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THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

# A MODEL FOR THE MOVEMENT OF SELENIUM IN A CLOSED AQUATIC SYSTEM

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

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degree of

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BY

JERRY J. NELSEN

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A MODEL FOR THE MOVEMENT

OF SELENIUM IN A CLOSED AQUATIC SYSTEM

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# CHAPTER I

# INTRODUCTION AND LITERATURE SURVEY

## Introduction

Selenium is widely distributed in the earth's crust. It is frequently found in industrial processes and occurs in our energy resources. It is an important trace element in the biological world, but may become a toxic substance through bio-magnification. It has been given quality criteria limitations in air and water. Despite this availability and potential hazard, the biochemistry of selenium is not well known and its movement and distribution in ecosystems has not been investigated to any significant extent.

The scope of this work, then is to develop the beginnings of a modeling effort which will ultimately lead to a predictive capability in the various trophic levels of natural systems. Completion of the model will be reserved for future works. The present effort will be limited to

preliminary aspects of "system identification" (Patten 1969) rather than system analysis. An attempt will be made to hypothesize a model on biological grounds and to observe its ability to simulate a physical laboratory model.

## Historical Background and Literature Survey

Historically, selenium poisoning was known to farmers and stockmen as "alkali disease." The symptoms of selenium poisoning were called, "blind staggers" (Franke, 1934). Enormous losses of livestock occurred in some of the areas of the midwest and southwest. The cattle and horses would become lame, lose hair and hooves and develope loss of control of voluntary muscles. Death eventually occurred from internal hemorrages. The woody aster (Xyloriza) and milk-vetch (Astragalus) involved in the historic selenium poisonings, were shown to accumulate selenium to 10,000 ppm. These plants have a growth requirement for selenium and can apparently accumulate it from the soil no matter what chemical form it is in (Rosenfeld & Beath 1964). This concentration was then passed trophically to the livestock and accumulated readily to toxic levels.

Robinson (1933) could reproduce this pathology with native forage that was shown to accumulate selenium. Shortly thereafter Franke (1934), using grains grown in areas where alkali disease occurred, demonstrated the toxic substance to be selenium. He subsequently demonstrated (Franke and Potter 1935) that selenium-containing feed would produce toxic effects in rats. Grains containing 25-30 ppm resulted in growth inhibition, jaundice, anemia, and hemorrage.

The role of selenium in biological systems is unclear and diverse. Its position in group VI of the periodic table reflects its chemical similarity to sulfur in living organisms (White, Handler, and Smith 1959). Painter, Edgar, and Page (1940), suggest the association of sulfur and selenium in soils and biologic materials in constant ratios. Franke showed an association of selenium with protein (1934). Schultz and Lewis (1940) observed the conversion of selenite to dimethylselenide in rats. The blue-green alga, Anacystis nidulans replaced sulfur compounds with the uptake of selenium analogues (Kumer and Prakash 1971).

Selenate toxicity was suggested by Shrift (1954) to be due to competitive inhibition of sulfur for metabolic enzymes. This inhibition occurred at membrane sites also.

Others suggest selenium to have antagonistic relationships with arsenic (Rhian and Moxon, 1943).

Selenium has been suggested to have a synergistic effect with Vitamin E and a relation to the reduction of lipids (O'Hara 1970, Schroeder 1970, Young 1970). It was found necessary in small amounts.

Irrespective of its biochemical role in the living system, selenium represents a potential hazard to man (Moxon and Rhian 1943). Clinton (1947) described the sequence of acute selenosis from selenium fume exposure. Smith and others (1938) described a high absorption through the intestine and subsequent elimination through the kidney. Franke (1936) demonstrated toxicity of selenium in rats. Lekin (1972) showed acute and chronic selenosis in animals feeding on vegetation containing selenium at levels less than 30 ppm.

In addition to toxic effects of selenium accumulation, Muth and others (1958) prevented White Muscle Disease (WMD) in lambs by the addition of selenium to feed. Glover (1967) described calves and lambs with muscular dystrophy, inhibition of growth, and reduced fertility on selenium deficient diets.

In general, the normal dietary levels of selenium for most species range from 0.1 to 0.5 ppm (Weswig 1972). Concentrations around five ppb produce the selenium defiency syndrome, and at higher concentrations of one to ten ppm can produce toxic effects. In addition, levels in the latter range are more likely to produce toxic effects through chronic trophic relation.

The U.S. Public Health Service has recognized a hazard to potable waters and recommended a safe upper limit to be 0.01 ppm. In addition, the American Conference of Governmental and Industrial Hygienists in 1962, documented a threshold limit value (TLV) of 0.1 $mg/m^3$ for a forty-hour week occupational exposure.

The distribution of selenium is widespread (Goldschmidt 1954). It occurs in minute concentrations in soil and sulfide minerals. The average earth's crust value is only 0.09 ppm. The widespread distribution and relationship to sulfur was suggested by Pillay and Sivasankara (1971) to be used as an indicator of sulfur dioxide pollution. They held that measurable selenium:sulfur ratios could be indicative of petroleum or other fossil fuel sources used for combustion. Mast and Ruch (1973) in a survey of Illinois crude oil wells found an association of selenium in the sulfur-containing

wells ranging from 0.2 to 0.4 ppm. Johnson (1970) found that burning of coal released 0.7 ppm to 7.38 ppm selenium. Volcanic deposits have been found to contain as much as 120 ppm (Byers 1935), and values of 680 ppm have been reported from carbonaceous siltstone in western Wyoming (Beath, Hagner and Gilbert 1946).

Other sources and forms of input into the environment have been reported. Johnson (1970) reported nearly 20 ppm from the burning of solid waste such as newspapers, cardboard and tissue. Olson (1970) measured 0.05 ppm in paper and 0.03 ppm to approximately 1 ppm to tobaccos. Selenium collected in air filters from United States cities was found to range from 0.05 to 10 ppm selenium. Hashimoto (1967) measured 0.21 ppb in rainwater.

In addition to levels and sources mentioned, there is a fairly significant industrial input into the environment (Lakin and Davidson 1967). Major industrial sources of selenium are from mining and refining of copper, lead, gold, nickel, and silver (Ledicotte, 1961). Selenium is also a waste product in the manufacture of sulfuric acid, pigments, insecticides, stainless steel, photo-electric cells, rubber, and glass.

Sources of selenium in the environment are widely distributed. The potential for greater input from man's energy use is becoming more prevalent. Mechanisms for the availability to the biotic system are present and bio-accumulation to high concentrations has been shown. Toxicity has been demonstrated. All of these facts suggest a potential hazard in the movement and accumulation of selenium in an ecosystem. Therefore, there is a need for ecosystem research.

# CHAPTER II

## DEVELOPMENT OF THE SELENIUM MODEL

### Selenium Living Systems

There is little knowledge of the importance of selenium as a trace element in living systems (Wainerdi 1971). The classic studies of Franke (1934) demonstrated bioaccumulation and trophic movement. However, the data was not collected with an ecosystem view. Subsequent research often involved feeding animals specified levels of selenium as opposed to observing movement and accumulation of ambient levels in the natural forage. In other studies of terrestrial living systems, Allaway (1964) demonstrated bioaccumulation by detecting levels of selenium in various biological materials. Aquatic surveys by Kifer (1969) found natural levels of selenium in marine fish (See Table 1).

TABLE 1

KIFER DATA

| | |
|---|---|
| East Canadian Herring | 1.3-2.6 ppm |
| Tuna | 3.4-6.2 ppm |
| Smelt | 0.49-1.23 ppm |
| Menhaden | 0.75-4.2 ppm |

Wiersma and Lee (1971) sampled several Wisconsin lakes and found 0.5 ppm to 3.5 ppm in sediments. Work in trophic systems is lacking or absent. Where studies have been made, at least in earlier work, emphasis has been on health aspects or survey rather than characterization of ecological association and movement of the selenium.

## Physical Model

The lack of data makes it difficult to observe movements and flows of selenium which might occur in natural situations. No postulates can be made based on field observations. Therefore, a model must be developed from basic ideas; synthesized from biological, chemical, and physical principles. The kind of model selected was based on these principles.

There are many types and categories of models depending on the criteria one uses to distinguish among them. The choice of models was narrowed somewhat by the nature of the system being studied. It seemed prudent (Patten 1969,

St. Petersburg) to investigate both the physical and mathematical aspects of the selenium movement to approach a more realistic representation of what may occur in a natural system. A batch system was decided upon. A closed system such as an an aquarium would allow an added check on the model. The total amount of selenium is constant throughout the experimental period. (With a plug flow system or flume, one would have to be able to measure accurately the flows in and out of the system.) Thus, if projected to the natural environment, a batch system would represent an idealized lake rather than a stream.

A further decision was obvious from the nature of the problem. Little is known of the chemical transformations or even of the chemical forms that are biologically mediated in the movement of selenium into and out of organisms. Thus, the biological model or non-mechanistic model was chosen. Such a model could not account for mechanisms of uptake or for transformations within the living organism. It would, however, be a summarizing description of the mechanisms of flow among compartments. A mechanistic model would logically succeed the knowledge gained from a non-mechanistic model or biological type model. In addition, a continuous system type of mathematics was chosen. This would be more

representative of selenium movement, growth, or bioaccumulation than a discrete or stochastic mathematical representation. Thus, the initial model chosen was a non-mechanistic, continuous, closed biological model representing a batch system.

At this point, decisions about the physical systems were made which would allow a more precise definition of the mathematical model. A system representing natural conditions was desired, so a sample of water from a natural source was chosen. Lake Thunderbird was in close proximity to the University of Oklahoma and represented a typical impounded water of the southwestern United States. The lake was selected for the source of water and sediment. It was undesirable to use a laboratory alga such as Chlorella sp. for want of indigenous biota. A diverse natural flora and fauna would enhance the meaning of any result that might be obtained.

A physical system was then envisioned in which a diverse biota in a closed aquatic bounded aquarium would interact with the bottom sediment in a natural manner (Figure 1). Continuous lighting was considered necessary for maintenance of algal growth for sufficient oxygen production. A rich growth was desired from the standpoint

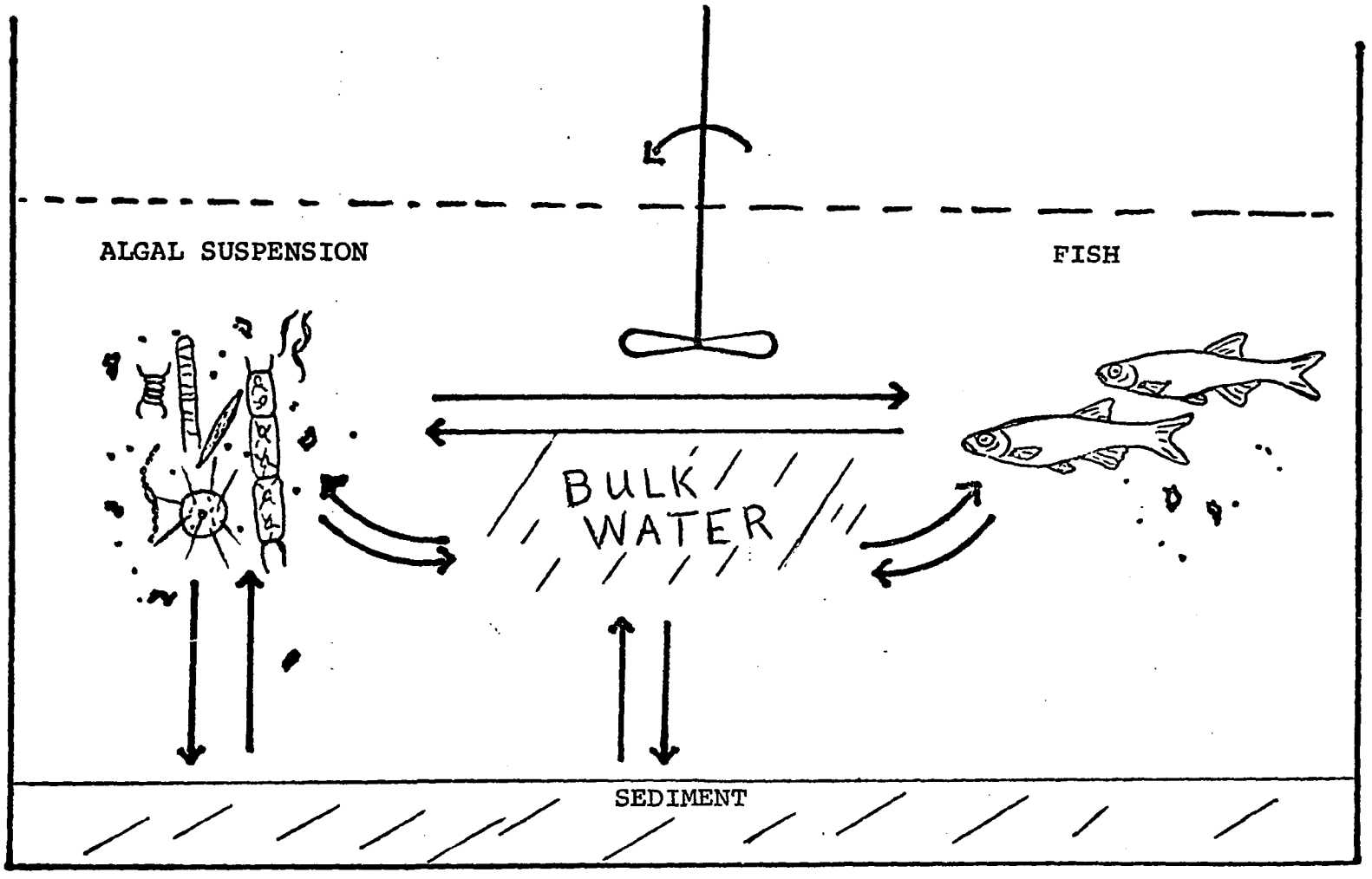



FIGURE 1

PHYSICAL BATCH SYSTEM OF SELENIUM MODEL

of measurement of selenium in the various suspended materials. A motorized propeller would be used to enhance the mixing of oxygen and exposure of algae to light. The control of pH could be affected by the addition of free carbon dioxide.

Minnows (Cyprinidae) were also selected for use in the system. A bottom feeder would complicate a model by an added variable, the changes in mass of the sediment. It would be more tractable to keep the masses of compartments discrete and constant. A strict algae-eating fish might be readily obtained, as an exotic species, but it was considered of value again to use an idigenous species.

In addition, it is documented information (Prosser 1945, Lovelace and Pololiak 1952, Rosenthal 1956, and Chipman 1956) that many chemical species may pass into fish through gills, skin and fins. Uptake does not necessarily infer feeding. Thus, a model may allow for predisposition to uptake through incidental feeding and membrane transfer without a strict trophic relationship. Also, the habit of constant gill ventillation was a desirable characteristic in the minnows for a system which may develop low oxygen levels.

Radiotracer methods were perhaps most attractive from the standpoint of continuous system data collection. A

sensitive colorimetric method is reported in Rosenfeld and Beath (1964). This was a complex procedure for continuous sampling and could be considered only as an alternate check. The radiotracer method was the preferred choice for repeated sampling.

Selenium has a number of isotopes which are radioactive with short half-lives. There are no naturally occurring radioactive isotopes. All are produced synthetically. Selenium-75 is produced by activation analysis according to the following schemes in Table 2.

TABLE 2
SELENIUM-75 BY ACTIVATION ANALYSIS

| |
|---|
| $^{74}Se(n,\gamma)^{75}Se$ |
| $^{75}As(d,2n)^{75}Se$ |
| $^{75}As(p,n)^{75}Se$ |

Selenium-75 is suitable for experimental purposes because it has a reasonably long half-life (121.4 days).

The subsequent decisions were not so clear and were made through step-by-step process (Klehr 1972) obviated in in the remaining discussion.

A transfer matrix was constructed as an expression of the physical system. It could be written in terms of a mathematical matrix. This process of constructing the matrix must: (a). Summarize information in a comprehensive manner which would allow interaction of the various disciplines in an expeditious way. (b). Identify significant aspects of the chemistry and biology involved. (c). Recognize areas of lack of knowledge. (d). Help organize and expedite the research effort. The format can be summarized in the following steps:

1. Identify system and boundaries.
2. Identify selenium carriers and develop flow charts for them.
3. Identify chemical forms and chemical transforming mechanisms.
4. Relate and superimpose forms and transformations onto carrier flow charts.

The result is found to be a transfer matrix.

## System Boundaries

The batch mix would be contained in an aquarium and the confines thereof considered to be the system boundaries. Flows into and out of the container, such as evaporation, would not be considered part of the system. Water would be added for evaporation loss. The container would be idealized and it would not be a part of the system. One must account for sorption onto the sides of the aquarium. The total

selenium in the system should remain constant and radiotracer methods must correct for radioactive decay.

## Carriers

The basic carriers include the biota, water, suspended material, and sediment. The carriers were listed at length considering each biologically and chemically. Simplifying decisions can be made if reasonable (Patten, 1969) by grouping carriers into functionally similar groups.

The selection of carriers was made with two important criteria in mind. The first was its biological correctness as a natural unit. The second was its ability to be discretely measured with techniques and instrumentation available.

There were numerous kinds of algae (Appendix B-24) including green and blue-green algae. It was considered that these would be discrete as a group of autotrophs and would make a reasonable biological entity. The differences of nutrient requirement between green and blue-green alga might suggest they be separate carriers. However, with mixing, constant lighting, addition of nutrients, and pH control, these differences might be resolved. This would unify the group for purposes of the model.

In addition to algae, the culture contained bacteria, minute fauna, such as protozoa and ashelminths, and other particles. The particles were made of reentrained sediment and a range of suspended and colloidal materials. To sample the water as a compartment carrier, a technique would have to be devised that would allow precise repeatable sampling, and make ecological sense.

A further investigation of sorption and uptake by bacteria and fine particles (Jones 1960) points out that uptake onto small organisms may be related to sorption onto fine particles associated closely with bacteria and algae. The discrete separation of these is not afforded by a simple technique. The 0.45 micron membrane filter was chosen to distinguish the water, colloids, and the dissolved solids from the particles in suspension greater than 0.45 microns. The suspended particulate compartment would contain all particles greater than 0.45 micron. Fish feces would also be included in the suspended particulate compartment. Fine colloids may be excluded.

The fish were seen to be discrete, well-defined entities except for fine particles that would closely adhere to the surface. Larger particles might be quickly rinsed off for repeatability of measurement. The finer particles

that closely adhere would not readily be disturbed in a natural situation.

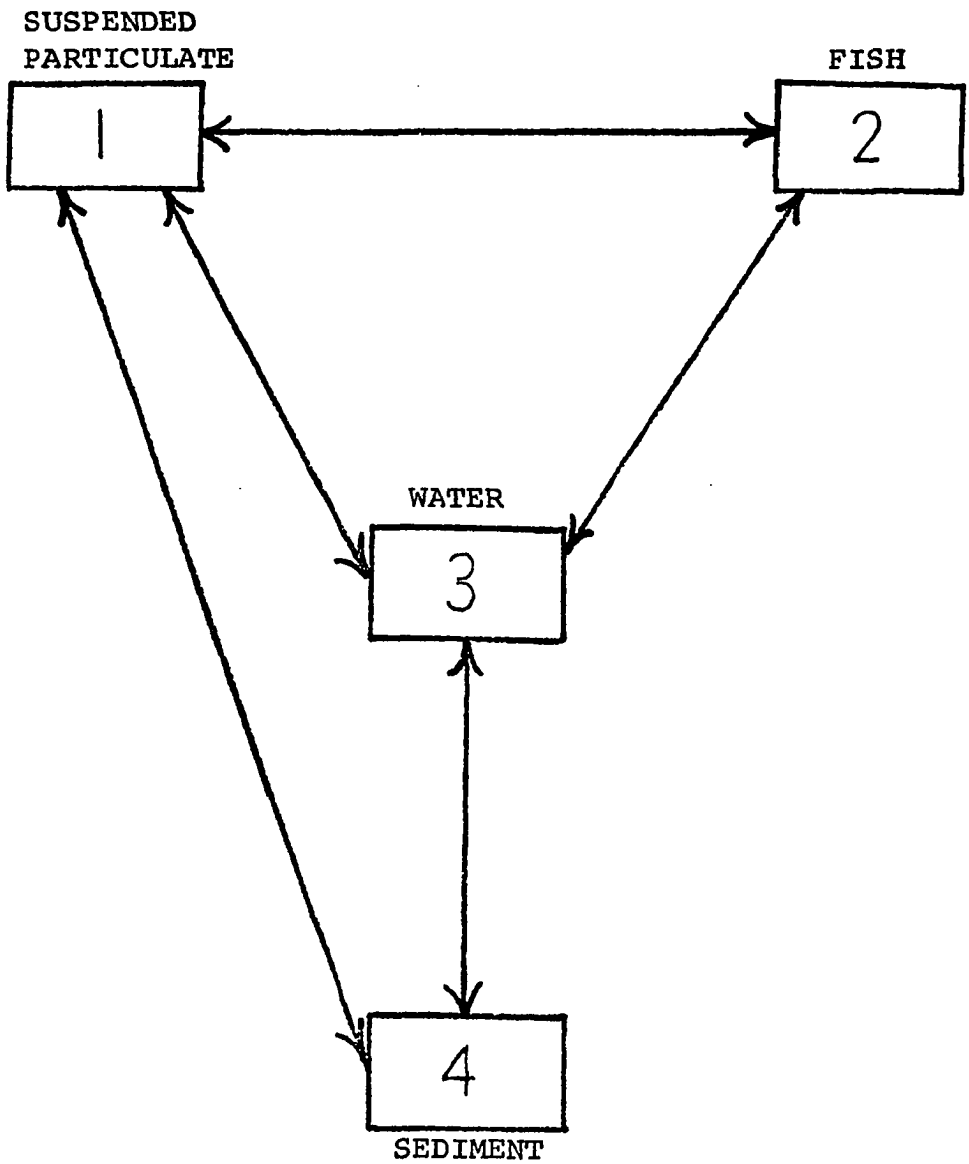
The sediment would be recognized as the unsuspended bulk. Settling and reentrainment were accepted as natural processes involved in selenium movement to be considered in the model.

The carriers then were simplified into four compartments called water, suspended particulate, fish, and sediment (Figure 2 ). Exchanges might occur among many of the compartments. For example, suspended particulate may have flows of selenium with fish, water, or sediment, that is, with compartment two, three, or four. The suspended particulate may release selenium to the water or may take it from the water. Flows occur in both directions between compartments. It will be noticed that no flows occur between compartments two and four.

To determine the nature of these flows, a carrier interaction table was constructed (Table 3 ). The selected carriers or compartments were listed such that the two-way interaction table was formed. The procedure was carefully carried out such that the list of carriers was written in sequence across the top of the table from left to right. They were then placed in the same sequence at

FIGURE 2

SIMPLIFIED FLOW DIAGRAM



the left of the table from top to bottom:

TABLE 3
CARRIER INTERACTION TABLE

| | (1) Suspended Particulate | (2) Fish | (3) Water | (4) Sediment |
|---|---|---|---|---|
| (1) Suspended Particulate | -- | X | X | X |
| (2) Fish | X | -- | X | 0 |
| (3) Water | X | X | -- | X |
| (4) Sediment | X | 0 | X | -- |

Decisions about interactions between any combination of carriers was made by focusing attention on a single interaction couple corresponding to a carrier on the left vs. a carrier on the top of the table. The question was asked, "Can selenium in this carrier (one selected from the left-hand column) become selenium in (or move into) a carrier at the top of a column?" An "X" indicating a positive decision was placed in the corresponding box. A negative decision was represented by an "O".

It was considered important that only single step processes be considered. Moreover, a judgement was made as

to the significance of a particular flow or interaction movement. An interaction might have been indicated "O" if, even though it occurred, its action in the movement of selenium was insignificant.

The carriers were numbered for convenience, and reference to a decision about a flow was made by a coordinate pair (e.g. suspended particulate to fish would correspond to 1,2). In a discussion, use of the carrier names would be considered a less confusing means of communicating with another person.

One, one; 2,2; 3,3; and 4,4 represent flows and interactions within a carrier and, although interesting, were not important to a non-mechanistic model. These would be storage interactions from the standpoint of the model.

One, two would mean a movement of suspended particles directly to the fish in a phytophagous action, although not primarily a feeding response. This would be the case of incidental swallowing of material not a normal food substance. This was not considered insignificant to the model since even a small flow in this case might be the only flow in the considered direction between the two carriers. Thus, it may have a controlling effect on the movement of selenium.

The reverse flow, 2,1 would involve defecation and in

one step would mean a biological flow from fish to suspended particulate. One, three and 3,1 are representative of chemical flows between the water and suspended particulate in one step.

One, four and 4,1 would result from the natural physical action of mixing and gravity.

Two, three and 3,2 are separate biological actions involved with transport of materials across membranes.

Two, four and 4,2 would involve death of the fish or would not occur in a one-step process. An attrition rate through death was not considered a desired research object in the early development of a selenium model. Thus, no provision was made for it and the assumption of no death was made. These were considered insignificant flows.

Three, four and 4,3 would represent chemical interactions in a one-step flow between the sediment and the water.

## Chemical Forms and Transformation Mechanisms

The chemical forms were first selected, by investigation of natural forms and chemical reactions (Rosenfeld and Beath 1964, Subcommittee on Selenium 1971, Sienko and Plane 1961, Leddicotte 1961).

Positive oxidation states are +4 and +6 and only a few

unstable compounds are in the +2 states. The binding in these states is primarily covalent. In the +4 state, the elements show both reducing and oxidizing properties but in the +6 state act as oxidants. In selenide, selenium assumes the oxidation state of -2. Polyselenides are known, but they are less stable than polysulfides.

Inorganic selenium compounds in natural water are oxides, acids, halides, sulfides, and selenides (Rosenfeld and Beath 1964). All selenium oxides are less stable than their sulfur analogues. The most stable state is $SeO_2$ rather than $SeO_3$. Selenium trioxide reacts vigorously with water producing selenic acid, $H_2SeO_3$. This form was chosen as the experimental source for the initial condition of selenium to be added to the water.

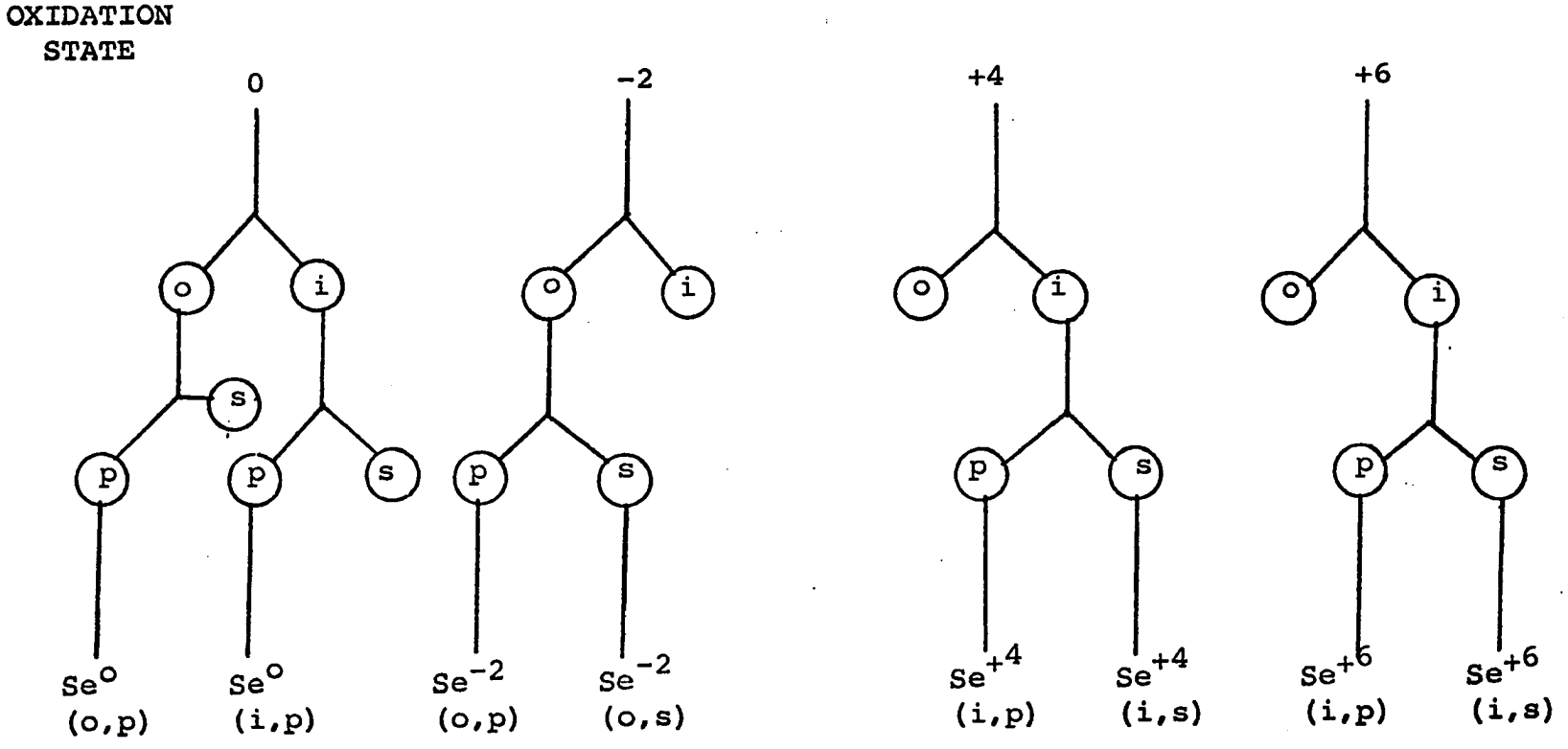
The acid formed from dissolution of selenium dioxide is selenious acid, a weak dibasic acid. Selenic acid is less stable and a stronger oxidizing agent. Selenic acid forms selenate and acid selenate salts. The halides are unstable in aqueous solutions and decompose. The sulfides, SeS and $SeS_2$, are insoluble in water. Hydrogen selenide is a colorless, very toxic gas resembling hydrogen sulfide in odor and properties. It is less stable. The selenide is a stronger acid than hydrogen sulfide and much more soluble.

Organic selenium compounds that may exist in biological systems and aquatic environments are as follows (Rosenfeld and Beath 1964): (1) Seleno-amino acids such as selenocysteine, selenomethionine, selenocystamine, selenohypotaurine, selenotaurine. (2) Homocyclic and heterocyclic seleno compounds such as selenoguanine, selenocystosine. (3) Selenopantethine. (4) Dimethyl selenide.

The selenium forms possible in water are summarized in Table 4. This list was subsequently reduced in preparation for the interaction table of forms and transformation mechanisms (Table 5). By consideration of chemical properties, various chemical forms of selenium were eliminated from consideration. This was done in sequence of oxidation states as they appear in Table 4, starting with selenium in the elemental state ($Se^{o}$). Elemental selenium is not soluble; thus, the possibility of soluble forms of free selenium were eliminated from consideration.

The oxidizing conditions of the system proposed would not allow formation of inorganic selenides of the -2 oxidation state. This reduction would occur in biological systems to form organic selenides, but selenious acid would not undergo the reduction in the system. Another possibility was the formation of sodium selenide. This is improbable

TABLE 4
FORMS OF SELENIUM IN NATURAL WATER




i = inorganic

o = organic

s = soluble

p = particulate

TABLE 5
SELENIUM FORMS AND THEIR TRANSFORMATION MECHANISMS

| INPUT FORM | OUTPUT FORM: $Se^{o}$ (o,p) | $Se^{o}$ (i,p) | $Se^{-2}$ (o,p) | $Se^{-2}$ (o,s) | $Se^{+4}$ (i,p) | $Se^{+4}$ (i,s) | $Se^{+6}$ (i,p) | $Se^{+6}$ (i,s) |
|---|---|---|---|---|---|---|---|---|
| $Se^{o}$ (o,p) | ——— | Desorption | Metabolism | Metabolism and Release | Multistep | Metabolism and Release | Multistep | Metabolism and Release |
| $Se^{o}$ (i,p) | Adsorption | ——— | Metabolism | Metabolism and Release | Multistep | Multistep | Multistep | Multistep |
| $Se^{-2}$ (o,p) | Oxidation and Adsorption | Oxidation | ——— | Decomposition | Multistep | Metabolism and Release | Multistep | Metabolism and Release |
| $Se^{-2}$ (o,s) | Oxidation and Adsorption | Oxidation | Diffusion or Membrane Transport | ——— | Multistep | Multistep | Multistep | Multistep |
| $Se^{+4}$ (i,p) | Multistep | Multistep | Multistep | Reduction by Metabolites | ——— | Dissolution or ion-exch. or Reduction | Oxidation | Oxidation and Dissolution |
| $Se^{+4}$ (i,s) | Reduction and Adsorption | Bacterial Metabolism or Reduction | Reduction by metabolites or Metabolism | Reduction by metabolites or Metabolism | Precipitation or Ion-Exchange | ——— | Oxidation and Ion-Exchange | Oxidation |
| $Se^{+6}$ (i,p) | Multistep | Multistep | Metabolism | Multistep | Reduction | Reduction | ——— | Ion-Exchange |
| $Se^{+6}$ (i,s) | Reduction and Adsorption | Bacterial Metabolism Reduction | 2-step Reduction or Metabolism | 2-step Reduction or Metabolism | 2-step Reduction or Metabolism | Reduction | Ion-Exchange | ——— |

due to the instability of the compound. Anaerobic production of hydrogen selenide was not considered likely to be significant. Only the organic forms of the -2 oxidation state were considered.

Selenites and selenates were thought to be significant in inorganic forms. Organic forms exist only in the reduced state. The +4 and +6 oxidation states of inorganic selenium were thought to be important both as soluble and particulate forms.

This elimination process left eight chemical forms of importance. Table 5 was prepared to summarize the interaction possibilities of these forms. They were considered as one-step processes, but for convenience, sometimes more than one step was recorded. Each change of solubility, oxidation state, form, or carrier, would constitute a step.

The table was interpreted in the same manner as the previous interaction matrix, with the considered transformation going from row to column. For example, by row (the first input form), elemental selenium in the organic particulate form can be transformed into inorganic particulate by desorption, a single step process. It may transform itself into organic selenide particles by metabolic processes. This would be a single step in which proteins may be formed within the living organisms. The formation

of soluble organic selenide requires an additional transfer of carrier by release after the metabolic process. This requires a two step process. The remaining selenites and selenates require more than a single step.

Continuing down to the second row, elemental selenium in the inorganic particulate form may transform to the organic particulate form by adsorption, a single step. It may also form organic selenide particles through the metabolic process. However, to form the soluble organic selenide, two processes are required; that of metabolic synthesis and release of a soluble form. The process is more than a single step since the formation of a product requires a change of carriers or compartments. The remaining oxidized forms all require processes in addition to metabolism and are therefore multi-step processes.

Continuing with the third and remaining rows, transfers of various kinds are suggested.

This table was thought to illustrate most of the significant kinds of chemical transformations that might occur in the proposed selenium model. These transformations are superimposed on the carrier flow diagram to identify the chemical, physical, and biological flows between the carrier couples. The following section explains the process in more detail.

## The Superimposing of Chemical Forms and Transformations onto the Carrier Flow Table

Each of the chemical forms and transformation mechanisms was compared with a carrier flow interaction couple and the transforming chemical change was identified as a chemical, physical, or biological mechanism and recorded in the corresponding box (Table 6 ). Each carrier couple was treated in the same manner until all possibilities were recorded in the transfer matrix. For example, if Table 5 is observed for one-step processes, the first transfer is a desorption as described previously. Free selenium particulate is changed from organic to inorganic. Desorption would result in free, metallic selenium which is insoluble. This process is chemical, and would probably occur only within a given carrier and would not be represented as a flow in the final transfer matrix.

An additional example would occur with the metabolic change of free organic selenium particles to the organic selenide, particulate form. This reduction represents a complex process of oxidative deamination of proteins and the anabolic process of synthesis of biological material containing selenium. This would be identified on the final transfer matrix as feeding of the fish. This also occurs in the transformation of free inorganic particulate to organic

TABLE 6

TRANSFER MATRIX

| | SUSPENDED PARTICULATE | FISH | WATER | SEDIMENT |
|---|---|---|---|---|
| SUPENDED PARTICULATE | ——— | FEEDING<br>ADSORPTION | ION EXCHANGE<br>OXIDATION<br>REDUCTION<br>DISSOLUTION<br>DECOMPOSITION | SETTLING<br>IMPINGEMENT |
| FISH | DEFECATION | ——— | URINATION | 0 |
| WATER | DIFFUSION<br>ION EXCHANGE<br>OXIDATION<br>REDUCTION<br>PRECIPITATION<br>MEMBRANE TRANSPORT | MEMBRANE<br>TRANSPORT<br>DIFFUSION | ——— | ION EXCHANGE<br>PRECIPITATION<br>OXIDATION<br>REDUCTION |
| SEDIMENT | REINTRAINMENT | 0 | DECOMPOSITION<br>DISSOLUTION<br>REDUCTION | ——— |

selenide particles.

The next occurrence of a single step process in Table 5 is adsorption of inorganic free selenium particles to form organic particles of free selenium. This would be a flow in the transfer of suspended particulate by adsorption onto fish.

Additional single-step processes from Table 5 not already mentioned, are listed directly as a chemical process or included in a physical or biological process on the transfer matrix. Oxidation represents the transformation of soluble and particulate selenide to free, inorganic particles. The former would represent a flow from water to suspended particulate. The latter would cause no change of carrier. An additional oxidation of soluble selenite to soluble selenate would likewise result in no flow since this would occur without a change of carrier. The same is true with the particulate selenite to particulate selenate oxidation.

Decomposition would be a cause of flow of organic selenide particulate to soluble organic selenide. This flow would be found from suspended particulate to water and from sediment to water as bacteria decompose the organic material.

Diffusion or membrane transport is the biological uptake that would transform soluble, organic selenide into

a particulate organic selenide. No other transformation of this type occurs as a single step. The flows which would result would be from water to fish and water to suspended particulate.

Reduction by metabolites is a transformation of particulate and soluble selenites to selenides. The particulate selenite becomes soluble selenide representing flows from suspended particulate and from sediment to water. Soluble selenite forms particulate selenide in the same way, representing a flow from water to suspended particulate or from water to sediment.

Dissolution is the process transforming particulate selenite to soluble form and represents a flow in the final transfer matrix of suspended particulate to water, and sediment to water.

Reduction is a chemical process which makes selenium more soluble when it has been precipitated with ferric ion flock formation. The reduction of the iron complex releases the selenium. An example of reduction is the transformation of particulate selenate to soluble selenite. This would be part of the flow of suspended particulate to water or sediment to water. The reverse case might occur in the reduction of soluble selenate to a particulate selenite

such as an insoluble calcium selenium oxide or sulfide. This transformation would represent flow from water to suspended particulate or water to sediment. The transformation of particulate selenate to particulate selenite and the transformation of soluble selenate to soluble selenite represent no flows when superimposed on the carrier flow matrix.

Precipitation is the process transforming soluble selenite to particulate selenite and may be represented by the scavenging action of the ferric ion or the reaction of selenious acid with calcium ion. The flow represented on the transfer matrix would be from water to suspended particulate or from water to sediment.

Ion-exchange occurs as a single step when the oxidation state does not change. The ion-exchange in both directions between particulate selenite and soluble selenite would constitute flows of selenium between suspended particulate and water, and sediment and water. Similar flows would occur among the selenates.

The chemical, physical and biological actions were thus identified and are summarized as shown in the final transfer matrix (Table 6). Physical flows which were not recognized by identification of chemical and biological

processes were due to the physical mixing of the system and were identified in the proper places. Settling and impingement would cause suspended particles to become sediment by definition. Likewise, reentrainment of sediment would define suspended particulate.

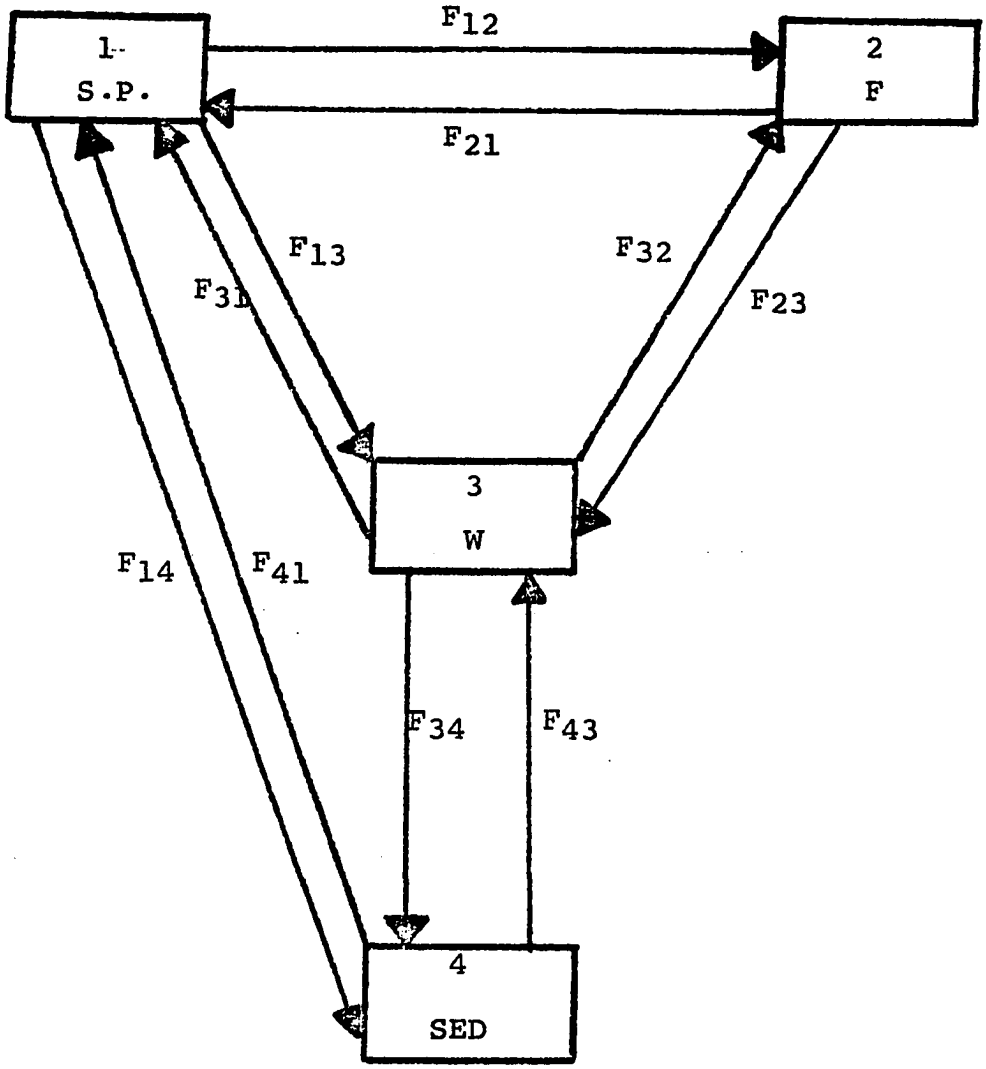
## The Mathematical Expression of the Model

The transfer matrix represents a summary of the preceeding discussions and lends itself to mathematical expression. The transfer matrix was diagrammed in schematic form so that the flow relationships could more readily be visualized for mathematical expression (Figure 3). The arrows $F_{i1}$, $F_{i2}$, $F_{i3}$,... represent the sum of the flows out of a certain compartment ($X_i$)and are part of the sum of flows into other compartments. The boxes represent the chosen carriers and are frequently referred to as compartments in the model.

The model chosen was assumed to be linear as suggested by Patten (1969) when no clear knowledge of non-linear relationships occur. A classic model (Odum 1957) utilized completely the donor controlled model. That is, with a given variable $X_i$, and a time-related constant $a_{ij}$, consider the flow $F_{ij} = a_{ij}X_i$. This represents a donor controlled relationship. Other types of flows may be:

$$F_{ij} = a_{ij}X_j \quad \text{or} \quad F_{ij} = a_{ij} X_iX_j.$$

FIGURE 3
FLOW DIAGRAM




S.P. - Suspended Particulate
F - Fish
W - Water
SED - Sediment

The former is of the acceptor controlled type and the latter nonlinear, controlled by both the donating carrier and accepting carrier. An example of acceptor controlled flow would be a cow foraging on lush vegetation. The flow into the cow, $F_{ij}$, is related to the capacity of the cow to eat and not to some quality of the grass. If, on the other hand, the amount of grass were limited, the donor (grass) would control the flow of energy since the cow would not be eating to capacity. In ecosystem modeling the assumption is frequently made that the donor has nonlimiting amounts and therefore controls the flow. This assumption was made with each forward and reverse flow in the selenium model.

From this point, the complete model was readily expressed mathematically (Table 7) as a system of linear donor-controlled equations. The equations were expressed in matrix form (Figure 4) for convenient notation.

Related information was put in tabular form for concise expression of pertinent assumptions surrounding the model (Table 8).

With the completion of the theoretical aspects of the model, the experimental methods and procedures were next to be developed.

TABLE 7

EQUATIONS--LINEAR DONOR CONTROLLED

$$\dot{X}_1 = F_{21} + F_{31} + F_{41} - F_{12} - F_{13} - F_{14}$$

$$= a_{21}X_2 + a_{31}X_3 + a_{41}X_4 - a_{12}X_1 - a_{13}X_1 - a_{14}X_1$$

$$\dot{X}_2 = F_{12} + F_{32} - F_{21} - F_{23}$$

$$= a_{12}X_1 + a_{32}X_3 - a_{21}X_2 - a_{23}X_2$$

$$\dot{X}_3 = F_{13} + F_{23} + F_{43} - F_{31} - F_{32} - F_{34}$$

$$= a_{13}X_1 + a_{23}X_2 + a_{43}X_4 - a_{31}X_3 - a_{32}X_3 - a_{34}X_3$$

$$\dot{X}_4 = F_{14} + F_{34} - F_{41} - F_{43}$$

$$= a_{14}X_1 + a_{34}X_3 - a_{41}X_4 - a_{43}X_4$$

FIGURE 4

MATHEMATICAL MODEL

$$\begin{pmatrix} \dot{X}_1 \\ \dot{X}_2 \\ \dot{X}_3 \\ \dot{X}_4 \end{pmatrix} = \begin{bmatrix} b_{11} & b_{12} & b_{13} & b_{14} \\ b_{21} & b_{22} & b_{23} & 0 \\ b_{31} & b_{32} & b_{33} & b_{34} \\ b_{41} & 0 & b_{43} & b_{44} \end{bmatrix} \begin{pmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \end{pmatrix}$$

The notation $b_{ij}$ represents uptake rate constants $a_{ij}$ in matrix form.

TABLE 8
SUMMARIZING DEFINITIONS

OBJECTIVE - The objective of the study was to propose a model of the movement of selenium in a simplified, closed aquatic system.

CRITERIA - Experimentally determined parameters and estimated values would be substituted into the mathematical model and simulation would be made with analog computer programs.

COMPONENTS - $X_1$ = Suspended particulate-algal mixture, bacteria, other biota, feces, sorbed and suspended particles.

$X_2$ = Fish-Minnows, Hybognathus nuchalis

$X_3$ = Water-Lake water culture filterable through 0.45 micron filter.

$X_4$ = Sediment-Dredge sample lake sediment, unsuspended bulk.

INITIAL CONDITION - Spike selenium-75 and stable selenium in form of selenious acid into $X_3$.

VARIABLES - $X_i$ = Milligrams selenium per compartment.

$a_{ij}$ = Average uptake constants, fraction per hour.

$F_{ij}$ = Flows between compartments representing physical, chemical, and biological activities describing the movement of selenium between compartments.

# CHAPTER III

## EXPERIMENTAL PROCEDURES AND METHODS

The flow diagram in Figure 3 summarizes the model. The objective is to obtain parameters which will lead to simulation of the model. The experimental procedures were designed with this objective in mind. The physical system was set up to allow flows of selenium from the water to the other three compartments as seen in Figure 3. Methods were devised to measure the amount of selenium in each compartment as a function of time. Statistical analyses of the data are used to determine flow rate constants which will ultimately develop the final simulation.

### Experimental System Preparation

The laboratory container selected for use in the experimental system was a twenty gallon aquarium (one foot by two feet) with a depth of one foot. Precise dimensions can be seen in the diagram (Figure 5). The system was run with duplicate aquaria (Tanks I and II). The tanks were stirred continuously throughout the experimental period.

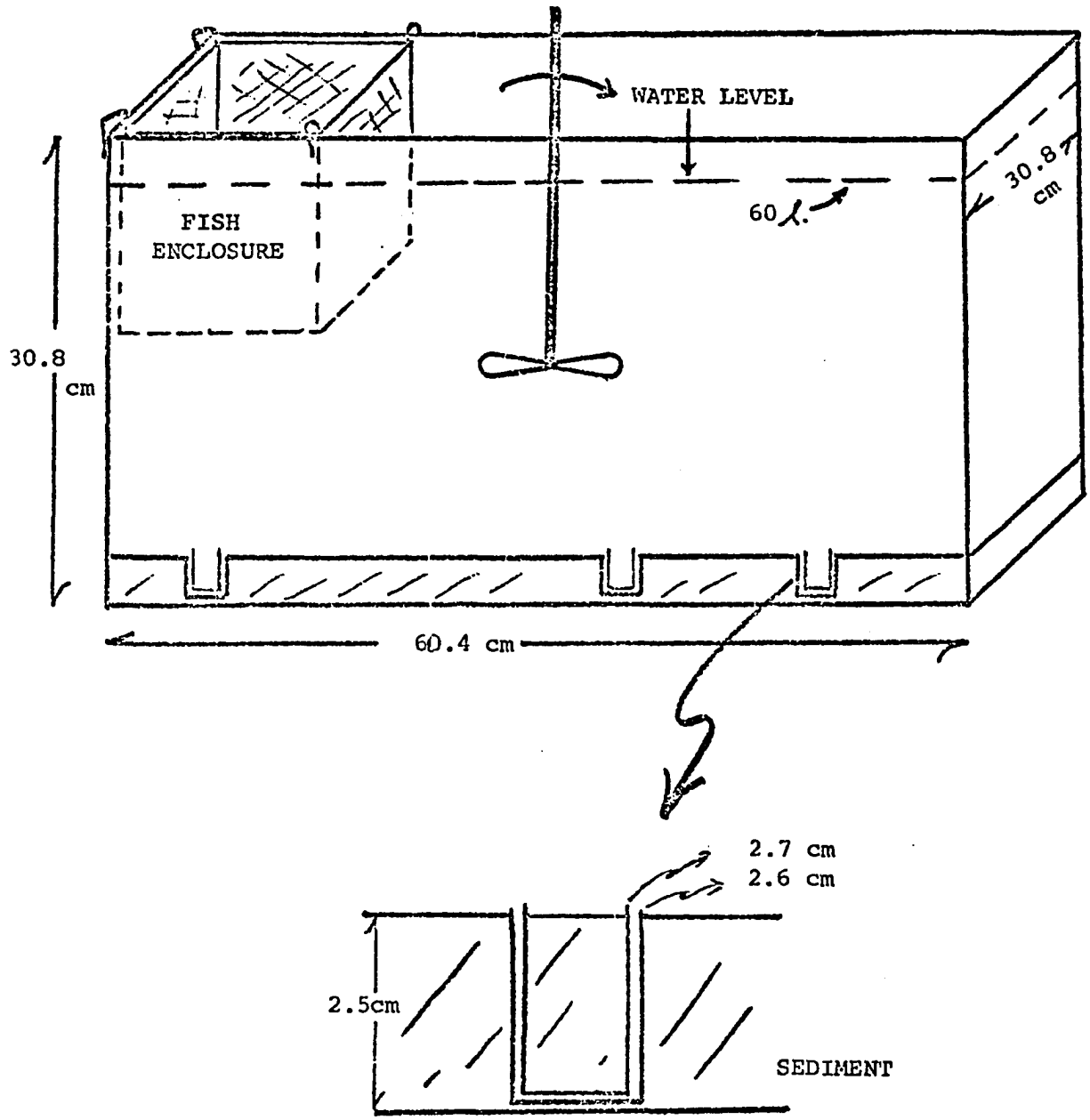



FIGURE 5. PHYSICAL MODEL,
CLOSEUP OF SEDIMENT CONTAINER IN SITU

The tanks were situated in front of identical banks of General Electric Cool White fluorescent bulbs. They were continuously illuminated with approximately 100-300 foot-candles light intensity as measured with a light meter through the tanks. The variation of light intensity was a result of changes of turbidity within the system during operation.

A fish enclosure 15cm. x 15cm. x 30cm. was hung over the edge of each of the tanks. A four millimeter nylon mesh was used (Figure 5 ).

## Water

The water selected for the experimental tanks was taken locally from Lake Thunderbird, a Bureau of Reclamation impoundment at Norman, Oklahoma. The samples were taken in open water, filtered through cotton and used in the laboratory for preparation of the stock cultures. To the culture was added a modified Knop's nutrient media (Appendix A-1). The culture was stirred constantly and put under continuous lighting similar to the experimental tanks. This was the stock culture for the water and suspended particulate compartments.

## Sediment

The sediment was also obtained from Lake Thunderbird by means of an Eckman dredge sampler. Three open water sites were selected at random and samples were combined. The sediment was air dried, ground and passed through a No. 10 sieve. A particle size analysis by sieve series was carried out (Appendix A-2).

The sediment thus prepared was spread in an even layer on large porcelain trays. It was sectioned into 16 regular sections and portions were drawn at random from the tray and combined to make up the sediment compartment to be put into the bottom of the experimental tanks. A small cup was used to procure the combined sediment by dipping it to overflowing and leveling it with a spatula. This technique was used to prevent discrimination against particles of a given size.

It was considered that free grab samples of the sediment would be disruptive and result in non-reproducible sampling. Therefore, a method was devised which would allow for standardized in situ sampling containers which would be retrievable for measurement and could be replaced without disturbing either the sample or the sediment. The sampling containers were prepared (Figure 5) in the following manner.

The sediment sample containers were made from the 19 mm. diameter plastic autoclavable caps for 16 x 160 mm. culture tubes. A band saw was used to cut from the open end until the desired height was reached. The 26 mm. vials thus produced were prepared to be recessed into the sediment.

Since removal of samples would allow selenium flow into the hole or cause its walls to collapse, a sleeve with a bottom was used to line the hole in which the sample container was placed. This lining sleeve was fashioned by cutting the top from a 15 ml. screwcap polyethylene bottle, resulting in a wide top cyclinder with a bottom. Thus, when the sample container was in place, it nested in the sleeve so that the top was protruding only enough to allow grasping by the sample retriever.

The sample containers were filled with sediment by weighing out particle size grades (Appendix A-3) of sediment that represented precisely the particle size distribution for the whole sediment as previously determined. Such a distribution totaling 10.8289 g. was carefully weighed into each container. This weight represented

$$\frac{10.82g}{7200g} = \frac{1}{664.887}$$

of the total sediment compartment. Eleven containers were

saturated with water and put in place in the sediment in each tank (Figure 6).

In order to decide representative placement of the sediment sample containers, some sort of bottom profile of dynamic similarities was sought. Before putting sediment into the experimental tanks, a 30.8 x 60.4 cm. rectangle of blotting paper was saturated with water and placed on the bottom of each of the tanks. The tank was filled with water to the 60 l. mark and the propeller was then turned on. A representative sample of sediment was introduced around the center of the tanks above the propeller by graded particle size in sequence. The particles were allowed to impinge upon the paper at the bottom. In addition, a quantity of suspended particulate (algae, fish, feces, etc.) was treated in the same manner and allowed also to impinge onto the bottom paper. The resultant bottom profile (Figure 6) was removed carefully with the paper and allowed to dry. It was fixed with spray shellac, and photographed. The profile was then used as a rationale for the positioning of sediment sample containers.

The bottom profile was divided into four geometric areas (Figure 5), concentrically inscribed within each other as follows: an outside rectangle containing an elipse,

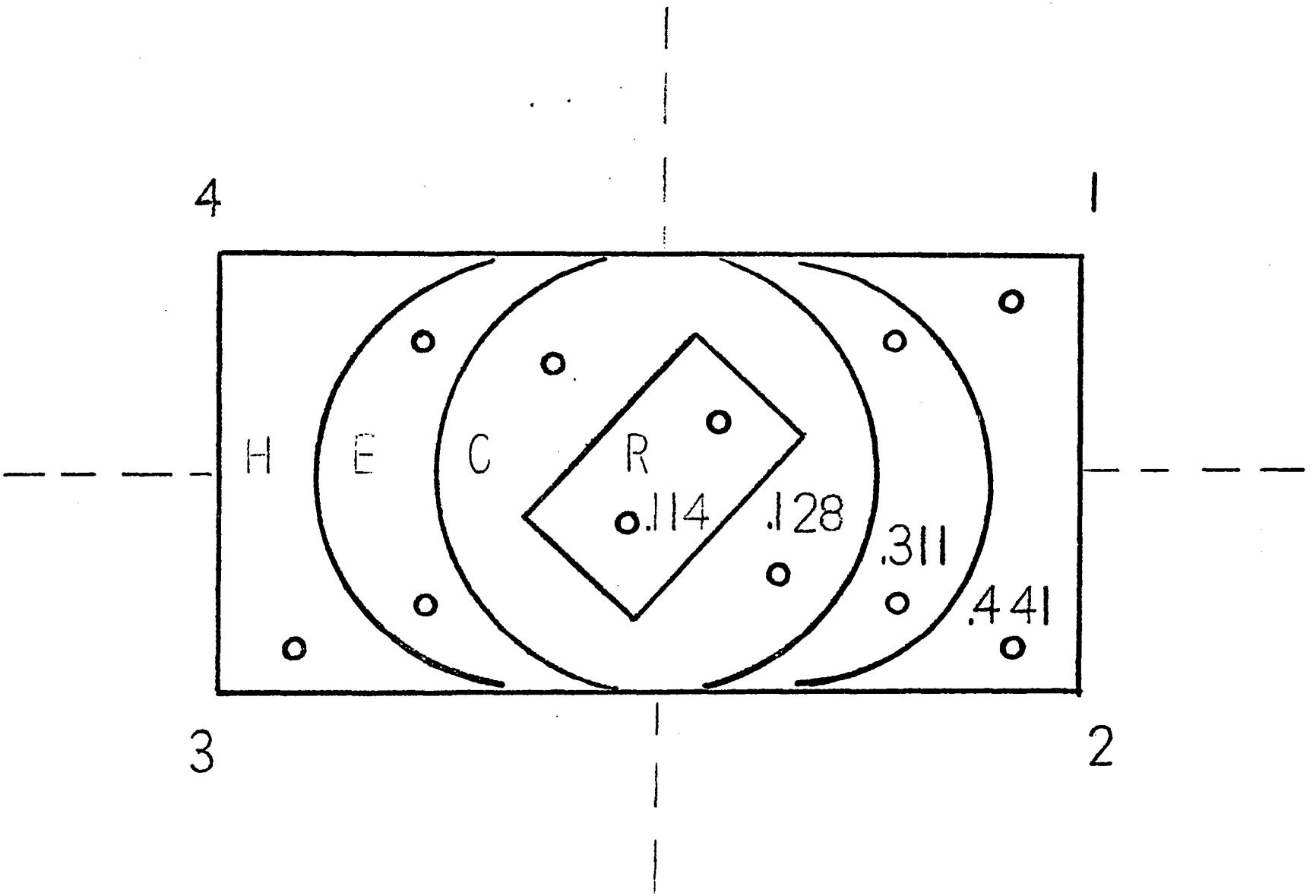



FIGURE 6, PLAN VIEW ACQUARIUM
GEOMETRIC AREAS, DISTRIBUTION
OF SEDIMENT SAMPLE CONTAINERS, QUADRANTS

a circle, and in turn, a small rectangle. The dimensions for these areas was determined by a combination of tracing on acetate overlay, inspection, and measurement with a metric ruler. The idealized areas were drawn more carefully to actual size. Placement of sampling containers was based on a combination of calculated centroid position, symmetrical placement of duplicate samples and wall reflection interference (Figure 6 ). The geometric areas were symbolized by letter for their mutually exclusive areas, starting with the inner rectangle, R, the circle, C, elipse, E, and the corners, H (from hyperbola). The areas of each of the regular geometric figures was calculated and the area of the mutually exclusive sampling regions was determined by subtraction. The total bottom area was calculated to be 1860.32 $cm^2$, and the described geometric mutually exclusive areas were determined to be fractions of the bottom area:

H=.4408, E=.3111 C=.1289, R=.1142.

## Fish

The supply of fish was obtained from a local bait shop and the fish were sorted into a rough size range. Only those within the one to three gram range were used experimentally. Hybognathus nuchalis was used for the stock fish source. The fish were kept in the same tank used for the

stock culture of water and of suspended particulate compartments.

The fish enclosures in the experimental tanks were suspended over quadrants 3 and 4 of Tank I and over quadrants 1 and 2 of Tank II (Figure 6).

The fish were fed at the rate of 0.11 g. food per g. fish per day using crushed pellets under the commercial name of SHRIMP-EL-ETTES. Both the lake water, lake sediment, and the fish food were analyzed for selenium by the aminobenzidine procedure taken from APHA, "Standard Methods for the Examination of Water and Waste Water." The fish food and sediment were crushed and homogenized in 0.1N. HCl and diluted in a volume of water before the standardized procedure was followed. The samples and standards were read in the Beckman D-B Spectrophotometer at 420 nanometers. Percent transmittance was recorded, and concentrations of selenium determined.

## Suspended Particulate

The suspended particulate was that which developed naturally from the culture. The diverse biota which developed in the experimental tanks was examined occasionally for species and types, but no stringent attempt was made to characterize it (Appendix B-24).

The first run weights of suspended particulate were small enough so that it contributed in part to the lack of statistical precision in count rate data. Nutrients were added prior to the second run to stimulate a higher level of algal growth and improve the data obtained.

## Experimental System Operation

To prepare for the experimental period, the sediment containers were filled as described previously. When wetted, the sediment sample containers had a depth the same as total sediment depth in the tank. The sediment and sample containers were left in place and the supply stock culture of suspended particulate and water was added carefully without disturbing the sediment. Time was allowed for the sand to be wetted and the voids filled with water. Then water was added up to a volume of sixty liters. The propellers were positioned and turned on. The light banks were lighted and the fish were introduced into the enclosure. The system was operated for a few days prior to addition of the radioselenium.

## Sampling The Experimental System

### Sampling

Sampling both experimental variables and stability

parameters of the physical system were made on a daily or near daily basis. Parameters that were chosen to monitor the stability of the system were temperature, pH, dissolved oxygen, and filterable residue. Sampling of the compartment variables in the experimental tanks was done on a logarithmic time basis. Samples were taken at first by minutes, then increased to a daily interval. The sampling routine was as follows: The stability parameters were measured first as explained below. Then, the experimental variables were sampled in sequence: the water compartment, suspended particulate, fish, and sediment. With the completion of sampling, the sides of the tanks and other immersed structures (net, propeller) were scraped or brushed clean of deposition of suspended material. A microscope slide permanently fixed onto a glass rod was used as a scraper for the tank walls. The fish were fed, and the level of the tanks was returned to the 60 l. ± 3%. Evaporation loss accounted primarily for the approximately 250 ml. of water added per day.

The only water used in all experimental work or associated procedures, with the exception of the stock culture, was deionized water prepared by distillation and subsequent percolation through an ion exchange resin.

The stability parameters measured were temperature, dissolved oxygen, pH, and filterable residue. The temperature was measured to the nearest degree by suspending a thermometer in each tank. The thermometer was read through the glass wall without removal.

Dissolved oxygen was determined to the nearest 0.1 p.p.m. A membrane-type dissolved oxygen meter was used. It was calibrated and checked by the alkaline azide dissolved oxygen modification in Standard Methods.

A dip sample was taken for pH determination on a Photovolt digital pH meter to the nearest 0.1 pH unit. The sample was then returned to the tank. If the pH approached 9.0 units, it was lowered with the addition of carbon dioxide gas.

Filterable residue was determined with a total dissolved solids meter. The filtrate sample used to determine the water compartment counting rate was used for the determination. The reading was taken directly from the meter, adjusted for dilution, and recorded to the nearest part per million. The sample was returned to the tank.

Water Compartment, Suspended Particulate Compartment

The water and suspended particulate compartments were

sampled together. In the first experimental run a 20.0 ml sample was freely drawn from a point approximately 10 cm. below the surface of the tank. A pipette was used which had been broken, fire-polished to a larger orifice, (Appendix A-5) and re-calibrated. The sample was pipetted into a 47 mm. diameter glass Millipore filter apparatus which was fitted to a 1,000 ml. suction flask operated off a water faucet aspirator. After the pipetting was complete, the sample was filtered through a 0.45 micron cellulose acetate Millipore filter and collected directly into a clean 25 X 250 mm Pyrex test tube. The tube was removed and the count rate determined. The value was recorded as the water compartment sample counting rate. The filtrate was used for filterable residue determination and then returned to the experimental tank. The filter was removed with the filter cake and dried in a planchet oven at 50° C. for 24 hours. The filter was placed in a 50 mm. petri dish, covered, removed from the oven, and allowed to cool for a short time before weighing to constant weight. The weight was recorded to the nearest 0.1 milligrams. The dried filter was rolled and inserted into the bottom of a 25 x 250 mm. Pyrex test tube and a count rate determined. This was recorded as the suspended particulate sample rate.

In the second experimental run, the water and suspended particulate sampling was done as 2 consecutive 20.0 ml. samples. The first 20.0 ml. pipetting was superimposed on top of the filter cake such that it was completely re-suspended by the additional 20.0 ml. Then the suction was turned on. The filtrate thus obtained was simply returned to the experimental tanks. The filter cake was treated as above, dried, weighed, and counted with the recording of weight and count rate to reflect a 40.0 ml. sample instead of a 20.0 ml sample.

In both experimental runs, the filter apparatus was rinsed 6 times with deionized water after each sample was filtered. Pipettes were likewise rinsed with dilute HCl and then acetone.

## Fish

The fish were handled one at a time. Each was netted, clasped in gloved hand, and given a quick rinse in a beaker of deionized water. The purpose of this was to remove any loosely adhering particles properly belonging to the suspended particulate compartment. The fish was then put anterior end down into a 25 x 250 mm. clean test tube. Deionized water was used to bring the volume of fish and water to 20 ml. The tube containing the fish was put into

the counting chamber and a counting rate was determined. This was recorded for each fish as a sampling of the fish compartment. The fish was placed in a waiting tank containing oxygenated, deionized water until all the fish in the tank were counted; and then they were all returned to the experimental tank. After counting each fish, the water in which the fish was counted was returned to the counting chamber for the detection of loss from the fish while being counted.

## Sediment

The sediment was of constant depth and organized for the purpose of sampling into four geometric areas as described in a previous section. The samples were removed with the help of a retrieving device similar to those used in grasping objects that have fallen into small tubular orifices such as sink drains. The grasping device was used as a sample retriever by immersing the distal end to the bottom of the experimental tank. By squeezing the top, one could carefully grasp the container without disturbing the sediment or the sleeve in which it was sitting. If the visibility of the sample container was occluded by the turbidity of the suspended material, a depth-viewing device was employed. This allowed the experimenter to see the

container with greater clarity. This was simply a 1000 ml. graduated cylinder with the projecting part of the base removed to allow juxtaposition of the viewer to the sample retriever. The viewing device was held by hand and the otherwise nonvisible samples could be seen clearly and retrieved with the necessary care.

When the sample containers were removed, each was drained of excess water and put into the counting chamber. A count rate was recorded for each sample container. During the time when the samples of sediment were removed, it was almost never necessary to turn off the propeller or to disturb the mixing dynamics of the experimental tanks.

There was a separate Roman Numeral designation for each tank (I, II) and numerals for the quadrant relative to a tank center origin (1, 2, 3, 4). Thus, a sample container in the lower left hand corner of tank II, would be designated II3H (Figure 6).

## Radioisotope Tracer Procedures

### Radioisotope Source Preparation

The radioisotope was received as selenium-75 in the chemical form $H_2SeO_3$ in 0.5N. HCl. The 1 mCi. source had a specific activity of 175 mCi. per mg., having a total of 0.0057 mg. solids in 0.1 ml. The isotope was removed from

the container, checked for contamination and opened. The total volume was made up to 5.0 ml. by adding deionized water. This was the stock solution of radioselenium with a specific activity of 1 mCi per 5.0 ml.

Specific Activity for Run I

Several five lambda aliquots of radioselenium were removed and diluted 1:200,000. This was the same material as used for the efficiency calibration (see Appendix C-7, 8).

A total quantity of the $2.4316 \times 10^6$ cpm was added to a volume of water containing 1.200 mg. selenium. The selenium solution was prepared from $H_2SeO_3$ reagent and deionized water. The labeled selenium mixture was diluted to 400 ml, mixed for 15 minutes, and then divided into two aliquots for spiking the two experimental tanks for the first run.

The specific activity for the first run spike quantity was then:

$$\frac{2.4316 \times 10^6 \text{ cpm}}{1.200 \text{ mgSe}} = 2.0263 \times 10^6 \frac{\text{cpm}}{\text{mgSe}} .$$

Specific Activity for Run II

Approximately 50 lambda were removed from the stock radioselenium solution and diluted 1:200,000 as in the first run. Four aliquots were taken for readings in the

standardized 20.0 ml. 25 x 250 mm. test tube. Count rates were as follows in TABLE 9.

TABLE 9

SPECIFIC ACTIVITY FOR EXPERIMENTAL RUN

| Aliquot from Dilution of Radioselenium Solution | Count Rate Standard Geometry cpm per 20.0 ml |
|---|---|
| 1 | 64,377 |
| 2 | 63,992 |
| 3 | 64,234 |
| 4 | 64,572 |
| Average..... | 64,294 cpm ± 508 cpm |

A total quantity of the dilution containing 25,717,600 cpm was added to a volume of water containing 12.000 mgSe. The selenium was prepared from $H_2SeO_3$ reagent and deionized water. The labeled selenium mixture was diluted to 400 ml; mixed for 15 minutes, and divided into two aliquots for spiking the two tanks of experimental run II.

The specific activity for the second run spike quantity was then:

$$\frac{25.7.76 \times 10^6 \text{ cpm}}{12.000 \text{ mg Se}} = 2.1431 \times 10^6 \frac{\text{cpm}}{\text{mg Se.}}$$

## Counting System

A gamma counting system was set up consisting of a 3 inch sodium iodide well crystal, a photomultiplier, and an Ortec Model 420 single channel analyzer. The detection unit was fixed upright in a counting chamber constructed of lead bricks which were precleaned to provide low background counting rates.

The following standard sources were used to calibrate the single channel analysis system. The linearity of the system was determined by using the same sources.

TABLE 10

CALIBRATION ENERGIES

| |
|---|
| $^{57}Co$---0.136 M.e.v. |
| $^{133}Ba$---0.080,0.276,0.302,0.356,0.382 M.e.v. |
| $^{137}Cs$---0.662 M.e.v. |

A gamma spectrum of the selenium-75 was run to establish the proper operating voltage, baseline, and window width for the detection of the isotope. A source was placed in the counting chamber and the spectrum was obtained by recording count rate for the source at incremental increases

in voltage. A plot was made of count rate vs. pulse height voltage (Appendix C-5).

Optimum operating parameters for the counting system were a baseline setting of 0.029 V. to eliminate noise, and a window width of 0.500 V. to allow greatest sensitivity for detection of the complete selenium-75 spectrum.

## Counting Efficiency

Several 5 lambda aliquots were removed from the selenium-75 stock solution and placed into 25 x 250 mm. test tubes in a droplet at the bottom. The tubes were diluted by the addition of 20.0 ml. of deionized water. The count rate was determined after gentle swirling. A 100 lambda aliquot of the dilution was removed and put into a similar clean test tube. To this second tube were added 19.9 ml of the deionized water bringing the volume to 20.0 ml. The total dilution from the 1 mCi. stock bottle was then a factor of $2 \times 10^{-5}$. The machine efficiency was then calculated on the basis of this fraction of the source activity in a 20.0 ml. volume contained in a 25 x 250 mm. Pyrex test tube (Appendix C-7). The efficiency was determined to be 64.2%.

One lambda of radiolabeled $H_2SeO_3$ from the stock solution was pipetted into each of eight 25 x 250 mm. Pyrex test tubes. A series of concentrations of the same compound with stable selenium was prepared and 20.0 ml. of each respective concentration was added to the tubes containing the isotope. All dilution and rinse water was deionized water. Tubes were pre-cleaned in an acid bath of the same water. The pre-counted tubes were filled as described, allowed to set 15 minutes, and placed into the counting chamber. Counting rates were recorded before and after emptying and rinsing a series of times. The fraction of selenium sorption on glass test tubes was determined (Appendix C-9).

Calculation of amounts of selenium added with the tracer was made to see if the very dilute concentrations of stable selenium compound were significantly altered by the addition of the isotope (Appendix C-2).

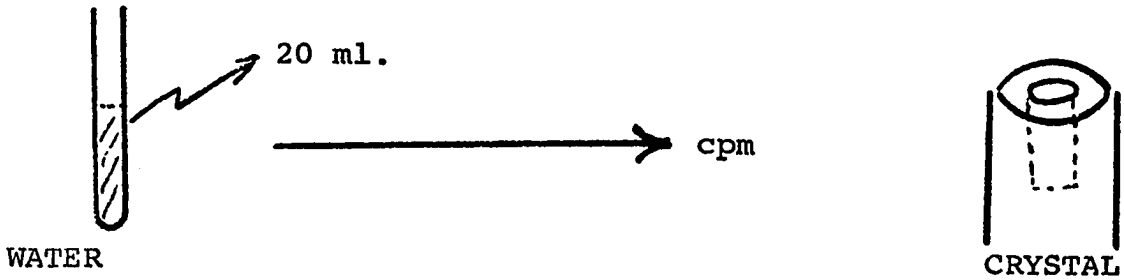
Sorption was checked in the experimental tanks by daily scraping of the walls with a microscope slide fixed to a glass rod. As a check on this, another microscope slide was left in the tanks throughout the duration of the experiment. A second slide was put into each tank on occasion and left

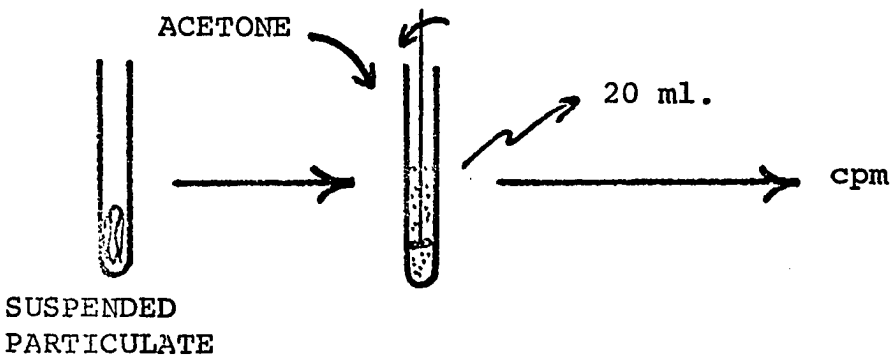
for a 24 hour period after which it was removed and scraped in a manner similar to the above tank walls, and placed on the crystal detector to be checked for remaining activity. At the end of the experimental period, the slide that had remained in each of the tanks for the duration of the experiment, was removed and counted, then scraped and again counted.

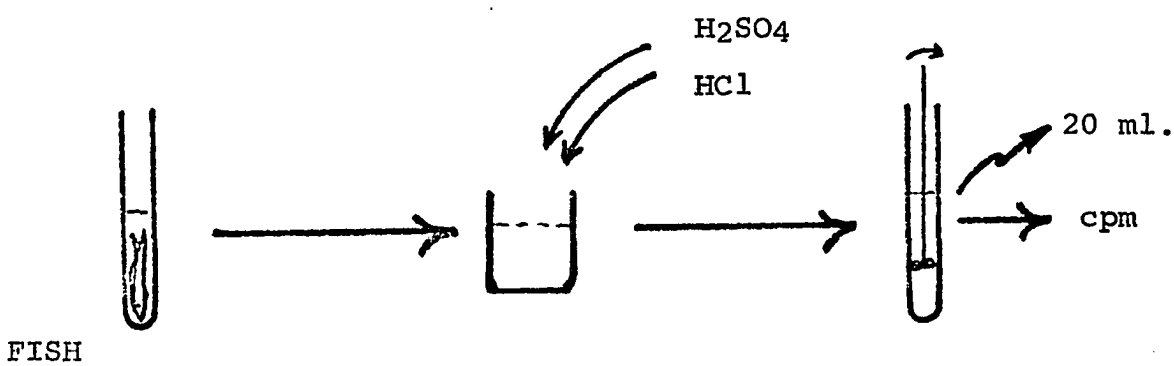
## Normalization

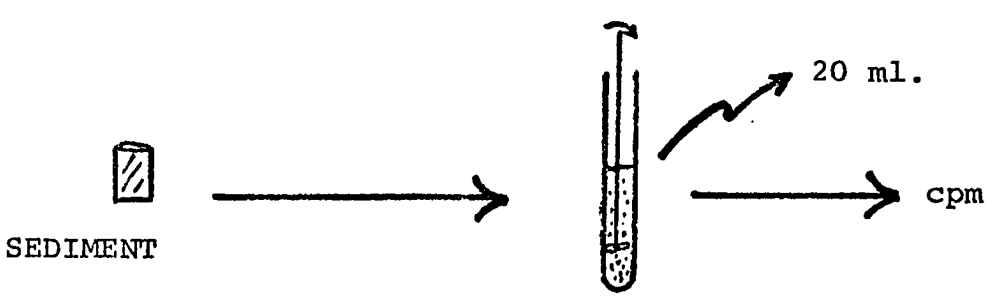
Since the specific activity was determined in a standard 20.0 ml. volume, the water and other compartments must be normalized to this geometry (Figure 7). Count rates can then be converted to milligrams of selenium. The water compartment was normalized in the following manner: Five lambda were removed from the source stock bottle and diluted to 20.0 ml. A 100 lambda aliquot was removed and placed into each of several previously counted standard test tubes. A counting rate was determined and the tubes were filled with 20.0 ml. of $10^{-2}$ p.p.m. unlabeled selenium solution and again counted. A more complete set of paired data was obtained in a similar manner with the exception that counting rates were determined for 1.0 ml. increments up to 20.0 ml. (Appendix C-10).

FIGURE 7. COMPARTMENT NORMALIZATION SCHEMES



The effect of stirring was observed by preparing two series of test tubes as above, all with the same amounts of radioactive stock selenium solution and 20.0 ml. of $10^{-2}$ p.p.m. unlabeled selenium solution. Counting rates were determined on each of the tubes in both series, one series, while being stirred, the other not stirred at all (Appendix C-15).

The sediment compartment was normalized by washing the contents of the sediment sample containers into 25 x 250 mm. Pyrex tube and diluting to 20.0 ml. with the deionized water. The counting rate was determined while stirring (Appendix C-15).

The effect of attenuation by sand was observed by preparing two series of test tubes. Into all tubes was pipetted identical amounts of the radioactive selenium solution. One series had the subsequent addition of 20.0 ml. of $10^{-2}$ p.p.m. unlabeled selenium solution, and to the other series was added 10.82 g. of non-radioactive sand from the same source as used to prepare the experimental tanks. This second series was then diluted to a total volume of 20.0 ml. allowing time for the saturation of the void space in the sand. Stirred counting rates were determined on all tubes in both series (Appendix C-15).

Calculations were made of the theoretical attenuation by the sandy sediment assuming the sediment to be glass homogeniously distributed throughout the 20.0 ml. volume (Appendix C-16, 17).

The normalization of the fish compartment was determined by preparing a separate tank with uptake conditions similar to the experimental tanks and allowing the group of fish to build up in an activity to a reasonable level for detection significance. Radioselenium-75 of the same specific activity as that used in the experimental tanks was introduced. The fish were treated in the same manner as the experimental fish. A count rate was determined prior to wet ashing in a sequence of sulfuric and hydrochloric acids. Concentrated acids were used and the resulting solution was diluted to 20.0 ml. for an additional count rate determination for each fish (Appendix C-12).

The suspended particulate compartment was normalized by dissolving the previously counted dried filters containing the samples of suspended material in a 20.0 ml. quantity of acetone. The suspension was stirred while a count rate was determined (Appendix C-11).

## Counting Statistics and Data Analysis

Background counting rates were kept to near 100 c.p.m. by detector shielding and by frequent wiping of the inside of the counting chamber and well crystal. All glassware was washed and rinsed when re-used so that its counting rate fell within 95% confidence limits of the background counting rates. When practical, a thin food wrap was used to line the well crystal to avoid contamination of the counting chamber.

When repeated daily sample counting rates fell within 95% confidence limits of the average value, the system was considered to have reached steady state or completion of uptake for the experimental sampling.

Regression analyses were made on the uptake data to determine the parameters for the selenium model.

## Post Experimental Procedure

At the end of the experimental period the tanks were drained and the sediment removed with a spatula. Each of the geometric areas was separated and kept in a separate container. Each area was mixed in a blender to homogeneity with the aid of deionized water. The sample areas were air dried and a 10.82 g. aliquot was put into a clean sediment sample container, re-saturated with the deionized water

and placed in the counting chamber as a representative of its respective geometric area. The counting rate was recorded as such.

Samples of these areas were treated in a blender with hot methanol and homogenized in volumes of deionized water. The samples were analyzed for selenium using the diaminobenzidine procedure as in the APHA "Standard Methods for the Treatment of Water and Waste Water." Standard solutions were prepared and samples and standards were read in a Beckman D-B Spectrophotometer. Recordings were made of % transmittance and concentrations were determined.

# CHAPTER IV

# DATA AND DISCUSSION

## Organization

The analysis of the data will be divided into four parts. The first part will be a discussion of the stability parameters. How stable was the system in terms of the design of the model?

The second part will be an analysis of the uptake data by compartments. Pre and post-experimental work will be included in the discussion. The primary objective will be the determination of uptake constants for the simulation of the model in Chapter V. This will be done through the use of regression analysis.

The third part will assess the validity of radiotracer methods and selenium concentrations obtained.

The last part will be a projection of the data to determine other parameters related to the data. These are not germain to the simulation of the model, but are important for suggesting additional research.

## Stability Parameters

The stability parameters were sampled as a part of experimental data to determine the stability of the system. All of this data is located in Appendix B-17, 18. Significant changes in these parameters might cause changes in the physiological function of the living organisms. They may produce flows or rates of uptake which were not considered in the design of the model.

Changes in pH (Appendix B-17, 18) occurred with a relatively small variation. The highest and lowest values from either tank in both runs varied no more than a pH unit. This relatively small deviation would not likely result in any physiological stress for the fish. The algae were able to maintain a relatively constant pH after approximately one week of acclimation by addition of carbon dioxide. The tendency of the algal culture to drive the pH up was moderated and very little addition of carbon dioxide was necessary after the first week.

Since the pH change was so small, there was likely no important change in the driving force influencing chemical reactions.

Dissolved oxygen fluctuated a considerable amount, but the variations of both runs was approximately the same.

The only generalization that might be made is that perhaps the values were slightly higher during the first week of each run. It is possible that the algae were still in the log phase of growth and liberating oxygen at a maximum rate. During the remaining weeks, there was a cycling of decomposition and growth at a relatively constant and stable rate. This hypothesis is somewhat verified by the suspended particulate weight data (Appendix B-19, 20) which indicates a mass increase and weight fluctuations after an initial period.

The primary concern for dissolved oxygen is not for fluctuation, but for a minimum level for support of life. The minnows have the habit of constant gill ventillation and seemed not to be under any physiological stress when the dissolved oxygen dropped below four parts per million. This habit and the mixing action of the propeller probably maintained the oxygen transfer across the gill membrane well within normal values.

The only other concern, then, was for maintenance of an oxidizing state for chemical reactions which may have occurred. As long as any oxygen tension remained, this state was maintained. Only until oxygen is depleted completely, would the redox potential begin to change.

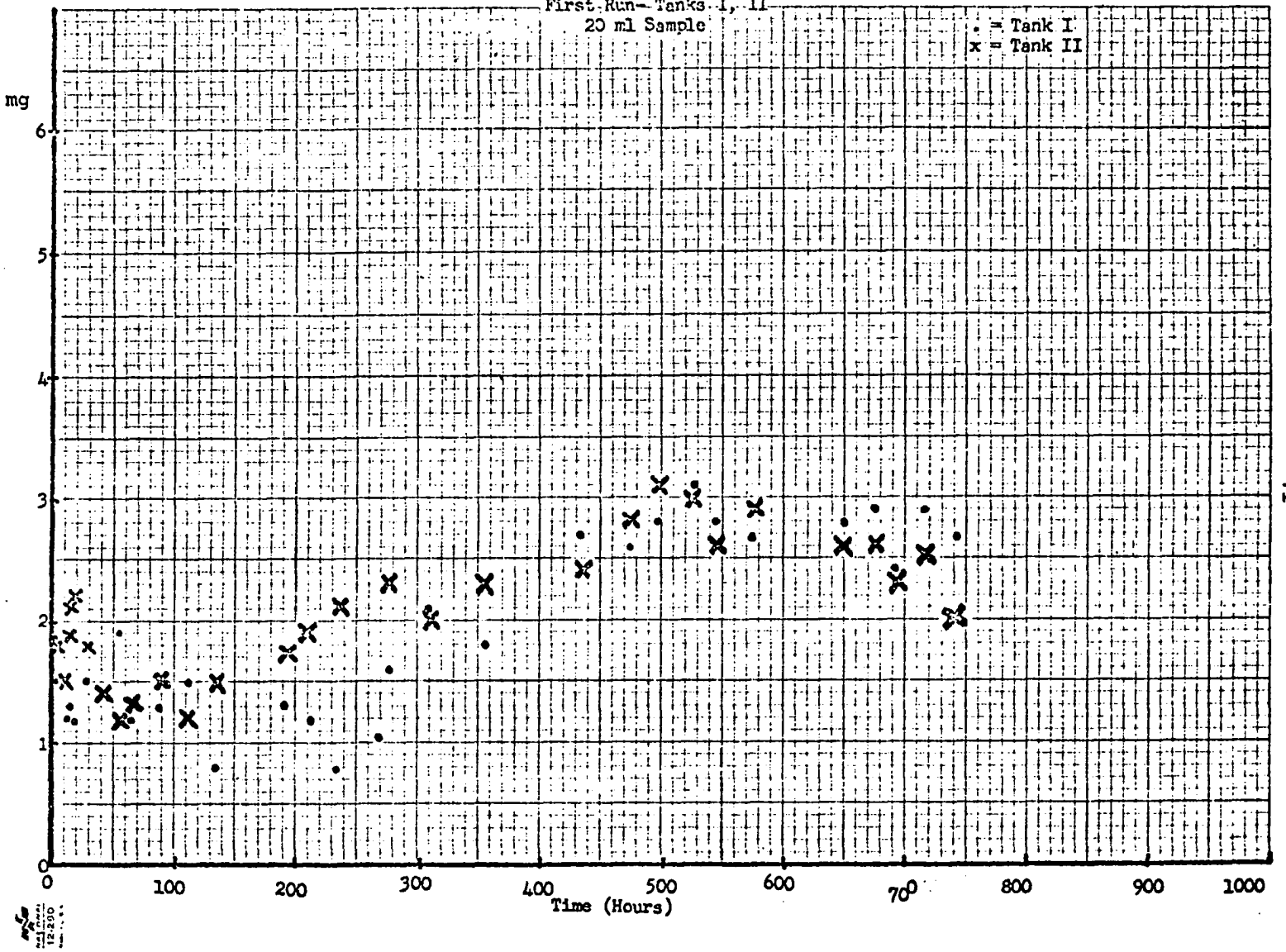
The total dissolved solids changed very little within runs; but the second run was significantly higher in TDS (Appendix B-17, B-18). This may be attributed in part to added nutrients in establishing the culture for the second run. The TDS was constant for each run and was therefore controlled for any experimental run. No effects were observable with this change in dissolved ions. The most significant factor was probably the tenfold increase in selenium concentration in the system. This may have made a significant contribution to the increase of dissolved material; however, the loss of selenium from the water was not accompanied by a drop in TDS throughout the course of the experiment. The additional selenious acid may have increased the solubility product for compounds which allowed more to be dissolved. The increased dissolved materials, then, may not have precipitated upon removal of selenium from solution. They may have super-saturated without precipitating and maintained a constant TDS. Calcium ions, for instance, may have increased in solubility with the increase of selenious acid. The trophic loss of selenium from the water was not accompanied by a precipitation of selenium because of a shift in the bicarbonate equilibrium to more acid conditions. The pH would not shift

due to a loss of free $CO_2$. This type of equilibrium, however, could not account for the doubling of TDS alone. The limits of dissolved materials were not excessive, and normal physiology and constant chemistry within any run were maintained.

Temperature changes of a degree up or down were the maximum limits of variation. The slight changes would not be considered significant to change the physiology or chemistry of the system. The first run averaged a degree or two lower than the second run. This was due to an increase in room temperatures. This difference would not be significant for purposes of the model.

The suspended particulate weights remained relatively constant throughout the experimental period. Fluctuations were due to sampling error. This was primarily a function of the mixing, since the pipetting error was considered to be less than 5 per cent, and the weighing error a maximum range of 0.4 mg. (See Figures 8 and 9.) Outside the bounds of the sampling error there seemed to be a slightly cyclic variation of weight. This was found to be true in both experimental runs. This cyclic nature might be explained as alternating growth and decomposition release periods. Changes in free nutrient levels could cause this to occur.

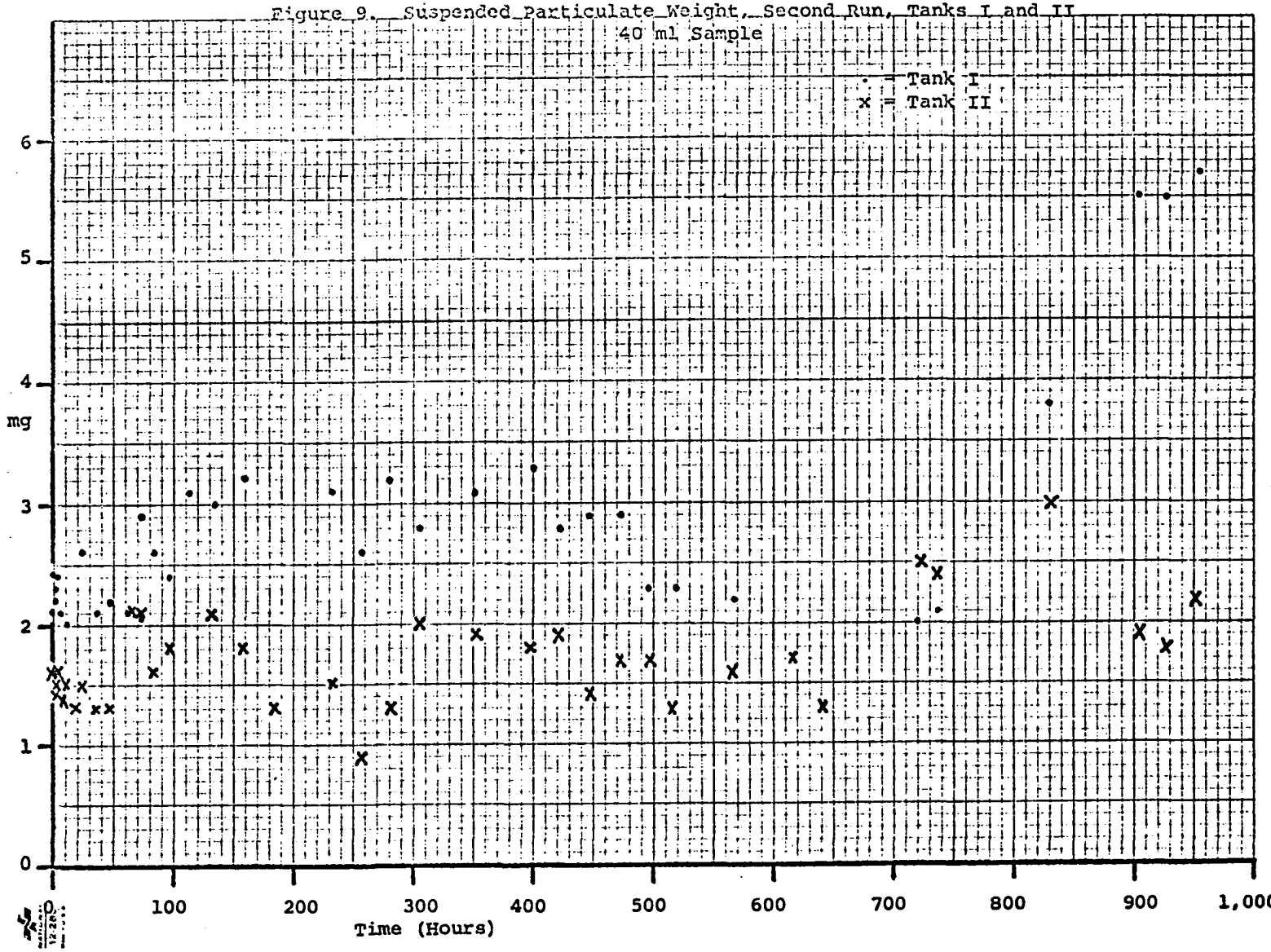
Figure 8.-SUSPENDED PARTICULATE WEIGHT
First Run-Tanks I, II
20 ml Sample






10 Squares to the Inch

Figure 9. Suspended Particulate Weight, Second Run, Tanks I and II
40 ml Sample



This fluctuation might be related to variation in levels of dissolved oxygen. No statistical correlation was made, but a visual scanning of the data would reveal relationships of this kind. In general, this cycling would seem to have no significant effect on the movement of selenium in the total system. This will be discussed later in this chapter.

Other biota in the system would indicate stability of the system (Appendix B-24). Diversity of types and small numbers would indicate a stability. Stalked protozoans and rotifers would indicate the more advanced successional stages. The adundance of an alga such as Ankistrodesmus sp. and Scenedemus sp. is common for ponds and aquaria. They are considered planktonic algae when mixing action occurs. Blue-green forms were not abundant. Thus the algal forms also represent species established for periods of time in pools and ponds.

The non-experimental parameters and biota in general represent a system that is established for a period of time and relatively constant.

## Experimental Runs and Associated Data

The two experimental runs represent four similar systems which responded with repeatable similarity at two different levels of selenium concentration (Figures 10-13).

Figure 10--UPTAKE OF SELENIUM
First Run -- Tank I

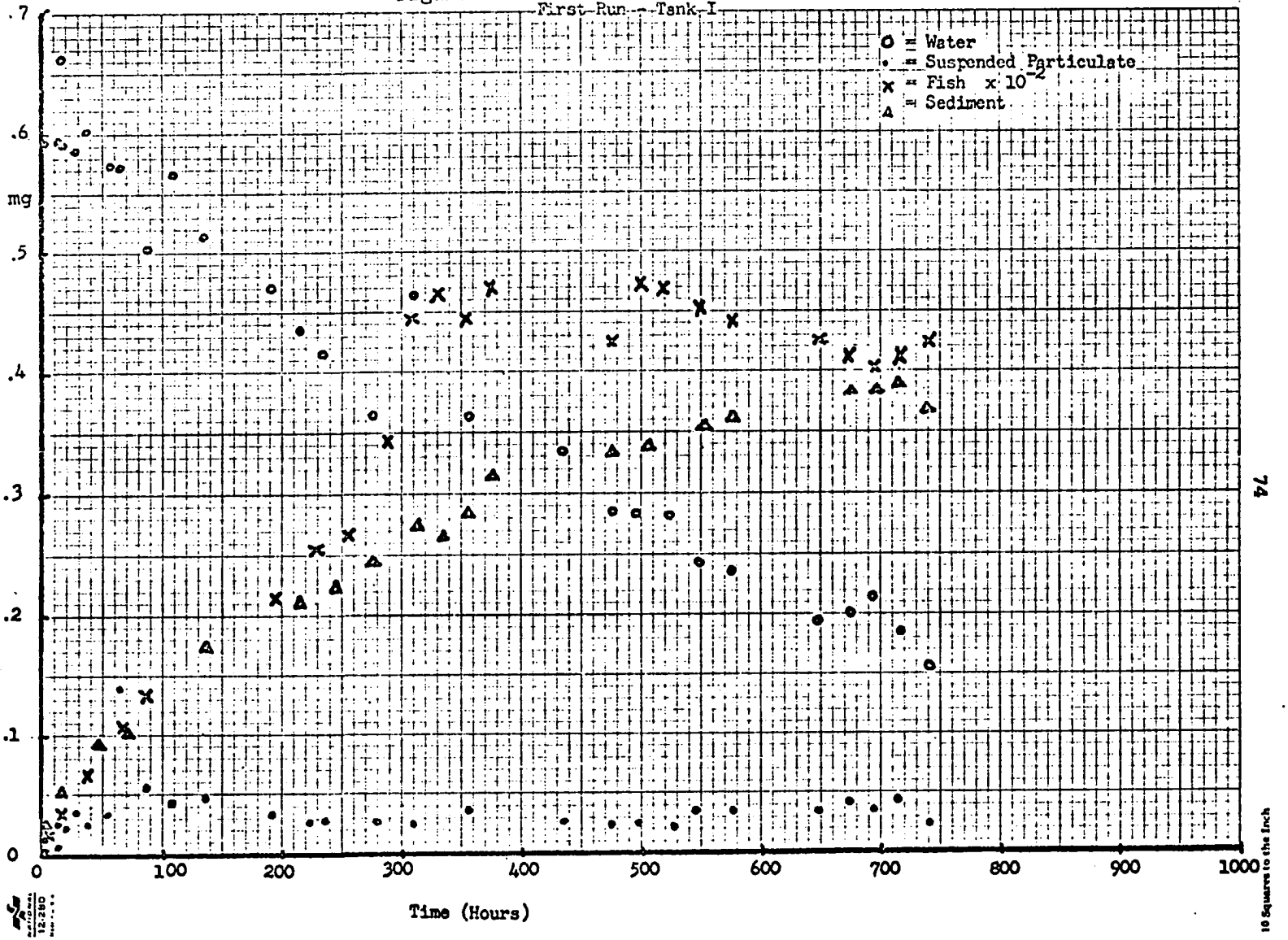
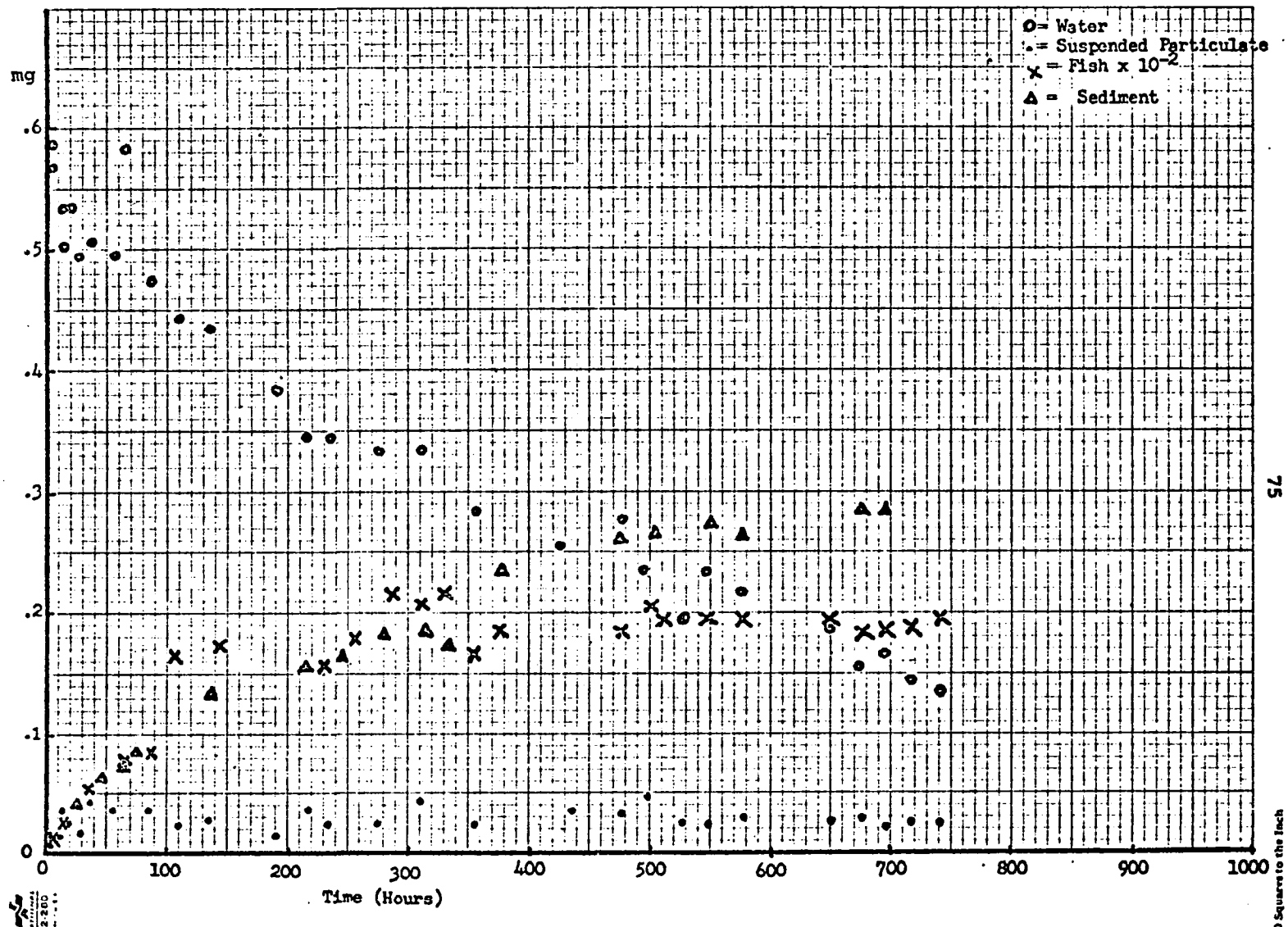


Figure 11 .-- UPTAKE OF SELENIUM
First Run- Tank II






10 Squares to the Inch

Figure 12. Uptake of Selenium (Second Run, Tank I)

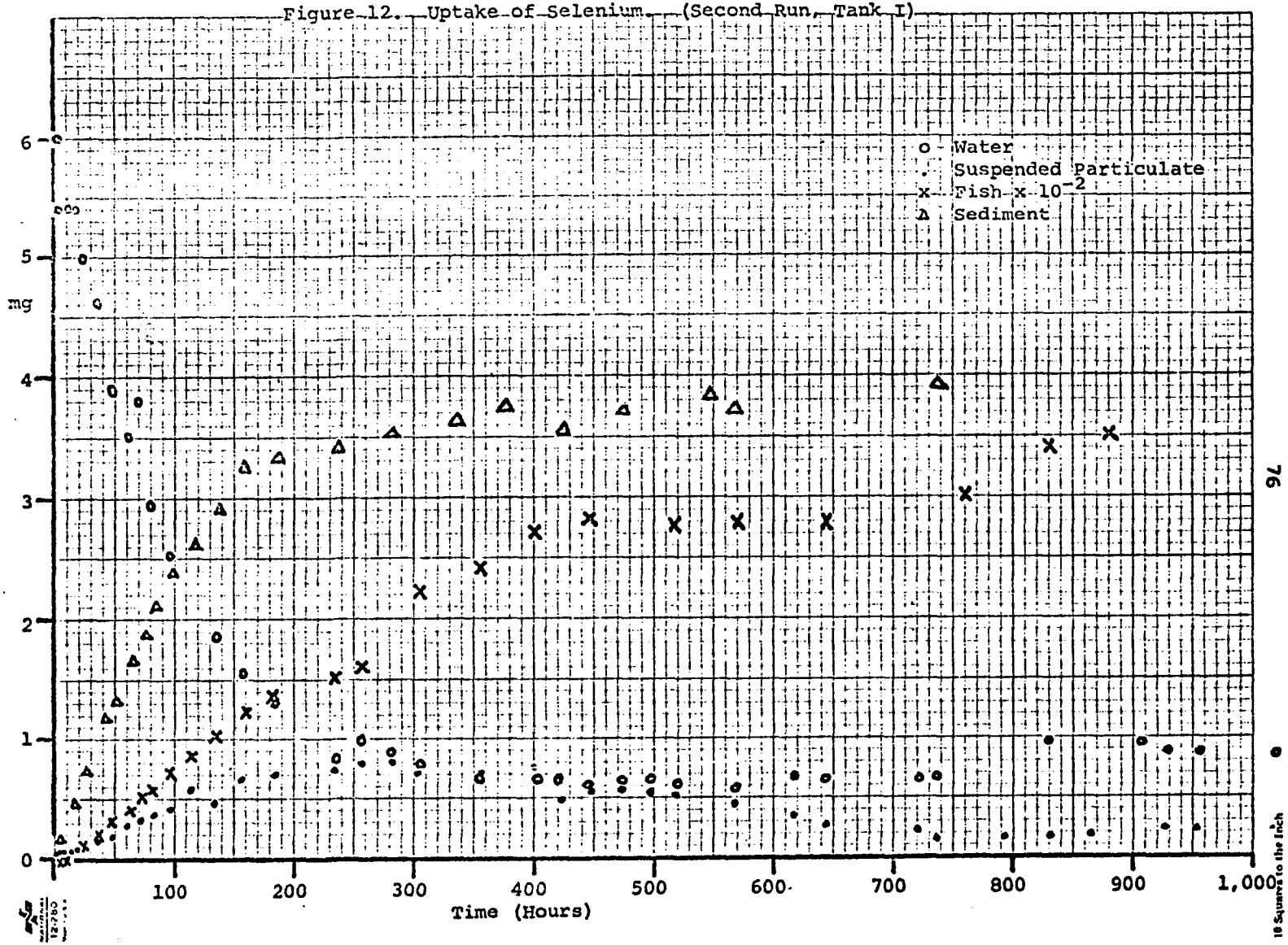
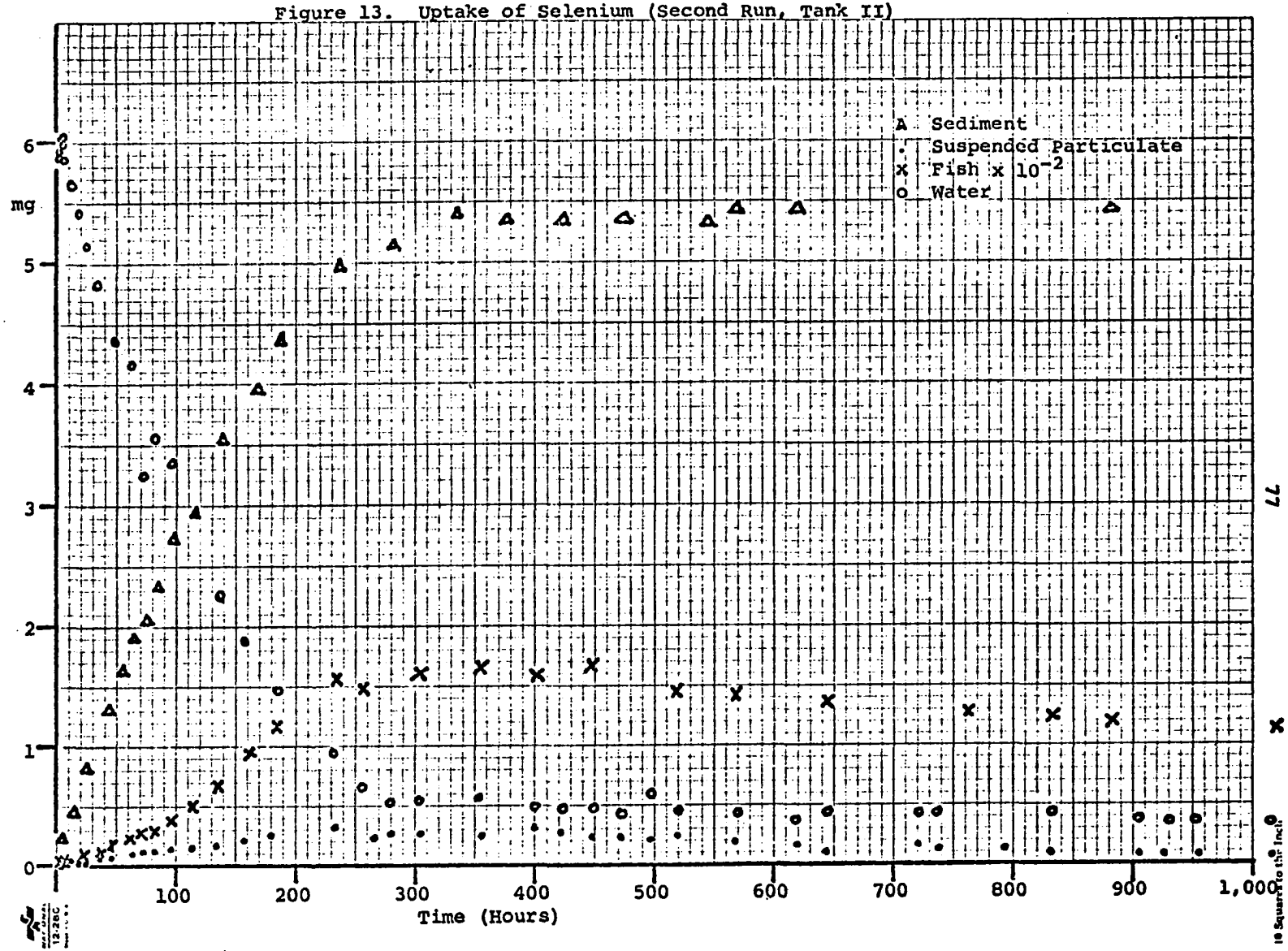


Figure 13. Uptake of Selenium (Second Run, Tank II)



The first run was more truly experimental. Techniques were untried and the precision of sampling was not developed by the experimenter as well as in the second run. Reliability of equilibrium values is not quite as good in the first run. The specific activity of selenium-75 in stable selenium was such that the random fluctuation of the count rate was greater than the variation in selenium amounts. This occurred particularly when the water became somewhat devoid of selenium, near the equilibrium value (or steady state).

The equilibrium time in general was suggested by consecutive variations of sampling data which were within a 95% confidence interval. This was the judgement used for completion of experimental data.

The increase or loss of selenium over a period of time is related to the unique character of each compartment and must be examined compartment by compartment.

## Water

The water compartment is by logic the first to be discussed since the selenium is introduced into the system in a completely soluble form and becomes immediately a part of the water compartment. The remaining three compartments are initially devoid of selenium and the flow begins out of

the water to the remaining three compartments. Since the total amount of selenium is contained in the system, the other compartments take up the selenium as the water loses it.

The loss of selenium by water in the first run (Figure 10, 11) did not obtain as low a value as in the second run. The reliability of the data in the first run was not as good as that in the second run (Appendix B-1, 5, 9, 13). The two tanks in the first run showed values at 700 hours to be about 0.2 mg loss from 0.6 mg. The count rate for the first run ranges from approximately 2500 counts per ten minutes to 1900 counts per ten minutes for the last 200 hours of run time. This final value with correction for decay falls nearly within the 95% confidence interval for approximately a week run time. This is close enough to suggest steady state or equilibrium time is approaching. The value can be looked at more carefully with regression analysis as will be discussed later in this chapter.

The water compartment in the second run (Figures 12, 13) shows a lower value on approach of steady state. This would be expected since the 95% confidence interval about the 400 hour counting rate contains the curve for more than a week (Appendix B-9, 13).

Within the second run, the final values compare very well for the two tanks. A variation of 0.3 mg or less than 5% for more than a week occurs. The tanks are then identical for the water compartment within the sampling error.

The water is a massive compartment (60,000g.) which reached equilibrium in about 400 hours. The data from the second run suggests the most reliable values but is not contradicted by the values from the first run.

There would appear to be no complication in the geometry or normalization of the sample data, since the standardization of counting rate to mg. of selenium was identical to the sampling of the water compartment. Sorption loss was insignificant (Appendix C-9). In concentration ranges from $10^{-4}$ ppm. to 10 ppm., glass sorption was linear and amounted to only about 2%.

## Suspended Particulate

The accumulation of selenium in the suspended particulate was related to the mass of suspended particulate. The mass of the algae was very small compared to the water or sediment mass, and smaller uptake values were apparent.

It is difficult to determine the equilibrium value from the first experimental run (Figures 10-11). The

count rate is so low that the significance of selenium amounts cannot be detected above background (Appendix C-18). The 62 hour counting rate of 1,618 counts per ten minutes is significantly above background at the 95% confidence interval. The value reached by the suspended particulate appears to be 0.05 mg or about 8% of the total amount.

After the initial sample in the second run, the count rates were significant throughout the experimental period. In both tanks of the second run, there was an overgrowth of selenium uptake and subsequent drop to the equilibrium value. Tank II did not reach as high a value and was lower during the latter part of the run. An examination of the suspended particulate weights (Appendix B-19, 20), show that Tank I averaged 1.46 times the weight of Tank II. The selenium uptake in the suspended particulate (Figures 12, 13), are in agreement with this factor.

The rich culture was produced by a Knopp's modified media (Appendix A-1). This provided micro nutrients and trace materials necessary to stimulate a rich growth. This was probably more rich than most natural waters, but provided large enough samples for statistical meaning with the count rates obtained.

Standardization and normalization procedures were verified by data found in Appendix C-11. Ten samples of suspended particulate were counted at a standard geometry and found to average a slightly lower count rate than those obtained with the experimental sampling procedure. The variance of the samples was relatively small and supports the validity of only a small correction factor (0.9055). In the sampling procedure, the rolled filter was placed directly into the test tube and counted. With this method, the center of density of particulate would go slightly deeper into the well of the detecting crystal as compared to the standard geometry. This would allow fewer of the gamma emissions to escape detection and thus result in a counting rate higher than with standard geometry. A large difference would not be expected.

The buildup and continued drop, or latent depression of compartment uptake in suspended particulate is not unusual. When flow occurs into a compartment and a subsequent flow out, an overshoot sometimes occurs. There is a lag time before the loss rate equilibrates with the inflow. It may exceed the inflow for a period of time in which the amount in the compartment is decreasing to a final equilibration.

An experiment was done, however, which provides some contradictory data (Appendix A-5). A comparison of pipettes was made in which a broken-end pipette was compared to the normal-end pipette used in sampling. The broken-end pipette was calibrated to an identical volume, but had a larger orifice for the sample to enter. The broken-end pipette seemed to be collecting a different statistical population than the normal pipette. The broken-end pipette was collecting 1.62 times the weight of suspended material than the normal pipette was obtaining. The standard deviation of this pipette was also more than two times the normal pipette. This strongly suggests that the experimenter was not obtaining the larger aggregates of suspended particulate in the sampling technique. The obvious particles excluded would be fish feces, but no other data substantiates this suggestion. If this were so, the selenium concentration of the excluded portion may be at variance with the concentration in the remaining portion. Results would lower uptake values in proportion to the amounts excluded.

The growth of selenium in the suspended particulate is not surprising and may be considered consistent from first to second run. The differences within the second run can be explained such that they are considered identical in response

to the modeling effort.

## Fish

The uptake into fish was relatively small (Appendix B-3, 7, 11, 15). Their physiology appeared normal. They suffered no apparent stress from dissolved oxygen, temperature, pH, or salinity (Appendix B-17, 18). It may be concluded that the results obtained are representative of normal biological activities of the minnows and represent a consistent pattern in all four situations. Weight data (Appendix B-23), showed some growth for most fish. This was apparently continuous and did not cause perterbations in the uptake values obtained. Although normal fluctuations might be expected with living organisms, these were for the most part smooth and continuous. In the first run, Tank II fish weight, there was a loss amounting to nearly 2 grams through the death of two fish. The accompanying data (Appendix B-7) and Figure 11 show this. The equilibrium value approached by Tank II is a lower value than that in Tank I. The final mass of the fish compartment is lower in Tank II also. This weight difference was continued into the second run using the same fish and the uptake response reflected the mass difference in a very similar way. The final values for Tank I in the first and second runs were

about 0.006 total selenium. Tank II had a similar response and it was lower, reflecting the mass difference as before.

The curve of Tank I in the first run showed more erratic values at the final portion of the curve, which made judgement of an equilibrium time more difficult without the use of statistical analysis. A 95% confidence interval was exceeded occasionally from the 300 hour time to the completion of sampling. These differences might be accounted for in the physiology of the fish itself. Living organisms may deviate from what may be considered normal activity on an individual basis without being under stress. This is a variable that is difficult to control without large populations of the living organisms.

A further observation might be made on fish number 2 from the first run, Tank I (Appendix B-3). The notation "up" indicates the fish was counted with its anterior end up. This was a habitual response of certain fish, that when placed anterior end down to determine the count rate, they reversed themselves in the tube. Some fish were so difficult as to make it impractical to keep them in the proper position. They were simply counted anterior end up. This produced a difference in their counting geometry so that a correction was needed.

In an attempt to determine this correction factor, 20 samplings of 10 different fish were obtained with count rates normal and inverted. The results may be seen in Appendix B. The fish inversions are compared and an adjustment fraction determined. Therefore, if a fish was counted anterior-end up, the count rate could be adjusted by this factor to make up for the undetected counts.

If fish number 2, as referred to above, was normally uptaking at a low rate, then the adjustment would cause values to be erratically high on the uptake curve. If the reverse were true, the values would be low.

In addition to this fact, the count rate depended on the fish to remain straight. If it curved its body, it could increase the count rate by settling deeper into the well crystal. On the other hand, it could decrease its count rate by remaining high in the tube. The water volume was little enough (20 ml. total volume) so that the latter was not likely.

Another variability that could occur was due to the inability of the investigator to observe the position of the fish while in the counting chamber. The fish was observed before and after counting. If the duplicate counts were similar, it was assumed that the fish had

maintained the proper position throughout the counting time. It would be possible, however, for a fish with a tendency to invert, to do so while in the chamber and resume its proper position just prior to removal. The counting rate could be lessened significantly. If the fish remained inverted for most of both duplicate counts, they would show no difference and would be recorded as counts taken in the proper position.

The greatest amount of uptake in the fish must be due to membrane uptake (gills, etc.). This would be expected since minnows do not normally feed upon algae or suspended materials of this nature. The trophic relation is more incidental.

The normalization of fish data was attempted two ways (Appendix C-12). Both a wet and dry ashing procedure was attempted. The dry ashing procedure resulted in poorest recovery of counting rate. The values were erratic. The best yield was obtained by the wet ash technique and resulted in data which was consistent with little variation. For this reason, the wet ash correction factor was used (0.706). The liberation of heat during the solubilizing action may be cause for loss of activity from volatilization. Since the total amount of selenium in the system is constant,

losses should be conspicuous when summing up the values of all compartments. The fraction of total selenium in fish is in the order of a few thousandths and would never be observed by such a procedure since it would be so small. The consistency of the wet ash data is supportive of its correctness. It would be expected that differences in addition of acids would show up in more variation of data if this kind of loss were significant.

## Sediment

The sediment compartment was a massive compartment consisting of 7,200 g. The major portion of selenium moved to the sediment. The sediment is made up of inorganic particles and living material. The forces moving selenium into the sediment are thus physical and biological. The final observations of the sediment showed a well developed green surface layer composed of algae and organic material. Settled particulates could function as sediment to uptake selenium in addition to the original inorganic particles.

Sieve analysis showed the sediment to be of a sandy nature with a distribution of particle size about a mean of the hundred mesh size (Appendix A-2). The distribution was skewed slightly to the fine particle size since the size greater than ten mesh was excluded in an initial screening.

The fine particles were any particle less than 200 mesh or 74 microns. The fine particles were a relatively small fraction of the total distribution constituting 7.6% of the weight. Jones (1960) suggests the importance of fine particles on uptake due to the large surface area. Ten identical sediment sampling containers were filled with sediment by an impartial procedure and a sieve analysis done on each. The results were consistent and the averages accepted for the amounts to be placed in the sediment samplers. The samplers were assumed to be identical units which could be retrieved as such and returned without disturbance. The amount contained in each sampler was calculated to be a known fraction of the total sediment mass. This was done by area ratio of the container to total bottom (Appendix A-3). The largest error would be in the measurement of the diameter of the sampling container. This measurement would be consistent in both Tank I and Tank II.

The distribution of particle size on the bottom (Appendix A-4), was consistent with the choice of geometric areas for sampler placement. The observation of falling particles by size showed them to fall in the distinct areas which were hypothesized from a look at the bottom. If particles would grade themselves into separate areas, then

these areas might have different uptake rates and should be sampled likewise. The calculation of these areas was shown in Figure 6. The fractions of bottom area represented were used to adjust the respective sample data so that the total selenium in the sediment compartment could be determined (Appendix B-4, 8, 12, 16). Each of the areas showed continuous increase in selenium as did the sediment compartment. It is interesting to note that raw data shows certain areas to uptake at faster rates. The pattern in general follows the qualitative particle size distribution (Appendix A-4). The area predisposed to smaller particle sizes had higher uptake values in terms of count rates. Areas E and H in general seemed to have higher values than C or R. This was true for both tanks in both runs. This would seem to support the contention that smaller particles have a greater uptake for a given mass as compared to larger particles. An important factor, however, must be the settling of living particles in the same areas that fine particles are collected. This would add significantly to the uptake of these areas since small masses of algal material uptake selenium well from solution. In addition, if the fecal material from the fish contains a large amount of selenium, these areas would uptake at a faster rate.

Since the fish do not accumulate very much selenium, one might ignore this suggestion. But if fish uptake rates were high, their loss rates could be very high so as to result in little accumulation in the fish. The result would be to add large amounts of selenium in the form of feces to the suspended particulate. This is possible since accumulation in the fish is very low. It would seem reasonable that large volumes of water ventilate the gills and could allow intake rates that would be high. The late depression of suspended particulate noted earlier in this chapter could support this hypothesis. If by the comparison of pipettes data (Appendix A-5), one accepts the sampling method to be excluding feces, this hypothesis is supported. That is, the high loss rate via fish feces does not show up as suspended particulate, but is settled to the bottom and shows up as additional sediment uptake. An additional perspective can be gained by careful comparison of the values of raw counting rate in the E and H areas in Tanks I and II of both runs. A higher uptake rate is in most cases associated with quadrants three and four in Tank I, but with 1 and 2 in Tank II. This is meaningful since the fish enclosure is above these quadrants in the respective tanks as mentioned. All of this discussion strongly supports a

possibility of a high uptake and loss by the fish which is not accounted for by the model, and shows up as sediment uptake. In this case, a balance of total selenium would still occur. The balance of total selenium in all cases supports the area correction for sediment samplers.

In general, the approach of sediment uptake to a steady state value could be assessed by the same means as done previously with other compartments. Ninety-five percent confidence limits could contain the uptake curves for a week in most cases. The stability of this massive compartment was greater than others. Higher count rates near equilibrium allows better statistical fit.

An additional correction used on the sediment samplers was a geometry normalization and attenuation factor. Normalization factors can be observed on data from both tanks (Appendix C-13). The stirring was used to maintain homogeneity while a counting rate was determined on sediment sampling containers. A normalization factor was determined from averages taken on both tanks and used to modify the sample counting rates for the sediment uptake data. This factor was supported by sediment transmission and stirring data (Appendix C-14). This demonstrated that the effect of stirring did not change the count rate by observing the

mean and approximated standard deviation. They indicated the same statistical population. For example, proper stirring would not allow formation of a vortex that would produce a different counting geometry. The sediment however produced different count rates when stirred. This indicated there was some attenuation by the sediment distribution. Sediment transmission calculations from the data (Appendix C-15) shows the attenuation to be 4.5%.

If an additional study is made of the theoretical calculation of transmission (Appendix C-16), a comparison can be made of the probable limits of attenuation by the sediment. Since the sediment was essentially sand, the maximum and minimum mass attenuation coefficents could be referenced in a handbook (Bureau of Radiological Health 1970). The two values represent the range of gamma energies of selenium-75 in silicon dioxide. Subsequent calculations suggest a theoretical attenuation by the sediment to be from 5% to about 19%. The significance of the attenuation calculation (Appendix C-17) shows by examination of per cent emissions the 5% value to be the most probable attenuation! This fits the data precisely and supports the factors of attenuation and geometry used to modify the sample data.

## Radiotracer Methods and Selenium Amounts

The selenium-75 decay scheme (Appendix C-I) shows four energy ranges of gamma to be important in detection. These constitute the significantly large percentages that will be detectable. Optimum detection efficiency was obtained with a window width corresponding to the spectrum energy range. Standard energy sources were used to verify the spectrum energies (Table 10). The determined spectrum corresponded to published data (Appendix C-6) throughout the energy range.

Calculations of amount of selenium showed the weight of selenium-75 to be insignificant chemically when added to stable selenium (Appendix C-2).

The efficiency calibration data and calculations (Appendix C-7, 8), are verified by the fact that the total selenium was equal to the sum of the four compartment amounts.

Sorption of selenium-75 experiments (Appendix C-9) showed a linear relationship of sorption on glass to all concentrations of selenium. The approximately 2% value was insignificant and would not be observed in any of the compartment values for selenium uptake. It was observed that sorption occurred within 15 minutes. The data collected demonstrates a stability of sorption within 4 hours.

Sorption on a microscope slide (Appendix B-21) gives in situ indication of greater percentages remaining on the glass. However, standard geometry could not be used and the statistical confidence in the value is not nearly so good as the sorption experiment. At a count rate of approximately 130 cpm, the fluctuation of 2 to 16% is still within a 95% confidence interval for that low count rate. The in situ data was considered to support the 2% value. The sorption was accepted as insignificant on the experimental tanks.

The background counting rates were relatively constant throughout the period of experimentation. Clean, heavy shielding would account for this. One-hundred-minute counting times were used daily. The 95% confidence interval of the background counting rate was never more than plus or minus four counts per minute. Due to a longer counting time, this was always a smaller value than the confidence limits around any of the sample data.

A complication in background occurred with the use of the same tanks for the second run. This meant that the total concentrations of the second run would have to be considerably higher than that of the first run. Also, the specific activities of the first and second run spike amounts

was made similar. Similar specific activities would allow residual counting rates to be subtracted in the same manner as background. The residual counting rates could be subtracted directly from the raw counting rates of the second run data. For example, the residual selenium was measured in all compartments possible. Background was subtracted and the remainder was taken as the residual value from the first run. This value was used to construct a schedule of decay of residual selenium for each of the compartments (Appendix C-19). This schedule was prepared by calculation according to the laws of radioactive decay.

Thus, the total background in the second run was different from the normal background of the first run. In addition to normal background, it contained a residual selenium-75 background from the first run. In order to adjust the raw counting rates for the second run, two subtractions were necessary. The raw counting rate was determined, normal background was subtracted, and then residual selenium was subtracted according to the schedule of decay (Appendix C-19) for that compartment and tank.

The calculations from measured values of residual selenium was accepted as the true value and used to adjust the raw counting rates for the second run. In most cases,

the residual amount was insignificant.

The spectrophotometric method to determine selenium amounts did not achieve a 100 per cent yield (Appendix D-1). The standard curve and samples corresponded in linearity however and all were consistently lacking in yield. The loss is not surprising since the hot methanol would only lyse cells. Soluble selenium would be most readily released. Any refractory organic material would not likely be degraded to release selenium. As a consequence, it was lost to the preliminary oxidation of the standard method used.

Water and fish food samples lacked selenium to the limits of detection. Assuming maximum interference and best technique, the value found in the samples was probably less than 0.001 parts per million.

## Parameters Projected from Data

The basic technique of data reduction used was the linear regression analyses of all uptake curves (Figures 14-21). This technique was used to determine the initial uptake constants and is based on the data approaching equilibrium. For this reason, the regression analysis was done on the initial data. The initial data was chosen by an approximation of the 68% confidence interval, two

Figure 14. Water Compartment
Second Run, Tank I (Linear Regression)

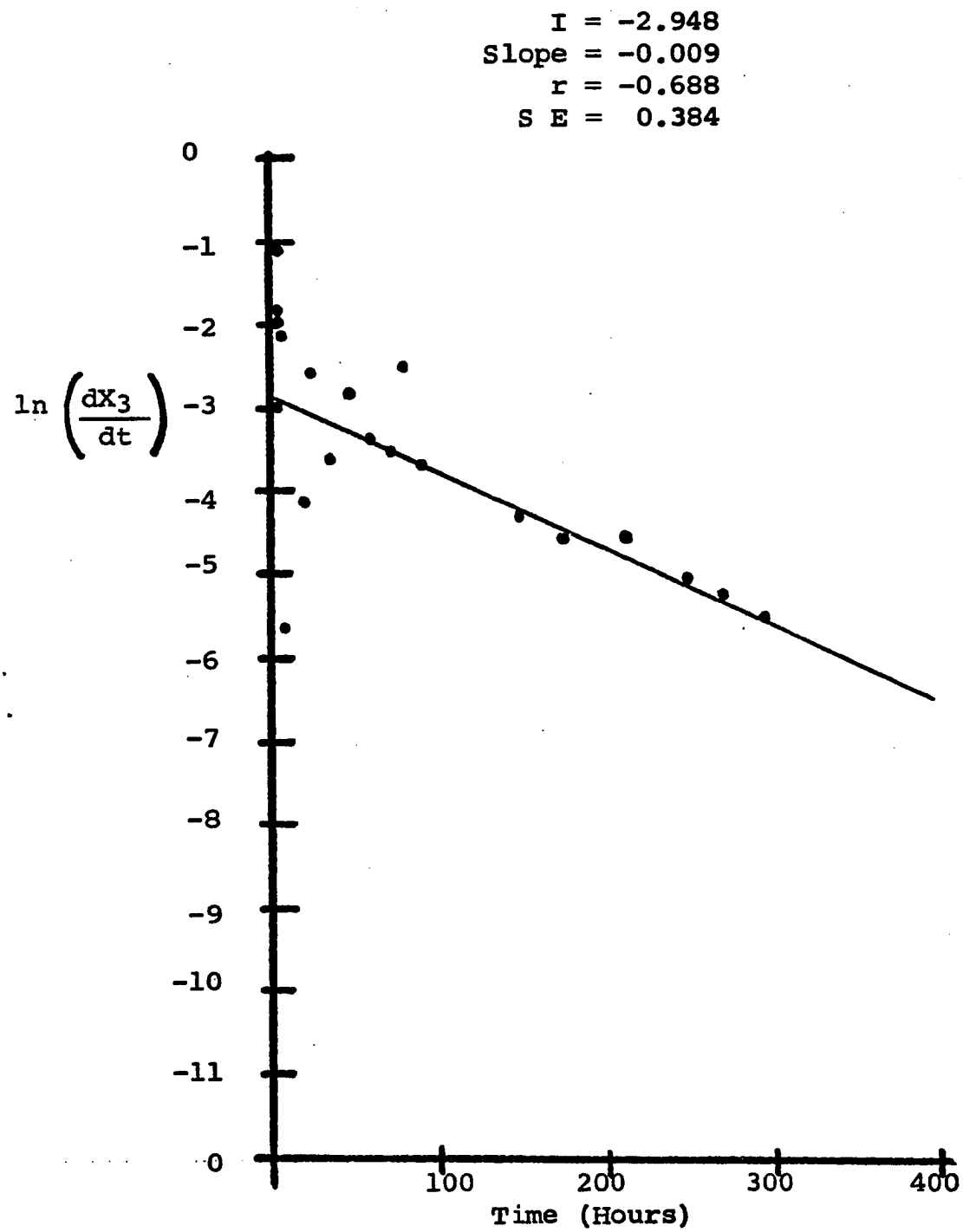


Figure 15. Suspended Particulate Compartment
Second Run, Tank I (Linear Regression)

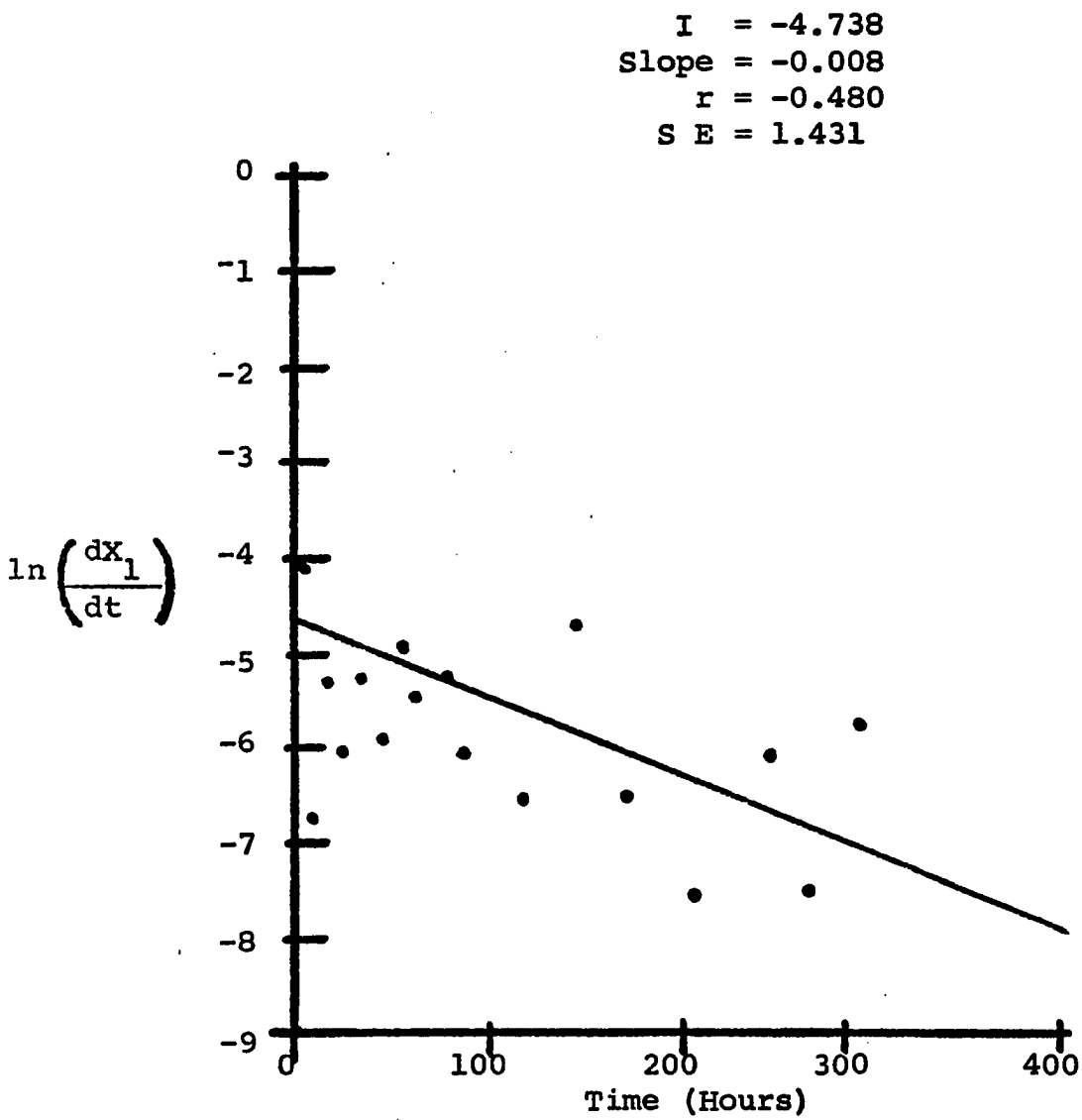


Figure 16. Fish Compartment
Second Run, Tank I (Linear Regression)

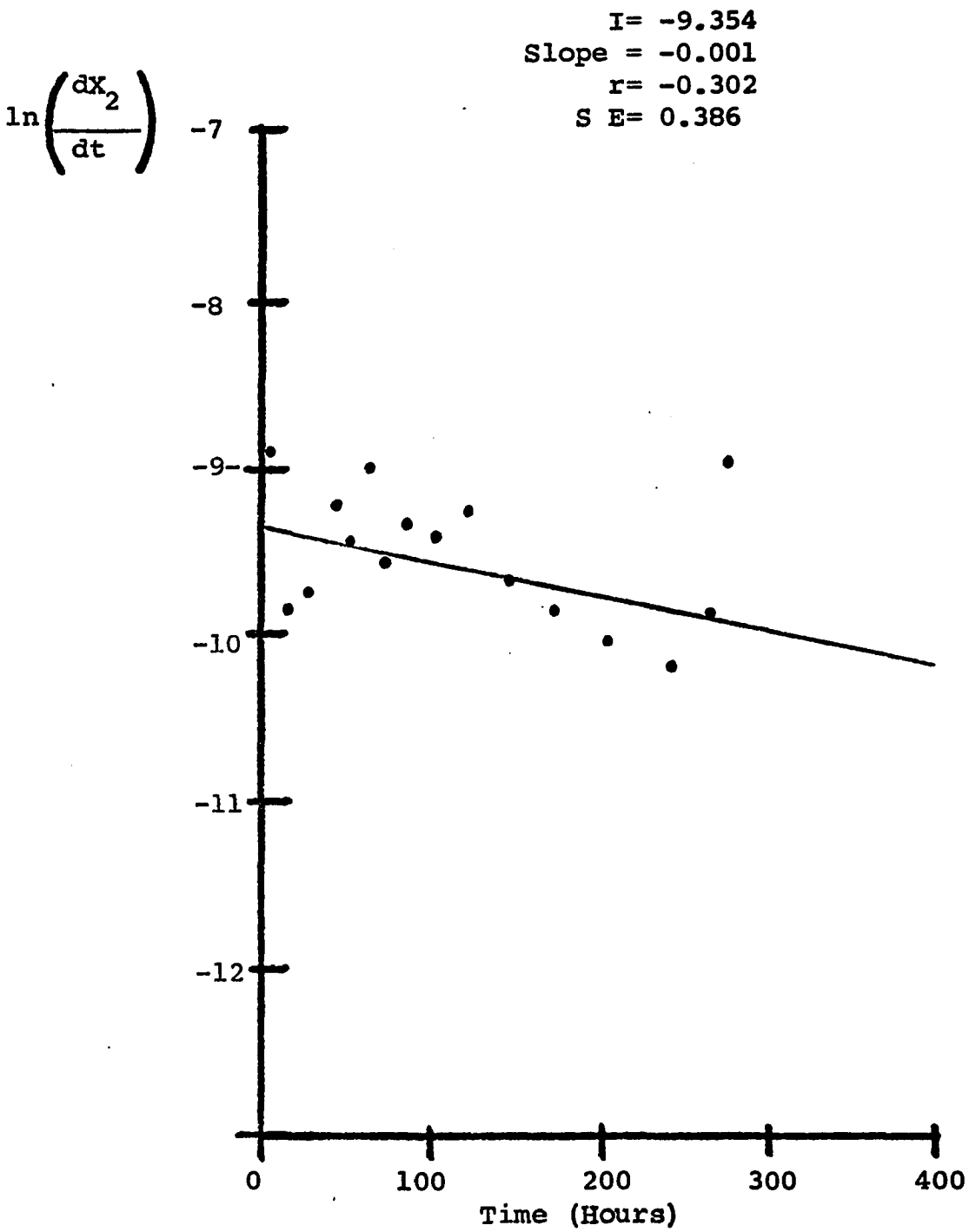


Figure 17. Sediment Compartment
Second Run, Tank I (Linear Regression)

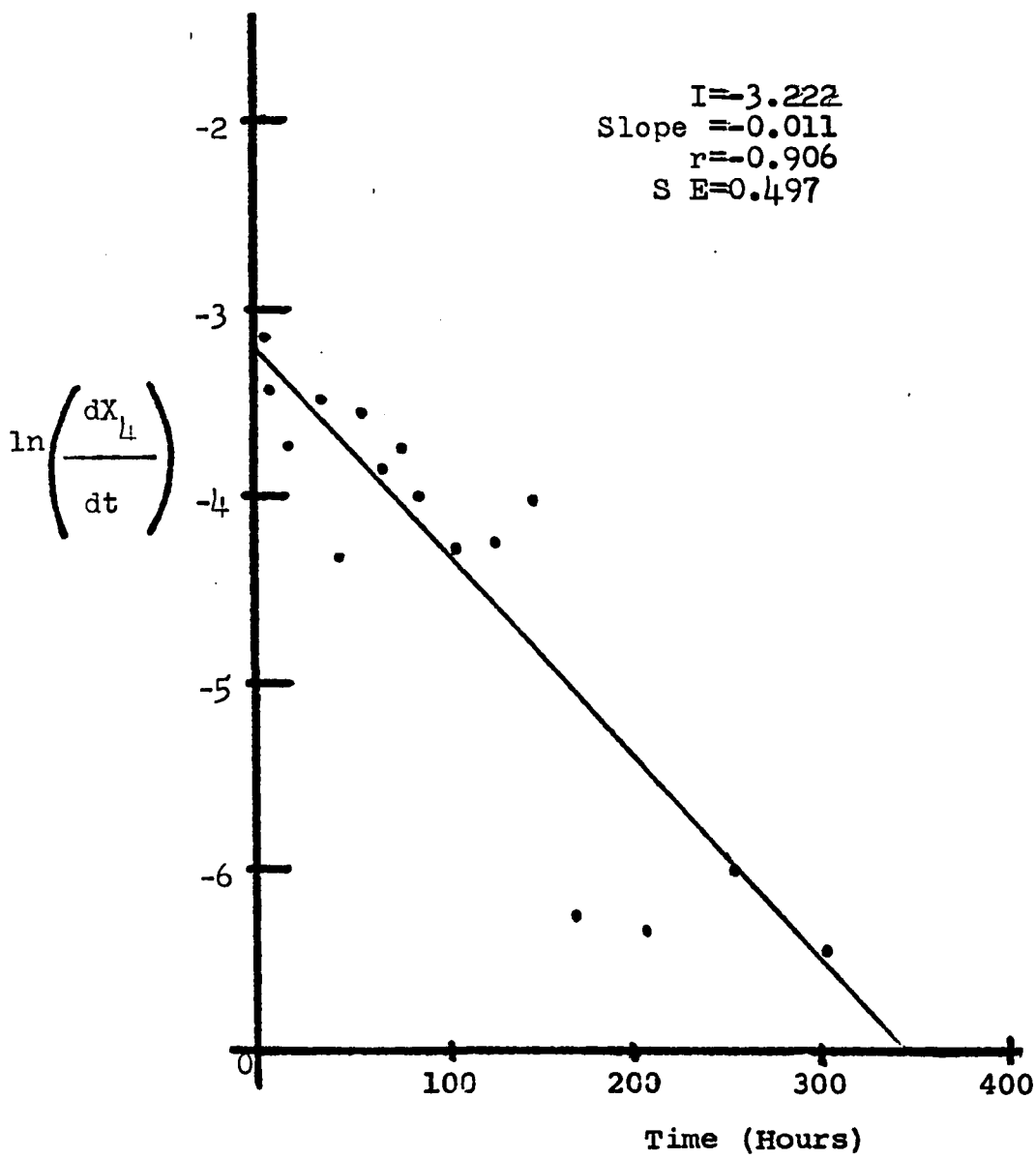


Figure 18. Water Compartment
Second Run, Tank II (Linear Regression)

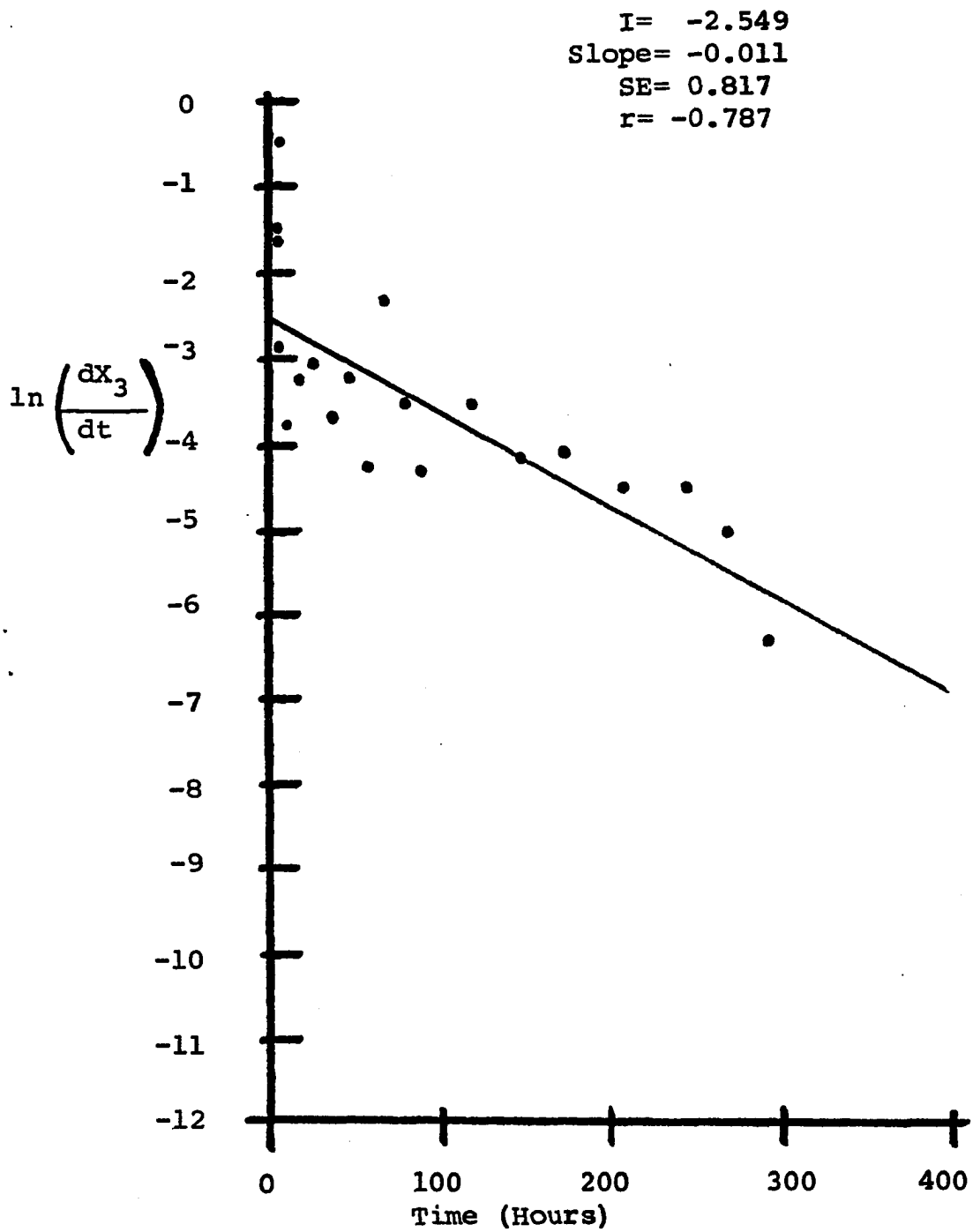


Figure 19. Suspended Particulate Compartment
Second Run, Tank II (Linear Regression)

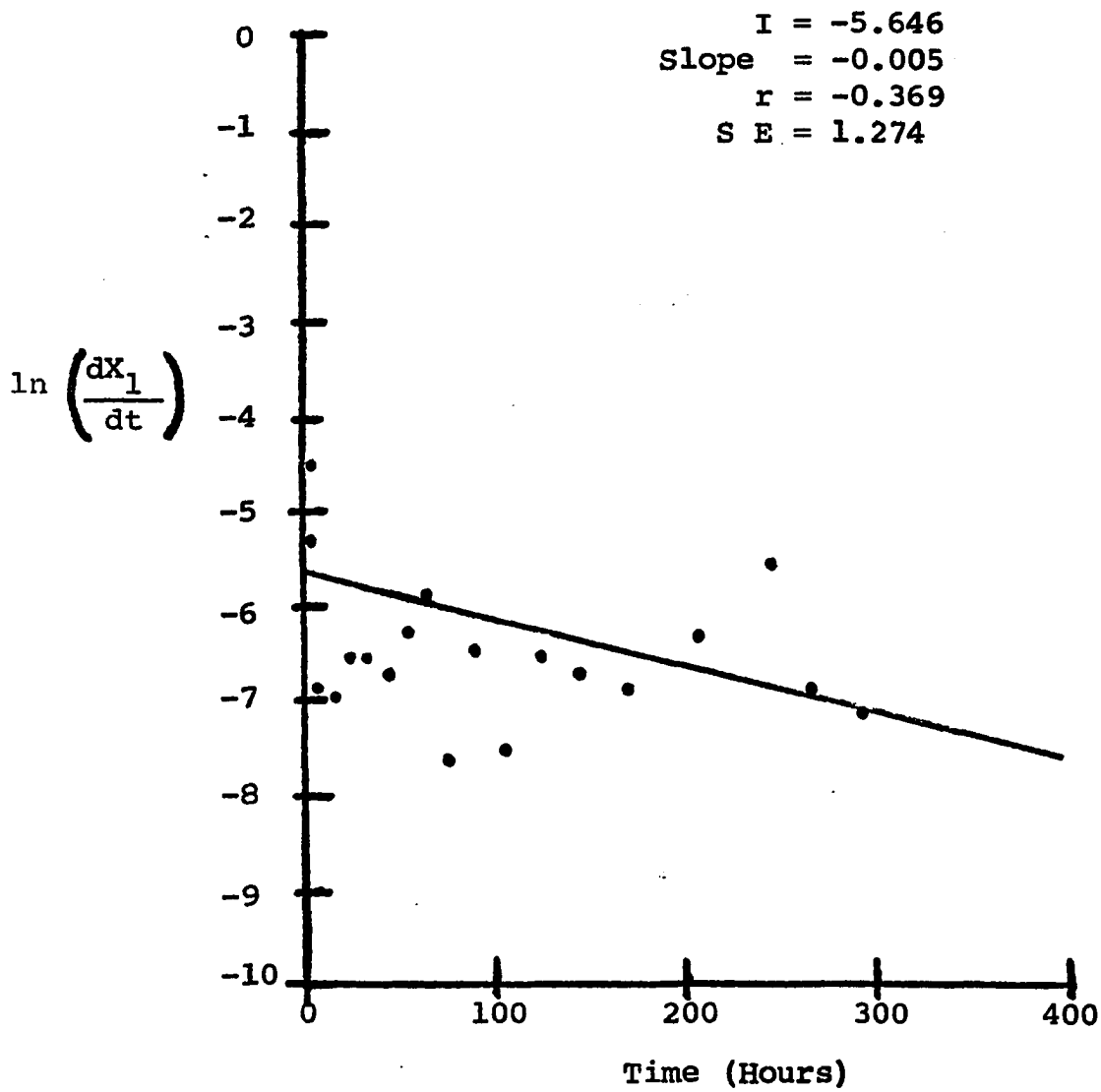


Figure 20. Fish Compartment
Second Run, Tank II (Linear Regression)

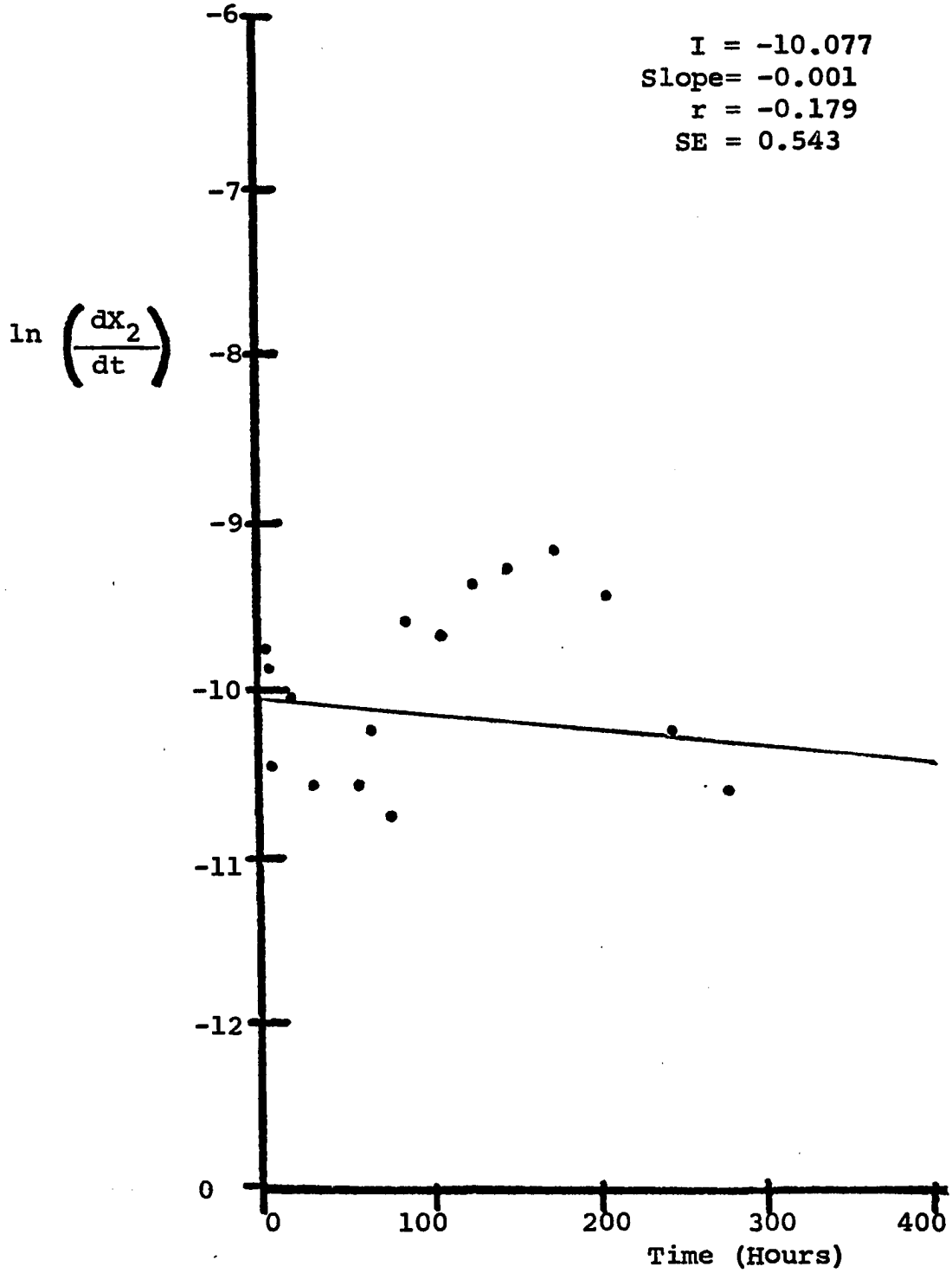
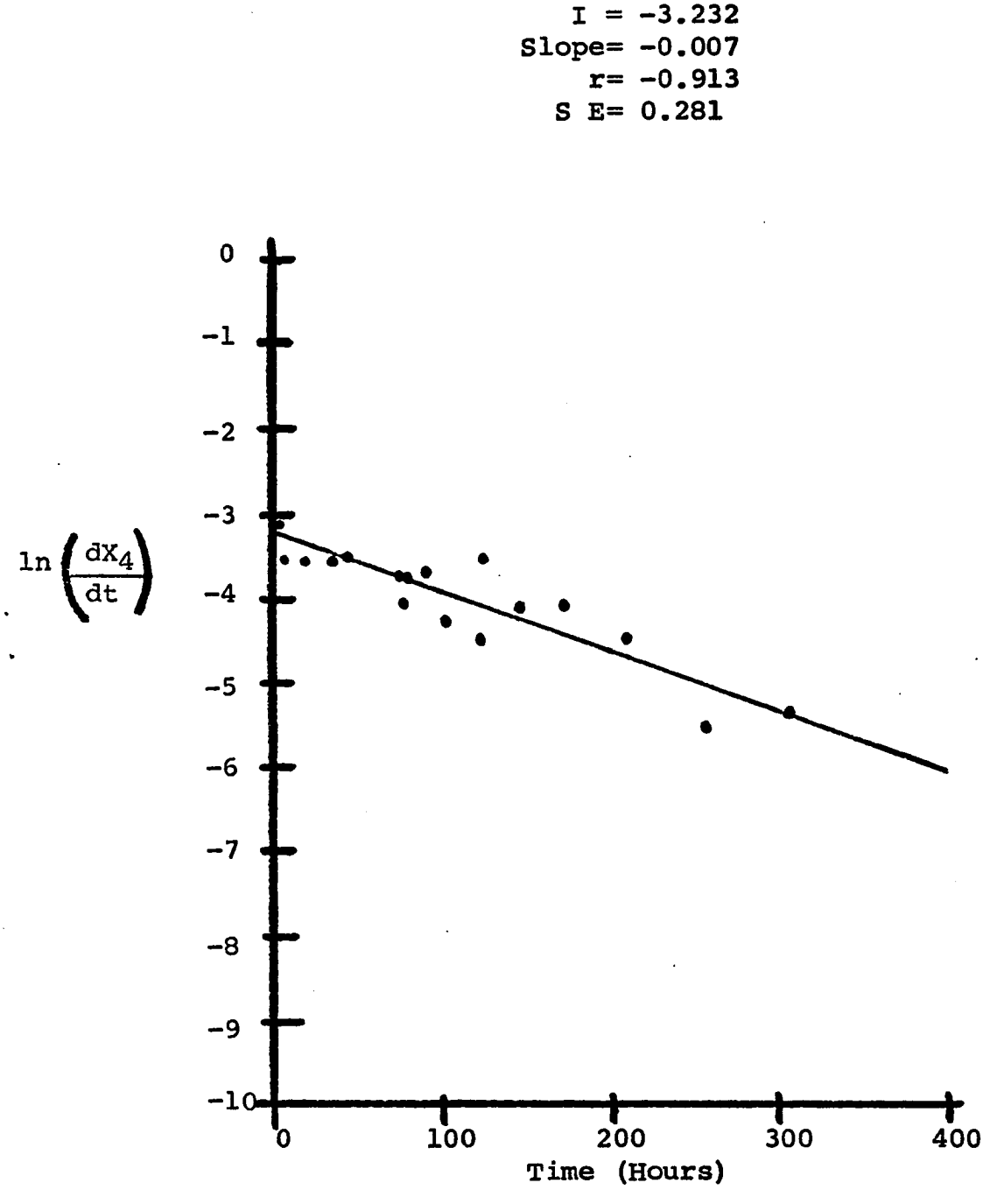


Figure 21. Sediment Compartment
Second Run, Tank II (Linear Regression)



times the square root of a mean value, as will be described. When the time occurred in which the data first came near equilibrium, the mean value was determined for the data of an additional equivalent length of time. The confidence interval was constructed about this mean. The initial data for the regression analysis was considered to be that data collected prior to the interval.

This method for logarithmic growth and decay curves was based on the principle of developing a linear relationship. The differentials, $\Delta X_i$ and $\Delta t$, were calculated for each sample interval. A linear regression analysis was made on the natural logarithm of the differential quotient as a function of time. The relationship is shown by the mathematical expression in Table 11. The initial uptake rate ($a_{ij}$) is obtained from the value projected to zero time. The antilog to base 10 is needed to determine equilibrium values. This equilibrium value represented a best fit value for a linear uptake relationship.

The initial uptake rate ($a_{ij}$) is the primary objective of the analysis. These values for each compartment will be used directly as necessary parameters in the simulation of the model. This will be discussed more fully in Chapter V.

The calculations derive values which are consistent with the previous discussions of uptake curves. The first run has a larger error, and was not analysed by this method. The second run shows a precise fit in both tanks and conforms well to a total selenium balance. This in general would support the model design as being a reasonable representative of the flows between compartments.

The greatest source of contradiction is the calculated values for suspended particulate found in the second run (Table 11). This would add validity to the alternate hypothesis concerning the latent depression in suspended particulate uptake.

Further analyses are helpful for projecting new meaning into the data obtained. The following types of calculations are useful for adding perspective or suggesting research efforts needed (Table 12). The table lists uptake constants, turnover times, and equilibrium values to steady states. Biological half lives are also calculated.

This determination of equilibrium times and calculation of steady state values is shown in Tables 13 and 14.

Additional parameters (Table 15) are calculated. Concentration factors and parts per million selenium show the bio-accumulation of selenium and suggest potential hazard.

TABLE 11

CALCULATION OF EQUILIBRIUM VALUES ($x_i$) BY INITIAL SLOPE
(Second Run, Tanks I, and II)

RELATIONSHIP: $X_i = x_i\ (1-e^{-a_{ij}t})$

DIFFERENTIAL: $\ln \frac{dX_i}{dt} = \ln(a_{ij}x_i) - a_{ij}t$

At to.....Intercept = $\ln (a_{ij}x_i) - a_{ij}(0)$

TANK I

-WATER... $2.948 = \ln(-.009\ x_3)$

$x_3 = \frac{5.24 \times 10^{-2}}{.009} = 5.82$ mg (lost)

-SUSPENDED PARTICULATE... $-4.738 = \ln(-.008\ x_1)$

$x_1 = \frac{8.730}{.008} = 1.09$ mg

-FISH... $-9.354 = \ln(-.001\ x_2)$

$x_2 = \frac{8.64 \times 10^{-5}}{.001} = .086$ mg

-SEDIMENT... $-3.222 = \ln(-.011\ x_4)$

$x_4 = \frac{4.00 \times 10^{-2}}{.011} = 3.63$ mg

TABLE 11 (CONTINUED)

CALCULATION OF EQUILIBRIUM VALUES ($x_1$) BY INITIAL SLOPE
(Second Run, Tanks I, and II)

TANK II

-WATER... $-2.549 = \ln(-.011\, x_3)$

$$x_3 = \frac{.078}{.011} = 7.09 \text{ mg (lost)}$$

-SUSPENDED PARTICULATE...

$$-5.646 = \ln(-.005\, x_1)$$

$$x_1 = \frac{3.52 \times 10^{-3}}{.005} = .704 \text{ mg}$$

-FISH... $-10.077 = \ln(-.001\, x_2)$

$$x_2 = \frac{4.19 \times 10^{-5}}{.001} = .0419 \text{ mg}$$

-SEDIMENT... $-3.232 = \ln(-.007\, x_4)$

$$\frac{-3.94 \times 10^{-2}}{.007} = 5.62 \text{ mg}$$

TABLE 12
PARAMETERS FROM UPTAKE DATA

| | UPTAKE CONSTANT $a_{ij}$ ($hr^{-1}$) | TURNOVER$_{-1}$ TIME T (hr) | EQUILIBRIUM VALUE $x_i$ (mgSe) | EQUILIBRIUM TIME $t_{ss}$ (hr) | EFFECTIVE HALF TIME $t_{eff}$ (hr) | BIOLOGICAL HALF TIME $t_B$ (hr) |
|---|---|---|---|---|---|---|
| WATER | 0.010 | 100 | 5.15 loss | 230 | 69 | 71 |
| SUSPENDED PARTICULATE | 0.006 | 166 | 0.212 | 383 | 115 | 120 |
| FISH | 0.001 | 1000 | 0.034 | 230 | 693 | 71 |
| SEDIMENT | 0.009 | 111 | 3.93 | 256 | 77 | 79 |

TABLE 13

DETERMINATION OF EQUILIBRIUM TIME

$t_{ss}$ = time to steady state

$x_i$ = equilibrium value $X_i$

Equation for Regression Line:

$$\ln \left[ \frac{\Delta X_i}{\Delta t} \right] = \ln (a_{ij} x) - a_{ij} t$$

If: $$\ln \left[ \frac{\Delta X_i}{\Delta t} \right] = 0, \text{ then } t = t_{ss}$$

And: $$\frac{-\ln 0.1}{a_{ij}} = t_{ss}$$

TABLE 14

CALCULATION OF BIOLOGICAL HALF TIMES

$$\frac{x_i}{x_i} = 1-e^{-a_{ij}t}$$

Since true equilibrium is reached at infinite time, 0.9 $x_i$ is practical equilibrium. (Davis and Foster 1958).

$$0.9 = 1-e^{-a_{ij}t_{ss}}$$

$$0.1 = e^{-a_{ij}t_{ss}}$$

$$-\ln(0.1) = a_{ij}\, t_{ss}$$

Since.... $\left[a_{ij} = \frac{.693}{t_{eff}}\right]$

$$-\ln(0.1) = \frac{.693}{t_{eff}}\, t_{ss}$$

$$t_{ss} = t_{eff}\, \frac{(-\ln 0.1)}{.693}$$

And $$\frac{1}{t_{eff}} = \frac{1}{t_B} + \frac{1}{t_R}$$

Then at 90% Equilibrium:

$$t_{ss} = \frac{2.302}{\frac{.693}{t_B} + \frac{.693}{t_R}}$$

And $$t_B = \frac{.693\, t_{ss}}{2.302 - \frac{.693}{2889.6}\, t_{ss}}$$

TABLE 15

CONCENTRATION FACTORS AND FINAL
SELENIUM CONCENTRATION
SECOND RUN

| | TANK I | | | TANK II | | |
|---|---|---|---|---|---|---|
| | mg / g Compartment | C.F.* | Selenium ppm | mg / g Compartment | C.F.* | Selenium ppm |
| WATER | 0.848 / 60,000 | 1 | 0.014 | 0.379 / 60,000 | 1 | 0.0063 |
| SUSPENDED PARTICULATE | 0.212 / 4.62 | 3,248 | 45.8 | 0.065 / 2.65 | 3,883 | 24.5 |
| FISH | 0.034 / 14.3 | 168 | 2.37 | 0.0108 / 10.8 | 158 | 1.00 |
| SEDIMENT | 3.934 / 7,200 | 38 | 0.546 | 5.454 / 7,200 | 120 | 0.757 |

*(mg/g Compartment) / (mg/g Water)

## Summary

In summary, the four compartments uptake as expected. The separate tanks of both runs compare favorably and the four sets of data can be considered similar systems. The summing of compartments to a constant value of total selenium is good and supportive of the model.

The objective was continued in determination of rate constants for simulation in Chapter V.

The late depression of uptake in suspended particulate is probably due to slow equilibration of intake with losses.

Good supportive data has been obtained for the correction factors used and the model itself substantiates them by a good fit.

An hypothesis has been suggested which would account for the depression of the suspended particulate uptake by a failure of sampling design which caused added sediment uptake. It would propose that the low uptake amounts in the fish compartment is due to high intake and high loss rates.

In general, the data are statistically good, internally consistent and fitting to the proposed model. Radiotracer methods are sound and analytical methods substantiate the amounts of selenium detected.

Summary (Continued)

Regression analyses add validity to steady state values, and parameters determined by calculation should support the model and suggest new research.

## CHAPTER V

## SIMULATION OF THE MODEL AND CONCLUSIONS

It will be the objective in this final chapter to adapt the selenium model in a meaningful way to an analog computer program. An attempt will be made to simulate the data collected in the laboratory.

The outcome of this simulation will be productive in substantiating the value of the modeling effort for verification and for raising research questions.

The initial uptake constants obtained from the linear regression analyses are important in developing the model. The diagonal of the matrix of the selenium model represents the sum of the flows out of the respective compartments. The remaining entries in each column $b_{i1} \ldots b_{i4}$ represent the flows into each of the respective compartments, $X_i$. At steady state $\frac{dx_i}{dt} = 0$ and $\sum_{i=1}^{4} b_{ij} = 0$ for all columns (See Table 16).

TABLE 16

DIAGONAL MATRIX

$$\begin{pmatrix} b_{11} & -- & -- & -- \\ -- & b_{22} & -- & -- \\ -- & -- & b_{33} & -- \\ -- & -- & -- & b_{44} \end{pmatrix}$$

---

The solution to the matrix is affected by obtaining uptake constants in sufficient number to solve the set of simultaneous equations. Table 17 represents the incomplete solution in which there are four equations in ten unknowns.

TABLE 17

MATRIX FORM WITH INCOMPLETE SOLUTION

$$\begin{pmatrix} .006 & b_{12} & b_{13} & b_{14} \\ b_{21} & .001 & b_{23} & 0 \\ b_{31} & b_{32} & .010 & b_{34} \\ b_{41} & 0 & b_{43} & .009 \end{pmatrix} \begin{pmatrix} 0.89 \\ 0.063 \\ -6.5 \\ 4.6 \end{pmatrix} \cong \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}$$

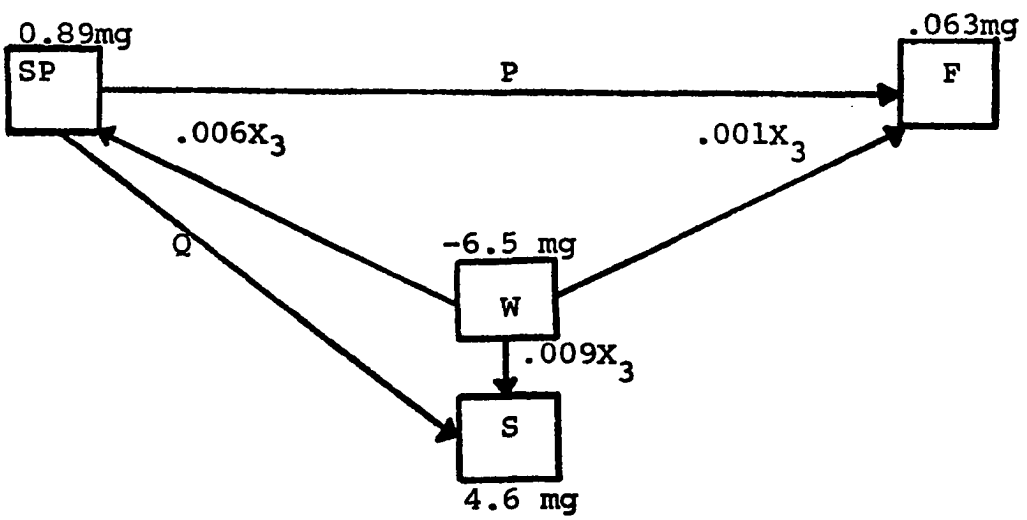
---

Average values from the second run were used, therefore, a precise materials balance of 6.0 mg. total is not possible. A solution is impossible without the use of analog simulation. Knowing the columns add to zero yields eight equations. Simulation of two additional unknowns would allow solution.

A simpler model is conceived in which the initial flows are assumed as unidirectional (Figure 22).

FIGURE 22

SIMPLIFIED FLOW DIAGRAM WITH INITIAL FLOWS



An analog computer program can be written to fit this simpler model (Figure 23). With this simple model, a search can be made to find flows P and Q between suspended particulate and fish and suspended particulate and sediment (Figure 22). These are assumed as initial flows and would represent the initial flows and would represent the initial uptake rates.

The simulation occurred with the flow $P \cong 0.001$ and $Q \cong 0.010$.

The matrix can be completed (Figure 24) with the simulation of the original data on the complete model.

Figure 24. Completed Matrix.

$$\begin{bmatrix} .006 & .0005 & .001 & .008 \\ .001 & .001 & .008 & 0 \\ .001 & .0005 & .010 & .001 \\ .004 & 0 & .001 & .009 \end{bmatrix}$$

The complete analog computer program that produced this simulation is shown in Figure 25. The analog simulation obtained from this matrix is shown in Figure 26.

Figure 23. Simplified Analog Computer Program

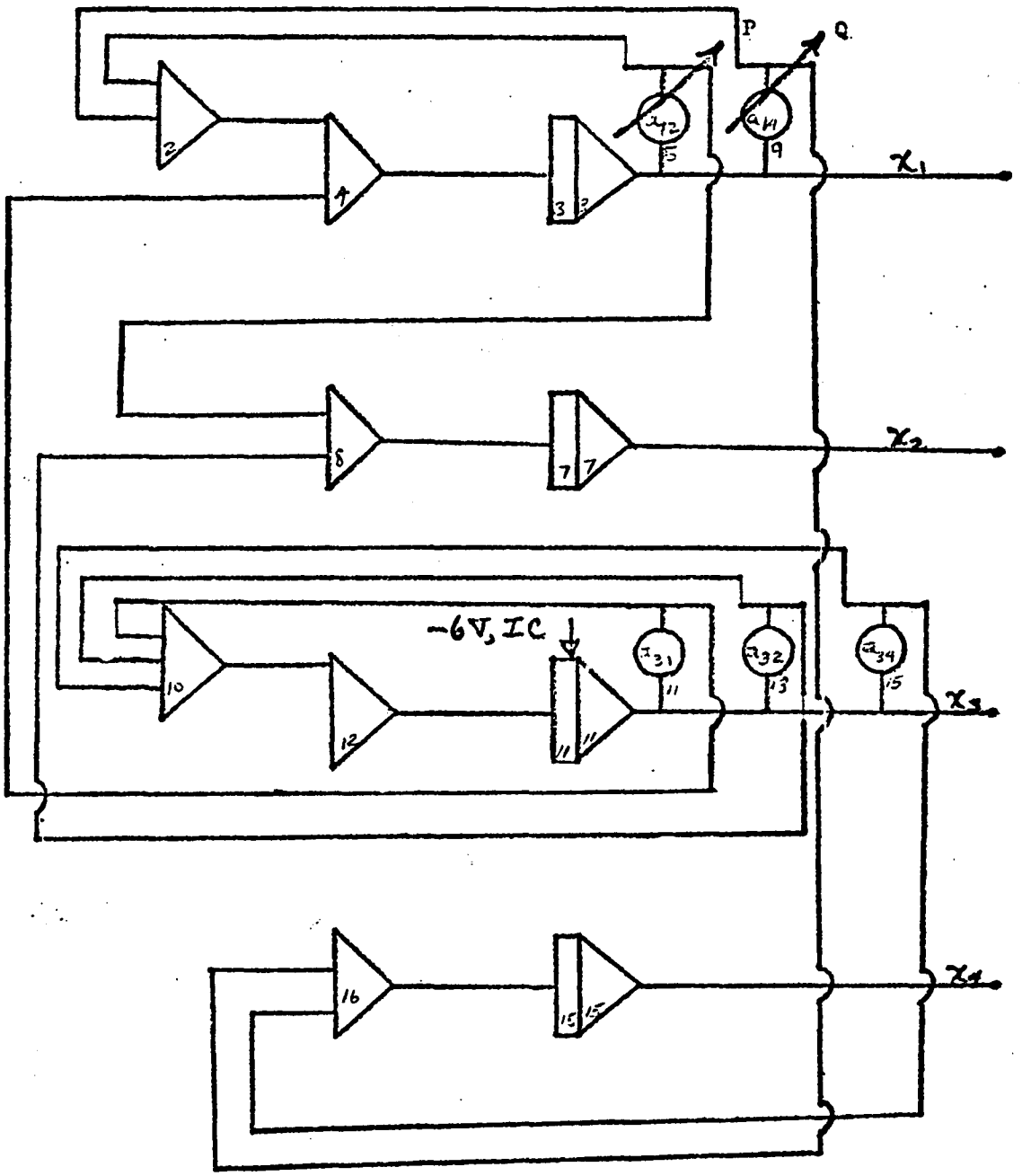


Figure 25. Complete Analog Computer Program

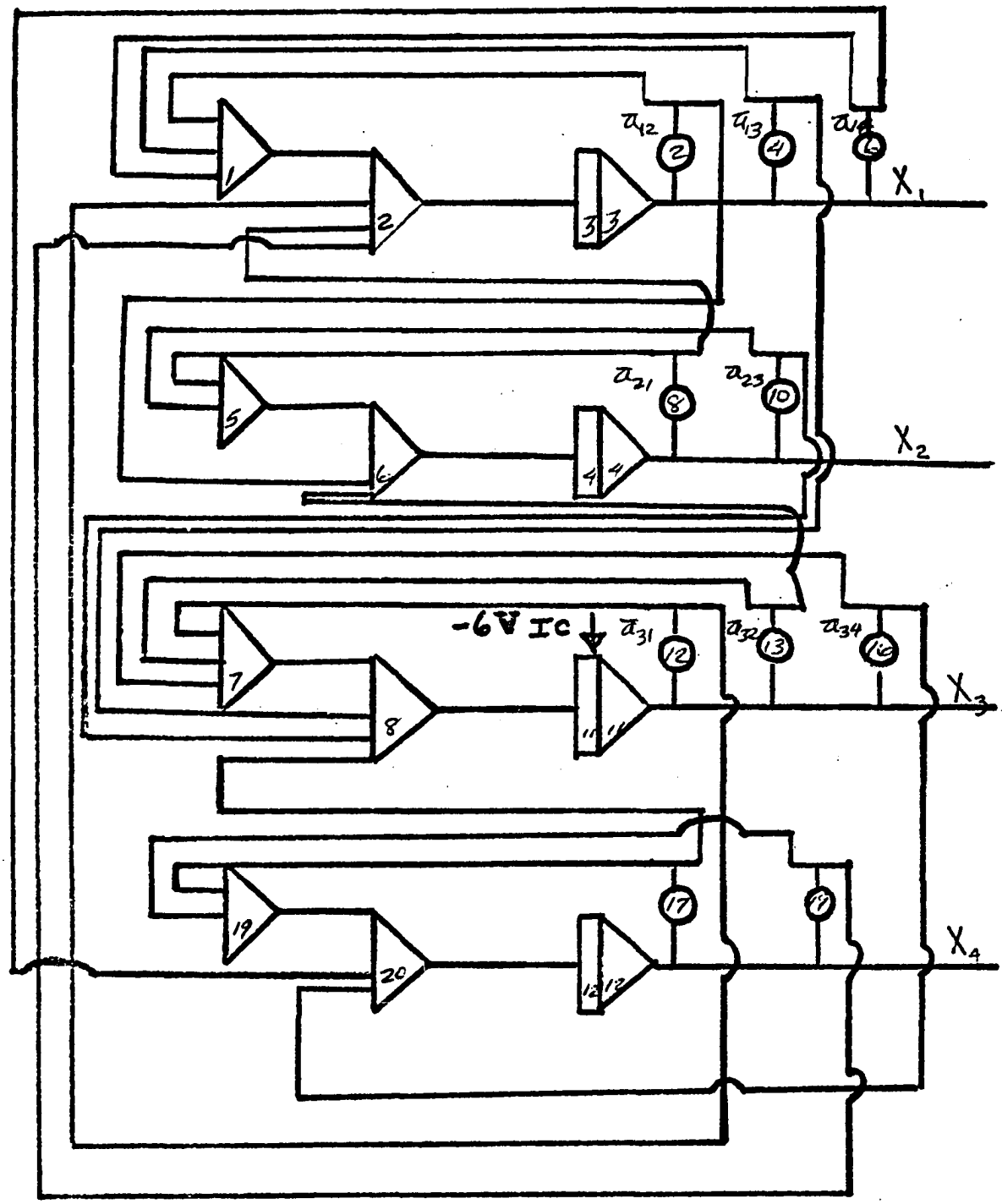
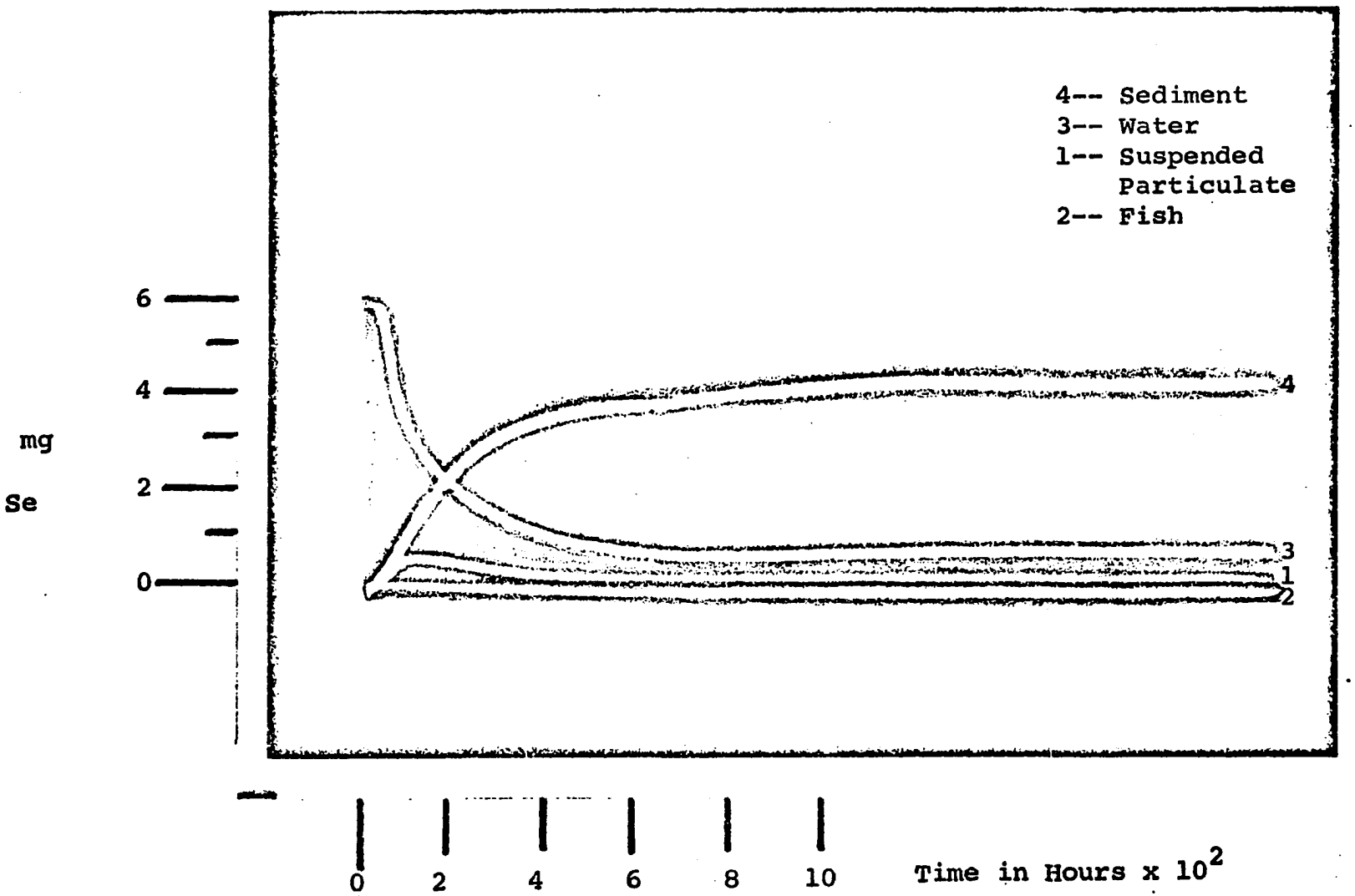


Figure 26. Analog Simulation of Selenium Model



An examination of the solution matrix (Figure 24) can summarize the thinking that went into the development of the selenium model.

The suspended particulate shows almost equal flows in and out of the fish. This fits our knowledge that the fish is not accumulating selenium by feeding on algae. Its rate of uptake from water is equal to its loss rate. One would expect sorption and metabolic uptake to produce accumulation. The transfer rate to sediment is double the reverse rate. Settling is going on at a higher rate than re-entrainment.

The fish compartment shows a much lower rate of uptake from water than loss and again no trophic gain appears from the suspended particulate. Apparently what is eaten is passed through without much absorption in the gut wall. This is supported by the observation of green fecal material which appears to have been passed by the fish without damage to the algal cells.

As expected, the water compartment shows rates to the other compartments greater than the incoming rates.

The sediment shows an uptake rate from the water no greater than the reverse flow. Both chemical and physical actions are greater for flow into the sediment than out. Sorption would occur more likely than desorption, and

apparently precipitation or ion exchange reactions tend to move selenium to the sediment. The rate from the suspended particulate is greater than the loss by sediment to that compartment.

A brief reiteration would allow that the primary interaction of suspended particulate is a water uptake and a settling loss to sediment. The water is donating to all compartments, and the fish is accumulating mostly by membrane uptake with relatively little loss through the kidney. The sediment is gaining selenium both from the water and suspended particulate at favorably large rates.

From the conclusions, certain other relationships are evident from Tables 12 and 15 (Chapter IV). The suspended particulate has a small mass, rapid loss to sediment, and good uptake from water. This results in a high concentration factor and fairly rapid turnover rate with a short equilibrium time and biological half life. The fish has only one uptake source and a relatively large mass. Its concentration factor is thus low. It has a longer turnover time and biological half life because of a possible low excretion rate. The water loses to all compartments and would have a short turnover time. The large mass of sediment and relative

rates of uptake from two compartments give it a relatively low concentration factor and large accumulation. Since it contains settled suspended particulate it might be expected to have shorter turnover rates than fish.

The simulation fits the data and the uptake constants generated make good biological sense. The model seems to have no obvious contradiction. However, it would still allow for the alternate hypothesis suggested in the previous chapter by the latent depression of the suspended particulate uptake. It is possible that the large settling rate of the suspended particulate is due to the swallowing, concentration, and defecating action of the fish. The fecal pellets, being larger, settle at a high rate. The function of the fish would be to advance the settling rate of the suspended particulate with a very low absorption such that the fish receives no significant build up of selenium. The biological half life of the fish that has been calculated, then is essentially due to kidney excretion vs. membrane uptake.

The important value of the model must be to stimulate meaningful questions which can verify or contradict various aspects of the model. For instance, questions arise: Is the high concentration factor of suspended particulate

associated with the bacteria or other flora or is it associated with fine particles? It would be interesting to find the biological half life of the fish in a feeding relationship compared to membrane uptake alone. The fraction absorbed in the gut should be investigated. Questions about migration rates in the sediment would be valuable studies. In addition, further trophic studies should be undertaken to elucidate a more complete food chain.

The ultimate modeling effort should be related to field observations. For example, if field observations show a different equilibrium time than is measured in the laboratory, then $a_{ij} = \frac{-\ln 0.1}{\text{time}}$ assuming 90% equilibrium. Selenium could be measured in the lake and converted to laboratory values with the assumptions of equilibrium.

Additional modeling efforts will become more mechanistic. Better analytical chemistry is needed to help this kind of modeling.

As all of these kinds of studies continue, the model will change. A model represents only a fabrication of the methods used to investigate the problem. As new techniques are developed, the model must change also. In doing so, it improves predictability and stimulates new questions.

# APPENDIX A

## APPENDIX A-1

## CULTURE MEDIA

(Fogg 1965, P. 35)

| NUTRIENT | % |
|---|---|
| $KNO_3$ | 0.1 |
| $Ca(NO_3)_2$ | 0.01 |
| $K_2HPO_4$ | 0.02 |
| $MgSO_4 \cdot 7 H_2O$ | 0.01 |
| $FeCl_3$ | 0.0001 |
| Vitamins | Trace |
| Difco-Peptone | Excess |

## APPENDIX A-2

### SEDIMENT SIEVE SIZE ANALYSIS

| SAMPLE NUMBER | MESH SIZE | WEIGHT(g) PLANCHET & SEDIMENT | WEIGHT(g) PLANCHET | | WEIGHT(g) SEDIMENT | % TOTAL |
|---|---|---|---|---|---|---|
| #1 | >40 | 10.0780 | 9.4320 | | 0.6460 | 4.4 |
| | >60 | 11.6203 | 9.5509 | | 2.0694 | 14.1 |
| | >100 | 15.4725 | 9.2750 | | 6.1975 | 42.4 |
| | >140 | 12.5833 | 9.4950 | | 3.0883 | 21.2 |
| | >200 | 10.9557 | 9.4049 | | 1.5508 | 10.6 |
| | Fines | 10.2210 | 9.1760 | | 1.0450 | 7.1 |
| | | | | TOTAL | 14.5970 | 100.00% |
| #2 | >40 | 10.0758 | 9.4377 | | 0.6381 | 4.5 |
| | >60 | 11.4850 | 9.5504 | | 1.9346 | 13.8 |
| | >100 | 15.2162 | 9.3772 | | 5.8390 | 41.7 |
| | >140 | 12.4495 | 9.4119 | | 3.0376 | 21.7 |
| | >200 | 10.8245 | 9.2923 | | 1.5322 | 10.9 |
| | Fines | 10.4691 | 9.4581 | | 1.0110 | 7.2 |
| | | | | TOTAL | 13.9925 | 100.00% |
| #3 | >40 | 9.9476 | 9.3388 | | 0.6088 | 4.3 |
| | >60 | 11.3613 | 9.3753 | | 1.9860 | 14.1 |
| | >100 | 15.2750 | 9.4605 | | 5.8145 | 41.4 |
| | >140 | 12.3570 | 9.3501 | | 3.0069 | 21.4 |
| | >200 | 11.1528 | 9.6052 | | 1.5476 | 11.0 |
| | Fines | 10.7743 | 9.7019 | | 1.0724 | 7.6 |
| | | | | TOTAL | 14.0362 | 100.00% |

APPENDIX A-2 (CONTINUED)

SEDIMENT SIEVE SIZE ANALYSIS

| SAMPLE NUMBER | MESH SIZE | WEIGHT(g) PLANCHET & SEDIMENT | WEIGHT(g) PLANCHET | | WEIGHT(g) SEDIMENT | % TOTAL |
|---|---|---|---|---|---|---|
| #4 | > 40 | 10.0132 | 9.3427 | | 0.6705 | 4.6 |
| | > 60 | 11.6136 | 9.5000 | | 2.1136 | 14.7 |
| | > 100 | 15.3995 | 9.3816 | | 6.0179 | 42.0 |
| | > 140 | 12.2059 | 9.1738 | | 3.0321 | 21.1 |
| | > 200 | 10.5961 | 9.1038 | | 1.4923 | 10.4 |
| | Fines | 10.3237 | 9.3264 | | 0.9973 | 6.9 |
| | | | | TOTAL | 14.3237 | 100.00% |
| #5 | > 40 | 10.1666 | 9.6166 | | 0.5500 | 3.9 |
| | > 60 | 11.3345 | 9.5847 | | 1.7498 | 12.5 |
| | > 100 | 15.0418 | 9.3282 | | 5.7136 | 41.0 |
| | > 140 | 12.7642 | 9.6089 | | 3.1553 | 22.6 |
| | > 200 | 10.8727 | 9.2262 | | 1.6465 | 11.8 |
| | Fines | 10.7669 | 9.6500 | | 1.1169 | 8.0 |
| | | | | TOTAL | 13.9321 | 100.00% |
| #6 | > 40 | 10.0830 | 9.5992 | | 0.4838 | 3.3 |
| | > 60 | 11.2306 | 9.5064 | | 1.7242 | 12.0 |
| | > 100 | 15.3916 | 9.5718 | | 5.8698 | 41.1 |
| | > 140 | 12.8586 | 9.6185 | | 3.2401 | 22.6 |
| | > 200 | 11.0693 | 9.3479 | | 1.7214 | 12.0 |
| | Fines | 10.6684 | 9.4270 | | 1.2414 | 8.6 |
| | | | | TOTAL | 14.2807 | 100.00% |

APPENDIX A-2 (CONTINUED)

SEDIMENT SIEVE SIZE ANALYSIS

| SAMPLE NUMBER | MESH SIZE | WEIGHT(g) PLANCHET & SEDIMENT | WEIGHT(g) PLANCHET | | WEIGHT(g) SEDIMENT | % TOTAL |
|---|---|---|---|---|---|---|
| #7 | > 40 | 10.0152 | 9.3847 | | 0.6305 | 4.4 |
| | > 60 | 11.3121 | 9.4318 | | 1.8803 | 13.1 |
| | > 100 | 15.6200 | 9.5346 | | 6.0854 | 42.6 |
| | > 140 | 12.5013 | 9.3975 | | 3.1038 | 21.8 |
| | > 200 | 11.1506 | 9.6288 | | 1.5218 | 10.6 |
| | Fines | 10.4720 | 9.4094 | | 1.0626 | 7.4 |
| | | | | TOTAL | 14.2844 | 100.00% |
| #8 | > 40 | 9.8383 | 9.2390 | | 0.5993 | 4.8 |
| | > 60 | 11.5137 | 9.5793 | | 1.9344 | 13.2 |
| | > 100 | 15.3616 | 9.2600 | | 6.1016 | 41.8 |
| | > 140 | 12.5747 | 9.4327 | | 3.1420 | 21.3 |
| | > 200 | 11.1962 | 9.6048 | | 1.5914 | 10.9 |
| | Fines | 10.6371 | 9.5397 | | 1.0974 | 7.7 |
| | | | | TOTAL | 14.4661 | 100.00% |
| #9 | > 40 | 9.9803 | 9.2920 | | 0.6883 | 4.8 |
| | > 60 | 11.5579 | 9.6962 | | 1.8617 | 13.2 |
| | > 100 | 15.5643 | 9.6754 | | 5.8889 | 41.8 |
| | > 140 | 12.6444 | 9.6463 | | 2.9981 | 21.3 |
| | > 200 | 11.1283 | 9.5867 | | 1.5416 | 10.9 |
| | | | | | 1.0865 | 7.7 |

# APPENDIX A-3

## DISTRIBUTION OF SEDIMENT IN SAMPLING CONTAINERS ACCORDING TO SIEVE ANALYSIS

- Area of Experimental Tanks = 1860.32 $cm^2$

- Area of 1 sampling container $= \pi\left(\frac{D}{2}\right)^2$

$$= \frac{(3.1416)\ (1.89/2)^2}{} \ cm^2$$

$$= 2.805 \ cm^2$$

where container diameter = 1.89 cm.

- Fraction of sediment in one container by area ratio =

$$\frac{2.805 \ cm^2}{1860.32 \ cm^2} = .001508$$

- Total weight sediment in tank = 7200g

and

- Weight of Sediment to be placed in one container =

(.001508) 7200g = 10.857 g/container.

- Weight by particle size required for container to be representative.

PARTICLE SIZE DISTRIBUTION

| SIZE | % | WEIGHT(g) |
|---|---|---|
| > 40 | ( 4.3% ) | 0.4668g |
| > 60 | (13.42%) | 1.4578g |
| > 100 | (41.81%) | 4.5361g |
| > 140 | (21.63%) | 2.3483g |
| > 200 | (11.03%) | 1.1975g |
| Fines | ( 7.6 %) | 0.8251g |
| TOTAL | 99.99% | 10.8289g |

## APPENDIX A-4

## QUALITATIVE DISTRIBUTION OF PARTICLE SIZE ON BOTTOM

The blotter paper was positioned on the bottom of the tanks and a particle size distribution was introduced in the center by the propeller sequentially by size.

The following visual observations were made. Water was in the tank. See FIGURE VI for letter code.

| | MESH SIZE | DISTRIBUTION |
|---|---|---|
| FINES | < 200 | General, primarily H |
| | < 140 | C and E |
| | < 100 | C |
| | < 60 | R and C |
| | < 40 | R |

# APPENDIX A-5

## COMPARISON OF PIPETTES

Normal Pipette: 20.0 ml

Broken End Pipette: Tip broken off and recalibrated to 20.0 ml to allow larger orifice.

| | SAMPLE NUMBER | WEIGHT SUSPENDED PARTICULATE MILLIGRAMS | STATISTICAL ANALYSIS |
|---|---|---|---|
| NORMAL | 1 | 1.7 | mean = 1.83 mg |
| | 2 | 1.8 | |
| | 3 | 1.7 | $\sqrt{n}$ = 0.105 mg |
| | 4 | 1.7 | |
| | 5 | 1.9 | 1.96 $\sqrt{n}$ = 0.207 mg |
| | 6 | 1.9 | |
| | 7 | 1.8 | |
| | 8 | 1.9 | |
| | 9 | 2.0 | |
| | 10 | 1.9 | |
| BROKEN END | 11 | 3.1 | mean = 2.98 mg |
| | 12 | 2.9 | |
| | 13 | 2.6 | $\sqrt{n}$ = 0.253 mg |
| | 14 | 3.1 | |
| | 15 | 2.7 | 1.96 $\sqrt{n}$ = 0.495 mg |
| | 16 | 3.0 | |
| | 17 | 2.8 | |
| | 18 | 3.3 | |
| | 19 | 2.9 | |
| | 20 | 3.4 | |

# APPENDIX B

APPENDIX B-1

WATER COMPARTMENT (FIRST RUN, TANK I)

| HOURS ELAPSED TIME | FILTER NUMBER | RAW 10 MIN. COUNT 20 ml SAMPLE | cpm CORRECTED FOR BACKGROUND | cpm CORRECTED FOR DECAY | mg Se 20 ml SAMPLE x $10^{-3}$ | mg Se 60 l TANK |
|---|---|---|---|---|---|---|
| 0 | | | | | | |
| 1.5 | 19 | 536-476 * | 401 | 401 | .1978 | .5936 |
| 2.0 | 17 | 602-559 * | 476 | 476 | .2349 | .7047 |
| 12 | 5 | 512-500 * | 401 | 401 | .1978 | .5936 |
| 13 | 7 | 4,941 | 389 | 389 | .1919 | .5759 |
| 19 | 9 | 5,510 | 446 | 446 | .2201 | .6603 |
| 29 | 11 | 5,035 | 398 | 398 | .1966 | .5899 |
| 37 | 13 | 5,164 | 411 | 411 | .2030 | .6090 |
| 55 | 15 | 4,900 | 385 | 389 | .1922 | .5766 |
| 62 | 2 | 4,891 | 384 | 388 | .1917 | .5751 |
| 87 | 3 | 4,417 | 336 | 340 | .1680 | .5042 |
| 110 | 21 | 4,797 | 375 | 383 | .1892 | .5676 |
| 134 | 23 | 4,429 | 338 | 346 | .1711 | .5134 |
| 190 | 25 | 4,078 | 304 | 318 | .1569 | .4709 |
| 212 | 27 | 3,855 | 282 | 295 | .1454 | .4364 |
| 232 | 29 | 3,685 | 266 | 281 | .1387 | .4163 |
| 278 | 31 | 3,342 | 231 | 248 | .1222 | .3667 |
| 310 | 33 | 3,976 | 294 | 315 | .1552 | .4657 |
| 354 | 35 | 3,235 | 220 | 241 | .1187 | .3562 |
| 432 | 37 | 3,095 | 206 | 228 | .1124 | .3374 |
| 476 | 39 | 2,801 | 174 | 195 | .0963 | .2889 |

* one minute count

APPENDIX B-1 (CONTINUED)

WATER COMPARTMENT (FIRST RUN, TANK I)

| HOURS ELAPSED TIME | FILTER NUMBER | RAW 10 MIN. COUNT 20 ml SAMPLE | cpm CORRECTED FOR BACKGROUND | cpm CORRECTED FOR DECAY | mg Se 20 ml SAMPLE x $10^{-3}$ | mg Se 60 l TANK |
|---|---|---|---|---|---|---|
| 498 | 41 | 2,750 | 171 | 192 | .0945 | .2837 |
| 526 | 43 | 2,695 | 169 | 190 | .0939 | .2818 |
| 549 | 45 | 2,474 | 145 | 164 | .0810 | .2432 |
| 573 | 47 | 2,415 | 141 | 161 | .0796 | .2388 |
| 650 | 49 | 2,170 | 115 | 134 | .0659 | .1977 |
| 672 | 51 | 2,180 | 117 | 137 | .0678 | .2035 |
| 692 | 53 | 2,242 | 124 | 146 | .0720 | .2160 |
| 716 | 55 | 2,065 | 105 | 124 | .0612 | .1838 |
| 740 | 57 | 1,913 | 90 | 108 | .0532 | .1596 |

APPENDIX B-2

SUSPENDED PARTICULATE (First Run, Tank I)

| ELAPSED TIME IN HOURS | FILTER NUMBER | RAW cpm ROLLED FILTER 20 ml SAMPLE | cpm CORRECTED FOR BACKGROUND | cpm DECAY CORRECTED | NORMALIZED cpm (x .9055) | $10^{-6}$ mg Se ** 20 ml SAMPLE | mg Se COMPARTMENT (x 3,000) |
|---|---|---|---|---|---|---|---|
| 0 | 00 | 987* | 0 | 0 | 0 | 0 | 0 |
| 1.5 | 19 | 1,032* | 4 | 5 | 5 | 3 | .007 |
| 2.0 | 17 | 99, 114 107 | 8 | 10 | 9 | 4 | .013 |
| 12 | 5 | 126, 106 108 | 14 | 18 | 16 | 8 | .024 |
| 13 | 7 | 102, 94, 119 | 6 | 7 | 7 | 3 | .009 |
| 19 | 9 | 118, 94, 122 | 12 | 15 | 14 | 7 | .021 |
| 29 | 11 | 126, 123, 116 | 23 | 28 | 25 | 12 | .038 |
| 37 | 13 | 113, 115, 117 | 16 | 20 | 18 | 9 | .027 |
| 55 | 15 | 1,187* | 20 | 25 | 22 | 11 | .033 |
| 62 | even 2 | 1,618* | 63 | 78 | 71 | 35 | .105 |
| 87 | 3 | 1,327* | 34 | 42 | 38 | 18 | .056 |

* ten minute count ** mg per cpm = 0.4935

APPENDIX B-2 (CONTINUED)

SUSPENDED PARTICULATE (First Run, Tank I )

| ELAPSED TIME IN HOURS | FILTER NUMBER | RAW cpm ROLLED FILTER 20 ml SAMPLE | cpm CORRECTED FOR BACKGROUND | cpm DECAY CORRECTED | NORMALIZED cpm (x .9055) | $10^{-6}$ mg Se ** 20 ml SAMPLE | mg Se COMPARTMENT (x 3,000) |
|---|---|---|---|---|---|---|---|
| 110 | 21 | 142, 101, 129 | 25 | 31 | 28 | 14 | .042 |
| 134 | 23 | 1,280* | 29 | 36 | 33 | 16 | .049 |
| 190 | 25 | 114, 120, 115, 126 | 20 | 25 | 22 | 11 | .033 |
| 212 | 27 | 116, 103, 120 | 14 | 17 | 16 | 8 | .024 |
| 232 | 29 | 1,168* | 18 | 22 | 20 | 10 | .030 |
| 278 | 31 | 106, 108, 134 | 17 | 21 | 19 | 9 | .029 |
| 310 | 33 | 115, 113, 115 | 15 | 19 | 17 | 8 | .026 |
| 354 | 35 | 116, 113, 137 | 23 | 29 | 26 | 13 | .039 |
| 432 | 37 | 1,150* | 16 | 20 | 18 | 9 | .027 |

* ten minute count ** mg per cpm = 0.4935

APPENDIX B-2 (CONTINUED)

SUSPENDED PARTICULATE (First Run, Tank I)

| ELAPSED TIME IN HOURS | FILTER NUMBER | RAW cpm ROLLED FILTER 20 ml SAMPLE | cpm CORRECTED FOR BACKGROUND | cpm DECAY CORRECTED | NORMALIZED cpm (x .9055) | $10^{-6}$ mg Se ** 20 ml SAMPLE | mg Se COMPARTMENT (x 3,000) |
|---|---|---|---|---|---|---|---|
| 476 | 39 | 121, 111, 109 | 15 | 18 | 16 | 8 | .025 |
| 498 | 41 | 117, 128, 96 | 15 | 18 | 16 | 8 | .025 |
| 526 | 43 | 134, 91 | 13 | 17 | 15 | 7 | .023 |
| 549 | 45 | 125, 118 | 22 | 28 | 25 | 12 | .038 |
| 573 | 47 | 114, 128 | 22 | 27 | 25 | 12 | .037 |
| 650 | 49 | 1,204* | 21 | 27 | 24 | 12 | .036 |
| 672 | 51 | 123, 124 | 24 | 30 | 28 | 13 | .041 |
| 692 | 53 | 119, 125 | 23 | 29 | 26 | 13 | .039 |
| 716 | 55 | 109, 140 | 25 | 32 | 29 | 14 | .043 |
| 740 | 57 | 117, 121 | 20 | 25 | 22 | 11 | .034 |

* ten minute count ** mg per cpm = 0.4935

APPENDIX B-3

FISH COMPARTMENT (First Run, Tank I)

| ELAPSED TIME IN HRS. | FISH NUMBER 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 0 | 121-105 | 111-106 | 111-98 | 105-108 | 113-104 | 109-110 |
| 2.75 | 139 | 158 | 160 | 165 | - | - |
| 13 | 262-250 | 255-287 | 274-273 | 302 | 332 | - |
| 38 | 337-394<br>357 | 403-366 | 412 | 465-450 | 545-551<br>545 | - |
| 63 | 446-430 | 478-484 | 514-561 | 649-645 | 659-639 | 756-727 |
| 88 | 568-596 | 631-617 | 714-725 | 722-713 | 785-793 | 906-849 |
| 191 | 284-151 | 722-703 | 1,080-1,031 | 1,079-1,100 | 1,512-1,623 | 1,784-1,817 |
| 230 | 879-788 | 863-893 | 1,047-1,054 | 1,147-1,208 | 1,625-1,734 | 1,939-1,933 |
| 254 | 733-734 | 859-882 | 1,015-970 | 1,228-1,276 | 2,001-2,010 | 1,996-2,031 |
| 287 | 746-839 | 1,172<br>940 up | 1,495-1,430 | 1,697-1,738 | 1,845-1,897 | 2,333-2,366 |
| 310 | 1,248-1,192 | 1,171<br>1,388 up | 1,752-1,733 | 1,901-1,878 | 2,694-2,630 | 2,980-3,003<br>2,985-3,031 |
| 330 | 1,091-1,073 | 1,040<br>1,126 up | 1,284<br>1,303 up | 1,675-1,657 | 2,784-2,908 | 3,146-3,042 |
| 354 | 1,045-1,099 | 1,250<br>1,167 up | 1,597-1,617 | 1,869-1,914 | 2,927-2,823 | 2,826-2,931 |
| 374 | 1,109-1,051 | 1,436<br>1,177 up | 1,671-1,718 | 1,950-1,958 | 2,913-3,090 | 3,129-2,955 |

APPENDIX B-3 (CONTINUED)

FISH COMPARTMENT (First Run, Tank I)

| ELAPSED TIME IN HRS. | FISH NUMBER 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 476 | 1,095-1,025 | 1,083-1,182 | 1,219<br>1,208 up | 1,666-1,670 | 2,960-2,792 | 2,943-2,919 |
| 500 | 1,008-1,043<br>995 | 1,037<br>1,035 up | 1,577-1,576 | 1,661-1,903<br>1,749 | 2,861-2,929<br>2,830-2,787 | 2,964-3,063 |
| 518 | 1,028-1,129 | 1,164<br>1,158 up | 1,183<br>1,180 up | 1,637-1,654 | 2,756-2,779 | 2,995-2,892<br>2,905 |
| 549 | 985-990 | 1,087-1,149 | 1,135-1,150<br>1,156 | 1,564-1,570 | 2,087-2,683<br>1,984 up<br>2,680 | 2,788-2,774 |
| 574 | 950 down<br>1,051 | 1,096<br>1,083 up | 1,518-1,543 | 1,643-1,685 | 2,765-2,686 | 2,876-2,707 |
| 650 | 926-882 | 1,056-1,094up | 1,388-1,449<br>1,452 | 1,700-1,685 | 2,630-2,608 | 2,606-2,689 |
| 672 | 881-871 | 1,090-1,007<br>1,003 up | 1,410-1,411 | 1,591-1,589 | 2,409-2,371 | 2,612-2,724 |
| 694 | 889-895 up | 1,348-1,270 | 1,451-1,385 | 1,561-1,550 | 2,609-2,621 | 2,682-2,589<br>2,652 |
| 716 | 931-886 | 1,200-1,109 | 1,159-1,208<br>1,231 | 1,610-1,594 | 2,528-2,470 | 2,660-2,597 |
| 740 | 942-886 | 1,135<br>1,105 up | 1,138 up<br>1,105-1,108 | 1,135-1,193 | 2,466-2,558 | 2,626-2,643 |

APPENDIX B-3 (CONTINUED)

FISH COMPARTMENT (First Run, Tank I)

| ELAPSED TIME IN HOURS | BACKGROUND CORRECTED SUM COMPARTMENT | COMPARTMENT cpm DECAY CORRECTED | $10^{-6}$ COMPARTMENT mg Se* | $10^{-6}$ COMPARTMENT mg Se NORMALIZED** |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 2.75 | 303 | 303 | 149 | 105 |
| 13 | 1,090 | 1,090 | 538 | 379 |
| 38 | 1,961 | 1,961 | 967 | 683 |
| 63 | 2,864 | 2,897 | 1,429 | 1,009 |
| 88 | 3,705 | 3,748 | 1,849 | 1,306 |
| 191 | 5,816 | 6,090 | 3,005 | 2,122 |
| 230 | 6,933 | 7,260 | 3,583 | 2,529 |
| 254 | 7,246 | 7,675 | 3,787 | 2,674 |
| 287 | 9,210 | 9,869 | 4,870 | 3,438 |
| 310 | 11,994 | 12,851 | 6,342 | 4,477 |
| 330 | 12,252 | 13,278 | 6,553 | 4,626 |
| 354 | 11,760 | 12,745 | 6,289 | 4,440 |
| 374 | 12,304 | 13,492 | 6,658 | 4,701 |
| 476 | 10,966 | 12,164 | 6,003 | 4,237 |
| 500 | 12,063 | 13,536 | 6,679 | 4,716 |
| 518 | 12,020 | 13,488 | 6,656 | 4,699 |
| 549 | 11,420 | 12,963 | 6,397 | 4,517 |
| 574 | 11,051 | 12,688 | 6,261 | 4,420 |
| 650 | 10,541 | 12,242 | 6,042 | 4,265 |
| 672 | 10,116 | 11,885 | 5,865 | 4,140 |
| 694 | 9,831 | 11,550 | 5,700 | 4,024 |
| 716 | 9,941 | 11,814 | 5,830 | 4,116 |
| 740 | 10,232 | 12,160 | 6,001 | 4,236 |

* $(0.49350 \times 10^{-6})$ mg/cpm

** Normalization Factor = .706

APPENDIX B-4

SEDIMENT COMPARTMENT (First Run, Tank I, Raw cpm)

| ELAPSED TIME IN HRS. | I 3 H | I 2 H | I 1 H | I 3 R | I 1 R | I 4 C |
|---|---|---|---|---|---|---|
| 0 | 1,045* | 1,032* | 1,029* | 1,052* | 1,055* | 1,035* |
| 3 | 147 | 190 | - | 215 | - | 233 |
| 19 | 1,959* | 2,960* | 2,855* | 3,366* | 3,403* | 4,104* |
| 44 | 3,153* | 4,363* | 4,205* | 4,654* | 5,154* | 5,755* |
| 70 | 306-322 | 516-481 | 497-574 | 539-554 | 563-566 | 699-735 |
| 133 | 6,997* | 7,775* | 6,752* | 6,360* | 8,355* | 9,513* |
| 212 | 8,313* | 8,919* | 7,523* | 7,202* | 8,564* | 9,217* |
| 242 | 898-848 | 847-874 | 865-896 | 743-747 | 931-949 | 947-1,009 |
| 278 | 1,268-1,248 | 814-736 | 889-946 | 801-776 | 802-823 | 1,031-984 |
| 311 | 1,515 | 751-790 | 1,024-1,051 | 833-839 | 931-929 | 1,017-984 |
| 332 | 1,459-1,484 | 786-815 | 945-1,002 | 870-855 | 771-794 | 975-1,004 |
| 355 | 1,485-1,471 | 905-932 | 1,066 | 839-876 | 907-920 | 1,047-1,096 |
| 375 | 1,497-1,550 | 950-1,003 | 1,171-1,148 | 968-919 | 1,125-1,055 | 1,298-1,321 |
| 477 | 1,625-1,556 | 1,016-1,058 | 1,176-1,198 | 955-952 | 1,098-1,084 | 1,294-1,284 |
| 502 | 15,380* | 10,264* | 1,166-1,223 | 9,665* | 1,039-1,090 | 13,219* |
| 550 | 15,985* | 10,613* | 1,277-1,253 | 9,810* | 1,125-1,133 | 13,227* |
| 574 | 16,490* | 10,463* | 1,209-1,306 | 10,274* | 1,084-1,126 | 13,402* |
| 673 | 18,623* | 10,818* | 1,308-1,346 | 10,310* | 1,100-1,094 | 13,503* |
| 693 | 17,902* | 10,586* | 1,352-1,325 | 9,938* | 1,058-1,158 | 13,544* |
| 717 | 17,761* | 10,556* | 1,346-1,282 | 9,539* | 1,130-1,108 | 13,076* |
| 735 | 1,699-1,697 | 999-1,063 | 1,290-1,304 | 8,802* | 1,044-1,038 | 1,308-1,360 |

* ten minute count

APPENDIX B-4 (CONTINUED)

SEDIMENT COMPARTMENT (First Run, Tank I, Raw cpm)

| ELAPSED TIME IN HRS. | I 2 C | I 4 E | I 2 E | I 3 E | I 1 E |
|---|---|---|---|---|---|
| 0 | 1,045* | 1,059* | 1,039* | 1,022* | 1,063* |
| 3 | - | 230 | - | 209 | - |
| 19 | 4,001* | 3,878* | 3,536* | 3,744* | 2,991* |
| 44 | 5,880* | 5,484* | 5,111 | 5,447* | 489-437 |
| 70 | 662-653 | 587-631 | 667-657 | 551-562 | 470-476 |
| 133 | 9,402* | 8,898* | 7,912* | 7,727* | 5,758* |
| 212 | 11,195* | 10,567* | 10,326* | 9,224* | 7,234* |
| 242 | 1,073-1,094 | 1,004-1,036 | 970-942 | 968-955 | 755-703 |
| 278 | 1,083-1,044 | 1,028-1,006 | 878-929 | 952-898 | 743-705 |
| 311 | 1,149-1,198 | 991-1,034 | 949-947 | 1,014-1,038 | 714-720 |
| 332 | 1,148-1,078 | 972-980 | 930-911 | 994-940 | 850-813 |
| 355 | 1,178-1,315 | 1,105-1,125 | 996-1,041 | 1,037-1,039 | 747-890 |
| 375 | 1,411-1,400 | 1,168-1,057 | 1,048 | 1,161-1,128 | 948-927 |
| 477 | 1,470-1,482 | 1,279-1,223 | 1,127-1,101 | 1,268-1,251 | 978-928 |
| 502 | 1,398-1,431 | 1,249-1,266 | 11,781* | 12,553* | 930-942 |
| 550 | 1,433-1,434 | 1,376-1,261 | 12,363* | 12,937* | 975-977 |
| 574 | 1,413-1,419 | 1,264-1,299 | 12,444* | 13,323* | 975-1,002<br>939-996 |
| 673 | 1,453-1,394 | 1,264-1,255 | 12,460* | 13,421* | 997-1,005 |
| 693 | 1,460-1,361 | 1,280-1,222 | 12,416* | 12,968* | 1,013-964 |
| 717 | 1,420-1,416 | 1,309-1,255 | 12,137* | 12,949* | 969-965 |
| 735 | 1,327-1,362 | 1,249-1,287 | 1,211-1,216 | 1,268-1,237 | 967-974 |

* ten minute count

APPENDIX B-4 (CONTINUED)

SEDIMENT COMPARTMENT (First Run, Tank I, Corrected* for Background, Normalized+ for Attenuation, Geometry)

| ELAPSED TIME IN HRS. | I 3 H | I 2 H | I 1 H | I 3 R | I 1 R | I 4 C |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 42-34 | 85-68 | - | 110-88 | - | 128-103 |
| 19 | 91-73 | 191-153 | 180-144 | 232-186 | 235-189 | 305-245 |
| 44 | 210-169 | 331-266 | 315-253 | 360-289 | 410-330 | 471-378 |
| 70 | 209-168 | 394-316 | 430-346 | 441-355 | 460-369 | 612-491 |
| 133 | 595-478 | 673-541 | 570-458 | 532-427 | 731-587 | 847-680 |
| 212 | 727-584 | 788-632 | 648-521 | 616-495 | 752-604 | 817-656 |
| 242 | 770-618 | 758-609 | 778-624 | 642-516 | 837-672 | 875-703 |
| 278 | 1,154-926 | 671-538 | 813-653 | 684-550 | 709-569 | 903-726 |
| 311 | 1,411-1,133 | 667-535 | 934-950 | 732-587 | 826-663 | 896-720 |
| 332 | 1,367-1,098 | 697-560 | 870-698 | 759-609 | 678-544 | 886-711 |
| 355 | 1,374-1,103 | 814-654 | 962-773 | 753-605 | 809-650 | 968-777 |
| 375 | 1,417-1,138 | 870-699 | 1,053-846 | 838-673 | 984-790 | 1,203-966 |
| 477 | 1,486-1,193 | 933-749 | 1,187-953 | 849-682 | 987-792 | 1,185-952 |
| 502 | 1,437-1,154 | 925-743 | 1,093-878 | 865-695 | 963-774 | 1,220-980 |
| 550 | 1,498-1,202 | 960-770 | 1,164-934 | 880-707 | 1,028-825 | 1,221-981 |
| 574 | 1,547-1,242 | 945-759 | 1,156-929 | 926-744 | 1,004-806 | 1,238-994 |
| 673 | 1,761-1,414 | 980-787 | 1,226-985 | 930-747 | 996-800 | 1,249-1,003 |
| 693 | 1,689-1,356 | 957-769 | 1,237-993 | 892-717 | 1,007-809 | 1,253-1,006 |
| 717 | 1,675-1,345 | 954-767 | 1,213-974 | 852-685 | 1,018-817 | 1,206-969 |
| 735 | 1,597-1,282 | 930-747 | 1,196-960 | 779-626 | 940-755 | 1,233-990 |

*Left Entry +Right Entry

APPENDIX B-4 (CONTINUED)

SEDIMENT COMPARTMENT (First Run, Tank I, Corrected* for Background, Normalized+for Attenuation, Geometry)

| ELAPSED TIME IN HRS. | I 2 C | I 4 E | I 2 E | I 3 E | I 1 E |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | - | 125-100 | - | 107-86 | - |
| 19 | 295-237 | 283-227 | 249-200 | 269-216 | 194-156 |
| 44 | 483-388 | 443-356 | 406-326 | 440-353 | 358-287 |
| 70 | 552-444 | 504-405 | 557-447 | 451-363 | 368-296 |
| 133 | 836-672 | 785-631 | 687-552 | 669-537 | 471-379 |
| 212 | 1,015-816 | 953-765 | 929-746 | 819-657 | 619-497 |
| 242 | 981-787 | 916-736 | 853-685 | 858-689 | 626-503 |
| 278 | 960-771 | 913-733 | 800-642 | 821-659 | 620-498 |
| 311 | 1,069-859 | 908-730 | 844-678 | 922-740 | 613-492 |
| 332 | 1,009-810 | 872-700 | 817-656 | 863-693 | 728-584 |
| 355 | 1,143-917 | 1,011-812 | 915-734 | 934-750 | 714-573 |
| 375 | 1,300-1,044 | 1,006-808 | 942-756 | 1,039-834 | 831-667 |
| 477 | 1,372-1,102 | 1,147-921 | 1,010-811 | 1,156-928 | 849-681 |
| 502 | 1,314-1,055 | 1,156-929 | 1,077-864 | 1,154-926 | 835-670 |
| 550 | 1,333-1,070 | 1,217-978 | 1,135-912 | 1,193-958 | 875-703 |
| 574 | 1,315-1,056 | 1,180-947 | 1,143-918 | 1,231-988 | 877-704 |
| 673 | 1,322-1,062 | 1,158-930 | 1,145-919 | 1,241-996 | 900-722 |
| 693 | 1,314-1,055 | 1,150-923 | 1,140-916 | 1,196-960 | 887-712 |
| 717 | 1,317-1,058 | 1,181-948 | 1,112-893 | 1,194-959 | 866-695 |
| 735 | 1,244-999 | 1,167-937 | 1,112-893 | 1,151-925 | 869-698 |

*Left Entry +Right Entry

APPENDIX B-4 (CONTINUED)

SEDIMENT COMPARTMENT (First Run, Tank I, Decay Correction, Geometric Average, Mg Selenium)

| HOURS ELAPSED TIME | H | | R | | C | | E | |
|---|---|---|---|---|---|---|---|---|
| | AVERAGE cpm | FRACTION cpm | AVERAGE cpm | FRACTION cpm | AVERAGE cpm | FRACTION cpm | AVERAGE cpm | FRACTION cpm |
| 0 | - | - | - | - | - | - | - | - |
| 3 | 51 | 22 | 88 | 10 | - | - | 93 | 29 |
| 19 | 111 | 49 | 188 | 21 | 241 | 31 | 200 | 62 |
| 44 | 214 | 94 | 310 | 35 | 383 | 49 | 331 | 103 |
| 70 | 249 | 110 | 362 | 41 | 468 | 60 | 378 | 118 |
| 133 | 489 | 215 | 507 | 58 | 676 | 87 | 525 | 163 |
| 212 | 580 | 256 | 550 | 63 | 736 | 95 | 666 | 207 |
| 242 | 617 | 272 | 594 | 68 | 745 | 96 | 653 | 203 |
| 278 | 760 | 335 | 560 | 64 | 749 | 97 | 633 | 197 |
| 311 | 938 | 413 | 625 | 71 | 790 | 102 | 660 | 205 |
| 332 | 864 | 381 | 576 | 66 | 761 | 98 | 658 | 205 |
| 355 | 908 | 400 | 628 | 72 | 847 | 109 | 717 | 223 |
| 375 | 955 | 421 | 732 | 84 | 1,005 | 130 | 766 | 238 |
| 477 | 1,022 | 451 | 737 | 84 | 1,027 | 132 | 835 | 260 |
| 502 | 982 | 433 | 735 | 84 | 1,018 | 131 | 847 | 264 |
| 550 | 1,027 | 453 | 766 | 87 | 1,026 | 132 | 888 | 276 |
| 574 | 1,043 | 460 | 775 | 89 | 1,025 | 132 | 889 | 277 |
| 673 | 1,150 | 507 | 774 | 88 | 1,033 | 133 | 892 | 277 |
| 693 | 1,118 | 493 | 763 | 87 | 1,031 | 133 | 878 | 273 |
| 717 | 1,107 | 488 | 751 | 86 | 1,014 | 131 | 874 | 272 |
| 735 | 1,068 | 471 | 690 | 79 | 995 | 128 | 863 | 269 |

APPENDIX B-4 (CONTINUED)

SEDIMENT COMPARTMENT (First Run, Tank I,
Decay Correction, Geometric Average, Mg Selenium)

| HOURS ELAPSED TIME | IDEALIZED CONTAINER SUM OF FRACTIONS | $10^6$ cpm COMPARTMENT* | $10^6$ cpm DECAY CORRECTED | mg Se ** COMPARTMENT |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 3 | 70 | .0465 | .0465 | .0229 |
| 19 | 163 | .1083 | .1083 | .0534 |
| 44 | 281 | .1868 | .1889 | .0932 |
| 70 | 329 | .2187 | .2212 | .1092 |
| 133 | 523 | .3477 | .3558 | .1756 |
| 212 | 621 | .4128 | .4323 | .2133 |
| 242 | 639 | .4248 | .4500 | .2221 |
| 278 | 693 | .4607 | .4880 | .2408 |
| 311 | 791 | .5259 | .5635 | .2781 |
| 332 | 750 | .4986 | .5435 | .2682 |
| 355 | 804 | .5345 | .5826 | .2875 |
| 375 | 873 | .5804 | .6328 | .3123 |
| 477 | 927 | .6163 | .6875 | .3393 |
| 502 | 912 | .6063 | .6842 | .3377 |
| 550 | 948 | .6303 | .7176 | .3541 |
| 574 | 958 | .6369 | .7313 | .3609 |
| 673 | 1,005 | .6682 | .7851 | .3874 |
| 693 | 986 | .6555 | .7741 | .3820 |
| 717 | 977 | .6495 | .7719 | .3809 |
| 735 | 947 | .6296 | .7483 | .3693 |

* (Idealized) x (664.88747)

** $(0.49350 \times 10^{-6} \frac{mg}{cpm})$

APPENDIX B-5

WATER COMPARTMENT (FIRST RUN, TANK II)

| HOURS ELAPSED TIME | FILTER NUMBER | RAW 10 MIN. COUNT 20 ml SAMPLE | cpm CORRECTED FOR BACKGROUND | cpm CORRECTED FOR DECAY | mg Se 20 ml SAMPLE x $10^{-3}$ | mg Se 60 l TANK |
|---|---|---|---|---|---|---|
| 0 | | | | | | |
| 1.5 | 20 | 510-496 * | 398 | 398 | .1964 | .5892 |
| 2.0 | 18 | 523-449 * | 381 | 381 | .1880 | .5690 |
| 12 | 6 | 494-436 * | 360 | 360 | .1776 | .5329 |
| 13 | 8 | 459-437 * | 343 | 343 | .1692 | .5078 |
| 19 | 10 | 4,677 | 363 | 363 | .1789 | .5369 |
| 29 | 12 | 4,404 | 335 | 335 | .1655 | .4965 |
| 37 | 14 | 4,493 | 344 | 344 | .1699 | .5097 |
| 55 | 16 | 4,364 | 331 | 335 | .1654 | .4963 |
| 62 | 1 | 4,931 | 389 | 394 | .1942 | .5827 |
| 87 | 4 | 4,201 | 316 | 320 | .1578 | .4734 |
| 110 | 22 | 3,983 | 294 | 301 | .1486 | .4458 |
| 134 | 24 | 3,903 | 286 | 293 | .1445 | .4337 |
| 190 | 26 | 3,501 | 246 | 258 | .1271 | .3815 |
| 212 | 28 | 3,296 | 225 | 236 | .1165 | .3497 |
| 232 | 30 | 3,240 | 221 | 234 | .1155 | .3465 |
| 278 | 32 | 3,137 | 210 | 225 | .1108 | .3326 |
| 310 | 34 | 3,026 | 198 | 212 | .1044 | .3134 |

* one minute count

APPENDIX B-5 (CONTINUED)

WATER COMPARTMENT (FIRST RUN, TANK II)

| HOURS ELAPSED TIME | FILTER NUMBER | RAW 10 MIN. COUNT 20 ml SAMPLE | cpm CORRECTED FOR BACKGROUND | cpm CORRECTED FOR DECAY | mg Se 20 ml SAMPLE x $10^{-3}$ | mg Se 60 l TANK |
|---|---|---|---|---|---|---|
| 354 | 36 | 2,802 | 176 | 193 | .0953 | .2859 |
| 432 | 38 | 2,593 | 155 | 172 | .0849 | .2549 |
| 476 | 40 | 2,443 | 138 | 155 | .0765 | .2295 |
| 498 | 42 | 2,470 | 143 | 160 | .0791 | .2373 |
| 526 | 44 | 2,199 | 114 | 130 | .0643 | .1930 |
| 549 | 46 | 2,410 | 139 | 158 | .0777 | .2333 |
| 573 | 48 | 2,308 | 129 | 148 | .0731 | .2192 |
| 650 | 50 | 2,066 | 105 | 121 | .0599 | .1798 |
| 672 | 52 | 1,918 | 91 | 106 | .0526 | .1578 |
| 692 | 54 | 1,960 | 90 | 113 | .0556 | .1668 |
| 716 | 56 | 1,866 | 84 | 101 | .0496 | .1488 |
| 740 | 58 | 1,785 | 78 | 93 | .0459 | .1378 |

APPENDIX B-6
SUSPENDED PARTICULATE (First Run, Tank II)

| ELAPSED TIME IN HOURS | FILTER NUMBER | RAW cpm ROLLED FILTER | cpm CORRECTED FOR BACK-GROUND | cpm DECAY CORRECTED | NORMALIZED cpm (x .9055) | $10^{-6}$ mg Se ** 20 ml SAMPLE | mg Se COMPARTMENT (x 3,000) |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 974* | 0 | 0 | 0 | 0 | 0 |
| 1.5 | 20 | 108, 105, 112 | 9 | 12 | 10 | 5 | .016 |
| 2 | 18 | 108, 112, 93 | 5 | 7 | 6 | 3 | .009 |
| 12 | 6 | 111, 101, 109 | 8 | 10 | 9 | 4 | .014 |
| 13 | 8 | 124, 116, 131 | 25 | 31 | 28 | 13 | .041 |
| 19 | 10 | 114, 120, 109 | 15 | 19 | 17 | 8 | .026 |
| 29 | 12 | 117, 117, 97 | 11 | 14 | 13 | 6 | .019 |
| 37 | 14 | 1,265* | 27 | 34 | 31 | 15 | .046 |
| 55 | 16 | 1,219* | 23 | 28 | 26 | 12 | .038 |
| 62 | 1 | 1,431* | 44 | 55 | 50 | 24 | .074 |
| 87 | 4 | 1,215* | 22 | 28 | 25 | 12 | .038 |
| 110 | 22 | 107, 116, 113 | 13 | 16 | 15 | 7 | .022 |

* ten minute count ** mg per cpm = 0.4935 x $10^{-6}$

APPENDIX B-6 (CONTINUED)

SUSPENDED PARTICULATE (First Run, Tank II)

| ELAPSED TIME IN HOURS | FILTER NUMBER | RAW cpm ROLLED FILTER | cpm CORRECTED FOR BACK-GROUND | cpm DECAY CORRECTED | NORMALIZED cpm (x .9055) | $10^{-6}$ mg Se ** 20 ml SAMPLE | mg Se COMPARTMENT (x 3,000) |
|---|---|---|---|---|---|---|---|
| 134 | 24 | 1,152* | 16 | 20 | 18 | 9 | .027 |
| 190 | 26 | 107, 98, 114 | 7 | 9 | 8 | 4 | .012 |
| 212 | 28 | 1,221* | 23 | 29 | 26 | 13 | .039 |
| 232 | 30 | 1,153* | 16 | 20 | 18 | 9 | .027 |
| 278 | 32 | 103, 131, 113 | 17 | 21 | 19 | 9 | .028 |
| 310 | 34 | 118, 115, 147 | 28 | 34 | 31 | 15 | .046 |
| 354 | 36 | 118, 113, 112 | 15 | 19 | 17 | 8 | .026 |
| 432 | 38 | 112, 129, 123 | 22 | 28 | 25 | 12 | .037 |
| 476 | 40 | 137, 117, 108 | 22 | 27 | 24 | 12 | .036 |
| 498 | 42 | 125, 121, 135 | 28 | 35 | 32 | 15 | .047 |

* ten minute count ** mg per cpm = 0.4935 x $10^{-6}$

APPENDIX B-6 (CONTINUED)

SUSPENDED PARTICULATE (First Run, Tank II)

| ELAPSED TIME IN HOURS | FILTER NUMBER | RAW cpm ROLLED FILTER | cpm CORRECTED FOR BACK-GROUND | cpm DECAY CORRECTED | NORMALIZED cpm (x .9055) | $10^{-6}$ mg Se ** 20 ml SAMPLE | mg Se COMPARTMENT (x 3,000) |
|---|---|---|---|---|---|---|---|
| 526 | 44 | 113<br>115 | 15 | 19 | 17 | 8 | .025 |
| 549 | 46 | 108<br>117 | 13 | 17 | 15 | 7 | .023 |
| 573 | 48 | 108<br>126 | 18 | 22 | 20 | 10 | .030 |
| 650 | 50 | 1,164* | 17 | 22 | 20 | 9 | .029 |
| 672 | 52 | 1,170* | 18 | 22 | 20 | 10 | .030 |
| 692 | 54 | 1,120* | 13 | 16 | 15 | 7 | .022 |
| 716 | 56 | 1,157* | 17 | 21 | 19 | 9 | .028 |
| 740 | 58 | 1,129* | 14 | 17 | 16 | 7 | .024 |

* ten minute count ** mg per cpm = 0.4935 x $10^{-6}$

APPENDIX B-7
FISH COMPARTMENT (First Run, Tank II)

| ELAPSED TIME IN HRS. | FISH NUMBER 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 0 | 117-103 | 98-103 | 104-112 | 100-93 | 105-101 | 112-101 |
| 3 | 162 | 165 | 171 | 172 | 176 | - |
| 14 | 134-145 | 167-205 | 221-218 | 209-228 | 271-278 | 350-308 |
| 38 | 222-224 | 339-340 | 358-354 | 360-378 | 405-427 | 507-517 |
| 63 | 233-229 | 315-364 | 356-379 | 467-515 | 565-642 | 756-778 |
| 88 | 232-232 | 428-457 | 464 | 553-546 | 792-767 | |
| 118 | 267 up 280 up | 549-485 | 691-703 | 1,049-1,077 | 1,205-1,224 | 1,393-1,366 |
| 191 | 531-588 | 774-855 | 1,198-1,265 | 1,226-1,248 | 1,400-1,350 | |
| 230 | 673-669 | 882-879 | 983-995 | 1,147-1,148 | 1,205-1,144 | dead |
| 254 | 810-716 | 934-978 | 973-984 | 1,256-1,304 | 1,397-1,413 | |
| 287 | 959-912 | 1,138-1,190 | 1,175-1,317 | 1,445-1,462 | 1,491-1,424 | |
| 310 | 979-931 | 1,059-943 | 1,241 | 1,478-1,396 | 1,511-1,445 | |
| 330 | 997-995 | 920-923 up | 1,383-1,349 | 1,388-1,347 | 1,320-1,428 | |
| 354 | 968-1,078 | 1,042-1,005 | 1,296-1,265 | 1,426-1,444 | dead | |
| 374 | 1,013-1,042 | 1,008-1,010up | 1,389-1,496 | 1,510-1,579 | | |
| 476 | 754-828 | 1,354-1,337 | 1,457-1,442 | 1,155-1,115 up | | |
| 500 | 859-891 up | 1,441-1,583 | 1,082-1,046up | 1,143-1,179 up | | |
| 518 | 807-1,026 1,011 | 1,281-1,353 | 1,506-1,560 | 1,176-1,087 up | | |
| 549 | 1,020-996 | 1,257-1,357 | 1,052-1,101up | 1,562-1,506 | | |

APPENDIX B-7 (CONTINUED)

FISH COMPARTMENT (First Run, Tank II)

| ELAPSED TIME IN HRS. | FISH NUMBER 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 574 | 951-1,010 | 1,355-1,251 | 1,100<br>1,048 up | 1,460-1,512 | | |
| 650 | 817-723 up | 1,216-1,265 | 1,037-1,070up | 1,053-1,112 up | | |
| 672 | 791-726 up | 820-850 up | 979-1,015up | 1,523 | | |
| 694 | 919-979 | 1,122-1,127 | 953-1,005up | 1,191-1,154 up | | |
| 716 | 967-972 | 1,188-1,103 | 1,435-1,327 | 1,082-1,098 up | | |
| 740 | 1,062-958 | 1,210-1,224<br>1,087-1,241 | 1,043-972 up | 1,063-1,088 up | | |

APPENDIX B-7 (CONTINUED)

FISH COMPARTMENT (First Run - Tank II)

| ELAPSED TIME IN HOURS | BACKGROUND CORRECTED SUM COMPARTMENT | COMPARTMENT cpm DECAY CORRECTED | $10^{-6}$ COMPARTMENT mg Se* | $10^{-6}$ COMPARTMENT mg Se NORMALIZED** |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 3 | 385 | 385 | 189 | 134 |
| 14 | 740 | 740 | 365 | 257 |
| 38 | 1,585 | 1,585 | 782 | 552 |
| 63 | 2,215 | 2,240 | 1,105 | 780 |
| 88 | 2,318 | 2,344 | 1,157 | 817 |
| 118 | 4,610 | 4,717 | 2,328 | 1,643 |
| 191 | 4,691 | 4,912 | 2,424 | 1,711 |
| 230 | 4,338 | 4,542 | 2,241 | 1,582 |
| 254 | 4,857 | 5,144 | 2,538 | 1,792 |
| 287 | 5,730 | 6,139 | 3,029 | 2,139 |
| 310 | 5,587 | 5,986 | 2,954 | 2,085 |
| 330 | 5,826 | 6,314 | 3,116 | 2,199 |
| 354 | 4,371 | 4,737 | 2,337 | 1,650 |
| 374 | 4,960 | 5,438 | 2,683 | 1,894 |
| 476 | 4,704 | 5,217 | 2,574 | 1,817 |
| 500 | 5,297 | 5,943 | 2,933 | 2,070 |
| 518 | 4,912 | 5,511 | 2,720 | 1,920 |
| 549 | 4,968 | 5,639 | 2,782 | 1,964 |
| 574 | 4,805 | 5,516 | 2,722 | 1,922 |
| 650 | 4,793 | 5,566 | 2,747 | 1,939 |
| 672 | 4,526 | 5,317 | 2,624 | 1,852 |
| 694 | 4,576 | 5,376 | 2,653 | 1,873 |
| 716 | 4,553 | 5,411 | 2,670 | 1,885 |
| 740 | 4,604 | 5,471 | 2,700 | 1,906 |

* $(0.49350 \times 10^{-6})$ mg/cpm

** Normalization Factor .706

APPENDIX B-8

SEDIMENT COMPARTMENT (First Run, Tank II, Raw Data)

| ELAPSED TIME IN HRS. | II 3 H | II 2 H | II 1 H | II 3 R | II 1 R | II 4 C |
|---|---|---|---|---|---|---|
| 0 | 1,059* | 1,032* | 1,051* | 1,043* | 1,057* | 1,029* |
| 3 | - | 143 | - | - | - | - |
| 23 | 2,457* | 2,484* | 2,432* | 2,238* | 2,032* | 2,457* |
| 47 | 349 | 3,755* | 3,082* | 2,886* | 2,451* | 3,043* |
| 71 | 427-412 | 427-454 | 466-464 | 304-312 | 302-286 | 332-338 |
| 137 | 5,077* | 6,144* | 6,701* | 5,258* | 3,735* | 4,329* |
| 214 | 523-558 | 834-877 | 999-1,112 | 551-560 | 346-374 | 522-546 |
| 243 | 561-540 | 900-952 | 1,076-1,080 | 505-527 | 464-473 | 484-490 |
| 280 | 647-684 | 1,007-1,113 | 1,089-1,041 | 568-550 583-607 | 413-435 | 455 eroded 536 |
| 312 | 605-543 | 979-1,008 1,027 | 1,212-1,189 | 538-539 | 409-403 | 504-545 |
| 333 | 582-630 | 1,084-1,138 | 1,219-1,244 | 608-599 | 436-474 | 494 eroded 511 |
| 376 | 728-708 | 1,520-1,467 | 1,703-1,652 | 695-672 | 515-525 | 643-704 |
| 478 | 766-686 | 1,600-1,699 | 1,875-1,872 | 761-726 | 559-568 | 633-693 |
| 503 | 746-698 | 1,611-1,568 | 1,609-1,656 | 668-730 | 562-537 | 675-687 |
| 550 | 766-762 | 1,784-1,726 | 1,826-1,773 | 720-733 | 523-520 | 692-697 |
| 575 | 788-787 | 1,769-1,743 | 1,336 feces washed out 1,430 | 769-800 | 542-579 | 691-686 |
| 674 | 792-800 | 1,807-1,912 | 1,673 eroded 1,533 | 793-782 | 548-567 633 | 741-741 |
| 695 | 819-769 | 1,918-1,806 | 1,725-1,691 | 723-786 | 591-592 | 686-736 714 |
| 736 | 791-816 | 1,914-1,800 | | | | |

* ten minute count

APPENDIX B-8 (CONTINUED)

SEDIMENT COMPARTMENT (First Run, Tank II, Raw Data)

| ELAPSED TIME IN HRS. | II 2 C | II 4 E | II 2 E | II 3 E | II 1 E |
|---|---|---|---|---|---|
| 0 | 1,060* | 1,049* | 1,044* | 1,037* | 1,050* |
| 3 | - | - | 155 one | - | - |
| 23 | 3,610* | 2,752* | 2,900* | 294 | 3,295* |
| 47 | 5,239* | 398 | 412 | 375 | 446<br>420 |
| 71 | 486-516<br>558-506 | 500-471 | 402-425 | 460-485 | 531-529 |
| 137 | 6,749* | 7,108* | 5,763* | 8,045* | 8,239* |
| 214 | 678-729 | 619-637 | 692-709 | 731-689 | 834-810 |
| 243 | 741-750 | 665-717 | 636-621 | 645-706 | 872-911 |
| 280 | 769-800 | 549 eroded<br>573 | 666-612 | 740 erosion<br>826 | 918-951 |
| 312 | 769-789 | 421-454 | 701-696 | 640-678 | 954-913 |
| 333 | 708-696 | 457 eroded<br>464 | 615-642 | 602-604 | 896-916 |
| 376 | 956-905 | 610-585 | 817-840 | 782 dumped &<br>813 eroded | 1,178-1,090<br>1,082-1,134 |
| 478 | 892-890 | 669-593 | 859-860 | 768-804 | 1,067-1,027 |
| 503 | 959-991 | 634-624 | 873-821 | 810-799 | 1,192-1,174 |
| 550 | 915-965 | 654-658 | 841-900 | 859-816 | 1,186-1,133<br>1,186 |
| 575 | 1,019-959 | 663-642 | 868-896 | 845-822 | 1,179-1,164 |
| 674 | 943-1,006 | 721, 697<br>675 | 817-911 | 868-833 | 1,214-1,254 |
| 695 | 954-944 | 678-673 | 843-853 | 865-801 | 1,132-1,209 |

APPENDIX B-8 (CONTINUED)

SEDIMENT COMPARTMENT (First Run, Tank II, Corrected for Background, Normalized for Attenuation, Geometry) *

| ELAPSED TIME IN HRS. | II 2 C | II 4 E | II 2 E | II 3 E | II 1 E |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | - | - | 50-40 | - | - |
| 23 | 256-205 | 170-136 | 185-148 | 189-151 | 224-180 |
| 47 | 418-336 | 293-235 | 307-246 | 270-216 | 328-263 |
| 71 | 411-330 | 380-305 | 308-247 | 367-295 | 425-341 |
| 137 | 569-457 | 605-486 | 471-378 | 699-561 | 718-577 |
| 214 | 598-480 | 523-419 | 595-478 | 605-485 | 717-575 |
| 243 | 640-514 | 586-470 | 521-418 | 570-458 | 786-631 |
| 280 | 679-545 | 456-366 | 534-428 | 678-544 | 829-666 |
| 312 | 674-541 | 378-303 | 593-476 | 554-444 | 828-665 |
| 333 | 597-479 | 355-285 | 523-420 | 498-399 | 801-643 |
| 376 | 825-662 | 492-395 | 723-580 | 692-556 | 1,016-815 |
| 478 | 786-631 | 526-422 | 754-605 | 681-546 | 942-756 |
| 503 | 870-698 | 524-420 | 742-595 | 699-561 | 1,078-865 |
| 550 | 835-670 | 551-442 | 765-614 | 732-588 | 1,063-853 |
| 575 | 884-709 | 547-439 | 777-623 | 728-584 | 1,066-856 |
| 674 | 869-698 | 592-475 | 759-609 | 745-598 | 1,129-906 |
| 695 | 844-677 | 570-458 | 743-596 | 728-584 | 1,065-855 |
| 736 | | | | | |
| 1,912 | | | | | |

* Left entry corrected for background. Right entry normalized for attenuation and geometry.

APPENDIX B-8 (CONTINUED)

SEDIMENT COMPARTMENT (First Run, Tank II, Corrected for Background, Normalized for Attenuation, Geometry) *

| ELAPSED TIME IN HRS. | II 3 H | II 2 H | II 1 H | II 3 R | II 1 R | II 4 C |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | - | 38-30 | - | - | - | - |
| 23 | 140-112 | 143-115 | 138-110 | 118-95 | 98-78 | 140-112 |
| 47 | 244-195 | 270-217 | 203-163 | 183-147 | 140-112 | 199-160 |
| 71 | 314-252 | 335-269 | 360-289 | 203-163 | 189-151 | 230-184 |
| 137 | 402-323 | 509-409 | 565-453 | 420-337 | 268-215 | 327-269 |
| 214 | 435-349 | 750-602 | 950-763 | 450-361 | 255-205 | 429-344 |
| 243 | 445-357 | 821-659 | 973-781 | 411-330 | 363-291 | 382-306 |
| 280 | 560-450 | 955-766 | 960-770 | 470-377 | 319-256 | 390-313 |
| 312 | 469-376 | 903-725 | 1,095-879 | 434-348 | 301-241 | 419-336 |
| 333 | 501-402 | 1,006-807 | 1,126-904 | 498-400 | 350-281 | 397-319 |
| 376 | 613-492 | 1,388-1,114 | 1,572-1,262 | 578-464 | 415-333 | 568-456 |
| 478 | 621-498 | 1,544-1,240 | 1,768-1,420 | 638-512 | 458-368 | 558-448 |
| 503 | 617-495 | 1,484-1,192 | 1,527-1,656 | 594-476 | 444-356 | 576-462 |
| 550 | 659-529 | 1,650-1,324 | 1,694-1,360 | 621-499 | 416-334 | 589-473 |
| 575 | 682-548 | 1,651-1,325 | 1,278-1,026 | 679-545 | 455-365 | 583-468 |
| 674 | 691-554 | 1,754-1,408 | 1,498-1,202 | 682-548 | 477-383 | 636-510 |
| 695 | 689-553 | 1,757-1,410 | 1,603-1,287 | 649-521 | 486-390 | 607-487 |
| 736 | 698-560 | 1,752-1,406 | | | | |
| 1,912 | 506-406 | 1,522-1,222 | | | | |

* Left entry corrected for background. Right entry normalized for attenuation and geometry.

APPENDIX B-8 (CONTINUED)

SEDIMENT COMPARTMENT (First Run, Tank II, Decay Correction, Geometric Average Mg Selenium)

| HOURS ELAPSED TIME | H | | R | | C | | E | |
|---|---|---|---|---|---|---|---|---|
| | AVERAGE cpm | FRACTION cpm | AVERAGE cpm | FRACTION cpm | AVERAGE cpm | FRACTION cpm | AVERAGE cpm | FRACTION cpm |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 30 | 13 | - | - | - | - | 40 | 12 |
| 23 | 112 | 49 | 86 | 9 | 158 | 20 | 153 | 47 |
| 47 | 192 | 84 | 129 | 14 | 248 | 31 | 240 | 74 |
| 71 | 265 | 117 | 157 | 17 | 257 | 33 | 297 | 92 |
| 137 | 377 | 166 | 276 | 31 | 363 | 46 | 500 | 155 |
| 214 | 515 | 227 | 283 | 32 | 412 | 53 | 489 | 152 |
| 243 | 538 | 237 | 310 | 35 | 412 | 53 | 494 | 153 |
| 280 | 609 | 268 | 316 | 36 | 429 | 55 | 501 | 155 |
| 312 | 589 | 259 | 294 | 33 | 438 | 56 | 472 | 146 |
| 333 | 628 | 277 | 340 | 38 | 399 | 51 | 436 | 135 |
| 376 | 840 | 370 | 398 | 45 | 559 | 72 | 586 | 182 |
| 478 | 914 | 402 | 440 | 50 | 539 | 69 | 582 | 181 |
| 503 | 959 | 422 | 416 | 47 | 580 | 74 | 610 | 189 |
| 550 | 935 | 412 | 416 | 47 | 571 | 73 | 624 | 194 |
| 575 | 861 | 379 | 455 | 51 | 588 | 75 | 625 | 194 |
| 674 | 929 | 409 | 465 | 53 | 604 | 77 | 647 | 201 |
| 695 | 950 | 419 | 455 | 52 | 582 | 75 | 623 | 193 |

APPENDIX B-8 (CONTINUED)

SEDIMENT COMPARTMENT (First Run, Tank II,
Decay Correction, Geometric Average Mg Selenium)

| HOURS ELAPSED TIME | IDEALIZED CONTAINER SUM OF FRACTIONS | $10^6$ cpm COMPARTMENT* | $10^6$ cpm DECAY CORRECTED | mg Se ** COMPARTMENT |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 3 | - | - | - | - |
| 23 | 125 | .0831 | .0831 | .0410 |
| 47 | 203 | .1350 | .1366 | .0674 |
| 71 | 259 | .1722 | .1742 | .0860 |
| 137 | 398 | .2646 | .2739 | .1352 |
| 214 | 464 | .3085 | .3230 | .1594 |
| 243 | 478 | .3178 | .3366 | .1661 |
| 280 | 514 | .3418 | .3662 | .1807 |
| 312 | 494 | .3285 | .3520 | .1737 |
| 333 | 501 | .3331 | .3610 | .1782 |
| 376 | 669 | .4448 | .4821 | .2379 |
| 478 | 702 | .4668 | .5238 | .2585 |
| 503 | 732 | .4867 | .5461 | .2695 |
| 550 | 726 | .4827 | .5479 | .2704 |
| 575 | 699 | .4648 | .5337 | .2634 |
| 674 | 740 | .4920 | .5781 | .2853 |
| 695 | 739 | .4914 | .5773 | .2849 |

* (Idealized Container) x (664.88747)
** ($0.49350 \times 10^{-6}$ mg/cpm)

APPENDIX B-9

WATER COMPARTMENT (Second Run, Tank I)

| Elapsed Time in Hours | Filter Number | Raw cpm 20 ml Sample | cpm Corrected Background | cpm Corrected Decay | mg Se 20 ml Sample x $10^{-3}$ | mg Se Tank |
|---|---|---|---|---|---|---|
| 0 | 1 | 1,556* | 0 | 0 | 0 | 0 |
| .083 | 3 | 44,467* | 4,291 | 4,291 | 2.002 | 6.006 |
| .25 | 5 | 44,202* | 4,264 | 4,264 | 1.989 | 5.968 |
| .5 | 7 | 44,407* | 4,285 | 4,285 | 1.999 | 5.997 |
| 1.0 | 9 | 45,000* | 4,344 | 4,344 | 2.026 | 6.080 |
| 3 | 11 | 40,581* | 3,902 | 3,902 | 1.820 | 5.462 |
| 12 | 13 | 4,110 | 3,922 | 3,922 | 1.830 | 5.890 |
| | | 4,046 | | | | |
| 18 | 15 | 3,935 | 3,853 | 3,853 | 1.797 | 5.393 |
| | | 4,082 | | | | |
| 23.5 | 17 | 3,702 | 3,562 | 3,562 | 1.662 | 4.986 |
| | | 3,733 | | | | |
| 37 | 19 | 3,456 | 3,300 | 3,300 | 1.539 | 4.619 |
| 48 | 21 | 2,977 | 2,797 | 2,830 | 1.320 | 3.961 |
| | | 2,994 | | | | |
| | | 2,889 | | | | |
| 61 | 23 | 2,682 | 2,500 | 2,529 | 1.180 | 3.540 |
| | | 2,630 | | | | |
| 70.5 | 25 | 2,794 | 2,691 | 2,722 | 1.270 | 3.810 |
| | | 2,899 | | | | |
| 81 | 27 | 2,244 | 2,074 | 2,098 | 0.978 | 2.936 |
| | | 2,216 | | | | |

* Ten minute count

APPENDIX B-9 (CONTINUED)

WATER COMPARTMENT (Second Run, Tank I)

| Elapsed Time in Hours | Filter Number | Raw cpm 20 ml Sample | cpm Corrected Background | cpm Corrected Decay | mg Se 20 ml Sample x $10^{-3}$ | mg Se Tank |
|---|---|---|---|---|---|---|
| 96 | 29 | 1,898 | 1,782 | 1,824 | 0.8510 | 2.553 |
| | | 1,989 | | | | |
| 134 | 33 | 1,490 | 1,297 | 1,343 | 0.6266 | 1.879 |
| | | 1,428 | | | | |
| 157 | 35 | 1,239 | 1,082 | 1,120 | 0.5225 | 1.567 |
| | | 1,249 | | | | |
| 183 | 37 | 1,066 | 894 | 936 | 0.4367 | 1.310 |
| | | 1,062 | | | | |
| 232 | 39 | 719 | 556 | 587 | 0.2748 | 0.8244 |
| | | 713 | | | | |
| 256 | 41 | 7,895* | 662 | 701 | 0.3270 | 0.9812 |
| 280 | 43 | 757 | 567 | 608 | 0.2836 | 0.8510 |
| | | 695 | | | | |
| 303 | 45 | 667 | 503 | 539 | 0.2514 | 0.7544 |
| | | 654 | | | | |
| 353 | 47 | 5,940* | 436 | 475 | 0.2216 | 0.6649 |
| 400 | 49 | 5,873* | 429 | 473 | 0.2207 | 0.6621 |
| 421 | 55 | 5,883* | 430 | 475 | 0.2216 | 0.6649 |
| 447 | 57 | 591 | 390 | 435 | 0.2029 | 0.6089 |
| | | 505 | | | | |

* Ten minute count

APPENDIX B-9 (CONTINUED)

WATER COMPARTMENT (Second Run, Tank I)

| Elapsed Time in Hours | Filter Number | Raw cpm 20 ml Sample | cpm Corrected Background | cpm Corrected Decay | mg Se 20 ml Sample x $10^{-3}$ | mg Se Tank |
|---|---|---|---|---|---|---|
| 472 | 59 | 5,190* | 411 | 459 | 0.2141 | 0.6425 |
| 496 | 61 | 501 | 408 | 460 | 0.2146 | 0.6439 |
| | | 501 | | | | |
| 518 | 63 | 515 | 383 | 432 | 0.2015 | 0.6047 |
| | | 515 | | | | |
| 568 | 65 | 504 | 359 | 412 | 0.1922 | 0.5767 |
| | | 520 | | | | |
| 617 | 67 | 542 | 413 | 480 | 0.2239 | 0.6719 |
| | | 577 | | | | |
| 641 | 69 | 527 | 386 | 448 | 0.2090 | 0.6271 |
| | | 538 | | | | |
| 720 | 71 | 552 | 380 | 452 | 0.2109 | 0.6327 |
| | | 497 | | | | |
| 736 | 73 | 532 | 397 | 472 | 0.2202 | 0.6607 |
| | | 554 | | | | |
| 830 | 77 | 726 | 560 | 685 | 0.3196 | 0.9588 |
| | | 687 | | | | |
| 904 | 81 | 6,732* | 527 | 656 | 0.3061 | 0.9182 |

* Ten minute count

APPENDIX B-9 (CONTINUED)

WATER COMPARTMENT (Second Run, Tank I)

| Elapsed Time in Hours | Filter Number | Raw cpm 20 ml Sample | cpm Corrected Background | cpm Corrected Decay | mg Se 20 ml Sample x $10^{-3}$ | mg Se Tank |
|---|---|---|---|---|---|---|
| 928 | 83 | 680<br>612 | 494 | 615 | 0.2869 | 0.8608 |
| 952 | 85 | 639<br>644 | 494 | 622 | 0.2902 | 0.8706 |
| 1,024 | 87 | 635<br>603 | 472 | 605 | 0.2822 | 0.8468 |

APPENDIX B-10

SUSPENDED PARTICULATE COMPARTMENT (Second Run, Tank I)

| Elapsed Time in Hours | Filter Number | Raw Ten Minute Count Rate 40 ml | Background Corrected cpm | Decay Corrected cpm | Normalization (x .9055) | mg Se 40 ml Sample x $10^{-6}$ | mg Se Compartment |
|---|---|---|---|---|---|---|---|
| 0.0 | 1 | 1,305 | 10 | 11 | 10 | 0 | 0 |
| .083 | 3 | 1,697 | 48 | 52 | 47 | 21.93 | 0.03289 |
| .25 | 5 | 1,782 | 57 | 63 | 57 | 26.59 | 0.03975 |
| .5 | 7 | 1,636 | 43 | 47 | 42 | 19.59 | 0.02938 |
| 1 | 9 | 1,758 | 55 | 61 | 55 | 25.66 | 0.03849 |
| 3 | 11 | 1,779 | 57 | 63 | 57 | 26.59 | 0.03988 |
| 12 | 13 | 1,925 | 72 | 79 | 72 | 33.59 | 0.05038 |
| 18 | 15 | 2,326 | 112 | 124 | 112 | 52.26 | 0.07839 |
| 23.5 | 17 | 2,506 | 130 | 143 | 130 | 60.66 | 0.09099 |
| 37 | 19 | 3,440 | 223 | 246 | 222 | 103.59 | 0.15538 |
| 48 | 21 | 3,903 | 269 | 297 | 269 | 125.48 | 0.18822 |
| 61 | 23 | 5,168 | 396 | 438 | 397 | 185.05 | 0.27758 |
| 70.5 | 25 | 5,794 | 458 | 505 | 457 | 213.24 | 0.31986 |
| 81 | 27 | 6,602 | 539 | 594 | 538 | 251.03 | 0.37654 |
| 96 | 29 | 7,081 | 588 | 648 | 587 | 273.89 | 0.41083 |
| 113 | 31 | 9,449 | 825 | 910 | 824 | 384.48 | 0.57672 |
| 134 | 33 | 9,835 | 864 | 953 | 863 | 309.36 | 0.46404 |
| 157 | 35 | 10,777 | 958 | 1,056 | 956 | 446.07 | 0.66910 |
| 183 | 37 | 11,410 | 1,014 | 1,118 | 1,012 | 472.20 | 0.70880 |
| 232 | 39 | 11,772 | 1,052 | 1,160 | 1,050 | 489.93 | 0.73489 |
| 256 | 41 | 12,571 | 1,126 | 1,242 | 1,125 | 524.93 | 0.78739 |
| 280 | 43 | 12,465 | 1,116 | 1,231 | 1,145 | 534.26 | 0.80139 |

APPENDIX B-10 (CONTINUED)

SUSPENDED PARTICULATE COMPARTMENT (Second Run, Tank I)

| Elapsed Time in Hours | Filter Number | Raw Ten Minute Count Rate 40 ml | Background Corrected cpm | Decay Corrected cpm | Normalization (x .9055) | mg Se 40 ml Sample x $10^{-6}$ | mg Se Compartment |
|---|---|---|---|---|---|---|---|
| 303 | 45 | 11,959 | 1,034 | 1,140 | 1,032 | 481.53 | 0.72229 |
| 353 | 51 | 11,239 | 1,003 | 1,106 | 1,002 | 467.53 | 0.70129 |
| 400 | 53 | 12,237 | 1,103 | 1,216 | 1,102 | 514.19 | 0.77128 |
| 421 | 55 | 7,923 | 671 | 740 | 670 | 312.62 | 0.46893 |
| 447 | 57 | 9,020 | 781 | 861 | 780 | 363.95 | 0.54592 |
| 472 | 59 | 9,432 | 822 | 906 | 820 | 382.61 | 0.57391 |
| 496 | 61 | 9,071 | 787 | 868 | 785 | 366.28 | 0.54942 |
| 518 | 63 | 8,572 | 718 | 792 | 717 | 334.55 | 0.50182 |
| 568 | 65 | 6,888 | 549 | 637 | 577 | 269.22 | 0.40384 |
| 617 | 67 | 5,809 | 462 | 537 | 486 | 226.76 | 0.34015 |
| 641 | 69 | 5,032 | 384 | 446 | 404 | 188.50 | 0.28275 |
| 720 | 71 | 3,617 | 235 | 321 | 291 | 135.78 | 0.20367 |
| 736 | 73 | 2,705 | 144 | 197 | 178 | 83.05 | 0.12458 |
| 792 | 75 | 2,829 | 156 | 213 | 193 | 90.05 | 0.13508 |
| 830 | 77 | 3,161 | 199 | 248 | 225 | 104.78 | 0.15717 |
| 904 | 81 | 4,015 | 281 | 366 | 332 | 170.88 | 0.25633 |
| 928 | 83 | 3,905 | 273 | 355 | 322 | 150.31 | 0.22547 |
| 952 | 85 | 3,928 | 273 | 355 | 322 | 150.31 | 0.22547 |
| 1,024 | 87 | 3,774 | 257 | 334 | 303 | 141.50 | 0.21225 |

APPENDIX B-11

FISH COMPARTMENT (Second Run, Tank I)

| ELAPSED TIME | FISH NUMBER 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 0 | 731 | 431 | 956 | 1,509 | 1,363 |
| | 750 | 892 | 1,005 | 1,566 | 1,451 |
| 1.5 | 628 | 711 | 1,037 | 1,317 | 1,417 |
| | 586 | 703 | 1,015 | 1,378 | 1,368 |
| 6 | 1,029 | 1,064 | 1,198 | 1,430 | 1,602 |
| | 995 | 1,048 | 1,196 | 1,495 | 1,714 |
| 22.5 | 1,588 | 1,583 | 1,760 | 1,763 | 2,363 |
| | 1,556 | 1,666 | 1,750 | 1,824 | 2,345 |
| 37 | 1,973 | 2,115 | 2,205 | 2,351 | 3,230 |
| | 2,010 | 1,978 | 2,159 | 2,310 | 3,123 |
| | | 2,018 | | 2,322 | |
| | | | | 2,326 | |
| 47.5 | 1,993 | 2,766 | 2,880 | 3,237 | 3,975 |
| | 2,002 | 2,807 | 2,822 | 3,207 | 3,750 |
| | | | | | 3,792 |
| 62 | 2,914 | 3,180 | 3,741 | 3,773 | 4,581 |
| | 3,067 | 3,215 | 3,626 | 3,601 | 4,462 |
| 71 | 3,616 | 3,915 | 3,955 | 4,260 | 5,262 |
| | 3,708 | 4,065 | 4,181 | 4,081 | 5,358 |
| 81 | 3,904 | 4,123 | 4,283 | 4,746 | 6,304 |
| | 3,962 | 4,119 | 4,243 | 4,570 | 6,262 |
| 96 | 4,555 | 4,658 | 5,327 | 5,452 | 6,944 |
| | 4,628 | 4,556 | 5,163 | 5,594 | 6,768 |
| 113 | 5,254 | 5,392 | 6,355 | 6,601 | 7,396 |
| | 5,233 | 5,672 | 6,346 | 6,436 | 7,369 |
| 134 | 6,163 | 7,307 | 7,264 | 7,349 | 8,839 |
| | 6,305 | 7,018 | 7,320 | 7,478 | 8,691 |
| 160 | 8,068 | 8,282 | 8,184 | 8,355 | 8,145 |
| | 8,231 | 8,075 | 8,383 | 8,221 | 8,538 |
| 183 | 8,087 | 8,108 | 8,985 | 9,570 | 9,895 |
| | 8,038 | 8,198 | 8,843 | 10,025 | 9,908 |
| | 8,106 | | | 9,641 | |
| 232 | 8,363 | 10,355 | 10,407 | 10,722 | 10,875 |
| | 8,281 | 10,225 | 10,287 | 10,729 | 10,745 |
| 256 | 8,098 | 10,691 | 10,822 | 10,884 | 11,886 |
| | 8,057 | 10,825 | 10,839 | | 11,573 |
| 303 | 8,447 | 11,626 | 12,223 | 14,039 | 22,341 |
| | 8,516 | 11,776 | 12,221 | 14,051 | 22,105 |
| 353 | 9,376 | 12,324 | 13,595 | 15,020 | 22,830 |
| | 9,292 | | 14,162 | 15,149 | 22,325 |

APPENDIX B-11 (CONTINUED)

FISH COMPARTMENT (Second Run, Tank I)

| ELAPSED TIME | FISH NUMBER 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 400 | 9,767 | 13,833 | 16,244 | 16,579 | 24,245 |
| | 9,565 | 14,251 | 15,209 | 16,336 | 23,681 |
| 447 | 10,454 | 15,441 | 15,770 | 17,549 | 23,607 |
| | 10,372 | 15,167 | 15,420 | 17,727 | 23,802 |
| 518 | 9,336 | 14,961 | 15,457 | 17,262 | 22,957 |
| | 9,464 | 15,034 | 14,889 | 17,114 | 22,970 |
| 568 | 10,351 | 14,064 | 16,044 | 16,915 | 22,714 |
| | 10,207 | 13,799 | 16,821 | 16,518 | 22,731 |
| 641 | 9,452 | 13,134 | 15,494 | 17,395 | 22,175 |
| | 9,490 | 13,005 | 15,600 | 17,600 | 22,032 |
| 760 | 11,141 | 14,608 | 16,537 | 20,169 | 23,790 |
| | 11,331 | 14,388 | 16,732 | 20,270 | 23,532 |
| | | | | 20,078 | |
| | | | | 21,287 | |
| 830 | 12,353 | 16,295 | 17,828 | 19,754 | 24,451 |
| | 12,354 | 16,146 | 18,247 | 20,274 | 24,424 |
| 880 | 12,617 | 16,600 | 18,439 | 19,192 | 24,770 |
| | 12,763 | 16,619 | 18,488 | 19,393 | 24,758 |
| 1,024 | 11,595 | 15,893 | 17,079 | 19,278 | 23,273 |
| | 11,591 | 16,163 | 16,817 | 19,078 | 23,095 |

APPENDIX B-11 (CONTINUED)

FISH COMPARTMENT (Second Run, Tank I)

| ELAPSED TIME | Total Compartment cpm | Compartment Corrected for Background cpm | Compartment Corrected for Decay cpm | Compartment (x .46660 x $10^{-6}$) mg Se | Compartment Normalized (x .706) Mg Se |
|---|---|---|---|---|---|
| 0 | 5,577 | 0 | 0 | 0 | 0 |
| 1.5 | 5,050 | 0 | 0 | 0 | 0 |
| 6 | 6,386 | 809 | 809 | .0003 | .00026 |
| 22.5 | 9,100 | 3,523 | 3,523 | .0016 | .00115 |
| 37 | 11,714 | 6,142 | 6,142 | .0028 | .00202 |
| 47.5 | 14,696 | 9,182 | 9,289 | .0043 | .00305 |
| 62 | 18,080 | 12,566 | 12,712 | .0059 | .00418 |
| 71 | 21,201 | 15,687 | 15,869 | .0074 | .00522 |
| 81 | 23,258 | 17,744 | 17,950 | .0083 | .00591 |
| 96 | 26,873 | 21,416 | 21,915 | .0102 | .00721 |
| 113 | 31,027 | 25,570 | 26,167 | .0122 | .00861 |
| 134 | 36,867 | 31,410 | 32,142 | .0149 | .0105 |
| 160 | 41,241 | 35,800 | 37,058 | .0172 | .0122 |
| 183 | 44,766 | 39,335 | 40,718 | .0189 | .0134 |
| 232 | 50,495 | 45,120 | 47,247 | .0220 | .0155 |
| 256 | 52,280 | 46,975 | 49,757 | .0232 | .0163 |
| 303 | 68,673 | 63,368 | 67,899 | .0316 | .0223 |
| 353 | 73,199 | 68,003 | 74,137 | .0345 | .0244 |
| 400 | 79,855 | 74,717 | 82,400 | .0384 | .0271 |
| 447 | 82,655 | 77,565 | 85,541 | .0399 | .0281 |
| 518 | 79,722 | 74,684 | 84,279 | .0393 | .0277 |
| 568 | 80,082 | 75,089 | 86,202 | .0402 | .0283 |
| 641 | 77,553 | 72,672 | 84,400 | .0393 | .0278 |
| 760 | 86,626 | 81,854 | 91,676 | .0427 | .0301 |
| 830 | 91,064 | 86,363 | 105,621 | .0492 | .0347 |
| 880 | 91,820 | 87,177 | 108,099 | .0504 | .0356 |
| 1,024 | 84,931 | 82,382 | 104,611 | .0488 | .0344 |

APPENDIX B-12

SEDIMENT COMPARTMENT (Second Run, Tank I, Raw cpm)

| HOURS ELAPSED TIME | I3H | I2H | I1H | I3R | I1R |
|---|---|---|---|---|---|
| 0 | | | | | |
| 4.25 | 2,309 | 1,232 | 1,516 | 1,556 | 1,483 |
| | | | 1,591 | | 1,477 |
| 13 | 3,504 | 2,050 | 2,314 | 3,160 | 2,716 |
| | 3,894 | 1,934 | 2,280 | 3,018 | 2,718 |
| | 4,010 | | | | |
| 25 | 5,175 | 2,376 | 3,522 | 4,541 | 3,955 |
| | 5,208 | 2,490 | 3,470 | 4,523 | 3,862 |
| 40 | 7,939 | 3,335 | 4,816 | 7,229 | 5,731 |
| | 8,085 | 3,373 | 4,829 | 7,136 | 5,543 |
| 50 | 7,554 | 3,678 | 5,844 | 8,929 | 6,889 |
| | 7,632 | 3,718 | 5,914 | 8,779 | 6,818 |
| 63 | 9,274 | 4,794 | 7,370 | 10,884 | 7,890 |
| | 9,457 | 4,765 | 7,436 | 10,900 | 7,951 |
| 72 | 9,693 | 5,684 | 8,694 | 12,025 | 8,400 |
| | 9,640 | 5,714 | 8,534 | 11,909 | 8,626 |
| 82 | 10,455 | 6,678 | 9,547 | 13,093 | 9,688 |
| | 10,309 | 6,500 | 9,381 | 12,830 | 9,542 |
| 97 | 10,909 | 7,364 | 10,992 | 14,457 | 10,989 |
| | 10,847 | 7,355 | 10,937 | 14,491 | 10,902 |
| 114 | 11,601 | 8,481 | 11,932 | 14,893 | 11,891 |
| | 11,355 | 8,634 | 11,849 | 15,189 | 11,751 |
| 136 | | 9,833 | 13,045 | 15,473 | 12,791 |
| | | 9,744 | 13,125 | 15,301 | 12,987 |

APPENDIX B-12 (CONTINUED)

SEDIMENT COMPARTMENT (Second Run, Tank I, Raw cpm)

| HOURS ELAPSED TIME | I4C | I2C | I4E | I2E | I3E | I1E |
|---|---|---|---|---|---|---|
| 0 | | | | | | |
| 4.25 | 1,574 | 2,038 | 1,508 | 1,508 | 2,272 | 1,741 |
| | | 2,135 | | | 2,260 | 1,724 |
| 13 | 2,054 | 2,832 | 2,450 | 2,236 | 3,845 | 2,542 |
| | 2,031 | 2,785 | 2,474 | 2,221 | 3,818 | 2,522 |
| 25 | 2,759 | 4,054 | 3,468 | 3,098 | 5,489 | 3,579 |
| | 2,733 | 4,196 | 3,537 | 3,072 | 5,630 | 3,561 |
| 40 | 3,587 | 5,623 | 4,795 | 4,245 | 7,626 | 4,875 |
| | 3,640 | 5,690 | 4,809 | | 7,636 | 4,985 |
| 50 | 4,144 | 6,573 | 5,541 | 4,994 | 9,238 | 6,223 |
| | 4,039 | 6,580 | 5,702 | 5,139 | 9,200 | 6,499 |
| 63 | 4,454 | 7,937 | 6,426 | 6,274 | 10,372 | 7,654 |
| | 4,489 | 8,003 | 6,459 | 6,490 | 10,177 | |
| 72 | 4,873 | 8,509 | 7,246 | 7,340 | 11,496 | 8,437 |
| | 4,773 | 8,463 | 7,229 | 7,308 | 11,495 | 8,542 |
| 82 | 5,157 | 9,627 | 8,194 | 8,387 | 12,506 | 9,777 |
| | 5,121 | 9,730 | 8,021 | 8,476 | 12,547 | 9,671 |
| 97 | 5,683 | 10,816 | 8,889 | 9,673 | 13,712 | 10,965 |
| | 5,365 | 10,566 | 8,954 | 9,672 | 13,576 | 11,052 |
| 114 | 5,597 | 11,761 | 8,841 | 10,600 | 13,578 | 11,835 |
| | 5,618 | 12,053 | 9,013 | 10,476 | 13,876 | 11,849 |
| 136 | 6,030 | 13,172 | 10,097 | 11,517 | 14,359 | 13,115 |
| | 6,089 | 13,173 | 10,430 | 11,373 | 14,193 | 13,209 |

APPENDIX B-12 (CONTINUED)

SEDIMENT COMPARTMENT (Second Run, Tank I, Raw cpm)

| HOURS ELAPSED TIME | I3H | I2H | I1H | I3R | I1R |
|---|---|---|---|---|---|
| 158 | 17,938 | 10,527 | 14,023 | 14,935 | 13,729 |
| | 18,255 | 10,531 | 14,064 | 14,934 | 13,544 |
| 184 | 16,305 | 10,693 | 14,739 | 15,304 | 13,925 |
| | 16,818 | 10,757 | 14,616 | 15,159 | 14,128 |
| 233 | 15,299 | 11,113 | 15,545 | 15,546 | 14,995 |
| | 15,544 | 11,439 | 15,454 | 15,592 | 15,026 |
| 280 | 15,271 | 11,510 | 15,685 | 15,974 | 15,337 |
| | 15,452 | 11,585 | 15,836 | 15,957 | 15,258 |
| 332 | 15,482 | 10,766 | 15,311 | 16,406 | 15,575 |
| | 15,723 | 10,850 | 15,436 | 16,354 | 15,684 |
| 375 | 16,841 | 11,195 | 15,449 | 16,349 | 15,204 |
| | 16,684 | 11,221 | 15,500 | 16,111 | 15,063 |
| 421 | 13,978 | 11,121 | 15,386 | 15,972 | 15,184 |
| | 13,862 | 11,264 | 15,457 | 15,854 | 15,256 |
| 472 | 14,015 | 11,749 | 15,810 | 15,280 | 15,875 |
| | 14,078 | 11,574 | 16,018 | 15,232 | 15,872 |
| 543 | 15,562 | 11,595 | 15,791 | 16,161 | 15,435 |
| | 15,751 | 11,519 | 15,646 | 15,928 | 15,210 |
| 568 | 12,853 | 11,616 | 15,324 | 15,720 | 15,313 |
| | 12,772 | 11,935 | 15,804 | 15,927 | 15,445 |
| 736 | 14,041 | 11,928 | 16,409 | 16,124 | 15,868 |
| | 14,180 | 12,267 | 16,199 | 15,988 | 15,717 |

APPENDIX B-12 (CONTINUED)

SEDIMENT COMPARTMENT (Second Run, Tank I, Raw cpm)

| HOURS ELAPSED TIME | I4C | I2C | I4E | I2E | I3E | I1E |
|---|---|---|---|---|---|---|
| 158 | 6,743 | 13,574 | 11,413 | 12,000 | 14,191 | 13,481 |
| | 6,698 | 13,470 | 11,428 | 11,906 | 14,534 | 13,563 |
| 184 | 7,059 | 14,241 | 12,814 | 12,492 | 14,420 | 13,132 |
| | 6,940 | 14,647 | 12,633 | 12,574 | 14,677 | 13,468 |
| 233 | 8,142 | 15,109 | 13,313 | 13,306 | 14,292 | 14,046 |
| | 7,949 | 15,114 | 13,265 | 13,337 | 14,337 | 13,915 |
| 280 | 8,227 | 15,506 | 14,140 | 13,513 | 13,942 | 15,196 |
| | 8,043 | 15,702 | 14,190 | 13,481 | 14,143 | 15,171 |
| 332 | 9,119 | 16,299 | 14,482 | 14,061 | 14,669 | 15,369 |
| | 9,248 | 16,061 | 14,479 | 14,123 | 14,868 | 15,369 |
| 375 | 8,780 | 15,794 | 15,107 | 13,874 | 14,906 | 14,875 |
| | 8,798 | 15,721 | 15,436 | 13,438 | 14,263 | 14,981 |
| | | | 15,334 | | | |
| 421 | 9,440 | 15,263 | 15,208 | 14,044 | 14,151 | 15,251 |
| | 9,337 | 15,272 | 15,557 | 14,128 | 14,358 | 15,110 |
| 472 | 9,385 | 15,965 | 15,696 | 13,632 | 14,716 | 15,357 |
| | 9,587 | 15,796 | 15,737 | 13,717 | 14,817 | 15,328 |
| 543 | 9,667 | 15,810 | 15,812 | 13,710 | 14,306 | 15,132 |
| | 9,542 | 15,982 | 15,703 | 13,979 | 14,443 | 15,174 |
| 568 | 9,511 | 15,885 | 15,513 | 14,202 | 14,738 | 14,978 |
| | 9,270 | 16,055 | 15,299 | 14,392 | 14,574 | 15,204 |
| 736 | 10,033 | 16,018 | 15,955 | 13,825 | 13,765 | 15,692 |
| | 9,932 | 16,465 | 16,141 | 13,613 | 13,699 | 15,670 |

APPENDIX B-12 (CONTINUED)

SEDIMENT COMPARTMENT (Second Run, Tank I, Correction for Background, Normalization, Attenuation)

| HOURS ELAPSED TIME | I3H | I2H | I1H | I3R | I1R |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 |
| 4.25 | 909 | 494 | 588 | 750 | 699 |
| | 730 | 396 | 472 | 602 | 561 |
| 13 | 2,402 | 1,254 | 1,332 | 2,283 | 1,936 |
| | 1,928 | 1,006 | 1,069 | 1,833 | 1,554 |
| 25 | 3,806 | 1,702 | 2,541 | 3,734 | 3,135 |
| | 3,056 | 1,366 | 2,040 | 2,998 | 2,517 |
| 40 | 6,627 | 2,629 | 3,867 | 6,384 | 4,916 |
| | 5,321 | 2,111 | 3,105 | 5,126 | 3,947 |
| 50 | 6,208 | 2,967 | 4,924 | 5,056 | 6,080 |
| | 4,985 | 2,382 | 3,953 | 4,059 | 4,882 |
| 63 | 7,980 | 4,048 | 6,448 | 10,094 | 7,147 |
| | 6,407 | 3,750 | 5,177 | 8,105 | 5,739 |
| 72 | 8,296 | 4,976 | 7,669 | 11,207 | 7,748 |
| | 6,661 | 3,995 | 6,158 | 8,999 | 6,221 |
| 82 | 9,012 | 5,866 | 8,519 | 12,171 | 8,850 |
| | 7,236 | 4,710 | 6,840 | 9,773 | 7,106 |
| 97 | 9,508 | 6,636 | 10,019 | 13,684 | 10,180 |
| | 7,634 | 5,328 | 8,045 | 10,988 | 8,174 |

LEGEND: Above Number - cpm corrected for background
Below Number - cpm with additional correction for normalization and attenuation.

APPENDIX B-12 (CONTINUED)

SEDIMENT COMPARTMENT (Second Run, Tank I, Correction for Background, Normalization, Attenuation)

| HOURS ELAPSED TIME | I3H | I2H | I1H | I3R | I1R |
|---|---|---|---|---|---|
| 114 | 10,123 | 7,841 | 10,955 | 14,259 | 11,064 |
| | 8,128 | 6,296 | 8,796 | 11,449 | 8,884 |
| 136 | 13,000 | 9,072 | 12,150 | 14,605 | 13,132 |
| | 9,636 | 7,284 | 9,756 | 11,727 | 10,544 |
| 158 | 16,741 | 9,813 | 13,108 | 14,152 | 12,879 |
| | 13,443 | 7,879 | 10,525 | 11,364 | 10,341 |
| 184 | 15,220 | 10,015 | 13,752 | 14,457 | 13,282 |
| | 12,221 | 8,042 | 11,042 | 11,608 | 10,665 |
| 233 | 14,095 | 10,580 | 14,583 | 14,803 | 14,269 |
| | 11,318 | 8,495 | 11,710 | 11,886 | 11,458 |
| 280 | 14,049 | 10,858 | 14,854 | 15,207 | 14,564 |
| | 11,281 | 8,718 | 11,927 | 12,211 | 11,694 |
| 332 | 14,226 | 10,227 | 14,477 | 15,297 | 14,612 |
| | 11,423 | 8,209 | 11,600 | 12,283 | 11,773 |
| 375 | 15,478 | 10,533 | 14,587 | 15,488 | 14,416 |
| | 12,428 | 8,457 | 11,713 | 12,436 | 11,576 |
| 421 | 12,150 | 10,523 | 14,533 | 15,179 | 14,510 |
| | 9,756 | 8,449 | 11,669 | 12,188 | 11,651 |

**LEGEND:** Above Number - cpm corrected for background
Below Number - cpm with additional correction for normalization and attenuation.

APPENDIX B-12 (CONTINUED)

SEDIMENT COMPARTMENT (Second Run, Tank I, Correction for Background, Normalization, Attenuation)

| HOURS ELAPSED TIME | I3H | I2H | I1H | I3R | I1R |
|---|---|---|---|---|---|
| 472 | 12,790 | 10,999 | 15,045 | 14,530 | 15,170 |
| | 10,270 | 8,832 | 12,081 | 11,667 | 12,181 |
| 543 | 14,414 | 10,901 | 14,858 | 15,325 | 14,626 |
| | 11,574 | 8,753 | 11,930 | 12,305 | 11,744 |
| 568 | 11,695 | 11,126 | 14,713 | 15,111 | 14,690 |
| | 9,391 | 8,929 | 11,828 | 12,134 | 11,796 |
| 736 | 12,376 | 11,466 | 15,480 | 15,407 | 15,124 |
| | 9,937 | 9,207 | 12,430 | 12,371 | 12,144 |

LEGEND: Above Number - cpm corrected for background
Below Number - cpm with additional correction for normalization and attenuation.

APPENDIX B-12 (CONTINUED)

SEDIMENT COMPARTMENT (Second Run, Tank I, Correction for Background, Normalization, Attenuation)

| HOURS ELAPSED TIME | I4C | I2C | I4E | I2E | I3E | I1E |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4.25 | 733 | 1,271 | 657 | 743 | 1,197 | 1,085 |
| | 588 | 1,020 | 527 | 596 | 961 | 871 |
| 13 | 1,201 | 1,992 | 1,611 | 1,463 | 2,762 | 1,885 |
| | 964 | 1,599 | 1,293 | 1,174 | 2,217 | 1,513 |
| 25 | 1,914 | 3,319 | 2,661 | 2,328 | 4,501 | 2,930 |
| | 1,536 | 2,665 | 2,136 | 1,869 | 3,614 | 2,352 |
| 40 | 2,893 | 4,906 | 3,961 | 3,488 | 6,573 | 4,290 |
| | 2,323 | 3,939 | 3,180 | 2,800 | 5,278 | 3,444 |
| 50 | 3,259 | 5,876 | 4,780 | 4,309 | 8,161 | 5,721 |
| | 2,616 | 4,718 | 3,838 | 3,460 | 6,553 | 4,593 |
| 63 | 3,639 | 7,164 | 5,598 | 5,625 | 9,216 | 7,014 |
| | 2,922 | 5,752 | 4,495 | 4,516 | 7,400 | 5,632 |
| 72 | 4,000 | 7,688 | 6,406 | 6,575 | 10,448 | 7,856 |
| | 3,212 | 6,173 | 5,144 | 5,279 | 8,389 | 6,308 |
| 82 | 4,316 | 8,880 | 7,275 | 7,682 | 11,479 | 9,091 |
| | 3,465 | 7,130 | 5,841 | 6,168 | 9,217 | 7,300 |
| 97 | 4,701 | 9,893 | 8,089 | 8,923 | 12,597 | 10,390 |
| | 3,774 | 7,944 | 6,495 | 7,165 | 10,115 | 8,343 |

LEGEND: Above Number - cpm corrected for background
Below Number - cpm with additional correction for normalization and attenuation.

APPENDIX B-12 (CONTINUED)

SEDIMENT COMPARTMENT (Second Run, Tank I, Correction for Background, Normalization, Attenuation)

| HOURS ELAPSED TIME | I4C | I2C | I4E | I2E | I3E | I1E |
|---|---|---|---|---|---|---|
| 114 | 4,793 | 11,113 | 8,104 | 9,797 | 12,691 | 11,215 |
| | 3,848 | 8,923 | 6,507 | 7,866 | 10,190 | 9,005 |
| 136 | 5,245 | 12,374 | 9,440 | 11,212 | 13,240 | 12,535 |
| | 4,211 | 9,936 | 7,580 | 9,003 | 10,631 | 10,065 |
| 158 | 5,906 | 12,732 | 10,597 | 11,792 | 13,326 | 12,882 |
| | 4,742 | 10,223 | 8,509 | 9,468 | 10,700 | 10,344 |
| 184 | 6,194 | 13,654 | 11,909 | 12,588 | 13,523 | 12,679 |
| | 4,973 | 10,964 | 9,562 | 10,108 | 10,858 | 10,181 |
| 233 | 7,248 | 14,337 | 12,484 | 12,772 | 13,300 | 13,365 |
| | 5,820 | 11,512 | 10,024 | 10,255 | 10,679 | 10,732 |
| 280 | 7,346 | 14,838 | 13,368 | 12,780 | 13,039 | 14,574 |
| | 5,898 | 11,914 | 10,734 | 10,262 | 10,470 | 11,702 |
| 332 | 8,141 | 15,403 | 13,808 | 13,452 | 13,654 | 14,531 |
| | 6,537 | 12,368 | 11,087 | 10,801 | 10,964 | 11,668 |
| 375 | 8,016 | 15,007 | 17,511 | 12,953 | 13,603 | 14,331 |
| | 6,436 | 12,050 | 14,061 | 10,401 | 10,923 | 11,507 |
| 421 | 8,623 | 14,525 | 14,609 | 13,390 | 13,283 | 14,589 |
| | 6,924 | 11,663 | 11,731 | 10,752 | 10,666 | 11,714 |

LEGEND: Above Number - cpm corrected for background
Below Number - cpm with additional correction for normalization and attenuation.

APPENDIX B-12 (CONTINUED)

SEDIMENT COMPARTMENT (Second Run, Tank I, Correction for Background, Normalization, Attenuation)

| HOURS ELAPSED TIME | I4C | I2C | I4E | I2E | I3E | I1E |
|---|---|---|---|---|---|---|
| 472 | 8,729 | 15,146 | 14,951 | 12,985 | 13,805 | 14,757 |
| | 7,009 | 12,162 | 12,005 | 10,426 | 11,085 | 11,849 |
| 543 | 8,789 | 15,170 | 15,000 | 13,162 | 13,423 | 14,574 |
| | 7,057 | 12,181 | 12,045 | 10,569 | 10,778 | 11,702 |
| 568 | 8,649 | 15,252 | 14,657 | 13,622 | 13,595 | 14,518 |
| | 6,945 | 12,247 | 11,769 | 10,938 | 10,916 | 11,657 |
| 736 | 8,935 | 15,221 | 15,113 | 12,960 | 12,069 | 15,126 |
| | 7,174 | 12,222 | 12,135 | 10,406 | 9,691 | 12,146 |

LEGEND: Above Number - cpm corrected for background
Below Number - cpm with additional correction for normalization and attenuation.

APPENDIX B-12 (CONTINUED)

SEDIMENT COMPARTMENT (Second Run, Tank I, Decay Correction, Geometric Average of Area, Milligrams Selenium)

| HOURS ELAPSED TIME | H | | R | | C | | E | |
|---|---|---|---|---|---|---|---|---|
| | AVERAGE cpm | FRACTION cpm | AVERAGE cpm | FRACTION cpm | AVERAGE cpm | FRACTION cpm | AVERAGE cpm | FRACTION cpm |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4.25 | 533 | 235 | 581 | 66 | 804 | 103 | 739 | 230 |
| 13 | 1,483 | 654 | 1,693 | 193 | 1,281 | 165 | 1,549 | 482 |
| 25 | 2,379 | 1,049 | 2,757 | 314 | 2,101 | 270 | 2,493 | 775 |
| 40 | 3,964 | 1,747 | 4,536 | 518 | 3,131 | 403 | 3,676 | 1,143 |
| 50 | 4,076 | 1,796 | 4,471 | 510 | 3,667 | 472 | 4,611 | 1,434 |
| 63 | 5,311 | 2,341 | 6,922 | 790 | 4,337 | 559 | 5,511 | 1,714 |
| 72 | 5,869 | 2,587 | 7,610 | 869 | 4,692 | 604 | 6,280 | 1,953 |
| 82 | 6,506 | 2,867 | 8,439 | 963 | 5,298 | 682 | 7,132 | 2,218 |
| 97 | 7,160 | 3,156 | 9,581 | 1,094 | 5,859 | 755 | 8,029 | 2,498 |
| 114 | 7,837 | 3,454 | 10,167 | 1,161 | 6,386 | 823 | 8,942 | 2,780 |
| 136 | 9,078 | 4,001 | 11,136 | 1,271 | 7,074 | 911 | 9,320 | 2,899 |
| 158 | 11,322 | 4,991 | 10,852 | 1,239 | 7,483 | 964 | 9,755 | 3,035 |
| 184 | 10,882 | 4,796 | 11,137 | 1,271 | 7,968 | 1,027 | 10,177 | 3,166 |
| 233 | 10,710 | 4,721 | 11,672 | 1,332 | 8,666 | 1,117 | 10,423 | 3,242 |
| 280 | 10,802 | 4,761 | 11,453 | 1,365 | 8,906 | 1,148 | 10,792 | 3,357 |
| 332 | 10,664 | 4,700 | 12,008 | 1,371 | 9,452 | 1,218 | 11,130 | 3,462 |
| 375 | 11,257 | 4,962 | 12,006 | 1,371 | 9,243 | 1,191 | 11,723 | 3,647 |
| 421 | 9,908 | 4,367 | 11,920 | 1,361 | 9,293 | 1,197 | 11,216 | 3,489 |
| 472 | 10,363 | 4,568 | 11,924 | 1,361 | 9,585 | 1,235 | 11,341 | 3,528 |
| 543 | 10,958 | 4,830 | 12,025 | 1,373 | 9,619 | 1,239 | 11,273 | 3,507 |
| 568 | 9,885 | 4,357 | 11,965 | 1,366 | 9,596 | 1,236 | 11,320 | 3,521 |
| 736 | 10,378 | 4,574 | 12,258 | 1,399 | 9,698 | 1,250 | 11,095 | 3,451 |

APPENDIX B-12 (CONTINUED)

SEDIMENT COMPARTMENT (Second Run, Tank I, Decay Correction, Geometric Average of Area, Milligrams Selenium)

| HOURS ELAPSED TIME | IDEALIZED CONTAINER SUM OF FRACTIONS | COMPARTMENT cpm* | COMPARTMENT mg Se | DECAY CORRECTED mg |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 4.25 | 634 | 421,538 | .1966 | .1966 |
| 13 | 1,494 | 993,341 | .4634 | .4634 |
| 25 | 2,408 | 1,601,049 | .7469 | .7469 |
| 40 | 3,811 | 2,533,886 | 1.1821 | 1.195 |
| 50 | 4,212 | 2,800,506 | 1.306 | 1.321 |
| 63 | 5,404 | 3,593,051 | 1.676 | 1.695 |
| 72 | 6,013 | 3,997,968 | 1.865 | 1.886 |
| 82 | 6,730 | 4,474,692 | 2.087 | 2.111 |
| 97 | 7,503 | 4,988,650 | 2.327 | 2.381 |
| 114 | 8,218 | 5,464,045 | 2.549 | 2.608 |
| 136 | 9,082 | 6,038,508 | 2.817 | 2.916 |
| 158 | 10,229 | 6,801,133 | 3.172 | 3.283 |
| 184 | 10,260 | 6,821,745 | 3.182 | 3.332 |
| 233 | 10,412 | 6,922,808 | 3.229 | 3.420 |
| 280 | 10,631 | 7,068,418 | 3.297 | 3.533 |
| 332 | 10,751 | 7,148,205 | 3.334 | 3.617 |
| 375 | 11,171 | 7,427,457 | 3.465 | 3.797 |
| 421 | 10,414 | 6,924,138 | 3.230 | 3.578 |
| 472 | 10,692 | 7,108,976 | 3.316 | 3.717 |
| 543 | 10,949 | 7,279,852 | 3.396 | 3.864 |
| 568 | 10,480 | 6,968,020 | 3.250 | 3.731 |
| 736 | 10,674 | 7,097,008 | 3.311 | 3.934 |

* = (664.88747) x (Idealized Container)

APPENDIX B-13

WATER COMPARTMENT (Second Run, Tank II)

| HOURS ELAPSED TIME | FILTER NUMBER | RAW COUNT cpm 20 ml SAMPLE | BACKGROUND CORRECTED cpm | DECAY CORRECTED cpm | (x .4666 x $10^{-6}$) mg Se 20 ml SAMPLE | COMPARTMENT mg Se (SAMPLE x 3,000) |
|---|---|---|---|---|---|---|
| 0 | 2 | 1,418 ten* | - | - | - | - |
| .083 | 4 | 43,684 ten* | 4,225 | 4,225 | 1,971 | 5.91 |
| .25 | 6 | 4,357 | 4,201 | 4,201 | 1,960 | 5.88 |
| | | 4,331 | | | | |
| .5 | 8 | 44,591 ten* | 4,316 | 4,316 | 2,013 | 6.04 |
| 1 | 10 | 44,035 ten* | 4,260 | 4,260 | 1,987 | 5.96 |
| 3 | 12 | 43,260 ten* | 4,183 | 4,183 | 1,951 | 5.85 |
| 12 | 14 | 41,847 ten* | 4,041 | 4,041 | 1,885 | 5.65 |
| 18 | 16 | 4,005 | 3,863 | 3,863 | 1,802 | 5.41 |
| | | 4,006 | | | | |
| 23.5 | 18 | 3,733 | 3,680 | 3,680 | 1,717 | 5.15 |
| | | 3,913 | | | | |
| 37 | 20 | 3,601 | 3,439 | 3,439 | 1,604 | 4.81 |
| | | 3,564 | | | | |
| 48 | 22 | 3,229 | 3,091 | 3,126 | 1,459 | 4.37 |
| | | 3,239 | | | | |
| 61 | 24 | 3,115 | 2,948 | 2,982 | 1,391 | 4.18 |
| | | 3,068 | | | | |
| 70.5 | 26 | 2,466 | 2,299 | 2,326 | 1,085 | 3.26 |
| | | 2,419 | | | | |
| 81 | 28 | 2,672 | 2,510 | 2,539 | 1,185 | 3.56 |
| | | 2,635 | | | | |

* ten minute count

APPENDIX B-13 (CONTINUED)

WATER COMPARTMENT (Second Run, Tank II)

| HOURS ELAPSED TIME | FILTER NUMBER | RAW COUNT cpm 20 ml SAMPLE | BACKGROUND CORRECTED cpm | DECAY CORRECTED cpm | (x .4666 x $10^{-6}$) mg Se 20 ml SAMPLE | COMPARTMENT mg Se (SAMPLE x 3,000) |
|---|---|---|---|---|---|---|
| 96 | 30 | 2,440 | 2,333 | 2,387 | 1,114 | 3.34 |
| | | 2,421 | | | | |
| | | 2,565 | | | | |
| 134 | 34 | 1,721 | 1,562 | 1,598 | 746 | 2.24 |
| | | 1,688 | | | | |
| 157 | 36 | 1,472 | 1,305 | 1,351 | 630 | 1.89 |
| | | 1,423 | | | | |
| 183 | 38 | 1,192 | 1,026 | 1,062 | 495 | 1.49 |
| | | 1,145 | | | | |
| 232 | 40 | 789 | 652 | 683 | 318 | 0.956 |
| | | 798 | | | | |
| 256 | 42 | 600 | 459 | 486 | 226 | 0.681 |
| 280 | 44 | 464 | 351 | 371 | 173 | 0.520 |
| | | 520 | | | | |
| 303 | 46 | 488 | 374 | 401 | 187 | 0.562 |
| | | 543 | | | | |
| 353 | 48 | 5,236 ten* | 383 | 418 | 195 | 0.585 |
| 400 | 50 | 4,651 ten* | 325 | 358 | 167 | 0.501 |
| 421 | 56 | 4,633 | 323 | 356 | 166 | 0.499 |

* ten minute count

APPENDIX B-13 (CONTINUED)

WATER COMPARTMENT (Second Run, Tank II)

| HOURS ELAPSED TIME | FILTER NUMBER | RAW COUNT cpm 20 ml SAMPLE | BACKGROUND CORRECTED cpm | DECAY CORRECTED cpm | (x .4666 x $10^{-6}$) mg Se 20 ml SAMPLE | COMPARTMENT mg Se (SAMPLE x 3,000) |
|---|---|---|---|---|---|---|
| 447 | 58 | 422 | 307 | 339 | 158 | 0.475 |
| | | 473 | | | | |
| 472 | 60 | 4,556* | 314 | 350 | 163 | 0.491 |
| 496 | 62 | 458 | 323 | 364 | 170 | 0.510 |
| | | 439 | | | | |
| 520 | 64 | 432 | 282 | 318 | 148 | 0.446 |
| | | 411 | | | | |
| 568 | 66 | 418 | 268 | 308 | 143 | 0.431 |
| | | 397 | | | | |
| 617 | 68 | 380 | 239 | 274 | 128 | 0.384 |
| | | 376 | | | | |
| 641 | 70 | 400 | 254 | 295 | 137 | 0.413 |
| | | 371 | | | | |
| | | 409 | | | | |
| 720 | 72 | 384 | 249 | 295 | 138 | 0.414 |
| | | 390 | | | | |
| 736 | 74 | 397 | 255 | 303 | 141 | 0.424 |
| | | 389 | | | | |

* Ten minute count

APPENDIX B-13 (CONTINUED)

WATER COMPARTMENT (Second Run, Tank II)

| HOURS ELAPSED TIME | FILTER NUMBER | RAW COUNT cpm 20 ml SAMPLE | BACKGROUND CORRECTED cpm | DECAY CORRECTED cpm | (x .4666 x $10^{-6}$) mg Se 20 ml SAMPLE | COMPARTMENT mg Se (SAMPLE x 3,000) |
|---|---|---|---|---|---|---|
| 830 | 78 | 396<br>398 | 260 | 318 | 148 | 0.445 |
| 904 | 82 | 3,652 ten* | 228 | 283 | 132 | 0.397 |
| 928 | 84 | 364<br>354 | 223 | 277 | 129 | 0.388 |
| 952 | 86 | 390<br>344 | 222 | 277 | 129 | 0.387 |
| 1,024 | 88 | 346<br>356 | 215 | 270 | 126 | 0.379 |

* ten minute count

APPENDIX B-14

SUSPENDED PARTICULATE COMPARTMENT (Second Run, Tank II)

| HOURS ELAPSED TIME | FILTER NUMBER | RAW 10 MIN. COUNT RATE 40 ml | BACKGROUND CORRECTED cpm | DECAY CORRECTED cpm | cpm NORMALIZED (x .9055) | mg Se PER 40 ml SAMPLE | COMPARTMENT mg Se |
|---|---|---|---|---|---|---|---|
| 0 | 2 | 1,274 | 0 | 0 | 0 | 0 | 0 |
| .083 | 4 | 1,745 | 16 | 18 | 16 | 8 | .0114 |
| .25 | 6 | 1,665 | 8 | 9 | 8 | 4 | .0057 |
| .5 | 8 | 1,685 | 10 | 11 | 10 | 5 | .0069 |
| 1 | 10 | 1,611 | 2 | 2 | 2 | 1 | .0012 |
| 3 | 12 | 1,670 | 8 | 9 | 8 | 4 | .0057 |
| 12 | 14 | 1,795 | 21 | 23 | 21 | 10 | .0145 |
| 18 | 16 | 1,723 | 13 | 14 | 13 | 6 | .0088 |
| 23.5 | 18 | 1,826 | 24 | 26 | 24 | 11 | .0164 |
| 37 | 20 | 2,081 | 49 | 54 | 49 | 23 | .0342 |
| 48 | 22 | 2,272 | 68 | 75 | 68 | 32 | .0475 |
| 61 | 24 | 2,627 | 104 | 115 | 104 | 49 | .0728 |
| 70.5 | 26 | 3,033 | 144 | 159 | 144 | 67 | .1007 |
| 81 | 28 | 3,096 | 151 | 167 | 151 | 71 | .1058 |
| 96 | 30 | 3,438 | 185 | 204 | 185 | 86 | .1292 |
| 113 | 32 | 3,581 | 199 | 219 | 198 | 93 | .1387 |
| 134 | 34 | 3,999 | 241 | 266 | 241 | 112 | .1685 |
| 157 | 36 | 4,394 | 280 | 309 | 280 | 131 | .1958 |
| 183 | 38 | 4,767 | 318 | 351 | 318 | 148 | .2224 |
| 232 | 40 | 6,135 | 455 | 502 | 455 | 212 | .3181 |
| 256 | 42 | 4,717 | 313 | 345 | 312 | 146 | .2186 |
| 280 | 44 | 5,099 | 351 | 387 | 350 | 164 | .2452 |

APPENDIX B-14 (CONTINUED)

SUSPENDED PARTICULATE COMPARTMENT (Second Run, Tank II)

| HOURS ELAPSED TIME | FILTER NUMBER | RAW 10 MIN. COUNT RATE 40 ml | BACKGROUND CORRECTED cpm | DECAY CORRECTED cpm | cpm NORMALIZED (x .9055) | mg Se PER 40 ml SAMPLE | COMPART-MENT mg Se |
|---|---|---|---|---|---|---|---|
| 303 | 46 | 5,359 | 377 | 416 | 377 | 176 | .2636 |
| 353 | 48 | 5,147 | 356 | 393 | 356 | 166 | .2490 |
| 400 | 50 | 6,146 | 456 | 503 | 455 | 212 | .3187 |
| 421 | 56 | 5,265 | 368 | 415 | 376 | 175 | .2630 |
| 447 | 58 | 4,721 | 317 | 358 | 324 | 151 | .2268 |
| 472 | 60 | 4,778 | 323 | 365 | 331 | 154 | .2313 |
| 496 | 62 | 4,394 | 286 | 325 | 294 | 137 | .2059 |
| 520 | 64 | 4,608 | 307 | 351 | 318 | 148 | .2224 |
| 568 | 66 | 4,192 | 266 | 310 | 281 | 131 | .1964 |
| 617 | 68 | 3,516 | 198 | 231 | 209 | 98 | .1463 |
| 641 | 70 | 2,891 | 136 | 158 | 143 | 67 | .1001 |
| 720 | 72 | 3,635 | 211 | 258 | 234 | 109 | .1635 |
| 736 | 74 | 3,259 | 173 | 212 | 192 | 90 | .1343 |
| 792 | 76 | 2,958 | 143 | 175 | 158 | 74 | .1109 |
| 830 | 78 | 2,681 | 120 | 149 | 135 | 63 | .0944 |
| 904 | 82 | 2,561 | 108 | 141 | 128 | 60 | .0893 |
| 928 | 84 | 2,517 | 104 | 136 | 123 | 58 | .0862 |
| 952 | 86 | 2,432 | 95 | 124 | 112 | 52 | .0785 |
| 1,024 | 88 | 2,343 | 80 | 104 | 94 | 44 | .0659 |

APPENDIX B-15

DATA FISH COMPARTMENT (Second Run, Tank II)

| HOURS ELAPSED TIME | FISH NUMBER 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 0 | 617 | 696 | 681 | 857 |
| | 542 | 679 | 777 | 753 |
| 2 | 634 | 766 | 778 | 915 |
| | 654 | 761 | 791 | 921 |
| 6.5 | 799 | 794 | 880 | 1,023 |
| | 781 | 790 | 911 | 1,017 |
| 23 | 1,023 | 1,278 | 1,275 | 1,645 |
| | 1,024 | 1,199 | 1,274 | 1,700 |
| 37 | 1,330 | 1,485 | 1,533 | 2,041 |
| | 1,332 | 1,447 | 1,491 | 1,959 |
| | | | 1,546 | |
| 47.5 | 1,705 | 1,808 | 2,179 | 2,836 |
| | 1,745 | 1,758 | 2,038 | 2,755 |
| 62 | 1,889 | 2,234 | 2,533 | 2,857 |
| | 1,957 | 2,102 | 2,617 | 2,942 |
| 71 | 2,295 | 2,316 | 2,555 | 3,377 |
| | 2,285 | 2,385 | 2,696 | 3,193 |
| 81 | 2,448 | 2,668 | 2,773 | 3,321 |
| | 2,408 | 2,715 | 2,717 | 3,315 |
| 96 | 2,975 | 3,476 | 3,550 | 4,117 |
| | 2,940 | 3,563 | 3,613 | 3,958 |
| 113 | 3,763 | 4,303 | 4,714 | 5,483 |
| | 3,737 | 4,461 | 4,562 | 4,808 |
| 134 | 4,839 | 5,439 | 5,688 | 7,389 |
| | 4,749 | 5,326 | 5,580 | 7,442 |
| | | | 5,628 | |
| 160 | 6,186 | 6,741 | 8,365 | 8,975 |
| | 6,194 | 6,763 | 8,483 | 9,033 |
| 183 | 7,911 | 7,877 | 9,841 | 11,952 |
| | 7,780 | 7,937 | 9,601 | 11,507 |
| 232 | 10,863 | 11,558 | 11,842 | 14,071 |
| | 10,782 | 11,517 | 11,909 | 14,046 |
| 256 | 9,915 | 10,394 | 11,010 | 14,238 |
| | 9,845 | 10,436 | 10,903 | 13,843 |
| | | | | 13,903 |

APPENDIX B-15 (CONTINUED)

DATA FISH COMPARTMENT (Second Run, Tank II)

| HOURS ELAPSED TIME | FISH NUMBER 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 303 | 10,536 | 10,569 | 11,615 | 14,607 |
| | 10,665 | 11,004 | 12,004 | 14,607 |
| | | 11,064 | 12,100 | |
| | | 10,764 | | |
| 353 | 11,018 | 10,894 | 11,322 | 15,344 |
| | 10,874 | 11,059 | 11,363 | 15,156 |
| 400 | 10,266 | 16,482 | 11,238 | 14,668 |
| | 10,339 | 10,375 | 11,186 | 14,146 |
| 447 | 10,437 | 11,380 | 11,315 | 15,466 |
| | 10,407 | 11,177 | 11,346 | 15,469 |
| 518 | 8,637 | 9,851 | 10,036 | 13,438 |
| | 8,476 | 10,035 | 10,410 | 13,246 |
| 568 | 8,299 | 9,138 | 10,082 | 12,392 |
| | 8,267 | 9,070 | 10,303 | 12,270 |
| 641 | 7,584 | 8,263 | 10,005 | 12,120 |
| | 7,854 | 8,029 | 9,996 | 11,856 |
| 760 | 7,176 | 7,834 | 9,371 | 11,091 |
| | | 7,769 | | 10,683 |
| 830 | 6,521 | 7,186 | 9,217 | 9,948 |
| | 6,464 | 7,109 | 9,438 | 10,039 |
| 880 | 6,262 | 6,508 | 9,474 | 9,700 |
| | 6,450 | 6,514 | 9,495 | 9,603 |
| 1,024 | 5,146 | 5,539 | 8,126 | 9,264 |
| | 5,287 | 5,374 | 8,265 | 9,239 |

APPENDIX B-15 (CONTINUED)

DATA FISH COMPARTMENT (Second Run, Tank II)

| HOURS ELAPSED TIME | cpm Compartment Corrected for Background | cpm Compartment Corrected for Decay | (x .4666 x $10^{-6}$) Compartment Mg Se | Compartment Mg Se Normalized |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 2 | 308 | 308 | 143 | .00010 |
| 6.5 | 696 | 696 | 324 | .00022 |
| 23 | 2,408 | 2,408 | 1,123 | .00079 |
| 37 | 3,519 | 3,519 | 1,642 | .00115 |
| 47.5 | 5,638 | 5,703 | 2,661 | .00187 |
| 62 | 6,791 | 6,870 | 3,205 | .00226 |
| 71 | 7,777 | 7,867 | 3,670 | .00259 |
| 81 | 8,408 | 8,506 | 3,968 | .00280 |
| 96 | 11,349 | 11,613 | 5,418 | .00382 |
| 113 | 15,168 | 15,522 | 7,242 | .00511 |
| 134 | 20,477 | 20,954 | 9,777 | .00690 |
| 160 | 27,649 | 28,621 | 13,354 | .00942 |
| 183 | 34,482 | 35,694 | 16,655 | .01175 |
| 232 | 45,649 | 47,800 | 22,303 | .01574 |
| 256 | 42,577 | 45,099 | 21,043 | .01485 |
| 303 | 45,322 | 48,562 | 22,659 | .01599 |
| 353 | 45,898 | 50,028 | 23,343 | .01648 |
| 400 | 43,738 | 47,958 | 22,377 | .01579 |
| 447 | 45,930 | 50,945 | 23,771 | .01678 |
| 518 | 39,521 | 44,599 | 20,809 | .01469 |
| 568 | 37,391 | 42,562 | 19,859 | .01402 |
| 641 | 35,381 | 41,091 | 19,173 | .01353 |
| 760 | 32,832 | 39,020 | 18,207 | .01285 |
| 830 | 30,581 | 37,299 | 17,404 | .01228 |
| 880 | 29,675 | 36,614 | 17,084 | .01206 |
| 1,024 | 25,827 | 32,796 | 15,302 | .01080 |

APPENDIX B-16

SEDIMENT COMPARTMENT RAW DATA CPM (Second Run, Tank II)

| HOURS ELAPSED TIME | II3H | II2H | II1H | II3R | II1R |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 |
| 5.5 | 1,338 | 2,860 | 3,204 | 1,354 | 1,176 |
| | 1,308 | 2,990 | 3,262 | 1,442 | 1,144 |
| 13.5 | 2,000 | 4,756 | 5,065 | 2,200 | 1,612 |
| | 2,076 | 4,903 | 5,040 | 2,213 | 1,571 |
| | 2,059 | | | | |
| 26 | 3,077 | 7,886 | 7,758 | 3,577 | 2,212 |
| | 2,984 | 7,858 | 7,858 | 3,605 | 2,201 |
| 41 | 4,699 | 12,848 | 10,811 | 5,353 | 2,912 |
| | 4,804 | 13,010 | 11,110 | 3,250 | 2,974 |
| | 4,804 | | | | |
| 51 | 5,674 | 15,724 | 12,705 | 6,292 | 3,220 |
| | 5,679 | 15,903 | 12,598 | 6,315 | 3,237 |
| 64 | 6,584 | 17,780 | 15,101 | 7,549 | 3,865 |
| | 6,554 | 17,861 | 14,886 | 7,668 | 3,873 |
| 73 | 7,450 | 18,393 | 16,170 | 8,454 | 4,127 |
| | 7,451 | 18,668 | 16,345 | 8,441 | 4,225 |
| 83 | 8,096 | 19,713 | 18,281 | 9,316 | 4,703 |
| | 8,380 | 19,311 | 18,534 | 9,402 | 4,795 |
| | 8,490 | | | | |
| 98 | 9,851 | 20,073 | 21,322 | 10,634 | 5,312 |
| | 9,943 | 20,426 | 21,732 | 10,554 | 5,205 |
| 115 | 11,290 | 21,509 | 21,777 | 11,527 | 5,517 |
| | 11,329 | 21,549 | 21,551 | 11,764 | 5,681 |

APPENDIX B-16 (CONTINUED)

SEDIMENT COMPARTMENT RAW DATA CPM (Second Run, Tank II)

| HOURS ELAPSED TIME | II3H | II2H | II1H | II3R | II1R |
|---|---|---|---|---|---|
| 136 | 14,514 | 23,157 | 26,763 | 13,649 | 6,583 |
| | 14,659 | 23,071 | 27,034 | 13,795 | 6,620 |
| 159 | 16,707 | 23,269 | 29,339 | 15,287 | 7,473 |
| | 16,704 | 23,448 | 29,326 | 15,190 | 7,315 |
| 185 | 18,847 | 23,550 | 30,441 | 16,824 | 7,327 |
| | 19,050 | 23,793 | 30,242 | 16,802 | 7,214 |
| 234 | 21,806 | 23,976 | 36,478 | 19,295 | 8,413 |
| | 21,878 | 23,791 | 36,480 | 19,534 | 8,397 |
| 280 | 22,634 | 22,662 | 31,466 | 19,859 | 8,344 |
| | 22,665 | 22,627 | 32,010 | 19,989 | 8,306 |
| 332 | 23,325 | 24,241 | 39,981 | 20,045 | 8,669 |
| | 23,338 | 24,419 | 40,304 | 20,560 | 8,696 |
| 375 | 23,048 | 25,565 | 37,105 | 20,053 | 8,329 |
| | 23,313 | 25,640 | 37,502 | 20,249 | 8,508 |
| 421 | 23,347 | 25,898 | 37,559 | 20,037 | 8,400 |
| | 23,242 | 26,162 | 37,540 | 20,154 | 8,296 |
| 472 | 23,383 | 25,206 | 37,758 | 19,981 | 8,348 |
| | 23,108 | 25,347 | 37,634 | 19,917 | 8,375 |
| 543 | 22,582 | 24,137 | 37,386 | 19,648 | 8,193 |
| | 22,902 | 23,952 | 37,189 | 19,781 | 7,948 |
| | | | | | 8,140 |

APPENDIX B-16 (CONTINUED)

SEDIMENT COMPARTMENT RAW DATA CPM (Second Run, Tank II)

| HOURS ELAPSED TIME | II3H | II2H | II1H | II3R | II1R |
|---|---|---|---|---|---|
| 568 | 22,332 | 24,246 | 37,508 | 19,870 | 8,054 |
| | 22,666 | 24,102 | 37,303 | 19,768 | 8,155 |
| 617 | 22,185 | 24,592 | 35,918 | 19,437 | 8,147 |
| | 22,142 | 24,461 | 36,057 | 19,442 | 8,042 |
| 880 | 22,269 | 23,285 | 32,637 | 18,543 | 7,928 |
| | 22,298 | 23,322 | 32,799 | 18,674 | 7,899 |
| 1,024 | | | | | |

APPENDIX B-16 (CONTINUED)

SEDIMENT COMPARTMENT RAW DATA CPM (Second Run, Tank II)

| HOURS ELAPSED TIME | II4C | II2C | II4E | II2E | II3E | II1E |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5.5 | 13,670 ten* | 1,563 | 1,380 | 1,452 | 1,562 | 1,699 |
| | | 1,497 | 1,378 | 1,436 | 1,507 | 1,620 |
| 13.5 | 1,772 | 2,187 | 2,083 | 2,268 | 2,206 | 2,426 |
| | 1,904 | 2,171 | 2,160 | 2,227 | 2,163 | 2,466 |
| 26 | 2,441 | 3,075 | 3,000 | 3,294 | 3,211 | 3,561 |
| | 2,446 | 3,069 | 3,128 | 3,344 | 3,040 | 3,553 |
| 41 | 3,241 | 4,224 | 4,005 | 5,254 | 4,550 | 5,285 |
| | 3,322 | 4,285 | 4,095 | 5,076 | 4,614 | 5,368 |
| 51 | 3,581 | 5,159 | 5,055 | 6,649 | 5,565 | 6,185 |
| | 3,520 | 5,198 | 4,862 | 6,671 | 5,625 | 6,128 |
| 64 | 3,945 | 5,087 | 6,056 | 6,715 | 6,463 | 7,303 |
| | 3,825 | 5,258 | 5,940 | 6,721 | 6,634 | 7,397 |
| 73 | 4,235 | 5,981 | 6,766 | 6,933 | 7,248 | 8,590 |
| | 4,058 | 6,117 | 6,771 | 6,948 | 7,166 | 8,434 |
| | | | | 6,823 | | |
| | | | | 7,035 | | |
| 83 | 4,803 | 6,701 | 7,499 | 7,878 | 8,019 | 8,736 |
| | 4,735 | 6,810 | 7,555 | 7,974 | 8,047 | 9,772 |
| | | | | | | 9,798 |

* ten minute count

APPENDIX B-16 (CONTINUED)

SEDIMENT COMPARTMENT RAW DATA CPM (Second Run, Tank II)

| HOURS ELAPSED TIME | II4C | II2C | II4E | II2E | II3E | II1E |
|---|---|---|---|---|---|---|
| 98 | 4,739 | 7,566 | 8,668 | 9,343 | 9,369 | 11,328 |
| | 4,754 | 7,829 | 8,662 | 9,364 | 9,355 | 11,044 |
| 115 | 5,407 | 8,638 | 9,431 | 11,078 | 9,841 | 12,338 |
| | 5,272 | 8,646 | 9,492 | 11,076 | 10,100 | 12,698 |
| 136 | 6,264 | 10,427 | 10,338 | 13,330 | 11,859 | 14,290 |
| | 6,948 | 10,567 | 10,516 | 13,519 | 11,548 | 14,510 |
| 159 | 6,845 | 12,367 | 11,182 | 16,036 | 13,328 | 15,933 |
| | 6,727 | 12,296 | 11,138 | 15,930 | 13,302 | 15,801 |
| 185 | 7,689 | 13,507 | 12,494 | 18,160 | 14,883 | 17,813 |
| | 7,606 | 13,622 | | 18,090 | 14,676 | 18,139 |
| 234 | 8,472 | 15,574 | 12,912 | 21,724 | 16,526 | 19,682 |
| | 8,566 | 15,770 | 13,336 | 22,279 | 16,355 | 19,664 |
| 280 | 8,659 | 15,790 | 14,379 | 22,164 | 17,214 | 19,789 |
| | 8,346 | 15,614 | 14,285 | 22,340 | 17,148 | 19,880 |
| 332 | 8,250 | 14,684 | 15,009 | 22,791 | 16,894 | 19,391 |
| | 8,213 | 14,604 | 14,809 | 22,824 | 16,511 | 19,487 |
| 375 | 8,229 | 14,388 | 13,887 | 21,925 | 16,501 | 18,890 |
| | 8,272 | 14,028 | 13,864 | 22,102 | 16,548 | 19,188 |
| 421 | 8,143 | 13,820 | 14,285 | 22,201 | 16,390 | 18,655 |
| | 8,102 | 13,942 | 13,893 | 22,344 | 16,324 | 18,855 |

APPENDIX B-16 (CONTINUED)

SEDIMENT COMPARTMENT RAW DATA CPM (Second Run, Tank II)

| HOURS ELAPSED TIME | II4C | II2C | II4E | II2E | II3E | II1E |
|---|---|---|---|---|---|---|
| 472 | 8,147 | 13,314 | 13,735 | 21,717 | 16,198 | 18,565 |
| | 8,092 | 13,520 | 13,935 | 21,820 | 16,147 | 18,623 |
| 543 | 8,092 | 13,247 | 13,303 | 21,228 | 15,064 | 18,275 |
| | 8,124 | 13,350 | 13,215 | 21,498 | 15,712 | 17,866 |
| 568 | 7,936 | 12,927 | 14,666 | 21,238 | 15,570 | 17,618 |
| | 8,017 | 13,007 | 14,443 | 21,256 | 15,565 | 17,514 |
| 617 | 7,945 | 12,805 | 14,622 | 20,837 | 15,514 | 17,674 |
| | 8,065 | 12,810 | 14,777 | 20,819 | 15,543 | 17,747 |
| 880 | 7,738 | 12,695 | 14,748 | 19,755 | 14,957 | 17,000 |
| | 7,898 | 12,764 | 14,642 | 19,986 | 14,739 | 17,165 |

APPENDIX B-16 (CONTINUED)

SEDIMENT COMPARTMENT CPM (Second Run, Tank II)
(Corrected for Background, Normalized for Attenuation, Geometry)

| HOURS ELAPSED TIME | II3H | II2H | II1H | II3R | II1R |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 |
| 5.5 | 712 | 1,298 | 1,639 | 853 | 666 |
| | 571 | 1,042 | 1,316 | 684 | 534 |
| 13.5 | 1,434 | 3,202 | 3,458 | 1,661 | 1,097 |
| | 1,151 | 2,571 | 2,777 | 1,334 | 881 |
| 26 | 2,419 | 6,245 | 6,214 | 3,046 | 1,712 |
| | 1,942 | 5,014 | 4,989 | 2,445 | 1,375 |
| 41 | 4,172 | 11,302 | 9,366 | 4,756 | 2,449 |
| | 3,350 | 9,075 | 7,521 | 3,819 | 1,966 |
| 51 | 5,071 | 14,204 | 11,075 | 5,763 | 2,739 |
| | 4,072 | 11,406 | 8,893 | 4,628 | 2,199 |
| 64 | 5,964 | 16,211 | 13,417 | 7,068 | 3,380 |
| | 4,789 | 13,017 | 10,774 | 5,676 | 2,714 |
| 73 | 6,845 | 16,921 | 14,681 | 7,907 | 3,687 |
| | 5,496 | 13,587 | 11,789 | 6,349 | 2,960 |
| 83 | 7,717 | 17,903 | 16,831 | 8,819 | 4,260 |
| | 6,196 | 14,376 | 13,515 | 7,081 | 3,420 |

LEGEND: Above Number - cpm corrected for all background.
Below Number - cpm normalized, corrected for geometry.

APPENDIX B-16 (CONTINUED)

SEDIMENT COMPARTMENT CPM (Second Run, Tank II)
( Corrected for Background, Normalized for Attenuation, Geometry)

| HOURS ELAPSED TIME | II3H | II2H | II1H | II3R | II1R |
|---|---|---|---|---|---|
| 98 | 9,298 | 18,657 | 19,967 | 10,059 | 4,773 |
| | 7,466 | 14,981 | 16,033 | 8,077 | 3,833 |
| 115 | 10,710 | 19,937 | 20,104 | 11,110 | 5,114 |
| | 8,600 | 16,009 | 16,143 | 8,921 | 4,106 |
| 136 | 13,992 | 21,539 | 25,355 | 13,192 | 6,121 |
| | 11,235 | 17,295 | 20,360 | 10,593 | 4,915 |
| 159 | 16,111 | 21,781 | 27,789 | 14,708 | 6,914 |
| | 12,937 | 17,490 | 22,314 | 11,810 | 5,551 |
| 185 | 18,360 | 22,113 | 28,814 | 16,288 | 6,794 |
| | 14,743 | 17,757 | 23,138 | 13,079 | 5,455 |
| 234 | 21,254 | 22,325 | 34,952 | 18,889 | 7,929 |
| | 17,066 | 17,927 | 28,066 | 15,168 | 6,366 |
| 280 | 22,067 | 21,103 | 36,800 | 19,404 | 7,853 |
| | 17,720 | 16,946 | 29,551 | 15,581 | 6,305 |
| 332 | 22,754 | 22,805 | 38,648 | 19,787 | 8,214 |
| | 18,271 | 18,312 | 31,034 | 15,889 | 6,596 |
| 375 | 22,608 | 24,093 | 35,825 | 19,640 | 7,954 |
| | 18,154 | 19,347 | 28,767 | 15,770 | 6,387 |

LEGEND: Above Number - cpm corrected for all background.
Below Number - cpm normalized, corrected for geometry.

APPENDIX B-16 (CONTINUED)

SEDIMENT COMPARTMENT CPM (Second Run, Tank II)
(Corrected for Background, Normalized for Attenuation, Geometry)

| HOURS ELAPSED TIME | II3H | II2H | II1H | II3R | II1R |
|---|---|---|---|---|---|
| 421 | 22,722 | 24,521 | 36,071 | 19,584 | 7,884 |
| | 18,246 | 19,690 | 28,965 | 15,726 | 6,330 |
| 472 | 22,678 | 23,783 | 36,233 | 19,443 | 7,901 |
| | 18,210 | 19,098 | 29,095 | 15,612 | 6,344 |
| 543 | 22,185 | 22,583 | 35,855 | 19,217 | 7,641 |
| | 17,814 | 18,134 | 28,791 | 15,431 | 6,136 |
| 568 | 21,948 | 22,728 | 35,988 | 19,326 | 7,656 |
| | 17,624 | 18,250 | 28,898 | 15,518 | 6,148 |
| 617 | 21,617 | 23,096 | 34,585 | 18,951 | 7,650 |
| | 17,358 | 18,546 | 27,772 | 15,218 | 6,143 |
| 880 | 21,762 | 21,947 | 31,389 | 18,141 | 7,488 |
| | 17,475 | 17,623 | 25,205 | 14,567 | 6,013 |

LEGEND: Above Number - cpm corrected for all background.
Below Number - cpm normalized, corrected for geometry.

APPENDIX B-16 (CONTINUED)

SEDIMENT COMPARTMENT CPM (Second Run, Tank II)
(Corrected for Background, Normalized for Attenuation, Geometry)

| HOURS ELAPSED TIME | II4C | II2C | II4E | II2E | II3E | II1E |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5.5 | 827 | 904 | 865 | 790 | 993 | 679 |
| | 664 | 725 | 694 | 634 | 797 | 545 |
| 13.5 | 1,298 | 1,553 | 1,607 | 1,593 | 1,643 | 1,466 |
| | 1,042 | 1,247 | 1,290 | 1,279 | 1,319 | 1,177 |
| 26 | 1,903 | 2,446 | 2,550 | 2,665 | 2,584 | 2,577 |
| | 1,528 | 1,964 | 2,047 | 2,139 | 2,075 | 2,069 |
| 41 | 2,741 | 3,628 | 3,536 | 4,511 | 4,041 | 4,346 |
| | 2,201 | 2,913 | 2,839 | 3,622 | 3,244 | 3,490 |
| 51 | 3,015 | 4,558 | 4,449 | 6,013 | 5,059 | 5,186 |
| | 2,421 | 3,660 | 3,572 | 4,828 | 4,062 | 4,164 |
| 64 | 3,350 | 4,552 | 5,489 | 6,071 | 6,012 | 6,380 |
| | 2,690 | 3,655 | 4,407 | 4,875 | 6,671 | 5,123 |
| 73 | 3,611 | 5,429 | 6,259 | 6,300 | 6,671 | 7,542 |
| | 2,900 | 4,359 | 5,026 | 5,059 | 5,356 | 6,056 |
| 83 | 4,234 | 6,135 | 7,008 | 7,279 | 7,497 | 8,465 |
| | 3,399 | 4,926 | 5,627 | 5,845 | 6,020 | 6,797 |

LEGEND: Above Number - cpm corrected for all background
Below Number - cpm normalized, corrected for geometry.

APPENDIX B-16 (CONTINUED)

SEDIMENT COMPARTMENT CPM (Second Run, Tank II)
(Corrected for Background, Normalized for Attenuation, Geometry)

| HOURS ELAPSED TIME | II4C | II2C | II4E | II2E | II3E | II1E |
|---|---|---|---|---|---|---|
| 98 | 4,216 | 7,083 | 8,161 | 8,712 | 8,831 | 10,226 |
| | 3,385 | 5,688 | 6,553 | 6,996 | 7,091 | 8,211 |
| 115 | 4,809 | 8,028 | 8,957 | 10,436 | 9,439 | 11,558 |
| | 3,862 | 6,446 | 7,192 | 8,380 | 7,579 | 9,281 |
| 136 | 6,081 | 9,889 | 9,927 | 12,789 | 11,177 | 13,450 |
| | 4,883 | 7,940 | 7,971 | 10,269 | 8,975 | 10,800 |
| 159 | 6,261 | 11,723 | 10,660 | 15,348 | 12,789 | 14,917 |
| | 5,027 | 9,413 | 8,559 | 12,324 | 10,269 | 11,978 |
| 185 | 7,127 | 12,952 | 11,999 | 17,496 | 14,258 | 17,036 |
| | 5,723 | 10,400 | 9,635 | 14,049 | 11,449 | 13,679 |
| 234 | 7,999 | 15,070 | 12,629 | 21,372 | 15,919 | 18,733 |
| | 6,423 | 12,101 | 10,141 | 17,162 | 12,783 | 15,042 |
| 280 | 7,987 | 15,105 | 13,841 | 21,629 | 16,665 | 18,903 |
| | 6,413 | 12,129 | 11,114 | 17,368 | 13,381 | 15,179 |
| 332 | 7,720 | 14,053 | 14,422 | 22,190 | 16,190 | 18,518 |
| | 6,199 | 11,284 | 11,580 | 17,818 | 13,000 | 14,869 |
| 375 | 7,744 | 13,622 | 13,393 | 21,402 | 16,017 | 18,127 |
| | 6,218 | 10,938 | 10,754 | 17,186 | 12,862 | 14,555 |

LEGEND: Above Number - cpm corrected for all background.
Below Number - cpm normalized, corrected for geometry.

APPENDIX B-16 (CONTINUED)

SEDIMENT COMPARTMENT CPM (Second Run, Tank II)
(Corrected for Background, Normalized for Attenuation, Geometry)

| HOURS ELAPSED TIME | II4C | II2C | II4E | II2E | II3E | II1E |
|---|---|---|---|---|---|---|
| 421 | 7,616 | 13,295 | 13,607 | 21,661 | 15,850 | 17,843 |
| | 6,116 | 10,675 | 10,926 | 17,394 | 12,727 | 14,327 |
| 472 | 7,617 | 12,837 | 13,357 | 21,162 | 15,669 | 17,691 |
| | 6,116 | 10,308 | 10,725 | 16,993 | 12,582 | 14,205 |
| 543 | 7,615 | 12,729 | 12,789 | 20,769 | 14,894 | 17,185 |
| | 6,114 | 10,221 | 10,269 | 16,677 | 11,959 | 13,799 |
| 568 | 7,488 | 12,403 | 14,088 | 20,658 | 15,078 | 16,690 |
| | 6,013 | 9,959 | 11,313 | 16,588 | 12,108 | 13,402 |
| 617 | 7,521 | 12,248 | 14,238 | 20,245 | 15,043 | 16,843 |
| | 6,039 | 9,835 | 11,433 | 16,256 | 12,079 | 13,525 |
| 880 | 7,355 | 12,195 | 14,253 | 19,313 | 14,384 | 16,257 |
| | 5,906 | 9,792 | 11,445 | 15,508 | 11,550 | 13,054 |

LEGEND: Above Number - cpm corrected for all background.
Below Number - cpm normalized, corrected for geometry.

APPENDIX B-16 (CONTINUED)

SEDIMENT (Second Run, Tank II, cpm)
Decay Correction, Geometric Average, Mg Selenium

| HOURS ELAPSED TIME | H | | R | | C | | E | |
|---|---|---|---|---|---|---|---|---|
| | AVERAGE cpm | FRACTION cpm | AVERAGE cpm | FRACTION cpm | AVERAGE cpm | FRACTION cpm | AVERAGE cpm | FRACTION cpm |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5.5 | 875 | 385 | 609 | 69 | 694 | 89 | 667 | 207 |
| 13.5 | 1,912 | 842 | 1,107 | 126 | 1,144 | 147 | 1,266 | 393 |
| 26 | 3,471 | 1,530 | 1,910 | 217 | 1,746 | 224 | 2,082 | 647 |
| 41 | 5,824 | 2,566 | 2,892 | 329 | 2,557 | 329 | 3,298 | 1,026 |
| 51 | 7,110 | 3,133 | 3,413 | 389 | 3,040 | 391 | 4,156 | 1,292 |
| 64 | 8,342 | 3,676 | 4,195 | 478 | 3,172 | 408 | 5,269 | 1,638 |
| 73 | 9,092 | 4,006 | 4,654 | 530 | 3,629 | 467 | 5,374 | 1,671 |
| 83 | 10,070 | 4,438 | 5,250 | 598 | 4,162 | 536 | 6,072 | 1,888 |
| 98 | 11,486 | 5,062 | 5,955 | 678 | 4,536 | 584 | 7,212 | 2,243 |
| 115 | 12,338 | 5,437 | 6,513 | 742 | 5,154 | 664 | 8,108 | 2,522 |
| 136 | 15,031 | 6,624 | 7,754 | 883 | 6,411 | 826 | 9,503 | 2,956 |
| 159 | 16,419 | 7,236 | 8,680 | 989 | 7,220 | 930 | 10,782 | 3,354 |
| 185 | 17,595 | 7,754 | 9,267 | 1,056 | 8,061 | 1,038 | 12,200 | 3,795 |
| 234 | 20,031 | 8,827 | 10,767 | 1,227 | 9,262 | 1,193 | 13,782 | 4,287 |
| 280 | 20,484 | 9,027 | 10,943 | 1,247 | 9,271 | 1,194 | 14,260 | 4,435 |
| 332 | 21,472 | 9,462 | 11,242 | 1,281 | 8,741 | 1,126 | 14,316 | 4,453 |
| 375 | 21,105 | 9,301 | 11,078 | 1,262 | 8,578 | 1,105 | 13,839 | 4,304 |
| 421 | 21,286 | 9,381 | 11,028 | 1,257 | 8,395 | 1,081 | 13,843 | 4,306 |
| 472 | 21,153 | 9,322 | 10,978 | 1,251 | 8,212 | 1,058 | 13,626 | 4,238 |
| 543 | 20,638 | 9,095 | 10,783 | 1,229 | 8,167 | 1,052 | 13,176 | 4,098 |
| 568 | 20,599 | 9,077 | 10,833 | 1,234 | 7,986 | 1,028 | 13,352 | 4,153 |
| 617 | 20,258 | 8,927 | 10,680 | 1,217 | 7,937 | 1,022 | 13,323 | 4,144 |
| 880 | 19,444 | 8,569 | 10,290 | 1,173 | 7,849 | 1,011 | 12,889 | 4,009 |

APPENDIX B-16 (CONTINUED)

SEDIMENT (Second Run, Tank II, cpm)
Decay Correction, Geometric Average, Mg Selenium

| HOURS ELAPSED TIME | IDEALIZED CONTAINER SUM OF FRACTIONS | Cpm COMPARTMENT | mg Se COMPARTMENT | DECAY CORRECTED mg Se |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 5.5 | 750 | 498,665 | .2326 | .2326 |
| 13.5 | 1,508 | 1,002,650 | .4678 | .4678 |
| 26 | 2,618 | 1,740,675 | .8121 | .8121 |
| 41 | 4,250 | 2,825,771 | 1.318 | 1.318 |
| 51 | 5,205 | 3,460,739 | 1.614 | 1.631 |
| 64 | 6,200 | 4,122,302 | 1.923 | 1.944 |
| 73 | 6,674 | 4,437,458 | 2.070 | 2.092 |
| 83 | 7,460 | 4,960,060 | 2.314 | 2.339 |
| 98 | 8,567 | 5,696,090 | 2.657 | 2.715 |
| 115 | 9,365 | 6,226,671 | 2.905 | 2.969 |
| 136 | 11,289 | 7,505,914 | 3.502 | 3.579 |
| 159 | 12,509 | 8,317,077 | 3.880 | 3.965 |
| 185 | 13,643 | 9,071,059 | 4.232 | 4.373 |
| 234 | 15,534 | 10,328,361 | 4.819 | 4.979 |
| 280 | 15,903 | 10,573,705 | 4.933 | 5.153 |
| 332 | 16,322 | 10,852,293 | 5.063 | 5.406 |
| 375 | 15,972 | 10,619,582 | 4.954 | 5.348 |
| 421 | 16,025 | 10,654,821 | 4.971 | 5.366 |
| 472 | 15,869 | 10,551,099 | 4.923 | 5.373 |
| 543 | 15,474 | 10,288,468 | 4.772 | 5.323 |
| 568 | 15,492 | 10,300,436 | 4.806 | 5.420 |
| 617 | 15,310 | 10,179,427 | 4.749 | 5.415 |
| 880 | 14,762 | 9,815,068 | 4.579 | 5.454 |

APPENDIX B-17

STABILITY PARAMETERS FIRST RUN
(Data of Non-Experimental Parameters, Tanks I, II)

| | pH | | DO | | TDS | | TEMPERATURE | |
|---|---|---|---|---|---|---|---|---|
| DAY | I | II | I | II | I | II | I | II |
| 1 | 8.4 | 8.3 | 9.8 | 8.4 | 410 | 460 | 21 | 21 |
| 2 | 8.5 | 8.4 | | | 420 | 440 | 21 | 22 |
| 3 | 8.5 | 8.4 | 9.0 | 8.2 | | | | |
| 4 | 8.5 | 8.4 | 8.3 | 7.6 | 400 | 450 | 22 | 22 |
| 5 | 8.5 | 8.5 | 8.0 | 8.3 | 430 | 450 | 21 | 22 |
| 6 | 8.3 | 8.4 | | | | | 21 | 22 |
| 7 | 8.5 | 8.4 | 7.8 | 9.1 | 410 | 465 | | |
| 8 | 8.4 | 8.3 | | | | | 22 | 22 |
| 9 | 8.5 | 8.3 | 7.2 | 8.3 | 400 | 480 | 22 | 23 |
| 10 | 8.4 | 8.3 | 7.8 | 8.0 | | | 22 | 23 |
| 11 | | | | | 450 | 470 | 21 | 23 |
| 12 | 8.6 | 8.5 | 8.2 | 7.5 | | | 22 | 23 |
| 13 | 8.5 | 8.4 | 7.8 | 7.2 | 435 | 470 | 21 | 22 |
| 14 | 8.5 | 8.6 | 8.1 | 7.5 | | | 21 | 22 |
| 15 | 8.5 | 8.4 | 6.2 | 7.4 | 410 | 480 | 21 | 22 |
| 16 | 8.3 | 8.6 | 6.8 | 6.6 | | | 22 | 22 |
| 17 | 8.4 | 8.5 | 7.2 | 6.2 | 430 | 450 | 21 | 22 |
| 18 | 8.3 | 8.4 | | | 440 | 460 | 21 | 22 |
| 19 | 8.5 | 8.5 | 6.5 | 7.1 | | | 21 | 22 |
| 20 | | | | | 420 | 475 | 22 | 23 |
| 21 | 8.5 | 8.4 | 6.6 | 6.8 | 420 | 470 | 22 | 23 |
| 22 | 8.4 | 8.6 | 5.4 | 7.3 | 430 | 465 | 21 | 22 |
| 23 | 8.5 | 8.6 | 5.8 | 6.4 | | | 21 | 22 |
| 24 | | | | | 425 | 485 | | |
| 25 | 8.5 | 8.4 | 6.1 | 5.9 | 430 | 480 | 22 | 22 |
| 26 | | | | | | | | |
| 27 | | | | | | | 21 | 22 |
| 28 | 8.4 | 8.5 | 6.2 | 5.8 | 430 | 485 | 21 | 22 |
| 29 | 8.5 | 8.4 | 5.9 | 6.2 | 440 | 490 | | |
| 30 | 8.5 | 8.5 | 6.4 | 6.5 | | | 21 | 22 |
| 31 | 8.4 | 8.5 | 5.9 | 6.7 | | | 21 | 23 |

## APPENDIX B-18

## STABILITY PARAMETERS SECOND RUN

(Data of Non-Experimental Parameters, Second Run, Tanks I, II)

| | pH | | DO | | TDS | | TEMP. | |
|---|---|---|---|---|---|---|---|---|
| DAY | I | II | I | II | I | II | I | II |
| 0 | 8.9 | 8.5 | 7.3 | 6.2 | 800 | 790 | 24 | 24 |
| 1 | 8.7 | 8.4 | 9.0 | 8.4 | 800 | 780 | 24 | 25 |
| 2 | 8.9 | 8.5 | 8.2 | 6.5 | 800 | 780 | 24 | 24 |
| 3 | 8.5 | 8.4 | 7.9 | 7.3 | 820 | 800 | 23 | 24 |
| 4 | | | 8.1 | 7.9 | | | 23 | 24 |
| 5 | | | 9.2 | 7.5 | 840 | 800 | 24 | 25 |
| 6 | 8.5 | 8.5 | | | 860 | 800 | 24 | 25 |
| 7 | | | 8.3 | 8.0 | | | 24 | 25 |
| 8 | 8.5 | 8.5 | 7.9 | 7.6 | 840 | 800 | 23 | 24 |
| 9 | | | | | 840 | 800 | 24 | 25 |
| 10 | | | 6.4 | 5.9 | 840 | 800 | 29 | 25 |
| 11 | | | 5.8 | 5.8 | 830 | 810 | 24 | 24 |
| 12 | 8.4 | 8.3 | 5.5 | 6.0 | 850 | 840 | 25 | 26 |
| 13 | | | 7.2 | 6.5 | 780 | 820 | 25 | 26 |
| 14 | | | | | | | 25 | 26 |
| 15 | 8.4 | 8.3 | 8.5 | 7.9 | 830 | 800 | 25 | 26 |
| 16 | | | 8.3 | 8.1 | 825 | 810 | 24 | 26 |
| 17 | 8.5 | 8.4 | 7.6 | 7.7 | 830 | 830 | 24 | 26 |
| 18 | | | 6.5 | 6.0 | 835 | 810 | 24 | 26 |
| 19 | 8.4 | 8.4 | | | 800 | 790 | 24 | 25 |
| 20 | | | 5.0 | 4.8 | 840 | 805 | 23 | 24 |
| 21 | | | 4.2 | 5.1 | 810 | 780 | 23 | 25 |
| 22 | 8.3 | 8.2 | 3.9 | 3.5 | 830 | 820 | 24 | 25 |
| 23 | | | 4.5 | 4.5 | 770 | 780 | 24 | 25 |
| 24 | 8.3 | 8.3 | 4.2 | 3.8 | 800 | 790 | 24 | 25 |
| 25 | | | 4.5 | 4.3 | 860 | 800 | 23 | 24 |
| | 8.4 | 8.3 | 3.2 | 3.9 | | | | |
| 29 | | | 3.0 | 4.5 | 850 | 805 | 24 | 25 |
| 30 | 8.3 | 8.5 | 4.2 | 6.1 | 875 | 820 | 24 | 26 |
| 34 | | | 3.4 | 5.6 | 800 | 800 | 25 | 25 |
| 37 | 8.3 | 8.4 | 4.7 | 6.0 | 780 | 810 | 25 | 25 |
| 38 | | | 3.7 | 3.5 | 800 | 790 | 24 | 25 |
| 39 | | | 5.2 | 4.1 | 800 | 780 | 24 | 24 |
| 42 | 8.3 | 8.5 | 4.8 | 4.0 | 800 | 780 | 24 | 25 |

APPENDIX B-19

SUSPENDED PARTICULATE

FILTER WEIGHTS (First Run, Tank I, 20 ml Sample)

| FILTER NUMBER | FILTER WEIGHT GRAMS | SUSPENDED PARTICULATE + FILTER GRAMS | DIFFERENCE mg |
|---|---|---|---|
| 00 | .0781 | .0796 | 1.6 |
| 19 | .0717 | .0732 | 1.5 |
| 17 | .0688 | .0696 | 0.8 |
| 5 | .0953 | .0965 | 1.2 |
| 7 | .0861 | .0874 | 1.3 |
| 9 | .0856 | .0868 | 1.2 |
| 11 | .0565 | .0580 | 1.5 |
| 13 | .0707 | .0721 | 1.4 |
| 15 | .0708 | .0727 | 1.9 |
| 2 even | .0818 | .0830 | 1.2 |
| 3 | .0836 | .0849 | 1.3 |
| 21 | .0586 | .0871 | 1.5 |
| 23 | .0625 | .0633 | 0.8 |
| 25 | .0659 | .0672 | 1.3 |
| 27 | .0707 | .0719 | 1.2 |
| 29 | .0663 | .0671 | 0.8 |
| 31 | .0665 | .0681 | 1.6 |
| 33 | .0830 | .0851 | 2.1 |
| 35 | .1012 | .1030 | 1.8 |
| 37 | .1082 | .1109 | 2.7 |
| 39 | .1006 | .1032 | 2.6 |
| 41 | .1013 | .1041 | 2.8 |
| 43 | .1025 | .1056 | 3.1 |
| 45 | .1010 | .1038 | 2.8 |
| 47 | .0987 | .1014 | 2.7 |
| 49 | .0989 | .1017 | 2.8 |
| 51 | .1029 | .1058 | 2.9 |
| 53 | .1033 | .1057 | 2.4 |
| 55 | .1022 | .1051 | 2.9 |
| 57 | .1061 | .1068 | 2.7 |
| AVERAGE | | | 1.88 |

APPENDEX B-19 (CONTINUED)

SUSPENDED PARTICULATE

FILTER WEIGHTS (First Run, Tank II, 20 ml Sample)

| FILTER NUMBER | FILTER WEIGHT GRAMS | SUSPENDED PARTICULATE + FILTER GRAMS | DIFFERENCE mg |
|---|---|---|---|
| 0 | .0672 | .0690 | 1.8 |
| 20 | .0649 | .0665 | 1.6 |
| 18 | .0681 | .0699 | 1.8 |
| 6 | .0878 | .0899 | 2.1 |
| 8 | .0858 | .0877 | 1.9 |
| 10 | .0566 | .0588 | 2.2 |
| 12 | .0605 | .0623 | 1.8 |
| 14 | .0702 | .0716 | 1.4 |
| 16 | .0706 | .0718 | 1.2 |
| 1 | .0855 | .0868 | 1.3 |
| 4 | .0859 | .0874 | 1.5 |
| 22 | .0639 | .0651 | 1.2 |
| 24 | .0592 | .0607 | 1.5 |
| 26 | .0660 | .0677 | 1.7 |
| 28 | .0701 | .0720 | 1.9 |
| 30 | .0658 | .0679 | 2.1 |
| 32 | .1003 | .1026 | 2.3 |
| 34 | .0810 | .0830 | 2.0 |
| 36 | .1038 | .1061 | 2.3 |
| 38 | .1124 | .1148 | 2.4 |
| 40 | .0941 | .0969 | 2.8 |
| 42 | .1003 | .1034 | 3.1 |
| 44 | .1016 | .1046 | 3.0 |
| 46 | .0976 | .1002 | 2.6 |
| 48 | .0990 | .1019 | 2.9 |
| 50 | .1029 | .1055 | 2.6 |
| 52 | .1034 | .1060 | 2.6 |
| 54 | .1014 | .1037 | 2.3 |
| 56 | .1016 | .1041 | 2.5 |
| 58 | .1047 | .1067 | 2.0 |
| AVERAGE | | | 2.08 |

APPENDIX B-20

SUSPENDED PARTICULATE FILTER WEIGHTS
(Second Run, Tank I, 40 ml Sample)

| FILTER NO. | TIME ELAPSED | FILTER WT. G. | FILTER & SAMPLE G. | WEIGHT SAMPLE mg |
|---|---|---|---|---|
| 1 | 0 | .1011 | .1035 | 2.4 |
| 3 | 0.083 | .0937 | .0958 | 2.1 |
| 5 | 0.25 | .1079 | .1101 | 2.2 |
| 7 | 0.5 | .0949 | .0972 | 2.3 |
| 9 | 1 | .0931 | .0955 | 2.4 |
| 11 | 3 | .0882 | .0903 | 2.1 |
| 13 | 12 | .0860 | .0880 | 2.0 |
| 15 | 18 | | | |
| 17 | 23.5 | .0870 | .0896 | 2.6 |
| 19 | 37 | .1011 | .1032 | 2.1 |
| 21 | 48 | .0860 | .0882 | 2.2 |
| 23 | 61 | .0856 | .0877 | 2.1 |
| 25 | 70.5 | .1015 | .1044 | 2.9 |
| 27 | 81 | .1006 | .1032 | 2.6 |
| 29 | 96 | .0998 | .1022 | 2.4 |
| 31 | 113 | .0995 | .1026 | 3.1 |
| 33 | 134 | .0982 | .1012 | 3.0 |
| 35 | 157 | .1025 | .1057 | 3.2 |
| 39 | 232 | .1213 | .1244 | 3.1 |
| 41 | 256 | .1097 | .1123 | 2.6 |
| 43 | 280 | .0997 | .1029 | 3.2 |
| 45 | 303 | .0870 | .0898 | 2.8 |
| 51 | 353 | .0993 | .1024 | 3.1 |
| 53 | 400 | .0992 | .1025 | 3.3 |
| 55 | 421 | .1008 | .1036 | 2.8 |
| 57 | 447 | .1059 | .1088 | 2.9 |
| 59 | 472 | .1026 | .1055 | 2.9 |
| 61 | 496 | .0971 | .0994 | 2.3 |
| 63 | 518 | .1021 | .1044 | 2.3 |
| 65 | 568 | .1055 | .1077 | 2.2 |
| 71 | 720 | .1013 | .1033 | 2.0 |
| 73 | 736 | .0994 | .1015 | 2.1 |
| 75 | 792 | .1008 | .1028 | 2.0 |
| 77 | 830 | .1039 | .1082 | 4.3 |
| 81 | 904 | .1001 | .1056 | 5.5 |
| 83 | 928 | .1000 | .1055 | 5.5 |
| 85 | 952 | .1014 | .1071 | 5.7 |
| 87 | 1,024 | .1005 | .1076 | 7.1 |
| 89 | | .1002 | .1081 | 7.9 |
| AVERAGE | | | | 3.08 |

APPENDIX B-20 (CONTINUED)

SUSPENDED PARTICULATE FILTER WEIGHTS
(Second Run, Tank II, 40 ml Sample)

| FILTER NO. | TIME ELAPSED | FILTER WT. G. | FILTER & SAMPLE | WEIGHT SAMPLE mg |
|---|---|---|---|---|
| 2 | 0 | .0936 | .0952 | 1.6 |
| 4 | 0.033 | .1038 | .1054 | 1.6 |
| 6 | 0.25 | .0957 | .0971 | 1.4 |
| 8 | 0.5 | .0960 | .0978 | 1.8 |
| 10 | 1 | .0927 | .0942 | 1.5 |
| 12 | 3 | .0852 | .0866 | 1.4 |
| 14 | 12 | .0862 | .0877 | 1.5 |
| 16 | 18 | .0873 | .0886 | 1.3 |
| 18 | 23.5 | .1007 | .1022 | 1.5 |
| 20 | 37 | .1007 | .1020 | 1.3 |
| 22 | 48 | .0861 | .0874 | 1.3 |
| 24 | 61 | .1000 | .1021 | 2.1 |
| 26 | 70.5 | .1038 | .1059 | 2.1 |
| 28 | 81 | .1030 | .1046 | 1.6 |
| 30 | 96 | .1042 | .1060 | 1.8 |
| 34 | 134 | .1010 | .1031 | 2.1 |
| 36 | 157 | .0970 | .0988 | 1.8 |
| 38 | 183 | .1047 | .1060 | 1.3 |
| 40 | 232 | .1076 | .1091 | 1.5 |
| 42 | 256 | .1101 | .1110 | .9 |
| 44 | 280 | .1064 | .1077 | 1.3 |
| 46 | 303 | .1092 | .1112 | 2.0 |
| 48 | 353 | .1023 | .1042 | 1.9 |
| 50 | 400 | .1037 | .1055 | 1.8 |
| 56 | 421 | .1080 | .1099 | 1.9 |
| 58 | 447 | .1061 | .1075 | 1.4 |
| 60 | 472 | .0949 | .0966 | 1.7 |
| 62 | 496 | .1067 | .1084 | 1.7 |
| 64 | 518 | .1067 | .1080 | 1.3 |
| 66 | 568 | .1009 | .1025 | 1.6 |
| 68 | 617 | .1044 | .1061 | 1.7 |
| 70 | 641 | .1033 | .1046 | 1.3 |
| 72 | 712 | .1002 | .1027 | 2.5 |
| 74 | 736 | .1000 | .1024 | 2.4 |
| 76 | 792 | .1027 | .1046 | 1.9 |
| 78 | 830 | .1048 | .1078 | 3.0 |
| 82 | 904 | .1001 | .1020 | 1.9 |

APPENDIX B-20 (CONTINUED)

SUSPENDED PARTICULATE FILTER WEIGHTS
(Second Run, Tank II, 40 ml Sample)

| FILTER NO. | TIME ELAPSED | FILTER WT. G. | FILTER & SAMPLE | WEIGHT SAMPLE mg |
|---|---|---|---|---|
| 84 | 928 | .0993 | .1011 | 1.8 |
| 86 | 952 | .1011 | .1033 | 2.2 |
| 88 | 1,024 | .0996 | .1026 | 3.0 |
| 90 | | .1000 | .1029 | 2.9 |
| AVERAGE | | | | 1.77 |

APPENDIX B-21

SORPTION ON MICROSCOPE SLIDE

SECOND RUN

A microscope slide was *in situ* for the duration of the experiment.

It was counted and then scraped clean and counted again.

A second slide was immersed for 15 minutes and allowed to drip dry and then counted.

| | RAW COUNT PER TEN MINUTES | | CORRECTED cpm | |
|---|---|---|---|---|
| | TANK I | TANK II | TANK I | TANK II |
| Duration Slide | 2,442 | 2,371 | 132 | 125 |
| Scraped | 1,226 | 1,562 | 10.6 | 44 |
| 15 minute slide | 1,212 | 1,327 | 9.2 | 20.7 |
| % Remaining on Glass (Duration Slide) | | | 8% | 16% |

Background = 11,212 per 100 minutes.

APPENDIX B-22

FISH ORIENTATION COMPARISON
(Count Rates Anterior End Up Compared) (Down/Up)

| INVERSION OCCURENCE | ANTERIOR UP cpm | AVE. | ANTERIOR DOWN cpm | AVE. | ADJUSTMENT FRACTION |
|---|---|---|---|---|---|
| 1 | 968 | 999 | 1,389 | 1,442 | 1.44 |
| | 1,030 | | 1,496 | | |
| 2 | 1,349 | 1,349 | 1,441 | 1,512 | 1.12 |
| | | | 1,583 | | |
| 3 | 1,089 | 1,148 | 1,562 | 1,534 | 1.33 |
| | 1,207 | | 1,506 | | |
| 4 | 820 | 825 | 1,062 | 1,010 | 1.22 |
| | 830 | | 958 | | |
| 5 | 940 | 925 | 1,172 | 1,172 | 1.26 |
| | 911 | | | | |
| 6 | 1,177 | 1,177 | 1,436 | 1,436 | 1.22 |
| 7 | 2,087 | 2,035 | 2,683 | 2,684 | 1.31 |
| | 1,984 | | 2,686 | | |
| 8 | 1,096 | 1,102 | 1,603 | 1,622 | 1.47 |
| | 1,109 | | 1,641 | | |
| 9 | 754 | 754 | 931 | 911 | 1.20 |
| | | | 892 | | |
| 10 | 1,505 | 1,484 | 1,973 | 1,991 | 1.34 |
| | 1,464 | | 2,010 | | |
| 11 | 1,974 | 1,959 | 2,857 | 2,899 | 1.48 |
| | 1,944 | | 2,942 | | |
| 12 | 2,798 | 2,790 | 4,123 | 4,121 | 1.47 |
| | 2,783 | | 4,119 | | |
| 13 | 5,644 | 5,644 | 7,349 | 7,413 | 1.31 |
| | | | 7,478 | | |
| 14 | 5,358 | 5,467 | 8,282 | 8,178 | 1.49 |
| | 5,576 | | 8,075 | | |
| 15 | 9,593 | 9,593 | 12,324 | 12,324 | 1.28 |
| 16 | 11,506 | 11,507 | 16,579 | 16,457 | 1.43 |
| | 11,509 | | 16,336 | | |
| 17 | 12,140 | 12,228 | 16,915 | 16,716 | 1.36 |
| | 12,316 | | 16,518 | | |
| 18 | 7,504 | 7,515 | 12,353 | 12,353 | 1.64 |
| | 7,526 | | 12,354 | | |
| 19 | 7,261 | 7,187 | 9,948 | 9,993 | 1.39 |
| | 7,114 | | 10,039 | | |
| 20 | 6,892 | 6,971 | 9,474 | 9,484 | 1.36 |
| | 7,050 | | 9,495 | | |
| AVERAGE | | | | | 1.356 |

APPENDIX B-23

FISH COMPARTMENT WEIGHTS
(Weight in Grams)

| First Run | Tank I | | | | | | | Tank II | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fish Number* | | | | | | Total g | Fish Number* | | | | | | Total g. |
| Beginning | 1 | 2 | 3 | 4 | 5 | 6 | | 1 | 2 | 3 | 4 | 5 | 6 | |
| Weight | 1.8 | 1.6 | 1.9 | 2.3 | 2.3 | 2.4 | = 12.3g | 1.7 | 1.9 | 2.0 | 2.3 | 2.2 | 2.5 | = 12.65 g |
| End Weight | - | - | - | - | - | - | = 13.6g | - | - | - | - | - | - | = 10.80 g |

| Second Run | Tank I | | | | | | | Tank II | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fish Number | | | | | | Total g. | | | | | | Total g. |
| Beginning | 1 | 2 | 3 | 4 | 5 | 6 | | 1 | 2 | 3 | 4 | | |
| Weight | 1.7 | 2.2 | 2.4 | 2.9 | 3.7 | | = 11.95 g. | 2.4 | 3.0 | 3.0 | 3.4 | | = 11.8 g |
| End Weight | 2.4 | 2.4 | 2.4 | 2.5 | 3.5 | 3.7 | = 14.3 g. | 2.2 | 2.4 | 2.9 | 3.3 | | = 10.8 g |

* Numbers do not correspond to the same fish from first to second runs but do within the second run.

# APPENDIX B-24

## SPECIES LIST

ALGAE

MYXOPHYCEAE
- Phormidium (abundant in bottom)
- Oscillatoria

SCENEDESMACEAE
- Scenedesmus (Predominant Plankton First Run)

OOCYSTACEAE
- Ankistrodesmus (Predominant Plankton Second Run)

CHLOROCOCCACEAE
- Golenkinia (Abundant First Run)

ULOTRICHACEAE
- Ulothrix

DESMIDACEAE
- Tetmemorus

BACILLARIOPHYCEAE
- Navicula (common)
- Stauroneis

PROTOZOA
- Vorticella
- Stylonychia
- Amoeba

ASHELMINTHES
- Philodina
- Nematode

# APPENDIX C

# APPENDIX C-1

## SELENIUM-75 DECAY SCHEME

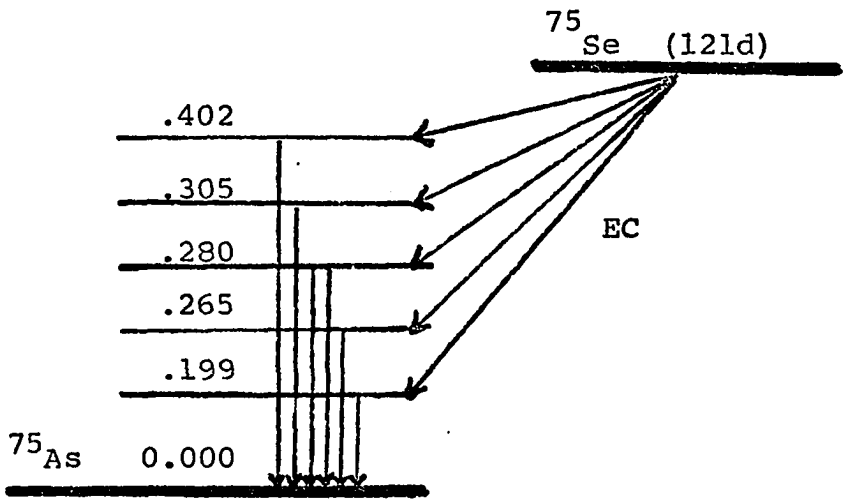
The mode of decay is by electron capture and gamma emission of various energies ranging from 0.402 Mev to 0.199 Mev:

0.136 Mev...57%

0.265 Mev...60%

0.280 Mev...25%

0.402 Mev...12%



APPENDIX C-2

PARTS PER MILLION SELENIUM IN ASSAY AMOUNT

Assay: $\left[0.0057 \text{ mg}/0.1 \text{ ml}\right]$ $H_2SeO_3$

then 0.0057 mg/0.1 ml = $\left[\frac{0.057 \text{ mg}}{\text{ml}}\right]$ $H_2SeO_3$

and $\frac{0.057 \text{ mg } H_2SeO_3}{\text{ml}}$ $\left(\frac{0.612 \text{ Se-79}}{H_2SeO_3}\right)$

$= \left[0.0348 \text{ mg/ml}\right]$ Se = .0348 grams per liter

= 34.8 mg/l = 34.8 ppm Se

If use whole 0.1 ml Assay amount

= 0.00348 mg/60 liter

= $5.8 \times 10^{-5}$ mg/l = ppm insignificant

to levels in experimental tanks 0.01 ppm

If use 5 lambda from whole Assay amounts then order of $10^{-3}$ less significant.

# APPENDIX C-3

## SPIKE QUANTITY FOR EXPERIMENTAL SYSTEM

Stock Solution:

5.0 ml = 0.0057 mg $H_2SeO_3$ in 0.5 N. NCL

= 1 mCi April 2, 1973

= 175 mCi/mg.

Remove: 1 lambda from stock:

Contains $\frac{1}{5000}$ mCi

and $\frac{0.0057}{5 \times 10^3}$

= $1.14 \times 10^{-6}$ mg $H_2SeO_3$

and $1.14 \times 10^{-6}$ (.612) = $0.697 \times 10^{-6}$ mg Se

Remove: 5 lambda from stock:

Contains $\frac{1}{1000}$ mCi

and $5.7 \times 10^{-6}$ mg $H_2SeO_3$

and $5.7 \times 10^{-6}$ (.612) $\frac{\text{Se a. m. u.}}{H_2SeO_3 \text{ a. m. u.}}$

= $3.48 \times 10^{-6}$ mg Se

## APPENDIX C-4

### SELENIUM-75 SPECTRUM (ΔE=.050V)

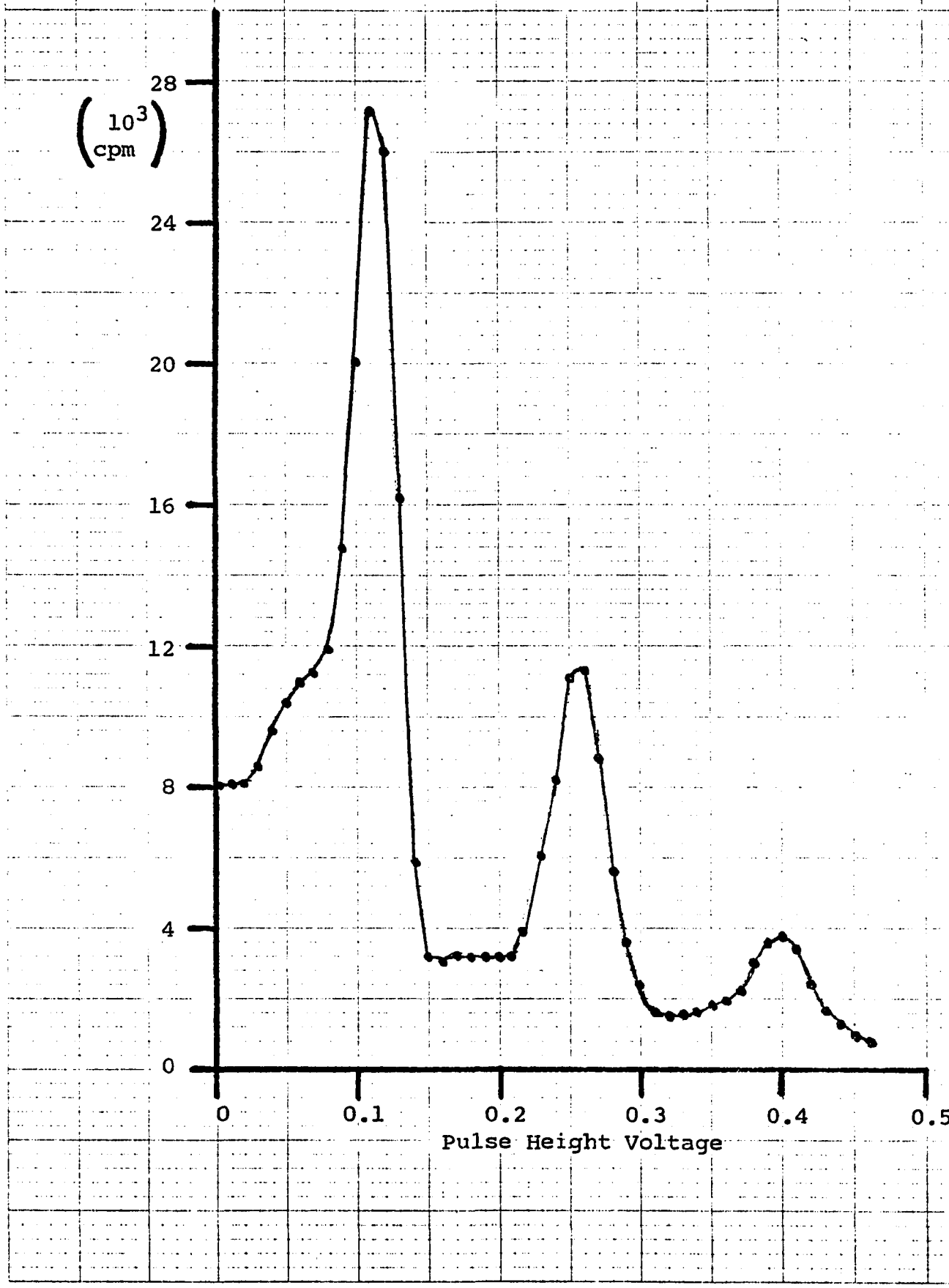
| PULSE HEIGHT VOLTAGE | COUNTS PER MINUTE | PULSE HEIGHT VOLTAGE | COUNTS PER MINUTE | PULSE HEIGHT VOLTAGE | COUNTS PER MINUTE |
|---|---|---|---|---|---|
| 0.010 | 8,178 | 0.166 | 2,742 | 0.268 | 9,012 |
| 0.028 | 8,201 | 0.168 | 2,863 | 0.270 | 8,637 |
| 0.030 | 8,568 | 0.170 | 2,856 | 0.272 | 8,175 |
| 0.040 | 9,706 | 0.172 | 2,874 | 0.274 | 7,818 |
| 0.050 | 10,523 | 0.174 | 2,878 | 0.276 | 7,013 |
| 0.060 | 10,864 | 0.176 | 2,857 | 0.278 | 6,248 |
| 0.070 | 11,057 | 0.178 | 2,990 | 0.280 | 5,653 |
| 0.080 | 11,821 | 0.180 | 2,967 | 0.282 | 5,416 |
| 0.090 | 14,668 | 0.182 | 2,896 | 0.284 | 4,764 |
| 0.100 | 20,049 | 0.184 | 2,875 | 0.286 | 4,458 |
| 0.102 | 22,193 | 0.186 | 2,911 | 0.288 | 3,986 |
| 0.104 | 23,593 | 0.188 | 2,946 | 0.290 | 3,544 |
| 0.106 | 25,273 | 0.190 | 2,999 | 0.300 | 2,327 |
| 0.108 | 26,226 | 0.192 | 2,848 | 0.310 | 1,575 |
| 0.110 | 27,114 | 0.194 | 2,829 | 0.320 | 1,431 |
| 0.112 | 27,731 | 0.196 | 2,893 | 0.330 | 1,438 |
| 0.114 | 27,618 | 0.198 | 2,794 | 0.340 | 1,409 |
| 0.116 | 27,712 | 0.200 | 2,867 | 0.350 | 1,608 |
| 0.118 | 26,889 | 0.208 | 2,949 | 0.360 | 1,759 |
| 0.120 | 25,851 | 0.216 | 3,725 | 0.370 | 2,172 |
| 0.122 | 24,343 | 0.224 | 4,433 | 0.380 | 2,759 |
| 0.124 | 22,226 | 0.226 | 4,899 | 0.390 | 3,380 |
| 0.126 | 20,263 | 0.228 | 5,453 | 0.392 | 3,386 |
| 0.128 | 18,077 | 0.230 | 6,033 | 0.394 | 3,474 |
| 0.130 | 16,263 | 0.232 | 6,726 | 0.396 | 3,568 |
| 0.132 | 14,197 | 0.234 | 7,203 | 0.398 | 3,601 |
| 0.134 | 11,670 | 0.236 | 7,438 | 0.400 | 3,701 |
| 0.136 | 8,194 | 0.238 | 7,901 | 0.402 | 3,544 |
| 0.138 | 6,547 | 0.240 | 8,362 | 0.404 | 3,648 |
| 0.140 | 5,770 | 0.243 | 9,103 | 0.406 | 3,652 |
| 0.142 | 4,736 | 0.244 | 9,583 | 0.408 | 3,563 |
| 0.144 | 4,135 | 0.246 | 10,127 | 0.410 | 3,343 |
| 0.146 | 3,627 | 0.248 | 10,768 | 0.412 | 3,315 |
| 0.148 | 3,262 | 0.250 | 11,040 | 0.414 | 2,973 |
| 0.150 | 3,059 | 0.252 | 11,345 | 0.416 | 2,824 |
| 0.152 | 2,863 | 0.254 | 11,818 | 0.418 | 2,736 |
| 0.154 | 2,880 | 0.256 | 11,559 | 0.420 | 2,388 |

APPENDIX C-4 (CONTINUED)

SELENIUM-75 SPECTRUM ($\Delta$E=.050V)

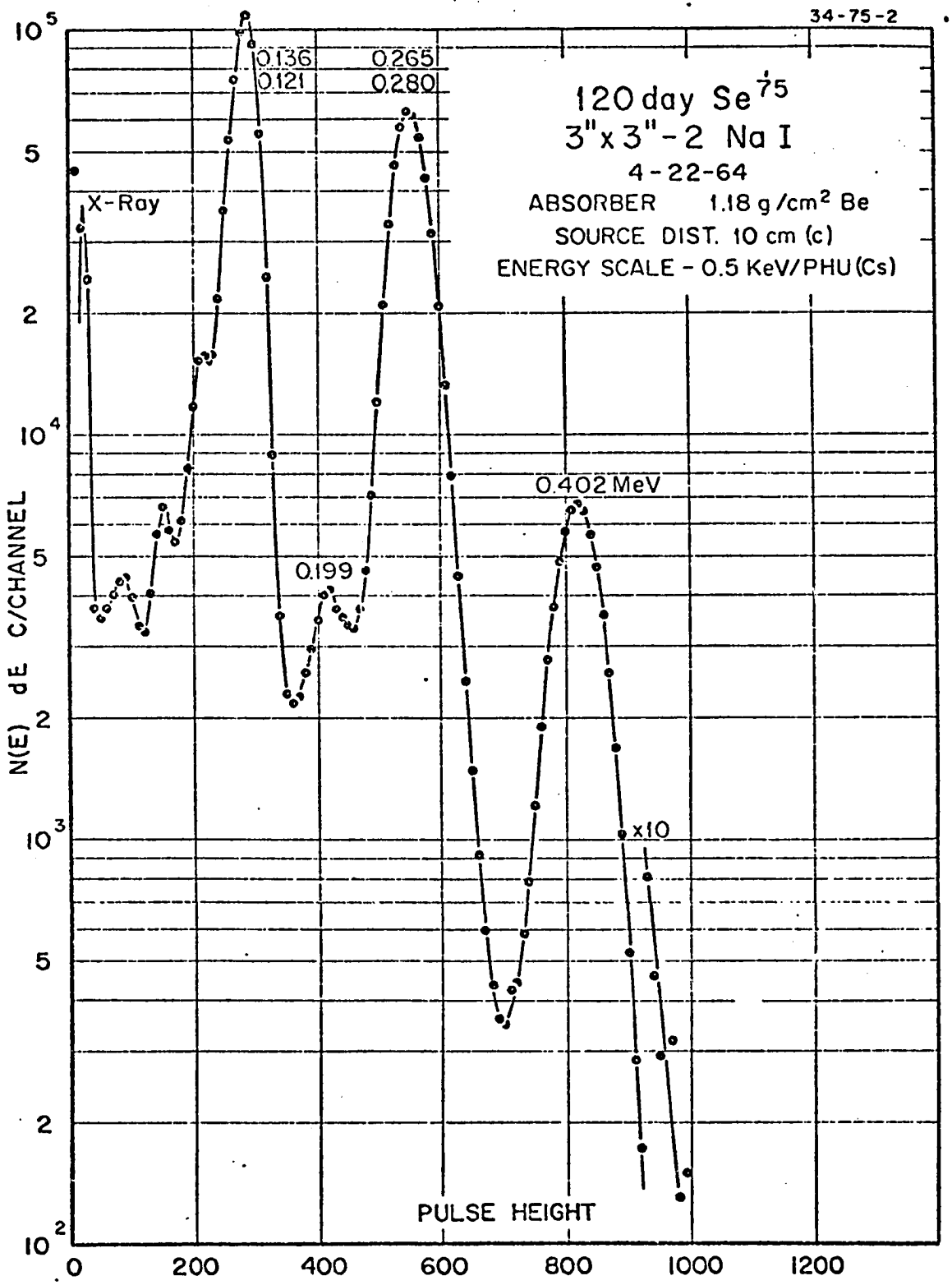
| PULSE HEIGHT VOLTAGE | COUNTS PER MINUTE | PULSE HEIGHT VOLTAGE | COUNTS PER MINUTE | PULSE HEIGHT VOLTAGE | COUNTS PER MINUTE |
|---|---|---|---|---|---|
| 0.156 | 2,748 | 0.258 | 11,341 | 0.430 | 1,567 |
| 0.158 | 2,753 | 0.260 | 11,379 | 0.440 | 1,071 |
| 0.160 | 2,749 | 0.262 | 10,715 | 0.450 | 678 |
| 0.162 | 2,759 | 0.264 | 10,286 | 0.460 | 536 |
| 0.164 | 2,846 | 0.266 | 9,084 | | |

# APPENDIX C-5
## SELENIUM-75 SPECTRUM PLOT




10 Squares to the Inch

APPENDIX C-6
SELENIUM-75 SPECTRUM PUBLISHED




Heath, R. L. USAEC. Scintillation Spectrometry Gamma-Ray Spectrum Catalogue, 2nd Edition, Volume.II, August 1964.

## APPENDIX C-7

## COUNTING EFFICIENCY CALIBRATION

May 1, 1973

A five lambda aliquot was taken from stock solution of 1 mCi. in 5 ml. and diluted to 20.0 ml. as a standard counting volume. The 100 lambda aliquot of such dilution was taken and diluted to 20.0 ml standard volume.

Activity and Calibration Solution=

$$\frac{5\,\lambda \text{ aliquot} \quad 1\text{mCi} \quad 100\,\lambda \quad \text{ml} \quad \text{ml}}{20\text{ ml.} \quad 5\text{ ml.} \quad 20\text{ ml.} \quad 1000\,\lambda \quad 1000\,\lambda} =$$

$$\frac{1\text{ mCi}}{4{,}000{,}000\text{ ml.}}, \text{ or } \frac{1}{200{,}000} \text{ mCi in 20 ml.}$$

Count Rate

| Test Tube Sample | Counts / m/ 20.0 ml |
|---|---|
| 1 | 6096 |
| 2 | 6086 |
| 3 | 6033 |
| 4 | 6101 |
| 5 | 6081 |
| 6 | 6037 |
| 7 | 6153 |
| 8 | 6053 |
| 9 | 6121 |
| 10 | 6192 |
| 11 | 5916 |
| Average | 6079 |

# APPENDIX C-8
# CALCULATION OF EFFICIENCY

Assay Amount:

1 mCi $H_2SeO_3$ in 0.1 ml
containing 0.0057 mg $H_2SeO_3$

Stock Solution of Radioselenium:

Upon arrival of the above source, 4.9 ml distilled ion exchange water was added to dilute to a 5.0 ml stock solution.

Efficiency:

Use calibration data previously determined with $\frac{1}{200,000}$ dilution to calculate efficiency.

$$\text{Efficiency} = \frac{\text{cpm}}{\text{dpm}}$$ , where decay correction is 1.173

$$= \frac{(1.173)(6.079 \text{ counts})(\text{min})(\text{s})(\text{mCi})(2 \times 10^5)}{(\text{min})(60)(\text{s})(3.7 \times 10^7)(\text{d})(\text{mCi})}$$

$$= 0.642$$

=64.2% Efficiency

APPENDIX C-9
SORPTION OF SELENIUM-75 ON TEST TUBES

| Total Selenium ppm | Time to Reading | cpm in 20 ml | cpm after decanting | cpm after 3 rinses | cpm after 3 added rinses | cpm washed tube / cpm in 20 ml (Sorbed Fraction) | ppm sorbed |
|---|---|---|---|---|---|---|---|
| | Immediate | 225569 | | | (Repeated count) | (Average of 8 hour, | |
| 10 | 8 hours | 149522 | 7298 | 2018 | 1777-1721 | 4 days) | |
| | 4 days | 149408 | | | Average 1749 | $1.17 \times 10^{-2}$ | $1.17 \times 10^{-1}$ |
| | Immediate | 196348 | | | | | |
| 1 | 8 hours | 174569 | 8079 | 3832 | 3553-3558 | | |
| | 4 days | 172858 | | | Average 3555 | $2.40 \times 10^{-2}$ | $2.40 \times 10^{-2}$ |
| | Immediate | 245049 | | | | | |
| $10^{-1}$ | 8 hours | 179328 | 9389 | 4681 | 4324-4239 | $2.47 \times 10^{-2}$ | $2.47 \times 10^{-3}$ |
| | 4 days | 166483 | | | Average4281 | | |
| | Immediate | 245217 | | | | | |
| $10^{-2}$ | 8 hours | 175241 | 8100 | 5407 | 5114-5131 | $2.99 \times 10^{-2}$ | $2.99 \times 10^{-4}$ |
| | 4 days | 166929 | | | Average 5122 | | |
| | Immediate | 209772 | | | | | |
| $10^{-3}$ | 8 hours | 175676 | 9625 | 6548 | 6002-5985 | $3.48 \times 10^{-2}$ | $3.48 \times 10^{-5}$ |
| | 4 days | 168699 | | | Average 5993 | | |
| | Immediate | 198180 | | | | | |
| $10^{-4}$ | 8 hours | 169917 | 12809 | 4538 | 4155-4241 | $2.50 \times 10^{-2}$ | $2.50 \times 10^{-6}$ |
| | 4 days | 165173 | | | Average 4198 | | |

## APPENDIX C-10

## NORMALIZATION OF WATER

Five λ from Stock Selenium Solution was diluted to 20.0 ml. A 100 λ aliquot was removed and diluted stepwise as follows:

| 100 λ ml | Corrected cpm | Corrected cpm |
|---|---|---|
| 1.0 | 7776 | 7700 |
| 2.0 | 7682 | 7734 |
| 3.0 | 7644 | 7596 |
| 4.0 | 7496 | 7638 |
| 5.0 | 7578 | 7499 |
| 6.0 | 7456 | 7380 |
| 7.0 | 7435 | 7520 |
| 8.0 | 7478 | 7421 |
| 9.0 | 7331 | 7245 |
| 10.0 | 7281 | 7168 |
| 11.0 | 7120 | 7135 |
| 12.0 | 6940 | 6893 |
| 13.0 | 6750 | 6965 |
| 14.0 | 6711 | 6744 |
| 15.0 | 6755 | 6576 |
| 16.0 | 6630 | 6456 |
| 17.0 | 6601 | 6235 |
| 18.0 | 6574 | 6130 |
| 19.0 | 6356 | 5963 |
| 20.0 | 6154 | 5809 |

APPENDIX C-11

NORMALIZATION OF SUSPENDED PARTICULATE

The filter containing suspended particulate was dissolved in 20 ml. acetone and stirred while a counting rate was determined. This was the standardized geometry.

| FILTER NO. | cpm ROLLED FILTER AND SUSPENDED PARTICULATE | cpm DISSOLVED FILTER AND SUSPENDED PARTICULATE | cpm CORRECTED FOR DECAY | GEOMETRY CORRECTION FRACTION |
|---|---|---|---|---|
| 50 | 6,146 | 4,796 | 5,051 | .823 |
| 51 | 11,239 | 9,422 | 9,923 | .883 |
| 52 | 5,067 | 4,166 | 4,388 | .866 |
| 53 | 12,237 | 10,808 | 11,383 | .930 |
| 54 | 5,760 | 5,171 | 5,446 | .945 |
| 55 | 7,923 | 7,010 | 7,383 | .932 |
| 56 | 5,265 | 4,514 | 4,754 | .903 |
| 57 | 9,020 | 7,430 | 7,825 | .868 |
| 58 | 4,721 | 4,231 | 4,456 | .944 |
| 59 | 9,432 | 8,025 | 8,452 | .896 |
| 60 | 4,778 | 4,406 | 4,640 | .971 |
| AVE. | | | | .9055 |
| RANGE | | | | .148 |

APPENDIX C-12

NORMALIZATION OF FISH

Individual fish were wet or dry ashed then dissolved to 20.0 ml and counting rate determined while stirring.

Wet Ash: $H_2SO_4$ + HCl  Dry Ash: 250°C Muffle furnace + HCl

| | FISH NUMBER | FISH WHOLE cpm | BACKGROUND CORRECTED cpm | FISH SOLUABILIZED cpm | BACKGROUND CORRECTED cpm | DECAY CORRECTED cpm | FRACTION COUNT RECOVERED | AVE. |
|---|---|---|---|---|---|---|---|---|
| | 1 | 357 | 246 | 201 | 89 | 99 | .40 | |
| | 2 | 2,240 | 2,130 | 2001 | 1,888 | 2,109 | .99 | |
| Dry | 3 | 712 | 601 | 321 | 209 | 234 | .38 | 0.46 |
| Ash | 4 | 754-712 | 623 | 404 | 292 | 326 | .52 | |
| | 5 | 1,018-1,023 | 911 | 590 | 478 | 534 | .58 | |
| | 6 | 767-745 | 646 | 401 | 289 | 323 | .50 | |
| | 7 | 1,027-1,016 | 912 | 697 | 584 | 653 | .71 | |
| Wet | 8 | 694-692 | 583 | 477 | 365 | 408 | .69 | |
| Ash | 9 | 926-892 | 799 | 651 | 539 | 602 | .75 | 0.706 |
| | 10 | 1,163-1,126 | 1,034 | 765 | 653 | 730 | .70 | |
| | 11 | 1,229-1,166 | 1,088 | 812 | 700 | 782 | .71 | |
| | 12 | 1,454 | 1,344 | 927 | 815 | 912 | .68 | |

APPENDIX C-13

NORMALIZATION OF SEDIMENT

| TANK I CONTAINER NUMBER | SAMPLE CONTAINER | | STIRRED IN 20 ml | |
|---|---|---|---|---|
| | RAW COUNT cpm | BACKGROUND CORRECTED cpm | RAW COUNT cpm | BACKGROUND CORRECTED cpm |
| 3 H | 6,511-6,388 | 6,341 | 4,606-4,601<br>4,621 | 4,490 |
| 2 H | 7,987-7,924 | 7,797 | 5,951-5,402<br>5,383-5,360 | 5,405 |
| 1 H | 9,781-9,780 | 9,672 | 7,416-7,490 | 7,334 |
| 3 R | 15,043-15,316 | 15,071 | 12,075-12,713 | 12,394 |
| 1 R | 11,669-11,614 | 11,533 | 8,529-8,688<br>8,836-8,722 | 8,587 |
| 4 C | 7,141-7,341 | 7,133 | 5,466-5,551<br>5,856-5,703 | 5,525 |
| 2 C | 11,300-11,481 | 11,282 | 8,238-8,380 | 8,190 |
| 4 E | 11,651-11,668 | 11,551 | 9,212<br>9,386-9,115 | 9,118 |
| 2 E | 9,761-9,907 | 9,726 | 7,298-7,174 | 7,104 |
| 3 E | 10,088-10,096 | 9,984 | 8,058-8,098 | 7,959 |
| 1 E | 8,818-8,939 | 8,770 | 7,091-7,154 | 7,003 |

APPENDIX C-13 (Continued)

NORMALIZATION OF SEDIMENT

| TANK II CONTAINER NUMBER | SAMPLE CONTAINER cpm | SAMPLE CONTAINER BACKGROUND CORRECTED cpm | STIRRED IN 20 ml cpm | STIRRED IN 20 ml BACKGROUND CORRECTED cpm |
|---|---|---|---|---|
| 3 H | 16,178-16,021 | 15,991 | 11,001-11,361 | 11,181 |
| 2 H | 8,467-8,576 | 8,413 | 6,444 | 6,325 |
| 1 H | 22,423-22,540 | 22,373 | 17,741-18,399 | 17,951 |
| 3 R | 14,984-14,769 | 14,768 | 11,195-11,294 | 11,125 |
| 1 R | 6,304-6,135 | 6,111 | 4,837-4,573 | 4,502 |
| | | | 4,454 | |
| 4 C | 5,471-5,318 | 5,286 | 4,044-4,072 | 3,939 |
| 2 C | 9,442-9,218 | 9,222 | 7,016-7,126 | 6,952 |
| 4 E | 9,629-9,574 | 9,493 | 7,034-7,079 | 6,937 |
| 2 E | 12,806-12,608 | 12,599 | 9,698-10,331 | 10,235 |
| | | | 10,755-10,632 | |
| 3 E | 11,147-11,104 | 11,017 | 8,196-8,263 | 8,110 |
| 1 E | 15,300-15,315 | 15,199 | 13,624 | 13,158 |
| | | | 13,147 | |
| | | | 13,025 | |
| | | | 13,388 | |
| | | | 13,201 | |
| AVERAGE OF TANKS I AND II | | 10,878 | | 8,342 |

NORMALIZATION FACTOR: $\frac{8,342}{10,878} = .766$

# APPENDIX C-14

## SEDIMENT TRANSMISSION AND STIRRING DATA

(All tubes 20.0 ml volumes total)
(All tubes identical aliquots of stock radioselenium)

| | TUBE NO. | REPEATED COUNTS CPM | AVE. CPM | MEAN CPM | $\sqrt{n}$ |
|---|---|---|---|---|---|
| NOT STIRRED | 1 | 9,120 | 8,945 | 9,009 | 94.92 |
| | | 8,770 | | | |
| | 2 | 9,009 | 8,937 | | |
| | | 8,865 | | | |
| | 3 | 9,023 | 8,993 | | |
| | | 8,962 | | | |
| | 4 | 8,926 | 9,014 | | |
| | | 9,101 | | | |
| | 5 | 9,158 | 9,155 | | |
| | | 9,152 | | | |
| STIRRED | 1 | 9,058 | 9,032 | 9,023 | 94.99 |
| | | 9,005 | | | |
| | 2 | 9,092 | 9,024 | | |
| | | 8,955 | | | |
| | 3 | 8,954 | 9,006 | | |
| | | 9,058 | | | |
| | 4 | 9,024 | 8,987 | | |
| | | 8,950 | | | |
| | 5 | 9,219 | 9,064 | | |
| | | 8,909 | | | |
| 10.82g SEDIMENT + STIRRING | 1 | 8,723 | 8,651 | 8,610 | 92.79 |
| | | 8,579 | | | |
| | 2 | 8,618 | 8,606 | | |
| | | 8,597 | | | |
| | 3 | 8,458 | 8,498 | | |
| | | 8,538 | | | |
| | 4 | 8,574 | 8,727 | | |
| | | 8,880 | | | |
| | 5 | 8,497 | 8,569 | | |
| | | 8,640 | | | |

# APPENDIX C-15

## SEDIMENT TRANSMISSION CALCULATIONS

### Attenuation Calculated from Data

-Average unattenuated counting rate=

$$\frac{(9{,}009) + (9{,}023)}{2} = 9{,}016 \text{ c.p.m.}$$

-Variation of attenuated from unattenuated counting rates=

$$\frac{(9{,}016) - (8{,}610)}{9{,}016} = 4.5\% \text{ Attenuation}$$

-Transmission =

$$\frac{8{,}610}{9{,}016} = 95.4\%$$

# APPENDIX C-16
# THEORETICAL CALCULATION OF TRANSMISSION

## Range for $SiO_2$

| MINIMUM | MAXIMUM |
|---|---|
| - 100 Kev | 500 Kev |
| .087 $cm^2/g$ | .169 $cm^2/g$ |

- Linear Attenuation Coefficient: $= (\mu/\rho)\,\rho$

| | |
|---|---|
| (.087) (1.9) = .165 | (.169) (1.9) = .32 |

- Relaxation Length = $(-\mu x)$

| | |
|---|---|
| (.165) (.675) = .1114 | (.321) (.675) = .2167 |

Use x = 0.675 cm, S.G. silicon dioxide=1.86
Since 10.85 g Sand in 20 $cm^2$ volume
when stirred = $\frac{10.85g}{1.86g/cm^3}$ = 5.84 $cm^3$
This volume spread the length of 20.0 ml in a test tube would have a radius of .675 cm solid sand.

-Transmission $\frac{I}{I_0} = e^{-\mu x}$

| | |
|---|---|
| .950 | .816 |

## APPENDIX C-17

### SIGNIFICANCE OF TRANSMISSION CALCULATION

Since Se-75

0.136 Mev= 57%
0.265 Mev= 60%
0.280 Mev= 25%
0.402 Mev= 12%

154%

.136 Mev plus .265 Mev spectra

= 57
60

117 %

and $\frac{117\ \%}{154\ \%} \simeq .76$

thus ~ 3/4 of spectra occurs in lower half of energy range making attenuation less significant.

APPENDIX C-18
BACKGROUND COUNT RATES (FIRST AND SECOND RUN)

| FIRST RUN | | SECOND RUN | |
|---|---|---|---|
| ELAPSED TIME IN HRS. | BACKGROUND COUNT 100 MINUTES | ELAPSED TIME IN HRS. | BACKGROUND COUNT 100 MINUTES |
| 0 | 10,576 | | |
| | | 0 | 11,022 |
| 62 | 10,503 | | |
| 87 | 10,410 | 72 | 11,094 |
| 117 | 10,402 | 96 | 10,977 |
| 134 | 10,398 | | |
| 191 | 10,421 | 168 | 11,735 |
| 230 | 10,356 | 192 | 11,506 |
| 254 | 10,430 | 216 | 12,100 |
| 287 | 10,525 | 264 | 11,248 |
| 311 | 10,498 | 312 | 11,292 |
| 330 | 10,410 | | |
| 354 | 10,404 | 384 | 11,202 |
| 374 | 10,684 | 408 | 11,154 |
| 470 | 10,447 | 456 | 11,286 |
| 494 | 10,150 | | |
| 518 | 10,246 | 552 | 11,319 |
| 549 | 10,191 | | |
| 573 | 10,228 | 576 | 11,203 |
| 638 | 10,171 | 600 | 11,106 |
| 662 | 10,015 | 624 | 11,106 |
| 692 | 10,228 | 648 | 11,128 |
| 710 | 10,103 | 696 | 10,985 |
| 734 | 10,010 | 720 | 10,910 |
| 762 | 10,131 | 840 | 11,441 |
| 800 | 10,193 | 864 | 12,214 |
| 900 | 10,002 | 888 | 11,464 |
| 950 | 10,136 | 936 | 11,111 |
| 1,000 | 10,079 | 960 | 12,125 |
| 1,032 | 10,023 | 1,008 | 11,212 |
| | | 1,032 | 11,206 |

APPENDIX C-19

WATER COMPARTMENT

SCHEDULE OF DECAY RESIDUAL SELENIUM BACKGROUND FROM FIRST RUN

| ELAPSED TIME IN HRS. | CALCULATED RESIDUAL SELENIUM CPM | |
|---|---|---|
| | TANK I | TANK II |
| 0 | 45 | 31 |
| 48 | 44 | 31 |
| 96 | 43 | 30 |
| 144 | 43 | 30 |
| 192 | 43 | 29 |
| 240 | 42 | 29 |
| 288 | 42 | 29 |
| 336 | 42 | 28 |
| 384 | 41 | 28 |
| 432 | 41 | 28 |
| 480 | 40 | 27 |
| 528 | 40 | 27 |
| 576 | 39 | 27 |
| 624 | 38 | 27 |
| 672 | 38 | 26 |
| 720 | 38 | 26 |
| 768 | 37 | 26 |
| 816 | 37 | 25 |
| 864 | 37 | 25 |
| 912 | 36 | 25 |
| 960 | 36 | 24 |
| 1,008 | 35 | 24 |
| 1,056 | 35 | 24 |

TANK I: (Residual Selenium from First Run)
1,428 counts per 10 minutes per 20 ml sample
TANK II: (Residual Selenium from First Run)
1,289 counts per 10 minutes per 20 ml sample
BACKGROUND: 9,789 counts per 100 minutes.

TIME: zero hours elapsed.

APPENDIX C-19 (Continued)
SUSPENDED PARTICULATE COMPARTMENT
SCHEDULE OF DECAY RESIDUAL SELENIUM BACKGROUND FROM FIRST RUN

| ELAPSED TIME DAYS | CALCULATED cpm RESIDUAL SELENIUM (-) BACKGROUND 40 ml SAMPLE | |
|---|---|---|
| | TANK I | TANK II |
| 0 | 9.1 | 47.2 |
| 17 | 8.2 | 42.8 |
| 21 | 8.0 | 41.8 |
| 22 | 8.0 | 41.5 |
| 23 | 7.9 | 41.3 |
| 27 | 7.8 | 40.5 |
| 35 | 7.4 | 38.6 |
| 38 | 7.3 | 37.9 |
| 46 | 6.9 | 36.2 |
| 89 | 5.4 | 28.4 |
| 96 | 5.2 | 27.1 |

TANK I: Zero Time: (Residual Selenium from First Run)
8,410 counts per ten minutes per 0.1999 g suspended particulate.
Background = 11,202 counts per 100 minutes and

$$\frac{728.1 \text{ cpm}}{0.1999 \text{g}} = \frac{9.1 \text{ cpm}}{40 \text{ ml sample}}$$

(Based on 792 hour ave. 2.5 mg per 40 ml sample, Appendix B-20)

TANK II: Zero Time: (Residual Selenium from First Run)
42,280 counts per 10 minutes per 0.1543 g suspended particulate.
Background = 11,202 counts per 100 minutes, and

$$\frac{411.6 \text{ cpm}}{.1543 \text{g suspended particulate}} =$$

$$\frac{47.2 \text{ cpm}}{40 \text{ ml sample}}$$

(Based on Ave. of 1.7 mg per 40 ml sample, Appendix B-20)

APPENDIX C-19 (Continued)

FISH COMPARTMENT

SCHEDULE OF DECAY RESIDUAL SELENIUM BACKGROUND FROM FIRST RUN

| ELAPSED TIME IN HRS. | RESIDUAL Se (-) BACKGROUND COMPARTMENT cpm | |
|---|---|---|
| | TANK I | TANK II |
| 0 | 5,027 | 2,353 |
| 48 | 4,969 | 2,326 |
| 96 | 4,912 | 2,299 |
| 144 | 4,856 | 2,273 |
| 192 | 4,800 | 2,247 |
| 240 | 4,745 | 2,221 |
| 288 | 4,690 | 2,195 |
| 336 | 4,636 | 2,169 |
| 384 | 4,583 | 2,144 |
| 432 | 4,530 | 2,120 |
| 480 | 4,478 | 2,095 |
| 528 | 4,427 | 2,071 |
| 576 | 4,375 | 2,047 |
| 624 | 4,326 | 2,024 |
| 672 | 4,276 | 2,001 |
| 720 | 4,227 | 1,978 |
| 768 | 4,178 | 1,955 |
| 816 | 4,130 | 1,932 |
| 864 | 4,083 | 1,910 |
| 912 | 4,036 | 1,888 |
| 960 | 3,990 | 1,867 |
| 1,008 | 3,944 | 1,845 |
| 1,056 | 3,813 | 1,824 |

| | FISH NUMBER | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| TANK I (Zero Time) | 731 | 931 | 956 | 1,363 | 1,509 |
| cpm | 750 | 892 | 1,005 | 1,451 | 1,566 |
| TANK II (Zero Time) | 617 | 696 | 681 | 857 | |
| cpm | 542 | 679 | 777 | 753 | |

BACKGROUND = 11,006 counts per 100 minutes.

APPENDIX C-19 (Continued)

SEDIMENT COMPARTMENT

SCHEDULE OF DECAY RESIDUAL SELENIUM BACKGROUND FROM FIRST RUN*

| HOURS ELAPSED TIME | COUNTS PER MINUTE | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | II3H | II2H | II1H | II3R | II1R | II4C | II2C | II4E | II2E | II3E | II1E |
| 0 | 499 | 1,515 | 1,482 | 433 | 382 | 428 | 514 | 402 | 542 | 429 | 868 |
| 51 | 493 | 1,497 | 1,464 | 428 | 377 | 423 | 508 | 397 | 535 | 424 | 858 |
| 98 | 487 | 1,480 | 1,448 | 423 | 373 | 418 | 502 | 392 | 529 | 419 | 848 |
| 136 | 482 | 1,463 | 1,431 | 418 | 368 | 413 | 496 | 388 | 523 | 414 | 838 |
| 185 | 476 | 1,446 | 1,415 | 413 | 364 | 408 | 490 | 383 | 517 | 409 | 828 |
| 280 | 470 | 1,429 | 1,398 | 408 | 360 | 403 | 485 | 379 | 511 | 404 | 819 |
| 332 | 465 | 1,413 | 1,382 | 403 | 356 | 399 | 479 | 375 | 505 | 400 | 809 |
| 375 | 460 | 1,397 | 1,366 | 399 | 352 | 394 | 474 | 370 | 499 | 395 | 800 |
| 472 | 455 | 1,381 | 1,351 | 394 | 348 | 390 | 468 | 366 | 494 | 391 | 791 |
| 543 | 445 | 1,349 | 1,320 | 385 | 340 | 381 | 457 | 358 | 482 | 382 | 773 |
| 568 | 439 | 1,334 | 1,305 | 381 | 336 | 376 | 452 | 354 | 477 | 377 | 764 |
| 617 | 434 | 1,318 | 1,290 | 376 | 332 | 372 | 447 | 349 | 471 | 373 | 755 |
| 880 | 409 | 1,244 | 1,217 | 355 | 313 | 351 | 422 | 330 | 445 | 352 | 713 |
| 1,024 | 396 | 1,202 | 1,176 | 343 | 303 | 339 | 407 | 319 | 430 | 340 | 688 |

* Corrected for Background = 11,200 counts per 100 minutes

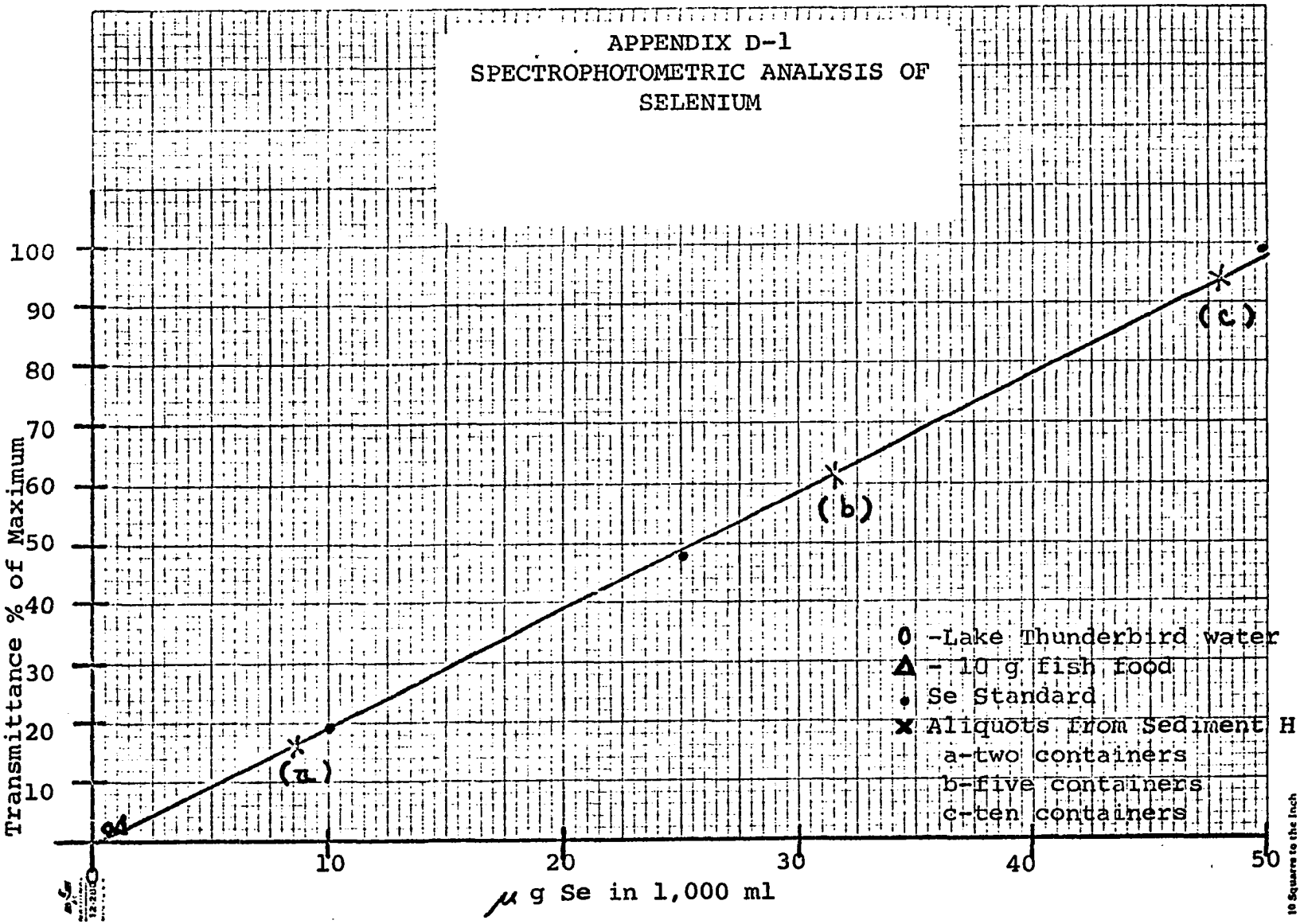
Appendix C-19 (Continued)

SEDIMENT COMPARTMENT
SCHEDULE OF DECAY RESIDUAL SELENIUM BACKGROUND FROM FIRST RUN *

| ELAPSED TIME | COUNTS PER MINUTE | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| IN HRS. | I3H | I2H | I1H | I3R | I1R | I4C | I2C | I4E | I2E | I3E | I1E |
| 0 | 1,288 | 626 | 853 | 694 | 669 | 729 | 703 | 739 | 653 | 957 | 535 |
| 25 | 1,273 | 619 | 843 | 680 | 661 | 720 | 694 | 729 | 645 | 946 | 528 |
| 72 | 1,258 | 611 | 833 | 678 | 653 | 711 | 686 | 728 | 637 | 935 | 521 |
| 114 | 1,243 | 604 | 823 | 670 | 645 | 702 | 678 | 711 | 629 | 924 | 515 |
| 184 | 1,229 | 599 | 813 | 662 | 637 | 693 | 670 | 702 | 621 | 913 | 509 |
| 233 | 1,214 | 584 | 804 | 654 | 629 | 685 | 662 | 693 | 613 | 902 | 503 |
| 280 | 1,200 | 577 | 794 | 646 | 621 | 677 | 654 | 685 | 605 | 891 | 497 |
| 332 | 1,186 | 570 | 784 | 638 | 613 | 669 | 646 | 677 | 598 | 880 | 491 |
| 375 | 1,172 | 563 | 775 | 630 | 605 | 661 | 638 | 669 | 591 | 869 | 485 |
| 421 | 1,158 | 557 | 766 | 622 | 598 | 653 | 630 | 661 | 584 | 859 | 479 |
| 472 | 1,144 | 550 | 757 | 614 | 591 | 645 | 622 | 653 | 577 | 849 | 473 |
| 543 | 1,130 | 544 | 748 | 607 | 584 | 637 | 614 | 645 | 570 | 839 | 467 |
| 568 | 1,117 | 537 | 739 | 600 | 577 | 629 | 606 | 637 | 563 | 829 | 461 |
| 736 | 1,078 | 519 | 712 | 579 | 556 | 605 | 585 | 613 | 542 | 799 | 443 |
| 880 | 1,027 | 495 | 678 | 551 | 528 | 577 | 557 | 584 | 515 | 761 | 421 |

* Corrected for Background = 11,200 counts per 100 minutes.

# APPENDIX D


APPENDIX D-1
SPECTROPHOTOMETRIC ANALYSIS OF SELENIUM
Transmittance % of Maximum
100
90
80
70
60
50
40
30
20
10
0
10
20
30
40
50
μg Se in 1,000 ml
(a)
(b)
(c)
O -Lake Thunderbird water
Δ - 10 g fish food
• Se Standard
X Aliquots from Sediment H
a-two containers
b-five containers
c-ten containers

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