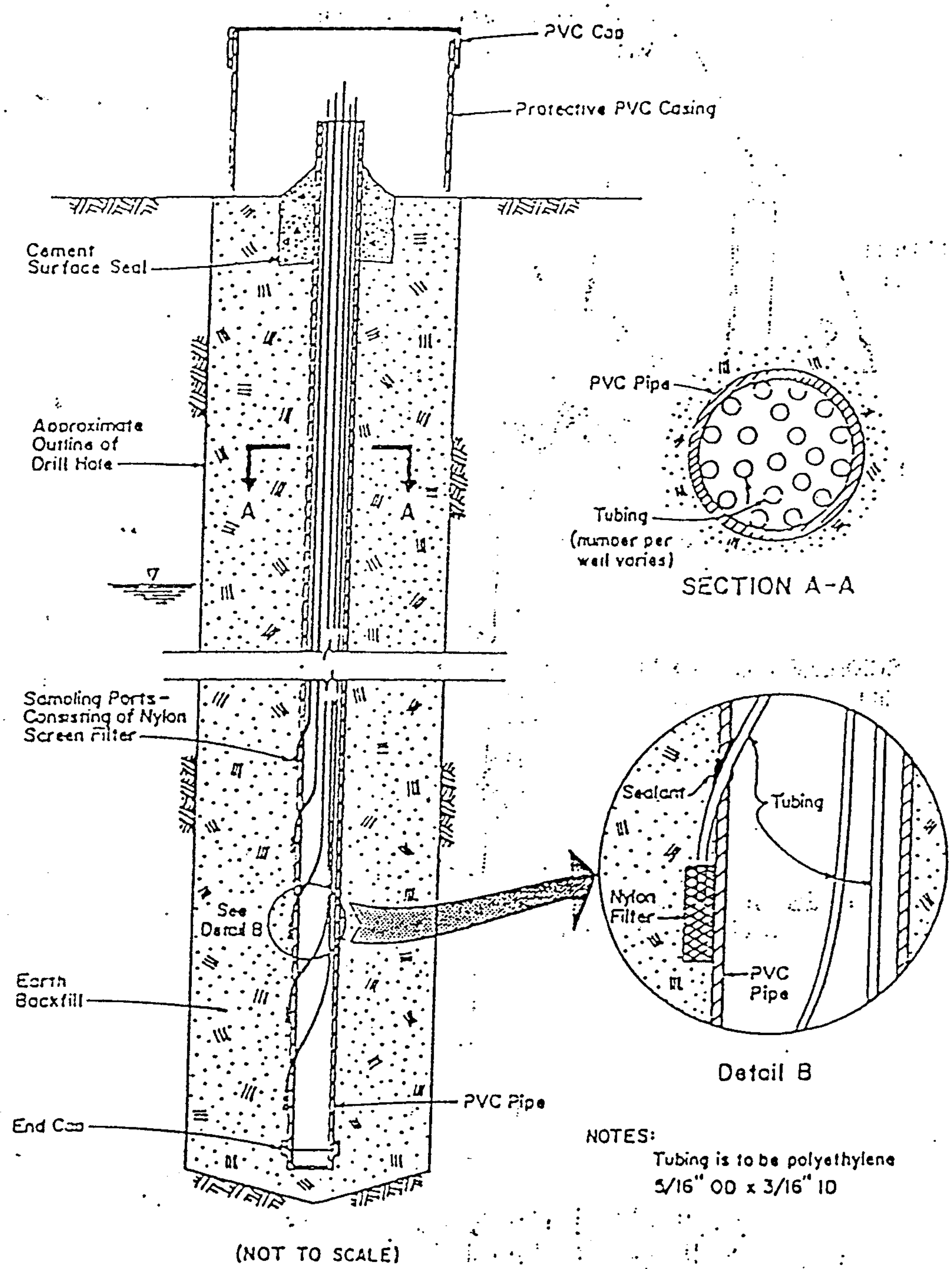
____

TVA 30044E INROPS-1-481

Reviewed by ______________ Date __________

Attachment 3

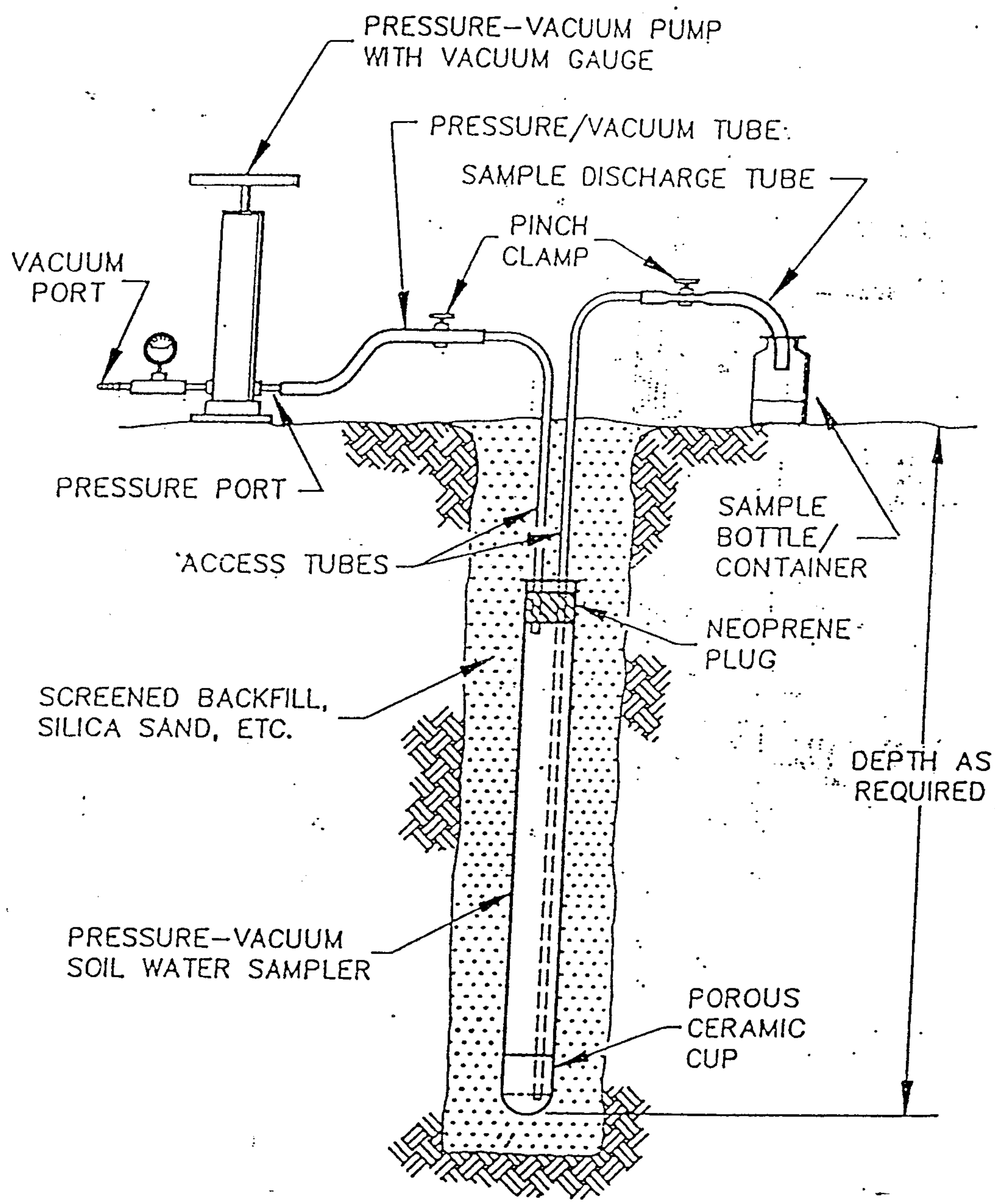
Schematic Drawing of a Multilevel Sampling (MLS) Well



NOTES:
Tubing is to be polyethylene 5/16" OD x 3/16" ID

Engineering Lab-Nov 1987

Attachment 4



TYPICAL LYSIMETER INSTALLATION
(PRESSURE–VACUUM SOIL WATER SAMPLER)

Attachment 5

Tennessee Valley Authority
Division of Natural Resources Services
Ground-Water Level Measurements (Field)

Date
Location
Measured by

Well No.	Elev. of M.P.	W.L. Below M.P.	W.L. Elev. M.S.L.	Remarks:

Abbreviations: M.P.: Measuring Point (top of casing, etc.)
W.L.: Water Level
M.S.L.: Mean Sea Level

TVA 11552 (NRS-5-79)

Attachment 6

Records (Use, Distribution, and Retention)

Record	Use	Distribution	Retention Location	Retention Time[a,b]
TVA 30066A/B	GW Quality Data Field Worksheet (Chemical/Physical Data)	. Original forwarded to WQU . Copy 1 retained by FENG . Copy 2 forwarded to client	. WQU files (STORET) . FENG project notebook . Client files	. 20 years . 1 year . As needed
TVA 11552	Groundwater Elevations (piezometers, well, water bodies, etc.)	. Original data forwarded to to DHGT and/or WQU . Copy 1 retained by FENG . Copy 2 forwarded to client	. DHGT/WQU files . FENG project notebook . Client files	. 20 years . 1 year . As needed
TVA 991	Request for Analysis	. Original forwarded with samples to laboratory . Copy 1 retained by FENG . Copy 2 forwarded to WQU	. Laboratory files . FENG project notebook . WQU files	. 1 year . 1 year . 2 years
TVA 11064	Sample Custody Record	. Original forwarded with samples to laboratory . Copy retained by FENG	. Laboratory files . FENG project notebook	. 1 year . 1 year
Various	Laboratory Results	. Original results forwarded to WQU by laboratory . Copy 1 forwarded to FENG by WQU . Copy 2 forwarded to client by FENG/WQU (after review)	. WQU files (STORET) . FENG project notebook . Client files	. 2 years . 1 year . As needed

a. Retention time for STORET-related data and field worksheets is 20 years.

b. Retention time for STORET-related laboratory results report forms is 2 years beyond project completion.

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APPENDIX E

PROBABLE CLOSURE COSTS

COST ESTIMATE

WORK SHEET A:

CLOSURE ACTIVITIES

NOTES:
1) This worksheet is to be submitted as part of the C/PC Plan.
2) Provide a cost for all activities which apply.
3) Additional cost information may be attched as needed.

1. Establishing final cover:

A. Top soil

1.	Quantity needed (cu. yd.)	62,500
2.	Excavation unit cost ($/cu. yd.)	$3
3.	Excavation cost (1. x 2.)	$187,500
4.	Placement and spreading unit cost ($/cu. yd.)	$7
5.	Placement cost (1. x 4.)	$437,500
*TOTAL:	Top soil (3. + 5.)	$625,000

B. Landfill cap

1. On–site Clay

a.	Quantity needed (cu. yd.)	
b.	Excavation unit cost ($/cu. yd.)	
c.	Excavation cost (a. x b.)	
d.	Placement/ spreading unit cost ($/cu. yd.)	
e.	Placement cost (a. x d.)	
f.	Compaction unit cost ($/cu. yd.)	
g.	Compaction cost (a. x f.)	
*TOTAL:	On–site clay (c. + e. + g.)	N/A

2. Off–site clay

a.	Quantity needed (cu. yd.)	62,500
b.	Purchase unit cost ($/cu. yd.)	$1
c.	Purchase cost (a. x b.)	$62,500
d.	Delivery unit cost ($/cu. yd.)	$4
e.	Delivery cost (a. x d.)	$250,000
f.	Placement/ spreading unit cost ($/cu. yd.)	$2
g.	Placement cost (a. x f.)	$125,000
h.	Compaction unit cost ($/cu. yd.)	$1
i.	Compaction cost (a. x h.)	$62,500
*TOTAL:	Off–site clay (c. + e. + g. + i.)	$500,000

3. Quality control/testing of clay

a.		
b.		
c.		
*TOTAL:	Clay testing (c.) (L.S.)	$20,000

C. Synthetic membrane
1. Quantity needed (sq. yd.) ______
2. Purchase unit cost ($/sq. yd.) ______
3. Purchase cost (1. x 2.) ______
4. Installation unit cost ($/sq. yd.) ______
5. Installation cost (1. x 4.) ______

*TOTAL: Synthetic membrane (3. + 5.) N/A

D. Geotextile filter fabric
1. Quantity needed (sq. yd.) ______
2. Purchase unit cost ($/sq. yd.) ______
3. Purchase cost (1. x 2.) ______
4. Installation unit cost ($/sq. yd.) ______
5. Installation cost (1. x 4.) ______

*TOTAL: Geotextile filter fabric (3. + 5.) N/A

TOTAL for establishing final cover (*): (A. + B. + C. + D.) $1,145,000

2. Establishing vegetation cover:
A. Labor ($/acre) $350.00
B. Seeding ($/acre) $350.00
C. Fertilizing ($/acre) $250.00
D. Mulching ($/acre) $50.00
E. Number of acres 69

TOTAL for establishing vegetation cover: E. x (A. + B. + C. + D.) $69,000

3. Establishing or completing a system to minimize and control erosion/sedimentation:
A. Sediment pond
1. Excavation/construction ($) ______
2. Materials (e.g. pipe, riprap) ($) ______

*TOTAL: (1. + 2.) N/A

B. Diversion ditch
1. Construction ($) ______
2. Materials ($) ______

*TOTAL: (1. + 2.) N/A

C. Temporary structures (e.g. silt fence, swales)
1. Construction ($) ______
2. Materials ($) ______

*TOTAL: (1. + 2.) N/A

TOTAL for establishing or completing a system to minimize and control erosion and sedimentation (*): (A. + B. + C.) N/A

4. Establishing or completing leachate collection removal, and treatment system:

A. Installation

1.	Number of feet	
2.	Piping system unit cost ($/ft)	
3.	Piping system cost (1. x 2.)	
4.	Storage tanks ($)	
5.	Pumps ($)	

TOTAL for establishing or completing leachate system: (3. + 4. + 5.) — N/A

5. Establishing or completing a system to collect or vent gases:

A. Installation

1.	Materials (e.g. piping)	
2.	Equipment (e.g. pumps)	
3.	Labor (e.g. drilling)	

TOTAL for establishing or completing a system to collect or vent gases: (1. + 2. + 3.) — N/A

6 Establishing or completing groundwater/surface water monitoring system:

A. Installation

1.	Number of wells	
2.	Drilling unit cost ($/well)	
3.	Drilling Cost (1. x 2.)	
4.	Materials unit cost (e.g. casing) ($/well)	
5.	Materials (1. x 4.)	
6.	Equipment (e.g. pumps)	
7.	Labor	

TOTAL for establishing or completing groundwater monitoring system: (3. + 5. + 6. + 7.) — N/A

TOTAL CLOSURE COSTS: (Sum of TOTALS for Sections 1. thru 6.) — $1,214,000

COST ESTIMATE

WORK SHEET B:

POST CLOSURE ACTIVITIES

Notes:

1) This worksheet is to be submitted as part of the C/CP Plan.

2) The facility will be maintained and monitored for 30 years after final closure fo Class I and II landfills and 2 years after final closure of Class III and IV landfills.

3) Fill in blanks for all activities which apply.

4) All costs are to be calculated on an ANNUAL BASIS.

1. Survey inspections to confirm final grade and drainage are maintained:

A.	Transportation	INCLUSIVE
B.	Labor	INCLUSIVE
	TOTAL for Surveying inspections: (A. + B.)	$12,000

2. Maintain healthy vegetation:

A.	Transportation	INCLUSIVE
B.	Labor	$3,000
C.	Seeding	$3,000
D.	Fertilizing	$2,100
E.	Mulching	$500
F.	Rodent Control	N/A
G.	Mowing	$12,000
	TOTAL for Maintaining healthy vegetation: (A. + B. + C. + D. + E. + F. + G.)	$20,600

3. Maintain the drainage facilities, sediment ponds and other erosion/sedimentation control measures:

A.	Transportation	N/A
B.	Labor	6,000
C.	Cleaning out of systems	6,000
D.	Repair of gullies or rills	
	1. Soil aquistion	
	a. Quantity	1,200
	b. Purchase unit cost ($/cu. yd.)	$1
	c. Purchase cost (a. x b.)	$1,200
	d. Delivery unit cost ($/cu. yd.)	$4
	e. Delivery cost (a. x d.)	$4,800
	Total 1: (c. + e.)	$6,000
	2. Placement/spreading/compaction	$2,500
	3. Revegetation	$4,000
	Total D: (1. + 2. + 3.)	$12,500
	TOTAL for Maintaining drainage: (A. + B. + C. + D.)	$24,500

4. Maintain and monitor the leachate collection, removal and treatment system:

A. Treatment of leachate

1. On–site
   - a. Quantity (cu. yd.) ________
   - b. Treatment unit cost ($/cu. yd.) ________
   - c. Treatment costs (a. x b.) ________
   - d. Sewer discharge unit cost ________
   - e. Discharge cost (a. x d.) ________
   - Total 1: On–site (c. + e.) N/A
2. Off–site
   - a. Quantity (cu. yd.) ________
   - b. Hauling unit cost ($/cu. yd.) ________
   - c. Hauling cost (a. x b.) ________
   - d. Treatment unit cost ($/cu. yd.) ________
   - e. Treatment cost (a. x d.) ________
   - Total 2: Off–site (c. + e.) N/A

*TOTAL: (1. or 2. Total) N/A

B. Maintenance of leachate collection system:

1. Transportation ________
2. Labor ________
3. Repairs/Materials (e.g. below)
   - a. Pumps ________
   - b. Cleaning out system ________
   - c. Leak detection ________
   - d. Other ________
   - Total 3: (a. + b. + c. + d.) ________

*TOTAL: (1. + 2. + 3.) N/A

TOTAL for Monitoring and maintaining leachate system (*): (A. + B.) N/A

5. Maintain and monitor the gas collection or venting system:

A. Transportation ________

B. Labor ________

C. Repairs/Materials (e.g. below)

1. Cleaning ________
2. Caps ________
3. Other ________

Total: (1. + 2. + 3.) ________

TOTAL for Maintaining and monitoring gas control system: (A. + B. + C.) N/A

6. Maintain and monitor the groundwater and/or surface water monitoring system:

A.	Monitoring of groundwater systems:	
1.	Number of wells/springs	5
2.	Number of samples/well	2
3.	Unit cost of analysis	$1,000
4.	Cost of sampling + analysis (1. x 2. x 3.)	$10,000
5.	Labor cost per well	INCLUSIVE
6.	Labor costs (1. x 5.)	INCLUSIVE
*TOTAL A:	(4. + 6.)	$10,000
B.	Inspection and maintenance of system:	
1.	Transportation	N/A
2.	Labor	$4,000
3.	Repairs/Materials	
a.	Caps	$400
b.	Tubing	$400
c.	Pumps	$400
d.	Well replacement	$400
e.	Other	$400
Total 3:	(a. + b. + c. + d. + e.)	$2,000
*TOTAL B:	(1. + 2. + 3.)	$6,000
TOTAL for Maintaining and monitoring groundwater systems (*):	(A. + B.)	$16,000

TOTAL POST CLOSURE COSTS:

Annual Basis: (Sum of Sections 1. thru 6.)	$73,100
Inflation Rate Utilized:	5.00%
30 Year Basis: (Annual cost) (Inflation rate) (30 yrs.)	4,856,680

NOTE: If desired because of anticipated cost or inflation fluctuations, we recommend submitting a separate sheet with the year–by–year annual costs (30 year breakdown) for maintaining and monitoring facility.

APPENDIX F

BACKGROUND GROUNDWATER MONITORING REPORT

CLEAN OUT AND DRY STACK RAILROAD LOOP DREDGE CELL
PCN 4629
22JUN93
FLUOR ESTIMATE

ITEM	QUANTITY	UOM	UNIT PRICE	START DATE	END DATE	TOTAL COST
MOBILIZATION	0		$0.00			$0
EXCAVATE AND PLACE ASH	300000	CY	$1.87			$561,000
FLOWABLE FILL	300	CY	$77.50			$23,250
6" INTERIM EARTH COVER	16500	CY	$5.75			$94,875
FINAL COVER	49500	CY	$5.75			$284,625
SEED AND MULCH	29	ACRE	$2,600.00			$75,400
EXCAVATE DITCHES	72000	CY	$1.35			$97,200
*FILL DITCHES	28000	CY	$5.65			$158,200
RIPRAP DITCHES	6000	CY	$14.00			$84,000
ROAD CONSTRUCTION						
A) EARTH (IN FINAL COVER)						
B) STONE	3100	CY	$15.16			$46,996
*SURVEY (SUB-CONTRACT)	54	HR	$65.00			$3,510
TOTAL PHASE I COSTS						**$1,429,056**

* ITEMS NOT ON ORIGINAL WORKSHEET

INFORMATION FURNISHED BY FLUOR (LARRY LEE)

ASSUMED START OF PROJECT 7/1/93

EJ REED

ATTACHMENT 1

AREA 2

JOHNSONVILLE FOSSIL PLANT
PARTIAL CLOSURE OF DRY ASH STACK RAILROAD LOOP-1993/94

General

The Partial dry ash stacking in railroad loop area is located approximately 800 feet east of the plant, the area 2 contains approximately 29 acres. The Partial stacking operation is schedule for completion soon at which the facility must be closed according with the DSWS solid waste regulation (March 18, 1990) the dredged ash disposal facility (Rail Loop Area) must be closed by March 18, 1994. This project will be to close the stacking facility according to the state permit by:

1. Finish grading of the ash stack in preparation for placement of the clay cap.
2. Placement of a 12" minimum thickness compacted clay cap (60,000 +/- cubic yard on approximately 29 acres).
3. Placement of a 12" minimum thickness soil cover (60,000 +/- cubic yards on approximately 29 acres) to support vegetative growth.
4. Establish a good vegetative cover over the complete area.

This work is to be performed by a contractor to be hired by TVA.

Scope of Work for Quality Assurance/Quality Control (QA/QC)

The QA/QC shall be performed by a contractor independent of the construction contractor. The QA/QC shall be performed in accordance with Section III-Quality Assurance/Quality Control of "CLOSURE/POST-CLOSURE PLAN PARTIAL CLOSURE OF DRY ASH STACK RAILROAD LOOP-1993/94 TENNESSEE VALLEY AUTHORITY JOHNSONVILLE FOSSIL PLANT" (see attachment 2). This work will include, but not necessarily be limited to, earthfill testing, earthfill borrow source testing, moisture density tests, earthfill construction oversight, remedial action procedures, clay cap thickness verification, quality control documentation, daily log, and final report.

TVA request that the same QA/QC inspector be used for all inspections. Also, QA/QC reports must be provided for the weekly meeting

It is anticipated that the QA/QC work will begin as early as July 26, 1993, and extend approximately 22 weeks.

ATTACHMENT 1

JOHNSONVILLE FOSSIL PLANT
PARTIAL CLOSURE OF DRY ASH STACK RAILROAD LOOP-1993/94

General

The Partial dry ash stacking in railroad loop area is located approximately 800 feet east of the plant. The area to be stacked on is Area 2 which is approximately 29 acres. The Partial stacking operation is schedule for completion soon at which the facility must be closed according with the DSWS solid waste regulation (March 18, 1990) the dredged ash disposal facility (Rail Loop Area) must be closed by March 18, 1994.

This initial stacking operation will consist of the following:

1. Finish grading of the ash stack in preparation for placement of the clay cap.
2. Placement of a 12" minimum thickness compacted clay cap (66,000 +/- cubic yard on approximately 29 acres).
3. Placement of a 12" minimum thickness soil cover (66,000 +/- cubic yards on approximately 29 acres) to support vegetative growth.
4. Establish a good vegetative cover over the complete area.
5. Flowable fill
6. Road Construction
7. Drainage
8. Temporary cover

This work is to be performed by a contractor to be hired by TVA.

Scope of Work for Quality Assurance/Quality Control (QA/QC)

The QA/QC shall be performed by a contractor independent of the construction contractor. The QA/QC shall be performed in accordance with Section III-Quality Assurance/Quality Control of "CLOSURE/POST-CLOSURE PLAN PARTIAL CLOSURE OF DRY ASH STACK RAILROAD LOOP-1993/94 TENNESSEE VALLEY AUTHORITY JOHNSONVILLE FOSSIL PLANT" (see attachment 2). This work will include, but not necessarily be limited to, earthfill testing, earthfill borrow source testing, moisture density tests, earthfill construction oversight, remedial action procedures, clay cap thickness verification, quality control documentation, daily log, and final report.

TVA request that the same QA/QC inspector be used for all inspections. ~~Also~~, QA/QC reports must be provided for the weekly meeting

It is anticipated that the ash stacking work will begin as early as July 26, 1993, and extend approximately 22 weeks.

1. [illegible] the [illegible] given in the design [illegible].

2. [illegible] party independent of the [illegible]

B. [illegible]

(1) [illegible]
(1-[illegible] [illegible] of [illegible])

a) [illegible] hydraulic [illegible]
[illegible]

b) soil classification of CH or [illegible]
[illegible]

(A) [illegible]

a) [illegible] taken [illegible] every [illegible]

b) [illegible]
1) [illegible] — 22 [illegible] (ASTM D6[illegible])
2) [illegible] (ASTM [illegible])
[illegible] (ASTM D4318)

(2B) [illegible]

a) [illegible] for each [illegible]

b) [illegible]
1) [illegible] (ASTM [illegible] 9100)
2) [illegible] by [illegible]

(3) [illegible]

a) [illegible]

b) [illegible] 1×10[illegible] [illegible]) (ASTM D6[illegible])

c) [illegible]
[illegible]
(D) [illegible] ([illegible])

e) [illegible]

f) [illegible]

g) [illegible]

h) [illegible]

i) [illegible]
(3:1 [illegible])

j) [illegible]

D. [illegible]

Any [illegible] and [illegible] [illegible] [illegible] [illegible] of [illegible]

[illegible]

2. [illegible]

3. [illegible]

4. [illegible]

5. [illegible]

6. [illegible]

7. [illegible]

f) [illegible]
[illegible] will [illegible] [illegible] than [illegible]

a) [illegible] for [illegible]

b) [illegible] 1 ft - 5 cm of cap
[illegible]

→ c) [illegible]

d) [illegible] & cell [illegible]

e) [illegible] shall be [illegible]

f) verify [illegible]
[illegible] cap

g) verify [illegible]

h) verify [illegible] (bypass [illegible])

C. [illegible] Placement
1) Confirmation [illegible]
a) [illegible] to be [illegible] to the [illegible] (allowing [illegible] earth cap)
b) It may be [illegible] the [illegible] and grade [illegible] area 2.
c) designate [illegible] with 20 [illegible]