NONIDEAL TRANSPORT OF PESTICIDES THROUGH THE VADOSE ZONE

by

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ABSTRACT

A major field-scale transport experiment and a series of supporting laboratory sorption studies have been conducted in order to investigate processes controlling vadose-zone pesticide transport. The sorption experiments focused on three herbicides: bromacil (5-bromo-3-*sec*-butyl-6-methyluracil), napropamide (2-(α-naphthoxy)-*N,N*-diethylpropionamide), and prometryn (2,4-bis(isopropylamino)-6-(methylthio)-*s*-triazine), and the field experiment involved these same herbicides and four different nonreactive fluororganic tracers. In addition to providing a well-documented database for use by other researchers studying vadose-zone transport or model validation, the experiments were specifically designed to identify and investigate nonideal transport behavior.

Nonideal transport behavior is defined as behavior that deviates from the classical one-dimensional advection-dispersion equation. Commonly observed departures include variable solute peak location, accelerated transport, extensive peak tailing, and in two field experiments, bimodal concentration profiles. These nonideal effects have been attributed to numerous processes, including preferential flow, multi-dimensional flow, soil heterogeneity, physical or chemical nonequilibrium, anion exclusion, sorption nonlinearity or hysteresis, and solute/solute interactions. A major goal of the present research was to quantify the relative importance of these various processes.

The laboratory studies examined the sorption behavior of the herbicides onto surface soil collected from the site of the field study. Napropamide and prometryn are both relatively nonpolar molecules, and both displayed linear sorption, while the more polar bromacil showed nonlinear Freundlich sorption behavior. All three herbicides showed some degree of sorption hysteresis. Bromacil, and to a lesser degree napropamide, showed decreased sorption in the presence of the other herbicides.

At the field site at the Maricopa Agricultural Center, in Maricopa, Arizona, the three herbicides and four tracers were applied to the surface of fifteen 6-m × 6-m test plots in different combinations and concentrations. The plots were flood-irrigated every two weeks with 7.5 cm of water. An on-site meteorological station enabled estimation of net infiltration rates, and regular neutron-probe profiles provided soil moisture data. After two months, 45 270-cm soil cores were collected, sectioned, and analyzed for herbicide and tracer concentrations.

Transport parameters including velocities, dispersion coefficients, and retardation factors were estimated from the resulting solute concentration profiles using an analytical model (CXTFIT) and the method of moments. Due to the sensitivity of higher-order moments to data outliers, the method of moments proved useful only for velocity estimation. The CXTFIT results indicated that tracer velocities were approximately normally distributed, and roughly twice that predicted by dividing the net infiltration rate by the soil water content. This accelerated transport has been attributed to preferential flow effects. The distribution of observed tracer velocities suggests that the scale of the preferential pathways is smaller than the sample diameters, indicating pore-sized pathways rather than macropore flow along roots or through burrows.

Herbicide retardation factors, representing velocities relative to the tracers, were reasonably well predicted using laboratory batch sorption study results. Bromacil's sorption nonlinearity and competition effects observed in the laboratory also appeared in the field data. Dispersion coefficient and dispersivity values fitted to individual cores were log-normally distributed and showed much scatter and no correlation from one solute to another, but analysis of the field-averaged concentration profile yielded far better correlations. About 10% of the observed concentration profiles showed some evidence of a bimodal distribution.

Accelerated transport induced by preferential flow was clearly the most significant cause of nonideal behavior. Soil heterogeneity and bromacil's sorption nonlinearity also played major roles in the observed behavior. No strong evidence for physical nonequilibrium conditions was observed.

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I

INTRODUCTION

AGRICULTURAL CHEMICALS AND GROUNDWATER CONTAMINATION

Groundwater provides 50% of the nation's drinking water, 40% of our irrigation water, and drinking water for 90% of rural households (Office of Technology Assessment, 1984; Goodrich et al., 1991). Its importance as a natural resource both in the United States and around the world can hardly be overestimated. Groundwater contamination is a serious and growing problem that threatens this valuable resource.

Much media and public attention has focused on a few dramatic and severe cases of groundwater contamination at major hazardous waste sites, yet more wide-spread "non-point" sources of contamination, including agricultural chemicals, may pose an equal threat. In 1984, Congress's Office of Technology Assessment (Office of Technology Assessment, 1984) estimated that up to 280 million acres may be affected by pesticide applications totaling 42 million tons per year. OTA concluded that "non-point sources ... including fertilizer and pesticide applications ... are often as important as point sources or hazardous waste sources." The 1960s and 1970s saw a sharp increase in pesticide use (Goodrich et al., 1991), a trend that continues today. At the same time, product changes are resulting in less persistent but more mobile pesticides (Goodrich et al., 1991). Together, these trends suggest increased dangers of groundwater contamination with pesticides. A recent U.S. EPA survey indicated that 74 pesticides have been detected in groundwater in 38 states (Goodrich et al., 1991).

Prevention is certainly better than cure when it comes to groundwater contamination. While remediation of groundwater contamination at hazardous waste sites and other point sources is extremely expensive, it is feasible. Remediation of contaminated groundwater beneath 280 million acres of farmland is out of the question, so prevention is critical. Prevention of contamination by agricultural chemicals is likely to take the form of government regulations and guidelines. Developing appropriate regulations that safeguard our groundwater resources without imposing unnecessary hardships on the nation's economy requires a thorough understanding of the physical, chemical, and biological processes that control the ultimate fate and downward transport of pesticides applied to our lands. This research project represents one small step towards that understanding.

In recent years, numerical models intended to predict the fate and vadose-zone transport of pesticides and other solutes have begun to change from research tools to management tools. In this new role, these models have an ever-increasing effect on the development and enforcement of environmental regulations. Unfortunately, due to the labor-intensive nature of field transport studies, not all of these models have not been adequately validated against field observations. There is thus an acknowledged and increasing need for actual field transport data to validate existing and future transport models (Smith et al., 1990). In addition to the discussion and conclusions presented in this paper, the raw data presented here may prove useful to transport modelers.

Although this research was focused on pesticide transport through the vadose zone, many of the processes investigated also affect other organic solutes, and to a lesser extent, solute transport in general, both in the vadose and phreatic zones.

VADOSE-ZONE SOLUTE TRANSPORT

The study of vadose-zone solute transport has blossomed in the three decades since Nielsen and Biggar's pioneering work (Nielsen and Biggar, 1961, 1962; Biggar and Nielsen, 1962). The extensive body of literature on this field will not be reviewed here -- the interested reader is referred to an excellent recent review by Nielsen et al. (1986).

A basic form of the differential equation describing solute transport and degradation is:

$$\frac{\partial C}{\partial t} = \nabla\cdot(\bar{\bar{D}}\nabla C) - \bar{v}\,\nabla C - L - \frac{\rho_B}{\theta}\frac{\partial S}{\partial t} \qquad (1\text{-}1)$$

where:

C = Solution concentration [M/L^3]

t = Time [T]

D = Dispersion coefficient (tensor) [L^2/T]

v = Solution velocity (vector) [L/T]

L = Solute loss rate [M/L^3T]

ρ_B = Soil bulk density [M/L^3]

θ = Volumetric water content [L^3/L^3]

S = Sorbed concentration [M/M]

(All terms used in this paper are defined in Appendix A)

The first term on the right side of Equation 1-1 describes dispersive flux, the second term advective flux, the third term represents net loss due to degradation or other transformation reactions, and the final term describes changes in solution concentration caused by changes in sorbed concentration, adjusted by ρ_B/θ, the ratio of solid sorbent to solution. Note that the parameters D, v, and L are not assumed constant in this formulation. Implicit in this equation are the assumptions that dispersion is Fickian, vapor-phase transport is negligible, and each solute acts independently. If flow and transport are assumed to be one-dimensional, the equation simplifies to:

$$\frac{\partial C}{\partial t} = \frac{\partial\left(D\frac{\partial C}{\partial z}\right)}{\partial z} - v\frac{\partial C}{\partial z} - L - \frac{\rho_B}{\theta}\frac{\partial S}{\partial t} \tag{1-2}$$

where:

z = Distance [L]

If D is assumed constant in space, and the loss term is assumed to follow first-order kinetics, the equation becomes:

$$\frac{\partial C}{\partial t} = D\frac{\partial^2 C}{\partial z^2} - v\frac{\partial C}{\partial z} - \mu C - \frac{\rho_B}{\theta}\frac{\partial S}{\partial t} \tag{1-3}$$

where:

μ = First-order degradation rate [1/T]

Rearrange:

$$\frac{\partial C}{\partial t} + \frac{\rho_B}{\theta}\frac{\partial S}{\partial t} = D\frac{\partial^2 C}{\partial z^2} - v\frac{\partial C}{\partial z} - \mu C \tag{1-4}$$

If S and C are assumed to be in equilibrium with one another (the local equilibrium assumption), then:

$$\frac{\partial S}{\partial t} = \frac{\partial C}{\partial t}\cdot\frac{\partial S}{\partial C} \tag{1-5}$$

By substitution:

$$\frac{\partial C}{\partial t}\left[1+\frac{\rho_B}{\theta}\frac{\partial S}{\partial C}\right] = D\frac{\partial^2 C}{\partial z^2}-v\frac{\partial C}{\partial z}-\mu C \tag{1-6}$$

Let us define the retardation factor:

$$R = 1+\frac{\rho_B}{\theta}\frac{\partial S}{\partial C} \tag{1-7}$$

where:

R = Retardation factor [ ]

and substitute it into Equation 1-6:

$$R\frac{\partial C}{\partial t} = D\frac{\partial^2 C}{\partial z^2}-v\frac{\partial C}{\partial z}-\mu C \tag{1-8}$$

This is the familiar one-dimensional advection-dispersion equation (ADE; all abbreviations are defined in Appendix A). Notice that we have not made any assumptions about the time-dependence of the flow-field or the functional relationship between S and C. Without these assumptions, neither v nor R is necessarily constant in either time or space. If, however, we assume uniform and steady-state flow conditions and uniform, linear, single-valued sorption, v and R become constants. While any of these equations could be solved numerically, these last assumptions finally permit Equation 1-8 to be solved analytically (see, for example, van Genuchten and Alves, 1982).

For the purposes of this paper, we shall define ideal transport as transport behavior in accord with the classic one-dimensional ADE (Eq. 1-8), with constant and uniform values for D, R, v, and μ. The assumptions that lead to ideal transport are reviewed in Table 1-1.

Table 1-1. Assumptions Leading to Ideal Transport.

- Dispersion can be modeled as a Fickian process
- Vapor-phase transport and evaporation effects are negligible
- Solutes do not interact or compete
- Flow is one-dimensional
- Soil is uniform and homogeneous
- Degradation follows simple first-order kinetics
- System remains in a state of local equilibrium
- Flow and moisture content are in steady state
- Sorption is linear and non-hysteretic

If any of the assumptions in Table 1-1 are significantly violated, the system may display nonideal transport behavior.

NONIDEAL TRANSPORT

Brusseau and Rao (1989) used the term "nonideal" to describe certain solute transport phenomena that lead to departures from the one-dimensional advection-dispersion equation. In this paper, their use of the term is expanded to include aspects of soil heterogeneity and degradation effects.

A brief review of major sources of nonideal behavior follows. These may all be considered "nonideal" processes.

Multi-Dimensional Flow

The one-dimension ADE (Eq. 1-8) is obviously only valid for one-dimensional flow, and cannot be expected to describe solute transport in other geometries, such as radial flow from a drip emitter (Gerstl and Yaron, 1983b).

Scale-Dependent (Non-Fickian) Dispersion

The ADE assumes that hydrodynamic dispersion is a Fickian process that can be described by equations analogous to those for diffusion. This assumption is by no means obvious, and recent studies seem to indicate that the dispersion coefficient may be scale-dependent, implying non-Fickian behavior (Anderson, 1984).

Nonequilibrium Processes

The one-dimensional ADE is based on the local equilibrium assumption, which states that the rate of sorption and desorption processes is fast relative to advection and dispersion, and that all water present locally is in chemical equilibrium. There are two potential rate-limiting processes: physical transport of the solute through the soil solution, and chemical sorption (Brusseau and Rao, 1989; Harmon et al., 1989). Either of these two processes can lead to nonequilibrium conditions. The former, termed physical nonequilibrium, is often conceptualized as a two-region system of mobile and immobile water, while the latter, termed chemical nonequilibrium, postulates the existence of two types of sorption sites, one at equilibrium and one subject to rate-limited sorption. Van Genuchten and Wagenet (1989) have developed detailed mathematical descriptions of the two-site/two-region model, complete with analytical solutions. Nkedi-Kizza et al. (1984) have shown that mathematically, chemical and physical nonequilibrium take the same form, and may not be readily distinguishable experimentally. However, physical nonequilibrium affects both conservative tracers and sorbed species, while chemical nonequilibrium affects only sorbed species.

Nonequilibrium effects have been observed in numerous laboratory column studies (e.g. Davidson and Chang, 1972; van Genuchten and Wierenga, 1977; van Genuchten et al., 1977; De Smedt and Wierenga, 1984; De Smedt et al., 1986; Bouchard et al., 1988) and have been implicated in the results of the Borden landfill study (Roberts et al., 1986).

Preferential Flow

We can describe preferential flow by starting with the nonequilibrium mobile/immobile water model, and considering a situation in which transfer between the mobile and immobile water domains is extremely slow or negligible. In this case, the immobile water is bypassed by the flow and therefore plays no significant role in solute transport. The resulting decreased effective water content (soil water participating in transport) leads to increased flow velocity (assuming a given flux) and accelerated solute transport. This description can now be generalized by replacing the two-regime mobile/immobile model with a model that includes water moving with a range of velocities. Accelerated solute transport due to preferential flow will occur if the solute is concentrated in the higher-velocity regions. In this case, an effective moisture content can still be calculated, but no longer has an obvious physical meaning. Preferential flow has been observed in at least two field studies using conservative tracers (Bowman and Rice, 1986a; Rice et al., 1986), as well as under natural conditions (Sharma and Hughes, 1985). Gish and Shirmohammadi (1991) have edited a large collection of papers describing recent research in preferential flow.

This broad definition of preferential flow includes any situation in which different water domains are contributing to transport in varying degrees. This phenomenon can occur at various scales.

Most obvious, perhaps, is macropore flow, in which applied water rapidly infiltrates via burrows, root casts, mud cracks, or other visible soil features. The spacing of these macropores is likely to be on the order of 5-10 cm or more, and observations made on a smaller-diameter soil core will vary tremendously depending on whether the core contains a macropore. Preferential flow on an intermediate scale may be caused by features in the 0.1-1 mm size range, such as sand grains or soil aggregates. On this scale, soil pore geometry may include dead-end pores and particularly small pores, which contribute negligibly to solute transport but which contain a measurable amount of water. Small-scale preferential flow can occur when the soil grains themselves are porous. This microporosity may contribute significantly to total water content, but not to transport. A given soil core will be much larger than the features causing either intermediate-scale or small-scale preferential flow, and will contain a random mixture of preferential pathways and low-flow matrix. During the discussion of the field study results, I shall return to this concept of preferential flow scale.

Jury et al. (1986a, 1986b) have observed an interesting variation on preferential flow in a field study of herbicide transport. They found that a small fraction of the applied herbicide appeared to move downward without apparent adsorption, resulting in distinctly bimodal depth profiles. The precise cause of this behavior is not certain, and one objective of the present study was to check for bimodal profiles at a different field site.

Anion Exclusion

Anion exclusion may be considered a variation on preferential flow. Preferential flow occurs when the water content participating in transport is less than the total water content, and solutes are effectively barred from a portion of the water present, due to physical or geometric effects. In cases of anion exclusion, electrostatic effects bar only anions from a portion of the water present, typically in a layer surrounding negatively-charged clay surfaces (Smith, 1972). Because of the scale of the electrostatic interaction, anion exclusion necessarily operates at microscopic scales where it is analogous to the small-scale preferential flow effects previously described -- there is no anion exclusion analog to macropore flow. The effects of anion exclusion are similar to those of preferential flow: decreased effective water content leads to increased transport velocities for anionic species. This velocity increase has been observed in lab column studies (Smith, 1972), field transport experiments (Bowman and Rice, 1985) and under natural field conditions (Gvirtzman et al., 1986). Gvirtzman and Gorelick (1991) have recently reported field evidence suggesting that under unusual conditions anion exclusion can lead to increased anion dispersion as well as increased anion velocity.

Sorption Nonlinearity

Linear sorption is described by:

$$S = K_D C \qquad (1\text{-}9)$$

where:

K_D = Linear distribution coefficient [L^3/M]

The assumption of a linear sorption isotherm (Eq. 1-9) is not inherent to the ADE (Eq. 1-8), but rather is required if the retardation factor R (Eq. 1-2) is to be a constant, necessary for analytical solutions of the ADE. Nonlinear sorption of any desired form may be incorporated into Equation 1-2, but R will then generally be a function of concentration rather than a constant, and solving the ADE will require numerical methods. Brusseau and Rao (1989) described the marked departures from ideal behavior that can result from nonlinear sorption.

Numerous laboratory batch studies have shown that pesticide sorption is often described by a nonlinear Freundlich-type isotherm (Eq. 1-10) (e.g. Rhodes et al., 1970; Davidson and McDougal, 1973; Murray et al., 1975; Rao and Davidson, 1979; Kozak et al., 1983; Corwin and Farmer, 1984; Madhun et al., 1986). Rao and Davidson (1979) also demonstrated the effects of nonlinear sorption on column-study breakthrough curves.

$$S = K_F C^n \tag{1-10}$$

where:

K_F, n = Freundlich isotherm parameters [*]

* n is dimensionless, but the dimensions of K_F are problematic (Bowman, 1981). Throughout this paper, K_F will be based on S in μg/g and C in μg/mL.

Sorption Hysteresis

The classical ADE assumes that desorption and sorption are single-valued with no hysteresis. Numerous laboratory batch studies have indicated sorption hysteresis (e.g. Davidson and McDougal, 1973; Hornsby and Davidson, 1973; Lee and Farmer, 1989; see also the review by Bowman and Sans, 1985). Although two papers have suggested that many reported examples of hysteresis may be due to faulty methodology, both papers conclude that there is some strong evidence that true sorption hysteresis does exist, and can affect solute transport behavior (Bowman and Sans, 1985; Brusseau and Rao, 1989).

Volatilization and Evaporation

The ADE assumes that all of the solute is either in aqueous solution or sorbed, and neglects vapor-phase transport. This assumption is clearly invalid for many compounds, and in some cases volatilization can play a major role in solute fate and transport (see the review by Glotfelty and Schomberg, 1989). Spencer et al. (1988) have shown that volatilization effects may not be negligible even for low-volatility compounds, which can be transported upwards and concentrated near the soil surface as soil moisture evaporates.

Complex Degradation Kinetics

Degradation is typically included in the ADE as a first-order kinetic process, with no appreciable lag-term (Eq. 1-3). The prevalence of this assumption is demonstrated in compilations of pesticide properties (e.g. Jury et al., 1984) which list pesticide half-lives, the concept of which implies simple first-order kinetics. This form leads to mathematical and modeling convenience, but may not always be appropriate. Alexander and Scow (1989) have recently reviewed various degradation models, and present numerous examples of non-first-order kinetics.

An additional complicating factor in degradation is the potential effect of high solute concentrations on the microbes responsible for biodegradation. Two independent studies have shown that biodegradation of phenoxy acid herbicides can be completely suppressed by high herbicide concentrations (Ou et al., 1978; Majka et al., 1982).

Solute-Solute Interactions

At the present time, there is a general consensus that the primary mechanism for sorption of nonpolar organic molecules eliminates significant solute competition (Chiou, 1989). However, Rao et al. (1989) have pointed out that even in the absence of direct solute-solute interactions, indirect effects may lead to altered behavior. One example may be effects of one solute on the soil microbiological community, which could in turn alter the degradation of other solutes present.

Soil Heterogeneity

The previous nonideal processes have all been effective on a local scale, and could therefore be observed in a perfectly homogeneous soil. Actual field soils display heterogeneity that will complicate solute transport behavior, even if the behavior can be considered ideal at a single point. Soil heterogeneities may be considered to fall into three categories: heterogeneous hydraulic properties, sorption properties, and degradation properties.

Heterogeneous Hydraulic Properties

Variations in soil conductivity and moisture content will affect the rate of water flow, and therefore the transport of both conservative tracers and sorbed solutes. Field studies using conservative tracers have revealed both log-normal (Biggar and Nielsen, 1976; Van De Pol et al., 1977; Bowman and Rice, 1986a; Sudicky, 1986) and normal (Rice et al., 1986) velocity distributions.

Heterogeneous Sorption Properties

Variations in soil sorption properties will affect the transport of sorbed solutes, but not conservative tracers. Elabd et al. (1986) found that K_D values in a single field are approximately normally distributed with a coefficient of variation of 31%, while Mackay et al. (1986) found that K_D values varied over an order of magnitude within a single core from the Borden landfill site.

Heterogeneous Degradation Properties

A major removal process for many organic solutes is microbial degradation. Microbial population densities are not uniform in soil, but may be expected to vary both laterally and as a function of depth. Jury et al. (1987) have modeled the effects of nonuniform degradation rates on solute transport and contaminant leaching.

Transient Moisture Content and Soil Moisture Hysteresis

Although a general description of solute transport in the vadose zone should consider water flow as well as transport, most studies make the simplifying assumption that moisture content and water flow are in a steady state (e.g. Nielsen et al., 1986: "While transport under field conditions generally requires the simultaneous solution of the unsaturated flow and transport equations, we restrict ourselves here to simplifications ... for steady flow at constant water contents").

A rationale for this assumption was provided by Wierenga (1977) who demonstrated that a steady state model yielded excellent agreement with a more complex transient model, if the results were considered in terms of cumulative drainage. A more recent field study (Butters et al., 1989), however, suggests that transient moisture effects can significantly influence solute transport. If transient water flow is important, soil moisture hysteresis will need to be considered, and the resulting description of solute flow will be complicated considerably (e.g. Russo et al., 1989a).

PROJECT GOALS AND OBJECTIVES

The primary goal of this project was to determine the relative importance of various nonideal processes to solute transport behavior in the vadose zone. Achievement of this goal will help focus future research efforts, with the ultimate goal of improved prediction and understanding of vadose-zone solute transport. A secondary goal was the production of a set of observational data on vadose-zone herbicide transport, for use in future model validation and research efforts.

Specific objectives included:

- Determination of batch-scale sorption parameters of three herbicides, including competitive effects and desorption hysteresis.
- Determination of field-scale transport properties of three different herbicides and five nonreactive tracers.
- Determination of the variability of these parameters.
- Comparison of observed field behavior to ideal 1-D ADE behavior.
- Quantification of concentration effects on nonideal behavior.
- Quantification of herbicide/herbicide interactions.
- Determination of relative importance of various nonideal processes.
- Investigation of whether bimodal herbicide depth profiles, similar to those reported by Jury et al. (1986a, 1986b) appear at a different field site.

- Development of a well-documented data set describing the results of a field-scale herbicide and tracer transport experiment, for use by other researchers.

These objectives have been met through a three-fold approach, combining laboratory studies, field studies, and analytical modeling techniques.

PROJECT OUTLINE

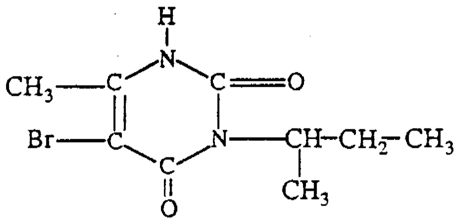
Three herbicides were selected for investigation: bromacil (5-bromo-3-*sec*-butyl-6-methyluracil), napropamide (2-(α-naphthoxy)-*N,N*-diethylpropionamide), and prometryn (2,4-bis(isopropylamino)-6-(methylthio)-*s*-triazine) (Fig. 1-1). Relevant partitioning and degradation data for the three herbicides are shown in Table 1-2. The herbicide selection criteria included:

- A broad range of sorption and degradation characteristics
- Relatively low animal toxicity
- Relatively low volatility
- Ease of analysis by gas chromatography

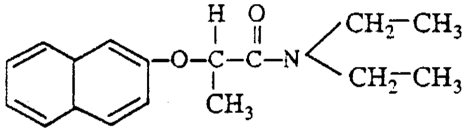
Bromacil is a member of the uracil family of herbicides, and functions non-selectively by inhibiting photosynthetic electron transport (Worthing, 1991). Bromacil is the most polar, most mobile, and most widely used of the three herbicides, and the only one of the three that is a known groundwater contaminant (Goodrich et al., 1991). Bromacil was first reported in 1962, and is currently marketing under the trademark 'Hyvar X' (Worthing, 1991).

Napropamide is a aryloxyalkanamide herbicide that works by inhibiting cell division. It was first

BROMACIL



NAPROPAMIDE



PROMETRYN

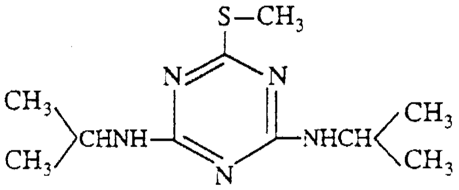


Figure 1-1. Herbicide Molecular Structures.

Table 1-2. Herbicide Physical and Chemical Parameters.

Herbicide	Aqueous Solubility (mg/L)	K_{OC} (mL/g)	K_{OW}	Half-Life in Soil (days)	Henry's Constant
Bromacil	815-820	72	69-74	350	3.7×10^{-8}
Napropamide	73	300	1201-3116	70	7.9×10^{-7}
Prometryn	33-48	610	2190	60	5.6×10^{-7}

K_{OC}: organic carbon partitioning coefficient.
K_{OW}: octanol-water partitioning coefficient.
Range shown reflects range reported in literature.
Sources: Gerstl and Yaron, 1983a; Jury et al., 1984; Madhun et al., 1986; WSSA, 1989; Worthing, 1991.

reported in 1969 and is marketed under the trademark 'Devrinol' (Worthing,1991).

Prometryn is a member of the important triazine class of herbicides, and like bromacil is a photosynthetic electron transport inhibitor. It was first reported in 1962, and is marketed under the trademark 'Caparol' (Worthing, 1991).

Laboratory Sorption Studies

Objectives

Batch sorption studies can be used to determine both the degree of sorption of a compound, and the shape of the sorption isotherm. They will therefore indicate sorption nonlinearity, a possible cause of nonideal transport behavior. Properly designed batch studies can also reveal sorption hysteresis and competitive sorption effects, two additional potential contributors to nonideal behavior.

Previous Work

Bromacil. Numerous batch studies of bromacil sorption onto various soils have been conducted in the past (Rhodes et al., 1970; Gerstl and Yaron, 1983a; Corwin and Farmer, 1984; Madhun et al., 1986; White et al., 1986). Four of these five studies reported nonlinear, Freundlich-type sorption. Three of the studies also measured desorption isotherms; of these, two reported hysteresis.

Napropamide. Three studies of napropamide sorption onto soil were reviewed (Gerstl and Yaron, 1983a; Elabd et al., 1986; White et al., 1986), and all reported linear sorption. One of the studies reported desorption hysteresis.

Prometryn. Two studies of prometryn sorption onto soil (Murray et al., 1975; Kozak et al., 1983) both reported nonlinear Freundlich-type behavior. Only one of the studies measured desorption isotherms, and found marked hysteresis.

Field Transport Experiment

Objectives

The field transport experiment was the heart of this project. The field setup consisted of fifteen 6-m × 6-m plots at an agricultural research center in Arizona. The plots were equipped with neutron probe access tubes for water content measurement, and an on-site micrometeorology station permitted estimation of net recharge rates. The three herbicides were applied to the soil in different concentrations and combinations, together with four nonreactive fluororganic tracers: 2,6-difluorobenzoic acid (2,6-DFBA), *meta*-trifluoromethylbenzoic acid (*m*-TFMBA), *ortho*-trifluoromethylbenzoic acid (*o*-TFMBA), and pentafluorobenzoic acid (PFBA). At two different times, three 270 cm cores were collected from each plot, sectioned, and analyzed for tracer and herbicide concentrations. The tracer profiles enabled estimates of downward water velocity, while the range of herbicide treatments applied to different plots permitted an evaluation of the effects of concentration and competition on herbicide transport. The large number of sampling locations enabled a statistical analysis of the results and an assessment of soil heterogeneity. Full details of the field experiment are given in Chapter 2.

Previous Work

Tracers. Numerous field studies of tracer transport have been conducted throughout North America. Recent reviews include Anderson (1987) and Gee et al. (1991).

Bromacil. Of the three herbicides under consideration, bromacil is the most important commercially and has been studied the most extensively. Field studies of bromacil fate and transport have been reported by Leistra et al. (1975), Smith et al. (1975), Hebb and Wheeler (1978), Bowman and Rice (1986b) and Jaynes (1991).

Napropamide. Jury et al. (1986a, 1986b) have conducted two field studies of napropamide transport, both of which resulted in the bimodal napropamide depth profiles mentioned earlier.

Prometryn. Jury et al. (1986a) have reported that a single field prometryn transport study resulted in bimodal depth profiles similar to those found for napropamide.

Modeling

Objectives

Modeling provides the bridge between experimental observations and the underlying governing processes. Modeling natural phenomena typically consists of two stages: development of a conceptual model, followed by application of a computer model. Although more attention is often paid to the latter stage, developing an appropriate conceptual model may well be more important. It is in this stage that relevant processes are identified and their functional forms defined. The choice of a conceptual model determines which computer model will be appropriate.

In this project, a model was used to predict ideal transport behavior, to determine observed field transport parameters, and to compare the importance of various nonideal processes.

Previous Work

The broad range of solute transport modeling efforts for the saturated zone has been recently reviewed by Abriola (1987). Much of her discussion applies equally well to the vadose zone.

Analytical Models. Analytical models for solute transport typically consist of solutions to the 1-D ADE. Solutions to numerous forms of the equation subject to various boundary conditions have been compiled by van Genuchten and Alves (1982). Computer models based on these solutions that can solve both the forward problem (predicting solute distributions given parameter values) and the inverse problem (determining transport parameters given observed distributions) include CXTFIT (Parker and van Genuchten, 1984) and CXT4 (Gamerdinger et al., 1990).

Numerical Models. The development of numerical models for unsaturated flow and transport is currently an extremely active research field, as two recent review articles demonstrate (van Genuchten and Jury, 1987; Jury and Ghodrati, 1989). As the awareness of nonideal aspects of transport spreads, new models that include these aspects are being developed. Recent advances include models that simulate pesticide volatilization (Wagenet et al., 1989), multiple types of nonequilibrium in homogeneous systems (Brusseau et al., 1989) and in layered systems (Brusseau, 1991), transient moisture content combined with soil heterogeneity and hysteresis (Russo et al., 1989a), and transient moisture content combined with mobile/immobile water (Russo et al., 1989b).

Assessment of Nonideal Processes

The combined results of the laboratory studies and the field study permitted an estimate of the relative impacts of the various nonideal processes previously described. The results of this assessment will be described in detail in Chapter 4.

II

METHODS AND MATERIALS

LABORATORY BATCH STUDIES

The major objectives of the laboratory sorption studies were to determine the sorption linearity and singularity of the three herbicides, to check for competition effects between them, and to provide laboratory predictions of R.

Preparation of Soil

The laboratory batch studies were conducted using surface soil from the same plot at the Maricopa Agricultural Center (MAC) that was used for the field study described below. Approximately 4.5 kg of soil from the surface to a depth of 10 cm was collected by hand on March 23, 1989, and brought back to the New Mexico Institute of Mining and Technology (NMT) in Socorro for further preparation.

The soil was sieved through a 2-mm sieve, using a mortar and pestle to break up clods. Approximately 2% (by weight) of the soil sample consisted of gravel greater than 2 mm in diameter. Obvious vegetable matter (wood fragments and leaf debris) was also removed at this time. The sieved soil was allowed to air-dry approximately 24 hours, and was then stored in a plastic bag until used. The gravimetric water content of the air-dried soil was measured at 2.0%. The air-dried soil was determined to contain 0.2% organic carbon by weight using a potassium persulfate oxidation method (Huddleston, 1990, his Appendix E). A textural analysis of this soil confirmed its identification as a sandy loam, with 61.8% sand, 24.0% silt, and 14.2% clay.

Preliminary Studies

Before beginning the actual sorption studies, three preliminary studies were conducted to help determine procedural details.

Liquid Scintillation Counting Quenching

The herbicide assay method used for all of the laboratory sorption studies was liquid scintillation counting (LSC) of ^{14}C-labeled herbicide solutions. In some cases, organic compounds found in aqueous soil extracts have been observed to interfere with LSC by absorbing the emitted photons. If this "quenching" phenomenon is significant, various compensation methods are available. To determine the importance of quenching under the conditions of these experiments, a quench curve was produced.

The first step was to produce a concentrated soil extract, by shaking soil with 5 m*M* $CaCl_2$ solution (735 g reagent grade $CaCl_2 \cdot 2H_2O$ (Aldrich Chemical Co., Milwaukee, WI) in double-distilled or type-1 water produced with a Milli-Q Plus water system (Millipore Corp., Bedford, MA) to make 1 L solution) in a 2:1 w:w ratio. The extract was collected by centrifuging. A constant amount of ^{14}C-labeled bromacil (DuPont Agricultural Products, Wilmington, DE) was added to each of 11 scintillation vials. 2.0 mL of a mixture of the soil extract and 5 m*M* $CaCl_2$ were then added to each vial, with the ratio of extract to $CaCl_2$ solution varying from 0:1 to 1:0. Scintillation cocktail (Ecolite(+), ICN Biomedicals, Irvine, CA) was added to each vial, and the vials were counted using the New Mexico Tech Biology Department's Liquid Scintillation Spectrometer (Packard Tri-Carb 460 CD, Packard Instrument Co., Downers Grove, IL). No consistent trend in either counts observed or in either of two established quenching parameters was observed. This result indicated that LSC quenching would not be a significant problem under the conditions of the experiments.

Sorption Onto Plastic Labware

Results from the soil sorption studies were analyzed by a difference method, in which any herbicide lost from solution is assumed to have sorbed onto the soil. Therefore, any herbicide sorbed onto labware during the experiment could be considered sorbed to the soil, introducing errors into the final results. Plastic labware evaluated for herbicide sorption included polyallomer and teflon centrifuge tubes, and plastic pipet tips.

In the first experiment, 10 mL of a ^{14}C-labeled 100 ppm bromacil solution were shaken overnight in 50-mL glass centrifuge tubes with ground-glass stoppers, in 50-mL polyallomer centrifuge tubes (Nalge Co., Rochester, NY), and in the glass tubes together with an Eppendorf® plastic pipet tip (Brinkmann Instruments, Inc., Westbury, NY). The bromacil solution concentration in the glass tubes both with and without the pipet tips was unchanged, while overnight shaking in the polyallomer tubes reduced the solution concentration by 3%. This result effectively eliminated the polyallomer tubes from further consideration. A second experiment showed that overnight shaking in teflon centrifuge tubes (Nalge Co., Rochester, NY) had no effect on a 100 ppm bromacil solution. Additional experiments showed that overnight shaking in teflon tubes or in glass tubes containing a plastic pipet tip had no effect on a 19 ppm prometryn solution or a 15 ppm napropamide solution.

These results showed that the use of teflon centrifuge tubes and plastic pipet tips would not introduce errors into the sorption studies.

Sorption Kinetics

In batch sorption studies, the object is to determine the equilibrium solution and sorbed concentrations. It is therefore necessary to demonstrate that sorption equilibrium has been reached before measurements are made. In order to determine the time required to reach equilibrium, a series of sorption kinetic experiments were conducted.

For these experiments, 10 mL of ^{14}C-labeled herbicide solution were added to 10 g of soil in a centrifuge tube. The labeled herbicides were provided by the herbicide manufacturers: bromacil, DuPont Agricultural Products, Wilmington, DE; napropamide, ICI Americas, Richmond, CA; and prometryn, CIBA-GEIGY, Greensboro, NC. Each kinetic study was run in duplicate, using a concentration of 50 ppm for bromacil, 19 ppm for prometryn, and 15 ppm for napropamide. The tubes were shaken continuously for 72 hours, and 0.5-mL samples were removed for analysis at intervals throughout the experiment. In all cases, solution equilibrium was practically complete within 2 hours, with only very slight concentration changes after that time. No significant concentration changes were observed after 24 hours of shaking.

Desorption kinetics were checked in separate tubes, by replacing a known volume of the herbicide solution in the tube with $CaCl_2$ solution after 24 hours of shaking. Again, a new equilibrium concentration was quickly attained, often within 2 hours of shaking.

Although the results of the sorption kinetics experiment suggest that a shorter time interval would be acceptable, I decided to use 24-hour equilibrations for the sorption experiments, primarily for scheduling convenience. A longer equilibration would increase the possibility of significant herbicide degradation affecting the results.

Sorption Studies

Single-stage Sorption/Desorption

Single-stage sorption/desorption studies were conducted for each herbicide at five or six different concentrations. An initial stock solution of herbicide in 5 m*M* $CaCl_2$ was prepared using high-purity unlabeled herbicides (small quantities were provided by the herbicide manufacturers listed above, and additional quantities packaged by Riedel-de Haën under their Pestanal® label were purchased from the Crescent Chemical Company, Hauppauge, NY). The labeled herbicide solutions for use in the sorption study were prepared by serial dilution of stock solution using $CaCl_2$ solution, followed by the introduction of a small amount of the ^{14}C-labeled compound. Each concentration was studied in triplicate.

For each test, 10.0 g (± 0.1) of soil were weighed into a 50-mL teflon centrifuge tube. The weight was recorded to 0.01 g. 10.0 mL of the ^{14}C-labeled herbicide solution were pipetted into the tube, which was then placed on a platform shaker. After 24 hours of shaking, the tubes were centrifuged for 15 minutes to yield a clear supernatant. 1.0 mL of the supernatant was pipetted into a scintillation vial for counting, and an additional 2-4 mL were discarded.

For the desorption part of the experiment, sufficient fresh $CaCl_2$ solution was then added to the centrifuge tube to replace the supernatant that had been removed. The tubes were shaken for 24 hours, centrifuged for 15 minutes, and once again 1 mL was sampled for scintillation counting. Typically, a second desorption stage was then performed in the same manner. In this way, each centrifuge tube yields one point for a sorption isotherm and two points for a desorption scanning curve. Calculations were performed as described below.

Competitive Sorption

Competitive sorption studies were performed for each of the three herbicides, to determine whether the presence of the other two herbicides had an effect on the sorption of the herbicide in question. These studies were virtually identical to the sorption phase of the single-stage sorption/desorption described above, but the diluent used both for preparation of the solutions and for the desorption stage consisted of an approximately 50% saturated solution of the other two herbicides in $CaCl_2$. The bromacil study was conducted in a 5 m*M* $CaCl_2$ solution containing 35 ppm napropamide and 25 ppm prometryn, the napropamide study was conducted in a $CaCl_2$ solution containing 410 ppm bromacil and 24 ppm prometryn, and the prometryn study was conducted in a $CaCl_2$ solution containing 420 ppm bromacil and 38 ppm napropamide. The procedure was otherwise identical to the single-stage sorption, with three tubes per solution concentration.

Multi-Stage Sorption

Sorption isotherms developed using single-stage sorption experiments are inherently limited in their description of high-concentration effects. This problem is particularly troublesome for highly-sorbed compounds. As an example, consider napropamide, with a K_D of approximately 1 mL/g. With the 1:1 solution:soil ratio used in these experiments, starting with a saturated napropamide solution will lead to an equilibrium solution concentration at 50% saturation. One way to extend the sorption isotherm to higher concentrations is multi-stage sorption studies.

These studies began much like a standard single-stage study, using a high initial solution concentration. Twenty-four hours of shaking were followed by centrifugation and removal of the supernatant, as described for the single-stage studies. In this case, however, the removed supernatant was replaced not with fresh $CaCl_2$ solution, but with an equal amount of the initial high-concentration herbicide solution. The mixture was once again shaken for 24 hours, centrifuged, and the supernatant removed. The entire process was repeated for a total of five successive sorption stages. No desorption stages were included in these studies.

Calculations

The results of the sorption studies were analyzed and isotherms produced using a simple computer spreadsheet. After each equilibration step of the studies, the equilibrium solution concentration was determined by LSC. The sorbed mass of herbicide was calculated by comparing the initial solution concentration and the equilibrium solution concentration.

FIELD STUDY

Site Description

The field experiments were conducted at field #F110 at the Maricopa Agricultural Center (MAC), an experiment station owned and operated by the University of Arizona. MAC is located in south-central Arizona, three miles east of the town of Maricopa, approximately 25 miles south of Phoenix (Fig. 2-1).

The environment at MAC (elev. 358 m, 1175 ft) is typical of the Sonoran Desert alluvial basins of Southern Arizona. Hot summers with "monsoon" afternoon thunderstorms alternate with moderate winters with some precipitation. Warm, dry weather marks the spring and autumn seasons. Agriculture is the major land-use in the vicinity of the MAC, with cotton, alfalfa, pecans, and pistachios as the major crops.

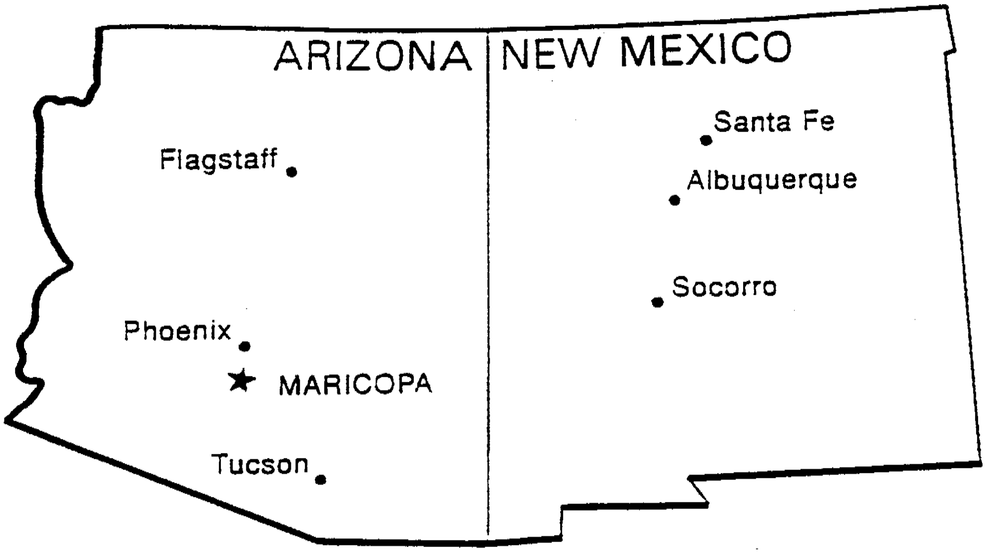


Figure 2-1. Location Map for Maricopa Agricultural Center.

The soil at the specific field site within the MAC has been mapped as reclaimed Casa Grande sandy loam. This soil is a deep, well-drained slowly permeable soil formed on old alluvium, and would be classified as a fine-loamy, mixed, hyperthermic Typic Natrargid in its original state (Hendricks, 1985; Post et al., 1988). Successful agricultural reclamation of this soil has decreased its salinity and sodium concentrations to acceptable levels. Post et al. (1988) described a typical Casa Grande profile at MAC as:

> a brown to reddish brown sandy loam or sandy clay loam surface horizon from 0-30 cm deep. The subsoil horizon from 30 to 60 cm is usually a reddish brown sandy clay loam, which increases in calcium carbonate content with depth. Below this horizon at a depth of 60 to 100 cm is a horizon enriched with calcium carbonate (calcic horizon), which also has a sandy clay loam texture. The depth

to the calcic horizon varies from 25 to 100 cm in depth, but commonly occurs between 50 and 80 cm in depth.

Rice et al. (1986) measured a soil bulk density profile in a nearby field. Their data were used in this study -- no additional bulk data measurements were collected.

Site Preparation

(Note: Site preparation and day-to-day site operations were managed by Robert C. Rice, U.S. Water Conservation Laboratory, Phoenix (USWCL)).

Before the beginning of this study, the soil at the field site had been bare for at least 24 months. Prior to the beginning of construction at the site, the field was disked and floated to smooth the surface. Sixteen 6-m × 6-m plots were laid out in a 2 × 8 grid. An additional 3-m - 7-m wide border surrounded the 16 plots on three sides (Fig. 2-2). Sheet-metal partitions extending 15 cm beneath and 25 cm above the ground surface were installed around each plot, and a 3-m long aluminum neutron-probe access tube was installed in the center of each plot.

A meteorology station equipped with a data logger was installed in plot 9 (Fig. 2-2). Precipitation data were collected at a nearby weather station operated by MAC.

Metered irrigation pipes extended along both sides of the plot array. Individual gates on the pipes permitted each plot to be irrigated individually. Additional gates permitted irrigation of the border area.

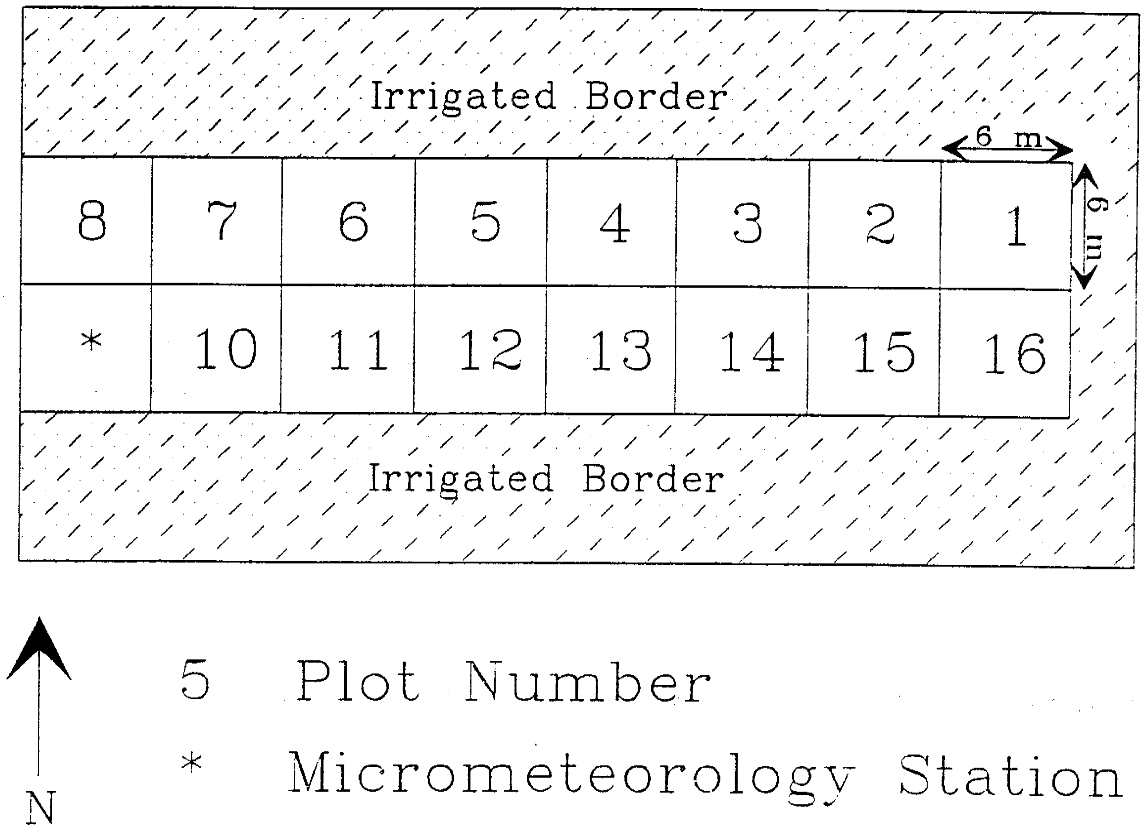


Figure 2-2. Plot Layout.

To better approach steady-state initial conditions, two 15-cm flood irrigations took place at the site before the beginning of the experiment.

Routine Site Operations

Irrigation

The sixteen experimental plots and the surrounding border zone were flood-irrigated with 7.5 cm water every two weeks. Each plot was irrigated independently, while the water flow was monitored using totalizing flow-meters installed on the irrigation lines. The irrigations are shown on the project time-line (Fig. 2-3).

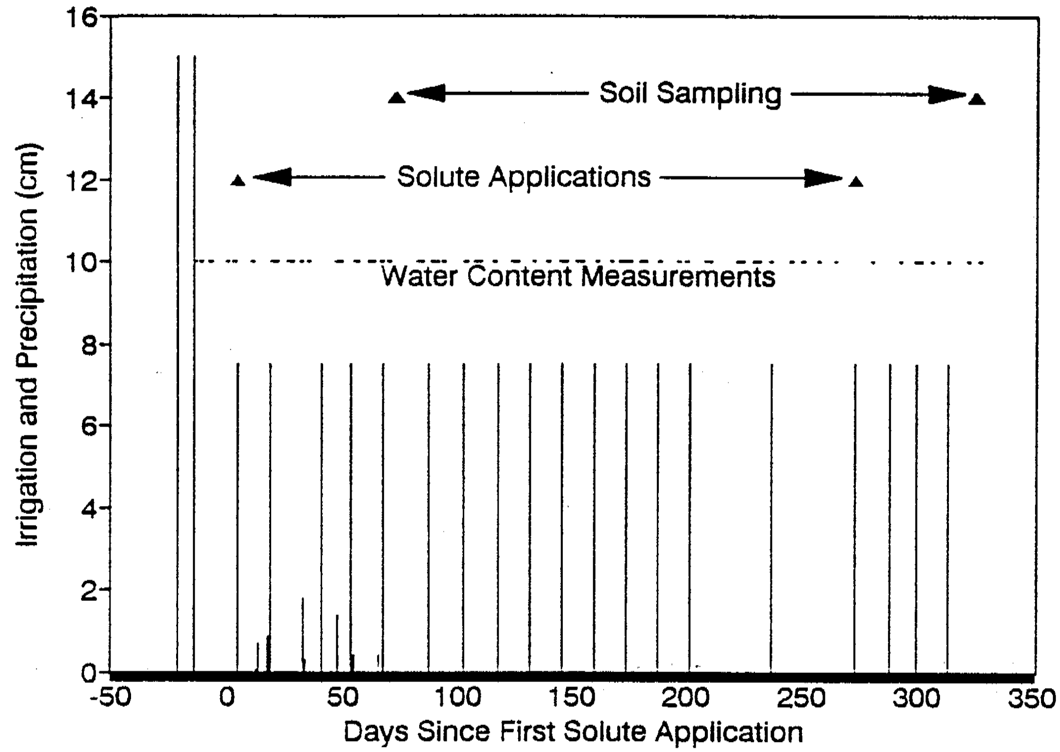


Figure 2-3. Field Study Time-Line. Vertical lines indicate irrigation or precipitation amounts.

Irrigation water was local groundwater, pumped from MAC well number E13-7-3. Water quality data provided by MAC and shown in Table 2-1 indicate this water to be a sodium chloride type water with a TDS between 600 and 800 ppm.

Micrometeorology Monitoring

The onsite meteorology station located in plot 9 automatically measured seven different environmental parameters every minute, including net radiation, wind speed, air temperature, vapor pressure, soil temperature at 5-cm depth and soil surface temperature, and soil heat flux.

Table 2-1. Irrigation Water Quality, MAC Well E13-7-3.

Date	Ca^{2+}	Mg^{2+}	Na^{+}	HCO_3^-	Cl^-	SO_4^{2-}	NO_3^-	TDS	pH
	<———mg/L———>								
09/03/82	46	11	132	122	128	151	2	598	7.8
09/06/83	49	14	152	111	144	203	13	691	7.5
09/12/85	41	18	143	78	143	146	20	659	7.8
11/15/85	43	24	118	73	117	96	18	653	7.8
01/07/86	41	12	120	65	93	101	21	614	8.1
03/25/86	35	6	126	68	116	126	26	813	8.1
05/09/86	33	18	119	55	93	187	21	659	8.1
07/10/86	27	16	117	55	93	190	20	666	7.9
08/03/87	48	26	210	202	260	242	18	806	8.2
01/14/88	38	15	116	58	85	103	2	730	8.1
03/09/88	37	8	119	71	90	128	3	589	8.2
04/12/88	42	16	131	64	101	116	2	681	8.0
05/09/88	51	20	143	73	115	130	2	681	7.7
06/10/88	78	17	233	264	217	122	2	704	8.0
01/31/90	64	7	150	-	152	59	2	640	-

Hourly averages were automatically computed and recorded in the data logger (Model CR-21, Campbell Scientific, Logan, UT). The data logger was periodically down-loaded to microcomputer for data analysis by USWCL personnel. Rice and Jackson (1985) provided full details on the instrumentation, as well as the energy balance calculations that provide field evaporation rates using the meteorological data.

Neutron Probe Soil Moisture Measurements

Soil moisture profiles in each of the 16 plots were measured using a neutron probe (Model 503 HydroProbe Moisture Depth Gauge, Campbell Pacific Nuclear Corp., Martinez, CA) before and after each irrigation, and usually once or twice between irrigations. Moisture measurements were collected at 20-cm intervals from 20-cm depth to 280 cm, and a surface probe was used to obtain a water content estimate for the top 10 cm.

Herbicide/Tracer Application

Procedures - First Application

The first application of herbicides and tracers took place on December 20 and 21, 1989. Each experimental plot received a different mixture of herbicides and tracers, as described in Table 2-2. Herbicide and tracer sources are shown in Table 2-3. The specific mixtures were prepared ahead of time and dissolved in approximately 4 L of ethanol (190-proof non-denatured ethanol) at the USWCL in Phoenix. At the field site, the herbicide/tracer mixture was poured into the spray tank, which was then topped off with ethanol to its capacity of approximately 5 L. The mixtures were applied to the plots using a CO_2-pressurized backpack-mounted sprayer, equipped with a 5-foot wide, 3 nozzle spray boom.

Prior to spraying each plot, six 9-cm glass petri dishes fitted with a glass-fiber filter circle were arranged on the soil surface. Marks were placed on the sheet-metal partitions to guide the spray team along four parallel traverses in each of two perpendicular directions (Fig. 2-4). The spray team followed the pattern shown in Figure 2-4 while attempting to maintain a constant velocity until the mixture was exhausted, usually after 5-7 passes. Any residual mixture was discarded, and the sprayer was thoroughly rinsed with ethanol between plots.

The petri dishes and filter circles were collected, placed in labeled sample bags, and returned to NMT. They were stored in a freezer while awaiting analysis.

Table 2-2. First Application: Target Rates.

Plot	Treatment	Bromacil	Napropamide	Prometryn	2,6-DFBA	*m*-TFMBA	*o*-TFMBA	PFBA
		<------------------------			(g/m^2)			------------------------>
1	High Mix	10	5.1	2.0	-	-	2.0	-
2	High Mix	10	5.1	2.0	-	-	-	2.0
3	Low Mix	1.0	0.51	0.2	-	-	2.0	-
4	Prometryn	-	-	2.0	-	-	-	2.0
5	Napropamide	-	5.1	-	-	-	2.0	-
6	Low Mix	1	0.51	0.2	-	-	-	2.0
7	Napropamide	-	5.1	-	-	-	2.0	-
8	Bromacil	10	-	-	-	-	-	2.0
10	Napropamide	-	5.1	-	2.0	-	-	-
11	Bromacil	10	-	-	-	2.0	-	-
12	Prometryn	-	-	2.0	2.0	-	-	-
13	High Mix	10	5.1	2.0	-	2.0	-	-
14	Low Mix	1.0	0.51	0.2	2.0	-	-	-
15	Prometryn	-	-	2.0	-	2.0	-	-
16	Bromacil	10	-	-	2.0	-	-	-

Table 2-3. Solute Sources.

	Solute	Form	Assay	Source
Herbicides	Bromacil	Hyvar-X, commercial formulation	80%	DuPont Agricultural Products, Wilmington, DE
	Napropamide	Technical Grade	91.9%	ICI Americas, Richmond, CA
	Prometryn	Technical Grade	97%	CIBA-GEIGY, Greensboro, NC
Tracers	2,6-DFBA		97+%	Yarsley Fluorochemicals, Ltd., Wolverhampton, England
	m-TFMBA			
	o-TFMBA			
	PFBA			
	Bromide	Purified Grade KBr		Atlas Chemicals, San Diego, CA

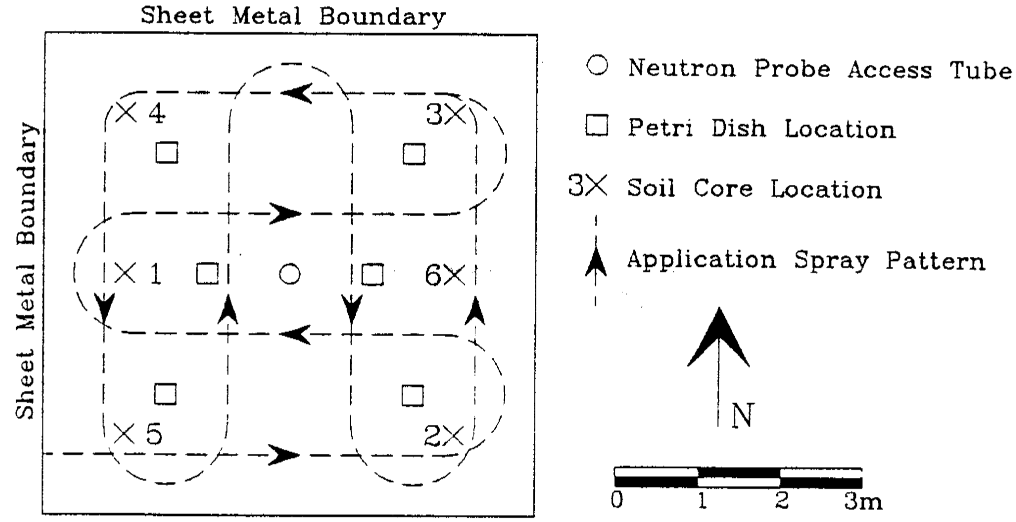


Figure 2-4. Application Pattern and Sample Layout.

Immediately following the herbicide/tracer application, the sixteen experimental plots and the border zone were flood-irrigated with 7.5 cm water.

Procedures - Second Application

A second application of herbicide and tracer took place on September 12, 1990. A bromide tracer was applied to all of the plots, and selected plots received a second treatment of bromacil.

The overall application method was the same as described above for the first application, with different chemical mixtures and solvents as follows. Plots 8, 11, and 16 were treated with a mixture of 4 L of bromacil solution in ethanol and 4 L of bromide in water, and the remaining plots were treated with 5 L of bromide in water. Rates for the second applications are shown in Table 2-4. Four glass petri dishes with filter paper inserts were distributed within each plot before spraying, to determine spray uniformity and actual application rates.

Table 2-4. Second Application: Target Rates.

Plot	Bromacil	Bromide
	<--- (g/m^2) --->	
1-7,10,12-15	-	13.5
8,11,16	10	13.5

Soil Coring and Subsampling

First Sampling

<u>Field Procedures.</u> The first sampling episode took place on February 26 and 27, 1990. Three locations in each plot (locations 1-3 on Fig. 2-4) were cored to a total depth of 270 cm in two stages. Shallow samples from the surface to a depth of 90 cm were collected in a single intact

core, using a 5-cm diameter core sampler with a polybutyrate plastic liner. After driving the sampler to a depth of 90 cm, the sampler was pulled from the soil and the liner with intact core removed. The core was sealed at both ends with aluminum foil, then placed in a cooler awaiting transport back to USWCL for further processing.

Deeper samples were then collected starting in the same hole, in 30-cm increments. A 5-cm OD aluminum liner was placed in the hole to prevent soil caving during subsequent sampling. A 2.2-cm ID Veihmeyer tube (Soiltest, Evanston, IL) of appropriate length was then driven by hand 30 cm into the soil. The tube was removed from the hole, and the soil within shaken into a labeled foil-lined sample bag (Fisher Scientific, Pittsburgh, PA). The sample bags were sealed, placed in Ziploc® plastic bags and transported in coolers to USWCL.

All sampling equipment was rinsed with reagent-grade acetone between uses. The core holes were backfilled with local soil. Throughout the process, care was taken to minimize disturbance of the soil within the plots. For this reason, no heavy machinery was used during the sampling process.

Laboratory Procedures. At USWCL, the shallow sample cores were sectioned into six 10-cm intervals from the surface to 60-cm depth, and a single 30-cm long sample from 60-90 cm depth. In many cases, driving the core sampler resulted in some soil compaction, so that a full 90-cm long soil column was not present. In these cases, compaction was assumed to be uniform throughout the core, and the core was proportionately divided into the seven samples described above. The core was divided by cutting through the polybutyrate liner and soil core with a mechanical PVC tubing cutter, a scissor-like tool with a sharp blade. Individual soil samples were then extruded from the short lengths of liner into labeled sample bags.

For the remainder of the process, both the shallow core samples and the deep Veihmeyer tube samples were treated identically. The soil sample was dumped out of the sample bag onto a clean piece of aluminum foil. Using acetone-rinsed knives or spatulas, the soil sample was thoroughly chopped and homogenized. A 65 - 70-g portion of the homogenized sample was returned to the aluminum foil-lined sample bag, weighed, sealed, and packed for shipment to NMT for herbicide analysis. In nine cases, two or three herbicide subsamples were collected from a single homogenized soil sample, to permit an assessment of the homogenization and analysis reproducibility. The remaining soil was stored in a labeled plastic bag, awaiting moisture content and tracer analysis, both conducted at USWCL.

The herbicide analysis samples were frozen upon arrival at NMT, and the moisture content/tracer samples were refrigerated until analysis at USWCL.

Second Sampling Episode

Field Procedures. The second sampling episode took place on November 5 and 6, 1990. Three additional cores (locations 4-6 on Fig. 2-4) were collected from each plot. For plots 8, 11, and 16, all of which received additional herbicide during the second application, field procedures were the same as during the first sampling episode. For the remaining plots, the shallow core-sampler was not used. Instead, a specially-machined 14" long 1⅜" I.D. tube was driven into the soil to a depth of 30 cm. The tube was then withdrawn, and the soil within collected in a labeled sample bag. The empty tube was then replaced in the hole, to stabilize the hole for further sampling. Additional samples were collected in 30-cm increments to a total depth of 270 cm, using a Veihmeyer tube. Throughout the second sampling episode, all equipment was rinsed with 190-proof ethanol instead of acetone.

Laboratory Procedures. Laboratory sample homogenization, division, and weighing procedures were identical to those described for the first sampling episode.

Laboratory Procedures

Soil Moisture Determination

Gravimetric soil moisture measurements were conducted at USWCL under the supervision of Robert C. Rice. The soil subsamples were dried in a 105° C oven for 24 hours, and moisture content was determined by comparing dry soil weight and initial weight.

Tracer Analysis

Soil analyses for the fluororganic and bromide tracers were conducted at USWCL, under the supervision of Robert C. Rice. A 10-g soil subsample at field moisture content was extracted with 10 mL of water by shaking for 20 minutes in a 50-mL polypropylene centrifuge tube. After centrifugation and filtering, the tracers were quantified via HPLC (Bowman, 1984a). The tracer detection limit for soils was estimated at 0.1 mg/kg, which corresponds to a volumetric concentration of 0.1 - 0.2 $\mu g/cm^3$.

Herbicide Analysis

Petri Dish Filter Extraction. The glass petri dishes with their glass fiber filter circles in place were extracted with 4 successive 10-mL aliquots of a 1:1 v:v mixture of acetone and hexane (Optima® grade, Fisher Scientific, Pittsburgh, PA). The 4 extracts were combined and brought to a total volume of 40 mL. Two 2-mL subsamples were transferred to glass autosampler vials for GC herbicide and HPLC tracer analysis, and the remainder of the extract was discarded.

Soil Extraction. Typically, 8-10 soil samples were extracted together as a group, but the following description is written in terms of a single sample.

Approximately 24 hours before extraction, the soil sample was moved from the freezer to a refrigerator to thaw. Once thawed, the entire 60 - 70-g (M_T in Eq. 2-1) sample was transferred to a 250-mL polyallomer centrifuge bottle (Nalge Co., Rochester, NY) with 140 mL (V_M) of a 4:1 v:v mixture of methanol (reagent grade, J.T. Baker Inc., Phillipsburg, NJ) and water (either double-distilled or type I produced using the Milli-Q Plus water system, Millipore Corp., Bedford, MA). The bottle was shaken on a platform shaker for 1 hour, then centrifuged for 15 minutes to yield a clear supernatant. The collected supernatant was measured to the nearest mL (V_C), then poured into a 1-L Erlenmeyer flask. NaCl diluent solution (25% w/v reagent grade NaCl, J.T. Baker, Phillipsburg, NJ) was then added to the Erlenmeyer flask to bring the total volume to approximately 1 L.

Meanwhile, a solid-phase extraction (SPE) column (packed with 1 g of phenyl-coated silica, catalogue # 188-0560, J&W Scientific, Folsom, CA) was conditioned by rinsing with 3-5 mL of reagent-grade methanol, followed by 3-5 mL of NaCl diluent solution. The solutions were forced through the column by air pressure applied by hand through a syringe tipped with a rubber stopper.

The tip of the conditioned SPE column was attached to a vacuum manifold, and the soil extract mixture drawn through the column via a teflon tube. The length of time required for processing the entire liter of extract ranged from 1-12 hours, depending primarily on the batch of SPE column and the strength of the available vacuum.

After the entire extract was processed, 1 mL of water was drawn through the SPE column to flush out any residual NaCl. The vacuum was then left on an additional 15 minutes to dry the column. 0.1 - 0.5 mL of the internal spike solution (5.0 mg of Pestanal®-grade chlorpyrifos, Crescent Chemical Company, Hauppauge, NY, in 100 mL of Optima®-grade methanol) was then measured into a 5-mL (V_E) volumetric flask. The herbicides sorbed onto the SPE column were eluted into the volumetric flask using four 0.9-mL aliquots of reagent-grade methanol, forced through the column using air pressure applied by hand as before. The eluent was brought to volume in the volumetric flask and mixed by shaking. Approximately 1 mL of the eluent was transferred to a labeled 2-mL glass autosampler vial, and the remainder stored in a labeled 5-mL serum vial. Both vials were sealed with teflon-coated septa and crimp-top seals and stored in a freezer awaiting GC analysis.

Gas Chromatography. Both the soil and petri dish extracts were analyzed by gas chromatography under the conditions shown in Table 2-5. Chromatography runs were calibrated using herbicide standards prepared by dissolving high-purity herbicides in Optima-grade methanol. Sample chromatograms are presented in Appendix B.

Precision and Accuracy Studies

Field Soil Replicates. As mentioned above, nine soil samples were divided into replicates during sample splitting. These replicates were extracted and analyzed as completely independent

Table 2-5. Gas Chromatography Conditions.

GC:	5890A (Hewlett-Packard Co., Palo Alto, CA)
Column:	30 m x 0.530 mm ID FSOT Fused Silica Econo-Cap® (Alltech Associates, Deerfield, IL)
Stationary Phase:	1.2μ layer SE-54
Inlet:	Split Injection, 5:1 - 10:1 split ratio
Detector:	Nitrogen-Phosphorus Detector
Carrier:	Helium, at 5-10 mL/min
Inlet Temperature:	250° C
Oven Temperature:	200° C, isothermal
Detector Temperature:	250° C
Autosampler:	Hewlett-Packard 7673A
Integrator:	Hewlett-Packard 3396A
Data System:	ChromPerfect (Justice Innovations, Palo Alto, CA)

samples, thereby provided a measure of the reproducibility of the entire herbicide analysis process, from sample homogenization through gas chromatography.

Spiked Soil Analyses. As an additional test of extraction efficiency and reproducibility, samples of untreated soil from the MAC experimental site were "spiked" with known concentrations of the three herbicides. A 500-g sample of soil was spiked with each of three concentrations of herbicide solution in methanol, by spraying the soil surface the solution using an atomizer. The soil was then well mixed and subdivided into ten 50-g samples. The samples were frozen for 10-15 days, then eight samples were extracted and analyzed identically to the field soil samples.

Concentration Calculations

The soil herbicide concentrations (C_S) were calculated from the concentration in the final extract (C_E), corrected for soil moisture and fraction of extractant recovered using Equation 2-1.

$$C_S = \frac{(C_E V_E)}{\frac{M_T}{\rho_B}\left(\frac{1}{1+w}\right)} \cdot \left(\frac{V_M + \frac{M_T}{\rho_W}\left(\frac{w}{1+w}\right)}{V_C}\right) \tag{2-1}$$

where:

C_S = Soil herbicide concentration (per volume soil) [M/L^3]

C_E = Herbicide concentration in final extract [M/L^3]

V_C = Volume of supernatant collected during extraction [L^3]

V_M = Volume of methanol/water extractant added during extraction [L^3]

V_E = Volume of extract eluted from SPE column [L^3]

w = Soil gravimetric water content [M/M]

ρ_W = Soil moisture density [M/L^3] ($\approx$ 1 g/cm^3)

M_T = Total mass of soil sample at field moisture content [M]

III

RESULTS AND DATA ANALYSIS

RESULTS

This project resulted in a multitude of data. Most of these data are contained in appendices to this paper and are referenced in this chapter.

Laboratory Batch Studies

Single-Stage Sorption/Desorption

The results of the single-stage sorption/desorption experiments are presented in Appendix C and shown in Figure 3-1. The Freundlich equation (Eq. 3-1) was fitted to the observed sorption data by linear regression of log-transformed data, using the SAS General Linear Model Package (SAS Institute, 1988b). The desorption isotherm for each centrifuge tube was analyzed separately, and the resulting *n* parameters were then averaged. Prior to analysis, the data were log-transformed, which both simplifies the determination of Freundlich isotherm parameters and increases the overall uniformity of variance of the data, strengthening the validity of the statistical analysis (Bowman et al., 1984). The fitted Freundlich parameters for each herbicide are shown in Table 3-1.

$$S = K_F C^n \tag{3-1}$$

Table 3-1. Freundlich Parameters for Single-Stage Sorption/Desorption Experiments.

Herbicide	Sorption		Desorption	n_{sorp}/n_{des}
	K_F	n	n	
Bromacil	0.116	0.916	0.541 ± 0.135	1.69
Napropamide	1.005	0.993	0.568 ± 0.142	1.75
Prometryn	0.372	1.000	0.791 ± 0.194	1.26

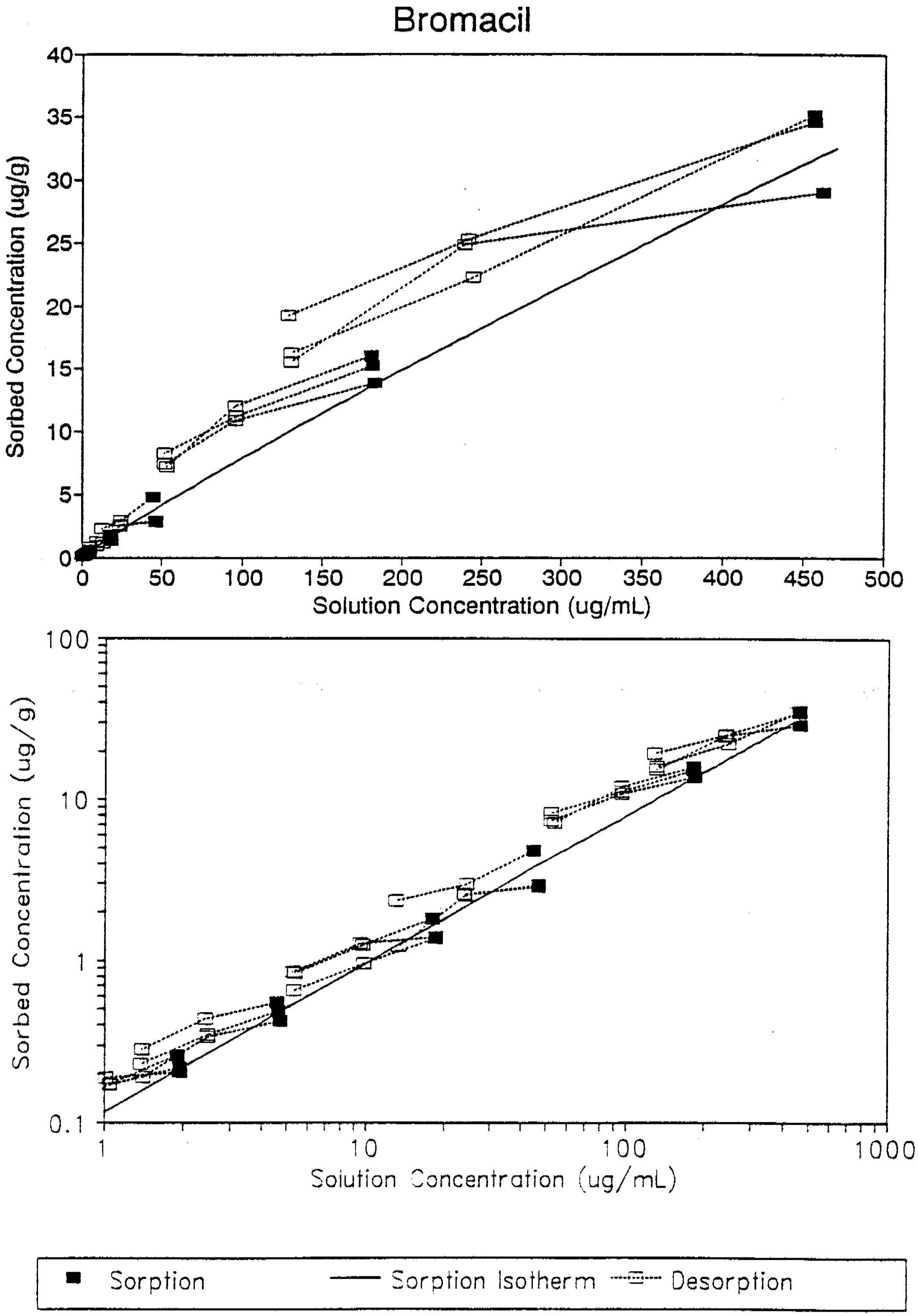


Figure 3-1. Single-Stage Sorption/Desorption Results -- Bromacil.

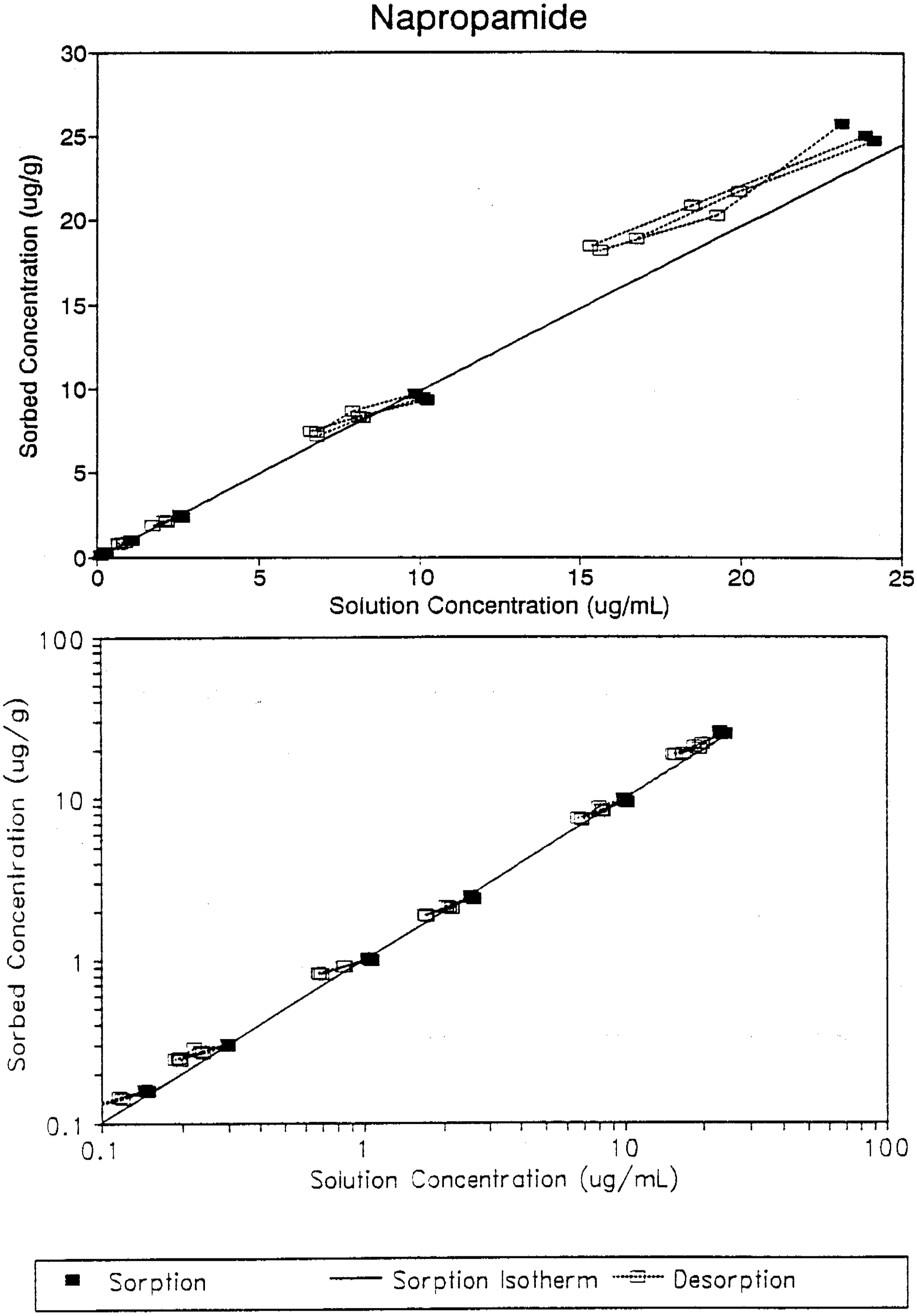


Figure 3-1 (cont). Single-Stage Sorption/Desorption Results -- Napropamide.

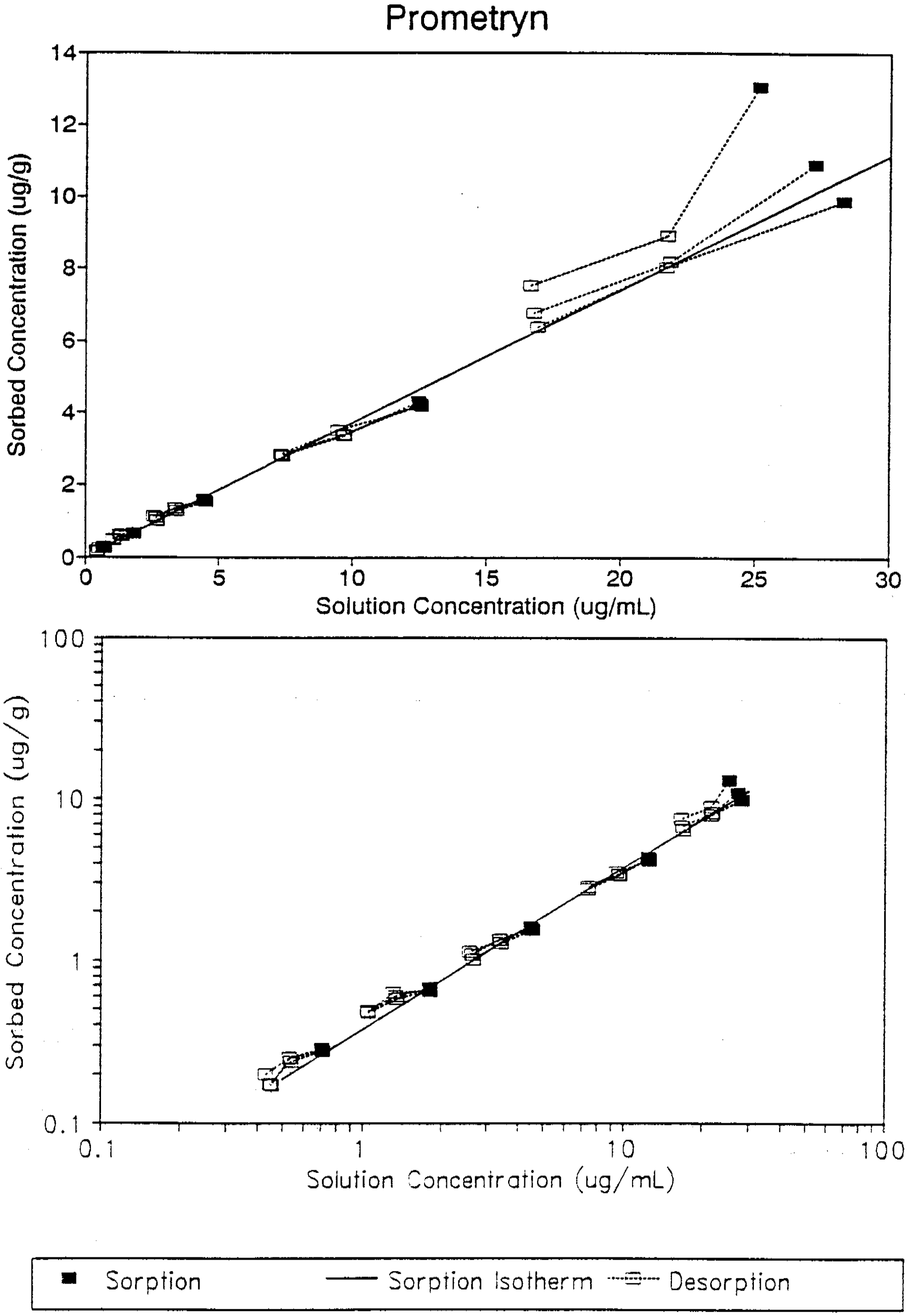


Figure 3-1 (cont). Single-Stage Sorption/Desorption Results -- Prometryn.

Napropamide and prometryn sorption followed a linear isotherm (napropamide $n = 0.99$, prometryn $n = 1.00$), while bromacil displayed non-linear sorption ($n = 0.92$) that was well-described by the Freundlich equation. All three herbicides displayed apparent desorption hysteresis, as demonstrated by the significantly lower desorption n value compared to the sorption value. The observed n_{sorp}/n_{des} ratio varied from 1.26 to 1.75, lower than ratios for other pesticides reported and cited by van Genuchten et al. (1977). This experiment was vulnerable to some of the experimental difficulties that have caused some authors (Bowman and Sans, 1985; Brusseau and Rao, 1989) to question the validity of much reported hysteresis, but many of the problems (sorption onto the container, volatilization loss, degradation and transformation) were minimized, suggesting that at least some of the observed hysteresis may be real.

Multi-Stage Sorption

The results of the multi-stage sorption experiments are presented in Appendix D and shown, together with the single-stage data, in Figure 3-2. When the initial bromacil and prometryn experiments yielded data that appeared quite erratic, these experiments were repeated but again produced erratic results, those shown in Figure 3-2. The napropamide data, on the other hand, appear relatively well-behaved and amenable to further analysis. The Freundlich equation was fitted to the multi-stage napropamide sorption data, both alone and in combination with the single-stage data. Resulting parameters are shown in Table 3-2.

The use of multi-stage experiments to extend sorption isotherms to higher concentrations was clearly not a great success. The napropamide experiment yielded useful data, but the obvious slope break between the single-stage and multi-stage isotherms (Fig. 3-2), and the difference between the fitted Freundlich parameters (Table 3-2) indicate some problems in the procedure.

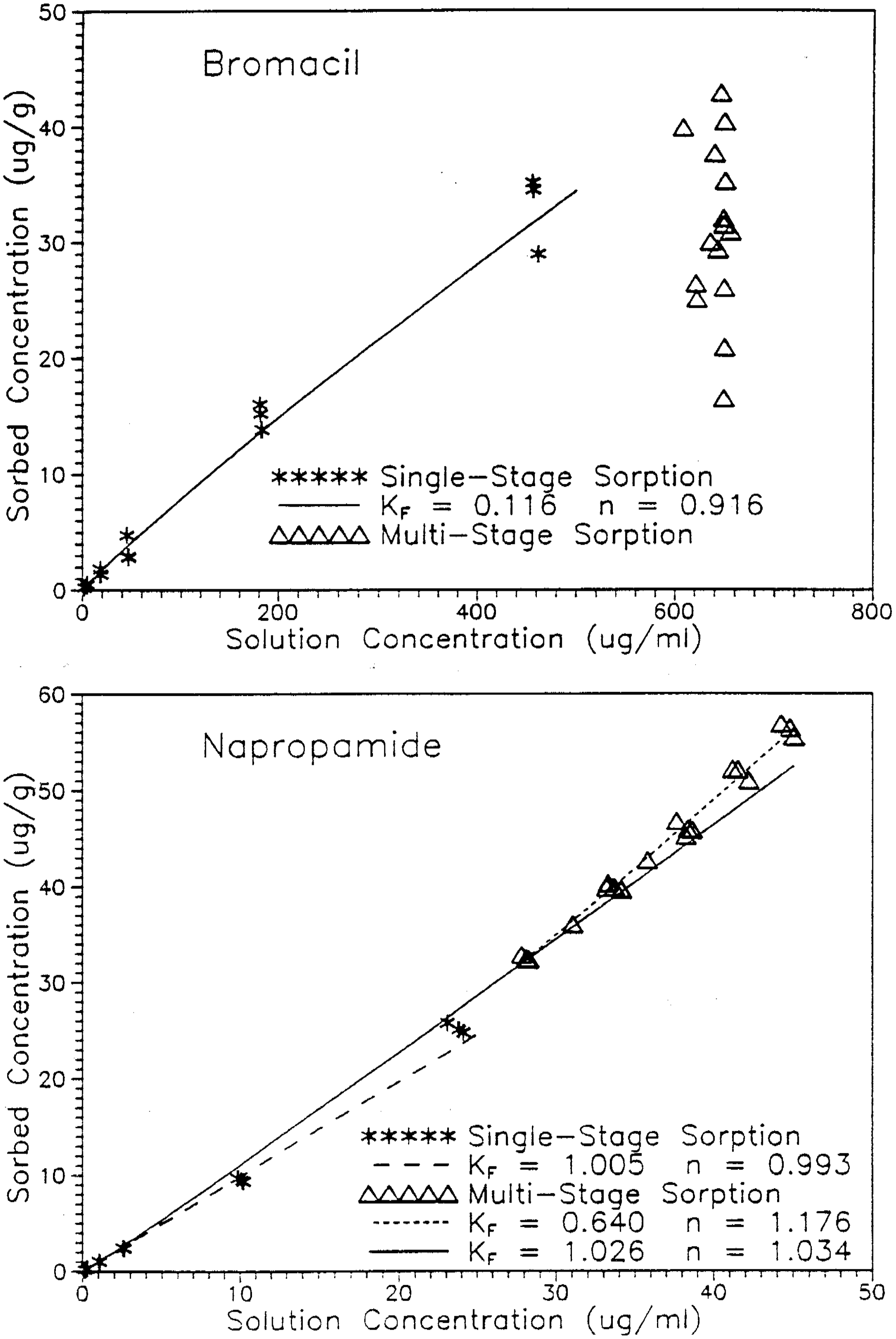


Figure 3-2. Multi-Stage Sorption Results.

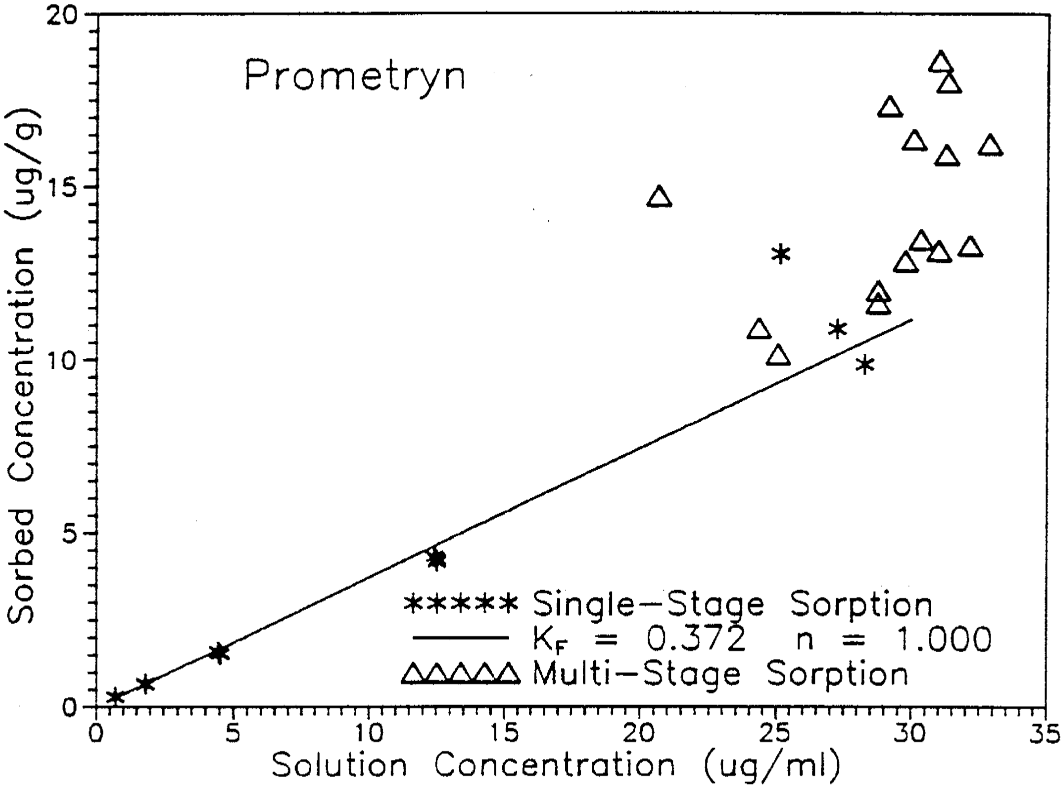


Figure 3-2 (cont). Multi-Stage Sorption Results.

Table 3-2. Freundlich Parameters for Napropamide Multi-stage Sorption Experiment

	K_F	*n*
Single-Stage Sorption	1.005	0.993
Multi-Stage Sorption	0.640	1.176
Combined	1.026	1.034

Each point that helps define a single-stage sorption isotherm represents an independent experiment, taking place in a single centrifuge tube. The unavoidable variations due to soil heterogeneity and measurement uncertainties therefore tend to cancel each other out. During a multi-stage sorption experiment, on the other hand, each tube is used repeatedly, and the results of one stage are used as input parameters during the analysis of the succeeding stage. In this situation, natural variations tend to propagate and increase with each stage. This error propagation effect may help explain the discrepancy between the single-stage and multi-stage sorption results for napropamide.

The bromacil and prometryn results are more problematic. The erratic results defy conventional analysis, and cannot provide a meaningful estimate of high-concentration sorption behavior. The distribution of points shown in Figure 3-2 suggest that there may be an upper limit to the equilibrium solution concentration in contact with soil, and that the experimental method breaks down when that limit is reached. The observed limit for bromacil is below the literature solubility concentrations, but may reflect decreased solubility in a soil-water-$CaCl_2$ system, perhaps due to dissolved natural organic compounds, or to a "salting out" effect caused by the presence of the $CaCl_2$. The reported aqueous solubility of prometryn is subject to some uncertainty: WSSA (1989) and the manufacturer (CIBA-GEIGY, n.d.) report a solubility of 48 mg/L, while Worthing (1991) cites a value of 33 mg/L, very close to the apparent multi-stage concentration limit of 32-33 mg/L.

Competitive Sorption

A second single-stage sorption experiment was conducted for each of the three herbicides in the presence of the other herbicides in solution. The results of these experiments are presented in Appendix E and shown in Figure 3-3. The resulting Freundlich parameters are compared to the single-stage sorption results in Table 3-3. To determine whether the isotherms are significantly different in the presence of competing herbicides, a statistical analysis using the methods of Dao et al. (1982) was conducted. The results indicate that sorption of bromacil and napropamide is significantly decreased by the presence of the other herbicides, while prometryn sorption is not significantly affected.

Table 3-3. Freundlich Parameters for Competitive Sorption Experiments.

Herbicide	No Competition		With Competition		Significant Difference?
	K_F	n	K_F	n	
Bromacil	0.116	0.916	0.0896	0.912	yes
Napropamide	1.005	0.993	0.859	1.01	yes
Prometryn	0.372	1.000	0.404	0.996	no

Field Study

Micrometeorology / Water Balance

Robert C. Rice of the U.S. Water Conservation Laboratory in Phoenix analyzed the microclimatological data as described in the previous chapter. This analysis resulted in estimated net daily evapotranspiration (ET) rates. Unfortunately, the meteorology station equipment and data logger were plagued by problems throughout much of the experiment. Reliable ET information is available for the period between the first solute application and the first sampling episode, but not much after that.

The available data show that during the 75-day period from 12/20/89 to 3/5/90 which spans the first application and sampling episodes, total cumulative ET was approximately 19.4 cm. During that same time period, irrigation and precipitation totaled 43.5 cm. By subtraction, the net infiltration over this time period was 24.1 cm, 55% of total applied water. The average net infiltration rate over this 75-day period was 0.321 cm/day. This average rate, combined with moisture content data, can provide us with an estimate of the average downward water velocity

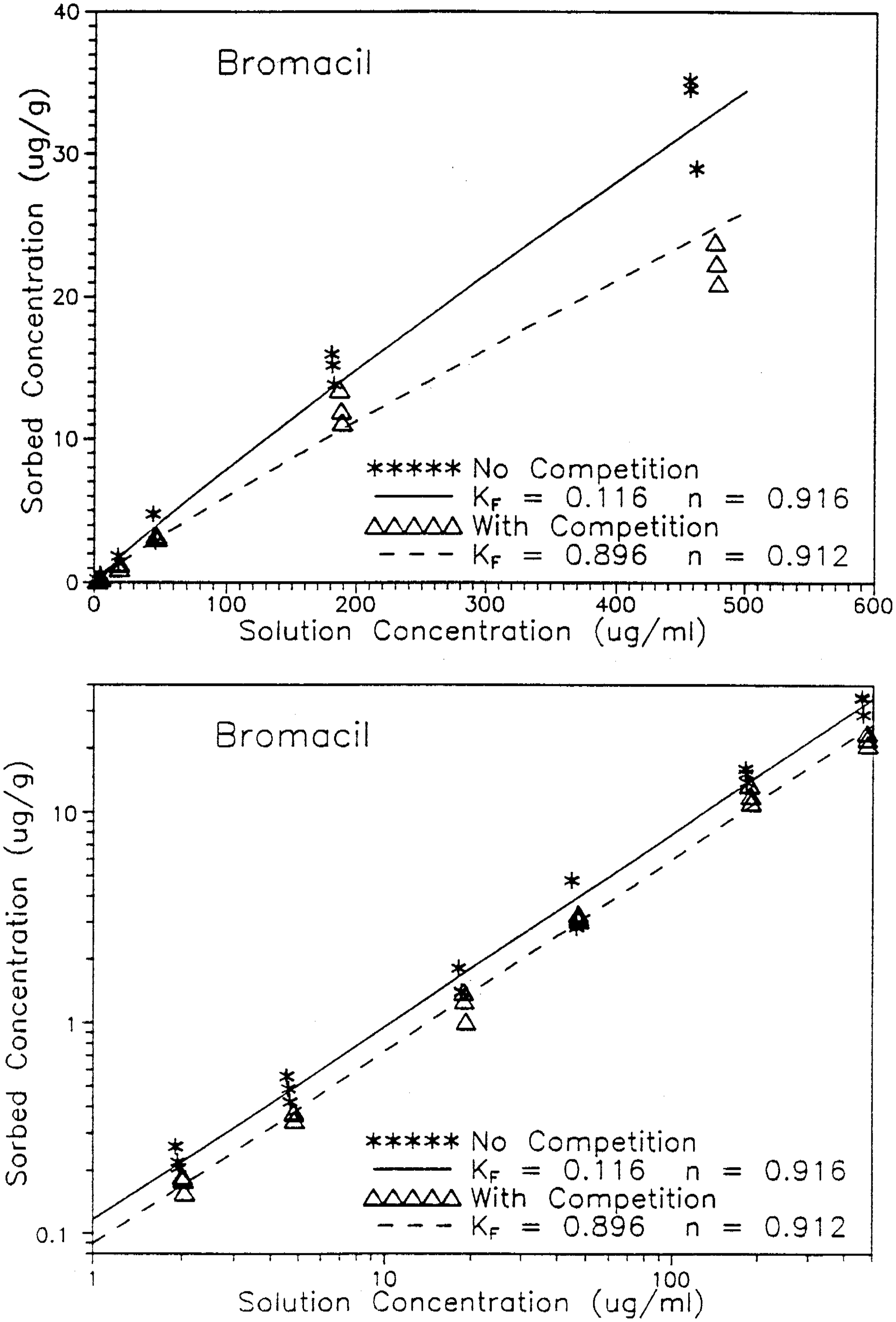


Figure 3-3. Sorption Competition Results -- Bromacil.

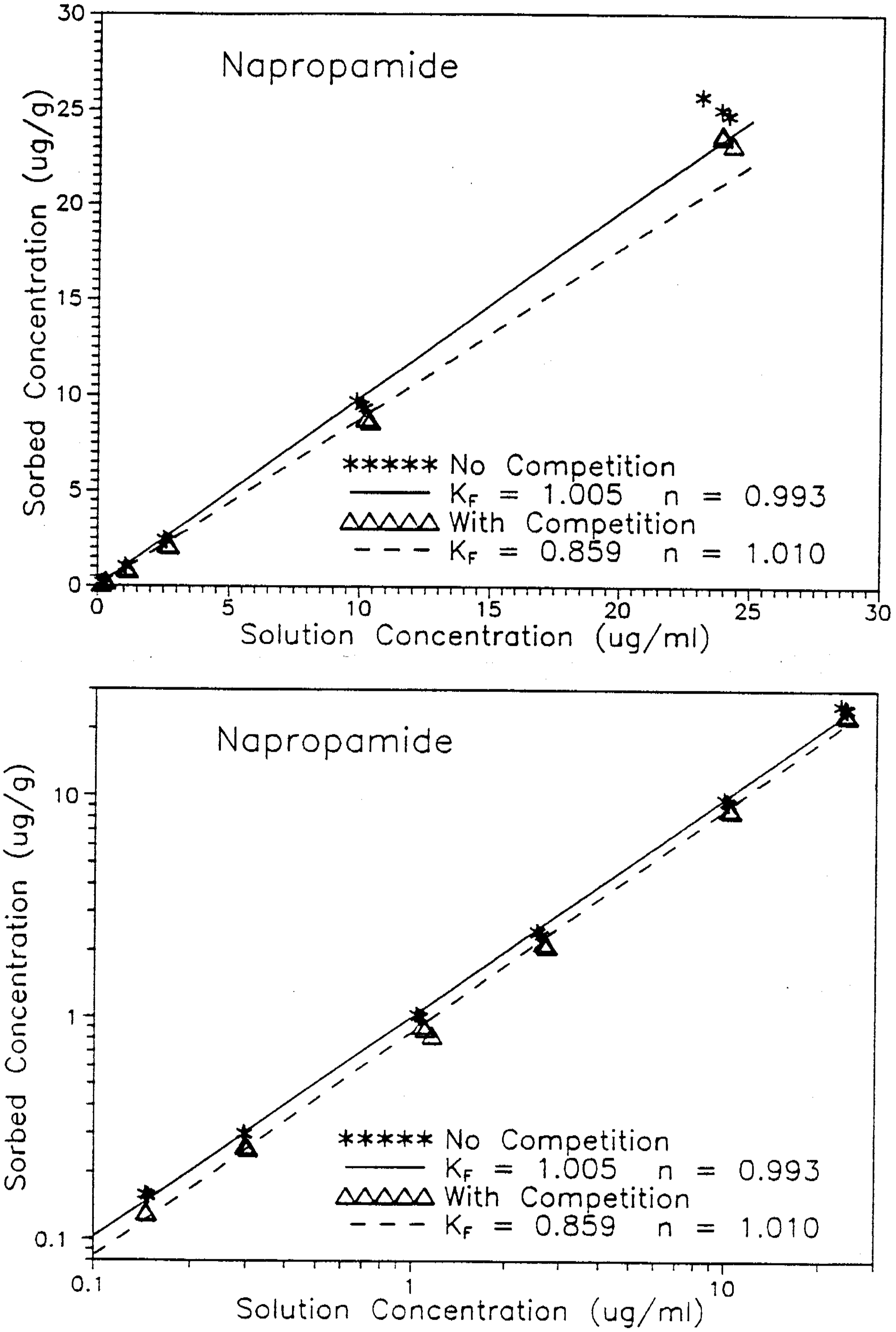


Figure 3-3 (cont). Sorption Competition Results -- Napropamide.

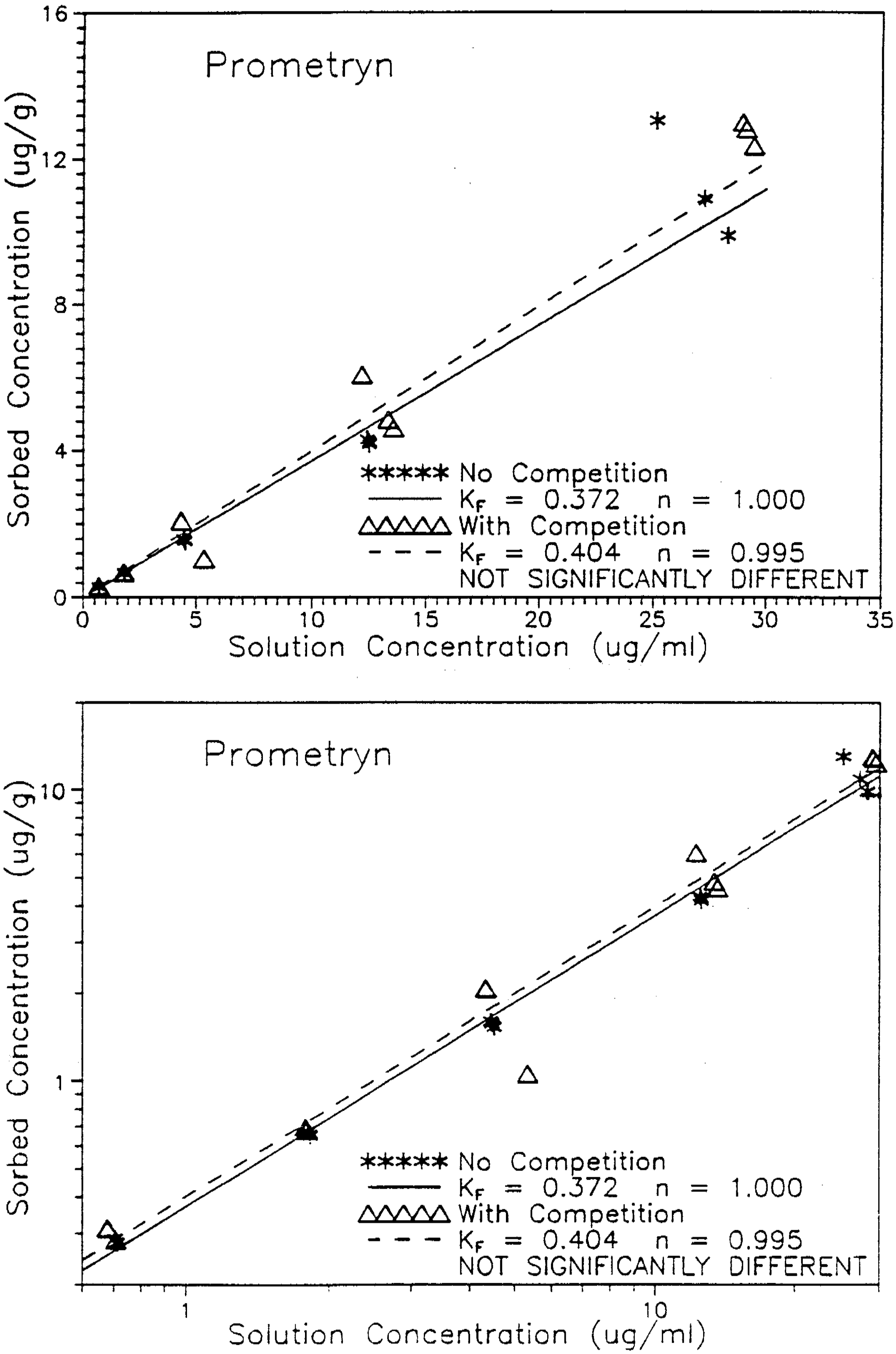


Figure 3-3 (cont). Sorption Competition Results -- Prometryn.

(v_a) within the plots during this time period. This calculated velocity will be later be compared to measured tracer velocities (v_t).

Neutron Probe Measurements

During the 11-month course of the field experiment, the water content in each of the sixteen plots was measured at 17 depths using a neutron probe a total of 67 times. The results of these measurements are tabulated in Appendix F. Depth profiles for each plot showing the average water content and the one SD range can be found in Appendix G. As expected, near-surface water content showed considerable variability in response to the biweekly flood irrigations, but this variability was rapidly damped out with depth. A depth profile of the average coefficient of variation (Fig. 3-4) shows the average CV decreasing from 38% near the surface to less than 10% at all depths greater than 10 cm. Below 40 cm, the average CV is on the order of 5%.

This suggests that although transient water conditions may dominate flow and transport in the top 10 cm, the natural damping in water content variability with depth may permit quasi-steady state conditions to exist at depth.

Spray Application Rate and Uniformity

Prior to application of the herbicides, six petri dishes containing glass-fiber filter circles were arranged in each plot. The herbicide concentration on each filter circle was measured to determine actual application rates and variability. Results of this analysis are tabulated in Appendix H, and summarized in Table 3-4. The overall application rate showed a CV of 21%. This measurement is to some extent a function of the physical sample size, in this case determined by the 9-cm diameter of the petri dishes. By analogy to the effects of soil sample size

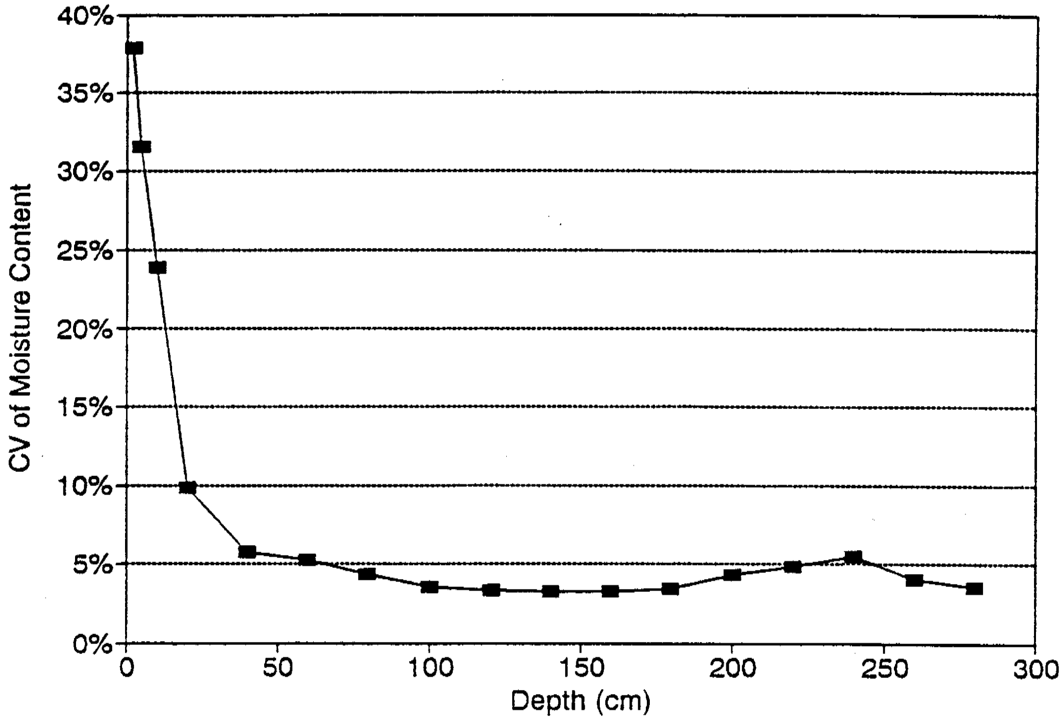


Figure 3-4. Decrease in Average Water Content CV with Depth.

(Rice and Bowman, 1988), smaller diameter petri dishes would presumably show somewhat higher variability. A second set of extracts was sent to USWCL for tracer analysis, but was lost prior to analysis.

Tracer and Herbicide Concentrations

Precision and Accuracy Studies - Spiked Soil Analyses. The measured herbicide concentrations in 24 spiked soil samples are summarized in Table 3-5. These results suggest that in the soil concentration ranges that define the observed herbicide profiles, measurement CV's are approximately 5-10%. The GC peak sizes resulting from the low-concentration soil spike indicate that useful detection limits are on the order of 10 μg/kg, corresponding to 0.01 - 0.02 μg/cm^3.

Precision and Accuracy Studies - Field Soil Replicates. Nine of the field soil samples were split

Table 3-4. Petri Dish Herbicide Recovery Data.

Plot	Treatment	Measured Herbicide Application Rate (g/m^2), mean ± 1 SD		
		Bromacil	Napropamide	Prometryn
1	High Mix	7.214 ± 1.083	3.977 ± 0.655	1.093 ± 0.166
2	High Mix	7.139 ± 1.544	4.552 ± 1.013	1.062 ± 0.219
3	Low Mix	0.830 ± 0.140	0.301 ± 0.056	0.110 ± 0.019
4	Prometryn			1.136 ± 0.116
5	Napropamide		4.198 ± 0.793	
6	Low Mix	0.704 ± 0.081	0.263 ± 0.027	0.095 ± 0.009
7	Napropamide		3.873 ± 0.854	
8	Bromacil	6.925 ± 1.460		
10	Napropamide		4.034 ± 0.929	
11	Bromacil	7.323 ± 3.636		
12	Prometryn			1.315 ± 0.208
13	High Mix	6.815 ± 2.056	3.661 ± 1.199	1.011 ± 0.311
14	Low Mix	0.790 ± 0.217	0.278 ± 0.081	0.106 ± 0.027
15	Prometryn			1.138 ± 0.246
16	Bromacil	8.470 ± 1.557		
	Average CV	23.5%	21.5%	18.5%
	Overall CV		21.2%	

at the time of sampling, providing replicate samples to assess herbicide extraction and analysis reproducibility. The analysis results for these replicate samples are shown in Table 3-6. At the time of splitting, it was not known which samples contained significant herbicide concentrations. Those samples containing negligible or trace concentrations near the detection limit of the extraction/analysis method show great variability in concentrations, while those samples with higher concentrations show a concentration variability on the order of 5-15%. The averages of

Table 3-5. Spiked Soil Recovery and Reproducibility.

Spike Concentration	Herbicide	Soil Herbicide Concentration (mg/kg)	Average Recovery (%)	CV (%)
Low	Bromacil	0.101	114.6	27.7
	Napropamide	0.112	100.2	14.1
	Prometryn	0.073	102.3	11.6
Medium	Bromacil	1.005	139.3	11.2
	Napropamide	1.122	98.3	2.9
	Prometryn	0.729	98.2	5.0
High	Bromacil	5.03	125.4	6.3
	Napropamide	5.61	93.3	3.5
	Prometryn	3.65	95.7	2.9

the replicates were used for all further analyses.

Field Soil Results. Each soil sample collected was individually analyzed for tracer concentration, herbicide concentrations, and water content. The results of these soil analyses from the first sampling episode are tabulated in Appendix I. Some deep soil samples collected during the second sampling episode contained measurable prometryn, but revealed that the peak of the prometryn profile had leached beyond the sampling interval. No measurable napropamide was detected. Since their relative mobilities indicate that the napropamide peak should be above the prometryn peak, the lack of napropamide detections is probably due to napropamide degradation rather than leaching.

The main purpose of the second sampling episode was to follow the napropamide and prometryn profiles through time -- the second tracer and bromacil experiment was considered less important.

Table 3-6. Replicate Soil Sample Analysis Results.

Sample ID	Herbicide Concentration (μg/cm^3)		
	Prometryn	Bromacil	Napropamide
1 1 3	**0.939**	**0.279**	0.102
1 1 3D	**0.936**	**0.339**	0.014
1 1 3T	**1.012**	**0.211**	0.000
avg. ± CV	**0.962 ± 4.4%**	**0.276 ± 23.2%**	0.039 ± 142.8%
3 2 3	0.092	0.092	0.000
3 2 3D	0.081	0.106	0.000
avg. ± CV	0.087 ± 6.0%	0.099 ± 7.1%	0.000 ± 0.0%
4 1 3	**0.476**	0.000	0.000
4 1 3D	**0.358**	0.000	0.000
4 1 3T	**0.473**	0.023	0.000
avg. ± CV	**0.435 ± 15.5%**	0.008 ± 173.2%	0.000 ± 0.0%
4 3 3	**0.127**	0.003	0.000
4 3 3D	**0.074**	0.052	0.000
avg. ± CV	0.101 ± 26.5%	0.028 ± 87.5%	0.000 ± 0.0%
7 2 5	0.000	0.019	0.000
7 2 5D	0.000	0.015	0.000
avg. ± CV	0.000 ± 0.0%	0.017 ± 13.2%	0.000 ± 0.0%
7 3 3	0.002	0.061	0.000
7 3 3D	0.003	0.033	0.037
avg. ± CV	0.002 ± 20.9%	0.047 ± 30.6%	0.018 ± 100.0%
8 2 3	0.008	**12.444**	0.000
8 2 3D	0.006	**9.173**	0.000
avg. ± CV	0.007 ± 18.0%	**10.809 ± 15.1%**	0.000 ± 0.0%
8 3 3	0.000	**6.022**	0.000
8 3 3D	0.000	**5.048**	0.000
avg. ± CV	0.000 ± 0.0%	**5.535 ± 8.8%**	0.000 ± 0.0%
12 3 3	**0.966**	0.044	0.000
12 3 3D	**0.828**	0.030	0.000
avg. ± CV	**0.897 ± 7.7%**	0.037 ± 19.8%	0.000 ± 0.0%

Notes: Significant herbicide concentrations are shown in bold.
When sample is duplicated, CV is half the range divided by the mean.

The inability to locate the napropamide and prometryn peaks and the lack of reliable ET information for the second tracer and bromacil experiment led to a decision to ignore the results of the second soil sampling and concentrate additional resources on the analysis of the results of the first soil sampling. The rest of this paper will therefore deal exclusively with the first soil sampling results.

The four different fluororganic tracers were applied to the plots in a regular checkerboard pattern. The appearance in a core of a tracer that was not applied to that plot would be strong evidence of significant lateral transport. In no case was any "foreign" tracer detected in the soil samples, and all of the reported tracer concentration data refer to the applied tracer in each plot. As will be discussed in Chapter 4, the lack of foreign tracer detections may reflect the relatively high detection limit of the tracer extraction and analysis techniques.

Total mass recoveries for each solute in each core can be calculated using Equation 3-2.

$$M_R = \sum_i C_i \cdot \Delta z_i \tag{3-2}$$

where:

M_R = Total solute mass recovered in core [M/L^2]

C_i = Solute concentration in *i*th sample in core [M/L^3]

Δz_i = Thickness of *i*th sample in core [L]

Volume-averaged water contents for each core can also be calculated, using Equation 3-3.

$$\bar{\theta} = \frac{\sum_i \theta_i \cdot \Delta z_i}{\sum_i \Delta z_i} \tag{3-3}$$

where:

$\bar{\theta}$ = Volume averaged water content for core [ ]

θ_i = Water content in *i*th sample in core [ ]

The fractional recovery can now be defined as:

$$Rec = \frac{M_R}{M_A} \tag{3-4}$$

where:

Rec = Fractional recovery of solute [ ]

M_A = Average actual application rate of solute [M/L^2]

Mass recoveries are tabulated together with average application rates and percentage recoveries in Appendix J.

The concentration data in Appendix I show that low herbicide concentrations were detected in some unexpected locations, including in plots that received no application of that herbicide, and at depth in some cores, far below the main herbicide peak. These low concentrations are typically 2-3 orders of magnitude lower than the concentrations defining the main peaks, and are perilously close to the analytical method's detection limits. The reliability and significance of these low concentration values will be discussed in Chapter 4.

DATA ANALYSIS

Two primary methods were used to analyze the observed solute concentration profiles: the CXTFIT computer model and the method of moments. CXTFIT attempts to fit the observed profile to analytical solutions of the 1-D ADE by varying the controlling transport parameters. The method of moments, on the other hand, is a purely geometrical analysis of the size, location, and shape of the solute profile, with no reference to underlying mechanisms.

CXTFIT Modeling

Introduction

The primary tool used in the analysis of these concentration data was CXTFIT (Parker and van Genuchten, 1984), a computer program that solves the inverse problem of determining transport parameters by fitting given concentration-distance-time (C-X-T) data. The program relies on a nonlinear least-squares regression method to iteratively fit analytical ADE solutions to observed data.

The code's reliance on analytical solutions to the ADE restricts its applicability to relatively simple conditions: homogeneous soil profiles, steady-state flow, single-valued and linear sorption isotherms, and zeroth- or first-order production and degradation kinetics. A kinetic solution option permits the incorporation of a single source of nonequilibrium, which can either represent physical nonequilibrium (two-region model) or sorption nonequilibrium (two-site model), but not both simultaneously. Although the published version of the code requires concentration data to be expressed as concentrations in the mobile liquid phase alone, a later modification (J.C. Parker, 1986, pers. comm.) permits analysis of bulk soil concentration data, such as determined in this study. A newly-developed coordinate transformation, presented in Appendix K, permits modeling of limited spatial heterogeneity.

Other numerical transport codes exist that would permit more accurate representation of the complexities at the site (e.g. van Genuchten and Wierenga, 1974; Brusseau et al., 1989, Brusseau, 1991). Unfortunately, these codes all solve the forward problem of predicting profiles given transport parameters, and parameter estimation would require a lengthy manual trial and error process. With the 45 tracer profiles and 81 herbicide profiles resulting from the first sampling episode, a manual parameter-fitting procedure was decidedly impractical.

A series of different CXTFIT runs were performed on the observed concentration data (Table 3-7). Each run and its results will be described in turn below. The discussion in this chapter will be limited to specific findings from each run, while a broader discussion of the implications of these results will be deferred until the next chapter.

Some modeling decisions common to all the CXTFIT runs include the selection of concentration basis and input pulse form.

Concentration Basis. Analytical solutions to the ADE depend on whether the measured data represent flux-averaged concentrations (e.g. collecting effluent flowing out of a column) or resident (volume-averaged) values (e.g. extracting solutes from a sectioned column). In this study, soil cores were collected in the field and sectioned into distinct samples, which were then extracted in the lab. Therefore, the resident concentration solutions to the ADE were used for all runs.

Input Pulse Form. Although applicable to various types of experiments, CXTFIT was written with column experiments in mind. The auxiliary conditions to the ADE used in the analytical solutions implicit in CXTFIT assume a slug type solute pulse, in which the input water jumps

Table 3-7. Description of CXTFIT Runs.

Run #	Solute	Coordinate System	CXTFIT Version	Assumptions*	Fitted Parameters	Appendix with Results	
						Fitted Parameters	Fitted Profiles
1	Tracers	Spatial	Equilibrium	Homogeneous Profile Local Equilibrium	C_0,v,D	M	N
1A	Averaged Tracer Data	"	"	"	"		
2	Herbicides	"	"	"	C_0,R		
3	"	"	"	"	C_0,D,R	M	N
3A	Averaged Herbicide Data	"	"	"	"		
4	Tracers	Volumetric	"	Heterogeneous Moisture Content Profile Local Equilibrium	C_0,v,D	O	P
5	Herbicides	"	"	"	C_0,D,R	O	P
6	Tracers	Spatial	Two-region	Homogeneous Profile Physical Disequilibrium	C_0,v,D,β,ω	Q	R
7	Herbicides	"	Two-site	Homogeneous Profile Chemical Disequilibrium	C_0,D,R,β,ω	Q	R

*All runs assume steady-state flow, single-valued and linear sorption from an initial solute concentration (C_i) to a different (usually higher) concentration (C_0), stays at that level for a specific time period (t_0), then returns to the initial level.

How to apply this input structure to the conditions of the field experiment is not immediately obvious. Recall that in the field experiment the solutes were applied to the soil surface in an ethanol solution. The ethanol rapidly evaporated, leaving a dry surface residue of the combined solutes. Within a few hours of this application, the plots were flood-irrigated with 7.5 cm of water. Determining appropriate values for C_0 and t_0 under these conditions depends somewhat on how the initial dissolution of solutes into the irrigation water is visualized. After considering various alternatives, I decided to assume that the solutes would dissolve uniformly in the entire 7.5 cm of applied water. Since CXTFIT requires steady-state flow conditions, this biweekly 7.5-cm input is spread over 14 days, so t_0 was set at 14 days for all runs.

The obvious corollary of this decision would be to set C_0 by calculating a solution concentration by dividing the surface application rate by 7.5 cm. This proved unworkable, however, due to widely-varying solute recoveries. Although CXTFIT can model first-order degradation, the recovery variability is probably due as much to variability in application rates as it is to variability in degradation rates, so letting CXTFIT arbitrarily assign the recovery variability to degradation seemed unwise. Instead, C_0 for each run was manually varied to obtain the best fit to the data, with a very low ($\approx$ 0.0002 day^{-1}) degradation rate. In effect, this decision removed degradation from the processes modeled by CXTFIT, which then considered all four solutes as conservative tracers. The total mass in the fitted profile was then calculated using Equation 3-5.

$$M_F = \frac{t_0 * v_t * C_0}{R} e^{-\mu t^*/R} \tag{3-5}$$

where:

M_F = Total solute mass in fitted profile [M/L^2]

t_0 = Input pulse width [T] (= 14 days)

v_t = Fitted tracer velocity [L/T]

C_0 = Fitted input solute concentration [M/L^3]

t^* = Time available for degradation [T] (= $t - t_0/2$)

In summary, the CXTFIT runs were performed with t_0 set to 14 days, and C_0 varied to obtain the best data fit with insignificant degradation. A sensitivity analysis for this decision was performed by duplicating run 1 with t_0 set to 1 day and the fitted C_0 values multiplied by 14. These changes caused only slight changes in the values of the fitted parameters, suggesting that the choice of input pulse form is not terribly important to the final results.

Goodness of Fit Estimates. In addition to estimated transport parameters, CXTFIT also yields a measure of the discrepancies between the final fitted profile and the observed data. This measure is the sum of squares (SSQ) of the residuals, where the residuals are the differences between the fitted and observed concentration at each observation depth. Before comparing SSQs between two profiles, it is necessary to normalize the SSQ values, because they are scaled to the square of the concentrations. Herbicide concentrations in the low-concentration plots are approximately one-tenth those at the high concentration plots, so the SSQs from the low concentration plots must be multiplied by 100 for direct comparisons.

Run by Run Results

Run 1: Tracer Data, Spatial Coordinates, fit C_0,v,D

In run 1, CXTFIT was used to determine tracer v and D values for each of the 45 collected cores. C_0 was manually adjusted for best fit with a low degradation rate, as described above. An example CXTFIT output file from this run is included in Appendix L. Resulting fitted parameters are shown in Appendix M; graphs of the fitted profiles combined with those from run 3 are shown in Appendix N. Note that 6 of the 45 cores could not be analyzed, because no well-defined tracer peak was recovered, suggesting that the local velocity was so great that the peak had migrated beneath the 270 cm sampling depth. By permitting the tracer v_t to vary from the average pore water velocity calculated using the infiltration data and water content measurements, we are implicitly acknowledging the possibility of accelerated transport.

Run 1A: Averaged Tracer Data, Spatial Coordinates, fit C_0,v,D

An averaged tracer profile was analyzed as run 1A. This profile was produced by simply averaging the tracer concentrations for each depth from all 45 cores. Averaging all of the tracer profiles makes sense only if the different tracers behaved similarly, a question that will be addressed in Chapter 4. Table 3-8 shows the resulting transport parameters and fitted profiles are shown in Figure 3-5.

Run 2: Herbicide Data, Spatial Coordinates, Tracer v,D, fit R

Run 2 attempted to fit the herbicide profiles to the ADE, using the local velocities and dispersion coefficients determined from the tracer data in run 1 and permitting CXTFIT to vary R. This run could not fit the observed data with any degree of success, as demonstrated by large SSQs and visibly poor curve matches. The results of this run were not considered further.

Table 3-8. CXTFIT Parameters for Averaged Solute Profiles.

Solute	v (cm/day)	R	D (cm^2/day)	α (cm)
Tracer	2.79		27.05	9.69
Bromacil	1.51	1.85	27.26	9.77
Napropamide	0.28	9.99	11.37	4.07
Prometryn	0.61	4.59	25.17	9.02

Run 3: Herbicide Data, Spatial Coordinates, Tracer v, fit C_0,D,R

The observed herbicide profiles were more successfully fit by allowing CXTFIT to vary both R and D, while still using the tracer velocities determined in run 1. No attempt was made to analyze profiles from the 6 cores without a well-defined tracer peak. The resulting parameters are shown in Appendix M, and the predicted profiles are graphed in Appendix N.

Run 3A: Averaged Herbicide Data, Spatial Coordinates, Tracer v, fit C_0,D,R

A single average profile was constructed for each of the three herbicides, by first multiplying the concentrations from the low-concentration plots by 10, and then averaging these normalized concentrations at each depth. As with the averaged tracer profile, this really only makes sense if the different treatment variables had little impact on transport behavior, a question that will be addressed in Chapter 4. Herbicide R, D, and C_0 values were found for these averaged profiles using the averaged-profile tracer velocity found in run 1A. Results of this analysis are given in Table 3-8, and graphed in Figure 3-5.

Run 4: Tracer Data, Volumetric Coordinates, fit C_0,q,δ

Run 4 was identical to run 1, except the analysis was conducted in a volumetric coordinate

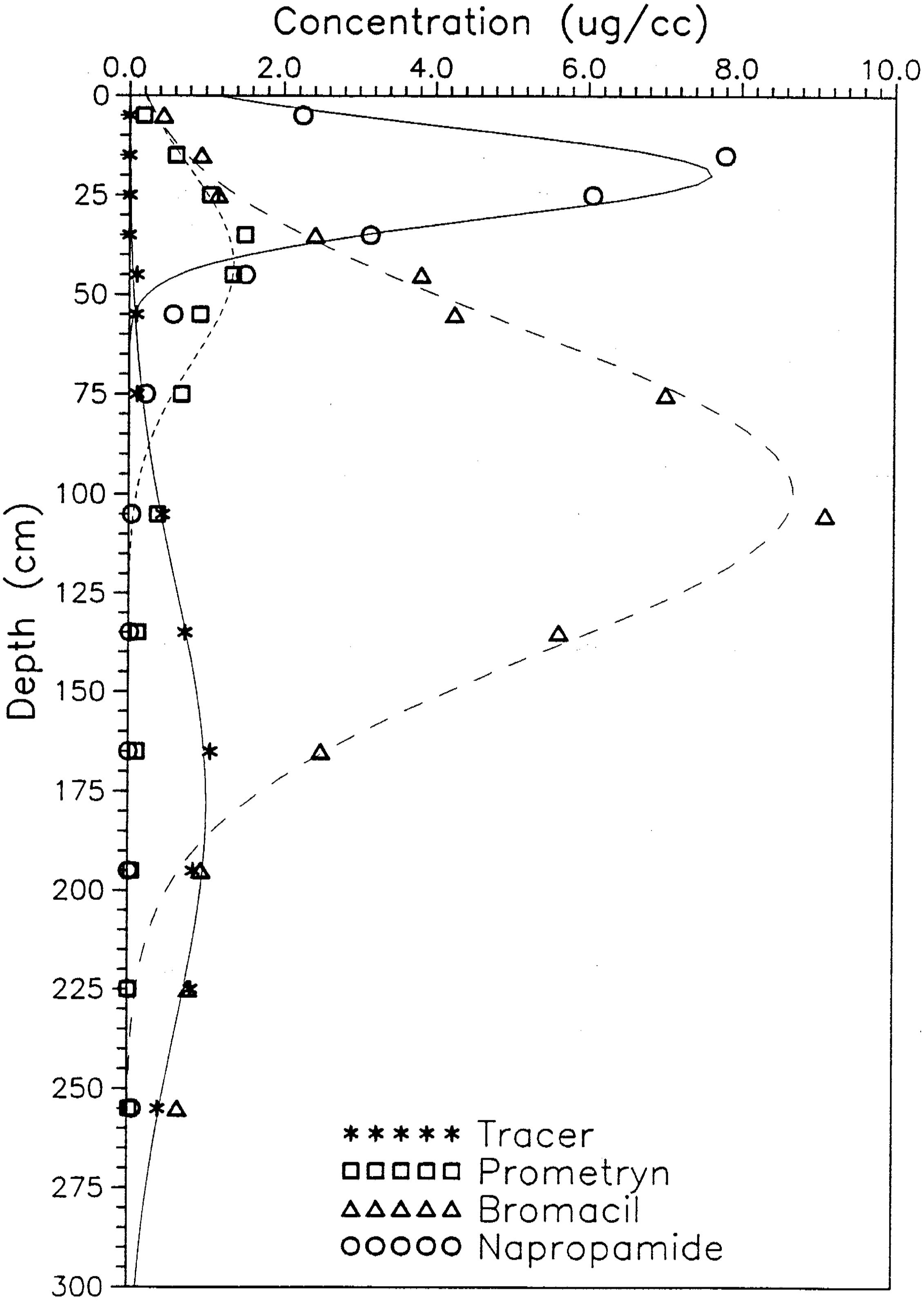


Figure 3-5. Field-Averaged Concentration Profiles: Observed and Fitted.

system (Appendix K), which accounts for spatial variations in water content, and therefore velocity. This transformation does not relax the steady-state flow assumption, but replaces the assumption of constant v with one of constant q, the specific discharge (Darcy velocity). The fitted dispersion parameter changes from D, the dispersion coefficient, to the quantity δ, related to the dispersivity α. The results of this run are presented in Appendix O, and graphed in Appendix P.

Run 5: Herbicide Data, Volumetric Coordinates, Tracer q, fit C_0,δ,R

The herbicide data were similarly analyzed in volumetric coordinates using the tracer q values found in run 4. The results of this run are presented in Appendix O, and graphed along with run 4 results in Appendix P.

Run 6: Tracer Data, Spatial Coordinates, 2-Region, fit C_0,v,D,β,ω

All previous runs used the equilibrium transport mode of CXTFIT. Run 6 introduces the nonequilibrium formulation. As mentioned earlier, chemical and physical nonequilibrium are mathematically indistinguishable, but only physical nonequilibrium can affect transport of nonreactive tracers. The physical nonequilibrium model considered by CXTFIT postulates that the soil moisture present is distributed between two regions, a mobile region in which all flow occurs, and an immobile region of water that does not participate in flow but that can affect solute transport by its connectedness to the mobile region. This model introduces two additional transport parameters: β, which is a function of the ratio of mobile to immobile water, and ω, which is a function of the rate of solute exchange between the two regions (Parker and van Genuchten, 1984).

We are now explicitly considering bypass flow, a major contributor to the accelerated transport that was implicitly considered in run 1. Therefore, the velocity under consideration is no longer variable, depending on the degree of bypass flow, but is rather the total average velocity, v_a. For this run, the velocity was fixed at v_a and R fixed at unity (for non-reactive tracers), C_0 was fixed at the values determined during run 1, and CXTFIT fitted values to β and ω. The results of run 6 are presented in Appendix Q, and graphed along with herbicide results in Appendix R. The results, which will be further discussed in the next chapter, suggest that exchange between the mobile and immobile water regions is relatively unimportant, and that the immobile water region can be neglected, greatly simplifying the analysis.

Run 7: Herbicide Data, Spatial Coordinates, 2-Site, Tracer v, fit C_0,D,R,β,ω

Nonequilibrium analysis of the herbicide profiles using CXTFIT would be problematic if both physical and chemical nonequilibrium processes significantly affected transport. Fortunately, the results of run 6 suggest that physical nonequilibrium processes can be neglected, and the effects of bypass flow can be accounted for by using v_t, the fitted tracer velocity, instead of v_a. Chemical nonequilibrium can then be modeled using the same nonequilibrium form of the ADE, but with different meanings given to the nonequilibrium parameters β and ω. The chemical nonequilibrium model postulates the existence of two types of sorption sites: type-1 sites that are always in a state of equilibrium with the local soil solution, and type-2 sites that respond to solution concentration changes in a time-dependent fashion. In this formulation, β is a function of the population ratio of the two sit types, and ω is proportional to the first-order rate constant controlling sorption onto and desorption from the type-2 sites (Parker and van Genuchten, 1984).

In run 7, herbicide profiles were analyzed using CXTFIT in the nonequilibrium mode by fixing v at v_t, C_0 at the C_0 values determined in run 3, and letting CXTFIT fit D, R, β, and ω. A sample CXTFIT output file can be found in Appendix S, fitted parameter results are presented in Appendix Q, and the fitted profiles are graphed in Appendix R. Some of the fitted herbicide profiles in Appendix R show abrupt discontinuities (e.g. Plot 4, Hole 2). These are caused by a numerical problem in the CXTFIT nonequilibrium model (Nobuo Toride, 1992, pers. comm.).

An examination of the sample output in Appendix S reveals a problem affecting the results of run 7, and to a lesser extent, run 6. By allowing CXTFIT to fit so many transport parameters (3 in run 6; 4 in run 7), the transport problem has become increasingly poorly defined. As parameters are added to the model, they become less independent of one another, and estimates of each parameter become increasingly uncertain. This interdependence is revealed in the parameter correlation matrix, and the uncertainty appears in the high Standard Error (S.E.) and broader confidence limits, all included in the CXTFIT output file (Appendix S).

Statistical Analysis

The results of runs 1 and 3 were selected for in-depth statistical analysis. These runs were chosen because run 2 did not fit the observed data well, runs 4 and 5 produced profiles similar to runs 1 and 3, and the nonequilibrium transport parameters fitted during runs 6 and 7 have much associated uncertainty, as just discussed.

Three primary analyses were conducted, using the SAS statistical software package (SAS Institute, 1988a; SAS Institute, 1988b). These analyses included univariate tests to determine the forms of the parameter distributions; multiple correlation analyses among the parameters; and a *t* test and general linear model analysis to determine the effects of different treatments on the transport parameters.

Development of the SAS dataset. The analyzed SAS dataset consisted of a series of values for each core. These included the average water content, percentage recoveries for each solute, and the fitted transport parameters, specifically v_t and D for the tracer, and R and D for each herbicide. Also analyzed were derived variables including dispersivity for each solute, defined as:

$$\alpha_i = \frac{D_i}{v_t} \quad ; \quad i = \begin{cases} \textit{tracer} \\ \textit{bromacil} \\ \textit{napropamide} \\ \textit{prometryn} \end{cases} \tag{3-6}$$

where:

α = Dispersivity [L]

and herbicide velocities, defined as:

$$v_i = \frac{v_t}{R_i} \quad ; \quad i = \begin{cases} \textit{bromacil} \\ \textit{napropamide} \\ \textit{prometryn} \end{cases} \tag{3-7}$$

Univariate Analyses. A univariate analysis using the SAS UNIVARIATE procedure (SAS Institute, 1988a) yielded simple statistics including mean, variance, and CV for each variable. This procedure also calculates the Shapiro-Wilks statistic, W, which is a test for the null hypothesis that the data are random samples from a normal population (SAS Institute, 1988a). Determining the form of a distribution is important both for what it may tell us about causative processes and because some further statistical techniques assume normally distributed variables. W always varies from 0 to 1, and small values of W lead to a rejection of the null hypothesis, a decision that the underlying population is not normally distributed. In addition to W, the procedure calculates an associated probability, representing the chances that a true normal population would produce a W value equal to or less than that obtained. For this analysis, I have decided to consider any variable with a W probability less than 0.10 as non-normally distributed. To determine whether some of the variables may be log-normally distributed, a second analysis was performed on transformed data, produced by taking the common logarithm of each value.

The results of the univariate analyses are presented in Table 3-9. Geometric means are shown for those variables that were reasonably well-fit by a log-normal distribution. The statistics suggest that observed tracer velocities may be normally distributed, while both dispersion coefficients and dispersivities for all four solutes are clearly not. These dispersion parameters are fit well by a log-normal distribution. While the data do not permit us to rule out a normal distribution for the herbicide retardation factors, they suggest that the log-normal distribution provides a better fit.

<u>Correlation Analysis.</u> The SAS CORR procedure (SAS Institute, 1988a) was used to calculate Spearman nonparametric rank-order correlations among the variables in the data set. The Spearman statistic is a nonparametric version of the more familiar Pearson product-moment correlation, calculated by determining the Pearson statistic on ranked rather than raw data, thereby eliminating any assumptions about the underlying population distribution. In addition to the correlation coefficient, the procedure also provides the significance probability of the correlation, the probability that the true correlation is actually zero. The smaller this probability, the more confidence we can have that there is a true correlation between the variables in question. Again, I have selected a probability level of 0.10 as statistically significant.

Table 3-9. Univariate Statistical Analysis of Fitted Transport Parameters.

		Arithmetic Mean	CV (%)	Shapiro-Wilks Probability		Geometric Mean
				Normal	Log-normal	
θ		0.2258	7.485	0.1579	0.1596	0.2252
Tracer						
v	(cm/day)	2.779	21.09	0.1656	0.0720	
D	(cm^2/day)	2.332	121.9	0.0001	0.6174	1.309
α	(cm)	0.8954	122.4	0.0001	0.3660	0.4822
Rec	(%)	67.94	52.67	0.0096	0.0037	
Bromacil						
v	(cm/day)	1.626	29.32	0.6189	0.4435	1.556
R		1.768	19.99	0.4273	0.9815	1.736
D	(cm^2/day)	11.00	99.93	0.0004	0.3894	6.809
α	(cm)	4.092	101.2	0.0003	0.4844	2.520
Rec	(%)	123.6	44.64	0.3004	0.0306	
Napropamide						
v	(cm/day)	0.2962	38.34	0.0254	0.7092	0.2782
R		10.07	26.66	0.6955	0.9756	9.734
D	(cm^2/day)	5.850	81.53	0.0003	0.9823	4.483
α	(cm)	2.086	81.32	0.0001	0.7260	1.655
Rec	(%)	65.37	64.89	0.0065	0.0656	51.99
Prometryn						
v	(cm/day)	0.7161	30.69	0.4693	0.8267	0.6841
R		4.407	26.34	0.4916	0.8965	4.265
D	(cm^2/day)	33.37	120.4	0.0001	0.8307	19.688
α	(cm)	10.47	106.5	0.0001	0.9903	6.748
Rec	(%)	90.55	50.07	0.0103	0.9608	81.05

Note: The Shapiro-Wilks Probability is the probability that a random sample from an ideal distribution would diverge from that distribution as much as the observed sample (SAS Institute, 1988a). A higher value indicates a better fit to the ideal distribution.

With the large numbers of fitted, derived, and measured variables available for each core, the number of possible correlation comparisons runs well into the hundreds. Although the SAS software would enable an exhaustive analysis of all these combinations, this would be undesirable for two reasons. First, the resulting mountain of statistics would be difficult to assimilate and present in any meaningful way. Second, and more important, is a problem inherent in the statistical nature of this analysis.

To understand this problem, consider a set of completely independent random variables, produced using a random number generator. At the 0.10 significance level mentioned above, a complete correlation analysis of this data set would conclude that about 10% of the variable pairs are significantly correlated, when in fact there are no true underlying connections. Clearly, the number of "false positives" will increase with the number of analyses, and performing a massive correlation analysis on all available data will lead to a number of apparent statistical correlations that have no true basis (an excellent discussion of this effect, in a slightly different context, is found in SAS Institute (1988b), pp. 593-599). Therefore, rather than analyzing all possible combinations of variables, a correlation analysis was performed on a few selected subsets of the data.

Correlations between average core water content, solute velocities, and herbicide retardation factors; between dispersion coefficients, dispersivities, and solute velocities; and between percentage recoveries and solute velocities are all included in Appendix T.

t Test and General Linear Model Analysis. To determine whether the various herbicide and tracer treatments had a significant effect on solute fate and transport, the fitted transport parameters under different treatments were compared using the *t* test or a general linear model analysis (SAS TTEST and GLM procedures, SAS Institute, 1988b). When the treatment under consideration has only two choices (e.g. the applied bromacil concentration was either "high" or "low"), the *t* test is appropriate. On the other hand, when there are more than 2 classes (e.g. the tracer applied was either 2,6-DFBA, *m*-TFMBA, *o*-TFMBA, or PFBA), the GLM method must be used.

The standard *t* test assumes that the variables in question are normally distributed and that the two population being compared have equal variances. In addition to the standard *t* test, the TTEST procedure provides two variations on the *t* test for cases of unequal variance, and an *F* test to check the equality of variance (SAS Institute, 1988b). The *t* test was used to compare the effects of high vs. low concentration, and mixed vs. single herbicide applications on herbicide transport parameters including dispersion coefficient, dispersivity, retardation factor, and percent recovery. The univariate analysis described above revealed that the first three of these parameters showed a log-normal distribution, so they were log-transformed before the *t* test analysis.

The GLM procedure (SAS Institute, 1988b) is a more complex method of comparing results when more than two treatment choices are being considered. The Tukey-Kramer standardized range test (SAS Institute, 1988b) was chosen as most appropriate for the data in question, and was used to compare the effects of the different tracers and different herbicide treatments on solute transport parameters, including velocities, retardation factors, dispersion coefficients, dispersivities, and percent recovery. The dispersion coefficients and dispersivities were log-transformed prior to analysis. Results of the *t* test and GLM analyses will be discussed in Chapter 4.

Method of Moments

The method of moments is a standard analytical tool used in many branches of science and engineering. Given any arbitrary distribution of data, various moments can be calculated. In our case, where we have concentration data for specific depth intervals, we can define the *n*th moment as:

$$m_n = \sum_i C_i z_i^n \Delta z_i \; ; \; n=0,1,2,3... \tag{3-8}$$

and then normalize the moments:

$$m_n^* = \frac{m_n}{m_0} \; ; \; n=1,2,3... \tag{3-9}$$

where:

m_n = *n*th moment $[ML^{n-2}]$

m_n^* = Normalized *n*th moment $[L^n]$

z_i = Depth below surface of center of *i*th sample in core [L]

Note that the normalizing denominator of Equation 3-8, m_0, is simply M_R, the total solute mass recovery defined in Equation 3-2.

The relationship between the moments of a solute profile or breakthrough curve and transport parameter values can be obtained by determining the moments of a specific solution of the ADE. Jury and Sposito (1985) present such a set of equations for the specific case of a spatial profile of resident concentrations of a nonreactive tracer. By dividing the ADE through by R, these formulas can be adopted to sorbed solutes as follows:

$$\alpha = (m_1^* - \sqrt{4m_1^{*2} - 3m_2^*})/3 \tag{3-10}$$

$$v_i = \frac{(m_1^* - \alpha)}{t} \; ; \; i = \begin{cases} \mathit{tracer} \\ \mathit{bromacil} \\ \mathit{napropamide} \\ \mathit{prometryn} \end{cases} \tag{3-11}$$

$$D = \alpha v_i R_i = \alpha v_t \; ; \; i = \begin{cases} \mathit{tracer} \\ \mathit{bromacil} \\ \mathit{napropamide} \\ \mathit{prometryn} \end{cases} \tag{3-12}$$

where:

t = Profile observation time [T]

The results of the moments analysis for the individual cores and the field-averaged profile are presented in Appendix U, and will be compared to CXTFIT results in Chapter 4. Notice that the methods of moments failed for about 17% of the profiles, resulting in the square root of a negative number in Equation 3-10. The reasons and implications of these failures will be discussed in Chapter 4.

IV

DISCUSSION

LABORATORY SORPTION STUDIES

The major objectives of the laboratory sorption studies were to determine the sorption linearity and singularity of the three herbicides, to check for competition effects between them, and to provide laboratory predictions of R.

Linearity

As predicted by the partition theory of nonpolar solute sorption (Chiou, 1989), napropamide exhibited linear sorption in both the single-stage and multi-stage experiments. Prometryn also showed linear sorption in the single-stage experiment, while the multi-stage prometryn experiment revealed an apparent solubility limit.

Bromacil is more polar than the other two herbicides, and its greater departure from Chiou's (1989) partitioning model is therefore not surprising. The single-stage experiment yielded a good fit to the Freundlich isotherm with an *n* value of 0.92, while the results of the multi-stage experiment may reflect decreased solubility of bromacil in the soil-water-$CaCl_2$ system.

Sorption competition studies suggest that both napropamide and bromacil sorption decreased slightly in the presence of the other two herbicides, while prometryn sorption was not significantly affected.

Although these competition effects and the bromacil sorption nonlinearity are statistically significant, their practical significance is not assured. I will address the practical significance here by assessing the effects on retardation factors, and return to this issue later in reference to the field experiment.

Predicted Retardation Factors

Under the local equilibrium assumption, in Chapter 1 the retardation factor was shown to be:

$$R = 1 + \frac{\rho_b}{\theta}\frac{dS}{dC} \tag{4-1}$$

If sorption follows the Freundlich isotherm:

$$S = K_F C^n \tag{4-2}$$

Then:

$$\frac{dS}{dC} = nK_F C^{n-1} \tag{4-3}$$

and:

$$R = 1 + \frac{\rho_b}{\theta} n K_F C^{n-1} \tag{4-4}$$

(Linear sorption can be considered a special case of Freundlich sorption, with $n = 1$, in which case:

$$\frac{dS}{dC} = K_D \tag{4-5}$$

where K_F is replaced with K_D, the familiar distribution coefficient.)

Predicted retardation factors can be easily calculated for the linearly sorbed herbicides napropamide and prometryn, using Equation 4-1 and the overall average bulk soil density of 1.573 g/cm^3 and average moisture content from the first sampling episode, 0.226. The results, shown in Table 4-1, suggest that the observed change in K_D due to competition could lead to a change in R of up to one full unit. However, it is important to bear in mind that this result is from a batch study in which the solute under consideration and the competing solutes were maintained in close contact. In a field transport situation, the gross R variations between the different solutes would act to separate them spatially, thereby decreasing their potential interactions.

Table 4-1. Laboratory Partitioning Coefficients and Predicted Retardation Factors -- Napropamide and Prometryn.

NO COMPETITION

	K_D (mL/g)	R	K_{OC} (mL/g)	Lit. K_{OC} (Jury et al., 1984) (mL/g)
Napropamide	1.01	8.00	503	300
Prometryn	0.372	3.59	186	610

WITH COMPETITION

	K_D (mL/g)	R	K_{OC} (mL/g)
Napropamide	0.859	6.98	429
Prometryn	0.404	3.81	202

For nonlinear sorption ($n \neq 1$), R is not a constant but varies with C. Most analytical solutions to the ADE require a constant R, so various methods of linearizing a nonlinear isotherm and producing a constant linearized K_L have been considered. All of these methods require setting a concentration of interest, C_i. The first method simply determines the tangent to the isotherm at C_i, and can be thought of as the "marginal" sorption coefficient at C_i:

$$K_{L1} = \left.\frac{dS}{dC}\right|_{C=C_i} = nK_F C_i^{n-1} \tag{4-6}$$

where:

K_{L1} = "Marginal" linearized distribution coefficient $[L^3/M]$

C_i = Concentration of interest $[M/L^3]$

The marginal coefficient is valid only at C_i, and neglects the fact that as a peak passes, the soils sees a whole range of concentrations from 0 to C_i.

A second possibility would be to determine the linear distribution coefficient that would result in the observed distribution at C_i:

$$K_{L2} = \left.\frac{S}{C}\right|_{C=C_i} = K_F C_i^{n-1} \tag{4-7}$$

where:

K_{L2} = "Average" linearized distribution coefficient $[L^3/M]$

This "average" coefficient (Brusseau and Rao, 1989) completely ignores the observed nonlinearity of the isotherm.

A third possibility (van Genuchten et al., 1977) finds a linear coefficient that would result in an equal area under the isotherm to that observed:

$$\int_0^{C_i} K_{L3} C \, dC = \int_0^{C_i} K_F C^n \, dC \qquad (4\text{-}8)$$

$$K_{L3} = \frac{2K_F C^{n-1}}{n+1} \qquad (4\text{-}9)$$

where:

K_{L3} = "Equal-Area" linearized distribution coefficient [L^3/M]

This "equal-area" coefficient both accounts for the range in concentration seen by the soil and acknowledges the nonlinearity of the isotherm, and therefore may be preferable on theoretical grounds.

All three linearizing methods are illustrated in Figure 4-1, using a highly ($n = 0.5$) nonlinear isotherm. The differences between these methods decrease as n approaches 1, and all converge to K_D at $n = 1$.

The results of all three methods applied to the bromacil isotherm are shown in Table 4-2. Two different values for C_i have been used: 2 mg/L and 20 mg/L. These are somewhat arbitrary, but are of roughly the same order of magnitude as those encountered in the field experiment at the low and high application rates. These results indicate that with bromacil's degree of nonlinearity ($n = 0.916$) and relatively low sorption, the different linearization methods lead to a maximum variation in R of only 0.1 units. The expected R differences associated with the two concentration levels, and with the presence of interfering herbicides is also minor, on the order of 0.15 R units. Only the equal-area linearization results will be considered from now on.

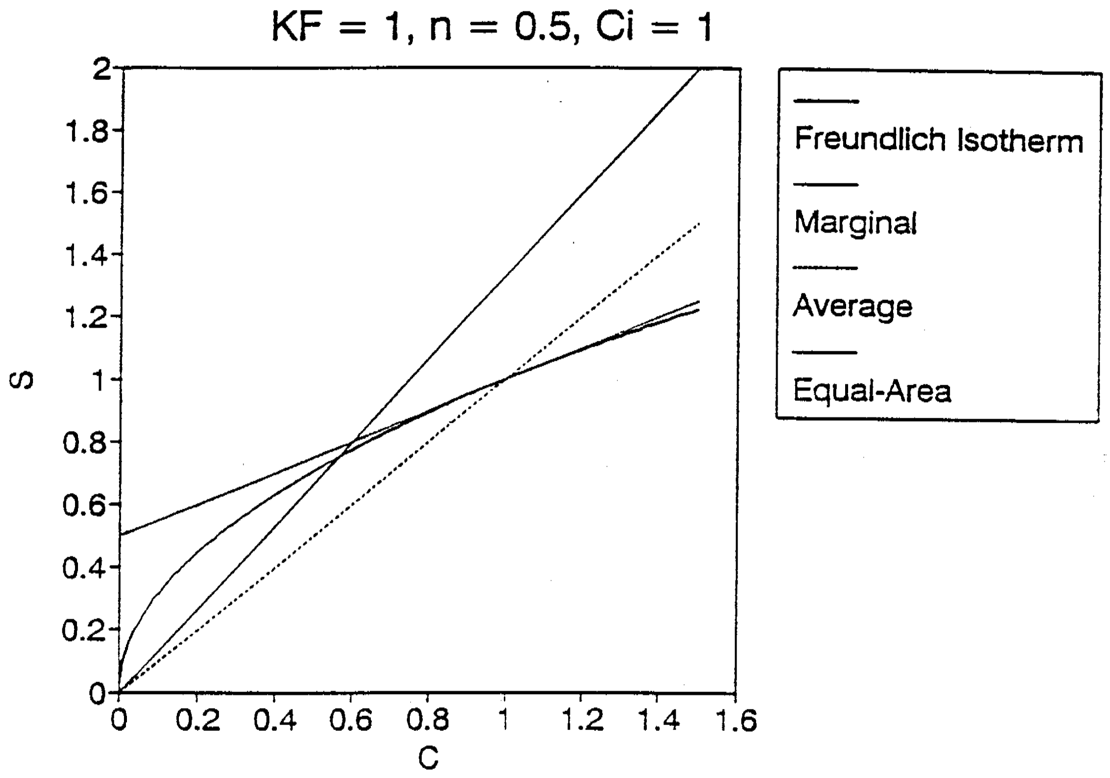


Figure 4-1. Isotherm Linearization Methods.

K_{OC} Values

K_{OC} values can be calculated from the observed or linearized K_D values by dividing by the measured organic carbon content, 0.2%. These calculated K_{OC} values are compared to literature values in Tables 4-1 and 4-2. Considering the single-digit precision of the organic carbon analysis, the numbers for bromacil and napropamide agree quite well, while the discrepancy for prometryn is significant. Notice that the literature values indicate that prometryn is more highly sorbed than napropamide, while both the present laboratory and field studies show the reverse. This discrepancy may be due to the low organic carbon content of the Casa Grande soil, in which

Table 4-2. Linearized Partitioning Coefficients and Predicted Retardation Factors -- Bromacil.

		NO COMPETITION		WITH COMPETITION	
Freundlich Parameters	K_F	0.1161		0.0896	
	n	0.916		0.912	
	C_i (mg/L)	2	20	2	20
Marginal Coefficient					
	K_{L1} (mL/g)	0.1003	0.0827	0.0769	0.0628
	R	1.70	1.58	1.54	1.44
Average Coefficient					
	K_{L2} (mL/g)	0.1095	0.0903	0.0843	0.0688
	R	1.76	1.63	1.59	1.48
Equal-Area Coefficient					
	K_{L3} (mL/g)	0.1143	0.0942	0.0882	0.0720
	R	1.80	1.66	1.61	1.50
	K_{OC} (mL/g)	57.2	47.1	44.1	36.0
Lit. K_{OC} (mL/g) (Jury et al., 1984)			72		

sorption processes other than organic phase partitioning may play a significant role.

Sorption Hysteresis

All three herbicides demonstrated marked sorption hysteresis, with an average n_{sorp}/n_{des} ratio ranging from 1.26 (prometryn) to 1.69 (bromacil) and 1.75 (napropamide). No clear trend relating degree of hysteresis to polarity or solubility is apparent.

Directly estimating the effect of this degree of hysteresis is difficult, due to the lack of an analytical solution or a readily available numerical code for transport with hysteretic sorption. In column transport studies using 2,4,5-T, van Genuchten et al. (1977) found that hysteresis was unimportant compared to physical nonequilibrium effects, despite the compounds marked hysteresis (n_{sorp}/n_{des} = 2.3). Brusseau and Rao (1989) concluded that hysteresis effects are likely to be relatively insignificant compared to sorption nonequilibrium effects.

FIELD SOLUTE CONCENTRATION PROFILES

Lateral Transport of Tracers and Herbicides

Although no "foreign" (not applied to the plot in question) tracers were detected in any of the soil samples, significant foreign herbicide concentrations were detected in some of the samples. These concentrations are generally low, less than 0.1 μg/cm^3, compared to the main peak-defining concentrations of 1 - 20 μg/cm^3.

There are six main alternative explanations for the alleged presence of these foreign herbicides: (1) Laboratory contamination of samples; (2) Gas chromatography misidentifications; (3) Contamination of the applied solute mixture; (4) Spray drift during application; (5) Soil contamination with the herbicides prior to the beginning of the experiment; (6) Significant lateral transport between plots. Note that under alternatives 1 and 2, the foreign herbicides are not actually present in the soil sample.

Although laboratory contamination cannot be totally ruled out, it is not a likely explanation for two reasons - careful cleaning of all glassware resulted in minimal cross-contamination, as demonstrated by periodic lab blanks; and lab contamination would lead to a random distribution of spurious detections, while the observed foreign herbicide occurrences often group into reasonable-looking peaks on depth profiles.

Gas chromatography misidentification is a likely cause for some of the foreign herbicide detections. Both GC identification and quantification problems are accentuated at low concentrations, such as those for the foreign herbicides. Compound identification in gas chromatography relies primarily on a single number, the retention time, and secondarily on detector selectivity. This is why in critical applications such as Superfund investigations or drug-testing, a second confirmatory analysis is performed, using a different chromatography column. In this study, approximately 1200 soil samples were analyzed for herbicide content, and confirmatory analysis was not practical. Furthermore, the analysis method was automated as much as possible, necessarily reducing the personal attention paid to an individual sample. A detailed personal examination of some of the foreign herbicide peaks has revealed slight variations in retention time or peak width, suggesting peak misidentification, but others appear legitimate.

Alternative 3, contamination of the applied solute mixture, includes mispreparation of the herbicide/tracer solution and/or inadequate rinsing of the sprayer between plots. Contamination of the spray mixture would show up in the petri dish data, and could result in an unpredictable pattern of contamination. The best way to examine this alternative would be to analyze samples of the actual mixture applied, collected directly from the sprayer. Unfortunately, such samples were not collected. The petri dish data revealed no significant presence of foreign herbicides, and the petri dish extracts for tracer analysis were lost before analysis.

The next alternative (4), spray drift, may or may not be reflected in the petri dish data, depending on whether the petri dishes were collected before adjacent plots were sprayed. Unfortunately, at the time of application, this use of the petri dish data had not been considered, and the collection sequence of the dishes was not particularly systematic. While contamination of the spray mixture would result in an unpredictable pattern of contamination, spray drift would transport all the applied solutes together, including the tracer. Spray drift would therefore lead to the appearance of foreign tracers as well as foreign herbicides. However, foreign tracer concentrations proportionate to the foreign herbicide concentrations would be below the tracer analysis detection limit, so the lack of foreign tracer detections cannot rule spray drift out. Spray drift would be expected to decrease with distance, and might be expected to correlate with the layout of the plots. However, with the random plot layout, almost every plot has the other herbicides applied in an adjacent plot, and spatial layout is of little help in solving this problem.

Alternative 5 assumes significant herbicide residuals in the soil prior to the beginning of the experiment, due to either previous transport experiments at the Maricopa Agricultural Center or agricultural use prior to the creation of the Center. No known herbicide experiments have been conducted at the site, and based on the relatively short half-lives of the herbicides in question (literature values of 2-12 months), it seems unlikely that residuals remain from agricultural use. Prior to the beginning of this field experiment, 3 soil cores were collected at the site to check for prior herbicide contamination. These cores were analyzed in the same way as the soil samples. Chromatograms for the surface soil samples revealed numerous small peaks, including peaks with retention times corresponding to the three herbicides. Deeper samples contained consistent small quantities of a compound with bromacil's retention time. In all cases, the areas of these peaks corresponded to herbicide concentrations of less than 0.05 $\mu g/cm^3$. These results suggest that any residual herbicides or coelutants present are at very low concentrations.

Alternative 6 considers significant lateral transport of solutes between plots. This is an important alternative, because it implies that transport at the site is strongly 3-dimensional, potentially invalidating much of the data analysis based on the 1-dimensional ADE. This is a difficult alternative to prove or disprove, because tortuous 3-dimensional flow paths that yield just about any conceivable transport pattern can be imagined. However, I believe that this alternative can be substantially discounted for four reasons. First, the experiment was carefully designed to minimize 3-dimensional flow and transport by the use of an irrigated border and near-simultaneous irrigation of all plots. Second, there were no observed major soil heterogeneities that would cause 3-dimensional flow. Third, significant lateral transport would affect the tracers as well as herbicides, leading to the appearance of foreign tracers (although the detection limit issue described for alternative 4 would also apply here). Finally, the overall consistency and reasonableness of the results of the one-dimensional analysis suggest that three-dimensional effects are not very important.

In summary, the most likely contributors leading to the appearance of foreign herbicides in the profiles are GC misidentifications at these low concentrations, and contamination at time of application, due to either mixture contamination or spray drift. In both cases, the low-concentration presence of foreign herbicides is not important to the overall objectives of this project.

Evidence for Bimodal Profiles

Some of the herbicide depth profiles appear to contain two herbicide peaks, with a deep, small peak below the main peak. This phenomenon, if real, would corroborate findings reported by

Jury et al. (1986a, 1986b). A summary of the apparent bimodal depth profiles appears in Table 4-3. Determining what constitutes significant evidence of bimodality is clearly subjective. Some of the factors that went into the development of Table 4-3 include the number and magnitude of the measurements that define the deep peak and the approximate precision of the analytical method at these concentration levels. For example, a secondary peak evidenced by a single low-concentration measurement is not considered significant, while a peak defined by 2 or 3 measurements or 1 higher-concentration measurement would be considered significant. Measurement precision at these low concentrations is probably on the order of ± 25% at best, so a small irregularity on the downward tail of a major peak is probably not significant. Using these criteria, roughly 18% of the profiles show some significant evidence of double peaks.

The source of these apparent low herbicide concentrations deep in the profile poses some of the same questions as did the appearance of foreign herbicides. Possible explanations include: (1) Laboratory contamination; (2) Residual herbicides in the soil at the start of the experiment; (3) GC misidentification; (4) Radically 3-dimensional transport; (5) True peak bimodality. Alternatives 1 and 4 can be eliminated here just as they were when considering foreign herbicides. The background soil analysis described above checked for the presence of residual herbicides at the start of the experiment and revealed low concentrations of a compound that shares bromacil's retention time, and may therefore explain some to the observed bromacil bimodality. Neither napropamide nor prometryn (both shorter-lived than bromacil) appeared in the deep background samples, so residuals probably cannot explain bimodal profiles of those compounds. The low soil concentrations that define the deep peaks (usually less than 0.1 μg/cm^3, sometimes less than 0.01 μg/cm^3), suggest that alternative 3, GC problems, may explain some of the observations. Each of the gas chromatograms that contribute "significant evidence" of

Table 4-3. Cores Showing Evidence of Bimodal Herbicide Profiles.

No Evidence	Some Evidence, Discounted	Some Evidence, Not Discounted
BROMACIL		
1-1,1-2,1-3		
2-1,2-2,2-3		
3-1	3-2	3-3
6-1	6-2	6-3
8-1,8-2,8-3		
11-1,11-3	11-2	
13-2,13-3	13-1	
14-1,14-2,14-3		
16-1,16-2,16-3		
NAPROPAMIDE		
1-3	1-1	1-2
2-1	2-3	2-2
3-1,3-2		3-3
5-1,5-2,5-3		
6-1,6-2,6-3		
7-1,7-2,7-3		
10-2,10-3		10-1
13-1,13-3		13-2
14-1,14-2,14-3		
PROMETRYN		
1-2	1-1,1-3	
2-3		2-1,2-2
3-1,3-2		3-3
4-1,4-2,4-3		
6-1,6-2,6-3		
12-3	12-1	12-2
		13-1,13-2,13-3
14-1,14-3	14-2	
15-1,15-2,15-3		

Note: 13-2: Plot 13, Core 2.

peak bimodality was carefully examined for chromatography problems, and a number of the supposed peaks were discounted after this reexamination. (These low concentration detections have only minimal impact on the analysis of the major peaks, so the overall concentration data set was not edited to remove these spurious observations prior to further analysis.) After this second culling process, convincing evidence for bimodal herbicide distributions remain in only 14 out of the total 135 herbicide profiles.

This result contrasts markedly with the results of Jury et al. (1986b), who found "evidence of deep penetration ... in virtually all of the 19 replicates" (p. 752). The appearance of double peaks in 10% of the observed profiles provides further evidence that the deep penetration phenomenon is real and worthy of further study, but provides little definitive data for further analysis. A few points are worth mentioning, however. The observed bimodal profiles do not appear to favor any one herbicide treatment, and appear in both low and high concentration plots, and in single-herbicide and mixed-herbicide plots. The location of the second peak often does not exactly coincide with the tracer location in the same core, suggesting that rapid transport may be a better description of the phenomenon than non-adsorbed transport. In contrast to the multiple herbicide results of Jury et al. (1986a), the phenomenon affects all three herbicides, although double peaking of bromacil is less frequently observed than the other herbicides. This can be explained by the lower retardation factor of bromacil, which indicates that a second bromacil peak is more likely to have escaped the sampled interval than a second napropamide or prometryn peak. Further investigation of this phenomenon would benefit from a specially designed field experiment, with improved analytical detection limits and low-concentration precision to better define the deep peaks, and either deeper cores or earlier sampling to decrease the chance of losing a deep peak.

Recovery

Tracer Recovery

Tracer recovery would ideally be defined as mass of tracer recovered (M_R, Eq. 3-2) divided by mass applied, as determined by the petri dish data. Unfortunately, the loss of the petri dish extracts at USWCL prior to analysis effectively precludes this calculation. Instead, the recoveries shown in Appendix J are calculated using the target application rate of 200 μg/cm^2. The average recovery based on this calculation was 67.9%, with a CV of 53%. This level of variability is high, but not out of line with other tracer studies conducted at the site (R.C. Rice, pers. comm., 1992). When compared to the overall herbicide application rate CV of 21% (Table 3-4), this tracer recovery CV suggests that post-application processes, including subsurface processes and subsampling, extraction, and analysis variability are contributing over half the observed variability.

The average recovery of 67.9% is surprisingly low. Assuming no degradation of the fluororganic tracers (Bowman, 1984b), a number of alternative hypotheses could explain the low recovery: (1) loss of tracer due to leaching out of the sampled region; (2) lower than expected application rates; (3) unrepresentative subsampling of field soil cores; and (4) loss during extraction or analysis.

If the local tracer velocity is so great that tracer has leached below a depth of 270 cm by the sampling time, that tracer will obviously not be recovered, and recovery in that core will fall below 100%. This is clearly the case in six of the cores (1-2, 3-1, 7-2, 10-3, 16-1, and 16-3 - see Appendix N), where either no tracer or just the tail end of the tracer peak was recovered. (The unusual tracer pattern in core 1-2 defies explanation, and may reflect analytical problems.)

In other cases, such as core 4-3, the leading edge of the tracer peak has leached past the sampled interval, but the recovered portion of the peak enables estimation of the whole peak. All of these leaching effects can be accounted for by considering M_F, the CXTFIT-fitted mass in the profile (Eq. 3-5) instead of M_R. No M_F can be calculated for the six cores lacking a tracer peak, but for the remaining 39 cores, using M_F for the recovery calculations allows for the loss of some tracer out of the profile. As shown in Appendix J, calculating recoveries using M_F increases the average recovery from 67.9% to 70.7%, and decreases the CV from 53% to 49%. A slight improvement, but still a surprisingly low average recovery.

The possibility of lower than expected application rates must remain untested in the absence of petri dish tracer data. The main factors that could lead to low application rates include errors during solute mixture preparation, lower than labeled tracer purity, or incomplete application of the prepared mixture. These same factors could also affect the herbicides, for which petri dish data is available. Comparing target herbicide application rates to the petri dish data is quite informative (Table 4-4). The target values shown in Table 4-4 were calculated by multiplying the mass of herbicide added to the mixture by the labeled purity of the herbicide (percent active ingredient for commercial formulations, assay for technical preparations) and dividing by 36 m^2, the area of each plot. As the table shows, the percentage of the target application rate achieved, according to the petri dish data, ranges from 50% to 80%. The reasons for this shortfall may include mislabeled purity (there is independent evidence that the technical-grade prometryn, labeled at 97% purity, is actually closer to 73%), unapplied residue left in the sprayer, and spray-drift loss. Regardless of the reasons, the average tracer recovery of 70.7% no longer appears so unreasonable.

Table 4-4. Target and Actual Herbicide Application Rates.

	Low Concentration Plots			High Concentration Plots		
	Target Appl. Rate (table 2-2)	Actual Appl. Rate (table 3-4)	Percent of Target Achieved	Target Appl. Rate (table 2-2)	Actual Appl. Rate (table 3-4)	Percent of Target Achieved
	(g/m^2)		(%)	(g/m^2)		(%)
Bromacil	1.00	0.77	77.5	10.00	7.31	73.1
Napropamide	0.51	0.28	55.0	5.11	4.05	79.3
Prometryn	0.20	0.10	50.6	2.05	1.13	55.0

The subsampling step in the sample collection process is unlikely to introduce a significant bias to the recovered tracer concentrations. Unrepresentative subsampling would lead to increased variability, but the errors would tend to average out among the 585 samples collected during the first sampling episode.

The extraction and analytical methods used to quantify soil tracer concentrations are well-established and tested (Bowman, 1984a; Bowman and Gibbens, 1992), and unlikely to contribute to the apparent loss of tracer.

In summary, it seems quite likely that the apparent low tracer recovery relative to target application concentrations is due to lower actual application concentrations rather than any subsurface process.

A statistical analysis using the SAS GLM procedure (SAS Institute, 1988b) showed some evidence that tracer recovery varies from tracer to tracer, with 2,6-DFBA showing significantly lower recovery rates than *m*-TFMBA and *o*-TFMBA. This directly contradicts a previous study of the four fluorobenzoic acid tracers which showed some degradation of *m*-TFMBA and *o*-TFMBA (Bowman and Rice, 1986a), but in light of the overall uncertainty associated with tracer application and recovery rates in this experiment, little weight should be attached to this finding.

Herbicide Recovery

The percentage recoveries of three herbicides are presented in Appendix J. These values were calculated by dividing total mass recovered (M_R, Eq. 3-2) by the average application rate, as determined by the petri dish data. Some of the variability in recovery is undoubtedly due to application variability, and the possibility of decreasing this variability by normalizing the herbicide recoveries by the tracer recovery was considered but eventually discarded for two reasons. First, as just described, the tracer recovery data are quite variable. Second, as will be described below, statistical analysis revealed a general lack of correlation between the herbicide and tracer recoveries, indicating that little would be gained by the proposed normalization process. The recovery values shown in Appendix J were therefore used for all further data analysis.

Bromacil showed an average recovery of 126%, with a CV of 45%. Napropamide's average recovery was 65%, with a CV of 65%, while prometryn recovery averaged 91% with a CV of 50%. The high CVs are similar to the corrected tracer recovery CV of 49%, and quite similar to the 45% recovery CV observed for bromacil during another experiment in the same vicinity (Bowman and Rice, 1986b). The elevated bromacil recovery is peculiar, and may be partially explained by analytical problems.

With only a single observation time, we have no way to determine the kinetics of herbicide degradation. Assuming first-order degradation, we can use the average recovery at this single point to calculate an estimated degradation half-life, using Equation 4-10:

$$T_{1/2} = \frac{-t \cdot \ln(2)}{\ln(Rec)} \qquad (4\text{-}10)$$

where:

$T_{1/2}$ = Degradation half-life [T]

With an average recovery of over 100%, bromacil degradation cannot be estimated, but the data for the other two herbicides yield half-life estimates of 110 days for napropamide and 500 days for prometryn. These numbers greatly exceed literature values cited in Table 1-2 of 60 days for napropamide and 70 days for prometryn. The high degree of uncertainty associated with the recovery data cast doubt on the validity of these measurements, but we can speculate on two possible causes for slow degradation during the field experiment. First, the experiment was run during the winter months, which even in southern Arizona are cooler than typical agricultural growing-season temperatures. Second, the low organic content of the soil and the fact that the field had been uncropped for at least two years suggest that the soil microbial population may have been lower than in an average agricultural soil. Both factors suggest that field degradation rates would be lower than typically measured.

The mass recovery distribution varied from solute to solute, and was often not well described by either a normal or log-normal distribution. Recovery variability was quite similar for all four solutes, ranging from a CV of 45% for bromacil to 65% for napropamide. This similarity among both the non-degraded tracers and the biodegradable herbicides suggest that physical processes alone can account for the observed variability, and that degradation rate may not vary widely across the plots.

A statistical analysis (SAS CORR procedure, SAS Institute, 1988a) was performed to check for correlations among the solute recovery data, but found that the recovery rates were not correlated among the four solutes, nor were they correlated to the solute velocities. An additional analysis using the Tukey-Kramer test (SAS Institute, 1988b) showed that neither bromacil nor prometryn recovery was affected by the application rate or the presence of the other two herbicides. Napropamide recovery, on the other hand, showed significant differences between the various treatments. The presence of the other herbicides significantly enhanced recovery, as did the low application rate. Therefore, the highest napropamide recovery rate (95%) occurred in plots that received the low-concentration mixed herbicide treatment, while the lowest recovery (41%) occurred where napropamide was applied alone at a high concentration. These observations suggest that bromacil and/or prometryn suppress degradation of the napropamide, and that at the concentrations applied, napropamide itself actually enhances degradation. The increased sensitivity of napropamide to these effects relative to bromacil or prometryn may be inherent in napropamide's degradation pathways, or may reflect its longer residence time in the biologically active shallow soil. It is impossible to reach any firm conclusions based on these field observations, but they suggest that napropamide degradation is worthy of further study.

CXTFIT RESULTS

The transport parameters fitted by CXTFIT during runs 1 and 3 were subjected to statistical analysis. Before discussing the results of that analysis, let us once again mention the major assumptions that constitute the conceptual model behind those runs. The profiles were analyzed in a normal spatial coordinate system, implying homogeneous soil conditions within each core. R is held constant, implying linear and non-hysteretic sorption. Both physical and chemical local equilibrium conditions are assumed, and flow is assumed to be both one-dimensional and steady-state. Average pore-water velocity is not held constant, but is fitted by CXTFIT, in effect modeling preferential flow. (The degree of preferential flow will later be evaluated by comparing v_t, the fitted tracer velocity, to v_a, the net infiltration rate divided by the moisture content.) CXTFIT fits each core individually, thereby letting the transport parameters vary from core to core, representing lateral soil heterogeneity. The ability of CXTFIT to fit the observed profiles under these relatively strict assumptions is some measure of the validity of those assumptions. One's first observation upon looking at the results of these runs in Appendix N is the overall good fit to the observed profiles. This good fit lends credence to the underlying conceptual model, and suggests that the fitted transport parameters have some physical significance.

Tracer Velocity

Tracer velocities appear normally distributed, with a mean of 2.78 cm/day, and a 21% CV. Appendix V lists tracer v_a and v_t for each profile. v_a is the expected velocity calculated as the net infiltration rate (0.321 cm/day, from the micrometeorology data) divided by the volume-averaged water content of the core (from the measured water content of each soil sample), while v_t is the observed tracer velocity in the core, based on CXTFIT modeling. Appendix V also presents the β parameter for each core, defined as

$$\beta = \frac{v_t}{v_a} \tag{4-11}$$

where:

β = Degree of accelerated transport [ ]

β averages 1.96, indicating that, on average, the tracer moved almost twice as fast as predicted by the water budget calculation. Other solute transport studies under intermittent flood irrigation have reported average β values of 2.5 (Bowman and Rice, 1986b) and 5.1 (Rice et al., 1986) at MAC, and 1.6 - 1.7 (Bowman and Rice, 1986a) at USWCL. These results contrast with field transport experiments conducted under continuous ponding (Biggar and Nielsen, 1976) and constant trickle irrigation (Van De Pol et al., 1977) which reported no significant difference between observed tracer velocities and predicted velocities based on infiltration rates, and a study with natural rainfall (Jury et al., 1982) which showed tracer velocities lower than predicted using net water application rates. The observed accelerated transport is one of the major findings of this experiment, and will be discussed at length below.

Herbicide Velocities and Retardation Factors

While the statistics do not rule out a normal distribution for herbicide velocities and retardation factors, a log-normal distribution generally fit the observed data better. Untransformed herbicide velocity data CVs range from 29% for bromacil to 38% for napropamide. In all cases, the herbicide retardation factors were less variable than herbicide velocities, with CVs ranging from 19% for bromacil to 26% for both napropamide and prometryn. This implies that tracer velocity is a useful predictor of herbicide velocity in a given core.

This conclusion is furthered strengthened by the correlation study results in Appendix T. All four solute velocities are strongly correlated with each other, all at a greater than 1% significance level. The strength of the correlation seems to be related to the solutes' similarity in relative retardation. Recalling the order in which the solutes move through the soil (tracer, bromacil, prometryn, napropamide), it is interesting that the napropamide velocity is most highly correlated with prometryn, then bromacil, and finally tracer. Similarly, prometryn velocity is most correlated with bromacil, than napropamide, and than tracer. The pattern continues consistently except that the tracer-napropamide velocity correlation is slightly stronger than is the tracer-prometryn correlation. This observation reflects the fact that those solutes that remained closest spatially will have encountered more of the same soil, and therefore be affected by more of the same processes than solutes that have diverged more.

None of the solute velocities were significantly correlated (negatively or positively) with the average moisture content of the core at the time of sampling. This indicates that the observed velocity variability reflects infiltration rate and/or preferential flow variability, rather than simply moisture content variability superimposed on a constant infiltration rate.

A search for correlations among the herbicide retardation factors revealed some correlation between the bromacil and prometryn Rs, while the napropamide R showed no correlation to the other two.

The Tukey-Kramer test (SAS Institute, 1988b) showed that the specific herbicide treatment had no significant effect on the napropamide or prometryn retardation factors. Bromacil retardation, on the other hand, was significantly affected by the presence of the other herbicides and perhaps by the application concentration. Bromacil retardation was significantly lower in those plots which received a mixture of all three herbicides, suggesting that the competition effects seen in the laboratory batch studies were also manifest in the field. A *t*-test, somewhat less rigorous than the Tukey-Kramer test, showed that the other herbicides had some effect on the napropamide retardation factor, which was higher in the mixed plots than in the napropamide-only plots. This effect, if real, directly contradicts the lab sorption studies which showed a slight decrease in napropamide sorption in the presence of bromacil and prometryn. This field retardation factor difference was significant at the 0.1 level, but not at a 0.05 level, and considering the large number of *t*-tests conducted, may not be of great importance.

The average retardation factors are summarized in Table 4-5, together with the predicted retardation factors based on the laboratory batch studies. The observed retardation factors appear consistently higher than the predicted values, but overall, the observed and predicted retardation factors agree surprisingly well, especially considering that the batch studies were conducted using surface soil, while in the field the herbicides encountered soil throughout the profile. The consistently higher observed values may reflect anion exclusion of the tracers, as will be discussed later in this chapter.

Dispersion Parameters

For each of the four solutes, the dispersion parameters D and α were all well-fit by log-normal distributions, and all were extremely variable. CVs for these parameters were all in the range of 80% - 120%. For prometryn, α was less variable than D (107% vs. 120%) while the two parameters showed nearly identical CVs for the other solutes.

Correlation analyses of the dispersion parameters turned up some interesting results, or more accurately, lack of results. The dispersion coefficient and the dispersivity theoretically are both properties of the porous medium (and for the dispersion coefficient, the flow field), and not the

Table 4-5. Predicted and Observed Retardation Factors.

	Retardation Factor	
	Predicted from Lab K Values	Geometric Mean of Observed Values
Bromacil		
Low Concentration, with Competition	1.61	1.80
High Concentration, without Competition	1.66	1.93
High Concentration, with Competition	1.50	1.53
Napropamide		
Without Competition	8.02	8.52
With Competition	6.98	10.36
Prometryn		
All Cases	3.59	4.27

transported solute. Therefore, again theoretically, the same dispersion coefficient that describes tracer transport through a core should also describe transport of the herbicides following behind. CXTFIT run 2's complete failure to fit the herbicide profiles using the tracer dispersion coefficient values demonstrated that this theory did not apply during this study, and the correlation analysis confirmed that fact. A correlation analysis among the four solute dispersion coefficients revealed absolutely <u>no</u> significant (10% level) correlations among them. The same applies for the four solute dispersivity values, derived by dividing the solute dispersion coefficient by the tracer velocity. In addition to a lack of correlation, the dispersion coefficients show widely varying ranges, shown in histogram form in Figure 4-2. Furthermore, there is no obvious relationship between the observed order in dispersion coefficient (tracer < napropamide < bromacil < prometryn) and any other solute properties.

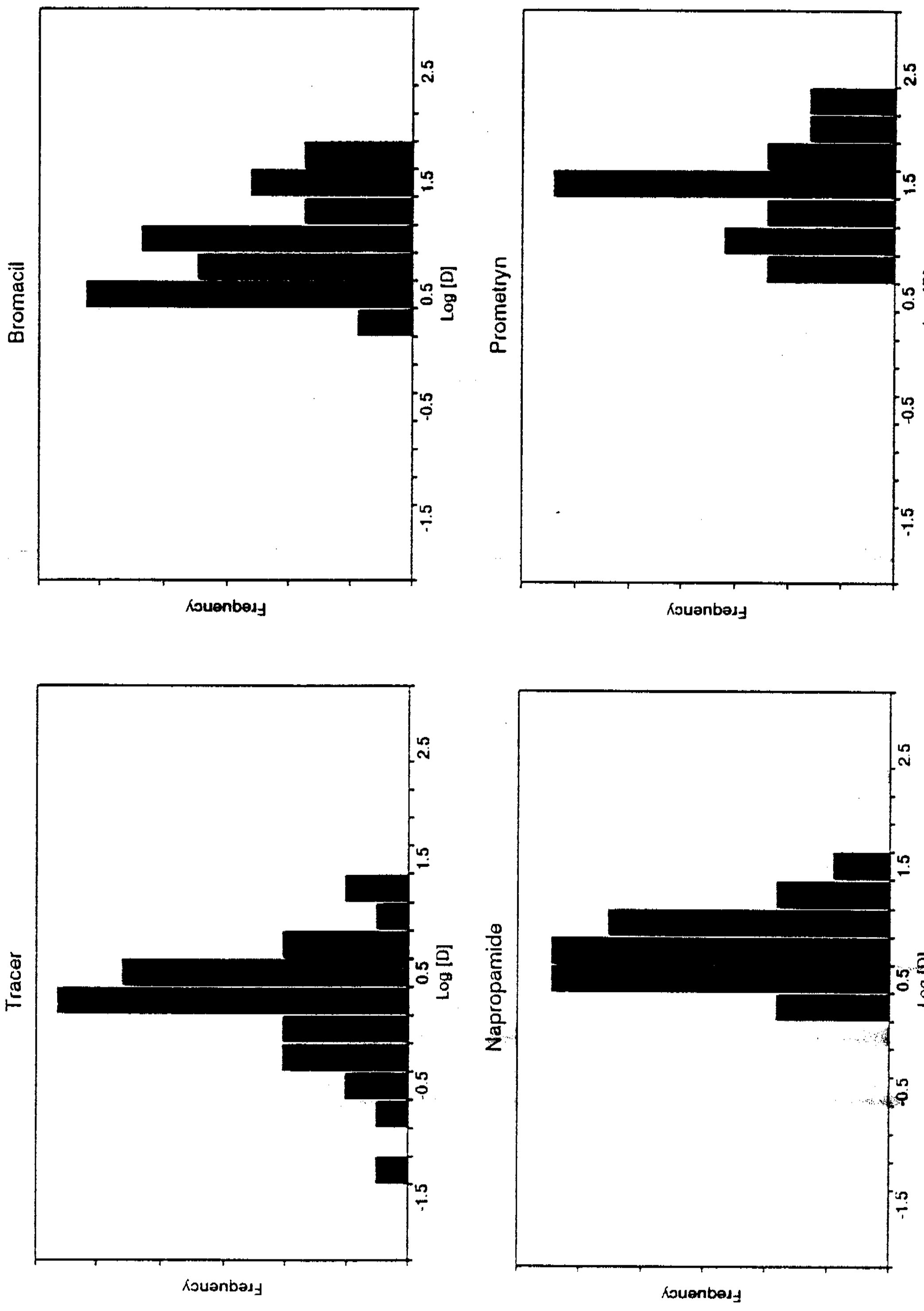


Figure 4-2. Frequency Distributions of Log-Transformed Fitted Dispersion Coefficients.

A *t*-test (SAS Institute, 1988b) revealed that a few of the dispersion coefficients also show some significant dependence on the application concentration and presence of other herbicides, but these effects were inconsistent in direction. Again, considering the great variability observed in the dispersion parameters and the lax significance level (0.1) of the test, not much physical significance should be placed on these results.

Comparison with Field-Averaged Data

As has been shown, neither the specific tracer used nor the different herbicide concentrations and combinations had much effect on transport behavior. This confirms the validity of averaging all the observed profiles to obtain a single field-averaged profile for each solute. The field-averaged profiles were analyzed using CXTFIT, and the fitted parameters are compared to the average of the parameters fitted to the individual cores in Table 4-6. Note that in keeping with their observed log-normal distribution, individual core dispersion and retardation parameters are averaged using a geometric mean.

The field-averaged velocities and retardation factors are quite similar to the corresponding averaged local parameters, while the field-averaged dispersion parameters differ markedly from the averaged local parameters. This difference in response to the averaging method is entirely predictable from the nature of the parameters: velocity and R are basically linear functions of the distance traveled by the solute, while the dispersion parameters are higher-order functions representing the variability in that distance. The field-averaged profile incorporates more variability than the individual profiles, and increased dispersion parameters are therefore expected. This apparent increase in dispersion is due to soil heterogeneity on scales greater than

Table 4-6. Field-Averaged Transport Parameters Compared to Averages of Individual Profile Parameters.

	v (cm/day)	R	D (cm^2/day)	α (cm)
Tracer				
average of individual profiles	2.78		1.31	0.48
field-averaged profile	2.79		27.05	9.69
Bromacil				
average of individual profiles	1.63	1.74	6.81	2.52
field-averaged profile	1.51	1.85	27.26	9.77
Napropamide				
average of individual profiles	0.30	9.73	4.48	1.66
field-averaged profile	0.28	9.99	11.37	4.07
Prometryn				
average of individual profiles	0.72	4.27	19.69	6.75
field-averaged profile	0.61	4.59	25.17	9.02

Note: Average v is arithmetic mean; average R,D,α are geometric means.

a single core, an effect which has been referred to as macrodispersion.

Another striking effect of this field-scale averaging is the apparent convergence of the dispersion parameters for the different solutes. With the exception of napropamide, the dispersion coefficients are all around 25-27 cm^2/day, and the dispersivities around 9-10 cm. As mentioned earlier, the dispersion parameters are theoretically solute-independent. Although observations for the individual cores did not follow that theory, here we see that the field-averaged profiles do seem to reflect solute-independent dispersion. Notice that napropamide displays much lower dispersion parameters than bromacil and the tracers, while prometryn's dispersion parameters are slightly lower. These differences are probably a function of the relative retardation of the solutes. Napropamide and prometryn's higher retardations lead to lower velocities and lower Peclet numbers ($P \approx vt/\alpha$, proportional to distance from the upper boundary), which make these solutes more susceptible to boundary condition effects leading to departures from ideal 1-D ADE behavior. This explanation predicts that a second sampling after additional leaching would show field-averaged napropamide and prometryn dispersion parameters increasing and approaching the bromacil and tracer values.

Because more napropamide remains in the top 10 cm of the soil, it is more sensitive to transient flow conditions and evaporation-driven head gradients. Upward water flow between irrigations may cause upward transport of the entire napropamide pulse, decreasing the vertical spreading and apparent dispersion of napropamide, or primarily affect the trailing edge of the pulse, increasing the apparent dispersion. A proper evaluation of this effect would require a numerical code capable of modeling transient flow and transport.

Yet another possible explanation for higher dispersion parameters for the tracers and bromacil as compared to napropamide and prometryn is anion exclusion-enhanced dispersion (Gvirtzman and Gorelick, 1991). Table 4-7 shows the solutes' acid-base properties and their ionic form at pH 8, a value close to the expected soil water pH during the field study, based on the pH of the applied irrigation water and on measurements in irrigated soils elsewhere in southern Arizona (Rice et al., 1989). These data indicate that during the field study, the tracers were anionic, bromacil was partially anionic, and napropamide and prometryn were neutral. Anion-exclusion-enhanced dispersion could therefore increase the observed dispersion of the anionic tracers and the partially-ionized bromacil, while not affecting the neutral species napropamide and prometryn. However, the dispersion enhancement would be expected to be stronger for the fully-ionized tracers than for bromacil, while prometryn and napropamide would both show unaffected and therefore equal dispersion. The data do not reflect this pattern, so anion exclusion-enhanced dispersion is playing at most a small role in the observed variations.

The field-averaged behavior is key to potential groundwater contamination, because it represents the total solute loading to the water table over a large area. The analysis results for the field-averaged profiles are encouraging, suggesting that although local tracer dispersion behavior doesn't help us predict local herbicide behavior, field-averaged tracer dispersion may be a good predictor of field-averaged dispersion for other solutes, and therefore of groundwater loading. Field-averaged transport experiments in tile-drained fields are relatively easy and inexpensive, and may prove to be an important research and management tool.

Comparison with Volumetric Results

As mentioned in Chapter 3, the results of the CXTFIT runs using volumetric coordinates are generally quite similar to the spatial coordinate results just discussed, as is apparent in the fitted profiles shown in Appendix P. The volumetric coordinate runs produce estimates of q, R and δ instead of v, R and D, but the variability in the corresponding parameters is quite similar, as shown in Table 4-8. Accelerated transport in the volumetric coordinate runs can be quantified by comparing the average fitted q value of 0.656 cm/day with the average infiltration rate calculated at 0.321 cm/day. This comparison yields a β ratio of 2.04, very close to the spatial

Table 4-7. Solute Acid/Base Properties.

Solute	Category	pK_a	Form at pH 8	Reference
2,6-DFBA	acid	3.0	anion	Bowman and Gibbens (1992)
m-TFMBA	acid	3.8	anion	"
o-TFMBA	acid	3.0	anion	"
PFBA	acid	2.7	anion	"
Bromacil	acid	9.1	neutral, some anionic	Weber and Whitacre (1982)
Napropamide	neutral	-	neutral	Merle Kleinschmidt, pers.comm. (1992)
Prometryn	basic	4.1	neutral	Worthing (1991)

coordinate result of 1.96. Overall, the goodness-of-fit as expressed by the average SSQ (Table 4-9) shows only a slight improvement for napropamide and no significant change for the tracers, bromacil, or prometryn.

Use of the volumetric coordinate system permits modeling of one very specific type of spatial heterogeneity -- vertically-varying moisture content within a single core. It does not address vertically-varying hydraulic or chemical properties that can also affect flow and transport processes. The general similarity between the volumetric and spatial coordinate CXTFIT runs indicates that at this site, vertically variable moisture content does not play a significant role is solute transport.

Table 4-8. Comparison of Spatial and Volumetric Coordinate CXTFIT Results.

	Spatial Coordinates				Volumetric Coordinates			
	v (cm/day)	R	D (cm^2/day)	α (cm)	q (cm/day)	R	δq (cm^2/day)	δ (cm)
Tracer								
AM:	2.779		2.332	0.895	0.656		0.109	0.182
CV (%):	21.1		121.9	122.4	18.8		103.2	113.8
GM:			1.309	0.482			0.060	0.093
Bromacil								
AM:	1.626	1.768	11.00	4.092		1.812	0.656	1.054
CV (%):	29.3	20.0	99.9	101.2		21.1	94.5	95.3
GM:		1.736	6.809	2.520		1.777	0.427	0.684
Napropamide								
AM:	0.296	10.07	5.850	2.086		11.56	0.326	0.478
CV (%):	38.3	26.7	81.5	81.3		25.1	109.3	102.5
GM:	0.278	9.734	4.483	1.655		11.22	0.230	0.355
Prometryn								
AM:	0.716	4.407	33.37	10.47		4.744	1.896	2.523
CV (%):	30.7	26.3	120.4	106.5		27.1	119.7	104.6
GM:	0.684	4.265	19.69	6.748		4.583	1.138	1.684

Notes: AM: arithmetic mean; GM: geometric mean.

Comparison with Nonequilibrium Results

The two-region/two-site version of CXTFIT was used to model physical or chemical nonequilibrium processes, but as explained in Chapter 3, the fitted parameters are of dubious value. However, the ability of the nonequilibrium model to accurately fit the observed profiles can provide some insight into the potential importance of nonequilibrium process. The quality of the fit is revealed in the average SSQ values shown in Table 4-9.

Table 4-9. Average Sum of Squares Values for CXTFIT Runs.

	Accelerated Transport Variable R	Variable Water Content	Nonequilibrium (2-region/2-site)
CXTFIT Run	1,3	4,5	6,7
Tracer	14.0	22.8	14.1
Bromacil	16.3	17.1	11.2
Napropamide	9.7	9.5	8.1
Prometryn	10.8	11.8	10.5

The tracers are not subject to sorption, nonequilibrium or otherwise, so when modeling the tracer profiles CXTFIT is modeling physical nonequilibrium. Despite the addition of two fitting parameters, adding physical nonequilibrium to the model does not improve the fit to the observed tracer profiles, suggesting that physical nonequilibrium processes are not playing a significant role in tracer transport. This result may be partially due to the poor spatial resolution of the tracer peaks caused by the 30-cm sampling interval at the depths where the tracers were found. Many of the tracer peaks are defined by only two or three data points (see profiles in Appendix N), which makes detection of tailing unlikely. This sampling interval represents the inevitable trade-off between sampling resolution and number of cores collected.

If physical nonequilibrium is not affecting tracer transport, neither is it affecting herbicide transport. Therefore, CXTFIT's nonequilibrium model represents only chemical nonequilibrium when applied to the herbicide profiles. As shown in Table 4-9, introduction of chemical nonequilibrium to the model greatly improves the fit to the bromacil data (SSQ = 11.2 vs. 16.3), slightly improves the napropamide fit (8.1 vs. 9.7), and leaves the prometryn fit about the same

(10.5 vs. 10.8). This improvement in fit is readily visible, comparing the equilibrium and nonequilibrium fits to the bromacil profile in core 13-3 (Fig. 4-3). The equilibrium model always predicts a symmetric profile, while the nonequilibrium model fits the observed tailing of the profile.

It is important to stress that these results do not enable us to conclude that chemical nonequilibrium is affecting the herbicide profiles. As was pointed out in Chapter 1, many different nonideal processes including sorption nonlinearity and hysteresis can lead to peak tailing. CXTFIT does not model these processes, so any observed tailing will be ascribed to nonequilibrium. Additional information is required to distinguish among these nonideal processes, as will be discussed later in this chapter.

Comparison with Method of Moments Results

The method of moments was investigated as an alternative method of profile analysis to CXTFIT. Potential benefits included straightforward mathematical procedures that could be easily automated and a process-independent measurement of peak asymmetry.

The field experiment resulted in 45 tracer profiles and 81 herbicide profiles. Any gain in analysis efficiency would save time, enabling more complex or varied analyses. Determination of the moments of each profile using Equation 3-8 is very simple and readily incorporated into a batch processing code to calculate the moments for all 126 profiles. The next step is to relate the moments to the transport parameters, using Equations 3-10,11,12.

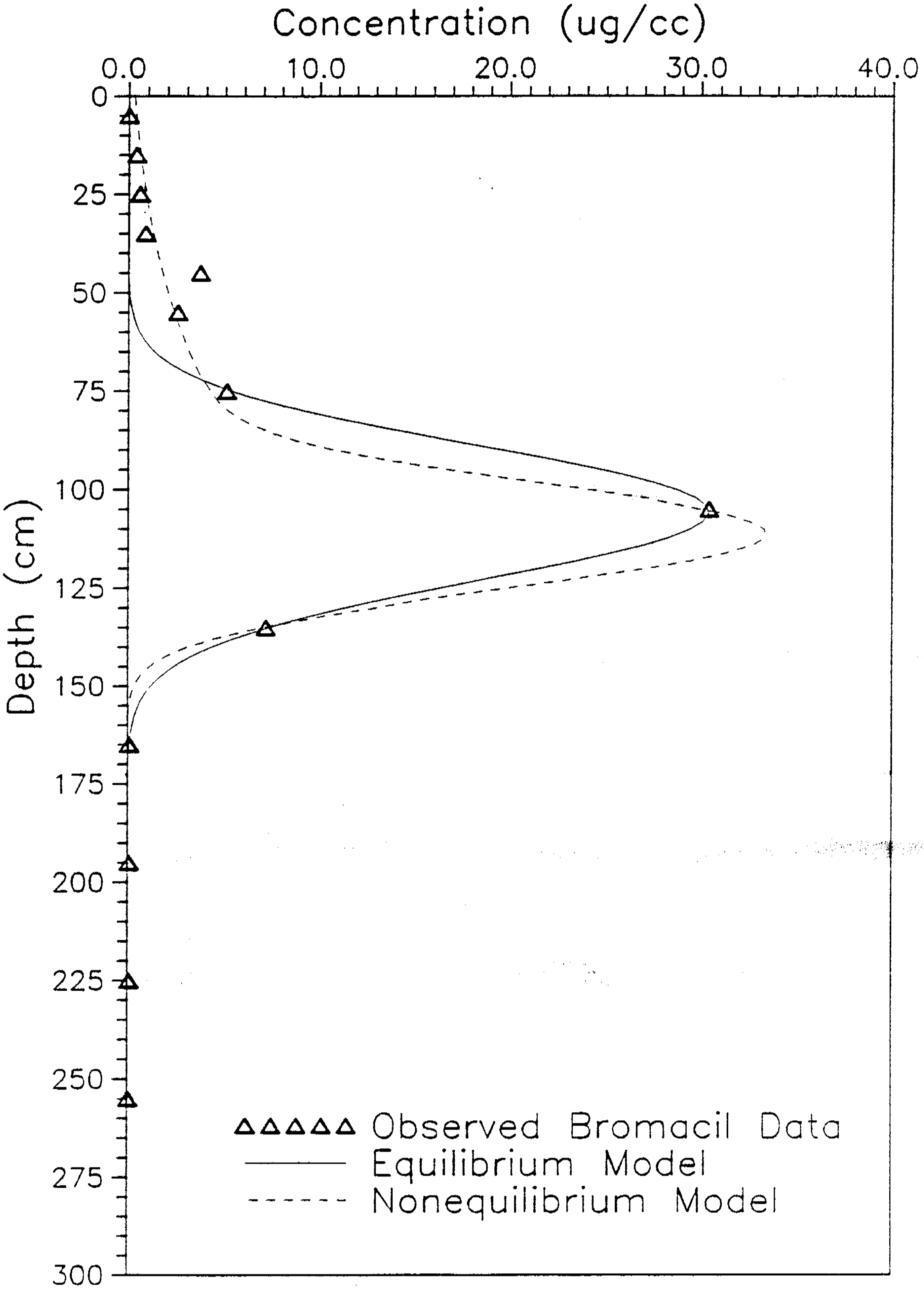


Figure 4-3. Comparison of Equilibrium and Nonequilibrium Fits to Bromacil Profile, Plot 13, Core 3.

At this point, about 17% of the profiles resulted in the square root of a negative value during the dispersivity calculation (Eq. 3-10). This problem occurred in none of the tracer profiles, none of the bromacil profiles, 37% of the prometryn profiles, and 44% of the napropamide profiles. This pattern of increasing problems with increased retardation points to the explanation. The model upon which Jury and Sposito's (1985) equations are based assumes a very narrow slug input, and requires that the slug be completely within the profile at the time of observation. In reality, the applied slug of solutes was of significant duration, and due to retardation, some napropamide and prometryn is still very close to the surface. Like all boundary condition effects, the importance of these discrepancies decreases with increasing Peclet number. Napropamide displays the lowest Peclet numbers and is therefore most affected by these departures from the assumed boundary conditions, as is prometryn to a lesser degree. Bromacil and the tracers exhibit high enough Peclet numbers that the boundary conditions are irrelevant and the model satisfactorily fits the observed profiles.

A second goal of the moments analysis was to investigate the usefulness of skewness as an indicator of nonideal transport. Many nonideal processes, including physical and chemical nonequilibrium, sorption nonlinearity, and sorption hysteresis, can lead to asymmetric solute peaks. Available codes can model a few of these individual processes, but it would be useful to develop a general measurement of peak asymmetry, perhaps correlated to some sort of overall level of nonideality. This measurement should be scaled to the profile, so that different profiles with different total masses or penetration depths can be compared directly. Skewness is just such a measure. Skewness is mathematically defined as:

$$Sk = \frac{E[x_i - \mu]^3}{\sigma^3} \tag{4-12}$$

and can be expressed in terms of the normalized moments m_n^* defined in Equation 3-9, as:

$$Sk = \frac{m_3^* - 3m_1^* m_2^* + 2(m_1^*)^3}{\left(m_2^* - (m_1^*)^2\right)^{3/2}} \tag{4-13}$$

where:

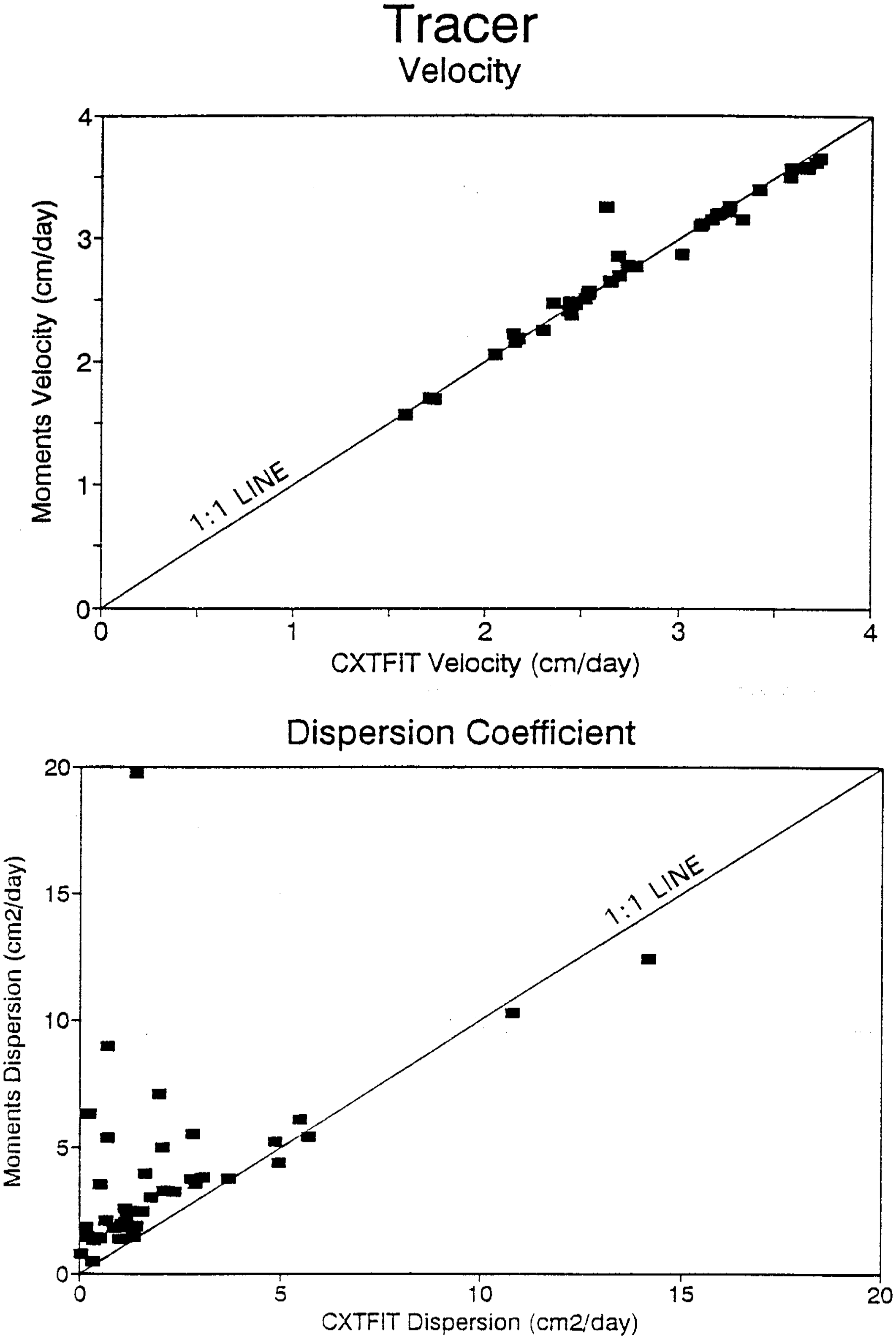
Sk = Skewness of a profile or distribution [ ]

This calculation was performed for the observed solute profiles, but when the resulting skewness values were examined, they did not seem to correlate to the observed relative asymmetry of the profiles. This paradox is caused by the great sensitivity of skewness to outlying data points, due to its dependence on the third moment. While the human eye and curve-fitting programs such as CXTFIT will automatically ignore obvious data outliers, moment analysis includes all of the data. Furthermore, the higher the moment's order, the more weight is given to outlying data. In other words, the zeroth and first moments are relatively insensitive to outliers, the second moment is more so, and the third moment, crucial to the skewness calculation, is extremely sensitive to outliers. This sensitivity is demonstrated in Table 4-10, which shows skewness calculations for the napropamide profile in core 2-3. This profile includes some low-concentration (< 0.1 μg/cm^3) data points at depths greater than 100 cm, while the major peak is within the top 50 cm and reaches a peak concentration of 11.6 μg/cm^3. The deep low-concentration points represent less than 2% of the total mass present, and are completely invisible on a graph of the data, yet they have a profound effect on the calculated skewness. Table 4-10 shows that removing the bottom two data points reduces the skewness from 7.3 to 4.9, and removing an additional two points further reduces the skewness to 0.3. Neither of these changes would be visible on the plotted profile. This over-sensitivity to data outliers effectively eliminates skewness as a useful analytical tool for real-world profiles.

Table 4-10. Sensitivity of Skewness to Data Outliers.

Depth (cm)	Plot 2, Core 3 Napropamide Concentration ($\mu g/cm^3$)		
	Full Profile	Two Points Removed	Four Points Removed
5	0.5497	0.5497	0.5497
15	7.2163	7.2163	7.2163
25	11.6371	11.6371	11.6371
35	2.7766	2.7766	2.7766
45	0.2350	0.2350	0.2350
55	0.0500	0.0500	0.0500
75	0.0000	0.0000	0.0000
105	0.0681	0.0681	0.0000
135	0.0351	0.0351	0.0000
165	0.0000	0.0000	0.0000
195	0.0000	0.0000	0.0000
225	0.0254	0.0000	0.0000
255	0.0089	0.0000	0.0000
Skewness:	7.2894	4.8642	0.3047

The results of the successful moments analyses are compared to the CXTFIT results in Figure 4-4 and Table 4-11. The method of moments velocity and retardation factor estimates, which depend only on the zeroth and first moments, agree quite well with the CXTFIT estimates. The dispersion parameter estimates, which also depend on the second moment, show greater discrepancies and consistently higher values than the CXTFIT estimates. As discussed previously, the sensitivity of the second moment to data outliers leads to these increased dispersion parameter estimates. These results suggest that the method of moments is an efficient and practical method of determining solute velocities, but the sensitivity of the second and higher-order moments casts doubts on method of moments dispersion parameter estimates.



Tracer

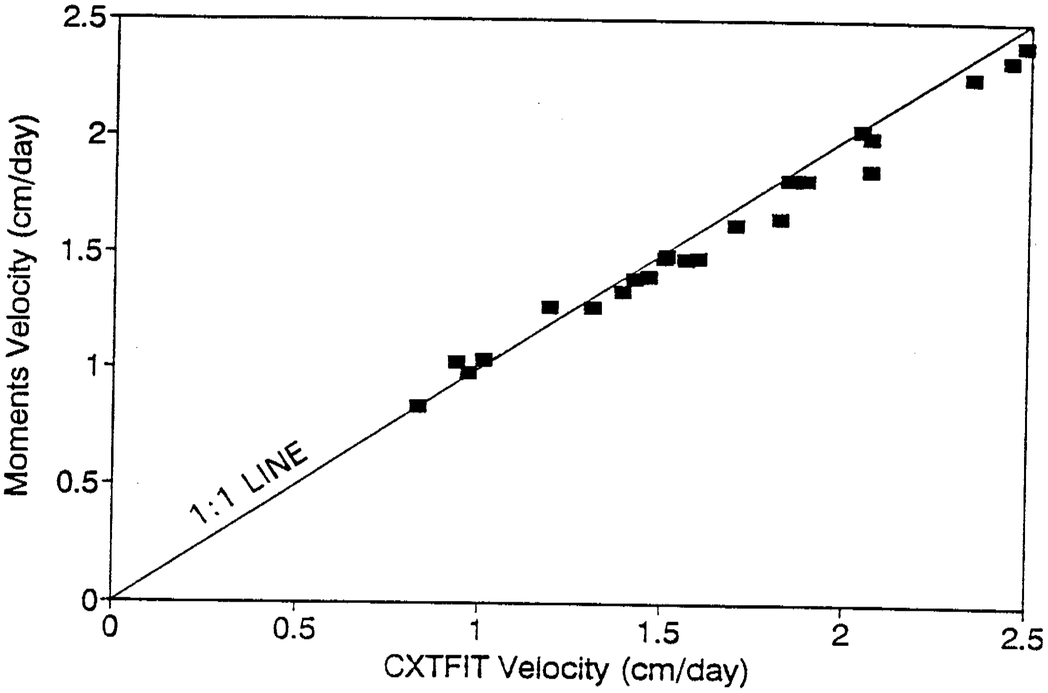
Velocity

Dispersion Coefficient

Figure 4-4. Comparison of CXTFIT and Method of Moments Parameters -- Tracer.

Bromacil

Velocity



Dispersion Coefficient

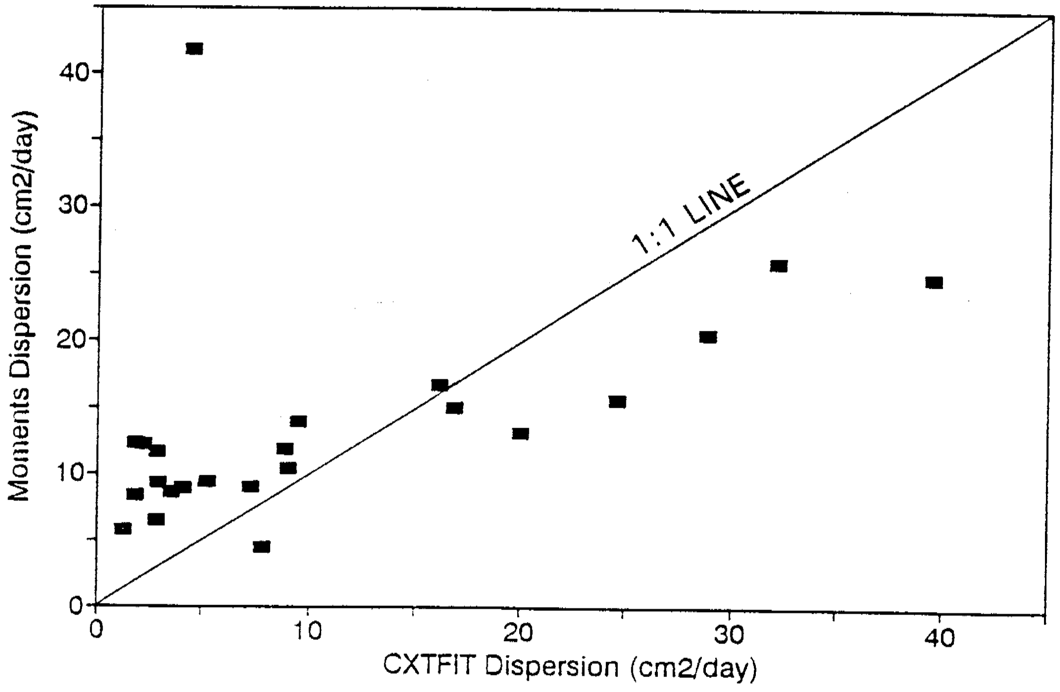
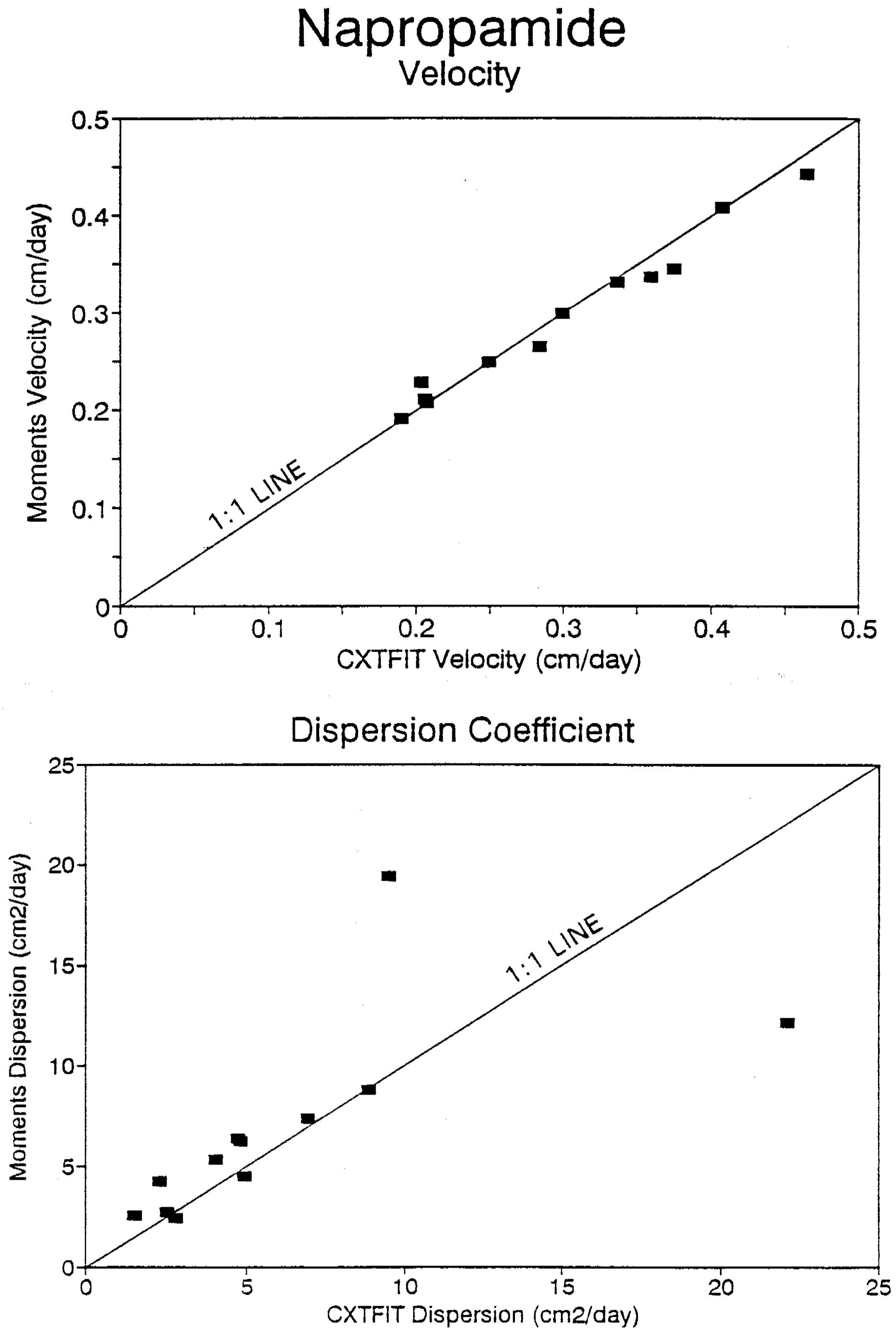


Figure 4-4 (cont). Comparison of CXTFIT and Method of Moments Parameters -- Bromacil.

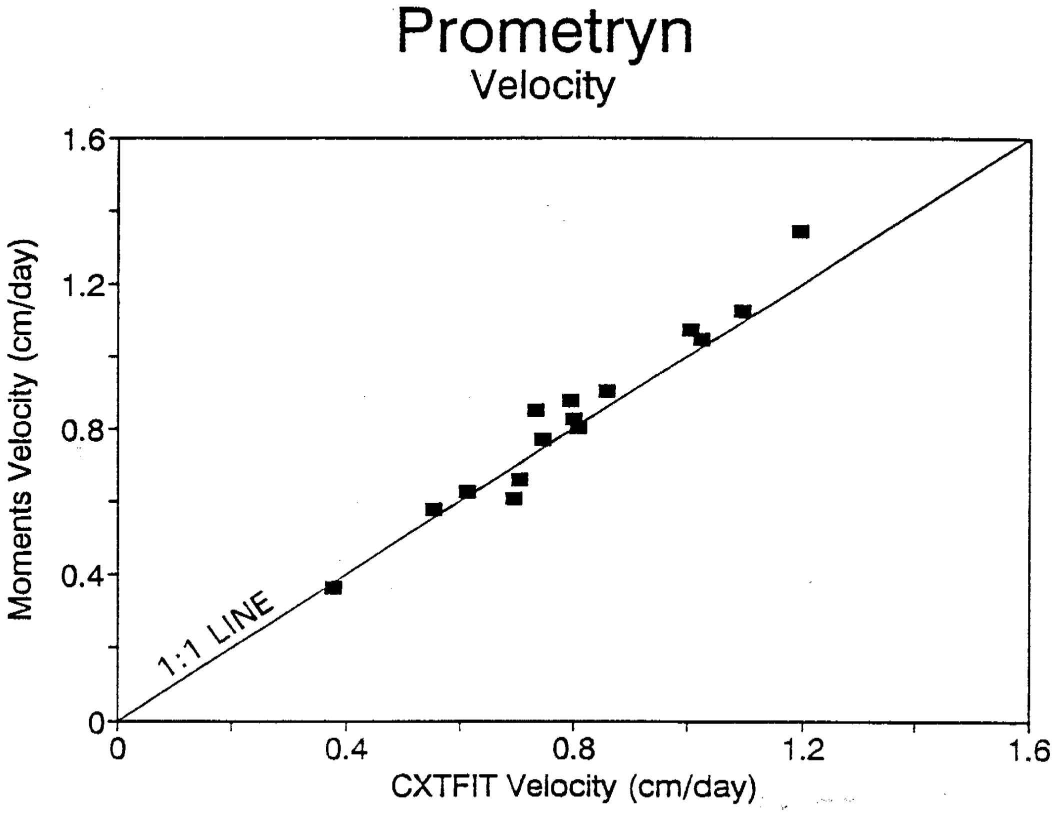


Napropamide

Velocity

Dispersion Coefficient

Figure 4-4 (cont). Comparison of CXTFIT and Method of Moments Parameters -- Napropamide.



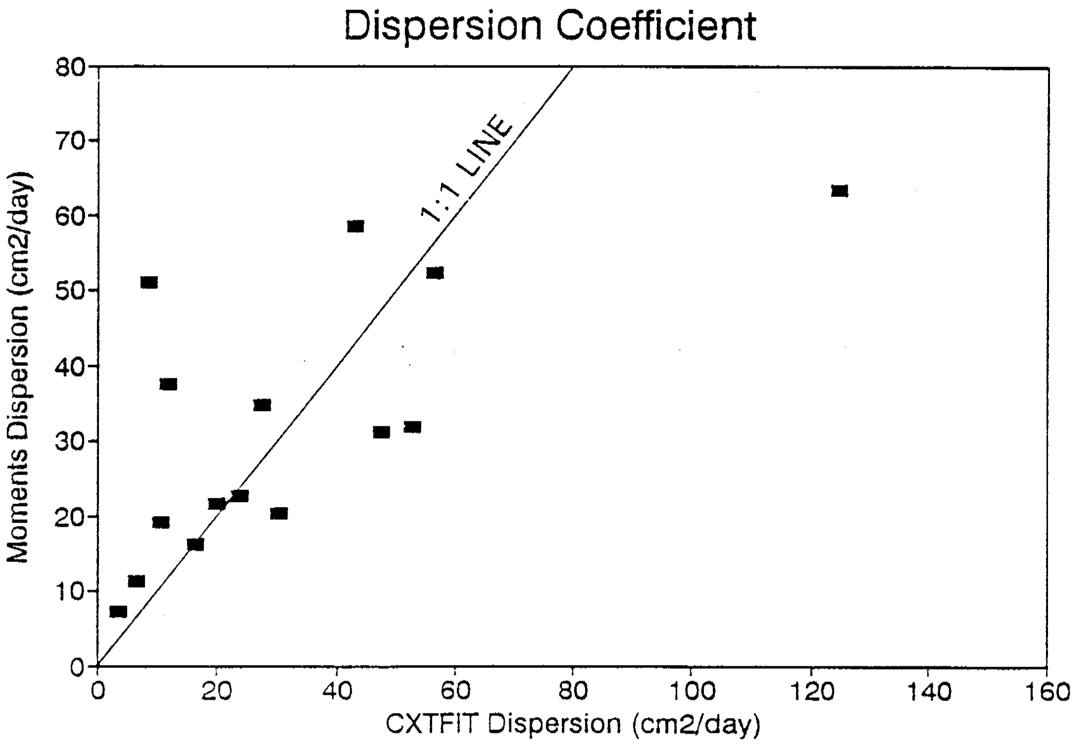


Figure 4-4 (cont). Comparison of CXTFIT and Method of Moments Parameters -- Prometryn.

Table 4-11. Comparison of CXTFIT and Method of Moments (M-o-M) Results.

	v (cm/day)	R	D (cm^2/day)	α (cm)
Tracer				
CXTFIT avg.:	2.78		1.31	0.48
M-o-M avg.:	2.78		3.16	1.17
Bromacil				
CXTFIT avg.:	1.63	1.74	6.81	2.52
M-o-M avg.:	1.72	1.79	12.04	4.51
Napropamide				
CXTFIT avg.:	0.30	9.73	4.48	1.66
M-o-M avg.:	0.32	9.53	5.65	2.55
Prometryn				
CXTFIT avg.:	0.72	4.27	19.69	6.75
M-o-M avg.:	0.92	3.75	27.21	9.38

Note: Average v is arithmetic mean; average R,D,α are geometric means.

IMPLICATIONS FOR NONIDEAL TRANSPORT PROCESSES

At this point, let us consider the implications of these findings for nonideal transport by comparing the observed transport properties to ideal transport predictions based on the 1-D ADE with constant parameters. These predictions require estimating the transport parameters v, D, R, and μ, and the boundary condition variables C_0 and t_0. The available data on net infiltration rate and average water content provide an estimate of v. The linearized distribution coefficients, combined with moisture content and bulk density information, lead to estimates of R for each of the herbicides. μ can be estimated from published degradation rates for the herbicides. D is more difficult to estimate, but can be calculated from an estimate for α of 10 cm, based on the scale of the experiment and the relative homogeneity of the soil at the site. Under ideal assumptions, D will be the same for all solutes. As discussed in the introduction to the CXTFIT model, t_0 will be 14 days, and C_0 can be determined from the application rate and the other parameters, using Equation 3-5. Once values for all these parameters are available, ideal predicted profiles are easily obtained using an analytical solution of the ADE, such as is implemented in the predictive mode of CXTFIT. Values for these estimated parameters are presented in Table 4-12, and predicted profiles for the high-concentration mixed herbicide treatment are compared to the field-averaged profile in Figure 4-5.

Comparing these predicted profiles to the observed profiles highlights the differences between them which represent the effects of nonideal transport processes, and also enables some ranking of the importance of these differences (Table 4-13).

First-order effects are immediately obvious on even a cursory visual examination of the profiles. These effects are unquestionably demonstrated by the data, and had a profound effect on solute transport during the experiment. Although the relative positions of the solute peaks are about the same in the observed and predicted profiles, it is apparent that the observed peaks are deeper than the predicted peaks. Thus, accelerated transport is a first-order effect. Furthermore, the sizes of the peaks and their locations vary from core to core, so peak location and mass recovery variability is another first-order effect.

Second-order effects are not immediately obvious on casual observation, but require a more quantitative analysis of the individual profiles, using tools such as CXTFIT. Included in this

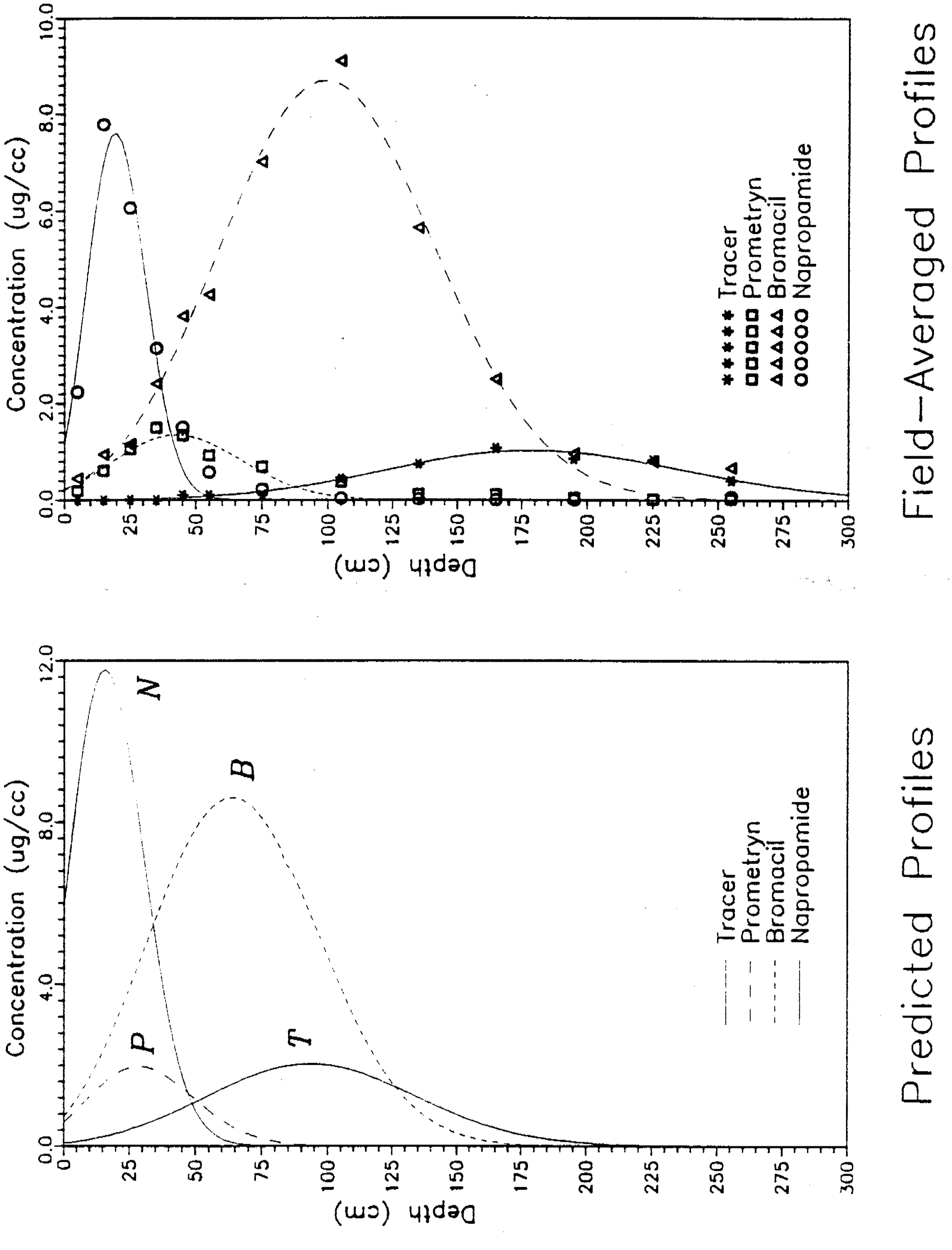


Figure 4-5. Predicted Solute Profiles, Assuming Ideal Behavior.

Table 4-12. Predicted Transport Parameters, Assuming Ideal Behavior.

	v (cm/day)	R	D (cm^2/day)	μ (/day)
Tracer	1.42	1.00	14.2	0.0
Bromacil	1.42	1.50	14.2	2.0×10^{-3}
Napropamide	1.42	6.98	14.2	9.9×10^{-3}
Prometryn	1.42	3.59	14.2	1.2×10^{-2}

Table 4-13. Observed Nonideal Effects, Ranked by Importance.

First-Order Effects

Accelerated Transport
Peak Location Variability
Recovery Variability

Second-Order Effects

Lower than Expected Dispersion
Solute/Solute Dispersion Variability
Herbicide Tailing

Third-Order Effects

Higher than Expected Retardation
Concentration and Mixture Effects on Bromacil Transport
Concentration and Mixture Effects on Napropamide Recovery

category are the unpredictably low fitted dispersivity values, the lack of dispersivity agreement between the solutes within a given core, and the increased tailing observed among the herbicides, especially bromacil, as demonstrated by the improved fit afforded by the nonequilibrium CXTFIT model.

Third-order effects become apparent only with statistical analysis of the quantitative results. These effects have the most uncertainty associated with them, and the least overall significance in predicting solute transport. Third-order effects include the slightly higher than predicted herbicide retardation factors and the apparent effects of application concentration and solute/solute interactions on bromacil retardation and napropamide recovery.

This ranking of nonideal effects is useful because it stresses the relative importance of the various observations. For example, the apparent interference effects on field-scale bromacil transport is both interesting and provocative, but it is important to realize that it is completely insignificant compared to the observed accelerated transport. For the solute fate and transport questions that provide today's challenges in applied hydrology, the first-order effects are probably all that matter. The rest is interesting academically and important theoretically, but when the ideal model underpredicts overall solute transport by a factor of 2, discussing percentage differences in retardation factors is of little practical importance. This said, all of the various observed nonideal effects will be discussed in turn, from first-order to third-order.

First-Order Effects

Accelerated Transport

On average, the solutes moved roughly twice as fast as was predicted using the idealized ADE. Any theory invoked to explain this phenomenon must address the fact that accelerated transport affected all of the solutes approximately equally, as demonstrated by the presence of the peaks in their predicted <u>relative</u> positions, and the general agreement between observed and predicted retardation factors. (A more complex theory could include one process that leads to differential accelerated transport among the solutes and a second process that somehow affects sorption in such a way that the two cancel out, producing the expected retardation factors, but this seems unnecessarily convoluted and coincidental.) This eliminates some form of hindered sorption or other chemical effect, which could not explain the tracer acceleration, and strong anion exclusion, which could not explain the acceleration of prometryn and napropamide, both of which are neutral species. Physical kinetic effects are unlikely, as shown by the results of the nonequilibrium modeling of the tracer profiles. This leaves preferential flow as the most likely explanation for accelerated transport.

As discussed in Chapter 1, preferential flow can be thought of as an extreme case of the mobile/immobile water model, with no significant exchange between the two domains. Preferential flow can occur at different scales, ranging from macropore flow with a characteristic scale on the order of 10 cm or more, to bypass flow in individual soil pores, with a characteristic scale of less than 1 mm. The relationship between the preferential flow scale and the scale of the soil samples collected determines the observed velocity distribution. If the preferential flow scale greatly exceeds the sample diameter, most samples will miss the preferential pathways and exhibit a relatively uniform and low velocity, while a few samples that happen to capture a pathway will show very high velocities. The resulting velocity distribution will be highly skewed, with the median velocity below the mean and a small percentage of high-velocity observations. The observed distribution will in many ways resemble a log-normal distribution.

If, on the other hand, the preferential flow scale is small relative to the sample diameter, each sample will contain a mixture of preferential pathways and bulk soil. The ratio of the two will vary from sample to sample, but since each sample represents a large random sampling from the same population, all the samples will exhibit similar properties. The observed velocity distribution will therefore resemble a normal distribution.

The statistics of the observed tracer velocity distribution do not rule out a log-normal distribution, but do indicate that a normal distribution is more likely (the W probability is 0.17 for normal vs. 0.07 for log-normal). This statistical indication, combined with the lack of high-velocity outliers, suggests a preferential flow scale significantly smaller than the 2.2 cm-diameter of the Veihmeyer tube used to collect samples. A lower limit to the scale of the preferential pathways is provided by Turney (1991), who investigated preferential flow of a tracer and of bromacil in intact and repacked soil columns using soil from MAC. She observed significant accelerated transport in intact soil columns, but far less accelerated transport in columns packed with dried and sieved soil. Since this treatment destroyed the preferential pathways, they must be larger than a single soil grain, which eliminates intra-particle micropores within the actual mineral structure of the soil. This leaves inter-particle pores that are probably on the same scale as the soil particles, approximately 0.1 to 1.0 mm. We may therefore conclude that the primary cause of the observed accelerated transport is flow through pore-scale preferential pathways.

Peak Location Variability

The observed core-to-core variability in peak location and therefore solute velocity represents the sum of four major sources of variability. First, as just discussed, each sample contains a random mixture of pathways with different velocities. This random sampling will introduce a certain variability. Second, the soil hydraulic properties will exhibit a certain spatial heterogeneity, leading to variable flow rates even with uniform irrigation and evapotranspiration. Third, irrigation and ET were not perfectly uniform throughout the site. Finally, a factor that affects only the observed herbicide velocities is spatial heterogeneity in the soil's sorption properties.

Of these four, only the last is easy to quantify. By comparing the CVs for the herbicide velocities (29% for bromacil, 38% for napropamide, and 31% for prometryn) and the tracer velocity CV (21%), it seems that roughly one third to one half the observed herbicide velocity variability is due to sorption variability. The remaining variability must be attributed to soil and net infiltration variations across the plots.

Recovery Variability

The observed solute mass recoveries were quite variable, with CVs ranging from 45 - 65%. This variability represents contributions from four sources: application variability, physical transport effects, degradation variability for the herbicides, and variability in the extraction and analysis procedures. Application variability was measured at about 21% at the 9-cm diameter petri dish scale, and is probably only slightly greater at the 2.2-cm soil sample scale (Rice and Bowman, 1988). Extraction and analysis variability has been estimated at 5-15%. Herbicide recoveries are no more variable than tracer recoveries, suggesting that degradation rate variability is not a major contributor to recovery variability. This leaves approximately 20-30% variability attributable to subsurface processes, including leaching out of the profile and converging or diverging (multi-dimensional) flowpaths.

Second-Order Effects

Lower than Expected Dispersivity Values

This observation obviously depends on our dispersivity expectations. Unlike the velocity and retardation factor, we have no independent method of estimating dispersivity, but must instead make a prediction based on literature values under similar conditions. Dispersivity was estimated at 10 cm based on the relatively homogeneous soil at the site and the 270-cm scale of the sampled profile. Rice et al. (1986) conducted a bromide transport test at MAC and reported dispersion coefficient and velocity data that indicate average dispersivities were roughly 14-21 cm.

The geometric means of the fitted dispersivities in the present experiment range from 0.48 cm for the tracers to 6.7 cm for prometryn. These low values can be partially explained by comparing them to the dispersivities fitted to the field-averaged profiles, which, with the exception of napropamide as discussed above, range from 9.0 to 9.8 cm. This apparent increase in dispersivity was attributed to the spatial averaging process which incorporated macrodispersion caused by field-scale heterogeneities. The individual cores do not contain these heterogeneities, and the observed dispersion within a single core is due solely to hydrodynamic dispersion, quite low in this relatively homogeneous fine-loamy soil. Thus, the individual cores each act more like a column transport experiment than like a typical field study. In fact, the observed tracer dispersivities for the individual cores are very similar to Turney's (1991) intact column dispersivities of 0.5 and 0.8 cm, measured under steady-state unsaturated flow conditions with v = 3.1 cm/day. In summary, the low individual core dispersivities are due to the lack of macrodispersion and soil homogeneity at the core scale.

Solute/Solute Dispersion Variability

The lack of correlation between dispersivities fitted to the different solutes within each core is another reflection of the local nature of the hydrodynamic dispersion affecting each solute. As differential sorption separates the solutes, they spend different amounts of time in different soil environments with different hydrodynamic properties. The profile collected after 2 months of irrigation represents a single snapshot of an ongoing process, and reflects the varying histories of the different solutes. Macrodispersion dominates the observed dispersion in the field-averaged profile, and this averaging process tends to obscure the small-scale variability seen in the individual cores. As a result, dispersivities for the various solutes converge towards a single value.

Herbicide Tailing

Both visual inspection and the nonequilibrium CXTFIT runs suggest that the herbicide profiles show more tailing than the tracer profiles, and that among the herbicides, bromacil tails the most. Possible explanations include chemical nonequilibrium, sorption nonlinearity, and sorption hysteresis. A direct comparison of these alternatives would require the development of a numerical model that incorporates these processes, but some indirect evidence suggests that sorption nonlinearity may play a key role.

This indirect evidence is the greater tailing exhibited by bromacil. Bromacil does not stand out from the other herbicides either in kinetic sorption properties or in sorption hysteresis, both of which were determined during the laboratory sorption studies. Bromacil does, however, stand alone in its sorption nonlinearity. This suggests that perhaps the minor tailing exhibited by napropamide and prometryn is due to either kinetic or hysteresis effects (prometryn displays both the least tailing, as shown by the improvement in CXTFIT SSQs, and the least hysteresis, shown by the n_{sorp}/n_{des} ratio), while bromacil's nonlinear sorption causes far more tailing for that herbicide. Until a suitable code is available, this must remain speculative.

Third-Order Effects

Higher than Predicted Retardation Factors

The comparison of observed retardation factors and calculated factors based on laboratory distribution coefficients in Table 4-5 seems to show that observed Rs are consistently higher than predicted. An obvious explanation is spatial variability in the soil's sorption characteristics. The calculated Rs are based on laboratory studies all conducted using a single surface soil sample. Elabd et al. (1986) measured K_D values for napropamide and found a 31% CV in a single field. Slightly higher subsurface K_D values could easily lead to the observed discrepancy.

There is, however, an alternate explanation. As shown in Table 4-7, the four fluorobenzoate tracers are all anionic at the field soil water pH levels. Napropamide and prometryn are both neutral, and bromacil is mostly neutral, partially anionic. In a dual-tracer study conducted at USWCL, Bowman and Rice (1985) showed that anion exclusion led to anion velocity increases of just under 15%. The soil at MAC is more coarse-grained than that at USWCL, and anion exclusion is therefore likely to be less significant, but just for illustration let us consider the potential effect of anion exclusion on the observed retardation factors. If anion exclusion is forcing the anionic tracers to travel 15% faster than the average water velocity, than the average water velocity is 15% less than previously thought. The retardation factors are properly defined as the ratio of water velocity (rather than tracer velocity) to herbicide velocity, so decreasing the water velocity will cause a proportional decrease in the reported retardation factor. Table 4-14 shows the results of decreasing the observed Rs by 15% for napropamide and prometryn, and by 10% for bromacil (to allow for slight anion exclusion of this partially anionic herbicide). The resulting closer fit may well be coincidental, but suggests that although anion exclusion does not play a major role in this study, it may contribute to third-order effects.

Concentration and Interference Effects on Bromacil Retardation Factors

The differences in observed bromacil Rs under different treatments are well-correlated to those

Table 4-14. Predicted Herbicide Retardation Factors, Corrected for 10% - 15% Tracer Acceleration Due to Anion Exclusion.

	Retardation Factor		
	Predicted from Lab K Values	Prediction Adjusted for Anion Exchange	Geometric Mean of Observed Values
Bromacil			
Low Concentration, with Competition	1.61	1.77	1.80
High Concentration, without Competition	1.66	1.83	1.93
High Concentration, with Competition	1.50	1.65	1.53
Napropamide			
Without Competition	8.02	9.22	8.52
With Competition	6.98	8.03	10.36
Prometryn			
All Cases	3.59	4.13	4.27

predicted using the linearized laboratory partition coefficients (Table 4-2), although the observed differences are roughly twice those predicted. The same caveats just discussed on comparing sorption data from a single surface soil sample to the whole experiment apply here as well, and the results may well be fortuitous. Nevertheless, the correlation with the laboratory predictions suggests that the minor concentration and interference effects seen in the lab do have an effect at the field scale.

The laboratory sorption studies also demonstrated interference effects on napropamide sorption, which were not observed in the field study. This apparent lack of field-scale expression does not detract from the bromacil data, however, because napropamide differs from bromacil in two important respects. The laboratory data showing sorption interference are less convincing for napropamide than for bromacil (Fig. 3-3), and as discussed previously, napropamide's high retardation and low Peclet number leads to other distortions of napropamide transport. In summary, this experiment provides some evidence of field-scale interference and concentration effects on bromacil transport, but these effects require additional experimental confirmation.

Concentration and Interference Effects on Napropamide Recovery

Despite the variability in the herbicide recovery rates, the Tukey-Kramer test indicated significant variations in napropamide recovery as function of concentration and interference. Average napropamide recovery was over twice as high (suggesting reduced degradation) when applied at low concentration in the presence of the other herbicides as when applied alone at high concentration. One possible explanation is a soil microbe that can use napropamide as a food source, but that is inhibited by the other herbicides. The presence of the other herbicides would therefore reduce the degradation rate of napropamide, while high napropamide concentrations would permit higher microbe populations and faster degradation. Other explanations are certainly possible, and could be investigated with laboratory degradation studies.

SENSITIVITY OF RESULTS TO MEASUREMENT UNCERTAINTY

This project involved many different types of measurements, each of which has some associated uncertainty. If this uncertainty has introduced significant or systematic errors into the results, some of the conclusions presented in this chapter may be questionable. In this section, I shall discuss three possibly significant sources of error and their potential impacts on the conclusions of the project. This discussion is obviously not exhaustive, but the three topics were chosen for their particular uncertainty.

Evapotranspiration Estimate

Because the ET estimate determines v_a, the average pore-water velocity, it is critical to the accelerated transport results. As mentioned previously, the meteorology instruments and data logger were plagued by problems during the experiment, and the ET estimate may therefore not be completely reliable.

ET was estimated using a complex energy balance method which relies on measurements of numerous soil properties. The total precipitation/irrigation estimate, on the other hand, was based on actual flow measurements during irrigation and a nearby precipitation gauge, far more reliable than the ET instruments. The precipitation/irrigation estimate is therefore probably quite reliable. We can use this number to construct a "worst-case" scenario to judge the sensitivity of the conclusions to errors in the ET estimate.

For our conclusions on accelerated transport, the worst-case scenario would be no ET whatsoever. In the absence of ET, all the applied precipitation and irrigation water would infiltrate. As discussed in Chapter 3, the total water applied during a 75-day period including the transport experiment was 43.5 cm, for an average of 0.58 cm/day. This infiltration rate, combined with the overall average field water content of 0.226, would produce an average downward pore-water velocity of 2.57 cm/day, close to the average observed tracer velocity of 2.78 cm/day (Table 3-9). In this scenario, the average β factor would be 1.08, far less conclusive evidence of accelerated transport than the β factor of 1.96 obtained using the calculated ET estimates. Zero ET is obviously not a reasonable assumption, but this exercise has demonstrated that near-zero ET is required to eliminate evidence for accelerated transport. We can therefore conclude that although our ET estimate may be somewhat in error, any significant ET during the field study would indicate some degree of accelerated transport.

Soil Bulk Density

The laboratory analyses yielded solute concentrations on a soil mass basis, while both the transport model and recovery calculations require volume-based concentrations. The conversion factor between the two is the soil bulk density, which as mentioned in Chapter 2, was not measured during this project. Instead, a 2.1-m profile measured by Rice et al. (1986) in a nearby field within MAC was used. Turney (1991) collected a 30-cm core from the irrigated border area of this project (Fig. 2-2), and measured a soil bulk density of 1.61-1.65 g/cm^3, about 10% higher than the 1.48 g/cm^3 value reported by Rice et al. (1986) for the 0 - 30-cm depth interval. A 10% range encompasses almost all the variability observed in the 1986 core (1.48 - 1.68 g/cm^3), and may represent close to the maximum variability expected. Let us consider what effect a 10% error in soil bulk density might have on the conclusions of this project.

A 10% error in the soil bulk density would lead to a parallel 10% error in the volumetric soil concentration (Eq. 2-1). This could obviously affect the solute recovery data, particularly if an entire soil core erred consistently in the same direction. However, under this scenario, the maximum recovery error is 10%, which is not overwhelming compared to the 21% application rate CV or the 45% - 65% overall recovery CVs. The recovery results in this project are quite variable, and have been interpreted accordingly. Therefore, we may conclude that an additional 10% variation due to bulk density uncertainty does not significantly alter those conclusions based on recovery data.

The same 10% concentration error might also affect estimated transport parameters. However, the location and shape of the observed solute peaks are generally quite well-defined in the concentration profiles (see, for example, appendices P, R, or T), and changing the concentration at any given point or collection of points by 10% will actually have very little effect on the overall peak, and therefore on the fitted transport parameters. While specific parameter values would be altered by such a change, the overall patterns and conclusions would remain intact.

Bromacil Analysis Difficulties

Bromacil proved to be somewhat challenging to quantify in the soil samples. Of the three herbicides, bromacil required the most rigorous extraction/concentration method, and was also most susceptible to degradation on the GC column. These difficulties are reflected in the higher bromacil CVs observed in the spiked soil analysis (Table 3-5), and may contribute to the anomalous recovery values both from the spiked soil (115 - 139%) and from the field experiment (124%). Another possible explanation for these recovery data is a mislabeled analytical bromacil standard obtained from the manufacturer. Whatever the cause, these strange recovery values may confuse those conclusions based on overall recovery rates, but just as in the case of soil bulk density, these difficulties have little effect on the overall shape of the bromacil peaks, and correspondingly little effect on the fitted transport parameters.

V

SUMMARY AND CONCLUSIONS

SUMMARY

This project has produced a set of data describing the field-scale fate and transport of nonreactive tracers and three sorbed herbicides through the vadose zone under intermittent flood irrigation. It is hoped that these data will prove useful to other researchers in the field by providing real-world observations for the validation of solute transport models and insights into nonideal transport processes.

Analysis of these data point out the strengths and weaknesses in our current ability to predict vadose-zone transport. The most glaring result is that a prediction based on a net infiltration rate estimate would underestimate solute transport by a factor of 2. This strong degree of accelerated transport is due to pore-scale preferential flow.

Although preferential flow seriously undermines our ability to predict absolute solute velocities, relative velocities, as expressed by retardation factors, can be reasonably well-predicted using laboratory sorption studies. This indicates that field measurements of tracer velocities may enable improved estimates of sorbed-solute velocities.

Local dispersion parameters are extremely variable and seemingly uncorrelated from one solute to another. Furthermore, the local dispersion coefficient shows no correlation to local tracer velocity. Therefore, localized field measurements of tracer dispersion will not enable satisfactory dispersion estimates for other solutes. At the field scale, on the other hand, dispersion is dominated by macrodispersion caused by soil heterogeneities. Macrodispersion causes the field-averaged profile to exhibit increased dispersion, and more importantly, in the field-averaged profiles the different solutes exhibit similar dispersion parameters. This suggests that field-averaged tracer dispersion data, such as may be obtained by monitoring tile drains, can enable satisfactory estimation of the field-averaged dispersion of other solutes.

Bromacil, and to a lesser extent the other herbicides, exhibited more peak-tailing than did the tracers. This suggests that some nonideal chemical process, perhaps sorption nonlinearity or hysteresis, affects reactive solute transport. Further study of this phenomenon will require implementation of numerical transport codes that include these processes.

The method of moments proved to be a reasonable and efficient way of determining solute velocities from the observed concentration profiles, but was too sensitive to data outliers to provide useful estimates of dispersion parameters or peak asymmetry.

CONCLUSIONS

- All solutes in the field experiment moved on the average twice as fast as predicted using net infiltration rates. This accelerated transport is caused by pore-scale preferential flow.

- Laboratory batch sorption studies predicted the relative velocities of the solutes reasonably well.

- Dispersion parameters are highly variable and uncorrelated at the local core-scale, but are more predictable at the field-averaged scale.

- Bromacil sorption nonlinearity and solute/solute interactions appear to affect the observed field retardation factors and bromacil peak tailing.

- Sorption hysteresis or nonequilibrium may play a role in the observed herbicide tailing.

- No convincing evidence of physical nonequilibrium processes is apparent, perhaps due to the limited spatial resolution of the tracer peaks.

- Anion exclusion plays at most a minor role in affecting solute transport.

- 10% of the observed profiles show some evidence of bimodal herbicide distributions.

- Roth et al. (1991) were right: "Experiments in natural soils are inherently expensive and laborious...."

SUGGESTIONS FOR FURTHER RESEARCH

- Additional analysis of the solute profiles using a numerical code capable of modeling sorption nonlinearity and hysteresis.

- Analysis of the individual core data and the field-averaged profiles from a geostatistical viewpoint. The apparent macrodispersion demonstrated in the field-averaged profiles may yield useful information on the spatial correlation structure of the transport parameters.

- Transient analysis of the data to determine the validity of the steady-state flow assumption.

- Additional laboratory batch sorption studies to confirm and further investigate the apparent solute/solute interactions.

- Additional laboratory batch sorption studies to confirm and further investigate the apparent sorption hysteresis.

- Laboratory degradation studies to investigate the apparent effect of concentration and other herbicides on napropamide degradation.

- Continued improvement in efficiency, precision, and detection limits of the extraction and analytical methods, in order to improve future field studies.

- Additional field studies to determine effects of irrigation mode (flood, drip, or sprinkler) and frequency on accelerated tracer transport.

- Additional field studies to determine effects of soil condition (cropped vs. uncropped, cultivated vs. undisturbed) on accelerated tracer transport.

- Additional field studies specifically designed to study bimodal solute profiles.

- Detailed small-scale soil studies to investigate mechanisms of preferential flow. Possible avenues of research include microscope, X-ray, or computerized tomography examination of the transport of a suitable dye and column studies of the effects of different fluid and soil properties (e.g. surface tension, wettability) on preferential flow.

VI

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APPENDIX A

Abbreviations and Notation

ABBREVIATIONS

2,6-DFBA : 2,6-difluorobenzoic acid - a nonreactive tracer

ADE : Advection-Dispersion Equation

CV : Coefficient of Variation (one standard deviation divided by the mean for three or more samples, one half the range divided by the mean for two samples)

CXTFIT : An analytical transport model (Parker and van Genuchten, 1984)

ET : Evapotranspiration

GC : Gas Chromatograph, Gas Chromatography

GLM : General Linear Model - an SAS statistical analysis procedure

HPLC : High-Pressure Liquid Chromatography

LSC : Liquid Scintillation Counting

m-TFMBA : *meta*-trifluoromethylbenzoic acid - a nonreactive tracer

MAC : Maricopa Agricultural Center, Maricopa, AZ

NMT : New Mexico Institute of Mining and Technology (New Mexico Tech), Socorro, NM

o-TFMBA : *ortho*-trifluoromethylbenzoic acid - a nonreactive tracer

PFBA : pentafluorobenzoic acid - a nonreactive tracer

SAS : A commercial statistical analysis software package

S.E. : Standard Error in CXTFIT parameter estimates

SD : Standard Deviation

SPE : Solid Phase Extraction, method used in soil herbicide analysis

SSQ : Sum of Squares, indicating poorness of fit of CXTFIT profiles

USWCL : U.S. Water Conservation Laboratory, Phoenix, AZ

NOTATION

α = Dispersivity [L]

β = CXTFIT nonequilibrium fitting parameter [ ] (chapter 3)

β = Degree of accelerated transport [ ] (chapter 4)

δ = "Volumetric dispersivity" [L] (see Appendix K)

θ = Volumetric water content $[L^3/L^3]$

θ_i = Water content in *i*th sample in core [ ]

$\bar{\theta}$ = Volume averaged water content for core [ ]

μ = First-order degradation rate [1/T]

ρ_B = Soil bulk density $[M/L^3]$

ρ_W = Soil moisture density $[M/L^3]$ ($\approx$ 1 g/cm^3)

χ = Volumetric coordinate [L] (see Appendix K)

ω = CXTFIT nonequilibrium fitting parameter [ ]

C = Solution concentration $[M/L^3]$

C_0 = Fitted input solute concentration $[M/L^3]$

C_E = Herbicide concentration in final extract $[M/L^3]$

C_i = Solute concentration in *i*th sample in core $[M/L^3]$

C_i = Concentration of interest $[M/L^3]$ (isotherm linearization)

C_S = Soil herbicide concentration (per volume soil) $[M/L^3]$

D = Dispersion coefficient $[L^2/T]$

K_D = Linear distribution coefficient $[L^3/M]$

K_F = Freundlich isotherm parameter [*]

K_{L1} = "Marginal" linearized distribution coefficient $[L^3/M]$

K_{L2} = "Average" linearized distribution coefficient $[L^3/M]$

K_{L3} = "Equal-Area" linearized distribution coefficient $[L^3/M]$

K_{OC} = Organic carbon distribution coefficient $[L^3/M]$

K_{OW} = Octanol-water partitioning coefficient [ ]

L = Solute loss rate $[M/L^3T]$

---

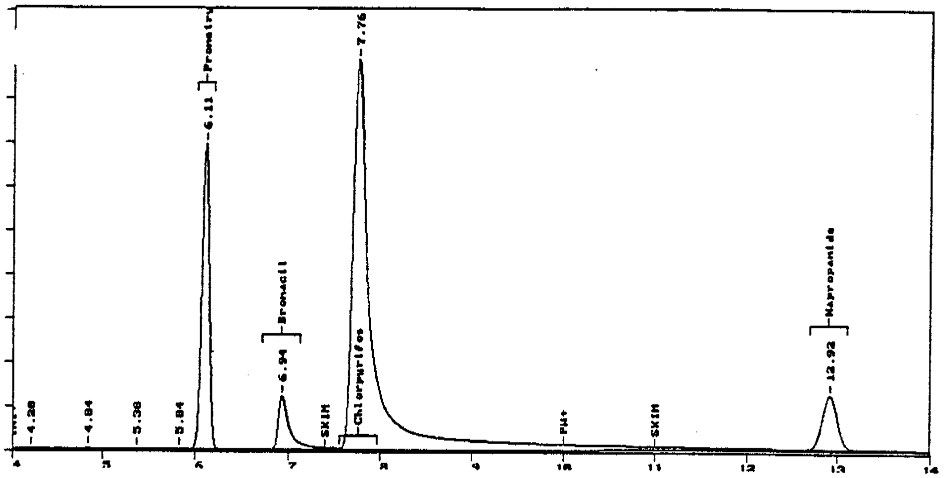
* The dimensions of K_F are problematic (Bowman, 1981). Throughout this paper, K_F is based on C in μg/mL, S in μg/g.

M_A = Average actual application rate of solute $[M/L^2]$
M_F = Total solute mass in fitted profile $[M/L^2]$
M_R = Total solute mass recovered in core $[M/L^2]$
M_T = Total mass of soil sample at field moisture content [M]
m_n = *n*th moment $[ML^{n-2}]$
m_n^* = Normalized *n*th moment $[L^n]$
n = Freundlich isotherm parameter [ ]
P = Peclet number [ ]
q = Specific discharge (Darcy velocity) [L/T]
R = Retardation factor [ ]
R_i = Retardation factor of solute *i* (= v_t/v_i) [ ]
Rec = Fractional recovery of solute [ ]
S = Sorbed concentration [M/M]
Sk = Skewness of a profile or distribution [ ]
t = Time [T]
t^* = Time available for degradation [T] (= $t - t_0/2$)
t_0 = Input pulse width [T] (= 14 days)
$T_{1/2}$ = Degradation half-life [T]
v = Velocity [L/T]
v_a = Average pore water velocity [L/T]
v_i = Velocity of solute *i* [L/T]
v_t = Fitted tracer velocity [L/T]
V_C = Volume of supernatant collected during extraction $[L^3]$
V_E = Volume of extract eluted from SPE column $[L^3]$
V_M = Volume of methanol/water extractant added during extraction $[L^3]$
w = Soil gravimetric water content [M/M]
z = Distance [L]
z_i = Depth below surface of center of *i*th sample in core [L]
Δz_i = Thickness of *i*th sample in core [L]

APPENDIX B

Example Chromatograms

File=e:\blue\SMPL13.39R Date printed = 05-16-1991 Time = 11:07:04
4.00 to 14.00 min. Low Y = 0.53450 mv High Y = 41.30410 mv Span = 40.76959 mv

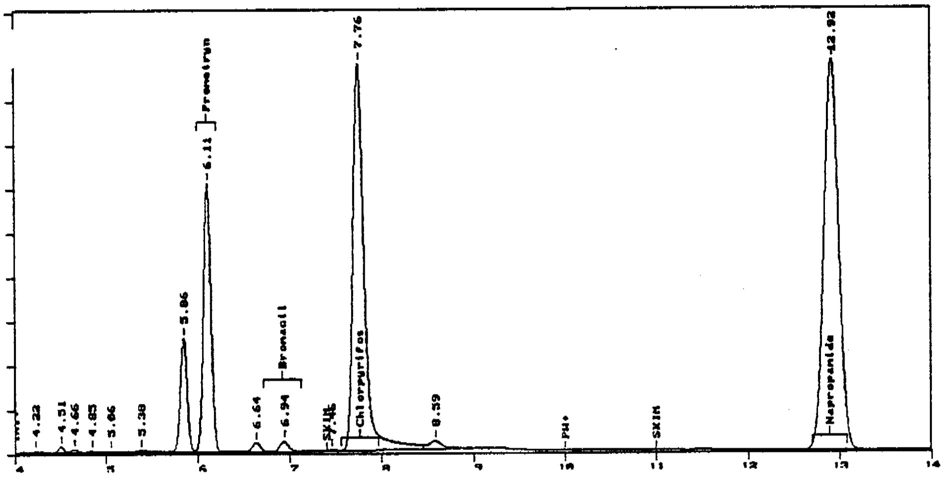


Temp 250,200,250. 10 ml/min, 10:1, 5 inj.
Starts on Integ #15. Fused-Si packed cyclosplitter
Data file = e:\blue\SMPL13.39R
Date stamp = 05/15/91 Time = 22:09:06
Sample name = 40 ppm std
Collected on MAY 15, 1991 21:55:06 from port # 1
Operator = Jake
Reference file name = Q2A1913B.BNC
Instrument = HP 5890
Method name = e:\blue\smpl-c.MET version # 7
Date method last modified = 05/15/91 Time = 13:36:58
Calibration file = e:\blue\CAL-C.CAL version # 41
Date cal file last modified = 05/16/91 Time = 03:50:26
Run time = 14.00 minutes Area reject = 0
Amount injected = 1 Dilution Factor = 1
Sample Weight = 1 Internal Standard Amount = 0
Sampling rate = 10 per second Starting peak width = .08 minutes
Peak detect threshold = -4
Chrom-Perfect Software Serial number = 9110 Version = 4.01 For New
Today's date = 05-16-1991 Time = 11:07:15

PK	Ret Time	Name	Amount	Amount %	Area	Area %	Type	Width	Height	Height %
1	4.205		0.0000	0.0000%	97.7	0.012%	BB	0.115	14.18	0.0192%
2	4.838		0.0000	0.0000%	390.8	0.047%	BV	0.076	86.08	0.1167%
3	5.375		0.0000	0.0000%	76.5	0.009%	VB	0.138	9.24	0.0125%
4	5.835		0.0000	0.0000%	85.2	0.010%	BV	0.081	17.47	0.0237%
5	6.110	Prometryn	40.7269	25.5363%	154,827.6	18.747%	VB	0.092	28,037.57	37.9944%
6	6.937	Bromacil	38.4379	24.1010%	42,664.0	5.166%	BV	0.145	4,905.98	6.6482%
7	7.762	Chlorpyrifos	40.3979	25.3299%	571,216.2	69.164%	SBB	0.266	35,791.00	48.5012%
8	12.920	Napropamide	39.9240	25.0328%	56,530.0	6.845%	TVB	0.191	4,932.49	6.6841%

Total area = 825887.9 Total amount = 159.4867 Sample units = ug / ml Total height = 73794.02

```
File=e:\blue\SMPL13.44R  Date printed = 05-16-1991 Time = 11:09:26
  4.00 to  14.00 min.  Low Y =      0.67974 mv    High Y =      7.35556 mv      Span =       6.67581 mv
```



```
Temp 250,200,250.  10 ml/min, 10:1, 5 inj.
Starts on Integ #15.  Fused-Si packed cyclosplitter
Data file = e:\blue\SMPL13.44R
    Date stamp = 05/15/91 Time = 23:26:34
Sample name = 2-1-30
Collected on MAY 15, 1991  23:12:34   from port # 1
Operator =    Jake
Reference file name = Q2A1A363.BNC
Instrument = HP 5890
Method name = e:\blue\smpl-c.MET  version # 7
    Date method last modified = 05/15/91 Time = 13:36:58
Calibration file = e:\blue\CAL-C.CAL version # 41
    Date cal file last modified = 05/16/91 Time = 03:50:26
Run time =   14.00 minutes   Area reject =              0
Amount injected =  1    Dilution Factor =  1
Sample Weight =  1    Internal Standard Amount =  0
Sampling rate =  10  per second  Starting peak width =  .08  minutes
Peak detect threshold = -4
Chrom-Perfect Software Serial number =  9110 Version =  4.01 For New
Today's date = 05-16-1991   Time = 11:09:38

PK Ret Time      Name                     Amount  Amount %        Area    Area % Type   Width        Height  Height %
 1   4.223                                0.0000   0.0000%       136.6    0.089% BB     0.119         19.11   0.1060%
 2   4.513                                0.0000   0.0000%       359.5    0.235% BV     0.069         86.60   0.4802%
 3   4.658                                0.0000   0.0000%       204.1    0.133% VV     0.072         46.95   0.2603%
 4   4.853                                0.0000   0.0000%        97.1    0.063% VV     0.087         18.55   0.1029%
 5   5.062                                0.0000   0.0000%        77.6    0.051% VV     0.147          8.78   0.0487%
 6   5.382                                0.0000   0.0000%       239.9    0.157% VV     0.146         27.38   0.1518%
 7   5.855                                0.0000   0.0000%     8,805.6    5.746% VV     0.086      1,703.17   9.4452%
 8   6.112 Prometryn                      5.2127   9.1499%    22,533.1   14.704% VV     0.093      4,021.27  22.3006%
 9   6.638                                0.0000   0.0000%       865.5    0.565% VB     0.106        136.59   0.7575%
10   6.940 Bromacil                       0.9189   1.6129%     1,015.2    0.662% BV     0.111        151.92   0.8425%
11   7.458                                0.0000   0.0000%        99.7    0.065% SBB    0.151         10.98   0.0609%
     7.757 Chlorpyrifos                   4.2420   7.4459%    50,870.9   33.196% TVV    0.146      5,814.21  32.2436%
13   8.588                                0.0000   0.0000%     1,495.4    0.976% TVB    0.204        122.42   0.6789%
14  12.918 Napropamide                   46.5968  81.7912%    66,443.5   43.358% BB     0.189      5,864.19  32.5208%
Total area =  153243.6    Total amount =  56.97036   Sample units = ug / ml      Total height =  18032.13
```

APPENDIX C

Single-Stage Sorption/Desorption Results

SORPTION / DESORPTION

BROMACIL

Stock Solution Preparation: 125.10 mg
99.80% purity
in 250 ml
Stock Solution : 499.40 mg/l

C-14 solution: 400.00 mg/l
Soil Moisture: 2.0%

****

Tube Set: A

Concentration relative to stock: 1.000
C-14 spike:
25.00 ul, added to 50.00 ml

Actual sol'n concentration: 499.60 mg/l
Average CPM of solution: 12171.50

		Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	EQUILIBRIUM	
								Liq Conc (mg/l)	Sorbed Conc (ug/g)
Tube A1		1	0.00	0.00	10.00	499.60	11108.30	455.96	35.18
10.01	g soil	2	5.00	455.96	5.00	0.00	5964.23	244.81	22.33
		3	5.00	244.81	5.00	0.00	3183.83	130.69	16.22
Tube A2		1	0.00	1.00	10.00	499.60	11121.10	456.48	34.59
10.02	g soil	2	5.00	456.48	5.00	0.00	5888.43	241.70	25.27
		3	5.00	241.70	5.00	0.00	3143.43	129.03	19.24
Tube A3		1	0.00	1.00	10.00	499.60	11244.30	461.54	28.99
10.11	g soil	2	5.00	461.54	5.00	0.00	5831.23	239.35	24.87
		3	5.00	239.35	5.00	0.00	3194.83	131.14	15.51

****

Tube Set: B

Concentration relative to stock: 0.400
C-14 spike:
25.00 ul, added to 45.00 ml

Actual sol'n concentration: 199.98 mg/l
Average CPM of solution: 13764.80

		Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	Liq Conc (mg/l)	Sorbed Conc (ug/g)
Tube B1		1	0.00	1.00	10.00	199.98	12440.00	180.73	15.99
9.98	g soil	2	5.00	180.73	5.00	0.00	6603.83	95.94	12.02
		3	5.00	95.94	5.00	0.00	3687.43	53.57	7.16
Tube B2		1	0.00	1.00	10.00	199.98	12491.50	181.48	15.21
9.98	g soil	2	5.00	181.48	5.00	0.00	6631.03	96.34	11.23
		3	5.00	96.34	5.00	0.00	3575.43	51.95	8.27
Tube B3		1	0.00	1.00	10.00	199.98	12579.10	182.76	13.85
10.00	g soil	2	5.00	182.76	5.00	0.00	6610.83	96.05	10.85
		3	5.00	96.05	5.00	0.00	3599.43	52.29	7.39

****

Tube Set: C

Concentration relative to stock: 0.100
C-14 spike:
25.00 ul, added to 45.00 ml

Actual sol'n concentration: 50.16 mg/l
Average CPM of solution: 13715.80

		Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	Liq Conc (mg/l)	Sorbed Conc (ug/g)
Tube C1		1	0.00	1.00	10.00	50.16	12194.50	44.60	4.76
10.01	g soil	2	5.00	44.60	5.00	0.00	6690.23	24.47	2.96
		3	5.00	24.47	5.00	0.00	3576.23	13.08	2.33
Tube C2		1	0.00	1.00	10.00	50.16	12699.90	46.45	2.84
10.00	g soil	2	5.00	46.45	5.00	0.00	6538.83	23.91	2.60
Tube C3		1	0.00	1.00	10.00	50.16	12682.80	46.38	2.91
9.99	g soil	2	5.00	46.38	5.00	0.00	6575.23	24.05	2.49
		3	5.00	24.05	5.00	0.00	3683.83	13.47	1.23

SORPTION / DESORPTION

BROMACIL

Stock Solution Preparation: 125.10 mg
99.80% purity
in 250 ml

Stock Solution : 499.40 mg/l

C-14 solution: 400.00 mg/l
Soil Moisture: 2.0%

****

Tube Set: D

Concentration relative to stock: 0.040
C-14 spike:
25.00 ul, added to 45.00 ml

Actual sol'n concentration: 20.20 mg/l
Average CPM of solution: 13623.20

Tube		Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	EQUILIBRIUM Liq Conc (mg/l)	EQUILIBRIUM Sorbed Conc (ug/g)
Tube D1		1	0.00	1.00	10.00	20.20	12180.00	18.06	1.81
10.01	g soil	2	5.00	18.06	5.00	0.00	6575.63	9.75	1.25
		3	5.00	9.75	5.00	0.00	3615.43	5.36	0.84
Tube D2		1	0.00	1.00	10.00	20.20	12454.60	18.47	1.38
10.05	g soil	2	5.00	18.47	5.00	0.00	6626.43	9.82	0.96
		3	5.00	9.82	5.00	0.00	3577.23	5.30	0.65
Tube D3		1	0.00	1.00	10.00	20.20	12435.60	18.44	1.40
10.09	g soil	2	5.00	18.44	5.00	0.00	6419.83	9.52	1.28
		3	5.00	9.52	5.00	0.00	3556.03	5.27	0.85

****

Tube Set: E

Concentration relative to stock: 0.010
C-14 spike:
25.00 ul, added to 50.00 ml

Actual sol'n concentration: 5.19 mg/l
Average CPM of solution: 11971.10

Tube		Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	EQUILIBRIUM Liq Conc (mg/l)	EQUILIBRIUM Sorbed Conc (ug/g)
Tube E1		1	0.00	1.00	10.00	5.19	10659.00	4.62	0.49
9.99	g soil	2	5.00	4.62	5.00	0.00	5735.03	2.49	0.35
		3	5.00	2.49	5.00	0.00	3188.83	1.38	0.23
Tube E2		1	0.00	1.00	10.00	5.19	10501.60	4.56	0.56
9.99	g soil	2	5.00	4.56	5.00	0.00	5622.23	2.44	0.44
		3	5.00	2.44	5.00	0.00	3201.43	1.39	0.29
Tube E3		1	0.00	1.00	10.00	5.19	10801.30	4.69	0.42
10.00	g soil	2	5.00	4.69	5.00	0.00	5692.03	2.47	0.34
		3	5.00	2.47	5.00	0.00	3227.43	1.40	0.19

****

Tube Set: F

Concentration relative to stock: 0.004
C-14 spike:
25.00 ul, added to 50.00 ml

Actual sol'n concentration: 2.20 mg/l
Average CPM of solution: 11923.70

Tube		Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	EQUILIBRIUM Liq Conc (mg/l)	EQUILIBRIUM Sorbed Conc (ug/g)
Tube F1		1	0.00	1.00	10.00	2.20	10532.60	1.94	0.22
10.11	g soil	2	5.00	1.94	5.00	0.00	5624.23	1.04	0.17
		3	5.00	1.04	5.00	0.00	3255.23	0.60	0.10
Tube F2		1	0.00	1.00	10.00	2.20	10617.00	1.96	0.21
10.02	g soil	2	5.00	1.96	5.00	0.00	5492.23	1.01	0.19
		3	5.00	1.01	5.00	0.00	3151.03	0.58	0.12
Tube F3		1	0.00	1.00	10.00	2.20	10340.10	1.91	0.26
9.98	g soil	2	5.00	1.91	5.00	0.00	5717.23	1.05	0.17
		3	5.00	1.05	5.00	0.00	3133.63	0.58	0.13

SORPTION / DESORPTION

NAPROPAMIDE

Stock Solution Preparation: 12.30 mg
99.00% purity
in 250 ml
Stock Solution : 48.71 mg/l

C-14 solution: 22.00 mg/l
Soil Moisture: 2.0%

											EQUILIBRIUM	
					Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	Liq Conc (mg/l)	Sorbed Conc (ug/g)
***												
Tube Set: A			Tube A1		1	0.00	1.00	10.00	48.82	4490.57	23.08	25.74
			10.02	g soil	2	4.00	23.08	4.00	0.00	3750.10	19.27	20.29
Concentration relative to stock:	1.000				3	3.00	19.27	3.00	0.00	3042.00	15.63	18.19
C-14 spike:												
250.00 ul, added to	50.00	ml										
			Tube A2		1	0.00	1.00	10.00	48.82	4690.61	24.11	24.75
Actual sol'n concentration:	48.82	mg/l	9.99	g soil	2	3.00	24.11	3.00	0.00	3875.30	19.92	21.73
Average CPM of solution:	9499.29				3	3.00	19.92	3.00	0.00	3262.50	16.77	18.91
			Tube A3		1	0.00	1.00	10.00	48.82	4634.87	23.82	25.05
			9.99	g soil	2	4.00	23.82	4.00	0.00	3595.90	18.48	20.88
					3	3.00	18.48	3.00	0.00	2983.40	15.33	18.50
***												
Tube Set: B			Tube B1		1	0.00	1.00	10.00	19.61	5791.43	9.87	9.72
			10.01	g soil	2	3.00	9.87	3.00	0.00	4664.87	7.95	8.70
Concentration relative to stock:	0.400				3	3.00	7.95	3.00	0.00	4025.31	6.86	7.40
C-14 spike:												
250.00 ul, added to	45.00	ml										
			Tube B2		1	0.00	1.00	10.00	19.61	5916.00	10.08	9.49
Actual sol'n concentration:	19.61	mg/l	10.02	g soil	2	3.00	10.08	3.00	0.00	4858.81	8.28	8.28
Average CPM of solution:	11503.80				3	3.00	8.28	3.00	0.00	4027.82	6.86	7.22
			Tube B3		1	0.00	1.00	10.00	19.61	5988.19	10.21	9.35
			10.03	g soil	2	3.00	10.21	3.00	0.00	4781.18	8.15	8.37
					3	3.00	8.15	3.00	0.00	3888.80	6.63	7.47
***												
Tube Set: C			Tube C1		1	0.00	1.00	10.00	4.99	5767.03	2.53	2.46
			10.00	g soil	2	3.00	2.53	3.00	0.00	4895.51	2.15	2.09
Concentration relative to stock:	0.100				3	3.00	2.15	3.00	0.00	3886.30	1.70	1.89
C-14 spike:												
250.00 ul, added to	45.00	ml										
			Tube C2		1	0.00	1.00	10.00	4.99	5803.82	2.54	2.44
Actual sol'n concentration:	4.99	mg/l	10.03	g soil	2	3.00	2.54	3.00	0.00	4791.28	2.10	2.12
Average CPM of solution:	11392.00				3	3.00	2.10	3.00	0.00	3867.00	1.69	1.90
			Tube C3		1	0.00	1.00	10.00	4.99	5963.11	2.61	2.38
			9.99	g soil	2	3.00	2.61	3.00	0.00	4670.65	2.05	2.17
					3	3.00	2.05	3.00	0.00	3918.10	1.72	1.88

SORPTION / DESORPTION

NAPROPAMIDE

Stock Solution Preparation: 12.30 mg
99.00% purity
in 250 ml
Stock Solution : 48.71 mg/l

C-14 solution: 22.00 mg/l
Soil Moisture: 2.0%

* * *

Tube Set: D

Concentration relative to stock: 0.040
C-14 spike:
250.00 ul, added to 45.00 ml

Actual sol'n concentration: 2.07 mg/l
Average CPM of solution: 11369.50

	Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	EQUILIBRIUM	
							Liq Conc (mg/l)	Sorbed Conc (ug/g)
Tube D1	1	0.00	1.00	10.00	2.07	5682.87	1.03	1.03
10.03 g soil	2	3.00	1.03	3.00	0.00	4645.61	0.85	0.91
	3	3.00	0.85	3.00	0.00	3795.10	0.69	0.82
Tube D2	1	0.00	1.00	10.00	2.07	5866.95	1.07	1.00
9.99 g soil	2	3.00	1.07	3.00	0.00	4565.92	0.83	0.92
	3	3.00	0.83	3.00	0.00	3700.80	0.67	0.83
Tube D3	1	0.00	1.00	10.00	2.07	5763.40	1.05	1.02
10.05 g soil	2	3.00	1.05	3.00	0.00	4590.90	0.84	0.92
	3	3.00	0.84	3.00	0.00	3730.30	0.68	0.82

* * *

Tube Set: E

Concentration relative to stock: 0.010
C-14 spike:
250.00 ul, added to 50.00 ml

Actual sol'n concentration: 0.60 mg/l
Average CPM of solution: 10675.50

	Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	Liq Conc (mg/l)	Sorbed Conc (ug/g)
Tube E1	1	0.00	1.00	10.00	0.60	5330.64	0.30	0.30
10.02 g soil	2	3.00	0.30	3.00	0.00	4269.59	0.24	0.27
	3	3.00	0.24	3.00	0.00	3380.10	0.19	0.25
Tube E2	1	0.00	1.00	10.00	0.60	5296.19	0.30	0.30
9.97 g soil	2	3.00	0.30	3.00	0.00	4213.12	0.24	0.27
	3	3.00	0.24	3.00	0.00	3532.70	0.20	0.24
Tube E3	1	0.00	1.00	10.00	0.60	5325.27	0.30	0.30
10.01 g soil	2	3.00	0.30	3.00	0.00	3956.50	0.22	0.29
	3	3.00	0.22	3.00	0.00	3467.40	0.19	0.25

* * *

Tube Set: F

Concentration relative to stock: 0.004
C-14 spike:
250.00 ul, added to 50.00 ml

Actual sol'n concentration: 0.30 mg/l
Average CPM of solution: 10764.60

	Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	Liq Conc (mg/l)	Sorbed Conc (ug/g)
Tube F1	1	0.00	1.00	10.00	0.30	5181.16	0.15	0.16
10.00 g soil	2	3.00	0.15	3.00	0.00	4241.44	0.12	0.14
	3	3.00	0.12	3.00	0.00	3362.50	0.10	0.13
Tube F2	1	0.00	1.00	10.00	0.30	5218.79	0.15	0.16
10.02 g soil	2	3.00	0.15	3.00	0.00	4115.94	0.12	0.14
	3	3.00	0.12	3.00	0.00	3414.90	0.10	0.13
Tube F3	1	0.00	1.00	10.00	0.30	5115.82	0.14	0.16
10.03 g soil	2	3.00	0.14	3.00	0.00	4106.79	0.12	0.15
	3	3.00	0.12	3.00	0.00	3337.20	0.09	0.13

SORPTION / DESORPTION

PROMETRYN

Stock Solution Preparation: 9.10 mg
99.00% purity
in 250 ml
Stock Solution : 36.04 mg/l

C-14 solution: 5000.00 mg/l
Soil Moisture: 2.0%

											EQUILIBRIUM	
					Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	Liq Conc (mg/l)	Sorbed Conc (ug/g)
**												
Tube Set:	A		Tube A1		1	0.00	0.00	10.00	38.54	3779.23	25.13	13.04
			10.09	g soil	2	3.00	25.13	3.00	0.00	3267.67	21.73	8.93
Concentration relative to stock:		1.000			3	3.00	21.73	3.00	0.00	2507.43	16.68	7.55
C-14 spike:												
25.00 ul, added to	50.00	ml										
			Tube A2		1	0.00	1.00	10.00	38.54	4252.13	28.28	9.88
Actual sol'n concentration:	38.54	mg/l	10.01	g soil	2	3.00	28.28	3.00	0.00	3263.43	21.70	8.07
Average CPM of solution:	5794.64				3	3.00	21.70	3.00	0.00	2543.43	16.91	6.41
			Tube A3		1	0.00	1.00	10.00	38.54	4097.64	27.25	10.90
			10.05	g soil	2	3.00	27.25	3.00	0.00	3283.63	21.84	8.21
					3	3.00	21.84	3.00	0.00	2525.73	16.80	6.78
**												
Tube Set:	B		Tube B1		1	0.00	1.00	10.00	16.91	5190.02	12.53	4.18
			10.10	g soil	2	3.00	12.53	3.00	0.00	3927.83	9.48	3.52
Concentration relative to stock:		0.400			3	3.00	9.48	3.00	0.00	3040.03	7.34	2.86
C-14 spike:												
25.00 ul, added to	50.00	ml										
			Tube B2		1	0.00	1.00	10.00	16.91	5156.59	12.45	4.31
Actual sol'n concentration:	16.91	mg/l	9.99	g soil	2	3.00	12.45	3.00	0.00	4020.46	9.70	3.35
Average CPM of solution:	7007.71				3	3.00	9.70	3.00	0.00	3063.43	7.39	2.79
			Tube B3		1	0.00	1.00	10.00	16.91	5187.24	12.52	4.24
			9.98	g soil	2	3.00	12.52	3.00	0.00	3995.41	9.64	3.40
					3	3.00	9.64	3.00	0.00	3046.13	7.35	2.83
**												
Tube Set:	C		Tube C1		1	0.00	1.00	10.00	6.10	5034.39	4.44	1.60
			10.03	g soil	2	3.00	4.44	3.00	0.00	3847.53	3.39	1.33
Concentration relative to stock:		0.100			3	3.00	3.39	3.00	0.00	2930.43	2.59	1.13
C-14 spike:												
25.00 ul, added to	50.00	ml										
			Tube C2		1	0.00	1.00	10.00	6.10	5118.09	4.52	1.53
Actual sol'n concentration:	6.10	mg/l	9.97	g soil	2	3.00	4.52	3.00	0.00	3884.43	3.43	1.28
Average CPM of solution:	6918.29				3	3.00	3.43	3.00	0.00	3032.53	2.68	1.02
			Tube C3		1	0.00	1.00	10.00	6.10	5067.64	4.47	1.57
			10.03	g soil	2	3.00	4.47	3.00	0.00	3824.63	3.37	1.34
					3	3.00	3.37	3.00	0.00	2983.63	2.63	1.08

SORPTION / DESORPTION

PROMETRYN

Stock Solution Preparation: 9.10 mg
99.00% purity
in 250 ml
Stock Solution : 36.04 mg/l

C-14 solution: 5000.00 mg/l
Soil Moisture: 2.0%

****

Tube Set: D

Concentration relative to stock: 0.000
C-14 spike:
25.00 ul, added to 50.00 ml

Actual sol'n concentration: 2.50 mg/l
Average CPM of solution: 6929.75

		Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	EQUILIBRIUM Liq Conc (mg/l)	EQUILIBRIUM Sorbed Conc (ug/g)
Tube D1		1	0.00	1.00	10.00	2.50	5051.21	1.82	0.66
9.95	g soil	2	3.00	1.82	3.00	0.00	3778.63	1.36	0.58
		3	3.00	1.36	3.00	0.00	2942.33	1.06	0.47
Tube D2		1	0.00	1.00	10.00	2.50	4999.25	1.80	0.67
10.02	g soil	2	3.00	1.80	3.00	0.00	3722.13	1.34	0.60
		3	3.00	1.34	3.00	0.00	2919.33	1.05	0.49
Tube D3		1	0.00	1.00	10.00	2.50	5058.33	1.82	0.65
10.02	g soil	2	3.00	1.82	3.00	0.00	3635.03	1.31	0.63
		3	3.00	1.31	3.00	0.00	2947.23	1.06	0.48

****

Tube Set: E

Concentration relative to stock: 0.000
C-14 spike:
10.00 ul, added to 50.00 ml

Actual sol'n concentration: 1.00 mg/l
Average CPM of solution: 2770.03

		Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	EQUILIBRIUM Liq Conc (mg/l)	EQUILIBRIUM Sorbed Conc (ug/g)
Tube E1		1	0.00	1.00	10.00	1.00	1952.43	0.70	0.29
9.97	g soil	2	3.00	0.70	3.00	0.00	1464.73	0.53	0.26
		3	3.00	0.53	3.00	0.00	1184.23	0.43	0.20
Tube E2		1	0.00	1.00	10.00	1.00	1975.53	0.71	0.28
9.99	g soil	2	3.00	0.71	3.00	0.00	1471.03	0.53	0.25
		3	3.00	0.53	3.00	0.00	1249.53	0.45	0.17
Tube E3		1	0.00	1.00	10.00	1.00	1969.73	0.71	0.28
10.01	g soil	2	3.00	0.71	3.00	0.00	1494.63	0.54	0.24
		3	3.00	0.54	3.00	0.00	1232.33	0.44	0.17

APPENDIX D

Multi-Stage Sorption Results

MULTI-STAGE SORPTION

BROMACIL

Stock Solution Preparation: 66.00 mg
99.80% purity
in 100 ml
Stock Solution : 658.68 mg/l

C-14 solution: 400.00 mg/l
Soil Moisture: 2.0%

****

2nd attempt. 9/26/91

Concentration relative to stock: 1.000
C-14 spike:
50.00 ul, added to 100.00 ml

Actual sol'n concentration: 658.88 mg/l
Average CPM of solution: 12657.60

								EQUILIBRIUM	
		Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	Liq Conc (mg/l)	Sorbed Conc (ug/g)
Tube 1		A-1	0.00	0.00	10.00	658.88	11669.80	607.46	39.91
10.03	g soil	B-1	5.00	607.46	5.00	658.88	12349.40	642.84	29.36
		C-1	5.00	642.84	5.00	658.88	12461.20	648.66	31.48
		D-1	5.00	648.66	5.00	658.88	12487.10	650.00	35.28
		E-1	5.00	650.00	5.00	658.88	12475.20	649.39	40.44
Tube 2		A-2	0.00	0.00	10.00	658.88	11925.40	620.77	26.38
9.96	g soil	B-2	5.00	620.77	5.00	658.88	12465.90	648.90	16.50
		C-2	5.00	648.90	5.00	658.88	12479.30	649.60	20.89
		D-2	5.00	649.60	5.00	658.88	12472.10	649.22	26.03
		E-2	5.00	649.22	5.00	658.88	12452.50	648.20	32.05
Tube 3		A-3	0.00	0.00	10.00	658.88	11945.40	621.81	25.06
10.02	g soil	B-3	5.00	621.81	5.00	658.88	12203.10	635.22	30.01
		C-3	5.00	635.22	5.00	658.88	12284.00	639.43	37.68
		D-3	5.00	639.43	5.00	658.88	12593.00	655.52	30.87
		E-3	5.00	655.52	5.00	658.88	12401.60	645.55	42.93

MULTI-STAGE SORPTION

NAPROPAMIDE

Stock Solution Preparation: 6.10 mg
99.00% purity
in 100 ml
Stock Solution : 60.39 mg/l

C-14 solution: 22.00 mg/l
Soil Moisture: 2.0%

****

Concentration relative to stock: 1.000
C-14 spike:
500.00 ul, added to 100.00 ml

Actual sol'n concentration: 60.50 mg/l
Average CPM of solution: 11525.70

								EQUILIBRIUM	
		Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	Liq Conc (mg/l)	Sorbed Conc (ug/g)
Tube 5		A	0.00	0.00	10.00	60.50	5364.51	28.16	32.39
10.01	g soil	B	4.00	28.16	4.00	60.50	6415.19	33.67	39.85
		C	4.00	33.67	4.00	60.50	7306.51	38.35	45.92
		D	4.00	38.35	4.00	60.50	8034.39	42.17	50.98
		E	4.00	42.17	4.00	60.50	8579.93	45.04	55.47
Tube 6		A	0.00	0.00	10.00	60.50	5302.52	27.83	32.83
9.98	g soil	B	4.00	27.83	4.00	60.50	6500.38	34.12	39.63
		C	4.00	34.12	4.00	60.50	7170.01	37.64	46.76
		D	4.00	37.64	4.00	60.50	7906.24	41.50	52.08
		E	4.00	41.50	4.00	60.50	8531.24	44.78	56.43
Tube 7		A	0.00	0.00	10.00	60.50	5366.94	28.17	32.41
10.00	g soil	B	4.00	28.17	4.00	60.50	6337.91	33.27	40.30
		C	4.00	33.27	4.00	60.50	7359.15	38.63	45.84
		D	4.00	38.63	4.00	60.50	7840.33	41.15	52.14
		E	4.00	41.15	4.00	60.50	8422.52	44.21	56.85
Tube 8		A	0.00	0.00	10.00	60.50	5385.39	28.27	32.35
9.99	g soil	B	2.00	28.27	2.00	60.50	5916.51	31.06	36.02
		C	2.00	31.06	2.00	60.50	6321.41	33.18	39.83
		D	2.00	33.18	2.00	60.50	6813.91	35.77	42.71
		E	2.00	35.77	2.00	60.50	7283.85	38.23	45.20

MULTI-STAGE SORPTION

PROMETRYN

Stock Solution Preparation: 3.10 mg
98.40% purity
in 100 ml
Stock Solution : 30.50 mg/l

C-14 solution: 5000.00 mg/l
Soil Moisture: 2.0%
****

Concentration relative to stock: 1.000
C-14 spike:
100.00 ul, added to 100.00 ml

Actual sol'n concentration: 35.50 mg/l
Average CPM of solution: 14396.20

								EQUILIBRIUM	
		Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	Liq Conc (mg/l)	Sorbed Conc (ug/g)
Tube 4		A	0.00	0.00	10.00	35.50	9868.18	24.34	10.91
9.99	g soil	B	5.00	24.34	5.00	35.50	11663.00	28.76	12.00
		C	5.00	28.76	5.00	35.50	12560.60	30.98	13.14
		D	5.00	30.98	5.00	35.50	11825.50	29.16	17.34
		E	5.00	29.16	5.00	35.50	12575.10	31.01	18.65
Tube 5		A	0.00	0.00	10.00	35.50	8376.55	20.66	14.73
10.00	g soil	B	5.00	20.66	5.00	35.50	12061.90	29.75	12.84
		C	5.00	29.75	5.00	35.50	13029.40	32.13	13.30
		D	5.00	32.13	5.00	35.50	12672.70	31.25	15.93
		E	5.00	31.25	5.00	35.50	12700.10	31.32	18.03
Tube 6		A	0.00	0.00	10.00	35.50	10159.90	25.06	10.16
9.99	g soil	B	5.00	25.06	5.00	35.50	11662.10	28.76	11.64
		C	5.00	28.76	5.00	35.50	12293.90	30.32	13.46
		D	5.00	30.32	5.00	35.50	12188.70	30.06	16.37
		E	5.00	30.06	5.00	35.50	13318.60	32.85	16.25

APPENDIX E

Competitive Sorption Results

SORPTION / DESORPTION

BROMACIL, with N & P present

Stock Solution Preparation: 51.00 mg
99.80% purity
in 100 ml
Stock Solution : 508.98 mg/l

C-14 solution: 400.00 mg/l
Soil Moisture: 2.0%

* * *

Tube Set: A

Concentration relative to stock: 1.000
C-14 spike:
50.00 ul, added to 75.00 ml

Actual sol'n concentration: 509.25 mg/l
Average CPM of solution: 16184.70

Tube		Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	EQUILIBRIUM Liq Conc (mg/l)	EQUILIBRIUM Sorbed Conc (ug/g)
Tube A1		1	0.00	0.00	10.00	509.25	15178.80	477.60	22.42
10.04	g soil	2	5.00	477.60	5.00	0.00	8215.20	258.49	6.88
		3	5.00	258.49	5.00	0.00	4496.19	141.47	-3.16
Tube A2		1	0.00	0.00	10.00	509.25	15221.70	478.95	21.02
10.04	g soil	2	5.00	478.95	5.00	0.00	8136.40	256.01	8.76
		3	5.00	256.01	5.00	0.00	4326.48	136.13	2.95
Tube A3		1	0.00	0.00	10.00	509.25	15141.60	476.43	23.90
9.96	g soil	2	5.00	476.43	5.00	0.00	7953.47	250.25	16.18
		3	5.00	250.25	5.00	0.00	4367.01	137.41	5.90

* * *

Tube Set: B

Concentration relative to stock: 0.400
C-14 spike:
25.00 ul, added to 45.00 ml

Actual sol'n concentration: 203.81 mg/l
Average CPM of solution: 14080.40

Tube		Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	EQUILIBRIUM Liq Conc (mg/l)	EQUILIBRIUM Sorbed Conc (ug/g)
Tube B1		1	0.00	0.00	10.00	203.81	13005.40	188.25	12.00
10.02	g soil	2	5.00	188.25	5.00	0.00	6812.27	98.61	9.27
		3	5.00	98.61	5.00	0.00	3705.07	53.63	5.78
Tube B2		1	0.00	0.00	10.00	203.81	12908.00	186.84	13.50
10.00	g soil	2	5.00	186.84	5.00	0.00	6830.43	98.87	9.74
		3	5.00	98.87	5.00	0.00	3731.37	54.01	5.98
Tube B3		1	0.00	0.00	10.00	203.81	13061.80	189.07	11.17
10.01	g soil	2	5.00	189.07	5.00	0.00	6788.30	98.26	9.23
		3	5.00	98.26	5.00	0.00	3691.67	53.44	5.75

* * *

Tube Set: C

Concentration relative to stock: 0.100
C-14 spike:
25.00 ul, added to 45.00 ml

Actual sol'n concentration: 51.12 mg/l
Average CPM of solution: 13645.90

Tube		Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	EQUILIBRIUM Liq Conc (mg/l)	EQUILIBRIUM Sorbed Conc (ug/g)
Tube C1		1	0.00	0.00	10.00	51.12	12531.10	46.94	3.30
10.00	g soil	2	5.00	46.94	5.00	0.00	6731.86	25.22	1.96
		3	5.00	25.22	5.00	0.00	3677.47	13.78	1.01
Tube C2		1	0.00	0.00	10.00	51.12	12583.10	47.14	3.08
10.04	g soil	2	5.00	47.14	5.00	0.00	6687.69	25.05	2.03
		3	5.00	25.05	5.00	0.00	3654.47	13.69	1.08
Tube C3		1	0.00	0.00	10.00	51.12	12556.00	47.04	3.17
10.08	g soil	2	5.00	47.04	5.00	0.00	6748.13	25.28	1.83
		3	5.00	25.28	5.00	0.00	3600.87	13.49	1.21

Note: Desorption steps from competition studies were not used.

SORPTION / DESORPTION

BROMACIL, with N & P present

Stock Solution Preparation: 51.00 mg
99.80% purity
in 100 ml
Stock Solution : 508.98 mg/l

C-14 solution: 400.00 mg/l
Soil Moisture: 2.0%

					Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	EQUILIBRIUM Liq Conc (mg/l)	EQUILIBRIUM Sorbed Conc (ug/g)
**												
Tube Set:	D		Tube D1		1	0.00	0.00	10.00	20.58	12874.20	18.94	1.27
			10.08	g soil	2	5.00	18.94	5.00	0.00	6740.49	9.92	1.00
Concentration relative to stock:	0.040				3	5.00	9.92	5.00	0.00	3753.57	5.52	0.52
C-14 spike:												
25.00 ul, added to	45.00	ml										
			Tube D2		1	0.00	0.00	10.00	20.58	13051.00	19.20	1.02
Actual sol'n concentration:	20.58	mg/l	9.99	g soil	2	5.00	19.20	5.00	0.00	6974.43	10.26	0.52
Average CPM of solution:	13988.00				3	5.00	10.26	5.00	0.00	3744.37	5.51	0.23
			Tube D3		1	0.00	0.00	10.00	20.58	12798.70	18.83	1.40
			10.03	g soil	2	5.00	18.83	5.00	0.00	7065.16	10.40	0.57
					3	5.00	10.40	5.00	0.00	3750.17	5.52	0.35
**												
Tube Set:	E		Tube E1		1	0.00	0.00	10.00	5.29	11079.00	4.85	0.35
			9.99	g soil	2	5.00	4.85	5.00	0.00	5867.11	2.57	0.25
Concentration relative to stock:	0.010				3	5.00	2.57	5.00	0.00	3176.07	1.39	0.16
C-14 spike:												
25.00 ul, added to	50.00	ml										
			Tube E2		1	0.00	0.00	10.00	5.29	11017.20	4.83	0.37
Actual sol'n concentration:	5.29	mg/l	10.01	g soil	2	5.00	4.83	5.00	0.00	5874.06	2.57	0.26
Average CPM of solution:	12075.80				3	5.00	2.57	5.00	0.00	3108.57	1.36	0.21
			Tube E3		1	0.00	0.00	10.00	5.29	11007.30	4.82	0.38
			9.99	g soil	2	5.00	4.82	5.00	0.00	5839.35	2.56	0.28
					3	5.00	2.56	5.00	0.00	3145.57	1.38	0.20
**												
Tube Set:	F		Tube F1		1	0.00	0.00	10.00	2.24	11140.00	2.01	0.19
			10.00	g soil	2	5.00	2.01	5.00	0.00	5985.72	1.08	0.13
Concentration relative to stock:	0.004				3	5.00	1.08	5.00	0.00	3304.27	0.60	0.08
C-14 spike:												
25.00 ul, added to	50.00	ml										
			Tube F2		1	0.00	0.00	10.00	2.24	11300.30	2.04	0.16
Actual sol'n concentration:	2.24	mg/l	10.01	g soil	2	5.00	2.04	5.00	0.00	6005.50	1.08	0.11
Average CPM of solution:	12378.40				3	5.00	1.08	5.00	0.00	3242.77	0.59	0.08
			Tube F3		1	0.00	0.00	10.00	2.24	11166.10	2.02	0.18
			10.07	g soil	2	5.00	2.02	5.00	0.00	6024.49	1.09	0.12
					3	5.00	1.09	5.00	0.00	3228.57	0.58	0.09

Note: Desorption steps from competition studies were not used.

SORPTION / DESORPTION

NAPROPAMIDE WITH B & P PRESENT

Stock Solution Preparation:	4.80	mg
	99.00%	purity
in	100	ml
Stock Solution :	47.52	mg/l
C-14 solution:	22.00	mg/l
Soil Moisture:	2.0%	

****

Tube Set: A

Concentration relative to stock: 1.000

C-14 spike:

300.00 ul, added to 75.00 ml

Actual sol'n concentration: 47.61 mg/l

Average CPM of solution: 8269.12

Tube	g soil	Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	EQUILIBRIUM Liq Conc (mg/l)	EQUILIBRIUM Sorbed Conc (ug/g)
Tube A1	10.05 g soil	1	0.00	0.00	10.00	47.61	4143.51	23.86	23.63
		2	3.00	23.86	3.00	0.00	3520.00	20.27	20.08
		3	3.00	20.27	3.00	0.00	2962.80	17.06	17.23
Tube A2	9.98 g soil	1	0.00	0.00	10.00	47.61	4144.35	23.86	23.79
		2	3.00	23.86	3.00	0.00	3519.40	20.26	20.23
		3	3.00	20.26	3.00	0.00	2962.90	17.06	17.35
Tube A3	10.04 g soil	1	0.00	0.00	10.00	47.61	4214.15	24.26	23.23
		2	3.00	24.26	3.00	0.00	3390.50	19.52	20.75
		3	3.00	19.52	3.00	0.00	2896.50	16.68	17.75

****

Tube Set: B

Concentration relative to stock: 0.400

C-14 spike:

200.00 ul, added to 45.00 ml

Actual sol'n concentration: 19.11 mg/l

Average CPM of solution: 9475.56

Tube	g soil	Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	EQUILIBRIUM Liq Conc (mg/l)	EQUILIBRIUM Sorbed Conc (ug/g)
Tube B1	9.96 g soil	1	0.00	0.00	10.00	19.11	5093.20	10.27	8.84
		2	3.00	10.27	3.00	0.00	4242.83	8.55	7.48
		3	3.00	8.55	3.00	0.00	3515.80	7.09	6.38
Tube B2	10.03 g soil	1	0.00	0.00	10.00	19.11	5073.40	10.23	8.82
		2	3.00	10.23	3.00	0.00	4200.10	8.47	7.53
		3	3.00	8.47	3.00	0.00	3465.80	6.99	6.48
Tube B3	9.99 g soil	1	0.00	0.00	10.00	19.11	5155.98	10.40	8.68
		2	3.00	10.40	3.00	0.00	4113.82	8.29	7.69
		3	3.00	8.29	3.00	0.00	3456.40	6.97	6.53

****

Tube Set: C

Concentration relative to stock: 0.100

C-14 spike:

200.00 ul, added to 45.00 ml

Actual sol'n concentration: 4.85 mg/l

Average CPM of solution: 9727.76

Tube	g soil	Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	EQUILIBRIUM Liq Conc (mg/l)	EQUILIBRIUM Sorbed Conc (ug/g)
Tube C1	10.00 g soil	1	0.00	0.00	10.00	4.85	5395.65	2.69	2.15
		2	3.00	2.69	3.00	0.00	4461.24	2.22	1.81
		3	3.00	2.22	3.00	0.00	3608.20	1.80	1.57
Tube C2	10.01 g soil	1	0.00	0.00	10.00	4.85	5315.59	2.65	2.19
		2	3.00	2.65	3.00	0.00	4092.26	2.04	2.01
		3	3.00	2.04	3.00	0.00	3613.80	1.80	1.64
Tube C3	9.99 g soil	1	0.00	0.00	10.00	4.85	5454.57	2.72	2.12
		2	3.00	2.72	3.00	0.00	3923.80	1.96	2.08
		3	3.00	1.96	3.00	0.00	3582.60	1.79	1.66

Note: Desorption steps from competition studies were not used.

SORPTION / DESORPTION

NAPROPAMIDE WITH B & P PRESENT

Stock Solution Preparation: 4.80 mg
99.00% purity
in 100 ml
Stock Solution : 47.52 mg/l

C-14 solution: 22.00 mg/l
Soil Moisture: 2.0%

****

Tube Set: D

Concentration relative to stock: 0.040
C-14 spike:
200.00 ul, added to 45.00 ml

Actual sol'n concentration: 2.00 mg/l
Average CPM of solution: 9376.43

								EQUILIBRIUM	
		Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	Liq Conc (mg/l)	Sorbed Conc (ug/g)
Tube D1		1	0.00	0.00	10.00	2.00	5062.93	1.08	0.92
9.96	g soil	2	3.00	1.08	3.00	0.00	4231.14	0.90	0.77
		3	3.00	0.90	3.00	0.00	3552.70	0.76	0.65
Tube D2		1	0.00	0.00	10.00	2.00	5179.05	1.10	0.89
10.01	g soil	2	3.00	1.10	3.00	0.00	4303.07	0.92	0.75
		3	3.00	0.92	3.00	0.00	3415.50	0.73	0.66
Tube D3		1	0.00	0.00	10.00	2.00	5436.41	1.16	0.83
10.02	g soil	2	3.00	1.16	3.00	0.00	4235.81	0.90	0.74
		3	3.00	0.90	3.00	0.00	3443.30	0.73	0.64

****

Tube Set: E

Concentration relative to stock: 0.010
C-14 spike:
200.00 ul, added to 50.00 ml

Actual sol'n concentration: 0.56 mg/l
Average CPM of solution: 8680.76

		Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	Liq Conc (mg/l)	Sorbed Conc (ug/g)
Tube E1		1	0.00	0.00	10.00	0.56	4639.57	0.30	0.26
9.99	g soil	2	3.00	0.30	3.00	0.00	3811.60	0.25	0.23
		3	3.00	0.25	3.00	0.00	3169.40	0.21	0.19
Tube E2		1	0.00	0.00	10.00	0.56	4595.83	0.30	0.26
10.00	g soil	2	3.00	0.30	3.00	0.00	3921.40	0.25	0.22
		3	3.00	0.25	3.00	0.00	3125.30	0.20	0.19
Tube E3		1	0.00	0.00	10.00	0.56	4705.84	0.31	0.26
9.97	g soil	2	3.00	0.31	3.00	0.00	3830.30	0.25	0.22
		3	3.00	0.25	3.00	0.00	3164.30	0.21	0.19

****

Tube Set: F

Concentration relative to stock: 0.004
C-14 spike:
200.00 ul, added to 50.00 ml

Actual sol'n concentration: 0.28 mg/l
Average CPM of solution: 8694.27

		Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	Liq Conc (mg/l)	Sorbed Conc (ug/g)
Tube F1		1	0.00	0.00	10.00	0.28	4553.13	0.15	0.13
10.01	g soil	2	3.00	0.15	3.00	0.00	3804.10	0.12	0.11
		3	3.00	0.12	3.00	0.00	3083.20	0.10	0.10
Tube F2		1	0.00	0.00	10.00	0.28	4551.42	0.15	0.13
9.98	g soil	2	3.00	0.15	3.00	0.00	3763.10	0.12	0.11
		3	3.00	0.12	3.00	0.00	3053.10	0.10	0.10
Tube F3		1	0.00	0.00	10.00	0.28	4573.98	0.15	0.13
10.00	g soil	2	3.00	0.15	3.00	0.00	3763.60	0.12	0.11
		3	3.00	0.12	3.00	0.00	3092.30	0.10	0.10

Note: Desorption steps from competition studies were not used.

SORPTION / DESORPTION

PROMETRYN INTERFERENCE

Stock Solution Preparation: 10.10 mg
98.40% purity
in 250 ml
Stock Solution : 39.75 mg/l

C-14 solution: 5000.00 mg/l
Soil Moisture: 2.0%

****

Tube Set: A

Concentration relative to stock: 1.000
C-14 spike:
25.00 ul, added to 50.00 ml

Actual sol'n concentration: 42.25 mg/l
Average CPM of solution: 6338.40

								EQUILIBRIUM	
		Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	Liq Conc (mg/l)	Sorbed Conc (ug/g)
Tube A1		1	0.00	0.00	10.00	42.25	4340.85	28.94	13.00
10.00	g soil	2	4.00	28.94	4.00	0.00	3081.37	20.54	9.93
Tube A2		1	0.00	0.00	10.00	42.25	4415.00	29.43	12.35
10.10	g soil	2	4.00	29.43	4.00	0.00	3090.67	20.60	9.56
Tube A3		1	0.00	0.00	10.00	42.25	4364.05	29.09	12.82
10.01	g soil	2	4.00	29.09	4.00	0.00	3031.97	20.21	10.19

****

Tube Set: B

Concentration relative to stock: 0.400
C-14 spike:
25.00 ul, added to 50.00 ml

Actual sol'n concentration: 18.40 mg/l
Average CPM of solution: 6916.00

Tube B1		1	0.00	0.00	10.00	18.40	5109.18	13.59	4.61
10.03	g soil	2	4.00	13.59	4.00	0.00	3544.47	9.43	3.40
Tube B2		1	0.00	0.00	10.00	18.40	4585.91	12.20	6.08
10.00	g soil	2	4.00	12.20	4.00	0.00	3586.77	9.54	3.86
Tube B3		1	0.00	0.00	10.00	18.40	5022.84	13.36	4.85
10.03	g soil	2	4.00	13.36	4.00	0.00	3567.17	9.49	3.43

****

Tube Set: C

Concentration relative to stock: 0.100
C-14 spike:
25.00 ul, added to 50.00 ml

Actual sol'n concentration: 6.48 mg/l
Average CPM of solution: 6849.21

Tube C1		1	0.00	0.00	10.00	6.48	5637.63	5.33	1.06
10.02	g soil	2	4.00	5.33	4.00	0.00	3924.07	3.71	0.57
Tube C2		1	0.00	0.00	10.00	6.48	4579.31	4.33	2.09
10.07	g soil	2	4.00	4.33	4.00	0.00	3174.07	3.00	1.70
Tube C3		1	0.00	0.00	10.00	6.48	4593.03	4.34	2.07
10.08	g soil	2	4.00	4.34	4.00	0.00	3188.57	3.01	1.68

Note: Desorption steps from competition studies were not used.

SORPTION / DESORPTION

PROMETRYN INTERFERENCE

Stock Solution Preparation: 10.10 mg
98.40% purity
in 250 ml
Stock Solution : 39.75 mg/l

C-14 solution: 5000.00 mg/l
Soil Moisture: 2.0%

****

Tube Set: D

Concentration relative to stock: 0.000
C-14 spike:
25.00 ul, added to 50.00 ml

Actual sol'n concentration: 2.50 mg/l
Average CPM of solution: 6452.17

									EQUILIBRIUM	
			Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	Liq Conc (mg/l)	Sorbed Conc (ug/g)
Tube D1			1	0.00	0.00	10.00	2.50	4598.47	1.78	0.69
	10.04	g soil	2	4.00	1.78	4.00	0.00	3261.67	1.26	0.51
Tube D2			1	0.00	0.00	10.00	2.50	4629.25	1.79	0.68
	10.07	g soil	2	4.00	1.79	4.00	0.00	3229.07	1.25	0.51
Tube D3			1	0.00	0.00	10.00	2.50	4631.89	1.79	0.68
	10.06	g soil	2	4.00	1.79	4.00	0.00	3247.27	1.26	0.51

****

Tube Set: E

Concentration relative to stock: 0.000
C-14 spike:
10.00 ul, added to 50.00 ml

Actual sol'n concentration: 1.00 mg/l
Average CPM of solution: 2898.07

									EQUILIBRIUM	
			Step	Vol Removed (ml)	Conc Removed (mg/l)	Vol added (ml)	Conc added (mg/l)	Liq Conc. (cpm)	Liq Conc (mg/l)	Sorbed Conc (ug/g)
Tube E1			1	0.00	0.00	10.00	1.00	2047.47	0.71	0.28
	10.02	g soil	2	4.00	0.71	4.00	0.00	1426.27	0.49	0.22
Tube E2			1	0.00	0.00	10.00	1.00	1970.77	0.68	0.31
	10.06	g soil	2	4.00	0.68	4.00	0.00	1413.27	0.49	0.23
Tube E3			1	0.00	0.00	10.00	1.00	1961.07	0.68	0.31
	10.10	g soil	2	4.00	0.68	4.00	0.00	1397.17	0.48	0.24

Note: Desorption steps from competition studies were not used.

APPENDIX F

Field Water Content Data from Neutron Probe Measurements

Volumetric Water Content -- 12/89 - 11/90

Plot 1

Month	Date	DEPTH (cm) 2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
12	1	0.6304	0.604	0.5086	0.1465	0.1499	0.144	0.1457	0.1641	0.1829	0.1743	0.1865		0.1565	0.1468	0.2119	0.2007	0.2049
12	4	0.1657	0.1923	0.2076	0.162	0.1646	0.1542	0.1563	0.1727	0.1865	0.1924	0.1974		0.1859	0.1655	0.2353	0.2381	0.2572
12	8	0.1646	0.1913	0.2069	0.139	0.1545	0.1477	0.1453	0.16	0.1776	0.1871	0.1907	0.1904	0.1782	0.1553	0.2194	0.2338	0.2488
12	15	0.0503	0.09	0.1328	0.131	0.1463	0.1394	0.1319	0.1505	0.1708	0.1757	0.1808		0.1646	0.1484	0.2203	0.2244	0.2407
12	18	0.05	0.0898	0.1326	0.1312	0.1486	0.1401	0.137	0.155	0.1714	0.1813	0.1805		0.1607	0.1457	0.217	0.2257	0.2334
12	26	0.2337	0.2525	0.2516	0.1546	0.1617	0.1511	0.1532	0.1653	0.1752	0.1853	0.1834		0.1896	0.1721	0.1521	0.2271	0.2307
1	3	0.1924	0.216	0.2249	0.155	0.1429	0.137	0.1551	0.1738	0.1764	0.1841	0.1821	0.1663	0.1478	0.1731	0.2235	0.2397	0.2424
1	5	0.1693	0.1955	0.2099	0.1843	0.1817	0.1711	0.1712	0.18	0.1903	0.1856	0.1889	0.1831	0.1625	0.1457	0.2164	0.2211	0.2393
1	10	0.1728	0.1986	0.2122	0.1575	0.1582	0.1496	0.1465	0.1652	0.1835	0.187	0.1912	0.1907	0.1752	0.1554	0.2293	0.2326	0.2504
1	12	0.1716	0.1975	0.2114	0.1586	0.1564	0.1491	0.1456	0.1645	0.183	0.1838	0.192	0.1908	0.1746	0.1548	0.2288	0.2316	0.2503
1	16	0.206	0.228	0.2337	0.1527	0.1619	0.1515	0.1522	0.1685	0.1888	0.1899	0.1991	0.1985	0.1838	0.159	0.2349	0.2443	0.2621
1	19	0.3294	0.3374	0.3137	0.1655	0.1566	0.1402	0.1374	0.1507	0.1729	0.1764	0.1837	0.1866	0.1673	0.148	0.2201	0.222	0.2402
1	31	0.1983	0.2212	0.2287	0.1648	0.1626	0.1528	0.1538	0.169	0.1852	0.1864	0.1972	0.1931	0.1784	0.1566	0.2316	0.2361	0.2534
2	2	0.1911	0.2148	0.224	0.1675	0.1603	0.146	0.1472	0.1612	0.1814	0.1817	0.1925	0.1887	0.1745	0.1536	0.2244	0.2282	0.2444
2	8	0.1298	0.1605	0.1843	0.1494	0.1522	0.1424	0.1434	0.1581	0.1755	0.1793	0.1861	0.1837	0.168	0.1493	0.2253	0.2258	0.2439
2	9	0.2319	0.2509	0.2504	0.1933	0.1875	0.174	0.1738	0.18	0.1913	0.1856	0.1888	0.1825	0.165	0.149	0.2214	0.226	0.2407
2	14	0.1214	0.153	0.1789	0.1494	0.1531	0.1466	0.143	0.1568	0.1762	0.1791	0.187	0.1822	0.1675	0.1495	0.2234	0.2282	0.2425
2	16	0.1446	0.1736	0.1939	0.1498	0.1542	0.1422	0.1435	0.1592	0.1789	0.1821	0.1878	0.1864	0.1696	0.1528	0.225	0.2313	0.2452
2	20	0.1373	0.1672	0.1892	0.15	0.1543	0.1441	0.1383	0.1586	0.1775	0.1801	0.1869	0.1864	0.1682	0.1528	0.2296	0.2316	0.2469
2	23	0.2236	0.2436	0.2451	0.1763	0.1756	0.1655	0.1634	0.1809	0.1896	0.1894	0.1966	0.195	0.1763	0.1539	0.2285	0.2284	0.2489
3	7	0.129	0.1598	0.1838	0.1359	0.1495	0.1406	0.1414	0.1531	0.1722	0.1756	0.1869	0.1857	0.1718	0.1475	0.2269	0.2266	0.2431
3	9	0.0869	0.1224	0.1565	0.1274	0.1435	0.1353	0.1332	0.1483	0.1686	0.1685	0.1812	0.1797	0.1598	0.1448	0.2207	0.2262	0.2417
3	14	0.2303	0.2495	0.2494	0.1495	0.1556	0.1458	0.1448	0.1628	0.1799	0.1823	0.193	0.1904	0.1738	0.1543	0.2284	0.231	0.2472
3	16	0.1767	0.2021	0.2147	0.1593	0.1604	0.1502	0.1458	0.1548	0.1708	0.1713	0.178	0.1789	0.16	0.1429	0.2164	0.2196	0.2333
3	19	0.169	0.1952	0.2097	0.1608	0.1604	0.1517	0.1474	0.1541	0.1724	0.1721	0.176	0.1802	0.1616	0.1457	0.2171	0.2224	0.2336
3	28	0.0883	0.1237	0.1575	0.1313	0.1461	0.134	0.1283	0.1466	0.1647	0.1682	0.1768	0.1758	0.1597	0.144	0.2124	0.2175	0.2366
3	29	0.2206	0.2409	0.2431	0.1873	0.1822	0.1703	0.1644	0.1757	0.1859	0.18	0.1897	0.182	0.1676	0.1494	0.2246	0.2273	0.2446
4	2			0.065	0.1537	0.158	0.1494	0.1468	0.1609	0.1756	0.1794	0.1852	0.1871	0.1687	0.1539	0.2242	0.2237	0.2372
4	4	0.1361	0.166	0.1884	0.1515	0.152	0.1452	0.1466	0.1593	0.1763	0.175	0.1827	0.1833	0.1709	0.15	0.2251	0.2245	0.2431
4	10	0.1355	0.1656	0.188	0.1347	0.1478	0.1375	0.1354	0.15	0.1712	0.1717	0.1817	0.1805	0.1646	0.1475	0.2198	0.2224	0.2346
4	18	0.1434	0.1726	0.1931	0.1518	0.1591	0.1457	0.1474	0.1627	0.179	0.1813	0.1895	0.1877	0.1734	0.1549	0.2278	0.2305	0.2472
4	20	0.1399	0.1694	0.1909	0.1509	0.1584	0.1436	0.146	0.162	0.1773	0.1789	0.1882	0.1863	0.1722	0.1527	0.2279	0.2295	0.2461
4	27	0.2439	0.2616	0.2582	0.1895	0.1834	0.1703	0.1745	0.1849	0.1926	0.1916	0.196	0.1846	0.1653	0.1486	0.2221	0.2216	0.2426
5	3	0.1282	0.159	0.1833	0.1516	0.1554	0.1456	0.1414	0.1618	0.1794	0.1796	0.1943	0.1873	0.1762	0.1551	0.2346	0.2341	0.2453
5	9	0.1239	0.1552	0.1805	0.1449	0.1521	0.1423	0.1415	0.1564	0.176	0.1797	0.1892	0.1855	0.1702	0.1541	0.2301	0.2267	0.251
5	11	0.2856	0.2985	0.2853	0.181	0.1782	0.1638	0.161	0.1682	0.177	0.1747	0.1808	0.1834	0.1678	0.1462	0.2212	0.2264	0.2413

Volumetric Water Content -- 12/89 - 11/90

Plot 1 (cont.)

Month	Date	DEPTH (cm)																
		2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
5	16	0.1111	0.1439	0.1722	0.1508	0.157	0.1449	0.1464	0.1616	0.1792	0.1765	0.1872	0.187	0.1706	0.1533	0.2245	0.2279	0.2449
5	18	0.127	0.158	0.1825	0.1506	0.1566	0.1447	0.1459	0.1616	0.1793	0.1756	0.1871	0.1872	0.1685	0.1533	0.2243	0.2284	0.2439
5	25	0.2724	0.2868	0.2767	0.1918	0.1876	0.1727	0.173	0.1831	0.1878	0.1788	0.1852	0.1853	0.163	0.1459	0.222	0.2221	0.2406
5	31	0.1649	0.1916	0.2071	0.1498	0.1556	0.1421	0.1401	0.1554	0.1745	0.1752	0.1861	0.1829	0.1685	0.1472	0.2229	0.2271	0.2422
6	4	0.1359	0.1659	0.1883	0.1392	0.1509	0.1394	0.1366	0.1515	0.1688	0.1754	0.1819	0.1839	0.1637	0.1473	0.2196	0.2264	0.2404
6	6	0.0955	0.1301	0.1621	0.1342	0.1501	0.1357	0.1348	0.1505	0.1698	0.1719	0.1777	0.1843	0.1683	0.1451	0.2214	0.2228	0.2454
6	8	0.2838	0.297	0.2841	0.1895	0.187	0.1739	0.1684	0.1787	0.1867	0.1789	0.1834	0.183	0.1667	0.1463	0.2216	0.221	0.2426
6	13	0.1429	0.1721	0.1928	0.1517	0.1563	0.1473	0.1438	0.1603	0.1783	0.1819	0.1898	0.1885	0.1717	0.1562	0.2281	0.2317	0.2506
6	15	0.1391	0.1688	0.1904	0.1531	0.1546	0.1466	0.1414	0.1547	0.1791	0.1811	0.1895	0.1908	0.1726	0.1536	0.2282	0.2329	0.2511
6	21	0.0948	0.1295	0.1617	0.1522	0.1537	0.1372	0.1329	0.1481	0.1704	0.174	0.1821	0.1815	0.164	0.1471	0.2238	0.2219	0.24
6	29	0.0673	0.1051	0.1438	0.1488	0.1546	0.144	0.1433	0.1573	0.1755	0.1825	0.1882	0.1876	0.1709	0.1511	0.228	0.2313	0.2508
7	3	0.0835	0.1194	0.1543	0.1417	0.149	0.1355	0.1334	0.1511	0.17	0.1738	0.1825	0.1834	0.166	0.1474	0.2233	0.2249	0.2439
7	11	0.1314	0.1619	0.1853	0.154	0.1627	0.145	0.1422	0.1578	0.1743	0.1801	0.1843	0.1857	0.172	0.1486	0.2243	0.2306	0.2437
7	13	0.1374	0.1672	0.1892	0.1525	0.1527	0.1419	0.1386	0.1524	0.1721	0.1736	0.1823	0.1835	0.1682	0.147	0.2231	0.2251	0.239
7	25	0.1659	0.1925	0.2077	0.1451	0.1506	0.1373	0.1347	0.148	0.1692	0.1737	0.1818	0.1795	0.1656	0.1459	0.2214	0.2276	0.2397
7	27	0.0771	0.1138	0.1502	0.1462	0.1503	0.1363	0.1435	0.1464	0.1656	0.1722	0.1804	0.1736	0.1597	0.1509	0.2052	0.2067	0.217
8	1	0.0601	0.0987	0.1392	0.1403	0.1543	0.1401	0.1378	0.153	0.1733	0.18	0.1879	0.188	0.172	0.1498	0.2308	0.2352	0.2548
8	3	0.1015	0.1354	0.166	0.148	0.1611	0.1445	0.1407	0.1486	0.1715	0.1754	0.1798	0.1797	0.164	0.144	0.2209	0.2217	0.2396
8	8	0.0959	0.1304	0.1623	0.1428	0.1474	0.1314	0.1278	0.1437	0.1649	0.1676	0.1736	0.1762	0.1593	0.1423	0.2175	0.2219	0.2381
8	17	0.1514	0.1796	0.1983	0.158	0.1578	0.1401	0.133	0.1468	0.1649	0.1676	0.1767	0.1809	0.1604	0.1411	0.2156	0.222	0.2408
8	22	0.2153	0.2363	0.2397	0.1477	0.1542	0.1349	0.1307	0.1435	0.1622	0.1668	0.176	0.1747	0.161	0.1404	0.2204	0.2203	0.2417
8	29	0.1243	0.1556	0.1808	0.1352	0.148	0.1321	0.1248	0.1412	0.1623	0.1673	0.1765	0.1766	0.1589	0.1391	0.2177	0.221	0.2376
9	5	0.2365	0.255	0.2534	0.1323	0.15	0.1328	0.1277	0.1422	0.1627	0.1652	0.1795	0.1771	0.1585	0.14	0.2177	0.2171	0.236
9	21	0.1299	0.1605	0.1844	0.1612	0.1671	0.1535	0.1527	0.1676	0.1814	0.1863	0.1946	0.1937	0.1746	0.1544	0.2302	0.2338	0.254
10	3	0.1668	0.1933	0.2083	0.1672	0.171	0.156	0.1564	0.1719	0.1869	0.1898	0.1942	0.1953	0.1821	0.1588	0.2309	0.2382	0.2545
10	10	0.1013	0.1353	0.1659	0.1513	0.1581	0.1459	0.1429	0.1599	0.1766	0.1823	0.1885	0.1907	0.1756	0.1547	0.2278	0.2364	0.2479
10	12	0.3065	0.317	0.2988	0.1954	0.1922	0.177	0.17	0.1784	0.1889	0.1847	0.1892	0.1872	0.1769	0.1514	0.2279	0.2358	0.2499
10	17	0.1392	0.1688	0.1904	0.161	0.1667	0.155	0.1542	0.1666	0.1856	0.1898	0.1948	0.1961	0.1816	0.1566	0.2298	0.2387	0.2569
10	24	0.096	0.1306	0.1624	0.1616	0.1676	0.1521	0.1519	0.1618	0.185	0.1889	0.1935	0.1967	0.1825	0.1574	0.2286	0.2369	0.2557
11	2				0.1687	0.1685	0.155	0.1513	0.1696	0.1884	0.1896	0.1975	0.1952	0.1854	0.1585	0.2309	0.2408	0.256
11	7	0.1174	0.1495	0.1763		0.1608	0.1488	0.1439	0.1615	0.1789	0.1852	0.1926	0.1938	0.1813	0.1544	0.236	0.2362	0.2459
Avg.:		0.16344	0.19029	0.20398	0.15487	0.15939	0.14752	0.14589	0.16016	0.17713	0.17923	0.18646	0.18536	0.16943	0.15087	0.22301	0.22763	0.24358
C.V.:		52.3%	39.8%	28.3%	10.5%	7.2%	7.5%	8.0%	6.7%	4.4%	3.8%	3.3%	3.4%	4.7%	4.3%	4.7%	3.3%	3.6%

Volumetric Water Content -- 12/89 - 11/90

Plot 2

DEPTH (cm)

Month	Date	2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
12	1	0.6317	0.6051	0.5095	0.126	0.1602	0.1585	0.1494	0.1488	0.1593	0.1682	0.1627		0.1578	0.1624	0.1889	0.1833	0.1884
12	4	0.1693	0.1955	0.2099	0.1517	0.1797	0.1758	0.1607	0.1673	0.1875	0.1971	0.201		0.2035	0.2012	0.2258	0.2083	0.1946
12	8	0.1682	0.1945	0.2092	0.1324	0.1643	0.164	0.1509	0.1614	0.1782	0.1961	0.1966	0.2134	0.1963	0.1959	0.2232	0.2139	0.2146
12	15	0.0877	0.1232	0.1571	0.1208	0.1542	0.1559	0.142	0.1506	0.1719	0.1914	0.1933		0.1925	0.1895	0.2154	0.2051	0.2144
12	18	0.0867	0.1223	0.1564	0.1199	0.1546	0.1583	0.1436	0.1537	0.1678	0.192	0.193		0.1976	0.1928	0.2196	0.2038	0.2157
12	26	0.2229	0.243	0.2446	0.1454	0.1725	0.1705	0.1564	0.1656	0.1834	0.1999	0.2003		0.197	0.1995	0.2219	0.21	0.2177
1	3	0.1713	0.1972	0.2112	0.1593	0.1693	0.1626	0.1467	0.158	0.1752	0.1894	0.1961	0.2118	0.1937	0.1923	0.2174	0.2068	0.2114
1	5	0.1714	0.1973	0.2113	0.1753	0.1883	0.1834	0.1724	0.1773	0.1847	0.1933	0.1904	0.2089	0.1893	0.1889	0.2112	0.2019	0.2105
1	10	0.1711	0.1971	0.2111	0.1525	0.1727	0.168	0.1566	0.1682	0.1807	0.1982	0.2027	0.2162	0.1969	0.2002	0.2206	0.2127	0.2199
1	12	0.1698	0.1959	0.2102	0.1538	0.1746	0.1686	0.156	0.1677	0.1808	0.1998	0.2028	0.2163	0.1965	0.2017	0.2217	0.2132	0.219
1	16	0.2417	0.2596	0.2568	0.1503	0.1766	0.1702	0.1583	0.1692	0.188	0.2068	0.2089	0.227	0.2078	0.2087	0.2321	0.2209	0.232
1	19	0.2953	0.3071	0.2916	0.1596	0.1694	0.16	0.1461	0.1541	0.1729	0.1915	0.1954	0.2092	0.1937	0.192	0.2162	0.2053	0.2158
1	31	0.1724	0.1983	0.2119	0.159	0.1753	0.1736	0.1614	0.1697	0.1877	0.2017	0.2042	0.219	0.2021	0.2009	0.2257	0.2152	0.2207
2	2	0.2088	0.2305	0.2355	0.1621	0.1721	0.1682	0.1563	0.1648	0.1824	0.1959	0.1991	0.2132	0.1974	0.1978	0.2229	0.211	0.2215
2	8	0.1608	0.1879	0.2044	0.1466	0.1665	0.161	0.1505	0.159	0.1798	0.1944	0.1999	0.2153	0.1952	0.196	0.2171	0.2086	0.2148
2	9	0.2669	0.282	0.2731	0.1817	0.193	0.1873	0.1718	0.1726	0.1786	0.1913	0.196	0.2091	0.1927	0.1953	0.2188	0.2061	0.212
2	14	0.1411	0.1705	0.1916	0.1453	0.1662	0.159	0.1517	0.156	0.1833	0.1928	0.2007	0.2219	0.1924	0.1964	0.216	0.2096	0.2192
2	16	0.1436	0.1727	0.1933	0.1443	0.1649	0.1649	0.1495	0.1612	0.1794	0.195	0.1961	0.212	0.1964	0.1954	0.2206	0.2075	0.2137
2	20	0.1304	0.161	0.1847	0.1493	0.1665	0.1646	0.1474	0.1612	0.1814	0.1992	0.1985	0.2122	0.1939	0.1972	0.2197	0.2096	0.2209
2	23	0.2087	0.2304	0.2354	0.1735	0.1861	0.1824	0.167	0.1758	0.1897	0.2041	0.2056	0.2182	0.1968	0.1969	0.218	0.2096	0.214
3	7	0.1507	0.179	0.1979	0.1345	0.1629	0.1615	0.1451	0.1586	0.1751	0.198	0.2009	0.211	0.1932	0.1947	0.218	0.2085	0.2124
3	9	0.0751	0.112	0.1489	0.13	0.1533	0.1547	0.14	0.1529	0.1697	0.1909	0.1913	0.2085	0.1858	0.1879	0.2144	0.2037	0.2093
3	14	0.2174	0.2381	0.2411	0.1457	0.1633	0.1635	0.1556	0.162	0.1828	0.1996	0.2021	0.212	0.1981	0.1983	0.2272	0.2063	0.2213
3	16	0.1817	0.2064	0.2179	0.1559	0.169	0.1619	0.143	0.1533	0.1697	0.1867	0.1885	0.2075	0.1834	0.1895	0.2115	0.2006	0.2085
3	19	0.1787	0.2038	0.216	0.1561	0.1706	0.1626	0.1422	0.1541	0.1697	0.1867	0.1896	0.2091	0.1816	0.2016	0.2137	0.2022	0.2094
3	28	0.0786	0.1152	0.1512	0.1246	0.1548	0.1532	0.1381	0.1517	0.1669	0.187	0.1856	0.2048	0.1846	0.1866	0.2098	0.1977	0.2062
3	29	0.2706	0.2853	0.2756	0.1778	0.1915	0.1834	0.1585	0.1624	0.175	0.194	0.197	0.2138	0.1942	0.1961	0.2167	0.2065	0.2158
4	2			0.0669	0.1534	0.1707	0.1658	0.1539	0.1559	0.1738	0.1903	0.1918	0.2076	0.1891	0.1894	0.2138	0.2029	0.2097
4	4	0.1289	0.1597	0.1837	0.1457	0.1645	0.1628	0.1478	0.1552	0.1719	0.1905	0.1927	0.208	0.1911	0.1911	0.2133	0.2021	0.2118
4	10	0.1291	0.1599	0.1839	0.1322	0.1581	0.1549	0.1415	0.1544	0.1712	0.1899	0.1903	0.2069	0.1864	0.1895	0.2115	0.2008	0.2118
4	18	0.1316	0.1621	0.1855	0.1468	0.1663	0.1681	0.1525	0.1647	0.1811	0.1975	0.1989	0.213	0.1941	0.1964	0.2166	0.2085	0.2166
4	20	0.1288	0.1596	0.1837	0.1451	0.1653	0.1666	0.1535	0.1639	0.1797	0.1935	0.2018	0.2117	0.1938	0.1951	0.216	0.2095	0.2154
4	27	0.232	0.251	0.2505	0.1749	0.185	0.1844	0.1674	0.1697	0.1786	0.1943	0.1922	0.2067	0.1914	0.1885	0.2156	0.203	0.2074
5	3	0.1312	0.1618	0.1852	0.1491	0.166	0.1619	0.151	0.1597	0.1777	0.2007	0.1965	0.2138	0.1937	0.1953	0.2194	0.2136	0.2176
5	9	0.1145	0.1469	0.1744	0.1484	0.1627	0.1609	0.1483	0.1579	0.1774	0.1937	0.196	0.2132	0.1922	0.1958	0.2196	0.2077	0.2186
5	11	0.2863	0.2991	0.2857	0.1747	0.1846	0.1804	0.1586	0.1609	0.1725	0.1917	0.1927	0.2082	0.1905	0.1893	0.2131	0.2016	0.2117

Volumetric Water Content -- 12/89 - 11/90

Plot 2 (cont.)

Month	Date	DEPTH (cm)																
		2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
5	16	0.1243	0.1556	0.1808	0.1414	0.17	0.1632	0.1508	0.1616	0.1779	0.1936	0.1977	0.2154	0.1968	0.1931	0.2178	0.2088	0.217
5	18	0.1054	0.1388	0.1685	0.1412	0.1699	0.1635	0.1509	0.1612	0.1768	0.1935	0.1976	0.2134	0.1963	0.1923	0.2173	0.209	0.2169
5	25	0.2746	0.2888	0.2781	0.1807	0.1915	0.1872	0.1713	0.1693	0.1754	0.1914	0.1918	0.2067	0.1878	0.1918	0.2121	0.201	0.2109
5	31	0.1931	0.2166	0.2254	0.1475	0.1666	0.1621	0.1475	0.1557	0.1756	0.1924	0.1945	0.2133	0.1916	0.192	0.2144	0.2065	0.2108
6	4	0.1731	0.1988	0.2124	0.1357	0.1611	0.1588	0.1444	0.1525	0.1729	0.1932	0.1908	0.2117	0.191	0.1873	0.2205	0.2048	0.2154
6	6	0.0879	0.1234	0.1572	0.1335	0.1624	0.1565	0.1428	0.1557	0.1715	0.189	0.1916	0.2112	0.1934	0.1901	0.2182	0.2054	0.2138
6	8	0.293	0.3051	0.2901	0.1789	0.1909	0.1908	0.1689	0.1696	0.1757	0.1922	0.1912	0.21	0.1893	0.1918	0.2124	0.2017	0.2113
6	13	0.1365	0.1664	0.1886	0.1454	0.166	0.1624	0.1529	0.1595	0.1784	0.1949	0.1973	0.2135	0.1937	0.1905	0.218	0.2066	0.2116
6	15	0.1315	0.162	0.1854	0.1457	0.1665	0.1648	0.1541	0.16	0.1787	0.1948	0.1936	0.2156	0.194	0.1908	0.215	0.2068	0.2123
6	21	0.0898	0.1251	0.1584	0.1301	0.1585	0.156	0.1431	0.1532	0.1704	0.1885	0.1884	0.211	0.1929	0.1881	0.2142	0.2078	0.21
6	29	0.1054	0.1389	0.1685	0.1445	0.1718	0.1648	0.1497	0.1587	0.178	0.1957	0.2002	0.215	0.1982	0.1944	0.2223	0.2126	0.2207
7	3	0.0869	0.1225	0.1565	0.1386	0.16	0.157	0.1416	0.1562	0.1715	0.1914	0.1956	0.2127	0.1938	0.1892	0.2134	0.2054	0.2113
7	11	0.1439	0.173	0.1935	0.1568	0.1687	0.1671	0.1524	0.1618	0.1774	0.194	0.1991	0.2167	0.1978	0.1947	0.2189	0.2095	0.2153
7	13	0.1517	0.1799	0.1985	0.1546	0.1663	0.1623	0.1478	0.1565	0.1723	0.1912	0.1949	0.2123	0.1904	0.1897	0.2162	0.2058	0.2153
7	25	0.1729	0.1986	0.2122	0.1535	0.1614	0.1452	0.1536	0.1615	0.1747	0.1759	0.1828	0.1879	0.1772	0.1796	0.2197	0.2178	0.22
7	27	0.087	0.1225	0.1566	0.1377	0.1625	0.1582	0.1435	0.1573	0.172	0.193	0.1926	0.2114	0.1929	0.1915	0.2172	0.2039	0.2136
8	1	0.0844	0.1203	0.1549	0.1326	0.1638	0.1592	0.1465	0.1587	0.1762	0.1999	0.2018	0.2189	0.2032	0.198	0.2242	0.2141	0.2201
8	3	0.1225	0.154	0.1796	0.1364	0.165	0.1562	0.1426	0.1532	0.1685	0.1895	0.1924	0.2056	0.193	0.19	0.2153	0.2068	0.2091
8	8	0.1112	0.144	0.1723	0.1259	0.155	0.1526	0.1374	0.1505	0.1698	0.1857	0.192	0.2102	0.1905	0.1888	0.2114	0.201	0.2116
8	17	0.1536	0.1815	0.1997	0.1588	0.1659	0.1589	0.1401	0.1516	0.1683	0.1891	0.1903	0.2092	0.1913	0.1871	0.213	0.2011	0.2083
8	22	0.2163	0.2372	0.2404	0.1378	0.1595	0.1549	0.1383	0.1511	0.1683	0.1867	0.1911	0.2059	0.1906	0.1864	0.2116	0.2014	0.2064
8	29	0.1327	0.1631	0.1862	0.1241	0.154	0.1509	0.1374	0.148	0.1674	0.1868	0.1854	0.2073	0.1857	0.1823	0.2099	0.1983	0.209
9	5	0.2353	0.2539	0.2527	0.1278	0.1542	0.1506	0.1377	0.1506	0.1673	0.1835	0.183	0.2069	0.1866	0.1833	0.2082	0.1964	0.2075
9	21	0.1219	0.1535	0.1792	0.1578	0.174	0.1719	0.1584	0.1666	0.1806	0.2018	0.2036	0.2215	0.2028	0.2008	0.2221	0.212	0.2216
10	3	0.1641	0.1909	0.2066	0.1596	0.1812	0.178	0.1555	0.1643	0.1796	0.2003	0.2005	0.2189	0.204	0.1941	0.2223	0.2132	0.2161
10	10	0.1017	0.1355	0.1661	0.1416	0.1728	0.1666	0.1488	0.1598	0.1777	0.197	0.1998	0.2165	0.1999	0.1946	0.221	0.2111	0.2182
10	12	0.2944	0.3063	0.2909	0.1647	0.2011	0.1859	0.1725	0.1563	0.1621	0.2089	0.2096	0.2154	0.2108	0.209	0.2207	0.2104	0.2172
10	17	0.1336	0.1638	0.1868	0.1563	0.1821	0.1749	0.1633	0.1696	0.1894	0.2017	0.2076	0.2239	0.2091	0.2035	0.2283	0.219	0.2235
10	24	0.0971	0.1315	0.1631	0.1521	0.185	0.1743	0.1626	0.1739	0.1877	0.2027	0.21	0.2217	0.21	0.203	0.226	0.2147	0.2218
11	2				0.1647	0.1835	0.1778	0.1634	0.1716	0.19	0.2063	0.2113	0.2307	0.2144	0.2048	0.2367	0.228	0.233
11	7	0.1153	0.1477	0.175	0.1544	0.1746	0.1728	0.1572	0.1631	0.1831	0.2039	0.2058	0.2255	0.2072	0.2008	0.2287	0.2202	0.224
Avg.:		0.16763	0.194	0.20668	0.14872	0.16987	0.1658	0.15177	0.16028	0.17643	0.1939	0.19605	0.21283	0.19416	0.19343	0.21776	0.20744	0.21445
C.V.:		49.8%	38.1%	27.3%	10.3%	6.4%	6.1%	6.1%	4.4%	3.8%	3.5%	3.9%	3.0%	4.3%	3.6%	3.0%	3.2%	3.2%

Volumetric Water Content -- 12/89 - 11/90

Plot 3

DEPTH (cm)

Month	Date	2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
12	1	0.6358	0.6088	0.5121	0.1249	0.1817	0.1876	0.2231	0.2176	0.208	0.2018	0.1751		0.152	0.1847	0.1902	0.1869	0.175
12	4	0.1768	0.2022	0.2148	0.1562	0.1972	0.2026	0.2329	0.2335	0.231	0.2247	0.213		0.1854	0.2178	0.2252	0.2147	0.1911
12	8	0.1757	0.2012	0.2141	0.1449	0.1906	0.1928	0.2279	0.2266	0.2238	0.2195	0.2074	0.1905	0.181	0.2136	0.2211	0.2119	0.2072
12	15	0.0818	0.118	0.1532	0.1256	0.1748	0.1846	0.2191	0.223	0.2222	0.2183	0.2034		0.1721	0.2094	0.2146	0.2086	0.2025
12	18	0.0841	0.12	0.1547	0.1261	0.1749	0.1808	0.2194	0.2256	0.2207	0.2171	0.2036		0.175	0.2174	0.2157	0.2078	0.204
12	26	0.2356	0.2542	0.2529	0.1505	0.1919	0.1951	0.2351	0.2337	0.2266	0.2263	0.2101		0.1806	0.2142	0.2251	0.2149	0.2084
1	3	0.1848	0.2092	0.22	0.1635	0.1876	0.1921	0.2259	0.2289	0.2236	0.2188	0.2048	0.1886	0.171	0.209	0.2209	0.2109	0.2047
1	5	0.1721	0.198	0.2117	0.1771	0.2099	0.2147	0.2359	0.2354	0.2287	0.2229	0.2065	0.187	0.1722	0.2055	0.2143	0.2091	0.2002
1	10	0.1723	0.1981	0.2119	0.1629	0.1945	0.1957	0.2264	0.2304	0.2263	0.2245	0.2074	0.1911	0.1807	0.2118	0.2259	0.2172	0.2119
1	12	0.172	0.1979	0.2117	0.1635	0.195	0.1948	0.2252	0.2302	0.2276	0.2248	0.2098	0.1909	0.1789	0.214	0.2268	0.2175	0.2143
1	16	0.2678	0.2828	0.2738	0.1536	0.1964	0.2018	0.2375	0.2413	0.2369	0.2328	0.2201	0.2011	0.1886	0.2235	0.2366	0.227	0.2232
1	19	0.3034	0.3143	0.2968	0.1642	0.1911	0.1924	0.2258	0.2261	0.2185	0.2218	0.199	0.1866	0.1747	0.2068	0.2186	0.21	0.2054
1	31	0.2042	0.2264	0.2325	0.1578	0.197	0.2051	0.2329	0.2326	0.2302	0.2282	0.2137	0.1995	0.1877	0.218	0.2295	0.2217	0.216
2	2	0.2055	0.2276	0.2334	0.1734	0.1937	0.1995	0.2289	0.2277	0.2262	0.2225	0.2103	0.1896	0.1798	0.2122	0.2252	0.2197	0.2098
2	8	0.1558	0.1835	0.2011	0.1514	0.1883	0.1949	0.2271	0.2274	0.2262	0.2223	0.2075	0.1904	0.1785	0.2123	0.2223	0.2115	0.2063
2	9	0.2583	0.2743	0.2675	0.1859	0.2145	0.2175	0.2401	0.2351	0.23	0.2224	0.2079	0.1904	0.1762	0.2095	0.2212	0.2116	0.2046
2	14	0.1473	0.176	0.1957	0.1519	0.1901	0.1917	0.2317	0.2255	0.2252	0.2201	0.2057	0.19	0.1784	0.2134	0.2232	0.2067	0.2039
2	16	0.1434	0.1725	0.1931	0.1457	0.1877	0.1907	0.2277	0.2253	0.2244	0.2171	0.2082	0.1888	0.1769	0.2099	0.2258	0.2129	0.2088
2	20	0.1467	0.1755	0.1953	0.1494	0.1861	0.1925	0.2261	0.2316	0.2257	0.2238	0.2065	0.1872	0.1781	0.2106	0.2264	0.2142	0.2121
2	23	0.2213	0.2416	0.2436	0.1734	0.2056	0.2118	0.2357	0.2383	0.2312	0.2293	0.2135	0.1996	0.1912	0.2123	0.2259	0.2145	0.2082
3	7	0.1864	0.2106	0.221	0.1398	0.1836	0.1882	0.2239	0.2261	0.2233	0.2227	0.2074	0.19	0.1791	0.211	0.2219	0.2141	0.2117
3	9	0.1326	0.1629	0.1861	0.1319	0.1758	0.1856	0.2197	0.2238	0.2177	0.2167	0.2028	0.1821	0.1723	0.2074	0.2187	0.2101	0.2006
3	14	0.2202	0.2406	0.2429	0.1526	0.1876	0.1963	0.2298	0.2306	0.2258	0.2204	0.2117	0.1917	0.1809	0.2136	0.223	0.2198	0.2137
3	16	0.1839	0.2084	0.2194	0.1575	0.1951	0.1956	0.2269	0.2258	0.2172	0.2152	0.2015	0.1805	0.1704	0.2031	0.2107	0.2053	0.1989
3	19	0.1804	0.2053	0.2171	0.1577	0.1949	0.1957	0.2274	0.2262	0.2176	0.2155	0.203	0.1812	0.1692	0.2026	0.2104	0.2056	0.199
3	28	0.1199	0.1517	0.1779	0.1328	0.1764	0.1835	0.2217	0.2212	0.217	0.2135	0.1992	0.1797	0.1706	0.2039	0.2139	0.2043	0.1992
3	29	0.2365	0.2551	0.2535	0.1828	0.2111	0.2139	0.2405	0.2391	0.2264	0.2259	0.2085	0.1891	0.1731	0.2103	0.2194	0.2099	0.2045
4	2		0.0003	0.0672	0.1559	0.1915	0.1966	0.2257	0.2294	0.225	0.2198	0.2062	0.1856	0.176	0.2093	0.2182	0.2089	0.2017
4	4	0.1409	0.1703	0.1915	0.1497	0.187	0.1919	0.2281	0.2239	0.2218	0.2207	0.2063	0.1878	0.1775	0.2036	0.2143	0.2078	0.204
4	10	0.1409	0.1704	0.1915	0.136	0.1806	0.1852	0.2206	0.2233	0.2175	0.2168	0.2028	0.1805	0.179	0.2031	0.2163	0.2084	0.1998
4	18	0.1437	0.1728	0.1933	0.155	0.1915	0.1971	0.2298	0.2292	0.2238	0.2201	0.2052	0.1892	0.1795	0.2097	0.2224	0.2152	0.2073
4	20	0.1407	0.1701	0.1914	0.1526	0.1893	0.1984	0.2267	0.2279	0.2231	0.218	0.2047	0.1891	0.1773	0.2084	0.2225	0.2138	0.2063
4	27	0.2883	0.301	0.287	0.1817	0.2074	0.2135	0.2325	0.2331	0.2268	0.2182	0.2042	0.1818	0.1723	0.2054	0.2151	0.2094	0.2011
5	3	0.1356	0.1656	0.1881	0.1509	0.188	0.1955	0.2276	0.2289	0.2279	0.2269	0.208	0.1898	0.1805	0.2127	0.2238	0.2141	0.2107
5	9	0.133	0.1633	0.1864	0.1532	0.1885	0.1947	0.228	0.2273	0.2237	0.2228	0.2064	0.1851	0.1791	0.211	0.2236	0.2092	0.2078
5	11	0.288	0.3007	0.2868	0.1739	0.2033	0.208	0.2328	0.2282	0.2205	0.218	0.2044	0.1848	0.1716	0.204	0.217	0.2082	0.2033

Volumetric Water Content -- 12/89 - 11/90

Plot 3 (cont.)

Month	Date	DEPTH (cm)																
		2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
5	16	0.1362	0.1662	0.1885	0.1435	0.19	0.1967	0.2299	0.2277	0.2234	0.2171	0.2096	0.1857	0.1747	0.2087	0.2172	0.2107	0.203
5	18	0.121	0.1527	0.1786	0.1431	0.1889	0.1963	0.2292	0.2276	0.2235	0.2174	0.2092	0.1859	0.1751	0.2088	0.2176	0.2114	0.2031
5	25	0.2748	0.289	0.2783	0.1825	0.2123	0.217	0.2356	0.2308	0.2298	0.222	0.2076	0.1821	0.1785	0.2087	0.2206	0.2121	0.2034
5	31	0.1928	0.2163	0.2252	0.1491	0.1899	0.1958	0.2248	0.2268	0.2276	0.2229	0.2076	0.1888	0.176	0.2084	0.2188	0.2107	0.2035
6	4	0.1508	0.1791	0.1979	0.138	0.1851	0.191	0.2264	0.2303	0.2227	0.2186	0.2074	0.1881	0.175	0.2073	0.2188	0.2125	0.2057
6	6	0.1002	0.1343	0.1652	0.1337	0.1848	0.1903	0.2233	0.2278	0.2212	0.2214	0.207	0.1848	0.177	0.2084	0.2143	0.2168	0.2022
6	8	0.294	0.306	0.2907	0.1818	0.2127	0.2179	0.2356	0.2345	0.2287	0.2223	0.2065	0.1822	0.177	0.2091	0.221	0.2118	0.204
6	13	0.1585	0.1859	0.2029	0.1205	0.192	0.1951	0.2282	0.2313	0.2231	0.2203	0.2079	0.1903	0.1793	0.2108	0.2201	0.2123	0.2086
6	15	0.1538	0.1817	0.1999	0.1218	0.1926	0.1936	0.227	0.2292	0.2282	0.2182	0.2064	0.1927	0.1806	0.2111	0.2206	0.2124	0.2089
6	21	0.0991	0.1333	0.1644	0.1337	0.1795	0.1853	0.2211	0.2263	0.2219	0.2165	0.2043	0.1841	0.1745	0.2096	0.2173	0.21	0.2039
6	29	0.0813	0.1175	0.1529	0.1504	0.1935	0.1963	0.2344	0.2369	0.2321	0.2263	0.2142	0.1896	0.1815	0.2145	0.2285	0.2184	0.2102
7	3	0.0892	0.1245	0.158	0.1451	0.1831	0.1875	0.2265	0.2276	0.2241	0.2178	0.2081	0.1883	0.1774	0.2079	0.2191	0.2091	0.2071
7	11	0.1538	0.1817	0.1999	0.1617	0.1968	0.1957	0.2338	0.2349	0.2282	0.2178	0.2113	0.1893	0.1827	0.2127	0.2234	0.2171	0.2075
7	13	0.167	0.1934	0.2084	0.1588	0.191	0.1958	0.2311	0.2295	0.2266	0.2212	0.2088	0.1883	0.1762	0.2089	0.2202	0.2122	0.2059
7	25	0.1768	0.2021	0.2147	0.1557	0.1846	0.215	0.2278	0.2301	0.2273	0.2234	0.218	0.2112	0.1767	0.1674	0.2091	0.2021	0.2026
7	27	0.0961	0.1307	0.1625	0.1419	0.1855	0.1918	0.2276	0.2274	0.2231	0.2202	0.207	0.1865	0.1759	0.2072	0.2171	0.2107	0.2041
8	1	0.0725	0.1097	0.1472	0.1371	0.1894	0.1963	0.2354	0.2337	0.2344	0.2284	0.2159	0.1945	0.1808	0.218	0.227	0.2206	0.2124
8	3	0.106	0.1394	0.1689	0.1464	0.1828	0.1879	0.2237	0.2185	0.2198	0.2191	0.2177	0.1867	0.177	0.2094	0.2175	0.2069	0.2137
8	8	0.1012	0.1352	0.1658	0.1404	0.1818	0.1842	0.2201	0.2249	0.2207	0.2192	0.2093	0.1816	0.1697	0.205	0.2161	0.2072	0.2012
8	17	0.1488	0.1773	0.1966	0.164	0.1939	0.1983	0.2315	0.2303	0.224	0.2224	0.2073	0.1867	0.1738	0.2089	0.2169	0.2067	0.1995
8	22	0.2184	0.239	0.2418	0.1463	0.1862	0.1901	0.2228	0.2302	0.2225	0.2195	0.206	0.1814	0.1778	0.2064	0.2154	0.2064	0.203
8	29	0.137	0.1668	0.189	0.1421	0.1823	0.1876	0.2184	0.2252	0.2189	0.2169	0.2067	0.1821	0.1789	0.2043	0.2137	0.2047	0.2033
9	5	0.2369	0.2554	0.2537	0.1426	0.1807	0.1873	0.2156	0.2281	0.2188	0.2166	0.2067	0.1814	0.1771	0.2035	0.2126	0.2045	0.2046
9	21	0.1132	0.1458	0.1736	0.1637	0.2005	0.2073	0.2397	0.2416	0.236	0.2309	0.2179	0.1989	0.1826	0.216	0.2252	0.2147	0.208
10	3	0.1644	0.1911	0.2067	0.1647	0.2048	0.2075	0.2392	0.2412	0.2349	0.2303	0.2183	0.1982	0.184	0.2151	0.2234	0.2188	0.2042
10	10	0.1056	0.139	0.1686	0.1468	0.1967	0.1959	0.2341	0.2376	0.2321	0.228	0.2136	0.1944	0.1824	0.2146	0.2245	0.2173	0.2112
10	12	0.3031	0.3141	0.2966	0.1766	0.2188	0.2175	0.245	0.2371	0.2326	0.2258	0.2138	0.1939	0.1859	0.2113	0.2246	0.2173	0.2171
10	17	0.1475	0.1761	0.1958	0.1623	0.2014	0.2055	0.2382	0.2412	0.235	0.2281	0.2178	0.2032	0.1891	0.2183	0.2288	0.2238	0.2193
10	24	0.0978	0.1321	0.1636	0.1626	0.2014	0.2069	0.2404	0.2382	0.237	0.2269	0.216	0.2019	0.1855	0.2169	0.2252	0.2219	0.2179
11	2				0.168	0.2067	0.2045	0.24	0.2403	0.2379	0.2325	0.2218	0.2028	0.1901	0.223	0.2291	0.2242	0.2211
11	7	0.1133	0.1459	0.1736	0.1545	0.1953	0.2026	0.2409	0.2423	0.2369	0.235	0.2174	0.1991	0.1853	0.2233	0.2282	0.2266	0.2186
Avg.:		0.17426	0.19686	0.21092	0.15291	0.19232	0.1973	0.22945	0.23028	0.22569	0.22169	0.2084	0.18942	0.17799	0.20968	0.22026	0.21232	0.20636
C.V.:		47.8%	39.3%	26.8%	10.3%	5.2%	4.8%	2.8%	2.5%	2.6%	2.4%	3.1%	3.5%	3.3%	3.7%	2.9%	3.0%	3.4%

Volumetric Water Content -- 12/89 - 11/90

Plot 4

		DEPTH (cm)																
Month	Date	2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
12	1			0.0421	0.1491	0.1816	0.2105	0.227	0.2241	0.2216	0.2145	0.2022		0.145	0.1379	0.1845	0.1785	0.1787
12	4	0.1903	0.2141	0.2235	0.17	0.1957	0.2226	0.2349	0.2335	0.2388	0.2304	0.2284		0.1911	0.1839	0.2272	0.2178	0.2094
12	8	0.1891	0.213	0.2227	0.1601	0.1967	0.214	0.2272	0.2301	0.2293	0.2264	0.2239	0.2142	0.1839	0.1777	0.2163	0.2106	0.2044
12	15	0.1117	0.1445	0.1726	0.1414	0.1734	0.2095	0.2252	0.2297	0.2297	0.2226	0.22		0.1764	0.1676	0.2102	0.2027	0.2004
12	18	0.1115	0.1442	0.1724	0.1417	0.1764	0.2113	0.2257	0.2301	0.2314	0.2243	0.2216		0.1777	0.1677	0.2093	0.2014	0.1993
12	26	0.2431	0.2609	0.2577	0.1626	0.187	0.2225	0.2362	0.2353	0.2354	0.2308	0.2305		0.183	0.1765	0.2165	0.2069	0.2097
1	3	0.2047	0.2268	0.2328	0.162	0.169	0.2204	0.2105	0.2183	0.2183	0.216	0.1953	0.1822	0.1621	0.1757	0.2192	0.2056	0.2092
1	5	0.1851	0.2095	0.2201	0.183	0.2008	0.2287	0.2367	0.2389	0.2331	0.223	0.2217	0.2099	0.1726	0.1663	0.2076	0.2014	0.202
1	10	0.1831	0.2077	0.2188	0.1663	0.1872	0.2199	0.2342	0.2334	0.2339	0.2285	0.2273	0.216	0.183	0.1786	0.2186	0.2087	0.2094
1	12	0.1799	0.2049	0.2168	0.1706	0.1837	0.2178	0.2349	0.235	0.2338	0.2308	0.2288	0.219	0.1803	0.1831	0.2194	0.2098	0.2081
1	16	0.2651	0.2804	0.272	0.1682	0.1912	0.2257	0.2392	0.2465	0.2461	0.2411	0.2416	0.2247	0.1886	0.1852	0.2297	0.2185	0.2206
1	19	0.3486	0.3544	0.3261	0.156	0.1837	0.209	0.2263	0.2277	0.2303	0.2217	0.2218	0.2113	0.1752	0.1694	0.2121	0.2061	0.204
1	31	0.223	0.2431	0.2447	0.1729	0.193	0.2258	0.2384	0.2393	0.2399	0.2343	0.2329	0.221	0.1869	0.1852	0.2265	0.2172	0.2175
2	2	0.2363	0.2549	0.2533	0.1732	0.1878	0.2192	0.2312	0.2323	0.2311	0.2277	0.2238	0.2171	0.1841	0.1767	0.2188	0.2096	0.2065
2	8	0.1789	0.204	0.2161	0.162	0.184	0.216	0.2291	0.231	0.2359	0.2253	0.2249	0.2157	0.1788	0.1695	0.2153	0.2079	0.2057
2	9	0.2512	0.2681	0.263	0.192	0.2033	0.2317	0.2381	0.2389	0.2334	0.2225	0.2236	0.2127	0.1806	0.169	0.213	0.2054	0.2047
2	14	0.1601	0.1873	0.2039	0.1637	0.1832	0.2184	0.2295	0.2317	0.2353	0.2255	0.2299	0.2142	0.1792	0.1686	0.2159	0.2063	0.2008
2	16	0.1731	0.1988	0.2124	0.1569	0.1842	0.214	0.2293	0.2326	0.2297	0.227	0.2234	0.2142	0.1832	0.1758	0.2152	0.2087	0.2083
2	20	0.1619	0.1889	0.2051	0.1643	0.1837	0.2176	0.231	0.2335	0.2325	0.2275	0.2267	0.2153	0.1793	0.1763	0.2143	0.2085	0.2085
2	23	0.2395	0.2577	0.2554	0.1787	0.2028	0.2304	0.2387	0.2397	0.2384	0.2283	0.2293	0.2162	0.1801	0.1768	0.213	0.2091	0.2065
3	7	0.165	0.1917	0.2071	0.1516	0.1799	0.2136	0.2279	0.2314	0.229	0.2276	0.2256	0.2133	0.1777	0.1735	0.216	0.2063	0.2075
3	9	0.1196	0.1514	0.1777	0.1457	0.1758	0.204	0.2219	0.2255	0.2269	0.2223	0.22	0.2053	0.1717	0.1698	0.2099	0.2027	0.2017
3	14	0.2316	0.2506	0.2503	0.161	0.1859	0.2163	0.2308	0.2325	0.2314	0.2286	0.2274	0.2139	0.186	0.1754	0.217	0.2104	0.2082
3	16	0.2104	0.2319	0.2365	0.169	0.1905	0.2194	0.2304	0.2297	0.2256	0.2208	0.2182	0.2061	0.173	0.1648	0.2058	0.1996	0.1969
3	19	0.2045	0.2267	0.2327	0.1694	0.1882	0.2208	0.224	0.227	0.2268	0.2213	0.2187	0.2062	0.1741	0.1649	0.2064	0.1997	0.1979
3	28	0.1082	0.1414	0.1704	0.1477	0.1758	0.2099	0.2271	0.2276	0.2261	0.2216	0.2196	0.2108	0.1733	0.1678	0.2058	0.198	0.1996
3	29	0.2628	0.2783	0.2705	0.1888	0.2074	0.236	0.2422	0.2419	0.2379	0.2297	0.23	0.2135	0.1779	0.1753	0.2106	0.2045	0.2102
4	2		0.0082	0.073	0.1655	0.1876	0.2215	0.2312	0.2329	0.2303	0.2271	0.224	0.2144	0.1786	0.1748	0.2106	0.2033	0.2042
4	4	0.1579	0.1854	0.2025	0.1617	0.1844	0.2125	0.2289	0.2305	0.2307	0.2198	0.2232	0.2144	0.1778	0.172	0.2137	0.2074	0.2048
4	10	0.1585	0.1859	0.2029	0.1504	0.1778	0.21	0.2249	0.2279	0.2274	0.222	0.222	0.2082	0.1756	0.1707	0.2103	0.202	0.2017
4	18	0.1658	0.1924	0.2076	0.1615	0.1874	0.2194	0.2334	0.2374	0.2321	0.2265	0.2267	0.2149	0.1828	0.1799	0.2173	0.2092	0.2103
4	20	0.1614	0.1885	0.2048	0.1609	0.1868	0.2169	0.2282	0.2351	0.2306	0.2267	0.2242	0.2134	0.1806	0.1781	0.2159	0.2087	0.2099
4	27	0.2667	0.2818	0.273	0.1901	0.2035	0.2323	0.2364	0.2362	0.2332	0.225	0.2194	0.2083	0.177	0.1678	0.21	0.2014	0.2053
5	3	0.1572	0.1848	0.2021	0.1642	0.19	0.2151	0.2292	0.2293	0.2287	0.2249	0.225	0.215	0.1814	0.1746	0.2164	0.2094	0.2103
5	9	0.1276	0.1585	0.1829	0.1615	0.1844	0.2163	0.2305	0.2314	0.231	0.2269	0.226	0.2119	0.1778	0.1767	0.2151	0.2076	0.2106
5	11	0.2893	0.3018	0.2877	0.1841	0.1979	0.2224	0.2323	0.23	0.2291	0.2246	0.2187	0.2094	0.1767	0.1638	0.2081	0.2023	0.2026

Volumetric Water Content -- 12/89 - 11/90

Plot 4 (cont.)

Month	Date	DEPTH (cm)																
		2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
5	16	0.1429	0.1721	0.1928	0.157	0.1862	0.2182	0.2315	0.2349	0.2347	0.2234	0.2287	0.2172	0.1805	0.1725	0.2122	0.2042	0.2016
5	18	0.1339	0.1641	0.187	0.156	0.1854	0.2183	0.2316	0.2354	0.2336	0.2231	0.2286	0.2157	0.1794	0.1717	0.2119	0.2036	0.201
5	25	0.2776	0.2914	0.2801	0.19	0.2013	0.2352	0.2387	0.2388	0.2358	0.2253	0.218	0.2076	0.1774	0.1665	0.2075	0.2026	0.2027
5	31	0.2133	0.2344	0.2384	0.1625	0.1855	0.214	0.2281	0.2315	0.2272	0.2259	0.2209	0.2137	0.1781	0.1672	0.2083	0.2015	0.2028
6	4	0.1914	0.215	0.2242	0.1507	0.1794	0.2144	0.2279	0.2281	0.2304	0.2299	0.2236	0.2116	0.1757	0.1645	0.2082	0.2038	0.201
6	6	0.1077	0.1409	0.17	0.1462	0.1794	0.2116	0.2274	0.2254	0.2298	0.2254	0.2215	0.2133	0.1765	0.1645	0.2105	0.2016	0.2024
6	8	0.2942	0.3062	0.2908	0.1907	0.2031	0.235	0.2406	0.2398	0.2357	0.2275	0.2184	0.2093	0.1776	0.1668	0.2076	0.2016	0.2065
6	13	0.1582	0.1856	0.2027	0.1595	0.1861	0.218	0.2312	0.234	0.2311	0.2286	0.221	0.2145	0.1772	0.1716	0.2093	0.2055	0.2034
6	15	0.1552	0.183	0.2008	0.1561	0.1889	0.2149	0.2329	0.2353	0.2319	0.229	0.2222	0.2155	0.1773	0.1689	0.2048	0.2053	0.2049
6	21	0.0976	0.132	0.1635	0.1464	0.1786	0.2128	0.2285	0.2295	0.2315	0.2252	0.2189	0.211	0.1769	0.1644	0.2091	0.2018	0.2017
6	29	0.1076	0.1408	0.1699	0.151	0.184	0.2191	0.2352	0.2363	0.2383	0.2319	0.2254	0.2173	0.1823	0.1695	0.2153	0.2078	0.2077
7	3	0.1	0.1341	0.165	0.1555	0.1828	0.2119	0.2316	0.2289	0.2294	0.2264	0.2237	0.2129	0.1778	0.1646	0.2141	0.2031	0.2029
7	11	0.1811	0.206	0.2176	0.1695	0.1915	0.2257	0.233	0.2361	0.2348	0.229	0.2276	0.2185	0.1803	0.1719	0.2107	0.2052	0.2054
7	13	0.1804	0.2053	0.2171	0.1687	0.189	0.2211	0.2369	0.2312	0.236	0.2283	0.2268	0.2193	0.1817	0.172	0.2146	0.2078	0.2045
7	25	0.1883	0.2123	0.2222	0.155	0.1823	0.2131	0.2231	0.2281	0.2235	0.2112	0.2167	0.2064	0.1784	0.1666	0.2038	0.2078	0.2077
7	27	0.1162	0.1485	0.1755	0.1569	0.186	0.2166	0.2295	0.2318	0.229	0.225	0.2196	0.2127	0.178	0.1687	0.2106	0.2035	0.2041
8	1	0.0983	0.1325	0.1639	0.1467	0.1858	0.2187	0.2361	0.2373	0.2386	0.2358	0.2346	0.2199	0.1854	0.1722	0.2212	0.2105	0.2126
8	3	0.1373	0.1671	0.1892	0.1405	0.1831		0.2255	0.2258	0.2158	0.2244	0.2216	0.212	0.1791	0.1648	0.215	0.2035	0.2042
8	8	0.1276	0.1585	0.1829	0.1346	0.1741	0.2048	0.2219	0.2277	0.2266	0.2216	0.2214	0.2087	0.1738	0.1613	0.2075	0.202	0.1983
8	17	0.1638	0.1906	0.2063	0.1744	0.1914	0.22	0.2306	0.2342	0.232	0.227	0.2248	0.2162	0.1811	0.171	0.2135	0.2035	0.2031
8	22	0.2286	0.248	0.2483	0.1574	0.1838	0.2148	0.2255	0.2278	0.2329	0.2252	0.2228	0.2133	0.1759	0.1683	0.2139	0.2062	0.2005
8	29	0.1432	0.1723	0.193	0.1547	0.1824	0.2121	0.2253	0.2266	0.2306	0.2253	0.2192	0.214	0.1748	0.1702	0.2143	0.2083	0.1964
9	5	0.2424	0.2602	0.2573	0.1529	0.1808	0.2089	0.2236	0.2247	0.2281	0.2243	0.2174	0.2122	0.1726	0.169	0.2134	0.2075	0.1932
9	21	0.0983	0.1326	0.1639	0.1711	0.2024	0.2301	0.2413	0.2473	0.2409	0.2378	0.2373	0.2264	0.1845	0.1733	0.2184	0.2106	0.212
10	3	0.1927	0.2162	0.2251	0.1731	0.203	0.23	0.2416	0.2463	0.2454	0.2431	0.235	0.2282	0.1969	0.1808	0.2263	0.217	0.2137
10	10	0.1108	0.1436	0.172	0.161	0.1921	0.2234	0.2392	0.2439	0.2375	0.2376	0.2315	0.2252	0.1862	0.173	0.2199	0.2129	0.2122
10	12	0.2976	0.3091	0.293	0.188	0.2113	0.2439	0.2511	0.253	0.2363	0.2372	0.2313	0.2248	0.1838	0.1725	0.2239	0.2178	0.2139
10	17	0.1409	0.1703	0.1915	0.1754	0.2016	0.2282	0.2427	0.2429	0.2453	0.2371	0.2369	0.228	0.1932	0.1829	0.23	0.2192	0.2197
10	24	0.1	0.1341	0.165	0.1765	0.2027	0.2257	0.241	0.2432	0.245	0.2357	0.2379	0.2265	0.193	0.1829	0.226	0.2159	0.2206
11	2				0.1792	0.1989	0.2274	0.2429	0.2446	0.2415	0.2405	0.2378	0.2298	0.1963	0.182	0.2263	0.22	0.2183
11	7	0.1214	0.153	0.1788	0.1668	0.1967	0.2261	0.2425	0.242	0.241	0.2381	0.2376	0.2297	0.1895	0.1771	0.2267	0.2168	0.2172
Avg.:		0.17924	0.20127	0.21153	0.16346	0.18853	0.21948	0.23196	0.23374	0.23261	0.2273	0.2247	0.21474	0.17962	0.1718	0.21412	0.20674	0.20584
C.V.:		33.0%	28.5%	22.1%	8.2%	4.9%	3.7%	2.9%	2.8%	2.5%	2.7%	3.3%	3.4%	4.1%	4.2%	3.4%	3.1%	3.3%

Volumetric Water Content -- 12/89 - 11/90

Plot 5

Month	Date	DEPTH (cm) 2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
12	1			0.0235	0.1385	0.1657	0.1771	0.1933	0.2088	0.1994	0.174	0.1841		0.1217	0.1216	0.1339	0.1802	0.201
12	4	0.1853	0.2097	0.2203	0.1655	0.1812	0.1941	0.2167	0.2238	0.2174	0.2102	0.2201		0.164	0.16	0.1789	0.2233	0.2363
12	8	0.1842	0.2087	0.2196	0.1472	0.1751	0.1822	0.2104	0.2224	0.21	0.2038	0.2182	0.1959	0.1567	0.1514	0.1672	0.2162	0.2365
12	15	0.1033	0.137	0.1671	0.1306	0.1598	0.1728	0.1936	0.2126	0.2081	0.1975	0.2145		0.147	0.1436	0.158	0.2109	0.2259
12	18	0.104	0.1376	0.1676	0.1353	0.1594	0.1722	0.1932	0.212	0.2089	0.1974	0.2149		0.1471	0.1438	0.158	0.2119	0.2261
12	26	0.2268	0.2464	0.2471	0.1513	0.1745	0.19	0.2089	0.2211	0.2159	0.2085	0.222		0.1599	0.1553	0.1663	0.2144	0.2319
1	3	0.1776	0.2028	0.2153	0.1629	0.1677	0.1951	0.2083	0.2225	0.2161	0.2268	0.191	0.1825	0.1633	0.1624	0.2163	0.2022	0.2095
1	5	0.17	0.1961	0.2104	0.1742	0.1897	0.2018	0.2146	0.2205	0.2131	0.1971	0.212	0.1893	0.152	0.1467	0.1603	0.2099	0.2273
1	10	0.1713	0.1972	0.2112	0.1551	0.1736	0.1898	0.2092	0.2189	0.2149	0.2049	0.2182	0.1926	0.1571	0.1546	0.1691	0.2203	0.2345
1	12	0.172	0.1979	0.2117	0.1556	0.1749	0.1935	0.2073	0.2163	0.221	0.2029	0.2198	0.1919	0.1564	0.156	0.1731	0.2201	0.234
1	16	0.3034	0.3143	0.2968	0.155	0.1783	0.1884	0.2145	0.2304	0.2222	0.2141	0.2314	0.2066	0.1661	0.1611	0.1753	0.2267	0.2451
1	19	0.3304	0.3382	0.3143	0.1615	0.1716	0.1776	0.1978	0.2154	0.2076	0.2001	0.2152	0.19	0.1531	0.1472	0.1579	0.2112	0.2313
1	31	0.2128	0.234	0.2381	0.1585	0.1797	0.1878	0.2206	0.2283	0.2201	0.2129	0.2291	0.2052	0.1631	0.1619	0.1783	0.2248	0.2451
2	2	0.247	0.2643	0.2602	0.1652	0.1764	0.1829	0.2063	0.2183	0.2131	0.2086	0.2203	0.1968	0.1563	0.1531	0.1702	0.2159	0.2452
2	8	0.189	0.2129	0.2227	0.1487	0.1712	0.1797	0.206	0.2176	0.2132	0.2035	0.2193	0.1962	0.1554	0.1524	0.1619	0.2161	0.2335
2	9	0.2571	0.2732	0.2668	0.1848	0.1998	0.207	0.2251	0.2287	0.2205	0.2152	0.2208	0.195	0.1525	0.1462	0.1615	0.2135	0.2364
2	14	0.1618	0.1888	0.2051	0.1473	0.1699	0.1795	0.2052	0.2184	0.2134	0.2026	0.2175	0.1954	0.154	0.1519	0.1596	0.216	0.2324
2	16	0.1613	0.1884	0.2047	0.1477	0.1701	0.179	0.2056	0.2148	0.2125	0.2029	0.2132	0.1951	0.1568	0.152	0.1665	0.2165	0.2372
2	20	0.1423	0.1715	0.1924	0.1499	0.169	0.1795	0.2039	0.2164	0.2125	0.2062	0.2192	0.1951	0.1567	0.1495	0.1655	0.2196	0.2388
2	23	0.2483	0.2655	0.2611	0.173	0.1896	0.1991	0.2201	0.226	0.2202	0.2133	0.2265	0.2039	0.1622	0.1555	0.1672	0.2188	0.2356
3	7	0.1639	0.1907	0.2064	0.1379	0.1674	0.1815	0.2007	0.2168	0.2105	0.2007	0.2184	0.1947	0.151	0.1507	0.1651	0.2171	0.2398
3	9	0.1072	0.1404	0.1697	0.1346	0.1602	0.1715	0.1946	0.2093	0.2061	0.1994	0.2119	0.1905	0.148	0.1456	0.1615	0.2104	0.2312
3	14	0.2451	0.2627	0.2591	0.1461	0.1738	0.1858	0.2048	0.215	0.2163	0.2051	0.2188	0.198	0.1579	0.1539	0.1701	0.2191	0.2411
3	16	0.2224	0.2426	0.2443	0.1602	0.1804	0.1913	0.2121	0.219	0.2114	0.2066	0.2169	0.1919	0.1527	0.1481	0.1621	0.2089	0.2325
3	19	0.2205	0.2408	0.2431	0.1604	0.1815	0.1882	0.2124	0.2193	0.2108	0.2073	0.2156	0.1914	0.1539	0.1498	0.1622	0.2099	0.2331
3	28	0.0999	0.134	0.165	0.1338	0.1603	0.1722	0.1934	0.2127	0.2064	0.1954	0.2107	0.1904	0.1471	0.1464	0.1585	0.21	0.2326
3	29	0.2818	0.2951	0.2828	0.1968	0.2068	0.2061	0.2242	0.2297	0.2214	0.2095	0.2221	0.1975	0.1557	0.1521	0.166	0.2198	0.2387
4	2		0.013	0.0765	0.1549	0.1731	0.1866	0.2056	0.2187	0.2128	0.2009	0.2149	0.1944	0.1556	0.1536	0.1704	0.2133	0.2335
4	4	0.1483	0.1769	0.1963	0.1496	0.1693	0.1834	0.2059	0.2128	0.2113	0.2022	0.2186	0.1924	0.1551	0.1526	0.1673	0.2143	0.2365
4	10	0.1478	0.1764	0.196	0.1364	0.1599	0.1712	0.1969	0.2123	0.2095	0.1976	0.2148	0.1887	0.1501	0.1477	0.1619	0.2112	0.2337
4	18	0.1577	0.1852	0.2024	0.1519	0.1727	0.1863	0.2108	0.2179	0.2114	0.2019	0.2189	0.1973	0.1602	0.1543	0.1736	0.2204	0.2432
4	20	0.1527	0.1808	0.1992	0.1505	0.2066	0.1863	0.2102	0.2154	0.2102	0.1996	0.2179	0.1947	0.16	0.1516	0.173	0.2162	0.2415
4	27	0.2644	0.2797	0.2715	0.1795	0.1895	0.206	0.2199	0.2252	0.2143	0.2068	0.2198	0.1923	0.1507	0.1486	0.1644	0.2128	0.2409
5	3	0.1486	0.1771	0.1965	0.1659	0.1953	0.217	0.2324	0.2262	0.2305	0.2263	0.2167	0.1982	0.1823	0.1915	0.2187	0.1995	0.2093
5	9	0.1142	0.1467	0.1742	0.1445	0.1692	0.1802	0.2042	0.2167	0.2123	0.2036	0.2163	0.1967	0.1546	0.1504	0.1716	0.2171	0.2434
5	11	0.3342	0.3416	0.3167	0.1442	0.1918	0.2004	0.2172	0.2215	0.212	0.1986	0.2159	0.1947	0.1536	0.1449	0.1599	0.2102	0.2366

Volumetric Water Content -- 12/89 - 11/90

Plot 5 (cont.)

DEPTH (cm)

Month	Date	2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
5	16	0.1572	0.1848	0.2021	0.143	0.1742	0.1843	0.2072	0.2188	0.2123	0.2067	0.2173	0.1982	0.1587	0.1516	0.1696	0.2181	0.2416
5	18	0.1372	0.167	0.1891	0.1422	0.1729	0.1816	0.2057	0.2165	0.2121	0.2057	0.2164	0.1972	0.158	0.1509	0.1681	0.2185	0.2415
5	25	0.3135	0.3232	0.3033	0.1827	0.199	0.2067	0.2226	0.2267	0.2232	0.213	0.2187	0.1906	0.151	0.1428	0.1549	0.2155	0.2269
5	31	0.2314	0.2505	0.2501	0.1485	0.172	0.1808	0.2008	0.2176	0.2118	0.202	0.2189	0.1958	0.1535	0.1511	0.1628	0.2086	0.2378
6	4	0.1965	0.2196	0.2276	0.1378	0.1659	0.1773	0.2015	0.2135	0.2102	0.2033	0.2158	0.1923	0.1544	0.146	0.1621	0.209	0.2378
6	6	0.104	0.1377	0.1676	0.131	0.1671	0.175	0.1978	0.2163	0.2127	0.1999	0.2185	0.1937	0.1532	0.1448	0.1611	0.2081	0.2377
6	8	0.3061	0.3167	0.2985	0.1828	0.199	0.207	0.2236	0.2248	0.2235	0.2134	0.2187	0.1915	0.1531	0.1427	0.1591	0.2157	0.2273
6	13	0.1352	0.1653	0.1878	0.1522	0.1717	0.1819	0.2031	0.2173	0.2093	0.2042	0.2175	0.1987	0.1574	0.1485	0.1665	0.2127	0.2334
6	15	0.1333	0.1636	0.1866	0.1527	0.1666	0.1814	0.2047	0.2149	0.2088	0.2047	0.2168	0.1985	0.1553	0.1493	0.1684	0.2155	0.2342
6	21	0.0994	0.1335	0.1646	0.1309	0.1624	0.1705	0.1968	0.2149	0.209	0.1988	0.2145	0.1911	0.1517	0.1464	0.1592	0.2098	0.2352
6	29	0.0884	0.1238	0.1575	0.1472	0.174	0.1854	0.2051	0.2218	0.2144	0.2045	0.223	0.1981	0.1548	0.1511	0.1666	0.2162	0.2415
7	3	0.0897	0.125	0.1583	0.137	0.1634	0.1759	0.1959	0.2133	0.2082	0.2021	0.2175	0.1959	0.1532	0.146	0.1588	0.2117	0.2401
7	11	0.1449	0.1738	0.1941	0.1592	0.1748	0.1844	0.2066	0.2215	0.2142	0.2055	0.2202	0.1977	0.1586	0.1511	0.1667	0.2187	0.2426
7	13	0.1637	0.1906	0.2063	0.1549	0.1738	0.184	0.2031	0.2189	0.2135	0.2039	0.2204	0.1971	0.1577	0.1526	0.1647	0.2153	0.2449
7	25	0.1804	0.2053	0.2171	0.1592	0.1804	0.2165	0.2238	0.2322	0.2341	0.2159	0.2173	0.1998	0.1746	0.1609	0.1818	0.201	0.2065
7	27	0.0905	0.1256	0.1588	0.1289	0.1636	0.1767	0.1979	0.2143	0.2098	0.1987	0.2188	0.1962	0.1552	0.1467	0.1614	0.2131	0.2493
8	1	0.0753	0.1122	0.149	0.1352	0.169	0.1823	0.205	0.2263	0.2214	0.2082	0.2291	0.2022	0.1574	0.1509	0.1662	0.2204	0.2545
8	3	0.1075	0.1407	0.1699	0.1403	0.1626	0.1748	0.1955	0.2196	0.2088	0.1957	0.2176	0.192	0.1528	0.1429	0.1598	0.2074	0.2383
8	8	0.1055	0.139	0.1686	0.133	0.1596	0.1698	0.1915	0.2119	0.2078	0.1992	0.2174	0.193	0.1499	0.1444	0.1553	0.21	0.2468
8	17	0.1565	0.1841	0.2016	0.1599	0.1741	0.1799	0.2011	0.2153	0.2118	0.2034	0.2179	0.1919	0.1541	0.1471	0.1605	0.209	0.2469
8	22	0.2235	0.2435	0.245	0.1481	0.1691	0.18	0.2019	0.222	0.2098	0.1995	0.2208	0.1985	0.1547	0.1477	0.1593	0.2135	0.246
8	29	0.1472	0.1759	0.1956	0.1438	0.1704	0.1799	0.2007	0.218	0.2074	0.1962	0.2177	0.1962	0.1542	0.1459	0.1562	0.2147	0.2364
9	5	0.2388	0.257	0.2549	0.1489	0.1667	0.177	0.1994	0.2157	0.205	0.1931	0.2196	0.1918	0.1529	0.142	0.1542	0.2134	0.2338
9	21	0.1265	0.1575	0.1822	0.1616	0.1817	0.1943	0.2187	0.232	0.2262	0.2139	0.231	0.2105	0.1695	0.1638	0.1777	0.2305	0.2696
10	3	0.1943	0.2176	0.2261	0.1638	0.1883	0.1976	0.2177	0.2301	0.2255	0.2141	0.2269	0.21	0.1696	0.1603	0.1739	0.2256	0.2681
10	10	0.1343	0.1645	0.1873	0.1489	0.1725	0.1826	0.2069	0.2255	0.2187	0.2075	0.2262	0.2049	0.1622	0.1527	0.1653	0.2217	0.2619
10	12	0.3404	0.3471	0.3208	0.1813	0.1989	0.2154	0.23	0.2318	0.2201	0.2075	0.2271	0.2025	0.1614	0.1564	0.1654	0.2316	0.2633
10	17	0.1449	0.1739	0.1941	0.1628	0.185	0.1932	0.2142	0.2292	0.2218	0.2143	0.2309	0.2095	0.1698	0.1594	0.173	0.2252	0.2654
10	24	0.1178	0.1498	0.1765	0.1603	0.1849	0.1897	0.214	0.2281	0.2229	0.212	0.2305	0.2106	0.1654	0.1603	0.1727	0.2226	0.262
11	2				0.167	0.1818	0.1911	0.2136	0.2301	0.2227	0.2129	0.2322	0.209	0.1693	0.1601	0.1743	0.2253	0.2681
11	7	0.1161	0.1484	0.1755	0.1546	0.1774	0.1887	0.2103	0.2265	0.2207	0.2145	0.2313	0.2057	0.1626	0.1569	0.1686	0.2241	0.2673
Avg.:		0.17745	0.19978	0.21018	0.15306	0.17579	0.1867	0.2078	0.22011	0.2144	0.20505	0.21884	0.19671	0.15666	0.15136	0.16665	0.21494	0.23907
C.V.:		38.2%	32.1%	24.8%	9.7%	6.7%	6.2%	4.6%	2.8%	3.0%	3.8%	3.5%	3.0%	5.0%	5.5%	7.0%	3.6%	5.7%

Volumetric Water Content -- 12/89 - 11/90

Plot 6

Month	Date	DEPTH (cm) 2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
12	1	0.1699	0.196	0.2103	0.1458	0.1807	0.1828	0.2228	0.2104	0.1984	0.1984	0.1897		0.1206	0.1039	0.1108	0.1373	0.1737
12	4	0.217	0.2377	0.2408	0.1797	0.1959	0.2197	0.2351	0.2355	0.2414	0.2328	0.2212		0.1667	0.1426	0.1484	0.1696	0.2088
12	8	0.2157	0.2366	0.24	0.1603	0.1965	0.2088	0.2347	0.2304	0.2413	0.229	0.2186	0.1988	0.1633	0.1383	0.1423	0.1642	0.2047
12	15	0.0937	0.1285	0.1609	0.1487	0.176	0.2007	0.2278	0.2242	0.2306	0.2276	0.2184		0.1561	0.1286	0.1368	0.1589	0.1987
12	18	0.0943	0.129	0.1613	0.1495	0.1762	0.2004	0.2281	0.2239	0.2323	0.229	0.2182		0.155	0.1288	0.1375	0.1589	0.2006
12	26	0.3008	0.312	0.2951	0.1708	0.1942	0.2173	0.2376	0.2357	0.2461	0.2319	0.226		0.1634	0.1384	0.1445	0.165	0.2066
1	3	0.1755	0.201	0.2139	0.1609	0.193	0.2195	0.2172	0.2183	0.2325	0.2151	0.1922	0.1895	0.1544	0.1271	0.2147	0.2044	0.2083
1	5	0.1969	0.22	0.2278	0.1894	0.2123	0.2265	0.2403	0.2342	0.2445	0.2288	0.2163	0.196	0.1549	0.1307	0.1353	0.1601	0.1992
1	10	0.1917	0.2154	0.2245	0.1726	0.1934	0.2138	0.2352	0.2325	0.2402	0.2296	0.2198	0.1965	0.1627	0.1374	0.1424	0.1681	0.2071
1	12	0.1875	0.2116	0.2217	0.1736	0.2023	0.213	0.2319	0.2319	0.2406	0.2355	0.2164	0.1968	0.1624	0.1345	0.1417	0.1653	0.2089
1	16	0.2887	0.3013	0.2873	0.1981	0.2243	0.2453	0.2384	0.2403	0.2537	0.2418	0.2362	0.2073	0.1671	0.1441	0.1484	0.1744	0.215
1	19	0.3222	0.3309	0.309	0.1775	0.1912	0.2071	0.2294	0.2284	0.2361	0.2239	0.219	0.1918	0.1564	0.1346	0.1383	0.1602	0.2045
1	31	0.222	0.2422	0.2441	0.1758	0.2011	0.2186	0.2434	0.2353	0.249	0.2368	0.2299	0.2077	0.165	0.1455	0.1492	0.1737	0.2136
2	2	0.2399	0.258	0.2556	0.1818	0.1961	0.2141	0.2351	0.2339	0.2422	0.2311	0.2219	0.1974	0.1604	0.138	0.1427	0.1651	0.2122
2	8	0.2033	0.2256	0.2319	0.1596	0.1881	0.211	0.2335	0.2299	0.2435	0.2291	0.2211	0.1966	0.1588	0.1369	0.1382	0.1674	0.2066
2	9	0.2704	0.285	0.2754	0.1955	0.2126	0.2271	0.2393	0.2366	0.2396	0.2285	0.2212	0.1952	0.159	0.136	0.1369	0.1607	0.2117
2	14	0.1748	0.2003	0.2135	0.159	0.1883	0.2105	0.2321	0.2321	0.242	0.2317	0.2199	0.1932	0.1587	0.1368	0.1384	0.1685	0.206
2	16	0.1862	0.2104	0.2209	0.1622	0.1883	0.2108	0.231	0.2296	0.2397	0.229	0.2178	0.1933	0.1595	0.1338	0.1402	0.164	0.2103
2	20	0.1804	0.2053	0.2171	0.1633	0.1892	0.2121	0.2324	0.2304	0.2435	0.2303	0.2215	0.1954	0.1577	0.134	0.1397	0.1649	0.2118
2	23	0.2593	0.2753	0.2682	0.1866	0.2079	0.228	0.2441	0.2379	0.2488	0.233	0.2251	0.1986	0.1619	0.1385	0.1392	0.1649	0.2105
3	7	0.209	0.2307	0.2357	0.1555	0.1834	0.2103	0.2315	0.2346	0.2417	0.232	0.2227	0.1943	0.1583	0.1344	0.1372	0.1633	0.2114
3	9	0.1337	0.1639	0.1868	0.1483	0.1738	0.2038	0.2274	0.2228	0.233	0.2241	0.2167	0.1888	0.1529	0.1305	0.1342	0.1602	0.2067
3	14	0.2572	0.2734	0.2669	0.1678	0.193	0.2138	0.2356	0.2357	0.2415	0.2294	0.2229	0.2	0.16	0.139	0.1418	0.1658	0.2146
3	16	0.2356	0.2543	0.2529	0.1735	0.1977	0.2171	0.2363	0.2317	0.2421	0.224	0.2171	0.1941	0.1557	0.1315	0.135	0.1611	0.2065
3	19	0.2306	0.2498	0.2496	0.1741	0.1979	0.2185	0.2371	0.2316	0.2428	0.2235	0.2184	0.1945	0.1561	0.1322	0.136	0.1623	0.2036
3	28	0.1618	0.1888	0.205	0.1493	0.1765	0.2015	0.226	0.2211	0.2328	0.2202	0.2127	0.1874	0.1517	0.1323	0.1328	0.1618	0.2033
3	29	0.2481	0.2653	0.261	0.1978	0.2125	0.2265	0.2464	0.2356	0.2441	0.235	0.2208	0.1956	0.1586	0.1347	0.1408	0.1643	0.2122
4	2		0.0164	0.079	0.1741	0.1953	0.212	0.2367	0.2277	0.2352	0.2259	0.2213	0.1937	0.1577	0.1383	0.139	0.1613	0.2112
4	4	0.1799	0.2049	0.2168	0.1642	0.1913	0.2107	0.2333	0.2296	0.2397	0.2245	0.2164	0.1935	0.1579	0.1357	0.1378	0.1636	0.2131
4	10	0.1808	0.2057	0.2174	0.1518	0.1797	0.2037	0.2316	0.2255	0.2408	0.2249	0.2191	0.1888	0.1514	0.13	0.136	0.1602	0.2094
4	18	0.1857	0.21	0.2205	0.1704	0.1935	0.2155	0.2327	0.2317	0.2427	0.2293	0.2178	0.1954	0.1589	0.1337	0.1397	0.1673	0.2147
4	20	0.1806	0.2055	0.2172	0.1685	0.1914	0.213	0.2307	0.2299	0.241	0.2279	0.2134	0.1902	0.1553	0.1472	0.1381	0.164	0.2099
4	27	0.2457	0.2632	0.2594	0.1871	0.2096	0.2233	0.2369	0.228	0.2343	0.226	0.2175	0.1951	0.155	0.132	0.135	0.1597	0.2119
5	3	0.1724	0.1983	0.212	0.1725	0.1912	0.2158	0.2321	0.2252	0.2298	0.2251	0.213	0.19	0.1782	0.1857	0.2182	0.2034	0.2032
5	9	0.1669	0.1934	0.2084	0.1741	0.1897	0.2114	0.2363	0.2274	0.2402	0.2244	0.2187	0.1984	0.1577	0.1359	0.1389	0.1646	0.2135
5	11	0.344	0.3503	0.3231	0.1532	0.1903	0.211	0.2196	0.223	0.2149	0.2116	0.214	0.1881	0.1535	0.1466	0.1484	0.2201	0.2066

Volumetric Water Content -- 12/89 - 11/90

Plot 6 (cont.)

Month	Date	DEPTH (cm)																
		2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
5	16	0.1332	0.1635	0.1866	0.1583	0.1928	0.2123	0.237	0.2319	0.239	0.2303	0.2198	0.1989	0.1663	0.1386	0.1421	0.1646	0.2162
5	18	0.1517	0.1799	0.1985	0.1578	0.1924	0.2127	0.2371	0.2317	0.2364	0.229	0.2193	0.1986	0.1667	0.1398	0.1419	0.164	0.2164
5	25	0.3269	0.3351	0.312	0.1941	0.2153	0.2272	0.2422	0.233	0.2429	0.2281	0.2185	0.1947	0.1525	0.1336	0.136	0.1601	0.2027
5	31	0.2461	0.2635	0.2597	0.1934	0.2145	0.2263	0.2413	0.2321	0.242	0.2273	0.2177	0.194	0.1519	0.133	0.1354	0.1594	0.2019
6	4	0.1884	0.2124	0.2223	0.1393	0.1797	0.2021	0.2292	0.226	0.2394	0.2342	0.2191	0.1934	0.1537	0.1341	0.1373	0.1569	0.2089
6	6	0.0576	0.0965	0.1376	0.1268	0.1719	0.2007	0.2314	0.2275	0.2361	0.2288	0.2217	0.1935	0.1552	0.1288	0.135	0.1594	0.2064
6	8	0.33	0.3379	0.314	0.1938	0.2171	0.2273	0.2411	0.2273	0.229	0.2167	0.2176	0.1952	0.1579	0.1451	0.1293	0.1555	0.2017
6	13	0.1564	0.184	0.2015	0.1609	0.1907	0.2117	0.2321	0.2291	0.241	0.2288	0.2199	0.1976	0.159	0.1365	0.1357	0.16	0.2083
6	15	0.1496	0.178	0.1971	0.1618	0.1929	0.2119	0.2297	0.2301	0.2423	0.2297	0.2209	0.1985	0.1608	0.1413	0.1407	0.1606	0.2068
6	21	0.0664	0.1043	0.1433	0.1432	0.1786	0.2073	0.2304	0.2273	0.2373	0.2284	0.2189	0.1944	0.1559	0.132	0.1368	0.1592	0.2072
6	29	0.1008	0.1348	0.1655	0.1601	0.1904	0.214	0.2394	0.2361	0.2462	0.2371	0.2262	0.2015	0.1656	0.1374	0.1432	0.1669	0.2131
7	3	0.1108	0.1437	0.172	0.1552	0.1846	0.2096	0.2317	0.2274	0.237	0.2298	0.2205	0.196	0.1602	0.1335	0.1387	0.1599	0.208
7	11	0.1622	0.1892	0.2053	0.1675	0.1965	0.2164	0.2348	0.2355	0.2432	0.2336	0.2252	0.1988	0.1629	0.1395	0.1398	0.1619	0.2128
7	13	0.1728	0.1986	0.2122	0.1692	0.1936	0.2125	0.2354	0.2289	0.2391	0.2312	0.2196	0.1977	0.1623	0.1365	0.1381	0.16	0.2118
7	25	0.1953	0.2185	0.2267	0.1556	0.1793	0.212	0.2274	0.2281	0.2333	0.2161	0.2168	0.1991	0.1701	0.1592	0.1794	0.2011	0.2076
7	27	0.1163	0.1485	0.1756	0.1503	0.1839	0.2091	0.2327	0.2286	0.2384	0.234	0.2191	0.1972	0.157	0.1302	0.1371	0.1606	0.2207
8	1	0.1014	0.1353	0.1659	0.15	0.1909	0.2172	0.2447	0.237	0.2497	0.2406	0.2312	0.2029	0.166	0.1345	0.1412	0.1675	0.2294
8	3	0.1375	0.1673	0.1893	0.1432	0.1798	0.2079	0.2323	0.2291	0.2384	0.2323	0.221	0.1944	0.1557	0.1347	0.1404	0.1555	0.2196
8	8	0.1412	0.1705	0.1917	0.1409	0.1798	0.2021	0.2278	0.227	0.2375	0.2322	0.218	0.1965	0.1558	0.1293	0.1365	0.1592	0.2136
8	17	0.1828	0.2075	0.2187	0.1688	0.195	0.2138	0.2357	0.2326	0.2426	0.2321	0.2195	0.1988	0.1602	0.135	0.1355	0.1595	0.2181
8	22	0.2564	0.2726	0.2663	0.1583	0.1873	0.2071	0.2343	0.2286	0.2387	0.2339	0.2236	0.198	0.1596	0.1353	0.1348	0.1584	0.2198
8	29	0.1631	0.19	0.2059	0.1534	0.1824	0.2038	0.2321	0.2311	0.2379	0.233	0.2195	0.1942	0.1596	0.1309	0.1343	0.1575	0.2188
9	5	0.2386	0.2569	0.2548	0.1523	0.1792	0.2017	0.2192	0.2316	0.2364	0.2314	0.2196	0.1925	0.1569	0.1323	0.1348	0.1533	0.2192
9	21	0.1561	0.1838	0.2014	0.1739	0.205	0.2267	0.2448	0.2417	0.2548	0.2451	0.2375	0.2099	0.1671	0.1429	0.1478	0.1686	0.2086
10	3	0.1986	0.2215	0.2289	0.174	0.2005	0.2237	0.2466	0.2393	0.2491	0.2465	0.2282	0.2068	0.1685	0.1391	0.1423	0.1629	0.2224
10	10	0.1283	0.1591	0.1833	0.1589	0.1918	0.2134	0.2395	0.2398	0.248	0.2448	0.2279	0.2069	0.1643	0.1352	0.1415	0.1597	0.2201
10	12	0.3417	0.3482	0.3216	0.1883	0.2109	0.2441	0.245	0.2452	0.2502	0.2444	0.2238	0.2073	0.1683	0.1389	0.1444	0.1646	0.2234
10	17	0.1525	0.1806	0.199	0.1775	0.2064	0.2252	0.2467	0.241	0.2497	0.2473	0.2334	0.2127	0.1713	0.1469	0.147	0.1689	0.227
10	24	0.1222	0.1537	0.1794	0.1743	0.2068	0.2216	0.2457	0.2398	0.247	0.2469	0.2331	0.2105		0.1479	0.1467	0.17	0.2264
11	2				0.1823	0.2008	0.2202	0.2444	0.2384	0.2511	0.2458	0.2311	0.2098	0.1698	0.1454	0.148	0.1651	0.2254
11	7	0.1217	0.1533	0.1791	0.1715	0.1986	0.2178	0.2435	0.2407	0.2503	0.2495	0.2333	0.2103	0.1696	0.1431	0.1473	0.1702	0.2226
Avg.:		0.19121	0.21189	0.22191	0.16639	0.19349	0.21424	0.23485	0.23128	0.2401	0.23059	0.22051	0.19746	0.1596	0.137	0.14214	0.16522	0.21098
C.V.:		34.6%	29.8%	20.8%	9.5%	6.0%	4.7%	2.8%	2.6%	3.5%	3.8%	3.4%	3.0%	4.6%	6.8%	10.6%	7.3%	4.0%

Volumetric Water Content -- 12/89 - 11/90

Plot 7

Month	Date	DEPTH (cm)																
		2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
12	1	0.1413	0.1706	0.1917	0.1445	0.1694	0.1941	0.219	0.217	0.2071	0.184	0.1961		0.1243	0.1174	0.1262	0.1802	0.1825
12	4	0.2131	0.2343	0.2383	0.1807	0.187	0.2138	0.2315	0.2253	0.2305	0.2188	0.2159		0.1626	0.1535	0.1579	0.2159	0.2287
12	8	0.2119	0.2332	0.2375	0.1503	0.1908	0.2052	0.2332	0.2283	0.2265	0.2186	0.2156	0.1725	0.157	0.1485	0.1492	0.2126	0.2207
12	15	0.1273	0.1583	0.1827	0.1399	0.1608	0.1945	0.2245	0.2234	0.2228	0.211	0.2126		0.1477	0.1402	0.1479	0.2049	0.2143
12	18	0.126	0.1571	0.1818	0.1397	0.1615	0.1938	0.2252	0.2245	0.2234	0.2114	0.2129		0.1468	0.1322	0.1489	0.2042	0.2133
12	26	0.2827	0.2959	0.2833	0.1674	0.1775	0.2106	0.2366	0.2326	0.2317	0.219	0.2208		0.16	0.15	0.1522	0.2134	0.2218
1	3	0.1917	0.2153	0.2244	0.1566	0.1758	0.2229	0.2242	0.2303	0.2228	0.2291	0.1954	0.1961	0.1556	0.1431	0.2203	0.205	0.2177
1	5	0.1777	0.2029	0.2154	0.1946	0.1969	0.2159	0.2354	0.2279	0.2284	0.2123	0.2137	0.1675	0.1503	0.1399	0.1447	0.2073	0.2141
1	10	0.1788	0.2039	0.2161	0.1714	0.1785	0.2097	0.2338	0.2299	0.2302	0.2182	0.2208	0.1732	0.1581	0.1482	0.1547	0.2129	0.2216
1	12	0.18	0.2049	0.2168	0.1697	0.1785	0.2062	0.2352	0.2323	0.2344	0.2182	0.2198	0.1705	0.1572	0.1504	0.155	0.2161	0.222
1	16	0.272	0.2865	0.2764	0.1683	0.1845	0.2151	0.2465	0.241	0.2402	0.2306	0.2311	0.1804	0.1648	0.153	0.16	0.2233	0.2345
1	19	0.3326	0.3401	0.3157	0.1756	0.1769	0.2026	0.2288	0.2257	0.2234	0.2135	0.2144	0.1701	0.1492	0.1438	0.1472	0.2091	0.2167
1	31	0.2135	0.2347	0.2386	0.1729	0.1854	0.2127	0.2373	0.2372	0.2352	0.2246	0.2234	0.179	0.163	0.1486	0.1571	0.2177	0.2297
2	2	0.2347	0.2535	0.2523	0.1809	0.1828	0.2068	0.2327	0.233	0.2307	0.22	0.2142	0.1712	0.1577	0.1493	0.1533	0.2131	0.2203
2	8	0.1704	0.1965	0.2107	0.1626	0.1774	0.2066	0.2313	0.23	0.2282	0.2177	0.2188	0.1717	0.1562	0.1473	0.1502	0.2121	0.2171
2	9	0.2768	0.2907	0.2796	0.1985	0.2025	0.2237	0.2404	0.2366	0.2305	0.2185	0.2146	0.167	0.1549	0.1423	0.1504	0.2073	0.2169
2	14	0.1606	0.1878	0.2043	0.163	0.1784	0.2052	0.2317	0.2308	0.2285	0.2175	0.2184	0.1711	0.1554	0.147	0.1507	0.2081	0.2186
2	16	0.1789	0.204	0.2161	0.1603	0.1735	0.2036	0.2313	0.2277	0.227	0.2165	0.2158	0.1728	0.1536	0.1454	0.1491	0.2096	0.2192
2	20	0.1572	0.1847	0.202	0.1617	0.1771	0.2021	0.233	0.2304	0.2295	0.221	0.2174	0.1711	0.1524	0.1462	0.1495	0.2143	0.2223
2	23	0.25	0.267	0.2622	0.1872	0.1959	0.217	0.241	0.2363	0.2336	0.2225	0.2249	0.1778	0.1655	0.1506	0.1524	0.2108	0.2195
3	7	0.1567	0.1844	0.2018	0.1497	0.1705	0.2028	0.2317	0.2274	0.2291	0.2165	0.2174	0.1686	0.1541	0.1432	0.1506	0.2121	0.2196
3	9	0.1358	0.1658	0.1882	0.1444	0.1657	0.1952	0.2277	0.223	0.2202	0.2107	0.2094	0.1625	0.151	0.1396	0.1465	0.2057	0.2125
3	14	0.2503	0.2672	0.2624	0.1665	0.1782	0.2073	0.2284	0.2308	0.2266	0.217	0.2183	0.1748	0.1558	0.1489	0.151	0.2116	0.2239
3	16	0.2303	0.2495	0.2494	0.1738	0.1827	0.2067	0.2338	0.2268	0.2273	0.2148	0.2132	0.1738	0.1546	0.1423	0.1436	0.2014	0.2118
3	19	0.2251	0.2449	0.2461	0.1741	0.1836	0.2085	0.2354	0.2263	0.2295	0.2185	0.2134	0.1741	0.1553	0.1427	0.1438	0.2022	0.212
3	28	0.1239	0.1552	0.1805	0.1425	0.1667	0.1985	0.2243	0.2234	0.2204	0.2096	0.2118	0.1655	0.1501	0.1423	0.1448	0.2029	0.2137
3	29	0.285	0.298	0.2849	0.1942	0.2014	0.225	0.243	0.2354	0.2343	0.2216	0.2189	0.1749	0.1566	0.1487	0.1517	0.2131	0.2176
4	2		0.0144	0.0775	0.1691	0.1796	0.2078	0.2335	0.2295	0.225	0.2169	0.2178	0.1714	0.1556	0.1473	0.1539	0.2092	0.2155
4	4	0.1857	0.2101	0.2206	0.1621	0.1777	0.2075	0.2288	0.2286	0.2251	0.2173	0.218	0.1677	0.1534	0.1467	0.1508	0.209	0.2188
4	10	0.1855	0.2099	0.2204	0.1511	0.1684	0.1992	0.2293	0.231	0.2249	0.2132	0.211	0.1686	0.1529	0.139	0.1487	0.2059	0.2107
4	18	0.19	0.2139	0.2233	0.1522	0.1695	0.2005	0.2307	0.2325	0.2263	0.2145	0.2123	0.1697	0.1539	0.14	0.1497	0.2073	0.2211
4	20	0.1867	0.2109	0.2212	0.1516	0.1686	0.2001	0.2303	0.2324	0.2255	0.2142	0.2112	0.1665	0.153	0.1516	0.1502	0.2063	0.2207
4	27	0.2652	0.2804	0.272	0.1899	0.1989	0.2148	0.2337	0.2303	0.2255	0.2149	0.2125	0.1652	0.1511	0.1431	0.144	0.2037	0.2137
5	3	0.1695	0.1956	0.21	0.1738	0.1978	0.2142	0.2321	0.226	0.2272	0.2219	0.2131	0.1912	0.1794	0.1848	0.2082	0.2	0.2119
5	9	0.1362	0.1662	0.1885	0.1516	0.1706	0.2076	0.2288	0.2283	0.225	0.2156	0.2147	0.1691	0.1536	0.146	0.1473	0.2103	0.2177
5	11	0.3374	0.3445	0.3188	0.1511	0.182	0.207	0.2282	0.2276	0.2243	0.215	0.2141	0.1806	0.1532	0.1456	0.1469	0.2097	0.2171

Volumetric Water Content -- 12/89 - 11/90

Plot 7 (cont.)

DEPTH (cm)

Month	Date	2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
5	16	0.1458	0.1746	0.1947	0.153	0.1764	0.2047	0.2361	0.2285	0.2324	0.2186	0.2213	0.1741	0.1565	0.1464	0.1504	0.2102	0.2198
5	18	0.1276	0.1585	0.1829	0.1531	0.1752	0.2044	0.2363	0.2281	0.2313	0.218	0.2213	0.1733	0.1567	0.1463	0.1511	0.2104	0.2197
5	25	0.3186	0.3278	0.3066	0.1985	0.2012	0.2187	0.2369	0.2302	0.2308	0.22	0.2152	0.1698	0.1526	0.1425	0.1469	0.2083	0.2142
5	31	0.2401	0.2582	0.2558	0.1977	0.2005	0.2179	0.236	0.2293	0.2299	0.2192	0.2144	0.1691	0.152	0.1419	0.1463	0.2075	0.2134
6	4	0.1955	0.2187	0.2269	0.1329	0.1664	0.198	0.2293	0.2271	0.2239	0.2171	0.219	0.1703	0.1538	0.1457	0.1482	0.2065	0.2153
6	6	0.0285	0.0707	0.1187	0.114	0.1626	0.194	0.2309	0.2297	0.2276	0.2157	0.2198	0.17	0.152	0.1424	0.1465	0.2085	0.2155
6	8	0.3373	0.3443	0.3187		0.1912	0.2019	0.2207	0.2372	0.2306	0.2219	0.2152	0.1691	0.1536	0.1428	0.1447	0.2091	0.2116
6	13	0.1321	0.1625	0.1858	0.1573	0.1747	0.2029	0.2315	0.2277	0.2274	0.2131	0.2175	0.1675	0.1546	0.1417	0.1463	0.2048	0.2126
6	15	0.1282	0.1591	0.1833	0.1585	0.1754	0.2053	0.2329	0.2284	0.2294	0.2132	0.2182	0.1694	0.1553	0.1444	0.1452	0.2068	0.2135
6	21	0.0516	0.0912	0.1336	0.1414	0.1681	0.1995	0.2273	0.2269	0.2229	0.2129	0.2157	0.1693	0.1512	0.1401	0.1447	0.2037	0.2107
6	29	0.0619	0.1003	0.1403	0.1572	0.1812	0.2113	0.2339	0.2377	0.2323	0.2175	0.2226	0.1776	0.1605	0.1463	0.1507	0.2092	0.22
7	3	0.0757	0.1125	0.1493	0.1474	0.1728	0.2019	0.2281	0.2284	0.2277	0.2162	0.2194	0.1702	0.1529	0.1443	0.1458	0.205	0.2137
7	11	0.1793	0.2043	0.2164	0.1616	0.1839	0.2106	0.2381	0.2321	0.2311	0.2213	0.2193	0.1704	0.1553	0.1456	0.1489	0.2087	0.2193
7	13	0.1576	0.1851	0.2023	0.1632	0.178	0.205	0.233	0.2308	0.2325	0.2164	0.219	0.1726	0.1546	0.1457	0.1488	0.2086	0.2173
7	25	0.1781	0.2033	0.2156	0.1519	0.1941	0.1953	0.2128	0.216	0.2266	0.229	0.2265	0.1886	0.1651	0.1626	0.2091	0.2169	0.2216
7	27	0.1047	0.1383	0.1681	0.1427	0.173	0.2026	0.2301	0.2306	0.226	0.2132	0.2184	0.1705	0.1521	0.1425	0.1458	0.2051	0.2128
8	1	0.0932	0.128	0.1606	0.1256	0.1744	0.2039	0.2402	0.2392	0.2396	0.2235	0.2285	0.1767	0.1578	0.1462	0.1523	0.2152	0.2242
8	3	0.1304	0.161	0.1847	0.1347	0.1696	0.1955	0.2319	0.2324	0.2257	0.2151	0.2173	0.1688	0.1468	0.1404	0.144	0.2087	0.2173
8	8	0.1352	0.1653	0.1878	0.1348	0.1698	0.1956	0.2321	0.2326	0.2259	0.2153	0.2175	0.1689	0.1469	0.1405	0.1442	0.2088	0.2175
8	17	0.2005	0.2232	0.2302	0.1706	0.1777	0.2052	0.2311	0.2329	0.2299	0.2175	0.2199	0.1675	0.1533	0.1436	0.1474	0.2036	0.213
8	22	0.2742	0.2884	0.2779	0.157	0.1715	0.1999	0.2291	0.2302	0.2257	0.2132	0.22	0.1666	0.1493	0.1426	0.1478	0.203	0.2158
8	29	0.1766	0.2019	0.2146	0.153	0.1681	0.1961	0.2308	0.2291	0.2248	0.2141	0.2202	0.1679	0.1496	0.1435	0.1479	0.2047	0.2175
9	5	0.2521	0.2688	0.2636	0.1533	0.1689	0.1914	0.2281	0.2301	0.2246	0.2156	0.2183	0.1699	0.1458	0.147	0.1433	0.2035	0.2134
9	21	0.1489	0.1774	0.1967	0.1662	0.1878	0.2181	0.2473	0.2453	0.2419	0.2303	0.2342	0.1833	0.1637	0.1544	0.1591	0.2166	0.226
10	3	0.1898	0.2137	0.2232	0.1707	0.1871	0.2111	0.2424	0.2381	0.2377	0.2239	0.2313	0.1829	0.1658	0.1498	0.1551	0.2136	0.2247
10	10	0.1255	0.1567	0.1816	0.1547	0.1749	0.2045	0.2371	0.2345	0.2366	0.2198	0.2273	0.1772	0.1577	0.1486	0.1521	0.2083	0.2213
10	12	0.332	0.3397	0.3153	0.1848	0.2011	0.2191	0.246	0.2398	0.2381	0.2264	0.2275	0.1797	0.1694	0.1576	0.1569	0.2075	0.2234
10	17	0.1592	0.1865	0.2034	0.1736	0.1884	0.2125	0.2458	0.2418	0.2386	0.2289	0.2305	0.1833	0.1652	0.1559	0.1617	0.2177	0.2301
10	24	0.1183	0.1503	0.1769	0.1733	0.1868	0.2119	0.2457	0.2429	0.2369	0.2254	0.2302	0.1831	0.1621	0.1481	0.1602	0.2181	0.2278
11	2				0.1751	0.1875	0.2082	0.2459	0.2413	0.238	0.2264	0.2307	0.1807	0.1663	0.1575	0.1586	0.2142	0.2265
11	7	0.1202	0.152	0.1781	0.1651	0.1854	0.2101	0.2436	0.2412	0.2396	0.227	0.2342	0.1812	0.1619	0.1502	0.1573	0.2158	0.2274
Avg.:		0.18553	0.2069	0.21826	0.16161	0.1798	0.2063	0.23318	0.23104	0.22906	0.21792	0.21842	0.17332	0.15547	0.14621	0.15248	0.20891	0.21801
C.V.:		38.0%	32.1%	22.3%	11.0%	6.0%	3.8%	2.9%	2.5%	2.5%	3.0%	3.3%	3.8%	4.6%	5.3%	9.3%	2.8%	3.2%

Volumetric Water Content -- 12/89 - 11/90

Plot 8

DEPTH (cm)

Month	Date	2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
12	1	0.1541	0.182	0.2	0.1462	0.1908	0.1929	0.2068	0.2031	0.1946	0.1762	0.1816		0.1338	0.1361	0.1802	0.1826	0.1917
12	4	0.2062	0.2282	0.2338	0.1752	0.2054	0.21	0.2264	0.2184	0.2328	0.234	0.2231		0.1684	0.1703	0.2131	0.2163	0.2163
12	8	0.205	0.2271	0.2331	0.155	0.1989	0.1966	0.2152	0.2186	0.227	0.2333	0.2235	0.1844	0.1687	0.1684	0.2132	0.218	0.2224
12	15	0.099	0.1332	0.1644	0.1368	0.1844	0.1896	0.2083	0.2138	0.2254	0.2285	0.2202		0.1649	0.1644	0.2076	0.2119	0.2175
12	18	0.0983	0.1326	0.1639	0.1353	0.1833	0.1896	0.1974	0.212	0.2287	0.2287	0.2162		0.1649	0.1652	0.2085	0.2124	0.2178
12	26	0.2624	0.278	0.2702	0.1603	0.1997	0.2055	0.2213	0.2223	0.2311	0.2379	0.228		0.1707	0.1677	0.2163	0.2223	0.226
1	3	0.1843	0.2087	0.2196	0.158	0.1926	0.2185	0.2294	0.2292	0.2228	0.2312	0.1876	0.1928	0.1623	0.1746	0.2194	0.2036	0.2183
1	5	0.2056	0.2277	0.2334	0.1969	0.2187	0.2204	0.2308	0.2277	0.2316	0.2375	0.2243	0.1883	0.1692	0.1646	0.2009	0.2122	0.2166
1	10	0.2052	0.2273	0.2332	0.1693	0.201	0.203	0.2188	0.2202	0.2294	0.2322	0.2248	0.189	0.1711	0.1717	0.22	0.2231	0.2265
1	12	0.1989	0.2217	0.2291	0.1696	0.2027	0.2033	0.2201	0.2188	0.226	0.2355	0.2313	0.1905	0.1698	0.1697	0.2174	0.2202	0.2301
1	16	0.3058	0.3164	0.2983	0.1647	0.2024	0.209	0.2271	0.2328	0.2408	0.2468	0.2403	0.1974	0.1797	0.1777	0.226	0.228	0.1837
1	19	0.33	0.3379	0.314	0.1754	0.1999	0.1943	0.2111	0.2145	0.2254	0.233	0.2243	0.1811	0.1643	0.162	0.2054	0.212	0.2207
1	31	0.2115	0.2328	0.2372	0.1692	0.2057	0.2049	0.2271	0.2245	0.2369	0.2397	0.2341	0.1926	0.1747	0.1765	0.2226	0.224	0.2334
2	2	0.2487	0.2658	0.2614	0.1751	0.2019	0.2044	0.2187	0.2182	0.2304	0.2348	0.2268	0.19	0.1696	0.1692	0.2183	0.2211	0.2288
2	8	0.1841	0.2086	0.2195	0.1564	0.1983	0.1992	0.2134	0.2178	0.2272	0.2305	0.2239	0.185	0.166	0.1649	0.2105	0.2162	0.2196
2	9	0.3091	0.3194	0.3005	0.2042	0.2238	0.2232	0.2307	0.2308	0.2355	0.2353	0.2242	0.1872	0.1668	0.164	0.2083	0.2111	0.2224
2	14	0.162	0.189	0.2052	0.1547	0.1968	0.1998	0.213	0.216	0.2262	0.2281	0.224	0.1857	0.1662	0.1687	0.2079	0.2199	0.22
2	16	0.1567	0.1843	0.2017	0.1591	0.1957	0.1982	0.2173	0.215	0.2292	0.2291	0.2229	0.1844	0.1645	0.1678	0.2108	0.2164	0.2285
2	20	0.1415	0.1708	0.1919	0.1615	0.1973	0.1979	0.2152	0.2201	0.2283	0.2348	0.2286	0.1855	0.1695	0.1676	0.2163	0.2182	0.2249
2	23	0.2427	0.2605	0.2575	0.1843	0.2121	0.2153	0.2328	0.2276	0.2354	0.2371	0.2302	0.1923	0.1765	0.174	0.2159	0.2163	0.225
3	7	0.162	0.189	0.2052	0.1524	0.1936	0.1966	0.2097	0.217	0.2259	0.2315	0.2252	0.1853	0.1697	0.1673	0.2121	0.2162	0.2227
3	9	0.1205	0.1522	0.1783	0.1432	0.1903	0.1909	0.2085	0.2097	0.223	0.226	0.2226	0.1775	0.1622	0.161	0.2038	0.2097	0.2185
3	14	0.2317	0.2508	0.2503	0.1627	0.1938	0.2042	0.2165	0.2202	0.2286	0.2345	0.2272	0.1893	0.1685	0.1686	0.217	0.2203	0.2333
3	16	0.2038	0.2261	0.2323	0.1737	0.2021	0.2068	0.2166	0.221	0.229	0.2301	0.2265	0.1861	0.1689	0.1667	0.2082	0.2101	0.216
3	19	0.0694	0.1069	0.1452	0.175	0.1989	0.2024	0.2184	0.2216	0.2295	0.2306	0.2289	0.1873	0.1695	0.1668	0.2089	0.2114	0.2171
3	28	0.1269	0.1579	0.1824	0.1441	0.1865	0.1906	0.207	0.2079	0.2252	0.2271	0.2178	0.1799	0.1656	0.1627	0.2099	0.2079	0.2231
3	29	0.2709	0.2855	0.2757	0.1971	0.2192	0.2209	0.2362	0.2294	0.2402	0.2413	0.2338	0.19	0.1693	0.1668	0.2162	0.2163	0.2299
4	2		0.0103	0.0745	0.1679	0.2008	0.2009	0.2188	0.2196	0.2292	0.2308	0.2261	0.1851	0.1698	0.1717	0.2182	0.217	0.2287
4	4	0.1458	0.1747	0.1947	0.1622	0.1962	0.2013	0.2161	0.2171	0.229	0.2334	0.226	0.1823	0.1703	0.1674	0.2182	0.2167	0.2267
4	10	0.146	0.1749	0.1948	0.1461	0.1889	0.1931	0.2114	0.2139	0.2247	0.2279	0.2229	0.1803	0.1664	0.1643	0.2092	0.211	0.2226
4	18	0.1527	0.1808	0.1992	0.1637	0.1979	0.2019	0.2179	0.2209	0.2278	0.2321	0.2241	0.1876	0.1715	0.1696	0.2196	0.2219	0.2295
4	20	0.1493	0.1778	0.197	0.1627	0.1978	0.2014	0.2158	0.2203	0.2273	0.2315	0.2237	0.1866	0.1712	0.1685	0.2195	0.2224	0.2289
4	27	0.2439	0.2616	0.2583	0.1938	0.2159	0.217	0.2281	0.2249	0.2316	0.2302	0.2247	0.1824	0.1641	0.1648	0.2083	0.2099	0.2235
5	3	0.1465	0.1753	0.1952	0.1715	0.1866	0.2134	0.2251	0.2264	0.225	0.2206	0.2229	0.1879	0.1782	0.177	0.2068	0.2024	0.2166
5	9	0.127	0.158	0.1825	0.1557	0.1936	0.1948	0.2149	0.2166	0.2285	0.2328	0.2215	0.1858	0.1669	0.1657	0.2161	0.2167	0.2274
5	11	0.3445	0.3507	0.3234	0.1552	0.1811	0.1943	0.2143	0.216	0.223	0.2202	0.2209	0.1853	0.1652	0.1556	0.216	0.2148	

Volumetric Water Content -- 12/89 - 11/90

Plot 8 (cont.)

Month	Date	DEPTH (cm)																
		2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
5	16	0.1887	0.2127	0.2225	0.1522	0.2004	0.2019	0.2169	0.2213	0.2317	0.2336	0.2251	0.1917	0.1716	0.1709	0.2189	0.2219	0.2309
5	18	0.1399	0.1694	0.1908	0.1512	0.1999	0.1993	0.2166	0.2206	0.2318	0.2318	0.2235	0.1902	0.1685	0.1699	0.2189	0.2226	0.2312
5	25	0.326	0.3343	0.3114	0.1946	0.2157	0.2126	0.2273	0.2268	0.2281	0.2302	0.2233	0.1891	0.1627	0.1627	0.2066	0.2155	0.2148
5	31	0.2001	0.2228	0.2299	0.1938	0.2149	0.2118	0.2265	0.2259	0.2272	0.2293	0.2225	0.1884	0.162	0.1621	0.2059	0.2147	0.214
6	4	0.1574	0.1849	0.2022	0.132	0.1889	0.1929	0.21	0.2144	0.2241	0.2305	0.2247	0.1884	0.1654	0.1633	0.2042	0.2113	0.2228
6	6	0.0995	0.1336	0.1647	0.1279	0.1889	0.1913	0.2139	0.2149	0.2226	0.2337	0.2235	0.1865	0.1665	0.1604	0.2075	0.2138	0.2212
6	8	0.3466	0.3526	0.3248	0.1978	0.2163	0.2146	0.2265	0.2235	0.2289	0.2294	0.2253	0.1891	0.1625	0.1632	0.2069	0.215	0.217
6	13	0.1489	0.1774	0.1967	0.1639	0.1984	0.1999	0.2161	0.2188	0.2289	0.2311	0.228	0.1878	0.169	0.1687	0.2128	0.2154	0.2233
6	15	0.1449	0.1739	0.1941	0.1654	0.1991	0.2068	0.2167	0.2195	0.2292	0.2342	0.229	0.195	0.1689	0.1667	0.2135	0.2171	0.2288
6	21	0.0987	0.1329	0.1642	0.1432	0.1936	0.1914	0.2136	0.2131	0.2224	0.2313	0.2241	0.1863	0.1643	0.1612	0.2118	0.2143	0.221
6	29	0.1039	0.1376	0.1676	0.1626	0.1992	0.2056	0.2211	0.2219	0.2348	0.2358	0.2335	0.1942	0.1729	0.1694	0.2144		0.2301
7	3	0.0844	0.1202	0.1549	0.1557	0.1903	0.1991	0.2142	0.213	0.2276	0.2292	0.2243	0.1882	0.167	0.1635	0.2083	0.2145	0.2188
7	11	0.1629	0.1898	0.2058	0.1678	0.2047	0.2054	0.2188	0.2222	0.2311	0.2366	0.2282	0.1938	0.1689	0.1685	0.215	0.2236	0.2297
7	13	0.1316	0.1621	0.1855	0.1713	0.1996	0.1989	0.2137	0.219	0.2284	0.2358	0.2272	0.1892	0.167	0.1689	0.213	0.2179	0.2255
7	25	0.147	0.1757	0.1955	0.1518	0.2036	0.195	0.2132	0.2193	0.2279	0.2279	0.2241	0.1999	0.1673	0.1632	0.2077	0.2158	0.2197
7	27	0.0958	0.1303	0.1623	0.1531	0.1956	0.1967	0.2144	0.2176	0.2283	0.2307	0.2282	0.19	0.1663	0.1638	0.2107	0.2185	0.2232
8	1	0.1066	0.1399	0.1693	0.1445	0.1987	0.2028	0.22	0.2238	0.2413	0.2426	0.2341	0.1977	0.1718	0.1713	0.2204	0.2231	0.2298
8	3	0.1531	0.1811	0.1994	0.1464	0.1914	0.1955	0.2115	0.2147	0.2319	0.232	0.2234	0.1895	0.1652	0.1651	0.2201	0.2147	0.2195
8	8	0.1454	0.1744	0.1945	0.1478	0.1927	0.1934	0.2122	0.2145	0.233	0.2293	0.2233	0.1898	0.1656	0.1665	0.2185	0.2146	0.2184
8	17	0.2021	0.2245	0.2312	0.1724	0.2001	0.1985	0.2143	0.2141	0.2285	0.2352	0.2255	0.1873	0.1648	0.1636	0.2076	0.2157	0.2214
8	22	0.277	0.2909	0.2797	0.155	0.1961	0.1958	0.2132	0.2155	0.2261	0.2307	0.2243	0.1885	0.1683	0.1649	0.2092	0.213	0.2169
8	29	0.1705	0.1966	0.2107	0.1519	0.1945	0.1933	0.2164	0.2148	0.2255	0.2291	0.2225	0.1911	0.1741	0.1685	0.2087	0.2142	0.2146
9	5	0.2297	0.249	0.249	0.1525	0.1929	0.1897	0.2156	0.2144	0.2247	0.2255	0.2215	0.189	0.173	0.168	0.2064	0.2217	0.2122
9	21	0.1573	0.1849	0.2021	0.1718	0.2137	0.21	0.227	0.2296	0.2401	0.2445	0.2397	0.2017	0.1792	0.1767	0.2259	0.228	0.2345
10	3	0.2065	0.2284	0.234	0.1718	0.2136	0.2135	0.2288	0.2334	0.2403	0.243	0.2397	0.2058	0.1754	0.1793	0.2227	0.2314	0.2349
10	10	0.1137	0.1463	0.1739	0.158	0.2026	0.2036	0.2196	0.2237	0.2355	0.2426	0.2391	0.1974	0.1755	0.1722	0.2163	0.2248	0.2327
10	12	0.3274	0.3355	0.3123	0.1863	0.2258	0.2301	0.2325	0.2275	0.2386	0.2448	0.2326	0.1958	0.1722	0.1734	0.2138	0.2279	0.2326
10	17	0.1404	0.1699	0.1912	0.1721	0.2095	0.2125	0.228	0.2301	0.2417	0.2441	0.2397	0.2038	0.176	0.1794	0.2189	0.2322	0.2354
10	24	0.1069	0.1402	0.1695	0.1682	0.2028	0.2104	0.2258	0.2307	0.2415	0.2437	0.2383	0.2033	0.1764	0.1788	0.2179	0.2307	0.2358
11	2				0.1733	0.2086	0.2096	0.2282	0.2291	0.2404	0.2462	0.2394	0.2037	0.1787	0.1731	0.22	0.2278	0.2358
11	7	0.135	0.1651	0.1877	0.1674	0.2106	0.2084	0.2288	0.2272	0.2413	0.247	0.2424	0.2011	0.1776	0.1773	0.2237	0.2314	0.2338
Avg.:		0.18154	0.20335	0.21567	0.16355	0.20026	0.20293	0.21877	0.22028	0.22979	0.23278	0.22589	0.18997	0.16871	0.16767	0.21303	0.21718	0.22326
C.V.:		38.3%	32.3%	22.3%	10.1%	4.9%	4.5%	3.5%	2.9%	3.0%	3.9%	4.1%	3.2%	3.7%	3.8%	3.3%	3.6%	4.0%

Volumetric Water Content -- 12/89 - 11/90

Plot 9

Month	Date	DEPTH (cm)																
		2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
12	1	0.1719	0.1978	0.2116	0.1457	0.1826	0.205	0.2279	0.2205	0.2084	0.2145	0.193		0.1734	0.1651	0.1957	0.1958	0.1729
12	4	0.223	0.2431	0.2447	0.1713	0.1935	0.2151	0.2363	0.2254	0.2178	0.2199	0.1992		0.1794	0.1772	0.2103	0.2214	0.2284
12	8	0.2218	0.242	0.2439	0.1474	0.1821	0.2075	0.2351	0.2234	0.2143	0.2145	0.1957	0.1953	0.1783	0.1677	0.1894	0.2166	0.2146
12	15	0.1014	0.1353	0.1659	0.1342	0.1764	0.2028	0.2299	0.2249	0.2165	0.2196	0.2024		0.1791	0.1642	0.1969	0.2085	0.2093
12	18	0.1008	0.1348	0.1655	0.1355	0.1758	0.2036	0.2328	0.2256	0.2114	0.2173	0.2022		0.1792	0.164	0.1907	0.2082	0.211
12	26	0.2886	0.3012	0.2872	0.1536	0.1908	0.2149	0.2454	0.2407	0.2279	0.2269	0.2092		0.1894	0.1755	0.2057	0.2161	0.2145
1	3	0.1911	0.2148	0.224	0.1593	0.1875	0.2145	0.2214	0.2348	0.2246	0.2242	0.2225	0.1997	0.1799	0.1731	0.2093	0.2117	0.2193
1	5	0.2221	0.2422	0.2441	0.1734	0.2043	0.2215	0.244	0.2365	0.2231	0.2227	0.2042	0.2022	0.1843	0.1705	0.2036	0.2127	0.2056
1	10	0.2193	0.2398	0.2423	0.1578	0.1884	0.2183	0.2411	0.2349	0.2231	0.2271	0.2091	0.2085	0.1885	0.1762	0.2054	0.216	0.2126
1	12	0.2151	0.2361	0.2396	0.1573	0.1902	0.2185	0.2444	0.231	0.2234	0.2304	0.2059	0.2073	0.1907	0.1766	0.2059	0.2198	0.2139
1	16	0.2963	0.308	0.2922	0.1561	0.1946	0.2214	0.2558	0.2478	0.2389	0.2381	0.2161	0.2194	0.1973	0.182	0.2145	0.2248	0.2215
1	19	0.3228	0.3315	0.3094	0.1695	0.1887	0.2073	0.2337	0.2331	0.2195	0.2235	0.2025	0.2063	0.1832	0.166	0.198	0.2092	0.2087
1	31	0.2196	0.24	0.2425	0.161	0.1967	0.2202	0.2522	0.2403	0.2322	0.2342	0.2136	0.2147	0.1946	0.1809	0.2139	0.2231	0.2222
2	2	0.2357	0.2543	0.2529	0.1705	0.1938	0.2163	0.2433	0.2362	0.2271	0.226	0.2069	0.2091	0.1874	0.1742	0.2059	0.2142	0.2151
2	8	0.2061	0.2281	0.2338	0.1532	0.186	0.2129	0.2408	0.2345	0.2213	0.2262	0.2067	0.2101	0.1859	0.1734	0.201	0.2123	0.2104
2	9	0.2767	0.2906	0.2795	0.1876	0.2033	0.2289	0.2435	0.2364	0.224	0.2221	0.2079	0.2048	0.1861	0.1736	0.2006	0.2124	0.209
2	14	0.1821	0.2068	0.2182	0.1511	0.1868	0.2129	0.2381	0.2321	0.2197	0.2269	0.2052	0.2089	0.1854	0.1735	0.2004	0.2134	0.2099
2	16	0.1913	0.215	0.2241	0.1512	0.1874	0.2118	0.2368	0.233	0.2194	0.2213	0.2068	0.2035	0.1847	0.1727	0.2017	0.2106	0.2108
2	20	0.1843	0.2088	0.2196	0.1532	0.1869	0.212	0.2437	0.2349	0.2265	0.2255	0.2069	0.2101	0.1853	0.1706	0.2042	0.2128	0.2094
2	23	0.2221	0.2423	0.2441	0.1759	0.2038	0.227	0.2522	0.244	0.2306	0.2322	0.2167	0.2137	0.1948	0.1857	0.209	0.2194	0.2172
3	7	0.1909	0.2146	0.2239	0.1451	0.1822	0.2132	0.2381	0.2358	0.2222	0.2265	0.2056	0.2079	0.1866	0.1698	0.2033	0.2097	0.2141
3	9	0.148	0.1766	0.1961	0.1372	0.1799	0.2069	0.2345	0.2297	0.2159	0.2195	0.1995	0.2037	0.1795	0.1664	0.1986	0.2086	0.2098
3	14	0.2226	0.2427	0.2444	0.1508	0.1888	0.2096	0.2365	0.2401	0.2243	0.2284	0.2099	0.2099	0.1908	0.172	0.206	0.2179	0.2152
3	16	0.2141	0.2352	0.2389	0.165	0.189	0.2172	0.2413	0.2312	0.2204	0.2221	0.2054	0.2044	0.1828	0.1719	0.2021	0.2031	0.2033
3	19	0.2102	0.2317	0.2364	0.1662	0.1867	0.2185	0.242	0.2328	0.2216	0.2229	0.205	0.2052	0.1832	0.1746	0.2024	0.2036	0.2036
3	28	0.1647	0.1914	0.207	0.1408	0.1786	0.2059	0.2316	0.2313	0.2227	0.2227	0.202	0.2014	0.1816	0.1692	0.1984	0.2071	0.2052
3	29	0.2559	0.2722	0.266	0.1852	0.2121	0.2262	0.2395	0.2398	0.2342	0.2384	0.2251	0.1977	0.1779	0.1743	0.2127	0.2144	0.1817
4	2		0.0099	0.0742	0.1622	0.1888	0.2163	0.2395	0.234	0.2241	0.2249	0.2057	0.205	0.1864	0.1738	0.2064	0.2123	0.2089
4	4	0.2075	0.2293	0.2346	0.1543	0.1888	0.2122	0.2377	0.2339	0.2199	0.2242	0.2047	0.2063	0.186	0.1687	0.2034	0.2129	0.2092
4	10	0.2073	0.2292	0.2345	0.1404	0.182	0.2068	0.2363	0.2283	0.2194	0.2216	0.2003	0.1975	0.18	0.1674	0.2007	0.2114	0.2081
4	18	0.2119	0.2333	0.2375	0.15	0.1567	0.1908	0.2145	0.2419	0.2369	0.2219	0.2247	0.2082	0.205	0.1855	0.176	0.2055	0.211
4	20	0.2097	0.2313	0.2361	0.1629	0.156	0.1877	0.211	0.2383	0.2345	0.2225	0.2243	0.2086	0.2038	0.1845	0.1755	0.2047	0.2111
4	27	0.2209	0.2412	0.2433	0.1808	0.1996	0.2239	0.2428	0.2322	0.2223	0.2196	0.2013	0.2039	0.1832	0.1701	0.2024	0.2101	0.2078
5	3	0.1928	0.2163	0.2252	0.1779	0.2106	0.2167	0.232	0.2342	0.2363	0.2262	0.2124	0.2023	0.2046	0.1857	0.195	0.2019	0.2165
5	9	0.1855	0.2099	0.2204	0.1533	0.1868	0.2126	0.2374	0.233	0.2244	0.223	0.2049	0.2079	0.184	0.174	0.2021	0.2093	0.2098
5	11	0.3116	0.3215	0.3021	0.1529	0.1743	0.2001	0.2127	0.2156	0.2238	0.2103	0.2043	0.1953	0.1715	0.1495	0.1656	0.2014	0.2104

Volumetric Water Content -- 12/89 - 11/90

Plot 9 (cont.)

Month	Date	DEPTH (cm)																
		2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
5	16	0.1328	0.1631	0.1863	0.1496	0.1893	0.2156	0.2388	0.2351	0.2247	0.2249	0.2063	0.2076	0.1887	0.1732	0.202	0.2138	0.2131
5	18	0.1824	0.207	0.2184	0.1487	0.1873	0.2131	0.2368	0.2354	0.2237	0.224	0.2056	0.208	0.1871	0.1721	0.2018	0.2131	0.2119
5	25	0.2968	0.3085	0.2925	0.1868	0.2028	0.2286	0.2518	0.2401	0.2271	0.2277	0.2072	0.2027	0.1825	0.1733	0.2023	0.2121	0.2085
5	31	0.1989	0.2217	0.2291	0.1861	0.202	0.2278	0.2509	0.2392	0.2263	0.2269	0.2064	0.2019	0.1818	0.1726	0.2015	0.2113	0.2077
6	4	0.1816	0.2064	0.2179	0.1392	0.1845	0.2098	0.2378	0.2338	0.2186	0.2244	0.2048	0.2083	0.1855	0.1718	0.2002	0.2136	0.2131
6	6	0.1666	0.1931	0.2082	0.1434	0.1856	0.209	0.2357	0.2355	0.2246	0.2249	0.2041	0.205	0.1855	0.171	0.2044	0.2096	0.2084
6	8	0.3204	0.3293	0.3078	0.1904	0.2031	0.2271	0.2477	0.2401	0.2265	0.2271	0.2079	0.2034	0.1828	0.1746	0.2026	0.2112	0.2072
6	13	0.1916	0.2152	0.2243	0.1533	0.1855	0.2175	0.2376	0.2331	0.221	0.2241	0.207	0.2063	0.1867	0.1753	0.2036	0.2114	0.205
6	15	0.1858	0.2101	0.2206	0.1546	0.186	0.218	0.239	0.2344	0.2225	0.2237	0.2072	0.2071	0.1871	0.1768	0.2029	0.2123	0.2063
6	21	0.1295	0.1602	0.1841	0.1337	0.1835	0.2047	0.2369	0.23	0.2182	0.2219	0.2044	0.2061	0.1834	0.1689	0.1988	0.21	0.2046
6	29	0.14	0.1696	0.191	0.1518	0.1933	0.2174	0.2479	0.2379	0.2241	0.227	0.2091	0.214	0.19	0.1736	0.2032	0.2187	0.2133
7	3	0.1525	0.1806	0.199	0.1474	0.1852	0.209	0.2399	0.2319	0.2219	0.2218	0.2013	0.2086	0.1838	0.1727	0.2018	0.2116	0.2115
7	11	0.1798	0.2048	0.2167	0.1636	0.1944	0.2221	0.2438	0.2387	0.228	0.2279	0.2101	0.2087	0.1948	0.1796	0.2089	0.2202	0.2152
7	13	0.2086	0.2303	0.2354	0.165	0.1928	0.2182	0.24	0.2383	0.2246	0.2291	0.2066	0.2101	0.1846	0.173	0.2038	0.2137	0.2142
7	25	0.1886	0.2125	0.2224	0.1643	0.201	0.1951	0.2124	0.2193	0.2253	0.2197	0.2233	0.1951	0.1628	0.1591	0.183	0.2158	0.2194
7	27	0.1031	0.1368	0.167	0.1572	0.2037	0.1959	0.2166	0.2201	0.2248	0.2253	0.2245	0.2001	0.1701	0.1531	0.2075	0.2163	0.2189
8	1	0.1157	0.148	0.1752	0.1408	0.1903	0.2167	0.2495	0.2428	0.2343	0.233	0.2118	0.2158	0.194	0.1764	0.2087	0.2194	0.2172
8	3	0.1775	0.2027	0.2152	0.1469	0.1821	0.2082	0.2389	0.2321	0.2236	0.2235	0.2036	0.2054	0.1871	0.1716	0.1961	0.2082	0.2074
8	8	0.1727	0.1985	0.2121	0.1478	0.1812	0.2089	0.239	0.2309	0.2236	0.2197	0.2043	0.2056	0.1804	0.1744	0.1966	0.2057	0.2088
8	17	0.1533	0.1813	0.1995	0.1599	0.1893	0.2079	0.2345	0.2292	0.2215	0.2198	0.2021	0.2054	0.1838	0.1681	0.1947	0.208	0.2037
8	22	0.216	0.2368	0.2402	0.1513	0.1867	0.2041	0.2355	0.228	0.2211	0.2233	0.2045	0.2049	0.1805	0.1643	0.1964	0.2077	0.2041
8	29	0.133	0.1633	0.1864	0.148	0.184	0.2007	0.2324	0.2255	0.2169	0.2205	0.2068	0.2036	0.1804	0.1641	0.1925	0.2048	0.2043
9	5	0.2357	0.2544	0.253	0.1491	0.1829	0.2011	0.2305	0.2246	0.2192	0.2157	0.2052	0.2022	0.1781	0.1656	0.1907	0.2024	0.2045
9	21	0.1341	0.1643	0.1871	0.1568	0.1899	0.2154	0.2422	0.2409	0.2329	0.2333	0.2108	0.2174	0.1947	0.1731	0.2066	0.2151	0.2081
10	3	0.1845	0.2089	0.2197	0.1654	0.2036	0.2162	0.2504	0.2414	0.2306	0.2336	0.2138	0.2154	0.1946	0.1736	0.2024	0.2122	0.2077
10	10	0.1316	0.1621	0.1855	0.1522	0.1925	0.2125	0.2447	0.2406	0.2266	0.2318	0.2121	0.2133	0.1934	0.1761	0.2036	0.2139	0.2085
10	12	0.3338	0.3412	0.3165	0.1818	0.2177	0.2325	0.253	0.2444	0.2235	0.2325	0.2138	0.2152	0.1947	0.1742	0.203	0.2134	0.2109
10	17	0.1688	0.195	0.2096	0.1607	0.1992	0.2231	0.2532	0.241	0.2334	0.2324	0.2104	0.2177	0.1977	0.1811	0.2079	0.2198	0.2135
10	24	0.1203	0.1521	0.1782	0.1605	0.1995	0.2241	0.2521	0.2384	0.2325	0.2305	0.2119	0.216	0.1979	0.1807	0.2073	0.2206	0.2119
11	2				0.1657	0.1988	0.224	0.2489	0.2443	0.2303	0.2337	0.2142	0.2153	0.1937	0.1821	0.2104	0.2224	0.2163
11	7	0.1523	0.1805	0.1989	0.1631	0.197	0.2199	0.2474	0.2504	0.2331	0.2395	0.2163	0.2169	0.1959	0.1789	0.2082	0.2224	0.2177
Avg.:		0.19745	0.21723	0.22581	0.15783	0.19008	0.21345	0.23868	0.23432	0.22444	0.22524	0.20814	0.20713	0.18624	0.17261	0.20099	0.21229	0.21022
C.V.:		27.5%	25.0%	17.6%	8.7%	5.6%	4.3%	4.2%	2.9%	2.7%	2.5%	3.3%	2.8%	4.2%	3.9%	4.3%	2.7%	3.7%

Volumetric Water Content -- 12/89 - 11/90

Plot 10

DEPTH (cm)

Month	Date	2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
12	1	0.1647	0.1914	0.2069	0.1599	0.2001	0.219	0.214	0.1856	0.1824	0.1717	0.1811		0.1136	0.1133	0.1186	0.121	0.1777
12	4	0.2143	0.2354	0.2391	0.1943	0.2191	0.2398	0.2304	0.2273	0.231	0.2127	0.2132		0.1583	0.1524	0.152	0.142	0.2048
12	8	0.2131	0.2343	0.2383	0.1832	0.2104	0.2298	0.2269	0.2223	0.2228	0.2123	0.2118	0.1637	0.1533	0.15	0.1508	0.143	0.2079
12	15	0.0941	0.1288	0.1612	0.1635	0.2008	0.221	0.2174	0.2143	0.2201	0.2102	0.2081		0.1483	0.1474	0.1512	0.1426	0.202
12	18	0.0977	0.132	0.1635	0.1638	0.2012	0.221	0.2178	0.2156	0.2216	0.211	0.2101		0.1485	0.1483	0.1505	0.1434	0.2035
12	26	0.2561	0.2724	0.2661	0.1883	0.2128	0.2377	0.234	0.225	0.2328	0.2174	0.2153		0.1583	0.1568	0.1553	0.1453	0.2084
1	3	0.1881	0.2121	0.2221	0.1775	0.1851	0.2068	0.2349	0.2309	0.2213	0.2282	0.2135	0.2137	0.1595	0.1621	0.1632	0.1666	0.2065
1	5	0.2132	0.2343	0.2383	0.2107	0.2249	0.2445	0.2351	0.228	0.2314	0.2123	0.21	0.1632	0.1497	0.1478	0.1501	0.139	0.2045
1	10	0.208	0.2297	0.235	0.1903	0.2138	0.231	0.2344	0.225	0.2293	0.2156	0.2127	0.169	0.1577	0.1544	0.1553	0.1485	0.2087
1	12	0.2007	0.2233	0.2303	0.2141	0.217	0.2316	0.2339	0.2283	0.2299	0.2162	0.2139	0.1697	0.1572	0.1548	0.1564	0.1467	0.2101
1	16	0.2709	0.2855	0.2757	0.1935	0.2165	0.2448	0.2384	0.2334	0.2354	0.2244	0.2259	0.1738	0.1633	0.1605	0.163	0.152	0.2192
1	19	0.2891	0.3016	0.2875	0.1956	0.212	0.2237	0.2216	0.2203	0.2232	0.2069	0.2114	0.1601	0.1517	0.1465	0.1499	0.1421	0.2072
1	31	0.227	0.2466	0.2473	0.194	0.2173	0.2382	0.2348	0.2288	0.2321	0.2193	0.219	0.1719	0.1628	0.1566	0.1601	0.1506	0.217
2	2	0.2306	0.2498	0.2496	0.1961	0.2125	0.2365	0.2305	0.2214	0.2283	0.2149	0.2118	0.166	0.1589	0.1552	0.1535	0.1482	0.2123
2	8	0.2065	0.2285	0.234	0.1817	0.2086	0.226	0.226	0.2254	0.2262	0.2108	0.2131	0.1655	0.1525	0.1522	0.1509	0.1437	0.2096
2	9	0.2812	0.2946	0.2824	0.2147	0.2272	0.2449	0.2402	0.2316	0.2284	0.2085	0.2079	0.1627	0.1521	0.1496	0.1519	0.1428	0.2061
2	14	0.1748	0.2003	0.2135	0.1816	0.2089	0.2257	0.2317	0.2247	0.2254	0.2103	0.2137	0.1649	0.1524	0.1523	0.1509	0.1432	0.209
2	16	0.2253	0.2451	0.2462	0.1832	0.208	0.2289	0.2264	0.2211	0.2288	0.2113	0.2119	0.1658	0.1547	0.1527	0.1525	0.1472	0.2068
2	20	0.1785	0.2036	0.2159	0.1836	0.2085	0.2286	0.2252	0.2233	0.2264	0.2079	0.2148	0.1643	0.1549	0.1518	0.1533	0.1423	0.209
2	23	0.268	0.2829	0.2739	0.2068	0.2232	0.2441	0.2369	0.2298	0.2363	0.2182	0.2202	0.1732	0.1639	0.1546	0.1563	0.1464	0.2054
3	7	0.166	0.1926	0.2078	0.1758	0.2053	0.2271	0.2248	0.2206	0.2255	0.2115	0.2127	0.1651	0.1539	0.1509	0.1505	0.1436	0.2101
3	9	0.1319	0.1624	0.1857	0.1627	0.199	0.2226	0.2171	0.2172	0.2225	0.2063	0.2076	0.1597	0.1482	0.1474	0.1476	0.1389	0.2026
3	14	0.2662	0.2814	0.2727	0.1871	0.2103	0.2324	0.2308	0.2242	0.2285	0.2127	0.2138	0.1664	0.1552	0.1543	0.1534	0.1449	0.2135
3	16	0.2169	0.2376	0.2407	0.194	0.217	0.234	0.2302	0.2263	0.2289	0.2109	0.2145	0.1661	0.158	0.156	0.1552	0.1405	0.2004
3	19	0.2115	0.2328	0.2372	0.1945	0.2173	0.2348	0.2307	0.2262	0.2171	0.2111	0.2145	0.1661	0.1581	0.1559	0.1553	0.1406	0.2029
3	28	0.1348	0.1649	0.1876	0.1682	0.1967	0.2241	0.221	0.2151	0.2199	0.2089	0.2095	0.1591	0.1478	0.148	0.1494	0.1411	0.2044
3	29	0.2879	0.3006	0.2867	0.185	0.2054	0.2321	0.2485	0.241	0.2315	0.2325	0.207	0.2111	0.1909	0.1776	0.2063	0.2147	0.2143
4	2		0.0101	0.0744	0.1911	0.2141	0.2295	0.2273	0.2238	0.2267	0.2127	0.2117	0.165	0.1588	0.1545	0.1531	0.1439	0.2075
4	4	0.1693	0.1955	0.2099	0.1854	0.2082	0.2297	0.2266	0.2219	0.2248	0.2058	0.209	0.1615	0.156	0.1518	0.1513	0.1437	0.2074
4	10	0.1689	0.1951	0.2096	0.1726	0.2009	0.2244	0.2192	0.2173	0.2233	0.2088	0.2079	0.1592	0.1495	0.1479	0.1479	0.1405	0.2027
4	18	0.1783	0.2034	0.2157	0.1852	0.2095	0.2304	0.2285	0.2216	0.2263	0.2124	0.213	0.1644	0.1575	0.1557	0.1554	0.1446	0.2111
4	20	0.1737	0.1994	0.2127	0.1846	0.2088	0.229	0.2273	0.217	0.2231	0.2108	0.2111	0.1629	0.1567	0.1531	0.1535	0.1436	0.2111
4	27	0.2728	0.2872	0.2769	0.2139	0.2254	0.243	0.2334	0.2267	0.2237	0.2092	0.2102	0.1564	0.1492	0.1469	0.1507	0.1426	0.2045
5	3	0.17	0.1961	0.2104	0.1743	0.1901	0.1936	0.2312	0.2314	0.2373	0.2292	0.2192	0.201	0.1913	0.1791	0.1861	0.1984	0.2107
5	9	0.1299	0.1606	0.1844	0.1731	0.2066	0.2271	0.2242	0.2216	0.2249	0.212	0.211	0.1616	0.1551	0.1543	0.1519	0.1501	0.2069
5	11	0.3365	0.3436	0.3182	0.1726	0.1941	0.2025	0.2236	0.215	0.2229	0.2119	0.2104	0.1851	0.1667	0.1538	0.1634	0.1976	0.2039

Volumetric Water Content -- 12/89 - 11/90

Plot 10 (cont.)

DEPTH (cm)

Month	Date	2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
5	16	0.1824	0.2071	0.2184	0.1714	0.2078	0.2299	0.2252	0.2224	0.2249	0.2121	0.2151	0.1641	0.1537	0.1486	0.1493	0.1402	0.2042
5	18	0.1265	0.1576	0.1822	0.1685	0.2076	0.2285	0.2241	0.2213	0.224	0.2121	0.2143	0.1664	0.1526	0.1483	0.1487	0.1402	0.2032
5	25	0.3189	0.328	0.3068	0.2123	0.2277	0.2401	0.2383	0.2286	0.2283	0.2089	0.2103	0.1584	0.1508	0.1458	0.151	0.1415	0.2052
5	31	0.2162	0.237	0.2403	0.2115	0.2268	0.2392	0.2374	0.2277	0.2274	0.2081	0.2095	0.1578	0.1502	0.1452	0.1504	0.1409	0.2044
6	4	0.1357	0.1657	0.1882	0.1639	0.2034	0.2248	0.2223	0.2188	0.2261	0.2118	0.2136	0.1675	0.1564	0.1498	0.1506	0.1401	0.2046
6	6	0.1282	0.159	0.1833	0.1572	0.1986	0.2219	0.2215	0.2215	0.2231	0.2122	0.2128	0.1624	0.1516	0.1461	0.1505	0.1425	0.2045
6	8	0.3446	0.3508	0.3235	0.157	0.1984	0.2217	0.2213	0.2213	0.2228	0.212	0.2126	0.1622	0.1514	0.1459	0.1503	0.1423	0.2043
6	13	0.1813	0.2061	0.2177	0.1769	0.2065	0.2279	0.2242	0.2199	0.2246	0.2098	0.2126	0.1611	0.1538	0.1506	0.1495	0.1402	0.2016
6	15	0.1763	0.2016	0.2144	0.1787	0.2064	0.2281	0.2231	0.2173	0.2289	0.2029	0.2124	0.1633	0.1577	0.1531	0.1501	0.145	0.2029
6	21	0.1133	0.1459	0.1736	0.1645	0.2008	0.2225	0.22	0.2164	0.2215	0.208	0.2111	0.1601	0.15	0.1488	0.1466	0.139	0.1993
6	29	0.0761	0.1129	0.1495	0.1797	0.214	0.2354	0.234	0.2272	0.2281	0.2171	0.2208	0.1693	0.1594	0.1574	0.1549	0.147	0.2101
7	3	0.1099	0.1428	0.1714	0.1706	0.2051	0.2263	0.2239	0.2204	0.2246	0.2123	0.2131	0.1608	0.1532	0.1479	0.1482	0.1426	0.2013
7	11	0.1894	0.2133	0.223	0.1889	0.2126	0.2365	0.2314	0.2276	0.2291	0.2125	0.2188	0.1686	0.161	0.157	0.1577	0.1469	0.2119
7	13	0.1502	0.1786	0.1976	0.1816	0.2097	0.2285	0.2279	0.2215	0.226	0.2139	0.2163	0.1649	0.1537	0.1523	0.1551	0.1429	0.2086
7	25	0.1681	0.1944	0.2091	0.1648	0.1915	0.1915	0.2234	0.2194	0.2241	0.2158	0.2249	0.1915	0.1632	0.1518	0.1789	0.2157	0.2158
7	27	0.1094	0.1424	0.1711	0.1653	0.2016	0.2237	0.2237	0.2209	0.2255	0.2112	0.2175	0.1632	0.1532	0.1464	0.1482	0.1369	0.205
8	1	0.0764	0.1132	0.1497	0.1652	0.2113	0.2321	0.2304	0.2292	0.2315	0.2204	0.2218	0.1672	0.1554	0.1566	0.1525	0.142	0.2153
8	3	0.1334	0.1636	0.1866	0.1554	0.2039	0.2202	0.2201	0.2208	0.2242	0.2194	0.2161	0.1599	0.1574	0.1627	0.1551	0.1464	0.2079
8	8	0.1383	0.1681	0.1899	0.1561	0.2054	0.2184	0.2178	0.221	0.2238	0.221	0.2179	0.1572	0.1555	0.1569	0.1571	0.1478	0.2095
8	17	0.1569	0.1845	0.2019	0.1914	0.2129	0.2306	0.2295	0.2258	0.2264	0.2081	0.2145	0.1656	0.1548	0.1506	0.1536	0.1408	0.204
8	22	0.2196	0.2401	0.2425	0.1756	0.2058	0.231	0.226	0.2215	0.2263	0.2082	0.2157	0.1628	0.1533	0.1479	0.1488	0.1379	0.206
8	29	0.1395	0.169	0.1906	0.1763	0.2047	0.2255	0.2251	0.2193	0.2255	0.2048	0.2145	0.1619	0.1521	0.1473	0.1471	0.1342	0.2052
9	5	0.2748	0.289	0.2783	0.1767	0.2045	0.2243	0.2236	0.2189	0.2255	0.2049	0.2143	0.1623	0.1534	0.1469	0.147	0.1359	0.2063
9	21	0.1467	0.1754	0.1952	0.1928	0.2213	0.2406	0.2378	0.2329	0.2377	0.2223	0.2251	0.172	0.1631	0.1565	0.1548	0.1448	0.2095
10	3	0.211	0.2324	0.2369	0.2	0.2235	0.2464	0.242	0.2363	0.2381	0.2208	0.2282	0.1762	0.1682	0.1626	0.1612	0.1461	0.2091
10	10	0.1245	0.1558	0.1809	0.1811	0.2127	0.2342	0.2334	0.2309	0.2346	0.2154	0.2267	0.1693	0.1623	0.1561	0.1543	0.1481	0.2115
10	12	0.3309	0.3386	0.3146	0.2063	0.2327	0.244	0.2438	0.2276	0.2338	0.2154	0.2255	0.1713	0.1646	0.1571	0.1521	0.1568	0.2209
10	17	0.1586	0.186	0.2029	0.1925	0.2216	0.2416	0.2404	0.2353	0.2383	0.2208	0.2263	0.1773	0.1654	0.1614	0.1604	0.1457	0.2145
10	24	0.1177	0.1497	0.1765	0.1879	0.2213	0.2382	0.24	0.2342	0.2376	0.2215	0.2255	0.1792	0.1603	0.1619	0.1631	0.1474	0.1897
11	2				0.1948	0.2182	0.2375	0.2359	0.2305	0.2355	0.221	0.2273	0.1776	0.1637	0.1568	0.1581	0.1482	0.2139
11	7	0.1389	0.1686	0.1902	0.1875	0.2159	0.239	0.2389	0.232	0.2404	0.2258	0.2267	0.1743	0.1656	0.1616	0.1579	0.1486	0.2182
Avg.:		0.18939	0.21019	0.22067	0.18282	0.21001	0.2294	0.22897	0.22384	0.22699	0.21309	0.21469	0.16829	0.15659	0.1529	0.15433	0.14747	0.20714
C.V.:		34.3%	29.6%	20.6%	8.5%	4.6%	4.7%	3.2%	3.3%	3.3%	3.7%	3.3%	6.7%	6.0%	5.3%	6.6%	10.9%	3.1%

Volumetric Water Content -- 12/89 - 11/90

Plot 11

		DEPTH (cm)																
Month	Date	2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
12	1	0.1792	0.2042	0.2163	0.1686	0.182	0.1909	0.2127	0.2103	0.1957	0.1943	0.2033		0.1292	0.1156	0.1406	0.2012	0.1948
12	4	0.2046	0.2267	0.2328	0.1892	0.1975	0.2091	0.2301	0.2401	0.2402	0.24	0.2352		0.17	0.1535	0.1676	0.2354	0.2323
12	8	0.2034	0.2257	0.232	0.1756	0.1842	0.1983	0.2217	0.2329	0.2355	0.2344	0.2318	0.1734	0.1627	0.1444	0.167	0.2309	0.2337
12	15	0.1202	0.1519	0.1781	0.1568	0.1753	0.1861	0.22	0.2329	0.2355	0.2326	0.2263		0.1569	0.1389	0.1569	0.2234	0.2241
12	18	0.1177	0.1497	0.1765	0.1576	0.1754	0.1865	0.2204	0.2334	0.235	0.2334	0.2264		0.1579	0.1392	0.1574	0.2235	0.2258
12	26	0.2691	0.2839	0.2746	0.1805	0.1906	0.203	0.2288	0.243	0.2409	0.2375	0.2385		0.169	0.147	0.1677	0.2331	0.2311
1	3	0.196	0.2192	0.2272	0.1774	0.1908	0.2028	0.227	0.2391	0.2368	0.2307	0.2359	0.2136	0.1667	0.1474	0.1665	0.2298	0.2283
1	5	0.2145	0.2355	0.2392	0.2009	0.2053	0.2148	0.233	0.2384	0.2399	0.2365	0.2317	0.1724	0.1568	0.1389	0.1554	0.2259	0.2253
1	10	0.2114	0.2328	0.2372	0.1822	0.1911	0.2048	0.2264	0.2365	0.243	0.2372	0.2325	0.1737	0.1642	0.1458	0.1652	0.2356	0.234
1	12	0.2072	0.2291	0.2345	0.1823	0.204	0.2042	0.2279	0.2433	0.2368	0.238	0.2307	0.1668	0.1646	0.1463	0.1704	0.2344	0.2345
1	16	0.2732	0.2875	0.2772	0.1814	0.1948	0.2095	0.2358	0.2477	0.2532	0.248	0.249	0.1844	0.1701	0.1538	0.1709	0.2431	0.2374
1	19	0.2977	0.3092	0.2931	0.1832	0.1859	0.1938	0.2198	0.2312	0.23	0.2298	0.2309	0.1694	0.1536	0.1404	0.159	0.2293	0.2277
1	31	0.2061	0.2281	0.2338	0.1886	0.1951	0.2104	0.2323	0.2423	0.243	0.2436	0.2375	0.1782	0.1662	0.1505	0.1773	0.2377	0.2439
2	2	0.2213	0.2416	0.2436	0.1852	0.1911	0.2037	0.2277	0.2354	0.2431	0.2364	0.2312	0.1741	0.161	0.1432	0.1709	0.231	0.2337
2	8	0.1793	0.2043	0.2164	0.1769	0.1852	0.1997	0.2241	0.2366	0.2394	0.2368	0.229	0.1695	0.1571	0.142	0.169	0.2301	0.2298
2	9	0.2734	0.2877	0.2774	0.2073	0.2114	0.224	0.2347	0.2381	0.2449	0.2351	0.2285	0.1671	0.1578	0.1395	0.1656	0.2269	0.2239
2	14	0.1856	0.2099	0.2205	0.1755	0.1852	0.199	0.2236	0.2361	0.2385	0.2368	0.2291	0.1681	0.1572	0.1416	0.1693	0.2291	0.2295
2	16	0.2124	0.2337	0.2379	0.1743	0.1857	0.1963	0.2224	0.231	0.2367	0.2348	0.2277	0.168	0.1593	0.1409	0.1654	0.2292	0.2317
2	20	0.1707	0.1967	0.2108	0.1767	0.1892	0.1974	0.2231	0.2358	0.2377	0.2353	0.2306	0.1702	0.1598	0.1471	0.1738	0.2313	0.233
2	23	0.2458	0.2633	0.2595	0.1984	0.207	0.2199	0.2352	0.2416	0.2516	0.2451	0.2324	0.1757	0.167	0.1484	0.1711	0.2318	0.2286
3	7	0.1653	0.1919	0.2073	0.1671	0.182	0.1948	0.2234	0.2327	0.2394	0.2353	0.2292	0.1696	0.1577	0.1403	0.1695	0.231	0.2297
3	9	0.1457	0.1746	0.1947	0.1615	0.1749	0.1902	0.2181	0.2297	0.232	0.2299	0.2247	0.1634	0.1557	0.1369	0.1669	0.225	0.2219
3	14	0.2472	0.2645	0.2604	0.1792	0.1921	0.2058	0.2285	0.2327	0.24	0.2398	0.2315	0.172	0.161	0.1449	0.1726	0.2343	0.231
3	16	0.2241	0.244	0.2454	0.1927	0.1932	0.2099	0.2266	0.2352	0.2419	0.2372	0.2312	0.1734	0.1648	0.1459	0.1684	0.2266	0.2212
3	19	0.2193	0.2398	0.2423	0.1934	0.1945	0.2099	0.2259	0.234	0.242	0.2384	0.2312	0.1755	0.1655	0.1458	0.1693	0.2263	0.2215
3	28	0.1524	0.1805	0.199	0.1623	0.182	0.1913	0.2211	0.2305	0.2364	0.2309	0.2222	0.1664	0.1548	0.1344	0.1683	0.2227	0.2222
3	29	0.2788	0.2925	0.2809	0.2109	0.231	0.2473	0.24	0.2345	0.2306	0.214	0.2149	0.161	0.1531	0.1529	0.1517	0.1415	0.2083
4	2		0.0128	0.0763	0.1818	0.1901	0.204	0.2258	0.2328	0.2403	0.2357	0.226	0.1729	0.159	0.1456	0.1746	0.2291	0.2283
4	4	0.1945	0.2178	0.2262	0.1759	0.1885	0.199	0.2218	0.2342	0.2355	0.2334	0.2263	0.1688	0.1606	0.1428	0.1746	0.2289	0.2327
4	10	0.1942	0.2175	0.226	0.1629	0.1801	0.1933	0.2185	0.2286	0.2354	0.2344	0.2259	0.1657	0.1554	0.1384	0.1692	0.2264	0.2284
4	18	0.1961	0.2193	0.2273	0.1783	0.1941	0.1996	0.2242	0.2319	0.2405	0.2352	0.2279	0.1718	0.1635	0.144	0.1762	0.233	0.2284
4	20	0.1931	0.2166	0.2253	0.1773	0.1926	0.1991	0.2228	0.2304	0.2389	0.235	0.2287	0.1676	0.1623	0.142	0.1755	0.228	0.2275
4	27	0.2672	0.2822	0.2733	0.2008	0.2049	0.2198	0.2305	0.235	0.2427	0.2359	0.2248	0.1682	0.1502	0.1375	0.1732	0.2244	0.2249
5	3	0.1789	0.204	0.2162	0.1628	0.1805	0.1872	0.2329	0.2369	0.2354	0.2311	0.2154	0.2116	0.1991	0.1912	0.1914	0.2128	0.2153
5	9	0.1463	0.1751	0.195	0.1743	0.1884	0.1992	0.2233	0.2327	0.2404	0.2301	0.2257	0.1662	0.1578	0.1408	0.18	0.2281	0.2282
5	11	0.3349	0.3422	0.3172	0.1976	0.2054	0.199	0.228	0.2128	0.2227	0.2187	0.2115	0.1904	0.1552	0.1528	0.1655	0.2175	0.2126

Volumetric Water Content -- 12/89 - 11/90

Plot 11 (cont.)

DEPTH (cm)

Month	Date	2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
5	16	0.14	0.1695	0.1909	0.1716	0.1893	0.2044	0.2269	0.2337	0.2387	0.2382	0.2304	0.1706	0.1631	0.1447	0.1728	0.2309	0.2291
5	18	0.1763	0.2017	0.2145	0.1693	0.1889	0.2034	0.224	0.2337	0.2361	0.2361	0.2291	0.1693	0.1631	0.1451	0.1729	0.229	0.2293
5	25	0.3202	0.3292	0.3077	0.2021	0.2056	0.2249	0.2337	0.2397	0.2395	0.2279	0.2321	0.1709	0.1579	0.1406	0.1549	0.2267	0.225
5	31	0.2226	0.2427	0.2444	0.2013	0.2049	0.224	0.2329	0.2388	0.2386	0.2271	0.2312	0.1702	0.1573	0.14	0.1543	0.2259	0.2241
6	4	0.1832	0.2078	0.2189	0.1673	0.1884	0.1967	0.2244	0.2342	0.2387	0.2331	0.2326	0.1706	0.1593	0.1408	0.1638	0.2299	0.2286
6	6	0.1622	0.1892	0.2053	0.1615	0.187	0.1956	0.2223	0.2309	0.2369	0.2333	0.2301	0.1703	0.1568	0.1395	0.1649	0.2273	0.2255
6	8	0.3373	0.3444	0.3188	0.2027	0.2058	0.2239	0.2344	0.2411	0.2374	0.2311	0.2338	0.1695	0.1579	0.1422	0.1546	0.2271	0.2253
6	13	0.1792	0.2043	0.2163	0.1733	0.1854	0.2035	0.2241	0.2339	0.2387	0.2351	0.2324	0.1691	0.1597	0.1421	0.1692	0.2289	0.2239
6	15	0.1752	0.2007	0.2137	0.175	0.1869	0.2031	0.2243	0.239	0.2365	0.2353	0.2317	0.1686	0.1594	0.1416	0.1691	0.2284	0.2236
6	21	0.1556	0.1834	0.2011	0.161	0.1772	0.1936	0.2236	0.232	0.2351	0.2295	0.2279	0.1693	0.1555	0.1406	0.1627	0.2241	0.2241
6	29	0.0993	0.1335	0.1646	0.1764	0.1898	0.2032	0.2296	0.2402	0.2432	0.2392	0.2363	0.1766	0.1607	0.1461	0.171	0.2327	0.2361
7	3	0.0971	0.1315	0.1631	0.1679	0.1838	0.1976	0.2244	0.2324	0.2376	0.2331	0.2307	0.1691	0.1583	0.1418	0.1667	0.2278	0.228
7	11	0.1802	0.2051	0.217	0.1786	0.1923	0.2046	0.2286	0.2357	0.2411	0.2359	0.2296	0.1723	0.1605	0.1406	0.169	0.2279	0.2272
7	13	0.1756	0.201	0.214	0.1752	0.1884	0.2018	0.2279	0.237	0.2357	0.2363	0.2331	0.1742	0.1602	0.1418	0.1691	0.231	0.2292
7	25	0.1913	0.215	0.2242	0.1561	0.1773	0.1981	0.2241	0.2315	0.2367	0.2312	0.2176	0.1917	0.1548	0.1275	0.1235	0.203	0.2173
7	27	0.1262	0.1573	0.182	0.166	0.193	0.193	0.225	0.221	0.2257	0.2173	0.2265	0.193	0.1645	0.153	0.1803	0.2173	0.2174
8	1	0.1206	0.1524	0.1784	0.1619	0.1885	0.2019	0.2316	0.2431	0.2444	0.2413	0.2401	0.1781	0.1628	0.148	0.1724	0.2368	0.2352
8	3	0.1807	0.2055	0.2173	0.1553	0.183	0.1955	0.2176	0.2323	0.236	0.2299	0.2318	0.171	0.1551	0.1525	0.1669	0.2262	0.221
8	8	0.1737	0.1994	0.2128	0.1512	0.1773	0.1881	0.2179	0.2294	0.2356	0.2327	0.2307	0.168	0.1541	0.1356	0.1615	0.2228	0.2257
8	17	0.2028	0.2252	0.2316	0.1554	0.1839	0.1925	0.2019	0.2269	0.2333	0.2348	0.2317	0.1709	0.1602	0.1412	0.1658	0.2269	0.225
8	22	0.2712	0.2857	0.2759	0.1679	0.1845	0.1995	0.2238	0.231	0.2374	0.2367	0.23	0.1678	0.1555	0.1397	0.1656	0.227	0.2242
8	29	0.1787	0.2038	0.216	0.1663	0.1825	0.197	0.2228	0.2291	0.2368	0.2351	0.2253	0.1669	0.1549	0.1357	0.1668	0.2286	0.2229
9	5	0.2668	0.2819	0.2731	0.166	0.183	0.1932	0.2193	0.2308	0.2336	0.2318	0.2306	0.1682	0.1561	0.1323	0.1671	0.2278	0.2196
9	21	0.1567	0.1843	0.2017	0.1845	0.1972	0.2082	0.2378	0.2456	0.2508	0.2468	0.2478	0.1779	0.168	0.1487	0.1711	0.237	0.2339
10	3	0.2238	0.2438	0.2452	0.1911	0.2005	0.2108	0.2345	0.2414	0.2457	0.2444	0.2463	0.1847	0.1679	0.1502	0.1639	0.2369	0.2303
10	10	0.129	0.1598	0.1838	0.1734	0.1918	0.2061	0.232	0.2392	0.2443	0.2365	0.2444	0.1789	0.1656	0.1436	0.1662	0.2356	0.2329
10	12	0.3344	0.3417	0.3169	0.1976	0.2141	0.2397	0.2462	0.245	0.2494	0.2339	0.246	0.1805	0.1648	0.1454	0.1614	0.2337	0.2339
10	17	0.1502	0.1786	0.1976	0.1873	0.1996	0.2084	0.2345	0.2441	0.246	0.2443	0.2429	0.1812	0.1684	0.1487	0.1687	0.2397	0.2344
10	24	0.1181	0.1501	0.1767	0.1865	0.1978	0.2081	0.2332	0.2437	0.2451	0.2398	0.2425	0.1772	0.1652	0.1483	0.1652	0.2344	0.239
11	2				0.1856	0.1985	0.2087	0.2339	0.2386	0.2457	0.2447	0.2463	0.1828	0.1725	0.15	0.1673	0.2372	0.2357
11	7	0.1139	0.1464	0.174	0.1834	0.1958	0.207	0.2355	0.2458	0.2515	0.2461	0.2524	0.1809	0.1679	0.1487	0.1666	0.2386	0.2405
Avg.:		0.19798	0.21774	0.2262	0.17785	0.19139	0.20358	0.22673	0.23509	0.23856	0.23447	0.23118	0.17418	0.16076	0.14384	0.1667	0.22739	0.22736
C.V.:		29.2%	26.2%	18.4%	8.0%	5.4%	5.7%	3.0%	2.8%	3.2%	3.4%	3.7%	5.5%	4.9%	6.0%	5.5%	5.6%	3.3%

Volumetric Water Content -- 12/89 - 11/90

Plot 12

Month	Date	DEPTH (cm)																
		2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
12	1	0.2049	0.227	0.233	0.157	0.1773	0.1979	0.2251	0.2217	0.2187	0.2177	0.2018		0.1191	0.1014	0.1019	0.1722	0.1885
12	4	0.2143	0.2354	0.2391	0.1819	0.1939	0.2062	0.2367	0.2376	0.238	0.2327	0.223		0.1681	0.1453	0.1422	0.2191	0.2298
12	8	0.2131	0.2343	0.2383	0.1664	0.1795	0.2041	0.2265	0.2368	0.2357	0.233	0.2205	0.1931	0.1622	0.1345	0.1338	0.2101	0.2269
12	15	0.0889	0.1243	0.1578	0.1479	0.1662	0.1971	0.2224	0.2279	0.2347	0.2253	0.2177		0.1556	0.1278	0.1237	0.2049	0.2194
12	18	0.0878	0.1233	0.1571	0.1476	0.164	0.1975	0.223	0.228	0.2348	0.2258	0.2192		0.1544	0.128	0.1235	0.2046	0.2204
12	26	0.2867	0.2995	0.286	0.1723	0.1852	0.2061	0.2347	0.2373	0.2412	0.2342	0.2266		0.1618	0.1384	0.1325	0.2096	0.2244
1	3	0.2188	0.2393	0.242	0.1665	0.1796	0.2025	0.2336	0.2348	0.2373	0.2308	0.2239	0.1908	0.1621	0.1386	0.1337	0.2036	0.2182
1	5	0.1917	0.2154	0.2244	0.1931	0.1982	0.2151	0.2378	0.2371	0.24	0.2292	0.2189	0.193	0.1538	0.1286	0.1245	0.2073	0.2162
1	10	0.1927	0.2162	0.2251	0.1759	0.1877	0.2081	0.2316	0.234	0.2412	0.2326	0.2234	0.1922	0.1639	0.1372	0.1387	0.2201	0.2278
1	12	0.1945	0.2178	0.2262	0.1763	0.1885	0.2077	0.232	0.2344	0.2369	0.234	0.2202	0.187	0.164	0.1386	0.1385	0.2216	0.2284
1	16	0.2586	0.2746	0.2678	0.1767	0.1887	0.2116	0.2449	0.2474	0.2524	0.2423	0.2345	0.2027	0.1673	0.1383	0.139	0.2271	0.2361
1	19	0.3144	0.3241	0.3039	0.1762	0.1833	0.2003	0.2276	0.2333	0.2325	0.2288	0.2196	0.1872	0.1549	0.1327	0.1257	0.2087	0.2208
1	31	0.2133	0.2345	0.2384	0.1786	0.1915	0.2134	0.239	0.2415	0.2486	0.2381	0.23	0.202	0.1671	0.1447	0.1432	0.2188	0.2336
2	2	0.2135	0.2346	0.2385	0.1832	0.1881	0.2062	0.2318	0.2359	0.239	0.2323	0.2195	0.1958	0.1611	0.1344	0.132	0.2134	0.2254
2	8	0.188	0.212	0.222	0.1696	0.1813	0.2047	0.2298	0.2362	0.2413	0.2302	0.2225	0.1918	0.1561	0.1337	0.1287	0.2102	0.2248
2	9	0.2654	0.2807	0.2722	0.2	0.2031	0.2211	0.2373	0.2387	0.2435	0.2315	0.22	0.1929	0.1578	0.1341	0.1287	0.2087	0.2229
2	14	0.1601	0.1873	0.2039	0.1699	0.1806	0.2008	0.2291	0.2361	0.2383	0.2318	0.222	0.1931	0.1554	0.1339	0.1365	0.2093	0.2247
2	16	0.1887	0.2126	0.2225	0.1655	0.1777	0.2016	0.2277	0.2332	0.2358	0.2294	0.2198	0.1933	0.1603	0.1356	0.1315	0.2141	0.2244
2	20	0.1716	0.1975	0.2114	0.1708	0.1812	0.2029	0.2291	0.2389	0.2385	0.236	0.2205	0.1928	0.1571	0.1298	0.1303	0.2168	0.2259
2	23	0.252	0.2688	0.2635	0.1885	0.1951	0.2143	0.2387	0.2469	0.2413	0.2375	0.2283	0.2001	0.1648	0.1315	0.1306	0.2102	0.2249
3	7	0.1635	0.1904	0.2062	0.1553	0.1752	0.1984	0.2279	0.2343	0.2368	0.2322	0.222	0.1898	0.1587	0.1325	0.1321	0.2118	0.2224
3	9	0.1292	0.1599	0.1839	0.1509	0.1697	0.1921	0.2243	0.2306	0.232	0.2271	0.2196	0.1866	0.154	0.1252	0.1251	0.2089	0.217
3	14	0.2512	0.2681	0.263	0.1736	0.1834	0.2069	0.2351	0.2408	0.2381	0.232	0.2249	0.1956	0.1622	0.1471	0.14	0.2137	0.225
3	16	0.2299	0.2491	0.2491	0.1788	0.1897	0.2079	0.2329	0.234	0.2337	0.2303	0.2193	0.1919	0.1555	0.1308	0.1249	0.2039	0.2147
3	19	0.2251	0.2449	0.2461	0.1791	0.1867	0.208	0.2341	0.2355	0.234	0.2299	0.2193	0.1903	0.1577	0.1305	0.1295	0.205	0.2148
3	28	0.133	0.1633	0.1864	0.1548	0.1745	0.1978	0.2276	0.232	0.2367	0.2257	0.2187	0.1854	0.1582	0.1322	0.127	0.2085	0.2175
3	29	0.2575	0.2736	0.2671	0.2035	0.2092	0.2217	0.2388	0.2402	0.2428	0.2373	0.2329	0.1703	0.1594	0.1435	0.1732	0.2336	0.2297
4	2		0.0144	0.0775	0.174	0.1836	0.206	0.2291	0.2366	0.2339	0.2288	0.2174	0.1916	0.1602	0.1358	0.1308	0.2114	0.221
4	4	0.184	0.2085	0.2194	0.1676	0.1823	0.2028	0.2301	0.232	0.2371	0.227	0.2209	0.1913	0.1588	0.1348	0.1326	0.2165	0.2209
4	10	0.184	0.2085	0.2194	0.1546	0.173	0.1975	0.2245	0.2295	0.2331	0.2267	0.2204	0.1886	0.153	0.1311	0.126	0.2075	0.2185
4	18	0.19	0.2139	0.2233	0.1696	0.1841	0.2007	0.2293	0.2293	0.2386	0.2321	0.2242	0.1937	0.1587	0.1353	0.1331	0.2112	0.224
4	20	0.1869	0.2111	0.2213	0.1685	0.1841	0.1998	0.2292	0.2279	0.2374	0.2316	0.2229	0.1918	0.1577	0.1509	0.1406	0.2108	0.2231
4	27	0.2505	0.2675	0.2625	0.1886	0.1977	0.2158	0.2319	0.2346	0.2339	0.2278	0.2166	0.1838	0.1555	0.1282	0.1259	0.2103	0.2183
5	3	0.1714	0.1974	0.2113	0.1525	0.179	0.1938	0.214	0.2364	0.2372	0.2291	0.2153	0.2098	0.2006	0.1914	0.1886	0.2125	0.2158
5	9	0.1323	0.1627	0.1859	0.1624	0.1783	0.2047	0.2319	0.2314	0.2379	0.2287	0.2219	0.1912	0.1589	0.132	0.1331	0.2145	0.223
5	11	0.3072	0.3176	0.2992	0.186	0.195	0.2048	0.2294	0.2314	0.2351	0.2267	0.2175	0.191	0.1561	0.1295	0.1261	0.2073	0.2177

Volumetric Water Content -- 12/89 - 11/90

Plot 12 (cont.)

		DEPTH (cm)																
Month	Date	2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
5	16	0.1623	0.1893	0.2054	0.1586	0.1841	0.2009	0.2294	0.2349	0.236	0.2294	0.2224	0.1944	0.1593	0.1322	0.1281	0.2075	0.2203
5	18	0.1321	0.1626	0.1858	0.1559	0.1794	0.1993	0.2277	0.235	0.2355	0.2278	0.2218	0.1897	0.1585	0.1403	0.1388	0.2076	0.2184
5	25	0.2934	0.3055	0.2903	0.1946	0.2036	0.2186	0.2403	0.2368	0.2403	0.2308	0.2161	0.19	0.1559	0.1285	0.1267	0.2028	0.2177
5	31	0.2242	0.2442	0.2455	0.1651	0.1846	0.2025	0.2283	0.235	0.2378	0.2327	0.2234	0.1941	0.1602	0.1325	0.1305	0.206	0.2219
6	4	0.1375	0.1673	0.1893	0.1665	0.1858	0.198	0.2271	0.235	0.2387	0.2312	0.2282	0.1741	0.1579	0.1405	0.1552	0.2267	0.2274
6	6	0.1172	0.1493	0.1761	0.149	0.177	0.1989	0.2243	0.2332	0.2389	0.2338	0.2225	0.1932	0.1601	0.1308	0.1255	0.2085	0.2171
6	8	0.3063	0.3169	0.2987	0.1951	0.203	0.2176	0.2357	0.2379	0.2409	0.2328	0.2168	0.1911	0.1564	0.1297	0.1288	0.2046	0.2184
6	13	0.1467	0.1754	0.1953	0.1678	0.1824	0.2052	0.2272	0.2339	0.2377	0.2305	0.2211	0.1913	0.1587	0.1334	0.1278	0.2103	0.2218
6	15	0.1425	0.1718	0.1926	0.1665	0.1822	0.2027	0.227	0.2346	0.2363	0.2309	0.2227	0.1919	0.159	0.1369	0.1388	0.2168	0.2232
6	21	0.1274	0.1583	0.1827	0.1491	0.1734	0.1954	0.2258	0.2328	0.238	0.2249	0.2164	0.1926	0.1544	0.1297	0.125	0.2051	0.2192
6	29	0.147	0.1757	0.1955	0.1645	0.1822	0.2068	0.2341	0.2414	0.243	0.2407	0.2262	0.1971	0.1615	0.1396	0.1313	0.2137	0.2273
7	3	0.1045	0.1381	0.168	0.157	0.1765	0.1983	0.2285	0.2337	0.2365	0.23	0.2196	0.1934	0.1582	0.1306	0.1303	0.2082	0.2189
7	11	0.1588	0.1862	0.2031	0.1694	0.1859	0.2057	0.2299	0.2339	0.2418	0.2322	0.2217	0.1935	0.1599	0.1305	0.1242	0.2098	0.2202
7	13	0.1881	0.2121	0.2221	0.1716	0.1805	0.203	0.2276	0.235	0.2377	0.2298	0.2219	0.1904	0.1574	0.1311	0.1273	0.2075	0.2204
7	25	0.2016	0.2241	0.2308	0.1628	0.1782	0.1956	0.2237	0.2279	0.2366	0.2306	0.2197	0.204	0.1929	0.1782	0.1903	0.2089	0.2077
7	27	0.1008	0.1348	0.1656	0.1581	0.1812	0.1964	0.23	0.2332	0.2379	0.2313	0.2204	0.1967	0.1569	0.1372	0.1212	0.1923	0.2213
8	1	0.1029	0.1366	0.1669	0.1511	0.1813	0.2045	0.2366	0.2433	0.2459	0.2414	0.2338	0.1994	0.1617	0.1335	0.1317	0.2195	0.2316
8	3	0.1491	0.1776	0.1968	0.1526	0.1749	0.2005	0.2294	0.2335	0.234	0.2316	0.2245	0.1915	0.1552	0.131	0.1342	0.2115	0.2209
8	8	0.1493	0.1777	0.1969	0.1427	0.1696	0.1934	0.2244	0.2305	0.2316	0.2288	0.2195	0.187	0.1532	0.126	0.1201	0.2033	0.2145
8	17	0.1691	0.1953	0.2098	0.175	0.1893	0.2066	0.2308	0.2382	0.2378	0.2311	0.2213	0.1948	0.1584	0.1307	0.1246	0.2067	0.217
8	22	0.235	0.2537	0.2525	0.1618	0.1802	0.2008	0.2321	0.232	0.2357	0.2295	0.2204	0.1939	0.158	0.1295	0.1234	0.2051	0.22
8	29	0.1432	0.1723	0.193	0.1551	0.1786	0.2003	0.2324	0.232	0.2336	0.229	0.2191	0.2048	0.1574	0.1307	0.1232	0.2043	0.2182
9	5	0.2425	0.2604	0.2574	0.1565	0.1779	0.1965	0.2315	0.2319	0.2347	0.2252	0.2193	0.2049	0.1543	0.1331	0.1239	0.2032	0.218
9	21	0.1892	0.2131	0.2228	0.1773	0.1918	0.2157	0.2438	0.2479	0.2509	0.2444	0.236	0.2052	0.1706	0.1392	0.1347	0.2178	0.2321
10	3	0.1852	0.2096	0.2202	0.1763	0.193	0.2108	0.2387	0.243	0.2499	0.2419	0.2335	0.2068	0.1668	0.1368	0.1318	0.2095	0.227
10	10	0.128	0.1589	0.1831	0.164	0.1825	0.2055	0.2376	0.2404	0.2472	0.2397	0.2286	0.2	0.1659	0.1351	0.1301	0.2117	0.2261
10	12	0.327	0.3352	0.3121	0.1904	0.1863	0.21	0.2441	0.2439	0.2464	0.2326	0.225	0.2008	0.1654	0.1384	0.1325	0.2114	0.225
10	17	0.1417	0.1711	0.192	0.1782	0.1937	0.2138	0.2396	0.2443	0.2481	0.2397	0.236	0.2024	0.1665	0.1409	0.1431	0.2142	
10	24	0.1222	0.1538	0.1794	0.1798	0.1869	0.2142	0.2379	0.243	0.2469	0.2379	0.2369	0.198	0.1664	0.1442	0.1454	0.2139	
11	2				0.1779	0.1901	0.2111	0.2388	0.2424	0.2458	0.2385	0.2306	0.2028	0.1704	0.1389	0.135	0.2126	0.2302
11	7	0.1095	0.1425	0.1712	0.1732	0.1893	0.2104	0.2443	0.2478	0.2524	0.246	0.2354	0.2063	0.1691	0.1393	0.1335	0.2126	0.2335
Avg.:		0.18768	0.20878	0.21963	0.16936	0.1842	0.20473	0.2316	0.23586	0.23884	0.23198	0.22278	0.19398	0.16028	0.13563	0.13321	0.21032	0.22188
C.V.:		31.4%	27.4%	19.0%	8.1%	4.8%	3.4%	2.6%	2.2%	2.4%	2.2%	2.7%	3.6%	5.8%	8.1%	10.1%	3.8%	3.1%

Volumetric Water Content -- 12/89 - 11/90

Plot 13

Month	Date	DEPTH (cm)																
		2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
12	1	0.2097	0.2313	0.2361	0.1402	0.1761	0.1849	0.2013	0.2291	0.2273	0.2228	0.2123		0.1868	0.1485	0.1709	0.1817	0.1854
12	4	0.2266	0.2463	0.2471	0.1737	0.1942	0.2004	0.2134	0.2426	0.2381	0.2432	0.2333		0.2123	0.1983	0.2156	0.2192	0.2152
12	8	0.2254	0.2452	0.2462	0.1589	0.1825	0.1891	0.2068	0.2359	0.2333	0.2362	0.2288	0.22	0.2125	0.1938	0.2138	0.2174	0.2171
12	15	0.0815	0.1176	0.153	0.1404	0.1682	0.1755	0.2	0.2304	0.2279	0.2288	0.2275		0.2065	0.1823	0.2072	0.2116	0.2126
12	18	0.0763	0.113	0.1496	0.1393	0.1678	0.176	0.1992	0.2299	0.2283	0.2293	0.2275		0.204	0.1848	0.2077	0.2119	0.2126
12	26	0.2421	0.26	0.2571	0.1624	0.187	0.1953	0.2126	0.2363	0.2358	0.2348	0.2301		0.2159	0.187	0.2075	0.2164	0.2162
1	3	0.207	0.2289	0.2344	0.1591	0.1833	0.1908	0.2087	0.2326	0.2311	0.2324	0.2272	0.2062	0.2163	0.181	0.2051	0.2135	0.2159
1	5	0.1883	0.2123	0.2222	0.1869	0.2022	0.2125	0.2167	0.24	0.2315	0.232	0.2261	0.2126	0.2052	0.1777	0.2035	0.2071	0.2101
1	10	0.1867	0.2109	0.2212	0.1699	0.1854	0.1916	0.2105	0.2346	0.234	0.2363	0.2298	0.2197	0.2168	0.1894	0.2126	0.2137	0.2157
1	12	0.1855	0.2098	0.2204	0.1697	0.1874	0.1908	0.2101	0.2324	0.2312	0.2369	0.2295	0.2195	0.217	0.19	0.213	0.2133	0.2163
1	16	0.2531	0.2697	0.2642	0.1707	0.1892	0.1938	0.217	0.2494	0.2455	0.2453	0.2457	0.2314	0.2241	0.2008	0.2208	0.2254	0.2272
1	19	0.2665	0.2816	0.2729	0.1671	0.1822	0.1835	0.2034	0.2326	0.2275	0.2327	0.2275	0.2208	0.2099	0.1846	0.2027	0.2104	0.2127
1	31	0.2057	0.2278	0.2335	0.1744	0.1918	0.1978	0.2157	0.2448	0.2402	0.2396	0.2365	0.2293	0.2203	0.1986	0.2182	0.2229	0.2242
2	2	0.23	0.2493	0.2493	0.1756	0.1879	0.1909	0.2119	0.2362	0.2323	0.2319	0.2319	0.224	0.2167	0.1896	0.2141	0.2128	0.2194
2	8	0.1793	0.2043	0.2164	0.1595	0.1769	0.1855	0.2068	0.2341	0.2297	0.2349	0.2326	0.2206	0.213	0.1858	0.2097	0.2137	0.217
2	9	0.2524	0.2691	0.2638	0.1968	0.2083	0.2134	0.2201	0.2367	0.2329	0.2318	0.2296	0.2191	0.2107	0.1877	0.2067	0.2097	0.2146
2	14	0.1681	0.1944	0.2091	0.1571	0.1766	0.1856	0.2053	0.2321	0.2306	0.2321	0.2321	0.2197	0.2124	0.1838	0.2099	0.2138	0.2178
2	16				0.158	0.1762	0.1873	0.2069	0.234	0.2342	0.2337	0.2265	0.2194	0.2122	0.1918	0.2097	0.2137	0.2203
2	20				0.1633	0.179	0.1863	0.2134	0.2345	0.2345	0.2357	0.2288	0.2247	0.2113	0.1898	0.2095	0.2173	0.219
2	23				0.1888	0.1995	0.2039	0.2194	0.2179	0.2393	0.2417	0.2307	0.2226	0.2155	0.189	0.2064	0.2142	0.2158
3	7				0.1449	0.1735	0.1808	0.2056	0.2348	0.2353	0.2301	0.2307	0.2208	0.2113	0.1885	0.2088	0.2102	0.2156
3	9				0.1413	0.1676	0.1753	0.1982	0.2251	0.226	0.226	0.2233	0.2143	0.2084	0.1783	0.2004	0.2093	0.2093
3	14	0.2353	0.254	0.2527	0.1615	0.1828	0.1872	0.2104	0.2387	0.2343	0.2325	0.2343	0.2229	0.215	0.1924	0.214	0.2163	0.2253
3	16	0.1936	0.217	0.2257	0.1672	0.1874	0.1894	0.2081	0.2269	0.2227	0.2268	0.2232	0.2144	0.2067	0.1813	0.2032	0.2046	0.208
3	19			0.008	0.1669	0.1871	0.1903	0.2089	0.2276	0.2229	0.2275	0.2228	0.2143	0.2022	0.1818	0.2001	0.2036	0.209
3	28	0.1391	0.1687	0.1903	0.1433	0.1677	0.1773	0.1969	0.227	0.2248	0.2275	0.2249	0.2116	0.2071	0.1802	0.2016	0.2058	0.2108
3	29	0.2189	0.2395	0.2421	0.1997	0.205	0.2189	0.2399	0.2412	0.241	0.2347	0.2253	0.1955	0.162	0.1325	0.131	0.2096	0.2517
4	2		0.0031	0.0693	0.1689	0.1849	0.193	0.2072	0.2363	0.2282	0.2319	0.2251	0.216	0.2082	0.1841	0.2048	0.2103	0.2105
4	4	0.169	0.1952	0.2097	0.1628	0.18	0.1871	0.2054	0.2348	0.2276	0.23	0.226	0.2199	0.2104	0.1866	0.2042	0.2122	0.2123
4	10	0.165	0.1917	0.2071	0.1468	0.1703	0.175	0.2	0.2301	0.2258	0.2312	0.2237	0.2164	0.2087	0.1811	0.2014	0.2079	0.2117
4	18	0.1747	0.2003	0.2134	0.1636	0.1809	0.1872	0.2097	0.2324	0.2301	0.2322	0.226	0.2196	0.2124	0.1839	0.2043	0.2083	0.2106
4	20	0.1723	0.1981	0.2118	0.1632	0.1797	0.1864	0.2063	0.2309	0.2275	0.2303	0.2239	0.2191	0.2108	0.1826	0.2032	0.2074	0.2111
4	27	0.2508	0.2677	0.2627	0.1871	0.1998	0.2049	0.2131	0.2375	0.2285	0.2283	0.2243	0.2161	0.2115	0.1834	0.2015	0.209	0.2105
5	3	0.1651	0.1918	0.2072	0.1623	0.178	0.1871	0.2085	0.2373	0.2349	0.2305	0.2257	0.2202	0.2157	0.1885	0.2057	0.211	0.2145
5	9	0.1436	0.1727	0.1933	0.1557	0.1767	0.184	0.2083	0.234	0.2289	0.2296	0.2286	0.2162	0.2103	0.186	0.2092	0.2112	0.2133
5	11	0.3002	0.3114	0.2947	0.1824	0.1956	0.1986	0.2071	0.2308	0.2296	0.2299	0.2246	0.2184	0.2092	0.1818	0.2025	0.2091	0.2106

Volumetric Water Content -- 12/89 - 11/90

Plot 13 (cont.)

DEPTH (cm)

Month	Date	2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
5	16	0.1507	0.179	0.1979	0.1597	0.1804	0.1864	0.2087	0.2345	0.2294	0.2333	0.2273	0.2198	0.2101	0.1832	0.2046	0.2109	0.2123
5	18	0.1555	0.1833	0.201	0.1553	0.1782	0.1819	0.2063	0.2318	0.2303	0.2311	0.2269	0.2184	0.2088	0.1826	0.2024	0.2096	0.212
5	25	0.2885	0.3011	0.2872	0.1931	0.2076	0.2156	0.2193	0.2446	0.2358	0.2267	0.2267	0.2163	0.2061	0.1813	0.2029	0.2096	0.2149
5	31	0.1928	0.2163	0.2251	0.1614	0.1827	0.1872	0.2092	0.2322	0.2327	0.2323	0.2291	0.2192	0.2133	0.1863	0.2063	0.2128	0.2131
6	4	0.1616	0.1887	0.205	0.173	0.1893	0.1939	0.2054	0.2309	0.2307	0.2308	0.2295	0.2181	0.2141	0.1892	0.1907	0.2172	0.222
6	6	0.1235	0.1549	0.1802	0.1453	0.1722	0.1786	0.2013	0.2313	0.2309	0.232	0.2267	0.2219	0.2124	0.1846	0.2057	0.2104	0.2157
6	8	0.3079	0.3183	0.2997	0.1922	0.2086	0.2183	0.2184	0.2434	0.2362	0.2293	0.2267	0.2185	0.2062	0.1791	0.2026	0.209	0.2151
6	13	0.1643	0.1911	0.2067	0.1655	0.1809	0.1858	0.2088	0.2353	0.2298	0.229	0.2258	0.2194	0.2109	0.1843	0.2027	0.2067	0.2131
6	15	0.1515	0.1797	0.1984	0.1687	0.1785	0.1867	0.2157	0.2369	0.2269	0.2308	0.227	0.2197	0.2123	0.1827	0.2028	0.2088	0.212
6	21	0.1243	0.1556	0.1807	0.143	0.1686	0.1754	0.2009	0.231	0.224	0.2293	0.2261	0.2193	0.2076	0.1813	0.2014	0.2082	0.208
6	29	0.1417	0.1711	0.1921	0.1636	0.1849	0.1875	0.2106	0.2411	0.2367	0.238	0.232	0.226	0.2166	0.189	0.2092	0.2153	0.2168
7	3	0.1249	0.1561	0.1811	0.1546	0.173	0.1787	0.2015	0.2302	0.2298	0.2347	0.2272	0.2197	0.2126	0.1836	0.2043	0.2097	0.211
7	11	0.1846	0.2091	0.2198	0.1675	0.1819	0.1878	0.208	0.2352	0.2315	0.2325	0.2295	0.2196	0.2134	0.1839	0.2062	0.2102	0.2157
7	13	0.1761	0.2015	0.2143	0.167	0.1804	0.1865	0.2059	0.2358	0.2357	0.2362	0.2262	0.2214	0.2147	0.1835	0.209	0.2093	0.2114
7	25	0.193	0.2165	0.2253	0.1643	0.1793	0.1915	0.2234	0.2274	0.2319	0.2234	0.2158	0.2036	0.1915	0.1794	0.1888	0.2087	0.2076
7	27	0.1046	0.1382	0.168	0.1484	0.1723	0.1791	0.2043	0.2326	0.2288	0.2304	0.2266	0.2197	0.213	0.1812	0.2041	0.2086	0.2117
8	1	0.1086	0.1417	0.1706	0.1459	0.1758	0.1814	0.2104	0.2447	0.2376	0.2455	0.2392	0.2279	0.2218	0.1905	0.2098	0.2214	0.223
8	3	0.1691	0.1953	0.2098	0.1407	0.1673	0.1708	0.201	0.2323	0.2309	0.2335	0.2294	0.2198	0.2082	0.183	0.2011	0.2133	0.2172
8	8	0.1698	0.1959	0.2102	0.1408	0.1675	0.171	0.2012	0.2325	0.2311	0.2337	0.2296	0.22	0.2084	0.1832	0.2012	0.2135	0.2173
8	17	0.1544	0.1823	0.2003	0.1708	0.1874	0.1884	0.2081	0.2368	0.2302	0.2325	0.2292	0.2198	0.215	0.1827	0.2037	0.2107	0.2119
8	22	0.22	0.2404	0.2428	0.1575	0.1781	0.1815	0.2034	0.236	0.2295	0.2322	0.2244	0.2202	0.2106	0.1819	0.2015	0.2079	0.2099
8	29				0.1551	0.1772	0.1797	0.203	0.2347	0.2139	0.2291	0.22	0.2177	0.2093	0.1804	0.2004	0.2049	0.2083
9	5	0.2419	0.2598	0.257	0.1587	0.1786	0.1796	0.2033	0.2342	0.2126	0.2316	0.2185	0.2155	0.2063	0.1814	0.2015	0.2038	0.2048
9	21	0.1537	0.1817	0.1998	0.1776	0.1884	0.1967	0.2168	0.2475	0.2454	0.2412	0.2391	0.2277	0.2202	0.1894	0.2115	0.22	0.2204
10	3	0.1768	0.2022	0.2148	0.1776	0.1918	0.1975	0.213	0.2435	0.2391	0.2419	0.2372	0.2292	0.2209	0.1881	0.2084	0.2121	0.2209
10	10	0.1131	0.1457	0.1735	0.162	0.1834	0.1841	0.21	0.2417	0.2382	0.2393	0.2327	0.2253	0.2188	0.1902	0.2119	0.2154	0.2171
10	12	0.3173	0.3266	0.3058	0.1925	0.215	0.2114	0.24	0.2451	0.24	0.2364	0.2358	0.2234	0.2238	0.1941	0.2114	0.215	0.2233
10	17	0.1492	0.1777	0.1969	0.1727	0.1917	0.1978	0.2192	0.2441	0.2423	0.2441	0.2379	0.2272	0.2246	0.1904	0.212	0.2163	
10	24	0.1136	0.1461	0.1738	0.1729	0.1895	0.1992	0.2205	0.2425	0.239	0.2433	0.2369	0.2256	0.2239	0.1868	0.2106	0.2168	
11	2				0.1712	0.1879	0.1944	0.2147	0.2438	0.2448	0.2456	0.2364	0.2339	0.23	0.2029	0.2256	0.2292	0.2314
11	7	0.1292	0.16	0.184	0.1685	0.184	0.1932	0.2117	0.2474	0.2444	0.2453	0.2403	0.235	0.2265	0.1939	0.2148	0.2224	0.2243
Avg.:		0.18403	0.20506	0.21344	0.16443	0.1836	0.18963	0.2098	0.23556	0.23214	0.23352	0.22869	0.2199	0.21166	0.1848	0.20492	0.21184	0.21511
C.V.:		29.7%	26.8%	22.5%	9.0%	5.9%	5.8%	3.8%	2.6%	2.7%	2.3%	2.5%	2.9%	4.4%	5.2%	5.8%	3.0%	3.6%

Volumetric Water Content -- 12/89 - 11/90

Plot 14

		DEPTH (cm)																
Month	Date	2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
12	1	0.2024	0.2248	0.2313	0.1349	0.1664	0.1746	0.1903	0.1942	0.1945	0.2067	0.2069		0.182	0.1793	0.173	0.1928	0.1939
12	4	0.1838	0.2083	0.2193	0.1656	0.1821	0.1879	0.1999	0.205	0.2115	0.2215	0.2216		0.2147	0.2091	0.2144	0.2349	0.2329
12	8	0.2032	0.2255	0.2319	0.1461	0.1691	0.1751	0.1936	0.1992	0.2017	0.2129	0.2151	0.2133	0.2085	0.2037	0.2161	0.2284	0.2325
12	15	0.081	0.1173	0.1527	0.1322	0.1587	0.1658	0.1859	0.1953	0.196	0.2091	0.2112		0.2003	0.2016	0.2063	0.2229	0.2231
12	18	0.0822	0.1183	0.1535	0.1336	0.1593	0.1656	0.187	0.1946	0.188	0.2098	0.2114		0.2018	0.203	0.2053	0.2233	0.2234
12	26	0.2478	0.265	0.2607	0.1573	0.1755	0.1819	0.1975	0.2058	0.2067	0.2157	0.2188		0.207	0.2028	0.21	0.2251	0.226
1	3	0.2076	0.2294	0.2348	0.1555	0.1676	0.1798	0.192	0.2056	0.2034	0.2126	0.2158	0.2135	0.2053	0.2	0.2039	0.2226	0.2171
1	5	0.165	0.1916	0.2071	0.1806	0.1946	0.2009	0.2035	0.207	0.2024	0.2127	0.2076	0.2054	0.1985	0.1984	0.2037	0.2204	0.2188
1	10	0.1711	0.197	0.2111	0.1583	0.1748	0.1815	0.1969	0.204	0.2066	0.2127	0.2162	0.2113	0.2107	0.2054	0.2092	0.2291	0.2297
1	12	0.1723	0.1982	0.2119	0.157	0.1731	0.1826	0.1961	0.2041	0.2073	0.213	0.2162	0.2066	0.2102	0.2041	0.2077	0.2319	0.2315
1	16	0.2454	0.2629	0.2592	0.1582	0.1778	0.1834	0.2021	0.2108	0.2135	0.2261	0.2281	0.224	0.2172	0.2154	0.2204	0.2389	0.2404
1	19	0.2896	0.3021	0.2878	0.176	0.18	0.1792	0.1928	0.1958	0.1979	0.2095	0.2098	0.2112	0.2045	0.1982	0.2076	0.2214	0.2247
1	31	0.1954	0.2186	0.2268	0.162	0.1809	0.1846	0.2041	0.21	0.2105	0.2206	0.2182	0.22	0.2134	0.2151	0.2194	0.2379	0.2369
2	2	0.2277	0.2473	0.2478	0.1827	0.1828	0.1779	0.1979	0.1989	0.206	0.2164	0.2163	0.2133	0.2084	0.205	0.2157	0.2279	0.2292
2	8	0.188	0.212	0.222	0.1545	0.1698	0.1763	0.194	0.2057	0.2053	0.2128	0.2157	0.2134	0.2069	0.2047	0.2109	0.2261	0.2254
2	9	0.2752	0.2893	0.2785	0.19	0.1987	0.2032	0.2036	0.2089	0.2065	0.2139	0.2131	0.2106	0.2046	0.2052	0.2098	0.2248	0.2283
2	14	0.162	0.189	0.2052	0.1564	0.1693	0.1761	0.1917	0.2039	0.2049	0.2138	0.217	0.2138	0.2089	0.2053	0.2092	0.2259	0.2243
2	16				0.1483	0.1682	0.177	0.1928	0.2015	0.2024	0.2107	0.213	0.2104	0.2078	0.2075	0.2107	0.2242	0.2274
2	20				0.1522	0.1692	0.1774	0.1923	0.2007	0.2003	0.2131	0.2115	0.2127	0.2057	0.2039	0.2109	0.2246	0.2263
2	23				0.1782	0.1869	0.1932	0.2058	0.2103	0.2107	0.2215	0.2182	0.2147	0.2093	0.2058	0.2116	0.2272	0.2253
3	7				0.1416	0.1646	0.1681	0.188	0.201	0.2007	0.2121	0.2122	0.2146	0.2033	0.2028	0.2123	0.2265	0.224
3	9				0.1349	0.1621	0.1638	0.1874	0.1927	0.1952	0.2062	0.2123	0.2091	0.2004	0.1977	0.2027	0.2221	0.2193
3	14	0.2267	0.2464	0.2471	0.1506	0.1708	0.1767	0.1966	0.206	0.2042	0.2143	0.2202	0.2179	0.2082	0.2051	0.2143	0.2271	0.2296
3	16	0.2166	0.2374	0.2406	0.1597	0.1754	0.1734	0.1876	0.1919	0.1938	0.2038	0.2097	0.2059	0.1985	0.1945	0.2024	0.2144	0.2161
3	19	0.211	0.2325	0.237	0.1601	0.1762	0.1745	0.1914	0.1921	0.1947	0.2053	0.2109	0.2026	0.203	0.195	0.2036	0.2149	0.2174
3	28	0.1123	0.145	0.173	0.1363	0.1631	0.1628	0.1845	0.1941	0.1959	0.2043	0.2094	0.2065	0.2017	0.1961	0.2026	0.2153	0.217
3	29			0.0015	0.1885	0.2064	0.2096	0.2228	0.2418	0.2353	0.2369	0.2261	0.2185	0.2093	0.1828	0.2063	0.2115	0.2549
4	2		0.0101	0.0743	0.1569	0.1748	0.1766	0.1944	0.1982	0.203	0.2106	0.2121	0.2106	0.2039	0.1981	0.2041	0.2203	0.2156
4	4	0.15	0.1783	0.1974	0.1503	0.1663	0.1753	0.1914	0.198	0.1994	0.2078	0.2134	0.2083	0.2022	0.2014	0.2048	0.2224	0.219
4	10	0.1492	0.1777	0.1969	0.1397	0.1614	0.1669	0.1877	0.1945	0.1955	0.204	0.2077	0.2058	0.2008	0.1983	0.2018	0.2203	0.2159
4	18	0.1537	0.1817	0.1998	0.1578	0.1799	0.1852	0.2058	0.2058	0.1968	0.2179	0.2165	0.2093	0.208	0.1935	0.2039	0.2092	0.2171
4	20	0.1512	0.1794	0.1982	0.1552	0.1785	0.1808	0.2038	0.2034	0.1966	0.2158	0.2146	0.2086	0.2066	0.1917	0.2023	0.2066	0.2154
4	27	0.2029	0.2252	0.2317	0.1805	0.1889	0.195	0.1993	0.2032	0.2013	0.2078	0.2092	0.2087	0.1997	0.1973	0.2054	0.217	0.2178
5	3	0.1429	0.1721	0.1928	0.1533	0.1681	0.1749	0.1951	0.2019	0.2025	0.2134	0.2172	0.2128	0.2059	0.2014	0.2089	0.2232	0.2245
5	9	0.1292	0.16	0.1839	0.1452	0.1693	0.173	0.1912	0.1997	0.2012	0.2077	0.213	0.2113	0.2052	0.2	0.2072	0.2246	0.2199
5	11	0.293	0.3051	0.2901	0.177	0.1892	0.1937	0.1978	0.1991	0.1971	0.2085	0.2129	0.2087	0.2019	0.1954	0.2047	0.2184	0.2222

Volumetric Water Content -- 12/89 - 11/90

Plot 14 (cont.)

DEPTH (cm)

Month	Date	2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
5	16	0.1374	0.1673	0.1893	0.1464	0.17	0.1754	0.1927	0.202	0.2023	0.2132	0.2159	0.2145	0.2061	0.1999	0.2075	0.2252	0.2232
5	18	0.1443	0.1733	0.1937	0.1439	0.1684	0.1733	0.1901	0.2008	0.1994	0.212	0.2132	0.213	0.2044	0.1993	0.2064	0.2241	0.2234
5	25	0.2786	0.2923	0.2807	0.1871	0.1947	0.203	0.2083	0.2061	0.2088	0.2157	0.2181	0.2047	0.203	0.1988	0.2023	0.2233	0.2214
5	31	0.2031	0.2255	0.2318	0.1508	0.1696	0.1748	0.1937	0.2026	0.1993	0.2111	0.2121	0.2095	0.2021	0.2013	0.2049	0.2225	0.2206
6	4	0.145	0.1739	0.1942	0.1536	0.173	0.1775	0.1933	0.2018	0.2026	0.2115	0.2127	0.2088	0.203	0.2003	0.2027	0.2264	0.2187
6	6	0.1256	0.1568	0.1816	0.1364	0.1677	0.1679	0.1902	0.1963	0.2002	0.2091	0.2137	0.2128	0.2016	0.1975	0.2037	0.2229	0.2219
6	8	0.2916	0.3038	0.2891	0.1943	0.1987	0.2052	0.2103	0.2109	0.2116	0.2171	0.2155	0.2034	0.2033	0.1997	0.2027	0.2273	0.2185
6	13	0.1447	0.1737	0.194	0.1518	0.1719	0.1753	0.1919	0.1997	0.1967	0.2091	0.2117	0.2083	0.2042	0.1981	0.201	0.2223	0.2223
6	15	0.1315	0.162	0.1854	0.1506	0.1719	0.1744	0.1907	0.1996	0.1974	0.2088	0.2144	0.2088	0.204	0.1985	0.2035	0.2225	0.2269
6	21	0.1218	0.1534	0.1792	0.1335	0.1631	0.1653	0.1853	0.1959	0.1935	0.2052	0.2111	0.2066	0.202	0.1958	0.2028	0.217	0.2192
6	29	0.1091	0.1421	0.1709	0.1533	0.1721	0.1781	0.1969	0.2071	0.2089	0.2179	0.2194	0.2144	0.2114	0.2071	0.2106	0.2315	0.2278
7	3	0.0991	0.1333	0.1644	0.1414	0.165	0.1673	0.189	0.1957	0.2015	0.211	0.213	0.2098	0.2044	0.1999	0.2066	0.2212	0.2202
7	11	0.156	0.1837	0.2013	0.1581	0.173	0.1745	0.1934	0.2003	0.2001	0.2084	0.2144	0.2143	0.2099	0.2008	0.2068	0.2233	0.2212
7	13	0.1901	0.2139	0.2234	0.1563	0.172	0.1707	0.1929	0.1973	0.2028	0.2098	0.216	0.2131	0.2059	0.202	0.2097	0.223	0.2247
7	25	0.2025	0.2249	0.2314	0.1632	0.1808	0.1951	0.2198	0.2279	0.2314	0.2198	0.219	0.2076	0.1995	0.183	0.1955	0.2076	0.2076
7	27	0.0915	0.1266	0.1595	0.1439	0.1664	0.1676	0.1887	0.1996	0.1994	0.2091	0.211	0.2096	0.203	0.2027	0.2049	0.2233	0.2184
8	1	0.1065	0.1399	0.1693	0.1416	0.171	0.1704	0.1953	0.2067	0.2051	0.2183	0.2212	0.2191	0.2113	0.208	0.2159	0.2299	0.2306
8	3	0.1481	0.1767	0.1962	0.1464	0.1631	0.1631	0.1883	0.1958	0.1945	0.2094	0.2115	0.2094	0.2026	0.1959	0.2068	0.2195	0.2172
8	8	0.1455	0.1744	0.1945	0.1465	0.1633	0.1633	0.1884	0.196	0.1946	0.2096	0.2117	0.2096	0.2027	0.1961	0.2069	0.2197	0.2174
8	17	0.1549	0.1827	0.2006	0.1644	0.174	0.1741	0.1883	0.1978	0.1949	0.2052	0.2107	0.2114	0.1999	0.1965	0.2055	0.2203	0.2205
8	22	0.2306	0.2498	0.2496	0.1513	0.1695	0.1688	0.1871	0.1981	0.1958	0.2035	0.2128	0.2073	0.2007	0.1962	0.2037	0.2184	0.2156
8	29				0.1477	0.1672	0.1669	0.1833	0.1958	0.1934	0.2003	0.2073	0.2043	0.1994	0.1938	0.2028	0.2132	0.2142
9	5	0.234	0.2528	0.2518	0.1496	0.1678	0.166	0.1795	0.1951	0.1914	0.1989	0.2023	0.207	0.1956	0.1949	0.2025	0.2191	0.2126
9	21	0.1341	0.1643	0.1871	0.1697	0.1823	0.1846	0.1977	0.2076	0.2096	0.2209	0.2231	0.2172	0.21	0.2087	0.209	0.2298	0.2275
10	3	0.1947	0.218	0.2264	0.1672	0.1868	0.1895	0.2018	0.2083	0.2096	0.2214	0.2267	0.218	0.2099	0.205	0.2092	0.2266	0.2276
10	10	0.1097	0.1427	0.1713	0.1536	0.1757	0.174	0.1981	0.2057	0.2062	0.2149	0.2203	0.2163	0.2102	0.2042	0.2123	0.2291	0.2289
10	12	0.3072	0.3177	0.2993	0.1818	0.2013	0.2068	0.2385	0.2275	0.2071	0.2117	0.2238	0.215	0.2114	0.2141	0.2114	0.2239	0.23
10	17	0.1468	0.1755	0.1953	0.1571	0.1794	0.1823	0.2011	0.2096	0.2107	0.2172	0.2208	0.2204	0.209	0.2047	0.2099	0.2294	
10	24	0.1001	0.1341	0.1651	0.1518	0.1771	0.1771	0.199	0.2075	0.2094	0.2154	0.2213	0.2201	0.2074	0.2005	0.2102	0.2307	0.1891
11	2				0.1597	0.1751	0.1788	0.1978	0.2063	0.2053	0.2173	0.2179	0.2192	0.2109	0.2074	0.211	0.2302	0.2331
11	7	0.1318	0.1622	0.1856	0.1631	0.1779	0.1811	0.1985	0.211	0.2087	0.2214	0.2259	0.2237	0.2159	0.2143	0.2152	0.2203	0.2361
Avg.:		0.17507	0.19737	0.2078	0.15647	0.17477	0.1786	0.19574	0.20294	0.20271	0.21247	0.21504	0.21178	0.20521	0.20074	0.20697	0.2228	0.22272
C.V.:		32.7%	28.4%	23.5%	9.5%	5.9%	6.3%	4.8%	4.1%	3.9%	3.0%	2.4%	2.3%	2.6%	3.3%	3.1%	3.3%	4.1%

Volumetric Water Content -- 12/89 - 11/90

Plot 15

DEPTH (cm)

Month	Date	2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
12	1	0.2165	0.2373	0.2405	0.0994	0.1694	0.1711	0.1604	0.1615	0.1735	0.1807	0.1914		0.1657	0.1923	0.2022	0.1846	0.2044
12	4	0.1824	0.2071	0.2184	0.1324	0.18	0.1804	0.1721	0.169	0.1878	0.205	0.221		0.2118	0.231	0.2412	0.2198	0.2147
12	8	0.1813	0.2061	0.2177	0.2361	0.1594	0.1683	0.1711	0.1594	0.1612	0.1784	0.1998	0.2132	0.2054	0.2291	0.2346	0.2236	0.2361
12	15			0.0385	0.0855	0.1591	0.1585	0.1488	0.1532	0.1709	0.1897	0.2039		0.1973	0.2252	0.2283	0.2179	0.2318
12	18			0.0387	0.1249	0.1603	0.1555	0.1495	0.1536	0.1713	0.1893	0.2036		0.1976	0.2287	0.2317	0.2172	0.2319
12	26	0.2378	0.2562	0.2543	0.1187	0.1767	0.177	0.1672	0.1668	0.1784	0.1969	0.2126		0.2054	0.2261	0.234	0.22	0.2349
1	3	0.1993	0.2221	0.2294	0.135	0.1756	0.1755	0.1651	0.1666	0.1762	0.1918	0.2076	0.217	0.2053	0.2209	0.2336	0.2183	0.2305
1	5	0.1766	0.202	0.2146	0.1513	0.1946	0.1928	0.1824	0.1791	0.1886	0.1961	0.2044	0.212	0.1975	0.2186	0.2255	0.2177	0.2285
1	10	0.1733	0.199	0.2125	0.129	0.1738	0.1773	0.1637	0.1659	0.1833	0.1984	0.2152	0.2216	0.2084	0.2307	0.2366	0.2258	0.2409
1	12	0.1734	0.1991	0.2126	0.1466	0.1706	0.1821	0.1641	0.1665	0.183	0.1959	0.2158	0.2198	0.2077	0.2276	0.2372	0.2283	0.2423
1	16	0.2414	0.2594	0.2567	0.1272	0.1827	0.1775	0.163	0.1702	0.187	0.2072	0.2229	0.2272	0.2147	0.2398	0.249	0.2359	0.2515
1	19				0.1529	0.1754	0.1673	0.1508	0.1565	0.1721	0.1916	0.2059	0.2115	0.1998	0.2235	0.228	0.218	0.233
1	31	0.2032	0.2255	0.2319	0.1324	0.1764	0.1785	0.169	0.1686	0.1878	0.2046	0.2183	0.2211	0.2164	0.2338	0.2412	0.2248	0.2414
2	2	0.2105	0.2319	0.2366	0.1535	0.1815	0.1705	0.162	0.164	0.1825	0.1986	0.2134	0.2173	0.2063	0.2283	0.2324	0.2252	0.2346
2	8	0.1695	0.1956	0.21	0.1256	0.1734	0.168	0.1588	0.1612	0.1739	0.1909	0.2085	0.2164	0.2016	0.2256	0.2336	0.2202	0.2322
2	9	0.26	0.2758	0.2687	0.1661	0.1989	0.1997	0.1821	0.1834	0.191	0.1944	0.209	0.2129	0.1954	0.2242	0.2299	0.2208	0.2331
2	14	0.1422	0.1714	0.1923	0.1421	0.1693	0.1693	0.1567	0.1572	0.1685	0.1905	0.2089	0.2196	0.2052	0.2259	0.2335	0.2197	0.2318
2	16	0.1486	0.1771	0.1965	0.1242	0.1712	0.1713	0.1598	0.161	0.1775	0.1938	0.2131	0.2142	0.2029	0.2278	0.232	0.2174	0.235
2	20	0.1581	0.1855	0.2026	0.1257	0.1727	0.1683	0.1581	0.1611	0.1772	0.1973	0.2103	0.217	0.2065	0.2298	0.237	0.223	0.2361
2	23	0.2249	0.2448	0.246	0.1893	0.1871	0.1747	0.1763	0.1799	0.19	0.2016	0.2165	0.2182	0.2036	0.2305	0.2349	0.2232	0.2383
3	7	0.1548	0.1827	0.2005	0.1604	0.17	0.1632	0.1547	0.1559	0.1758	0.1939	0.2072	0.2136	0.1998	0.2258	0.2327	0.2337	0.2441
3	9	0.1166	0.1488	0.1758	0.1094	0.1601	0.1612	0.1487	0.1533	0.1703	0.1853	0.2056	0.2069	0.1963	0.2223	0.2252	0.2147	0.2293
3	14	0.2253	0.2451	0.2462	0.1558	0.1713		0.1618	0.1646	0.1808	0.1998	0.2162	0.2172	0.2131	0.2318	0.2325	0.2262	0.2401
3	16	0.1717	0.1976	0.2115	0.1359	0.1774	0.1632	0.1496	0.1499	0.1665	0.1861	0.2015	0.2062	0.1931	0.2207	0.2231	0.2071	0.2229
3	19	0.168	0.1943	0.209	0.137	0.1777	0.1634	0.1498	0.1503	0.1672	0.1874	0.2014	0.2066	0.1943	0.2217	0.2238	0.207	0.2234
3	28	0.104	0.1377	0.1676	0.109	0.1636	0.1572	0.1472	0.1508	0.1711	0.183	0.1999	0.2077	0.1887	0.2176	0.227	0.2081	0.2242
3	29	0.2006	0.2232	0.2302	0.1816	0.1931	0.1955	0.207	0.2064	0.205	0.2143	0.2148	0.2106	0.2005	0.2007	0.206	0.2246	0.2228
4	2			0.0642	0.1335	0.1765	0.1739	0.1601	0.1605	0.1738	0.1879	0.2041	0.2106	0.1972	0.2174	0.2234	0.2099	0.2225
4	4	0.133	0.1634	0.1864	0.1263	0.1719	0.1683	0.1573	0.1591	0.1741	0.1895	0.2046	0.212	0.1945	0.2209	0.2241	0.2125	0.225
4	10	0.1334	0.1637	0.1867	0.1128	0.1609	0.1638	0.1489	0.1543	0.1694	0.1864	0.2014	0.2079	0.1939	0.2182	0.2224	0.213	0.2265
4	18	0.1382	0.1679	0.1898	0.1304	0.1712	0.1712	0.1584	0.1601	0.1753	0.1963	0.2078	0.2132	0.1964	0.2233	0.2305	0.2148	0.2263
4	20	0.1354	0.1655	0.188	0.1299	0.1688	0.1698	0.1565	0.1584	0.1745	0.1935	0.206	0.2116	0.1942	0.2225	0.2292	0.213	0.2237
4	27	0.2323	0.2513	0.2508	0.1591	0.1904	0.187	0.1658	0.1631	0.175	0.1864	0.203	0.21	0.1965	0.2213	0.2286	0.218	0.2281
5	3	0.1352	0.1653	0.1878	0.1242	0.1689	0.168	0.157	0.1587	0.1752	0.1922	0.2082	0.2121	0.1976	0.2251	0.23	0.2277	0.2288
5	9	0.1195	0.1513	0.1776	0.1209	0.17	0.164	0.1544	0.1587	0.1728	0.1928	0.204	0.2096	0.1973	0.2239	0.2251	0.2153	0.2306
5	11	0.2863	0.2991	0.2857	0.1527	0.1913	0.1875	0.1674	0.1593	0.172	0.1833	0.2037	0.2089	0.1961	0.2206	0.2269	0.2114	0.2263

Volumetric Water Content -- 12/89 - 11/90

Plot 15 (cont.)

Month	Date	DEPTH (cm)																
		2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
5	16	0.1209	0.1526	0.1786	0.1196	0.1739	0.172	0.1584	0.1592	0.1745	0.1909	0.2078	0.2166	0.1996	0.2254	0.2298	0.2157	0.2284
5	18	0.1311	0.1616	0.1852	0.1273	0.1661	0.1693	0.1559	0.16	0.1721	0.1891	0.2057	0.2156	0.1992	0.2236	0.2282	0.2132	0.2274
5	25	0.2739	0.2882	0.2777	0.16	0.1956	0.1924	0.1831	0.1714	0.1818	0.1906	0.2028	0.2088	0.1952	0.2231	0.227	0.2116	0.2301
5	31	0.1611	0.1882	0.2046	0.1238	0.1701	0.1676	0.1574	0.158	0.1756	0.1886	0.2074	0.215	0.2006	0.2275	0.2294	0.2181	0.2293
6	4	0.1276	0.1585	0.1829	0.1363	0.1722	0.1694	0.1601	0.1623	0.1782	0.1904	0.2097	0.2156	0.2026	0.229	0.2329	0.2206	0.2309
6	6	0.1068	0.1401	0.1694	0.1056	0.1662	0.1666	0.1534	0.1533	0.1709	0.1894	0.2061	0.2142	0.2007	0.2174	0.2302	0.2185	0.2283
6	8	0.2929	0.305	0.29	0.1631	0.1978	0.1909	0.1862	0.1725	0.179	0.1913	0.2031	0.2104	0.1945	0.2267	0.2304	0.2115	0.2305
6	13	0.1592	0.1866	0.2034	0.1321	0.1726	0.168	0.1592	0.161	0.173	0.1903	0.2079	0.2129	0.2033	0.2245	0.2305	0.2191	0.2274
6	15	0.1542	0.1821	0.2001	0.1418	0.1748	0.1688	0.1601	0.1627	0.1738	0.1894	0.2054	0.2179	0.2013	0.2257	0.2302	0.218	0.227
6	21	0.111	0.1438	0.1721	0.113	0.1638	0.1619	0.147	0.1534	0.1674	0.1883	0.203	0.2105	0.1977	0.2183	0.2284	0.2125	0.2272
6	29	0.0903	0.1255	0.1587	0.1275	0.1759	0.1699	0.1586	0.1635	0.1763	0.1938	0.2087	0.2152	0.2041	0.2281	0.2352	0.2225	0.2313
7	3	0.0817	0.1178	0.1531	0.1208	0.1688	0.1642	0.1504	0.1545	0.1716	0.1882	0.2046	0.2119	0.1979	0.2212	0.2294	0.2147	0.2259
7	11	0.1584	0.1858	0.2029	0.1376	0.1752	0.1678	0.161	0.1617	0.1758	0.1912	0.2072	0.2131	0.201	0.226	0.2307	0.2195	0.2298
7	13	0.152	0.1802	0.1987	0.1394	0.1745	0.1677	0.1551	0.1613	0.1722	0.1899	0.2102	0.2148	0.2002	0.227	0.2338	0.2164	0.2291
7	25	0.1721	0.198	0.2117	0.1339	0.162	0.1528	0.1438	0.1465	0.144	0.1575	0.1919	0.2224	0.2134	0.1696	0.1915	0.2212	0.2239
7	27	0.1028	0.1366	0.1668	0.1126	0.1665	0.1625	0.1482	0.1527	0.1708	0.1862	0.2034	0.214	0.1978	0.2225	0.2262	0.2132	0.2295
8	1	0.0781	0.1147	0.1508	0.1146	0.1653	0.1637	0.1508	0.1583	0.1749	0.1933	0.2132	0.2222	0.2029	0.2313	0.2403	0.2214	0.2379
8	3	0.1184	0.1504	0.1769	0.131	0.1554	0.1562	0.1517	0.1525	0.1767	0.1889	0.2039	0.2131	0.192	0.2202	0.2298	0.212	0.2297
8	8	0.1305	0.1611	0.1848	0.1409	0.1548	0.1553	0.1529	0.1539	0.1794	0.1909	0.2043	0.2129	0.1916	0.2208	0.2293	0.2096	0.2172
8	17	0.1584	0.1858	0.2029	0.1483	0.177	0.1703	0.1543	0.1479	0.1705	0.1827	0.201	0.2128	0.1951	0.2217	0.2281	0.2126	0.2251
8	22	0.2328	0.2517	0.251	0.1322	0.172	0.1628	0.1508	0.152	0.1688	0.1808	0.197	0.2052	0.1995	0.2186	0.226	0.2166	0.2283
8	29	0.1404	0.1698	0.1912	0.1294	0.1688	0.1593	0.1496	0.1542	0.164	0.1767	0.1945	0.2007	0.197	0.2177	0.2242	0.2145	0.2257
9	5	0.2218	0.242	0.2439	0.1389	0.1658	0.1565	0.1487	0.1536	0.1678	0.1827	0.1948	0.1994	0.195	0.2176	0.2236	0.2153	0.2243
9	21	0.1068	0.1401	0.1694	0.1396	0.1801	0.1695	0.1517	0.1535	0.1724	0.1877	0.2056	0.2188	0.1983	0.229	0.2352	0.2178	0.2365
10	3	0.1798	0.2048	0.2167	0.1509	0.1871	0.1835	0.1715	0.168	0.1806	0.194	0.2112	0.2172	0.2025	0.2246	0.2357	0.2221	0.2318
10	10	0.0975	0.1319	0.1634	0.1301	0.1779	0.1716	0.157	0.1625	0.1758	0.1921	0.2126	0.2198	0.2022	0.2258	0.2373	0.221	0.2317
10	12	0.2938	0.3058	0.2906	0.1808	0.2095	0.1991	0.1847	0.1799	0.1874	0.1933	0.2114	0.2155	0.2057	0.2289	0.2414	0.2222	0.2329
10	17	0.1553	0.1831	0.2009	0.1402	0.1831	0.179	0.1651	0.1699	0.1833	0.1949	0.2163	0.222	0.2129	0.2321	0.2361	0.2238	0.2325
10	24	0.0911	0.1262	0.1592	0.1391	0.1822	0.1769	0.1624	0.1702	0.1824	0.191	0.2141	0.2205	0.2115	0.2306	0.2345	0.2221	0.2307
11	2				0.1449	0.1789	0.1727	0.1586	0.1638	0.1777	0.192	0.2099	0.2176	0.2068	0.2288	0.234	0.221	0.2315
11	7	0.1198	0.1517	0.1779	0.1408	0.1809	0.178	0.1609	0.1622	0.1793	0.1959	0.2131	0.2201	0.2081	0.2306	0.246	0.2289	0.2365
Avg.:		0.16571	0.1923	0.20018	0.13691	0.17472	0.17132	0.16021	0.16156	0.1758	0.19094	0.20715	0.21404	0.20051	0.22339	0.23003	0.21799	0.23009
C.V.:		32.5%	24.8%	24.1%	16.4%	6.2%	6.2%	7.1%	5.9%	4.7%	4.0%	3.1%	2.5%	3.7%	4.3%	3.7%	3.3%	3.0%

Volumetric Water Content -- 12/89 - 11/90

Plot 16

Month	Date	DEPTH (cm)																
		2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
12	1	0.201	0.2235	0.2304	0.1217	0.159	0.162	0.1544	0.1559	0.1525	0.1588	0.1897		0.2095	0.16	0.1685	0.2008	0.2039
12	4	0.1766	0.2019	0.2146	0.1557	0.1791	0.1699	0.1659	0.1696	0.1723	0.18	0.2086		0.2334	0.1882	0.2033	0.2368	0.2438
12	8	0.1755	0.2009	0.2139	0.1308	0.1663	0.1618	0.1522	0.158	0.1566	0.1695	0.1988	0.2268	0.2223	0.1767	0.2005	0.2314	0.2362
12	15			0.0298	0.1167	0.1556	0.1534	0.1439	0.149	0.1481	0.1611	0.193		0.2131	0.172	0.1963	0.2284	0.2242
12	18			0.0296	0.1172	0.1558	0.1526	0.1452	0.1482	0.1481	0.161	0.164		0.2168	0.1618	0.2292	0.2287	0.2258
12	26	0.253	0.2696	0.2641	0.1438	0.1719	0.165	0.1528	0.1512	0.1574	0.1647	0.1991		0.216	0.1738	0.194	0.2255	0.2255
1	3	0.1786	0.2037	0.2159	0.1421	0.1701	0.1632	0.1513	0.1435	0.1596	0.1543	0.1919	0.2134	0.2131	0.1732	0.1918	0.2185	0.2227
1	5	0.18	0.2049	0.2168	0.1681	0.1925	0.1846	0.1798	0.17	0.1662	0.1637	0.1918	0.2203	0.2114	0.1677	0.1898	0.2167	0.227
1	10	0.1806	0.2055	0.2172	0.1435	0.1701	0.1654	0.157	0.1644	0.1601	0.1725	0.202	0.2273	0.2189	0.1791	0.2009	0.2292	0.2316
1	12	0.1816	0.2064	0.2179	0.1434	0.1677	0.1659	0.1537	0.1659	0.1542	0.1668	0.2023	0.2284	0.2167	0.1784	0.2073	0.2309	0.2315
1	16				0.143	0.1786	0.167	0.1601	0.165	0.1647	0.1739	0.2102	0.2374	0.2289	0.1865	0.2101	0.2406	0.2454
1	19	0.7871	0.7428	0.6101	0.1539	0.1707	0.1573	0.1462	0.15	0.1487	0.1632	0.1959	0.2226	0.2119	0.1698	0.1939	0.2256	0.2268
1	31	0.1813	0.2061	0.2177	0.1487	0.1757	0.1674	0.1641	0.1665	0.1664	0.1781	0.2078	0.2359	0.2256	0.182	0.2099	0.2347	0.2387
2	2	0.2033	0.2256	0.2319	0.1584	0.1767	0.1637	0.1553	0.1605	0.1628	0.1732	0.2061	0.2316	0.2212	0.1786	0.1994	0.2281	0.234
2	8	0.1489	0.1774	0.1967	0.139	0.168	0.1608	0.148	0.1547	0.1541	0.1658	0.2	0.2279	0.2177	0.1738	0.1977	0.2294	0.2297
2	9	0.2587	0.2747	0.2678	0.1799	0.1967	0.195	0.1878	0.1825	0.1788	0.1797	0.1995	0.2247	0.2149	0.1751	0.1928	0.2242	0.2249
2	14	0.1401	0.1696	0.191	0.1378	0.1672	0.1588	0.147	0.1556	0.16	0.1696	0.2004	0.2312	0.2196	0.1693	0.1936	0.2317	0.232
2	16	0.1623	0.1893	0.2054	0.1362	0.1669	0.1602	0.1512	0.1544	0.1559	0.1732	0.2043	0.227	0.2185	0.1767	0.2017	0.2328	0.2328
2	20	0.1469	0.1756	0.1954	0.1413	0.1654	0.1579	0.1501	0.1528	0.1568	0.1682	0.1996	0.2281	0.2183	0.1746	0.2022	0.2292	0.2366
2	23	0.226	0.2458	0.2467	0.1598	0.1824	0.1803	0.1765	0.1731	0.172	0.1844	0.2079	0.232	0.2192	0.1792	0.1989	0.2288	0.229
3	7	0.1577	0.1852	0.2024	0.1262	0.1619	0.1567	0.1471	0.149	0.1502	0.1651	0.1976	0.226	0.2171	0.1728	0.1992	0.2262	0.2272
3	9	0.1141	0.1466	0.1742	0.1207	0.1551	0.1536	0.1426	0.1478	0.145	0.1597	0.1923	0.2222	0.2144	0.1689	0.1939	0.2238	0.2251
3	14	0.2163	0.2371	0.2404	0.1476	0.1679	0.161	0.1506	0.1562	0.1579	0.1751	0.2046	0.2302	0.2229	0.1792	0.2028	0.2307	0.2373
3	16	0.1772	0.2025	0.2151	0.1485	0.1747	0.1586	0.147	0.1475	0.1459	0.1577	0.1911	0.2201	0.2133	0.1645	0.1921	0.2169	0.2207
3	19	0.1711	0.1971	0.2111	0.1497	0.1758	0.1594	0.1487	0.149	0.147	0.159	0.1919	0.2202	0.2141	0.165	0.193	0.2176	0.2211
3	28	0.092	0.127	0.1598	0.1232	0.157	0.151	0.1383	0.1427	0.1426	0.1532	0.1919	0.2213	0.212	0.1681	0.19	0.2171	0.2231
3	29				0.1596	0.196	0.1908	0.1699	0.1627	0.1731	0.19	0.2029	0.2149	0.1977	0.2255	0.2294	0.2133	0.2292
4	2			0.0651	0.1435	0.1681	0.1609	0.1551	0.1562	0.1564	0.1683	0.1981	0.2242	0.2135	0.1707	0.1952	0.2217	0.2246
4	4	0.1446	0.1736	0.1939	0.1429	0.1644	0.1592	0.1515	0.1534	0.1523	0.1664	0.1945	0.2229	0.2148	0.1689	0.1994	0.2208	0.2237
4	10	0.1447	0.1737	0.194	0.1267	0.1592	0.1537	0.1415	0.1466	0.1482	0.1623	0.1933	0.2231	0.2113	0.1673	0.1958	0.2216	0.2254
4	18	0.1514	0.1796	0.1983	0.1382	0.1676	0.1594	0.1529	0.154	0.1549	0.1701	0.1983	0.2226	0.2155	0.1717	0.2005	0.2254	0.229
4	20	0.1493	0.1778	0.197	0.1382	0.165	0.1578	0.1503	0.1516	0.1538	0.1685	0.1986	0.2226	0.2134	0.1681	0.1986	0.2252	0.2279
4	27	0.1947	0.218	0.2264	0.1712	0.186	0.1703	0.1508	0.15	0.1459	0.1615	0.1956	0.2182	0.2134	0.1692	0.1958	0.2238	0.2252
5	3	0.1645	0.1912	0.2068	0.1391	0.166	0.1568	0.1465	0.1505	0.1492	0.1675	0.1968	0.224	0.2141	0.1693	0.1991	0.2282	0.2241
5	9	0.1161	0.1483	0.1754	0.1336	0.164	0.1562	0.1475	0.1528	0.1468	0.1634	0.196	0.2236	0.2146	0.1711	0.1999	0.2255	0.2252
5	11	0.2772	0.2911	0.2798	0.1608	0.1835	0.1727	0.1543	0.1507	0.1479	0.1573	0.187	0.2223	0.215	0.1678	0.1926	0.2214	0.2231

Volumetric Water Content -- 12/89 - 11/90

Plot 16 (cont.)

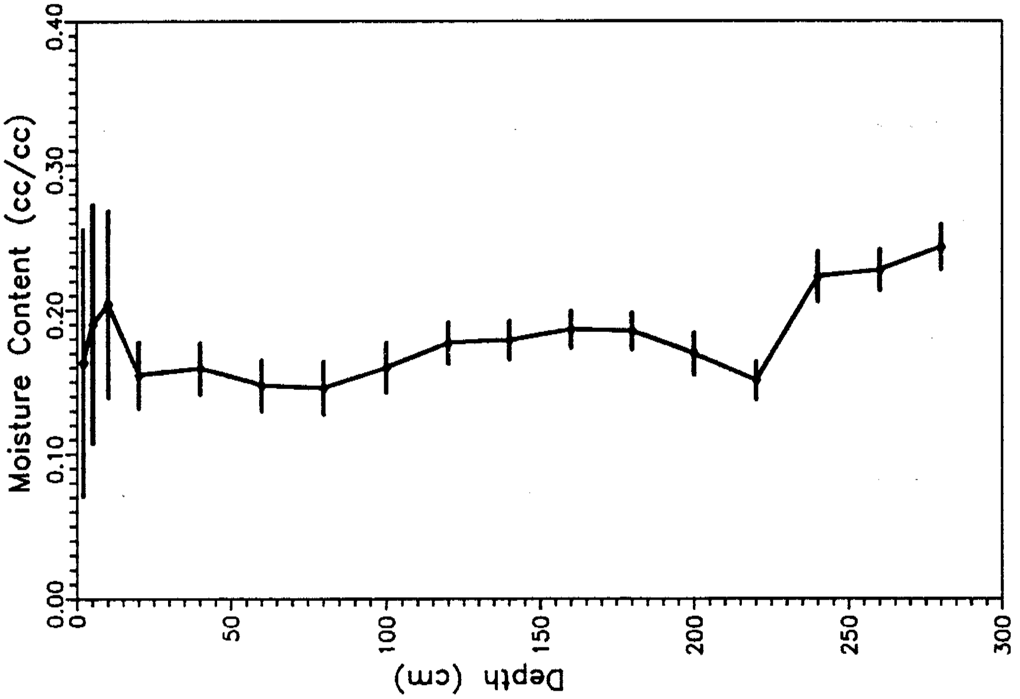
DEPTH (cm)

Month	Date	2	5	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280
5	16			0.0093	0.1342	0.1686	0.1614	0.1473	0.1492	0.1511	0.1651	0.1932	0.2228	0.217	0.1697	0.1966	0.2272	0.2224
5	18	0.1195	0.1514	0.1777	0.1338	0.1669	0.1599	0.1472	0.1466	0.1509	0.1633	0.1911	0.2201	0.2157	0.1661	0.195	0.2243	0.2205
5	25	0.267	0.282	0.2732	0.1735	0.1912	0.1908	0.1811	0.1767	0.1651	0.1659	0.1949	0.2235	0.213	0.1669	0.1916	0.2233	0.2234
5	31	0.1718	0.1977	0.2115	0.1385	0.1688	0.1593	0.1485	0.155	0.1545	0.1653	0.195	0.2298	0.2211	0.1741	0.197	0.227	0.2284
6	4			0.0134	0.1467	0.1741	0.1536	0.1578	0.1601	0.155	0.1688	0.1966	0.2328	0.222	0.1773	0.1948	0.2295	0.2281
6	6	0.0881	0.1236	0.1573	0.1267	0.1596	0.1578	0.145	0.1478	0.1466	0.1612	0.1934	0.2239	0.2214	0.1709	0.1965	0.2266	0.2276
6	8	0.288	0.3007	0.2868	0.1748	0.1942	0.1934	0.183	0.179	0.1669	0.1671	0.1946	0.2267	0.2154	0.1671	0.1945	0.2237	0.2236
6	13	0.1302	0.1608	0.1846	0.1433	0.1663	0.1594	0.1499	0.152	0.1523	0.1652	0.1973	0.2227	0.2193	0.1741	0.1971	0.2246	0.2263
6	15	0.1267	0.1577	0.1823	0.145	0.1669	0.1616	0.1506	0.1548	0.1541	0.1679	0.198	0.2264	0.2209	0.1772	0.1948	0.2234	0.2269
6	21	0.0888	0.1241	0.1577	0.1243	0.1626	0.1511	0.1387	0.1469	0.1454	0.1591	0.1866	0.2224	0.2147	0.1697	0.1938	0.2225	0.2243
6	29	0.0905	0.1257	0.1589	0.1431	0.17	0.1577	0.152	0.1559	0.1528	0.1673	0.1996	0.2323	0.224	0.1751	0.1988	0.2286	0.2347
7	3	0.0725	0.1097	0.1472	0.1298	0.1625	0.1526	0.143	0.1488	0.1486	0.16	0.1904	0.2229	0.2149	0.1721	0.1946	0.2266	0.2261
7	11	0.1581	0.1856	0.2027	0.1434	0.1693	0.1577	0.1474	0.1505	0.1504	0.1618	0.1969	0.2253	0.2166	0.1722	0.1939	0.2277	0.2292
7	13	0.1257	0.1568	0.1816	0.1485	0.1677	0.1561	0.1473	0.15	0.1489	0.1605	0.1902	0.2219	0.2185	0.1762	0.1935	0.2221	0.2283
7	25	0.1384	0.1681	0.1899														
7	27	0.0754	0.1122	0.1491	0.1326	0.1613	0.1511	0.1409	0.1443	0.147	0.1594	0.1884	0.2238	0.2146	0.1682	0.1905	0.2266	0.2275
8	1	0.0862	0.1219	0.1561	0.1272	0.1667	0.1556	0.1429	0.1509	0.1468	0.16	0.1986	0.237	0.2237	0.178	0.1988	0.2328	0.2368
8	3	0.1375	0.1673	0.1893	0.1362	0.16	0.1486	0.1477	0.1433	0.1427	0.1526	0.1904	0.2261	0.2158	0.1708	0.1917	0.2238	0.2249
8	8	0.1422	0.1715	0.1924	0.121	0.1554	0.1458	0.134	0.1416	0.1406	0.1509	0.1856	0.2201	0.2174	0.1673	0.1899	0.2201	0.2245
8	17	0.1667	0.1932	0.2082	0.1538	0.1714	0.1533	0.1407	0.1419	0.1426	0.1519	0.1871	0.2209	0.2164	0.1648	0.1902	0.2188	0.224
8	22	0.234	0.2528	0.2518	0.1384	0.1647	0.1511	0.1369	0.1442	0.1391	0.1488	0.1872	0.2239	0.2118	0.164	0.1878	0.2174	0.2247
8	29	0.1547	0.1826	0.2005	0.1305	0.1645	0.1467	0.1305	0.1427	0.1344	0.1459	0.1839	0.2213	0.207	0.1617	0.1844	0.2163	0.2224
9	5			0.0284	0.1398	0.166	0.1464	0.1314	0.1463	0.1355	0.1477	0.1794	0.2198	0.2062	0.1584	0.1822	0.2133	0.2213
9	21	0.108	0.1412	0.1702	0.1511	0.1776	0.1586	0.1453	0.1482	0.1492	0.1552	0.1958	0.2334	0.2268	0.1722	0.1982	0.2287	0.2346
10	3	0.1868	0.211	0.2213	0.1568	0.1826	0.1741	0.1634	0.1589	0.1565	0.166	0.1951	0.2304	0.2327	0.1812	0.1949	0.2282	0.2306
10	10	0.1072	0.1404	0.1697	0.141	0.1726	0.162	0.1541	0.1552	0.1506	0.1602	0.1939	0.2284	0.2285	0.1779	0.1963	0.2301	0.2329
10	12	0.3066	0.3172	0.2989	0.1673	0.2013	0.185	0.1601	0.1571	0.1525	0.1613	0.1996	0.2254	0.2292	0.1799	0.2062	0.2265	0.2336
10	17	0.124	0.1554	0.1806	0.1532	0.1771	0.1685	0.1589	0.1592	0.1579	0.1684	0.1986	0.2342	0.2262	0.181	0.2005	0.2308	0.2323
10	24	0.1012	0.1351	0.1658	0.1479	0.1741	0.1658	0.1588	0.1573	0.1574	0.1669	0.1963	0.2352	0.2239	0.1805	0.2017	0.2307	0.2308
11	2					0.1725	0.1637	0.1513	0.154	0.1534	0.1636	0.1962	0.2295	0.2243	0.1735	0.1967	0.2263	0.2274
11	7	0.1097	0.1427	0.1713	0.1484	0.1753	0.165	0.1537	0.1556	0.1572	0.1647	0.1962	0.2395	0.2278	0.1801	0.2008	0.2374	0.2372
Avg.:		0.17169	0.19759	0.19438	0.1431	0.17092	0.16218	0.15192	0.15433	0.15331	0.16438	0.19536	0.22583	0.21774	0.17322	0.19701	0.2254	0.22802
C.V.:		57.4%	44.2%	41.7%	10.0%	6.1%	6.8%	7.5%	5.8%	5.7%	5.0%	3.7%	2.4%	2.9%	5.2%	4.3%	2.8%	2.7%

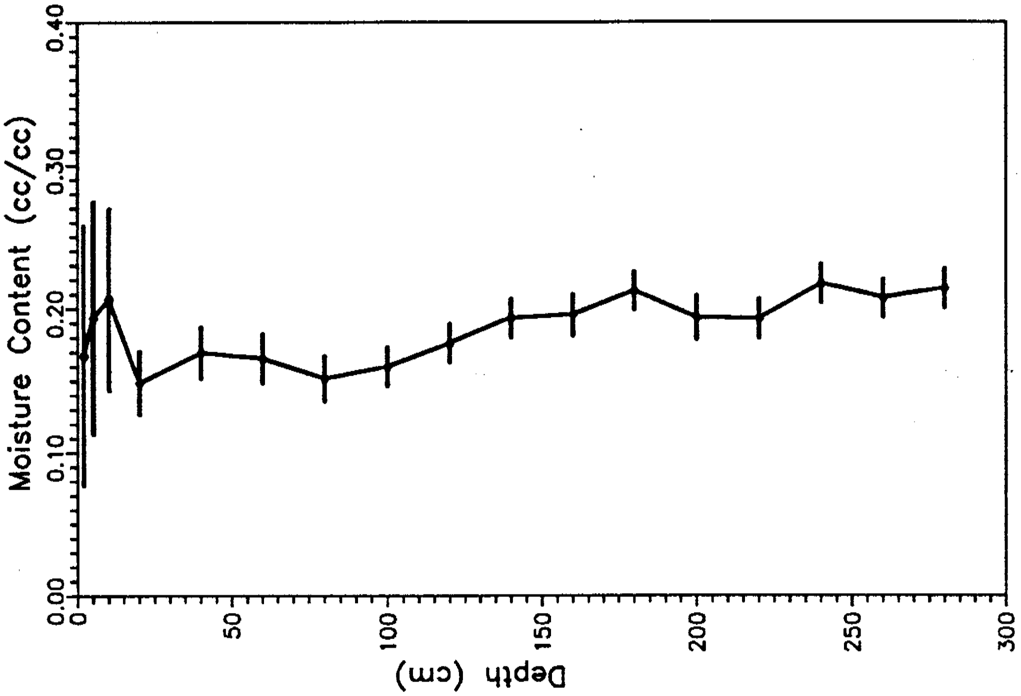
APPENDIX G

Plot-Averaged Water Content Profiles

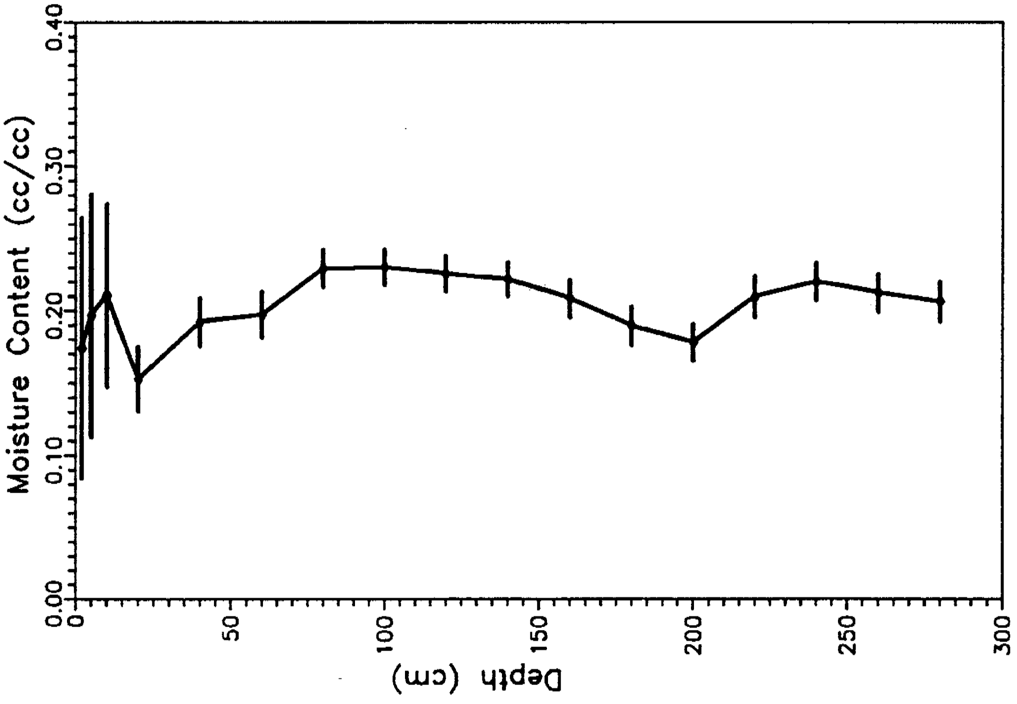
The moisture content profiles on the following pages show the average moisture content in each plot over the entire 11-month course of the field experiment, and represent the average of 67 different neutron probe profiles. The error bars shown are one standard deviation above and below the mean.


Moisture Content (cc/cc)
0.00
0.10
0.20
0.30
0.40
Depth (cm)
0
50
100
150
200
250
300

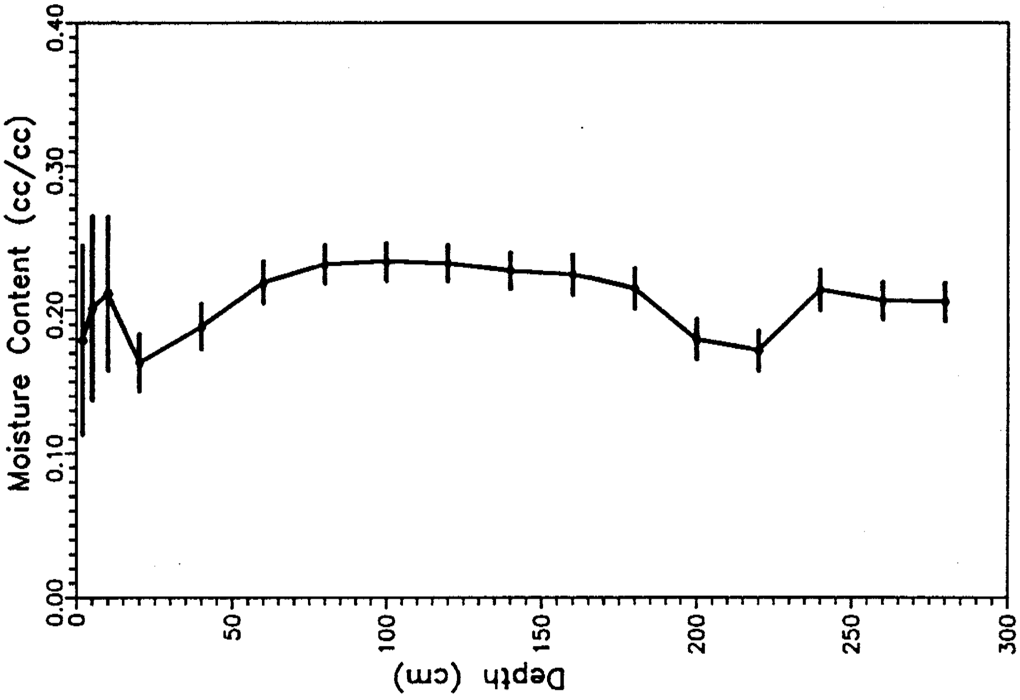
Plot 1


Moisture Content (cc/cc)
0.00
0.10
0.20
0.30
0.40
Depth (cm)
0
50
100
150
200
250
300

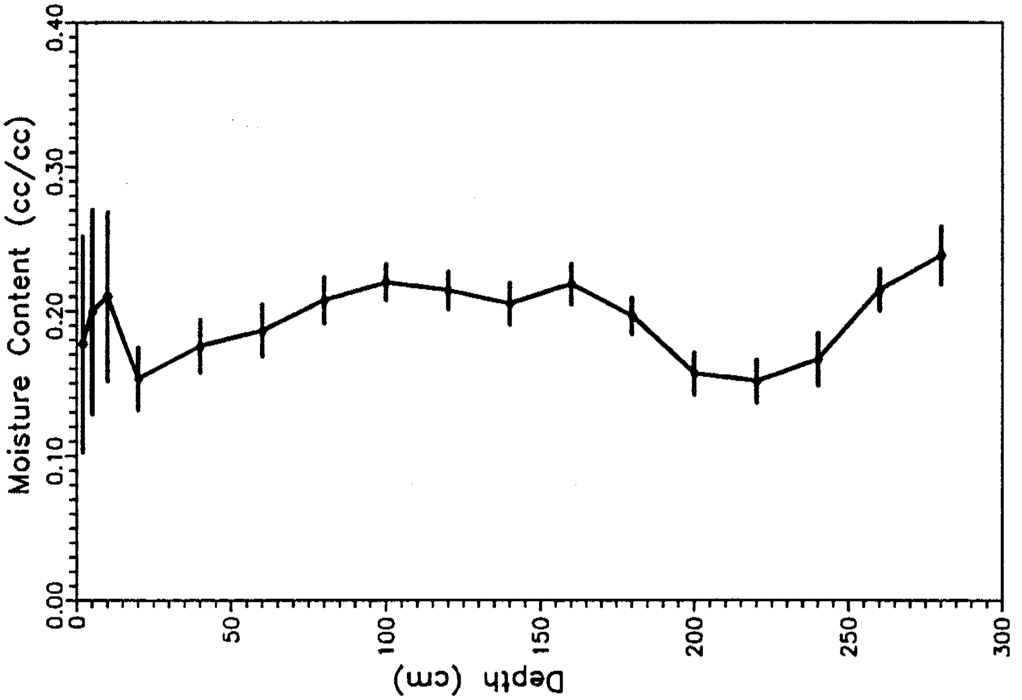
Plot 2


Moisture Content (cc/cc)
0.00
0.10
0.20
0.30
0.40
Depth (cm)
0
50
100
150
200
250
300

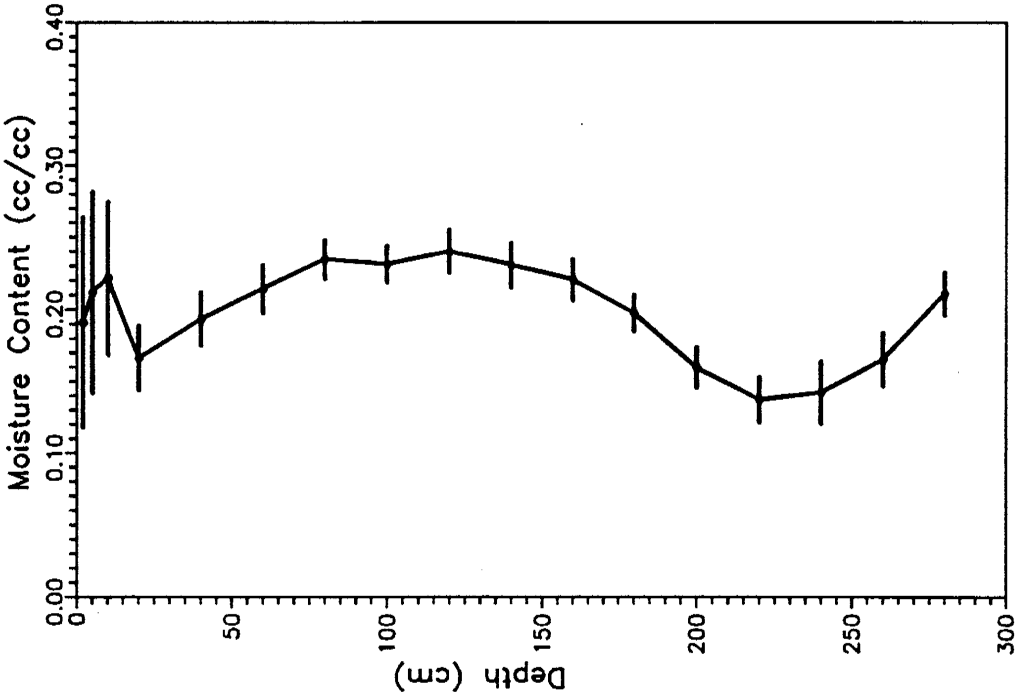
Plot 3


Moisture Content (cc/cc)
0.00
0.10
0.20
0.30
0.40
Depth (cm)
0
50
100
150
200
250
300

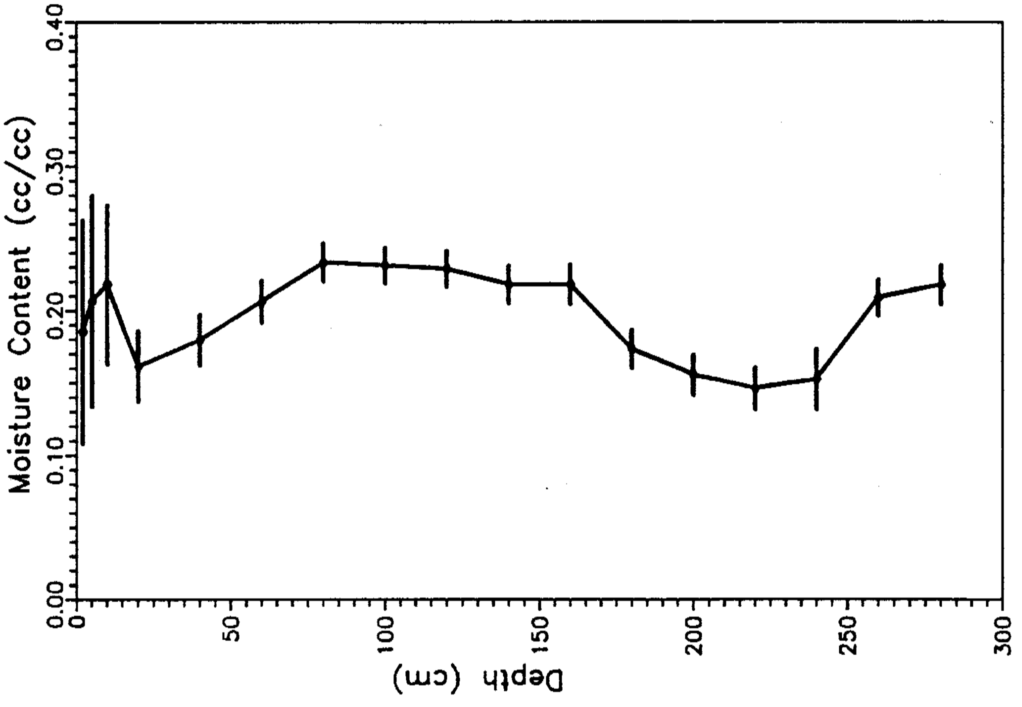
Plot 4


Moisture Content (cc/cc)
0.00
0.10
0.20
0.30
0.40
Depth (cm)
0
50
100
150
200
250
300

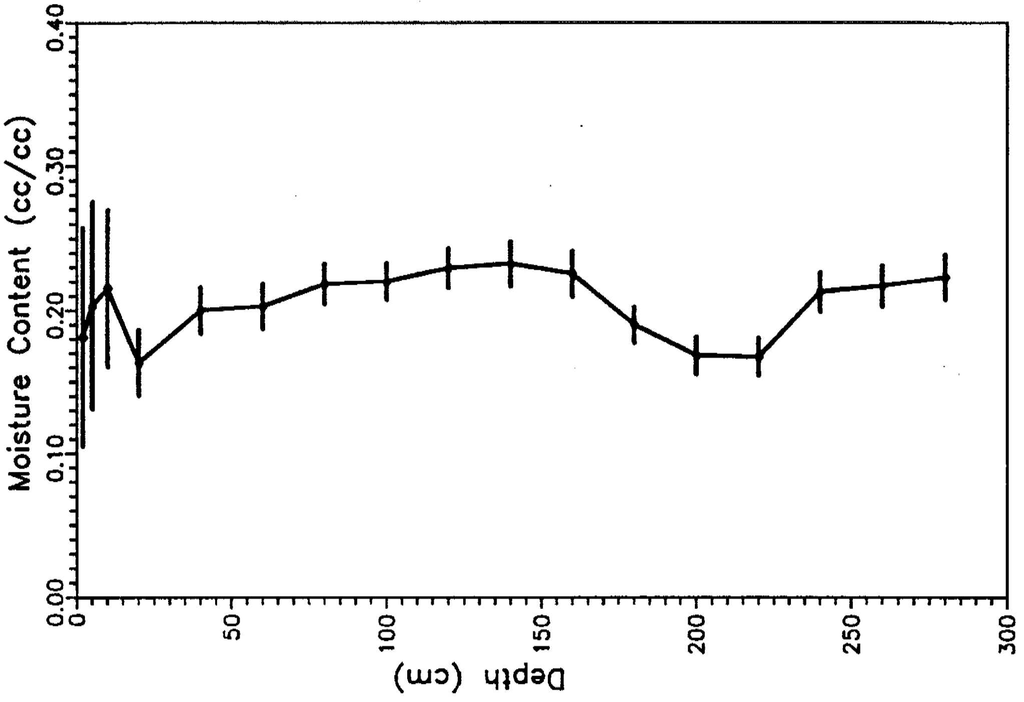
Plot 5


Moisture Content (cc/cc)
0.00
0.10
0.20
0.30
0.40
Depth (cm)
0
50
100
150
200
250
300

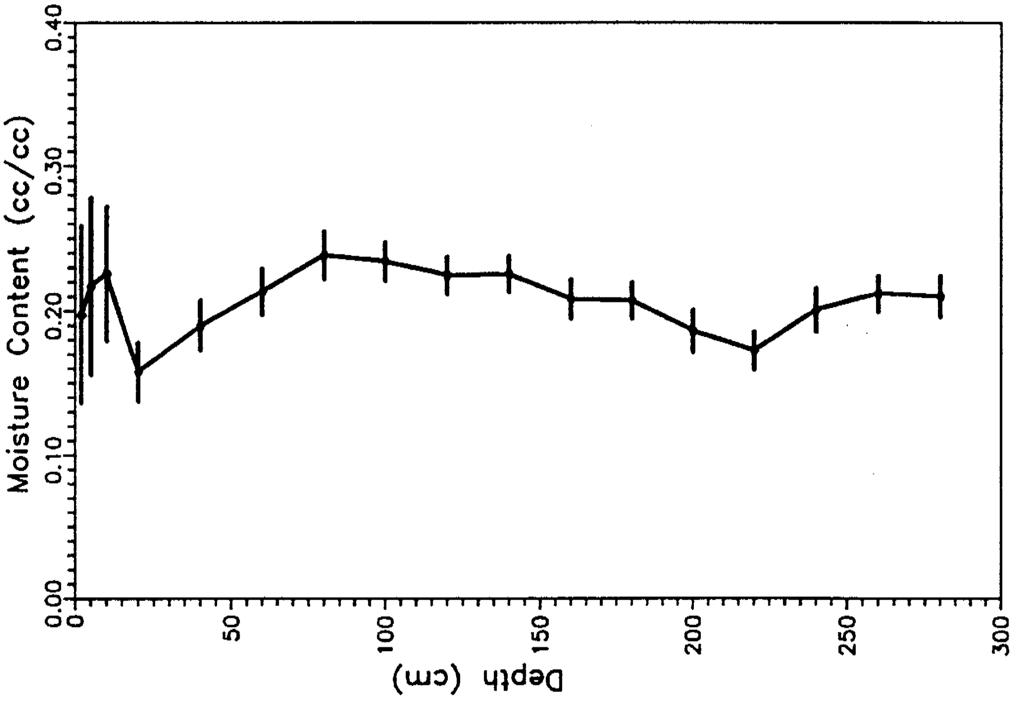
Plot 6


Moisture Content (cc/cc)
0.00
0.10
0.20
0.30
0.40
Depth (cm)
0
50
100
150
200
250
300

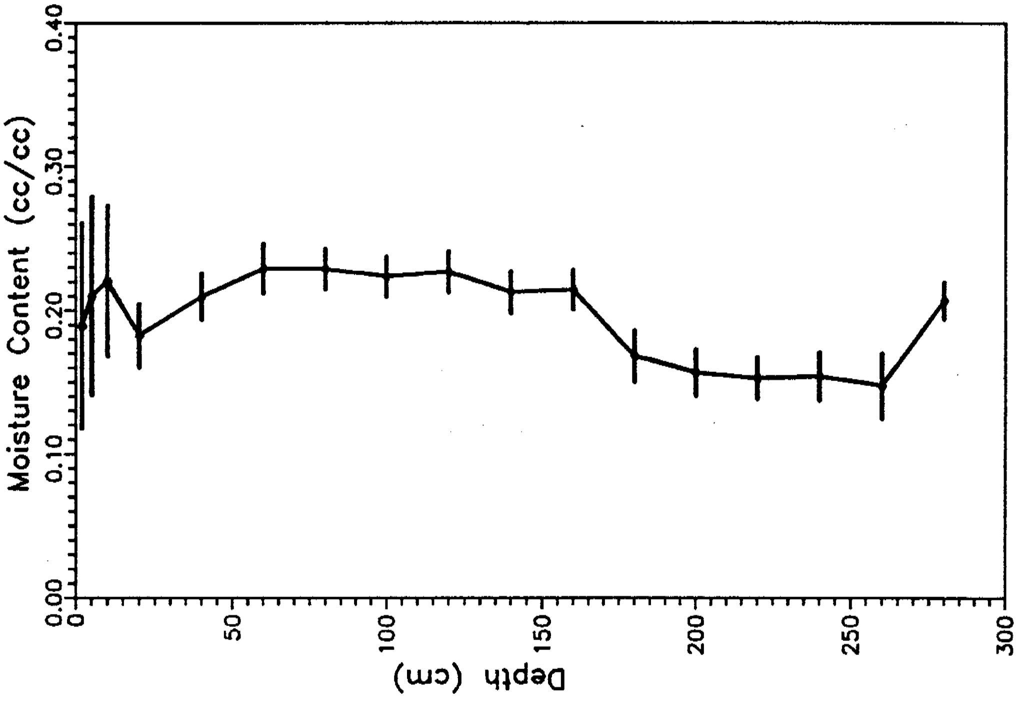
Plot 7


Moisture Content (cc/cc)
0.00
0.10
0.20
0.30
0.40
Depth (cm)
0
50
100
150
200
250
300

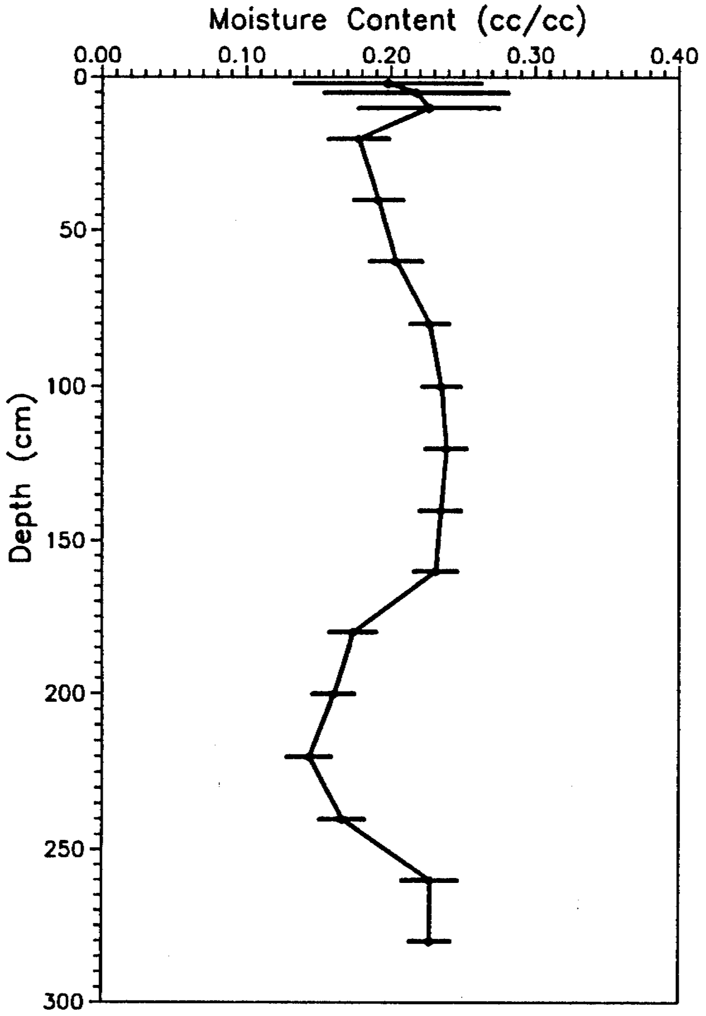
Plot 8



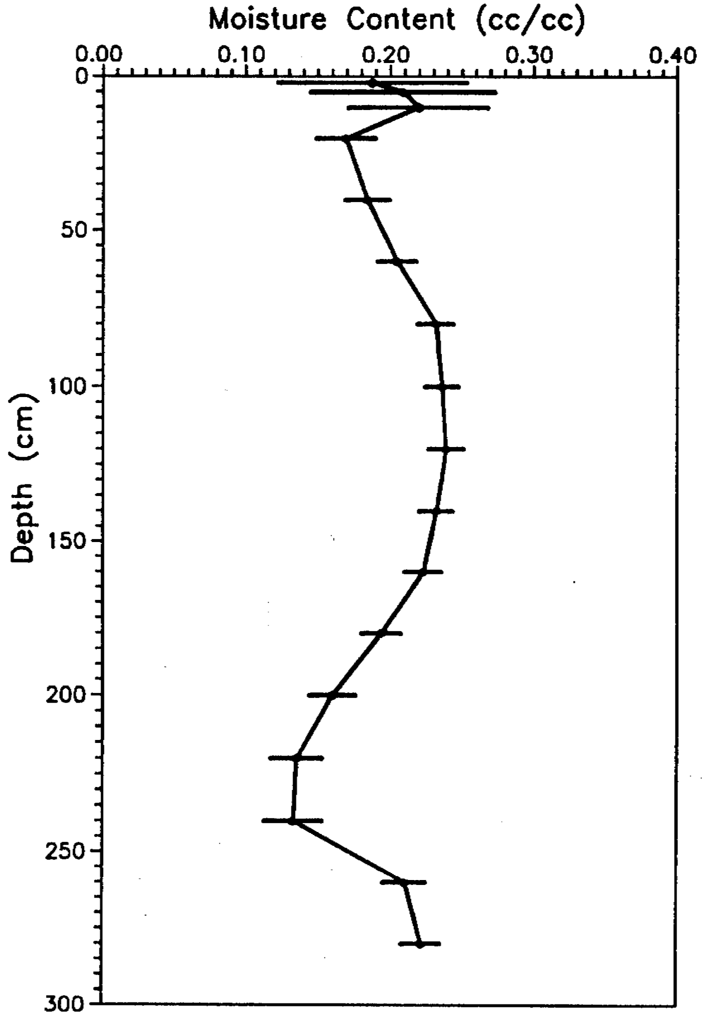
Plot 9



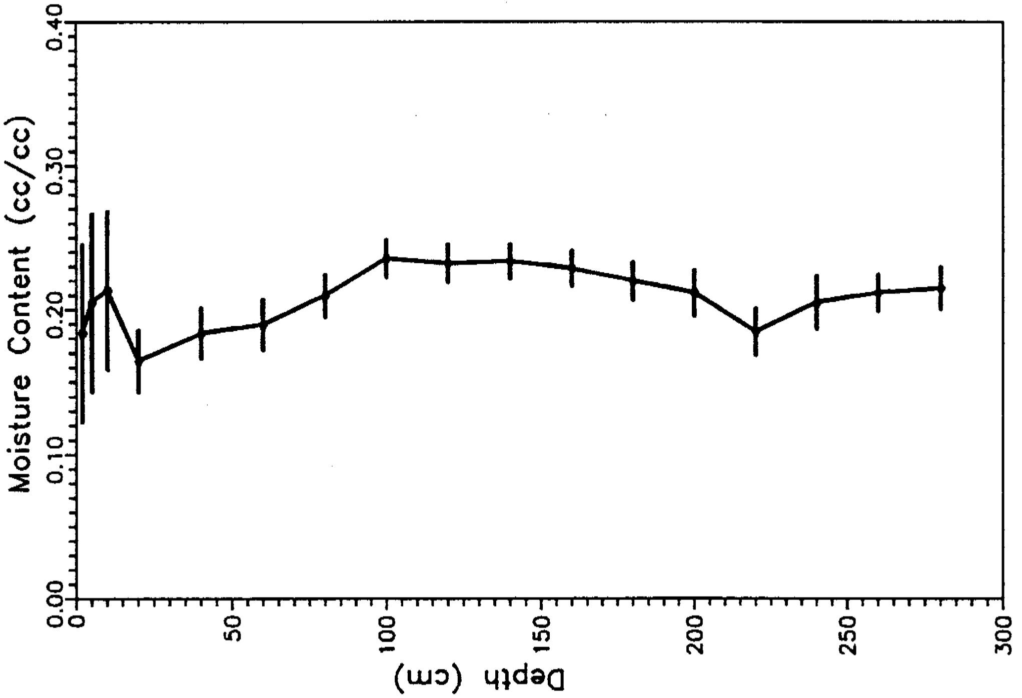
Plot 10



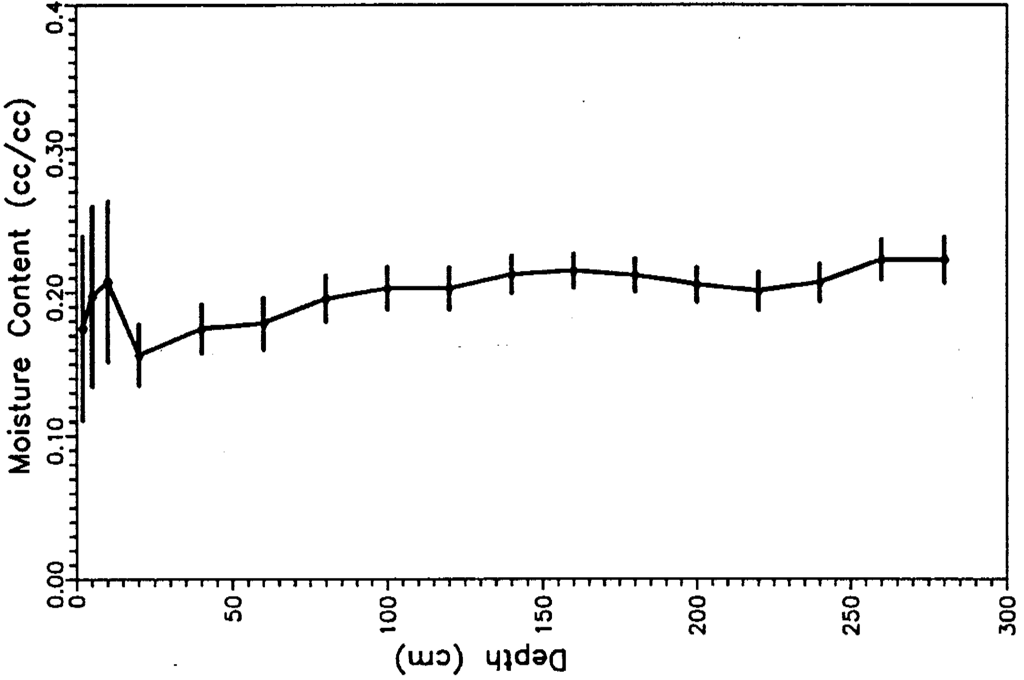
Plot 11



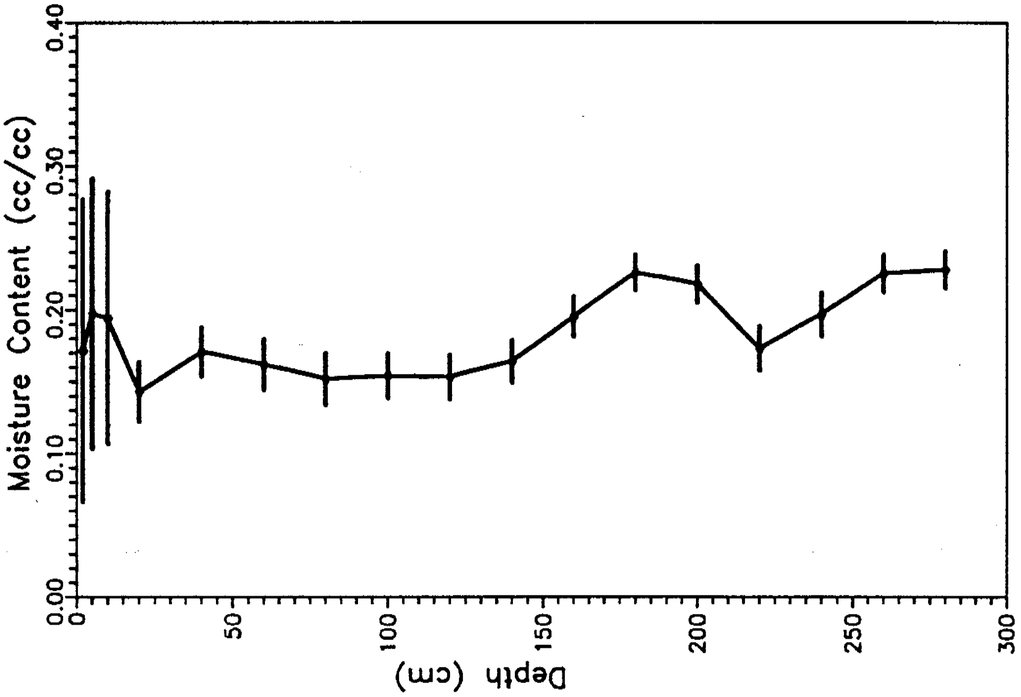
Plot 12



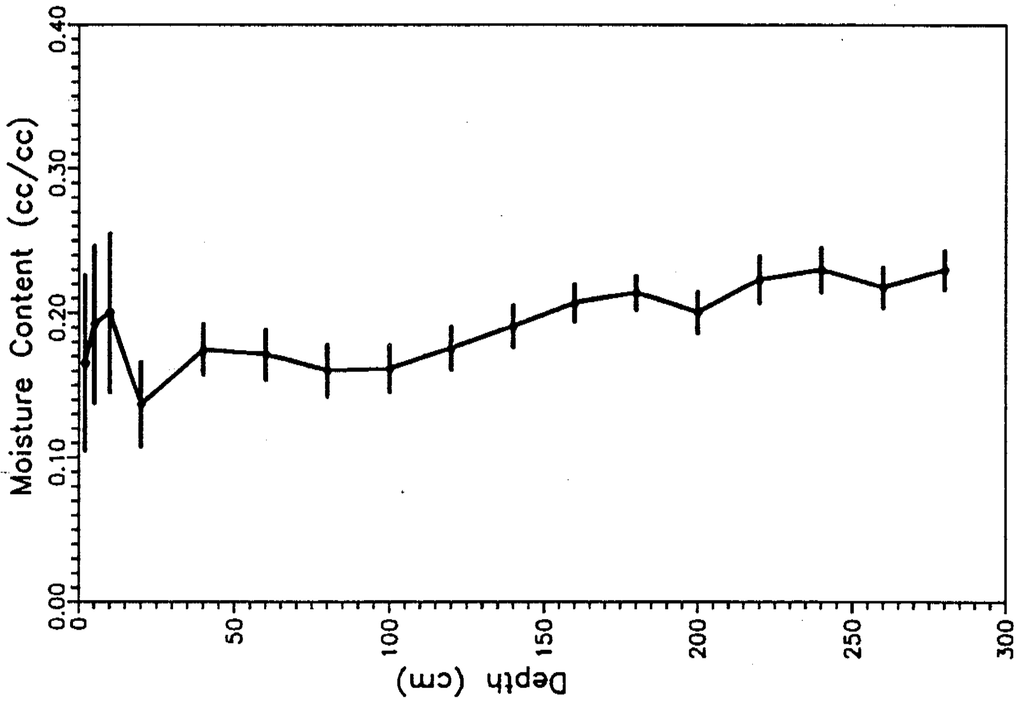
Plot 13



Plot 14



Plot 16



Plot 15

APPENDIX H

Herbicide Application Rate and Uniformity Data

	Application Rate			P		B		N	
Dish	P	B (g/m^2)	N	avg. s.d.	CV	avg. s.d.	CV	avg. s.d.	CV
1-1	1.253	8.222	4.628						
1-2	1.198	7.872	4.407						
1-3	0.970	6.395	3.483						
1-4	0.850	5.647	3.026						
1-5	1.039	6.856	3.756						
1-6	1.246	8.291	4.562	1.093	15.2%	7.214	15.0%	3.977	16.5%
				0.166		1.083		0.655	
2-1	0.841	5.622	3.554						
2-2	1.038	6.949	4.488						
2-3	1.050	7.002	4.440						
2-5	0.957	6.409	4.045						
2-6	1.424	9.716	6.236	1.062	20.6%	7.139	21.6%	4.552	22.3%
				0.219		1.544		1.013	
3-1	0.106	0.816	0.292						
3-2	0.120	0.906	0.335						
3-3	0.093	0.697	0.244						
3-4	0.092	0.675	0.248						
3-5	0.110	0.829	0.293						
3-6	0.142	1.056	0.392	0.110	16.9%	0.830	16.9%	0.301	18.6%
				0.019		0.140		0.056	
4-1	1.035	0.000	0.000						
4-3	1.122	0.000	0.000						
4-4	1.084	0.000	0.015						
4-5	1.105	0.000	0.007						
4-6	1.334	0.000	0.004	1.136	10.2%	0.000	ERR	0.005	117.4%
				0.116		0.000		0.006	
5-1	0.000	0.000	3.010						
5-2	0.000	0.000	4.723						
5-4	0.000	0.000	3.782						
5-5	0.001	0.000	4.544						
5-6	0.000	0.002	4.931	0.000	223.6%	0.000	223.6%	4.198	18.9%
				0.000		0.001		0.793	
6-1	0.085	0.631	0.241						
6-2	0.093	0.686	0.261						
6-3	0.089	0.663	0.236						
6-4	0.091	0.676	0.258						
6-5	0.097	0.705	0.274						
6-6	0.112	0.862	0.310	0.095	9.9%	0.704	11.6%	0.263	10.2%
				0.009		0.081		0.027	
7-2	0.000	0.005	3.547						
7-3	0.000	0.001	3.411						
7-4	0.001	0.000	2.876						
7-5	0.000	0.004	4.847						
7-6	0.000	0.008	4.682	0.000	223.6%	0.004	89.2%	3.873	22.0%
				0.000		0.003		0.854	
8-1	0.000	8.738	0.000						
8-2	0.000	7.220	0.000						
8-3	0.000	4.424	0.000						
8-4	0.000	6.251	0.000						
8-5	0.002	7.413	0.012						
8-6	0.001	7.502	0.000	0.001	183.3%	6.925	21.1%	0.002	244.9%
				0.001		1.460		0.005	

	Application Rate			P		B		N	
Dish	P	B (g/m^2)	N	avg. s.d.	CV	avg. s.d.	CV	avg. s.d.	CV
10-1	0.002	0.399	4.364						
10-2	0.000	0.028	3.244						
10-4	0.000	0.013	3.078						
10-5	0.000	0.015	4.111						
10-6	0.000	0.028	5.374	0.000	223.6%	0.096	175.7%	4.034	23.0%
				0.001		0.169		0.929	
11-1									
11-2									
11-3	0.000	4.334	0.000						
11-4	0.000	4.036	0.000						
11-5	0.001	10.810	0.000						
11-6	0.000	10.110	0.024	0.000	200.0%	7.323	49.7%	0.006	200.0%
				0.000		3.636		0.012	
12-1	1.080	0.000	0.000						
12-2	1.292	0.000	0.000						
12-5	1.586	0.000	0.000						
12-6	1.303	0.000	0.000	1.315	15.8%	0.000	ERR	0.000	ERR
				0.208		0.000		0.000	
13-1	1.295	8.682	4.795						
13-2	0.901	6.006	3.228						
13-3	0.603	4.217	2.098						
13-4	0.772	5.219	2.756						
13-5	1.413	9.562	5.212						
13-6	1.082	7.203	3.877	1.011	30.7%	6.815	30.2%	3.661	32.8%
				0.311		2.056		1.199	
14-1	0.113	0.855	0.298						
14-2	0.093	0.675	0.236						
14-3	0.070	0.509	0.174						
14-4	0.087	0.640	0.222						
14-5	0.136	1.035	0.377						
14-6	0.136	1.027	0.360	0.106	25.7%	0.790	27.4%	0.278	29.1%
				0.027		0.217		0.081	
15-2	1.362	0.000	0.000						
15-3	0.862	0.000	0.000						
15-4	0.892	0.000	0.000						
15-5	1.360	0.000	0.015						
15-6	1.214	0.000	0.000	1.138	21.6%	0.000	ERR	0.003	223.6%
				0.246		0.000		0.007	
16-1	0.003	9.104	0.000						
16-2	0.004	8.377	0.013						
16-3	0.001	5.823	0.010						
16-5	0.002	9.343	0.000						
16-6	0.008	9.701	0.022	0.004	74.1%	8.470	18.4%	0.009	103.5%
				0.003		1.557		0.009	

APPENDIX I

Soil Herbicide and Tracer Concentrations

Plot 1, High Concentration Mix

Depth (cm)	χ (cm)	θ	Tracer	Brom	Napr	Prom
			<-----------	(μg/cm^3)		---------->
Hole 1						
5	.9465	.1893	.00000	.29092	1.76410	.15784
15	2.8055	.1825	.00000	.35584	18.86290	.30806
25	4.6475	.1859	.00000	.19190	8.94522	.49198
35	6.5860	.2018	.00000	.11331	2.24354	.68957
45	8.5885	.1987	.00000	.12320	.29722	.96248
55	10.3915	.1619	.00000	.07357	.21480	.58410
75	13.5710	.1580	.00000	.27620	.03864	.96237
105	19.1690	.2152	.00000	2.75538	.00000	.87093
135	25.4105	.2009	.42312	12.26005	.00000	.09561
165	31.6880	.2176	.20382	12.90596	.00000	.00000
195	37.9775	.2017	.72200	.13639	.00000	.00000
225	44.2640	.2174	5.11480	.25589	.11631	.00664
255	50.9660	.2294	1.68416	.00000	.20050	.00351
Hole 2						
5	.9245	.1849	.00000	.02284	.52507	.02435
15	2.7665	.1835	.00000	.02994	7.47561	.04641
25	4.6070	.1846	.00000	.04428	12.64756	.07634
35	6.5390	.2018	.00000	.04128	13.52397	.09526
45	8.5370	.1978	4.25760	.03960	9.54710	.07763
55	10.3970	.1742	2.81760	.03262	6.72571	.07502
75	13.6185	.1567	1.41912	.12208	2.99188	.16331
105	18.5640	.1730	.10080	.83637	.60747	.25531
135	24.1560	.1998	.00000	.80617	.07615	.89391
165	30.3165	.2109	.00000	2.06849	.00000	1.00031
195	37.0680	.2392	.00000	12.04507	.01933	.40244
225	44.3910	.2490	.00000	17.21224	.02493	.05698
255	52.1730	.2698	.00000	13.66520	.00000	.00000
Hole 3						
5	.9650	.1930	.00000	.00000	1.07936	.06577
15	2.8460	.1832	.00000	.00000	7.37636	.25008
25	4.6760	.1828	.00000	.11913	6.45780	1.03784
35	6.6045	.2029	.00000	.19651	.66240	2.25320
45	8.6120	.1986	.00000	.29770	.52138	2.97701
55	10.5345	.1859	.00000	.40571	.02715	1.72986
75	14.0950	.1754	.00000	3.11933	.00000	.78854
105	19.4500	.1816	.94248	2.09955	.00000	.09836
135	25.4650	.2194	.12300	3.39842	.00000	.01189
165	32.4790	.2482	.26860			
195	39.0685	.1911	5.76992	.14739	.00000	.02239
225	45.9940	.2706	3.32424	.04178	.00000	.02725
255	53.7670	.2476	.00000	.00000	.00000	.01886

Plot 2, High Concentration Mix

Depth	χ	θ	Tracer	Brom	Napr	Prom
(cm)	(cm)		<-----------($\mu g/cm^3$)---------->			
Hole 1						
5	.9485	.1897	.00000	.10549	.32735	.06826
15	2.8670	.1940	.00000	.07979	2.34130	.27679
25	4.8040	.1934	.00000	.13514	6.84481	.76526
35	6.4840	.1426	.00000	.16648	2.17928	1.12293
45	8.3210	.2248	.00000	.23246	2.19131	1.34275
55	10.4600	.2030	.00000	.29779	.34742	.98237
75	14.6415	.2111	.00000	1.48097	.06553	1.33352
105	22.4880	.3120	.00000	11.40198	.00000	.33865
135	31.6185	.2967	.69700	6.56818	.08986	.02875
165	41.0835	.3343	1.91970	.00000	.00000	.00000
195	49.2015	.2069	.26448	.27438	.00000	.00000
225	55.8930	.2392	.00000	.13992	.00000	.00345
255	63.1500	.2446	2.48824	.00000	.00000	.00520
Hole 2						
5	.9215	.1843	.00000	.00000	1.44808	.08667
15	2.8205	.1955	.00000	.00000	12.61694	.90851
25	4.5315	.1467	.00000	.81705	1.53269	2.09333
35	6.3040	.2078	.00000	4.35346	.04302	2.20222
45	8.3430	.2000	.00000	9.62805	.00000	.57997
55	10.2455	.1805	.00000	9.94397	.00000	.22603
75	13.6125	.1643	.00000	11.58762	.00000	.09812
105	18.4200	.1562	.44520	9.53207	.10312	.01719
135	23.5305	.1845	2.33864	2.11539	.05707	.00787
165	29.5545	.2171	1.97974	1.02262	.04411	.01202
195	35.5380	.1818	.96520	.00000	.04961	.00827
225	41.5185	.2169	.00000	.00000	.04329	.00000
255	48.2220	.2300	.00000	.00000	.03023	.00000
Hole 3						
5	.9650	.1930	.00000	.07547	.54966	.03987
15	2.8670	.1874	.00000	.51056	7.21632	.41606
25	4.7395	.1871	.00000	.12740	11.63711	.33248
35	6.7070	.2064	.00000	.22914	2.77659	.88946
45	8.7320	.1986	.00000	.68240	.23498	.99301
55	10.6915	.1933	.00000	1.44834	.05000	.96555
75	15.0120	.2236	.00000	2.39872	.00000	.17371
105	22.0935	.2485	.00000	4.81896	.06811	.10406
135	29.3985	.2385	.00000	11.37448	.03513	.06819
165	36.1095	.2089	.44872	.39672	.00000	.00000
195	41.8425	.1733	1.40600	.07640	.00000	.00000
225	47.5725	.2087	.52896	.01015	.02538	.00000
255	54.2340	.2354	.00000	.06044	.00889	.00000

Plot 3, Low Concentration Mix

Depth (cm)	χ (cm)	θ	Tracer	Brom	Napr	Prom
			<-----------	($\mu g/cm^3$)	---------->	
Hole 1						
5	1.0055	.2011	.00000	.18460	.27768	.01706
15	3.0520	.2082	.00000	.35743	.32285	.07412
25	5.2395	.2293	.00000	.02405	.36560	.03047
35	7.6210	.2470	.00000	.02728	.94298	.04774
45	10.0330	.2354	.00000	.02008	.74485	.08704
55	12.4170	.2414	.00000	.02614	.21443	.07670
75	17.0425	.2279	.00000	.03059	.00000	.05775
105	24.4270	.2644	.00000	.18191	.00000	.04502
135	32.4865	.2729	.00000	.47629	.00000	.03000
165	40.3105	.2487	.04108	.79205	.00000	.00684
195	47.1730	.2088	.16264	.44994	.00000	.00334
225	53.4745	.2113	1.32544	.00000	.00000	.00000
255	59.8660	.2148	2.75120	.00000	.00000	.00000
Hole 2						
5	.9850	.1970	.00000	.02426	.45652	.02282
15	2.9455	.1951	.00000	.03747	.39821	.05153
25	4.9400	.2038	.00000	.02908	.23556	.07125
35	6.9990	.2080	.00000	.03248	.44400	.08843
45	9.1175	.2157	.00000	.05238	.10968	.10477
55	11.1960	.2000	.00000	.07318	.00000	.08432
75	15.6565	.2307	.00000	.09870	.00000	.08650
105	22.5865	.2313	.00000	1.69779	.00000	.06592
135	29.8645	.2539	.00000	2.81670	.00000	.00000
165	36.9835	.2207	.46452	.21896	.00000	.00000
195	42.8410	.1698	2.70864	.02396	.00000	.00000
225	49.3990	.2674	1.12024	.15341	.00000	.00000
255	56.7025	.2195	.00000	.03484	.00000	.00348
Hole 3						
5	.9525	.1905	.00000	.22912	.15895	.02864
15	2.8915	.1973	.00000	.02895	.12593	.01157
25	4.8645	.1973	.00000	.02988	.21201	.00854
35	6.9775	.2253	.00000	.06078	.55030	.01280
45	9.3225	.2437	.00000	.05461	.56786	.02184
55	11.6490	.2216	.00000	.02549	.22938	.01434
75	17.0725	.2877	.00000	.07902	.05330	.02389
105	25.7275	.2893	.00000	.16071	.00000	.03177
135	34.0345	.2645	.00000	.95925	.00000	.01210
165	41.2210	.2146	.19750	.60307	.00000	.01304
195	47.9575	.2345	.62168	.07035	.00000	.00000
225	55.3720	.2598	1.39992	.00000	.00000	.00000
255	63.3295	.2707	.53048	.31067	.14442	.03359

Plot 4, High Prometryn

Depth (cm)	χ (cm)	θ	Tracer	Brom	Napr	Prom
			<-----------($\mu g/cm^3$)---------->			
Hole 1						
5	1.0560	.2112	.00000	.03197	.04567	.12028
15	3.2140	.2204	.00000	.00000	.04515	.61709
25	5.4255	.2219	.00000	.00000	.00000	1.37604
35	7.7400	.2410	.00000	.00000	.00000	2.60163
45	10.2820	.2674	.00000	.01882	.00000	2.48891
55	12.9860	.2734	.00000	.04339	.00000	1.27294
75	18.2680	.2610	.00000	.00768	.00000	.43547
105	26.1475	.2643	.00000	.01097	.00000	.00731
135	33.2710	.2106	2.68796	.01907	.00000	.00348
165	40.3900	.2640	2.98462	.01288	.00000	.00368
195	47.2225	.1915	.00000	.01087	.00000	.00155
225	53.3275	.2155	.00000	.00000	.00000	.00000
255	60.5065	.2631	.00000	.02332	.00000	.00000
Hole 2						
5	1.1120	.2224	.00000	.00000	.02411	.04672
15	3.3955	.2343	.00000	.00000	.07490	.20132
25	5.6710	.2208	.00000	.00000	.04390	.50564
35	8.0180	.2486	.00000	.00000	.01510	1.06206
45	10.8235	.3125	.00000	.00000	.00000	1.34347
55	13.8490	.2926	.00000	.06448	.00000	.77013
75	19.6890	.2918	.00000	.10617	.00000	1.36918
105	28.7865	.3147	.00000	.15362	.00000	1.30281
135	37.7040	.2798	.41492	.18678	.00000	.06166
165	45.6315	.2487	2.64650	.01569	.00000	.04533
195	51.9480	.1724	1.04576	.00000	.00000	.00967
225	58.0200	.2324	.00000	.03037	.00000	.00894
255	65.1855	.2453	.00000	.01409	.00000	.00000
Hole 3						
5	1.0775	.2155	.00000	.01033	.00000	.18752
15	3.2065	.2103	.00000	.00000	.02911	.19307
25	5.3515	.2187	.00000	.01054	.00000	.37053
35	7.6555	.2421	.00000	.01437	.00000	.65480
45	10.0610	.2390	.00000	.01133	.02104	.50808
55	12.4310	.2350	.00000	.03509	.00000	.33579
75	17.8165	.2807	.00000	.02752	.00000	.10064
105	26.3770	.2900	.00000	.05436	.00000	.02438
135	34.5280	.2534	.00000	.01622	.00000	.00361
165	41.6260	.2198	.59092	.02007	.08570	.00730
195	48.3595	.2291	1.26008	.02718	.00000	.00000
225	54.4885	.1795	2.10064	.01363	.00000	.00000
255	61.0645	.2589	.85728	.00000	.00000	.00000

Plot 5, High Napropamide

Depth (cm)	χ (cm)	θ	Tracer	Brom	Napr	Prom
			<-----------	($\mu g/cm^3$)	----------->	
Hole 1						
5	1.1100	.2220	.00000	.00000	3.26532	.00336
15	3.3980	.2356	.00000	.00000	11.32139	.00000
25	5.7180	.2284	.00000	.00000	10.29482	.00000
35	8.1080	.2496	.00000	.00710	.99018	.00000
45	10.7350	.2758	.00000	.04181	.00000	.00726
55	13.8140	.3400	.00000	.01968	.00000	.00787
75	20.3980	.3256	.12474	.11525	.07820	.01440
105	29.9110	.3086	.60144	.00000	.00000	.00000
135	38.7805	.2827	2.74044	.00000	.00000	.00000
165	46.0975	.2051	1.49942	.00000	.00000	.00000
195	51.5710	.1598	.00000	.06948	.00000	.00150
225	56.7220	.1836	.00000	.01420	.00000	.00000
255	63.6730	.2798	.00000	.00000	.00000	.00000
Hole 2						
5	1.0915	.2183	.00000	.11094	.66711	.00289
15	3.3050	.2244	.00000	.13286	1.55205	.00000
25	5.5095	.2165	.00000	.03583	6.78903	.00448
35	7.7160	.2248	.00000	.04210	6.07368	.00312
45	10.1065	.2533	.00000	.00000	1.29253	.00000
55	12.6835	.2621	.00000	.03290	.00000	.00000
75	18.6905	.3131	.00000	.00000	.00000	.01440
105	27.3890	.2668	.00000	.01472	.00000	.00000
135	35.4335	.2695	.00000	.01307	.00000	.00374
165	43.1630	.2458	.20224	.00000	.00000	.00000
195	49.8005	.1967	2.24200	.00000	.00000	.00000
225	56.0840	.2222	2.01704	.00000	.00000	.00000
255	63.1790	.2508	.00000	.01024	.00000	.00000
Hole 3						
5	1.0880	.2176	.00000	.26165	.88368	.00823
15	3.3125	.2273	.00000	.03404	2.58193	.00972
25	5.6095	.2321	.00000	.08927	7.38624	.01434
35	7.9130	.2286	.00000	.00000	1.09309	.00000
45	10.1750	.2238	.00000	.19750	.04427	.00851
55	12.9980	.3408	.00000	.27310	.00000	.01232
75	19.1705	.2979	.00000	.24451	.00000	.00000
105	27.6200	.2654	.00000	.00380	.00000	.00190
135	35.5400	.2626	.00000	.00956	.00000	.00000
165	42.5405	.2041	.63042	.00000	.00000	.00000
195	47.5145	.1275	3.22088	.00000	.00000	.00000
225	51.9140	.1658	.65816	.00503	.00000	.00000
255	58.1540	.2502	.00000	.00000	.00000	.00000

Plot 6, Low Concentration Mix

Depth	χ	θ	Tracer	Brom	Napr	Prom
(cm)	(cm)		<-----------($\mu g/cm^3$)----------->			
Hole 1						
5	1.0745	.2149	.00000	.02423	.41844	.02586
15	3.2870	.2276	.00000	.04322	2.35462	.10724
25	5.5890	.2328	.00000	.10521	.91588	.20698
35	8.1145	.2723	.00000	1.23858	.00000	.09093
45	10.8640	.2776	.00000	2.00467	.00000	.02259
55	13.6830	.2862	.00000	1.70990	.00000	.00000
75	19.7475	.3089	.00000	2.18041	.00000	.00376
105	27.7875	.2271	.74088	.00000	.00000	.00000
135	35.1765	.2655	1.58916	.00000	.00000	.00000
165	42.4515	.2195	.05530	.00000	.00000	.00000
195	48.0315	.1525	.00000	.00000	.00000	.00000
225	52.0260	.1138	.00000	.00000	.00000	.00000
255	57.5775	.2563	.00000	.00000	.00000	.00000
Hole 2						
5	1.0760	.2152	.00000	.01504	.55814	.04663
15	3.2800	.2256	.00000	.03441	.74443	.14858
25	5.4380	.2060	.00000	.17381	.24765	.22304
35	7.6950	.2454	.00000	.35490	.02261	.15830
45	10.2965	.2749	.00000	.83486	.08226	.03675
55	13.1605	.2979	.00000	.65290	.00000	.01155
75	19.3060	.3104	.00000	2.13401	.00000	.00000
105	26.9380	.1984	.00000	1.32371	.00000	.01068
135	33.5470	.2422	.83968	.07206	.00000	.00369
165	39.8485	.1779	2.72866	.00665	.00000	.00000
195	44.5255	.1339	.68248	.00632	.00000	.00000
225	48.1180	.1056	1.07464	.00988	.00000	.00000
255	53.5645	.2575	.00000	.00860	.00000	.00345
Hole 3						
5	1.1425	.2285	.00000	.03857	.31656	.03857
15	3.4660	.2362	.00000	.04424	.50551	.12321
25	5.9330	.2572	.00000	.06194	.30479	.13039
35	8.7230	.3008	.00000	.20078	.23138	.14915
45	11.6285	.2803	.00000	.35658	.00000	.14902
55	14.4380	.2816	.00000	.60045	.00000	.11411
75	20.6430	.3198	.00000	1.74476	.00000	.02710
105	29.4645	.2683	.00000	2.18071	.00000	.00380
135	38.4285	.3293	.51168	.68176	.00000	.01278
165	45.6795	.1541	2.48692	.04501	.00000	.00000
195	50.0340	.1362	.78888	.00000	.00000	.00000
225	55.9650	.2592	.25232	.06145	.00000	.00351
255	63.8265	.2649	.00000	.00585	.00000	.00000

Plot 7, High Napropamide

Depth	χ	θ	Tracer	Brom	Napr	Prom
(cm)	(cm)		<-----------	($\mu g/cm^3$)	---------->	
Hole 1						
5	1.0695	.2139	.00000	.01692	2.44526	.00000
15	3.2720	.2266	.00000	.07807	3.52569	.00000
25	5.5625	.2315	.00000	.28150	.00000	.00000
35	7.8310	.2222	.00000	.42322	.00000	.00000
45	10.1475	.2411	.24480	.42088	.00000	.00000
55	12.5770	.2448	1.01600	.35062	.00000	.00000
75	17.8840	.2722	1.58274	.20198	.00000	.00000
105	26.1295	.2775	6.67632	.00000	.00000	.00388
135	34.4020	.2740	2.44688	.00000	.00000	.00000
165	41.0575	.1697	.00000	.00000	.00000	.00477
195	45.5935	.1327	.00000	.00000	.00000	.00000
225	50.1175	.1689	.00000	.00000	.00000	.00655
255	56.4475	.2531	.00000	.00000	.03791	.00000
Hole 2						
5	1.1315	.2263	.00000	.00000	1.91798	.00956
15	3.4980	.2470	.00000	.88380	15.69861	.01095
25	6.0065	.2547	.00000	.96773	8.27009	.02469
35	8.6030	.2646	.00000	.01626	5.54149	.00000
45	11.4460	.3040	.00000	.01194	4.95338	.00000
55	14.7430	.3554	.00000	.01522	1.18304	.00000
75	21.3920	.3248	.00000	.15252	.07731	.00000
105	30.3335	.2713	.00000	.05425	.00000	.00701
135	38.3780	.2650	.00000	.01704	.00000	.00000
165	44.3765	.1349	.12008	.01305	.00000	.00000
195	48.2240	.1216	1.06856	.01107	.00000	.00000
225	52.8815	.1889	1.64160	.00853	.00000	.00000
255	59.1260	.2274	2.52168	.00990	.00000	.00000
Hole 3						
5	1.0390	.2078	.00000	.17020	1.66596	.01587
15	3.1785	.2201	.00000	.17027	2.75617	.01909
25	5.4025	.2247	.00000	.08957	1.38531	.01080
35	7.9950	.2938	.00000	.09787	.09450	.01181
45	11.0785	.3229	.00000	.04027	.02094	.00483
55	13.9905	.2595	.00000	.04826	.00000	.00357
75	19.2300	.2628	.00000	.04694	.01841	.00235
105	27.7080	.3024	.33768	.00000	.00000	.00383
135	36.3330	.2726	2.42228	.00000	.00000	.00595
165	42.8535	.1621	.21172	.00000	.00000	.00329
195	47.0205	.1157	.00000	.00863	.00000	.00000
225	50.6805	.1283	.00000	.00000	.00000	.00000
255	56.0610	.2304	.00000	.00000	.00000	.00000

Plot 8, High Bromacil

Depth (cm)	χ (cm)	θ	Tracer	Brom	Napr	Prom
			<-----------	($\mu g/cm^3$)	---------->	
Hole 1						
5	1.1150	.2230	.00000	.38684	.02729	.00160
15	3.3290	.2198	.00000	6.79160	.01693	.00169
25	5.6535	.2451	.00000	7.97243	.03027	.00000
35	8.2670	.2776	.00000	15.25366	.03672	.00000
45	10.9630	.2616	.00000	20.03171	.02262	.00000
55	13.8340	.3126	.00000	14.02194	.02589	.00000
75	19.8385	.2961	.00000	12.10931	.03404	.00000
105	27.9490	.2446	.00000	14.23037	.00000	.01504
135	35.1400	.2348	.31652	3.41727	.00000	.00677
165	41.3800	.1812	.88322	.06432	.00000	.00338
195	46.0660	.1312	.00000	.02023	.00000	.00622
225	51.4720	.2292	.00000	.00000	.00000	.00000
255	58.5535	.2429	.00000	.01836	.00000	.01002
Hole 2						
5	1.0840	.2168	.00000	.25283	.11767	.00477
15	3.3240	.2312	.00000	.89145	.08025	.00438
25	5.5820	.2204	.00000	1.65804	.00000	.00000
35	7.8480	.2328	.00000	4.31280	.00000	.00000
45	10.2530	.2482	.00000	5.45787	.00000	.00709
55	12.6950	.2402	.00000	14.55861	.00000	.00000
75	18.4155	.3013	.00000	10.80852	.00000	.00694
105	26.5440	.2406	1.18104	2.12229	.00000	.00000
135	34.3740	.2814	2.60760	.27490	.00000	.00382
165	41.0805	.1657	1.68586	.02522	.03868	.00167
195	45.9525	.1591	1.22968	.00000	.01503	.00000
225	52.0935	.2503	.58976	.00000	.00000	.00000
255	59.7060	.2572	.00000	.00000	.03944	.00000
Hole 3						
5	1.0900	.2180	.00000	.08671	.08190	.00482
15	3.2735	.2187	.00000	.33105	.03733	.00324
25	5.4600	.2186	.00000	.74995	.00000	.00333
35	7.7290	.2352	.00000	4.63029	.00000	.00000
45	10.1560	.2502	.00000	3.05458	.00000	.00000
55	12.8100	.2806	.00000	.86522	.00000	.00000
75	18.3875	.2783	.00000	5.53492	.00000	.00000
105	27.0950	.3022	.29904	6.03557	.16056	.03370
135	35.4650	.2558	.35916	3.63298	.02944	.00786
165	41.6300	.1552	.64938	.31230	.00000	.00490
195	45.2090	.0834	.78888	.04124	.00000	.00147
225	49.8305	.2247	.74784	.00000	.00000	.00181
255	56.9795	.2519	.00000	.03288	.00000	.00328

Plot 10, High Napropamide

Depth (cm)	χ (cm)	θ	Tracer	Brom	Napr	Prom
			<-----------($\mu g/cm^3$)----------->			
Hole 1						
5	1.0380	.2076	.00000	.01258	.57066	.00157
15	3.0900	.2028	.00000	.00000	8.68100	.00295
25	5.2615	.2315	.00000	.00000	4.42588	.00000
35	7.6700	.2502	.00000	.05430	.25053	.00000
45	10.2850	.2728	.00000	.07429	.02653	.00000
55	13.1780	.3058	.00000	.05627	.01814	.00363
75	19.2310	.3016	.00000	.03660	.65305	.00386
105	27.8050	.2700	.37632	.02040	.00000	.00371
135	35.9020	.2698	2.05984	.01105	.00000	.00000
165	42.6100	.1774	.34444	.02812	.00000	.00000
195	46.9405	.1113	.00000	.10137	.00000	.00000
225	50.9740	.1576	.00000	.09242	.00000	.00319
255	56.7445	.2271	.00000	.07682	.00000	.00000
Hole 2						
5	1.1135	.2227	.00000	.00000	.12555	.00000
15	3.3510	.2248	.00000	.00000	.50835	.00734
25	5.6175	.2285	.00000	.01120	1.35498	.00000
35	8.2410	.2962	.00000	.03574	.11747	.00000
45	11.2380	.3032	.00000	.03342	.00000	.00000
55	14.5765	.3645	.00000	.02595	.00000	.00000
75	20.9920	.3062	.00000	.03005	.00000	.00000
105	29.1715	.2391	.29904	.01035	.00000	.00000
135	36.5680	.2540	1.51536	.00000	.00000	.00000
165	43.1965	.1879	1.84702	.00000	.00000	.00000
195	48.7720	.1838	.07752	.00000	.00000	.00000
225	54.0910	.1708	.00000	.00000	.00000	.00000
255	60.6265	.2649	.00000	.00000	.00000	.00000
Hole 3						
5	.8275	.1655	.00000	.05559	1.01272	.00601
15	2.7360	.2162	.00000	.01177	6.09609	.00147
25	4.9775	.2321	.00000	.02165	7.73861	.04484
35	7.4790	.2682	.00000	.00000	4.79467	.05141
45	10.1370	.2634	.00000	.00000	1.35837	.03749
55	12.8650	.2822	.00000	.00000	.62552	.04826
75	18.5945	.2879	.00000	.00000	.68834	.03622
105	26.9345	.2681	.00000	.01342	.14567	.03642
135	35.0000	.2696	.00000	.08743	.09325	.00000
165	41.8400	.1864	.14852	.06431	.00000	.00000
195	46.5005	.1243	.00000	.03087	.07615	.00000
225	50.0570	.1128	.00000	.00000	.00000	.00000
255	54.4400	.1794	.29792	.00000	.00000	.00509

Plot 11, High Bromacil

Depth	χ	θ	Tracer	Brom	Napr	Prom
(cm)	(cm)		<-----------(μg/cm^3)---------->			
Hole 1						
5	1.0685	.2137	.00000	3.36861	.17001	.01714
15	3.2410	.2208	.00000	7.79726	.02301	.00614
25	5.5090	.2328	.03996	8.41383	.01471	.00295
35	7.9635	.2581	.00000	7.08014	.00971	.00162
45	10.7150	.2922	.04160	10.87699	.02432	.00749
55	13.5335	.2715	.54880	15.28534	.01235	.00354
75	19.1855	.2863	1.18260	13.06864	.00000	.00000
105	27.1520	.2448	2.07816	4.42835	.00000	.00000
135	34.3745	.2367	.84624	.32100	.04726	.00984
165	40.3655	.1627	.00000	.00000	.01891	.00172
195	44.6600	.1236	.00000	.00000	.01742	.00158
225	48.4295	.1277	.00000	.00000	.02289	.00000
255	52.3010	.1304	.00000	.00000	.03096	.00163
Hole 2						
5	.9330	.1866	.00000	.19709	.09219	.00795
15	2.9345	.2137	.00000	.16699	.04814	.00451
25	5.0020	.1998	.00000	.25308	.00000	.00943
35	7.0400	.2078	.00000	.70842	.00000	.00162
45	9.1620	.2166	.00000	1.58234	.00000	.00000
55	11.4160	.2342	.00000	4.32891	.00000	.00170
75	16.1300	.2362	.00000	8.58679	.00000	.00000
105	23.4005	.2485	.00000	12.79965	.00000	.00000
135	30.8960	.2512	.28372	3.64075	.00000	.10330
165	37.3940	.1820	1.39514	.10426	.00000	.03534
195	42.0575	.1289	.25992	.02490	.00000	.00312
225	46.4735	.1655	.00000	.11324	.00000	.00000
255	53.0075	.2701	.00000	.02348	.00000	.00000
Hole 3						
5	1.0510	.2102	.00000	.10073	.15652	.00465
15	3.2320	.2260	.00000	.26322	.17391	.00471
25	5.4000	.2076	.00000	2.60387	.00000	.00764
35	7.6235	.2371	.00000	1.82242	.00000	.00165
45	10.0320	.2446	.00000	3.12747	.00000	.00490
55	12.3950	.2280	.00000	5.10469	.00000	.00333
75	17.2820	.2498	.00000	14.94202	.09577	.00000
105	25.0385	.2673	.21504	18.73714	.21843	.00000
135	32.9720	.2616	1.29888	3.46566	.00000	.00384
165	40.1240	.2152	1.46940	.01826	.00000	.00332
195	45.8810	.1686	.22040	.10015	.00000	.00000
225	50.4530	.1362	.00000	.01292	.00000	.00000
255	54.7235	.1485	.00000	.00000	.00000	.00000

Plot 12, High Prometryn

Depth (cm)	χ (cm)	θ	Tracer	Brom	Napr	Prom
			<-----------	($\mu g/cm^3$)		---------->
Hole 1						
5	1.1280	.2256	.00000	.00000	.12996	.12044
15	3.4380	.2364	.00000	.00996	.35020	.62074
25	5.7870	.2334	.00000	.01128	.17246	.96384
35	8.2925	.2677	.00000	.03070	.00000	1.95186
45	11.1175	.2973	.00000	.02307	.00000	1.55950
55	14.2090	.3210	.00000	.05106	.00000	1.63941
75	20.5240	.3140	.00000	.13569	.00000	.79824
105	29.2390	.2670	.00000	.26599	.06080	.04370
135	37.0330	.2526	.00000	.04715	.00000	.00362
165	44.2915	.2313	.39500	.06309	.00000	.01928
195	49.8790	.1412	2.34080	.06048	.00000	.01395
225	53.8945	.1265	.15504	.03002	.00000	.00301
255	59.4040	.2408	.00000	.07311	.00000	.02380
Hole 2						
5	1.0175	.2035	.00000	.14667	.14226	.10706
15	3.0770	.2084	.00000	.05594	.09469	.11619
25	5.1735	.2109	.00000	.00000	.10264	.36211
35	7.3000	.2144	.00000	.00000	.00000	.98704
45	9.5560	.2368	.00000	.13614	.00000	1.58880
55	12.0330	.2586	.00000	.17224	.00000	1.17720
75	17.8920	.3044	.00000	.23569	.00000	.84779
105	26.7345	.2851	.00000	.33854	.00000	.11936
135	34.9815	.2647	.19188	.00000	.00000	.00766
165	42.6285	.2451	4.55040	.00000	.00000	.00525
195	48.5250	.1480	.13376	.00000	.00000	.01052
225	53.5350	.1860	.00000	.00000	.00000	.00611
255	60.3690	.2696	.00000	.00000	.00000	.00359
Hole 3						
5	1.0195	.2039	.00000	.00000	.18954	.07073
15	3.1185	.2159	.00000	.00000	.34699	.40170
25	5.2335	.2071	.00000	.00000	.45081	.61416
35	7.4745	.2411	.00000	.01563	.07507	1.21677
45	9.8680	.2376	.00000	.01701	.00000	1.53037
55	12.3970	.2682	.00000	.02107	.00000	1.16830
75	18.2755	.3025	.00000	.03696	.00000	.89696
105	27.1630	.2900	.00000	.04052	.00000	.05673
135	35.6650	.2768	.41000	.04000	.00000	.00600
165	43.4245	.2405	3.05888	.01777	.00000	.00356
195	49.1320	.1400	.74000			
225	53.8420	.1740	.00000	.01544	.00000	.00617
255	57.3250	.0582	.00000	.00000	.00000	.00000

Plot 13, High Concentration Mix

Depth	χ	θ	Tracer	Brom	Napr	Prom
(cm)	(cm)		<-----------(μg/cm^3)---------->			
Hole 1						
5	1.0820	.2164	.00000	.27775	4.16479	.26528
15	3.2550	.2182	.00000	.43873	10.70469	1.07361
25	5.4595	.2227	.00000	.89009	1.26111	2.59707
35	7.7860	.2426	.00000	1.61526	.12560	3.32752
45	10.2160	.2434	.00000	.99456	.01328	2.83256
55	12.8755	.2885	.00000	1.93264	.00710	1.41974
75	18.7700	.2968	.54594	14.65392	.00000	.74888
105	27.5030	.2854	5.71368	10.50212	.00000	.00192
135	35.6360	.2568	.89380	.21309	.00000	.00728
165	43.0505	.2375	.00000	.03026	.00000	.08067
195	49.7090	.2064	.00000	.29157	.00000	.06121
225	55.7765	.1981	.00000	.66547	.00000	.02572
255	62.5145	.2511	.00000	.18280	.00000	.04484
Hole 2						
5	.9915	.1983	.00000	.00000	2.57545	.16079
15	3.0220	.2078	.00000	.00000	6.85757	.57674
25	5.1250	.2128	.00000	.00000	5.57390	1.38969
35	7.2820	.2186	.00000	.48312	1.87826	1.77994
45	9.5125	.2275	.00000	.43677	.48605	2.38098
55	11.7930	.2286	.00000	.15090	.10115	1.33982
75	16.0095	.2049	.00000	.22380	.04701	1.02309
105	22.7070	.2416	.00000	.69266	.13526	1.02465
135	30.2430	.2608	.00000	8.71694	.08264	.49984
165	37.3800	.2150	1.18816	14.27544	.08807	.05121
195	43.5165	.1941	2.82416	.33861	.01844	.02683
225	49.4940	.2044	2.28456	.01996	.02177	.00725
255	56.0190	.2306	.00000	.02134	.05512	.02134
Hole 3						
5	1.0365	.2073	.00000	.00000	4.00757	.76528
15	3.1155	.2085	.00000	.39287	8.87642	2.59654
25	5.2185	.2121	.00000	.57460	3.51137	2.88696
35	7.1575	.1757	.00000	.85330	1.07464	4.85510
45	9.2705	.2469	.00000	3.68723	.02880	4.03968
55	11.8995	.2789	.00000	2.51787	.00000	2.80520
75	17.8555	.3041	.00000	5.07256	.00000	1.64283
105	27.4165	.3333	.00000	30.42023	.00000	.07624
135	36.6550	.2826	1.56456	7.11931	.00000	.00179
165	43.9630	.2046	3.30378	.06478	.00000	.00000
195	50.2120	.2120	.10488	.06016	.00000	.01503
225	57.1660	.2516	.00000	.06937	.00000	.00169
255	64.6015	.2441	.00000	.02297	.00000	.00492

Plot 14, Low Concentration Mix

Depth (cm)	χ (cm)	θ	Tracer	Brom	Napr	Prom
			<-----------(μg/cm^3)---------->			
Hole 1						
5	1.0765	.2153	.00000	.06895	.42253	.03228
15	3.1710	.2036	.00000	.11992	1.13136	.12308
25	5.2170	.2056	.00000	.14813	.32800	.22976
35	7.4220	.2354	.00000	.14069	.01438	.26539
45	9.7390	.2280	.00000	.14202	.00000	.17712
55	11.9255	.2093	.00000	.24245	.00000	.08874
75	16.6440	.2448	.00000	.96499	.00000	.16054
105	24.7155	.2933	.00000	2.46513	.00000	.14058
135	33.4035	.2859	1.31856	.15496	.00000	.00000
165	41.4930	.2534	4.09852	.04015	.00000	.03372
195	48.0300	.1824	.03496	.01040	.00000	.00149
225	54.9540	.2792	.00000	.00000	.00000	.00000
255	63.2625	.2747	.00000	.01155	.00000	.00000
Hole 2						
5	.9585	.1917	.00000	.05773	.33861	.02341
15	2.9265	.2019	.00000	.00000	1.15492	.02864
25	4.8630	.1854	.00000	.00000	1.61720	.04100
35	6.8030	.2026	.00000	.03946	.74314	.10851
45	8.8705	.2109	.00000	.44144	.08437	.14312
55	10.9410	.2032	.00000	.41210	.04122	.03386
75	14.6390	.1788	.00000	.54473	.00000	.08617
105	21.0590	.2492	.00000	1.50565	.00000	.08353
135	28.4060	.2406	.00000	1.81646	.00000	.02080
165	35.6630	.2432	.00000	.62100	.00000	.06265
195	42.2915	.1987	.26296	.03253	.00000	.03415
225	49.4405	.2779	1.85288	.00000	.00000	.00362
255	57.6110	.2668	.00000	.00000	.00000	.00733
Hole 3						
5	.8710	.1742	.00000	.01678	.20695	.00699
15	2.6795	.1875	.00000	.01912	.77984	.02184
25	4.5540	.1874	.00000	.02461	1.51848	.05230
35	6.4630	.1944	.00000	.03917	1.18581	.07362
45	8.4445	.2019	.00000	.00000	.38034	.05973
55	10.3980	.1888	.00000	.12307	.15096	.04758
75	14.0345	.1795	.00000	.11126	.08729	.04450
105	20.0735	.2231	.00000	.33078	.00000	.07022
135	27.0995	.2453	.00000	.21730	.00000	.05770
165	33.9020	.2082	.35708	.40742	.00000	.03814
195	39.6440	.1746	.24320	.09134	.00000	.01860
225	45.9155	.2435	2.07784	.00883	.00000	.00176
255	53.2115	.2429	1.27528	.00000	.00000	.00000

Plot 15, High Prometryn

Depth	χ	θ	Tracer	Brom	Napr	Prom
(cm)	(cm)		<-----------	(μg/cm^3)	---------->	
Hole 1						
5	.9515	.1903	.00000	.00000	.00000	.21404
15	2.9040	.2002	.00000	.00000	.00000	.62243
25	4.8425	.1875	.00000	.00000	.00000	1.21782
35	6.8305	.2101	.00000	.01573	.00000	2.17170
45	8.9210	.2080	.00000	.05658	.00000	.52216
55	10.8330	.1744	.00000	.04198	.00000	1.31450
75	14.1770	.1648	.00000	.02292	.00000	.36027
105	19.4255	.1851	.00000	.02009	.00000	.09381
135	25.7525	.2367	.15908	.03077	.00000	.01197
165	33.0590	.2504	1.53734	.06344	.00000	.03339
195	39.6785	.1909	2.78768	.00693	.00000	.03467
225	46.3085	.2511	1.86048	.00000	.00000	.00340
255	54.3770	.2868	.16720	.00000	.00000	.00000
Hole 2						
5	.9945	.1989	.00000	.00000	.02488	.05130
15	2.9275	.1877	.00000	.00000	.03024	.11338
25	4.8280	.1924	.00000	.00000	.03444	.39378
35	6.7845	.1989	.00000	.00000	.07517	.90208
45	8.7365	.1915	.00000	.00000	.05557	.62072
55	10.5995	.1811	.00000	.00000	.06811	.53878
75	14.0490	.1696	.00000	.00000	.07377	.68129
105	19.4055	.1875	.00000	.09324	.00000	.71427
135	25.4880	.2180	.00000	.09587	.00000	.17978
165	32.6355	.2585	.72996	.00000	.00000	.00662
195	39.5910	.2052	1.68416	.00000	.00000	.01072
225	45.4830	.1876	.62776	.00000	.00000	.00479
255	52.1280	.2554	.00000	.51186	.00000	.00511
Hole 3						
5	.9540	.1908	.00000	.00000	.06980	.06220
15	2.8870	.1958	.00000	.00000	.13085	.32353
25	4.7660	.1800	.00000	.00000	.06000	1.18282
35	6.6260	.1920	.00000	.04208	.00000	1.77350
45	8.6100	.2048	.00000	.00000	.00000	2.02221
55	10.6650	.2062	.00000	.00000	.00000	2.04152
75	14.1065	.1607	.00000	.00000	.00000	1.40334
105	19.0820	.1710	.00000	.13008	.00000	.64228
135	25.4420	.2530	.00000	.03275	.00000	.10822
165	32.5430	.2204	.90060	.03391	.00000	.07851
195	39.2420	.2262	1.94104	.00000	.00000	.00354
225	46.4285	.2529	5.26832	.00520	.00000	.00693
255	54.0380	.2544	2.81504	.19071	.00000	.00000

Plot 16, High Bromacil

Depth (cm)	χ (cm)	θ	Tracer	Brom	Napr	Prom
			<------------	($\mu g/cm^3$)	-----------	--->
Hole 1						
5	.8970	.1794	.00000	.04224	.00000	.00000
15	2.7000	.1812	.00000	.06229	.00000	.00000
25	4.5635	.1915	.00000	.21456	.00000	.00000
35	6.4955	.1949	.00000	1.21869	.00000	.00000
45	8.4700	.2000	.00000	2.64686	.00000	.00333
55	10.5310	.2122	.00000	3.48510	.00000	.00000
75	13.9095	.1545	.00000	4.23168	.00000	.00000
105	18.7245	.1665	.00000	6.82639	.00000	.00000
135	24.0510	.1886	.00000	12.16216	.03746	.00312
165	30.0315	.2101	.00000	5.97558	.10232	.02117
195	36.4110	.2152	.00000	.24966	.01895	.00474
225	42.6000	.1974	1.35432	.19889	.01765	.01283
255	48.5985	.2025	2.80744	.16022	.01550	.02067
Hole 2						
5	.9370	.1874	.00000	.23819	.05578	.00753
15	2.7895	.1831	.00000	.46956	.00000	.00144
25	4.5805	.1751	.00000	.43913	.00000	.00000
35	6.4030	.1894	.00000	.50048	.00000	.00000
45	8.3250	.1950	.00000	.74795	.00000	.00000
55	10.1930	.1786	.00000	1.50805	.00000	.00000
75	13.6855	.1733	.00000	2.03705	.00000	.00000
105	19.1095	.1883	.10416	8.57843	.00000	.00000
135	25.5925	.2439	2.44524	.40907	.00000	.00000
165	33.0550	.2536	.06478	.13231	.00000	.00000
195	40.1620	.2202	.11856	.01806	.00000	.06072
225	46.5970	.2088	.01064	.04437	.00000	.00170
255	53.3890	.2440	.04104	.00520	.00000	.00000
Hole 3						
5	.8460	.1692	.00000	.02248	.02698	.01049
15	2.5635	.1743	.00000	.04634	.06876	.02242
25	4.2825	.1695	.00000	.04153	.06154	.01999
35	6.0725	.1885	.00000	.04662	.03830	.01666
45	8.0125	.1995	.00000	.19389	.01907	.01112
55	9.9475	.1875	.00000	.15789	.00000	.00632
75	13.4320	.1698	.00000	.28316	.00000	.00303
105	18.9445	.1977	.00000	.55902	.00000	.00344
135	25.2925	.2255	.00000	.40462	.00000	.00172
165	33.0625	.2925	.00000	2.67112	.04991	.03882
195	41.5240	.2716	.00000	5.28686	.04777	.05513
225	49.5385	.2627	.00000	.41855	.01418	.00354
255	57.3670	.2592	.00000	.02315	.00000	.00000

APPENDIX J

Solute Recovery Data

TRACER RECOVERY

Plot, Hole	Tracer	M_A	M_R	% Recovery	M_F	% Recovery
1_1	*o*-TFMBA		244.44	122.2%	266.42	133.2%
1_2	*o*-TFMBA	200.00	116.35	58.2%		
1_3	*o*-TFMBA		304.79	152.4%	283.08	141.5%
2_1	PFBA		161.08	80.5%	87.41	43.7%
2_2	PFBA	200.00	171.86	85.9%	175.40	87.7%
2_3	PFBA		71.51	35.8%	72.29	36.1%
3_1	*o*-TFMBA		128.41	64.2%		
3_2	*o*-TFMBA	200.00	128.80	64.4%	131.11	65.6%
3_3	*o*-TFMBA		82.49	41.2%	79.03	39.5%
4_1	PFBA		170.18	85.1%	142.22	71.1%
4_2	PFBA	200.00	123.22	61.6%	124.20	62.1%
4_3	PFBA		144.27	72.1%	148.86	74.4%
5_1	*o*-TFMBA		148.98	74.5%	147.69	73.8%
5_2	*o*-TFMBA	200.00	133.84	66.9%	131.88	65.9%
5_3	*o*-TFMBA		135.28	67.6%	145.67	72.8%
6_1	PFBA		71.56	35.8%	72.62	36.3%
6_2	PFBA	200.00	159.76	79.9%	130.98	65.5%
6_3	PFBA		121.19	60.6%	115.23	57.6%
7_1	*o*-TFMBA		333.79	166.9%	331.67	165.8%
7_2	*o*-TFMBA	200.00	160.56	80.3%		
7_3	*o*-TFMBA		89.15	44.6%	89.97	45.0%
8_1	PFBA		35.99	18.0%	34.16	17.1%
8_2	PFBA	200.00	218.82	109.4%	219.44	109.7%
8_3	PFBA		85.33	42.7%	87.41	43.7%
10_1	2,6-DFBA		83.42	41.7%	83.54	41.8%
10_2	2,6-DFBA	200.00	112.17	56.1%	109.62	54.8%
10_3	2,6-DFBA		13.39	6.7%		
11_1	*m*-TFMBA		129.51	64.8%	132.06	66.0%
11_2	*m*-TFMBA	200.00	58.16	29.1%	59.25	29.6%
11_3	*m*-TFMBA		96.11	48.1%	95.97	48.0%
12_1	2,6-DFBA		86.73	43.4%	102.31	51.2%
12_2	2,6-DFBA	200.00	146.28	73.1%	168.81	84.4%
12_3	2,6-DFBA		126.27	63.1%	126.21	63.1%
13_1	*m*-TFMBA		214.60	107.3%	212.28	106.1%
13_2	*m*-TFMBA	200.00	188.91	94.5%	196.51	98.3%
13_3	*m*-TFMBA		149.20	74.6%	149.15	74.6%
14_1	2,6-DFBA		163.56	81.8%	165.64	82.8%
14_2	2,6-DFBA	200.00	63.48	31.7%	93.16	46.6%
14_3	2,6-DFBA		118.60	59.3%	109.97	55.0%
15_1	*m*-TFMBA		195.35	97.7%	200.04	100.0%
15_2	*m*-TFMBA	200.00	91.26	45.6%	92.70	46.3%
15_3	*m*-TFMBA		327.75	163.9%	319.42	159.7%
16_1	2,6-DFBA		124.85	62.4%		
16_2	2,6-DFBA	200.00	83.53	41.8%	79.38	39.7%
16_3	2,6-DFBA		0.00	0.0%		
	Average Recovery:			67.9%		70.7%
	CV:			52.7%		49.1%

BROMACIL RECOVERY

Plot, Hole	Herbicide Treatment	M_A	M_R	%Rec
1_1	High Concentration Mix		869.18	120.5%
1_2	High Concentration Mix	721.38	1404.77	194.7%
1_3	High Concentration Mix		274.38	38.0%
2_1	High Concentration Mix		606.13	84.9%
2_2	High Concentration Mix	713.94	975.16	136.6%
2_3	High Concentration Mix		604.81	84.7%
3_1	Low Concentration Mix		64.32	77.5%
3_2	Low Concentration Mix	82.98	153.82	185.4%
3_3	Low Concentration Mix		69.78	84.1%
4_1	High Prometryn		3.49	
4_2	High Prometryn	0.00	15.85	
4_3	High Prometryn		5.59	
5_1	High Napropamide		6.65	
5_2	High Napropamide	0.00	4.69	
5_3	High Napropamide		16.44	
6_1	Low Concentration Mix		116.67	165.8%
6_2	Low Concentration Mix	70.38	127.50	181.2%
6_3	Low Concentration Mix		154.61	219.7%
7_1	High Napropamide		21.77	
7_2	High Napropamide	0.00	26.94	
7_3	High Napropamide		7.83	
8_1	High Bromacil		1540.38	222.4%
8_2	High Bromacil	692.46	668.24	96.5%
8_3	High Bromacil		564.87	81.6%
10_1	High Napropamide		12.98	
10_2	High Napropamide	0.00	2.28	
10_3	High Napropamide		6.77	
11_1	High Bromacil		1062.76	145.1%
11_2	High Bromacil	732.27	831.16	113.5%
11_3	High Bromacil		1248.51	170.5%
12_1	High Prometryn		21.53	
12_2	High Prometryn	0.00	22.34	
12_3	High Prometryn		5.06	
13_1	High Concentration Mix		857.67	125.8%
13_2	High Concentration Mix	681.50	739.37	108.5%
13_3	High Concentration Mix		1365.14	200.3%
14_1	Low Concentration Mix		118.04	149.4%
14_2	Low Concentration Mix	79.02	145.12	183.7%
14_3	Low Concentration Mix		37.24	47.1%
15_1	High Prometryn		5.47	
15_2	High Prometryn	0.00	21.03	
15_3	High Prometryn		12.20	
16_1	High Bromacil		970.83	114.6%
16_2	High Bromacil	846.97	375.77	44.4%
16_3	High Bromacil		294.48	34.8%
	Average Recovery:			126.3%
	CV:			44.6%

NAPROPAMIDE RECOVERY

Plot, Hole	Herbicide Treatment	M_A	M_R	%Rec
1_1	High Concentration Mix		333.94	84.0%
1_2	High Concentration Mix	397.69	616.04	154.9%
1_3	High Concentration Mix		161.24	40.5%
2_1	High Concentration Mix		146.98	32.3%
2_2	High Concentration Mix	455.25	166.23	36.5%
2_3	High Concentration Mix		228.77	50.3%
3_1	Low Concentration Mix		28.68	95.4%
3_2	Low Concentration Mix	30.06	16.44	54.7%
3_3	Low Concentration Mix		24.38	81.1%
4_1	High Prometryn		0.91	
4_2	High Prometryn	0.00	1.58	
4_3	High Prometryn		3.07	
5_1	High Napropamide		261.06	62.2%
5_2	High Napropamide	419.80	163.74	39.0%
5_3	High Napropamide		119.89	28.6%
6_1	Low Concentration Mix		36.89	140.1%
6_2	Low Concentration Mix	26.34	16.55	62.8%
6_3	Low Concentration Mix		13.58	51.6%
7_1	High Napropamide		60.85	15.7%
7_2	High Napropamide	387.28	377.97	97.6%
7_3	High Napropamide		59.78	15.4%
8_1	High Bromacil		2.62	
8_2	High Bromacil	0.00	4.77	
8_3	High Bromacil		6.89	
10_1	High Napropamide		159.32	39.5%
10_2	High Napropamide	403.41	21.06	5.2%
10_3	High Napropamide		246.36	61.1%
11_1	High Bromacil		6.66	
11_2	High Bromacil	0.00	1.40	
11_3	High Bromacil		12.73	
12_1	High Prometryn		8.35	
12_2	High Prometryn	0.00	3.40	
12_3	High Prometryn		10.62	
13_1	High Concentration Mix		162.77	44.5%
13_2	High Concentration Mix	366.10	188.17	51.4%
13_3	High Concentration Mix		174.99	47.8%
14_1	Low Concentration Mix		18.96	68.3%
14_2	Low Concentration Mix	27.78	39.79	143.3%
14_3	Low Concentration Mix		44.84	161.4%
15_1	High Prometryn		0.00	
15_2	High Prometryn	0.00	5.10	
15_3	High Prometryn		2.61	
16_1	High Bromacil		5.76	
16_2	High Bromacil	0.00	0.56	
16_3	High Bromacil		5.50	
	Average Recovery:			65.4%
	CV:			64.9%

PROMETRYN RECOVERY

Plot, Hole	Herbicide Treatment	M_A	M_R	%Rec
1_1	High Concentration Mix		90.11	82.5%
1_2	High Concentration Mix	109.26	87.12	79.7%
1_3	High Concentration Mix		112.16	102.6%
2_1	High Concentration Mix		96.87	91.2%
2_2	High Concentration Mix	106.20	65.27	61.5%
2_3	High Concentration Mix		46.74	44.0%
3_1	Low Concentration Mix		7.62	69.0%
3_2	Low Concentration Mix	11.04	8.91	80.7%
3_3	Low Concentration Mix		4.41	39.9%
4_1	High Prometryn		98.31	86.5%
4_2	High Prometryn	113.61	123.22	108.5%
4_3	High Prometryn		26.58	23.4%
5_1	High Napropamide		0.66	
5_2	High Napropamide	0.00	0.65	
5_3	High Napropamide		0.59	
6_1	Low Concentration Mix		4.65	49.2%
6_2	Low Concentration Mix	9.45	6.78	71.8%
6_3	Low Concentration Mix		8.46	89.5%
7_1	High Napropamide		0.46	
7_2	High Napropamide	0.00	0.66	
7_3	High Napropamide		1.12	
8_1	High Bromacil		1.28	
8_2	High Bromacil	0.00	0.54	
8_3	High Bromacil		1.70	
10_1	High Napropamide		0.40	
10_2	High Napropamide	0.00	0.07	
10_3	High Napropamide		4.23	
11_1	High Bromacil		0.83	
11_2	High Bromacil	0.00	4.50	
11_3	High Bromacil		0.48	
12_1	High Prometryn		95.73	72.8%
12_2	High Prometryn	131.55	73.39	55.8%
12_3	High Prometryn		79.10	60.1%
13_1	High Concentration Mix		144.27	142.7%
13_2	High Concentration Mix	101.09	155.91	154.2%
13_3	High Concentration Mix		231.76	229.3%
14_1	Low Concentration Mix		19.25	182.2%
14_2	Low Concentration Mix	10.57	12.73	120.5%
14_3	Low Concentration Mix		9.55	90.3%
15_1	High Prometryn		76.75	67.4%
15_2	High Prometryn	113.81	74.28	65.3%
15_3	High Prometryn		141.34	124.2%
16_1	High Bromacil		1.91	
16_2	High Bromacil	0.00	1.96	
16_3	High Bromacil		4.04	
	Average Recovery:			90.6%
	CV:			50.1%

APPENDIX K

Development of the Volumetric Coordinate System

The goal of this derivation is to develop a version of the ADE for a soil with variable θ. Let us begin with the 1-dimensional advection-dispersion equation for steady-state flow in a heterogeneous medium:

$$\theta R\frac{\partial C}{\partial t} = \frac{\partial\left(\theta D(\theta)\frac{\partial C}{\partial z}\right)}{\partial z} - q\frac{\partial C}{\partial z} \qquad \text{(K-1)}$$

where:

θ = Volumetric water content [ ]

R = Retardation factor [ ]

C = Concentration [M/L^3]

t = Time [T]

z = Spatial coordinate, here, depth measured downwards [L]

D = Dispersion coefficient [L^2/T]

q = Darcy velocity (specific flux) [L/T]

Define the new volumetric coordinate χ:

$$\chi(z_i) = \int_0^{z_i}\theta(z)\,dz \qquad \text{(K-2)}$$

where:

χ = Volumetric coordinate, corresponding to z_i [L]

$\theta(z)$ = Volumetric water content at depth z [ ]

Notice that χ represents the amount of soil water from the surface to depth z.

From the definition of χ, it follows that:

$$\frac{d\chi}{dz} = \theta(z) \tag{K-3}$$

and

$$dz = \frac{d\chi}{\theta} \tag{K-4}$$

Substitute equation K-4 into K-1 and divide through by θ:

$$R\frac{\partial C}{\partial t} = \frac{\partial\left(\theta^2 D(\theta)\frac{\partial C}{\partial \chi}\right)}{\partial \chi} - q\frac{\partial C}{\partial \chi} \tag{K-5}$$

To proceed further, we need to describe the relationship between D and θ. Let us assume that:

$$\alpha = \frac{\delta}{\theta} \tag{K-6}$$

where the dispersivity α is defined as usual:

$$\alpha = \frac{D}{v} = \frac{\theta D}{q} \tag{K-7}$$

and

α = Dispersivity [L]

δ = Volumetric dispersivity [L]

v = Velocity [L/T]

Note that although both α and D may vary in space, δ is assumed constant.

Set equation K-6 equal to K-7, and rearrange:

$$\theta^2 D = \delta q \qquad \text{(K-8)}$$

Substitute K-8 into K-5:

$$R\frac{\partial C}{\partial t} = \frac{\partial\left(\delta q \frac{\partial C}{\partial \chi}\right)}{\partial \chi} - q\frac{\partial C}{\partial \chi} \qquad \text{(K-9)}$$

δ is constant by definition, and q is constant in steady state, so δq can be moved outside the partial derivative:

$$R\frac{\partial C}{\partial t} = \delta q \frac{\partial^2 C}{\partial \chi^2} - q\frac{\partial C}{\partial \chi} \qquad \text{(K-10)}$$

It is apparent that equation K-10, the volumetric coordinate ADE, is mathematically identical to equation K-11, the standard spatial coordinate (homogeneous soil) ADE

$$R\frac{\partial C}{\partial t} = D\frac{\partial^2 C}{\partial z^2} - v\frac{\partial C}{\partial z} \qquad \text{(K-11)}$$

with the following substitutions:

Spatial Coordinates	Volumetric Coordinates
z	χ
v	q
D	δq

Therefore, CXTFIT can be used to fit observed profiles to the volumetric ADE, provided these substitutions are consistently performed.

APPENDIX L

Example CXTFIT Output - Run 1 (Equilibrium Model)

This is a sample output from CXTFIT's equilibrium mode. Compare the correlation matrix, standard errors (S.E.COEFF.) and confidence limits with those produced using the nonequilibrium mode (appendix S).

```
*********************************************************************************
*                                                                               *
*          ONE-DIMENSIONAL CONVECTION-DISPERSION EQ. SOLUTION                   *
*          NON-LINEAR LEAST-SQUARES ANALYSIS                                    *
*                                                                               *
*          DETERMINISTIC LINEAR EQUILIBRIUM ADSORPTION FOR PULSE INJECTION      *
*          WITH FIRST- AND ZERO-ORDER PRODUCTION AND DECAY                      *
*          SOLUTION FOR RESIDENT CONCENTRATIONS                                 *
*                                                                               *
*          Plot  1, Hole 1, High Concentration Mix: TRACER data                 *
*    (UNITS: CENTIMETERS, DAYS, MICROGRAMS) - Spatial Coordinates               *
*                                                                               *
*********************************************************************************

INITIAL VALUES OF COEFFICIENTS
==============================
 NAME           INITIAL VALUE
V.........        3.0000
D.........        1.0000
R.........        1.0000
TO........       14.0000
RX1.......         .0100
RXO.......         .0000
CI........         .0000
CO........        5.2200


OBSERVED DATA
=============
OBS. NO.     CONCENT RATION      DISTANCE         TIME
    1             .0000           5.0000        68.0000
    2             .0000          15.0000        68.0000
    3             .0000          25.0000        68.0000
    4             .0000          35.0000        68.0000
    5             .0000          45.0000        68.0000
    6             .0000          55.0000        68.0000
    7             .0000          75.0000        68.0000
    8             .0000         105.0000        68.0000
    9             .4231         135.0000        68.0000
   10             .2038         165.0000        68.0000
   11             .7220         195.0000        68.0000
   12            5.1148         225.0000        68.0000
   13            1.6842         255.0000        68.0000


ITERATION       SSQ            V.....       D.....        RX1...
    0        32.809443        3.00000      1.00000        .01000
    1        25.018294        3.05651      4.23634        .01154
    2        11.935516        3.72285     25.03075        .00093
    3         9.913088        3.79548     18.80667        .00008
    4         9.756949        3.79772     18.32846        .00002
    5         9.719504        3.79820     18.21397        .00000
    6         9.714867        3.79825     18.19984        .00000
    7         5.791642        3.72976      7.16286        .00027
    8         3.918545        3.74282      4.48429        .00016
    9         2.673283        3.74155      2.94666        .00034
   10         1.191444        3.73583      1.27277        .00150
   11          .456839        3.72175       .24989        .00192
   12          .222364        3.71196       .25093        .00027
   13          .220581        3.71291       .24068        .00034
   14          .220573        3.71292       .24160        .00034
   15          .220573        3.71292       .24161        .00034
```

```
CORRELATION MATRIX
==================
        1          2          3
  1   1.0000
  2   -.1224     1.0000
  3    .2288      .2482     1.0000

RSQUARE FOR REGRESSION = .99104549


NON-LINEAR LEAST SQUARES ANALYSIS, FINAL RESULTS
================================================

                                                         95% CONFIDENCE LIMITS
VARIABLE     NAME         VALUE        S.E.COEFF.   T-VALUE    LOWER          UPPER
   1        V.....       3.71292         .00614     604.96     3.69924        3.72659
   2        D.....        .24161         .05137       4.70      .12715         .35607
   3        RX1...        .00034         .00048        .70    -.00073         .00140

-----------------------ORDERED BY COMPUTER INPUT-----------------------
                                          CONCENTRATION             RESI-
NO      DISTANCE        TIME        OBS          FITTED           DUAL
1         5.0000      68.0000      .0000          .0000           .0000
2        15.0000      68.0000      .0000          .0000           .0000
3        25.0000      68.0000      .0000          .0000           .0000
4        35.0000      68.0000      .0000          .0000           .0000
5        45.0000      68.0000      .0000          .0000           .0000
6        55.0000      68.0000      .0000          .0000           .0000
7        75.0000      68.0000      .0000          .0000           .0000
8       105.0000      68.0000      .0000          .0000           .0000
9       135.0000      68.0000      .4231          .0000           .4231
10      165.0000      68.0000      .2038          .0000           .2038
11      195.0000      68.0000      .7220          .7220           .0000
12      225.0000      68.0000     5.1148         5.1148           .0000
13      255.0000      68.0000     1.6842         1.6842           .0000

---------------------------ORDERED BY RESIDUAL---------------------------
                                          CONCENTRATION             RESI-
NO      DISTANCE        TIME        OBS          FITTED           DUAL
9       135.0000      68.0000      .4231          .0000           .4231
10      165.0000      68.0000      .2038          .0000           .2038
11      195.0000      68.0000      .7220          .7220           .0000
2        15.0000      68.0000      .0000          .0000           .0000
1         5.0000      68.0000      .0000          .0000           .0000
3        25.0000      68.0000      .0000          .0000           .0000
4        35.0000      68.0000      .0000          .0000           .0000
7        75.0000      68.0000      .0000          .0000           .0000
8       105.0000      68.0000      .0000          .0000           .0000
6        55.0000      68.0000      .0000          .0000           .0000
5        45.0000      68.0000      .0000          .0000           .0000
12      225.0000      68.0000     5.1148         5.1148           .0000
13      255.0000      68.0000     1.6842         1.6842           .0000
```

APPENDIX M

CXTFIT-Fitted Parameters - Runs 1 & 3 (Equilibrium Model)

Fitted Tracer Parameters -- CXTFIT Run 1

Plot, Hole	SSQ	C_0	v (cm/day)	D (cm^2/day)	μ (/day)
1,1	0.2206	5.2200	3.7129	0.2416	0.0003
1,2					
1,3	0.9035	6.0500	3.3282	0.6950	0.0001
2,1	0.0000	2.4100	2.6224	1.3787	0.0002
2,2	0.1751	5.1900	2.4436	5.7023	0.0002
2,3	0.0002	1.6300	3.2067	1.7824	0.0002
3,1					
3,2	0.0001	2.9100	3.2578	1.1301	0.0002
3,3	0.0336	1.5700	3.6619	2.0508	0.0003
4,1	0.0000	4.1400	2.4688	0.1728	0.0001
4,2	0.0004	3.2400	2.7716	1.5666	0.0002
4,3	0.1338	2.9900	3.5778	5.4999	0.0001
5,1	0.0259	4.6400	2.3015	2.7895	0.0002
5,2	0.0197	2.7900	3.4177	1.1770	0.0002
5,3	0.0000	3.3000	3.1918	0.6669	0.0002
6,1	0.0000	2.5400	2.0548	1.1606	0.0001
6,2	1.1295	3.6400	2.6823	1.9761	0.0007
6,3	0.0577	3.0500	2.7317	1.6414	0.0002
7,1	0.8036	13.8500	1.7315	2.8929	0.0002
7,2					
7,3	0.0000	2.9900	2.1758	1.0020	0.0002
8,1	0.0000	1.0030	2.5390	0.2091	0.0007
8,2	0.5491	6.7300	2.3576	10.8205	0.0002
8,3	0.1337	2.1000	3.0097	14.1642	0.0002
10,1	0.0000	2.8000	2.1577	1.4242	0.0002
10,2	0.0652	3.2400	2.4468	2.1087	0.0002
10,3					
11,1	0.0586	6.0300	1.5838	4.9555	0.0002
11,2	0.0000	1.6200	2.6452	1.1721	0.0002
11,3	0.0065	2.8500	2.4353	3.0669	0.0002
12,1	0.0000	2.3800	3.1088	0.3522	0.0002
12,2	0.0000	4.6200	2.6425	0.3252	0.0002
12,3	0.0000	3.4600	2.6875	1.0833	0.0002
13,1	0.0000	9.0100	1.7039	1.3632	0.0002
13,2	0.2434	4.3700	3.2520	3.7152	0.0002
13,3	0.0000	4.2900	2.5143	0.8698	0.0002
14,1	0.0000	4.7300	2.5325	0.5033	0.0002
14,2	0.0000	1.8800	3.5838	0.0352	0.0002
14,3	0.1275	2.1300	3.7339	0.6815	0.0002
15,1	0.0606	4.5700	3.1656	4.8610	0.0002
15,2	0.0016	2.1500	3.1181	2.3731	0.0002
15,3	0.6832	6.2900	3.6726	2.8021	0.0002
16,1					
16,2	0.0159	2.6700	2.1502	0.5196	0.0002
16,3					

Note: C_0 and μ are fitting parameters only and should not be interpreted literally (see text).

Fitted Bromacil Parameters -- CXTFIT Run 3

Plot, Hole	SSQ	C_0	R	D (cm^2/day)	μ (/day)
1,1	5.2030	24.8500	1.5181	4.0674	0.0002
1,2					
1,3	3.3640	12.5600	1.8383	24.7262	0.0002
2,1	0.3871	23.1400	1.4224	3.5387	0.0002
2,2	13.9417	59.2900	2.0480	16.8327	0.0002
2,3	8.6187	17.6400	1.5511	1.8556	0.0002
3,1					
3,2	0.0425	5.0700	1.5960	2.8550	0.0002
3,3	0.0678	1.6500	1.5628	4.3394	0.0002
4,1					
4,2					
4,3					
5,1					
5,2					
5,3					
6,1	0.7108	8.9300	2.1220	7.7676	0.0002
6,2	0.2808	6.7200	2.0452	8.8025	0.0002
6,3	0.0196	7.1400	1.8090	9.4358	0.0002
7,1					
7,2					
7,3					
8,1	93.1643	123.1400	2.7118	39.5148	0.0002
8,2	13.3426	43.2800	2.3318	5.1813	0.0003
8,3	17.0004	28.5200	2.1119	28.8067	0.0002
10,1					
10,2					
10,3					
11,1	26.8442	94.0000	1.9045	20.0167	0.0002
11,2	2.0556	39.8600	1.7595	8.9619	0.0002
11,3	9.0878	59.9800	1.6654	7.2306	0.0002
12,1					
12,2					
12,3					
13,1	4.4734	40.2200	1.2234	2.1969	0.0002
13,2	0.9549	20.2200	1.3088	1.2384	0.0002
13,3	20.0364	54.6700	1.4823	2.8687	0.0002
14,1	0.1166	5.0700	1.6204	2.8698	0.0002
14,2	0.2410	5.6100	1.8949	16.1358	0.0001
14,3	0.0476	1.3500	1.8067	32.1233	0.0003
15,1					
15,2					
15,3					
16,1					
16,2	3.4368	15.1900	1.3461	1.8427	0.0002
16,3					

Note: C_0 and μ are fitting parameters only and should not be interpreted literally (see text).

Fitted Napropamide Parameters -- CXTFIT Run 3

Plot, Hole	SSQ	C_0	R	D (cm^2/day)	μ (/day)
1,1	3.8870	80.2300	13.7537	4.2744	0.0002
1,2					
1,3	0.3045	37.5700	11.1832	4.8646	0.0002
2,1	4.4784	21.7700	6.6331	2.8345	0.0002
2,2	0.0226	47.4000	10.5609	2.1225	0.0002
2,3	0.0280	45.2500	9.1160	3.9539	0.0002
3,1					
3,2	0.0608	14.9500	39.3544	224.8851	0.0002
3,3	0.0354	1.9500	5.7815	6.2213	0.0004
4,1					
4,2					
4,3					
5,1	1.7558	65.7900	8.1019	4.7331	0.0002
5,2	0.3793	24.4600	7.3540	4.0495	0.0001
5,3	0.7324	21.2700	8.5171	2.2853	0.0001
6,1	0.0012	10.6500	8.2465	2.8027	0.0002
6,2	0.0066	6.8400	16.5495	11.1514	0.0002
6,3	0.0114	4.8100	13.4458	22.1101	0.0001
7,1	0.0014	33.2700	10.6997	1.0390	0.0001
7,2					
7,3	0.0179	21.8600	11.2453	8.5832	0.0001
8,1					
8,2					
8,3					
10,1	0.4437	35.8900	7.8321	2.0657	0.0002
10,2	0.0149	3.9700	6.8129	1.5248	0.0001
10,3					
11,1					
11,2					
11,3					
12,1					
12,2					
12,3					
13,1	0.0136	60.5900	8.9764	2.5219	0.0002
13,2	0.1298	46.8600	12.4740	11.2213	0.0002
13,3	0.5392	58.3900	12.2258	6.9685	0.0002
14,1	0.0000	6.5000	12.2380	4.9662	0.0001
14,2	0.0120	8.3700	10.6478	8.9055	0.0001
14,3	0.0197	7.2700	9.1694	9.5280	0.0001
15,1					
15,2					
15,3					
16,1					
16,2					
16,3					

Note: C_0 and μ are fitting parameters only and should not be interpreted literally (see text).

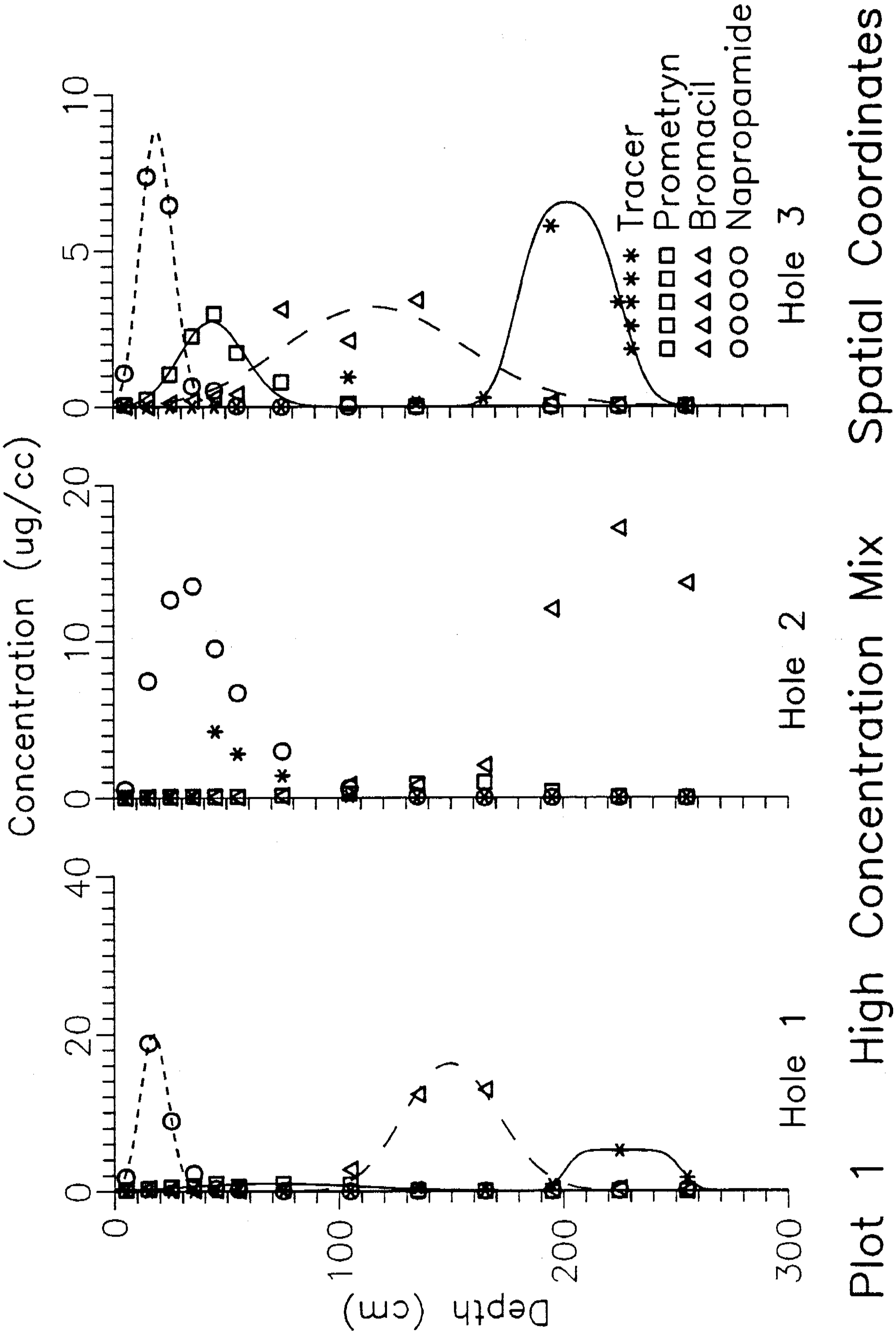
Fitted Prometryn Parameters -- CXTFIT Run 3

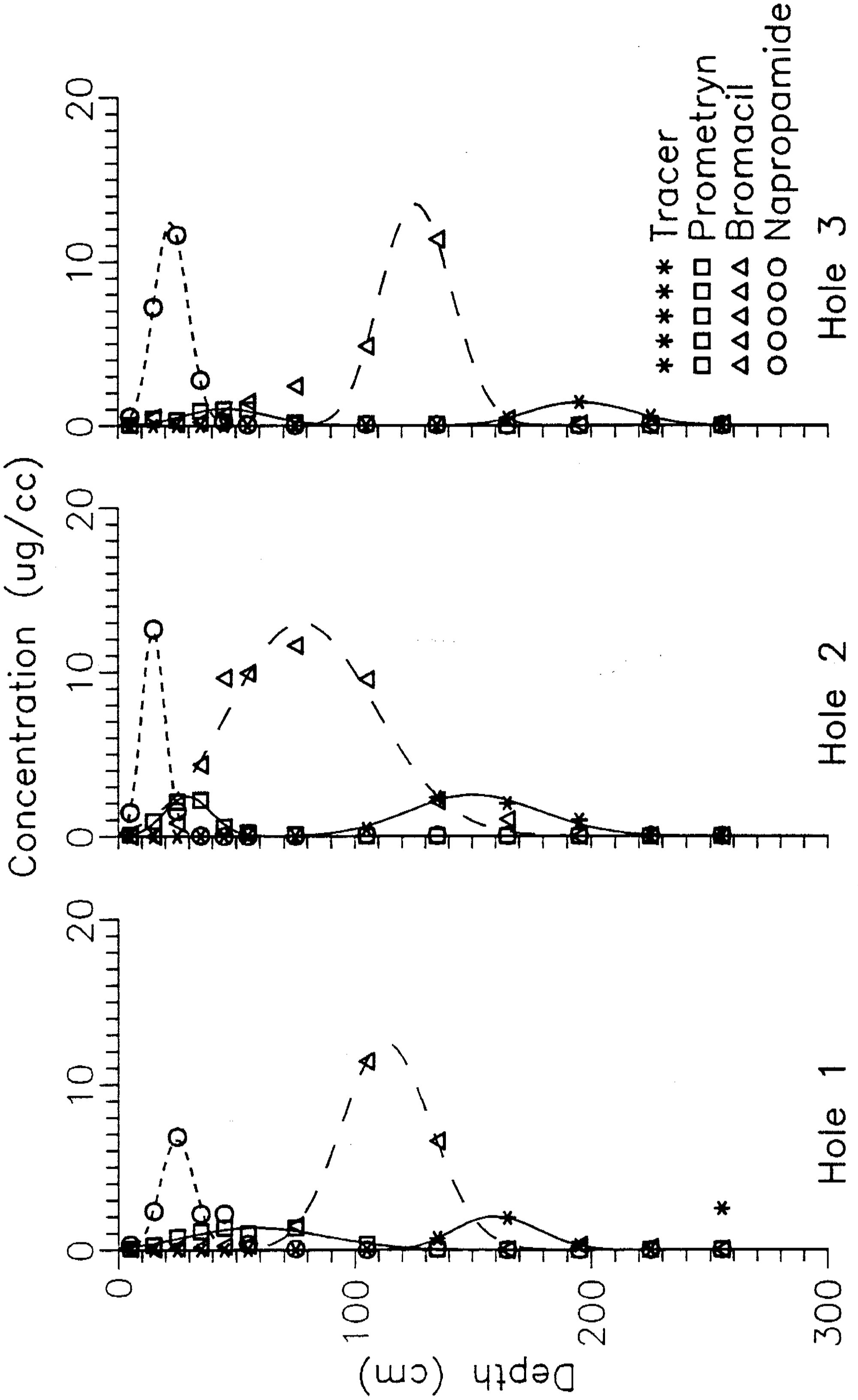
Plot, Hole	SSQ	C_0	R	D (cm^2/day)	μ (/day)
1,1	0.2130	6.4200	3.6269	52.6888	0.0001
1,2					
1,3	0.4217	10.3000	4.8220	8.6446	0.0002
1,3	0.4217	10.3000	4.7956	8.5973	0.0002
2,1	0.2451	8.0000	3.0512	23.8556	0.0001
2,2	0.0880	9.3900	5.3214	4.5064	0.0002
2,3	0.1072	4.5200	4.5557	11.9514	0.0002
3,1					
3,2	0.0011	0.8000	4.0261	56.5592	0.0001
3,3	0.0006	0.2470	3.6753	175.3963	0.0003
4,1	0.1682	10.6700	4.0337	6.5579	0.0003
4,2	0.6290	8.2700	2.5319	30.2787	0.0002
4,3	0.0285	3.1500	6.3208	18.0028	0.0001
5,1					
5,2					
5,3					
6,1	0.0003	0.8320	5.4448	3.4951	0.0003
6,2	0.0004	1.1940	7.1922	8.1951	0.0002
6,3	0.0013	1.1800	5.4549	25.2949	0.0001
7,1					
7,2					
7,3					
8,1					
8,2					
8,3					
10,1					
10,2					
10,3					
11,1					
11,2					
11,3					
12,1	0.2263	10.1400	4.6499	19.0478	0.0001
12,2	0.1709	6.2530	3.2964	10.7221	0.0003
12,3	0.1093	7.5900	3.6096	16.4480	0.0001
13,1	0.4085	16.5700	3.1478	6.4027	0.0002
13,2	1.4642	13.9000	4.4406	43.1775	0.0013
13,3	1.4167	29.0700	4.5371	20.0534	0.0002
14,1	0.0321	2.1000	4.0521	71.1571	0.0010
14,2	0.0217	0.3780	5.5491	3.8209	0.0002
14,3	0.0021	0.6040	3.1277	124.6029	0.0002
15,1	1.3441	9.3900	6.0202	18.4422	0.0001
15,2	0.2614	5.4400	3.1015	47.4855	0.0002
15,3	0.2825	12.0400	4.6220	27.4314	0.0001
16,1					
16,2					
16,3					

Note: C_0 and μ are fitting parameters only and should not be interpreted literally (see text).

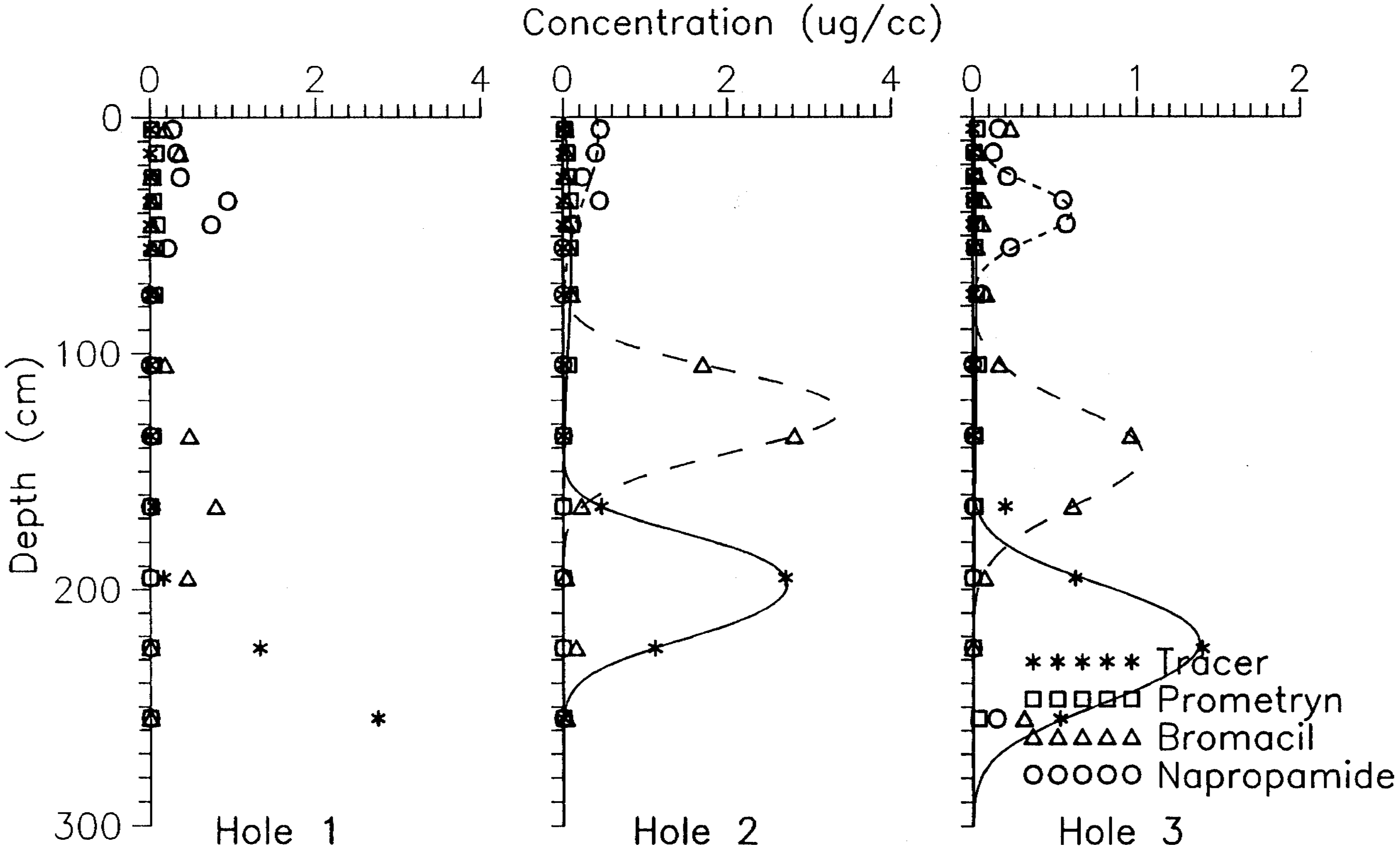
APPENDIX N

CXTFIT-Fitted Profiles - Runs 1 & 3 (Equilibrium Model)

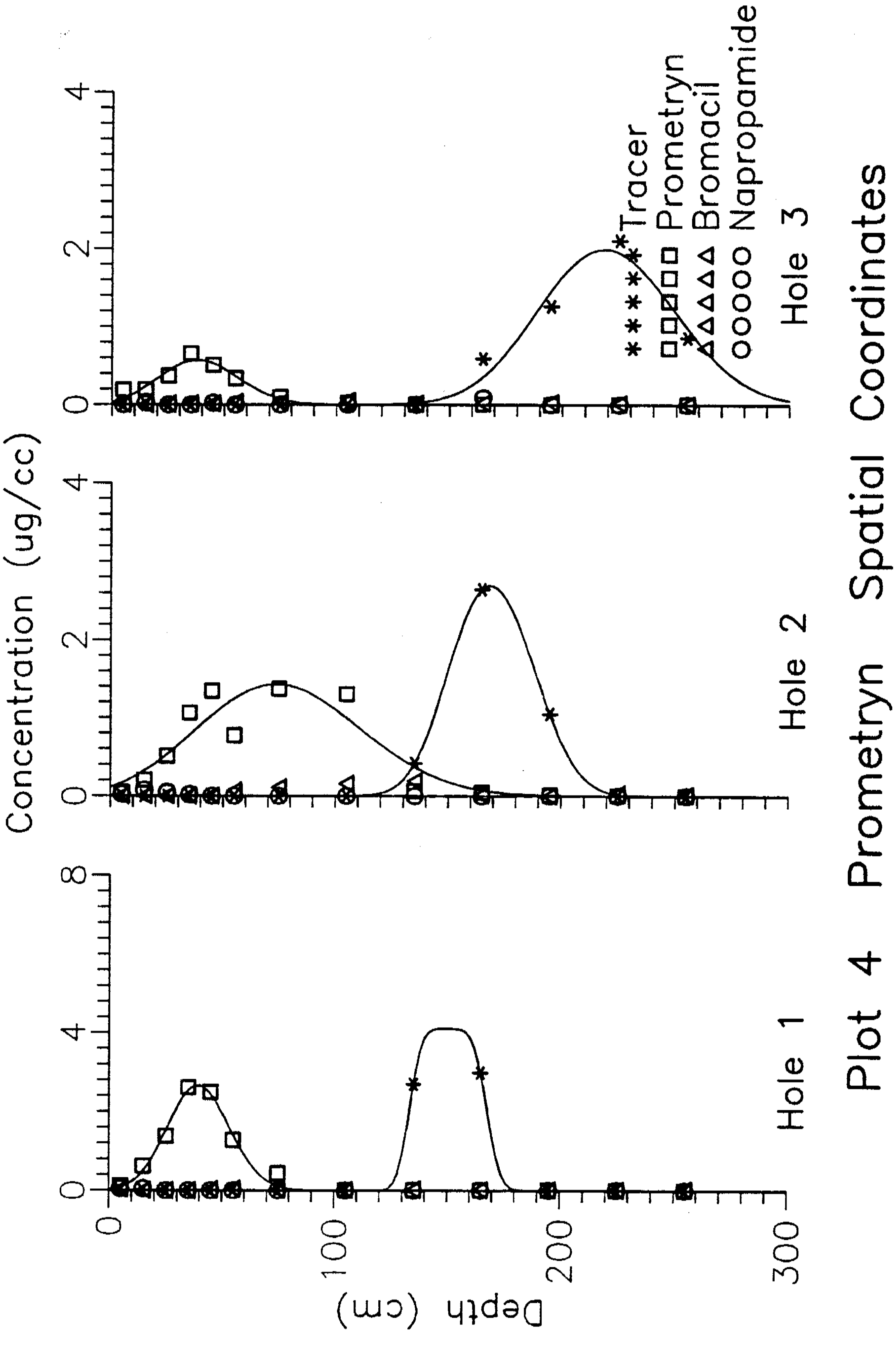

Plot 1 High Concentration Mix Spatial Coordinates
Concentration (ug/cc)
Depth (cm)
0
100
200
300
Hole 1
0
20
40
Hole 2
0
10
20
Hole 3
0
5
10
✱✱✱✱✱ Tracer
□□□□□ Prometryn
△△△△△ Bromacil
ooooo Napropamide

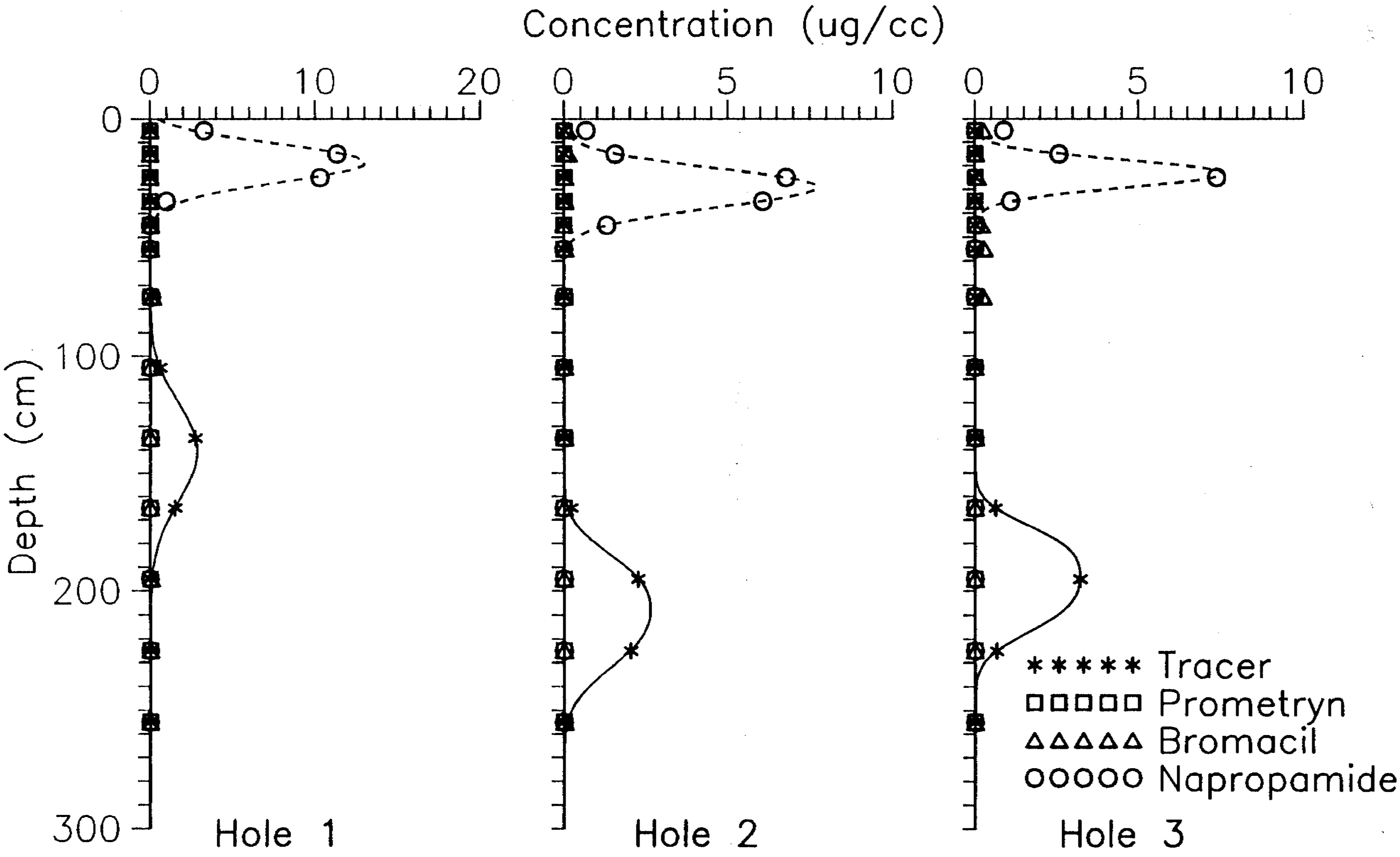


Plot 2 High Concentration Mix Spatial Coordinates

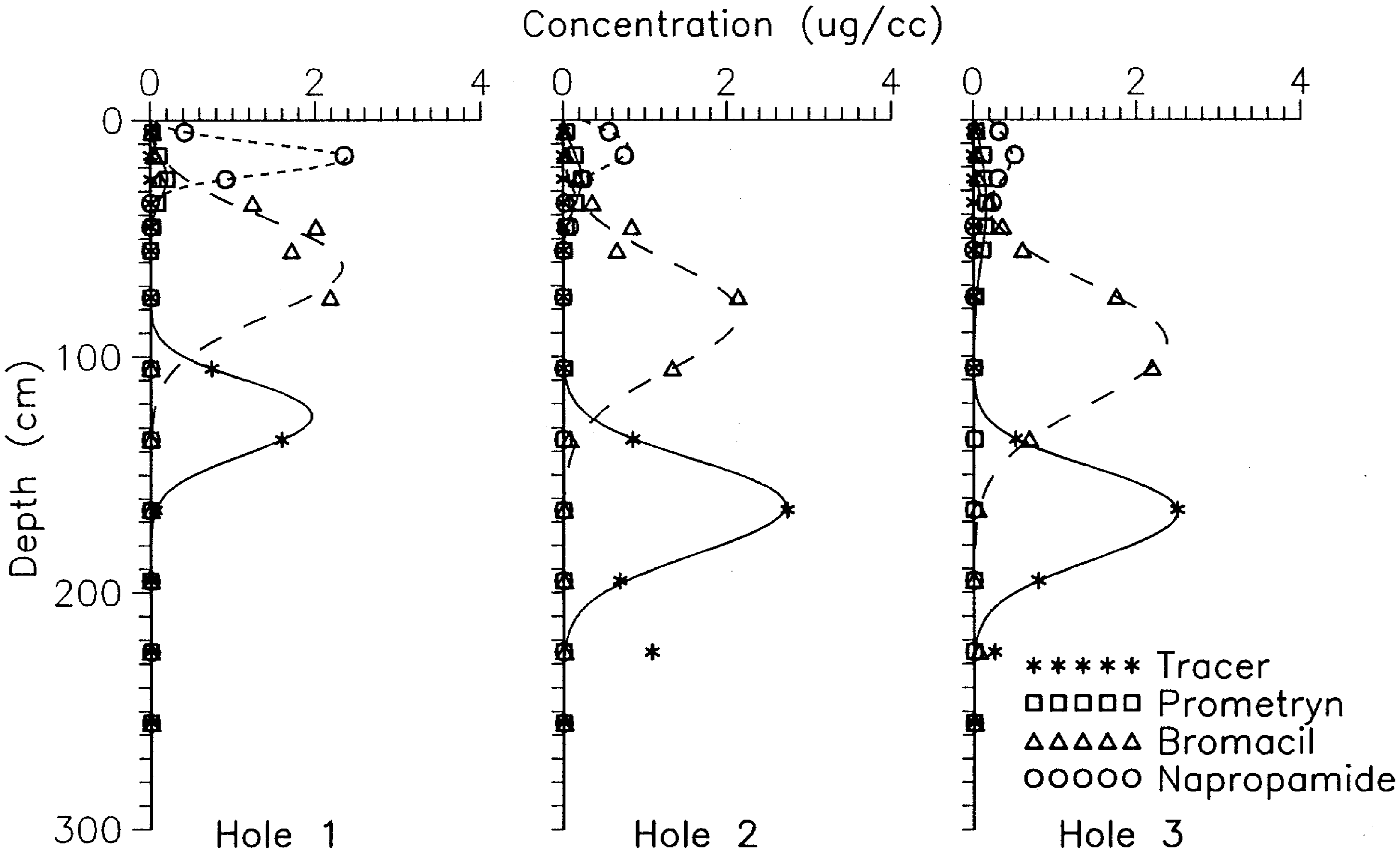


Plot 3 Low Concentration Mix Spatial Coordinates

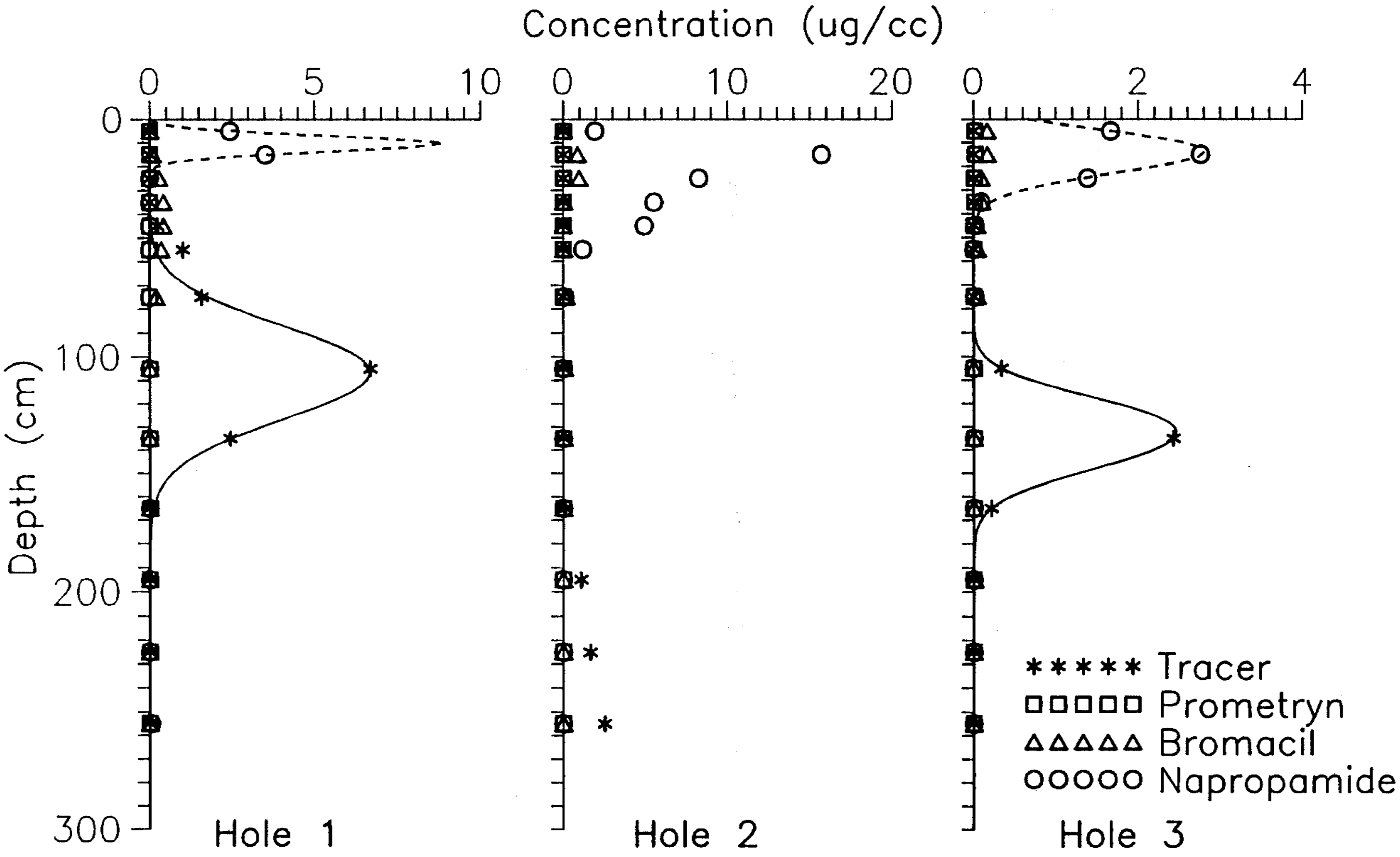

Plot 4 Prometryn Spatial Coordinates
Concentration (ug/cc)
Depth (cm)
Hole 1
Hole 2
Hole 3
0
4
8
2
0
100
200
300
***** Tracer
□□□□□ Prometryn
△△△△△ Bromacil
ooooo Napropamide



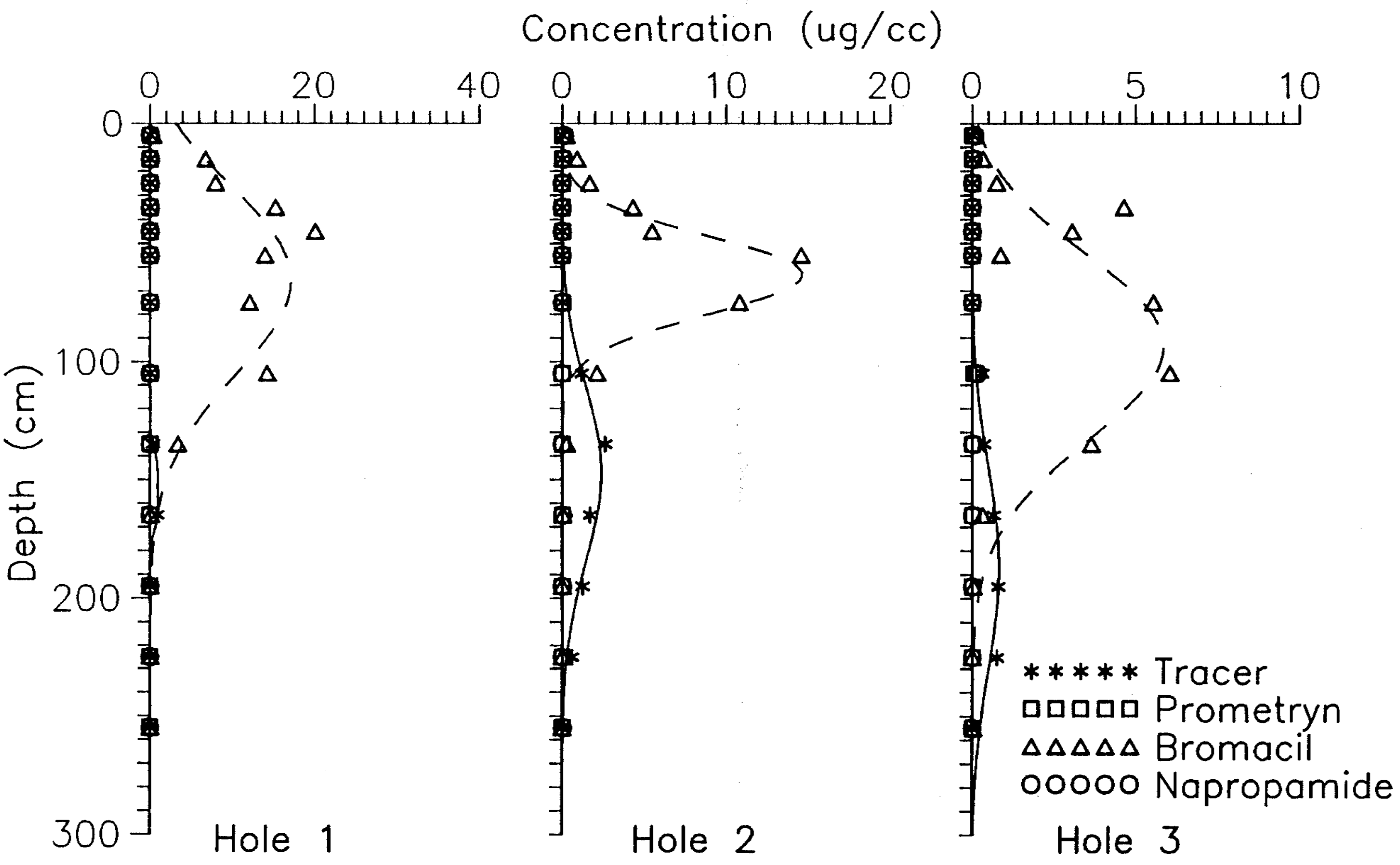
Plot 5 Napropamide Spatial Coordinates



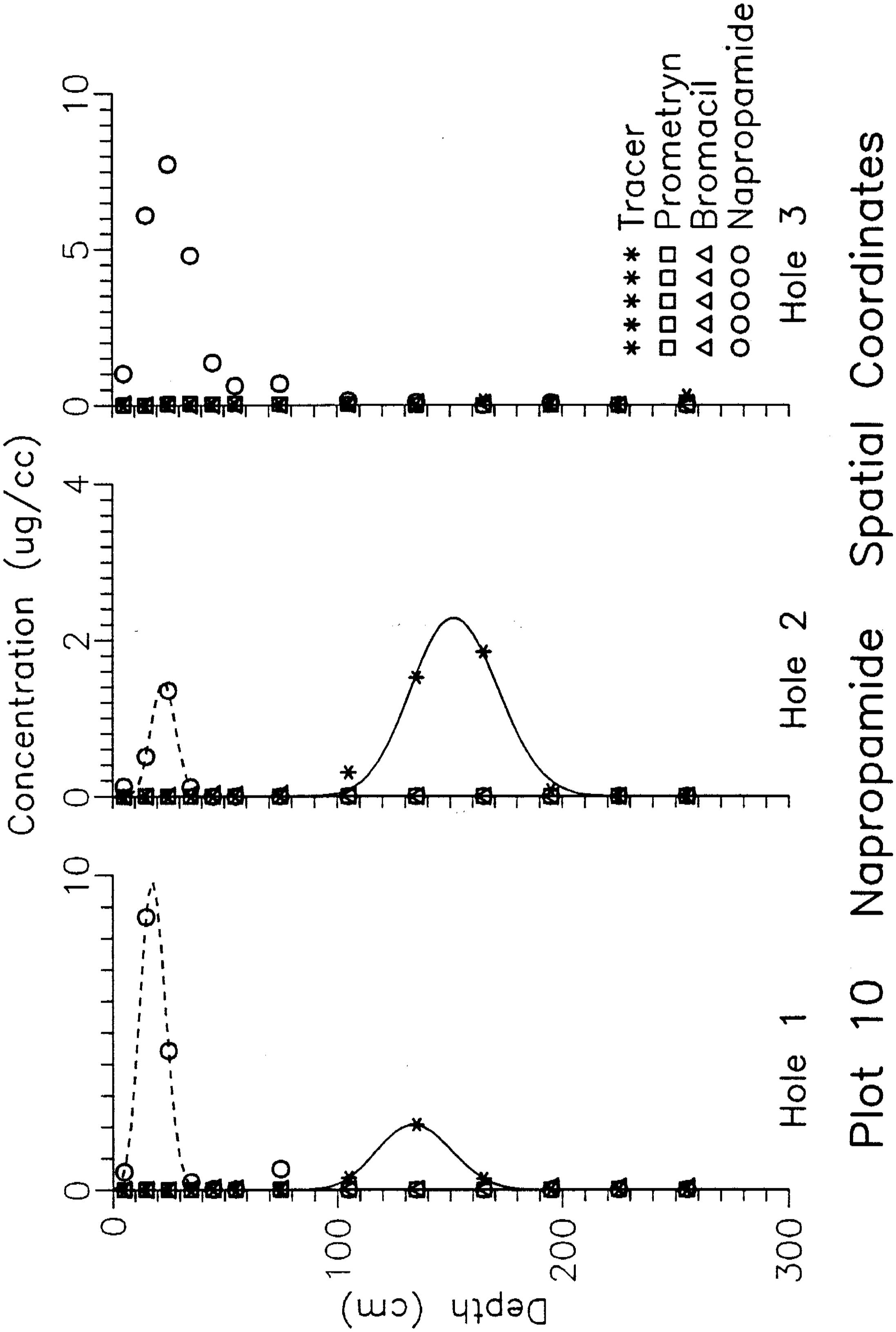
Plot 6 Low Concentration Mix Spatial Coordinates

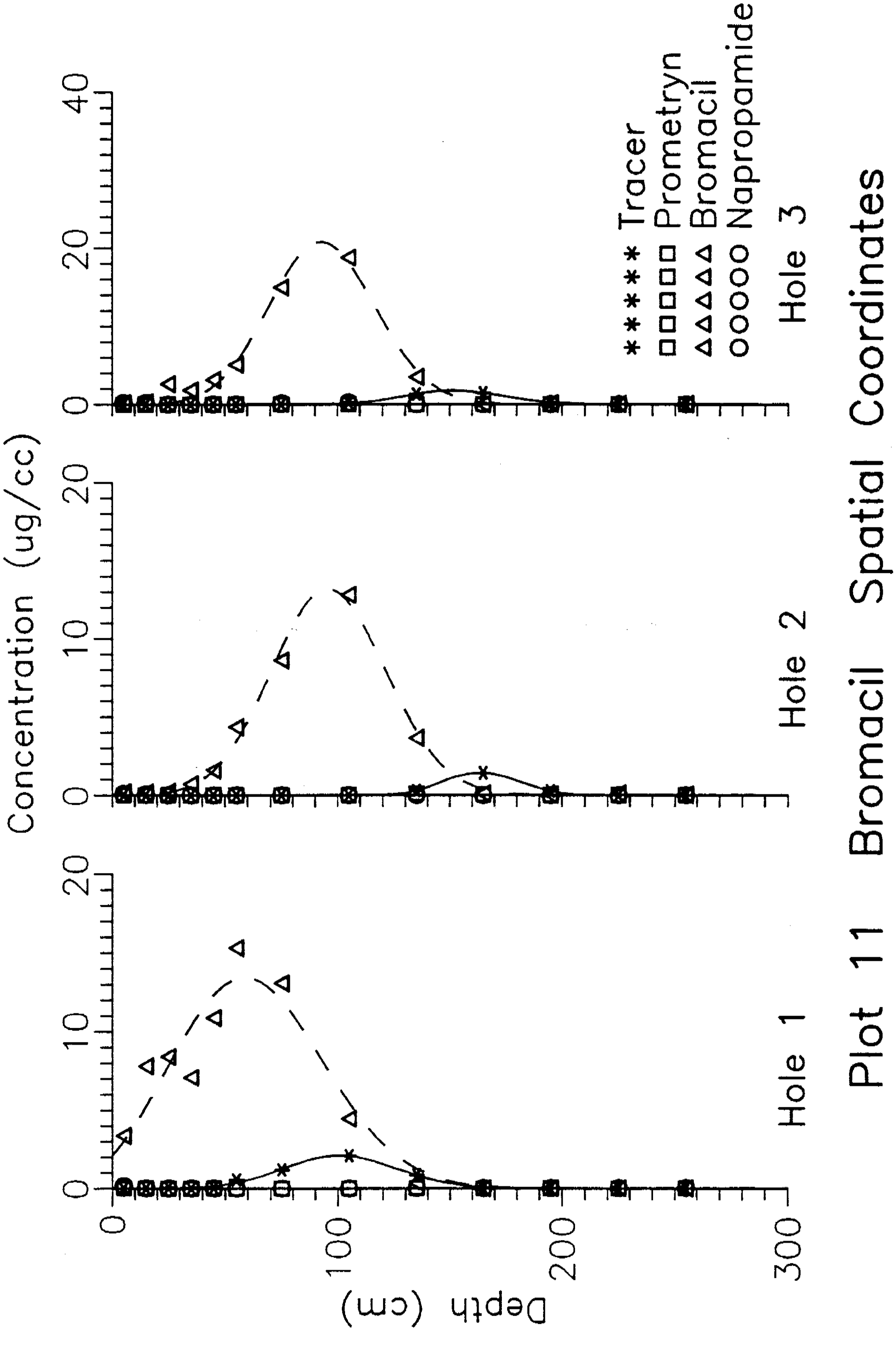


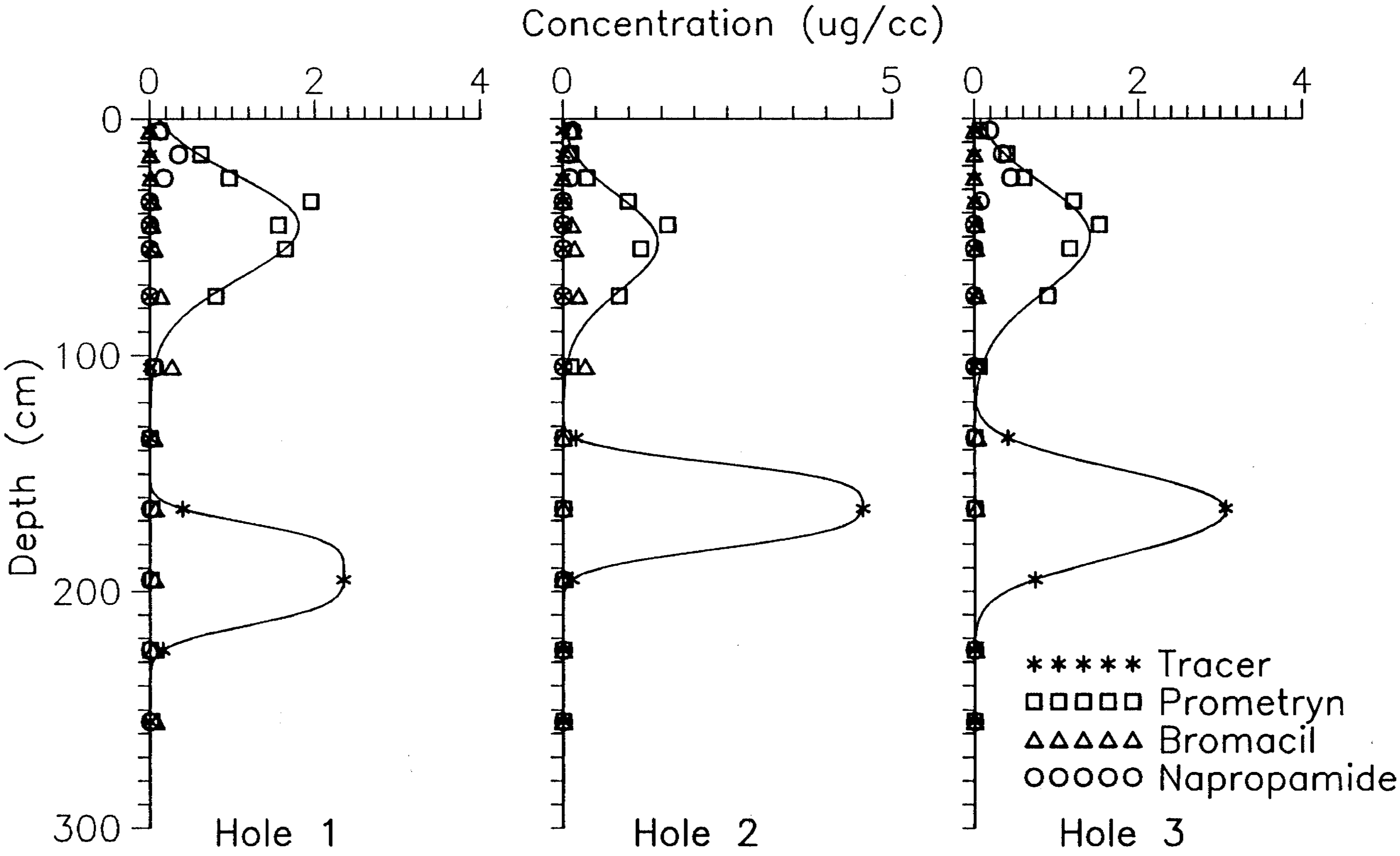
Plot 7 Napropamide Spatial Coordinates



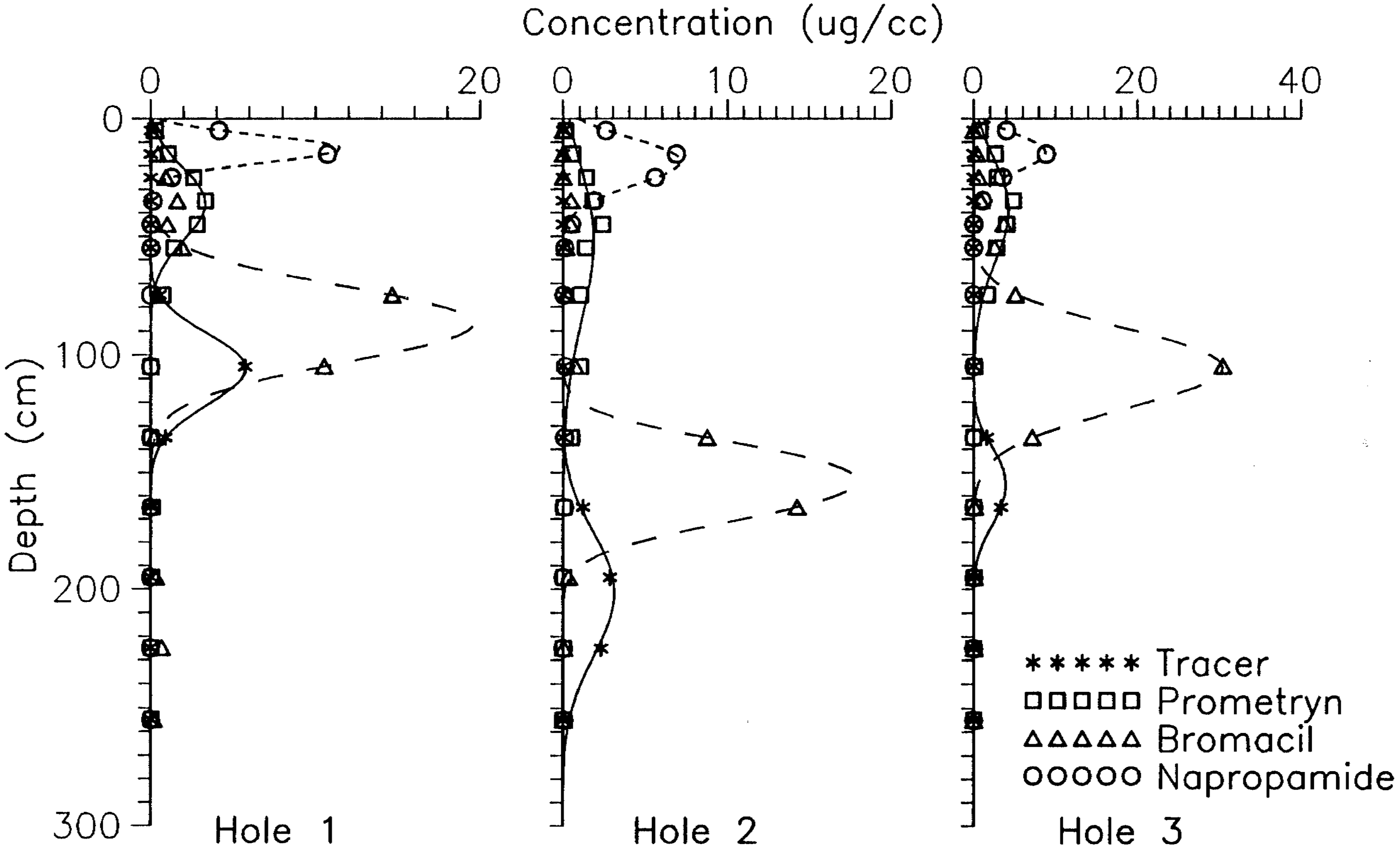
Plot 8 Bromacil Spatial Coordinates


Plot 10 Napropamide Spatial Coordinates
Concentration (ug/cc)
Depth (cm)
Hole 1
Hole 2
Hole 3
0
10
0
2
4
0
5
10
0
100
200
300
✱✱✱✱✱ Tracer
□□□□□ Prometryn
△△△△△ Bromacil
○○○○○ Napropamide

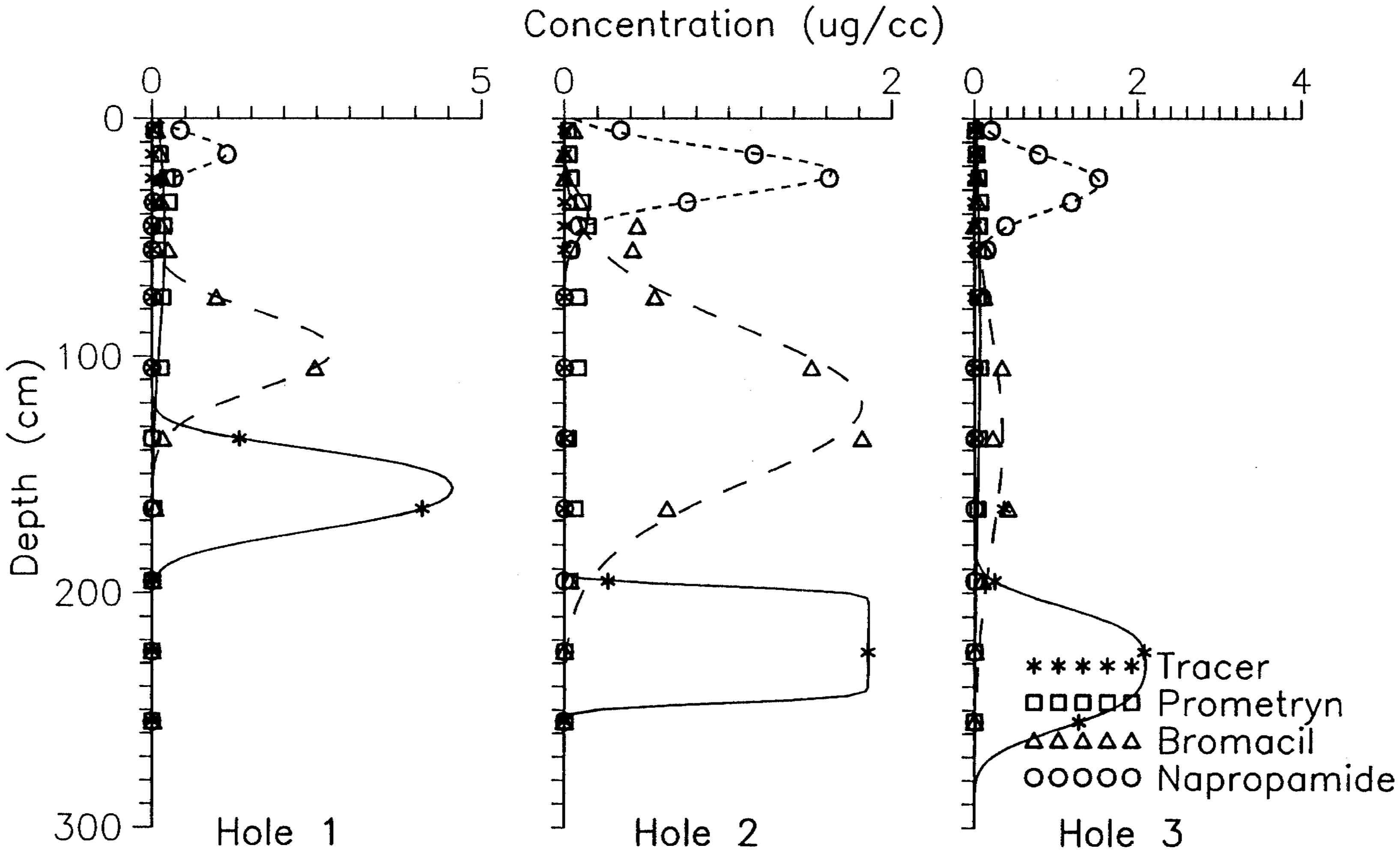

Plot 11 Bromacil Spatial Coordinates
Hole 1
Hole 2
Hole 3
Concentration (ug/cc)
Depth (cm)
0
100
200
300
0
10
20
40
***** Tracer
□□□□□ Prometryn
ΔΔΔΔΔ Bromacil
ooooo Napropamide



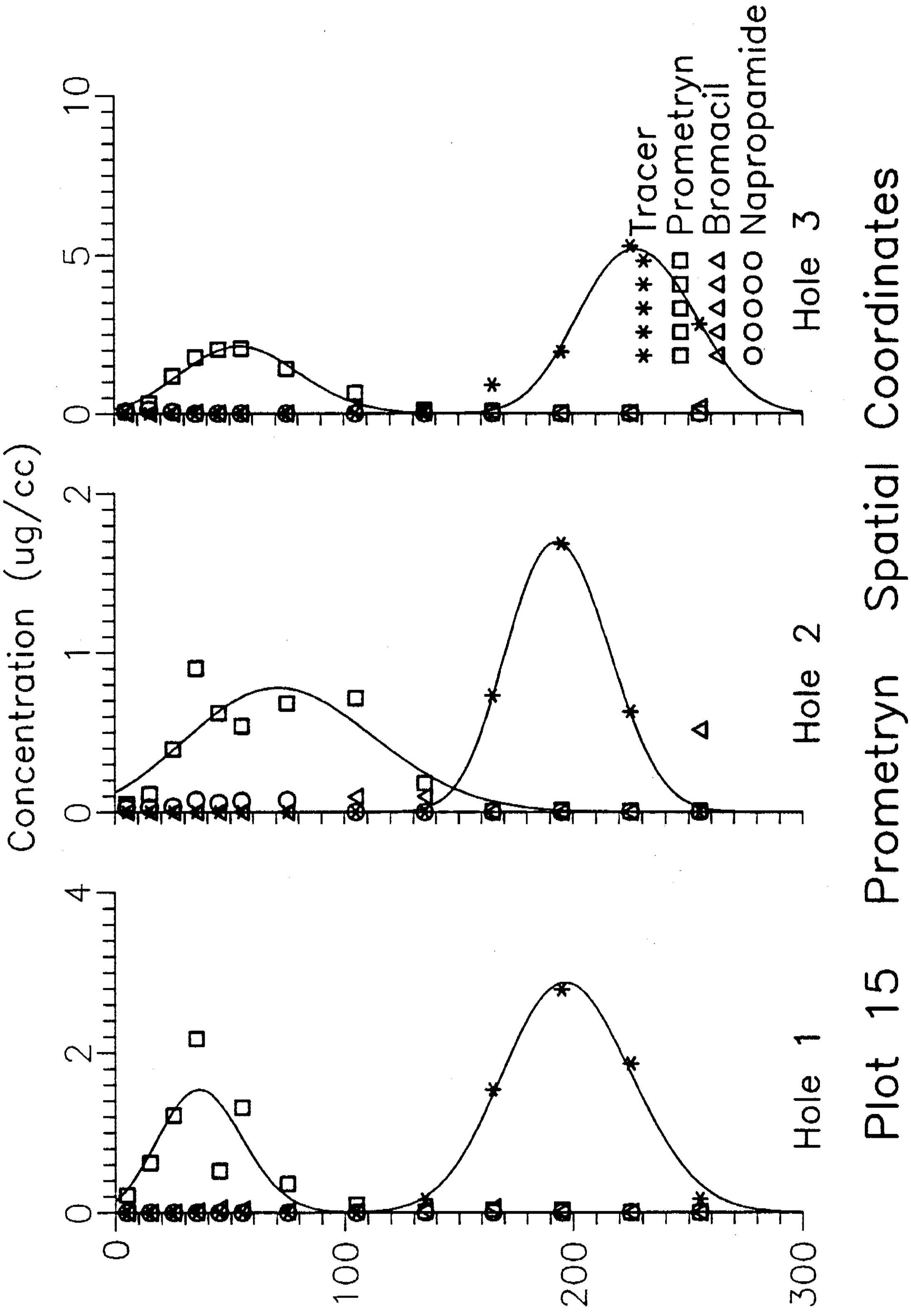
Plot 12 Prometryn Spatial Coordinates

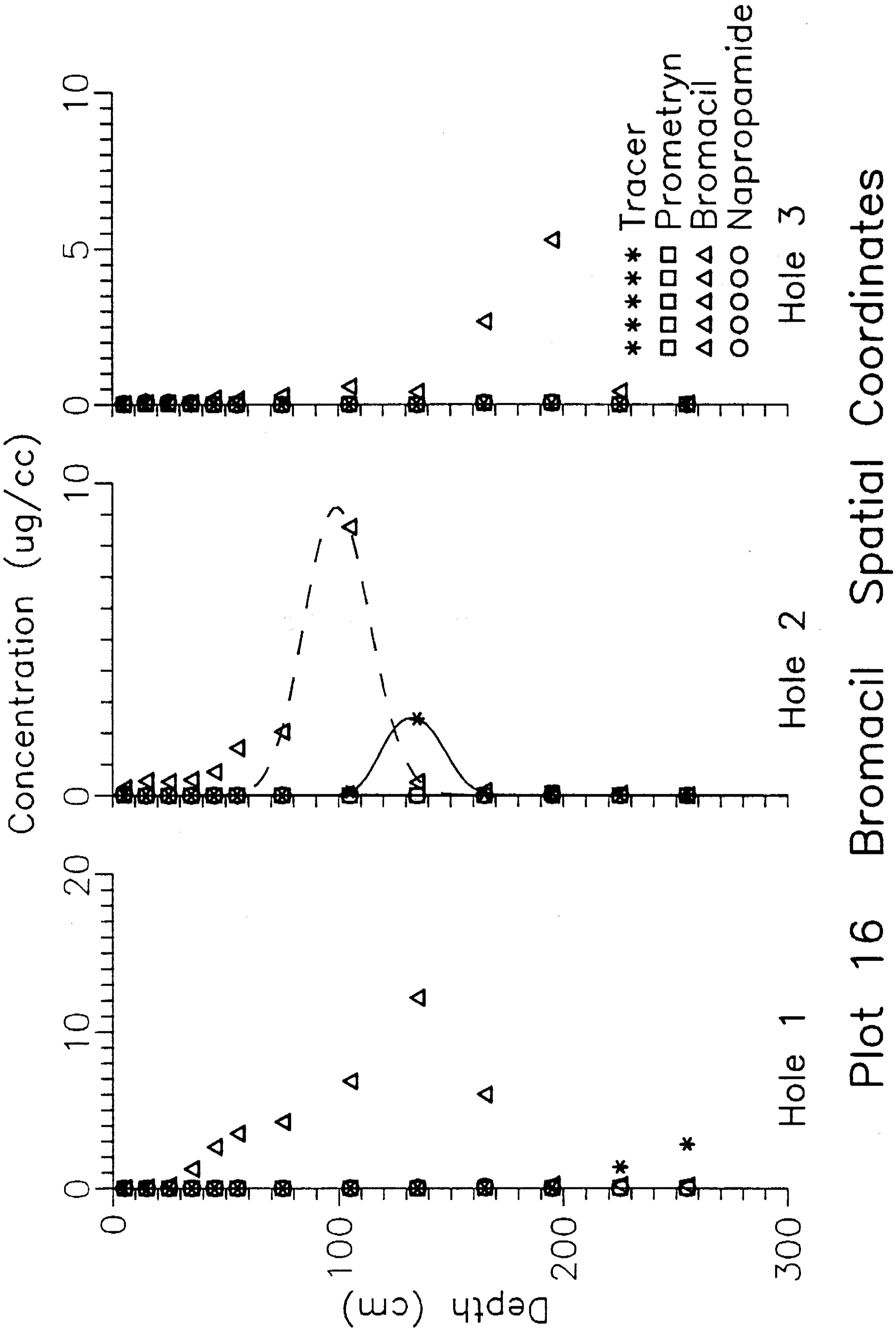


Plot 13 High Concentration Mix Spatial Coordinates



Plot 14 Low Concentration Mix Spatial Coordinates


Plot 15 Prometryn Spatial Coordinates


Concentration (ug/cc)
Depth (cm)
0
100
200
300
0
10
20
0
10
0
5
10
Hole 1
Hole 2
Hole 3
***** Tracer
□□□□□ Prometryn
ΔΔΔΔΔ Bromacil
ooooo Napropamide
Plot 16 Bromacil Spatial Coordinates

APPENDIX O

CXTFIT-Fitted Parameters - Runs 4 & 5 (Volumetric Coordinates)

Fitted Tracer Parameters -- CXTFIT Run 4

Plot, Hole	SSQ	C_0	q (cm/day)	δq (cm^2/day)	μ (/day)
1,1	0.2206	5.1800	0.7371	0.0265	0.0001
1,2					
1,3	0.9035	6.7610	0.6761	0.0493	0.0002
2,1	0.0000	2.9820	0.6368	0.1424	0.0001
2,2	0.2671	5.5800	0.4347	0.2101	0.0001
2,3	0.0000	1.4640	0.6878	0.0400	0.0002
3,1					
3,2	0.0000	2.7880	0.7189	0.0338	0.0001
3,3	0.0248	1.6550	0.9041	0.1609	0.0004
4,1	0.0000	4.1500	0.6067	0.0116	0.0007
4,2	0.0006	2.8520	0.7496	0.0643	0.0002
4,3	0.1597	2.6470	0.8728	0.2424	0.0002
5,1	0.1058	4.2860	0.6460	0.1836	0.0002
5,2	0.0060	2.4250	0.8589	0.0430	0.0002
5,3	2.1892	2.3310	0.7759	0.0522	0.0002
6,1	0.0000	2.3900	0.5380	0.0642	0.0002
6,2	0.9951	3.0130	0.6450	0.0886	0.0002
6,3	0.0637	2.5400	0.7276	0.0101	0.0003
7,1	0.8082	15.2800	0.4298	0.2243	0.0002
7,2					
7,3	0.0000	3.1070	0.5694	0.0573	0.0003
8,1	0.0000	0.8990	0.6532	0.0012	0.0003
8,2	0.2423	6.1420	0.5782	0.4918	0.0002
8,3	0.1332	1.4300	0.7253	0.3634	0.0002
10,1	0.0004	2.7150	0.5632	0.0789	0.0002
10,2	0.0891	2.3470	0.6514	0.0328	0.0002
10,3					
11,1	0.0925	6.0300	0.4020	0.3173	0.0001
11,2	0.0000	1.4760	0.5862	0.0222	0.0002
11,3	0.0347	2.5970	0.5932	0.1167	0.0002
12,1	1.6698	1.5710	0.7865	0.0464	0.0002
12,2	0.0000	4.6200	0.6700	0.0107	0.0002
12,3	0.0000	3.2120	0.6889	0.0352	0.0002
13,1	0.0001	9.7260	0.4413	0.1130	0.0002
13,2	0.1851	3.9820	0.7233	0.1425	0.0002
13,3	0.0000	3.7660	0.6728	0.0286	0.0003
14,1	0.0000	5.0620	0.6272	0.0272	0.0002
14,2	0.0000	1.8800	0.7792	0.0025	0.0002
14,3	0.1272	2.3240	0.7766	0.0554	0.0001
15,1	0.0167	5.0750	0.6448	0.2747	0.0002
15,2	0.0011	2.3250	0.6237	0.1177	0.0002
15,3	0.5358	7.6010	0.7611	0.2219	0.0002
16,1					
16,2	0.0159	2.9910	0.4134	0.0367	0.0002
16,3					

Note: C_0 and μ are fitting parameters only and should not be interpreted literally (see text).

Fitted Bromacil Parameters -- CXTFIT Run 5

Plot, Hole	SSQ	C_0	R	δq (cm²/day)	μ (/day)
1,1	5.0120	27.2800	1.5864	0.1967	0.0001
1,2					
1,3	3.2105	12.9190	1.9278	1.0114	0.0002
2,1	0.2416	30.5290	1.5544	0.3261	0.0002
2,2	11.9563	56.4710	2.0464	0.4944	0.0002
2,3	8.6248	19.9410	1.5524	0.1047	0.0002
3,1					
3,2	0.0413	5.6040	1.6098	0.1747	0.0002
3,3	0.0678	1.6610	1.5501	0.2913	0.0002
4,1					
4,2					
4,3					
5,1					
5,2					
5,3					
6,1	0.7983	10.0400	2.1911	0.6415	0.0001
6,2	0.3150	7.2410	1.9795	0.6376	0.0002
6,3	0.0206	7.6450	1.7379	0.8151	0.0002
7,1					
7,2					
7,3					
8,1	116.3814	129.2530	2.9759	2.4247	0.0014
8,2	12.8065	48.0040	2.4096	0.3293	0.0002
8,3	18.0063	30.6950	2.0483	1.8587	0.0002
10,1					
10,2					
10,3					
11,1	23.8994	100.3190	1.9477	1.3863	0.0002
11,2	1.7256	43.5800	1.7681	0.5344	0.0001
11,3	7.3502	65.3430	1.7225	0.4984	0.0002
12,1					
12,2					
12,3					
13,1	4.2595	46.1020	1.2453	0.2022	0.0002
13,2	0.9756	21.1010	1.2964	0.0522	0.0002
13,3	19.6443	66.1750	1.5344	0.3160	0.0002
14,1	0.0935	5.9710	1.7189	0.2640	0.0002
14,2	0.1733	6.3460	1.9883	0.8929	0.0003
14,3	0.0514	1.4520	1.8947	1.5577	0.0002
15,1					
15,2					
15,3					
16,1					
16,2	3.2621	15.8300	1.3926	0.0841	0.0002
16,3					

Note: C_0 and μ are fitting parameters only and should not be interpreted literally (see text).

Fitted Napropamide Parameters -- CXTFIT Run 5

Plot, Hole	SSQ	C_0	R	δq (cm^2/day)	μ (/day)
1,1	4.1426	79.2580	14.6312	0.1545	0.0002
1,2					
1,3	0.2895	37.0600	12.0777	0.1855	0.0001
2,1	4.5403	20.9590	8.5803	0.1167	0.0001
2,2	0.0225	47.4220	10.3223	0.0671	0.0002
2,3	0.0293	45.2070	10.2376	0.1657	0.0001
3,1					
3,2					
3,3	0.0326	2.1780	7.0212	0.3941	0.0004
4,1					
4,2					
4,3					
5,1	1.4287	67.0790	9.9893	0.3171	0.0002
5,2	0.3883	24.8580	8.3718	0.2379	0.0002
5,3	0.7214	21.8700	9.2541	0.1326	0.0001
6,1	0.0004	10.8900	9.7374	0.1690	0.0002
6,2	0.0067	6.8750	18.3239	0.5832	0.0002
6,3	0.0131	5.1440	15.3432	1.7510	0.0002
7,1	0.0014	39.1780	12.2404	0.0461	0.0000
7,2					
7,3	0.0043	22.4460	13.7857	0.5224	0.0001
8,1					
8,2					
8,3					
10,1	0.4658	36.7010	9.7536	0.1127	0.0002
10,2	0.0140	4.1150	7.9234	0.1121	0.0001
10,3					
11,1					
11,2					
11,3					
12,1					
12,2					
12,3					
13,1	0.0143	60.6950	10.6873	0.1444	0.0001
13,2	0.1906	47.9020	13.5964	0.5368	0.0002
13,3	0.4217	58.5650	15.7010	0.3918	0.0002
14,1	0.0000	6.4060	14.3860	0.2489	0.0002
14,2	0.0118	8.3870	11.9006	0.3815	0.0002
14,3	0.0185	7.5680	10.4199	0.3970	0.0003
15,1					
15,2					
15,3					
16,1					
16,2					
16,3					

Note: C_0 and μ are fitting parameters only and should not be interpreted literally (see text).

Fitted Prometryn Parameters -- CXTFIT Run 5

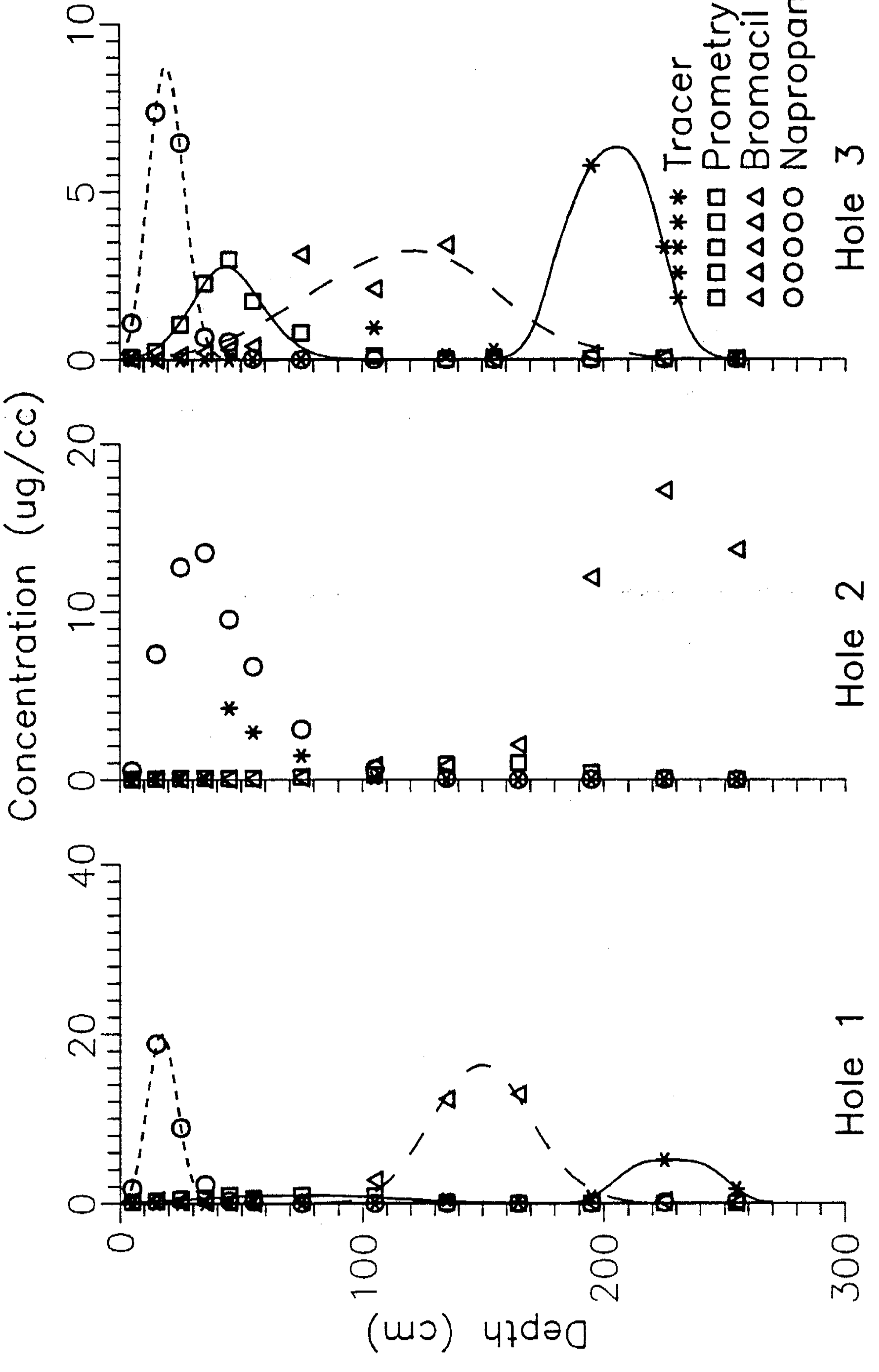
Plot, Hole	SSQ	C_0	R	δq (cm^2/day)	μ (/day)
1,1	0.1931	6.3850	3.8716	1.9651	0.0002
1,2					
1,3	0.3530	10.4640	5.1542	0.3388	0.0001
1,3	0.2578	8.5380	3.6941	1.3183	0.0002
2,1	0.0528	9.3240	5.1575	0.1466	0.0002
2,2	0.0968	4.6940	5.0318	0.5438	0.0001
2,3					
3,1	0.0011	0.8330	4.2097	2.8897	0.0001
3,2	0.0006	0.2510	3.6265	9.6977	0.0001
3,3	0.1653	11.5450	4.3682	0.4276	0.0001
4,1	0.6831	9.0970	2.6001	2.6329	0.0001
4,2	0.0279	3.3260	6.9776	1.0791	0.0006
4,3					
5,1					
5,2					
5,3	0.0004	0.8880	6.3172	0.2428	0.0002
6,1	0.0003	1.2220	7.8480	0.4702	0.0001
6,2	0.0013	1.2640	5.6756	2.0060	0.0003
6,3					
7,1					
7,2					
7,3					
8,1					
8,2					
8,3					
10,1					
10,2					
10,3					
11,1					
11,2					
11,3	0.2991	11.2960	4.6003	1.5517	0.0002
12,1	0.2400	7.1410	3.6979	0.8075	0.0002
12,2	0.1545	8.4630	3.9927	1.2194	0.0001
12,3	0.5284	17.2780	3.6127	0.4016	0.0002
13,1	1.5478	13.2890	4.9048	1.6831	0.0000
13,2	2.1168	31.0180	5.5977	1.4382	0.0002
13,3	0.0445	1.5490	6.0183	0.7299	0.0012
14,1	0.0125	0.9210	3.7674	6.8795	0.0001
14,2	0.0021	0.6240	3.2610	5.5213	0.0002
14,3	1.2987	9.3980	6.2610	0.6663	0.0002
15,1	0.2490	5.3600	3.2795	1.7724	0.0003
15,2	0.2376	11.4500	5.0770	0.9620	0.0000
15,3					
16,1					
16,2					
16,3					

Note: C_0 and μ are fitting parameters only and should not be interpreted literally (see text).

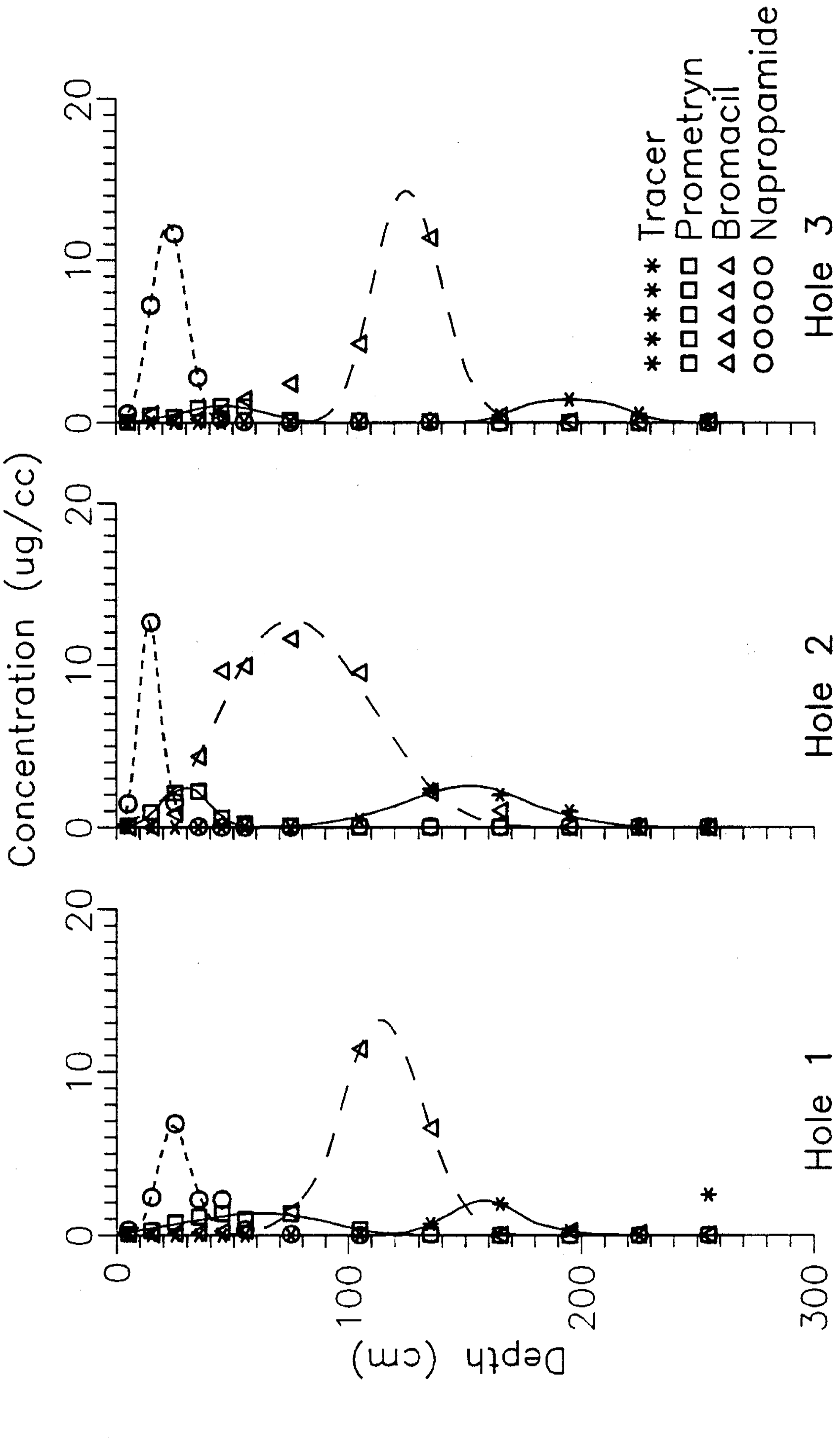
APPENDIX P

CXTFIT-Fitted Profiles - Runs 4 & 5 (Volumetric Coordinates)

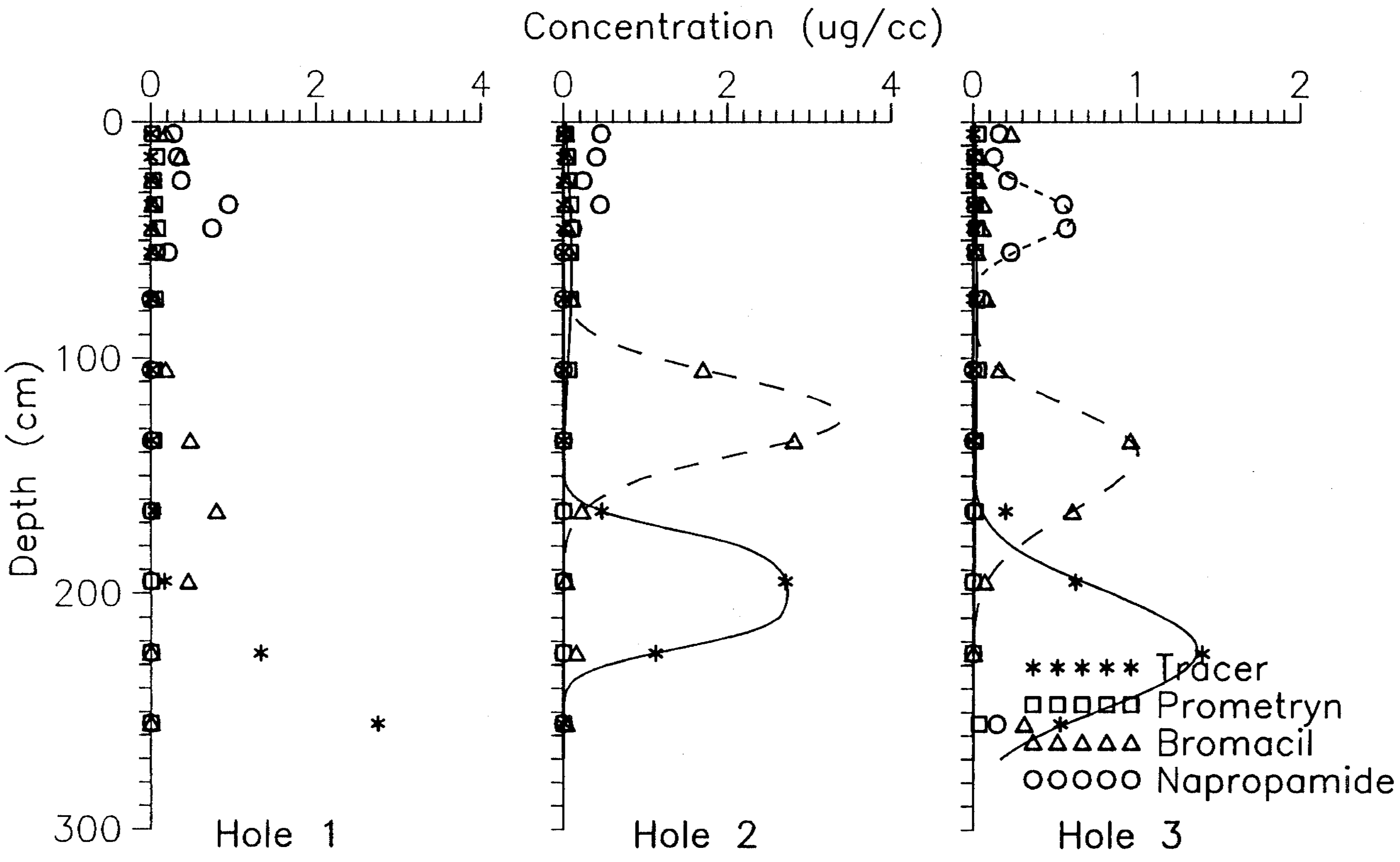
P-2



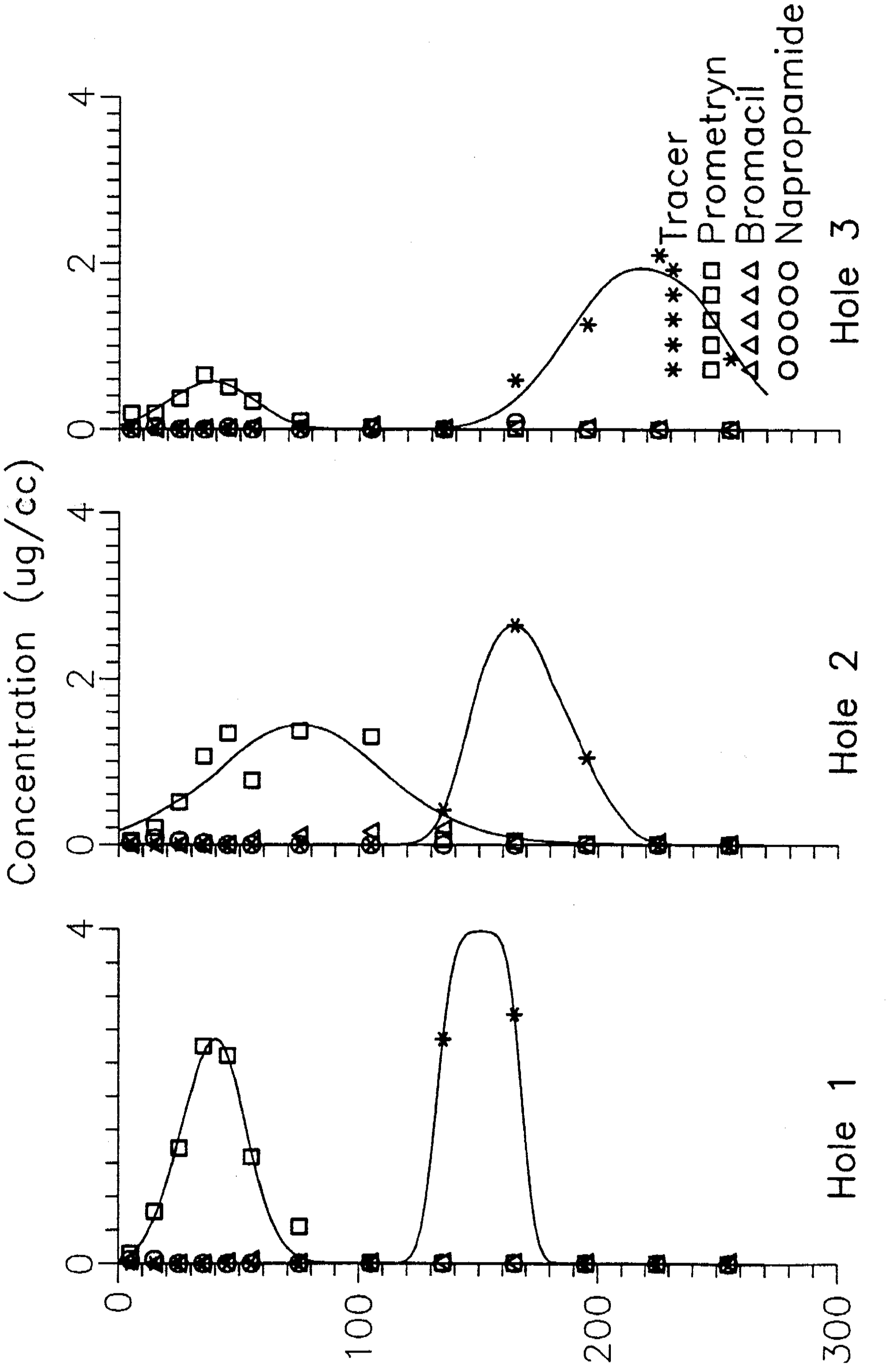
Plot 1 High Concentration Mix Volumetric Coordinates



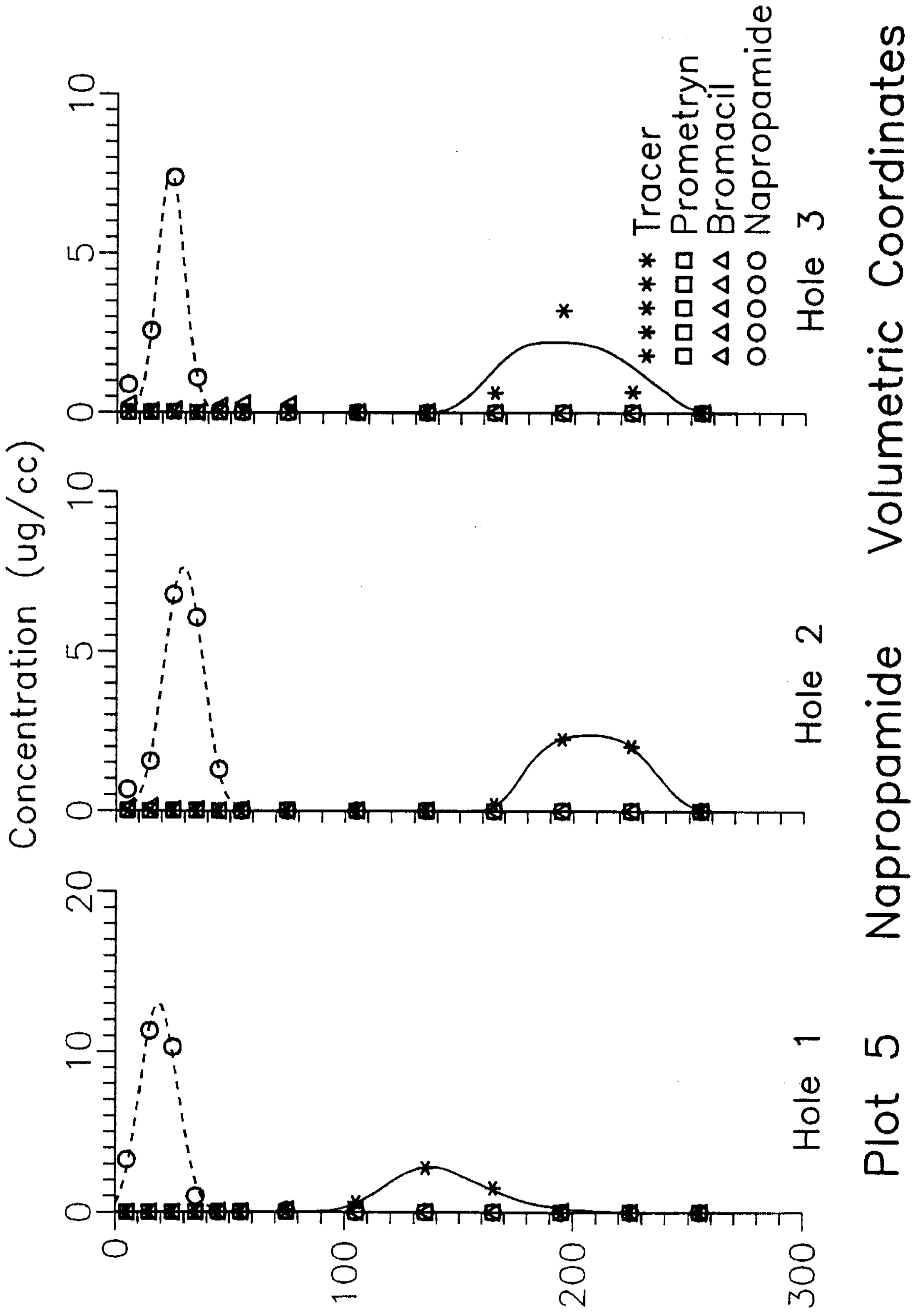
Plot 2 High Concentration Mix Volumetric Coordinates

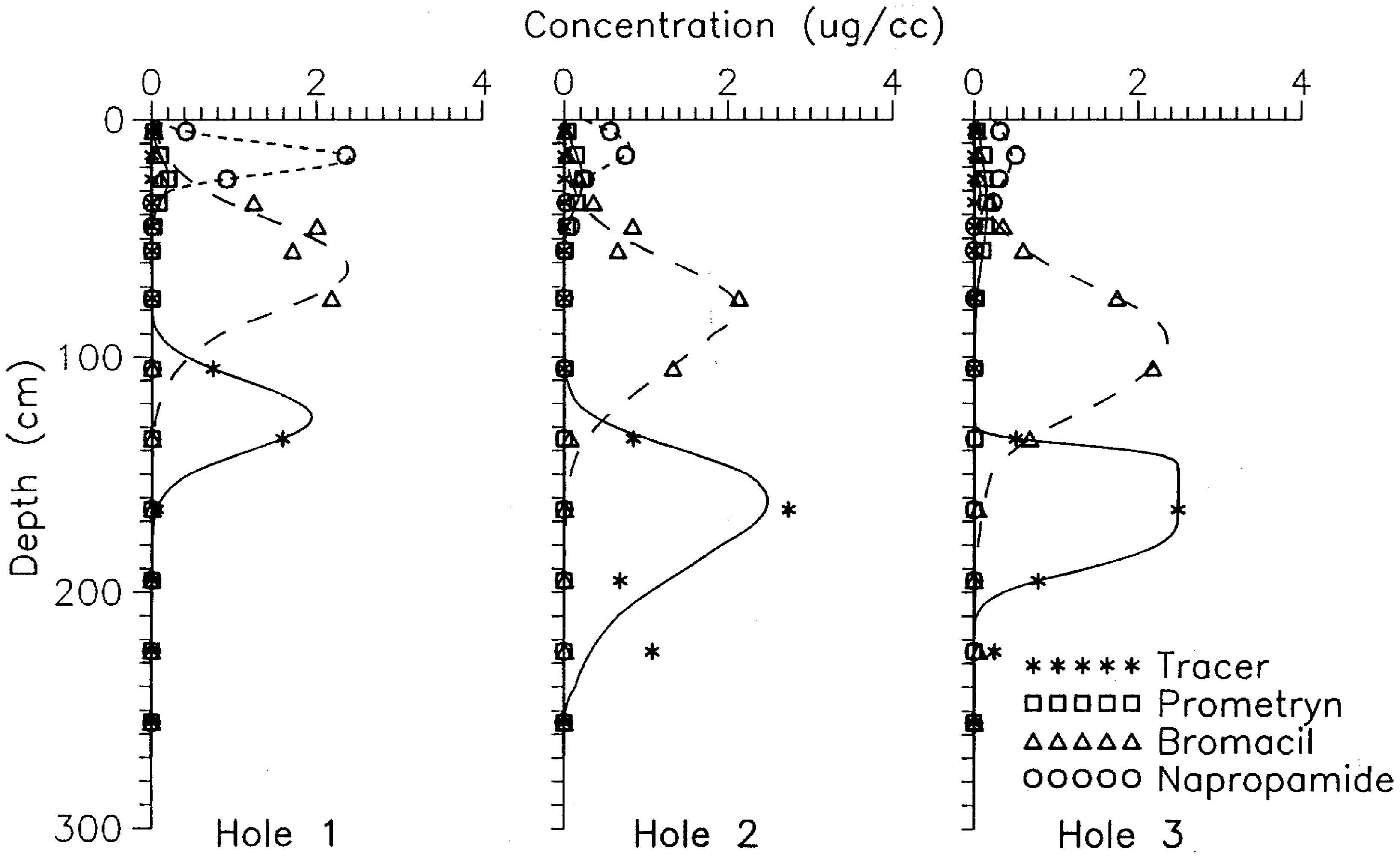


Plot 3 Low Concentration Mix Volumetric Coordinates

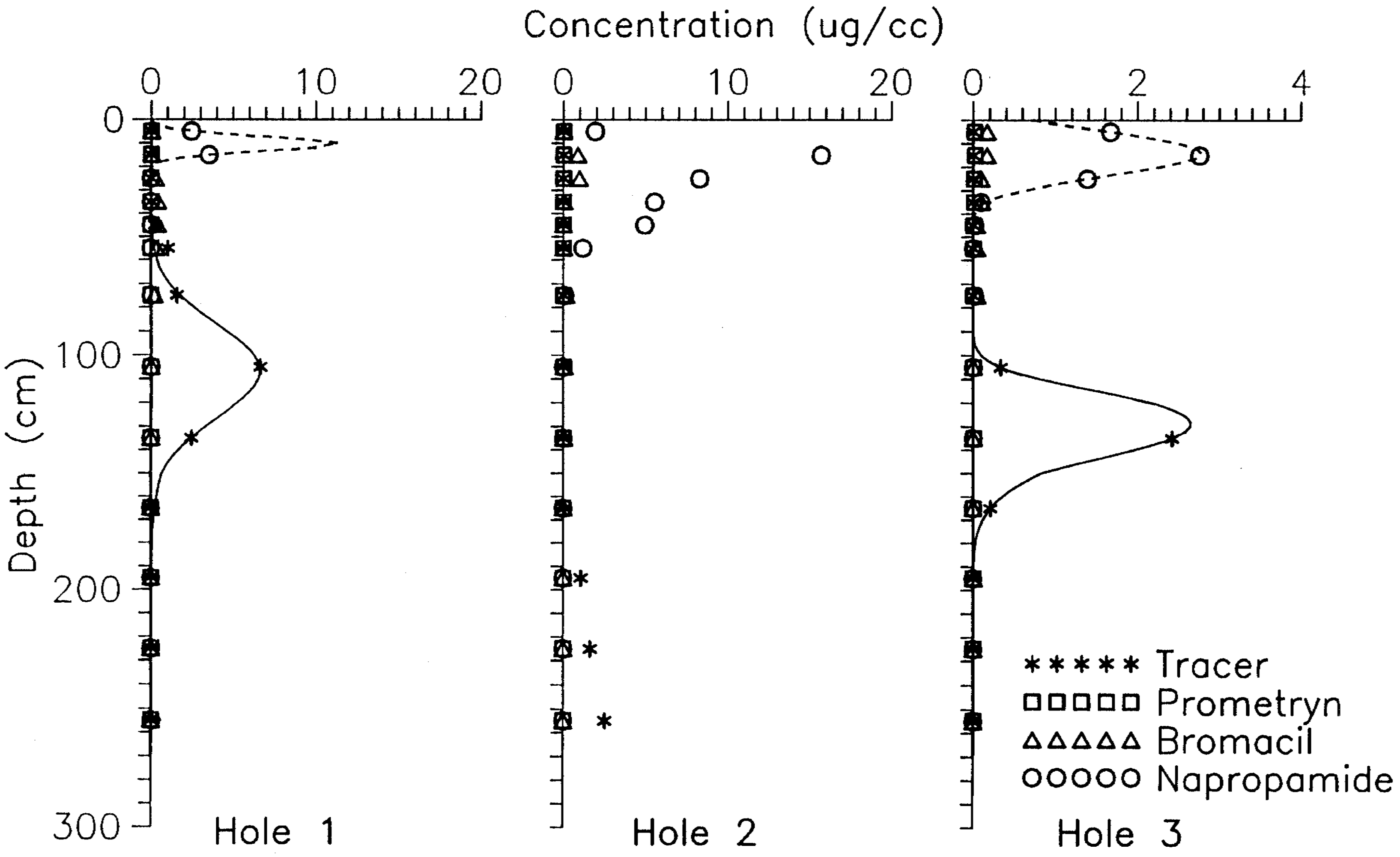


Plot 4 Prometryn Volumetric Coordinates

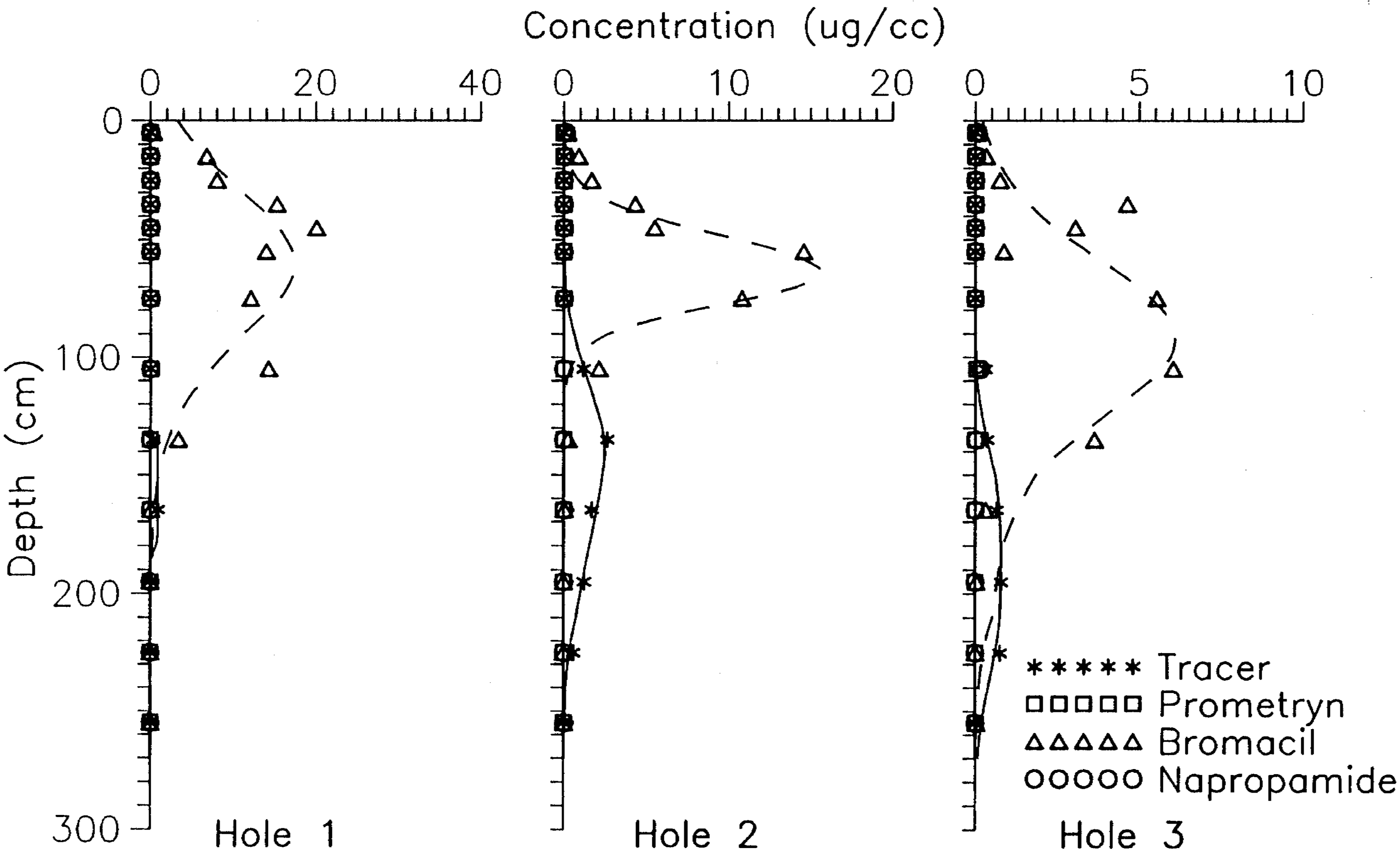

Plot 5 Napropamide Volumetric Coordinates
Concentration (ug/cc)
Depth (cm)
0
100
200
300
0
10
20
0
5
10
0
5
10
Hole 1
Hole 2
Hole 3
***** Tracer
□□□□□ Prometryn
ΔΔΔΔΔ Bromacil
ooooo Napropamide



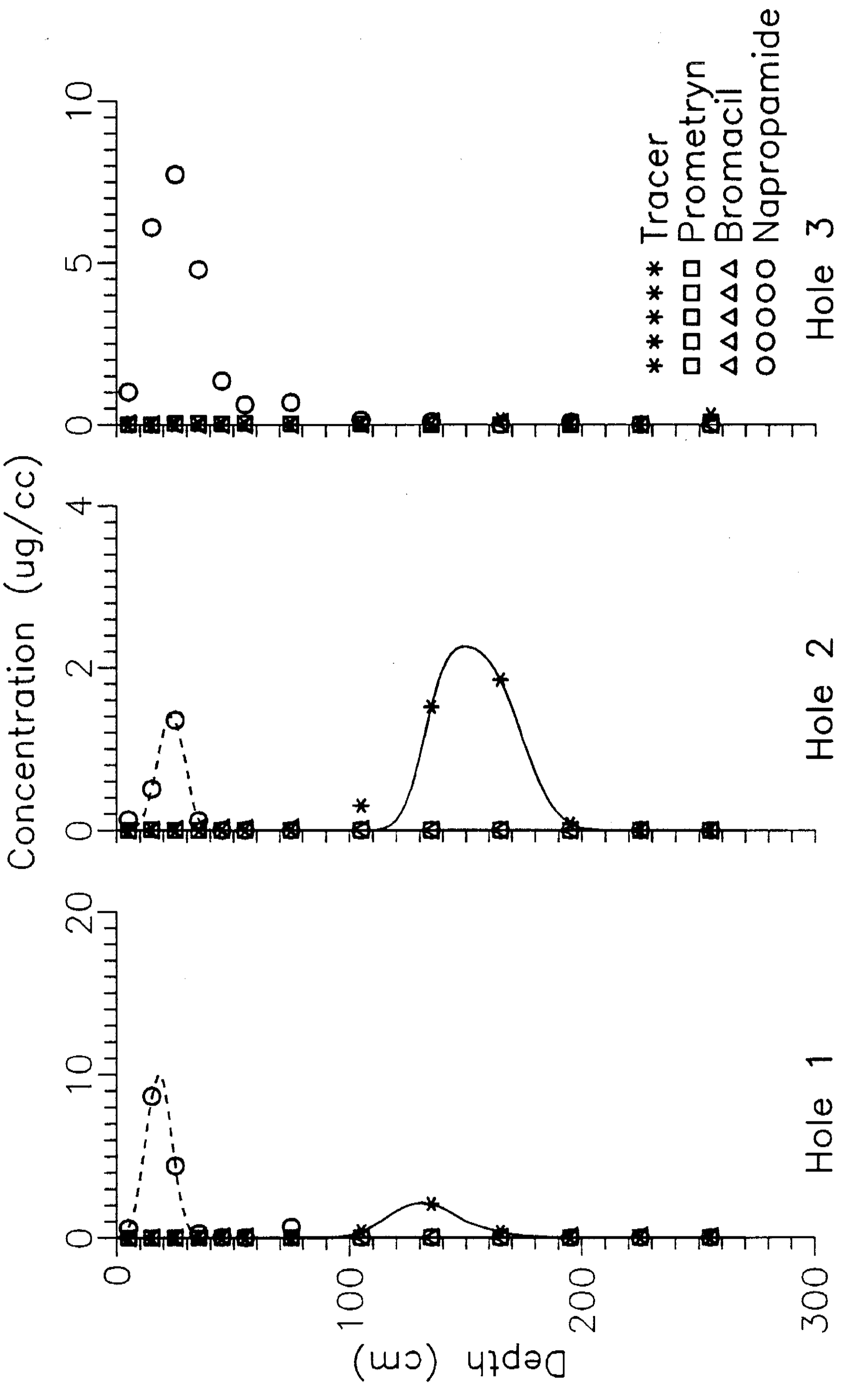
Plot 6 Low Concentration Mix Volumetric Coordinates



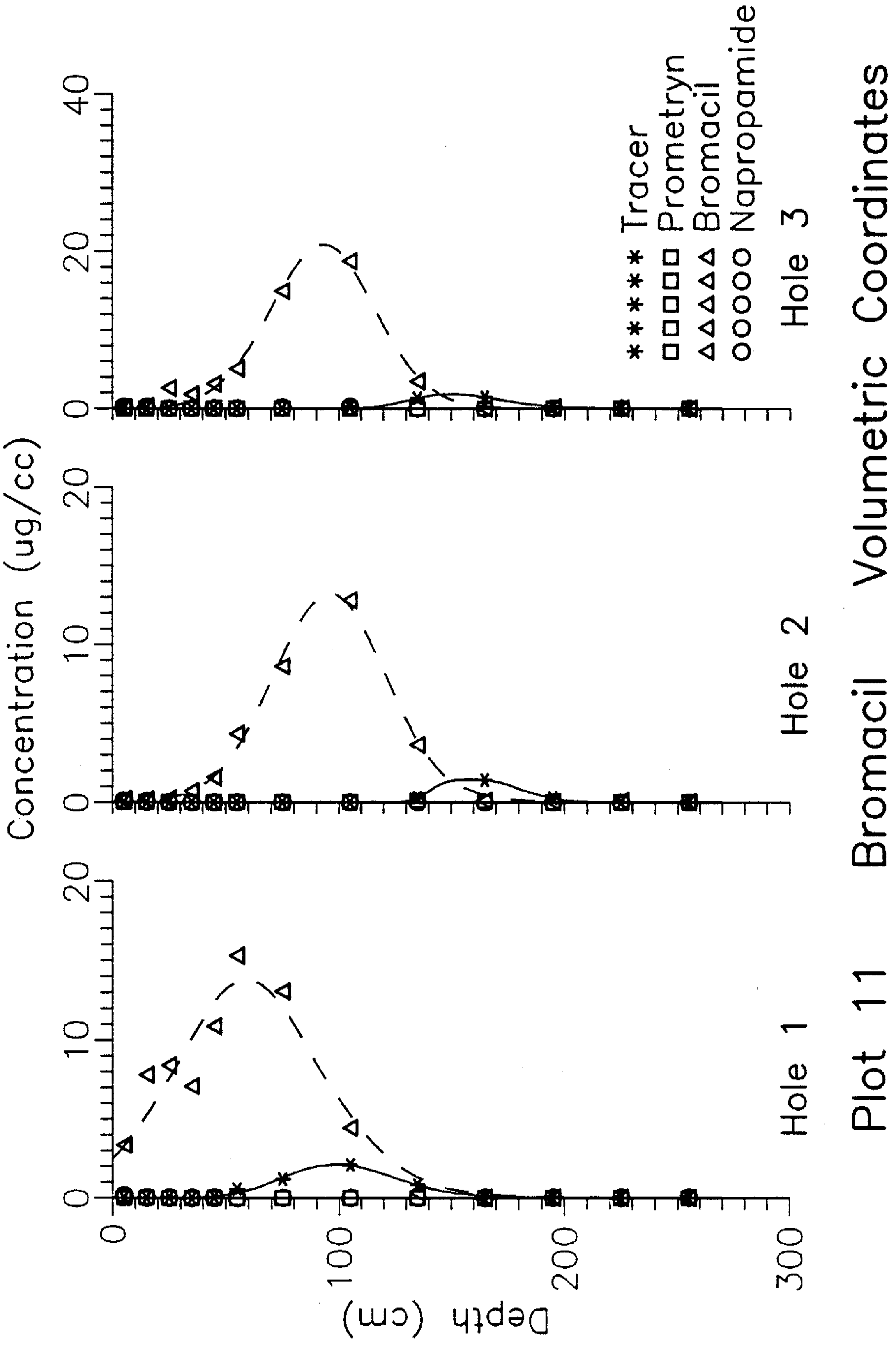
Plot 7 Napropamide Volumetric Coordinates



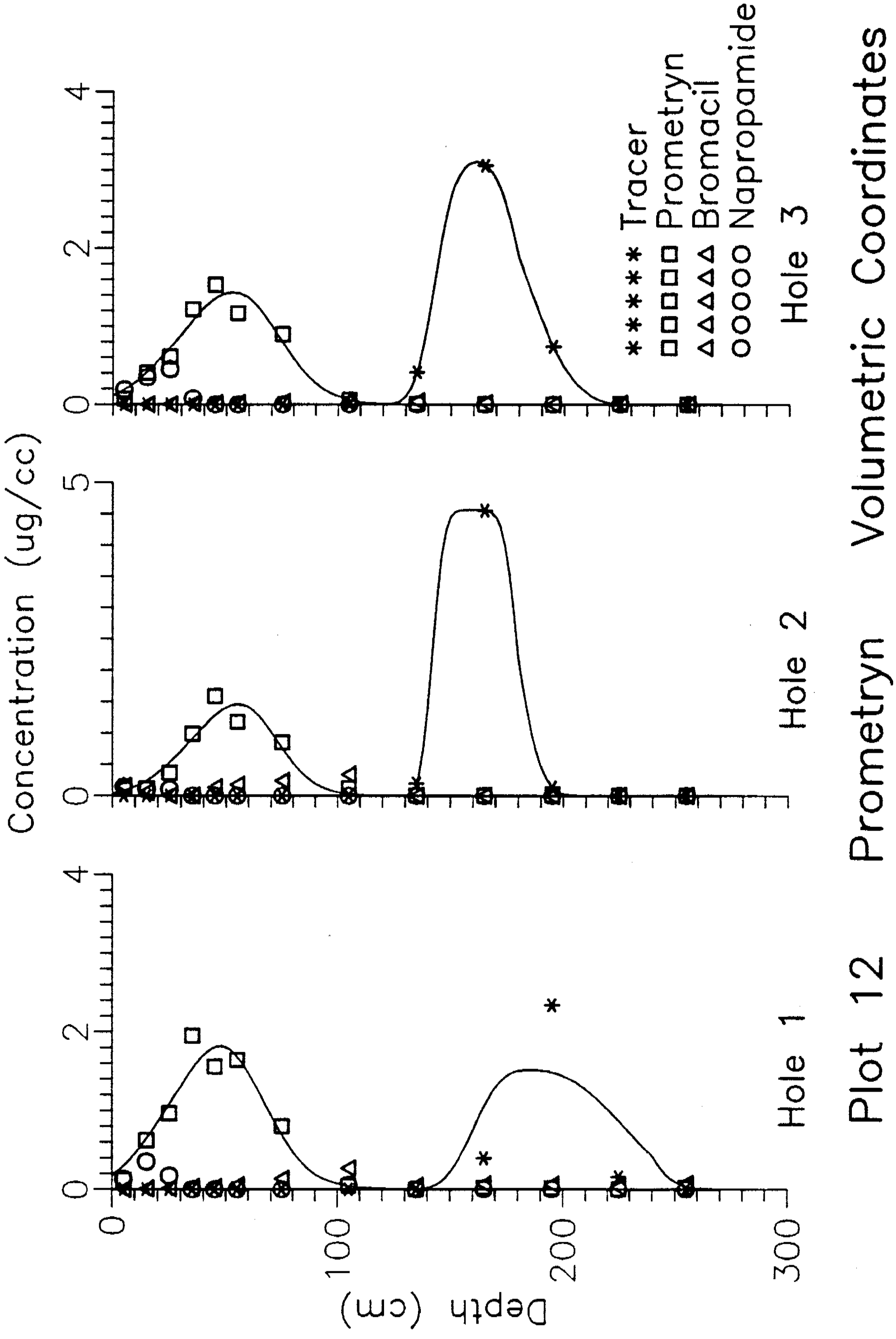
Plot 8 Bromacil Volumetric Coordinates

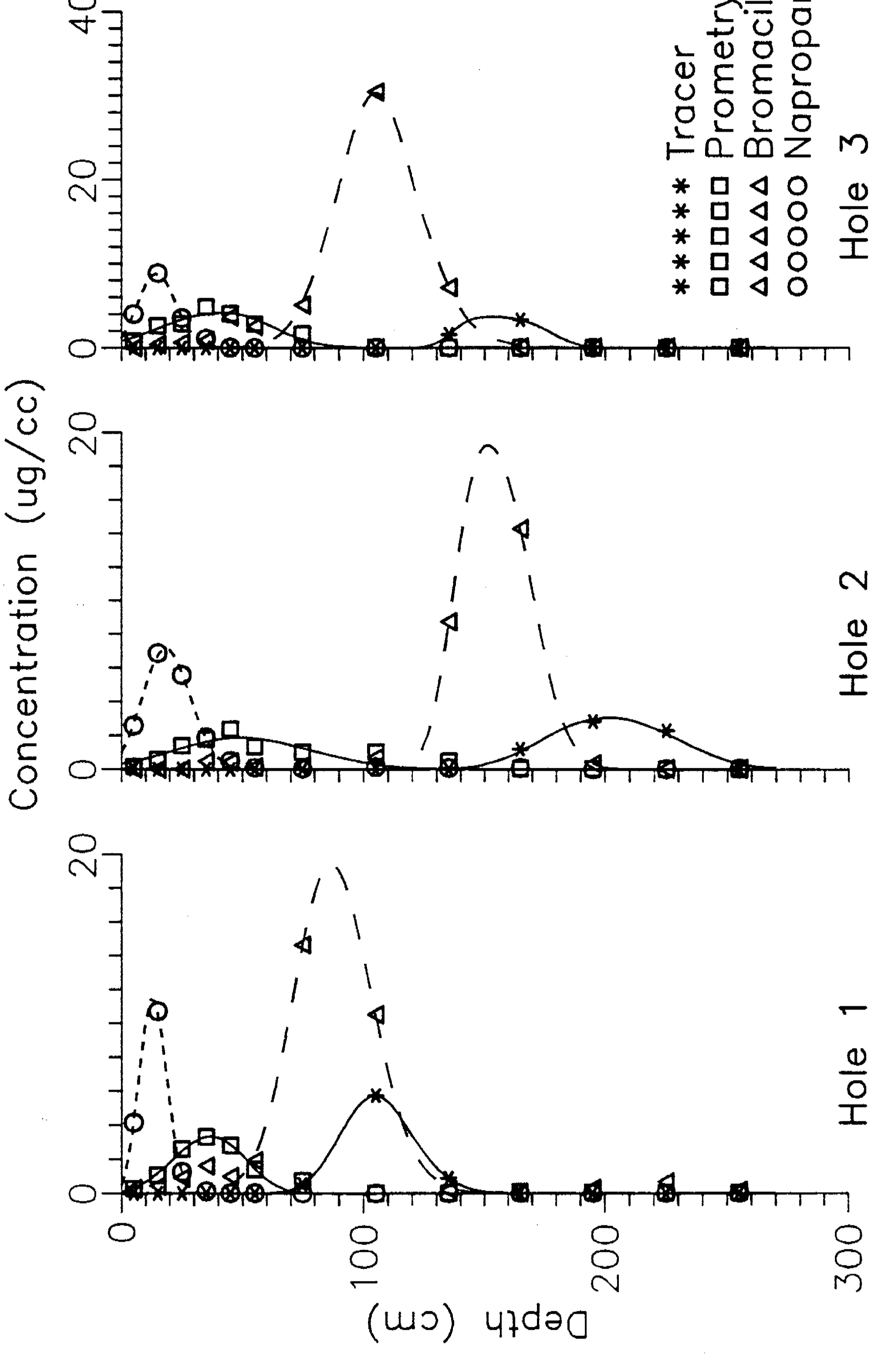


Plot 10 Napropamide Volumetric Coordinates

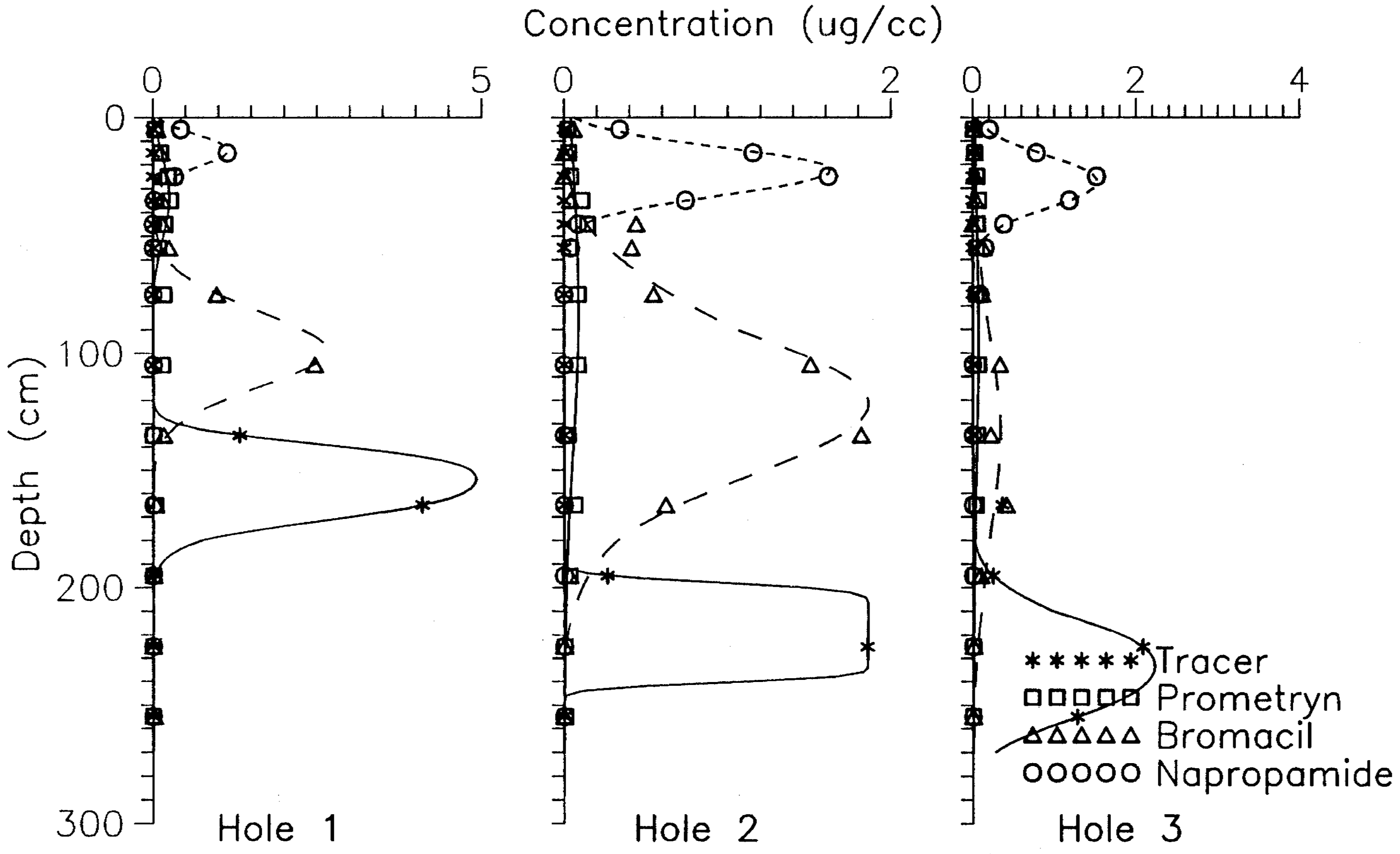


Plot 11 Bromacil Volumetric Coordinates

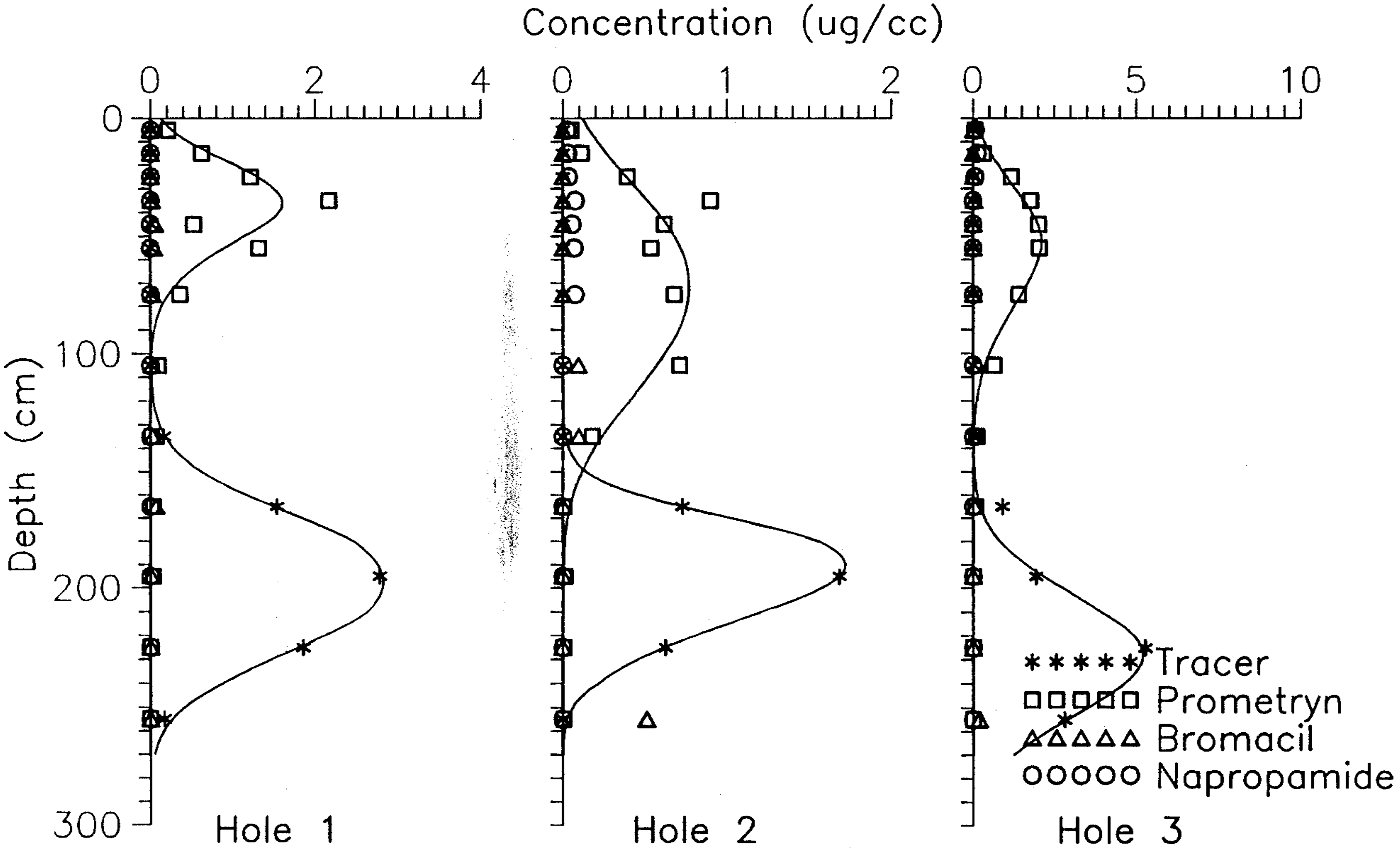

Plot 12 Prometryn Volumetric Coordinates
Concentration (ug/cc)
Depth (cm)
Hole 1
Hole 2
Hole 3
***** Tracer
□□□□□ Prometryn
ΔΔΔΔΔ Bromacil
ooooo Napropamide
0
2
4
0
5
0
2
4
0
100
200
300



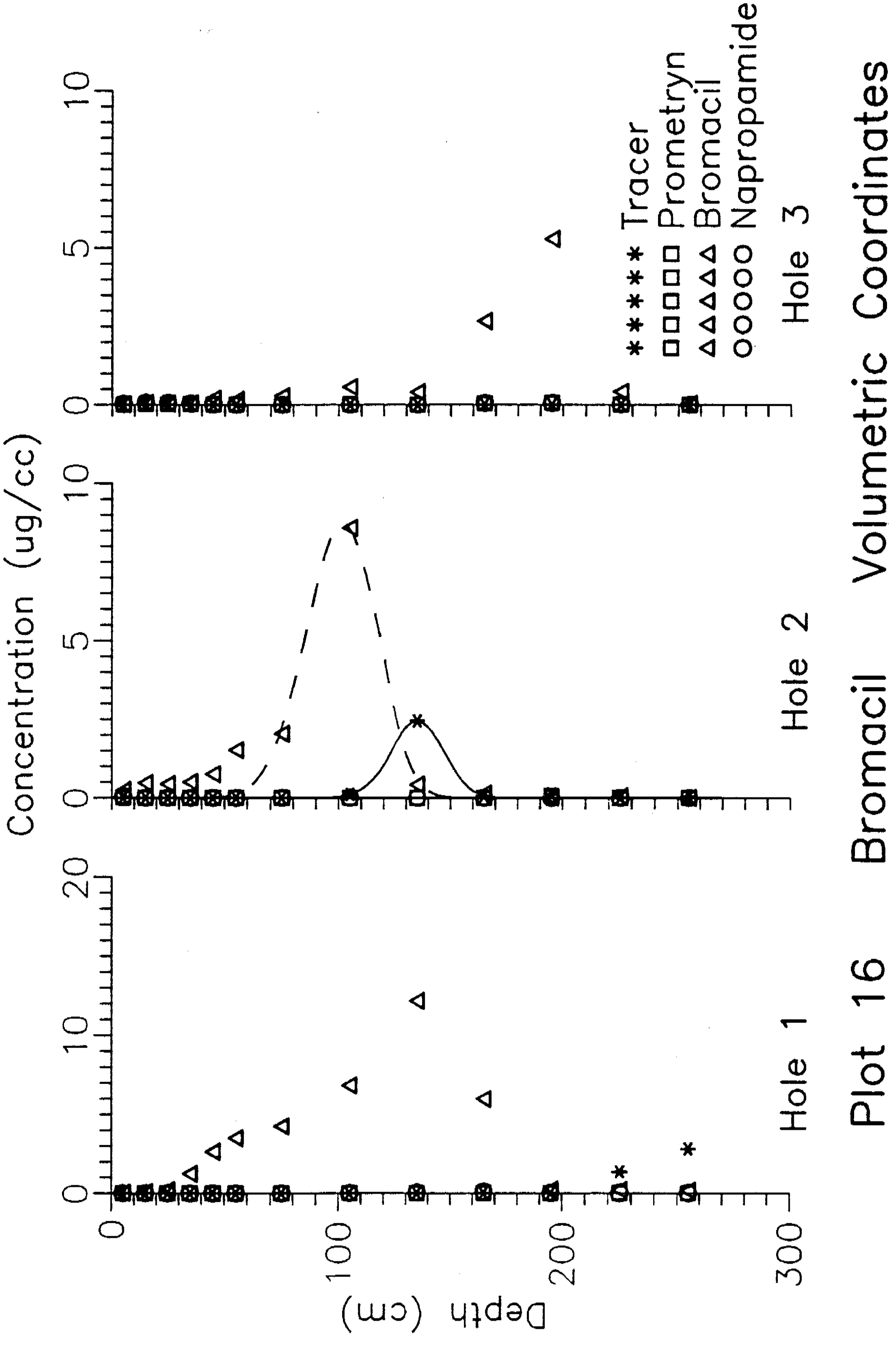
Plot 13 High Concentration Mix Volumetric Coordinates



Plot 14 Low Concentration Mix Volumetric Coordinates



Plot 15 Prometryn Volumetric Coordinates


Concentration (ug/cc)
Depth (cm)
0
100
200
300
0
10
20
0
5
10
0
5
10
Hole 1
Hole 2
Hole 3
***** Tracer
□□□□□ Prometryn
ΔΔΔΔΔ Bromacil
ooooo Napropamide
Plot 16 Bromacil Volumetric Coordinates

APPENDIX Q

CXTFIT-Fitted Parameters - Runs 6 & 7 (Nonequilibrium Model)

Fitted Tracer Parameters -- CXTFIT Run 6

Plot, Hole	SSQ	C_0	D (cm^2/day)	β	ω
1,1	0.221	5.125	0.093	0.423	0.002
1,2					
1,3	0.924	6.569	0.640	0.447	0.000
2,1	6.191	2.381	0.620	0.485	0.013
2,2	0.143	5.127	3.617	0.667	0.012
2,3	0.000	1.610	0.744	0.460	0.013
3,1					
3,2	0.000	2.875	0.449	0.436	0.009
3,3	0.035	1.542	0.600	0.345	0.021
4,1	0.000	4.115	0.082	0.537	0.000
4,2	0.000	3.201	0.645	0.446	0.013
4,3	0.134	2.972	1.732	0.367	0.020
5,1	0.022	4.584	1.397	0.544	0.007
5,2	0.020	2.756	0.407	0.373	0.000
5,3	0.000	3.260	0.264	0.432	0.000
6,1	0.000	2.525	0.735	0.672	0.011
6,2	1.135	3.488	0.993	0.552	0.012
6,3	0.059	3.013	0.692	0.459	0.014
7,1	0.824	13.682	2.125	0.810	0.022
7,2					
7,3	0.000	2.954	0.619	0.657	0.008
8,1	0.000	0.961	0.122	0.540	0.000
8,2	0.550	6.648	5.440	0.561	0.000
8,3	0.131	2.075	5.880	0.459	0.031
10,1	0.000	2.765	0.870	0.655	0.005
10,2	0.086	3.200	1.026	0.542	0.016
10,3					
11,1	0.060	5.956	4.399	0.974	0.033
11,2	0.000	1.600	0.614	0.564	0.011
11,3	0.009	2.815	1.718	0.610	0.024
12,1	0.000	2.351	0.143	0.436	0.002
12,2	0.000	4.563	0.154	0.501	0.000
12,3	0.000	3.417	0.548	0.545	0.009
13,1	0.000	8.899	0.963	0.751	0.003
13,2	0.259	4.316	1.519	0.440	0.006
13,3	0.000	4.237	0.405	0.496	0.004
14,1	0.000	4.672	0.238	0.499	0.008
14,2	0.000	1.857	0.006	0.389	0.003
14,3	0.128	2.104	0.260	0.402	0.001
15,1	0.045	4.514	2.032	0.457	0.019
15,2	0.001	2.124	1.056	0.488	0.015
15,3	0.694	6.212	1.034	0.399	0.007
16,1					
16,2	0.016	2.637	0.343	0.694	0.007
16,3					

Note: C_0 is a fitting parameter only and should not be interpreted literally. All parameters are subject to <u>major</u> uncertainty! (see text)

Fitted Bromacil Parameters -- CXTFIT Run 7

Plot, Hole	SSQ	C_0	R	D (cm^2/day)	β	ω
1,1	0.379	16.238	1.595	0.175	0.906	1.659
1,2						
1,3	3.295	6.824	1.818	23.023	0.985	0.000
2,1	0.156	16.129	1.433	2.337	0.961	0.409
2,2	11.366	28.778	2.033	14.661	0.984	0.000
2,3	3.021	11.283	1.704	0.000	0.854	1.575
3,1						
3,2	0.032	3.153	1.633	2.360	0.966	0.099
3,3	0.039	1.048	17.909	2.571	0.086	0.253
4,1						
4,2						
4,3						
5,1						
5,2						
5,3						
6,1	0.682	4.184	2.111	7.308	0.985	0.000
6,2	0.133	3.266	2.179	2.115	0.819	2.017
6,3	0.027	3.920	1.767	8.338	1.000	44.363
7,1						
7,2						
7,3						
8,1	74.001	45.205	2.594	31.540	0.961	0.502
8,2	13.610	18.416	2.268	3.901	0.990	0.378
8,3	14.872	13.427	2.268	8.857	0.714	2.126
10,1						
10,2						
10,3						
11,1	14.930	49.036	2.268	4.978	0.585	2.625
11,2	0.745	22.495	1.800	0.000	0.662	8.222
11,3	8.644	35.748	1.665	7.204	0.990	0.015
12,1						
12,2						
12,3						
13,1	1.869	32.544	1.330	1.547	0.898	0.311
13,2	0.334	15.304	1.384	0.492	0.945	0.192
13,3	4.678	36.575	1.554	1.013	0.883	0.888
14,1	0.021	3.105	1.779	1.930	0.889	0.502
14,2	0.086	2.951	2.011	5.625	0.811	1.675
14,3	0.041	0.740	2.070	25.267	0.832	0.115
15,1						
15,2						
15,3						
16,1						
16,2	0.212	11.181	1.506	0.468	0.806	1.513
16,3						

Note: C_0 is a fitting parameter only and should not be interpreted literally. All parameters are subject to <u>major</u> uncertainty! (see text)

Fitted Napropamide Parameters -- CXTFIT Run 7

Plot, Hole	SSQ	C_0	R	D (cm^2/day)	β	ω
1,1	3.994	5.828	13.663	3.965	0.983	0.000
1,2						
1,3	0.265	3.374	27.122	4.031	0.393	0.611
2,1	4.580	3.276	33.013	2.247	0.196	0.320
2,2	0.090	4.483	10.309	1.636	0.963	2.263
2,3	0.044	4.957	8.902	3.316	0.964	4.900
3,1						
3,2	0.054	0.380	25.050	111.682	1.000	94.439
3,3	0.038	0.336	5.789	6.151	0.991	0.081
4,1						
4,2						
4,3						
5,1	0.008	8.108	9.539	2.051	0.715	4.375
5,2	0.222	3.323	7.438	3.169	0.942	1.104
5,3	0.054	2.496	9.592	0.800	0.746	7.581
6,1	0.001	1.290	19.334	1.908	0.388	1.732
6,2	0.007	0.413	15.618	8.588	0.881	11.162
6,3	0.009	0.358	12.194	16.069	0.900	5.465
7,1	0.001	3.108	10.634	0.966	0.984	0.000
7,2						
7,3	0.005	1.943	13.114	3.984	0.614	8.353
8,1						
8,2						
8,3						
10,1	0.445	4.575	7.807	1.990	0.987	0.022
10,2	0.000	0.582	7.417	0.661	0.779	8.546
10,3						
11,1						
11,2						
11,3						
12,1						
12,2						
12,3						
13,1	0.155	6.741	8.975	2.522	0.990	0.000
13,2	0.163	3.753	12.358	10.317	0.979	0.000
13,3	0.407	4.771	11.708	6.157	0.852	28.492
14,1	0.000	0.531	11.934	4.393	0.940	9.853
14,2	0.002	0.786	11.328	5.455	0.806	4.260
14,3	0.018	0.792	38.690	7.609	0.224	0.778
15,1						
15,2						
15,3						
16,1						
16,2						
16,3						

Note: C_0 is a fitting parameter only and should not be interpreted literally. All parameters are subject to major uncertainty! (see text)

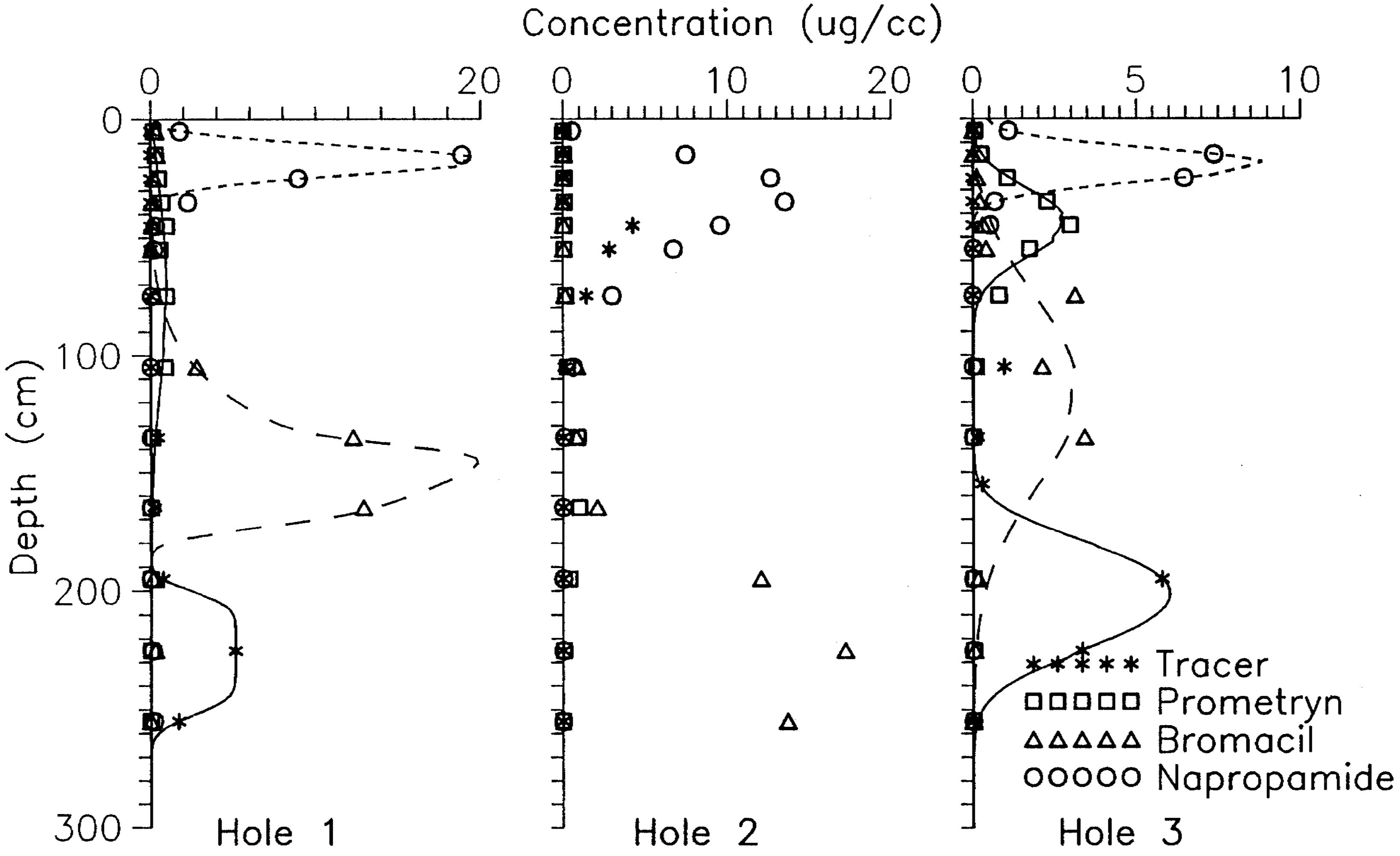
Fitted Prometryn Parameters -- CXTFIT Run 7

Plot, Hole	SSQ	C_0	R	D (cm^2/day)	β	ω
1,1	0.205	1.767	3.608	41.771	0.909	0.551
1,2						
1,3	0.534	2.142	4.769	7.305	0.985	0.000
1,3	0.220	2.617	3.002	22.841	1.000	********
2,1	0.080	1.761	5.277	3.973	0.971	0.607
2,2	0.080	0.990	4.864	4.814	0.747	4.569
2,3						
3,1	0.001	0.198	4.027	56.436	0.990	0.000
3,2	0.000	0.067	13.189	18.313	0.154	1.258
3,3	0.181	2.633	4.042	6.392	0.987	0.000
4,1	0.609	3.251	2.478	26.671	0.989	0.088
4,2	0.030	0.498	6.318	18.002	0.989	0.025
4,3						
5,1						
5,2						
5,3	0.000	0.152	5.772	2.274	0.866	2.305
6,1	0.000	0.166	7.061	6.190	0.953	0.825
6,2	0.001	0.216	5.324	22.922	0.991	0.000
6,3						
7,1						
7,2						
7,3						
8,1						
8,2						
8,3						
10,1						
10,2						
10,3						
11,1						
11,2						
11,3	0.163	2.178	4.535	16.617	1.000	5.899
12,1	0.126	1.886	3.294	9.200	0.973	0.000
12,2	0.077	2.099	3.554	13.691	0.977	0.000
12,3	0.460	5.243	3.069	5.331	1.000	1.59E+04
13,1	1.350	3.074	4.315	35.826	1.000	36.842
13,2	1.545	6.390	4.469	16.737	0.973	0.000
13,3	0.032	0.510	4.010	63.200	0.978	0.000
14,1	0.020	0.068	7.402	1.456	0.697	2.688
14,2	0.002	0.192	2.997	94.683	0.926	0.403
14,3	1.187	1.558	5.837	16.462	0.988	0.526
15,1	0.251	1.747	3.063	40.896	0.977	0.000
15,2	0.263	2.601	4.591	23.813	0.983	0.000
15,3						
16,1						
16,2						
16,3						

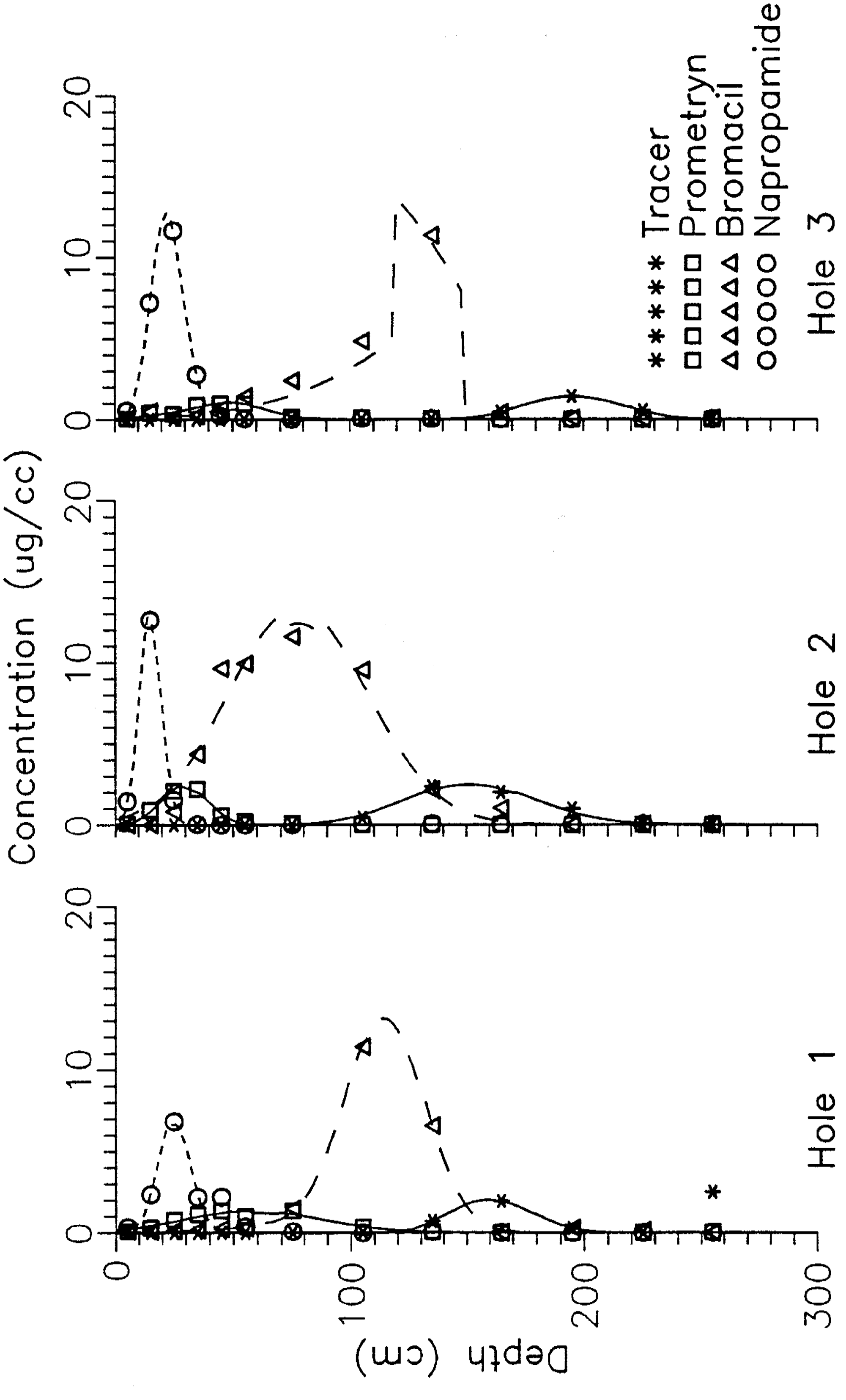
Note: C_0 is a fitting parameter only and should not be interpreted literally. All parameters are subject to <u>major</u> uncertainty! (see text)

APPENDIX R

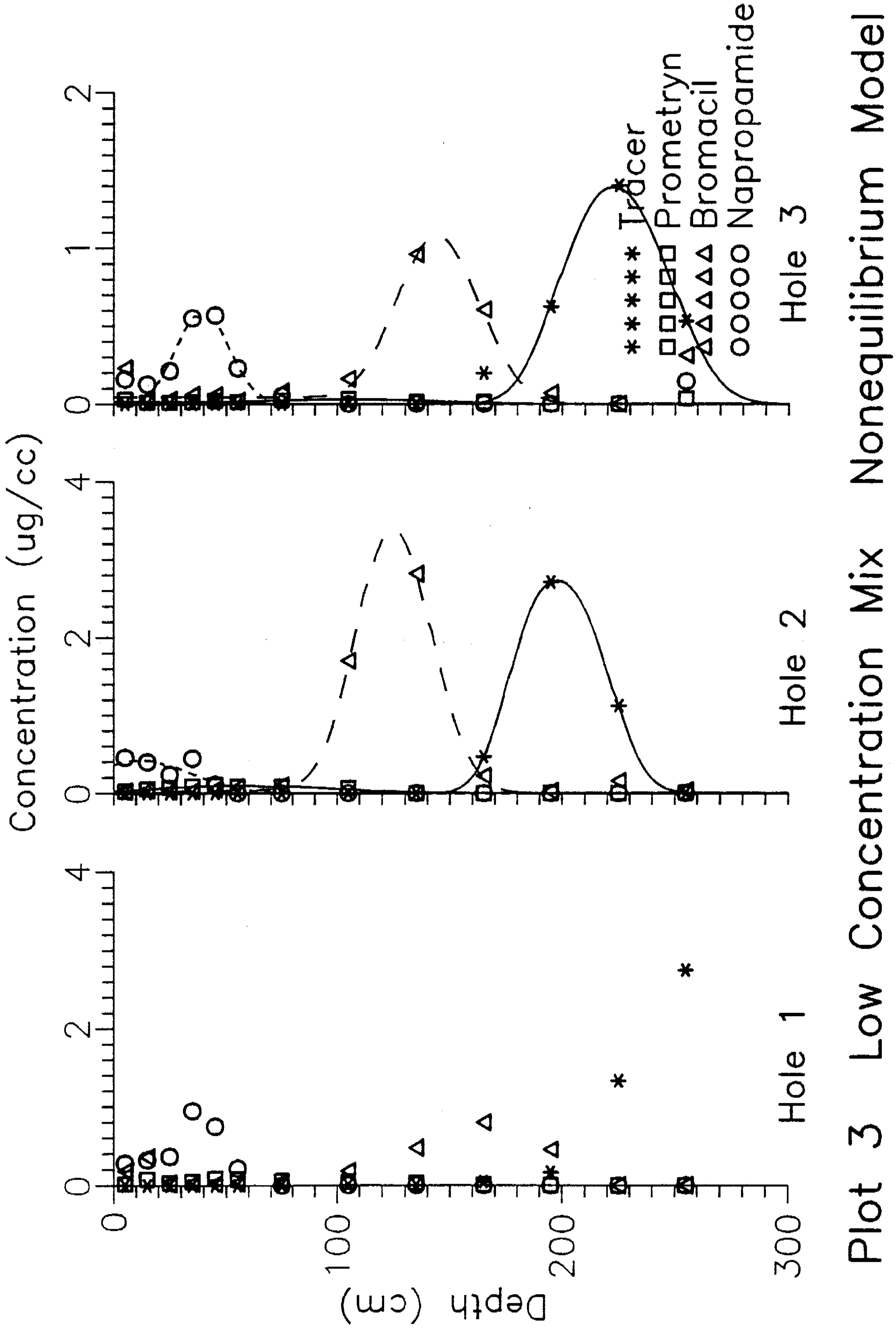
CXTFIT-Fitted Profiles - Runs 6 & 7 (Nonequilibrium Model)



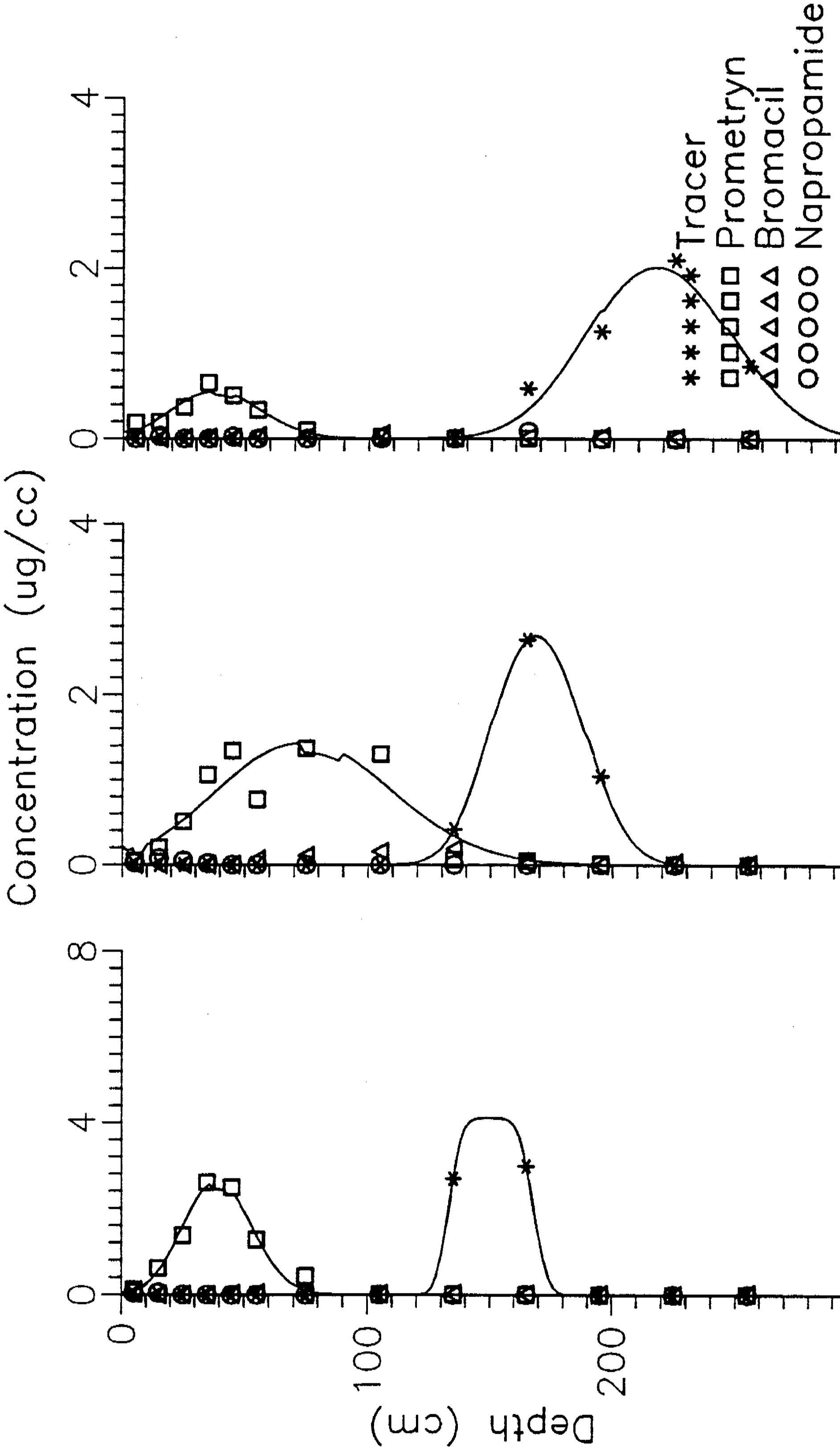
Plot 1 High Concentration Mix Nonequilibrium Model



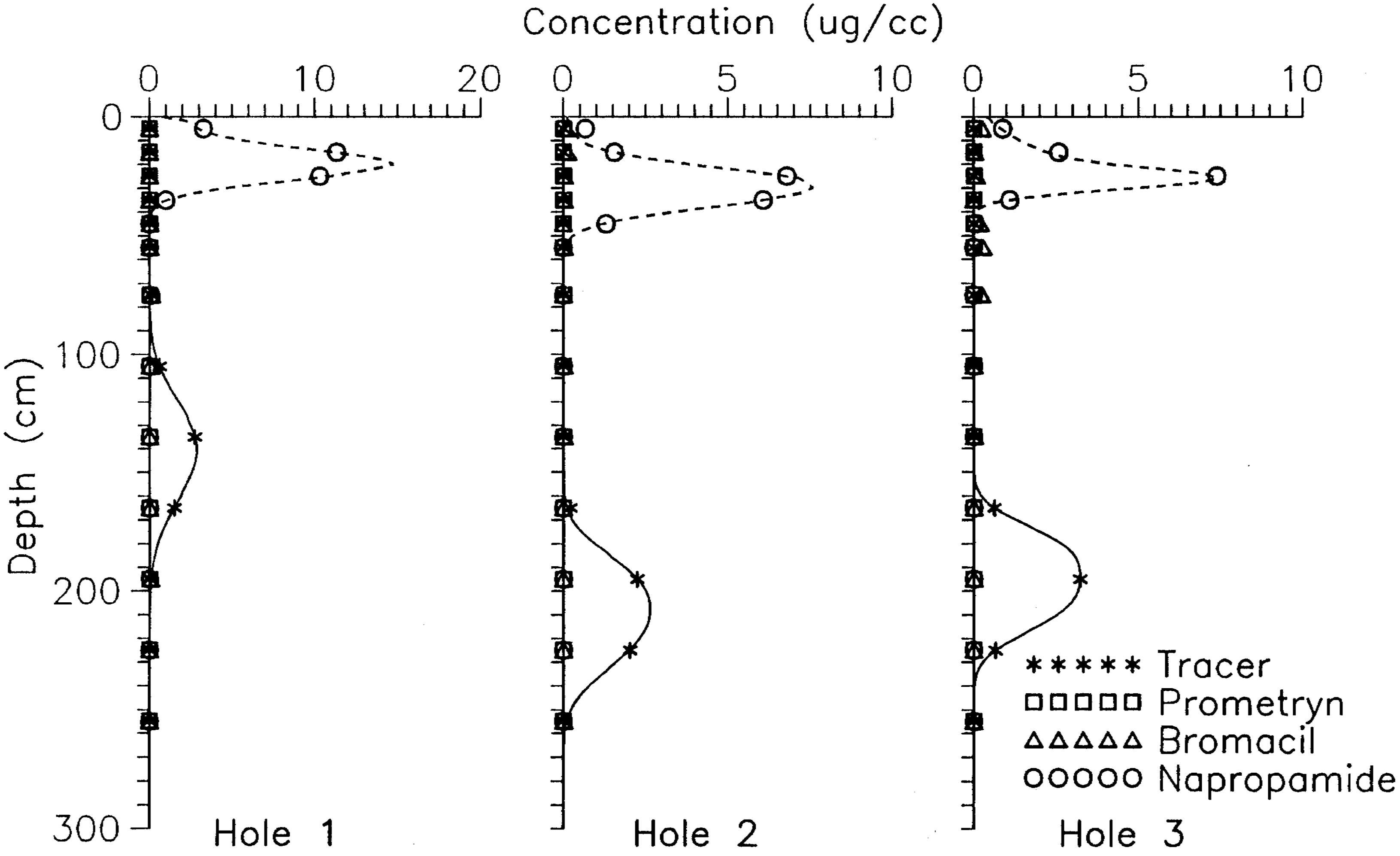
Plot 2 High Concentration Mix Nonequilibrium Model



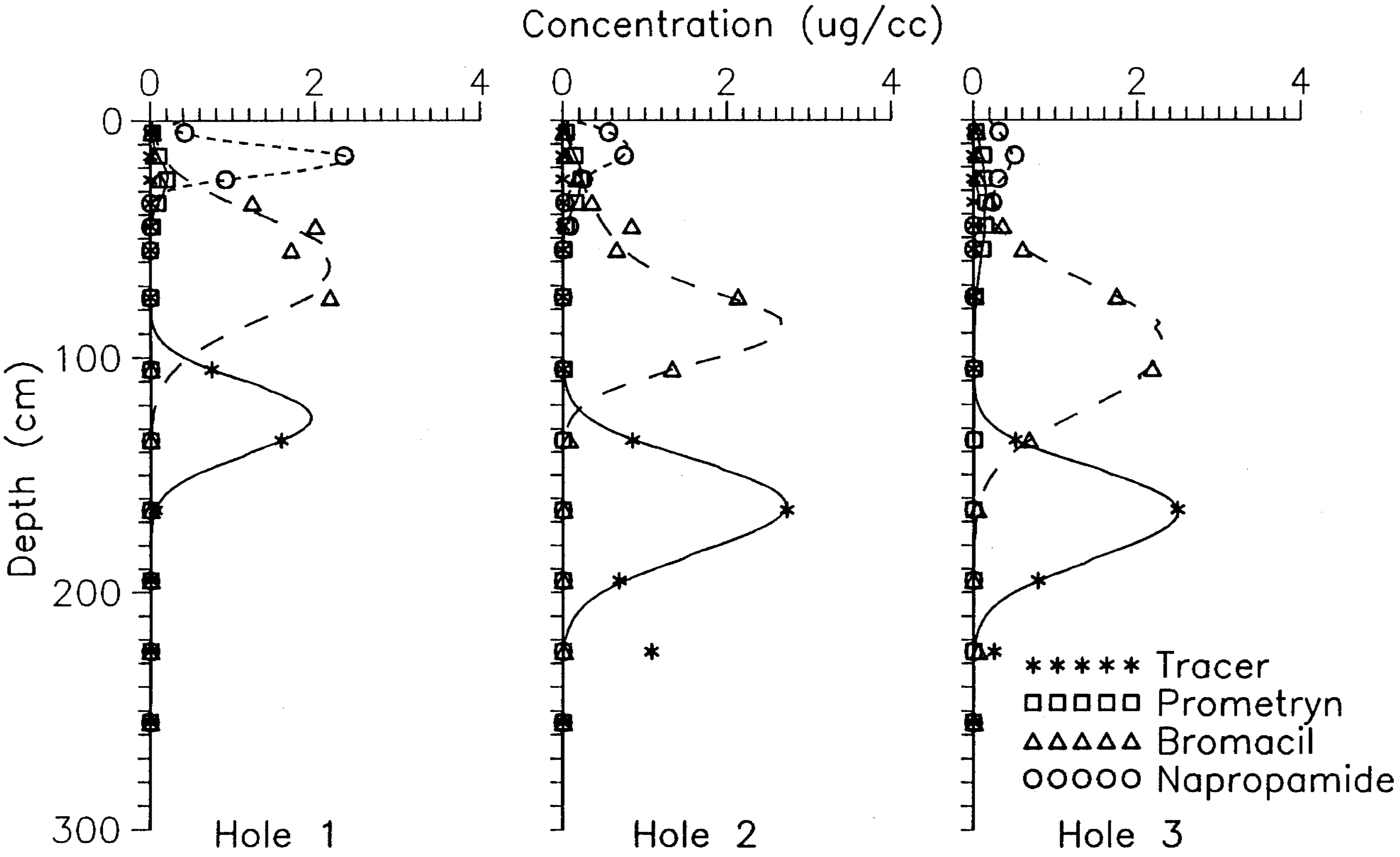
Plot 3 Low Concentration Mix Nonequilibrium Model



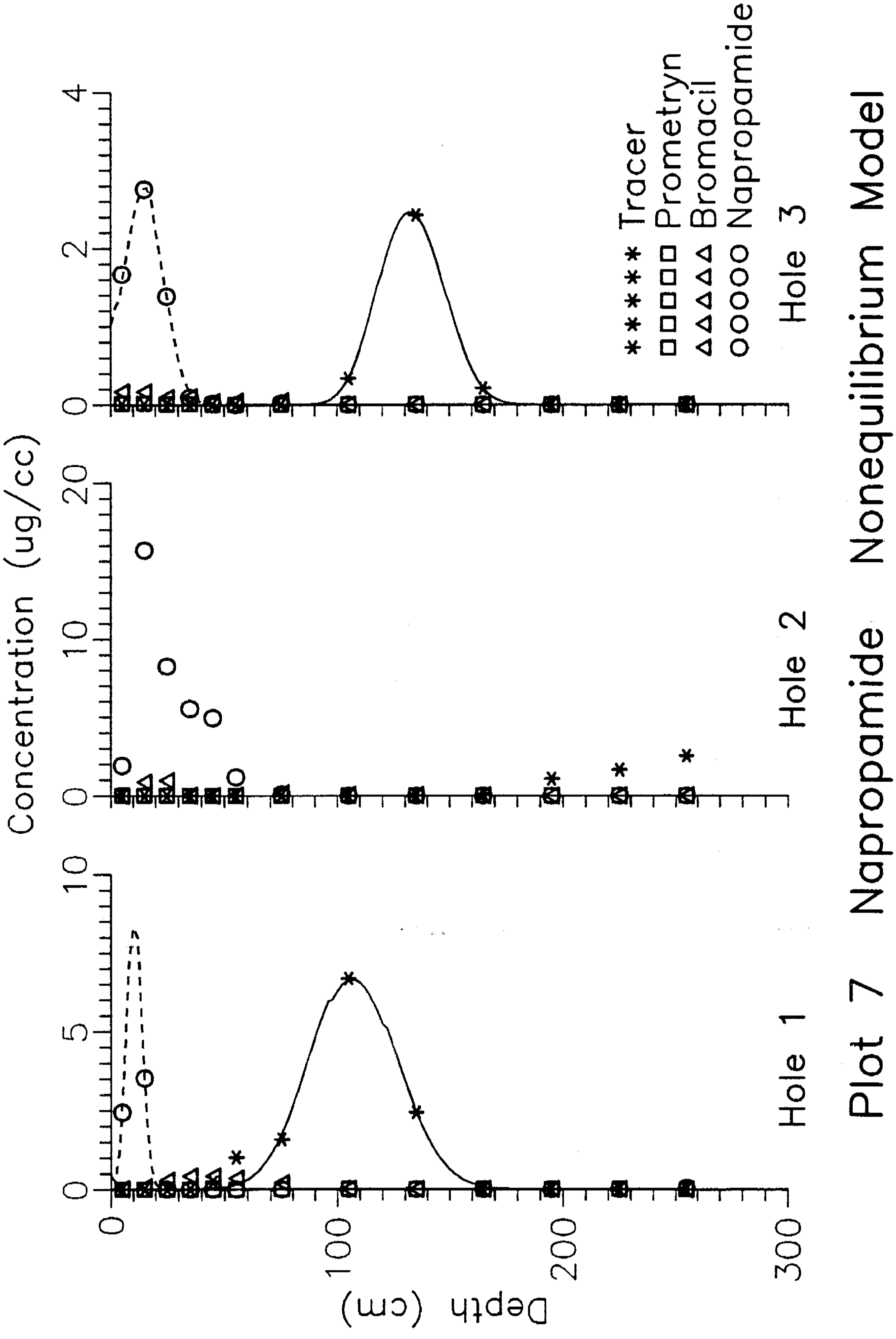
Plot 4 Prometryn Nonequilibrium Model

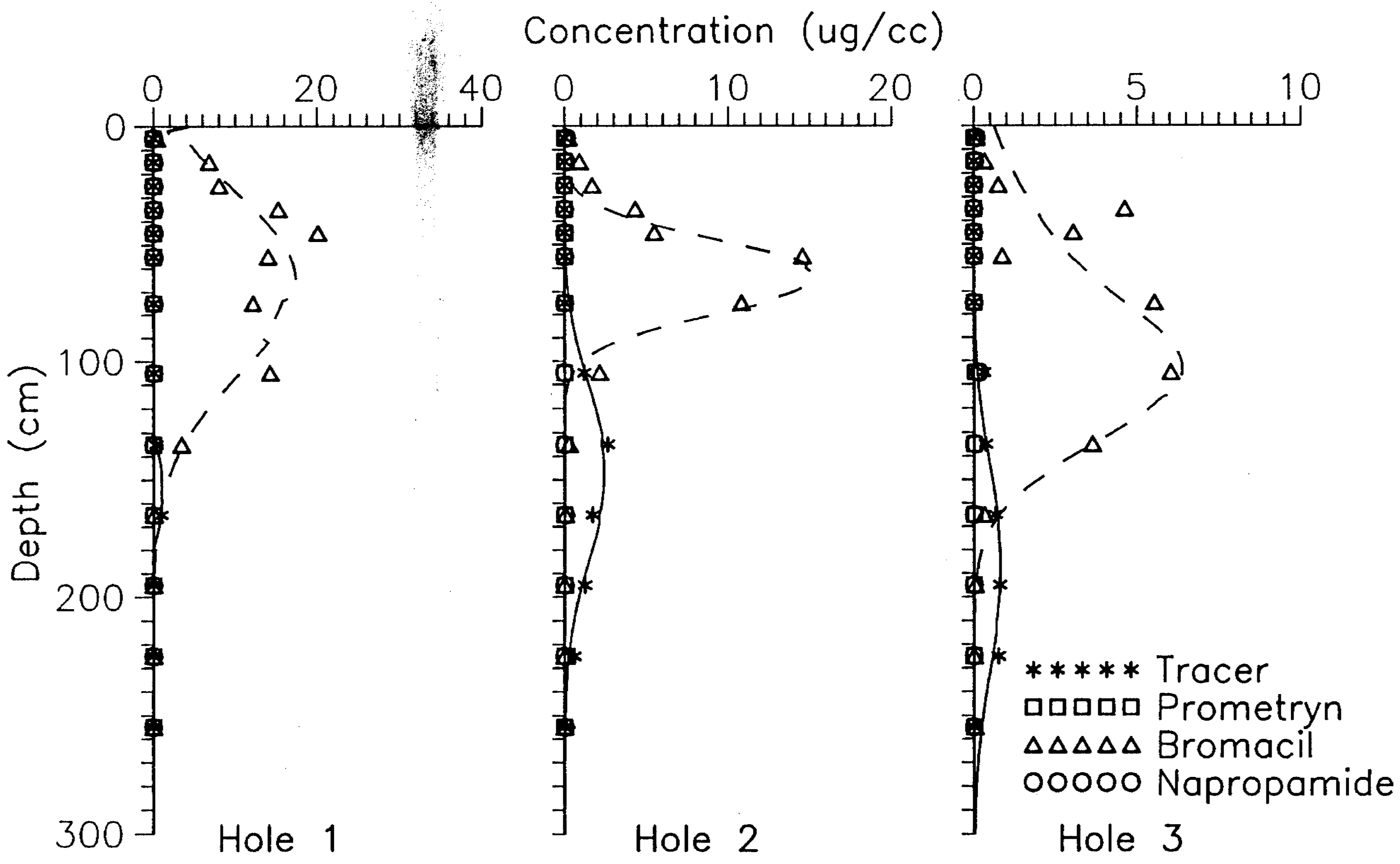


Plot 5 Napropamide Nonequilibrium Model

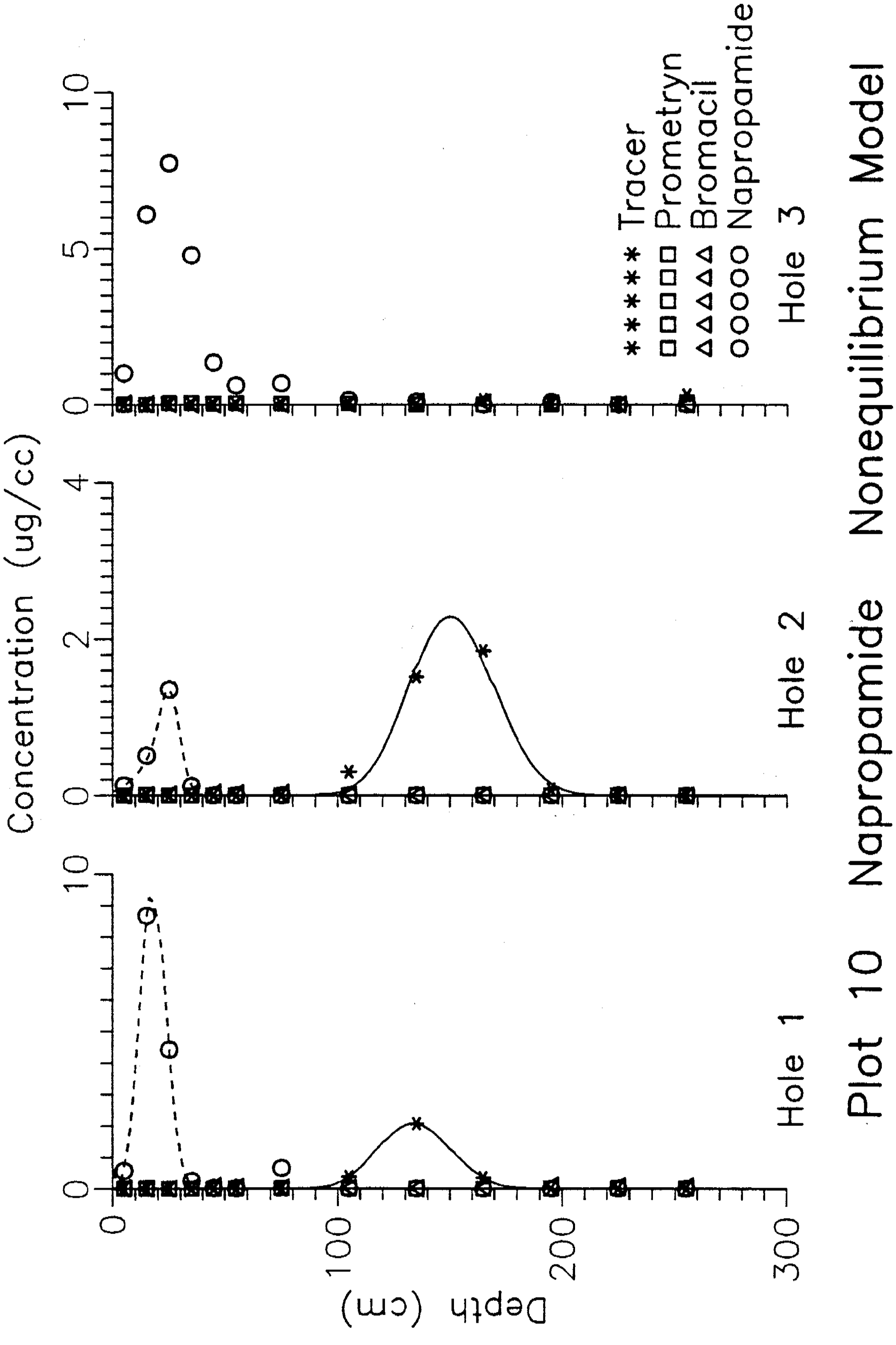


Plot 6 Low Concentration Mix Nonequilibrium Model

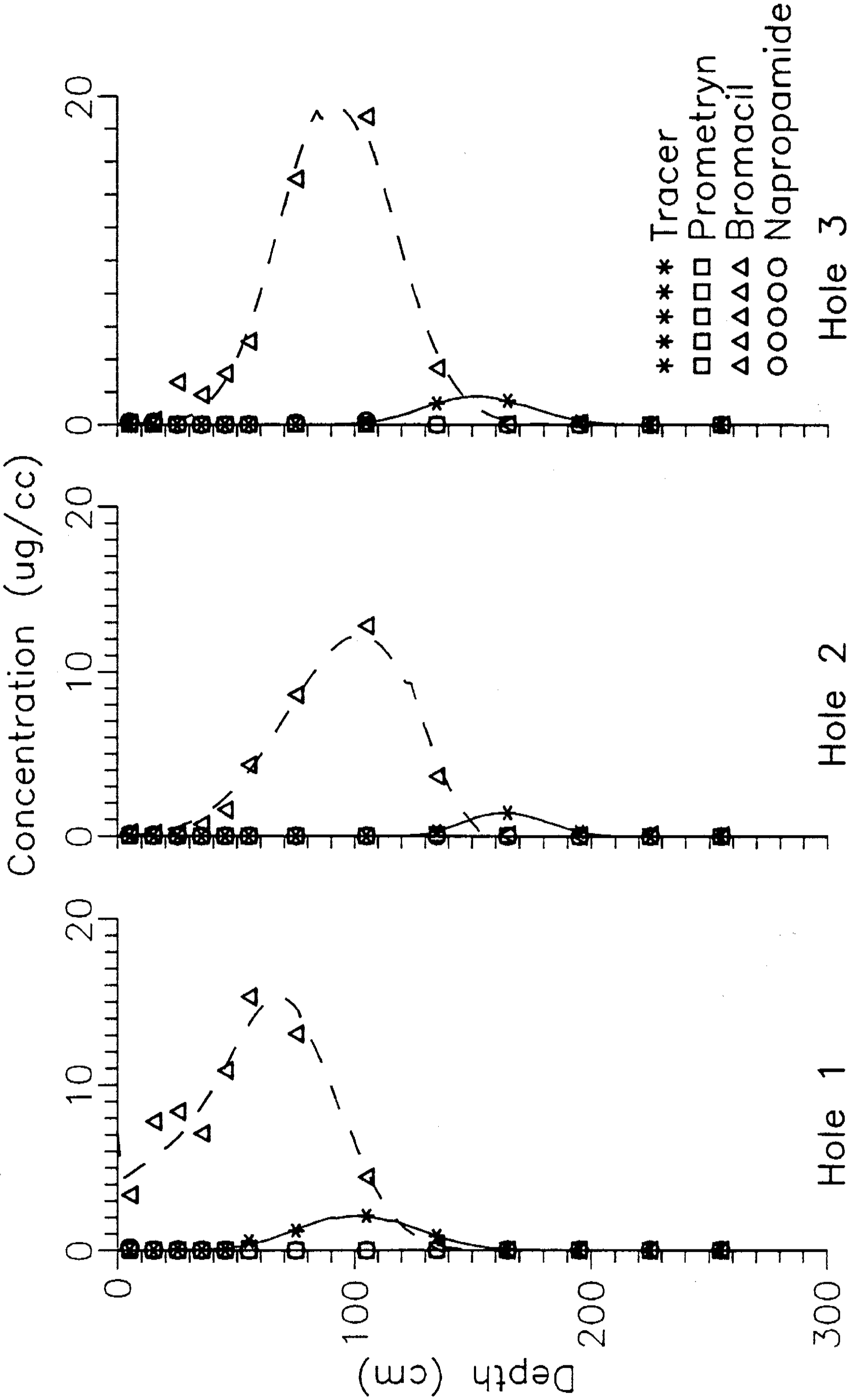

Plot 7 Napropamide Nonequilibrium Model
Concentration (ug/cc)
Depth (cm)
Hole 1
Hole 2
Hole 3
0
5
10
0
10
20
0
2
4
0
100
200
300
***** Tracer
□□□□□ Prometryn
△△△△△ Bromacil
ooooo Napropamide



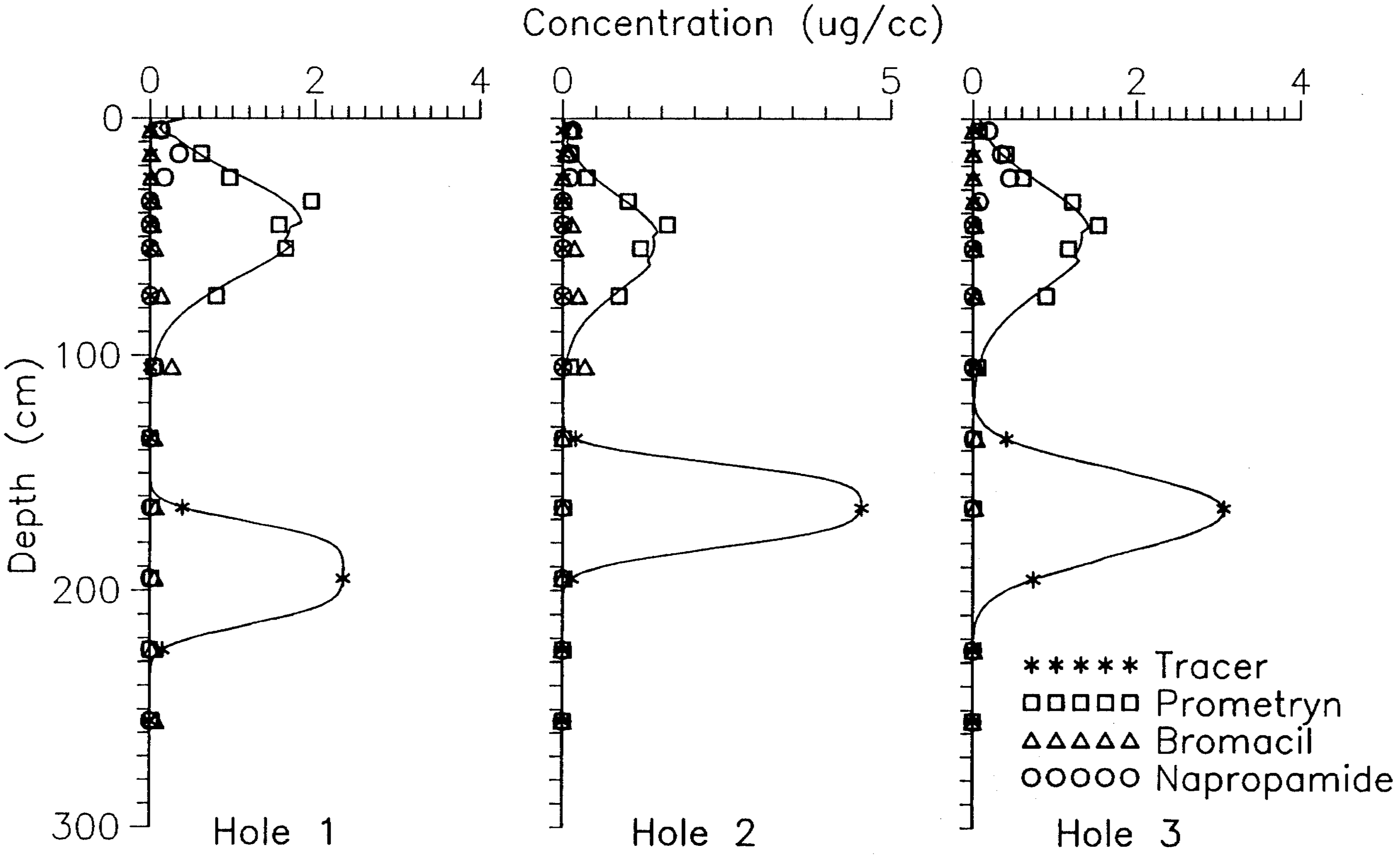
Plot 8 Bromacil Nonequilibrium Model



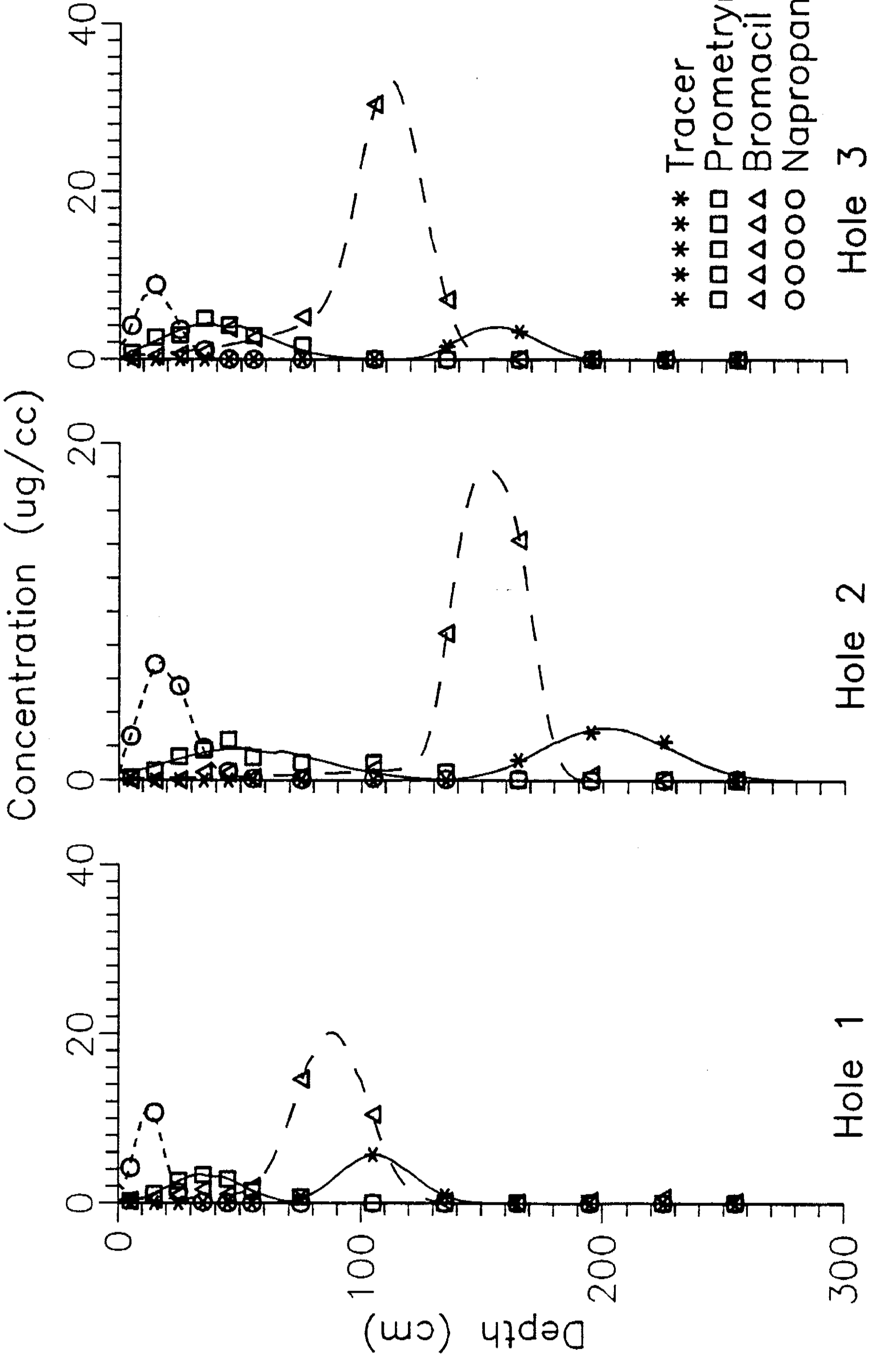
Plot 10 Napropamide Nonequilibrium Model



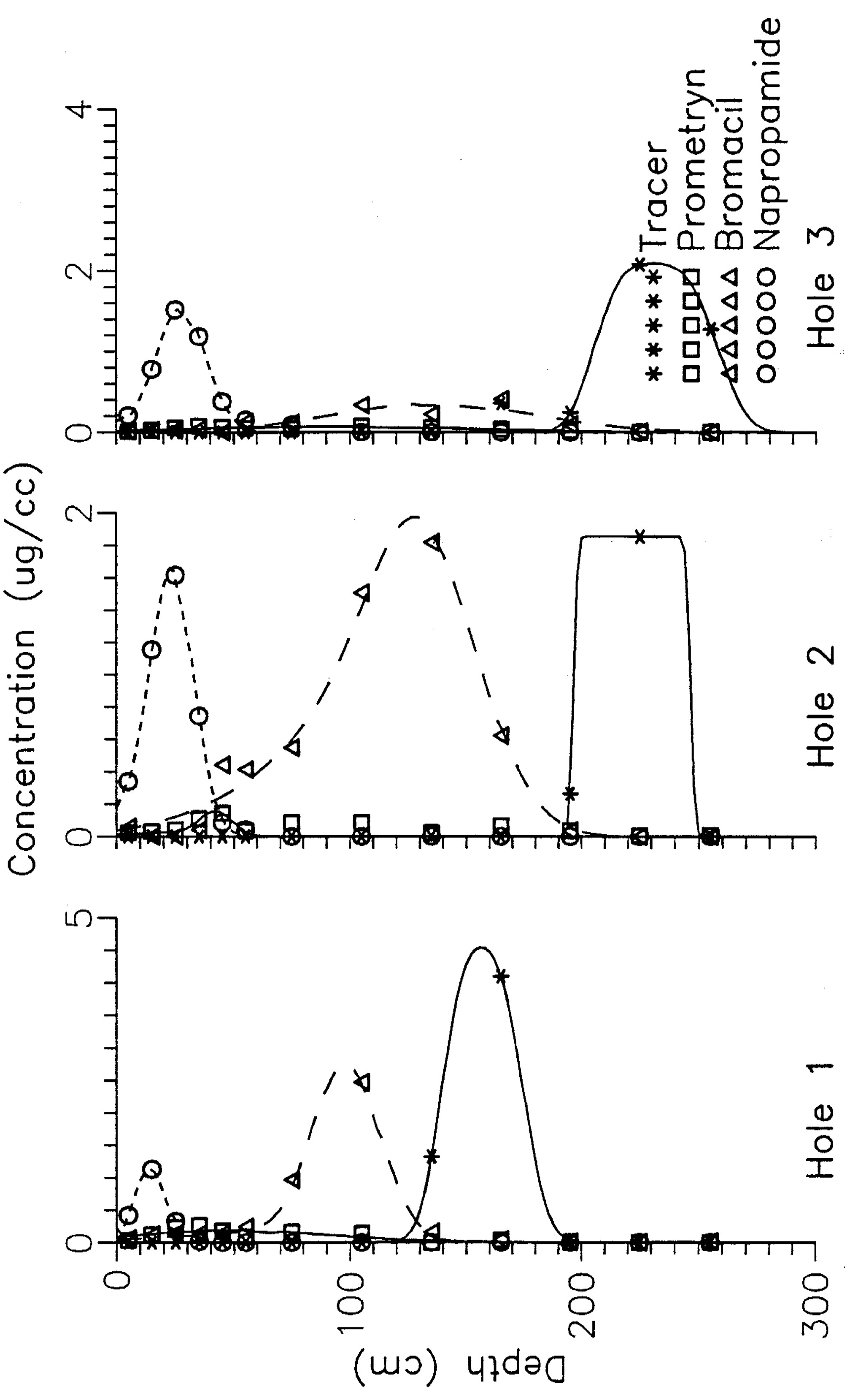
Plot 11 Bromacil Nonequilibrium Model



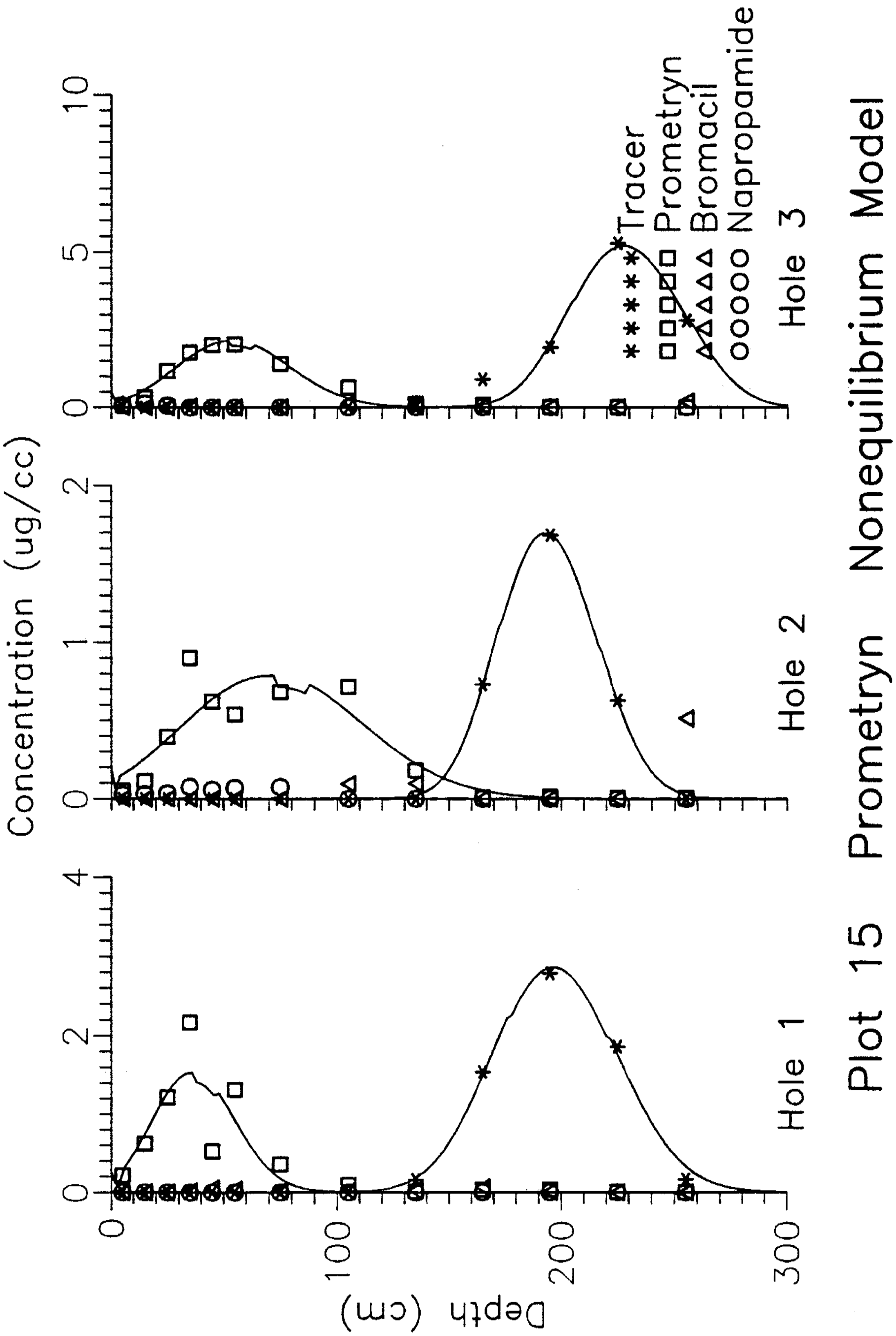
Plot 12 Prometryn Nonequilibrium Model

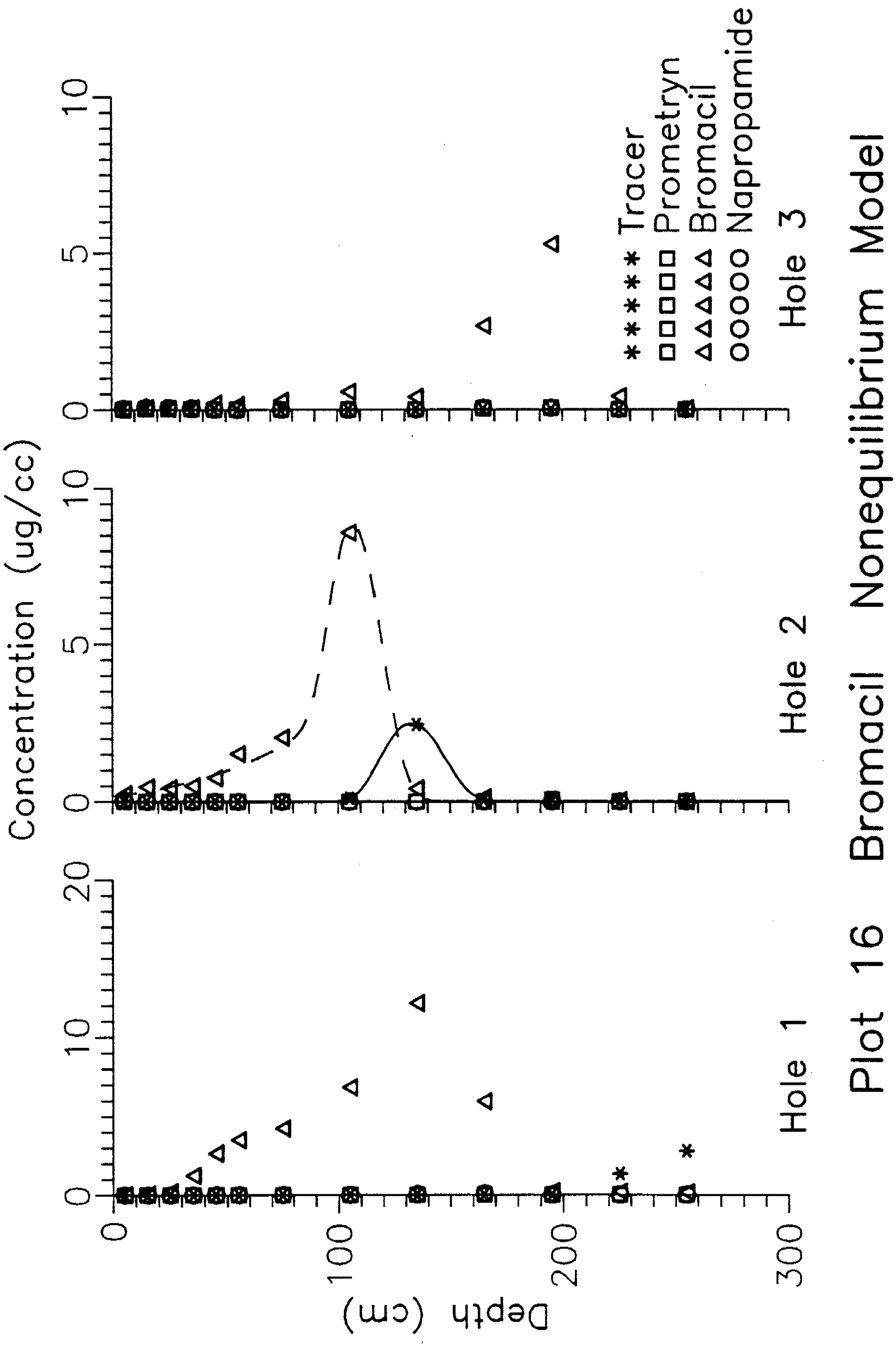


Plot 13 High Concentration Mix Nonequilibrium Model



Plot 14 Low Concentration Mix Nonequilibrium Model


Plot 15 Prometryn Nonequilibrium Model
Concentration (ug/cc)
Depth (cm)
Hole 1
Hole 2
Hole 3
0
2
4
0
1
2
0
5
10
0
100
200
300
***** Tracer
□□□□□ Prometryn
ΔΔΔΔΔ Bromacil
ooooo Napropamide


Plot 16 Bromacil Nonequilibrium Model
Concentration (ug/cc)
Depth (cm)
0
100
200
300
Hole 1
Hole 2
Hole 3
0
10
20
0
5
10
0
5
10
***** Tracer
□□□□□ Prometryn
△△△△△ Bromacil
ooooo Napropamide

APPENDIX S

Example CXTFIT Output, Run 7 (Nonequilibrium Model)

This is a sample output from CXTFIT's nonequilbrium mode. Note the high cross-correlations between the fitted parameters, and the high Standard Errors (S.E.COEFF.) and excessive confidence limits associated with them.

```
*********************************************************************************
*                                                                               *
*          ONE-DIMENSIONAL CONVECTION-DISPERSION EQ. SOLUTION                   *
*          NON-LINEAR LEAST-SQUARES ANALYSIS                                    *
*                                                                               *
*          DETERMINISTIC TWO-SITE/TWO-REGION NONEQUILIBRIUM MODEL FOR           *
*          PULSE-TYPE INJECTION WITH NO PRODUCTION OR DECAY                     *
*          SOLUTION FOR RESIDENT CONCENTRATIONS                                 *
*                                                                               *
*          Plot   1, Hole 1, High Concentration Mix: BROMACIL data              *
*    (UNITS: CENTIMETERS, DAYS, MICROGRAMS) - Spatial Coordinates               *
*                                                                               *
*********************************************************************************

INITIAL VALUES OF COEFFICIENTS
==============================
 NAME           INITIAL VALUE
V.........       3.7129
D.........       4.0674
R.........       1.5181
TO........      14.0000
Beta......        .9900
Omega.....        .0100
CI........        .0000
CO........      16.2380

OBSERVED DATA
=============
OBS. NO.      CONCENT RATION      DISTANCE         TIME
    1              .2909           5.0000         68.0000
    2              .3558          15.0000         68.0000
    3              .1919          25.0000         68.0000
    4              .1133          35.0000         68.0000
    5              .1232          45.0000         68.0000
    6              .0736          55.0000         68.0000
    7              .2762          75.0000         68.0000
    8             2.7554         105.0000         68.0000
    9            12.2601         135.0000         68.0000
   10            12.9060         165.0000         68.0000
   11              .1364         195.0000         68.0000
   12              .2559         225.0000         68.0000
   13              .0000         255.0000         68.0000
```

```
ITERATION      SSQ            D.....        R.....        Beta..        Omega.
    0       5.535302        4.06740       1.51810        .99000        .01000
    1       4.519805        3.24679       1.51721        .98901        .09978
    2       3.580988        2.77456       1.51845        .97396        .31014
    3       1.179654        1.49817       1.55251        .93301        .89729
    4        .457913         .84102       1.57087        .91008       1.55145
    5        .405660         .57227       1.57665        .90289       1.83791
    6        .398113         .57805       1.58087        .90718       1.57228
    7        .393130         .40589       1.58333        .90336       1.76806
    8        .392632         .28778       1.58851        .90452       1.68994
    9        .382277         .27431       1.58972        .90469       1.69104
   10        .381581         .25474       1.59057        .90476       1.68973
   11        .381084         .24089       1.59123        .90485       1.68662
   12        .380727         .23055       1.59176        .90494       1.68330
   13        .380466         .22246       1.59219        .90503       1.68031
   14        .380272         .21593       1.59254        .90510       1.67772
   15        .380123         .21058       1.59283        .90516       1.67551
   16        .380007         .20612       1.59307        .90522       1.67362
   17        .379915         .20238       1.59327        .90527       1.67199
   18        .379841         .19920       1.59345        .90531       1.67059
   19        .379781         .19649       1.59360        .90535       1.66937
   20        .379731         .19415       1.59373        .90539       1.66830
   21        .379690         .19214       1.59384        .90542       1.66737
   22        .379655         .19039       1.59394        .90544       1.66655
   23        .379626         .18886       1.59402        .90547       1.66583
   24        .379601         .18753       1.59410        .90549       1.66519
   25        .379576         .17437       1.59467        .90568       1.66107
   26        .379492         .18148       1.59451        .90559       1.66111
   27        .379437         .17436       1.59475        .90570       1.65990
   28        .379403         .17540       1.59477        .90570       1.65943
   29        .379403         .17544       1.59477        .90570       1.65940


CORRELATION MATRIX
==================
          1          2          3          4
   1   1.0000
   2   -.9998     1.0000
   3   -.9998      .9995     1.0000
   4    .9984     -.9991     -.9985     1.0000

RSQUARE FOR REGRESSION = .99852302


NON-LINEAR LEAST SQUARES ANALYSIS, FINAL RESULTS
================================================

                                                           95% CONFIDENCE LIMITS
VARIABLE    NAME        VALUE       S.E.COEFF.   T-VALUE     LOWER          UPPER
    1       D.....       .17544      10.49731       .02    -23.57079       23.92167
    2       R.....      1.59477        .45873      3.48       .55706        2.63247
    3       Beta..       .90570        .16978      5.33       .52163        1.28977
    4       Omega.      1.65940       3.76049       .44     -6.84730       10.16611
```

```
----------------------ORDERED BY COMPUTER INPUT-----------------------
                                        CONCENTRATION            RESI-
 NO    DISTANCE         TIME          OBS         FITTED         DUAL
  1      5.0000       68.0000        .2909         .0008         .2901
  2     15.0000       68.0000        .3558         .0030         .3529
  3     25.0000       68.0000        .1919         .0085         .1834
  4     35.0000       68.0000        .1133         .0216         .0917
  5     45.0000       68.0000        .1232         .0503         .0729
  6     55.0000       68.0000        .0736         .1098        -.0362
  7     75.0000       68.0000        .2762         .4483        -.1721
  8    105.0000       68.0000       2.7554        2.6682         .0872
  9    135.0000       68.0000      12.2601       12.2528         .0073
 10    165.0000       68.0000      12.9060       12.8794         .0265
 11    195.0000       68.0000        .1364         .0000         .1364
 12    225.0000       68.0000        .2559         .0000         .2559
 13    255.0000       68.0000        .0000         .0000         .0000

--------------------------ORDERED BY RESIDUAL--------------------------
                                        CONCENTRATION            RESI-
 NO    DISTANCE         TIME          OBS         FITTED         DUAL
  2     15.0000       68.0000        .3558         .0030         .3529
  1      5.0000       68.0000        .2909         .0008         .2901
 12    225.0000       68.0000        .2559         .0000         .2559
  3     25.0000       68.0000        .1919         .0085         .1834
 11    195.0000       68.0000        .1364         .0000         .1364
  4     35.0000       68.0000        .1133         .0216         .0917
  8    105.0000       68.0000       2.7554        2.6682         .0872
  5     45.0000       68.0000        .1232         .0503         .0729
 10    165.0000       68.0000      12.9060       12.8794         .0265
  9    135.0000       68.0000      12.2601       12.2528         .0073
 13    255.0000       68.0000        .0000         .0000         .0000
  6     55.0000       68.0000        .0736         .1098        -.0362
  7     75.0000       68.0000        .2762         .4483        -.1721
```

APPENDIX T

Correlation Analysis Results

The correlation matrices on the following pages represent the results of three correlation analyses conducted using the SAS CORR procedure (SAS Institute, 1988a). Each position in the matrix contains a stack of three items: the Spearman Correlation Coefficient, the associated probability that the true value of the coefficient is zero, and the number of observations contributing to the calculation. The parameters being compared include field-averaged water content (θ), solute velocity (v), retardation factor (R), dispersion coefficient (D), dispersivity (α), and fractional recovery (Rec). In each case, the specific solute is identified by subscript: t=tracer, b=bromacil, n=napropamide, p=prometryn.

```
                           CORRELATION ANALYSIS

 8 'VAR' Variables:    θ       Vt       Vb      Vn       Vp       Rb       Rn       Rp

      Spearman Correlation Coefficients / Prob > |R| under Ho: Rho=0
      / Number of Observations

                      θ                 Vt                Vb                Vn

 θ              1.00000          -0.06842           0.05731           0.09091
                0.0               0.6790            0.7951            0.6874
                     45                39                23                22

Vt             -0.06842           1.00000           0.77372           0.61717
                0.6790            0.0               0.0001            0.0022
                     39                39                23                22

Vb              0.05731           0.77372           1.00000           0.67500
                0.7951            0.0001            0.0               0.0058
                     23                23                23                15

Vn              0.09091           0.61717           0.67500           1.00000
                0.6874            0.0022            0.0058            0.0
                     22                22                15                22

Vp             -0.08846           0.56769           0.87941           0.81071
                0.6741            0.0031            0.0001            0.0002
                     25                25                16                15

 Rb            -0.13043          -0.11759          -0.66206          -0.08929
                0.5530            0.5931            0.0006            0.7517
                     23                23                23                15

 Rn            -0.33484           0.12931           0.01429          -0.66685
                0.1277            0.5663            0.9597            0.0007
                     22                22                15                22

 Rp            -0.13538           0.04154          -0.46765          -0.42143
                0.5188            0.8437            0.0678            0.1177
                     25                25                16                15
```

CORRELATION ANALYSIS

Spearman Correlation Coefficients / Prob > |R| under Ho: Rho=0
/ Number of Observations

	V_p	R_b	R_n	R_p
θ	-0.08846 0.6741 25	-0.13043 0.5530 23	-0.33484 0.1277 22	-0.13538 0.5188 25
V_t	0.56769 0.0031 25	-0.11759 0.5931 23	0.12931 0.5663 22	0.04154 0.8437 25
V_b	0.87941 0.0001 16	-0.66206 0.0006 23	0.01429 0.9597 15	-0.46765 0.0678 16
V_n	0.81071 0.0002 15	-0.08929 0.7517 15	-0.66685 0.0007 22	-0.42143 0.1177 15
V_p	1.00000 0.0 25	-0.49118 0.0534 16	-0.21071 0.4510 15	-0.76538 0.0001 25
R_b	-0.49118 0.0534 16	1.00000 0.0 23	0.09286 0.7420 15	0.70882 0.0021 16
R_n	-0.21071 0.4510 15	0.09286 0.7420 15	1.00000 0.0 22	0.39643 0.1435 15
R_p	-0.76538 0.0001 25	0.70882 0.0021 16	0.39643 0.1435 15	1.00000 0.0 25

```
                              CORRELATION ANALYSIS

 12 'VAR' Variables:   D_t       D_b       D_n       D_p          α_t       α_b        α_n        α_p   V_t
V_b      V_n      V_p

      Spearman Correlation Coefficients / Prob > |R| under Ho: Rho=0
      / Number of Observations

                  D_t        D_b        D_n        D_p        α_t        α_b

D_t           1.00000    0.00889   -0.21626    0.07923    0.96721    0.06324
              0.0        0.9679     0.3337     0.7066     0.0001     0.7744
                   39         23         22         25         39         23

D_b           0.00889    1.00000    0.11786   -0.16765   -0.00988    0.96047
               0.9679    0.0        0.6757     0.5349     0.9643     0.0001
                   23         23         15         16         23         23

D_n          -0.21626    0.11786    1.00000    0.41786   -0.34049   -0.04643
               0.3337     0.6757    0.0        0.1212     0.1210     0.8695
                   22         15         22         15         22         15

D_p           0.07923   -0.16765    0.41786    1.00000   -0.06923   -0.38529
               0.7066     0.5349     0.1212    0.0        0.7423     0.1405
                   25         16         15         25         25         16

α_t           0.96721   -0.00988   -0.34049   -0.06923    1.00000    0.10079
               0.0001     0.9643     0.1210     0.7423    0.0        0.6472
                   39         23         22         25         39         23

α_b           0.06324    0.96047   -0.04643   -0.38529    0.10079    1.00000
               0.7744     0.0001     0.8695     0.1405     0.6472    0.0
                   23         23         15         16         23         23

α_n          -0.13721    0.01429    0.93224    0.22857   -0.16431   -0.02857
               0.5426     0.9597     0.0001     0.4126     0.4650     0.9195
                   22         15         22         15         22         15

α_p           0.06000   -0.24412    0.34286    0.98000   -0.05154   -0.41176
               0.7757     0.3622     0.2109     0.0001     0.8067     0.1130
                   25         16         15         25         25         16

V_t          -0.13239    0.13241    0.52343    0.51154   -0.33603   -0.08597
               0.4217     0.5470     0.0124     0.0090     0.0365     0.6965
                   39         23         22         25         39         23

V_b          -0.28063   -0.44466    0.32143    0.63235   -0.45949   -0.59684
               0.1946     0.0335     0.2427     0.0086     0.0274     0.0026
                   23         23         15         16         23         23

V_n          -0.15641    0.16429   -0.07736    0.37500   -0.38679    0.08214
               0.4870     0.5585     0.7322     0.1684     0.0754     0.7710
                   22         15         22         15         22         15

V_p          -0.19538   -0.10882    0.11429    0.67077   -0.33692   -0.25882
               0.3493     0.6883     0.6851     0.0002     0.0996     0.3331
                   25         16         15         25         25         16
```

```
                        CORRELATION ANALYSIS

       Spearman Correlation Coefficients / Prob > |R| under Ho: Rho=0
       / Number of Observations

               αn         αp         Vt         Vb         Vn         Vp

  Dt     -0.13721    0.06000   -0.13239   -0.28063   -0.15641   -0.19538
           0.5426     0.7757     0.4217     0.1946     0.4870     0.3493
               22         25         39         23         22         25

  Db      0.01429   -0.24412    0.13241   -0.44466    0.16429   -0.10882
           0.9597     0.3622     0.5470     0.0335     0.5585     0.6883
               15         16         23         23         15         16

  Dn      0.93224    0.34286    0.52343    0.32143   -0.07736    0.11429
           0.0001     0.2109     0.0124     0.2427     0.7322     0.6851
               22         15         22         15         22         15

  Dp      0.22857    0.98000    0.51154    0.63235    0.37500    0.67077
           0.4126     0.0001     0.0090     0.0086     0.1684     0.0002
               15         25         25         16         15         25

  αt     -0.16431   -0.05154   -0.33603   -0.45949   -0.38679   -0.33692
           0.4650     0.8067     0.0365     0.0274     0.0754     0.0996
               22         25         39         23         22         25

  αb     -0.02857   -0.41176   -0.08597   -0.59684    0.08214   -0.25882
           0.9195     0.1130     0.6965     0.0026     0.7710     0.3331
               15         16         23         23         15         16

  αn      1.00000    0.22857    0.21626    0.02143   -0.28967   -0.18214
           0.0        0.4126     0.3337     0.9396     0.1910     0.5159
               22         15         22         15         22         15

  αp      0.22857    1.00000    0.38308    0.55588    0.26786    0.64308
           0.4126     0.0        0.0587     0.0254     0.3344     0.0005
               15         25         25         16         15         25

  Vt      0.21626    0.38308    1.00000    0.77372    0.61717    0.56769
           0.3337     0.0587     0.0        0.0001     0.0022     0.0031
               22         25         39         23         22         25

  Vb      0.02143    0.55588    0.77372    1.00000    0.67500    0.87941
           0.9396     0.0254     0.0001     0.0        0.0058     0.0001
               15         16         23         23         15         16

  Vn     -0.28967    0.26786    0.61717    0.67500    1.00000    0.81071
           0.1910     0.3344     0.0022     0.0058     0.0        0.0002
               22         15         22         15         22         15

  Vp     -0.18214    0.64308    0.56769    0.87941    0.81071    1.00000
           0.5159     0.0005     0.0031     0.0001     0.0002     0.0
               15         25         25         16         15         25
```

```
                              CORRELATION ANALYSIS

  8 'VAR' Variables:   Rec_t    Rec_b    Rec_n    Rec_p    v_t     v_b     v_n      v_p

      Spearman Correlation Coefficients / Prob > |R| under Ho: Rho=0
      / Number of Observations

                   Rec_t             Rec_b             Rec_n             Rec_p

Rec_t            1.00000          -0.01709          -0.25580           0.42125
                   0.0              0.9326            0.1978            0.0287
                    45                27                27                27

Rec_b           -0.01709           1.00000           0.08359           0.17647
                  0.9326            0.0               0.7416            0.4836
                    27                27                18                18

Rec_n           -0.25580           0.08359           1.00000          -0.22188
                  0.1978            0.7416            0.0               0.3762
                    27                18                27                18

Rec_p            0.42125           0.17647          -0.22188           1.00000
                  0.0287            0.4836            0.3762            0.0
                    27                18                18                27

v_t              0.00789          -0.22628           0.47134          -0.06231
                  0.9620            0.2992            0.0232            0.7673
                    39                23                23                25

v_b              0.08300          -0.34289           0.22353           0.01471
                  0.7065            0.1092            0.4053            0.9569
                    23                23                16                16

v_n             -0.41050          -0.71429           0.08639          -0.31429
                  0.0577            0.0028            0.7023            0.2539
                    22                15                22                15

v_p             -0.12077          -0.58824           0.20882           0.04385
                  0.5653            0.0165            0.4377            0.8351
                    25                16                16                25
```

```
                         CORRELATION ANALYSIS

      Spearman Correlation Coefficients / Prob > |R| under Ho: Rho=0
      / Number of Observations

                     V_t               V_b               V_n               V_p

Rec_t            0.00789           0.08300          -0.41050          -0.12077
                  0.9620            0.7065            0.0577            0.5653
                      39                23                22                25

Rec_b           -0.22628          -0.34289          -0.71429          -0.58824
                  0.2992            0.1092            0.0028            0.0165
                      23                23                15                16

Rec_n            0.47134           0.22353           0.08639           0.20882
                  0.0232            0.4053            0.7023            0.4377
                      23                16                22                16

Rec_p           -0.06231           0.01471          -0.31429           0.04385
                  0.7673            0.9569            0.2539            0.8351
                      25                16                15                25

V_t              1.00000           0.77372           0.61717           0.56769
                  0.0               0.0001            0.0022            0.0031
                      39                23                22                25

V_b              0.77372           1.00000           0.67500           0.87941
                  0.0001            0.0               0.0058            0.0001
                      23                23                15                16

V_n              0.61717           0.67500           1.00000           0.81071
                  0.0022            0.0058            0.0               0.0002
                      22                15                22                15

V_p              0.56769           0.87941           0.81071           1.00000
                  0.0031            0.0001            0.0002            0.0
                      25                16                15                25
```

APPENDIX U

Method of Moments Results

Tracer Parameters -- Method of Moments

Plot, Hole	m_0 ($\mu g/cm^2$)	m'_1 (cm)	m'_2 (cm^2)	m'_3 (cm^3)	α (cm)	v (cm/day)	D (cm^2/day)	Sk
1,1	2.44E+02	2.22E+02	5.02E+04	1.15E+07	1.751	3.617	6.332	-1.590
1,2	1.16E+02	6.00E+01	3.82E+03	2.58E+05				
1,3	3.13E+02	1.95E+02	3.91E+04	7.98E+06	2.844	3.149	8.957	-1.690
2,1	1.61E+02	2.04E+02	4.41E+04	9.97E+06	6.074	3.249	19.738	-0.039
2,2	1.72E+02	1.53E+02	2.41E+04	3.90E+06	2.196	2.475	5.435	0.108
2,3	7.15E+01	1.96E+02	3.88E+04	7.75E+06	0.946	3.198	3.026	-0.034
3,1	1.28E+02	2.43E+02	5.92E+04	1.45E+07				
3,2	1.29E+02	2.00E+02	4.01E+04	8.14E+06	0.785	3.259	2.557	-0.056
3,3	8.25E+01	2.20E+02	4.89E+04	1.10E+07	1.396	3.579	4.995	-0.437
4,1	1.70E+02	1.51E+02	2.30E+04	3.53E+06	0.749	2.460	1.843	-0.103
4,2	1.23E+02	1.70E+02	2.91E+04	5.03E+06	0.888	2.766	2.455	-0.015
4,3	1.44E+02	2.15E+02	4.70E+04	1.04E+07	1.744	3.498	6.100	-0.294
5,1	1.49E+02	1.39E+02	1.98E+04	2.86E+06	1.671	2.250	3.759	-0.612
5,2	1.34E+02	2.07E+02	4.32E+04	9.08E+06	0.725	3.385	2.452	-0.339
5,3	1.35E+02	1.95E+02	3.84E+04	7.59E+06	0.662	3.189	2.112	0.003
6,1	7.16E+01	1.26E+02	1.62E+04	2.10E+06	0.904	2.057	1.860	-0.381
6,2	1.60E+02	1.76E+02	3.19E+04	5.94E+06	2.487	2.848	7.082	0.497
6,3	1.21E+02	1.71E+02	2.97E+04	5.24E+06	1.425	2.777	3.958	0.644
7,1	3.34E+02	1.05E+02	1.15E+04	1.30E+06	2.095	1.693	3.547	-0.424
7,2	1.61E+02	2.32E+02	5.44E+04	1.29E+07				
7,3	8.92E+01	1.34E+02	1.80E+04	2.46E+06	0.621	2.182	1.355	-0.250
8,1	3.60E+01	1.57E+02	2.49E+04	3.96E+06	0.559	2.566	1.435	-1.064
8,2	2.19E+02	1.54E+02	2.51E+04	4.28E+06	4.171	2.464	10.278	0.405
8,3	8.53E+01	1.79E+02	3.35E+04	6.51E+06	4.325	2.864	12.385	-0.473
10,1	8.34E+01	1.35E+02	1.84E+04	2.54E+06	0.875	2.158	1.888	-0.029
10,2	1.12E+02	1.49E+02	2.25E+04	3.46E+06	1.380	2.376	3.278	-0.431
10,3	1.34E+01	2.25E+02	5.24E+04	1.26E+07				
11,1	1.30E+02	1.00E+02	1.06E+04	1.16E+06	2.795	1.569	4.387	-0.135
11,2	5.82E+01	1.65E+02	2.74E+04	4.59E+06	0.772	2.643	2.039	-0.018
11,3	9.61E+01	1.51E+02	2.32E+04	3.65E+06	1.579	2.408	3.802	-0.089
12,1	8.67E+01	1.93E+02	3.72E+04	7.23E+06	0.429	3.098	1.331	-0.436
12,2	1.46E+02	1.65E+02	2.72E+04	4.49E+06	0.182	2.653	0.484	-0.561
12,3	1.26E+02	1.67E+02	2.82E+04	4.81E+06	0.722	2.688	1.941	0.124
13,1	2.15E+02	1.06E+02	1.15E+04	1.26E+06	0.851	1.703	1.450	0.217
13,2	1.89E+02	2.00E+02	4.06E+04	8.31E+06	1.182	3.210	3.794	-0.276
13,3	1.49E+02	1.56E+02	2.46E+04	3.91E+06	0.724	2.508	1.817	-0.398
14,1	1.64E+02	1.58E+02	2.51E+04	4.02E+06	0.552	2.538	1.401	-1.010
14,2	6.35E+01	2.21E+02	4.91E+04	1.09E+07	0.221	3.565	0.787	-2.156
14,3	1.19E+02	2.27E+02	5.24E+04	1.22E+07	1.476	3.644	5.380	-1.009
15,1	1.95E+02	1.97E+02	3.93E+04	7.98E+06	1.668	3.143	5.244	-0.086
15,2	9.13E+01	1.94E+02	3.80E+04	7.53E+06	1.041	3.112	3.241	0.037
15,3	3.28E+02	2.22E+02	5.02E+04	1.15E+07	1.549	3.563	5.520	-0.583
16,1	1.25E+02	2.45E+02	6.03E+04	1.49E+07				
16,2	8.35E+01	1.39E+02	1.98E+04	2.91E+06	1.583	2.220	3.514	3.489
16,3	0.00E+00	ERR	ERR	ERR				
FAP	1.36E+02	1.75E+02	3.30E+04	6.57E+06	7.126	2.731	19.459	-0.242

FAP: Field-Averaged Profile. Refer to text for details.

Bromacil Parameters -- Method of Moments

Plot, Hole	m_0 (μg/cm^2)	m_1^* (cm)	m_2^* (cm^2)	m_3^* (cm^3)	α (cm)	v (cm/day)	R	D (cm^2/day)	Sk
1,1	8.69E+02	1.45E+02	2.16E+04	3.29E+06	2.453	2.329	1.553	8.871	-1.426
1,2	1.40E+03	2.19E+02	4.91E+04	1.12E+07	2.624	3.547			-1.355
1,3	2.74E+02	1.06E+02	1.21E+04	1.50E+06	4.969	1.651	1.908	15.649	0.315
2,1	6.06E+02	1.13E+02	1.35E+04	1.66E+06	2.641	1.817	1.789	8.582	0.513
2,2	9.75E+02	8.33E+01	7.85E+03	8.19E+05	6.106	1.266	1.955	15.109	0.525
2,3	6.05E+02	1.17E+02	1.46E+04	1.89E+06	3.840	1.858	1.721	12.279	-0.732
3,1	6.43E+01	1.43E+02	2.31E+04	3.87E+06	10.001	2.187			-1.446
3,2	1.54E+02	1.27E+02	1.71E+04	2.42E+06	3.558	2.030	1.606	11.595	1.004
3,3	6.98E+01	1.49E+02	2.54E+04	4.71E+06	11.689	2.258	1.585	41.831	-0.014
4,1	3.49E+00								
4,2	1.58E+01								
4,3	5.59E+00								
5,1	6.65E+00								
5,2	4.69E+00								
5,3	1.64E+01								
6,1	1.17E+02	6.18E+01	4.08E+03	2.81E+05	2.187	0.978	2.103	4.499	-0.698
6,2	1.27E+02	8.14E+01	7.25E+03	7.08E+05	4.169	1.266	2.251	11.874	1.057
6,3	1.55E+02	9.59E+01	1.01E+04	1.16E+06	5.018	1.489	1.864	13.935	0.941
7,1	2.18E+01								
7,2	2.69E+01								
7,3	7.83E+00								
8,1	1.54E+03	7.24E+01	6.37E+03	6.31E+05	9.690	1.029	2.494	24.865	0.179
8,2	6.68E+02	6.70E+01	4.96E+03	3.97E+05	3.818	1.036	2.379	9.408	0.241
8,3	5.65E+02	9.19E+01	9.62E+03	1.10E+06	7.188	1.389	2.061	20.582	0.050
10,1	1.30E+01								
10,2	2.28E+00								
10,3	6.77E+00								
11,1	1.06E+03	6.01E+01	4.41E+03	3.60E+05	8.382	0.834	1.881	13.156	-0.024
11,2	8.31E+02	9.56E+01	9.84E+03	1.08E+06	3.943	1.478	1.788	10.420	0.451
11,3	1.25E+03	9.05E+01	8.83E+03	9.11E+05	3.746	1.399	1.721	9.021	-0.181
12,1	2.15E+01								
12,2	2.23E+01								
12,3	5.06E+00								
13,1	8.58E+02	8.98E+01	9.20E+03	1.12E+06	7.170	1.333	1.278	12.212	2.276
13,2	7.39E+02	1.51E+02	2.32E+04	3.64E+06	1.789	2.401	1.337	5.743	-1.856
13,3	1.37E+03	1.03E+02	1.12E+04	1.25E+06	2.573	1.624	1.544	6.452	-0.432
14,1	1.18E+02	9.50E+01	9.69E+03	1.05E+06	3.657	1.474	1.722	9.284	0.009
14,2	1.45E+02	1.17E+02	1.48E+04	1.97E+06	4.699	1.817	1.962	16.752	-0.468
14,3	3.72E+01	1.31E+02	1.88E+04	2.88E+06	7.113	1.997	1.825	25.922	-0.432
15,1	5.47E+00								
15,2	2.10E+01								
15,3	1.22E+01								
16,1	9.71E+02	1.21E+02	1.60E+04	2.27E+06	6.269	1.851			-0.164
16,2	3.76E+02	9.55E+01	9.80E+03	1.06E+06	3.741	1.480	1.500	8.306	-0.458
16,3	2.94E+02	1.75E+02	3.18E+04	5.92E+06	3.886	2.752			-1.719
FAP	9.31E+02	1.09E+02	1.41E+04	2.13E+06	13.195	1.552	1.759	36.031	0.773

FAP: Field-Averaged Profile. Refer to text for details.

Napropamide Parameters -- Method of Moments

Plot, Hole	m_0 ($\mu g/cm^2$)	m_1' (cm)	m_2' (cm^2)	m_3' (cm^3)	α (cm)	v (cm/day)	R	D (cm^2/day)	Sk
1,1	3.34E+02	2.57E+01	2.14E+03	4.30E+05	ERR	ERR	ERR	ERR	5.295
1,2	6.16E+02	4.26E+01	2.38E+03	1.71E+05	10.309	0.530			1.634
1,3	1.61E+02	2.02E+01	4.76E+02	1.28E+04	1.972	0.299	10.542	6.211	0.791
2,1	1.47E+02	3.08E+01	1.29E+03	8.25E+04	ERR	ERR	ERR	ERR	3.407
2,2	1.66E+02	2.38E+01	1.93E+03	3.33E+05	ERR	ERR	ERR	ERR	4.373
2,3	2.29E+02	2.50E+01	9.92E+02	9.44E+04	ERR	ERR	ERR	ERR	7.289
3,1	2.87E+01	3.27E+01	1.26E+03	5.26E+04	3.577	0.477			-0.514
3,2	1.64E+01	2.11E+01	6.17E+02	2.08E+04	ERR	ERR	ERR	ERR	0.198
3,3	2.44E+01	7.71E+01	1.30E+04	3.02E+06	ERR	ERR	ERR	ERR	1.553
4,1	9.08E-01								
4,2	1.58E+00								
4,3	3.07E+00								
5,1	2.61E+02	1.90E+01	4.44E+02	1.31E+04	2.834	0.265	8.495	6.376	1.899
5,2	1.64E+02	2.85E+01	8.96E+02	2.99E+04	1.567	0.442	7.659	5.303	-0.444
5,3	1.20E+02	2.24E+01	5.55E+02	1.46E+04	1.343	0.345	9.256	4.282	-0.576
6,1	3.69E+01	1.63E+01	3.02E+02	6.05E+03	1.178	0.249	8.271	2.423	-0.033
6,2	1.66E+01	1.49E+01	3.21E+02	9.01E+03	ERR	ERR	ERR	ERR	1.319
6,3	1.36E+01	1.83E+01	4.38E+02	1.21E+04	4.373	0.229	12.144	12.143	0.281
7,1	6.08E+01	1.55E+01	1.36E+03	3.12E+05	ERR	ERR	ERR	ERR	6.873
7,2	3.78E+02	2.52E+01	8.06E+02	3.09E+04	4.797	0.334			0.840
7,3	5.98E+01	1.55E+01	3.34E+02	1.01E+04	ERR	ERR	ERR	ERR	2.242
8,1	2.62E+00								
8,2	4.77E+00								
8,3	6.89E+00								
10,1	1.59E+02	2.52E+01	1.01E+03	5.91E+04	ERR	ERR	ERR	ERR	1.943
10,2	2.11E+01	2.20E+01	5.26E+02	1.33E+04	1.089	0.336	7.060	2.588	-0.779
10,3	2.46E+02	3.39E+01	1.91E+03	1.76E+05	ERR	ERR	ERR	ERR	2.899
11,1	6.66E+00								
11,2	1.40E+00								
11,3	1.27E+01								
12,1	8.35E+00								
12,2	3.40E+00								
12,3	1.06E+01								
13,1	1.63E+02	1.34E+01	2.15E+02	3.94E+03	1.606	0.190	8.945	2.735	0.503
13,2	1.88E+02	2.90E+01	2.22E+03	3.44E+05	ERR	ERR	ERR	ERR	3.890
13,3	1.75E+02	1.60E+01	3.24E+02	7.66E+03	2.934	0.211	11.904	7.357	0.541
14,1	1.90E+01	1.47E+01	2.57E+02	5.07E+03	1.771	0.208	12.217	4.496	0.199
14,2	3.98E+01	2.30E+01	6.24E+02	1.90E+04	2.477	0.331	10.772	8.832	0.264
14,3	4.48E+01	3.06E+01	1.18E+03	5.52E+04	5.330	0.408	8.938	19.423	1.169
15,1	0.00E+00								
15,2	5.10E+00								
15,3	2.61E+00								
16,1	5.76E+00								
16,2	5.58E-01								
16,3	5.50E+00								
FAP	2.24E+02	2.77E+01	1.58E+03	2.14E+05	ERR	ERR	ERR	ERR	5.376

FAP: Field-Averaged Profile. Refer to text for details.

Prometryn Parameters -- Method of Moments

Plot, Hole	m_0 ($\mu g/cm^2$)	m_1' (cm)	m_2' (cm^2)	m_3' (cm^3)	α (cm)	v (cm/day)	R	D (cm^2/day)	Sk
1,1	9.01E+01	7.26E+01	6.32E+03	6.18E+05	8.822	1.045	3.460	31.907	0.238
1,2	8.71E+01	1.45E+02	2.26E+04	3.68E+06	5.956	2.277			-0.901
1,3	1.12E+02	5.32E+01	3.77E+03	3.98E+05	16.204	0.607	5.187	51.030	3.400
2,1	9.69E+01	6.21E+01	4.59E+03	3.92E+05	7.001	0.904	3.594	22.750	0.890
2,2	6.53E+01	3.42E+01	1.63E+03	1.24E+05	ERR	ERR	ERR	ERR	3.709
2,3	4.67E+01	5.20E+01	3.51E+03	2.95E+05	11.739	0.660	4.843	37.537	1.240
3,1	7.62E+00	7.41E+01	7.28E+03	8.41E+05	21.338	0.864			0.475
3,2	8.91E+00	6.51E+01	5.56E+03	6.06E+05	16.070	0.804	4.053	52.372	1.522
3,3	4.41E+00	1.25E+02	2.23E+04	4.72E+06	ERR	ERR	ERR	ERR	0.475
4,1	9.83E+01	4.29E+01	2.17E+03	1.28E+05	4.581	0.628	3.916	11.267	1.124
4,2	1.23E+02	7.58E+01	6.69E+03	6.61E+05	7.357	1.121	2.467	20.348	0.347
4,3	2.66E+01	4.24E+01	2.42E+03	1.78E+05	ERR	ERR	ERR	ERR	1.518
5,1	6.62E-01								
5,2	6.49E-01								
5,3	5.88E-01								
6,1	4.65E+00	2.57E+01	8.06E+02	3.08E+04	3.538	0.364	5.656	7.278	1.514
6,2	6.78E+00	3.44E+01	2.51E+03	3.72E+05	ERR	ERR	ERR	ERR	4.000
6,3	8.46E+00	4.53E+01	3.26E+03	3.58E+05	ERR	ERR	ERR	ERR	2.444
7,1	4.56E-01								
7,2	6.62E-01								
7,3	1.12E+00								
8,1	1.28E+00								
8,2	5.35E-01								
8,3	1.70E+00								
10,1	4.04E-01								
10,2	7.34E-02								
10,3	4.23E+00								
11,1	8.32E-01								
11,2	4.50E+00								
11,3	4.84E-01								
12,1	9.57E+01	5.18E+01	3.62E+03	3.72E+05	ERR	ERR	ERR	ERR	3.043
12,2	7.34E+01	5.85E+01	4.11E+03	3.58E+05	7.264	0.826	3.211	19.268	2.004
12,3	7.91E+01	5.38E+01	3.43E+03	2.57E+05	6.053	0.770	3.491	16.269	1.108
13,1	1.44E+02	4.88E+01	3.83E+03	5.02E+05	ERR	ERR	ERR	ERR	3.133
13,2	1.56E+02	7.09E+01	6.61E+03	7.49E+05	18.205	0.850	3.779	58.444	0.883
13,3	2.32E+02	4.44E+01	2.52E+03	1.77E+05	8.658	0.576	4.350	21.710	1.304
14,1	1.93E+01	6.64E+01	5.92E+03	6.36E+05	ERR	ERR	ERR	ERR	0.708
14,2	1.27E+01	9.96E+01	1.33E+04	2.10E+06	ERR	ERR	ERR	ERR	0.544
14,3	9.55E+00	1.01E+02	1.27E+04	1.81E+06	17.395	1.341	2.717	63.390	0.119
15,1	7.68E+01	4.78E+01	3.34E+03	3.37E+05	ERR	ERR	ERR	ERR	2.255
15,2	7.43E+01	7.66E+01	7.10E+03	7.55E+05	10.016	1.073	2.899	31.172	0.526
15,3	1.41E+02	6.42E+01	5.09E+03	4.81E+05	9.770	0.878	4.058	34.811	0.985
16,1	1.91E+00								
16,2	1.96E+00								
16,3	4.04E+00								
FAP	9.80E+01	6.46E+01	6.07E+03	7.61E+05	ERR	ERR	ERR	ERR	1.490

FAP: Field-Averaged Profile. Refer to text for details.

APPENDIX V

Tracer Velocities and β Parameters

Plot, Hole	Avg. θ	V_a (cm/day)	V_t (cm/day)	β
1,1	0.2015	1.593	3.713	2.331
1,2	0.2082	1.542		
1,3	0.2129	1.508	3.328	2.207
2,1	0.2475	1.297	2.622	2.022
2,2	0.1914	1.677	2.444	1.457
2,3	0.2139	1.500	3.207	2.137
3,1	0.2337	1.374		
3,2	0.2222	1.445	3.258	2.255
3,3	0.2496	1.286	3.662	2.847
4,1	0.2387	1.345	2.469	1.836
4,2	0.2551	1.259	2.772	2.202
4,3	0.2405	1.334	3.578	2.681
5,1	0.2514	1.277	2.302	1.802
5,2	0.2479	1.295	3.418	2.640
5,3	0.2293	1.400	3.192	2.280
6,1	0.2275	1.411	2.055	1.456
6,2	0.2127	1.509	2.682	1.777
6,3	0.2511	1.278	2.732	2.137
7,1	0.2231	1.439	1.732	1.204
7,2	0.2316	1.386		
7,3	0.2204	1.456	2.176	1.494
8,1	0.2304	1.393	2.539	1.822
8,2	0.2354	1.364	2.358	1.729
8,3	0.2250	1.426	3.010	2.110
10,1	0.2228	1.441	2.158	1.497
10,2	0.2393	1.342	2.447	1.824
10,3	0.2116	1.517		
11,1	0.2010	1.597	1.584	0.991
11,2	0.2113	1.519	2.645	1.741
11,3	0.2109	1.522	2.435	1.600
12,1	0.2334	1.375	3.109	2.260
12,2	0.2386	1.346	2.643	1.964
12,3	0.2155	1.489	2.688	1.805
13,1	0.2455	1.308	1.704	1.303
13,2	0.2203	1.457	3.252	2.232
13,3	0.2528	1.270	2.514	1.980
14,1	0.2496	1.286	2.533	1.969
14,2	0.2282	1.407	3.584	2.548
14,3	0.2106	1.524	3.734	2.449
15,1	0.2173	1.477	3.166	2.143
15,2	0.2073	1.549	3.118	2.013
15,3	0.2143	1.498	3.673	2.452
16,1	0.1912	1.678		
16,2	0.2113	1.519	2.150	1.415
16,3	0.2269	1.415		
Avg.:	0.2258	1.430	2.779	1.964

This dissertation is accepted on behalf of the faculty of the Institute by the following committee:

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