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ENGINEERING CHANGE NOTICE

Page 1 of 2

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Proj. ECN ~~[illegible]~~

2. ECN Category (mark one)	3. Originator's Name, Organization, MSIN, and Telephone No.	3a. USQ Required?	4. Date
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[ ] Yes (fill out Blk. 11b) [X] No (NA Blks. 11b, 11c, 11d)	N/A	N/A Cog. Engineer Signature & Date	N/A Cog. Engineer Signature & Date

12. Description of Change

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13a. Justification (mark one)

Criteria Change	[ ]	Design Improvement	[X]	Environmental	[ ]	Facility Deactivation	[ ]
As-Found	[ ]	Facilitate Const	[ ]	Const. Error/Omission	[ ]	Design Error/Omission	[ ]

13b. Justification Details

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14. Distribution (include name, MSIN, and no. of copies)

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BY WHC
DATE MAY 04 1995

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RELEASE AUTHORIZATION

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Document Title:	Hanford Facilities Tracer Study Report (315 Water Treatment Facility)
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This document was reviewed following the procedures described in WHC-CM-3-4 and is:

APPROVED FOR PUBLIC RELEASE

WHC Information Release Administration Specialist:

V.L. Birkland — May 3, 1995

V.L. Birkland

MAY 04 1995 (67) SW (36)

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1. Total Pages 21 95

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2. Title	3. Number	4. Rev No.
HANFORD FACILITIES TRACER STUDY REPORT (315 WATER TREATMENT FACILITY)	WHC-SD-ER5480-ER-001	1

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WATER TREATMENT-SURFACE WATER TREATMENT RULE-CONTACT TIME- TRACER STUDY- 300 AREA	Name: THIRUCHITR(TOM) AMBALAM Signature Organization/Charge Code 57200

7. Abstract

Reported are the results and findings of a tracer study to determine contact time for the disinfection process of 315 Water Treatment Facility at 300 Area. The study utilized fluoride as the tracer and contact times were determined for two flow rates. Interpolation of data and short circuiting effects are also discussed.

8. RELEASE STAMP

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RECORD OF REVISION

(1) Document Number	WHC-SD-ER5480-ER-001
Page	1

(2) Title
Hanford Facilities Tracer Study Report (315 Water Treatment Facility)

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ENGINEERING REPORT

HANFORD FACILITIES TRACER STUDY REPORT, 315 WATER TREATMENT FACILITY (ID# 418408)

WORK ORDER ER5480

Prepared for

WASHINGTON STATE DEPARTMENT OF HEALTH

May 1995

For the U.S. Department of Energy

Contract DE-AC06-93RL12359

Prepared by

ICF Kaiser Hanford Company

Richland, Washington

ER5480ER

ER5480ER

ENGINEERING REPORT
FOR
HANFORD FACILITIES TRACER STUDY REPORT,
315 WATER TREATMENT FACILITY
(ID# 418408)

WORK ORDER ER5480

Prepared by

ICF Kaiser Hanford Company

Richland, Washington

Thiruchitr Ambalam 5/2/95		Tina D. Bayless 5/3/95	
Principal Lead Engineer	Date	Technical Documents	Date

PE Seal or Stamp

James Wang 5-2-95		William W. Scott 5/2/95	
Utilities Engineering	Date	Technical Author	Date

MASTER

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Appendix D. 315 Water Treatment Facility Layout

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ENGINEERING REPORT

HANFORD FACILITIES TRACER REPORT,
315 WATER TREATMENT FACILITY (ID# 418408)

WORK ORDER ER5480

I. INTRODUCTION

Historically, water from the Columbia River has been pumped from several locations to be used on the Hanford Nuclear Reservation for nuclear reactors, processing facilities, steam generation, fire protection, and drinking water.

Five surface water treatment facilities currently supply drinking water to various areas on the reservation which include the 183-N Water Treatment Facility (ID# 418532); the 183-K Water Treatment Facility (ID# 0177J); the 283-E Water Treatment Facility (ID# 41866V); the 283-W Water Treatment Facility (ID# 001004); and the 315 Water Treatment Facility (ID# 418408) that supplies sanitary water for the 300 Area.

The Surface Water Treatment Rule (SWTR), outlined in the 1986 Safe Drinking Water Act Amendments enacted by the EPA in 1989 and regulated by the Washington State Department of Health (DOH) in Section 246-290-600 of the Washington Administrative Code (WAC) , stipulates filtration and disinfection requirements for public water systems under the direct influence of surface water. The SWTR disinfection guidelines require that each treatment system achieves

predetermined inactivation ratios. The inactivation by disinfection is approximated with a measure called CxT, where C is the disinfectant residual concentration and T is the effective contact time of the water with the disinfectant.

According to WAC 246-290-636, "Determination of Disinfectant Contact Time," the water purveyor shall use tracer studies or empirical methods to determine T. Empirical methods to calculate T may not be used unless the system components are demonstrated to have configurations analogous to components on which tracer studies have been conducted and results have been documented. The CxT calculations for the Hanford water treatment facilities were derived from the total volume of the contact basin(s). In the absence of empirical data to support CxT calculations, the DOH determined that the CxT values used in the monthly reports for the water treatment facilities on the Hanford Site were invalid and required the performance of a tracer study at each facility. In response to that determination, a tracer study will be performed to determine the actual contact times of the facilities for the CxT calculations. The facility located at 300 Area was selected for study now and studies for other facilities will follow.

II. SUMMARY

A tracer study at two flow rates (Q peak and 0.90* Q peak) was performed at the 315 Water Treatment Facility in accordance with the Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems using Surface Water Sources (Guidance Manual), and the Disinfection

Contact Time Study Plan (CTS Plan), (ref 1 and 2). The CTS Plan was submitted and approved by the DOH (ref 3).

The actual detention times at each flow were determined. Table 1 shows the results of the two tracer tests.

TABLE 1. Results of Two Tracer Tests at the 315 Water Treatment Facility

Target Flow	Average Test Flow	Theoretical Residence Time (T)	Actual Residence Time (T_{10})	% Tracer Recovered
2,400 gpm	2,380 gpm	178 min	102 min	85%
2,160 gpm	2,127 gpm	199 min	167 min	45%

The study results were evaluated to provide a means for determining the actual residence time (T_{10}) at any flow experienced at the 315 Water Treatment Facility when it is operating under a configuration similar to the configuration during the tracer tests. Figure 1 is a graph that was developed from the 315 Water Treatment Facility tracer study results.

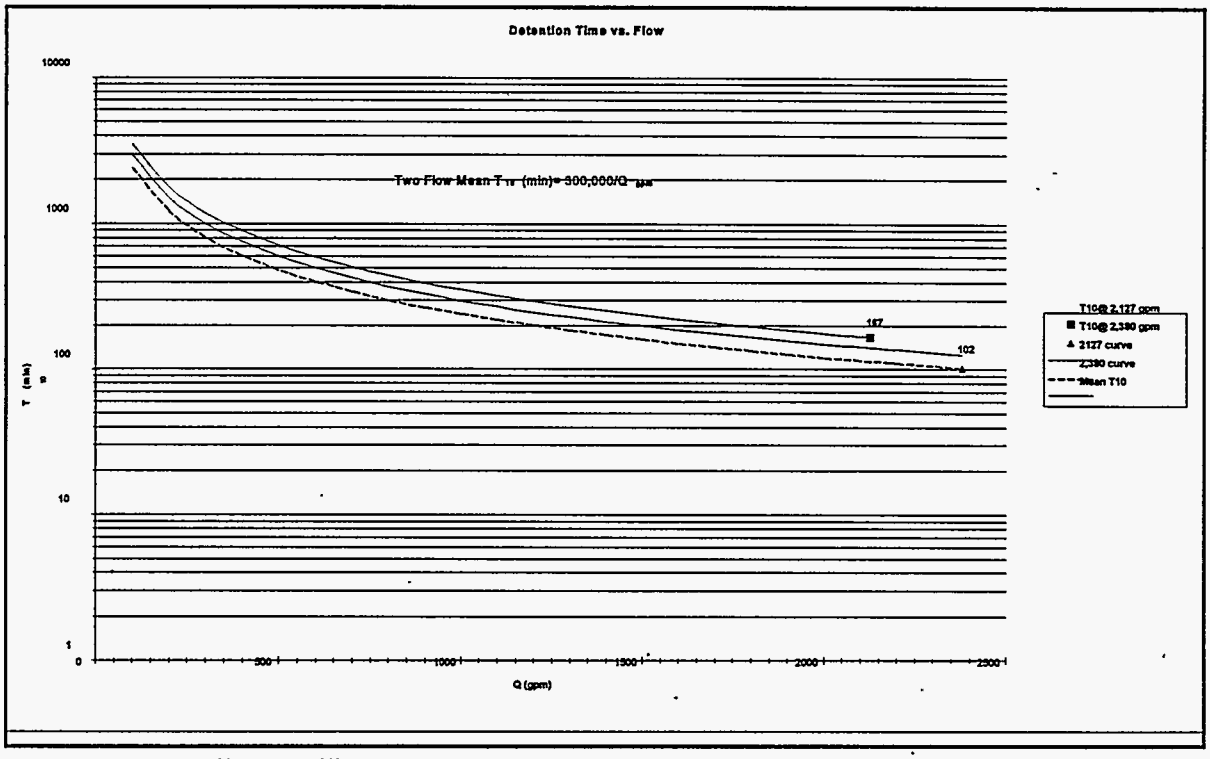

Figure 1: 315 Filter Facility T_{10} determination for any flow (Appendix A, p. A-C-13)

III. PURPOSE

The objective of this report is to outline the results of tracer studies at the 315 Water Treatment Facility, answer potential questions, give the facility operators a tool for determining the actual detention time experienced at the facility under various flow conditions, and fulfill the DOH requirement for a Tracer Study Evaluation Work Sheet. The worksheet is contained in Appendix E.

In order to provide the tool, a tracer is tracked in the treatment train and the results are analyzed in accordance with the Guidance Manual. The Guidance

Manual requires at least one tracer test at a flowrate of no less then 91% of the highest flow experienced at that section (ref 1, p. C-2). By conducting tracer studies, the detention time for corresponding peak hourly flow conditions can be determined. When tracer tests are performed at peak flows, they provide a conservative estimate in CxT calculations for flowrates less than or equal to the tracer test flowrate (ref 1, p. C-2).

If the tracer tests are not performed, the facilities will not be in compliance with the SWTR and there is an inability to ensure that sufficient contact time has occurred for disinfection prior to delivery of the water to the customers.

IV. DESCRIPTION

A. PLAN OF STUDY

The tracer studies are proposed to meet the requirements of WAC 246-290-636, "Determination of Disinfection Contact Time." The 315 Water Treatment Facility tracer study was performed in accordance with the Guidance Manual and the CTS Plan.

The tracer study flowrates are based on the peak hourly flows recorded on the SWTR CxT Determination Logsheets that are submitted to the DOH. System demand in the future will vary due to source reduction and other water conservation measures scheduled for implementation on the Hanford Reservation. The future peak flows are expected to be less than the current flowrates at the treatment facility.

A tracer study using sodium fluoride was performed on the treatment train typically used at the facility for final disinfection. Of the two most common methods of tracer addition employed in water treatment evaluations, the step-dose method was selected because the resulting normalized concentration versus time profile can be used directly to determine the detention time (T_{10}) required for calculating CxT. The step-dose method entails introduction of a tracer chemical at a constant dosage and monitoring for that tracer at the desired end point. Fluoride was chosen as the tracer chemical because it is approved for potable water use and is not normally added for water treatment on the Hanford Reservation.

Immediately prior to the test, the background fluoride concentration was determined and recorded. Appropriate fluoride injection flowrates were calculated after the predetermined flowrates had been established in the facility. The sodium fluoride was injected with a Liquid Metronics Injector® (LMI) Fluoride saturator and an electronic metering pump. The sodium fluoride was injected as close to the point of chlorination as possible. The tracer was monitored prior to the first service connection with a HACH DR/700 Colorimeter at a point downstream of the export pump.

Based on fluoride loss due to alum precipitation and raw water residual concentration, fluoride was added at a calculated dosage that would result in a residual concentration of approximately 1.5 mg/L in the

facility effluent (ref 1 and Appendix C, p. C-3). Recommended fluoride concentrations as low as 1.0 to 1.5 mg/L are practical when the raw water fluoride level is not significant. The duration for fluoride addition was selected to be twice the theoretical detention times as suggested by Hudson (ref 4).

Sampling occurred at 10 minute intervals until the tracer concentration in the effluent exceeded the background levels. Once a concentration change was observed, sampling was performed at 2 - 5 minute sampling intervals until a steady-state concentration was reached, or twice the theoretical detention time had elapsed which provided data for a well-defined plot of tracer concentration versus time. At this point, the tracer addition was discontinued. The receding tracer concentration was monitored at reasonable sampling intervals based on overall detention. Tracking the receding curve allowed for calculation of tracer recovery. Monitoring of the tracer was discontinued when 90% of the tracer was accounted for or the fluoride levels reached background. The water level, flow, and temperature were recorded during the test.

B. 300 AREA FILTER FACILITY

The 300 Area Water Treatment Facility (ID# 418408) pumps raw water from the Columbia River. The raw water is treated and supplied to various process and domestic users throughout the 300 Area. The water system distribution piping in the 300 Area provides potable and process water to less than 214 buildings. The water system consists of a river

water pumphouse, the water treatment facility, the water distribution system, and two above-ground water storage tanks. The tanks are used as storage vessels to supply potable water to the distribution system for a short period of time during an emergency. During emergencies and maintenance outages, the City of Richland can supply potable water to the 300 Area.

The river water pumps supply raw water to the water treatment facility and fish study facilities in the Pacific Northwest Laboratory Life Sciences Building 331. The river water pumphouse (312 Building) contains two motor-driven vertical turbine pumps and a smaller emergency (biology) pump. The two primary pumps are operated alternately at one-week intervals. Each of the two river water pumps is rated at 10,000 gal/min.

The 315 Water Treatment Facility is supplied water at approximately 70 psi through a 10-inch line branched from the 24-inch raw water line downstream of the river pumps. Water treatment consisting of coagulation, chlorination, sedimentation, and filtration is accomplished at the 315 Water Treatment Facility. A layout of the facility is contained in Appendix D. Coagulation occurs at the flash mix chamber which contains two upright mixing baffles where the water mixes with alum. At the exit of the chamber, chlorine is injected to deter algae formations, disinfect the water, and provide residual chlorine in the distribution system. The flash mixer overflows a weir into a

distribution flume. The flume has four 14-inch openings in the bottom, spaced to supply water to the center of the entrance of four sedimentation basins. The water strikes stilling baffles and continues out into the sedimentation basins.

At the discharge of the sedimentation basins, the clarified water overflows a weir into the filter influent flume. Water from this flume is fed to the four filter entrance gullets. Preastol 2515, an anionic acrylamide copolymer, is sometimes added at the gullets to aid in filtration when high turbidity conditions exist in the Columbia River. The four filters are designed for a flow of 6 gpm per square foot. Water flows from the filter influent gullet into two troughs over each filter. The water overflows the troughs onto the top of the filter bed. From the bottom of the filter, the water flows into the clearwell. The clearwell has a capacity of approximately 70,000 gallons. Though rarely practiced, chlorine can be fed directly to the clearwell from each of the filter inlets. Two clearwell pumps supply filtered water to the 300 Area distribution grid.

The 315 Water Treatment Facility typically experiences flows less than those maintained during the tracer tests, as shown in Table 2. Frequently, when lower flows are experienced in the facility, one or two filters will be removed from service.

TABLE 2. Seasonal Conditions at the 315 Water Treatment Facility

	Winter	Spring	Summer	Fall
Maximum Temp (C°)	10	15.3	24.0	20.2
Average Temp (C°)	6.2	10.6	19.8	13.2
Average Flow (gpm)	763	802	1,112	913

1. TEST SETUP

The layout of the 315 Water Treatment Facility in Appendix D shows the four basins and filters that were utilized during the tests. In accordance with the CTS Plan, the background fluoride concentration was determined by monitoring prior to beginning the tests at the sampling point where the disinfectant residual is measured for CxT calculations. An onsite analysis was performed using a HACH Colorimeter and fluoride reagent packs (SPADNS). Background monitoring was performed for 30 minutes at 5 minute intervals. The background was determined to be 0.4 mg/l during all tracer tests in the 315 Water Treatment Facility.

When the desired flowrate (2,400 gpm or 2,160 gpm) was established, the fluoride feed supplied from a LMI Model

28850 Fluoride Saturator was energized and left at a constant rate for the duration of the test. Fluoride was added at the exit of the mixing chamber leading to the sedimentation basins and was monitored from a sample tap off of the discharge line from the clearwell. The tracer study was performed on the treatment train starting at the exit of the flash mix chamber, and included four sedimentation basins, four filters, and the clearwell. The combined volume of these components is approximately 424,000 gallons (Appendix B, p. B-3).

During the 2,400 gpm test on March 6, 1995 (Test 1), tracer was added at a rate of 620.8 ml/min for 6 hrs. The fluoride injector was then de-energized and the receding curve was tracked for an additional 4 hrs and 55 min until the tank storage space was exhausted and the artificially elevated flowrate could no longer be maintained.

A 2,160 gpm tracer test (Test 2) was attempted at the 315 Water Treatment Facility on March 10, 1995. The results of the test were not consistent with estimates of fluoride residual. Therefore, a retest was scheduled.

During the 2,160 gpm test on March 23, 1995 (Test 3), tracer was added at a rate of 580 ml/min for 6 hrs and 35 min. The

fluoride injector was de-energized and the receding curve was tracked for an additional 5 hrs and 5 min until background fluoride concentrations were detected again.

C. DISCUSSION OF RESULTS

A two-flow tracer study (Q peak and 0.90* Q peak) was performed at the 315 Water Treatment Facility in the 300 Area, and the actual detention time at those flows was determined. Table 3 shows a summary of the data taken during the two reliable tracer tests and the corresponding results.

TABLE 3. 315 Water Treatment Facility
Step-Dose Method Sodium Fluoride Tracer Study

Test Date	March 6, 1995 (Test 1)	March 23,1995 (Test 3)
Target Flow	2,400 gpm	2,160 gpm
Average Test Flow	2,380 gpm	2,127 gpm
Average Clearwell Depth	10.8 ft	10.8 ft
Normal Clearwell Depth	10.8 ft	10.8 ft
Average Water Temp	5.8 °C	7.9 °C
Normal Seasonal Temp	6.2 °C	6.2 °C

TABLE 3 -continued		
Background Tracer Levels	0.4 mg/l	0.4 mg/l
Tracer Dose	1.21 mg/l	1.27 mg/l
Alum Dose	20 mg/l	25 mg/l
Expected Tracer Loss Due to Alum	0.1 mg/l	0.15-0.2 mg/l
Expected Maximum Detected Tracer Residuals	1.51 mg/l	1.47 mg/l
Actual Maximum Detected Tracer Residuals	1.5 mg/l	1.2 mg/l
Injection Period	6 hrs	6.6 hrs
Sampling Period	10.9 hrs	11.7 hrs
Theoretical Residence Time (T)	178 min	199 min
Actual Residence Time (T_{10})	102 min	167 min
% Tracer Recovered	85%	45%

Source: Appendix A.

The March 6, 1995 tracer test (Test 1) appears to be a textbook example of the step-dose method tracer test. The flowrate during the peak flow test averaged 2,380 gpm (-0.8% of the target flow). There was apparently some short circuiting with the actual residence time being approximately 60% of theoretical. However, some channeling effect (short circuiting) can be expected in the long sedimentation basins that have no baffling. The clearwell is a large single basin that may experience some effects similar to the sedimentation basins. These slight short circuiting problems do not appear to be extensive. The tracer mass recovery was calculated at 85% and an additional 10% can be attributed to alum loss (see Appendices A and C). The calculated maximum tracer residual of 1.5 mg/l was obtained during effluent testing. Figure 2, a graph of relative concentration versus time, shows that the tracer approached a steady state level before the end of the tracer addition (twice the theoretical detention time).

The data was evaluated numerically and the correlation coefficient indicated a good statistical fit (0.95). Therefore, T_{10} was determined as the solution to an equation based on the straight-line parameters to a linear regression analysis of the tracer test data instead of an "eyeball" estimate from a data plot (ref 1, p. C-19; Appendix A, p. A-C-4 and A-C-5).

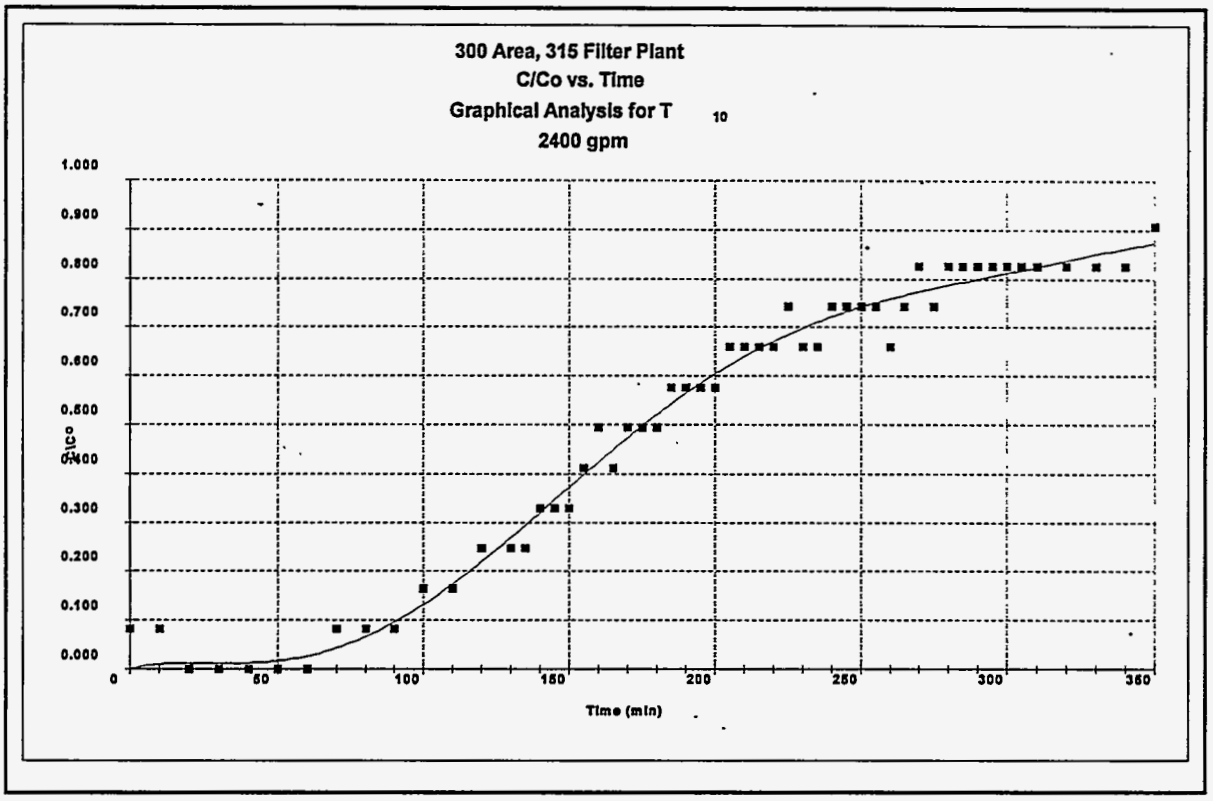

Figure 2: 315 Filter Facility 2,400 gpm tracer test (Source: Appendix A, p. A-C-4)

The March 23, 1995 tracer test (Test 3) appears to provide an actual detention time that is in agreement with Test 1. The flowrate during Test 3 averaged 2,127 gpm (-1.5% of the target flow). Compared to the results of Test 1, less short circuiting was seen with the actual residence time being approximately 84% of theoretical. However, the mass of tracer recovered appears to be a lower then the first test. The tracer mass recovery was calculated at 45% with an additional 16% attributed to alum loss. The calculated maximum tracer residual was never reached in the effluent. The maximum detected tracer concentration was 1.2 mg/l when a concentration of 1.47 mg/l was

expected.

The data was evaluated numerically and the correlation coefficient was not high enough to indicate a good statistical fit (0.87). As a result, T_{10} was required to be determined graphically as an estimate from a data plot (Appendix A, p. A-C-11).

The disparities between the two tests have been examined as follows: the alum dosage during Test 3 was slightly higher then during Test 1; and the increased alum dosage doubles the fluoride loss that can be attributed to alum (see Appendix C).

The second potential cause of these disparities is the potential interference of Preastol 2515. Preastol 2515 is a polymer that is sometimes added to the filter beds to enhance filtration. The polymer attracts colloidal material through its affinity for charged particles. The negatively charged fluoride ions could become adsorbed in the filter beds in the presence of this material and never reach the effluent stream. The polymer was not in use during the first test and it hadn't been used during the previous week. Prior to March 10, 1995, Preastol 2515 was introduced to the filter media again. A 2,160 gpm tracer test (Test 2) was attempted at the 315 Water Treatment Facility on March 10 while the polymer was being used. Due to polymer interference, the results of Test 2 were not consistent with estimates of fluoride residual; therefore, Test 3 was scheduled. When the manufacturer of the polymer

(Stockhauser) was contacted, the individual knew of no test to determine residual concentrations in a media and did not know the half-life of the material. In preparation for Test 3, the filters were backwashed every day to flush out as much polymer as possible. Nevertheless, the degree of polymer removal is unknown. The lower recovery rate for the tracer may be attributed to residual polymer in the media.

Finally, a review of the graph of relative concentration versus time (Figure 3) shows that the tracer had not quite reached a steady state level before the end of the tracer addition (twice the theoretical detention time) during Test 3. However, according to the Guidance Manual, "it is not necessary to reach a steady state concentration in the exiting water to determine T_{10}; however, it is necessary to determine tracer recovery. It is recommended that the tracer recovery be determined to identify hydraulic characteristics or density problems" (ref 1, p. C-10). Therefore, the T_{10} determination is still valid for this test.

The T_{10} values determined from these two tests provide conservative T_{10} estimates for any flow less than the tests flows. Averaging the T_{10} analyses will provide conservative estimates of T_{10} for all flows less then or equal to 2,318 gpm.

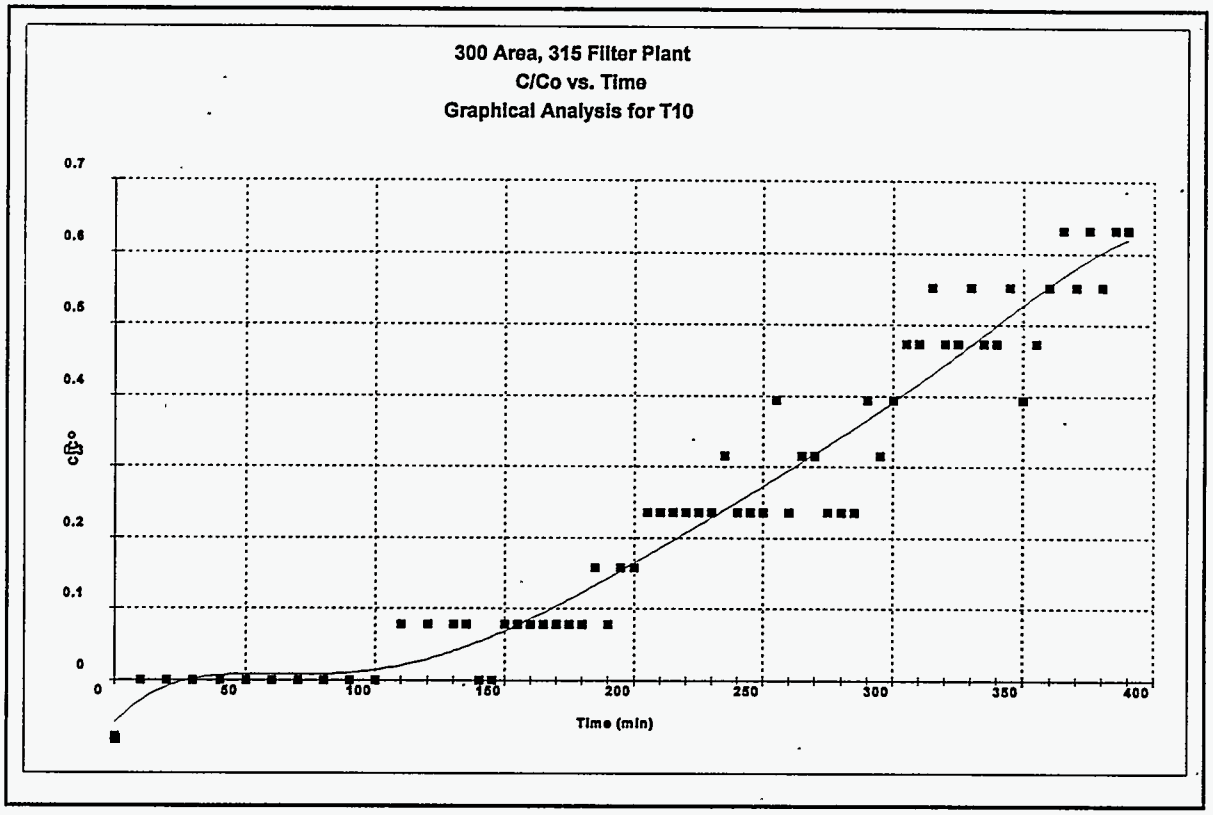

Figure 3: 315 Filter Facility 2,160 gpm tracer test (Source: Appendix A, p. A-C-10)

V. CONCLUSIONS AND RECOMMENDATIONS

The results of the two flow tracer studies (Q peak and 0.90* Q peak) performed at the 315 Water Treatment Facility are shown in Table 4.

TABLE 4 Results of Two Tracer Tests at The 315 Water Treatment Facility

Target Flow	Average Test Flow	Theoretical Residence Time (T)	Actual Residence Time (T_{10})	% Tracer Recovered
2,400 gpm (Test 1)	2,380 gpm	178 min	102 min	85%
2,160 gpm (Test 3)	2,127 gpm	199 min	167 min	45%

T_{10} for any flow can be determined by the following equation:

$$T_{10} = T_{10T} \times Q_T/Q$$

Where: (ref 1, p. C-3)

T_{10} = Detention time at system flow rate

Q = System flow rate

T_{10T} = Detention time from tracer test

Q_T = Flow during tracer test

This equation, when used in conjunction with the results of the 315 Water Treatment Facility tracer tests, simplifies to the following:

$$T_{10} = 300{,}000/Q$$

Where: (Appendix A, p. A-8)

T_{10} = Detention time at any flow (minutes)

Q = Flow (gallons per minute)

Because of the change in mission at Hanford from weapons production to environmental restoration, the water treatment facilities are expected to continue having decreased demands. The high flow tracer study performed at the 315 Water Treatment Facility (ID# 418408) would continue to provide conservative T_{10} estimates if future flows do not exceed test flows.

The March 6 tracer test verified that there were no unfavorable hydraulic characteristics or density problems with 95% of the tracer recovered or accounted for when the test was stopped. The March 6 test appeared to provide a reliable determination of T_{10}. The results from the March 23 test were analogous to the first test, but such a high recovery was not indicated. However, conditions that may have affected tracer recovery should not have impacted the T_{10} determination. The data was not far from a good statistical fit (0.85) and the calculated retention time fell in line with the results of the first test. A steady state concentration in the exiting water is not necessary to determine T_{10} which would indicate that the T_{10} determinations from these tests provide a reliable means to determine T_{10} at any flow through the same configuration using the average of the two tests.

VI. REFERENCES

1. Guidance Manual for Compliance With The Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources; U.S. Environmental Protection Agency, March 1991.

2. Disinfection Contact Time Study Plan, "300 Area Tracer Study," Rev. 2, prepared by ICF Kaiser Hanford Company, December 1994.

3. Letter, C.L Riley (Washington State Department of Health) to D.J. Ortiz (U.S. Dept. of Energy), "Hanford Nuclear Reservation, Surface Water Treatment Plants Tracer Study Requirements," October 19, 1994.

4) Hudson, H.E., Jr; "Water Clarification Processes: Practical Design and Evaluation," Van Nostrand Reinhold Company, New York, 1981.

APPENDIX A

Calculation No. ER5480-G-007
Contact Time in the 300 Area Filter Facility
Determined From A Two Flow Tracer Test, Rev. 0

KAISER ENGINEERS HANFORD

CALCULATION IDENTIFICATION AND INDEX

Page i of ii
Date 3/28/95

This sheet shows the status and description of the attached Design Analysis sheets.

Discipline Environmental Eng WO/Job No. ER5480 Calculation No. ER5480-G-007

Project No. & Name TRACER/Contact Study of Hanford WATER PLANTS

Calculation Item Contact Time in 300 AREA Filter Plant Determined From Two Flow TRACER TEST

These calculations apply to:

Dwg. No. _____ Rev. No. _____

Dwg. No. _____ Rev. No. _____

Other (Study, CDR) _____

_____ Rev. No. _____

The status of these calculations is:

☐ Preliminary Calculations

☐ Final Calculations

☐ Check Calculations (On Calculation Dated _____)

☐ Void Calculation (Reason Voided _____)

Incorporated in Final Drawings? ☐ Yes ☐ No

This calculation verified by independent "check" calculations? ☐ Yes ☐ No

Original and Revised Calculation Approvals:

	Rev. 0 Signature/Date	Rev. 1 Signature/Date	Rev. 2 Signature/Date
Originator	William W Pelstt 3/27/95		
Checked by	J.W. Funk 3/31/95		
Approved by			
Checked Against Approved Vendor Data			

INDEX

KEH 0378.00 (06/92)

CALCULATION CROSS INDEX (Typical)

Subject Calculation No. ER5480-6-007

Page CC of CC

Subject Calculation Revision No.	Superceded by Calculation No.	These interfacing calculation/documents provide input to the subject calculation, and if revised may require revision of the subject calculation.		Results and conclusions of the subject calculation are used in these interfacing calculations and/or documents.		Does the output interface calculation/ documents require revision?		Has the output interface calculation/ documents been revised?		Discipline manager's signature and date indicating evaluation complete.
		Calculation/Document No.	Revision No.	Calculation/Document No.	Revision No.	Yes	No	Yes	No	
3	2	ER5480-6-005	3			—	—	—	—	
0	—	ER5480-6-004	0			—	—	—	—	

KAISER ENGINEERS HANFORD

DESIGN ANALYSIS

Calc. No. ER5480-6-007
Revision 0
Page No. 1 of 10

Client ICF-KH
WO/Job No. ER5480 / F00884
Subject 315 Filter Plant Retention Time
Date 3/27/95 By William W. Pickett
Checked 3/31/95 By J.W. Funk
Location 300 AREA
Revised By

OBJECTIVE: The Purpose of this Calculation is to Determine the Actual Detention Time (T_{10}) in the 300 AREA Filter Plant Based on Results of a Sodium Fluoride Tracer Study

Given Data: 315 Filter Plant Volume with Four Basins and Four Filters on Line is 1.605×10^6 l (Ref 3 P.3)

The Fluoride ion concentration in the Feed Solution is 17.6 g/l (Ref 3 P.4)

The Background Fluoride Conentration was 0.4 mg/l and the Fluoride Feed Rate was 620.8 ml/min during the 2,400 gpm Test. (Appendix A P.A-1

The Background Fluoride Concentration was 0.4 mg/l and the Fluoride Feed Rate was 580.0 ml/min during the 2,160 gpm Test. (Appendix A P.A-12

Fluoride Ion Loss Due to 20 ppm alum Dosage is 0.1 mg/l (Ref 4 P.3)

Fluoride Ion Loss Due to 25 ppm alum Dosage is 0.2 mg/l (Ref 4 P.3)

METHODS: The calculations are performed using methods outlined in Reference 2 and Standard engineering equations. Excel 5.0 was used as a spreadsheet for Repetitive calculations and Graphing.

REFERENCES:

1) Disinfection Contact Time Study Plan, 300 AREA TRACER Study, Rev. 2, December 1994.

2) Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems using Surface Water Sources; March 1991.

3) Calculation ER5480-6-005 Rev. 3 "Theoretical Detention Time and Fluoride Injection Rate (300 AREA)

4) Calculation ER5480-6-004 Rev. 0 "Fluoride Loss From addition of Alum"

KAISER ENGINEERS HANFORD

DESIGN ANALYSIS

Calc. No. ER5480-6-007
Revision 0
Page No. 2 of 10

Client ICF-KH
WO/Job No. ER5480-6-007
Subject 315 Filter Plant Retention Time
Date 3/27/95 By William W. Pickett
Checked 3/31/95 By J.W. Ful
Location 300 AREA
Revised By

Findings:

The Residence Time of the 315 Filter Plant in the 300 AREA were Determined to Be:

Target Flow	Average Flow	Residence Time (T_{10})	% Fluoride Recov.
2,400 gpm	2,380	102 min	85%
2,160 gpm	2,127 gpm	167 min	45%

(Appendix A, P. C-3, C-9, C-10)

The Residence Time (T_{10}) in the 315 Filter Plant can be calculated using the following equation if 4 Filters and 4 Basins are being used:

$$T_{10(min)} = \frac{300{,}000}{Flow\ (gpm)}$$

Appendix A contains the Field notes and Data that were taken during the Test that supplied the data for this Residence Time calculation.

Appendix B contains the Spreadsheet cell Formulas that were used to calculate % Fluoride Recovery and Residence Time.

Appendix C contains the Spreadsheet calculations and Graphs used to calculate % Fluoride Recovery and Residence Time.

Calculations:

The majority of these calculations will be preformed on the Data gathered at 13:40 during the March 6, 1995 2,400 gpm Test. These Calculation were Performed over and over with an Excel Spread sheet (See Appendix C).

Data From a step dose Tracer Study can be evaluated Two ways. 1) graphical method (Ref 2, P. C-14)
2) Numerical method

KAISER ENGINEERS HANFORD

DESIGN ANALYSIS

Calc. No. ER5480-6-00?
Revision 0
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Client ICF-KH
WO/Job No. ER5480 / F00884
Subject 315 Bldg Retention Time
Date 3/27/95 By William W. Pickett
Checked 3/31/95 By J. W. Fast
Location 300 AREA
Revised By

Determination of Detention Time T_{10}:

In the graphical method, T_{10} is read directly from a graph of dimensionless concentration versus time.

In the numerical method, the data is evaluated numerically and a straight line is developed through a semi-logarithmic plot of the data. The resulting equation of the line is used to calculate the T_{10} value, assuming the correlation coefficient indicates a good statistical fit (0.9 or above).

(Ref. 2, P. C-14)

With the numerical method, T_{10} is determined as the solution to an equation instead of an "eyeball" estimate from a data plot.

(Ref. 2, P. C-18, C-19)

The Tracer Fluoride concentration is obtained as follows

Tracer conc (C) = Fluoride measured − Baseline

$C = 1.1 - 0.4$

(Ref. 2; P. C-16)

$C = 0.7$ mg/L

Dimensionless concentrations are developed by dividing Tracer Concentrations by the applied Fluoride dose (C_o).

(Ref. 2, P. C-16)

C_o is determined from the Sodium Fluoride injection Rate and the average Flow as follows:

$C_o = 620.8$ mL/min (Appendix A, P. A-1)

Fluoride Ion Concentration = 17.6 g F / L injected sol (Ref. 3, P4)

KAISER ENGINEERS HANFORD

DESIGN ANALYSIS

Calc. No. ER5480-6-007
Revision 0
Page No. 4 of 10

Client ICF-KH
WO/Job No. ER5480/F00B84
Subject 315 Facility Retention Time
Date 3/27/95 By William W. Pickett
Checked 3/31/95 By J. W. Funk
Location 300
Revised By

T10 cont'

Average Test Flow = 9009 ℓ/min (Appendix C, P. C-1)

$$C_o = \frac{(\text{Injection Feed Rate})(\text{F Conc in Feed})}{\text{Average Flow}}$$

$$C_o = \frac{620.8\ \frac{\text{ml Feed}}{\text{min}}\left(\frac{17.6\text{ g F}}{1\text{ Feed}}\right)\left(\frac{1\ \ell}{1000\text{ mL}}\right)\left(\frac{1000\text{ mg}}{1\text{ g}}\right)}{9009\ \frac{\ell}{\text{min}}}$$

$$C_o = 1.213\ \text{mg/}\ell$$

The Dimensionless Concentration is Now determined:

$$C/C_o = \frac{0.7}{1.213}$$

$$= 0.577$$

For the Graphical method a plot of C/C_o versus Time is developed. T_{10} is Read directly From the graph When $C/C_o = 0.10$. (Ref 2, P C-17)

Graphical analysis of T_{10} For 2,400 gpm is approximately:

90 min (See Appendix C P. C-4)

The Numerical analysis For T_{10} Requires the Additional Steps:

determination of $\log_{10}(1 - C/C_o)$

determination of t/T

(Ref 2, P C-17)

Where: t = elapsed time

and T = Theoretical Residence Time

KAISER ENGINEERS HANFORD

DESIGN ANALYSIS

Calc. No. ER5480-6-007
Revision 0
Page No. 5 of 10

Client ICF-KH
WO/Job No. ER5480/F00BB4
Subject 315 Facility Retention Time
Date 3/7/95 By William W. Pickett
Checked 3/31/95 By J. W. Fuhr
Location 300 AREA
Revised By

Tlo Con't

In the example used earlier Time = 13:40

$t = 13:40 - 10:20$

$t = 200 \text{ min}$

$$T = \frac{\text{Plant Volume}}{\text{Average Test Flow}}$$

$$T = \frac{1.605 \times 10^6 \text{ L}}{9009 \text{ L/min}}$$

$T = 178 \text{ min}$

Therefore the two missing pieces can be solved for and the graphical analysis completed

$\log_{10}(1 - C/C_0) = \log_{10}(1 - 0.577)$

$= -0.374$

$$t/T = \frac{200}{178}$$

$= 1.12$

These calculations are repeated at each time interval. These data are linearly regressed as $\log_{10}(1 - C/C_0)$ versus t/T to obtain the fitted straight-line parameters to the following equation:

$$\log_{10}(1 - C/C_0) = m(t/T) + b \quad \text{(Ref 2, p C-18)}$$

Where Slope = $m = -0.6059$
Intercept = $b = 0.3004$
Correlation coefficient = 0.95 (Appendix C, p C5-C6)

KAISER ENGINEERS HANFORD

Calc. No. ER5480-6-007
Revision 0
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DESIGN ANALYSIS

Client ICF-KH
WO/Job No. ER5480 / F00BB4
Subject 3/5 Facility Retention Time
Date 3/27/95 By William W Pickett
Checked 3/31/95 By J. W. Funk
Location 300 AREA
Revised By

T10 cont'

The numerical Analysis, as with the graphical analysis, is evaluated at $Y/C_0 = 0.10$. Rearranging the previous equation:

$$T = \frac{(\log_{10}(1 - Y/C_0) - b)(T)}{m}$$

When $T = T_{10}$

$$T_{10} = \frac{(\log_{10}(1-0.1) - 0.3004)(178)}{-0.6059}$$

@ 2,380 gpm $T_{10} = 107$ min

Because the Regression is a good statistical Fit (0.95) and the numerical method eliminates the need to "eyeball" a T10 value, the Numerical Results will be used.

The data from the 3/23/95 Tracer Test were not a good statistical Fit (0.87). Therefore the graphical method had to be used.

@ 2,127 gpm $T_{10} = 167$ min (Appendix C, P. C-9, C-10)

Determination of % Mass Recovery:

The First Part of Determining % Mass Recovered is calculating mass injected

$$\text{mass injected} = (\text{injection Feed Rate})(\text{Time injected})$$

$$= 620.8 \frac{mL}{min}\left(\frac{17.6\,g\,F}{L}\right)\left(\frac{1L}{1000mL}\right)(360\,min)$$

@ 2,380 gpm mass injected = 3,933.9

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DESIGN ANALYSIS

Calc. No. ER5480-6-017
Revision 0
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Client ICF-KH
WO/Job No. ER5480/F00BB4
Subject 315 Facility Retention Time
Date 3/27/95 By William W. Ricket
Checked 3/31/95 By J. W. Fuhr
Location 300 AREA
Revised By

Mass Recovery Cont'

Determination of Mass Recovered:
The mass recovered is obtained by determing the total area under the rising and falling STEP dose curve.

The area is found with a numerical integration technique called the rectangle rule.

The Flouride concentration at the end of a time interval is multiplied times the time interval to obtain an incremental area.

Our March 6, 1995 13:40 Example

Incremental area = Sampling Time Interval × Fluoride conc

$= (200 - 195 \text{ min})(0.7)$

$= 3.5 \frac{\text{mg} \cdot \text{min}}{\text{L}}$ (Ref 2 P. C-21)

The incremental areas are summed and and the total area determined

Total AREA = $370 \frac{\text{mg} \cdot \text{min}}{\text{L}}$ (Appendix B, P. B-3)

The mass Recovered can now be determined

Total Mass Recovered = (Total AREA)(average Flow)

$= \left(370 \frac{\text{mg} \cdot \text{min}}{\text{L}}\right)\left(\frac{1 \text{ g}}{1000 \text{ mg}}\right)\left(900 \frac{\text{L}}{\text{min}}\right)$

$= 3,333 \text{ g}$ (Ref 2, P. C-23)

% Recover = $\frac{\text{mass Recovered}}{\text{mass injected}} \times 100$

@ 2,380 gpm % Recovery = 85%

@ 2,127 gpm % Recovery = 45%

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DESIGN ANALYSIS

Calc. No. ER5480-6-007
Revision 0
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Client FCF-KH
WO/Job No. ER5480/F00B34
Subject 315 Facility Retention Time
Date 3/27/95 By William W. Pickett
Checked 3/31/95 By J. W. Funk
Location 300 AREA
Revised By

Determination of T_{10} at any Flow in the 315 Filter Plant using 4 Filters and 4 Basins.

T_{10} is inversely proportional to Flow Rate, therefore, the T_{10} at a flow rate other than that which the Tracer Study was conducted can be determined with the following:

$$T_{10}@Q = \frac{(T_{10T})(Q_T)}{Q}$$

(Ref 2, P.C-3) Where T_{10T} = T_{10} at Tracer Study Flow Rate
Q_T = Tracer Study Flow Rate
Q = ANY System Flow Rate
$T_{10}@Q$ = T_{10} at any system Flow Rate

From Previously: T_{10} @ 2,380 gpm = 102 min
T_{10} @ 2,127 gpm = 167 min

Using the above equation and the T_{10} at 2,380 gpm a calculated T_{10} can be determined for the 2,127 Flow Rate

$$@\ 2{,}127\ \text{gpm}\ T_{10}\ \text{calculate} = \frac{(102)(2380)}{2{,}127}$$

$$T_{10}\ \text{calc} = 114.13\ \text{min}$$

Using T_{10} calc and T_{10} actual an average T_{10} can be determined and used to calculate T_{10} for any Flow.

@ 2,127 gpm T_{10} actual = 167 min
T_{10} Calculated from 2,380 gpm = 114.13 min

$\overline{T_{10}}$ = 141 min when Flow = 2,127 gpm

An equation is developed for all Flows:

$$T_{10}@Q = \frac{(141)(2127)}{Q}$$

$$T_{10}@Q = \frac{300{,}000}{Q}$$

Following is a plot of this calculation.

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DESIGN ANALYSIS

Calc. No. ER5480-6-00
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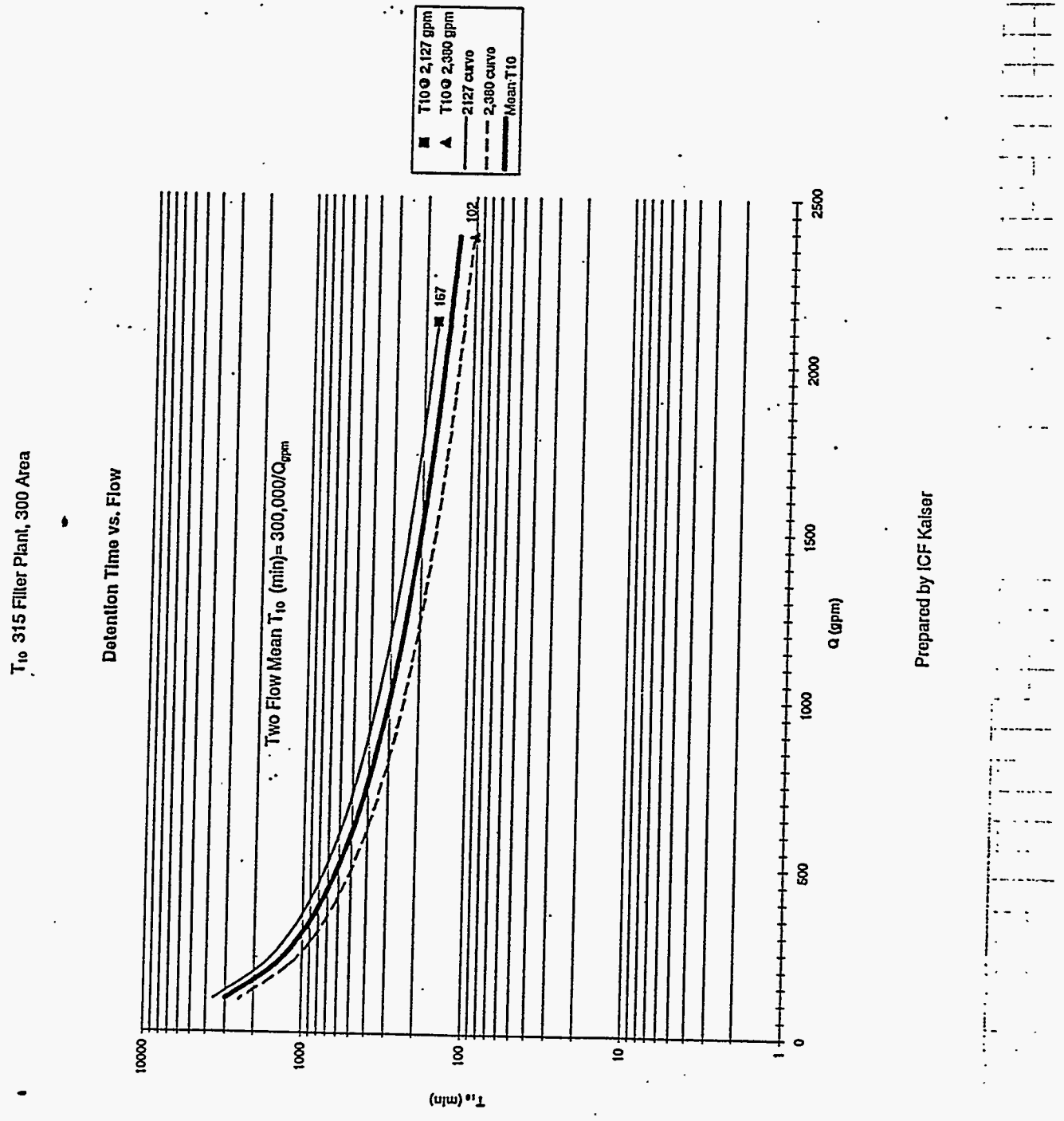
Client ICF- KH
WO/Job No. ER5480FOOBB4
Subject 315 Facility Retention Time
Date 3/27/95 By William W. PICKETT
Checked 3/31/95 By J. W. Funk
Location 300 AREA
Revised By

THE DATA FOR THIS PLOT and THIS PLOT are in Appendix C, pC-13 and C-14.



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DESIGN ANALYSIS

Calc. No. ER5480-G-007
Revision 0
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Client ICF-KH
WO/Job No. ER5480/F00BB4
Subject 315 Facility Retention Time
Date 3/27/95 By William W Pickett
Checked 3/31/95 By J. W Fulton
Location 300 AREA
Revised By

Conclusions:

The 315 Filter Plant Theoretical Detention times are as Follows:

T @ 9009 ℓ/min (2380 gpm) = 178 min

T @ 8050 ℓ/min (2127 gpm) = 199 min

The 315 Filter Plant actual Detention Time (T_{10}) are as Follows:

T_{10} @ 9009 ℓ/min = 102 min (Determined Numerically)

T_{10} @ 8050 ℓ/min = 167 min (Determined Graphically)

The mass Recovery of the Injected Tracer at the 315 Filter Plant are as Follows:

Mass Fluoride Recovered @ 9009 ℓ/min = 85%

Mass Fluoride Recovered @ 8050 ℓ/min = 45%

Detention Time at any Flow can be Determined From the Following equation

$$T_{10}(\text{min}) = \frac{300{,}000}{Q\ (\text{gpm})}$$

APPENDIX A

Field Notes and Data

2,400 gpm 3/6 Tracer Test

Engineers: Will Pickett
Todd Buechler
Dennis Cacciola

Operators: Roy Hammond - lead
Lynn Adams - relief
Barry Bowe
Luanne Brewster

OTHers:
Safety + Health Steve Stevenson
Utilities Sam Camp, Jim Day, Dan Gleason
Lynn Kelly

Basins on-line — 1, 2, 3, 4
Filters on-line — 1, 2, 3, 4
Alum Dosage (ppm) — 20 ppm
Average Background F (ppm) — 0.30 ~~0.40~~ 1.20 - 1.25
Required Injection Concentration (ppm) — ~~1.25~~ ppm
Injection Flow Rate (mL/min) — 620.8
Required Pump Speed Setting (%) — 62.5

90% × 1.7 = 1.08

1.4 - 1.08 = 0.32

Pre 506 8:00 – 9:00

Load saturate 9:10 - 9:30

Background established 10:00

FL 0.38 ppm - 0.40 ppm

$C_i = 1.5 + 0.1 - 0.35$

$C_i = 1.25$ ppm

$Q_{injection} = 1.25 \cdot Flow \cdot 0.2474$

$= 645.3$

Pump speed %

$= Q_{injection} / 9.9535 + 1.311783$

P.S = 66.14%

@ Flow = 2,280

Pspeed = 62.8%

10:10 A.M. Flow established

2404

PSet 62.5 %

Flow = 620.8 ml/min

Start pump 10:20:45 Pump OFF

Test over 9:20 10:20:45 4:20:00

(1) 1440 GPM Tracer Recovery

Time	0.4 ppb Fluoride - Background	Area Incremental	Cumulative Area
0	1	1	2
	1		
	0.8		
	0.6		
	0		
80	.1	1	3
90	.1	1	4
100	.1	1	5
110	.2	1	6
120	.2	1	7
130	.3	1.5	8.5
135	.3	1.5	10.0
140	.3	1.5	11.5
145	.4	2.0	13.5
150	.4	2.0	15.5
155	.4	2.0	17.5
160	.5	2.5	20.0
165	.6	3.0	23.0
170	.5	2.5	25.5
175	.6	3.0	28.5
180	.6	3.0	31.5
185	.7	3.5	35.0
190	.7	3.5	38.5
195	.7	3.5	42.0
			45.5

Area injected

Dose $\left(\frac{mg\text{-}min}{L}\right)$ =

inj. conc x Time injected

= 620.8 $\frac{mL}{min}$ @ 4% sat

$\left(620.8\frac{mL}{min}\right)\left(17.69\frac{gF}{L\ sat\ soln}\right)\left(\frac{1500}{1440}\frac{L}{1000mL}\right)$

$\left(608\frac{L}{min}\right)$

= 10.939 F

Pump off @ 4:00

6 hrs = 3,935 gal off

Time	A-B.G.	Area	Cum area
200	.7	3.5	45.5
205	.7	3.50	49.0
210	.8	4.0	53.0
215	.8	4.0	57.0
220	.8	4.0	61.0
225	.8	4.0	65.0
230	.9	4.5	69.5
235	.8	4.0	73.5
240	.8	4.0	77.5
245	.9	4.5	82.0
250	.9	4.5	86.5
255	.9	4.5	91.0
260	.9	4.5	95.5
265	.8	4.0	99.5
270	.9	4.5	104.0
275	1.0	5.0	109.0
280	.9	4.5	113.5
285	1.0	5.0	118.5
290	1.0	5.0	123.5
295	1.0	5.0	128.5
300	1.0	5.0	133.5
305	1.0	5.0	138.5
310	1.0	5.0	143.5
320	1.0	10.0	153.5
330	1.0	10.0	163.5
340	1.0	10.0	173.5
350	1.0	10.0	183.5
[illegible]	[illegible]	[illegible]	[illegible]

-14:10

-4:15

Flow = 9.084 l/min

(2) 3,935 (1000 mg / g) / 9.084 l/min

= 433 mg-min / L

1.4 - .4 = 1.0   90% = 90% = .90   1.4 - .90 = 0.5 mg/l

1.5 - .4 = 1.1   0.99   1.5 - 0.99 = 0.51

(3/10) (13)

Dosed
3,935 gal F

Recovered =
(area/1000) x (4,084)

[illegible]

Time	F-B.G	Area	Cum Area
360	1.1	11	194.5
370	1.0	10	204.5
385	1.1	16.5	221.0
400	1.0	15	236.0
415	1.0	15	251
430	1.0	15	266
445	0.9	13.5	279.5
500	0.9	13.5	293.0
515	0.8	12.0	305.0
530	0.7	10.5	315.5
545	0.6	9.0	324.5
600	0.5	7.5	332.0
615	0.5	7.5	339.5
630	0.4	6.0	345.5
645	0.3	4.5	350
700	0.3	4.5	354.5
715	0.3	4.5	359.0
730	0.2	3.0	362.0
745	0.2	3.0	365.0

(4)

Time	F-15,6.	AREA	Cumulative
745	0.2	3.0	365.0
800	0.1	1.5	366.5
815	0.1	1.5	~~368.0~~ 371

Rsed = 3.935

area/1000 + 7,089

7380

SHEET 1 OF 1

ICF KAISER HANFORD COMPANY — BACKGROUND FLOURIDE CONCENTRATIONS

DATE: 3/6/95 FACILITY: 315 Filter Plant 300 AREA

TIME OF SAMPLING: 09:30 - 09:55

SAMPLES TAKEN BY: Dennis Laubala SIGNITURE: Dennis Laubala

SAMPLE NUMBER #-B	TIME OF SAMPLE (H:MM)	WATER LEVEL IN CLEARWELL (FT)	SYSTEM FLOWRATE (GPM)	TIME OF ANALYSIS (H:MM)	TEMP BEFORE TESTING (F°)	RESIDUAL FLUORIDE (MG/L)	COMMENTS
1-B	09:30	10.81	720	9:32		0.3	Bkgrd Test
2-B	09:35	10.74	1163	9:38		0.4	"
3-B	09:40	10.81	1451	9:42		0.3	"
4-B	09:45	10.80	1733	9:47		0.4	"
5-B	09:50	10.78	2026	9:53		0.3	"
6-B	09:55	10.80	2240	9:57		0.4	"
AVERAGES		WATER LEVEL IN CLEARWELL (FT)	SYSTEM FLOWRATE (GPM)		TEMP BEFORE TESTING (°F)	RESIDUAL FLUORIDE (MG/L)	

Rev. 0, 11/16/94

SHEET 1 OF 3

ICF KAISER HANFORD COMPANY — FLUORIDE TRACER TEST

DATE: 3/16/95 FACILITY: 315 Filter Plant 300 Area

SAMPLES TAKEN BY: Dennis Lachuta, Will Pickett SIGNITURE: Dennis Lachuta Will Pickett

PUMP SPEED: 62.5% PUMP STROKE: 50%

TIME OF INJECTION OF FLUORIDE TRACER: 10:20 – 16:20

SAMPLE NUMBER # - T	TIME OF SAMPLE (H:MM)	WATER LEVEL IN CLEARWELL (FT)	SYSTEM FLOWRATE (GPM)	TIME OF ANALYSIS (H:MM)	TEMP BEFORE TESTING (F°)	RESIDUAL FLUORIDE (MG/L)	COMMENTS
1-T	10:30	10.80	2359	10:32	45	0.5	
2-T	10:48	10.80	2354	10:49	45	0.5	
3-T	10:50	10.80	2342	10:52	44	0.4	
4-T	11:00	10.80	2398	11:02	44	0.4	
5-T	11:10	10.80	2408	11:12	44	0.4	
6-T	11:20	10.80	2411	11:22	44	0.4	
7-T	11:30	10.80	2440	11:32	44	0.4	
8-T	11:40	10.79	2447	11:41	44	0.5	
9-T	11:50	10.79	2411	11:52	44	0.5	
10-T	12:00	10.80	2433	12:02	44	0.5	
11-T	12:10	10.80	2424	12:11	43	0.6	
12-T	12:20	10.80	2424	12:22	43	0.6	
13-T	12:30	10.80	2408	12:32	43	0.7	
14-T	12:35	10.80	2413	12:37	43	0.7	
15-T	12:40	10.80	2430	12:42	43	0.7	
16-T	12:45	10.79	2456	12:47	43	0.8	
17-T	12:50	10.79	2431	12:53	42	0.8	
18-T	12:55	10.80	2410	12:57	42	0.8	
19-T	13:00	10.80	2447	13:02	42	0.9	
20-T	13:05	10.80	2459	13:07	42	1.0	
21-T	13:10	10.80	2432	13:13	42	0.9	
22	13:15	10.79	2416	13:17	42	1.0	
23	13:20	10.80	2398	13:22	43	1.0	
24	13:25	10.79	2403	13:27	43	1.0	
25	13:30	10.79	2408	13:32	43	1.1	
26	13:35	10.80	2386	13:37	43	1.1	
27	13:40	10.80	2388	13:42	43	1.1	
28	13:45	10.80	2375	13:47	42	1.1	
29	13:50	10.80	2380	13:52	42	1.2	
30	13:55	10.80	2367	13:57	43	1.2	
31-T	14:00	10.80	2382	14:02	42	1.2	
32-T	14:05	10.80	2384	14:07	42	1.2	
33-T	14:18	10.79	2383	14:17	42	1.3	

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SHEET 2 OF 3

ICF KAISER HANFORD COMPANY — FLUORIDE TRACER TEST

DATE: 3/16/95 FACILITY: 315 Filter Plant 300 AREA

SAMPLES TAKEN BY: Dennis Laubala/Will Pickett SIGNITURE: Dennis Laubala Will Pickett

PUMP SPEED: 62.5% PUMP STROKE: 50%

TIME OF INJECTION OF FLUORIDE TRACER: 10:20 -16:20

SAMPLE NUMBER #-T	TIME OF SAMPLE (H:MM)	WATER LEVEL IN CLEARWELL (FT)	SYSTEM FLOWRATE (GPM)	TIME OF ANALYSIS (H:MM)	TEMP BEFORE TESTING (F°)	RESIDUAL FLUORIDE (MG/L)	COMMENTS
34	14:15	10.8	2363	14:16	43	1.2	
35	14:20	10.8	2386	14:22	42	1.2	
36	14:25	10.8	2385	14:27	42	1.3	
37	14:30	10.8	2372	14:32	42	1.3	
38	14:35	10.79	2385	14:38	42	1.3	
39	14:40	10.8	2375	14:42	42	1.3	
40	14:45	10.8	2360	14:47	42	1.2	
41	14:50	10.8	2374	14:52	42	1.3	
42	14:55	10.79	2367	14:57	42	1.4	
43	15:00	10.80	2356	15:02	42	1.3	
44	15:05	10.79	2370	15:07	42	1.4	
45	15:10	10.79	2384	15:12	42	1.4	
46	15:15	10.80	2378	15:17	42	1.4	
47	15:20	10.79	2395	15:22	42	1.4	
48	15:25	10.80	2384	15:27	42	1.4	
49	15:30	10.80	2395	15:32	42	1.4	
50	15:40	10.8	2389	15:42	42	1.4	
51	15:50	10.8	2368	15:52	42	1.4	
52	16:00	10.8	2353	16:02	42	1.4	
53	16:10	10.8	2342	16:12	42	1.4	
54	16:20	10.8	2341	16:22	42	1.5	Saturator turned off
55	16:30	10.8	2374	16:32	42	1.4	
56	16:45	10.8	2383	16:47	42	1.5	
57	17:00	10.8	2373	17:02	42	1.4	
58	17:15	10.8	2352	17:17	42	1.4	
59	17:30	10.8	2366	17:33	42	1.4	
60	17:45	10.79	2346	17:47	42	1.3	
61	18:00	10.80	2351	18:02	42	1.3	
62	18:15	10.79	2332	18:17	42	1.2	
63	18:30	10.79	2343	18:32	42	1.1	
64	18:45	10.79	2342	18:47	42	1.0	
65	19:00	10.80	2341	19:02	42	0.9	
66	19:15	10.80	2337	19:17	42	0.9	

500

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SHEET 3 OF 3

ICF KAISER HANFORD COMPANY . FLUORIDE TRACER TEST

DATE: 3/6/95 FACILITY: 315 Filter Plant 300 AREA

SAMPLES TAKEN BY: Dennis Lambdin/Will Pickett SIGNITURE: Dennis Lambdin Will Pickett

PUMP SPEED: 62.5% PUMP STROKE: 50%

TIME OF INJECTION OF FLUORIDE TRACER: 10:20 -16:20

SAMPLE NUMBER #-T	TIME OF SAMPLE (H:MM)	WATER LEVEL IN CLEARWELL (FT)	SYSTEM FLOWRATE (GPM)	TIME OF ANALYSIS (H:MM)	TEMP BEFORE TESTING (F°)	RESIDUAL FLUORIDE (MG/L)	COMMENTS
67	19:30	10.79	2345	19:32	42	0.8	
68	19:45	10.8	2339	19:47	42	0.7	
69	20:00	10.8	2341	20.02	42	0.7	
70	20:15	10.8	2328	20.16	43	0.7	
71	20:30	10.8	2337	20.31	43	0.6	
72	20:45	10.8	2336	20.47	42	0.6	
73	21:00	10.8	2328	21.02	42	0.5	
74	21.15	10.79	2340	21.17	42	0.5	Plant shut down
	10:	594.		44	35-		
	10.79						
		794		42	20:7		

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3/23/95 2160 6pm Tracer Test

Engineers: Will Pickett
Dennis Lalhula

Operators: Roy Hammond
Luanne Brewster
Lynn Adams
Berry Bowe

OTHers: Sam Camp
Lynn Kelly
Jim Ray
Dan Gleason

Basins on Line: 1, 2, 3, 4
Filters on Line: 1, 2, 3, 4
alum Dosage: 3.5 ppm
F Loss Due To Alum: 0.15 - 0.20 ppm

Test Start Time 8:54 (C Tank valve Opened)

F Background Established : 9:12

F Background Conc : 0.4 mg/l

2160 gpm established : 9:25

Injection Concentration :

C_i = Desired Effluent Conc + Alum Loss − Background

$C_i = 1.5 + 0.15 - 0.4$

$C_i = 1.25$ mg/l

Calculated Injection Flow Rate :

$Q_i = C_i \cdot Flow \cdot 0.21474$

$Q_i = 1.25 \cdot 2160 \cdot 0.21474$

$Q_i = 580$ ml/min

Actual Injection Flow Rate : Pump speed = 55-56

V_1	V_2	ΔV	Time	ml/min
1000	425	575	60.05	575
1000	410	590	60.20	588
1000	420	580	60.20	578

Injection Flow Rate = 580 ml/min

Injection Start Time: 9:50:00

Pump OFF Time : 16:25:00

Test over : 21:30:00

SHEET 1 OF 1

ICF KAISER HANFORD COMPANY — BACKGROUND FLOURIDE CONCENTRATIONS

DATE: 3/23/95 FACILITY: 315 Filter Plant 300 AREA

TIME OF SAMPLING: 8:45 - 9:10

SAMPLES TAKEN BY: Dennis Laubala SIGNITURE: Dennis Laubala

SAMPLE NUMBER #-B	TIME OF SAMPLE (H:MM)	WATER LEVEL IN CLEARWELL (FT)	SYSTEM FLOWRATE (GPM)	TIME OF ANALYSIS (H:MM)	TEMP BEFORE TESTING (F°)	RESIDUAL FLUORIDE (MG/L)	COMMENTS
1	8:45	10.81	495	8:47	50	0.3	
2	8:50	10.79	493	8:51	50	0.4	
3	8:55	10.81	438	8:57	50	0.4	
4	9:00	10.82	775	9:02	49	0.4	
5	9:05	10.79	1318	9:07	48	0.4	
6	9:10	10.79	1567	9:12	48	0.3	

AVERAGES	WATER LEVEL IN CLEARWELL (FT)	SYSTEM FLOWRATE (GPM)	TEMP BEFORE TESTING (°F)	RESIDUAL FLUORIDE (MG/L)

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SHEET 1 OF 3

ICF KAISER HANFORD COMPANY — FLUORIDE TRACER TEST

DATE: 3/23/95 FACILITY: 315 Fifty Plant

SAMPLES TAKEN BY: Dennis Lambert / Will Pickett SIGNITURE: Dennis L. Lambert / William W. Pickett

PUMP SPEED: 56% PUMP STROKE: 50%

TIME OF INJECTION OF FLUORIDE TRACER: 9:50 - 16:25

SAMPLE NUMBER #-T	TIME OF SAMPLE (H:MM)	WATER LEVEL IN CLEARWELL (FT)	SYSTEM FLOWRATE (GPM)	TIME OF ANALYSIS (H:MM)	TEMP BEFORE TESTING (F°)	RESIDUAL FLUORIDE (MG/L)	COMMENTS Start Saturate 09:50
1	10:00	10.79	2161	10:02	47	0.3	
2	10:10	10.81	2106	10:12	45	0.4	
3	10:20	10.79	2108	10:22	47	0.4	
4	10:30	10.80	2092	10:32	46	0.4	
5	10:40	10.80	2105	10:42	46	0.4	
6	10:50	10.82	2159	10:52	46	0.4	
7	11:00	10.80	2118	11:02	46	0.4	
8	11:10	10.80	2134	11:12	45	0.4	
9	11:20	10.82	2133	11:22	46	0.4	
10	11:30	10.82	2123	11:32	46	0.4	
11	11:40	10.80	2098	11:42	46	0.4	
12	11:50	10.80	2172	11:52	45	0.5	
13	12:00	10.80	2150	12:02	45	0.5	
14	12:05	10.80	2128	12:07	45	0.5	
15	12:10	10.80	2128	12:12	45	0.5	
16	12:15	10.79	2118	12:17	45	0.4	
17	12:20	10.81	2160	12:22	45	0.4	
18	12:25	10.80	2130	12:27	45	0.5	
19	12:30	10.80	2135	12:32	45	0.5	
20	12:35	10.5	2146	12:37	45	0.5	
21	12:40	10.8	2148	12:42	45	0.5	
22	12:45	10.8	2176	12:47	45	0.5	
23	12:50	10.8	2184	12:52	45	0.5	
24	12:55	10.8	2142	12:57	44	0.5	
25	13:00	10.8	2138	13:02	44	0.6	
26	13:05	10.8	2165	13:07	45	0.5	
27	13:10	10.8	2170	13:12	45	0.6	
28	13:15	10.79	2239	13:17	45	0.6	
29	13:20	10.80	2182	13:22	45	0.7	
30	13:25	10.81	2023	13:27	45	0.7	
31	13:30	10.80	2071	13:32	45	0.7	
32	13:35	10.80	2071	13:37	45	0.7	
33	13:40	10.80	2110	13:43	45	0.7	

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SHEET 2 OF 3

ICF KAISER HANFORD COMPANY — FLUORIDE TRACER TEST

DATE: 3/23/95 FACILITY: 315 Filter Plant

SAMPLES TAKEN BY: Degnan Lockard/Hall/Ricketts SIGNITURE: D. L. Lockard / Willow Ricketts

PUMP SPEED: 56% PUMP STROKE: 50%

TIME OF INJECTION OF FLUORIDE TRACER: 9:50–16:25

SAMPLE NUMBER #-T	TIME OF SAMPLE (H:MM)	WATER LEVEL IN CLEARWELL (FT)	SYSTEM FLOWRATE (GPM)	TIME OF ANALYSIS (H:MM)	TEMP BEFORE TESTING (F°)	RESIDUAL FLUORIDE (MG/L)	COMMENTS
34	13:45	10.79	2200	13:47	46	0.7	
35	13:50	10.81	2150	13:53	44	0.8	
36	13:55	10.78	2059	13:58	44	0.7	
37	14:00	10.78	2072	14:02	45	0.7	
38	14:05	10.80	2136	14:07	45	0.7	
39	14:10	10.82	2117	14:12	45	0.9	
40	14:15	10.80	2107	14:17	46	0.7	
41	14:20	10.79	2242	14:22	45	0.8	
42	14:25	10.80	2105	14:27	46	0.8	
43	14:30	10.80	2100	14:33	45	0.7	
44	14:35	10.80	2086	14:37	45	0.7	
45	14:40	10.80	2101	14:42	45	0.7	
46	14:45	10.80	2116	14:47	45	0.9	
47	14:50	10.80	2109	14:52	45	0.8	
48	14:55	10.80	2111	14:57	45	0.9	
49	15:00	10.80	2100	15:02	45	1.0	
50	15:05	10.80	2112	15:07	45	1.0	
51	15:10	10.81	2141	15:12	45	1.1	
52	15:15	10.80	2163	15:17	45	1.0	
53	15:20	10.80	2136	15:22	45	1.0	
54	15:25	10.80	2093	15:27	45	1.1	
55	15:30	10.80	2136	15:32	45	1.0	
56	15:35	10.80	2132	15:37	45	1.0	
57	15:40	10.80	2111	15:42	46	1.1	
58	15:45	10.80	2114	15:48	45	0.9	
59	15:50	10.81	2106	15:52	46	1.0	
60	15:55	10.79	2126	15:57	45	1.1	
61	16:00	10.80	2114	16:02	46	1.2	
62	16:05	10.80	2087	16:07	45	1.1	
63	16:10	10.80	2111	16:12	45	1.2	
64	16:15	10.80	2112	16:17	46	1.1	
65	16:20	10.80	2107	16:22	45	1.2	
66	16:25	10.82	2143	16:27	45	1.2	Saturator off

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SHEET 3 OF 3

ICF KAISER HANFORD COMPANY — FLUORIDE TRACER TEST

DATE: 3/23/95 FACILITY: 3/5 Filter Plant

SAMPLES TAKEN BY: Dennis Lockard/Will Pickett SIGNITURE: Dennis Lockard / William Pickett

PUMP SPEED: 56% PUMP STROKE: 50%

TIME OF INJECTION OF FLUORIDE TRACER: 9:50 - 16:25

SAMPLE NUMBER #-T	TIME OF SAMPLE (H:MM)	WATER LEVEL IN CLEARWELL (FT)	SYSTEM FLOWRATE (GPM)	TIME OF ANALYSIS (H:MM)	TEMP BEFORE TESTING (F°)	RESIDUAL FLUORIDE (MG/L)	COMMENTS
67	16:30	10.80	2115	16:30	45	1.0	
68	16:45	10.80	2131	16:47	45	1.0	
69	17:00	10.80	2153	17:02	45	1.0	
70	17:15	10.80	2108	17:17	45	1.0	
71	17:30	10.80	2112	17:32	45	1.0	
72	17:45	10.80	2108	17:48	45	1.0	
73	18:00	10.80	2088	18:05	45	1.0	
74	18:15	10.80	2127	18:19	45	1.0	
75	18:30	10.80	2137	18:33	45	0.8	
76	18:45	10.80	2134	18:47	45	1.0	
77	19:00	10.80	2140	19:03	45	0.8	
78	19:15	10.80	2140	19:18	45	0.8	
79	19:30	10.80	2129	19:33	46	0.9	
80	19:45	10.80	2134	19:47	46	0.8	
81	20:00	10.80	2142	20:02	45	0.6	
82	20:15	10.80	2136	20:17	45	0.8	
83	20:30	10.80	2137	20:33	45	0.2	?? Need Reagent &
84	20:40	10.80	2131	20:43	45	0.6	Changed ZE80 Gauge
85	20:45	10.80	2126	20:47	45	0.6	@ 8:40
86	21:00	10.80	2120	21:02	45	0.4	(0.6)
87	21:15	10.80	2126	21:17	45	0.4	
88	21:30	10.80	2119	21:32	45	0.4	
89	21:45						
90	22:00				47	1.4	
	10.12	10.72			46	736	
	10.11	54.05			45	2,970	
	10.8	711.4			461	220	
	10.94	99.07					

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APPENDIX B

Spread Sheet Formulas

~1700 GPM

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	ICF KAI										240		
2	Date: 34764								entration (Baseline)= 0.4				
3			ge test flow = =AVERAGE(E18:E91)		=D3*3.785306				de loss due to alum ~ 0.1	=J3/J4			
4				Theoretical Resedence Time (T)= =1605000/$E$3					oride Dosage (Co) = 620.78	=$I$4*17.6/$E$3			
5													
6													
7		Time	Time t (h:mm)	Time t (min)	Flowrate (gpm)	Fluoride Measured (mg/L)	Tracer concentration (mg/L)	Incrimental Area (mg-min/L)	Cumulative Area (mg-min/L)	C/Co	1-C/Co	Log_{10}(1-C/Co)	t/T
8													
9	Background	0.395833333			720	0.3	0	N/A	N/A				
10		0.399305555			1163	0.4	0	N/A	N/A				
11		0.402777777			1451	0.3	0	N/A	N/A				
12		0.40625			1733	0.4	0	N/A	N/A				
13		0.409722222			2028	0.3	0	N/A	N/A				
14		0.413194444			2240	0.4	0	N/A	N/A				
15													
16		0.423611111			2404								
17	Start injection	0.430555555	=B17-$B$17	0					0				
18		0.4375	=B18-$B$17	10	2359	0.5	=F18-0.4	0	=I17+H18	=G18/$J$4	=1-J18	=LOG10(K18)	=D18/$E$4
19		0.444444444	=B19-$B$17	20	2354	0.5	=F19-0.4	=G19*(D19-D18)	=I18+H19	=G19/$J$4	=1-J19	=LOG10(K19)	=D19/$E$4
20		0.451388888	=B20-$B$17	30	2344	0.4	=F20-0.4	=G20*(D20-D19)	=I19+H20	=G20/$J$4	=1-J20	=LOG10(K20)	=D20/$E$4
21		0.458333333	=B21-$B$17	40	2398	0.4	=F21-0.4	=G21*(D21-D20)	=I20+H21	=G21/$J$4	=1-J21	=LOG10(K21)	=D21/$E$4
22		0.465277777	=B22-$B$17	50	2408	0.4	=F22-0.4	=G22*(D22-D21)	=I21+H22	=G22/$J$4	=1-J22	=LOG10(K22)	=D22/$E$4
23		0.472222222	=B23-$B$17	60	2411	0.4	=F23-0.4	=G23*(D23-D22)	=I22+H23	=G23/$J$4	=1-J23	=LOG10(K23)	=D23/$E$4
24		0.479166666	=B24-$B$17	70	2440	0.4	=F24-0.4	=G24*(D24-D23)	=I23+H24	=G24/$J$4	=1-J24	=LOG10(K24)	=D24/$E$4
25		0.486111111	=B25-$B$17	80	2441	0.5	=F25-0.4	=G25*(D25-D24)	=I24+H25	=G25/$J$4	=1-J25	=LOG10(K25)	=D25/$E$4
26		0.493055555	=B26-$B$17	90	2411	0.5	=F26-0.4	=G26*(D26-D25)	=I25+H26	=G26/$J$4	=1-J26	=LOG10(K26)	=D26/$E$4
27		0.5	=B27-$B$17	100	2433	0.5	=F27-0.4	=G27*(D27-D26)	=I26+H27	=G27/$J$4	=1-J27	=LOG10(K27)	=D27/$E$4
28		0.506944444	=B28-$B$17	110	2424	0.6	=F28-0.4	=G28*(D28-D27)	=I27+H28	=G28/$J$4	=1-J28	=LOG10(K28)	=D28/$E$4
29		0.513888888	=B29-$B$17	120	2424	0.6	=F29-0.4	=G29*(D29-D28)	=I28+H29	=G29/$J$4	=1-J29	=LOG10(K29)	=D29/$E$4
30		0.520833333	=B30-$B$17	130	2408	0.7	=F30-0.4	=G30*(D30-D29)	=I29+H30	=G30/$J$4	=1-J30	=LOG10(K30)	=D30/$E$4
31		0.524305555	=B31-$B$17	135	2413	0.7	=F31-0.4	=G31*(D31-D30)	=I30+H31	=G31/$J$4	=1-J31	=LOG10(K31)	=D31/$E$4
32		0.527777777	=B32-$B$17	140	2434	0.7	=F32-0.4	=G32*(D32-D31)	=I31+H32	=G32/$J$4	=1-J32	=LOG10(K32)	=D32/$E$4
33		0.531250000	=B33-$B$17	145	2456	0.8	=F33-0.4	=G33*(D33-D32)	=I32+H33	=G33/$J$4	=1-J33	=LOG10(K33)	=D33/$E$4
34		0.534722222	=B34-$B$17	150	2431	0.8	=F34-0.4	=G34*(D34-D33)	=I33+H34	=G34/$J$4	=1-J34	=LOG10(K34)	=D34/$E$4
35		0.538194444	=B35-$B$17	155	2410	0.8	=F35-0.4	=G35*(D35-D34)	=I34+H35	=G35/$J$4	=1-J35	=LOG10(K35)	=D35/$E$4
36		0.541666666	=B36-$B$17	160	2447	0.9	=F36-0.4	=G36*(D36-D35)	=I35+H36	=G36/$J$4	=1-J36	=LOG10(K36)	=D36/$E$4
37		0.545138888	=B37-$B$17	165	2459	1	=F37-0.4	=G37*(D37-D36)	=I36+H37	=G37/$J$4	=1-J37	=LOG10(K37)	=D37/$E$4
38		0.548611111	=B38-$B$17	170	2432	0.9	=F38-0.4	=G38*(D38-D37)	=I37+H38	=G38/$J$4	=1-J38	=LOG10(K38)	=D38/$E$4
39		0.552083333	=B39-$B$17	175	2416	1	=F39-0.4	=G39*(D39-D38)	=I38+H39	=G39/$J$4	=1-J39	=LOG10(K39)	=D39/$E$4
40		0.555555555	=B40-$B$17	180	2398	1	=F40-0.4	=G40*(D40-D39)	=I39+H40	=G40/$J$4	=1-J40	=LOG10(K40)	=D40/$E$4
41		0.559027777	=B41-$B$17	185	2403	1	=F41-0.4	=G41*(D41-D40)	=I40+H41	=G41/$J$4	=1-J41	=LOG10(K41)	=D41/$E$4
42		0.562500000	=B42-$B$17	190	2408	1.1	=F42-0.4	=G42*(D42-D41)	=I41+H42	=G42/$J$4	=1-J42	=LOG10(K42)	=D42/$E$4
43		0.565972222	=B43-$B$17	195	2386	1.1	=F43-0.4	=G43*(D43-D42)	=I42+H43	=G43/$J$4	=1-J43	=LOG10(K43)	=D43/$E$4
44		0.569444444	=B44-$B$17	200	2388	1.1	=F44-0.4	=G44*(D44-D43)	=I43+H44	=G44/$J$4	=1-J44	=LOG10(K44)	=D44/$E$4
45		0.572916666	=B45-$B$17	205	2375	1.1	=F45-0.4	=G45*(D45-D44)	=I44+H45	=G45/$J$4	=1-J45	=LOG10(K45)	=D45/$E$4
46		0.576388888	=B46-$B$17	210	2380	1.2	=F46-0.4	=G46*(D46-D45)	=I45+H46	=G46/$J$4	=1-J46	=LOG10(K46)	=D46/$E$4
47		0.579861111	=B47-$B$17	215	2367	1.2	=F47-0.4	=G47*(D47-D46)	=I46+H47	=G47/$J$4	=1-J47	=LOG10(K47)	=D47/$E$4
48		0.583333333	=B48-$B$17	220	2382	1.2	=F48-0.4	=G48*(D48-D47)	=I47+H48	=G48/$J$4	=1-J48	=LOG10(K48)	=D48/$E$4
49		0.586805555	=B49-$B$17	225	2384	1.2	=F49-0.4	=G49*(D49-D48)	=I48+H49	=G49/$J$4	=1-J49	=LOG10(K49)	=D49/$E$4
50		0.590277777	=B50-$B$17	230	2383	1.3	=F50-0.4	=G50*(D50-D49)	=I49+H50	=G50/$J$4	=1-J50	=LOG10(K50)	=D50/$E$4
51		0.593750000	=B51-$B$17	235	2363	1.2	=F51-0.4	=G51*(D51-D50)	=I50+H51	=G51/$J$4	=1-J51	=LOG10(K51)	=D51/$E$4
52		0.597222222	=B52-$B$17	240	2386	1.2	=F52-0.4	=G52*(D52-D51)	=I51+H52	=G52/$J$4	=1-J52	=LOG10(K52)	=D52/$E$4
53		0.600694444	=B53-$B$17	245	2385	1.3	=F53-0.4	=G53*(D53-D52)	=I52+H53	=G53/$J$4	=1-J53	=LOG10(K53)	=D53/$E$4
54		0.604166666	=B54-$B$17	250	2372	1.3	=F54-0.4	=G54*(D54-D53)	=I53+H54	=G54/$J$4	=1-J54	=LOG10(K54)	=D54/$E$4
55		0.607638888	=B55-$B$17	255	2365	1.3	=F55-0.4	=G55*(D55-D54)	=I54+H55	=G55/$J$4	=1-J55	=LOG10(K55)	=D55/$E$4
56		0.611111111	=B56-$B$17	260	2375	1.3	=F56-0.4	=G56*(D56-D55)	=I55+H56	=G56/$J$4	=1-J56	=LOG10(K56)	=D56/$E$4
57		0.614583333	=B57-$B$17	265	2360	1.2	=F57-0.4	=G57*(D57-D56)	=I56+H57	=G57/$J$4	=1-J57	=LOG10(K57)	=D57/$E$4
58		0.618055555	=B58-$B$17	270	2374	1.3	=F58-0.4	=G58*(D58-D57)	=I57+H58	=G58/$J$4	=1-J58	=LOG10(K58)	=D58/$E$4
59		0.621527777	=B59-$B$17	275	2367	1.4	=F59-0.4	=G59*(D59-D58)	=I58+H59	=G59/$J$4	=1-J59	=LOG10(K59)	=D59/$E$4
60		0.625000000	=B60-$B$17	280	2356	1.3	=F60-0.4	=G60*(D60-D59)	=I59+H60	=G60/$J$4	=1-J60	=LOG10(K60)	=D60/$E$4
61		0.628472222	=B61-$B$17	285	2370	1.4	=F61-0.4	=G61*(D61-D60)	=I60+H61	=G61/$J$4	=1-J61	=LOG10(K61)	=D61/$E$4
62		0.631944444	=B62-$B$17	290	2389	1.4	=F62-0.4	=G62*(D62-D61)	=I61+H62	=G62/$J$4	=1-J62	=LOG10(K62)	=D62/$E$4
63		0.635416666	=B63-$B$17	295	2378	1.4	=F63-0.4	=G63*(D63-D62)	=I62+H63	=G63/$J$4	=1-J63	=LOG10(K63)	=D63/$E$4
64		0.638888888	=B64-$B$17	300	2345	1.4	=F64-0.4	=G64*(D64-D63)	=I63+H64	=G64/$J$4	=1-J64	=LOG10(K64)	=D64/$E$4
65		0.642361111	=B65-$B$17	305	2384	1.4	=F65-0.4	=G65*(D65-D64)	=I64+H65	=G65/$J$4	=1-J65	=LOG10(K65)	=D65/$E$4
66		0.645833333	=B66-$B$17	310	2398	1.4	=F66-0.4	=G66*(D66-D65)	=I65+H66	=G66/$J$4	=1-J66	=LOG10(K66)	=D66/$E$4
67		0.652777777	=B67-$B$17	320	2389	1.4	=F67-0.4	=G67*(D67-D66)	=I66+H67	=G67/$J$4	=1-J67	=LOG10(K67)	=D67/$E$4
68		0.659722222	=B68-$B$17	330	2368	1.4	=F68-0.4	=G68*(D68-D67)	=I67+H68	=G68/$J$4	=1-J68	=LOG10(K68)	=D68/$E$4
69		0.666666666	=B69-$B$17	340	2353	1.4	=F69-0.4	=G69*(D69-D68)	=I68+H69	=G69/$J$4	=1-J69	=LOG10(K69)	=D69/$E$4
70		0.673611111	=B70-$B$17	350	2342	1.4	=F70-0.4	=G70*(D70-D69)	=I69+H70	=G70/$J$4	=1-J70	=LOG10(K70)	=D70/$E$4
71	Feed Off	0.680555555	=B71-$B$17	360	2341	1.5	=F71-0.4	=G71*(D71-D70)	=I70+H71	=G71/$J$4	=1-J71	=LOG10(K71)	=D71/$E$4
72		0.687500000	=B72-$B$17	370	2374	1.4	=F72-0.4	=G72*(D72-D71)	=I71+H72				
73		0.697916666	=B73-$B$17	385	2383	1.5	=F73-0.4	=G73*(D73-D72)	=I72+H73				
74		0.708333333	=B74-$B$17	400	2373	1.4	=F74-0.4	=G74*(D74-D73)	=I73+H74				
75		0.718749999	=B75-$B$17	415	2352	1.4	=F75-0.4	=G75*(D75-D74)	=I74+H75				

2400 gpm

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	ICF KAI										240		
2	Date: 34764								entration (Baseline)= 0.4				
3			ge test flow =	=AVERAGE(E18:E91)	=D3*3.785308				de loss due to alum = 0.1	=J3/J4			
4				Theoretical Resedence Time (T)= =1605000/$E$3					oride Dosage (Co) = 820.78	=$I$4*17.6/$E$3			
5													
6													
7		Time	Time t (h:mm)	Time t (min)	Flowrate (gpm)	Fluoride Measured (mg/L)	Tracer concentration (mg/L)	Incrimental Area (mg-min/L)	Cumulative Area (mg-min/L)	C/Co	1-C/Co	$Log_{10}(1-C/Co)$	t/T
8													
76		0.729166666	=B76-$B$17	430	2366	1.4	=F76-0.4	=G76*(D76-D75)	=I75+H76				
77		0.739583333	=B77-$B$17	445	2346	1.3	=F77-0.4	=G77*(D77-D76)	=I76+H77				
78		0.749999999	=B78-$B$17	460	2351	1.3	=F78-0.4	=G78*(D78-D77)	=I77+H78				
79		0.760416666	=B79-$B$17	475	2332	1.2	=F79-0.4	=G79*(D79-D78)	=I78+H79				
80		0.770833333	=B80-$B$17	490	2343	1.1	=F80-0.4	=G80*(D80-D79)	=I79+H80				
81		0.781249999	=B81-$B$17	505	2342	1	=F81-0.4	=G81*(D81-D80)	=I80+H81				
82		0.791666666	=B82-$B$17	520	2341	0.9	=F82-0.4	=G82*(D82-D81)	=I81+H82				
83		0.802083333	=B83-$B$17	535	2337	0.9	=F83-0.4	=G83*(D83-D82)	=I82+H83				
84		0.812499999	=B84-$B$17	550	2345	0.8	=F84-0.4	=G84*(D84-D83)	=I83+H84				
85		0.822916666	=B85-$B$17	565	2339	0.7	=F85-0.4	=G85*(D85-D84)	=I84+H85				
86		0.833333333	=B86-$B$17	580	2341	0.7	=F86-0.4	=G86*(D86-D85)	=I85+H86				
87		0.843749999	=B87-$B$17	595	2329	0.7	=F87-0.4	=G87*(D87-D86)	=I86+H87				
88		0.854166666	=B88-$B$17	610	2337	0.6	=F88-0.4	=G88*(D88-D87)	=I87+H88				
89		0.864583333	=B89-$B$17	625	2336	0.6	=F89-0.4	=G89*(D89-D88)	=I88+H89				
90		0.874999999	=B90-$B$17	640	2328	0.5	=F90-0.4	=G90*(D90-D89)	=I89+H90				
91		0.885416666	=B91-$B$17	655	2340	0.5	=F91-0.4	=G91*(D91-D90)	=I90+H91				
92			e Time (T_{10}) =	=((LOG10(0.9)-$C$114)/$C$115)*$E$4					s Fluoride Injected =	=$I$4*360*17.6/1000			
93									Fluoride Recovered =	=$I$91*$E$3/1000			
94			Coefficient =	=$C$102					Fluoride Recovered =	=$I$93/$I$92			

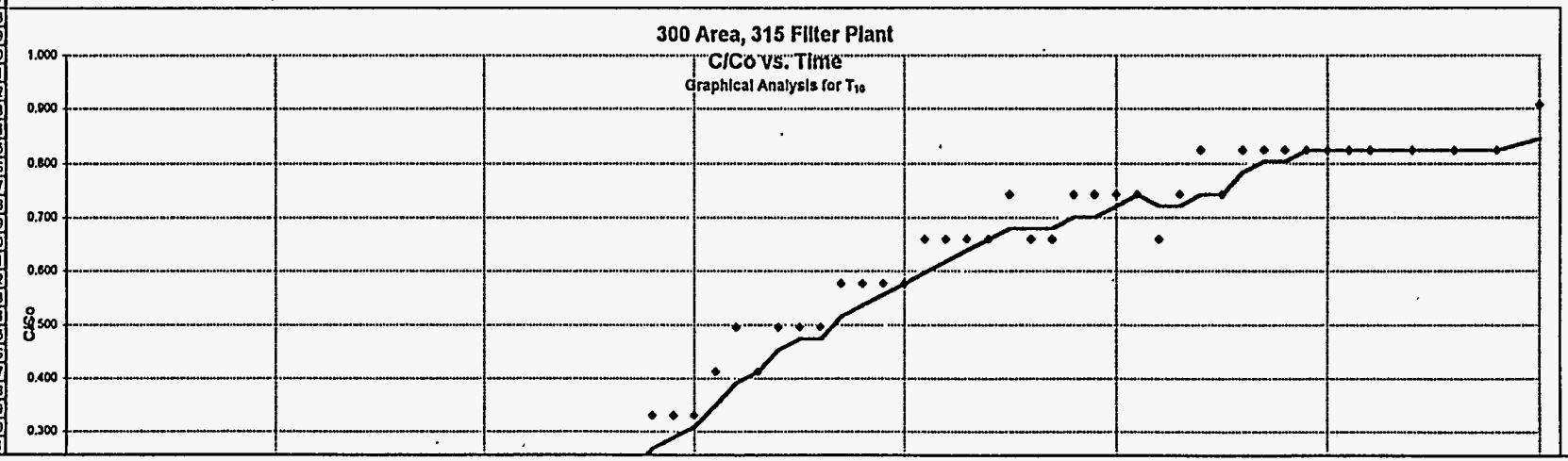
SUMMARY O

Regressio	
Multiple R	0.975984634
R Square	0.952546006
Adjusted R S	0.951491473
Standard Erro	0.056745113
Observations	47

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	2.9085909525717	2.9085909525717	903.2868954700	1.99138991335831
Residual	45	0.144900356157186	0.00322000791460		
Total	46	3.05349130872889			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.000%*	*Upper 95.000%*
Intercept	0.300440620	0.0262356533462038	11.4516157256624	6.300423341811	0.24759930439987	0.35328193646496	0.247590304399871	0.353281936464
X Variable 1	-0.605909356	0.0201601985210871	-30.054731665247	1.991389913358	-0.6465140792780	-0.565304634460765	-0.64651407927802	-0.56530463446



	A	B	C	D	E	F	G	H	I	J	K	L	M
1	ICF KAISER HANF										216		
2	Date: 34781								centration (Baseline)= 0.4				
3			age test flow = =AVERAGE(E18:E104)		=D3*3.785306				lde loss due to alum = 0.2	=J3/J4			
4			Theoretical Resedence Time (T)= =1605000/$E$3						de Dosage (Co) = 580	=$I$4*17.6/$E$3			
5													
6 7 8		Time	Time t (h:mm)	Time t (min)	Flowrate (gpm)	Fluoride Measured (mg/L)	Tracer oncentratio (mg/L)	Incremental Area (mg-min/L)	Cumulative Area (mg-min/L)	C/Co	1-C/Co	Log10(1-C/Co)	I/T
9	Background	0.3645833			495	0.3	0	N/A	N/A				
10		0.3680555			493	0.4	0	N/A	N/A				
11		0.3715277			438	0.4	0	N/A	N/A				
12		0.375			775	0.4	0	N/A	N/A				
13		0.3784722			1318	0.4	0	N/A	N/A				
14		0.3819444			1567	0.3	0	N/A	N/A				
15													
16													
17	Start Injection	0.4097222	=B17-$B$17	0					0				
18		0.4166666	=B18-$B$17	10	2161	0.3	=F18-0.4	0	=I17+H18	=G18/$J$4	=1-J18	=LOG10(K18)	=D18/$E$4
19		0.4236111	=B19-$B$17	20	2106	0.4	=F19-0.4	=G19*(D19-D18)	=I18+H19	=G19/$J$4	=1-J19	=LOG10(K19)	=D19/$E$4
20		0.4305555	=B20-$B$17	30	2108	0.4	=F20-0.4	=G20*(D20-D19)	=I19+H20	=G20/$J$4	=1-J20	=LOG10(K20)	=D20/$E$4
21		0.4375	=B21-$B$17	40	2092	0.4	=F21-0.4	=G21*(D21-D20)	=I20+H21	=G21/$J$4	=1-J21	=LOG10(K21)	=D21/$E$4
22		0.4444444	=B22-$B$17	50	2105	0.4	=F22-0.4	=G22*(D22-D21)	=I21+H22	=G22/$J$4	=1-J22	=LOG10(K22)	=D22/$E$4
23		0.4513888	=B23-$B$17	60	2159	0.4	=F23-0.4	=G23*(D23-D22)	=I22+H23	=G23/$J$4	=1-J23	=LOG10(K23)	=D23/$E$4
24		0.4583333	=B24-$B$17	70	2118	0.4	=F24-0.4	=G24*(D24-D23)	=I23+H24	=G24/$J$4	=1-J24	=LOG10(K24)	=D24/$E$4
25		0.4652777	=B25-$B$17	80	2124	0.4	=F25-0.4	=G25*(D25-D24)	=I24+H25	=G25/$J$4	=1-J25	=LOG10(K25)	=D25/$E$4
26		0.4722222	=B26-$B$17	90	2133	0.4	=F26-0.4	=G26*(D26-D25)	=I25+H26	=G26/$J$4	=1-J26	=LOG10(K26)	=D26/$E$4
27		0.4791666	=B27-$B$17	100	2123	0.4	=F27-0.4	=G27*(D27-D26)	=I26+H27	=G27/$J$4	=1-J27	=LOG10(K27)	=D27/$E$4
28		0.4861111	=B28-$B$17	110	2098	0.4	=F28-0.4	=G28*(D28-D27)	=I27+H28	=G28/$J$4	=1-J28	=LOG10(K28)	=D28/$E$4
29		0.4930555	=B29-$B$17	120	2172	0.5	=F29-0.4	=G29*(D29-D28)	=I28+H29	=G29/$J$4	=1-J29	=LOG10(K29)	=D29/$E$4
30		0.5	=B30-$B$17	130	2150	0.5	=F30-0.4	=G30*(D30-D29)	=I29+H30	=G30/$J$4	=1-J30	=LOG10(K30)	=D30/$E$4
31		0.5034722	=B31-$B$17	135	2128	0.5	=F31-0.4	=G31*(D31-D30)	=I30+H31	=G31/$J$4	=1-J31	=LOG10(K31)	=D31/$E$4
32		0.5069444	=B32-$B$17	140	2128	0.5	=F32-0.4	=G32*(D32-D31)	=I31+H32	=G32/$J$4	=1-J32	=LOG10(K32)	=D32/$E$4
33		0.5104166	=B33-$B$17	145	2118	0.4	=F33-0.4	=G33*(D33-D32)	=I32+H33	=G33/$J$4	=1-J33	=LOG10(K33)	=D33/$E$4
34		0.5138888	=B34-$B$17	150	2160	0.4	=F34-0.4	=G34*(D34-D33)	=I33+H34	=G34/$J$4	=1-J34	=LOG10(K34)	=D34/$E$4
35		0.5173611	=B35-$B$17	155	2130	0.5	=F35-0.4	=G35*(D35-D34)	=I34+H35	=G35/$J$4	=1-J35	=LOG10(K35)	=D35/$E$4
36		0.5208333	=B36-$B$17	160	2135	0.5	=F36-0.4	=G36*(D36-D35)	=I35+H36	=G36/$J$4	=1-J36	=LOG10(K36)	=D36/$E$4
37		0.5243055	=B37-$B$17	165	2146	0.5	=F37-0.4	=G37*(D37-D36)	=I36+H37	=G37/$J$4	=1-J37	=LOG10(K37)	=D37/$E$4
38		0.5277777	=B38-$B$17	170	2148	0.5	=F38-0.4	=G38*(D38-D37)	=I37+H38	=G38/$J$4	=1-J38	=LOG10(K38)	=D38/$E$4
39		0.53125	=B39-$B$17	175	2176	0.6	=F39-0.4	=G39*(D39-D38)	=I38+H39	=G39/$J$4	=1-J39	=LOG10(K39)	=D39/$E$4
40		0.5347222	=B40-$B$17	180	2184	0.5	=F40-0.4	=G40*(D40-D39)	=I39+H40	=G40/$J$4	=1-J40	=LOG10(K40)	=D40/$E$4
41		0.5381944	=B41-$B$17	185	2142	0.5	=F41-0.4	=G41*(D41-D40)	=I40+H41	=G41/$J$4	=1-J41	=LOG10(K41)	=D41/$E$4
42		0.5416666	=B42-$B$17	190	2138	0.6	=F42-0.4	=G42*(D42-D41)	=I41+H42	=G42/$J$4	=1-J42	=LOG10(K42)	=D42/$E$4
43		0.5451388	=B43-$B$17	195	2165	0.5	=F43-0.4	=G43*(D43-D42)	=I42+H43	=G43/$J$4	=1-J43	=LOG10(K43)	=D43/$E$4
44		0.5486111	=B44-$B$17	200	2170	0.6	=F44-0.4	=G44*(D44-D43)	=I43+H44	=G44/$J$4	=1-J44	=LOG10(K44)	=D44/$E$4
45		0.5520833	=B45-$B$17	205	2239	0.6	=F45-0.4	=G45*(D45-D44)	=I44+H45	=G45/$J$4	=1-J45	=LOG10(K45)	=D45/$E$4
46		0.5555555	=B46-$B$17	210	2182	0.7	=F46-0.4	=G46*(D46-D45)	=I45+H46	=G46/$J$4	=1-J46	=LOG10(K46)	=D46/$E$4
47		0.5590277	=B47-$B$17	215	2063	0.7	=F47-0.4	=G47*(D47-D46)	=I46+H47	=G47/$J$4	=1-J47	=LOG10(K47)	=D47/$E$4
48		0.5625	=B48-$B$17	220	2071	0.7	=F48-0.4	=G48*(D48-D47)	=I47+H48	=G48/$J$4	=1-J48	=LOG10(K48)	=D48/$E$4
49		0.5659722	=B49-$B$17	225	2071	0.7	=F49-0.4	=G49*(D49-D48)	=I48+H49	=G49/$J$4	=1-J49	=LOG10(K49)	=D49/$E$4
50		0.5694444	=B50-$B$17	230	2110	0.7	=F50-0.4	=G50*(D50-D49)	=I49+H50	=G50/$J$4	=1-J50	=LOG10(K50)	=D50/$E$4
51		0.5729166	=B51-$B$17	235	2200	0.7	=F51-0.4	=G51*(D51-D50)	=I50+H51	=G51/$J$4	=1-J51	=LOG10(K51)	=D51/$E$4
52		0.5763888	=B52-$B$17	240	2150	0.8	=F52-0.4	=G52*(D52-D51)	=I51+H52	=G52/$J$4	=1-J52	=LOG10(K52)	=D52/$E$4
53		0.5798611	=B53-$B$17	245	2059	0.7	=F53-0.4	=G53*(D53-D52)	=I52+H53	=G53/$J$4	=1-J53	=LOG10(K53)	=D53/$E$4
54		0.5833333	=B54-$B$17	250	2072	0.7	=F54-0.4	=G54*(D54-D53)	=I53+H54	=G54/$J$4	=1-J54	=LOG10(K54)	=D54/$E$4
55		0.5868055	=B55-$B$17	255	2136	0.7	=F55-0.4	=G55*(D55-D54)	=I54+H55	=G55/$J$4	=1-J55	=LOG10(K55)	=D55/$E$4

	A	B	C	D	E	F	G	H	I	J	K	L	M
56		0.5902777	=B56-$B$17	260	2117	0.9	=F56-0.4	=G56*(D56-D55)	=I55+H56	=G56/$J$4	=1-J56	=LOG10(K56)	=D56/$E$4
57		0.59375	=B57-$B$17	265	2107	0.7	=F57-0.4	=G57*(D57-D56)	=I56+H57	=G57/$J$4	=1-J57	=LOG10(K57)	=D57/$E$4
58		0.5972222	=B58-$B$17	270	2202	0.8	=F58-0.4	=G58*(D58-D57)	=I57+H58	=G58/$J$4	=1-J58	=LOG10(K58)	=D58/$E$4
59		0.6006944	=B59-$B$17	275	2105	0.8	=F59-0.4	=G59*(D59-D58)	=I58+H59	=G59/$J$4	=1-J59	=LOG10(K59)	=D59/$E$4
60		0.6041666	=B60-$B$17	280	2100	0.7	=F60-0.4	=G60*(D60-D59)	=I59+H60	=G60/$J$4	=1-J60	=LOG10(K60)	=D60/$E$4
61		0.6076388	=B61-$B$17	285	2086	0.7	=F61-0.4	=G61*(D61-D60)	=I60+H61	=G61/$J$4	=1-J61	=LOG10(K61)	=D61/$E$4
62		0.6111111	=B62-$B$17	290	2101	0.7	=F62-0.4	=G62*(D62-D61)	=I61+H62	=G62/$J$4	=1-J62	=LOG10(K62)	=D62/$E$4
63		0.6145833	=B63-$B$17	295	2116	0.9	=F63-0.4	=G63*(D63-D62)	=I62+H63	=G63/$J$4	=1-J63	=LOG10(K63)	=D63/$E$4
64		0.6180555	=B64-$B$17	300	2109	0.8	=F64-0.4	=G64*(D64-D63)	=I63+H64	=G64/$J$4	=1-J64	=LOG10(K64)	=D64/$E$4
65		0.6215277	=B65-$B$17	305	2111	0.9	=F65-0.4	=G65*(D65-D64)	=I64+H65	=G65/$J$4	=1-J65	=LOG10(K65)	=D65/$E$4
66		0.625	=B66-$B$17	310	2100	1	=F66-0.4	=G66*(D66-D65)	=I65+H66	=G66/$J$4	=1-J66	=LOG10(K66)	=D66/$E$4
67		0.6284722	=B67-$B$17	315	2112	1	=F67-0.4	=G67*(D67-D66)	=I66+H67	=G67/$J$4	=1-J67	=LOG10(K67)	=D67/$E$4
68		0.6319444	=B68-$B$17	320	2141	1.1	=F68-0.4	=G68*(D68-D67)	=I67+H68	=G68/$J$4	=1-J68	=LOG10(K68)	=D68/$E$4
69		0.6354166	=B69-$B$17	325	2163	1	=F69-0.4	=G69*(D69-D68)	=I68+H69	=G69/$J$4	=1-J69	=LOG10(K69)	=D69/$E$4
70		0.6388888	=B70-$B$17	330	2136	1	=F70-0.4	=G70*(D70-D69)	=I69+H70	=G70/$J$4	=1-J70	=LOG10(K70)	=D70/$E$4
71		0.6423611	=B71-$B$17	335	2093	1.1	=F71-0.4	=G71*(D71-D70)	=I70+H71	=G71/$J$4	=1-J71	=LOG10(K71)	=D71/$E$4
72		0.6458333	=B72-$B$17	340	2136	1	=F72-0.4	=G72*(D72-D71)	=I71+H72	=G72/$J$4	=1-J72	=LOG10(K72)	=D72/$E$4
73		0.6493055	=B73-$B$17	345	2132	1	=F73-0.4	=G73*(D73-D72)	=I72+H73	=G73/$J$4	=1-J73	=LOG10(K73)	=D73/$E$4
74		0.6527777	=B74-$B$17	350	2111	1.1	=F74-0.4	=G74*(D74-D73)	=I73+H74	=G74/$J$4	=1-J74	=LOG10(K74)	=D74/$E$4
75		0.6562499	=B75-$B$17	355	2114	0.9	=F75-0.4	=G75*(D75-D74)	=I74+H75	=G75/$J$4	=1-J75	=LOG10(K75)	=D75/$E$4
76		0.6597222	=B76-$B$17	360	2106	1	=F76-0.4	=G76*(D76-D75)	=I75+H76	=G76/$J$4	=1-J76	=LOG10(K76)	=D76/$E$4
77		0.6631944	=B77-$B$17	365	2128	1.1	=F77-0.4	=G77*(D77-D76)	=I76+H77	=G77/$J$4	=1-J77	=LOG10(K77)	=D77/$E$4
78		0.6666666	=B78-$B$17	370	2114	1.2	=F78-0.4	=G78*(D78-D77)	=I77+H78	=G78/$J$4	=1-J78	=LOG10(K78)	=D78/$E$4
79		0.6701388	=B79-$B$17	375	2087	1.1	=F79-0.4	=G79*(D79-D78)	=I78+H79	=G79/$J$4	=1-J79	=LOG10(K79)	=D79/$E$4
80		0.6736111	=B80-$B$17	380	2111	1.2	=F80-0.4	=G80*(D80-D79)	=I79+H80	=G80/$J$4	=1-J80	=LOG10(K80)	=D80/$E$4
81		0.6770833	=B81-$B$17	385	2112	1.1	=F81-0.4	=G81*(D81-D80)	=I80+H81	=G81/$J$4	=1-J81	=LOG10(K81)	=D81/$E$4
82		0.6805555	=B82-$B$17	390	2107	1.2	=F82-0.4	=G82*(D82-D81)	=I81+H82	=G82/$J$4	=1-J82	=LOG10(K82)	=D82/$E$4
83	Feed Off	0.6840277	=B83-$B$17	395	2143	1.2	=F83-0.4	=G83*(D83-D82)	=I82+H83	=G83/$J$4	=1-J83	=LOG10(K83)	=D83/$E$4
84		0.6874999	=B84-$B$17	400	2115	1	=F84-0.4	=G84*(D84-D83)	=I83+H84	=G84/$J$4	=1-J84	=LOG10(K84)	=D84/$E$4
85		0.6979166	=B85-$B$17	415	2131	1	=F85-0.4	=G85*(D85-D84)	=I84+H85				
86		0.7083333	=B86-$B$17	430	2153	1	=F86-0.4	=G86*(D86-D85)	=I85+H86				
87		0.7187500	=B87-$B$17	445	2108	1	=F87-0.4	=G87*(D87-D86)	=I86+H87				
88		0.7291666	=B88-$B$17	460	2112	1	=F88-0.4	=G88*(D88-D87)	=I87+H88				
89		0.7395833	=B89-$B$17	475	2108	1	=F89-0.4	=G89*(D89-D88)	=I88+H89				
90		0.7500000	=B90-$B$17	490	2088	1	=F90-0.4	=G90*(D90-D89)	=I89+H90				
91		0.7604166	=B91-$B$17	505	2127	1	=F91-0.4	=G91*(D91-D90)	=I90+H91				
92		0.7708333	=B92-$B$17	520	2131	0.8	=F92-0.4	=G92*(D92-D91)	=I91+H92				
93		0.7812500	=B93-$B$17	535	2134	1	=F93-0.4	=G93*(D93-D92)	=I92+H93				
94		0.7916666	=B94-$B$17	550	2140	0.8	=F94-0.4	=G94*(D94-D93)	=I93+H94				
95		0.8020833	=B95-$B$17	565	2140	0.8	=F95-0.4	=G95*(D95-D94)	=I94+H95				
96		0.8125000	=B96-$B$17	580	2129	0.9	=F96-0.4	=G96*(D96-D95)	=I95+H96				
97		0.8229166	=B97-$B$17	595	2134	0.8	=F97-0.4	=G97*(D97-D96)	=I96+H97				
98		0.8333333	=B98-$B$17	610	2142	0.6	=F98-0.4	=G98*(D98-D97)	=I97+H98				
99		0.8437500	=B99-$B$17	625	2126	0.8	=F99-0.4	=G99*(D99-D98)	=I98+H99				
100		0.8611111	=B100-$B$17	650	2131	0.6	=F100-0.4	=G100*(D100-D99	=I99+H100				
101		0.8645833	=B101-$B$17	655	2126	0.6	=F101-0.4	=G101*(D101-D10	=I100+H101				
102		0.875	=B102-$B$17	670	2120	0.4	=F102-0.4	=G102*(D102-D10	=I101+H102				
103		0.8854166	=B103-$B$17	685	2126	0.4	=F103-0.4	=G103*(D103-D10	=I102+H103				
104		0.8958333	=B104-$B$17	700	2119	0.4	=F104-0.4	=G104*(D104-D10	=I103+H104				
105			) Time (T10) = =((LOG10(0.9)-$C$143)/$C$144)*$E$4						Fluoride Injected = =$I$4*395*17.6/1000				
106									oride Recovered = =$I$104*$E$3/1000				
107			n Coefficient = =$C$131						oride Recovered = =$I$106/$I$105				
108													
109													
110													
111													

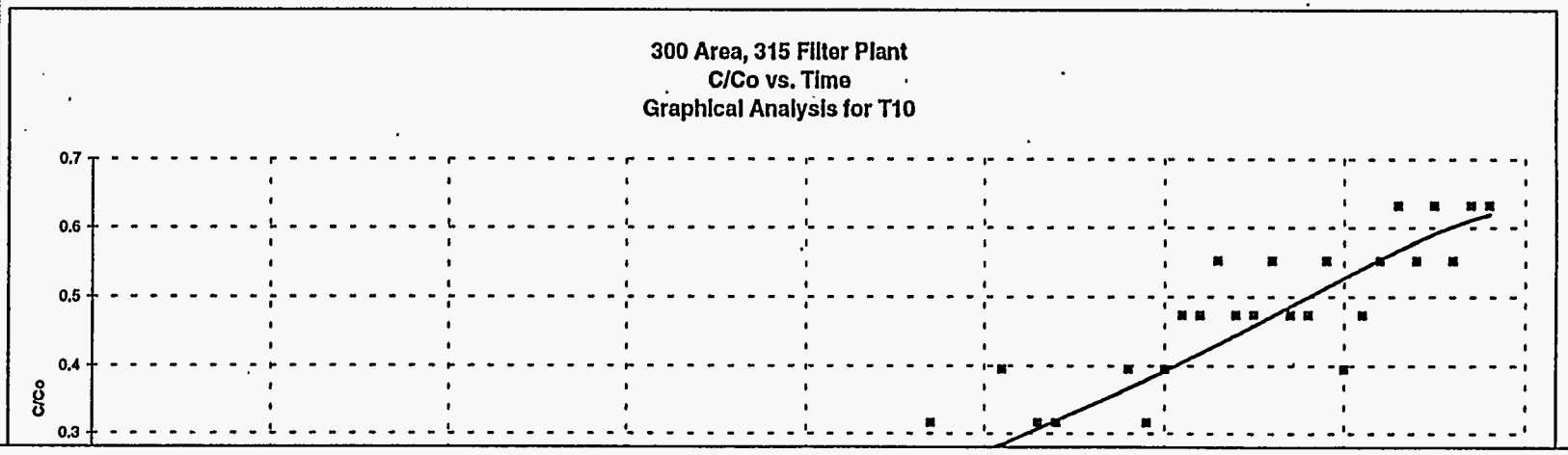
SUMMAR

Regress	
Multiple R	0.9351759610
R Square	0.8745540782
Adjusted F	0.8716850160
Standard E	0.0446383462
Observatic	49

ANOVA

	df	SS	MS	F	ignificance F
Regressio	1	0.652896248989564	0.652896248989	327.66345	8.03811421
Residual	47	0.0936513518568435	0.001992581956		
Total	48	0.746547600946407			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.000%	Upper 95.000%
Intercept	0.2584365460	0.0256070717468724	10.09238965655	2.378138(	0.206921810	0.309951281100910	0.206921810964925	0.309951281100911
X Variable	-0.3254898151	0.0179813853196062	-18.10147605307	8.038114;	-0.3616634	-0.2893157685519	-0.361663462974199	-0.2893157685519



APPENDIX C

Spread Sheet Calculations

ICF KAISER HANFORD COMPANY					315 Filter Plant, 300 Area						2400 GPM Tracer Test	
Date: 3/6/95					Background Fluoride Concentration (Baseline)= 0.40 mg/L							
Average test flow = 2380 gpm (9009 L/min)					Fluoride loss due to alum ~ 0.10 mg/L (8%)							
Theoretical Resedence Time (T)= 178 min					Applied Fluoride Dosage (Co) = 620.8 ml/min (1.21 mg/L)							
	Time	Time t (h:mm)	Time t (min)	Flowrate (gpm)	Fluoride Measured (mg/L)	Tracer concentration (mg/L)	Incrimental Area (mg-min/L)	Cumulative Area (mg-min/L)	C/Co	1-C/Co	$Log_{10}(1-C/Co)$	t/T
Background	9:30			720	0.3	0	N/A	N/A				
	9:35			1163	0.4	0	N/A	N/A				
	9:40			1451	0.3	0	N/A	N/A				
	9:45			1733	0.4	0	N/A	N/A				
	9:50			2026	0.3	0	N/A	N/A				
	9:55			2240	0.4	0	N/A	N/A				
	10:10			2404								
Start injection	10:20	0:00	0					0				
	10:30	0:10	10	2359	0.5	0.1	0	0	0.082	0.918	-0.037	0.06
	10:40	0:20	20	2354	0.5	0.1	1	1	0.082	0.918	-0.037	0.11
	10:50	0:30	30	2344	0.4	0	0	1	0.000	1.000	0.000	0.17
	11:00	0:40	40	2398	0.4	0	0	1	0.000	1.000	0.000	0.22
	11:10	0:50	50	2408	0.4	0	0	1	0.000	1.000	0.000	0.28
	11:20	1:00	60	2411	0.4	0	0	1	0.000	1.000	0.000	0.34
	11:30	1:10	70	2440	0.4	0	0	1	0.000	1.000	0.000	0.39
	11:40	1:20	80	2441	0.5	0.1	1	2	0.082	0.918	-0.037	0.45
	11:50	1:30	90	2411	0.5	0.1	1	3	0.082	0.918	-0.037	0.51
	12:00	1:40	100	2433	0.5	0.1	1	4	0.082	0.918	-0.037	0.56
	12:10	1:50	110	2424	0.6	0.2	2	6	0.165	0.835	-0.078	0.62
	12:20	2:00	120	2424	0.6	0.2	2	8	0.165	0.835	-0.078	0.67
	12:30	2:10	130	2408	0.7	0.3	3	11	0.247	0.753	-0.123	0.73
	12:35	2:15	135	2413	0.7	0.3	1.5	12.5	0.247	0.753	-0.123	0.76
	12:40	2:20	140	2434	0.7	0.3	1.5	14	0.247	0.753	-0.123	0.79
	12:45	2:25	145	2456	0.8	0.4	2	16	0.330	0.670	-0.174	0.81
	12:50	2:30	150	2431	0.8	0.4	2	18	0.330	0.670	-0.174	0.84
	12:55	2:35	155	2410	0.8	0.4	2	20	0.330	0.670	-0.174	0.87
	13:00	2:40	160	2447	0.9	0.5	2.5	22.5	0.412	0.588	-0.231	0.90
	13:05	2:45	165	2459	1	0.6	3	25.5	0.495	0.505	-0.296	0.93
	13:10	2:50	170	2432	0.9	0.5	2.5	28	0.412	0.588	-0.231	0.95
	13:15	2:55	175	2416	1	0.6	3	31	0.495	0.505	-0.296	0.98
	13:20	3:00	180	2398	1	0.6	3	34	0.495	0.505	-0.296	1.01
	13:25	3:05	185	2403	1	0.6	3	37	0.495	0.505	-0.296	1.04
	13:30	3:10	190	2408	1.1	0.7	3.5	40.5	0.577	0.423	-0.374	1.07
	13:35	3:15	195	2386	1.1	0.7	3.5	44	0.577	0.423	-0.374	1.09
	13:40	3:20	200	2388	1.1	0.7	3.5	47.5	0.577	0.423	-0.374	1.12
	13:45	3:25	205	2375	1.1	0.7	3.5	51	0.577	0.423	-0.374	1.15

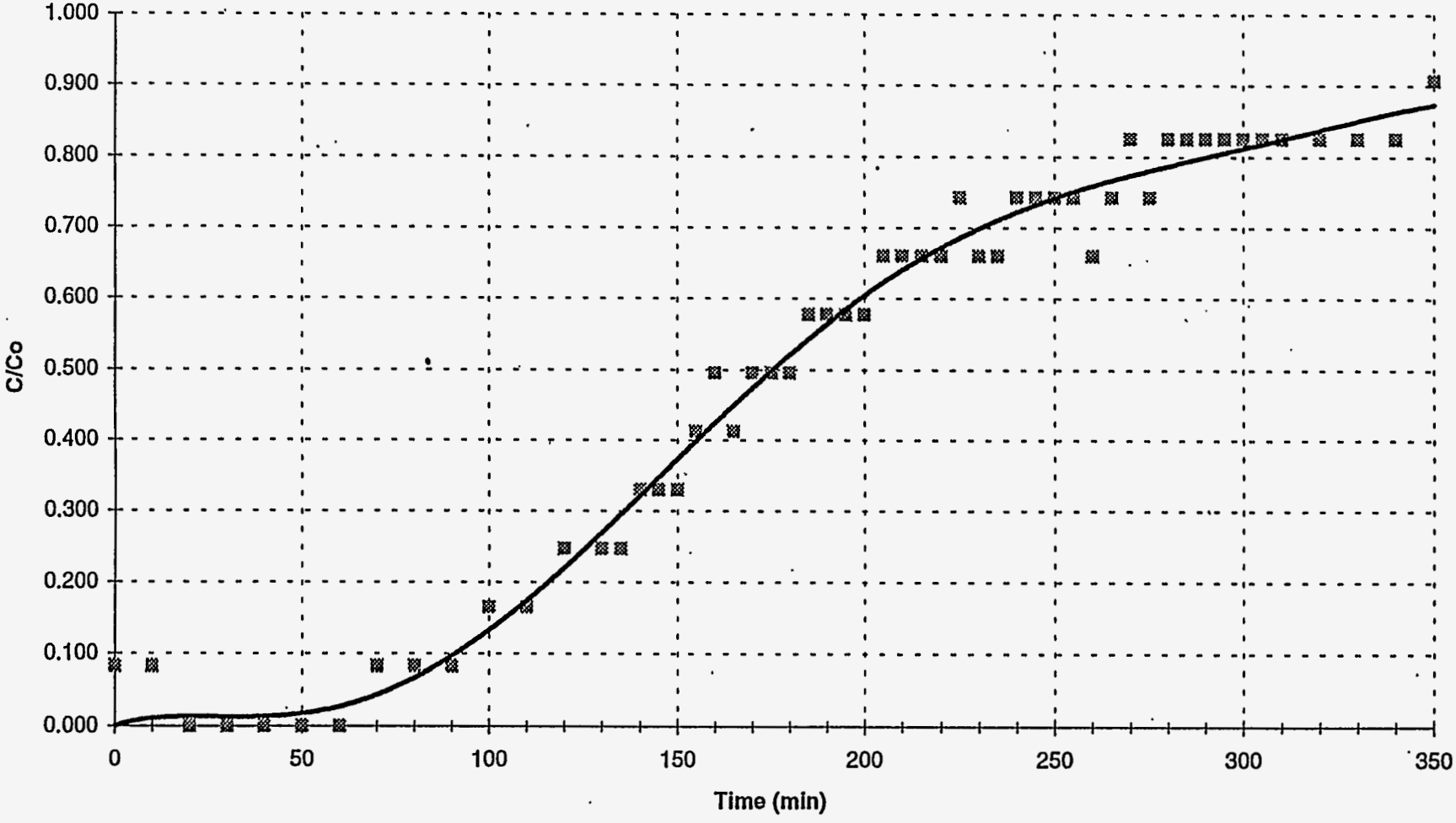
ICF KAISER HANFORD COMPANY					315 Filter Plant, 300 Area						2400 GPM Tracer Test	
Date: 3/6/95					Background Fluoride Concentration (Baseline)= 0.40 mg/L							
Average test flow = 2380 gpm (9009 L/min)					Fluoride loss due to alum ~ 0.10 mg/L (8%)							
Theoretical Resedence Time (T)= 178 min					Applied Fluoride Dosage (Co) = 620.8 ml/min (1.21 mg/L)							
	Time	Time t (h:mm)	Time t (min)	Flowrate (gpm)	Fluoride Measured (mg/L)	Tracer concentration (mg/L)	Incrimental Area (mg-min/L)	Cumulative Area (mg-min/L)	C/Co	1-C/Co	$Log_{10}(1-C/Co)$	t/T
	13:50	3:30	210	2380	1.2	0.8	4	55	0.660	0.340	-0.468	1.18
	13:55	3:35	215	2367	1.2	0.8	4	59	0.660	0.340	-0.468	1.21
	14:00	3:40	220	2382	1.2	0.8	4	63	0.660	0.340	-0.468	1:23
	14:05	3:45	225	2384	1.2	0.8	4	67	0.660	0.340	-0.468	1.26
	14:10	3:50	230	2383	1.3	0.9	4.5	71.5	0.742	0.258	-0.589	1.29
	14:15	3:55	235	2363	1.2	0.8	4	75.5	0.660	0.340	-0.468	1.32
	14:20	4:00	240	2386	1.2	0.8	4	79.5	0.660	0.340	-0.468	1.35
	14:25	4:05	245	2385	1.3	0.9	4.5	84	0.742	0.258	-0.589	1.38
	14:30	4:10	250	2372	1.3	0.9	4.5	88.5	0.742	0.258	-0.589	1.40
	14:35	4:15	255	2385	1.3	0.9	4.5	93	0.742	0.258	-0.589	1.43
	14:40	4:20	260	2375	1.3	0.9	4.5	97.5	0.742	0.258	-0.589	1.46
	14:45	4:25	265	2360	1.2	0.8	4	101.5	0.660	0.340	-0.468	1.49
	14:50	4:30	270	2374	1.3	0.9	4.5	106	0.742	0.258	-0.589	1.52
	14:55	4:35	275	2367	1.4	1	5	111	0.825	0.175	-0.756	1.54
	15:00	4:40	280	2356	1.3	0.9	4.5	115.5	0.742	0.258	-0.589	1.57
	15:05	4:45	285	2370	1.4	1	5	120.5	0.825	0.175	-0.756	1.60
	15:10	4:50	290	2389	1.4	1	5	125.5	0.825	0.175	-0.756	1.63
	15:15	4:55	295	2378	1.4	1	5	130.5	0.825	0.175	-0.756	1.66
	15:20	5:00	300	2345	1.4	1	5	135.5	0.825	0.175	-0.756	1.68
	15:25	5:05	305	2384	1.4	1	5	140.5	0.825	0.175	-0.756	1.71
	15:30	5:10	310	2398	1.4	1	5	145.5	0.825	0.175	-0.756	1.74
	15:40	5:20	320	2389	1.4	1	10	155.5	0.825	0.175	-0.756	1.80
	15:50	5:30	330	2368	1.4	1	10	165.5	0.825	0.175	-0.756	1.85
	16:00	5:40	340	2353	1.4	1	10	175.5	0.825	0.175	-0.756	1.91
	16:10	5:50	350	2342	1.4	1	10	185.5	0.825	0.175	-0.756	1.96
Feed Off	16:20	6:00	360	2341	1.5	1.1	11	196.5	0.907	0.093	-1.032	2.02
	16:30	6:10	370	2374	1.4	1	10	206.5				
	16:45	6:25	385	2383	1.5	1.1	16.5	223				
	17:00	6:40	400	2373	1.4	1	15	238				
	17:15	6:55	415	2352	1.4	1	15	253				
	17:30	7:10	430	2366	1.4	1	15	268				
	17:45	7:25	445	2346	1.3	0.9	13.5	281.5				
	18:00	7:40	460	2351	1.3	0.9	13.5	295				
	18:15	7:55	475	2332	1.2	0.8	12	307				
	18:30	8:10	490	2343	1.1	0.7	10.5	317.5				
	18:45	8:25	505	2342	1	0.6	9	326.5				
	19:00	8:40	520	2341	0.9	0.5	7.5	334				

2400gpm

ICF KAISER HANFORD COMPANY					315 Filter Plant, 300 Area							2400 GPM Tracer Test
Date: 3/6/95					Background Fluoride Concentration (Baseline)= 0.40 mg/L							
Average test flow = 2380 gpm (9009 L/min)					Fluoride loss due to alum ~ 0.10 mg/L (8%)							
Theoretical Resedence Time (T)= 178 min					Applied Fluoride Dosage (Co) = 620.8 ml/min (1.21 mg/L)							
	Time	Time t (h:mm)	Time t (min)	Flowrate (gpm)	Fluoride Measured (mg/L)	Tracer concentration (mg/L)	Incrimental Area (mg-min/L)	Cumulative Area (mg-min/L)	C/Co	1-C/Co	$Log_{10}(1-C/Co)$	t/T
	19:15	8:55	535	2337	0.9	0.5	7.5	341.5				
	19:30	9:10	550	2345	0.8	0.4	6	347.5				
	19:45	9:25	565	2339	0.7	0.3	4.5	352				
	20:00	9:40	580	2341	0.7	0.3	4.5	356.5				
	20:15	9:55	595	2329	0.7	0.3	4.5	361				
	20:30	10:10	610	2337	0.6	0.2	3	364				
	20:45	10:25	625	2336	0.6	0.2	3	367				
	21:00	10:40	640	2328	0.5	0.1	1.5	368.5				
	21:15	10:55	655	2340	0.5	0.1	1.5	370				
Calculated Resedence Time (T_{10}) = 102 min					Mass Fluoride injected = 3933 g							
					Mass Fluoride Recovered = 3333 g							
Correlation Coefficient = 0.95					% Fluoride Recovered = 85%							

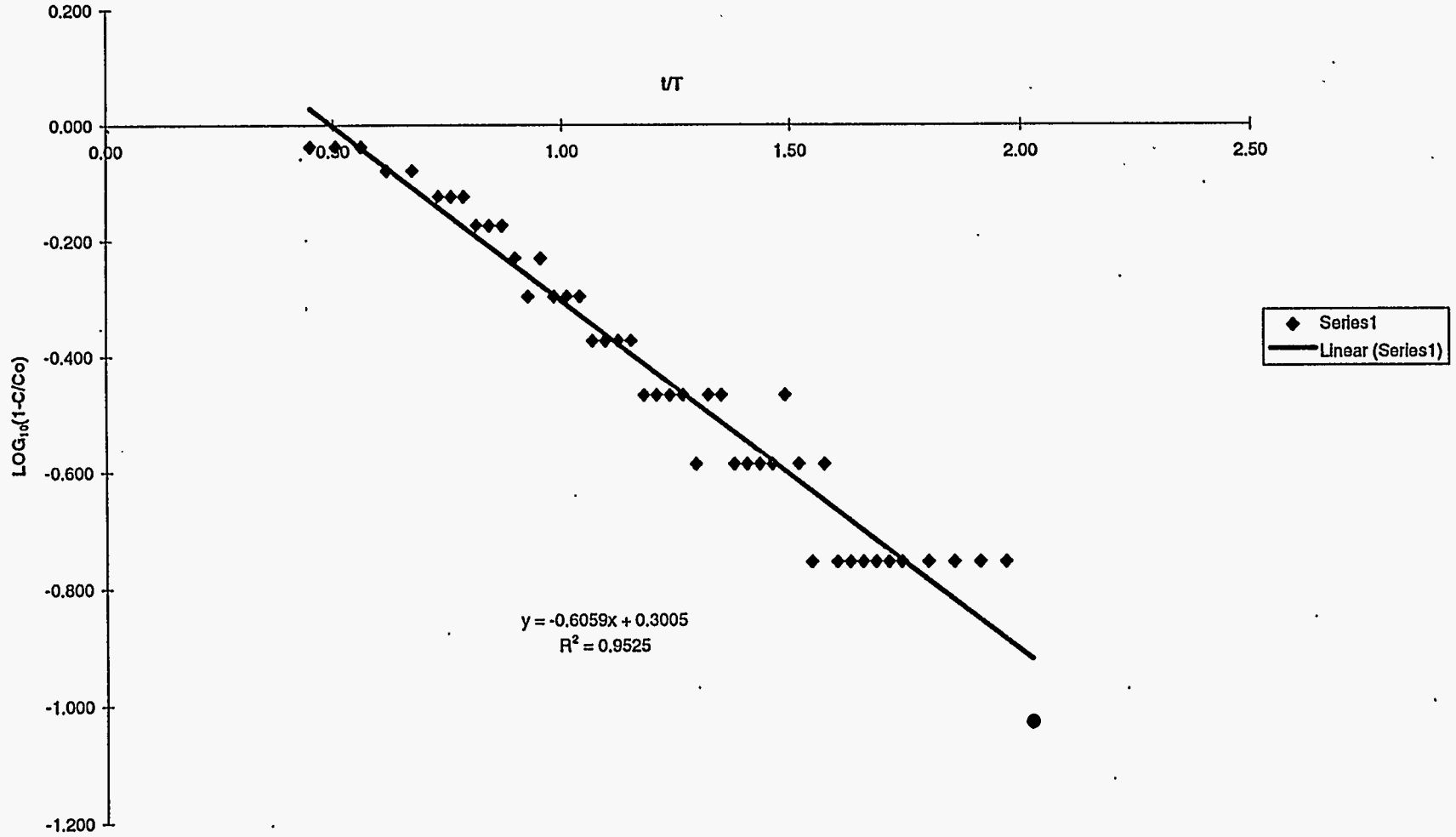
Chart 1
2400 GPM

300 Area, 315 Filter Plant
C/Co vs. Time
Graphical Analysis for T_{10}
2400 gpm



Prepared by ICF Kaiser

300 Area, 315 Filter Plant
$LOG_{10}(1-C/Co)$ vs. t/T
Numerical Analysis for T_{10}
2400 gpm



Prepared by ICF Kaiser

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.9759846
R Square	0.952546
Adjusted	0.9514915
Standard	0.0567451
Observati	47

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regressio	1	2.908591	2.90859095	903.2869	1.9914E-31
Residual	45	0.1449004	0.00322001		
Total	46	3.0534913			

	Coefficients	*tandard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.000*	*pper 95.000%*
Intercept	0.3004406	0.0262357	11.4516157	6.3E-15	0.2475993	0.353281936	0.247599304	0.35328194
X Variable	-0.6059094	0.0201602	-30.054732	1.99E-31	-0.64651408	-0.56530463	-0.64651408	-0.5653046

ICF KAISER HANFORD COMPANY					315 Filter Plant, 300 Area						2160 GPM Tracer Test	
Date: 3/23/95					Background Fluoride Concentration (Baseline)= 0.40 mg/L							
Average test flow = 2127 gpm (8050 L/min)					Fluoride loss due to alum = 0.20 mg/L (16%)							
Theoretical Resedence Time (T)= 199 min					Applied Fluoride Dosage (Co) = 580.0 ml/min (1.27 mg/L)							
	Time	Time t (h:mm)	Time t (min)	Flowrate (gpm)	Fluoride Measured (mg/L)	Tracer concentration (mg/L)	Incrimental Area (mg-min/L)	Cumulative Area (mg-min/L)	C/Co	1-C/Co	Log10(1-C/Co)	t/T
Background	8:45			495	0.3	0	N/A	N/A				
	8:50			493	0.4	0	N/A	N/A				
	8:55			438	0.4	0	N/A	N/A				
	9:00			775	0.4	0	N/A	N/A				
	9:05			1318	0.4	0	N/A	N/A				
	9:10			1567	0.3	0	N/A	N/A				
Start injection	9:50	0:00	0					0				
	10:00	0:10	10	2161	0.3	-0.1	0	0	-0.079	1.079	0.033	0.05
	10:10	0:20	20	2106	0.4	0	0	0	0.000	1.000	0.000	0.10
	10:20	0:30	30	2108	0.4	0	0	0	0.000	1.000	0.000	0.15
	10:30	0:40	40	2092	0.4	0	0	0	0.000	1.000	0.000	0.20
	10:40	0:50	50	2105	0.4	0	0	0	0.000	1.000	0.000	0.25
	10:50	1:00	60	2159	0.4	0	0	0	0.000	1.000	0.000	0.30
	11:00	1:10	70	2118	0.4	0	0	0	0.000	1.000	0.000	0.35
	11:10	1:20	80	2124	0.4	0	0	0	0.000	1.000	0.000	0.40
	11:20	1:30	90	2133	0.4	0	0	0	0.000	1.000	0.000	0.45
	11:30	1:40	100	2123	0.4	0	0	0	0.000	1.000	0.000	0.50
	11:40	1:50	110	2098	0.4	0	0	0	0.000	1.000	0.000	0.55
	11:50	2:00	120	2172	0.5	0.1	1	1	0.079	0.921	-0.036	0.60
	12:00	2:10	130	2150	0.5	0.1	1	2	0.079	0.921	-0.036	0.65
	12:05	2:15	135	2128	0.5	0.1	0.5	2.5	0.079	0.921	-0.036	0.68
	12:10	2:20	140	2128	0.5	0.1	0.5	3	0.079	0.921	-0.036	0.70
	12:15	2:25	145	2118	0.4	0	0	3	0.000	1.000	0.000	0.73
	12:20	2:30	150	2160	0.4	0	0	3	0.000	1.000	0.000	0.75
	12:25	2:35	155	2130	0.5	0.1	0.5	3.5	0.079	0.921	-0.036	0.78
	12:30	2:40	160	2135	0.5	0.1	0.5	4	0.079	0.921	-0.036	0.80
	12:35	2:45	165	2146	0.5	0.1	0.5	4.5	0.079	0.921	-0.036	0.83
	12:40	2:50	170	2148	0.5	0.1	0.5	5	0.079	0.921	-0.036	0.85
	12:45	2:55	175	2176	0.5	0.1	0.5	5.5	0.079	0.921	-0.036	0.88
	12:50	3:00	180	2184	0.5	0.1	0.5	6	0.079	0.921	-0.036	0.90
	12:55	3:05	185	2142	0.5	0.1	0.5	6.5	0.079	0.921	-0.036	0.93
	13:00	3:10	190	2138	0.6	0.2	1	7.5	0.158	0.842	-0.075	0.95

ICF KAISER HANFORD COMPANY				315 Filter Plant, 300 Area					2160 GPM Tracer Test		
Date: 3/23/95				Background Fluoride Concentration (Baseline)= 0.40 mg/L							
Average test flow = 2127 gpm (8050 L/min)				Fluoride loss due to alum ~ 0.20 mg/L (16%)							
Theoretical Resedence Time (T)= 199 min				Applied Fluoride Dosage (Co) = 580.0 ml/min (1.27 mg/L)							
	Time	Time t (h:mm)	Time t (min)	Flowrate (gpm)	Fluoride Measured (mg/L)	Tracer concentration (mg/L)	Incrimental Area (mg-min/L)	Cumulative Area (mg-min/L)	C/Co	1-C/Co	Log10(1-C/Co)	t/T
	13:05	3:15	195	2165	0.5	0.1	0.5	8	0.079	0.921	-0.036	0.98
	13:10	3:20	200	2170	0.6	0.2	1	9	0.158	0.842	-0.075	1.00
	13:15	3:25	205	2239	0.6	0.2	1	10	0.158	0.842	-0.075	1.03
	13:20	3:30	210	2182	0.7	0.3	1.5	11.5	0.237	0.763	-0.117	1.05
	13:25	3:35	215	2063	0.7	0.3	1.5	13	0.237	0.763	-0.117	1.08
	13:30	3:40	220	2071	0.7	0.3	1.5	14.5	0.237	0.763	-0.117	1.10
	13:35	3:45	225	2071	0.7	0.3	1.5	16	0.237	0.763	-0.117	1.13
	13:40	3:50	230	2110	0.7	0.3	1.5	17.5	0.237	0.763	-0.117	1.15
	13:45	3:55	235	2200	0.7	0.3	1.5	19	0.237	0.763	-0.117	1.18
	13:50	4:00	240	2150	0.8	0.4	2	21	0.315	0.685	-0.165	1.20
	13:55	4:05	245	2059	0.7	0.3	1.5	22.5	0.237	0.763	-0.117	1.23
	14:00	4:10	250	2072	0.7	0.3	1.5	24	0.237	0.763	-0.117	1.25
	14:05	4:15	255	2136	0.7	0.3	1.5	25.5	0.237	0.763	-0.117	1.28
	14:10	4:20	260	2117	0.9	0.5	2.5	28	0.394	0.606	-0.218	1.30
	14:15	4:25	265	2107	0.7	0.3	1.5	29.5	0.237	0.763	-0.117	1.33
	14:20	4:30	270	2202	0.8	0.4	2	31.5	0.315	0.685	-0.165	1.35
	14:25	4:35	275	2105	0.8	0.4	2	33.5	0.315	0.685	-0.165	1.38
	14:30	4:40	280	2100	0.7	0.3	1.5	35	0.237	0.763	-0.117	1.40
	14:35	4:45	285	2086	0.7	0.3	1.5	36.5	0.237	0.763	-0.117	1.43
	14:40	4:50	290	2101	0.7	0.3	1.5	38	0.237	0.763	-0.117	1.45
	14:45	4:55	295	2116	0.9	0.5	2.5	40.5	0.394	0.606	-0.218	1.48
	14:50	5:00	300	2109	0.8	0.4	2	42.5	0.315	0.685	-0.165	1.50
	14:55	5:05	305	2111	0.9	0.5	2.5	45	0.394	0.606	-0.218	1.53
	15:00	5:10	310	2100	1	0.6	3	48	0.473	0.527	-0.278	1.55
	15:05	5:15	315	2112	1	0.6	3	51	0.473	0.527	-0.278	1.58
	15:10	5:20	320	2141	1.1	0.7	3.5	54.5	0.552	0.448	-0.349	1.60
	15:15	5:25	325	2163	1	0.6	3	57.5	0.473	0.527	-0.278	1.63
	15:20	5:30	330	2136	1	0.6	3	60.5	0.473	0.527	-0.278	1.66
	15:25	5:35	335	2093	1.1	0.7	3.5	64	0.552	0.448	-0.349	1.68
	15:30	5:40	340	2136	1	0.6	3	67	0.473	0.527	-0.278	1.71
	15:35	5:45	345	2132	1	0.6	3	70	0.473	0.527	-0.278	1.73
	15:40	5:50	350	2111	1.1	0.7	3.5	73.5	0.552	0.448	-0.349	1.76
	15:45	5:55	355	2114	0.9	0.5	2.5	76	0.394	0.606	-0.218	1.78
	15:50	6:00	360	2106	1	0.6	3	79	0.473	0.527	-0.278	1.81

ICF KAISER HANFORD COMPANY					315 Filter Plant, 300 Area							2160 GPM Tracer Test
Date: 3/23/95					Background Fluoride Concentration (Baseline)= 0.40 mg/L							
Average test flow = 2127 gpm (8050 L/min)					Fluoride loss due to alum – 0.20 mg/L (16%)							
Theoretical Resedence Time (T)= 199 min					Applied Fluoride Dosage (Co) = 580.0 ml/min (1.27 mg/L)							
	Time	Time t (h:mm)	Time t (min)	Flowrate (gpm)	Fluoride Measured (mg/L)	Tracer concentration (mg/L)	Incrimental Area (mg-min/L)	Cumulative Area (mg-min/L)	C/Co	1-C/Co	Log10(1-C/Co)	t/T
	15:55	6:05	365	2128	1.1	0.7	3.5	82.5	0.552	0.448	-0.349	1.83
	16:00	6:10	370	2114	1.2	0.8	4	86.5	0.631	0.369	-0.433	1.86
	16:05	6:15	375	2087	1.1	0.7	3.5	90	0.552	0.448	-0.349	1.88
	16:10	6:20	380	2111	1.2	0.8	4	94	0.631	0.369	-0.433	1.91
	16:15	6:25	385	2112	1.1	0.7	3.5	97.5	0.552	0.448	-0.349	1.93
	16:20	6:30	390	2107	1.2	0.8	4	101.5	0.631	0.369	-0.433	1.96
Feed Off	16:25	6:35	395	2143	1.2	0.8	4	105.5	0.631	0.369	-0.433	1.98
	16:30	6:40	400	2115	1	0.6	3	108.5	0.473	0.527	-0.278	2.01
	16:45	6:55	415	2131	1	0.6	9	117.5				
	17:00	7:10	430	2153	1	0.6	9	126.5				
	17:15	7:25	445	2108	1	0.6	9	135.5				
	17:30	7:40	460	2112	1	0.6	9	144.5				
	17:45	7:55	475	2108	1	0.6	9	153.5				
	18:00	8:10	490	2088	1	0.6	9	162.5				
	18:15	8:25	505	2127	1	0.6	9	171.5				
	18:30	8:40	520	2131	0.8	0.4	6	177.5				
	18:45	8:55	535	2134	1	0.6	9	186.5				
	19:00	9:10	550	2140	0.8	0.4	6	192.5				
	19:15	9:25	565	2140	0.8	0.4	6	198.5				
	19:30	9:40	580	2129	0.9	0.5	7.5	206				
	19:45	9:55	595	2134	0.8	0.4	6	212				
	20:00	10:10	610	2142	0.6	0.2	3	215				
	20:15	10:25	625	2126	0.8	0.4	6	221				
	20:40	10:50	650	2131	0.6	0.2	5	226				
	20:45	10:55	655	2126	0.6	0.2	1	227				
	21:00	11:10	670	2120	0.4	0	0	227				
	21:15	11:25	685	2126	0.4	0	0	227				
	21:30	11:40	700	2119	0.4	0	0	227				

Calculated Resedence Time (T10) = 186 min

Correlation Coefficient = 0.87

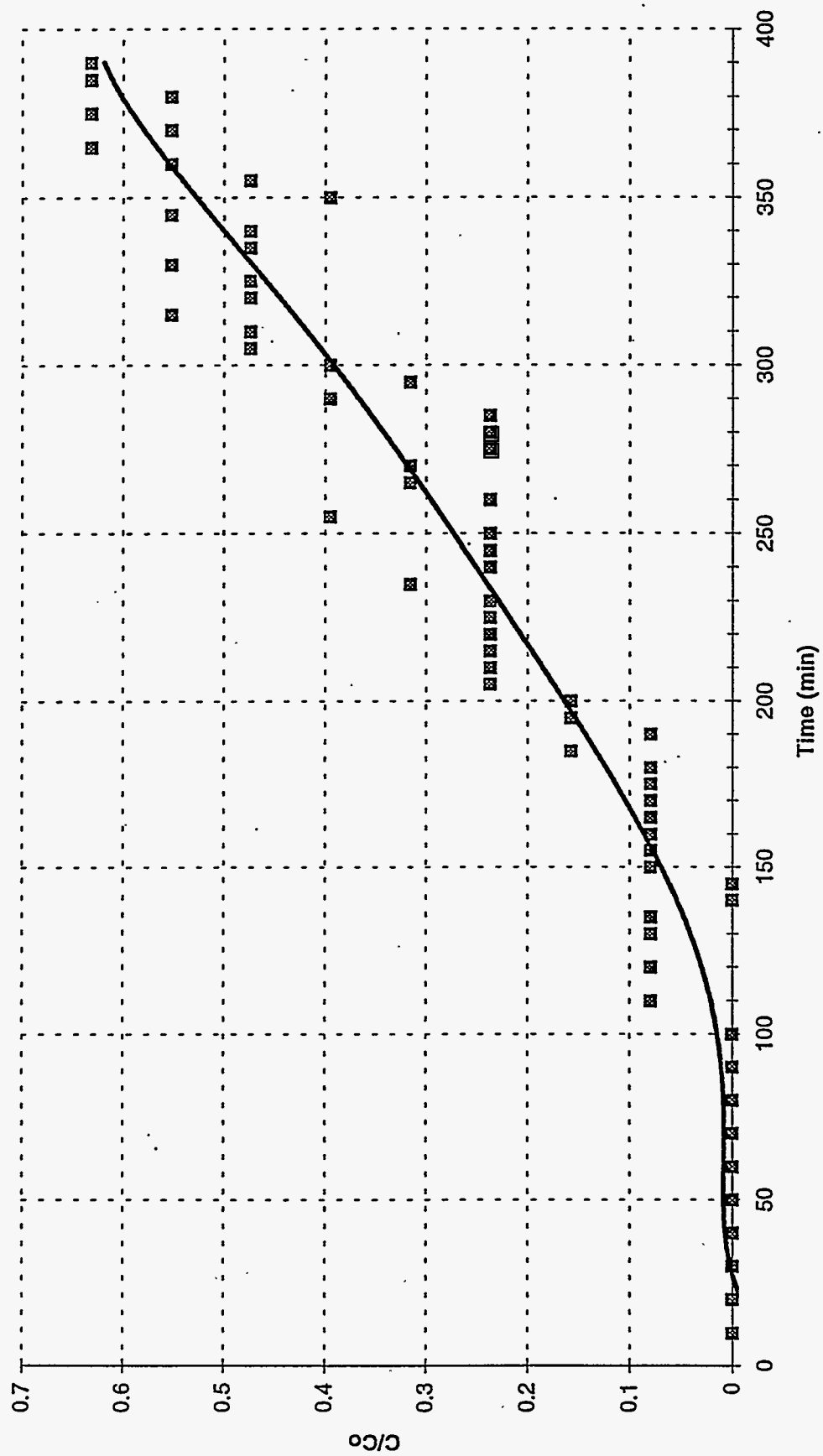
Mass Fluoride injected = 4032 g

Mass Fluoride Recovered = 1827 g

% Fluoride Recovered = 45%

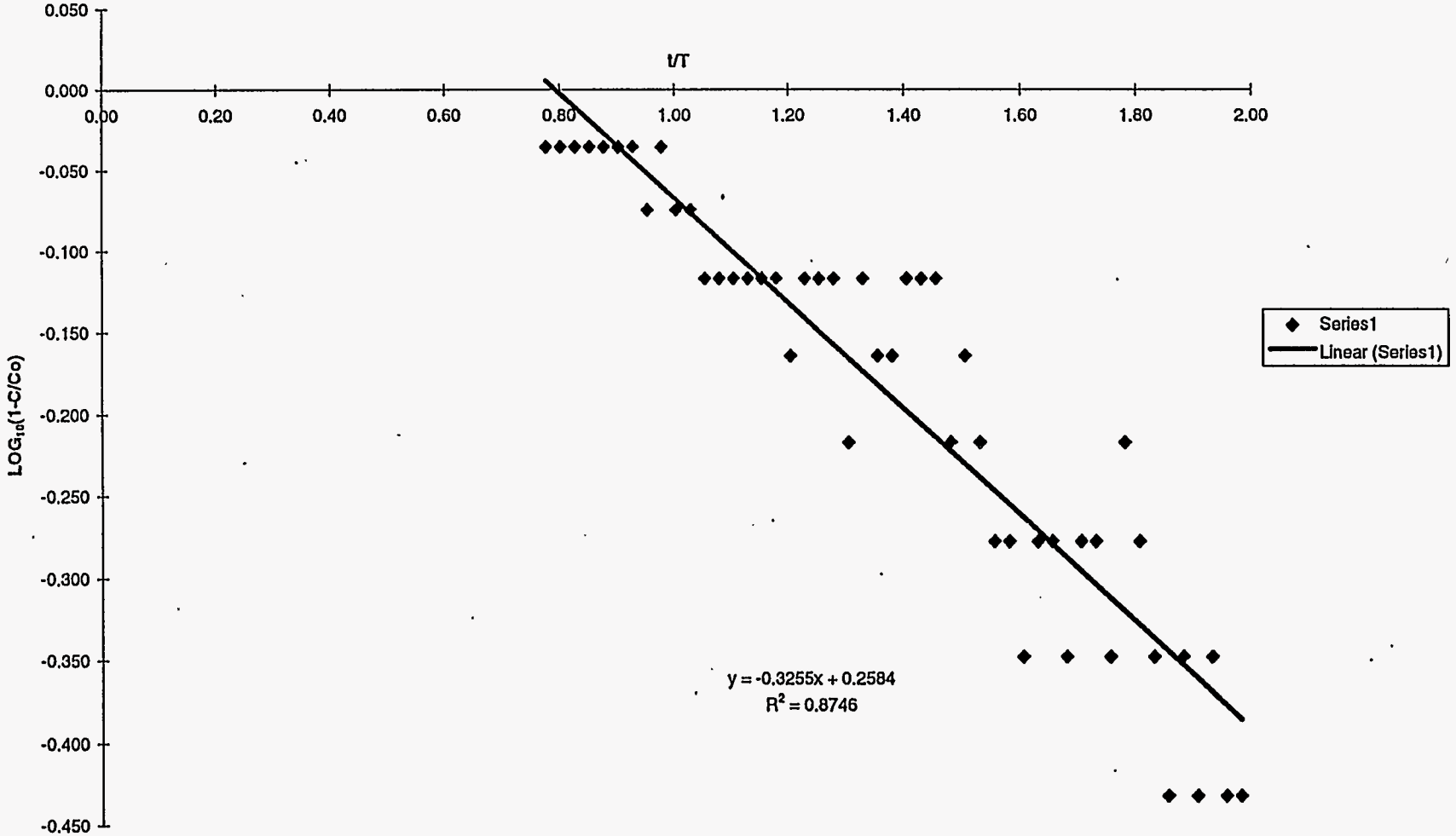
Chart 1
2160 GPM

300 Area, 315 Filter Plant
C/Co vs. Time
Graphical Analysis for T10



Prepared by ICF Kaiser

300 Area, 315 Filter Plant
$LOG_{10}(1-C/Co)$ vs. t/T
Numerical Analysis for T_{10}
2160 gpm



Prepared by ICF Kaiser

SUMMARY OUTPUT

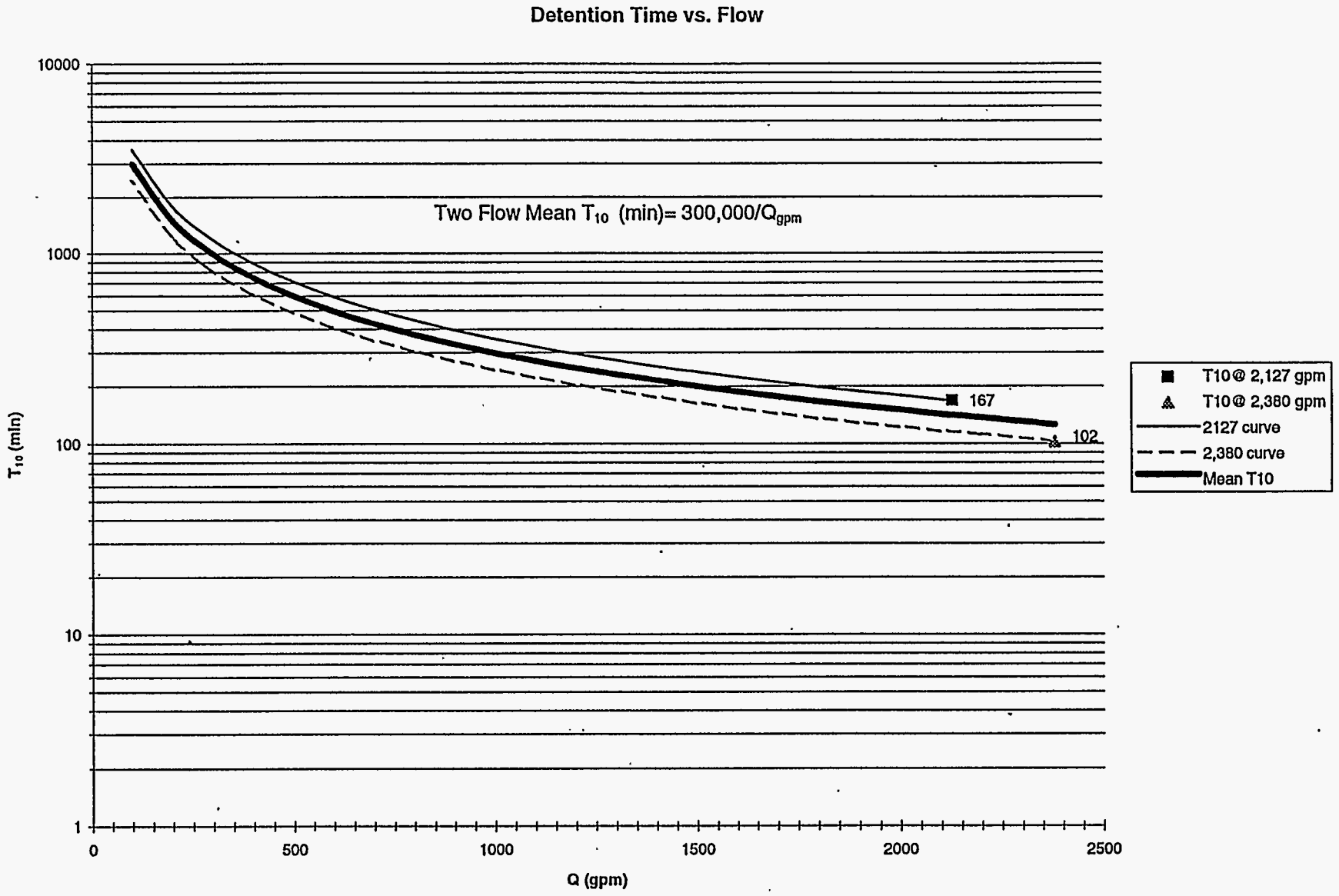
Regression Statistics	
Multiple R	0.935176
R Square	0.874554
Adjusted F	0.871885
Standard E	0.044638
Observatic	49

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regressior	1	0.652896	0.652896249	327.6634	8.03811E-23
Residual	47	0.093651	0.001992582		
Total	48	0.746548			

	Coefficients	*tandard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.000%*	*Jpper 95.000%*
Intercept	0.258437	0.025607	10.09238966	2.38E-13	0.206921811	0.30995128	0.206921811	0.30995128
X Variable	-0.32549	0.017981	-18.1014761	8.04E-23	-0.361663463	-0.2893158	-0.361663463	-0.28931577

T_{10} 315 Filter Plant, 300 Area



Prepared by ICF Kaiser

T_{10} 315 Filter Plant, 300 Area

FLOW	T10							
2127 gpm	167							
2380	102							
2380 GPM RESULTS			2127 GPM RESULTS				AVERAGED RESULTS	
							FLOW	Average
FLOW	T10			FLOW	T10			T10
2380	102			2380	149		2380	126
2200	110			2127	167		2164	139
2100	116			2100	169		2100	142
2000	121			2000	178		2000	149
1900	128			1900	187		1900	157
1800	135			1800	197		1800	166
1700	143			1700	209		1700	176
1600	152			1600	222		1600	187
1500	162			1500	237		1500	199
1400	173			1400	254		1400	214
1300	187			1300	273		1300	230
1200	202			1200	296		1200	249
1100	221			1100	323		1100	272
1000	243			1000	355		1000	299
900	270			900	395		900	332
800	303			800	444		800	374
700	347			700	507		700	427
600	405			600	592		600	498
500	486			500	710		500	598
400	607			400	888		400	747
300	809			300	1184		300	997
200	1214			200	1776		200	1495
100	2428			100	3552		100	2990
0				0			0	0

APPENDIX B

Calculation No. ER5480-G-005
Theoretical Detention Time and Fluoride Injection Rate, Rev. 2

KAISER ENGINEERS HANFORD	CALCULATION IDENTIFICATION AND INDEX	Page 1 of 4
		Date 11/5/94

This sheet shows the status and description of the attached Design Analysis sheets.

Discipline ENVIRONMENTAL (ZZ) WO/Job No. ER5480 Calculation No. ER5480-G-005

Project No. & Name TRACER STUDIES OF 300 FILTER TREATMENT PLANT

Calculation Item THEORETIAL DETENTION TIME AND FLUORIDE INJECTION RATE

These calculations apply to:

Dwg. No. _____ Rev. No. _____

Dwg. No. _____ Rev. No. _____

Other (Study; CDR) _____

_____ Rev. No. _____

The status of these calculations is:

☐ Preliminary Calculations

☒ Final Calculations

☐ Check Calculations (On Calculation Dated _____)

☐ Void Calculation (Reason Voided _____

_____)

Incorporated in Final Drawings? ☐ Yes ☐ No

This calculation verified by independent "check" calculations? ☐ Yes ☐ No

Original and Revised Calculation Approvals:

	Rev. 0 Signature/Date	Rev. 1 Signature/Date	Rev. 2 Signature/Date
Originator	Todd D. Boucher 11/5/94	Todd D. Boucher 12/22/94	William W. Foldett 3/28/95
Checked by	William W. Foldett 11/15/94	William W. Foldett 12/27/94	Dennis G. Faulk 3/28/95
Approved by			
Checked Against Approved Vendor Data			

INDEX

KAISER ENGINEERS
HANFORD

Calc. No. ER5480-G-00
Revision 2
Page No. 2 of 4

DESIGN ANALYSIS

Client ICF-KH | WO/Job No. ER 5480
Subject THEORETICAL DETENTION TIME & INJECTION QUANTITY | Date 11/5/94 By TODD BOUCHER | Checked By
Location 300 AREA FILTER PLANT | Revised 12-22-94 By TODD BOUCHER

OBJECTIVE: THE PURPOSE OF THIS CALCULATION IS TO DETERMIN THE THEORETICAL DETENTION TIME AND THE FLUORI INJECTION CONCENTRATION FOR A TRACER STUDY.

DESIGN INPUTS: A TRACER STUDY WILL BE PERFORMED ON THE FLASH MIXER, THREE SEDIMENTATION BASINS, THREE FILTERS AND THE CLEARWELL. THE HACH COLORIMETE DETECTS FLUORIDE BETWEEN 0.0 mg/l to 2.0 mg/l; THEREFORE, FLUORIDE WILL BE INJECTED AT 1.0 mg/l to 1.5 mg/l

ASSUMPTIONS: THE PLANT WILL BE MAINTAINED AT THE TWO FLOWRATES OF 2,400 GPM AND 2,160 GPM. BACKGROUND FLUORIDE CONCENTRATIONS WILL NOT VARY SIGNIFICANTLY. AVERAGE FILTER POROSITY = TO 40%.

METHOD: HAND CALCULATION WILL BE PERFORMED.

REFERENCES: (1) DRAWING NUMBERS: H-3-14193, 6 SHEETS
H-3-14192, 6 SHEETS
(2) MONTHLY FLOW RATES FOR PLANT 1994
(3) CALCULATION ER5480-G-004
(4) HANFORD ENVIRONMENTAL HEALTH FOUNDATION REPORT FOR CY 1992.
(5) GUIDANCE FOR COMPLIANCE WITH FILTRATION AND DISINFECTION REQUIREMENTS, EPA, MARCH 199
(6) LMI Catalog Sec 31 Pg 1900

FINDINGS: THE THEORETICAL DETENTION TIME AND CORRESPONDING FLUORIDE INJECTION RATE IS AS FOLLOWS:

$T_{300,1} = 2.3$ HRS, $Q_{FIN,1} = 46.4$ l/min
$T_{300,2} = 2.6$ HRS, $Q_{FIN,2} = 41.8$ l/min

CALCULATION: THE PLANT VOLUME WAS DETERMINE USING ORGINAL DRAWINGS. ONCE THE VOLUME OF EACH UNIT IS KNOWN, THE VOLUME OF THE SYSTEM CAN BE DETERMINED. THE THEORETICAL DETENTION TIME CAN BE DETERMINED GIVEN THE VOLUME OF WATER IN THE PLANT AND THE PEAK HOURLY FLOW RATE.

KAISER ENGINEERS HANFORD

DESIGN ANALYSIS

Calc. No. ER5480-G-00
Revision 2
Page No. 3 of 4

Client ICF-KM WO/Job No. ER5480
Subject THEORETICAL DETENTION TIME + INJECTION QUANITTY Date 11-5-94 By TODD BOUCHER Checked By
Location 300 AREA FILTER PLANT Revised 12-22-94 By TODD BOUCHER

THEORETICAL DENTENTION TIME OF 300 AREA FILTER PLANT.

THE VOLUME OF THE 300 AREA PLANT: ①

3F:17cr 3Basins V_{300} = FLASH MIXER + 3 (FLOCCULATORS + SEDIMENTATION BASINS) + CLEARWELL + 3 (FILTERS)

V_{300} = $7.78 \times 10^9 mm^3$ + 3 ($5.42 \times 10^{10} mm^3$ + $2.59 \times 10^{11} mm^3$)
3F:17cr 3Basins (4' * 5.5' * 12.5') (17' * 15' * 7.5') + (53' * 15' * 11.5')

+ $2.76 \times 10^{11} mm^3$ + 3 [(40% POROSITY) $4.78 \times 10^{10} mm^3$]
(18' * 47' * 11.5') (17' * 12' * 10.5')

V_{300} = $1.28 \times 10^{12} mm^3$ ($\frac{1 \text{ LITER}}{1.0 \times 10^6 mm^3}$) = $1.28 \times 10^6 l$
3F:17cr 3Basins (45,012 ft³)

V_{300} 4F:17cr + 4Basins = $1.605 \times 10^6 l$ (4F:17cr 4Basins)

$Q_{300,1}$ = 9,084 l/MIN (2,400 gal/MIN) ② @ 90% OF Q_{PEAK}

$Q_{300,2}$ = 8175 l/MIN (2,160 gal/MIN)

$Q = \frac{V}{T}$ OR $T = \frac{V}{Q}$

$T_{300,1} = \frac{1.605 \times 10^6 l}{9,084 \frac{l}{M}} = 177$ MINUTES ($\frac{HR}{60 \text{ MINUTES}}$) =

$T_{300,1}$ = 2.95 HRS @ 9,084 l/min

$T_{300,2} = \frac{1.605 \times 10^6 l}{8,175 \text{ l/min}} = 196$ MIN ($\frac{HR}{60 \text{ MINUTES}}$) =

$T_{300,2}$ = 3.3 HRS @ 8,175 l/min

KAISER ENGINEERS HANFORD

DESIGN ANALYSIS

Calc. No. ER5480-G-005
Revision 2
Page No. 4 of 4

Client ICF-KH WO/Job No. ER5480
Subject THEORETICAL DETENTION TIME + INJECTION QUANTITY Date 11-5-94 By TODD BOUCHER
Checked By
Location 300 AREA FILTER PLANT Revised 12-22-94 By TODD BOUCHER

THE TRACER INJECTION CONCENTRATION IS DEPENDENT ON TWO FACTORS: THE EFFECTS OF ALUM ON THE FLUORIDE AND THE BACKGROUND FLUORIDE CONCENTRATIONS

FLUORIDE LOSS DUE TO ALUM = $F_A \cong 0.1$ mg/l (3)

FLUORIDE BACKGROUND CONCENTRATION (300 AREA) = $F_B = 0.1$ mg/l (4)

FLUORIDE INJECTION CONCENTRATION = F_C = ?

MAXIMUM FLUORIDE CONCENTRATION = $F_m = 1.5$ mg/l (5)

$F_m = F_B + F_C - F_A$ OR $F_m + F_A - F_B = F_C$

$F_C = 1.5$ mg/l + 0.1 mg/l − 0.1 mg/l

$F_C = 1.5$ mg/l

THE FLOWRATE OF SODIUM FLUORIDE NEEDED TO DO THE TEST CAN BE DETERMINED.

$$1.5 \text{ ppm} = \frac{1.5 \text{ GRAMS}}{1.0 \times 10^6 \text{ GRAMS OF } H_2O}$$

$$\frac{1.5 \text{ g OF F}}{1.0 \times 10^6 \text{ g OF WATER}} = X \; 9{,}084 \text{ l/min} \left(\frac{1000 \text{ g OF WATER}}{\text{l}}\right)$$

$$X = 13.6 \frac{\text{g OF F}}{\text{MIN}}$$

(Ref. 6) 44% SATURATION SOLUTION AND 44% FLUORIDE ION CONCENTRAT

$$\frac{0.04 \text{ g OF NAF}}{\text{g OF } H_2O} \left(\frac{1000 \text{ g OF } H_2O}{1 \text{ l}}\right) (44\% \text{ F}) = 17.6 \text{ g OF F/l sat sol}$$

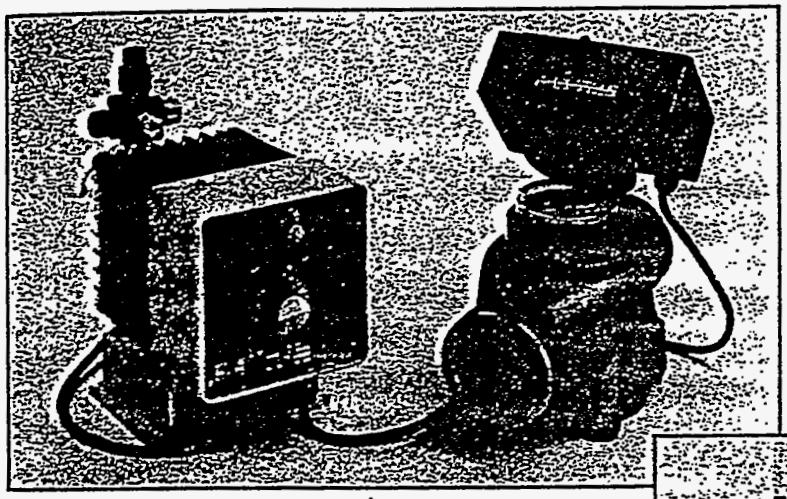
$$Q_{FIN/l} = \frac{13.6 \text{ g OF F}}{\text{MIN}} \left(\frac{1 \text{ l}}{17.6 \text{ g}}\right) \left(\frac{60 \text{ MIN}}{\text{HR}}\right) = 46.4 \text{ l/hr or } 12.25 \text{ g/l}$$

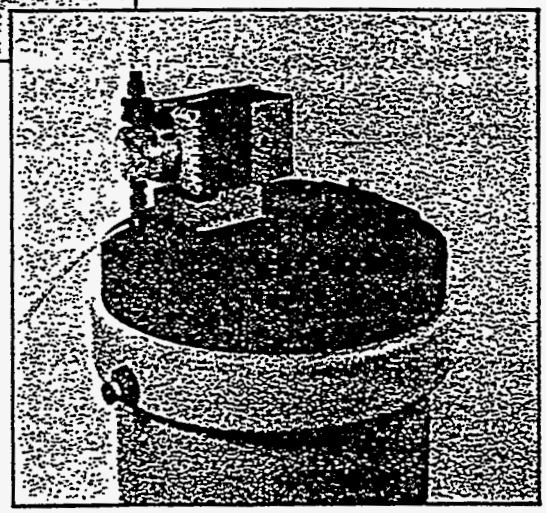
@ 9,084 l/min

$$Q_{FIN/2} = \frac{12.3 \text{ g OF F}}{\text{MIN}} \left(\frac{\text{l}}{17.6 \text{ g}}\right) \left(\frac{60 \text{ MIN}}{\text{HR}}\right) = 41.8 \text{ l/hr or } 11.04 \text{ g/l hr}$$

@ 8,175 l/min

FLUORIDATION





CHEMICAL CHOICE

The three most common fluoridation chemicals are sodium silicofluoride, sodium fluoride and hydrofluosilicic acid. This brochure deals with solution feed systems, utilizing the latter two of these chemicals.

Chemical	Properties	Typical Comm. Strength	Fluoride Ion Content
Sodium Fluoride NaF	white, odorless powder/crystals	90-98%	44%
Hydrofluosilicic Acid H_2SiF_6	clear to yellow liquid, pungent odor, skin irritant	30% 25% 22%	23.7% 19.8% 17.4%

The optimum concentration of fluoride in a public water supply has been set at approximately one part per million (1 ppm) according to the U.S. Department of Health and Human Services, Center for Disease Control 1982 Fluoridation Handbook. Levels may vary. Be sure to check with local health authorities when designing your fluoridation system.

LMI
LIQUID METRONICS DIVISION
MILTON ROY

8 Post Office Square Acton, MA 01720 U.S.A.
TEL (508) 263-9800 • TLX 95-1781
FAX (508) 264-9172

Catalog Sec. 3.1, pg. 1900
Replaces same of 5/85
1242.B 3/87

APPENDIX C

Calculation No. ER5480-G-004
Fluoride Loss Due to Addition of Alum, Rev. 0

KAISER ENGINEERS HANFORD

CALCULATION IDENTIFICATION AND INDEX

Page 1 of 3

Date Nov 11, 1994

This sheet shows the status and description of the attached Design Analysis sheets.

Discipline General WO/Job No. ER5480 Calculation No. ER5480-C-004

Project No. & Name EQ6BA4 - Tracer Study

Calculation Item Fluoride Loss from addition of alum.

These calculations apply to:

Dwg. No. _____ Rev. No. _____

Dwg. No. _____ Rev. No. _____

Other (Study, CDR) _____

_____ Rev. No. _____

The status of these calculations is:

☐ Preliminary Calculations

☒ Final Calculations

☐ Check Calculations (On Calculation Dated _____)

☐ Void Calculation (Reason Voided _____

_____)

Incorporated in Final Drawings? ☐ Yes ☒ No

This calculation verified by independent "check" calculations? ☐ Yes ☐ No

Original and Revised Calculation Approvals:

	Rev. 0 Signature/Date	Rev. 1 Signature/Date	Rev. 2 Signature/Date
Originator	Dennis G Lenhart 11/11/94		
Checked by	Todd D. Boucher 11/11/94		
Approved by			
Checked Against Approved Vendor Data			

INDEX

KAISER ENGINEERS HANFORD

DESIGN ANALYSIS

Calc. No. ER5480-G-00H
Revision 0
Page No. 2 of 3

Client ICF KH | WO/Job No. F00BB4
Subject Fluoride Loss due to addition of Alum | Date Nov 11, 1994 By Dina A Zaulk | Checked 11/11/94 By Todd D. Boucher
Location | Revised By

OBJECTIVE:

Alum is used in water treatment plants to reduce the turbidity of the water by flocculation. During this process, residual fluoride is adsorped onto the $Al(OH)_3$ molecules created by the following reaction of alum in water:

$$Al_2(SO_4)_3 \cdot 14.3H_2O + 3Ca(HCO_3)_2 \rightarrow 2Al(OH)_3 + 3CaSO_4 + 14.3H_2O + 6CO_2 \quad (1)$$

Since Fluoride is being added for a tracer study test, we must determine the amount of the tracer that will be lost.

DESIGN INPUTS:

CRITERIA:

The maximum allowable fluoride concentration in the exit stream may not exceed 2 ppm because the equipment used to test for residual fluoride has a maximum detection range of 2.0 ppm. We will assume that the maximum amount of alum will be added throughout the study. Sam Cump, 300 Area Treatment Plant, stated that alum addition in the 300 area water treatment plant to be from 5 to 20 ppm. We will use 20 ppm for determining fluoride loss.

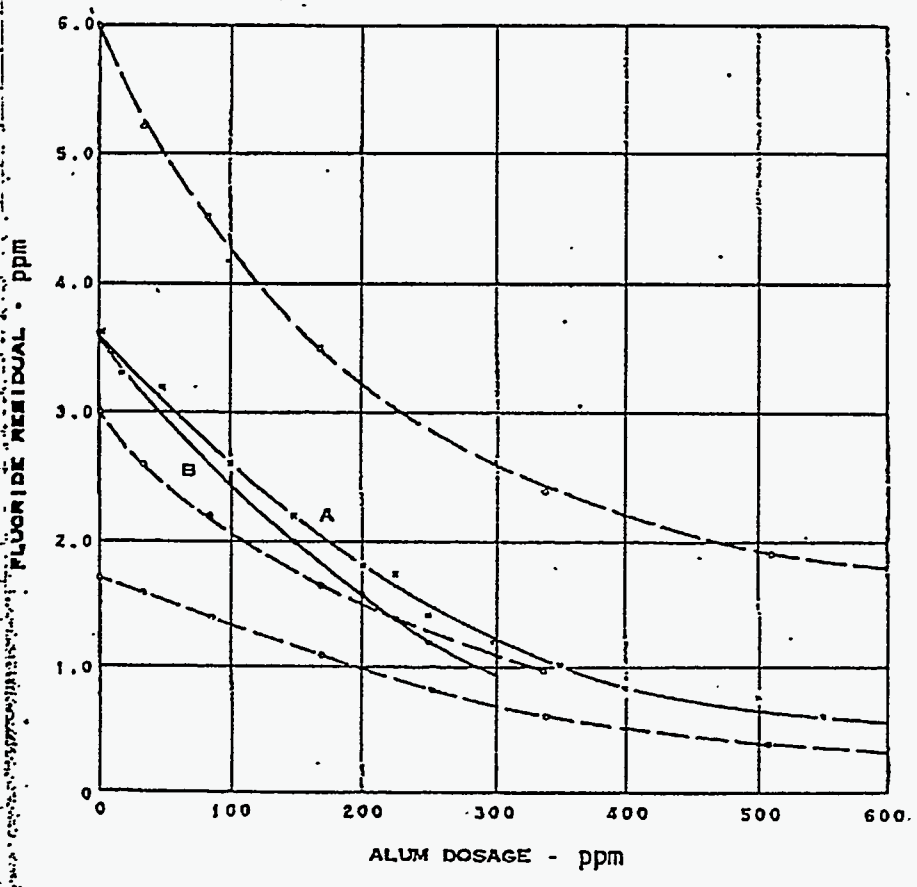
(1) Culp, Handbook of Public Water Systems, 1986, p656.

KAISER ENGINEERS HANFORD

DESIGN ANALYSIS

Calc. No. ER5480-C-001
Revision 0
Page No. 3 of 3

Client TCF KH
WO/Job No. F00884
Subject Fluoride loss due to addition of Alum
Date Nov 11, 1994 By Dana D Lambe
Checked 11/11/94 By Todd N. Boucher
Location
Revised By



The above figure is the plotted data results from tests conducted by Culp and Stallenberg on fluoride removal at various alum dosages.(1)

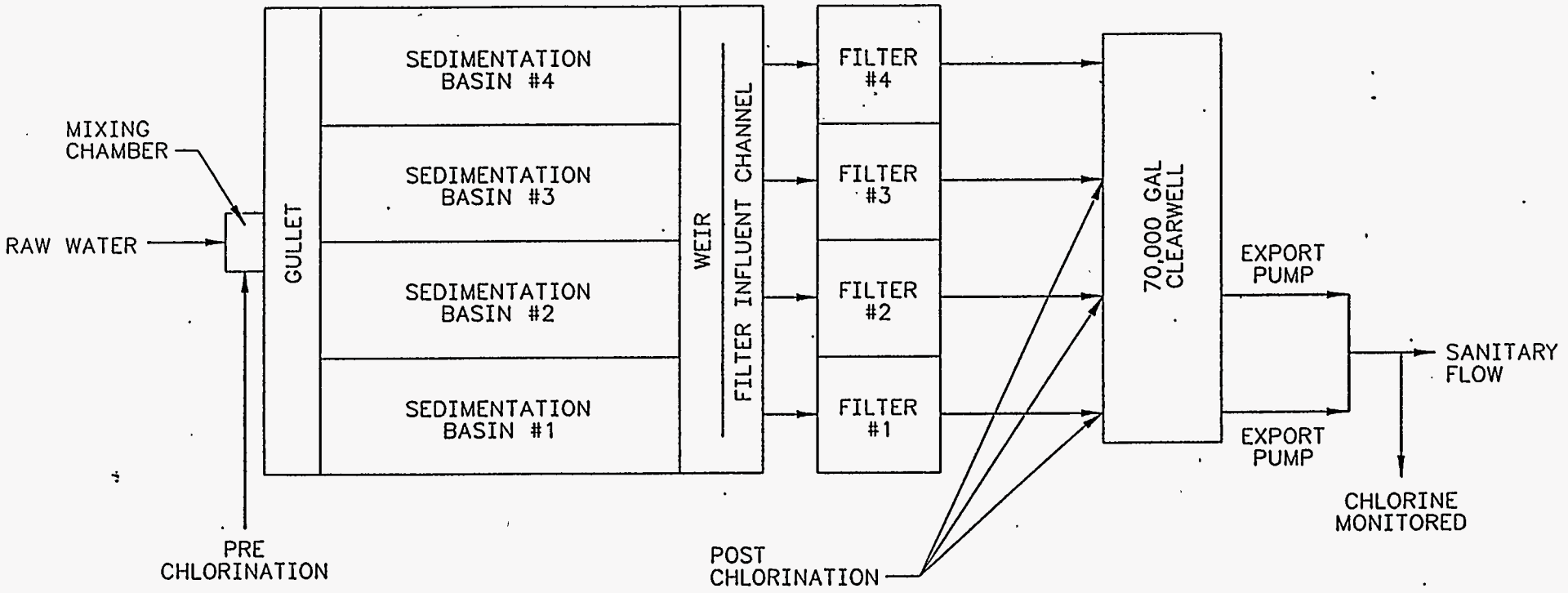
RESULTS:

From the above plot, we can see that a 1.8 ppm initial concentration of fluoride is reduced to 1.7 ppm (5.9% loss) with a 20 ppm alum dosage. Thus, the alum will not greatly effect the fluoride added to the system for the tracer study. The study will inject at a maximum of 1.5 ppm, so a loss of 0.1 ppm can be assumed.

(1) Culp, Handbook of Public Water Systems, 1986, p. 656.

APPENDIX D

315 Water Treatment Facility Layout



-(1 BASIN IN WINTER, 2 OR 3 DURING SUMMER)

ICF KAISER HANFORD	ENGINEERING SKETCH		
Attachment To Or Description: 300 AREA WATER TREATMENT PLANT	Prepared by: BA LORENZO Checked by:	Sh 1 of 1 Coalite ES5480E1	Rev 0

APPENDIX E

Washington State DOH
Tracer Evaluation Work Sheet

Tracer Study Evaluation Work Sheet

Evaluation by: T. Ambalam Date: April 3, 1995
Utility Name: Dept of Energy Richland Operations
Treatment Plant/ Facility Name: 315 Water Treatment Facility
Basin/Treatment Train Designation: 418408 Flashmixer: Sedementation basins, filter clearwe
Sample Point Designation: Sample Tap off clearwell discharge line.
Plant Flow Rates: 2,400 gpm (Q_p) Peak/Design Flow [MGD/GPD/gpm]
898 gpm (Q_{av}) Average Flow [MGD/GPD/gpm]
Basin Volume: 424,000 gal (V) [cubic feet/gallons]
Theoretical detention time: 177 min (T) [days/hours/minutes]
$T = V/Q_p$
Study flow rate:

☒ Multiple Flow Rate Study: (Equal increments required)

Q_1 = 2,400 gpm [MGD/GPD/gpm] (=QP)

Q_2 = 2,160 gpm [MGD/GPD/gpm] (0.90 QP)

Q_3 = _____ [MGD/GPD/gpm] (= Q_{av})

Q_4 = _____ [MGD/GPD/gpm] (> 0.91 Q_p)

☐ Single Flow Rate Study:

Q_t = _____ [MGD/GPD/gpm] (> 0.91 Q_p)

Basin Water Level = 10.8 feet (depth)

Normal Basin Water Level = 10.8 feet (depth)

Water temperature: Test Period 42.5-46.2 °F

Normal Temperature for Season 43-51 °F

Seasonal Variation:	Winter	Spring	Summer	Fall
Maximum (°F)	50	59.5	75.2	68.4
Average (°F)	43.2	51.1	67.6	55.8
Fall (°F)				

Tracer Selection

Chemical Tracer: Sodium Fluoride Dose: 1.21-1.27 ppm

Note: Recommended dosage for chloride = 20 ppm if background chloride levels are < 10 ppm;

Recommended dosage for fluoride $1 < C_t < 2$ ppm;

Rhodamine WT is acceptable if maximum concentration is . 10 ppm, drinking water concentration < 0.1 ppb, exposure is brief and infrequent, and tracer concentrations should be 2 ppb;

Common tracer chemicals not recommended for use are Rhodamine B; potassium permanganate; alum; chlorine; and sodium carbonate..

Compatibility with potable water usage : Yes

Background levels of tracer in raw water: 0.4 ppm

Feeding equipment & methods: LMI Model 28850 Fluoride saturator as an electronic metering pump

Consumer acceptance of tracer chemical: Yes

Test Procedure

☒ Step-dose method

☐ Slug-dose method

Tracer Addition & Sampling:

Sampling Period: 10.9-11.7H [days/hours/minutes] (t_s)

t_s < 2 T Yes ☐ No ☒

Sampling Frequency: 2-5 min Acceptable ☒ Unacceptable ☐

Note: Sampling required every 10 minutes for first 10 minutes or until background concentration is exceeded; sampling every 2 to 5 minutes during required for remaining sampling period; sampling continued until steady-state effluent concentration is reached beyond t_s.

Health concerns:

Is effluent tracer concentration limited? Yes ☒ No ☐

Maximum level: 1.5 ppm;

How is concentration maintained: Flow rates maintained to ensure concentrations do not exceed 2.0 ppm

Step-dose method:

Tracer addition = sampling period? Yes ☐ No ☒

Slug-dose method:

Instantaneous injection period: _____ t_i (t_i < 2% T)

Is injected mass based on basin volume equal to step-dose level?
Yes ☐ No ☐

Density current effects (Mitigation efforts): _____

Tracer recovery:

Is alum used in plant treatment? Yes ☒ No ☐

90% tracer recovery? Yes ☐ No ☒

Data Evaluation:

Evaluation technique: graphical ☒ numerical ☒

T_s = 300,000/Q minutes
Q=Flow (gpm)

END DATE

7-25-95