REACTIVE TRANSPORT OF PERCHLOROETHYLENE THROUGH SURFACTANT-MODIFIED ZEOLITE

by

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ABSTRACT

A current problem in Hydrogeology is how to remove a wide variety of contaminants from polluted groundwater. We have determined that chlorinated organic compounds can be removed from contaminated water using surfactant-modified zeolite (SMZ). To test the effectiveness of hexadecyltrimethylammonium(HDTMA)-modified zeolite for removing the chlorinated organic compounds perchloroethylene (PCE) from contaminated water, I performed the following three tasks: quantifying sorption of HDTMA on zeolite and producing a large batch of treated material; determining the effects of water chemistry, particularly ionic strength, on PCE sorption; and testing PCE movement through columns of SMZ.

The amount of HDTMA ion sorbed onto St. Cloud zeolite containing about 74% clinoptilolite mineral reaches a plateau at about 220 mmol/kg of treated zeolite, twice the external cation exchange capacity. Also, HDTMA sorption on the zeolite is complete within eight hours. Most importantly, HDTMA does not readily desorb with repeated water washing unless it is sorbed at a concentration exceeding the plateau level. This suggests that SMZ will not lose sorption capacity in an in-situ decontamination scheme.

Linear sorption coefficients (K_d's) for PCE in three waters with different chemical compositions varied from 10.6-10.9 L/kg. The primary difference among the waters was ionic strength, with two of the water having $I \approx 0.008M$ and one having $I \approx 0$. The sorption isotherms were all linear in the 50-200 ppm mg/L range. Also, the ionic strength and chemical speciation differences among the waters did not appear to affect the amount of PCE sorption. These observations suggest a partitioning sorption mechanism.

A column study using PCE as a contaminant and tritiated water as a nonreactive tracer was performed to test prediction capabilities based on PCE batch sorption isotherms. Retardation factors calculated from batch study data were 15.3 and 17.2 for two different columns filled with SMZ. Modeling of column effluent data resulted in R predictions of 42.0 and 45.4, respectively. The high R values may be due to diffusion into immobile water in treated columns in the column study. Untreated columns did not exhibit appreciable amounts of immobile water (eg, no tailing of PCE or tritium concentrations), but mobile water fractions for the treated columns were 0.511 and 0.764. We noted that, despite the lower fraction of mobile water in the treated columns, there is some early initial breakthrough of PCE (though breakthrough is retarded overall), probably because the contaminant is only moving in larger, faster flow channels. Also, the batch study K_d values may not be valid for the low PCE concentration of 320 ppb used in the column study. However, because the lower concentration is more commonly encountered in contaminated groundwater, we can assume that the higher retardation observed in the column study is closer to what we will see in field installations of SMZ barriers.

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On a personal note, I would like to dedicate this thesis to my father, whose struggle with Alzheimer's disease has been an inspiration to me and a lesson in how to enjoy every moment of this life with a positive attitude; and to my mother, who is the supreme example of strength and faith in my life. I also need to thank my wonderful roommate, Bernadette Tsosie, who continues to give encouragement even from afar, and my younger sister Barbara, who knows how to listen. My little nephew Jacob also pitched in during his summer visits - I hope he learned what radioactivity is! - and helped me remember to have a little bit of fun at Elephant Butte. Thanks to CDM Federal, who funded my entire first year at Tech by feeding me projects to work on; this enabled me to support myself and give a boost to my younger siblings, of whom I am so proud as I see them achieve their own goals! Finally, I thank my very patient husband, Alex Feldman, who has waited for me to come home at last for almost a year.

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1.0 INTRODUCTION

1.1 Purpose

An important problem in the field of Hydrogeology is how to most effectively remove from contaminated groundwater pollutants ranging from manmade chemicals such as chlorinated hydrocarbons to natural inorganic compounds such as arsenate. Various technologies have been developed to remove different classes of contaminants both in situ and aboveground; these include soil vapor extraction for volatile organic contaminants, enhanced biodegradation for organic contaminants, and pump and treat for a variety of contaminants. However, many existing technologies such as soil vapor extraction remediate water for only one type of contaminant at a time; others, particularly pump and treat schemes, require large amounts of energy and time to remove and treat contaminated water. It is highly desirable, therefore, to develop a treatment technology that remediates water in situ for several different types of contaminants, from volatile organics to radiochemicals to inorganic heavy metals.

The ultimate goal for this research project is to develop and test a zeolite-based permeable barrier system for the remediation of contaminated groundwater. The immediate goal of the research discussed in this paper is to develop the zeolite-based material and describe sorption and transport of organic contaminants in this material. This document describes the work performed to assess the ability of a surfactant-modified zeolite material (SMZ) to adsorb nonpolar volatile organic chemicals both at test-tube scale and in a packed bed configuration. In particular, the following three tasks were completed: developing lab production of SMZ; determining the effects of water chemistry on sorption of nonpolar organic chemicals; and predicting nonpolar organic contaminant movement through beds of SMZ.

1.2 Background

Use of Surfactant-Modified Clay Minerals in Groundwater Remediation

Clays have been used as impermeable barriers at least since the early 1970s due to their low hydraulic conductivity. They have become sufficiently widely accepted that they are now required in EPA specifications for hazardous waste disposal landfill design under RCRA regulations (40CFR 264.301). However, the idea of modifying mineral surfaces with organic material to promote adsorption of organic contaminants is fairly recent. Researchers have added dodecylpyridinium (DP) to increase soil organic matter and "promote sorption of hydrophobic organic compounds" (Westall et al, 1994). They injected DP into different aquifer materials and noted that the DP sorbs up to two times more strongly to clay minerals than to sand. This is because most clay minerals have a net negative surface charge, which makes them attractive to cations like DP. Sand, however, has no permanent surface charge and a very low cation exchange capacity (CEC).

Smith and Jaffe (1994) also modified bentonite clay by replacing surface cations with four different quaternary amine surfactants. They found that all four modified bentonites showed strong sorption of benzene, tetrachloromethane, trichloroethylene, 1,2-dichlorobenzene, and naphthalene from aqueous solutions (Smith and Jaffe, 1994). Other results obtained using a quaternary-amine-modified bentonite/montmorillonite mixed with anthracite show removal of several nonpolar organic compounds, transmission oil, diesel fuel, PCBs, and lead (Alther, 1996).

Organic Contaminant Sorption Mechanisms

We know that nonpolar organic contaminants are sorbed onto surfactant-modified mineral surfaces. The mechanism for that sorption has recently been attributed to a partitioning of the organic contaminant into the organic "layer" on the mineral surface out of the aqueous phase (Chiou, 1989). In other words, the contaminant is more soluble in the organic surfactant layer than it is in the aqueous phase. Dr. Cary Chiou defines partitioning as a type of sorption in which the "sorbed organic chemical permeates into the network of an organic medium by forces common to solution," such as van der Waals forces. He compares partitioning to the extraction of an organic compound from an aqueous into an organic phase, suggesting that if the organic phase is solid, then the partitioning is like adsorption, except that it is evenly distributed throughout the solid phase volume.

Chiou asserts the following criteria provide evidence for partitioning as the chief mechanism for soil uptake of contaminants from water: dependence of sorption on organic-matter content of the soil; sorption following a linear isotherm up to high concentrations (often up to the aqueous solubility of the contaminant); heats of sorption for solutes which are less exothermic than heats of solute condensation from water (i.e. reverse heat of solution); and lack of solute sorption competition. Chiou also noted that there is an empirical correlation between K_{om} (organic matter partitioning coefficient) and K_{ow} (octanol water partitioning coefficient) values for organic contaminants because both of these depend strongly on water solubility. A linear isotherm is expected because the solute partitioning coefficient, K, is virtually independent of solute concentration, so the ratio of material on the mineral surface to material in solution does not change with increasing solute/contaminant concentration. Next, in the case of solute sorption from an aqueous solution into a solvent, the "heat of partitioning" or ΔH for the sorption reaction is relatively smaller in magnitude and less exothermic than its heat of condensation from water, contrary to the normal behavior for solute adsorption; this is because the solute is nonpolar and preferentially soluble in the solvent. In other words, the driving force is for the solute to condense out of the aqueous solution, rather than for the solute to be sorbed into the solvent. However, entropy-driven hydrophobic interaction, the unusually strong attraction between hydrophobic molecules and surfaces in water, also strongly encourages partitioning of nonpolar organic solutes into organic solvents (Israelachvili, 1992). Finally, lack of solute competition is expected for a partitioning mechanism in which there is not a finite number of sorption sites and the amount of each species sorbed depends only on its solubility.

Previous results in early stages of this project indicated that the amount of organic matter in zeolite strongly influenced nonpolar organic compound sorption because the organic matter created a hydrophobic medium on the mineral surface, increasing sorption of nonionic organic compounds by up to 200 times. This suggests that the mechanism for sorption of nonpolar organic contaminants to surfactant-modified zeolites is partitioning. Specifically, Huddleston (1990) noted the following: K_{om}/K_{oc} (organic carbon partitioning coefficient) values for PCE, ethyl benzene, and trichloroethane were similar across different zeolites; linear isotherms occurred at concentrations near the solubility of the contaminant; and there was a strong correlation between K_{ow} and K_{oc} for contaminants (Huddleston, 1990). These results show the importance of the amount of organic material on the mineral surface and exhibit some of Chiou's criteria for partitioning.

It is desirable, then, to increase the amount of organic material on the mineral surface as much as possible in order to achieve a maximum amount of contaminant sorption. The surfactant we used, hexadecyltrimethylammonium chloride (HDTMA), has 16 carbons per molecule adsorbed or exchanged onto the mineral surface. We would also expect the least soluble organic solutes to be most strongly sorbed to our SMZ.

Preliminary research showed that nonpolar organic contaminants such as perchloroethylene (PCE), trichloroethane, and ethylbenzene are adsorbed by HDTMA-treated zeolite according to linear isotherms (Huddleston, 1990). Specifically, Neel (1992) found linear sorption isotherms for p-xylene, toluene, and benzene. For toluene, up to 1300 mg/kg of treated zeolite was sorbed. Little sorption competition was observed among these contaminants (Neel, 1992). Also, the most soluble (in water) contaminant, benzene, was the least-sorbed, with the lowest K_d of the three solutes (Bowman et al, 1995). All of these behaviours are expected if partitioning is occurring.

1.3 Overview of Work Performed

Lab production of SMZ, assessment of water chemistry effects on contaminant sorption, and prediction of contaminant transport in a packed bed configuration were completed for this project.

In order to develop lab production of SMZ, the zeolite was modified by the addition of the cationic quaternary ammonium surfactant HDTMA. Several test-tube studies were performed to delineate the sorption isotherm for HDTMA in order to determine how much should be added in the preparation of a large batch. Test-tube studies also determined the length of time necessary for HDTMA sorption to be complete and quantified the stability of HDTMA on the mineral surface after repeated washings with water. The latter information was required to assure that the SMZ would not lose sorption capacity in a packed bed or barrier situation where many pore volumes of contaminated water might pass through the material. The sorption isotherm data was then used to generate a 30 kg batch of SMZ for use in the remaining laboratory-scale work.

To assess the effect of site-specific water chemistry on nonpolar organic contaminant sorption, three different waters were used to perform test-tube scale sorption experiments. One of the waters was high purity water with an ionic strength of almost zero. The other two waters, each with an ionic strength close to 0.01M, were synthesized based on water analyses from two contaminated sites, one a United States Coast Guard (USCG) site in Elizabeth City, NC and one at Oak Ridge National Laboratories, TN.

Finally, the organic contaminant sorption data generated was used to predict contaminant transport through packed columns of SMZ. Then a column experiment was performed using the Elizabeth City water, which contained both the organic and inorganic contaminants of concern. The column effluent was sampled, analyzed, and modeled to estimate a retardation factor for comparison with the batch-scale prediction.

2.0 Materials

A wide variety of materials and analytical equipment were used during batch sorption and column study experiments. Chemicals and raw zeolite mineral described in detail below. Other materials are described in Section 3.0.

2.1 Chemicals

Radiolabelled chemicals were used in batch and column studies to quantify the amount of HDTMA or PCE sorption occurring. Concentrated radiolabelled standards of ^{14}C and ^{3}H were diluted and used to spike pre-sorption solutions with a known amount of the solute to be sorbed.

2.1.1 Surfactant

We used the organic cationic surfactant hexadecyltrimethylammonium bromide (HDTMA-Br), as this was determined in previous work to maximize the amount of organic material sorbed onto the mineral surface (Huddleston, 1990), which is very important for sorption of nonpolar organic contaminants. HDTMA was also found to be very stable on the zeolite mineral surface. HDTMA has an ammonium cation headgroup to which are attached one 16-carbon chain and three methyl groups.

^{14}C-labeled hexadecyltrimethylammonium bromide supplied by American Radiolabelled Chemical Company was used for batch studies of HDTMA sorption. The standards used had been diluted with Type I water to an activity of 9.99 x 10^{6} cpm/ml. These standards were used to make solutions with concentrations ranging from 0.004 to 0.15M HDTMA for batch sorption studies. The critical micelle concentration (CMC) of HDTMA-Br in aqueous solution is 0.9 mM, so we worked at concentrations at which micelle formation should be occurring. This had important implications for the sorption mechanism, since there is some question as to whether HDTMA molecules are sorbing onto the mineral surface as individual molecules or as micelles which subsequently rearrange on the surface.

Regular HDTMA was used in batch HDTMA sorption studies and to prepare a 30 kg batch of treated zeolite for batch contaminant sorption and column studies. Radiolabelled HDTMA was used to spike initial solutions in batch studies of surfactant sorption. The non-labeled HDTMA purchased from Sigma Chemical Company (#H-5882) was 99% pure, with an aqueous solubility of about 10% (w/v) and formula weight of 364.5 g. We did encounter solubility problems when treating a large batch of zeolite with a solution concentration of 0.05M; the solubility was decreased by the cool temperature in our work area (about 60°F and colder overnight), so the HDTMA formed a viscous gel on the bottom of the mixing container. The surfactant was finally dissolved by using hot plates under the mixing container to elevate the temperature. Approximately 2213 g HDTMA were used to prepare the large batch of treated zeolite.

2.1.2 PCE for Batch and Column Studies

Two separate batches of PCE were purchased from Sigma Chemical Corporation, with the total and specific activities differing. The ^{14}C isotope has an average decay energy of 49.3 KeV and an Emax (maximum energy of decay) of 156 KeV. PCE has an aqueous solubility of about 150 mg/L (Verschueren, 1983), though it may be as high as 220 ppm (Z. Li, personal communication). It also has a density of 1.623 mg/l and a Henry's Law constant K_H = 0.833 @ 20°C.

The first batch consisted of 1.8 microliters of PCE with a specific activity of 58.7 mCi/ml and a total activity of about 100 microCuries. After dilution in 10 ml of unlabelled PCE, the concentration should have been about 10.6 microCuries/ml. However, a 1-ml sample was counted at 178388 cpm or 196084 dpm (assuming a 91% efficiency for ^{14}C on a 4-156 KeV energy region). This is the equivalent of about 17.7 microCuries/ml (see Appendix C). This discrepancy may exist because the counting efficiency was not correctly measured or the scintillation counter calibration needed to be updated. The 178388 cpm figure was used in calculations of initial solution concentrations for PCE sorption batch-scale studies.

The second batch had an activity of 250 µCi, with a specific activity of 2.8 mCi/mmol. All of this material that could be recovered (before volatilization) from its flame-sealed shipping vial was dissolved in 10 ml of ethanol to increase its aqueous solubility and then dissolved in 21 liters of Type I water. Two samples collected after mixing showed a C-14 activity of about 11900 dpm/ml (assuming a counting efficiency of 0.4180), or 320 ppb PCE. This calculation is shown in Appendix C.

2.1.3 Tritium for Column Study

The tritium used as a nonreactive tracer in the column study was tritiated counted at 1.26×10^8 cpm/ml. For the PCE study, the nonreactive tracer was to be input at the same time as the reactive contaminant due to time constraints and the column lengths. With a counting background of about 50 cpm/ml, the detection limit is about 500 cpm/ml. This number should be about 1% of the maximum concentration of the column effluent. Since we wanted to see the input solution concentration at the column outlet for modeling purposes, the input solution would need an activity of about 50,000 cpm/ml. Initial counting of 1-ml samples of ^{3}H Solutions #1 and #2 exceeded the maximum quantification limit of the HP Liquid Scintillation counter. After a 99:1 water/tritium dilution, 1 ml samples of each mixture were counted at about 1.2×10^6 cpm/ml.

Because the actual concentration of Solution #1 was known and could be used to make standards, we decided to use this material in the column study input solution. The original activity, A_o, was 0.2 mCi = 4.44×10^8 dpm in 11/88. Accounting for decay, the activity in 6/96 should be 2.92×10^8 dpm (see Appendix C for calculation). To get down to 50,000 cpm/ml, we needed a 2399:1 input water/Sol #1 dilution, or about 8.75 ml of Sol #1 in 21 liters of input water.

2.1.4 Other Chemicals

Numerous other chemical compounds were used throughout the batch and column studies. The most important are listed below.

During the HDTMA sorption study, we used biodegradable Ecolite organic scintillation cocktail purchased from ICN Biomedical (Cat # 882475). This cocktail is appropriate for samples with low to medium ionic concentrations and up to 30% sample loading (v/v). The highest sample/cocktail ratio we used was 1:6 ml, or 17%.

We synthesized contaminated groundwater analogs for PCE sorption studies to test the effects of water chemistry such as pH and ionic strength on PCE sorption. The following chemicals used in the synthesis were all obtained from Sigma Chemical Company: Sodium Bicarbonate ($NaHCO_3$), Sodium Sulfate (Na_2SO_4), Calcium Chloride ($CaCl_2 \bullet 2H_2O$), Magnesium Chloride ($MgCl_2 \bullet 6H_2O$), Manganese Chloride ($MnCl_2 \bullet 4H_2O$), Aluminum Chloride ($AlCl_3 \bullet 6H_2O$), Sodium Chloride (NaCl), and Sodium Chromate (Na_2CrO_4), and Ferric Oxide (Fe_2O_3).

Industrial-grade compressed gases were provided by NM Tech Physical Plant. Air and Hydrogen gases were used as fuel for the GC Flame Ionization Detector (FID). Helium and Nitrogen were used as carrier gases. 1-ml GC standards with 200 μg/ml (ppm) in methanol were purchased from Supelco (#4-8609) and supplied in flame sealed vials. The standards were transferred to 1-ml amber glass vials with crimp-top lids containing rubber septa. As a result of puncture holes in the septa, these standards lost material over time and had to be refrigerated.

Finally, Carbon Dioxide gas was used to purge air out of packed columns. Also, 10 ml of ethanol was used as a cosolvent to remove all radiolabelled PCE from its flame-sealed shipping vial.

2.2 Zeolite

The zeolite used for all phases of this experiment was obtained from the St. Cloud Mining Company near Truth or Consequences, NM. The chemical composition of the material determined by x-ray fluorescence (NM Bureau of Mines) is shown in Table 2.1.

Table 2.1: Chemical Composition

Compound	Weight %
SiO_2	67.94
TiO_2	0.23
Al_2O_3	12.06
Fe_2O_3 (total)	1.40
MgO	1.22
CaO	2.87
Na_2O	0.62
K_2O	2.87
Trace Ba, Mn, and P	

Zeolite is a hydrated aluminosilicate mineral with high internal and external surface areas measuring up to several hundred square meters per gram. It also has a high cation-exchange capacity, which is one of its most important characteristics for our work, since our organic cationic surfactant exchanges with surface cations when it is sorbed. The St. Cloud zeolite has a high percentage by weight (74 ± 4%) clinoptilolite, the most abundant naturally-occurring zeolite mineral. Other minerals present include 12 ± 2% feldspar, 12 ± 2% quartz, and 6 ± 3% smectite and illite clays. Because of the isomorphic substitution of aluminum for the higher valence state silicon in the clinoptilolite crystal structure, a net negative charge exists in the mineral skeleton, which is balanced by surface cations such as Na, Ca, and K. This makes it amenable to sorption of cationic contaminants, such as lead, cadmium, and ammonium, by exchange. The St. Cloud zeolite has a high external cation exchange capacity (CEC) of 110 mmol/kg (Sullivan, 1996, personal communication).

Clinoptilolite also has a cage-like structure with a maximum internal channel aperture of 0.44 x 0.72 nm (Newsom, 1986), which makes it impossible for the organic cationic surfactant used, HDTMA, to access the internal surface. Also, it has a low 6% clay content and very little organic matter on the mineral surface, so that it has little natural affinity for sorption of organic compounds (Huddleston, 1990; Neel, 1992).

3.0 Methods

The work completed for this project included the following five tasks: batch-scale studies of HDTMA sorption, mixing a large 30-kg batch of surfactant-modified zeolite, batch-scale studies of PCE sorption on HDTMA-treated zeolite, column studies of PCE sorption from a chromium-contaminated water, and modeling of column study results. Detailed procedures for each of these tasks, including analytical procedures, are described in the following sections.

3.1 Batch Studies of HDTMA Sorption

We performed test-tube scale experiments to determine the quantity of HDTMA that can be adsorbed on the St. Cloud zeolite. For each experiment, we used 5 g of zeolite with 20 ml of ^{14}C radiolabelled HDTMA solution, preserving a 4:1 liquid to solid ratio so that data would be comparable. Materials were weighed on a Ohaus Precision Standard Balance with three significant figures. Each 50-ml Nalgene test tube was shaken for 24 hours at 25°C (except in the reaction time experiment), centrifuged on a Beckman J2-MI Centrifuge at 13000 rpm (10600 x g relative centrifugal force [RCF]) for 30 minutes, and sampled, with 1 ml of the equilibrium supernatant withdrawn using a Brinkmann Eppendorf 1-ml autopipette with plastic pipette tips. These samples were then placed in 9-ml of scintillation cocktail and analyzed by liquid scintillation counting for ^{14}C.

Duplicate or triplicate samples were prepared for each initial solution concentration to quantify precision of data. To determine counting background, one test tube was prepared for each batch with 5 grams of zeolite and 20 ml of pure water containing no radiolabelled HDTMA. This test tube was treated identically to all other test tubes in the batch and was sampled and analyzed. The number of counts (cpm/ml) analyzed for this sample was considered a measurement of background radiation and was subtracted from the total number of counts for all other samples. Finally, reaction test-tubes containing solutions at high concentrations such as 0.15M often had to be warmed to prevent crystallization of HDTMA, especially when room temperatures fluctuated below 24° C.

3.1.1 Sorption Isotherm Procedure

In the first set of experiments, we reacted HDTMA with raw zeolite to determine the amount of sorption occurring with our batch of St. Cloud zeolite, which had not previously been quantified. A sorption isotherm is a graph of the amount of material sorbed on the mineral surface for a particular equilibrium (post-sorption) solution concentration. A range of initial (pre-sorption) concentrations of HDTMA-Br from 0.15M, near the aqueous solubility of HDTMA-Br, to 0.028M were used to produce an isotherm. These concentrations provided a large range over which we should be able to see any curvature of the sorption isotherm, with all concentrations above the CMC of 0.9 mM. This procedure was repeated three times, for a total of four different data sets.

To make the initial solutions, we first mixed the highest desired concentration using non-radiolabelled HDTMA and then diluted from that solution. For instance, if we needed 50 ml of a 0.15 M HDTMA-Br solution, we weighed and dissolved the required amount of solid HDTMA-Br (see Calculations in Appendix C). Then we diluted 25 ml of that solution with 25 ml Type I water to produce 50 ml of 0.075M solution, and so on. We used glass pipettes from 5 to 100-ml sizes and 3-way pipette bulbs to perform the dilutions. After preparing the solutions, we spiked each with enough ^{14}C-radiolabelled HDTMA-Br to achieve an initial concentration of 70000 cpm/ml. Assuming 99% sorption, this concentration would still leave 700 cpm/ml in the equilibrium solution, high enough above the 50 cpm/ml background that it would be quantifiable. The amount of spike required was in the microliter range and was so small compared to the amount of solid HDTMA-Br (usually several grams) added that it did not affect the overall solution HDTMA concentration. A sample spike calculation is shown in Appendix C.

For each initial concentration, we had three to four test-tubes - two or three replicates and one standard containing only 20 ml of initial solution and no zeolite. Using the procedure previously described, we reacted the zeolite and

HDTMA solutions, then obtained and analyzed samples of the equilibrium supernatant. Both the replicate samples and a 1-ml sample of the standard were analyzed by liquid scintillation counting. The results in cpm/ml were put into an EXCEL database and compared; the difference between initial and final solution concentrations was assumed to be the amount sorbed onto the mineral surface. Finally, the amount sorbed was graphed versus the equilibrium solution concentration to produce the sorption isotherm. Sample calculations for determining the amount sorbed are shown in Appendix C.

3.1.2 Time Dependence

We performed an experiment to determine how quickly sorption occurs, and at what time it is complete, with no further sorption occurring. The procedure was basically the same as for the HDTMA sorption study, except that we used only one initial concentration and analyzed aliquots of the test-tube supernatant at regular intervals from 15 minutes to 72 hours. The initial solution had an HDTMA concentration of 0.0375M, which was 75% of the 0.05M initial concentration corresponding to the maximum plateau amount of sorbed material observed in the first series of experiments. We prepared a total of 21 test tubes so that we could take duplicate samples at each of ten different times. The extra sample was a blank containing no zeolite. The data were graphed as amount of HDTMA sorbed per kg of zeolite versus time.

3.1.3 HDTMA Stability on Zeolite Surface

Because of concerns about desorption of HDTMA and loss of sorption capacity of treated zeolite during groundwater remediation projects, we needed to determine how much HDTMA desorbs when the treated zeolite is washed with several pore volumes of water. The procedure was almost identical to that of the HDTMA sorption study, with one exception. After reacting the materials for 24 hours and then centrifuging, we removed 10 of the 20 ml of supernatant solution with a calibrated glass pipette and replaced it with 10 ml of Type I (pure) water, so that the solution HDTMA concentration decreased by 50% after every withdrawal. In each case, 1-ml of the ten withdrawn was counted by liquid scintillation counting. The withdrawal and replacement sequence was repeated a total of five times. The data were graphed as amount of HDTMA sorbed (mmol) per kg zeolite versus number of washes.

The accounting to determine the HDTMA concentration sorbed after each new equilibrium was more complex than in previous experiments, since we determined the initial amount in solution in each diluted volume of water to compare with the equilibrium solution concentration. The new initial amount in solution (mmol) was assumed to be half that of the old amount, since the equilibrium solution from the previous step was diluted by exactly 50%. After allowing 24 hours for a new equilibrium to be established, we then analyzed equilibrium solutions, calculating the amount of HDTMA in solution. The initial solution concentration (cpm/ml) for each wash was obtained by halving the final (equilibrium) cpm/ml figure from the previous wash. Finally, the equilibrium solution concentration was compared with that of the previous wash to determine how much HDTMA had gone into or sorbed out of the solution. This figure was then added to or subtracted from the amount sorbed in the previous step. Sample calculations are provided in Appendix C.

3.2 Large Batch Mixing

Two processes were involved in the preparation of a 30 kg batch of treated zeolite; one was the actual mixing and the second was an HPLC method for analyzing the HDTMA concentration in the mix supernatant. For this batch, we used non-radioactive HDTMA-Br to avoid generating large amounts of radioactive waste and to simplify zeolite handling during later experiments. Since we could not use liquid scintillation counting, the HPLC analysis was necessary to determine when sorption was complete and the zeolite was treated to the desired level of HDTMA sorbed on the mineral surface. The amount sorbed would affect the contaminant sorption and column study processes in which the treated zeolite was intended to be used.

The first step in the mixing process was to determine how much material would be needed. We decided to use a concentration corresponding to an amount of HDTMA sorbed at 90% of the plateau maximum level. The initial solution reaching the plateau level, as will be discussed in Section 4.1, was about 0.05625 M, so 90% is 0.0506 M. Also, we conservatively needed about 30 kg of treated zeolite to perform batch contaminant sorption and column studies. Preserving the 4:1 liquid to solid ratio used in the HDTMA batch experiments, we thus needed 120 kg of HDTMA solution, or 120 liters, which is about 32 gallons. For 120 L of 0.0506M HDTMA solution, then, we needed about 2213 g of HDTMA.

We found a 60-gallon steel shipping cask in which to mix the batch, allowing extra room for anticipated foaming of the surfactant. The container was cleaned with copper wool and soapy water. It had two bars attached to the bottom for use with a forklift and steel rings at three points on its rim. We used a piece of hollow steel conduit pipe open at both ends, bent at a 90° angle using a vise, to suspend mixing tools over the solution in the container. The pipe was secured at the container rim through one of the steel rings and at the bottom between the container and the attached metal bar, so that it did not move when mixing tools were in operation. Then, using a Black and Decker heavy-duty drill (provided by the NM Tech Physical Plant) with 12 inch bars on either side of the motor, we inserted the left bar into the conduit pipe so that the drill was centered, facing downward, over the shipping container. The chuck was then adjusted to accept a medium-thickness paint mixing tyne (Furrow Building Supply).

The next task was to test the amount of breakdown of the zeolite with our mixing process. The zeolite had seemed to physically break down to smaller particle sizes with vigorous handling in previous experiments, though we were not certain how much of the decrease was due to the presence of surfactant molecules. We mixed a 30 kg batch of zeolite with tap water using the apparatus for 24 hours. We weighed the 30 kg and added 120 liters of water using calibrated 5 gallon plastic containers. This also gave us an opportunity to test the equipment and ascertain that the drill and conduit pipe were strong and stable enough to mix the desired volume of solution and zeolite. After mixing, the water was siphoned off with hoses and the zeolite was dried on plastic sheeting. Finally, a particle size analysis was performed by sampling the dried zeolite and sieving it through a set of 20, 30, and 40 mesh sieves. Each sample was weighed and shaken in a sieving apparatus for three minutes. The data was plotted in a bar graph as % Retained (by weight) versus Sieve Size.

During this test, we realized that the paint mixer, with its small radius of about four inches, was not large enough to move the zeolite and keep it in constant contact with the solution. Therefore, we modified it with a lawn-mower blade welded flat onto the bottom (welding provided by technicians at EMRTC).

Unfortunately, the blade was too long for the drill speed that was available, so that it mixed the container solution too vigorously. As a result, we instead used an unmodified heavy-duty paint mixer and manually mixed the zeolite with shovels once every hour.

To make the large batch, we first prepared 120 L of 0.0506M HDTMA-Br in our container, using tap water measured in 5 gallon plastic containers marked with volume measurements. We mixed this solution with the paint mixer apparatus. We had some trouble getting all of the HDTMA to dissolve due to the low temperature of the ambient air, which decreased its solubility considerably; the surfactant formed a thick gel on the bottom of the container. To solve the problem, we used stirring bars and hot plates placed beneath the container to elevate the temperature of the supernatant and keep HDTMA from forming a gel. After about 24 hours, we sampled the HDTMA solution; then we weighed and added 30 kg of St. Cloud zeolite in the 14-40 mesh size. The supernatant was periodically sampled so that we would know when the desired amount of HDTMA was adsorbed. This point was expected to be at a supernatant concentration of 3.2mM, which corresponded on our sorption isotherm to an initial solution concentration of 0.0506.

After much variation in the supernatant HDTMA concentration over three days of mixing, the liquid finally had a sufficiently low concentration. We then siphoned off 86 liters of supernatant using garden hoses and added 86 liters of tap water to rinse the treated batch. After another eight hours of mixing, we siphoned off 78 liters of wash water and spread the solid material on 10-mil plastic sheeting to dry.

The drying process took 11 days. A particle size analysis was performed on the dry material using 20, 30, 40, 100, and 140 mesh sieves borrowed from Dr. Jan Hendrixx of the NMIMT Hydrology Program; the smaller meshes were needed due to the apparent increase in fine material. Again, sieves were shaken for three minutes, with all fractions weighed and results reported in weight %. Finally, the batch was split into eight equal lots using a sample splitter belonging to the NM Bureau of Mines. The treated material was sampled and analyzed for organic carbon content to independently quantify the amount of HDTMA sorbed.

HPLC Analysis of Supernatant

Before analyzing the mixing supernatant by HPLC, we prepared a mobile phase of 55% methanol/ 45% water with 5mM p-toluenesulphonate. We purchased 100 g of p-Toluenesulphonic Acid, Monohydrate ($C_7H_8O_3S \bullet H_2O$) from Sigma Chemical Corporation (#T-3751); it has a molecular weight of 190.2 g/mol, so 3.80 g were needed to prepare 4L of mobile phase. We degassed each batch of mobile phase using vacuum lines, Erlenmeyer flasks with vacuum sidearms, filter paper, and filter glassware with a fine glass frit.

To determine the amount of HDTMA in solution, we used the ion-pairing agent, p-toluenesulphonate, which, combined with the HDTMA, absorbs UV energy at the 254 nm wavelength (Helboe, 1983). After equilibrating the required Supelco Nucleosil 5CN 4.6 mm x 150 mm (Cat #Z226254) column with degassed mobile phase, we calibrated a Waters Lambda-Max Model 481 LC Spectrophotometer UV detector over a concentration range from 0.0003 - 0.051M; we used this range because the high end is the concentration of our initial solution, so the sample concentrations should never be higher than this amount. The low end is one tenth of the equilibrium solution concentration that should correspond to our initial solution concentration. We checked the linearity of response over this concentration range, injected samples and compared the area of the sample peaks to the areas of standard peaks. We used a Waters Millipore Model 510 pump and HP-3396A Integrator, with an injection size of 25 μL and pump rate of 0.5 ml/min.

3.3 Batch Studies of Contaminant Sorption

Batch studies of organic contaminant sorption were conducted to determine the ability of the HDTMA-treated zeolite to sorb organic nonpolar contaminants.

This data was required to calculate a retardation factor, R, for the treated zeolite that would enable us to predict contaminant transport in a packed column. The contaminant PCE, or Tetrachloroethylene, was used due to its low toxicity, easy availability of a radiolabelled substitute, and widespread industrial use, which has resulted in its omnipresence at contaminated sites.

The primary difference of the PCE batch study procedure from that of the HDTMA sorption batch study procedure is that PCE is a volatile compound, with a saturated vapor pressure at 20°C of 14 mm Hg, or 0.27 psi (Verschueren, 1983). Therefore, all reactions had to be carried out in air-tight vessels with a minimum of headspace above the solution; we used 10-ml crimp-top vials of borosilicate glass from Cole Parmer and Teflon-lined rubber septa or a combination of Teflon and rubber septa. Also, the solutions containing PCE could have no air contact as this would allow volatilization of the contaminant and appear as sorption in the final results, inflating our estimate of the amount of PCE sorbed. Only gas-tight glass syringes were used to prepare PCE solutions. In addition, the scintillation procedure was changed slightly to deal with volatilization problems. Primarily, samples withdrawn for analysis were injected into the bottom of scintillation vials pre-filled with cocktail, which also minimized volatilization losses by eliminating solution-air contact. We also switched to from 20 ml to 7 ml scintillation vials to eliminate headspace in the scintillation vial, which would allow volatilization of PCE and prevent it from interacting with the scintillator in the solution. To hold the smaller vials in the sample trays, we used glass vial holders from Cole Parmer (#H-08980-15). Finally, all of the materials used had to be inert to the PCE solution, so only glass and Teflon were allowed to directly contact solutions.

3.3.1 Groundwater Compositions

Three waters of different chemical composition were used as solvents for the PCE solution to quantify effects of solution chemistry on sorption. Two of the waters were synthesized to copy conditions at actual contaminated sites in Oak Ridge, TN and Elizabeth City, NJ. The most important difference in solution chemistry among the waters was the ionic strength. Since PCE is nonpolar, solution pH was not expected to have a strong effect on sorption, except perhaps to mildly increase the hydrophobicity of the PCE for the aqueous solution and force it more strongly into the organic medium on the mineral surface. Therefore, we did not test solutions with strongly different pHs.

Analyses of the three waters are shown in Table 3.1. The Oak Ridge analogue contained far more of the monovalent bicarbonate anion than did the Elizabeth City water, which contained more of the divalent sulfate anion.

Table 3.1: PCE Sorption Study Solution Chemistries			
Parameter	Type I DI Water	Oak Ridge, TN (mg/L)	Elizabeth City, NC (mg/L)
Al^{+3}	Trace	3.1	0.07
Ca^{+2}	Trace	56.5	25.7
Fe^{+3}	Trace	2.45	0.21
Mg^{+2}	Trace	6.57	16.0
K^{+1}	Trace	5.30	None
Na^{+1}	Trace	14.5	81
Cl^{-1}	Trace	29.5	103
$(HCO_3)^{-1}$	Trace	170.5	57
Cr	Trace	None	6.41
$(SO_4)^{-2}$	Trace	12.2	82
Ionic Strength	<1 mM	7 mM	9 mM

The recipes used to synthesize the two contaminated water analogues are shown in Table 3.2. These formulas were based on the closest possible adherence to contaminated water analytical data provided by the two sites. $FeCl_3 \bullet 6H_2O$ was used only for the first batch of the Elizabeth City, NJ water after it was determined that it forms an insoluble precipitate which could be problematic in the column study phase.

Table 3.2: Synthetic Groundwater Recipes

Compound	ORNL (mg/L)	Elizabeth City (mg/L)
K_2SO_4	11.8	
$AlCl_3 \bullet 6H_2O$	27.8	0.627
$(MgCO_3)_4Mg(OH)_2$	21.5	
$NaHCO_3$	53.0	84.0
$MgSO_4$	21.5	
$CaCO_3$	141	
$FeSO_4 \bullet 7H_2O$	6.68	
$FeCl_3 \bullet 6H_2O$		1.0
NaCl		29.2
Na_2SO_4		121.3
$MgCl_2 \bullet 6H_2O$		135
$MnCl_2 \bullet 4H_2O$		4.75
$CaCl_2 \bullet 2H_2O$		94.2
Na_2CrO_4		11.6

3.3.2 Spike Preparation

Assuming 90% PCE sorption based on Huddleston's (1990) data, we desired at least 1000 cpm/ml = 2.48×10^{-3} μCi/ml in our initial solutions, as this would result in equilibrium solutions with activities twice background. Also, we decided to prepare 40 ml of solution for each initial concentration in order to make three replicate reaction vials and one blank with 10 ml of PCE solution in each. If we wanted to make six different initial concentrations and run the experiment in triplicate, then, we would need at least 2.48×10^{-3} μCi/ml x 40 ml x 6 x 3 = 1.8 μCi of radiolabelled PCE. The smallest lot of material available for purchase was 100 μCi, so this amount was ordered.

The ^{14}C-radiolabelled PCE received from the manufacturer consisted of 1.8 μL with a specific activity of 6.0 mCi/mmol. I diluted the entire amount, 106 μCi (see calculation in Appendix C), in 10 ml PCE, so that the spike solution had an activity of about 10.6 μCi/ml, assuming that I was able to capture all 1.8 μL of material from the flame-sealed transportation vial.

The following amounts were used to make initial solutions; sample calculations are shown in Appendix C.

Table 3.3: Spike Calculations for PCE Solutions

Desired Concentration (ppm)	Amt Spike Needed (μL) for 40 ml of Solution	Resulting Activity (cpm/ml)
200	8	4271
150	6	3203
120	4.8	2562
100	4	2135
75	3	1601
50	2	1067

3.3.3 Sorption Reaction

The sorption experiment was carried out in 10-ml glass crimp-top vials containing 10 ml of PCE solution and 2.5 g treated zeolite. This left a very small, reproducible bubble of headspace in the vial. The crimp tops were comprised of the following three pieces: an aluminum shell with a cut-out center; a rubber septum; and a Teflon septum, which was placed at the bottom of the lid assembly before crimping, so that it, rather than the rubber septum, would be in contact with the solution.

Solution PCE concentrations ranged from 50 to 200 ppm, a range quantifiable by gas chromatography (GC) using an FID detector and used previously by other researchers (Huddleston, 1990). I prepared a 5 μL standard of the radiolabelled spike material; it was dissolved in 1 ml of pure water and 10 ml scintillation cocktail and counted with all of the samples. The initial solution concentrations were determined by comparison to this standard, which contained a known amount of PCE, so that the real concentration was known even if losses occurred due to volatilization. As previously, duplicate or triplicate reaction vessels were prepared for each initial PCE concentration. These were compared with blank vials containing initial solution and no treated zeolite. Any non-sorption losses such as volatilization occurring in the reaction vials should also occur in the blank vials, provided that the vials were treated identically. The amount of PCE sorbed was calculated as the difference between the concentrations in the initial and final (post-sorption) solutions, as in the HDTMA sorption experiments. In this way, we insured that volatilization losses in the sorption vials did not affect our results.

Based on Huddleston's time-dependent data (1990), vials were shaken for 24 hours at 120 rpm on an Innova 433S Refrigerated Incubator Shaker from New

Brunswick Scientific, set at 25°C. They were then centrifuged at about 390xg RCF for one hour and sampled. The lower centrifuge speed was used to prevent shattering of the vials, which were less durable than the polymer test-tubes used for HDTMA sorption studies.

3.3.4 GC Method

Some PCE sorption samples were analyzed by gas chromatography using a Hewlett Packard (HP) 5890A Gas Chromatograph with an FID detector. Other necessary equipment included the following: HP-3396A integrator; HP Split Vent Trap (#5181-8802) to remove PCE from split vent gas; and a HP-5 5% Phenyl Methylsilicone capillary column, 10m x 0.53mm.

The following specifications in Table 3.4 were used:

Table 3.4: Gas Chromatography Parameters

Oven Temperature	75°C
Carrier Gas: Flow Rate	Helium: 6 ml/min
Makeup Gas: Flow Rate	Nitrogen: 21 ml/min
Air Flow Rate	382 ml/min
Fuel Gas: Flow Rate	Hydrogen: 40 ml/min
PCE Retention Time	1.35 min
Sample Size	2-4 μL
Inlet Temperature	200°C
Detector Temperature	250°C
Split Vent	5.6 ml/min
Septum Purge	3.0 ml/min

A bubble meter was used to measure flow rates. I had problems igniting the flame in the FID detector, so I tried several standard preventive maintenance procedures, such as cleaning the detector jets and venting. The main problem, however, was that the instrument instructions did not account for the altitude of Socorro, at which the fuel mixture needs to be richer. By turning off the nitrogen makeup gas completely to enrich the fuel and blowing onto the ignition glow plug to supply additional oxygen, I was able to light the detector.

Samples of initial and equilibrium solutions for GC analysis were collected during one sorption experiment using a gas-tight syringe. About 1.5 ml of sample were placed in amber glass vials with screw top septum lids; this volume was enough to completely fill the vial, leaving a negligible amount of headspace. Samples were injected using 10 μl Hamilton gas-tight syringes. GC PCE standards were prepared from Supelco standards of PCE in methanol in the following concentrations: 200 ppm, 150 ppm, 120 ppm, 100 ppm, 75 ppm, and 50 ppm. When these were analyzed, the methanol peak eluted first at about 0.25 seconds. Standards were only good for one use due to volatilization through the septa after puncturing. One standard of aqueous solution saturated with PCE was also prepared using a large excess of PCE stirred with water. GC results were expressed as areas; areas for standards with known concentrations were compared to sample data to determine sample concentrations. Also, the results of the GC analysis were compared to liquid scintillation results to determine the comparability of the methods. Data were entered in a spreadsheet with scintillation results; spreadsheet calculations are detailed in Appendix C.

3.3.5 Liquid Scintillation

Liquid scintillation counting was performed in the same manner as for the HDTMA sorption isotherms. However, we performed a test to determine whether headspace in the scintillation vials affected counting results. The data are discussed in Section 4.3. As a result of this test, we decided to use 7-ml scintillation vials with 6 ml cocktail, after checking with the cocktail manufacturer to ascertain that this would not substantially affect counting efficiency.

3.3.6 R Estimate

The PCE sorption batch study results were used to estimate a retardation coefficient, R, for use in predictive modeling. The slope of the linear sorption isotherms fitted to batch data is the sorption coefficient, K_d. This value was used in the following equation to calculate R:

$$R = 1 + \frac{\rho_b K_d}{\theta},$$

where ρ_b is dry bulk density and θ is the volumetric moisture content (equal to porosity under fully saturated conditions).

3.4 Column Study

The column study was performed to help us determine how accurately we can predict contaminant breakthrough in treated zeolite media. This data would be used in later phases of the project to design an actual barrier. We also hoped to confirm our R based on batch study data. The basic process involves introducing a contaminant into a column packed with the material to be tested and comparing its transport, as measured in column effluent concentrations, with that of a non-reactive tracer, for which we used tritium.

3.4.1 Predictive Modeling

We estimated porosity based on the particle size analysis of the treated zeolite as 0.5. We used different methods of estimation. In the first qualitative method, we determined that the treated zeolite is primarily in the medium to fine sand range of particle sizes, according to Wentworth Classification system. The second more quantitative method was to find the effective particle size, the size corresponding to 90% retained on the sieve analysis curve (Driscoll, 1986, p. 410), and assign the grain size based on this number, which was about 0.10

mm. The treated zeolite was, according to the Wentworth Classification system, a very fine sand. The porosity could then be considered the average of the range for that particular grain size, as given in Table 2.1 of Domenico & Schwartz (Domenico and Schwartz, 1990); this procedure yielded an estimate of about 0.40. Looking at the two different ranges, we decided that 0.5 would be a good starting estimate for porosity. This number would later be determined during the column study based on masses of columns filled with dry and wet zeolite.

Using the K_d from batch experiments and the dry bulk density estimated as ρ_b = 0.876 g/cc, we calculated $R \approx 19.4$ for the Elizabeth City water. Using the computer program CXTFIT2 described in Appendix D, we then performed a number of forward simulations to optimize flow velocity and pulse input duration. We assumed D = 15 cm^2/d and began with a velocity of 35 cm/d, which would move fluid through the column with a long enough residence time for sorption to occur. We wanted the column study duration to not exceed one month, so we varied the parameters velocity (v_x) and pulse duration to achieve breakthrough of the input concentration (C/Co close to 1, where Co is the input concentration) and complete breakthrough with concentrations decreasing to 1% of the input concentration within 30 days. We also varied D from 10 to 25 because this parameter was only estimated. The optimal combination was found to be v_x = 40 cm/d, with pulse duration of 11 days.

3.4.2 Preparation

The columns were filled and weighed according to procedures described in Appendix E. The mass and density data relevant to modeling calculations are shown in Table 3.5. Dry bulk density is required in order to calculate expected retardation factors for each column. This density includes a 10% correction subtracted from the dry weight of the zeolite to account for 10% (by mass) moisture content in the dry material (Anghel, 1996, personal communication).

Table 3.5: Column and Fitting Weights

Column #	Zeolite Mass (g)	Dry Bulk Density (ρ_b, g/cc) w/ 10% Moisture Cont Corr
Col 1 (Untreated)	299.1	0.867
Col 2 (Treated)	315.7	0.915
Col 3 (Untreated)	310.5	0.900
Col 4 (Treated)	330.8	0.959

After purging the columns with CO_2 to displace pore space air, I saturated all four columns with PCE-free synthetic contaminated water. The conductivity of each column outlet solution was monitored until it was no longer decreasing, about 15 days; then the treated zeolite in the columns was assumed to have equilibrated with the synthetic water. After equilibration, the saturated columns were weighed to determine actual porosity. Again, the dry zeolite mass was corrected for 10% water. Also, the column volume was assumed to be π *

$(2.525)^2 * 15.5 = 310.5\ cm^2$, since the zeolite only occupied about 15.5 cm of the column length. The mass and porosity data are shown in Table 3.6. Porosity was calculated according to the following equation:

Porosity = (Mass of wet col - Mass of dry col + 10% Corr - Mass of Water in Fittings)/Col Vol.

Table 3.6: Data for Porosity Calculation

Col #	Wet Mass (g)	Dry Mass (g)	Mass of H_2O (g)	10% MCC (g)	H_2O in Fittings (g)	n
1	1463.8	1260.9	188.8	29.9	14.2	0.704
2	1467.9	1275.3	179.0	31.6	13.6	0.678
3	1452.6	1258.9	188.0	31.0	14.2	0.705
4	1467.8	1287.5	166.3	33.1	14.0	0.642

When the columns were equilibrated, we prepared the 21L batch of Elizabeth City synthetic water without the radiolabelled chemicals. This solution was transferred into the collapsible Teflon bag, which had been placed in the hood on a large flat tray to avoid accidental tears. We put a stainless steel luer fitting on the bag and fixed the fitting in place using clamps attached to ring stands on either side of the tray, hoping to prevent tears due to twisting of the fitting during syringe filling. The radiolabelled chemicals were then added as described previously. The solution was mixed by kneading the bag and sampled to ensure that the mixing was adequate.

3.4.3 Column Study

The PCE-contaminated water was added to the columns by filling 100-ml Teflon Luer-lock gas tight syringes (Supelco, #2-1967) from the bag reservoir and placing those syringes in the syringe pumps. The syringes were filled by screwing the luer fitting on the syringe end into the luer fitting on the bag. After the syringes were filled, a luer plug fitting was placed on the bag fitting to prevent volatilization of the PCE in solution. Each syringe was then screwed into the luer stopcock fitting at the bottom of column inlet tubing and placed in the holding piece on the syringe pump. Finally, the three-way luer stopcock fitting was opened to the syringe port so that solution could move from the syringe into the tubing. This fitting was closed whenever syringes were removed for refilling so that no solution would leak out of the column. Each syringe was weighed before and after filling so that we could track the amount of contaminated water supplied to each column. Syringe logs were prepared to record the necessary information, including date and time, volume in the syringe (from calibration marks on the side), rate settings, and column number to which the syringe was attached. A separate log was kept for each pump. Sample logs are shown in Appendix A.7. The contaminant pulse was ended after 9.1 days. At this time, we began injecting the same PCE-free synthetic water used to saturate the columns initially.

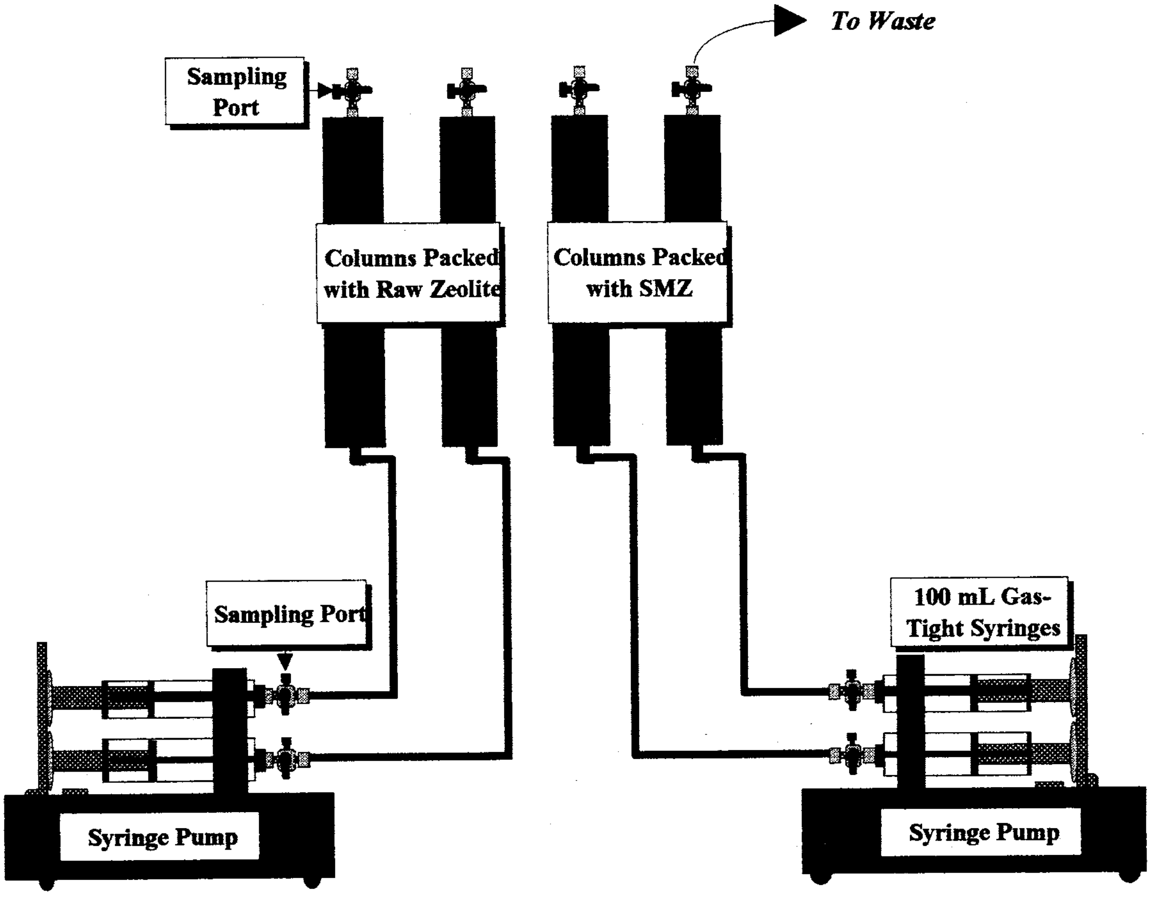
Two way stopcocks at the column outlet were placed in the open position. Three-way stopcocks attached to this fitting were also turned 180° to allow flow into tubing connected to waste containers in the hood.

After 18 days, we switched the Model 44 loaner pump to a 4-channel pump we had purchased from Harvard. Unfortunately, this pump exhibited erratic flow rates and shattered all four syringes within 12 hours of its installment. We then switched to a pulsed pump that delivered solution in one-minute cycles of 0.35 ml/cycle to all four columns. There was about a three-hour lapse in the delivery of solution to the columns during this time.

3.4.4 Sampling

Samples were collected using 2.5-ml Teflon Luer-lock Hamilton gas-tight syringes (Cole Parmer, #H-07939-82) at two points in the column apparatus, the three-way stopcock adjacent to the syringe pump in the column inlet and a three-way stopcock at the column outlet (Figure 3.1). The inlet samples were collected to provide input concentration data for modeling; we anticipated some decrease in concentration over time due to either diffusion through the Teflon bag or due to volatilization into the headspace, though we hoped that the bag's ability to collapse as liquid was removed would decrease the latter. Outlet samples were collected to record the contaminant breakthrough.

Figure 3-1: Column Study Schematic



Samples were collected from the three-way stopcocks by screwing the sampling syringe into the female luer sidearm of the stopcock and opening the stopcock 90° to this sidearm. The plunger in the syringe was then withdrawn, creating a vacuum into which the sample flowed. 1-ml samples were collected for PCE analysis and Cr samples were about 1.5 ml, enough to fill the sample vials. Again, syringes were weighed before and after filling to record the amount of fluid withdrawn. This information was especially important at the column inlet, where the amount of fluid withdrawn would have to be subtracted from the mass dispensed from the connected syringe if data was to be plotted versus pore volumes of contaminated water. Finally, the stopcocks were turned back to the 180° flow-through position.

Clear 7-ml liquid scintillation vials with screw-top foil-lined lids (Cole Parmer, #H-08980-00) were prepared in advance containing 6 ml of cocktail. These were also weighed before and after filling so that the sample mass would be known exactly. The sample was then dispensed by placing the syringe needle at the bottom of each vial and ejecting the solution underneath the cocktail to avoid sample volatilization. The vials were immediately capped and shaken until the solutions were clear, then labeled with the sample ID number comprised of the inlet or outlet number, date, and military time. Each syringe was then rinsed with Type I water, including the syringe needle, to prevent contamination of the next sample.

Both PCE and Cr samples were collected at the column outlet. Sampling frequency at the outlet was set at once/hour until contaminant breakthrough was largely completed. Samples were counted within 24 hours after they were collected. After the input slug was completed, outlet concentrations were monitored carefully. When the decrease in effluent concentration did not change appreciably between samples, sampling frequency was decreased gradually to once/day.

Chromium samples were collected once per day because the retardation factor for Cr was large enough that we anticipated a gradual breakthrough. Samples were placed in Target DP vials with amber 2-ml screw-top glass vials with Teflon/red rubber septa (National Scientific Company). We did not collect Cr samples for quantitative analysis and modeling, as we had added Cr in the synthetic water in the initial equilibration phase before we began adding PCE. No samples were collected for Cr during this period. Quantitative data on Cr breakthrough was to be collected in another concurrent column experiment using shorter columns.

Sampling frequency of the column inlet was conducted once for each syringe refill until the input pulse was ended after ten days. Sampling was not necessary after this point, when input solution PCE concentrations were zero.

Dual label counting of samples was conducted using a Packard Tri-Carb 460CD liquid scintillation counter with maximum quantifiable counting on the order of 10^7 cpm/ml. With each batch of column study samples analyzed, a 1-ml water blank was also analyzed to provide background count data. Sample vials were kept in the dark until counted and were always counted within 24 hours of sample collection. Counting details are described in Appendix B.

3.4.5 Data Manipulation

Sample data was collected and entered into an EXCEL database, where background counts were subtracted from each cpm/ml number. Copies of the database are provided in Appendix A.7. The count data for each sample were then normalized by sample to give cpm/ml figures. The elapsed time was also calculated as described in Appendix C.

Before modeling the data, we transformed values from cpm/ml to dpm/ml using efficiencies calculated from analysis of standards. Next, data were reduced to one point per day using a moving average. We used only one point per day because this was the minimum sampling frequency used toward the end of the experiment. Pore volume data including the volume supplied to each column was also recorded in spreadsheets; pore volumes were calculated by dividing the volume dispensed in a given time by the column pore volume. The details of these calculations and chromium data manipulations are described in Appendix F. Spreadsheet calculations are shown in Appendix C.

3.5 Data Modeling Procedure

Some preliminary calculations based on the data were performed to prepare for inverse modeling. These included calculating the mass of contaminant eluted, extrapolating for the recovery of 100% of the mass at the end of the data set, and finding a best fit linear function to describe the input of PCE contaminant, since the input concentration of PCE decreased during the pulse addition. The description of input functions is described in Appendix F. Finally, the data were entered in input files and inversely modeled to find unknown transport parameters.

3.5.1 Mass Balance

Mass balance calculations were performed with raw data using both EXCEL during the column experiment and MATLAB software as a final mass balance check. The following formula was used to find the mass under the concentration versus time curve for each time datum:

$$(\Delta T \times Conc(2)) - (0.5 \times \Delta T \times \Delta C),$$

where ΔT = Time(2) - Time (1), and ΔC = Conc (2) - Conc (1). The sum of all these individual areas was, then the total mass under the breakthrough or input curve. The formula is based on the trapezoidal rule, which is the mathematical equivalent of replacing the concentration curve with a series of line segments between data points (Hildebrand, 1974).

The MATLAB function used to calculate the integral numerically was TRAPZ(T,C), where T and C are time and concentration, respectively. The results obtained with Matlab agreed closely with results obtained using the EXCEL spreadsheet.

3.5.2 Extrapolation to Total Mass

For the two treated columns, significantly less than 100% of the PCE contaminant was recovered in the effluent. Because CXTFIT2 uses the total mass in the input function as a fixed parameter, it would not correctly fit these two data sets without using a decay parameter to account for the missing mass. But since we did not have a constant-rate loss of mass due to chemical decay, this model would not produce realistic parameter estimates. The solution is to extrapolate the data set past the last concentration to a point in time at which all of the mass would be eluted, as would have occurred if we had continued the experiment until concentrations were indistinguishable from background. This most accurately reflects the physical conditions.

To determine how much additional mass to account for, I examined the % Recovery (= Mass input - Mass output) data for Columns 2 and 4, the treated columns. I determined that an additional approximately 30% of PCE mass was needed for both columns (see Section 4.5). To add this amount to the end, I used a triangle with Area = 0.5 * base (time) * (Last concentration datum in the data set). Solving for the unknown time, I added that time onto the final time datum and create a data point with Concentration = 0 at that time. I also added one point per day along the line from the last concentration datum to this point so that the tail data would be as heavily weighted as the other data. These additions were performed in an EXCEL spreadsheet.

4.0 Results and Discussion

Many of the results obtained in this study are favorable for the use of HDTMA-treated zeolite in groundwater remediation schemes. First, the HDTMA-zeolite sorption reaction appears to occur quickly at concentrations below or near the maximum level of sorption, so that it should be possible to prepare large amounts of treated material quickly. In addition, the reaction seems to be irreversible, in that HDTMA does not desorb from the mineral surface when washed with large volumes of water. Therefore, we may be optimistic that treated zeolite will not lose sorption capacity in the middle of a remediation project. Finally, PCE appears to be even more strongly retarded than our batch studies showed, which may be helpful in remediation schemes requiring the immobilization of a nonpolar organic contaminant. The experimental results are discussed in detail in the following sections.

4.1 HDTMA Sorption Studies

For our first task, laboratory production of treated zeolite, we performed sorption studies to find the HDTMA sorption isotherm on St. Cloud zeolite, the amount of time required for complete sorption, and the effect of washing treated material with pure water. The results are summarized below.

4.1.1 Sorption Isotherm

The amount of HDTMA sorbed on St. Cloud zeolite was graphed versus the equilibrium solution concentration to produce the sorption isotherm; the isotherm is shown in Figure 4-1. The concentration data are given in Appendix A.1. Two of the data points provided in the Appendix were omitted from the graph due to HDTMA solubility problems at high initial concentrations. These problems were later minimized by keeping the vials heated throughout the sorption experiment. The amount of sorption appears to reach a maximum or "plateau" at about 220 mmol/kg zeolite. If the surface configuration of HDTMA is a double layer of the molecules with the tails associated, then this number would be approximately twice the external CEC, which it is. This is one of the strongest pieces of evidence supporting the existence of a double layer of HDTMA on the zeolite surface.

The concentrations above the plateau may be due to sorption of an excess amount of HDTMA which would be washed off with one aliquot of water. The mechanism for such sorption might be sorption of HDTMA micelles, since our concentrations were well above the CMC for HDTMA in water. In fact, micelle sorption may be the predominant mechanism for HDTMA sorption from solutions above CMC concentrations; once sorbed onto the surface, according to Sullivan (1996, personal communication), the micelles may rearrange, ultimately

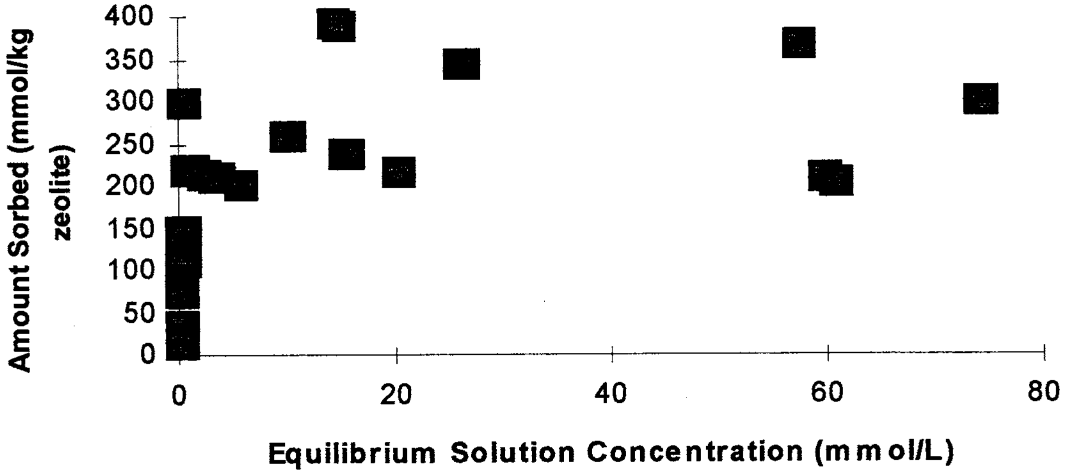


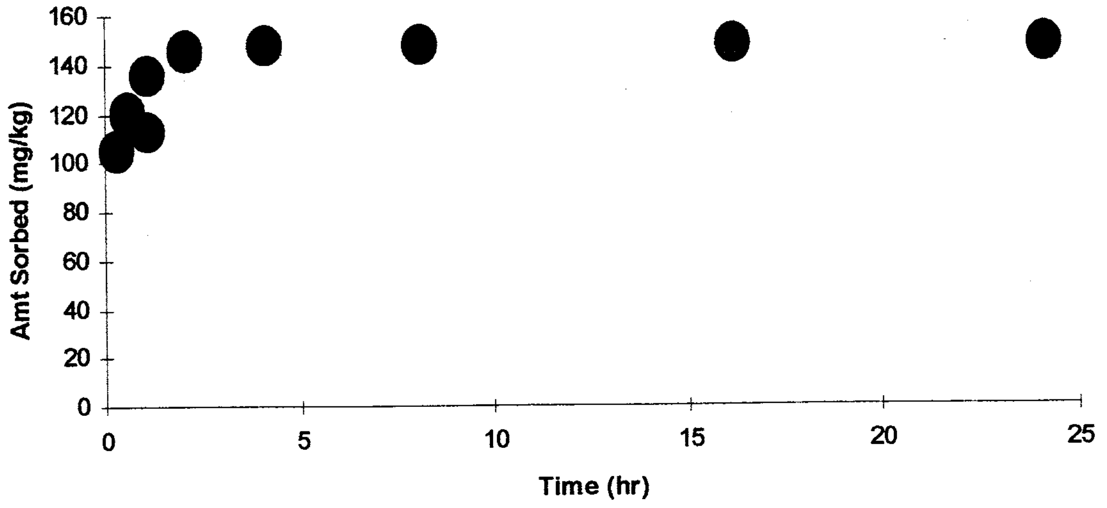
Figure 4-1: HDTMA Sorption Isotherm

breaking up into the relatively stable bilayer configuration. It may be possible, then, that excess molecules of HDTMA remain in the bilayer unless washed off or, if the rearrangement on the surface is rate-limited, until a sufficient amount of time has passed. If we examined the change in equilibrium solution concentration over time for high initial concentrations (0.110 M or higher) above the amount required to reach the sorption plateau (0.051 M), we might determine the time required for rearrangement of micelles into a stable surface configuration. In addition, results of a desorption experiment in which zeolite treated with an excess of HDTMA was washed with water are provided in Section 4.1.3. We also note that Huddleston found poor replicate agreement at very high HDTMA concentrations, with up to 7.5 times the external CEC amount sorbed (Huddleston, 1990). He attributed the poor replication to an amphipathic sorption mechanism dependent upon the amount of HDTMA already on the surface and the continuity of the organic phase created by the HDTMA tail groups.

4.1.2 Sorption Time Dependence

Working with a solution concentration corresponding to 75% of the plateau amount sorbed, we noted that sorption is complete within eight hours. This can be seen in Figure 4-2, where we note that the amount sorbed does not increase perceptibly after about six hours. As discussed previously, however, this may not be the case for initial concentrations corresponding to greater than 220 mmol/kg sorbed, since some rearrangement of molecules on the mineral surface may be taking place. Time sorption data are compiled in Appendix A.2.

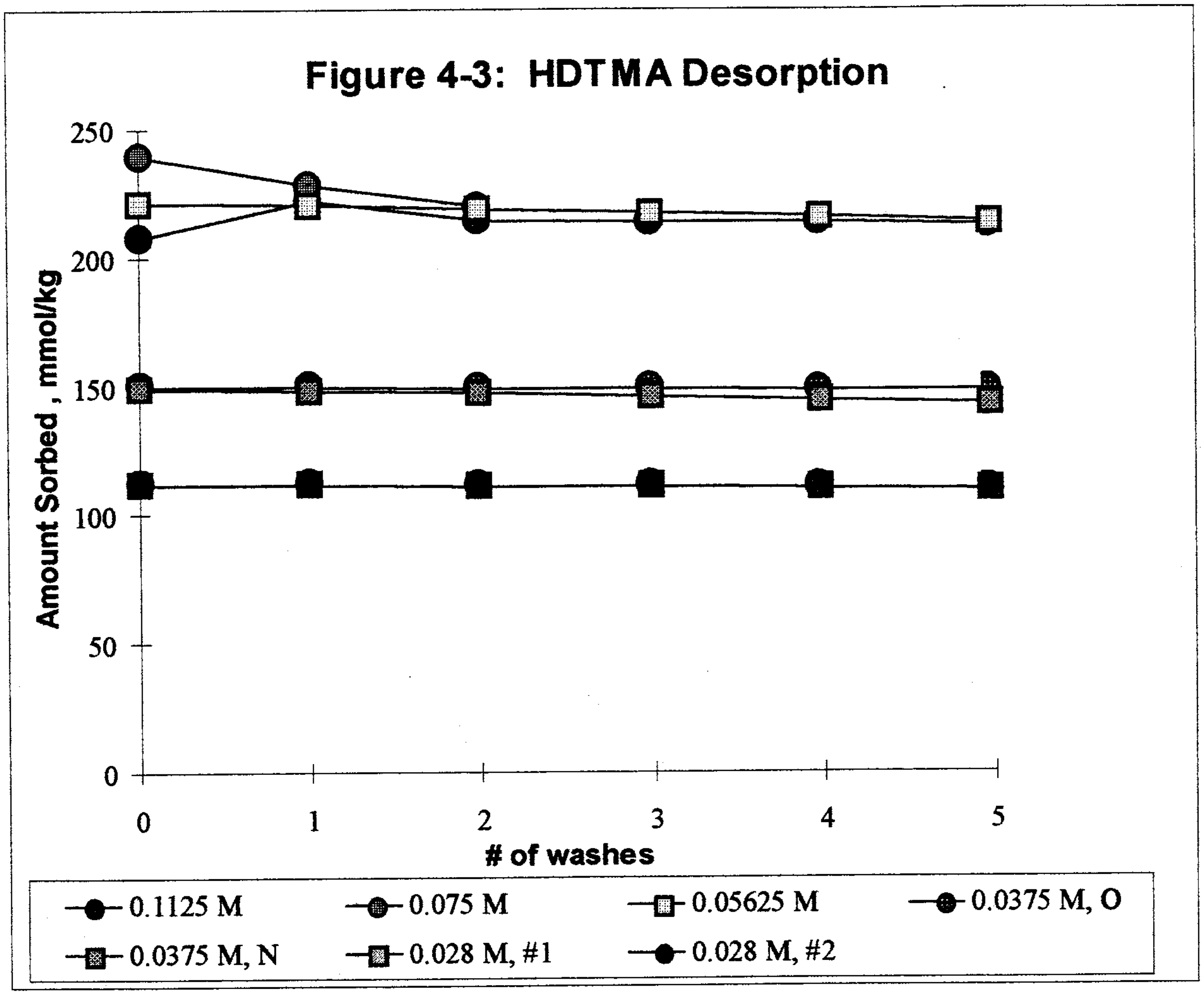
Figure 4-2: HDTMA Sorption vs. Time



4.1.3 Desorption in Water

Data for the desorption of HDTMA with repeated water washing are compiled in Appendix A.3 and shown in Figure 4-3. Note that at concentrations below the sorption maximum, the amount sorbed does not decrease substantially after five washes; each wash corresponds to about three pore volumes (5 g @ 0.9 g/cc). At concentrations above the sorption plateau, the amount sorbed decreases after repeated washing to the plateau level near 220 mmol/kg. In other words, excess HDTMA washes off of the mineral surface until it reaches the stable plateau configuration.

Other research by Li (1996, personal communication) suggests that HDTMA is stable on the zeolite mineral surface in a variety of solutions ranging from pure water to high pH to high ionic strength. The stability of the sorption reaction suggests that strong bonds are formed between surfactant molecules or micelles and the mineral surface. We know that when HDTMA sorbs, other cations such as calcium and sodium desorb, although not in exact stoichiometric ratios; so we know that the mechanism involves some sort of cation exchange, with strong polar interactions. Additionally, the enthalpy change for the sorption process, ΔH, is negative, so the process is exothermic (Sullivan, 1996, personal communication); thus energy (heat or work) would have to be supplied to reverse the process. The hydrophobic tail-tail interactions posited in a bilayer model would also prohibit washing off of surfactant molecules because it would be difficult for water to directly access the mineral surface. All of these ideas help explain why HDTMA is retained so strongly by the St. Cloud zeolite.



The implication of this data is that treated zeolite used for groundwater remediation schemes would retain its "sorption capacity," or ability to retard or immobilize contaminants, through many pore volumes of contaminated water.

This makes it more attractive for technologies from permeable barriers to ex-situ treatment units, such as those which currently use activated charcoal.

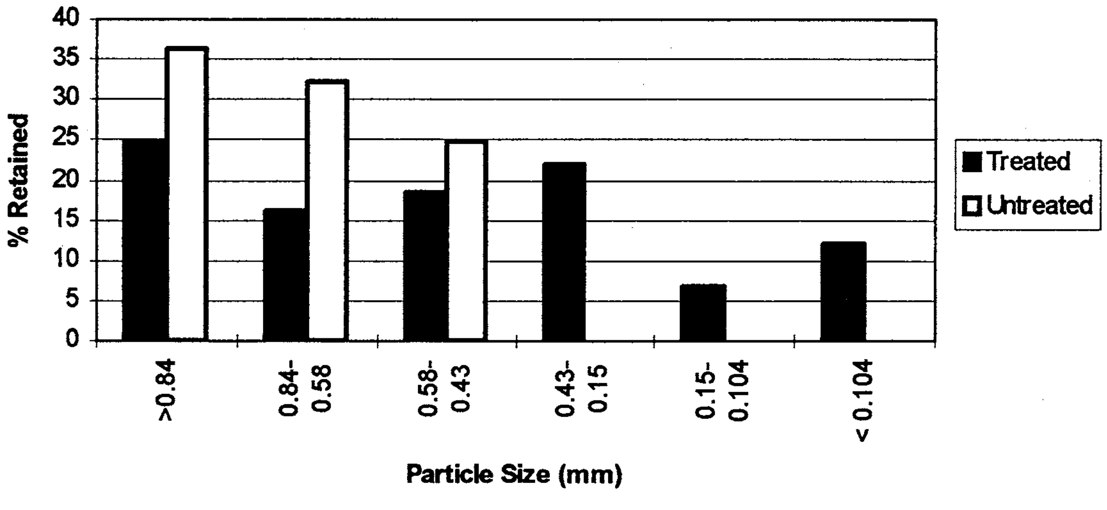
4.2 Large Batch Results

While preparing the 30 kg batch of treated zeolite, we sampled the HDTMA solution before adding zeolite and periodically thereafter so that we would know when the desired amount of HDTMA was adsorbed. Our target was a supernatant concentration of 3.2mM, which corresponded on our sorption isotherm to an initial solution concentration of 0.0506 M. The first supernatant sample at 7.5 hours after addition of zeolite was 9.123 mM. The supernatant concentration decreased thereafter to 0.846 mM and then up to 3.32-3.46 mM (replicate samples) after three days of mixing.

A particle size analysis of untreated zeolite was performed before treatment to provide data on the effects of surfactant treatment on particle size. After mixing, there was an apparent increase in fine material, as evidenced by suspended particles in the mixing supernatant and as a dry crust in the mixing container. The particle size analysis results from sieving of the dry treated and untreated material are shown in Figure 4-4. Particle size data are provided in Appendix A.4. It is important to note that the particle size of the treated material was significantly smaller than that of the raw zeolite, with almost 20% below the 0.1

mm size. In fact, the amount of material with a particle size below 0.43 mm increased from about 7% for the untreated zeolite (not shown graphically because we did not break this small amount down into separate size fractions) to over 40% for the treated zeolite. This was not due to physical agitation only, since we did not see this much breakdown when testing the mixing equipment without HDTMA in solution. Rather, it must be due to action of the surfactant on the mineral surface combining with the vigorous mixing to access more surface area and break apart mineral aggregates.

Figure 4-4: Zeolite Particle Sizes



The treated zeolite was sampled and analyzed for organic carbon content to independently quantify the amount of HDTMA sorbed - this amount was quantified as 2.4-3.5% carbon (by weight) by different analytical methods

(Anghel, 1997). These amounts are lower than the 200 mmol/kg ≈ 4.8 % carbon that we hoped to achieve. This may be due to the loss of very fine material siphoned off with the supernatant. We would expect the greatest amount of sorption on very fine particles, which would have more surface area available for interaction with the surfactant. If our solution concentration was low because much of the HDTMA was sorbed on such fine material, we could have lost a significant mass of HDTMA with the fines. We also note that it is difficult to quantify the amount of organic material sorbed with methods that require digestion or volatilization of the organic, as evidenced by the wide range of values obtained. The stability of HDTMA on the mineral surface under oxidizing or high temperature conditions is not very well known; some methods for digesting the organic material in the soil being tested may not be adequate to remove HDTMA. Therefore, some methods of TOC determination may not be appropriate for determining the amount of surfactant sorbed.

4.3 PCE Sorption Study Data

The most important results obtained in this portion of the experimental work were sorption coefficients, or K_d's, for PCE on treated zeolite. PCE sorption isotherms are shown in Figure 4-5, with raw data in a spreadsheet in Appendix A.5. The K_ds are as follows: pure water = 10.91 L/kg; ORNL water = 10.64 L/kg; and Elizabeth City water = 10.75 L/kg. Note that the K_d's are almost the same for all three waters, but are considerably less than Huddleston's $K_d = 50.04$ (Huddleston, 1990), possibly due to a lower amount of sorbed HDTMA on the zeolite. The primary difference among these waters is ionic strength; the pure water has I close to zero, whereas the ORNL and Elizabeth City waters have $I \approx 0.008$ M. Intuitively, we would expect higher ionic strength to drive PCE more strongly out of the aqueous solution into the organic phase on the mineral surface - so we would expect a higher K_d. If anything, our results show that the K_d is slightly lower, although the data are probably not statistically distinguishable. This may be because the difference in ionic strength is not great enough to produce a noticeable effect on sorption. In any case, the ionic strengths used are based on real contaminated water, so we may consider the results to reflect a realistic amount of sorption.

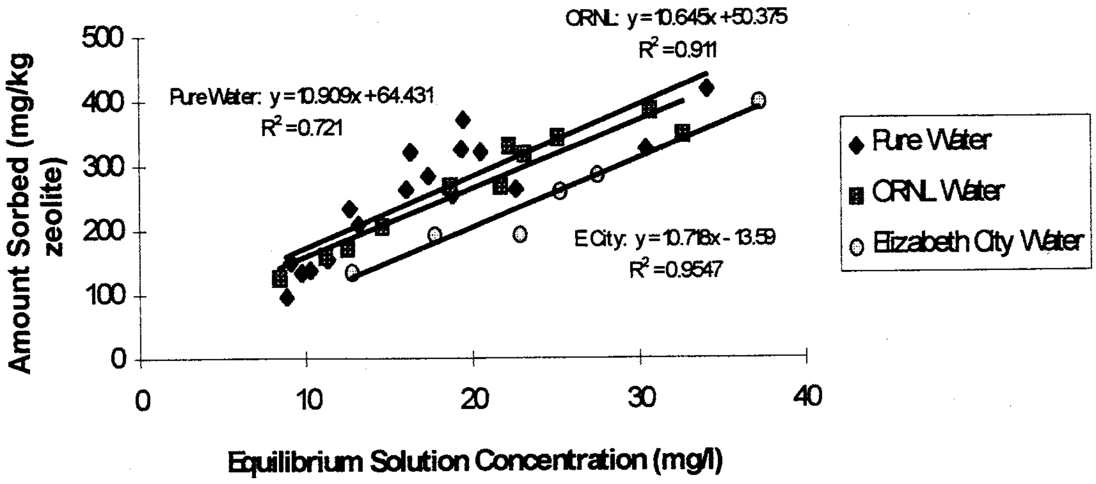


Figure 4-5: PCE Sorption Data, Averaged Replicates

The resulting R estimate for sorption from Elizabeth City water on treated zeolite, based on our assumption of n=0.5 and ρ_b=0.876 g/cc, was R= 19.8. Considering the porosity and dry bulk density data obtained during the column study, we have the following estimates for R: Column 2 - 15.27; and Column 4 - 17.16.

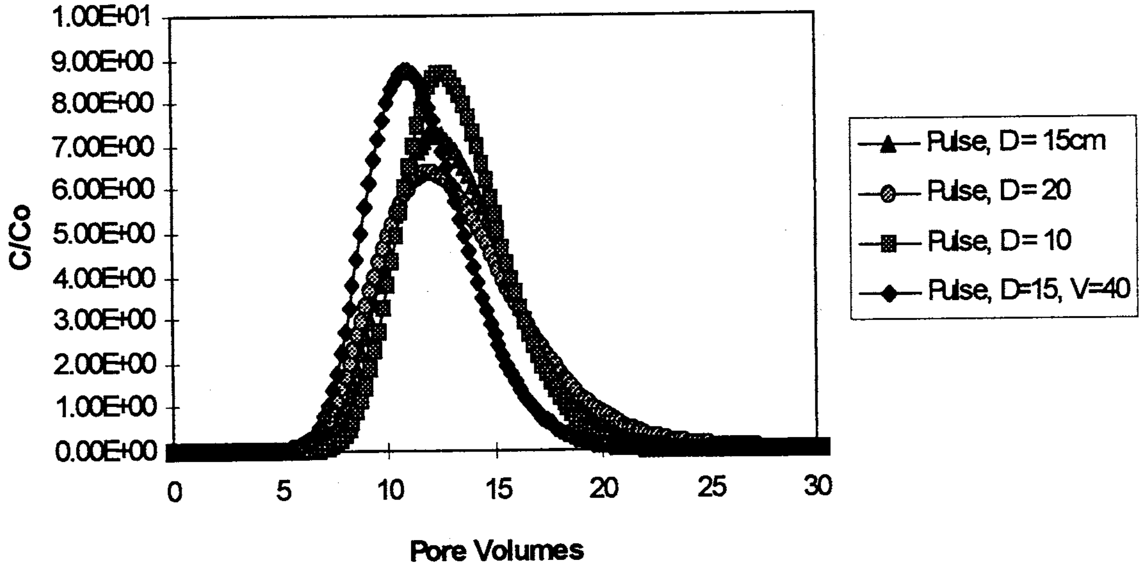
Other useful results helpful to our process design were obtained. We found that gas chromatography with an FID detector corroborated our liquid scintillation results. A spreadsheet containing the GC data is included in Appendix A.5. For a 200 ppm PCE initial solution, the analyzed initial and final (equilibrium) concentrations were 186.1 and 45.32, respectively; this means that 75.49% of the PCE was sorbed. For a 50 ppm initial solution, 75.9% of the PCE was sorbed. These figures compare with 74.70% sorbed for the 200 ppm sample and 73% sorbed for the 50 ppm solution, based on liquid scintillation counting. The close agreement gave us more confidence in the accuracy of our scintillation technique for determining amount of sorption.

Another useful result was finding that punctured septa and large headspace in scintillation vials do significantly affect sorption experiment results. To test these hypotheses, we prepared samples with identical solutions and treated them differently, puncturing septa or allowing headspace in some vials but not in their replicates; vials with punctured septa or headspace were allowed to equilibrate for the normal 24 hours. For the punctured sample, the activity was about 1370 cpm/ml, whereas the unpunctured replicate had an activity of 1761.3 cpm/ml, or 30% more. The scintillation results compiled in Appendix A.5 helped us decide to put initial solutions into vials before capping them, rather than dispensing the solutions through the septa with syringes. It also motivated a change to smaller 7-ml scintillation vials with little headspace when filled.

4.4 Column Study Data

Predictive models using the R from batch data helped us to determine the length of the input pulse (or amount of mass to input) and flow velocity to use during the column study. Figure 4-6 below illustrates that increasing velocity (from 35 to 40 cm/d in this case) with all other parameters constant makes the breakthrough curve elute earlier and more sharply, narrowing the peak width and increasing the maximum concentration. The effect of increasing the dispersion coefficient, D, is to broaden the peak and decrease the maximum concentration, slightly increasing the time of initial breakthrough. At this stage of the modeling, we assumed no physical nonequilibrium, or only one region comprised of mobile water.

Figure 4-6: Predicted PCE Breakthrough Curves



From counting of radiolabeled standards we determined the following average scintillation counting efficiencies: for ^{14}C in Region A, Eff = 0.578; for ^{14}C in Region B, Eff = 0.410; and for ^{3}H in Region A, Eff = 0.288. All column effluent activity results in cpm/ml were normalized to dpm/ml by these numbers. The tritium efficiency was close to the normal single-label efficiency of about 0.3.

4.4.1 Column and Pump Logs

Column logs for each syringe pump containing all flow rate and electrical conductivity measurements from the saturation phase of the column experiment were maintained. They also contained the syringe mass data used to monitor the amount of solution applied to each column. Conductivities seem to change more for some columns than for others because not all columns were saturated simultaneously due to pump problems. Columns 3 and 4 were equilibrated with the input solution over about two weeks, with some time out for pump problems. Columns 1 and 2 were equilibrated over about the same period. The equilibrated effluent conductivities for the treated columns (2 and 4) are about twice as high as for the untreated columns, possibly because excess HDTMA and counterion are being washed out of the treated columns.

Spreadsheets based on pump log syringe data were used to calculate pore volumes as a function of time and an overall velocity for each column. The syringe initial mass on these logs was the mass of the emptied syringe at the time the pump was stopped; the syringe final mass was the filled syringe mass at the time the pump was restarted. The pore volume calculation spreadsheets for each column are displayed in Appendix A.6. A total of about 50 pore volumes were used throughout the column study. Pore volumes and average linear velocities for each column are shown in Table 4.1. The velocity calculation was very important, since our model assumes constant velocity; it is described in Section 3.5.3.

Table 4.1: Pore Volume and Velocity Data

Column #	Pore Volume (ml)	Pore Volumes Supplied	Velocity (cm/d)
1 (Untreated)	217.01	75.8	39.4
2 (Treated)	211.11	78.0	38.05
3 (Untreated)	219.18	50.3	38.35
4 (Treated)	200.56	56.3	42.90

4.4.2 Sample Collection Logs and Data

A sample log containing sample numbers and vial masses for keeping track of sample weights is provided in Appendix A.7. Other information such as power outages and system leaks are recorded in the comments section of these logs. Sample number, time, and mass data are also compiled in the first six columns of the spreadsheet in Appendix A.7.

4.4.3 Column Data

In the spreadsheet in Appendix A.8, data are corrected to dpm/ml concentrations using counting efficiency as described in Section 3.4. Tritium input concentrations are shown in Figure 4-7. The large decrease at about three days is coincident with a power outage, so some mass may have been lost from the syringes at this time. However, the tritium concentration in the input solution remains fairly constant over the total input time of 9.1 days, suggesting that no tritium was lost due to diffusion through the Teflon reservoir bag. Table 4.2 summarizes the average tritium input concentrations used in modeling. Tritium breakthrough curves are shown in Figure 4-8. Breakthrough for all four columns occurs very quickly, but note that there is a small amount of "tailing" of the tritium in the two treated columns. We should not see any tailing with a nonreactive tracer such as tritium, but the data suggest there is some diffusion-controlled retention of tritium, as is consistent with a mobile-immobile water or physical nonequilibrium model (van Genuchten and Wierenga, 1976). The tritium data for the treated Columns 2 and 4 enabled us to estimate the transport parameters beta (the dimensionless variable describing partitioning) and omega (coefficient of mass transfer between mobile and immobile phases) for the nonequilibrium model (see Appendix D).

Table 4.2: Input Concentrations

Col #	Average ^{3}H Conc (dpm/ml)	^{14}C Input Function
1	245583	-523.67t + 16218
2	248651	-509.96t + 16262
3	247898	-509.22t + 16197
4	248803	-567.27t + 16482

PCE input curves are shown in Figures 4-9 and 4-10. I was surprised to see that the PCE concentration in the input solution decreased over time, but this is consistent with loss of mass into an increasingly large headspace, despite the collapsibility of the reservoir. I know that the solution was well-mixed because the two samples I collected to check the mixing showed close agreement within 15%. Since the concentration data are not consistent with a slug input for modeling purposes, I used Excel to fit a line to the data for each column and used these lines as the function $C_o(t)$, the input concentration at the column inlet, in CXTFIT2's boundary value problem Block D, specifying MODB=6. The $C_o(t)$ function was entered in the source code in User.for and the source code recompiled to create unique executable files for each column.

Figure 4-7: Tritium Input Concentrations

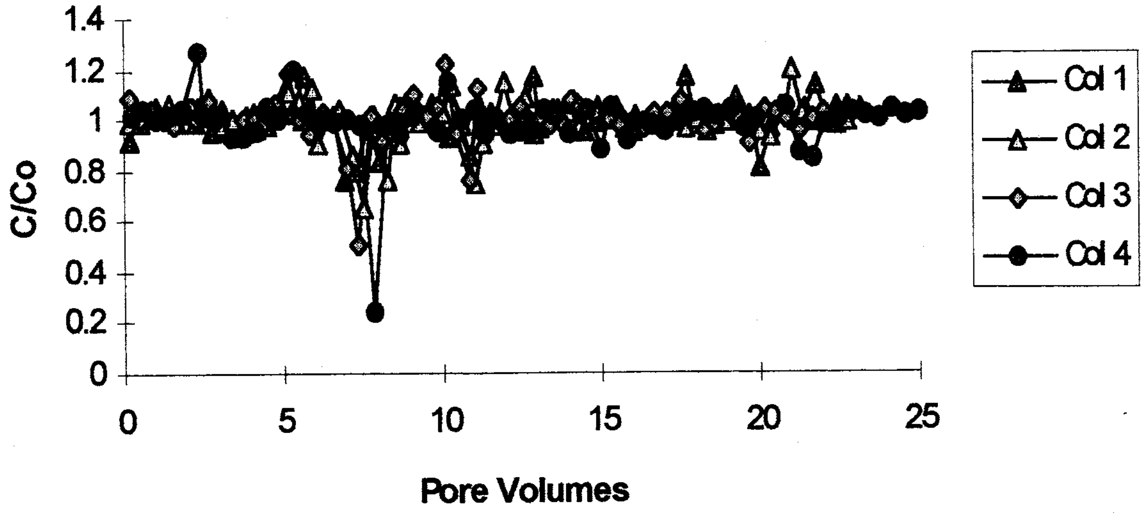


Figure 4-8a: Column 1 (Untreated) Tritium Breakthrough Curve

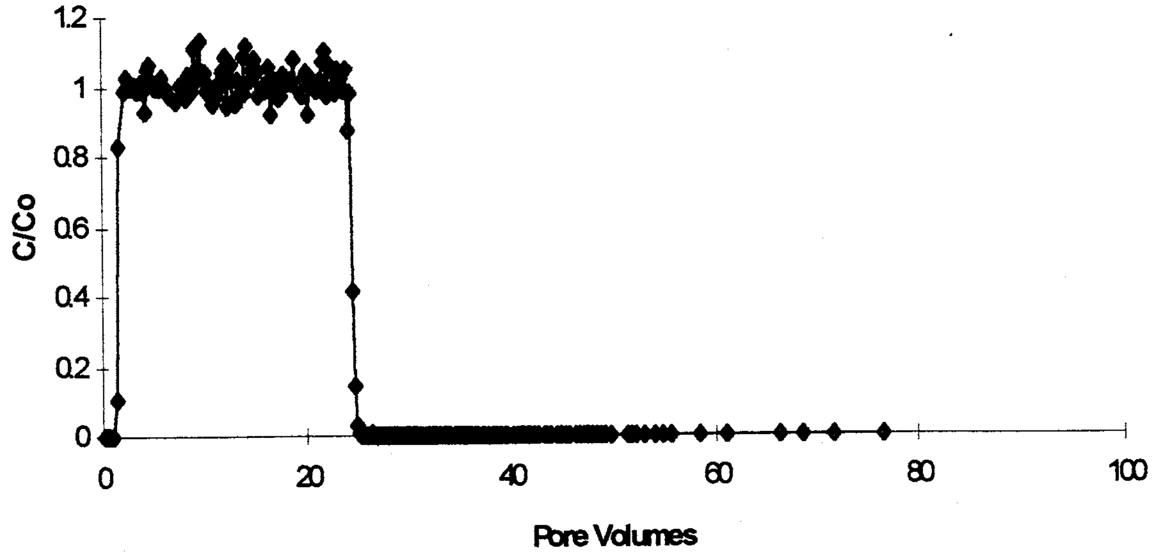


Figure 4-8b: Column 3 (Untreated) Tritium Breakthrough Curve

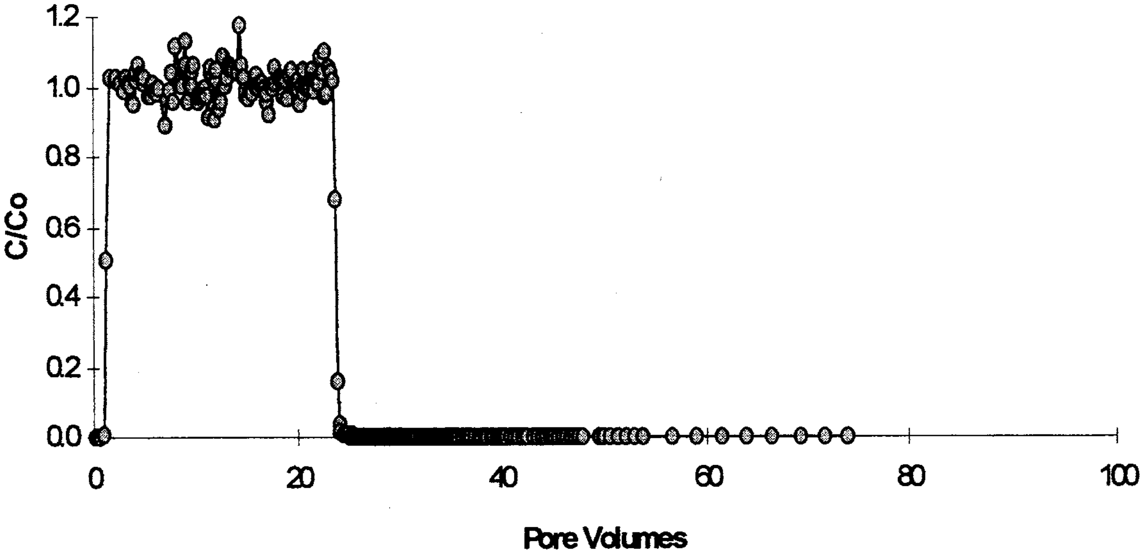


Figure 4-8c: Column 2 (Treated) Tritium Breakthrough Curve

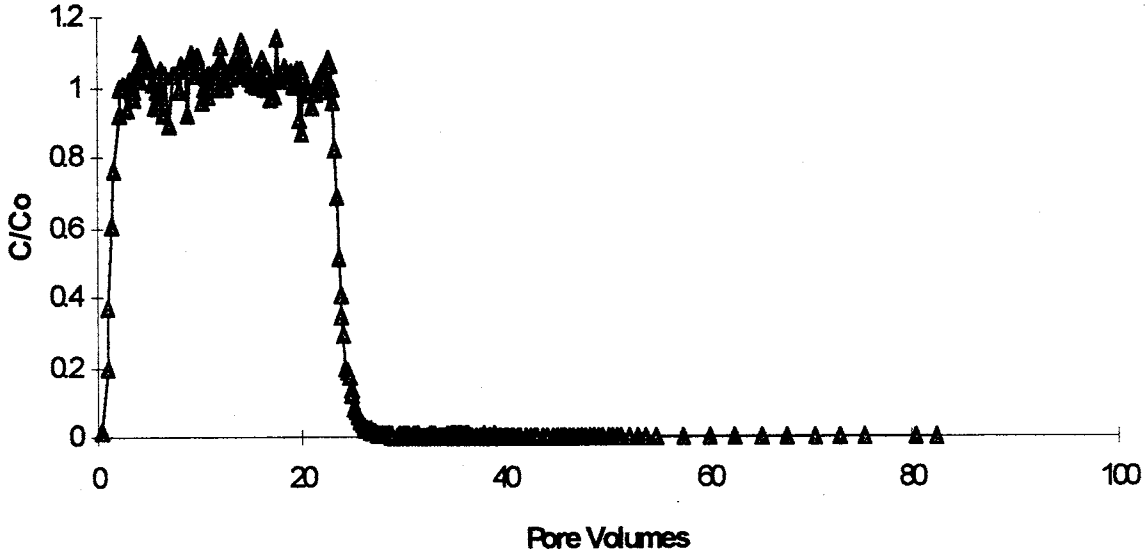


Figure 4-8d: Column 4 (Treated) Tritium Breakthrough Curve

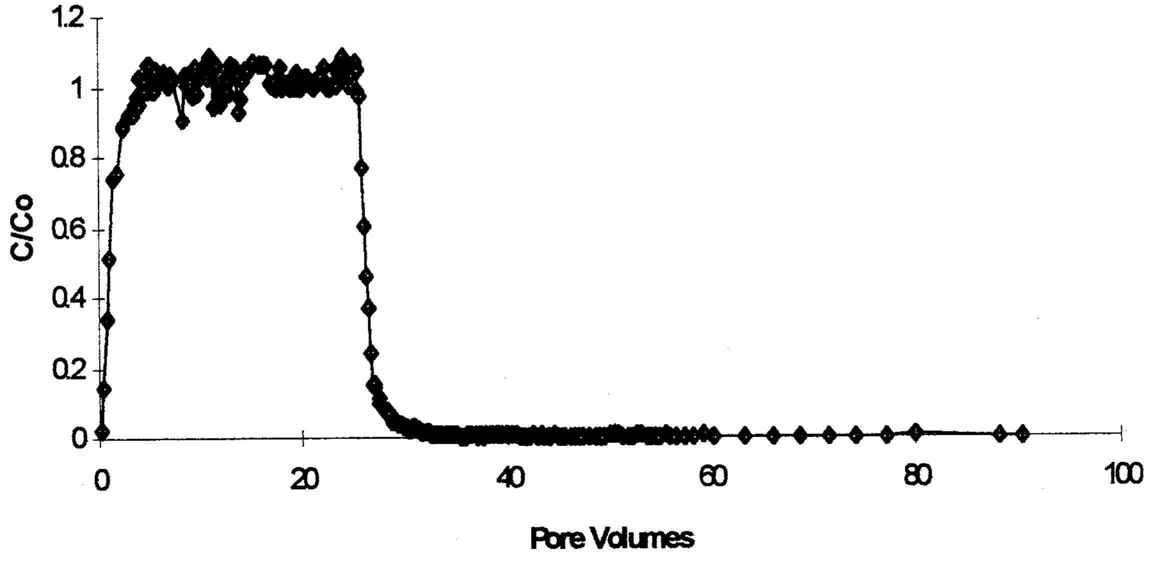
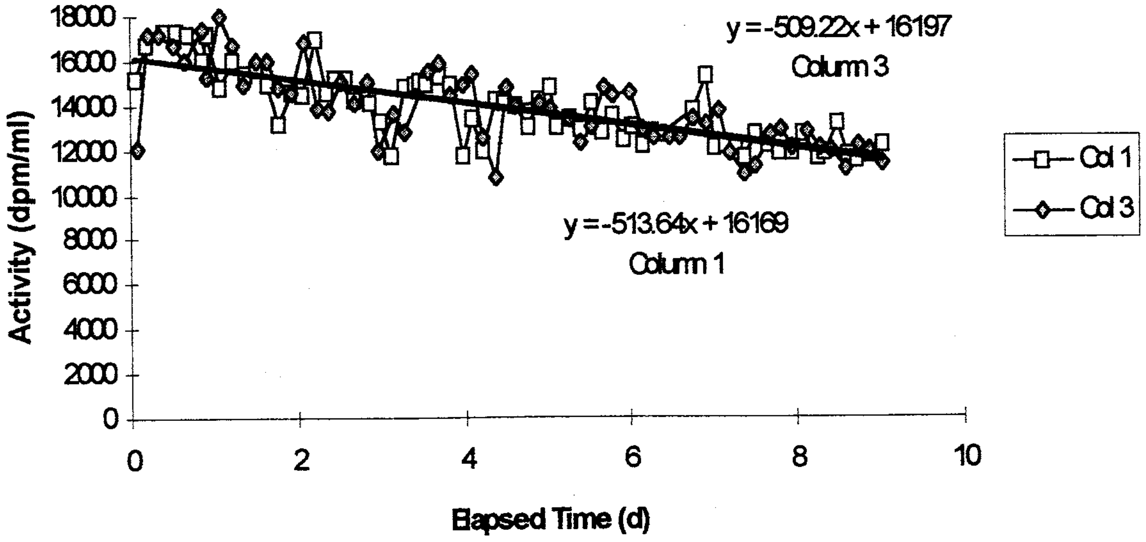


Figure 4-9: PCE Input, Untreated Columns



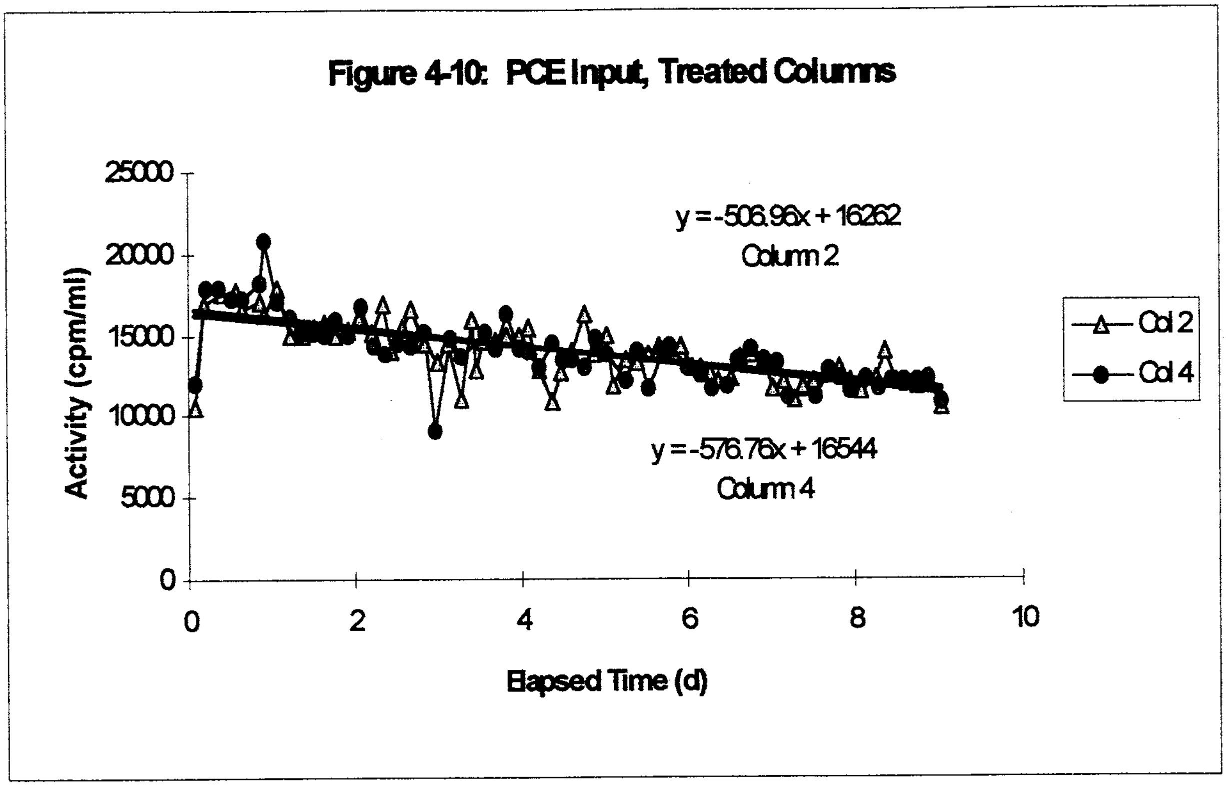


Figure 4-10: PCE Input, Treated Columns

PCE breakthrough data and a graph of the raw data are also compiled in Appendix A.7. Note that the data for the untreated Columns 1 and 3 show a decrease from about 16000 to 12000 dpm/ml during the slug input, exactly mirroring the input concentration curves. This means that the PCE is essentially unretarded through the untreated columns, as expected. The concentrations in the treated columns, however, never reach the input concentration and decrease very slowly after the slug input is concluded at about 9 days. Again, this type of behavior was expected in the treated columns based on the results of batch sorption experiments.

Note also the early initial breakthrough of PCE. In Column 2, we begin to see some PCE at 1.5 pore volumes, or half a day. In Column 4, it is within 0.74 pore volumes, or 0.26 days. While breakthrough as a whole is slower, some material is moving through the column more quickly than expected. This suggests that the organic coating has either closed smaller, more tortuous flow paths or that it increases the velocity in the center of channels by making all of the pore spaces smaller.

PCE breakthrough data with respect to pore volumes for all four columns are shown in Figure 4-11. To decrease modeling time and eliminate some of the data noise in PCE concentrations, the PCE data were refined using a moving average in an EXCEL spreadsheet. Averaged data for each of the four columns are shown in Figures 4-12a-d. The density of the averaged points is about 1/day, with slightly more at the beginning and end of the slug input to better define periods of rapid concentration changes. This point density is necessary to ensure that all portions of the column study are equally weighted by the model; sampling density toward the end of the experiment was reduced to only once/day. The averaging process did not significantly affect the outcome of the modeling process, changing estimated parameters by no more than 10%; however, it did increase the R^2 goodness of fit parameter by up to 4%.

Figure 4-11: PCE Breakthrough Curves, Raw Data

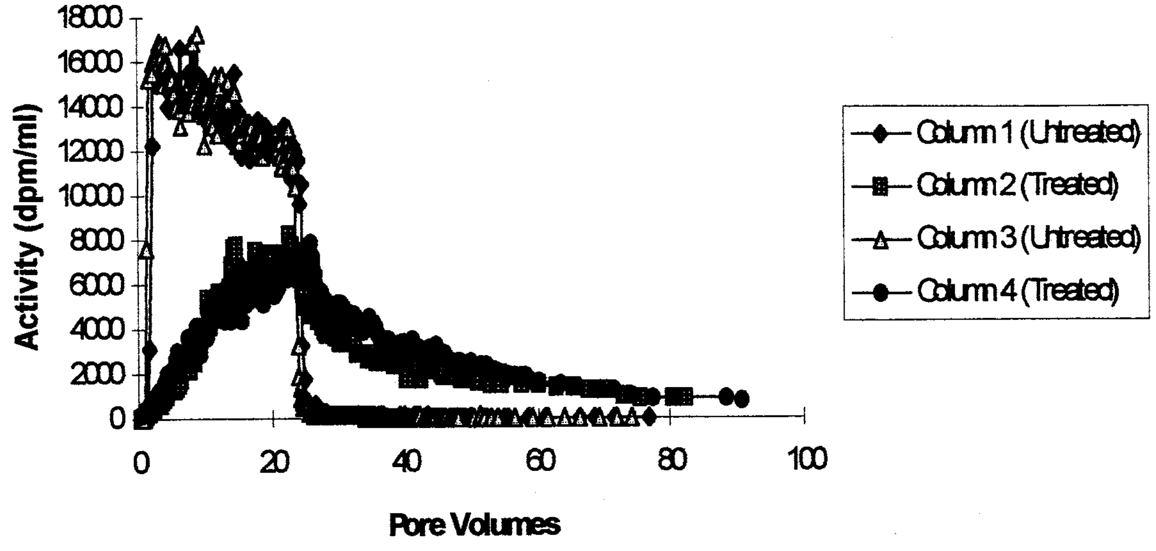


Figure 4-12a: Column 1 (Untreated) PCE Breakthrough Curve w/ Moving Average

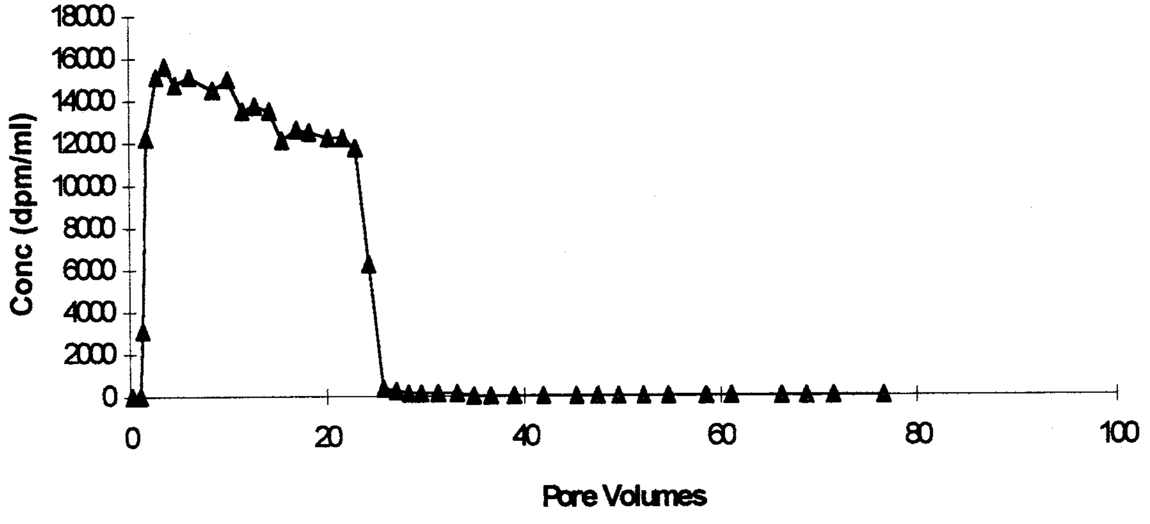


Figure 4-12b: Column 3 (Untreated) PCE Breakthrough Curve w/ Moving Average

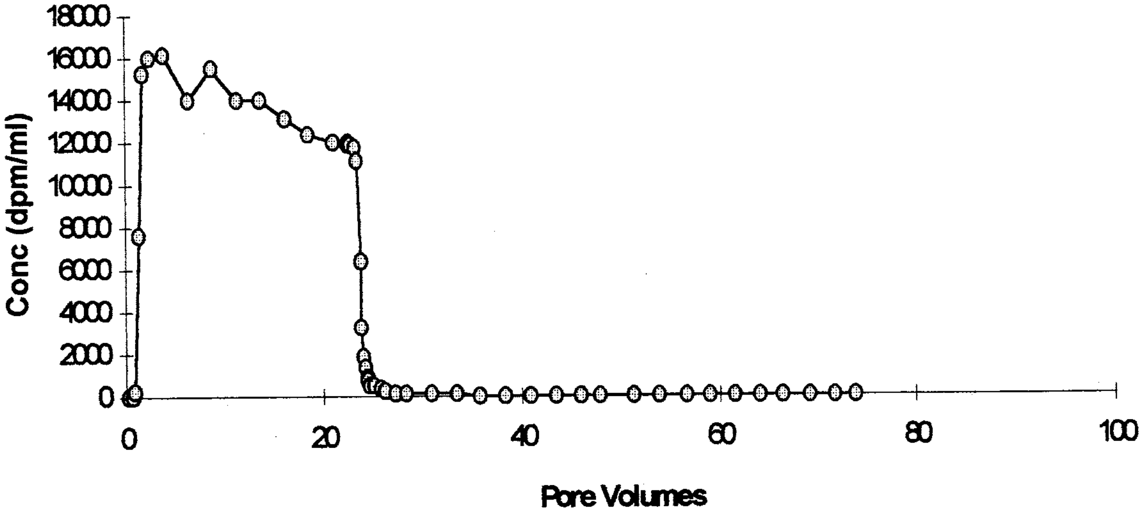
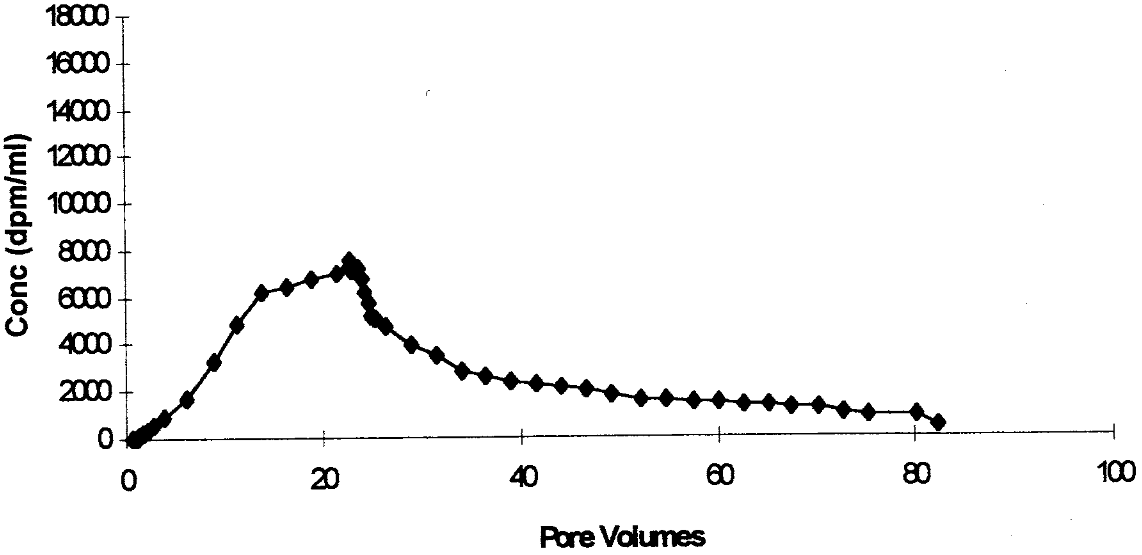
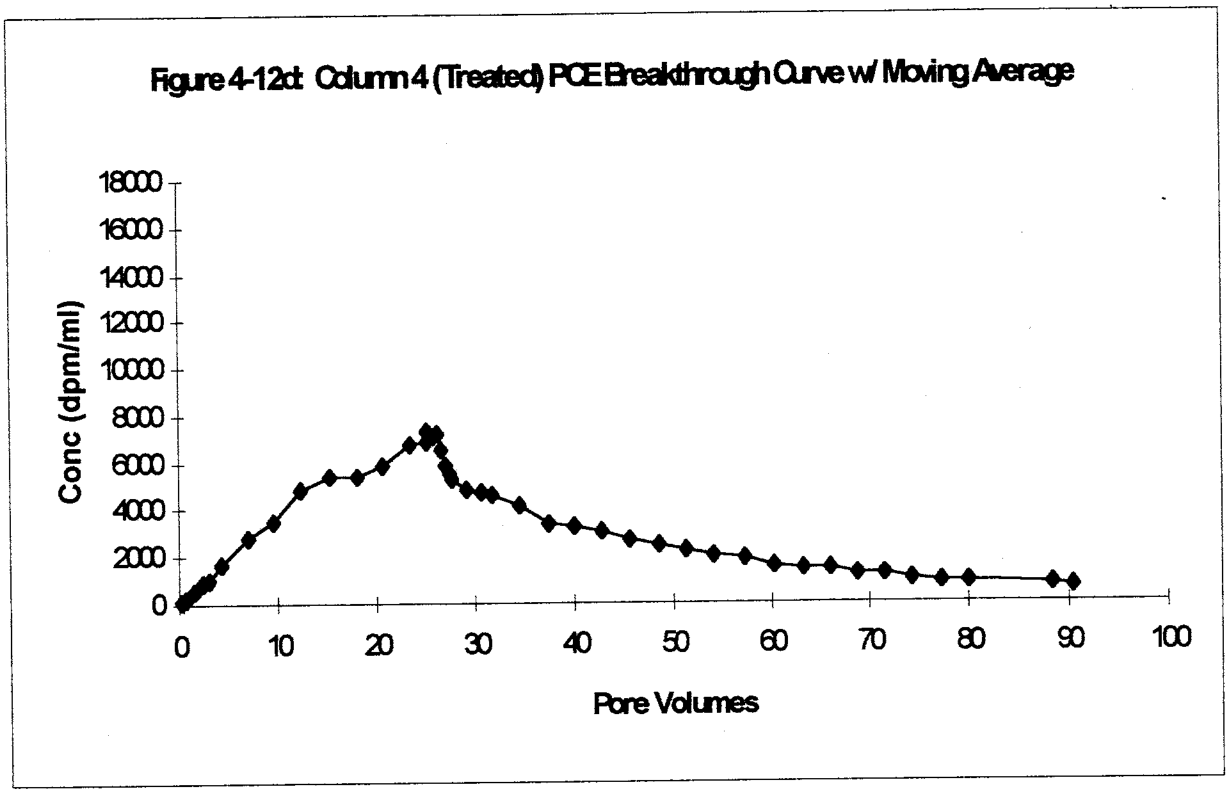
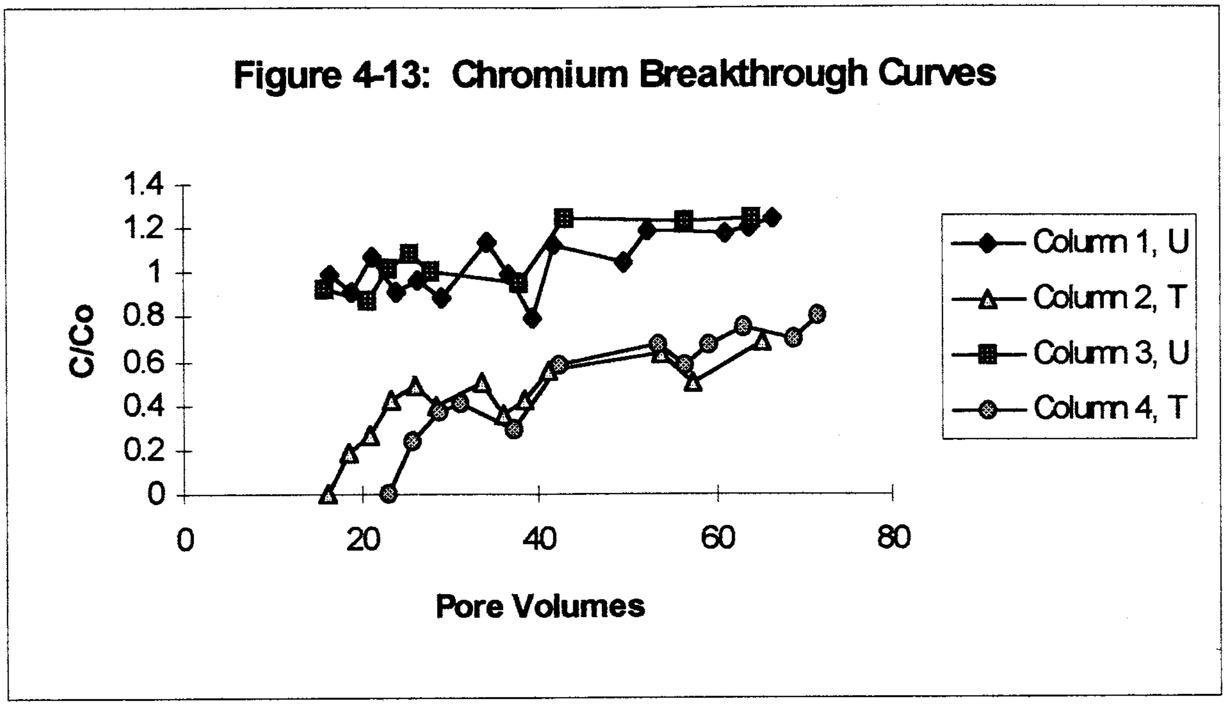


Figure 4-12c: Column 2 (Treated) PCE Breakthrough Curve w/ Moving Average





Chromium data are compiled in Appendix A.8. Breakthrough curves are shown in Figure 4-13. We could not quantitatively determine any transport parameters based on this data because chromium was added to the columns during the saturation phase in unrecorded volumes. However, it is clear that we are seeing Cr breakthrough in the treated columns much later than it had occurred in the untreated columns; in fact, a yellowish color denoting Cr was detectable in untreated column effluent even before the PCE and tritium input solution was introduced. It is clear, therefore, that the treated columns strongly retard Cr transport.



4.5 Modeling Results

We used the CXTFIT2 program to inversely model column outlet data to find the values of the transport parameters D and R for all columns. Where physical nonequilibrium assumptions were appropriate, as in the case of tritium and PCE transport in treated columns, we also tried to quantify beta and omega parameters. We assumed no production or radioactive decay of contaminant in the columns. We also used a pulse input of tritium contaminant.

The CXTFIT2 input file for an inverse model has seven blocks containing different information. The first block, Block A, is the same for all columns. The following input values were used: INVERSE = 1; MODE = 2 (deterministic or nonstochastic nonequilibrium); NREDU = 0; MODC = 1 (Flux-averaged concentration, since our outlet samples were collected outside of the column); and ZL = 15.5 cm. Block B is also constant for all columns, with the following input values: MIT = 100; ILMT = 0 or 1, depending on whether I needed to constrain parameter values; MASS = 0; MNEQ = 0; and MDEG = 0 (only a dummy value is needed here).

In Block C, we entered transport parameter values. For all columns, we used the velocity estimated from the syringe log sheets. For the equilibrium model, we had only D, R, and μ parameters to estimate, with μ=0 since it is a decay constant. For the nonequilibrium model, we also estimated β and ω. For nonreactive solutes like tritium, β is θ_m/θ. For reactive solutes, $\beta = (\theta_m + f\rho_b K_d)/(\theta + \rho_b K_d)$, where f is the fraction of adsorption sites that equilibrate with the liquid mobile phase (Toride, 1995). We began with an initial guess of 0.5 for these two parameters, as this number is in the middle of the possible range for both. We also began with D = 25, since we used this value in our initial models.

In both equilibrium and nonequilibrium cases, we used the tritium data for each column to estimate D (and beta and omega for the nonequilibrium case) for that column. We ran the inverse model for the following three different values of R: R=1 for the nonreactive tracer; R from tritium batch sorption experiments (Anghel, 1996, personal communication); and R fitted from an initial guess of the batch experiment value. The R values calculated from tritium batch sorption data are shown in Table 4.3.

Table 4.3: R Estimates from Tritium Batch Sorption Data

Col #	K_d from Batch Study	Dry Bulk Density, ρ_b	n	$R = 1 + (\rho_b K_d/n)$
1	0.2112	0.867	0.704	1.26
2	0.0758	0.915	0.678	1.10
3	0.2112	0.900	0.705	1.27
4	0.0758	0.959	0.642	1.11

The D and nonequilibrium beta and omega parameter values were used in input files with PCE data to find the best fit R estimates for PCE transport. The initial R estimates for PCE sorption were R = 1 for untreated columns and the following values for R in treated columns: for Column 2, R = 15.5; and for Column 4, R = 17.6. The first modeling step was to hold all other parameters constant and let R only vary. However, we expected all of the parameters except D to vary, since D is strictly a physical parameter and should not be affected by sorption chemistry. When the R value was not reasonable or the fit was poor, omega and beta were also allowed to be fitted, first at the same time and then individually. If the shape of the curve did not capture "tailing" well, we fixed the beta parameter at a reasonable value and allowed the other parameters to vary. Finally, where parameter values consistently increased or "blew up" to unreasonable values, we used the ILMT variable (=1) to constrain the parameters so that local minima near initial parameter estimates are not overshot.

Mass balance results calculated with MATLAB using concentration (dpm/ml) data are shown in Table 4.4. The treated Columns 2 and 4 needed to have a significant amount of PCE mass added in order to be fitted by CXTFIT2, which uses the total mass from the input function to as a non-fitting parameter. In short, in order to model these columns within the time that we collected data, CXTFIT2 would have to assume that the missing mass, almost 30%, had decayed out of the columns; since we had no constant mass loss throughout the experiment due to decay, this would result in an unrealistic fit.

Table 4.4: Mass Balance

Col #	Input Mass (cpm-d/ml)	Output Mass (cpm-d/ml)	% Recovered
1 (Untreated) Tritium	2203400	2225500	100
1 (U) - PCE	124020	122640	98.9
2 (Treated) - Tritium	2230000	2290000	100
2 (T) - PCE	125450	87977	70.1
3 (U) - Tritium	2220800	2262800	100
3 (U) - PCE	124260	126470	102
4 (T) - Tritium	2199000	2307400	100
4 (T) - PCE	124130	91600	73.8

The additional mass needed for Column 2 was 37473 cpm-d/ml, or 29.9%; for Column 4, it was 32530 cpm-d/ml, or 26.2%. To determine the equation of the line that would define the extrapolated data set, I used a right triangle with the same area as the additional mass required. The height of this triangle was the average of the last two concentration data. Then since the triangle area of 1/2 base x height = additional mass, I solved for the base, which was the time required to get the concentration down to zero. The slope of the hypotenuse was also the slope for the extrapolation line. The intercept was calculated using the line equation, C - mt = b (m=slope, b=intercept), substituting one of the points on the line into the equation. The extrapolation line for Column 2 was $C = -6.41t + 900.6$; for Column 4, the line was $C = -8.77t + 1039$. The extrapolation was performed in the Excel spreadsheet shown in Appendix A.7. One concentration per day was added to each data set along these extrapolation lines in order to preserve point density.

4.5.1 Model Parameter Estimates for Tritium

The breakthrough curves for tritium in all four columns are shown in Figure 4-8. Note that the curves are almost identical except for slightly later peaking and a small amount of tailing in the treated columns. Because of these slightly nonequilibrium features, we modeled the untreated columns using equilibrium assumptions and the treated columns using mobile-immobile water nonequilibrium assumptions. The parameter results are shown in Table 4.5. These were obtained using constant parameter values of L (characteristic length) = 15.5 cm, $\mu_1 = 0$, and $\mu_2 = 0$ (no decay of the contaminant). For all four columns, R is greater than expected for a nonreactive tracer, although we also got reasonable parameter values when we fixed R=1; we allowed R to vary to get the best possible fits to the observed data. In the case of the untreated columns, the lower R's may be due to a small amount of sorption on the negatively-charged mineral surface, as suggested by the nonzero $K_d = 0.0758$ L/kg (Anghel, 1996, personal communication). For the treated columns, tritium retardation may be caused by diffusion into immobile water trapped within or below the organic layer on the mineral surface; this would also account for the values of $\beta < 1$ and $\omega > 0$. In any case, R values are based on only a few data points at critical breakthrough times because the tritium column effluent concentrations changed very quickly relative to the once-per-hour sampling time.

Table 4.5: Tritium Modeling Parameter Results

Col #	D (cm^2/d)	R	β	ω (d^{-1})	R^2
1 (Untreated)	24.14	1.180	NA	NA	0.9963
3 (Untreated)	2.76	1.443	NA	NA	0.9972
2 (Treated)	41.03	1.211	0.5113	1.369	0.9946
4 (Treated)	75.44	1.279	0.7642	0.2797	0.9958

We also noted that beta values for the treated columns are both greater than 0.5, but the omega values differed by half an order of magnitude. This is probably because D and omega describe some of the same curve shape effects and the much smaller D value for Column 2 allowed omega to be fitted as a larger value. This type of problem commonly occurs when too many parameters must be fitted. Constraining omega to be less than one did not solve the problem, nor did numerous permutations of initial values. In any case, the R^2 correlation coefficient was close to one for both columns and the 95% confidence intervals for D, beta, and omega values in each column included the values obtained for the replicate column.

Dispersion is smaller for the untreated columns, suggesting that either (or both) less longitudinal dispersion takes place or less diffusion takes place. We don't really know the configuration of the organic phase on the mineral surface, but we would expect less mechanical dispersion in the treated columns because the organic phase probably closes off some of the mineral's internal channels and other small pore spaces. Since we observe a larger D in the treated columns, other factors must account for this condition, such as relatively less tritium diffusion into the smaller amount of immobile water in the untreated column. The alternative is that the flow path is actually longer in the treated columns, which is not likely, or that the treated surface somehow enhances dispersion.

The model fits to the observed data for all four columns are shown in Figures 4-14 through 4-17. The limited number of points at breakthrough is especially evident in the untreated Columns 1 and 3. I also noted that the breakthrough was steeper in the untreated columns, which we expect due to the presence of immobile water in the treated columns.

Figure 4-14: Column 1 (Untreated) Tritium Nonequilibrium Model

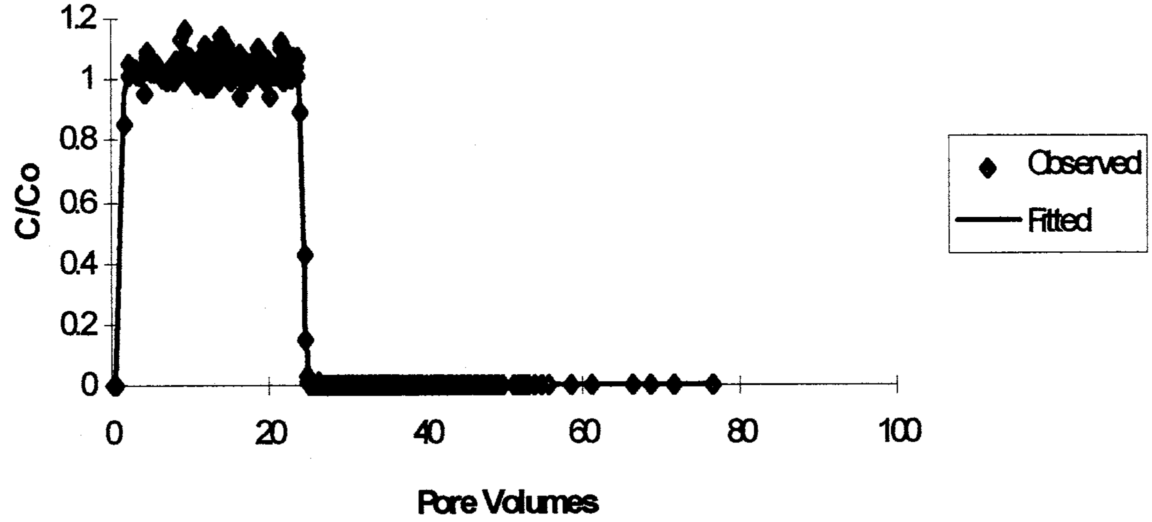
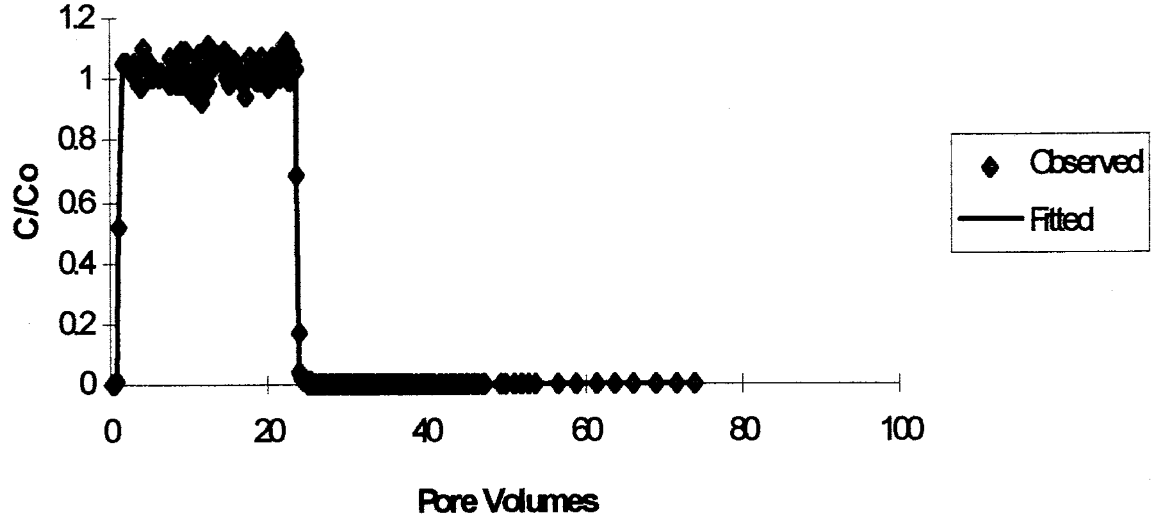


Figure 4-15: Column 3 (Untreated) Tritium Equilibrium Model



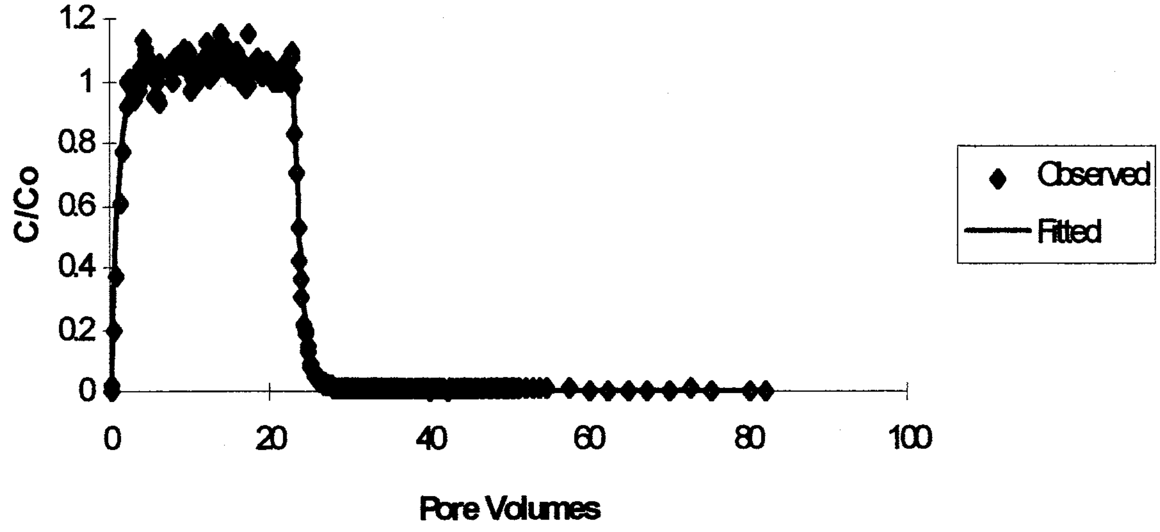


Figure 4-16: Column 2 (Treated) Nonequilibrium Model

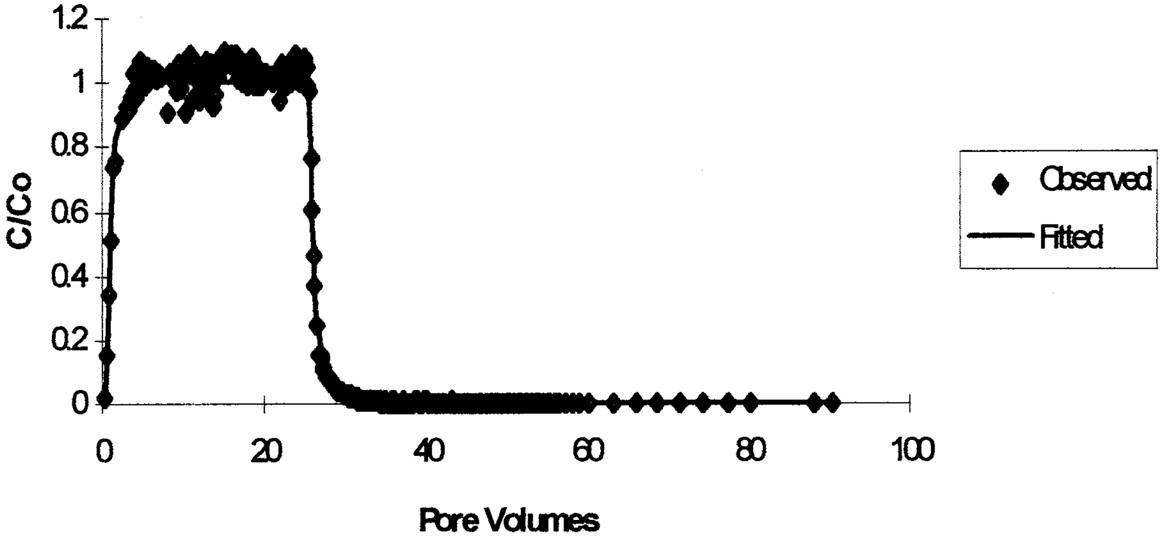


Figure 4-17: Column 4 (Treated) Tritium Nonequilibrium Model

4.5.2 Model Parameter Estimates for PCE

I used the D values obtained from tritium data fits for all four columns to fit the PCE data. The fits are shown in Figures 4-18 through 4-21. The PCE data fits for untreated columns are best, with the pulse exactly mirroring the decrease in concentration observed in the input solution. These columns were modeled assuming equilibrium conditions; the parameter values obtained are shown in Table 4.6. The D value from the Column 3 tritium fit was very low compared to the estimate for Column 1, so D was allowed to vary for this column only. The resulting value of 10.54 cm^2/d is closer to the value we expect considering the length of our columns. The R values obtained for the untreated columns are

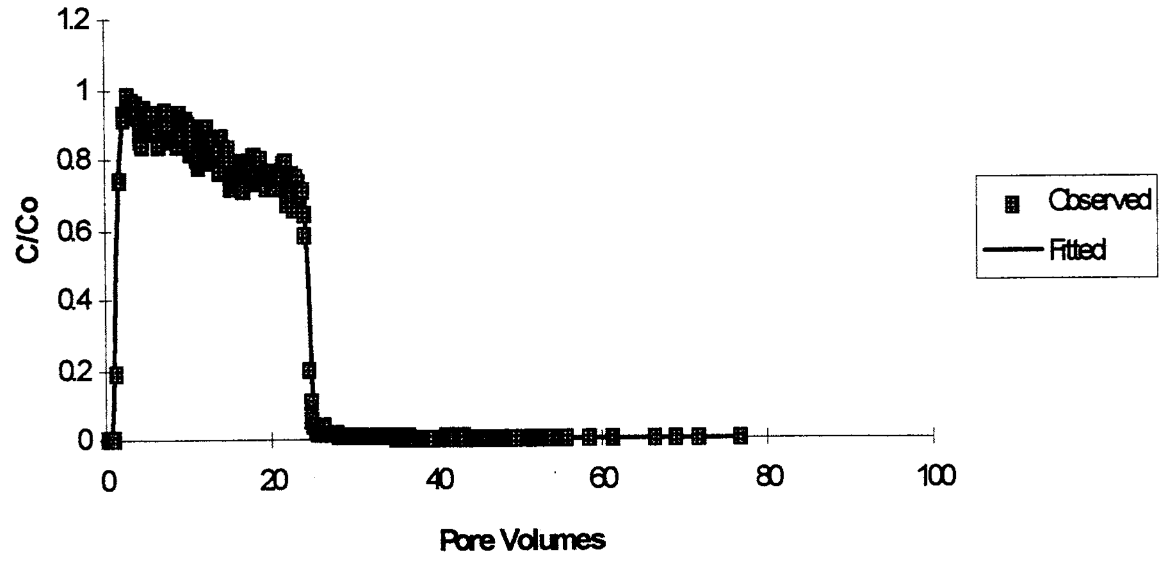
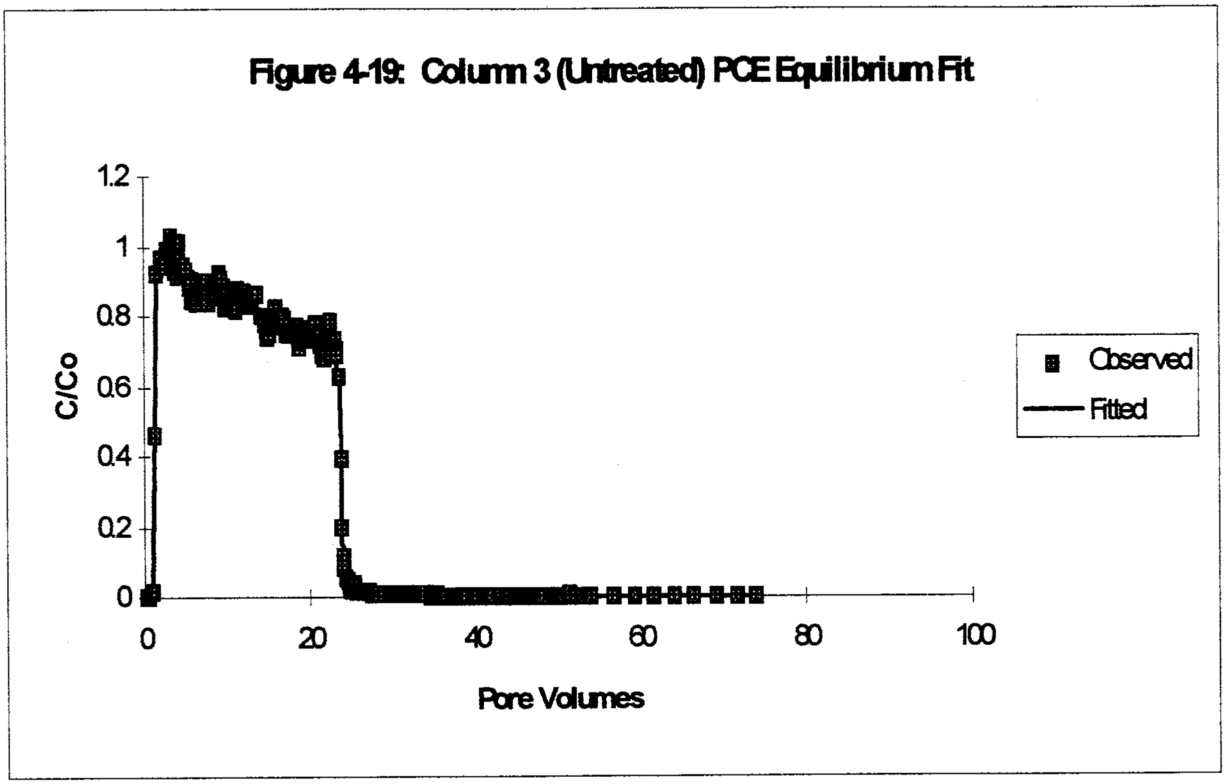


Figure 4-18: Column 1 (Untreated) PCE Equilibrium Fit



slightly larger than those for tritium transport and larger than the expected value of 1. This must be due to sorption or other chemical interaction between the PCE and the mineral surface, since there is little organic matter in the raw zeolite.

Table 4.6: PCE Modeling Parameter Results

Col #	D (fixed)	R	β	ω (d^{-1})	R^2
1 (Untreated)	24.14	1.61	NA	NA	0.9880
3 (Untreated)	10.54 (fitted)	1.47	NA	NA	0.9958
2 (Treated)	41.03	42.00	0.190	0.950	0.9572
4 (Treated)	75.44	45.44	0.174	1.135	0.9785

Obtaining R estimates for the treated columns was more difficult. The input function specification produced some problems with the executable file, causing the program to ignore mass balance and take up to 36 hours for completion of one modeling run. The problem was circumvented by using an input function consisting of ten pulses approximating the original linear function. To test this approximation, I first used a ten-pulse input concentration approximation with an untreated column data set. Each pulse could clearly be seen in the model fit, but the parameters varied only slightly from the solution obtained using the continuous function; also the model still fit the data to within $R^2>0.95$. For Column 1, for instance, the R value achieved with the linear input function was 1.612 with $R^2 = 0.9880$. With the 10 pulse input function approximation, I achieved $R = 1.578$ with $R^2 = 0.9841$. Because the contaminant moved more slowly in the treated columns, no discreet steps could be detected in the model results. As a result of these findings, I decided to use the linear input functions for untreated columns and ten-pulse approximations for the treated columns. The final input files are provided in Appendix D.

Using the D values obtained from tritium data, I used CXTFIT2 to estimate R, β, and ω for the treated columns. The R^2 values for the data fits are both greater than 90%. We expect D to remain the same for tritium and PCE contaminants because it is a physical, rather than a chemical, parameter. Although the D is considerably smaller for Column 2 than for Column 4, allowing it to vary in the modeling process results in a D estimate exceeding 1000 cm^2/d. Also, when I fixed D at the Column 4 value of 78.44 cm^2/d, the resulting fit and curve shape was not as good as for D=41.03 cm^2/d. We also expect β to decrease, since its definition is different for reactive and nonreactive solutes. Recall that for nonreactive tritium, $\beta = \theta_m/\theta$; for PCE, however, $\beta = (\theta_m + f\rho_bK_d)/(\theta + \rho_bK_d)$ (Toride, 1995). Since $1 \geq f$, $f\rho_bK_d < \rho_bK_{d.}$, so β must decrease. The β estimates for both treated columns are similar but do decrease significantly from their tritium values, suggesting that the fraction of exchange sites at equilibrium with the mobile phase, f, is not close to one. Both ω values are close to 1.0, but one increased and one decreased from the tritium values; therefore, we cannot suggest any possibilities for the physical meaning of this parameter. The estimated parameter values were used to predict PCE breakthrough; the results are shown in Figures 4-20 and 4-21.

Figure 4-20: Predicted Model, Column 2 (Treated) PCE Data

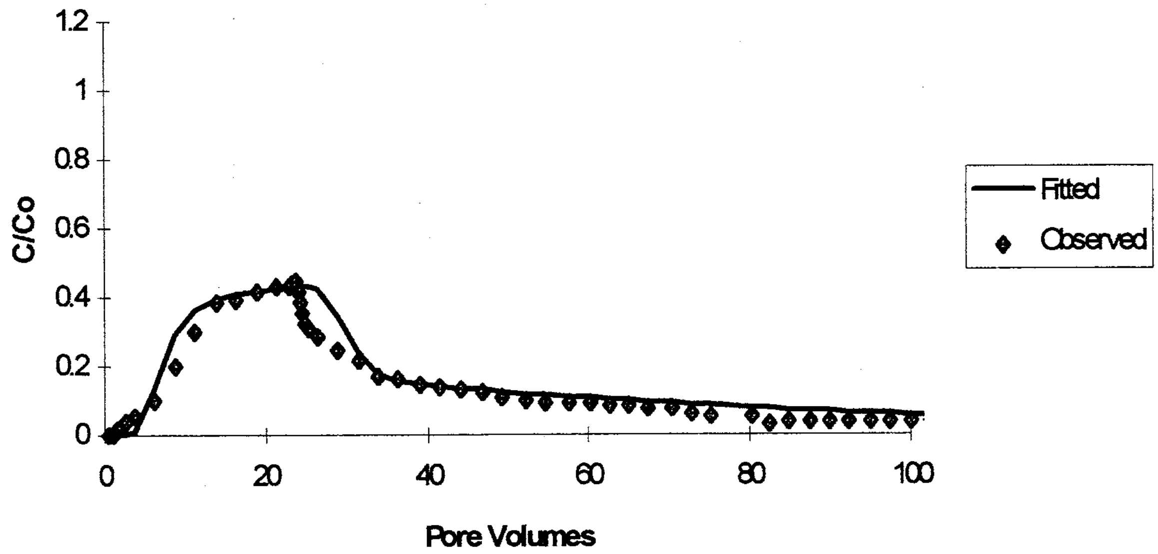
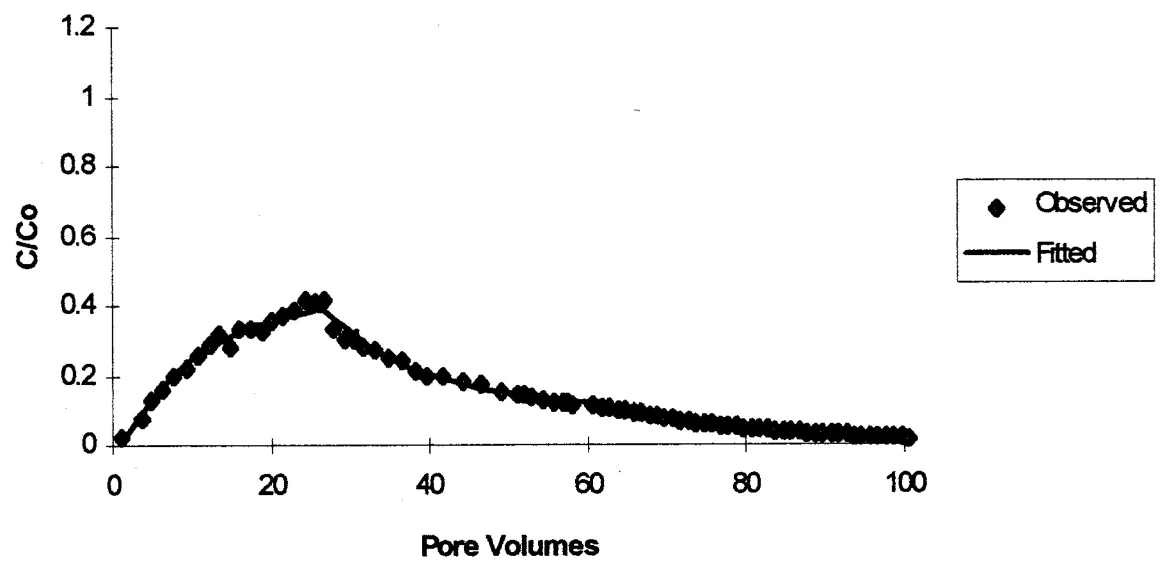


Figure 4-21: Column 4 (Treated) PCE Model Prediction



One of our primary goals was to predict breakthrough of PCE in treated zeolite. To summarize, the batch R estimate for Column 2 was 15.3; the column study R estimate is 42.0. For Column 4, the batch R estimate was 17.2 and the column study estimate was 45.4. The R values for PCE in the treated columns are significantly larger than predicted based on the batch study. This discrepancy may be due to a greater sorption isotherm K_d at the very low ppb-level concentrations used in the column study, as compared with the higher 50-200 ppm-level concentrations used in the batch studies; note that the sorption isotherms shown in Figure 4-5 did not intersect the origin. Previous data on PCE sorption also suggests nonlinear sorption at low concentrations, with nonzero intercepts (at equilibrium solution concentrations) of 24.67 mg/kg

(Huddleston, 1990). My best estimate for the lower concentration K_d, based on a least squares fit of my two lowest concentration data (at 50 ppm) for the Elizabeth City water with the line intercept at zero, is 10.68 L/kg. The best estimate based on Huddleston's lowest two concentrations of 12 and 28 ppm is K_d=56.17 L/kg. This may be closer to the concentration range in which curvature of the sorption isotherm begins to occur. Using the latter K_d, I would predict an R = 77 and 88 for Columns 2 and 4, respectively. These values are certainly within the range of model predictions with $R^2 > 0.90$. The only way to be certain of the actual K_d, however, is to perform batch experiments at PCE concentrations ranging from about 200 to 500 ppb.

Other possibilities include model sensitivity to small parameter variations and the effect of immobile water. Different parameter values cause different parts of the curve to be better fitted; for instance, smaller R values may result in better fits of the peak portion of the curve, but much worse fits in the tail section. Small variations in beta and omega values can cause large variations in R. For instance, changing beta and omega values in Column 2 by less than 20% results in a 42% change in R. In addition, the batch study data do not help us quantify diffusion into any immobile water in unconnected pore spaces, so we may predict a speedier, advection-dominated breakthrough, or a smaller R; indeed there is physically immobile water in the column study that is not present in the batch study. The beta values obtained with tritium data suggest that a significant fraction of the water in the column is immobile - almost half of the water in Column 2 may be immobile! The importance of diffusional processes in such a case is impossible to predict with batch data.

The implications for permeable barrier design are favorable. Retardation is greater than anticipated, so we can say that treated zeolite is more efficient at slowing contaminants than we had hoped. This means that barrier systems can be thinner and thus less expensive. However, we must also consider that low levels of contaminants may break through barriers more quickly than expected. Perhaps a double-layered design could mitigate this problem.

5.0 Conclusions

Several of the conclusions obtained during our work were favorable for permeable barrier design or increased our understanding of organic nonpolar contaminant sorption to HDTMA-modified zeolite. On the basis of the data collected, we can make the following conclusions:

- The amount of sorption of HDTMA onto St. Cloud zeolite levels off at 220 mmol/kg, about twice the external CEC of the zeolite; this suggests that sorbed HDTMA forms a stable bilayer.

- HDTMA sorption to raw zeolite is complete within about eight hours.

- HDTMA desorbs from zeolite to the plateau level of 220 mmol/kg. Otherwise, it is stable on and difficult to desorb from zeolite mineral surfaces.

- Under vigorous agitation, the particle size of treated zeolite decreases significantly from that of raw zeolite, with 40% more fines (below 0.43 mm diameter); this is primarily due to the action of the surfactant on the mineral surface, rather than due to physical agitation.

- Batch study K_ds for PCE are as follows: pure water, 10.9 L/kg; ORNL water, 10.6 L/kg; and Elizabeth City water, 10.8 L/kg. Ionic strength does not appear to significantly influence the amount of sorption.

- The R values for PCE in treated columns are significantly larger than predicted. The batch and column study R estimates are as follows: Column 2, 15.27 and 42, respectively; Column 4, 17.16 and 45.44, respectively. The discrepancy may be due to a greater K_d at the low concentrations used in the column study, as compared with the higher concentrations used in the batch studies. Also, the batch study data cannot predict immobile water, causing us to predict a smaller R; beta values suggesting up to 49% of immobile water make this an important parameter in describing transport.

- Breakthrough curves for tritium in all columns are similar except for slightly later peaking and a small amount of tailing in treated columns. For all columns, R is greater than one, perhaps due to some sorption on the negatively-charged mineral surface. Dispersion of tritium is smaller in untreated columns, probably due to less mechanical dispersion caused by the organic phase blocking some small pore spaces.

- Estimates for PCE transport in treated columns agree well and are significantly smaller than their tritium values, suggesting that the fraction of exchange sites at equilibrium with the mobile phase, f, is not close to one. We cannot suggest any possibilities for the physical meaning of the ω parameter, since it did not vary in the same way for both treated columns.

Overall, the implications for permeable barrier design are favorable. Retardation is greater than anticipated, so barrier systems can be thinner and less expensive. However, low levels of contaminant may break through barriers more quickly than expected from batch studies.

6.0 Suggestions for Future Work

To improve batch-scale PCE sorption data, the following additional work should be performed: batch sorption studies to find K_d in the column study PCE concentration range (perhaps 200 to 500 ppb); for more thorough characterization of water chemistry effects, a batch sorption study using a higher ionic strength water (such as I=0.2M or greater); and time of sorption batch studies for PCE sorption. The latter information should be used to determine the flow rate in any future column studies.

One of the primary goals of this work has been to provide data for a field-scale installation of a treated zeolite permeable barrier technology. Although I hope the results of my column studies will be somewhat useful in the barrier design process, I feel strongly that certain physical parameters should be better characterized, since we ended up fitting too many parameters in the modeling step. In particular, we should estimate dispersion (D) using a couple of slugs of nonreactive tracer prior to the introduction of contaminant, since this mechanical dispersion parameter should be the same for both tracer and contaminant.

Another troubling question was how to estimate porosity/volumetric water content in the packed columns - and whether or not to include the moisture naturally present in treated zeolite. Should the water present within the zeolite be considered void space filled by water for the purpose of porosity calculations? The resolution of this question affects dry bulk density and thus R estimates; it also affects porosity and thus specific discharge and pore volume calculations. Because we could only estimate our effective porosities (due to uncertainty about the amount of water in the zeolite and how much of it is available for flow), our specific discharge (v_x) estimates used for modeling are approximate at best. For future column studies, we must be better able to quantify effective porosity.

In future column studies, greater attention should be paid to details, including painstaking measurements of column dimensions and the amount of water in fittings that are not part of the column but are weighed with it. Also, digitally-controlled pumps should be used as they are able to supply a very accurate flow rate.

Finally, the next logical step is to test treated zeolite in a carefully controlled large scale experiment. The column study data suggest that some low concentrations of contaminant may break through a barrier very quickly, but that breakthrough overall is very much retarded. A large-scale study is the last step necessary to demonstrate whether this technology will be effective at real contaminated sites.

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Appendix A - Raw Data and Spreadsheets

Appendix A.1: HDTMA Sorption Isotherm Data

The HDTMA sorption isotherm data is included in the following spreadsheet. Data in columns F and G are based on counting data. Figures in Column C are from initial solution calculations described in the main text. The following calculations are embedded in the spreadsheet:

Col D = Initial solution concentration (mol/L) * 284 mg/mmol * 1000 mmol/mol =
Col C * 284000 [mg/L];

Col E = Initial solution concentration (mol/L) * 0.020 L * 1000 mmol/mol =
Col C * 20 [mmol];

Col H = Initial cpm/ml - Final cpm/ml = Col F - Col G [cpm/ml];

Col I = 1 - (Final cpm/ml ÷ Initial cpm/ml) = 1 - (Col G/Col F);

Col J = 100 * (Final cpm/ml ÷ Initial cpm/ml) = 100 * (Col G/Col F);

Col K = (1 - Fraction sorbed) * Initial solution concentration (mol/L) * 1000 mmol/mol =
(1 - Col I) * Col C * 1000 [mmol/L];

Col L = Fraction sorbed * Initial amount (mmol) / 0.005 kg = Col I * Col E * 200 [mmol/kg]

HDTMA Sorption Isotherm Data

% of ECEC	Init. conc (M)	Init conc mg/L	Initial mmol/L	Init.mmol HDTMA	Initial cpm/ml	Final cpm/ml	Amt sorb. cpm/ml	Fraction Sorbed	% Remaining	Amt Sorbed mmol/kg z	Final Soln Conc mmol/L
400	0.15	42697.5	150	3	9622.35	3677.95	5944.4	0.61777	38.2229913	370.6620524	57.33449
400	0.15	42697.5	150	3	9622.35	31.85	9590.5	0.99669	0.33100022	598.0139987	0.4965
300	0.1125	32023.13	112.5	2.25	10029.05	5320.55	4708.5	0.469486	53.0513857	211.2687642	59.68281
300	0.1125	32023.13	112.5	2.25	10029.05	28.55	10000.5	0.997153	0.28467302	448.7189714	0.320257
200	0.075	21348.75	75	1.5	10320.95	2764.85	7556.1	0.732113	26.7887162	219.6338515	20.09154
200	0.075	21348.75	75	1.5	10320.95	28.25	10292.7	0.997263	0.27371511	299.1788547	0.205286
150	0.05625	16011.56	56.25	1.125	10335.25	387.05	9948.2	0.96255	3.74495053	216.5738613	2.106535
150	0.05625	16011.56	56.25	1.125	10335.25	106.85	10228.4	0.989662	1.0338405	222.6738589	0.581535
100	0.0375	10674.38	37.5	0.75	10803.85	23.05	10780.8	0.997867	0.21334987	149.6799752	0.080006
100	0.0375	10674.38	37.5	0.75	10803.85	19.15	10784.7	0.998227	0.17725163	149.7341226	0.066469
75	0.028125	8005.781	28.125	0.5625	9867.25	23.75	9843.5	0.997593	0.24069523	112.2292179	0.067696
75	0.028125	8005.781	28.125	0.5625	9867.25	23.15	9844.1	0.997654	0.23461451	112.2360587	0.065985
50	0.01875	5337.188	18.75	0.375	10967.85	7.85	10960	0.999284	0.07157282	74.94632038	0.01342
50	0.01875	5337.188	18.75	0.375	10967.85	11.65	10956.2	0.998938	0.10621954	74.92033534	0.019916
25	0.009375	2668.594	9.375	0.1875	9663.05	9.15	9653.9	0.999053	0.0946906	37.46449103	0.008877
25	0.009375	2668.594	9.375	0.1875	9663.05	8.65	9654.4	0.999105	0.08951625	37.46643141	0.008392
15	0.005625	1601.156	5.625	0.1125	9925.95	5.65	9920.3	0.999431	0.0569215	22.48719266	0.003202
15	0.005625	1601.156	5.625	0.1125	9925.95	3.65	9922.3	0.999632	0.0367723	22.49172623	0.002068
10	0.00375	1067.438	3.75	0.075	10566.85	3.45	10563.4	0.999674	0.03264928	14.99510261	0.001224
10	0.00375	1067.438	3.75	0.075	10566.85	5.05	10561.8	0.999522	0.04779097	14.99283135	0.001792
300	0.1125	32023.13	112.5	2.25	25944.1	13995.5	11948.6	0.460552	53.9448	207.2484	60.6879
150	0.05625	16011.56	56.25	1.125	10340.2	192.2	10148	0.981412	1.8588	220.8177	1.045575
100	0.0375	10674.38	37.5	0.75	23967.8	54.1	23913.7	0.997743	0.2257	149.66145	0.084637
100	0.0375	10674.38	37.5	0.75	10903	77.8	10825.2	0.992864	0.7136	148.9296	0.2676
75	0.02812	8004.358	28.12	0.5624	10619.6	60.8	10558.8	0.994275	0.5725	111.836052	0.160987
75	0.02812	8004.358	28.12	0.5624	10619.6	61.6	10558	0.994199	0.5801	111.8275035	0.163124
400	0.15	42697.5	150	3	10289.2	5078.65	5210.5	0.50641	49.359	303.846	74.0385
300	0.1125	32023.1	112.5	2.25	10379.8	2413.3	7966.45	0.7675	23.25	345.375	26.15625
300	0.1125	32023.1	112.5	2.25	10421.5	1354.6	9066.9	0.87002	12.998	391.509	14.62275
300	0.1125	32023.1	112.5	2.25	10341.2	2389.25	7951.9	0.76896	23.104	346.032	25.992
300	0.1125	32023.1	112.5	2.25	10341.2	1289.05	9052.1	0.87535	12.465	393.9075	14.02313
200	0.075	21348.8	75	1.5	9975.9	2059.5	7916.4	0.79355	20.645	238.065	15.48375
200	0.075	21348.8	75	1.5	9975.9	1329	8646.9	0.86678	13.322	260.034	9.9915
200	0.075	21348.8	75	1.5	9887.95	2008.95	7879	0.79683	20.317	239.049	15.23775
200	0.075	21348.8	75	1.5	9887.95	1275.35	8612.6	0.87102	12.898	261.306	9.6735

HDTMA Sorption Isotherm Data

% of ECEC	Init. conc (M)	Init conc mg/L	Initial mmol/L	Init.mmol HDTMA	Initial cpm/ml	Final cpm/ml	Amt sorb. cpm/ml	Fraction Sorbed	% Remaining	Amt Sorbed mmol/kg z	Final Soln Conc mmol/L	
150	0.0563	16011.6	56.25	1.126	10151.5	591.9	9559.6	0.94169	5.831	212.068588	3.279938	
150	0.0563	16011.6	56.25	1.126	10151.5	991.4	9160.1	0.90234	9.766	203.206968	5.493375	
150	0.0563	16011.6	56.25	1.126	9985.45	570.25	9415.2	0.94289	5.711	212.338828	3.212438	
150	0.0563	16011.6	56.25	1.126	9985.45	963.95	9021.5	0.90346	9.654	203.459192	5.430375	
100	0.0375	10674.4	37.5	0.75	10093.4	62.9	10030.5	0.99377	0.623	149.0655	0.233625	
100	0.0375	10674.4	37.5	0.75	10093.4	62.4	10031	0.99382	0.618	149.073	0.23175	
100	0.0375	10674.4	37.5	0.75	10027.5	18.85	10008.6	0.99812	0.188	149.718	0.0705	
100	0.0375	10674.4	37.5	0.75	10027.5	14.25	10013.2	0.99858	0.142	149.787	0.05325	
75	0.0281	8004.36	28.12	0.562	10624.4	57	10567.4	0.99463	0.537	111.796412	0.151004	
75	0.0281	8004.36	28.12	0.562	10624.4	57.2	10567.2	0.99462	0.538	111.795288	0.151286	
75	0.0281	8004.36	28.12	0.562	10613.1	13.95	10599.1	0.99869	0.131	112.252756	0.036837	
75	0.0281	8004.36	28.12	0.562	10613.1	17.05	10596	0.99839	0.161	112.219036	0.045273	

Appendix A.2: HDTMA Sorption vs Time Data

The data for a study to determine how much time is required for complete sorption is compiled in the file Timexp.xls reproduced in this Appendix. The initial solution concentration of 37.5 mmol/kg is entered in Column B, and the time data are in Column A. Also, scintillation results are in Columns C and E. The figures in Column D are the Column C data corrected for background. The Column E figures are already corrected as entered. Operations for other columns are as follows:

Col F = Init conc (mmol/L) * Fraction in Equilib Solution = Col B * Col E/Col D [mmol/L];

Col G = Amt Sorbed = Init mmol/L - Final mmol/L = Col B - Col F [mmol/l];

Col H = Amt Sorbed mmol/L * 0.02L ÷ 0.005 kg = Col G * 4 [mmol/kg].

Rate of Sorption Below Plateau

ADSORPTION OF HDTMA VERSUS TIME								
ime (hrs)	Initial conc mmol/L	Initial cpm	Init conc cpm/ml	Final conc cpm/ml	Final conc mmol/L	Equil Soln Conc mmol/L	HDTMA Sorbed mmol/kg zeolite	
0.25	37.5	9758.9	9716.4	2815.7	10.86706	26.63293504	106.532	
0.25	37.5	9758.9	9716.4	2873.8	11.0913	26.40870075	105.635	
0.5	37.5	10032.1	9989.6	1942.9	7.29346	30.2065398	120.826	
0.5	37.5	10032.1	9989.6	1853.3	6.95711	30.54288961	122.172	
1	37.5	10367.7	10325.2	902.6	3.278145	34.22185527	136.887	
1	37.5	10367.7	10325.2	2457.2	8.924282	28.57571766	114.303	
2	37.5	10061.4	10018.9	195	0.729871	36.77012946	147.081	
2	37.5	10061.4	10018.9	256.8	0.961183	36.53881664	146.155	
4	37.5	14135.8	14093.3	71.8	0.191048	37.30895177	149.236	
4	37.5	14135.8	14093.3	75	0.199563	37.30043709	149.202	
8	37.5	14647.7	14605.2	63	0.161757	37.33824254	149.353	
8	37.5	14647.7	14605.2	80.9	0.207717	37.29228289	149.169	
16	37.5	10006.1	9963.6	61.7	0.23222	37.26777972	149.071	
16	37.5	10006.1	9963.6	62.9	0.236737	37.26326328	149.053	
24	37.5	10075.3	10032.8	61.4	0.229497	37.27050275	149.082	
24	37.5	10075.3	10032.8	68	0.254166	37.24583367	148.983	

Appendix A.3: HDTMA Desorption Data

This Appendix contains data for the HDTMA desorption study. The data in column G was obtained by liquid scintillation counting of 1-ml samples. The figures in Column A were based on estimates of the external cation exchange coefficient. Initial concentrations listed in Column B came from the amount of HDTMA-Br surfactant mixed in water. The spreadsheet calculations for the first data set are as follows:

Column C = Initial concentration (M) * 284.65 g/mol *1000 mg/mmol = Col B * 284.65 [mg/L];

Column D = Initial concentration (M) * 1000 mmol/mol = Col B * 1000 [mmol/L];

Column E = Initial mmol/L * (0.02L) = Col D * 0.02 [mmol];

Column F = Based on count data;

Column H = Final - Initial cpm/ml = Col F - Col G [cpm/ml];

Column I = Amt Sorbed (cpm/ml) / Initial Amount (cpm/ml) = Col H / Col F;

Column J = Fraction Sorbed * Initial mmol HDTMA = Col I * Col E [mmol];

Column K = Amount Sorbed (mmol) / 0.005 kg = Col J / 0.005 [mmol/kg];

Column L = (1 - Fraction Sorbed) * Initial mmol HDTMA = (1 - Col I) * Col E [mmol];

Column M = Equilibrium Solution mmol / 0.02 L = Col L / 0.02 [mmol/L];

For all of the wash data sets, we begin with Column D, which has 1/2 of the Column M mmol/L concentration from the previous data set for each sample.

Column D = Previous Equilibrium Solution Conc / 2 = Previous Col M / 2 [mmol/L];

Column B = Initial mmol/L ÷ 1000 mmol/mol = Col D * 0.001 [M];

Column C = Initial mmol/L * 284.65 mg/mmol = Col D * 284.65 [mg/L];

Column E = Initial mmol/L * 0.02L = Col D * 0.02 [mmol];

Column F = 1/2 of the previous Final cpm/ml = 0.5 * previous Col G [cpm/ml];

Column G = based on count data;

Columns H - M same as for the first data set.

Column N = Sample designator

Column O = Same as Column M

Column P = Equilibrium Solution Conc - Initial Solution Conc = Col O - Col D [mmol/L];

Column Q = Amount Desorbed (mmol/L) * 0.02 L = Col P * 0.02 [mmol];

Column R = Previous Amount Sorbed - Amt Desorbed = Previous Col J - Col Q [mmol];

Column S = New Amt Sorbed (mmol) / 0.005 kg = Col R / 0.005 [mmol/kg].

DESORPTION DATA (7/22-7/23)												
% of	Init. conc	Conc.	Init.	Init.mmol	Initial	Final	Amt sorb.	Fraction	Amount	Sorbed	Final HDTMA conc.	
ECEC	(M)	mg/L	mmol/L	HDTMA	cpm/ml	cpm/ml	cpm/ml	Sorbed	mmol	mmol/kg z	mmol	mmol/L
300	0.1125	32023.125	112.5	2.25	25944.1	13995.5	11948.6	0.460552	1.0362414	207.248276	1.2137586	60.687931
150	0.05625	16011.563	56.25	1.125	10340.2	192.2	10148	0.981412	1.1040889	220.817779	0.0209111	1.0455552
100, #1	0.0375	10674.375	37.5	0.75	23967.8	54.1	23913.7	0.997743	0.7483071	149.661421	0.0016929	0.0846448
100, #2	0.0375	10674.375	37.5	0.75	10903	77.8	10825.2	0.992864	0.7446483	148.929652	0.0053517	0.2675869
75	0.02812	8004.358	28.12	0.5624	10619.6	60.8	10558.8	0.994275	0.5591801	111.836022	0.0032199	0.1609944
75	0.02812	8004.358	28.12	0.5624	10619.6	61.6	10558	0.994199	0.5591377	111.827549	0.0032623	0.1631127
200	0.075	21348.75	75	1.5	10132	2050.7	8081.3	0.797602	1.1964025	239.280497	0.3035975	15.179876
Run A - Wash 1												
300	0.030344	8637.4098	30.34397	0.606879	6997.75	6136.6	861.15	0.123061	0.0746832	14.936633	0.5321961	26.609807
150	0.000523	148.80865	0.522778	0.010456	96.1	112.7	-16.6	-0.172737	-0.001806	-0.3612116	0.0122616	0.6130805
100, #1	4.23E-05	12.047073	0.042322	0.000846	27.05	65.1	-38.05	-1.406654	-0.001191	-0.238132	0.0020371	0.1018554
100, #2	0.000134	38.084306	0.133793	0.002676	38.9	88.5	-49.6	-1.275064	-0.003412	-0.682381	0.0060878	0.3043887
75	8.05E-05	22.913526	0.080497	0.00161	30.4	57.5	-27.1	-0.891447	-0.001435	-0.287036	0.0030451	0.1522562
75	8.16E-05	23.21502	0.081556	0.001631	30.8	54.6	-23.8	-0.772727	-0.00126	-0.2520833	0.0028915	0.1445772
200	0.00759	2160.4758	7.589938	0.151799	1025.35	1411	-385.65	-0.376115	-0.057094	-11.418772	0.2088926	10.444631
Run B- Wash 2												
300	0.013305	3787.2408	13.3049	0.266098	3068.3	3540.9	-472.6	-0.154027	-0.040986	-8.1972394	0.3070843	15.354213
150	0.000307	87.256682	0.30654	0.006131	56.35	135.5	-79.15	-1.404614	-0.008611	-1.7222829	0.0147422	0.737111
100, #1	5.09E-05	14.496571	0.050928	0.001019	32.55	68.1	-35.55	-1.092166	-0.001112	-0.222486	0.002131	0.1065492
100, #2	0.000152	43.322122	0.152194	0.003044	44.25	112.5	-68.25	-1.542373	-0.004695	-0.9389618	0.0077387	0.3869348
75	7.61E-05	21.669864	0.076128	0.001523	28.75	71.5	-42.75	-1.486957	-0.002264	-0.4527967	0.0037865	0.1893273
75	7.23E-05	20.57695	0.072289	0.001446	27.3	66	-38.7	-1.417582	-0.00205	-0.4099002	0.0034953	0.1747636
200	0.005222	1486.5321	5.222315	0.104446	705.5	978.7	-273.2	-0.387243	-0.040446	-8.0892223	0.1448924	7.244621
Run C - Wash 3												
300	0.007677	2185.2884	7.677107	0.153542	1770.45	1781.7	-11.25	-0.006354	-0.000976	-0.1951311	0.1545178	7.7258895
150	0.000369	104.90932	0.368555	0.007371	67.75	140.8	-73.05	-1.078229	-0.007948	-1.5895486	0.0153189	0.7659426
100, #1	5.33E-05	15.164615	0.053275	0.001065	34.05	82.9	-48.85	-1.434655	-0.001529	-0.3057227	0.0025941	0.1297053
100, #2	0.000193	55.070494	0.193467	0.003869	56.25	152.2	-95.95	-1.705778	-0.0066	-1.3200495	0.0104696	0.5234798
75	9.47E-05	26.946005	0.094664	0.001893	35.75	69.7	-33.95	-0.94965	-0.001798	-0.3595894	0.0036912	0.184561
75	8.74E-05	24.873236	0.087382	0.001748	33	75.7	-42.7	-1.293939	-0.002261	-0.4522671	0.004009	0.2004486

Run D - Wash 4												
300	0.003863	1099.5872	3.862945	0.077259	890.85	893	-2.15	-0.002413	-0.000186	-0.0372917	0.0774454	3.8722677
150	0.000383	109.01279	0.382971	0.007659	70.4	148.6	-78.2	-1.110795	-0.008508	-1.7016112	0.0161675	0.8083741
100, #1	6.49E-05	18.460303	0.064853	0.001297	41.45	95.7	-54.25	-1.308806	-0.001698	-0.339518	0.0029946	0.1497321
100, #2	0.000262	74.504259	0.26174	0.005235	76.1	178.5	-102.4	-1.345598	-0.007044	-1.4087866	0.0122787	0.6139365
75	9.23E-05	26.267644	0.092281	0.001846	34.85	78.3	-43.45	-1.246772	-0.002301	-0.4602109	0.0041467	0.2073332
75	0.0001	28.528848	0.100224	0.002004	37.85	79.8	-41.95	-1.108322	-0.002222	-0.4443233	0.0042261	0.2113051
Run E - Wash 5												
300	0.001936	551.1205	1.936134	0.038723	446.5	549.2	-102.7	-0.230011	-0.008907	-1.7813299	0.0476293	2.3814663
150	0.000404	115.05185	0.404187	0.008084	74.3	176.9	-102.6	-1.380888	-0.011163	-2.2325487	0.0192465	0.9623242
100, #1	7.49E-05	21.310627	0.074866	0.001497	47.85	108.1	-60.25	-1.259143	-0.001885	-0.3770684	0.0033827	0.1691332
100, #2	0.000307	87.378517	0.306968	0.006139	89.25	196	-106.75	-1.196078	-0.007343	-1.4686325	0.0134825	0.6741264
75	0.000104	29.508702	0.103667	0.002073	39.15	89	-49.85	-1.273308	-0.00264	-0.527998	0.0047133	0.2356661
75	0.000106	30.074003	0.105653	0.002113	39.9	87.8	-47.9	-1.200501	-0.002537	-0.5073442	0.0046498	0.2324886

FIG43.XLS

Wash 1	mmol/L	Desorbed mmol/L	mmol desorbed	mmol sorbed	mmol/kg
300	26.60981	-3.734158248	-0.074683165	1.110924545	222.18491
150	0.613081	0.090302895	0.001806058	1.102282838	220.45657
100 o	0.101855	0.059532998	0.00119066	0.747116444	149.42329
100 n	0.304389	0.170595249	0.003411905	0.741236357	148.24727
75	0.152256	0.071759012	0.00143518	0.557744932	111.54899
75	0.144577	0.063020829	0.001260417	0.557877329	111.57547
200	10.44463	2.854693052	0.057093861	1.139308626	227.86173
Run B- Wash 2					
300	15.35421	2.049309862	0.040986197	1.069938348	213.98767
150	0.737111	0.430570734	0.008611415	1.093671423	218.73428
100 o	0.106549	0.055621501	0.00111243	0.746004014	149.2008
100 n	0.386935	0.234740438	0.004694809	0.736541548	147.30831
75	0.189327	0.113199179	0.002263984	0.555480948	111.09619
75	0.174764	0.102475046	0.002049501	0.555827828	111.16557
200	7.244621	2.022305567	0.040446111	1.098862515	219.7725
Run C - Wash 3					
300	7.72589	0.048782768	0.000975655	1.068962693	213.79254
150	0.765943	0.39738714	0.007947743	1.08572368	217.14474
100 o	0.129705	0.076430669	0.001528613	0.7444754	148.89508
100 n	0.52348	0.330012382	0.006600248	0.729941301	145.98826
75	0.184561	0.08989736	0.001797947	0.553683001	110.7366
75	0.200449	0.113066782	0.002261336	0.553566492	110.7133
Run D - Wash 4					
300	3.872268	0.009322929	0.000186459	1.068776234	213.75525
150	0.808374	0.425402797	0.008508056	1.077215624	215.44312
100 o	0.149732	0.084879505	0.00169759	0.74277781	148.55556
100 n	0.613937	0.352196643	0.007043933	0.722897368	144.57947
75	0.207333	0.115052733	0.002301055	0.551381947	110.27639
75	0.211305	0.111080832	0.002221617	0.551344876	110.26898

FIG43.XLS

Run E - Wash 5					
300	2.381466	0.445332465	0.008906649	1.059869585	211.97392
150	0.962324	0.558137173	0.011162743	1.066052881	213.21058
100 o	0.169133	0.0942671	0.001885342	0.740892468	148.17849
100 n	0.674126	0.367158122	0.007343162	0.715554205	143.11084
75	0.235666	0.13199951	0.00263999	0.548741956	109.74839
	0.232489	0.126836039	0.002536721	0.548808155	109.76163

Appendix A.4: Particle Size Data

This Appendix contains a spreadsheet of particle size data for treated and untreated zeolite. The masses are entered in grams. The % Retained data are calculated from the mass for a particular mesh or particle size divided by the total mass.

Untreated Zeolite

Mesh#	Particle Size(mm)	#1 Mass	#2 Mass	#3 Mass	#4 Mass	#5 Mass
20	0.84	294.3	394.2	351.2	321.2	323.3
30	0.58	256.2	240.7	490.4	243	258.6
40	0.43	302.4	239.7	37	294.9	278.9
<40	<0.43	70.2	53.1	52.6	69.7	65.8
Total Mass		923.1	927.7	931.2	928.8	926.6

		#1 %Ret	#2 %Ret	#3 %Ret	#4 %Ret	#5 %Ret	**Average % Retained**
20	0.84	31.8817	42.49218	37.71478	34.58226	34.891	**36.31238**
30	0.58	27.75431	25.94589	52.66323	26.16279	27.90848	**32.08694**
40	0.43	32.75918	25.83809	3.973368	31.75065	30.09929	**24.88412**
<40	<0.43	7.60481	5.723833	5.648625	7.504307	7.10123	**6.716561**

Treated Zeolite

Mesh#	Particle Size(mm)	#1 Mass	#2 Mass	#3 Mass
20	0.84	270.2	194.7	208.1
30	0.58	143.6	150.8	140
40	0.43	147.2	171	181.1
<40	<0.43	374.5	438.2	419.4
Total Mass		935.5	954.7	948.6

		#1 %Ret	#2 %Ret	#3 %Ret	**Average % Retained**
20	0.84	28.88295	20.39384	21.93759	**23.73813**
30	0.58	15.35008	15.79554	14.75859	**15.3014**
40	0.43	15.7349	17.91139	19.09129	**17.57919**
<40	<0.43	40.03207	45.89924	44.21252	**43.38128**
					100

Mesh#	Particle Size(mm)	#1 Mass	#2 Mass	#3 Mass	#4 Mass
40	0.43	578.9	542.7	610.5	636.7
100	0.15	204.8	198.7	197.7	190
140	0.104	55.9	65.9	64	57
<140	< 0.104	96.1	131.2	107.5	101.7
Total Mass		935.7	938.5	979.7	985.4

		#1 %Ret	#2 %Ret	#3 %Ret	#4 %Ret	**Average % Retained**
40	0.43	61.86812	57.82632	62.31499	61.95454	**60.99099**
100	0.15	21.88736	21.17208	20.17965	20.06292	**20.8255**
140	0.104	5.974137	7.021843	6.532612	6.494824	**6.505854**
<140	< 0.104	10.27039	13.97975	10.97275	10.90928	**11.53304**

Appendix A.5: PCE Sorption Isotherm Data

Gas Chromatography Data

Data compiled for analysis of PCE sorption samples by gas chromatography are included in the following spreadsheet. The Average Area column uses the formula Average(ColB:ColD) to calculate the average of two or three different runs of a sample or standard. The Conc(ppm) column uses the following formula to convert average area to a concentration, based on the 200 ppm standard with area = 93642.1:

Col F = Col E * 200 ppm/93642.1 = Col E * 0.0021358.

The amount sorbed figure in the last two rows is calculated by subtracting the sample concentrations in ppm from the blank (initial solution) concentrations; so the 50 ppm sample concentration is subtracted from the 50 ppm blank concentration, or 43.04 - 10.36 = 32.69. The % Sorbed figure, then is the Amount Sorbed divided by the blank concentration. For example, for the 50 ppm sample, % Sorbed = 32.69/43.04 (x100).

GC PCE Sorption Data

xperiment 3

C Data	**Area 1**	**Area 2**	**Area 3**	**Average Area**	**Conc (ppm)**
atd PCE Std	100983.5	105877.8	102956.8	103272.7	220.569
00 ppm Std	90901.8	96382.4		93642.1	200
00 ppm Blank	87201.2	82249.1	91980.6	87143.63333	**186.1206**
50 ppm Blank	77963.5	78584.6		78274.05	167.177
20 ppm Blank	47639.7	45873.1	43058.8	45523.86667	97.22949
00 ppm Blank	44387.2	45801	46671.8	45620	97.43481
5 ppm Blank	23963.4	24861.8	25152.4	24659.2	52.66691
0 ppm Blank	19979.2	20776.8	19709.1	20155.03333	**43.04695**
0 ppm Sampl	4991.9	4706.7		4849.3	**10.35709**
314-200-2	21563.9	21151.1		21357.5	**45.61517**

onc	**Amt Sorb (ppm)**	**% Sorbed**
200	140.5054602	0.754916
50	32.68985495	0.7594

cintillation Data for this experiment show 74.70% sorbed for the 200 ppm initial solution
nd about 73% sorbed for the 50 ppm samples.

PCE Sorption Spreadsheet Calculations

The following spreadsheet contains liquid scintillation data from analysis of PCE sorption samples. Columns D through F contain cpm/ml data entered from liquid scintillation counter data sheets. Column A contains the sample or blank number. The first row of each data set contains the count data for a 5 microliter aliquot of spike material. This spike is our standard for comparison with initial solution counts. Also, the data in Columns L and M are averages of the replicates for each concentration. The following calculations are used for the remaining columns:

Col B = (Init cpm/ml ÷ Spike cpm) * 5 µL * 1.623 mg/µL = (Col E / Spike cpm) * 8.115 [mg/ml];

Col C = Init mg/ml * 10 ml = Col B * 10 [mg];

Col G = 1 - (Eq soln cpm/Init cpm) = 1 - (F/E);

Col H = (1 - Fraction Sorbed) * Init mg = (1 - Col G) * Col C [mg];

Col I = (Eq Soln Amt (mg) * 1000 ml/L) / 10 ml = Col H * 100 [mg/L];

Col J = Fraction Sorbed * Init mg = Col G * Col C [mg];

Col K = Amt Sorbed / 0.0025 kg zeolite = Col J / 0.0025 [mg/kg].

PCE Sorption Isotherm Data

	A	B	C	D	E	F	G	H	I	J	K	L	M
1						Bckgd.	Lambda	mmol	mg				
2	Counted Spike-5 microL			178388	178349.4	45.1	2.3E-10	1.3E-06	8.12E+00				
3	**Sample#**	**Init mg/ml**	**Init mg**	**Init cpm**	**w/o Bckgd**	**Eq cpm**	**% Srbd**	**Equl Soln Conc.**		**Amt Sorbed**		**Averaged Values**	
4	**119-150-S**	**0.0993824**	**0.99382**	**2222.8**	**2184.2**			**mg**	**mg/L**	**mg**	**mg/kg**	**mg/L**	**mg/kg**
5	119-150-1	0.1004971	**1.00497**	2247.3	2208.7	432.9	0.804	0.19697	19.6972	0.808	323.1997	19.27708	324.8802
6	119-150-2	0.1004971	**1.00497**	2247.3	2208.7	453.5	0.79468	0.20635	20.63451	0.7986	319.4504		
7	119-150-3	0.1004971	**1.00497**	2247.3	2208.7	384.6	0.82587	0.175	17.49952	0.83	331.9904		
8	**119-120-S**	**0.0894314**	**0.89431**	**2004.1**	**1965.5**								
9	119-120-1	0.0885487	0.88549	1984.7	1946.1	433.3	0.77735	0.19715	19.7154	0.6883	275.3331	17.38122	284.6698
10	119-120-2	0.0885487	0.88549	1984.7	1946.1	428.5	0.77982	0.19497	19.497	0.6905	276.2067		
11	119-120-3	0.0885487	0.88549	1984.7	1946.1	284.2	0.85396	0.12931	12.93126	0.7562	302.4696		
12	**119-100-S**	**0.0631138**	**0.63114**	**1425.7**	**1387.1**								
13	119-100-1	0.0648611	0.64861	1464.1	1425.5	293.8	0.7939	0.13368	13.36807	0.5149	205.972	13.10265	207.0337
14	119-100-2	0.0648611	0.64861	1464.1	1425.5	312.5	0.78078	0.14219	14.21893	0.5064	202.5686		
15	119-100-3	0.0648611	0.64861	1464.1	1425.5	257.6	0.81929	0.11721	11.72095	0.5314	212.5605		
16	**119-75-S**	**0.0499869**	**0.49987**	**1137.2**	**1098.6**								
17	119-75-1	0.050037	0.50037	1138.3	1099.7	252.2	0.77066	0.11475	11.47524	0.3856	154.2469	11.31296	154.8961
18	119-75-2	0.050037	0.50037	1138.3	1099.7	251.6	0.77121	0.11448	11.44794	0.3859	154.3561		
19	119-75-3	0.050037	0.50037	1138.3	1099.7	242.1	0.77985	0.11016	11.01569	0.3902	156.0852		
20	**119-50-S**	**0.0428388**	**0.42839**	**980.1**	**941.5**								
21	119-50-1	0.0428752	0.42875	980.9	942.3	234.5	0.75114	0.1067	10.66988	0.3221	128.8212	9.703756	132.6857
22	119-50-2	0.0428752	0.42875	980.9	942.3	238.5	0.7469	0.10852	10.85189	0.3202	128.0932		
23	119-50-3	0.0428752	0.42875	980.9	942.3	166.8	0.82299	0.07589	7.589496	0.3529	141.1428		
24													
25	Experiment 2 - 2/19				Init	Final							
26	Counted Spike-5 microL			170362	170316.8	45.1	2.3E-10	1.2E-06	2.03E-04				
27	**219-200-S**	**0.100334**	**1.00334**	**2151**	**2105.8**			mg	mg/L	mg			
28	219-200-1	0.100334	1.00334	2151	2105.8	441.2	0.79048	0.21022	21.02164	0.7931	317.2495	20.53803	319.1839
29	219-200-2	0.100334	1.00334	2151	2105.8	420.9	0.80012	0.20054	20.05441	0.8028	321.1184		
30	**219-150-S**	**0.1125696**	**1.1257**	**2407.8**	**2362.6**								
31	219-150-1	0.1125696	1.1257	2407.8	2362.6	428	0.81884	0.20393	20.3927	0.9218	368.7077	19.47074	372.3955
32	219-150-2	0.1125696	1.1257	2407.8	2362.6	389.3	0.83522	0.18549	18.54878	0.9402	376.0834		
33	**219-120-S**	**0.0965604**	**0.9656**	**2065.2**	**2026.6**								
34	219-120-1	0.0965604	0.9656	2065.2	2026.6	355.7	0.82448	0.16948	16.94786	0.7961	318.4502	16.25222	321.2327
35	219-120-2	0.0965604	0.9656	2065.2	2026.6	326.5	0.83889	0.15557	15.55658	0.81	324.0153		
36	**219-100-S**	**0.0820806**	**0.82081**	**1761.3**	**1722.7**								

PCE Sorption Isotherm Data

	A	B	C	D	E	F	G	H	I	J	K	L	M
3	**Sample#**	**Init mg/ml**	**Init mg**	**Init cpm**	**w/o Bckgd**	**Eq cpm**	**% Srbd**	**Equl Soln Conc.**		**Amt Sorbed**		**Averaged Values**	
37	219-100-1	0.0820806	0.82081	1761.3	1722.7	336.7	0.80455	0.16043	16.04258	0.6604	264.1522	16.04258	264.1522
38	**219-75-S**	**0.0711172**	**0.71117**	**1531.2**	**1492.6**								
39	219-75-1	0.0711172	0.71117	1531.2	1492.6	265.5	0.82212	0.1265	12.65015	0.5847	233.8681	12.57629	234.1635
40	219-75-2	0.0711172	0.71117	1531.2	1492.6	262.4	0.8242	0.12502	12.50244	0.5861	234.4589		
41	**219-50-S**	**0.0465602**	**0.4656**	**1015.8**	**977.2**								
42	219-50-1	0.0465602	0.4656	1015.8	977.2	195.5	0.79994	0.09315	9.314891	0.3725	148.9811	9.019483	150.1627
43	219-50-2	0.0465602	0.4656	1015.8	977.2	183.1	0.81263	0.08724	8.724075	0.3784	151.3444		
44													
45	Counted Spike-5 microL			161834	161789.3	45.1	2.3E-10	1.2E-06	1.93E-04				
46	**314-200-S**	**0.1383503**	**1.3835**	**2802.5**	**2758.3**			mg	mg/L	mg			
47	314-200-1	0.1383503	1.3835	2802.5	2758.3	660.5	0.76054	0.33129	33.12925	1.0522	420.8844	34.0672	417.1326
48	314-200-2	0.1383503	1.3835	2802.5	2758.3	697.9	0.74698	0.35005	35.00515	1.0335	413.3808		
49	**314-150-S**	**0.1114708**	**1.11471**	**2266.6**	**2222.4**								
50	314-150-1	0.1114708	1.11471	2266.6	2222.4	631.4	0.71589	0.3167	31.66965	0.798	319.2044	30.44079	324.1199
51	314-150-2	0.1114708	1.11471	2266.6	2222.4	582.4	0.73794	0.29212	29.21192	0.8226	329.0354		
52	**314-120-S**	**0.0880621**	**0.88062**	**1799.9**	**1755.7**								
53	314-120-1	0.0880621	0.88062	1799.9	1755.7	443.5	0.74739	0.22245	22.245	0.6582	263.2684	22.60864	261.8138
54	314-120-2	0.0880621	0.88062	1799.9	1755.7	458	0.73914	0.22972	22.97229	0.6509	260.3593		
55	**314-100-S**	**0.0820983**	**0.82098**	**1681**	**1636.8**								
56	314-100-1	0.0820983	0.82098	1681	1636.8	366.8	0.7759	0.18398	18.39789	0.637	254.8018	18.80417	253.1767
57	314-100-2	0.0820983	0.82098	1681	1636.8	383	0.76601	0.1921	19.21045	0.6289	251.5515		
58	**314-75-S**	**0.0446405**	**0.4464**	**934.2**	**890**								
59	314-75-1	0.0446405	0.4464	934.2	890	214.9	0.75854	0.10779	10.77892	0.3386	135.4462	10.26229	137.5127
60	314-75-2	0.0446405	0.4464	934.2	890	194.3	0.78169	0.09746	9.745666	0.3489	139.5792		
61	**314-50-S**	**0.0325825**	**0.32583**	**693.8**	**649.6**								
62	314-50-1	0.0325825	0.32583	693.8	649.6	179.1	0.72429	0.08983	8.983267	0.236	94.39703	8.755049	95.30991
63	314-50-2	0.0325825	0.32583	693.8	649.6	170	0.7383	0.08527	8.526831	0.2406	96.22278		
64													
65													
66													
67	**ORNL Synthetic Water**												
68	Counted Spike-5 microL			167460	167416.1	45.1	2.3E-10	1.2E-06	2.00E-04				
69	**329-200-1-**	**0.1166964**	**1.16696**	**2451.4**	**2407.5**			mg	mg/L	mg	mg/kg		
70	329-200-1-	0.1166964	1.16696	2451.4	2407.5	581.2	0.75859	0.28172	28.17195	0.8852	354.098	32.64234	344.1386
71	329-200-1-	0.1166964	1.16696	2451.4	2407.5	566.2	0.76482	0.27445	27.44487	0.8925	357.0063		

PCE Sorption Isotherm Data

	A	B	C	D	E	F	G	H	I	J	K	L	M
3	Sample#	Init mg/ml	Init mg	Init cpm	w/o Bckgd	Eq cpm	% Srbd	Equl Soln Conc.		Amt Sorbed		Averaged Values	
72	329-200-1-	0.1166964	1.16696	2451.4	2407.5	942.6	0.63743	0.4231	42.3102	0.8033	321.3115		
73	**329-200-2-**	**0.1260176**	**1.26018**	**2643.7**	**2599.8**								
74	329-200-2-	0.1260176	1.26018	2643.7	2599.8	686.5	0.73594	0.33276	33.27606	0.9274	370.9662	30.67472	381.3716
75	329-200-2-	0.1260176	1.26018	2643.7	2599.8	625.5	0.7594	0.30319	30.31926	0.957	382.7934		
76	329-200-2-	0.1260176	1.26018	2643.7	2599.8	586.5	0.77441	0.28429	28.42885	0.9759	390.355		
77	**329-150-1-**	**0.0882724**	**0.88272**	**1865**	**1821.1**								
78	329-150-1-	0.0882724	0.88272	1865	1821.1	495	0.72819	0.23994	23.99366	0.6428	257.1151	21.64923	266.4928
79	329-150-1-	0.0882724	0.88272	1865	1821.1	439.4	0.75872	0.21299	21.29861	0.6697	267.8953		
80	329-150-1-	0.0882724	0.88272	1865	1821.1	405.5	0.77733	0.19655	19.65541	0.6862	274.4681		
81	329-150-2-	0.1109477	1.10948	2332.8	2288.9								
82	329-150-2-	0.1109477	1.10948	2332.8	2288.9	549.4	0.75997	0.26631	26.63054	0.8432	337.2685	25.08428	343.4535
83	329-150-2-	0.1109477	1.10948	2332.8	2288.9	551.3	0.75914	0.26723	26.72264	0.8423	336.9001		
84	329-150-2-	0.1109477	1.10948	2332.8	2288.9	451.8	0.80261	0.219	21.89967	0.8905	356.1919		
85	**329-120-1-**	**0.0848842**	**0.84884**	**1795.1**	1751.2								
86	329-120-1-	0.0848842	0.84884	1795.1	1751.2	403.5	0.76959	0.19558	19.55847	0.6533	261.3031	18.67951	264.8189
87	329-120-1-	0.0848842	0.84884	1795.1	1751.2	396.3	0.7737	0.19209	19.20947	0.6567	262.6991		
88	329-120-1-	0.0848842	0.84884	1795.1	1751.2	356.3	0.79654	0.17271	17.27059	0.6761	270.4546		
89	**329-120-2-**	**0.1021694**	**1.02169**	**2151.7**	**2107.8**								
90	329-120-2-	0.1021694	1.02169	2151.7	2107.8	485	0.7699	0.23509	23.50894	0.7866	314.6417	23.13894	316.1217
91	329-120-2-	0.1021694	1.02169	2151.7	2107.8	475.9	0.77422	0.23068	23.06784	0.791	316.4061		
92	329-120-2-	0.1021694	1.02169	2151.7	2107.8	471.2	0.77645	0.2284	22.84003	0.7933	317.3174		
93	**329-120-4-**	**0.104782**	**1.04782**	**2205.6**	**2161.7**								
94	329-120-4-	0.104782	1.04782	2205.6	2161.7	493	0.77194	0.23897	23.89672	0.8089	323.5412	22.26644	330.0623
95	329-120-4-	0.104782	1.04782	2205.6	2161.7	446.8	0.79331	0.21657	21.65731	0.8312	332.4988		
96	329-120-4-	0.104782	1.04782	2205.6	2161.7	438.3	0.79724	0.21245	21.2453	0.8354	334.1469		
97	**329-75-1-S**	**0.0661207**	**0.66121**	**1408**	**1364.1**								
98	329-75-1-1	0.0661207	0.66121	1408	1364.1	313.8	0.76996	0.15211	15.21053	0.5091	203.6407	14.56827	206.2098
99	329-75-1-2	0.0661207	0.66121	1408	1364.1	287.3	0.78938	0.13926	13.92602	0.5219	208.7788		
100	**329-75-2-S**	**0.0546959**	**0.54696**	**1172.3**	**1128.4**								
101	329-75-2-1	0.0546959	0.54696	1172.3	1128.4	282.3	0.74982	0.13684	13.68366	0.4101	164.0488	12.49771	168.7926
102	329-75-2-2	0.0546959	0.54696	1172.3	1128.4	244.7	0.78314	0.11861	11.86111	0.4283	171.339		
103	329-75-2-.	0.0546959	0.54696	1172.3	1128.4	246.5	0.78155	0.11948	11.94836	0.4275	170.99		
104	**329-60-S**	**0.0391412**	**0.39141**	**851.4**	**807.5**								
105	329-60-1	0.0391412	0.39141	851.4	807.5	175	0.78328	0.08483	8.482607	0.3066	122.6343	8.411515	122.9186
106	329-60-2	0.0391412	0.39141	851.4	807.5	186.1	0.76954	0.09021	9.020647	0.3012	120.4821		

PCE Sorption Isotherm Data

	A	B	C	D	E	F	G	H	I	J	K	L	M
3	**Sample#**	**Init mg/ml**	**Init mg**	**Init cpm**	**w/o Bckgd**	**Eq cpm**	**% Srbd**	**Equl Soln Conc.**		**Amt Sorbed**		**Averaged Values**	
107	329-60-3	0.0391412	0.39141	851.4	807.5	159.5	0.80248	0.07731	7.73129	0.3141	125.6395		
108	**329-50-S**	**0.0512349**	**0.51235**	**1100.9**	**1057**								
109	329-50-1	0.0512349	0.51235	1100.9	1057	238.6	0.77427	0.11565	11.56543	0.3967	158.6781	11.19543	160.1581
110	329-50-2	0.0512349	0.51235	1100.9	1057	231.7	0.78079	0.11231	11.23097	0.4	160.0159		
111	329-50-3	0.0512349	0.51235	1100.9	1057	222.6	0.7894	0.1079	10.78988	0.4045	161.7803		
112													
113													
114	**Elizabeth City Synthetic Water**												
115	Sample#	Init mg/ml	Init mg	Init cpm	w/oBckgd	Final cpm	Fraction	Equl Soln Conc.		Amt Sorbed			
116				Assumed Conc		Bckgd	Lambda	mmol	mg				
117	Counted Spike-5 microL			178388	178349.4	45.1	2.3E-10	1.3E-06	8.12E+00				
118	428-200-S	0.1284527	1.28453	2868.2	2823.1			**mg**	**mg/L**	**mg**	**mg/kg**		
119	428-200-1	0.1284527	1.28453	2868.2	2823.1	872	0.69112	0.39677	39.6765	0.8878	355.1047	34.25587	376.7872
120	428-200-2	0.1284527	1.28453	2868.2	2823.1	713.5	0.74726	0.32465	32.46466	0.9599	383.952		
121	428-200-3	0.1284527	1.28453	2868.2	2823.1	673.1	0.76157	0.30626	30.62644	0.9783	391.3049		
122	428-150-S	0.0926847	0.92685	2082.1	2037								
123	428-150-1	0.0926847	0.92685	2082.1	2037	615.1	0.69804	0.27987	27.9874	0.647	258.7891	25.68962	267.9802
124	428-150-2	0.0926847	0.92685	2082.1	2037	553.1	0.72847	0.25166	25.16637	0.6752	270.0732		
125	428-150-3	0.0926847	0.92685	2082.1	2037	525.6	0.74197	0.23915	23.9151	0.6877	275.0783		
126	428-120-S	0.0849314	0.84931	1911.7	1866.6								
127	428-120-1	0.0849314	0.84931	1911.7	1866.6	512.3	0.72554	0.2331	23.30994	0.6162	246.4857	23.03694	247.5777
128	428-120-2	0.0849314	0.84931	1911.7	1866.6	510.2	0.72667	0.23214	23.21439	0.6172	246.8679		
129	428-120-3	0.0849314	0.84931	1911.7	1866.6	496.4	0.73406	0.22586	22.58648	0.6234	249.3795		
130	428-100-S	0.0663808	0.66381	1504	1458.9								
131	428-100-1	0.0663808	0.66381	1504	1458.9	492.4	0.66249	0.22404	22.40448	0.4398	175.9052	21.0971	181.1348
132	428-100-2	0.0663808	0.66381	1504	1458.9	454.7	0.68833	0.20689	20.68911	0.4569	182.7667		
133	428-100-3	0.0663808	0.66381	1504	1458.9	443.9	0.69573	0.20198	20.1977	0.4618	184.7323		
134	428-75-S	0.0618808	0.61881	1405.1	1360								
135	428-75-1	0.0618808	0.61881	1405.1	1360	387.7	0.71493	0.17641	17.64057	0.4424	176.9608	15.82965	184.2045
136	428-75-2	0.0618808	0.61881	1405.1	1360	358.7	0.73625	0.16321	16.32106	0.4556	182.2389		
137	428-75-3	0.0618808	0.61881	1405.1	1360	297.3	0.7814	0.13527	13.52732	0.4835	193.4138		
138	428-50-S	0.0432346	0.43235	995.3	950.2								
139	428-50-1	0.0432346	0.43235	995.3	950.2	262.9	0.72332	0.11962	11.9621	0.3127	125.0902	11.5617	126.6918
140	428-50-2	0.0432346	0.43235	995.3	950.2	259.9	0.72648	0.11826	11.8256	0.3141	125.6362		
141	428-50-3	0.0432346	0.43235	995.3	950.2	239.5	0.74795	0.10897	10.89739	0.3234	129.349		

PCE Sorption Isotherm Data

	A	B	C	D	E	F	G	H	I	J	K	L	M
3	**Sample#**	**Init mg/ml**	**Init mg**	**Init cpm**	**w/o Bckgd**	**Eq cpm**	**% Srbd**	**Equl Soln Conc.**		**Amt Sorbed**		**Averaged Values**	
142													
143	Reanalysis of Second Water w/ Std												
144	Sample#	Init mg/ml	Init mg	Init cpm	w/oBckgd	Final cpm	Fraction	Equl Soln Conc.		Amt Sorbed			
145				Assumed Conc		Bckgd	Lambda	mmol	mg				
146	Counted Spike-5 microL			167252	167212	40	2.3E-10	1.2E-06	8.12E+00				
147	428-200-S	0.1367221	1.36722	2857.2	2817.2			**mg**	**mg/L**	**mg**	**mg/kg**		
148	428-200-1	0.1367221	1.36722	2857.2	2817.2	890.1	0.68405	0.43198	43.19763	0.9352	374.0979	37.28976	397.7294
149	428-200-2	0.1367221	1.36722	2857.2	2817.2	735.1	0.73907	0.35675	35.67529	1.0105	404.1873		
150	428-200-3	0.1367221	1.36722	2857.2	2817.2	679.9	0.75866	0.32996	32.99637	1.0373	414.903		
151	428-150-S	0.098135	0.98135	2062.1	2022.1								
152	428-150-1	0.098135	0.98135	2062.1	2022.1	584.7	0.71085	0.28376	28.3762	0.6976	279.035	27.52528	282.4387
153	428-150-2	0.098135	0.98135	2062.1	2022.1	575.2	0.71554	0.27915	27.91515	0.7022	280.8792		
154	428-150-3	0.098135	0.98135	2062.1	2022.1	541.6	0.73216	0.26285	26.2845	0.7185	287.4018		
155	428-120-S	0.0900011	0.90001	1894.5	1854.5								
156	428-120-1	0.0900011	0.90001	1894.5	1854.5	533.1	0.71254	0.25872	25.87199	0.6413	256.5165	25.32358	258.7102
157	428-120-2	0.0900011	0.90001	1894.5	1854.5	520.5	0.71933	0.2526	25.26049	0.6474	258.9625		
158	428-120-3	0.0900011	0.90001	1894.5	1854.5	511.8	0.72402	0.24838	24.83827	0.6516	260.6514		
159	428-100-S	0.0711322	0.71132	1505.7	1465.7								
160	428-100-1	0.0711322	0.71132	1505.7	1465.7	496.6	0.66119	0.24101	24.1006	0.4703	188.1264	22.8679	193.0571
161	428-100-2	0.0711322	0.71132	1505.7	1465.7	466	0.68206	0.22616	22.61554	0.4852	194.0666		
162	428-100-3	0.0711322	0.71132	1505.7	1465.7	451	0.6923	0.21888	21.88757	0.4924	196.9785		
163	428-75-S	0.0657986	0.65799	1395.8	1355.8								
164	428-75-1	0.0657986	0.65799	1395.8	1355.8	404.9	0.70136	0.1965	19.65029	0.4615	184.5933	17.7511	192.19
165	428-75-2	0.0657986	0.65799	1395.8	1355.8	381.1	0.71891	0.18495	18.49524	0.473	189.2135		
166	428-75-3	0.0657986	0.65799	1395.8	1355.8	311.3	0.77039	0.15108	15.10776	0.5069	202.7634		
167	428-50-S	0.0459736	0.45974	987.3	947.3								
168	428-50-1	0.0459736	0.45974	987.3	947.3	280.3	0.70411	0.13603	13.6033	0.3237	129.4813	12.77665	132.7879
169	428-50-2	0.0459736	0.45974	987.3	947.3	271	0.71392	0.13152	13.15196	0.3282	131.2866		
170	428-50-3	0.0459736	0.45974	987.3	947.3	238.5	0.74823	0.11575	11.57469	0.344	137.5957		

Appendix A.6: Pore Volume Data

This Appendix contains the spreadsheet in which column log data including fill syringe masses are converted to pore volume calculations. Data from Columns A - F were entered directly from the spreadsheet of sample data, Column~1.xls, or from column log sheets maintained during the column experiment. Other spreadsheet calculations are as follows:

Col G = Volume Dispensed = Previous row final mass - Current row initial mass [ml];

Col H = Total Vol = Previous row total vol + Current Row Vol Dispensed = Col (H-1) + Col G [ml];

Col I = Pore Volume = Total Vol / Column Pore Volume = Col H/Pore Volume [unitless];

Col J = Flow Rate = (Vol Disp / (Current time [min] - previous time)) ÷ (24 hr/d * 60 min/hr) [ml/d].

Column 1 Pore Volumes

Column #1			Time							
Date	Hr	Min	Elapsed (d)	Init Mass	Final Mass	Vol Disp.	Total Vol	Pore Vol	Flow Rate	
23	18	4	0	224.94	302.78	0	0	0	0.39ml/min	
23	21	15	0.132638889	221.75	292.25	80.03	80.03	0.368785	0.419005	
24	1	54	0.326388889	228.2	304.82	63.05	143.08	0.659324	0.225986	
24	6	8	0.502777778	227.05	306.16	76.77	219.85	1.013087	0.302244	
24	9	18	0.634722222	230.48	304.52	74.68	294.53	1.357219	0.393053	
24	11	14	0.715277778	262.29	307.12	41.23	335.76	1.54721	0.355431	
24	14	37	0.85625	227.92	306.15	78.2	413.96	1.907562	0.385222	
24	18	2	0.998611111	222.58	297.25	82.57	496.53	2.288051	0.40278	
24	22	5	1.167361111	239.37	304.27	56.88	553.41	2.550159	0.234074	
25	1	24	1.305555556	226.78	297.54	76.49	629.9	2.902631	0.384372	
25	4	24	1.430555556	230.13	299.32	66.41	696.31	3.208654	0.368944	
25	7	31	1.560416667	226.85	304	71.47	767.78	3.537994	0.382193	
25	10	42	1.693055556	233.16	305.42	69.84	837.62	3.859822	0.365654	
25	14	30	1.851388889	238.65	305.74	65.77	903.39	4.162896	0.288465	
25	17	54	1.993055556	225.11	306.06	79.63	983.02	4.529837	0.390343	
25	21	5	2.125694444	228.32	303.3	76.74	1059.76	4.883462	0.40178	
26	0	25	2.264583333	236.37	306.19	65.93	1125.69	5.187272	0.32965	
26	3	27	2.390972222	233.78	307.34	71.41	1197.1	5.516336	0.392363	
26	6	38	2.523611111	229.77	303.78	76.57	1273.67	5.869177	0.40089	
26	9	29	2.642361111	236.92	303.56	65.86	1339.53	6.172665	0.385146	
26	13	4	2.791666667	222.7	303.63	79.86	1419.39	6.540666	0.371442	
26	16	17	2.925694444	231.25	302.94	71.38	1490.77	6.869591	0.369845	
26	19	46	3.070833333	234.75	305.02	67.19	1557.96	7.179208	0.321483	
26	23	31	3.227083333	227.68	303.45	76.34	1634.3	7.530989	0.339289	
27	2	32	3.352777778	233.96	306.73	68.49	1702.79	7.846597	0.378398	
27	5	58	3.495833333	236.23	303.84	69.5	1772.29	8.166859	0.337379	
27	9	10	3.629166667	233.23	305.14	69.61	1841.9	8.487627	0.362552	
27	12	32	3.769444444	243.64	304.67	60.5	1902.4	8.766416	0.299505	
27	15	42	3.901388889	231.75	301.58	71.92	1974.32	9.09783	0.378526	
27	18	53	4.034027778	238.7	304.14	61.88	2036.2	9.382978	0.323979	
27	22	21	4.178472222	229.15	304.16	73.99	2110.19	9.72393	0.355721	
28	1	31	4.310416667	227.38	299.9	75.78	2185.97	10.07313	0.398842	
28	4	29	4.434027778	233.11	301.11	65.79	2251.76	10.3763	0.369607	
28	7	24	4.555555556	234.98	301.03	65.13	2316.89	10.67642	0.372171	
28	10	37	4.689583333	225.63	305.34	74.4	2391.29	11.01926	0.385492	

Column 1 Pore Volumes

Date	Hr	Min	Elapsed (d)	Init Mass	Final Mass	Vol Disp.	Total Vol	Pore Vol	Flow Rate	
28	13	46	4.820833333	246.22	304.43	58.12	2449.41	11.28708	0.307513	
28	15	42	4.901388889	236.48	302.78	66.95	2516.36	11.59559	0.577155	
28	18	52	5.033333333	230.56	307.83	71.22	2587.58	11.92378	0.374842	
28	22	38	5.190277778	226.24	303.51	80.59	2668.17	12.29515	0.356593	
29	2	8	5.336111111	228.94	304.75	73.57	2741.74	12.63416	0.350333	
29	5	16	5.466666667	243.08	307.13	60.67	2802.41	12.91374	0.322713	
29	8	43	5.610416667	249	304.2	57.13	2859.54	13.177	0.27599	
29	11	35	5.729861111	229.26	304.81	73.94	2933.48	13.51772	0.429884	
29	14	53	5.867361111	236.91	303.3	66.9	3000.38	13.826	0.337879	
29	17	27	5.974305556	243.19	297.08	59.11	3059.49	14.09838	0.383831	
29	20	9	6.086805556	235.22	302.49	60.86	3120.35	14.37883	0.375679	
29	23	2	6.206944444	235.31	303.85	66.18	3186.53	14.68379	0.382543	
30	1	31	6.310416667	224.79	300.89	78.06	3264.59	15.0435	0.523893	
30	4	53	6.450694444	229.11	307.23	70.78	3335.37	15.36966	0.350396	
30	7	43	6.56875	224.92	305.15	81.31	3416.68	15.74434	0.478294	
30	10	52	6.7	229.51	303.42	74.64	3491.32	16.08829	0.394921	
30	14	18	6.843055556	234.77	306.98	67.65	3558.97	16.40003	0.328398	
30	17	10	6.9625	226.75	306.04	79.23	3638.2	16.76513	0.46064	
30	20	16	7.091666667	236.31	304.03	68.73	3706.93	17.08184	0.369516	
30	23	8	7.211111111	241.37	298.29	61.66	3768.59	17.36597	0.358488	
31	2	0	7.330555556	223.51	304.3	73.78	3842.37	17.70596	0.428953	
31	5	11	7.463194444	229.17	307.06	74.13	3916.5	18.04756	0.388115	
31	8	30	7.601388889	228.92	305.24	77.14	3993.64	18.40302	0.387638	
31	12	1	7.747916667	223.58	304.94	80.66	4074.3	18.77471	0.382275	
31	15	25	7.889583333	223.59	305.08	80.35	4154.65	19.14497	0.393873	
31	18	35	8.021527778	235.04	305.91	69.04	4223.69	19.46311	0.363368	
31	22	1	8.164583333	222.19	303.22	82.72	4306.41	19.84429	0.401553	
32	1	15	8.299305556	237.32	307.55	64.9	4371.31	20.14336	0.334536	
32	4	24	8.430555556	227.46	305.23	79.09	4450.4	20.50781	0.418466	
32	7	45	8.570138889	225.46	304.03	78.77	4529.17	20.87079	0.391891	
32	10	27	8.682638889	233.55	305.61	69.48	4598.65	21.19096	0.428889	
32	13	34	8.8125	226.08	304.44	78.53	4677.18	21.55283	0.419947	
32	17	35	8.979861111		304.94	82	4759.18	21.93069	0.340249	0.512751
32	20	47	9.113194444	223.73	305.17	80.21	**4839.39**	22.30031	0.41776	
33	0	11	9.254861111	2	82	80	4919.39	22.66896	0.392157	
33	3	4	9.375	13	82	69	4988.39	22.98691	0.398844	

Column 1 Pore Volumes

Date	Hr	Min	Elapsed (d)	Init Mass	Final Mass	Vol Disp.	Total Vol	Pore Vol	Flow Rate	
33	5	56	9.494444444	13	82	69	5057.39	23.30487	0.401163	
33	9	0	9.622222222	8	82	74	5131.39	23.64587	0.402174	
33	11	48	9.738888889	15	82	67	5198.39	23.95461	0.39881	
33	14	58	9.870833333	6	82	76	5274.39	24.30482	0.4	
33	18	18	10.00972222	2	82	80	5354.39	24.67347	0.4	
33	21	37	10.14791667	3	80	79	5433.39	25.03751	0.396985	
34	0	51	10.28263889	3	82	77	5510.39	25.39233	0.396907	
34	4	10	10.42083333	3	82	79	5589.39	25.75637	0.396985	
34	7	30	10.55972222	3	82	79	5668.39	26.12041	0.395	
34	10	35	10.68819444	7.5	82	74.5	5742.89	26.46371	0.402703	
34	13	40	10.81666667	8.5	82	73.5	5816.39	26.80241	0.397297	
34	16	47	10.94652778	7	82	75	5891.39	27.14801	0.40107	
34	20	0	11.08055556	5	82	77	5968.39	27.50283	0.398964	
34	23	14	11.21527778	55	82	27	5995.39	27.62725	0.139175	
35	2	37	11.35625	1	82	81	6076.39	28.00051	0.399015	
35	5	58	11.49583333	2	82	80	6156.39	28.36915	0.39801	
35	9	19	11.63541667	3	82	79	6235.39	28.73319	0.393035	
35	12	41	11.77569444	2	82	80	6315.39	29.10184	0.39604	
35	14	26	11.84861111	41	82	41	6356.39	29.29077	0.390476	
35	17	46	11.9875	2	82	80	6436.39	29.65942	0.4	
35	20	17	12.09236111	22	82	60	6496.39	29.9359	0.397351	
35	23	37	12.23125	3	82	79	6575.39	30.29994	0.395	
36	2	56	12.36944444	4	82	78	6653.39	30.65937	0.39196	
36	4	48	12.44722222	38	82	44	6697.39	30.86213	0.392857	
36	6	55	12.53541667	32	80	50	6747.39	31.09253	0.393701	
36	8	50	12.61527778	34	80	46	6793.39	31.3045	0.4	
36	11	6	12.70972222	27	80	53	6846.39	31.54873	0.389706	
36	13	6	12.79305556	35	80	45	6891.39	31.75609	0.375	
36	16	8	12.91944444	8	81	72	6963.39	32.08788	0.395604	
36	19	18	13.05138889	6	81	75	7038.39	32.43348	0.394737	
36	22	15	13.17430556	10	81	71	7109.39	32.76066	0.40113	
37	1	18	13.30138889	8	81	73	7182.39	33.09705	0.398907	
37	4	30	13.43472222	4	82	77	7259.39	33.45187	0.401042	
37	7	50	13.57361111	2	82	80	7339.39	33.82052	0.4	
37	11	13	13.71458333	1	82	81	7420.39	34.19377	0.399015	
37	13	42	13.81805556	22	82	60	7480.39	34.47025	0.402685	

Column 1 Pore Volumes

Date	Hr	Min	Elapsed (d)	Init Mass	Final Mass	Vol Disp.	Total Vol	Pore Vol	Flow Rate	
37	17	4	13.95833333	1	82	81	7561.39	34.84351	0.40099	
37	19	50	14.07361111	16	81	66	7627.39	35.14764	0.39759	
37	22	45	14.19513889	12	81	69	7696.39	35.4656	0.394286	
38	2	5	14.33402778	1	82	80	7776.39	35.83425	0.4	
38	5	22	14.47083333	4	82	78	7854.39	36.19368	0.395939	
38	8	18	14.59305556	11	82	71	7925.39	36.52085	0.403409	
38	11	4	14.70833333	16	82	66	7991.39	36.82499	0.39759	
38	13	58	14.82916667	12.5	82	69.5	8060.89	37.14525	0.399425	
38	17	37	14.98125	1	82	81	8141.89	37.5185	0.369863	
38	19	4	15.04166667	49	82	33	8174.89	37.67057	0.37931	
38	22	13	15.17291667	7	82	75	8249.89	38.01617	0.396825	
39	5	6	15.45972222	0	82	82	8331.89	38.39404	0.198547	
39	8	19	15.59375	6	82	76	8407.89	38.74425	0.393782	
39	11	29	15.72569444	6	82	76	8483.89	39.09447	0.4	
39	14	33	15.85347222	8	82	74	8557.89	39.43546	0.402174	
39	16	29	15.93402778	37	82	45	8602.89	39.64283	0.387931	
39	19	14	16.04861111	16	82	66	8668.89	39.94696	0.4	
39	22	14	16.17361111	11	82	71	8739.89	40.27413	0.394444	
40	1	35	16.31319444	2	82	80	8819.89	40.64278	0.39801	
40	2	23	16.34652778	63	100	19	8838.89	40.73034	0.395833	ml/min
New Pump			Time (d)	Cycle #	Vol Supplied	Total Vol		Flow Rate		
40	13	30	16.809722	0	0	8838.89	40.730335			
41	1	56	17.327778	860	301	9139.89	42.117368	581.0183		
41	16	10	17.920833	852	298.2	9438.09	43.491498	502.8201		
41	21	27	18.140972	1172	112	9550.09	44.007603	508.7695		
42	1	44	18.319444	1427	89.25	9639.34	44.418875	500.0784		
42	16	39	18.940972	2321	312.9	9952.24	45.860744	503.4367		
43	1	43	19.31875	2865	190.4	10142.64	46.738123	503.9997		
43	17	45	19.986806	3827	336.7	10479.34	48.289664	503.9997		
44	2	24	20.347222	4345	181.3	10660.64	49.125109	503.0298		
44	18	5	21.000694	5287	329.7	10990.34	50.644394	504.5358		
45	1	50	21.323611	5751	162.4	11152.74	51.392747	502.9156		
46	13	45	22.820139	7905	753.9	11906.64	54.86678	503.7661		
47	13	14	23.798611	9317	494.2	12400.84	57.144095	505.0732		
48	14	22	24.845833	10820	526.05	12926.89	59.568177	502.329		
50	11	55	26.74375	13552	956.2	13883.09	63.974425	503.8155		

Column 1 Pore Volumes

Date	Hr	Min	Elapsed (d)	Init Mass	Final Mass	Vol Disp.	Total Vol	Pore Vol	Flow Rate	
52	13	24	28.805556	16519	1038.45	14921.54	68.759688	503.6604	508.2993	
53	14	26	29.848611	18020	525.35	15446.89	71.180545	503.6647	0.352986	
55	14	21	**31.845139**	20896	1006.6	**16453.49**	75.819041	504.1752	**516.6719**	Average

Column 2 Pore Volumes

Column #2			Time						
Date	Hr	Min	Elapsed (d)	Init Mass	Final Mass	Vol Disp.	Total Vol	Pore Vol	Flow Rate
23	18	4	0	225.82	299.25	0	0	0	0.39ml/min
23	21	15	0.132638889	228.74	302.83	80.03	80.03	0.379091	0.419005
24	1	54	0.326388889	229.57	304.22	72.26	152.29	0.721377	0.258996
24	6	8	0.502777778	230.7	305.4	72.52	224.81	1.064895	0.285512
24	9	18	0.634722222	230.84	301.36	73.56	298.37	1.413339	0.387158
24	11	14	0.715277778	259.57	306.64	40.79	339.16	1.606556	0.351638
24	14	37	0.85625	224.76	303.23	80.88	420.04	1.989674	0.398424
24	18	2	0.998611111	231.37	302.35	70.86	490.9	2.325328	0.345659
24	22	5	1.167361111	237.28	303.27	64.07	554.97	2.628819	0.263663
25	1	24	1.305555556	233.09	301.12	69.18	624.15	2.956516	0.347638
25	4	24	1.430555556	227.57	302.32	72.55	696.7	3.300175	0.403056
25	7	31	1.560416667	232.88	306.03	68.44	765.14	3.624366	0.365989
25	10	42	1.693055556	230.14	303.74	74.89	840.03	3.97911	0.392094
25	14	30	1.851388889	225.11	306.06	77.63	917.66	4.346833	0.340482
25	17	54	1.993055556	223.4	310.8	81.66	999.32	4.733646	0.400294
25	21	5	2.125694444	229.74	304.43	80.06	1079.38	5.11288	0.419162
26	0	25	2.264583333	225.5	303.98	77.93	1157.31	5.482024	0.38965
26	3	27	2.390972222	230.39	305.78	72.59	1229.9	5.825873	0.398846
26	6	38	2.523611111	232.67	306.53	72.11	1302.01	6.167448	0.377539
26	9	29	2.642361111	234.06	307.05	71.47	1373.48	6.505992	0.417953
26	13	4	2.791666667	226.54	307.08	79.51	1452.99	6.88262	0.369814
26	16	17	2.925694444	248.24	306.12	57.84	1510.83	7.156601	0.299689
26	19	46	3.070833333	225.67	301.48	79.45	1590.28	7.532945	0.380144
26	23	31	3.227083333	225.93	303.7	74.55	1664.83	7.886078	0.331333
27	2	32	3.352777778	225.45	306.83	77.25	1742.08	8.252001	0.426796
27	5	58	3.495833333	225.67	307.17	80.16	1822.24	8.631709	0.389126
27	9	10	3.629166667	227.73	302.16	78.44	1900.68	9.003268	0.408542
27	12	32	3.769444444	227.63	305.3	73.53	1974.21	9.35157	0.36401
27	15	42	3.901388889	231.04	303.02	73.26	2047.47	9.698593	0.385579
27	18	53	4.034027778	229.18	302.44	72.84	2120.31	10.04363	0.381361
27	22	11	4.171527778	230.24	307.49	71.2	2191.51	10.38089	0.359596
28	1	31	4.310416667	230.79	303.31	75.7	2267.21	10.73947	0.3785
28	4	29	4.434027778	236.88	304.38	65.43	2332.64	11.04941	0.367584
28	7	24	4.555555556	237.85	304.31	65.53	2398.17	11.35981	0.374457
28	10	37	4.689583333	230.75	305.22	72.56	2470.73	11.70352	0.375959

Column 2 Pore Volumes

Date	Hr	Min	Elapsed (d)	Init Mass	Final Mass	Vol Disp.	Total Vol	Pore Vol	Flow Rate		
28	13	46	4.820833333	233.1	305.01	71.12	2541.85	12.04041	0.376296		
28	15	42	4.901388889	261.85	304.02	42.16	2584.01	12.24011	0.363448		
28	18	52	5.033333333	228.16	307.08	74.86	2658.87	12.59471	0.394		
28	22	38	5.190277778	225.57	306.78	80.51	2739.38	12.97608	0.356239		
29	2	8	5.336111111	224.52	303.45	81.26	2820.64	13.361	0.386952		
29	5	16	5.466666667	231.43	304.9	71.02	2891.66	13.69741	0.377766		
29	8	43	5.610416667	227.65	304.54	76.25	2967.91	14.0586	0.368357		
29	11	35	5.729861111	237.33	304.38	66.21	3034.12	14.37222	0.384942		
29	14	53	5.867361111	229.4	305.62	73.98	3108.1	14.72266	0.373636		
29	17	27	5.974305556	245.77	293.72	58.85	3166.95	15.00142	0.382143		
29	20	9	6.086805556	237.02	304.51	55.7	3222.65	15.26526	0.343827		
29	23	2	6.206944444	237.49	306.06	66.02	3288.67	15.57799	0.381618		
30	1	31	6.310416667	248.12	305.92	56.94	3345.61	15.84771	0.382148		
30	4	53	6.450694444	229.31	307.06	75.61	3421.22	16.20586	0.374307		
30	7	43	6.56875	241.91	307.23	64.15	3485.37	16.50973	0.377353		
30	10	52	6.7	232.44	304.68	73.79	3559.16	16.85927	0.390423		
30	14	18	6.843055556	223.9	303.9	79.78	3638.94	17.23717	0.387282		
30	17	10	6.9625	239.17	306.71	63.73	3702.67	17.53906	0.370523		
30	20	16	7.091666667	237.39	302.95	68.32	3770.99	17.86268	0.367312		
30	23	8	7.211111111	236.88	297.77	65.07	3836.06	18.17091	0.378314		
31	2	0	7.330555556	231.42	305.72	65.35	3901.41	18.48046	0.379942		
31	5	11	7.463194444	230.15	306.7	74.57	3975.98	18.83369	0.390419		
31	8	30	7.601388889	228.46	306.7	77.24	4053.22	19.19956	0.388141		
31	12	1	7.747916667	243.15	303.42	62.55	4115.77	19.49586	0.296445		
31	15	25	7.889583333	237.65	306.65	64.77	4180.54	19.80266	0.3175		
31	18	35	8.021527778	230.5	304.47	75.15	4255.69	20.15864	0.395526		
31	22	1	8.164583333	225.02	306.02	78.45	4334.14	20.53024	0.380825		
32	1	15	8.299305556	232.32	306.88	72.7	4406.84	20.87462	0.374742		
32	4	24	8.430555556	234.38	306.72	71.5	4478.34	21.2133	0.378307		
32	7	45	8.570138889	229.65	306.97	76.07	4554.41	21.57363	0.378458		
32	10	27	8.682638889	241.71	301.71	64.26	4618.67	21.87803	0.396667		
32	13	34	8.8125	235.65	304.92	65.06	4683.73	22.18621	0.347914		
32	17	35	8.979861111	224.96	304.02	82	4765.73	22.57463	0.340249	0.51293	
32	20	47	9.113194444	225.9	307.53	77.12	**4842.85**	22.93994	0.401667		
33	0	11	9.254861111	2	82	80	4922.85	23.04166	0.392157		
33	3	4	9.375	13	82	69	4991.85	23.36462	0.398844		

Column 2 Pore Volumes

Date	Hr	Min	Elapsed (d)	Init Mass	Final Mass	Vol Disp.	Total Vol	Pore Vol	Flow Rate		
33	5	56	9.494444444	13	82	69	5060.85	23.68757	0.401163		
33	9	0	9.622222222	8	82	74	5134.85	24.03393	0.402174		
33	11	48	9.738888889	15	82	67	5201.85	24.34753	0.39881		
33	14	58	9.870833333	6	82	76	5277.85	24.70325	0.4		
33	18	18	10.00972222	2	82	80	5357.85	25.0777	0.4		
33	21	37	10.14791667	3	80	79	5436.85	25.44746	0.396985		
34	0	51	10.28263889	3	82	77	5513.85	25.80786	0.396907		
34	4	10	10.42083333	3	82	79	5592.85	26.17763	0.396985		
34	7	30	10.55972222	3	82	79	5671.85	26.54739	0.395		
34	10	35	10.68819444	7.5	82	74.5	5746.35	26.89609	0.402703		
34	13	40	10.81666667	8.5	82	73.5	5819.85	27.24011	0.397297		
34	16	47	10.94652778	7	82	75	5894.85	27.59115	0.40107		
34	20	0	11.08055556	5	82	77	5971.85	27.95156	0.398964		
34	23	14	11.21527778	55	82	27	5998.85	28.07793	0.139175		
35	2	37	11.35625	1	82	81	6079.85	28.45706	0.399015		
35	5	58	11.49583333	2	82	80	6159.85	28.8315	0.39801		
35	9	19	11.63541667	3	82	79	6238.85	29.20126	0.393035		
35	12	41	11.77569444	2	82	80	6318.85	29.57571	0.39604		
35	14	26	11.84861111	41	82	41	6359.85	29.76761	0.390476		
35	17	46	11.9875	2	82	80	6439.85	30.14205	0.4		
35	20	17	12.09236111	22	82	60	6499.85	30.42289	0.397351		
35	23	37	12.23125	3	82	79	6578.85	30.79265	0.395		
36	2	56	12.36944444	4	82	78	6656.85	31.15773	0.39196		
36	4	48	12.44722222	38	82	44	6700.85	31.36368	0.392857		
36	6	55	12.53541667	32	80	50	6750.85	31.59771	0.393701		
36	8	50	12.61527778	34	80	46	6796.85	31.81301	0.4		
36	11	6	12.70972222	27	80	53	6849.85	32.06108	0.389706		
36	13	6	12.79305556	35	80	45	6894.85	32.27171	0.375		
36	16	8	12.91944444	8	81	72	6966.85	32.60871	0.395604		
36	19	18	13.05138889	6	81	75	7041.85	32.95975	0.394737		
36	22	15	13.17430556	10	81	71	7112.85	33.29207	0.40113		
37	1	18	13.30138889	8	81	73	7185.85	33.63375	0.398907		
37	4	30	13.43472222	4	82	77	7262.85	33.99415	0.401042		
37	7	50	13.57361111	2	82	80	7342.85	34.36859	0.4		
37	11	13	13.71458333	1	82	81	7423.85	34.74772	0.399015		
37	13	42	13.81805556	22	82	60	7483.85	35.02855	0.402685		

Column 2 Pore Volumes

Date	Hr	Min	Elapsed (d)	Init Mass	Final Mass	Vol Disp.	Total Vol	Pore Vol	Flow Rate		
37	17	4	13.95833333	1	82	81	7564.85	35.40768	0.40099		
37	19	50	14.07361111	16	81	66	7630.85	35.71659	0.39759		
37	22	45	14.19513889	12	81	69	7699.85	36.03955	0.394286		
38	2	5	14.33402778	1	82	80	7779.85	36.41399	0.4		
38	5	22	14.47083333	4	82	78	7857.85	36.77908	0.395939		
38	8	18	14.59305556	11	82	71	7928.85	37.1114	0.403409		
38	11	4	14.70833333	16	82	66	7994.85	37.42031	0.39759		
38	13	58	14.82916667	12.5	82	69.5	8064.35	37.74561	0.399425		
38	17	37	14.98125	1	82	81	8145.35	38.12474	0.369863		
38	19	4	15.04166667	49	82	33	8178.35	38.27919	0.37931		
38	22	13	15.17291667	7	82	75	8253.35	38.63024	0.396825		
39	5	6	15.45972222	0	82	82	8335.35	39.01404	0.198547		
39	8	19	15.59375	6	82	76	8411.35	39.36976	0.393782		
39	11	29	15.72569444	6	82	76	8487.35	39.72549	0.4		
39	14	33	15.85347222	8	82	74	8561.35	40.07185	0.402174		
39	16	29	15.93402778	37	82	45	8606.35	40.28247	0.387931		
39	19	14	16.04861111	16	82	66	8672.35	40.59139	0.4		
39	22	14	16.17361111	11	82	71	8743.35	40.92371	0.394444		
40	1	35	16.31319444	2	82	80	8823.35	41.29815	0.39801		
40	2	23	16.34652778	63	100	19	8842.35	41.38708	0.395833	ml/min	
New Pump			Time (d)	Cycle #	Vol Supplied	Total Vol		Flow Rate			
40	13	30	16.809722	0	0	8842.35	41.885036				
41	1	56	17.327778	860	301	9143.35	43.310833	581.0183			
41	16	10	17.920833	852	298.2	9441.55	44.723367	502.8201			
41	21	27	18.140972	1172	112	9553.55	45.253896	508.7695			
42	1	44	18.319444	1427	89.25	9642.8	45.676661	500.0784			
42	16	39	18.940972	2321	312.9	9955.7	47.158827	503.4367			
43	1	43	19.31875	2865	190.4	10146.1	48.060727	503.9997			
43	17	45	19.986806	3827	336.7	10482.8	49.65563	503.9997			
44	2	24	20.347222	4345	181.3	10664.1	50.514424	503.0298			
44	18	5	21.000694	5287	329.7	10993.8	52.076169	504.5358			
45	1	50	21.323611	5751	162.4	11156.2	52.845436	502.9156			
46	13	45	22.820139	7905	753.9	11910.1	56.41656	503.7661			
47	13	14	23.798611	9317	494.2	12404.3	58.75752	505.0732			
48	14	22	24.845833	10820	526.05	12930.35	61.249349	502.329			
50	11	55	26.74375	13552	956.2	13886.55	65.778741	503.8155			

Column 2 Pore Volumes

Date	Hr	Min	Elapsed (d)	Init Mass	Final Mass	Vol Disp.	Total Vol	Pore Vol	Flow Rate		
52	13	24	28.805556	16519	1038.45	14925	70.697741	503.6604	508.2993		
53	14	26	29.848611	18020	525.35	15450.35	73.186254	503.6647	0.352986		
55	14	21	**31.845139**	20896	1006.6	**16456.95**	77.954384	504.1752	**516.7806**	Average	ml/d

Column 3 Pore Volumes

COL #3			Time					Total		1pv =	219.1841
Date	Hr	Min	Elapsed (min)	Init Mass	Final Mass	Mass Deliv	FlwRt(ml/min)	Vol Deliv	# Pore Vols		
23	18	19	0	224.69	303.26	0		0	0		
23	21	38	199	225.54	303.09	76.72	0.385527638	76.72	0.350025		
24	1	19	420	224.61	314.44	77.48	0.350588235	154.2	0.703518		
24	5	6	647	228.41	309.1	85.03	0.374581498	239.23	1.091457		
24	8	34	855	230.97	306.74	77.13	0.370817308	316.36	1.443353		
24	11	4	1005	250.32	310.16	55.42	0.369466667	371.78	1.6962		
24	14	31	1212	231.87	312.74	77.29	0.373381643	449.07	2.048826		
24	18	20	1441	226.2	305.58	85.54	0.373537118	534.61	2.439091		
24	21	50	1651	228.59	308	75.99	0.361857143	610.6	2.785786		
25	1	16	1857	230.45	302.52	76.55	0.371601942	687.15	3.135036		
25	4	35	2056	222.37	304.64	79.15	0.397738693	766.3	3.496148		
25	7	41	2242	221.17	310.73	82.47	0.443387097	848.77	3.872407		
25	11	0	2441	228.28	308.04	81.45	0.409296482	930.22	4.244012		
25	14	54	2675	226.12	319.54	80.92	0.345811966	1011.14	4.6132		
25	18	48	2909	229.5	317.6	89.04	0.380512821	1100.18	5.019434		
25	22	27	3128	230.69	311.22	85.91	0.392283105	1186.09	5.411387		
26	2	2	3343	225.1	307.41	85.12	0.395906977	1271.21	5.799737		
26	5	27	3548	232.1	315.45	74.31	0.362487805	1345.52	6.138767		
26	9	8	3769	232.06	312.9	82.39	0.37280543	1427.91	6.514661		
26	13	0	4001	224.5	312.8	87.4	0.376724138	1515.31	6.913412		
26	15	56	4177	246.81	312.69	64.99	0.369261364	1580.3	7.209921		
26	20	0	4421	229.26	308.77	82.43	0.337827869	1662.73	7.585998		
26	23	41	4642	222.18	308.46	85.59	0.387285068	1748.32	7.976491		
27	2	51	4832	234.59	314.31	72.87	0.383526316	1821.19	8.308951		
27	6	24	5045	231.32	310.43	81.99	0.384929577	1903.18	8.683021		
27	9	21	5222	230.69	309.91	78.74	0.444858757	1981.92	9.042262		
27	12	43	5424	223.36	305.14	85.55	0.423514851	2067.47	9.432573		
27	15	52	5613	232.08	307.74	72.06	0.381269841	2139.53	9.761338		
27	19	14	5815	230.76	303.68	75.98	0.376138614	2215.51	10.10799		
27	22	22	6003	NA	313	76	0.404255319	2291.51	10.45473		
28	1	44	6205	236.11	308.1	75.89	0.375693069	2367.4	10.80097		
28	4	40	6381	246.85	312.96	60.25	0.342329545	2427.65	11.07585		
28	7	34	6555	248.84	315.07	63.12	0.362758621	2490.77	11.36383		
28	10	48	6749	229.25	304.43	84.82	0.437216495	2575.59	11.75081		

Column 3 Pore Volumes

Date	Hr	Min	Elapsed (min)	Init Mass	Final Mass	Mass Deliv	FlwRt(ml/min)	Vol Deliv	# Pore Vols		
28	13	52	6933	233.67	304.53	69.76	0.379130435	2645.35	12.06908		
28	19	16	7257	226.61	311.18	76.92	0.237407407	2722.27	12.42002		
28	22	58	7479	224.84	318.81	85.34	0.384414414	2807.61	12.80937		
29	2	20	7681	227.93	319.84	89.88	0.444950495	2897.49	13.21944		
29	5	28	7869	230.38	316.85	88.46	0.470531915	2985.95	13.62302		
29	9	30	8111	225.31	310.99	90.54	0.374132231	3076.49	14.0361		
29	12	48	8309	239.5	312.76	70.49	0.356010101	3146.98	14.3577		
29	16	29	8530	229.71	314.77	82.05	0.371266968	3229.03	14.73205		
29	20	0	8741	236.16	314.74	77.61	0.367819905	3306.64	15.08613		
29	23	17	8938	244.58	315.76	69.16	0.35106599	3375.8	15.40166		
30	3	10	9171	245.66	314.16	69.1	0.296566524	3444.9	15.71693		
30	7	4	9405	228.42	312.58	84.74	0.362136752	3529.64	16.10354		
30	10	37	9618	240.87	313.63	70.71	0.331971831	3600.35	16.42615		
30	14	24	9845	236.29	308.99	76.34	0.336299559	3676.69	16.77444		
30	18	0	10061	NA	308.96	75	0.347222222	3751.69	17.11662		
30	21	8	10249	229.79	311.62	78.17	0.415797872	3829.86	17.47326		
31	1	6	10487	236.44	318.15	74.18	0.311680672	3904.04	17.81169		
31	5	2	10723	232.07	311.33	85.08	0.360508475	3989.12	18.19986		
31	8	54	10955	246.09	313	64.24	0.276896552	4053.36	18.49295	Slow flow due to	
31	12	18	11159	225.01	313.54	86.99	0.426421569	4140.35	18.88983	power outage	
31	15	42	11363	235.63	316.29	76.91	0.377009804	4217.26	19.24072		
31	19	30	11591	232.65	314.17	82.64	0.36245614	4299.9	19.61776		
31	23	22	11823	224.43	311.74	88.74	0.3825	4388.64	20.02262		
32	3	5	12046	229.63	313.53	81.11	0.363721973	4469.75	20.39267		
32	6	58	12279	233.19	309.61	79.34	0.340515021	4549.09	20.75465		
32	10	18	12479	227.5	307.72	81.11	0.40555	4630.2	21.12471		
32	13	46	12687	235.64	308.39	71.08	0.341730769	4701.28	21.449		
32	17	40	12921	222.17	310.24	85.22	0.364188034	4786.5	21.83781		
32	21	26	13147	224.92	319.63	84.32	0.373097345	4870.82	22.22251		
33	1	28	13389	1	95	317.63	1.312520661	5188.45	23.67165	Last syringe with PCE	
33	5	22	13623	5	95	90	0.384615385	5278.45	24.08227		
33	8	57	13838	13	95	82	0.381395349	5360.45	24.45638		
33	11	46	14007	30	95	65	0.384615385	5425.45	24.75294		
33	15	0	14201	19	95	76	0.391752577	5501.45	25.09968		
33	18	32	14413	13	93	82	0.386792453	5583.45	25.47379		
33	22	28	14649	2	90	91	0.38559322	5674.45	25.88897		

Column 3 Pore Volumes

Date	Hr	Min	Elapsed (min)	Init Mass	Final Mass	Mass Deliv	FlwRt(ml/min)	Vol Deliv	# Pore Vols		
38	22	15	21836	21	95	74	0.387434555	8352.95	38.10929		
39	1	58	22059	9	95	86	0.385650224	8438.95	38.50165		
39	5	20	22261	18	95	77	0.381188119	8515.95	38.85296		
39	9	8	22489	7	95	88	0.385964912	8603.95	39.25444		
39	12	56	22717	5	95	90	0.394736842	8693.95	39.66506		
39	16	26	22927	14	95	81	0.385714286	8774.95	40.03461		
39	19	16	23097	29	95	66	0.388235294	8840.95	40.33573		
39	22	16	23277	26	95	69	0.383333333	8909.95	40.65053		
40	2	14	23515	3	95	92	0.386554622	9001.95	41.07027		
40	2	24	23525	91	100	4	0.4	9005.95	41.08852		
40	2	45	23546	100	100	0		9005.95	41.08852	Switching pumps	
40	4	33	23654	58	58	42	0.388888889	9047.95	41.28014		
40	6	29	23770	0	100	58	0.5	9105.95	41.54476		
40	6	39	23780	100	100	0	0	9105.95	41.54476		
40	6	41	23782	95	95	5	2.5	9110.95	41.56757		
40	6	57	23798	89	89	6	0.375	9116.95	41.59494		
40	8	9	23870	66	66	23	0.319444444	9139.95	41.69988	Pump Malfunction	
				Most of the 66 ml were				9205.95			
				dispensed before the							
				syringes were							
				shattered						Total Vol	
40	13	30	24191	0	0	0	0	9205.95	42.00099	9033.33	
41	1	55	24936	860	860	301	0.404026846	9506.95	43.37427		
41	16	10	25791	852	852	298.2	0.34877193	9805.15	44.73477		
41	21	27	26108	1172	1172	112	0.353312303	9917.15	45.24576		
42	1	44	26365	1427	1427	89.25	0.347276265	10006.4	45.65295		
42	16	39	27260	2321	2321	312.9	0.349608939	10319.3	47.08051		
43	1	43	27804	2865	2865	190.4	0.35	10509.7	47.94919		
43	17	45	28766	3827	3827	336.7	0.35	10846.4	49.48534		
44	2	24	**29285**	4345	4345	181.3	0.349325626	**11027.7**	50.3125	11027.7	
							Av Flow Rate	**542.2533**			

Column 4 Pore Volumes

Column #4			Time							
Date	Hr	Min	Elapsed (d)	Init Mass	Final Mass	Vol Disp.	Total	Pore Vol	Flow Rate ml/d	
23	18	19			308.11	0	0	0	0.39ml/min	
23	21	42	0.140972222	228.87	308.37	78.24	78.24	0.390108	555.003	568.8191
24	1	20	0.292361111	226.61	305.62	80.76	159	0.79278	533.4606	
24	5	6	0.449305556	226.51	309.1	78.11	237.11	1.18224	497.692	
24	8	34	0.59375	233.6	304.73	74.5	311.61	1.5537	515.7692	
24	11	9	0.701388889	230.89	309.9	72.84	384.45	1.916883	676.7071	
24	14	31	0.841666667	248.61	310.76	60.29	444.74	2.217491	429.7901	
24	18	20	1.000694444	224.3	305.01	85.46	530.2	2.643598	537.3904	
24	21	53	1.148611111	226	308.53	78.01	608.21	3.032559	527.3915	
25	1	16	1.289583333	231.92	304.29	75.61	683.82	3.409553	536.3468	
25	4	35	1.427777778	228.16	304.72	75.13	758.95	3.784154	543.6543	
25	7	41	1.556944444	232.91	313.9	70.81	829.76	4.137216	548.2065	
25	10	57	1.693055556	236.18	306.47	76.72	906.48	4.519745	563.6571	
25	14	54	1.857638889	221.96	315.75	83.51	989.99	4.936129	507.4025	
25	18	48	2.020138889	231.4	318.1	83.35	1073.34	5.351715	512.9231	
25	22	27	2.172222222	236.12	310.73	80.98	1154.32	5.755485	532.4712	
26	2	2	2.321527778	231.19	310.69	78.54	1232.86	6.147088	526.0353	
26	5	27	2.463888889	232.26	317.44	77.43	1310.29	6.533157	543.8985	
26	9	8	2.617361111	231.89	315.05	84.55	1394.84	6.954727	550.914	
26	13	0	2.778472222	238.05	314.33	76	1470.84	7.333666	471.7241	
26	15	56	2.900694444	225.81	314.26	87.52	1558.36	7.770044	716.0727	
26	20	0	3.070138889	236.15	307.25	77.11	1635.47	8.154517	455.0754	
26	23	41	3.223611111	226.21	309.57	80.04	1715.51	8.5536	521.5276	
27	2	51	3.355555556	238.06	312.04	70.51	1786.02	8.905166	534.3916	
27	6	24	3.503472222	224.82	311.72	86.22	1872.24	9.335062	582.8958	
27	9	21	3.626388889	242.38	308.43	68.34	1940.58	9.675808	555.9864	
27	12	43	3.766666667	233.65	308.16	73.78	2014.36	10.04368	525.9564	
27	15	52	3.897916667	235.42	304.43	71.74	2086.1	10.40138	546.5905	
27	19	14	4.038194444	232.23	304.63	71.2	2157.3	10.75638	507.5644	
27	22	22	4.16875	232.94	314.57	70.69	2227.99	11.10885	541.4553	
28	1	44	4.309027778	237.69	311.69	75.88	2303.87	11.48719	540.9267	
28	4	40	4.43125	248.2	313.39	62.49	2366.36	11.79876	511.2818	
28	7	34	4.552083333	247.24	314.28	65.15	2431.51	12.1236	539.1724	
28	10	48	4.686805556	245.75	306.04	67.53	2499.04	12.46031	501.2536	
28	13	52	4.814583333	235.24	301.82	69.8	2568.84	12.80834	546.2609	

Column 4 Pore Volumes

Date	Hr	Min	Elapsed (d)	Init Mass	Final Mass	Vol Disp.	Total	Pore Vol	Flow Rate ml/d		
28	15	52	4.897916667	234.48	306.68	66.34	2635.18	13.13911	796.08		
28	19	16	5.039583333	229.97	314.2	75.71	2710.89	13.5166	534.4235		
28	22	58	5.19375	230.68	319.63	82.52	2793.41	13.92805	535.2649		
29	2	20	5.334027778	242.12	319.51	76.51	2869.92	14.30953	545.4178		
29	5	28	5.464583333	249.59	319.95	68.92	2938.84	14.65317	527.8979		
29	9	31	5.633333333	225.2	310.62	93.75	3032.59	15.12061	555.5556		
29	12	48	5.770138889	236.1	309.26	73.52	3106.11	15.48719	537.4051		
29	16	28	5.922916667	226.46	308.75	81.8	3187.91	15.89504	535.4182		
29	20	1	6.070833333	232.92	313.47	74.83	3262.74	16.26815	505.893		
29	23	17	6.206944444	241.43	313.2	71.04	3333.78	16.62236	521.9265		
30	3	10	6.36875	225.95	312.73	86.25	3420.03	17.0524	533.0472		
30	7	4	6.53125	223.83	310.08	87.9	3507.93	17.49068	540.9231		
30	10	37	6.679166667	231.82	312.99	77.26	3585.19	17.8759	522.3211		
30	14	25	6.8375	227.38	313.61	84.61	3669.8	18.29777	534.3789		
30	18	0	6.986805556	231.98	309.68	80.63	3750.43	18.69979	540.0335		
30	21	8	7.117361111	237.85	311.24	70.83	3821.26	19.05295	542.5277		
31	1	7	7.283333333	223.52	314.74	86.72	3907.98	19.48534	522.4971		
31	5	2	7.446527778	225.56	307.96	88.18	3996.16	19.92501	540.337		
31	8	54	7.607638889	229.02	315.01	77.94	4074.1	20.31362	483.7655		
31	12	18	7.749305556	237.51	313.93	76.5	4150.6	20.69505	540		
31	15	42	7.890972222	222.24	312.72	90.69	4241.29	21.14724	640.1647		
31	20	0	8.070138889		313.29	311.72	4553.01	22.70149	1739.833		
31	23	22	8.210416667	237.15	314.13	75.14	4628.15	23.07614	535.6515		
32	3	5	8.365277778	229.75	317.38	83.38	4711.53	23.49187	538.4179		
32	6	58	8.527083333	229.25	309.27	87.13	4798.66	23.92631	538.4858		
32	10	18	8.665972222	233.46	310.3	74.81	4873.47	24.29931	538.632		
32	13	46	8.810416667	229.24	309.96	80.06	4953.53	24.69849	554.2615		
32	17	40	8.972916667	222.17	310.24	86.79	5040.32	25.13123	534.0923		
32	21	26	9.129861111	222.21	319.61	87.03	5127.35	25.56517	554.5274		
33	1	30	9.299305556	1	95	317.61	5444.96	27.14878	1874.42		
33	5	22	9.460416667	5	95	90	5534.96	27.59753	558.6207		
33	8	57	9.609722222	13	95	82	5616.96	28.00638	549.2093		
33	11	46	9.727083333	30	95	65	5681.96	28.33047	553.8462		
33	15	0	9.861805556	19	95	76	5757.96	28.70941	564.1237		
33	18	32	10.00902778	13	93	82	5839.96	29.11827	556.9811		
33	22	28	10.17291667	2	90	91	5930.96	29.572	555.2542		

Appendix A.7: Tritium and PCE Sample Data

Sample Column Log

Column Sample Log

Sample ID	Full Syringe Mass (g)	Syringe Mass w/o Sample (g)	Pre-Sample Vial Mass (g)	Vial Mass w/ Sample (g)	Sample Mass (g)	Comments		Initials

PCE and Tritium Sample Data Spreadsheet

The primary spreadsheet of PCE and tritium sample data is provided in the following pages. Raw data in cpm from liquid scintillation counting are entered in Columns 7 and 8 and adjusted for background in Columns 9 and 10. They are then normalized by the sample mass from Column 6 to get activities in cpm/ml for each region. As previously discussed, the counts in Region B are due only to ^{14}C decay, but the counts in Region A come from both ^{14}C and ^{3}H decay. Elapsed time is also calculated in Column 5 from time data embedded in the sample number.

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
14C Std P6					0.000005						
I-623-0500	0			<0		89486.5	8077.1	89457.7	8065.5		
I-623-0530	0			<0		82662.3	6864.9	82633.5	6853.3		
I1-623-1822	0	18	22	0.06	1.11	84708.1	6936	84679.3	6924.4	76287.7	6238.2
I1-623-2108	0	21	8	0.17	1.06	90219.5	7252.9	90190.7	7241.3	85085.6	6831.4
I1-624-0217	1	2	17	0.39	1.03	90344.3	7325.7	90315.5	7314.1	87685.0	7101.1
I1-624-0614	1	6	14	0.55	0.95	82558	6765.4	82529.2	6753.8	86872.8	7109.3
I2-623-1834	0	18	34	0.07	1.01	84266.8	6989	84238	6977.4	83404.0	6908.3
I2-623-2132	0	21	32	0.19	1.07	92370.4	7721	92341.6	7709.4	86300.6	7205.0
I2-624-0212	1	2	12	0.38	0.94	84239.1	6814.7	84210.3	6803.1	89585.4	7237.3
I2-624-0620	1	6	20	0.56	1.05	87428	7171.9	87399.2	7160.3	83237.3	6819.3
I3-623-1849	0	18	49	0.08	1.03	87328.3	7277.1	87299.5	7265.5	84756.8	7053.9
I3-623-2142	0	21	42	0.20	0.99	86261.9	7003.9	86233.1	6992.3	87104.1	7062.9
I3-624-0125	1	1	25	0.35	0.97	82081.4	6651.6	82052.6	6640	84590.3	6845.4
I3-624-0514	1	5	14	0.51	1.13	92130.2	7397.9	92101.4	7386.3	81505.7	6536.5
I4-623-1907	0	19	7	0.09	1.06	91414.7	7757.7	91385.9	7746.1	86213.1	7307.6
I4-623-2152	0	21	52	0.20	1.04	91234.7	7606	91205.9	7594.4	87698.0	7302.3
I4-624-0136	1	1	36	0.36	1	85179.1	7063.6	85150.3	7052	85150.3	7052.0
I4-624-0521	1	5	21	0.51	1.04	89101.7	7336.1	89072.9	7324.5	85647.0	7042.8
O1-623-1917	0	19	17	0.10	0.98	61.8	29	33	17.4	33.7	17.8
O1-623-2035	0	20	35	0.15	1.07	29	11.8	0.2	0.2	0.2	0.2
O1-623-2257	0	22	57	0.25	1.06	34.4	12.8	5.6	1.2	5.3	1.1
O1-624-0222	1	2	22	0.39	1.11	32.5	14.9	3.7	3.3	3.3	3.0
O1-624-0554	1	5	54	0.54	1.09	10244.9	1405.7	10216.1	1394.1	9372.6	1279.0
O2-623-1924	0	19	24	0.10	1.08	39.2	20.3	10.4	8.7	9.6	8.1
O2-623-2042	0	20	42	0.15	0.97	1223.9	11.8	1195.1	0.2	1232.1	0.2
O2-623-2302	0	23	2	0.25	1.09	15781.5	17.5	15752.7	5.9	14452.0	5.4
O2-624-0228	1	2	28	0.39	1	27450.1	27.2	27421.3	15.6	27421.3	15.6
O2-624-0608	1	6	8	0.55	1	45204.3	68.4	45175.5	56.8	45175.5	56.8
O3-623-1931	0	19	31	0.10	1.02	39.3	14	10.5	2.4	10.3	2.4
O3-623-2047	0	20	47	0.16	1.04	32.7	8.7	3.9	-2.9	3.8	-2.8
O3-623-2307	0	23	7	0.25	1.1	30.6	12.2	1.8	0.6	1.6	0.5
O3-624-0150	1	1	50	0.37	0.98	635.9	95	607.1	83.4	619.5	85.1
O3-624-0527	1	5	27	0.52	0.94	39467.8	2940.2	39439	2928.6	41956.4	3115.5
O4-623-1944	0	19	44	0.11	1.05	1668.3	39.7	1639.5	28.1	1561.4	26.8

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O4-623-2058	0	20	58	0.17	0.99	10947.9	46.3	10919.1	34.7	11029.4	35.1
O4-623-2314	0	23	14	0.26	1.05	26756	102.2	26727.2	90.6	25454.5	86.3
O4-624-0207	1	2	7	0.38	0.99	38284.8	167.1	38256	155.5	38642.4	157.1
O4-624-0536	1	5	36	0.53	0.98	54489.7	244.5	54460.9	232.9	55572.3	237.7
I3-624-0836	1	8	36	0.65	0.99	87338.5	7094	87309.7	7082.4	88191.6	7153.9
O4-624-0843	1	8	43	0.65	1.05	59542.1	237	59513.3	225.4	56679.3	214.7
I4-624-0847	1	8	47	0.66	0.99	86815.2	7381.7	86786.4	7370.1	87663.0	7444.5
O3-624-0851	1	8	51	0.66	1	85212.5	6253.8	85183.7	6242.2	85183.7	6242.2
I2-624-0855	1	8	55	0.66	0.99	87276.7	6945.3	87247.9	6933.7	88129.2	7003.7
O2-624-0859	1	8	59	0.67	0.97	55539.8	94.6	55511	83	57227.8	85.6
I1-624-0903	1	9	3	0.67	1.03	88391.7	7269.8	88362.9	7258.2	85789.2	7046.8
O1-624-0906	1	9	6	0.67	1.03	70102.4	5166.1	70073.6	5154.5	68032.6	5004.4
I4-624-1328	1	13	28	0.85	0.62	66039	5279.1	66010.2	5267.5	106468.1	8496.0
I3-624-1334	1	13	34	0.86	1.13	93821.2	7069.2	93792.4	7057.6	83002.1	6245.7
I2-624-1340	1	13	40	0.86	1.04	86681.4	6942.3	86652.6	6930.7	83319.8	6664.1
I1-624-1342	1	13	42	0.86	1.04	87898.2	6847.7	87869.4	6836.1	84489.8	6573.2
O4-624-1349	1	13	49	0.87	1.01	67497	366.3	67468.2	354.7	66800.2	351.2
O3-624-1350	1	13	50	0.87	0.98	83510.3	6427.9	83481.5	6416.3	85185.2	6547.2
O2-624-1352	1	13	52	0.87	0.95	65339.1	156.6	65310.3	145	68747.7	152.6
O1-624-1356	1	13	56	0.87	1	81577	6271.5	81548.2	6259.9	81548.2	6259.9
I4-624-1438	1	14	38	0.90	1.06	90377.7	7414.5	90348.9	7402.9	85234.8	6983.9
I3-624-1441	1	14	41	0.90	0.93	84172.1	6863.5	84143.3	6851.9	90476.7	7367.6
O2-624-1444	1	14	44	0.91	0.73	54296.7	160.6	54267.9	149	74339.6	204.1
I2-624-1449	1	14	49	0.91	0.74	67934.4	5415.9	67905.6	5404.3	91764.3	7303.1
I1-624-1451	1	14	51	0.91	0.82	71459.7	5800.3	71430.9	5788.7	87110.9	7059.4
O4-624-1454	1	14	54	0.91	1.1	73139	367.3	73110.2	355.7	66463.8	323.4
O3-624-1457	1	14	57	0.91	0.84	71555.9	5358.7	71527.1	5347.1	85151.3	6365.6
O1-624-1500	1	15	0	0.92	1.02	85775.7	6284.1	85746.9	6272.5	84065.6	6149.5
I1-624-1832	1	18	32	1.06	1.12	88361.1	6826.9	88332.3	6815.3	78868.1	6085.1
I2-624-1840	1	18	40	1.07	1.01	82417.3	6168.5	82388.5	6156.9	81572.8	6095.9
I3-624-1844	1	18	44	1.07	1	85282.7	6835.8	85253.9	6824.2	85253.9	6824.2
I4-624-1848	1	18	48	1.08	1.08	91683.7	7117.9	91654.9	7106.3	84865.6	6579.9
O1-624-1903	1	19	3	1.09	1.06	87908.3	7014.7	87879.5	7003.1	82905.2	6606.7
O2-624-1859	1	18	59	1.08	1.09	81977.3	273.7	81948.5	262.1	75182.1	240.5
O3-624-1856	1	18	56	1.08	1.03	87206	6894.5	87177.2	6882.9	84638.1	6682.4

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O4-624-1852	1	18	52	1.08	1.04	72364.7	467.8	72335.9	456.2	69553.8	438.7
I1-624-2216	1	22	16	1.22	1.02	87871.8	6696.3	87843	6684.7	86120.6	6553.6
I2-624-2223	1	22	23	1.22	1.02	85409.7	6289	85380.9	6277.4	83706.8	6154.3
I3-624-2227	1	22	27	1.23	1.11	86531.8	6817	86503	6805.4	77930.6	6131.0
I4-624-2232	1	22	32	1.23	1.12	87360.8	6922.3	87332	6910.7	77975.0	6170.3
O4-624-2237	1	22	37	1.23	1.03	71378.4	533.8	71349.6	522.2	69271.5	507.0
O3-624-2242	1	22	42	1.24	1.09	90167.3	7285.5	90138.5	7273.9	82695.9	6673.3
O2-624-2245	1	22	45	1.24	1.13	79510.6	298.3	79481.8	286.7	70337.9	253.7
O1-624-2250	1	22	50	1.24	1.01	83802.4	6584.1	83773.6	6572.5	82944.2	6507.4
O1-625-0021	2	0	21	1.31	0.943	77108.4	6042.5	77079.6	6030.9	81738.7	6395.4
O2-625-0029	2	0	29	1.31	1.069	81608.6	373.1	81579.8	361.5	76314.1	338.2
O3-625-0105	2	1	5	1.34	1	86043.9	6954.1	86015.1	6942.5	86015.1	6942.5
O4-625-0132	2	1	32	1.36	1.098	78919.4	613.3	78890.6	601.7	71849.4	548.0
I4-625-0139	2	1	39	1.36	1.201	93942.1	7425.6	93913.3	7414	78195.9	6173.2
I3-625-0144	2	1	44	1.36	0.997	83891.8	6527.9	83863	6516.3	84115.3	6535.9
I2-625-0149	2	1	49	1.37	1.171	94040.1	7438.6	94011.3	7427	80282.9	6342.4
I1-625-0156	2	1	56	1.37	1.175	95544.1	7448.6	95515.3	7437	81289.6	6329.4
O1-625-0210	2	2	10	1.38	1.127	92221.3	7242.5	92192.5	7230.9	81803.5	6416.1
O2-625-0215	2	2	15	1.39	1.026	77854	329.8	77825.2	318.2	75853.0	310.1
O3-625-0221	2	2	21	1.39	1.011	85637.4	6942.5	85608.6	6930.9	84677.2	6855.5
O4-625-0226	2	2	26	1.39	1.078	79063.8	608.5	79035	596.9	73316.3	553.7
O1-625-0329	2	3	29	1.44	1.048	85820.2	6776.1	85791.4	6764.5	81862.0	6454.7
O2-625-0334	2	3	34	1.44	1.114	80755.1	391	80726.3	379.4	72465.3	340.6
O3-625-0340	2	3	40	1.44	0.043	89731.1	7270.6	89702.3	7259	2086100.0	168814.0
O4-625-0346	2	3	46	1.45	1.011	78635.1	660.9	78606.3	649.3	77751.0	642.2
O1-625-0441	2	4	41	1.49	1.069	87470	6730.7	87441.2	6719.1	81797.2	6285.4
O2-625-0445	2	4	45	1.49	1.081	79986.4	383.9	79957.6	372.3	73966.3	344.4
O3-625-0450	2	4	50	1.49	1.054	88697.9	7060.2	88669.1	7048.6	84126.3	6687.5
O4-625-0455	2	4	55	1.50	1.133	81301.4	689.8	81272.6	678.2	71732.2	598.6
I1-625-0502	2	5	2	1.50	1.064	89602.3	6837.7	89573.5	6826.1	84185.6	6415.5
I2-625-0506	2	5	6	1.50	1.097	94225.7	7112.8	94196.9	7101.2	85867.7	6473.3
I3-625-0510	2	5	10	1.51	1.058	88578.7	6957.1	88549.9	6945.5	83695.6	6564.7
I4-625-0515	2	5	15	1.51	1.173	93759.2	7210	93730.4	7198.4	79906.6	6136.7
O1-625-0557	2	5	57	1.54	1.037	86393.7	6633.1	86364.9	6621.5	83283.4	6385.2
O2-625-0602	2	6	2	1.54	1.059	82974.9	428	82946.1	416.4	78324.9	393.2

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O3-625-0607	2	6	7	1.55	1.152	92441.3	7269.4	92412.5	7257.8	80219.2	6300.2
O4-625-0614	2	6	14	1.55	1.122	83302.8	958.5	83274	946.9	74219.3	843.9
O1-625-0748	2	7	48	1.62	1.06	87270.7	6608.3	87241.9	6596.7	82303.7	6223.3
O2-625-0753	2	7	53	1.62	1.098	84358.6	460	84329.8	448.4	76803.1	408.4
O3-625-0758	2	7	58	1.62	1.027	81352.1	6338.1	81323.3	6326.5	79185.3	6160.2
O4-625-0805	2	8	5	1.63	1.055	78815.5	843.2	78786.7	831.6	74679.3	788.2
I1-625-0810	2	8	10	1.63	1.143	91595.2	6995.2	91566.4	6983.6	80110.6	6109.9
I2-625-0818	2	8	18	1.64	0.991	83703	6081.9	83674.2	6070.3	84434.1	6125.4
I3-625-0822	2	8	22	1.64	1.18	95749.2	7161.7	95720.4	7150.1	81119.0	6059.4
I4-625-0824	2	8	24	1.64	0.89	77996.4	5796	77967.6	5784.4	87604.0	6499.3
O1-625-0925	2	9	25	1.68	1.121	85730.9	6468.8	85702.1	6457.2	76451.5	5760.2
O2-625-0927	2	9	27	1.69	0.982	75193	438.3	75164.2	426.7	76542.0	434.5
O3-625-0930	2	9	30	1.69	0.976	83228.9	6478.1	83200.1	6466.5	85246.0	6625.5
O4-625-0933	2	9	33	1.69	1.004	77367.1	806.3	77338.3	794.7	77030.2	791.5
O1-625-1022	2	10	22	1.72	1.028	84919.7	6238.9	84890.9	6227.3	82578.7	6057.7
O2-625-1024	2	10	24	1.73	0.918	77833.1	536.4	77804.3	524.8	84754.1	571.7
O3-625-1026	2	10	26	1.73	1.005	86844.6	6541.9	86815.8	6530.3	86383.9	6497.8
O4-625-1028	2	10	28	1.73	0.987	79611.6	826.1	79582.8	814.5	80631.0	825.2
I1-625-1114	2	11	14	1.76	1.121	89484.2	6050.3	89455.4	6038.7	79799.6	5386.9
I2-625-1116	2	11	16	1.76	1.007	87454.5	6287.5	87425.7	6275.9	86818.0	6232.3
I3-625-1118	2	11	18	1.76	0.907	79262.4	5410	79233.6	5398.4	87357.9	5951.9
I4-625-1120	2	11	20	1.76	0.971	81339.5	5950.9	81310.7	5939.3	83739.1	6116.7
O1-625-1126	2	11	26	1.77	0.974	83156.3	5533.6	83127.5	5522	85346.5	5669.4
O2-625-1128	2	11	28	1.77	1.031	83502.6	520.5	83473.8	508.9	80963.9	493.6
O3-625-1130	2	11	30	1.77	0.934	83265.1	6430.4	83236.3	6418.8	89118.1	6872.4
O4-625-1135	2	11	35	1.77	1.266	94787.8	1037	94759	1025.4	74849.1	810.0
O1-625-1308	2	13	8	1.84	0.953	83248.3	6074.9	83220	6070	87324.2	6369.4
O2-625-1316	2	13	16	1.84	0.924	76548.6	478	76520.3	473.1	82814.2	512.0
O3-625-1322	2	13	22	1.85	0.994	85473	6274.1	85444.7	6269.2	85960.5	6307.0
O4-625-1331	2	13	31	1.85	1	80538.3	949.1	80510	944.2	80510.0	944.2
I1-625-1504	2	15	4	1.92	0.975	83634.5	5815.8	83606.2	5810.9	85749.9	5959.9
I2-625-1510	2	15	10	1.92	0.933	85678	6180.9	85649.7	6176	91800.3	6619.5
I3-625-1516	2	15	16	1.93	0.366	35673.4	2522.4	35645.1	2517.5	97391.0	6878.4
I4-625-1520	2	15	20	1.93	0.869	85795.3	5946.8	85767	5941.9	98696.2	6837.6
O1-625-1545	2	15	45	1.95	1.084	89874.8	6533	89846.5	6528.1	82884.2	6022.2

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O2-625-1551	2	15	51	1.95	1.066	85947.3	639	85919	634.1	80599.4	594.8
O3-625-1556	2	15	56	1.96	1.02	87276.6	6507.6	87248.3	6502.7	85537.5	6375.2
O4-625-1558	2	15	58	1.96	1.091	82322.6	1097.6	82294.3	1092.7	75430.2	1001.6
O1-625-1720	2	17	20	2.01	1.048	86982.6	6429.4	86954.3	6424.5	82971.7	6130.2
O2-625-1723	2	17	23	2.02	1.024	81001.1	695.5	80972.8	690.6	79075.0	674.4
O3-625-1726	2	17	26	2.02	0.977	82350.5	6086.4	82322.2	6081.5	84260.2	6224.7
O4-625-1729	2	17	29	2.02	1.004	78444.8	1093.1	78416.5	1088.2	78104.1	1083.9
I1-625-1822	2	18	22	2.06	1.04	86973.5	6152.4	86945.2	6147.5	83601.2	5911.1
I2-625-1823	2	18	23	2.06	1.075	89664.2	6649.2	89635.9	6644.3	83382.2	6180.7
I3-625-1854	2	18	54	2.08	1.083	89765.7	6177.9	89737.4	6173	82860.0	5699.9
I4-625-1855	2	18	55	2.08	1.027	86752.7	6030.8	86724.4	6019.2	84444.4	5861.0
O1-625-1908	2	19	8	2.09	1.026	84241.2	6196.2	84212.9	6184.6	82078.8	6027.9
O2-625-1909	2	19	9	2.09	1.045	83418.9	690.7	83390.6	679.1	79799.6	649.9
O3-625-1910	2	19	10	2.09	1.017	86540.8	6380.9	86512.5	6369.3	85066.4	6262.8
O4-625-1911	2	19	11	2.09	1.015	81372.7	1269.4	81344.4	1257.8	80142.3	1239.2
O1-625-2035	2	20	35	2.15	1.08	88716.8	6788.6	88688.5	6777	82119.0	6275.0
O2-625-2041	2	20	41	2.15	1.36	86659.8	721.1	86631.5	709.5	63699.6	521.7
O3-625-2047	2	20	47	2.16	1.08	24957.8	4547.7	24929.5	4536.1	23082.9	4200.1
O4-625-2053	2	20	53	2.16	1.07	82591.3	1082.6	82563	1071	77161.7	1000.9
O1-625-2157	2	21	57	2.21	1.09	89091.2	6543	89062.9	6531.4	81709.1	5992.1
O2-625-2203	2	22	3	2.21	1.12	85549.9	673.1	85521.6	661.5	76358.6	590.6
O3-625-2206	2	22	6	2.21	1.05	85110.7	6307.5	85082.4	6295.9	81030.9	5996.1
O4-625-2210	2	22	10	2.22	1.07	83893.8	1169.5	83865.5	1157.9	78379.0	1082.1
I1-625-2215	2	22	15	2.22	0.94	90052.9	6526.1	90024.6	6514.5	95770.9	6930.3
I2-625-2219	2	22	19	2.22	0.92	85729.5	6378.7	85701.2	6367.1	93153.5	6920.8
I3-625-2234	2	22	34	2.23	1.11	86190	6254.3	86161.7	6242.7	77623.2	5624.1
I4-625-2237	2	22	37	2.23	1.04	85907.6	5874.9	85879.3	5863.3	82576.3	5637.8
O1-625-2323	2	23	23	2.27	1.11	93035	6569.2	93006.7	6557.6	83789.8	5907.7
O2-625-2329	2	23	29	2.27	1.18	83908.8	668.9	83880.5	657.3	71085.2	557.0
O3-625-2334	2	23	34	2.27	1.07	86664.9	6453.9	86636.6	6442.3	80968.8	6020.8
O4-625-2337	2	23	37	2.28	1.03	80910.7	1125.3	80882.4	1113.7	78526.6	1081.3
I1-626-0114	3	1	14	2.34	1.021	82908.1	6107.5	82879.8	6095.9	81175.1	5970.5
I2-626-0120	3	1	20	2.35	1.233	93350.8	7048.7	93322.5	7037.1	75687.3	5707.3
O1-626-0124	3	1	24	2.35	1.062	87381.6	6346.6	87353.3	6335	82253.6	5965.2
O2-626-0127	3	1	27	2.35	1.065	79531.4	671.4	79503.1	659.8	74650.8	619.5

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O3-626-0133	3	1	33	2.36	0.893	74315.9	5123.5	74287.6	5111.9	83188.8	5724.4
O4-626-0135	3	1	35	2.36	0.925	73209.1	998.7	73180.8	987.1	79114.4	1067.1
I3-626-0207	3	2	7	2.38	1.001	84789.1	6178.9	84760.8	6167.3	84676.1	6161.1
I4-626-0210	3	2	10	2.38	1.02	83994.1	6049.7	83963.1	6038.1	82316.8	5919.7
O1-626-0301	3	3	1	2.42	0.877	82973.6	5970.6	82942.6	5959	94575.4	6794.8
O2-626-0305	3	3	5	2.42	1.129	80581.7	717.7	80550.7	706.1	71346.9	625.4
O3-626-0311	3	3	11	2.42	0.97	79380.4	5577	79349.4	5565.4	81803.5	5737.5
O4-626-0315	3	3	15	2.43	0.99	77227.9	1141.4	77196.9	1129.8	77976.7	1141.2
I1-626-0333	3	3	33	2.44	1.106	92768.1	6891.7	92737.1	6880.1	83849.1	6220.7
I2-626-0336	3	3	36	2.44	1.167	97717.3	7372	97686.3	7360.4	83707.2	6307.1
O1-626-0437	3	4	37	2.48	1.068	87233.1	6317.3	87202.1	6305.7	81649.9	5904.2
O2-626-0442	3	4	42	2.49	0.984	78004.9	718.3	77973.9	706.7	79241.8	718.2
O3-626-0447	3	4	47	2.49	0.418	84637.9	5953.3	84606.9	5941.7	202408.9	14214.6
O4-626-0454	3	4	54	2.50	1.033	79291.9	1186.3	79260.9	1174.7	76728.8	1137.2
I3-626-0538	3	5	38	2.53	1.165	95682.7	6742.2	95651.7	6730.6	82104.5	5777.3
I4-626-0546	3	5	46	2.53	1.102	91470.7	6491.6	91439.7	6480	82976.1	5880.2
O1-626-0614	3	6	14	2.55	0.857	81145.3	5855.6	81114.3	5844	94649.1	6819.1
O2-626-0618	3	6	18	2.55	1.106	77342	800.9	77311	789.3	69901.4	713.7
O3-626-0623	3	6	23	2.56	0.98	79158.6	5589.7	79127.6	5578.1	80742.4	5691.9
O4-626-0627	3	6	27	2.56	0.964	76010.9	1190.4	75979.9	1178.8	78817.3	1222.8
I1-626-0642	3	6	42	2.57	1.049	88047.6	6533.5	88016.6	6521.9	83905.2	6217.3
I2-626-0645	3	6	45	2.57	1.074	93965.7	7318.1	93934.7	7306.5	87462.5	6803.1
O1-626-0754	3	7	54	2.62	1.057	84476.1	6012.9	84445.1	6001.3	79891.3	5677.7
O2-626-0759	3	7	59	2.62	1.045	81801	903.8	81770	892.2	78248.8	853.8
O3-626-0805	3	8	5	2.63	0.917	75423.3	5223.4	75392.3	5211.8	82216.2	5683.5
O4-626-0815	3	8	15	2.64	1.208	94002.3	1496.8	93971.3	1485.2	77790.8	1229.5
I4-626-0915	3	9	15	2.68	1.073	87680.1	6628.1	87648.6	6616.1	81685.6	6166.0
O4-626-0918	3	9	18	2.68	1.027	59670.6	1518.2	59639.6	1506.6	58071.7	1467.0
I3-626-0921	3	9	21	2.68	1.004	69283.2	6210	69252.2	6198.4	68976.3	6173.7
O3-626-0924	3	9	24	2.68	1.006	63642.8	5401.7	63611.8	5390.1	63232.4	5358.0
I2-626-0933	3	9	33	2.69	1.102	80144.6	6572.3	80113.6	6560.7	72698.4	5953.4
O2-626-0935	3	9	35	2.69	1.013	61375.8	1001.1	61344.8	989.5	60557.6	976.8
I1-626-0938	3	9	7-Feb	2.69	0.904	58111.3	5269.2	58080.3	5257.6	64248.1	5815.9
O1-626-0942	3	9	42	2.70	1.063	56256.8	5348	56225.8	5336.4	52893.5	5020.1
I4-626-1312	3	13	12	2.84	1.086	25775.9	4092.8	25744.9	4081.2	23706.2	3758.0

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O4-626-1315	3	13	15	2.84	1.052	53428.6	1540.2	53397.6	1528.6	50758.2	1453.0
I3-626-1317	3	13	17	2.85	1.038	46275.9	5118.8	46244.9	5107.2	44551.9	4920.2
O3-626-1321	3	13	21	2.85	0.986	73633.6	5705.1	73602.6	5693.5	74647.7	5774.3
I2-626-1323	3	13	23	2.85	1.012	56730.5	5554.8	56699.5	5543.2	56027.2	5477.5
O2-626-1326	3	13	26	2.85	1.028	69772.4	1074.9	69741.4	1063.3	67841.8	1034.3
I1-626-1328	3	13	28	2.85	1.057	70249.4	6112.6	70218.4	6101	66431.8	5772.0
O1-626-1332	3	13	32	2.86	0.955	76232.1	6072.6	76201.1	6061	79791.7	6346.6
O4-626-1625	3	16	25	2.98	1.092	75936.3	1482.4	75905.3	1470.8	69510.3	1346.9
I4-626-1629	3	16	29	2.98	1.07	87359.6	6515.1	87328.6	6503.5	81615.5	6078.0
O1-626-1631	3	16	31	2.98	0.986	81354	5885.7	81321.7	5874.5	82476.4	5957.9
I3-626-1633	3	16	33	2.98	0.956	79530.2	5362	79497.9	5350.8	83156.8	5597.1
O3-626-1635	3	16	35	2.98	1.265	102037	7681.45	102004.7	7670.25	80636.1	6063.4
I1-626-1644	3	16	44	2.99	0.982	79530.2	5362	79497.9	5350.8	80955.1	5448.9
O2-626-1652	3	16	52	2.99	0.96	75811.3	1068.3	75779	1057.1	78936.5	1101.1
I2-626-1659	3	16	59	3.00	0.946	79150.7	5625.8	79118.4	5614.6	83634.7	5935.1
O1-626-1810	3	18	10	3.05	1.008	82420.6	6144.1	82388.3	6132.9	81734.4	6084.2
O2-626-1812	3	18	12	3.05	1.074	84570.2	1212.9	84537.9	1201.7	78713.1	1118.9
O3-626-1813	3	18	13	3.05	1.061	86655.1	6199.9	86622.8	6188.7	81642.6	5832.9
O4-626-1815	3	18	15	3.05	1.046	82558.3	1442.3	82526	1431.1	78896.7	1368.2
I2-626-2002	3	20	2	3.13	1.318	82937.2	5999.6	82904.9	5988.4	62902.0	4543.6
I1-626-1957	3	19	57	3.12	1.226	83456.8	5909	83424.5	5897.8	68046.1	4810.6
O1-626-2012	3	20	12	3.13	1.384	82837.3	6157.7	82805	6146.5	59830.2	4441.1
O2-626-2016	3	20	16	3.14	1.344	82206.8	1197.9	82174.5	1186.7	61141.7	883.0
O3-626-2018	3	20	18	3.14	0.971	83453.5	5673	83421.2	5661.8	85912.7	5830.9
O4-626-2020	3	20	20	3.14	1.075	82775.1	1390.9	82742.8	1379.7	76970.0	1283.4
I3-626-2021	3	20	21	3.14	1.096	82873.3	5782.5	82841	5771.3	75584.9	5265.8
I4-626-2023	3	20	23	3.14	1.092	85264.7	6102.6	85232.4	6091.4	78051.6	5578.2
O1-626-2158	3	21	58	3.21	1.072	84960.4	6186.6	84928.1	6175.4	79224.0	5760.6
O2-626-2200	3	22	0	3.21	1.102	83550.9	1480.1	83518.6	1468.9	75788.2	1332.9
O3-626-2201	3	22	1	3.21	1.068	84978.1	6042.2	84945.8	6031	79537.3	5647.0
O4-626-2202	3	22	2	3.21	1.036	81221.5	1757.3	81189.2	1746.1	78368.0	1685.4
I1-626-2349	3	23	49	3.28	1.053	87022.3	6384.2	86990	6373	82611.6	6052.2
I2-626-2351	3	23	51	3.29	1.008	88764.6	6599.4	88732.3	6588.2	88028.1	6535.9
I3-626-2356	3	23	56	3.29	1.062	91609	6790.3	91576.7	6779.1	86230.4	6383.3
I4-626-2358	3	23	58	3.29	1.011	85455.6	6278.4	85423.3	6267.2	84493.9	6199.0

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O1-627-0005	4	0	5	3.30	1.038	88506.7	6526.5	88474.4	6515.3	85235.5	6276.8
O2-627-0006	4	0	6	3.30	1.028	83942.6	1459.7	83910.3	1448.5	81624.8	1409.0
O3-627-0008	4	0	8	3.30	0.94	87421.5	6446.7	87389.2	6435.5	92967.2	6846.3
O4-627-0009	4	0	9	3.30	1.065	82916.8	1771	82884.5	1759.8	77825.8	1652.4
O1-627-0150	4	1	50	3.37	1.016	83757.1	5868.2	83724.8	5857	82406.3	5764.8
O2-627-0200	4	2	0	3.38	1.173	78048.3	1238.5	78016	1227.3	66509.8	1046.3
O3-627-0209	4	2	9	3.38	0.854	82696.2	5912.9	82663.9	5901.7	96796.1	6910.7
O4-627-0216	4	2	16	3.39	1.053	78048.3	1238.5	78016	1227.3	74089.3	1165.5
I1-627-0238	4	2	38	3.40	1.022	87673.4	6265.4	87641.1	6254.2	85754.5	6119.6
I2-627-0242	4	2	42	3.40	1.091	81553.7	5777.3	81521.4	5766.1	74721.7	5285.2
O1-627-0353	4	3	53	3.45	1.046	84687.2	5942.5	84654.9	5931.3	80932.0	5670.5
O2-627-0357	4	3	57	3.46	0.954	76170.7	1232.3	76138.4	1221.1	79809.6	1280.0
O3-627-0403	4	4	3	3.46	1.047	82817	6066.4	82784.7	6055.2	79068.5	5783.4
O4-627-0408	4	4	8	3.46	1.017	82489.9	1692.8	82457.6	1681.6	81079.3	1653.5
I1-627-0414	4	4	14	3.47	1.004	87717.5	6214.1	87685.2	6202.9	87335.9	6178.2
I2-627-0416	4	4	16	3.47	0.99	84154.7	5961.4	84122.4	5950.2	84972.1	6010.3
O1-627-0546	4	5	46	3.53	0.929	84001.7	5858.4	83969.4	5847.2	90386.9	6294.1
O2-627-0551	4	5	51	3.54	1.132	79474.6	1347.2	79442.3	1336	70178.7	1180.2
O3-627-0603	4	6	3	3.54	0.943	78491.3	5677.8	78459	5666.6	83201.5	6009.1
O4-627-0607	4	6	7	3.55	1.016	76338.1	1508.7	76305.8	1497.5	75104.1	1473.9
I1-627-0611	4	6	11	3.55	1.035	88094.1	6348.1	88061.8	6336.9	85083.9	6122.6
I2-627-0614	4	6	14	3.55	1.111	91806.5	6673.5	91774.2	6662.3	82605.0	5996.7
I3-627-0628	4	6	28	3.56	0.943	86076	6157.3	86043.7	6146.1	91244.6	6517.6
I4-627-0630	4	6	30	3.56	1.153	91925.7	6698.1	91893.4	6686.9	79699.4	5799.6
O2-627-0658	4	6	58	3.58	0.884	81139	1381.6	81107.5	1369.6	91750.6	1549.3
O4-627-0701	4	7	1	3.58	1.008	79443.6	1604.6	79412.1	1592.6	78781.8	1580.0
O1-627-0828	4	8	28	3.64	1	83118.3	5864.9	83086.8	5852.9	83086.8	5852.9
O2-627-0830	4	8	30	3.65	0.978	78225.2	1331	78193.7	1319	79952.7	1348.7
O3-627-0832	4	8	32	3.65	0.925	76900.7	5599	76869.2	5587	83101.8	6040.0
O4-627-0835	4	8	35	3.65	1.052	78603.5	1563.7	78572	1551.7	74688.2	1475.0
I1-627-0930	4	9	30	3.69	1.042	87091.9	6542.9	87060.4	6530.9	83551.2	6267.7
I2-627-0940	4	9	40	3.69	0.754	66566.1	4651.1	66534.6	4639.1	88242.2	6152.7
I3-627-0942	4	9	42	3.70	1.038	87337	6165.6	87305.5	6153.6	84109.3	5928.3
I4-627-0945	4	9	45	3.70	0.866	82211.8	5801	82180.3	5789	94896.4	6684.8
O1-627-0955	4	9	55	3.70	0.929	80227.6	5748.1	80196.1	5736.1	86325.2	6174.5

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O2-627-0958	4	9	58	3.71	0.969	81250.3	1427	81218.8	1415	83817.1	1460.3
O3-627-1000	4	10	0	3.71	0.993	87298.2	6221.3	87266.7	6209.3	87881.9	6253.1
O4-627-1002	4	10	2	3.71	0.958	90077.9	1903.1	90046.4	1891.1	93994.2	1974.0
O1-627-1125	4	11	25	3.77	0.918	85397	6328.8	85365.5	6316.8	92990.7	6881.0
O2-627-1130	4	11	30	3.77	0.956	85935.9	1638.6	85904.4	1626.6	89858.2	1701.5
O3-627-1132	4	11	32	3.77	1.016	80560.4	5941.8	80528.9	5929.8	79260.7	5836.4
O4-627-1135	4	11	35	3.77	1.122	78373.9	1695.6	78342.4	1683.6	69823.9	1500.5
O1-627-1255	4	12	55	3.83	1.017	86356.4	6270.3	86324.9	6258.3	84881.9	6153.7
O2-627-1258	4	12	58	3.83	0.985	81440.2	1541.6	81408.7	1529.6	82648.4	1552.9
O3-627-1300	4	13	0	3.83	0.966	81272.6	5929.1	81241.1	5917.1	84100.5	6125.4
O4-627-1302	4	13	2	3.83	0.919	75374.8	1555.1	75343.3	1543.1	81984.0	1679.1
I1-627-1310	4	13	10	3.84	0.973	82557.9	5958.1	82526.4	5946.1	84816.4	6111.1
I2-627-1312	4	13	12	3.84	0.985	84188.7	6017	84157.2	6005	85438.8	6096.4
I3-627-1314	4	13	14	3.84	0.961	83575.7	5873.1	83544.2	5861.1	86934.7	6099.0
I4-627-1316	4	13	16	3.84	1.029	85294.5	5965.9	85263	5953.9	82860.1	5786.1
O1-627-1430	4	14	30	3.90	0.817	78050.2	5538.1	78018.7	5526.1	95494.1	6763.9
O2-627-1432	4	14	32	3.90	1.035	82290.4	1539.4	82258.9	1527.4	79477.2	1475.7
O3-627-1434	4	14	34	3.90	0.603	51944	3624.9	51912.5	3612.9	86090.4	5991.5
O4-627-1440	4	14	40	3.90	1.04	82161	1706.8	82129.5	1694.8	78970.7	1629.6
O1-627-1556	4	15	56	3.96	0.987	84282.3	6006.9	84250.8	5994.9	85360.5	6073.9
O2-627-1558	4	15	58	3.96	1.008	83949.8	1613.9	83918.3	1601.9	83252.3	1589.2
O3-627-1602	4	16	2	3.96	1.025	85055.7	6057	85024.2	6045	82950.4	5897.6
O4-627-1606	4	16	6	3.96	0.949	79169.5	1676	79138	1664	83390.9	1753.4
I1-627-1619	4	16	19	3.97	1.128	84664.8	5431	84633.3	5419	75029.5	4804.1
I2-627-1627	4	16	27	3.98	0.88	82324.6	5549.4	82293.1	5537.4	93514.9	6292.5
I3-627-1630	4	16	30	3.98	0.859	85222.3	5433.5	85190.8	5421.5	99174.4	6311.4
I4-627-1631	4	16	31	3.98	1.073	91568.2	6185	91536.7	6173	85309.1	5753.0
O1-627-1729	4	17	29	4.02	1.068	85984.3	5881	85952.8	5869	80480.1	5495.3
O2-627-1730	4	17	30	4.02	1.02	82744.1	1666.3	82712.6	1654.3	81090.8	1621.9
O3-627-1732	4	17	32	4.02	0.908	78933.6	5068.4	78902.1	5056.4	86896.6	5568.7
O4-627-1733	4	17	33	4.02	1.029	83986.2	1850.6	83954.7	1838.6	81588.6	1786.8
O1-627-1902	4	19	2	4.08	1.015	83696.9	6109.8	83665.4	6097.8	82429.0	6007.7
O2-627-1902	4	19	2	4.08	1.083	80204.9	1754	80173.4	1742	74029.0	1608.5
O3-627-1903	4	19	3	4.09	1.138	83294.5	5748.6	83263	5736.6	73166.1	5040.9
O4-627-1903	4	19	3	4.09	1.13	82794.1	2237.4	82762.6	2225.4	73241.2	1969.4

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
I1-627-1904	4	19	4	4.09	1.034	83365.1	5697	83333.6	5685	80593.4	5498.1
I2-627-1907	4	19	7	4.09	1.048	84119.9	5524	84088.4	5512	80237.0	5259.5
I3-627-1921	4	19	21	4.10	1.066	82574.9	5513.3	82543.4	5501.3	77432.8	5160.7
I4-627-1922	4	19	22	4.10	1.115	86666.8	5985.7	86635.3	5973.7	77699.8	5357.6
O1-627-2027	4	20	27	4.14	1.053	85237.8	5971.4	85206.3	5959.4	80917.7	5659.4
O2-627-2031	4	20	31	4.15	0.865	86778.3	1897.2	86746.8	1885.2	100285.3	2179.4
O3-627-2034	4	20	34	4.15	1.2	95397.3	6982.2	95365.8	6970.2	79471.5	5808.5
O4-627-2038	4	20	38	4.15	1.047	85794	2100.8	85762.5	2088.8	81912.6	1995.0
O1-627-2154	4	21	54	4.20	1.151	91901.8	6564.3	91870.3	6552.3	79817.8	5692.7
O2-627-2158	4	21	58	4.21	1.064	81601.7	1793.6	81570.2	1781.6	76663.7	1674.4
O3-627-2201	4	22	1	4.21	1.11	89671.6	6573.4	89640.1	6561.4	80756.8	5911.2
O4-627-2204	4	22	4	4.21	1.015	83573.3	2040.4	83541.8	2028.4	82307.2	1998.4
I1-627-2229	4	22	29	4.23	1.298	90675.6	6362.3	90644.1	6350.3	69833.7	4892.4
I2-627-2232	4	22	32	4.23	1.472	91719.1	6587.5	91687.6	6575.5	62287.8	4467.1
I3-627-2235	4	22	35	4.23	1.491	93325.7	6611.4	93294.2	6599.4	62571.6	4426.2
I4-627-2237	4	22	37	4.23	1.024	84960.3	6111.2	84928.8	6099.2	82938.3	5956.3
O1-627-2325	4	23	25	4.27	1.126	88145.3	6313.1	88113.8	6301.1	78253.8	5596.0
O2-627-2328	4	23	28	4.27	1.184	89555	2147.2	89523.5	2135.2	75611.1	1803.4
O3-627-2330	4	23	30	4.27	1.183	90961.8	6648.7	90930.3	6636.7	76864.2	5610.1
O4-627-2333	4	23	33	4.27	1.138	84495	2103.5	84463.5	2091.5	74221.0	1837.9
O1-628-0100	5	1	0	4.33	#VALUE!	82095	5503.4	82063.5	5491.4	#VALUE!	#VALUE!
O2-628-0105	5	1	5	4.34	1.04	78388	1916	78356.5	1904	75342.8	1830.8
O3-628-0112	5	1	12	4.34	1.037	83562.7	5791.4	83531.2	5779.4	80550.8	5573.2
O4-628-0119	5	1	19	4.35	1.09	80088.5	2022.8	80057	2010.8	73446.8	1844.8
I1-628-0153	5	1	53	4.37	1.053	89398.6	6154.4	89367.1	6142.4	84869.0	5833.2
I2-628-0159	5	1	59	4.37	1.153	86553.5	5959.5	86522	5947.5	75040.8	5158.3
I3-628-0204	5	2	4	4.38	0.87	80454.9	5272.3	80423.4	5260.3	92440.7	6046.3
I4-628-0209	5	2	9	4.38	1.084	84460.7	6022.2	84429.2	6010.2	77886.7	5544.5
O1-628-0220	5	2	20	4.39	1.037	84233.8	5616.1	84202.3	5604.1	81198.0	5404.1
O2-628-0226	5	2	26	4.39	1.053	84403.3	2104.1	84371.8	2092.1	80125.2	1986.8
O3-628-0230	5	2	30	4.40	1.033	84727.7	5950.7	84696.2	5938.7	81990.5	5749.0
O4-628-0235	5	2	35	4.40	1.09	84210.6	2142.1	84179.1	2130.1	77228.5	1954.2
O1-628-0358	5	3	58	4.46	1.093	86321	5754.7	86289.5	5742.7	78947.4	5254.1
O2-628-0403	5	4	3	4.46	1.075	83161.9	2145.8	83130.4	2133.8	77330.6	1984.9
O3-628-0408	5	4	8	4.46	1.043	83912.4	5853.2	83880.9	5841.2	80422.7	5600.4

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O4-628-0413	5	4	13	4.47	1.059	82569.2	2079.3	82537.7	2067.3	77939.3	1952.1
I1-628-0446	5	4	46	4.49	1.043	87289.7	6047.3	87258.2	6035.3	83660.8	5786.5
I2-628-0452	5	4	52	4.49	1.057	85908.7	6061.7	85877.2	6049.7	81246.2	5723.5
I3-628-0457	5	4	57	4.50	0.965	78786.2	5533.1	78754.7	5521.1	81611.1	5721.3
I4-628-0501	5	5	1	4.50	1.059	83270	5829.4	83238.5	5817.4	78601.0	5493.3
O1-628-0525	5	5	25	4.52	1.071	86777.6	5729.4	86746.1	5717.4	80995.4	5338.4
O2-628-0528	5	5	28	4.52	1.089	84909.5	2192.9	84878	2180.9	77941.2	2002.7
O3-628-0533	5	5	33	4.52	1.073	86110.2	5944.1	86078.7	5932.1	80222.5	5528.5
O4-628-0539	5	5	39	4.53	1.051	83553.9	2125.3	83522.4	2113.3	79469.5	2010.8
O1-628-0703	5	7	3	4.59	1.042	86266.1	5741.5	86234.6	5729.5	82758.7	5498.6
O2-628-0708	5	7	8	4.59	1.051	84884.8	2273.2	84853.3	2261.2	80735.8	2151.5
O3-628-0713	5	7	13	4.59	1.095	83014.8	5901.1	82983.3	5889.1	75783.8	5378.2
O4-628-0717	5	7	17	4.60	1.065	83796.7	2100.9	83765.2	2088.9	78652.8	1961.4
I1-628-0743	5	7	43	4.61	1.067	87361.7	6122.6	87330.2	6110.6	81846.5	5726.9
I2-628-0747	5	7	47	4.62	0.907	86178.6	6066.6	86147.1	6054.6	94980.3	6675.4
I3-628-0752	5	7	52	4.62	1.041	85758	6027.1	85726.5	6015.1	82350.1	5778.2
I4-628-0756	5	7	56	4.62	1.043	81858.9	5578.5	81827.4	5566.5	78453.9	5337.0
O1-628-0828	5	8	28	4.64	0.988	84736.4	5771.4	84704.9	5759.4	85733.7	5829.4
O2-628-0830	5	8	30	4.65	1.026	82031.7	2139.1	82000.2	2127.1	79922.2	2073.2
O3-628-0832	5	8	32	4.65	0.968	83082.4	5739.6	83050.9	5727.6	85796.4	5916.9
O4-628-0834	5	8	34	4.65	1.079	81578.8	1958.8	81547.3	1946.8	75576.7	1804.3
O1-628-0958	5	9	58	4.71	0.996	84587.2	5744.3	84555.3	5732.7	84894.9	5755.7
O2-628-1000	5	10	0	4.71	1.026	81034.8	2186.1	81002.9	2174.5	78950.2	2119.4
O3-628-1002	5	10	2	4.71	0.996	87324.8	6265.5	87292.9	6253.9	87643.5	6279.0
O4-628-1004	5	10	4	4.71	1.046	85697.1	1894.3	85665.2	1882.7	81897.9	1799.9
I1-628-1112	5	11	12	4.76	1.02	81837.4	5471.3	81805.5	5459.7	80201.5	5352.6
I2-628-1116	5	11	16	4.76	1.142	92712	6484.9	92680.1	6473.3	81156.0	5668.4
I3-628-1120	5	**11**	**20**	4.76	**-0.029**	80565.1	5211.7	80533.2	5200.1	-2777006.9	-179313.8
I4-628-1124	5	11	24	4.77	1.048	90658.5	6350.7	90626.6	6339.1	86475.8	6048.8
O1-628-1128	5	11	28	4.77	0.941	83414.1	5655.3	83382.2	5643.7	88610.2	5997.6
O2-628-1130	5	11	30	4.77	1.028	85201.2	2371	85169.3	2359.4	82849.5	2295.1
O3-628-1136	5	11	36	4.78	1.023	86397.9	5987.5	86366	5975.9	84424.2	5841.5
O4-628-1140	5	11	40	4.78	0.86	84519.8	2077.5	84487.9	2065.9	98241.7	2402.2
O1-628-1310	5	13	10	4.84	1.096	84686.4	5974.6	84654.5	5963	77239.5	5440.7
O2-628-1314	5	13	14	4.84	0.943	81573.4	2200.1	81541.5	2188.5	86470.3	2320.8

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O3-628-1316	5	13	16	4.84	1.156	86268.6	6043.1	86236.7	6031.5	74599.2	5217.6
O4-628-1318	5	13	18	4.85	1.003	82331.4	2125	82299.5	2113.4	82053.3	2107.1
I1-628-1412	5	14	12	4.88	1.017	84653.1	5953.9	84621.2	5942.3	83206.7	5843.0
I2-628-1414	5	14	14	4.88	0.96	85788.8	5867.5	85756.9	5855.9	89330.1	6099.9
I3-628-1416	5	14	16	4.89	0.874	75601.5	4989	75569.6	4977.4	86464.1	5695.0
I4-628-1420	5	14	20	4.89	1.002	83487.3	5657	83455.4	5645.4	83288.8	5634.1
O1-628-1428	5	14	28	4.89	0.95	82660.1	5723.8	82628.2	5712.2	86977.1	6012.8
O2-628-1430	5	14	30	4.90	1.022	83257	2238.6	83225.1	2227	81433.6	2179.1
O3-628-1435	5	14	35	4.90	1.005	84641.3	5922.2	84609.4	5910.6	84188.5	5881.2
O4-628-1436	5	14	36	4.90	0.894	86471.6	2201.2	86439.7	2189.6	96688.7	2449.2
O1-628-1551	5	15	51	4.95	0.99	86091.5	5791.2	86059.6	5779.6	86928.9	5838.0
O2-628-1553	5	15	53	4.95	1.015	84073	2301.7	84041.1	2290.1	82799.1	2256.3
O3-628-1554	5	15	54	4.95	0.98	84761.7	6002.1	84729.8	5990.5	86459.0	6112.8
O4-628-1558	5	15	58	4.96	0.852	80546.3	2068.2	80514.4	2056.6	94500.5	2413.8
O1-628-1730	5	17	30	5.02	1.14	95129.4	6610.9	95097.5	6599.3	83418.9	5788.9
O2-628-1734	5	17	34	5.02	1.189	91776.3	2634.9	91744.4	2623.3	77161.0	2206.3
O3-628-1737	5	17	37	5.03	1.172	91396.1	6755.8	91364.2	6744.2	77955.8	5754.4
O4-628-1739	5	17	39	5.03	1.225	87875.9	2232.9	87844	2221.3	71709.4	1813.3
I1-628-1745	5	17	45	5.03	0.764	72245.3	4650.1	72213.4	4638.5	94520.2	6071.3
I2-628-1747	5	17	47	5.03	1.185	91715.9	5790.2	91684	5778.6	77370.5	4876.5
I3-628-1750	5	17	50	5.03	1.063	87481.8	5846.5	87449.9	5834.9	82267.1	5489.1
I4-628-1752	5	17	52	5.04	1.11	85817.5	5552.4	85785.6	5540.8	77284.3	4991.7
O1-628-1902	5	19	2	5.08	1.186	92705.5	6402.5	92673.6	6390.9	78139.6	5388.6
O2-628-1906	5	19	6	5.09	1.162	90267.6	2459	90235.7	2447.4	77655.5	2106.2
O3-628-1908	5	19	8	5.09	1.122	89056.9	6343.4	89025	6331.8	79344.9	5643.3
O4-628-1911	5	19	11	5.09	1.274	95101.2	2314.2	95069.3	2302.6	74622.7	1807.4
I1-628-1922	5	19	22	5.10	1.169	92524.2	6275.3	92492.3	6263.7	79120.9	5358.2
I2-628-1924	5	19	24	5.10	1.158	95336.8	6441.3	95304.9	6429.7	82301.3	5552.4
I3-628-1927	5	19	27	5.10	0.132	89944.4	5986	89912.5	5974.4	681155.3	45260.6
I4-628-1929	5	19	29	5.10	0.176	96225.7	6551.1	96193.8	6539.5	546555.7	37156.3
O1-628-2038	5	20	38	5.15	1.173	91106.2	6306.5	91074.3	6294.9	77642.2	5366.5
O2-628-2041	5	20	41	5.15	1.118	90446.5	2483.1	90414.6	2471.5	80871.7	2210.6
O3-628-2045	5	20	45	5.16	1.049	94322.9	6632.1	94291	6620.5	89886.6	6311.2
O4-628-2047	5	20	47	5.16	0.997	78397.6	1884.8	78365.7	1873.2	78601.5	1878.8
O1-628-2216	5	22	16	5.22	0.892	73758.1	4879.8	73726.2	4868.2	82652.7	5457.6

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml	
O2-628-2220	5	22	20	5.22	0.934	74300.3	1986.4	74268.4	1974.8	79516.5	2114.3	
O3-628-2224	5	22	24	5.23	0.861	71431.5	4907.7	71399.6	4896.1	82926.4	5686.5	
O4-628-2227	5	22	27	5.23	0.936	75910.4	1771.8	75878.5	1760.2	81066.8	1880.6	
I1-628-2303	5	23	3	5.25	1.004	84544.5	5515.7	84512.6	5504.1	84175.9	5482.2	
I2-628-2306	5	23	6	5.25	0.968	82259.4	5314.5	82227.5	5302.9	84945.8	5478.2	
I3-628-2310	5	23	10	5.26	1.07	85009.2	5416.6	84977.3	5405	79418.0	5051.4	
I4-628-2313	5	23	13	5.26	0.97	83390.3	5581.4	83358.4	5569.8	85936.5	5742.1	
O1-628-2355	5	23	55	5.29	1.277	82472.5	5439.5	82440.6	5427.9	64558.0	4250.5	Sample wt
O2-628-2359	5	23	59	5.29	1.006	82185.8	2282.3	82153.9	2270.7	81663.9	2257.2	
O3-629-0003	6	0	3	5.29	0.986	83270.1	5655.9	83238.2	5644.3	84420.1	5724.4	
O4-629-0009	6	0	9	5.30	1.027	82594.6	1970.5	82562.7	1958.9	80392.1	1907.4	
O1-629-0141	6	1	41	5.36	1.003	81928.9	5402.9	81897	5391.3	81652.0	5375.2	
O2-629-0145	6	1	45	5.36	0.962	79340.7	2346.3	79308.8	2334.7	82441.6	2426.9	
O3-629-0150	6	1	50	5.37	0.957	82961.6	5486.1	82929.7	5474.5	86655.9	5720.5	
O4-629-0155	6	1	55	5.37	0.985	79674.4	1942	79642.5	1930.4	80855.3	1959.8	
I1-629-0224	6	2	24	5.39	0.976	80937	5195.1	80905.1	5183.5	82894.6	5311.0	
I2-629-0229	6	2	29	5.40	0.994	84270.8	5651.5	84238.9	5639.9	84747.4	5673.9	
I3-629-0234	6	2	34	5.40	1.013	82542.3	5418.5	82510.4	5406.9	81451.5	5337.5	
I4-629-0238	6	2	38	5.40	1.154	83542.9	5569.6	83511	5558	72366.6	4816.3	
O1-629-0311	6	3	11	5.42	1.033	82237.8	5328.4	82205.9	5316.8	79579.8	5147.0	
O2-629-0315	6	3	15	5.43	0.994	81128.3	2318.8	81096.4	2307.2	81585.9	2321.1	
O3-629-0320	6	3	20	5.43	0.974	85367.7	5666.2	85335.8	5654.6	87613.8	5805.5	
O4-629-0325	6	3	25	5.43	1.011	85073.2	2144.1	85041.3	2132.5	84116.0	2109.3	
O1-629-0450	6	4	50	5.49	0.961	84417.1	5361.1	84385.2	5349.5	87809.8	5566.6	
O2-629-0454	6	4	54	5.50	0.977	83160.4	2474.2	83128.5	2462.6	85085.5	2520.6	
O3-629-0458	6	4	58	5.50	0.984	85963.9	6123.6	85932	6112	87329.3	6211.4	
O4-629-0503	6	5	3	5.50	1	82832.6	2159.9	82800.7	2148.3	82800.7	2148.3	
I1-629-0533	6	5	33	5.52	0.999	87212	5769.5	87180.1	5757.9	87267.4	5763.7	
I2-629-0536	6	5	36	5.53	0.989	86738.5	5808.5	86706.6	5796.9	87671.0	5861.4	
I3-629-0541	6	5	41	5.53	0.953	84523.7	5779.4	84491.8	5767.8	88658.8	6052.3	
I4-629-0545	6	5	45	5.53	0.966	83403	5553.6	83371.1	5542	86305.5	5737.1	
O1-629-0627	6	6	27	5.56	0.989	89787.3	5738	89755.4	5726.4	90753.7	5790.1	
O2-629-0629	6	6	29	5.56	1.053	88099.5	2987.9	88067.6	2976.3	83634.9	2826.5	
O3-629-0630	6	6	30	5.56	1.07	92140	6253.5	92108.1	6241.9	86082.3	5833.6	
O4-629-0631	6	6	31	5.56	1.052	89768.2	2506.9	89736.3	2495.3	85300.7	2372.0	

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O1-629-0759	6	7	59	5.62	0.932	89243.6	5912.1	89211.7	5900.5	95720.7	6331.0
O2-629-0800	6	8	0	5.63	0.979	87260.7	3075.3	87228.8	3063.7	89099.9	3129.4
O3-629-0801	6	8	1	5.63	1.344	87315	5753.1	87283.1	5741.5	64942.8	4271.9
O4-629-0802	6	8	2	5.63	1.388	87796.9	2500.8	87765	2489.2	63231.3	1793.4
I1-629-0849	6	8	49	5.66	1.129	88021.6	5933.2	87989.7	5921.6	77936.0	5245.0
I2-629-0854	6	8	54	5.66	1.056	90091.8	6155.4	90059.9	6143.8	85284.0	5818.0
I3-629-0938	6	9	38	5.69	0.998	86660.2	5933.3	86628.3	5921.7	86801.9	5933.6
I4-629-0941	6	9	41	5.70	1.014	77688.7	5933.3	77656.8	5921.7	76584.6	5839.9
O1-629-0947	6	9	47	5.70	1.063	88094.1	5649.7	88062.2	5638.1	82843.1	5304.0
O2-629-0948	6	9	48	5.70	1.034	84001.7	2954.1	83969.8	2942.5	81208.7	2845.7
O3-629-0949	6	9	49	5.70	0.963	82730.6	5199.1	82698.7	5187.5	85876.1	5386.8
O4-629-0950	6	9	50	5.70	0.97	80540.8	2305.9	80508.9	2294.3	82998.9	2365.3
O1-629-1124	6	11	24	5.77	1.061	89906.3	5507.1	89874.4	5495.5	84707.3	5179.5
O2-629-1125	6	11	25	5.77	1.045	85609.7	3093.7	85577.8	3082.1	81892.6	2949.4
O3-629-1126	6	11	26	5.77	1.048	89483.2	5673.8	89451.3	5662.2	85354.3	5402.9
O4-629-1127	6	11	27	5.77	1.007	83682	2702.7	83650.1	2691.1	83068.6	2672.4
I1-629-1141	6	11	41	5.78	1.037	84056.9	5776.3	84025	5764.7	81027.0	5559.0
I2-629-1143	6	11	43	5.78	1.01	87428.8	5951.2	87396.9	5939.6	86531.6	5880.8
I3-629-1156	6	11	56	5.79	1.074	90637.6	6427.6	90606.8	6415.1	84363.9	5973.1
I4-629-1158	6	11	58	5.79	1.017	82545.9	5401	82515.1	5388.5	81135.8	5298.4
O1-629-1307	6	13	7	5.84	0.989	86810.8	5575.6	86780	5563.1	87745.2	5625.0
O2-629-1308	6	13	8	5.84	0.97	83553.1	3092.3	83522.3	3079.8	86105.5	3175.1
O3-629-1309	6	13	9	5.84	0.906	87088	5432.3	87057.2	5419.8	96089.6	5982.1
O4-629-1310	6	13	10	5.84	0.995	83690.1	2333.5	83659.3	2321	84079.7	2332.7
O1-629-1430	6	14	30	5.90	1.064	90813.2	5653.7	90782.4	5641.2	85321.8	5301.9
O2-629-1431	6	14	31	5.90	1.055	87552.6	2916.2	87521.8	2903.7	82959.1	2752.3
O3-629-1432	6	14	32	5.90	0.996	86398.4	5241.8	86367.6	5229.3	86714.5	5250.3
O4-629-1433	6	14	33	5.90	1.067	88198.1	2277.4	88167.3	2264.9	82631.0	2122.7
I1-629-1503	6	15	3	5.92	1.025	83766.7	5256.7	83735.9	5244.2	81693.6	5116.3
I2-629-1504	6	15	4	5.92	0.997	83626.7	5302.7	83595.9	5290.2	83847.4	5306.1
O1-629-1607	6	16	7	5.96	1.012	84574.1	4899.1	84543.3	4886.6	83540.8	4828.7
O2-629-1608	6	16	8	5.96	1.129	90313	2751.6	90282.2	2739.1	79966.5	2426.1
O3-629-1609	6	16	9	5.96	1.049	88150.9	5659.2	88120.1	5646.7	84003.9	5382.9
O4-629-1609	6	16	9	5.96	1.055	86970.7	2302.8	86939.9	2290.3	82407.5	2170.9
I3-629-1637	6	16	37	5.98	1.069	88167.2	5684.5	88136.4	5672	82447.5	5305.9

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
I4-629-1642	6	16	42	5.99	1.06	84945.7	5428.8	84914.9	5416.3	80108.4	5109.7
I1-629-1735	6	17	35	6.02	1.041	88604.4	5569.9	88573.6	5557.4	85085.1	5338.5
I2-629-1738	6	17	38	6.03	1.079	88340.1	5780.1	88309.3	5767.6	81843.7	5345.3
O1-629-1742	6	17	42	6.03	1.076	84765.7	5232.1	84734.9	5219.6	78749.9	4850.9
O2-629-1745	6	17	45	6.03	1.075	83881.3	1808.3	83850.5	1795.8	78000.5	1670.5
O3-629-1750	6	17	50	6.03	1.06	84598.4	5433	84567.6	5420.5	79780.8	5113.7
O4-629-1754	6	17	54	6.04	0.984	83568.2	2413	83537.4	2400.5	84895.7	2439.5
O1-629-1916	6	19	16	6.09	1.047	54228.1	5310.4	54197.3	5297.9	51764.4	5060.1
O2-629-1920	6	19	20	6.10	1.062	84079.6	2837.9	84048.8	2825.4	79142.0	2660.5
O3-629-1925	6	19	25	6.10	1.057	85138.1	5303	85107.3	5290.5	80517.8	5005.2
O4-629-1929	6	19	29	6.10	1.063	83856.8	2346.6	83826	2334.1	78857.9	2195.8
I1-629-2013	6	20	13	6.13	1.156	90402.7	5809.7	90371.9	5797.2	78176.4	5014.9
I2-629-2018	6	20	18	6.14	1.061	86571.4	5544.3	86540.6	5531.8	81565.1	5213.8
I3-629-2022	6	20	22	6.14	1.08	86502.3	5556.6	86471.5	5544.1	80066.2	5133.4
I4-629-2028	6	20	28	6.14	1.065	82993.7	5111	82962.9	5098.5	77899.4	4787.3
O1-629-2045	6	20	45	6.16	1.083	86879.9	5399.1	86849.1	5386.6	80193.1	4973.8
O2-629-2050	6	**20**	**50**	6.16	**139.052**	**83602.5**	**2784.9**	83571.7	2772.4	601.0	19.9
O3-629-2053	6	20	53	6.16	1.076	84853.4	5468.1	84822.6	5455.6	78831.4	5070.3
O4-629-2055	6	20	55	6.16	1.065	83455.6	2386.3	83424.8	2373.8	78333.1	2228.9
O1-629-2213	6	22	13	6.22	1.009	81864.9	5089.1	81834.1	5076.6	81104.2	5031.3
O2-629-2217	6	22	17	6.22	1.062	83529.6	2833.4	83498.8	2820.9	78624.1	2656.2
O3-629-2220	6	22	20	6.22	1.073	87065.5	5677.3	87034.7	5664.8	81113.4	5279.4
O4-629-2225	6	22	25	6.23	1.058	82980.6	2434.5	82949.8	2422	78402.5	2289.2
I1-629-2307	6	23	7	6.25	1.058	86828.6	5581.6	86797.8	5569.1	82039.5	5263.8
I2-629-2311	6	23	11	6.26	1.083	85095.5	5397.7	85064.7	5385.2	78545.4	4972.5
I3-629-2322	6	23	22	6.27	1.065	85798.8	5505	85768	5492.5	80533.3	5157.3
I4-629-2326	6	23	26	6.27	1.045	84169.9	5104	84139.1	5091.5	80515.9	4872.2
O1-629-2340	6	23	40	6.28	1.039	82925.7	5166.4	82894.9	5153.9	79783.3	4960.4
O2-629-2344	6	23	44	6.28	0.995	82520.9	2738.6	82490.1	2726.1	82904.6	2739.8
O3-629-2347	6	23	47	6.28	1.069	86705.7	5681.2	86674.9	5668.7	81080.4	5302.8
O4-629-2351	6	23	51	6.29	1.06	82463	2362.2	82432.2	2349.7	77766.2	2216.7
O1-630-0113	7	1	13	6.34	1.057	85686.9	5244.1	85656.1	5231.6	81037.0	4949.5
O2-630-0116	7	1	16	6.34	1.06	83923.8	2895.2	83893	2882.7	79144.3	2719.5
O3-630-0120	7	1	20	6.35	1.066	85597	5606.8	85566.2	5594.3	80268.5	5247.9
O4-630-0124	7	1	24	6.35	1.082	85528	2451.3	85497.2	2438.8	79017.7	2254.0

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
I1-630-0138	7	1	38	6.36	1.051	84453.1	5469.5	84422.3	5457	80325.7	5192.2
I2-630-0142	7	1	42	6.36	1.073	85645	5469.2	85614.2	5456.7	79789.6	5085.5
O1-630-0314	7	3	14	6.43	0.884	75580.3	4733.8	75549.5	4721.3	85463.2	5340.8
O2-630-0325	7	3	25	6.43	0.885	74637.9	2431.6	74607.1	2419.1	84301.8	2733.4
O3-630-0334	7	3	34	6.44	0.943	80006.6	5243.5	79975.8	5231	84810.0	5547.2
O4-630-0345	7	3	45	6.45	0.924	75680.2	2073.5	75649.4	2061	81871.6	2230.5
I3-630-0352	7	3	52	6.45	1.087	86376.5	5609.4	86345.7	5596.9	79434.9	5148.9
I4-630-0356	7	3	56	6.46	1.062	89263.7	5901.7	89232.9	5889.2	84023.4	5545.4
O1-630-0458	7	4	58	6.50	1.359	101174	6498.69	101143.2	6486.19	74424.7	4772.8
O2-630-0506	7	5	6	6.50	1.05	81916.5	2666.6	81885.7	2654.1	77986.4	2527.7
O3-630-0509	7	5	9	6.51	1.02	83757.2	5439.2	83726.4	5426.7	82084.7	5320.3
O4-630-0514	7	5	14	6.51	1.039	80450.8	2280.2	80420	2267.7	77401.3	2182.6
I1-630-0521	7	5	21	6.51	1.068	57072	5638.4	57041.2	5625.9	53409.4	5267.7
I2-630-0524	7	5	24	6.52	1.053	88819.7	5934.3	88788.9	5921.8	84319.9	5623.7
O1-630-0707	7	7	7	6.59	1.073	85268.6	5534.5	85237.8	5522	79438.8	5146.3
O2-630-0711	7	7	11	6.59	1.065	85071.2	2825.3	85040.4	2812.8	79850.1	2641.1
O3-630-0716	7	7	16	6.59	0.966	78953	5197.4	78922.2	5184.9	81700.0	5367.4
O4-630-0721	7	7	21	6.60	1.043	82182.2	2298.1	82151.4	2285.6	78764.5	2191.4
I3-630-0727	7	7	27	6.60	1.043	87537.2	5731	87506.4	5718.5	83898.8	5482.7
I4-630-0731	7	7	31	6.60	1.067	91011.8	6158.5	90981	6146	85268.0	5760.1
I1-630-0747	7	7	47	6.62	1.121	95285.4	6314.4	95254.6	6301.9	84972.9	5621.7
I2-630-0751	7	7	51	6.62	1.107	90774.8	6250	90744	6237.5	81972.9	5634.6
O1-630-0828	7	8	28	6.64	1.094	90631.5	5796.6	90600.7	5784.1	82816.0	5287.1
O2-630-0831	7	8	31	6.65	1.147	92088.2	3120.6	92057.4	3108.1	80259.3	2709.8
O3-630-0835	7	8	35	6.65	1.084	89810.1	5902.8	89779.3	5890.3	82822.2	5433.9
O4-630-0838	7	8	38	6.65	1.14	89098.4	2530.1	89067.6	2517.6	78129.5	2208.4
O1-630-1000	7	10	0	6.71	1.123	89540.3	5750.1	89509.5	5737.6	79705.7	5109.2
O2-630-1003	7	10	3	6.71	1.109	90515.8	2952.1	90485	2939.6	81591.5	2650.7
O3-630-1009	7	10	9	6.71	1.076	88916.1	5831	88885.3	5818.5	82607.2	5407.5
O4-630-1012	7	10	12	6.72	1.148	96404.7	2776.2	96373.9	2763.7	83949.4	2407.4
I3-630-1045	7	10	45	6.74	1.128	94603	6071.6	94572.2	6059.1	83840.6	5371.5
I4-630-1047	7	10	47	6.74	1.144	95095.2	6358	95064.4	6345.5	83098.3	5546.8
I1-630-1056	7	10	56	6.75	1.104	105336	6949.16	105305.2	6936.66	95385.1	6283.2
I2-630-1058	7	10	58	6.75	1.171	99042.4	6476	99011.6	6463.5	84553.0	5519.6
O1-630-1137	7	11	37	6.78	1.101	86567.6	5855.2	86535.1	5843.8	78596.8	5307.7

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O2-630-1140	7	11	40	6.78	1.231	93140.1	3232.1	93107.6	3220.7	75635.7	2616.3
O3-630-1143	7	11	43	6.78	1.122	91759.2	6082	91726.7	6070.6	81752.9	5410.5
O4-630-1146	7	11	46	6.78	1.145	90133	2431.3	90100.5	2419.9	78690.4	2113.4
O1-630-1312	7	13	12	6.84	1.158	92307.9	6128.1	92275.4	6116.7	79685.1	5282.1
O2-630-1315	7	13	15	6.84	1.15	88038.5	2817.7	88006	2806.3	76527.0	2440.3
O3-630-1318	7	13	18	6.85	1.157	91251.4	6037.2	91218.9	6025.8	78840.9	5208.1
O4-630-1321	7	13	21	6.85	1.195	92483.5	2620.4	92451	2609	77364.9	2183.3
I1-630-1438	7	14	38	6.90	1.095	86955.4	5415.7	86922.9	5404.3	79381.6	4935.4
I2-630-1440	7	14	40	6.90	1.136	89888.1	5480.8	89855.6	5469.4	79098.2	4814.6
I3-630-1441	7	14	41	6.90	1.031	90597.1	5807.9	90564.6	5796.5	87841.5	5622.2
I4-630-1443	7	14	43	6.90	0.981	83425.3	5364.9	83392.8	5353.5	85008.0	5457.2
O1-630-1500	7	15	0	6.92	1.103	86964.8	5668.7	86932.3	5657.3	78814.4	5129.0
O2-630-1502	7	15	2	6.92	1.151	87825.2	2869	87792.7	2857.6	76275.2	2482.7
O3-630-1505	7	15	5	6.92	1.126	90772.1	6071.9	90739.6	6060.5	80585.8	5382.3
O4-630-1508	7	15	8	6.92	1.13	89198.9	2661.6	89166.4	2650.2	78908.3	2345.3
O1-630-1643	7	16	43	6.99	0.945	79247.4	5189.6	79214.9	5178.2	83825.3	5479.6
O2-630-1646	7	16	46	6.99	0.997	89168.9	3102.6	89136.4	3091.2	89404.6	3100.5
O3-630-1649	7	16	49	6.99	1.23	92880.8	6222.9	92848.3	6211.5	75486.4	5050.0
O4-630-1652	7	16	52	6.99	1.175	91457.1	2841.9	91424.6	2830.5	77808.2	2408.9
I1-630-1715	7	17	15	7.01	1.123	92471.2	5648.7	92438.7	5637.3	82314.1	5019.9
I2-630-1717	7	17	17	7.01	1.199	98418	5969.8	98385.5	5958.4	82056.3	4969.5
I3-630-1806	7	18	6	7.05	1.079	89387.5	5254.5	89355	5243.1	82812.8	4859.2
I4-630-1811	7	18	11	7.05	1.074	83976.7	4944	83944.2	4932.6	78160.3	4592.7
O1-630-1836	7	18	36	7.07	1.06	88176.8	5524.3	88144.3	5512.9	83155.0	5200.8
O2-630-1841	7	18	41	7.07	1.055	84972.5	2990.9	84940	2979.5	80511.8	2824.2
O3-630-1844	7	18	44	7.07	1.065	87106.2	5473.3	87073.7	5461.9	81759.3	5128.5
O4-630-1849	7	18	49	7.08	1.02	82832.4	2618.9	82799.9	2607.5	81176.4	2556.4
O1-630-1959	7	19	59	7.12	1.07	87106.4	5409.7	87073.9	5398.3	81377.5	5045.1
O2-630-2003	7	20	3	7.13	1.041	83161	2918.7	83128.5	2907.3	79854.5	2792.8
O3-630-2006	7	20	6	7.13	1.066	86769.9	5547	86737.4	5535.6	81367.2	5192.9
O4-630-2009	7	20	9	7.13	1.068	83165.6	2578.2	83133.1	2566.8	77840.0	2403.4
I1-630-2022	7	20	22	7.14	1.072	85322.7	5303.2	85290.2	5291.8	79561.8	4936.4
I2-630-2025	7	20	25	7.14	1.071	82997.7	4889.6	82965.2	4878.2	77465.2	4554.8
I3-630-2114	7	21	14	7.18	1.076	83075.7	4793	83043.2	4781.6	77177.7	4443.9
I4-630-2117	7	21	17	7.18	1.065	86632.1	4884.7	86599.6	4873.3	81314.2	4575.9

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O1-630-2121	7	21	21	7.18	1.057	8674938	5326.2	8674906	5314.8	8207100.8	5028.2
O2-630-2124	7	21	24	7.18	1.028	82210.5	2855.9	82178	2844.5	79939.7	2767.0
O3-630-2127	7	21	27	7.19	0.991	84910.7	5152	84878.2	5140.6	85649.0	5187.3
O4-630-2132	7	21	32	7.19	1.062	82356.8	2512.7	82324.3	2501.3	77518.2	2355.3
O1-630-2251	7	22	51	7.24	1.054	85833.8	5246.5	85801.3	5235.1	81405.4	4966.9
O2-630-2255	7	22	55	7.25	1.047	83702	2965.5	83669.5	2954.1	79913.6	2821.5
O3-630-2259	7	22	59	7.25	1.057	86866.6	5393.6	86834.1	5382.2	82151.5	5092.0
O4-630-2302	7	23	2	7.25	1.079	85334.3	2616.7	85301.8	2605.3	79056.3	2414.6
I1-630-2313	7	23	13	7.26	1.069	85481.9	5083.1	85449.4	5071.7	79934.0	4744.3
I2-630-2316	7	23	16	7.26	1.053	84133.5	5142.9	84101	5131.5	79868.0	4873.2
O1-701-0115	8	1	15	7.34	0.911	79181.3	4922.4	79148.8	4911	86881.2	5390.8
O2-701-0122	8	1	22	7.35	0.89	73676.5	2438.3	73644	2426.9	82746.1	2726.9
O3-701-0129	8	1	29	7.35	0.899	74947.6	4634	74915.1	4622.6	83331.6	5141.9
O4-701-0138	8	1	38	7.36	0.975	77791.8	2222.6	77759.3	2211.2	79753.1	2267.9
I3-701-0144	8	1	44	7.36	1.085	85848.3	4994.1	85815.8	4982.7	79092.9	4592.4
I4-701-0148	8	1	48	7.37	0.087	90023.9	5338.7	89991.4	5327.3	1034383.9	61233.3
I1-701-0203	8	2	3	7.38	1	87697.2	5194.3	87664.7	5182.9	87664.7	5182.9
I2-701-0207	8	2	7	7.38	1.168	94020	5833.9	93987.5	5822.5	80468.8	4985.0
O1-701-0310	8	3	10	7.42	1.014	82141.6	5096.3	82109.1	5084.9	80975.4	5014.7
O2-701-0315	8	3	15	7.43	1.051	84707.8	2870.2	84675.3	2858.8	80566.4	2720.1
O4-701-0319	8	3	19	7.43	1.021	81364.7	2356.5	81332.2	2345.1	79659.4	2296.9
O1-701-0435	8	4	35	7.48	1.07	86834.3	5288.2	86801.8	5276.8	81123.2	4931.6
O2-701-0440	8	4	40	7.49	1.076	85823.1	2898.7	85790.6	2887.3	79731.0	2683.4
O3-701-0446	8	4	46	7.49	1.031	85762.7	5359	85730.2	5347.6	83152.5	5186.8
O4-701-0451	8	4	51	7.49	0.922	81664.8	2426.3	81632.3	2414.9	88538.3	2619.2
I1-701-0515	8	5	15	7.51	1.164	95635	5811.7	95602.5	5800.3	82132.7	4983.1
I2-701-0518	8	5	18	7.51	1.055	87854	5442.2	87821.5	5430.8	83243.1	5147.7
I3-701-0521	8	5	21	7.51	1.081	90042.4	5615.2	90009.9	5603.8	83265.4	5183.9
I4-701-0525	8	5	25	7.52	1.03	88416.7	5415.9	88384.2	5404.5	85809.9	5247.1
O2-701-0610	8	6	10	7.55	1.065	87279.7	3046.2	87247.2	3034.8	81922.3	2849.6
O3-701-0615	8	6	15	7.55	1.063	84219	5134.4	84186.5	5123	79197.1	4819.4
O4-701-0621	8	6	21	7.56	1.022	80209.7	2389.9	80177.2	2378.5	78451.3	2327.3
O1-701-0803	8	8	3	7.63	1.078	87835.7	5255.2	87803.2	5243.8	81450.1	4864.4
O2-701-0808	8	8	8	7.63	1.085	85589.7	2928.5	85557.2	2917.1	78854.6	2688.6
o3-701-0814	8	8	14	7.63	0.992	82412.1	4926.4	82379.6	4915	83044.0	4954.6

Sampling Data

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o4-701-0818	8	8	18	7.64	1.033	80643.6	2491.1	80611.1	2479.7	78035.9	2400.5
I2-701-0844	8	8	44	7.66	1.064	85818.6	5705.4	85788.5	5693.9	80628.3	5351.4
I1-701-0848	8	8	48	7.66	1.169	77932.9	5664.1	77902.8	5652.6	66640.5	4835.4
I4-701-0858	8	8	58	7.67	1.038	74807.5	5262.9	74777.4	5251.4	72039.9	5059.2
I3-701-0900	8	9	0	7.67	0.907	74670.3	4815.8	74640.2	4804.3	82293.5	5296.9
O1-701-0941	8	9	41	7.70	1.161	91820.7	5998.1	91790.6	5986.6	79061.7	5156.4
O2-701-0944	8	9	44	7.70	1.008	80532.7	3083.7	80502.6	3072.2	79863.7	3047.8
O3-701-0947	8	9	47	7.70	1.01	80033.7	5092.7	80003.6	5081.2	79211.5	5030.9
O4-701-0950	8	9	50	7.70	0.81	64713.1	2204.4	64683	2192.9	79855.6	2707.3
I1-701-1204	8	12	4	7.79	0.915	71100.3	4473.3	71070.2	4461.8	77672.3	4876.3
I2-701-1207	8	12	7	7.80	0.885	69218.1	4449.2	69188	4437.7	78178.5	5014.4
O1-701-1210	8	12	10	7.80	1.059	84918.9	5335.8	84888.8	5324.3	80159.4	5027.7
O2-701-1213	8	12	13	7.80	1.045	86243.4	3034.9	86213.3	3023.4	82500.8	2893.2
I3-701-1220	8	12	20	7.81	1.138	84785.4	5646.9	84755.3	5635.4	74477.4	4952.0
I4-701-1223	8	12	23	7.81	1.017	71305.6	4811.1	71275.5	4799.6	70084.1	4719.4
O3-701-1225	8	12	25	7.81	0.86	72350.9	4376.8	72320.8	4365.3	84094.0	5075.9
O4-701-1227	8	12	27	7.81	1.096	87070.5	2895.2	87040.4	2883.7	79416.4	2631.1
O1-701-1403	8	14	3	7.88	1.054	88406.3	5461.6	88376.2	5450.1	83848.4	5170.9
O2-701-1406	8	14	6	7.88	1.09	78005.9	3097.4	77975.8	3085.9	71537.4	2831.1
O3-701-1409	8	14	9	7.88	0.904	77257.5	4679.7	77227.4	4668.2	85428.5	5163.9
O4-701-1411	8	14	11	7.88	1.051	84700.5	2865.2	84670.4	2853.7	80561.8	2715.2
I1-701-1529	8	15	29	7.94	0.839	70975	4369.1	70944.9	4357.6	84558.9	5193.8
I2-701-1531	8	15	31	7.94	1.029	78476.4	4849.9	78446.3	4838.4	76235.5	4702.0
O1-701-1534	8	15	34	7.94	1.19	88762.7	5829.2	88732.6	5817.7	74565.2	4888.8
O2-701-1537	8	15	37	7.94	1.054	86597.2	3073	86567.1	3061.5	82132.0	2904.6
I3-701-1544	8	15	44	7.95	0.892	75450.7	4673.9	75420.6	4662.4	84552.2	5226.9
I4-701-1550	8	15	50	7.95	1.141	91230	5820.7	91199.9	5809.2	79929.8	5091.3
O3-701-1554	8	15	54	7.95	1.068	87330.6	5436.7	87300.5	5425.2	81742.0	5079.8
O4-701-1557	8	15	57	7.96	1.054	78449.5	2830.4	78419.4	2818.9	74401.7	2674.5
O1-701-1718	8	17	18	8.01	1.138	93777.3	5534.6	93747.2	5523.1	82378.9	4853.3
O2-701-1721	8	17	21	8.01	1.335	91036.5	3057.4	91006.4	3045.9	68169.6	2281.6
O3-701-1725	8	17	25	8.02	1.049	86016	5204	85985.9	5192.5	81969.4	4950.0
O4-701-1729	8	17	29	8.02	0.896	74025.9	2331.6	73995.8	2320.1	82584.6	2589.4
O1-701-1846	8	18	46	8.07	1.226	99857.2	6219.1	99827.1	6207.6	81425.0	5063.3
O2-701-1849	8	18	49	8.08	1.178	94555.2	3262.2	94525.1	3250.7	80242.0	2759.5

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O3-701-1852	8	18	52	8.08	1.099	89568.9	5533.2	89538.8	5521.7	81473.0	5024.3
O4-701-1854	8	18	54	8.08	1.108	87897.2	2893	87867.1	2881.5	79302.4	2600.6
I1-701-1842	8	18	42	8.07	1.092	87061.6	5201.2	87031.5	5189.7	79699.2	4752.5
I2-701-1844	8	18	44	8.07	1.045	88499.4	5320.1	88469.3	5308.6	84659.6	5080.0
I3-701-2009	8	20	9	8.13	1.204	99923	5964.9	99892.9	5953.4	82967.5	4944.7
I4-701-2011	8	20	11	8.13	1.195	97328.7	5716	97298.6	5704.5	81421.4	4773.6
O1-701-2015	8	20	15	8.14	1.007	57567.2	5253.1	57537.1	5241.6	57137.1	5205.2
O2-701-2021	8	20	21	8.14	1.177	90563.7	3128.8	90533.6	3117.3	76918.9	2648.5
O3-701-2023	8	20	23	8.14	0.893	74262.1	4528.8	74232	4517.3	83126.5	5058.6
O4-701-2026	8	20	26	8.14	1.156	90347.6	2991.3	90317.5	2979.8	78129.3	2577.7
O1-701-2148	8	21	48	8.20	1.142	91157.7	5766.6	91127.6	5755.1	79796.5	5039.5
O2-701-2151	8	21	51	8.20	1.218	94222	3336.8	94191.9	3325.3	77333.3	2730.1
O3-701-2154	8	21	54	8.20	1.25	97432.9	6181.4	97402.8	6169.9	77922.2	4935.9
O4-701-2157	8	21	57	8.21	1.192	92733.7	3104.4	92703.6	3092.9	77771.5	2594.7
O1-701-2310	8	23	10	8.26	1.187	95065.8	6099.2	95035.7	6087.7	80063.8	5128.6
O2-701-2312	8	23	12	8.26	1.159	89200.9	3209.1	89170.8	3197.6	76937.7	2758.9
O3-701-2315	8	23	15	8.26	1.113	90896.4	5698.7	90866.3	5687.2	81640.9	5109.8
O4-701-2317	8	23	17	8.26	1.15	89856.6	3088.8	89826.5	3077.3	78110.0	2675.9
I1-701-2306	8	23	6	8.25	1.115	92646	5400	92615.9	5388.5	83063.6	4832.7
I2-701-2308	8	23	8	8.26	0.885	86418.2	5070.4	86388.1	5058.9	97613.7	5716.3
I3-701-2325	8	23	25	8.27	1.103	90247	5429.9	90216.9	5418.4	81792.3	4912.4
I4-701-2327	8	23	27	8.27	1.116	92979.1	5567.2	92949	5555.7	83287.6	4978.2
O1-702-0045	9	0	45	8.32	1.066	87109.4	5422	87079.3	5410.5	81687.9	5075.5
O2-702-0053	9	0	53	8.33	1.15	88736.5	3196.3	88706.4	3184.8	77136.0	2769.4
O3-702-0058	9	0	58	8.33	1.102	88060.4	5457.3	88030.3	5445.8	79882.3	4941.7
O4-702-0100	9	1	0	8.33	1.074	84536.2	2860.9	84506.1	2849.4	78683.5	2653.1
I1-702-0118	9	1	18	8.35	0.966	88255	5211.4	88224.9	5199.9	91330.1	5382.9
I2-702-0123	9	1	23	8.35	1.104	92816.7	5557.3	92786.6	5545.8	84045.8	5023.4
O1-702-0220	9	2	20	8.39	1.041	85879.6	5333	85849.5	5321.5	82468.3	5111.9
O2-702-0230	9	2	30	8.40	1.138	84210.7	3049.8	84180.6	3038.3	73972.4	2669.9
O3-702-0240	9	2	40	8.40	0.878	75157.1	4613.4	75127	4601.9	85566.1	5241.3
O4-702-0248	9	2	48	8.41	0.93	77162.1	2563.2	77132	2551.7	82937.6	2743.8
I3-702-0310	9	3	10	8.42	1.072	83356.9	4914.8	83326.8	4903.3	77730.2	4574.0
I4-702-0315	9	3	15	8.43	1.042	86250.9	5235.1	86220.8	5223.6	82745.5	5013.1
O1-702-0356	9	3	56	8.46	1.066	92350.5	5644.2	92320.4	5632.7	86604.5	5284.0

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O2-709-0359	9	3	59	8.46	1.118	86486.9	3203.1	86456.8	3191.6	77331.7	2854.7
O3-702-0404	9	4	4	8.46	1.04	85145.4	5210.8	85115.3	5199.3	81841.6	4999.3
O4-702-0411	9	4	11	8.47	1.11	87456.6	3027.2	87426.5	3015.7	78762.6	2716.8
I1-702-0428	9	4	28	8.48	1.088	87420.1	5226	87390	5214.5	80321.7	4792.7
I2-702-0431	9	4	31	8.48	1.174	94641.1	5802	94611	5790.5	80588.6	4932.3
O1-702-0541	9	5	41	8.53	0.996	88433.8	5346.7	88404.6	5335.9	88759.6	5357.3
O2-702-0549	9	5	49	8.53	1.126	87374.6	3321.5	87345.4	3310.7	77571.4	2940.2
O3-702-0554	9	5	54	8.54	1.048	84808.6	5210.2	84779.4	5199.4	80896.4	4961.3
O4-702-0559	9	5	59	8.54	1.035	84654.5	2985.2	84625.3	2974.4	81763.6	2873.8
I3-702-0703	9	7	3	8.59	1.101	90057.3	5499.8	90028.1	5489	81769.4	4985.5
I4-702-0707	9	7	7	8.59	1.057	86728.2	5254.3	86699	5243.5	82023.7	4960.7
O1-702-0713	9	7	13	8.59	1.09	86966.3	5228.9	86937.1	5218.1	79758.8	4787.2
O2-702-0719	9	7	19	8.60	1.1	86815.1	3323.6	86785.9	3312.8	78896.3	3011.6
O3-702-0724	9	7	24	8.60	1.027	83289.2	4974.3	83260	4963.5	81071.1	4833.0
O4-702-0730	9	7	30	8.60	1.068	86180	3036.8	86150.8	3026	80665.5	2833.3
I1-702-0750	9	7	50	8.62	1.032	81252.5	4881.9	81223.3	4871.1	78704.7	4720.1
I2-702-0753	9	7	53	8.62	1.002	82045.5	4886.8	82016.3	4876	81852.6	4866.3
O1-702-0832	9	8	32	8.65	1.034	80740.8	4722.9	80711.6	4712.1	78057.6	4557.2
O2-702-0835	9	8	35	8.65	0.961	77314.2	2893.8	77285	2883	80421.4	3000.0
O3-702-0840	9	8	40	8.65	0.948	81021.7	4817.5	80992.5	4806.7	85435.1	5070.4
O4-702-0844	9	8	44	8.66	0.944	80833.1	2906.3	80803.9	2895.5	85597.4	3067.3
O1-702-1000	9	10	0	8.71	0.98	83750.9	4754.6	83721.7	4743.8	85430.3	4840.6
O2-702-1002	9	10	2	8.71	0.999	80768.8	2909.6	80739.6	2898.8	80820.4	2901.7
O3-702-1004	9	10	4	8.71	1.011	83430.5	4899	83401.3	4888.2	82493.9	4835.0
O4-702-1008	9	10	8	8.71	1.036	85302.5	3002.5	85273.3	2991.7	82310.1	2887.7
I1-702-1038	9	10	38	8.73	1.012	85082.4	4880.7	85053.2	4869.9	84044.7	4812.2
I2-702-1040	9	10	40	8.74	0.97	83253.4	4919.7	83224.2	4908.9	85798.1	5060.7
I3-702-1042	9	10	42	8.74	1.013	84057.1	4955.9	84027.9	4945.1	82949.6	4881.6
I4-702-1046	9	10	46	8.74	1.035	88081.7	5271.3	88052.5	5260.5	85074.9	5082.6
O1-702-1124	9	11	24	8.77	1.025	86419.1	5261	86389.9	5250.2	84282.8	5122.1
O2-702-1126	9	11	26	8.77	0.99	80983	2835.6	80953.8	2824.8	81771.5	2853.3
O3-702-1128	9	11	28	8.77	1	80008.7	4682.3	79979.5	4671.5	79979.5	4671.5
O4-702-1130	9	11	30	8.77	0.97	79046.8	2532.7	79017.6	2521.9	81461.4	2599.9
O1-702-1300	9	13	0	8.83	1.044	87667.3	4913.4	87638.1	4902.6	83944.5	4696.0
O2-702-1301	9	13	1	8.83	1.098	89626	3092.9	89596.8	3082.1	81600.0	2807.0

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O3-702-1302	9	13	2	8.83	1.06	87540.6	4889.7	87511.4	4878.9	82557.9	4602.7
O4-702-1304	9	13	4	8.84	1.069	85535.2	2909.4	85506	2898.6	79986.9	2711.5
I1-702-1416	9	14	16	8.89	1.114	93367.2	5578.4	93338	5567.6	83786.4	4997.8
I2-702-1418	9	14	18	8.89	1.069	85763.6	4660.9	85734.4	4650.1	80200.6	4350.0
I3-702-1421	9	14	21	8.89	1.078	88139.5	5029.2	88110.3	5018.4	81735.0	4655.3
I4-702-1424	9	14	24	8.89	1.057	87142.2	4734.9	87113	4724.1	82415.3	4469.3
O1-702-1434	9	14	34	8.90	1.041	83711.1	4964	83681.9	4953.2	80386.1	4758.1
O2-702-1435	9	14	35	8.90	1.033	82529.7	2909.8	82500.5	2899	79865.0	2806.4
O3-702-1436	9	14	36	8.90	1.079	88859.5	5153.1	88830.3	5142.3	82326.5	4765.8
O4-702-1437	9	14	37	8.90	1.055	82805.6	2796.8	82776.4	2786	78461.0	2640.8
O1-702-1604	9	16	4	8.96	1.065	83757.4	4730.8	83728.2	4720	78618.0	4431.9
O2-702-1605	9	16	5	8.96	1.308	101828	3636.93	101798.8	3626.13	77827.8	2772.3
O3-702-1606	9	16	6	8.96	1.034	84517.8	4945.7	84488.6	4934.9	81710.4	4772.6
O4-702-1608	9	16	8	8.96	1.082	87530.3	2885.3	87501.1	2874.5	80869.8	2656.7
I1-702-1754	9	17	54	9.04	1.101	88361.5	4805.8	88332.3	4795	80229.2	4355.1
I2-702-1756	9	17	56	9.04	0.996	87070.1	4921.7	87040.9	4910.9	87390.5	4930.6
I3-702-1758	9	17	58	9.04	0.997	85515.9	4935.9	85486.7	4925.1	85743.9	4939.9
I4-702-1800	9	18	0	9.04	0.984	81756.9	4606.5	81727.7	4595.7	83056.6	4670.4
O1-702-1808	9	18	8	9.05	0.965	81272.2	4878.1	81243	4867.3	84189.6	5043.8
O2-702-1810	9	18	10	9.05	1.031	88073.6	3483.8	88044.4	3473	85397.1	3368.6
O3-702-1811	9	18	11	9.05	0.975	85862.5	4954.2	85833.3	4943.4	88034.2	5070.2
O4-702-1813	9	18	13	9.05	0.977	81541.4	2769.5	81512.2	2758.7	83431.1	2823.6
O1-702-1919	9	19	19	9.10	1.04	86516.5	5075.8	86487.3	5065	83160.9	4870.2
O2-702-1920	9	19	20	9.10	1.039	87022.9	3314.3	86993.7	3303.5	83728.3	3179.5
O3-702-1922	9	19	22	9.10	1.055	88892.8	5141.7	88863.6	5130.9	84230.9	4863.4
O4-702-1924	9	19	24	9.10	1.057	89149.7	3162.9	89120.5	3152.1	84314.6	2982.1
O1-702-2034	9	20	34	9.15	1.234	101787	6088.1	101757.8	6077.3	82461.8	4924.9
O2-702-2036	9	20	36	9.15	1.268	95705.5	3420.5	95676.3	3409.7	75454.5	2689.0
O3-702-2039	9	20	39	9.15	1.06	94607.5	5649.2	94578.3	5638.4	89224.8	5319.2
O4-702-2041	9	20	41	9.15	1.257	103417	3702.9	103387.8	3692.1	82249.6	2937.2
O1-702-2159	9	21	59	9.21	1.197	95582.5	5672.3	95553.3	5661.5	79827.3	4729.7
O2-702-2201	9	22	1	9.21	1.203	94144.2	3358.3	94115	3347.5	78233.6	2782.6
O3-702-2204	9	22	4	9.21	1.146	90814.8	5322.5	90785.6	5311.7	79219.5	4635.0
O4-702-2206	9	22	6	9.21	1.166	90942.7	3249.4	90913.5	3238.6	77970.4	2777.5
O1-702-2320	9	23	20	9.26	1.213	96487.5	5700.8	96458.3	5690	79520.4	4690.8

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O2-702-2323	9	23	23	9.27	1.205	78709.1	3456.8	78679.9	3446	65294.5	2859.8
O3-702-2325	9	23	25	9.27	1.205	95899.8	5631.5	95870.6	5620.7	79560.7	4664.5
O4-702-2327	9	23	27	9.27	1.167	90037.4	3483.2	90008.2	3472.4	77127.8	2975.5
O1-703-0105	10	1	5	9.34	0.933	78320.3	4470.4	78291.1	4459.6	83913.3	4779.8
O2-703-0111	10	1	11	9.34	0.985	54803.8	3024.9	54774.6	3014.1	55608.7	3060.0
O3-703-0119	10	1	19	9.35	0.965	82759.3	4777.1	82730.1	4766.3	85730.7	4939.2
O4-703-0124	10	1	24	9.35	1.006	62267.1	3251.5	62237.9	3240.7	61866.7	3221.4
O1-703-0238	10	2	38	9.40	1.252	87776	4954.5	87746.8	4943.7	70085.3	3948.6
O2-703-0243	10	2	43	9.40	1.034	43936.5	3094.7	43907.3	3083.9	42463.5	2982.5
O3-703-0248	10	2	48	9.41	1.02	85670.6	4881.1	85641.4	4870.3	83962.2	4774.8
O4-703-0254	10	2	54	9.41	1.059	52384.1	3167	52354.9	3156.2	49438.1	2980.4
O1-703-0408	10	4	8	9.46	1.206	94444.1	5232.1	94414.9	5221.3	78287.6	4329.4
O2-703-0413	10	4	13	9.47	1.042	36143.2	2972.5	36114	2961.7	34658.3	2842.3
O3-703-0418	10	4	18	9.47	1.084	89447.2	5031.6	89418	5020.8	82488.9	4631.7
O4-703-0423	10	4	23	9.47	1.041	40035.7	3102	40006.5	3091.2	38430.8	2969.5
O1-703-0525	10	5	25	9.52	0.661	85260.9	3976.7	85231.7	3965.9	128943.6	5999.8
O2-703-0532	10	5	32	9.52	1.099	32615	3092.4	32585.8	3081.6	29650.4	2804.0
O3-703-0538	10	5	38	9.53	1.082	88400.7	4622.1	88371.5	4611.3	81674.2	4261.8
O4-703-0543	10	5	43	9.53	1.087	34387.4	3115	34358.2	3104.2	31608.3	2855.7
O1-703-0718	10	7	18	9.60	1.588	51917	2116	51887.8	2105.2	32674.9	1325.7
O2-703-0723	10	7	23	9.60	1.037	26508.7	2752.6	26479.5	2741.8	25534.7	2644.0
O3-703-0729	10	7	29	9.60	1.041	56341.3	2753.6	56312.1	2742.8	54094.2	2634.8
O4-703-0734	10	7	34	9.61	1.107	24115.1	2960	24085.9	2949.2	21757.8	2664.1
O1-703-0902	10	9	2	9.67	0.921	10707.2	657.1	10673.6	645.5	11589.1	700.9
O2-703-0905	10	9	5	9.67	1.023	18943.5	2609.3	18909.9	2597.7	18484.8	2539.3
O3-703-0907	10	9	7	9.67	1.076	15010.3	1468.2	14976.7	1456.6	13918.9	1353.7
O4-703-0910	10	9	10	9.67	1.071	15643.9	2720.6	15610.3	2709	14575.4	2529.4
O1-703-1039	10	10	39	9.74	0.986	2756.5	358.6	2722.9	347	2761.6	351.9
O2-703-1044	10	10	44	9.74	0.875	15438.7	2164.5	15405.1	2152.9	17605.8	2460.5
O3-703-1049	10	10	49	9.74	1	4118.4	755.4	4084.8	743.8	4084.8	743.8
O4-703-1053	10	10	53	9.75	1.043	14911.5	2519.7	14877.9	2508.1	14264.5	2404.7
O1-703-1149	10	11	49	9.78	1.23	1213.6	306.6	1180	295	959.3	239.8
O2-703-1152	10	11	52	9.79	0.834	13503.2	1987.1	13469.6	1975.5	16150.6	2368.7
O3-703-1154	10	11	54	9.79	0.844	1839.3	466	1805.7	454.4	2139.5	538.4
O4-703-1157	10	11	57	9.79	0.968	13781.8	2176.6	13748.2	2165	14202.7	2236.6

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O1-703-1356	10	13	56	9.87	0.875	476.6	161.3	443	149.7	506.3	171.1
O2-703-1359	10	13	59	9.87	0.825	11158.8	1887.4	11125.2	1875.8	13485.1	2273.7
O3-703-1401	10	14	1	9.88	1.03	1281.8	374.3	1248.2	362.7	1211.8	352.1
O4-703-1404	10	14	4	9.88	0.862	10329	1998.4	10295.4	1986.8	11943.6	2304.9
O1-703-1502	10	15	2	9.92	1.03	481.8	170.6	448.2	159	435.1	154.4
O2-703-1504	10	15	4	9.92	0.994	11745.8	2121.6	11712.2	2110	11782.9	2122.7
O3-703-1507	10	15	7	9.92	1.047	1017.2	308.6	983.6	297	939.4	283.7
O4-703-1509	10	15	9	9.92	1.009	10915.2	2312.8	10881.6	2301.2	10784.5	2280.7
O1-703-1712	10	17	12	10.01	1.079	359.6	145.5	326	133.9	302.1	124.1
O2-703-1712	10	17	12	10.01	1.088	9926.6	2216.2	9893	2204.6	9092.8	2026.3
O3-703-1713	10	17	13	10.01	1.077	955.1	239.3	921.5	227.7	855.6	211.4
O4-703-1714	10	17	14	10.01	1.1	10921.7	2322.9	10888.1	2311.3	9898.3	2101.2
O1-703-1807	10	18	7	10.05	1.107	344.2	141.8	310.6	130.2	280.6	117.6
O2-703-1807	10	18	7	10.05	1.067	8908.7	2189.1	8875.1	2177.5	8317.8	2040.8
O3-703-1808	10	18	8	10.05	1.018	847.1	223.4	813.5	211.8	799.1	208.1
O4-703-1808	10	18	8	10.05	1.038	9406.1	2164.7	9372.5	2153.1	9029.4	2074.3
O1-703-1936	10	19	36	10.11	1.038	261.7	121.5	228.1	109.9	219.7	105.9
O2-703-1937	10	19	37	10.11	1.087	8254	2248.3	8220.4	2236.7	7562.5	2057.7
O3-703-1938	10	19	38	10.11	1.031	647.8	198.3	614.2	186.7	595.7	181.1
O4-703-1938	10	19	38	10.11	1.081	9514.7	2302.4	9481.1	2290.8	8770.7	2119.1
O1-703-2108	10	21	8	10.17	1.026	328.7	164	295.1	152.4	287.6	148.5
O2-703-2109	10	21	9	10.17	1.03	7582.5	2134.3	7548.9	2122.7	7329.0	2060.9
O3-703-2111	10	21	11	10.17	1.017	598.6	215.3	565	203.7	555.6	200.3
O4-703-2112	10	21	12	10.18	1.059	9396.1	2291.1	9362.5	2279.5	8840.9	2152.5
O1-703-2234	10	22	34	10.23	1.144	412.4	199.9	378.8	188.3	331.1	164.6
O2-703-2235	10	22	35	10.23	1.056	6695	2109.1	6661.4	2097.5	6308.1	1986.3
O3-703-2236	10	22	36	10.23	1.067	987.8	296.2	954.2	284.6	894.3	266.7
O4-703-2237	10	22	37	10.23	1.123	9224.9	2355.8	9191.3	2344.2	8184.6	2087.4
O1-704-0002	11	0	2	10.29	1.059	781.2	258.6	747.6	247	705.9	233.2
O2-704-0003	11	0	3	10.29	1.048	6034.7	2116.4	6001.1	2104.8	5726.2	2008.4
O3-704-0004	11	0	4	10.29	0.997	507.9	208	474.3	196.4	475.7	197.0
O4-704-0007	11	0	7	10.30	1.075	8352.8	2153.1	8319.2	2141.5	7738.8	1992.1
O1-704-0139	11	1	39	10.36	1.028	213.5	105.9	179.9	94.3	175.0	91.7
O2-704-0145	11	1	45	10.36	1.271	6588.8	2453	6555.2	2441.4	5157.5	1920.8
O3-704-0153	11	1	53	10.37	0.972	273.9	131.2	240.3	119.6	247.2	123.0

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O4-704-0201	11	2	1	10.38	0.947	6144.4	1963.3	6110.8	1951.7	6452.8	2060.9
O1-704-0308	11	3	8	10.42	1.002	197.1	102.9	169.6	91.7	169.3	91.5
O2-704-0313	11	3	13	10.43	1.033	4981.5	2100.1	4954	2088.9	4795.7	2022.2
O3-704-0317	11	3	17	10.43	1.051	246.4	121.2	218.9	110	208.3	104.7
O4-704-0322	11	3	22	10.43	1.09	6781.5	2216.6	6754	2205.4	6196.3	2023.3
O1-704-0441	11	4	41	10.49	1.087	217.9	114	190.4	102.8	175.2	94.6
O2-704-0442	11	4	42	10.49	1.088	4907.1	2094.1	4879.6	2082.9	4484.9	1914.4
O3-704-0450	11	4	50	10.49	1.059	226.5	115.2	199	104	187.9	98.2
O4-704-0454	11	4	54	10.50	1.104	6717.9	2267.8	6690.4	2256.6	6060.1	2044.0
O1-704-0610	11	6	10	10.55	1.124	218.7	117.7	191.2	106.5	170.1	94.8
O2-704-0615	11	6	158	10.65	1.124	4730.7	2075	4703.2	2063.8	4184.3	1836.1
O3-704-0619	11	6	19	10.55	1.111	212.6	100.5	185.1	89.3	166.6	80.4
O4-704-0624	11	6	24	10.56	1.08	6226.5	2153	6199	2141.8	5739.8	1983.1
O1-704-0733	11	7	33	10.61	1.083	213.5	105.9	186	94.7	171.7	87.4
O2-704-0737	11	7	37	10.61	1.046	4369.6	1987.6	4342.1	1976.4	4151.1	1889.5
O3-704-0742	11	7	42	10.61	1.061	187.6	96	160.1	84.8	150.9	79.9
O4-704-0747	11	7	47	10.62	1.078	5966.5	2148.4	5939	2137.2	5509.3	1982.6
O1-704-0902	11	9	2	10.67	0.996	170	97	142.5	85.8	143.1	86.1
O2-704-0905	11	9	5	10.67	1	3752.7	1825.2	3725.2	1814	3725.2	1814.0
O3-704-0908	11	9	8	10.67	0.954	161.7	82.8	134.2	71.6	140.7	75.1
O4-704-0910	11	9	10	10.67	0.946	5168.1	1816.5	5140.6	1805.3	5434.0	1908.4
O1-704-1026	11	10	26	10.73	1.07	196.8	108.2	169.3	97	158.2	90.7
O2-704-1028	11	10	28	10.73	0.945	3570.4	1870	3542.9	1858.8	3749.1	1967.0
O3-704-1030	11	10	30	10.73	0.738	168.1	92.8	140.6	81.6	190.5	110.6
O4-704-1032	11	10	32	10.73	0.994	5488	2039.3	5460.5	2028.1	5493.5	2040.3
O1-704-1158	11	11	58	10.79	0.95	192.8	109.2	165.3	98	174.0	103.2
O2-704-1200	11	12	0	10.79	1.046	3657.3	1866.8	3629.8	1855.6	3470.2	1774.0
O3-704-1202	11	12	2	10.79	0.751	170.8	94.8	143.3	83.6	190.8	111.3
O4-704-1204	11	12	4	10.79	0.979	5117.2	2057.5	5089.7	2046.3	5198.9	2090.2
O1-704-1328	11	13	28	10.85	0.968	185.3	96.3	157.8	85.1	163.0	87.9
O2-704-1330	11	13	30	10.85	0.993	3304.6	1836.4	3277.1	1825.2	3300.2	1838.1
O3-704-1332	11	13	32	10.86	0.872	163.3	90.9	135.8	79.7	155.7	91.4
O4-704-1334	11	13	34	10.86	0.982	4917.6	2080.5	4890.1	2069.3	4979.7	2107.2
O1-704-1508	11	15	8	10.92	1.077	192.5	104.5	165	93.3	153.2	86.6
O2-704-1511	11	15	11	10.92	0.984	3077.7	1773.6	3050.2	1762.4	3099.8	1791.1

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O3-704-1515	11	15	15	10.93	0.987	205.4	110.8	177.9	99.6	180.2	100.9
O4-704-1517	11	15	17	10.93	0.962	4666.3	2022.5	4638.8	2011.3	4822.0	2090.7
O1-704-1633	11	16	33	10.98	1.142	163.5	85.1	136	73.9	119.1	64.7
O2-704-1634	11	16	34	10.98	1.039	3153.3	1789.1	3125.8	1777.9	3008.5	1711.2
O3-704-1635	11	16	35	10.98	0.944	174.5	98	147	86.8	155.7	91.9
O4-704-1636	11	16	36	10.98	1.026	4823.6	2156.2	4796.1	2145	4674.6	2090.6
O1-704-1805	11	18	5	11.05	0.994	150.9	77.2	123.4	66	124.1	66.4
O2-704-1806	11	18	6	11.05	1.026	3063.7	1730.5	3036.2	1719.3	2959.3	1675.7
O3-704-1807	11	18	7	11.05	0.964	142	78.7	114.5	67.5	118.8	70.0
O4-704-1808	11	18	8	11.05	1.047	4623.2	1953.8	4595.7	1942.6	4389.4	1855.4
O1-704-1940	11	19	40	11.11	1.01	145.5	75.6	118	64.4	116.8	63.8
O2-704-1942	11	19	42	11.11	0.981	2668.7	1599.2	2641.2	1588	2692.4	1618.8
O3-704-1943	11	19	43	11.11	0.997	129.9	66.9	102.4	55.7	102.7	55.9
O4-704-1944	11	19	44	11.11	1.063	4615.2	1526.2	4587.7	1515	4315.8	1425.2
O1-704-2026	11	20	26	11.14	1.346	161.2	76.4	133.7	65.2	99.3	48.4
O2-704-2028	11	20	28	11.14	1.176	3238.6	1874.2	3211.1	1863	2730.5	1584.2
O3-704-2030	11	20	30	11.15	1.19	147.3	72	119.8	60.8	100.7	51.1
O4-704-2032	11	20	32	11.15	0.979	5253.9	2000.3	5226.4	1989.1	5338.5	2031.8
O1-704-2226	11	22	26	11.23	1.183	141.6	71.4	114.1	60.2	96.4	50.9
O2-704-2229	11	22	29	11.23	1.114	3078	1863.3	3050.5	1852.1	2738.3	1662.6
O3-704-2231	11	22	31	11.23	1.171	130.3	74.2	102.8	63	87.8	53.8
O4-704-2233	11	22	33	11.23	1.378	5753.4	2629.9	5725.9	2618.7	4155.2	1900.4
O1-704-2328	11	23	28	11.27	1.196	139.3	66.2	111.8	55	93.5	46.0
O2-704-2331	11	23	31	11.27	1.115	3090.7	1744.4	3063.2	1733.2	2747.3	1554.4
O3-704-2334	11	23	34	11.27	1.02	128.4	61	100.9	49.8	98.9	48.8
O4-704-2337	11	23	37	11.28	1.148	4923	2204.5	4895.5	2193.3	4264.4	1910.5
O1-705-0108	12	1	8	11.34	1.002	109.1	51.9	81.6	40.7	81.4	40.6
O2-705-0117	12	1	17	11.35	0.945	2951.3	1819.5	2923.8	1808.3	3094.0	1913.5
O3-705-0125	12	1	25	11.35	0.944	105.4	55.8	77.9	44.6	82.5	47.2
O4-705-0131	12	1	31	11.35	1.025	4092.9	2019.3	4065.4	2008.1	3966.2	1959.1
O1-705-0246	12	2	46	11.41	1.008	134.9	70.2	107.4	59	106.5	58.5
O2-705-0251	12	2	51	11.41	1.101	2884.7	1796.4	2857.2	1785.2	2595.1	1621.4
O3-705-0256	12	2	56	11.41	1.003	110.2	56.8	82.7	45.6	82.5	45.5
O4-705-0301	12	3	1	11.42	1.104	4215.5	2146.4	4188	2135.2	3793.5	1934.1
O1-705-0413	12	4	13	11.47	1.115	130	61	96.3	50	86.4	44.8

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O2-705-0417	12	4	17	11.47	1.075	2810.2	1785.7	2776.5	1774.7	2582.8	1650.9
O3-705-0421	12	4	21	11.47	1.046	110.7	51.2	77	40.2	73.6	38.4
O4-705-0426	12	4	26	11.48	1.169	4453.1	2251.5	4419.4	2240.5	3780.5	1916.6
O1-705-0627	12	6	27	11.56	1.072	129.3	68.9	95.6	57.9	89.2	54.0
O2-705-0632	12	6	32	11.56	0.067	2766.8	1684.7	2733.1	1673.7	40792.5	24980.6
O3-705-0636	12	6	36	11.57	1.088	108.7	56.8	75	45.8	68.9	42.1
O4-705-0640	12	6	40	11.57	1.073	3896.9	2012.8	3863.2	2001.8	3600.4	1865.6
O1-705-0830	12	8	30	11.65	0.961	120.5	67.3	86.8	56.3	90.3	58.6
O2-705-0832	12	8	32	11.65	0.944	2390.4	1504.9	2356.7	1493.9	2496.5	1582.5
O3-705-0834	12	8	34	11.65	0.905	93.4	44	59.7	33	66.0	36.5
O4-705-0836	12	8	36	11.65	0.971	3243.4	1685.5	3209.7	1674.5	3305.6	1724.5
O1-705-1026	12	10	26	11.73	0.938	109.4	58	75.7	47	80.7	50.1
O2-705-1028	12	10	28	11.73	1.03	2549.1	1528.5	2515.4	1517.5	2442.1	1473.3
O3-705-1030	12	10	30	11.73	0.949	96.4	48.6	62.7	37.6	66.1	39.6
O4-705-1032	12	10	32	11.73	0.958	3218.3	1819.1	3184.6	1808.1	3324.2	1887.4
O1-705-1230	12	12	30	11.81	0.962	116.5	66.9	82.8	55.9	86.1	58.1
O2-705-1232	12	12	32	11.81	0.901	2178.7	1466.2	2145	1455.2	2380.7	1615.1
O3-705-1235	12	12	35	11.82	0.901	134.7	72.7	101	61.7	112.1	68.5
O4-705-1238	12	12	38	11.82	0.991	3266.8	1864	3233.1	1853	3262.5	1869.8
O1-705-1428	12	14	28	11.89	0.801	129.5	65.4	95.8	54.4	119.6	67.9
O2-705-1430	12	14	30	11.90	0.969	2500.2	1513.5	2466.5	1502.5	2545.4	1550.6
O3-705-1435	12	14	35	11.90	1.005	126.7	69.2	93	58.2	92.5	57.9
O4-705-1434	12	14	34	11.90	0.984	3257	1777.7	3223.3	1766.7	3275.7	1795.4
O1-705-1632	12	16	32	11.98	1.061	140.9	76.9	107.2	65.9	101.0	62.1
O2-705-1634	12	16	34	11.98	1.178	2785.3	1664.4	2751.6	1653.4	2335.8	1403.6
O3-705-1637	12	16	37	11.98	1.073	110.4	51.6	76.7	40.6	71.5	37.8
O4-705-1640	12	16	40	11.99	1.107	3363.2	1927.7	3329.5	1916.7	3007.7	1731.4
O1-705-1829	12	18	29	12.06	1.159	111	55.2	77.3	44.2	66.7	38.1
O2-705-1832	12	18	32	12.06	1.142	2581.7	1580.5	2548	1569.5	2231.2	1374.3
O3-705-1834	12	18	34	12.07	1.072	104	47.7	70.3	36.7	65.6	34.2
O4-705-1836	12	18	36	12.07	1.176	3480.8	1928.9	3447.1	1917.9	2931.2	1630.9
O1-705-2025	12	20	25	12.14	1.181	110	51.6	76.3	40.6	64.6	34.4
O2-705-2027	12	20	27	12.14	1.121	2498.1	1533.9	2464.4	1522.9	2198.4	1358.5
O3-705-2030	12	20	30	12.15	1.113	99.1	48.6	65.4	37.6	58.8	33.8
O4-705-2032	12	20	32	12.15	1.069	3008.5	1697.4	2974.8	1686.4	2782.8	1577.5

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O1-705-2227	12	22	27	12.23	0.99	83.6	43.9	55.8	31.7	56.4	32.0
O2-705-2232	12	22	32	12.23	0.968	2133.7	1407.7	2105.9	1395.5	2175.5	1441.6
O3-705-2236	12	22	36	12.23	0.942	88.4	42.1	60.6	29.9	64.3	31.7
O4-705-2241	12	22	41	12.24	0.981	2677.3	1617.1	2649.5	1604.9	2700.8	1636.0
O1-706-0036	13	0	36	12.32	0.984	91.9	44.4	64.1	32.2	65.1	32.7
O2-706-0039	13	0	39	12.32	1.04	2438.1	1433.4	2410.3	1421.2	2317.6	1366.5
O3-706-0045	13	0	45	12.32	0.977	98	53	70.2	40.8	71.9	41.8
O4-706-0051	13	0	51	12.33	0.98	2780.8	1702.2	2753	1690	2809.2	1724.5
O1-706-0235	13	2	35	12.40	0.998	98.1	54.4	70.3	42.2	70.4	42.3
O2-706-0239	13	2	39	12.40	0.982	2370.1	1430.9	2342.3	1418.7	2385.2	1444.7
O3-706-0243	13	2	43	12.40	0.984	94.7	53	66.9	40.8	68.0	41.5
O4-706-0249	13	2	49	12.41	0.984	2844.8	1693.2	2817	1681	2862.8	1708.3
O1-706-0428	13	4	28	12.48	0.962	101.1	48.1	73.3	35.9	76.2	37.3
O2-706-0432	13	4	32	12.48	0.999	2375	1460.2	2347.2	1448	2349.5	1449.4
O3-706-0437	13	4	37	12.48	0.94	88.5	43.7	60.7	31.5	64.6	33.5
O4-706-0441	13	4	41	12.49	0.972	2759.8	1739.7	2732	1727.5	2810.7	1777.3
O1-706-0645	13	6	45	12.57	1.033	110.6	59.6	82.8	47.4	80.2	45.9
O2-706-0646	13	6	46	12.57	0.071	2573.3	1596.4	2545.5	1584.2	35852.1	22312.7
O3-706-0647	13	6	47	12.57	1.041	141.4	79	113.6	66.8	109.1	64.2
O4-706-0648	13	6	48	12.58	1.068	3148	1981.4	3120.2	1969.2	2921.5	1843.8
O1-706-0840	13	8	40	12.65	1.066	138.2	65.7	110.4	53.5	103.6	50.2
O2-706-0841	13	8	41	12.65	1.116	2522.6	1559.6	2494.8	1547.4	2235.5	1386.6
O3-706-0842	13	8	42	12.65	1.004	163.8	86.3	136	74.1	135.5	73.8
O4-706-0843	13	8	43	12.65	1.108	3048.4	1804	3020.6	1791.8	2726.2	1617.1
O1-706-1058	13	10	58	12.75	1.06	136.5	71.4	108.7	59.2	102.5	55.8
O2-706-1059	13	10	59	12.75	1.064	2355.2	1477.7	2327.4	1465.5	2187.4	1377.3
O3-706-1100	13	11	0	12.75	1.055	160.3	81.2	132.5	69	125.6	65.4
O4-706-1101	13	11	1	12.75	1.075	2833.4	1858.5	2805.6	1846.3	2609.9	1717.5
O1-706-1256	13	12	56	12.83	1.045	147.4	79	119.6	66.8	114.4	63.9
O2-706-1257	13	12	57	12.83	1.047	2384.6	1587.4	2356.8	1575.2	2251.0	1504.5
O3-706-1258	13	12	58	12.83	1.009	136.6	69.3	108.8	57.1	107.8	56.6
O4-706-1259	13	12	59	12.83	1.049	2908.2	1856	2880.4	1843.8	2745.9	1757.7
O1-706-1504	13	15	4	12.92	0.972	143.2	73.6	115.4	61.4	118.7	63.2
O2-706-1505	13	15	5	12.92	1.027	2224.6	1415.1	2196.8	1402.9	2139.0	1366.0
O3-706-1506	13	15	6	12.92	1.017	125.3	66.2	97.5	54	95.9	53.1

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O4-706-1507	13	15	7	12.92	1.04	2733.9	1764.3	2706.1	1752.1	2602.0	1684.7
O1-706-1701	13	17	1	13.00	1.064	142.5	57.3	114.7	45.1	107.8	42.4
O2-706-1707	13	17	7	13.00	1.073	2176.8	1271.6	2149	1259.4	2002.8	1173.7
O3-706-1711	13	17	11	13.01	1.062	121.1	58.8	93.3	46.6	87.9	43.9
O4-706-1716	13	17	16	13.01	1.057	2733.8	1653.3	2706	1641.1	2560.1	1552.6
O1-706-1903	13	19	3	13.09	1.057	120.5	59.5	92.7	47.3	87.7	44.7
O2-706-1907	13	19	7	13.09	1.072	2135	1274.3	2107.2	1262.1	1965.7	1177.3
O3-706-1910	13	19	10	13.09	1.069	115.7	59.2	87.9	47	82.2	44.0
O4-706-1913	13	19	13	13.09	1.078	2655.8	1526.7	2628	1514.5	2437.8	1404.9
O1-706-2106	13	21	6	13.17	1.056	95.5	51.4	67.7	39.2	64.1	37.1
O2-706-2109	13	21	9	13.17	1.069	2122.6	1264.5	2094.8	1252.3	1959.6	1171.5
O3-706-2113	13	21	13	13.18	1.069	125.8	68.4	98	56.2	91.7	52.6
O4-706-2116	13	21	16	13.18	1.061	2545	1533	2517.2	1520.8	2372.5	1433.4
O1-706-2305	13	23	5	13.25	1.057	101.5	47.8	73.7	35.6	69.7	33.7
O2-706-2308	13	23	8	13.26	1.072	2041.8	1279.9	2014	1267.7	1878.7	1182.6
O3-706-2311	13	23	11	13.26	1.051	88	51.3	60.2	39.1	57.3	37.2
O4-706-2314	13	23	14	13.26	1.081	2576.8	1590.7	2549	1578.5	2358.0	1460.2
O1-707-0103	14	1	3	13.34	1.077	99.7	45.1	71.9	32.9	66.8	30.5
O2-707-0106	14	1	6	13.34	1.045	2032.8	1225.8	2005	1213.6	1918.7	1161.3
O3-707-0109	14	1	9	13.34	1.068	110.8	53.2	83	41	77.7	38.4
O4-707-0113	14	1	13	13.34	1.044	2380.1	1479.3	2352.3	1467.1	2253.2	1405.3
O1-707-0311	14	3	11	13.42	1.086	81.6	41	53.8	28.8	49.5	26.5
O2-707-0319	14	3	19	13.43	1.005	1963.3	1189.7	1935.5	1177.5	1925.9	1171.6
O3-707-0327	14	3	27	13.44	0.97	88.6	40.4	60.8	28.2	62.7	29.1
O4-707-0334	14	3	34	13.44	1.065	2543.2	1488	2515.4	1475.8	2361.9	1385.7
O1-707-0510	14	5	10	13.51	1.048	78.8	38.2	48.3	27.1	46.1	25.9
O2-707-0514	14	5	14	13.51	1.046	2007.6	1266.9	1977.1	1255.8	1890.2	1200.6
O3-707-0520	14	5	20	13.51	1.108	99.5	42.5	69	31.4	62.3	28.3
O4-707-0526	14	5	26	13.52	1.123	2628.9	1601.9	2598.4	1590.8	2313.8	1416.6
O1-707-0728	14	7	28	13.60	1.111	86.1	40.8	55.6	29.7	50.0	26.7
O2-707-0732	14	7	32	13.61	1.069	2084	1187.7	2053.5	1176.6	1921.0	1100.7
O3-707-0736	14	7	36	13.61	1.067	86.2	41.2	55.7	30.1	52.2	28.2
O4-707-0740	14	7	40	13.61	1.095	2528.6	1573.9	2498.1	1562.8	2281.4	1427.2
O1-707-0929	14	9	29	13.69	1.144	82.3	35.8	51.8	24.7	45.3	21.6
O2-707-0931	14	9	31	13.69	1.156	2101.7	1259.1	2071.2	1248	1791.7	1079.6

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O3-707-0934	14	9	34	13.69	1.099	83.2	43.1	52.7	32	48.0	29.1
O4-707-0936	14	9	36	13.69	1.146	2649.8	1603.7	2619.3	1592.6	2285.6	1389.7
O1-707-1135	14	11	35	13.77	1.161	75	35.3	44.5	24.2	38.3	20.8
O2-707-1137	14	11	37	13.78	1.296	2393.1	1411.8	2362.6	1400.7	1823.0	1080.8
O3-707-1140	14	11	40	13.78	1.179	74.8	35.2	44.3	24.1	37.6	20.4
O4-707-1142	14	11	42	13.78	1.157	2639.3	1612.9	2608.8	1601.8	2254.8	1384.4
O1-707-1333	14	13	33	13.86	1.098	78.4	37.2	47.9	26.1	43.6	23.8
O2-707-1335	14	13	35	13.86	1.123	2215.2	1282.2	2184.7	1271.1	1945.4	1131.9
O3-707-1337	14	13	37	13.86	0.907	86.3	43.8	55.8	32.7	61.5	36.1
O4-707-1339	14	13	39	13.86	1.116	2464.8	1478.1	2434.3	1467	2181.3	1314.5
O1-707-1534	14	15	34	13.94	1.088	75.5	36.8	45	25.7	41.4	23.6
O2-707-1536	14	15	36	13.94	1.15	2175.3	1296.9	2144.8	1285.8	1865.0	1118.1
O3-707-1539	14	15	39	13.94	1.162	81	39.6	50.5	28.5	43.5	24.5
O4-707-1540	14	15	40	13.94	1.312	2925.1	1629.3	2894.6	1618.2	2206.3	1233.4
O1-707-1730	14	17	30	14.02	1.073	84.7	39.1	54.2	28	50.5	26.1
O2-707-1732	14	17	32	14.02	1.067	2085.6	1239.6	2055.1	1228.5	1926.1	1151.4
O3-707-1734	14	17	34	14.02	1.177	81.2	40	50.7	28.9	43.1	24.6
O4-707-1736	14	17	36	14.03	1.205	2806.7	1627.9	2776.2	1616.8	2303.9	1341.7
O1-707-1930	14	19	30	14.10	1.052	86.9	44.2	56.4	33.1	53.6	31.5
O2-707-1934	14	19	34	14.11	1.06	1995.2	1184.2	1964.7	1173.1	1853.5	1106.7
O3-707-1937	14	19	37	14.11	1.054	95.9	43.5	65.4	32.4	62.0	30.7
O4-707-1941	14	19	41	14.11	1.055	2394.6	1373.1	2364.1	1362	2240.9	1291.0
O1-707-2131	14	21	31	14.19	1.043	86.7	50.9	56.2	39.8	53.9	38.2
O2-707-2133	14	21	33	14.19	1.057	1942.3	1109.1	1911.8	1098	1808.7	1038.8
O3-707-2135	14	21	35	14.19	1.061	115.4	52.5	84.9	41.4	80.0	39.0
O4-707-2138	14	21	38	14.19	1.062	2381.9	1419.2	2351.4	1408.1	2214.1	1325.9
O1-707-2331	14	23	31	14.27	1.052	85	39.5	54.5	28.4	51.8	27.0
O2-707-2334	14	23	34	14.27	0.999	1778.7	1109.4	1748.2	1098.3	1749.9	1099.4
O3-707-2337	14	23	37	14.28	1.078	91.8	40.8	61.3	29.7	56.9	27.6
O4-707-2340	14	23	40	14.28	1.056	2437	1473.9	2406.5	1462.8	2278.9	1385.2
O1-708-0144	15	1	44	14.36	1.108	71.5	35.3	41	24.2	37.0	21.8
O2-708-0157	15	1	57	14.37	1.098	2114.6	1181.2	2084.1	1170.1	1898.1	1065.7
O3-708-0209	15	2	9	14.38	1.065	73.9	32.5	43.4	21.4	40.8	20.1
O4-708-0215	15	2	15	14.39	1.111	2586.7	1505.5	2556.2	1494.4	2300.8	1345.1
O1-708-0353	15	3	53	14.45	1.07	69.8	33.4	39.3	22.3	36.7	20.8

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O2-708-0357	15	3	57	14.46	1.097	2026.9	1184.7	1996.4	1173.6	1819.9	1069.8
O3-708-0402	15	4	2	14.46	1.143	66.9	31.5	36.4	20.4	31.8	17.8
O4-708-0408	15	4	8	14.46	1.132	2688.3	1591.3	2657.8	1580.2	2347.9	1395.9
O1-708-0713	15	7	13	14.59	1.114	74.9	34.7	45.7	23.5	41.0	21.1
O2-708-0718	15	7	18	14.60	1.135	2104.7	1270.6	2075.5	1259.4	1828.6	1109.6
O3-708-0722	15	7	22	14.60	1.092	65.7	29.8	36.5	18.6	33.4	17.0
O4-708-0727	15	7	27	14.60	1.116	2511	1489.3	2481.8	1478.1	2223.8	1324.5
O1-708-1016	15	10	16	14.72	1.086	60.7	27.2	31.5	16	29.0	14.7
O2-708-1019	15	10	19	14.72	1.083	1885.8	1243.1	1856.6	1231.9	1714.3	1137.5
O3-708-1022	15	10	22	14.72	1.176	69.4	31.6	40.2	20.4	34.2	17.3
O4-708-1024	15	10	24	14.73	1.228	2789.4	1682.9	2760.2	1671.7	2247.7	1361.3
O1-708-1348	15	13	48	14.87	1.029	66.2	28.3	37	17.1	36.0	16.6
O2-708-1350	15	13	50	14.87	1.059	1805.1	1112	1775.9	1100.8	1677.0	1039.5
O3-708-1352	15	13	52	14.87	1.044	64	28.5	34.8	17.3	33.3	16.6
O4-708-1355	15	13	55	14.87	1.018	2242.5	1468.5	2213.3	1457.3	2174.2	1431.5
O1-708-1556	15	15	56	14.96	1.167	64.4	29.9	35.2	18.7	30.2	16.0
O2-708-1600	15	16	0	14.96	1.102	1867.8	1128.5	1838.6	1117.3	1668.4	1013.9
O3-708-1603	15	16	3	14.96	1.044	63.8	30.2	34.6	19	33.1	18.2
O4-708-1606	15	16	6	14.96	0.957	2027	1266.4	1997.8	1255.2	2087.6	1311.6
O1-708-1854	15	18	54	15.08	1.192	63	28.6	33.8	17.4	28.4	14.6
O2-708-1856	15	18	56	15.08	1.171	2051.5	1192.2	2022.3	1181	1727.0	1008.5
O3-708-1858	15	18	58	15.08	1.118	65.6	30.9	36.4	19.7	32.6	17.6
O4-708-1900	15	19	0	15.08	1.253	2555.9	1575.4	2526.7	1564.2	2016.5	1248.4
O1-708-2203	15	22	3	15.21	1.156	59.3	28.5	30.1	17.3	26.0	15.0
O2-708-2206	15	22	6	15.21	1.12	1900	1130.2	1870.8	1119	1670.4	999.1
O3-708-2208	15	22	8	15.21	1.034	63.4	28.5	34.2	17.3	33.1	16.7
O4-708-2210	15	22	10	15.22	1.06	2216.7	1356.7	2187.5	1345.5	2063.7	1269.3
O1-709-0103	16	1	3	15.34	1.03	62.6	26.9	33.4	15.7	32.4	15.2
O2-709-0110	16	1	10	15.34	0.954	1627.6	1014.7	1598.4	1003.5	1675.5	1051.9
O3-709-0119	16	1	19	15.35	0.975	58	29.6	28.8	18.4	29.5	18.9
O4-709-0127	16	1	27	15.35	1.048	2141.7	1278.9	2112.5	1267.7	2015.7	1209.6
O1-709-0409	16	4	9	15.46	1.078	65	29.9	35.8	18.7	33.2	17.3
O2-709-0415	16	4	15	15.47	1.056	1824	1041.6	1794.8	1030.4	1699.6	975.8
O3-709-0420	16	4	20	15.47	1.144	63.6	33.5	34.4	22.3	30.1	19.5
O4-709-0426	16	4	26	15.48	1.054	2076.4	1285	2047.2	1273.8	1942.3	1208.5

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O1-709-0711	16	7	11	15.59	1.294	11.4	1.5	0	0	0.0	0.0
O2-709-0724	16	7	24	15.60	1.059	1794.7	1079.4	1765.5	1068.2	1667.1	1008.7
O3-709-0729	16	7	29	15.60	1.066	66.3	26.5	37.1	15.3	34.8	14.4
O4-709-0735	16	7	35	15.61	1.219	2432.5	1353.3	2403.3	1342.1	1971.5	1101.0
O1-709-1004	16	10	4	15.71	1.012	69.8	35	41.3	23	40.8	22.7
O2-709-1006	16	10	6	15.71	0.948	1536.8	1000.4	1508.3	988.4	1591.0	1042.6
O3-709-1008	16	10	8	15.71	0.919	65.9	29.5	37.4	17.5	40.7	19.0
O4-709-1010	16	10	10	15.72	0.958	1833.1	1156.7	1804.6	1144.7	1883.7	1194.9
O1-709-1302	16	13	2	15.83	1.101	76.6	38.9	48.1	26.9	43.7	24.4
O2-709-1303	16	13	3	15.84	1.002	1702.5	1071.5	1674	1059.5	1670.7	1057.4
O3-709-1304	16	13	4	15.84	0.978	74.8	39	46.3	27	47.3	27.6
O4-709-1305	16	13	5	15.84	1	2049.6	1306.6	2021.1	1294.6	2021.1	1294.6
O1-709-1616	16	16	16	15.97	1.482	80	35.8	51.5	23.8	34.8	16.1
o2-709-1617	16	16	17	15.97	1.434	1602.8	1055.3	1574.3	1043.3	1097.8	727.5
O3-709-1618	16	16	18	15.97	1.256	79.4	37.8	50.9	25.8	40.5	20.5
O4-709-1619	16	16	19	15.97	1.035	2115.4	1341.1	2086.9	1329.1	2016.3	1284.2
O1-709-1905	16	19	5	16.09	1.056	85.7	43.6	57.2	31.6	54.2	29.9
O2-709-1906	16	19	6	16.09	1.068	1690.3	1011.3	1661.8	999.3	1556.0	935.7
O3-709-1907	16	19	7	16.09	0.813	93.5	45.4	65	33.4	80.0	41.1
O4-709-1908	16	19	8	16.09	1.046	2044.4	1214.5	2015.9	1202.5	1927.2	1149.6
O1-709-2204	16	22	4	16.21	1.128	89.6	42	61.1	30	54.2	26.6
O2-709-2206	16	22	6	16.21	1.172	1926.1	1187	1897.6	1175	1619.1	1002.6
O3-709-2208	16	22	8	16.21	1.139	73.8	37.3	45.3	25.3	39.8	22.2
O4-709-2210	16	22	10	16.22	1.22	2519.5	1612.4	2491	1600.4	2041.8	1311.8
O1-710-0109	17	1	9	16.34	0.933	54.3	22.5	25.8	10.5	27.7	11.3
O2-710-0117	17	1	17	16.35	0.998	1593.7	1013	1565.2	1001	1568.3	1003.0
O3-710-0125	17	1	25	16.35	1.007	64.2	29.7	35.7	17.7	35.5	17.6
O4-710-0130	17	1	30	16.35	1.069	2010.3	1251.9	1981.8	1239.9	1853.9	1159.9
O1-710-0407	17	4	7	16.46	1.102	52.4	22.9	23.9	10.9	21.7	9.9
O2-710-0413	17	4	13	16.47	1.079	1731.3	1042.2	1702.8	1030.2	1578.1	954.8
O3-710-0418	17	4	18	16.47	1.114	59.4	24.8	30.9	12.8	27.7	11.5
O4-710-0424	17	4	24	16.48	1.074	1968	1240.7	1939.5	1228.7	1805.9	1144.0
O1-710-0810	17	8	10	16.63	1.026	51.4	22.7	22.9	10.7	22.3	10.4
O2-710-0822	17	8	22	16.64	1.078	1660.4	1057.9	1631.9	1045.9	1513.8	970.2
O3-710-0826	17	8	26	16.64	1.234	63.8	30.2	35.3	18.2	28.6	14.7

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O4-710-0828	17	8	28	16.64	1.348	2455.3	1594.6	2426.8	1582.6	1800.3	1174.0
O1-710-1306	17	13	6	16.84	1.193	94.7	48.8	66.2	36.8	55.5	30.8
O2-710-1310	17	13	10	16.84	1.217	1435.8	897.4	1407.3	885.4	1156.4	727.5
O3-710-1313	17	13	13	16.84	1.228	84.9	40.6	56.4	28.6	45.9	23.3
O4-710-1315	17	13	15	16.84	1.003	1402.9	967	1374.4	955	1370.3	952.1
O1-710-1605	17	16	5	16.96	1.214	68.3	32.9	39.8	20.9	32.8	17.2
O2-710-1613	17	16	13	16.97	1.034	1529.4	957.9	1500.9	945.9	1451.5	914.8
O3-710-1614	17	16	14	16.97	0.963	53	30.3	24.5	18.3	25.4	19.0
O4-710-1615	17	16	15	16.97	0.968	1655.2	1028.4	1626.7	1016.4	1680.5	1050.0
O1-710-1953	17	19	53	17.12	0.972	69.3	35.5	40.8	23.5	42.0	24.2
O2-710-1954	17	19	54	17.12	1.015	1490.7	914.7	1462.2	902.7	1440.6	889.4
O3-710-1955	17	19	55	17.12	0.998	98.2	49	69.7	37	69.8	37.1
O4-710-1956	17	19	56	17.12	1.051	1802.8	1093.9	1774.3	1081.9	1688.2	1029.4
O1-711-0111	18	1	11	17.34	1.068	50.9	19.9	22.4	7.9	21.0	7.4
O2-711-0119	18	1	19	17.35	1.012	1535	973.2	1506.5	961.2	1488.6	949.8
O3-711-0131	18	1	31	17.35	1.402	68.8	29.1	40.3	17.1	28.7	12.2
O4-711-0139	18	1	39	17.36	1.159	2020.7	1209.9	1992.2	1197.9	1718.9	1033.6
O1-711-0515	18	5	15	17.51	1.054	41.9	16	13.4	4	12.7	3.8
O2-711-0520	18	5	20	17.51	1.074	1566	977.1	1537.5	965.1	1431.6	898.6
O3-711-0525	18	5	25	17.52	1.14	50.3	21.8	21.8	9.8	19.1	8.6
O4-711-0531	18	5	31	17.52	1.028	1764.9	1040.1	1736.4	1028.1	1689.1	1000.1
O1-711-0928	18	9	28	17.69	0.93	49.5	21.2	21	9.2	22.6	9.9
O2-711-0930	18	9	30	17.69	0.913	1313	804.4	1284.5	792.4	1406.9	867.9
O3-711-0932	18	9	32	17.69	0.869	73.6	33.4	45.1	21.4	51.9	24.6
O4-711-0934	18	9	34	17.69	0.999	1669.4	982.4	1640.9	970.4	1642.5	971.4
O1-711-1328	18	13	28	17.85	0.989	60.1	34	31.6	22	32.0	22.2
O2-711-1330	18	13	30	17.85	1.008	1474	912.2	1445.5	900.2	1434.0	893.1
O3-711-1332	18	13	32	17.86	0.891	51.6	21.1	23.1	9.1	25.9	10.2
O4-711-1334	18	13	34	17.86	0.969	1624.1	958	1595.6	946	1646.6	976.3
O1-711-1734	18	17	34	18.02	1.029	44.7	20.1	16.2	8.1	15.7	7.9
O2-711-1735	18	17	35	18.02	1.042	1538.9	880.3	1510.4	868.3	1449.5	833.3
O3-711-1736	18	17	36	18.03	1.009	55.9	24.6	27.4	12.6	27.2	12.5
O4-711-1737	18	17	37	18.03	1.021	1772.3	1035.7	1743.8	1023.7	1707.9	1002.6
O1-711-2132	18	21	32	18.19	1.053	63.4	31.2	34.9	19.2	33.1	18.2
O2-711-2135	18	21	35	18.19	1.053	1457.1	833.3	1428.6	821.3	1356.7	780.0

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O3-711-2138	18	21	38	18.19	1.058	58	23.9	29.5	11.9	27.9	11.2
O4-711-2141	18	21	41	18.20	1.061	1730.8	991.3	1702.3	979.3	1604.4	923.0
O1-712-0129	19	1	29	18.35	0.932	45.8	22.3	17.3	10.3	18.6	11.1
O2-712-0133	19	1	33	18.36	0.983	1356.9	802.1	1328.4	790.1	1351.4	803.8
O3-712-0137	19	1	37	18.36	0.851	47.4	22.2	18.9	10.2	22.2	12.0
O4-712-0141	19	1	41	18.36	0.994	1615.1	903.8	1586.6	891.8	1596.2	897.2
O1-712-0548	19	5	48	18.53	0.964	45.3	18.5	15.1	7.2	15.7	7.5
O2-712-0552	19	5	52	18.54	0.979	1396.5	876.4	1366.3	865.1	1395.6	883.7
O3-712-0556	19	5	56	18.54	0.899	47.6	24	17.4	12.7	19.4	14.1
O4-712-0559	19	5	59	18.54	0.974	1535.6	948.8	1505.4	937.5	1545.6	962.5
O1-712-0934	19	9	34	18.69	1.058	42.3	19.4	12.1	8.1	11.4	7.7
O2-712-0936	19	9	36	18.69	0.927	1284.6	801.3	1254.4	790	1353.2	852.2
O3-712-0938	19	9	38	18.69	0.94	46.3	22.1	16.1	10.8	17.1	11.5
O4-712-0940	19	9	40	18.69	0.925	1481.3	931.2	1451.1	919.9	1568.8	994.5
O1-712-1325	19	13	25	18.85	0.989	51.9	25.7	21.7	14.4	21.9	14.6
O2-712-1330	19	13	30	18.85	0.953	1303.7	814.1	1273.5	802.8	1336.3	842.4
O3-712-1335	19	13	35	18.86	0.9	52.3	24.9	22.1	13.6	24.6	15.1
O4-712-1340	19	13	40	18.86	1.003	1594	988.4	1563.8	977.1	1559.1	974.2
O1-712-1727	19	17	27	19.02	1.034	55	27.3	24.8	16	24.0	15.5
O2-712-1729	19	17	29	19.02	1.069	1487	833.9	1456.8	822.6	1362.8	769.5
O3-712-1731	19	17	31	19.02	0.992	55.7	27.4	25.5	16.1	25.7	16.2
O4-712-1733	19	17	33	19.02	1.054	1673.1	937	1642.9	925.7	1558.7	878.3
O1-712-2127	19	21	27	19.19	1.031	53.3	22.7	23.1	11.4	22.4	11.1
O2-712-2129	19	21	29	19.19	1.019	1314.9	752.3	1284.7	741	1260.7	727.2
O3-712-2131	19	21	31	19.19	1.08	56.2	23	26	11.7	24.1	10.8
O4-712-2133	19	21	33	19.19	1.065	1638.6	905.9	1608.4	894.6	1510.2	840.0
O1-713-0145	20	1	45	19.36	1.024	45.9	16.3	15.7	5	15.3	4.9
O2-713-0152	20	1	52	19.37	1.054	1413.6	814.7	1383.4	803.4	1312.5	762.2
O3-713-0200	20	2	0	19.38	0.961	38.1	18.8	7.9	7.5	8.2	7.8
O4-713-0212	20	2	12	19.38	1.414	2064.8	1207.5	2034.6	1196.2	1438.9	846.0
O2-713-0530	20	5	30	19.52	1.035	1354.7	798.7	1324.5	787.4	1279.7	760.8
O4-713-0535	20	5	35	19.52	1.082	1517.3	889	1487.1	877.7	1374.4	811.2
O2-713-0940	20	9	40	19.69	1	1289.1	703.2	1258.9	691.9	1258.9	691.9
O4-713-0941	20	9	41	19.70	0.962	1333.7	789.5	1303.5	778.2	1355.0	808.9
O2-713-1332	20	13	32	19.86	1.04	1283	756.5	1252.8	745.2	1204.6	716.5

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O4-713-1333	20	13	33	19.86	1.016	1425.5	858	1395.3	846.7	1373.3	833.4
O1-713-1735	20	17	35	20.02	1.058	57.7	32.8	27.5	21.5	26.0	20.3
O2-713-1737	20	17	37	20.03	1.056	1311.7	762.2	1281.5	750.9	1213.5	711.1
O3-713-1739	20	17	39	20.03	1.066	54.6	25.7	24.4	14.4	22.9	13.5
O4-713-1741	20	17	41	20.03	1.062	1497.6	836.6	1467.4	825.3	1381.7	777.1
O1-713-2134	20	21	34	20.19	1.06	51.7	21.9	21.5	10.6	20.3	10.0
O2-713-2136	20	21	36	20.19	1.051	1292.3	718.4	1262.1	707.1	1200.9	672.8
O3-713-2138	20	21	38	20.19	1.072	49.8	26.1	19.6	14.8	18.3	13.8
O4-713-2140	20	21	40	20.19	1.009	1340.5	792.5	1310.3	781.2	1298.6	774.2
O1-714-0150	21	1	50	20.37	1.259	42.8	16.9	12.6	5.6	10.0	4.4
O2-714-0156	21	1	56	20.37	1.207	1565.5	863	1535.3	851.7	1272.0	705.6
O3-714-0205	21	2	5	20.38	0.86	34.3	15.8	4.1	4.5	4.8	5.2
O4-714-0211	21	2	11	20.38	1.06	1493.2	841.3	1463	830	1380.2	783.0
O1-714-0955	21	9	55	20.70	0.954	36.3	13.8	6.1	2.5	6.4	2.6
O2-714-1000	21	10	0	20.71	0.965	1166.9	700.8	1136.7	689.5	1177.9	714.5
O3-714-1002	21	10	2	20.71	0.816	58.5	35.4	28.3	24.1	34.7	29.5
O4-714-1005	21	10	5	20.71	0.942	1201.8	752.5	1171.6	741.2	1243.7	786.8
O1-714-1757	21	17	57	21.04	1.057	56.6	24.1	26.4	12.8	25.0	12.1
O2-714-1759	21	17	59	21.04	1.074	1208	686.1	1177.8	674.8	1096.6	628.3
O3-714-1801	21	18	1	21.04	1.044	55.5	24.6	25.3	13.3	24.2	12.7
O4-714-1803	21	18	3	21.04	1.064	1496.1	854.4	1465.9	843.1	1377.7	792.4
O1-715-0153	22	1	53	21.37	1.087	45.6	17.3	15.4	6	14.2	5.5
O2-715-0158	22	1	58	21.37	1.026	1230.6	693	1200.4	681.7	1170.0	664.4
O3-715-0205	22	2	5	21.38	1.016	44.7	16.6	14.5	5.3	14.3	5.2
O4-715-0210	22	2	10	21.38	1.117	1427.1	763.1	1396.9	751.8	1250.6	673.1
O1-715-1012	22	10	12	21.72	1.025	41.7	15.2	11.5	3.9	11.2	3.8
O2-715-1014	22	10	14	21.72	1.001	1142.8	649.6	1112.6	638.3	1111.5	637.7
O3-715-1016	22	10	16	21.72	1.041	66.3	30.1	36.1	18.8	34.7	18.1
O4-715-1018	22	10	18	21.72	1.022	1206.9	677.9	1176.7	666.6	1151.4	652.3
O1-716-1300	23	13	0	22.83	0.927	41.3	17.7	11.1	6.4	12.0	6.9
O2-716-1302	23	13	2	22.83	1.046	1149.8	650.7	1119.6	639.4	1070.4	611.3
O3-716-1304	23	13	4	22.84	1.034	57.8	27.3	27.6	16	26.7	15.5
O4-716-1310	23	13	10	22.84	1.026	1111	618.2	1080.8	606.9	1053.4	591.5
O1-717-1321	24	13	21	23.85	1.278	41.4	21	11.2	9.7	8.8	7.6
O2-717-1324	24	13	24	23.85	1.212	1263.4	752.3	1233.2	741	1017.5	611.4

Sampling Data

Sample ID	Day	Hour	Min	Elapsed Time (d)	Smpl Mass (g)	Counts - Ch A	Counts - Ch B	A - Bckgd	B - Bckgd	A - cpm/ml	B cpm/ml
O3-717-1326	24	13	26	23.85	1.194	48.9	21.7	18.7	10.4	15.7	8.7
O4-717-1329	24	13	29	23.85	1.122	1095.7	666.2	1065.5	654.9	949.6	583.7
O2-718-1322	25	13	22	24.85	0.964	891.8	533.6	858.6	522.6	890.7	542.1
O3-718-1325	25	13	25	24.85	0.913	36.6	17.2	3.4	6.2	3.7	6.8
O4-718-1330	25	13	30	24.85	0.999	891.8	537	858.6	526	859.5	526.5
O1-719-1330	26	13	30	25.85	1.029	41	18.6	7.8	7.6	7.6	7.4
O2-719-1332	26	13	32	25.86	1.01	916.4	561.9	883.2	550.9	874.5	545.4
O3-719-1334	26	13	34	25.86	0.911	49	24.3	15.8	13.3	17.3	14.6
O4-719-1338	26	13	38	25.86	1.025	878.7	510.5	845.5	499.5	824.9	487.3
O1-720-1210	27	12	10	26.80	1.067	44.9	20	11.7	9	11.0	8.4
O2-720-1212	27	12	12	26.80	1.074	934.6	536.3	901.4	525.3	839.3	489.1
O3-720-1214	27	12	14	26.80	0.997	46.7	21	13.5	10	13.5	10.0
O4-720-1216	27	12	16	26.80	1.079	799.6	447.2	766.4	436.2	710.3	404.3
O1-721-1504	28	15	4	27.92	1.063	45.4	17.8	12.2	6.8	11.5	6.4
O2-721-1507	28	15	7	27.92	1.006	875	508.9	841.8	497.9	836.8	494.9
O3-721-1509	28	15	9	27.92	0.993	48.1	21	14.9	10	15.0	10.1
O4-721-1511	28	15	11	27.92	1.069	779.5	413.5	746.3	402.5	698.1	376.5
O2-722-1529	29	15	29	28.94	1.079	964.1	463.9	932.9	452.6	864.6	419.5
O3-722-1531	29	15	31	28.94	1.068	48	18.3	16.8	7	15.7	6.6
O4-722-1535	29	15	35	28.94	1.141	989.2	421	958.9	409.3	840.4	358.7
O1-723-1355	30	13	55	29.87	0.867	37.2	15	6.9	3.3	8.0	3.8
O2-723-1400	30	14	0	29.88	0.842	631.9	334.8	601.6	323.1	714.5	383.7
O3-723-1405	30	14	5	29.88	0.894	45.8	17.7	15.5	6	17.3	6.7
O4-723-1410	30	14	10	29.88	0.959	726.9	732.9	696.6	721.2	726.4	752.0
O2-725-1410	32	14	10	31.88	0.951	732.9	360.7	702.6	349	738.8	367.0
O4-725-1418	32	14	18	31.89	0.943	647.9	327.9	617.6	316.2	654.9	335.3
O2-726-0920	33	9	20	32.68	1.02	752.1	373.8	721.8	362.1	707.6	355.0
O4-726-0924	33	9	24	32.68	1.141	732.3	335.7	702	324	615.2	284.0

Appendix A.8: Data Corrected by Efficiency

Input Concentration Spreadsheet

This spreadsheet contains the conversion of inlet concentration data from cpm/ml to dpm/ml for ^{14}C and ^{3}H. The data in the first four columns is entered from the spreadsheet in Appendix A.7. Column E uses the Channel B counts in Column D divided by 0.410, the ^{14}C efficiency on Channel (region) B. The following equation is used to calculate tritium dpm/ml in Column F:

{Column C [Ch A cpm/ml] - (Col E * ^{14}C efficiency on Ch A)} / ^{3}H Efficiency on Channel A =
{Col C - (Col E * 0.578)} / 0.288.

ample #	Elapsd Time	Ch A cpm/ml	Ch B cpm/ml	14C dpm/ml	3H dpm/ml
-623-1822	0.056944444	76287.65766	6238.198198	15215.1176	234246.1
-623-2108	0.172222222	85085.56604	6831.415094	16661.988	261880.6
-624-0217	0.386805556	87684.95146	7101.067961	17319.678	269581.7
-624-0614	0.551388889	86872.84211	7109.263158	17339.6662	266721.7
-624-0903	0.66875	85789.2233	7046.796117	17187.3076	263265.9
-624-1342	0.8625	84489.80769	6573.173077	16032.1295	261080.5
-624-1451	0.910416667	87110.85366	7059.390244	17218.025	267793.1
-624-1832	1.063888889	78868.125	6085.089286	14841.6812	243958.2
-624-2216	1.219444444	86120.58824	6553.627451	15984.4572	266838.9
-625-0156	1.372222222	81289.61702	6329.361702	15437.4676	251166.3
-625-0502	1.501388889	84185.6203	6415.507519	15647.5793	260798.7
-625-0810	1.631944444	80110.58618	6109.886264	14902.1616	248150.5
-625-1114	1.759722222	79799.64318	5386.886708	13138.7481	250622.1
-625-1504	1.919444444	85749.94872	5959.897436	14536.3352	268468.3
-625-1822	2.056944444	83601.15385	5911.057692	14417.2139	261247.1
-625-2215	2.21875	95770.85106	6930.319149	16903.2174	298496.5
-626-0114	2.343055556	81175.12243	5970.519099	14562.2417	252531.3
-626-0333	2.439583333	83849.09584	6220.705244	15172.4518	260587.1
-626-0642	2.570833333	83905.24309	6217.254528	15164.0354	260799
-626-0938	2.693055556	64248.11947	5815.929204	14185.1932	194516.3
-626-1328	2.852777778	66431.78808	5771.996216	14078.0396	202314.3
-626-1644	2.988888889	80955.09165	5448.879837	13289.9508	254329.6
-626-1957	3.122916667	68046.08483	4810.603589	11733.1795	212641.8
-626-2349	3.284027778	82611.58594	6052.231719	14761.5408	257117.7
-627-0238	3.401388889	85754.50098	6119.569472	14925.7792	267699.8
-627-0414	3.468055556	87335.85657	6178.187251	15068.7494	272902.7
-627-0611	3.549305556	85083.86473	6122.608696	14933.1919	265356.3
-627-0930	3.6875	83551.25	6267.658	15286.9707	259322.2
-627-1310	3.840277778	84816.44399	6111.099692	14905.1212	264484.3
-627-1619	3.971527778	75029.52128	4804.078014	11717.2634	236921.9
-627-1904	4.086111111	80593.4236	5498.065764	13409.9165	252832.2
-627-2229	4.228472222	69833.66718	4892.372881	11932.6168	218447
-628-0153	4.370138889	84869.04084	5833.238367	14227.4107	266031.7
-628-0446	4.490277778	83660.78619	5786.481304	14113.369	262066.1
-628-0743	4.613194444	81846.48547	5726.897844	13968.0435	256059.1
-628-1112	4.758333333	80201.47059	5352.647059	13055.2367	252185.5
-628-1412	4.883333333	83206.68633	5842.969518	14251.1452	260211.9
-628-1745	5.03125	94520.15707	6071.335079	14808.1343	298373.1
-628-1922	5.098611111	79120.87254	5358.169376	13068.7058	248406.3
-628-2303	5.252083333	84175.89641	5482.171315	13371.1495	265349.4
629-0224	5.391666667	82894.56967	5310.963115	12953.5686	261741.3
629-0533	5.522916667	87267.36737	5763.663664	14057.7163	274701
629-0849	5.659027778	77935.96103	5244.995571	12792.6721	244848
629-1141	5.778472222	81027.00096	5559.016393	13558.5766	254038.3
629-1503	5.91875	81693.56098	5116.292683	12478.7626	258527.4
629-1735	6.024305556	85085.11047	5338.520653	13020.7821	269212
629-2013	6.134027778	78176.38408	5014.878893	12231.4119	246813.1
629-2307	6.254861111	82039.50851	5263.799622	12838.5357	259004
630-0138	6.359722222	80325.68982	5192.197907	12663.8973	253405
630-0521	6.514583333	53409.3633	5267.696629	12848.0406	159574.7

ample #	Elapsd Time	Ch A cpm/ml	Ch B cpm/ml	14C dpm/ml	3H dpm/ml
-630-0747	6.615972222	84972.88136	5621.677074	13711.4075	267431.5
-630-1056	6.747222222	95385.14493	6283.206522	15324.894	300335.8
-630-1438	6.901388889	79381.64384	4935.43379	12037.6434	251388.2
-630-1715	7.010416667	82314.06946	5019.857524	12243.5549	261155.6
-630-2022	7.140277778	79561.75373	4936.380597	12039.9527	252009
-630-2313	7.259027778	79933.95697	4744.340505	11571.5622	254244.6
-701-0203	7.377083333	87664.7	5182.9	12641.2195	278933.3
-701-0515	7.510416667	82132.73196	4983.075601	12153.8429	260706.6
-701-0848	7.658333333	66640.54748	4835.414885	11793.6948	207639.6
-701-1204	7.794444444	77672.34973	4876.284153	11893.376	245743.7
-701-1529	7.936805556	84558.87962	5193.802145	12667.8101	268095.7
-701-1842	8.070833333	79699.17582	4752.472527	11591.3964	253389.5
-701-2306	8.254166667	83063.58744	4832.735426	11787.1596	264677.2
-702-0118	8.345833333	91330.12422	5382.919255	13129.0714	290678
-702-0428	8.477777778	80321.69118	4792.738971	11689.6072	255353.2
-702-0750	8.618055556	78704.74806	4720.05814	11512.3369	250095.8
-702-1038	8.734722222	84044.66403	4812.15415	11736.9613	268184.8
-702-1416	8.886111111	83786.35548	4997.845601	12189.8673	266375.8
-702-1754	9.0375	80229.15531	4355.131698	10622.2724	257181.4
-623-1834	0.07	83403.96	6908.316832	16849.5532	255664
-623-2132	0.19	86300.561	7205.046729	17573.2847	264264.1
-624-0212	0.38	89585.426	7237.340426	17652.0498	275511.2
-624-0620	0.56	83237.333	6819.333333	16632.5203	255522.5
-624-0855	0.66	88129.192	7003.737374	17082.2863	271602.3
-624-1340	0.86	83319.808	6664.134615	16253.9869	256571.2
-624-1449	0.91	91764.324	7303.108108	17812.4588	282753.8
-624-1840	1.07	81572.772	6095.940594	14868.1478	253296
-624-2223	1.22	83706.765	6154.313725	15010.5213	260419
-625-0149	1.37	80282.921	6342.442357	15469.3716	247606.5
-625-0506	1.5	85867.73	6473.290793	15788.5141	266355.5
-625-0818	1.64	84434.107	6125.42886	14940.0704	263086.3
-625-1116	1.76	86817.974	6232.274081	15200.6685	270838.8
-625-1510	1.92	91800.322	6619.506967	16145.1389	286236.6
-625-1823	2.06	83382.233	6180.744186	15074.9858	259162.3
-625-2219	2.22	93153.478	6920.76087	16879.9046	289455.3
-626-0120	2.35	75687.348	5707.29927	13920.2421	234769.5
-626-0336	2.44	83707.198	6307.112254	15383.2006	259669.9
-626-0645	2.57	87462.477	6803.072626	16592.8601	270273
-626-0933	2.69	72698.367	5953.448276	14520.6056	223182
-626-1323	2.85	56027.174	5477.470356	13359.6838	167633.9
-626-1659	3	83634.672	5935.095137	14475.8418	261245.4
-626-2002	3.13	62902.049	4543.550835	11081.8313	196092.3
-626-2351	3.29	88028.075	6535.912698	15941.2505	273549.1
-627-0242	3.4	74721.723	5285.151237	12890.6128	233490.2
-627-0416	3.47	84972.121	6010.30303	14659.2757	265519.9
-627-0614	3.55	82605.041	5996.669667	14626.0236	257367.9
-627-0940	3.694444	88242.18	6152.653	15006.4707	276175.1
-627-1312	3.84	85438.782	6096.446701	14869.3822	266717.2
-627-1627	3.98	93514.886	6292.5	15347.561	293796.2
-627-1907	4.09	80237.023	5259.541985	12828.1512	252766.3

ample #	Elapsd Time	Ch A cpm/ml	Ch B cpm/ml	14C dpm/ml	3H dpm/ml
-627-2232	4.23	62287.772	4467.05163	10895.2479	194335.2
-628-0159	4.37	75040.763	5158.282741	12581.1774	235221.1
-628-0452	4.49	81246.168	5723.46263	13959.665	253991.5
-628-0747	4.62	94980.265	6675.413451	16281.4962	297003.5
-628-1116	4.76	81155.954	5668.388792	13825.3385	253948.8
-628-1414	4.88	89330.104	6099.895833	14877.7947	280211.7
-628-1747	5.03	77370.464	4876.455696	11893.7944	244694.7
-628-1924	5.1	82301.295	5552.417962	13542.4828	258495.3
-628-2306	5.25	84945.764	5478.202479	13361.4695	268042.1
-629-0229	5.4	84747.384	5673.943662	13838.887	266391.8
-629-0536	5.53	87670.981	5861.375126	14296.0369	275622.5
-629-0854	5.66	85283.996	5817.992424	14190.2254	267547.4
-629-1143	5.78	86531.584	5880.792079	14343.3953	271570.9
-629-1504	5.92	83847.442	5306.118355	12941.7521	265073.7
-629-1738	6.03	81843.652	5345.319741	13037.3652	257923.5
-629-2018	6.14	81565.127	5213.760603	12716.4893	257602.7
-629-2311	6.26	78545.429	4972.483841	12128.0094	248302.7
-630-0142	6.36	79789.562	5085.461323	12403.5642	252067.7
-630-0524	6.52	84319.943	5623.74169	13716.4431	265154.2
-630-0751	6.62	81972.9	5634.598013	13742.922	256951.4
-630-1058	6.75	84553.032	5519.641332	13462.5398	266474.9
-630-1440	6.9	79098.239	4814.612676	11742.9577	250997.7
-630-1717	7.01	82056.297	4969.474562	12120.6697	260508
-630-2025	7.14	77465.173	4554.80859	11109.2892	246603.4
-630-2316	7.26	79867.996	4873.219373	11885.9009	253382.5
2-701-0207	7.38	80468.75	4985.017123	12158.5783	254919.4
2-701-0518	7.51	83243.128	5147.677725	12555.3115	263753.6
2-701-0844	7.66	80628.289	5351.409774	13052.219	253673.6
2-701-1207	7.8	78178.531	5014.350282	12230.1226	246823.1
2-701-1531	7.94	76235.471	4702.040816	11468.3922	241610.4
2-701-1844	8.07	84659.617	5080	12390.2439	269004.4
2-701-2308	8.26	97613.672	5716.271186	13942.1248	310858.5
2-702-0123	8.35	84045.833	5023.369565	12252.1209	267151.4
2-702-0431	8.48	80588.586	4932.282794	12029.958	255594.5
2-702-0753	8.62	81852.595	4866.267465	11868.945	260307.7
2-702-1040	8.74	85798.144	5060.721649	12343.2235	273052.3
2-702-1418	8.89	80200.561	4349.953227	10609.642	257107.5
2-702-1756	9.04	87390.462	4930.62249	12025.9085	279220.3
3-623-1849	0.08	84756.796	7053.883495	17204.5939	259646.3
3-623-2142	0.2	87104.141	7062.929293	17226.6568	267752.4
3-624-0125	0.35	84590.309	6845.360825	16696.002	260092.5
3-624-0514	0.51	81505.664	6536.548673	15942.8016	250898.7
3-624-0836	0.65	88191.616	7153.939394	17448.6327	271081.3
3-624-1334	0.86	83002.124	6245.663717	15233.3261	257523.6
3-624-1441	0.9	90476.667	7367.634409	17969.84	277965.8
3-624-1844	1.07	85253.9	6824.2	16644.3902	262500.5
3-624-2227	1.23	77930.631	6130.990991	14953.6366	240477.5
3-625-0144	1.36	84115.346	6535.907723	15941.2383	259963.3
3-625-0510	1.51	83695.558	6564.744802	16011.5727	258364
3-625-0822	1.64	81118.983	6059.40678	14779.0409	251899.8

ample #	Elapsd Time	Ch A cpm/ml	Ch B cpm/ml	14C dpm/ml	3H dpm/ml	
-625-1118	1.76	87357.883	5951.929438	14516.9011	274090.6	
-625-1516	1.93	97390.984	6878.415301	16776.6227	304376.9	
-625-1854	2.08	82860.018	5699.907664	13902.2138	259710.9	
-625-2234	2.23	77623.153	5624.054054	13717.205	241899.9	
-626-0207	2.38	84676.124	6161.138861	15027.168	263751.3	
-626-0538	2.526389	82104.46	5777.339	14091.0707	256707.1	
-626-0921	2.68	68976.295	6173.705179	15057.8175	209176.3	
-626-1317	2.85	44551.927	4920.231214	12000.5639	130526.4	
-626-1633	2.98	83156.799	5597.07113	13651.393	261246.5	
-626-2021	3.14	75584.854	5265.784672	12843.3772	236582.3	
-626-2356	3.29	86230.414	6383.333333	15569.1057	268056.7	
-627-0628	3.56	91244.645	6517.603393	15896.5936	284807.7	
-627-0942	3.7	84109.345	5928.323699	14459.3261	262926.9	
-627-1314	3.84	86934.651	6098.959417	14875.5108	271898.8	
-627-1630	3.98	99174.389	6311.408615	15393.6795	313354.4	
-627-1921	4.1	77432.833	5160.694184	12587.059	243515.1	
-627-2235	4.23	62571.563	4426.156942	10795.5047	195521.4	
-628-0204	4.38	92440.69	6046.321839	14747.1264	291275.5	
-628-0457	4.5	81611.088	5721.34715	13954.5052	255269	
-628-0752	4.62	82350.144	5778.194044	14093.1562	257555.9	
-628-1416	4.89	86464.073	5694.965675	13890.1602	272249.2	
-628-1750	5.03	82267.074	5489.087488	13388.0183	258687.6	
-628-2310	5.26	79418.037	5051.401869	12320.4924	250945	
-629-0234	5.4	81451.53	5337.51234	13018.3228	256600.4	
-629-0541	5.53	88658.762	6052.256034	14761.6001	278114.7	
-629-0938	5.69	86801.904	5933.567134	14472.115	272250.3	
-629-1156	5.79	84363.873	5973.091248	14568.5152	263590.7	
-629-1637	5.98	82447.521	5305.893358	12941.2033	260214	
-629-2022	6.14	80066.204	5133.425926	12520.551	252792.7	
-629-2322	6.27	80533.333	5157.276995	12578.7244	254297.5	
-630-0352	6.45	79434.867	5148.942042	12558.3952	250524.3	
-630-0727	6.6	83898.754	5482.74209	13372.5417	264384.3	
-630-1045	6.74	83840.603	5371.542553	13101.3233	264728.6	
-630-1441	6.9	87841.513	5622.211445	13712.7108	277389.4	
-630-1806	7.05	82812.79	4859.221501	11851.7598	263676.3	
-630-2114	7.18	77177.695	4443.866171	10838.698	246150.2	
-701-0144	7.36	79092.903	4592.35023	11200.8542	252070.9	
-701-0521	7.51	83265.402	5183.903793	12643.6678	263653	
-701-0900	7.67	82293.495	5296.9129	12919.2998	259723.3	
-701-1220	7.81	74477.417	4952.02109	12078.1002	234278.2	
-701-1544	7.95	84552.242	5226.90583	12748.5508	267910	
-701-2009	8.13	82967.525	4944.684385	12060.2058	263793.8	
-701-2325	8.27	81792.294	4912.420671	11981.5138	259871.6	
-702-0310	8.42	77730.224	4573.973881	11156.0339	247429.6	
-702-0703	8.59	81769.391	4985.467757	12159.6775	259433.3	
-702-1042	8.74	82949.556	4881.638697	11906.4358	264041.1	
-702-1421	8.89	81734.972	4655.28757	11354.3599	260935.6	
-702-1758	9.04	85743.932	4939.919759	12048.5848	273457.5	
-623-1907	0.09	86213.113	7307.641509	17823.5159	263456.5	
-623-2152	0.2	87697.981	7302.307692	17810.5066	268638.5	

ample #	Elapsd Time	Ch A cpm/ml	Ch B cpm/ml	14C dpm/ml	3H dpm/ml	
-624-0136	0.36	85150.3	7052	17200	261021.9	
-624-0521	0.51	85647.019	7042.788462	17177.5328	262791.8	
-624-0847	0.66	87663.03	7444.545455	18157.4279	267818.5	
-624-1328	0.85	106468.06	8495.967742	20721.8725	327949.2	
-624-1438	0.9	85234.811	6983.867925	17033.8242	261650	
-624-1848	1.08	84865.648	6579.907407	16048.5547	262352.4	
-624-2232	1.23	77975	6170.267857	15049.4338	240438.6	
-625-0139	1.36	78195.92	6173.189009	15056.5586	241191.4	
-625-0515	1.51	79906.564	6136.743393	14967.6668	247310.1	
-625-0824	1.64	87604.045	6499.325843	15852.0143	272256.5	
-625-1120	1.76	83739.135	6116.683831	14918.7411	260716.2	
-625-1520	1.93	98696.203	6837.629459	16677.145	309109.2	
-625-1855	2.08	84444.401	5860.954236	14295.0103	264421.2	
-625-2237	2.23	82576.25	5637.788462	13750.7036	259030.7	
-626-0210	2.38	82316.765	5919.705882	14438.307	256745	
-626-0546	2.53	82976.134	5880.217786	14341.9946	259228.4	
-626-0915	2.68	81685.555	6165.983225	15038.9835	253343.6	
-626-1312	2.84	23706.169	3758.01105	9165.88061	63854.02	
-626-1629	2.98	81615.514	6078.037383	14824.4814	253532.3	
-626-2023	3.14	78051.648	5578.205128	13605.3784	243612.9	
-626-2358	3.29	84493.867	6199.01088	15119.5387	262932.4	
-627-0630	3.56	79699.393	5799.566349	14145.2838	248247	
-627-0945	3.7	94896.42	6684.757506	16304.2866	296666.4	
-627-1316	3.84	82860.058	5786.103013	14112.4464	259287.6	
-627-1631	3.98	85309.133	5753.028891	14031.7778	267953.8	
-627-1922	4.1	77699.821	5357.578475	13067.2646	243475	
-627-2237	4.23	82938.281	5956.25	14527.439	258723.5	
-628-0209	4.38	77886.716	5544.464945	13523.0852	243206	
-628-0501	4.5	78601.039	5493.295562	13398.2819	245937.6	
-628-0756	4.62	78453.883	5337.008629	13017.0942	246194.3	
-628-1124	4.77	86475.763	6048.759542	14753.0721	270552	
-628-1420	4.89	83288.822	5634.131737	13741.7847	261522.9	
-628-1752	5.036111	77284.32	4991.712	12174.9073	243829.4	
-628-2313	5.26	85936.495	5742.061856	14005.0289	270186	
-629-0238	5.4	72366.551	4816.291161	11747.0516	227615.5	
-629-0545	5.53	86305.487	5737.060041	13992.8294	271491.8	
-629-0941	5.7	76584.615	5839.940828	14243.7581	237233.5	
-629-1158	5.79	81135.792	5298.426745	12922.9921	255696	
-629-1642	5.99	80108.396	5109.716981	12462.7243	253055.6	
-629-2028	6.14	77899.437	4787.323944	11676.3999	246969.2	
-629-2326	6.27	80515.885	4872.248804	11883.5337	255636.9	
-630-0356	6.46	84023.446	5545.386064	13525.3319	264509.6	
-630-0731	6.6	85268.041	5760.074977	14048.9634	267776.5	
-630-1047	6.74	83098.252	5546.765734	13528.6969	261290.3	
-630-1443	6.9	85007.951	5457.186544	13310.2111	268361.2	
-630-1811	7.05	78160.335	4592.73743	11201.7986	248830.9	
-630-2117	7.18	81314.178	4575.868545	11160.655	259864.6	
-701-0525	7.52	85809.903	5247.087379	12797.7741	272177.8	
-701-0858	7.67	72039.884	5059.152216	12339.3956	225288.3	
-701-1223	7.81	70084.071	4719.370698	11510.6602	220166.3	

ample #	Elapsd Time	Ch A cpm/ml	Ch B cpm/ml	14C dpm/ml	3H dpm/ml
-701-1550	7.95	79929.798	5091.323401	12417.862	252525.8
-701-2011	8.13	81421.423	4773.640167	11643.0248	259265.5
-701-2327	8.27	83287.634	4978.225806	12142.0142	264740.5
-702-0315	8.43	82745.489	5013.051823	12226.9557	262687
-702-0707	8.59	82023.652	4960.737938	12099.3608	260437.6
-702-1046	8.74	85074.879	5082.608696	12396.6066	270433.5
-702-1424	8.89	82415.326	4469.347209	10900.8469	264211.2
-702-1800	9.04	83056.606	4670.426829	11391.2849	265450.2

Outlet Concentration Spreadsheet

This spreadsheet contains column outlet PCE and tritium dpm/ml calculations. The calculations in the fourth and sixth columns are identical to those in the previous spreadsheet.

l 1 Output Data							
apsd T (d)	Pore Vol	cpm/ml A	3H dpm/ml	dpm/ml B	dpm/ml 14C		
0.10	0.24	33.67	29.7100548	17.755102	43.3051269		
0.15	0.38	0.19	0	0.1869159	0.45589241		
0.25	0.63	5.28	12.7831467	1.1320755	2.76115969		
0.39	0.99	3.33	0	2.972973	7.25115359		
0.54	1.36	9372.57	26261.3358	1278.9908	3119.48982		
0.67	1.70	68032.62	211643.299	5004.3689	12205.7779		
0.87	2.21	81548.20	252405.318	6259.9	15268.0488		
0.92	2.33	84065.59	261688.478	6149.5098	14998.8044		
1.09	2.76	82905.19	255413.639	6606.6981	16113.8978		
1.24	3.16	82944.16	256036.569	6507.4257	15871.7701		
1.31	3.32	81738.71	252401.036	6395.4401	15598.6344		
1.38	3.51	81803.46	252524.592	6416.0603	15648.9277		
1.44	3.65	81862.02	252538.258	6454.6756	15743.1112		
1.49	3.77	81797.19	253144.592	6285.4069	15330.2608		
1.54	3.91	83283.41	257814.676	6385.2459	15573.7705		
1.62	4.10	82303.68	255208.277	6223.3019	15178.7851		
1.68	4.28	76451.47	237162.765	5760.2141	14049.3027		
1.72	4.38	82578.70	256976.697	6057.6848	14774.841		
1.77	4.49	85346.51	268494.361	5669.4045	13827.8159		
1.84	4.67	87324.24	271923.351	6369.3599	15535.0242		
1.95	4.95	82884.23	258211.699	6022.2325	14688.3719		
2.01	5.11	82971.66	257984.729	6130.2481	14951.8246		
2.09	5.30	82078.85	255387.541	6027.8752	14702.1347		
2.15	5.46	82118.98	254313.029	6275	15304.878		
2.21	5.60	81709.08	254279.302	5992.1101	14614.9027		
2.27	5.75	83789.82	261918.466	5907.7477	14409.1408		
2.35	5.97	82253.58	256302.288	5965.1601	14549.1709		
2.42	6.14	94575.37	295011.383	6794.7548	16572.5728		
2.48	6.31	81649.91	254505.571	5904.2135	14400.5207		
2.55	6.48	94649.12	295147.713	6819.1365	16632.0403		
2.62	6.65	79891.30	249512.036	5677.6727	13847.9821		
2.86	7.25	79791.73	245880.608	6346.5969	15479.5045		
2.98	7.57	82476.37	257111.476	5957.9108	14531.4896		
3.05	7.74	81734.42	253914.828	6084.2262	14839.5761		
3.21	8.14	79223.97	246787.444	5760.6343	14050.3276		
3.30	8.37	85235.45	265125.355	6276.7823	15309.2251		
3.37	8.55	82406.30	257816.901	5764.7638	14060.3995		
3.45	8.77	80932.03	253161.118	5670.4589	13830.3875		
3.53	8.97	90386.87	282927.249	6294.0797	15351.4138		
3.64	9.25	83086.80	259746.833	5852.9	14275.3659		
3.70	9.41	86325.19	269411.617	6174.4887	15059.7285		
3.77	9.57	92990.74	289085.342	6881.0458	16783.0384		
3.83	9.72	84881.91	264502.401	6153.6873	15008.9935		
3.90	9.89	95494.12	298353.097	6763.8923	16497.2983		
3.96	10.04	85360.49	266556.237	6073.8602	14814.2931		
4.02	10.21	80480.15	252452.378	5495.3184	13403.2155		
4.08	10.37	82428.97	256702.394	6007.6847	14652.8896		
4.14	10.52	80917.66	253165.325	5659.4492	13803.5346		
4.20	10.67	79817.81	249183.055	5692.702	13884.639		

apsd T (d)	Pore Vol	cpm/ml A	3H dpm/ml	cpm/ml B	dpm/ml 14C		
4.27	10.83	78253.82	244227.504	5596.0036	13648.7892		
4.39	11.14	81197.97	255392.655	5404.1466	13180.8453		
4.46	11.32	78947.39	248315.291	5254.0714	12814.8082		
4.52	11.47	80995.42	255012.419	5338.3754	13020.4277		
4.59	11.64	82758.73	260348.201	5498.5605	13411.1231		
4.64	11.79	85733.70	269053.138	5829.3522	14217.9323		
4.71	11.95	84894.88	266502.213	5755.7229	14038.3485		
4.77	12.11	88610.20	278214.773	5997.5558	14628.1849		
4.84	12.29	77239.51	241468.46	5440.6934	13269.984		
4.89	12.43	86977.05	272469.031	6012.8421	14665.4685		
4.95	12.57	86928.89	273160.706	5837.9798	14238.9751		
5.02	12.75	83418.86	261214.379	5788.8596	14119.1699		
5.08	12.91	78139.63	244849.677	5388.6172	13142.9688		
5.15	13.08	77642.20	243231.149	5366.4962	13089.015		
5.22	13.25	82652.69	260181.077	5457.6233	13311.2764		
5.36	13.61	81652.04	257111.592	5375.1745	13110.1817		
5.42	13.77	79579.77	251037.207	5146.9506	12553.5381		
5.49	13.95	87809.78	277552.371	5566.5973	13577.0666		
5.56	14.12	90753.69	286676.494	5790.091	14122.1732		
5.62	14.28	95720.71	301266.136	6331.0086	15441.4844		
5.70	14.47	82843.09	261596.998	5303.9511	12936.4661		
5.77	14.64	84707.26	268680.876	5179.5476	12633.0429		
5.84	14.82	87745.20	277041.374	5624.9747	13719.4505		
5.90	14.97	85321.80	270213.835	5301.8797	12931.4139		
5.96	15.14	83540.81	266354.265	4828.6561	11777.2101		
6.03	15.31	78749.91	249609.78	4850.9294	11831.535		
6.09	15.47	51764.37	154882.7	5060.0764	12341.6498		
6.16	15.63	80193.07	254017.363	4973.7765	12131.1623		
6.22	15.79	81104.16	256898.223	5031.3181	12271.5077		
6.28	15.94	79783.35	252660.2	4960.4427	12098.6408		
6.34	16.10	81036.99	257066.974	4949.4797	12071.9016		
6.43	16.32	85463.24	270513.558	5340.8371	13026.432		
6.50	16.50	74424.72	234975.713	4772.7667	11640.8945		
6.59	16.73	79438.77	250550.735	5146.3187	12551.9969		
6.64	16.87	82816.00	261585.652	5287.1115	12895.3939		
6.71	17.03	79705.70	251660.035	5109.1719	12461.3948		
6.78	17.20	78596.82	246834.51	5307.7203	12945.6592		
6.84	17.37	79685.15	250739.144	5282.1244	12883.2301		
6.92	17.56	78814.42	248467.847	5129.0118	12509.7848		
6.99	17.74	83825.29	264144.773	5479.5767	13364.8213		
7.07	17.94	83155.00	263186.463	5200.8491	12684.9977		
7.12	18.09	81377.48	257779.337	5045.1402	12305.22		
7.18	18.23	82071.76	260273.276	5028.193	12263.8854		
7.24	18.39	81405.41	258260.689	4966.888	12114.3611		
7.34	18.65	86881.23	275191.836	5390.7794	13148.2423		
7.42	18.85	80975.44	256532.938	5014.6943	12230.9617		
7.48	19.00	81123.18	257454.11	4931.5888	12028.2653		
7.63	19.37	81450.09	258919.364	4864.3785	11864.3378		
7.70	19.54	79061.67	249191.762	5156.4169	12576.6265		
7.80	19.80	80159.40	253635.713	5027.6676	12262.6039		

apsd T (d)	Pore Vol	cpm/ml A	3H dpm/ml	cpm/ml B	dpm/ml 14C		
7.88	20.00	83848.39	265741.298	5170.8729	12611.885		
7.94	20.16	74565.21	234893.449	4888.8235	11923.9598		
8.01	20.34	82378.91	262198.649	4853.3392	11837.4127		
8.07	20.50	81425.04	257855.314	5063.2953	12349.5007		
8.20	20.82	79796.50	252317.569	5039.4921	12291.4442		
8.26	20.96	80063.77	252807.708	5128.6436	12508.8869		
8.32	21.13	81687.90	258707.988	5075.5159	12379.3072		
8.39	21.30	82468.30	261238.941	5111.9116	12468.0771		
8.46	21.47	86604.50	274755.675	5283.9587	12887.7042		
8.53	21.65	88759.64	281878.394	5357.3293	13066.6569		
8.59	21.82	79758.81	253425.706	4787.2477	11676.2139		
8.65	21.96	78057.64	248649.065	4557.1567	11115.0163		
8.71	22.11	85430.31	272856.287	4840.6122	11806.3713		
8.77	22.26	84282.83	267489.119	5122.1463	12493.0399		
8.83	22.43	83944.54	268407.815	4695.977	11453.6025		
8.90	22.59	80386.07	255746.792	4758.1172	11605.1639		
8.96	22.75	78618.03	251209.986	4431.9249	10809.5729		
9.05	22.97	84189.64	267550.199	5043.8342	12302.0346		
9.10	23.10	83160.87	264830.99	4870.1923	11878.5178		
9.15	23.23	82461.75	262134.893	4924.8784	12011.8986		
9.21	23.38	79827.32	253946.06	4729.741	11535.9537		
9.26	23.52	79520.45	253071.562	4690.8491	11441.0954		
9.34	23.71	83913.29	267887.332	4779.8499	11658.1706		
9.40	23.87	70085.30	223956.318	3948.6422	9630.83457		
9.46	24.03	78287.65	250566.239	4329.4362	10559.6004		
9.60	24.36	32674.94	106942.941	1325.6927	3233.39682		
9.67	24.55	11589.14	36797.4637	700.86862	1709.43566		
9.74	24.72	2761.56	7860.11787	351.92698	858.358482		
9.78	24.84	959.35	2153.01188	239.8374	584.969264		
9.87	25.07	506.29	917.576461	171.08571	417.28223		
9.92	25.18	435.15	752.67385	154.36893	376.50959		
10.01	25.41	302.13	439.516038	124.09639	302.674111		
10.05	25.51	280.58	396.512829	117.61518	286.866283		
10.11	25.67	219.75	242.960913	105.87669	258.235819		
10.17	25.83	287.62	269.079476	148.53801	362.287833		
10.23	25.98	331.12	341.225932	164.5979	401.458298		
10.30	26.15	705.95	1305.56003	233.2389	568.875377		
10.36	26.31	175.00	157.060636	91.731518	223.735409		
10.42	26.46	169.26	138.189069	91.516966	223.212112		
10.49	26.63	175.16	143.66634	94.572217	230.663944		
10.55	26.78	170.11	125.239297	94.75089	231.099731		
10.61	26.93	171.75	166.827442	87.44229	213.273878		
10.67	27.09	143.07	73.6431498	86.144578	210.108728		
10.73	27.23	158.22	104.103348	90.654206	221.107819		
10.79	27.40	174.00	97.4629154	103.15789	251.604621		
10.85	27.56	163.02	134.206533	87.913223	214.422495		
10.92	27.73	153.20	106.43839	86.629526	211.291528		
10.98	27.88	119.09	95.6488877	64.711033	157.831788		
11.05	28.04	124.14	104.914719	66.39839	161.947294		
11.11	28.21	116.8317	92.4696128	63.762376	155.517991		

apsd T (d)	Pore Vol	cpm/ml A	3H dpm/ml	cpm/ml B	dpm/ml 14C		
11.14	28.29	99.33	106.9678	48.439822	118.145907		
11.23	28.50	96.45	84.9389041	50.887574	124.116034		
11.27	28.61	93.48	98.6944966	45.986622	112.162493		
11.34	28.79	81.44	83.2515186	40.618762	99.0701524		
11.41	28.96	106.55	82.4535155	58.531746	142.760356		
11.47	29.12	86.37	79.6222368	44.843049	109.373291		
11.56	29.35	89.18	44.3507817	54.011194	131.73462		
11.65	29.57	90.32	25.8559427	58.584807	142.889774		
11.73	29.77	80.70	34.101054	50.10661	122.211243		
11.81	29.99	86.07	13.4339311	58.108108	141.727093		
11.89	30.20	119.60	81.6856639	67.915106	165.6466		
11.98	30.42	101.04	45.7364965	62.111216	151.49077		
12.06	30.62	66.70	44.2586123	38.136324	93.0154254		
12.14	30.83	64.61	55.4669232	34.377646	83.8479172		
12.23	31.04	56.36	38.4262681	32.020202	78.0980537		
12.32	31.27	65.14	65.4527315	32.723577	79.813603		
12.40	31.48	70.44	36.8878	42.284569	103.133095		
12.48	31.68	76.20	81.2638389	37.318087	91.0197252		
12.57	31.92	80.15	52.9281672	45.88577	111.916511		
12.65	32.13	103.56	113.081982	50.187617	122.408823		
12.75	32.37	102.55	81.7402337	55.849057	136.217211		
12.83	32.58	114.45	83.4078915	63.923445	155.910841		
12.92	32.80	118.72	101.957102	63.168724	154.070059		
13.00	33.01	107.80	166.105368	42.387218	103.383459		
13.09	33.22	87.70	84.7123833	44.74929	109.144611		
13.17	33.44	64.11	40.2670634	37.121212	90.5395418		
13.25	33.65	69.73	76.6681922	33.680227	82.1468953		
13.34	33.86	66.76	81.755315	30.547818	74.5068732		
13.42	34.08	49.54	41.751511	26.519337	64.6813098		
13.51	34.29	46.09	33.0106772	25.858779	63.0701918		
13.60	34.54	50.05	42.4585141	26.732673	65.2016421		
13.69	34.75	45.28	51.1683439	21.590909	52.6607539		
13.77	34.97	38.33	30.7022612	20.8441	50.8392681		
13.86	35.18	43.62	34.7160519	23.770492	57.9768093		
13.94	35.39	41.36	27.5859836	23.621324	57.6129842		
14.02	35.60	50.51	47.2139507	26.095061	63.6464892		
14.10	35.81	53.61	31.6051758	31.463878	76.7411667		
14.19	36.02	53.88	0	38.159156	93.0711129		
14.27	36.24	51.81	47.2789602	26.996198	65.8443847		
14.36	36.47	37.00	21.2026601	21.841155	53.2711103		
14.45	36.70	36.73	25.1611453	20.841121	50.8320036		
14.59	37.05	41.02	38.8243615	21.095153	51.4515917		
14.72	37.37	29.01	28.3464218	14.732965	35.934061		
14.87	37.75	35.96	43.2248006	16.618076	40.5318922		
14.96	37.97	30.16	26.0233429	16.023993	39.0829101		
15.08	38.29	28.36	26.7564022	14.597315	35.6032084		
15.21	38.62	26.04	16.9010395	14.965398	36.5009705		
15.34	38.94	32.43	37.7233141	15.242718	37.1773621		
15.46	39.26	33.21	30.1044317	17.34694	42.3096098		
15.71	39.89	40.81	30.0677354	22.72727	55.4323659		

apsd T (d)	Pore Vol	cpm/ml A	3H dpm/ml	cpm/ml B	dpm/ml 14C		
15.83	40.20	43.69	31.6831657	24.43233	59.5910488		
15.97	40.55	34.75	41.7784468	16.05938	39.1692195		
16.09	40.84	54.17	41.0931191	29.92424	72.9859512		
16.21	41.16	54.17	57.4424585	26.59574	64.8676585		
16.34	41.49	27.65	40.7375313	11.25402	27.4488293		
16.46	41.80	21.69	26.720633	9.891107	24.1246512		
16.63	42.23	22.32	26.2732038	10.42885	25.4362195		
16.84	42.75	55.49	41.1586535	30.84661	75.2356341		
16.96	43.07	32.78	29.2711568	17.21582	41.9898049		
17.12	43.47	41.98	26.9922603	24.17695	58.9681707		
17.34	44.03	20.97	36.4921026	7.397004	18.0414732		
17.51	44.46	12.71	25.5029168	3.795066	9.25625854		
17.69	44.91	22.58065	29.813958	9.892473	24.1279829		
17.85	45.32	31.95147	1.67837483	22.24469	54.2553415		
18.02	45.75	15.74344	15.9994309	7.87172	19.1993171		
18.19	46.18	33.1434	25.5190921	18.23362	44.4722439		
18.35	46.59	18.56223	10.1680581	11.0515	26.954878		
18.53	47.05	15.66	17.7019699	7.46888	18.2167805		
18.69	47.45	11.44	2.1051897	7.655955	18.673061		
18.85	47.86	21.94	4.66684197	14.56016	35.5125854		
19.02	48.29	23.98	7.27304455	15.47389	37.7411951		
19.19	48.72	22.41	23.4843572	11.05723	26.9688537		
19.36	49.16	15.33	29.2522083	4.882813	11.9093		
20.02	50.83	25.99	0	20.32136	49.5642927		
20.19	51.26	20.28	21.3079116	10	24.3902439		
20.37	51.72	10.01	12.901676	4.447975	10.8487195		
20.70	52.56	6.39	9.32992209	2.620545	6.39157317		
21.04	53.42	24.98	27.2413135	12.10974	29.5359512		
21.37	54.26	14.17	22.0797297	5.519779	13.4628756		
21.72	55.15	11.22	20.2673599	3.804878	9.28019024		
22.83	57.97	11.97	7.66489092	6.903991	16.8390024		
23.85	60.56	8.76	0	7.589984	18.5121561		
25.85	65.63	7.58	0	7.385811	18.0141732		
26.80	68.05	10.97	0	8.434864	20.572839		
27.92	70.89	11.48	8.42899136	6.39699	15.6024146	**Col 1**	
29.87	75.84	7.96	8.93770105	3.806228	9.28348293	**Total Mass**	**1621171**
0.1	0.27	9.63	0	8.0555556	19.6476965	Col 2	
0.15	0.41	1232.06	4276.97334	0.2061856	0.50289163	**Total Mass**	**956326.1**
0.25	0.67	14452.02	50154.0375	5.412844	13.2020586		
0.39	1.05	27421.3	95136.2212	15.6	38.0487805		
0.55	1.46	45175.5	156580.378	56.8	138.536585		
0.67	1.78	57227.84	198287.479	85.56701	208.700025		
0.87	2.32	68747.68	237957.507	152.63158	372.272144		
0.91	2.42	74339.59	257121.006	204.10959	497.828266		
1.08	2.89	75182.11	259867.878	240.45872	586.484673		
1.24	3.31	70337.88	242982.512	253.71681	618.821498		
1.31	3.5	76314.13	263318.57	338.16651	824.796368		
1.39	3.7	75853.02	261855.175	310.13645	756.430371		
1.44	3.85	72465.26	249942.61	340.57451	830.669527		
1.49	3.98	73966.33	255135.852	344.40333	840.008122		

apsd T (d)	Pore Vol	cpm/ml A	3H dpm/ml	cpm/ml B	dpm/ml 14C		
1.54	4.12	78324.93	270030.188	393.20113	959.027154		
1.62	4.33	76803.1	264671.505	408.37887	996.046027		
1.69	4.5	76541.96	263636.358	434.52139	1059.80826		
1.73	4.61	84754.14	291477.172	571.67756	1394.33551		
1.77	4.73	80963.92	278700.204	493.59845	1203.89865		
1.84	4.93	82814.18	285034.267	512.01299	1248.81216		
1.95	5.21	80599.44	276937.355	594.84053	1450.83055		
2.02	5.38	79075	271253.302	674.41406	1644.91235		
2.09	5.58	79799.62	273889.968	649.85646	1585.01575		
2.15	5.75	63699.63	218616.763	521.69118	1272.4175		
2.21	5.9	76358.57	262232.818	590.625	1440.54878		
2.27	6.06	71085.17	244087.399	557.0339	1358.61926		
2.35	6.28	74650.8	256161.08	619.53052	1511.05004		
2.42	6.46	71346.94	244660.411	625.42073	1525.4164		
2.49	6.64	79241.77	271617.335	718.19106	1751.6855		
2.55	6.82	69901.45	239207.96	713.6528	1740.61659		
2.62	7.01	78248.8	267503.52	853.7799	2082.39001		
2.69	7.19	60557.55	205471.296	976.80158	2382.44288		
2.85	7.62	67841.83	230481.317	1034.3385	2522.77688		
2.99	8	78936.46	268676.186	1101.1458	2685.72154		
3.05	8.15	78713.13	267813.521	1118.9013	2729.02756		
3.14	8.38	61141.74	207960.669	882.96131	2153.56417		
3.21	8.57	75788.2	256606.172	1332.9401	3251.07344		
3.3	8.8	81624.81	276498.349	1409.0467	3436.69924		
3.38	9.01	66509.8	225797.501	1046.2916	2551.93063		
3.46	9.23	79809.64	270829.646	1279.979	3121.9001		
3.54	9.44	70178.71	237878.965	1180.212	2878.56588		
3.58	9.57	91750.57	310968.22	1549.3213	3778.83237		
3.65	9.74	79952.66	270988.834	1348.6708	3289.44088		
3.71	9.9	83817.13	283858.974	1460.2683	3561.63005		
3.77	10.07	89858.16	303650.036	1701.4644	4149.91327		
3.83	10.24	82648.43	279346.021	1552.8934	3787.54488		
3.9	10.41	79477.2	268713.734	1475.7488	3599.38729		
3.96	10.57	83252.28	281264.453	1589.1865	3876.06466		
4.02	10.74	81090.78	273598.742	1621.8628	3955.7628		
4.08	10.91	74028.99	249144.299	1608.4949	3923.15834		
4.15	11.08	100285.3	337507.761	2179.422	5315.66334		
4.21	11.24	76663.72	257968.769	1674.4361	4083.99046		
4.27	11.4	75611.06	253680.345	1803.3784	4398.48385		
4.34	11.58	75342.79	252614.31	1830.7692	4465.2908		
4.39	11.73	80125.17	268453.387	1986.7996	4845.85273		
4.46	11.91	77330.6	258759.201	1984.9302	4841.29324		
4.52	12.07	77941.23	260792.342	2002.663	4884.54388		
4.59	12.26	80735.78	269764.689	2151.4748	5247.49949		
4.65	12.41	79922.22	267324.323	2073.1969	5056.57776		
4.71	12.58	78950.19	263722.293	2119.3957	5169.25783		
4.77	12.74	82849.51	276398.375	2295.1362	5597.89315		
4.84	12.94	86470.31	288844.613	2320.7847	5660.45056		
4.9	13.08	81433.56	272052.036	2179.0607	5314.78212		
4.95	13.23	82799.11	276414.351	2256.2562	5503.0638		

apsd T (d)	Pore Vol	cpm/ml A	3H dpm/ml	cpm/ml B	dpm/ml 14C		
5.02	13.42	77160.98	257082.853	2206.3078	5381.23859		
5.09	13.59	77655.51	259291.712	2106.1962	5137.06393		
5.15	13.76	80871.74	269946.137	2210.644	5391.81466		
5.22	13.95	79516.49	265713.412	2114.3469	5156.94366		
5.29	14.13	81663.92	272468.294	2257.1571	5505.26112		
5.36	14.33	82441.58	274334.624	2426.9231	5919.32459		
5.43	14.5	81585.92	271883.246	2321.1268	5661.28478		
5.5	14.68	85085.47	283054.796	2520.5732	6147.73946		
5.56	14.86	83634.95	276515.599	2826.4957	6893.89202		
5.63	15.02	89099.9	294003.19	3129.4178	7632.72627		
5.7	15.22	81208.7	267996.571	2845.7447	6940.84068		
5.77	15.4	81892.63	269862.289	2949.378	7193.60485		
5.84	15.6	86105.46	283381.679	3175.0516	7744.02817		
5.9	15.75	82959.05	274533.059	2752.3223	6712.98115		
5.96	15.93	79966.52	265744.565	2426.1293	5917.38859		
6.03	16.11	78000.47	262629.539	1670.5116	4074.41861		
6.1	16.29	79142	261730.673	2660.452	6488.90727		
6.16	16.45	79440.78	262891.348	2635.361	6427.70976		
6.22	16.61	78624.11	259953.257	2656.2147	6478.57241		
6.28	16.78	82904.62	274405.579	2739.799	6682.43656		
6.34	16.95	79144.34	261448.619	2719.5283	6632.99585		
6.43	17.19	84301.81	279288.137	2733.4463	6666.94227		
6.5	17.37	77986.38	258370.101	2527.7143	6165.1568		
6.59	17.6	79850.14	264284.416	2641.1268	6441.77259		
6.65	17.75	80259.29	265367.932	2709.7646	6609.18195		
6.71	17.92	81591.52	270283.968	2650.6763	6465.0641		
6.78	18.1	75635.74	249772.892	2616.3282	6381.28827		
6.84	18.28	76526.96	253732.235	2440.2609	5951.85578		
6.92	18.48	76275.15	252649.384	2482.7107	6055.39193		
6.99	18.67	89404.61	295203.246	3100.5015	7562.19878		
7.07	18.88	80511.85	265682.923	2824.1706	6888.22102		
7.13	19.04	79854.47	263554.466	2792.7954	6811.69607		
7.18	19.19	79939.69	263976.959	2767.0234	6748.83744		
7.25	19.36	79913.56	263618.694	2821.49	6881.68285		
7.35	19.63	82746.07	273918.643	2726.8539	6650.86324		
7.43	19.84	80566.41	266383.672	2720.0761	6634.332		
7.49	20	79731.04	263663.407	2683.3643	6544.791		
7.55	20.16	81922.25	270455.349	2849.5775	6950.18893		
7.63	20.38	78854.56	260594.497	2688.5714	6557.49129		
7.7	20.56	79863.69	262333.831	3047.8175	7433.70112		
7.8	20.84	82500.77	272249.8	2893.2057	7056.59937		
7.88	21.05	71537.43	234487.701	2831.1009	6905.1242		
7.94	21.21	82131.97	270913.036	2904.649	7084.50966		
8.01	21.41	68169.59	225493.052	2281.573	5564.81227		
8.08	21.57	80242.02	265063.633	2759.5076	6730.50644		
8.14	21.74	76918.95	254070.392	2648.5132	6459.78822		
8.2	21.91	77333.25	255108.031	2730.1314	6658.85698		
8.26	22.06	76937.7	253593.136	2758.9301	6729.09783		
8.33	22.25	77136	254230.293	2769.3913	6754.61293		
8.4	22.43	73972.41	243734.499	2669.8594	6511.8522		

apsd T (d)	Pore Vol	cpm/ml A	3H dpm/ml	cpm/ml B	dpm/ml 14C		
8.53	22.79	77571.4	254902.948	2940.2309	7171.2949		
8.6	22.96	78896.27	259152.453	3011.6364	7345.45454		
8.65	23.1	80421.44	264505.339	3000	7317.07317		
8.71	23.26	80820.42	266373.52	2901.7017	7077.32122		
8.77	23.42	81771.52	269913.532	2853.3333	6959.34959		
8.83	23.6	81600	269545.5	2807.0128	6846.37256		
8.9	23.77	79864.96	263524.118	2806.3892	6844.85161		
8.96	23.94	77827.83	256618.338	2772.2706	6761.63571		
9.05	24.17	85397.09	279971.493	3368.5742	8216.03463		
9.1	24.3	83728.3	275105.804	3179.4995	7754.87688		
9.15	24.44	75454.5	248786.442	2689.0379	6558.6289		
9.21	24.6	78233.58	257976.323	2782.6268	6786.89456		
9.27	24.75	65294.52	212670.203	2859.751	6975.00254		
9.34	24.95	55608.73	178055.38	3060	7463.41463		
9.4	25.12	42463.54	132793.057	2982.4952	7274.37844		
9.47	25.29	34658.35	106380.221	2842.3225	6932.4938		
9.52	25.43	29650.41	89179.7594	2804.0036	6839.03327		
9.6	25.64	25534.72	75675.2275	2643.973	6448.71463		
9.67	25.83	18484.75	51710.3295	2539.2962	6193.40534		
9.74	26.01	17605.83	49045.7754	2460.4571	6001.11498		
9.79	26.14	16150.6	44443.5728	2368.705	5777.32937		
9.87	26.37	13485.09	35655.0022	2273.697	5545.60237		
9.92	26.49	11782.9	30486.127	2122.7364	5177.4059		
10.01	26.73	9092.83	21619.3596	2026.2868	4942.16283		
10.05	26.83	8317.81	18857.1847	2040.7685	4977.48417		
10.17	27.17	7329.03	15325.1652	2060.8738	5026.52144		
10.23	27.33	6308.14	12146.8616	1986.2689	4844.55839		
10.29	27.48	5726.24	10017.6844	2008.397	4898.52915		
10.36	27.68	5157.51	8472.95276	1920.8497	4684.99932		
10.43	27.85	4795.74	6719.13707	2022.1684	4932.11815		
10.49	28.01	4484.93	6169.13798	1914.4302	4669.34183		
10.65	28.45	4184.34	5510.07131	1836.121	4478.3439		
10.61	28.34	4151.15	5132.71447	1889.4838	4608.49695		
10.67	28.5	3725.2	4024.49187	1814	4424.39024		
10.73	28.65	3749.1	3356.03154	1966.9841	4797.52227		
10.79	28.82	3470.17	3335.46676	1773.9962	4326.81995		
10.85	28.99	3300.2	2430.58475	1838.0665	4483.08895		
10.92	29.18	3099.8	1965.65881	1791.0569	4368.43149		
10.98	29.33	3008.47	2040.96582	1711.1646	4173.57215		
11.05	29.5	2959.26	2044.14487	1675.731	4087.14876		
11.11	29.67	2692.355	1397.24536	1618.7564	3948.18627		
11.14	29.77	2730.53	1699.61697	1584.1837	3863.86261		
11.23	29.99	2738.33	1341.68576	1662.5673	4055.04224		
11.27	30.11	2747.26	1903.80855	1554.4395	3791.31576		
11.35	30.3	3093.97	1343.7637	1913.545	4667.18285		
11.41	30.48	2595.1	1046.39791	1621.4351	3954.71966		
11.47	30.64	2582.79	859.005271	1650.8837	4026.54566		
11.65	31.11	2496.5	895.178775	1582.5212	3859.80778		
11.73	31.32	2442.14	1242.91021	1473.301	3593.417		
11.81	31.55	2380.69	333.063879	1615.0943	3939.25449		

apsd T (d)	Pore Vol	cpm/ml A	3H dpm/ml	cpm/ml B	dpm/ml 14C		
11.9	31.77	2545.41	1221.95877	1550.5676	3781.8722		
11.98	32	2335.82	1216.27952	1403.5654	3423.33017		
12.06	32.22	2231.17	996.448249	1374.3433	3352.05673		
12.14	32.44	2198.39	960.355484	1358.5192	3313.46141		
12.23	32.67	2175.52	472.700767	1441.6322	3516.17617		
12.32	32.9	2317.6	1334.889	1366.5385	3333.02063		
12.4	33.13	2385.23	1185.76885	1444.7047	3523.66995		
12.48	33.34	2349.55	1038.57401	1449.4495	3535.24256		
12.65	33.8	2235.48	951.410051	1386.5591	3381.85156		
12.75	34.05	2187.41	829.736792	1377.3496	3359.38932		
12.83	34.27	2251	426.036318	1504.489	3669.48541		
12.92	34.51	2139.05	717.482492	1366.0175	3331.75007		
13	34.74	2002.8	1188.95021	1173.7186	2862.72817		
13.09	34.96	1965.67	1042.27717	1177.3321	2871.54168		
13.17	35.18	1959.59	1049.96678	1171.4687	2857.24063		
13.26	35.41	1878.73	714.742864	1182.556	2884.28285		
13.34	35.62	1918.66	957.601357	1161.3397	2832.53588		
13.43	35.87	1925.87	932.033044	1171.6418	2857.6629		
13.43	35.87	1925.87	932.033044	1171.6418	2857.6629		
13.51	36.08	1890.15	665.894361	1200.5736	2928.22832		
13.61	36.34	1920.95	1263.63232	1100.6548	2684.52395		
13.69	36.56	1791.7	918.342036	1079.5848	2633.13361		
13.78	36.79	1822.99	1021.08246	1080.787	2636.06595		
13.86	37.01	1945.41	1195.19256	1131.8789	2760.68024		
13.94	37.24	1865.04	983.875027	1118.087	2727.04137		
14.02	37.45	1926.05	1032.28581	1151.359	2808.19256		
14.11	37.68	1853.49	999.712027	1106.6981	2699.26368		
14.19	37.9	1808.7	1177.75544	1038.789	2533.63178		
14.27	38.12	1749.95	676.048848	1099.3994	2681.46195		
14.37	38.39	1898.09	1356.1254	1065.6649	2599.18256		
14.46	38.61	1819.87	1064.08499	1069.8268	2609.33366		
14.6	38.99	1828.63	899.12143	1109.6035	2706.35005		
14.72	39.32	1714.31	365.208276	1137.4885	2774.3621		
14.87	39.71	1676.96	716.974119	1039.4712	2535.29561		
14.96	39.95	1668.42	813.004463	1013.8839	2472.88744		
15.08	40.28	1726.99	1042.62253	1008.5397	2459.85295		
15.21	40.63	1670.36	892.322638	999.10714	2436.84669		
15.34	40.97	1675.47	650.816072	1051.8868	2565.57754		
15.47	41.32	1699.62	1108.61104	975.7576	2379.89659		
15.6	41.67	1667.14	834.086551	1008.687	2460.2122		
15.71	41.97	1591.03	403.159045	1042.616	2542.96585		
15.84	42.3	1670.66	607.107893	1057.385	2578.9878		
15.97	42.66	1097.84	238.297138	727.5453	1774.50073		
16.09	42.97	1555.99	806.782385	935.6742	2282.1322		
16.21	43.3	1619.11	697.411077	1002.56	2445.26829		
16.35	43.66	1568.34	518.935637	1003.006	2446.3561		
16.47	43.98	1578.13	789.84602	954.7729	2328.71439		
16.64	44.45	1513.82	490.659654	970.2226	2366.39659		
16.84	44.98	1156.37	441.617666	727.5267	1774.45537		
16.97	45.32	1451.55	546.691209	914.7969	2231.21195		

apsd T (d)	Pore Vol	cpm/ml A	3H dpm/ml	cpm/ml B	dpm/ml 14C		
17.12	45.73	1440.59	633.581741	889.3596	2169.16976		
17.35	46.33	1488.64	503.531572	949.8024	2316.59122		
17.51	46.78	1431.56	556.82273	898.6034	2191.71561		
17.69	47.25	1406.9	621.971206	867.908	2116.84878		
17.85	47.68	1434.028	592.642547	893.0556	2178.18439		
18.02	48.13	1449.52	939.942801	833.3013	2032.4422		
18.19	48.59	1356.695	879.632368	779.962	1902.34634		
18.36	49.04	1351.373	744.239583	803.764	1960.4		
18.54	49.52	1395.61	505.412907	883.6568	2155.26049		
18.69	49.92	1353.18	512.543936	852.2114	2078.56439		
18.85	50.35	1336.31	502.19773	842.3924	2054.61561		
19.02	50.8	1362.77	952.094038	769.5042	1876.83951		
19.19	51.26	1260.75	805.733994	727.1835	1773.61829		
19.37	51.74	1312.52	813.300491	762.2391	1859.11976		
19.52	52.14	1279.71	706.578743	760.7729	1855.54366		
19.69	52.59	1258.9	972.620257	691.9	1687.56098		
19.86	53.05	1204.62	663.125593	716.5385	1747.65488		
20.03	53.5	1213.54	720.912009	711.0795	1734.34024		
20.19	53.93	1200.86	864.970156	672.7878	1640.94585		
20.37	54.41	1272	950.646985	705.6338	1721.05805		
20.71	55.32	1177.93	580.426626	714.5078	1742.70195		
21.04	56.2	1096.65	721.624051	628.3054	1532.4522		
21.37	57.08	1169.98	798.825373	664.425	1620.54878		
21.72	58.01	1111.49	727.191446	637.6623	1555.2739		
22.83	60.98	1070.36	713.961399	611.2811	1490.92951		
23.85	63.7	1017.49	529.869258	611.3861	1491.18561		
24.85	66.37	890.66	429.735806	542.1162	1322.23463		
25.86	69.07	874.46	357.132537	545.4455	1330.35488		
26.8	71.58	839.29	511.749339	489.1061	1192.94171		
27.92	74.57	836.78	474.425542	494.9304	1207.14732		
28.94	77.3	864.6	941.715362	419.4625	1023.07927		
29.88	79.81	714.49	596.019343	383.7292	935.924878		
31.88	85.15	738.8	762.689549	366.9821	895.078293		
32.68	87.29	707.65	713.384993	355	865.853659		
0.1	0.27	10.29	24.1716981	2.3529412	5.73888093	**Col 3**	
0.16	0.4	3.75	13.0208333	0	0	**Total Act =**	**1693007**
0.25	0.65	1.64	3.01521308	0.5454546	1.33037695		
0.37	0.93	619.49	1732.99218	85.102041	207.565953		
0.52	1.32	41956.38	130378.619	3115.5319	7598.85832		
0.66	1.68	85183.7	265115.523	6242.2	15224.878		
0.87	2.2	85185.2	263622.374	6547.2449	15968.89		
0.91	2.32	85151.31	264396.95	6365.5952	15525.842		
1.08	2.74	84638.06	261058.578	6682.4272	16298.6029		
1.24	3.14	82695.87	254359.681	6673.3028	16276.3482		
1.34	3.4	86015.1	264562.508	6942.5	16932.9268		
1.39	3.53	84677.15	260344.237	6855.4896	16720.7064		
1.49	3.79	84126.28	259256.763	6687.4763	16310.9178		
1.55	3.93	80219.18	247592.845	6300.1736	15366.2771		
1.62	4.12	79185.3	244690.645	6160.1753	15024.8177		
1.69	4.29	85246	263449.042	6625.5123	16159.7861		

apsd T (d)	Pore Vol	cpm/ml A	3H dpm/ml	cpm/ml B	dpm/ml 14C		
1.73	4.39	86383.88	268027.273	6497.811	15848.3194		
1.77	4.5	89118.09	275681.219	6872.3769	16761.8948		
1.85	4.7	85960.46	267494.106	6307.0423	15383.0299		
1.96	4.97	85537.55	265690.903	6375.1961	15549.2587		
2.02	5.13	84260.18	261994.976	6224.6674	15182.1155		
2.09	5.31	85066.37	264606.785	6262.8319	15275.1997		
2.16	5.48	23082.87	59518.3181	4200.0926	10244.1283		
2.21	5.62	81030.86	251904.788	5996.0952	14624.6225		
2.27	5.77	80968.79	251567.717	6020.8411	14684.9783		
2.36	5.98	83188.8	260732.122	5724.4121	13961.9807		
2.42	6.16	81803.51	255857.674	5737.5258	13993.9653		
2.56	6.5	80742.45	252397.358	5691.9388	13882.7775		
2.63	6.68	82216.25	257556.006	5683.5333	13862.2762		
2.68	6.82	63232.41	193239.124	5357.9523	13068.1763		
2.85	7.23	74647.67	230830.175	5774.3408	14083.758		
2.98	7.58	80636.13	250203.412	6063.4387	14788.875		
3.05	7.75	81642.6	254830.52	5832.8935	14226.5695		
3.14	7.97	85912.67	269666.963	5830.896	14221.6975		
3.21	8.15	79537.27	248433.422	5647.0038	13773.1799		
3.3	8.37	92967.23	289174.491	6846.2766	16698.2356		
3.38	8.59	96796.14	302153.092	6910.6557	16855.2579		
3.46	8.79	79068.48	246135.804	5783.3811	14105.8075		
3.54	9	83201.48	259377.687	6009.1198	14656.3898		
3.65	9.26	94119.35	292122.99	7060.4324	17220.5669		
3.71	9.42	87881.87	274430.769	6253.0715	15251.3939		
3.77	9.58	79260.73	246542.829	5836.4173	14235.1642		
3.83	9.74	84100.52	261928.38	6125.3623	14939.9081		
3.9	9.9	86090.38	269494.929	5991.5423	14613.5178		
3.96	10.06	82950.44	259053.989	5897.561	14384.2951		
4.02	10.22	86896.59	274371.129	5568.7225	13582.2499		
4.09	10.38	73166.08	229288.13	5040.949	12294.9976		
4.15	10.54	79471.5	247411.797	5808.5	14167.0732		
4.21	10.69	80756.85	251370.505	5911.1712	14417.4907		
4.27	10.85	76864.16	239333.259	5610.0592	13683.0711		
4.34	11.03	80550.82	252315.252	5573.1919	13593.151		
4.4	11.17	81990.51	256450.7	5748.9835	14021.9111		
4.46	11.34	80422.72	251736.897	5600.3835	13659.472		
4.52	11.49	80222.46	251394.547	5528.5182	13484.1907		
4.59	11.66	75783.84	236721.153	5378.1735	13117.4964		
4.65	11.8	85796.38	268840.526	5916.9422	14431.5662		
4.71	11.96	87643.47	273475.554	6279.0161	15314.6733		
4.78	12.13	84424.24	264446.499	5841.5445	14247.6695		
4.84	12.3	74599.22	233396.808	5217.5606	12725.7574		
4.9	12.44	84188.46	263433.063	5881.194	14344.3757		
4.95	12.58	86458.98	270179.402	6112.7551	14909.1588		
5.03	12.77	77955.8	242414.504	5754.4369	14035.2119		
5.09	12.93	79344.92	247783.657	5643.3155	13764.1842		
5.16	13.1	89886.56	281105.736	6311.2488	15393.2898		
5.23	13.27	82926.36	260006.959	5686.5273	13869.5788		
5.29	13.45	84420.08	265007.252	5724.4422	13962.0541		

apsd T (d)	Pore Vol	cpm/ml A	3H dpm/ml	cpm/ml B	dpm/ml 14C		
5.37	13.63	86655.9	272789.975	5720.4807	13952.3919		
5.43	13.79	87613.76	275698.052	5805.5442	14159.8638		
5.5	13.97	87329.27	272716.794	6211.3821	15149.7125		
5.56	14.13	86082.34	270243.052	5833.5514	14228.1741		
5.7	14.48	85876.12	271721.36	5386.8121	13138.566		
5.77	14.65	85354.29	269830.611	5402.8626	13177.7137		
5.84	14.83	96089.62	304260.798	5982.1192	14590.5347		
5.9	14.98	86714.46	275302.794	5250.3012	12805.6127		
5.96	15.15	84003.91	265239.669	5382.9361	13129.1125		
6.03	15.33	79780.75	251898.489	5113.6793	12472.3884		
6.1	15.5	80517.79	254990.48	5005.2034	12207.8132		
6.16	15.65	78831.41	248815.44	5070.2602	12366.4883		
6.22	15.8	81113.42	255711.79	5279.4035	12876.594		
6.28	15.96	81080.36	255482.045	5302.8064	12933.674		
6.35	16.12	80268.48	252932.536	5247.9362	12799.8444		
6.44	16.36	84809.97	267231.687	5547.1898	13529.7313		
6.51	16.53	82084.71	258883.473	5320.2941	12976.3271		
6.59	16.75	81700	257316.337	5367.3913	13091.1983		
6.65	16.89	82822.23	260886.499	5433.8561	13253.3075		
6.71	17.06	82607.16	260269.05	5407.5279	13189.0924		
6.78	17.22	81752.85	257288.014	5410.5169	13196.3828		
6.85	17.39	78840.88	248171.143	5208.1245	12702.7426		
6.92	17.58	80585.79	253374.19	5382.3268	13127.6264		
6.99	17.76	75486.42	237300.408	5050	12317.0732		
7.07	17.96	81759.34	258695.575	5128.5446	12508.6454		
7.13	18.11	81367.17	257017.91	5192.8705	12665.5379		
7.19	18.25	85649.04	271912.947	5187.2856	12651.916		
7.25	18.41	82151.47	260236.847	5091.9584	12419.4107		
7.35	18.68	83331.59	264089.002	5141.9355	12541.306		
7.49	19.03	83152.47	263246.642	5186.8089	12650.7535		
7.55	19.18	79197.08	251317.437	4819.3791	11754.5832		
7.63	19.39	83043.95	264010.247	4954.6371	12084.4807		
7.7	19.56	79211.49	250328.541	5030.8911	12270.4661		
7.81	19.83	84093.95	267060.298	5075.9302	12380.3176		
7.88	20.02	85428.54	271262.003	5163.9381	12594.9709		
7.95	20.2	81742.04	258875.057	5079.7753	12389.6958		
8.02	20.36	81969.4	260302.182	4949.9523	12073.0545		
8.08	20.52	81472.98	258213.337	5024.2948	12254.3776		
8.14	20.68	83126.54	263786.524	5058.5666	12337.9674		
8.2	20.84	77922.24	246318.469	4935.92	12038.8293		
8.26	20.98	81640.88	258376.361	5109.7934	12462.9106		
8.33	21.16	79882.3	253095.634	4941.7423	12053.03		
8.4	21.34	85566.06	271359.291	5241.344	12783.7658		
8.46	21.49	81841.63	259616.012	4999.3269	12193.4803		
8.54	21.69	80896.37	256520.843	4961.2595	12100.633		
8.6	21.84	81071.08	257757.433	4833.0088	11787.8262		
8.65	21.98	85435.13	271744.54	5070.3587	12366.7284		
8.71	22.13	82493.87	262687.823	4835.0148	11792.7191		
8.77	22.27	79979.5	254760.544	4671.5	11393.9024		
8.83	22.44	82557.92	264051.155	4602.7359	11226.185		

lapsd T (d)	Pore Vol	cpm/ml A	3H dpm/ml	cpm/ml B	dpm/ml 14C		
8.9	22.61	82326.51	262446.681	4765.8017	11623.9065		
8.96	22.76	81710.44	260274.006	4772.6306	11640.5623		
9.05	22.99	88034.15	280769.921	5070.1539	12366.2289		
9.1	23.11	84230.9	268579.691	4863.4123	11861.9813		
9.15	23.25	89224.81	283680.639	5319.2453	12973.769		
9.21	23.4	79219.55	252301.157	4634.9913	11304.8568		
9.27	23.54	79560.66	253340.713	4664.4813	11376.7837		
9.35	23.74	85730.67	273415.104	4939.171	12046.7585		
9.41	23.9	83962.16	268081.803	4774.8039	11645.8632		
9.47	24.06	82488.93	263669.168	4631.7343	11296.913		
9.53	24.2	81674.21	262657.222	4261.8299	10394.7072		
9.6	24.39	54094.24	174885.411	2634.7743	6426.27868		
9.67	24.57	13918.87	41680.0522	1353.7175	3301.74993		
9.74	24.75	4084.8	10529.8442	743.8	1814.14634		
9.79	24.86	2139.45	4784.12176	538.38863	1313.14299		
9.88	25.08	1211.84	2478.11285	352.13592	858.868102		
9.92	25.2	939.45	1868.62533	283.66762	691.872249		
10.01	25.42	855.62	1932.42077	211.42061	515.660032		
10.05	25.52	799.12	1752.7718	208.05501	507.451244		
10.11	25.68	595.73	1179.02466	181.08632	441.673961		
10.17	25.84	555.56	945.19401	200.29499	488.524354		
10.23	25.99	894.28	1794.98556	266.72915	650.558895		
10.29	26.14	475.7272	684.225775	196.99097	480.465788		
10.37	26.34	247.22	254.013763	123.04527	300.110407		
10.43	26.49	208.28	209.101532	104.66223	255.273722		
10.49	26.65	187.91	170.085572	98.205855	239.526475		
10.55	26.81	166.61	183.696122	80.378038	196.043995		
10.61	26.96	150.9	131.374766	79.924599	194.938047		
10.67	27.11	140.67	119.785753	75.052411	183.054661		
10.73	27.25	190.51	118.385997	110.56911	269.680746		
10.79	27.41	190.81	115.747964	111.31824	271.507907		
10.86	27.57	155.73	91.7838084	91.399083	222.924592		
10.93	27.75	180.24	130.161964	100.91185	246.126473		
10.98	27.9	155.72	89.0471845	91.949153	224.266226		
11.05	28.06	118.78	68.49396	70.020747	170.78231		
11.11	28.23	100.69	80.5972361	54.768928	133.582752		
11.15	28.31	100.67	98.5864375	51.092437	124.6157		
11.23	28.52	87.79	40.5640323	53.800171	131.219929		
11.27	28.63	98.92	103.654751	48.823529	119.081779		
11.35	28.83	82.52	54.4601764	47.245763	115.233568		
11.41	28.99	82.45	62.9709236	45.463609	110.886852		
11.47	29.14	73.61	66.8146088	38.432122	93.7368839		
11.57	29.38	68.93	32.5699428	42.095588	102.672166		
11.65	29.59	65.97	49.9536647	36.464088	88.936801		
11.73	29.79	66.07	34.7960797	39.620653	96.6357398		
11.82	30.01	112.1	52.870164	68.479467	167.023091		
11.9	30.22	92.54	36.8677191	57.910448	141.244995		
11.98	30.44	71.48	62.3378563	37.837838	92.2874093		
12.07	30.65	65.58	59.5482447	34.235075	83.500182		
12.15	30.85	58.76	38.0903593	33.78257	82.3965112		

apsd T (d)	Pore Vol	cpm/ml A	3H dpm/ml	cpm/ml B	dpm/ml 14C		
12.23	31.07	64.33	67.458787	31.740977	77.4170161		
12.32	31.3	71.85	44.3548022	41.760491	101.854857		
12.4	31.51	67.99	32.4112426	41.463415	101.13028		
12.48	31.71	64.57	59.5996764	33.510638	81.7332641		
12.57	31.94	109.13	63.7300173	64.169068	156.509922		
12.65	32.14	135.46	107.823739	73.804781	180.011661		
12.75	32.39	125.59	114.822584	65.402844	159.519131		
12.83	32.59	107.83	96.4405775	56.590684	138.026058		
12.92	32.82	95.87	72.0718144	53.097345	129.50572		
13.01	33.04	87.85	89.5020819	43.879473	107.023104		
13.09	33.25	82.23	69.5615875	43.966324	107.234936		
13.18	33.47	91.67	60.0664916	52.572498	128.225604		
13.26	33.67	57.28	16.1522258	37.202664	90.7382051		
13.34	33.88	77.72	81.2947358	38.389513	93.6329588		
13.44	34.13	62.68	74.8386209	29.072165	70.9077193		
13.51	34.33	62.27	77.01454	28.33935	69.1203663		
13.61	34.57	52.2	42.6849428	28.209934	68.804718		
13.69	34.77	47.95	23.4706974	29.117379	71.0179985		
13.78	35	37.57	30.046494	20.441052	49.8562237		
13.86	35.2	61.52	36.5218954	36.052922	87.9339554		
13.94	35.42	43.46	30.4295961	24.526678	59.8211661		
14.02	35.62	43.08	28.9761907	24.553951	59.8876846		
14.11	35.84	62.05	64.4586548	30.740038	74.9757024		
14.19	36.05	80.02	86.1849618	39.019793	95.1702259		
14.28	36.26	56.86	62.1020339	27.55102	67.1976107		
14.38	36.53	40.75	42.7933597	20.093897	49.0095041		
14.46	36.73	31.85	22.9233908	17.847769	43.5311439		
14.6	37.08	33.42	32.3770252	17.032967	41.543822		
14.72	37.4	34.18	33.4737085	17.346939	42.3096068		
14.87	37.77	33.33	34.3342556	16.570881	40.4167834		
14.96	38	33.14	25.6761895	18.199234	44.3883749		
15.08	38.31	32.56	26.5037622	17.620751	42.9774422		
15.21	38.64	33.08	32.6790151	16.731141	40.8076615		
15.35	38.98	29.54	9.8726199	18.871795	46.028768		
15.47	39.3	30.07	8.66153625	19.49301	47.5439268		
15.6	39.63	34.8	50.3338618	14.35272	35.0066341		
15.71	39.91	40.7	47.7844241	19.04244	46.4449756		
15.84	40.22	47.34	28.7697425	27.60736	67.3350244		
15.97	40.57	40.53	39.8313686	20.5414	50.1009756		
16.09	40.86	79.95	75.8104861	41.08241	100.201		
16.21	41.18	39.77	28.9843106	22.21247	54.1767561		
16.35	41.53	35.45	36.753584	17.57696	42.8706341		
16.47	41.84	27.74	39.8807978	11.49013	28.0247073		
16.64	42.27	28.61	26.8953896	14.74878	35.9726341		
16.84	42.78	45.93	45.0809451	23.2899	56.8046341		
16.97	43.1	25.44	0	19.00312	46.3490732		
17.12	43.49	69.84	60.3945884	37.07415	90.4247561		
17.35	44.08	28.74	39.8816159	12.19686	29.748439		
17.52	44.49	19.12	24.1635774	8.596491	20.9670512		
17.69	44.93	51.89873	59.2428311	24.62601	60.063439		

lapsd T (d)	Pore Vol	cpm/ml A	3H dpm/ml	cpm/ml B	dpm/ml 14C		
17.86	45.36	25.92593	39.8539304	10.21324	24.9103415		
18.03	45.8	27.1556	32.952085	12.48761	30.4575854		
18.19	46.2	27.8828	41.5677236	11.24764	27.4332683		
18.36	46.63	22.20917	18.2413423	11.9859	29.2339024		
18.54	47.09	19.35	0	14.12681	34.4556341		
18.69	47.47	17.13	3.04430217	11.48936	28.0228293		
18.86	47.9	24.56	11.0531521	15.11111	36.8563659		
19.02	48.31	25.71	9.55109079	16.22984	39.5849756		
19.19	48.74	24.07	30.363894	10.83333	26.4227561		
19.38	49.23	8.22	0	7.80437	19.0350488		
20.03	50.88	22.89	13.1267344	13.50844	32.9474146		
20.19	51.28	18.28	0	13.80597	33.6730976		
20.38	51.77	4.77	0	5.232558	12.7623366		
20.71	52.6	34.68	0	29.53431	72.0349024		
21.04	53.44	24.23	21.5566836	12.73946	31.0718537		
21.38	54.31	14.27	23.925387	5.216535	12.7232561		
21.72	55.17	34.68	31.7094783	18.05956	44.0477073		
22.84	58.01	26.69	16.6670376	15.47389	37.7411951		
23.85	60.58	15.66	11.5910701	8.710218	21.2444341		
24.85	63.12	3.72	0	6.7908	16.5629268		
25.86	65.68	17.34	0	14.59934	35.6081463		
26.8	68.07	13.54	0	10.03009	24.4636341		
27.92	70.92	15.01	2.65257283	10.07049	24.5621707		
28.94	73.51	15.73	22.4237969	6.554307	15.9861146		
29.88	75.9	17.34	27.2424016	6.711409	16.3692902		
0.11	0.33	1561.43	5290.1795	26.761905	65.2729385	**Col 4**	
0.17	0.47	11029.39	38124.3276	35.050505	85.4890368	**Total Act =**	**1013157**
0.26	0.74	25454.48	87959.7822	86.285714	210.452962		
0.38	1.08	38642.42	133403.55	157.07071	383.099285		
0.53	1.5	55572.35	191792.215	237.65306	579.641612		
0.65	1.87	56679.33	195748.803	214.66667	523.577237		
0.87	2.48	66800.2	230220.129	351.18812	856.556388		
0.91	2.61	66463.82	229188.815	323.36364	788.691795		
1.08	3.09	69553.75	239351.442	438.65385	1069.88743		
1.23	3.53	69271.46	238035.605	506.99029	1236.56169		
1.36	3.88	71849.36	246785.228	547.99636	1336.57648		
1.39	3.99	73316.33	251850.806	553.71058	1350.5136		
1.45	4.15	77751.04	266814.277	642.23541	1566.42783		
1.5	4.28	71732.22	246129.99	598.58782	1459.97029		
1.55	4.44	74219.25	253560.363	843.93939	2058.38877		
1.63	4.66	74679.34	255431.457	788.24645	1922.5523		
1.69	4.84	77030.18	263577.948	791.53387	1930.5704		
1.73	4.95	80631	275915.293	825.22796	2012.75113		
1.77	5.08	74849.13	255914.387	809.95261	1975.49416		
1.85	5.31	80510	274910.772	944.2	2302.92683		
1.96	5.6	75430.16	256990.7	1001.5582	2442.82488		
2.02	5.78	78104.08	265870.862	1083.8645	2643.57205		
2.09	5.99	80142.27	272184.856	1239.2118	3022.46785		
2.16	6.19	77161.68	263005.985	1000.9346	2441.30385		
2.22	6.34	78378.97	266833.765	1082.1495	2639.3891		

lapsd T (d)	Pore Vol	cpm/ml A	3H dpm/ml	cpm/ml B	dpm/ml 14C		
2.28	6.52	78526.6	267350.728	1081.2621	2637.22473		
2.36	6.75	79114.38	269461.022	1067.1351	2602.76863		
2.43	6.95	77976.67	265146.779	1141.2121	2783.4442		
2.5	7.15	76728.85	260833.909	1137.1733	2773.59337		
2.56	7.33	78817.32	267664.843	1222.8216	2982.49166		
2.64	7.55	77790.81	264067.915	1229.4702	2998.7078		
2.68	7.67	58071.67	194431.993	1466.9912	3578.02741		
2.84	8.14	50758.17	169106.415	1453.0418	3544.00446		
2.98	8.52	69510.35	234739.578	1346.8865	3285.0889		
3.05	8.74	78896.75	267226.729	1368.1644	3336.98644		
3.14	8.99	76970.05	260952.949	1283.4419	3130.346		
3.21	9.19	78367.95	263832.259	1685.4247	4110.79198		
3.3	9.44	77825.82	262112.106	1652.3944	4030.23017		
3.39	9.69	74089.27	251529.429	1165.5271	2842.74895		
3.46	9.92	81079.25	273403.353	1653.4907	4032.90405		
3.55	10.15	75104.13	253538.459	1473.9173	3594.92029		
3.58	10.26	78781.85	265787.445	1579.9603	3853.56176		
3.71	10.62	93994.15	316672.397	1974.0084	4814.65451		
3.77	10.81	69823.89	235073.55	1500.5348	3659.84088		
3.83	10.98	81984	276419.017	1679.1077	4095.38471		
3.9	11.17	78970.67	266199.168	1629.6154	3974.67166		
3.96	11.34	83390.94	280939.186	1753.4247	4276.64551		
4.02	11.52	81588.63	274517.31	1786.7833	4358.008		
4.09	11.7	73241.24	244636.413	1969.3805	4803.36715		
4.15	11.89	81912.61	274619.332	1995.0334	4865.9352		
4.21	12.06	82307.19	275972.749	1998.4237	4874.20402		
4.27	12.23	74221	248684.311	1837.8735	4482.6182		
4.35	12.44	73446.79	245962.203	1844.7706	4499.44059		
4.4	12.6	77228.53	258555.637	1954.2202	4766.39068		
4.47	12.79	77939.28	261033.812	1952.1247	4761.27963		
4.53	12.96	79469.46	266058.965	2010.7517	4904.27237		
4.6	13.16	78652.77	263465.606	1961.4085	4783.92305		
4.65	13.31	75576.74	253556.832	1804.2632	4400.64198		
4.71	13.49	81897.9	275526.714	1799.9044	4390.01073		
4.78	13.68	98241.74	329317.683	2402.2093	5859.04707		
4.85	13.87	82053.34	274557.62	2107.0788	5139.21649		
4.9	14.03	96688.7	323694.285	2449.217	5973.7		
4.96	14.19	94500.47	316269.985	2413.8498	5887.43846		
5.03	14.39	71709.39	240084.115	1813.3061	4422.69785		
5.09	14.58	74622.68	250228.823	1807.3783	4408.23985		
5.16	14.77	78601.5	263693.173	1878.8365	4582.52807		
5.23	14.97	81066.77	272244.694	1880.5556	4586.72088		
5.3	15.17	80392.11	269770.266	1907.4002	4652.19559		
5.37	15.38	80855.33	271121.3	1959.797	4779.99256		
5.43	15.56	84116.02	281708.803	2109.2977	5144.62861		
5.5	15.75	82800.7	276950.144	2148.3	5239.7561		
5.56	15.93	85300.67	284532.003	2371.9582	5785.26383		
5.63	16.11	63231.27	210744.115	1793.3718	4374.07746		
5.7	16.32	82998.87	276572.554	2365.2577	5768.92129		
5.77	16.52	83068.62	275306.115	2672.3933	6518.03232		

apsd T (d)	Pore Vol	cpm/ml A	3H dpm/ml	cpm/ml B	dpm/ml 14C		
5.84	16.72	84079.7	280485.538	2332.6633	5689.42273		
5.9	16.89	82631.02	276486.819	2122.6804	5177.26929		
5.96	17.08	82407.49	275473.82	2170.9005	5294.8792		
6.04	17.29	84895.73	282794.042	2439.5325	5950.07932		
6.1	17.47	78857.95	263026.887	2195.7667	5355.52854		
6.16	17.65	78333.15	261041.817	2228.9202	5436.39071		
6.23	17.82	78402.46	260986.265	2289.225	5583.47549		
6.29	18	77766.23	259133.379	2216.6981	5406.58076		
6.35	18.18	79017.74	263295.803	2253.9741	5497.49785		
6.45	18.46	81871.65	273320.42	2230.5195	5440.29141		
6.51	18.64	77401.35	258034.023	2182.5794	5323.36439		
6.6	18.89	78764.53	262724.103	2191.3711	5344.80744		
6.65	19.04	78129.47	260435.285	2208.4211	5386.3928		
6.72	19.23	83949.39	279665.951	2407.4042	5871.71751		
6.78	19.42	78690.39	262849.416	2113.4498	5154.75556		
6.85	19.61	77364.85	257903.926	2183.2636	5325.03317		
6.92	19.82	78908.32	262467.239	2345.3097	5720.26763		
6.99	20.03	77808.17	258334.745	2408.9362	5875.45407		
7.08	20.26	81176.37	269305.688	2556.3726	6235.055		
7.13	20.42	77839.98	258472.533	2403.3708	5861.87998		
7.19	20.58	77518.17	257591.39	2355.2731	5744.56846		
7.25	20.76	79056.35	262641.126	2414.5505	5889.14759		
7.36	21.07	79753.13	265780.85	2267.8974	5531.45717		
7.43	21.27	79659.35	265312.935	2296.8658	5602.11176		
7.49	21.45	88538.29	294559.319	2619.1974	6388.28634		
7.56	21.63	78451.27	260968.725	2327.2994	5676.34002		
7.64	21.87	78035.91	259167.025	2400.484	5854.8391		
7.7	22.05	79855.56	263978.277	2707.284	6603.13159		
7.81	22.36	79416.42	262827.63	2631.1131	6417.34912		
7.88	22.57	80561.75	266391.326	2715.2236	6622.49659		
7.96	22.78	74401.71	245202.437	2674.4782	6523.11751		
8.02	22.96	82584.6	274033.16	2589.3973	6315.60322		
8.08	23.13	79302.44	262581.589	2600.6318	6343.00432		
8.14	23.31	78129.33	258621.019	2577.6817	6287.02844		
8.21	23.49	77771.48	257294.819	2594.7148	6328.57261		
8.26	23.65	78110	258071.396	2675.913	6526.61717		
8.33	23.86	78683.52	260174.975	2653.0726	6470.90885		
8.41	24.07	82937.63	274500.724	2743.7634	6692.10595		
8.47	24.24	78762.61	260136.339	2716.8469	6626.45573		
8.54	24.45	81763.57	269785.316	2873.8164	7009.30837		
8.6	24.63	80665.54	266171.562	2833.3333	6910.5691		
8.66	24.78	85597.35	282146.838	3067.267	7481.1389		
8.71	24.95	82310.14	271614.731	2887.7413	7043.27149		
8.77	25.11	81461.44	270081.726	2599.8969	6341.21198		
8.84	25.3	79986.9	264413.58	2711.5061	6613.42946		
8.9	25.48	78461.04	259462.962	2640.7583	6440.87388		
8.96	25.66	80869.78	267748.563	2656.6543	6479.64473		
9.05	25.91	83431.12	275821.865	2823.6438	6886.93612		
9.1	26.05	84314.57	278110.98	2982.1192	7273.46149		
9.15	26.21	82249.64	271161.57	2937.2315	7163.97927		

ıpsd T (d)	Pore Vol	cpm/ml A	3H dpm/ml	cpm/ml B	dpm/ml 14C		
9.21	26.38	77970.41	257087.574	2777.53	6774.46346		
9.27	26.54	77127.85	253189.64	2975.4927	7257.29932		
9.3	26.62	7738.79	17085.7889	1992.093	4858.76346		
9.35	26.77	61866.7	198991.797	3221.3718	7857.00432		
9.41	26.95	49438.05	157020.599	2980.3588	7269.16788		
9.47	27.12	38430.84	118854.692	2969.4525	7242.56695		
9.53	27.28	31608.28	95723.746	2855.7498	6965.24334		
9.61	27.5	21757.81	62461.9111	2664.1373	6497.89588		
9.67	27.7	14575.44	38184.888	2529.4118	6169.29698		
9.75	27.9	14264.53	37717.924	2404.698	5865.11705		
9.79	28.03	14202.69	38329.0325	2236.5703	5455.04939		
9.88	28.28	11943.62	30149.5445	2304.8724	5621.63998		
9.92	28.41	10784.54	26243.8222	2280.6739	5562.61934		
10.01	28.66	9898.27	24048.1474	2101.1818	5124.83371		
10.05	28.77	9029.383	21163.3322	2074.2775	5059.21332		
10.11	28.94	8770.68	20044.6512	2119.1489	5168.65595		
10.18	29.13	8840.89	20124.6065	2152.5024	5250.00576		
10.23	29.3	8184.59	18165.347	2087.4444	5091.32768		
10.3	29.49	7738.791	17085.7913	1992.093	4858.76346		
10.38	29.71	6452.8	12282.4275	2060.9293	5026.65671		
10.43	29.87	6196.33	11576.7251	2023.3028	4934.88476		
10.5	30.05	6060.14	11002.0731	2044.0217	4985.41888		
10.56	30.23	5739.81	10188.8226	1983.1482	4836.94671		
10.62	30.39	5509.28	9391.25869	1982.5603	4835.51293		
10.67	30.56	5434.04	9494.51939	1908.351	4654.51451		
10.73	30.72	5493.46	9052.50856	2040.3421	4976.44402		
10.79	30.9	5198.88	7784.79195	2090.1941	5098.03434		
10.86	31.08	4979.74	6940.20934	2107.2301	5139.58571		
10.93	31.29	4822.04	6473.59675	2090.7484	5099.38644		
10.98	31.45	4674.56	5962.03001	2090.6433	5099.12993		
11.05	31.63	4389.4	6127.40604	1855.3964	4525.357		
11.11	31.82	4315.8	7984.88509	1425.2117	3476.12602		
11.15	31.91	5338.51	8556.60718	2031.7671	4955.52954		
11.23	32.16	4155.225	5093.42651	1900.3628	4635.03132		
11.28	32.28	4264.37	5422.41243	1910.5401	4659.85383		
11.35	32.51	3966.24	4148.60831	1959.122	4778.34622		
11.42	32.69	3793.48	3671.85956	1934.058	4717.21456		
11.48	32.86	3780.496	3712.55184	1916.5954	4674.62288		
11.57	33.12	3600.37	3337.5478	1865.6104	4550.26937		
11.65	33.35	3305.56	3006.97265	1724.5108	4206.12393		
11.73	33.58	3324.22	2271.81469	1887.3695	4603.34029		
11.82	33.84	3262.46	2143.5306	1869.8285	4560.55722		
11.9	34.07	3275.71	2554.9927	1795.4268	4379.08983		
11.99	34.32	3007.68	1938.64956	1731.4363	4223.01539		
12.07	34.55	2931.21	2167.11583	1630.8674	3977.72524		
12.15	34.78	2782.79	1913.66376	1577.5491	3847.68076		
12.24	35.03	2700.82	1342.01948	1635.9837	3990.20412		
12.33	35.29	2809.18	1283.53418	1724.4898	4206.07268		
12.41	35.53	2862.8	1549.07409	1708.3333	4166.66666		
12.49	35.75	2810.7	1029.59219	1777.2634	4334.78871		

apsd T (d)	Pore Vol	cpm/ml A	3H dpm/ml	cpm/ml B	dpm/ml 14C		
12.58	36	2921.54	1087.5311	1843.8202	4497.12249		
12.65	36.23	2726.17	1522.55974	1617.148	3944.26344		
12.75	36.51	2609.86	625.84134	1717.4884	4188.99602		
12.83	36.74	2745.85	900.640173	1757.674	4287.00971		
12.92	36.99	2602.02	759.616419	1684.7115	4109.05254		
13.01	37.25	2560.08	1262.90493	1552.6017	3786.83341		
13.09	37.48	2437.85	1563.91365	1404.9165	3426.62563		
13.18	37.73	2372.48	1197.19889	1433.3648	3496.01159		
13.26	37.96	2358	1015.00024	1460.222	3561.51712		
13.34	38.2	2253.16	920.901457	1405.2682	3427.48341		
13.44	38.48	2361.88	1394.38291	1385.7277	3379.82366		
13.52	38.7	2313.8	1075.97889	1416.5628	3455.03117		
13.61	38.97	2281.37	911.053745	1427.2146	3481.01124		
13.69	39.2	2285.6	1109.99386	1389.7033	3389.52029		
13.78	39.45	2254.8	1028.89006	1384.4425	3376.68907		
13.86	39.68	2181.27	1117.05068	1314.5161	3206.1369		
13.94	39.92	2206.25	1602.30092	1233.3842	3008.25402		
14.03	40.15	2303.9	1409.11425	1341.7427	3272.54327		
14.11	40.4	2240.85	1439.45841	1290.9953	3148.76893		
14.19	40.63	2214.12	1175.2233	1325.8945	3233.88912		
14.28	40.88	2278.88	1108.64654	1385.2273	3378.6031		
14.39	41.19	2300.81	1381.92144	1345.0945	3280.71832		
14.46	41.41	2347.88	1295.62744	1395.9364	3404.72293		
14.6	41.81	2223.84	1216.00801	1324.4624	3230.39602		
14.73	42.16	2247.72	1117.88662	1361.3192	3320.29078		
14.87	42.58	2174.17	517.622768	1431.5324	3491.54249		
14.96	42.84	2087.57	806.03341	1311.5988	3199.02134		
15.08	43.18	2016.52	869.936658	1248.3639	3044.79007		
15.22	43.56	2063.68	930.655661	1269.3396	3095.95029		
15.35	43.95	2015.74	1057.4501	1209.6374	2950.33512		
15.48	44.31	1942.32	807.914804	1208.539	2947.6561		
15.61	44.68	1971.53	1437.64041	1100.984	2685.32683		
15.72	44.99	1883.72	671.509993	1194.885	2914.35366		
15.84	45.34	2021.1	658.731369	1294.6	3157.56098		
15.97	45.73	2016.33	693.473916	1284.155	3132.08537		
16.09	46.06	1927.25	1045.0039	1149.618	2803.94634		
16.22	46.42	2041.8	646.106538	1311.803	3199.51951		
16.35	46.82	1853.88	739.894817	1159.869	2828.94878		
16.48	47.17	1805.87	650.939363	1144.041	2790.3439		
16.64	47.65	1800.3	484.265921	1174.036	2863.50244		
16.84	48.22	1370.29	81.0942751	952.1436	2322.30146		
16.97	48.58	1680.48	677.479675	1050	2560.97561		
17.12	49.02	1688.2	805.465955	1029.401	2510.73415		
17.36	49.7	1718.9	891.619749	1033.563	2520.88537		
17.52	50.16	1689.11	952.564702	1000.097	2439.26098		
17.69	50.65	1642.543	931.971697	971.3714	2369.19854		
17.86	51.13	1646.646	922.185163	976.2642	2381.1322		
18.03	51.62	1707.933	1005.41167	1002.644	2445.47317		
18.2	52.11	1604.43	1037.24529	922.9972	2251.21268		
18.36	52.56	1596.177	1135.38594	897.1831	2188.25146		

lapsd T (d)	Pore Vol	cpm/ml A	3H dpm/ml	cpm/ml B	dpm/ml 14C		
18.54	53.08	1545.59	638.778743	962.5257	2347.62366		
18.69	53.51	1568.76	562.241108	994.4865	2425.57683		
18.86	54	1559.12	628.525152	974.1775	2376.04268		
19.02	54.45	1558.73	1098.24563	878.2732	2142.12976		
19.19	54.94	1510.24	1117.87263	840	2048.78049		
19.38	55.48	1438.9	840.845512	845.9689	2063.33878		
19.52	55.89	1374.4	787.752879	811.183	1978.49512		
19.7	56.4	1354.99	731.375965	808.9397	1973.02366		
19.86	56.86	1373.33	675.075898	833.3661	2032.60024		
20.03	57.35	1381.73	980.526016	777.1186	1895.41122		
20.19	57.8	1298.61	706.094157	774.2319	1888.37049		
20.38	58.35	1380.19	946.196968	783.0189	1909.8022		
20.71	59.29	1243.74	453.660484	786.8365	1919.11341		
21.04	60.24	1377.73	891.638923	792.3872	1932.65171		
21.38	61.21	1250.58	1036.30738	673.0528	1641.5922		
21.72	62.18	1151.37	794.007537	652.2505	1590.85488		
22.84	65.39	1053.41	752.1698	591.5205	1442.73293		
23.85	68.28	949.64	430.321104	583.6898	1423.63366		
24.85	71.15	859.46	397.977896	526.5265	1284.21098		
25.86	74.04	824.88	470.502049	487.3171	1188.57829		
26.8	76.73	710.29	480.57456	404.2632	986.007805		
27.92	79.93	698.13	574.624339	376.5201	918.341707		
28.94	82.86	840.4	1156.04817	358.7204	874.927805		
31.89	91.3	654.93	627.03147	335.3128	817.836098		
32.68	93.56	615.25	741.487873	283.9614	692.58878		

Appendix A.9: Chromium Data

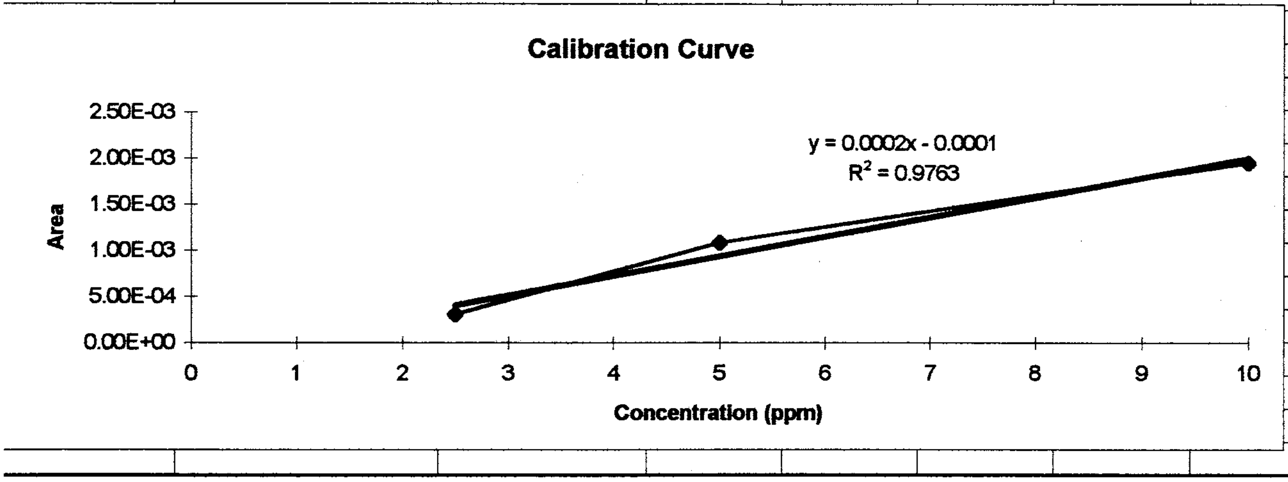
This Appendix contains chromium data calculations to translate HPLC peak area measurements into concentration data based on calibration curves prepared using standards of known concentration.

HROMIUM DATA SPREADSHEET

	Known Conc (ppm)	Area
td 1	0.625	0.00E+00
td 2	1.25	6.14E-06
td 3	2.5	3.08E-04
td 4	5	1.08E-03
td 5	10	1.95E-03

ample #	Time (d)	Area	Conc (ppm)
let sample, 6/24		1.13E-03	6.17
1-630-0314	6.43	1.20E-03	6.975
1-701-0115	7.34	1.08E-03	6.39
1-702-0220	8.39	1.30E-03	7.48
1-703-0105	9.34	1.08E-03	6.41
1-704-0139	10.36	1.16E-03	6.785
1-705-0108	11.34	1.14E-03	6.215
1-707-0311	13.42	1.39E-03	7.97
1-708-0144	14.36	1.28E-03	6.91
1-709-0103	15.34	1.00E-03	5.52
1-710-0109	16.34	1.27E-03	7.855
1-713-0145	19.36	1.26E-03	7.31
1-714-0150	20.37	1.37E-03	8.35
1-717-1321	23.85	1.34E-03	8.195
1-718-1335	24.87	1.39E-03	8.44
1-719-1340	25.9	1.43E-03	8.645
2-701-0122	7.35	6.58E-05	1.3292
2-702-0230	8.4	1.61E-04	1.8035
2-703-0111	9.34	3.89E-04	2.944
2-704-0145	10.36	4.91E-04	3.4555
2-705-0117	11.35	4.53E-04	2.7665
2-707-0319	13.43	4.07E-04	3.536
2-708-0157	14.37	3.91E-04	2.455
2-709-0110	15.34	4.95E-04	2.9725
2-710-0117	16.35	5.75E-04	3.8755
2-715-0158	21.37	5.93E-04	4.4635
2-716-1302	22.83	6.02E-04	3.5105
2-719-1345	25.87	7.65E-04	4.823
3-630-0334	6.44	1.09E-03	6.47
3-702-0240	8.4	1.01E-03	6.065
3-703-0119	9.35	1.23E-03	7.155
3-704-0153	10.37	1.33E-03	7.625
3-705-0125	11.35	1.31E-03	7.04
3-709-0119	15.35	1.23E-03	6.67
3-711-0131	17.35	1.44E-03	8.695
3-716-1304	22.84	1.42E-03	8.61
3-719-1349	25.9	1.44E-03	8.69
4-630-0345	6.45	0.00E+00	1
4-703-0124	9.35	1.41E-04	1.7025
4-704-0201	10.38	3.17E-04	2.583
4-705-0131	11.35	3.78E-04	2.8905
4-707-0334	13.44	2.99E-04	1.996

4-709-0127	15.35	6.16E-04	4.079				
4-713-0212	19.38	7.45E-04	4.7245				
4-714-0211	20.38	6.10E-04	4.0485				
4-715-0210	21.38	7.45E-04	4.7265				
4-716-1310	22.84	8.50E-04	5.25				
4-718-1342	24.86	8.84E-04	4.922				
4-719-1352	25.87	9.26E-04	5.63				



Appendix B - Scintillation Counting Procedures

Appendix B - Scintillation Counting Procedures

Liquid Scintillation Counting Procedure for ^{14}C Only

Programs 10 and 11 preset in the Packard Tri-Carb 460CD Liquid Scintillation Counter were designed specifically to count for ^{14}C. Recall that E_{max} ^{14}C = 156 KeV and E_{av} = 49.3 KeV. Program 11 was set up with two channels counting different energies. Region A looked at 0-156 KeV and Region B counted only in the 4-156 KeV range, thus screening out some low level noise without losing much counting efficiency for the ^{14}C isotope. Program 10 counted in the same energy regions, but used an internal standard to estimate counting efficiency and deliver dpm as well as cpm data. Since I was interested in the difference between initial and final (post-sorption) solutions, however, I did not need the dpm data supplied by Program 10 during the HDTMA or PCE sorption studies; therefore, Program 11 was most often used to analyze samples.

Sample preparation details are described in the following subsections. All samples were handled similarly so that data would be comparable. Sample vials were shaken well to mix the aqueous sample and organic cocktail and provide maximum contact of the scintillator in the cocktail with the sample. Samples were kept out of light, including indoor synthetic light, for as long as possible before analysis. Also, they were kept cool to avoid temperature effects on counting efficiency. Finally, sample vials were wiped before counting and handled with gloves to avoid fingerprints.

Dual Label Scintillation Counting

Because we were using two different radionuclides in our column study contaminant and nonreactive tracer, ^{14}C and ^{3}H respectively, we could no longer use a scintillation program set up to count for a single isotope. Therefore, we used Program #3, with counting regions A and B set at intervals designed to allow us to distinguish between tritium and carbon isotopes. Recall that the energy of decay for tritium ranges from 0-18 KeV and from 0-156 KeV for ^{14}C. The problem with counting in a single 0-156 range is that we then cannot distinguish counts due to tritium from counts due to ^{14}C, so we cannot quantify either. Therefore, we must use two energy regions and the question becomes where to cut off the first region and begin the second region. We must also remember that the tritium energy can be excluded from the Carbon-14 region, but the Carbon-14 energy can never be neglected when analyzing counts in the tritium region (Kobayashi, p. 3-3). For instance, we could count on 0-18 and 18-156 KeV regions. Then we would know that all counts in the second region came from ^{14}C; but we still would not know how many counts in the first region were from tritium and how many were from ^{14}C. Using parameters suggested as optimal by Kessler, we used a counting Program #3, which had energy Region A counting at 0-12 KeV and Region B at 12-156 (Kessler, p. 4-4). Region C data was not used for our samples.

I prepared standards of known concentration from two different sources. The ^{14}C-only standard was P6, a radiolabelled HDTMA standard used in the batch sorption studies. An HDTMA source was used, rather than a PCE standard, in order to avoid volatility problems during standard preparation. The activity of this material should be 0.005 mCi/ml, according to the manufacturer's data sheet and its dilution in 10 ml ethanol. To prepare the P6B standard, I diluted 0.302 g = 0.383 ml in 3390 ml. The resulting solution was mixed for three hours and should have a solution concentration of 1254 dpm/ml. Calculations are shown in Appendix C; the amounts used and counted activities are shown in Table B.1.

The tritium standard was the same #1 solution used to spike our initial solution for the column study. As discussed previously, the activity of this material should be 2.92 x 10^8 dpm/ml. I diluted 1.020 ml in 999 ml Type 1 H_2O (measured in a volumetric flask), so the resulting solution should have a concentration of 3.043 x 10^5 dpm.

I used these two solutions to prepare two mixed-isotope standards, S3 and S4, containing both ^{14}C and tritium. Resulting solution activities and counted activities are shown in Table B.1.

Table B.1: Standard Preparation, Activity, and Efficiency

Sample #	PCE Mass (g)	3H Mass (g)	Counted Activity (cpm/ml)	Real Activity (dpm/ml)	Efficiency
P6B	0.975		Ch A - 711 Ch B - 355.5	1254	Ch A - 0.567 Ch B - 0.283
3HB		1.055	Ch A - 96463.2 Ch B - 8.6	304264	Ch A - 0.317 Ch B - 0.00003
S3	0.512	0.568	Ch A - 51772 Ch B - 269.2	^{14}C - 642 dpm ^{3}H - 172822 dpm	^{14}C Ch B - 0.418 ^{3}H Ch A - 0.297
S4	0.494	0.562	Ch A - 47941 Ch B - 249.5	^{14}C - 619.5 dpm ^{3}H - 170996 dpm	^{14}C Ch B - 0.403 ^{3}H Ch A - 0.278

To calculate the efficiency, I found the ratio of cpm/ml to dpm/ml for each nuclide on each channel. In this process, then, I had the following four unknowns: tritium efficiency on Channel A; tritium efficiency on Channel B; ^{14}C efficiency on Channel A; and ^{14}C efficiency on Channel B. The first step was to find the ^{14}C efficiency on Channel B, as we have all of the information needed for this calculation. We use result from Standard 3HB that the efficiency for tritium on Channel B is negligible. Therefore, all of the counts in this region are attributable to ^{14}C. Sample calculations are shown in Appendix C.

To find ^{14}C efficiency on Channel A, we must separate counts due to ^{14}C decay from counts due to tritium decay. Since the ^{14}C efficiency increases on Channel B in the sample with tritium, it is reasonable to assume that it also increases in Channel A. However, the total efficiency on both channels cannot exceed 1. Therefore, the most that the Ch A activity could increase in Standard S3 is to 1 - 0.418 = 0.582. On Channel B, it would be 1 - 0.403 = 0.597. Also, we would not expect the tritium efficiency to change significantly on Channel A, since it has a very high concentration relative to that of the ^{14}C. For this reason, changes in the efficiency for ^{14}C on Channel A do not greatly affect our efficiency estimate for tritium on Channel A. In fact, if we calculate tritium efficiency on Channel A with the lowest and highest efficiencies available from S3 for ^{14}C, we find the same result of 0.297 - there is no difference within three significant digits (see calculations in Appendix C).

Appendix C - Calculations

CALCULATIONS

Section 2.1

Calculation of Perchloroethylene Concentration in Column Input Solution

$$\text{Average Counts on Region B for two samples} = \frac{5334.2 + 4591.4}{2} = 4962.8 \text{ cpm / ml;}$$

$$\text{Activity}\left[\frac{\text{dpm}}{\text{ml}}\right] = \frac{\text{cpm / ml}}{\text{Efficiency}} = \frac{4962.8\text{cpm / ml}}{0.4180} = 11873\,{}^{\text{dpm}}\!\!\diagup_{\text{ml}}\text{''},$$

where the Efficiency is obtained from counting standards for ${}^{14}C$ (see Calculations in Section 3.x).

$$\text{Concentration} = (11873\frac{\text{dpm}}{\text{ml}})\left(\frac{1\text{min}}{60\text{s}}\right)\left(\frac{1\text{Ci}}{3.7\text{x}10^{10}\text{dps}}\right)\left(1000\frac{\text{mCi}}{\text{Ci}}\right)\left(\frac{1\text{ mmol}}{2.8\text{mCi}}\right)\left(165.85\frac{\text{mg}}{\text{mmol}}\right)$$

$$= (3.168\text{x}10^{-4}\text{mg / ml})(1000\text{ml / L}) = 0.3168\text{mg / L(ppm)} = 317\text{ppb.}$$

Tritium Spike Calculations for Column Study Input Water

Activity of Solution #1

Tritium spike counted at 1261570 cpm after a 99:1 dilution

$$\lambda = \frac{\ln 2}{t_{1/2}};\ A = \text{Aoexp}(-\lambda t);$$

$$A_o = 0.2\,\frac{\text{mCi}}{\text{ml}}\left(3.7\text{x}10^{10}\text{dps / Ci}\right)\left(\frac{1\text{Ci}}{1000\text{mCi}}\right)\left(\frac{60\text{s}}{\text{min}}\right) = 4.44\text{x}10^{8}\,\frac{\text{dpm}}{\text{ml}};$$

Since our standard is about 7 years and 7 months old, t = 91.5 months = 3.9528 x 10^6 min. Then

$$A = (4.44\text{x}10^{8}\text{dpm / ml})\exp\left(-\left(1.061\text{x}10^{-7}\text{min}^{-1}\right)\left(3.9528\text{x}10^{6}\text{min}\right)\right) = 2.919\text{x}10^{8}\text{dpm / ml.}$$

To get a 50,000 cpm/ml ${}^{3}H$ concentration in our input solution, we need a dilution of

$$\frac{1.26\text{x}10^{8}\text{ cpm / ml}}{50{,}000\text{cpm / ml}} \approx 2400,\text{or a 2399:1 dilution in 21 L; then}$$

$$\frac{2399}{1} = \frac{21}{X};\text{so } X = 8.75\text{x}10^{-3}\text{L} = 8.75\text{ ml.}$$

Section 3.1 HDTMA Sorption Studies

Sorption Study Initial Solution Concentrations

To make 50 ml of 0.15M solution, we would need (0.15 mol/L) (0.050 L) = (0.0075 mol) (346.46 g/mol HDTMA-Br) = 2.598 g HDTMA. The amount added is as radiolabelled spike is negligible compared to the amount needed to make the desired concentration - so we need to add about

2.6 g of non-radiolabelled HDTMA. First we dissolve the non-radiolabelled material, then add the spike.

We want to have a solution activity of about 7000 cpm/ml as discussed in Section 3.1; then with 99% sorption, we will still have 700 cpm/ml, far enough above background to be quantified. For 50 ml of a 0.15M solution, using a spike material with 9.99×10^6 cpm/ml, we need the following:

$$\left(9.99\text{x}10^6 \text{ cpm/ml}\right) (\text{X ml}) = \left(7000 \text{ cpm/ml}\right) (50 \text{ ml});$$

$$\text{X} = 0.035\text{ml} = 35\ \mu\text{L of spike to be added.}$$

Section 3.3 - Contaminant Sorption Study

Spike Dilution

Amount Received:	1.8 µL
Specific Activity:	6.0 mCi/mmol

$$1.8\mu\text{L}*6.0\frac{\text{mCi}}{\text{mmol}}*\left(\frac{1\text{mmol}}{165.8\text{mg}}\right)*(1.623 \text{ g/ml})*(1000 \text{ mg/g})*(1 \text{ ml}/1000\mu\text{L}) = 0.106\text{mCi}$$
$$= 106\mu\text{Ci in spike material.}$$

To make 200 ml of a 120 ppm initial solution, we need

$$\left(\frac{120x10^{-6}\,\text{mlPCE}}{\text{ml solution}}\right)(200 \text{ ml solution}) = \mathbf{0.024\ ml\ PCE\ spike}; \text{ then}$$

$$\left(10.6\ \frac{\mu\text{Ci}}{\text{ml}}\right)(0.024 \text{ ml}) = (X\ {}^{\mu\text{Ci}}\!/_{\text{ml}})\ (200 \text{ ml});$$

$$\text{X} = 0.0012684\ {}^{\mu\text{Ci}}\!/_{\text{ml}} \text{ in initial solution} =$$

$$\left(0.0012684\ {}^{\mu\text{Ci}}\!/_{\text{ml}}\right)\left(\frac{\{3.7x10^{10}\text{dps}\}\{60\text{s/min}\}}{1\text{Ci}}\right)\left(\frac{1\text{Ci}}{1x10^6\,\mu\text{Ci}}\right)(0.91\text{cpm/dpm})$$

$$= \mathbf{2570cpm/ml} > 1000\text{cpm/ml.}$$

Section 3.4: Column Studies

Dual Label Efficiency Calculation

Preparation of PB6 Standard Solution

Target ~ 2500 cpm/ml in S3 and S4 samples

Dilution - 9.991×10^7 cpm/ml x 0.25 ml = $\dfrac{2.498x10^7\,\text{cpm}}{3390 \text{ ml H}_2\text{O}} = 7369 \text{ cpm/ml.}$

We used 0.302g of P6 Standard in 3390 ml H2O. Since P6 is in Ethanol, with ρ_E = 0.7893 g/ml, we have

$$\frac{0.302\text{g}}{0.7893\ \text{g/ml}} = 0.383\ \text{ml used;}$$

$$\text{The P6 Std} - \frac{0.05\ \text{mCi}}{10\ \text{ml}} = 0.005\ \text{mCi / ml concentration;}$$

$$(0.005\ \text{mCi / ml})(0.383\text{ml}) = \left(\frac{0.00192\text{mCi}}{3390\text{ml}}\right)(3.7x10^{10}\,\text{dps}/Ci)(60\ \text{s / min}) =$$

$$= 1254000\frac{\text{dpm} - \text{mCi}}{\text{ml} - \text{Ci}}\left(\frac{1\text{Ci}}{1000\ \text{mCi}}\right) = 1254\ \text{dpm / ml.}$$

Preparation of 3HB Solution

$$\text{Std Activity} = \frac{2.98\text{x}10^{8}\,\text{dpm / ml}}{999\text{ml}} = 2.983x10^{5}\,\text{dpm / ml}^{2};$$

To make 3HB, we used 1.020 ml standard, or $(2.983\text{x}10^5)(1.020\text{ml})=3.043\text{x}10^5$ dpm/ml.

S3 Mixed Isotope Standard Preparation

^{14}C Activity: (1254 dpm/ml) (0.512 ml) = 642 dpm;

^{3}H Activity: ($3.043\text{x}10^5$ dpm/ml)(0.568 ml) = 172822 dpm.

S4 Mixed Isotope Standard Preparation

^{14}C Activity: (1254 dpm/ml) (0.494 ml) = 620 dpm;

^{3}H Activity: ($3.043\text{x}10^5$ dpm/ml)(0.562 ml) = 170996 dpm.

Efficiency Calculations

^{14}C Efficiency on Channel B

$$\text{For S3, Efficiency} = \frac{\text{cpm / ml}}{\text{dpm / ml}} = \frac{269.2}{642} = 0.418;$$

$$\text{For S4, Efficiency} = \frac{\text{cpm / ml}}{\text{dpm / ml}} = \frac{249.5}{619.5} = 0.403.$$

^{3}H Efficiency on Channel A

$$\text{Efficiency} = \frac{\text{Total cpm / ml}-{}^{14}\text{C cpm / ml}}{\frac{\text{dpm }^{3}\text{H}}{\text{ml}}};$$

Two Cases w/ Standard S3
Highest possible ^{14}C efficiency on Ch A = 0.567; Lowest possible efficiency = 0.582;

$$\text{Max }^{3}\text{H Eff} = \frac{51772\text{ cpm} - (642\text{ dpm / ml})(0.567)}{172822\text{ dpm}} = 0.297;$$

$$\text{Min }^{3}\text{H Eff} = \frac{51772\text{ cpm} - (642\text{ dpm / ml})(0.582)}{172822\text{ dpm}} = 0.297;$$

For S4, minimum ^{14}C efficiency on Ch A = 0.567; maximum efficiency = 0.597;

$$\text{Max }^{3}\text{H Eff} = \frac{47941\text{ cpm} - (620\text{ dpm / ml})(0.567)}{170996\text{dpm}} = 0.278;$$

$$\text{Min }^{3}\text{H Eff} = \frac{47941\text{ cpm} - (620\text{ dpm / ml})(0.597)}{170996\text{ dpm}} = 0.278;$$

Thus, average efficiencies are as follows: ^{3}H Efficiency on Channel A = 0.288; ^{14}C efficiency on Ch A = 0.578; and ^{14}C efficiency on Channel (region) B = 0.410.

Input Solution Tritium Calculation

We also need about 100,000 cpm/ml of ^{3}H in our 21 L input solution.

$$\frac{1\text{ ml}^{3}\text{H Std}}{21000\text{ mlWater}} = \frac{1.26157x10^{8}\text{ cpm}}{21000\text{ml}} = 6007\text{ cpm / ml};$$

$$\frac{\text{XmlStd}}{21000\text{mlWater}} = 6007 * \text{X ml Std} = 100000\text{ cpm / ml in initial solution};$$

X = 16.6 ml 3H Std needed

Appendix D: Computer Software/Programs

Database maintenance, data analysis, and modeling were all greatly simplified by the use of the following computer software.

CXTFIT2 Program

The CXTFIT Code for Estimating Transport Parameters from Laboratory or Field Tracer Experiments Version 2.0, developed at the US Salinity Laboratory (Toride et al, 1995), was used to model column study data collected at column inlets and outlets.

We used CXTFIT2 for the following two purposes: to solve the direct problem of using transport parameters based on experimental data to predict contaminant breakthrough curves; and to solve the inverse problem of estimating transport parameters based on column effluent data. In direct mode, the program predicts solute concentrations as a function of time at a given location (the column outlet). In its inverse mode, CXTFIT2 uses a nonlinear least-squares algorithm to optimize unknown parameters; the optimization criteria is to minimize the difference between predicted and observed data points. Because of this, the solutions are nonunique and may vary according to starting estimates of the parameters.

CXTFIT2 also allows for the consideration of the following two types of "nonequilibrium" conditions: physical nonequilibrium, as in a two-region system with different transport parameters in each region; and chemical nonequilibrium caused by rate-dependent processes. We used both physical nonequilibrium and equilibrium conditions to model our data. We did not allow for chemical nonequilibrium because we assumed that our sorption is not kinetically limited since the flow rate allows a sufficiently long column residence time for equilibrium to occur. The physical nonequilibrium condition was used to allow for sorption in two distinct phases - a mobile and immobile water phase. The program uses the following 1-D advection-dispersion equation as a transport model for the mobile region:

$$\left(\theta_m + f\rho_b K_d\right)\frac{\partial c_m}{\partial t} = \theta_m D_m \frac{\partial^2 c_m}{\partial x^2} - J_w \frac{\partial c_m}{\partial x} - \alpha\left(c_m - c_{im}\right) - \left(\theta_m \mu_{l,m} + f\rho_b K_d \mu_{s,m}\right)c_m + \\ \theta_m \gamma_{l,m}(x) + f\rho_b \gamma_{s,m}(x),$$

where θ is porosity or volumetric moisture content, ρ_b is dry bulk density, γ is a zero-order contaminant production term, μ is a first-order contaminant decay coefficient, α is a first-order kinetic rate coefficient, f is the fraction of adsorption sites that equilibrate with the liquid mobile phase, K_d is the sorption coefficient for linear sorption (from batch studies), c is contaminant concentration, D is the dispersion coefficient, J_w is the volumetric water flux density in the column, the subscripts m and im stand for mobile and immobile regions, and the subscripts l and s stand for liquid and solid phases. We neglect γ and μ since these processes did not not occur in our column study. The equation in the immobile region is as follows:

$$\left(\theta_{im} + (1-f)\rho_b K_d\right)\frac{\partial c_{im}}{\partial t} = \alpha\left(c_m - c_{im}\right) - \left(\theta_{im}\mu_{l,im} + (1-f)\rho_b K_d \mu_{s,im}\right)c_{im} + \\ \theta_{im}\gamma_{l,im}(x) + (1-f)\rho_b \gamma_{s,im}(x).$$

The most important assumptions implicit in the CXTFIT2 program are a constant flux or velocity, homogeneous packing of the zeolite in the columns (with homogeneous properties of the medium, including porosity), and saturated conditions. Another important assumption in the nonequilibrium model is that solute transfer between the mobile and immobile phases can be mathematically described as a first-order process, which may not be valid. Also, we assumed no production or radioactive decay of contaminant in the columns. The boundary condition at the column inlet was assumed to be a pulse (constant concentration) input of tritium. The input PCE concentration, $C_o(T)$, is discussed further below.

Required input includes boundary and initial values conditions, column length (or thickness of porous material, since we are collecting data at the column outlet), average linear velocity (which is dependent on porosity). The initial condition for the column inlet is $C_r\ (0,T) = C_o(T)$. The top (column outlet) boundary condition is flux-averaged concentration (MODC = 2); we assume a semiinfinite system with zero concentration gradient, or $\frac{\partial C_r}{\partial Z}(\infty, T) = 0$. Table D.1 shows all relevant model parameters, how they are calculated, and their physical meaning. Parameters describing production of contaminant are omitted since they were assumed constant and equal to zero in all cases. θ, which normally denotes water content, is equal to porosity here since we are modeling a saturated porous medium. Note also that for nonreactive solutes like tritium, β is θ_m/θ; however, for reactive solutes, $\beta = (\theta_m + f\rho_b K_d)/(\theta + \rho_b K_d)$ (Toride, 1995).

Table D.1: CXTFIT2 Parameters

Parameter	**Formula**	**Meaning**	**Explicit?**
R - Retardation factor	$R = 1 + (\rho_b K_d/\theta)$	Quantifies retard. of reactive solute compared to non-reactive (R=1 for nonreactive)	Yes (Estimated from Batch Studies)
v - Average linear velocity	$v = Jw$ (or q)$/\theta$	Average linear velocity	Yes (Known)
D -Hydrodynamic dispersion coefficient	$D = \alpha_L v$ (α_L = Coeff of Longi-tudinal Dispersion)	Quantifies non-advective transport of solute	Yes (Estimated or Fitted)
ω -Dimensionless mass transfer coefficient	$\omega = (\alpha \bullet L)/(\theta \bullet v)$	Quantifies mass transfer between mobile & immobile water (=0 for equilibr model)	Yes (Fitted)
α - Solute exchange coefficient	None	1st-order solute exchange coefficient between mobile and immobile water	No
β - Dimensionless partitioning variable	θ_m/θ (for 2-Region Physical Noneq only)	Fraction of mobile water	Yes (Fitted)
μ - Decay coefficient	None	1st-order decay coefficient for solute	Yes (Assumed =0)

Modeling Input Function for CXTFIT

The PCE input data adjusted to dpm/ml values was plotted in an EXCEL spreadsheet. Using the Trendline function in the INSERT menu, a least-squares best fit (minimization of differences) line was fitted to each set of input data for each column. Using the equations for these lines, I assumed a linear input function of concentration as a function of time. I put these functions, which were slightly different for each column, into the CINPUT routine in the FORTRAN source code program file USER.FOR. The modified line is highlighted in the source code provided in this Appendix. Then I used Microsoft FORTRAN Power Station software to recompile the source code and create a new executable file for each column, naming each executable file CXTFITa.exe, with the a character designating which column corresponded to the file (Col 1 = a, Col 2 = b, and so on).

The input function specification produced some problems with the executable file, causing the program to ignore mass balance and require very long time periods for each modeling run. This problem was discussed with one of the program authors, Dr. M. Van Genuchten, but no solution was immediately found. The length-of-time problem is possibly due to either inappropriate convergence criteria or a problematically small time step, $d\tau$, for evaluation of the concentration integral; but the mass balance problem denotes a more serious inability of the code to handle the specified input function. The problem was circumvented by using an input function consisting of ten pulses approximating the original linear function. To test this approximation, I first used a ten-pulse input concentration approximation with an untreated column data set. Each pulse could clearly be seen in the model fit, but the parameters varied only slightly from the solution obtained using the continuous function; also the model still fit the data to within $R^2>0.95$. For Column 1, for instance, the R value achieved with the linear input function was 1.612 with $R^2 = 0.9880$. With the 10 pulse input function approximation, I achieved R = 1.578 with $R^2 = 0.9841$. Because the contaminant moved more slowly in the treated columns, no discreet steps could be detected in the model results. As a result of these findings, I decided to use the linear input functions for untreated columns and ten-pulse approximations for the treated columns.

The CXTFIT2 input file for an inverse model has seven blocks containing different information. The first block, Block A, is the same for all columns. The following input values were used:

INVERSE = 1; MODE = 2 (deterministic or nonstochastic nonequilibrium); NREDU = 0; MODC = 1 (Flux-averaged concentration, since our outlet samples were collected outside of the column); and ZL = 15.5 cm. Block B is also constant for all columns, with the following input values: MIT = 100; ILMT = 0 or 1, depending on whether I needed to constrain parameter values; MASS = 0; MNEQ = 0; and MDEG = 0 (only a dummy value is needed here).

In Block C, we entered transport parameter values. For the equilibrium model, we had only D, R, and μ parameters to estimate, with μ=0 since it is a decay constant. For the nonequilibrium model, we also estimated β and We began with an initial guess of 0.5 for these two parameters, as this number is in the middle of the possible range for both. We also began with D = 25, since we used this value in our initial models.

For v_x in Block C, we used the velocity data from log sheets used to report pore volume versus time data. The velocity used for modeling was calculated as the total volume supplied to the column divided by the total elapsed time. We measured the amount of solution supplied to each column, or Q, updated at each syringe refilling in the pore volume spreadsheets shown in Appendix A.6. Sample calculations are shown in Appendix C. Since $v_x = Q/(A*n) = q/n$, v_x is slightly different for each column.

Microsoft EXCEL

Microsoft EXCEL Version 5.0a software (1993) was used to maintain a database of all data collected during this project, including the HDTMA batch study, PCE sorption batch study, and the column study. In addition, the spreadsheets were used to manipulate and graph data. CXTFIT2 output files were also graphed using EXCEL.

MATLAB

I used the Student Addition of MATLAB, Version 4 (1995) by The Math Works to perform trapezoidal integral approximations for mass balances of contaminant input and output from the column study. Mass balances were critical for PCE sorption, since the study was ended before all of the contaminant had eluted. The M-files created for evaluation of the contaminant mass were simple four-line programs. A sample is included in this Appendix.

FORTRAN Power Station

Microsoft FORTRAN Power Station software with FORTRAN Visual Workbench Version 1.00 (1993) was used to edit CXTFIT2 source code to specify contaminant input functions for each column. Separate executable functions were recompiled for each column. The modified source code subroutine is included in this Appendix.

Modified CXTFIT2 Source Code

Modified Source Code, CXTFIT2

```
JBROUTINE CONST1(MAXTRY,STOPCR,GA,GD,DERL,STSQ,MM,ICHEB,NU1,NU2,
                 OMMAX,MIT)

IETERS FOR CONTROL NUMERICAL EVALUATIONS

IPLICIT REAL*8(A-H,O-Z)
:MENSION DERL(30)

'    Maximum number of trial allowed within an iteration to find
)arameter values that decreases SSQ ( It is suggested that MAXTRY
1 the range 10 to 50; smaller values may reduce the run time but
 a convergent solution.).
 MAXTRY=50
-----------------------------------------------------------
:R; Iteration criterion.  The curve-fitting process stops when the
ıtive change in the ratio of all coefficients becomes less than STOPCR.
 STOPCR=0.0005
ters for the Marquardt inversion method
ı:   GA*GD = INITIAL VALUE FOR FUDGE FACTOR
        (lambda OF EQ.(5.24), SEE ALSO Marquardt, 1963)
':   TRY AND ERROR FACTOR FOR GA
   If a step succeeds, GA decreases to GA/GD.  If it fails,
       GA increases to GA*GD.
'RL: INCREMENT TO EVALUATE VECTOR DERIVATIVES IN TERMS OF
       MODEL PARAMETERS
     DERL FOR B(I)  = DERL(NU1+I)   SEE TABLE 7.4
'IT version 1
A=0.02
D=10.0
ERL=1.D-2
(GA=0.05)
(GD=20.0)
O 5 I=1,30
ERL(I)=0.0

GA=0.01
GD=10.0
DO 10 I=NU1,NU2
DERL(I)=1.D-2
CONTINUE
Stop criteria for the iteration based on the improvement
Q.  If the relative improvement in SSQ is less than STSQ
ree times, the iteration will stop.
STSQ=1.E-6
-----------------------------------------------------------
 Initial number of integration points for Gauss Chebychev
MM=75
; Integration mode  for Gauss Chebychev.  If ICHEB=1, number of
gration will increase until the result satisfies the error criteria.

ICHEB=1
NVERSE PROBLEM, USE A FIXED NUMBER OF INTEGRATION POINTS FOR
 NONEQUILIBRIUM CDE (SEE SUBROUTINE CHEBYCON)
(MIT.GE.1) ICHEB=0

UM CONSTRAINT FOR OMEGA
K = 100 IS RECOMMENDED WHEN L IS EQUAL TO THE OBSERVATION SCALE
OMMAX=100.

RETURN
END

--------------------------------------------------------------
BROUTINE CONST2(MODE,STOPER,LEVEL,MSTOCH,P,ICHEB)

ETER FOR LOG TRANSFORMED ROMBERG
PLICIT REAL*8(A-H,O-Z)
R;  Stop criteria for log-transformed Romberg integration
al setting is 5.E-9 and the value will be adjusted internally
ending on the Peclet number)
; The maximum order for log-transformed Romberg integration
value will be adjusted internally depending on the Peclet number).
```

```
 STOPER=1.E-9
 LEVEL=12
F(MOD(MODE,2).EQ.1) THEN
IF(P.LE.1.E+03) THEN
 STOPER=5.E-7
 LEVEL=11
ELSE IF(P.GE.1.E+05) THEN
 STOPER=1.E-10
 LEVEL=15
ELSE IF(P.GE.1.E+03.AND.P.LE.5.E+05) THEN
 STOPER=5.E-8
 LEVEL=12
ND IF
ND IF
F(MOD(MODE,2).EQ.0.AND.MSTOCH.EQ.4) THEN
TOPER=0.00005
EVEL=9
ND IF
ASTIC NONEQUILIBRIUM MODEL
F(MOD(MODE,2).EQ.0.AND.MSTOCH.EQ.4) ICHEB=0

ETURN
ND

------------------------------------------------------------
EAL*8 FUNCTION CINPUT(TAU)

URPOSE: ARBITRARY FUNCTION DEFINED BY USER

MPLICIT REAL*8(A-H,O-Z)
OMMON/MODAT/INDEX(15),INVERSE,NREDU,NVAR,ZL,MIT,MDEG,MASS,
        DUMTP(10),DUMGA1(10),MNEQ,ISKIP,PHIM,PHIIM
OMMON/STOCH/MODD,MODK,MODS,MSTOCH,CORR,MCORR,MSD,SDLNK,
,SDLNV,VMAX,VMIN,D,AVEY,SDLNY,YMAX,YMIN,ALPHA,SDLND
DK,RHOTH,MD56,MK34,MAL8


F(NREDU.LE.1) THEN
 T=TAU/V*ZL
LSE
 T=TAU
ND IF
F (T.LE.9.1) THEN
CINPUT=(-560.39*T) + 16528
LSE
CINPUT=0
NDIF

ETURN
ND
```

```
1
*** Block A:  Model Description ******************
Column 2 PCE Data, Linear Input, Moving Avgd Data
Nonequilibrium Model w/10 pulses:  Vary omega
INVERSE   MODE    NREDU
1       2       1
MODC   ZL(BLANK IF MODE=NREDU=1)
3     15.5
***  BLOCK B:  INVERSE PROBLEM  *****************
MIT    ILMT   MASS
0     0     0
MNEQ   MDEG
0     0
***  BLOCK C:  TRANSPORT PARAMETERS  ****************
V     D      R      BETA    OMEGA  MU1     MU2
39.02  41.03   42.0   0.1900  .9500  0      0
0     0      0     1     0     0     0
***  BLOCK D:  BVP;  MODB=0 ZERO; =1 DIRAC; =2 STEP; =3  A PULSE  ****
MODB
4
10
16006  0
15494  1.01
14982  2.02
14470  3.03
13958  4.04
13446  5.06
12934  6.07
12422  7.08
11910  8.09
0     9.10
***  BLOCK E: IVP;  MODI =0 ZERO; =1 CONSTANT; =2 STEPWISE; =3 EXPONENTIAL  ***
MODI
0
***  BLOCK F: PVP; MODP =0 ZERO; =1 CONSTANT; =2 STEPWISE; =3 EXPONENTIAL  ***
MODP
0
***  BLOCK G:  DATA FOR INVERSE PROBLEM  ********************
INPUTM "=0; Z,T,C =1; T,C FOR SAME Z =2; Z,C FOR SAME T"
1
15.5
Time   14C dpm/ml
0.25   13.20206
0.39   38.04878
0.55   138.5366
0.67   208.7
0.87   359.6001
1.08   567.7115
1.49   876.5683
2.49   1672.573
3.54   3259.766
4.46   4857.23
5.5    6234.305
6.5    6424.624
```

7.49	6709.771
8.53	7009.534
9.15	7033.467
9.27	7075.104
9.4	7223.429
9.52	6740.081
9.67	6214.412
9.79	5774.682
9.92	5221.724
10.05	5012.158
10.49	4686.718
11.47	3951.764
12.48	3456.323
13.51	2773.812
14.46	2614.063
15.47	2399.855
16.47	2255.463
17.51	2142.314
18.54	1979.261
19.52	1771.953
20.71	1629.781
21.72	1555.274
22.83	1490.93
23.85	1491.186
24.85	1322.235
25.86	1330.355
26.8	1192.942
27.92	1207.147
28.94	1023.079
29.88	935.9249
31.88	895.0783
32.68	491.8214
33.68	684.7112
34.68	678.3012
35.68	671.8912
36.68	665.4812
37.68	659.0712
38.68	652.6612
39.68	646.2512
40.68	639.8412
41.68	633.4312
42.68	627.0212
43.68	620.6112
44.68	614.2012
45.68	607.7912
46.68	601.3812
47.68	594.9712
48.68	588.5612
49.68	582.1512
50.68	575.7412
51.68	569.3312
52.68	562.9212
53.68	556.5112
54.68	550.1012

55.68	543.6912
56.68	537.2812
57.68	530.8712
58.68	524.4612
59.68	518.0512
60.68	511.6412
61.68	505.2312
62.68	498.8212
63.68	492.4112
64.68	486.0012
65.68	479.5912
66.68	473.1812
67.68	466.7712
68.68	460.3612
69.68	453.9512
70.68	447.5412
71.68	441.1312
72.68	434.7212
73.68	428.3112
74.68	421.9012
75.68	415.4912
76.68	409.0812
77.68	402.6712
78.68	396.2612
79.68	389.8512
80.68	383.4412
81.68	377.0312
82.68	370.6212
83.68	364.2112
84.68	357.8012
85.68	351.3912
86.68	344.9812
87.68	338.5712
88.68	332.1612
89.68	325.7512
90.68	319.3412
91.68	312.9312
92.68	306.5212
93.68	300.1112
94.68	293.7012
95.68	287.2912
96.68	280.8812
97.68	274.4712
98.68	268.0612
99.68	261.6512
100.68	255.2412
101.68	248.8312
102.68	242.4212
103.68	236.0112
104.68	229.6012
105.68	223.1912
106.68	216.7812
107.68	210.3712
108.68	203.9612

109.68	197.5512
110.68	191.1412
111.68	184.7312
112.68	178.3212
113.68	171.9112
114.68	165.5012
115.68	159.0912
116.68	152.6812
117.68	146.2712
118.68	139.8612
119.68	133.4512
120.68	127.0412
121.68	120.6312
122.68	114.2212
123.68	107.8112
124.68	101.4012
125.68	94.9912
126.68	88.5812
127.68	82.1712
128.68	75.7612
129.68	69.3512
130.68	62.9412
131.68	56.5312
132.68	50.1212
133.68	43.7112
134.68	37.3012
135.68	30.8912
136.68	24.4812
137.68	18.0712
138.68	11.6612
139.68	5.2512
140.68	0
0	0

```
1
*** Block A:  Model Description ******************
Column 4 PCE Data, 10 pulses-best fit params
Nonequilibrium Model: Fit beta
INVERSE    MODE    NREDU
1    2       1
MODC    ZL(BLANK IF MODE=NREDU=1)
3     15.5
***  BLOCK B:  INVERSE PROBLEM  *****************
MIT    ILMT    MASS
0    0      0
MNEQ    MDEG
0      0
***  BLOCK C:  TRANSPORT PARAMETERS  ****************
V      D       R      BETA    OMEGA   MU1     MU2
42.9   75.44   45.44   0.1737  1.135   0       0
0      0       0       1       0       0       0
***  BLOCK D:  BVP;  MODB=0 ZERO; =1 DIRAC; =2 STEP; =3  A PULSE  ****
MODB
4
10
16252  0
15669  1.01
15086  2.02
14503  3.03
13920  4.04
13337  5.06
12754  6.07
12171  7.08
11588  8.09
0      9.10
***  BLOCK E: IVP;  MODI =0 ZERO; =1 CONSTANT; =2 STEPWISE; =3 EXPONENTIAL  ***
MODI
0
***  BLOCK F: PVP; MODP =0 ZERO; =1 CONSTANT; =2 STEPWISE; =3 EXPONENTIAL  ***
MODP
0
***  BLOCK G:  DATA FOR INVERSE PROBLEM  ********************
INPUTM "=0; Z,T,C =1; T,C FOR SAME Z =2; Z,C FOR SAME T"
1
15.5
Time (d)       Conc (dpm/ml)
0.11   65.27294
0.26   210.453
0.53   579.6416
0.87   856.5564
1.08   1031.714
1.5    1694.929
2.5    2846.51
3.46   3490.191
4.47   4810.648
5.5    5389.883
6.51   5609.488
7.49   5888.913
```

8.47	6775.957
9.05	6886.936
9.27	7100.31
9.47	7158.993
9.61	6544.145
9.75	5829.821
9.88	5546.436
10.01	5248.889
10.5	4888.643
11.05	4698.75
11.48	4593.791
12.49	4201.89
13.52	3709.652
14.46	3317.398
15.48	2991.007
16.48	2735.034
17.52	2434.859
18.54	2278.136
19.52	2002.769
20.71	1920.522
21.72	1558.393
22.84	1442.733
23.85	1423.634
24.85	1284.211
25.86	1188.578
26.8	986.0078
27.92	918.3417
28.94	874.9278
31.89	817.8361
32.68	692.5888
33.68	743.1028
34.68	734.3367
35.68	725.5706
36.68	716.8045
37.68	708.0384
38.68	699.2722
39.68	690.5061
40.68	681.74
41.68	672.9739
42.68	664.2078
43.68	655.4417
44.68	646.6756
45.68	637.9095
46.68	629.1434
47.68	620.3773
48.68	611.6112
49.68	602.8451
50.68	594.079
51.68	585.3129
52.68	576.5468
53.68	567.7807
54.68	559.0146
55.68	550.2485
56.68	541.4823

57.68	532.7162
58.68	523.9501
59.68	515.184
60.68	506.4179
61.68	497.6518
62.68	488.8857
63.68	480.1196
64.68	471.3535
65.68	462.5874
66.68	453.8213
67.68	445.0552
68.68	436.2891
69.68	427.523
70.68	418.7569
71.68	409.9908
72.68	401.2247
73.68	392.4585
74.68	383.6924
75.68	374.9263
76.68	366.1602
77.68	357.3941
78.68	348.628
79.68	339.8619
80.68	331.0958
81.68	322.3297
82.68	313.5636
83.68	304.7975
84.68	296.0314
85.68	287.2653
86.68	278.4992
87.68	269.7331
88.68	260.967
89.68	252.2009
90.68	243.4348
91.68	234.6686
92.68	225.9025
93.68	217.1364
94.68	208.3703
95.68	199.6042
96.68	190.8381
97.68	182.072
98.68	173.3059
99.68	164.5398
100.68	155.7737
101.68	147.0076
102.68	138.2415
103.68	129.4754
104.68	120.7093
105.68	111.9432
106.68	103.1771
107.68	94.41096
108.68	85.64485
109.68	76.87875
110.68	68.11264

111.68	59.34654
112.68	50.58043
113.68	41.81432
114.68	33.04822
115.68	24.28211
116.68	15.51601
117.68	6.749901
118.68	0
0	0

Appendix E: Column Study Preparation

Appendix E: Column Study Preparation

Input Solution Preparation

The first step in preparing column study input solutions was to count ^{14}C and ^3H standards to develop a recipe for the solution. We needed to know how much ^{14}C-radiolabelled PCE to purchase, since cost was a limiting factor. We also determined counting efficiencies for the two isotopes, since we intended to use dual labeled scintillation counting to analyze column effluent samples and track the contaminant breakthrough.

First, to calculate the amount of input solution needed, we determined the column pore volume from column dimensions listed in Table E.1 using the following equation: # Pore Vols = $(v_x t) / L$ = 26.7. Also, one pore volume = n x column volume = 196 cm^3, so the total volume needed for each column was 5233 ml. For four columns, then, we required a total volume of 20.9 liters of input solution. The volumetric flux, $J_w = v_x \times$ (Column Cross-Sectional Area) x n = 401 cm^3/d.

Table E.1: Column Dimensions	
Radius	2.525 cm
Length (L)	16.5 cm
Volume	392 cm^3
Pore Volume (assuming n=0.5)	196 cm^3
Cross-Sectional Area	20.0 cm^2
Outlet Fittings	1/8" NPT
Volumetric Flux (for v_x = 40 cm/d)	401 cm^3/d
Porosity Estimate	0.5

For the input solution, we needed the ability to quantify 1% of the maximum input concentration. Since the background for PCE (on the higher channel) in out counting program is 15 cpm/ml, the minimum detectable concentration is 75 cpm/ml. Since the ^{14}C efficiency was about 41.8%, the minimum detectable activity is 180 dpm/ml and the input solution concentration should have about 18000 dpm/ml.

For 21 L of solution, we needed a total of 18000 dpm/ml x 210000 ml ÷ (3.7 x 10^{10} dps/Ci x 60 s/min) = 170 μCi of radiolabelled PCE. We ordered 250 μCi, diluted the entire amount recovered from a flame-sealed transportation vial in 10 ml of a cosolvent, ethanol, and diluted that 10 ml in 21 L of pure Type I water. After mixing, we sampled the solution twice to determine the activity. In addition, we used Tritium Standard #1, which was counted at 1.26157 x 10^8 cpm/ml, to spike the initial solution. Since we could accurately quantify tritium counts at 1000 cpm/ml, we needed an initial solution with 100000 cpm/ml. For 21 L at 100000 cpm/ml, we needed a total of 2.1 x 10^9 cpm, or 16.6 ml.

Column Packing and Plumbing

A column experiment schematic is shown in Figure 3-1. We used stainless steel columns purchased from Soil Measurement Systems of Tucson, AZ, and borrowed from Dr. Tom Kieft of the NMIMT Biology Department. The columns had an inner dimension of 16.5 cm length by 5.05 cm diameter. The bottom caps had an external 1/8" NPT aperture and a porous plate, which prevented zeolite from washing out of the column but allowed water to pass through freely. Both end caps have Teflon O-rings to ensure a leak-proof fit. The top caps are solid stainless steel except for the 1/8" NPT aperture. The following fittings were used to connect the syringe pumps to the columns and sample the column outlets: stainless steel (SS) 1/4" and 1/16" OD tubing; SS 1/8" NPT to 1/4" reducing elbow; Swagelock SS 1/4" tubing connectors; SS 1/4" - 1/16" reducing union; SS 2-way male luer to female luer stopcock (Cole-Parmer); SS Micro-Mate female luer to 1/8" NPT (Popper & Sons, Inc., #6455); SS needle with female luer end attached to 1/16" SS tubing hardware assembly (Waters, #WAT-025559); and SS 3-way stopcock with female luer to male luer lock and female luer sidearm (Cole Parmer, #H-31507-12).

Next, I weighed and packed the columns with zeolite. Two of the columns were filled with treated and two with untreated zeolite. The weights were used to calculate a dry bulk density as the mass of zeolite per filled volume of the column. The column volume for this calculation was assumed to be for a column length of 15.5 cm, since there was some headspace in the top of the column after the experiment was completed. Column and fitting weights, both filled and empty, are provided in Table E.2.

Table E.2: Column Fitting Masses

Col #	Empty Mass (g)	Filled Mass (g)	Top Fitting Mass (g)	Screen Mass (g)
1	968.3	1251.3	9.57	1.06
2	950.0	1265.7	9.56	1.10
3	939.8	1249.4	9.14	1.06
4	934.9	1277.9	9.60	1.14

Before wetting the columns with Elizabeth City analogue water, I pumped Carbon Dioxide gas through all four columns for about 24 hours to displace air. To do this, we attached Teflon tubing to the cylinder regulator and split the flow eight ways with plastic tee fittings. The column outlets were opened and hooked to Tygon tubing to vent to the hood.

The three different syringe pumps to be used were exhaustively tested, cleaned, and oiled. The first, an older Harvard model with 30 discreet flow rate settings, was borrowed from Dr. Mike Whitworth of the NM Bureau of Mines. Its holding piece was modified by Floyd Hewitt of the NM Tech E & RD Machine Shop to a Plexiglas design that could hold four 100-ml syringes. The flow rate was tested at Setting 17(0.35 ml/min, close to the desired 475 cc/d = 0.33 ml/min) with the syringes open to the air for several hours. It was determined that the pump did not supply enough pressure to empty four syringes simultaneously once they were connected to the zeolite columns, so this pump controlled only two syringes during the column experiment. The second pump was a Sage/Orion model borrowed from Dr. Brandvold of the NM Tech Chemistry Department. This pump also had a holding piece inadequate to control the large 100 ml syringes consistently, so it was used only before the actual experiment began to saturate two of the columns. The third pump was a Harvard Model 44 Heavy-Duty High Pressure Industrial Multi syringe pump (#980759), on loan from Harvard Apparatus, Inc. This pump was fitted with a holding piece specifically designed to hold two large syringes, so it was used to control flow in

Columns 1 and 2. It had a digital display and data entry, so that it was set to exactly the desired flow rate.

I used the Harvard and Orion pumps to saturate all four columns with PCE-free synthetic contaminated water. The synthetic water was prepared according to the recipe in Table 3.2. At the same time, the pump's flow rate precision through the columns was being tested, first on only one column and eventually on all four. Because it could not supply enough pressure to pump solution through three columns, it was partially disassembled and the gears were oiled. A log was kept of flow rate and conductivity measurements from 6/7/96 until the experiment began (Appendix E). The best flow rate precision that could be achieved was a rate at Setting 16 between 0.38 and 0.40 ml/min supplied to Columns 1 and 2. Similarly, the Sage/Orion pump was used to saturate Columns 3 and 4. During the saturation period, a new Model 44 Harvard pump was switched with the Sage/Orion pump and the final stainless steel inlet fitting and tubing configuration was prepared and leak tested. The flow rate of the new pump was tested and accurate to within ± 0.003 ml/min of the digital setting. We also removed the top column lids and placed small aperture aluminum screens over the zeolite because we observed some very fine zeolite particles washing out of the column outlets into the Tygon tubing in one of the columns.

I calculated the head drop across the column using Darcy' Law, $q = -K\ dh/dx$. Considering the most conservative (smallest) K estimate I could find for silty/fine sand-sized particles, $K = 10^{-3}$ cm/s, I calculated $dh = (40\ \text{cm/d} * 16.5\ \text{cm}) / (10^{-3}\ \text{cm/s} * 60\ \text{s/min} * 60\ \text{min/hr} * 24\ \text{hr/d}) = 7.64$ cm H_2O, or 0.11 psi. With the column cross sectional area of $20.0\ \text{cm}^2 = 3.10\ \text{in}^2$, this is about 0.34 pounds. For four columns, then, the pressure supplied would have to be close to two pounds, not including additional pressure to move the column of water in the tubing at the column outlet into the hood. Here, however, the potential energy required would be small, since the hood is actually lower than the column outlet. The porous plate in the bottom of the stainless steel column should not be limiting factor, as water moves through it readily under very slight pressures. Once the required pressure was calculated, we ordered a pump that would supply that pressure at the desired velocity.

A collapsible reservoir was needed for the column input solution because the volatile PCE in the solution would evaporate into the headspace of a rigid container, decreasing the solution concentration with each withdrawal of solution. A 50-L Ultraclean Gas Bag with Teflon septum was purchased from Cole Parmer (#H-01412-90) and used as a reservoir. The septum was removed and replaced with a stainless steel luer fitting to which the luer-lock syringes could be attached for refilling. We also used a SS male luer plug when syringes were not being filled. Although this arrangement was not perfect, as noted with the decrease in input solution PCE concentration over time (Section 4), the bag was thick enough to prevent loss of tritium. Had a smaller-sized bag been available for the 21 L of input solution, the decrease in input concentration due to increased headspace might have been smaller.

Appendix F: Column Study Data Manipulation

Appendix F: Column Study Data Manipulation

Sample data was collected and entered into an EXCEL database with filename Column~1.XLS. Background counts were subtracted from each cpm/ml number. Sample masses and time of collection were entered on the same database. Copies of the database are provided in Appendix A. The database was also used to record count data, which was adjusted by subtracting background counts for each batch in the I and J columns. These data were then normalized by sample mass [Col F] in the K and L columns to give cpm/ml figures. The elapsed time was calculated from the date and time embedded in the sample ID number according to the following equations: ((Hour [Col C]-17) + (Minute [Col D]/60))/24 during the first 7 hours, since the addition of contaminated water began in the 17th hour of the day; ((7 + Hour)+ (Minute/60))/24 within the first 24 hours; and (((7 + Hour)+ (Minute/60))/24) + (Day-1) after 24 hours.

Before modeling the data, we transformed values from cpm/ml to dpm/ml using the efficiencies calculated from analysis of standards. The following efficiencies were used: tritium efficiency on Channel A = 0.288; average ^{14}C efficiency on Channel A = 0.578; and average ^{14}C efficiency on Channel B = 0.410. Total ^{14}C concentration was calculated simply by dividing the counts from Region B by the ^{14}C efficiency on Region B, 0.410. Total tritium concentration was calculated as the total counts in Region A subtracted by the total counts in Region A due to ^{14}C, or ^{14}C efficiency on Channel A (= 0.578) times the total ^{14}C concentration, all divided by the tritium efficiency on Channel A, or 0.288. The dpm/ml information was recorded and graphed in the spreadsheet Col1.XLS.

Next, data were reduced to one point per day using a moving average. This function was also performed in the Col1.XLS spreadsheet on Sheet 3. We used only one point per day because this was the minimum sampling frequency used toward the end of the experiment. If we did not use a uniformly spaced (in time) data frequency for modeling, CXTFIT2's sum of squares difference minimization scheme would more heavily weight the more frequently sampled time periods. A greater data point density was maintained for time periods during which concentrations changed rapidly, as at the very beginning of the experiment and immediately after the contaminant pulse was shut off. Also, a three-point moving average was used for the treated columns, where contaminant concentrations changed continuously, than for untreated columns, where concentrations changed rapidly and then stabilized for long periods of time.

Pore volume data was recorded in the spreadsheet COL1PV.XLS, COL3PV.XLS, and COL4.XLS. In these spreadsheets, the volume supplied to each column is calculated from filled and emptied syringe weights recorded during the column experiment. The pore volumes were calculated by dividing volume dispensed by the column pore volume, which is calculated as Pore Volume = $\pi * r^2 * L * n = \pi * (2.525)^2 * (15.5) * n = 310.46n$. Spreadsheet calculations are shown in Appendix C.

Chromium samples were analyzed by HPLC and data were entered in the spreadsheet CR.XLS. Here, data values in units of area were converted to concentration in ppm based on area values for standards of known concentration. One set of standards in the 0.625 - 10 ppm range were analyzed for every ten samples. In the spreadsheet, a line was fitted to the data for each standard set to get an equation for concentration in terms of area. The area data were then used in this equation to get concentration figures. The equations varied from Area = M * Concentration (ppm) - 0.0001, with M varying from 0.0003 to 0.0001 for different standard sets. Chromium data were then graphed as concentration versus elapsed time.