DOE/OR/21548-411
CONTRACT NO. DE-AC05-86OR21548

CONCEPTUAL DESIGN REPORT FOR REMEDIAL ACTION AT THE CHEMICAL PLANT AREA OF THE WELDON SPRING SITE, VOLUME II TECHNICAL INFORMATION DOCUMENT
BOOK 5 OF 5

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

JANUARY 1994

REV. 0

U.S. Department of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

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Weldon Spring Site Remedial Action Project

Conceptual Design Report, for Remedial Action at the Chemical Plant Area of the Weldon Spring Site, Volume II Technical Information Document
Appendixes A and B
Book 5 of 5

Revision 0

January 1994

Prepared by

MK-FERGUSON COMPANY
and
JACOBS ENGINEERING GROUP
7295 Highway 94 South
St. Charles, Missouri 63304

for the

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
Under Contract DE-AC05-86OR21548

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Conceptual Design Report, for Remedial Action at the Chemical Plant Area of the Weldon Spring Site, Volume II Technical Information Document

Book 1 of 5 contains Sections 1-5

Book 2 of 5 contains Sections 6-12

Book 3 of 5 contains the figures for all sections

Book 4 of 5 contains the tables for all sections

Book 5 of 5 contains Appendix A, Unpublished Documents, and Appendix B, Acronyms

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APPENDIX A
Unpublished Documents

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R-C. Environmental Serivces and Technologies, March 4, 1992. Subject: EST Proposal P508068.

Enger, J., February 12, 1993. Subject: *Summary of On-Site Flocculation-Settling Tests of Raffinate Pit Sludges.*

Enger, J., March 10, 1993. Subject: *Comprehensive Analytical Results of On-Site CSS Testing.*

John Zinc, Co., December 4, 1991. Document No. 3840-D:EN-L-08-6954-00.

Powers, J.R., July 31, 1992. Subject: *Off-Site Release Guidelines.*

Powers, J.R., November 3, 1992. Subject: *Revised Waste Quantities Quarterly Report: 10/01/92 - 12/31/92.*

Schmidt, Glen, August 12, 1992. Radon Emanation Test Procedure and Results

Uhlmeyer, T., September 9, 1992. Subject: *Land Disposal Restriction Table.*

Warbritton, K. and J. Carman, November 23, 1992. Subject: *Technical Memorandum Presenting Results of Recent Laboratory and Field Permeability Tests.*

3840-D:EN-L-08-6944-00

R-C Environmental Services & Technologies

A Research-Cottrell Company

My direct dial number is 908-685-4771

March 4, 1992

Mr. Jim Pickett
Environmental Specialist
Morrison Knudsen Corporation
P.O. Box 73
Boise, Idaho 83729

RE: EST Proposal P508068
3840-D:PM-Y-08-7085-00

Dear Mr. Pickett:

Research-Cottrell is pleased to submit this Order of Magnitude Proposal for the removal of NO_X and SO_2 from the off-gas generated by vitrifying mixed hazardous waste in melters.

In order to achieve 60-70% NO_X and 70-80% SO_2 removal, NO_XOUT solution and calcium hydroxide are used as reagents. The by-products such as calcium sulfate and sulfite, particulate and some un-reacted lime will be dishcarged from the baghouse. In addition to SO_2 and NO_X removal metals such as mercury and others are adsorbed on Tesisorb in a dry venturi before the baghouse.

Research-Cottrell has extensive experience in emission control from various processes and incinerators. Our units have demonstrated extremely low emission levels for acid gases, particulates, heavy metals and dioxins/furans.

Please feel free to call us if you have any questions regarding your review of this proposal.

Very truly yours,

Nicholas Confuorto
Director
Process & Engineered Systems

NC/pam

Attachments

H:\WP51\P508068

3840-D:PM-Y-08-7085-00

Proposal P508068
March 4, 1992

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1.0 INTRODUCTION

R-C Environmental Services & Technologies is pleased to submit this proposal for the design, fabrication, and delivery of equipment for the removal of NO_x and some metals from off-gases produced from Vitification operation conducted in melters.

The proposed air pollution control system is based on NO_xOUT and the R-C Teller dry scrubbing process. Different variations of the process have been in operation in over 200 installations since the early 1970's. The proposed design also incorporates Research-Cottrell's extensive experience in air pollution control systems in U.S. as well as worldwide applications.

The R-C Teller process has demonstrated the lowest emission levels for SO_2, NO_x, HF, particulates, heavy metals. Recent data from the City of Commerce, California (300 TPD) has demonstrated over 98.5 percent removal of SO_2 and HCl, and particulate emissions less than 0.05 gr/dscf.

1.1 INLET CONDITIONS

Contaminant	Mass Flow (lbs/hour)
Solids	175.7
Lead	8.1
Arsenic	11.6
Cadmium	3.8
Selenium	.9
Mercury	.2
H_2O	20%
NO_2 NO_x	161.0
SO_2	84.4
HC	.2
HF	1.8
Temperature	1500°C
Flow	1600 ACFM

2.0 PROCESS

2.1 Processes Off-Gas Treatment and NO_xOUT Solution Injection

The mixed hazardous waste is continuously fed to the Vitrification melter. Due to presence of Silicates in soil and some other components, possibily, added to produce molten glass map at a temperature of 1500°C. The molten glass encapulates the radioactive waste and discharges from the bottom of the melter to specially designed stainless steel cyclinders. The off-gas leaving melter at 1500°C and possibily under a slight vacuum carries some molten glass also. R-C EST process will cool the off-gas and treat for NO_x removal in a manner as described below:

Schematic I presents the unit operations and processes that are utilized for such gases. Off-gas from the melter is cooled to 1800-1500°F by directly injecting atmospheric air. A NO_xOUT solution is injected at a temperature of 1700°F, a perfect temperature window for NO_x removal. The off-gas is cooled further by exchanging the heat with saturated off-gas exiting the submerged scrubber at approximately 150 to 160°F. The submerged off-gas is heated to 450°F but it still has high humidity. For SO_x removal based on R-C Teller System, this gas is dried to contain a moisture level of .1 lb of H_2O/lb of dry gas. The dried gas then proceeds to R-C Teller System (Schematic II attached).

The water removed from the SBR is returned to the plant because of its radioactive nature.

2.2 R-C Teller System

The proposed system for controlling the emission from vitrification melters consists of the following:

1. Quench Reactor
2. Dry Venturi
3. Baghouse
4. ID Fan & Stack (by others)
5. HEPA Filters

2.2.1 Quench Reactor

It is a cylindrical vessel designed to remove the sulfur dioxide and cool the hot off-gas from the melters to a desired reaction temperature.

Calcium hydroxide droplets from three fluid nozzles are used for cooling the gas. Adequate residence time is provided with the specially designed vessel to avoid the wet bottom potential and achieve the desired air pollutants removal.

The specifically designed nozzle assemblies include a constant purge air around the spray nozzle so that nozzle overheating is minimized and as a result nozzle life is extended.

Special alloys are used to minimize corrosion and provide the most maintenance free and reliable system available.

2.2.2 Dry Venturi™

Dry Venturi™ is a spool piece in the ductwork. Tesisorb® along with the reagents is injected into the Dry Venturi™ to capture the submicron particulates as well as the hydrocarbon. From the recent experience in operating a similar system, the gas from meters contains a small amount of radionuclides, mercury and other metals. A very high humidity in the gas can blind filter bags in the baghouse. Dry Venturi™ provides the first stage of neutralization of the acid gases. The pressure drop across the Dry Venturi™ is approximately 1 IWC.

2.2.3 Baghouse

The Baghouse has been used since the temperature entering baghouse is below fusion temperature. The Baghouse acts as a reactor for additional removals of SO_2, and a final particulate collecting device. The particulate cake also acts as a fixed bed reactor for continuing and completing the acid gas neutralization process. In addition, a long cleaning cycle is established with low pressure drop across the baghouse.

2.2.4 I.D. Fan

One (1) I.D. Fan rated at 85 B.H.P. will be supplied. The fan shall be driven by a TEFC variable speed drive (VFD) motor (to be supplied by others).

2.2.5 HEPA Filters

HEPA filters will be housed in an enclosure (6 ft high x 4 ft wide). The collection efficiency of HEPA filters is 99.97% for particulate size ranging from .3 to 1.0 microns.

2.2.6 Process Flows

Off-gas from the dryers enter the Quench Reactor where it is contacted with a calcium hydroxide slurry spray for SO_2 and other acids neutralization. A thick cake is formed because of the calcium hydroxide reaction with sulfur dioxide which permits an extended residence time with no significant increase in pressure drop. The final neutralization takes place in the accumulated thick cake on the filter bags. The cleaned gas leaves the baghouse at approximately 200°F. The overall pressure drop across the proposed system is expected to be 16.0 iwc during normal operating condition.

2.3 Process Control

2.3.1 Quench Reactor

The Calcium Hydroxide Slurry feed rate to the Quench Reactor is controlled so that a desired outlet temperature is maintained.

2.3.2 Tesisorb® and Reagent Feed

The feed rate of Tesisorb and reagents is controlled normally at a constant rate, so that a required SO_2, HF and other pollutants removal efficiency is achieved.

2.3.3 Baghouse

Instrumentation will be provided to allow the option of cleaning the baghouse modules by presetting the time cycle or a specific pressure drop across the baghouse.

2.3.4 Instrumentation

Research-Cottrell will provide complete instrumentation for air cooling NO_xOUT Quench Chamber, Dry Venturi™, baghouse and I.D. Fan operation. A control panel will be supplied.

2.3.5 Support Steel

Structural supports, fabricated of ASTM-A36, will be furnished for the supplied equipment.

2.3.6 Access

Stairs and ladders will be furnished to provide access to equipment for normal inspection and maintenance.

2.3.7 O&M Manuals

Four (4) O&M Manuals will be supplied.

2.3.8 System Check-out and Startup

We have included 10 mandays for checkout, startup and instruction supervision for the proper operation of the system. Additional service will be supplied at a per diem rate, if required. Travel time, airfare and local living expenses will be invoiced as additional cost.

2.3.9 Piping

All piping valves, insulation, connections, etc. as required for the proposed system within Research-Cottrell's battery limits are included. All piping shall be carbon steel. Pump switch over shall be manual.

3.0 Work by Others

The following equipment and services will be furnished by others.

A. Foundations and concrete slabs at-grade for support of structures and equipment including all anchor bolts, embedded metals and other embedded items therein to meet the Seller's requirements.

B. All interconnecting signal cables, wire, conduit, tray and lighting required.

C. Isolation valve and ductwork before Research-Cottrell's system inlet. This can be negotiated after site conditions have been investigated.

D. Field installation of supplied equipment, and field supply and installation of heat insulation.

E. All piping, valves, connections, etc. not included in Research-Cottrell's battery limits.

F. All structural supports and expansion joints outside the Seller's battery limits.

G. Ash discharging system, including the slide gate valves.

H. Stack emissions monitoring equipment (available from Research-Cottrell Companies).

I. All instrumentation and controls outside the Seller's battery limits including data highway and emission monitoring equipment.

J. Access road and related site work.

K. Plant intercommunication systems.

L. Performance acceptance tests.

M. 480V, 3 phase electric supply for startup and operation

N. Reagent for startup and operation.

O. Service water for startup and operation.

P. Portable fir extinguishers.

Q. Access to hopper doors.

R. Stack

4. PRICING

4.1 Taxes

The cost of sales, use, and value added taxes payable to any governmental unit within the United States with respect to any materials purchased for use in constructing and testing the Air Quality Control System is not included in Bidder's proposal. The direct cost of any such sales, use, and value added taxes, if required, will be handled by change order upon proper substantiation of the cost incurred.

4.2 Order of Magnitude Prices: Order of Magnitude price for supplying

5.2.1 Engineering, manufacturing and supply of Equipment .... [redacted]

These costs include freight.

5.0 SCHEDULE

The expected schedule outlined below is based on the equipment and scope defined in the proposal. Research-Cottrell is willing to negotiate a different schedule, if necessary, to conform to the overall schedule for the project.

All dates are from receipt of purchase order.

Preliminary GA's, not to exceed loadings, mass balance	4 Weeks
P & I Diagrams	8 Weeks
Final arrangement drawings	12 Weeks
Engineering drawings - Release for Construction	14-20 Weeks
Vendor Drawings	16-24 Weeks
Equipment fabrication start	16-18 Weeks
Equipment fabrication completion	36 Weeks
Start delivery of equipment	28 Weeks
Complete delivery	40 Weeks
Complete installation	46 Weeks

6.0 TERMS AND CONDITIONS

EQUIPMENT & MATERIALS CONTRACT

STANDARD CONDITIONS OF SALE

The following terms and conditions form part of each proposal submitted by (SELLER) hereinafter called "Vendor" for the sale of equipment or serv to a Client/Customer hereinafter called "Purchaser" and any contract made by and between the parties includes as a part thereof these terms conditions.

1.0 MATERIAL WARRANTY

1.1 Warranty - Vendor warrants to Purchaser that the equipment manufactured by it is free from defects in material, workmanship and de under normal use and service for a period of eighteen (18) months after shipment or twelve (12) months after initial operation, whicr occurs first. Initial operation is defined as the date of first heat load of the equipment. All auxiliary equipment not manufactured by Ve carries such warranty as given by the manufacturer thereof and which is hereby assigned to Purchaser.

1.2 Terms - Vendor's obligation under this warranty is to supply, pursuant to the delivery terms of the proposal, at Vendor's sole option repa or replacement parts for those parts which are shown to Vendor's satisfaction to have been defective as to material, workmanship or de: provided that:

(i) written notice of such defect is given to Vendor within thirty (30) calendar days of discovery thereof;

(ii) the equipment has been operated in accordance with the operating and maintenance instructions provided by Vendor; and

(iii) no alterations or substitutions have been made in the equipment without the express written authorization of Contractor.

2.0 PURCHASER'S ACTS VOIDING WARRANTIES

2.1 The warranty furnished by Vendor herein will be rendered void and of no further force or effect by the Purchaser's use and operation o equipment in a manner which, in Vendor's reasonable judgment is inconsistent with recommendations contained in Vendor's Operation and Mainten manual issued for the equipment including but not limited to improper erection, damage caused by abrasion, corrosion or excess temperature or c operational causes. Additionally, the warranty is voided by the Purchaser's unauthorized alteration of, or making of substitutions to the equipment h supplied. The Purchaser shall defend, hold harmless and indemnify Vendor and its officers, directors, employees and agents from and against liability for personal injury or property damage arising out of the above-mentioned causes as well as from any fires internal to the equipment sup under this contract.

3.0 PATENT WARRANTY

Vendor shall defend at its expense any suit or proceeding brought against Purchaser based on any claim that the equipment covered herein, ex for equipment/material manufactured and/or designed to Purchaser's specifications, infringes any United States patent issued as of the date of proposal and pay any court imposed damages and costs finally awarded against Purchaser, but not to exceed the amount theretofore paid to Ve by Purchaser hereunder provided:

a) Vendor is promptly notified by Purchaser in writing of such claim; and

b) Vendor is given full authority, information, and assistance by Purchaser which Vendor deems necessary for the conduct of such defense.

Vendor shall have the right and option at any time in order to avoid such claims or actions and minimize potential liability to:

a) procure for the Purchaser the right to use the equipment; or

b) modify the equipment so that it no longer infringes; or

c) replace the equipment with non-infringing equipment

4.0 DELAYS AND DAMAGES - FORCE MAJEURE

In the event of delays or damages due to conditions beyond Vendor's reasonable control, including, but not limited to, Acts of God, Acts of Purchaser or Purchaser's Customer or of other Contractor's employed by Purchaser, Acts of Civil or Military Authority, priorities, fire, strikes,floods, epidemics, quarantine restrictions, war, riot, delays in transportation, car shortages, and Vendor's inability to obtain necessary labor, materials or manufacturing facilities. In the event of such delay, the Contract dates shall be extended by an equitable period of time and Vendor shall be entitled to an equitable adjustment in the Contract price.

5.0 PERFORMANCE GUARANTEE

Vendor's sole guarantees are those contained in its proposal to Purchaser. These guarantees are contingent upon the correctness and accuracy of information provided by the Purchaser and are based upon the operating conditions specified in Vendor's proposal. These guarantees will be deer satisfied by successful completion of performance tests in accordance with applicable standard procedures as specified in the proposal and in e on the date of this proposal. Performance tests shall be conducted by the Purchaser and witnessed by Vendor within 90 days of the date of in operation of the equipment. In the event the said tests are not conducted within 90 days of initial operation or within six (6) months of shipm whichever is earlier and through no fault of the Vendor, the equipment shall be deemed accepted by the Purchaser and in compliance with all com tual requirements. In the event the equipment fails to meet the contract performance guarantees as verified by certified test results, Vendor will sup at its sole option, repaired or replacement parts pursuant to the delivery terms of the proposal subject to the limitations stated in Article 6.0.

6.0 IMPLIED WARRANTIES DISCLAIMER

THE WARRANTIES FURNISHED BY VENDOR AS EXPRESSLY INCLUDED HEREIN CONSTITUTE VENDOR'S SOLE OBLIGATION HEREUNDER AND IN LIEU OF ANY OTHER WARRANTIES OR GUARANTEES, EXPRESS OR IMPLIED, INCLUDING WARRANTIES OF MERCHANTABILITY OR FITNESS F A PARTICULAR PURPOSE.

[illegible]

The Vendor shall not be liable to Purchaser for indirect or consequential damages including, but not limited to, loss of profits or revenue, loss of of equipment, costs of replacement power, or product, additional expenses incurred in the use of equipment or facilities, or the claims of third part This disclaimer shall apply to consequential damages based upon any cause of action whatsoever asserted against Vendor, including one arising of any Breach of Warranty or Guarantee, Products Liability, Negligence, Tort, or any other cause of action.

8.0 PURCHASER'S NEGLIGENCE AND INSURANCE

Vendor shall not be responsible for losses or damages arising out of the negligence of the Purchaser, its employees, agents or architects or losses which the Purchaser has agreed to provide insurance. In the event that both the Vendor and the Purchaser are negligent and the negligence of t is proximate cause of the accident, then in such event each party will be responsible for their portion of the liability or damages (excluding conseque or indirect damages which are disclaimed by the Vendor) resulting therefrom equal to such party's comparative share of the total negligence. B the Vendor and the Purchaser hereby agree to mutually waive any rights which each may have against the other with respect to subrogation under policy of insurance relating to the equipment or services provided under this contract.

9.0 LIMITATION OF LIABILITY

In no event will Vendor's liability to the Purchaser for any and all claims, including property damage and personal injury claims, allegedly resulting f breach of contract, tort, or any other theory of liability exceed the amount of the initial purchase price paid to the Vendor.

10.0 PRICE ADJUSTMENT - EQUIPMENT, MATERIALS & LABOR

Unless otherwise noted in the Vendor's proposal, equipment and material prices set forth in the proposal are firm for delivery in accordance with Schedule therein. In the event the Schedule is modified due to acts of Purchaser or conditions beyond Contractor's control and contract costs escal an equitable adjustment to the Contract price shall be granted to Contractor.

11.0 TAXES

Sales Tax, Personal Property Tax, Use Tax, Excise Tax, or other taxes imposed by Federal, State or municipal authority and incurred by Vendor through performance on the contract shall be to the Purchaser's account and are in addition to the prices quoted in the proposal. Vendor shall not be responsible for any additional costs associated with the Purchasers tax exemption certificate and the governing body's acceptance of same.

12.0 DELIVERY

12.1 Title - Title to all equipment shall pass to Purchaser at the FOB point or points of shipment and risk of loss will thereafter be borne by Purcha

12.2 Storage - If the Purchaser declines or is unable to take delivery at the time(s) specified in the proposal or contract, Vendor will have the equipr stored for Purchaser at Purchaser's risk and account, and the materials shall be considered "shipped".

13.0 PAYMENT

13.1 Terms of Payment

Unless otherwise agreed, the payment schedule shall be as outlined herein and payments shall be made within thirty (30) days of presenta of an invoice. Payments not received by the due date shall be subject to a monthly interest charge at the rate of 2% per month or maximum allowed by law, whichever is less, due and payable until the payment is received.

13.2 Payment Schedule

- 10% down with the order
- Engineering progress payments (monthly, based upon percent completed)
- Material & Equipment delivered to project (monthly, based upon percent shipped)

In the event a retention value is required and agreed, it shall accrue interest at the rate of 1% per month on the outstanding balance exchanged for a letter of credit or paid to Vendor. Vendor retains the unqualified option to provide Purchaser with a letter of credit in of retention at any time during the performance of the contract.

13.3 Payment Discounts

A. If Purchaser pays any amounts due within ten (10) calendar days of presentation of an invoice to Purchaser, Purchaser shall be entitle a one percent (1%) discount on the invoiced amount. Vendor shall provide such discount by rebate or credit on subsequent invoices.

B. If Purchaser agrees to pay cash on delivery (or something which Vendor in its sole discretion accepts as a cash equivalent) in the amo of the full purchase price for equipment, material or services purchased hereunder, Purchaser shall be entitled to a two and one-half per (2 1/2%) discount on the purchase price.

C. If Purchaser and Vendor agree to an installment payment plan for equipment, material or services purchased hereunder, Purchaser sha entitled to a discount for early payments equivalent to one percent (1%) of the installment amount due for each full month that the paym is received prior to the due date, subject to a maximum cumulative discount, of five (5%) percent.

13.4 Default in Payment

A. If any payment due to Vendor is more than thirty (30) days past due, Vendor shall have the right at its sole option to accelerate the payr of all outstanding amounts, including, but not limited to, amounts previously retained pursuant to the agreement, by notifying Purchas writing that all outstanding amounts are immediately due and presenting Purchaser with an invoice for said amount. Vendor shall also the right in such event to discontinue all work on the project without incurring any liability to Purchaser for such action.

B. In the event the total aggregate amount of delinquent payments exceeds at any point during the term of the agreement ten (10%) of the contract amount, Purchaser shall provide at Vendor's request, additional collateral, including but not limited to irrevocable letters of c sufficient to secure payment of all contract amounts.

right to obtain liens on Purchaser's assets through legal or equitable proceedings.

13.5 **Security Agreements**

A. Purchaser hereby grants to Vendor a security interest in the equipment and/or materials sold hereunder to secure the purchase price c Purchaser shall execute any financing or other statements or filings which in Vendor's sole judgment are necessary or appropriate so a or perfect such security interest, which shall thereafter be filed by Purchaser with the appropriate recording officer. This contra constitute the security agreement between the parties and is intended to and shall afford the Vendor all rights of a secured party unde 9 of the Uniform Commercial Code.

B. Until Purchaser has paid the full amount due and owing for any equipment or materials purchased hereunder, Purchaser shall be pr from transferring such equipment or materials to any creditor of Purchaser other than Vendor, unless Vendor provides its prior written to such transfer, such consent not to be unreasonably withheld.

C. In the event Purchaser becomes insolvent, files for bankruptcy or goes into receivership or liquidation, Purchaser agrees to use its bes and to provide all assistance requested by Vendor in order to secure Vendor's position as a preferred creditor with respect to all amou to Vendor.

13.6 **Payment of Retained Amounts**

A. If this contract permits Purchaser to withhold final payment, and acceptance is not based upon performance tests, su payments shall be due and payable within thirty (30) days after the equipment is ready for operation.

B. If such deferred payment is contingent upon tests and such tests are delayed through no fault of Vendor for more than thi days after the equipment is first ready for operation, final payment shall be due and payable upon expiration of such thirty (period.

14.0 CANCELLATION

Purchaser's cancellation of the contract is subject to a cancellation charge of 10% of the total price of the contract, plus Vendor's actual expens expenses to which Vendor has become committed for fulfillment of the contract before notice of cancellation is received.

15.0 SUSPENSION

In the event Purchaser suspends the execution of work on this contract, Purchaser shall reimburse Vendor for all costs incurred by Vendor as a of such suspension, including, without limitation, all borrowing and opportunity costs. In the event the suspension exceeds 180 days in dura addition to being entitled to full reimbursement of costs as aforesaid, Vendor shall have the unqualified right to cancel the unfinished portion contract without liability to Purchaser of any kind. Should the contract be canceled the provisions of Article 13.0 shall apply.

16.0 OSHA - FEDERAL, STATE AND LOCAL

Vendor agrees to comply with the Federal OSHA requirements in effect as of the date of this proposal relative to the design of the equipment fur within its scope of supply as defined in this proposal. Where state or local safety and health requirements differ from the Federal OSHA require modifications or changes in design to meet state or local safety and health requirements will be incorporated at Purchaser's request. Additiona arising from such requests and from erection procedures required by state or local safety and health regulations which deviate from Federal requirements will be for Purchaser's account.

17.0 PROPRIETARY AND CONFIDENTIAL MATERIALS

All drawings, patterns, specifications and information included in Vendors proposal or contract and all other information otherwise supplied by V as to design, manufacture, erection, operation and maintenance of the equipment shall be the proprietary and confidential property of Vendor an be returned to Vendor at its request. Purchaser shall have no rights in Vendors proprietary and confidential property and shall not disclose such pr ary and confidential property to others or allow others to use such property, except as required for the Purchaser to obtain service, maintenanc installation for the equipment purchased from the Vendor. This clause shall survive the termination of this contract and be in effect as long Purchaser has possession of any of the Vendor's proprietary or confidential property.

18.0 ASSIGNMENT

Vendor retains the right to assign this cor ract to any subsidiary or affiliated company of Vendor without the Purchaser's prior approval. All other assignments by either Vendor or P. chaser require the prior written consent of the other party.

19.0 HAZARDOUS MATERIALS

The Purchaser's facilities may contain hazardous materials, including asbestos bearing materials. If any such materials are encountered, Vendo have no obligation to remove or remediate them in the absence of a separate agreement which includes separate consideration to Vendor for such If Vendor or any of its subcontractors is required o perform work within or immediately adjacent to any facilities that are determined to contain haza materials and/or asbestos, and the said work must be interrupted to allow for the remediation or removal of such materials by others, Vendor sh entitled to any and all costs and other expenses associated with such interruption in work. Purchaser shall fully defend, hold harmless and inde Vendor and its agents from and against any claims arising out of exposure to such hazardous and/or asbestos bearing materials.

20.0 DISPUTES

In the event of a dispute arising hereunder, the parties will attempt to amicably resolve the dispute. If after good faith negotiations, the parties cannot reach agreement, then the matter shall be resolved in a court having jurisdiction.

21.0 CONTRACT INTERPRETATION

21.1 If any of the provisions of these Standard Conditions of Sale (including statements made in the proposal) conflict with any provisions I Purchaser's documents, the former shall govern unless Vendor expressly agrees to the contrary in writing. Any contract resulting from this pro shall be construed, and the legal regulations of the Vendor and Purchaser shall be determined in accordance with the laws of the State of New Je U.S.A.

21.2 All communications, written and verbal, between the parties hereto with reference to the subject of this proposal prior to the date of its accep are merged herein and this proposal, when duly accepted and approved, shall constitute the sole and entire agreement and contract between the

as to the subject matter hereof. No changes in or modifications of [illegible]
shall be in writing duly accepted by the Purchaser and approved in writing by Vendor.

22.0 ACCEPTANCE

This proposal is subject to acceptance by the Purchaser within thirty (30) days and shall constitute a binding agreement with Vendor only when ther[e] approved by Vendor and signed by an authorized officer.

23.0 SEVERABILITY

Should any part of this Agreement be declared invalid or unenforceable, such decision shall not affect the validity of any remaining portion, [ ] remaining portion, shall remain in full force and effect, and Seller shall have the right to replace the part declared invalid or unenforceable [ ] provision which serves as much as validly possible the same commercial purpose as the part determined to be invalid or unenforceable.

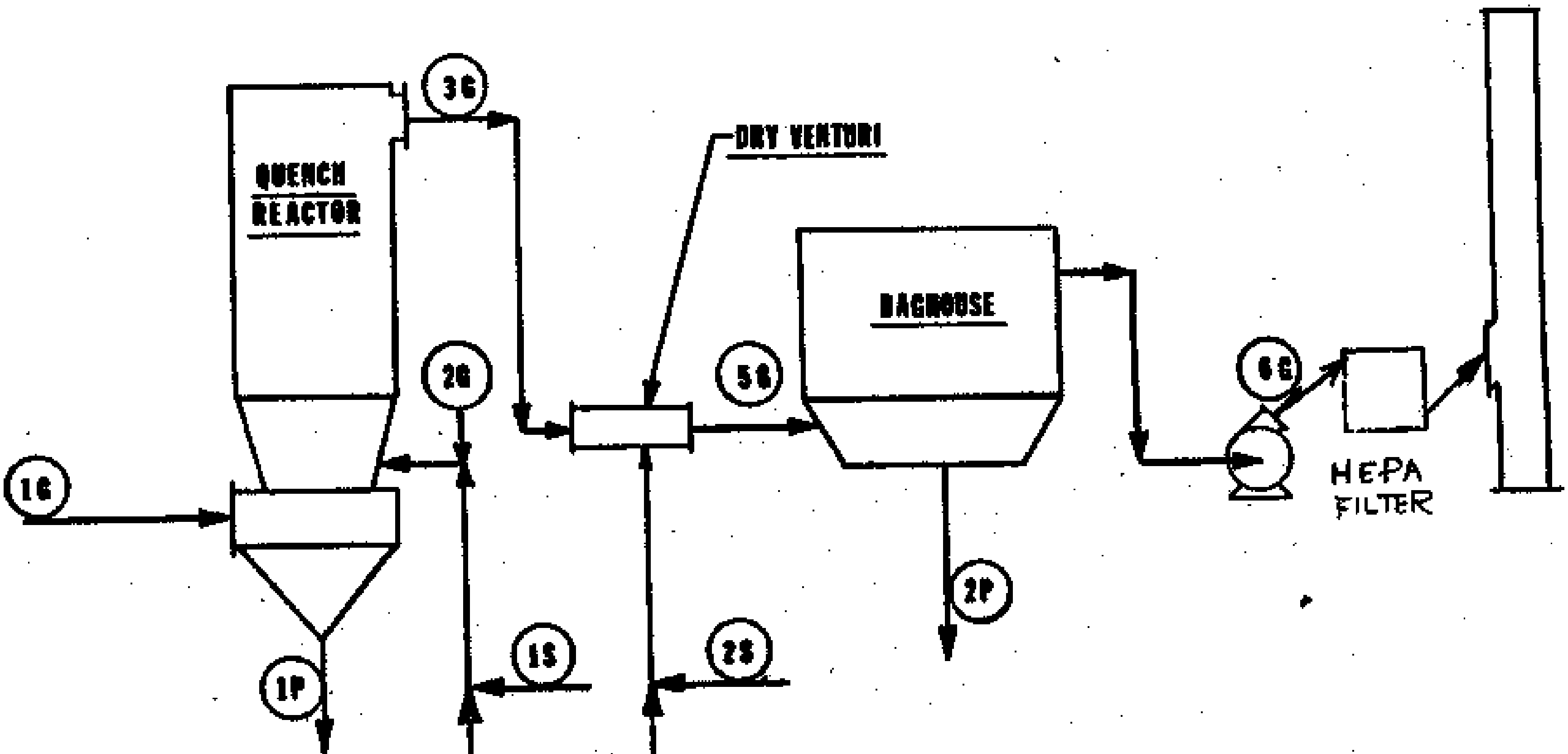
24.0 CHANGES/ADDITIONAL WORK

Vendor is not obligated to incur any expense or do any work in excess of that reasonably anticipated unless the Purchaser issues a Change Order for such expense or work with mutually acceptable terms and conditions.

c:\wp51\jrf\stdoe2(4/24/91)

7.0 APPENDIX

SCHEMATIC II



Tellee System

Research-Cottrell

ENGINEERING DEPARTMENT

CLIENT—JOB NO. ____________

SUBJECT ____________

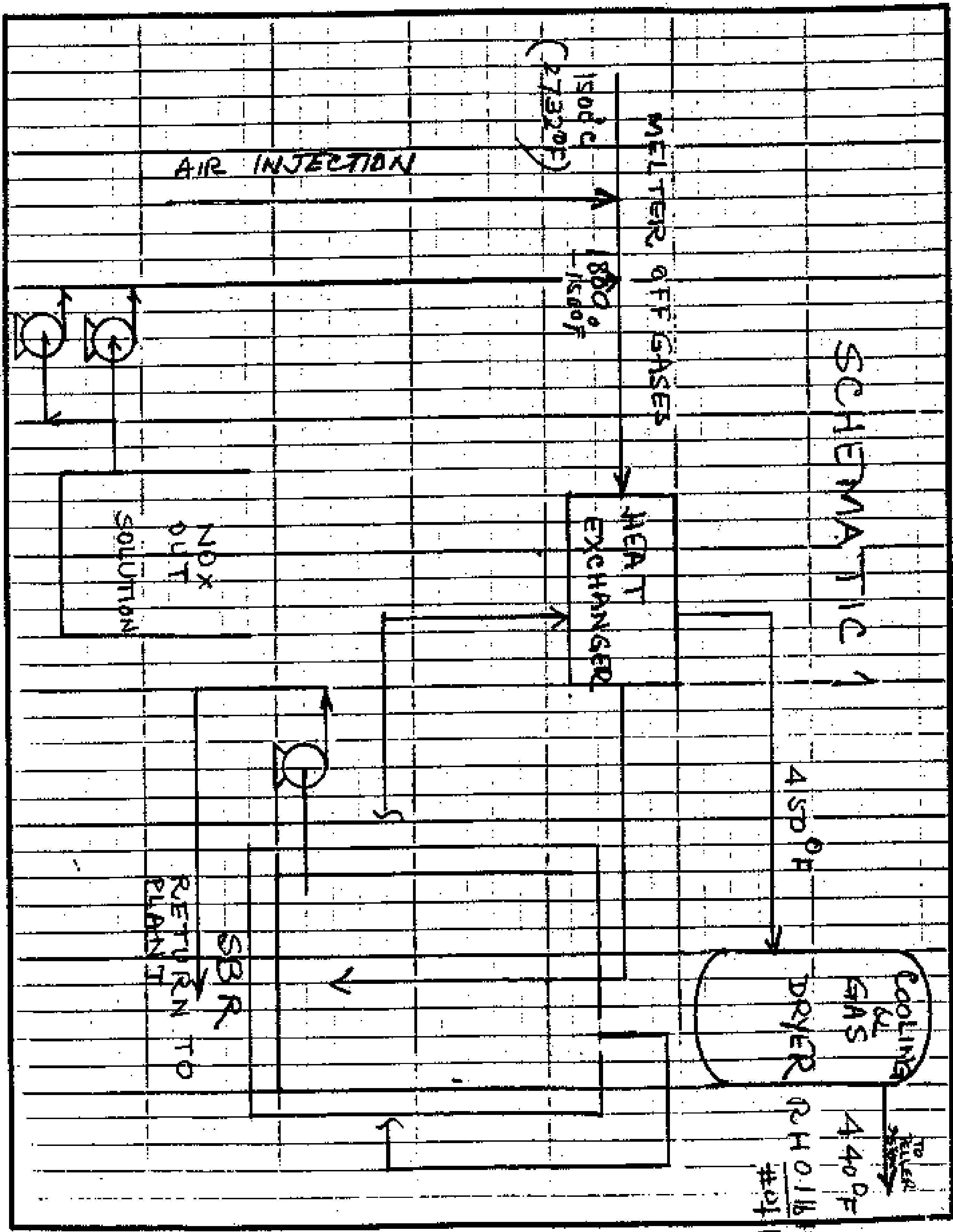
SHEET 1 OF ____

MADE BY ASM DATE 3/4/92

CHKD. ____ DATE ____

APPVD. BY ____ DATE ____

RV. NO ____ BY ____ APPVD. ____ DATE ____



PC-939

MK-FERGUSON
A DIVISION OF MORRISON KNUDSEN CORPORATION

INTER-OFFICE CORRESPONDENCE

DATE: February 12, 1993

TO: Distribution

FROM: John Enger

SUBJECT: **SUMMARY OF ON-SITE FLOCCULATION-SETTLING TESTS OF RAFFINATE PIT SLUDGES**

In June and July 1992, flocculation-settling tests were performed on sludges from raffinate pits 3 and 4. The purpose of these tests was to identify the optimal flocculant and concentration for flocculating raffinate slurries. Additional flocculation data were obtained in October 1992 during the on-site cement stabilization/solidification (CSS) testing performed in the period August to November 1992.

June/July 1992 Flocculation Testing

Screening

Prior to conducting the flocculant-settling tests, archived raffinate samples collected during the 1988 sludge sampling effort were composited according to the raffinate pits from which they came and mixed/rehydrated by adding water from the respective raffinate pits. The following 18 flocculants were screened for their relative effectiveness:

Allied Colloids
- Percol - 351

Calgon Corp.
- WT - 2640
- CA - 250L
- POL-E-Z 7736

American Cyanamid
- SuperFloc - 204
- SuperFloc - 208
- SuperFloc - 210
- SuperFloc - 212

Mazer Chemical
- MaFloc - 720
- MaFloc - 721
- MaFloc - 900

Nalco Chemical Co.
- No. 7127
- No. 7148
- No. 7741
- No. 7744
- No. 7769
- No. 7774
- No. 7778

The flocculants were screened by (1) mixing sludge and water in 250 ml graduated cylinders to suspend the solids in solution, (2) adding flocculant mixed in stock solutions, (3) mixing by repeatedly inverting the stoppered cylinders, and (4) observing floc size, the ultimate settling height of the sludge, and the clarity of the supernatant. Percol 351, American Cyanamid 212, Mazer Chemical Mafloc-900, and Nalco No. 7774 performed well on the sludge from both pits 3 and 4.

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Form 232-A 30M 6-87

However, Nalco 7769 appeared to perform more effectively than any of the other products. Nalco 7769 is a slightly anionic high molecular weight polyacrylamide polymer (see Attachment A for Nalco literature).

Flocculant Tests

Following the screening tests, flocculant tests were performed in 250 ml graduated cylinders on pit 3 and 4 slurries containing 15% solids. The Nalco 7769 flocculant was used in stock solution. Nalco 7769 concentrations (based on total weight of sludge slurry) of approximately 1,200 to 1,500 ppm satisfactorily flocculated the 15% solids slurry of Pit 3 raffinate. Concentrations of approximately 95 to 150 ppm satisfactorily flocculated the 15% solids slurry of Pit 4 raffinate.

The next set of tests consisted of varying the percent solids in the slurries. In a 1-liter graduated cylinder, Nalco 7769 stock solution was added to the slurry incrementally until adequate flocculation was observed. The concentrations needed for adequate flocculation were thereby determined for various percentages of solids. The table below summarizes the results.

PERCENT SOLIDS IN SLUDGE SLURRY AND FLOCCULANT CONCENTRATIONS

Raffinate Pit	Pit 3			Pit 4		
Percent Solids	14.3	16.5	22.0	16.9	21.0	26.2
Nalco 7769 (ppm)*	1,180	1,950	(2,180)**	100	135 and 155	295

* Concentration based on weight of flocculant added to total weight of sludge slurry.

** Pit 3 22.0% solids slurry could not be satisfactorily flocculated. At 2,180 ppm of Nalco 7769, the slurry coagulated into a single mass as opposed to flocs.

Observations

Two important observations were made during these tests. First, the manner in which the flocculant is added affects the amount required. This was demonstrated when, by mistake, flocculant was added to Pit 4 raffinate water and sludge prior to suspending the solids into solution for a 21% solids test. Since the flocculant had already been added, it was decided to test the sample by suspending the solids into the solution with the flocculant already present. Flocculation occurred at a flocculant concentration of 95 ppm.

This concentration is significantly lower than the 135 and 155 ppm concentrations required when the solids were suspended into solution before adding the flocculant. However, mixing the solids into suspension before adding the flocculant was the normal test procedure because this method was a better simulation of the conditions that will result from dredging activities at the pits. That is, the solids will be suspended before the flocculant is added.

Although adding flocculant stock solution to the raffinate slurry simulates the planned dredging and flocculation process, flocculant dispersion throughout the slurry is likely improved by adding the flocculant stock solution to the raffinate water before the sludge is suspended into solution. Flocculation of larger samples in October 1992 during the on-site CSS testing confirmed that an improved method of mixing flocculant stock solution (i.e., dispersion of the flocculant) into the sludge slurry resulted in lower flocculant concentrations. In those tests, an average flocculant concentration of approximately 220 ppm in a sludge slurry containing about 15% solids satisfactorily flocculated a composite of Pits 1, 2, and 3 sludges. These results are described below in the discussion of the October 1992 flocculation work.

The second important observation made during the June/July 1992 tests was the fact that the Pit 3 22% solids slurry could not be flocculated. The slurry simply coagulated into a single mass. This indicates that a maximum percent solids concentration may exist which prevents flocculation of suspended solids despite continued addition of flocculant.

Settling Rates

When possible, the settling rates of the flocculated sludge were measured. This was possible only with Pit 4 flocculated slurries, which settled relatively slowly compared to Pit 3 flocculated slurries. Accurate settling measurements could not be recorded for Pit 3 flocculated slurries because they flocculated and settled in a matter of seconds.

Attachment B contains plots of the settling measurements for unflocculated and flocculated pits 3 and 4 sludges. Based on these plots and the resulting thickener sizing calculations contained in the CDR Dewatering Additional Assessment Report (TM No. 3840TM-7108-0), flocculation of the dredged raffinate will likely be the first step in dewatering the sludge prior to treatment.

Moisture Content

After they were flocculated and had settled, the sludges were placed in paper filters and allowed to gravity drain. After they were drained, they were squeezed in the paper filters with varying effort by hand to remove additional water. The moisture content was then measured to determine any change from the initial sludge moisture content.

In all cases, the percentage of water in flocculated and filtered Pit 3 and 4 sludges increased over that of unflocculated sludges. The water content of Pit 3 sludge increased approximately 1% to 3% when flocculated/filtered (i.e., from a range of 71.1% to 72.8% to a range of 71.9% to 76.2%). (Note that Pit 3 sludge slurry with 22% solids is not included in these ranges because it did not flocculate.)

The water content of flocculated/filtered sludge from Pit 4 increased approximately 1% to 5.5% (i.e., from a range of 47.4% to 49.5% to a range of 48.5% to 55.0%).

The supernatant from each of the pit 3 and 4 varying percent solids flocculation tests (except Pit 3 at 22% solids) was sampled and analyzed for the following parameters:

SUMMARY OF ON-SITE FLOCCULATION-SETTLING TESTS OF RAFFINATE PIT SLUDGES

Raffinate Pit	Pit 3	Pit 4
Solids	TSS/TDS	TSS/TDS
Anions	Cl, Fl, SO_4, NO_3	Cl, Fl, SO_4
Cations	Sb, As, Be, Cr, Fe, Mn, Se	Be, Cr, Fe, Mn, Se

The results are presented in the attached table.

October 1992 Flocculant Results

In October 1992, as part of CSS bench-scale testing, raffinate pit sludges were flocculated and dewatered prior to mixing with binders and soil. Sludges from pits 1, 2, and 3 from both the 1988 and 1991 sampling efforts were combined, homogenized, slurried, and flocculated in relatively large quantities as compared to the June/July 1992 flocculation-settling tests. These samples were diluted and mixed in a 32 gallon plastic barrel. The flocculant stock solution was slowly added as the solids were kept in solution by gently stirring the slurry.

Flocculant Concentrations

Slurry samples ranging from 24.46 kg to 50.99 kg and 14.2% to 15.1% solids were flocculated at concentrations ranging from 65 to 351 ppm and averaging 222 ppm. The table below summarizes the October 1992 percent solids and respective flocculant concentration data. See Attachment C for test data and calculations regarding flocculant consumption and estimated cost to flocculate the raffinate sludge.

PERCENT SOLIDS IN PITS 1, 2, AND 3 COMPOSITED SLUDGE SLURRY AND FLOCCULANT CONCENTRATIONS

Percent Solids	15.1	14.2	14.3	14.5	14.7	14.7	14.6**
Nalco 7769 (ppm)*	308	121	174	351	65	281	222**

* Concentration based on weight of flocculant added to total weight of sludge slurry.

** Weighted average of the preceding six percent solids and flocculant concentrations data sets in table.

Moisture Content

Following flocculation, the sludge was allowed to gravity drain in a fine mesh nylon bag, then squeezed by hand. Because nylon rather than paper filter material was used, more pressure was applied than in the June/July 1992 testing. The water content prior to dilution with raffinate water ranged from 60.4 to 60.6%. The water content of the flocculated/filtered sludge ranged from 60.2 to 65.7%.

The information from the June/July and October 1992 flocculation tests described in this memo will be used along with sludge characterization data (e.i., Chen-Northern January 1989, BNI/ESE October 1983, ORNL June 1989, and WTG May 1992) as a basis for scoping and performing mechanical dewatering tests.

Distribution:

Dale Durrett
Mel Roberts
Butch Freeman
Marj Wesely
Al Munio
Larry Lisot - MKES
Joe Foldyna - MKES
RC-22-26-42

Attachments

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		Pit 3			Pit 4		
Parameter	Percent Solids	14.3[1]		16.5	16.9	21.0	26.2
	Floc Concentration (ppm)	1,180		1,950	100	155	295
TSS	mg/L	110 (4)[2]	--[3]	62 (4)	ND (4)	8 (4)	6 (4)
TDS	mg/L	30,800 (10)	--	35,000 (10)	1,360 (10	1,750 (10)	1,860 (10)
Chlorine	mg/L	87.6 (0.020)	88.1 (0.020)	124 (0.020)	25.7 (0.20)	31.2 (0.020)	32.6 (0.020)
Fluorine	mg/L	2.90 (0.10)	--	2.90 (0.10)	13.2 (0.10)	13.2 (0.10)	13.2 (0.10)
Sulfate	mg/L	1,280 (0.100)	1,260 (0.100)	1,260 (0.100)	412 (0.100)	573 (0.100)	560 (0.100)
Nitrate	mg/L	4,970 (0.020)	--	5,800 (0.020)	---	---	---
Antimony	µg/L	ND (5)	ND (5)	ND (5)	---	---	---
Arsenic	µg/L	ND (74)	ND (74)	ND (74)	---	---	---
Beryllium	µg/L	10 (4)	15 (4)	11 (4)	ND (4)	6 (4)	ND (4)
Chromium	µg/L	36 (6)	36 (6)	48 (6)	ND (6)	10 (6)	6 (6)
Iron	µg/L	38 (21)	ND (21)	168 (21)	ND (21)	64 (21)	177 (21)
Manganese	µg/L	44 (4)	40 (4)	67 (4)	6 (4)	10 (4)	104 (4)
Selenium	µg/L	1,650 (60)	1,660 (60)	1,970 (60)	ND (60)	ND (60)	ND (60)

(1) Duplicate analyses performed for selected parameters.
(2) Detection limits in parentheses.
(3) -- : Not analyzed.

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ATTACHMENT A

Nalco Chemical Co. Flocculant Literature

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NALCO

FAX COVER SHEET

FROM: NALCO CHEMICAL COMPANY
514 Earth City Expressway
Suite 231
Earth City, Missouri 63045

FAX NUMBER: (314) 739-1465

VERIFICATION NO.
(314) 298-7510 G-12 (Mary Mathias)
(314) 739-8484 W-27 (Marva Mizelle)
(314) 739-4969 D-52 (Donna Hartman)
(314) 739-3378 G-35 (Dennie Campagna)

Pages: 12

Date: 7/17/92

Time: 1330

To: John Enger

From: Von Marler

Comments: I have sent this same information to Larry Lisot.

2760
Bulk : 500 gal
#1.55/lb
#1.50/lb
#1.25/lb
2127
2148

NALCO CHEMICAL COMPANY
ONE NALCO CENTER • NAPERVILLE, ILLINOIS 60563-1198

Water Clarification/ Pollution Control Chemicals | Product Bulletin

NALCO

NALCLEAR® 7763/7766/7767 7768/7769 LIQUID ANIONIC FLOCCULANTS

Product Benefits

NALCLEAR liquid anionic flocculants offer the following benefits:

- Provide rapid solid/liquid separation
- Help produce a clear effluent that is low in suspended solids
- Assist formation of a dense sludge, minimizing the volume of waste for disposal

Principal Uses

NALCLEAR flocculants are particularly effective in primary clarification in steel mills, foundries, pulp and paper mills, refineries, tanneries, and municipal water and sewage treatment plants. They are effective as sludge conditioning chemicals in dewatering applications involving vacuum filters, belt presses, centrifuges, thickeners, or drying beds. NALCLEAR 7763, 7766 and 7768 are particularly effective in steel mills and foundries for waste treatment plant clarification, BOF, Q-BOP, and blast furnace thickeners. NALCLEAR 7767 is also very effective when treating inorganic wastes and dewatering inorganic sludges (i.e., alum, ferric, and lime sludges). NALCLEAR 7769 is also very effective over a wide pH range (typical 2–8).

General Description

NALCLEAR flocculants are anionic high molecular weight single-component liquid products that have the following typical properties:

	7763	7766	7767	7768	7769
Odor	Slight	Slight	Slight	Slight	Slight
Color	Cream	Cream	Cream	Cream	Cream
Charge in Solution	Intermediate	Low	Very high	Intermediate	Low
Density (± 0.1 lb/gal; typical)	8.65–8.75	8.5–8.6	8.7–8.8	8.65–8.75	8.7–8.8
Freeze-Thaw Recovery	Complete	Complete	Complete	Complete	Complete
Viscosity	Typical viscosities for neat products and product solutions are shown in Figures 1–10.				

NALCLEAR 7766 has been approved by the United States EPA for use in potable systems when the dosages do not exceed 1 ppm in the water flow.

NALCO CHEMICAL COMPANY
WATER TREATMENT CHEMICALS
1801 WEST DIEHL ROAD □ NAPERVILLE, ILLINOIS 60566
SUBSIDIARIES IN ARGENTINA, AUSTRIA, BRAZIL, CHILE, COLOMBIA, ECUADOR, FINLAND, FRANCE, HOLLAND, HONG KONG, ITALY, JAPAN, PHILIPPINES, SAUDI ARABIA, SPAIN, SWEDEN, VENEZUELA AND WEST GERMANY • AFFILIATED IN AUSTRALIA, CANADA, MEXICO, SINGAPORE, SOUTH AFRICA, TAIWAN, UNITED KINGDOM AND THE UNITED STATES

 Printed in U.S.A. 11-84

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Viscosity Curves

Figure 1 — *NALCLEAR 7763 (neat)* viscosity vs. temperature

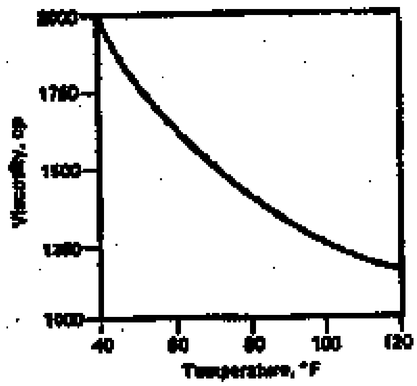


Figure 2 — *NALCLEAR 7763* solution viscosity

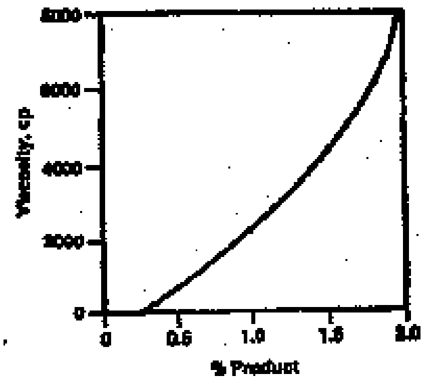


Figure 3 — *NALCLEAR 7766 (neat)* viscosity vs. temperature

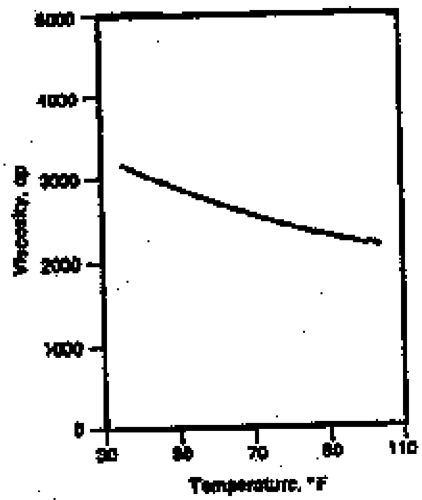


Figure 4 — *NALCLEAR 7766* solution viscosity

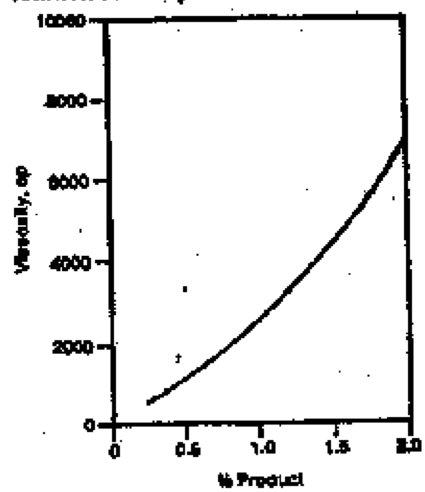


Figure 5 — *NALCLEAR 7767 (neat)* viscosity vs temperature

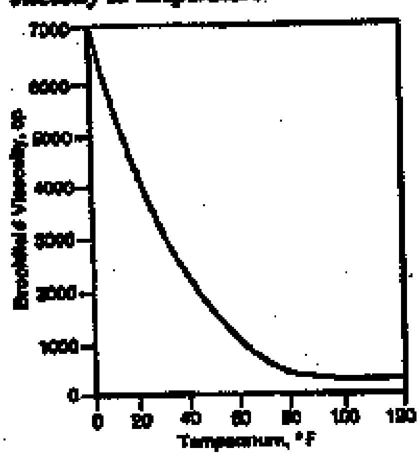
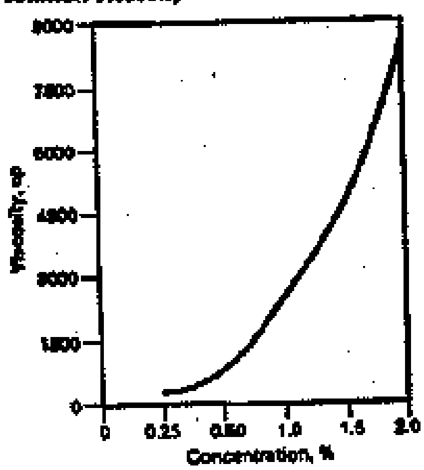


Figure 6 — *NALCLEAR 7767* solution viscosity



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Viscosity Curves
(Cont'd)

Figure 7 — NALCLEAR 7768 (neat) viscosity

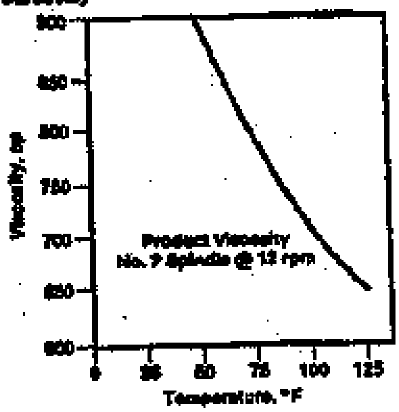


Figure 8 — NALCLEAR 7768 solution viscosity

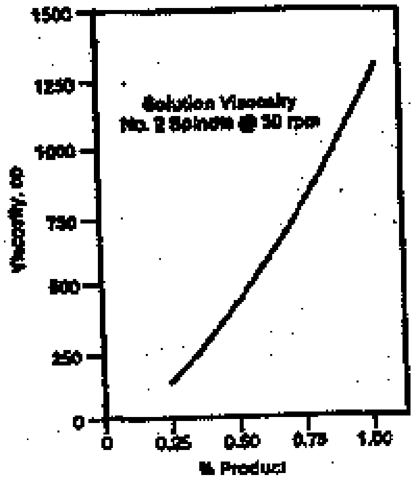


Figure 9 — NALCLEAR 7769 (neat) viscosity

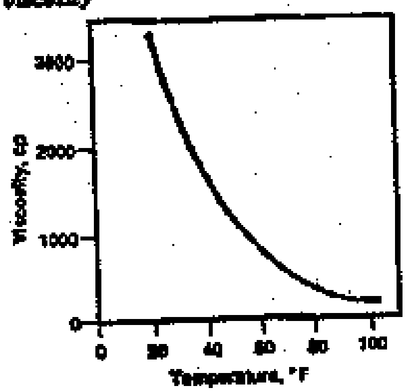
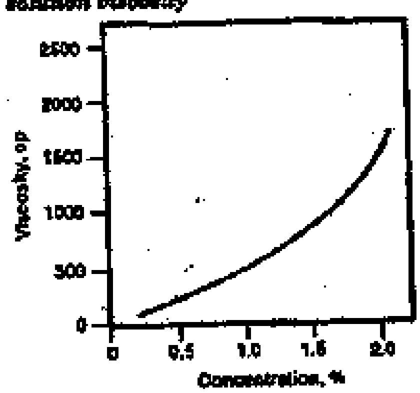


Figure 10 — NALCLEAR 7769 solution viscosity



Solution Preparation

For batch preparation of solutions, concentrations of 0.5 to 2.0% are recommended. The following procedure is suggested to achieve optimum solution activity.

1. Pre-mix in the drum for a minimum of 2 hours for each new drum. Mix 10 minutes for each subsequent withdrawal.
2. Add sufficient make-up water to the make-up tank to cover the agitator, and half fill the tank. The make-up water must be clean and between 40 and 120°F. Start the agitator.
3. With make-up water flowing at maximum velocity through the eductor portion of a modified Nalco Type III Disperser, pour or transfer the desired volume of polymer into the funnel. The disperser modification consists of the insertion of an orifice plug (Part No. P4594) into the polymer metering portion of the eductor. If an eductor is not applicable, pour polymer into the vortex for mixing.
4. After all of the polymer has been added, top off the tank with make-up water to achieve the desired final concentration, and mix for an additional 20 minutes to develop maximum activity. Further mixing is not required and may decrease activity.

Automated make-up systems are available from Nalco. Consult your Nalco representative for complete details.

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Dosage

The dosage is highly dependent upon the application and system. Generally, the dosage range for thickening is 0.01 to 1.0 lb/ton dry solids; for sludge dewatering, 0.2 to 20.0 lb/ton dry solids; and for primary clarification, 0.1 to 5.0 ppm. Your Nalco representative can determine the optimum dosage and application method for your system.

Feeding

A feed tank separate from the make-up tank is recommended to ensure uninterrupted supply of flocculant solution. A centrifugal pump may be used to transfer solutions from one tank to another. A positive displacement pump is strongly recommended for metering and feeding solutions.

The stock solution should be metered into a mixing tee or dilution water line for continuous dilution upstream from the point of addition. The extent of dilution required will vary, but normally dilution to 0.1% or less is recommended. An in-line static mixer, after the mixing tee, allows the flocculant to be properly dispersed.

Feed the diluted flocculant in a manner that provides maximum distribution to the slurry solids. This can be accomplished with a distribution header. Multiple addition points usually deliver the best performance. Your Nalco representative can help you develop the most effective feed method for your plant.

Carbon steel, fiberglass, stainless steel, PVC, and polyethylene may be used for tank and pump construction. Teflon or other inert hydrocarbon materials should be used for gaskets and pump seals. Galvanized metals and natural or synthetic rubber should be avoided.

Handling

As with any chemical reagent, NALCLEAR liquid flocculants should be handled with caution. Precautions should be taken to avoid contact with skin, eyes, and clothing. Launder all contaminated clothing before reuse. Do not take internally. If spilled, contain with absorbent material. Keep container closed when not in use.

Storage

NALCLEAR liquid flocculants should be stored at temperatures between 40 and 100°F. Although NALCLEAR liquid flocculants have complete freeze-thaw recovery, storage below 40°F may cause handling difficulties related to increased viscosity. The use of a moisture trap on the bulk tank breather is recommended. The suggested in-plant storage limit is one year in unopened drums.

Shipping

The products are shipped in nonreturnable 55-gallon steel drums and in bulk quantities.

NALCO

MATERIAL SAFETY DATA SHEET

PRODUCT

NALCLEAR 7769 FLOCCULANT

Emergency Telephone Number
Medical (708) 920-1510 (24 hours)

SECTION 1 PRODUCT IDENTIFICATION

TRADE NAME: NALCLEAR 7769 FLOCCULANT
DESCRIPTION: A polyacrylamide in a water and hydrocarbon solvent

NFPA 704M/HMIS RATING: 1/1 HEALTH 1/1 FLAMMABILITY 0/0 REACTIVITY 0 OTHER
0=Insignificant 1=Slight 2=Moderate 3=High 4=Extreme

SECTION 2 HAZARDOUS INGREDIENTS

Our hazard evaluation has identified the following chemical ingredient as hazardous under OSHA's Hazard Communication Rule, 29 CFR 1910.1200. Consult Section 14 for the nature of the hazard(s).

INGREDIENT(S)	CAS #	APPROX.%
Ethoxylated nonylphenol	9016-45-9	1-5
Hydrotreated light distillate	64742-47-8	20-40

SECTION 3 PRECAUTIONARY LABEL INFORMATION

CAUTION: May cause irritation to skin and eyes. Avoid contact with skin, eyes and clothing. Do not take internally.

Empty containers may contain residual product. Do not reuse container unless properly reconditioned.

SECTION 4 FIRST AID INFORMATION

EYES: Flush with water for 15 minutes. Call a physician.
SKIN: Wash thoroughly with soap and rinse with water. Call a physician.
INGESTION: Do not induce vomiting. Give water. Call a physician.
INHALATION: Remove to fresh air. Treat symptoms. Call a physician.

NOTE TO PHYSICIAN: Based on the individual reactions of the patient, the physician's judgment should be used to control symptoms and clinical condition.

CAUTION: If unconscious, having trouble breathing or in convulsions, do not induce vomiting or give water.

SECTION 5 HEALTH EFFECTS INFORMATION

PRIMARY ROUTE(S) OF EXPOSURE: Eye, Skin

EYE CONTACT: Can cause mild to moderate irritation.

MATERIAL SAFETY DATA SHEET

PRODUCT

NALCLEAR 7769 FLOCCULANT

Emergency Telephone Number
Medical (708) 920-1510 (24 hours)

NALCO

(CONTINUED)

SECTION 5 HEALTH EFFECTS INFORMATION

SKIN CONTACT: Can cause mild to moderate irritation.

SYMPTOMS OF EXPOSURE: A review of available data does not identify any symptoms from exposure not previously mentioned.

AGGRAVATION OF EXISTING CONDITIONS: A review of available data does not identify any worsening of existing conditions.

SECTION 6 TOXICOLOGY INFORMATION

ACUTE TOXICITY STUDIES: Acute toxicity studies have not been conducted on this product, but toxicity studies of the ingredient(s) in Section 2 have been reviewed. The results are shown below.

ACUTE ORAL TOXICITY (ALBINO RATS):
Ethoxylated nonylphenol LD50 = 3,000 mg/kg
Hydrotreated light distillate LD50 = 40,000 mg/kg

ACUTE DERMAL TOXICITY (ALBINO RABBITS):
Ethoxylated nonylphenol LD50 = Greater than 3,000 mg/kg
Hydrotreated light distillate LD50 = 2,000 - 4,000 mg/kg

PRIMARY SKIN IRRITATION TEST (ALBINO RABBITS):
SKIN IRRITATION INDEX DRAIZE RATING:
2.4/8.0 Ethoxylated nonylphenol
6.2/8.0 Hydrotreated light distillate

PRIMARY EYE IRRITATION TEST (ALBINO RABBITS):
EYE IRRITATION INDEX DRAIZE RATING:
35.5/110.0 Ethoxylated nonylphenol
5/110.0 Hydrotreated light distillate

SECTION 7 PHYSICAL AND CHEMICAL PROPERTIES

COLOR: Cream	FORM: Liquid	ODOR: Slight organic
DENSITY:	8.8 lbs/gal.	
SOLUBILITY IN WATER:	Completely	
SPECIFIC GRAVITY:	1.05 @ 60 Degrees F	ASTM D-1298
pH (AT 1%):	7	ASTM E-70
VISCOSITY:	700 - 800 cps @ 60 Degrees F	ASTM D-2983
FLASH POINT:	Greater than 200 Degrees F (PMCC)	ASTM D-93

NOTE: These physical properties are typical values for this product.

MATERIAL SAFETY DATA SHEET

NALCO

PRODUCT

NALCLEAR 7769 FLOCCULANT

Emergency Telephone Number
Medical (708) 920-1510 (24 hours)

SECTION 8 FIRE AND EXPLOSION INFORMATION

FLASH POINT: Greater than 200 Degrees F (PMCC) ASTM D-93

EXTINGUISHING MEDIA: This product would not be expected to burn unless all the water is boiled away. The remaining organics may be ignitable. Use water to cool containers exposed to fire.

UNUSUAL FIRE AND EXPLOSION HAZARD: May evolve NOx under fire conditions. If the water is driven off, the remaining organics may be ignitable.

SECTION 9 REACTIVITY INFORMATION

INCOMPATIBILITY: Avoid water contamination which may cause gelling.

Avoid contact with strong oxidizers (eg. chlorine, peroxides, chromates, nitric acid, perchlorates, concentrated oxygen, permanganates) which can generate heat, fires, explosions and the release of toxic fumes.

THERMAL DECOMPOSITION PRODUCTS: In the event of combustion CO, CO2, NOx may be formed. Do not breathe smoke or fumes. Wear suitable protective equipment.

SECTION 10 PERSONAL PROTECTION EQUIPMENT

RESPIRATORY PROTECTION: Respiratory protection is not normally needed since the volatility and toxicity are low. If significant mists are generated, use either a chemical cartridge respirator with a dust/mist prefilter or supplied air.

For large spills, entry into large tanks, vessels or enclosed small spaces with inadequate ventilation, a pressure-demand, self-contained breathing apparatus is recommended.

VENTILATION: General ventilation is recommended.

PROTECTIVE EQUIPMENT: Use impermeable gloves and chemical splash goggles when attaching feeding equipment, doing maintenance or handling product. Examples of impermeable gloves available on the market are neoprene, nitrile, PVC, natural rubber, viton, and butyl (compatibility studies have not been performed).

The availability of an eye wash fountain and safety shower is recommended.

If clothing is contaminated, remove clothing and thoroughly wash the affected area. Launder contaminated clothing before reuse.

NALCO

MATERIAL SAFETY DATA SHEET

PRODUCT

NALCLEAR 7769 FLOCCULANT

Emergency Telephone Number
Medical (708) 920-1510 (24 hours)

SECTION 11 SPILL AND DISPOSAL INFORMATION

IN CASE OF TRANSPORTATION ACCIDENTS, CALL THE FOLLOWING 24-HOUR TELEPHONE NUMBER (708-920-1510)

SPILL CONTROL AND RECOVERY:

Small liquid spills: Contain with absorbent material, such as clay, soil or any commercially available absorbent. Shovel reclaimed liquid and absorbent into recovery or salvage drums for disposal. Refer to CERCLA in Section 14.

Large liquid spills: Dike to prevent further movement and reclaim into recovery or salvage drums or tank truck for disposal. Refer to CERCLA in Section 14.

DISPOSAL: If this product becomes a waste, it does not meet the criteria of a hazardous waste as defined under the Resource Conservation and Recovery Act (RCRA) 40 CFR 261, since it does not have the characteristics of Subpart C, nor is it listed under Subpart D.

As a non-hazardous liquid waste, it should be solidified with stabilizing agents (such as sand, fly ash, or cement) so that no free liquid remains before disposal to an industrial waste landfill. A non-hazardous liquid waste can also be incinerated in accordance with local, state and federal regulations.

SECTION 12 ENVIRONMENTAL INFORMATION

BIOLOGICAL OXYGEN DEMAND (5-day BOD): 204,000 ppm

CHEMICAL OXYGEN DEMAND: 1,000,000 ppm

AQUATIC DATA: Results below based upon a 1% solution of a similar product.

96 hour static acute LC50 to Rainbow Trout = Greater than 1,000 ppm

96 hour LC50 to Sheepshead Minnow = Greater than 1,000 ppm

48 hour LC50 to Daphnia Magna = 160 - 860 ppm

If released into the environment, see CERCLA in Section 14.

SECTION 13 TRANSPORTATION INFORMATION

DOT PROPER SHIPPING NAME/HAZARD CODE - PRODUCT IS NOT REGULATED DURING TRANSPORTATION

MATERIAL SAFETY DATA SHEET

NALCO

PRODUCT

NALCLEAR 7769 FLOCCULANT

Emergency Telephone Number
Medical (708) 920-1510 (24 hours)

SECTION 14 REGULATORY INFORMATION

The following regulations apply to this product.

FEDERAL REGULATIONS:

OSHA'S HAZARD COMMUNICATION RULE, 29 CFR 1910.1200:
Based on our hazard evaluation, the following ingredients in this product are hazardous and the reasons are shown below.

Ethoxylated nonylphenol - Eye irritant
Hydrotreated light distillate - Skin irritant

Hydrotreated light distillate = TWA 5 mg/m3 (oil mist) ACGIH/TLV

CERCLA/SUPERFUND, 40 CFR 117, 302:
Notification of spills of this product is not required.

SARA/SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT OF 1986 (TITLE III) - SECTIONS 302, 311, 312 AND 313:

SECTION 302 - EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355):
This product does not contain ingredients listed in Appendix A and B as an Extremely Hazardous Substance.

SECTIONS 311 and 312 - MATERIAL SAFETY DATA SHEET REQUIREMENTS (40 CFR 370):
Our hazard evaluation has found this product to be hazardous. The product should be reported under the following EPA hazard categories:

XX Immediate (acute) health hazard
-- Delayed (chronic) health hazard
-- Fire hazard
-- Sudden release of pressure hazard
-- Reactive hazard

SECTION 313 - LIST OF TOXIC CHEMICALS (40 CFR 372):
This product does not contain ingredients on the List of Toxic Chemicals.

TOXIC SUBSTANCES CONTROL ACT (TSCA):
The chemical ingredients in this product are on the 8(b) Inventory List (40 CFR 710).

RESOURCE CONSERVATION AND RECOVERY ACT (RCRA), 40 CFR 261 SUBPART C & D:
Consult Section 11 for RCRA classification.

FEDERAL WATER POLLUTION CONTROL ACT, Clean Water Act, 40 CFR 401.15

MATERIAL SAFETY DATA SHEET

NALCO

PRODUCT

NALCLEAR 7769 FLOCCULANT

Emergency Telephone Number
Medical (708) 920-1510 (24 hours)

SECTION 14 REGULATORY INFORMATION (CONTINUED)

(formerly Sec. 307), 40 CFR 116 (formerly Sec. 311):
None of the ingredients are specifically listed.

CLEAN AIR ACT, 40 CFR 60, Section 111, 40 CFR 61, Section 112:
This product does not contain ingredients covered by the Clean Air Act.

STATE REGULATIONS:

CALIFORNIA PROPOSITION 65:
This product does not contain any chemicals which require warning under California Proposition 65.

MICHIGAN CRITICAL MATERIALS:
This product does not contain ingredients listed on the Michigan Critical Materials Register.

STATE RIGHT TO KNOW LAWS:
The following ingredient(s) are disclosed for compliance with State Right To Know laws:

Ethoxylated nonylphenol	9016-45-9
Hydrotreated light distillate	64742-47-8
Sodium chloride	7647-14-5
Vinyl copolymer	Trade secret
Water	7732-18-5

INTERNATIONAL REGULATIONS:

This is a WHMIS controlled product under The House of Commons of Canada Bill C-70 (Class D2B). The product contains the following substance(s), (with CAS # and % range) from the Ingredient Disclosure List or has been evaluated based on its toxicological properties, to contain the following hazardous ingredient(s):

Ethoxylated nonylphenol	9016-45-9	1-5
Hydrotreated light distillate	64742-47-8	20-40

SECTION 15 ADDITIONAL INFORMATION

Nalco internal number 100661

SECTION 16 USER'S RESPONSIBILITY

This product material safety data sheet provides health and safety information. The product is to be used in applications consistent with

MATERIAL SAFETY DATA SHEET

NALCO

PRODUCT

NALCLEAR 7769 FLOCCULANT

Emergency Telephone Number
Medical (708) 920-1510 (24 hours)

SECTION 16 USER'S RESPONSIBILITY (CONTINUED)

our product literature. Individuals handling this product should be informed of the recommended safety precautions and should have access to this information. For any other uses, exposures should be evaluated so that appropriate handling practices and training programs can be established to ensure safe workplace operations. Please consult your local sales representative for any further information.

SECTION 17 BIBLIOGRAPHY

ANNUAL REPORT ON CARCINOGENS, U.S. Department of Health and Human Services, Public Health Service, PB 33-135855, 1983.

CASARETT AND DOULL'S TOXICOLOGY, THE BASIC SCIENCE OF POISONS, Doull, J., Klaassen, C. D., and Admur, M. O., eds., Macmillian Publishing Company, Inc., N. Y., 2nd edition, 1980.

CHEMICAL HAZARDS OF THE WORKPLACE, Proctor, N. H., and Hughes, J. P., eds., J. P. Lipincott Company, N.Y., 1981.

DANGEROUS PROPERTIES OF INDUSTRIAL MATERIALS, Sax, N. Irving, ed., Van Nostrand Reinhold Company, N.Y., 6th edition, 1984.

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REGISTRY OF TOXIC EFFECTS ON CHEMICAL SUBSTANCES, U.S. Department of Health and Human Services, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, 1983 supplement of 1981-1982 edition, Vol. 1-3, OH, 1984.

Title 29 Code of Federal Regulations Part 1910, Subpart Z, Toxic and Hazardous Substances, Occupational Safety and Health Administration (OSHA).

THRESHOLD LIMIT VALUES FOR CHEMICAL SUBSTANCES AND PHYSICAL AGENTS IN THE WORKROOM ENVIRONMENT WITH INTENDED CHANGES, American Conference of Governmental Industrial Hygienists, OH.

MATERIAL SAFETY DATA SHEET

NALCO

PRODUCT

NALCLEAR 7769 FLOCCULANT

Emergency Telephone Number
Medical (708) 920-1510 (24 hours)

(CONTINUED)

SECTION 17 BIBLIOGRAPHY

PREPARED BY: Ricky A. Stackhouse PhD., Toxicologist
DATE CHANGED: 10/24/91 DATE PRINTED: 07/16/92

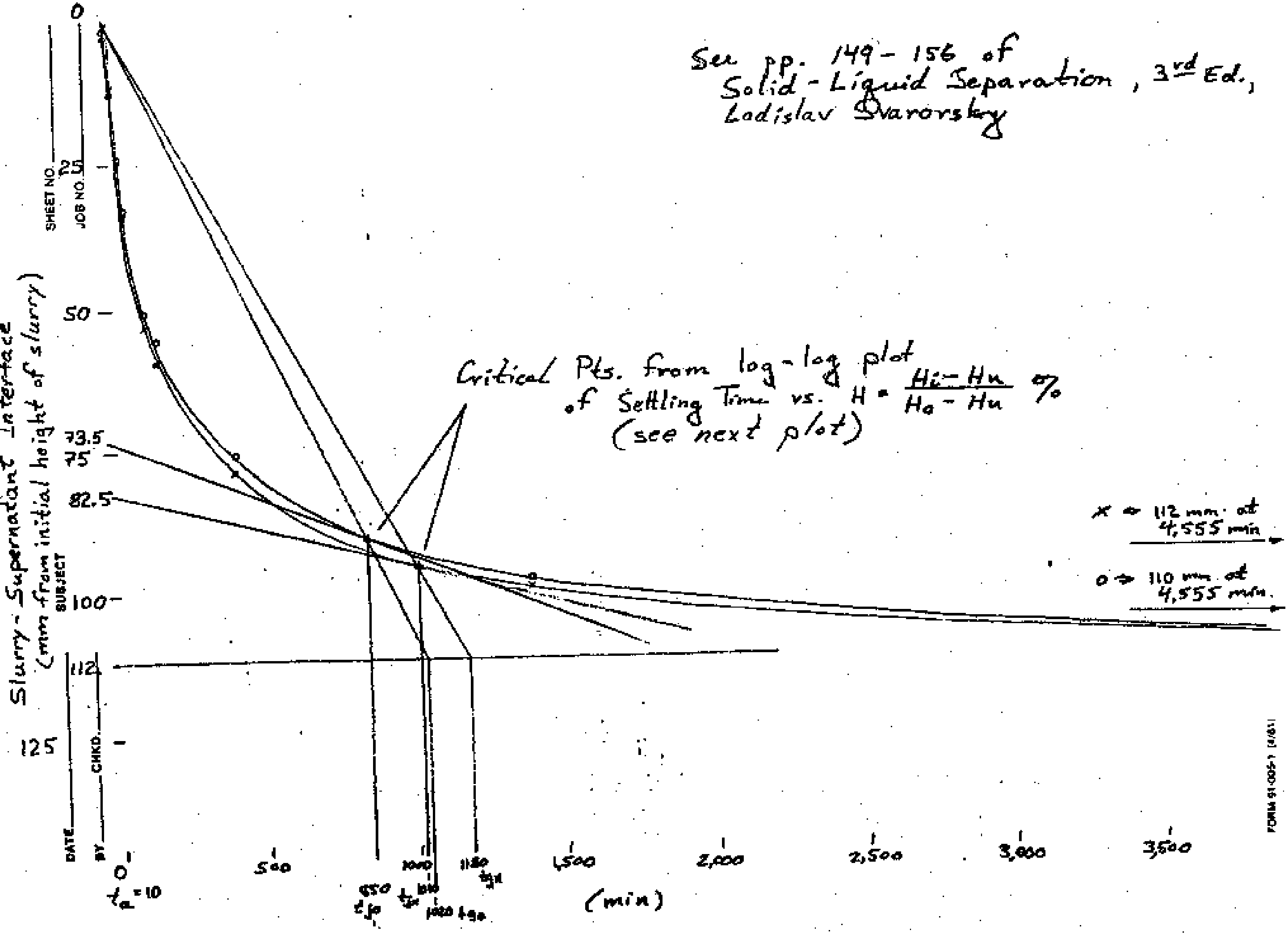
ATTACHMENT B

Raffinate Slurry Settling Curves

m:\users\mcclintk\document\je\floc93.212

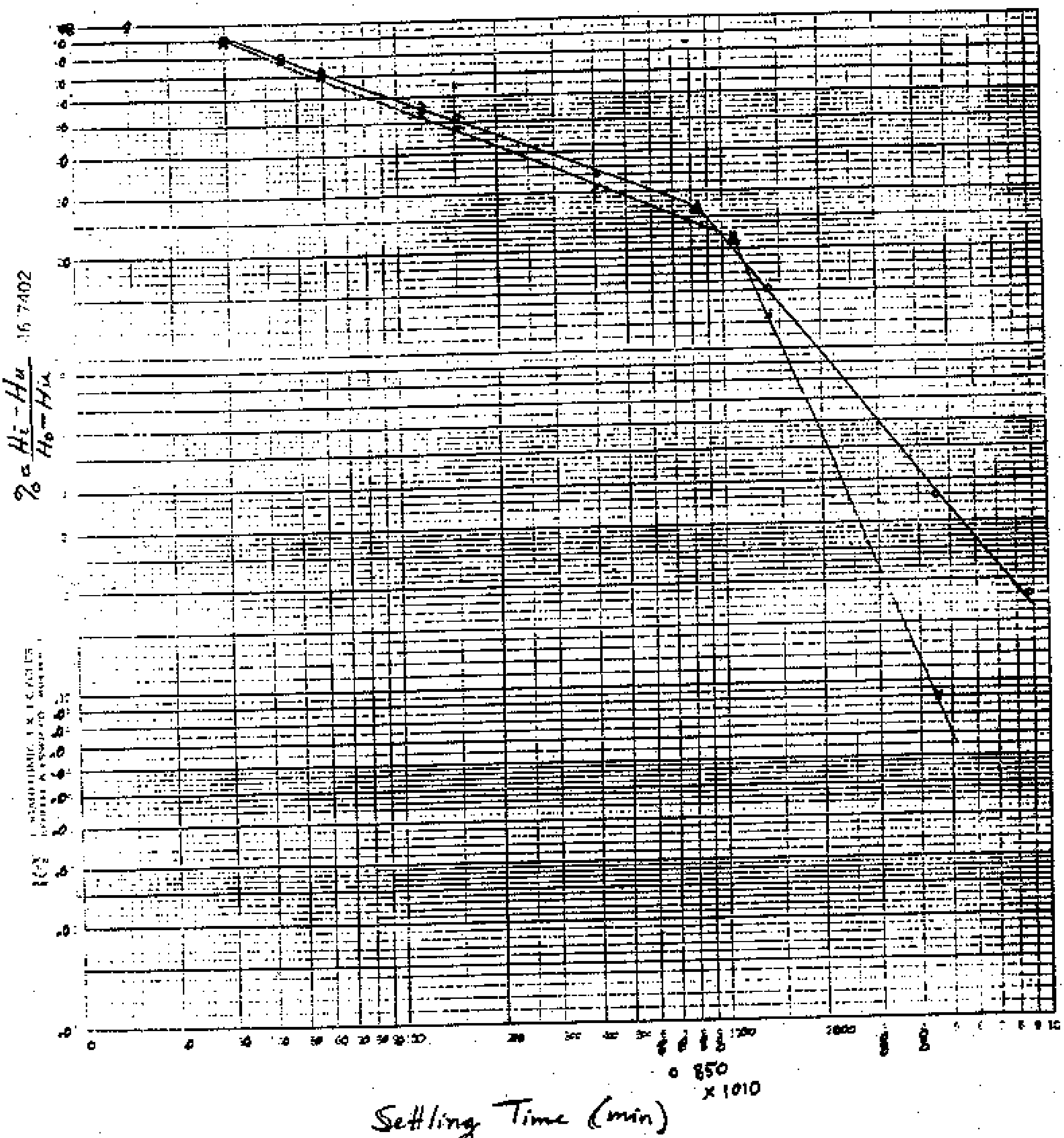
One-liter 15% Solids Pit 3 Control (Unflocced) Settling Tests

See pp. 149 - 156 of Solid-Liquid Separation, 3rd Ed., Ladislav Svarovsky



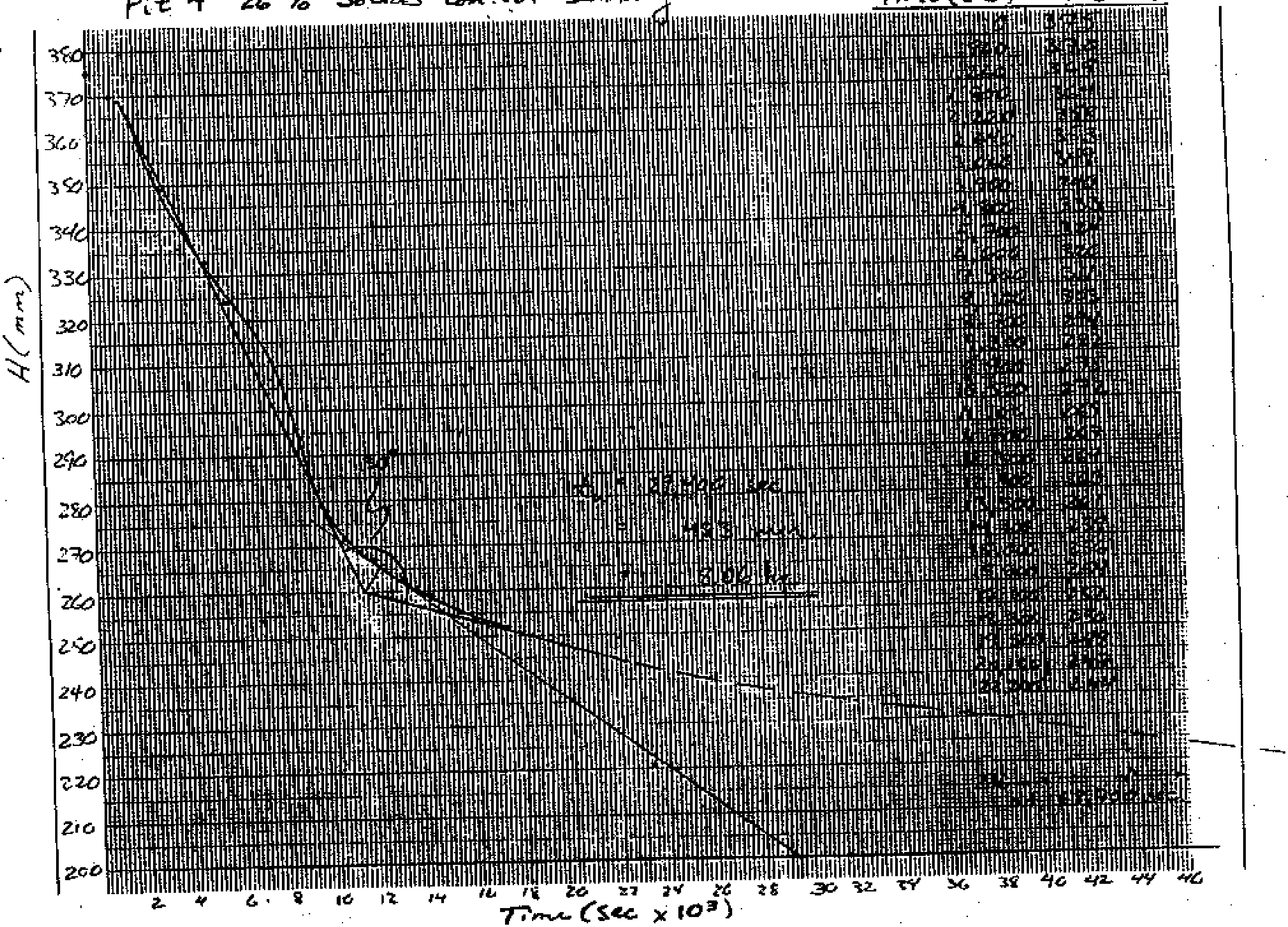
SHEET NO. JOB NO. SUBJECT DATE BY CHKD.

FORM 91-0057 (4/81)

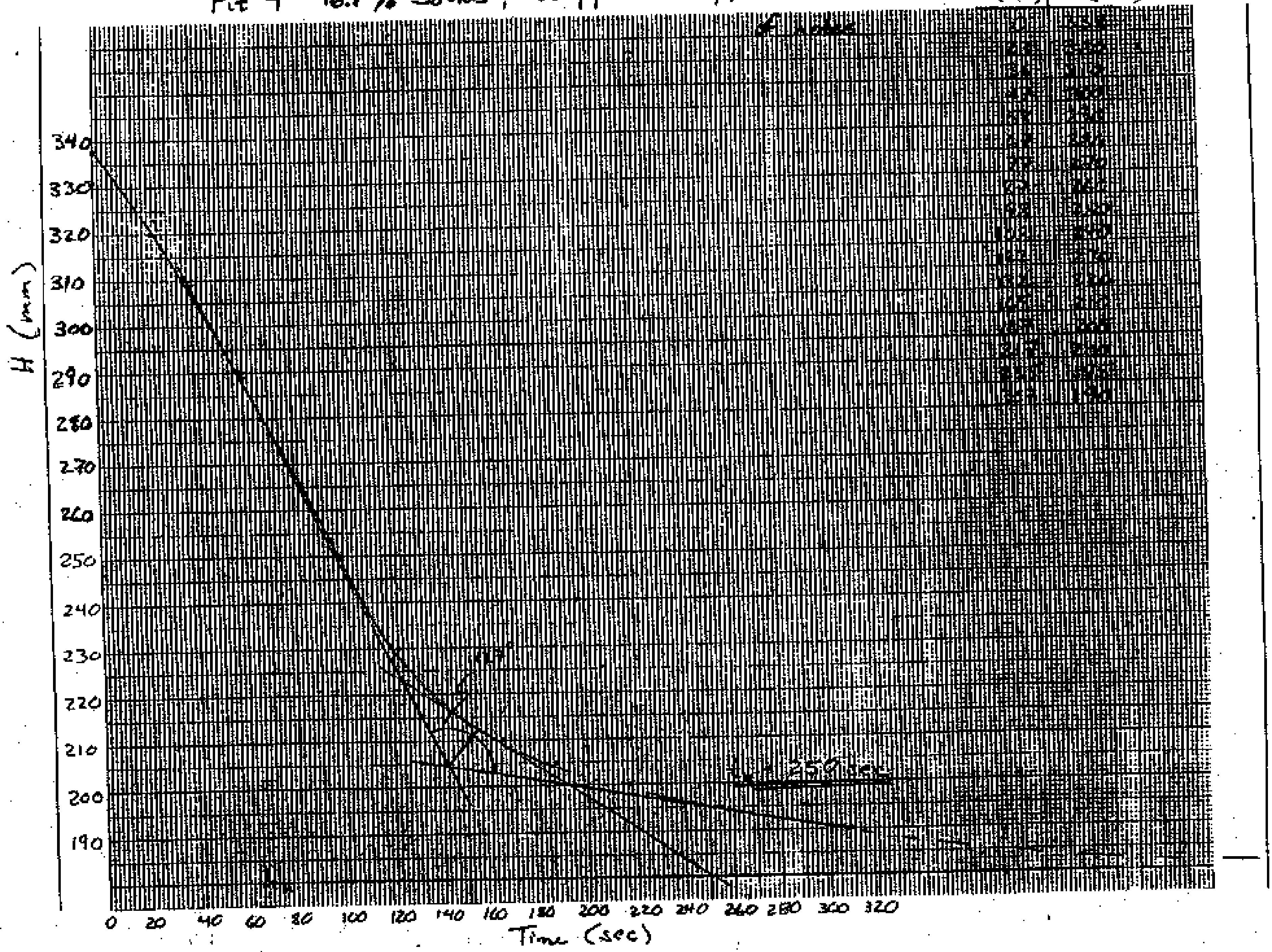


$\% = \frac{H_i - H_u}{H_o - H_u}$
o 850
x 1010
Settling Time (min)

Pit 4 26 % Solids Control Settling Test

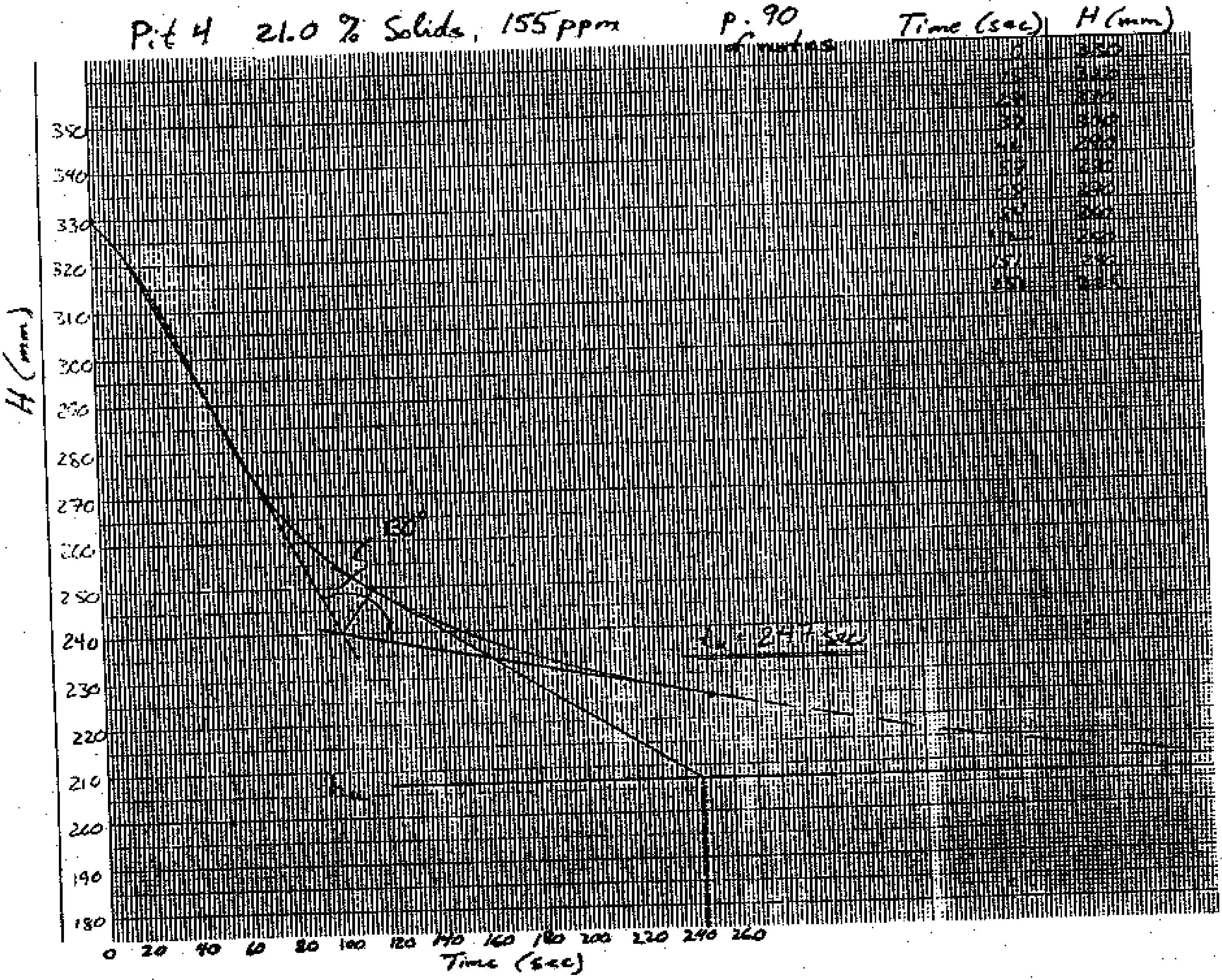


Pit 4 16.9% Solids, 100 ppm pp 86-87 Time (sec), H (mm)

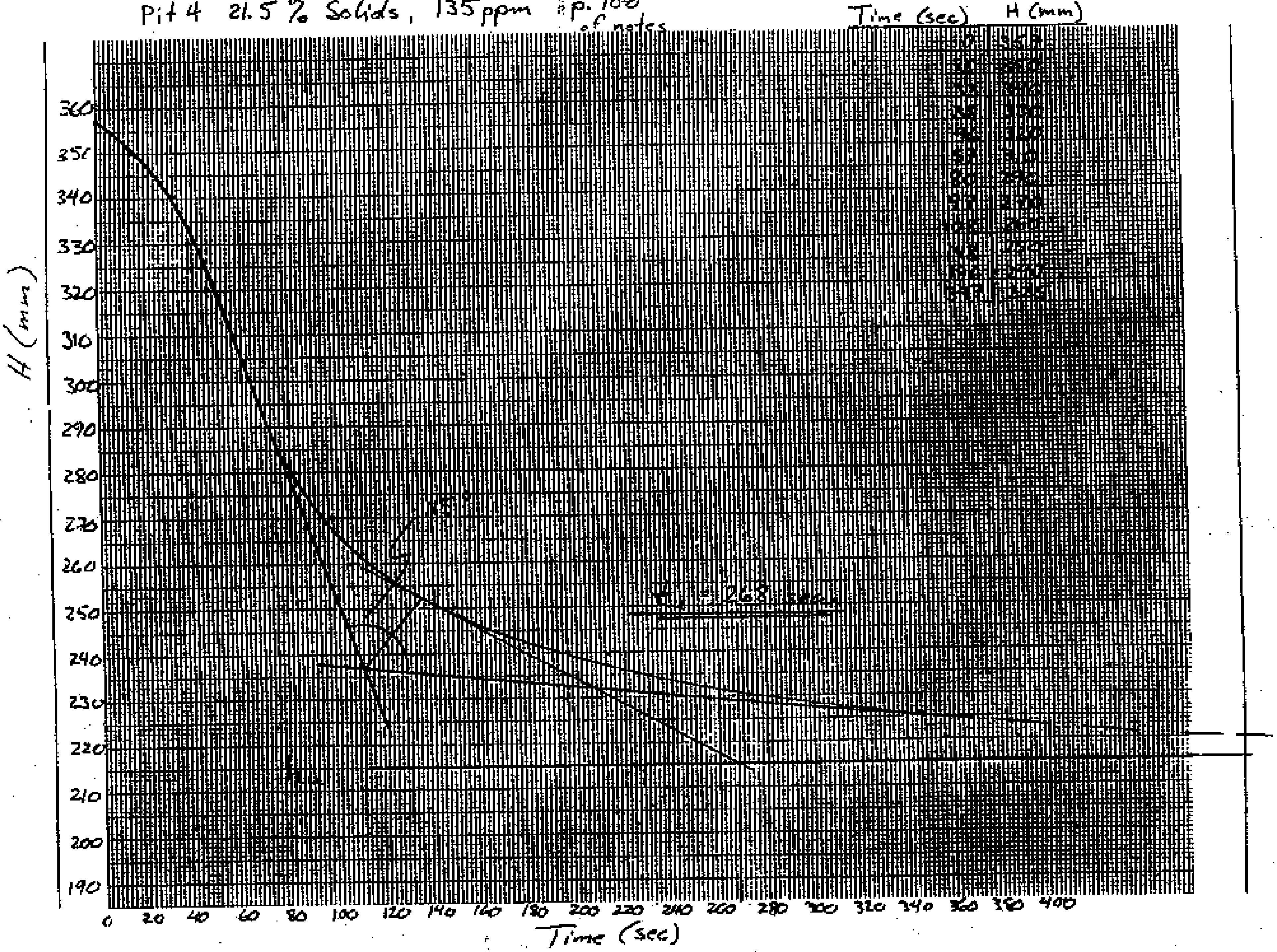


6

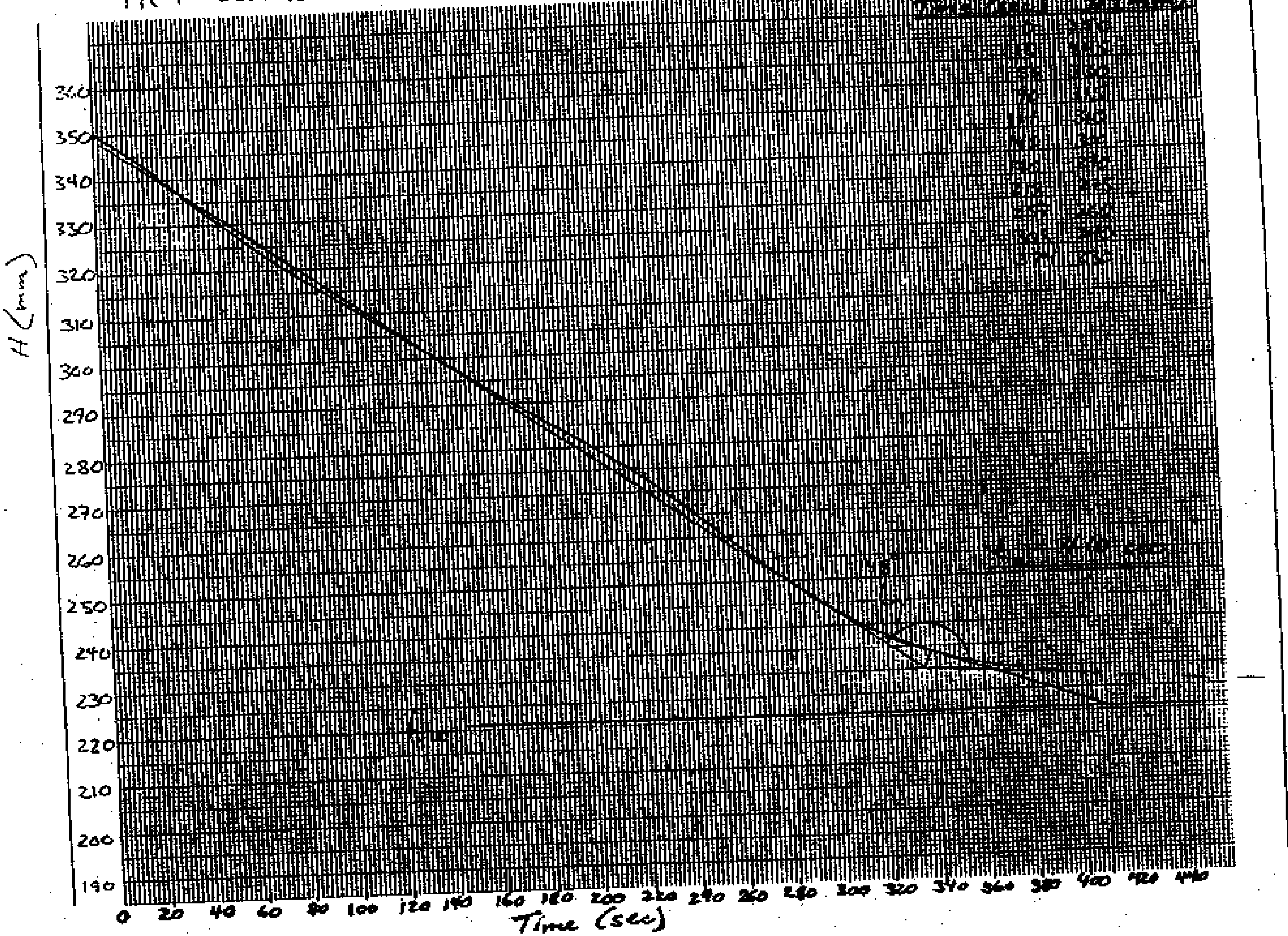
Pit 4 21.0 % Solids, 155 ppm p. 90 minutes



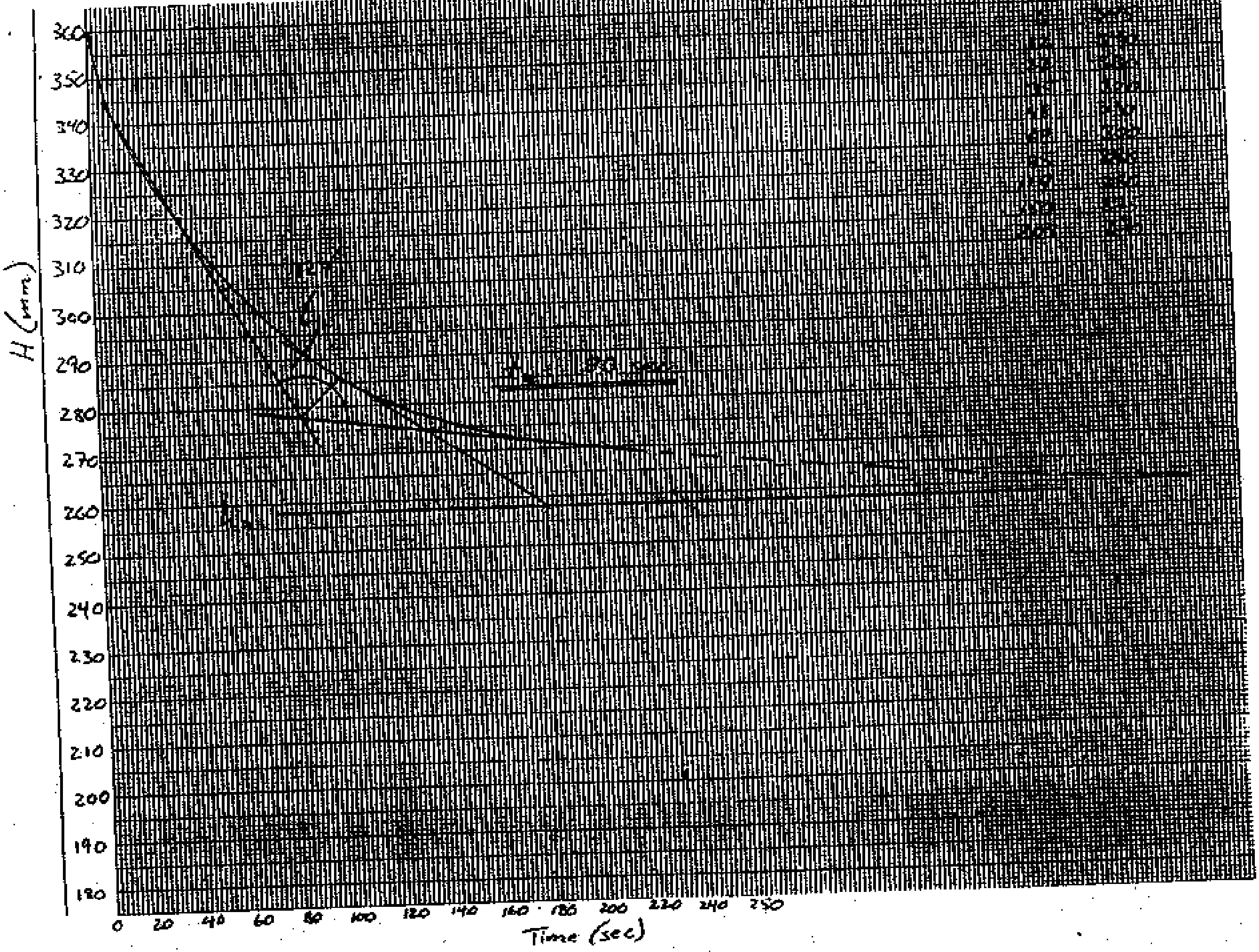
Pit 4 21.5 % Solids, 135 ppm # p. 100 of notes



Pit 4 22.0 % Solids, 95 ppm (added as slug prior to suspending solids) p. 97 of notes



Pit 4 26.2% Solids, 295 ppm p. 93, Time (sec) | H (mm)



ATTACHMENT C

Flocculant Concentration, Consumption, and Cost Estimate

October 8, 1992

Required flocculant concentration to flocculate pit 1, 2 and 3 composited sludge. (See pages 50-52 of onsite CSS testing notes.)

Three batches of sludge slurries at approximately 14 to 15 % solids were flocculated using a 21,323 ppm stock solution of Nalco 7769 flocculant.

The sludge used was a composite of pits 1, 2 and 3 sludge at 60.4% water/152% moisture content. Pit 3 water collected from pit 3 earlier in the week was used to dilute the sludge to the 14 to 15% solids concentration. Once flocculation was achieved, the supernatant from the initial batch was drained and reuse for the second batch. Likewise, the supernatant of the second batch was used to dilute the sludge of the third batch.

Batch 1:

Amount of sludge = 18.74 kg
Raffinate water added = 29.82 kg
Flocculant stock solution = 710.9 g

$$\% \ Solids = \frac{18.74\ (1-0.604)\ kg}{18.74 + 29.82 + 0.711\ kg} = 15.1\ \%\ Solids$$

$$Resulting\ flocculant\ concentration = \frac{0.711\ (21,323\ X\ 10^{-6})\ kg}{49.27 kg}$$

= 308 ppm

Batch 2:

Amount of sludge = 17.88 kg
Raffinate water added = 31.62 kg
Flocculant stock solution = 281.8 g

$$\% \ Solids = \frac{17.88\ (1-0.604)\ kg}{17.88 + 31.62 + 0.282\ kg} = 14.2\ \%\ Solids$$

$$Resulting\ flocculant\ concentration = \frac{0.282\ (21,323\ X\ 10^{-6})\ kg}{49.78 kg}$$

= 121 ppm

==========

Batch 3:

Amount of sludge = 8.84 kg
Raffinate water added = 15.42 kg
Flucculant stock solution = 199.5 g

$$\% \; Solids = \frac{8.84\ (1-0.604)\ kg}{8.84 + 15.42 + 0.200 kg} = 14.3\ \%\ Solids$$

$$Resulting\ flocculant\ concentration = \frac{0.200\ (21,323\ X\ 10^{-6})\ kg}{24.46 kg}$$

= 174 ppm

==========

Average concentration of Na 7769 in sludge slurry near 15% solids to floccuate sludge:

$$ppm = \frac{710.9 + 281.8 + 199.5)\ (X\ 10^{-3})\ (21,323\ X\ 10^{-6})\ kg}{49.27 + 49.78 + 24.46\ kg}$$

= 206 ppm

==========

The amount of neat flocculant required to flocculate the sludge on a $lbs._{floc}$ per ton of dry solids is:

$$\frac{(0.0254)\ floc\ kg}{(18.74 + 17.88 + 8.84)\ (1-0.604)\ solids,\ kg} = \frac{0.0254\ kg}{18.00\ kg} = \frac{0.0560\ lbs}{39.69\ lbs}$$

$$\frac{0.0560\ lbs}{(39.69\ lbs)\ (ton/2000\ lbs)} = \frac{2.82\ lbs_{floc}}{ton\ solids}$$

Assuming for the time being that pit 4 will flocculate at the same concentration (probably less) than pits 1, 2 and 3, the total cost of flocculant is estimated as follows:

$$\frac{(170{,}000\ yd^3)}{\text{total volume of sludge}} \quad \frac{\left(\frac{27\ ft^3}{yd^3}\right)\left(\frac{78\ lbs}{ft^3}\right)\left(\frac{ton}{2000\ lbs}\right)}{\text{in place weight}} \quad \frac{(1-0.70)}{\text{in place solids portion}}$$

= 53,703 tons of solids

At $1.63/lb cost of Na 7769 as quoted, total cost of the flocculant to flocculate all of the raffinate sludge is:

$$(53{,}703\ tons\ solids)\left(\frac{\$1.63}{lb_{floc}}\right)\left(\frac{2.82\ lbs\ floc}{ton\ solids}\right)$$

= $247,000

October 16, 1992

As on October 8, 1992, pit 1, 2 and 3 composited sludge was flocculated using a stock solution of Nalco Na7769 flocculant. (See pages 67 - 69 of onsite CSS testing notes.)

Three batches of sludge slurries at approximately 14 to 15% solids were flocculated. Below are the calculations providing the resulting flocculant concentrations, overall average flocculant concentration, and amount of flocculant required per ton of dry raffinate solids.

The sludge used was a composite of pits 1, 2 and 3 at 60.6% water/154% moisture content. Pit 3 water collected on October 7, 1992, and used to flocculate the same sludge on October 8, 1992, was again used to dilute the additional sludge to be flocculated (see October 8, 1992, calculations). The supernatant from the initial batch was used to dilute sludge for the second batch. Likewise, the supernatant from the second batch was used to dilute the sludge in the third batch. (For the first batch, approximately 30% of the raffinate water added was "fresh" pit 3 water not used in the October 8 flocculation of sludge.)

<u>Batch 1:</u>

Amount of sludge = 18.82 = (21.90 - 3.08) kg
Raffinate water added = 31.28 Kg
Flocculant stock solution = 892.5 g

$$\% \ Solids = \frac{18.82\ (1-0.606)\ kg}{18.82 + 31.28 + 0.893\ kg} = 14.5\ \% \ Solids$$

$$Resulting\ flocculant\ concentration = \frac{0.893\ (20{,}062\ X\ 10^{-6})\ kg}{50.99 kg}$$

= 351 ppm
==========

<u>Batch 2:</u>

Amount of sludge = 18.72 = (21.80 - 3.08) kg
Raffinate water added = 31.18 kg
Flocculant stock solution = 161.6 g

$$\% \ Solids = \frac{18.72\ (1-0.606)\ kg}{18.72 + 31.18 + 0.162\ kg} = 14.7\ \% \ Solids$$

$$\textit{Resulting flocculant concentration} = \frac{0.162\ (20{,}062\ X\ 10^{-6})\ kg}{50.06 kg}$$

= 65 ppm

==========

Batch 3:

Amount of sludge = 18.78 = (21.86 - 3.08) kg
Raffinate water added = 30.94 kg
Flucculant stock solution = 706.0 g

$$\%\ Solids = \frac{18.78\ (1-0.606)\ kg}{18.78 + 30.94 + 0.706\ kg} = 14.7\ \%\ Solids$$

$$\textit{Resulting flocculant concentration} = \frac{0.706\ (20{,}062\ X\ 10^{-6})\ kg}{50.43 kg}$$

= 281 ppm

==========

Average concentration of Na 7769 in sludge slurry near 15% solids to flocculate sludge:

$$ppm = \frac{(892.5 + 161.6 + 706.0)\ (X\ 10^{-3})\ (20{,}062\ X\ 10^{-6})\ kg}{50.10 + 49.90 + 49.72\ kg}$$

= 236 ppm

==========

The amount of neat flocculant required to flocculate the sludge on a lbs_{floc} per ton of dry solids is:

$$\frac{(0.0353)\ floc\ kg}{(18.82 + 18.72 + 18.78)\ (1-0.606)\ solids,\ kg} = \frac{0.0353\ kg}{22.19\ kg}$$

$$\frac{(0.0778)\ lbs}{(48.92\ lbs)\ (ton/2000\ lbs)} =$$

$$\frac{3.18\ lb_{floc}}{ton\ solids}$$

==

Using data from flocculation performed on both October 8, 1992, and October 16, 1992, the overall average flocculant concentration required in a sludge slurry of 14 to 15% solids and total neat flocculant consumption is estimated below.

Average percent solids in the six batches of flocculated sludge slurry:

$$\frac{(18.74+17.88+8.84)(1-0.604)+(18.82+18.72+18.78)(1-0.606)}{49.27+49.78+24.46+50.99+50.06+50.43} =$$

$$\frac{40.19}{274.99} = 14.6\ \%\ Solids$$

Average flocculant concentration in sludge slurries:

$$\frac{[(710.9+281.7+199.5)(21{,}323X10^{-6})+(892.5+161.6+706.0)(20{,}062X10^{-6})](X10^{-3}),k}{49.27+49.78+24.46+50.10+49.90+49.72,\ kg}$$

$$\frac{0.0607\ kg}{273.23\ kg} = \underline{222\ ppm}$$

Neat flocculant consumption:

$$\frac{(0.0560+0.0778)\ lbs_{floc}}{(39.69+47.92\ lbs)(ton/2000\ lbs)} = \underline{3.05\ lbs\frac{floc}{ton\ solids}}$$

Total Flocculant Cost:

$$(53{,}703\ tons\ solids)\left(\frac{\$1.63}{lb_{floc}}\right)\left(\frac{3.05\ lbs\ floc}{ton\ solids}\right)$$

= $267,000
==========

MK-FERGUSON
A DIVISION OF MORRISON KNUDSEN CORPORATION

INTER-OFFICE CORRESPONDENCE

DATE: March 10, 1993

TO: Distribution

FROM: John Enger

SUBJECT: **COMPREHENSIVE ANALYTICAL RESULTS OF ON-SITE CSS TESTING**

In reference to my January 29, 1993 IOC to you, attached is a table summarizing all of the TCLP and total chemical analyses relating to the on-site bench scale CSS testing. Analyses are of various CSS mixes (grouts and soil-like) and components of the mixes (i.e., sludge, raffinate dike soil, sieved quarry-nitroaromatic soils, class C flyash, class F flyash, and Portland Type II cement).

The total arsenic and TCLP semi-volatile analyses that were not available to include in the January 29, 1993 IOC table are incorporated in the attached table. Also attached is another table of pH measurements taken in conjunction with the TCLP analyses. The TCLP pH measurements indicate the relative buffering capacities of the binders used in the CSS mixes.

The total arsenic analyses of nonflocculated pit 2 1991 and pit 3 1988 sludges reflect WTG 1991 and MKF-JEG 1988 arsenic analyses, respectively. The range in arsenic concentrations (1770/1800 ppm to 2200/2200 ppm) of two flocculated/dewatered pit 2 1991 samples could be explained by the different raffinate water used in flocculating the two samples and observations made during the flocculation.

Pit 2 and 4 raffinate water not previously used in flocculation of sludge was used in flocculating pit 2 1991-2/4, and pit 3 raffinate water/supernatant used repeatedly in flocculations of other sludge slurries was reused in flocculating pit 2 1991-3S. Supernatant from the flocculation of pit 2 1991-2/4 was observed to contain more suspended solids than the supernatant from the flocculation of pit 2 1991-3S. These two factors may explain the higher arsenic content of pit 2 1991-3S (2200/2200 ppm) than pit 2 1991-2/4 (1770/1800 ppm).

Although pit 2 1991-2/4 flocculated/dewatered sludge containing lower arsenic content was used in pit 2 CSS mixes, TCLP arsenic levels of both pit 2 flocculated/dewatered sludges compared well and were significantly less than the respective nonflocculated 1991 pit 2 sludge. Also, in view of the fact that all CSS mixes passed the arsenic TC level of 5.0 mg/l by an order of magnitude, using pit 2 1991-2/4 versus pit 2 1991-3S is not significant.

a:\users\mcclintx\document\csscomp

The most recent TCLP semivolatile analyses confirm that a soil:sludge:binder mix of 1:1:0.4 using quarry soil and class C flyash/Portland Type II (60/40) binder passes the 2,4 DNT TC level of 130 µg/l. Because the quarry soil used in the CSS soil-like mixes was sieved through a No. 4 sieve (4.75 mm), the nitroaromatic contaminants were concentrated in the quarry soil by removing the larger limestone gravel. The 1:1:0.4 proportions should therefore be considered a conservative mix with respect to the amount of binder.

In regard to radiological analyses, the ES&H department measured uranium activities of CSS grout leachates using the on-site KPA (kinetic phosphorescent analyzer). Leachates were generated by adding deionized water to each CSS grout at a ratio of 1.5 to 1 by weight and shaking until the grout became a slurry. The uranium activities of the grout leachates ranged from 12.46 to 137.34 pCi/l. The attached March 9, 1993 IOC from Michelle Vaughn to File tabulates the KPA results and discusses the data quality.

Because much of the on-site bench scale tests data has been generated and distributed piecemeal, the following is a listing of IOC's and TCT analytical submissions relating to on-site flocculation and CSS bench scale testing:

IOC's

- December 22, 1992; Enger to Distribution, "Raffinate TCLP Results"
- January 6, 1993; Enger to Distribution, "Additional CSS TCLP Tests"
- January 29, 1993; Enger to Distribution, "Results of Additional CSS TCLP Testing"
- February 3, 1993; Pier to Hodges, "Finalizing Formulas for Waste-Binder Mixes for PNL Experimental Work"
- February 12, 1993; Enger to Distribution, "Summary of On-Site Flocculation-Settling Tests of Raffinate Pit Sludges"
- February 23, 1992; Ferguson/Enger to Dille, "Continuation of Task 942, Raffinate Dewatering Support Study"

TCT - St. Louis Analytical Submissions

- August 18, 1992, Srour to Henry, Request #55

- December 10, 1992, Srour to Claytor, Request #121
- January 28, 1993, Srour to Claytor, Request #168
- February 19, 1993, Srour to Claytor, Request #168.1
- February 22, 1993, Srour to Claytor, Request #121.1
- February 22, 1993, Srour to Claytor, Request #168.2

On-site bench scale data which hasn't been summarized and distributed include geotechnical data (percent moisture, percent water, compaction, Atterberg limits, paint filter, and penetrometer resistance) relating to raffinate sludges, soils, binders, and CSS mixes. Unconfined compressive strength (UCS) testing must be performed on selected CSS grout formulas. Based on ORNL penetrometer resistance and UCS results and our on-site penetrometer resistance measurements, we believe a sludge to binder ratio of 1:0.25 will meet the 50 psi UCS requirement for CSS grout. I'm trying to arrange the UCS testing at TCT - St. Louis and will provide a summary of the geotechnical data following the UCS tests.

If you have any questions concerning the above or attached, please contact me at X3302.

JGE/kem

Attachment

Distribution: Rick Ferguson
Marj Wesely
Glen Schmidt
Sheryl Hodges
Jean Pier
Jeff Serne
Jim Williams
Dale Durrett
Lannis Phillips
Al Munio
Joe Foldyna
RC-22-12-07-02a

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Materials	Samples	Analyses	
CSS Soil-Like Using Dike Soil	Soil:Sludge:Binder		As (µg/l)
Class C Flyash	Pit 2 1988 1:1:0.2	TC Arsenic	ND (110)
	Pit 3 1988 1:1:0.2	TC Arsenic	ND (110)
	Pit 2 1991 1:1:0.2[4]	TC Arsenic	423/ Blind Duplicate 4: 540
	Pit 3 1991 1:1:0.2	TC Arsenic	ND (110)
60/40 Class C Flyash/ Portland Type II Cement	Pit 2 1988 1:1:0.2	TC Arsenic	251
	Pit 3 1988 1:1:0.2[5]	TC Arsenic	ND (110)/ Blind Duplicate 5: 251
	Pit 2 1991 1:1:0.2	TC Arsenic	313
	Pit 3 1991 1:1:0.2	TC Arsenic	ND (110)

CSS Soil-Like Using Nitroaromatic (Quarry) Soil	Soil:Sludge:Binder		As (µg/l)	Ba (µg/l)	Cd (µg/l)	Cr (µg/l)	Pb (µg/l)	Hg (µg/l)	Se (µg/l)	Ag (µg/l)	2,4-DNT (µg/l)	
			5000	100,000	1000	5000	5000	200	1000	5000	130	TC Levels
Class C Flyash	Pit 2 1991 1:1:0.2	TC metals, TC semi-VOAs	342	1480	25.0	ND	ND	ND	ND	16.0	950	
	Pit 2 1991 1:1:0.4	TC metals, TC semi-VOAs	221	908	26.0	ND	36.0	ND	ND	12.0	570	
	Pit 3 1988 1:1:0.2	TC metals, TC semi-VOAs	ND	582	16.0	ND	ND	0.27	ND	ND	750	
	Pit 3 1988 1:1:0.4	TC metals, TC semi-VOAs	ND	552	20.0	197	ND	0.28	ND	ND	640	
60/40 Class C Flyash/ Portland Type II Cement	Pit 2 1991 1:1:0.2	TC metals, TC semi-VOAs	460	1090	17.0	ND	ND	ND	ND	12.0	280	
	Pit 2 1991 1:1:0.4	TC metals, TC semi-VOAs	325	1540	13.0	ND	ND	ND	ND	11.0	110	
	Pit 3 1988 1:1:0.2	TC metals, TC semi-VOAs	ND	1070	17.0	128	ND	0.49	ND	23.0	160	
	Pit 3 1988 1:1:0.4	TC metals, TC semi-VOAs	ND	1170	14.0	84.0	63.0	0.75	ND	31.0	77.0 94.8	

Materials	Samples	Analyses	As (µg/l)	Ba (µg/l)	Cd (µg/l)	Cr (µg/l)	Pb (µg/l)	Hg (µg/l)	Se (µg/l)	Ag (µg/l)	
CSS Monolithic (grout)	Sludge:Binder										
60/40 Class C Flyash/ Portland Type II Cement	Pit 2 1991 1:0.177[1]	TC Metals, Rad[2]	436	788	23.0	10.0	ND	ND	ND	ND	
			409	771	29.0	15.0	ND	0.10	ND	ND	
			Blind Duplicate 1:								
			832	808	47.0	59.0	ND	0.28	ND	19.0	
			685	657	40.0	78.0	ND	0.31	ND	32.0	
	Pit 2 1991 1:0.250	TC Metals, Rad	409	613	16.0	37.0	41.0	0.10	ND	ND	
	Pit 2 1991 1:0.333	TC Metals, Rad	289	612	11.0	89.0	ND	ND	ND	ND	
	Pit 3 1988 1:0.250[1]	TC Metals, Rad	ND	520	64.0	227	ND	ND	239	ND	
			Blind Duplicate 2:								
			ND	403	30.0	154	ND	5.96	ND	9.0	
60/40 Class F Flyash/ Portland Type II Cement	Pit 3 1988 1:0.177	TC Metals, Rad	ND	357	68.0	228	ND	9.50	277	ND	
	Pit 3 1988 1:0.250[1]	TC Metals, Rad	ND	357	20.0	282	ND	4.92	ND	ND	
			Blind Duplicate 3:								
			ND	389	33.0	270	ND	8.50	ND	45.0	
	Pit 3 1988 1:0.333	TC Metals, Rad	ND	559	50.0	347	ND	8.40	229	ND	
	Pit 2 1991 1:0.250	TC Metals, Rad	519	174	16.0	16.0	ND	ND	ND	ND	
Nonflocculated Sludge	Pit 2 1991 (33.1% solids)	TC Metals, Arsenic	5030	466	175	649	112	0.11	ND	10.0	TC Metals
			1680/ Duplicate 2690[3] µg/g (WTG/EcoTek pit 2 1991 2250 ppm)								Arsenic
	Pit 3 1988 (32.2% solids)	TC Metals, Arsenic	3810	152	128	558	119	6.60	379	25.0	TC Metals
			3570	210	127	545	90.0	7.26	379	9.0	TC Metals Dup
			1270/ Duplicate 1270 µg/g (MKF-JEG pit 3 1988 average of 1175 ppm)								Arsenic
Flocculated Sludge (Dewatered)	Pit 2 1991 - 2/4 (29.6% solids)	TC Metals, TC VOAs, TC Semi-VOAs, Arsenic	1150	280	55.0	15.0	ND	ND	ND	ND	TC Metals
			ND								TC VOAs
			ND								TC Semi-VOAs
			1770/ Duplicate 1800 µg/g								Arsenic
	Pit 2 1991 - 3S (31.7% solids)	TC Metals, TC VOAs, TC Semi-VOAs, Arsenic	1200	261	48.0	11.0	ND	0.10	ND	ND	TC Metals
			ND								TC VOAs
			ND								TC Semi-VOAs
			2200/ Duplicate 2200 µg/g								Arsenic

Materials	Samples	Analyses									
			As (µg/l)	Ba (µg/l)	Cd (µg/l)	Cr (µg/l)	Pb (µg/l)	Hg (µg/l)	Se (µg/l)	Ag (µg/l)	
	Pit 3 1988 - 3S (28.8% solids)	TC Metals, TC VOAs, TC Semi-VOAs, Arsenic	308	228	18.0	58.0	ND	7.64	324	ND	TC Metals
							ND				TC VOAs
							ND				TC Semi-VOAs
			1380/ Duplicate 1360 µg/g								Arsenic
Binders and Soil	Class C Flyash	TC Metals	ND	363	51.0	291	ND	ND	ND	ND	
	Class F Flyash	TC Metals	167	360	71.0	1780	ND	ND	267	ND	
	Portland Type II	TC Metals	ND	918	10.0	380	ND	ND	ND	ND	
	Pit Dike Soil	TC Metals	ND	977	ND	10.0	ND	ND	ND	ND	
	Nitroaromatic Soil[4]	TC Metals, Nitroaromatics, TC Semi-VOAs	As (µg/l)	Ba (µg/l)	Cd (µg/l)	Cr (µg/l)	Pb (µg/l)	Hg (µg/l)	Se (µg/l)	Ag (µg/l)	TC Metals
			ND	1070	ND	10.0	ND	0.12	ND	ND	
			1,3,5-TNB (µg/g)	1,3-DNB (µg/g)	2,4,6-TNT (µg/g)	NB (µg/g)	2,6-DNT (µg/g)	2,4-DNT (µg/g)			Nitroaromatics
			363	4.12	8610	ND	25.0	74.8			
			373	4.92	9420	ND	27.2	82.8			
			1600 2,4-DNT µg/l								TC Semi-VOAs[5]

(1) Duplicate extraction and analyses performed on blind duplicate samples. Laboratory quality control duplicate analyses are also provided.

(2) The ES&H on-site KPA (kinetic phosphorescent analyzer) was used in measuring the uranium activity of CSS grout leachate produced by mixing deionized water with CSS grout at a 1.5:1.0 deionized water to grout ratio by weight. See March 9, 1993 IOC from Michelle Vaughn to File for uranium activity results of the CSS grout leachates.

(3) Due to a Relative Percent Difference (RPD) of 46.2% between the original and duplicate analyses, a request for validation was submitted to the Validation /Verification section for these two analyses.

(4) Nitroaromatic soil used in the CSS soil-like mixes listed above and analysed by itself consists of Weldon Spring quarry soil collected in 1991 passing the No. 4 sieve (4.75 mm). Approximately 45% by total weight of the quarry soil sample passed the No. 4 sieve.

(5) All other TC semi-volatiles were non-detect (ND).

Materials	Samples	TCT-SL	Analyses	TCLP pH Measurements, 40CFR268, App. I		
CSS Soil-Like Using Dike Soil	Soil:Sludge:Binder	Lab. No.		Sect. 7.4.2	7.4.3	8.14
Class C Flyash	Pit 2 1988 1:1:0.2	93000132	TC Arsenic	9.73	6.88	4.81
	Pit 3 1988 1:1:0.2	93000133	TC Arsenic	9.87	5.84	4.60
	Pit 2 1991 1:1:0.2[(1)]	93000134 93000151	TC Arsenic	9.86 9.86	6.51 6.47	4.74 4.25
	Pit 3 1991 1:1:0.2	93000135	TC Arsenic	9.97	5.94	4.64
60/40 Class C Flyash/ Portland Type II Cement	Pit 2 1988 1:1:0.2	93000136	TC Arsenic	10.71	8.79	4.42
	Pit 3 1988 1:1:0.2[(1)]	93000137 93000152	TC Arsenic	11.10 11.14	8.83 8.90	4.49 4.38
	Pit 2 1991 1:1:0.2	93000138	TC Arsenic	11.14	8.57	4.45
	Pit 3 1991 1:1:0.2	93000139	TC Arsenic	11.04	8.77	4.42
CSS Soil-Like Using Nitroaromatic (Quarry) Soil	Soil:Sludge:Binder					
Class C Flyash	Pit 2 1991 1:1:0.2	93000140	TC metals, TC semi-VOAs	10.07 10.07	7.11 7.11	5.12 4.74
	Pit 2 1991 1:1:0.4	93000141	TC metals, TC semi-VOAs	10.39 10.39	7.54 7.54	5.28 4.74
	Pit 3 1988 1:1:0.2	93000142	TC metals, TC semi-VOAs	10.08 10.08	7.16 7.16	5.14 4.68
	Pit 3 1988 1:1:0.4	93000143	TC metals, TC semi-VOAs	10.31 10.31	7.49 7.49	5.08 4.73
60/40 Class C Flyash/ Portland Type II Cement	Pit 2 1991 1:1:0.2	93000144	TC metals, TC semi-VOAs	11.18 11.18	9.19 9.19	5.42 4.89
	Pit 2 1991 1:1:0.4	93000145	TC metals, TC semi-VOAs	11.05 11.05	10.03 10.03	5.70 5.13
	Pit 3 1988 1:1:0.2	93000146	TC metals, TC semi-VOAs	11.23 10.88	8.95 8.30	5.19 4.86
	Pit 3 1988 1:1:0.4	93000147	TC metals, TC semi-VOAs	11.85 11.30	10.10 9.85	5.53 4.98

Materials	Samples	TCT-SL	Analyses	TCLP pH Measurements, 40CFR268, App. 1		
CSS Monolithic (grout)						
60/40 Class C Flyash/ Portland Type II Cement	Pit 2 1991 1:0.177[1]	93000116 93000148	TC Metals	11.29 11.16	9.74 9.71	6.56 5.02
	Pit 2 1991 1:0.250	93000117	TC Metals	11.45	10.37	6.43
	Pit 2 1991 1:0.333	93000118	TC Metals	11.55	10.59	6.98
	Pit 3 1988 1:0.250[1]	93000119 93000149	TC Metals	11.41 11.63	10.36 10.47	5.40 5.11
60/40 Class F Flyash/ Portland Type II Cement	Pit 3 1988 1:0.177	93000120	TC Metals	11.36	10.05	5.25
	Pit 3 1988 1:0.250[1]	93000121 93000150	TC Metals	11.49 11.60	10.38 10.50	6.79 5.03
	Pit 3 1988 1:0.333	93000122	TC Metals	11.52	10.66	5.76
	Pit 2 1991 1:0.250	93000123	TC Metals	11.51	10.44	6.87
Flocculated Sludge	Pit 2 1991 2/4	93000124	TC Metals, TC VOAs, TC Semi-VOAs	7.98 7.98	6.93 6.93	5.10 5.35
	Pit 2 1991 3S	93000125	TC Metals, TC VOAs, TC Semi-VOAs	7.98 7.98	6.93 6.93	5.15 4.34
	Pit 3 1988 3S	93000126	TC Metals, TC VOAs, TC Semi-VOAs	8.70 8.70	7.02 7.02	4.67 4.17
Binders and Soil	Class C Flyash	93000127	TC Metals	11.40	9.06	4.94
	Class F Flyash	93000128	TC Metals	11.29	5.10	4.41
	Portland Type II	93000129	TC Metals	11.89	11.80	12.29
	Pit Dike Soil	93000130	TC Metals	8.02	1.72	5.10
	Nitroaromatic Soil	93000131	Nitroaromatics, and TC Semi-VOAs	8.70 8.70	7.62 7.62	5.72 (Dup) 5.34

1) Duplicate extraction and analyses.

MK-FERGUSON GROUP

INTER-OFFICE CORRESPONDENCE

DATE: March 9, 1993

TO: File

FROM: Michelle Vaughn MLV

SUBJECT: KPA RESULTS OF CSS GROUT SAMPLES

On February 5, 1993, the laboratory analyzed the liquid leachate from 13 CSS grout samples that were prepared by John Enger of the Environmental Documentation and Conceptual Design Department. The first set of data indicated potential interference problems as the sample intensity results varied tremendously on the QC and duplicate analyses. Also, a number of the samples were yielding results less than the blank sample. A number of factors can cause these types of interference to occur during KPA operations. These factors include such things as 1) the presence of dissolved minerals, dissolved organics, metals, or a high acidic content; 2) dirty cell windows; and/or 3) suspended particles. The CSS grout samples did not contain visible suspended particles and the cell windows were cleaned before analysis began. Consequently, the presence of organic material and/or some other potential quenching agent is believed to be the cause for the interference problems.

Sample dilution is one of the recommended methods of minimizing the interference problems if the sample result after dilution is expected to be above the instrument detection limit. Eight of the thirteen samples revealed signs of interference problems during the first analyses on 02-05-93. Thus, a dilution of the samples by a factor of 10 was performed in order to minimize the interference. A second and third set of analyses were performed on 03-04-93 and 03-09-93. The second set of analyses did not involve any dilution of the sample prior to analysis and it is evident from the results that interference is a definite problem. The third set of analyses were performed with the use of sample dilution methods. The table on the attached page illustrates the results for all three trials and also reports the regression coefficient (R^2) values for each analysis. The R^2 is typically 0.98 or better and decreases as the amount of sample interference increases.

There was good agreement in all three runs for the control and samples 2, 3, and 8. However, there existed a good deal of variability in the remaining samples. The shaded values on the attached table are believed to be most representative of the total uranium content of the liquid leachate for each CSS grout sample.

MLV/jn

cc: John Enger

Form 232-A 06/92

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KPA URANIUM ACTIVITY RESULTS FOR CSS GROUT LEACHATES

			February 5, 1993		March 4, 1993		March 9, 1993	
Sample ID	CSS Grout Sludge:Binder Ratio	Binder	Result (pCi/L)	R^2	Result (pCi/L)	R^2	Result (pCi/L)	R^2
1	Pit 2 1991 1:0.177	FAC/PCII	23.93	0.936	<Blank*	------	41.02	0.9914
1D	1 Duplicate	FAC/PCII	34.30	0.9427	<Blank*	------	88.90	0.9862
2	Pit 2 1991 1:0.250	FAC/PCII	10.93	0.9532	[illegible]	0.9909	9.88	0.9171
3	Pit 2 1991 1:0.333	FAC/PCII	16.28	0.9367	18.05*	0.9989	21.46	0.9644
4	Pit 3 1988 1:0.250	FAC/PCII	57.61	0.9834	<Blank*	------	22.48	0.9686
4D	4 Duplicate	FAC/PCII	18.45	0.8761	<Blank*	------	46.65	0.9875
5	Pit 3 1988 1:0.177	FAF/PCII	1.81*	0.7565	113.57*	0.8877	73.57	0.9912
6	Pit 3 1988 1:0.250	FAF/PCII	14.21	0.9477	<Blank*	------	11.48	0.9037
6D	6 Duplicate	FAF/PCII	137.34	0.994	<Blank*	------	80.88	0.9874
7	Pit 3 1988 1:0.333	FAF/PCII	100.10	0.9942	<Blank*	------	16.47	0.9940
8	Pit 2 1991 1:0.250	FAF/PCII	18.55	0.9662	18.84*	0.9807	10.53	0.9464
Control			<Blank	------	<Blank*	------	<Blank	------

*No attempt made to dilute sample to minimize interference.

Shaded values are most representative of the sample results based upon QC and duplicate results as well as better R^2 coefficients.

FAC/PCII - Binder consisting of 60/40 mix of class C flyash to Portland Type II cement.

FAF/PCII - Binder consisting of 60/40 mix of class F flyash to Portland Type II cement.

CSS grouts having sample IDs 1 through 4 were mixed on January 6, 1993 and sample IDs 5 through 8 were mixed on January 7, 1993. On January 13, 1993, 10.6 to 15.1 grams of each CSS grout mix were placed in 40 ml VOA vials for dilution with deionized water and subsequent leachate uranium activity analyses by KPA. On January 25 and 26, 1993, deionized water was incrementally added to each 40 ml VOA vial containing a CSS grout and shook until the grout completely dispersed. The final deionized water to grout ratio by weight was 1.5 to 1 prior to KPA analysis.

JZ JOHN ZINK COMPANY

KOCH
KOCH ENGINEERING COMPANY INC

International Headquarters
P.O. Box 702220
Tulsa, Oklahoma 74170
918/747-1371

December 4, 1991

Mr. Ken Clarke
MK Environmental Services Division
720 Park Avenue
Boise, Idaho 83707

Reference: Hydro-Sonic Scrubber for Vitrification Process
John Zink Budget Proposal TG9111-080LA

Dear Mr. Clarke:

We have made a preliminary analysis for the Vitrification Process Scrubber we discussed recently on the telephone. Either one Hydro-Sonic Model 1250 Tandem Nozzle or Steam Ejector Scrubber will handle the gas flows we discussed and will meet your cleaning requirements.

Our Budget Estimate for the Tandem Nozzle flange to flange scrubber is [redacted] F.O.B. point of shipment. Listed below are the items included in this estimate.

Quantity	Description	Material of Construction
1	Quench	FRP*
1	Tandem Nozzle Scrubber	FRP
1	Separator Housing	FRP
1	Separator 1st Stage Module	FRP
2	Separator 2nd & 3rd Stage Modules	Glass Filled Polypropylene

* Fiberglass Reinforced Plastic

Items outside of this scope would include fan, stack, inlet/outlet ductwork, piping, draft control damper, installation, recirculation water system and instrumentation.

Water Requirements

Quench	25 gpm at 60 psig
1st Stage Scrubber	90 gpm at 20 psig
2nd Stage Scrubber	55 gpm at 20 psig

4401 South Peoria Avenue • Tulsa, Oklahoma 74105 • FAX 918/747-2163 • TLX 497414

Our Budget Estimate for the Steam Ejector flange to flange scrubber is [redacted] F.O.B. point of shipment. Listed below are the items included in this estimate.

Quantity	Description	Material of Construction
1	Quench	FRP
1	Reducing Elbow/Mixing Tube	FRP
1	Separator Housing with Modules	FRP
1	Ejector/Injector Assembly	Hastelloy C-276

Items outside of this scope would include fan, stack, inlet/outlet ductwork, piping, draft control damper, installation, recirculation water system and instrumentation.

Water Requirements

Quench	25 gpm at 60 psig
Scrubber	27 gpm at 20 psig

For the Tandem Nozzle Scrubber we have estimated a scrubber pressure drop of approximately 40 i.w.g. will be required to limit particulate emission to 0.015 gr/dscf non-corrected which corresponds to less than 1.0 lb/hr.

For the Steam Ejector Scrubber we have estimated steam usage of approximately 6,250 lb/hr (100 psig saturated) will be required to limit particulate emission to 0.015 gr/dscf non-corrected which corresponds to less than 1.0 lb/hr.

I have included for your review a copy of our Input Parameters sheet showing the data we used to size the scrubber, along with some standard literature describing the scrubber.

If you have any questions or need additional information do not hesitate to contact me at (918) 234-5826 or Mr. Chris Oakes in our John Zink Western office at (213) 402-0119.

Sincerely,

JOHN ZINK COMPANY

Tim Hill
Applications Engineer
Incineration Systems

/ls

cc: T. Young, JZ Tulsa
C. Oakes, CA

JOHN ZINK/HYDRO-SONIC SCRUBBER ANALYSIS - VERSION 5.01?
INPUT PARAMETERS

Project: MK ENVIRONMENTAL
Project Number: T63[illegible]-950LA
1 each, Model 1250 ,Steam-Hydro Configuration, Single Cyclone
Forced Draft
Input Date: 11-27-1991 Time: 13:39
Run Date: 11-27-1991 Time: 13:42

GENERAL INFORMATION

Standard Temperature (F)	70
Standard Pressure (psia)	14.696
Gas Inlet Pressure (in H2O)	-2
Gas Exit Pressure (in H2O)	.5
Duct Losses (in H2O)	0
Ambient Temperature (F)	70
Altitude (ft)	5000

INLET GAS INFORMATION

Specie	Molecular Wt.	CALCULATED (WET GAS BASIS) Mole %	Weight %	CALCULATED (DRY GAS BASIS) Mole %	Weight %	AS INPUT Mole Fraction
AIR	28.965	34.919	46.313	100.000	100.000	1
H2O	18.0154	65.081	53.687	186.379	115.922	

Gas Molecular Wt. Calculated - Dry 28.965
Gas Molecular Wt. Calculated - Wet 21.839
Wet Bulb Temp (F) 180
Total Wet Inlet Flow Rate (acfm) 15000 Calculated SCFM= 3409 lb/hr= 33061
Dry Bulb Temperature (F) 180

STEAM INFORMATION

Pressure (psig)	100
Temperature (F)	335.9565

BLOWDOWN CALCULATION METHOD

For Scrubber

Suspended Solids (0-100%) 5

PARTICULATE CLEANING INFORMATION

Inlet Dust Load (gr/dscf)	17.12
(lb/hr)	500.0
Cleaning Standard (gr/dscf)	0.015
Corrected to	Uncorrected

JOHN ZINK COMPANY
A Division of Koch Engineering Company, Inc.

042511

HYDRO-SONICS SYSTEMS

MAR 19 1985

LONE STAR STEEL

Bechtel National, Inc.
Engineers—Constructors

Fifty Beale Street
San Francisco, California
Mail Address: P.O. Box 3965 San Francisco CA 94119

March 14, 1985

Hydrosonic Systems
P.O. Box 97
Lone Star, TX 75668

Attention: Bill Baker
(214) 656-6317

PROJECT S-1780-SAVANNAH RIVER PLANT-200S AREA
DEFENSE WASTE PROCESSING FACILITY-SLUDGE PLANT
CONTRACT AXC-1997-W, JOB NO. 13239
DESIGN AREA S350
PURCHASE ORDER AXC-21111
DESIGN ENGINEERING AND FABRICATION OF SUPERSONIC EJECTOR ASSEMBLIES

Below is the DOE recommended text of your press release:

"LONE STAR, TX -- Air and steam driven scrubber manufactured by Hydro-Sonic Systems have been tested and will be installed in the U. S. Department of Energy's Defense Waste Processing Facility under construction at the Savannah River Plant in South Carolina. This project is being managed by E.I. du Pont de Nemours and Company (Du Pont), with Bechtel National, Inc. doing the detailed design.

Selected as the best available control technology for cleaning off-gas from the vitrification of radioactive waste, Hydro-Sonic Systems had six prototype devices in operation at the Vitrification Pilot Plant being tested prior to selection as the air pollution control device for the main project.

Hydro-Sonic Systems, an affiliate of Lone Star Steel Company, manufactures a family of steam and compressed gas scrubbers and fan powered free-jet scrubbers capable of submicron particulate capture and toxic fume removal, such as HCL, SOx and NOx, in the same process. The company has been involved in successful pollution control systems at more than 40 installations world-wide and across a broad spectrum of industrial and municipal applications."

Inside EPA's
Clean Air Report
An exclusive biweekly report on the Clean Air Act and U.S. air policy
Vol. II, No. 20 — September 26, 1991

Radionuclide NESHAP

COMPLIANCE LEEWAY GIVEN TO PLANTS INSTALLING EPA-SUGGESTED DEVICE

EPA has offered an escape valve from radionuclide standards for elemental phosphorous plants that install an agency-selected control. The technology, which is currently in use by one phosphorous producer, is seen as possibly the only method of compliance with EPA's stringent radionuclides national emission standard. The revision to the NESHAP is the result of a settlement between EPA and the FMC Corporation, which had sued, saying EPA's two curies per year exposure limit was impossible to meet.

But EPA discovered that the Monsanto Co. was achieving the standard with a new scrubber device. In the settlement, EPA agreed to allow companies to meet a revised emission standard if the technology fails to perform as expected. Companies that attempt to meet the standard without the scrubber technology will not receive the exemption from EPA and could be subject to enforcement action for failure to meet the radionuclide NESHAP.

The FMC plant, the largest operating elemental phosphorous plant in the U.S., currently achieves 10-14 curies per year, according to an EPA official. The FMC lawsuit served to push EPA into investigating control devices that were achieving great reductions in radionuclide emissions. After exhaustive reviews, EPA discovered that a particular scrubber, called the "John Zink Tandem Nozzle Hydrosonic Fixed Throat Venturi Scrubber System," would be ideal for installation on FMC's Pocatello, Idaho facility and would be able to achieve EPA's emission standard.

FMC agreed to install the scrubber on the condition that EPA establish an escape route allowing FMC Corp. to bypass the standard if the John Zink scrubber did not work. The 4.5 curies/year ceiling would apply if FMC cannot achieve the two curies/year standard with the new scrubber. EPA officials stress that increasing the ceiling on the standard would result in negligible risks to human health. EPA created the emissions ceiling so FMC would not be caught in a Catch-22 situation with an emissions control device that could not meet the radionuclide standard.

The scrubber system is intended to "piggy-back" other facility control systems to achieve the new emissions standard. At FMC's plant, installation was initiated in March because of the settlement and in anticipation of EPA's rule, and is expected to be completed by December 15, the same time EPA officials anticipate issuing the final rulemaking, according to an agency official.

Elemental phosphorous plants are regulated by EPA under subpart K of the radionuclide NESHAP that establishes a two curies per year standard for emissions of polonium-210 -- a radioactive element formed naturally by disintegrating radium -- from the elemental phosphorous plants, a vaporous waste product produced by burning phosphate ore. Heating the phosphate ore results in release of large quantities of radionuclides. Elemental phosphorous plants operate by heating the ore until a radionuclide-containing gas is produced. The gas is "put off and collected" to be used as food additives and for metal treatments, according to an EPA official. The process produces elemental phosphorous slag waste that is a black glass-like substance. Companies such as FMC sell the by-product to road construction companies for a concrete aggregate.

The control device was selected because it fits well into current systems at the FMC facility in Idaho, according to an EPA source, and because it represents the best available control technology as required by the Clean Air Act Amendments. The scrubber is already in place at a Monsanto elemental phosphorous plant and is achieving "well below the two curies per year" for particulate (PM-10) emissions. The scrubber has a demonstrated operating history and officials believe it would not present "an unfair business exemption" to other sources because of its effectiveness, nor would it give the maker an unfair market advantage since there are only four operating elemental phosphorous plants in the U.S. and eight existing facilities, says an EPA official.

Representatives of FMC Corp. testified at an EPA public hearing held September 17 in Idaho to discuss the emission standard. FMC supports EPA's rulemaking, saying that "while EPA had determined that the pre-existing standard of 21 curies/year was unacceptable, it had not examined any intermediate level. As a result, FMC petitioned EPA to reconsider the 2 curies/year rule."

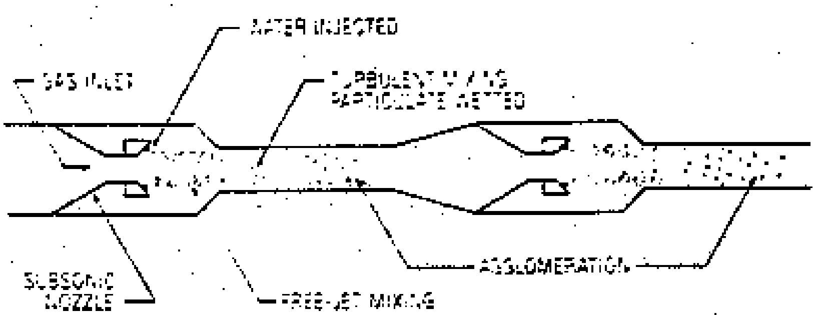
Other industry representatives testifying at the meeting included a member of the Shoshone Indian Tribe and an Idaho Department of Environmental Quality official. FMC's facility is located on a reservation and the Indian representative was concerned that the plant parameters be adequate for the scrubber fluid flow rate, according to an EPA official. The Idaho DEQ official was concerned that the allowance for the facility to go to 4.5 curies per year from two would produce particulate emissions violations. No other industry company representatives attended the meeting, according to an EPA source.

JOHN ZINK COMPANY

SYSTEMS

Gas Cleaning Equipment
Tandem Nozzle—Series TN

Tandem Nozzle Fan Drive



Performance Features

- Highly Efficient Capture of Fine Particulate
- Maintains High Overall Mass Efficiency
- Removes SO_2, H_2S, etc. in Same Device
- Free-Jet Action Optimizes Scrubbing
- Low Maintenance
- Low Energy Requirements

General Description

The Tandem Nozzle air cleaner is a fan-driven wet scrubber having the ability to scrub fine particulate, sulfur-containing gases, and condensable hydrocarbon vapors with an efficiency markedly better than conventional scrubbers. The free-jet action of two subsonic nozzles in series enables this system to make maximum use of turbulent mixing and droplet growth. The first section serves to condense vapors, remove the larger particles and to initiate growth of the finest particles so that they are more easily captured in the second nozzle section. No other series scrubber is known to show such a marked improvement in efficiency with equivalent contacting power.

Particulate is captured when the dirty gas is mixed with fine water droplets produced by spraying water onto the exhaust of the free-jet through which the gas must pass.* Mixing and droplet growth continue down the length of the mixing tube. Large droplets containing the particulate are then removed in a cyclone separator. Clean gases are vented to atmosphere.

Particulate Wetting

A water spray is formed by use of a ring of V-shaped nozzles. This spray is injected onto the exhaust of the particulate laden gas stream. When the water spray strikes the high speed gas stream, it is shattered into many small droplets. It is desirable to create fine water droplets because the finer dust particles tend to go around a droplet that is too large. The first step in the capture of fine particulate and gases, therefore, is the creation of water droplets of the proper characteristics. In the free-jet arrangement, water droplets serve as impact targets into which dust particles collide and are captured.

Mixing

The mixing process immediately follows and overlaps the wetting process. It insures complete wetting of any particles not already wetted by collision. Mixing is accelerated and enhanced in a free-jet as compared to mixing in a confined area or region. The jet action of the emerging gas stream creates a low pressure area around the base of the free-jet nozzle causing recirculation and high turbulence which optimizes mixing of the streams of water and gases.

Agglomeration

The growth process follows and partly overlaps the mixing process so that a single water drop may contain hundreds of micronic and submicronic dust particles. As a result of the growth of droplets containing particulate into increasingly larger size, the initial size and shape of the particulate in the gas stream has only a small effect on its removal.

Separation

Separation of cleaned gas from the water-encapsulated particulate is accomplished in a specially designed low-pressure-drop cyclone. Water and particulate are gravity drained from the cyclone bottom while the cleaned gases exit through the top. No demisters are required.

*Acid-forming gases are removed simultaneously by the addition of a caustic reagent.

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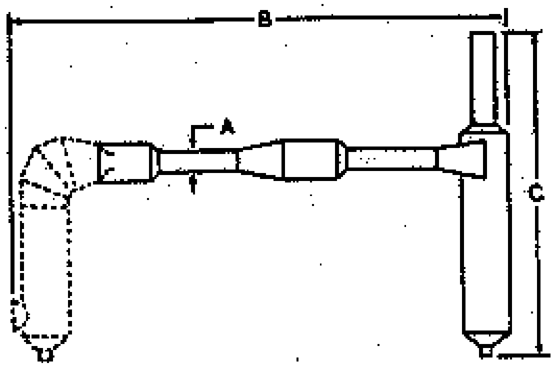
Stainless Steel
Carbon Steel
Fiberglass Reinforced Plastic
Corrosion Resistant Alloys



Options

Quenching (Atomizer) Chamber
Induced Draft or Forced Draft
Other Separator Types Available
Horizontal or Vertical Configuration
Variable Flow Cleaning Control

Liquid —
Water, chemical solutions, & recirculated liquids
Quantity & Pressure —
12-20 GPM/1000 ACFM saturated gas at 10-25 PSIG

Dimensions and Capacities

Other sizes and capacities are available.

ACFM CAPACITY Approx. ACFM @ Max 180°F Saturated	A Dim	B Dim	C Dim	MODEL No	ACFM CAPACITY Approx. ACFM @ Max 180°F Saturated	A Dim	B Dim	C Dim	MODEL No
530-900	3¾"	8½'	8¾'	45	24,000-40,000	25"	53½'	55¼'	2000
1,000-1,650	5¼"	11½'	12'	90	34,000-56,500	30"	63¾'	65½'	3000
2,100-3,500	7½"	16½'	16¾'	175	47,500-80,000	36"	75½'	77¾'	4000
4,300-7,200	10½"	22½'	23½'	350	56,500-94,000	39"	80¾'	60'	5000*
6,000-10,000	13"	27½'	27¾'	500	67,500-112,400	43"	88¾'	65½'	6000*
12,000-20,000	18"	38¼'	39¼'	1000	95,500-159,000	51"	104¾'	77¾'	8000*
17,000-28,500	21"	44¾'	46¼'	1500	113,000-188,000	56"	115'	84¾'	10000*

*B & C Dims Based on Twin Cyclone Separators

[illegible] Requirements*
[illegible] ACFM (Saturated)

Pressure Drop	HP/1000
10" W.C.	2.1
15" W.C.	3.2
20" W.C.	4.2
25" W.C.	5.2
30" W.C.	6.3

*75% Fan Efficiency

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WELDON SPRING REMEDIAL ACTION PROJECT
7295 HIGHWAY 94 SOUTH
ST. CHARLES, MISSOURI 63303
PHONE: (314) 441-8086

July 31, 1992

U. S. Department of Energy
Weldon Spring Site
Remedial Action Project
ATTN: Mr. Stephen H. McCracken
Project Manager
7295 Highway 94 South
St. Charles, MO 63304

SUBJECT: Contract No. DE-AC05-86OR21548
OFF-SITE RELEASE GUIDELINES

REFERENCE: Letter from James R. Powers to Stephen H. McCracken, Disposal of Hazardous Materials Containing Radioactive Contaminants, dated June 7, 1991 (Attached)

Dear Mr. McCracken:

The PMC recently completed all activities required for removal of the waste shipment moratorium imposed by DOE Headquarters on May 17, 1991. In the process, we performed a comprehensive review of the current off-site release procedures (see referenced letter) for all materials including wastes, recyclable materials, and property and equipment. Attached for your review and comment is the revised Off-Site Release Guidelines.

These guidelines are very similar to the policy expressed in the referenced letter. The primary differences are (1) subcontractor waste will now be retained on site and (2) the procedures (RC-32s) for release of any materials for disposal are more comprehensive. The PMC has begun implementation of these procedures.

Although these changes will increase the on-site waste inventory, the PMC is initiating measures to minimize waste generation. Incoming equipment and materials will be monitored to ensure that all packaging, wrapping, excess paper, crates, etc. are removed prior to entering the controlled area.

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For additional information concerning this matter, please contact David Hixson or Marc Nelson of my staff at ext. 3110.

Sincerely,

James R. Powers

James R. Powers
Project Director

JRP/dsh/lac

Attachments as stated

cc: Walker K. Love

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WSS OFF-SITE RELEASE GUIDELINES

The following describes the revised off-site release guidelines for the various types of wastes and materials encountered at the Weldon Spring site (WSS). The attached table details specific examples of the application of the guidelines to specific site waste streams. As a point of reference, the DOE and/or regulatory management requirements are included for each type of waste and material.

Four major categories have been identified for wastes and materials:

1. WASTES
2. RECYCLABLES
3. EQUIPMENT AND PROPERTY
4. SAMPLES

1.0 WASTES:

Site wastes can be categorized as radioactive, radioactive mixed, hazardous, toxic, and/or solid.

1.1 RADIOACTIVE WASTE: Radioactive waste is defined as a solid, liquid, or gaseous material that contains radionuclides regulated under the Atomic Energy Act of 1954, as amended, and of negligible economic value considering costs of recovery.

MANAGEMENT REQUIREMENTS: Radioactive waste shall be disposed of on the site at which it is generated, if practical, or if on-site disposal capability is not available, at another DOE disposal facility as required by DOE Order 5820.2A Radioactive Waste Management.

WSS PROCEDURE: Radioactive waste will be placed in interim storage on-site pending issuance of the Chemical Plant Record of Decision.

1.2 RADIOACTIVE MIXED WASTE: Radioactive mixed waste is defined as a waste consisting of a radioactive and hazardous component (i.e., RCRA and/or TSCA).

MANAGEMENT REQUIREMENTS: Radioactive mixed waste can be released off site for treatment, storage, and/or disposal to facilities which have the proper permits and radiological controls and hold the necessary NRC or agreement State licenses provided that the radioactive portion of the waste is returned to the DOE for final treatment and disposal as required by DOE Order 5820.2A Radioactive Waste Management.

WSS PROCEDURE: Release in accordance with the management requirements. However, due to the lack of available mixed waste TSDs, the site's radioactive mixed waste inventory remains in interim storage on site. The waste will remain in storage pending decisions in the Chemical Plant ROD.

1.3 HAZARDOUS WASTE: Hazardous waste is defined as a waste regulated under Subtitle C of the Resource Conservation and Recovery Act (RCRA).

MANAGEMENT REQUIREMENTS: Hazardous waste can be released off site for treatment, storage, and/or disposal to an EPA licensed facility if verified as nonradioactive under the moratorium guidelines which are delineated in Regulatory Compliance Procedure RC-32s.

WSS PROCEDURE: Release in accordance with the stated management requirements.

> NOTE: RC-32s is applicable to waste for which a natural background level of radioactivity can be established (i.e., virgin product). The majority of hazardous waste in storage is a result of combining chemically compatible wastes; therefore, it is impossible to obtain or create suitable "virgin" samples for comparison.

1.4 TOXIC WASTE: Toxic waste is defined as a waste regulated under the Toxic Substance Control Act (TSCA).

MANAGEMENT REQUIREMENTS: Toxic waste can be released off site for treatment, storage, and/or disposal to an EPA licensed facility if verified as nonradioactive under the moratorium guidelines which are delineated in Regulatory Compliance Procedure RC-32s.

WSS PROCEDURE: Release in accordance with the stated management requirements.

1.5 SITE-GENERATED SOLID WASTE: Site generated solid waste is defined as waste not included as part of original site property or inventory. Specific types of site-generated solid waste are personal protection equipment, waste from site characterization and investigation such as sampling equipment and laboratory wastes, miscellaneous trash, wastewaters, and construction and maintenance wastes which are not otherwise classified as regulated waste (i.e. RCRA, TSCA). These wastes are primarily generated as a result of characterization, support, and construction activities.

MANAGEMENT REQUIREMENTS: Site generated solid waste can be released off site for disposal at sanitary landfills under the moratorium guidelines which are delineated in Regulatory Compliance Procedure RC-32s.

WSS PROCEDURE: Solid waste generated in a Radioactive Materials Management Area (RMMA) will be placed in interim storage pending the Chemical Plant Record of Decision. Investigation-derived waste will be returned to its source or placed in on-site storage as defined in RC-18s, Handling and Disposition of Site Generated Waste. Solid waste generated outside an RMMA can be disposed of at a sanitary or demolition landfill.

1.6 DEMOLITION SOLID WASTE: Demolition solid waste is defined as waste which is part of the original site property or inventory. Specific types of wastes are building wastes (i.e., concrete, steel, wood, glass), soils, yard debris, and equipment.

MANAGEMENT REQUIREMENTS: Demolition solid waste can be released off site for disposal at a demolition landfill under the moratorium guidelines which are delineated in Regulatory Compliance Procedure RC-32s. Additionally, demolition waste from the WSS are classified as a "special waste" in accordance with Missouri Solid Waste Management Regulations 10 CSR 80. Special waste may be disposed of at a sanitary or demolition landfill under approval from the MDNR.

WSS PROCEDURE: Demolition solid waste is placed in interim storage on site pending issuance of the Chemical Plant Record of Decision.

1.7 SANITARY WASTE: Liquid and solid matter comprised largely of biological (human) refuse.

MANAGEMENT REQUIREMENTS: Sanitary wastes must be treated via an approved treatment facility prior to discharge.

WSS PROCEDURE:

- Sanitary waste generated within the RMMA will be released off site for treatment/disposal in accordance with RC-32s criteria (process knowledge) requirements.

- Sanitary waste generated outside the RMMA are treated and released via the WSS sanitary treatment plant.

2.0 RECYCLED MATERIALS: Recycled materials include lead/acid batteries, recoverable metals, and equipment.

MANAGEMENT REQUIREMENTS: Recyclable materials can be released off site in accordance with DOE 5400.5 guidelines. An ALARA evaluation must also be performed when using these guidelines.

WSS PROCEDURE: Recyclable material is released off site in accordance with the criteria outlined in RC-32s. (NOTE: WSS policy is more restrictive than the DOE 5400.5 guidelines).

3.0 EQUIPMENT AND OTHER PROPERTY: Equipment and other property largely consists of subcontractor vehicles, construction equipment, and tools.

MANAGEMENT REQUIREMENTS: Equipment and other property are surveyed and released in accordance with DOE 5400.5 guidelines. An ALARA evaluation must also be performed when using these guidelines.

WSS PROCEDURE: Equipment and other property are released off site in accordance with the DOE 5400.5 guidelines.

4.0 SAMPLES: Various types of samples are routinely shipped off site for waste characterization, environmental monitoring, and physical testing.

MANAGEMENT REQUIREMENTS: Samples can be released off site for analysis and/or testing provided the receiving laboratory or test facility holds the necessary NRC or agreement State licenses for the type of radionuclides potentially shipped.

WSS PROCEDURE: Contract laboratories or test facilities must provide current copies of their NRC or agreement State licenses prior to receiving samples. Sample residues must be returned to the site for storage pending issuance of the Chemical Plant Record of Decision.

RELEASE APPLICATION			
MATERIAL	CATEGORY	RELEASE REQUIREMENT	DISPOSITION
PCB Transformers, cleanup debris, and oils	Toxic Waste (TSCA)	≤ Natural background radioactive level (RC-32s criteria)	Incineration at commercial TSD facility
Tributyl phosphate (TBP)	Radioactive Mixed Waste (RCRA/TSCA)	Release to licensed TSD facility	Incineration at K-25 Oak Ridge, TN radioactive residue returned to WSS for disposal
Subcontractor office waste paper, plastic, and construction/ maintenance waste (i.e., oil, oil air filters, lumber, wire, pipe, personnel protective equipment, etc.)	Site-Generated Solid Waste (within RMMA)	≤ Natural background radioactive level (RC-32s criteria)	On-Site Storage • Compactibles - Building 434 • Bulk - MSA
(Same)	Site-Generated Solid Waste (Outside RMMA)	None	Disposal at sanitary landfill (oil-collection centers)
Lead/acid batteries	Recyclables	≤ Natural background radioactive level (RC-32s criteria)	Commercial Battery Recycler
Construction vehicles, tools, etc.	Equipment/Property	DOE 5400.5 Guidelines	Unrestricted release to subcontractors

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WELDON SPRING REMEDIAL ACTION PROJECT
7295 HIGHWAY 94 SOUTH
ST. CHARLES, MISSOURI 63303
PHONE (314) 441-8086

June 7, 1991

U. S. Department of Energy
Weldon Spring Site
Remedial Action Project
ATTN: Mr. Stephen H. McCracken
Project Manager
7295 Highway 94 South
St. Charles, MO 63303

SUBJECT: Contract No. DE-AC05-86OR21548
DISPOSAL OF HAZARDOUS MATERIALS CONTAINING RADIOACTIVE CONTAMINATES

REFERENCES: Letter from Stephen H. McCracken to James R. Powers, concerning shipments of radioactively contaminated wastes, dated May 28, 1991 (Attached).

Dear Mr. McCracken:

The following summarizes the PMCs policy and procedures for the release of materials.

Materials containing radioactive contaminants above background concentrations are not sent off site for disposal. Oil and debris contaminated with PCBs are sent to EPA-licensed disposal facilities from the WSSRAP after verification that no radiological contamination is present. Radiological contaminants are determined based on direct radiation survey results in accordance with site procedures or quantitative analytical results provided by outside laboratory contractors. Surveys and analytical results are in accordance with industry practices and established detection limits.

Radiological contamination surveys are performed in accordance with Environmental, Safety, and Health (ES&H) procedure 2.3.8s, Contamination Survey. The detection limit for the swipe counter is generally 3 to 6 disintigrations per minute per 100 cm^2 depending on the background and counting time. Direct radiological surveys are performed with Geiger Mueller (GM) or Alpha scintillator radiation detectors. The

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survey instruments are operated in accordance with ES&H procedure 2.6.3s, GM Detector Calibration, Operation, and Usage and 2.6.1s Alpha Detector Calibration and Operational Check, respectively. The detection limits for the portable Alpha scintillator and GM survey instruments are approximately 100 to 300 dpm per 100 cm^2, respectively, depending on the efficiency, background, and survey time. Detection limits for laboratory analysis are on the order of 0.1 to 1.0 pico curies per gram. Detector efficiency, background, and counting time are also considered for laboratory detection limits.

Construction debris and reusable materials are surveyed for release prior to leaving the Weldon Spring site. Materials which are suspected to be contaminated based on operational history are surveyed over 100 percent of their surface area. Materials which are suspected to be uncontaminated are surveyed where contamination would likely accumulate (e.g., greasy areas or locations where two surfaces joined). If these areas are found free of radioactivity, the remaining areas are surveyed by a statistical method which has been reviewed and approved by EPA, the State of Missouri and Oak Ridge Associated Universities. The radiological surveys are performed in accordance with approved site procedures (previously stated).

Subcontractor vehicles, tools and equipment are surveyed either 100% or statistically depending on potential for contamination. Survey results are compared to guidelines contained in DOE Order 5400.5. Once all reasonable efforts have been made to decontaminate to background levels, such materials are released to the subcontractor, provided they do not exceed the guidelines in DOE Order 5400.5.

To support environmental monitoring, waste characterization, and other monitoring activities at the WSSRAP, samples are sent to laboratories for analysis. Many of these samples are regulated by the Department of Transportation (DOT) for a variety of hazard classes. All materials regulated by the DOT are packaged and shipped in accordance with DOT regulations. Samples being sent to laboratories for quantitative analysis are not disposed of by the laboratory. All sample residuals are returned to the WSSRAP for disposal/archive as provided for in the laboratory contracts.

It is the PMC's policy not to ship RCRA waste or TSCA hazardous materials from the WSSRAP for disposal if they contain detectable radioactive contamination. Our criterion is that all waste shipped for disposal contains no more than

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background concentrations of radioactive contaminants. Initially, background is determined by obtaining a sample of the same material proposed for disposal except that the material is known to never to have been in a radiologically controlled area. If the concentration of radioactivity in the waste does not exceed the concentration of radioactivity in the uncontaminated material, the waste can be shipped off site for disposal.

We expect to ship oil containing PCB's from Pad 411 in the near future. It is important to note that Pad 411 is outside of the radiological controlled area. The results of laboratory analyses of the Pad 411 PCBs showed no detectable radiological contaminants.

Concrete rubble from the Building 409 slab, which is outside of controlled area as well, will also be shipped for disposal off site later this year. This waste is not regulated under RCRA or TSCA. The top of this slab has been surveyed and found to have no detectable radiological contamination. The slab has been cored and no contamination was found. A statistical survey will be performed on the underside of the slab after it has been broken for removal. If any radiological contamination is found, this waste will be retained on site.

If you have questions concerning this matter, please contact Newlyn Horton of my staff.

Sincerely,

James R. Powers
Project Director

JRP/cnh/lac

cc: Walker K. Love

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MORRISON KNUDSEN CORPORATION

MK-FERGUSON GROUP

INTER-OFFICE CORRESPONDENCE

DATE: November 3, 1992

TO: Distribution

FROM: James R. Powers

SUBJECT: **REVISED WASTE QUANTITIES QUARTERLY REPORT: 10/1/92 - 12/31/92**

Attached is the Revised Waste Quantities Quarterly Report. This report presents the official WSSRAP base inventory of waste material for the quarter of October 1, 1992, through December 31, 1992. Engineering calculations and designs developed for the WSSRAP must always reference the specific Waste Quantities Quarterly Report in effect at the time those calculations or designs were developed. Changes to the Revised Waste Quantities Quarterly Report include quantity changes based on MOD 8 estimates for concrete deck and foundation. Also the metal tank and equipment estimate now reflects metal volume.

The WSSRAP has formed a Waste Quantity Committee consisting of J. Cooney, F. Fry, L. Gonzales, S. Murray, and S. Myers. This committee developed the Waste Quantities Quarterly Report and welcomes any valid information concerning the waste quantities. If you have any such information, please contact one of the committee members.

Jim

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JRP/smm/lac

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WASTE QUANTITIES QUARTERLY REPORT TABLE: 10/01/92--12/31/92					
MATERIAL	**CONVERSION FACTOR**	**ORIGINAL AMOUNT**	**CONVERTED VOLUME (CYD)**	**CONVERTED WEIGHT (TON)**	**COMMENTS/REFERENCE**
SOILS & SEDIMENTS					
Raffinate Pits	1.52 ton/cyd	153,500 cyd	153,500	233,320	MOD 8 estimate and RI Report Rev. D December 1990 DOE/OR/21548-074 Plate 3 (Radiological Site Soil Zones) Includes Region 4 Zone 6 Region 9 Zones 1 & 2
Ash Pond	1.52 ton/cyd	8,200 cyd	8,200	12,460	RI Report Rev. D December 1990 DOE/OR/21548-074 Plate 3 (Radiological Site Soil Zones) Includes Region 4 Zones 1,2,3,5
Frog Pond	1.52 ton/cyd	7,000 cyd	7,000	10,640	RI Report Rev. D December 1990 DOE/OR/21548-074 Plate 3 (Radiological Site Soil Zones) Region 3 Zones 1,2,3 & 4

WASTE QUANTITIES QUARTERLY REPORT TABLE: 10/01/92 - 12/31/92					
MATERIAL	CONVERSION FACTOR	ORIGINAL AMOUNT	CONVERTED VOLUME (CYD)	CONVERTED WEIGHT (TON)	COMMENTS/REFERENCE
North Dump	1.52 ton/cyd	7,600 cyd	7,600	11,550	RI Report Rev. D December 1990 DOE/OR/21548-074 Plate 3 (Radiological Site Soil Zones) Region 1 Zones 1 & 2
South Dump	1.52 ton/cyd	16,900 cyd	16,900	25,690	RI Report Rev. D December 1990 DOE/OR/21548-074 Plate 3 (Radiological Site Soil Zones) Includes Region 4 Zone 4
TSA Area	1.52 ton/cyd	12,970 cyd	12,970	19,710	WP-244 TSA construction specifications final cost estimate November 1991
Site WT Plant Area	1.52 ton/cyd	25,000 cyd	25,000	38,000	Approximation of the actual amount removed during construction.

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WASTE QUANTITIES QUARTERLY REPORT TABLE: [illegible]

MATERIAL	CONVERSION FACTOR	ORIGINAL AMOUNT	CONVERTED VOLUME (CYD)	CONVERTED WEIGHT (TON)	COMMENTS/REFERENCE
Around Chemical Plant Buildings	1.52 ton/cyd	26,400 cyd	26,400	40,130	RI Report Rev. D December 1990 DOE/OR/21548-074 Plate 3 (Radiological Site Soil Zones) Includes Region 5 Zone 1 which is associated with contamination from the coal storage area and Region 5 Zones 1-11 Region 6 Zones 1-6 Region 10 Zones 1-14
Beneath Chemical Plant Buildings and Open Areas	1.52 ton/cyd	49,900 cyd	49,900	75,850	IOC: M. Peterson to S. Green Date: 02/27/92
Lakes 34, 35, 36	1.52 ton/cyd	20,000 cyd	20,000	30,400	Engineering assumption
Quarry (Bulk Waste Excavation)	2 ton/cyd	52,000 cyd	52,000	104,000	QY CDD February 1991 DOE/OR/21548-145
Vicinity Properties					

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WASTE QUANTITIES QUARTERLY REPORT TABLE: 10/01/92-12/31/92					
MATERIAL	CONVERSION FACTOR	ORIGINAL AMOUNT	CONVERTED VOLUME (CYD)	CONVERTED WEIGHT (TON)	COMMENTS/REFERENCE
Femme Osage	1.52 ton/cyd	80,500 cyd	80,500	122,360	Mod 8 estimate and Draft WSSRAP VP Femme Osage Slough Special Study June 1989
Army 1,2 & 3	1.52 ton/cyd	1,400 cyd	1,400	2,130	Vicinity Property CDR October 1987
Busch 3,4 & 5	1.52 ton/cyd	500 cyd	500	760	Vicinity Property CDR October 1987
Army 5 & 6	1.52 ton/cyd	1,700 cyd	1,700	2,580	Vicinity Property CDR October 1987
Southeast Drainage	1.52 ton/cyd	10,000 cyd	10,000	15,200	Vicinity Property CDR October 1987
TOTAL SOILS & SEDIMENTS			473,570	744,780	

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WASTE QUANTITIES QUARTERLY REPORT TABLE: [illegible]					
MATERIAL	CONVERSION FACTOR	ORIGINAL AMOUNT	CONVERTED VOLUME (CYD)	CONVERTED WEIGHT (TON)	COMMENTS/REFERENCE
SLUDGE					
Raffinate Pits	1.01 ton/cyd	220,000 cyd	220,000	222,200	Rev D December 1990 DOE/OR/21548-074 RI Report
Quarry	1.40 ton/cyd	4,100 cyd	4,100	5,740	QY CDD February 1991 DOE/OR/21548-145
Site Water Treatment Plant	70 #/cft	3,100 cyd	3,100	2,930	QY CDD February 1991 DOE/OR/21548-145
Quarry Water Treatment Plant	70 #/cft	500 cyd	500	470	Waste Managment Plan for QY WTP IOC Steffen to Tucker September 15, 1990 Assume 5 yr Operating life
TOTAL SLUDGE			227,700	231,340	

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WASTE QUANTITIES QUARTERLY REPORT TABLE: 10/01/92 - 12/31/92					
MATERIAL	CONVERSION FACTOR	ORIGINAL AMOUNT	CONVERTED VOLUME (CYD)	CONVERTED WEIGHT (TON)	COMMENTS/REFERENCE
CLEAR & GRUB					
Quarry	.63 ton/cyd	5,300 cyd	5,300	3,340	QY PER October 1989 DOE/OR/21548-094
Raffinate Pits	.63 ton/cyd	5,900 cyd	5,900	3,720	Assume 50% of Mod 8 Estimate
Chemical Plant	.63 ton/cyd	17,500 cyd	17,500	11,030	Assume 50% of Mod 8 Estimate. Includes MSA grubbing.
Vicinity Property Femme Osage	.63 ton/cyd	1,000 cyd	1,000	630	Assume 50% of Mod 8 Estimate
Quarry RR Ties	40 #/cft	130 cyd	130	70	Mod 8 Estimate. Quarry = 130 cyd Haul Road = 1070 cyd will be disposed of off site
Chemical Plant RR Ties	40 #/cft	300 cyd	300	160	Mod 8 Estimate
TOTAL CLEAR & GRUB			30,130	18,950	

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WASTE QUANTITIES QUARTERLY REPORT TABLE: 10/01/92 - 12/31/92					
MATERIAL	**CONVERSION FACTOR**	**ORIGINAL AMOUNT**	**CONVERTED VOLUME (CYD)**	**CONVERTED WEIGHT (TON)**	**COMMENTS/REFERENCE**
RUBBLE					
Quarry Bulk Metal	5 cyd/ton	10,500 cyd	10,500	2,100	QY Per October 1989 DOE/OR/21548-094
Quarry Bulk Rock/Concrete	4,100 #/cyd	30,200 cyd	30,200	61,910	QY PER October 1989 DOE/OR/21548-094 Density = Average of concrete and limestone densities
Quarry Residuals (Rock)	4,200 #/cyd	20,100 cyd	20,100	42,210	Mod 8 Estimate Density = Density of Limestone
Quarry WTP (Closure)	150 #/cft	300 cyd	300	610	Mod 8 Estimate
TSA (Closure Foundation)	4,100 #/cyd	22,000 cyd	22,000	45,100	Mod 8 Estimate Does not include material on TSA Density = Average of concrete and limestone densities
Raffinate Pits	5 cyd/ton	500 cyd	500	100	RI Report Rev. D December 1990 DOE/OR/21548-074

WASTE QUANTITIES QUARTERLY REPORT TABLE: 10/01/92 - 12/31/92

MATERIAL	CONVERSION FACTOR	ORIGINAL AMOUNT	CONVERTED VOLUME (CYD)	CONVERTED WEIGHT (TON)	COMMENTS/REFERENCE
Site WTP (Closure Foundation)	150 #/cft	400 cyd	400	810	Mod 8 Estimate
MSA (Closure Foundation)	3620 #/cyd	14,500 cyd	14,500	26,250	Mod 8 Estimate - Includes soil and gravel but does not include material on MSA. Density = Average of soil and limestone densities.
Treatment Facility (Closure)	150 #/cft	900 cyd	900	1,820	Mod 8 Estimate Density = Average of concrete and metal densities
Volume Reduction Facility (closure)	150 #/cft	500 cyd	500	1010	Mod 8 Estimate Density = Average of concrete and metal densities
Chemical Plant					
ACM					

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WASTE QUANTITIES QUARTERLY REPORT TABLE: [redacted]

MATERIAL	CONVERSION FACTOR	ORIGINAL AMOUNT	CONVERTED VOLUME (CYD)	CONVERTED WEIGHT (TON)	COMMENTS/REFERENCE
Friable	46 #/cft	1,240 cyd	1,240	770	IOC From : Dille/Hood To: Williams/Spittler Date: April 14, 1992 Subject: CP: Task 754 Material Quantities Assessment
Non-Friable (Roofing, Transite, Flooring)	158 #/cft	300 cyd	300 cyd	650	IOC From : Dille/Hood To: Williams/Spittler Date: April 14, 1992 Subject: CP: Task 754 Material Quantities Assessment
Concrete					
Masonry Block	56 #/cft	5,720 cyd	5,720	4,330	IOC From : Dille/Hood To: Williams/Spittler Date: April 14, 1992 Subject: CP: Task 754 Material
Slab (Deck, Foundation)	150 #/cft	2,470 cyd	[redacted]	5,000	[redacted]
Metal					

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WASTE QUANTITIES QUARTERLY REPORT TABLE: [redacted]

MATERIAL	CONVERSION FACTOR	ORIGINAL AMOUNT	CONVERTED VOLUME (CYD)	CONVERTED WEIGHT (TON)	COMMENTS/REFERENCE
Conduit	.064 cft/1f 5.793 #/1f	230 cyd	230	281	IOC From : Dille/Hood To: Williams/Spittler Date: April 14, 1992 Subject: CP: Task 754 Material
Piping	.11 cft/1ft 15 #/1ft	340 cyd	340	630	IOC From : Dille/Hood To: Williams/Spittler Date: April 14, 1992 Subject: CP: Task 754 Material
HVAC Ductwork	490 #/cft	333 ton	63	333	WITS Data Use 25% increase in volume because density gives vol. of solid block
Tanks	[redacted]	86 cyd	86	[redacted]	[redacted]
Misc. Equip. (process equipment, trucks, forklifts, etc.)	[redacted]	1,036 cyd	1,036	[redacted]	[redacted]

WASTE QUANTITIES QUARTERLY REPORT TABLE: 10/01/92 - 12/31/92

MATERIAL	CONVERSION FACTOR	ORIGINAL AMOUNT	CONVERTED VOLUME (CYD)	CONVERTED WEIGHT (TON)	COMMENTS/REFERENCE
Furniture	20 cyd/ton	6,849 cft	254	13	WITS Data
Side/Roof Aluminum	156 #/cft	70 cyd	70	147	IOC From : Dille/Hood To: Williams/Spittler Date: April 14, 1992 Subject: CP: Task 754 Material
Side/Roof Carbon Steel	490 #/cft	6 cyd	6	40	IOC From : Dille/Hood To: Williams/Spittler Date: April 14, 1992 Subject: CP: Task 754 Material
Structural	490 #/cft	4,500 cyd	4,500	29,800	IOC From : Dille/Hood To: Williams/Spittler Date: April 14, 1992 Subject: CP: Task 754 Material
RR Rails	490 #/cft	40	40	265	IOC From : Dille/Hood To: Williams/Spittler Date: April 14, 1992 Subject: CP: Task 754 Material

WASTE QUANTITIES QUARTERLY REPORT TABLE: [redacted]					
MATERIAL	CONVERSION FACTOR	ORIGINAL AMOUNT	CONVERTED VOLUME (CYD)	CONVERTED WEIGHT (TON)	COMMENTS/REFERENCE
Non-metal debris (ceramic, porcelain, glass, graphite, paper, debris)	100#/cft	325 cyd	325	440	IOC From : Dille/Hood To: Williams/Spittler Date: April 14, 1992 Subject: CP: Task 754 Material
Underground Piping (Clay, Concrete, etc.)	.55 cft/1ft 54 #/1ft	64,240 1ft	1,309	1,734	WITS Data Assume average diameter = 12 in.
Wood (no grubbing or RR Ties)	40#/cft	400 cyd	400	216	IOC From : Dille/Hood To: Williams/Spittler Date: April 14, 1992 Subject: CP: Task 754 Material
TOTAL RUBBLE			[redacted]	[redacted]	

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WASTE QUANTITIES QUARTERLY REPORT TABLE: [illegible]					
MATERIAL	**CONVERSION FACTOR**	**ORIGINAL AMOUNT**	**CONVERTED VOLUME (CYD)**	**CONVERTED WEIGHT (TON)**	**COMMENTS/REFERENCE**
ROADS & EMBANKMENTS CLOSURE					
Raffinate Pits					
Bottom	1.52 ton/cyd	15,400 cyd	15,400	23,410	Mod 8 Estimate
Roads	1.52 ton/cyd	10,800 cyd	10,800	16,420	Mod 8 Estimate
Retention Pond	1.52 ton/cyd	1,830 cyd	1,830	2,780	50% of Mod 8 Estimate
Vicinity Property					
Femme Osage	1.52 ton/cyd	1,600	1,600	2,430	50% of Mod 8 Estimate
Southeast	1.52 ton/cyd	6,750	6,750	10,260	50% of Mod 8 Estimate
Army 5 & 6	1.52 ton/cyd	1,800	1,800	2,740	50% of Mod 8 Estimate
Chemical Plant					
Ash Pond Bottom	1.52 ton/cyd	4,000 cyd	4,000	6,080	Mod 8 Estimate
Frog Pond Bottom	1.52 ton/cyd	800 cyd	800	1,220	Mod 8 Estimate
Retention Pond Dikes	1.52 ton/cyd	25,900 cyd	25,900	39,370	50% of Mod 8 Estimate
Haul Roads	1.52 ton/cyd	16,400 cyd	16,400	29,930	50% of Mod 8 Estimate
Quarry Haul Road	1.52 ton/cyd	3,500 cyd	3,500	5,320	25% of Mod 8 Estimate
TOTAL ROADS AND EMBANKMENTS			88,780	139,960	

WASTE QUANTITIES QUARTERLY REPORT TABLE: [redacted]					
MATERIAL	CONVERSION FACTOR	ORIGINAL AMOUNT	CONVERTED VOLUME (CYD)	CONVERTED WEIGHT (TON)	COMMENTS/REFERENCE
PERSONAL PROTECTIVE EQUIPMENT (PPE)		7,800 cyd	7,800		Based on 10 year estimate uncompacted. IOC Myers to Hixson May 1, 1991 Subject: Forecasted PPE Usage Quantities
CONTAINERIZED CHEMICALS		120 cyd	120		RCRA Waste 55 gal. = 7.5 ft^3 WITS Includes the tributylphosphate (TBP) waste.
		330 cyd	330		Non-RCRA Waste 55 gal. = 7.5 ft^3 WITS
GRAND TOTAL			[redacted]	[redacted]	

MK-FERGUSON
A DIVISION OF MORRISON KNUDSEN CORPORATION
INTER-OFFICE CORRESPONDENCE

DATE: August 12, 1992

TO: Distribution

FROM: Glen Schmidt

SUBJECT: **RADON EMANATION TEST PROCEDURE AND RESULTS**

Radon Emanation Experiments were conducted July 21 through July 29, 1992, on-site in building 410. The experiment was set up to provide experimental data for calculating radon emanation during the following activities: sludge excavation with a cutting head dredge; gravity settling within a continuous high rate thickener; and a continuous flow stirred vessel for feed storage prior to treatment (figure 1). Input parameters, physical conditions and radon flux were monitored for calculating radon emanation and processing requirements at full scale.

Throughout the experiment a notebook was used to record procedures observations and conclusions as they happened. Data sheets were used to record time, shaft speed, torque, room temperature, and sludge temperature. A Eberline RGA-40 recorded radon activity during the experiment. Data results from the radon gas analyzer (RGA) are attached in tabular form and figures. The tables are annotated to track steps taken which could affect the radon emanation levels along with the RGA-40 radon activity results. The figures provide a graphical representation of the data from the tables recorded by the RGA-40.

Test Procedure and Equipment

One 5-gallon bucket of raffinate pit 2 sludge collected in July 1991 and stored in building 408 was utilized for the test. On June 30, 92, the sludge was thoroughly homogenized using conventional plaster mixing tools. After homogenization two 8 oz. jars were filled for radiological and percent moisture analysis. The remaining sludge was transferred into two 5-L and two 7-L beakers. Each beaker contained approximately 0.86 gal. of sludge. Raffinate pit water was used to rinse down the bucket and mixing tools. The rinse water was then poured into the 7 L beakers for a water column of approximately 7 in. above the sludge. Based upon a conservative assumption that all radon was released while transferring the sludge, after 21 days radon levels will reach 97.75% of the calculated maximum; therefore, each beaker was allowed to set for a minimum of 21 days prior to testing.

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RADON EMANATION TEST PROCEDURE AND RESULTS

The two 5 L beakers were set up to simulate a well mixed storage tank of sludge without a water blanket. The beakers were of the same size with equal volumes of sludge. The beakers were label Beaker 1 and Beaker 2. The two 7 L beakers were set up to simulate sludge dredging and thickening. The beakers were of the same size with equal volumes of sludge and pit water. The beakers were labeled Beaker 3 and Beaker 4.

The following outline briefly describes the sequence of steps. The RGA-40 data table contains a more detailed description of steps taken during the experiment and should be referred to when reviewing the figures.

Beaker 1 Testing

Monday, July 20 The radon gas analyzer was set up in the lab and began recording background levels.

Tuesday, July 21 Beaker 1 Testing equipment was connected as shown in figure 2. The mixer was started and ran throughout the day and was stopped that night. The RGA-40 was left connected to monitor radon flux overnight. Figures 4 graphically show the results from beaker 1.

Wednesday, July 22 The mixer was restarted on beaker 1 to monitor radon buildup overnight and the subsequent release. Figure 5 has radon activity levels for the second start-up of beaker 1. Figure 6 combines the data from figures 4 & 5.

Beaker 2 Testing

A second beaker of sludge was tested to duplicate the test from beaker 1. Figure 7 has the radon activities from the test. Figure 8 combines the data from beaker 1 and 2 for comparison. The RGA-40 sampling tube was disconnected that evening to monitor background levels and progeny buildup within the monitor.

Thursday, July 23 Further mixing has been postponed until the RGA-40 drops back down to background levels.

Beaker 3 Testing

Tuesday, July 28 Testing equipment was connected as shown in figure 3. Water samples were collected prior to and during the test for radon 222 in water analysis and total suspended solids. The mixer ran throughout the day and was stopped that night. All equipment was left connected to monitor radon flux over night. Figure 9 graphically shows the results from beaker 3.

Beaker 4 Testing

Wednesday, July 29 A second beaker of sludge was tested to duplicate the test from beaker 3. Figure 10 has the radon activities from the test. Figure 11 combines the data from beaker 3 and 4 for comparison. Figure 12 is an expanded section of figure 11. The mixer was left running at 60 rpm throughout the night.

Thursday, July 30

The mixer was left running all night. At 13:14 the shaft speed was increased to 300 rpm then back to 200 rpm. The sludge became well mixed. The mixer was stopped and the RGA-40 tubing was disconnected at 16:73. Figure 13 provides the radon activity levels for the well mixed system. Figure 14 combines the data from figures 11 and 13.

No further testing was performed, however, the RGA-40 was left on through Monday August 3, to monitor progeny decay within the RGA-40.

Attachments:

1) Figures 1 through 14;
2) Annotated RGA-40 Data Results Table;
3) Radon Emanation Test Data Sheets;
4) Analytical Results.

Distribution:

Rick Ferguson	Mark Peterson
Jack Cooney	Michelle Vaughn
Steve Green	John Enger
Jim Williams	Don Carpenter - MKES
RC-22-26-48	

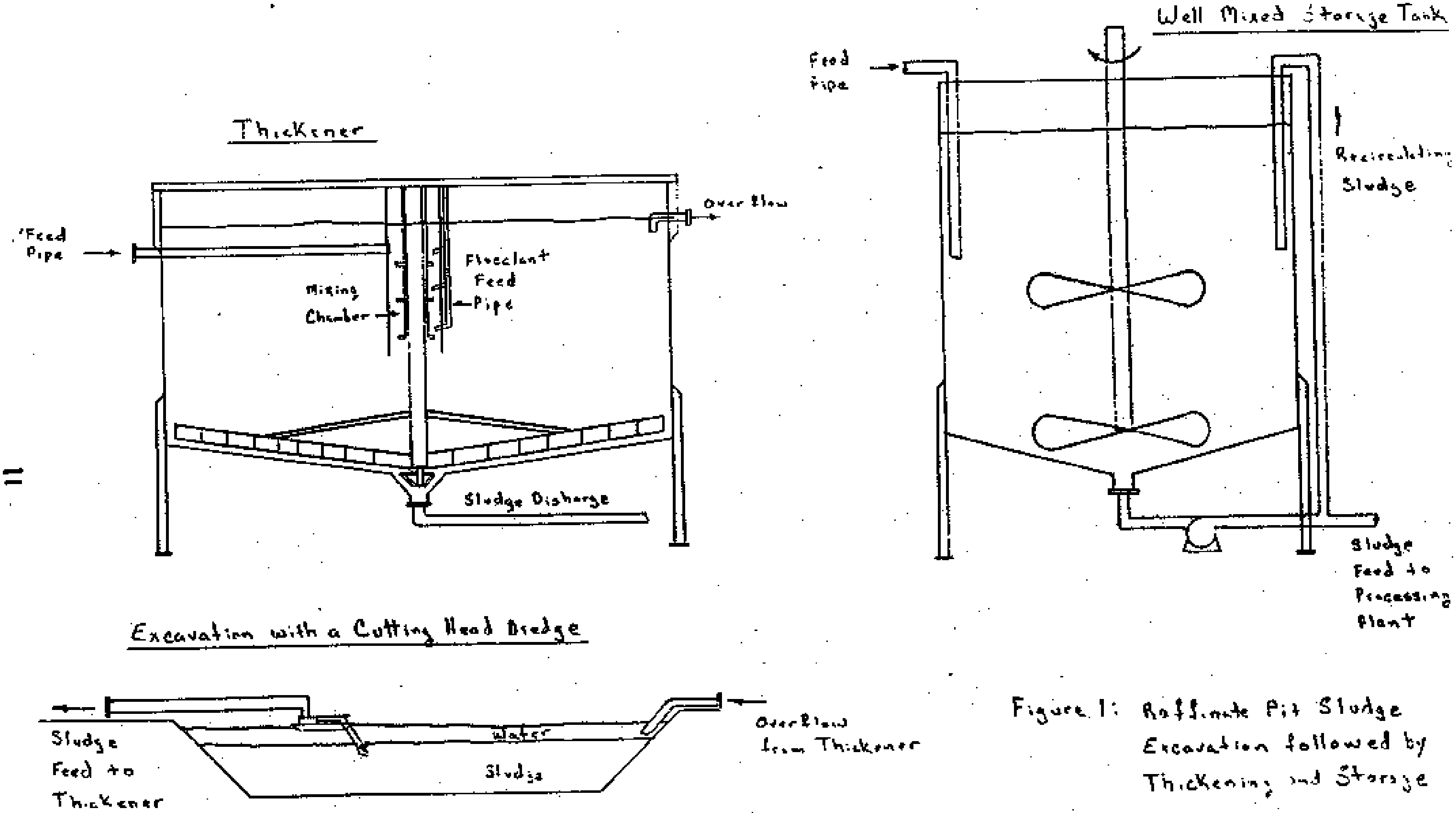


Figure 1: Raffinate Pit Sludge Excavation followed by Thickening and Storage

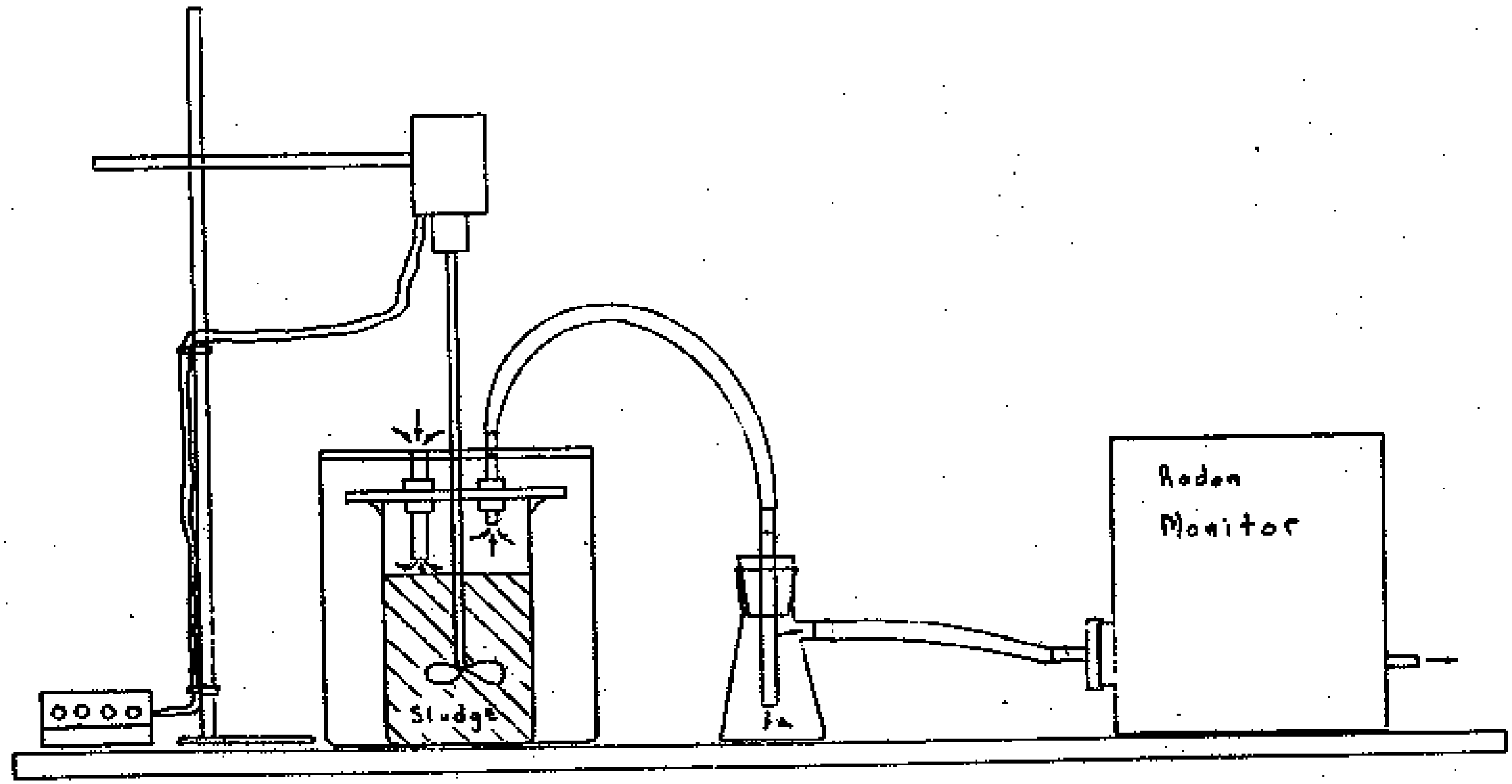


Figure 2: Radon Emission Test Schematic for a Well Mixed Tank

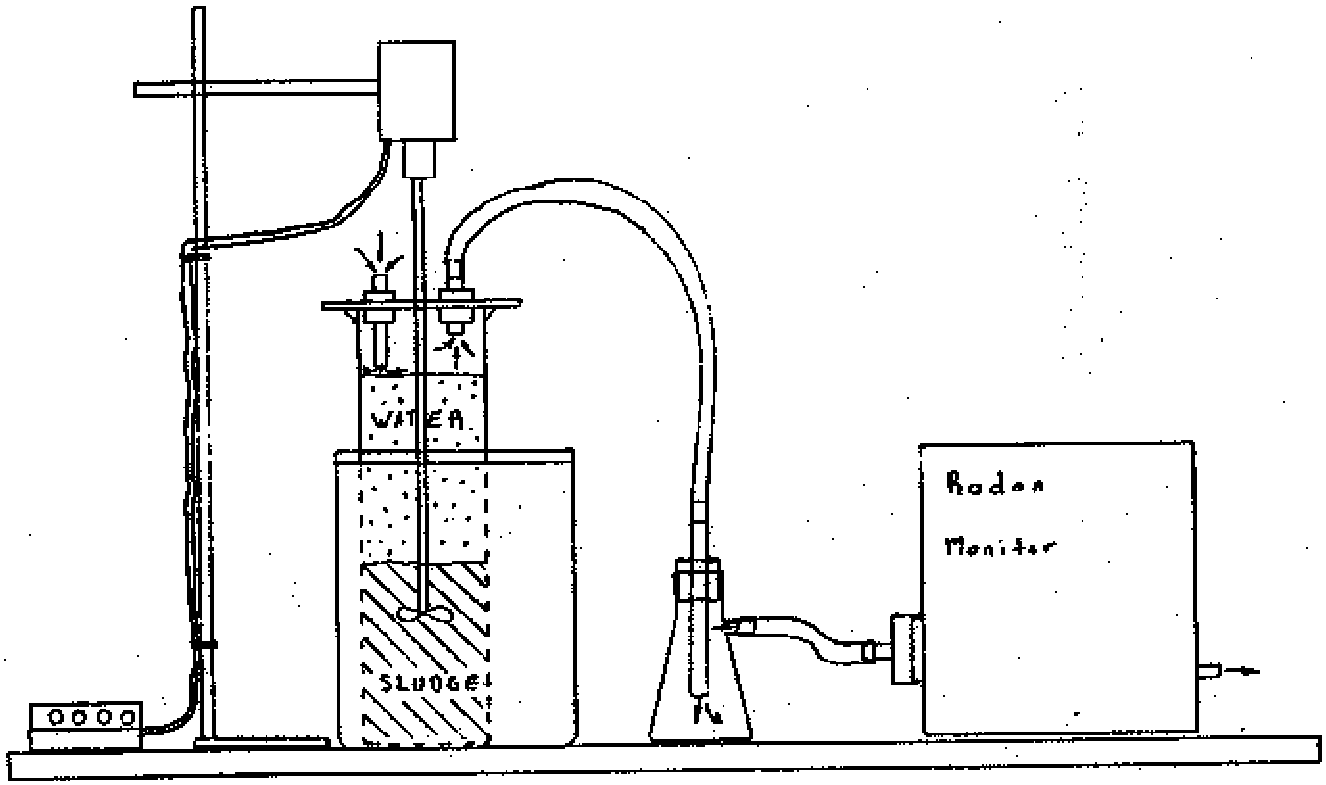


Figure 3: Radon Emission Test Schematic for Dredging and Thickening Operations

Figure 4: Radon Emanation Data From Beaker 1

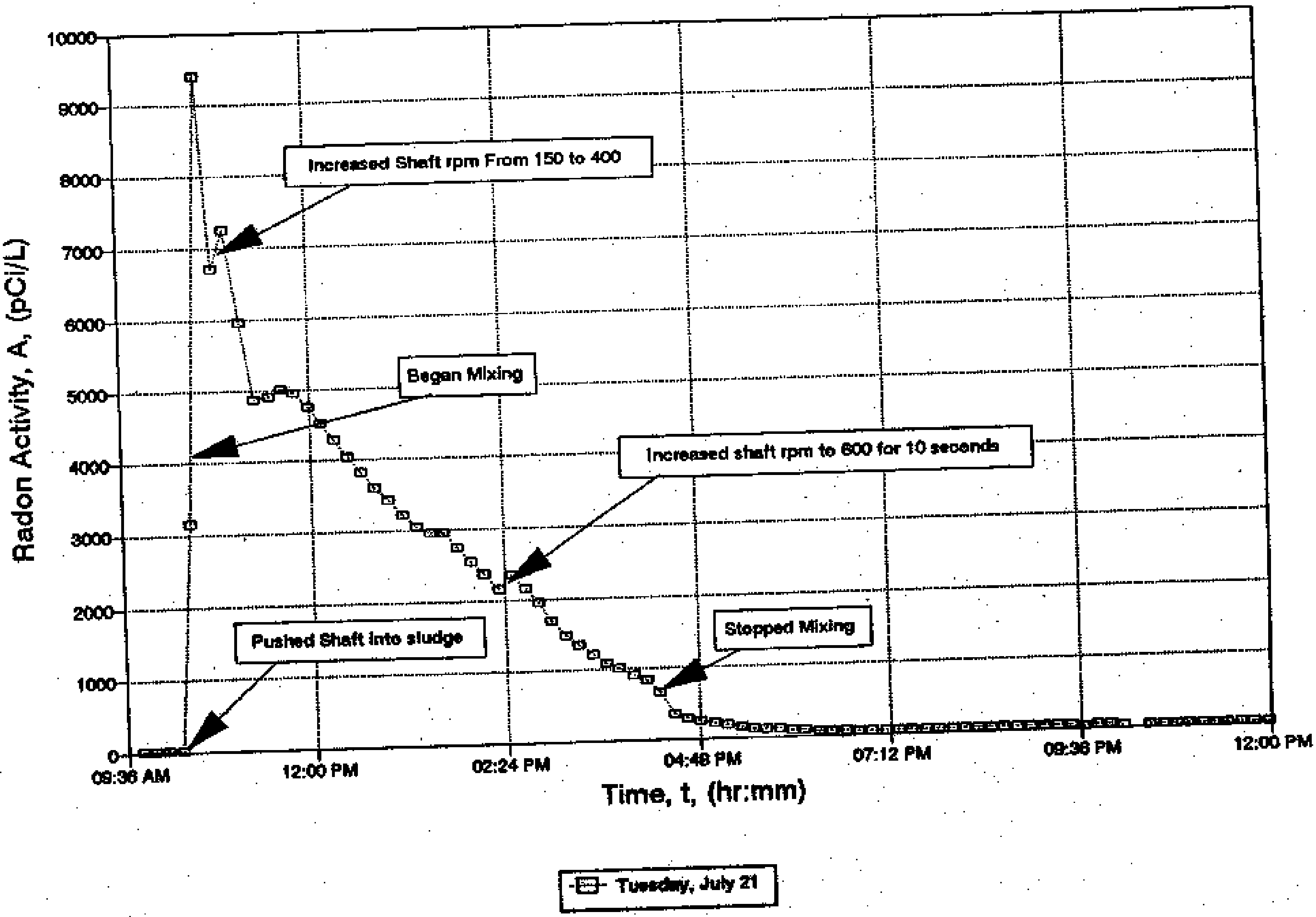


Figure 5: Radon Emanation Data From Beaker 1, (second startup)

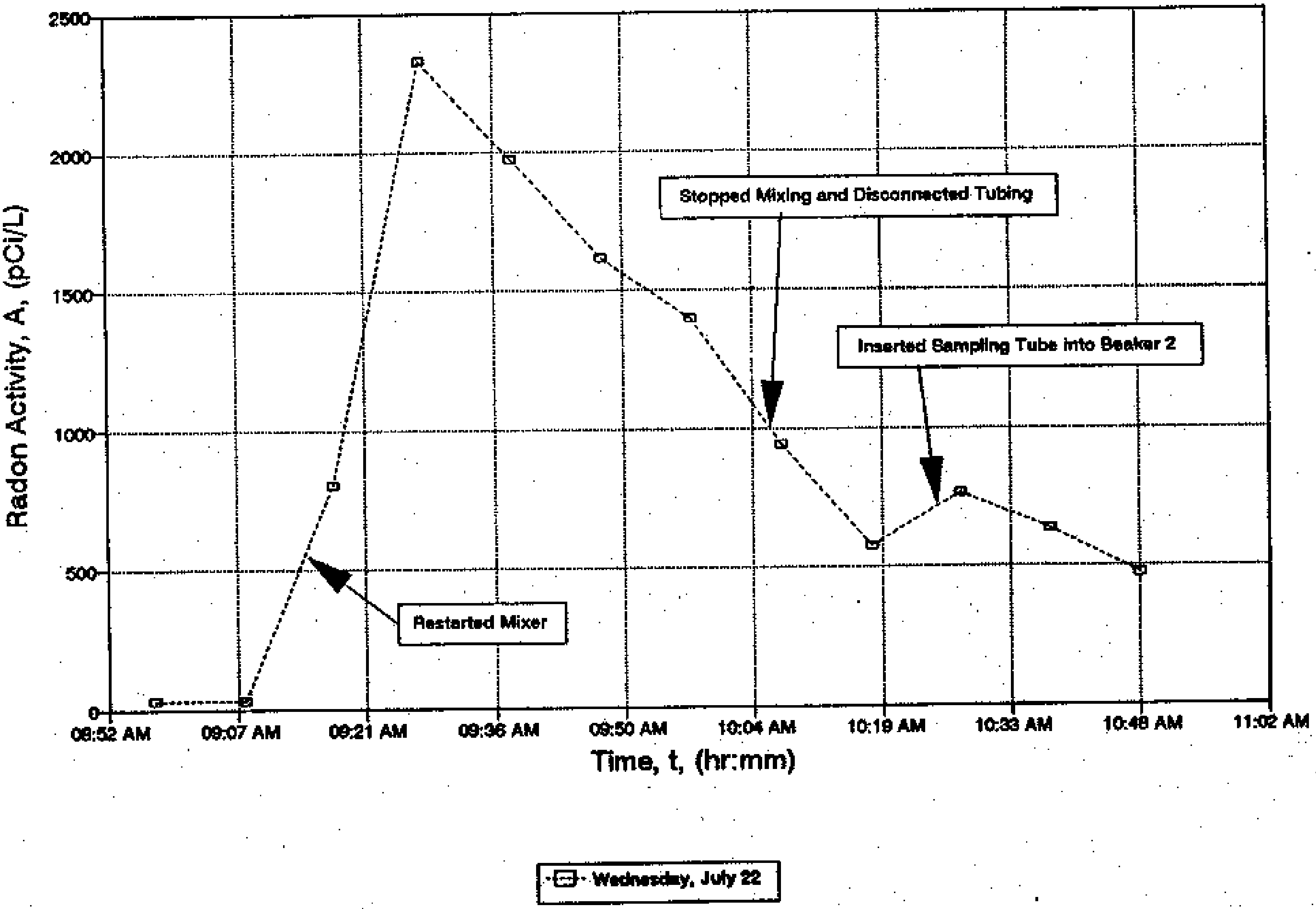


Figure 6: Radon Emanation Data From
Beaker 1, (includes 2nd startup)

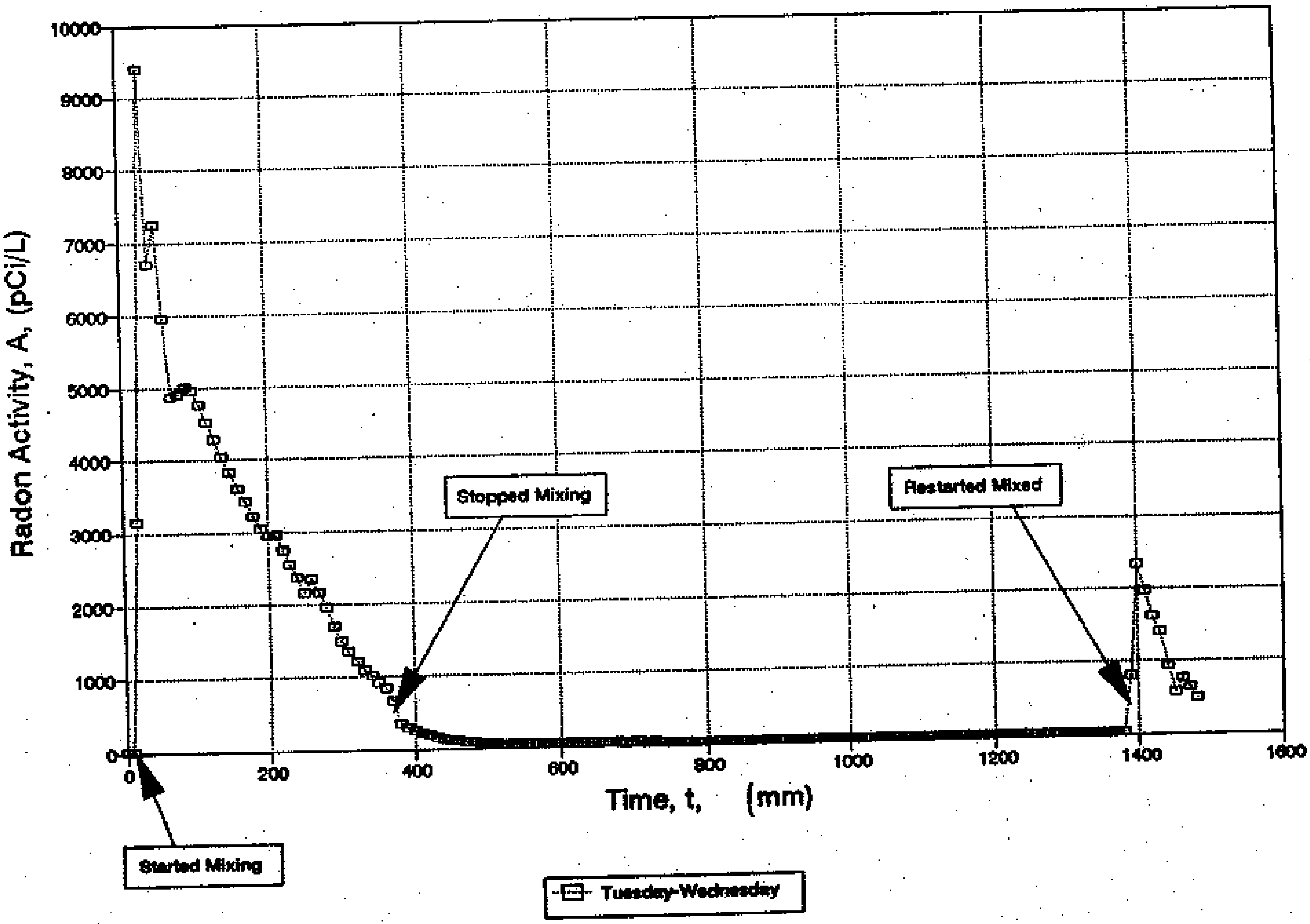


Figure 7: Radon Emanation Data From Beaker 2

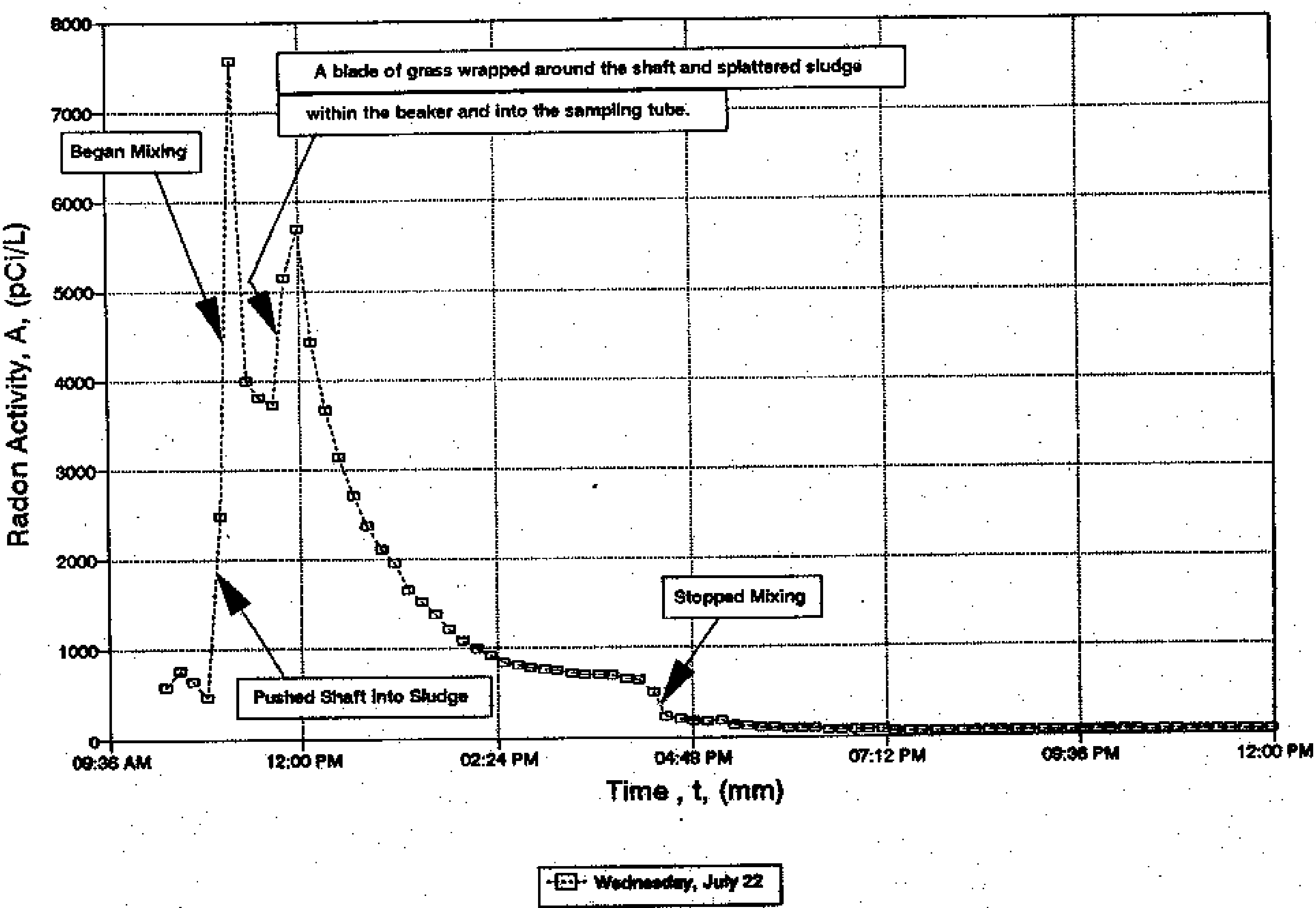


Figure 8: Radon Emation Data From Beakers 1 and 2

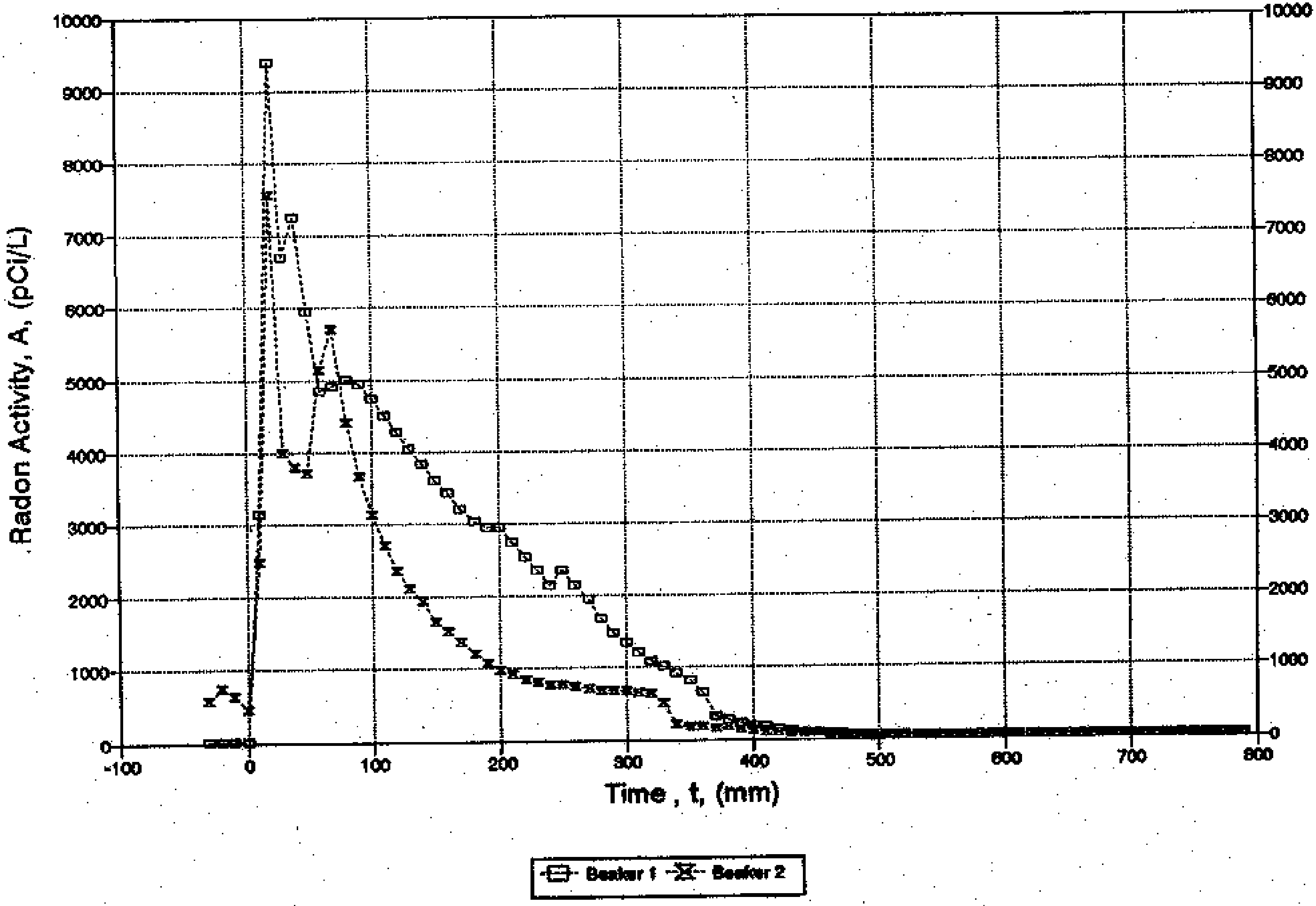


Figure 9: Radon Emanation Data From Beaker 3

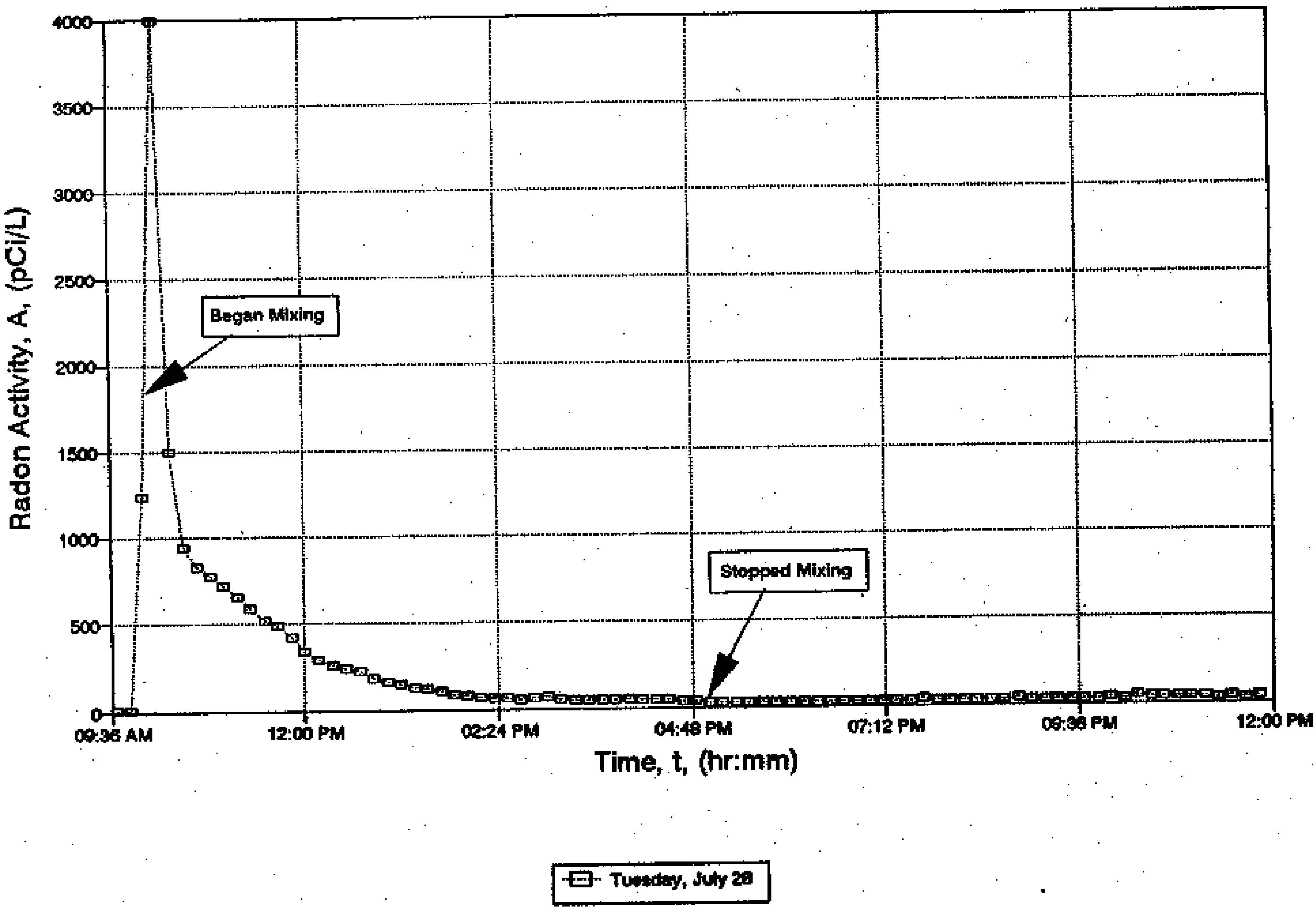


Figure 10: Radon Emanation Data From Beaker 4

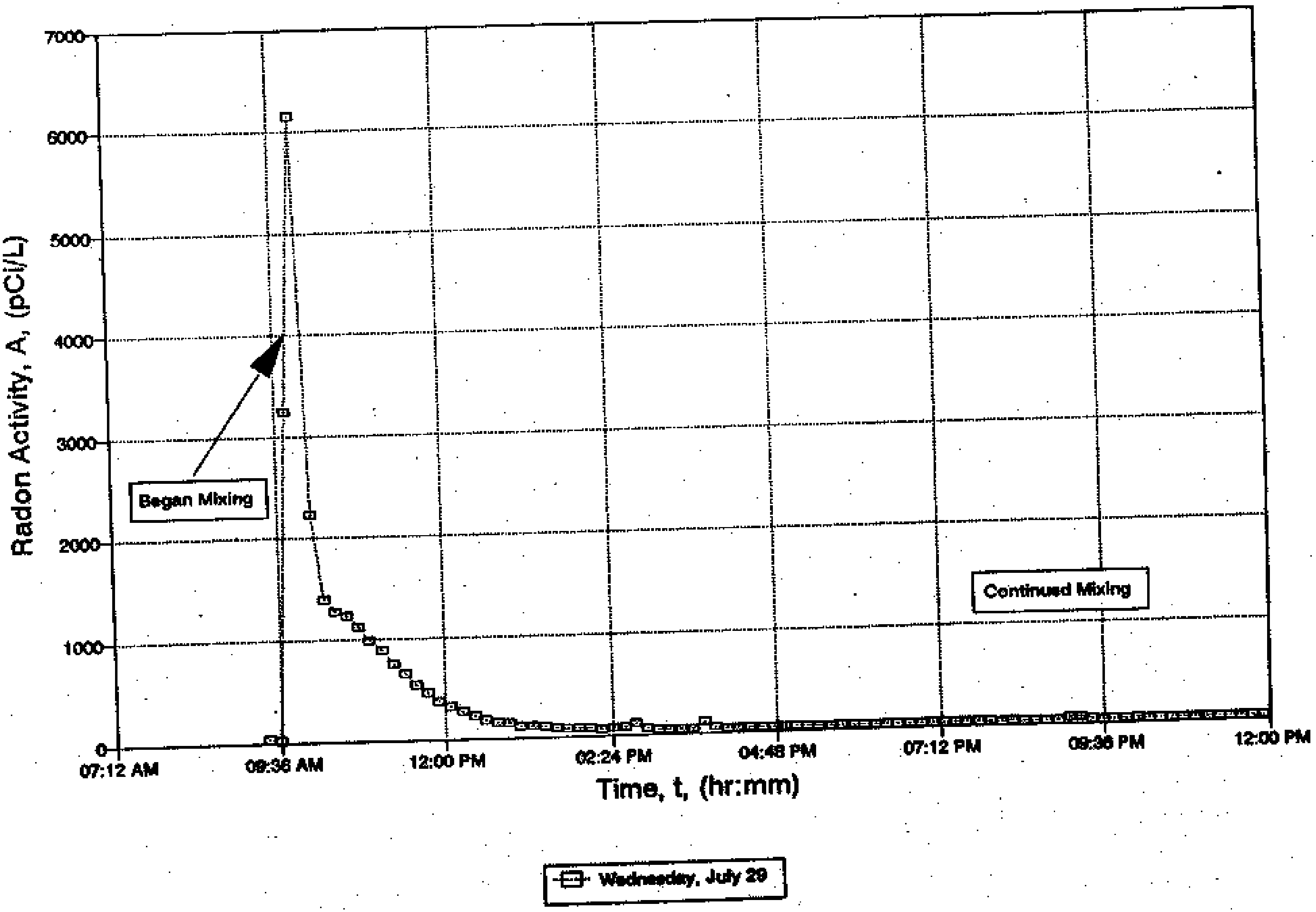


Figure 11: Radon Emanation Data From Beakers 3 & 4

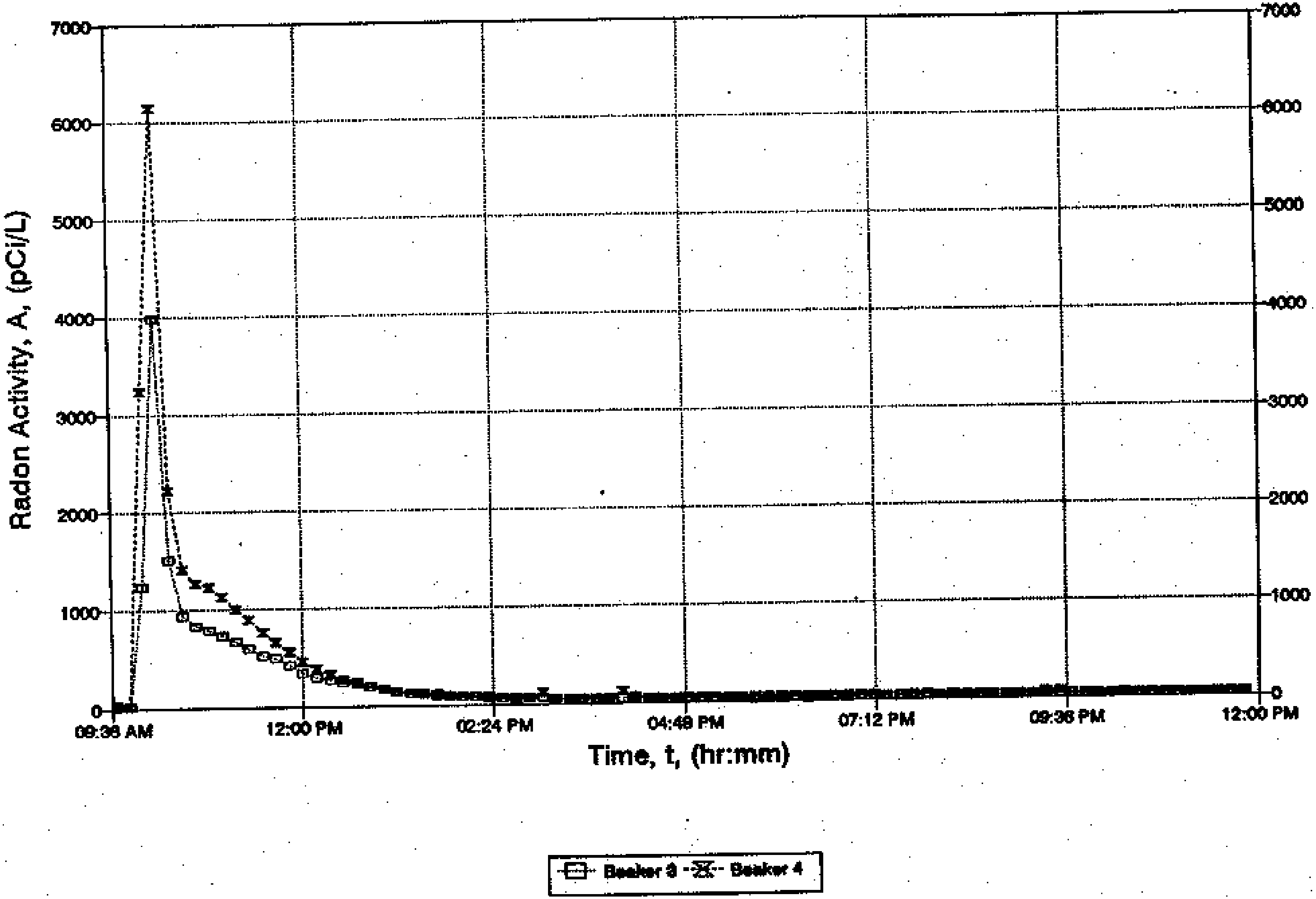


Figure 12: Radon Emanation Data From Beakers 3 & 4 (expanded section)

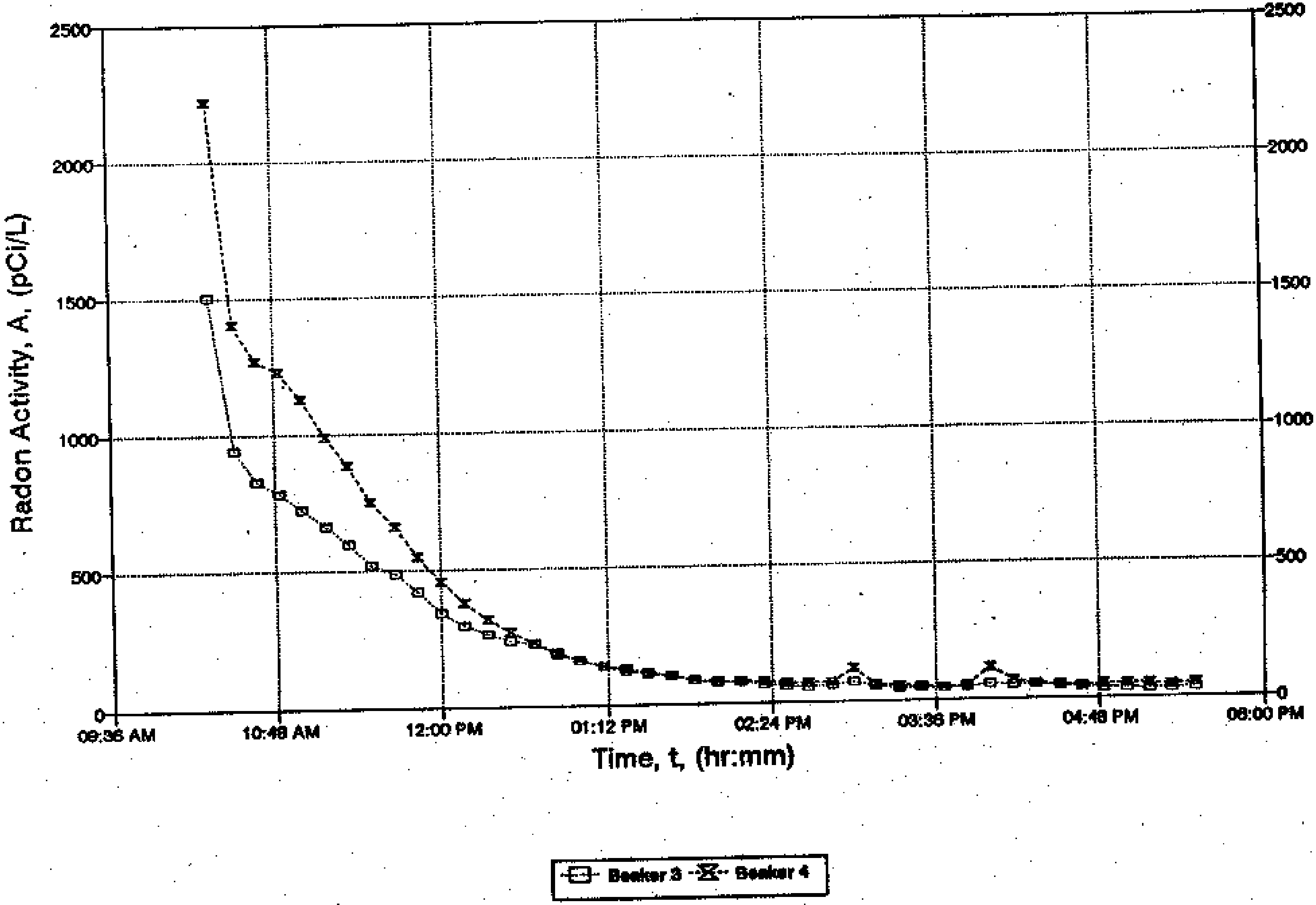


Figure 13 : Radon Emanation Data From Beaker 4 (200 rpm)

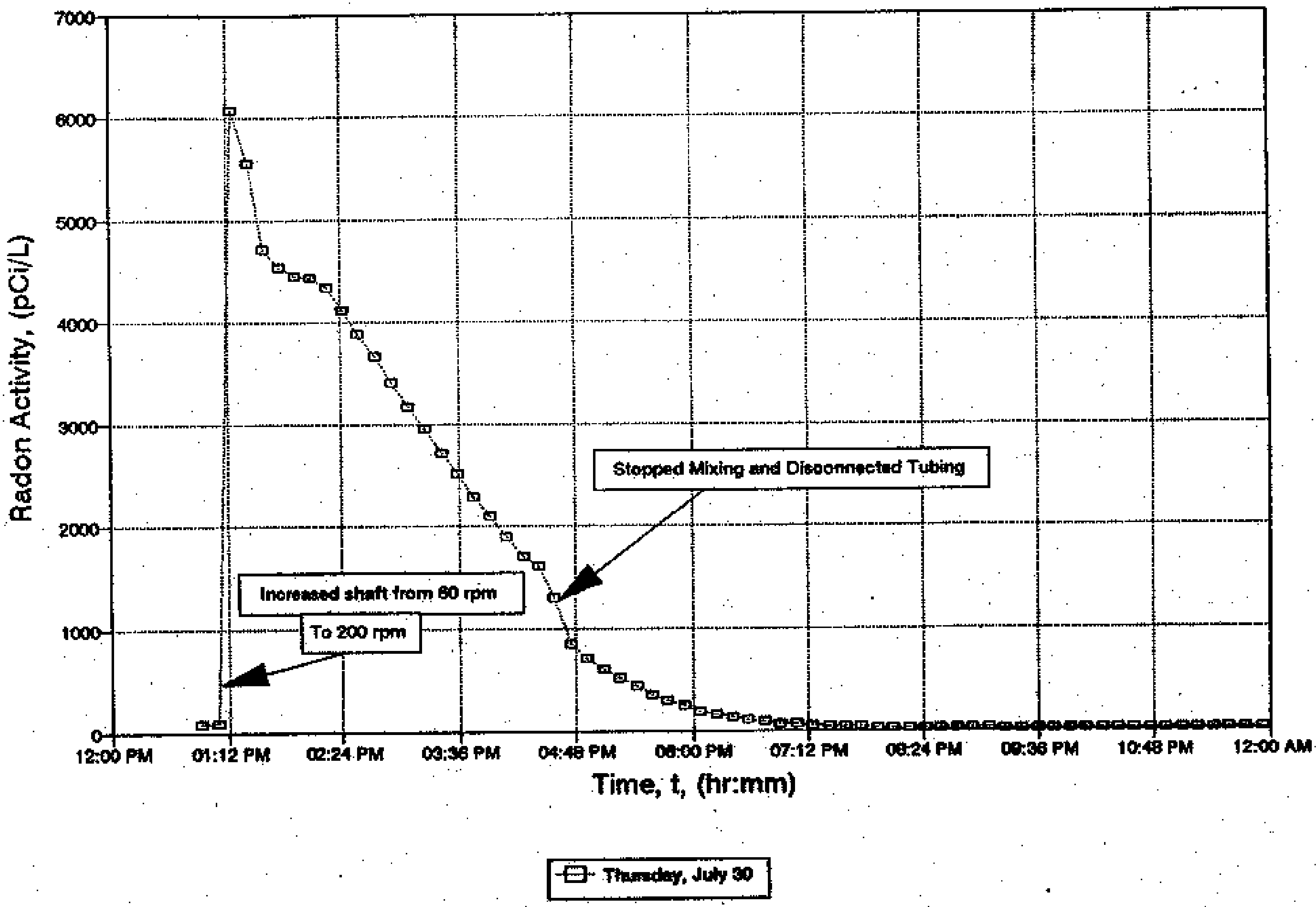
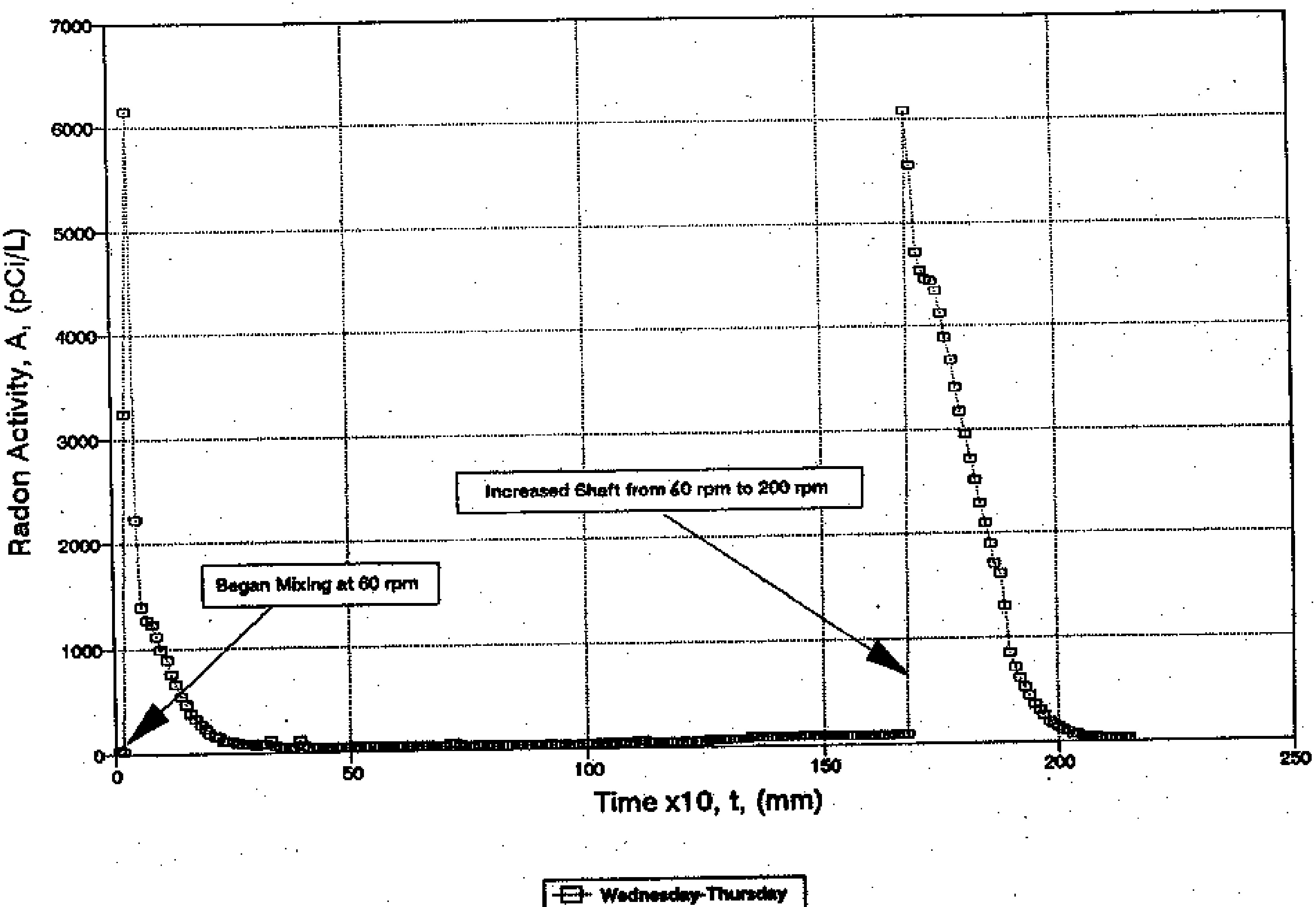


Figure 14: Radon Emanation Data From Beaker 4 (includes 200rpm portion)



The following data was collected with a Eberline model RGA-40 radon gas monitor. The data collection period is from Monday, July 20, at 11:16 am thru Monday August 3, at 11:05 am. In order to track the progression of the experiment, each step taken during the experiment are outlined along the right side of the table. During the experiment data was periodically downloaded and is presented here as one continuous table with two breaks during downloading and subsequent reprograming.

SERIAL #	A053
CURRENT TIME	7/24/92 08:14:25
START TIME	7/20/92 11:18:00
STOP TIME	7/24/92 08:13:00
SAMPLE INT	10 MINUTES
ALARM	0 PCI/L
EFFICIENCY	RN222 0.895 RND 0.026
MEMORY	65%

NUMBER OF READINGS 556

Time t hr:min	Sample	Activity A pCi/L	Activity A Bq/m^3	Notes Recorded During The Experiment
		Monday	July 20	
11:18	28	0.46	16.92	Began recording radon background levels in the lab.
11:28	29	0.47	17.33	
11:38	32	0.52	19.14	
11:48	37	0.60	22.14	
11:58	34	0.55	20.17	
12:08	38	0.61	22.50	
12:18	32	0.51	18.73	
12:28	41	0.65	24.11	
12:38	30	0.47	17.30	
12:48	40	0.63	23.33	
12:58	49	0.78	28.76	
13:08	42	0.66	24.39	
13:18	45	0.71	26.20	
13:28	53	0.84	30.97	
13:38	43	0.67	24.83	
13:48	50	0.79	29.09	
13:58	53	0.84	30.82	
14:08	60	0.95	35.00	
14:18	61	0.96	35.54	
14:28	37	0.57	21.00	
14:38	36	0.56	20.55	
14:48	39	0.60	22.35	

Monday July 20 (continued)

14:58	58	0.92	33.80	Recording radon background levels
15:08	32	0.48	17.95	
15:18	35	0.54	19.94	
15:28	39	0.61	22.46	
15:38	38	0.59	21.81	
15:48	35	0.54	20.01	
15:58	32	0.49	18.21	
16:08	36	0.56	20.63	
16:18	43	0.68	24.95	
16:28	38	0.59	21.85	
16:38	40	0.62	23.08	
16:48	45	0.71	26.07	
16:58	44	0.69	25.42	
17:08	42	0.65	24.20	
17:18	40	0.62	22.98	
17:28	29	0.44	16.33	
17:38	35	0.54	20.02	
17:48	42	0.66	24.32	
17:58	34	0.52	19.41	
18:08	38	0.59	21.88	
18:18	30	0.46	17.00	
18:28	31	0.48	17.64	
18:38	44	0.69	25.60	
18:48	37	0.58	21.37	
18:58	35	0.55	20.19	
19:08	30	0.46	17.16	
19:18	36	0.56	20.80	
19:28	52	0.83	30.52	
19:38	39	0.61	22.50	
19:48	22	0.33	12.29	
19:58	39	0.61	22.65	
20:08	28	0.43	15.98	
20:18	36	0.56	20.84	
20:28	23	0.35	13.03	
20:38	23	0.35	13.07	
20:48	28	0.44	16.19	
20:58	27	0.42	15.62	
21:08	29	0.46	16.91	
21:18	24	0.38	13.95	
21:28	26	0.41	15.25	
21:38	27	0.43	15.90	
21:48	33	0.53	19.56	
21:58	33	0.53	19.56	
22:08	43	0.69	25.51	
22:18	33	0.52	19.32	
22:28	43	0.69	25.34	
22:38	21	0.32	11.88	
22:48	33	0.52	19.21	
22:58	44	0.70	25.83	
23:08	34	0.53	19.63	
23:18	25	0.38	14.21	
23:28	41	0.65	23.89	

23:38	49	0.78	28.69	Recording radon background levels
23:48	36	0.56	20.72	
23:58	33	0.51	18.96	

Tuesday July 21

00:08	43	0.68	24.99
00:18	37	0.57	21.25
00:28	41	0.64	23.68
00:38	23	0.34	12.74
00:48	41	0.64	23.72
00:58	38	0.59	21.88
01:08	34	0.53	19.45
01:18	30	0.46	17.05
01:28	35	0.54	20.09
01:38	49	0.78	28.62
01:48	49	0.77	28.49
01:58	40	0.62	23.04
02:08	40	0.62	23.07
02:18	40	0.62	23.05
02:28	43	0.67	24.84
02:38	44	0.69	25.40
02:48	45	0.70	25.98
02:58	48	0.75	27.77
03:08	46	0.72	26.53
03:18	48	0.75	27.74
03:28	44	0.68	25.30
03:38	40	0.62	22.90
03:48	41	0.64	23.52
03:58	46	0.72	26.53
04:08	47	0.73	27.10
04:18	29	0.44	16.21
04:28	46	0.72	26.60
04:38	45	0.70	26.01
04:48	41	0.64	23.58
04:58	39	0.61	22.40
05:08	40	0.62	23.01
05:18	41	0.64	23.60
05:28	50	0.79	29.02
05:38	35	0.54	19.88
05:48	43	0.67	24.80
05:58	35	0.54	19.90
06:08	44	0.69	25.39
06:18	50	0.78	28.95
06:28	36	0.55	20.44
06:38	24	0.36	13.27
06:48	40	0.62	23.02
06:58	48	0.76	27.87
07:08	30	0.46	16.92
07:18	38	0.59	21.88
07:28	48	0.76	27.98
07:38	35	0.54	20.03
07:48	38	0.59	21.92
07:58	41	0.64	23.69

Tuesday July 21

08:08	39	0.61	22.44	Recording radon background levels
08:18	36	0.56	20.62	
08:28	39	0.61	22.43	
08:38	45	0.70	26.02	
08:48	42	0.65	24.15	
08:58	43	0.67	24.76	
09:08	51	0.80	29.58	
09:18	35	0.54	19.84	
09:28	38	0.59	21.75	
09:38	40	0.62	22.93	
09:48	37	0.57	21.10	
09:58	36	0.55	20.51	Preparing to start the experiment on
10:08	46	0.72	26.56	
10:18	39	0.60	22.26	
		**********	BEAKER 1	*********
10:28	191401	3155.07	115696.4	10:30 Pushed the mixing shaft into the sludge. Pockets of air were released.
10:38	572036	9393.83	344471.8	10:37 Began mixing at 60 rpm. 10:39 increased shaft to 150 rpm. 10:42 increased shaft. 250 rpm. 10:44 increased shaft to 400 rpm
10:48	414844	6721.14	246464.3	
10:58	447486	7258.38	266164.8	
11:08	369728	5950.77	218214.8	
11:18	304187	4862.96	178325.1	
11:28	307187	4909.09	180016.5	
11:38	313847	5008.31	1	
11:48	310612	4945.77	181361.4	Note: 400 rpm was used from here on.
11:58	298921	4747.53	174092.2	
12:08	285174	4518.83	165705.7	
12:18	271135	4287.49	157222.5	
12:28	256519	4048.25	148449.5	
12:38	243220	3832.16	140525.4	
12:48	229940	3617.28	132645.9	
12:58	218909	3440.37	126158.5	
13:08	204911	3214.86	1	
13:18	193569	3034.15	111262.3	
13:28	188813	2962.02	108617.5	
13:38	188560	2963.15	1	
13:48	175130	2746.07	100698.5	
13:58	162518	2544.87	93320.59	
14:08	151239	2366.41	86776.3	
14:18	138306	2160.02	79207.98	14:2
14:28	149850	2357.47	86448.76	~~10~~:28 Increased shaft to 600 rpm for 10 sec.
14:38	137144	2150.56	78861.27	
14:48	125266	1960.50	71891.84	
14:58	109351	1704.02	62486.71	
15:08	96095	1492.22	54719.98	
15:18	86615	1342.52	49230.49	
15:28	78501	1214.84	44548.32	

Tuesday July 21

15:38	70900	1095.37	40167.5	Continued mixing at 400 rpm
15:48	65987	1020.07	37406.11	
15:58	59884	924.55	33903.38	
16:08	54384	838.93	30763.79	
16:18	43757	668.50	24514.13	
				16:22 The mixer was stopped. All equipment is left in-place to monitor radon flux overnight (no mixing).
16:28	23635	342.30	12552.26	
16:38	19209	276.68	10146.15	
16:48	16840	242.65	8898.05	
16:58	14490	208.27	7637.42	
17:08	12441	178.57	6548.3	
17:18	10529	150.74	5527.70	
17:28	8982	128.53	4713.54	
17:38	7870	113.09	4147.15	
17:48	6853	98.79	3622.76	
17:58	5925	85.67	3141.54	
18:08	5566	81.61	2992.77	
18:18	4692	68.70	2519.42	
18:28	4427	65.67	2408.37	
18:38	4030	60.17	2206.72	
18:48	3759	56.60	2075.62	
18:58	3587	54.50	1998.54	
19:08	3362	51.38	1884.24	
19:18	3147	48.34	1772.68	
19:28	2957	45.63	1673.25	
19:38	2920	45.36	1663.65	
19:48	2948	46.08	1689.78	
19:58	2995	47.01	1724.12	
20:08	2667	41.73	1530.26	
20:18	2679	42.08	1543.40	
20:28	2572	40.41	1482.07	
20:38	2623	41.35	1516.33	
20:48	2680	42.34	1552.84	
20:58	2506	39.51	1449.09	
21:08	2579	40.78	1495.76	
21:18	2645	41.89	1536.44	
21:28	2622	41.53	1522.97	
21:38	2459	38.86	1425.19	
21:48	2586	41.00	1503.49	
21:58	2575	40.81	1496.63	
22:08	2446	38.69	1419.02	
22:18	2515	39.86	1461.86	
22:28	2413	38.18	1400.15	
22:38	2450	38.81	1423.44	
22:48	2361	37.35	1369.83	
22:58	2410	38.18	1400.32	
23:08	2387	37.81	1386.56	
23:18	2284	36.12	1324.76	
23:28	2415	38.31	1404.94	
23:38	2344	37.13	1361.59	
23:48	2364	37.47	1374.33	
23:58	2271	35.94	1318.25	

Wednesday July 22

Monitoring radon flux over the sludge in Beaker 1, no mixing.

00:08	2373	37.65	1380.77
00:18	2277	36.06	1322.35
00:28	2365	37.53	1376.23
00:38	2367	37.55	1377.11
00:48	2315	36.69	1345.64
00:58	2320	36.78	1349.00
01:08	2263	35.84	1314.58
01:18	2263	35.86	1315.02
01:28	2337	37.08	1359.93
01:38	2284	36.20	1327.54
01:48	2230	35.32	1295.3
01:58	2260	35.83	1313.94
02:08	2204	34.90	1280.14
02:18	2222	35.21	1291.49
02:28	2096	33.14	1215.43
02:38	2220	35.21	1291.44
02:48	2220	35.20	1291.01
02:58	2101	33.24	1219.21
03:08	2044	32.33	1185.71
03:18	2074	32.84	1204.58
03:28	2087	33.06	1212.65
03:38	1991	31.49	1154.80
03:48	2147	34.08	1250.01
03:58	2072	32.83	1204.07
04:08	2121	33.65	1234.24
04:18	2078	32.94	1208.07
04:28	2092	33.18	1216.81
04:38	2022	32.02	1174.49
04:48	2040	32.34	1185.92
04:58	2027	32.12	1178.11
05:08	1970	31.19	1143.90
05:18	2066	32.79	1202.47
05:28	1954	30.93	1134.38
05:38	2094	33.26	1219.76
05:48	2033	32.23	1182.16
05:58	1923	30.43	1116.03
06:08	1973	31.28	1147.09
06:18	1997	31.67	1161.56
06:28	1882	29.77	1092.02
06:38	1949	30.90	1133.32
06:48	1901	30.10	1104.11
06:58	1919	30.41	1115.42
07:08	1918	30.40	1114.91
07:18	1919	30.42	1115.72
07:28	1932	30.64	1123.75
07:38	1937	30.72	1126.85
07:48	1848	29.26	1073.03
07:58	1998	31.75	1164.31
08:08	2053	32.63	1196.76
08:18	1898	30.06	1102.51
08:28	1872	29.65	1087.59
08:38	1959	31.10	1140.46

Wednesday July 22

08:48	1857	29.40	1078.27	Monitoring radon over the sludge, no mixing.
08:58	1827	28.92	1060.79	
09:08	1856	29.41	1078.76	
09:18	48766	802.69	29434.82	The mixer was restarted in beaker 1 and set at 400 rpm.
09:28	141844	2328.26	85377.46	
09:38	121563	1974.01	72387.13	
09:48	100327	1620.35	59418.51	
09:58	86961	1398.17	51271.13	
10:08	59498	943.29	34590.68	10:07 Stopped the mixer and disconnected tubing
10:18	37165	576.70	21147.73	
10:28	48383	764.28	28026.48	10:30 Inserted sampling tube through plastic cover of beaker 2
10:38	40894	638.93	23429.73	
10:48	30733	472.82	17338.49	
	*************		BEAKER 2	***********
10:58	152049	2475.32	90770.13	10:52 Sampling tube is drawing directly from the air. 10:56 The shaft was pushed into the sludge with the sampling tube in-place.
				11:03 Began mixing Beaker 2 at 400 rpm
11:08	461906	7561.88	277294.3	
11:18	249844	4003.16	146795.9	
11:28	236574	3802.51	139438.4	
11:38	232828	3734.75	136953.6	
11:48	319328	5152.56	188944.5	
11:58	353689	5695.48	208853.5	
12:08	277454	4421.71	162144.1	
12:18	231689	3670.63	134602.2	
12:28	199354	3140.54	115163.8	
12:38	173067	2710.77	99403.92	
12:48	151541	2361.12	86582.52	
12:58	135888	2109.78	77365.96	
13:08	125901	1952.30	71590.88	
13:18	107694	1659.16	60841.74	
13:28	98995	1524.67	55909.65	
13:38	89654	1378.39	50545.64	
13:48	79015	1210.71	44396.72	
13:58	70552	1079.07	39569.77	
14:08	64949	994.06	36452.39	
14:18	60179	921.97	33808.98	
14:28	55594	852.62	31265.75	
14:38	52848	813.67	29837.41	
14:48	50583	781.30	28650.3	
14:58	50012	776.22	28464.11	
15:08	48602	756.51	27741.38	

Wednesday July 22

15:18	45990	716.79	26285.01	Continued mixing beaker 2 at 400 rpm.
15:28	45165	706.38	25903.01	
15:38	44783	702.45	25758.84	
15:48	43668	685.92	2	
15:58	41924	658.83	24159.34	
16:08	40675	639.77	23460.39	
16:18	32161	500.70	18360.8	16:21 Stopped mixing.
16:28	15219	223.92	8211.37	16:23 disconnected tubing from beaker.
16:38	12923	190.45	6983.88	
16:48	11837	174.91	6414.22	
16:58	10956	162.46	5957.53	
	**********		BEAKER 3	**********
17:08	12466	189.31	6942.02	17:00 connected tubing to beaker 3. 17:09 Disconnected tubing to monitor background levels and contamination within the monitor.
17:18	9330	138.99	5097.00	
17:28	8123	121.05	4439.21	
17:38	7371	110.23	4042.22	
17:48	6665	99.92	3664.40	
17:58	6129	92.27	3383.78	
18:08	5733	86.77	3181.98	
18:18	5353	81.38	2984.54	
18:28	4955	75.59	2772.05	
18:38	4663	71.45	2620.28	
18:48	4460	68.67	2518.37	
18:58	4165	64.29	2357.66	
19:08	4115	63.89	2343.17	
19:18	3976	61.94	2271.42	
19:28	3909	61.13	2241.65	
19:38	3631	56.78	2082.33	
19:48	3559	55.82	2047.04	
19:58	3556	55.91	2050.24	
20:08	3636	57.33	2102.42	
20:18	3509	55.31	2028.26	
20:28	3462	54.62	2003.21	
20:38	3314	52.26	1916.50	
20:48	3269	51.59	1892.08	
20:58	3262	51.53	1889.94	
21:08	3380	53.52	1962.76	
21:18	3351	53.05	1945.64	
21:28	3132	49.47	1814.22	
21:38	3175	50.24	1842.43	
21:48	3045	48.12	1764.59	
21:58	3092	48.94	1794.63	
22:08	3024	47.83	1754.10	
22:18	3188	50.56	1854.37	
22:28	2929	46.28	1697.37	
22:38	3041	48.18	1767.08	
22:48	3020	47.84	1754.40	
22:58	2973	47.08	1726.54	

23:08	2870	45.40	1664.96	Continued monitoring background and progeny buildup within the monitor.
23:18	2919	46.24	1695.71	
23:28	2824	44.68	1638.55	
23:38	2748	43.46	1593.67	
23:48	2762	43.71	1603.15	
23:58	2779	44.01	1614.01	

Thursday July 23

00:08	2670	42.22	1548.48
00:18	2667	42.21	1547.85
00:28	2697	42.72	1566.62
00:38	2617	41.41	1518.60
00:48	2583	40.87	1498.96
00:58	2616	41.44	1519.69
01:08	2547	40.31	1478.22
01:18	2516	39.82	1460.37
01:28	2616	41.49	1521.52
01:38	2533	40.11	1471.08
01:48	2467	39.05	1432.03
01:58	2465	39.03	1431.59
02:08	2405	38.06	1395.73
02:18	2517	39.92	1464.19
02:28	2424	38.38	1407.64
02:38	2306	36.46	1337.07
02:48	2361	37.40	1371.49
02:58	2254	35.64	1306.97
03:08	2250	35.60	1305.65
03:18	2285	36.19	1327.29
03:28	2259	35.77	1311.75
03:38	2173	34.36	1260.31
03:48	2187	34.62	1269.67
03:58	2193	34.73	1273.72
04:08	2149	34.01	1247.40
04:18	2155	34.13	1251.62
04:28	2131	33.74	1237.45
04:38	2018	31.89	1169.62
04:48	2075	32.86	1205.13
04:58	2049	32.43	1189.51
05:08	1998	31.61	1159.17
05:18	2086	33.08	1213.12
05:28	2021	32.00	1173.57
05:38	2027	32.11	1177.83
05:48	1885	29.78	1092.24
05:58	2000	31.71	1162.95
06:08	1935	30.63	1123.30
06:18	1880	29.74	1090.65
06:28	1818	28.73	1053.81
06:38	1838	29.08	1066.65
06:48	1881	29.80	1092.93
06:58	1791	28.32	1038.61
07:08	1824	28.89	1059.40
07:18	1752	27.70	1016.09
07:28	1797	28.47	1044.05

Thursday July 23

07:38	1750	27.69	1015.68
07:48	1745	27.63	1013.29
07:58	1767	28.00	1026.88
08:08	1694	26.80	982.83
08:18	1709	27.06	992.60
08:28	1700	26.92	987.34
08:38	1635	25.86	948.35
08:48	1687	26.73	980.46
08:58	1569	24.79	909.09
09:08	1571	24.85	911.26
09:18	1503	23.73	870.52
09:28	1552	24.56	900.94
09:38	1542	24.40	894.99
09:48	1497	23.67	868.12

Continued monitoring radon background levels

POWER FAIL

START TIME 7/23/92 10:13:00
SAMPLE INT 10 MINUTES

10:13	1411	23.25	852.91
10:23	1416	23.07	846.28
10:33	1410	22.90	839.83
10:43	1431	23.17	850.00
10:53	1398	22.56	827.33
11:03	1332	21.41	785.21
11:13	1369	21.97	805.81
11:23	1316	21.04	771.82
11:33	1285	20.50	751.88
11:43	1327	21.17	776.32
11:53	1310	20.85	764.80
12:03	1277	20.29	744.22
12:13	1269	20.15	739.02
12:23	1225	19.42	712.13
12:33	1250	19.83	727.28
12:43	1252	19.86	728.26
12:53	1231	19.50	715.42
13:03	1223	19.37	710.65
13:13	1174	18.57	681.03
13:23	1164	18.41	675.40
13:33	1116	17.63	646.52
13:43	1108	17.51	642.32
13:53	1160	18.38	674.08
14:03	1112	17.58	644.96
14:13	1121	17.75	650.96
14:23	1111	17.59	645.04
14:33	1013	15.98	586.03
14:43	1052	16.64	610.41
14:53	1034	16.35	599.62
15:03	1037	16.40	601.75
15:13	1082	17.15	629.24
15:23	1087	17.24	632.22

Thursday July 23

15:33	1048	16.60	608.73	Continued monitoring radon background level and potential progeny decay.
15:43	1050	16.64	610.31	
15:53	947	14.94	548.10	
16:03	1042	16.53	606.28	
16:13	997	15.78	578.71	
16:23	934	14.75	540.93	
16:33	971	15.37	563.87	
16:43	943	14.91	546.91	
16:53	910	14.38	527.36	
17:03	972	15.41	565.26	
17:13	886	13.99	513.15	
17:23	901	14.26	522.95	
17:33	922	14.61	535.80	
17:43	882	13.95	511.70	
17:53	879	13.91	510.23	
18:03	853	13.49	494.71	
18:13	876	13.87	508.93	
18:23	872	13.81	506.61	
18:33	842	13.32	488.60	
18:43	771	12.16	445.98	
18:53	805	12.74	467.22	
19:03	823	13.03	478.16	
19:13	743	11.72	429.82	
19:23	804	12.74	467.37	
19:33	776	12.27	450.27	
19:43	753	11.90	436.64	
19:53	742	11.73	430.34	
20:03	766	12.13	445.08	
20:13	757	11.98	439.62	
20:23	736	11.64	427.11	
20:33	746	11.81	433.41	
20:43	725	11.47	420.74	
20:53	709	11.21	411.29	
21:03	680	10.74	394.06	
21:13	745	11.82	433.71	
21:23	668	10.55	386.87	
21:33	719	11.40	418.24	
21:43	769	12.22	448.25	
21:53	655	10.33	379.10	
22:03	697	11.05	405.24	
22:13	702	11.13	408.19	
22:23	669	10.58	388.26	
22:33	676	10.71	392.79	
22:43	645	10.20	374.05	
22:53	617	9.74	357.38	
23:03	689	10.94	401.25	
23:13	650	10.28	377.32	
23:23	627	9.91	363.69	
23:33	609	9.62	353.10	
23:43	665	10.55	387.18	
23:53	605	9.56	350.63	

Friday July 24

00:03	629	9.96	365.51	Monitoring background
00:13	630	9.98	366.04	
00:23	608	9.62	352.80	
00:33	574	9.06	332.45	
00:43	592	9.37	343.63	
00:53	608	9.63	353.34	
01:03	582	9.20	337.67	
01:13	591	9.36	343.32	
01:23	593	9.39	344.61	
01:33	594	9.41	345.32	
01:43	563	8.90	326.68	
01:53	553	8.75	320.95	
02:03	563	8.92	327.15	
02:13	528	8.34	305.99	
02:23	553	8.76	321.40	
02:33	580	9.21	337.73	
02:43	518	8.18	300.09	
02:53	526	8.32	305.38	
03:03	508	8.03	294.59	
03:13	539	8.55	313.58	
03:23	522	8.26	303.20	
03:33	506	8.00	293.63	
03:43	508	8.04	295.06	
03:53	486	7.68	281.83	
04:03	479	7.57	277.82	
04:13	502	7.95	291.83	
04:23	506	8.02	294.15	
04:33	473	7.47	274.23	
04:43	490	7.76	284.77	
04:53	487	7.71	283.00	
05:03	500	7.93	290.89	
05:13	445	7.02	257.58	
05:23	441	6.96	255.55	
05:33	485	7.69	282.30	
05:43	444	7.01	257.32	
05:53	444	7.02	257.59	
06:03	428	6.76	248.04	
06:13	456	7.23	265.16	
06:23	405	6.38	234.22	
06:33	423	6.69	245.53	
06:43	457	7.25	266.15	
06:53	437	6.92	253.87	
07:03	438	6.94	254.67	
07:13	401	6.33	232.33	
07:23	393	6.21	227.77	
07:33	384	6.06	222.52	
07:43	414	6.56	240.84	
07:53	401	6.35	232.89	
08:03	399	6.32	231.75	

END OF DATA OUTPUT

Downloaded data Friday morning to ensure adequat memory capacity for the radon monitor to run through the weekend.

SERIAL #	A053
CURRENT TIME	7/29/92 08:00:27
START TIME	7/24/92 08:20:00
STOP TIME	7/29/92 08:00:00
SAMPLE INT	10 MINUTES
ALARM	0 PCI/L
EFFICIENCY	RN222 0.895 RND 0.026
MEMORY	84%

NUMBER OF READINGS 718

Time t hr:min	Sample	Activity A pCi/L	Activity A Bq/m³	Notes Recorded During The Experiment
		Friday July 24		
08:20	409	6.74	247.23	Monitoring radon background levels.
08:30	369	6.00	220.25	
08:40	388	6.30	231.16	
08:50	396	6.41	235.21	
09:00	383	6.18	226.62	
09:10	359	5.76	211.57	
09:20	373	5.98	219.63	
09:30	361	5.77	211.78	
09:40	380	6.07	222.93	
09:50	355	5.65	207.33	
10:00	329	5.22	191.49	
10:10	389	6.20	227.70	
10:20	369	5.86	215.13	
10:30	329	5.20	190.92	
10:40	329	5.21	191.07	
10:50	339	5.37	197.13	
11:00	328	5.19	190.43	
11:10	327	5.17	189.94	
11:20	331	5.24	192.41	
11:30	350	5.56	203.91	
11:40	332	5.26	192.94	
11:50	323	5.11	187.57	
12:00	353	5.61	205.83	
12:10	325	5.14	188.75	
12:20	328	5.19	190.67	
12:30	320	5.06	185.86	
12:40	288	4.54	166.61	
12:50	275	4.33	159.01	
13:00	296	4.68	171.83	
13:10	316	5.01	183.93	
13:20	301	4.76	174.74	
13:30	272	4.29	157.34	

Friday July 24

13:40	310	4.92	180.53	Monitoring radon background levels.
13:50	327	5.19	190.68	
14:00	272	4.28	157.30	
14:10	341	5.43	199.39	
14:20	305	4.83	177.27	
14:30	285	4.51	165.40	
14:40	271	4.28	157.06	
14:50	310	4.92	180.71	
15:00	287	4.54	166.64	
15:10	285	4.51	165.55	
15:20	279	4.41	161.91	
15:30	243	3.82	140.17	
15:40	273	4.32	158.65	
15:50	262	4.14	151.87	
16:00	263	4.16	152.64	
16:10	254	4.01	147.27	
16:20	267	4.23	155.27	
16:30	287	4.56	167.34	
16:40	246	3.88	142.48	
16:50	281	4.46	163.84	
17:00	243	3.83	140.68	
17:10	255	4.04	148.23	
17:20	258	4.09	149.99	
17:30	234	3.69	135.49	
17:40	239	3.78	138.71	
17:50	216	3.40	124.80	
18:00	231	3.65	134.05	
18:10	210	3.31	121.39	
18:20	223	3.52	129.40	
18:30	230	3.64	133.68	
18:40	218	3.44	126.37	
18:50	211	3.33	122.22	
19:00	220	3.48	127.82	
19:10	209	3.30	121.20	
19:20	189	2.98	109.28	
19:30	211	3.34	122.80	
19:40	228	3.62	133.00	
19:50	196	3.09	113.61	
20:00	235	3.74	137.34	
20:10	218	3.45	126.86	
20:20	209	3.31	121.45	
20:30	226	3.59	131.84	
20:40	210	3.32	122.09	
20:50	195	3.08	113.04	
21:00	222	3.53	129.52	
21:10	184	2.90	106.40	
21:20	206	3.26	119.87	
21:30	221	3.51	128.84	
21:40	219	3.47	127.56	
21:50	209	3.31	121.45	
22:00	237	3.77	138.49	
22:10	226	3.59	131.68	

Friday July 24

22:20	192	3.03	111.12	Monitoring radon background levels
22:30	168	2.63	96.77	
22:40	193	3.05	112.09	
22:50	205	3.25	119.21	
23:00	190	3.00	110.10	
23:10	221	3.51	129.00	
23:20	217	3.44	126.41	
23:30	217	3.44	126.36	
23:40	207	3.28	120.36	
23:50	212	3.36	123.48	

Saturday July 26

00:00	210	3.33	122.27
00:10	230	3.66	134.40
00:20	210	3.33	122.20
00:30	185	2.92	107.13
00:40	196	3.10	113.99
00:50	221	3.51	129.04
01:00	207	3.28	120.43
01:10	189	2.98	109.55
01:20	189	2.99	109.70
01:30	171	2.69	98.85
01:40	202	3.21	117.73
01:50	181	2.85	104.85
02:00	167	2.63	96.56
02:10	145	2.27	83.38
02:20	170	2.69	98.66
02:30	166	2.62	96.21
02:40	176	2.78	102.29
02:50	151	2.37	87.12
03:00	151	2.38	87.30
03:10	153	2.41	88.63
03:20	137	2.15	79.05
03:30	133	2.09	76.84
03:40	163	2.59	95.11
03:50	174	2.77	101.64
04:00	140	2.20	80.96
04:10	155	2.46	90.22
04:20	132	2.08	76.29
04:30	150	2.38	87.37
04:40	131	2.06	75.82
04:50	137	2.17	79.63
05:00	148	2.35	86.28
05:10	140	2.22	81.42
05:20	148	2.35	86.34
05:30	141	2.23	82.09
05:40	115	1.81	66.44
05:50	137	2.18	79.94
06:00	130	2.06	75.58
06:10	133	2.11	77.46
06:20	145	2.30	84.70

Saturday July 26

06:30	146	2.32	85.23	Monitoring radon background levels
06:40	135	2.14	78.58	
06:50	137	2.17	79.86	
07:00	137	2.17	79.85	
07:10	156	2.49	91.34	
07:20	130	2.05	75.50	
07:30	120	1.89	69.64	
07:40	127	2.01	73.94	
07:50	122	1.93	70.86	
08:00	142	2.26	82.99	
08:10	144	2.29	84.06	
08:20	149	2.37	87.07	
08:30	136	2.15	79.18	
08:40	145	2.31	84.71	
08:50	135	2.14	78.60	
09:00	116	1.83	67.19	
09:10	128	2.03	74.57	
09:20	137	2.17	79.92	
09:30	126	1.99	73.21	
09:40	132	2.09	76.92	
09:50	127	2.01	73.85	
10:00	136	2.16	79.33	
10:10	115	1.81	66.57	
10:20	136	2.16	79.41	
10:30	90	1.40	51.46	
10:40	100	1.57	57.82	
10:50	108	1.71	62.71	
11:00	121	1.92	70.50	
11:10	115	1.82	66.79	
11:20	104	1.64	60.17	
11:30	106	1.67	61.45	
11:40	92	1.44	52.96	
11:50	110	1.74	63.92	
12:00	107	1.69	62.10	
12:10	104	1.64	60.28	
12:20	93	1.46	53.65	
12:30	113	1.79	65.80	
12:40	95	1.49	54.89	
12:50	97	1.53	56.19	
13:00	78	1.22	44.80	
13:10	87	1.37	50.33	
13:20	100	1.58	58.23	
13:30	113	1.80	66.09	
13:40	88	1.38	50.84	
13:50	98	1.55	57.02	
14:00	82	1.29	47.36	
14:10	82	1.29	47.40	
14:20	87	1.37	50.51	
14:30	89	1.41	51.74	
14:40	94	1.49	54.82	
14:50	82	1.29	47.59	
15:00	74	1.16	42.90	

Saturday July 26

15:10	72	1.13	41.79	Monitoring radon background levels.
15:20	74	1.17	43.05	
15:30	80	1.27	46.70	
15:40	78	1.24	45.49	
15:50	84	1.34	49.15	
16:00	79	1.25	46.11	
16:10	85	1.35	49.78	
16:20	71	1.12	41.29	
16:30	79	1.26	46.23	
16:40	82	1.30	48.00	
16:50	70	1.11	40.73	
17:00	79	1.26	46.26	
17:10	68	1.07	39.55	
17:20	61	0.96	35.40	
17:30	69	1.09	40.28	
17:40	87	1.39	51.11	
17:50	73	1.15	42.52	
18:00	74	1.17	43.23	
18:10	83	1.32	48.66	
18:20	74	1.17	43.16	
18:30	67	1.06	38.99	
18:40	76	1.21	44.47	
18:50	61	0.96	35.34	
19:00	59	0.93	34.24	
19:10	87	1.39	51.18	
19:20	56	0.87	32.25	
19:30	77	1.23	45.16	
19:40	61	0.96	35.34	
19:50	66	1.04	38.47	
20:00	73	1.16	42.67	
20:10	60	0.94	34.76	
20:20	63	0.99	36.66	
20:30	81	1.29	47.52	
20:40	70	1.11	40.75	
20:50	68	1.08	39.62	
21:00	68	1.08	39.63	
21:10	54	0.85	31.17	
21:20	72	1.14	42.14	
21:30	79	1.26	46.25	
21:40	88	1.40	51.65	
21:50	72	1.14	41.91	
22:00	57	0.89	32.96	
22:10	77	1.23	45.15	
22:20	71	1.12	41.38	
22:30	61	0.96	35.38	
22:40	86	1.37	50.56	
22:50	83	1.32	48.57	
23:00	77	1.22	44.97	
23:10	76	1.21	44.41	
23:20	70	1.11	40.79	
23:30	64	1.01	37.20	
23:40	68	1.08	39.66	
23:50	79	1.26	46.28	

Sunday July 26

Monitoring radon background levels

00:00	78	1.24	45.60
00:10	88	1.40	51.65
00:20	58	0.91	33.45
00:30	66	1.04	38.49
00:40	50	0.78	28.76
00:50	72	1.15	42.17
01:00	81	1.29	47.46
01:10	83	1.32	48.61
01:20	79	1.25	46.18
01:30	87	1.39	51.04
01:40	96	1.53	56.43
01:50	65	1.02	37.63
02:00	77	1.22	44.97
02:10	64	1.01	37.04
02:20	94	1.50	55.26
02:30	87	1.38	50.83
02:40	87	1.38	50.77
02:50	69	1.08	39.91
03:00	73	1.15	42.46
03:10	74	1.17	43.06
03:20	58	0.91	33.40
03:30	63	0.99	36.55
03:40	64	1.01	37.14
03:50	66	1.04	38.36
04:00	57	0.89	32.92
04:10	69	1.09	40.25
04:20	58	0.91	33.53
04:30	73	1.16	42.68
04:40	67	1.06	38.96
04:50	80	1.27	46.87
05:00	60	0.94	34.69
05:10	64	1.01	37.26
05:20	65	1.03	37.84
05:30	80	1.27	46.90
05:40	62	0.97	35.92
05:50	65	1.03	37.86
06:00	67	1.06	39.05
06:10	67	1.06	39.03
06:20	60	0.94	34.80
06:30	66	1.04	38.48
06:40	56	0.88	32.39
06:50	70	1.11	40.92
07:00	67	1.06	39.01
07:10	61	0.96	35.41
07:20	57	0.90	33.03
07:30	55	0.86	31.85
07:40	68	1.08	39.72
07:50	65	1.03	37.82
08:00	77	1.22	45.09
08:10	88	1.40	51.66
08:20	58	0.91	33.45
08:30	60	0.95	34.87

Sunday July 26

08:40	58	0.91	33.64	Monitoring radon background levels.
08:50	80	1.28	46.95	
09:00	60	0.94	34.71	
09:10	69	1.09	40.29	
09:20	62	0.98	36.00	
09:30	70	1.11	40.88	
09:40	56	0.88	32.36	
09:50	55	0.86	31.86	
10:00	58	0.91	33.67	
10:10	50	0.78	28.82	
10:20	70	1.11	40.96	
10:30	71	1.12	41.43	
10:40	65	1.03	37.80	
10:50	57	0.90	33.00	
11:00	76	1.21	44.54	
11:10	72	1.14	41.99	
11:20	78	1.24	45.65	
11:30	57	0.89	32.91	
11:40	59	0.93	34.27	
11:50	93	1.49	54.80	
12:00	69	1.09	40.06	
12:10	70	1.11	40.84	
12:20	72	1.14	42.04	
12:30	71	1.12	41.42	
12:40	72	1.14	42.03	
12:50	83	1.32	48.67	
13:00	78	1.24	45.57	
13:10	83	1.32	48.63	
13:20	94	1.50	55.25	
13:30	91	1.45	53.36	
13:40	83	1.32	48.42	
13:50	87	1.38	50.90	
14:00	78	1.23	45.43	
14:10	98	1.57	57.59	
14:20	92	1.46	53.84	
14:30	87	1.38	50.74	
14:40	70	1.10	40.53	
14:50	65	1.02	37.63	
15:00	89	1.42	52.19	
15:10	69	1.08	39.95	
15:20	78	1.24	45.55	
15:30	66	1.04	38.25	
15:40	59	0.93	34.12	
15:50	67	1.06	39.02	
16:00	60	0.94	34.75	
16:10	58	0.91	33.60	
16:20	61	0.96	35.43	
16:30	46	0.71	26.35	
16:40	62	0.98	36.13	
16:50	47	0.73	26.96	
17:00	62	0.98	36.14	
17:10	50	0.78	28.78	

Sunday July 26

Monitoring radon backgroung levels

17:20	57	0.90	33.10
17:30	50	0.78	28.82
17:40	66	1.05	38.54
17:50	54	0.85	31.18
18:00	37	0.57	20.99
18:10	57	0.90	33.19
18:20	51	0.80	29.43
18:30	54	0.85	31.28
18:40	52	0.81	30.05
18:50	50	0.78	28.86
19:00	61	0.96	35.52
19:10	48	0.75	27.59
19:20	56	0.88	32.51
19:30	58	0.91	33.67
19:40	45	0.70	25.80
19:50	63	1.00	36.77
20:00	58	0.91	33.62
20:10	50	0.78	28.82
20:20	48	0.75	27.66
20:30	60	0.95	34.93
20:40	75	1.19	43.92
20:50	59	0.93	34.14
21:00	61	0.96	35.46
21:10	63	0.99	36.66
21:20	59	0.93	34.22
21:30	58	0.91	33.65
21:40	49	0.76	28.21
21:50	50	0.78	28.88
22:00	46	0.72	26.45
22:10	56	0.88	32.53
22:20	44	0.68	25.20
22:30	46	0.72	26.50
22:40	43	0.67	24.67
22:50	46	0.72	26.50
23:00	56	0.88	32.53
23:10	43	0.67	24.60
23:20	56	0.88	32.55
23:30	50	0.78	28.83
23:40	51	0.80	29.48
23:50	53	0.83	30.68

Monday July 27

00:00	55	0.86	31.87
00:10	56	0.88	32.47
00:20	53	0.83	30.65
00:30	70	1.11	40.94
00:40	66	1.04	38.41
00:50	57	0.89	33.00
01:00	73	1.16	42.73
01:10	53	0.83	30.53
01:20	82	1.31	48.20

Monday July 27

01:30	78	1.24	45.58	Monitoring radon background levels.
01:40	65	1.02	37.75	
01:50	57	0.90	33.00	
02:00	52	0.81	30.03	
02:10	65	1.03	37.93	
02:20	59	0.93	34.21	
02:30	76	1.21	44.53	
02:40	60	0.94	34.74	
02:50	71	1.13	41.50	
03:00	63	0.99	36.59	
03:10	81	1.29	47.52	
03:20	65	1.02	37.73	
03:30	54	0.85	31.19	
03:40	60	0.95	34.89	
03:50	75	1.19	43.92	
04:00	64	1.01	37.16	
04:10	63	0.99	36.64	
04:20	50	0.78	28.78	
04:30	69	1.10	40.36	
04:40	57	0.89	32.97	
04:50	62	0.98	36.08	
05:00	72	1.14	42.09	
05:10	65	1.03	37.79	
05:20	67	1.06	39.05	
05:30	62	0.98	36.01	
05:40	68	1.08	39.67	
05:50	56	0.88	32.38	
06:00	53	0.83	30.65	
06:10	67	1.06	39.13	
06:20	57	0.89	32.99	
06:30	50	0.78	28.83	
06:40	59	0.93	34.31	
06:50	65	1.03	37.88	
07:00	49	0.76	28.17	
07:10	55	0.87	31.90	
07:20	50	0.78	28.84	
07:30	55	0.86	31.90	
07:40	57	0.90	33.07	
07:50	63	1.00	36.68	
08:00	74	1.18	43.29	
08:10	68	1.07	39.59	
08:20	76	1.21	44.47	
08:30	64	1.01	37.16	
08:40	64	1.01	37.24	
08:50	68	1.08	39.66	
09:00	54	0.85	31.17	
09:10	46	0.72	26.43	
09:20	46	0.72	26.48	
09:30	50	0.78	28.90	
09:40	46	0.72	26.45	
09:50	41	0.63	23.46	
10:00	45	0.70	25.91	

Monday July 27

10:10	45	0.70	25.88	Monitoring radon background levels.
10:20	47	0.73	27.09	
10:30	62	0.98	36.15	
10:40	42	0.65	23.95	
10:50	41	0.64	23.49	
11:00	31	0.47	17.45	
11:10	45	0.70	25.98	
11:20	29	0.44	16.34	
11:30	30	0.46	17.04	
11:40	38	0.59	21.99	
11:50	33	0.51	19.02	
12:00	35	0.55	20.24	
12:10	33	0.51	19.00	
12:20	57	0.91	33.49	
12:30	38	0.59	21.81	
12:40	41	0.64	23.72	
12:50	54	0.85	31.53	
13:00	47	0.74	27.18	
13:10	41	0.64	23.57	
13:20	41	0.64	23.59	
13:30	35	0.54	19.94	
13:40	44	0.69	25.41	
13:50	37	0.57	21.10	
14:00	50	0.79	29.00	
14:10	34	0.52	19.23	
14:20	38	0.59	21.75	
14:30	31	0.47	17.48	
14:40	32	0.49	18.13	
14:50	34	0.53	19.45	
15:00	38	0.59	21.96	
15:10	42	0.66	24.34	
15:20	43	0.67	24.91	
15:30	35	0.54	20.06	
15:40	41	0.64	23.72	
15:50	34	0.52	19.42	
16:00	27	0.41	15.21	
16:10	36	0.56	20.68	
16:20	31	0.48	17.70	
16:30	21	0.31	11.66	
16:40	26	0.40	14.86	
16:50	31	0.48	17.94	
17:00	26	0.40	14.98	
17:10	35	0.56	20.54	
17:20	33	0.52	19.35	
17:30	28	0.44	16.28	
17:40	30	0.47	17.47	
17:50	22	0.34	12.68	
18:00	42	0.67	24.87	
18:10	26	0.41	15.10	
18:20	33	0.52	19.37	
18:30	38	0.61	22.41	
18:40	32	0.50	18.66	

Monday July 27

18:50	43	0.68	25.28	Monitoring radon background levels.
19:00	25	0.38	14.25	
19:10	40	0.63	23.38	
19:20	40	0.63	23.34	
19:30	41	0.65	23.87	
19:40	28	0.43	15.96	
19:50	45	0.71	26.27	
20:00	46	0.73	26.84	
20:10	43	0.68	24.96	
20:20	44	0.69	25.55	
20:30	53	0.84	30.95	
20:40	53	0.84	30.86	
20:50	50	0.79	29.01	
21:00	55	0.87	32.02	
21:10	60	0.95	34.99	
21:20	58	0.91	33.72	
21:30	47	0.73	27.07	
21:40	50	0.78	28.94	
21:50	46	0.72	26.49	
22:00	49	0.77	28.33	
22:10	48	0.75	27.69	
22:20	57	0.90	33.14	
22:30	47	0.73	27.02	
22:40	72	1.15	42.20	
22:50	55	0.86	31.75	
23:00	48	0.75	27.64	
23:10	50	0.78	28.89	
23:20	63	1.00	36.73	
23:30	50	0.78	28.78	
23:40	35	0.54	19.81	
23:50	52	0.82	30.18	

Tuesday July 28

00:00	39	0.60	22.21
00:10	43	0.67	24.72
00:20	44	0.68	25.29
00:30	60	0.95	34.96
00:40	29	0.43	16.11
00:50	58	0.92	33.85
01:00	63	1.00	36.80
01:10	48	0.75	27.69
01:20	63	1.00	36.86
01:30	48	0.75	27.68
01:40	45	0.70	25.96
01:50	45	0.70	25.97
02:00	53	0.83	30.79
02:10	34	0.52	19.24
02:20	56	0.89	32.66
02:30	53	0.83	30.68
02:40	61	0.96	35.54
02:50	62	0.98	36.08

Tuesday July 28

03:00	57	0.90	33.04	Monitoring radon background levels.
03:10	60	0.95	34.89	
03:20	61	0.96	35.47	
03:30	59	0.93	34.25	
03:40	53	0.83	30.63	
03:50	60	0.95	34.90	
04:00	59	0.93	34.25	
04:10	64	1.01	37.27	
04:20	65	1.03	37.84	
04:30	73	1.16	42.67	
04:40	72	1.14	42.01	
04:50	58	0.91	33.56	
05:00	68	1.08	39.70	
05:10	69	1.09	40.23	
05:20	80	1.27	46.88	
05:30	57	0.89	32.90	
05:40	74	1.18	43.33	
05:50	51	0.79	29.31	
06:00	57	0.90	33.10	
06:10	62	0.98	36.08	
06:20	62	0.98	36.04	
06:30	63	0.99	36.65	
06:40	88	1.41	51.75	
06:50	64	1.01	37.08	
07:00	55	0.86	31.80	
07:10	70	1.11	40.93	
07:20	65	1.03	37.80	
07:30	61	0.96	35.42	
07:40	79	1.26	46.33	
07:50	79	1.26	46.20	
08:00	83	1.32	48.62	
08:10	72	1.14	41.95	
08:20	66	1.04	38.40	
08:30	70	1.11	40.85	
08:40	69	1.09	40.22	
08:50	75	1.19	43.86	
09:00	73	1.16	42.61	
09:10	55	0.86	31.74	
09:20	59	0.93	34.28	
09:30	52	0.81	30.02	
09:40	49	0.77	28.25	

Tuesday July 28

********** BEAKER 3 ***********

09:45 Collected two 40 ml samples of water from the system 2" above the sludge water interface for radon 222 in water analysis.

Results 27100 +/- 401 pCi/l

09:50	108	1.74	63.94
10:00	75416	1243.13	45585.57
10:10	242793	3988.15	146245.5
10:20	94242	1504.04	55153.27
10:30	59328	943.40	34594.66
10:40	52211	828.69	30388.26
10:50	49495	782.63	28699.08
11:00	46056	724.87	26581.3
11:10	42097	659.60	24187.84
11:20	38042	593.57	21766.47
11:30	33461	519.41	19046.91
11:40	31469	488.39	17909.37
11:50	27258	420.59	15423.31
12:00	22427	343.05	12579.99
12:10	19264	293.27	10754.39
12:20	17170	260.92	9568.25
12:30	15788	240.13	8805.58
12:40	14699	223.97	8213.11
12:50	12408	187.84	6888.34
13:00	10760	162.42	5955.96
13:10	9258	139.22	5105.35
13:20	8493	128.06	4695.98
13:30	7651	115.55	4237.27

09:56 Connected tubing to the beaker.
10:03 Began mixing at 60 rpm.

13:37 Collected two 40 ml samples of water from the system 2" above the sludge water interface for radon 222 in water analysis

Results 47600 +/- 528 pCi/l

13:39 Collected 250 ml of water for total suspended solids analysis.

13:40 Added 300 ml of pit water back to the system.

13:40	6789	102.90	3773.49
13:50	5695	85.94	3151.67
14:00	5057	76.39	2801.24
14:10	4718	71.60	2625.89
14:20	4277	65.01	2384.13
14:30	3819	58.07	2129.76
14:40	3661	56.02	2054.53
14:50	3829	59.23	2172.24
15:00	4471	70.13	2571.85

Tuesday July 28

15:10	3465	53.71	1969.58
15:20	2939	45.41	1665.4
15:30	2807	43.53	1596.40
15:40	2817	43.90	1610.03
15:50	2878	45.06	1652.53
16:00	3487	55.22	2025.10
16:10	3057	48.13	1764.99
16:20	2940	46.33	1699.19
16:30	2729	42.94	1574.72
16:40	2556	40.18	1473.47
16:50	2213	34.61	1269.20
17:00	2046	31.97	1172.52
17:10	1863	29.05	1065.29
17:20	1875	29.34	1076.11
17:30	1968	30.94	1134.68
17:40	1764	27.62	1012.92
17:50	1814	28.53	1046.24
18:00	1782	28.04	1028.36
18:10	1858	29.34	1075.94
18:20	1793	28.29	1037.47
18:30	1832	28.97	1062.55
18:40	1873	29.67	1088.00
18:50	1737	27.43	1006.11
19:00	1886	29.92	1097.48
19:10	1835	29.07	1066.27
19:20	1891	30.01	1100.63
19:30	2001	31.82	1167.04
19:40	2258	36.04	1321.71
19:50	1945	30.82	1130.53
20:00	2032	32.30	1184.54
20:10	2024	32.15	1178.99
20:20	1970	31.25	1146.11
20:30	2046	32.51	1192.17
20:40	2009	31.88	1169.19
20:50	2128	33.84	1241.07
21:00	2042	32.40	1188.15
21:10	2020	32.04	1175.08
21:20	2035	32.29	1184.22
21:30	2037	32.32	1185.25
21:40	2047	32.48	1191.23
21:50	2052	32.56	1194.16
22:00	2064	32.76	1201.37
22:10	2021	32.04	1175.18
22:20	2921	46.88	1719.38
22:30	2199	34.81	1276.81
22:40	2075	32.86	1204.99
22:50	2202	34.97	1282.42
23:00	2153	34.13	1251.87
23:10	2127	33.71	1236.27
23:20	2043	32.33	1185.65
23:30	2066	32.72	1200.15
23:40	2052	32.50	1191.82
23:50	2128	33.76	1238.01

Mixing at 60 rpm.

16:45 Turned off the mixer. Sampling tube was left connected for the night.

Wednesday July 29

No mixing, monitoring radon flux from the water surface.

00:00	2099	33.27	1220.14
00:10	2076	32.90	1206.48
00:20	2055	32.56	1194.11
00:30	2327	37.05	1358.78
00:40	2620	41.83	1534.14
00:50	2142	33.89	1242.80
01:00	2085	33.01	1210.65
01:10	2156	34.19	1253.99
01:20	2149	34.07	1249.36
01:30	2065	32.68	1198.65
01:40	2069	32.77	1201.71
01:50	2150	34.11	1250.91
02:00	2106	33.37	1223.95
02:10	2081	32.97	1209.21
02:20	2099	33.28	1220.45
02:30	2180	34.61	1269.44
02:40	2013	31.85	1168.08
02:50	2108	33.44	1226.52
03:00	2055	32.56	1194.08
03:10	2181	34.65	1270.69
03:20	2196	34.87	1278.98
03:30	2148	34.07	1249.69
03:40	2149	34.10	1250.47
03:50	2201	34.95	1281.85
04:00	2142	33.97	1245.79
04:10	2189	34.75	1274.47
04:20	2084	33.01	1210.64
04:30	2162	34.31	1258.35
04:40	2164	34.33	1259.15
04:50	2215	35.17	1289.94
05:00	2175	34.50	1265.42
05:10	2272	36.11	1324.21
05:20	2178	34.54	1266.62
05:30	2146	34.02	1247.69
05:40	2290	36.40	1334.85
05:50	2183	34.61	1269.22
06:00	2226	35.33	1295.74
06:10	2286	36.31	1331.66
06:20	2214	35.11	1287.67
06:30	2248	35.68	1308.56
06:40	2185	34.63	1270.23
06:50	2260	35.88	1315.85
07:00	2327	36.97	1355.84
07:10	2383	37.88	1389.11
07:20	2283	36.21	1328.06
07:30	2289	36.32	1332.04
07:40	2344	37.22	1365.18
07:50	2279	36.14	1325.43

END OF DATA OUTPUT

Wednesday July 29

SERIAL # A053
CURRENT TIME 8/03/92 13:28:34
START TIME 7/29/92 08:05:00
STOP TIME 8/03/92 11:15:00
SAMPLE INT 10 MINUTES
ALARM 0 PCI/L
EFFICIENCY RN222 0.895 RND 0.026
MEMORY 86%

NUMBER OF READINGS 739

Time t hr:min	Sample	Activity A pCi/L	Activity A Bq/m^3	Notes Recorded During The Experiment
08:05	2622	43.22	1584.94	No mixing, monitoring radon flux at the water surface.
08:15	2930	47.80	1753.16	
08:25	2610	42.33	1552.41	
08:35	2304	37.20	1364.24	
08:45	2313	37.28	1367.13	
08:55	2269	36.44	1336.60	
09:05	2256	36.14	1325.59	
09:15	2208	35.28	1293.87	
09:25	2278	36.38	1334.20	
09:35	1700	26.79	982.58	

********** BEAKER 4 **********

09:36 Collected two 40 ml samples of water from the system 2" above the sludge water interface for radon 222 in water analysis.

Results 33500 +/- 434 pCi/l

09:39 Collected 250 ml of water for total suspended solids analysis.

09:44 Pushed the shaft into Beaker 4. The sampling tube is 1.5' above the beaker.

0946 Connected the tubing to the beaker and attached the mixer.

09:45	197099	3247.87	119099.4	09:48 Began mixing at 60 rpm.
09:55	375353	6149.77	225512.1	
10:05	139847	2223.69	81543.05	
10:15	88654	1404.43	51500.66	
10:25	80260	1269.96	46569.49	
10:35	77962	1230.03	45105.26	
10:45	71802	1126.95	41325.48	
10:55	63558	991.61	36362.65	
11:05	57207	889.02	32600.48	
11:15	48791	752.90	27608.92	

Wednesday July 29

Still mixing beaker 4 at 60 rpm.

11:25	42642	655.04	24020.48
11:35	36004	549.16	20138.02
11:45	30073	455.24	16693.81
11:55	25180	378.45	13878.1
12:05	21444	320.61	11756.81
12:15	18201	270.64	9924.41
12:25	15540	230.05	8436.04
12:35	13010	191.36	7017.31
12:45	10943	160.09	5870.80
12:55	9650	141.32	5182.28
13:05	8363	122.30	4484.83
13:15	7504	110.50	4052.06
13:25	6577	97.56	3577.54
13:35	5816	86.56	3174.33
13:45	5293	79.19	2904.05
13:55	5326	80.79	2962.57
14:05	4902	74.61	2736.23
14:15	4483	68.46	2510.45
14:25	4497	69.33	2542.40
14:35	4525	70.26	2576.69
14:45	7595	121.24	4446.01
14:55	3695	56.67	2078.39
15:05	3348	51.74	1897.62
15:15	3061	47.31	1735.07
15:25	2906	45.00	1650.26
15:35	3227	50.50	1851.98
15:45	7136	115.04	4218.71
15:55	3925	61.50	2255.46
16:05	3394	53.24	1952.46
16:15	3162	49.58	1818.17
16:25	2939	46.00	1687.16
16:35	2978	46.75	1714.62
16:45	3001	47.20	1731.03
16:55	3017	47.53	1743.00
17:05	2838	44.63	1636.94
17:15	3014	47.62	1746.39
17:25	2803	44.16	1619.61
17:35	2807	44.30	1624.76
17:45	2949	46.68	1712.11
17:55	2826	44.67	1638.09
18:05	2806	44.38	1627.61
18:15	2855	45.22	1658.46
18:25	2755	43.58	1598.39
18:35	2849	45.16	1656.36
18:45	2804	44.42	1629.01
18:55	2814	44.60	1635.65
19:05	2693	42.61	1562.82
19:15	2674	42.34	1552.63
19:25	2790	44.26	1623.26
19:35	2827	44.86	1645.25
19:45	2672	42.30	1551.42
19:55	2735	43.37	1590.54

Wednesday July 29

20:05	2519	39.81	1459.88	Mixing and monitoring beaker 4.
20:15	2650	42.01	1540.69	
20:25	2469	39.02	1430.90	
20:35	2374	37.49	1374.93	
20:45	2344	37.03	1358.04	
20:55	2545	40.37	1480.50	
21:05	3673	58.94	2161.67	
21:15	3965	63.56	2330.76	
21:25	2653	41.82	1533.65	
21:35	2533	40.02	1467.55	
21:45	2403	37.90	1389.90	
21:55	2495	39.44	1446.58	
22:05	2631	41.69	1528.79	
22:15	2512	39.72	1456.54	
22:25	2435	38.48	1411.12	
22:35	2392	37.80	1386.21	
22:45	2426	38.39	1407.78	
22:55	2417	38.25	1402.75	
23:05	2450	38.81	1423.36	
23:15	2535	40.22	1475.04	
23:25	2498	39.60	1452.42	
23:35	2386	37.77	1385.12	
23:45	2404	38.09	1396.86	
23:55	2460	39.02	1430.86	

Thursday July 30

00:05	2543	40.38	1480.87
00:15	2533	40.20	1474.34
00:25	2551	40.50	1485.26
00:35	2613	41.52	1522.65
00:45	2465	39.06	1432.65
00:55	2479	39.31	1441.79
01:05	2473	39.21	1438.10
01:15	2469	39.15	1435.74
01:25	2393	37.90	1389.87
01:35	2435	38.61	1415.86
01:45	2625	41.74	1530.62
01:55	2539	40.28	1477.39
02:05	2955	47.15	1729.13
02:15	2663	42.26	1549.74
02:25	2775	44.13	1618.51
02:35	2937	46.78	1715.44
02:45	2790	44.31	1624.95
02:55	2656	42.10	1544.14
03:05	2641	41.87	1535.62
03:15	2718	43.14	1582.15
03:25	2596	41.11	1507.82
03:35	2646	41.96	1538.77
03:45	3855	61.88	2269.42
03:55	3616	57.72	2116.72
04:05	3091	49.05	1798.67

Thursday July 30

04:15	2894	45.85	1681.50	Mixing and monitoring beaker 4.
04:25	2958	46.92	1720.89	
04:35	3023	47.98	1759.47	
04:45	3123	49.61	1819.24	
04:55	3241	51.53	1889.67	
05:05	3257	51.76	1898.18	
05:15	3236	51.40	1884.85	
05:25	3321	52.79	1935.89	
05:35	3270	51.92	1904.17	
05:45	3235	51.34	1882.81	
05:55	3388	53.86	1975.18	
06:05	3739	59.61	2186.13	
06:15	3679	58.54	2146.93	
06:25	3702	58.90	2160.07	
06:35	3695	58.75	2154.71	
06:45	3869	61.60	2259.01	
06:55	4023	64.08	2350.05	
07:05	3948	62.79	2302.54	
07:15	4074	64.85	2378.09	
07:25	4247	67.65	2480.87	
07:35	4389	69.93	2564.39	
07:45	4512	71.89	2636.41	
07:55	5125	81.93	3004.67	
08:05	5174	82.58	3028.54	
08:15	5108	81.42	2985.71	
08:25	5118	81.53	2989.73	A weather front moved in tonight.
08:35	4943	78.58	2881.81	
08:45	5026	79.93	2931.17	
08:55	4973	79.00	2897.20	
09:05	5068	80.54	2953.72	
09:15	5139	81.67	2995.08	
09:25	5383	85.65	3141.14	
09:35	5510	87.68	3215.37	
09:45	4864	76.97	2822.78	
09:55	4588	72.51	2659.04	
10:05	4636	73.35	2690.06	
10:15	4650	73.59	2698.81	
10:25	4446	70.25	2576.13	
10:35	4671	74.01	2714.21	
10:45	4823	76.51	2805.72	
10:55	4887	77.55	2843.97	
11:05	4816	76.37	2800.82	
11:15	4538	71.81	2633.29	
11:25	4844	76.91	2820.38	
11:35	4810	76.31	2798.34	
11:45	4793	76.03	2788.22	
11:55	4794	76.05	2789.03	
12:05	4930	78.29	2871.24	
12:15	5014	79.65	2921.09	
12:25	4971	78.92	2894.27	
12:35	4921	78.09	2863.86	
12:45	4898	77.71	2849.96	

Thursday July 30

12:55	5122	81.41	2985.33
13:05	5449	86.75	3181.28

13:14 Increased the shaft to 300 rpm then back to 200 rpm. The sludge and water became well mixed.

13:15	369026	6079.97	222952.8
13:25	341394	5556.57	203759.5
13:35	291823	4724.74	173256.3
13:45	281422	4546.07	166704.5
13:55	276958	4460.40	1
14:05	276605	4442.68	162913.4
14:15	271864	4353.70	159650.3
14:25	259029	4133.84	1
14:35	244660	3892.07	142722.3
14:45	231565	3673.66	134713.4
14:55	215949	3415.38	1
15:05	201491	3178.27	116547.4
15:15	187966	2957.89	108465.8
15:25	173680	2726.03	99963.64
15:35	160275	2509.84	92035.98
15:45	146547	2289.02	83938.69
15:55	134414	2095.21	76831.54
16:05	122094	1898.55	69620.13
16:15	109700	1701.05	62377.57
16:25	103087	1599.11	58639.63
16:35	84625	1300.97	47706.89

16:37 Turned the mixer off.
16:38 Disconected tubing

Note: The tubing is disconnected and the monitor will remain on until the progeny decay down to background.

16:45	56965	853.96	31314.86
16:55	47290	705.37	25866.16
17:05	40464	601.06	22041.04
17:15	34766	514.57	18869.61
17:25	29318	431.71	15830.96
17:35	24459	358.13	13132.64
17:45	20035	291.18	10677.66
17:55	16469	237.83	8721.36
18:05	13293	190.30	6978.33
18:15	10927	155.59	5705.79
18:25	8941	126.59	4642.09
18:35	7381	104.12	3818.31
18:45	5961	83.52	3062.70
18:55	4811	66.99	2456.79
19:05	4129	57.83	2120.84
19:15	3347	46.66	1711.36
19:25	2815	39.39	1444.44
19:35	2396	33.71	1236.49
19:45	2088	29.67	1088.03
19:55	1787	25.56	937.35

Thursday July 30

20:05	1604	23.23	852.18
20:15	1379	20.05	735.37
20:25	1241	18.22	668.13
20:35	1112	16.44	603.15
20:45	1033	15.43	566.16
20:55	983	14.85	544.54
21:05	993	15.20	557.43
21:15	889	13.62	499.58
21:25	858	13.24	485.54
21:35	836	12.97	475.63
21:45	834	13.01	477.16
21:55	815	12.75	467.69
22:05	807	12.66	464.54
22:15	803	12.63	463.37
22:25	748	11.75	431.05
22:35	700	10.99	403.11
22:45	759	11.99	439.74
22:55	732	11.55	423.63
23:05	713	11.25	412.72
23:15	683	10.77	395.03
23:25	741	11.74	430.66
23:35	672	10.60	388.84
23:45	722	11.44	419.66
23:55	738	11.70	429.21

Friday July 31

00:05	670	10.58	388.16
00:15	650	10.26	376.55
00:25	649	10.25	376.22
00:35	708	11.23	412.12
00:45	657	10.39	381.09
00:55	680	10.78	395.40
01:05	655	10.37	380.32
01:15	651	10.31	378.10
01:25	614	9.70	355.91
01:35	630	9.97	365.95
01:45	674	10.70	392.55
01:55	636	10.07	369.37
02:05	628	9.94	364.75
02:15	588	9.29	340.71
02:25	593	9.38	344.07
02:35	576	9.10	333.93
02:45	618	9.80	359.59
02:55	576	9.11	334.08
03:05	537	8.47	310.81
03:15	587	9.31	341.44
03:25	529	8.35	306.27
03:35	560	8.87	325.50
03:45	518	8.18	300.10
03:55	562	8.91	327.04
04:05	548	8.68	318.46

Friday July 31

04:15	548	8.68	318.57
04:25	548	8.68	318.60
04:35	498	7.86	288.38
04:45	511	8.08	296.57
04:55	502	7.94	291.16
05:05	484	7.64	280.44
05:15	499	7.90	289.73
05:25	527	8.36	306.65
05:35	480	7.58	278.13
05:45	498	7.89	289.40
05:55	506	8.02	294.17
06:05	486	7.69	282.08
06:15	461	7.28	267.15
06:25	471	7.45	273.40
06:35	481	7.62	279.53
06:45	473	7.49	274.76
06:55	493	7.82	286.90
07:05	468	7.41	271.79
07:15	453	7.16	262.87
07:25	420	6.63	243.14
07:35	463	7.34	269.45
07:45	414	6.53	239.62
07:55	452	7.17	263.01
08:05	475	7.54	276.71
08:15	403	6.35	233.09
08:25	453	7.19	263.73
08:35	425	6.72	246.64
08:45	400	6.31	231.74
08:55	405	6.40	234.96
09:05	411	6.50	238.71
09:15	460	7.31	268.42
09:25	407	6.43	236.05
09:35	379	5.98	219.49
09:45	400	6.34	232.49
09:55	384	6.07	222.76
10:05	352	5.55	203.62
10:15	377	5.97	219.04
10:25	391	6.20	227.40
10:35	400	6.34	232.81
10:45	377	5.96	218.91
10:55	369	5.84	214.27
11:05	391	6.20	227.66
11:15	381	6.04	221.50
11:25	388	6.15	225.83
11:35	374	5.92	217.34
11:45	351	5.55	203.54
11:55	329	5.19	190.42
12:05	344	5.44	199.64
12:15	336	5.31	194.83
12:25	346	5.48	201.05
12:35	306	4.82	176.92
12:45	285	4.48	164.61

Friday July 31

12:55	327	5.18	190.24
13:05	346	5.49	201.64
13:15	286	4.50	165.30
13:25	319	5.06	185.73
13:35	337	5.35	196.42
13:45	306	4.84	177.59
13:55	271	4.27	156.67
14:05	324	5.15	188.96
14:15	315	4.99	183.29
14:25	286	4.52	165.82
14:35	253	3.98	146.08
14:45	330	5.25	192.84
14:55	300	4.75	174.30
15:05	291	4.60	169.04
15:15	296	4.69	172.11
15:25	310	4.92	180.52
15:35	301	4.77	174.96
15:45	288	4.55	167.14
15:55	281	4.44	162.98
16:05	290	4.59	168.45
16:15	274	4.33	158.82
16:25	258	4.06	149.23
16:35	238	3.74	137.36
16:45	246	3.88	142.43
16:55	257	4.06	149.12
17:05	295	4.69	172.10
17:15	249	3.93	144.11
17:25	244	3.85	141.35
17:35	268	4.25	155.96
17:45	253	4.00	146.78
17:55	223	3.51	128.79
18:05	244	3.86	141.73
18:15	241	3.81	139.81
18:25	220	3.46	127.18
18:35	243	3.85	141.25
18:45	239	3.78	138.83
18:55	257	4.08	149.74
19:05	211	3.32	121.83
19:15	237	3.75	137.87
19:25	237	3.75	137.81
19:35	214	3.37	123.89
19:45	238	3.77	138.55
19:55	210	3.31	121.57
20:05	231	3.66	134.43
20:15	228	3.61	132.58
20:25	205	3.23	118.66
20:35	237	3.76	138.13
20:45	222	3.51	128.94
20:55	219	3.46	127.18
21:05	208	3.28	120.52
21:15	224	3.55	130.35
21:25	210	3.32	121.85

Friday July 31

21:35	182	2.86	104.97
21:45	221	3.51	128.83
21:55	209	3.30	121.37
22:05	216	3.42	125.62
22:15	208	3.29	120.82
22:25	223	3.54	129.99
22:35	218	3.46	126.92
22:45	182	2.86	105.12
22:55	201	3.18	116.91
23:05	193	3.05	111.98
23:15	198	3.13	115.10
23:25	199	3.15	115.71
23:35	191	3.02	110.91
23:45	219	3.48	127.92
23:55	186	2.94	107.80

Saturday August 1

00:05	194	3.07	112.89
00:15	208	3.30	121.32
00:25	185	2.92	107.34
00:35	189	2.99	109.92
00:45	214	3.40	125.02
00:55	200	3.17	116.39
01:05	202	3.20	117.70
01:15	197	3.12	114.67
01:25	209	3.32	121.96
01:35	182	2.87	105.56
01:45	174	2.75	100.91
01:55	186	2.95	108.23
02:05	193	3.06	112.38
02:15	174	2.75	100.84
02:25	200	3.18	116.69
02:35	201	3.19	117.11
02:45	183	2.89	106.23
02:55	157	2.47	90.64
03:05	185	2.93	107.74
03:15	168	2.65	97.39
03:25	186	2.95	108.38
03:35	186	2.95	108.26
03:45	178	2.82	103.42
03:55	198	3.15	115.55
04:05	194	3.08	112.98
04:15	185	2.93	107.56
04:25	159	2.50	91.89
04:35	154	2.42	89.04
04:45	152	2.39	87.85
04:55	175	2.77	101.89
05:05	172	2.72	100.02
05:15	162	2.56	93.98
05:25	149	2.35	86.18
05:35	192	3.06	112.24

Saturday August 1

05:45	176	2.79	102.37
05:55	158	2.49	91.56
06:05	144	2.26	83.20
06:15	168	2.66	97.90
06:25	144	2.27	83.30
06:35	167	2.65	97.33
06:45	145	2.28	83.97
06:55	176	2.80	102.80
07:05	144	2.27	83.33
07:15	165	2.62	96.18
07:25	164	2.60	95.51
07:35	159	2.52	92.43
07:45	151	2.38	87.58
07:55	142	2.24	82.14
08:05	157	2.49	91.34
08:15	122	1.91	70.14
08:25	146	2.31	84.96
08:35	132	2.08	76.40
08:45	149	2.36	86.83
08:55	133	2.10	77.10
09:05	127	2.00	73.63
09:15	124	1.96	71.90
09:25	146	2.32	85.26
09:35	157	2.50	91.78
09:45	133	2.10	77.23
09:55	135	2.14	78.49
10:05	129	2.04	74.88
10:15	126	1.99	73.12
10:25	150	2.39	87.66
10:35	128	2.02	74.22
10:45	133	2.11	77.41
10:55	111	1.74	64.10
11:05	101	1.58	58.22
11:15	115	1.82	66.76
11:25	107	1.68	61.84
11:35	119	1.88	69.15
11:45	120	1.90	69.68
11:55	96	1.50	55.17
12:05	117	1.85	68.04
12:15	122	1.93	70.92
12:25	88	1.37	50.34
12:35	102	1.61	59.03
12:45	102	1.61	59.06
12:55	112	1.77	65.10
13:05	95	1.49	54.76
13:15	95	1.49	54.87
13:25	89	1.40	51.36
13:35	88	1.38	50.89
13:45	105	1.67	61.28
13:55	91	1.43	52.79
14:05	111	1.77	64.94
14:15	85	1.34	49.17

Saturday August 1

14:25	84	1.32	48.69
14:35	67	1.04	38.49
14:45	91	1.45	53.17
14:55	78	1.23	45.20
15:05	95	1.51	55.62
15:15	77	1.21	44.67
15:25	87	1.38	50.75
15:35	86	1.36	50.13
15:45	62	0.97	35.66
15:55	88	1.40	51.57
16:05	77	1.22	44.77
16:15	79	1.25	46.09
16:25	78	1.24	45.49
16:35	91	1.45	53.38
16:45	82	1.30	47.86
16:55	76	1.20	44.31
17:05	79	1.25	46.18
17:15	83	1.32	48.59
17:25	79	1.25	46.15
17:35	89	1.42	52.23
17:45	83	1.32	48.54
17:55	85	1.35	49.80
18:05	78	1.24	45.55
18:15	72	1.14	41.97
18:25	63	0.99	36.58
18:35	63	0.99	36.64
18:45	95	1.52	55.99
18:55	74	1.17	43.07
19:05	83	1.32	48.53
19:15	69	1.09	40.02
19:25	77	1.22	44.95
19:35	92	1.47	53.97
19:45	83	1.32	48.44
19:55	72	1.14	41.86
20:05	70	1.11	40.74
20:15	84	1.34	49.23
20:25	68	1.07	39.47
20:35	79	1.26	46.24
20:45	75	1.19	43.75
20:55	83	1.32	48.62
21:05	71	1.12	41.32
21:15	93	1.49	54.71
21:25	66	1.04	38.24
21:35	97	1.55	57.17
21:45	89	1.42	52.12
21:55	66	1.04	38.15
22:05	98	1.57	57.66
22:15	79	1.25	45.96
22:25	72	1.13	41.74
22:35	84	1.33	49.07
22:45	66	1.03	38.12
22:55	79	1.25	46.12

Saturday August 1

23:05	81	1.28	47.26
23:15	72	1.14	41.83
23:25	75	1.19	43.72
23:35	72	1.14	41.91
23:45	66	1.04	38.32
23:55	56	0.88	32.33

Sunday August 2

00:05	83	1.32	48.73
00:15	58	0.91	33.44
00:25	72	1.14	42.09
00:35	73	1.16	42.60
00:45	57	0.89	32.93
00:55	75	1.19	43.92
01:05	71	1.12	41.39
01:15	60	0.94	34.77
01:25	72	1.14	42.10
01:35	77	1.22	45.04
01:45	56	0.88	32.32
01:55	66	1.05	38.51
02:05	79	1.26	46.29
02:15	68	1.07	39.56
02:25	70	1.11	40.84
02:35	63	0.99	36.60
02:45	65	1.03	37.85
02:55	59	0.93	34.21
03:05	67	1.06	39.09
03:15	68	1.08	39.64
03:25	66	1.04	38.42
03:35	51	0.80	29.37
03:45	69	1.10	40.35
03:55	70	1.11	40.83
04:05	69	1.09	40.22
04:15	78	1.24	45.67
04:25	77	1.22	45.00
04:35	63	0.99	36.55
04:45	56	0.88	32.41
04:55	57	0.90	33.06
05:05	67	1.06	39.10
05:15	72	1.14	42.06
05:25	59	0.93	34.16
05:35	78	1.24	45.74
05:45	63	0.99	36.54
05:55	72	1.14	42.08
06:05	84	1.34	49.27
06:15	65	1.02	37.71
06:25	65	1.03	37.84
06:35	73	1.16	42.67
06:45	64	1.01	37.18
06:55	72	1.14	42.08
07:05	50	0.78	28.72

Sunday August 2

07:15	55	0.86	31.90
07:25	65	1.03	37.91
07:35	69	1.09	40.26
07:45	66	1.04	38.42
07:55	62	0.98	36.02
08:05	64	1.01	37.25
08:15	64	1.01	37.24
08:25	46	0.71	26.36
08:35	68	1.08	39.78
08:45	59	0.93	34.19
08:55	52	0.81	30.02
09:05	52	0.82	30.07
09:15	50	0.78	28.86
09:25	56	0.88	32.50
09:35	51	0.80	29.44
09:45	63	1.00	36.72
09:55	52	0.81	29.99
10:05	52	0.82	30.07
10:15	50	0.78	28.86
10:25	60	0.95	34.92
10:35	65	1.03	37.87
10:45	53	0.83	30.58
10:55	47	0.73	27.04
11:05	62	0.98	36.15
11:15	45	0.70	25.77
11:25	58	0.92	33.74
11:35	55	0.86	31.84
11:45	50	0.78	28.84
11:55	47	0.73	27.06
12:05	71	1.13	41.59
12:15	44	0.68	25.10
12:25	51	0.80	29.52
12:35	52	0.82	30.07
12:45	44	0.68	25.23
12:55	54	0.85	31.33
13:05	49	0.77	28.24
13:15	48	0.75	27.67
13:25	54	0.85	31.30
13:35	36	0.55	20.38
13:45	50	0.79	28.97
13:55	47	0.73	27.06
14:05	43	0.67	24.66
14:15	50	0.78	28.92
14:25	47	0.73	27.06
14:35	55	0.87	31.92
14:45	52	0.81	30.05
14:55	46	0.72	26.44
15:05	45	0.70	25.88
15:15	32	0.49	18.03
15:25	45	0.70	25.97
15:35	34	0.52	19.36
15:45	47	0.74	27.28

Sunday August 2

15:55	35	0.54	19.94
16:05	28	0.43	15.78
16:15	45	0.71	26.10
16:25	42	0.66	24.28
16:35	47	0.74	27.30
16:45	56	0.89	32.69
16:55	35	0.54	19.92
17:05	45	0.71	26.09
17:15	44	0.69	25.40
17:25	50	0.79	29.01
17:35	42	0.65	24.12
17:45	42	0.65	24.16
17:55	47	0.74	27.17
18:05	48	0.75	27.73
18:15	43	0.67	24.69
18:25	47	0.74	27.14
18:35	41	0.64	23.47
18:45	41	0.64	23.51
18:55	43	0.67	24.71
19:05	56	0.88	32.56
19:15	41	0.63	23.40
19:25	40	0.62	22.90
19:35	48	0.75	27.73
19:45	52	0.82	30.09
19:55	49	0.77	28.25
20:05	54	0.85	31.30
20:15	36	0.55	20.38
20:25	48	0.75	27.76
20:35	43	0.67	24.65
20:45	42	0.65	24.08
20:55	51	0.80	29.53
21:05	55	0.86	31.89
21:15	52	0.81	30.05
21:25	44	0.68	25.23
21:35	49	0.77	28.31
21:45	57	0.90	33.11
21:55	55	0.86	31.85
22:05	48	0.75	27.63
22:15	51	0.80	29.49
22:25	46	0.72	26.45
22:35	40	0.62	22.86
22:45	45	0.70	25.92
22:55	46	0.72	26.49
23:05	50	0.78	28.90
23:15	58	0.91	33.71
23:25	50	0.78	28.82
23:35	50	0.78	28.87
23:45	51	0.80	29.48
23:55	66	1.05	38.54

Monday August 3

00:05	69	1.09	40.25
00:15	66	1.04	38.42
00:25	84	1.34	49.32
00:35	54	0.84	31.06
00:45	74	1.18	43.36
00:55	57	0.89	32.94
01:05	63	1.00	36.68
01:15	60	0.94	34.83
01:25	60	0.95	34.85
01:35	53	0.83	30.62
01:45	69	1.10	40.34
01:55	78	1.24	45.67
02:05	41	0.63	23.24
02:15	50	0.78	28.94
02:25	79	1.26	46.40
02:35	67	1.06	38.95
02:45	73	1.16	42.66
02:55	89	1.42	52.29
03:05	63	0.99	36.47
03:15	80	1.27	46.92
03:25	61	0.96	35.32
03:35	67	1.06	39.08
03:45	81	1.29	47.50
03:55	74	1.17	43.17
04:05	65	1.03	37.78
04:15	64	1.01	37.23
04:25	72	1.14	42.08
04:35	86	1.37	50.48
04:45	73	1.15	42.53
04:55	96	1.54	56.52
05:05	70	1.10	40.65
05:15	66	1.04	38.28
05:25	68	1.07	39.53
05:35	86	1.37	50.40
05:45	81	1.28	47.26
05:55	50	0.77	28.57
06:05	70	1.11	40.88
06:15	65	1.02	37.73
06:25	62	0.98	35.96
06:35	81	1.29	47.48
06:45	68	1.07	39.50
06:55	65	1.03	37.79
07:05	54	0.84	31.16
07:15	88	1.41	51.79
07:25	71	1.12	41.29
07:35	73	1.16	42.62
07:45	71	1.12	41.40
07:55	73	1.16	42.62
08:05	65	1.03	37.78
08:15	73	1.16	42.67
08:25	57	0.89	32.95
08:35	67	1.06	39.10

Monday August 3

08:45	62	0.98	36.01
08:55	66	1.04	38.46
09:05	63	0.99	36.62
09:15	57	0.90	33.02
09:25	62	0.98	36.08
09:35	65	1.03	37.86
09:45	61	0.96	35.42
09:55	68	1.08	39.68
10:05	59	0.93	34.19
10:15	51	0.80	29.42
10:25	58	0.91	33.70
10:35	58	0.91	33.65
10:45	53	0.83	30.63
10:55	59	0.93	34.29
11:05	39	0.60	22.16

END OF DATA OUTPUT

Radon Emanation Tests Data Sheet

Description: Beaker 1, Sludge Only   Sheet: 1/1

Recorders Name: Glen Schmidt   Date: 07.21.92

Time (hr:mm)	Shaft (rpm)	Torque (in-oz)	Room Temperature (°F)	Sludge Temperature (°F)	Barometric Pressure	Relative Humidity
10:30	0	0	71	71		
10:38	60	13	71	71		
10:39	150	18	71	-----		
10:40	150	14	71	-----		
10:41	150	13	70	-----		
10:42	250	17	70	-----		
10:44	400	26	69	-----		
10:55	450	28	69	-----		
11:04	450	29	69	-----		
11:20	400	26	69	-----		
14:00	400	26	68	-----		
14:34	400	24	68	78		
16:15	400	23	68	78.5		
16:21	400	23	71	-----		
16:22	0	0	71	-----		
DAY 2	=============	===========	=============	===========	===========	===========
09:19	400	24	69	-----		
10:01	400	23	69	71		
10:07	0	0	69	-----		

----- (Data was not recorded)

Radon Emanation Tests Data Sheet

Description: Beaker 2, Sludge Only Sheet: 1/1

Recorders Name: Glen Schmidt Date: 07.22.92

Time (hr:mm)	Shaft (rpm)	Torque (in-oz)	Room Temperature (°F)	Sludge Temperature (°F)	Barometric Pressure	Relative Humidity
11:02	0	0	69	69		
11:03	400	30	69	-----		
11:05	400	27	69	-----		
11:10	400	27	70	-----		
11:17	400	26	70	70		
16:10	400	22	73	-----		
16:21	0	0	-----	-----		

----- (Data not recorded)

Radon Emanation Tests Data Sheet

Description: Beaker 3, Sludge and Water   Sheet: 1/1

Recorders Name: Glen Schmidt   Date: 07.28.92

Time (hr:mm)	Shaft (rpm)	Torque (in-oz)	Room Temperature (°F)	Sludge Temperature (°F)	Barometric Pressure	Relative Humidity
10:01	0	0	76	76		
10:03	60	49	76	-----		
10:06	60	14	-----	-----		
10:09	60	10	-----	-----		
10:19	60	9	-----	-----		
10:24	60	8	-----	-----		
10:26	60	7	-----	-----		
13:37	60	4	72	-----		
14:00	60	4	71	71		
16:44	60	-----	-----	-----		
16:45	0	0	-----	-----		

---- (Data was not recorded)

Radon Emanation Tests Data Sheet

Description: Beaker 4, Sludge and Water   Sheet: 1/1

Recorders Name: Glen Schmidt   Date: 07.29.92

Time (hr:mm)	Shaft (rpm)	Torque (in-oz)	Room Temperature (°F)	Sludge Temperature (°F)	Barometric Pressure	Relative Humidity
09:48	60	16	75	75		
09:49	60	12	75	75		
09:54	60	12	-----	----		
09:57	60	11	-----	----		
10:00	60	10	-----	----		
10:05	60	9	-----	----		
10:07	60	9	71	----		
10:12	60	9	69	----		
10:30	60	8	72	----		
10:45	60	7	74	74		
14:30	60	6	75	75		
15:00	60	5	75	75		
Left mixer	running all	night at	60 rpm.			
July, 30 13:12	60	5	80	----		
13:14	300	15	80	----		
13:15	250	12	80	----		
13:16	200	9	80	----		
13:16	150	7	80	----		
13:18	200	9	80	----		
16:36	200	9	80	----		
16:37	0	0	80	----		

---- (data was not recorded)

MK-ENVIRONMENTAL SERVICES
A DIVISION OF MK-FERGUSON

Project Radon Emanation Test Contract No. ______ Sheet ______ File No. ______
Feature Pit 2 % moisture Designed GCS Date 8-13-92
Item ______ Checked ______ Date ______

	Dish/Beaker wet Sludge (g)	Beaker Tare (g)	wet Sludge (g)	Dish/Beaker dry Sludge (g)
A	331.8	174.4	157.4	217.7
B	348.2	174.2	174.0	221.8

A calculations

331.8 − 217.7 = 114.1 g H_2O

$$\frac{114.1 \text{ g } H_2O}{157.4 \text{ g wet sludge}} = \boxed{72.5\% \ H_2O/\text{total wt.}}$$

B calculations

348.2 − 221.8 = 126.4 g H_2O

$$\frac{126.4 \text{ g } H_2O}{174.0 \text{ g wet sludge}} = \boxed{72.6\% \ H_2O/\text{total wt}}$$

LABORATORY TESTS RESULTS

07/31/92

ATTN: ELLIS HENRY

JOB NUMBER: 921468 CUSTOMER: MK-FERGUSON COMPANY*

CLIENT I.D..........: REQUEST 144/P.O.3589-0002-5823
DATE SAMPLED........: 07/28/92
TIME SAMPLED........: :
WORK DESCRIPTION....: EW-3201-072892

LABORATORY I.D...: 921468-0001
DATE RECEIVED....: 07/29/92
TIME RECEIVED....: 11:00
REMARKS..........: WATER

TEST DESCRIPTION	FINAL RESULT	DETECTION LIMIT	UNITS OF MEASURE	TEST METHOD	DATE	TECHNICIAN
Radon 222	27100		pCi/L		07/29/92	DF
Radon 222 error, +/-	401		pCi/L		07/31/92	DF
Radon 222 LLD	141		pCi/L		07/31/92	DF

420 West First Street
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(307) 235-5741

LABORATORY TESTS RESULTS
07/31/92

JOB NUMBER: 921463 CUSTOMER: MK-FERGUSON COMPANY ATTN: ELLIS HENRY

CLIENT I.D..........: REQUEST 144/P.O.3539-0002-5885
DATE SAMPLED........: 07/28/92
TIME SAMPLED........:
WORK DESCRIPTION....: GW-3202-072892

LABORATORY I.D....: 921463-0002
DATE RECEIVED.....: 07/29/92
TIME RECEIVED.....: 11:00
REMARKS...........: WATER

TEST DESCRIPTION	FINAL RESULT	DETECTION LIMIT	UNITS OF MEASURE	TEST METHOD	DATE	TECHNICIAN
Radon 222	47600		pCi/l		07/29/92	DF
Radon 222 error, +/-	528		pCi/l		07/31/92	DF
Radon 222 LLD	142		pCi/l		07/31/92	DF

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QUALITY ASSURANCE REPORT

07/31/92

ATTN: ELLIS HENRY

JOB NUMBER: 921468 CUSTOMER: MK-FERGUSON COMPANY

ANALYSIS				DUPLICATES		REFERENCE STANDARDS		MATRIX SPIKES		
ANALYSIS TYPE	ANALYSIS SUB-TYPE	ANALYSIS I.D.	ANALYZED VALUE (A)	DUPLICATE VALUE (B)	RPD or (|A-B|)	TRUE VALUE	PERCENT RECOVERY	ORIGINAL VALUE	SPIKE ADDED	PERCENT RECOVERY
PARAMETER:Radon 222 REPORTING LIMIT/DF:		UNITS:pCi/l		DATE/TIME ANALYZED:07/29/92 09:22 METHOD REFERENCE :					QC BATCH NUMBER:124519 TECHNICIAN:DF	
DUPLICATE	PREP	921468-1	27100	26100	4					
DUPLICATE	PREP	921468-2	47600	49500	4					

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LABORATORY TESTS RESULTS
07/31/92

JOB NUMBER: 921469 CUSTOMER: MK-FERGUSON COMPANY* ATTN: ELLIS HENRY

CLIENT I.D.........: REQUEST 145/P.O.3569-0002-5883
DATE SAMPLED.......: 07/29/92
TIME SAMPLED.......: :
WORK DESCRIPTION...: SW-3204-072992

LABORATORY I.D...: 921469-0001
DATE RECEIVED....: 07/30/92
TIME RECEIVED....: 11:00
REMARKS..........: WATER

TEST DESCRIPTION	FINAL RESULT	DETECTION LIMIT	UNITS OF MEASURE	TEST METHOD	DATE	TECHNICIAN
Radon 222	33500		pCi/l		07/30/92	DF
Radon 222 error, +/-	434		pCi/l		07/31/92	
Radon 222 LLD	140		pCi/l		07/31/92	DF

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LABORATORY TESTS RESULTS
07/31/92

JOB NUMBER: 921469 CUSTOMER: MK-FERGUSON COMPANY* ATTN: ELLIS HENRY

CLIENT I.D.........: REQUEST 145/P.O.3589-0002-5553
DATE SAMPLED.......: 07/29/92
TIME SAMPLED.......: :
WORK DESCRIPTION...: SW-3205-072992

LABORATORY I.D...: 921469-0002
DATE RECEIVED....: 07/30/92
TIME RECEIVED....: 11:00
REMARKS..........: WATER

TEST DESCRIPTION	FINAL RESULT	DETECTION LIMIT	UNITS OF MEASURE	TEST METHOD	DATE	TECHNICIAN
Radon 222	55900		pCi/l		07/30/92	DF
Radon 222 error, +/-	559		pCi/l		07/31/92	
Radon 222 LLD	141		pCi/l		07/31/92	DF

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QUALITY ASSURANCE REPORT
07/31/92

JOB NUMBER: 921469 CUSTOMER: NK-FERGUSON COMPANY ATTN: ELLIS HENRY

ANALYSIS				DUPLICATES		REFERENCE STANDARDS		MATRIX SPIKES		
ANALYSIS TYPE	ANALYSIS SUB-TYPE	ANALYSIS I.D.	ANALYZED VALUE (A)	DUPLICATE VALUE (B)	RPD or (|A-B|)	TRUE VALUE	PERCENT RECOVERY	ORIGINAL VALUE	SPIKE ADDED	PERCENT RECOVERY
PARAMETER:Radon 222				DATE/TIME ANALYZED:07/30/92 15:09				QC BATCH NUMBER:124378		
REPORTING LIMIT/DF:		UNITS:pCi/l		METHOD REFERENCE :				TECHNICIAN:DF		
DUPLICATE	PREP	921469-1	33500	34600	3					
DUPLICATE	PREP	921469-2	55900	53900	4					

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Western Atlas International

QUALITY ASSURANCE FOOTER

07/31/92

NC = Not Calculable due to values lower than the detection limit
ND = Not detected at level in limits column

(1) EPA 600/4-79-020, Methods for Chemical Analysis of Water and Wastes, March 1983
(2) EPA SW-846, Test Methods for Evaluating Solid Waste, Third Edition, November 1986
(3) Standards Methods for the Examination of Water and Wastewater, 16th, 1985
(4) EPA/6004-80-032, Prescribed Procedures for Measurement of Radioactivity in Drinking Water, August 1980
(5) Federal Register, Friday, October 26, 1984 (40 CFR Part 136)
(6) EPA 600/8-78-017, Microbiological Methods for Monitoring the Environment, December 1978

NOTE - Data reported in QA report may differ from values on data page due to dilution of sample into analytical ranges.

420 West First Street
Casper, WY 82601
(307) 235-5741

MK-FERGUSON

INTER-OFFICE CORRESPONDENCE

DATE: September 9, 1992

TO: D. Hixson

FROM: T. Uhlmeyer

SUBJECT: LAND DISPOSAL RESTRICTION TABLE

Attached is an updated copy of the Land Disposal Restriction (LDR) table. The table has been updated from the August 4, 1992, revision to add the following WITS numbers and applicable LDR information: 0394, 0395, 0397, 0402, 0405, 0411, 0426, and 2012. The table also adds the waste code D001 to #0398 and D018 to #0309.

Attachment

cc: M. Gilbert
L. Phillips
R. Ferguson
[redacted]

TRU/lac

c:\doc\tru\ldrtable.rev

Form 232-A 30M 8-87

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

WITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
0255	Nitric Acid Liquid pH < 2	D002 D001	1/23/89	CA List 3rd 3rd	CA List: pH > 2 D001 (Oxidizer): Deactivation	CA List- Neutralization D001- Oxidizer: Chemical reduction, incineration	1. CA List Waste therefore subject to EPA Mixed Waste Policy until 12/93 (9/29/91 FR)
0256	Different Acids pH < 2 Liquid	D002	1/23/89	CA List 3rd 3rd	CA List: pH > 2	CA List- Neutralization	1. See #255 Comment 1
0257	Unknown Yellow Liquid	D008	1/19/89	3rd 3rd	D008: Lead = 5 mg/l	D008- WW: Chemical ppt., sludge dewatering NonWW: Stabilization	1. 3rd 3rd Mixed Waste placed into storage prior to 5/8/92, therefore, not subject to LDR storage prohibition 2. Lead = 25.7 mg/l
0258	Unknown Yellow Liquid	D008 D011	1/19/89	3rd 3rd	D008: Lead = 5 mg/l D011: Silver = 5 mg/l	D008 & D011- WW: Chemical precipitation NonWW: Stabilization	1. See #257 Comment 1 2. Lead = 28.5 mg/l
0266	Unknown Liquid pH < 2	D002	12/4/89	CA List 3rd 3rd	CA List: pH > 2	CA List- Neutralization	1. See #255 Comment 1
0288-0296	Barium Flouride	D005	12/14/88	3rd 3rd	D005: Barium = 100 mg/l	D005-	1. See #257 Comment 1

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

WITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
	Powder Solid					NonWW: Stabilization	
0295-0305	Betz Sodium Chromate Salts Solid	D007	12/15/88	3rd 3rd	D007: Chromium = 5 mg/l	D007- NonWW: Chromium reduction, stabilization	1. See #257 Comment 1
0308	Mixed Caustics, Potassium Hydroxide Liquid	D002	12/20/88	3rd 3rd	D002: Deactivation	D002- Neutralization, Incineration	1. See #257 Comment 1
0309	Chlorinated Hydrocarbons, Liquid	D001 D018 D022 D028 D035 D040	12/20/88	3rd 3rd	D001 (High TOC NonWW): Incineration, fuel substitution (F.S.), or recovery D018: N/A D022: N/A D028: N/A D035: N/A D040: N/A	D001- Same as T.S.	1. No Treatment Standards Promulgated For New TC Wastes at this Time. 2. See #257 Comment 1
0316	Barium Flouride Solid	D005	1/24/89	3rd 3rd	D005: Barium = 100 mg/l	D005- NonWW: Stabilization	1. See #257 Comment 1
0321	2,4-D	D016	2/21/89	N/A	N/A	N/A	1. See #309 Comment 1

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

WITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
	Powder Solid					NonWW: Stabilization	
0295-0305	Metz Sodium Chromate Salts Solid	D007	12/15/88	3rd 3rd	D007: Chromium = 5 mg/L	D007- NonWW: Chromium reduction, stabilization	1. See #257 Comment 1
0308	Mixed Caustics, Potassium Hydroxide Liquid	D002	12/20/88	3rd 3rd	D002: Deactivation	D002- Neutralization, Incineration	1. See #257 Comment 1
0309	Chlorinated Hydrocarbons, Liquid	D001 D018 D022 D028 D035 D040	12/20/88	3rd 3rd	D001 (High TOC NonWW): Incineration, fuel substitution (F.S.), or recovery D018: N/A D022: N/A D028: N/A D035: N/A D040: N/A	D001- Same as T.S.	1. No Treatment Standards Promulgated For New TC Wastes at this Time. 2. See #257 Comment 1
0316	Barium Flouride Solid	D005	1/24/89	3rd 3rd	D005: Barium = 100 mg/L	D005- NonWW: Stabilization	1. See #257 Comment 1
0321	2,4-D	D016	2/21/89	N/A	N/A	N/A	1. See #309 Comment 1

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

NITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
	Solid						
0323	Ammonia and Caustic Liquids	D002	1/23/89	3rd 3rd	D002: Deactivation	D002- Neutralization, Incineration	1. See #257 Comment 1
0324-0359	Liquid Heat, Barium Chloride Liquid	D005	12/13/88	3rd 3rd	D005: Barium = 100 mg/l	D005- NonWW: Stabilization	1. See #257 Comment 1
0364	Magnesium Nitrate Solid	D001	12/13/88	3rd 3rd	D001 (Oxidizer): Deactivation	D001- Oxidizer: chemical reduction, incineration	1. See #257 Comment 1
0380-0393	Magnesium Shavings Solid	D003	12/14/88	3rd 3rd	D003: Deactivation	D003- Water Reactives: Incineration, Controlled Reaction w/ water, chemical/ electrolytic oxidation, chemical reduction	1. See #257 Comment 1
0394-0395 0397	Oil, Liquid	D001	12/21/88	3rd 3rd	D001 (High TOC NonWW): Incineration, F.S.,	D001- Same as T.S.	1. See #257 Comment 1

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

WITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
					or recovery		
0398	Oil, Liquid	D001 D008	12/21/88	3rd 3rd	D001 (High TOC NonWW): Incineration, F.S., or recovery D008: Lead = 5 mg/l	D001- Same as T.S. D008- NonWW: Stabilization	1. See #257 Comment 1
0400	Oil, Liquid	D005	12/20/88	3rd 3rd	D005: Barium = 100 mg/l	D005- NonWW: Stabilization	1. See #257 Comment 1
0401	Oil, Liquid	D018	12/13/88	N/A	N/A	N/A	1. See #309 Comment 1
0402 0405	Oil, Liquid	D001	12/20/88 1/19/89	3rd 3rd	D001 (High TOC NonWW): Incineration, F.S., or recovery	D001- Same as T.S.	1. See #257 Comment 1
0407	Oil, Liquid	D008	12/19/88	3rd 3rd	D008: Lead = 5 mg/l	D008- NonWW: Stabilization	1. Lead = 181 mg/l 2. See #257 Comment 1
0411	Oil, Liquid	D001	1/19/89	3rd 3rd	D001 (High TOC NonWW): Incineration, F.S., or recovery	D001- Same as T.S.	1. See #257 Comment 1

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

WITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
0415	Paint Sludge Liquid PCBs	D001	1/25/89	CA List 3rd 3rd	CA List (PCBs): Incineration in accordance with 40 CFR 761.70 D001 (High TOC NonWW): Incineration, F.S., or recovery	CA List- PCBs: Incineration D001- Same as T.S.	1. See #255 Comment 1 2. PCBs = 4400 ppm
0418	Oil, Liquid	D018	12/19/88	N/A	N/A	N/A	1. See #309 Comment 1
0419	Oil, Liquid	D018	12/19/88	N/A	N/A	N/A	1. See #309 Comment 1
0420	Oil and Gas Liquid	D001 D008	12/20/88	3rd 3rd	D008: Lead = 5 mg/l D001 (High TOC NonWW): Incineration, F.S., or recovery	D001- Same as T.S. D008- NonWW: Stabilization,	1. See #257 Comment 1 2. Lead = 15.3 mg/l

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

WITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
0426 0427	Oil, Liquid	D001	12/21/88 12/16/88	3rd 3rd	D001 (High TOC NonWW): Incineration, F.S., or recovery	D001- Same as T.S.	1. See #257 Comment 1
0428	Waste Paint Liquid PCBs	D001 D007 D008 D018	1/20/89	CA List 3rd 3rd	CA List (PCBs): Incineration D001 (High TOC NonWW): Incineration, F.S., or recovery D007: Chromium = 5 mg/l D008: Lead = 5 mg/l D018: N/A	CA List- PCBs: Incineration D001- Same as T.S. D007- NonWW: Chromium reduction stabilization D008- NonWW: Stabilization	1. See #255 Comment 1 2. PCBs = 5100 ppm
0429	Paint Sludge No Free Liquids	D018	12/19/88	N/A	N/A	N/A	1. See #309 Comment 1
0430	Paint Sludge	D001 D009	12/19/88	3rd 3rd	D001 (High TOC NonWW): Incineration, F.S., or recovery D009: Mercury = .2 mg/l	D001- Same as T.S. D009- NonWW: Acid Leaching, chemical oxidation, dewatering WW: Chemical precipitation with sulfide	1. See #257 Comment 1

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

WITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
0432	Paint Solids with Residual Solvent, PCBs	D001 D035	12/19/88	3rd 3rd	D001 (High TOC NonWW): Incineration, F.S., or recovery D035: N/A	D001- Same as T.S.	1. See #257 Comment 1 2. PCBs = 12,000 ppm 3. MEK = 200 mg/l
0433	Paint Sludge (Paint, solvent, oil, some paint solids) PCBs	D001 D008 D018	2/21/89	CA List 3rd 3rd	CA List (PCBs): Incineration D001 (High TOC NonWW): Incineration, F.S., or recovery D008: Lead = 5 mg/l D018: N/A	CA List- PCBs: Incineration D001- Same as T.S. D008- NonWW: Stabilization	1. See #255 Comment 1 2. PCBs = 1300 ppm 3. Lead = 5.85 mg/l
0435	Paint Sludge PCBs	D001	2/21/89	CA List 3rd 3rd	CA List (PCBs): Incineration D001: Deactivation	CA List- PCBs: Incineration D001- Same as T.S.	1. See #255 Comment 1 2. PCBs = 160 ppm
0436	Paint Liquids and Solids	D001	12/19/88	3rd 3rd	D001 (High TOC NonWW): Incineration, F.S., or recovery	D001- Same as T.S.	1. See #257 Comment 1

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

WITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
0438	Paint solids and solvents	D001	12/19/88	3rd 3rd	D001 (High TOC NonWW): Incineration, F.S., or recovery	D001- Same as T.S.	1. See #257 Comment 1
0456-0457	Potassium Permangenate Solid Oxidizer	D001	12/15/88	3rd 3rd	D001 (Oxidizer): Deactivation	D001- Ignitable Oxidizer: chemical reduction, incineration	1. See #257 Comment 1
0491	Sodium Flouride Solid	D008	1/20/89	3rd 3rd	D008: Lead = 5 mg/l	D008- NonWW: Stabilization	1. See #257 Comment 1
0496	Sodium Nitrate Solid Oxidizer	D001	1/25/89	3rd 3rd	D001 (Oxidizer): Deactivation	D001- Ignitable Oxidizer: chemical reduction, incineration	1. See #257 Comment 1
0498	Calcium, Sodium Sulfite Solid	D003	1/24/89	3rd 3rd	D003: Deactivation	D003- Water Reactive: incineration, controlled reaction w/ water, chemical/electrolytic oxidation, chemical reduction	1. See #257 Comment 1

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

UITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
0501-0503 0506-0507 0509	Solvent	D001	12/20/88	3rd 3rd	D001 (High TOC NonWW): Incineration, F.S., or recovery	D001- Same as T.S.	1. See #257 Comment 1 2. The analysis for some of these drums may be repeated for TC
0504	Solvent	D001 D008 D028 D035 D039 D040	12/20/88	3rd 3rd	D001 (High TOC NonWW): Incineration, F.S., or recovery D008: Lead = 5 mg/l D028: N/A D035: N/A D039: N/A D040: N/A	D001- Same as T.S. D008- NonWW: Stabilization	1. See #257 Comment 1 2. See #309 Comment 1
0505	Solvent	D001 D008	12/20/88	3rd 3rd	D001 (High TOC NonWW): Incineration, F.S., or recovery D008: Lead = 5 mg/l	D001- Same as T.S. D008- NonWW: Stabilization	1. See #257 Comment 1 2. Lead = 2470 mg/l
0508	Paints and Related Liquids Solid?	D007 D009	12/19/89	3rd 3rd	D007: Chromium = 5 mg/l D009: Mercury = .2 mg/l	D007- NonWW: Chromium reduction, stabilization D009- NonWW: Acid leaching, chemical oxidation,	1. See #257 Comment 1

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

WITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
						dewatering	
0510	Solvent, Paint, Oil Liquid PCBs	D001 D008	12/20/88	CA List 3rd 3rd	CA List (PCBs): Incineration D001 (High TOC NonWW): Incineration, F.S., or recovery D008: Lead = 5 mg/l	CA List- PCBs: Incineration D001- Same as T.S. D008- Stabilization	1. See #255 Comment 1 2. PCBs = 62 ppm
0518	MIBK (Solvent) Liquid	D001	12/19/88	3rd 3rd	D001 (High TOC NonWW): Incineration, F.S., or recovery	D001- Same as T.S.	1. See #257 Comment 1
0519	Solvent, Oil Liquid	D001	12/19/88	3rd 3rd	D001 (High TOC NonWW): Incineration, F.S., or recovery	D001- Same as T.S.	1. See #257 Comment 1
0581	Tar, Solid	D007	2/21/89	3rd 3rd	D007: Chromium = 5 mg/l	D007-	1. See #257 Comment 1

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

WITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
						NonWW: Chromium reduction stabilization	2. Chromium = 6.9 mg/l
0592-	Betz Sodium Chromate Salts (Floor Debris) Solid	D007	2/21/89	3rd 3rd	D007: Chromium = 5 mg/l	D007- NonWW: Chromium reduction, stabilization	1. See #257 Comment 1
0627	Water Liquid	D008 D011	1/19/89	3rd 3rd	D008: Lead = 5 mg/l D011: Silver = 5 mg/l	D008- WW: Chemical ppt., sludge dewatering NonWW: Stabilization D011- WW: Chemical precipitation NonWW: Stabilization or recovery	1. See #257 Comment 1 2. Lead = 29.9 mg/l 3. Silver = 8.8 mg/l
0628	Water Liquid	D008	1/19/89	3rd 3rd	D008: Lead = 5 mg/l	D008- WW: Chemical ppt., sludge dewatering	1. See #257 Comment 1 2. Lead = 9.2 mg/l
0645	Barium Chloride, Liquid Heat Solid	D005	12/4/89	3rd 3rd	D005: Barium = 100 mg/l	D005- NonWW: Stabilization	1. See #257 Comment 1
0647	Ethylene Glycol Liquid	D039	12/7/88	N/A	N/A	N/A	1. See #309 Comment 1

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

UITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
0649-0650 0652	Ethylene Glycol Liquid	D039	12/7/88	N/A	N/A	N/A	1. See #309 Comment 1
0654-0659	Ethylene Glycol Liquid	D039	12/8/88 12/15/88	N/A	N/A	N/A	1. See #309 Comment 1
0662-0663 0665	Ethylene Glycol Liquid	D039	12/16/88 12/19/88	N/A	N/A	N/A	1. See #309 Comment 1
0673,0675 0677	Ethylene Glycol Liquid	D039	12/19/88	N/A	N/A	N/A	1. See #309 Comment 1
0684-0684	Ethylene Glycol	D039	12/20/88 12/21/88	N/A	N/A	N/A	1. See #309 Comment 1
0685-0687	Ethylene Glycol	D039	11/10/89	N/A	N/A	N/A	1. See #309 Comment 1
0690-0692	Ethylene Glycol	D039	1/12/89	N/A	N/A	N/A	1. See #309 Comment 1
0838	Batteries, Solid	D008	10/12/89	3rd 3rd	D008: (Lead Acid Batteries) = Thermal Recovery of Lead in Secondary Lead Smelters	D008- Same as T.S.	1. See #257 Comment 1 2. Also Treatment Standards for D008-Radioactive Lead Solids Which May Apply

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

WITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
0851	Acid Liquid pH < 2????	D002	4/20/90	CA List? 3rd 3rd	CA List: pH > 2	CA List- Neutralization	1. See #255 Comment 1
0854	Paint or Oil Liquid	D001	12/13/88	3rd 3rd	D001 (High TOC NonWW): Incineration, F.S., or recovery	D001- Same as T.S.	1. See #257 Comment 1
0857	Oil, Liquid	D008	4/20/90	3rd 3rd	D008: Lead = 5 mg/l	D008- NonWW: Stabilization	1. See #257 Comment 1 2. Lead = 44 mg/l
0859	Paint Liquid PCBs	D001 D008	4/20/90	CA List 3rd 3rd	CA List (PCBs): Incineration D001 (High TOC NonWW): Incineration, F.S., or recovery D008: Lead = 5 mg/l	CA List- PCBs: Incineration D001- Same as T.S. D008- NonWW: Stabilization	1. See #255 Comment 1
0861-0863	Sampling Debris Solid	D009	10/3/89 11/8/89 10/30/89	3rd 3rd	D009: Mercury = .2 mg/l	D009- NonWW: Acid Leaching, chemical oxidation, dewatering	1. See #257 Comment 1 2. LDR Standards for hazardous debris will be final soon.
0871	Potassium Permanganate,	D001	7/1/89	3rd 3rd	D001: Deactivation	D001- Ignitable Oxidizer:	1. See #257 Comment 1

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

WITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
	Solid Oxidizer					chemical reduction, incineration	
0872-0873	TCE Liquid	U228 D040	5/30/89	3rd 3rd	U228: Trichloroethylene = NonWW (total): 5.6 mg/kg D040: N/A	U228- NonWW: Incineration	1. See #257 Comment 1 2. See #309 Comment 1
0874-0875	Sampling Debris, Sheeting, Plastic Solid PCBs	D040	6/11/90	N/A	N/A	N/A	1. See #309 Comment 1
1315-1316	Field Lab Debris Solid	D011	4/17/90 6/1/90	3rd 3rd	D011: Silver = 5 mg/l	D011- NonWW: Stabilization, or recovery	1. See #257 Comment 1 2. See #861 Comment 2
1317	Paint (A variety of materials; inks, paints, solvents) Liquid	D001	9/15/90	3rd 3rd	D001 (High TOC NonWW): Incineration, F.S., or recovery	D001- Same as T.S.	1. See #257 Comment 1
1320-1321	Paint - variety Lead - variety Solids	D008	9/15/90	3rd 3rd	D008: Lead = 5 mg/l	D008- NonWW: Stabilization	1. See #257 Comment 1

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

WITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
1324	Equipment, Labware	D009	9/15/90	3rd 3rd	D009: Mercury = .2 mg/l	D009- NonWW: Acid Leaching, chemical oxidation, dewatering	1. See #257 Comment 1 2. See #861 Comment 2
1325	Equipment, Labware	D011	9/15/90	3rd 3rd	D011: Silver = 5 mg/l	D011- NonWW: Stabilization or recovery	1. See #257 Comment 1 2. See #861 Comment 2
1326	Magnesium Metal and Cadmium Metal Solid	D003 D006	9/15/90	3rd 3rd	D003: Deactivation D006: Cadmium = 1 mg/l	D003- Water Reactives: incineration, controlled reaction w/ water, chemical/electrolyte oxidation, chemical reduction D006- NonWW: Stabilization or metal recovery	1. See #257 Comment 1
1331	Inert Solid	D007	9/12/90	3rd 3rd	D007: Chromium = 5 mg/l	D007- NonWW: Chromium reduction, stabilization	1. See #257 Comment 1
1334	Solvents	D008	9/15/90	3rd 3rd	D008: Lead = 5 mg/l	D008-	1. See #257 Comment 1

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

NITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
	Liquid	D018 D029			D018: N/A D029: N/A	NonWW: Stabilization	2. See #309 Comment 1
1344	Solvents Liquid	D001	9/15/90	3rd 3rd	D001 (High TOC NonWW): Incineration, F.S., or recovery	D001- Same as T.S.	1. See #257 Comment 1
1347	Oil/Solvent, Liquid	D001 D008 D018 D029 D035	9/15/90	3rd 3rd	D001 (High TOC NonWW): Incineration, F.S., or recovery D008: Lead = 5 mg/L D018: N/A D029: N/A D035: N/A	D001- Same as T.S. D008- NonWW: Stabilization	1. See #257 Comment 1 2. See #309 Comment 1
1362-1363	Acids, Sulfuric & Phosphoric Liquid pH < 2 ?	D002	9/15/90	CA List? 3rd 3rd	CA List: pH > 2	CA List- Neutralization	1. See #255 Comment 1
1368	Paint Liquid	D001	9/15/90	3rd 3rd	D001 (High TOC NonWW): Incineration, F.S., or recovery	D001- Same as T.S.	1. See #257 Comment 1

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

WITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
1369	Lead Scrap Solid	D008	9/15/90	3rd 3rd	D008: Lead = 5 mg/l	D008- NonWW: Stabilization	1. See #257 Comment 1 2. See #838 Comment 1
1370-1371	Batteries	D008	9/15/90	3rd 3rd	D008: (Lead Acid Batteries) = Thermal Recovery of Lead in Secondary Lead Smelters	D008- Same as T.S.	1. See #257 Comment 1 2. See #838 Comment 1
1375	Grease, sludge	D005	9/15/90	3rd 3rd	D005: Barium = 100 mg/l	D005- WW: Chemical ppt. NonWW: Stabilization	See #257 Comment 1
1376	Barium Chloride Liquid Heat Solid	D005	9/15/90	3rd 3rd	D005: Barium = 100 mg/l	D005- NonWW: Stabilization	1. See #257 Comment 1
1380	Calcium Solid	D003	10/11/90	3rd 3rd	D003: Deactivation	D003- Water Reactive: Incineration, controlled reaction w/ water, chemical/electrolytic oxidation, chemical reduction	1. See #257 Comment 1
1381	Sodium Solid	D003	10/11/90	3rd 3rd	D003: Deactivation	D003- Water Reactive:	1. See #257 Comment 1

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

WITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
						Incineration, controlled reaction w/ water, chemical/electrolytic oxidation, chemical reduction	
1382	Lithium Solid	D003	10/11/90	3rd 3rd	D003: Deactivation	D003- Water Reactive: Incineration, controlled reaction w/ water, chemical/electrolytic oxidation, chemical reduction	1. See #257 Comment 1
1383	Magnesium Hydride Solid	D003	10/11/90	3rd 3rd	D003: Deactivation	D003- Water Reactives: Incineration, controlled reaction w/ water, chemical/electrolytic oxidation, chemical reduction	1. See #257 Comment 1
1384	Calcium Solid	D003	10/11/90	3rd 3rd	D003: Deactivation	D003- Water Reactives: Incineration, controlled reaction w/ water, chemical/electrolytic oxidation, chemical reduction	1. See #257 Comment 1

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

WITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
1385	Zirconium Hydride Solid	D003	10/11/90	3rd 3rd	D003: Deactivation	D003- Water Reactives: Incineration, controlled reaction w/ water, chemical/electrolytic oxidation, chemical reduction	1. See #257 Comment 1
1395-1398	Lead Metal Solid	D008	1/14/91- 1/31/91	3rd 3rd	D008: Lead = 5 mg/l	D008- NonWW: Stabilization	1. See #257 Comment 1 2. See #838 Comment 1
1400	Vanadium Pentoxide Solid	P120	1/31/91	3rd 3rd	P120: NonWW = stabilization	P120- NonWW: Stabilization	1. See #257 Comment 1
1401	Broken Glass with Mercury Contamination Solid	D009	1/30/91	3rd 3rd	D009: Mercury = .2 mg/l	D009- NonWW: Acid Leaching, chemical oxid., dewatering	1. See #257 Comment 1 2. See #861 Comment 2
1402	Broken Glass which Contained 2,4-D, 2,4,5-T, and 2,4,5-TP Solid	D016 D017?	2/6/91	3rd 3rd	D016: (NonWW) 2,4-D = 10 mg/l D017: (NonWW) 2,4,5-TP = 7.9 mg/l	D016- NonWW: Incineration D017- NonWW: Incineration	1. See #257 Comment 1 2. See #861 Comment 2
1403	2,4-D 2,4,5-T? Solid	D016 D017?	2/5/91	3rd 3rd	D016: (NonWW) 2,4-D = 10 mg/l D017: (NonWW)	D016: NonWW: Incineration D017-	1. See #257 Comment 1 2. See #861 Comment 1

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

WITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
					2,4,5-TP = 7.9 mg/L	NonWW: Incineration	
1406	Sulfide Solid	D003	2/8/91	3rd 3rd	D003 (Reactive Sulfides) Deactivation	D003- Reactive Sulfides (NonWW): Chemical/electrolytic oxidation, chemical reduction, incineration, stabilization	1. See #257 Comment 1
1407	Cyanide Solid	D003	2/8/91	3rd 3rd	D003: (NonWW) Cyanides = 590 mg/kg (total) Cyanides = 30 mg/kg (amenable)	D003- Reactive Cyanides (NonWW): Alkaline chlorination, wet air oxidation, or electrolytic oxidation	1. See #257 Comment 1
1408	Copper Nitrate Solid	D001	1/4/91	3rd 3rd	D001 (Oxidizer): Deactivation	D001- Ignitable Oxidizer: Chemical reduction, incineration	1. See #257 Comment 1
1409	Mercury Metal Solid	D009	1/4/91	3rd 3rd	D009: Depends on Treatability Group- (1) NonWW Hg < 260 mg/kg: Mercury = .2 mg/kg (2) NonWW Hg > 260 mg/kg: Roasting or retorting: or incineration followed	(1) Acid leaching, chemical oxidation, dewatering (2) Same as T.S. (3) Same as T.S.	1. See #257 Comment 1 2. Determine Treatability Subcategory

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

WITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
					by roasting or retorting 3) Elemental mercury contaminated with radioactive materials: Amalgation		
1412	2 Bottles Uranium Nitrate in TBP Thorium Nitrate in TBP Solid	D001	2/8/91	3rd 3rd	D001: Ignitable Oxidizer Deactivation	D001- Ignitable Oxidizer: Chemical reduction, incineration	1. See #257 Comment 1
1423	Paint Solids Solid	D005 D008	2/6/91	3rd 3rd	D005: Barium = 100 mg/l D008: Lead = 5 mg/l	D005- NonWW: Stabilization D008- NonWW: Stabilization	1. See #257 Comment 1
1426	Waste Oil Liquid	D008	3/21/91	3rd 3rd	D008: Lead = 5 mg/l	D008- NonWW: Stabilization	1. See #257 Comment 1 2. Lead = 62.6 mg/l
1441	Water Liquid	D040	3/6/91	N/A	N/A	N/A	1. See #309 Comment 1 2. Trichloroethene = 1.6 mg/L
1448	Acid pH < 2	D002 D007	5/17/91	CA List 3rd 3rd	CA List: pH > 2 D007: Chromium = 5 mg/l	CA List: Neutralization D007-	1. See #255 Comment 1 2. Chromium = 23.6 mg/l

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

WITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
	Liquid					WW: Chromium reduction, precipitation NonWW: Chromium reduction, stabilization	3. BDAT depends on if WW or NonWW
1454-1456	Magnesium Metal Solid	D003	6/5/91	3rd 3rd	D003 (Water Reactives): Deactivation	D003- Water Reactive (NonWW): Incineration, controlled reaction w/ water, chemical/electrolytic oxidation, chemical reduction	1. See #257 Comment 1
1478-1480	Liquid	D001 D008	7/9/91	3rd 3rd	D001 (High TOC NonWW): Incineration, F.S., or recovery D008: Lead = 5 mg/l	D001- Same as T.S. D008- NonWW: Stabilization	1. See #257 Comment 1
1481	Sludge	D001 D008	7/9/91	3rd 3rd	D001 (High TOC NonWW): Incineration, F.S., or recovery D008: Lead = 5 mg/l	D001- Same as T.S. D008- NonWW: Stabilization	1. See #257 Comment 1
1507	Water, Gas, Kerosene Liquid	D001	7/17/91	3rd 3rd	D001 (Low TOC NonWW): Deactivation	D001- Low TOC NonWW:	1. See #257 Comment 1

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

WITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
						Recovery of organics, incineration, wet-air oxidation, chemical/ electrolytic oxidation, biodegradation	
1510	Waste Oil Liquid PCBs	D008	5/24/91	CA List 3rd 3rd	CA List (PCBs): Incineration D008: Lead = 5 mg/l	CA List- PCBs: Incineration D008- NonWW: Stabilization	1. See #257 Comment 1 2. Lead = 80.9 mg/l 3. PCBs = 120 mg/kg
1515-1525	Rainwater Contaminated with TCE Liquid	D040	7/26/91	N/A	N/A	N/A	1. See #309 Comment 1
1526	Sludge PCBs	D001 D008	7/26/91	3rd 3rd	D001 (High TOC NonWW): Incineration, F.S., or recovery D008: Lead = 5 mg/l	D001: Same as T.S. D008- NonWW: Stabilization	1. See #257 Comment 1
1527-1530	Nonsoil, Sludge Solid PCBs	D001 D008	7/26/91	3rd 3rd	D001 (High TOC NonWW): Incineration, F.S., or recovery	D001- Same as T.S. D008- NonWW: Stabilization	1. See #257 Comment 1

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

WITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
					D008: Lead = 5 mg/L		
1565-1566	Caustic Liquid	D002	9/6/91	3rd 3rd	D002: Deactivation	D002- Neutralization, Incineration	1. See #257 Comment 1 2. pH = 14
1567	Lead Batteries, Solid	D008	9/18/91	3rd 3rd	D008: (Lead Acid Batteries) = Thermal Recovery of Lead in Secondary Lead Smelters	D008- Same as T.S.	1. See #257 Comment 1 2. See #838 Comment 1
1577	Nitric/Hydrochloric/ Water Acid Liquid	D002	11/4/91	3rd 3rd	D002: Deactivation	D002- WW: Neutralization, Incineration	1. See #257 Comment 1
1588	Caustic Liquid	D002	11/12/91	3rd 3rd	D002: Deactivation	D002- WW: Neutralization, Incineration	1. See #257 Comment 1 2. pH = 14
1595	Lead Batteries Solid	D008	11/22/91	3rd 3rd	D008: (Lead Acid Batteries) = Thermal Recovery of Lead in Secondary Lead Smelters	D008- Same as T.S.	1. See #257 Comment 1 2. See #838 Comment 1
1597-1637	Liquid	D018	11/27/91	N/A	N/A	N/A	1. See #309 Comment 1

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

UITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
1667	Gasoline/Soil Solid	D018	1/3/92	N/A	N/A	N/A	1. See #309 Comment 1
1648	Oil/Water/Gas Liquid	D018	1/3/92	N/A	N/A	N/A	1. See #309 Comment 1
1658	Cyanide, Liquid	D003	1/10/92	3rd 3rd	D003 (Reactive Cyanides Category): Cyanides (total) = 590 mg/kg Cyanides (amenable) = 30 mg/kg	D003 (Reactive Cyanides)- Alkaline chlorination, wet air oxidation, or electrolytic oxidation	1. See #257 Comment 1
1663	Field Lab Waste, Liquid	D040	2/28/92	N/A	N/A	N/A	1. See #309 Comment 1
1669	Transformer, Metal	D018	4/6/92	N/A	N/A	N/A	1. See #309 Comment 1
1673-1676	Liquid, (From HF Tanks in Bldg. 201)	D004 D006 D009 D011	2/3/92	3rd 3rd	D004: Arsenic = 5 mg/l D006: Cadmium = 1 mg/l D009: Mercury = .2 mg/l D011: Silver = 5 mg/l	NonWW: D004- Vitrification D006 & D011- Stabilization or metal recovery D009- Acid leaching, chemical oxidation,	1. See #257 Comment 1 2. BDAT depends on if WW or NonWW

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

WITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
						dewatering WW: D004, D006, D009, & D011- Chemical precipitation	
1678	Lead Batteries, Solid	D008	2/26/92	3rd 3rd	D008 (Lead Acid Batteries) = Thermal Recovery of Lead in Secondary Lead Smelters	D008- Same as T.S.	1. See #257 Comment 1
1698	Solvents, Liquid	D001	4/14/92	3rd 3rd	D001 (High TOC NonWW): Incineration, F.S., or recovery	D001- Same as T.S.	1. See #257 Comment 1
1699	Liquid	D002	4/14/92	CA List? 3rd 3rd	CA List: pH > 2	CA List- Neutralization	1. See #255 Comment 1
1700	Solvent, Liquid	D001	4/14/92	3rd 3rd	D001 (High TOC NonWW): Incineration, F.S., or recovery	D001- Same as T.S.	1. See #257 Comment 1
1705	Liquid	D002	1/19/89	CA List	CA List: pH > 2	CA List: Neutralization	1. See #255 Comment 1

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

WITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
		D004 D008 D011		3rd 3rd	D004: Arsenic = 5 mg/l D008: Lead = 5 mg/l D011: Silver = 5 mg/l	NonWW: D004- Vitrification D008- Stabilization D011- Stabilization or metal recovery WW: D004, D008, & D011- Chemical precipitation	2. Arsenic = 169 mg/l 3. Lead = 192 mg/l 4. Silver = 11.8 mg/l 5. BDAT depends on if WW or NonWW
1706	Liquid	D002 D004 D006 D007 D008 D010	12/4/89 1/19/89	CA List 3rd 3rd	CA List: pH > 2 D004: Arsenic = 5 mg/l D006: Cadmium = 1 mg/l D007: Chromium = 5 mg/l D008: Lead = 5 mg/l D010: Selenium = 5.7mg/l	CA List: Neutralization NonWW: D004- Vitrification D006- Stabilization or metal recovery D007- Chromium reduction, stabilization D008 & D010- Stabilization WW: D006- Chromium reduction, precipitation D004, D007, D008, & D010- Chemical precipitation	1. See #255 Comment 1 2. Arsenic = 110 mg/l 3. Cadmium = 1,460 mg/l 4. Chromium = 22.7 mg/l 5. Lead = 331 mg/l 6. Selenium = 408 mg/l 7. BDAT depends on if WW or NonWW
11783	Sludge	D040	5/21/92	N/A	N/A	N/A	1. See #309 Comment 1

RCRA LAND DISPOSAL RESTRICTIONS FOR BLDG. 434 WASTE (Date of Table - 9/8/92)

WITS #	DESCRIPTIONS	EPA WASTE CODE(S)	ACCUM. DATE	LAND BAN TYPE	TREATMENT STANDARDS	BDAT(S)	COMMENTS
2012	Herbicide, 2,4-D	D016	8/5/92	3rd 3rd	D016 (NonWW): 2,4-D = 10 mg/l	D016- NonWW: Incineration	1. See #257 Comment 1

MK-FERGUSON

A DIVISION OF MORRISON KNUDSEN CORPORATION

INTER-OFFICE CORRESPONDENCE

DATE: November 23, 1992

TO: R. Ferguson

FROM: Kenyon Warbritton/Jeff Carman

SUBJECT: **TECHNICAL MEMORANDUM PRESENTING RESULTS OF RECENT LABORATORY AND FIELD PERMEABILITY TESTS.**

The PMC has recently completed Two-Stage Borehole (TSB) field permeability testing performed at the request of MDNR/DGLS personnel. These tests were performed on the Ferrelview Formation and clay till unit at locations within the Disposal Facility Study Area.

An additional testing program, triaxial permeability testing of small undisturbed samples, is nearly complete. These tests were performed using both water and a synthesized leachate as a permeant. This program is not yet finalized, however key findings are available at this time for review by interested parties.

Samples of these test programs were obtained in accordance with "Sampling Plan for Determination of Hydraulic Properties of Undisturbed Soils in the Weldon Spring Disposal Facility Study Area", Rev. 1, MK-JEG, Oct. 92. Data and conclusions from these two test programs, in addition to prior WSSRAP testing, were utilized to calculate travel times for water through a 20 ft. layer of site soil. These travel time values were compared to travel time values calculated for a 30 ft. layer of material with a hydraulic conductivity of 1.0 E^{-07} cm/s (as described in 10 CSR 25-7).

<u>TWO-STAGE BOREHOLE FIELD PERMEABILITY TESTS</u>

I. Please find the following attachments relating to the TSB test effort.

Attachment 1 - Figure indicating the locations of TSB tests.

Attachments 2A and 2B - Spreadsheet calculation summaries which yield initial temperature corrected hydraulic conductivity values for stage 1 (K1CT) and stage 2 (K2CT).

Attachments 3A and 3B - Plots of time versus hydraulic conductivity for stage 1 and stage 2.

Attachment 4A and 4B - Calculations of the final time-weighted average hydraulic conductivity (K1' and K2').

Attachment 5 - Spreadsheet calculation summary of the derived Kv and Kh values.

Attachment 6 - TSB Method Reference, "The STEI Two-Stage Borehole Field Permeability Test", Boutwell, March 1992.

II. Results of the TSB test program are summarized as follows:

- Table 1 provides a summary of TSB test results.

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- Table 2 provides a summary of basic statistics generated from the TSB results presented in Table 1.

- Results of TSB testing indicate that *in situ* hydraulic conductivity is not affected by macropore features such as cracks or fractures.

- TSB no. 9 exhibited the highest permeability and also exhibited some erratic behavior early in the testing program, leading PMC staff to question the integrity of this test boring. This data is presented and is utilized in the attached data summaries. PMC staff have recently added dye to the permeameter (TSB-9) to investigate potential leakage when abandoning this hole using controlled excavation.

WATER/LEACHATE PERMEABILITY TESTING

I. Please find the following attachments relating to water/leachate permeability testing:

Attachment 7 - Figure indicating locations for undisturbed site soil samples which were subjected to permeability testing (ASTM Method D-5084).

Attachment 8 - Summary of leachate synthesis methodology.

II. Results of the water/leachate permeability testing are summarized as follows:

- Table 3 summarizes the results to date of permeability tests run using water and leachate as a permeant.

- The effect of synthesized leachate on permeability values for these undisturbed soils was not detectable. Permeability values for two samples increased slightly, values for two samples decreased slightly, and values for two samples remained essentially the same when synthesized leachate was used as the permeant after tap water. These slight differences are within the range of accuracy obtained by test measurements.

CONCLUSIONS RESULTING FROM COMBINED DATA

I. Please find the following attachments relating to water/leachate permeability testing:

Attachment 9 - Presents calculations of travel time and permittivity which compare a 20 ft. thickness with hydraulic conductivity values from various WSSRAP sampling efforts (laboratory and field efforts) to a 30 ft. layer of soil with a hydraulic conductivity of 1.0 E^{-07} cm/s (per 10 CSR 25-7).

Attachment 10 - Presents a list of pertinent reference documents associated with the data and conclusions in this technical memorandum.

II. Conclusions resulting from review of combined data are summarized as follows:

Studies conducted to date have focuses on the hydrologic performance of site soils on a conservative basis. Geochemical performance studies focusing on leachate/mineral interaction are currently being negotiated with Pacific Northwest Laboratory (PNL). The hydrologic data presented herein are considered a "worst case" assessment of the material effects of leachate/mineral interaction.

- Field hydraulic conductivity testing by the Two-Stage Borehole method indicates that macropore features such as cracks and fractures do not result in larger hydraulic conductivity values than have previously been determined for the Ferrelview Formation and clay till soil units in the Disposal Facility Study Area.

- Laboratory triaxial permeability tests have shown synthesized leachate to have an undetectable effect on hydraulic conductivity of Ferrelview Formation and clay till soil unit samples.

- Travel time and permittivity calculations are used to demonstrate that the soil units comprising the foundation of the proposed disposal facility will provide a level of protection superior to the minimum criteria specified under 10 CSR 25-7.

- The data and calculations presented herein for the Ferrelview Formation and clay till soil units satisfy the criteria set forth under 10 CSR 25-7.264 (2)(N)1.A.(III) which addressed minimum soil performance requirements relative to the movement of hazardous constituents.

This information substantiates the suitability of the WSSRAP site for location of a disposal facility. A formal report regarding this data is forthcoming, pending completion of all associated testing. If you have any questions or comments, please contact K. Warbritton (ext. 3309) or J. Carman (ext. 3506).

cc (w/attach.):

S. Grozescu	D. Conover (MKE-BHO)
R. Rager (MKE-BHO)	K. Lee (MKE-SFO)
G. Nibler (MKE-BHO)	J. Bognar
D. Daniel (UT)	RC-22-26-3A

cc (w/o attach.):

K. Meyer	J. Meier
J. Williams	P. Cate
K. Greenwell	

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TABLE 1

SUMMARY OF HYDRAULIC CONDUCTIVITY VALUES FROM TWO-STAGE BOREHOLE TESTING

TSB NO.	Formation	K1′	K2′	Kv	Kh
TSB-01	FF	3.03 E^{-09}	2.80 E^{-09}	4.09 E^{-09}	2.25 E^{-09}
TSB-02	CT	3.04 E^{-09}	2.58 E^{-08}	9.11 E^{-10}	1.01 E^{-08}
TSB-03	FF	2.23 E^{-09}	3.19 E^{-09}	1.08 E^{-09}	4.58 E^{-09}
TSB-04	CT	3.05 E^{-09}	5.56 E^{-09}	9.14 E^{-10}	1.02 E^{-08}
TSB-05	CT	5.07 E^{-09}	1.69 E^{-09}	1.52 E^{-09}	1.69 E^{-08}
TSB-06	CT	4.12 E^{-09}	1.21 E^{-08}	1.24 E^{-09}	1.37 E^{-08}
TSB-07	FF	2.40 E^{-09}	1.48 E^{-09}	2.09 E^{-09}	2.75 E^{-09}
TSB-08	CT	4.00 E^{-09}	4.33 E^{-08}	1.20 E^{-09}	1.33 E^{-08}
TSB-09	FF	9.59 E^{-09}	1.67 E^{-07}	8.36 E^{-09}	1.10 E^{-08}
TSB-10	FF	6.06 E^{-09}	5.01 E^{-08}	8.18 E^{-09}	4.49 E^{-09}
TSB-11	CT	1.83 E^{-09}	1.34 E^{-08}	5.49 E^{-10}	6.10 E^{-09}
TSB-12	FF	1.85 E^{-09}	2.42 E^{-08}	2.50 E^{-09}	1.37 E^{-09}
TSB-13	CT	2.59 E^{-09}	5.22 E^{-08}	7.76 E^{-10}	8.64 E^{-09}

All hydraulic conductivity values are presented in units of cm/s.

K1′ = Arithmetic time-weighted average stage 1 hydraulic conductivity.

K2′ = Arithmetic time-weighted average stage 2 hydraulic conductivity.

Kv = Final calculated vertical component of hydraulic conductivity.

Kh = Final calculated horizontal component of hydraulic conductivity.

FF = Ferrelview Formation

CT = Clay Till unit

TABLE 2

TWO STAGE BOREHOLE TESTING STATISTICS

	K1′	K2′	Kv	Kh
Maximum K Value (FF)	9.59 E^{-09}	1.67 E^{-09}	8.36 E^{-09}	1.10 E^{-08}
Minimum K Value (FF)	1.85 E^{-09}	1.48 E^{-09}	1.08 E^{-09}	1.37 E^{-09}
Logarithmic Mean (FF)	3.47 E^{-09}	1.18 E^{-08}	3.41 E^{-09}	3.52 E^{-09}
Maximum K Value (CT)	5.07 E^{-09}	5.22 E^{-08}	1.20 E^{-09}	1.69 E^{-08}
Minimum K Value (CT)	1.83 E^{-09}	1.69 E^{-09}	5.49 E^{-10}	6.10 E^{-09}
Logarithmic Mean (CT)	3.23 E^{-09}	1.37 E^{-08}	9.69 E^{-10}	1.08 E^{-08}
Maximum K (Both Units)	9.59 E^{-09}	1.67 E^{-07}	8.36 E^{-09}	1.69 E^{-08}
Minimum K (Both Units)	1.83 E^{-09}	1.48 E^{-09}	5.49 E^{-10}	1.37 E^{-09}
Logarithmic Mean (Both Units)	3.34 E^{-09}	1.28 E^{-08}	1.73 E^{-09}	6.43 E^{-09}

All hydraulic conductivity values are presented in units of cm/s.

K1′ = Arithmetic time-weighted average stage 1 hydraulic conductivity.

K2′ = Arithmetic time-weighted average stage 2 hydraulic conductivity.

Kv = Final calculated vertical component of hydraulic conductivity.

Kh = Final calculated horizontal component of hydraulic conductivity.

FF = Ferrelview Formation

CT = Clay Till unit

TABLE 3

SUMMARY OF WATER/LEACHATE HYDRAULIC CONDUCTIVITY DATA

Sample ID	Formation	Plasticity Index	Water K	Leachate K
GT80-ST12	CT	33	1.74 E^{-09}	1.22 E^{-09}
GT83-ST06	FF	44	1.25 E^{-09}	1.2 E^{-09}
GT83-ST12	CT	35	1.0 E^{-09}	1.2 E^{-09}
GT82-ST05	FF	60	5.0 E^{-10}	6.5 E^{-10}
GT82-ST08	CT	38	1.5 E^{-08}	2.68 E^{-09}
GT84-ST07	FF	61	1.3 E^{-09}	1.3 E^{-09}

Overall natural log mean hydraulic conductivity value for water is 1.66 E^{-09} cm/s.
Overall natural log mean hydraulic conductivity value for leachate is 1.26 E^{-09} cm/s.

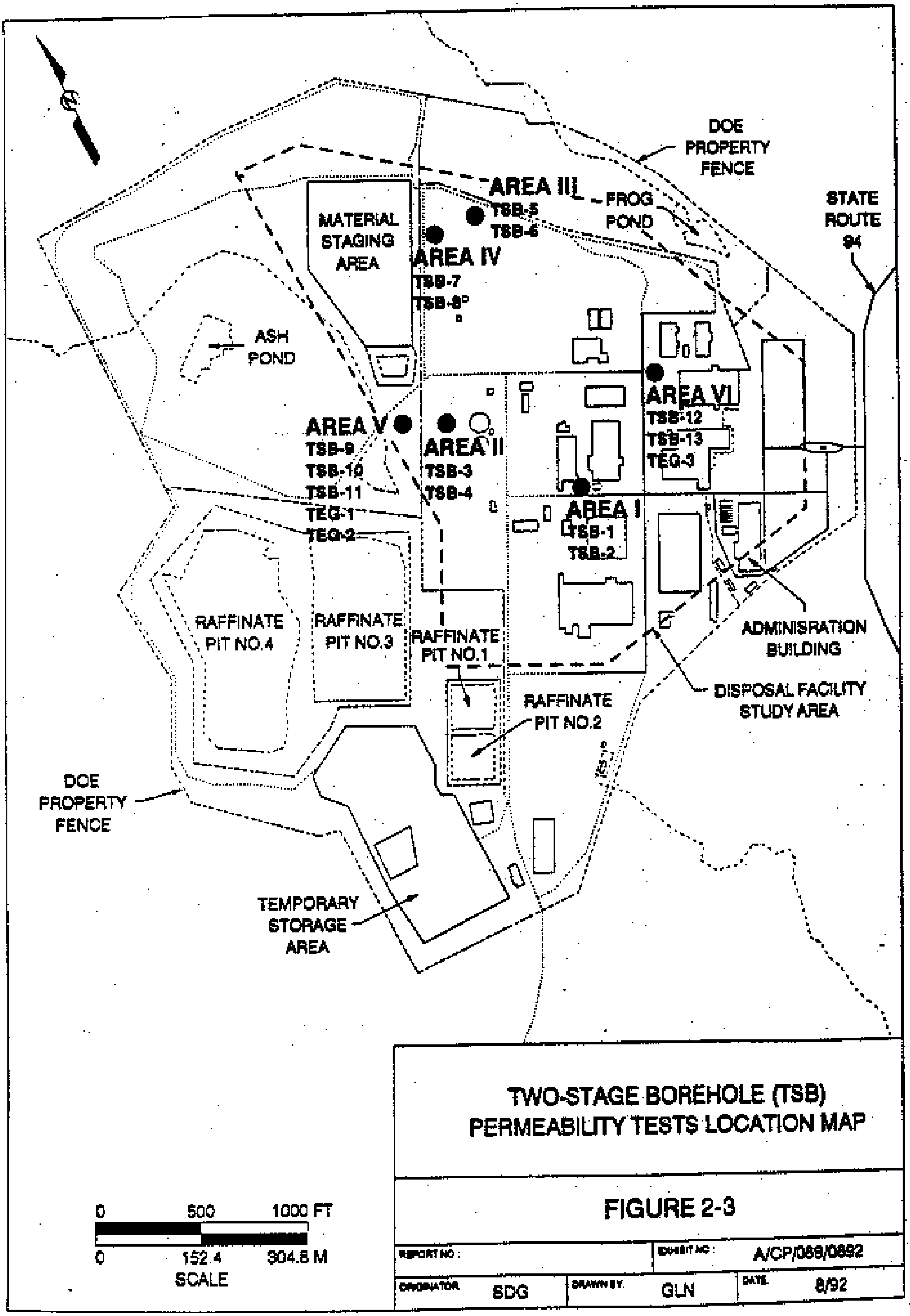
Sample ID	Formation	Days Water	Days Leachate	Water Pore Vol.	Leachate Pore Vol.	Total Pore Vol.
GT80-ST12	CT	5	38	0.18	0.70	0.88
GT83-ST06	FF	4	40	0.43	2.59	3.02
GT83-ST12	CT	7	23	0.53	1.79	2.32
GT82-ST05	FF	7	23	0.19	0.77	0.96
GT82-ST08	CT	8	16	3.53	3.91	7.44
GT84-ST07	FF	8	18	0.92	1.35	2.27

CT = Clay Till Soil Formation
FF = Ferrelview Clay Formation

Note: Values presented are current as of Nov. 16, 1992. Values for plasticity index are included for information. No correlations are proposed at this stage, relating PI to hydraulic conductivity. Hydraulic conductivity (K) values are shown in units of cm/s. Permeability testing with leachate will continue until all samples exceed 1.0 pore volume of leachate. Total pore volumes are estimated from calculations for total porosity for each sample.

ATTACHMENT 1

LOCATIONS OF TSB TESTS



TWO-STAGE BOREHOLE (TSB) PERMEABILITY TESTS LOCATION MAP

FIGURE 2-3

ATTACHMENT 2A

TSB
SPREADSHEET CALCULATION SUMMARY

STAGE 1 (K1')

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-1
Geometric factor=G=0.04030
Depth factor=239.12"
TC values from TBG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (tm)	BPD (K1 tm)	Comments
10/09	1010	-	0.00	33.25	-	-	-	-	-	0	-	-	START
10/09	1215	6960	1.93	32.93	6.81E-09	-0.12	4.25E-09	1.1	4.68E-09	1.03	4.48E-09	-	
10/09	1359	6240	3.67	32.68	1.19E-09	0.00	1.19E-09	1.1	1.31E-09	1.10	3.06E-09	41%	
10/09	1624	8700	6.08	31.75	1.93E-08	0.00	1.93E-08	1.1	2.12E-08	4.62	1.03E-08	108%	
10/10	822	57480	22.05	14.00	4.75E-08	-0.12	4.72E-08	1.1	5.19E-08	61.84	4.04E-08	119%	
10/10	1600	13080	25.68	12.50	1.63E-08	-0.19	1.60E-08	1.1	1.76E-08	66.68	3.72E-08	8%	
10/10	1601	14460	29.70	12.13	4.10E-09	0.06	4.77E-09	1.1	5.24E-09	67.55	3.29E-08	12%	
10/10	1605	240	29.77	35.31	4.10E-09	0.00	4.77E-09	1.1	5.25E-09	67.55	3.28E-08	0%	Refill
10/11	809	57840	45.83	20.75	3.80E-08	-0.12	3.77E-08	1.1	4.14E-08	114.62	3.58E-08	9%	
10/11	1133	12240	49.23	19.13	2.06E-08	-0.19	1.82E-08	1.1	2.00E-08	119.83	3.47E-08	3%	
10/11	1555	15720	53.60	17.88	1.24E-08	0.06	1.30E-08	1.1	1.43E-08	123.84	3.31E-08	5%	
10/11	1558	180	53.65	33.75	1.24E-08	0.00	1.30E-08	1.1	1.43E-08	123.84	3.31E-08	0%	Refill
10/12	750	57120	69.52	25.25	2.23E-08	-0.06	2.22E-08	1.1	2.44E-08	151.16	3.11E-08	6%	
10/12	1153	14580	73.57	23.31	2.04E-08	-0.19	1.84E-08	1.1	2.02E-08	157.36	3.05E-08	2%	
10/12	1535	13320	77.27	22.50	9.35E-09	0.12	1.07E-08	1.1	1.18E-08	159.96	2.98E-08	3%	
10/13	743	58080	93.40	18.81	9.66E-09	-0.12	9.53E-09	1.1	1.05E-08	171.83	2.63E-08	12%	
10/13	1705	33720	102.77	17.38	6.84E-09	-0.31	5.20E-09	1.1	5.72E-09	176.43	2.44E-08	7%	
10/14	810	54840	118.00	14.63	7.92E-09	0.06	8.00E-09	1.1	8.80E-09	185.28	2.24E-08	9%	
10/14	1600	27600	125.66	14.25	2.16E-09	0.38	4.37E-09	1.1	4.81E-09	186.48	2.13E-08	5%	
10/15	855	60900	142.60	10.50	9.57E-09	-0.50	6.54E-09	1.1	9.40E-09	196.53	1.99E-08	7%	
10/15	1356	18060	147.62	10.12	3.40E-09	0.12	4.47E-09	1.1	4.92E-09	198.75	1.94E-08	3%	
10/16	806	65400	165.78	7.75	5.69E-09	-0.12	5.59E-09	1.1	6.15E-09	207.36	1.80E-08	8%	
10/16	1623	29820	174.07	6.86	4.77E-09	-0.07	4.39E-09	1.1	4.83E-09	210.16	1.73E-08	4%	
10/17	847	59040	190.47	5.50	3.84E-09	0.00	3.84E-09	1.1	4.22E-09	214.59	1.62E-08	7%	
10/18	928	88860	215.15	3.69	3.37E-09	-0.06	3.26E-09	1.1	3.58E-09	220.41	1.48E-08	9%	
10/18	929	60	215.17	33.00	3.37E-09	0.00	3.26E-09	1.1	3.59E-09	220.41	1.48E-08	0%	Refill
10/19	921	85980	239.05	23.25	1.71E-08	0.00	1.71E-08	1.1	1.88E-08	251.73	1.52E-08	3%	
10/19	1630	25740	246.20	21.63	9.70E-09	-0.06	9.34E-09	1.1	1.03E-08	256.94	1.50E-08	1%	
10/20	1635	86700	270.28	17.13	8.09E-09	-0.25	7.64E-09	1.1	8.40E-09	271.39	1.44E-08	4%	
10/21	1635	86400	294.28	14.88	4.11E-09	-0.06	4.00E-09	1.1	4.40E-09	276.62	1.36E-08	6%	
10/22	1700	87900	318.70	13.13	3.17E-09	0.00	3.17E-09	1.1	3.49E-09	284.24	1.28E-08	6%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-1
Geometric factor-G=0.04030
Depth factor=239.12"
TC values from TBG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	Kt	TC	KtC	visc. factor	KtCT	cumulative volume (cc)	K (twm)	RPD (Ktwm)	Comments
10/23	1637	65020	342.32	11.60	3.07E-09	0.00	3.07E-09	1.1	3.38E-09	259.45	1.22E-08	5%	
10/24	1533	82560	365.25	9.94	3.05E-09	0.00	3.05E-09	1.1	3.35E-09	294.49	1.16E-08	6%	
10/25	1555	91320	390.62	8.69	2.22E-09	-0.31	1.87E-09	1.1	1.64E-09	296.50	1.10E-08	6%	+1 Hr Daylight
10/26	1310	76500	411.87	7.50	2.54E-09	-0.50	1.47E-09	1.1	1.62E-09	302.33	1.05E-08	5%	Savings Time

END OF TEST TSB-1

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-2
Geometric factor-G=0.04030
Depth factor=358.75"
TC values from TBG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (tws)	RPD (Ktws)	Comments
10/09	1020	-	0.00	33.12	-	-	-	-	-	0.00	-	-	START
10/09	1216	6980	1.93	31.61	1.94E-08	-0.12	1.75E-08	1.1	1.94E-08	4.21	1.94E-08	-	
10/09	1400	6240	3.87	31.31	8.27E-09	0.00	8.27E-09	1.1	9.10E-09	5.81	1.45E-08	29%	
10/09	1624	8640	6.07	30.81	5.96E-09	0.00	5.96E-09	1.1	6.56E-09	7.42	1.14E-08	24%	
10/10	823	57540	22.05	28.06	4.98E-09	-0.12	4.74E-09	1.1	5.22E-09	16.25	6.91E-09	49%	
10/10	852	5340	23.53	27.49	7.22E-09	-0.19	3.51E-09	1.1	3.86E-09	17.44	6.72E-09	3%	
10/10	955	180	23.58	32.75	7.22E-09	0.00	3.51E-09	1.1	3.86E-09	17.44	6.71E-09	0%	
10/10	1201	7560	25.68	32.44	4.22E-09	-0.19	1.63E-09	1.1	1.80E-09	67.85	6.31E-09	6%	
10/10	1607	14760	29.78	32.00	3.07E-09	0.06	3.49E-09	1.1	3.84E-09	69.26	5.97E-09	6%	
10/11	810	57780	45.83	29.63	4.24E-09	-0.12	4.03E-09	1.1	4.43E-09	76.66	5.43E-09	9%	
10/11	1134	12240	49.23	29.06	4.64E-09	-0.19	3.22E-09	1.1	3.55E-09	78.71	5.30E-09	2%	
10/11	1559	15900	53.65	26.81	1.63E-09	0.06	2.03E-09	1.1	2.23E-09	123.84	5.06E-09	5%	
10/12	751	57120	69.52	28.66	3.53E-09	-0.06	3.41E-09	1.1	3.75E-09	130.04	4.75E-09	6%	
10/12	1153	14520	73.55	26.31	4.41E-09	-0.10	2.74E-09	1.1	3.01E-09	131.87	4.60E-09	2%	
10/12	1536	13380	77.27	26.30	7.62E-11	0.12	1.02E-09	1.1	1.12E-09	131.90	4.49E-09	4%	
10/13	744	58080	93.40	24.25	3.70E-09	-0.12	3.49E-09	1.1	3.84E-09	136.49	4.38E-09	3%	
10/13	1706	33720	102.77	23.82	1.97E-09	-0.31	9.99E-10	1.1	1.10E-09	140.51	4.08E-09	7%	
10/14	519	54780	117.98	21.75	3.81E-09	0.06	3.72E-09	1.1	4.09E-09	146.52	4.06E-09	0%	
10/14	1602	27780	125.70	22.00	9.53E-10	0.38	4.96E-10	1.1	5.45E-10	145.72	3.86E-09	5%	
10/15	854	60720	142.57	19.81	3.83E-09	-0.50	2.95E-09	1.1	3.25E-09	152.75	3.79E-09	2%	
10/15	1357	18180	147.62	19.69	7.03E-10	0.12	1.41E-09	1.1	1.55E-09	153.14	3.71E-09	2%	
10/16	807	65400	165.78	17.50	3.58E-09	-0.12	3.38E-09	1.1	3.72E-09	160.17	3.71E-09	0%	
10/16	1624	29620	174.07	16.50	3.60E-09	-0.07	3.34E-09	1.1	3.68E-09	163.39	3.71E-09	0%	
10/17	846	58920	190.43	14.75	3.20E-09	0.00	3.20E-09	1.1	3.52E-09	169.01	3.69E-09	0%	
10/18	930	89040	215.17	12.02	3.32E-09	-0.06	3.25E-09	1.1	3.57E-09	177.75	3.65E-09	0%	
10/19	920	85800	239.00	9.88	2.72E-09	0.00	2.72E-09	1.1	2.99E-09	184.65	3.61E-09	2%	
10/19	1630	25600	246.17	9.25	2.87E-09	-0.06	2.42E-09	1.1	2.66E-09	188.68	3.56E-09	1%	
10/20	1637	86820	270.28	7.00	2.85E-09	-0.25	2.53E-09	1.1	2.78E-09	193.90	3.51E-09	2%	
10/21	1635	86280	294.25	5.13	2.39E-09	-0.06	2.32E-09	1.1	2.55E-09	199.91	3.43E-09	2%	
10/21	1640	300	294.33	34.81	2.39E-09	0.00	2.32E-09	1.1	2.55E-09	199.91	3.43E-09	0%	Refill
10/22	1701	87660	318.68	32.31	2.93E-09	0.00	2.93E-09	1.1	3.22E-09	207.94	3.42E-09	0%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-2
Geometric factor-G=0.04030
Depth factor=358.75"
TC values from TBC-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	R1	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (hm)	RPD (K1-hm)	Comments
10/23	1640	85140	342.33	29.88	2.95E-09	-	2.95E-09	1.1	3.25E-09	215.75	3.41E-09	0%	RTBG 3 Temp
10/24	1535	82500	365.25	27.38	3.15E-09	-	3.15E-09	1.1	3.47E-09	223.76	3.41E-09	0%	Stabilizing
10/25	1558	91380	390.83	25.13	2.58E-09	-0.37	2.15E-09	1.1	2.37E-09	231.01	3.34E-09	3%	+1 Hr Daylight
10/26	1308	78200	411.80	22.94	3.03E-09	0.12	3.19E-09	1.1	3.51E-09	238.04	3.35E-09	0%	Savings Time

END OF TEST TSB-2

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-3
Geometric factor-G=0.04030
Depth factor=162.25"
TC values from TEG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	R1	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (tus)	RPD (Ktus)	Comments
10/09	1515	0	0.00	32.61	-	-	-	-	-	0.00	-	-	START
10/09	1820	3900	1.06	32.75	3.16E-09	0.00	3.16E-09	1.1	3.50E-09	0.19	3.50E-09	-	
10/10	825	57000	17.17	30.13	9.42E-09	-0.13	8.94E-09	1.1	9.84E-09	8.81	9.44E-09	92%	
10/10	1207	13320	20.87	29.36	1.18E-08	-0.18	8.98E-09	1.1	9.88E-09	11.02	9.52E-09	1%	
10/10	1610	14560	24.92	29.13	3.61E-09	0.12	5.34E-09	1.1	5.88E-09	11.82	8.92E-09	6%	
10/11	814	57840	40.98	27.00	7.80E-09	-0.25	6.88E-09	1.1	7.57E-09	16.64	8.39E-09	6%	
10/11	1137	12180	44.37	26.54	7.70E-09	-0.19	4.37E-09	1.1	4.81E-09	20.08	8.12E-09	3%	
10/11	1603	15960	48.80	26.50	8.03E-10	0.12	2.41E-09	1.1	2.65E-09	20.27	7.82E-09	5%	
10/12	753	57000	64.63	24.86	6.09E-09	0.00	6.09E-09	1.1	6.70E-09	25.47	7.40E-09	3%	
10/12	1200	14820	68.75	24.63	3.84E-09	-0.32	6.09E-09	1.1	6.70E-09	26.28	7.38E-09	1%	
10/12	1538	13080	72.38	24.75	3.64E-09	0.19	1.15E-09	1.1	1.27E-09	25.80	7.06E-09	4%	
10/13	747	58140	88.53	23.13	6.03E-09	-0.12	5.58E-09	1.1	6.14E-09	31.10	6.86E-09	2%	
10/13	1656	32880	97.67	23.13	6.03E-09	0.06	3.97E-10	1.1	4.36E-10	31.10	6.28E-09	9%	
10/14	826	55800	113.16	22.00	4.41E-09	-0.25	3.43E-09	1.1	3.78E-09	34.73	5.94E-09	6%	
10/14	1609	27780	120.88	22.63	4.41E-09	0.43	3.43E-09	1.1	3.77E-09	32.70	5.80E-09	2%	
10/15	826	59620	137.52	21.00	5.97E-09	-0.50	4.13E-09	1.1	4.54E-09	37.94	5.65E-09	3%	
10/15	1402	16960	142.76	21.06	5.94E-09	0.06	4.11E-09	1.1	4.52E-09	37.75	5.61E-09	1%	
10/16	811	65340	160.93	19.62	4.56E-09	-0.06	4.66E-09	1.1	5.13E-09	42.37	5.55E-09	1%	
10/16	1629	29880	169.23	19.06	4.16E-09	0.00	4.16E-09	1.1	4.58E-09	44.17	5.50E-09	1%	
10/17	842	58380	185.45	17.86	4.51E-09	0.06	4.74E-09	1.1	5.21E-09	47.96	5.45E-09	0%	
10/18	924	88920	210.15	16.13	4.42E-09	0.00	4.42E-09	1.1	4.87E-09	53.56	5.41E-09	1%	
10/19	1635	112260	241.33	14.31	3.56E-09	-0.13	3.42E-09	1.1	3.76E-09	59.43	5.19E-09	4%	
10/20	1840	88700	265.42	13.00	3.46E-09	-0.25	2.80E-09	1.1	3.08E-09	63.64	5.00E-09	4%	
10/21	1643	86580	289.47	12.25	2.00E-09	0.13	2.34E-09	1.1	2.58E-09	66.05	4.80E-09	4%	
10/22	1704	87660	313.82	11.50	1.96E-09	0.00	1.96E-09	1.1	2.16E-09	68.48	4.60E-09	4%	
10/23	1642	85080	337.45	10.89	2.21E-09	0.00	2.21E-09	1.1	2.43E-09	71.06	4.45E-09	3%	
10/24	1543	82860	360.47	9.50	3.36E-09	0.00	3.36E-09	1.1	3.69E-09	74.88	4.40E-09	1%	
10/25	1600	91020	385.75	8.88	1.60E-09	-0.31	8.00E-10	1.1	8.80E-10	76.87	4.17E-09	5%	+1 Hr Daylight
10/26	1510	83400	406.92	7.88	2.83E-09	-0.44	1.58E-09	1.1	1.74E-09	80.09	4.03E-09	3%	Savings Time

END OF TEST TSB-3

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSH-4
Geometric factor-G=0.04030
Depth factor=239.25"
TC values from TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	H1	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (avg)	RPD (Kavg)	Comments
10/09	1616	0	0.00	34.25	-	-	-	-	-	0.00	-	-	START
10/09	1620	3640	1.07	34.06	7.29E-09	0.00	7.29E-09	1.1	8.02E-09	0.61	8.02E-09	-	
10/10	826	57960	17.17	32.13	4.93E-09	-0.12	4.62E-09	1.1	5.08E-09	6.81	5.26E-09	42%	
10/10	1208	13320	20.87	31.81	3.57E-09	-0.19	1.45E-09	1.1	1.59E-09	7.84	4.61E-09	13%	
10/10	1612	14640	24.93	31.75	6.09E-10	0.06	1.22E-09	1.1	1.34E-09	8.03	4.06E-09	12%	
10/11	815	57780	40.98	30.60	3.22E-09	-0.12	2.91E-09	1.1	3.21E-09	12.05	3.74E-09	9%	
10/11	1138	12180	44.37	30.13	4.64E-09	-0.19	2.21E-09	1.1	2.43E-09	17.44	3.64E-09	3%	
10/11	1604	15960	48.80	30.08	6.56E-10	0.06	1.22E-09	1.1	1.34E-09	67.85	3.43E-09	6%	
10/12	754	57000	64.63	29.13	2.45E-09	-0.06	2.29E-09	1.1	2.52E-09	70.84	3.21E-09	7%	
10/12	1200	14760	68.73	28.81	3.26E-09	-0.19	1.32E-09	1.1	1.46E-09	71.57	3.10E-09	3%	
10/13	748	71280	88.53	26.00	1.71E-09	0.00	1.71E-09	1.1	1.88E-09	74.47	2.83E-09	9%	
10/14	625	88620	113.15	25.75	2.13E-09	-0.25	1.70E-09	1.1	1.88E-09	78.48	2.62E-09	6%	
10/15	845	87600	137.48	14.13	2.24E-08	-0.12	2.21E-08	1.1	2.44E-08	119.02	6.47E-09	65%	
10/15	1401	18960	142.75	13.88	2.10E-09	0.12	3.11E-09	1.1	3.42E-09	119.63	6.36E-09	2%	
10/15	1442	60	142.77	34.75	2.10E-09	0.00	3.11E-09	1.1	3.42E-09	119.63	6.36E-09	0%	Refill
10/16	810	62880	160.23	31.25	8.24E-09	-0.12	7.98E-09	1.1	8.75E-09	131.07	6.62E-09	4%	
10/16	1637	29820	168.52	30.12	5.06E-09	-0.07	5.31E-09	1.1	5.84E-09	134.70	6.58E-09	1%	
10/17	841	58440	184.75	28.25	4.80E-09	0.00	4.80E-09	1.1	5.28E-09	140.71	6.45E-09	2%	
10/18	925	89040	209.48	25.89	4.35E-09	-0.06	4.25E-09	1.1	4.67E-09	148.93	6.25E-09	3%	
10/19	932	86820	233.60	23.31	4.19E-09	0.00	4.19E-09	1.1	4.61E-09	156.56	6.06E-09	3%	
10/19	1634	25320	240.63	22.89	3.75E-09	-0.06	3.40E-09	1.1	3.74E-09	158.57	6.01E-09	1%	
10/20	1642	86880	264.77	20.69	3.56E-09	-0.25	3.11E-09	1.1	3.42E-09	165.00	5.78E-09	4%	
10/21	1644	86520	288.80	19.00	3.04E-09	-0.06	2.93E-09	1.1	3.22E-09	170.43	5.57E-09	4%	
10/22	1705	87660	313.15	17.31	3.02E-09	0.00	3.02E-09	1.1	3.32E-09	175.85	5.39E-09	3%	
10/23	1645	85200	336.82	15.63	3.11E-09	0.00	3.11E-09	1.1	3.42E-09	181.25	5.25E-09	3%	
10/24	1545	82800	359.82	13.94	3.24E-09	0.00	3.24E-09	1.1	3.56E-09	186.68	5.14E-09	2%	
10/25	1602	91020	385.10	12.38	2.74E-09	-0.31	2.19E-09	1.1	2.41E-09	191.69	4.96E-09	4%	+1 Hr Daylight
10/26	1504	82920	408.13	10.75	3.16E-09	-0.50	2.19E-09	1.1	2.41E-09	196.93	4.82E-09	3%	Savings Time

END OF TEST TSH-4

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-5
Geometric factor-G=0.04534
Depth factor=153.5"
TC values from TEG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	RL	KI	TC	KtC	visc. factor	KICT	cumulative volume (cc)	K (tvs)	RPD (Ktvs)	Comments
10/10	853	0	0.00	33.50	–	–	–	–	–	0.00	–	–	START
10/10	1232	13140	3.65	33.13	6.53E-09	-0.18	3.51E-09	1.1	3.86E-09	1.19	3.88E-09	–	
10/10	1536	14840	7.72	33.06	1.18E-09	0.12	3.15E-09	1.1	3.47E-09	1.41	3.85E-09	5%	
10/11	833	57420	23.67	30.25	1.20E-08	-0.25	1.09E-08	1.1	1.20E-08	10.44	9.28E-09	67%	
10/11	1159	12360	27.10	29.69	1.12E-08	-0.19	7.39E-09	1.1	8.13E-09	12.24	9.13E-09	2%	
10/11	1608	14940	31.25	29.56	2.16E-09	0.12	4.14E-09	1.1	4.56E-09	12.88	8.53E-09	7%	
10/12	758	57000	47.08	26.94	1.15E-08	0.00	1.15E-08	1.1	1.26E-08	21.07	9.90E-09	15%	
10/12	1203	14700	51.17	26.25	1.18E-08	-0.32	8.33E-09	1.1	6.96E-09	23.29	9.87E-09	2%	
10/12	1541	13080	54.80	26.13	2.31E-09	0.19	5.98E-09	1.1	6.56E-09	23.88	9.46E-09	2%	
10/13	751	58200	70.97	23.56	1.12E-08	-0.12	1.07E-08	1.1	1.16E-08	31.93	9.99E-09	5%	
10/13	1641	31800	79.80	22.61	6.05E-09	0.06	6.54E-09	1.1	7.19E-09	34.34	9.66E-09	3%	
10/14	853	58320	96.00	20.88	6.55E-09	-0.25	7.44E-09	1.1	8.19E-09	40.54	9.43E-09	3%	
10/14	1636	27900	103.75	21.25	-3.4E-09	0.43	5.50E-10	1.1	6.15E-10	39.35	8.77E-09	7%	
10/15	830	57120	119.62	19.00	1.03E-08	-0.50	7.99E-09	1.1	8.70E-09	46.56	8.77E-09	0%	
10/15	1416	20760	125.38	18.75	3.17E-09	0.06	3.93E-09	1.1	4.32E-09	47.38	8.57E-09	2%	
10/16	827	65460	143.57	16.88	7.56E-09	-0.06	7.32E-09	1.1	6.05E-09	53.39	8.50E-09	1%	
10/16	1642	29700	151.82	16.25	5.66E-09	0.00	5.66E-09	1.1	6.22E-09	55.41	8.36E-09	1%	
10/17	825	56580	167.53	14.81	6.83E-09	0.06	7.11E-09	1.1	7.82E-09	60.04	8.32E-09	1%	
10/18	857	88320	192.07	12.88	6.92E-09	0.00	5.92E-09	1.1	6.51E-09	66.24	8.09E-09	3%	
10/19	952	89700	216.98	11.00	5.74E-09	0.19	6.33E-09	1.1	6.96E-09	72.28	7.94E-09	2%	
10/19	1650	25080	223.95	10.56	4.84E-09	-0.13	3.41E-09	1.1	3.75E-09	73.69	7.83E-09	2%	
10/20	1650	86400	247.95	9.00	5.01E-09	-0.25	4.21E-09	1.1	4.63E-09	78.70	7.62E-09	4%	
10/21	1648	86280	271.92	7.94	3.44E-09	0.13	3.58E-09	1.1	4.25E-09	82.11	7.23E-09	4%	
10/22	1709	87660	296.27	6.81	3.63E-09	0.00	3.63E-09	1.1	4.00E-09	85.74	6.97E-09	4%	
10/23	1647	85080	319.90	5.56	4.17E-09	0.00	4.17E-09	1.1	4.59E-09	89.76	6.79E-09	3%	
10/23	1650	180	343.58	34.00	4.17E-09	0.00	4.17E-09	1.1	4.59E-09	89.76	6.79E-09	0%	Refill
10/24	1546	82680	366.55	31.50	7.36E-09	0.00	7.36E-09	1.1	8.10E-09	97.79	6.44E-09	5%	
10/25	1605	91020	391.83	29.88	4.36E-09	-0.31	3.54E-09	1.1	3.89E-09	103.00	6.27E-09	3%	+1 Hr Daylight
10/26	1625	87600	418.17	28.13	4.98E-09	-0.44	3.71E-09	1.1	4.56E-09	108.62	6.14E-09	2%	Savings Time
10/27	805	56400	431.83	27.06	4.75E-09	0.06	5.02E-09	1.1	5.52E-09	112.06	6.12E-09	0%	
10/27	1110	11100	434.92	26.75	7.82E-09	-0.19	2.72E-09	1.1	2.99E-09	113.06	6.10E-09	0%	END OF TEST TS

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-6
Geometric factor-G=0.04534
Depth factor=231.5"
TC values from TSG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Ht	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (two)	RPD (K two)	Comments
10/10	923	0	0.00	33.62	-	-	-	-	-	0.00	-	-	START
10/10	959	2160	0.60	33.00	4.91E-08	0.00	4.91E-08	1.1	5.41E-08	1.99	5.41E-08	-	
10/10	1234	9300	3.18	31.31	3.13E-08	-0.19	2.77E-08	1.1	3.05E-08	7.42	3.49E-08	43%	
10/10	1636	14640	7.25	29.88	1.69E-08	0.08	1.76E-08	1.1	1.94E-08	12.01	2.62E-08	29%	
10/11	632	57240	23.15	26.50	1.03E-08	-0.12	9.24E-09	1.1	1.02E-08	22.67	1.57E-08	50%	
10/11	1200	12480	26.62	26.08	6.20E-09	-0.19	3.52E-09	1.1	3.87E-09	24.29	1.42E-08	10%	
10/11	1609	14940	30.77	25.88	2.12E-09	0.08	2.83E-09	1.1	3.11E-09	24.86	1.27E-08	11%	
10/12	759	57000	46.60	23.25	8.17E-09	-0.06	7.98E-09	1.1	8.76E-09	33.31	1.14E-08	11%	
10/12	1204	14700	50.68	22.88	4.48E-09	-0.19	2.18E-09	1.1	2.40E-09	34.50	1.06E-08	7%	
10/12	1542	13080	54.32	22.81	9.54E-10	0.12	2.59E-09	1.1	2.85E-09	34.73	1.01E-08	5%	
10/13	752	58200	70.48	20.25	7.86E-09	-0.12	7.51E-09	1.1	8.26E-09	42.95	9.69E-09	4%	
10/13	1643	31860	79.33	19.75	2.43E-09	-0.31	1.07E-09	1.1	1.18E-09	44.58	8.74E-09	10%	
10/14	854	58260	95.52	17.62	6.83E-09	0.04	6.81E-09	1.1	7.49E-09	51.40	8.63E-09	2%	
10/14	1639	27900	103.27	17.94	6.63E-09	0.36	3.91E-10	1.1	4.31E-10	50.37	7.92E-09	7%	
10/15	831	57120	119.13	15.83	7.30E-09	-0.50	5.78E-09	1.1	6.36E-09	57.79	7.71E-09	3%	
10/15	1416	20700	124.88	15.36	2.22E-09	0.12	3.28E-09	1.1	3.61E-09	58.59	7.52E-09	2%	
10/16	826	65400	143.05	13.00	6.72E-09	-0.12	6.38E-09	1.1	7.01E-09	66.24	7.46E-09	1%	
10/16	1627	29820	151.33	12.13	5.42E-09	-0.07	4.98E-09	1.1	5.48E-09	69.04	7.35E-09	1%	
10/17	841	58580	167.05	10.25	6.21E-09	0.00	6.21E-09	1.1	6.83E-09	75.07	7.30E-09	1%	
10/18	858	86820	191.58	7.94	4.93E-09	-0.06	4.80E-09	1.1	5.28E-09	82.50	7.04E-09	4%	
10/19	953	89700	216.50	5.50	5.18E-09	0.00	5.18E-09	1.1	5.70E-09	90.33	6.89E-09	2%	
10/19	953	0	216.50	31.44	5.18E-09	0.00	5.18E-09	1.1	5.70E-09	90.33	6.89E-09	0%	Refill
10/19	1650	25020	223.45	30.63	6.50E-09	-0.06	5.16E-09	1.1	5.69E-09	92.93	6.85E-09	1%	
10/20	1650	86400	247.45	28.31	4.67E-09	-0.25	4.16E-09	1.1	4.58E-09	100.38	6.63E-09	3%	
10/21	1651	86460	271.47	26.38	3.91E-09	-0.06	3.79E-09	1.1	4.17E-09	106.56	6.41E-09	3%	
10/22	1711	88824	296.14	24.36	3.97E-09	0.00	3.97E-09	1.1	4.37E-09	113.01	6.24E-09	3%	
10/23	1646	85020	319.76	22.38	4.18E-09	0.00	4.18E-09	1.1	4.60E-09	119.43	6.12E-09	2%	
10/24	1549	82860	342.77	20.50	4.07E-09	0.00	4.07E-09	1.1	4.47E-09	125.47	6.01E-09	2%	+1 Hr Daylight
10/25	1607	91080	368.07	18.50	3.97E-09	-0.31	3.35E-09	1.1	3.68E-09	131.90	5.85E-09	3%	Savings Time
10/26	1627	87600	392.41	16.31	4.55E-09	-0.50	3.51E-09	1.1	3.86E-09	136.93	5.73E-09	2%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-6
Geometric factor-G=0.04534
Depth factor=231.5"
TC values from TSG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	H1	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (tsm)	RPD (K1vs)	Comments
10/27	804	56220	408.02	14.88	4.57E-09	-0.25	3.65E-09	1.1	4.23E-09	143.53	5.67E-09	1%	
10/27	1125	12060	411.37	14.83	3.82E-09	-0.07	2.75E-09	1.1	3.02E-09	144.33	6.05E-09	0%	

END OF TEST TSB-6

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-7
Geometric factor-G=0.04534
Depth factor=161.25"
TC values from TEG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	H1	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (tsm)	RPD (Ktsm)	Comments
10/09	1112	0	0.00	33.50	-	-	-	-	-	0.00	-	-	START
10/09	1450	13080	3.63	33.31	3.36E-09	-0.06	1.96E-09	1.1	2.15E-09	0.61	2.15E-09	-	
10/10	836	63960	21.40	31.67	4.66E-09	-0.13	4.79E-09	1.1	5.27E-09	5.24	4.74E-09	75%	
10/10	1228	13920	25.27	31.63	3.56E-09	-0.16	1.01E-09	1.1	1.11E-09	6.01	4.16E-09	12%	
10/10	1632	14640	29.33	31.50	1.85E-09	0.12	4.02E-09	1.1	4.42E-09	6.42	4.22E-09	1%	
10/11	829	57420	45.28	30.25	4.54E-09	-0.25	4.11E-09	1.1	4.52E-09	10.44	4.32E-09	2%	
10/11	1141	11520	48.48	30.06	3.45E-09	-0.19	4.11E-09	1.1	4.52E-09	11.05	4.34E-09	0%	
10/11	1611	16200	52.98	29.94	1.55E-09	0.12	3.51E-09	1.1	3.86E-09	11.44	4.30E-09	1%	
10/12	800	56940	68.80	29.06	3.25E-09	0.00	3.67E-09	1.1	4.04E-09	14.24	4.24E-09	1%	
10/12	1205	14700	72.88	28.88	2.56E-09	-0.32	3.67E-09	1.1	4.04E-09	14.84	4.23E-09	0%	
10/12	1543	13080	76.52	28.88	2.56E-09	0.19	3.47E-09	1.1	3.81E-09	14.84	4.21E-09	0%	
10/13	754	58260	92.70	27.88	3.63E-09	-0.12	3.61E-09	1.1	3.97E-09	18.05	4.17E-09	1%	
10/13	1645	31860	101.55	27.75	8.65E-10	0.06	1.43E-09	1.1	1.57E-09	18.47	3.94E-09	6%	
10/14	850	57900	117.63	26.81	3.45E-09	-0.25	2.86E-09	1.1	3.15E-09	21.49	3.83E-09	3%	
10/14	1635	27900	125.38	27.19	3.45E-09	0.43	4.32E-10	1.1	4.75E-10	20.27	3.62E-09	6%	
10/15	834	57540	141.37	26.13	3.93E-09	-0.50	2.35E-09	1.1	2.58E-09	23.66	3.51E-09	3%	
10/15	1413	20340	147.02	26.06	7.36E-10	0.06	1.55E-09	1.1	1.70E-09	23.90	3.44E-09	2%	
10/16	823	65400	165.18	25.00	3.45E-09	-0.06	3.71E-09	1.1	4.08E-09	27.31	3.51E-09	2%	
10/16	1640	29520	173.47	24.62	2.75E-09	0.00	3.11E-09	1.1	3.42E-09	28.53	3.50E-09	0%	
10/17	831	57060	189.32	23.88	2.80E-09	0.06	3.43E-09	1.1	3.77E-09	30.90	3.53E-09	1%	
10/18	900	88140	213.80	22.75	2.75E-09	0.00	3.15E-09	1.1	3.46E-09	34.53	3.52E-09	0%	
10/19	950	89400	238.63	21.75	2.44E-09	0.19	3.29E-09	1.1	3.62E-09	37.75	3.53E-09	0%	
10/19	1645	24900	245.55	21.50	2.20E-09	-0.13	1.19E-09	1.1	1.31E-09	38.55	3.47E-09	2%	
10/20	1654	86940	269.70	20.56	2.36E-09	-0.25	1.97E-09	1.1	2.17E-09	41.57	3.35E-09	3%	
10/21	1654	86400	293.70	19.88	1.74E-09	0.13	2.34E-09	1.1	2.58E-09	43.75	3.29E-09	2%	
10/22	1713	87540	318.02	19.19	1.75E-09	0.00	1.98E-09	1.1	2.17E-09	45.97	3.20E-09	3%	
10/23	1655	85320	341.72	18.38	2.11E-09	-	2.39E-09	1.1	2.63E-09	48.57	3.16E-09	1%	
10/24	1552	82620	364.67	17.50	2.36E-09	0.19	3.28E-09	1.1	3.61E-09	51.40	3.19E-09	1%	
10/25	1606	90960	389.93	16.75	1.65E-09	-0.31	1.23E-09	1.1	1.35E-09	53.81	3.07E-09	4%	+1 Hr Daylight
10/26	1626	87600	414.27	15.75	2.58E-09	-0.44	1.63E-09	1.1	1.79E-09	57.02	3.00E-09	2%	Savings Time
10/27	807	56340	429.92	15.25	2.01E-09	0.06	2.55E-09	1.1	2.81E-09	58.63	2.99E-09	0%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-7
Geometric factor-G=0.04634
Depth factor=161.25"
TC values from TEC-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twm)	RPD (K1 vs)	Comments
10/27	930	4980	431.30	15.25	0.00E+00	0.06	3.10E-09	1.1	3.41E-09	68.63	2.90E-09	0%	

END OF TEST TSB-7

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-8
Geometric factor-G=0.04534
Depth factor=237.0"
TC values from TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	RL	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (ave)	RPD (K ave)	Comments
10/09	1110	0	0.00	33.62	–	–	–	–	–	0.00	–	–	START
10/09	1458	13680	3.80	33.31	3.80E-09	0.00	3.80E-09	1.1	4.18E-09	1.00	4.18E-09	–	
10/10	837	63540	21.45	31.08	5.96E-09	0.00	5.96E-09	1.1	6.56E-09	8.22	5.14E-09	38%	
10/10	1229	13920	25.32	30.75	3.77E-09	-0.19	1.48E-09	1.1	1.60E-09	9.22	5.45E-09	12%	
10/10	1633	14640	29.38	29.63	1.30E-08	0.06	1.37E-08	1.1	1.50E-08	12.82	6.77E-09	22%	
10/11	830	57420	45.33	27.83	5.95E-09	-0.12	5.69E-09	1.1	6.15E-09	19.24	6.55E-09	3%	
10/11	1142	11520	48.53	27.31	4.78E-09	-0.19	1.93E-09	1.1	2.13E-09	20.27	6.28E-09	5%	
10/11	1612	16200	53.03	27.19	1.27E-09	0.06	1.91E-09	1.1	2.10E-09	20.86	5.91E-09	6%	
10/12	801	56940	68.85	25.88	3.96E-09	-0.06	3.78E-09	1.1	4.16E-09	24.86	5.51E-09	7%	
10/12	1206	14700	72.93	25.63	2.93E-09	-0.19	7.04E-10	1.1	7.74E-10	25.67	5.24E-09	5%	
10/12	1544	13080	76.57	25.60	-7.96E-10	0.12	7.92E-10	1.1	8.71E-10	26.47	5.03E-09	4%	
10/13	755	58260	92.75	24.38	3.89E-09	-0.12	3.53E-09	1.1	3.89E-09	29.66	4.83E-09	4%	
10/14	852	89820	117.70	23.06	2.58E-09	-0.25	2.07E-09	1.1	2.28E-09	33.92	4.29E-09	12%	
10/15	833	85260	141.38	22.06	2.05E-09	-0.12	1.80E-09	1.1	1.98E-09	37.14	3.90E-09	9%	
10/15	1414	20460	147.07	22.00	5.13E-10	0.12	1.54E-09	1.1	1.69E-09	37.33	3.82E-09	2%	
10/16	824	65400	165.23	20.31	4.54E-09	-0.12	4.22E-09	1.1	4.64E-09	42.76	3.91E-09	2%	
10/16	1640	29760	173.50	19.63	4.03E-09	-0.07	3.62E-09	1.1	3.98E-09	44.94	3.91E-09	0%	
10/17	830	57000	189.33	18.44	3.70E-09	0.00	3.70E-09	1.1	4.07E-09	48.76	3.93E-09	0%	
10/18	900	88200	213.83	16.88	3.15E-09	-0.06	3.03E-09	1.1	3.33E-09	53.78	3.86E-09	2%	
10/19	950	89400	238.67	15.38	3.01E-09	0.00	3.01E-09	1.1	3.31E-09	58.59	3.50E-09	1%	
10/19	1647	25020	245.62	15.00	2.73E-09	-0.06	2.30E-09	1.1	2.53E-09	59.82	3.76E-09	1%	
10/20	1655	86880	269.75	13.89	2.72E-09	-0.25	2.20E-09	1.1	2.42E-09	64.02	3.64E-09	3%	
10/21	1655	86400	293.75	11.19	5.26E-09	-0.06	5.13E-09	1.1	5.65E-09	72.06	3.81E-09	4%	
10/22	1715	87600	318.08	9.25	4.06E-09	0.00	4.06E-09	1.1	4.47E-09	78.29	3.86E-09	1%	
10/23	1657	85320	341.78	7.25	4.33E-09	–	4.33E-09	1.1	4.77E-09	84.71	3.92E-09	2%	
10/24	1648	82260	364.63	5.50	3.96E-09	–	3.96E-09	1.1	4.36E-09	90.33	3.95E-09	1%	
10/25	1610	91320	390.00	3.94	3.20E-09	-0.31	2.57E-09	1.1	2.82E-09	95.35	3.88E-09	2%	+1 Hr Daylight
10/26	1629	87540	414.32	2.00	4.19E-09	-0.50	3.10E-09	1.1	3.42E-09	101.56	3.85E-09	1%	Savings Time
10/26	1632	180	414.37	22.38	4.19E-09	0.00	3.10E-09	1.1	3.41E-09	101.58	3.85E-09	0%	Refill
10/27	806	56040	429.93	20.50	5.89E-09	-0.25	4.57E-09	1.1	5.03E-09	107.62	3.89E-09	1%	
10/27	930	5040	431.33	20.50	5.89E-09	-0.25	4.57E-09	1.1	5.03E-09	114.04	3.59E-09	0%	Repeat

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-9
Geometric factor-G=0.04030
Depth factor=160.0"
TC values from TEG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (tw)	RPD (Ktw)	Comments
10/07	836	0	0.00	35.25	–	–	–	–	–	0.00	–	–	START
10/07	1109	12780	3.55	35.30	-8.1E-10	–	-8.1E-10	1.1	-8.9E-10	-0.16	-8.88E-10	–	
10/07	1720	22260	9.73	35.20	9.27E-10	–	9.27E-10	1.1	1.02E-09	0.16	3.24E-10	-430%	
10/08	732	51120	23.93	33.75	5.88E-09	–	5.88E-09	1.1	6.47E-09	4.82	3.97E-09	170%	
10/08	1214	16920	28.63	33.19	6.89E-09	–	6.89E-09	1.1	7.58E-09	6.82	4.55E-09	14%	
10/08	1544	12600	32.13	32.81	6.30E-09	-0.05	5.47E-09	1.1	6.01E-09	7.54	4.72E-09	3%	
10/09	815	59460	48.66	30.94	6.61E-09	-0.35	5.26E-09	1.1	5.78E-09	13.85	5.06E-09	7%	
10/09	1005	6600	50.48	30.88	6.32E-09	-0.13	4.16E-09	1.1	4.57E-09	14.58	5.06E-09	0%	
10/09	1541	20160	56.08	30.25	4.51E-09	-0.06	3.67E-09	1.1	4.04E-09	16.06	4.96E-09	2%	
10/10	830	60540	72.90	28.12	7.49E-09	-0.13	7.03E-09	1.1	7.74E-09	22.90	5.60E-09	12%	
10/10	1220	13800	76.73	27.83	7.62E-09	-0.18	4.82E-09	1.1	5.30E-09	24.48	5.59E-09	0%	
10/10	1620	14400	80.73	27.38	3.73E-09	0.12	5.52E-09	1.1	6.08E-09	25.28	5.61E-09	0%	
10/11	824	57840	96.80	24.89	1.01E-08	-0.25	9.13E-09	1.1	1.00E-08	33.92	6.25E-09	12%	
10/11	1153	12540	100.28	24.25	7.67E-09	-0.19	4.35E-09	1.1	4.79E-09	35.34	6.29E-09	1%	
10/11	1623	16200	104.78	23.81	5.96E-09	0.12	7.57E-09	1.1	8.33E-09	38.76	6.30E-09	1%	
10/12	815	57120	120.65	21.50	6.92E-09	0.00	8.02E-09	1.1	8.82E-09	44.17	6.83E-09	7%	
10/12	1215	14400	124.65	21.00	7.72E-09	-0.32	2.78E-09	1.1	3.06E-09	45.78	6.71E-09	2%	
10/12	1553	13080	128.28	20.63	8.30E-09	0.19	9.56E-09	1.1	1.05E-08	48.97	6.82E-09	2%	
10/13	807	58440	144.52	18.19	9.36E-09	-0.12	8.91E-09	1.1	9.81E-09	54.80	7.15E-09	5%	
10/13	1702	32100	153.43	17.31	6.22E-09	0.08	6.64E-09	1.1	7.30E-09	57.63	7.16E-09	0%	
10/14	828	55560	168.87	15.06	9.26E-09	-0.25	8.23E-09	1.1	9.05E-09	64.56	7.33E-09	2%	
10/14	1612	27840	176.60	14.50	4.54E-09	0.43	8.21E-09	1.1	9.03E-09	66.86	7.41E-09	1%	
10/15	837	59100	193.02	11.88	1.03E-08	-0.49	8.37E-09	1.1	9.21E-09	75.07	7.56E-09	2%	
10/15	1409	19920	198.55	11.25	7.43E-09	0.06	8.14E-09	1.1	8.95E-09	77.10	7.60E-09	1%	
10/16	819	65400	216.72	8.63	9.50E-09	-0.08	9.28E-09	1.1	1.02E-08	85.52	7.82E-09	3%	
10/16	1636	29820	225.00	7.38	1.01E-08	0.00	1.01E-08	1.1	1.11E-08	89.53	7.94E-09	2%	
10/17	834	57480	240.97	5.12	9.53E-09	0.06	9.79E-09	1.1	1.08E-08	96.79	8.13E-09	2%	
10/18	905	88260	265.48	1.88	9.05E-09	0.00	9.05E-09	1.1	9.95E-09	107.20	8.30E-09	2%	
10/18	906	88320	290.02	33.81	9.05E-09	0.00	9.05E-09	1.1	9.05E-09	107.20	8.36E-09	1%	Refill
10/19	1642	113760	321.62	27.88	1.10E-08	-0.13	1.06E-08	1.1	1.16E-08	128.25	8.70E-09	4%	
10/20	1702	87600	345.95	23.94	9.75E-09	-0.25	9.13E-09	1.1	1.00E-08	135.91	8.79E-09	1%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-9
Geometric factor=G=0.04030
Depth factor=160.0"
TC values from TEG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (Ktwa)	Comments
10/21	1707	86700	370.03	20.44	8.93E-09	0.13	9.26E-09	1.1	1.02E-08	150.15	8.59E-09	1%	
10/22	1725	87660	394.38	17.05	8.69E-09	0.00	8.69E-09	1.1	9.56E-09	161.01	8.93E-09	0%	
10/23	1710	85320	418.08	13.81	8.75E-09	–	8.75E-09	1.1	9.63E-09	171.45	8.97E-09	0%	
10/24	1610	82800	441.08	10.63	8.99E-09	–	8.99E-09	1.1	9.89E-09	181.66	9.02E-09	1%	
10/25	1625	90900	466.33	7.38	8.53E-09	-0.31	7.71E-09	1.1	8.48E-09	192.10	8.99E-09	0%	+1 Hr Daylight
10/26	1620	86100	490.25	4.13	9.16E-09	-0.44	7.92E-09	1.1	8.72E-09	202.55	8.97E-09	0%	Savings Time
10/26	1523	180	490.30	27.75	9.16E-09	0.00	7.92E-09	1.1	8.72E-09	202.55	8.97E-09	0%	Refill
10/27	813	57000	506.13	24.88	1.09E-08	0.08	1.11E-08	1.1	1.22E-08	211.77	9.07E-09	1%	

END OF TEST TSB-9

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-10
Geometric factor-G=0.04634
Depth factor=165.25"
TC values from TEG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	R1	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (Ktwa)	Comments
10/08	749	0	0.00	35.06	–	–	–	–	–	0.00	–	–	START
10/08	1032	9780	2.72	34.31	1.56E-08	–	1.56E-08	1.1	1.74E-08	2.41	1.74E-08	–	
10/08	1215	6180	4.43	33.58	2.51E-08	–	2.51E-08	1.1	2.76E-08	4.82	2.13E-08	20%	
10/08	1544	12540	7.92	33.00	9.27E-09	-0.05	8.44E-09	1.1	9.28E-09	6.82	1.60E-08	26%	
10/09	816	59520	24.45	30.31	9.45E-09	-0.38	6.11E-09	1.1	6.92E-09	15.28	1.12E-08	35%	
10/09	1006	6600	26.28	30.00	9.89E-09	-0.13	5.74E-09	1.1	6.31E-09	16.25	1.09E-08	3%	
10/09	1542	20160	31.88	29.44	6.66E-09	-0.06	5.02E-09	1.1	5.52E-09	16.05	9.94E-09	9%	
10/10	831	60540	48.70	27.00	8.56E-09	-0.13	6.10E-09	1.1	6.91E-09	25.69	9.56E-09	4%	
10/10	1222	13860	52.55	26.63	5.71E-09	-0.16	2.93E-09	1.1	3.22E-09	27.06	9.12E-09	5%	
10/10	1622	14400	56.56	26.25	6.65E-09	0.12	7.44E-09	1.1	8.18E-09	26.30	9.05E-09	1%	
10/11	826	57780	72.60	23.75	9.33E-09	-0.25	8.39E-09	1.1	9.23E-09	36.33	9.09E-09	0%	
10/11	1154	12540	76.08	23.31	7.62E-09	-0.19	4.33E-09	1.1	4.76E-09	37.76	8.69E-09	2%	
10/11	1624	16200	80.58	23.06	3.36E-09	0.12	4.97E-09	1.1	5.47E-09	38.55	8.70E-09	2%	
10/12	816	57120	96.45	20.88	8.35E-09	0.00	8.36E-09	1.1	9.19E-09	45.55	8.78E-09	1%	
10/12	1218	14400	100.45	20.44	6.73E-09	-0.32	1.83E-09	1.1	2.02E-09	46.97	8.51E-09	3%	
10/12	1563	13020	104.07	20.38	1.02E-09	0.19	4.24E-09	1.1	4.66E-09	47.16	8.36E-09	2%	
10/13	807	58440	120.30	18.06	8.50E-09	-0.12	8.35E-09	1.1	9.18E-09	54.61	8.49E-09	1%	
10/13	1700	31980	129.18	17.75	2.16E-09	0.06	2.58E-09	1.1	2.84E-09	55.61	8.10E-09	5%	
10/14	832	55920	144.72	15.75	8.03E-09	-0.25	7.02E-09	1.1	7.72E-09	62.03	8.08E-09	1%	
10/14	1632	28800	152.72	16.00	-2.0E-09	0.43	1.41E-09	1.1	1.55E-09	61.23	7.72E-09	4%	
10/15	836	57960	168.82	13.56	9.54E-09	-0.49	7.52E-09	1.1	8.38E-09	69.07	7.78E-09	1%	
10/15	1408	19800	174.32	13.38	2.07E-09	0.06	2.77E-09	1.1	3.04E-09	69.65	7.53E-09	2%	
10/16	818	65400	192.48	11.19	7.59E-09	-0.06	7.47E-09	1.1	8.22E-09	76.68	7.60E-09	1%	
10/16	1636	29880	200.78	10.25	7.28E-09	0.00	7.28E-09	1.1	8.01E-09	79.70	7.70E-09	0%	
10/17	835	57540	216.77	8.44	7.33E-09	0.06	7.57E-09	1.1	8.33E-09	85.52	7.75E-09	1%	
10/18	910	88500	241.35	6.00	6.49E-09	0.00	6.49E-09	1.1	7.14E-09	93.35	7.65E-09	1%	
10/18	911	60	241.37	31.50	6.49E-09	0.00	6.49E-09	1.1	7.14E-09	93.35	7.66E-09	0%	Refill
10/19	940	88140	265.85	28.50	7.17E-09	0.19	7.63E-09	1.1	8.39E-09	102.99	7.75E-09	1%	
10/19	1642	25320	272.88	27.44	8.90E-09	-0.13	7.81E-09	1.1	8.59E-09	106.39	7.77E-09	0%	
10/20	1704	87720	297.26	24.81	6.43E-09	-0.25	5.82E-09	1.1	6.40E-09	114.84	7.66E-09	1%	
10/21	1706	86640	321.32	22.75	5.16E-09	0.13	5.46E-09	1.1	6.03E-09	121.46	7.54E-09	2%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-10
Geometric factor-G=0.04634
Depth factor=165.25"
TC values from TBC-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	R1	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (Ktwa)	Comments
10/22	1729	87660	345.67	20.60	5.16E-09	0.00	5.15E-09	1.1	5.66E-09	128.08	7.41E-09	2%	
10/23	1711	85320	369.37	18.44	5.54E-09	-	5.54E-09	1.1	6.42E-09	135.30	7.34E-09	1%	
10/24	1613	82920	392.40	16.25	5.91E-09	-	5.91E-09	1.1	6.50E-09	142.34	7.29E-09	1%	
10/25	1626	90780	417.62	14.00	5.61E-09	-0.31	4.83E-09	1.1	5.32E-09	149.57	7.17E-09	2%	+1 Hr Daylight
10/26	1620	86040	441.62	11.69	6.16E-09	-0.44	4.97E-09	1.1	5.47E-09	156.99	7.06E-09	1%	Savings Time
10/27	813	57160	457.40	10.06	6.59E-09	0.06	6.83E-09	1.1	7.52E-09	162.22	7.10E-09	0%	

END OF TEST TSB-10

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TBB-11
Geometric factor-G=0.04030
Depth factor=234.75"
TC values from TBG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	RI	KI	TC	KI C	visc. factor	KI CT	cumulative volume (cc)	K (lm)	RPD (KI,m)	Comments
10/06	0	0	0.00	33.75	–	–	–	–	–	0.00	–	–	START
10/08	1216	16860	4.68	32.87	7.85E-09	0.00	7.85E-09	1.1	8.63E-09	2.83	8.63E-09	–	
10/08	1645	12540	8.17	32.56	3.72E-09	0.00	3.72E-09	1.1	4.10E-09	3.52	6.70E-09	25%	
10/09	816	59460	24.68	30.87	4.30E-09	-0.32	3.48E-09	1.1	3.83E-09	8.25	4.76E-09	33%	
10/09	1007	6660	26.53	30.66	4.33E-09	-0.12	1.59E-09	1.1	1.75E-09	9.66	4.57E-09	5%	
10/09	1542	20100	32.12	30.38	2.27E-09	0.00	2.27E-09	1.1	2.49E-09	10.83	4.21E-09	8%	
10/10	832	60600	48.95	28.94	3.62E-09	-0.12	3.32E-09	1.1	3.65E-09	15.45	4.02E-09	5%	
10/10	1225	13980	52.83	28.69	2.73E-09	-0.19	6.56E-10	1.1	7.22E-10	16.25	3.77E-09	6%	
10/10	1625	14400	56.83	28.50	2.02E-09	0.06	2.66E-09	1.1	2.92E-09	16.57	3.71E-09	2%	
10/11	826	57660	72.85	26.94	4.15E-09	-0.12	3.83E-09	1.1	4.22E-09	21.88	3.82E-09	3%	
10/11	1155	12540	76.33	26.69	3.07E-09	-0.19	7.37E-10	1.1	8.11E-10	22.66	3.69E-09	4%	
10/11	1626	16260	80.85	26.54	1.23E-09	0.06	1.80E-09	1.1	1.98E-09	23.10	3.59E-09	3%	
10/12	817	57060	96.70	25.38	3.20E-09	-0.06	3.03E-09	1.1	3.34E-09	26.89	3.55E-09	1%	
10/12	1216	14340	100.68	26.00	4.11E-09	-0.19	2.05E-09	1.1	2.26E-09	28.11	3.50E-09	1%	
10/12	1554	13080	104.32	26.00	0.00E+00	0.12	1.42E-09	1.1	1.57E-09	28.11	3.43E-09	2%	
10/13	808	58440	120.55	23.50	3.90E-09	-0.12	3.67E-09	1.1	4.04E-09	32.93	3.51E-09	2%	
10/14	833	87900	144.97	22.25	2.22E-09	-0.25	1.78E-09	1.1	1.96E-09	36.04	3.25E-09	6%	
10/14	1630	28620	152.92	22.58	-1.7E-09	0.35	3.84E-10	1.1	4.22E-10	35.96	3.40E-09	5%	
10/15	839	58140	169.07	21.00	4.22E-09	-0.50	2.86E-09	1.1	3.15E-09	40.96	3.11E-09	0%	
10/15	1408	19740	174.55	20.94	4.70E-10	0.12	1.44E-09	1.1	1.58E-09	41.46	3.08E-09	2%	
10/16	817	65340	192.70	19.50	3.48E-09	-0.12	3.19E-09	1.1	3.51E-09	45.78	3.10E-09	1%	
10/16	1635	29880	201.00	19.00	2.65E-09	-0.07	2.28E-09	1.1	2.51E-09	47.36	3.06E-09	1%	
10/17	835	57600	217.00	17.38	3.09E-09	0.00	3.09E-09	1.1	3.40E-09	50.98	3.10E-09	1%	
10/18	912	88620	241.62	16.38	2.71E-09	-0.06	2.60E-09	1.1	2.86E-09	55.80	3.08E-09	1%	
10/19	940	88080	266.08	14.88	2.74E-09	0.00	2.74E-09	1.1	3.02E-09	60.62	3.07E-09	0%	
10/19	1641	25260	273.10	14.50	2.43E-09	-0.06	2.05E-09	1.1	2.25E-09	61.84	3.05E-09	1%	
10/20	1706	87900	297.52	13.10	2.42E-09	-0.25	1.95E-09	1.1	2.15E-09	66.05	2.98E-09	2%	
10/21	1709	86580	321.57	12.25	1.77E-09	-0.06	1.65E-09	1.1	1.82E-09	69.07	2.89E-09	3%	
10/22	1730	87660	345.92	11.25	1.87E-09	0.00	1.87E-09	1.1	2.05E-09	72.28	2.83E-09	2%	
10/23	1715	85500	369.67	10.25	1.92E-09	–	1.92E-09	1.1	2.11E-09	75.49	2.79E-09	2%	
10/24	1615	82800	392.67	9.25	1.99E-09	–	1.99E-09	1.1	2.19E-09	78.70	2.75E-09	1%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-11
Geometric factor-G=0.04030
Depth factor=234.75"
TC values from TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Ht	Kt	TC	KtC	visc. factor	KtCT	cumulative volume (cc)	K (tm)	RPD (Ktm)	Comments
10/25	1630	00900	417.92	6.25	1.62E-09	-0.31	1.28E-09	1.1	1.36E-09	81.92	2.57E-09	3%	+1 Hr Daylight
10/26	1621	85860	441.77	7.00	2.42E-09	-0.50	1.45E-09	1.1	1.50E-09	85.93	2.61E-09	2%	Savings Time
10/27	813	57120	457.63	6.25	2.19E-09	-0.25	1.46E-09	1.1	1.51E-09	88.34	2.57E-09	1%	

END OF TEST TSB-11

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-12
Geometric factor-G=0.04534
Depth factor=266.0"
TC values from TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	H1	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (tws)	RPD (K1ws)	Comments
10/06	1057	0	0.00	31.00	–	–	–	–	–	0.00	–	–	START
10/06	1230	5580	1.55	28.38	7.20E-08	0.00	7.20E-08	1.1	7.92E-08	6.42	7.92E-08	–	
10/06	1716	17160	6.32	28.36	1.80E-10	0.00	1.80E-10	1.1	1.97E-10	8.46	1.06E-08	121%	
10/09	819	54180	21.37	27.38	2.70E-09	-0.32	1.88E-09	1.1	2.07E-09	11.63	7.24E-09	92%	
10/09	1212	13980	25.25	27.06	3.54E-09	-0.12	2.21E-09	1.1	2.43E-09	12.86	6.50E-09	11%	
10/09	1614	14520	29.28	27.06	3.54E-09	0.00	3.54E-09	1.1	3.89E-09	12.88	6.15E-09	6%	Repeated value
10/10	856	60120	45.98	26.12	2.43E-09	-0.12	2.11E-09	1.1	2.32E-09	15.86	4.78E-09	25%	
10/11	650	68040	69.88	24.94	2.13E-09	-0.26	1.68E-09	1.1	1.85E-09	19.47	3.78E-09	23%	
10/11	1130	9600	72.55	24.81	2.11E-09	-0.12	1.62E-10	1.1	1.79E-10	19.89	3.63E-09	4%	
10/12	745	72900	92.80	24.13	1.46E-09	0.00	1.46E-09	1.1	1.80E-09	22.07	3.19E-09	13%	
10/12	1149	14640	96.87	23.88	2.87E-09	-0.12	1.30E-09	1.1	1.53E-09	22.87	3.12E-09	2%	
10/13	740	71460	116.72	23.31	1.25E-09	-0.12	9.88E-10	1.1	1.08E-09	24.70	2.77E-09	12%	
10/14	906	91560	142.15	22.25	1.82E-09	-0.25	1.39E-09	1.1	1.53E-09	28.11	2.55E-09	8%	
10/15	618	83520	166.36	21.75	9.42E-10	-0.12	7.16E-10	1.1	7.88E-10	29.72	2.30E-09	10%	
10/16	656	88680	189.98	21.56	3.38E-10	0.00	3.38E-10	1.1	3.71E-10	30.33	2.05E-09	11%	
10/16	1652	28560	197.92	20.25	7.25E-09	-0.07	6.86E-09	1.1	7.55E-09	34.53	2.27E-09	10%	
10/17	612	55200	213.25	19.25	2.87E-09	0.00	2.87E-09	1.1	3.16E-09	37.75	2.34E-09	3%	
10/18	844	88320	237.78	17.94	2.36E-09	-0.06	2.25E-09	1.1	2.48E-09	41.86	2.35E-09	1%	
10/19	1006	91440	263.18	16.63	2.29E-09	0.00	2.29E-09	1.1	2.52E-09	46.16	2.37E-09	1%	
10/19	1657	24540	270.00	16.38	1.84E-09	-0.06	1.24E-09	1.1	1.37E-09	46.97	2.34E-09	1%	
10/20	1630	84780	293.55	15.31	2.03E-09	-0.25	1.56E-09	1.1	1.71E-09	50.40	2.29E-09	2%	
10/21	1625	86160	317.48	14.50	1.52E-09	-0.06	1.40E-09	1.1	1.55E-09	53.01	2.24E-09	2%	
10/22	1656	88200	341.98	13.59	1.49E-09	0.00	1.49E-09	1.1	1.64E-09	55.61	2.19E-09	2%	
10/23	1630	84840	365.55	12.63	2.03E-09	–	2.03E-09	1.1	2.23E-09	59.01	2.19E-09	0%	Replacement
10/24	1530	82800	388.55	11.50	2.23E-09	–	2.23E-09	1.1	2.45E-09	62.84	2.21E-09	1%	TEC Stabiling
10/25	1551	91260	413.90	10.63	1.56E-09	-0.31	1.00E-09	1.1	1.10E-09	65.44	2.14E-09	3%	+1 Hr Daylight
10/26	824	59580	430.45	9.50	3.11E-09	-0.35	2.15E-09	1.1	2.36E-09	69.07	2.15E-09	0%	Savings Time

END OF TEST TSB-12

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-13
Geometric factor-G=0.04030
Depth factor=356.5"
TC values from TBG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	H1	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (Ktwa)	Comments
10/08	1018	0	0.00	34.12	–	–	–	–	–	0.00	–	–	START
10/08	1233	8100	2.25	32.80	1.82E-08	0.00	1.82E-08	1.1	2.01E-08	4.59	2.01E-08	–	
10/08	1717	17040	6.98	31.75	5.71E-09	0.00	5.71E-09	1.1	6.29E-09	7.81	1.07E-08	61%	
10/09	820	54180	22.03	29.13	5.03E-09	-0.32	4.42E-09	1.1	4.86E-09	16.03	6.72E-09	46%	
10/09	1213	13980	25.92	28.50	4.71E-09	-0.12	3.81E-09	1.1	4.19E-09	18.05	6.34E-09	6%	
10/09	1615	14520	29.96	28.19	2.23E-09	0.00	2.23E-09	1.1	2.46E-09	19.06	5.82E-09	9%	
10/10	857	60120	46.65	26.06	3.72E-09	-0.12	3.51E-09	1.1	3.86E-09	25.89	5.12E-09	13%	
10/10	1244	13620	50.43	25.56	3.07E-09	-0.19	2.40E-09	1.1	2.64E-09	27.50	4.93E-09	4%	
10/11	851	72420	70.55	22.94	3.83E-09	-0.06	3.74E-09	1.1	4.11E-09	35.92	4.70E-09	5%	
10/11	1130	9540	73.20	22.58	4.23E-09	-0.19	2.11E-09	1.1	2.33E-09	37.14	4.61E-09	2%	
10/11	1550	15600	77.53	22.25	2.11E-09	0.05	2.52E-09	1.1	2.77E-09	38.13	4.51E-09	2%	
10/12	748	57380	93.47	20.50	3.25E-09	-0.06	3.14E-09	1.1	3.45E-09	43.75	4.33E-09	4%	
10/12	1150	14840	97.53	19.94	4.09E-09	-0.19	2.70E-09	1.1	2.97E-09	45.55	4.27E-09	1%	
10/12	1534	13440	101.27	19.81	1.03E-09	0.12	1.99E-09	1.1	2.19E-09	45.97	4.19E-09	2%	
10/13	741	58020	117.38	18.06	3.24E-09	-0.12	3.01E-09	1.1	3.31E-09	51.59	4.07E-09	3%	
10/13	1631	31800	126.22	17.44	2.10E-09	-0.31	1.05E-09	1.1	1.15E-09	53.58	3.87E-09	5%	
10/14	907	59780	142.82	15.63	3.27E-09	0.06	3.38E-09	1.1	3.72E-09	59.40	3.85E-09	0%	
10/14	1552	24300	149.57	15.81	-8.06E-10	0.36	8.91E-10	1.1	9.80E-10	58.82	3.72E-09	3%	
10/15	819	59220	166.02	13.81	3.86E-09	-0.50	2.75E-09	1.1	3.02E-09	65.24	3.65E-09	2%	
10/15	1432	22380	172.23	13.50	1.51E-09	0.12	2.09E-09	1.1	2.30E-09	66.24	3.60E-09	1%	
10/16	857	66300	190.65	11.56	3.19E-09	-0.12	2.99E-09	1.1	3.29E-09	72.47	3.57E-09	1%	
10/16	1653	28560	198.58	10.88	2.81E-09	-0.07	2.34E-09	1.1	2.57E-09	74.86	3.53E-09	1%	
10/17	813	55200	213.92	9.38	2.96E-09	0.00	2.98E-09	1.1	3.28E-09	79.48	3.52E-09	1%	
10/18	845	88320	238.45	7.25	2.66E-09	-0.06	2.59E-09	1.1	2.85E-09	86.32	3.45E-09	2%	
10/19	1009	91440	263.85	5.08	2.66E-09	0.00	2.66E-09	1.1	2.93E-09	93.35	3.40E-09	1%	
10/19	1658	24540	270.67	4.58	2.27E-09	-0.00	2.00E-09	1.1	2.20E-09	94.98	3.37E-09	1%	
10/20	1630	84720	294.20	2.75	2.39E-09	-0.25	2.06E-09	1.1	2.26E-09	100.77	3.28E-09	3%	
10/20	1730	3600	295.20	35.19	2.39E-09	0.00	2.06E-09	1.1	2.27E-09	101.02	3.27E-09	0%	Refill
10/21	1630	82800	318.20	32.88	2.58E-09	-0.06	2.80E-09	1.1	3.08E-09	108.44	3.26E-09	0%	
10/22	1658	87960	342.63	30.81	2.44E-09	0.00	2.44E-09	1.1	2.68E-09	115.09	3.22E-09	1%	
10/23	1633	85020	366.25	28.89	2.60E-09	–	2.60E-09	1.1	2.86E-09	121.90	3.20E-09	1%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-13
Geometric factor-G=0.04030
Depth factor=356.8"
TC values from TSG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	RL	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (Ktwa)	Comments
10/24	1630	62620	389.20	28.63	2.61E-09	–	2.61E-09	1.1	2.87E-09	128.52	3.16E-09	1%	
10/25	1552	91320	414.67	24.63	2.31E-09	-0.37	1.88E-09	1.1	2.07E-09	134.94	3.11E-09	2%	+1 Hr Daylight
10/26	825	59580	431.12	23.00	2.06E-09	-0.59	1.67E-09	1.1	1.64E-09	140.15	3.06E-09	2%	Savings Time

END OF TEST TSB-13

ATTACHMENT 2B

TSB
SPREADSHEET CALCULATION SUMMARY

STAGE 2 (K2')

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-1 STAGE TWO
Geometric factor - G = 0.006576"
Depth factor = 239.12"
TC values from Replacement TBG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	RL	KI	TC	KIC	visc. factor	KICT	cumulative volume (cc)	K (tvs)	RPD (Ktvs)	Comments
10/26	1500	0	0.00	32.06	-	-	-	-	-	0	-	-	START
10/27	756	60960	16.93	22.63	9.70E-09	-0.25	9.44E-09	1.1	1.04E-08	30.34	1.04E-08	-	
10/27	1356	21600	22.93	21.25	4.09E-09	-0.13	3.70E-09	1.1	4.07E-09	34.78	6.73E-09	17%	
10/27	1616	8400	25.27	20.81	3.36E-09	0.13	4.36E-09	1.1	4.79E-09	38.20	6.37E-09	4%	
10/28	751	56100	40.85	17.31	4.04E-09	0.08	4.41E-09	1.1	4.52E-09	47.46	6.00E-09	10%	
10/28	1320	19740	46.33	16.13	3.90E-09	-0.03	3.80E-09	1.1	4.18E-09	51.26	6.58E-09	5%	
10/28	1712	13920	50.20	15.58	2.88E-09	-0.12	2.12E-09	1.1	2.33E-09	53.09	6.25E-09	5%	
10/29	743	52260	64.72	12.80	3.62E-09	-0.13	3.46E-09	1.1	3.80E-09	62.32	5.70E-09	9%	
10/29	1140	14220	68.67	11.94	3.50E-09	0.00	3.50E-09	1.1	3.85E-09	64.74	5.59E-09	2%	
10/29	1603	15780	73.05	11.26	2.81E-09	0.13	3.46E-09	1.1	3.81E-09	66.96	5.49E-09	2%	
10/29	1606	300	73.13	34.38	2.91E-09	0.00	3.46E-09	1.1	3.81E-09	66.96	5.49E-09	0%	Refill
10/30	812	57840	89.20	30.13	4.52E-09	0.00	4.52E-09	1.1	4.97E-09	80.63	5.38E-09	2%	
10/30	1200	13680	93.00	29.10	4.27E-09	-0.19	3.41E-09	1.1	3.75E-09	83.56	5.33E-09	1%	
10/30	1600	14400	97.00	28.38	3.51E-09	0.00	3.51E-09	1.1	3.86E-09	86.27	5.27E-09	1%	
10/31	731	55860	112.52	26.25	3.52E-09	-0.06	3.45E-09	1.1	3.80E-09	96.34	5.06E-09	4%	
10/31	1140	14940	116.67	24.38	3.09E-09	-0.13	3.13E-09	1.1	3.45E-09	99.14	5.01E-09	1%	
10/31	1513	12780	120.22	23.75	3.13E-09	0.00	3.13E-09	1.1	3.44E-09	101.16	4.96E-09	1%	
11/01	933	66000	138.55	21.58	2.12E-09	-0.19	1.93E-09	1.1	2.13E-09	106.21	4.58E-09	8%	
11/01	1511	20280	144.18	19.75	5.74E-09	0.07	5.96E-09	1.1	6.56E-09	114.03	4.64E-09	2%	
11/02	806	60900	161.10	17.38	2.52E-09	0.25	2.79E-09	1.1	3.07E-09	121.86	4.49E-09	4%	
11/02	1324½	19080	166.40	16.38	3.42E-09	-0.07	3.18E-09	1.1	3.50E-09	124.88	4.46E-09	1%	
11/02	1538	8040	168.63	16.25	1.86E-09	0.13	2.12E-09	1.1	2.33E-09	125.30	4.43E-09	1%	
11/03	806	59220	185.08	13.56	2.99E-09	0.12	3.12E-09	1.1	3.43E-09	133.96	4.35E-09	3%	
11/03	1045	9780	187.80	13.00	3.79E-09	0.00	3.79E-09	1.1	4.17E-09	135.75	4.34E-09	0%	
11/03	1510	15720	192.17	12.56	1.66E-09	0.25	2.91E-09	1.1	3.20E-09	137.17	4.32E-09	1%	
11/04	812	61320	209.20	9.81	2.99E-09	0.00	2.99E-09	1.1	3.29E-09	146.02	4.23E-09	2%	
11/04	1609	28620	217.15	8.69	2.63E-09	0.07	2.80E-09	1.1	3.08E-09	149.62	4.19E-09	1%	
11/05	759	57000	232.98	8.25	2.90E-09	-0.06	2.83E-09	1.1	3.11E-09	157.47	4.12E-09	2%	
11/05	801	120	233.02	35.75	2.90E-09	0.00	2.83E-09	1.1	3.11E-09	157.47	4.12E-09	0%	Refill
11/05	1626	30300	241.43	33.63	4.27E-09	0.06	4.39E-09	1.1	4.83E-09	164.29	4.14E-09	1%	
11/06	805	56340	257.08	30.38	5.65E-09	0.06	5.92E-09	1.1	6.51E-09	174.75	4.13E-09	0%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-1 STAGE TWO
Geometric factor – G = 0.006578"
Depth factor = 239.12"
TC values from Replacement TRC-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	R1	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
11/06	1648	31360	265.50	28.69	3.35E-09	-0.08	3.23E-09	1.1	3.55E-09	180.19	4.11E-09	0%	
11/07	912	59040	282.20	25.63	3.25E-09	-0.06	3.19E-09	1.1	3.51E-09	190.03	4.07E-09	1%	
11/07	1600	24480	289.00	24.31	3.41E-09	-0.07	3.23E-09	1.1	3.55E-09	194.28	4.06E-09	0%	
11/08	835	59700	305.58	21.56	2.94E-09	0.07	3.01E-09	1.1	3.31E-09	203.13	4.02E-09	1%	
11/08	1605	27000	313.08	20.00	3.71E-09	-0.57	2.35E-09	1.1	2.59E-09	208.15	3.99E-09	1%	
11/09	722	55020	328.37	17.75	2.65E-09	-0.07	2.58E-09	1.1	2.82E-09	215.30	3.93E-09	1%	
11/09	1625	32580	337.42	16.38	2.74E-09	-0.13	2.48E-09	1.1	2.73E-09	219.79	3.90E-09	1%	
11/10	730	54300	352.50	14.19	2.65E-09	0.00	2.65E-09	1.1	2.91E-09	226.84	3.86E-09	1%	
11/10	1624	32040	361.40	12.76	2.97E-09	-0.19	2.58E-09	1.1	2.84E-09	231.47	3.83E-09	1%	END TEST

END OF TEST TSB-1 STAGE TWO

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-2 STAGE TWO
Geometric factor – G = 0.006459"
Depth factor = 356.75"
TC values from Replacement TSG-3

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (tsm)	RPD (K1m)	comments
10/26	1430	0	0.00	35.13	–	–	–	1.1	–	0	–	–	START
10/27	759	62940	17.48	32.35	–	–	–	1.1	–	106.60	–	–	Dry refill
10/27	1359	21600	23.48	17.94	2.66E-08	-0.13	2.83E-08	1.1	3.11E-08	153.06	7.96E-09	200%	
10/27	1616	8220	25.77	13.56	2.33E-08	0.10	2.44E-08	1.1	2.68E-08	167.15	9.63E-09	10%	
10/27	1623	420	25.88	32.83	2.33E-08	0.00	2.44E-08	1.1	2.68E-08	167.15	9.70E-09	1%	Refill
10/28	750	55620	41.33	2.31	2.36E-08	-0.10	2.36E-08	1.1	2.60E-08	264.71	1.56E-08	46%	
10/28	752	120	41.37	31.06	2.36E-08	0.00	2.36E-08	1.1	2.60E-08	264.71	1.56E-08	0%	Refill
10/28	1321	19740	46.85	19.50	2.50E-08	-0.13	2.47E-08	1.1	2.72E-08	301.91	1.71E-08	6%	
10/28	1713	13920	50.72	12.63	2.18E-08	0.32	2.26E-08	1.1	2.49E-08	324.01	1.77E-08	3%	
10/29	830	55020	66.00	35.50	2.16E-08	0.00	2.16E-08	1.1	2.38E-08	364.65	1.91E-08	8%	Dry refill
10/29	1141	11460	69.18	26.00	2.75E-08	-0.06	2.73E-08	1.1	3.00E-08	388.78	1.96E-08	3%	
10/29	1603	15720	73.55	19.13	2.42E-08	0.12	2.45E-08	1.1	2.70E-08	417.32	2.01E-08	2%	
10/29	1605	120	73.58	35.38	2.42E-08	0.00	2.45E-08	1.1	2.70E-08	417.32	2.01E-08	0%	Refill
10/30	615	58200	89.75	4.75	2.26E-08	-0.06	2.28E-08	1.1	2.50E-08	515.88	2.10E-08	4%	
10/30	617	120	89.78	35.50	2.26E-08	0.00	2.28E-08	1.1	2.51E-08	515.88	2.10E-08	0%	Refill
10/30	1202	13500	93.53	27.13	2.61E-08	-0.13	2.57E-08	1.1	2.82E-08	542.81	2.13E-08	1%	
10/30	1600	14280	97.50	19.13	2.41E-08	-0.06	2.39E-08	1.1	2.63E-08	568.55	2.15E-08	1%	
10/30	1605	300	97.58	35.50	2.41E-08	0.00	2.39E-08	1.1	2.63E-08	568.55	2.15E-08	0%	Refill
10/31	731	55560	113.02	6.50	2.28E-08	-0.12	2.25E-08	1.1	2.47E-08	661.88	2.19E-08	2%	
10/31	734	180	113.07	35.38	2.28E-08	0.00	2.25E-08	1.1	2.48E-08	661.88	2.19E-08	0%	Refill
10/31	1148	15240	117.30	25.94	2.61E-08	0.00	2.61E-08	1.1	2.87E-08	692.23	2.22E-08	1%	
10/31	1514	12360	120.73	19.38	2.28E-08	0.00	2.28E-08	1.1	2.51E-08	713.34	2.22E-08	0%	
10/31	1518	240	120.80	35.00	2.28E-08	0.00	2.28E-08	1.1	2.51E-08	713.34	2.22E-08	0%	Refill
11/01	931	65580	139.02	1.75	2.21E-08	-0.19	2.19E-08	1.1	2.41E-08	820.33	2.25E-08	1%	
11/01	937	360	139.12	33.63	2.21E-08	-0.19	2.19E-08	1.1	2.41E-08	820.33	2.25E-08	0%	Refill
11/01	1540	19080	144.87	21.61	2.51E-08	0.00	2.51E-08	1.1	2.76E-08	858.38	2.27E-08	1%	
11/02	611	61280	161.88	34.88	2.51E-08	0.00	2.51E-08	1.1	2.76E-08	926.54	2.01E-08	12%	Dry refill
11/02	1325	18840	166.92	23.50	2.56E-08	-0.13	2.53E-08	1.1	2.78E-08	966.15	2.33E-08	16%	
11/02	1540	8100	169.17	19.31	2.23E-08	0.05	2.28E-08	1.1	2.49E-08	978.84	2.34E-08	0%	
11/02	1636	3360	170.10	17.50	2.34E-08	0.13	2.51E-08	1.1	2.76E-08	984.46	2.34E-08	0%	
11/02	1640	240	170.17	35.19	2.34E-08	0.00	2.51E-08	1.1	2.76E-08	984.46	2.34E-08	0%	Refill

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-2 STAGE TWO
Geometric factor – G = 0.006459"
Depth factor = 358.75"
TC values from Replacement TEG-3

Date	Time	elapsed time seconds	cumulative elapsed time hours	Ht	K1	TC	K1C	visc factor	K1CT	cumulative volume (cc)	K (avg)	RPD (K1-avg)	comments
11/03	806	55560	185.60	5.88	2.28E-08	0.00	2.28E-08	1.1	2.51E-08	1078.77	2.35E-08	1%	
11/03	1049	9780	188.32	1.56	2.00E-08	0.00	2.00E-08	1.1	2.20E-08	1092.67	2.35E-08	0%	
11/03	1200	4260	189.50	35.50	2.00E-08	0.00	2.00E-08	1.1	2.20E-08	1097.69	1.80E-08	21%	Dry refill
11/03	1511	11460	192.68	28.50	2.56E-08	0.18	2.63E-08	1.1	2.89E-08	1120.21	2.36E-08	22%	
11/03	1601	3000	193.52	34.69	2.56E-08	0.00	2.63E-08	1.1	2.89E-08	1120.21	1.91E-08	21%	Refill
11/04	813	58320	209.72	4.06	2.28E-08	-0.12	2.27E-08	1.1	2.50E-08	1216.77	2.37E-08	22%	
11/04	815	120	209.75	33.88	2.28E-08	0.00	2.27E-08	1.1	2.50E-08	1216.77	2.37E-08	0%	Refill
11/04	1611	28560	217.68	17.50	2.45E-08	0.06	2.46E-08	1.1	2.70E-08	1271.47	2.38E-08	1%	
11/04	1614	180	217.73	35.75	2.45E-08	0.00	2.46E-08	1.1	2.71E-08	1271.47	2.38E-08	0%	Refill
11/05	804	57000	233.57	5.54	2.29E-08	0.00	2.29E-08	1.1	2.52E-08	1368.61	2.39E-08	0%	
11/05	806	120	233.60	35.56	2.29E-08	0.00	2.29E-08	1.1	2.52E-08	1368.61	2.39E-08	0%	Refill
11/05	1627	30060	241.95	18.81	2.37E-08	0.18	2.40E-08	1.1	2.63E-08	1422.50	2.40E-08	0%	
11/05	1629	120	241.98	35.38	2.37E-08	0.00	2.40E-08	1.1	2.64E-08	1422.50	2.40E-08	0%	Refill
11/06	806	56220	257.60	5.10	2.33E-08	-0.06	2.32E-08	1.1	2.55E-08	1519.64	2.41E-08	0%	
11/06	808	120	257.63	35.25	2.33E-08	0.00	2.32E-08	1.1	2.55E-08	1519.64	2.41E-08	0%	Refill
11/06	1649	31260	266.32	17.25	2.45E-08	0.18	2.46E-08	1.1	2.72E-08	1577.56	2.42E-08	0%	
11/06	1650	60	266.33	35.50	2.45E-08	0.00	2.46E-08	1.1	2.73E-08	1577.56	2.42E-08	0%	Refill
11/07	913	58980	282.72	3.56	2.35E-08	-0.06	2.35E-08	1.1	2.58E-08	1680.33	2.43E-08	0%	
11/07	915	120	282.75	35.25	2.35E-08	0.00	2.35E-08	1.1	2.59E-08	1680.33	2.43E-08	0%	Refill
11/07	1601	24360	289.52	20.94	2.49E-08	-0.06	2.48E-08	1.1	2.73E-08	1726.37	2.44E-08	0%	
11/07	1604	180	289.57	35.81	2.49E-08	0.00	2.48E-08	1.1	2.73E-08	1726.37	2.44E-08	0%	Refill
11/08	836	59520	306.10	4.75	2.26E-08	0.00	2.26E-08	1.1	2.49E-08	1826.31	2.44E-08	0%	
11/08	837	60	306.12	35.31	2.26E-08	0.00	2.26E-08	1.1	2.49E-08	1826.31	2.44E-08	0%	Refill
11/08	1607	27000	313.62	20.25	2.37E-08	-0.38	2.31E-08	1.1	2.54E-08	1874.77	2.44E-08	0%	
11/08	1608	60	313.63	35.81	2.37E-08	0.00	2.31E-08	1.1	2.54E-08	1874.77	2.44E-08	0%	Refill
11/09	723	54900	328.88	6.75	2.29E-08	0.44	2.32E-08	1.1	2.55E-08	1968.27	2.45E-08	0%	
11/09	724	60	328.90	34.81	2.29E-08	0.00	2.32E-08	1.1	2.55E-08	1968.27	2.45E-08	0%	Refill
11/09	1626	32520	337.93	16.38	2.42E-08	-0.12	2.40E-08	1.1	2.64E-08	2027.57	2.45E-08	0%	
11/09	1627	60	337.95	35.75	2.42E-08	0.00	2.40E-08	1.1	2.64E-08	2027.57	2.45E-08	0%	Refill
11/10	731	54240	353.02	6.25	2.35E-08	0.00	2.35E-08	1.1	2.59E-08	2122.49	2.46E-08	0%	
11/10	732	60	353.03	34.56	2.35E-08	0.00	2.35E-08	1.1	2.59E-08	2122.49	2.46E-08	0%	Refill
11/10	1620	31680	361.83	16.13	2.49E-08	-0.13	2.47E-08	1.1	2.71E-08	2181.79	2.46E-08	0%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-2 STAGE TWO
Geometric factor – G = 0.006459"
Depth factor = 358.75"
TC values from Replacement TBG-3

Date	Time	elapsed time seconds	cumulative elapsed time hours	R1	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (two)	RPD (K1vs)	comments
11/10	1621	60	361.85	35.94	2.49E-08	0.00	2.47E-08	1.1	2.72E-08	2181.79	2.46E-08	0%	Refill
11/11	735	54480	376.98	5.81	2.39E-08	0.00	2.39E-08	1.1	2.63E-08	2278.74	2.47E-08	0%	
11/11	736	60	377.00	35.00	2.39E-08	0.00	2.39E-08	1.1	2.63E-08	2278.74	2.47E-08	0%	Refill
11/11	1344	22080	383.13	21.50	2.59E-08	0.06	2.60E-08	1.1	2.86E-08	2322.16	2.48E-08	0%	END TEST

END OF TEST TSB-2 STAGE TWO

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-3 STAGE TWO
Geometric factor = G = 0.006401"
Depth factor = 152.25"
TC values from TBG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	BL	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (tm)	RPD (Ktm)	Comments
10/26	1500	0	0.00	33.63	–	–	–	–	–	0.00	–	–	START
10/27	800	61200	17.00	29.31	5.92E-09	0.08	6.01E-09	1.1	6.61E-09	13.90	6.61E-09	–	
10/27	1400	57900	33.08	28.69	9.10E-10	-0.31	4.55E-10	1.1	5.00E-10	15.89	3.84E-09	56%	
10/28	755	64500	51.00	26.06	3.50E-09	0.06	3.58E-09	1.2	4.29E-09	24.36	3.87E-09	6%	
10/28	1325	19800	58.50	25.50	2.45E-09	-0.06	2.16E-09	1.1	2.40E-09	26.16	3.73E-09	4%	
10/28	1730	14700	60.58	25.06	2.80E-09	0.25	4.07E-09	1.1	4.48E-09	27.57	3.78E-09	1%	
10/29	747	51420	74.87	23.19	3.17E-09	0.00	3.17E-09	1.1	3.49E-09	33.59	3.72E-09	1%	
10/29	1142	14100	78.78	22.63	3.49E-09	0.00	3.49E-09	1.1	3.84E-09	35.39	3.73E-09	0%	
10/29	1612	16200	83.28	22.13	2.72E-09	0.08	3.04E-09	1.1	3.35E-09	37.00	3.71E-09	1%	
10/30	821	58140	99.43	19.86	3.43E-09	0.00	3.43E-09	1.2	4.12E-09	44.24	3.77E-09	2%	
10/30	1209	13680	103.23	19.31	2.73E-09	-0.19	2.48E-09	1.2	2.98E-09	46.08	3.74E-09	1%	
10/30	1610	14460	107.25	18.88	2.67E-09	0.00	2.67E-09	1.1	2.93E-09	47.46	3.71E-09	1%	
10/31	739	55740	122.73	16.88	3.24E-09	0.00	3.24E-09	1.1	3.56E-09	53.69	3.70E-09	1%	
10/31	1151	15120	126.93	16.25	3.79E-09	-0.12	3.07E-09	1.1	3.37E-09	55.92	3.68E-09	0%	
10/31	1541	13800	130.77	15.81	2.91E-09	0.00	2.91E-09	1.1	3.20E-09	57.34	3.67E-09	0%	
11/01	940	64740	148.75	13.88	2.74E-09	-0.13	2.55E-09	1.1	2.81E-09	63.55	3.57E-09	3%	
11/01	1515	20100	154.33	13.44	2.02E-09	0.00	2.02E-09	1.1	2.23E-09	64.96	3.52E-09	1%	
11/02	816	61260	171.35	11.50	2.95E-09	0.32	3.44E-09	1.1	3.78E-09	71.21	3.54E-09	1%	
11/02	1326	18720	176.55	10.94	2.60E-09	-0.07	2.45E-09	1.2	2.94E-09	73.01	3.53E-09	1%	
11/02	1545	8220	178.83	10.75	2.17E-09	0.13	3.66E-09	1.2	4.39E-09	73.62	3.54E-09	0%	
11/03	810	59100	195.25	8.89	3.30E-09	0.12	3.49E-09	1.2	4.19E-09	80.25	3.59E-09	2%	
11/03	1053	9780	197.97	8.31	3.70E-09	0.00	3.70E-09	1.2	4.44E-09	81.47	3.60E-09	0%	
11/03	1520	16020	202.42	8.06	1.49E-09	0.32	3.40E-09	1.2	4.08E-09	82.27	3.61E-09	0%	
11/04	820	61200	219.42	5.94	3.33E-09	0.16	3.61E-09	1.2	4.33E-09	89.10	3.57E-09	2%	
11/04	822	120	219.45	35.35	3.33E-09	0.00	3.61E-09	1.2	4.33E-09	89.10	3.67E-09	0%	Refill
11/04	1617	28500	227.37	33.56	5.28E-09	0.07	5.46E-09	1.2	6.56E-09	94.96	3.77E-09	3%	
11/05	806	57060	243.22	30.69	4.21E-09	0.00	4.21E-09	1.2	5.05E-09	104.19	3.85E-09	2%	
11/05	1632	30240	251.62	29.38	3.66E-09	0.12	4.00E-09	1.2	4.80E-09	108.41	3.89E-09	1%	
11/06	812	56400	267.28	26.81	3.59E-09	0.06	3.98E-09	1.2	4.78E-09	116.87	3.94E-09	1%	
11/06	1654	31320	275.98	25.44	3.78E-09	-0.08	3.61E-09	1.2	4.33E-09	121.08	3.95E-09	0%	
11/07	859	57900	292.07	23.13	3.48E-09	0.13	3.87E-09	1.25	4.59E-09	128.52	3.99E-09	1%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-3 STAGE TWO
Geometric factor – G = 0.006401"
Depth factor = 162.25"
TC values from TBG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	Kt	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (Ktwa)	Comments
11/07	1609	25800	299.23	22.13	3.41E-09	-0.25	2.55E-09	1.2	3.07E-09	131.73	3.96E-09	1%	
11/08	840	59460	315.75	19.55	3.36E-09	0.16	3.83E-09	1.25	4.53E-09	136.97	3.99E-09	1%	
11/08	1610	27000	323.25	18.75	3.75E-09	-0.61	1.06E-09	1.2	1.27E-09	142.81	3.93E-09	2%	
11/09	728	55080	338.55	16.94	2.97E-09	0.13	3.16E-09	1.2	3.82E-09	146.43	3.93E-09	0%	
11/09	1629	32460	347.57	15.85	2.97E-09	-0.19	2.44E-09	1.2	2.93E-09	151.84	3.90E-09	1%	
11/10	737	54480	362.70	14.13	2.96E-09	0.06	3.05E-09	1.2	3.66E-09	157.47	3.89E-09	0%	
11/10	1629	31920	371.57	13.13	2.90E-09	-0.31	2.00E-09	1.1	2.20E-09	160.59	3.85E-09	1%	
11/11	749	54600	386.75	11.50	2.78E-09	-0.05	2.67E-09	1.1	2.94E-09	165.94	3.81E-09	1%	
11/11	1400	22800	393.08	10.81	2.84E-09	-0.08	2.59E-09	1.1	2.85E-09	168.16	3.80E-09	0%	END TEST

END OF TEST TSB-3 STAGE TWO

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-4 STAGE TWO
Geometric factor = G = 0.006514"
Depth factor = 239.25"
TC values from TRG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1C1	cumulative volume (cc)	K (twa)	RPD (Ktwa)	Comments
10/26	1649	0	0.00	31.06	–	–	–	–	–	0.00	–	–	START
10/27	602	58380	16.22	28.66	4.42E-09	-0.25	4.15E-09	1.1	4.57E-09	13.45	4.57E-09	–	
10/27	1402	21600	22.22	25.25	4.71E-09	-0.13	4.33E-09	1.1	4.76E-09	18.89	4.62E-09	1%	
10/28	755	64380	40.10	20.63	4.53E-09	0.06	4.59E-09	1.1	5.05E-09	33.56	4.81E-09	4%	
10/28	1325	19800	45.60	19.06	5.06E-09	-0.04	4.93E-09	1.1	5.43E-09	38.61	4.88E-09	2%	
10/28	1728	14580	49.65	18.19	3.63E-09	-0.12	3.30E-09	1.1	3.63E-09	41.41	4.76E-09	2%	
10/29	748	51600	63.98	14.56	4.55E-09	-0.13	4.39E-09	1.1	4.83E-09	53.09	4.79E-09	0%	
10/29	1143	14100	67.90	13.56	4.63E-09	0.00	4.63E-09	1.1	5.10E-09	56.31	4.81E-09	0%	
10/29	1613	16200	72.40	12.50	4.29E-09	0.13	4.82E-09	1.1	5.30E-09	59.72	4.84E-09	1%	
10/30	620	56020	88.52	9.69	4.35E-09	0.00	4.35E-09	1.1	4.78E-09	71.98	4.83E-09	0%	
10/30	1206	13560	92.28	7.75	4.63E-09	-0.19	3.70E-09	1.1	4.07E-09	75.00	4.80E-09	1%	
10/30	1206	120	92.32	32.83	4.63E-09	0.00	3.70E-09	1.1	4.07E-09	75.00	4.80E-09	0%	Refill
10/30	1606	14400	96.32	31.13	6.36E-09	0.00	6.36E-09	1.1	6.99E-09	79.83	4.89E-09	2%	
10/31	736	55800	111.82	26.25	5.40E-09	-0.06	5.33E-09	1.1	5.87E-09	95.53	5.03E-09	3%	
10/31	1151	15150	116.03	24.88	5.64E-09	-0.13	5.10E-09	1.1	5.61E-09	99.94	5.05E-09	0%	
10/31	1540	13740	119.85	23.75	5.16E-09	0.00	5.16E-09	1.1	5.68E-09	103.57	5.07E-09	0%	
11/01	942	64920	137.88	18.81	4.83E-09	-0.19	4.65E-09	1.1	5.11E-09	119.47	5.07E-09	0%	
11/01	1516	20040	143.45	17.44	4.30E-09	0.07	4.82E-09	1.1	5.06E-09	123.88	5.07E-09	0%	
11/02	614	61080	160.42	13.50	4.19E-09	0.25	4.46E-09	1.1	4.90E-09	136.55	5.05E-09	0%	
11/02	1328	16840	165.65	12.13	4.77E-09	-0.07	4.53E-09	1.1	4.98E-09	140.96	5.05E-09	0%	
11/02	1546	8280	167.95	11.75	3.02E-09	0.13	4.06E-09	1.1	4.46E-09	142.18	5.04E-09	0%	
11/03	611	59100	184.37	7.75	4.50E-09	0.12	4.63E-09	1.1	5.10E-09	155.05	5.05E-09	0%	
11/03	1052	9660	187.05	7.06	4.79E-09	0.00	4.79E-09	1.1	5.27E-09	157.27	5.05E-09	0%	
11/03	1522	16200	191.55	6.19	3.61E-09	0.25	4.65E-09	1.1	5.12E-09	160.07	5.05E-09	0%	
11/04	625	61380	208.60	2.25	4.36E-09	0.00	4.36E-09	1.1	4.80E-09	172.75	5.03E-09	0%	
11/04	628	180	208.65	35.75	4.36E-09	0.00	4.36E-09	1.1	4.80E-09	172.75	5.03E-09	0%	Refill
11/04	1618	28200	216.48	32.75	6.44E-09	0.07	6.59E-09	1.1	7.25E-09	182.40	5.11E-09	2%	
11/05	809	57060	232.33	27.63	5.51E-09	0.00	5.51E-09	1.1	6.06E-09	198.88	5.18E-09	1%	
11/05	1633	30240	240.73	25.13	6.15E-09	0.06	5.27E-09	1.1	5.80E-09	206.92	5.20E-09	0%	
11/06	813	56400	256.40	20.50	5.18E-09	0.06	5.25E-09	1.1	5.78E-09	221.52	5.23E-09	1%	
11/06	1655	31320	265.10	18.06	4.99E-09	-0.06	4.86E-09	1.1	5.35E-09	229.67	5.24E-09	0%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-4 STAGE TWO
Geometric factor – G = 0.006514"
Depth factor = 239.25"
TC values from TBG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	R1	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (tm)	RPD (K1ws)	Comments
11/07	900	57900	281.18	13.75	4.83E-09	-0.06	4.76E-09	1.1	5.24E-09	243.54	5.24E-09	0%	
11/07	1610	25800	288.36	11.86	4.76E-09	-0.07	4.58E-09	1.1	5.04E-09	249.55	5.23E-09	0%	
11/08	841	59460	304.87	7.81	4.55E-09	0.07	4.63E-09	1.1	5.09E-09	262.85	5.23E-09	0%	
11/08	842	60	304.88	36.00	4.66E-09	0.00	4.63E-09	1.1	5.09E-09	262.85	5.23E-09	0%	Refill
11/08	1611	26940	312.37	32.86	7.00E-09	-0.57	5.72E-09	1.1	6.29E-09	272.80	5.26E-09	0%	
11/09	729	55080	327.67	27.75	5.72E-09	-0.07	5.64E-09	1.1	6.20E-09	289.20	5.30E-09	1%	
11/09	1630	32460	336.68	24.81	6.64E-09	-0.13	5.39E-09	1.1	5.93E-09	298.85	5.31E-09	0%	
11/10	736	54480	351.82	20.38	5.14E-09	0.00	5.14E-09	1.1	5.65E-09	312.91	5.33E-09	0%	
11/10	1630	31920	360.68	17.88	5.52E-09	-0.19	4.63E-09	1.1	5.10E-09	320.85	5.32E-09	0%	
11/11	741	54660	375.87	14.00	4.60E-09	0.00	4.60E-09	1.1	5.06E-09	333.44	5.31E-09	0%	
11/11	1401	22800	382.20	12.38	4.66E-09	0.00	4.66E-09	1.1	5.12E-09	338.65	5.31E-09	0%	END TEST

END OF TEST TSB-4 STAGE TWO

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-5 STAGE TWO
Geometric factor = G = 0.006576"
Depth factor = 153.5"
TC values from TSG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	R1	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (1ws)	RPD (K1ws)	Comments
10/27	1140	0	0.00	33.66	–	–	–	1.1	–	0.00	–	–	START
10/27	1452	9900	2.75	32.31	1.42E-08	-0.31	4.46E-09	1.1	4.93E-09	5.05	4.93E-09	–	
10/27	1607	6120	4.45	32.21	1.47E-09	0.13	1.33E-09	1.1	1.46E-09	5.37	3.01E-09	31%	
10/28	810	57780	20.50	31.25	1.50E-09	0.06	6.27E-10	1.2	7.52E-10	8.46	1.37E-09	90%	
10/28	1345	20100	26.08	31.06	6.55E-10	-0.06	2.30E-10	1.1	2.53E-10	9.07	1.13E-09	19%	
10/28	1746	14580	30.13	31.00	3.72E-10	0.25	7.58E-10	1.1	8.34E-10	9.27	1.09E-09	4%	
10/29	751	50580	44.18	29.66	2.01E-09	0.00	7.92E-10	1.1	8.71E-10	12.87	1.03E-09	7%	
10/29	1158	14820	48.30	29.56	1.07E-09	0.00	7.75E-10	1.1	8.52E-10	13.90	1.01E-09	1%	
10/29	1638	16800	52.97	29.25	1.69E-09	0.06	7.92E-10	1.1	8.71E-10	14.90	9.96E-10	1%	
10/30	845	58020	69.08	27.88	2.17E-09	0.00	6.53E-10	1.2	1.02E-09	19.31	1.00E-09	1%	
10/30	1227	13320	72.78	27.50	2.83E-09	-0.10	5.17E-10	1.2	6.21E-10	20.53	9.83E-10	3%	
10/30	1636	15060	76.97	27.25	1.53E-09	0.00	6.04E-10	1.1	6.64E-10	21.33	9.65E-10	2%	
10/31	807	55740	92.45	26.75	2.60E-09	0.00	9.63E-10	1.1	1.06E-09	26.16	9.65E-10	2%	
10/31	1210	14580	96.50	25.38	2.37E-09	-0.12	6.29E-10	1.1	6.92E-10	27.35	9.72E-10	1%	
10/31	1552	13320	100.20	25.13	1.75E-09	0.00	6.90E-10	1.1	7.60E-10	29.15	9.65E-10	1%	
11/01	1018	66360	118.63	23.56	2.22E-09	-0.13	6.02E-10	1.1	6.62E-10	33.21	9.52E-10	1%	
11/01	1540	19320	124.00	23.25	1.51E-09	0.00	5.96E-10	1.1	6.56E-10	34.20	9.39E-10	1%	
11/02	853	61980	141.22	21.56	2.59E-09	0.32	1.21E-09	1.1	1.33E-09	39.84	9.57E-10	6%	
11/02	1343	17400	146.05	21.06	2.76E-09	-0.07	9.29E-10	1.2	1.12E-09	41.25	9.91E-10	0%	
11/02	1610	8820	148.50	20.75	3.37E-09	0.13	1.88E-09	1.2	2.26E-09	42.25	1.01E-09	2%	
11/03	815	57900	164.58	18.86	3.11E-09	0.12	1.30E-09	1.2	1.57E-09	46.76	1.07E-09	5%	
11/03	1107	10320	167.45	18.56	3.01E-09	0.00	1.18E-09	1.2	1.42E-09	49.29	1.07E-09	1%	
11/03	1536	15780	171.93	18.25	1.91E-09	0.32	1.53E-09	1.2	1.83E-09	50.29	1.09E-09	2%	
11/04	832	61320	188.87	16.06	3.50E-09	0.15	1.49E-09	1.2	1.79E-09	57.34	1.15E-09	6%	
11/04	1638	29160	196.97	15.31	2.54E-09	0.07	1.09E-09	1.2	1.31E-09	59.75	1.16E-09	1%	
11/05	838	57780	213.02	13.83	2.89E-09	0.00	1.14E-09	1.2	1.37E-09	65.16	1.18E-09	1%	
11/05	1358	19200	218.35	13.00	3.29E-09	0.00	1.29E-09	1.2	1.55E-09	67.16	1.19E-09	1%	
11/05	1700	11040	221.42	12.75	2.27E-09	0.12	1.33E-09	1.2	1.59E-09	67.99	1.19E-09	0%	
11/06	829	55740	236.90	11.00	3.17E-09	0.06	1.29E-09	1.2	1.55E-09	73.62	1.21E-09	2%	
11/06	1715	31560	245.67	10.06	3.03E-09	0.00	1.19E-09	1.2	1.43E-09	78.64	1.22E-09	1%	
11/07	833	55080	260.97	8.50	2.91E-09	0.13	1.24E-09	1.25	1.55E-09	81.66	1.24E-09	2%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-5 STAGE TWO
Geometric factor - G = 0.006576"
Depth factor = 153.5"
TC values from TBG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	R1	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (tvm)	RPD (K1 vm)	Comments
11/07	1613	27600	268.63	7.69	3.03E-09	-0.25	6.25E-10	1.2	9.90E-10	64.27	1.23E-09	1%	
11/08	906	60900	285.55	5.88	3.10E-09	0.16	1.34E-09	1.25	1.68E-09	90.09	1.26E-09	2%	
11/08	909	80	285.57	35.50	3.10E-09	0.00	1.34E-09	1.25	1.68E-09	90.09	1.26E-09	0%	Refill
11/08	1615	25560	292.67	34.00	5.21E-09	-0.81	9.41E-10	1.2	1.13E-09	94.92	1.26E-09	0%	
11/09	753	54280	308.30	31.94	3.28E-09	0.13	1.37E-09	1.2	1.65E-09	101.54	1.28E-09	2%	
11/09	1634	31260	316.98	30.88	3.06E-09	-0.19	9.80E-10	1.2	1.19E-09	104.96	1.27E-09	0%	
11/10	740	54360	332.08	29.19	2.83E-09	0.08	1.16E-09	1.2	1.36E-09	110.39	1.28E-09	0%	
11/10	1632	31920	340.95	27.69	4.31E-09	-0.31	1.35E-09	1.2	1.62E-09	115.22	1.29E-09	1%	
11/11	605	55980	356.50	25.25	4.06E-09	-0.06	1.55E-09	1.2	1.86E-09	123.07	1.31E-09	2%	
11/11	1354	20940	362.32	23.75	6.72E-09	-0.06	2.54E-09	1.2	3.05E-09	127.90	1.34E-09	2%	END TEST

END OF TEST TSB-5 STAGE TWO

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-6 STAGE TWO
Geometric factor = G = 0.006190"
Depth factor=231.5"
TC values from TBG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (fm)	RPD (K1 vs)	Comments
10/27	1210	0	0.00	32.63	-	-	-	1.1	-	0.00	-	-	START
10/27	1430	8400	2.33	29.25	2.41E-06	-0.13	2.32E-06	1.1	2.55E-06	10.66	2.55E-06	-	
10/27	1606	5760	3.93	27.75	1.57E-06	0.13	1.71E-06	1.1	1.88E-06	15.70	2.26E-06	11%	
10/28	809	57924	20.02	12.50	1.65E-06	0.06	1.65E-06	1.1	1.82E-06	64.77	1.91E-06	18%	
10/28	1346	20220	25.64	8.31	1.35E-06	-0.06	1.33E-06	1.1	1.46E-06	78.25	1.81E-06	5%	
10/28	1350	240	25.71	33.63	1.35E-06	0.00	1.33E-06	1.1	1.46E-06	78.25	1.81E-06	0%	Refill
10/28	1746	14160	29.64	29.75	1.64E-06	-0.12	1.59E-06	1.1	1.74E-06	90.73	1.80E-06	0%	
10/29	752	50760	43.74	17.38	1.50E-06	-0.13	1.49E-06	1.1	1.63E-06	130.54	1.75E-06	3%	
10/29	1200	14880	47.87	14.00	1.44E-06	0.00	1.44E-06	1.1	1.59E-06	141.41	1.73E-06	1%	
10/29	1640	16800	52.54	10.44	1.37E-06	0.13	1.42E-06	1.1	1.56E-06	152.87	1.72E-06	1%	
10/29	1642	120	52.57	34.25	1.37E-06	0.00	1.42E-06	1.1	1.56E-06	152.87	1.72E-06	0%	Refill
10/30	846	57840	68.64	20.00	1.50E-06	0.00	1.50E-06	1.1	1.65E-06	196.72	1.70E-06	1%	
10/30	1226	13200	72.31	17.25	1.31E-06	-0.19	1.22E-06	1.1	1.34E-06	207.57	1.68E-06	1%	
10/30	1639	15180	76.52	14.25	1.26E-06	0.00	1.26E-06	1.1	1.38E-06	217.22	1.67E-06	1%	
10/30	1644	300	76.61	34.63	1.26E-06	0.00	1.26E-06	1.1	1.39E-06	217.22	1.67E-06	0%	Refill
10/31	808	55440	92.01	21.50	1.43E-06	-0.06	1.43E-06	1.1	1.57E-06	259.47	1.65E-06	1%	
10/31	1211	14580	96.06	18.44	1.31E-06	-0.13	1.26E-06	1.1	1.38E-06	269.31	1.64E-06	1%	
10/31	1553	13320	99.76	15.75	1.28E-06	0.00	1.28E-06	1.1	1.41E-06	277.97	1.63E-06	1%	
10/31	1557	240	99.82	35.00	1.28E-06	0.00	1.28E-06	1.1	1.41E-06	277.97	1.63E-06	0%	Refill
11/01	1017	66000	118.16	20.31	1.35E-06	-0.19	1.33E-06	1.1	1.47E-06	325.24	1.60E-06	2%	
11/01	1541	19440	123.56	16.44	1.25E-06	0.07	1.28E-06	1.1	1.40E-06	337.69	1.60E-06	1%	
11/01	1545	240	216.50	34.56	1.25E-06	0.00	1.28E-06	1.1	1.41E-06	337.69	9.11E-09	55%	Refill
11/02	853	61680	233.63	21.81	1.25E-06	0.25	1.28E-06	1.1	1.40E-06	378.71	9.47E-09	4%	
11/02	1344	17460	236.48	18.63	1.14E-06	-0.07	1.11E-06	1.1	1.22E-06	388.95	9.53E-09	1%	
11/02	1612	8880	240.95	17.13	1.06E-06	0.13	1.16E-06	1.1	1.27E-06	393.77	9.56E-09	0%	
11/03	816	57640	257.02	7.13	1.12E-06	0.12	1.13E-06	1.1	1.24E-06	425.95	9.74E-09	2%	
11/03	1106	10200	259.85	5.44	1.10E-06	0.00	1.10E-06	1.1	1.21E-06	431.30	9.77E-09	0%	
11/03	1529	15780	264.23	3.13	9.76E-09	0.25	1.08E-06	1.1	1.19E-06	436.82	9.80E-09	0%	
11/03	1532	180	264.28	33.69	9.76E-09	0.00	1.08E-06	1.1	1.19E-06	436.82	9.80E-09	0%	Refill
11/04	833	61260	281.30	21.00	1.26E-06	0.00	1.26E-06	1.1	1.38E-06	479.65	1.00E-06	2%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-6 STAGE TWO
Geometric factor – G = 0.006190"
Depth factor=231.5"
TC values from TSG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Ht	H1	TC	H1C	visc. factor	H1CT	cumulative volume (cc)	K (twa)	RPD (Ktwa)	Comments
11/04	1639	29160	289.40	15.61	1.12E-06	0.07	1.14E-06	1.1	1.25E-06	496.35	1.01E-06	1%	
11/04	1642	180	289.45	34.25	1.13E-06	0.00	1.14E-06	1.1	1.25E-06	496.35	1.01E-06	0%	Refill
11/05	836	57360	305.38	22.94	1.19E-06	0.00	1.19E-06	1.1	1.31E-06	532.74	1.03E-06	2%	
11/05	1357	19140	310.70	19.50	1.12E-06	0.00	1.12E-06	1.1	1.23E-06	543.81	1.03E-06	0%	
11/05	1659	10920	313.73	17.63	1.09E-06	0.06	1.11E-06	1.1	1.22E-06	549.83	1.03E-06	0%	
11/06	830	55860	329.25	8.25	1.08E-06	0.06	1.09E-06	1.1	1.20E-06	580.01	1.04E-06	1%	
11/06	832	120	329.28	34.68	1.08E-06	0.00	1.09E-06	1.1	1.20E-06	580.01	1.04E-06	0%	Refill
11/06	1718	31440	338.02	28.25	1.26E-06	-0.06	1.25E-06	1.1	1.37E-06	601.34	1.05E-06	1%	
11/07	834	55080	353.32	18.19	1.13E-06	-0.06	1.12E-06	1.1	1.23E-06	633.71	1.06E-06	1%	
11/07	1614	27600	360.98	13.63	1.05E-06	-0.07	1.03E-06	1.1	1.14E-06	648.38	1.06E-06	0%	
11/08	911	61020	377.93	3.89	1.07E-06	0.07	1.07E-06	1.1	1.18E-06	660.37	1.06E-06	1%	
11/08	912	60	377.96	34.61	1.07E-06	0.00	1.07E-06	1.1	1.18E-06	660.37	1.06E-06	0%	Refill
11/08	1616	25440	385.02	29.63	1.21E-06	-0.57	1.06E-06	1.1	1.19E-06	697.04	1.07E-06	0%	
11/09	754	56280	400.65	19.13	1.16E-06	-0.07	1.14E-06	1.1	1.25E-06	730.82	1.07E-06	1%	
11/09	1636	31260	409.33	13.75	1.09E-06	-0.13	1.06E-06	1.1	1.17E-06	746.13	1.06E-06	0%	
11/09	1637	120	409.37	35.19	1.09E-06	0.00	1.06E-06	1.1	1.17E-06	746.13	1.06E-06	0%	Refill
11/10	741	54240	424.43	24.44	1.10E-06	0.00	1.10E-06	1.1	1.31E-06	782.72	1.08E-06	1%	
11/10	1633	31920	433.30	18.75	1.11E-06	-0.19	1.07E-06	1.1	1.18E-06	801.03	1.09E-06	0%	
11/11	803	55800	448.80	9.63	1.05E-06	0.00	1.05E-06	1.1	1.15E-06	830.37	1.09E-06	0%	
11/11	1355	21120	454.67	6.25	1.05E-06	0.00	1.05E-06	1.1	1.16E-06	841.25	1.09E-06	0%	END TEST

END OF TEST TSB-6 STAGE TWO

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-7 STAGE TWO
Geometric factor - G = 0.006634"
Depth factor = 161.25"
TC values from TBG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	H1	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (lsm)	RPD (Klsm)	Comments
10/27	1015	0	0.00	34.25	-	-	-	1.1	-	0.00	-	-	START
10/27	1421	14760	3.63	33.56	1.04E-09	-0.31	2.22E-09	1.1	2.44E-09	2.22	2.76E-09	-	
10/27	1605	6240	5.36	33.50	5.32E-10	0.13	2.53E-09	1.1	2.90E-09	2.41	2.80E-09	2%	
10/28	815	58200	21.53	32.81	1.03E-09	0.06	1.12E-09	1.2	1.34E-09	4.83	1.71E-09	49%	
10/28	1340	19500	26.96	32.56	1.11E-09	-0.06	8.46E-10	1.1	9.31E-10	5.44	1.55E-09	10%	
10/28	1751	57420	42.90	32.38	2.73E-10	0.25	4.52E-10	1.1	7.17E-10	6.02	1.24E-09	22%	
10/29	756	50700	56.98	31.75	1.06E-09	0.00	1.06E-09	1.1	1.10E-09	8.04	1.23E-09	1%	
10/29	1202	14760	61.08	31.63	7.10E-10	0.00	7.10E-10	1.1	7.81E-10	8.43	1.20E-09	2%	
10/29	1645	16980	65.80	31.44	9.78E-10	0.06	1.29E-09	1.1	1.42E-09	9.04	1.21E-09	1%	
10/30	849	57840	81.86	30.75	1.05E-09	0.00	1.05E-09	1.2	1.25E-09	11.26	1.22E-09	1%	
10/30	1230	13284	85.55	30.56	1.28E-09	-0.19	1.05E-09	1.2	1.25E-09	11.87	1.22E-09	0%	Repeated value
10/30	1632	14520	89.59	30.44	7.26E-10	0.00	7.26E-10	1.1	7.99E-10	12.26	1.20E-09	2%	
10/31	802	55800	105.09	29.75	1.09E-09	0.00	1.09E-09	1.1	1.20E-09	14.45	1.20E-09	0%	
10/31	1209	14820	109.20	29.50	1.49E-09	-0.12	7.74E-10	1.1	8.52E-10	15.28	1.19E-09	1%	
10/31	1545	12960	112.80	29.38	8.18E-10	0.00	8.18E-10	1.1	9.00E-10	15.67	1.18E-09	1%	
11/01	1009	66240	131.20	28.63	1.00E-09	-0.13	8.29E-10	1.1	9.12E-10	18.06	1.14E-09	3%	
11/01	1534	19500	136.62	28.44	8.65E-10	0.00	8.65E-10	1.1	9.52E-10	18.69	1.14E-09	1%	
11/02	850	62500	151.20	27.56	1.49E-09	0.32	2.04E-09	1.1	2.24E-09	21.53	1.24E-09	9%	
11/02	1341	17460	156.05	27.38	9.20E-10	-0.07	5.62E-10	1.2	6.75E-10	22.10	1.22E-09	1%	
11/02	1614	9180	158.60	27.25	1.27E-09	0.13	2.53E-09	1.2	3.04E-09	22.52	1.25E-09	2%	
11/03	818	57840	174.67	26.31	1.46E-09	0.12	1.64E-09	1.2	1.97E-09	25.55	1.32E-09	5%	
11/03	1105	10020	177.45	26.13	1.61E-09	0.00	1.61E-09	1.2	1.94E-09	26.13	1.33E-09	1%	
11/03	1525	15600	181.79	26.00	7.60E-10	0.32	2.60E-09	1.2	3.12E-09	26.55	1.37E-09	3%	
11/04	835	61600	198.95	24.94	1.55E-09	0.16	1.81E-09	1.2	2.17E-09	29.96	1.44E-09	5%	
11/04	1644	29340	207.10	24.50	1.36E-09	0.07	1.58E-09	1.2	1.89E-09	31.37	1.46E-09	1%	
11/05	841	57420	223.05	23.56	1.49E-09	0.00	1.49E-09	1.2	1.79E-09	34.40	1.48E-09	2%	
11/05	1354	18780	228.27	23.25	1.51E-09	0.00	1.51E-09	1.2	1.81E-09	35.39	1.49E-09	1%	
11/05	1655	10860	231.29	23.06	1.60E-09	0.12	2.61E-09	1.2	3.13E-09	36.00	1.51E-09	1%	
11/06	834	56340	246.94	22.19	1.42E-09	0.06	1.51E-09	1.2	1.82E-09	38.80	1.53E-09	1%	
11/06	1710	30960	255.54	21.63	1.66E-09	-0.06	1.49E-09	1.2	1.78E-09	40.61	1.54E-09	1%	
11/07	836	55560	270.97	20.69	1.56E-09	0.13	1.78E-09	1.25	2.22E-09	43.83	1.56E-09	3%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSH-7 STAGE TWO
Geometric factor – C = 0.006634"
Depth factor = 161.25"
TC values from TEG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	H1	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (tm)	RPD (K1tm)	Comments
11/07	1617	27680	278.65	20.25	1.48E-09	-0.25	6.37E-10	1.2	7.64E-10	45.05	1.56E-09	1%	
11/08	902	60300	295.40	19.19	1.54E-09	0.18	1.92E-09	1.25	2.39E-09	46.46	1.60E-09	3%	
11/08	1619	26220	302.69	16.75	1.57E-09	-0.51	1.32E-09	1.2	1.58E-09	49.87	1.60E-09	0%	
11/09	747	55680	318.15	17.04	1.36E-09	0.13	1.58E-09	1.2	1.90E-09	52.46	1.62E-09	1%	
11/09	1639	31920	327.02	17.50	1.30E-09	-0.19	7.37E-10	1.2	8.84E-10	53.89	1.60E-09	1%	
11/10	744	54300	342.10	16.69	1.41E-09	0.06	1.51E-09	1.2	1.82E-09	56.60	1.61E-09	1%	
11/10	1635	31860	350.95	16.13	1.67E-09	-0.31	7.44E-10	1.2	8.93E-10	58.30	1.59E-09	1%	
11/11	755	55200	366.29	15.44	1.19E-09	-0.06	1.09E-09	1.2	1.30E-09	60.52	1.56E-09	1%	
11/11	1357	21720	372.32	15.06	1.67E-09	-0.05	1.41E-09	1.2	1.69E-09	61.76	1.55E-09	0%	END TEST

END OF TEST TSH-7 STAGE TWO

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-6 STAGE TWO
Geometric factor = G = 0.006459"
Depth factor = 237.00"
TC values from Replacement TBG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	RL	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (lwa)	RPD (K1wa)	Comments
10/27	1110	0	0.00	34.88	-	-	-	-	-	0	-	-	START
10/27	1422	11520	3.20	25.83	4.93E-08	-0.13	4.86E-08	1.1	5.34E-08	29.76	5.34E-08	-	
10/27	1606	6240	4.93	21.00	4.88E-08	0.13	4.81E-08	1.1	5.29E-08	44.88	5.33E-08	0%	
10/28	815	58140	21.08	30.69	4.88E-08	0.00	4.81E-08	1.1	5.29E-08	112.23	5.30E-08	0%	Dry Refill
10/28	1341	19560	26.52	18.81	3.81E-08	-0.03	3.80E-08	1.1	4.18E-08	150.45	5.07E-08	4%	
10/28	1750	14040	30.67	12.31	2.83E-08	-0.12	2.77E-08	1.1	3.05E-08	171.37	4.80E-08	6%	
10/28	1755	300	30.75	34.86	2.83E-08	0.00	2.77E-08	1.1	3.05E-08	171.37	4.79E-08	0%	Refill
10/29	755	50400	44.75	6.94	3.26E-08	-0.13	3.25E-08	1.1	3.57E-08	254.83	4.41E-08	8%	
10/29	800	300	44.83	35.69	3.26E-08	0.00	3.25E-08	1.1	3.58E-08	254.83	4.41E-08	0%	Refill
10/29	1203	14580	48.88	26.31	3.94E-08	0.00	3.94E-08	1.1	4.33E-08	285.01	4.40E-08	0%	
10/29	1646	16980	53.60	17.81	3.17E-08	0.13	3.22E-08	1.1	3.54E-08	312.36	4.33E-08	2%	
10/29	1648	120	53.63	36.31	3.17E-08	0.00	3.22E-08	1.1	3.54E-08	312.36	4.33E-08	0%	Refill
10/30	850	57720	69.67	9.76	2.80E-08	0.00	2.80E-08	1.1	3.08E-08	394.80	4.04E-08	7%	
10/30	852	120	69.70	31.19	2.80E-08	0.00	2.80E-08	1.1	3.08E-08	394.80	4.04E-08	0%	Refill
10/30	1229	13020	73.32	25.56	2.87E-08	-0.19	2.58E-08	1.1	2.84E-08	412.72	3.90E-08	1%	
10/30	1631	14520	77.36	17.88	3.35E-08	0.00	3.35E-08	1.1	3.69E-08	437.43	3.96E-08	0%	
10/30	1635	240	77.42	35.69	3.35E-08	0.00	3.35E-08	1.1	3.69E-08	437.43	3.96E-08	0%	Refill
10/31	801	55500	92.83	7.88	3.18E-08	-0.06	3.17E-08	1.1	3.49E-08	526.91	3.89E-08	2%	
10/31	806	300	92.92	35.88	3.18E-08	0.00	3.17E-08	1.1	3.49E-08	526.91	3.89E-08	0%	Refill
10/31	1206	14520	96.95	28.50	3.95E-08	-0.13	3.90E-08	1.1	4.29E-08	557.09	3.90E-08	0%	
10/31	1546	13080	100.58	19.88	3.19E-08	0.00	3.19E-08	1.1	3.51E-08	578.39	3.89E-08	0%	
10/31	1550	240	100.65	35.53	3.19E-08	0.00	3.19E-08	1.1	3.51E-08	578.39	3.89E-08	0%	Refill
11/01	1011	66060	119.00	5.06	2.95E-08	-0.19	2.93E-08	1.1	3.23E-08	676.75	3.79E-08	3%	
11/01	1013	120	119.03	35.75	2.95E-08	0.00	2.93E-08	1.1	3.22E-08	676.75	3.79E-08	0%	Refill
11/01	1533	19200	124.37	24.44	3.62E-08	0.07	3.64E-08	1.1	4.01E-08	713.14	3.80E-08	0%	
11/01	1537	240	124.43	35.00	3.62E-08	0.00	3.64E-08	1.1	4.00E-08	713.14	3.80E-08	0%	Refill
11/02	849	61920	141.63	4.25	3.18E-08	0.25	3.21E-08	1.1	3.53E-08	812.08	3.76E-08	1%	
11/02	851	120	141.67	33.13	3.18E-08	0.00	3.21E-08	1.1	3.53E-08	812.08	3.76E-08	0%	Refill
11/02	1342	17460	146.52	20.50	4.50E-08	-0.07	4.47E-08	1.1	4.92E-08	852.72	3.80E-08	1%	
11/02	1615	9180	149.07	15.50	3.50E-08	0.13	3.60E-08	1.1	3.96E-08	868.81	3.80E-08	0%	
11/02	1618	180	149.12	35.56	3.50E-08	0.00	3.60E-08	1.1	3.96E-08	868.81	3.80E-08	0%	Refill

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-6 STAGE TWO
Geometric factor – G = 0.006459"
Depth factor = 237.00"
TC values from Replacement TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	H1	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K twa)	Comments
11/03	819	57660	165.13	4.13	3.49E-08	0.12	3.50E-08	1.1	3.85E-08	969.94	3.81E-08	0%	
11/03	820	60	165.15	35.25	3.49E-08	0.00	3.50E-08	1.1	3.85E-08	969.94	3.81E-08	0%	Refill
11/03	1105	9900	167.90	26.69	4.04E-08	0.00	4.04E-08	1.1	4.45E-08	991.05	3.82E-08	0%	
11/03	1526	15660	172.25	19.75	3.59E-08	0.25	3.69E-08	1.1	4.06E-08	1019.81	3.82E-08	0%	
11/03	1556	1800	172.75	18.50	4.45E-08	0.25	5.34E-08	1.1	5.87E-08	1023.83	3.83E-08	0%	
11/03	1557	60	172.77	36.00	4.45E-08	0.00	5.34E-08	1.1	5.87E-08	1023.83	3.83E-08	0%	Refill
11/04	836	59940	189.42	2.63	3.57E-08	0.00	3.57E-08	1.1	3.93E-08	1131.20	3.84E-08	0%	
11/04	840	240	189.48	35.88	3.57E-08	0.00	3.57E-08	1.1	3.93E-08	1131.20	3.84E-08	0%	Refill
11/04	1645	29100	197.57	17.00	4.04E-08	0.07	4.06E-08	1.1	4.46E-08	1191.95	3.86E-08	1%	
11/04	1646	60	197.58	35.75	4.04E-08	0.00	4.06E-08	1.1	4.47E-08	1191.96	3.86E-08	0%	Refill
11/05	840	57240	213.48	3.63	3.59E-08	0.00	3.59E-08	1.1	3.95E-08	1295.30	3.87E-08	0%	
11/05	842	120	213.52	35.50	3.59E-08	0.00	3.59E-08	1.1	3.95E-08	1295.30	3.87E-08	0%	Refill
11/05	1352	18600	218.68	22.81	4.21E-08	0.00	4.21E-08	1.1	4.63E-08	1334.13	3.89E-08	0%	
11/05	1656	11040	221.75	16.69	3.54E-08	0.06	3.56E-08	1.1	3.94E-08	1355.82	3.89E-08	0%	
11/05	1657	60	221.77	35.31	3.54E-08	0.00	3.56E-08	1.1	3.94E-08	1355.82	3.89E-08	0%	Refill
11/06	835	56280	237.40	5.00	3.44E-08	0.08	3.46E-08	1.1	3.79E-08	1453.35	3.88E-08	0%	
11/06	837	120	237.43	36.75	3.44E-08	0.00	3.45E-08	1.1	3.80E-08	1453.35	3.88E-08	0%	Refill
11/06	1712	30900	246.02	18.19	3.95E-08	0.00	3.95E-08	1.1	4.35E-08	1516.29	3.90E-08	0%	
11/06	1713	60	246.03	35.88	3.95E-08	0.00	3.95E-08	1.1	4.35E-08	1516.29	3.90E-08	0%	Refill
11/07	837	55440	261.43	4.19	3.65E-08	-0.06	3.65E-08	1.1	4.01E-08	1615.26	3.91E-08	0%	
11/07	838	60	261.45	35.75	3.65E-08	0.00	3.65E-08	1.1	4.02E-08	1615.26	3.91E-08	0%	Refill
11/07	1618	27600	269.12	18.31	3.93E-08	0.06	3.94E-08	1.1	4.34E-08	1674.37	3.92E-08	0%	
11/07	1620	120	269.15	36.00	3.93E-08	0.00	3.94E-08	1.1	4.33E-08	1674.37	3.92E-08	0%	Refill
11/08	903	60180	285.87	2.00	3.63E-08	0.07	3.63E-08	1.1	4.00E-08	1763.77	3.92E-08	0%	
11/08	904	60	285.88	34.38	3.63E-08	0.00	3.63E-08	1.1	3.99E-08	1763.77	3.92E-08	0%	Refill
11/08	1619	26100	293.13	14.88	4.69E-08	0.12	4.72E-08	1.1	5.19E-08	1846.51	3.95E-08	1%	
11/08	1620	60	293.15	35.88	4.69E-08	0.00	4.72E-08	1.1	5.19E-08	1846.51	3.95E-08	0%	Refill
11/09	749	55740	308.63	35.81	4.69E-08	0.00	4.72E-08	1.1	5.19E-08	1961.96	4.02E-08	2%	-25" Refill
11/09	1640	31860	317.48	13.44	4.41E-08	-0.13	4.36E-08	1.1	4.82E-08	2033.94	4.04E-08	1%	
11/09	1641	60	317.50	35.38	4.41E-08	0.00	4.36E-08	1.1	4.82E-08	2033.94	4.04E-08	0%	Refill
11/10	745	54240	332.57	4.19	3.68E-08	0.00	3.68E-08	1.1	4.05E-08	2134.30	4.04E-08	0%	
11/10	746	60	332.58	35.88	3.68E-08	0.00	3.68E-08	1.1	4.05E-08	2134.30	4.04E-08	0%	Refill

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-6 STAGE TWO
Geometric factor = G = 0.006459"
Depth factor = 237.00"
TC values from Replacement TRC-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	H1	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twm)	RFD (Ktwm)	Comments
11/10	1636	31600	341.42	16.69	3.76E-06	-0.19	3.72E-06	1.1	4.10E-06	2196.05	4.04E-06	0%	
11/10	1637	60	341.43	35.81	3.76E-06	0.00	3.72E-06	1.1	4.09E-06	2196.05	4.04E-06	0%	Refill
11/11	756	55140	356.75	6.25	3.41E-06	0.00	3.41E-06	1.1	3.75E-06	2291.16	4.03E-06	0%	
11/11	757	60	356.77	34.94	3.41E-06	0.00	3.41E-06	1.1	3.75E-06	2291.16	4.03E-06	0%	Refill
11/11	1356	21660	362.76	22.50	3.55E-06	0.00	3.55E-06	1.1	3.90E-06	2331.19	4.03E-06	0%	END TEST

END OF TEST TSB-6 STAGE TWO

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-9 STAGE TWO
Geometric factor – G = 0.006699"
Depth factor = 160.00"
TC values from Replacement TBG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	RL	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (lwa)	RPD (Klwa)	Comments
10/27	945	0	0.00	31.25	–	–	–	1.1	–	0	–	–	START
10/27	950	300	0.08	22.55	2.64E-06	0.06	2.66E-06	1.1	2.93E-06	27.99	2.93E-06	200%	
10/27	1000	600	0.25	13.13	1.50E-06	0.06	1.51E-06	1.1	1.66E-06	58.32	2.08E-06	34%	
10/27	1010	600	0.42	6.75	1.50E-06	0.06	1.51E-06	1.1	1.66E-06	76.83	1.92E-06	8%	
10/27	1020	600	0.58	1.25	9.51E-07	0.06	9.62E-07	1.1	1.06E-06	86.53	1.87E-06	14%	
10/27	1021	60	0.60	1.00	4.40E-07	0.06	5.46E-07	1.1	6.00E-07	97.33	1.84E-06	2%	
10/27	1407	13560	4.37	35.25	4.40E-07	0.00	5.46E-07	1.1	6.01E-07	100.55	7.43E-07	75%	Dry refill
10/27	1443	2160	4.97	21.25	5.86E-07	-0.13	5.80E-07	1.1	6.39E-07	146.80	7.31E-07	2%	
10/27	1601	4680	6.27	34.75	5.86E-07	0.00	5.80E-07	1.1	6.35E-07	213.97	7.12E-07	3%	Dry refill
10/28	804	57780	22.32	32.25	5.86E-07	0.00	5.80E-07	1.2	6.96E-07	325.75	7.00E-07	2%	Dry refill
10/28	1125	12060	25.67	32.75	5.86E-07	0.00	5.80E-07	1.1	6.38E-07	429.55	6.92E-07	1%	Dry refill
10/28	1335	7800	27.83	33.50	5.86E-07	0.00	5.80E-07	1.1	6.38E-07	534.93	6.86E-07	1%	Dry refill
10/28	1745	15000	32.00	35.50	5.86E-07	0.00	5.80E-07	1.1	6.38E-07	642.72	6.81E-07	1%	Dry refill
10/29	815	52200	46.50	35.00	5.86E-07	0.00	5.80E-07	1.1	6.38E-07	755.94	6.68E-07	2%	Dry refill
10/29	1150	12900	50.08	34.19	5.86E-07	0.00	5.80E-07	1.1	6.38E-07	869.56	6.66E-07	0%	Dry refill
10/29	1620	16200	54.58	35.25	5.86E-07	0.00	5.80E-07	1.1	6.38E-07	979.57	6.63E-07	0%	Dry refill
10/30	832	58320	70.78	35.00	5.86E-07	0.00	5.80E-07	1.2	6.96E-07	1092.99	6.71E-07	1%	Dry refill
10/30	1217	13500	58.33	9.69	1.75E-07	-0.19	1.74E-07	1.2	2.09E-07	1174.42	6.34E-07	5%	
10/30	1222	300	58.42	36.63	1.75E-07	0.00	1.74E-07	1.2	2.09E-07	1174.42	6.34E-07	0%	Refill
10/30	1616	14016	62.31	10.13	3.21E-08	0.00	3.20E-08	1.1	3.52E-08	1256.47	5.96E-07	6%	
10/31	747	55860	77.63	33.50	3.21E-08	0.00	3.20E-08	1.1	3.52E-08	1269.06	4.84E-07	21%	Dry refill
10/31	1157	15000	81.99	6.38	1.71E-07	-0.12	1.70E-07	1.1	1.88E-07	1376.32	4.69E-07	3%	
10/31	1204	420	82.11	34.88	1.71E-07	0.00	1.70E-07	1.1	1.87E-07	1376.32	4.69E-07	0%	Refill
10/31	1527	12180	85.49	11.56	1.78E-07	0.00	1.78E-07	1.1	1.96E-07	1451.35	4.58E-07	2%	
10/31	1528	60	85.51	35.00	1.78E-07	0.00	1.78E-07	1.1	1.96E-07	1451.35	4.56E-07	0%	Refill
11/01	958	66600	104.01	34.63	1.78E-07	0.00	1.78E-07	1.1	1.96E-07	1563.97	4.11E-07	11%	Dry refill
11/01	1530	19920	109.54	33.50	1.78E-07	0.00	4.97E-09	1.1	1.96E-07	1675.39	4.01E-07	3%	Dry refill
11/01	1602	1920	110.08	25.63	3.88E-07	0.00	3.88E-07	1.1	4.05E-07	1700.71	4.01E-07	0%	
11/02	834	59520	126.61	32.06	3.68E-07	0.00	3.68E-07	1.1	4.05E-07	1783.16	4.01E-07	0%	Dry refill
11/02	1350	18960	131.88	33.50	3.68E-07	0.00	3.68E-07	1.2	4.42E-07	1886.34	4.03E-07	0%	Dry refill
11/02	1400	600	132.04	32.19	1.93E-07	-0.05	1.85E-07	1.2	2.22E-07	1890.55	4.02E-07	0%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-8 STAGE TWO
Geometric factor - G = 0.006899"
Depth factor = 160.00"
TC values from Replacement TRG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	R1	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (lwa)	RPD (K1 wa)	Comments
11/02	1410	600	132.04	30.63	2.31E-07	-0.03	2.27E-07	1.2	2.72E-07	1895.57	4.03E-07	0%	
11/02	1420	600	132.21	29.31	1.97E-07	-0.01	1.96E-07	1.2	2.35E-07	1899.62	4.02E-07	0%	
11/02	1430	600	132.38	27.94	2.06E-07	0.01	2.07E-07	1.2	2.49E-07	1904.23	4.02E-07	0%	
11/02	1440	600	132.54	26.63	1.98E-07	0.03	2.03E-07	1.2	2.44E-07	1908.44	4.02E-07	0%	
11/02	1450	600	132.71	25.26	2.10E-07	0.05	2.16E-07	1.2	2.62E-07	1912.88	4.02E-07	0%	
11/02	1500	600	132.88	22.69	3.95E-07	0.07	4.06E-07	1.2	4.87E-07	1921.12	4.02E-07	0%	
11/02	1518	1080	133.18	22.00	5.96E-08	0.09	6.74E-08	1.2	8.09E-08	1923.34	4.01E-07	0%	
11/02	1530	720	133.38	20.54	1.88E-07	0.11	2.02E-07	1.2	2.43E-07	1927.97	4.01E-07	0%	
11/02	1550	1200	133.71	17.94	2.07E-07	0.13	2.18E-07	1.2	2.61E-07	1936.40	4.01E-07	0%	
11/02	1600	600	133.88	17.13	1.29E-07	0.13	1.50E-07	1.2	1.80E-07	1939.01	4.00E-07	0%	
11/02	1602	120	133.91	35.75	1.29E-07	0.00	1.50E-07	1.2	1.80E-07	1939.01	4.00E-07	0%	Refill
11/03	836	59640	150.48	36.00	1.29E-07	0.00	1.50E-07	1.2	1.80E-07	2054.04	3.76E-07	6%	Dry refill
11/03	1067	8460	152.83	19.83	1.75E-07	0.00	1.75E-07	1.2	2.10E-07	2106.71	3.73E-07	1%	
11/03	1545	17280	157.63	35.50	1.75E-07	0.00	1.75E-07	1.2	2.10E-07	2169.57	3.68E-07	1%	Dry refill
11/04	854	61740	174.78	34.56	1.75E-07	0.00	1.75E-07	1.2	2.10E-07	2284.10	3.53E-07	4%	Dry refill
11/04	1228	12720	178.31	11.13	1.72E-07	-0.06	1.71E-07	1.2	2.05E-07	2350.49	3.50E-07	1%	
11/04	1230	240	178.38	35.88	1.72E-07	0.00	1.71E-07	1.2	2.05E-07	2350.49	3.50E-07	0%	Refill
11/04	1623	13980	182.26	10.56	1.68E-07	0.13	1.69E-07	1.2	2.03E-07	2440.96	3.47E-07	1%	
11/04	1625	120	182.29	35.83	1.69E-07	0.00	1.69E-07	1.2	2.03E-07	2440.96	3.47E-07	0%	Refill
11/05	822	57420	198.24	33.50	1.69E-07	0.00	1.69E-07	1.2	2.03E-07	2555.80	3.36E-07	3%	Dry refill
11/05	1345	19380	203.63	2.31	1.54E-07	0.00	1.54E-07	1.2	1.85E-07	2655.96	3.31E-07	1%	
11/05	1346	60	203.64	35.75	1.54E-07	0.00	1.54E-07	1.2	1.85E-07	2655.96	3.31E-07	0%	Refill
11/05	1640	10440	206.54	16.61	1.66E-07	0.12	1.67E-07	1.2	2.00E-07	2716.90	3.29E-07	1%	
11/05	1641	60	206.56	35.61	1.66E-07	0.00	1.67E-07	1.2	2.00E-07	2716.90	3.29E-07	0%	Refill
11/06	820	56340	222.21	34.75	1.66E-07	0.00	1.67E-07	1.2	2.00E-07	2832.12	3.20E-07	3%	Dry refill
11/06	1412	21120	228.08	0.81	1.54E-07	-0.06	1.54E-07	1.2	1.85E-07	2941.33	3.17E-07	1%	
11/06	1413	60	228.09	35.94	1.54E-07	0.00	1.54E-07	1.2	1.85E-07	2941.33	3.17E-07	0%	Refill
11/06	1700	10020	230.88	18.13	1.62E-07	0.00	1.62E-07	1.2	1.94E-07	2998.64	3.15E-07	0%	
11/06	1701	60	230.89	35.88	1.62E-07	0.00	1.62E-07	1.2	1.94E-07	2998.64	3.15E-07	0%	Refill
11/07	846	56820	246.68	35.75	1.62E-07	0.00	1.62E-07	1.25	2.03E-07	3114.09	3.08E-07	2%	Dry refill
11/07	1414	19680	252.11	4.81	1.50E-07	-0.38	1.48E-07	1.2	1.77E-07	3213.64	3.06E-07	1%	
11/07	1415	60	252.13	35.75	1.50E-07	0.00	1.48E-07	1.2	1.78E-07	3213.64	3.06E-07	0%	Refill

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-9 STAGE TWO
Geometric factor - G = 0.006699"
Depth factor = 160.00"
TC values from Replacement TBG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	R1	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (tm)	RPD (Ktm)	Comments
11/07	1832	8220	254.41	21.63	1.55E-07	0.13	1.56E-07	1.2	1.86E-07	3259.07	3.04E-07	0%	
11/07	1833	60	254.43	35.86	1.55E-07	0.00	1.56E-07	1.2	1.87E-07	3259.07	3.04E-07	0%	Refill
11/08	857	59040	270.83	34.19	1.55E-07	0.00	1.55E-07	1.25	1.94E-07	3374.52	2.96E-07	2%	Dry refill
11/08	1328	16260	275.34	9.25	1.44E-07	-1.00	1.36E-07	1.2	1.63E-07	3454.76	2.95E-07	1%	
11/08	1329	60	275.36	35.81	1.44E-07	0.00	1.36E-07	1.2	1.63E-07	3454.76	2.95E-07	0%	Refill
11/08	1630	10860	278.36	18.50	1.45E-07	0.19	1.47E-07	1.2	1.76E-07	3510.46	2.94E-07	0%	
11/08	1631	60	278.38	35.66	1.45E-07	0.00	1.47E-07	1.2	1.76E-07	3510.46	2.94E-07	0%	Refill
11/09	738	54420	293.51	34.13	1.45E-07	0.00	1.47E-07	1.2	1.76E-07	3625.91	2.86E-07	2%	Dry refill
11/09	1347	22140	299.66	3.06	1.34E-07	-0.32	1.33E-07	1.2	1.59E-07	3725.86	2.85E-07	1%	
11/09	1348	60	299.68	35.63	1.34E-07	0.00	1.33E-07	1.2	1.60E-07	3725.86	2.85E-07	0%	Refill
11/09	1649	10860	302.69	18.00	1.46E-07	0.13	1.49E-07	1.2	1.79E-07	3762.61	2.84E-07	0%	
11/09	1650	60	302.71	35.50	1.46E-07	0.00	1.49E-07	1.2	1.79E-07	3762.61	2.84E-07	0%	Refill
11/10	751	54060	317.73	34.63	1.46E-07	0.00	1.49E-07	1.2	1.79E-07	3886.83	2.79E-07	2%	Dry Refill
11/10	1354	21780	323.78	4.56	1.31E-07	-0.25	1.30E-07	1.2	1.56E-07	3993.59	2.77E-07	1%	
11/10	1356	120	323.81	35.56	1.31E-07	0.00	1.30E-07	1.2	1.56E-07	3993.59	2.77E-07	0%	Refill
11/10	1645	10140	326.63	20.25	1.37E-07	-0.05	1.36E-07	1.2	1.63E-07	4042.85	2.76E-07	0%	
11/10	1646	60	326.64	36.00	1.37E-07	0.00	1.36E-07	1.2	1.63E-07	4042.85	2.76E-07	0%	Refill
11/11	747	54060	341.66	34.75	1.37E-07	0.00	1.36E-07	1.2	1.63E-07	4158.88	2.71E-07	2%	Dry Refill
11/11	930	6180	343.38	25.44	1.35E-07	-0.02	1.35E-07	1.2	1.61E-07	4168.64	2.70E-07	0%	
11/11	936	360	343.48	26.86	1.35E-07	0.00	1.35E-07	1.2	1.62E-07	4168.64	2.70E-07	0%	DYE Refill
11/11	1408	16320	348.01	6.06	1.23E-07	-0.06	1.23E-07	1.2	1.47E-07	4255.83	2.69E-07	1%	
11/11	1412	240	348.08	35.56	1.23E-07	0.00	1.23E-07	1.2	1.48E-07	4255.83	2.69E-07	0%	END TEST (Refill)

END OF TEST TSB-9 STAGE TWO

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-10 STAGE TWO
Geometric factor = G = 0.006634"
Depth factor = 165.25"
TC values from Replacement TBG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
10/27	915	0	0.00	33.00	-	-	-	-	-	0	-	-	START
10/27	1410	17700	4.92	27.43	2.37E-08	-0.31	2.23E-08	1.1	2.46E-08	17.28	2.46E-08	200%	
10/27	1555	6300	6.67	24.00	4.60E-08	0.13	4.77E-08	1.1	5.24E-08	28.96	3.19E-08	26%	
10/28	805	58200	22.83	33.50	4.60E-08	0.00	4.77E-08	1.2	5.72E-08	106.18	4.85E-08	44%	Dry Refill
10/28	1332	19620	28.28	15.56	7.35E-08	-0.08	7.32E-08	1.1	8.05E-08	163.90	5.58E-08	11%	
10/28	1736	14640	32.35	4.44	6.56E-08	0.25	6.71E-08	1.1	7.38E-08	199.88	5.80E-08	4%	
10/28	1740	240	32.42	35.00	6.56E-08	0.00	6.71E-08	1.1	7.38E-08	199.88	5.81E-08	0%	Refill
10/29	820	52800	47.08	35.31	6.54E-08	0.00	6.71E-08	1.1	7.38E-08	312.30	6.30E-08	8%	Dry Refill
10/29	1148	12480	50.55	22.88	7.83E-08	0.00	7.83E-08	1.1	8.62E-08	352.29	6.46E-08	2%	
10/29	1625	16620	55.17	12.50	5.19E-08	0.06	5.22E-08	1.1	5.74E-08	385.60	6.40E-08	1%	
10/29	1628	180	55.22	36.83	5.19E-08	0.00	5.22E-08	1.1	5.74E-08	385.60	6.39E-08	0%	Refill
10/30	836	58080	71.35	32.81	5.19E-08	0.00	5.22E-08	1.2	6.26E-08	500.33	6.37E-08	0%	Dry Refill
10/30	1216	13200	75.02	15.75	1.04E-07	-0.19	1.03E-07	1.2	1.23E-07	565.23	6.86E-08	4%	
10/30	1220	240	75.08	32.81	1.04E-07	0.00	1.03E-07	1.2	1.24E-07	565.23	6.86E-08	0%	Refill
10/30	1615	14100	79.00	15.94	9.62E-08	0.00	9.62E-08	1.1	1.06E-07	609.51	6.85E-08	3%	
10/30	1627	720	79.20	34.75	9.62E-08	0.00	9.62E-08	1.1	1.06E-07	609.51	6.87E-08	0%	Refill
10/31	746	55140	94.52	31.25	9.62E-08	0.00	9.62E-08	1.1	1.06E-07	721.32	7.47E-08	8%	Dry Refill
10/31	1158	15120	98.72	15.06	8.66E-08	-0.12	8.60E-08	1.1	9.45E-08	773.41	7.55E-08	1%	
10/31	1205	420	98.83	35.38	8.66E-08	0.00	8.60E-08	1.1	9.46E-08	773.41	7.55E-08	0%	Refill
10/31	1527	12120	102.20	21.08	9.33E-08	0.00	9.33E-08	1.1	1.03E-07	819.40	7.64E-08	1%	
10/31	1535	480	102.33	35.63	9.33E-08	0.00	9.33E-08	1.1	1.03E-07	819.40	7.66E-08	0%	Refill
11/01	1002	66420	120.78	35.81	9.33E-08	0.00	9.33E-08	1.1	1.03E-07	934.19	8.05E-08	5%	Dry refill
11/01	1526	19440	126.18	18.13	7.23E-08	0.00	7.23E-08	1.1	7.95E-08	981.02	8.04E-08	0%	
11/02	837	61860	143.37	31.44	7.23E-08	0.00	7.23E-08	1.1	7.95E-08	1049.38	8.03E-08	0%	Dry Refill
11/02	1335	17880	148.33	16.63	6.67E-08	-0.07	6.64E-08	1.2	7.97E-08	1097.01	8.03E-08	0%	
11/02	1600	8700	150.75	10.56	5.60E-08	0.13	5.73E-08	1.2	6.87E-08	1115.51	8.01E-08	0%	
11/02	1603	180	150.80	35.25	5.60E-08	0.00	5.73E-08	1.2	6.88E-08	1115.51	8.01E-08	0%	Refill
11/03	838	59700	167.38	35.81	5.60E-08	0.00	5.73E-08	1.2	6.88E-08	1228.93	7.90E-08	1%	Dry refill
11/03	1058	8400	169.72	28.19	7.04E-08	0.00	7.04E-08	1.2	8.44E-08	1253.45	7.91E-08	0%	
11/03	1546	17400	174.55	13.75	6.78E-08	0.32	6.94E-08	1.2	8.33E-08	1299.91	7.92E-08	0%	
11/03	1550	120	169.75	35.75	6.78E-08	0.00	6.94E-08	1.2	8.33E-08	1299.91	7.91E-08	0%	Refill

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-10 STAGE TWO
Geometric factor - G = 0.006634"
Depth factor = 186.25"
TC values from Replacement TEC-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (tws)	RPD (K1-ws)	Comments
11/04	858	61680	186.85	34.06	6.78E-08	0.00	6.94E-08	1.2	8.33E-08	1414.94	7.94E-08	0%	Dry refill
11/04	1231	12780	190.43	22.83	7.06E-08	-0.06	7.02E-08	1.2	8.42E-08	1451.72	7.95E-08	0%	
11/04	1626	14100	194.35	11.56	6.54E-08	0.13	6.62E-08	1.2	7.94E-08	1487.34	7.95E-08	0%	
11/04	1628	120	194.38	34.81	6.54E-08	0.00	6.62E-08	1.2	7.94E-08	1487.34	7.95E-08	0%	Refill
11/05	825	57420	210.33	35.31	6.54E-08	0.00	6.62E-08	1.2	7.94E-08	1599.34	7.95E-08	0%	Dry refill
11/05	1347	19320	215.70	18.69	6.83E-08	0.00	6.83E-08	1.2	8.20E-08	1652.52	7.96E-08	0%	
11/05	1644	10620	218.65	11.06	6.05E-08	0.12	6.15E-08	1.2	7.38E-08	1677.37	7.95E-08	0%	
11/05	1646	120	218.68	35.50	6.05E-08	0.00	6.15E-08	1.2	7.38E-08	1677.37	7.95E-08	0%	Refill
11/06	623	56220	234.30	35.75	6.05E-08	0.00	6.15E-08	1.2	7.38E-08	1791.59	7.91E-08	0%	Dry refill
11/06	1416	21160	240.18	18.44	6.49E-08	-0.06	6.47E-08	1.2	7.76E-08	1847.29	7.91E-08	0%	
11/06	1703	10020	242.97	11.00	6.26E-08	0.00	6.26E-08	1.2	7.51E-08	1871.23	7.90E-08	0%	
11/06	1704	60	242.98	35.54	6.26E-08	0.00	6.26E-08	1.2	7.51E-08	1871.23	7.90E-08	0%	Refill
11/07	852	56880	258.78	36.00	6.26E-08	0.00	6.26E-08	1.2	7.51E-08	1985.65	7.88E-08	0%	Dry refill
11/07	1417	19500	264.20	23.25	5.13E-08	-0.38	4.97E-08	1.2	5.97E-08	2026.87	7.84E-08	0%	
11/07	1635	8280	268.50	15.63	4.56E-08	0.13	4.69E-08	1.2	5.63E-08	2041.54	7.82E-08	0%	
11/07	1636	60	268.52	36.00	4.56E-08	0.00	4.69E-08	1.2	5.63E-08	2041.54	7.82E-08	0%	Refill
11/08	853	58620	282.80	3.50	4.57E-08	0.18	4.59E-08	1.25	5.74E-08	2146.11	7.70E-08	2%	
11/08	854	60	282.82	35.50	4.57E-08	0.00	4.59E-08	1.25	5.74E-08	2146.11	7.70E-08	0%	Refill
11/08	1331	16620	287.43	25.56	4.67E-08	-1.00	4.19E-08	1.2	5.03E-08	2178.09	7.66E-08	1%	
11/08	1632	10860	290.45	20.00	4.15E-08	0.19	4.29E-08	1.2	5.15E-08	2195.98	7.63E-08	0%	
11/08	1633	60	290.47	35.83	4.15E-08	0.00	4.29E-08	1.2	5.15E-08	2195.98	7.63E-08	0%	Refill
11/09	739	54360	305.57	8.54	4.06E-08	0.13	4.07E-08	1.2	4.89E-08	2283.08	7.50E-08	3%	
11/09	741	120	305.60	36.00	4.05E-08	0.00	4.07E-08	1.2	4.88E-08	2283.08	7.50E-08	0%	Refill
11/09	1651	33000	314.77	19.31	4.00E-08	-0.19	3.96E-08	1.2	4.75E-08	2338.78	7.42E-08	1%	
11/09	1652	60	314.78	36.00	4.00E-08	0.00	3.96E-08	1.2	4.75E-08	2338.78	7.42E-08	0%	Refill
11/10	752	54000	329.78	6.53	4.44E-08	0.06	4.45E-08	1.2	5.34E-08	2431.28	7.32E-08	1%	
11/10	753	60	329.80	36.00	4.44E-08	0.00	4.45E-08	1.2	5.34E-08	2431.28	7.32E-08	0%	Refill
11/10	1648	32100	338.72	17.13	4.66E-08	-0.31	4.60E-08	1.2	5.52E-08	2492.00	7.28E-08	1%	
11/10	1649	60	338.73	35.88	4.66E-08	0.00	4.60E-08	1.2	5.52E-08	2492.00	7.28E-08	0%	Refill
11/11	750	54060	353.75	9.31	3.99E-08	-0.06	3.96E-08	1.2	4.75E-08	2577.49	7.17E-08	1%	
11/11	751	60	353.77	36.00	3.99E-08	0.00	3.96E-08	1.2	4.75E-08	2577.49	7.17E-08	0%	Refill
11/11	1413	22920	360.13	24.38	3.97E-08	-0.06	3.95E-08	1.2	4.73E-08	2614.88	7.13E-08	1%	END TEST

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-11 STAGE TWO
Geometric factor – G = 0.006578"
Depth factor = 234.75"
TC values from Replacement TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	H	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (tws)	RPD (K1ws)	Comments
10/27	859	0	0.00	35.25	-	-	-	-	-	0.00	-	-	START
10/27	1411	18720	5.20	31.56	1.23E-06	-0.13	1.16E-06	1.1	1.30E-06	11.87	1.30E-06	-	
10/27	1559	6480	7.00	30.13	1.39E-06	0.13	1.51E-05	1.1	1.67E-06	16.47	1.40E-06	7%	
10/28	600	57660	23.02	17.50	1.42E-06	0.06	1.42E-06	1.1	1.56E-06	57.11	1.51E-06	6%	
10/28	1335	20100	28.60	14.36	1.03E-06	-0.03	1.02E-06	1.1	1.13E-06	67.15	1.44E-06	5%	
10/28	1737	14520	32.63	12.19	1.02E-06	-0.12	9.60E-09	1.1	1.06E-06	74.20	1.39E-06	3%	
10/29	611	52440	47.20	4.38	1.02E-06	-0.13	1.01E-06	1.1	1.11E-06	99.33	1.30E-06	6%	
10/29	825	240	47.27	33.00	1.02E-06	0.00	1.01E-06	1.1	1.11E-06	99.33	1.30E-06	0%	Refill
10/29	1149	12240	50.67	30.69	1.16E-06	0.00	1.16E-06	1.1	1.30E-06	106.76	1.30E-06	0%	
10/29	1630	16860	55.36	27.63	1.15E-06	0.13	1.20E-06	1.1	1.32E-06	116.61	1.30E-06	0%	
10/30	638	56060	71.48	17.50	1.13E-06	0.00	1.13E-06	1.1	1.25E-06	149.20	1.29E-06	1%	
10/30	1215	13020	75.10	16.19	1.16E-06	-0.19	1.08E-06	1.1	1.19E-06	156.64	1.29E-06	0%	
10/30	1614	14340	79.08	12.75	1.14E-06	0.00	1.14E-06	1.1	1.26E-06	164.49	1.28E-06	0%	
10/30	1625	660	79.27	36.81	1.14E-06	0.00	1.14E-06	1.1	1.25E-06	164.83	1.28E-06	0%	Refill
10/31	745	55960	95.55	25.50	1.10E-06	-0.06	1.09E-06	1.1	1.20E-06	196.01	1.27E-06	1%	
10/31	1158	15180	99.87	21.56	1.66E-06	-0.13	1.62E-06	1.1	1.79E-06	210.58	1.29E-06	2%	
10/31	1528	12600	103.37	19.25	1.20E-06	0.00	1.20E-06	1.1	1.32E-06	218.12	1.29E-06	0%	
11/01	950	65520	121.57	6.19	1.13E-06	-0.19	1.12E-06	1.1	1.23E-06	253.70	1.28E-06	1%	
11/01	1006	960	121.83	35.75	1.13E-06	0.00	1.12E-06	1.1	1.23E-06	260.05	1.28E-06	0%	Dry refill
11/01	1525	19140	127.15	31.75	1.30E-06	0.07	1.32E-06	1.1	1.45E-06	292.02	1.29E-06	1%	
11/02	822	61020	144.10	20.63	1.17E-06	0.25	1.19E-06	1.1	1.31E-06	328.70	1.29E-06	0%	
11/02	1334	18720	149.30	17.38	1.14E-06	-0.07	1.12E-06	1.1	1.23E-06	339.16	1.29E-06	0%	
11/02	1605	9060	151.82	15.25	1.56E-06	0.13	1.66E-06	1.1	1.83E-06	346.01	1.30E-06	1%	
11/03	834	59340	168.30	6.00	1.16E-06	0.12	1.19E-06	1.1	1.31E-06	379.00	1.30E-06	0%	
11/03	840	360	168.40	35.63	1.16E-06	0.00	1.19E-06	1.1	1.31E-06	379.19	1.30E-06	0%	Refill
11/03	1100	8400	170.73	33.88	1.29E-06	0.00	1.29E-06	1.1	1.42E-06	384.62	1.30E-06	0%	
11/03	1553	17560	175.62	30.31	1.27E-06	0.25	1.36E-06	1.1	1.50E-06	396.31	1.31E-06	0%	
11/04	651	61080	192.58	18.38	1.25E-06	0.00	1.26E-06	1.1	1.39E-06	434.70	1.31E-06	1%	
11/04	1232	13260	196.27	15.88	1.25E-06	0.00	1.25E-06	1.1	1.38E-06	442.74	1.32E-06	0%	
11/04	1621	13740	200.08	13.25	1.28E-06	0.07	1.32E-06	1.1	1.45E-06	451.20	1.32E-06	0%	
11/05	819	57480	216.05	3.50	1.17E-06	0.00	1.17E-06	1.1	1.28E-06	462.58	1.32E-06	0%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-11 STAGE TWO
Geometric factor – G = 0.006576"
Depth factor = 234.75"
TC values from Replacement TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (tvm)	RPD (K1vm)	Comments
11/05	827	480	216.18	35.56	1.17E-06	0.00	1.17E-06	1.1	1.29E-06	482.84	1.32E-06	0%	Refill
11/05	1349	19320	221.55	31.25	1.39E-06	0.00	1.39E-06	1.1	1.53E-06	496.70	1.32E-06	0%	
11/05	1649	10080	224.35	29.00	1.41E-06	0.06	1.45E-06	1.1	1.59E-06	503.94	1.32E-06	0%	
11/06	822	55980	239.90	17.56	1.32E-06	0.05	1.33E-06	1.1	1.46E-06	540.75	1.33E-06	1%	
11/06	1417	21300	245.82	13.56	1.25E-06	-0.05	1.23E-06	1.1	1.35E-06	553.62	1.33E-06	0%	
11/06	1707	10200	248.65	11.75	1.20E-06	0.00	1.20E-06	1.1	1.32E-06	559.45	1.33E-06	0%	
11/06	1708	60	248.67	35.50	1.20E-06	0.00	1.20E-06	1.1	1.32E-06	559.48	1.33E-06	0%	Refill
11/07	853	56700	264.42	23.31	1.36E-06	-0.06	1.35E-06	1.1	1.49E-06	598.70	1.34E-06	1%	
11/07	1418	19500	269.83	19.38	1.31E-06	-0.13	1.27E-06	1.1	1.40E-06	611.35	1.34E-06	0%	
11/07	1627	7740	271.98	17.88	1.28E-06	0.06	1.33E-06	1.1	1.46E-06	618.17	1.34E-06	0%	
11/08	651	59040	288.38	7.00	1.25E-06	0.07	1.26E-06	1.1	1.38E-06	651.18	1.35E-06	0%	
11/08	652	60	288.40	35.50	1.25E-06	0.00	1.25E-06	1.1	1.38E-06	651.22	1.35E-06	0%	Refill
11/08	1332	16800	293.07	31.56	1.48E-06	-0.59	1.20E-06	1.1	1.32E-06	663.59	1.35E-06	0%	
11/08	1635	10980	296.12	29.44	1.22E-06	0.12	1.28E-06	1.1	1.41E-06	670.72	1.35E-06	0%	
11/09	743	54480	311.25	16.75	1.27E-06	-0.07	1.26E-06	1.1	1.38E-06	705.11	1.35E-06	0%	
11/09	1654	33060	320.43	12.59	1.22E-06	-0.13	1.20E-06	1.1	1.32E-06	724.41	1.35E-06	0%	
11/09	1655	60	320.45	36.00	1.22E-06	0.00	1.20E-06	1.1	1.32E-06	724.65	1.36E-06	0%	Refill
11/10	755	54000	335.45	25.00	1.28E-06	0.00	1.28E-06	1.1	1.41E-06	760.04	1.35E-06	0%	
11/10	1650	32100	344.37	18.81	1.28E-06	-0.19	1.22E-06	1.1	1.34E-06	779.96	1.35E-06	0%	
11/11	752	54120	359.40	9.31	1.18E-06	0.00	1.18E-06	1.1	1.30E-06	810.52	1.35E-06	0%	
11/11	1414	22920	365.77	5.54	1.13E-06	0.00	1.13E-06	1.1	1.24E-06	822.59	1.35E-06	0%	END TEST

END OF TEST TSB-11 STAGE TWO

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-12 STAGE TWO
Geometric factor – G = 0.006401"
Depth factor = 266.00"
TC values from Replacement TEC-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (two)	RPD (K1,m)	Comments
10/26	1047	0	0.00	33.50	–	–	–	–	–	0.00	–	–	START
10/26	1130	2580	0.72	32.75	1.58E-08	-0.40	7.37E-09	1.1	8.11E-09	2.41	8.11E-09	–	
10/26	1500	12600	4.22	29.86	1.26E-08	-0.45	1.05E-08	1.1	1.15E-08	11.65	1.10E-08	30%	
10/26	1634	5640	5.78	27.75	2.08E-08	-0.50	1.59E-08	1.1	1.75E-08	19.50	1.27E-08	15%	
10/27	751	55020	21.07	0.69	2.86E-08	-0.25	2.83E-08	1.1	3.11E-08	105.57	2.61E-08	69%	
10/27	753	120	21.10	33.38	2.86E-08	0.00	2.83E-08	1.1	3.11E-08	105.76	2.61E-08	0%	Refill
10/27	1351	21480	27.07	18.69	3.81E-08	-0.13	3.77E-08	1.1	4.15E-08	153.03	2.95E-08	12%	
10/27	1612	8460	29.42	13.75	3.36E-08	0.13	3.45E-08	1.1	3.80E-08	168.92	3.02E-08	2%	
10/27	1627	300	29.50	34.50	3.36E-08	0.00	3.45E-08	1.1	3.80E-08	169.46	3.02E-08	0%	Refill
10/28	743	54960	44.77	1.25	3.47E-08	0.06	3.48E-08	1.1	3.52E-08	276.45	3.29E-08	9%	
10/28	820	2220	45.38	33.81	3.47E-08	0.00	3.48E-08	1.1	3.83E-08	280.60	3.30E-08	0%	Refill
10/28	1355	20100	50.97	20.13	3.78E-08	-0.03	3.77E-08	1.1	4.15E-08	324.52	3.39E-08	3%	
10/28	1715	12060	54.32	13.06	3.37E-08	-0.12	3.32E-08	1.1	3.65E-08	347.37	3.41E-08	0%	
10/28	1720	240	54.38	34.13	3.37E-08	0.00	3.32E-08	1.1	3.65E-08	347.81	3.41E-08	0%	Refill
10/29	740	51600	68.72	2.44	3.52E-08	-0.13	3.50E-08	1.1	3.85E-08	449.78	3.50E-08	3%	
10/29	835	3300	69.63	35.60	3.52E-08	0.00	3.50E-08	1.1	3.85E-08	455.91	3.51E-08	0%	Refill
10/29	1135	10800	72.63	28.00	3.98E-08	0.00	3.96E-08	1.1	4.36E-08	481.26	3.54E-08	1%	
10/29	1555	15600	76.97	18.06	3.58E-08	0.13	3.63E-08	1.1	4.00E-08	513.25	3.57E-08	1%	
10/29	1600	300	77.05	35.66	3.58E-08	0.00	3.63E-08	1.1	3.99E-08	513.85	3.57E-08	0%	Refill
10/30	800	57600	93.05	1.88	3.37E-08	0.00	3.37E-08	1.1	3.71E-08	623.25	3.59E-08	1%	
10/30	807	420	93.17	35.25	3.37E-08	0.00	3.37E-08	1.1	3.71E-08	624.04	3.59E-08	0%	Refill
10/30	1157	13800	97.00	25.81	3.75E-08	-0.19	3.67E-08	1.1	4.04E-08	654.41	3.61E-08	0%	
10/30	1545	13680	100.80	17.63	3.38E-08	0.00	3.36E-08	1.1	3.72E-08	680.73	3.61E-08	0%	
10/30	1549	240	100.87	35.38	3.38E-08	0.00	3.36E-08	1.1	3.72E-08	681.19	3.61E-08	0%	Refill
10/31	718	55740	116.35	2.75	3.34E-08	-0.06	3.34E-08	1.1	3.67E-08	786.15	3.62E-08	0%	
10/31	725	420	116.47	35.50	3.34E-08	0.00	3.34E-08	1.1	3.67E-08	786.96	3.62E-08	0%	Refill
10/31	1141	15360	120.73	25.06	3.73E-08	-0.13	3.68E-08	1.1	4.05E-08	820.55	3.64E-08	0%	
10/31	1501	12000	124.07	16.00	3.33E-08	0.00	3.33E-08	1.1	3.66E-08	843.27	3.64E-08	0%	
10/31	1509	480	124.20	35.38	3.33E-08	0.00	3.33E-08	1.1	3.66E-08	844.14	3.64E-08	0%	Refill
11/01	927	65880	142.50	33.00	3.33E-08	0.00	3.33E-08	1.1	3.66E-08	957.96	3.64E-08	0%	Dry refill
11/01	1458	19740	147.98	19.66	3.70E-08	0.07	3.72E-08	1.1	4.09E-08	1000.20	3.66E-08	0%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-12 STAGE TWO
Geometric factor - G = 0.006401"
Depth factor = 266.00"
TC values from Replacement TBG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
11/01	1507	660	146.17	35.44	3.70E-08	0.00	3.72E-08	1.1	4.09E-08	1001.56	3.66E-08	0%	Refill
11/02	754	60460	164.07	3.58	3.00E-08	0.25	3.03E-08	1.1	3.33E-08	1104.05	3.62E-08	1%	Refill
11/02	802	480	165.10	35.38	3.00E-08	0.00	3.03E-08	1.1	3.33E-08	1104.88	3.62E-08	0%	
11/02	1317	18900	170.35	24.00	3.31E-08	-0.07	3.29E-08	1.1	3.62E-08	1141.50	3.62E-08	0%	
11/02	1624	11220	173.47	16.19	2.93E-08	0.13	3.00E-08	1.1	3.30E-08	1160.19	3.62E-08	0%	Refill
11/02	1628	240	173.53	35.63	2.93E-08	0.00	3.00E-08	1.1	3.30E-08	1160.50	3.62E-08	0%	
11/03	755	55620	188.98	7.06	2.91E-08	0.12	2.92E-08	1.1	3.21E-08	1252.61	3.58E-08	1%	Refill
11/03	800	300	189.07	35.60	2.91E-08	0.00	2.92E-08	1.1	3.21E-08	1253.01	3.58E-08	0%	
11/03	1113	11580	192.29	29.50	3.00E-08	0.00	3.00E-08	1.1	3.30E-08	1273.53	3.58E-08	0%	
11/03	1503	13800	196.12	22.44	2.86E-08	0.25	2.96E-08	1.1	3.25E-08	1290.25	3.57E-08	0%	Dry refill
11/04	805	61320	213.15	35.63	2.86E-08	0.00	2.86E-08	1.1	3.14E-08	1368.45	3.54E-08	1%	
11/04	1215	15000	217.32	27.31	3.03E-08	0.00	3.03E-08	1.1	3.33E-08	1395.22	3.53E-08	0%	
11/04	1600	13500	221.07	20.89	2.75E-08	0.07	2.76E-08	1.1	3.04E-08	1418.52	3.53E-08	0%	
11/04	1650	3000	221.90	19.31	2.82E-08	0.07	2.75E-08	1.1	3.02E-08	1420.96	3.52E-08	0%	Refill
11/04	1652	120	221.93	35.25	2.82E-08	0.00	2.75E-08	1.1	3.03E-08	1421.13	3.52E-08	0%	
11/05	746	53640	236.83	10.06	2.85E-08	0.00	2.85E-08	1.1	2.91E-08	1502.10	3.49E-08	1%	Refill
11/05	750	240	236.90	35.81	2.85E-08	0.00	2.85E-08	1.1	2.92E-08	1502.55	3.49E-08	0%	
11/05	1332	20520	242.60	25.31	2.81E-08	0.00	2.81E-08	1.1	3.09E-08	1538.33	3.48E-08	0%	
11/05	1617	9900	245.35	20.88	2.52E-08	0.08	2.55E-08	1.1	2.81E-08	1550.59	3.47E-08	0%	Refill
11/05	1618	60	245.37	35.88	2.52E-08	0.00	2.55E-08	1.1	2.81E-08	1550.87	3.47E-08	0%	
11/06	755	56220	260.98	10.31	2.54E-08	0.06	2.57E-08	1.1	2.82E-08	1632.95	3.43E-08	1%	Refill
11/06	758	180	261.03	35.58	2.56E-08	0.00	2.57E-08	1.1	2.83E-08	1633.21	3.43E-08	0%	
11/06	1405	22020	267.15	24.75	2.70E-08	-0.06	2.68E-08	1.1	2.95E-08	1667.99	3.42E-08	0%	
11/06	1640	9300	269.73	20.69	2.46E-08	0.00	2.46E-08	1.1	2.70E-08	1681.06	3.41E-08	0%	Refill
11/06	1642	120	269.77	35.75	2.46E-08	0.00	2.46E-08	1.1	2.71E-08	1681.22	3.41E-08	0%	
11/07	825	56580	285.48	10.75	2.49E-08	-0.06	2.46E-08	1.1	2.73E-08	1761.66	3.37E-08	1%	Refill
11/07	826	60	285.50	35.88	2.49E-08	0.00	2.46E-08	1.1	2.73E-08	1761.75	3.37E-08	0%	
11/07	1358	19920	291.03	26.38	2.61E-08	-0.13	2.57E-08	1.1	2.83E-08	1792.31	3.36E-08	0%	
11/07	1640	5580	292.58	22.19	4.21E-08	0.08	4.27E-08	1.1	4.69E-08	1805.79	3.37E-08	0%	Refill
11/07	1641	60	292.60	35.88	4.21E-08	0.00	4.27E-08	1.1	4.70E-08	1805.94	3.37E-08	0%	
11/08	828	56820	308.38	12.19	2.34E-08	0.07	2.35E-08	1.1	2.58E-08	1882.15	3.33E-08	1%	
11/08	1315	17220	313.17	5.81	2.19E-08	-0.89	1.95E-08	1.1	2.15E-08	1902.69	3.31E-08	1%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-12 STAGE TWO
Geometric factor - G = 0.006401"
Depth factor = 266.00"
TC values from Replacement TBG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	RL	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (lwa)	RPD (K1-wa)	Comments
11/08	1318	60	313.18	36.00	2.19E-06	0.00	1.95E-06	1.1	2.15E-06	1902.76	3.31E-06	0%	Refill
11/08	1600	9840	315.92	31.63	2.41E-06	0.12	2.47E-06	1.1	2.72E-06	1916.82	3.31E-06	0%	
11/09	714	54840	331.15	16.44	2.19E-06	-0.07	2.16E-06	1.1	2.40E-06	1965.00	3.27E-06	1%	
11/09	715	60	331.17	35.94	2.19E-06	0.00	2.16E-06	1.1	2.40E-06	1965.06	3.27E-06	0%	Refill
11/09	1336	22860	337.52	25.94	2.40E-06	-0.19	2.35E-06	1.1	2.58E-06	2017.26	3.25E-06	0%	
11/09	1617	9660	340.20	22.13	2.21E-06	0.06	2.25E-06	1.1	2.47E-06	2029.51	3.25E-06	0%	
11/09	1618	60	340.22	35.75	2.21E-06	0.00	2.25E-06	1.1	2.48E-06	2029.59	3.25E-06	0%	Refill
11/10	721	54180	355.27	14.38	2.20E-06	0.00	2.20E-06	1.1	2.42E-06	2098.35	3.21E-06	1%	
11/10	723	120	355.30	35.61	2.20E-06	0.00	2.20E-06	1.1	2.42E-06	2098.50	3.21E-06	0%	Refill
11/10	1617	32040	364.20	22.63	2.27E-06	-0.19	2.23E-06	1.1	2.46E-06	2140.91	3.19E-06	1%	
11/10	1618	60	364.22	35.75	2.27E-06	0.00	2.23E-06	1.1	2.45E-06	2140.99	3.19E-06	0%	Refill
11/11	727	54540	379.37	14.88	2.14E-06	0.00	2.14E-06	1.1	2.35E-06	2206.14	3.16E-06	1%	
11/11	728	60	379.38	35.75	2.14E-06	0.00	2.14E-06	1.1	2.36E-06	2206.21	3.16E-06	0%	Refill
11/11	1338	22200	385.55	27.00	2.16E-06	0.00	2.16E-06	1.1	2.37E-06	2236.37	3.15E-06	0%	END TEST

END OF TEST TSB-12 STAGE TWO

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-13 STAGE TWO
Geometric factor - G = 0.006243"
Depth factor = 356.8"
TC values from TBG-3

Date	Time	elapsed time seconds	cumulative elapsed time hours	H1	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (tws)	RPD (K1,ws)	Comments
10/26	1130	0	0.00	33.56	–	–	–	1.1	–	0.00	–	–	START
10/26	1502	12720	3.53	19.38	4.61E-06	0.06	4.53E-06	1.1	5.10E-06	45.63	5.10E-06	–	
10/26	1634	5520	5.07	12.81	5.06E-06	-0.05	5.01E-06	1.1	5.52E-06	66.77	5.22E-06	2%	
10/26	1636	120	5.10	35.25	5.06E-06	0.00	5.01E-06	1.1	5.51E-06	67.21	5.23E-06	0%	Refill
10/27	754	55080	20.40	34.88	5.06E-06	0.00	5.01E-06	1.1	5.51E-06	180.84	5.44E-06	4%	Dry refill
10/27	1352	21480	26.37	14.25	3.90E-06	-0.13	3.97E-06	1.1	4.37E-06	247.01	5.20E-06	5%	
10/27	1613	8460	28.72	7.31	3.54E-06	0.19	3.64E-06	1.1	4.00E-06	269.34	5.10E-06	2%	
10/27	1626	900	28.97	34.63	3.54E-06	0.00	3.64E-06	1.1	4.00E-06	271.49	5.00E-06	0%	Refill
10/28	746	55080	44.27	31.00	3.54E-06	0.00	3.64E-06	1.1	4.00E-06	382.92	4.71E-06	6%	Dry refill
10/28	1318	19020	49.60	9.00	4.66E-06	-0.31	4.56E-06	1.1	5.04E-06	453.70	4.75E-06	1%	
10/28	1400	2520	50.50	6.56	4.21E-06	0.06	4.32E-06	1.1	4.75E-06	461.56	4.75E-06	0%	
10/28	1725	12300	53.92	32.75	4.21E-06	0.00	4.32E-06	1.1	4.75E-06	462.66	4.75E-06	0%	Dry refill
10/29	640	54900	69.17	32.61	4.21E-06	0.00	4.32E-06	1.1	4.75E-06	588.04	4.75E-06	0%	Dry refill
10/29	1135	10560	72.08	20.44	4.97E-06	-0.06	4.85E-06	1.1	5.33E-06	627.64	4.77E-06	0%	
10/29	1558	15660	76.43	4.26	4.44E-06	0.12	4.49E-06	1.1	4.92E-06	679.93	4.78E-06	0%	
10/29	1600	240	76.50	35.56	4.44E-06	0.00	4.48E-06	1.1	4.93E-06	680.72	4.79E-06	0%	Refill
10/30	805	57900	92.58	35.75	4.44E-06	0.00	4.48E-06	1.1	4.93E-06	796.14	4.81E-06	1%	Dry refill
10/30	1159	14040	96.48	17.75	5.30E-06	-0.13	5.26E-06	1.1	5.79E-06	853.05	4.85E-06	1%	
10/30	1547	13680	100.28	2.25	4.90E-06	-0.06	4.88E-06	1.1	5.37E-06	902.93	4.87E-06	0%	
10/30	1553	360	100.38	35.36	4.90E-06	0.00	4.88E-06	1.1	5.37E-06	904.21	4.87E-06	0%	Refill
10/31	719	55560	115.82	33.50	4.90E-06	0.00	4.88E-06	1.1	5.37E-06	1016.05	4.93E-06	1%	Dry refill
10/31	1142	15780	120.20	10.00	6.24E-06	0.00	6.24E-06	1.1	6.86E-06	1093.56	5.00E-06	1%	
10/31	1145	180	120.25	35.36	6.24E-06	0.00	6.24E-06	1.1	6.86E-06	1094.51	5.01E-06	0%	Refill
10/31	1502	11820	123.53	15.00	7.16E-06	0.00	7.16E-06	1.1	7.88E-06	1160.09	5.08E-06	2%	
10/31	1506	360	123.63	35.06	7.16E-06	0.00	7.16E-06	1.1	7.88E-06	1162.02	5.06E-06	0%	Refill
11/01	926	66000	141.97	35.00	7.16E-06	0.00	7.16E-06	1.1	7.88E-06	1274.83	5.44E-06	7%	Dry refill
11/01	1500	19920	147.50	5.31	6.27E-06	0.00	6.27E-06	1.1	6.90E-06	1370.36	5.50E-06	1%	
11/01	1505	300	147.58	35.56	6.27E-06	0.00	6.27E-06	1.1	6.90E-06	1371.78	5.50E-06	0%	Refill
11/02	754	60540	164.40	33.00	6.27E-06	0.00	6.27E-06	1.1	6.90E-06	1486.20	5.64E-06	3%	Dry refill
11/02	1318	19440	169.80	7.13	5.60E-06	-0.13	5.57E-06	1.1	6.13E-06	1549.44	5.66E-06	0%	
11/02	1321	180	169.85	34.86	5.60E-06	0.00	5.57E-06	1.1	6.13E-06	1570.29	5.66E-06	0%	Refill

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-13 STAGE TWO
Geometric factor - G = 0.006243"
Depth factor = 356.8"
TC values from TBG-3

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	Kt	TC	KtC	visc. factor	KtCT	cumulative volume (cc)	K (twa)	RPD (Ktwa)	Comments
11/02	1625	11040	172.92	19.50	5.75E-06	0.13	5.50E-06	1.1	6.36E-06	1619.69	5.67E-06	0%	
11/02	1630	300	173.00	35.44	5.75E-06	0.00	5.50E-06	1.1	6.36E-06	1621.00	5.67E-06	0%	Refill
11/03	756	55680	188.47	34.31	5.75E-06	0.00	5.50E-06	1.1	6.35E-06	1735.03	5.73E-06	1%	Dry refill
11/03	1114	11760	191.73	19.56	5.18E-06	0.00	5.18E-06	1.1	5.70E-06	1782.49	5.73E-06	0%	
11/03	1504	13800	195.57	3.38	5.05E-06	0.18	5.11E-06	1.1	5.62E-06	1834.55	5.73E-06	0%	
11/03	1507	180	195.62	35.31	5.05E-06	0.00	5.11E-06	1.1	5.62E-06	1835.22	5.73E-06	0%	Refill
11/04	806	61260	212.63	34.06	5.05E-06	0.00	5.11E-06	1.1	5.62E-06	1940.83	5.72E-06	0%	Dry refill
11/04	1216	14880	216.77	15.38	5.22E-06	0.00	5.22E-06	1.1	5.74E-06	2008.01	5.72E-06	0%	
11/04	1605	13740	220.58	35.25	5.22E-06	0.00	5.22E-06	1.1	5.74E-06	2058.43	5.72E-06	0%	Dry refill
11/05	755	57000	236.42	33.50	5.22E-06	0.00	5.22E-06	1.1	5.74E-06	2171.86	5.72E-06	0%	Dry refill
11/05	1333	20280	242.05	9.50	4.96E-06	-0.12	4.94E-06	1.1	5.43E-06	2240.07	5.71E-06	0%	
11/05	1335	120	242.08	35.75	4.96E-06	0.00	4.94E-06	1.1	5.43E-06	2240.52	5.71E-06	0%	Refill
11/05	1820	9900	244.83	23.63	5.02E-06	0.18	5.10E-06	1.1	5.61E-06	2288.52	5.71E-06	0%	
11/05	1822	120	244.87	35.81	5.02E-06	0.00	5.10E-06	1.1	5.61E-06	2288.99	5.71E-06	0%	Refill
11/06	800	56280	260.50	33.38	5.02E-06	0.00	5.10E-06	1.1	5.61E-06	2404.21	5.71E-06	0%	Dry refill
11/06	1406	21960	266.60	7.58	4.94E-06	-0.06	4.93E-06	1.1	5.43E-06	2487.29	5.70E-06	0%	
11/06	1407	60	266.62	35.25	4.94E-06	0.00	4.93E-06	1.1	5.42E-06	2487.51	5.70E-06	0%	Refill
11/06	1643	9360	269.22	23.63	5.10E-06	0.08	5.12E-06	1.1	5.64E-06	2524.90	5.70E-06	0%	
11/06	1644	60	269.23	35.88	5.10E-06	0.00	5.12E-06	1.1	5.63E-06	2525.14	5.70E-06	0%	Refill
11/07	828	56640	284.97	34.38	5.10E-06	0.00	5.12E-06	1.1	5.63E-06	2640.50	5.70E-06	0%	Dry refill
11/07	1400	19920	290.50	11.06	4.89E-06	-0.13	4.86E-06	1.1	5.35E-06	2715.62	5.69E-06	0%	
11/07	1401	60	290.52	35.75	4.89E-06	0.00	4.86E-06	1.1	5.35E-06	2715.85	5.69E-06	0%	Refill
11/07	1645	9840	293.25	23.69	5.03E-06	0.07	5.06E-06	1.1	5.56E-06	2754.65	5.69E-06	0%	
11/07	1647	120	293.28	36.00	5.03E-06	0.00	5.06E-06	1.1	5.57E-06	2755.12	5.69E-06	0%	Refill
11/08	830	56580	309.00	33.53	5.03E-06	0.00	5.06E-06	1.1	5.57E-06	2870.95	5.68E-06	0%	Dry refill
11/08	1316	17280	313.80	12.75	5.04E-06	-0.19	5.00E-06	1.1	5.50E-06	2936.14	5.68E-06	0%	
11/08	1319	60	313.82	35.75	5.04E-06	0.00	5.00E-06	1.1	5.50E-06	2936.37	5.68E-06	0%	Refill
11/08	1602	9680	316.51	24.13	4.92E-06	-0.19	4.84E-06	1.1	5.32E-06	2975.75	5.68E-06	0%	
11/08	1603	60	316.52	35.88	4.92E-06	0.00	4.84E-06	1.1	5.32E-06	2975.99	5.68E-06	0%	Refill
11/09	716	54900	331.77	33.44	4.92E-06	0.00	4.84E-06	1.1	5.32E-06	3091.44	5.66E-06	0%	Dry refill
11/09	1337	22740	338.09	7.50	4.80E-06	-0.12	4.77E-06	1.1	5.25E-06	3174.90	5.65E-06	0%	
11/09	1338	60	338.11	35.75	4.80E-06	0.00	4.77E-06	1.1	5.25E-06	3175.12	5.65E-06	0%	Refill

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-13 STAGE TWO
Geometric factor – G = 0.006243"
Depth factor = 358.8"
TC values from TEG-3

Date	Time	elapsed time seconds	cumulative elapsed time hours	R1	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (tsa)	RPD (Ktsa)	Comments
11/09	1619	9660	340.79	24.13	4.93E-08	0.00	4.93E-08	1.1	5.43E-08	3212.61	5.65E-08	0%	
11/09	1620	60	340.81	38.00	4.93E-08	0.00	4.93E-08	1.1	5.42E-08	3212.74	5.65E-08	0%	Refill
11/10	725	54300	355.89	34.25	4.93E-08	0.00	4.93E-08	1.1	5.42E-08	3328.57	5.64E-08	0%	Dry refill
11/10	1341	22560	362.16	9.00	4.89E-08	-0.13	4.87E-08	1.1	5.13E-08	3409.62	5.63E-08	0%	
11/10	1342	60	362.17	35.88	4.89E-08	0.00	4.87E-08	1.1	5.14E-08	3410.03	5.63E-08	0%	Refill
11/10	1620	9480	364.81	25.13	4.84E-08	0.00	4.84E-08	1.1	5.11E-08	3444.62	5.63E-08	0%	
11/10	1621	60	364.82	35.75	4.84E-08	0.00	4.84E-08	1.1	5.10E-08	3444.84	5.63E-08	0%	Refill
11/11	730	54540	379.97	34.88	4.84E-08	0.00	4.84E-08	1.1	5.10E-08	3559.87	5.61E-08	0%	Dry refill
11/11	1340	22200	386.14	10.56	4.56E-08	0.06	4.59E-08	1.1	5.05E-08	3638.12	5.60E-08	0%	END TEST

END OF TEST TSB-13 STAGE TWO

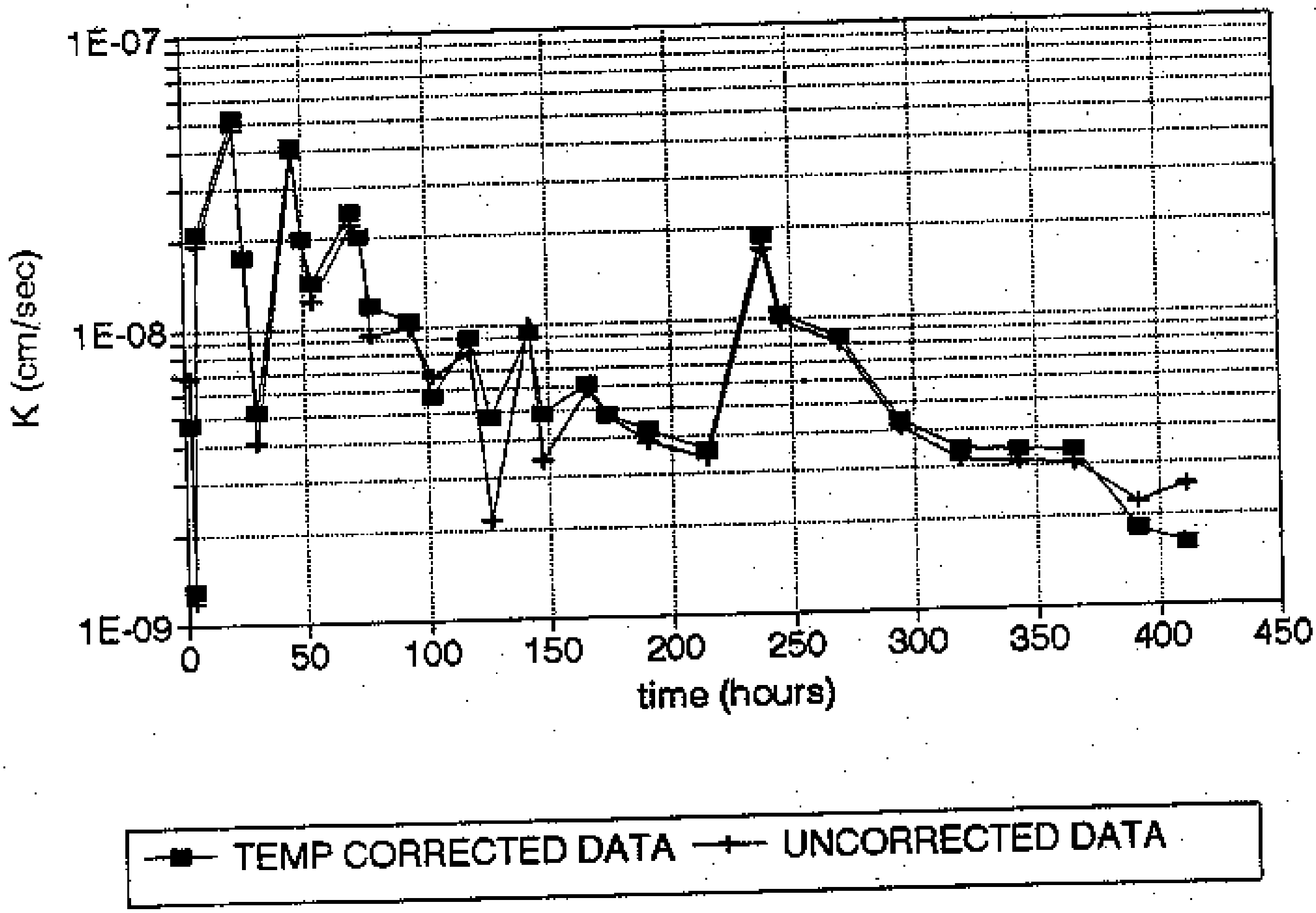
ATTACHMENT 3A

TSB DATA PLOTS

STAGE 1

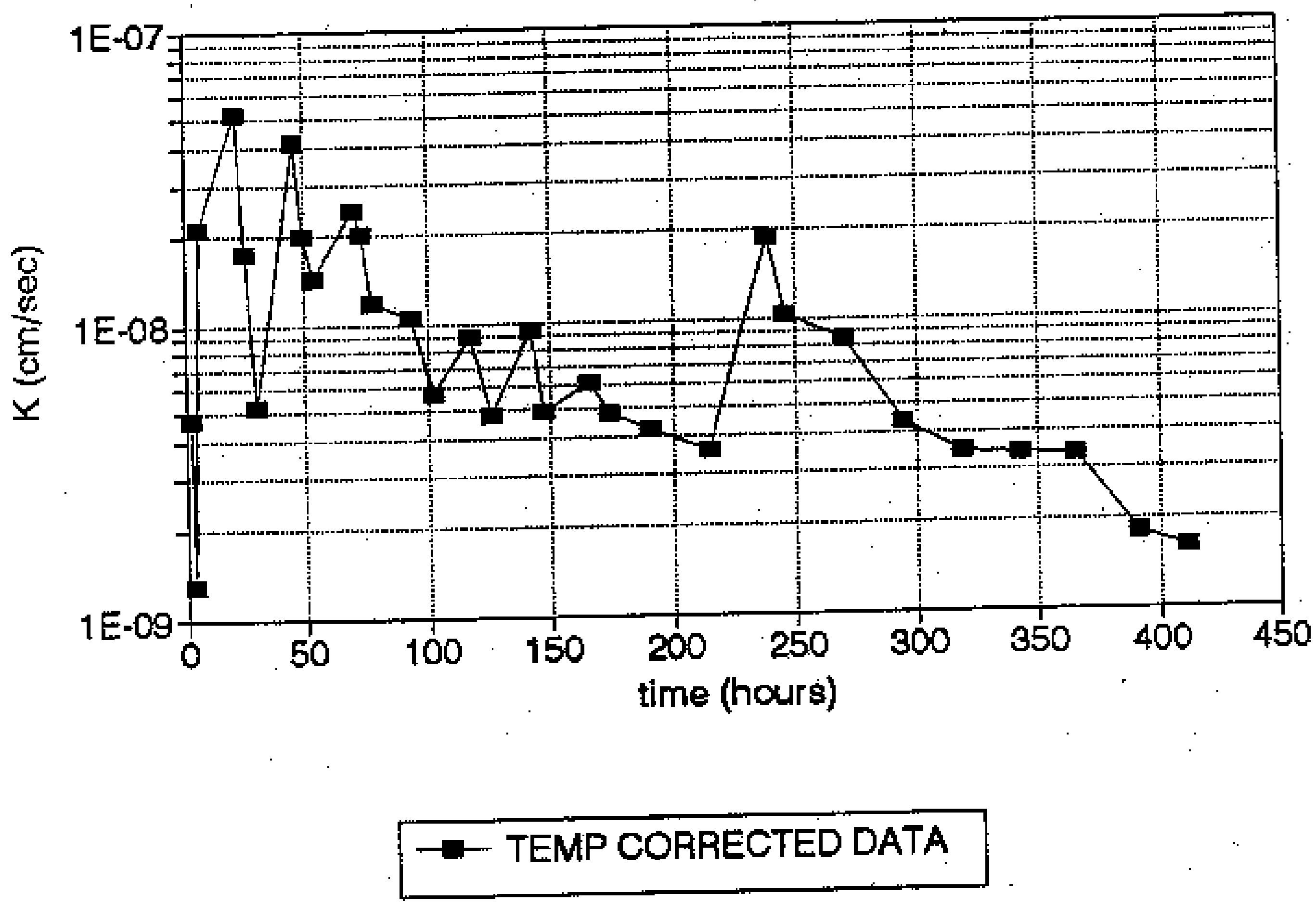
TSB-1 STAGE ONE

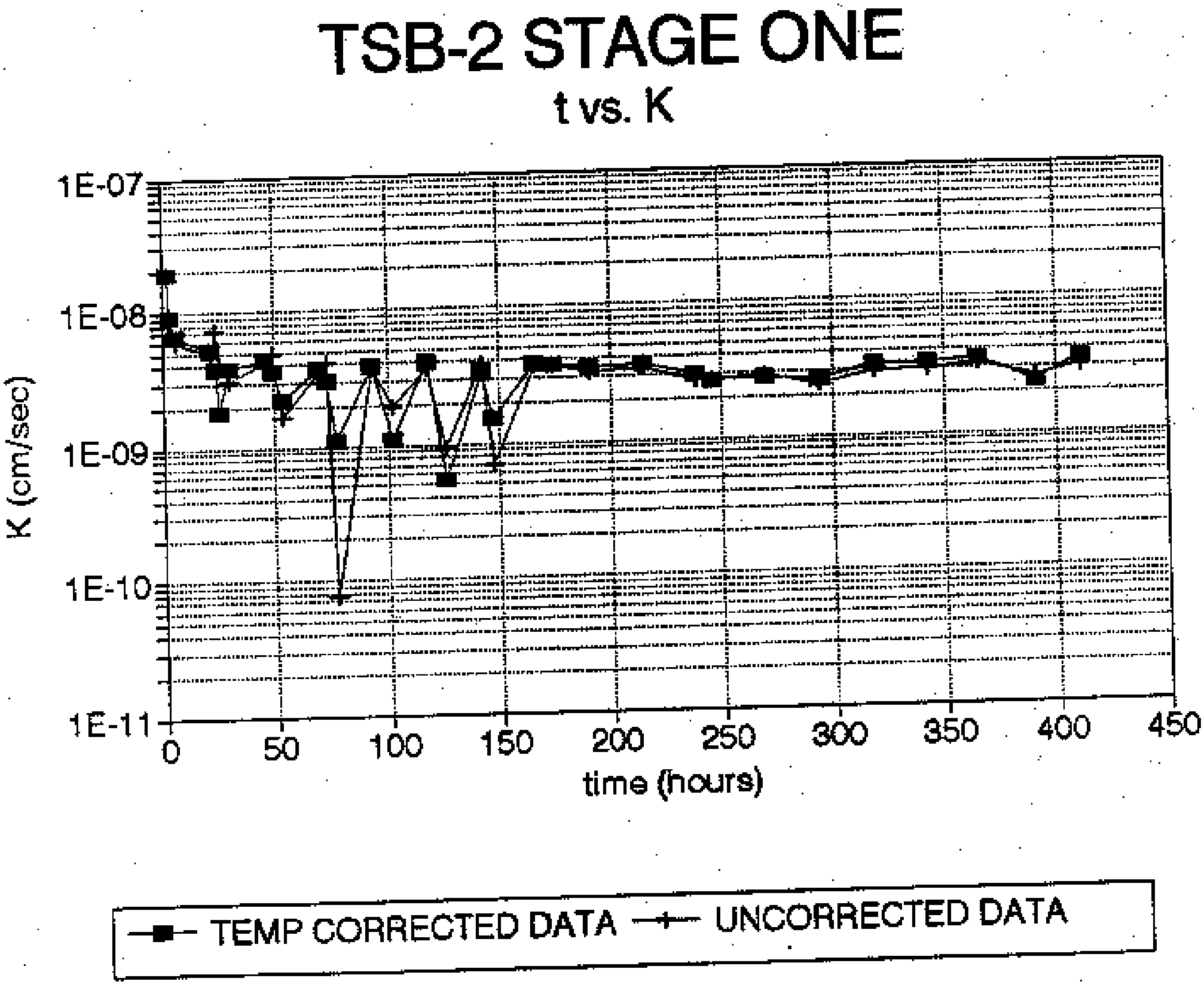
t vs. K



TSB-1 STAGE ONE

t vs. K

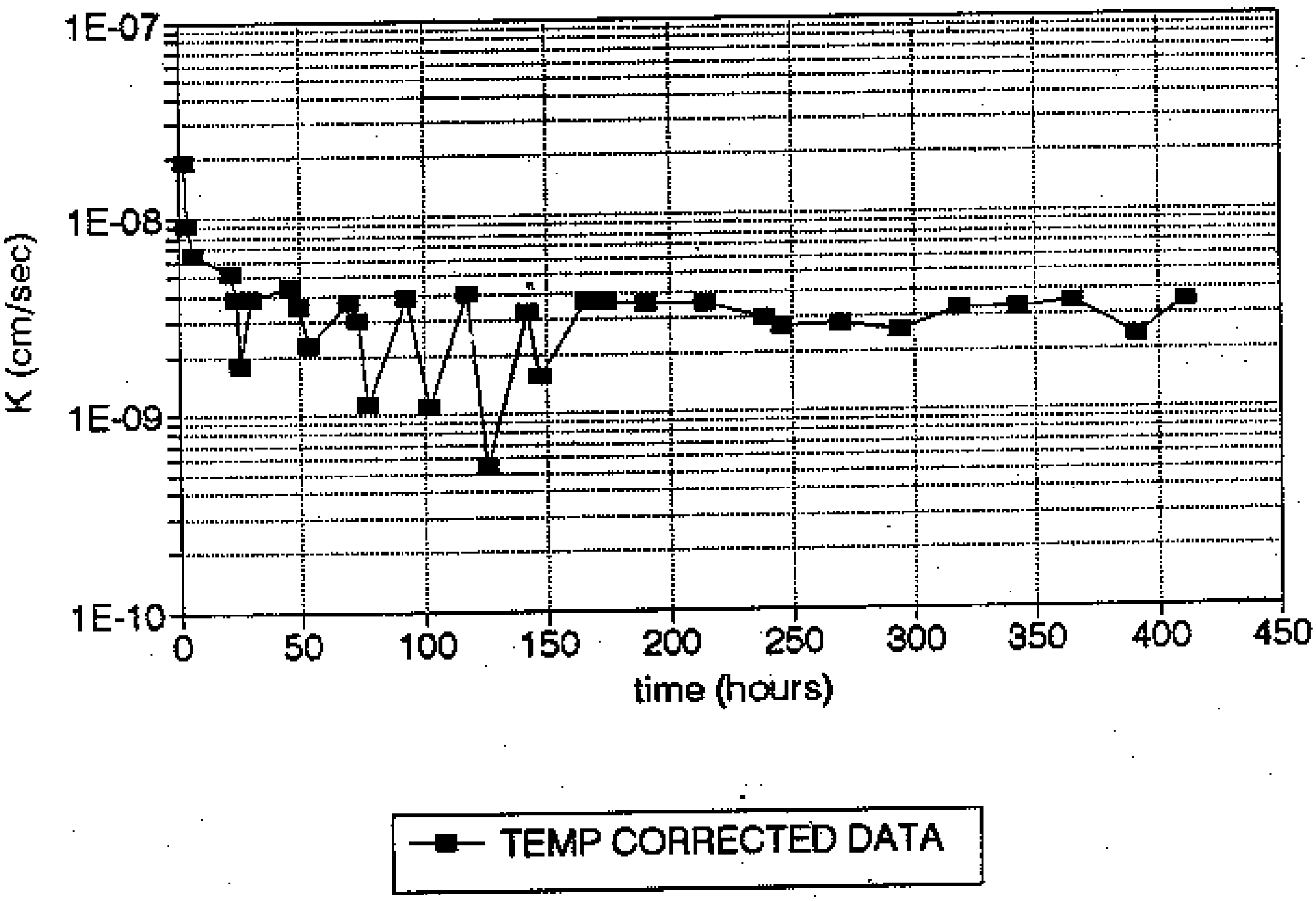


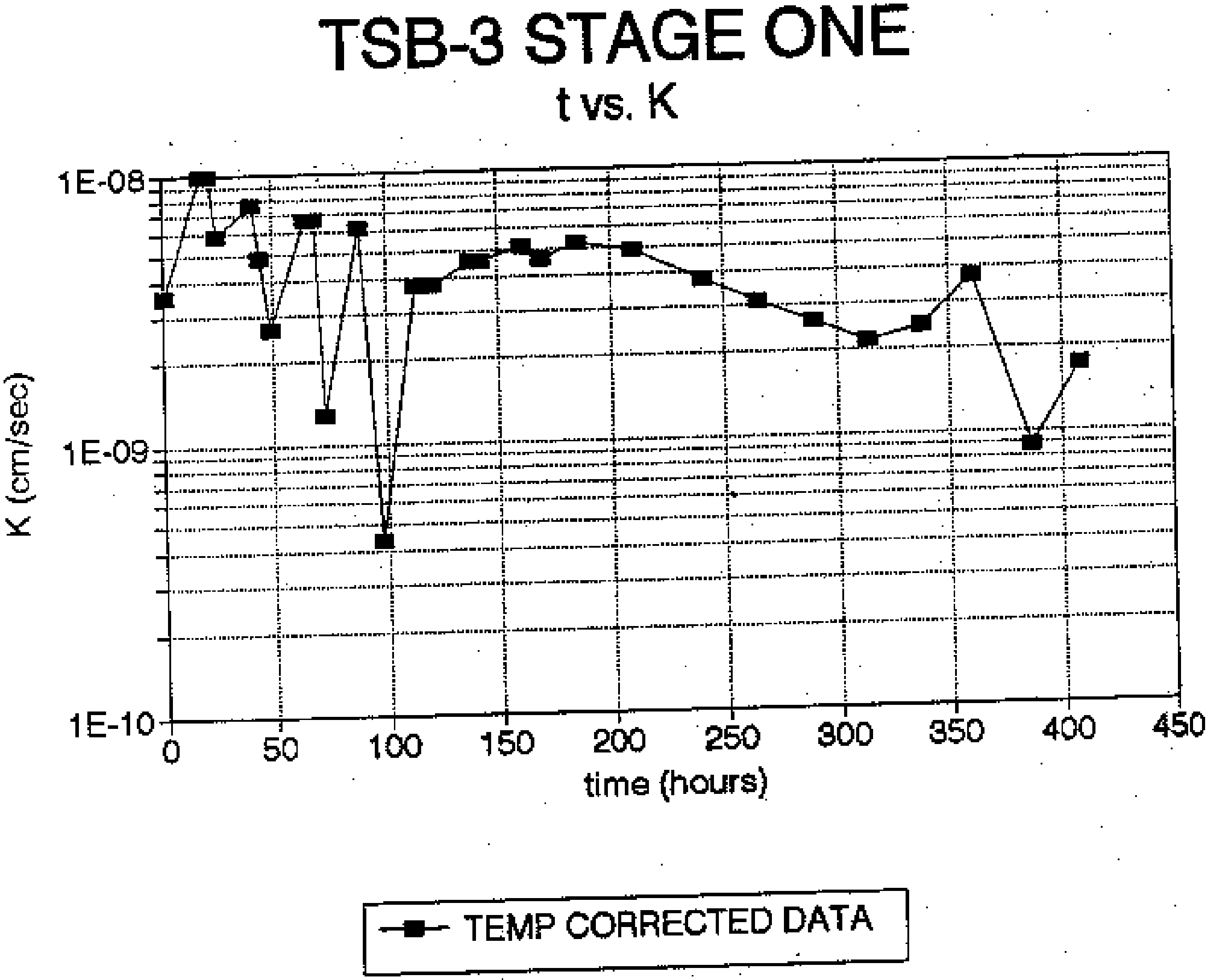


TSB-2 STAGE ONE
t vs. K
K (cm/sec)
1E-07
1E-08
1E-09
1E-10
1E-11
0
50
100
150
200
250
300
350
400
450
time (hours)
TEMP CORRECTED DATA
UNCORRECTED DATA

TSB-2 STAGE ONE

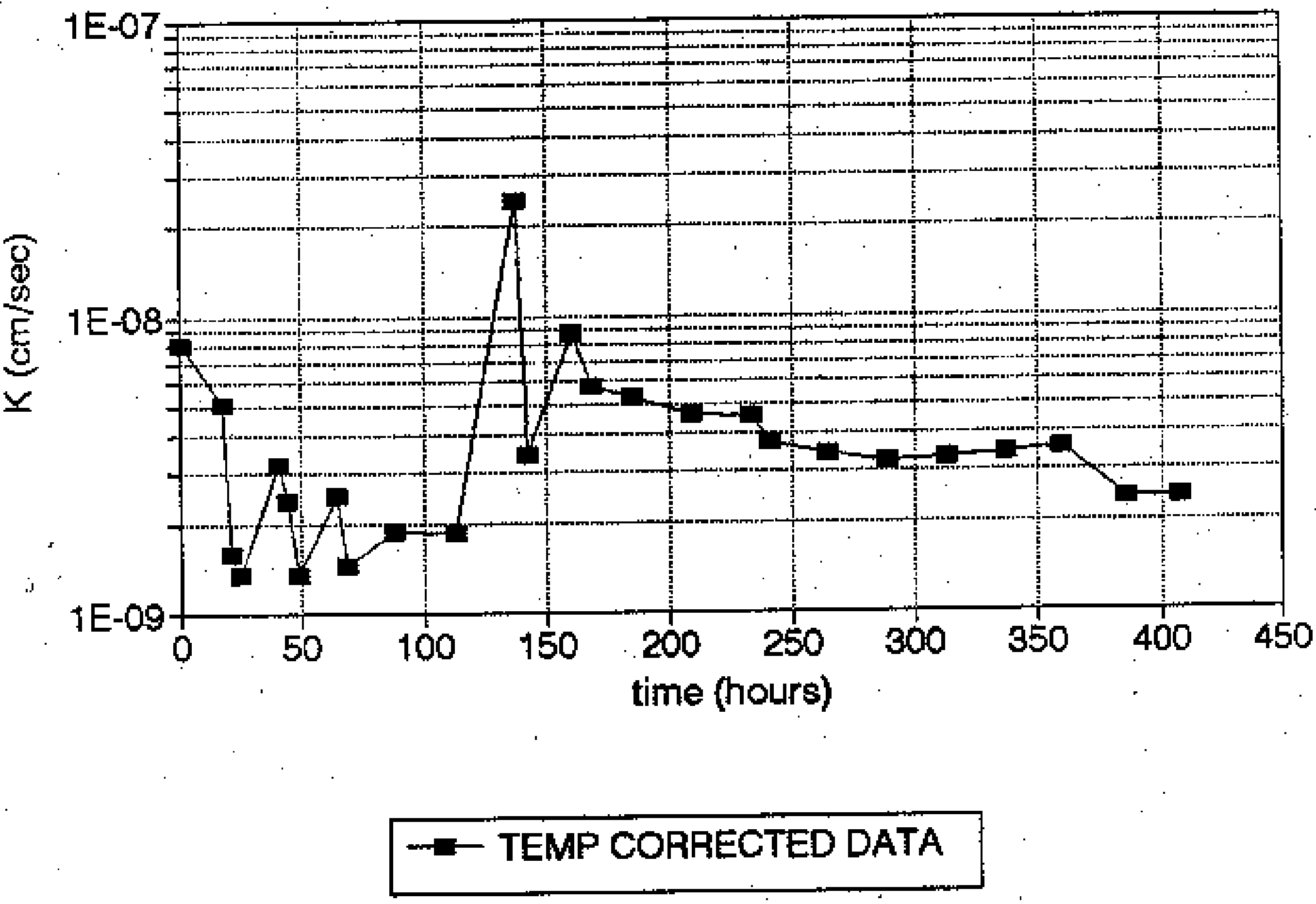
t vs. K




TSB-3 STAGE ONE
t vs. K
1E-08
1E-09
1E-10
K (cm/sec)
0
50
100
150
200
250
300
350
400
450
time (hours)
TEMP CORRECTED DATA

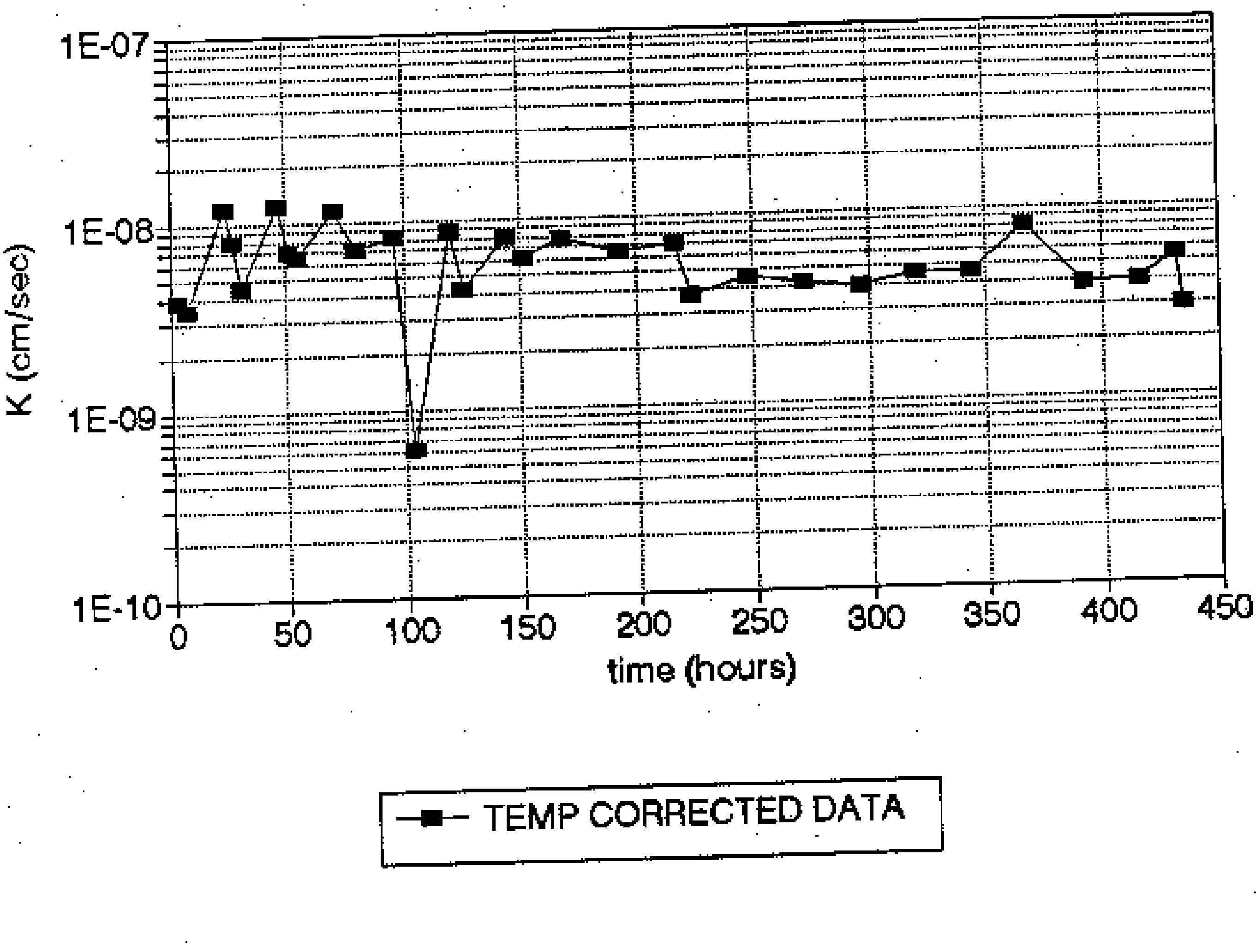
TSB-4 STAGE ONE

t vs. K



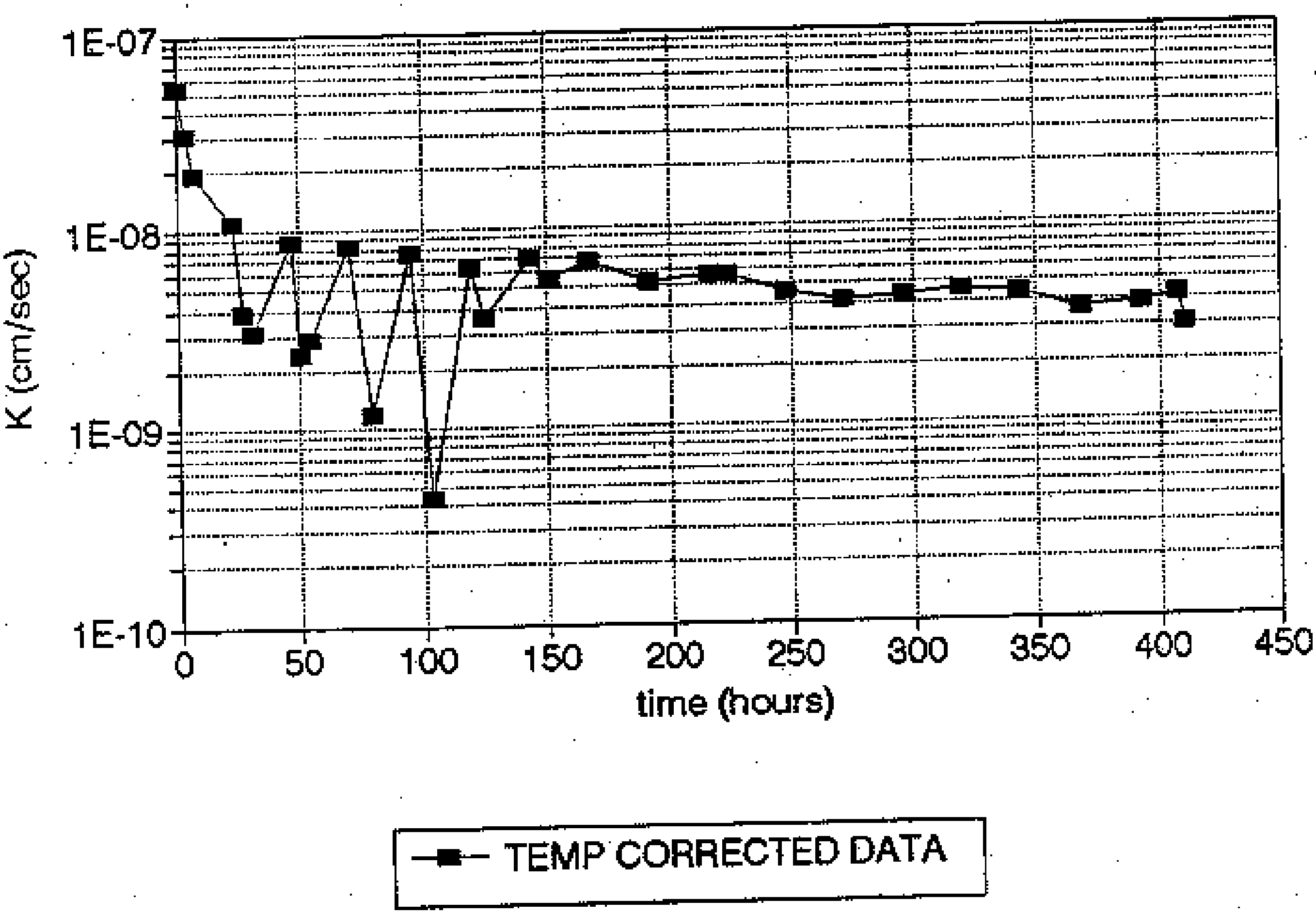
TSB-5 STAGE ONE

t vs. K



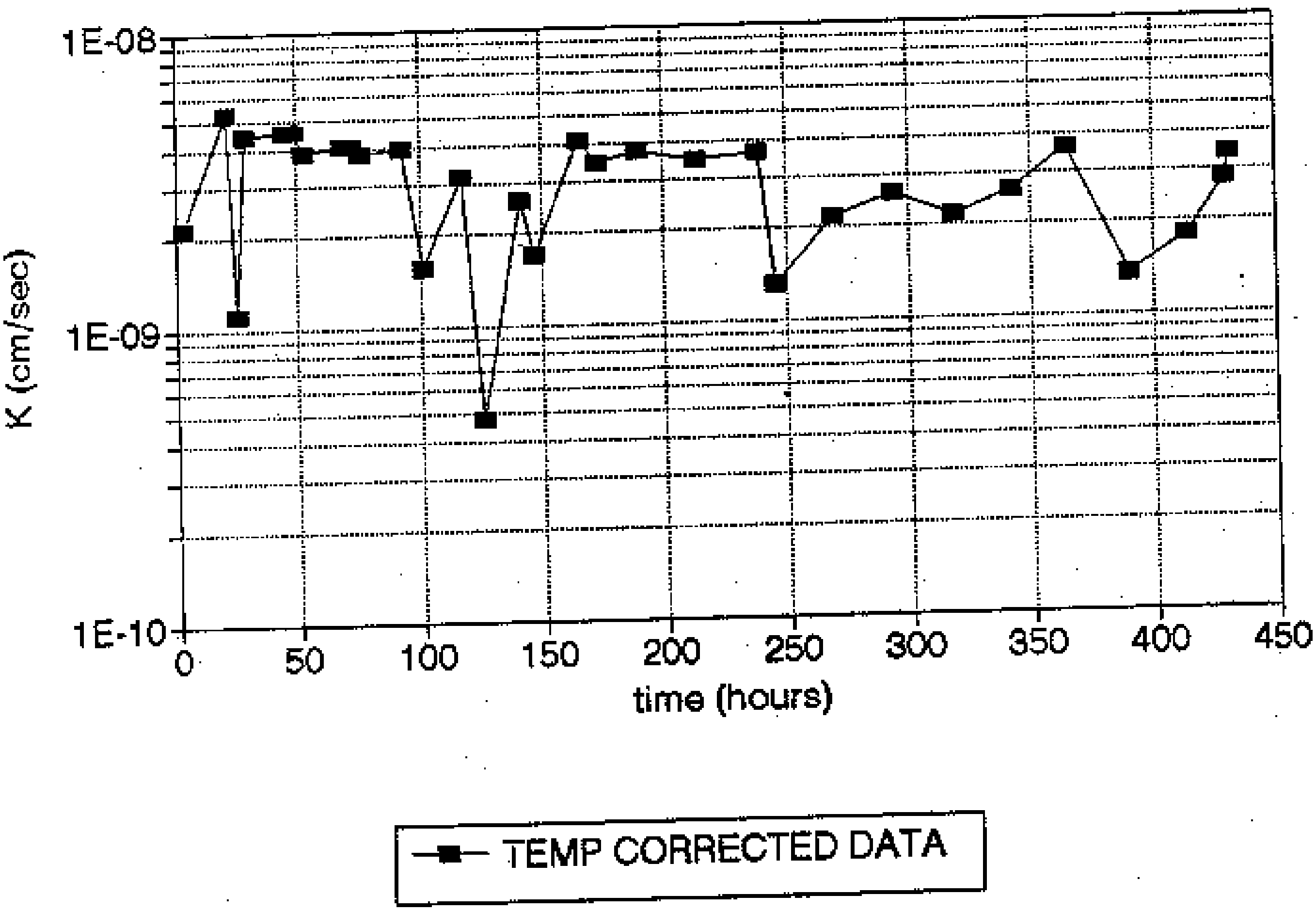
TSB-6 STAGE ONE

t vs. K



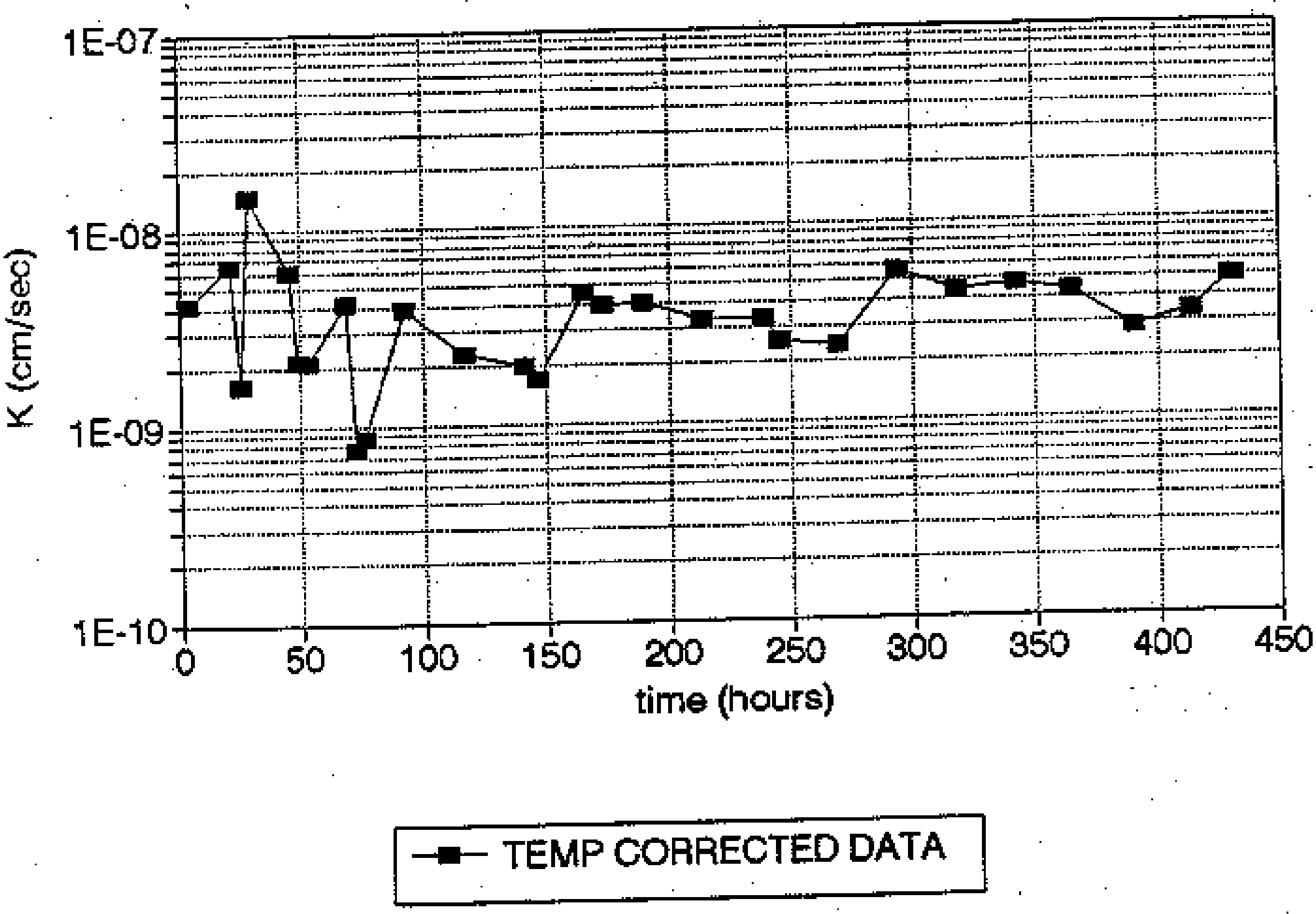
TSB-7 STAGE ONE

t vs. K



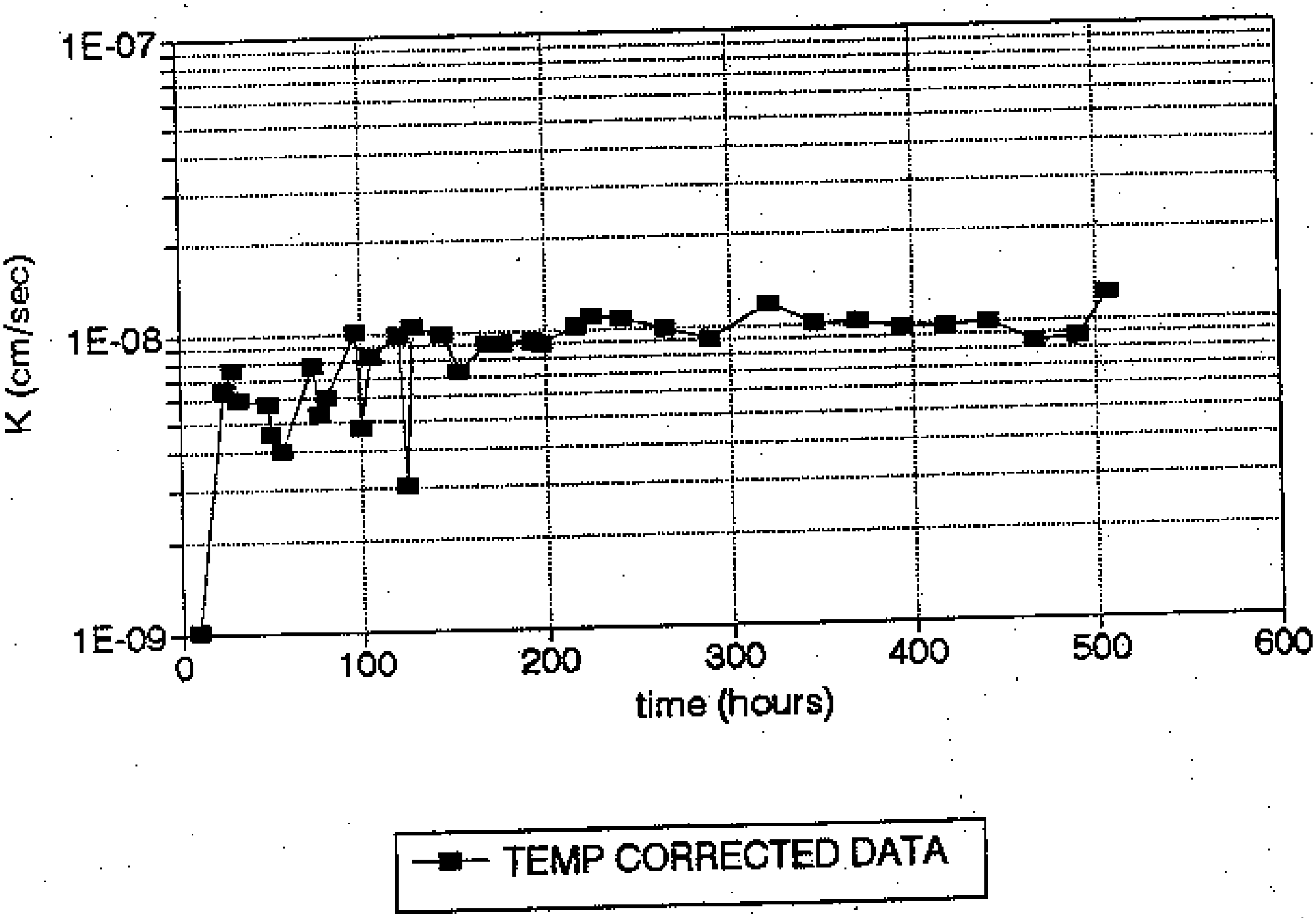
TSB-8 STAGE ONE

t vs. K



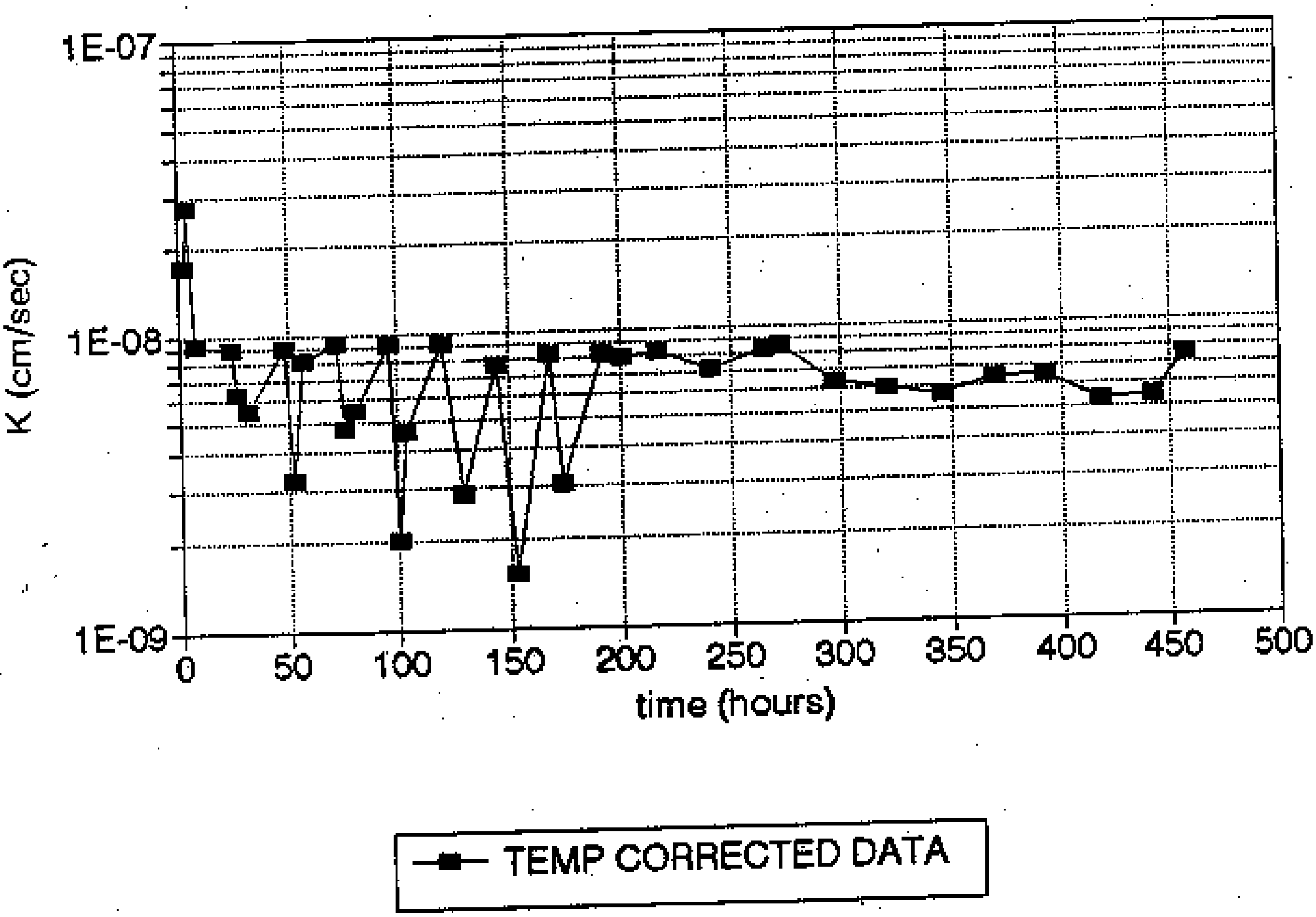
TSB-9 STAGE ONE

t vs. K



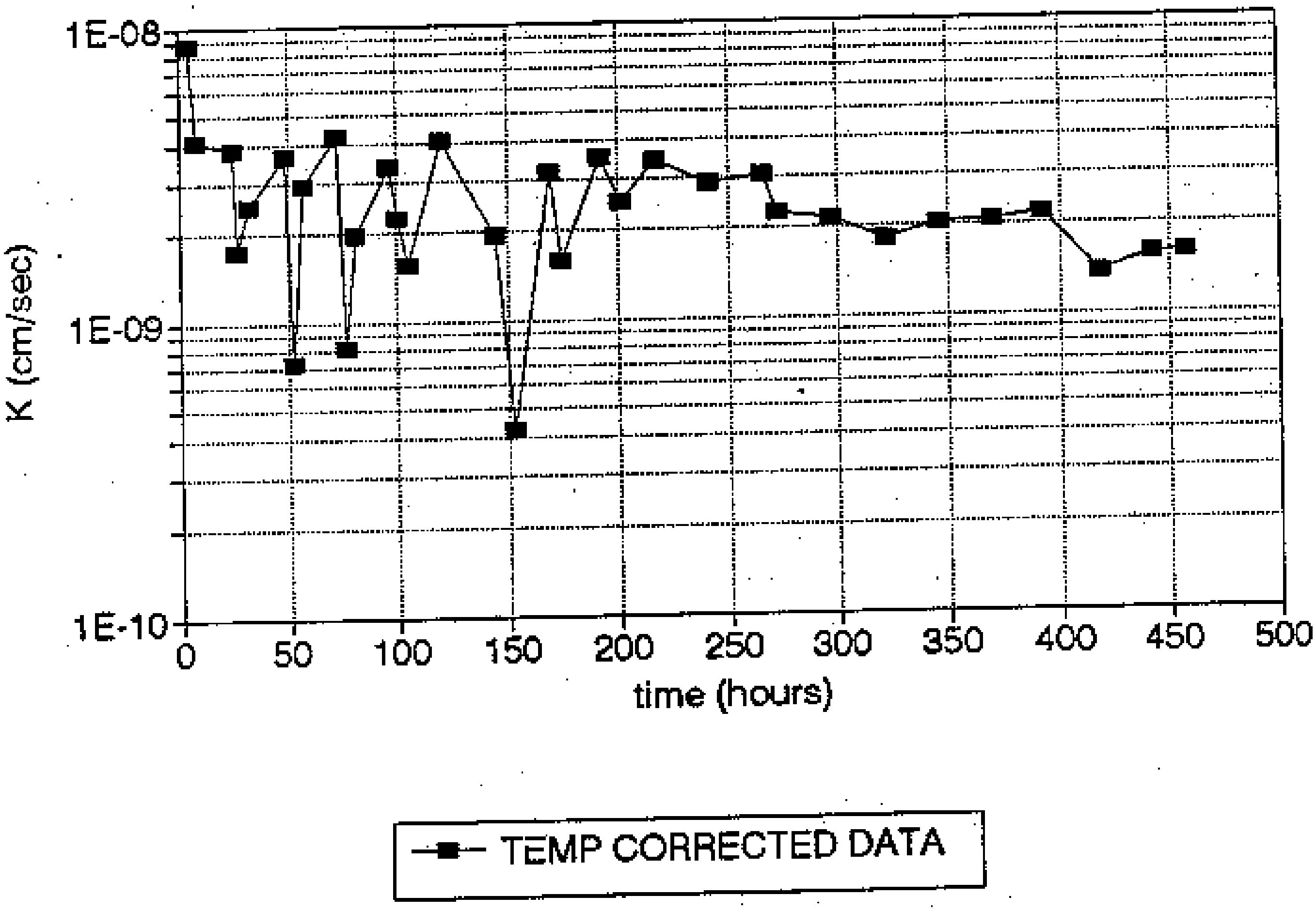
TSB-10 STAGE ONE

t vs. K



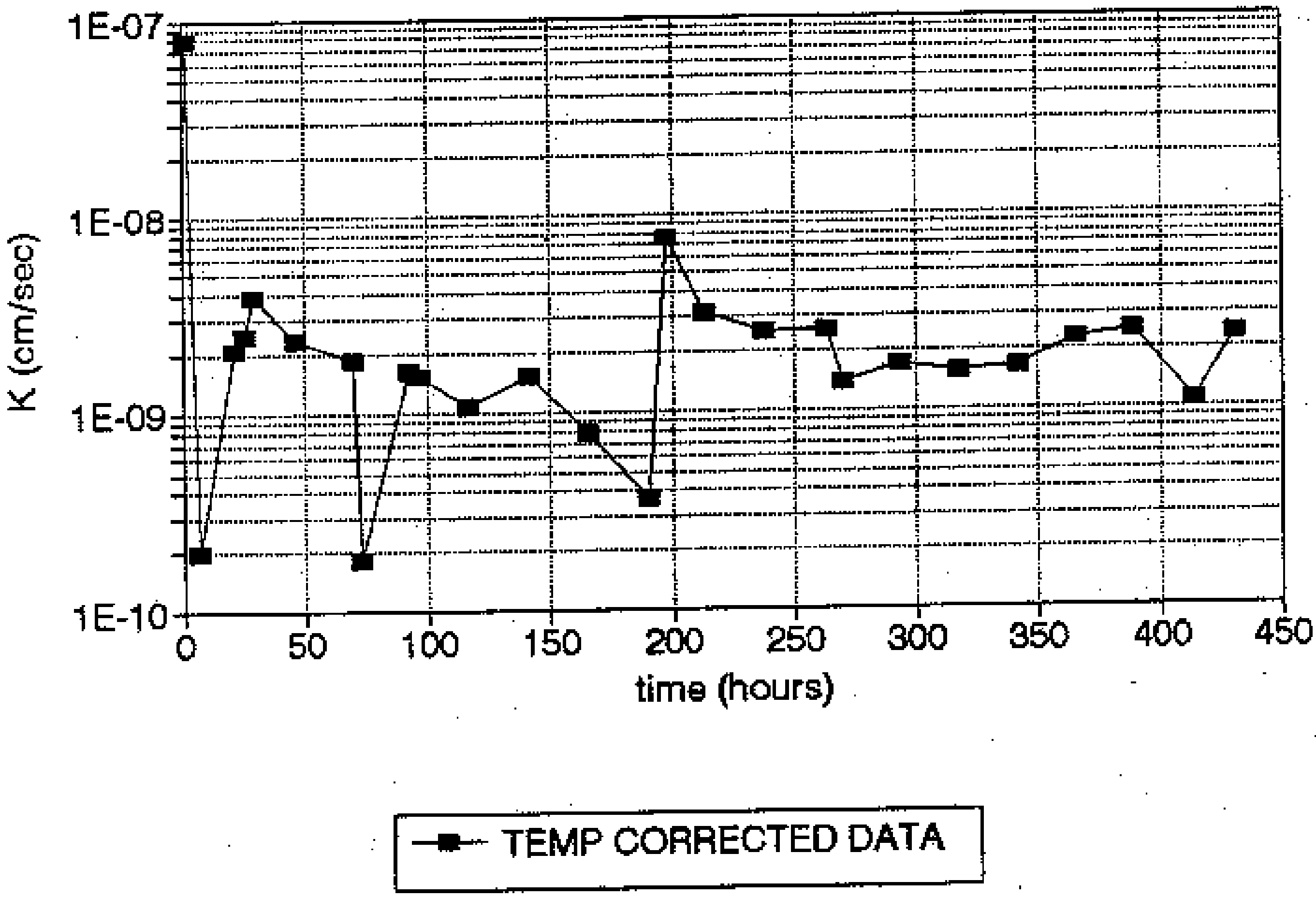
TSB-11 STAGE ONE

t vs. K



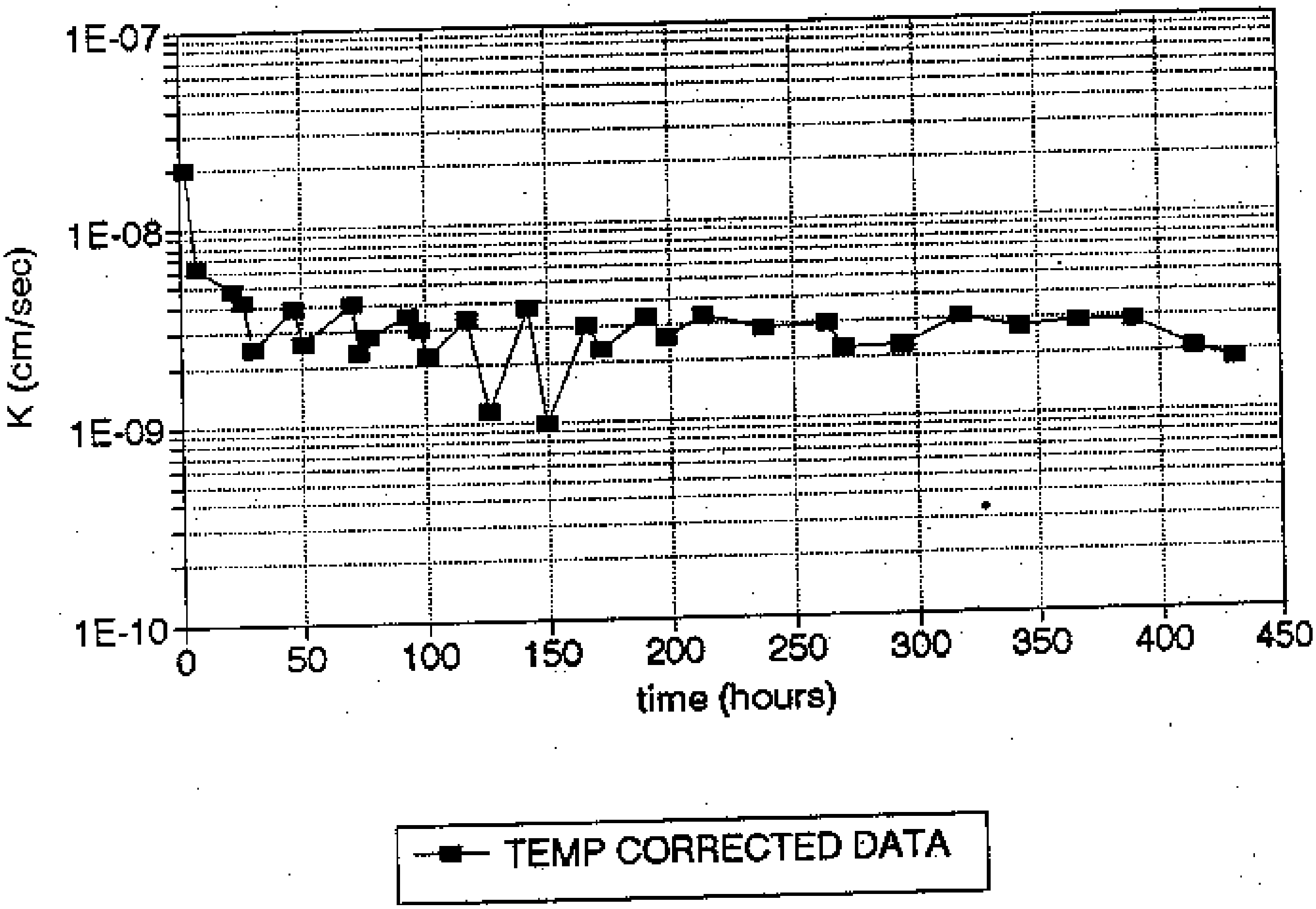
TSB-12 STAGE ONE

t vs. K



TSB-13 STAGE ONE

t vs. K



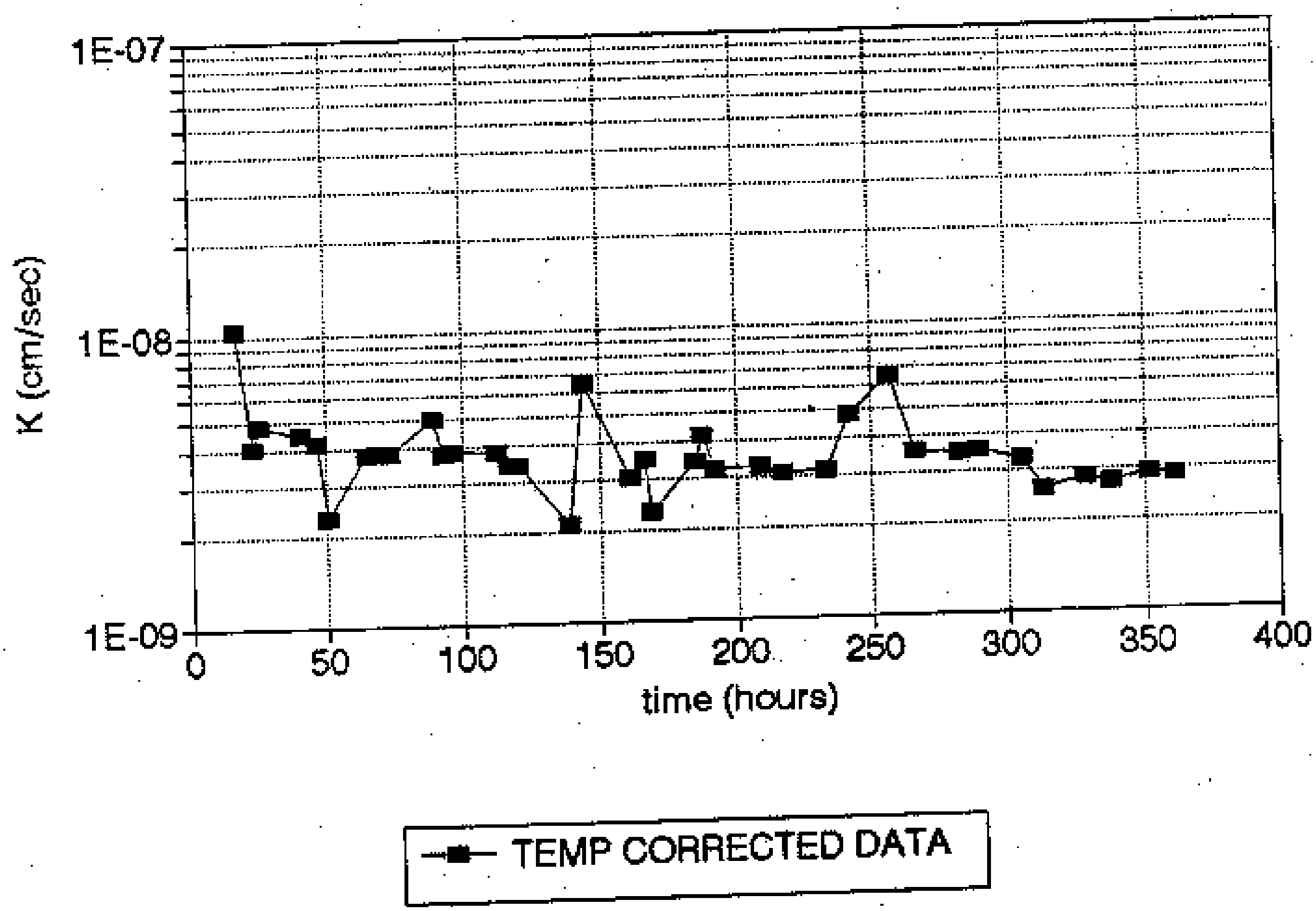
ATTACHMENT 3B

TSB DATA PLOTS

STAGE 2

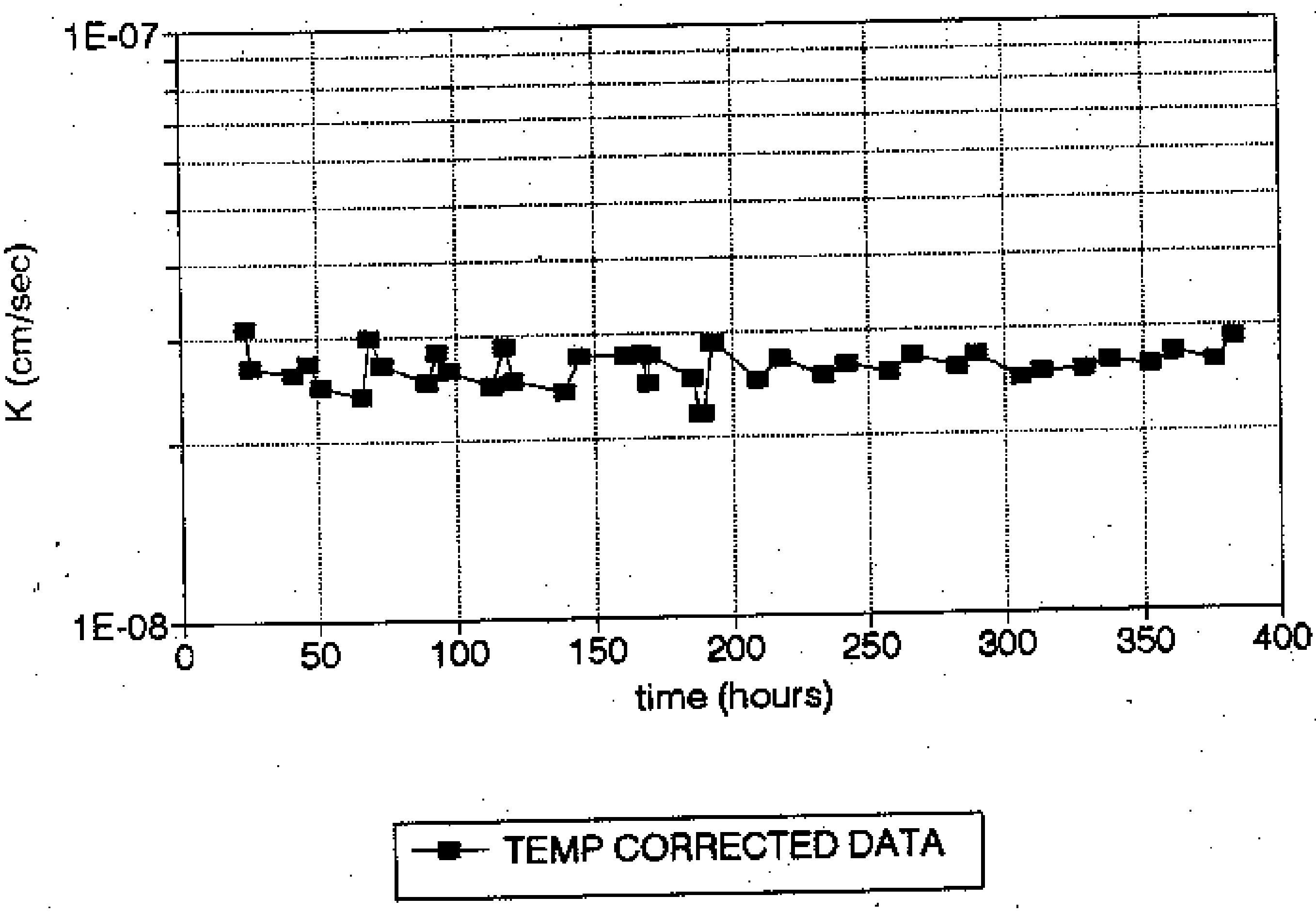
TSB-1 STAGE TWO

t vs. K



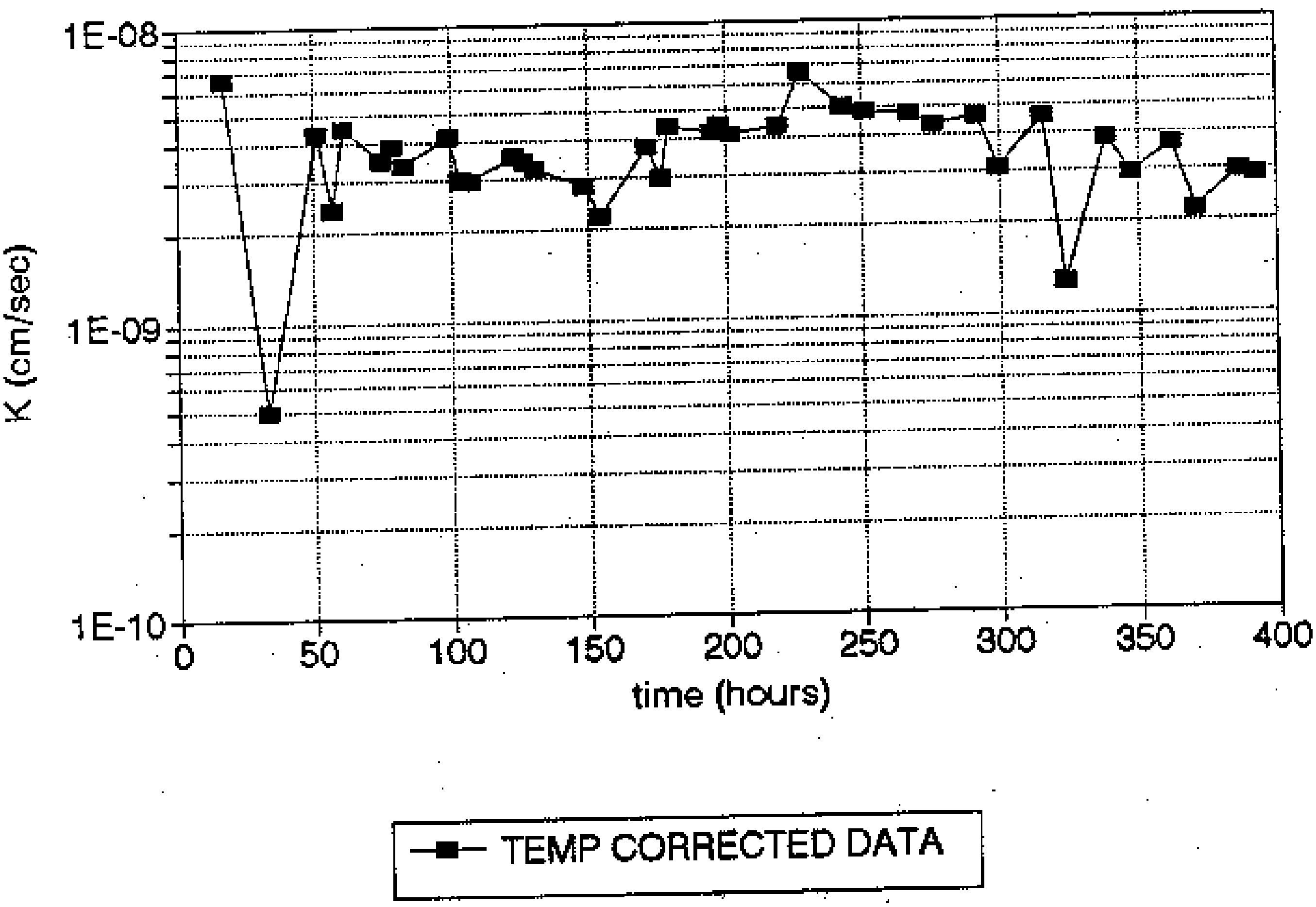
TSB-2 STAGE TWO

t vs. K



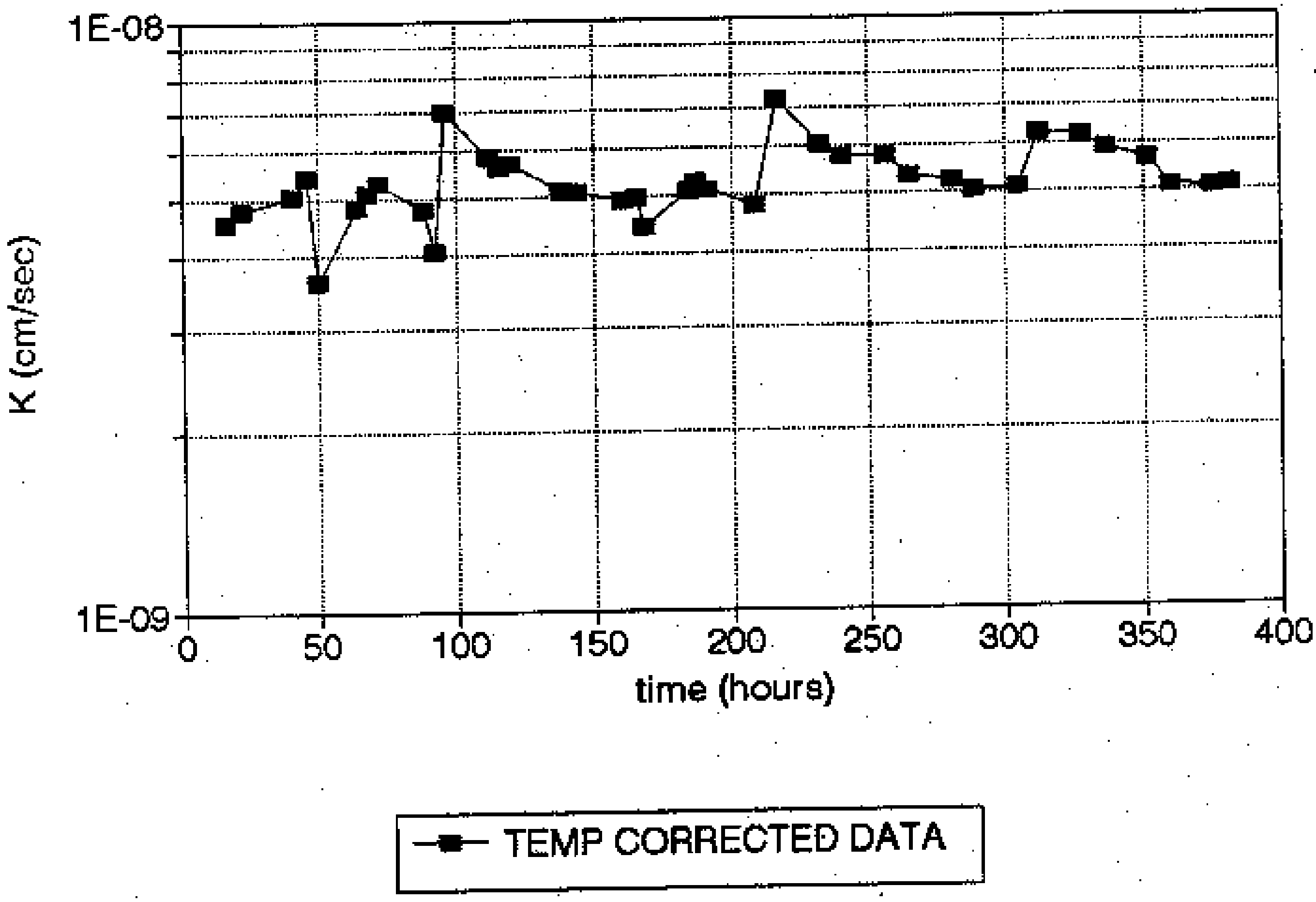
TSB-3 STAGE TWO

t vs. K



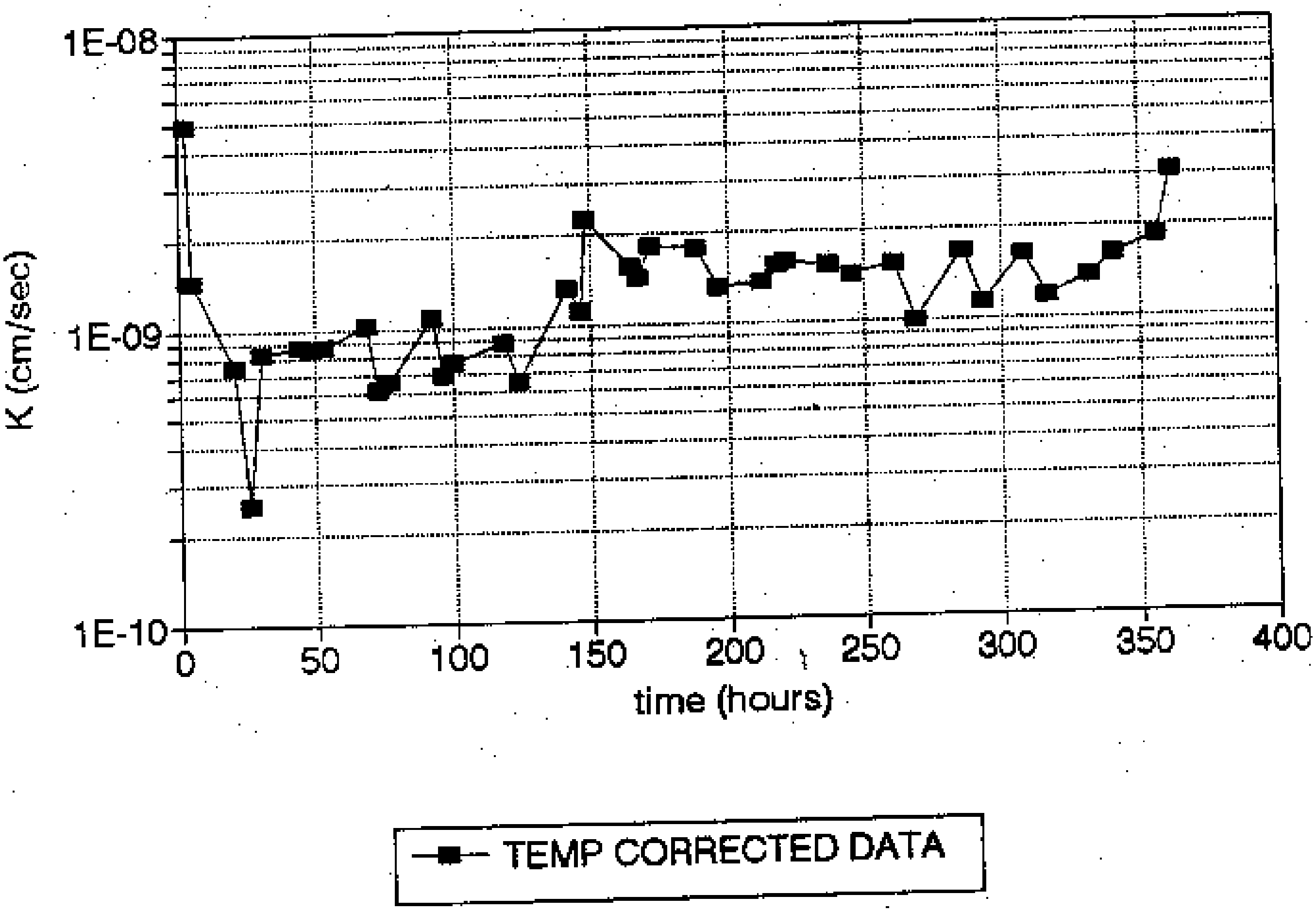
TSB-4 STAGE TWO

t vs. K



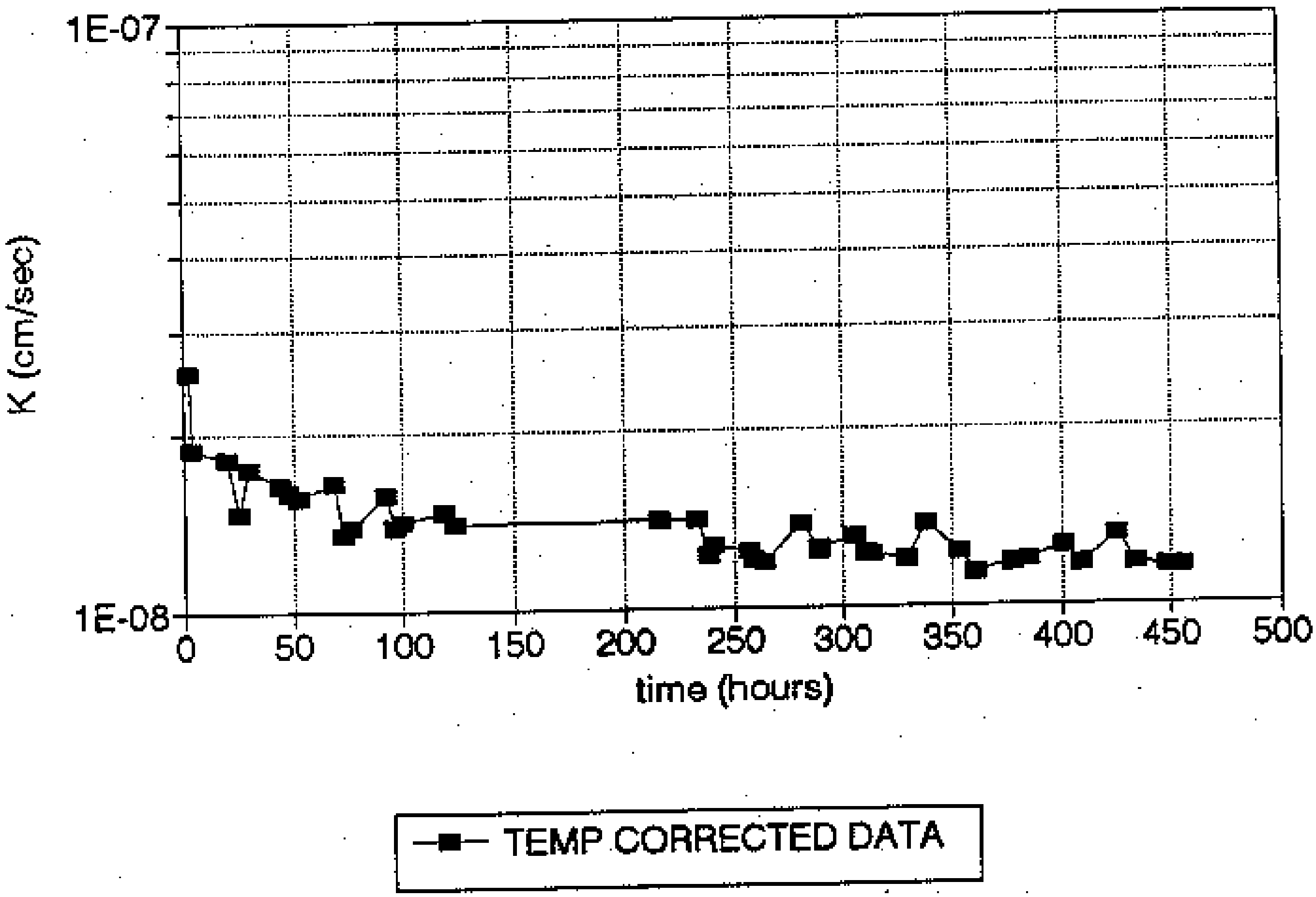
TSB-5 STAGE TWO

t vs. K



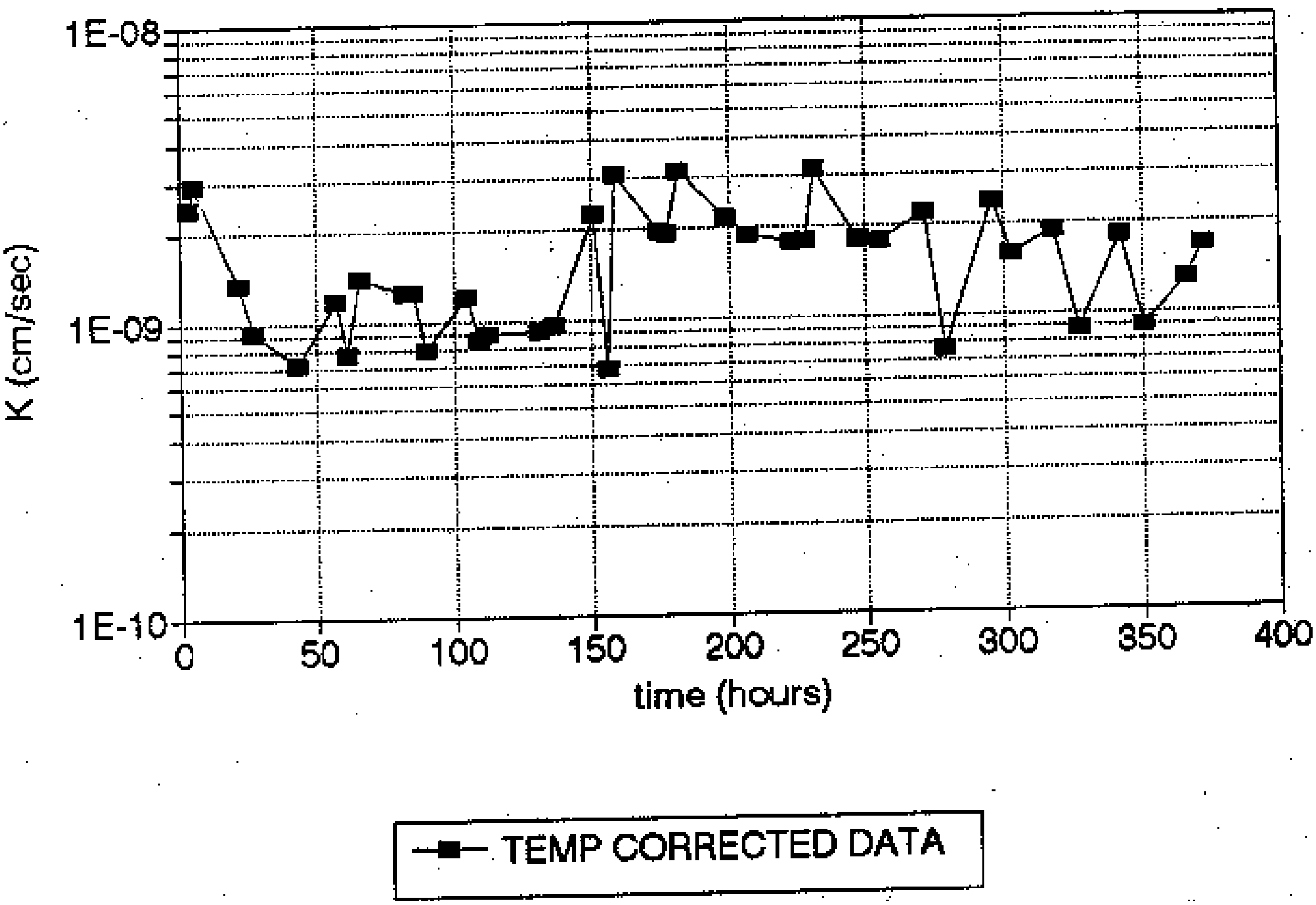
TSB-6 STAGE TWO

t vs. K



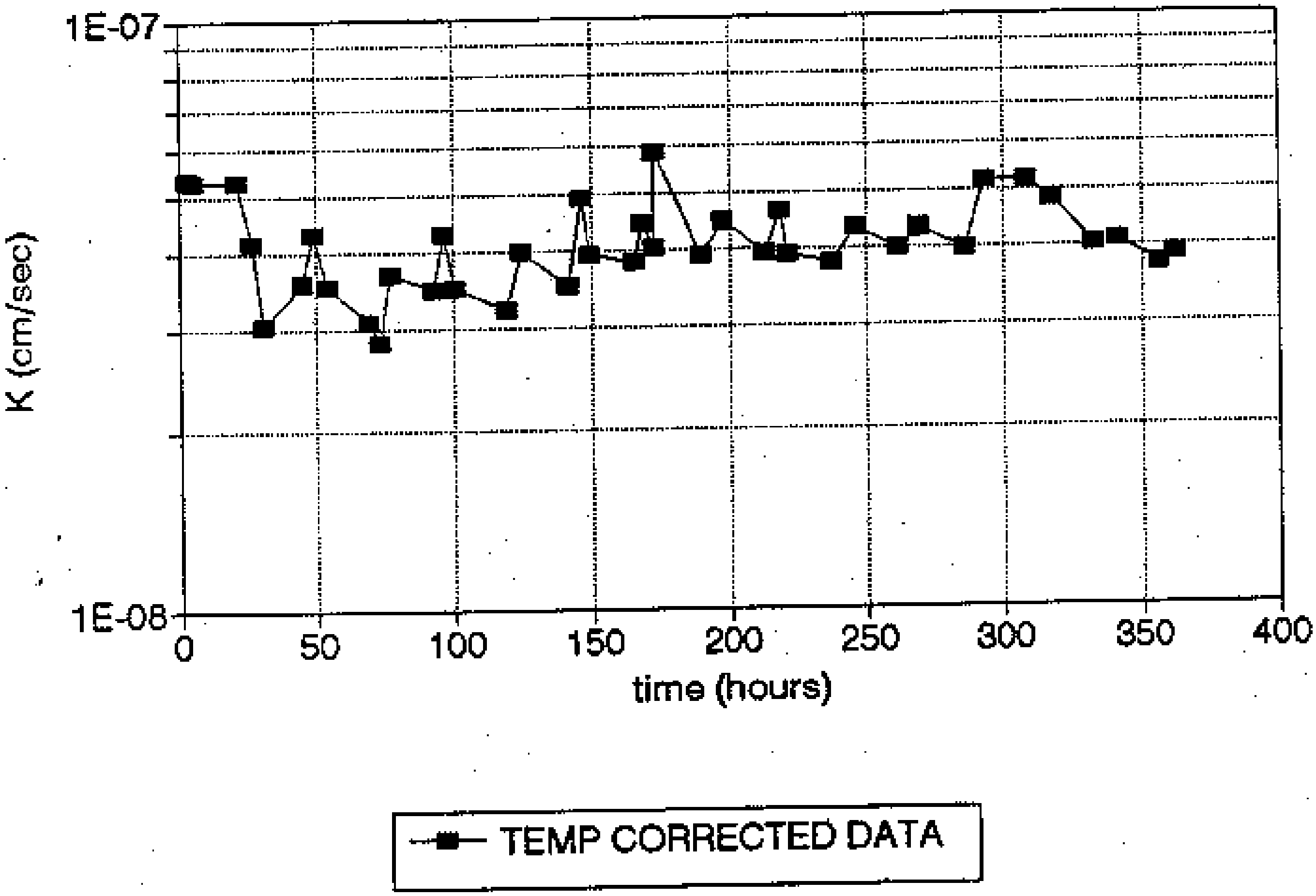
TSB-7 STAGE TWO

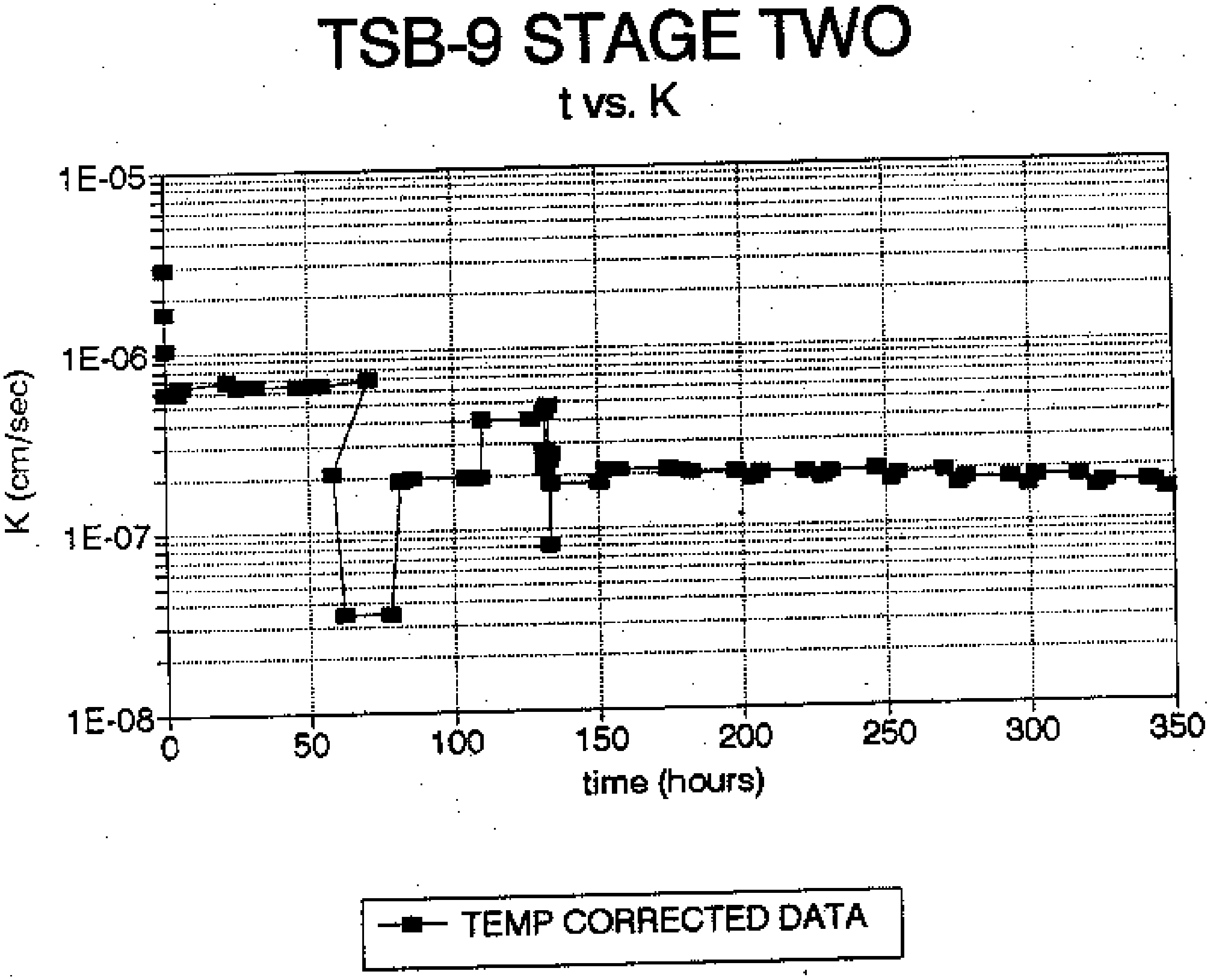
t vs. K



TSB-8 STAGE TWO

t vs. K

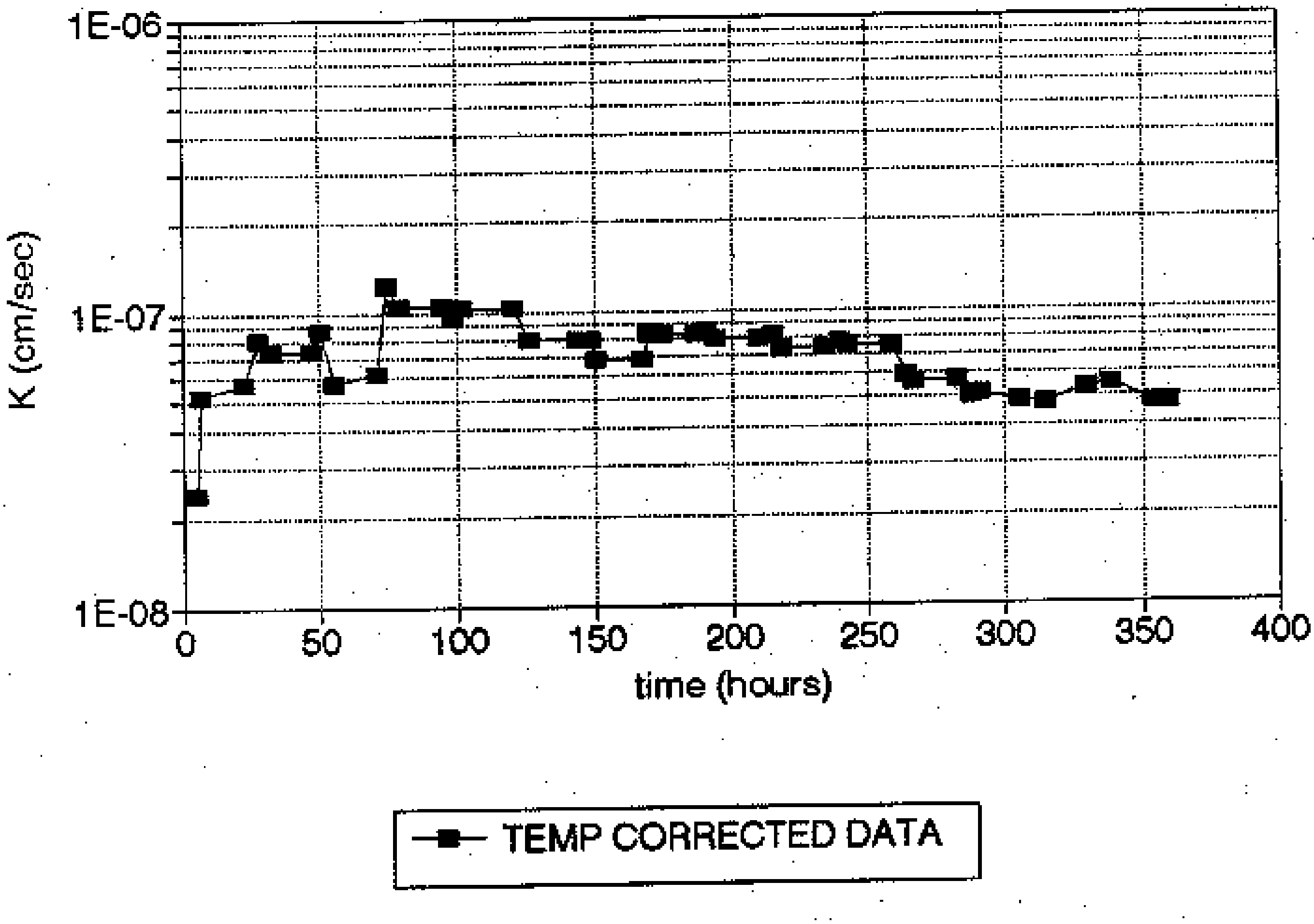




TSB-9 STAGE TWO
t vs. K
1E-05
1E-06
1E-07
1E-08
K (cm/sec)
0
50
100
150
200
250
300
350
time (hours)
TEMP CORRECTED DATA

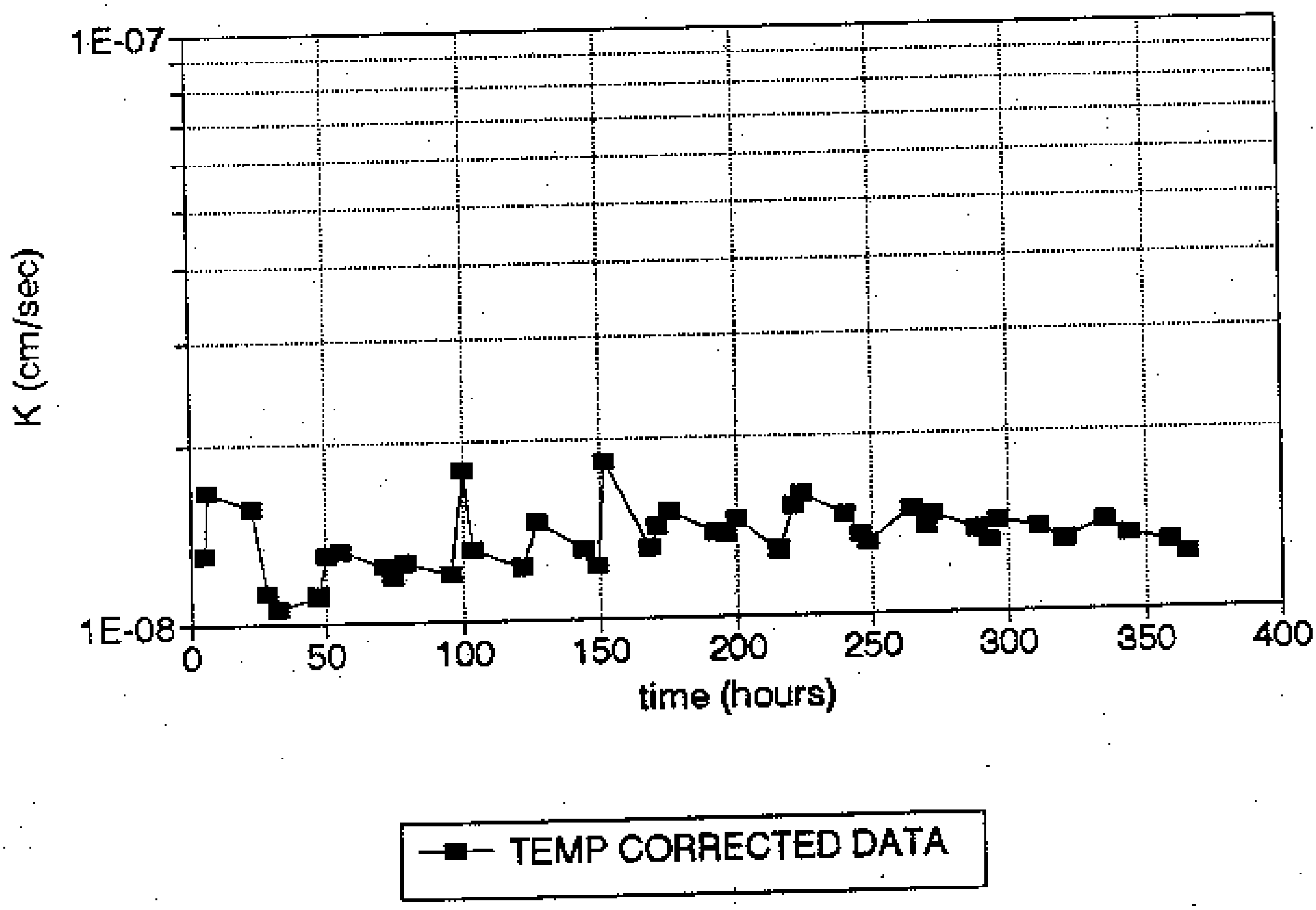
TSB-10 STAGE TWO

t vs. K



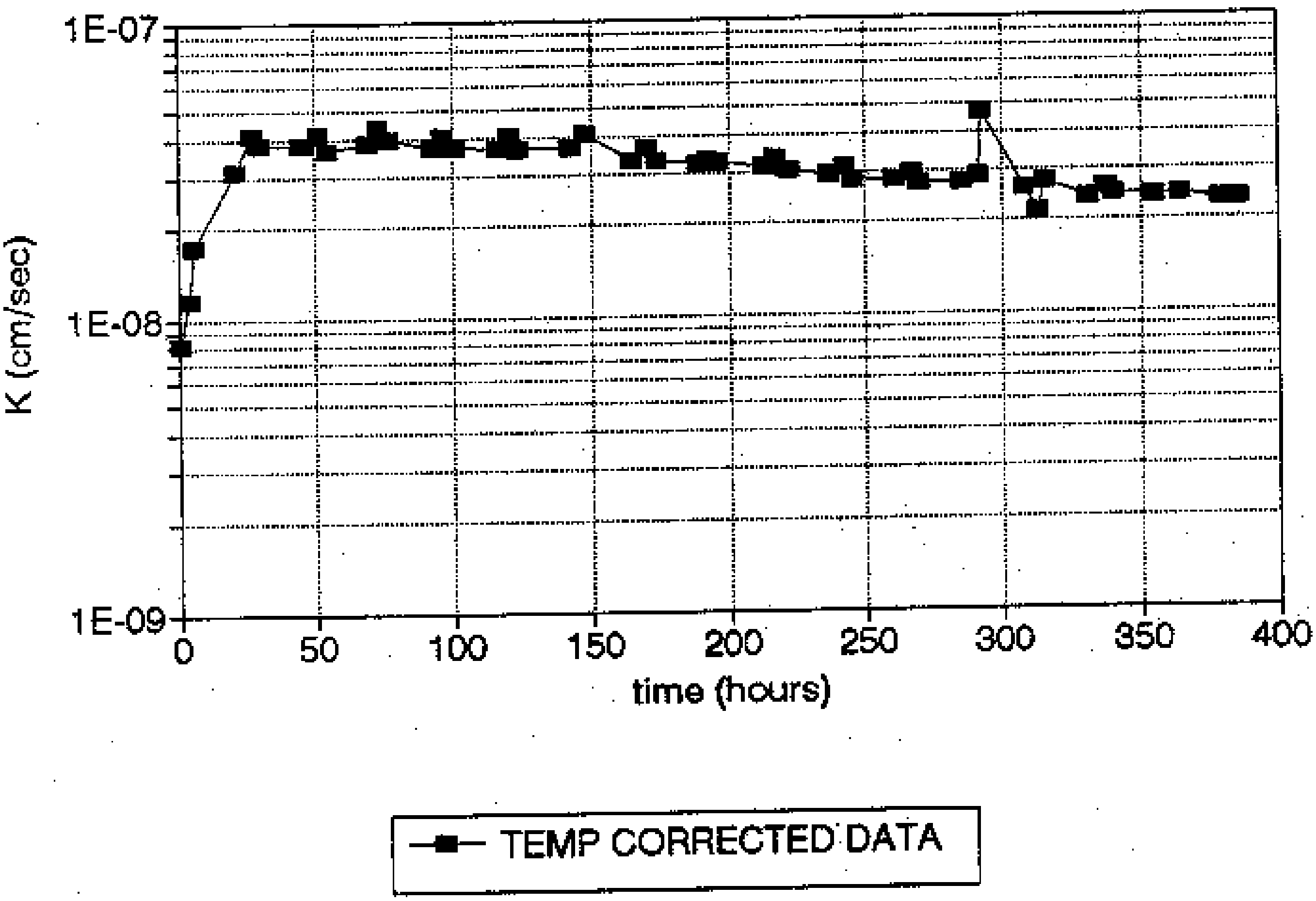
TSB-11 STAGE TWO

t vs. K



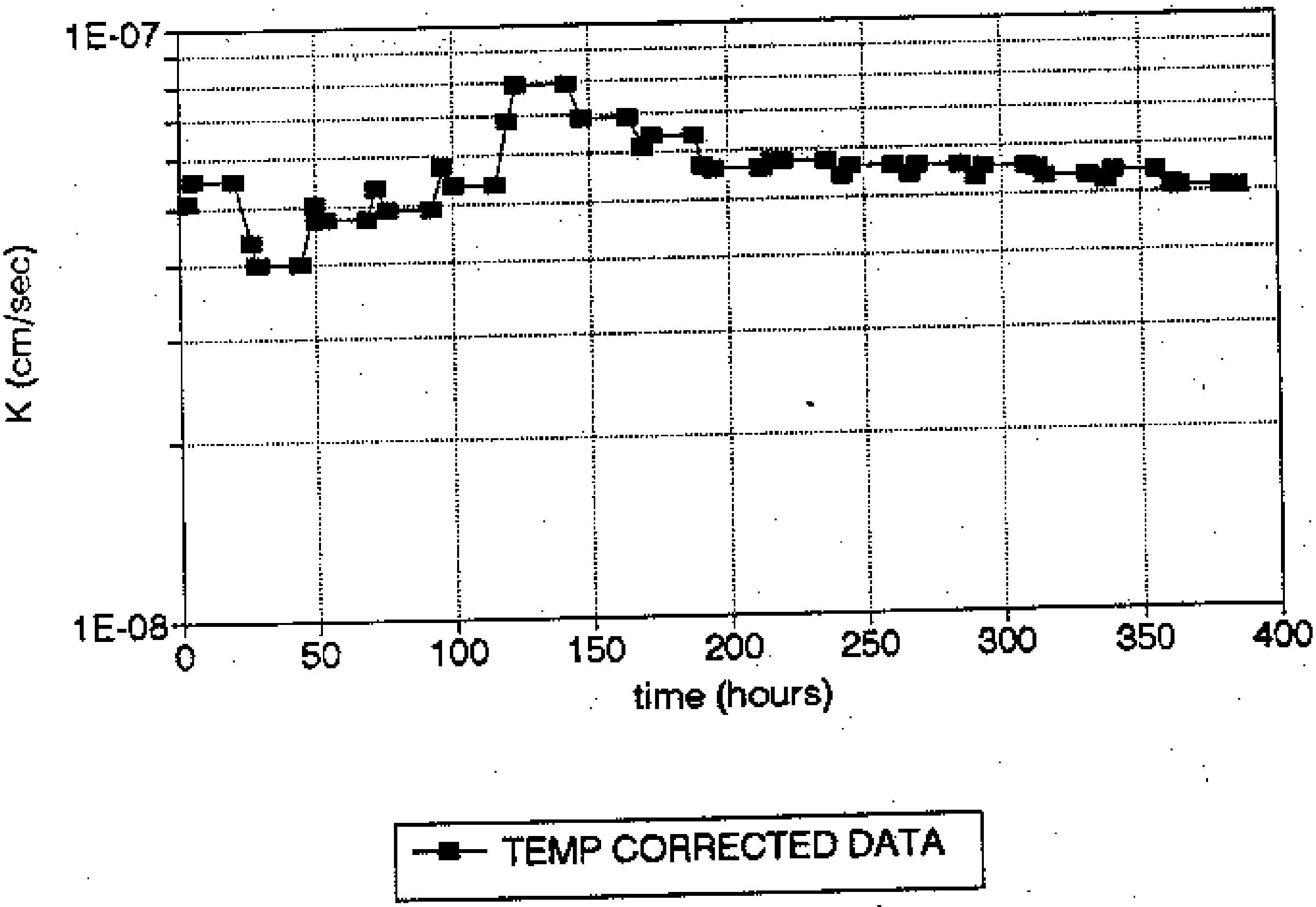
TSB-12 STAGE TWO

t vs. K



TSB-13 STAGE TWO

t vs. K



ATTACHMENT 4A

TSB CALCULATIONS

TIME-WEIGHTED AVERAGE

HYDRAULIC CONDUCTIVITY

K1′

CALC IV

SUBJECT STAGE I TSB FINAL VALUES SHEET 1/5

DATE 11-13-92 BY JDC CHKD. DE Conner JOB NO. 3940-827-01-403

FROM BARTWELL (1992):

$$KI' = \Sigma(K_i * T_i) / \Sigma(T_i)$$

WHERE:

KI' = ARITHMETIC TIME WEIGHTED AVERAGE HYDRAULIC CONDUCTIVITY (cm/sec)

T_i = TIME DURATION OF TEST INCREMENT (i) (sec)

K_i = HYDRAULIC CONDUCTIVITY MEASURED DURING TEST INCREMENT (i) (cm/sec) (TEMPERATURE CORRECTED VALUES - KCT)

1) USING LAST 6 MEASUREMENTS FROM TSB-1 WHERE $T_i > 1000$ s:

$$KI' = \frac{(1.4E{-}9 * 86400) + (3.49E{-}9 * 87900) + (3.38E{-}9 * 85020) + (3.35E{-}9 * 82560) + (1.84E{-}9 * 91320) + (1.62E{-}9 * 76500)}{86400 + 87900 + 85020 + 82560 + 91320 + 76500}$$

$$= \frac{1.54E{-}03}{509700} = \boxed{3.03E{-}09 \text{ cm/sec}}$$

2) USING THE LAST 6 MEASUREMENTS FROM TSB-2 WHERE $T_i > 1000$ s

$$KI' = \frac{(2.55E{-}9 * 86280) + (3.22E{-}9 * 87660) + (3.25E{-}9 * 85140) + (3.47E{-}9 * 82500) + (2.37E{-}9 * 91380) + (3.51E{-}9 * 76200)}{86280 + 87660 + 85140 + 82500 + 91380 + 76200}$$

$$= 1.55E{-}03 / 509160 = \boxed{3.04E{-}09 \text{ cm/sec}}$$

CALC IV

SUBJECT STAGE 1 TSB FINAL VALUES SHEET 2/5

DATE 11-13-92 BY JDC CHKD. QE Conner JOB NO. 3940-827-01-903

3) USING LAST 6 MEASUREMENTS FROM TSB-3 :

$$K1' = \frac{(2.58E-9 * 86580) + (2.18E-9 * 87660) + (2.43E-9 * 85080)}{86580 + 87660 + 85080}$$

$$\frac{+ (3.69E-9 * 82860) + (8.8E-10 * 91020) + (1.74E-9 * 83400)}{+ 82860 + 91020 + 83400}$$

$$= \frac{1.15E-3}{516600} = \boxed{2.23E-09 \text{ cm/sec}}$$

4) USING LAST 6 MEASUREMENTS FROM TSB-4 :

$$K1' = \frac{(3.22E-9 * 86520) + (3.32E-9 * 87660) + (3.42E-9 * 85200) +}{86520 + 87660 + 85200}$$

$$\frac{(5.56E-9 * 82800) + (2.41E-9 * 91020) + (2.41E-9 * 82920)}{+ 82800 + 91020 + 82920}$$

$$= \frac{1.57E-03}{516120} = \boxed{3.05E-09 \text{ cm/sec}}$$

5) USING LAST 6 MEASUREMENTS FROM TSB-5 :

$$K1' = \frac{(4.59E-9 * 85080) + (8.10E-9 * 82680) + (3.69E-9 * 91020)}{85080 + 82680 + 91020}$$

$$\frac{+ (4.08E-9 * 87600) + (5.52E-9 * 56400) + (2.99E-9 * 11100}{+ 87600 + 56400 + 11100}$$

$$= \frac{2.10E-03}{413880} = \boxed{5.07E-09 \text{ cm/sec}}$$

CALC IV

SUBJECT STAGE I TSB FINAL VALUES SHEET 3/5

DATE 11-13-92 BY JDC CHKD. [illegible] JOB NO. 3840-827-01-403

6) USING LAST 6 MEASUREMENTS FROM TSB-6 :

$$KI' = \frac{(4.6E-9*85020)+(4.47E-9*82860)+(3.63E-9*91080)+}{85020+82860+91080}$$

$$\frac{(3.86E-9*87600)+(4.23E-9*56220)+(3.02E-9*12060)}{+87600+56220+12060}$$

$$= \frac{1.71E-03}{414840} = \boxed{4.12E-09\ cm/sec}$$

7) USING LAST 6 MEASUREMENTS FROM TSB-7 :

$$KI' = \frac{(2.63E-9*85320)+(3.61E-9*82620)+(1.35E-9*90960)}{85320+82620+90960}$$

$$\frac{+(1.79E-9*87600)+(2.81E-9*56340)+(3.41E-9*4980)}{+87600+56340+4980}$$

$$= \frac{9.78E-04}{407820} = \boxed{2.40E-09\ cm/sec}$$

8) USING LAST 6 MEASUREMENTS FROM TSB-8 WHERE $T_i > 1000\,s$:

$$KI' = \frac{(4.36E-9*82260)+(2.82E-9*91320)+(3.42E-9*87540)}{82260+91320+87540}$$

$$\frac{+(4.77E-9*85320)+(5.03E-9*56040)+(5.03E-9*5040)}{+85320+56040+5040}$$

$$= \frac{1.63E-3}{407520} = \boxed{4.00E-09\ cm/sec}$$

CALC IV

SUBJECT: STAGE I TSB FINAL VALUES SHEET: 4/5

DATE: 11-13-92 BY: JDC CHKD: J.C. Conner JOB NO. 3840-827-01-403

9) USING LAST 6 MEASUREMENTS FROM TSB-9 WHERE $T_i > 1000s$:

$$K1' = \frac{(9.63E{-}9 * 85320) + (9.89E{-}9 * 82800) + (8.48E{-}9 * 90900) +}{85320 + 82800 + 90900 +}$$

$$\frac{+ (8.72E{-}9 * 86100) + (9.56E{-}9 * 87660) + (1.22E{-}8 * 57000)}{86100 + 87660 + 57000}$$

$$= \frac{4.7E{-}3}{489780} = \boxed{9.59E{-}09 \text{ cm/sec}}$$

10) USING THE LAST 6 MEASUREMENTS FROM TSB-10:

$$K1' = \frac{(5.66E{-}9 * 87660) + (6.42E{-}9 * 85320) + (6.5E{-}9 * 82920) +}{87660 + 85320 + 82920 +}$$

$$\frac{(5.32E{-}9 * 90780) + (5.47E{-}9 * 86040) + (7.52E{-}9 * 57180)}{90780 + 86040 + 57180}$$

$$= \frac{2.97E{-}3}{489900} = \boxed{6.06E{-}09 \text{ cm/sec}}$$

11) USING THE LAST 6 MEASUREMENTS FROM TSB-11:

$$K1' = \frac{(2.05E{-}9 * 87660) + (2.11E{-}9 * 85500) + (2.19E{-}9 * 82800) +}{87660 + 85500 + 82800}$$

$$\frac{(1.38E{-}9 * 90900) + (1.6E{-}9 * 85860) + (1.61E{-}9 * 57120)}{90900 + 85860 + 57120}$$

$$= \frac{8.96E{-}4}{489840} = \boxed{1.83E{-}09 \text{ cm/sec}}$$

CALC IV

SUBJECT STAGE I TSB FINAL VALUES SHEET 5/5

DATE 11-13-92 BY JDC CHKD. [illegible] JOB NO. 3840-[illegible]-903

12) USING LAST 6 MEASUREMENTS FROM TSB-12:

$$K1' = \frac{(1.55E-9 * 86160) + (1.64E-9 * 88200) + (2.23E-9 * 848[illegible]}{86160 + 88200 + 84840 +}$$

$$\frac{+ (2.45E-9 * 82800) + (1.10E-9 * 91260) + (2.36E-9 * 59580)}{82800 + 91260 + 59580}$$

$$= \frac{9.11E-4}{492840} = \boxed{1.85E-09\ cm/sec}$$

13) USING LAST 6 MEASUREMENTS FROM TSB-13:

$$K1' = \frac{(3.08E-9 * 82800) + (2.68E-9 * 87960) + (2.86E-9 * 85020) +}{82800 + 87960 + 85020}$$

$$\frac{(2.87E-9 * 82620) + (2.07E-9 * 91320) + (1.84E-9 * 59580)}{82620 + 91320 + 59580}$$

$$= \frac{1.27E-3}{489300} = \boxed{2.60E-09\ cm/sec}$$

ATTACHMENT 4B

TSB CALCULATIONS

TIME-WEIGHTED AVERAGE

HYDRAULIC CONDUCTIVITY

K2

CALCULATION NO. IV

SUBJECT: STAGE 2 TSB FINAL VALUES SHEET 1/5

DATE 11-12-92 BY JDC CHKD. [illegible] JOB NO. 3840-827-01-903

FROM BOUTWELL (1992):

$$K2' = \Sigma (K_i \times T_i) / \Sigma (T_i)$$

WHERE: $K2'$ = ARITHMETIC TIME WEIGHTED AVERAGE HYDRAULIC CONDUCTIVITY (cm/sec)

T_i = TIME DURATION OF TEST INCREMENT (i) (sec)

K_i = HYDRAULIC CONDUCTIVITY MEASURED DURING TEST INCREMENT (i) (cm/sec) (TEMPERATURE CORRECTED VALUES - KCT)

1) USING LAST 5 MEASUREMENTS FROM TSB-1:

$$K2' = \frac{([illegible]E\text{-}09 \times 27{,}000) + (2.82E\text{-}09 \times 55{,}020) + (2.78E\text{-}09 \times 32{,}590)}{27{,}000 + 55{,}020 + 32{,}580}$$

$$\frac{+ (2.91E\text{-}09 \times 54{,}300) + (2.84E\text{-}09 \times 32{,}040)}{+ 54{,}300 + 32{,}040} = \frac{5.63E\text{-}04}{200{,}940}$$

$$= 2.8E\text{-}09 \text{ cm/sec}$$

2) USING LAST 6 MEASUREMENTS FROM TSB-2 WHERE $T_i > 1000$s:

$$K2' = \frac{(2.55E\text{-}8 \times 54900) + (2.64E\text{-}8 \times 32520) + (2.59E\text{-}8 \times 54240) +}{54900 + 32520 + 54240}$$

$$\frac{(2.71E\text{-}8 \times 31680) + (2.39E\text{-}8 \times 54480) + (2.86E\text{-}8 \times 22080)}{+ 31680 + 54480 + 22080}$$

$$= \frac{6.46E\text{-}03}{249900} = 2.58E\text{-}08 \text{ cm/sec}$$

CALC No IV

SUBJECT STAGE 2 TSB FINAL VALUES SHEET 2/5

DATE 11-12-92 BY JDC CHKD. [signature] JOB NO. 3840.827-01-903

3) USING LAST 6 MEASUREMENTS FROM TSB 3 :

$$K2' = \frac{(3.82E-09 * 55080) + (2.93E-09 * 32460) + (3.66E-09 * 54480) +}{55080 + 32460 + 54480}$$

$$\frac{(2.20E-09 * 31920) + (2.94E-09 * 54660) + (2.95E-09 * 22800)}{+ 31920 + 54660 + 22800}$$

$$= \frac{8.01E-04}{251400} = \boxed{3.19E-09 \text{ cm/sec}}$$

4) USING LAST 6 MEASUREMENTS FROM TSB-4 :

$$K2' = \frac{(6.20E-09 * 55080) + (5.93E-09 * 32460) + (5.65E-09 * 54480) +}{55080 + 32460 + 54480}$$

$$\frac{(5.10E-09 * 31920) + (5.06E-09 * 54660) + (5.12E-09 * 22800)}{+31920 + 54660 + 22800}$$

$$= \frac{1.4E-03}{251400} = \boxed{5.56E-09 \text{ cm/sec}}$$

5) USING LAST 6 VALUES FROM TSB-5 :

$$K2' = \frac{(1.65E-09 * 56280) + (1.19E-09 * 31260) + (1.38E-09 * 54360)}{56280 + 31260 + 54360 +}$$

$$\frac{+ (1.62E-09 * 31920) + (1.86E-09 * 55980) + (3.05E-09 * 20940)}{31920 + 55980 + 20940}$$

$$= \frac{3.13E-4}{250740} = \boxed{1.24E-09 \text{ cm/sec}}$$

$$\frac{4.25E-4}{250740} = 1.69E-09 \text{ cm/sec}$$

CALC No. IV

SUBJECT STAGE 2 TSB FINAL VALUES SHEET 3/5

DATE 11-13-92 BY JBC CHKD. [illegible] JOB NO. 3840-827-01-903

6) USING THE LAST 6 MEASUREMENTS FROM TSB-6 WHERE $T_i > 1000s$:

$$K2' = \frac{(1.25E-8 * 56280) + (1.17E-8 * 31260) + (1.31E-08 * 54240) + (1.18E-08 * 31920) + (1.15E-08 * 55800) + (1.16E-08 * 21120)}{56280 + 31260 + 54240 + 31920 + 55800 + 21120}$$

$$= \frac{3.04E-3}{250620} = \boxed{1.21\ E-08\ cm/sec}$$

7) USING THE LAST 6 MEASUREMENTS FROM TSB-7:

$$K2' = \frac{(1.90E-9 * 55680) + (8.84E-10 * 31920) + (1.82E-09 * 54300) + (8.92E-10 * 31860) + (1.30E-09 * 55200) + (1.69E-9 * 21720)}{55680 + 31920 + 54300 + 31860 + 55200 + 21720}$$

$$= \frac{3.7E-04}{250680} = \boxed{1.47E-09\ cm/sec}$$

8) USING LAST 6 MEASUREMENTS FROM TSB 8 WHERE $T_i > 1000s$:

$$K2' = \frac{(5.19E-8 * 55740) + (4.82E-8 * 31860) + (4.05E-8 * 54240) + (4.1E-8 * 31800) + (3.75E-8 * 55140) + (3.9E-8 * 21660)}{55740 + 31860 + 54240 + 31800 + 55140 + 21660}$$

$$= \frac{1.08E-2}{250440} = \boxed{4.33E-08\ cm/sec}$$

9) USING THE LAST 6 MEASUREMENTS FROM TSB-9 WHERE $T_i > 1000s$

$$K2' = \frac{(1.79E-7*54060)+(1.56E-7*21780)+(1.63E-7*10140)+}{54060+21780+10140}$$

$$\frac{(1.63E-7*54060)+(1.61E-7*6180)+(1.62E-7*16560)}{+54060+6180+16560}$$

$$= \frac{2.72E-2}{162780} = \boxed{1.67E-07\ cm/sec}$$

10) USING LAST 6 MEASUREMENTS FROM TSB-10 WHERE $T_i > 1000s$:

$$K2' = \frac{(4.89E-8*54360)+(4.75E-8*33000)+(5.34E-8*54000)+}{54360+33000+54000}$$

$$\frac{(5.52E-8*32100)+(4.78E-8*54060)+(4.73E-8*22920)}{+32100+54060+22920}$$

$$= \frac{1.25E-2}{250440} = \boxed{5.01\ E-8\ cm/sec}$$

11) USING THE LAST 6 MEASUREMENTS FROM TSB-11:

$$K2' = \frac{(1.38E-8*54480)+(1.32E-8*33060)+(1.41E-8*54000)+}{54480+33060+54000}$$

$$\frac{(1.34E-8*32100)+(1.30E-8*54120)+(1.24E-8*22920)}{+32100+54120+22920}$$

$$= \frac{3.37E-3}{250680} = \boxed{1.34E-08\ cm/sec}$$

ATTACHMENT 5

SPREADSHEET CALCULATION SUMMARY

Kh AND Kv

CALC No II

SUBJECT STAGE 2 TSB FINAL VALUES SHEET 5/5

DATE 11-13-92 BY JDC CHKD. DE Carmen JOB NO. 3840-877-01-90

12) USING THE LAST 6 MEASUREMENTS FROM TSB 12 WHERE $T_i > 1000s$:

$$K2' = \frac{(2.58E\text{-}8 * 22860) + (2.47E\text{-}8 * 9660) + (2.42E\text{-}8 * 54180)}{22860 + 9660 + 54180}$$

$$+ \frac{(2.46E\text{-}8 * 32040) + (2.35E\text{-}8 * 54540) + (2.37E\text{-}8 * 22200)}{+ 32040 + 54540 + 22200}$$

$$= \frac{4.74E\text{-}03}{195480} = \boxed{2.42E\text{-}08 \text{ cm/sec}}$$

13) USING THE LAST 6 MEASUREMENTS FROM TSB-13 WHERE $T_i > 1000s$

$$K2' = \frac{(5.43E\text{-}8 * 9660) + (5.42E\text{-}8 * 54300) + (5.13E\text{-}8 * 22560)}{9660 + 54300 + 22560 +}$$

$$+ \frac{(5.11E\text{-}8 * 9480) + (5.10E\text{-}8 * 54540) + (5.05E\text{-}8 * 2220}{9480 + 54540 + 22200}$$

$$= \frac{9.01E\text{-}03}{172740} = \boxed{5.22E\text{-}08 \text{ cm/sec}}$$

ATTACHMENT 6

TSB METHOD REFERENCE

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE and STAGE TWO DATA REDUCTION
and CALCULATION of Kv and Kh VALUES
WSSRAP SUPPORTING STUDY 3A -
HYDRAULIC PROPERTIES OF UNDISTURBED SOILS

TSB INSTALLATION	K1' (cm/sec)	K2' (cm/sec)	K2'/K1'	p*	L (inches)	m**	Kv	Kh	Kh/Kv	Comments
TSB-01	3.03E-09	2.60E-09	0.9241	1	6.00	0.7410	4.09E-09	2.25E-09	0.5491	Best Kh & Kv
TSB-01	3.03E-09	2.60E-09	0.9241	2	6.00	0.9953	3.04E-09	3.02E-09	0.9806	
TSB-02	3.04E-09	2.58E-08	8.4868	1	6.25	30.7955	9.90E-11	9.33E-08	942.6277	
TSB-02	3.04E-09	2.58E-08	8.4868	***	6.25	3.3360	9.11E-10	1.01E-08	11.1289	Best Kh & Kv
TSB-03	2.23E-09	3.19E-09	1.4305	1	6.38	2.0560	1.08E-09	4.56E-09	4.2271	
TSB-04	3.05E-09	5.56E-09	1.8230	1	6.13	3.3360	9.14E-10	1.02E-08	11.1289	
TSB-05	5.07E-09	1.69E-09	0.3333	***	6.00	3.3360	1.52E-09	1.69E-08	11.1289	
TSB-06	4.12E-09	1.21E-08	2.9369	1	6.88	6.6060	6.05E-10	2.80E-08	46.3216	
TSB-06	4.12E-09	1.21E-08	2.9369	***	6.88	3.3360	1.24E-09	1.37E-08	11.1289	Best Kh & Kv
TSB-07	2.40E-09	1.48E-09	0.6167	10	5.88	1.1470	2.09E-09	2.75E-09	1.3156	Best Kh & Kv
TSB-07	2.40E-09	1.48E-09	0.6167	20	5.88	2.0630	1.16E-09	4.95E-09	4.2560	
TSB-08	4.00E-09	4.33E-08	10.8250	1	6.25	43.2103	9.26E-11	1.73E-07	1867.1300	
TSB-08	4.00E-09	4.33E-08	10.8250	***	6.25	3.3360	1.20E-09	1.33E-08	11.1289	Best Kh & Kv
TSB-09	9.59E-09	1.67E-07	17.4140	1	5.75	82.0455	1.17E-10	7.87E-07	6731.4641	
TSB-09	9.59E-09	1.67E-07	17.4140	****	5.75	1.1470	8.36E-09	1.10E-08	1.3156	Best Kh & Kv
TSB-10	6.06E-09	5.01E-08	8.2673	1	5.88	31.8615	1.90E-10	1.93E-07	1015.1552	
TSB-10	6.06E-09	5.01E-08	8.2673	*****	5.88	0.7410	8.18E-09	4.49E-09	0.5491	Best Kh & Kv
TSB-11	1.83E-09	1.34E-08	7.3224	1	6.00	26.9140	6.80E-11	4.93E-08	724.3634	
TSB-11	1.83E-09	1.34E-08	7.3224	***	6.00	3.3360	5.49E-10	6.10E-09	11.1289	Best Kh & Kv
TSB-12	1.85E-09	2.42E-08	13.0811	1	6.38	54.0530	3.42E-11	1.00E-07	2921.7268	
TSB-12	1.85E-09	2.42E-08	13.0811	****	6.38	1.1470	1.61E-09	2.12E-09	1.3156	
TSB-12	1.85E-09	2.42E-08	13.0811	*****	6.38	0.7410	2.50E-09	1.37E-09	0.5491	Best Kh & Kv
TSB-13	2.59E-09	5.22E-08	20.1544	1	6.75	66.7865	2.82E-11	2.30E-07	7683.3077	
TSB-13	2.59E-09	5.22E-08	20.1544	***	6.75	3.3360	7.76E-10	8.64E-09	11.1289	Best Kh & Kv

* Values for p from Table on Page 21 (Boutwell, 1992).

** From FORTRAN Program which solves for the given K2'/K1' using selected values for m.

*** m value for these TSBs is from TSB-04, closest TSB in depth and unit tested, with a < 20 Kh/Kv ratio.

**** m value for these TSBs is from TSB-07.

***** m value for this TSB is from TSB-01.

THE STEI TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST

by: Gordon P. Boutwell, PhD, P.E.

Presented to

"CONTAINMENT LINER TECHNOLOGY AND SUBTITLE D"

Seminar Sponsored by
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SYNOPSIS

In 1991, the Texas Department of Health began requiring field verification of the hydraulic conductivity for the waste-retention barriers under its jurisdiction. The TDH has approved two procedures: the Two-Stage Borehole (TSB) method and the Sealed, Double-Ring Infiltrometer (SDRI) method. The TSB method is discussed herein.

It is a falling-head infiltration test conducted in a cased borehole, typically 4 inches in diameter. The first stage is performed with the bottom of the hole flush with the bottom of the casing for maximum effect of vertical permeability (k_v). After steady-state is achieved, the hole is advanced some 6 to 8 inches below the bottom of the casing so that horizontal permeability (k_h) has a greater effect. The two stages yield the following:

Stage 1 - The maximum possible value for (k_v).
Stage 2 - The minimum possible value for (k_h).
Stage 1 + Stage 2 - Constants for two equations which can then be solved for the real (k_h, k_v).

Procedures are available for reduction of the data in the cases of both above and below water table testing, and for the bottom boundary conditions of a material far more permeable, equally permeable, or far less permeable than the medium being tested. The test has been successful in evaluating both compacted and natural materials with permeabilities as low as 1x10(-9) cm/sec.

The major test precautions include proper sealing of the casing along the outside, accounting for temperature effects, and correcting for sidewall smear during the second stage. The test is quick, simple, and relatively inexpensive. It allows results in days, rather than months. Multiple installations are feasible so that statistical confidence can be achieved. It is recognized in the literature, including U.S. EPA publications, and accepted by many State regulatory authorities.

I. INTRODUCTION

Clay barriers are an important component of waste retention structures. Their primary geotechnical characteristic for this use is hydraulic conductivity, which must be verified during the Construction Quality Assurance program. Until recently, practice relied on laboratory testing of small (7 to 10 cm diameter) undisturbed samples taken from the barrier or a similarly constructed test pad. Day and Daniel (1985) reported conductivities measured in the field which were 3 to 4 orders of magnitude higher than they obtained with laboratory tests. While that study was justly criticized, the horse was out of the barn and regulators all over the country galloped into field testing for hydraulic conductivity evaluation at waste facilities.

From the regulatory standpoint, a test procedure should be accurate and avoid false positives, i.e., not indicate compliance with the specified conductivity when the liner or pad truly has a higher value. This normally means testing a large soil volume searching for the elusive "macropores" which are thought to evade, somehow, even numerous laboratory tests. The regulated community wants the accuracy and avoidance of false positives for their own protection, but also wants to minimize testing times (and costs), and to avoid false negatives, both for economy.

In about the last two years, two methods have become accepted as meeting these criteria to a satisfactory degree: the Sealed, Double-Ring Infiltrometer (SDRI) and the Two-Stage Borehole (TSB) procedure. Each has its stronger and weaker points (see Daniel, 1989).

II. BASIC CONCEPTS

The vertical conductivity (k_v) governs flow, even in sidewall liners if built in the preferred manner: lifts parallel to the slope. However, the horizontal conductivity (k_h) is greater than the vertical. All field tests are affected by this anisotropy, unless flow in the horizontal direction is artificially blocked; the effect is to increase the test conductivity by factors of 2 to 5 over the real (k_v) value. Equations for flow from various source geometries in a cross-anisotropic medium are available in Hvorslev (1951). However, each equation has two unknowns: (k_v) and ($m^2 = k_h/k_v$).

The TSB procedure combines four old concepts into one new idea to find (k_v). The field procedure is taken from long-established US Bureau of Reclamation methods: their flush-bottom borehole test (E-18) and borehole packer test (E-19). Computations are based on the Hvorslev equations adapted for various bottom boundary conditions by the three-dimensional Image Potential Technique (Carslaw and Jaeger, 1959). The new idea is performing both USBR tests in the same borehole, yielding two equations which can be solved for the two unknowns, (k_h) and (k_v).

The TSB is a field infiltration test, conducted in a cased borehole so that the geometry of the infiltrating zone can be controlled. It is normally conducted as a falling-head test. The basic idea is to vary the geometry of the infiltrating area so as to vary the relative effects of (k_h) and (k_v). In the first stage, the geometry is chosen so that (k_v) has its maximum effect. The second stage geometry is such that (k_h) has its maximum effect. The results of the two stages yield two equations in two unknowns (k_h, k_v), which can then be solved. This concept is illustrated on Figure 1, below:

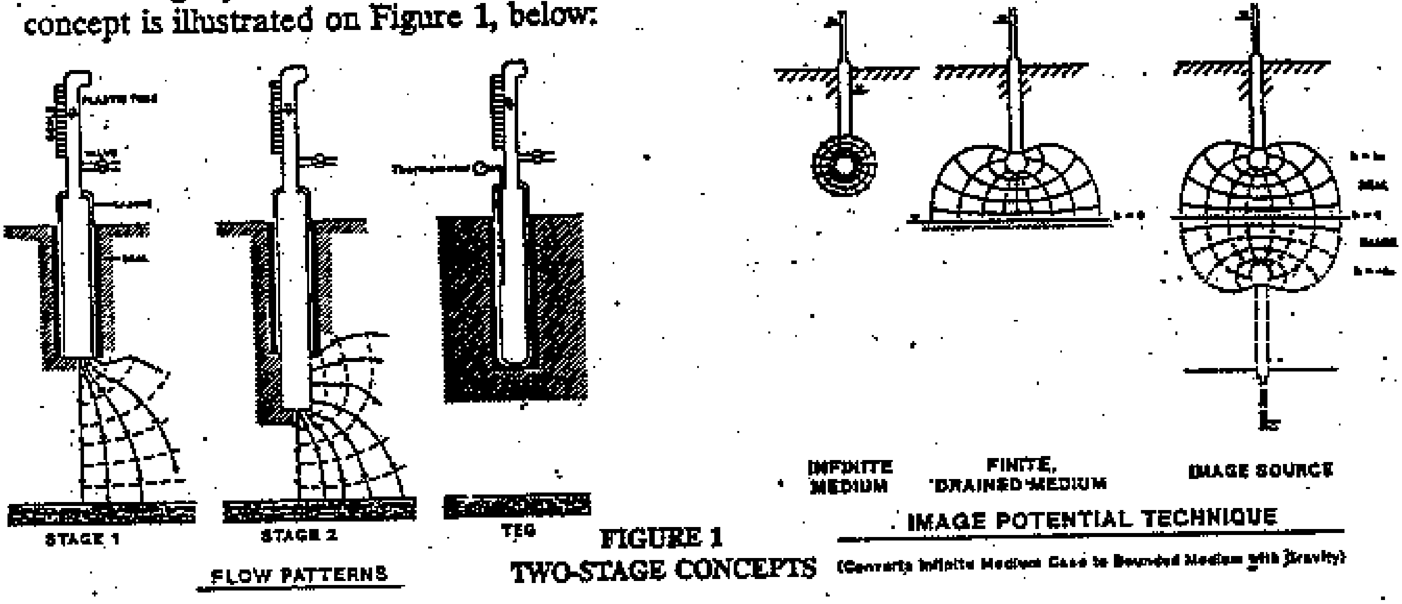


FIGURE 1
TWO-STAGE CONCEPTS

Stage 1 is normally conducted using a flat bottom flush with the base of the casing. Infiltration proceeds until a steady-state flow condition is achieved. Then, the borehole is advanced some 1.5 to 2 casing diameters (6 to 8 inches) below the bottom of the casing. The apparatus is refilled, and infiltration in this Stage 2 continues until it achieves steady-state flow.

During the test, the soil is assumed isotropic ($k_v = k_h$). Stage 1 then yields an apparent permeability (K1), and Stage 2 a different value (K2). The unknown ratio (k_h/k_v) is a unique function of the known test geometry and the known test ratio (K2/K1). When the former is determined, the real (k_v, k_h) can be computed from (K1) or (K2).

III. FIELD PROCEDURES

As is the case with virtually all field tests, and especially field permeability tests, the field procedures are of paramount importance. The most diligent office analyses cannot overcome all of the problems resulting from improper installation, inadequate monitoring, premature test termination, and the like.

<u>3.1 Test Program Design.</u> The test program should be designed to meet the conditions assumed in deriving the data reduction equations so that meaningful results can be obtained.

3.1.1 Vertical Boundaries. Certain clearances are required between the infiltrating surface and any boundaries, pervious or impervious. These can be summarized as:

a. **Minimum casing embedment below ground surface** **= 2.5D**
(Prevents uplift, minimizes hydraulic fracturing)

b. **Minimum thickness of tested material below bottom of Stage 2= 20D**
(Avoids violating boundary conditions of equations)

c. **Minimum recommended Stage 2 extension** **= 1.5D**
(Avoids theoretical problems at finite but small L/D)

D = Casing inside diameter
L = Length of Stage 2 extension

3.1.2 Horizontal Spacings. It is intuitively obvious that the tests must be spaced "far enough" apart so that their flows do not interfere with each other causing a falsely low permeability. Also, the presence of a drainage boundary (such as the edge of a test pad) which is "too close" to the test will increase the flow, yielding a falsely high permeability.

This can be avoided by maintaining at least the following clearances:

a. **Minimum horizontal distance between tests** **= 30D**
b. **Minimum horizontal distance to free surface** **= 30D**

3.1.3 Number and Size of Tests. The number of tests required for evaluation depends on the project, the acceptance criteria, and the variability of the stratum/fill being evaluated. As in virtually any other geotechnical testing, "the bigger the better".

> **However, the general practice has been to use 4-inch (ID) tests, with 5 tests for the typical liner or test pad.**

The scale effect, if any, of test size has not been fully researched. Virtually all of the known tests have been conducted using 4-inch (10 cm) ID casings. These tests typically permeate a volume of some 0.4 - 1.1 cubic feet each, or 2 to 5 cubic feet for a 5-test group. Benson (pers. comm., 1991) indicates that the minimum representative volume for a permeability determination is on the order of 0.5 - 1.0 cubic foot. This is about the volume permeated by a typical TSB test.

3.1.4 Other Details. There are a few other details in test planning which should be considered. Among these are:

a. **Protect the test area surface from desiccation, usually with <u>clear</u> or <u>white</u> plastic.**
(Avoids heat-induced problems).

b. **Use a "sock" to prevent collapse of the Stage 2 open hole in susceptible materials. The sock is a rigid cylinder of open-mesh plastic, lined with a filter geofabric. The cylinder is somewhat smaller in diameter than the casing ID (and thus the Stage 2 hole), and an inch or so longer than the extension for Stage 2. It is fitted with retrieving lines and not left in the hole after the test.**

c. **Minimize the distance (R_v) from the ground surface to the bottom of the measuring scale, especially for shallow tests. This also aids in having the longest possible reading time between standpipe refills and avoiding hydraulic fracturing.**

d. **Match the standpipe size to the flow rate so that accuracy is achieved but overnight readings are possible. For a 4-inch casing, this usually means a 0.5 - 0.75 inch ID standpipe.**

<u>3.2 Permeameter Installation.</u> Proper installation and checking the permeameters are vital to obtaining a valid test. Various field techniques have been developed through experience which minimize problems. These techniques are discussed in this section.

<u>3.2.1 Permeameter.</u> A typical permeameter is illustrated on Figure 2. The apparatus is simple; the permeameter can be assembled with a visit to a water-well driller and a hardware store. The elements for a falling-head system are:

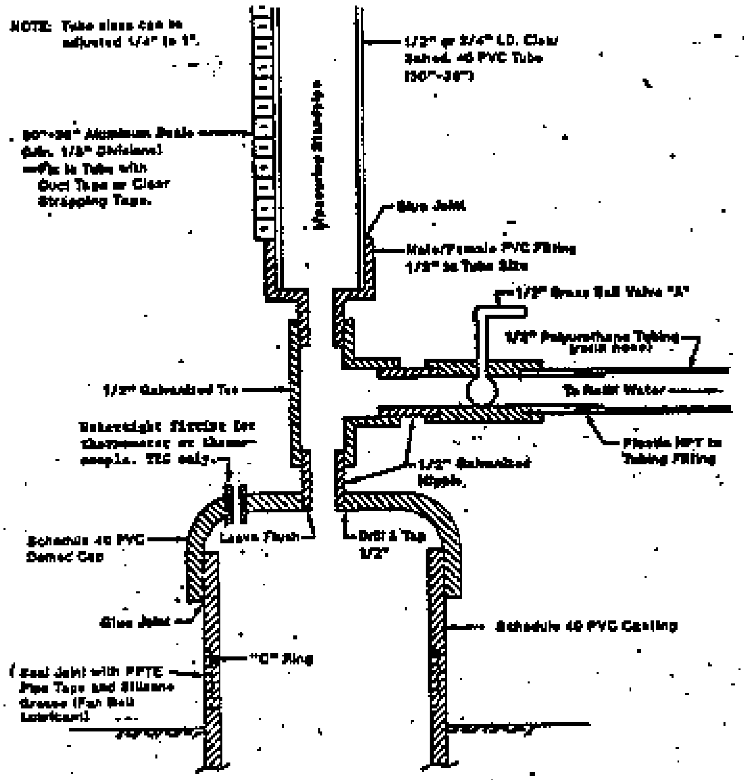
a. **<u>Casing.</u> Typically 4-inch ID Schedule 40 PVC monitoring well pipe, flush-threaded, with "O"-Ring joint. Other casings can be used.**

b. **<u>Cap.</u> To fit casing, preferably domed, and drilled and/or tapped to receive the standpipe apparatus.**

c. **<u>Standpipe.</u> *Clear* Schedule 40 PVC or acrylic tube, 0.5 to 1.0 inch ID, with scale. Include elbow with cover (having air-vent) to prevent rain entry and minimize evaporation.**

d. **<u>Fittings.</u> The small fittings necessary to assemble the apparatus.**

All joints which are not glued are assembled with PTFE Plumber's Tape and silicone grease (<u>not</u> sealant).



THIS HAS BEEN SIMPLIFIED. SEE FINAL SHEET

FIGURE 2
TYPICAL PERMEAMETER

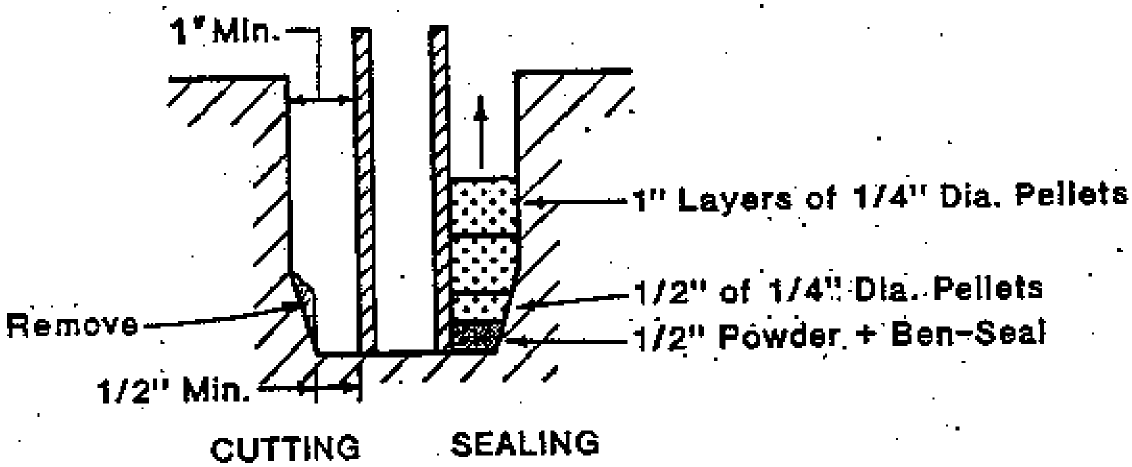


FIGURE 3
SEALING PROCEDURE

3.2.2 Borehole. The casing is set into a borehole. The holes have been drilled using rigs, power-operated hand equipment, and hand augers. The device depends on depth and hardness of material. The hole must have a large enough diameter to allow sealing the annular space between the borehole wall and the casing. Also, it must not disturb the soils below the casing bottom. The bottom must also be flat. Experience has shown the following to be acceptable:

a. **Borehole diameter at least 2 inches greater than the casing OD.** (To allow sealant to reach the bottom and for tamping).

b. **Stop point of auger about 1 inch above proposed casing bottom.** (To avoid testing in a disturbed material)

c. **Ream bottom of borehole to final depth with a flat auger.**

The bottom of the borehole should be flat and flush with the bottom of the casing in order to correspond with Hvorslev's (or H-I) Case "B" or "C" for Stage 1.

3.2.3 Sealing. This is the single most important step in installation. A poorly sealed test cannot be salvaged. The annular space between the casing and the wall of the borehole is sealed with bentonite. Best results have been attained using 1/4" (not 3/8" or larger) bentonite pellets or crushed bentonite (Baroid "Hole-Plug" or equivalent). The procedure, illustrated on Figure 3, is:

a. **Crush sufficient pellets, "Ben-Seal", or "Hole-Plug" to fill about 1/2 inch of the annulus. This should have about 1/16" size fragments with some powder.**

b. **Place this material into the annular space.**

c. **Place about 1/2 inch of bentonite pellets or "Hole-Plug" into hole,**

d. **Tamp the bentonite pellets or "Hole Plug",**

e. **Add water until it shows above the bentonite,**

f. **Repeat the process (but using only the pellets or "Hole Plug") in 1 inch increments to the ground surface or a minimum of 6D above the casing bottom, whichever occurs first. Grouting above the 6D level is allowable.**

g. **Allow the bentonite (and grout) to hydrate at least overnight.**

The casing must be steadied to prevent lateral motion while sealing. The bentonite seal is then allowed to hydrate overnight before any head is applied to the system.

3.2.4 Advancing for Stage 2. Upon completion of Stage 1, a borehole is advanced below the bottom of the casing to form the cylindrical infiltrating surface for Stage 2. The important points are:

a. **Do not disturb the casing - that can affect the seal.**

b. **Borehole diameter should equal casing ID.**

c. **Stop point of auger about 1 inch above proposed Stage 2 bottom. Ream flat and measure depth.**

d. **Roughen the sidewalls to minimize smear.**

This portion of the work is normally handled with hand equipment. The first step after removing the cap is to empty the casing of water (tests above groundwater level or where no seepage was noted during Stage 1 drilling and/or sealing). It is frequently useful to obtain an undisturbed sample during this process, using ASTM D2937 or D1587. However, undisturbed sampling should not be performed if the material being tested contains gravel-sized particles; they can disturb the sidewalls during the push or driving. After or in lieu of undisturbed sampling, the boring is augered until the point of the auger is about 1 inch above the desired bottom for Stage 2. The auger should be at least 1/2 inch in diameter smaller than the casing ID. The boring is then completed to depth and diameter with a flat-bottomed reamer.

The reamer is designed to minimize sidewall smear, having full casing ID only at the cutting edge. The sidewalls are then roughened with a wire brush or similar device, a procedure also recommended in USBR E-18. This step must not be omitted, since one of the significant problems encountered in Two-Stage testing has been artificially low values for Stage 2 due to smear. Equations to handle smear are included herein, but require some idea of the degree of smear.

After the borehole is completed and cleaned of cuttings, the depth is measured so that the correct length of the Stage 2 cylinder is known. For a typical test, a 1-inch depth error will yield the wrong Stage 2 permeability value by 7 to 8%. The cap is then reseated, and Stage 2 begins.

3.3 Ambient Condition Effects. Temperature changes cause the dominant effects of ambient conditions on this test, although there may be some contribution from barometric pressure changes. Temperature changes affect the test by:

* Volumetric changes in the water and apparatus.
* Viscosity changes with temperature.
* Freezing the test water.

The procedures for overcoming these effects are given below.

<u>3.3.1 Volumetric Effects (TEG).</u> At slow rates of flow, the field readings are affected by temperature, as has been noted on many such projects. Rising temperature causes the water column in the pressure/measurement standpipe to expand, so that the drop in water level is less than flow alone would produce. The net effect is a lower apparent permeability. Conversely, falling temperature produces a higher apparent permeability. A normal day's temperature variations can easily cause a 0.5 to 1 order of magnitude change in the apparent permeability of low-permeability materials.

Therefore, a complete "dummy" test setup is installed but with the <u>bottom</u> of the casing sealed with a cap which is normally glued on and pressure-tested. This dummy, or temperature effect gauge (TEG) is of the same construction and embedded to the same depth as the regular test setups. Since there is no flow from the TEG, any change in its readings must be due to changes in the ambient conditions (temperature and/or barometric pressure). Such changes would affect the regular test setups to exactly the same degree.

This correction is applied to the regular tests by:

* Reading the TEG at the same times as readings are taken on the regular tests.

* Determining any increase (decrease) in .water levels in the TEG between regular test readings.

* Subtracting any increase (adding any decrease) at the TEG from the readings at the regular tests for the ends of the same time increments.

<u>3.3.2 Viscosity Effects of Temperature.</u> Permeability is normally reported as the value for water at 20°C (68°F). The density and viscosity of liquids, including water, are affected by temperature. The effect on permeability is in direct ratio to the kinematic viscosity (U), which is the viscosity divided by the density. The kinematic viscosity decreases at higher temperatures. The net effect is that the apparent permeability is greater than the 68°F value at low temperatures. The reverse occurs with decreasing temperatures. The effects for ordinary conditions can be from -50% to +15% on the permeability value. The normal correction to the standard condition is given in ASTM D5084:

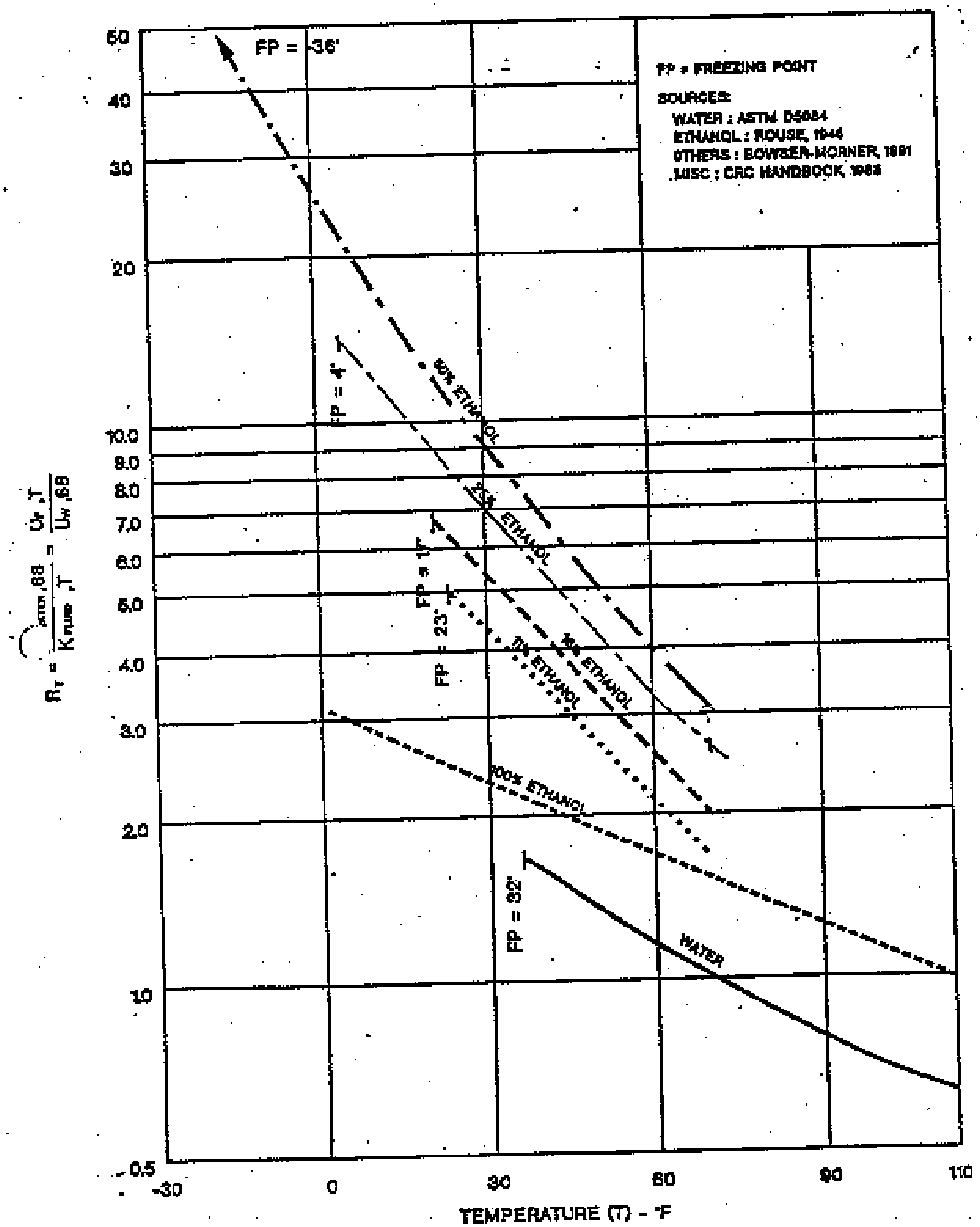


FIGURE 4
KINEMATIC VISCOSITY FACTORS

$$k_s/k_T = R_T = U_T/U_s \tag{3.3.-1}$$

where:

k_s = Permeability for water at 68°F
k_T = Permeability observed in test
R_T = Correction Factor
U_T = Kinematic viscosity for test fluid at test temperature
U_s = Kinematic viscosity for water at 68°F

The factors (R_T) are given for water at temperatures between freezing and 120°F (0 to 49°C) in ASTM D5084. See also Figure 4 which reproduces that data.

The temperature of the exfiltrating water is measured by a thermometer or thermocouple in the TEG. It should extend to roughly the bottom of the casing. The thermometer or the leads for the thermocouple should have its own (sealed) port into the TEG cap or casing. Running either through the TEG standpipe could easily affect its function of volumetric correction.

3.3.3 Freezing Conditions. Unfortunately, field testing must sometimes proceed when the air temperatures are below freezing. Landfill operators often complete a test pad in late fall, so that they will have approval from the regulators for construction in the spring. Even if the ground temperatures stay above freezing, one cannot get decent readings from a frozen standpipe. Three procedures have been used:

a. **Insulate the exposed test equipment, exposing only to make readings.**
(Only if mean daily air temperature exceeds freezing)

b. **Use an antifreeze.**
(Ethanol as Vodka is good, but needs its own R_T vs temperature graph. Does not attack clay at 25% or less alcohol).

c. **Heat the test units.**
(Potential for different temperatures - can invalidate the TEG).

3.4 Conducting the Test. The following discussion is applicable to both Stage 1 and Stage 2. Basically, the procedure is:

a. **Fill and assemble permeameters.**
(Use PTFE tape and silicone grease. Pour slowly to avoid bottom erosion).

b. **Read standpipe levels over time at the permeameter, plus level and temperature at the TEG.**
(Levels: to 1/16", temperature to 1°F).

c. **Convert these readings to apparent permeabilities.**

d. **Continue the test until these permeabilities remain steady.**

<u>3.5 Field Calculations - Apparent Permeability.</u> The data from each reading is converted into an apparent permeability, termed (K1) for Stage 1 and (K2) for Stage 2. Keeping up with the data in terms of a permeability has a physical meaning, and also yields a better "feel" for the behavior of the medium being tested. If that medium were isotropic ($k_h = k_v$), then (K1,K2) would be "the" permeability. Remember that the objective of most field permeability tests on regulated facilities is to determine that the vertical permeability (k_v) of the liner is not <u>greater</u> than some value, usually 1x10(-7) cm/sec, or to show that the horizontal permeability (k_h) of a drainage material is not <u>less</u> than some value, typically 1x10(-2) cm/sec. It can be shown that (K1) is the <u>maximum</u> possible value for (k_v) and that (K2) is the <u>minimum</u> possible value for (k_h). Hence, using these apparent permeabilities (K1,K2) frequently allows "pass-or-fail" determination early in the testing process. For example, (K1 < Spec) within 24 hours in 90% of tests where (k_v/Spec < 0.6), and 70% of all tests.

The equations for both Stage 1 and Stage 2 follow the generic falling-head test format:

$$k = R_T G \, Ln(H_1/H_2)/(t_2-t_1) \qquad (3.5\text{-}1)$$

where:

k	=	Permeability
H_1	=	Initial head (at $t=t_1$)
H_2	=	Final head (at $t=t_2$)
t_1	=	Initial time
t_2	=	Final time
G	=	Geometric Constant, depends on test geometry
R_T	=	Kinematic viscosity correction to water at 68°F

In both Stages, the head is taken as the distance from the level in the standpipe to the groundwater level. The distance from the bottom of the casing to the groundwater level is limited for calculation purposes (only) to no more than 20 times the casing ID. If the depth to groundwater is less than 20 times the casing ID, the true depth is used in the calculations. However, where the depth to groundwater exceeds this criterion, it is considered to be at this 20-diameter depth in the calculations. This limitation is derived by 3-dimensional analogy with the two-dimensional "effective radius" of a well. The volumetric effects of temperature are accounted for using a corrected final head, replacing (H_2) by (H_2'), where:

$$H_2' = H_2 - c \qquad (3.5\text{-}2)$$

where: c = Increase in TEG standpipe water level during time period from t_1 to t_2

If the TEG standpipe water level goes up between readings, (c) is positive and ($H_2' < H_2$). Conversely, (c) is negative and ($H_2' > H_2$) if the TEG standpipe level drops between readings. This step is not theoretically precise, but is close enough for test purposes. The theoretical solution yields a complex implicit equation in which the true permeability is a function of its own logarithm. However, for the geometry of the test setups and the observed magnitudes of increases/decreases, the apparent permeabilities calculated in this manner differ from the true permeabilities by no more than 2 to 5 percent. The net result is to "smooth" the apparent permeabilities. This smoothing is most apparent (and most useful) when the soil's apparent permeability is less than about 2 to 5x10(-7) cm/sec and especially for small-diameter standpipes.

The kinematic viscosity factor (R_T) used in the calculation is that for the <u>average</u> test water temperature during the period from (t_1) to (t_2).

<u>3.5.1 Stage 1.</u> The nomenclature for the various terms of the Stage 1 calculations is illustrated on Figure 5. The proper equation is given below; it is the solution for (k_v) for an isotropic medium ($k_h/k_v = 1$).

$$K1 = R_T(\pi d^2/11D_1)[1 + a(D_1/4b_1)]Ln(H_1/H_2')/(t_2 - t_1) \qquad (3.5\text{-}3)$$

where:

	d	=	ID of Standpipe
	D_1	=	Effective diameter of Stage 1 (Casing ID or OD)
	b_1	=	Depth of tested medium below bottom of casing
	a	=	+1 for impervious lower boundary
	a	=	0 for infinite depth of tested medium ($b_1 = \infty$)
	a	=	-1 for pervious lower boundary

And the other terms are as defined above. For field use, the geometric terms are combined into a single constant:

$$K1 = R_T\, G1\, Ln(H_1/H_2')/(t_2 - t_1) \qquad (3.5\text{-}4)$$

where: $G1 = (\pi d^2/11D_1)[1 + a(D_1/4b_1)]$

A complete example is given in the Sample Calculations, Appendix A.

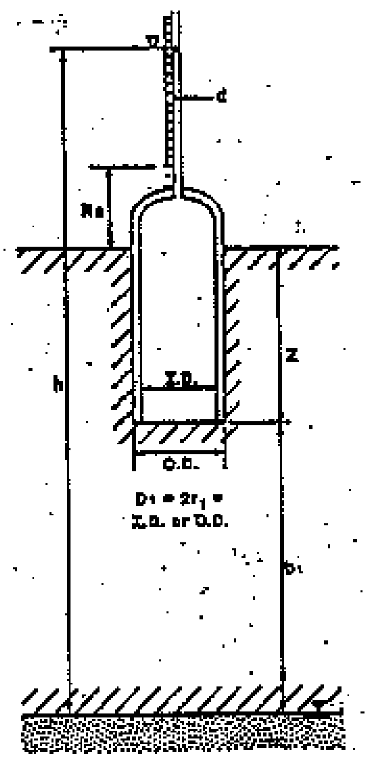


FIGURE 5
STAGE 1 NOMENCLATURE

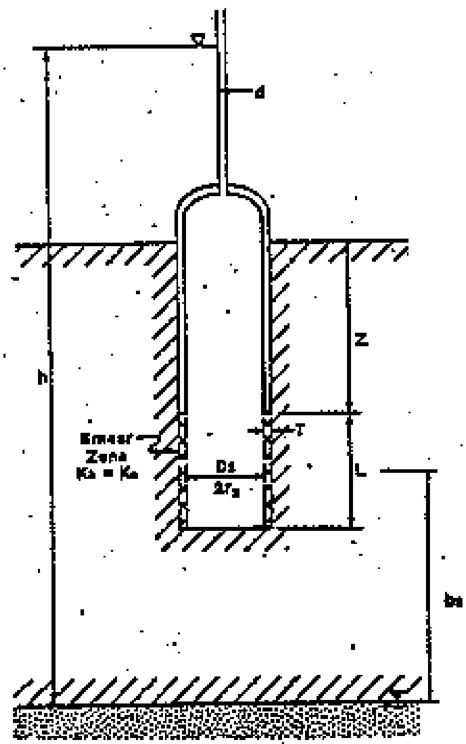


FIGURE 6
STAGE 2 NOMENCLATURE

3.5.2 Stage 2. The nomenclature for the various terms of the Stage 2 calculations is illustrated on Figure 6. The proper equation is that given below; it is the solution for (k_v) with the assumption that ($k_h/k_v = 1$).

$$K2 = R_T\,(d^2/16Lf)\,\{Ln[u(1,r_o,o)] + a\,Ln[u(1,r_o,2b_2)]\}\,Ln(H_1/H_2')/(t_2-t_1) \qquad (3.5\text{-}5)$$

where:

f	=	1-0.5623 Exp(-1.566 L/D)
L	=	Length of Stage 2 cylinder below casing
$u(1,r_o,o)$	=	$\{L/D_2 + \sqrt{1+(L/D_2)^2}\}^2$
$u(1,r_o,2b_2)$	=	$\dfrac{4b_2/D_2+L/D_2+\sqrt{1+(4b_2/D_2+L/D_2)^2}}{4b_2/D_2-L/D_2+\sqrt{1+(4b_2/D_2-L/D_2)^2}}$
D_2	=	Diameter of Stage 2 extension (normally casing ID)
b_2	=	Distance from center of Stage 2 extension to underlying boundary

And the other terms are as defined previously. The factor (f) was introduced to account for the non-convergence of the Hvorslev equations as ($L \to 0$). For field use, the geometric terms are combined into a single constant:

$$K2 = R_T\,G2\,Ln(H_1/H_2')/(t_2-t_1) \qquad (3.5\text{-}6)$$

where: $G2 = (d^2/16Lf)\,\{Ln[u(1,r_o,o)] + a\,Ln[u(1,r_o,2b_2)]\}$

A complete example is given in the Sample Calculation, Appendix A.

3.5.3 Time-Weighted Averaging. Whether one uses the Laplacian or the Green-Ampt model for groundwater flow, there are still transient effects at the beginning of every type of field or laboratory permeability test. The observed effect is to indicate a high permeability, gradually decreasing to some relatively constant value corresponding to a steady-state flow condition. Such an effect is usually noted in the TSB. Therefore, the test must be conducted "long enough" to achieve virtually the steady-state condition or the results will be not only too high but also erratic. In addition, a single value each of (K1) and (K2) must be used in the final data reduction (Section IV).

There is no reliable method for pre-calculating the length of time required to achieve steady-state. Rather, the observational method is used. The appropriate apparent permeability (K1 or K2) is calculated for each time-increment, and/or over longer periods of time; when these appear to be stable, they are checked using arithmetic time - weighted averages, e.g.,

$$K' = \Sigma\ (TiKi)/\Sigma\ (Ti) \tag{3.5-7}$$

where:
- K' = Arithmetic Time-Weighted Average (ATWA) Permeability
- Ti = Time Duration of Test Increment (i)
- Ki = Permeability Measured during Test Increment (i)

This is theoretically exact for a single run (between refills). Time - weighted averaging also provides a rational basis for smoothing the (often) slightly erratic individual (K1,K2) values from the various time increments. An example of time-weighted averaging is given in the Sample Calculations, Appendix A.

3.5.4 Termination Criteria. Infiltration theory indicates that the apparent permeabilities (K1,K2) should forever decrease at an ever-and-ever decreasing rate. Observations in over 200 of these tests show that a steady-state condition or a close approximation of it is achieved in reasonable testing periods. A log-log plot of apparent permeability versus time is useful in determining when steady-state is achieved. Eventually, the (K1,K2) plots fluctuate about stable values. An example of such a plot is given in the Sample Calculation, Appendix A. This plot illustrates the importance of fairly closely spaced readings at the beginning of each stage, which allow separating the long-term behavior from the short-term fluctuations, i.e., enhance the "signal-to-noise" ratio.

In most tests, time-weighted averages become quite stable, often to within 1 to 5%. A reasonable set of criteria for terminating a stage is as follows:

- The time-weighted averages do not show an upwards or downwards trend with time,

  and

- Do not fluctuate more than 10 to 20% among themselves,

  and

- Maintain this behavior over a "sufficiently long" time, 12 - 72 hours depending on permeability.

IV.- DATA REDUCTION

4.1 Basic Procedure. In some cases, the (K1') or (K2') values may be adequate for the purpose of the test. More generally, the test is performed to determine the actual (k_h,k_v). This section outlines how to convert the (K1',K2') values calculated as outlined in Paragraphs (3.5.1) and (3.5.2) into the real permeabilities (k_h,k_v). Details for the common case are covered below.

4.1.1 Simultaneous Equations. The equations presented earlier for determining (K1,K2) are special cases of more general relationships. These more general equations define the degree of anisotropy by the parameter:

$$m = \sqrt{k_h/k_v} \qquad (4.1\text{-}1)$$

This parameter affects the geometric terms of the various equations. Each stage has its own equation with a different effect of (m). In a general sense, these can be written as:

Stage 1: $k_v = G1_m \, Ln(H_1/H_2')(t_2\text{-}t_1)$
$K1 = G1 \, Ln(H_1/H_2')(t_2\text{-}t_1)$

or $k_v = K1\,(G1_m/G1) \qquad (4.1\text{-}2)$

where: $G1_m$ = Geometric factor including (m)

Similarly, for Stage 2,

$$k_v = K2'\,(G2_m/G2) \qquad (4.1\text{-}3)$$

If the soil medium being tested is homogeneous (although cross-anisotropic and possibly bounded), the vertical permeability (k_v) must be the same in both stages. Hence, (4.1-2) and (4.1-3) provide two equations in the two unknowns ($m = \sqrt{k_h/k_v}$) and (k_v). The resulting equation is:

$$K1'(G1_m/G1) = k_v = K2'(G2_m/G2)$$

or $K2'/K1' = (G1_m/G1)(G2/G2_m) \qquad (4.1\text{-}4)$

The standpipe area (A_p) cancels for each individual stage in (4.1-2 and 4.1-3), even though different (A_p) values may have been used for Stage 1 and Stage 2, and even for different portions of either stage. The actual equations for the geometric constants involving (m) are given in Paragraph (4.2).

The ratio (K2'/K1') is known from the test; the actual values introduced are the long-term time-weighted averages, (K1' and K2'). The geometric terms are also known. Therefore, Equation (4.1-4) is satisfied only for one value of (m). Due to the complex nature of (4.1-4), trial-and-error or graphical solution works best for specific problems.

4.1.2 Calculating (k_h) and (k_v). The value for (m) is obtained as outlined above in Paragraph (4.1.1). When (m) is known, (k_v) can be calculated directly from Equation (4.1-2), and, by the definition of (m) in Equation (4.1-1).

$$k_h = m^2 k_v \tag{4.1-5}$$

4.1.3 Stage 1 Only Method. In some individual tests, the ratio (K2'/K1') is so low that Equation (4.1-4) fails to converge. Others may have so large a (K2'/K1') ratio that the permeability values are obviously in error: (k_v) is far too low and (k_h) is far too high. This is usually due to inhomogeneity of the tested material. Advancing Stage 2 into a zone of lower permeability will cause a low (K2'/K1'). Conversely, advancing into a zone of higher permeability (such as a poor lift joint in fill or a silt/sand seam in natural materials) yields a very high (K2'/K1').

These events are handled by using a conservative (m) from the best-behaved tests and introducing that value into Equation (4.1-2).

4.2 Image Equation with Smear. The basic Hvorslev equations apply most directly to masses of infinite depth and below the groundwater level. Neither test pads nor liners often meet these criteria. Therefore, results calculated by using the Hvorslev equations directly for such cases will not be correct. For a given permeability, both proximity to a drainage zone and the vertical gradient due to gravity cause the flow to be greater than the basic Hvorslev equations would predict. The basic Hvorslev equations therefore predict a higher permeability than the material really has. The vertical gradient effect can be overcome by using the head as from the top of the standpipe to the groundwater level. A method for accounting for the proximity effect and proving the previous assertion was needed.

The method of image wells has been used in geohydrology for years. The classic example is the solution for a well near a river, found in many textbooks. However, the method is not limited to two-dimensional situations such as this illustration. Any solution for an infinite or semi-infinite medium which describes the potential field (head distribution) can be converted to a solution for a finite medium bounded by a plane by using the Image Potential technique (Carslaw & Jaeger, 1959).

The basic idea is that halfway between a source and a sink of equal but opposite strength will be a plane of zero potential. So, if there is a plane of zero potential (head), its effect can be replaced by an "image" source/sink located twice as far away from the sink/source as is the midway plane. If the test (source) is set a distance (b) above the drainage blanket, the flow field will be the same as if there were no blanket but there was an image test (sink) with negative head at a distance of (2b) below the real test. Since the drainage blanket is at zero head, the head at the test is taken as the total head lost: (b) plus the excess pressure (ht) applied at the infiltration point of the test.

Consider also the case where both the real and image sources have equal strengths and both are sources (positive head) or both are sinks (negative head). By the same logic as given above, the midway plane will be a no-flow boundary, corresponding to an impermeable bottom boundary located at a depth (b) below the real test.

4.2.1 Stage 1. The Hvorslev-Image equation (Case "C") for the flush-bottomed portion of the test is given by:

$$k_v = (\pi d^2/11mD_1)[1+a(D_1/4mb_1)]Ln(H_1/H_2')/(t_2-t_1) \qquad (4.2\text{-}1)$$

where:

d	=	ID of Standpipe
D_1	=	Test diameter for Stage 1
b_1	=	Thickness of test medium below base of casing
H_1	=	Initial head ($t=t_1$)
H_2'	=	Corrected final head = H_2-c (see Paragraph 3.5)
t_2	=	Final time
t_1	=	Initial time
a	=	-1 for permeable bottom boundary
a	=	0 for infinite depth to bottom boundary
a	=	+1 for impermeable bottom boundary

Equation (4.2-1) can also be written as:

$$k_v = G1_m \; Ln(H_1/H_2')/(t_2-t_1) \qquad (4.2\text{-}2)$$
$$G1_m = (\pi d^2/11mD_1)[1+a(D_1/4mb_1)]$$

4.2.2 Stage 2. Similarly, for the cylindrical case (Hvorslev "G"), the Image equation (with sidewall smear) is that given by:

$$k_v = (d^2/16Lfm^2)\{Ln[u(m,r_o+T,o)] + a\,Ln[u(m,r_o,2b_2)] + p\,Ln[u(m,r_o,o)/u(m,r_o+T,o)]\}\,Ln(H_1/H_2')/(t_2-t_1) \qquad (4.2\text{-}3)$$

where:	L	=	Length of Stage 2 extension
	f	=	$1-0.5623\ \mathrm{Exp}(-1.566\ L/D)$
	$u(m,r_o,o)$	=	$[mL/D_2 + \sqrt{1+(mL/D_2)^2}]^2$
	$u(m,r_o,2b_2)$	=	$\dfrac{4mb_2/D_2+mL/D_2+\sqrt{1+(4mb_2/D_2+mL/D_2)^2}}{4mb_2/D_2-mL/D_2+\sqrt{1+(4mb_2/D_2-mL/D_2)^2}}$
	$u(m,r_o+T,o)$	=	$\{mL/(D_2+2T) + \sqrt{1+[mL/(D_2+2T)]^2}\}^2$
	p	=	k_h/k_s
	k_s	=	Permeability of smeared zone
	T	=	Thickness of smeared zone (0.6cm = 0.25in)
	D_2	=	Diameter of Stage 2 extension
	b_2	=	Distance from <u>center</u> of Stage 2 cylinder to underlying boundary

And the other terms are as defined above for Stage 1. Equation (4.2-3) can be written in the generic format as:

$$k_v = G2S\ \mathrm{Ln}(H_1/H_2')/(t_2-t_1) \qquad (4.2\text{-}4)$$

where: $G2S = (d^2/16Lfm^2)\{\mathrm{Ln}[u(m,r_o+T,o)] + a\ \mathrm{Ln}[u(m,r_o,2b_2)]$
$+p\ \mathrm{Ln}[u(m,r_o,o)/u(m,r_o+T,o)]\}$

The generic expression for (K2'/K1') as a function of the test geometry is Equation (4.1-4). Following the steps outlined in Paragraph (4.1.1),

$$K2'/K1' = (G1_m/G1) \cdot (G2/G2S) \qquad (4.2\text{-}5)$$

where:

$$(G1_m/G1) = (1/m)\ [1+a(D_1/4mb_1)]/[1+a(D_1/4b_1)]$$

$$(G2/G2S) = \frac{m^2\{\mathrm{Ln}[u(1,r_o,o)]+a\mathrm{Ln}[u(1,r_o,2b_2)]\}}{\mathrm{Ln}[u(m,r_o+T,o)]+a\mathrm{Ln}[u(m,r_o,2b_2)]+p\mathrm{Ln}[u(m,r_o,o)/u(m,r_o+T,o)]}$$

Equation (4.2-5) is solved by taking an appropriate (p) and determining (m) by trial-and-error or by a graphical solution such as Figure 7.

The value of (p) is not determined in the test. The normal range of (p) is from 2 to 20; (p=1) indicates no smear. The following values for (p) have yielded satisfactory results, consistent with apparently non-smeared tests on the same tested units:

K2'/K1'	p
>1.1	1
0.9 - 1.1	1,2
0.8 - 0.9	2,5
0.7 - 0.8	5,10
0.6 - 0.7	10,20
0.4 - 0.6	15,20
0.4>	*

* Use Stage 1 Only Approach - Paragraph (4.1.3).

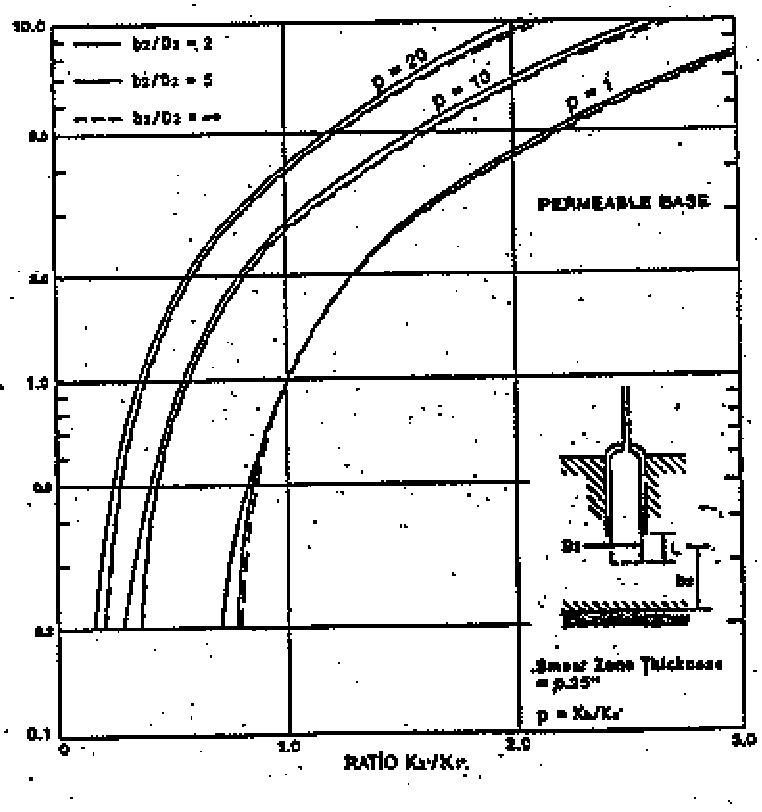


FIGURE 7
GRAPH FOR (m) - (L/D=1.5)

4.3 Non-Saturated Media. Field permeability tests are frequently performed on materials which are not fully saturated. Such materials affect the tests in two ways:

- The hydraulic head is dissipated over the (changing) distance from the point of inflow into the soil to the "wetting front", where the soil is considered fully saturated (Green-Ampt Model).
- Unsaturated clays exhibit "soil suction", which effectively adds to the hydraulic head.

In the Two-Stage test, infiltration into the soil is three-dimensional. The majority of the head loss occurs close to the inflow surface, even in a fully saturated material. About 50% of the loss occurs within one test radius of the inflow surface. For a typical Two-Stage test, disregarding wetting front distance theoretically yields a permeability 10 to 50% too high.

The effect of soil suction is roughly proportional to the ratio of suction to applied head. The effect of suction alone on a permeability test can be expressed as:

$$k_a/k_t = (1 + S/h_o) \qquad (4.3\text{-}1)$$

where:

	k_a	=	Observed permeability
	k_t	=	True saturated permeability
	S	=	Soil suction
	h_o	=	Applied head

The Two-Stage test normally operates with heads 3 to 6 times those of other test methods, minimizing the relative effect of suction.

These two effects can be handled using the graph presented on Figure 8. That figure is based on numerical solutions for the equipotential surfaces in an infinite medium (a=0). However, for the typical real test, the dimensionless flow volume is such that the equipotentials do not vary significantly from the ellipsoids in either the permeable-base (a=-1) or impermeable-base (a=+1) cases. The actual volume, which includes an allowance for the impermeable casing, has been included on Figure 8.

When using Figure 8, the initial volume (V_o) is taken as:

- Stage 1 - The volume of a hemi-ellipsoid having the diameter (D_1) and height ($D_1/4$).

$$V_{o1} = (\pi/24)\, D_1^3 \qquad (4.3\text{-}2)$$

- Stage 2 - The volume of the Stage 2 cylinder.

$$V_{o2} = (\pi/4)\, D_2^3\, (L/D_2) \qquad (4.3\text{-}3)$$

WE ALMOST NEVER USE NON.SAT EFFECTS.

The term (V_w) is the total volume of water which has infiltrated into the soil through the end of each stage, allowing for that removed in the Stage 2 extension. The (n_a) term is the soil's air porosity.

Figure 8 is applied first to the individual (K1) values from Stage 1:

$$K1_t = K1/[R(1+s/H_o)] \qquad (4.3\text{-}4)$$

where: $K1_t$ = K1 corrected for suction and wetting front
R = Permeability ratio from Figure 8

Then, Figure 8 is similarly applied to the individual (K2) values from Stage 2:

$$K2_t = K2/[R(1+s/H_o)] \qquad (4.3\text{-}5)$$

where: $K2_t$ = K2 corrected for suction and wetting front

Thereafter, ($K1_t$,$K2_t$) are used in Equation (3.5-7) for the average values ($K1'_t$,$K2'_t$). These are then introduced into Equations (4.2-5) for (m) then (4.1-2) for (k_v), and finally (4.1-5) for (k_h).

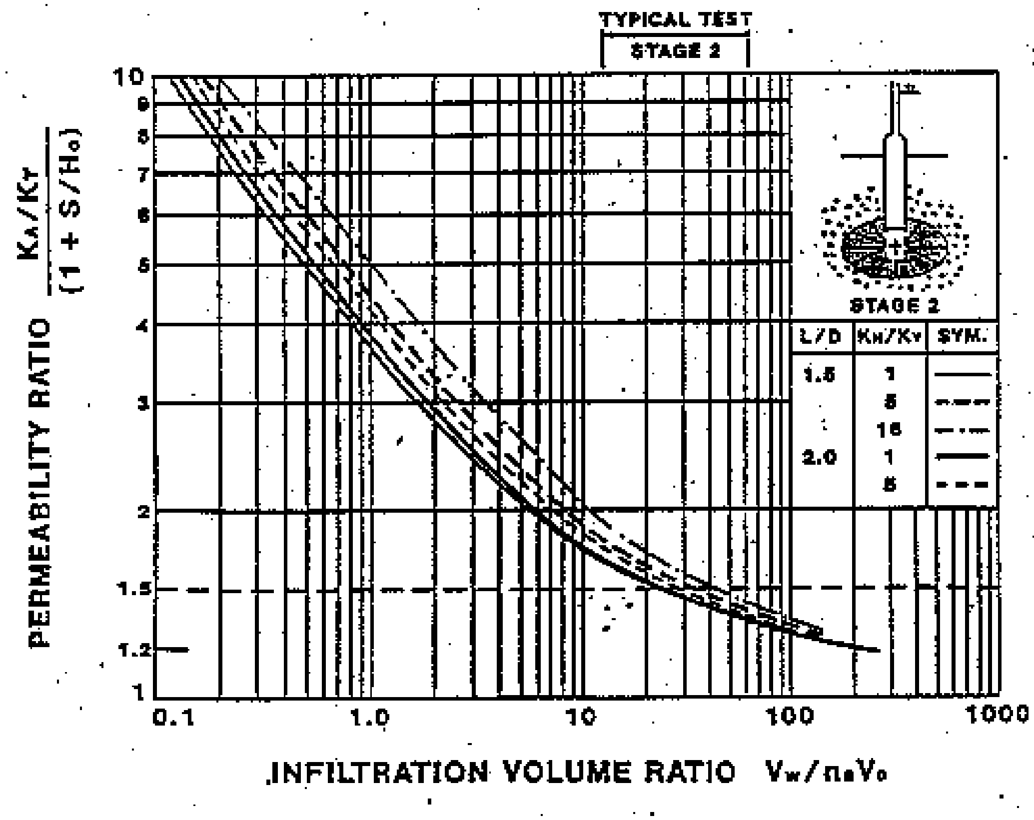


FIGURE 8
NON-SATURATION EFFECTS

V. EXPERIENCE WITH TSB TESTS

As of January, 1992, STEI alone has been involved in some 200 tests (40+ projects) on recompacted materials and 90 tests (6 projects) in natural materials. These have generally been of relatively low permeability [10(-6) to 10(-9) cm/sec]. Some conclusions from this experience are given below.

5.1 Types of Projects. The test has been successful in many types of soils:

5.1.1 Test Pads and Liners. It has been used in such conditions for test units from 20 to 60 inches thick. Materials have ranged from CH-OH (Liquid Limit 100+, clay content 70%+) to SC/GC (Liquid Limit 30-, gravel content up to 30%, clay content 12%). Vertical permeabilities have been successfully measured from the mid 10(-7)'s to the low 10(-9)'s (values in cm/sec).

5.1.2 "Natural" Deposits. It has been very successful in clays to depths of 10 to 15 feet. Where the clay does not make water, it has also been successful to about 20 to 25 feet. The test was moderately successful in soft, highly layered mine tailings clay at depths up to 30 feet. It has been used up to 7 feet deep in shales. Measured vertical permeabilities have been in the same ranges mentioned above.

5.2 Comparisons with Other Methods. The accuracy and lack of false negatives of the TSB can be evaluated by the comparisons with SDRI data shown on Figure 9 and with laboratory data from undisturbed samples given on Figure 10. Of the 11 known cases where both field methods were used on the same test pads/liners the mean ratio of their conductivities was 1.1 (TSB higher). In three known cases, the TSB proved failure defects in test pads that laboratory tests did not show, indicating the TSB avoids false positives. Experience to date can be summarized as:

5.2.1 Recompacted Clays. The vertical permeability (k_v) as obtained from laboratory tests, the TSB, and the SDRI generally agree quite well on test pads/liners (11 cases) which have had proper CQA. The laboratory tests tend to underestimate the horizontal permeability.

5.2.2 Natural Clays. Comparisons have only been made with small-scale laboratory tests. In general, there is good agreement with the TSB for vertical permeability, while laboratory tests again underestimate the horizontal permeability.

5.3 Speed. As soon as the test begins, so does the question from the client, "Does it Pass?" It is usual that (k_v) must be less than some specified value (Spec), or that (k_h) must be greater than a different (Spec). Since the maximum possible value for (k_v) is (K1), as soon as (K1<Spec), one knows the test for (k_v) must pass. Likewise, since (K2) is the minimum possible value for (k_h), if the long-term (K2) is greater than (Spec), the test for (k_h) must pass.

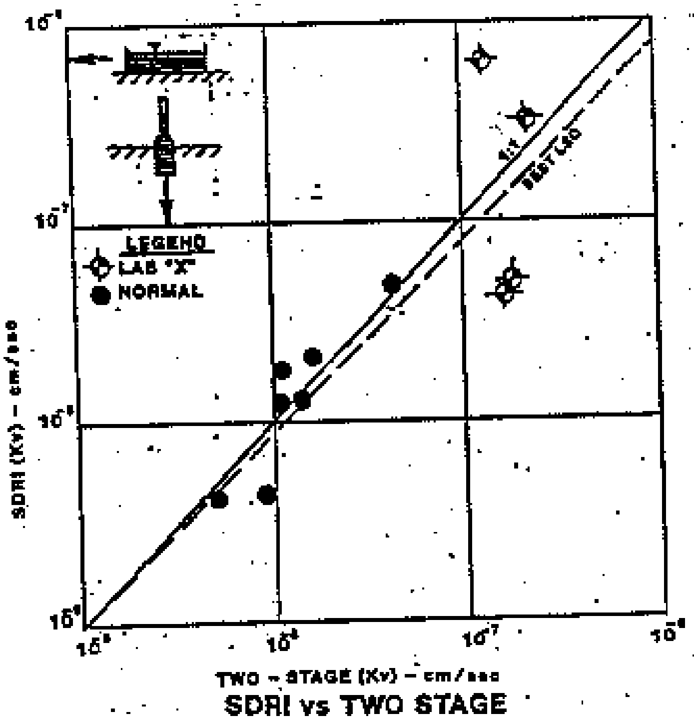


FIGURE 9
TSB AND SDRI RESULTS
(Tests on Same Liners/Test Pads)

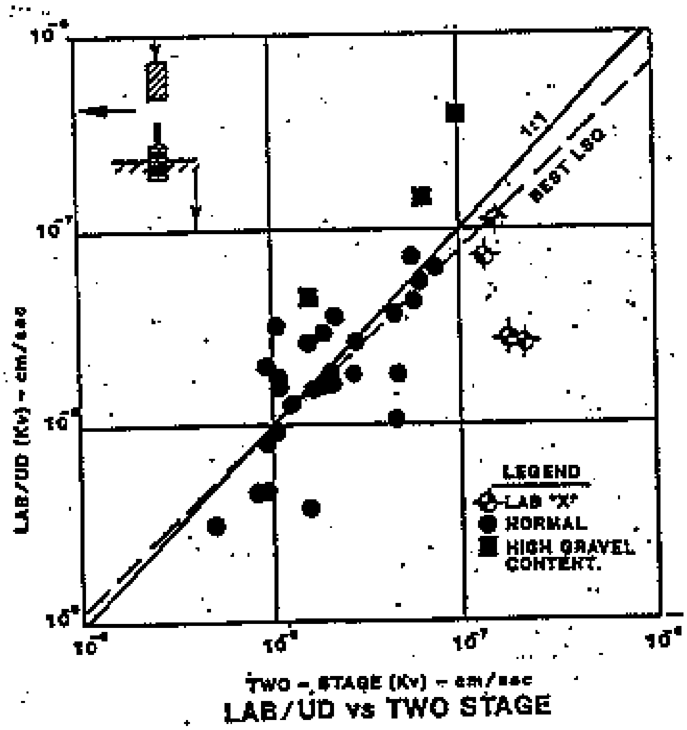


FIGURE 10
TSB AND LAB (k_v) RESULTS
(Tests on Same Liners/Test Pads)

Most of the TSB tests to date in test pads/liners have been for (k_v). The better the pad, i.e., the higher the (Spec/k_v) ratio, the sooner (K1<Spec). In 90% of the tests where (Spec/k_v>1.7), passing was indicated in 24 hours or less. Some 75% of all tests have indicated passing within 72 hours. A marginal test unit, whose (k_v) is just below (Spec), will require completing Stage 2. In general, each Stage lasts 4 to 14 days, the longer times being required to complete a test in lower permeability materials.

5.4 Volume Tested. A single typical TSB test permeates a volume around 0.6 to 1.1 cubic feet, or 60 to 200 times the volume of a typical plug tested in the laboratory (3 inch diameter, 3 inch height). The usual 5-test program thus tests about 10 to 20% the volume of an SDRI, yet yields about the same values. The TSB has a good balance of soil volume tested and speed.

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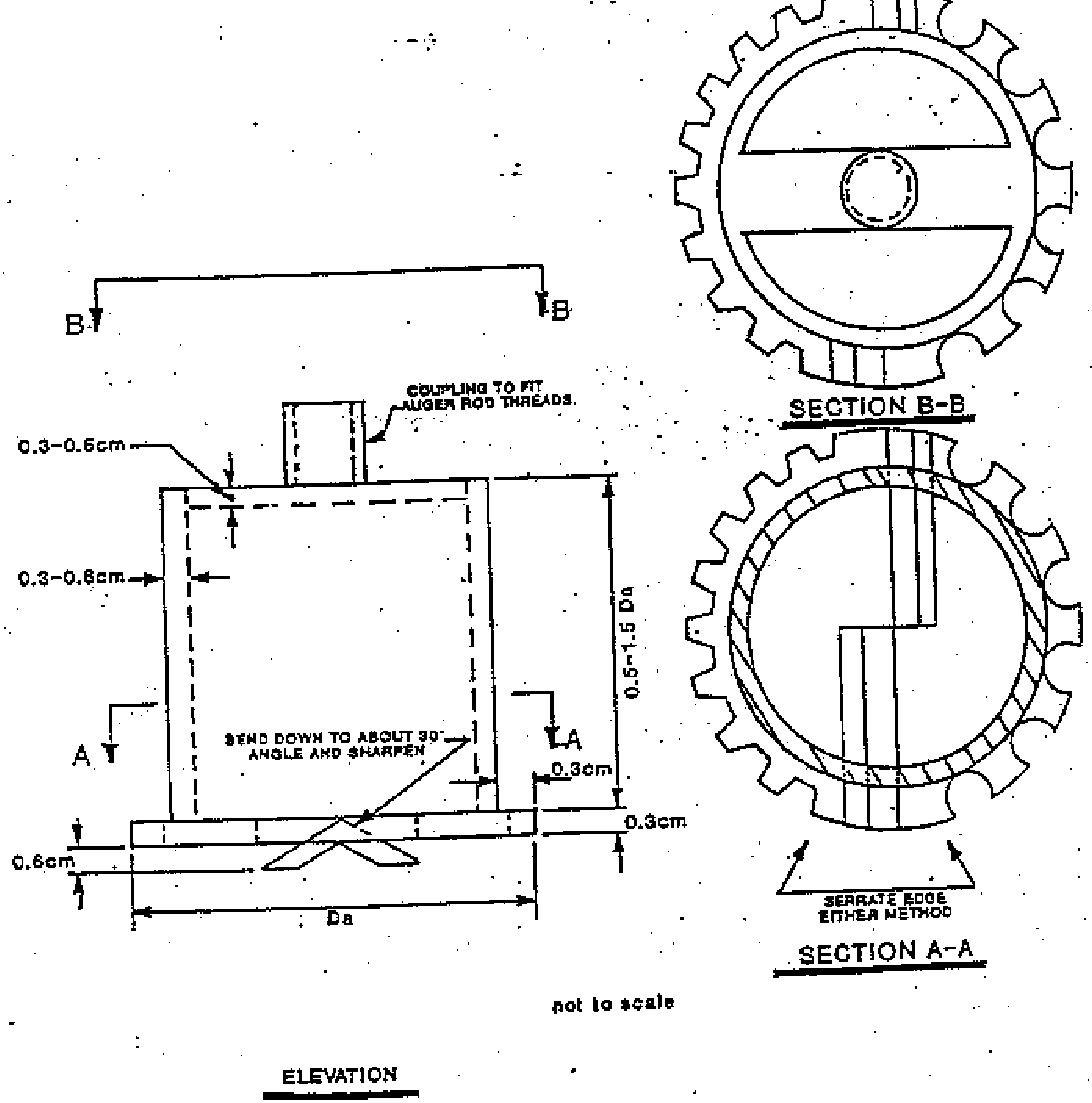
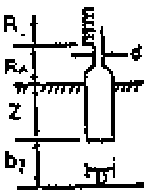


NOTE: FOR FLAT AUGER, Da=D+5cm
FOR REAMER, Da=D -0.1 cm

FLAT BOTTOM REAMING AUGER

STAGE 1 CALCULATIONS



d = 1.27 cm
D = 11.43 cm
Z = 61.0 cm
RA = 22.9 cm
b1 = 61.0 cm

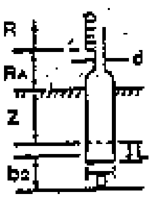
ΔV = 1.27 Δh
H = 144.8 +R
$K1 = 0.0384 / \frac{Ln (H_1/H_2)}{t_2 - t_1}$

Ground Elev.: ______
TOC Elev.: ______ (before)
______ (after)
Site Coords: ______
______

Project: ______
File No.: ______
Test No.: ______
Page: ______

Date	Time	Δt (hrs.)	Δt (sec.)	R (cm)	H1 (cm)	H2 (cm)	K1 (cm/sec)	C (cm)	H2' (cm)	K1' (cm/sec)	Temp. (°C)	Rt Factor	K1T (cm/sec)	Cum Vol. (cc)	Cum. Hrs.	Remarks
8/01	0800	—	—	64.8	—	209.6	—	0.0	—	—	21	—	—	0.0	0.0	Start
	0830	0.50	1800	47.8	209.6	192.6	1.80E-06	0.0	192.6	1.80E-06	21	0.97	1.76E-06	21.5	0.5	
	0900	0.50	1800	36.3	192.6	181.1	1.31E-06	0.0	181.1	1.31E-06	21	0.97	1.27E-06	36.0	1.0	
	1000	1.00	3600	19.7	181.1	164.5	1.03E-06	0.2	164.3	1.04E-06	22	0.96	9.99E-07	57.1	2.0	End Run
	1001	-	-	66.7	-	211.5	—	0.0	—	—	22	—	—	-	2.0	Refill
	1200	1hr59m	7140	47.0	211.5	191.8	5.26E-07	0.6	191.2	5.44E-07	23	0.94	5.09E-07	82.0	4.0	
								etc.								
8/05	1700			50.0		194.8					26				105.0	
8/06	0800	15.00	54000	38.1	194.8	182.9	4.49E-08	-2.8	185.7	3.33E-08	19	0.94	3.20E-08	208.5	120.0	Stop

STAGE 2 CALCULATIONS



d = 1.27 cm
D = 10.16 cm
Z = 61.0 cm
RA = 22.9 cm
b2 = 53.3 cm

L = 15.2 cm
ΔV = 1.27 Δh
H = 144.8 +R
$K2 = 0.01570 \frac{Ln (H_1/H_2)}{t_2 - t_1}$

Ground Elev.: ______
TOC Elev.: ______ (before)
______ (after)
Site Coords: ______
______

Project: ______
File No.: ______
Test No.: ______
Page: ______

Date	Time	Δt (hrs.)	Δt (sec.)	R (cm)	H1 (cm)	H2 (cm)	K2 (cm/sec)	C (cm)	H2' (cm)	K2' (cm/sec)	Temp. (°C)	Rt Factor	K2T (cm/sec)	Cum Vol. (cc)	Cum. Hrs.	Remarks
8/06	0930	—	—	65.4	—	210.2	—	-	—	—	20	—	—	0.0	0.0	Start
	1000	0.5	1800	59.4	210.2	204.2	2.52E-07	0.0	204.2	2.52E-07	21	0.99	2.49E-07	7.6	0.5	
	1030	0.5	1800	54.3	204.2	199.1	2.21E-07	+0.2	198.9	2.28E-07	22	0.96	2.19E-07	14.1	1.0	
	1130	1.0	3600	45.7	199.1	190.5	1.32E-07	+0.3	190.2	2.00E-07	23	0.94	1.87E-07	24.9	2.0	
	1330	2.0	7200	33.3	190.5	178.1	1.47E-07	+1.3	176.8	1.82E-07	24	0.91	1.48E-07	40.6	4.0	
							etc.									
8/09	0730			21.3		166.1					16			-	70.0	
	1600	9.5	30600	9.2	166.1	154.0	3.88E-08	+1.1	152.9	4.25E-08	19	1.07	4.56E-08	267.9	78.5	Stop

FIGURE 3.

APPENDIX A

SAMPLE CALCULATION
FOR
2-STAGE FIELD PERMEABILITY TEST

NOTE: This is an idealized case exhibiting virtually perfect behavior, and is not to be considered representative of field behavior.

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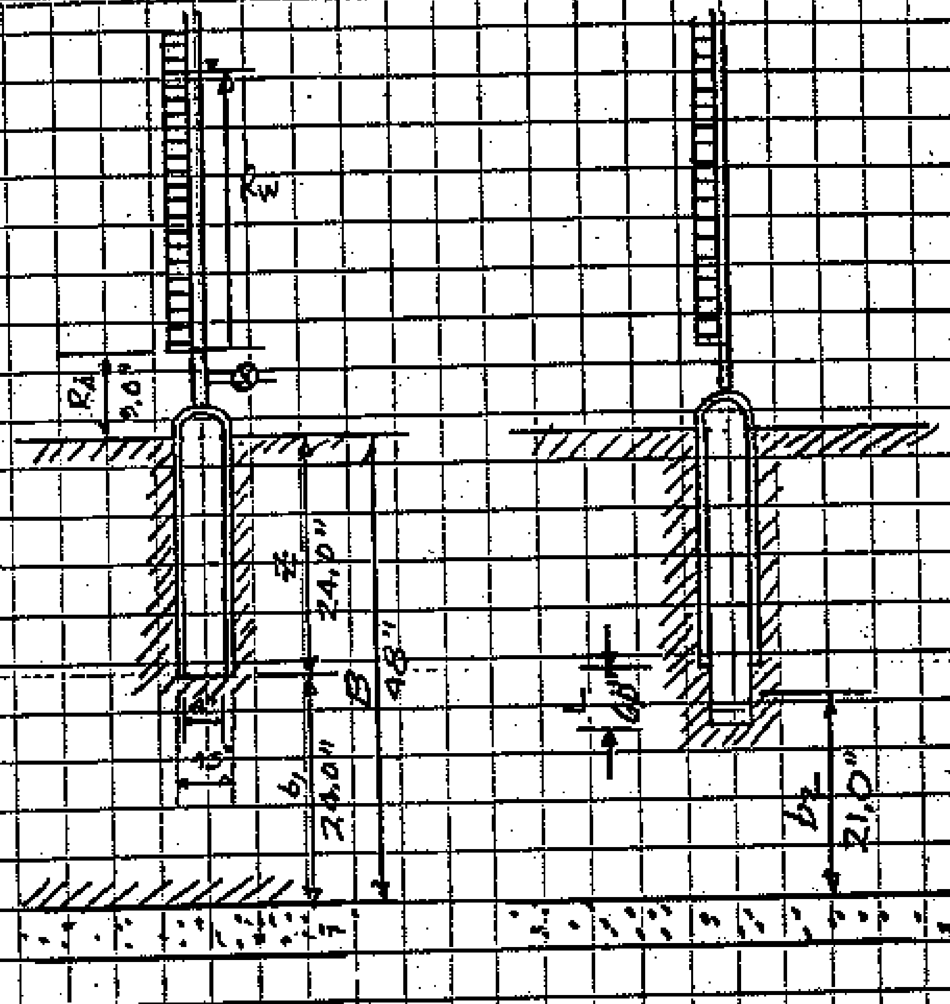
JOB SAMPLE – "A"
SHEET NO. 1 OF
CALCULATED BY [signature] DATE 08 Aug 91
CHECKED BY DATE
SCALE

SAMPLE 2-STAGE CALCULATION – HYPOTHETICAL TEST "A"

1. TEST SETUP



Note: Water seeped into casing during bentonite sealing. Therefore, use casing OD = 4.5" for Stage 1 Only

TO AVOID HYDRAULIC FRACTURING:

HEAD < 1.25 X OVERBURDEN AT CASING BOTTOM

$62.4 \frac{LB}{FT^3} H^{FT} < 1.25 \times 2.0^{FT} \times 124.8 \ ^{LB}/_{FT^3}$

$H^{FT} < 5.0 FT$

OR $R_W < 5.0 - 2.0 - 0.75 = 2.25 FT = 27.0^{IN}$

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2. TEST DATA

STAGE 1 DATA

Date	Time	RW (in.)	ΦC (in.)	Temp. (°F)	TEG (in.)
8/01	08:00	25.50	–	70	13.00
	0830	18.81	0	70	13.00
	0900	14.31	0	70	13.00
	1000	7.75	+0.06	72	13.06
Rf.	1001	26.25	–	72	13.06
	1200	18.50	+0.25	74	13.31
	1600	13.88	+1.00	80	14.31
Rf.	1601	26.00	–	80	14.31
8/02	0800	15.81	-1.50	65	12.81
	1700	14.06	+1.31	74	14.12
8/03	0800	9.06	-1.25	68	12.87
	1600	8.38	+1.06	76	13.93
8/04	0800	3.75	-1.44	62	12.49
Rf.	0801	26.50	–	62	12.49
	1701	24.88	+0.50	71	13.00
8/05	0700	20.88	-0.62	66	12.37
	1700	12.69	+1.25	78	13.62
8/06	0800	15.00	-1.12	67	12.50

STAGE 2 DATA

Date	Time	RW (in.)	ΦC (in.)	Temp. (°F)	TEG (in.)
8/06	0930	25.75	–	68	12.56
	1000	23.39	0.00	70	12.56
	1030	21.38	+0.06	72	12.62
	1130	18.00	+0.13	74	12.75
	1330	13.12	+0.50	76	13.25
	1700	7.12	+0.69	80	13.94
R	1701	26.56	–	80	13.94
8/07	0700	6.06	-1.12	70	12.82
R	0701	25.25	–	70	12.82
	1200	19.88	+0.31	74	13.03
	1700	15.94	+0.56	78	13.59
8/08	0800	3.81	-1.50	62	12.09
R	0802	26.31	–	62	12.09
	1700	20.56	+1.69	74	13.78
8/09	0730	8.38	-1.56	60	12.22
	1600	3.62	+0.44	66	12.66

READ FROM TEG

CALCULATED FROM TEG LEVELS

READ FROM TEG

Calculate from TEG Levels

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3. STAGE 1

A. CALCULATE FACTOR [Eq 3.5-4]

$$K1 = F_1 \frac{\ln(H_1/H_2)}{t_2 - t_1} \quad \text{where } F_1 = \frac{\pi d^2}{11 D}\left(1 - \frac{D}{4b_1}\right)$$

$d = 0.50'' = 1.27$ cm (See sketch on p. 1)
$D = 4.50'' = 11.43$ cm (See note on p. 1)
$b_1 = 24.0'' = 60.96$ cm (See sketch on p. 1)

$$F_1 = \frac{\pi (1.27)^2}{11 \times 11.43}\left(1 - \frac{11.43}{4 \times 60.96}\right)$$

$$\boxed{F_1 = 0.03841 \text{ cm}}$$

B. CALCULATIONS

i. $K1$ $H1 = B + R_A + R_{W1}$ = 48.00 + 9.00 + R_{W1} = 57.00 + R_{W1}
$H2' = B + R_A + R_{W2} - C$ = 48.00 + 9.00 + $(R_{W2} - C)$ = 57.00 + $(R_{W2}$

i. Period 1700 08/02 – 0800 08/03

$$K1 = .03841 \frac{\ln[(57.00 + R_{W1}) / (57.00 + R_{W2} + C)]}{\Delta t \text{ (sec)}}$$

$H1 = 57.00 + 14.06 = 71.06$
$H2' = 57.00 + 9.06 + 1.25 = 67.31$

Note: TEG fell 1.25" in this period. ∴ 1.25' of the test drop is purely temp.

$\Delta t = 15$ hrs $\times 3600$ s/hr $= 54000$ sec.

$$K1_c = 0.03841 \text{ cm} \frac{\ln(71.06/67.31)}{54000 \text{ sec}} = 3.86 \times 10^{(-8)}$$

Now, apply viscosity correction
Temp = $\frac{1}{2}(74 + 68) = 71°$
From chart, Viscosity Factor = 0.96 = R_T

$$K1_{\frac{1}{2}} = R_T \cdot K1_C = 0.96 \times [3.86 \times 10^{(-8)}] = 3.71 \times 10^{(-8)} \frac{cm}{sec}$$

See p. 6 for Tabulation of all points

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4. STAGE 2

A. CALCULATE FACTOR [Eq. 3.5-5, with a = -1]

$K2 = F \frac{\ln(H_1/H_2)}{t_2 - t_1}$

where: $F = \left(\frac{1}{f}\right)\left(\frac{d^2}{16 L}\right) \ln\left[\frac{U(l, D, 0)}{U(l, D, 2b_2)}\right]$

$f = 1 - 0.5623 e^{-1.566(L/D)}$

L = Extension below Casing (6 inches = 15.24 cm)

D = Borehole diameter = ID of Casing (4 inches)

$G_2 = D/2$

$b_2 = B - Z + L/2 = 48.00'' - 24.00'' - 6.00''/2 = 21.00''$

$U(l, D, z) = \frac{(2z/D + L/D) + \sqrt{1 + [2z/D + L/D]^2}}{2z/D - L/D + \sqrt{1 + [2z/D - L/D]^2}}$

$\therefore f = 1 - 0.5623 e^{-1.566(1.5)}$ $L/D = 6''/4'' = 1.5$

$= 0.9463$

$U(l, r_0, 0) = U(l, D, 0) = \frac{(0 + 1.5) + \sqrt{1 + [0 + 1.5]^2}}{(0 - 1.5) + \sqrt{1 + [0 - 1.5]^2}} = \frac{1.5 + \sqrt{1 + 1.5^2}}{-1.5 + \sqrt{1 + 1.5^2}}$ [U(l, r0, 0) Eq. 3.5-5]

$= [1.5 + \sqrt{1 + 1.5^2}]^2$

$= 10.9083$

$2b_2 = 2 \times 21 = 42''$

$U(l, r_0, 2b_2) = U(l, D, 42) = \frac{(84/4 + 1.5) + \sqrt{1 + [84/4 + 1.5]^2}}{(84/4 - 1.5) + \sqrt{1 + [84/4 - 1.5]^2}} = \frac{22.5 + \sqrt{1 + 22.5^2}}{19.5 + \sqrt{1 + 19.5^2}}$

[U(l, r0, 2b2) Eq. 3.5-5]

$= 1.1537$

$\therefore F = \frac{1}{0.9463} \times \frac{1.27^2 \text{ cm}^2}{16 \times 15.24 \text{ cm}} \ln(10.9083 / 1.1537)$

F = 0.01570 cm

STEI 16A

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5.B. Calculation for K2' (See p. 7 for the data points)

This is virtually the same calculation as on p. 8

Period (hrs)	Calculation		K2'
0.0 – 2.0	$\frac{24.9 \times 1.80 + 21.0 \times 1.80 + 18.7 \times 3.60}{1.80 + 1.80 + 3.60}$	$= \frac{151.56}{7.20} = 21.05 \times 10(-8))$	$2.11 \times 10(-7))$
2.0 – 21.5	$\frac{14.85 \times 7.20 + 11.0 \times 12.60 + 7.52 \times 50.94}{7.20 + 12.60 + 50.94}$	$= \frac{623.72}{70.74} = 8.89 \times 10(-8))$	$8.89 \times 10(-8))$
21.5 – 31.5	$\frac{5.94 \times 17.94 + 4.74 \times 18.00}{17.94 + 18.00}$	$= \frac{191.88}{35.94} = 5.34 \times 10(-8))$	$5.34 \times 10(-8))$
31.5 – 55.5	$\frac{4.46 \times 54.00 + 4.55 \times 32.28}{54.00 + 32.28}$	$= \frac{387.71}{86.28} = 4.49 \times 10(-8))$	$4.49 \times 10(-8))$
55.5 – 78.5	$\frac{4.49 \times 52.20 + 4.56 \times 30.60}{52.20 + 30.60}$	$= \frac{373.91}{82.80} = 4.52 \times 10(-8))$	$4.52 \times 10(-8))$

The last two periods are virtually identical and last some 24 hours each (appropriate for this permeability level)

$$\therefore K2' = \frac{387.71 + 373.91}{86.28 + 82.80} = \frac{761.62}{169.08} = 4.50 \times 10(-8))$$

$$\boxed{K2' = 4.50 \times 10^{-8} \text{ cm/sec}}$$

6.0 Calculate Kv and Kh

A. Smear.
check by K2/K1 ratio needed for next step

$$K2' / K1' = \frac{4.50 \times 10(-8)}{3.21 \times 10(-8)} = 1.40$$

Probably no smear since > 1.1

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B. EQUATION (FOR SHORTCUT, SEE P. 12)

$$K2'/K1' = \left(\frac{G1m}{G1}\right)\left(\frac{G2}{G2S}\right) \quad [\text{Eq. } 42-5]$$

NOW $G1m/G1 = (1/m)[1 + a(D_1/4mb_1)] / [1 + a(D_1/4b_1)]$

but, $D_1 = 11.43$ cm (p. 3) $a = -1$ (Num. Base)

$b_1 = 2.20$ cm (p. 3)

$$G1m/G_1 = (1/m)\left[1 - \frac{11.43}{4(m)(2.20)}\right] / \left[1 - \frac{11.43}{4(2.20)}\right]$$

$$= (1/m)\left(\frac{1}{.2998}\right)\left(1 - \frac{1}{2.33m}\right)$$

$$G2/G2S = \frac{m^2\{\ln[v(1, r_0, 0)] + a \ln[v(1, r_0, 2b_2)]\}}{\ln[v(m, r_0 T, 0)] + a \ln[v(m, r_0, 2b_2)] + p \ln[v(m, r_0, 0)/v(m, r_0 T, 0)]}$$

$a = -1$

$p = 1$

$$\text{Thus } G2/G2S = \frac{m^2 \ln[v(1, r_0, 0)/v(1, r_0, 2b_2)]}{\ln[v(m, r_0, 0)/v(m, r_0, 2b_2)]}$$

$$v(1, r_0, 0) = [L/D + \sqrt{1 + (L/D)^2}]^2 = [1.5 + \sqrt{1 + 1.5^2}]^2 = 10.20833$$

$$v(1, r_0, 2b_2) = \frac{4b_2/D_2 + L/D_2 + \sqrt{1 + (4b_2/D_2 + L/D_2)^2}}{4b_2/D_2 - L/D_2 + \sqrt{1 + (4b_2/D_2 - L/D_2)^2}}$$

$b_2 = 21''$ (See p. 1)

$D_2 = 4.0'$ (See p. 1)

$$= \frac{4(4/4) + 6/4 + \sqrt{1 + (4 \cdot 2/4 + 6/4)^2}}{4(4/4) - 6/4 + \sqrt{1 + (4 \cdot 2/4 - 6/4)^2}} = \frac{15.0323}{13.0256}$$

$v(1, r_0, 2b_2) = 1.15366$

$$G2/G2S = \frac{m^2 \ln[10.20833/1.15366]}{\ln[v(m, r_0, 0)/v(m, r_0, 2b_2)]} = \frac{2.24659\, m^2}{\ln[v(m, r_0, 0)/v(m, r_0, 2b_2)]}$$

$$K2'/K1' = \frac{1}{m}\frac{1}{.9464}\left(1 - \frac{1}{2.33m}\right) \cdot \frac{2.24659\, m^2}{\ln[v(m, r_0, 0)/v(m, r_0, 2b_2)]}$$

$$= 2.3738\, m \left(1 - \frac{1}{2.33m}\right) \frac{1}{\ln[v(m, r_0, 0)/v(m, r_0, 2b_2)]}$$

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(i) Try m = 2.0

$u(m,r_2,0) = [mL/D_2 + \sqrt{1+(mL/D_2)^2}]^2$

$= [1.5m + \sqrt{1+(1.5m)^2}]^2$

$u(2,r_2,0) = [1.5\times2 + \sqrt{1+(1.5\times2)^2}]^2 = 6.1623^2$

$= 37.9737$

$u(m,r_2,2b_2) = \dfrac{4mb_2/D_2 + mL/D + \sqrt{1+(4mb_2/D_2 + mL/D_2)^2}}{4mb_2/D_2 - mL/D + \sqrt{1+(4mb_2/D_2 - mL/D_2)^2}}$

$= \dfrac{4m\,21/4 + m\,6/4 + \sqrt{1+(4m\,21/4 + m\,6/4)^2}}{4m\,21/4 - m\,6/4 + \sqrt{1+(4m\,21/4 - m\,6/4)^2}}$

$= \dfrac{22.5m + \sqrt{1+(22.5m)^2}}{19.5m + \sqrt{1+(19.5m)^2}}$

$u(2,r_2,2b_2) = \dfrac{22.5\times2 + \sqrt{1+(22.5\times2)^2}}{19.5\times2 + \sqrt{1+(19.5\times2)^2}} = \dfrac{90.0111}{78.0128} = 1.1538$

$K2'/K1' = 1.40 \overset{?}{=} 2.3738(2.0)\left(1 - \frac{1}{21.33\times2}\right)\frac{1}{\ln[37.9737/1.1538]}$

$\overset{?}{=} 4.7476\,(.9766)\,\frac{1}{3.4938}$

$1.40 > 1.327$

∴ need larger m

ii. Try m = 2.4

$u(2.4,r_2,0) = [1.5\times2.4 + \sqrt{1+(1.5\times2.4)^2}]^2 = 53.8214$

$u(2,r_2,2b_2) = \dfrac{22.5\times2.4 + \sqrt{1+(22.5\times2.4)^2}}{19.5\times2.4 + \sqrt{1+(19.5\times2.4)^2}} = 1.1538$

$K2'/K1' = 1.40 \overset{?}{=} 2.3738(2.4)\left[1 - \frac{1}{21.33\times2.4}\right]\frac{1}{\ln[53.8214/1.1538]}$

$\overset{?}{=} 5.69712\,(.9805)\,(1/3.8426)$

$1.40 < 1.454$

∴ need smaller m

Successive trial-and-error yields m = 2.27

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JOB SAMPLE - A
SHEET NO. 12 OF
CALCULATED BY DATE
CHECKED BY DATE
SCALE

C. CALCULATE K_V, K_h

Note: One can avoid the calculations of pp. 10 and 11 by using the attached nomograph (Fig. 7 - Text)

The easiest calculation is using the Stage 1 equation:

$$K_v = \frac{G_{1m}}{G_{1i}} K_1' \quad [\text{Eq } 4.1-2]$$

$$= \frac{1}{m}\left[\frac{1 - D_1/4mb_1}{1 - D_1/4b_1}\right] K_1'$$

with $D_1 = 4.50''$
$b_1 = 24.0''$
$m = 2.27$

$$K_V = \frac{1}{2.27}\left[\frac{1 - \frac{4.5}{4(2.27)(24)}}{1 - \frac{4.5}{4(24)}}\right] \times [3.21 \times 10(-8)]$$

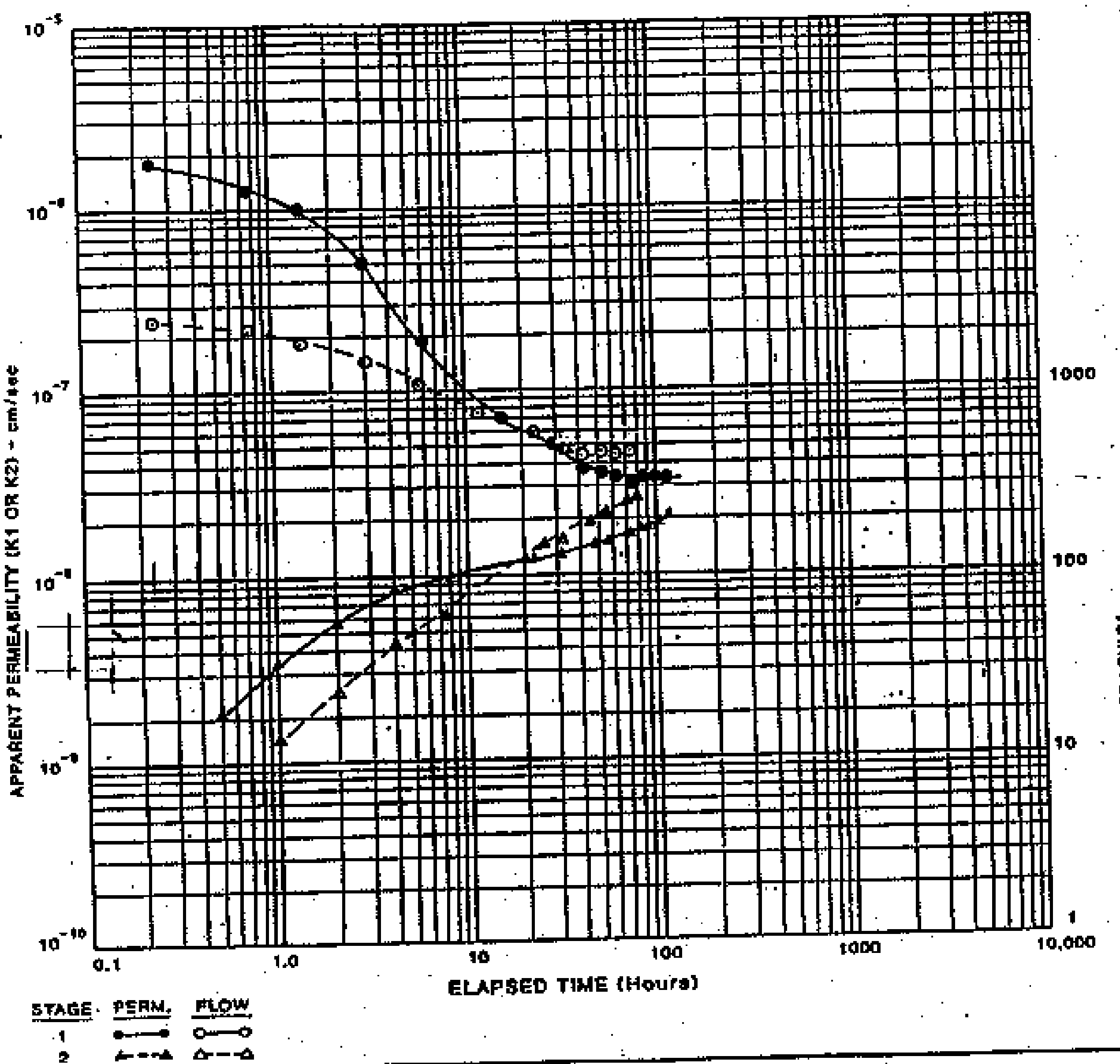
$$= \frac{1}{2.27}\left[\frac{.9792}{.9464}\right] 3.21 \times 10(-8)$$

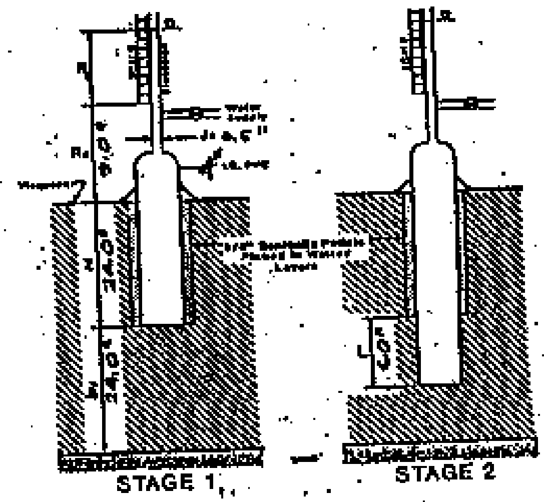
$K_V = 1.45 \times 10(-8)$ cm/sec

$$K_h = m^2 K_V \quad [\text{Eq } 4.1-5]$$

$$= 2.27^2 [1.45 \times 10(-8)]$$

$K_h = 7.47 \times 10(-8)$





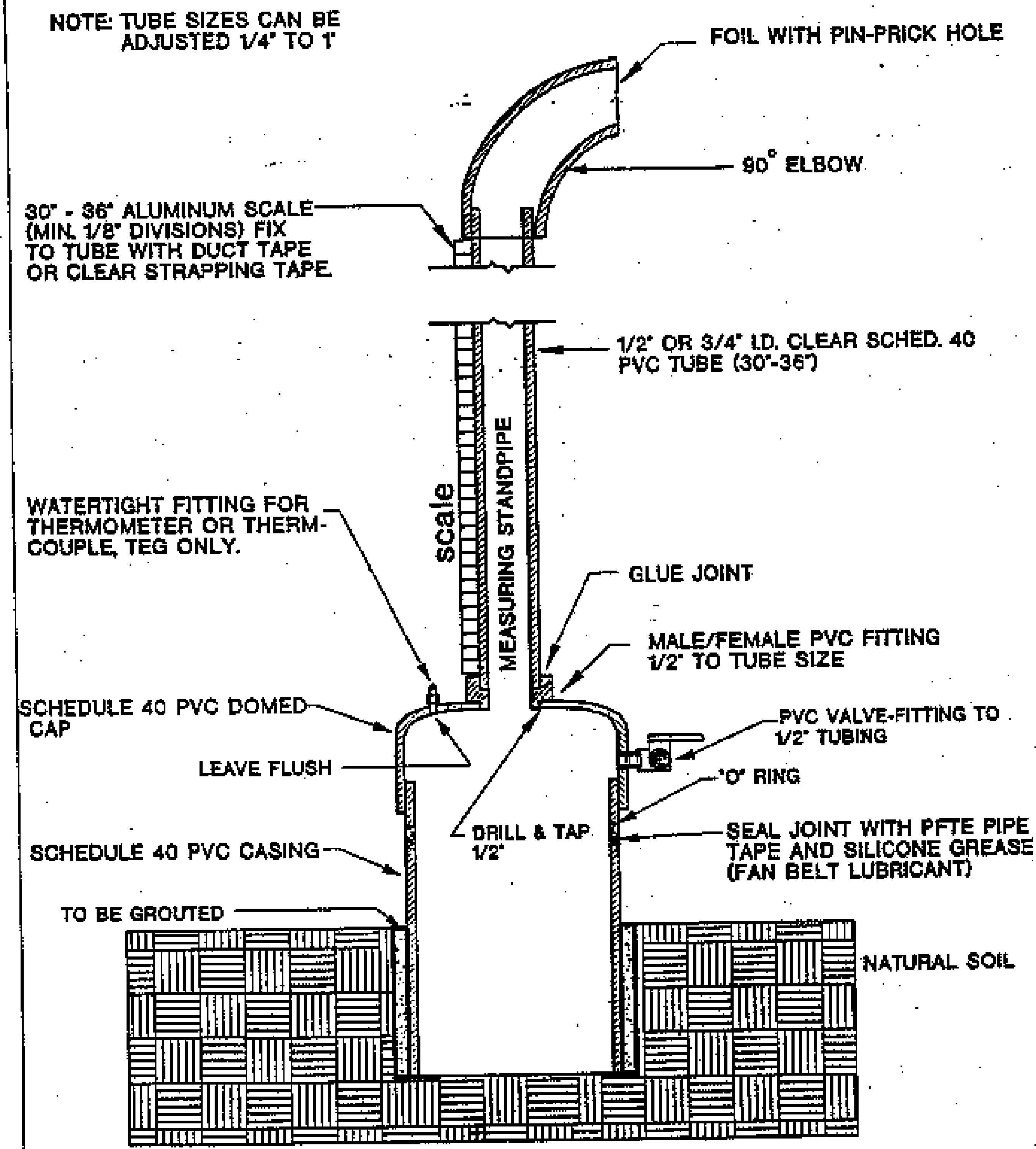
TWO - STAGE FIELD PERMEABILITY TEST
SUBBASE TEST PAD

SAMPLE TEST "A"
EREWHON, CALIVANIA

GEOTECHNICAL SERVICES BY
SOIL TESTING ENGINEERS, INC.

Project Engineer:	Drawn by:	Checked by:
G.P. BOUTWELL	SJT	C.H.TSAI
File No.: 91-081	Date:	Figure No.:

Title: BEHAVIOR OF TEST FP- "A"



TYPICAL PERMEAMETER

1450 10-6-92

TEG 1 FILLED 32"3/8

1508

TEG 2 FILLED 33 15/16"

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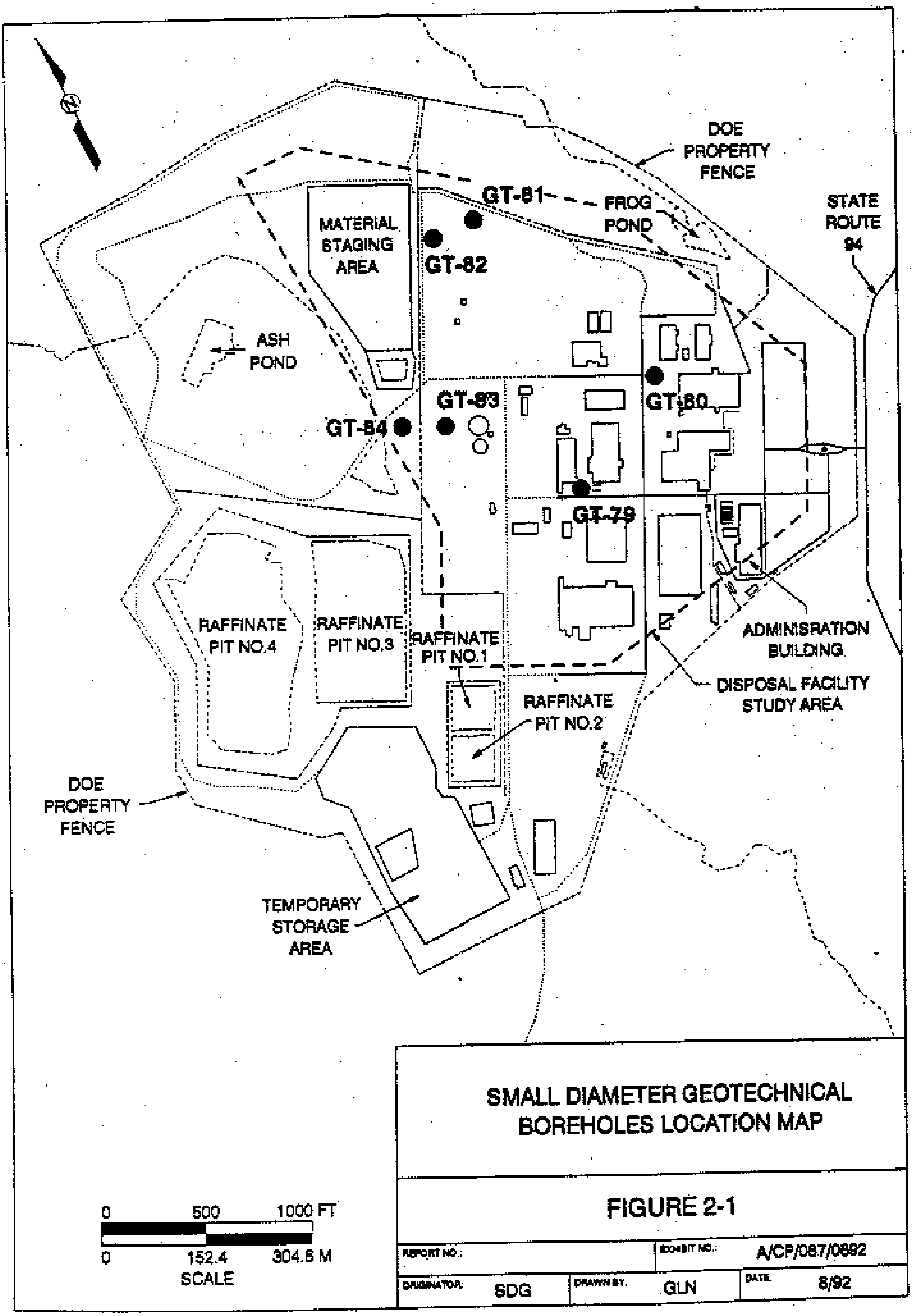
ATTACHMENT 7

LOCATIONS OF WATER/LEACHATE PERMEABILITY TESTING SAMPLES



SMALL DIAMETER GEOTECHNICAL BOREHOLES LOCATION MAP

FIGURE 2-1

REPORT NO.:			EXHIBIT NO.:	A/CP/087/0892	
ORIGINATOR: SDG	DRAWN BY: GLN		DATE: 8/92		

ATTACHMENT 8
SUMMARY OF LEACHATE SYNTHESIS METHODOLOGY

Permeability testing was accomplished by obtaining undisturbed samples of site soils (Ferrelview Formation and Clay Till) and subjecting these samples to triaxial permeability testing (ASTM Method D-5084). Samples were initially tested with water as a permeant, then the same samples were tested with leachate permeant.

The leachate was generated by mixing liquids generated by modified batch leach testing of chemically stabilized/solidified raffinate sludge (CSS Sludge), untreated radioactive soils, and untreated chemically contaminated soils. The liquids from these leaching tests were combined at the following ratio in order to provide a representative leachate:

> 2:1:1 (CSS Treated Sludge:Untreated Radioactive Soils:Untreated Chemical Contaminated Soils)

This ratio of materials is based upon proposed waste quantities including bulking factors for treated wastes. These quantities are found in the latest version of the PMC's Waste Management Quarterly Report.

Additional details relating to the leaching methodology and associated sampling of waste materials are presented in the pertinent references listed in Attachment 10.

ATTACHMENT 9

COMPARATIVE CALCULATIONS

TRAVEL TIME AND PERMITTIVITY

COMPARISON OF HYDRAULIC CONDUCTIVITY DATA

DATA SET	HYDRAULIC CONDUCTIVITY [K] (cm/sec)	POROSITY [n] (6)	EFFECTIVE POROSITY [n_e] (7)	FORMATION THICKNESS [b] (ft)	SEEPAGE VELOCITY [V] (cm/sec) (8)	PERMITTIVITY [P] (sec^{-1}) (9)	TRAVEL TIME [t] (YEARS) (10)
10 CSR 25-7[1]	1.0E-07	0.40		30	2.5E-07	1.1E-10	116
			0.08	30	1.25E-06		23
MKF & JEG 1991[2]	3.1E-08	0.40		20	7.7E-08	5.1E-11	250
			0.08	20	3.9E-07		50
TSB[3]	1.28E-08	0.40		20	3.2E-08	2.1E-11	604
			0.08	20	1.6E-07		121
1992 LAB (H_2O)[4]	1.5E-08	0.40		20	3.8E-08	2.5E-11	516
			0.08	20	1.9E-07		103
1992 LAB (LEACH)[5]	2.7E-09	0.40		20	6.8E-09	4.4E-12	2865
			0.08	20	3.4E-08		573

EXPLANATION:

1 10 CSR 25-7 - Basic regulatory criteria are 30 ft of soil with K= 1.0E-07 cm/sec.

2 Site suitability data on potential location of a disposal facility: *Collapse potential and permeability.*

3 Largest logarithmic mean value from Table 2.

4 Largest measured value for water from Table 3.

5 Largest measured value for leachate from Table 3.

6 Average total porosity from unpublished data - MKF & JEG 1992 Draft.

7 Estimated average effective porosity from [6].

8 Seepage velocity - $V = Ki/n$

9 Permittivity - P = Average hydraulic conductivity ÷ thickness (Koerner, R.M. 1990. Designing with geosynthetics. Prentic-Hall.)

10 Travel time - $t = b/V$

m:\users\kathym\document\kw\sitasoil

ATTACHMENT 10

LIST OF PERTINENT REFERENCE DOCUMENTS

The following documents are listed for reference in describing background and support activities associated with this effort. Copies of these reports have been submitted under separate cover:

Modified batch leach testing is described in the "Batch Leach Testing Plan", MK-JEG, Rev. 1, Nov. 92.

The chemical soil samples were collected in accordance with the "Soil Sampling Plan for Column Leach and Batch Tests and TCLP Analysis", Rev. 0, May 92.

The radioactive site soils were collected in accordance with the "Stabilization /Solidification/Dewatering Sampling Plan", MK-JEG, Rev. 0, May 91.

The undisturbed soil samples were obtained in accordance with the "Sampling Plan for Determination of Hydraulic Properties of Undisturbed Soils in the Weldon Spring Disposal Facility Study Area", Rev. 1, MK-JEG, Oct. 92.

APPENDIX B
Acronyms

Acronyms

ACGIH	American Conference of Governmental Industrial Hygienists
ACM	Asbestos Containing Material
A/E	Architecture/Engineering
ALARA	As Low As Reasonably Achievable
ANSI	American National Standards Institute
AOS	Average Opening Size
APEG	Alkaline Polyethylene Glycolate
APID	Ash Pond Isolation Dike
ARAR	Applicable or Relevant and Appropriate Requirements
ASTM	American Society for Testing and Materials
BA	Baseline Assessment
BACT	Best Available Control Technology
BDAT	Best Demonstrated Available Technology
BOCA	Building Officials and Code Administrators
CBR	California Bearing Ratio
CCL	Compacted Clay Liner
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CD	Conceptual Design
CDR	Conceptual Design Report
CENS	Centrifugal Scrubber
CFD	Clean-fill Dike
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
CMSA	Construction Materials Staging Area
C-NI	Chen Northern Inc.
CO	Carbon Monoxide
COL	Collision Scrubber
CRV	Counter Rotating Vortex
CSD	Cost and Scheduling Document
CSI	Construction Specification Institute
CSPE	Chlorosulfonated Polyethylene
CSR	Code of State Regulations
CSS	Chemical Stabilization/Solidification

CX	Categorical Exclusion
DBM	Design Basis Memorandum
DNT	Dinitrotoluene
DOE	Department of Energy
DRE	Destruction Removal Efficiency
DV	Dry Venturi
EA	Environmental Assessment
EDAP	Environmental Data Administration Plan
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
EM	Electromagnetic
EQAPjP	Environmental Quality Assurance Project Plan
ES&H	Environmental Safety and Health
ESP	Electrostatic Precipitator
FAST	Functional Analysis System Technique
FF	Fabric Filter
FFA	Federal Facilities Agreement
FFCA	Federal Facilities Compliance Act
FFHCM	Fossil Fuel Heated Ceramic Melter
FML	Flexible Membrane Liner
FONSI	Finding of No Significant Impact
FS	Feasibility Study
GCL	Geosynthetic Clay Liner
GIS	Geographic Information System
GM	Geiger-Mueller
GURU	Generic Universal Report Utility
H	Horizontal
HASP	Health and Safety Plan
HDPE	High-Density Polyethylene
HELP	Hydrologic Evaluation of Landfill Performance
HEPA	High-efficiency Particulate Air
HLW	High Level Waste
HPE	High-Pressure Drop Venturi
IFB	Invitation for Bids
IHPM	Inductively Heated Pot Melters

IWS	Ionizing West Scrubber
JEG	Jacobs Engineering Group
JHCM	Joule Heated Ceramic Meldter
KPA	Kinetic Phosphorescence Analyzer
KPEG	Potassium Polyethylene Glycolate
LCRS	Leachate Collection and Removal System
LPV	Low-Pressure Drop Venturi
MCE	Maximum Credible Event
MDNR	Missouri Department of Natural Resources
MDOC	Missouri Department of Conservation
METC	Morgantown Energy Technology Center
MHTD	Missouri Highway and Transportation Department
MKF	MK-Ferguson Group
MSA	Material Staging Area
MSL	Mean Sea Level
MVE	Modified Value Engineering
MWTP	Mobile Water Treatment Plant
NaPEG	Sodium Polyethylene Glycolate
NCFD	No Clean-Fill Dike
NEPA	National Environmental Policy Act
NESHAPS	Nation Emission Standards for Hazardous Air Pollutants
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	Nuclear Regulatory Commission
NSF	National Sanitary Foundation
NQA	Nuclear Quality Assurance
OSHA	Occupational Safety and Health Administration
PAH	Polycyclic (or Polynuclear) Aromatic Hydrocarbons
PAT	Plasma Arc Torch
PBS	Packed Bed Scrubber
PCB	Polychlorinated Biphenyls
PCT	Product Consistency Test
PES	Perimeter Encapsulation System
PI	Plasticity Index

PMC	Project Management Contractor
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipiation
PNL	Pacific Northwest Laboratory
PO	Purchase Order
PPE	Personal Protective Equipment
POHC	Principal Organic Hazardous Constituent
PT	Packed Tower
PVC	Polyvinyl Cloride
QA	Quality Assurance
QAP	Quality Assurance Program
QAPP	Quality Assurance Program Plan
QA/QA	Quality Assurance/Quality Control
QC/PT	Quality Control/Physical Testing
RCRA	Resource Conservation Recovery Act
RFP	Request for Proposal
RI/FS	Remedial Investigation/Feasibility Study
ROCA	Record of Completed Actions
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SB	Submerged Bed
SD	Spray Dryer
SDR	Standard Dimension Ratio
SI	Slagging Incinerators
SOP	Standard Operating Procedure
SOU	Site Operable Unit
SWTP	Site Water Treatment Plant
TDH	Total Design Head (pressure)
THC	Total Hydrocarbons
TID	Technical Information Document
TBC	To Be Considered
TBP	Tributyl Phosphate
TCLP	Toxic Characteristic Leaching Procedure
TLD	Thermoluminescent Dosimeter
TNS	Tandem Nozzle Scrubber

TNT	Trinitrotoluene
TSA	Temporary Storage Area
TSCA	Toxic Substance Control Act
UCS	Unconfined Compressive Strength
UMTRA	Uranium Mill Tailings Remedial Action
UMTRCA	Uranium Mill Tailings Radiation Control Act
UPARC	University of Pittsburgh's Advanced Research Center
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
USGS	U.S. Geological Survey
V	Vertical
VIT	Vitrification
VLDPE	Very Low Density Polyethylene
VLF EM	Very Low Frequency Electromagnetics
VSL	Vitreous State Laboratories
WBS	Work Breakdown Structure
WESP	Wet Electrostatic Precipitator
WITS	Waste Inventory/Tracking System
WSCA	Weldon Spring Conservation Area
WSCP	Weldon Spring Chemical Plant
WSSRAP	Weldon Spring Site Remedial Action Project
WTG	Waste Technology Group
WTP	Water Treatment Plant