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Kinetic Model for Orthophosphate Reactions in Mineral Soils

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KINETIC MODEL FOR ORTHOPHOSPHATE REACTIONS IN MINERAL SOILS

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ABSTRACT

The ability of a soil to remove wastewater phosphorus from solutions passing through the soil matrix is primarily related to the formation of relatively insoluble phosphate compounds of iron, aluminum, and calcium. Based on the solubility of these compounds, an estimate can be made of the minimum concentration of phosphorus which will be found at equilibrium in the soil solution.

The kinetics of orthophosphorus sorption with 25 viable mineral soils were experimentally measured under laboratory conditions. Several kinetic models were evaluated as a means of describing phosphorus sorption by soil. A diffusion limited Langmuir sorption model best fit the experimental data.

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SECTION I

CONCLUSIONS

The study showed the reaction of phosphorus with mineral soils is not instantaneous. Thus, using equilibrium isotherms will yield erroneous conclusions as to the ability of a soil to sorb phosphorus.

The suitability of several kinetic models describing phosphorus reactions in mineral soils was evaluated. Of the models evaluated, a diffusion-limited process paralleling heat flow theory for the storage of heat in spheres best describes the experimental data. Combining the kinetic model with a mass balance equation, one should be able to accurately predict the miscible displacement of phosphorus through mineral soils.

SECTION II

RECOMMENDATIONS

1. The study did not determine the effect of reducing conditions on phosphorus reactions. When considering wastewater treatment systems, reducing conditions may develop. Therefore, the effect of reducing conditions on phosphorus reactions should be evaluated.

2. The study did not determine the actual compounds formed. None of the simplified kinetic models perfectly fit the experimental data. Thus, one would anticipate multiple simultaneous reactions. It would be desirable to study the kinetics of the individual reactions which take place simultaneously to refine the model presented.

3. To evaluate the design of a wastewater treatment system using the proposed kinetic model, it will be necessary to combine the model with a mass balance equation and develop a transport model for phosphorus through soils. This should be undertaken immediately and compared with laboratory column studies to determine the validity of the transport model.

4. The study was limited in scope to evaluating phosphorus reactions in mineral soils. These models should not receive blanket application to highly organic soils without first determining their suitability for describing phosphorus reactions in organic soils.

SECTION III

GENERAL DISCUSSION OF PHOSPHORUS REACTIONS

In considering the soil as a possible medium for treating wastewater, the fate of both applied and in situ phosphorus must be understood. It is essential that the phosphorus concentration entering surface waters be sufficiently low to avoid degradation of aquatic systems and to avoid causing an accelerated eutrophication rate. When considering wastewater treatment there are two facets of the overall phosphorus problem which must be considered. First, without considering the addition of phosphorus by wastewater application, what residual phosphorus concentration would one anticipate in the soil solution? As considered here, the residual phosphorus concentration includes not only the effects of natural weathering but the effects of agricultural fertilization and resultant phosphorus in the soil solution. Since the majority of phosphorus added in agricultural fertilization is in the form of inorganic phosphorus compounds, it can be assumed that the residual phosphorus will be controlled by the solubility of phosphate minerals. A discussion of the residual phosphorus is handled by developing an equilibrium phosphorus solubility model.

The second facet of the phosphorus problem is the soil's capacity to sorb phosphorus and the kinetics of this reaction. The term "sorption" here refers to any process, physical, chemical, or biological, which causes phosphorus to be lost from the soil solution. It includes such processes as adsorption, absorption, chemisorption, and precipitation by chemical reaction. This is discussed in relation to various sorption models.

EQUILIBRIUM PHOSPHORUS SOLUBILITY MODEL

Considerable work has been conducted studying the reactions of phosphorus in soils. Qualitatively, the fate of applied phosphorus can be visualized through the phosphorus cycle shown in Figure 1. The phosphorus cycle was developed due to work directed toward soil fertility where phosphorus is not available to the plant in sufficient quantities to obtain optimum plant growth. Another area which receives attention and has helped in developing an understanding of the phosphorus cycle is soil water interactions of streams and lakes.

Most inorganic phosphate compounds found in soils can be classified into three groups: (1) those containing calcium phosphates, (2) those containing iron and aluminum phosphates, and (3) those combining with the silicate materials. The relative importance of these compounds can be roughly correlated to the pH of the soil environment. In acidic soils, iron

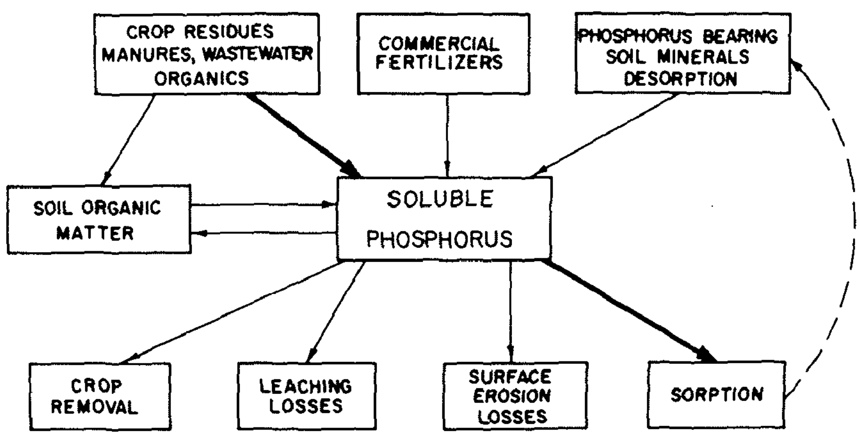

Figure 1. Phosphorus cycle.

and aluminum phosphates control the equilibrium concentration of phosphorus in the soil solution. In basic soils, calcium phosphates control the phosphorus in solution. Several authors[1-4] give a qualitative description of the fate of phosphates in soils versus pH where the soil system is not saturated with respect to phosphorus. Figure 2 gives a qualitative example of the phosphorus forms found in soils.

Blanchar and Hossner[5] concluded that in natural soil systems complex inorganic phosphate compounds would be transformed into pyrophosphate and orthophosphate within seven days.

Under conditions imposed by land application of municipal wastewater, detention times for wastewater in the soil system prior to release to free water bodies, in general, will be in excess of seven days. Thus, developing an equilibrium model considering only orthophosphate should adequately describe inorganic forms of phosphorus.

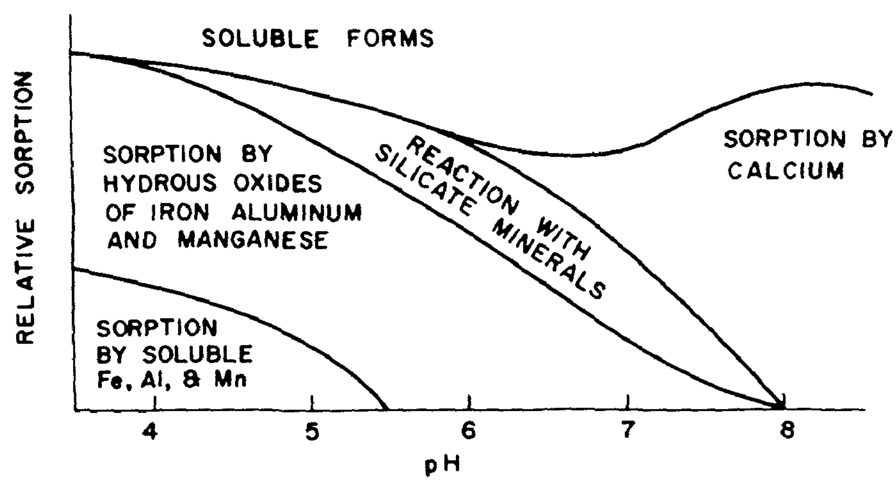

Figure 2. Fate of applied phosphorus in soils after Buckman and Brady.[2]

By studying the solubility of some of the more important iron, aluminum and calcium compounds found in soils, it is possible to estimate the residual phosphorus concentration in soil solution under given environmental conditions (i.e., pH, CO_2 partial pressure, etc.). Table 1 gives solubility products of sample orthophosphate compounds, along with the acidity and hydrolysis of phosphates and selected metal ions. The table was developed using several different references. Different references give different values for the equilibrium constant. In some cases more than one value is presented for a given equilibrium constant or solubility product; thus, it can be seen that there is some uncertainty in the degree of accuracy that can be anticipated.

Using the data presented in Table 1, example phase diagrams (Figure 3) are constructed. Using the phase diagrams, one can estimate equilibrium

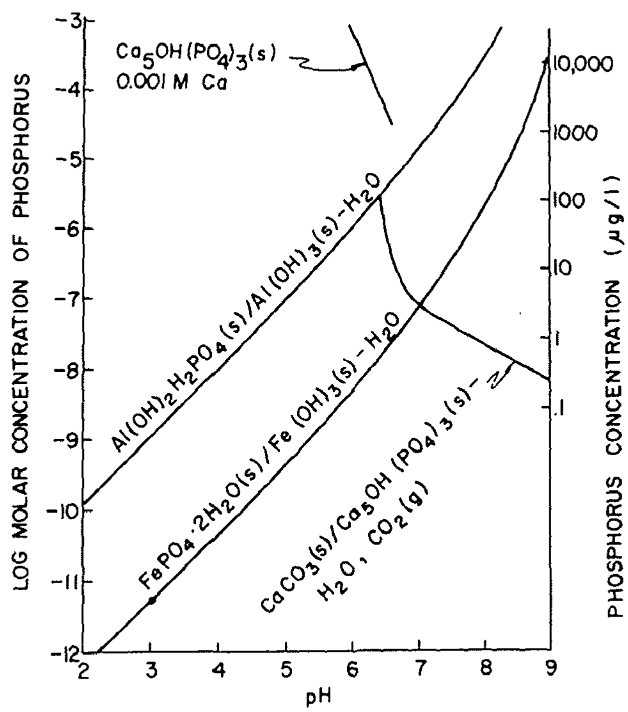

Figure 3. Phase diagram for the solubility of selected phosphate compounds.

Table 1. SOLUBILITY EQUILIBRIA OF ORTHOPHOSPHATE COMPOUNDS AND THE ACIDITY AND HYDROLYSIS OF PHOSPHATES AND METAL IONS

Reference Number*	Equilibrium	Equilibrium Constant
67	$MnHPO_4(s) \rightleftarrows Mn^{+2} + HPO_4^{-2}$	1.1×10^{-13}
68	$Al(OH)_2H_2PO_4(s) \rightleftarrows Al^{+3} + H_2PO_4^- + 2OH^-$	3.15×10^{-31}
69	$Ca_5OH(PO_4)_3(s) \rightleftarrows 5Ca^{+2} + 3PO_4^{-3} + OH^-$	2.51×10^{-56}
68	$Ca_4H(PO_4)_3 \cdot 3H_2O(s) \rightleftarrows 4Ca^{+2} + H^+ + 3PO_4^{-3} + 3H_2O$	1.26×10^{-47}
67	$FePO_4 \cdot 2H_2O$(strengite) $\rightleftarrows Fe^{+3} + PO_4^{-3} + 2H_2O$	9.9×10^{-29}
70†	$Fe(OH)_2H_2PO_4(s) \rightleftarrows Fe^{+3} + H_2PO_4^- + 2OH^-$	5.52×10^{-28}
67 71	$H_3PO_4 \rightleftarrows H_2PO_4^- + H^+$	7.1×10^{-3} 7.58×10^{-3}
67 71	$H_2PO_4^- \rightleftarrows HPO_4^{-2} + H^+$	6.2×10^{-8} 5.93×10^{-8}
67 71	$HPO_4^{-2} \rightleftarrows PO_4^{-3} + H^+$	4.51×10^{-13} 3.43×10^{-13}
67 & 71 69	$Al^{+3} + 3H_2O \rightleftarrows Al(OH)_3(s) + 3H^+$	4.1×10^{-11} 3.16×10^{-10}
67 69	$Fe^{+3} + 3H_2O \rightleftarrows Fe(OH)_3(s) + 3H^+$	1.1×10^{-10} 1.0×10^{-6}
67	$Mn(OH)_2 \rightleftarrows Mn^{+2} + 2OH^-$	2.0×10^{-13}
71	$Ca^{+2} + CO_3^{-2} \rightleftarrows CaCO_3$	5.0×10^{-9}
71	$H^+ + HCO_3^- \rightleftarrows H_2CO_3$	4.0×10^{-7}
71	$H^+ + CO_3^{-2} \rightleftarrows HCO_3^-$	5×10^{-11}
71	$H_2CO_3 \rightleftarrows P_{CO_2g} + H_2O$	3.4×10^{-2}

*The equilibrium constant was obtained from different sources. The reference number indicates the reference in the literature where the value was obtained.

†The value presented was calculated from experimental data.

residual phosphorus concentration in the natural soil solution. Four curves are presented in Figure 3. The first is for the solubility of $AlH_2PO_4(OH)_2$ in water. The second is for strengite ($FePO_4 \cdot 2H_2O$) in water. The third is for the solubility of $Ca_5OH(PO_4)_3$ in a 0.001 molar (M) calcium solution. The fourth is for $Ca_5OH(PO_4)_3$ in the presence of $CaCO_3$. Sample calculations are given in Appendix A which demonstrate how the figure is developed. It should be emphasized that those compounds selected are only some of the phosphorus compounds which might be present in soil systems. An example of a less soluble calcium phosphate is fluorapatite [$Ca_5(PO_4)_3F$] and that of a more soluble calcium phosphate is the dicalcium phosphate dihydrate ($CaHPO_4 \cdot 2H_2O$) (see for example H. E. Jensen[6]). Looking at Figure 3, one would anticipate the maximum phosphorus concentration naturally occurring in a soil water system to be approximately 0.01 ppm and this would be found at a pH between 6 and 7. This favorably compares to the qualitative description shown in Figure 2.

To point out some of the advantages and disadvantages of this approach, Figure 3 is reproduced in Figure 4 with the addition of some experimental data. *The data points indicate the measured concentrations of phosphorus* found in ground and subsurface drainage water. Some of the values represent data evaluated from "normal" agricultural lands and other is data obtained under wastewater treatment systems. Generally, the data compare favorably to the phase diagram; however, there are some cases with considerable discrepancy.

In Appendix A the phosphorus concentration was calculated based on the solubility of $Ca_5OH(PO_4)_3$ in the presence of $CaCO_3$. It was assumed that the concentration of phosphorus in solution would be controlled by the solubility of $CaCO_3$. The $CaCO_3$ solubility is controlled by the $CO_2(g)$ concentration in the soil atmosphere. The partial pressure of $CO_2(g)$ in well aerated soils ranges from 0.0003 atm to 0.01 atm. A $CO_2(g)$ pressure of 0.0003 atm controls the pH of the soil solution at approximately 8.7 where the solubility of $CaCO_3$ is relatively small, thus leading to low phosphorus concentrations. When considering wastewater treatment by

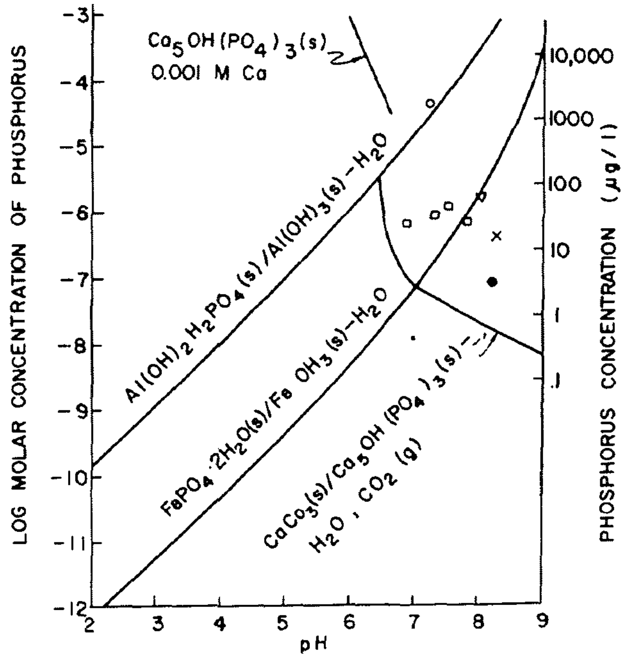

Figure 4. Comparison of phosphorus concentrations observed under field conditions and phase diagrams. (Legend: ¤ and × Aulenbach[81]; ○ Bouwer[82]; • Carter[83]; ∇ Johnston[84].)

application of waste materials to the land, quite often the objective is to see the maximum amount of effluent that can be treated using a minimum amount of land surface. This tends to increase the CO_2 partial pressure. In a $CaCO_3$ system, an increase in CO_2 partial pressure and corresponding decrease in O_2 partial pressure should increase the solubility of the $CaCO_3$ and thereby increase the phosphorus in drainage water. In acidic soils relying heavily on the formation of iron phosphates it is possible to reduce the oxidation state of iron. However, there is insufficient data available to accurately compare the solubilities of ferrous phosphates and ferric phosphates.

It should be pointed out that soil systems are at times designed to operate under reducing conditions where the partial pressure of CO_2 is relatively high. This is done to promote denitrification and is quite successful in removing nitrogen from the soil solution, provided there is sufficient energy available for the microorganisms[7] which perform the nitrogen transformations.

The above mentioned reducing conditions can have detrimental as well as beneficial effects. From a ground water point of view, it is generally beneficial to remove nitrates prior to their introduction into the ground water. In calcereous soils, the removal of the nitrates will be at the expense of increasing the calcium induced into the ground water. Also, once the calcium is removed from the profile it is no longer available for future reaction with orthophosphates and thus reduces the profile's net capacity to remove phosphorus from the soil solution. Thus, when considering the overall design of a wastewater treatment system, one must consider the total impact of the project and not just how to effectively treat one element.

Thus far organophosphates have been neglected. Neglecting the impact of organic phosphate compounds can, however, be misleading. Table 2 gives a comparison of total to orthophosphate at several points along the

Table 2. COMPARISON OF PHOSPHATE FORM
IN WASTE TREATMENT STREAM*

Site	Reference	Raw		Primary		Final	
		Total	Ortho	Total	Ortho	Total	Ortho
Mansfield, Ohio	72	9.0	4.1	7.0	3.4	6.4	5.1
Indianapolis, Indiana	73	10.0	5.2	6.3	5.8	6.3	5.7
Cleveland, Ohio	74	20.3	7.0	18.4	7.4	12.6	7.3
Baltimore, Maryland	75	9.1	5.2	12.4	8.6	0.7	0.4

*Units are presented as milligrams of elemental phosphorus per liter.

treatment system of four selected treatment facilities. In raw wastewater only about 40 percent of the phosphorus is in the form of orthophosphate while in the final effluent approximately 70 percent of the phosphorus is in the form of orthophosphate. The impact of the organic phosphorus fraction on a wastewater treatment system should not be ignored.

Organic phosphates are much more mobile than inorganic phosphates and can move rapidly through soil systems. To remove organic phosphates from solution using a soil system, the organic phosphate must be physically filtered and held for sufficient time to allow decomposition of the phosphate compound to an inorganic form. Acquaye[8] presented a discussion on the rate of mineralization of some organic phosphates found in soils.

In addition to the organic phosphates, the other organic forms such as the fatty acids, phenols, and natural chelates found in wastewater can likely form mobile compounds in soils systems fixing the ions which normally react with the phosphorus, thereby decreasing the sorption of the applied orthophosphates. Thus, for example, measuring the total calcium in the soil solution may suggest the phosphorus content should be much lower than the observed concentration based solely on the equilibrium solubility model.

PHOSPHORUS SORPTION

The above discussion of the equilibrium solubility model was limited to estimating the concentration of phosphorus in the soil solution assuming the soil profile was not supersaturated with respect to phosphorus. By itself, the equilibrium model does not give a valid method of estimating the quantity of phosphorus which can be sorbed by the soil. However, work has been attempted in pure systems by some individuals.[9] To design a wastewater treatment system, one also needs to know the amount of phosphorus that can be sorbed by the soil. Researchers[9-25] often relate the ability of a soil to sorb phosphorus to one of the equilibrium isotherms. The two equilibrium isotherms most often used for this purpose are the Langmuir equation and Freundlich equation. The

Langmuir equation[26] was originally developed to describe how a gas is adsorbed on "smooth" surfaces and assumes the gas is adsorbed in a monolayer. The Freundlich equation, often called the classical equation, was originally an empirical equation which seemed to fit a large range of experimental data. Later it was shown[27] that this equation is equivalent to the Langmuir equation except it includes the possibility of multilayer sorption with each successive monolayer being sorbed at reduced bonding energy. These isotherms can be written to relate the amount of phosphorus sorbed by the soil per unit mass of soil to the concentration of phosphorus in the soil solution. Note that this is a significant deviation from the equilibrium solubility model. The equilibrium solubility model would propose that the most insoluble compound would form first, then followed by more soluble compounds. There is no indication of the proportions of the compounds, thus one could not readily predict how much phosphorus could be sorbed. The Langmuir equation can be written as

$$S = \frac{S_m B C}{1 + B C} \tag{1}$$

where B = constant at constant temperature

C = concentration of sorbate species, phosphorus, in the liquid phase (mg/l)

S = concentration of the sorbate species in the solid phase [μg sorbate (phosphorus)/g sorbent (soil)]

S_m = the maximum concentration of the sorbate species in the solid phase [μg sorbate (phosphorus)/g sorbent (soil)]

The Freundlich equation can be written

$$S = m C^n \tag{2}$$

where m and n are constants at constant temperature. Several other equilibrium isotherm equations have been proposed for sorption of phosphorus by soil, such as those by Gunary[13] and Holford, et al.[16] Thus, assuming equilibrium conditions could be attained, it would be possible to estimate how much phosphorus could be sorbed at some given solution concentration.

In Figure 5(a-c), experimental data along with regression functions for a Langmuir equation and a Freundlich equation are shown. Both functions fit the experimental data reasonably well and different authors have discussed the pros and cons of each equation.[12, 18, 25]

There are numerous references to work relating the coefficients in the Langmuir or Freundlich equation to the physical/chemical properties of soils. Ahenkorah,[28] Saini and MacLean,[29] Williams et al.,[30] and Blanchar and Hossner[5] have developed regression equations to predict the coefficients in the sorption equations. In these studies, multiple linear regressions were performed which give a linear weighting to different

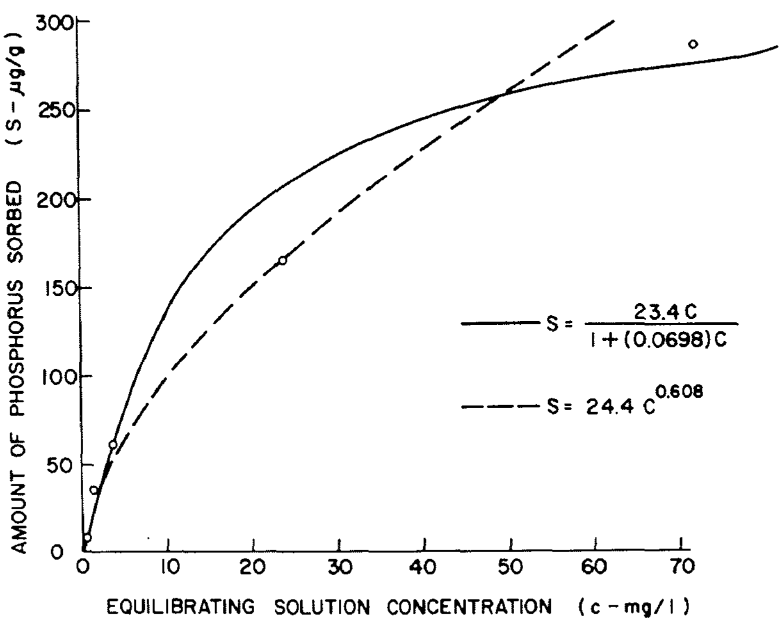

Figure 5a. Linear plot of Langmuir and Freundlich regression equation to experimental data for soil "S" (see Tables 3 and 4) measured after one hour of equilibration.

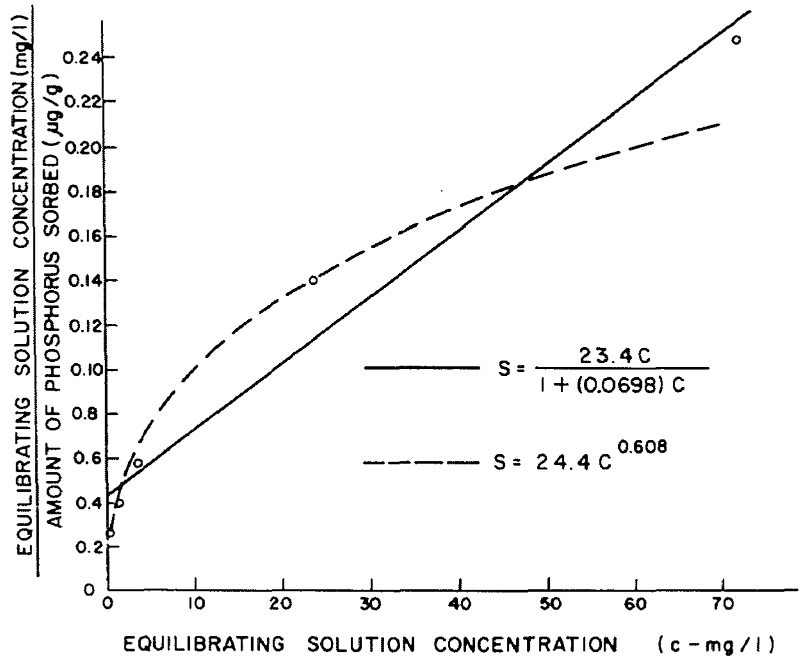

Figure 5b. Langmuir plot of Langmuir and Freundlich regression equation to experimental data for soil "S" (see Tables 3 and 4) measured after one hour of equilibration.

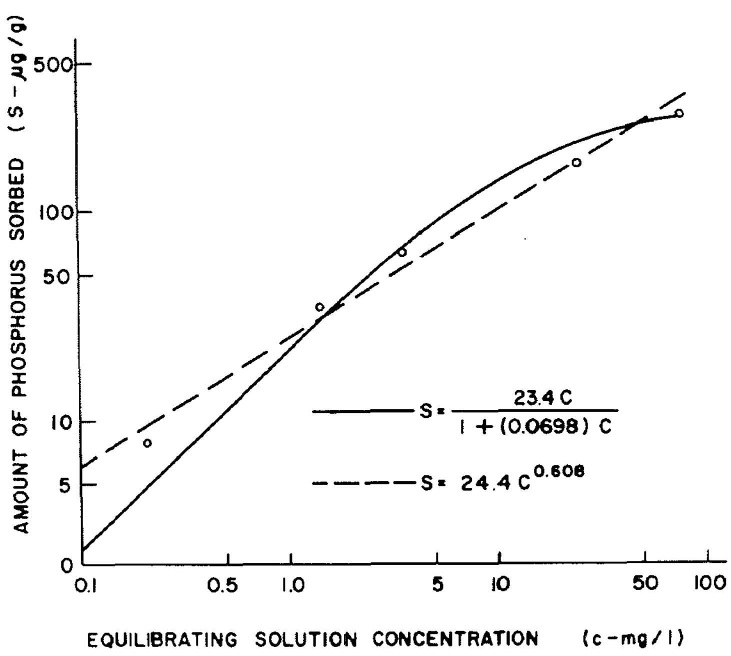

Figure 5c. Logarithmic plot of Langmuir and Freundlich regression equation to experimental data for soil "S" (see Tables 3 and 4) measured after one hour of equilibration.

physical/chemical properties such as amount of clay, aluminum, iron, etc. Similar work in this laboratory where a wide range of mineral soils were considered was not conclusive. Depending on which physical/chemical properties were chosen, illogical regression equations could be obtained. Thus, it is felt that this type of "black box" approach cannot achieve successful results for broad geographic regions where one is limited to those properties which are commonly measured at this time.

Another approach which has been used with some success is to relate extractable phosphorus to the solubility of some of the phosphate compounds found in soil.[9, 18, 19, 31-38] This approach, as it has been presented in the literature, is probably more adaptable to crop production than to wastewater treatment, since in crop production the amount of phosphorus which can be extracted by the plant is the important parameter. However, in wastewater treatment the total amount that can be sorbed by the soil without being toxic to the plant or be leached from the soil profile is what should be used as a design criteria. It should be pointed out that there is no evidence in the literature of a problem with phosphorus toxicity. For the few cases where toxicity was reported, generally it was found that high levels of phosphorus magnified deficiency symptoms for other elements rather than being toxic in itself.

KINETICS OF PHOSPHORUS SORPTION

Designing a wastewater treatment system for phosphorus removal using equilibrium isotherms will probably be adequate where applications of wastewater of less than 5.0 cm/wk are considered. The problems arise when considering higher application rates or how one can obtain equilibrium isotherms. There are numerous references indicating the sorption reaction is not instantaneous.[10, 11, 22, 39-46] Some references indicate the reactions are still continuing after ten years of equilibration. Figure 6 is sample data for sorption of phosphorus by a soil sample at one given concentration. These data were derived from equilibrating 10 g of soil with 100 ml of 0.01 M CaCl solution initially containing 40 mg/l P, then monitoring phosphorus concentration remaining in solution with time.

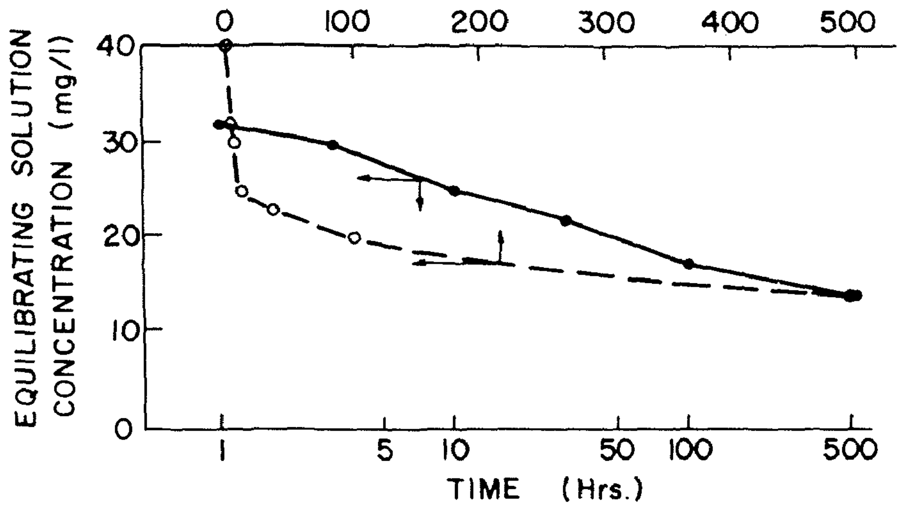

Figure 6. Sample data indicating the time dependency of phosphorus reactions.

Looking at the data using a logarithmic time base, it is easy to see there is no indication of the reaction reaching an equilibrium value. However, using a linear time scale it is easy to see why numerous researchers have indicated the reaction was "essentially complete" after a few hours. When considering a wastewater treatment system, one must consider time scales in tens of years rather than hours. Thus, it does not appear appropriate to consider "equilibrium" isotherms which were based on studies with a few hours of equilibration time. In high rate systems; i.e., systems with design flow >5.0 cm/wk, it may also be necessary to know how fast the reaction is taking place.

This introduces a requirement to have a means of describing the kinetics of the phosphorus reaction during the movement of phosphorus through soil profiles. The most common approach used to describe ion movement through soil systems uses a mass balance equation.

Considering the simplified one-dimensional case where the finite element is oriented such that flow occurs only through two opposite faces of the finite element, then the mass balance equation can be developed with some ease. In the mass balance equation, one is attempting to calculate how fast the solution concentration is changing at some spatial coordinate. Intuitively, one can see four components which will cause this change in solution concentration. First, flow will be caused by a concentration gradient. This is a diffusion process and essentially says a natural system will attempt to reach equilibrium and ions from a region of high concentration will migrate to a region of low concentration. The second term will be due to the flow of water which is carrying the ions under consideration. In other words, if a water containing a high concentration of ions flows into an area of low concentration, it will cause a change in the ion concentration in the finite element being considered. The velocity which is used in this calculation is not the velocity of the applied solution but the velocity in the pores of the soil. This points out a third aspect: the pore water velocity is not a constant. Water flows more easily through the large pores than the small pores which disperses the flow. The fourth term is a so-called sink or source term which takes into consideration the loss or gain of an ion from or to the flow stream by such actions as sorption, plant removal, solubilization, etc. When considering a wastewater treatment system, the flow of water is relatively high. Thus, the effect of diffusion will be minimal and one feels justified in ignoring these influences. This does not mean that one is justified in ignoring diffusion under all conditions such as under normal agricultural practices. Under normal agricultural practices, diffusion may be the significant factor for nutrient transport to the plant root. Several researchers[47-52] have studied the diffusion of phosphorus in soils and its implication on plant uptake of the mineral.

In addition to diffusion, hydrodynamic dispersion will be ignored in our discussion. The mass balance equation can then be written as

$$\frac{\partial C}{\partial t} = -V \frac{\partial C}{\partial x} - \frac{\rho}{\theta} \frac{\partial S}{\partial t} \qquad (3)$$

where C = solution phase concentration of phosphorus (mg/l)

$\overline{V}$ = average pore-water velocity (cm/hr)

x = distance from the beginning of the flow path (cm)

ρ = bulk density of the soil (g/cm^3)

θ = fractional solution-filled-volume in the porous media

S = solid phase concentration of phosphorus ($\mu g/g$).

In the above equation, the kinetics of sorption is directly related to the sink or source term ($\partial S/\partial t$). Several sink terms have been proposed and used to predict the movement of ions through soil systems, such as the work by Davidson and Chang,[53] Enfield et al.,[39, 41] Hendricks,[54] Hornsby and Davidson,[55] Kay and Elrick,[56] Lindstrom et al.,[57, 58] Oddson et al.,[59] Skopp and Warrick,[60] and van Genuchten et al.[61] However, very little of this work is related to the movement of phosphorus.

The majority of the models consider the sink term in differential form. A general equation may be written for the sorption part of the sink term, as follows:

$$\begin{Bmatrix} \text{RATE OF} \\ \text{SORPTION} \end{Bmatrix} = \begin{Bmatrix} \text{DIFFUSION IN} \\ \text{SOLID PHASE} \end{Bmatrix} \times \begin{Bmatrix} \text{DRIVING} \\ \text{FORCE} \end{Bmatrix}$$

$$\frac{\partial S}{\partial t} = \overline{D}\,(C, S) \times \left\{ F(C) - S \right\} \qquad (4)$$

where $\overline{D}(C, S)$ = the diffusion coefficient in the solid phase as a function of the solution phase concentration and solid phase concentration

$F(C)$ = equilibrium concentration of phosphorus in the solid phase, corresponding to the solution phase concentration.

These sink terms generally follow some previously described chemical kinetic model such as those described by Laidler.[62] Lapidus and Amundson[63] used the first order kinetic equation

$$\frac{\partial S}{\partial t} = \alpha\,(\kappa C - S) \tag{5}$$

where α and κ are constants, to describe the response of chromographic columns. This equation assumes the driving force is related to the difference between what can be sorbed at some concentration (i.e., an equilibrium isotherm) and what has already been sorbed. It further assumes the equilibrium is a linear function and the diffusion coefficient *(α) is a constant. Oddson et al.*[59] *and other workers used the same* kinetic equation to describe the movement of organic compounds in soils. Hornsby and Davidson[55] and others used the equation

$$\frac{\partial S}{\partial t} = \beta\,(m\,C^{n} - S) \tag{6}$$

where β, m and n are constants. This equation is similar to Equation (5) except it assumes the equilibrium isotherm can be described by the Freundlich equation rather than a linear equation. By non-linearizing the sorption function, they were better able to describe pesticide movement in soils.

An empirical function which has been used by Enfield[39] to describe the kinetics of phosphorus sorption is

$$\frac{\partial S}{\partial t} = a\,C^{b}\,S^{d} \tag{7}$$

where a, b, and d are constants. Since this is an empirical equation, it is difficult to describe what driving forces or what assumed relationships exist. However, earlier indications[39, 40, 41] suggested this model more accurately predicts the kinetics of phosphorus sorption than Equation (5).

Skopp and Warrick[60] developed an analytical solution for Equation (3) where they assumed sorption to be diffusion-limited. In Skopp and Warrick's development, an integral form of the sorption term was used rather than the differential form previously discussed. Skopp and Warrick's development used a solution presented in Carslaw and Jaeger[64] (p. 97, Equation 10) for heat flow in flat plates. Enfield et al.[41] used a similar approach for phosphorus except they assumed the soil particle was spherical rather than plate-like. This yields a diffusion limited model

$$S_{avg} = F(C) - \frac{6F(C)}{\pi^2} \sum_{n=1}^{\infty} \frac{1}{n^2} e^{-\kappa n^2 \pi^2 t/r^2} \qquad (8)$$

where S_{avg} = average solid phase concentration in the soil particle (μg "P"/g)

$F(C)$ = function describing the amount of phosphorus that can be sorbed at equilibrium as a function of solution concentration (i.e., equilibrium isotherm) (μg "P"/g)

κ = diffusion coefficient

r = radius of soil particle

after a solution presented by Carslaw and Jeager[64] (p. 234, Equation 8). The model further assumes the initial concentration of phosphorus in the soil particle is zero and the concentration of the phosphorus at the surface is constant.

SECTION IV

EXPERIMENTAL STUDIES

RESULTS AND DISCUSSION OF EXPERIMENTAL SORPTION STUDIES

Analyses were performed on 25 mineral soil samples. These samples were collected in Arizona, Florida, Indiana, Michigan, and Oklahoma. The samples were given an internal letter code which was used throughout the studies. Table 3 relates the internal code letter to the classification of the soil samples as given by various soil surveys developed by the USDA Soil Conservation Service in cooperation with state universities. These samples were then analyzed for several physical and chemical properties which are tabulated in Table 4. Appendix B is a listing of the methodologies used in the analyses. Samples were obtained from eight of the ten orders in the comprehensive soil classification system. However, data is not presented in this report for any of the Histosols. Histosols were not included in this report for two reasons. First, this is not a predominant order nationally. Secondly, the data that were obtained for the Histosols or organic soils did not fit any of the sorption models which were considered. For a discussion of soil classification, the reader is referred to a text on the subject by Boul et al.[65]

Experimental data for comparison with kinetic models was developed in batch equilibration studies. In the initial phases of the project, analyses were performed semi-nondestructively. An aliquot of the equilibrating solution was analyzed periodically and a volume equal to that removed was replaced for a continuation of the test. The procedure was later replaced with destructive analyses which proved to be easier to evaluate numerically. The experimental procedures are outlined in Appendix C. The data obtained in this manner are presented tabularly in Appendix D.

Table 3. SOIL CLASSIFICATION

Sample code	State	Soil series	Family	Subgroup	Order
A	OK	Konawa	Fine-loamy, mixed, thermic	Ultic Haplustalfs	Alfisol
B	OK	Vernon	Fine, mixed, thermic	Typic Ustochrepts	Inceptisol
C	OK	Clarita	Fine, montmorillonitic, thermic	Udic Pellusterts	Vertisol
D	OK	Windthorst	Fine, mixed, thermic	Ultic Paleustalfs	Alfisol
E	OK	Chigley	Fine, mixed, thermic	Ultic Paleustalfs	Alfisol
F	OK	Chigley	Fine, mixed, thermic	Ultic Paleustalfs	Alfisol
G			- - - Not classified. - - -		
H	AZ		- - - Not classified. - - -		
I	AZ	Whitehouse	Fine, mixed, thermic	Ustollic Haplargids	Aridisol
L	FL	Orangeburg	Fine-loamy, siliceous, thermic	Typic Paleudults	Ultisol
M	FL	Lakeland	Thermic, coated	Typic Quartzip-samnents	Entisol
N	AZ	Mohave	Fine-loamy, mixed, thermic	Typic Haplargids	Aridisol
O	AZ	Grabe	Coarse-loamy, mixed (calcareous), thermic	Anthropic Torrifluvents	Entisol
P	AZ	Pima	Fine-silty, mixed, thermic	Anthropic Torrifluvents	Entisol
Q	AZ	Vinton	Sandy, mixed, thermic	Typic Torrifluvents	Entisol
R	AZ	Gothard	Fine-loamy, mixed, thermic	Typic Natrargids	Aridisol
S	AZ	Anway	Fine-loamy, mixed, thermic	Typic Haplargids	Aridisol
T	AZ	Anthony	Coarse-loamy, mixed (calcareous), thermic	Typic Torrifluvents	Entisol
U	MI	Roscommon Au-Gres	Mixed, frigid	Molic Psammaquents	Entisol
V	MI	Roscommon Au-Gres	Mixed, frigid	Molic Psammaquents	Entisol
W	MI	Rubicon	Sandy, mixed, frigid	Entic Haplorthods	Spodosol
X	MI	Rubicon	Sandy, mixed, frigid	Entic Haplorthods	Spodosol
Y	IN	Maumee	Sandy, mixed, mesic	Typic Haplaquolls	Mollisol
Z	IN	Maumee	Sandy, mixed, mesic	Typic Haplaquolls	Mollisol
AA	IN	Bedford	Fine-silty, mixed, mesic	Typic Fragiudults	Ultisol

Table 4. SELECTED PHYSICAL/CHEMICAL PROPERTIES OF STUDY SOILS

SAMPLE		A	B	C	D	E	F	G
Surface area m^2/g		<1.	84.	203.	155.	25.	52.	<1.
Percent clay		15.	39.	54.	53.	16.	28.	<1.
Percent silt		<1.	13.	20.	16.	<1.	13.	<1.
Percent sand		85.	48.	26.	13.	84.	59.	>99.
Cation exchange capacity (meq/l)		2.0	32.	71.	53.	12.	23.	0.25
Percent organic matter		0.22	0.3	4.2	1.4	0.33	1.4	0.04
Total phosphorus (ppm)		44.6	14.7	255.	110.	166.	382.	17.9
Resin extractable phosphorus (ppm)		4.1	0.68	6.5	2.8	9.6	7.8	0.94
Total iron (percent)		1.0	1.8	3.1	3.5	1.3	2.0	.034
Exchangeable iron (ppm)		8.0	3.4	0.76	5.2	10.0	4.0	2.4
Total aluminum (percent)		1.0	4.8	6.0	5.8	2.4	5.1	<.5
Exchangeable aluminum (ppm)		<50.	340.	<50.	70.	<50.	<50.	<50.
Total calcium (percent)		0.10	0.24	0.92	0.46	7.70	5.80	0.027
Exchangeable calcium (ppm)		184.	1430.	1400.	3080.	5580.	2340.	12.
Total magnesium (percent)		0.035	0.37	0.73	0.56	0.19	1.52	0.080
Exchangeable magnesium (ppm)		20.	300.	940.	860.	50.	340.	2.
Saturated pH		7.2	4.5	7.1	4.9	8.0	8.0	6.8
Electrical conductivity of saturation extract (μmhos/cm)		230.	420.	450.	320.	380.	410.	200.
$\frac{\partial S}{\partial t} = a C^b S^d$	a	4.96	18600.	2580.	36100.	4.88	464.	-.0048
	b	2.3	2.23	2.29	2.30	1.92	2.23	2.10
	d	-2.4	-2.68	-2.45	-2.94	-1.05	-2.17	-.66
$\frac{\partial S}{\partial t} = \alpha (\kappa C - S)$	α	.13@-5	.43@-3	.16@-3	.147@-3	.93@-4	.24@-2	.13@-3
	κ	5480.	636.	797.	1010.	1200.	51.1	70.
$\frac{\partial S}{\partial t} = \beta (m C^n - S)$	m	25.	160.	79.	760.	1100.	170.	12.
	n	.44	0.52	0.62	0.11	0.54	0.56	0.33
	β	1.4@-2	1.9@-2	1.9@-2	4.8@-3	6.3@-4	4.9@-3	4.0@-3
DIFFUSION MODEL $F(C) = IC^J$	I	79.	430.	390.	570.	310.	210.	1.1
	J	0.56	0.52	0.54	0.36	0.68	0.62	0.66
	κ/r^2	3.98@-6	6.31@-5	1.@-3	1.58@-4	6.31@-5	1.@-3	2.51@-2
DIFFUSION MODEL $F(C) = \frac{S_m BC}{1 + BC}$	S_m	81.	2300.	2400.	1800.	5000.	2100.	10.
	B	0.32	0.43	0.34	1.9	0.094	.19	.12
	κ/r^2	6.31@-4	6.31@-5	1.@-4	1.58@-4	3.98@-5	6.31@-5	2.51@-2

Table 4 (continued). Selected Physical/Chemical Properties of Study Soils

SAMPLE	H	I	L	M	N	O	P
Surface area m^2/g	105.	178.	27.	4.8	72.	75.	136.
Percent clay	36.	44.	18.	8.	23.	26.	34.
Percent silt	24.	13.	17.	2.	7.	20.	39.
Percent sand	40.	43.	65.	90.	70.	54.	27.
Cation exchange capacity (meq/l)	30.	38.	16.	4.	17.	29.	40.
Percent organic matter	0.78	0.71	2.5	0.64	0.5	1.4	1.5
Total phosphorus (ppm)	764.	325.	150.	355.	220.	1320.	870.
Resin extractable phosphorus (ppm)	18.	6.7	1.1	4.3	98.	47.	19.
Total iron (percent)	3.2	3.55	1.17	0.14	2.10	0.74	3.64
Exchangeable iron (ppm)	3.6	3.2	6.4	5.3	6.4	4.0	2.8
Total aluminum (percent)	8.75	7.25	2.70	0.55	5.5	6.7	7.25
Exchangeable aluminum (ppm)	<50.	<50.	<50.	<50.	<50.	<50.	<50.
Total calcium (percent)	2.15	0.70	0.25	0.05	0.70	3.25	2.73
Exchangeable calcium (ppm)	7020.	2400.	142.	328.	1110.	6780.	6920.
Total magnesium (percent)	1.04	0.65	0.053	0.020	0.41	1.19	1.27
Exchangeable magnesium (ppm)	600.	960.	26.	12.8	200.	380.	400.
Saturated pH	8.0	7.7	4.8	7.2	7.7	8.4	8.0
Electrical conductivity of saturation extract (μmhos/cm)	1300.	550.	250.	260.	340.	1560.	2050.
$\frac{\partial S}{\partial t} = a C^b S^d$ — a	1.88	612000.	.87	183.	10.3	1.48	41.
b	1.87	2.81	.30	2.40	2.0	2.22	2.4
d	-0.90	-3.87	-.27	-2.91	-1.98	-.97	-1.7
$\frac{\partial S}{\partial t} = \alpha (\kappa C - S)$ — α	.40@-3	.89@-2	.50@-2	.18@-3	.98@-4	.89@-4	.11@-2
κ	326.	18.	40.3	171.	171.	188.	129.
$\frac{\partial S}{\partial t} = \beta (m C^n - S)$ — m	880.	84.	150.	22.	420.	2200.	330.
n	0.69	0.53	0.55	0.62	0.58	0.62	0.60
β	5.6@-4	1.9@-2	1.0@-2	1.4@-2	2.7@-4	7.7@-5	2.3@-5
DIFFUSION MODEL $F(C) = IC^J$ — I	380.	13.	1700.	26.	160.	320.	350.
J	0.58	0.47	0.20	0.80	0.54	0.68	0.74
κ/r^2	6.31@-5	3.98@-3	6.31@-5	1.@-3	6.31@-5	6.31@-5	2.51@-5
DIFFUSION MODEL $F(C) = \frac{S_m BC}{1 + BC}$ — S_m	520.	640.	1200.	100.	1200.	5700.	5900.
B	5.2	0.54	0.36	0.12	.13	0.07	0.07
κ/r^2	3.98@-4	3.98@-3	3.98@-4	1.58@-5	1.@-4	3.98@-5	2.51@-5

Table 4 (continued). Selected Physical/Chemical Properties of Study Soils

SAMPLE		Q	R	S	T	U	V
Surface area m^2/g		34.	90.5	179.	38.	1.7	10.
Percent clay		8.	34.	45.	13.	4.	12.5
Percent silt		2.	15.	42.	10.	4.	12.5
Percent sand		90.	51.	13.	77.	92.	75.
Cation exchange capacity (meq/l)		16.	15.	25.	4.2	3.4	14.
Percent organic matter		0.64	.71	1.81	.27	.32	1.8
Total phosphorus (ppm)		495.	900.	452.	265.	37.5	119.
Resin extractable phosphorus (ppm)		32.	86.	61.	72.	1.8	1.4
Total iron (percent)		3.34	1.5	3.6	2.0	0.27	0.4
Exchangeable iron (ppm)		4.4	4.2	2.4	2.8	2.	3.
Total aluminum (percent)		6.5	3.5	7.4	5.5	1.35	1.25
Exchangeable aluminum (ppm)		<50.	<50.	<50.	<50.	<50.	<50.
Total calcium (percent)		1.8	8.4	0.9	0.8	0.19	0.17
Exchangeable calcium (ppm)		3520.	5460.	4710.	1260.	950.	100.
Total magnesium (percent)		0.77	1.9	1.1	0.4	0.047	0.044
Exchangeable magnesium (ppm)		200.	510.	560.	150.	8.	25.
Saturated pH		8.4	8.5	7.6	8.2	5.4	5.2
Electrical conductivity of saturation extract (μmhos/cm)		480.	6000.	2400.	305.	100.	170.
$\frac{\partial S}{\partial t} = a C^b S^d$	a	0.56	3.6	23600.	5.37	1490.	385.
	b	1.93	2.06	3.15	2.18	2.03	1.99
	d	-1.26	-0.86	-3.33	-2.14	-3.86	-2.51
$\frac{\partial S}{\partial t} = \alpha (\kappa C - S)$	α	.41@-3	.56@-3	.64@-2	.46@-3	.1@-3	.17@-2
	κ	89.	470.	29.	59.	19.	10.
$\frac{\partial S}{\partial t} = \beta (m C^n - S)$	m	59.	2600.	91.	48.	31.	23.
	n	0.60	0.50	0.63	0.54	0.30	0.53
	β	4.3@-3	7.5@-4	1.1@-2	4.9@-3	1.4@-3	6.4@-2
DIFFUSION MODEL $F(C) = IC^J$	I	67.	580.	210.	79.	68.	110.
	J	0.68	0.72	0.70	0.62	0.4	0.58
	κ/r^2	3.98@-5	6.31@-5	1.@-3	1.58@-5	1.@-3	1.@-3
DIFFUSION MODEL $F(C) = \frac{S_m BC}{1 + BC}$	S_m	1200.	8800.	6400.	1000.	460.	1700.
	B	0.05	0.10	0.12	0.077	0.98	0.085
	κ/r^2	3.98@-5	3.98@-5	1.58@-6	1.58@-5	2.51@-6	6.31@-5

Table 4 (continued). Selected Physical/Chemical Properties of Study Soils

SAMPLE		W	X	Y	Z	AA
Surface area m^2/g		6.5	18.4	30.	18.	55.
Percent clay		4.	4.	4.	5.	18.
Percent silt		4.	4.	4.	15.	81.
Percent sand		92.	92.	92.	80.	>1.
Cation exchange capacity (meq/l)		12.	5.6	32.7	23.5	1.3
Percent organic matter		1.6	0.4	3.9	2.2	2.4
Total phosphorus (ppm)		216.	147.	731.	270.	703.
Resin extractable phosphorus (ppm)		2.6	2.5	45.	8.5	8.9
Total iron (percent)		0.68	0.67	0.98	0.61	2.0
Exchangeable iron (ppm)		3.	5.	10.	4.	2.
Total aluminum (percent)		1.30	1.50	2.56	2.62	5.18
Exchangeable aluminum (ppm)		<50.	<50.	<50.	<50.	<50.
Total calcium (percent)		0.20	0.18	0.33	0.37	0.25
Exchangeable calcium (ppm)		250.	260.	80.	580.	710.
Total magnesium (percent)		0.094	0.088	0.12	0.13	0.25
Exchangeable magnesium (ppm)		23.	6.	96.	77.	53.
Saturated pH		5.4	5.5	5.1	5.3	5.5
Electrical conductivity of saturation extract (μ mhos/cm)		120.	90.	400.	400.	100.
$\frac{\partial S}{\partial t} = a\, C^b\, S^d$	a	487.	107.	7.3	280.	34.6
	b	2.02	1.9	2.28	2.08	2.07
	d	-2.4	-2.0	-1.63	-2.08	-1.7
$\frac{\partial S}{\partial t} = \alpha\,(\kappa\, C - S)$	α	.67@-2	.37@-1	0.038	.74@-1	.24@-1
	κ	7.3	4.9	8.83	9.2	14.
$\frac{\partial S}{\partial t} = \beta\,(m\, C^n - S)$	m	44.	51.	24.	58.	44.
	n	0.48	0.47	.72	0.50	0.67
	β	4.2@-2	7.0@-2	5.5@-2	1.3@-1	3.5@-2
DIFFUSION MODEL $F(C) = IC^J$	I	200.	120.	33.	69.	100.
	J	0.54	0.56	0.82	0.58	0.66
	κ/r^2	3.98@-5	1.58@-4	1.@-3	2.51@-3	2.51@-4
DIFFUSION MODEL $F(C) = \frac{S_m BC}{1 + BC}$	S_m	1600.	1400.	1200.	780.	1400.
	B	0.13	0.12	0.026	0.17	0.089
	κ/r^2	1.@-3	1.58@-4	1.@-3	1.@-3	2.51@-4

SECTION V

DISCUSSION OF RESULTS

Looking at data in tabular form, it is not too clear how to interpret the experimental result. A logarithmic plot of sorption data for soil "S" is presented in Figure 7. If a Freundlich or Langmuir equation, Equation (2) or (1), respectively, were applied to the data at any one measurement time, a reasonable correlation would be obtained. It can also be seen that with longer equilibration times, more phosphorus is sorbed at a given equilibrating solution concentration. Looking at Figure 7, it does not appear reasonable to use one equilibration time to estimate the sorption capacity

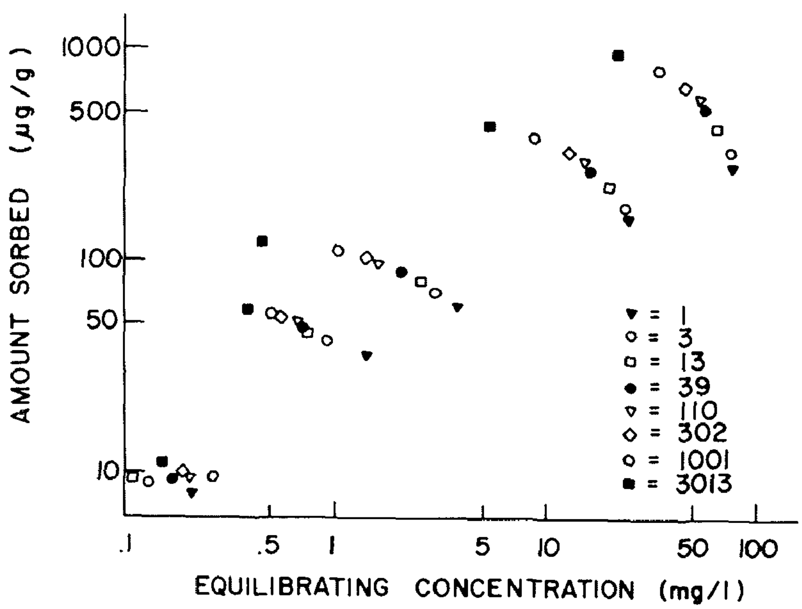

Figure 7. Logarithmic plot of experimental sorption data of soil "S" (see Tables 3 and 4).

of a soil for the purposes of designing a high rate wastewater treatment system. In the following paragraphs five kinetic models described earlier are considered and an attempt is made to evaluate which model is best suited for describing phosphorus sorption by mineral soils.

Linear least squares analysis is best suited for describing normally distributed data. The raw data collected were not normally distributed. The raw data had a more or less logarithmic distribution. When a linear regression is used with the type of data that were collected, the net result will overweight the large values and underweight the smaller values. With logarithmically distributed raw data, the authors feel that it would be best to perform log transformations on the kinetic models and data prior to performing regression analyses. This technique is useful when there are no negative values or zeros and the kinetic function lends itself to a log transformation.

The first function which will be considered is a first order kinetic equation, Equation (5). Since this equation is linear, regression analyses were performed without making any transformations on the raw data or function. The function can be thought of as a sorption rate surface. This surface can then be plotted in a manner similar to a topographic map. Plotting contours for equal rates of sorption, the sorption rate surface can be displayed. Figure 8 is a plot of the regression function for soil "Y" using Equation (5). Superimposed on this surface are the experimental data from the batch sorption data. A similar procedure is used to develop Figures 9 and 10 for Equations (6) and (7), respectively.

Looking at these figures conceptually or qualitatively it would appear that Figure 10 best fits the experimental data, followed by Figure 9, then Figure 8.

The first three functions are actually kinetic models in differential form. The diffusion limited model after Carslaw and Jaeger[64] is an integral form. To perform normal curve fitting, it is necessary to differentiate the function being fitted. Since the diffusion limited model requires a record of previous conditions to evaluate new conditions, it is not convenient to use standard

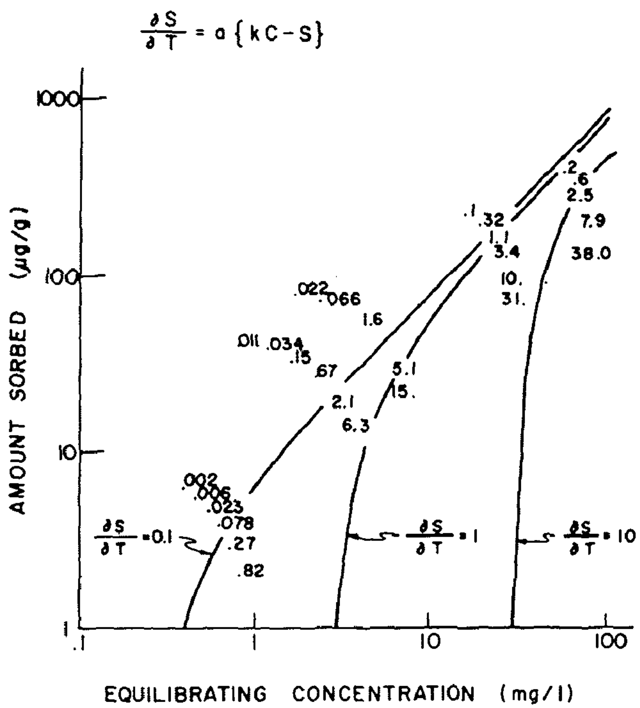

Figure 8. Regression of Equation (5) to the experimental data of soil "Y." In the figure, the rate of sorption is presented in parts per million per hour. The experimental data points are plotted numerically with the data point located at the decimal point of the value. (a = 0.074; k = 9.2)

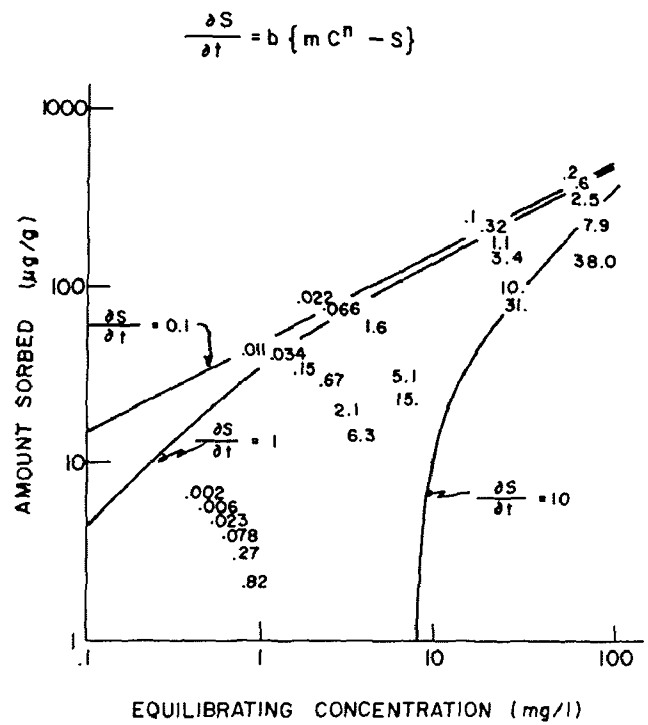

Figure 9. Regression of Equation (6) to the experimental data of soil "Y." In the figure, the rate of sorption is presented in parts per million per hour. The experimental data points are plotted numerically with the data point located at the decimal point of the value. (b = 0.055; m = 24; n = 0.72)

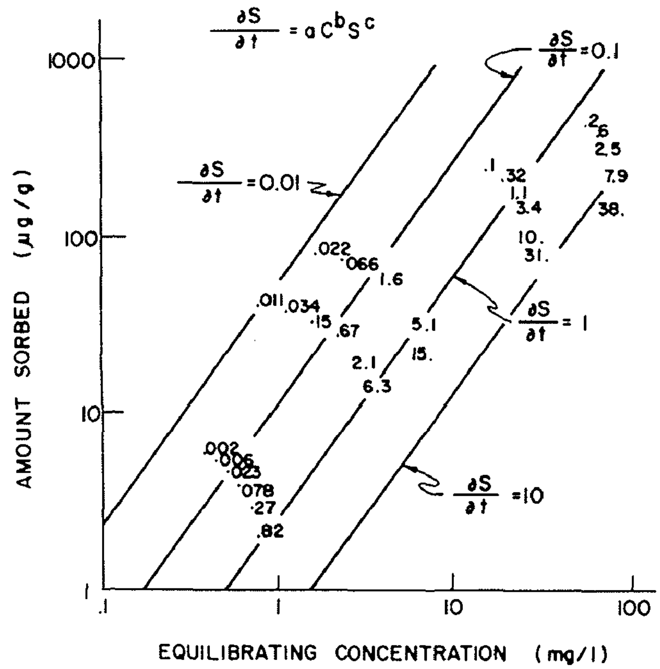

Figure 10. Regression of Equation (7) to the experimental data of soil "Y." In the figure, the rate of sorption is presented in parts per million per hour. The experimental data points are plotted numerically with the data point located at the decimal point of the value. (a = 7.3; b = 2.28; C = 1.63)

curve fitting techniques. This would not have been a problem if it had been possible to maintain a constant solution concentration and still measure the amount of sorption.

Thus, to obtain regression coefficients for this model, it is necessary to rewrite the model as a series. In other words, it was assumed the equilibrating solution concentration could be described by a series of step functions similar to that shown in Figure 11. Thus, the surface concentration was described as

$$F(C) = F(C_0) \qquad 0 < t < t_1$$

$$F(C) = F(C_1) \qquad t_1 < t < t_2$$

$$F(C) = F(C_2) \qquad t_2 < t < t_3$$

$$\vdots$$

$$F(C) = F(C_n) \qquad t > t_n \tag{9}$$

To condense the expression, Equation (8) was rewritten as

$$\frac{S_{avg}}{F(C)} = V(t) = 1 - \frac{6}{\pi^2} \sum_{n=1}^{\infty} \frac{1}{n^2} e^{-\kappa n^2 \pi^2 t/r^2} \tag{10}$$

Then, the average concentration in the soil particle becomes

$$S_{avg} = F(C_0)\, V(t) \qquad 0 < t < t_1$$

$$S_{avg} = F(C_0)\, V(t) + [F(C_1) - F(C_0)]\; V(t - t_1) \qquad t_1 < t < t_2$$

$$S_{avg} = F(C_0)\, V(t) + [F(C_1) - F(C_0)]\; V(t - t_1) + [F(C_2) - F(C_1)]\; V(t - t_2) \qquad t_2 < t < t_3$$

$$\vdots$$

$$S_{avg} = F(C_0)\, V(t) + [F(C_1) - F(C_0)]\; V(t - t_1) + [F(C_2) - F(C_1)]\, V\,(t - t_2) + \ldots + [F(C_n) - F(C_{n-1})]\; V\,(t - t_n) \qquad t > t_n \tag{11}$$

This can be written in the more condensed form as

$$S_{avg} = F(C_0)\, V(t) + \sum_{i=1}^{j} \left\{ F(C_i) - F(C_{i-1}) \right\} V(t - t_i) \qquad t_j < t < t_j + 1, \quad j = 1, 2, \ldots \tag{12}$$

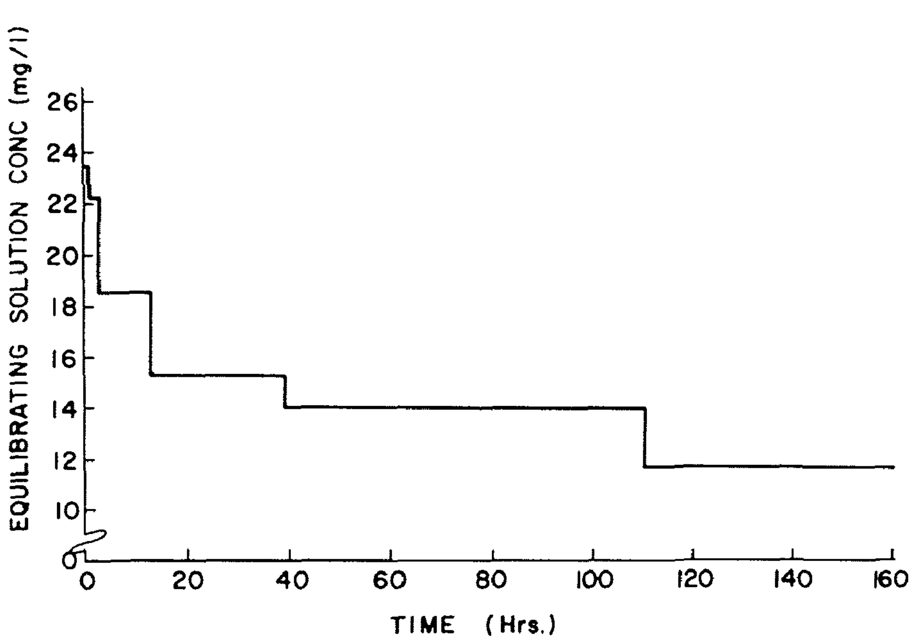

Figure 11. Typical time series step function used in describing the equilibrating solution concentration versus time for a solution to the diffusion model Equation (8).

Note, as mentioned earlier, F(C) is a function which relates the solution concentration to the equilibrium concentration which can be sorbed by the soil. Skopp and Warrick[60] assumed this to be a linear function or a constant times the solution concentration. This permitted obtaining an analytical solution to Equation (3) using Equation (8). Preliminary regression analyses were performed to this function using the data in Appendix D, but the correlation between predicted concentration and measured concentration was not good and the data is not presented in this report. However, when it was assumed the equilibrium relationship would follow either a Langmuir or Freundlich equation, reasonable correlations were obtained.

Regression coefficients for all the models are listed in Table 4, along with the physical/chemical properties of the soil. As mentioned earlier, several investigators[27, 28, 29] have developed regression equations which correlate the physical/chemical properties of the soil to sorption isotherms. This was done on soils from limited geographical areas, similar analyses were performed using our experimental data without developing satisfactory relationships and will not be presented.

To evaluate which model "best" fits the experimental data, it is necessary to develop a uniform evaluation procedure. Curve fitting was performed with some models in differential form and some in integral form. To compare the models, the differential models were integrated assuming that at the beginning of the sorption studies no phosphorus was on the soil (S = 0). Therefore, initially it would mathematically not be possible to desorb any phosphorus. Taking the concentration C as a constant with respect to time, Equation (5), the first order kinetic model, yields

$$S = \kappa C - \left[\frac{\kappa C}{e^{\alpha t}}\right] \tag{13}$$

where t is time and S approaches κC for large t.

Similarly, integrating Equation (6) yields

$$S = mC^n - \left[\frac{mC^n}{e^{\beta t}}\right] \tag{14}$$

The empirical model Equation (7) integrates yielding the equation

$$S = \left[C^b \ (1-d) \ a \ t\right]^{\frac{1}{1-d}} \tag{15}$$

but S is undefined for large t.

Using the regression coefficients listed in Table 4 and the sorption models in integral form, the projected amount of phosphorus that would be sorbed was calculated for the measurement times as listed in Appendix D. The equilibrating solution concentration was approximated using a step function with concentrations measured at the sampling time and given in Appendix D. The calculated, as well as the "measured," sorption is tabulated in Appendix E for all of the soils analyzed.

There are several ways that the data can be compared. One could look at the data linearly or with a logarithmic transformation. One could look at average correlation coefficients or one could compare the frequency a given model will "satisfactorily fit" the experimental data. Each of these approaches was considered and is presented here. In Table 5, linear correlation coefficients are presented without performing any transformations. In other words, a linear regression analysis was performed comparing measured

Table 5. CORRELATION COEFFICIENTS FOR SORPTION MODELS

Soil	Equation No.				
	(5)	(6)	(7)	(8-1)	(8-2)
A	0.67	0.79	0.87	0.67	0.85
B	0.74	0.93	0.93	0.86	0.91
C	0.64	0.90	0.92	0.84	0.94
D	0.69	0.55	0.95	0.75	0.90
E	0.94	0.81	0.90	0.94	0.87
F	0.86	0.87	0.93	0.94	0.83
G	0.35	0.44	0.43	0.80	0.81
H	0.94	0.80	0.69	0.51	0.85
I	0.87	0.91	0.96	0.91	0.97
L	0.85	0.91	0.66	0.95	0.80
M	0.72	0.87	0.92	0.89	0.87
N	0.80	0.83	0.88	0.88	0.89
O	0.91	0.72	0.59	0.94	0.85
P	0.86	0.85	0.78	0.97	0.92
Q	0.78	0.90	0.84	0.92	0.89
R	0.93	0.62	0.55	0.93	0.83
S	0.88	0.89	0.98	0.93	0.93
T	0.96	0.95	0.91	0.95	0.96
U	0.87	0.68	0.68	0.61	0.56
V	0.57	0.79	0.85	0.71	0.79
W	0.70	0.86	0.90	0.86	0.85
X	0.88	0.91	0.95	0.86	0.93
Y	0.94	0.95	0.97	0.98	0.97
Z	0.93	0.96	0.96	0.93	0.98
AA	0.94	0.95	0.97	0.97	0.98
Mean correlation coefficient	0.81	0.83	0.84	0.86	0.88

amount sorbed at some measurement time to the calculated amount sorbed using one of the sorption models. This analysis gives the slope and intercept of the regression curve as well as the correlation coefficient. The correlation coefficients were used to evaluate the suitability of a given model. In Table 5, the correlation coefficients are tabulated by equation number. The equation number refers to the equation as it was fitted to experimental sorption data. Equation (8-1) refers to the diffusion model Equation (8) where the Langmuir function, Equation (1), was substituted for F(C). Similarly in Equation (8-2), the Freundlich equation, Equation (2), was substituted for F(C). No one model was always most accurate in fitting the experimental data. Depending on the soil type, each of the models indicated an ability to yield satisfactory results. However, when comparing the mean correlation coefficients as listed in Table 5, it would appear that the diffusion model Equation (8), using a Freundlich isotherm equation, best fit the experimental data.

Table 6 is similar to Table 5 except the log of the measured sorption was correlated to the log of the calculated sorption. After performing this type of transformation on the data, there did not appear to be a significant difference between sorption models employing Equations (8-2), (8-1), and (7). This transformation, however, made Equation (6) appear less satisfactory. A graphical representation of the data in Tables 5 and 6 is presented in Figure 12. Figure 12 permits qualitatively comparing a level of accuracy by way of a regression coefficient, to the percentage of samples equal to or exceeding that accuracy.

These analyses do not prove statistically which of the models evaluated is best but do give the reader a qualitative approach to evaluating the suitability of a given model. From these studies, the authors have concluded the diffusion limited models, based on Equation (8), appear to be most generally applicable for describing the kinetics of phosphorus sorption by mineral soils.

Table 6. CORRELATION COEFFICIENTS FOR SORPTION MODELS WITH LOG TRANSFORMATIONS

Soil	Equation No. (5)	(6)	(7)	(8-1)	(8-2)
A	*	0.71	0.96	0.79	0.95
B	*	0.82	0.91	0.89	0.87
C	*	0.82	0.93	0.88	0.91
D	*	0.30	0.93	0.69	0.79
E	*	0.66	0.88	0.95	0.94
F	*	0.77	0.96	0.94	0.96
G	*	*	*	*	*
H	*	0.72	0.88	0.50	0.88
I	*	0.80	0.96	0.94	0.96
L	*	0.88	0.51	0.96	0.68
M	*	0.86	0.96	0.93	0.96
N	*	0.67	0.91	0.91	0.90
O	*	0.62	0.88	0.93	0.89
P	*	0.67	0.95	0.96	0.95
Q	*	0.80	0.94	0.96	0.94
R	*	0.51	0.81	0.88	0.86
S	*	0.75	0.96	0.95	0.94
T	*	0.71	0.95	0.97	0.95
U	*	0.56	0.75	0.72	0.72
V	*	0.85	0.96	0.93	0.94
W	*	0.84	0.97	0.93	0.96
X	*	0.89	0.97	0.93	0.96
Y	*	0.90	0.96	0.97	0.96
Z	*	0.92	0.95	0.97	0.95
AA	*	0.92	0.97	0.98	0.98
Mean correlation coefficient		0.75	0.91	0.89	0.91

*Not evaluated.

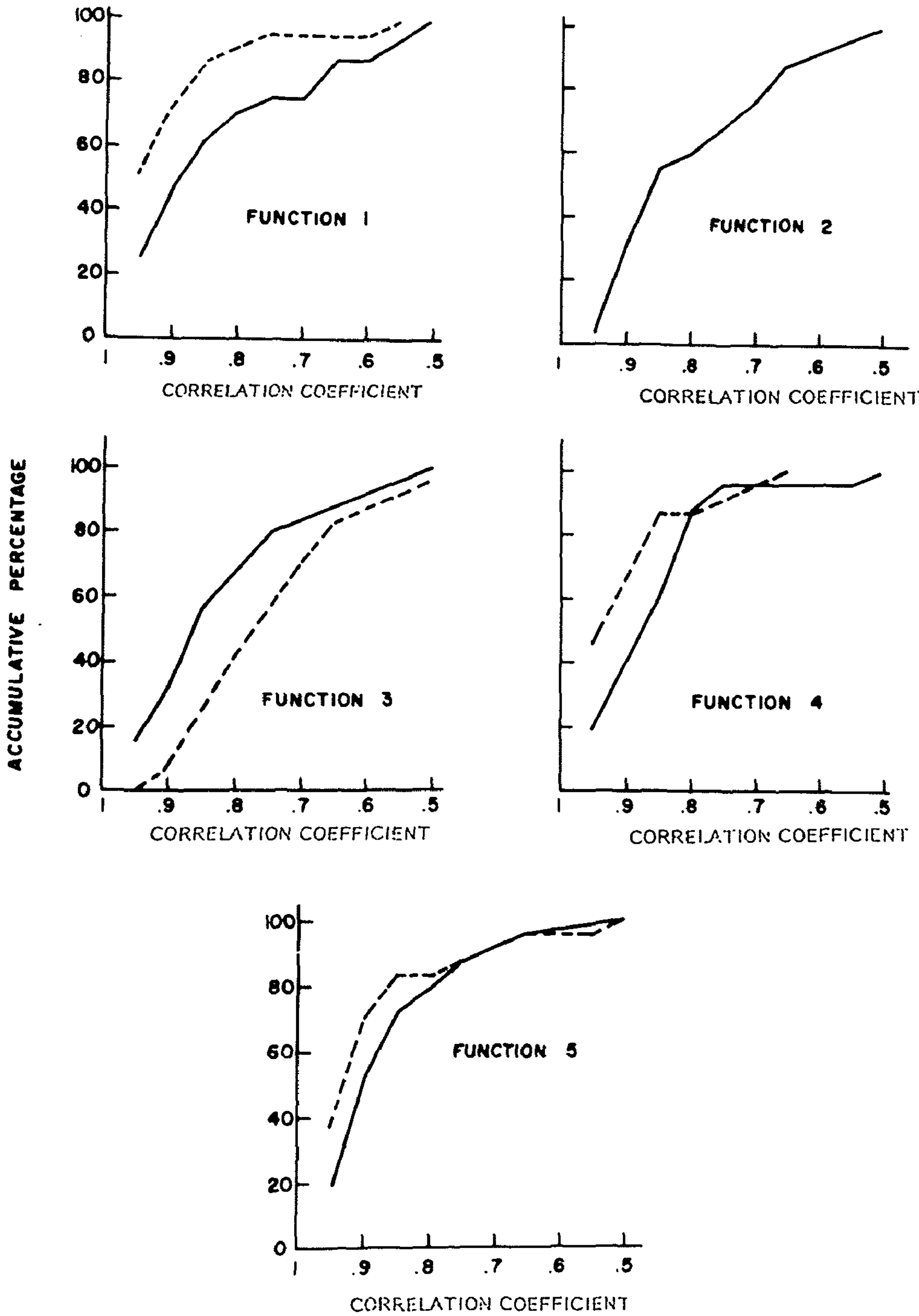

Figure 12. Correlation coefficient versus accumulative frequency for the five kinetic models. The log transformed data from Table 6 is represented by the dashed curve and linear presentation from Table 5 is represented by the solid curve. Function 1 is the kinetic model described by Equation (7). Function 2 is the kinetic model described by Equation (5). Function 3 is the kinetic model described by Equation (6). Function 4 is the kinetic model described by Equation (8-2). Function 5 is the kinetic model described by Equation (8-1).

SECTION VI

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SECTION VII

APPENDIXES

APPENDIX A

EXAMPLE CALCULATIONS FOR SOLUBILITY OF PHOSPHORUS COMPOUNDS

1. Solubility of $Al(OH)_2H_2PO_4(s)$ in the presence of excess $Al(OH)_3(s)$ and H_2O

	K_{sp}
$Al(OH)_2H_2PO_4(s) \rightleftarrows Al^{+3} + H_2PO_4^- + 2OH^-$	$10^{-30.5}$
$Al^{+3} + 3H_2O \rightleftarrows Al(OH)_3(s) + 3H^+$	$10^{-9.5}$
$Al(OH)_2H_2PO_4(s) + 3H_2O \rightleftarrows H_2PO_4^- + 2OH^- + 3H^+ + Al(OH)_3(s)$	10^{-40}
$2H^+ + 2OH^- \rightleftarrows 2H_2O$	10^{28}
$Al(OH)_2\,H_2PO_4(s) + H_2O \rightleftarrows H_2PO_4 + H^+ + Al(OH)_3(s)$	10^{-12}

Assuming the activities of $Al(OH)_2H_2PO_4(s)$, H_2O, and $Al(OH)_3(s)$ are equal to 1

$$[H_2PO_4^-]\ [H] = 10^{-12}$$

The occurrence of the different phosphate species is pH dependent. Thus, the total phosphorus in solution (P_T) is the sum of the different ionic species. Although only significant quantities of $H_2PO_4^-$ and HPO_4^{-2} will be found in soils, all species are included here for completeness.

$$P_T = [PO_4^{-3}] + [HPO_4^{-2}] + [H_2PO_4^-] + [H_3PO_4] \qquad (16)$$

$$P_T = \frac{[H_2PO_4^-]\ K_1 K_3}{[H^+]^2} + \frac{[H_2PO_4^-]\ K_2}{[H^+]} + [H_2PO_4^-] + \frac{[H_2PO_4^-][H^+]}{K_1} \qquad (17)$$

where K_1 is the ionization constant for $H_3PO_4 = 7.58 \times 10^{-3}$
K_2 is the ionization constant for $H_2PO_4^- = 5.93 \times 10^{-8}$
K_3 is the ionization constant for $HPO_4^{-2} = 3.43 \times 10^{-13}$

Thus, at pH 3

$P_T = 1.13 \times 10^{-9}$ M

2. Solubility of $Ca_5OH(PO_4)_3$ in the presence of 0.001 M Ca^{+2} ion in solution

$$Ca_5OH(PO_4)_3(s) \rightleftarrows 5Ca^{+2} + 3PO_4^{-3} + OH^- \qquad \frac{K_{sp}}{10^{-55.6}}$$

Assuming the activity of $Ca_5OH(PO_4)_3(s)$ is 1

$$[Ca^{+2}]^5\ [PO_4^{-3}]^3\ [OH] = 10^{-55.6}$$

$$P_T = [PO_4^{-3}] + \frac{[PO_4^{-3}][H]}{K_3} + \frac{[PO_4^{-3}][H^+]^2}{K_3K_2} + \frac{[PO_4^-][H^+]^3}{K_3K_2K_1} \qquad (18)$$

Thus, at pH 6

$P_T = 7.1 \times 10^{-4}$ M

3. System equilibrium of H_2O, $CaCO_3$, $Ca_5OH(PO_4)_3$ and $CO_2(g)$

This is a more complex system than those evaluated earlier. To simplify the system, consider first the $CaCO_3(s)$, H_2O, $CO_2(g)$ system to determine the $[Ca^{+2}]$ concentration which, in turn, permits determining the phosphorus in solution. In other words, the assumption is made that just $CaCO_3$ controls the solubility of Ca^{++}. Using the solubility data in Table 1 we obtain

$$P_{CO_2} + H_2O \rightleftarrows H_2CO_3 \qquad K = 3.4 \times 10^{-2}$$

$$[H_2CO_3] = K\, P_{CO_2} \tag{19}$$

$$H_2CO_3 \rightleftarrows H^+ + HCO_3^{-2} \qquad K_{1C} = 4 \times 10^{-7}$$

$$[HCO_3^-] = \frac{K\, P_{CO_2}\, K_{1C}}{[H^+]} \tag{20}$$

$$HCO_3^- \rightleftarrows H^+ + CO_3^{-2} \qquad K_{2C} = 5 \times 10^{-11}$$

$$[CO_3^{-2}] = \frac{K\, P_{CO_2}\, K_{1C}\, K_{2C}}{[H]^2} \tag{21}$$

$$CaCO_3 \rightleftarrows Ca^{+2} + CO_3^{-2} \qquad K_S = 5 \times 10^{-8}$$

$$[Ca^{+2}] = \frac{K_S\, [H]^2}{K\, P_{CO_2}\, K_{1C}\, K_{2C}} \tag{22}$$

For the system to be at equilibrium, electro-neutrality must also exist. Therefore,

$$2[Ca^{+2}] + [H^+] = 2[CO_3^{-2}] + [HCO_3^-] + [OH^-] \tag{23}$$

Substituting into Equation (23), one obtains

$$10^{-7}[H^+]^4 + 9.5 \times 10^{-19}\, P_{CO_2}\, [H^+]^3 = 9.2 \times 10^{-37}\, P_{CO_2}^2$$

$$+ 9.2 \times 10^{-27}\, P_{CO_2}^2 [H^+] + 6.8 \times 10^{-33}\, P_{CO_2} [H^+] \tag{24}$$

To solve Equation (24), a value for either the $CO_2(g)$ pressure or pH must be assumed. The partial pressure for $CO_2(g)$ in the atmosphere is approximately 0.0003 Atm. In soils, one would not expect to find the partial pressure of $CO_2(g)$ below what it is in the atmosphere. Solving for the pH based on a $CO_2(g)$ partial pressure of 0.0003 Atm, one finds the pH to be 8.7.

Knowing the pH and $CO_2(g)$ pressure, it is possible to calculate from Equation (22) the $[Ca^{++}]$ concentration as 9.76×10^{-4} M. This permits calculating $[PO_4^{-3}]$ as 1.79×10^{-12} M, which is used to calculate the total phosphorus from Equation (18) as 1.07×10^{-8} M.

4. System equilibrium of strengite $FePO_4 \cdot 2H_2O(s)$, FeOH(s) and H_2O.

From Table 1

$FePO_4 \cdot 2H_2O(s) \rightleftarrows Fe^{+3} + PO_4^{-3} + 2H_2O$ $\quad 9.9 \times 10^{-29}$

$Fe^{+3} + 3H_2O \rightleftarrows Fe(OH)_3(s) + 3H^+$ $\quad 1 \times 10^{-6}$

$FePO_4 \cdot 2H_2O(s) + H_2O \rightleftarrows PO_4^{-3} + 3H^+ + Fe(OH)_3(s)$ $\quad 10^{-34}$

Assuming the activity of the solid compounds and H_2O to be 1, then

$$[PO_4^{-3}] \simeq \frac{10^{-34}}{[H^+]^3}$$

Since the total phosphorus in solution is

$$P_T = PO_4^{-3} + HPO_4^{-2} + H_2PO_4^{-1} + H_3PO_4$$

P_T at pH 3 is equal to 5.65×10^{-12} M.

APPENDIX B

METHODOLOGIES OF SOIL ANALYSIS

Parameter	Reference No.	Page
Surface Area - Water Vapor Adsorption	76	
Particle Size Analysis	77	562-567
Cation Exchange Capacity	77	899-900
Percent Organic Matter	78	105-106
Total Phosphorus	79	175-176
Resin Extractable Phosphorus	38	482-483
Total Iron - Atomic Adsorption Determination	77	955-956
Exchangeable Aluminum - Atomic Adsorption Determination	77	967-968
Total Aluminum - Atomic Adsorption Determination	77	955-956
Exchangeable Aluminum - Atomic Adsorption Determination	77	986-987
Total Calcium - Atomic Adsorption Determination	77	955-956
Exchangeable Calcium - Atomic Adsorption Determination	77	894-895
Total Magnesium - Atomic Adsorption Determination	77	955-956
Exchangeable Magnesium - Atomic Adsorption Determination	77	894-895
Saturated pH	78	102
Electrical Conductivity	78	89-90

APPENDIX C

PROCEDURES FOR MEASURING PHOSPHORUS SORPTION ISOTHERMS

DESTRUCTIVE PROCEDURE FOR MEASURING PHOSPHORUS ISOTHERMS ON SOILS

Ten grams of air-dried soil were placed in a 250 milliliter flask containing 100 milliliters of a solution of 0.01M calcium chloride and a specified phosphorus concentration. Fourteen replicates were set up for each concentration. These were then placed on shaker tables in a constant temperature (20° C) room. Two of the flasks for each concentration were removed at specific time intervals for phosphorus analysis.[80]

The initial concentrations of phosphorus in the flasks were 1, 3, 10, 30, and 100 milligrams per liter. The time intervals for sampling and analyzing the different concentrations were 1, 3, 10, 30, 100, 300, and 1,000 hours.

NONDESTRUCTIVE PROCEDURE FOR MEASURING PHOSPHORUS ISOTHERMS ON SOILS

Ten grams of air-dried soil were placed in a 250 milliliter flask containing 100 milliliters of a solution of 0.01M calcium chloride and a specified phosphorus concentration. The flasks were then placed on shaker tables in a constant temperature (20° C) room. At specific intervals, 10 milliliters of soil suspension were withdrawn and placed in 15 milliliter centrifuge tubes and centrifuged for five minutes at 4.6×10^5 $cm\text{-}sec^{-2}$. Five milliliters of the supernate were withdrawn for phosphorus analysis.[80] This volume was replaced with five milliliters of the original solution concentration and the soil was hand shaken back into suspension and returned to the original flask for continuation of the isotherm.

The initial concentrations of phosphorus in the flasks were 1, 3, 10, 30, and 100 milligrams per liter. The time intervals for sampling and analyzing the different concentrations were 1, 3, 10, 30, 100, 300, 1,000, and 3,000 hours.

APPENDIX D

PHOSPHORUS SORPTION ISOTHERM DATA

This appendix is divided into two parts. Soils "A" through "U" were analyzed "nondestructively." They are included together with a computer program which was used to convert the raw experimental data into the data presented in the appendix. The data presented in this appendix was used as a basis for evaluating the kinetic models. It should be pointed out that some smoothing was used to calculate the rate of sorption from the experimental data. The remaining soils which were evaluated "destructively" are also included with their computer program which used the same smoothing technique to evaluate the rate of sorption. To clarify what is listed in the tabulated data, each table follows the following format:

Column 1 - Elapsed time from the initial application of equilibrating solution.

Column 2 - Initial concentration at the beginning of a time period. On the "destructively" sampled soils this is the concentration that was measured at the preceding time. On the "nondestructively" analyzed soils this concentration reflects the replacement of solution at a higher concentration.

Column 3 - The measured concentration at the time analyzed.

Column 4 - DC/DT is the rate of change in the solution concentration calculated from the previous columns of data.

Column 5 - DS/DT is the calculated rate of change of phosphorus sorbed by the soil.

Column 6 - Amount of phosphorus sorbed by the soil and was calculated based on the initial sample weight.

Column 7 - The sum of the resin extractable phosphorus and Column 6.

```
// JOB

LOG DRIVE   CART SPEC   CART AVAIL  PHY DRIVE
  0000        7209         7209        0000

V2 M11   ACTUAL 16K  CONFIG 16K

// FOR
*IOCS(DISK,1132 PRINTER,CARD,TYPEWRITER,KEYBOARD)
*EXTENDED PRECISION
*LIST SOURCE PROGRAM
*ONE WORD INTEGERS
C     PHOSPHORUS SORPTION ISOTHERM DATA CONVERSION ASSUMES 10 G SOIL SAMPLE
      DIMENSION CI(10,7),FC(10,7),DC(10,7), DS(10,7),SPAD(10,7),SPS(10,7
     *) ,T(10)
  100 FORMAT(I3)
      READ(2,100)N
C     N IS THE NUMBER OF SOIL SAMPLES
      DO 1000 ID=1,N
  110 FORMAT (A2)
      READ (2,110) SN
C     SN IS THE SOIL NAME
  120 FORMAT (2I5)
      READ (2,120) IN,JN
C     IN IS NO. OF TIMES& JN IS THE NO OF CONCENTRATIONS
  130 FORMAT (5F10.0)
      READ(2,130)(T(I),I=1,IN)
C     T IS THE TIMES MEASUREMENTS TAKEN
  140 FORMAT (10F7.3)
      READ (2,140)(CI(1,J),J=1,JN)
C     CI IS THE INITIAL CONCENTRATIONS
      DO 150 I=1,IN
  160 FORMAT (10F7.3)
      READ (2,160)(FC(I,J),J=1,JN)
C     FC ARE THE MEASURED CONCENTRATIONS
  150 CONTINUE
  170 FORMAT (F10.3)
      READ (2,170) REP
C     REP IS THE RESIN EXTRACTABLE PHOSPHORUS
      DO 1 I=2,IN
      DO 2 J=1,JN
    2 CI(I,J)=0.95*FC(I-1,J)+0.05*CI(1,J)
    1 CONTINUE
      DO 3 I=1,IN
      DO 4 J=1,JN
      PAD = (CI(I,J)-FC(I,J))/10.
      A=I
      IF (A-1)  8,8,9
    8 SPAD(I,J) = PAD*100.
      SPS(I,J) = SPAD(I,J)+REP
      GO TO 10
    9 SPAD (I,J) = SPAD(I-1,J)+(PAD*100.)
      SPS (I,J) = SPS (I-1,J)+(PAD*100.)
   10 CONTINUE
    4 CONTINUE
    3 CONTINUE
C     RATE CALCULATED ON + POINT MOVING
C     CURVE
      DO 50 J=1,JN
      I=1
      SUMX=ALOG(1.0E-10)+ALOG(T(1))
```

```
      SUMY=CI(I,J)+FC(I,J)
      A=T(I)
      B=FC(I,J)
      SUMXY=(-99.)*CI(I,J)+(B*ALOG(A))
      SUMXZ=ALOG(1.0E-10)**2.+(ALOG(T(I))**2.)
      DEMON=2.*SUMXZ-SUMX**2.
      RATE=(2.*SUMXY-SUMX*SUMY)/DEMON
      DC(I,J)=RATE/T(I)
      SUMY=SPAD(I,J)
      SUMXY=ALOG(T(I))*SPAD(I,J)
      RATE=((2.*SUMXY)-SUMX*SUMY)/DEMCN
      DS(I,J)=RATE/T(I)
      DO 49 I=2,IN
      SUMX=ALOG(T(I-1))+ALOG(T(I))
      SUMY=CI(I,J)+FC(I,J)
      SUMXY=(ALOG(T(I-1))*CI(I,J))+(ALOG(T(I)) *FC(I,J))
      SUMXZ=ALOG(T(I-1))**2.+(ALOG(T(I))**2.)
      DEMON=2.*SUMXZ-SUMX**2.
      RATE=((2.*SUMXY)-SUMX*SUMY)/DEMON
      DC(I,J)=RATE/T(I)
      SUMY=SPAD(I-1,J)+SPAD(I,J)
      SUMXY=ALOG(T(I-1))*SPAD(I-1,J)+(ALOG(T(I))*SPAD(I,J))
      RATE=((2.*SUMXY)-SUMX*SUMY)/DEMON
      DS(I,J)=RATE/T(I)
   49 CONTINUE
   50 CONTINUE
      WRITE (3,200) SN,REP
  200 FORMAT('1'/////14X'      PHOSPHORUS SORPTION ISOTHERM'//'
     *                  SOIL ',A2,///' RESIN EXTRACTABLE PHOSPHORUS O
     *N SOIL BEFORE SORPTION ',F5.1,' PPM'/'---------------------------
     *-----------------------------------'/)
  205 FORMAT(                                  '  TIME   INITIAL   FINAL
     *  DC        DS       SUM P      SUM P'/7X,'  CONC      CONC      DT
     *    DT      SORBED   ON SOIL'/'   HRS     MG/L      MG/L    PPM/HR
     * PPM/HR     PPM       PPM'/'----------------------------------------
     *------------------------ '/)
      WRITE(3,205)
      ICNT = 12
      DO 180 J=1,JN
  210 FORMAT(1X,F5.0,2F9.2,2E10.2,2F9.2)
      WRITE (3,210) (T(I),CI(I,J),FC(I,J),DC(I,J), DS(I,J),SPAD(I,J),SPS
     *(I,J),I=1,IN)
  220 FORMAT (/)
      WRITE(3,220)
      ICNT=ICNT+IN+2
      IDUM=54-IN
      IF(ICNT-IDUM)222,221,221
  223 FORMAT ('1'/////21X' SOIL ',A2,' CONTINUED'//)
  221 IF (J-JN)224,180,180
  224 WRITE(3,223) SN
      WRITE(3,205)
      ICNT = 5
      GO TO 180
  222 CONTINUE
  180 CONTINUE
 1000 CONTINUE
      CALL EXIT
      END

FEATURES SUPPORTED
 ONE WORD INTEGERS
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```
 EXTENDED PRECISION
 IOCS

CORE REQUIREMENTS FOR
 COMMON       0  VARIABLES   1344  PROGRAM   1222

END OF COMPILATION

// XEQ
```

PHOSPHORUS SORPTION ISOTHERM

SOIL A

RESIN EXTRACTABLE PHOSPHORUS ON SOIL BEFORE SORPTION 4.1 PPM

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	1.00	0.73	-0.29E 00	0.11E 00	2.69	6.79
3.	0.74	0.74	-0.13E-03	0.13E-02	2.69	6.79
10.	0.75	0.60	-0.12E-01	0.12E 00	4.20	8.30
30.	0.62	0.45	-0.51E-02	0.51E-01	5.90	10.00
100.	0.48	0.40	-0.68E-03	0.68E-02	6.73	10.83
300.	0.43	0.35	-0.24E-03	0.24E-02	7.53	11.63
387.	0.38	0.30	-0.76E-03	0.76E-02	8.28	12.38
1016.	0.34	0.33	-0.88E-05	0.88E-04	8.37	12.47
3001.	0.36	0.29	-0.21E-04	0.21E-03	9.05	13.15
1.	5.00	4.30	-0.14E 01	0.30E 00	6.98	11.08
3.	4.33	4.24	-0.28E-01	0.28E 00	7.92	12.02
10.	4.27	4.08	-0.16E-01	0.16E 00	9.86	13.96
30.	4.13	3.77	-0.10E-01	0.10E 00	13.43	17.53
100.	3.83	3.50	-0.27E-02	0.27E-01	16.79	20.89
300.	3.57	3.10	-0.14E-02	0.14E-01	21.54	25.64
387.	3.19	2.98	-0.21E-02	0.21E-01	23.65	27.75
1016.	3.08	2.96	-0.12E-03	0.12E-02	24.83	28.93
3001.	3.06	2.74	-0.10E-03	0.10E-02	28.11	32.21
1.	10.00	8.84	-0.29E 01	0.50E 00	11.56	15.66
3.	8.90	8.89	-0.29E-02	0.29E-01	11.65	15.75
10.	8.94	8.72	-0.18E-01	0.18E 00	13.89	17.99
30.	8.78	8.36	-0.12E-01	0.12E 00	18.13	22.23
100.	8.44	7.80	-0.53E-02	0.53E-01	24.58	28.68
300.	7.91	7.20	-0.21E-02	0.21E-01	31.68	35.78
387.	7.33	7.11	-0.22E-02	0.22E-01	33.94	38.04
1016.	7.25	7.10	-0.15E-03	0.15E-02	35.47	39.57
3001.	7.25	6.67	-0.17E-03	0.17E-02	41.25	45.35

SOIL A CONTINUED

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	40.00	37.51	-0.11E 02	0.10E 01	24.90	29.00
3.	37.63	35.23	-0.72E 00	0.72E 01	48.94	53.04
10.	35.46	37.63	0.17E 00	-0.17E 01	27.32	31.42
30.	37.74	36.19	-0.47E-01	0.47E 00	42.91	47.01
100.	36.38	34.00	-0.19E-01	0.19E 00	66.71	70.81
300.	34.30	33.00	-0.39E-02	0.39E-01	79.71	83.81
387.	33.35	32.13	-0.12E-01	0.12E 00	91.91	96.01
1016.	32.52	32.75	0.23E-03	-0.23E-02	89.65	93.75
3001.	33.11	30.77	-0.72E-03	0.72E-02	113.07	117.17
1.	100.00	81.26	-0.29E 02	0.81E 01	187.40	191.50
3.	82.19	94.44	0.37E 01	-0.37E 02	64.96	69.06
10.	94.71	95.64	0.76E-01	-0.76E 00	55.75	59.84
30.	95.85	95.64	-0.66E-02	0.66E-01	57.92	62.02
100.	95.85	90.00	-0.48E-01	0.48E 00	116.50	120.60
300.	90.50	88.50	-0.60E-02	0.60E-01	136.50	140.60
387.	89.07	86.96	-0.21E-01	0.21E 00	157.65	161.75
1016.	87.61	86.08	-0.15E-02	0.15E-01	172.97	177.07
3001.	86.77	83.26	-0.10E-02	0.10E-01	208.13	212.23

PHOSPHORUS SORPTION ISOTHERM

SOIL A

RESIN EXTRACTABLE PHOSPHORUS ON SOIL BEFORE SORPTION 4.1 PPM

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	0.50	0.49	-0.14E 00	0.43E-02	0.10	4.20
3.	0.49	0.43	-0.18E-01	0.18E 00	0.70	4.80
10.	0.43	0.34	-0.77E-02	0.77E-01	1.64	5.73
30.	0.34	0.29	-0.16E-02	0.16E-01	2.17	6.27
100.	0.30	0.20	-0.83E-03	0.83E-02	3.18	7.28
300.	0.21	0.17	-0.12E-03	0.12E-02	3.59	7.69
1007.	0.19	0.17	-0.13E-04	0.13E-03	3.75	7.85
3004.	0.19	0.08	-0.34E-04	0.34E-03	4.89	8.99
1.	1.00	0.88	-0.29E 00	0.52E-01	1.20	5.30
3.	0.88	0.77	-0.35E-01	0.35E 00	2.36	6.45
10.	0.78	0.65	-0.10E-01	0.10E 00	3.67	7.77
30.	0.66	0.52	-0.42E-02	0.42E-01	5.08	9.18
100.	0.54	0.38	-0.13E-02	0.13E-01	6.74	10.84
300.	0.41	0.34	-0.21E-03	0.21E-02	7.44	11.54
1007.	0.37	0.33	-0.36E-04	0.36E-03	7.89	11.99
3004.	0.36	0.20	-0.48E-04	0.48E-03	9.47	13.57
1.	3.00	2.59	-0.87E 00	0.17E 00	4.10	8.20
3.	2.61	2.35	-0.79E-01	0.79E 00	6.70	10.80
10.	2.38	2.08	-0.25E-01	0.25E 00	9.72	13.82
30.	2.12	999.99	0.30E 02	-0.30E 03	-9969.00	-9964.90
100.	950.14	999.99	0.41E 00	-0.41E 01	-10467.49	-10463.39
300.	950.14	999.99	0.15E 00	-0.15E 01	-10965.99	-10961.89
1007.	950.14	0.00	-0.77E 00	0.77E 01	-1464.50	-1460.40
3004.	0.15	0.00	-0.45E-04	0.45E-03	-1463.00	-1458.90
1.	7.00	6.25	-0.20E 01	0.32E 00	7.49	11.59
3.	6.28	5.88	-0.12E 00	0.12E 01	11.57	15.67
10.	5.93	5.50	-0.36E-01	0.36E 00	15.93	20.03
30.	5.57	5.32	-0.75E-02	0.75E-01	18.42	22.52
100.	5.40	5.18	-0.18E-02	0.18E-01	20.64	24.74
300.	5.27	4.47	-0.24E-02	0.24E-01	28.72	32.82
1007.	4.59	5.98	0.11E-02	-0.11E-01	14.83	18.93
3004.	6.03	4.13	-0.57E-03	0.57E-02	33.81	37.91
1.	15.00	13.50	-0.43E 01	0.65E 00	14.99	19.10
3.	13.57	13.20	-0.11E 00	0.11E 01	18.74	22.84
10.	13.29	13.00	-0.24E-01	0.24E 00	21.64	25.74
30.	13.10	13.04	-0.16E-02	0.16E-01	22.20	26.30
100.	13.14	13.20	0.51E-03	-0.51E-02	21.58	25.68
300.	13.29	11.72	-0.47E-02	0.47E-01	37.32	41.42
1007.	11.88	12.38	0.40E-03	-0.40E-02	32.36	36.46
3004.	12.51	11.18	-0.40E-03	0.40E-02	45.62	49.72

PHOSPHORUS SORPTION ISOTHERM

SOIL B

RESIN EXTRACTABLE PHOSPHORUS ON SOIL BEFORE SORPTION 0.6 PPM

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	1.00	0.11	-0.32E 00	0.38E 00	8.84	9.52
3.	0.16	0.16	0.20E-02	-0.20E-01	8.77	9.45
10.	0.20	0.10	-0.86E-02	0.86E-01	9.81	10.49
30.	0.14	0.07	-0.21E-02	0.21E-01	10.51	11.19
102.	0.12	0.08	-0.33E-03	0.33E-02	10.93	11.61
300.	0.12	0.08	-0.12E-03	0.12E-02	11.35	12.03
387.	0.13	0.09	-0.42E-03	0.42E-02	11.77	12.45
1000.	0.13	0.16	0.30E-04	-0.30E-03	11.48	12.16
3010.	0.20	0.00	-0.62E-04	0.62E-03	13.55	14.23
1.	5.00	1.56	-0.15E 01	0.14E 01	34.31	34.99
3.	1.74	0.40	-0.40E 00	0.40E 01	47.66	48.34
10.	0.63	0.26	-0.30E-01	0.30E 00	51.34	52.02
30.	0.50	0.17	-0.98E-02	0.98E-01	54.58	55.26
102.	0.42	0.14	-0.22E-02	0.22E-01	57.38	58.06
300.	0.38	0.12	-0.81E-03	0.81E-02	60.01	60.69
387.	0.36	0.11	-0.25E-02	0.25E-01	62.49	63.17
1000.	0.36	0.17	-0.19E-03	0.19E-02	64.32	65.00
3010.	0.41	0.09	-0.98E-04	0.98E-03	67.59	68.27
1.	10.00	5.03	-0.30E 01	0.21E 01	49.68	50.36
3.	5.28	2.94	-0.70E 00	0.70E 01	73.02	73.70
10.	3.29	0.91	-0.19E 00	0.19E 01	96.91	97.59
30.	1.36	0.53	-0.25E-01	0.25E 00	105.21	105.89
102.	1.00	0.37	-0.51E-02	0.51E-01	111.58	112.26
300.	0.85	0.27	-0.17E-02	0.17E-01	117.40	118.08
387.	0.75	0.25	-0.50E-02	0.50E-01	122.38	123.06
1000.	0.74	0.25	-0.51E-03	0.51E-02	127.28	127.96
3010.	0.74	0.16	-0.17E-03	0.17E-02	133.02	133.70

SOIL B CONTINUED

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	40.00	27.32	-0.12E 02	0.55E 01	126.80	127.48
3.	27.95	20.24	-0.23E 01	0.23E 02	203.94	204.62
10.	21.22	13.50	-0.64E 00	0.64E 01	281.22	281.89
30.	14.82	11.01	-0.11E 00	0.11E 01	319.36	320.04
102.	12.45	7.00	-0.43E-01	0.43E 00	373.96	374.64
300.	8.65	5.50	-0.97E-02	0.97E-01	405.46	406.14
387.	7.22	5.11	-0.21E-01	0.21E 00	426.61	427.29
1000.	6.85	4.36	-0.26E-02	0.26E-01	451.55	452.23
3010.	6.14	3.11	-0.91E-03	0.91E-02	481.87	482.55
1.	100.00	94.92	-0.28E 02	0.22E 01	50.80	51.48
3.	95.17	68.06	-0.82E 01	0.82E 02	321.94	322.61
10.	69.65	54.16	-0.12E 01	0.12E 02	476.90	477.58
30.	56.45	48.40	-0.24E 00	0.24E 01	557.43	558.10
102.	50.98	44.00	-0.55E-01	0.55E 00	627.22	627.90
300.	46.80	40.00	-0.21E-01	0.21E 00	695.22	695.90
387.	43.00	35.20	-0.79E-01	0.79E 00	773.22	773.90
1000.	38.44	32.10	-0.66E-02	0.66E-01	836.62	837.30
3010.	35.49	27.28	-0.24E-02	0.24E-01	918.77	919.45

PHOSPHORUS SORPTION ISOTHERM

SOIL C

RESIN EXTRACTABLE PHOSPHORUS ON SOIL BEFORE SORPTION 6.5 PPM

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	1.00	0.16	-0.32E 00	0.36E 00	8.33	14.83
3.	0.20	0.19	-0.50E-02	0.50E-01	8.49	14.99
10.	0.23	0.00	-0.19E-01	0.19E 00	10.82	17.32
30.	0.05	0.16	0.35E-02	-0.35E-01	9.65	16.15
100.	0.20	0.14	-0.57E-03	0.57E-02	10.33	16.83
300.	0.18	0.12	-0.19E-03	0.19E-02	10.96	17.46
410.	0.16	0.11	-0.37E-03	0.37E-02	11.44	17.94
1015.	0.16	0.15	-0.78E-05	0.78E-04	11.51	18.01
3025.	0.19	0.00	-0.59E-04	0.59E-03	13.47	19.97
1.	5.00	1.72	-0.15E 01	0.14E 01	32.76	39.26
3.	1.88	0.66	-0.36E 00	0.36E 01	44.94	51.44
10.	0.88	0.30	-0.48E-01	0.48E 00	50.75	57.25
30.	0.53	0.33	-0.63E-02	0.63E-01	52.85	59.35
100.	0.56	0.17	-0.32E-02	0.32E-01	56.78	63.28
300.	0.41	0.14	-0.82E-03	0.82E-02	59.50	66.00
410.	0.38	0.12	-0.19E-02	0.19E-01	62.04	68.54
1015.	0.37	0.16	-0.22E-03	0.22E-02	64.07	70.57
3025.	0.41	0.11	-0.88E-04	0.88E-03	67.01	73.51
1.	10.00	2.55	-0.31E 01	0.32E 01	74.50	81.00
3.	2.92	2.47	-0.13E 00	0.13E 01	79.02	85.52
10.	2.84	1.16	-0.14E 00	0.14E 01	95.89	102.39
30.	1.60	0.66	-0.28E-01	0.28E 00	105.30	111.80
100.	1.12	0.46	-0.55E-02	0.55E-01	111.97	118.47
300.	0.93	0.38	-0.16E-02	0.16E-01	117.54	124.04
410.	0.86	0.36	-0.39E-02	0.39E-01	122.55	129.05
1015.	0.84	0.35	-0.52E-03	0.52E-02	127.39	133.89
3025.	0.84	0.28	-0.16E-03	0.16E-02	132.94	139.44

SOIL C CONTINUED

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	40.00	23.00	-0.12E 02	0.73E 01	170.00	176.50
3.	23.85	18.60	-0.15E 01	0.15E 02	222.50	229.00
10.	19.67	14.60	-0.42E 00	0.42E 01	273.20	279.70
30.	15.87	12.70	-0.96E-01	0.96E 00	304.89	311.39
100.	14.06	10.50	-0.29E-01	0.29E 00	340.54	347.04
300.	11.97	8.30	-0.11E-01	0.11E 00	377.29	383.79
410.	9.88	8.04	-0.14E-01	0.14E 00	395.74	402.24
1015.	9.63	7.89	-0.18E-02	0.18E-01	413.22	419.72
3025.	9.49	6.79	-0.81E-03	0.81E-02	440.28	446.78
1.	100.00	69.00	-0.30E 02	0.13E 02	310.00	316.50
3.	70.55	61.80	-0.26E 01	0.26E 02	397.50	404.00
10.	63.71	58.00	-0.47E 00	0.47E 01	454.60	461.10
30.	60.10	54.20	-0.17E 00	0.17E 01	513.59	520.09
100.	56.49	51.50	-0.41E-01	0.41E 00	563.49	569.99
300.	53.92	49.00	-0.14E-01	0.14E 00	612.74	619.24
410.	51.55	43.90	-0.59E-01	0.59E 00	689.24	695.74
1015.	46.70	43.70	-0.32E-02	0.32E-01	719.29	725.79
3025.	46.51	40.60	-0.17E-02	0.17E-01	778.44	784.94

PHOSPHORUS SORPTION ISOTHERM

SOIL D

RESIN EXTRACTABLE PHOSPHORUS ON SOIL BEFORE SORPTION 2.8 PPM

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	1.00	0.05	-0.32E 00	0.41E 00	9.46	12.26
3.	0.10	0.00	-0.30E-01	0.30E 00	10.47	13.27
10.	0.05	0.00	-0.41E-02	0.41E-01	10.97	13.77
30.	0.05	0.14	0.27E-02	-0.27E-01	10.06	12.86
100.	0.18	0.10	-0.69E-03	0.69E-02	10.90	13.70
317.	0.14	0.10	-0.12E-03	0.12E-02	11.35	14.15
410.	0.14	0.07	-0.63E-03	0.63E-02	12.02	14.82
1015.	0.12	0.15	0.31E-04	-0.31E-03	11.73	14.53
3025.	0.19	0.00	-0.59E-04	0.59E-03	13.68	16.48
1.	5.00	1.49	-0.15E 01	0.15E 01	35.03	37.83
3.	1.67	0.56	-0.33E 00	0.33E 01	46.07	48.87
10.	0.78	0.27	-0.42E-01	0.42E 00	51.17	53.97
30.	0.51	0.26	-0.75E-02	0.75E-01	53.65	56.45
100.	0.50	0.17	-0.27E-02	0.27E-01	56.99	59.79
317.	0.41	0.14	-0.72E-03	0.72E-02	59.65	62.45
410.	0.38	0.14	-0.23E-02	0.23E-01	62.11	64.91
1015.	0.38	0.20	-0.19E-03	0.19E-02	63.94	66.74
3025.	0.44	0.09	-0.10E-03	0.10E-02	67.44	70.24
1.	10.00	4.45	-0.31E 01	0.24E 01	55.44	58.24
3.	4.73	2.17	-0.77E 00	0.77E 01	80.99	83.79
10.	2.50	1.03	-0.12E 00	0.12E 01	96.32	99.12
30.	1.48	0.81	-0.20E-01	0.20E 00	103.06	105.86
100.	1.26	0.55	-0.59E-02	0.59E-01	110.25	113.06
317.	1.02	0.40	-0.17E-02	0.17E-01	116.48	119.28
410.	0.88	0.36	-0.49E-02	0.49E-01	121.68	124.48
1015.	0.84	0.38	-0.49E-03	0.49E-02	126.26	129.06
3025.	0.86	0.29	-0.17E-03	0.17E-02	131.93	134.73

SOIL D CONTINUED

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	40.00	24.08	-0.12E 02	0.69E 01	159.20	162.00
3.	24.87	20.36	-0.13E 01	0.13E 02	204.36	207.16
10.	21.34	16.52	-0.40E 00	0.40E 01	252.58	255.37
30.	17.69	13.53	-0.12E 00	0.12E 01	294.22	297.02
100.	14.85	10.80	-0.33E-01	0.33E 00	334.75	337.55
317.	12.26	8.50	-0.10E-01	0.10E 00	372.35	375.15
410.	10.07	8.17	-0.18E-01	0.18E 00	391.40	394.20
1015.	9.76	7.70	-0.22E-02	0.22E-01	412.01	414.81
3025.	9.31	6.01	-0.99E-03	0.99E-02	445.01	447.81
1.	100.00	77.66	-0.29E 02	0.97E 01	223.40	226.20
3.	78.77	66.14	-0.38E 01	0.38E 02	349.77	352.57
10.	67.83	60.86	-0.57E 00	0.57E 01	419.50	422.29
30.	62.81	56.54	-0.19E 00	0.19E 01	482.26	485.06
100.	58.71	51.00	-0.64E-01	0.64E 00	559.39	562.19
317.	53.45	47.00	-0.17E-01	0.17E 00	623.89	626.69
410.	49.65	42.60	-0.66E-01	0.66E 00	694.39	697.19
1015.	45.46	42.38	-0.33E-02	0.33E-01	725.29	728.09
3025.	45.26	35.04	-0.30E-02	0.30E-01	827.50	830.30

PHOSPHORUS SORPTION ISOTHERM

SOIL E

RESIN EXTRACTABLE PHOSPHORUS ON SOIL BEFORE SORPTION 9.6 PPM

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	1.00	0.39	-0.31E 00	0.26E 00	6.07	15.67
3.	0.42	0.24	-0.55E-01	0.55E 00	7.88	17.48
10.	0.27	0.19	-0.73E-02	0.73E-01	8.77	18.37
30.	0.23	0.15	-0.24E-02	0.24E-01	9.58	19.18
100.	0.19	0.12	-0.60E-03	0.60E-02	10.31	19.91
295.	0.16	0.09	-0.21E-03	0.21E-02	11.00	20.60
363.	0.14	0.09	-0.65E-03	0.65E-02	11.49	21.09
1014.	0.13	0.19	0.52E-04	-0.52E-03	10.94	20.54
3000.	0.23	0.03	-0.61E-04	0.61E-03	12.95	22.55
1.	5.00	2.94	-0.15E 01	0.89E 00	20.53	30.13
3.	3.04	2.63	-0.12E 00	0.12E 01	24.66	34.26
10.	2.75	1.74	-0.83E-01	0.83E 00	34.72	44.32
30.	1.91	1.35	-0.17E-01	0.17E 00	40.33	49.93
100.	1.53	1.00	-0.44E-02	0.44E-01	45.65	55.25
295.	1.20	0.80	-0.12E-02	0.12E-01	49.65	59.25
363.	1.01	0.75	-0.34E-02	0.34E-01	52.22	61.82
1014.	0.96	0.80	-0.15E-03	0.15E-02	53.79	63.39
3000.	1.01	0.48	-0.16E-03	0.16E-02	59.09	68.69
1.	10.00	6.42	-0.30E 01	0.15E 01	35.76	45.38
3.	6.60	5.36	-0.37E 00	0.37E 01	48.10	57.70
10.	5.59	4.19	-0.11E 00	0.11E 01	62.18	71.78
30.	4.48	3.50	-0.29E-01	0.29E 00	72.00	81.60
100.	3.82	2.50	-0.11E-01	0.11E 00	85.25	94.85
295.	2.87	1.00	-0.58E-02	0.58E-01	104.00	113.60
363.	1.45	0.20	-0.16E-01	0.16E 00	116.44	126.04
1014.	0.69	1.00	0.29E-03	-0.29E-02	113.39	122.99
3000.	1.45	0.49	-0.29E-03	0.29E-02	122.94	132.54

SOIL E CONTINUED

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	40.00	31.39	-0.11E 02	0.37E 01	86.10	95.70
3.	31.82	29.95	-0.56E 00	0.56E 01	104.80	114.40
10.	30.45	25.52	-0.40E 00	0.40E 01	154.12	163.72
30.	26.24	18.00	-0.25E 00	0.25E 01	236.56	246.16
100.	19.10	7.00	-0.10E 00	0.10E 01	357.56	367.16
295.	8.65	2.60	-0.18E-01	0.18E 00	418.06	427.66
363.	4.47	1.08	-0.44E-01	0.44E 00	451.91	461.51
1014.	3.03	0.39	-0.25E-02	0.25E-01	478.25	487.85
3000.	2.37	0.14	-0.68E-03	0.68E-02	500.55	510.15
1.	100.00	84.84	-0.29E 02	0.65E 01	151.60	161.20
3.	85.59	82.44	-0.95E 00	0.95E 01	183.17	192.77
10.	83.31	72.86	-0.86E 00	0.86E 01	287.75	297.35
30.	74.21	52.00	-0.67E 00	0.67E 01	509.92	519.52
100.	54.40	23.00	-0.26E 00	0.26E 01	823.92	833.52
295.	26.85	5.00	-0.68E-01	0.68E 00	1042.42	1052.02
363.	9.75	1.02	-0.11E 00	0.11E 01	1129.70	1139.30
1014.	5.97	0.28	-0.54E-02	0.54E-01	1186.53	1196.13
3000.	5.27	0.70	-0.14E-02	0.14E-01	1232.21	1241.81

PHOSPHORUS SORPTION ISOTHERM

SOIL F

RESIN EXTRACTABLE PHOSPHORUS ON SOIL BEFORE SORPTION 7.8 PPM

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	1.00	0.27	-0.31E 00	0.31E 00	7.21	15.01
3.	0.31	0.21	-0.29E-01	0.29E 00	8.19	15.99
10.	0.25	0.14	-0.95E-02	0.95E-01	9.34	17.14
30.	0.18	0.13	-0.16E-02	0.16E-01	9.88	17.68
100.	0.17	0.09	-0.65E-03	0.65E-02	10.66	18.46
295.	0.14	0.08	-0.18E-03	0.18E-02	11.26	19.06
363.	0.12	0.07	-0.63E-03	0.63E-02	11.74	19.54
1014.	0.12	0.16	0.39E-04	-0.39E-03	11.33	19.13
3000.	0.20	0.02	-0.57E-04	0.57E-03	13.19	20.99
1.	5.00	3.50	-0.14E 01	0.65E 00	14.99	22.79
3.	3.57	1.49	-0.63E 00	0.63E 01	35.78	43.58
10.	1.67	0.65	-0.84E-01	0.84E 00	45.94	53.74
30.	0.87	0.45	-0.12E-01	0.12E 00	50.17	57.97
100.	0.67	0.37	-0.25E-02	0.25E-01	53.24	61.04
295.	0.60	0.25	-0.11E-02	0.11E-01	56.76	64.56
363.	0.48	0.23	-0.34E-02	0.34E-01	59.32	67.12
1014.	0.46	0.30	-0.15E-03	0.15E-02	60.95	68.75
3000.	0.54	0.11	-0.13E-03	0.13E-02	65.22	73.02
1.	10.00	7.00	-0.29E 01	0.13E 01	29.99	37.79
3.	7.15	4.79	-0.71E 00	0.71E 01	53.57	61.37
10.	5.05	3.01	-0.16E 00	0.16E 01	74.00	81.80
30.	3.35	2.30	-0.32E-01	0.32E 00	84.59	92.39
100.	2.68	1.70	-0.81E-02	0.81E-01	94.44	102.24
295.	2.11	1.10	-0.31E-02	0.31E-01	104.59	112.39
363.	1.54	0.94	-0.79E-02	0.79E-01	110.58	118.38
1014.	1.39	0.87	-0.50E-03	0.50E-02	115.85	123.65
3000.	1.32	0.65	-0.20E-03	0.20E-02	122.62	130.42

SOIL F CONTINUED

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	40.00	29.47	-0.11E 02	0.45E 01	105.30	113.09
3.	29.99	25.76	-0.12E 01	0.12E 02	147.66	155.46
10.	26.47	22.64	-0.31E 00	0.31E 01	185.98	193.78
30.	23.50	19.00	-0.13E 00	0.13E 01	231.06	238.86
100.	20.05	15.00	-0.41E-01	0.41E 00	281.56	289.36
295.	16.25	12.50	-0.11E-01	0.11E 00	319.06	326.86
363.	13.87	9.83	-0.53E-01	0.53E 00	359.51	367.31
1014.	11.33	3.91	-0.71E-02	0.71E-01	433.79	441.59
3000.	5.71	1.49	-0.12E-02	0.12E-01	476.04	483.84
1.	100.00	82.44	-0.29E 02	0.76E 01	175.60	183.40
3.	83.31	77.60	-0.17E 01	0.17E 02	232.78	240.58
10.	78.72	71.66	-0.58E 00	0.58E 01	303.38	311.18
30.	73.07	60.00	-0.39E 00	0.39E 01	434.14	441.94
100.	62.00	50.00	-0.99E-01	0.99E 00	554.14	561.94
295.	52.50	40.00	-0.39E-01	0.39E 00	679.14	686.94
363.	43.00	35.46	-0.10E 00	0.10E 01	754.54	762.34
1014.	38.68	15.28	-0.22E-01	0.22E 00	988.61	996.41
3000.	19.51	4.59	-0.45E-02	0.45E-01	1137.82	1145.62

PHOSPHORUS SORPTION ISOTHERM

SOIL G

RESIN EXTRACTABLE PHOSPHORUS ON SOIL BEFORE SORPTION 0.9 PPM

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	0.50	0.55	-0.14E 00	-0.21E-01	-0.49	0.44
3.	0.54	0.53	-0.53E-02	0.53E-01	-0.32	0.61
10.	0.52	0.53	0.12E-03	-0.12E-02	-0.34	0.59
30.	0.52	0.53	0.45E-04	-0.45E-03	-0.35	0.58
100.	0.52	0.47	-0.48E-03	0.48E-02	0.22	1.16
300.	0.47	0.46	-0.34E-04	0.34E-03	0.34	1.28
1007.	0.46	0.45	-0.98E-05	0.98E-04	0.46	1.40
3004.	0.45	0.32	-0.40E-04	0.40E-03	1.78	2.72
1.	1.00	0.98	-0.28E 00	0.86E-02	0.20	1.14
3.	0.98	0.89	-0.27E-01	0.27E 00	1.11	2.05
10.	0.89	0.95	0.45E-02	-0.45E-01	0.56	1.50
30.	0.95	0.98	0.83E-03	-0.83E-02	0.28	1.22
100.	0.98	0.94	-0.34E-03	0.34E-02	0.69	1.63
300.	0.94	0.86	-0.25E-03	0.25E-02	1.52	2.46
1007.	0.86	0.89	0.18E-04	-0.18E-03	1.29	2.23
3004.	0.89	0.73	-0.49E-04	0.49E-03	2.91	3.85
1.	3.00	2.88	-0.86E 00	0.52E-01	1.20	2.14
3.	2.88	2.83	-0.16E-01	0.16E 00	1.75	2.69
10.	2.83	2.83	-0.70E-03	0.70E-02	1.84	2.78
30.	2.83	2.83	-0.25E-03	0.25E-02	1.92	2.86
100.	2.83	2.94	0.84E-03	-0.84E-02	0.91	1.85
300.	2.94	2.76	-0.55E-03	0.55E-02	2.74	3.68
1007.	2.77	2.92	0.12E-03	-0.12E-02	1.26	2.20
3004.	2.92	2.82	-0.31E-04	0.31E-03	2.30	3.24
1.	7.00	6.88	-0.20E 01	0.52E-01	1.20	2.14
3.	6.88	6.60	-0.86E-01	0.86E 00	4.06	4.99
10.	6.61	6.64	0.16E-02	-0.16E-01	3.85	4.79
30.	6.65	6.67	0.36E-03	-0.36E-02	3.73	4.67
100.	6.68	6.86	0.14E-02	-0.14E-01	2.00	2.94
300.	6.86	6.50	-0.11E-02	0.11E-01	5.67	6.61
1007.	6.52	6.86	0.27E-03	-0.27E-02	2.32	3.26
3004.	6.86	6.49	-0.11E-03	0.11E-02	6.09	7.03
1.	15.00	14.80	-0.43E 01	0.86E-01	2.00	2.94
3.	14.81	14.64	-0.51E-01	0.51E 00	3.70	4.64
10.	14.65	14.32	-0.28E-01	0.28E 00	7.08	8.02
30.	14.35	14.41	0.16E-02	-0.16E-01	6.51	7.45
100.	14.43	14.46	0.17E-03	-0.17E-02	6.31	7.25
300.	14.48	13.72	-0.23E-02	0.23E-01	13.98	14.92
1007.	13.78	14.92	0.93E-03	-0.93E-02	2.62	3.56
3004.	14.92	14.54	-0.11E-03	0.11E-02	6.46	7.40

PHOSPHORUS SORPTION ISOTHERM

SOIL H

RESIN EXTRACTABLE PHOSPHORUS ON SOIL BEFORE SORPTION 18.0 PPM

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	1.00	0.58	-0.30E 00	0.18E 00	4.17	22.17
4.	0.60	0.33	-0.48E-01	0.48E 00	6.83	24.83
10.	0.37	0.32	-0.54E-02	0.54E-01	7.33	25.34
30.	0.35	0.25	-0.31E-02	0.31E-01	8.37	26.37
100.	0.28	0.30	0.10E-03	-0.10E-02	8.25	26.25
304.	0.33	0.24	-0.26E-03	0.26E-02	9.13	27.13
1007.	0.28	0.20	-0.63E-04	0.63E-03	9.90	27.90
3000.	0.24	0.29	0.15E-04	-0.15E-03	9.40	27.40
1.	5.00	3.12	-0.15E 01	0.81E 00	18.80	36.80
4.	3.21	2.48	-0.13E 00	0.13E 01	26.14	44.14
10.	2.60	2.11	-0.54E-01	0.54E 00	31.10	49.09
30.	2.25	1.46	-0.24E-01	0.24E 00	39.04	57.04
100.	1.63	1.80	0.13E-02	-0.13E-01	37.41	55.41
304.	1.95	1.28	-0.20E-02	0.20E-01	44.20	62.20
1007.	1.46	0.77	-0.57E-03	0.57E-02	51.10	69.10
3000.	0.98	0.16	-0.25E-03	0.25E-02	59.30	77.30
1.	10.00	7.40	-0.29E 01	0.11E 01	26.00	44.00
4.	7.53	5.96	-0.28E 00	0.28E 01	41.70	59.70
10.	6.16	5.47	-0.75E-01	0.75E 00	48.61	66.62
30.	5.69	3.80	-0.57E-01	0.57E 00	67.58	85.58
100.	4.10	4.80	0.57E-02	-0.57E-01	60.68	78.68
304.	5.06	2.90	-0.63E-02	0.63E-01	82.28	100.28
1007.	3.25	1.04	-0.18E-02	0.18E-01	104.43	122.43
3000.	1.48	0.53	-0.29E-03	0.29E-02	114.01	132.01
1.	40.00	37.50	-0.11E 02	0.10E 01	25.00	43.00
4.	37.62	32.33	-0.95E 00	0.95E 01	77.95	95.95
10.	32.71	27.80	-0.53E 00	0.53E 01	127.08	145.08
30.	28.41	16.56	-0.35E 00	0.35E 01	245.58	263.58
100.	17.73	2.86	-0.12E 00	0.12E 01	394.30	412.30
304.	4.71	0.84	-0.11E-01	0.11E 00	433.07	451.07
1007.	2.79	0.36	-0.20E-02	0.20E-01	457.42	475.42
3000.	2.34	0.42	-0.58E-03	0.58E-02	476.60	494.60
1.	100.00	89.85	-0.29E 02	0.44E 01	101.50	119.50
4.	90.35	86.30	-0.73E 00	0.73E 01	142.07	160.07
10.	86.98	66.50	-0.22E 01	0.22E 02	346.92	364.92
30.	68.17	49.15	-0.57E 00	0.57E 01	537.17	555.17
100.	51.69	10.05	-0.34E 00	0.34E 01	953.59	971.59
304.	14.54	1.04	-0.39E-01	0.39E 00	1088.67	1106.67
1007.	5.98	0.40	-0.46E-02	0.46E-01	1144.53	1162.53
3000.	5.38	0.20	-0.15E-02	0.15E-01	1196.34	1214.34

PHOSPHORUS SORPTION ISOTHERM

SOIL I

RESIN EXTRACTABLE PHOSPHORUS ON SOIL BEFORE SORPTION 6.7 PPM

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	1.00	0.11	-0.32E 00	0.38E 00	8.83	15.53
4.	0.16	0.00	-0.29E-01	0.29E 00	10.44	17.14
10.	0.05	0.10	0.54E-02	-0.54E-01	9.94	16.64
30.	0.14	0.00	-0.43E-02	0.43E-01	11.39	18.09
100.	0.05	0.11	0.49E-03	-0.49E-02	10.79	17.49
304.	0.15	0.11	-0.11E-03	0.11E-02	11.16	17.86
1007.	0.16	0.16	0.65E-05	-0.65E-04	11.08	17.78
3000.	0.21	0.05	-0.46E-04	0.46E-03	12.61	19.31
1.	5.00	1.89	-0.15E 01	0.13E 01	31.10	37.80
4.	2.04	1.31	-0.13E 00	0.13E 01	38.45	45.15
10.	1.49	0.87	-0.68E-01	0.68E 00	44.70	51.40
30.	1.07	0.61	-0.14E-01	0.14E 00	49.36	56.06
100.	0.82	0.27	-0.46E-02	0.46E-01	54.96	61.66
304.	0.50	0.23	-0.80E-03	0.80E-02	57.68	64.38
1007.	0.47	0.38	-0.69E-04	0.69E-03	58.51	65.21
3000.	0.61	0.13	-0.14E-03	0.14E-02	63.35	70.05
1.	10.00	3.98	-0.31E 01	0.26E 01	60.20	66.90
4.	4.28	2.87	-0.25E 00	0.25E 01	74.31	81.00
10.	3.22	2.03	-0.13E 00	0.13E 01	86.27	92.97
30.	2.42	1.46	-0.29E-01	0.29E 00	95.95	102.65
100.	1.88	0.79	-0.91E-02	0.91E-01	106.92	113.62
304.	1.25	0.67	-0.17E-02	0.17E-01	112.73	119.43
1007.	1.13	0.54	-0.49E-03	0.49E-02	118.69	125.39
3000.	1.01	0.47	-0.16E-03	0.16E-02	124.10	130.80
1.	40.00	25.22	-0.12E 02	0.64E 01	147.80	154.50
4.	25.95	22.00	-0.71E 00	0.71E 01	187.39	194.08
10.	22.90	18.60	-0.46E 00	0.46E 01	230.38	237.08
30.	19.67	16.04	-0.11E 00	0.11E 01	266.68	273.38
100.	17.23	13.00	-0.35E-01	0.35E 00	309.06	315.76
304.	14.35	10.70	-0.10E-01	0.10E 00	345.51	352.21
1007.	12.16	12.80	0.52E-03	-0.52E-02	339.21	345.91
3000.	14.16	9.44	-0.14E-02	0.14E-01	386.34	393.04
1.	100.00	73.38	-0.29E 02	0.11E 02	266.20	272.90
4.	74.71	69.18	-0.99E 00	0.99E 01	321.51	328.21
10.	70.72	62.00	-0.95E 00	0.95E 01	408.72	415.41
30.	63.90	60.78	-0.94E-01	0.94E 00	439.92	446.61
100.	62.74	54.43	-0.69E-01	0.69E 00	523.03	529.73
304.	56.70	46.82	-0.29E-01	0.29E 00	621.91	628.61
1007.	49.47	49.26	-0.18E-03	0.18E-02	624.10	630.80
3000.	51.79	49.13	-0.81E-03	0.81E-02	650.77	657.47

PHOSPHORUS SORPTION ISOTHERM

SOIL L

RESIN EXTRACTABLE PHOSPHORUS ON SOIL BEFORE SORPTION 1.1 PPM

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	1.00	0.32	-0.31E 00	0.29E 00	6.76	7.86
3.	0.35	0.14	-0.66E-01	0.66E 00	8.93	10.03
10.	0.18	0.00	-0.15E-01	0.15E 00	10.76	11.86
30.	0.05	0.00	-0.15E-02	0.15E-01	11.26	12.36
100.	0.05	0.00	-0.41E-03	0.41E-02	11.76	12.86
312.	0.05	0.00	-0.14E-03	0.14E-02	12.26	13.36
1015.	0.05	0.00	-0.41E-04	0.41E-03	12.76	13.86
3005.	0.05	0.04	-0.30E-05	0.30E-04	12.86	13.96
1.	5.00	2.80	-0.15E 01	0.95E 00	22.00	23.10
3.	2.91	1.50	-0.42E 00	0.42E 01	36.10	37.20
10.	1.67	0.31	-0.11E 00	0.11E 01	49.75	50.85
30.	0.54	0.14	-0.12E-01	0.12E 00	53.79	54.89
100.	0.38	0.10	-0.23E-02	0.23E-01	56.62	57.72
312.	0.34	0.00	-0.97E-03	0.97E-02	60.07	61.17
1015.	0.25	0.09	-0.13E-03	0.13E-02	61.65	62.75
3005.	0.33	0.05	-0.88E-04	0.88E-03	64.52	65.62
1.	10.00	6.70	-0.30E 01	0.14E 01	33.00	34.10
3.	6.86	4.00	-0.86E 00	0.86E 01	61.65	62.75
10.	4.30	1.40	-0.24E 00	0.24E 01	90.65	91.75
30.	1.83	0.45	-0.41E-01	0.41E 00	104.44	105.55
100.	0.92	0.20	-0.60E-02	0.60E-01	111.72	112.82
312.	0.69	0.16	-0.14E-02	0.14E-01	117.02	118.12
1015.	0.65	0.13	-0.43E-03	0.43E-02	122.24	123.34
3005.	0.62	0.05	-0.17E-03	0.17E-02	127.97	129.07
1.	40.00	30.00	-0.11E 02	0.43E 01	100.00	101.10
3.	30.50	23.90	-0.20E 01	0.20E 02	166.00	167.10
10.	24.70	17.20	-0.62E 00	0.62E 01	241.04	242.14
30.	18.34	11.80	-0.19E 00	0.19E 01	306.44	307.54
100.	13.21	7.00	-0.51E-01	0.51E 00	368.54	369.64
312.	8.65	4.10	-0.12E-01	0.12E 00	414.04	415.14
1015.	5.89	2.41	-0.29E-02	0.29E-01	448.89	449.99
3005.	4.28	0.76	-0.10E-02	0.10E-01	484.19	485.29
1.	100.00	82.00	-0.29E 02	0.78E 01	180.00	181.10
3.	82.90	73.40	-0.28E 01	0.28E 02	275.00	276.10
10.	74.73	64.60	-0.84E 00	0.84E 01	376.30	377.40
30.	66.37	53.40	-0.39E 00	0.39E 01	505.99	507.09
100.	55.73	46.00	-0.80E-01	0.80E 00	603.29	604.39
312.	48.70	39.60	-0.25E-01	0.25E 00	694.29	695.39
1015.	42.62	33.88	-0.72E-02	0.72E-01	781.69	782.79
3005.	37.18	18.50	-0.57E-02	0.57E-01	968.55	969.65

PHOSPHORUS SORPTION ISOTHERM

SOIL M

RESIN EXTRACTABLE PHOSPHORUS ON SOIL BEFORE SORPTION 43.0 PPM

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	1.00	0.76	-0.29E 00	0.10E 00	2.40	45.40
3.	0.77	0.60	-0.52E-01	0.52E 00	4.12	47.11
10.	0.61	0.44	-0.14E-01	0.14E 00	5.91	48.91
30.	0.46	0.36	-0.32E-02	0.32E-01	6.99	49.99
100.	0.39	0.26	-0.10E-02	0.10E-01	8.31	51.31
312.	0.29	0.24	-0.14E-03	0.14E-02	8.81	51.81
1015.	0.28	0.27	-0.12E-04	0.12E-03	8.96	51.96
3005.	0.30	0.13	-0.54E-04	0.54E-03	10.73	53.73
1.	5.00	4.00	-0.14E 01	0.43E 00	10.00	53.00
3.	4.05	3.40	-0.19E 00	0.19E 01	16.50	59.50
10.	3.47	2.50	-0.81E-01	0.81E 00	26.29	69.30
30.	2.62	2.10	-0.15E-01	0.15E 00	31.54	74.55
100.	2.24	1.60	-0.53E-02	0.53E-01	38.00	81.00
312.	1.77	1.41	-0.10E-02	0.10E-01	41.59	84.59
1015.	1.58	1.35	-0.20E-03	0.20E-02	43.99	86.99
3005.	1.53	0.70	-0.25E-03	0.25E-02	52.31	95.31
1.	10.00	7.60	-0.29E 01	0.10E 01	24.00	67.00
3.	7.71	6.70	-0.30E 00	0.30E 01	34.20	77.20
10.	6.86	6.00	-0.71E-01	0.71E 00	42.85	85.85
30.	6.20	5.40	-0.24E-01	0.24E 00	50.85	93.85
100.	5.63	4.70	-0.77E-02	0.77E-01	60.14	103.15
312.	4.96	4.07	-0.25E-02	0.25E-01	69.09	112.09
1015.	4.36	3.71	-0.54E-03	0.54E-02	75.66	118.66
3005.	4.02	2.13	-0.58E-03	0.58E-02	94.60	137.60
1.	40.00	34.90	-0.11E 02	0.22E 01	51.00	94.00
3.	35.15	33.20	-0.59E 00	0.59E 01	70.55	113.55
10.	33.54	31.20	-0.19E 00	0.19E 01	93.95	136.95
30.	31.64	30.70	-0.28E-01	0.28E 00	103.35	146.35
100.	31.16	29.00	-0.17E-01	0.17E 00	124.99	167.99
312.	29.55	27.03	-0.70E-02	0.70E-01	150.20	193.19
1015.	27.67	27.54	-0.11E-03	0.11E-02	151.58	194.58
3005.	28.16	16.40	-0.36E-02	0.36E-01	269.21	312.21
1.	100.00	94.60	-0.28E 02	0.23E 01	54.00	97.00
3.	94.87	91.20	-0.11E 01	0.11E 02	90.69	133.70
10.	91.64	88.30	-0.27E 00	0.27E 01	124.10	167.10
30.	88.88	86.60	-0.69E-01	0.69E 00	146.95	189.95
100.	87.26	83.00	-0.35E-01	0.35E 00	189.64	232.64
312.	83.85	80.82	-0.85E-02	0.85E-01	219.94	262.94
1015.	81.77	85.98	0.35E-02	-0.35E-01	177.93	220.93
3005.	86.68	73.50	-0.40E-02	0.40E-01	309.74	352.74

PHOSPHORUS SORPTION ISOTHERM

SOIL N

RESIN EXTRACTABLE PHOSPHORUS ON SOIL BEFORE SORPTION 98.0 PPM

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	1.00	0.61	-0.30E 00	0.16E 00	3.90	101.90
3.	0.62	0.60	-0.89E-02	0.89E-01	4.19	102.19
10.	0.61	0.47	-0.11E-01	0.11E 00	5.60	103.60
30.	0.50	0.42	-0.23E-02	0.23E-01	6.37	104.37
99.	0.45	0.46	0.79E-04	-0.79E-03	6.28	104.28
364.	0.49	0.47	-0.47E-04	0.47E-03	6.50	104.50
1009.	0.49	0.49	-0.63E-05	0.63E-04	6.57	104.57
3000.	0.51	0.27	-0.72E-04	0.72E-03	8.94	106.94
1.	5.00	3.47	-0.14E 01	0.66E 00	15.30	113.30
3.	3.54	3.07	-0.14E 00	0.14E 01	20.06	118.06
10.	3.16	2.75	-0.34E-01	0.34E 00	24.18	122.18
30.	2.86	2.39	-0.14E-01	0.14E 00	28.93	126.93
99.	2.52	2.04	-0.40E-02	0.40E-01	33.72	131.72
364.	2.19	1.35	-0.17E-02	0.17E-01	42.13	140.13
1009.	1.53	0.58	-0.92E-03	0.92E-02	51.66	149.66
3000.	0.80	0.31	-0.14E-03	0.14E-02	56.56	154.56
1.	10.00	7.56	-0.29E 01	0.10E 01	24.40	122.40
3.	7.68	7.04	-0.19E 00	0.19E 01	30.82	128.82
10.	7.18	6.56	-0.51E-01	0.51E 00	37.02	135.01
30.	6.73	5.69	-0.31E-01	0.31E 00	47.51	145.51
99.	5.90	3.76	-0.18E-01	0.18E 00	68.94	166.94
364.	4.07	2.29	-0.37E-02	0.37E-01	86.78	184.78
1009.	2.67	1.76	-0.88E-03	0.88E-02	95.94	193.94
3000.	2.17	1.09	-0.33E-03	0.33E-02	106.76	204.76
1.	40.00	34.90	-0.11E 02	0.22E 01	51.00	149.00
3.	35.15	34.00	-0.35E 00	0.35E 01	62.54	160.55
10.	34.30	32.84	-0.12E 00	0.12E 01	77.15	175.15
30.	33.19	31.03	-0.65E-01	0.65E 00	98.82	196.82
99.	31.47	29.35	-0.18E-01	0.18E 00	120.11	218.11
364.	29.88	26.40	-0.73E-02	0.73E-01	154.93	252.93
1009.	27.08	28.38	0.12E-02	-0.12E-01	141.93	239.93
3000.	28.96	17.32	-0.35E-02	0.35E-01	258.34	356.34
1.	100.00	93.40	-0.28E 02	0.28E 01	66.00	164.00
3.	93.73	92.00	-0.52E 00	0.52E 01	83.29	181.29
10.	92.40	94.64	0.18E 00	-0.18E 01	60.89	158.89
30.	94.90	85.60	-0.28E 00	0.28E 01	153.97	251.97
99.	86.32	84.30	-0.17E-01	0.17E 00	174.17	272.17
364.	85.08	82.40	-0.56E-02	0.56E-01	201.02	299.02
1009.	83.28	91.28	0.77E-02	-0.77E-01	121.02	219.02
3000.	91.71	63.10	-0.87E-02	0.87E-01	407.18	505.18

PHOSPHORUS SORPTION ISOTHERM

SOIL O

RESIN EXTRACTABLE PHOSPHORUS ON SOIL BEFORE SORPTION 47.0 PPM

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	1.00	0.48	-0.30E 00	0.22E 00	5.20	52.20
3.	0.50	0.34	-0.50E-01	0.50E 00	6.86	53.86
10.	0.37	0.42	0.45E-02	-0.45E-01	6.31	53.31
30.	0.45	0.35	-0.32E-02	0.32E-01	7.37	54.37
99.	0.38	0.42	0.38E-03	-0.38E-02	6.92	53.92
364.	0.45	0.31	-0.30E-03	0.30E-02	8.38	55.38
1009.	0.34	0.30	-0.43E-04	0.43E-03	8.83	55.83
3000.	0.33	0.23	-0.31E-04	0.31E-03	9.85	56.85
1.	5.00	2.63	-0.15E 01	0.10E 01	23.70	70.70
3.	2.74	2.15	-0.18E 00	0.18E 01	29.68	76.68
10.	2.29	1.77	-0.43E-01	0.43E 00	34.91	81.90
30.	1.93	1.44	-0.14E-01	0.14E 00	39.82	86.82
99.	1.61	1.26	-0.29E-02	0.29E-01	43.32	90.32
364.	1.45	1.02	-0.91E-03	0.91E-02	47.67	94.67
1009.	1.21	0.91	-0.30E-03	0.30E-02	50.76	97.76
3000.	1.11	0.39	-0.22E-03	0.22E-02	57.95	104.95
1.	10.00	6.00	-0.30E 01	0.17E 01	40.00	87.00
3.	6.20	5.26	-0.28E 00	0.28E 01	49.40	96.40
10.	5.49	4.49	-0.82E-01	0.82E 00	59.38	106.38
30.	4.77	3.72	-0.31E-01	0.31E 00	69.88	116.88
99.	4.03	3.10	-0.79E-02	0.79E-01	79.22	126.22
364.	3.44	1.63	-0.38E-02	0.38E-01	97.40	144.40
1009.	2.04	0.84	-0.11E-02	0.11E-01	109.49	156.49
3000.	1.29	0.38	-0.28E-03	0.28E-02	118.67	165.67
1.	40.00	31.80	-0.11E 02	0.35E 01	82.00	129.00
3.	32.21	31.70	-0.15E 00	0.15E 01	87.10	134.10
10.	32.11	24.83	-0.60E 00	0.60E 01	159.95	206.95
30.	25.58	13.71	-0.36E 00	0.36E 01	278.73	325.73
99.	15.02	4.05	-0.92E-01	0.92E 00	388.45	435.45
364.	5.85	0.76	-0.10E-01	0.10E 00	439.35	486.35
1009.	2.72	0.60	-0.20E-02	0.20E-01	460.57	507.57
3000.	2.57	0.23	-0.71E-03	0.71E-02	483.88	530.88
1.	100.00	85.60	-0.29E 02	0.62E 01	144.00	191.00
3.	86.32	93.40	0.21E 01	-0.21E 02	73.19	120.19
10.	93.73	76.50	-0.14E 01	0.14E 02	245.49	292.49
30.	77.67	48.88	-0.87E 00	0.87E 01	533.44	580.44
99.	51.43	20.70	-0.26E 00	0.26E 01	840.80	887.80
364.	24.66	1.55	-0.48E-01	0.48E 00	1071.95	1118.95
1009.	6.47	0.62	-0.56E-02	0.56E-01	1130.48	1177.48
3000.	5.58	0.53	-0.15E-02	0.15E-01	1181.07	1228.07

PHOSPHORUS SORPTION ISOTHERM

SOIL P

RESIN EXTRACTABLE PHOSPHORUS ON SOIL BEFORE SORPTION 19.0 PPM

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	1.00	0.30	-0.31E 00	0.30E 00	7.00	26.00
3.	0.33	0.22	-0.34E-01	0.34E 00	8.14	27.15
10.	0.25	0.18	-0.63E-02	0.63E-01	8.91	27.92
30.	0.22	0.19	-0.84E-03	0.84E-02	9.19	28.19
99.	0.23	0.18	-0.45E-03	0.45E-02	9.73	28.73
364.	0.22	0.16	-0.13E-03	0.13E-02	10.36	29.36
1009.	0.20	0.14	-0.60E-04	0.60E-03	10.98	29.98
3000.	0.18	0.11	-0.22E-04	0.22E-03	11.71	30.71
1.	5.00	1.77	-0.15E 01	0.14E 01	32.30	51.30
3.	1.93	1.54	-0.11E 00	0.11E 01	36.21	55.21
10.	1.71	1.30	-0.33E-01	0.33E 00	40.27	59.27
30.	1.49	1.08	-0.12E-01	0.12E 00	44.32	63.32
99.	1.28	0.88	-0.34E-02	0.34E-01	48.34	67.34
364.	1.08	0.71	-0.79E-03	0.79E-02	52.10	71.10
1009.	0.92	0.61	-0.30E-03	0.30E-02	55.25	74.25
3000.	0.82	0.31	-0.15E-03	0.15E-02	60.43	79.43
1.	10.00	4.42	-0.31E 01	0.24E 01	55.80	74.80
3.	4.69	4.14	-0.16E 00	0.16E 01	61.39	80.39
10.	4.43	3.62	-0.67E-01	0.67E 00	69.52	88.51
30.	3.93	2.97	-0.29E-01	0.29E 00	79.17	98.16
99.	3.32	2.27	-0.88E-02	0.88E-01	89.66	108.66
364.	2.66	1.73	-0.19E-02	0.19E-01	98.98	117.98
1009.	2.14	1.11	-0.10E-02	0.10E-01	109.31	128.31
3000.	1.55	0.49	-0.32E-03	0.32E-02	119.96	138.96
1.	40.00	27.20	-0.12E 02	0.55E 01	128.00	147.00
3.	27.83	26.40	-0.43E 00	0.43E 01	142.39	161.39
10.	27.08	22.63	-0.36E 00	0.36E 01	186.89	205.89
30.	23.49	14.36	-0.27E 00	0.27E 01	278.28	297.28
99.	15.64	10.22	-0.45E-01	0.45E 00	332.50	351.50
364.	11.70	1.53	-0.21E-01	0.21E 00	434.29	453.29
1009.	3.45	0.70	-0.26E-02	0.26E-01	461.82	480.82
3000.	2.66	0.28	-0.72E-03	0.72E-02	485.62	504.62
1.	100.00	78.00	-0.29E 02	0.95E 01	220.00	239.00
3.	79.10	71.60	-0.22E 01	0.22E 02	295.00	314.00
10.	73.01	69.83	-0.26E 00	0.26E 01	326.89	345.89
30.	71.33	54.82	-0.50E 00	0.50E 01	492.08	511.08
99.	57.07	39.58	-0.14E 00	0.14E 01	667.07	686.07
364.	42.60	18.90	-0.50E-01	0.50E 00	904.08	923.08
1009.	22.95	2.40	-0.19E-01	0.19E 00	1109.63	1128.63
3000.	7.28	0.54	-0.20E-02	0.20E-01	1177.00	1196.00

PHOSPHORUS SORPTION ISOTHERM

SOIL Q

RESIN EXTRACTABLE PHOSPHORUS ON SOIL BEFORE SORPTION 32.0 PPM

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	1.00	0.78	-0.29E 00	0.95E-01	2.20	34.20
3.	0.79	0.70	-0.27E-01	0.27E 00	3.11	35.10
13.	0.71	0.54	-0.89E-02	0.89E-01	4.81	36.81
39.	0.56	0.53	-0.85E-03	0.85E-02	5.18	37.18
110.	0.55	0.57	0.14E-03	-0.14E-02	5.02	37.02
302.	0.59	0.50	-0.28E-03	0.28E-02	5.88	37.88
1001.	0.52	0.42	-0.84E-04	0.84E-03	6.90	38.90
3013.	0.45	0.45	-0.10E-05	0.10E-04	6.94	38.94
1.	5.00	4.03	-0.14E 01	0.42E 00	9.70	41.70
3.	4.07	3.65	-0.13E 00	0.13E 01	13.98	45.98
13.	3.71	3.28	-0.22E-01	0.22E 00	18.35	50.35
39.	3.36	3.05	-0.73E-02	0.73E-01	21.51	53.51
110.	3.14	3.00	-0.12E-02	0.12E-01	22.99	54.99
302.	3.10	2.57	-0.17E-02	0.17E-01	28.26	60.26
1001.	2.69	1.70	-0.82E-03	0.82E-02	38.13	70.13
3013.	1.87	1.08	-0.23E-03	0.23E-02	46.05	78.05
1.	10.00	8.17	-0.29E 01	0.79E 00	18.30	50.30
3.	8.26	7.70	-0.17E 00	0.17E 01	23.91	55.91
13.	7.81	7.63	-0.97E-02	0.97E-01	25.76	57.76
39.	7.74	7.50	-0.57E-02	0.57E-01	28.25	60.24
110.	7.62	6.31	-0.11E-01	0.11E 00	41.39	73.39
302.	6.49	4.24	-0.73E-02	0.73E-01	63.94	95.94
1001.	4.52	1.42	-0.25E-02	0.25E-01	95.02	127.02
3013.	1.84	0.67	-0.35E-03	0.35E-02	106.72	138.72
1.	40.00	37.24	-0.11E 02	0.11E 01	27.60	59.60
3.	37.37	36.20	-0.35E 00	0.35E 01	39.37	71.38
13.	36.39	35.30	-0.57E-01	0.57E 00	50.28	82.28
39.	35.53	30.00	-0.12E 00	0.12E 01	105.62	137.62
110.	30.50	24.70	-0.50E-01	0.50E 00	163.62	195.62
302.	25.46	17.59	-0.25E-01	0.25E 00	242.37	274.37
1001.	18.71	5.83	-0.10E-01	0.10E 00	371.18	403.18
3013.	7.53	1.75	-0.17E-02	0.17E-01	429.06	461.06
1.	100.00	97.95	-0.28E 02	0.89E 00	20.50	52.50
3.	98.05	93.40	-0.14E 01	0.14E 02	67.02	99.02
13.	93.73	92.00	-0.90E-01	0.90E 00	84.32	116.32
39.	92.40	82.50	-0.23E 00	0.23E 01	183.32	215.32
110.	83.37	78.88	-0.39E-01	0.39E 00	228.27	260.27
302.	79.93	69.18	-0.35E-01	0.35E 00	335.83	367.83
1001.	70.72	43.20	-0.22E-01	0.22E 00	611.04	643.04
3013.	46.04	58.44	0.37E-02	-0.37E-01	487.04	519.04

PHOSPHORUS SORPTION ISOTHERM

SOIL R

RESIN EXTRACTABLE PHOSPHORUS ON SOIL BEFORE SORPTION 86.0 PPM

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	1.00	0.25	-0.31E 00	0.32E 00	7.49	93.50
3.	0.28	0.18	-0.32E-01	0.32E 00	8.55	94.55
13.	0.22	0.18	-0.21E-02	0.21E-01	8.96	94.96
39.	0.22	0.23	0.16E-03	-0.16E-02	8.89	94.89
110.	0.26	0.26	-0.74E-04	0.74E-03	8.97	94.97
302.	0.29	0.33	0.13E-03	-0.13E-02	8.57	94.57
329.	0.37	0.38	0.66E-03	-0.66E-02	8.38	94.38
1001.	0.41	0.64	0.20E-03	-0.20E-02	6.11	92.11
3013.	0.66	0.20	-0.13E-03	0.13E-02	10.75	96.75
1.	5.00	2.08	-0.15E 01	0.12E 01	29.20	115.20
3.	2.22	1.50	-0.22E 00	0.22E 01	36.46	122.46
13.	1.67	0.99	-0.35E-01	0.35E 00	43.25	129.25
39.	1.19	0.74	-0.10E-01	0.10E 00	47.81	133.81
110.	0.95	0.64	-0.27E-02	0.27E-01	50.94	136.94
302.	0.85	0.38	-0.15E-02	0.15E-01	55.65	141.65
329.	0.61	0.75	0.47E-02	-0.47E-01	54.31	140.31
1001.	0.96	0.59	-0.32E-03	0.32E-02	57.99	143.99
3013.	0.81	0.18	-0.18E-03	0.18E-02	64.27	150.27
1.	10.00	5.24	-0.30E 01	0.20E 01	47.60	133.60
3.	5.47	4.00	-0.44E 00	0.44E 01	62.38	148.37
13.	4.30	2.87	-0.75E-01	0.75E 00	76.68	162.67
39.	3.22	2.02	-0.28E-01	0.28E 00	88.74	174.74
110.	2.41	1.36	-0.92E-02	0.92E-01	99.33	185.33
302.	1.79	0.23	-0.51E-02	0.51E-01	114.95	200.95
329.	0.71	1.29	0.20E-01	-0.20E 00	109.24	195.23
1001.	1.72	0.65	-0.96E-03	0.96E-02	119.99	205.99
3013.	1.11	0.15	-0.28E-03	0.28E-02	129.62	215.61

SOIL R CONTINUED

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	40.00	30.00	-0.11E 02	0.43E 01	100.00	186.00
3.	30.50	24.70	-0.17E 01	0.17E 02	158.00	244.00
13.	25.46	17.50	-0.41E 00	0.41E 01	237.64	323.64
39.	18.62	5.40	-0.30E 00	0.30E 01	369.90	455.89
110.	7.13	2.02	-0.44E-01	0.44E 00	421.00	506.99
302.	3.91	0.70	-0.10E-01	0.10E 00	453.18	539.18
329.	2.66	0.99	-0.59E-01	0.59E 00	469.87	555.87
1001.	2.94	0.32	-0.23E-02	0.23E-01	496.10	582.10
3013.	2.30	0.13	-0.65E-03	0.65E-02	517.87	603.87
1.	100.00	85.65	-0.29E 02	0.62E 01	143.50	229.50
3.	86.36	73.70	-0.38E 01	0.38E 02	270.17	356.17
13.	75.01	54.98	-0.10E 01	0.10E 02	470.52	556.52
39.	57.23	8.75	-0.11E 01	0.11E 02	955.33	1041.33
110.	13.31	1.94	-0.99E-01	0.99E 00	1069.05	1155.05
302.	6.84	1.04	-0.19E-01	0.19E 00	1127.08	1213.08
329.	5.98	1.79	-0.14E 00	0.14E 01	1168.98	1254.98
1001.	6.70	0.35	-0.57E-02	0.57E-01	1232.57	1318.57
3013.	5.33	0.23	-0.15E-02	0.15E-01	1283.50	1369.50

PHOSPHORUS SORPTION ISOTHERM

SOIL S

RESIN EXTRACTABLE PHOSPHORUS ON SOIL BEFORE SORPTION 61.0 PPM

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	1.00	0.21	-0.32E 00	0.34E 00	7.90	68.90
3.	0.24	0.13	-0.36E-01	0.36E 00	9.09	70.09
13.	0.17	0.11	-0.29E-02	0.29E-01	9.65	70.66
39.	0.16	0.17	0.20E-03	-0.20E-02	9.57	70.57
110.	0.21	0.20	-0.10E-03	0.10E-02	9.68	70.68
302.	0.24	0.19	-0.14E-03	0.14E-02	10.13	71.13
1001.	0.23	0.27	0.31E-04	-0.31E-03	9.75	70.75
3013.	0.30	0.15	-0.46E-04	0.46E-03	11.30	72.30
1.	5.00	1.41	-0.15E 01	0.15E 01	35.90	96.90
3.	1.58	0.88	-0.21E 00	0.21E 01	42.99	103.99
13.	1.08	0.73	-0.18E-01	0.18E 00	46.47	107.47
39.	0.95	0.69	-0.60E-02	0.60E-01	49.08	110.08
110.	0.90	0.64	-0.23E-02	0.23E-01	51.74	112.74
302.	0.85	0.54	-0.10E-02	0.10E-01	54.88	115.88
1001.	0.76	0.50	-0.21E-03	0.21E-02	57.49	118.49
3013.	0.72	0.38	-0.10E-03	0.10E-02	60.91	121.91
1.	10.00	3.69	-0.31E 01	0.27E 01	63.10	124.10
3.	4.00	2.92	-0.32E 00	0.32E 01	73.95	134.95
13.	3.27	2.51	-0.40E-01	0.40E 00	81.59	142.59
39.	2.88	2.02	-0.20E-01	0.20E 00	90.24	151.24
110.	2.41	1.57	-0.74E-02	0.74E-01	98.73	159.73
302.	1.99	1.33	-0.21E-02	0.21E-01	105.34	166.34
1001.	1.76	1.06	-0.58E-03	0.58E-02	112.37	173.37
3013.	1.50	0.44	-0.32E-03	0.32E-02	123.00	184.00
1.	40.00	23.41	-0.12E 02	0.72E 01	165.90	226.90
3.	24.23	22.24	-0.60E 00	0.60E 01	185.89	246.89
13.	23.12	18.50	-0.24E 00	0.24E 01	232.17	293.17
39.	19.57	15.30	-0.99E-01	0.99E 00	274.92	335.92
110.	16.53	14.03	-0.21E-01	0.21E 00	299.97	360.97
302.	15.32	11.70	-0.11E-01	0.11E 00	336.25	397.25
1001.	13.11	7.37	-0.47E-02	0.47E-01	393.65	454.65
3013.	9.00	5.11	-0.11E-02	0.11E-01	432.62	493.62
1.	100.00	71.13	-0.29E 02	0.12E 02	288.70	349.70
3.	72.57	67.25	-0.16E 01	0.16E 02	341.93	402.93
13.	68.88	59.18	-0.50E 00	0.50E 01	439.01	500.01
39.	61.22	51.80	-0.21E 00	0.21E 01	533.22	594.22
110.	54.21	47.97	-0.54E-01	0.54E 00	595.62	656.62
302.	50.57	41.50	-0.29E-01	0.29E 00	686.33	747.33
1001.	44.42	30.52	-0.11E-01	0.11E 00	825.38	886.38
3013.	33.99	19.92	-0.42E-02	0.42E-01	966.12	1027.12

PHOSPHORUS SORPTION ISOTHERM

SOIL T

RESIN EXTRACTABLE PHOSPHORUS ON SOIL BEFORE SORPTION 72.0 PPM

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	1.00	0.80	-0.29E 00	0.86E-01	2.00	74.00
3.	0.81	0.62	-0.57E-01	0.57E 00	3.88	75.88
13.	0.64	0.54	-0.50E-02	0.50E-01	4.84	76.84
39.	0.56	0.47	-0.22E-02	0.22E-01	5.81	77.81
110.	0.49	0.47	-0.23E-03	0.23E-02	6.08	78.08
302.	0.49	0.42	-0.22E-03	0.22E-02	6.76	78.76
1001.	0.45	0.45	-0.21E-05	0.21E-04	6.79	78.79
3013.	0.48	0.32	-0.47E-04	0.47E-03	8.37	80.37
1.	5.00	3.76	-0.14E 01	0.53E 00	12.40	84.40
3.	3.82	3.36	-0.14E 00	0.14E 01	17.02	89.01
13.	3.44	3.14	-0.15E-01	0.15E 00	20.04	92.03
39.	3.23	2.95	-0.66E-02	0.66E-01	22.86	94.86
110.	3.05	2.80	-0.22E-02	0.22E-01	25.39	97.39
302.	2.91	2.53	-0.12E-02	0.12E-01	29.14	101.14
1001.	2.65	1.53	-0.93E-03	0.93E-02	40.33	112.33
3013.	1.71	0.98	-0.21E-03	0.21E-02	47.62	119.62
1.	10.00	8.47	-0.29E 01	0.66E 00	15.30	87.30
3.	8.54	7.91	-0.19E 00	0.19E 01	21.66	93.66
13.	8.01	7.50	-0.26E-01	0.26E 00	26.80	98.81
39.	7.62	6.70	-0.21E-01	0.21E 00	36.05	108.05
110.	6.86	6.10	-0.67E-02	0.67E-01	43.70	115.70
302.	6.29	4.53	-0.57E-02	0.57E-01	61.35	133.35
1001.	4.80	2.16	-0.22E-02	0.22E-01	87.79	159.79
3013.	2.55	1.24	-0.39E-03	0.39E-02	100.89	172.89
1.	40.00	34.78	-0.11E 02	0.22E 01	52.20	124.20
3.	35.04	34.78	-0.79E-01	0.79E 00	54.81	126.81
13.	35.04	34.14	-0.47E-01	0.47E 00	63.81	135.81
39.	34.43	32.60	-0.42E-01	0.42E 00	82.14	154.14
110.	32.97	31.16	-0.15E-01	0.15E 00	100.24	172.24
302.	31.60	27.67	-0.12E-01	0.12E 00	139.56	211.56
1001.	28.28	20.56	-0.64E-02	0.64E-01	216.83	288.83
3013.	21.53	20.75	-0.23E-03	0.23E-02	224.65	296.65
1.	100.00	96.33	-0.28E 02	0.15E 01	36.70	108.70
3.	96.51	91.80	-0.14E 01	0.14E 02	83.83	155.83
13.	92.21	93.10	0.46E-01	-0.46E 00	74.93	146.93
39.	93.44	92.50	-0.22E-01	0.22E 00	84.38	156.38
110.	92.87	91.15	-0.15E-01	0.15E 00	101.63	173.63
302.	91.59	86.62	-0.16E-01	0.16E 00	151.35	223.35
1001.	87.28	69.82	-0.14E-01	0.14E 00	326.04	398.04
3013.	71.32	41.90	-0.88E-02	0.88E-01	620.33	692.33

PHOSPHORUS SORPTION ISOTHERM

SOIL U

RESIN EXTRACTABLE PHOSPHORUS ON SOIL BEFORE SORPTION 1.8 PPM

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	1.00	0.71	-0.29E 00	0.12E 00	2.88	4.68
4.	0.72	0.44	-0.51E-01	0.51E 00	5.74	7.54
10.	0.46	0.32	-0.16E-01	0.16E 00	7.22	9.02
30.	0.35	0.26	-0.28E-02	0.28E-01	8.16	9.96
100.	0.29	0.20	-0.80E-03	0.80E-02	9.13	10.93
304.	0.24	0.16	-0.21E-03	0.21E-02	9.84	11.64
1007.	0.21	0.26	0.41E-04	-0.41E-03	9.34	11.14
3000.	0.29	0.07	-0.66E-04	0.66E-03	11.53	13.33
1.	5.00	3.89	-0.14E 01	0.48E 00	11.10	12.90
4.	3.94	3.07	-0.15E 00	0.15E 01	19.85	21.65
10.	3.16	2.81	-0.38E-01	0.38E 00	23.42	25.22
30.	2.91	2.60	-0.96E-02	0.96E-01	26.61	28.41
100.	2.72	2.39	-0.27E-02	0.27E-01	29.91	31.71
304.	2.52	2.22	-0.87E-03	0.87E-02	32.87	34.67
1007.	2.36	1.88	-0.39E-03	0.39E-02	37.62	39.42
3000.	2.04	1.86	-0.55E-04	0.55E-03	39.44	41.24
1.	10.00	9.21	-0.29E 01	0.34E 00	7.90	9.70
4.	9.24	7.81	-0.25E 00	0.25E 01	22.29	24.09
10.	7.91	7.42	-0.54E-01	0.54E 00	27.29	29.09
30.	7.54	7.14	-0.12E-01	0.12E 00	31.37	33.18
100.	7.28	6.88	-0.33E-02	0.33E-01	35.40	37.20
304.	7.03	6.52	-0.15E-02	0.15E-01	40.56	42.36
1007.	6.69	5.64	-0.87E-03	0.87E-02	51.10	52.90
3000.	5.85	5.45	-0.12E-03	0.12E-02	55.12	56.92
1.	40.00	37.70	-0.11E 02	0.99E 00	23.00	24.80
4.	37.81	37.50	-0.56E-01	0.56E 00	26.14	27.94
10.	37.62	36.20	-0.15E 00	0.15E 01	40.39	42.19
30.	36.39	40.08	0.11E 00	-0.11E 01	3.49	5.29
100.	40.07	35.43	-0.38E-01	0.38E 00	49.95	51.75
304.	35.65	34.90	-0.22E-02	0.22E-01	57.54	59.34
1007.	35.15	33.36	-0.14E-02	0.14E-01	75.49	77.29
3000.	33.69	39.56	0.17E-02	-0.17E-01	16.81	18.61
1.	100.00	95.02	-0.28E 02	0.21E 01	49.80	51.60
4.	95.26	94.07	-0.21E 00	0.21E 01	61.78	63.58
10.	94.36	97.80	0.37E 00	-0.37E 01	27.45	29.25
30.	97.90	98.90	0.30E-01	-0.30E 00	17.55	19.35
100.	98.95	95.03	-0.32E-01	0.32E 00	56.80	58.60
304.	95.27	97.20	0.56E-02	-0.56E-01	37.58	39.38
1007.	97.34	89.46	-0.65E-02	0.65E-01	116.38	118.18
3000.	89.98	61.04	-0.88E-02	0.88E-01	405.85	407.65

```
// JOB

LOG DRIVE   CART SPEC   CART AVAIL  PHY DRIVE
  0000        7209        7209        0000

V2 M11   ACTUAL 16K  CONFIG 16K

// FOR
*IOCS(DISK,1132 PRINTER,CARD,TYPEWRITER,KEYBOARD)
*EXTENDED PRECISION
*ONE WORD INTEGERS
*LIST SOURCE PROGRAM
C     PHOSPHORUS SORPTION ISOTHERM DATA CONVERSION ASSUMES 10 G SOIL SAMPLE
      DIMENSION CI(10,7),FC(10,7),DC(10,7), DS(10,7),SPAD(10,7),SPS(10,7
     *) ,T(10)
  100 FORMAT(I3)
      READ(2,100)N
C     N IS THE NUMBER OF SOIL SAMPLES
      DO 1000 ID=1,N
  110 FORMAT (A2)
      READ (2,110) SN
  120 FORMAT (2I5)
      READ (2,120) IN,JN
C     IN IS NO. OF TIMES& IJ IS THE NO OF CONCENTRATIONS
  130 FORMAT (5F10.0)
      READ(2,130)(T(I),I=1,IN)
C     T IS THE TIMES MEASUREMENTS TAKEN
  140 FORMAT (10F7.3)
      READ (2,140)(CI(1,J),J=1,JN)
C     CI IS THE INITIAL CONCENTRATIONS
      DO 150 I=1,IN
  160 FORMAT (10F7.3)
      READ (2,160)(FC(I,J),J=1,JN)
C     FC ARE THE MEASURED CONCENTRATIONS
  150 CONTINUE
  170 FORMAT (F10.3)
      READ (2,170) REP
C     REP IS THE RESIN EXTRACTABLE PHOSPHORUS
      DO 1 I=2,IN
      DO 2 J=1,JN
    2 CI(I,J)=FC(I-1,J)
    1 CONTINUE
      DO 3 I=1,IN
      DO 4 J=1,JN
      PAD = (CI(I,J)-FC(I,J))/10.
      A=I
      IF (A-1)  8,8,9
    8 SPAD(I,J) = PAD*100.
      SPS(I,J) = SPAD(I,J)+REP
      GO TO 10
    9 SPAD (I,J) = SPAD(I-1,J)+(PAD*100.)
      SPS (I,J) = SPS (I-1,J)+(PAD*100.)
   10 CONTINUE
    4 CONTINUE
    3 CONTINUE
C     RATE CALCULATED ON + POINT MOVING
C     CURVE
      DO 50 J=1,JN
      IC=0
      NN=IN-2
      DO 49 I=1,NN
```

```
      IC=IC+1
      SUMX=0.
      SUMY=0.
      SUMXY=0.
      SUMXZ=0.
      IIC = I+2
      DO 40 II=I,IIC
      SUMX=ALOG(T(II))+SUMX
      SUMY=FC(II,J)+SUMY
      SUMXY=ALOG(T(II))*FC(II,J)+SUMXY
      SUMXZ=ALOG(T(II))**2+SUMXZ
   40 CONTINUE
      DEMON=3.*SUMXZ-SUMX**2.
      RATE=((3.*SUMXY)-SUMX*SUMY)/DEMON
      IF(IC-1)42,42,43
   42 DC(1,J)=RATE/T(1)
   43 DC(IC+1,J)=RATE/T(IC+1)
      IF(IC-IN+2)46,45,44
   44 WRITE(3,175)
  175 FORMAT(5X,'ERROR')
   45 DC(IC+2,J)=RATE/T(IC+2)
   46 CONTINUE
      SUMX=0.
      SUMY=0.
      SUMXY=0.
      SUMXZ=0.
      DO 41 II=I,IIC
      SUMX=ALOG(T(II))+SUMX
      SUMY=SPAD(II,J)+SUMY
      SUMXY=ALOG(T(II))*SPAD(II,J)+SUMXY
      SUMXZ=ALOG(T(II))**2+SUMXZ
   41 CONTINUE
      DEMON=3.*SUMXZ-SUMX**2.
      RATE=((3*SUMXY)-SUMX*SUMY)/DEMON
      IF(IC-1)47,47,48
   47 DS(1,J)=RATE/T(1)
   48 DS(IC+1,J)=RATE/T(IC+1)
      IF(IC-IN+2)52,51,44
   51 DS(IC+2,J)=RATE/T(IC+2)
   52 CONTINUE
   49 CONTINUE
   50 CONTINUE
      WRITE (3,200) SN,REP
  200 FORMAT('1'/////14X'       PHOSPHORUS SORPTION ISOTHERM'//'
     *                       SOIL ',A2,///' RESIN EXTRACTABLE PHOSPHORUS O
     *N SOIL BEFORE SORPTION ',F5.1,' PPM'/'----------------------------
     *-------------------------------------'/)
  205 FORMAT(                                       '  TIME    INITIAL    FINAL
     *  DC         DS         SUM P      SUM P'/7X,'   CONC       CONC       DT
     *     DT      SORBED    ON SOIL'/'   HRS       MG/L       MG/L    PPM/HR
     * PPM/HR      PPM        PPM'/'----------------------------------------
     *------------------------ '/)
      WRITE(3,205)
      ICNT = 12
      DO 180 J=1,JN
  210 FORMAT(1X,F5.0,2F9.2,2E10.2,2F9.2)
      WRITE (3,210) (T(I),CI(I,J),FC(I,J),DC(I,J), DS(I,J),SPAD(I,J),SPS
     *(I,J),I=1,IN)
  220 FORMAT (/)
      WRITE(3,220)
      ICNT=ICNT+IN+2
```

```
      IDUM=54-IN
      IF(ICNT-IDUM)222,221,221
  223 FORMAT ('1'/////21X' SOIL ',A2,' CONTINUED'//).
  221 IF (J-JN)224,180,180
  224 WRITE(3,223) SN
      WRITE(3,205)
      ICNT = 5
      GO TO 180
  222 CONTINUE
  180 CONTINUE
 1000 CONTINUE
      CALL EXIT
      END

FEATURES SUPPORTED
 ONE WORD INTEGERS
 EXTENDED PRECISION
 IOCS

CORE REQUIREMENTS FOR
 COMMON        0  VARIABLES    1340  PROGRAM    1204

END OF COMPILATION

// XEQ
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PHOSPHORUS SORPTION ISOTHERM

SOIL V

RESIN EXTRACTABLE PHOSPHORUS ON SOIL BEFORE SORPTION 1.4 PPM

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	1.00	0.64	-0.13E 00	0.13E 01	3.53	4.93
10.	0.64	0.33	-0.13E-01	0.13E 00	6.63	8.03
30.	0.33	0.17	-0.13E-02	0.13E-01	8.30	9.69
277.	0.17	0.17	-0.14E-03	0.14E-02	8.25	9.64
1.	5.00	3.64	-0.59E 00	0.59E 01	13.54	14.94
10.	3.64	2.35	-0.59E-01	0.59E 00	26.46	27.86
30.	2.35	1.59	-0.18E-01	0.18E 00	34.10	35.50
277.	1.59	0.44	-0.20E-02	0.20E-01	45.54	46.94
1.	10.00	7.71	-0.94E 00	0.94E 01	22.90	24.30
10.	7.71	5.51	-0.94E-01	0.94E 00	44.90	46.30
30.	5.51	4.52	-0.32E-01	0.32E 00	54.80	56.20
277.	4.52	2.27	-0.35E-02	0.35E-01	77.24	78.64
1.	40.00	33.90	-0.20E 01	0.20E 02	61.00	62.40
10.	33.90	27.16	-0.20E 00	0.20E 01	128.40	129.80
30.	27.16	27.30	-0.62E-01	0.62E 00	127.00	128.40
277.	27.30	21.40	-0.67E-02	0.67E-01	186.00	187.40
1.	100.00	85.60	-0.85E 00	0.85E 01	144.00	145.40
10.	85.60	83.40	-0.85E-01	0.85E 00	166.00	167.40
30.	83.40	82.75	-0.10E 00	0.10E 01	172.50	173.90
277.	82.75	73.05	-0.11E-01	0.11E 00	269.50	270.90
1.	200.00	172.60	-0.16E 00	0.16E 01	274.00	275.40
10.	172.60	164.85	-0.16E-01	0.16E 00	351.50	352.90
30.	164.85	174.00	0.15E-01	-0.15E 00	260.00	261.40
277.	174.00	168.10	0.16E-02	-0.16E-01	319.00	320.40

PHOSPHORUS SORPTION ISOTHERM

SOIL W

RESIN EXTRACTABLE PHOSPHORUS ON SOIL BEFORE SORPTION 2.6 PPM

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	1.00	0.55	-0.12E 00	0.12E 01	4.43	7.03
10.	0.55	0.26	-0.12E-01	0.12E 00	7.40	10.00
30.	0.26	0.12	-0.23E-02	0.23E-01	8.80	11.40
121.	0.12	0.08	-0.12E-03	0.12E-02	9.20	11.80
277.	0.08	0.09	-0.52E-04	0.52E-03	9.09	11.69
1.	5.00	3.37	-0.65E 00	0.65E 01	16.25	18.85
10.	3.37	1.79	-0.65E-01	0.65E 00	32.02	34.62
30.	1.79	1.16	-0.16E-01	0.16E 00	38.40	41.00
121.	1.16	0.53	-0.35E-02	0.35E-01	44.70	47.30
277.	0.53	0.20	-0.15E-02	0.15E-01	47.99	50.59
1.	10.00	7.29	-0.89E 00	0.89E 01	27.10	29.70
10.	7.29	4.63	-0.89E-01	0.89E 00	53.70	56.30
30.	4.63	4.42	-0.42E-01	0.42E 00	55.80	58.40
121.	4.42	1.52	-0.13E-01	0.13E 00	84.80	87.40
277.	1.52	0.94	-0.58E-02	0.58E-01	90.55	93.15
1.	40.00	33.10	-0.27E 01	0.27E 02	69.00	71.60
10.	33.10	25.35	-0.27E 00	0.27E 01	146.50	149.10
30.	25.35	24.10	-0.11E 00	0.11E 01	159.00	161.60
121.	24.10	17.20	-0.31E-01	0.31E 00	228.00	230.60
277.	17.20	15.90	-0.13E-01	0.13E 00	241.00	243.60
1.	100.00	80.82	-0.10E 01	0.10E 02	191.80	194.40
10.	80.82	78.88	-0.10E 00	0.10E 01	211.20	213.80
30.	78.88	77.25	-0.19E 00	0.19E 01	227.50	230.10
121.	77.25	64.75	-0.81E-01	0.81E 00	352.50	355.10
277.	64.75	54.97	-0.35E-01	0.35E 00	450.25	452.85
1.	200.00	170.70	-0.16E 01	0.16E 02	293.00	295.60
10.	170.70	165.50	-0.16E 00	0.16E 01	345.00	347.60
30.	165.50	165.50	-0.14E 00	0.14E 01	345.00	347.60
121.	165.50	155.00	-0.10E-01	0.10E 00	450.00	452.60
277.	155.00	164.20	-0.47E-02	0.47E-01	358.00	360.60

PHOSPHORUS SORPTION ISOTHERM

SOIL X

RESIN EXTRACTABLE PHOSPHORUS ON SOIL BEFORE SORPTION 2.5 PPM

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	1.00	0.73	-0.19E 00	0.19E 01	2.62	5.12
10.	0.73	0.22	-0.19E-01	0.19E 00	7.79	10.29
30.	0.22	0.11	-0.15E-02	0.15E-01	8.90	11.39
121.	0.11	0.10	-0.17E-03	0.17E-02	9.00	11.49
277.	0.10	0.05	-0.78E-04	0.78E-03	9.41	11.91
1.	5.00	3.51	-0.76E 00	0.76E 01	14.83	17.33
10.	3.51	1.82	-0.76E-01	0.76E 00	31.76	34.26
30.	1.82	0.88	-0.95E-02	0.95E-01	41.20	43.70
121.	0.88	1.06	-0.24E-02	0.24E-01	39.40	41.90
277.	1.06	0.11	-0.10E-02	0.10E-01	48.83	51.33
1.	10.00	7.91	-0.14E 01	0.14E 02	20.90	23.40
10.	7.91	4.94	-0.14E 00	0.14E 01	50.60	53.10
30.	4.94	2.98	-0.20E-01	0.20E 00	70.20	72.70
121.	2.98	3.28	-0.81E-02	0.81E-01	67.20	69.70
277.	3.28	0.46	-0.35E-02	0.35E-01	95.34	97.84
1.	40.00	31.55	-0.22E 01	0.22E 02	84.50	87.00
10.	31.55	28.19	-0.22E 00	0.22E 01	118.10	120.60
30.	28.19	23.50	-0.77E-01	0.77E 00	165.00	167.50
121.	23.50	22.20	-0.34E-01	0.34E 00	178.00	180.50
277.	22.20	13.32	-0.15E-01	0.15E 00	266.80	269.30
1.	100.00	84.70	-0.29E 01	0.29E 02	153.00	155.50
10.	84.70	82.10	-0.29E 00	0.29E 01	179.00	181.50
30.	82.10	73.50	-0.11E 00	0.11E 01	265.00	267.50
121.	73.50	73.00	-0.61E-01	0.61E 00	270.00	272.50
277.	73.00	55.27	-0.26E-01	0.26E 00	447.25	449.75
1.	200.00	174.55	-0.46E 01	0.46E 02	254.50	257.00
10.	174.55	166.80	-0.46E 00	0.46E 01	332.00	334.50
30.	166.80	158.00	-0.98E-01	0.98E 00	420.00	422.50
121.	158.00	159.00	-0.60E-01	0.60E 00	410.00	412.50
277.	159.00	139.60	-0.26E-01	0.26E 00	604.00	606.50

PHOSPHORUS SORPTION ISOTHERM

SOIL Y

RESIN EXTRACTABLE PHOSPHORUS ON SOIL BEFORE SORPTION 45.0 PPM

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	1.00	0.80	-0.82E-01	0.82E 00	2.00	47.00
3.	0.80	0.71	-0.27E-01	0.27E 00	2.90	47.90
10.	0.71	0.61	-0.78E-02	0.78E-01	3.90	48.90
30.	0.61	0.53	-0.23E-02	0.23E-01	4.70	49.70
100.	0.53	0.45	-0.60E-03	0.60E-02	5.50	50.49
300.	0.45	0.39	-0.20E-03	0.20E-02	6.09	51.09
1.	5.00	3.60	-0.63E 00	0.63E 01	14.00	59.00
3.	3.60	3.10	-0.21E 00	0.21E 01	19.00	64.00
10.	3.10	2.15	-0.67E-01	0.67E 00	28.50	73.50
30.	2.15	1.55	-0.15E-01	0.15E 00	34.50	79.50
100.	1.55	1.10	-0.34E-02	0.34E-01	39.00	84.00
300.	1.10	0.75	-0.11E-02	0.11E-01	42.50	87.49
1.	10.00	7.73	-0.15E 01	0.15E 02	22.70	67.70
3.	7.73	6.90	-0.51E 00	0.51E 01	31.00	76.00
10.	6.90	4.20	-0.16E 00	0.16E 01	58.00	103.00
30.	4.20	3.10	-0.29E-01	0.29E 00	69.00	114.00
100.	3.10	2.15	-0.66E-02	0.66E-01	78.50	123.50
300.	2.15	1.58	-0.22E-02	0.22E-01	84.20	129.20
1.	40.00	32.10	-0.31E 01	0.31E 02	79.00	124.00
3.	32.10	30.00	-0.10E 01	0.10E 02	100.00	145.00
10.	30.00	25.00	-0.34E 00	0.34E 01	150.00	195.00
30.	25.00	22.00	-0.11E 00	0.11E 01	180.00	225.00
100.	22.00	17.30	-0.32E-01	0.32E 00	227.00	272.00
300.	17.30	14.50	-0.10E-01	0.10E 00	254.99	299.99
1.	100.00	85.80	-0.38E 01	0.38E 02	142.00	187.00
3.	85.80	85.40	-0.12E 01	0.12E 02	146.00	191.00
10.	85.40	77.00	-0.79E 00	0.79E 01	230.00	275.00
30.	77.00	67.00	-0.25E 00	0.25E 01	330.00	375.00
100.	67.00	59.50	-0.60E-01	0.60E 00	405.00	450.00
300.	59.50	53.00	-0.20E-01	0.20E 00	470.00	515.00

PHOSPHORUS SORPTION ISOTHERM

SOIL Z

RESIN EXTRACTABLE PHOSPHORUS ON SOIL BEFORE SORPTION 8.5 PPM

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	1.00	0.41	-0.73E-01	0.73E 00	5.85	14.35
3.	0.41	0.32	-0.24E-01	0.24E 00	6.80	15.30
10.	0.32	0.24	-0.56E-02	0.56E-01	7.55	16.05
30.	0.24	0.19	-0.14E-02	0.14E-01	8.10	16.60
100.	0.19	0.14	-0.33E-03	0.33E-02	8.55	17.04
300.	0.14	0.11	-0.11E-03	0.11E-02	8.88	17.37
1.	5.00	2.34	-0.62E 00	0.62E 01	26.53	35.03
3.	2.34	1.60	-0.20E 00	0.20E 01	34.00	42.50
10.	1.60	0.90	-0.46E-01	0.46E 00	41.00	49.50
30.	0.90	0.54	-0.85E-02	0.85E-01	44.59	53.09
100.	0.54	0.30	-0.15E-02	0.15E-01	46.95	55.45
300.	0.30	0.18	-0.52E-03	0.52E-02	48.20	56.70
1.	10.00	6.42	-0.16E 01	0.16E 02	35.74	44.24
3.	6.42	4.50	-0.56E 00	0.56E 01	55.00	63.50
10.	4.50	2.55	-0.13E 00	0.13E 01	74.50	83.00
30.	2.55	1.50	-0.24E-01	0.24E 00	85.00	93.50
100.	1.50	0.86	-0.42E-02	0.42E-01	91.40	99.90
300.	0.86	0.51	-0.14E-02	0.14E-01	94.84	103.34
1.	40.00	29.87	-0.34E 01	0.34E 02	101.30	109.80
3.	29.87	27.00	-0.11E 01	0.11E 02	130.00	138.50
10.	27.00	22.00	-0.36E 00	0.36E 01	180.00	188.50
30.	22.00	18.50	-0.96E-01	0.96E 00	215.00	223.50
100.	18.50	15.30	-0.24E-01	0.24E 00	247.00	255.50
300.	15.30	12.80	-0.82E-02	0.82E-01	272.00	280.50
1.	100.00	89.47	-0.80E 01	0.80E 02	105.30	113.80
3.	89.47	80.00	-0.26E 01	0.26E 02	200.00	208.50
10.	80.00	71.00	-0.75E 00	0.75E 01	290.00	298.50
30.	71.00	62.50	-0.20E 00	0.20E 01	375.00	383.50
100.	62.50	56.80	-0.49E-01	0.49E 00	432.00	440.50
300.	56.80	51.00	-0.16E-01	0.16E 00	490.00	498.50

PHOSPHORUS SORPTION ISOTHERM

SOIL AA

RESIN EXTRACTABLE PHOSPHORUS ON SOIL BEFORE SORPTION 8.9 PPM

TIME HRS	INITIAL CONC MG/L	FINAL CONC MG/L	DC DT PPM/HR	DS DT PPM/HR	SUM P SORBED PPM	SUM P ON SOIL PPM
1.	1.00	0.56	-0.10E 00	0.10E 01	4.36	13.26
3.	0.56	0.47	-0.33E-01	0.33E 00	5.30	14.20
10.	0.47	0.33	-0.11E-01	0.11E 00	6.70	15.60
30.	0.33	0.19	-0.23E-02	0.23E-01	8.05	16.95
100.	0.19	0.16	-0.15E-03	0.15E-02	8.35	17.25
300.	0.16	0.16	-0.51E-04	0.51E-03	8.39	17.29
1.	5.00	3.11	-0.52E 00	0.52E 01	18.90	27.80
3.	3.11	2.65	-0.17E 00	0.17E 01	23.50	32.40
10.	2.65	1.90	-0.75E-01	0.75E 00	31.00	39.90
30.	1.90	0.90	-0.20E-01	0.20E 00	41.00	49.90
100.	0.90	0.48	-0.26E-02	0.26E-01	45.20	54.09
300.	0.48	0.29	-0.88E-03	0.88E-02	47.09	55.99
1.	10.00	7.29	-0.11E 01	0.11E 02	27.10	36.00
3.	7.29	6.50	-0.37E 00	0.37E 01	35.00	43.89
10.	6.50	4.70	-0.16E 00	0.16E 01	53.00	61.89
30.	4.70	2.75	-0.52E-01	0.52E 00	72.50	81.40
100.	2.75	1.10	-0.95E-02	0.95E-01	89.00	97.90
300.	1.10	0.56	-0.31E-02	0.31E-01	94.40	103.29
1.	40.00	32.00	-0.28E 01	0.28E 02	80.00	88.90
3.	32.00	29.50	-0.94E 00	0.94E 01	105.00	113.90
10.	29.50	25.50	-0.41E 00	0.41E 01	145.00	153.90
30.	25.50	20.00	-0.19E 00	0.19E 01	200.00	208.90
100.	20.00	11.80	-0.54E-01	0.54E 00	282.00	290.90
300.	11.80	7.50	-0.18E-01	0.18E 00	325.00	333.89
1.	100.00	87.14	-0.44E 01	0.44E 02	128.60	137.50
3.	87.14	85.00	-0.14E 01	0.14E 02	150.00	158.90
10.	85.00	77.00	-0.99E 00	0.99E 01	230.00	238.90
30.	77.00	62.00	-0.40E 00	0.40E 01	380.00	388.90
100.	62.00	49.00	-0.10E 00	0.10E 01	510.00	518.90
300.	49.00	39.00	-0.33E-01	0.33E 00	610.00	618.90

APPENDIX E

COMPARISON OF SORPTION MODELS

In this appendix one can compare the measured amount of sorption listed in Appendix D with the calculated amount of sorption for any of the five kinetic models, along with the computer program used to develop the tables. The regression coefficients used in these calculations are tabulated in Table 4. The time and measured amount of sorption are the same as that given in Appendix D. The remaining five columns labeled 1 through 5 are for the five kinetic models described in the report.

Column 1 - refers to Equation (15).

Column 2 - refers to Equation (13).

Column 3 - refers to Equation (14).

Column 4 - refers to the diffusion limited model Equation (8) with Freundlich sorption Equation (2).

Column 5 - refers to the diffusion limited model Equation (8) with Langmuir sorption Equation (1).

PAGE 1

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// JOB

LOG DRIVE   CART SPEC   CART AVAIL  PHY DRIVE
  0000        7207        7207        0000

V2 M10   ACTUAL 16K  CONFIG  8K

// FOR
*IOCS(CARD,TYPEWRITER,DISK,1132 PRINTER,KEYBOARD)
*EXTENDED PRECISION
*ONE WORD INTEGERS
*LIST SOURCE PROGRAM
      DIMENSION CI(10,6),FC(10,6),S1(10,6),S2(10,6),S3(10,6),S4(10,6),
     *S5(10,6),SPAD(10,6),CAVG(10,6),T(10)
      DIMENSION TA(11),CAV(11,6)
  500 FORMAT('1'/////
     1   '                          SORPTION MODEL COMPARISON'//
     2   '                                   SOIL ',A2,///'-----------------
     3------------------------------------------')
  501 FORMAT (
     4   '                                        SORPTION (PPM)'/
     5   '              ---------------------------------------------------
     6---'/
     7   ' TIME                                          CALCULATED')
  502 FORMAT (
     8   ' (HRS)   MEASURED  --------------------------------------------
     9---'/
     *   '                          1         2         3         4        5'
     */  '--------------------------------------------------------------------
     *---'/)
  510 FORMAT (2X,F5.0,F9.2,2X,5F9.1)
  520 FORMAT (/)
  523 FORMAT ('1'/////21X' SOIL ',A2,' CONTINUED'///)
  100 FORMAT(I3)
      READ(2,100)N
C     N IS THE NUMBER OF SOIL SAMPLES
      DO 1000 ID=1,N
  110 FORMAT(A2)
      READ(2,110)SN
  115 FORMAT(2I5)
      READ(2,115)IN,JN
C     SN IS SOIL NAME, IN=NO. OF TIMES, JN=NO. OF CONCENTRATIONS
  130 FORMAT(5F10.0)
      READ(2,130)(T(I),I=1,IN)
C     T IS THE TIMES MEASUREMENTS TAKEN
  140 FORMAT(10F7.3)
      READ(2,140)(CI(1,J),J=1,JN)
C     CI IS INITIAL CONCENTRATIONS
      DO 150 I=1,IN
  150 READ(2,140)(FC(I,J),J=1,JN)
C     FC ARE MEASURED CONCENTRATIONS
      DO 1 I=2,IN
      DO 1 J=1,JN
    1 CI(I,J)=0.95*FC(I-1,J)+0.05*CI(1,J)
      DO 3 I=1,IN
      DO 3 J=1,JN
      PAD=(CI(I,J)-FC(I,J))/10.
      IF(I-1)8,8,9
    8 SPAD(I,J)=PAD*100.
      GO TO 10
    9 SPAD(I,J)=SPAD(I-1,J)+(PAD*100.)
```

```
   10 CONTINUE
    3 CONTINUE
      DO 20 I=1,IN
      DO 20 J=1,JN
   20 CAVG(I,J)=(CI(I,J)+FC(I,J))/2.
      READ (2,130)
      READ(2,130)A,B,D
      DO 30 J=1,JN
      DO 30 I=1,IN
      S1(I,J)=0.
      DO 40 JJ=1,I
      IF(I-1)35,35,45
   35 TT=T(I)
      S1(I,J)= ((CAVG(I,J)**B)*(1.-D)*A*TT)**(1./(1.-D))
      GO TO 40
   45 TT=T(I)-T(JJ-1)
      S1(I,J)=((CAVG(I,J)**B)*(1.-D)*A*TT+S1(I-1,J))**(1./(1.-D))
   40 CONTINUE
   30 CONTINUE
      READ(2,130)A,X
      DO 50 J=1,JN
      DO 50 I=1,IN
      S2(I,J)=0.
      DO 60 JJ=1,I
      IF(I-1)55,55,65
   55 TT=T(I)
      S2(I,J)=(CAVG(I,J)*X)-((CAVG(I,J)*X)/(EXP(A*TT)))
      GO TO 60
   65 TT=T(I)-T(JJ-1)
      S2(I,J)=(CAVG(I,J)*X)-((CAVG(I,J)*X)-S2(I-1,J))/EXP(A*TT)
   60 CONTINUE
   50 CONTINUE
      READ(2,130)A,X,Y
      DO 70 J=1,JN
      DO 70 I=1,IN
      S3(I,J)=0.
      DO 80 JJ=1,I
      IF(I-1)75,75,85
   75 TT=T(I)
      S3(I,J)=(CAVG(I,J)**Y)*X-((CAVG(I,J)**Y)*X/(EXP(A*TT)))
      GO TO 80
   85 TT=T(I)-T(JJ-1)
      S3(I,J)=(CAVG(I,J)**Y)*X-(((CAVG(I,J)**Y)*X)-S3(I-1,J))/EXP(A*TT)
   80 CONTINUE
   70 CONTINUE
      READ (2,130)EX,X,Y
      FXK=10.**(-EX)
      PI2=9.8696
C     DATA CONVERSION FOR INDEXING
      IIN=IN+1
      DO 300 J=1,JN
      DO 300 I=2,IIN
  300 CAV(I,J)=CAVG(I-1,J)
      DO 310 I=2,IIN
  310 TA(I)=T(I-1)
      TA(1)=0.0
      DO 320 J=1,JN
  320 CAV(1,J)=0.
      DO 90 J=1,JN
      DO 90 I=2,IIN
      S4(I,J)=0.
```

```
      DO 101 JJ=2,I
      TT=TA(I)-TA(JJ-1)
      CC=(CAV(JJ,J)**Y)*X-((CAV(JJ-1,J)**Y)*X )
      SUMX=0.
      DO 210 N=1,10
      XJ = (1./(N**2.))*EXP((-1.)*FXK*TT*PI2*(N**2.))
  210 SUMX=SUMX + XJ
      YJ=CC*(1.-(0.6092*SUMX))
  101 S4(I,J) = YJ + S4(I,J)
   90 CONTINUE
      READ (2,130) EX,SMAX,B
      FXK = 10**(-EX)
      DO 220 J=1,JN
      DO 220 I=2,IIN
      S5(I,J)=0.
      DO 230 JJ=2,I
      TT=TA(I)-TA(JJ-1)
      CC=((CAV(JJ,J)*SMAX*B)/(1.+B*CAV(JJ,J)))-((CAV(JJ-1,J)*SMAX*B)/
     2(1.+B*CAV(JJ-1,J)))
      SUMX=0.
      DO 250 N=1,10
      XJ = (1./(N**2.))*EXP((-1.)*FXK*TT*PI2*(N**2.))
  250 SUMX =SUMX + XJ
      YJ=CC*(1.-(0.6092*SUMX))
  230 S5(I,J)= YJ +S5(I,J)
  220 CONTINUE
      WRITE(3,500)SN
      WRITE (3,501)
      WRITE (3,502)
      ICNT=16
      DO 280 J=1,JN
      WRITE(3,510)(T(I),SPAD(I,J),S1(I,J),S2(I,J),S3(I,J),S4(I+1,J),
     *S5(I+1,J),I=1,IN)
      WRITE(3,520)
      ICNT=ICNT+IN+2
      IDUM=54-IN
      IF(ICNT-IDUM)522,521,521
  521 IF (J-JN)524,280,280
  524 WRITE(3,523)SN
      WRITE (3,501)
      WRITE(3,502)
      ICNT=5
      GO TO 280
  522 CONTINUE
  280 CONTINUE
 1000 CONTINUE
      CALL EXIT
      END

FEATURES SUPPORTED
 ONE WORD INTEGERS
 EXTENDED PRECISION
 IOCS

CORE REQUIREMENTS FOR
 COMMON        0  VARIABLES    1956  PROGRAM   1920

END OF COMPILATION

// XEQ
```

SORPTION MODEL COMPARISON

SOIL A

TIME (HRS)	SORPTION (PPM) MEASURED	CALCULATED 1	2	3	4	5
1.	2.69	2.0	0.0	0.3	4.0	1.5
3.	2.69	2.3	0.0	0.9	3.7	2.2
10.	4.20	3.1	0.0	2.8	3.7	3.6
30.	5.90	3.6	0.1	6.7	3.5	5.0
100.	6.73	4.6	0.3	13.4	3.9	6.8
300.	7.53	5.7	0.9	16.3	5.4	8.2
387.	8.28	4.2	1.1	15.8	5.8	7.9
1016.	8.37	7.3	2.6	15.4	8.8	7.8
3001.	9.05	10.1	7.3	15.3	14.2	7.7
1.	6.98	6.4	0.0	0.6	10.4	4.3
3.	7.92	7.5	0.0	1.9	10.1	6.6
10.	9.86	10.7	0.3	6.1	10.2	11.5
30.	13.43	14.0	0.8	15.8	10.7	18.5
100.	16.79	19.2	2.6	33.6	12.8	29.0
300.	21.54	24.6	7.4	41.9	18.0	38.0
387.	23.65	18.3	9.3	41.3	19.5	38.6
1016.	24.83	32.3	22.9	40.6	29.9	39.8
3001.	28.11	44.0	63.8	39.9	48.1	39.0
1.	11.56	10.4	0.0	0.9	15.5	5.4
3.	11.65	12.3	0.1	2.7	15.2	8.4
10.	13.89	17.7	0.6	8.5	15.5	14.8
30.	18.13	23.7	1.8	22.1	16.5	24.2
100.	24.58	33.0	5.9	47.5	20.0	38.7
300.	31.68	42.8	16.6	60.0	28.3	52.0
387.	33.94	32.5	21.1	59.7	31.2	53.7
1016.	35.47	57.9	53.2	59.5	48.3	56.3
3001.	41.25	79.5	151.4	58.7	78.3	55.9

SOIL A CONTINUED

TIME (HRS)	SORPTION (PPM)					
	MEASURED	CALCULATED				
		1	2	3	4	5
1.	24.90	27.2	0.2	1.7	34.3	6.7
3.	48.94	32.0	0.7	5.0	33.4	10.5
10.	27.32	46.4	2.6	15.9	34.5	18.5
30.	42.91	63.6	7.8	41.9	37.5	30.4
100.	66.71	89.0	25.4	90.5	45.4	49.1
300.	79.71	117.6	73.3	115.8	65.2	67.1
387.	91.91	90.4	93.6	115.9	72.2	69.9
1016.	89.65	161.4	239.7	115.8	112.6	73.8
3001.	113.07	223.0	690.2	114.7	183.5	73.7
1.	187.40	48.4	0.6	2.5	55.3	7.0
3.	64.96	58.3	1.9	7.4	54.9	11.0
10.	55.75	88.6	6.6	24.0	58.9	19.4
30.	57.92	121.2	20.2	63.6	63.9	31.9
100.	116.50	171.7	66.6	138.5	78.1	51.7
300.	136.50	228.0	194.1	178.0	112.7	70.9
387.	157.65	176.5	248.6	178.9	125.2	73.9
1016.	172.97	312.9	637.4	178.2	194.7	78.1
3001.	208.13	432.5	1836.[illegible]	176.5	317.5	78.1

SORPTION MODEL COMPARISON

SOIL B

TIME (HRS)	SORPTION (PPM) MEASURED	CALCULATED 1	2	3	4	5
1.	8.84	14.4	0.1	2.2	18.9	26.5
3.	8.77	8.3	0.2	4.4	11.7	11.1
10.	9.81	11.3	0.5	11.5	15.2	13.9
30.	10.51	12.4	1.1	24.2	20.5	16.6
102.	10.93	16.7	3.1	42.9	33.9	25.8
300.	11.35	22.4	8.4	50.1	55.2	41.9
387.	11.77	18.3	10.7	50.9	62.1	47.4
1000.	11.48	37.4	30.4	59.8	103.4	88.4
3010.	13.55	41.1	50.8	49.1	121.4	91.2
1.	34.31	42.3	0.8	5.5	47.5	80.2
3.	47.66	25.9	1.4	11.5	31.0	50.7
10.	51.34	21.5	2.3	23.2	28.1	38.7
30.	54.58	24.2	4.1	44.8	37.3	47.0
102.	57.38	30.4	9.4	72.9	57.9	66.6
300.	60.01	37.5	21.7	77.9	87.5	95.3
387.	62.49	29.2	26.5	76.5	95.8	103.0
1000.	64.32	53.2	60.0	80.8	143.2	157.1
3010.	67.59	71.2	119.3	78.7	192.1	207.2
1.	49.68	69.9	2.0	8.5	73.1	104.7
3.	73.02	58.6	4.3	20.7	61.1	99.2
10.	96.91	54.2	8.3	47.4	60.3	102.5
30.	105.21	45.0	13.4	81.6	66.4	107.0
102.	111.58	52.5	26.3	119.0	95.0	143.7
300.	117.40	61.0	53.3	118.4	135.3	193.4
387.	122.39	45.9	63.1	113.5	145.5	204.3
1000.	127.28	77.4	122.2	111.5	201.7	276.5
3010.	133.02	101.0	219.1	106.3	261.0	345.8

SOIL 8 CONTINUED

TIME (HRS)	SORPTION (PPM) MEASURED	CALCULATED 1	2	3	4	5
1.	126.80	173.5	9.2	18.7	159.6	128.2
3.	203.94	171.0	22.3	49.2	151.9	140.4
10.	281.22	197.1	55.4	131.0	175.0	183.0
30.	319.36	219.2	125.3	280.9	238.8	277.1
102.	373.96	261.4	310.1	460.8	365.2	470.1
300.	405.46	283.7	652.1	442.9	506.0	716.6
387.	426.61	208.8	772.2	417.9	539.0	781.6
1000.	451.55	335.0	1419.6	392.1	716.6	1087.5
3010.	481.87	411.7	2300.6	354.8	877.5	1398.4
1.	50.80	330.4	26.6	32.5	277.4	133.9
3.	321.94	358.3	71.2	90.2	285.1	149.5
10.	476.90	425.9	189.3	249.2	336.6	199.3
30.	557.43	512.2	473.2	566.8	486.7	310.8
102.	627.22	683.3	1379.6	1032.1	814.9	550.2
300.	695.22	851.7	3519.8	1134.1	1261.5	890.9
387.	773.22	639.4	4303.6	1087.6	1364.3	990.3
1000.	836.62	1021.2	8504.1	1020.4	1847.0	1427.6
3010.	918.77	1313.9	15134.5	960.3	2361.1	1942.9

SORPTION MODEL COMPARISON

SOIL C

TIME (HRS)	SORPTION (PPM) MEASURED	CALCULATED 1	2	3	4	5
1.	8.33	9.7	0.0	1.0	31.0	24.5
3.	8.49	5.9	0.1	2.1	32.5	12.5
10.	10.82	5.9	0.2	4.4	41.2	11.6
30.	9.65	7.6	0.5	9.3	60.3	16.3
100.	10.33	15.0	2.0	22.1	114.7	39.6
300.	10.96	18.5	5.7	24.4	136.6	58.8
410.	11.44	14.7	7.6	23.4	134.7	63.7
1015.	11.51	26.0	18.4	25.0	143.2	93.2
3025.	13.47	27.0	34.7	18.6	111.0	77.0
1.	32.76	31.2	0.4	3.1	80.0	79.0
3.	44.94	20.0	0.7	6.4	87.1	56.0
10.	50.75	17.3	1.2	12.7	101.8	49.8
30.	52.85	19.1	2.3	23.5	132.0	61.2
100.	56.78	24.5	5.6	37.3	179.5	87.2
300.	59.50	27.5	12.3	35.5	190.7	109.1
410.	62.04	22.0	15.7	34.1	187.1	116.8
1015.	64.07	37.5	34.1	35.1	192.5	158.7
3025.	67.01	52.2	82.5	34.5	189.9	191.9
1.	74.50	47.2	0.8	4.6	112.1	100.9
3.	79.02	32.9	1.4	9.8	128.2	86.4
10.	95.89	38.9	3.2	23.7	184.4	108.2
30.	105.30	36.0	6.1	43.0	222.8	128.7
100.	111.97	41.0	13.1	61.6	276.6	169.6
300.	117.54	49.1	29.2	60.9	304.6	229.0
410.	122.55	39.2	37.2	58.5	299.1	247.0
1015.	127.39	63.6	77.8	57.5	295.9	321.2
3025.	132.94	86.4	179.8	55.3	285.9	375.7

SOIL C CONTINUED

TIME (HRS)	SORPTION (PPM)					
	MEASURED	CALCULATED				
		1	2	3	4	5
1.	170.00	137.8	4.0	12.5	267.9	135.6
3.	222.50	129.6	9.4	31.5	369.8	154.2
10.	273.20	161.7	24.7	84.6	572.6	219.6
30.	304.89	194.2	60.9	187.3	833.1	350.6
100.	340.54	252.7	169.3	324.3	1181.3	598.2
300.	377.29	301.6	418.4	331.9	1329.5	928.9
410.	395.74	233.7	535.7	310.7	1281.7	1033.3
1015.	413.22	377.4	1130.7	303.4	1259.3	1398.0
3025.	440.28	509.0	2604.5	289.9	1210.2	1711.7
1.	310.00	265.3	10.7	23.1	456.5	143.2
3.	397.50	275.7	27.6	61.7	672.3	167.7
10.	454.60	375.0	81.9	179.1	1116.3	244.3
30.	513.59	487.6	227.1	428.2	1733.1	399.6
100.	563.49	675.2	703.9	801.4	2602.7	699.3
300.	612.74	886.6	1973.4	906.9	3178.5	1125.0
410.	689.24	709.2	2602.6	872.7	3139.1	1272.2
1015.	719.29	1121.2	5686.4	839.1	3054.0	1744.9
3025.	778.44	1549.4	13669.7	820.0	2993.3	2179.5

SORPTION MODEL COMPARISON

SOIL D

TIME (HRS)	SORPTION (PPM) MEASURED	CALCULATED 1	2	3	4	5
1.	9.46	13.9	0.0	3.3	29.4	58.6
3.	10.47	4.2	0.0	8.5	18.1	19.1
10.	10.97	3.8	0.1	25.0	21.9	16.4
30.	10.06	11.0	0.4	76.4	51.0	56.1
100.	10.90	19.1	1.8	229.6	103.4	136.6
317.	11.35	23.3	5.6	471.4	162.5	206.8
410.	12.02	17.8	7.1	516.6	175.3	217.8
1015.	11.73	32.5	18.4	606.2	243.1	323.4
3025.	13.68	36.0	38.9	588.4	246.0	281.9
1.	35.03	40.4	0.4	4.1	56.7	100.8
3.	46.07	25.8	0.8	11.4	51.0	103.2
10.	51.17	23.0	1.3	34.5	63.3	125.7
30.	53.65	25.1	2.5	94.0	92.6	176.6
100.	56.99	31.6	5.9	259.6	148.5	273.1
317.	59.65	37.7	14.6	518.8	221.8	388.0
410.	62.11	29.5	18.0	568.4	240.4	416.0
1015.	63.94	50.4	41.7	658.8	320.7	563.3
3025.	67.44	64.7	100.0	657.2	352.6	603.2
1.	55.44	64.4	1.0	4.5	75.6	109.2
3.	80.99	49.9	2.0	12.8	75.3	129.2
10.	96.32	46.9	3.9	39.1	96.6	184.9
30.	103.06	47.0	7.3	106.2	137.1	276.6
100.	110.25	56.5	16.6	290.5	213.7	439.2
317.	116.48	65.2	38.7	576.2	312.5	640.7
410.	121.68	48.5	46.6	628.3	332.5	677.8
1015.	126.26	77.5	95.4	715.1	422.1	856.4
3025.	131.93	102.0	221.2	715.9	466.7	940.5

SOIL D CONTINUED

TIME (HRS)	SORPTION (PPM) MEASURED	CALCULATED 1	2	3	4	5
1.	159.20	153.7	4.7	5.3	129.3	115.3
3.	204.36	149.6	11.4	15.5	145.8	144.5
10.	252.58	185.3	31.1	49.7	216.9	227.8
30.	294.22	216.1	77.3	139.2	339.6	379.3
100.	334.75	264.8	209.1	386.6	547.5	653.3
317.	372.35	311.9	531.7	772.6	815.9	1041.9
410.	391.40	233.3	649.6	843.4	870.8	1140.3
1015.	412.01	365.7	1344.7	957.9	1098.7	1487.6
3025.	445.01	459.8	2981.1	950.8	1181.8	1675.6
1.	223.40	278.8	13.1	5.9	186.7	116.5
3.	349.77	295.1	34.6	17.5	220.4	146.7
10.	419.50	378.5	101.5	56.6	335.0	232.0
30.	482.26	472.8	278.1	160.5	544.8	388.2
100.	559.39	618.6	842.4	451.6	915.4	672.8
317.	623.89	783.0	2408.6	916.0	1426.4	1081.8
410.	694.39	600.9	3008.5	1003.2	1538.9	1188.1
1015.	725.29	939.3	6527.6	1143.9	1959.5	1557.0
3025.	827.50	1208.9	15231.7	1140.8	2144.2	1767.2

SORPTION MODEL COMPARISON

SOIL E

TIME (HRS)	SORPTION (PPM) MEASURED	CALCULATED 1	2	3	4	5
1.	6.07	2.1	0.0	0.5	14.4	17.8
3.	7.88	2.1	0.1	1.3	10.1	9.8
10.	8.77	2.4	0.3	3.5	10.9	9.0
30.	9.58	3.1	0.7	9.1	14.9	10.9
100.	10.31	4.6	1.9	26.3	22.6	15.4
295.	11.00	6.2	4.7	65.6	32.4	21.0
363.	11.49	3.9	5.5	77.3	33.9	21.7
1014.	10.94	13.4	16.7	191.2	59.0	41.2
3000.	12.95	18.9	40.5	317.3	71.3	50.5
1.	20.53	11.1	0.4	1.4	47.2	79.2
3.	24.66	11.8	1.0	3.9	42.7	67.0
10.	34.72	17.2	2.8	11.4	49.7	70.0
30.	40.33	21.3	6.4	29.3	64.3	81.2
100.	45.65	30.7	16.2	82.3	94.7	113.3
295.	49.65	40.5	37.5	200.6	131.2	151.2
363.	52.22	22.1	43.9	235.5	136.8	155.8
1014.	53.79	64.9	103.9	504.5	193.6	221.8
3000.	59.09	96.0	238.8	819.2	235.1	275.8
1.	35.78	22.0	0.9	2.1	77.3	126.8
3.	48.10	23.4	2.2	5.8	70.8	114.1
10.	62.18	35.4	6.0	17.2	84.0	125.3
30.	72.00	48.7	14.9	46.3	116.1	161.9
100.	85.25	72.0	39.4	133.2	175.0	239.0
295.	104.00	75.1	80.5	300.5	212.9	280.7
363.	116.44	21.6	86.3	329.8	184.6	233.5
1014.	113.39	62.2	141.0	558.6	206.4	245.5
3000.	122.94	122.0	314.2	934.9	278.8	348.3

SOIL E CONTINUED

TIME (HRS)	SORPTION (PPM) MEASURED	CALCULATED 1	2	3	4	5
1.	86.10	87.5	3.9	4.8	210.1	224.4
3.	104.80	107.4	10.8	13.6	214.7	234.2
10.	154.12	180.2	32.7	43.0	271.2	284.0
30.	236.56	241.3	81.9	116.3	371.2	392.5
100.	357.56	271.2	183.0	302.4	477.4	573.1
295.	418.06	203.5	301.0	592.3	475.8	640.4
363.	451.91	63.9	320.2	647.9	424.2	570.4
1014.	478.25	120.2	422.2	926.4	370.4	496.6
3000.	500.55	155.6	606.4	1156.2	353.8	482.3
1.	151.60	213.3	10.3	8.0	401.3	261.2
3.	183.17	273.8	29.0	23.2	423.3	279.2
10.	287.75	470.8	90.0	74.4	543.3	344.2
30.	509.92	643.6	230.5	203.4	753.7	493.5
100.	823.92	750.1	530.4	538.4	992.4	796.9
295.	1042.42	538.5	864.3	1046.0	970.9	1048.5
363.	1129.70	118.3	899.6	1117.1	806.0	916.9
1014.	1186.53	211.2	1067.3	1428.1	615.8	803.0
3000.	1232.21	348.6	1492.4	1828.4	633.9	949.3

SORPTION MODEL COMPARISON

SOIL F

TIME (HRS)	SORPTION (PPM) MEASURED	CALCULATED 1	2	3	4	5
1.	7.21	7.2	0.0	0.6	16.9	13.8
3.	8.19	4.9	0.1	1.4	18.1	7.3
10.	9.34	5.9	0.3	3.7	25.3	7.6
30.	9.88	7.0	0.6	9.1	34.5	9.6
100.	10.66	9.3	1.6	22.9	47.6	14.0
295.	11.26	11.1	3.1	39.9	52.2	18.8
363.	11.74	7.6	3.4	42.3	51.1	19.7
1014.	11.33	19.7	6.5	58.2	63.2	37.1
3000.	13.19	23.7	5.8	51.5	54.6	42.0
1.	14.99	27.6	0.5	1.9	54.9	56.7
3.	35.78	23.9	1.1	4.7	69.6	47.3
10.	45.94	20.5	2.1	10.9	79.5	38.5
30.	50.17	19.2	3.5	22.8	89.8	39.8
100.	53.24	24.1	7.1	51.3	113.2	53.2
295.	56.76	28.8	12.6	86.1	121.2	69.8
363.	59.32	18.4	13.4	89.5	114.0	70.3
1014.	60.95	39.6	18.5	101.9	116.8	100.6
3000.	65.22	49.9	16.7	93.1	105.1	116.7
1.	29.99	44.9	1.0	2.8	84.4	78.1
3.	53.57	43.6	2.4	7.4	115.9	76.1
10.	74.00	49.1	5.8	19.9	161.6	85.5
30.	84.59	53.3	12.3	47.1	209.8	111.1
100.	94.44	66.2	27.7	111.9	271.8	163.7
295.	104.59	73.5	48.1	182.7	277.0	215.2
363.	110.58	44.1	50.4	186.6	251.4	213.4
1014.	115.85	84.2	56.4	186.8	227.2	267.4
3000.	122.62	108.7	50.6	172.9	208.6	314.7

SOIL F CONTINUED

TIME (HRS)	SORPTION (PPM)					
	MEASURED	CALCULATED				
		1	2	3	4	5
1.	105.30	121.0	4.2	6.2	202.0	109.1
3.	147.66	129.0	11.0	17.0	296.4	118.8
10.	185.98	175.2	31.7	51.7	478.4	156.5
30.	231.06	220.5	81.1	136.8	706.4	239.8
100.	281.56	285.8	207.1	348.2	972.6	406.8
295.	319.06	343.5	404.2	610.3	1070.4	633.2
363.	359.51	215.1	434.5	634.2	999.2	673.6
1014.	433.79	321.6	399.0	546.4	740.1	863.5
3000.	476.04	269.8	185.9	356.6	464.8	824.7
1.	175.60	238.8	11.1	10.6	367.6	118.5
3.	232.78	272.0	30.8	30.3	565.7	132.0
10.	303.38	385.1	94.3	95.2	948.8	176.7
30.	434.14	492.1	249.2	256.8	1425.8	275.2
100.	554.14	647.2	653.2	663.6	1993.0	479.0
295.	679.14	781.6	1292.3	1171.7	2207.7	767.9
363.	754.54	499.3	1399.6	1224.6	2085.6	831.9
1014.	988.61	782.5	1383.2	1106.5	1620.4	1184.1
3000.	1137.82	631.2	622.5	701.5	983.0	1362.1

SORPTION MODEL COMPARISON

SOIL G

TIME (HRS)	SORPTION (PPM)					
	MEASURED	CALCULATED				
		1	2	3	4	5
1.	-0.49	0.0	0.0	0.0	0.3	0.2
3.	-0.32	0.0	0.0	0.1	0.5	0.4
10.	-0.34	0.2	0.0	0.3	0.6	0.5
30.	-0.35	0.3	0.1	1.1	0.7	0.5
100.	0.22	0.4	0.4	3.1	0.6	0.5
300.	0.34	0.2	1.2	6.5	0.6	0.5
1007.	0.46	0.9	3.9	9.1	0.6	0.5
3004.	1.78	1.1	9.2	8.7	0.5	0.4
1.	0.20	0.0	0.0	0.0	0.5	0.4
3.	1.11	0.1	0.0	0.1	0.7	0.7
10.	0.56	0.2	0.0	0.4	0.9	0.9
30.	0.28	0.2	0.2	1.3	1.0	1.0
100.	0.69	0.4	0.8	3.9	1.0	1.0
300.	1.52	0.8	2.4	8.1	1.0	0.9
1007.	1.29	2.0	7.6	11.2	1.0	0.9
3004.	2.91	3.5	18.9	11.2	0.9	0.8
1.	1.20	0.2	0.0	0.0	1.0	1.1
3.	1.75	0.1	0.0	0.2	1.5	1.7
10.	1.84	0.4	0.2	0.6	2.0	2.4
30.	1.92	0.9	0.7	1.9	2.1	2.5
100.	0.91	2.3	2.5	5.6	2.2	2.5
300.	2.74	4.4	7.6	11.8	2.1	2.5
1007.	1.26	10.0	24.4	16.6	2.1	2.5
3004.	2.30	19.2	64.8	16.9	2.2	2.5
1.	1.20	0.6	0.0	0.0	1.8	2.0
3.	4.06	0.4	0.1	0.2	2.7	3.1
10.	3.85	1.7	0.6	0.8	3.6	4.2
30.	3.73	3.1	1.8	2.5	3.8	4.4
100.	2.00	7.4	6.0	7.4	3.8	4.4
300.	5.67	13.8	17.9	15.7	3.8	4.4
1007.	2.32	30.5	57.5	22.0	3.8	4.4
3004.	6.09	57.2	151.2	22.4	3.8	4.4
1.	2.00	1.6	0.1	0.1	3.0	2.9
3.	3.70	1.8	0.4	0.3	4.5	4.4
10.	7.08	4.7	1.3	1.1	6.0	6.0
30.	6.51	8.9	3.9	3.2	6.3	6.3
100.	6.31	19.8	13.0	9.5	6.4	6.3
300.	13.98	36.5	38.0	20.1	6.3	6.2
1007.	2.62	81.1	122.9	28.3	6.3	6.3
3004.	6.46	157.4	330.6	29.1	6.4	6.3

SORPTION MODEL COMPARISON

SOIL H

TIME (HRS)	MEASURED	CALCULATED 1	CALCULATED 2	CALCULATED 3	CALCULATED 4	CALCULATED 5
1.	4.17	1.5	0.1	0.4	19.7	32.6
4.	6.83	2.1	0.2	1.2	17.5	48.8
10.	7.33	2.3	0.5	2.7	19.1	68.7
30.	8.37	3.3	1.3	6.9	27.6	107.5
100.	8.25	5.8	3.9	21.2	46.9	175.4
304.	9.13	9.9	11.0	59.4	76.5	255.3
1007.	9.90	15.9	28.0	149.0	113.1	289.2
3000.	9.40	30.0	61.4	289.9	161.4	304.7
1.	18.80	7.7	0.5	1.2	51.0	38.8
4.	26.14	10.2	1.6	4.3	49.6	63.5
10.	31.10	12.2	3.4	9.6	57.5	96.5
30.	39.04	17.8	8.2	24.5	79.5	157.4
100.	37.41	31.5	23.5	72.7	131.6	260.1
304.	44.20	52.1	63.0	197.4	208.4	378.9
1007.	51.10	69.5	137.2	443.2	277.8	439.3
3000.	59.30	63.0	165.3	550.6	263.3	390.2
1.	26.00	16.4	1.1	2.1	79.4	39.7
4.	41.70	23.3	3.7	7.7	81.5	65.8
10.	48.61	28.9	8.3	17.6	96.5	100.8
30.	67.58	44.3	20.5	46.1	136.1	166.5
100.	60.68	80.0	60.1	139.2	227.8	276.8
304.	82.28	125.5	157.0	370.5	352.5	404.1
1007.	104.43	131.4	290.1	735.2	415.0	472.2
3000.	114.01	108.5	311.4	836.2	368.9	436.7
1.	25.00	71.4	5.0	6.1	188.9	40.4
4.	77.95	115.7	18.7	23.2	210.7	67.3
10.	127.08	144.5	42.3	54.2	250.2	103.3
30.	245.58	203.0	100.3	137.6	338.4	171.6
100.	394.30	182.4	190.2	301.3	403.7	283.7
304.	433.07	89.4	246.3	461.1	351.9	398.3
1007.	457.42	97.3	312.2	703.8	370.4	458.9
3000.	476.60	147.4	388.9	971.7	429.3	456.6
1.	101.50	172.6	12.3	11.4	317.7	40.5
4.	142.07	287.3	46.8	43.9	360.4	67.5
10.	346.92	360.3	106.7	102.7	428.9	103.7
30.	537.17	520.9	258.2	264.3	588.0	172.4
100.	953.59	535.7	529.0	614.8	748.2	286.9
304.	1088.67	244.2	686.6	940.2	641.2	414.1
1007.	1144.53	194.2	773.6	1272.5	583.8	485.2
3000.	1196.34	293.2	848.5	1618.4	650.9	486.4

SORPTION (PPM)

SORPTION MODEL COMPARISON

SOIL I

TIME (HRS)	SORPTION (PPM) MEASURED	CALCULATED 1	2	3	4	5
1.	8.83	15.2	0.0	1.1	1.9	29.6
4.	10.44	6.2	0.1	2.3	1.7	15.6
10.	9.94	6.9	0.1	4.3	2.2	16.7
30.	11.39	8.6	0.3	9.5	3.1	20.6
100.	10.79	11.8	0.8	18.7	3.9	26.1
304.	11.16	20.1	2.1	28.9	5.0	43.7
1007.	11.08	29.0	2.9	32.3	5.5	52.3
3000.	12.61	31.8	2.4	28.9	5.0	43.2
1.	31.10	43.5	0.5	3.0	4.6	83.2
4.	38.45	36.0	1.3	8.9	6.5	120.1
10.	44.70	33.9	2.3	17.9	8.2	146.7
30.	49.36	35.7	4.4	36.5	10.0	169.8
100.	54.96	36.1	6.9	54.6	9.7	146.6
304.	57.68	35.8	6.7	49.7	8.1	106.6
1007.	58.51	50.4	7.7	53.7	8.7	120.7
3000.	63.35	57.9	6.7	50.1	8.2	108.4
1.	60.20	65.5	1.1	4.4	6.4	101.2
4.	74.31	55.8	2.7	13.3	9.3	163.2
10.	86.27	53.8	5.0	26.9	11.8	215.1
30.	95.95	57.9	9.9	56.2	14.8	272.6
100.	106.92	60.4	16.5	86.9	14.8	267.3
304.	112.73	62.1	17.1	82.3	12.7	218.5
1007.	118.69	74.0	15.0	76.5	11.9	199.4
3000.	124.10	85.5	13.3	71.7	11.3	183.1
1.	147.80	159.4	5.2	10.0	13.3	121.1
4.	187.39	167.3	16.4	34.5	22.2	225.1
10.	230.38	177.4	35.0	75.9	30.6	327.0
30.	266.68	208.3	81.7	174.2	41.4	471.4
100.	309.06	244.8	170.0	306.7	46.1	563.6
304.	345.51	273.6	216.4	320.4	42.6	557.5
1007.	339.21	352.0	224.7	320.1	42.5	557.3
3000.	386.34	422.1	212.4	310.7	41.4	553.2
1.	266.20	280.3	13.8	16.8	21.1	125.3
4.	321.51	315.4	47.5	60.7	37.0	236.0
10.	408.72	347.0	107.2	137.8	52.4	345.7
30.	439.92	428.7	272.7	331.6	74.0	504.3
100.	523.03	534.9	635.2	622.0	87.1	613.0
304.	621.91	620.4	883.4	679.1	83.0	617.8
1007.	624.10	778.2	888.6	663.4	81.2	616.8
3000.	650.77	976.2	908.3	671.2	82.0	617.3

SORPTION MODEL COMPARISON

SOIL L

TIME (HRS)	SORPTION (PPM)					
	MEASURED	CALCULATED				
		1	2	3	4	5
1.	6.76	0.9	0.1	1.1	93.3	18.0
3.	8.93	2.0	0.2	2.5	87.0	13.6
10.	10.76	3.9	0.3	5.0	97.7	10.8
30.	11.26	6.7	0.4	7.7	122.3	6.7
100.	11.76	15.4	0.5	13.7	205.9	7.2
312.	12.26	35.4	0.8	19.0	339.0	9.2
1015.	12.76	87.4	1.0	19.7	540.4	10.6
3005.	12.86	221.9	1.8	27.2	820.2	19.1
1.	22.00	1.4	0.7	3.1	133.0	54.7
3.	36.10	3.1	1.6	7.6	134.0	63.8
10.	49.75	6.5	2.9	17.2	155.9	71.5
30.	53.79	11.6	4.0	29.2	203.4	58.3
100.	56.62	25.8	5.6	49.0	326.5	61.9
312.	60.07	55.4	6.5	56.0	505.5	62.6
1015.	61.65	136.0	6.8	56.7	796.5	69.1
3005.	64.52	313.4	7.8	60.8	1107.8	78.2
1.	33.00	1.7	1.6	4.7	154.9	70.3
3.	61.65	3.8	3.8	12.2	160.2	92.9
10.	90.65	8.1	7.6	29.4	191.6	128.3
30.	104.44	14.9	11.3	53.3	256.5	134.0
100.	111.72	31.5	14.6	81.5	390.7	130.6
312.	117.02	68.0	16.2	92.2	606.1	140.2
1015.	122.24	164.8	15.7	89.4	942.0	147.2
3005.	127.97	357.9	13.5	82.4	1244.2	129.7
1.	100.00	2.5	7.0	10.5	206.4	86.8
3.	166.00	5.3	17.8	28.6	220.6	125.3
10.	241.04	12.4	46.2	80.7	282.6	213.0
30.	306.44	25.8	99.6	186.9	418.2	340.2
100.	368.54	59.8	190.5	362.3	682.4	529.1
312.	414.04	126.6	233.9	409.1	1041.9	697.0
1015.	448.89	286.0	169.3	328.2	1525.4	714.7
3005.	484.19	573.8	101.7	249.6	1877.9	571.4
1.	180.00	3.1	18.2	17.8	249.8	91.0
3.	275.00	6.7	49.4	50.1	272.2	133.1
10.	376.30	16.2	144.3	151.3	358.0	231.0
30.	505.99	35.0	360.2	382.1	546.7	382.0
100.	603.29	86.0	859.2	845.2	933.1	632.4
312.	694.29	196.1	1460.4	1161.3	1513.4	926.9
1015.	781.69	475.8	1539.0	1113.1	2351.5	1106.4
3005.	968.55	998.0	1122.0	934.7	3017.4	1091.1

SORPTION MODEL COMPARISON.

SOIL M

TIME (HRS)	SORPTION (PPM)					
	MEASURED	CALCULATED				
		1	2	3	4	5
1.	2.40	4.9	0.0	0.2	2.5	6.0
3.	4.12	5.0	0.0	0.7	3.4	4.9
10.	5.91	5.9	0.1	2.0	5.0	4.3
30.	6.99	6.7	0.4	4.6	6.6	4.4
100.	8.31	8.0	1.1	8.6	8.4	5.7
312.	8.81	9.5	2.8	9.7	9.0	8.1
1015.	8.96	13.0	8.1	9.9	9.3	13.7
3005.	10.73	14.7	16.9	8.5	7.6	17.5
1.	10.00	13.5	0.1	0.7	9.2	22.0
3.	16.50	14.3	0.3	2.1	13.3	20.1
10.	26.29	17.3	1.0	5.9	19.9	19.2
30.	31.54	19.5	2.4	13.6	26.7	20.6
100.	38.00	23.7	6.5	25.7	34.8	28.0
312.	41.59	28.0	16.4	29.1	37.0	41.0
1015.	43.99	36.3	44.3	27.9	35.3	64.5
3005.	52.31	40.0	88.4	23.5	28.3	81.6
1.	24.00	20.4	0.2	1.1	15.7	32.2
3.	34.20	21.5	0.7	3.2	22.7	30.1
10.	42.85	27.6	2.0	9.4	36.2	31.4
30.	50.85	33.9	5.6	23.1	53.6	37.6
100.	60.14	43.6	16.6	46.7	75.6	55.8
312.	69.09	53.3	44.9	55.5	85.0	87.8
1015.	75.66	67.6	121.6	52.2	79.4	139.5
3005.	94.60	74.7	243.4	44.1	63.9	184.2
1.	51.00	49.6	1.1	2.8	50.3	51.2
3.	70.55	56.0	3.2	8.2	77.7	52.0
10.	93.95	74.6	10.2	25.2	130.2	57.1
30.	103.35	95.4	29.3	64.3	203.3	71.5
100.	124.99	128.6	93.3	137.5	306.3	112.3
312.	150.20	164.4	271.0	172.8	367.4	189.1
1015.	151.58	220.1	799.9	172.1	369.6	322.0
3005.	269.21	251.8	1706.2	150.7	311.4	481.6
1.	54.00	89.2	2.9	5.2	107.9	57.6
3.	90.69	103.6	8.7	15.1	171.9	59.3
10.	124.10	139.8	28.0	47.1	293.7	65.6
30.	146.95	180.1	81.8	121.7	463.9	82.5
100.	189.64	243.6	263.1	261.8	703.3	130.3
312.	219.94	316.8	780.4	334.9	862.6	221.6
1015.	177.93	435.4	2392.5	342.8	899.2	380.2
3005.	309.74	552.3	5795.4	333.1	866.6	593.6

SORPTION MODEL COMPARISON

SOIL N

TIME (HRS)	SORPTION (PPM) MEASURED	CALCULATED 1	2	3	4	5
1.	3.90	2.7	0.0	0.0	8.0	7.0
3.	4.19	2.9	0.0	0.2	7.0	6.6
10.	5.60	4.1	0.0	0.8	6.9	8.7
30.	6.37	5.2	0.2	2.2	7.1	12.4
99.	6.28	7.8	0.7	7.1	9.4	21.0
364.	6.50	12.5	2.8	25.6	16.6	37.7
1009.	6.57	17.2	7.8	66.1	27.1	55.6
3000.	8.94	21.7	18.4	140.7	40.3	57.7
1.	15.30	8.3	0.0	0.2	19.6	26.3
3.	20.06	8.9	0.1	0.7	17.4	26.6
10.	24.18	12.5	0.5	2.2	17.1	36.2
30.	28.93	16.5	1.4	6.1	18.1	54.7
99.	33.72	22.7	4.0	18.5	22.6	86.0
364.	42.13	30.1	11.6	57.6	34.4	124.3
1009.	51.66	28.7	22.0	117.7	44.0	121.8
3000.	56.56	27.2	34.9	193.0	52.1	83.0
1.	24.40	13.5	0.1	0.3	29.0	39.5
3.	30.82	15.2	0.3	1.1	26.8	43.0
10.	37.02	22.1	1.2	3.5	27.0	60.9
30.	47.51	29.3	3.2	10.0	28.8	95.0
99.	68.94	37.6	8.8	29.2	34.1	145.5
364.	86.78	44.6	22.5	83.9	48.0	196.9
1009.	95.94	47.2	44.4	177.0	64.9	219.5
3000.	106.76	56.0	85.9	335.3	89.2	208.0
1.	51.00	35.8	0.6	0.9	63.6	61.5
3.	62.54	42.9	1.7	2.6	61.8	71.6
10.	77.15	64.0	5.7	8.7	63.6	104.2
30.	98.82	88.4	16.4	25.6	69.7	169.6
99.	120.11	129.2	51.4	81.3	90.9	293.4
364.	154.93	192.7	173.4	276.6	150.6	506.0
1009.	141.93	257.1	453.2	693.5	241.0	726.1
3000.	258.34	332.4	1074.3	1485.3	362.3	874.4
1.	66.00	67.8	1.6	1.6	106.2	68.6
3.	83.29	83.3	4.7	4.7	105.3	80.8
10.	60.89	127.4	15.6	15.7	110.6	118.2
30.	153.97	177.0	45.8	46.4	121.8	193.5
99.	174.17	258.2	143.8	147.8	158.6	336.7
364.	201.02	400.6	507.3	515.8	270.2	588.9
1009.	121.02	555.1	1390.4	1330.0	444.4	851.1
3000.	407.18	747.6	3490.3	2952.9	689.8	1057.6

SORPTION MODEL COMPARISON

SOIL 0

TIME (HRS)	SORPTION (PPM) MEASURED	CALCULATED 1	2	3	4	5
1.	5.20	1.2	0.0	0.1	15.5	16.3
3.	6.86	1.4	0.0	0.3	12.2	10.5
10.	6.31	2.0	0.0	1.0	15.7	12.4
30.	7.37	3.1	0.2	2.9	24.5	18.1
99.	6.92	5.6	0.6	9.5	42.8	31.4
364.	8.38	10.2	2.3	33.9	74.2	54.4
1009.	8.83	13.2	5.5	85.0	100.2	72.4
3000.	9.85	20.0	13.3	216.2	124.6	92.3
1.	23.70	7.7	0.0	0.3	47.4	69.9
3.	29.68	7.3	0.1	0.9	40.0	53.3
10.	34.91	10.6	0.3	2.8	47.8	57.0
30.	39.82	14.5	0.9	7.4	66.6	72.1
99.	43.32	22.6	2.6	22.0	104.5	108.3
364.	47.67	37.5	7.9	72.3	167.4	169.9
1009.	50.76	49.7	18.6	179.6	226.4	228.1
3000.	57.95	59.7	38.6	416.7	246.4	245.1
1.	40.00	17.9	0.1	0.6	78.4	119.2
3.	49.40	18.0	0.3	1.6	71.0	103.5
10.	59.38	28.6	0.9	4.8	87.5	117.3
30.	69.88	40.6	2.3	13.1	124.1	154.3
99.	79.22	62.3	6.4	38.7	193.4	234.6
364.	97.40	83.9	17.4	117.1	278.3	328.8
1009.	109.49	70.1	31.5	245.3	296.7	330.6
3000.	118.67	67.3	52.0	490.8	273.6	289.2
1.	82.00	97.3	0.6	1.5	217.8	237.5
3.	87.10	121.8	1.6	4.4	226.6	248.0
10.	159.95	201.6	5.0	13.9	283.5	297.8
30.	278.73	226.3	11.5	35.3	360.2	388.3
99.	388.45	188.2	22.4	82.3	412.5	491.6
364.	439.35	113.4	36.4	173.9	381.9	462.9
1009.	460.57	82.1	51.8	311.5	354.C	409.9
3000.	483.88	119.7	86.2	653.2	382.4	448.2
1.	144.00	283.8	1.5	2.8	415.4	287.7
3.	73.19	389.6	4.5	8.3	456.3	309.4
10.	245.49	691.8	14.5	26.9	592.9	381.7
30.	533.44	844.1	35.6	71.2	786.8	538.0
99.	840.80	840.1	76.9	178.4	987.1	833.0
364.	1071.95	532.2	132.5	393.9	952.7	1063.1
1009.	1130.48	192.9	162.3	608.5	672.0	813.8
3000.	1181.07	287.3	229.4	1147.5	666.9	887.4

SORPTION MODEL COMPARISON

SOIL P

TIME (HRS)	SORPTION (PPM) MEASURED	CALCULATED 1	2	3	4	5
1.	7.00	3.8	0.0	0.5	14.6	14.7
3.	8.14	2.6	0.1	1.2	8.3	6.9
10.	8.91	3.2	0.3	3.3	8.2	6.5
30.	9.19	4.4	0.9	9.0	10.7	8.4
99.	9.73	6.8	2.8	26.6	17.7	13.7
364.	10.36	10.4	8.3	70.3	30.7	23.3
1009.	10.98	13.1	15.3	104.3	44.5	33.0
3000.	11.71	17.3	18.4	104.2	60.6	43.3
1.	32.30	16.8	0.4	1.5	49.5	64.8
3.	36.21	12.1	0.9	3.6	32.2	39.2
10.	40.27	16.9	2.4	10.3	34.0	40.6
30.	44.32	21.7	6.0	27.1	41.6	48.4
99.	48.34	29.4	15.7	73.9	61.4	69.4
364.	52.10	41.0	41.0	181.3	98.1	106.9
1009.	55.25	49.6	70.4	258.7	137.1	144.7
3000.	60.43	57.8	73.2	235.8	169.4	168.5
1.	55.80	33.0	1.0	2.4	86.6	113.5
3.	61.39	27.7	2.2	6.1	64.1	84.9
10.	69.52	40.5	6.2	18.2	69.9	92.4
30.	79.17	52.2	15.8	48.6	85.8	112.7
99.	89.66	68.5	41.0	131.3	124.5	161.1
364.	98.98	90.8	102.3	312.8	191.7	241.9
1009.	109.31	96.7	156.9	412.6	245.2	298.3
3000.	119.96	97.1	134.6	335.1	269.2	304.6
1.	128.00	129.9	4.7	6.2	270.6	237.5
3.	142.39	138.8	12.4	17.1	243.8	233.6
10.	186.89	204.3	36.9	53.1	267.2	264.2
30.	278.28	236.6	89.2	137.3	304.9	326.9
99.	332.50	266.8	204.6	342.1	397.6	466.0
364.	434.29	242.2	368.8	654.0	466.0	596.2
1009.	461.82	120.1	317.5	543.9	367.4	458.7
3000.	485.62	134.5	204.5	417.9	375.7	450.6
1.	220.00	308.9	12.6	11.2	556.4	291.7
3.	295.00	344.4	33.9	31.4	518.9	299.4
10.	326.89	522.3	104.3	99.1	582.2	345.9
30.	492.08	690.0	279.1	273.0	729.9	461.5
99.	667.07	861.4	714.4	729.1	1028.4	736.3
364.	904.08	948.6	1536.8	1572.7	1391.1	1212.0
1009.	1109.63	599.9	1586.9	1527.8	1274.3	1394.3
3000.	1177.00	320.2	625.7	756.0	886.6	1079.7

SORPTION MODEL COMPARISON

SOIL Q

TIME (HRS)	SORPTION (PPM) MEASURED	CALCULATED 1	2	3	4	5
1.	2.20	1.0	0.0	0.2	3.6	2.9
3.	3.11	1.4	0.0	0.6	3.4	2.7
13.	4.81	2.3	0.3	2.5	4.1	3.1
39.	5.18	3.0	0.8	6.5	5.8	4.2
110.	5.02	4.6	2.2	15.8	9.5	6.9
302.	5.88	6.9	5.7	30.0	14.9	10.7
1001.	6.90	10.8	14.9	37.5	22.8	15.9
3013.	6.94	16.5	29.2	36.7	32.0	21.9
1.	9.70	4.0	0.1	0.6	10.8	12.8
3.	13.98	5.0	0.4	1.7	10.6	12.2
13.	18.35	9.0	1.7	6.9	13.3	15.2
39.	21.51	12.8	4.7	18.7	19.3	21.7
110.	22.99	19.2	12.4	44.2	30.4	33.9
302.	28.26	27.8	30.6	81.3	46.0	50.6
1001.	38.13	39.6	71.7	94.0	65.4	68.6
3013.	46.05	44.9	105.2	74.5	74.1	71.3
1.	18.30	7.3	0.3	0.9	17.5	21.8
3.	23.91	9.0	0.9	2.7	17.3	21.6
13.	25.76	17.7	3.7	11.0	22.7	28.2
39.	28.25	26.7	10.8	30.9	34.4	42.7
110.	41.39	38.5	28.3	72.5	53.1	65.7
302.	63.94	47.8	62.3	122.6	72.9	88.6
1001.	95.02	51.2	112.7	113.9	84.4	95.2
3013.	106.72	39.4	112.6	67.9	71.7	68.8
1.	27.60	25.1	1.4	2.2	46.8	46.0
3.	39.37	32.9	4.0	6.6	48.9	48.9
13.	50.28	65.4	17.1	27.6	64.5	64.9
39.	105.62	92.4	47.8	75.3	93.5	96.5
110.	163.62	124.5	116.9	169.1	137.5	147.8
302.	242.37	156.3	253.1	283.2	188.3	213.3
1001.	371.18	171.4	462.1	266.4	220.8	268.1
3013.	429.06	119.4	434.7	148.2	176.8	210.3
1.	20.50	56.1	3.6	3.9	88.7	58.1
3.	67.02	74.2	10.5	11.7	93.8	62.4
13.	84.32	147.3	44.3	48.9	123.2	83.2
39.	183.32	213.6	126.4	134.9	181.8	126.0
110.	228.27	312.5	329.9	316.4	282.1	202.1
302.	335.83	451.5	807.2	579.2	425.9	317.1
1001.	611.04	635.5	1869.3	662.7	599.7	498.1
3013.	487.04	942.3	3430.9	633.3	813.3	708.3

SORPTION MODEL COMPARISON

SOIL R

TIME (HRS)	SORPTION (PPM) MEASURED	CALCULATED 1	2	3	4	5
1.	7.49	1.6	0.1	1.5	24.6	30.1
3.	8.55	1.5	0.2	3.4	14.4	13.4
13.	8.96	2.1	0.8	12.1	18.9	15.5
39.	8.89	3.5	2.3	35.8	31.8	25.2
110.	8.97	6.6	7.0	103.2	56.7	46.2
302.	8.57	13.5	21.5	285.7	100.8	86.9
329.	8.38	7.0	23.9	312.1	109.6	96.3
1001.	6.11	46.0	95.0	940.2	232.3	231.9
3013.	10.75	66.3	168.2	1540.1	289.2	299.1
1.	29.20	11.2	0.9	3.6	85.9	134.0
3.	36.46	8.9	1.9	8.9	62.6	89.0
13.	43.25	13.7	5.4	31.3	73.7	91.2
39.	47.81	16.1	11.9	80.1	96.4	108.3
110.	50.94	21.9	26.0	196.3	134.8	145.7
302.	55.65	28.4	53.2	445.1	178.0	185.6
329.	54.31	12.5	57.2	479.3	187.7	196.8
1001.	57.99	70.0	154.2	1198.4	317.4	349.4
3013.	64.27	78.2	209.4	1699.9	330.3	361.0
1.	47.60	26.3	2.0	5.3	149.2	221.7
3.	62.38	23.5	4.4	13.8	121.4	180.2
13.	76.68	39.9	13.8	50.5	148.4	200.7
39.	88.74	47.4	31.5	130.8	196.2	249.3
110.	99.33	56.4	64.8	309.4	256.0	317.7
302.	114.95	48.6	106.7	618.5	272.7	319.5
329.	109.24	18.6	112.1	658.3	279.1	326.5
1001.	119.99	111.5	252.0	1519.5	439.7	528.7
3013.	129.62	101.7	283.8	1951.3	400.6	469.8

SOIL R CONTINUED

TIME (HRS)	SORPTION (PPM) MEASURED	CALCULATED 1	2	3	4	5
1.	100.00	142.5	9.2	11.5	447.3	398.7
3.	158.00	160.0	23.7	31.9	426.9	407.2
13.	237.64	287.0	79.9	121.7	533.6	509.4
39.	369.90	252.7	160.4	293.4	610.9	645.7
110.	421.00	149.9	237.9	566.6	565.2	674.1
302.	453.18	119.9	324.3	1020.5	541.1	670.0
329.	469.87	35.0	332.4	1070.6	528.8	652.6
1001.	496.10	158.9	469.1	1962.9	607.1	768.2
3013.	517.87	207.5	539.2	2669.8	634.0	830.3
1.	143.50	419.9	24.4	18.7	902.8	462.8
3.	270.17	518.3	66.5	53.6	915.4	492.3
13.	470.52	976.7	236.7	209.8	1177.2	643.9
39.	955.33	771.5	457.4	494.1	1282.6	888.6
110.	1069.05	264.3	579.3	840.8	950.4	923.4
302.	1127.08	215.8	709.1	1420.3	857.8	977.8
329.	1168.98	76.4	725.9	1494.7	866.5	999.1
1001.	1232.57	372.3	1018.4	2836.6	1046.1	1351.7
3013.	1283.50	517.2	1215.0	4007.2	1141.3	1619.0

SORPTION MODEL COMPARISON

SOIL S

TIME (HRS)	MEASURED	SORPTION (PPM) CALCULATED 1	2	3	4	5
1.	7.90	9.9	0.1	0.7	15.7	24.4
3.	9.09	5.0	0.1	1.4	13.9	8.0
13.	9.65	6.0	0.4	4.0	20.2	6.3
39.	9.57	8.2	1.1	10.3	33.0	7.5
110.	9.68	12.1	2.8	22.9	54.0	10.1
302.	10.13	15.9	5.3	33.3	69.6	13.3
1001.	9.75	24.0	7.3	38.3	80.4	24.2
3013.	11.30	28.7	6.7	36.2	75.5	38.3
1.	35.90	33.4	0.5	2.0	50.6	100.1
3.	42.99	19.6	1.0	4.2	49.5	46.8
13.	46.47	22.8	2.6	12.7	72.6	36.4
39.	49.08	26.3	5.8	29.5	103.9	34.6
110.	51.74	31.8	11.9	55.4	140.8	36.4
302.	54.88	37.3	17.8	70.6	159.6	41.8
1001.	57.49	46.8	18.4	68.4	152.9	60.7
3013.	60.91	54.4	16.2	63.0	139.7	91.0
1.	63.10	58.1	1.2	3.3	86.0	162.2
3.	73.95	41.5	2.5	7.6	96.9	106.2
13.	81.59	52.8	7.5	25.3	158.6	94.9
39.	90.24	58.4	17.3	58.8	223.4	87.6
110.	98.73	63.4	32.1	103.1	277.7	83.3
302.	105.34	69.9	43.4	122.5	293.8	90.7
1001.	112.37	83.7	40.9	113.0	267.3	125.8
3013.	123.00	81.6	28.2	89.5	206.3	159.6
1.	165.90	177.3	5.8	8.7	251.7	284.1
3.	185.89	166.0	14.3	22.9	346.2	265.2
13.	232.17	222.2	50.8	84.7	618.6	261.7
39.	274.92	243.6	120.6	200.7	877.4	258.9
110.	299.97	279.2	238.4	366.7	1144.3	275.2
302.	336.25	321.2	346.9	456.8	1269.5	329.3
1001.	393.65	353.9	297.6	394.1	1070.5	470.5
3013.	432.62	344.5	204.6	311.6	824.7	670.8
1.	288.70	365.2	15.8	16.4	504.4	326.6
3.	341.93	370.0	41.4	44.8	737.1	321.4
13.	439.01	503.4	153.9	170.4	1351.3	323.7
39.	533.22	573.2	381.5	415.5	1982.5	332.6
110.	595.62	671.7	783.2	778.2	2649.3	364.1
302.	686.33	783.6	1173.5	987.0	2989.2	447.6
1001.	825.38	909.2	1087.6	892.2	2653.6	685.9
3013.	966.12	913.3	781.7	725.0	2107.1	1083.2

SORPTION MODEL COMPARISON

SOIL T

TIME (HRS)	SORPTION (PPM) MEASURED	CALCULATED 1	2	3	4	5
1.	2.00	2.2	0.0	0.0	4.2	3.6
3.	3.88	2.5	0.0	0.0	3.7	3.0
13.	4.84	3.6	0.2	0.2	3.8	2.9
39.	5.81	4.4	0.5	0.6	4.7	3.5
110.	6.08	5.8	1.4	1.7	6.9	4.9
302.	6.76	7.7	3.6	4.4	10.8	7.6
1001.	6.79	11.4	10.0	12.2	18.3	12.8
3013.	8.37	14.7	18.3	22.9	27.1	18.2
1.	12.40	6.8	0.1	0.0	11.2	14.3
3.	17.02	7.4	0.3	0.1	10.2	12.7
13.	20.04	11.7	1.2	0.5	11.2	13.7
39.	22.86	15.2	3.3	1.7	14.2	17.3
110.	25.39	20.1	8.7	4.5	21.0	25.2
302.	29.14	26.3	21.6	11.5	32.4	38.4
1001.	40.33	33.1	49.7	28.9	48.6	54.7
3013.	47.62	34.1	67.7	46.1	59.8	60.8
1.	15.30	11.5	0.2	0.0	17.9	23.6
3.	21.66	13.2	0.6	0.2	17.1	22.7
13.	26.80	21.2	2.7	0.9	19.1	25.4
39.	36.05	27.2	7.7	2.6	24.0	31.9
110.	43.70	34.9	19.8	7.0	34.6	45.8
302.	61.35	42.3	45.1	17.1	50.5	66.2
1001.	87.79	47.0	89.2	39.5	68.2	85.3
3013.	100.89	43.2	102.9	57.2	76.2	85.6
1.	52.20	30.3	1.0	0.1	42.3	42.1
3.	54.81	36.1	2.9	0.4	42.0	42.8
13.	63.81	59.9	12.2	2.0	48.2	49.3
39.	82.14	79.4	35.6	6.0	62.3	64.3
110.	100.24	106.1	95.2	16.5	92.6	96.8
302.	139.56	137.9	235.0	41.9	142.6	152.5
1001.	216.83	182.0	566.6	107.9	221.1	249.1
3013.	224.65	230.5	977.5	196.5	318.4	373.0
1.	36.70	59.3	2.6	0.2	77.1	50.1
3.	83.83	71.9	7.7	0.8	77.6	51.6
13.	74.93	118.7	32.8	3.5	88.8	59.4
39.	84.38	161.4	97.6	10.5	117.0	78.2
110.	101.63	220.6	268.9	29.0	177.1	118.9
302.	151.35	296.2	690.6	75.0	280.1	190.6
1001.	326.04	409.6	1775.1	200.2	452.1	324.8
3013.	620.33	456.9	2719.9	340.7	596.2	488.8

SORPTION MODEL COMPARISON

SOIL U

TIME (HRS)	SORPTION (PPM)					
	MEASURED	CALCULATED				
		1	2	3	4	5
1.	2.88	5.8	0.0	0.0	6.8	11.7
4.	5.74	6.2	0.0	0.1	11.2	9.4
10.	7.22	6.1	0.0	0.3	15.0	7.3
30.	8.16	7.0	0.0	0.9	21.6	6.4
100.	9.13	8.3	0.0	2.7	30.5	6.4
304.	9.84	9.5	0.1	6.8	35.1	7.6
1007.	9.34	13.1	0.4	15.1	38.1	13.8
3000.	11.53	14.7	0.9	18.5	34.8	19.9
1.	11.10	11.6	0.0	0.0	13.1	20.9
4.	19.85	13.1	0.0	0.2	22.8	20.1
10.	23.42	14.2	0.0	0.6	32.9	19.6
30.	26.61	17.6	0.1	1.7	51.0	20.2
100.	29.91	22.0	0.5	5.4	76.6	23.1
304.	32.87	26.6	1.4	14.0	93.3	31.0
1007.	37.62	32.8	4.0	29.5	91.9	50.5
3000.	39.44	39.3	10.0	37.3	88.8	82.0
1.	7.90	16.0	0.0	0.0	17.9	23.2
4.	22.29	19.1	0.0	0.3	32.3	23.2
10.	27.29	21.0	0.1	0.8	47.7	23.3
30.	31.37	26.5	0.4	2.3	75.2	24.3
100.	35.40	33.8	1.3	7.3	114.8	28.2
304.	40.56	41.3	3.9	19.1	141.9	38.4
1007.	51.10	51.2	11.6	40.6	140.7	63.8
3000.	55.12	61.3	28.9	51.4	136.0	105.4
1.	23.00	28.7	0.0	0.1	31.3	25.1
4.	26.14	35.5	0.2	0.5	58.2	25.2
10.	40.39	40.6	0.7	1.2	88.6	25.6
30.	3.49	52.8	2.1	3.7	144.4	27.0
100.	49.95	68.0	7.1	12.0	223.8	31.4
304.	57.54	82.3	20.5	31.4	274.6	42.9
1007.	75.49	104.9	63.3	67.8	279.5	72.0
3000.	16.81	133.7	177.6	89.8	237.0	120.6
1.	49.80	42.1	0.1	0.1	45.2	25.5
4.	61.78	52.2	0.7	0.6	84.2	25.7
10.	27.45	60.5	1.8	1.6	129.5	26.1
30.	17.55	78.4	5.5	5.0	210.7	27.4
100.	56.80	100.8	18.3	15.9	325.4	32.0
304.	37.58	125.2	54.9	42.3	409.7	43.7
1007.	116.38	159.5	171.6	91.5	417.4	73.4
3000.	405.85	180.9	399.8	112.0	383.4	122.4

```
// JOB

LOG DRIVE    CART SPEC    CART AVAIL   PHY DRIVE
  0000          7207          7207        0000

V2 M10    ACTUAL 16K   CONFIG  8K

// FOR
*IOCS(CARD,1132 PRINTER )
*EXTENDED PRECISION
*ONE WORD INTEGERS
*LIST SOURCE PROGRAM
      DIMENSION CI(10,6),FC(10,6),S1(10,6),S2(10,6),S3(10,6),S4(10,6),
     *S5(10,6),SPAD(10,6),CAVG(10,6),T(10)
      DIMENSION TA(11),CAV(11,6)
  500 FORMAT('1'/////
     1    '                          SORPTION MODEL COMPARISON'//
     2    '                                    SOIL ',A2,///'------------------
     3---------------------------------------------')
  501 FORMAT (
     4    '                                    SORPTION (PPM)'/
     5    '           ------------------------------------------------------
     6---'/
     7    '  TIME                                       CALCULATED')
  502 FORMAT (
     8    '  (HRS)   MEASURED   -----------------------------------------
     9---'/
     *    '                        1          2          3          4          5
     */   '----------------------------------------------------------------
     *---'/)
  510 FORMAT (2X,F5.0,F9.2,2X,5F9.1)
  520 FORMAT (/)
  523 FORMAT ('1'/////21X' SOIL ',A2,' CONTINUED'///)
  100 FORMAT(I3)
      READ(2,100)N
C     N IS THE NUMBER OF SOIL SAMPLES
      DO 1000 ID=1,N
  110 FORMAT(A2)
      READ(2,110)SN
  115 FORMAT(2I5)
      READ(2,115)IN,JN
C     SN IS SOIL NAME, IN=NO. OF TIMES, JN=NO. OF CONCENTRATIONS
  130 FORMAT(5F10.0)
      READ(2,130)(T(I),I=1,IN)
C     T IS THE TIMES MEASUREMENTS TAKEN
  140 FORMAT(10F7.3)
      READ(2,140)(CI(1,J),J=1,JN)
C     CI IS INITIAL CONCENTRATIONS
      DO 150 I=1,IN
  150 READ(2,140)(FC(I,J),J=1,JN)
C     FC ARE MEASURED CONCENTRATIONS
      DO 1 I=2,IN
      DO 1 J=1,JN
    1 CI(I,J)=FC(I-1,J)
      DO 3 I=1,IN
      DO 3 J=1,JN
      PAD=(CI(I,J)-FC(I,J))/10.
      IF(I-1)8,8,9
    8 SPAD(I,J)=PAD*100.
      GO TO 10
    9 SPAD(I,J)=SPAD(I-1,J)+(PAD*100.)
```

```
   10 CONTINUE
    3 CONTINUE
      DO 20 I=1,IN
      DO 20 J=1,JN
   20 CAVG(I,J)=(CI(I,J)+FC(I,J))/2.
      READ(2,130)
      READ(2,130)A,B,D
      DO 30 J=1,JN
      DO 30 I=1,IN
      S1(I,J)=0.
      DO 40 JJ=1,I
      IF(I-1)35,35,45
   35 TT=T(I)
      S1(I,J)= ((CAVG(I,J)**B)*(1.-D)*A*TT)**(1./(1.-D))
      GO TO 40
   45 TT=T(I)-T(JJ-1)
      S1(I,J)=((CAVG(I,J)**B)*(1.-D)*A*TT+S1(I-1,J))**(1./(1.-D))
   40 CONTINUE
   30 CONTINUE
      READ(2,130)A,X
      DO 50 J=1,JN
      DO 50 I=1,IN
      S2(I,J)=0.
      DO 60 JJ=1,I
      IF(I-1)55,55,65
   55 TT=T(I)
      S2(I,J)=(CAVG(I,J)*X)-((CAVG(I,J)*X)/(EXP(A*TT)))
      GO TO 60
   65 TT=T(I)-T(JJ-1)
      S2(I,J)=(CAVG(I,J)*X)-((CAVG(I,J)*X)-S2(I-1,J))/EXP(A*TT)
   60 CONTINUE
   50 CONTINUE
      READ(2,130)A,X,Y
      DO 70 J=1,JN
      DO 70 I=1,IN
      S3(I,J)=0.
      DO 80 JJ=1,I
      IF(I-1)75,75,85
   75 TT=T(I)
      S3(I,J)=(CAVG(I,J)**Y)*X-((CAVG(I,J)**Y)*X/(EXP(A*TT)))
      GO TO 80
   85 TT=T(I)-T(JJ-1)
      S3(I,J)=(CAVC(I,J)**Y)*X-(((CAVG(I,J)**Y)*X)-S3(I-1,J))/EXP(A*TT)
   80 CONTINUE
   70 CONTINUE
      READ (2,130)EX,X,Y
      FXK=10.**(-EX)
      PI2=9.8696
C     DATA CONVERSION FOR INDEXING
      IIN=IN+1
      DO 300 J=1,JN
      DO 300 I=2,IIN
  300 CAV(I,J)=CAVG(I-1,J)
      DO 310 I=2,IIN
  310 TA(I)=T(I-1)
      TA(1)=0.0
      DO 320 J=1,JN
  320 CAV(1,J)=0.
      DO 90 J=1,JN
      DO 90 I=2,IIN
      S4(I,J)=0.
```

```
      DO 101 JJ=2,I
      TT=TA(I)-TA(JJ-1)
      CC=(CAV(JJ,J)**Y)*X-((CAV(JJ-1,J)**Y)*X )
      SUMX=0.
      DO 210 N=1,10
      XJ = (1./(N**2.))*EXP((-1.)*FXK*TT*PI2*(N**2.))
  210 SUMX=SUMX + XJ
      YJ=CC*(1.-(0.6092*SUMX))
  101 S4(I,J) = YJ + S4(I,J)
   90 CONTINUE
      READ (2,130) EX,SMAX,B
      FXK = 10**(-EX)
      DO 220 J=1,JN
      DO 220 I=2,IIN
      S5(I,J)=0.
      DO 230 JJ=2,I
      TT=TA(I)-TA(JJ-1)
      CC=((CAV(JJ,J)*SMAX*B)/(1.+B*CAV(JJ,J)))-((CAV(JJ-1,J)*SMAX*B)/
     2(1.+B*CAV(JJ-1,J)))
      SUMX=0.
      DO 250 N=1,10
      XJ = (1./(N**2.))*EXP((-1.)*FXK*TT*PI2*(N**2.))
  250 SUMX =SUMX + XJ
      YJ=CC*(1.-(0.6092*SUMX))
  230 S5(I,J)= YJ +S5(I,J)
  220 CONTINUE
      WRITE(3,500)SN
      WRITE (3,501)
      WRITE (3,502)
      ICNT=16
      DO 280 J=1,JN
      WRITE(3,510)(T(I),SPAD(I,J),S1(I,J),S2(I,J),S3(I,J),S4(I+1,J),
     *S5(I+1,J),I=1,IN)
      WRITE(3,520)
      ICNT=ICNT+IN+2
      IDUM=54-IN
      IF(ICNT-IDUM)522,521,521
  521 IF (J-JN)524,280,280
  524 WRITE(3,523)SN
      WRITE (3,501)
      WRITE(3,502)
      ICNT=5
      GO TO 280
  522 CONTINUE
  280 CONTINUE
 1000 CONTINUE
      CALL EXIT
      END

FEATURES SUPPORTED
 ONE WORD INTEGERS
 EXTENDED PRECISION
 IOCS

CORE REQUIREMENTS FOR
 COMMON       0  VARIABLES   1956  PROGRAM   1896

END OF COMPILATION

// XEQ
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SORPTION MODEL COMPARISON

SOIL V

TIME (HRS)	SORPTION (PPM)					
	MEASURED	CALCULATED				
		1	2	3	4	5
1.	3.53	6.9	0.0	1.2	10.4	6.6
10.	6.63	9.7	0.0	7.6	22.7	6.2
30.	8.30	8.4	0.1	10.1	26.5	5.9
277.	8.25	13.8	0.7	9.0	38.3	10.1
1.	13.54	17.8	0.0	3.0	27.4	27.2
10.	26.46	27.1	0.5	19.7	64.5	31.3
30.	34.10	26.9	1.1	29.2	84.6	37.0
277.	45.54	37.8	4.2	23.2	107.6	56.1
1.	22.90	26.8	0.1	4.5	41.5	43.5
10.	44.90	42.5	1.1	29.9	101.8	55.2
30.	54.80	45.6	2.7	47.3	143.0	74.2
277.	77.24	74.9	13.4	43.9	215.7	153.2
1.	61.00	60.3	0.6	9.6	95.1	76.8
10.	128.40	101.2	5.2	67.0	246.6	110.4
30.	127.00	119.1	14.1	114.3	374.9	168.3
277.	186.00	228.9	92.8	124.9	673.9	452.4
1.	144.00	101.7	1.5	15.7	162.3	89.9
10.	166.00	180.4	14.3	114.5	443.9	134.0
30.	172.50	224.3	41.6	204.6	708.8	209.9
277.	269.50	442.6	294.4	231.3	1321.9	581.9
1.	274.00	151.0	3.1	22.7	243.2	95.3
10.	351.50	267.0	28.7	165.3	663.1	142.7
30.	260.00	336.0	84.4	298.0	1069.6	224.0
277.	319.00	691.3	641.9	350.9	2084.6	626.4

SORPTION MODEL COMPARISON

SOIL W

TIME (HRS)	SORPTION (PPM)					
	MEASURED	CALCULATED				
		1	2	3	4	5
1.	4.43	7.6	0.0	1.6	10.1	15.6
10.	7.40	9.9	0.2	10.1	9.7	25.7
30.	8.80	7.9	0.3	15.6	10.1	22.8
121.	9.20	8.5	0.5	14.5	13.6	18.8
277.	9.09	9.0	0.5	13.5	17.9	17.6
1.	16.25	20.7	0.2	3.5	25.2	60.1
10.	32.02	29.6	1.2	24.3	26.3	125.9
30.	38.40	26.9	2.4	40.6	30.0	140.1
121.	44.70	30.1	4.1	40.5	42.5	138.7
277.	47.99	21.4	3.1	27.1	43.7	79.5
1.	27.10	31.8	0.4	5.0	37.3	90.2
10.	53.70	48.7	2.9	36.1	41.2	216.6
30.	55.80	52.3	6.7	67.2	53.3	302.7
121.	84.80	63.6	13.5	74.0	82.0	375.0
277.	90.55	44.2	10.5	48.6	83.9	235.2
1.	69.00	75.0	1.7	10.1	81.3	140.9
10.	146.50	125.3	14.1	76.9	97.0	389.7
30.	159.00	143.5	35.0	149.8	131.9	608.3
121.	228.00	201.4	87.8	187.3	228.5	953.7
277.	241.00	206.9	109.2	169.2	303.1	1056.7
1.	191.80	128.5	4.4	15.7	132.6	157.2
10.	211.20	227.8	38.2	124.1	166.7	448.3
30.	227.50	284.2	104.9	256.0	242.1	721.6
121.	352.50	419.5	293.6	338.6	440.6	1176.2
277.	450.25	444.2	386.5	313.7	600.0	1364.2
1.	293.00	196.8	9.0	22.1	195.4	163.8
10.	345.00	354.5	80.3	177.2	249.1	469.8
30.	345.00	444.2	221.7	366.9	363.1	757.3
121.	450.00	680.5	654.5	500.2	680.8	1243.1
277.	358.00	795.5	985.5	502.2	995.0	1466.0

SORPTION MODEL COMPARISON

SOIL X

TIME (HRS)	SORPTION (PPM) MEASURED	CALCULATED 1	2	3	4	5
1.	2.62	6.2	0.1	3.2	7.2	8.6
10.	7.79	8.9	0.7	18.5	10.5	10.2
30.	8.90	6.0	0.7	21.0	10.9	7.9
121.	9.00	7.4	0.5	17.6	14.9	8.4
277.	9.41	7.4	0.3	15.4	17.8	8.7
1.	14.83	17.1	0.7	6.8	17.5	30.8
10.	31.76	26.5	4.2	41.4	27.4	44.9
30.	41.20	22.5	5.4	54.4	33.6	48.4
121.	39.40	30.2	4.7	50.2	50.6	64.5
277.	48.83	26.3	2.8	39.7	56.0	62.2
1.	20.90	27.4	1.5	9.6	26.6	47.2
10.	50.60	46.2	10.0	62.2	44.6	79.9
30.	70.20	44.4	14.9	88.7	59.7	104.5
121.	67.20	63.4	15.3	87.1	96.0	162.5
277.	95.34	54.8	9.1	68.4	106.6	166.2
1.	84.50	65.9	6.3	18.5	57.9	73.9
10.	118.10	122.4	46.0	127.5	105.0	142.5
30.	165.00	145.7	88.1	208.6	163.9	231.8
121.	178.00	223.4	111.1	221.9	287.2	422.8
277.	266.80	227.9	87.0	197.1	359.3	559.4
1.	153.00	120.3	16.4	28.9	98.5	83.6
10.	179.00	234.5	127.5	206.0	186.2	165.4
30.	265.00	292.9	260.1	348.2	301.3	275.4
121.	270.00	467.2	355.5	383.6	547.9	515.8
277.	447.25	514.1	314.4	360.5	724.4	716.9
1.	254.50	188.2	33.3	40.3	146.4	87.3
10.	332.00	369.2	260.7	288.4	278.0	173.5
30.	420.00	466.8	540.5	491.4	454.1	289.8
121.	410.00	761.8	768.5	551.4	841.8	545.4
277.	604.00	877.9	731.6	536.2	1151.1	765.2

SORPTION MODEL COMPARISON

SOIL Y

TIME (HRS)	SORPTION (PPM) MEASURED	CALCULATED 1	2	3	4	5
1.	2.00	2.8	0.2	1.1	3.2	2.9
3.	2.90	3.2	0.7	3.1	4.7	4.1
10.	3.90	4.6	1.9	7.8	7.3	6.4
30.	4.70	5.9	3.5	13.2	10.6	8.9
100.	5.50	8.4	4.2	14.3	14.4	11.9
300.	6.09	10.9	3.7	12.8	15.8	12.7
1.	14.00	10.8	1.4	3.6	11.6	12.8
3.	19.00	11.4	3.4	9.2	16.1	17.5
10.	28.50	14.9	8.0	21.6	23.3	24.7
30.	34.50	16.4	12.4	32.1	28.9	29.5
100.	39.00	19.7	11.7	29.4	33.7	32.7
300.	42.50	21.6	8.1	22.6	30.7	28.1
1.	22.70	20.3	2.9	6.1	21.0	23.9
3.	31.00	22.5	7.4	16.0	30.3	34.5
10.	58.00	28.5	17.1	37.2	43.3	48.8
30.	69.00	29.5	25.1	53.0	51.2	56.2
100.	78.50	35.7	23.3	48.1	59.2	62.9
300.	84.20	39.6	16.4	37.5	54.6	55.3
1.	79.00	68.8	11.8	16.9	66.5	61.9
3.	100.00	78.7	31.0	44.8	98.7	95.1
10.	150.00	114.0	80.5	113.9	156.9	155.9
30.	180.00	148.3	148.1	193.3	223.8	229.9
100.	227.00	204.5	171.7	204.6	299.2	318.1
300.	254.99	253.7	140.4	175.8	312.9	343.5
1.	142.00	156.3	30.5	33.5	144.6	90.5
3.	146.00	189.5	83.6	91.6	224.4	145.4
10.	230.00	291.5	231.5	244.1	376.6	250.9
30.	330.00	391.5	446.7	429.3	555.5	390.3
100.	405.00	563.4	550.6	474.3	774.7	578.6
300.	470.00	758.7	496.7	436.8	876.8	692.5

SORPTION MODEL COMPARISON

SOIL Z

TIME (HRS)	SORPTION (PPM) MEASURED	CALCULATED 1	2	3	4	5
1.	5.85	7.1	0.4	5.9	9.0	8.9
3.	6.80	5.7	0.8	12.6	11.2	9.1
10.	7.55	7.2	1.5	23.5	15.9	11.9
30.	8.10	8.5	1.9	26.7	20.7	14.8
100.	8.55	10.6	1.5	23.7	23.5	17.5
300.	8.88	12.5	1.1	20.7	20.9	16.5
1.	26.53	21.6	2.4	13.5	23.6	31.9
3.	34.00	17.8	4.5	29.1	29.6	37.4
10.	41.00	19.6	7.3	50.4	38.5	46.2
30.	44.59	19.0	6.7	49.3	43.0	48.1
100.	46.95	19.9	3.9	37.7	41.0	44.9
300.	48.20	19.2	2.2	28.5	30.3	31.6
1.	35.74	37.2	5.3	20.2	37.6	48.4
3.	55.00	35.3	11.5	46.6	52.1	68.0
10.	74.50	39.5	19.9	83.8	69.6	94.7
30.	85.00	38.2	18.9	82.6	78.1	108.4
100.	91.40	39.8	10.9	63.0	74.4	109.3
300.	94.84	38.9	6.3	48.0	55.5	82.7
1.	101.30	98.9	22.9	41.7	87.1	71.1
3.	130.00	107.8	55.7	103.0	132.5	113.7
10.	180.00	146.4	124.3	212.9	206.7	194.2
30.	215.00	181.0	172.1	257.4	283.3	301.7
100.	247.00	240.6	155.5	238.4	340.6	448.5
300.	272.00	298.7	129.2	217.4	319.5	534.3
1.	105.30	194.0	62.1	68.8	155.4	78.3
3.	200.00	225.4	160.8	175.2	247.1	127.7
10.	290.00	313.1	376.6	371.6	394.3	222.5
30.	375.00	405.1	560.0	466.2	561.8	355.7
100.	432.00	564.0	548.8	447.9	705.3	547.4
300.	490.00	740.6	495.8	425.8	696.8	681.5

SORPTION MODEL COMPARISON

SOIL AA

TIME (HRS)	SORPTION (PPM) MEASURED	CALCULATED 1	2	3	4	5
1.	4.36	0.0	1.6	0.3	37.3	2.3
3.	5.30	0.0	1.0	0.9	28.2	2.5
10.	6.70	0.0	0.8	2.9	23.8	3.5
30.	8.05	0.0	0.5	7.1	17.9	4.3
100.	8.35	0.0	0.3	12.7	13.9	5.3
300.	8.39	0.0	0.3	13.9	13.0	7.0
1.	18.90	0.0	8.3	0.3	112.4	5.1
3.	23.50	0.0	5.9	0.9	89.3	6.3
10.	31.00	0.0	4.7	2.9	76.3	9.8
30.	41.00	0.0	2.8	7.1	55.1	13.6
100.	45.20	0.0	1.4	12.7	34.3	15.7
300.	47.09	0.0	0.7	13.9	23.2	15.8
1.	27.10	0.0	17.8	0.3	186.6	5.9
3.	35.00	0.0	14.2	0.9	160.4	7.8
10.	53.00	0.0	11.5	2.9	139.5	12.7
30.	72.50	0.0	7.7	7.1	106.1	19.5
100.	89.00	0.0	3.9	12.7	68.2	26.9
300.	94.40	0.0	1.7	13.9	38.8	27.2
1.	80.00	0.0	74.5	0.3	485.4	6.7
3.	105.00	0.0	63.6	0.9	436.8	9.1
10.	145.00	0.0	56.9	2.9	405.3	15.2
30.	200.00	0.0	47.0	7.1	356.9	25.3
100.	282.00	0.0	32.9	12.7	280.7	42.1
300.	325.00	0.0	19.9	13.9	200.9	61.2
1.	128.60	0.0	193.6	0.3	920.6	6.9
3.	150.00	0.0	178.1	0.9	870.5	9.3
10.	230.00	0.0	167.6	2.9	835.8	15.7
30.	380.00	0.0	143.8	7.1	754.3	26.4
100.	510.00	0.0	114.8	12.7	648.8	44.8
300.	610.00	0.0	91.0	13.9	555.3	67.9

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(Please read Instructions on the reverse before completing)

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16. ABSTRACT

The ability of a soil to remove wastewater phosphorus from solutions passing through the soil matrix is primarily related to the formation of relatively insoluble phosphate compounds of iron, aluminum, and calcium. Based on the solubility of these compounds, an estimate can be made of the minimum concentration of phosphorus which will be found at equilibrium in the soil solution.

The kinetics of orthophosphorus sorption with 25 viable mineral soils were experimentally measured under laboratory conditions. Several kinetic models were evaluated as a means of describing phosphorus sorption by soil. A diffusion limited Langmuir sorption model best fit the experimental data.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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