

THE CHARACTERIZATION OF PHYSICAL PARAMETERS
OF A GRAVEL BED REACTOR USED FOR
THE TREATMENT OF ACID MINE DRAINAGE (AMD)
BY SULFATE REDUCING BACTERIA (SRB)

by

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fulfilment of the requirements for the degree of Doctor of Philosophy.

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ABSTRACT

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The treatment of acid mine drainage (AMD) by sulfate-reducing bacteria (SRB) has been reported in the literature as a possible alternative to chemical treatment. The overall objective of this study was to implement such a treatment process at the mine site and specifically within the open mine pit itself. The first step of this study was to characterize process parameters. To accomplish this, a reactor was designed and built to simulate hydrodynamic conditions found in the mine pit. This reactor contained a 6" deep gravel bed in which a mixed population of SRB was inoculated. The operation of this reactor demonstrated that treatment of a continuous flow of AMD by SRB was possible, however, the response to changes in the composition of the AMD and to flow conditions was limited. The results indicated that further studies should be directed at the gravel bed itself since this was where the SRB are located and is the active site within the system.

The role of various physical parameters of a gravel bed in the biological treatment of AMD by SRB was examined. This was accomplished by using gravel of different sizes (0.25" vs. 0.5") and composition (granite vs limestone) to form 12" beds in a series of column reactors. The difference in size results in variations in the total surface area, the void volume and various volume ratios within the system. The effect of potential geological buffering by limestone was examined by using and comparing with beds composed of granite.

The gravel beds were inoculated with a mixed culture of SRB and overlaid with 6 L of AMD. After the SRB were established, a series of experiments were performed in which 16.7%, 25%, 75% and 100% of the water column was replaced with an equivalent quantity of fresh AMD. Changes in pH, ORP, electric conductivity, and concentrations of metal and sulfate were monitored for at least 28 days. Sulfate and metal removal at days 7 and 28 of each experiment were compared. The SRB can tolerate a wide range of disturbances, however, an increase in the load of fresh AMD decreased the perform-

ance of the system. The results indicated that the total surface area is of greater importance than the void volume in the overall treatment process by SRB.

A dimensionless number was constructed to describe the relationships between the physical parameters of the gravel bed. A plot of the proportion of sulfate removed and this dimensionless number could provide essential information for the sizing of a gravel bed for the purposes of sulfate reduction. This was done for each type of gravel and comparison of the two curves indicated that there was no significant difference between the two gravels.

The importance of the physical substrate for the SRB has been reported in the literature. However, no known attempt has been made to quantify the relationships between the physical parameters and the biological activity. Such information would be useful for the sizing of wetlands and other passive treatment system that uses SRB activity for the purposes of treating AMD. This study is a step towards filling this void.

RÉSUMÉ

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PhD (Agr. Biosys. Eng.)

Le traitement des eaux de drainage minier acide (DMA) par des bactéries sulfato-reductrices (BRS) a été mentionné dans la littérature comme une alternative aux traitements chimiques. Le principal objectif de cette étude était de réaliser ce procédé biologique *in situ* au cite minier at au puit à ciel ouvert. La première étape fut de caractériser les paramètres du procédé. Pour cela, un réacteur fut conçu et construit simulant les conditions hydrodynamique de la mine. Le réacteur contenait une couche de gravier (d e 6" de profondeur) dans laquelle une population mixte de BSR fut inoculée. L'opération du réacteur montra que le traitement d'un flux de DMA par les BSR était possible. Toutefois, la reponse du système aux changements de composition et de flux de DMA était limitée. Les résultats indiquèrent que des investigation ultérieures devaient se concentrer sur la couche de gravier car les BSR se trouvaient à ce niveau.

Le rôle de certains paramètres physiques de la couche de gravier impliquée dans le traitement biologique du DMA par des BRS fut étudié. Cela fut accompli en utilisant du gravier de différentes tailles (1/4" vs. 1/2") et de différentes compositions (granit vs. pierres à chaux). Ces graviers furent utilisés pour former des couches de 12" dans une série de réacteurs en colonne. La différence en grandeur donna des variations dans les superficies totales, les volumes morts et les rapports entre les différents volumes dans le système. Les couches de pierres à chaux furent utilisées pour examiner l'hypothèse d'effets tampons des couches géologiques. Les resultats obtenus avec la pierre à chaux furent comparés à ceux du granit.

Les couches de graviers furent inoculées avec une culture mixte de BSR, 8 L de DMA ayant été ajoutés, dont 2 L se trouvait dans le volume mort et 6 L se trouvait dans la colonne d'eau au dessus de gravier). Une fois les BSR établis, 16.7%, 25%, 75% et 100% de la colonne de l'eau furent remplacés par du DMA frais lors une série des expériences. Les changements de pH, d'ORP, de conductivité électrique, et de concentrations en métaux et en sulfates furent suivis pendant 28 jours. Les resultats du

7ième jour de chaque cycle furent comparés. Les BSR purent tolérer de grandes perturbations dans le système. Toutefois une augmentation dans l'apport d'AMD frais entraînait une diminution dans la performance du système. Les résultats indiquèrent que l'influence de la superficie totale avait plus importance que celle du volume mort dans le traitement les BSR.

Des nombres sans dimensions furent établis pour décrire les rapports entre les différents paramètres physiques de la couche de gravier. Des représentations graphiques de la quantité et du taux d'enlèvement de sulfate en fonction de ces nombres sans dimension fournit l'information essentielle pour la construction d'un processus de traitement à grande échelle. Les tracés furent réalisés pour chaque type of gravier et la comparaison montra l'absence de différences significatives entre ces deux types de gravier.

L'importance du gravier les BSR a été décrite dans la littérature. Toutefois, nul n'a quantifié les rapports entre les paramètres physiques du gravier et l'activité des BSR. Ces renseignements seraient utiles pour déterminer la taille des systèmes maraîchageux et autres traitements passifs qui utilisent l'activité des SRB pour décontaminer les AMD. Cette étude a permis de remédier à ce manque.

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1. INTRODUCTION

1.1 Acid Mine Drainage

A major concern currently facing mining industries around the world is the treatment of acid mine drainage (AMD). This effluent is also known as acid mine water and acid rock drainage (ARD) since it can occur at sites other than mines. The problem lies in the severe nature of the water. AMD is characterized by high acidity and high levels of metals (e.g. Al, Fe, Zn) and sulfate. Typically, the pH is less than 3 and the concentration of sulfate is greater than 3000 mg/L.

AMD is generated wherever sulfide-bearing rock (e.g. pyrite) is exposed to oxygen and water such as in waste rock piles and on the walls of mine pits and shafts. The sulfide is oxidized to form sulfate in the form of sulfuric acid and the metals, initially complexed with the sulfide, are also mobilized. Water seeping through the rock piles or over the walls of the pit leaches out the sulfuric acid and metals, forming the AMD.

The oxidation process is spontaneous and is relatively slow at the beginning. However, the process is positively reinforced by the formation of intermediate products that are capable of oxidizing other metal sulfides in the rock. Also, when the pH has decreased to 3, the activity of *Thiobacilli* is stimulated and these bacteria speed the oxidation process even further.

The problem is compounded by the large volumes of AMD produced, and by the continuing generation of potentially huge quantities of this effluent over a long period of time. In Canada, there is an estimated 12,000 to 15,000 hectares of acid generating sites containing 350 million tonnes of waste rock (Filion, Sirois, and Ferguson, 1990; CIM Bulletin, 1993). This figure is an underestimation since it does not include gold mines, coal mines, uranium mines and abandoned mine sites that have reverted to the crown. In Ontario, 20 sites covering 830 hectares and containing 55 million tonnes of reactive

sulfide tailings were identified in 1990 as having problems with acid mine drainage. In Quebec, 21 similar sites covering about 4,500 hectares have been identified but no estimation of the tonnage of reactor tailings was reported. These numbers will probably increase since between 1990 and 1993, the number of reported abandoned mines had mushroomed from 100 to 2000 in Ontario alone. Also it will be just a matter of time before AMD generation will become manifest at many of these sites.

The environmental impact of AMD is potentially enormous. Canadian and American government regulations demand that this water be collected and treated before it can be discharged into the environment. The water from rock piles is collected in lagoons and ponds and sometimes in the mine pit itself, if the mine is decommissioned. Because of the large volumes of AMD produced and because of the isolation of many mining sites, an inexpensive, low maintenance, on-site treatment process is greatly desired.

1.2 Treatment of AMD

The treatment of AMD can be defined as the elevation of the pH to at least 6 and removal of metals and sulfate to levels set by government regulations. Several physico-chemical techniques such as reverse osmosis and ion exchange are available (Barton, 1978). However, because of the large quantities involved, most are too expensive to apply on a large scale.

The standard method of treatment is a chemical one based on the use of lime ($\text{Ca}(\text{OH})_2$, CaO , CaCO_3) (Barton, 1978). Lime is added directly to the AMD to neutralize the water. The Ca^{2+} complexes with the sulfate to form gypsum (CaSO_4). As the pH increases, different metals are precipitated from the water as metal hydroxides at different pH ranges. This method is low cost and easy to do, however it results in the production of large volumes of sludge. This sludge is a mixture of gypsum and metal precipitates and is itself considered a hazardous waste and presents a disposal problem. The sludge is dewatered as much as possible and landfilled. Landfilling has become an expensive proposition in many cases and the sludge is difficult to dewater. The possible remobilization of metals in the sludge as a result of a decrease in pH is also a major concern.

The use of biological processes has been considered as an alternative to chemical treatment. The most promising is based on the activity of a group of microorganisms called the sulfate-reducing bacteria (SRB). The SRB are known to play a critical role in the response of streams, lakes and wetlands to contamination by acid precipitation and mine drainage (Mills and Herlihy, 1985; Gyure *et al*, 1990). However, the specific use of these bacteria to treat AMD is not as simple as it would appear since this water is an extremely inhospitable environment for bacterial activity.

1.3 The Sulfate-Reducing Bacteria

The sulfate-reducing bacteria (SRB) is a grouping of bacteria from 7 different genera: *Desulfovibrio*, *Desulfotomaculum*, *Desulfobulbus*, *Desulfococcus*, *Desulfosarcina*, *Desulfobacter*, and *Desulfonema*. These bacteria are anaerobic and are found in soil and sediment in both freshwater and marine environments. *Desulfovibrio* and *Desulfotomaculum* can be isolated from most soil and sediment samples (Postgate, 1984).

These bacteria are grouped together because they reduce sulfate to sulfide by the metabolic pathway known as the "dissimilatory" reduction of sulfate (LeGall and Postgate, 1973). It is described as "dissimilatory" since the reduction of sulfate occurs without the assimilation of the sulfur into the cell. Sulfate reduction occurs as part of the respiration of the bacteria. The SRB are obligate anaerobes, being unable to tolerate exposure to oxygen. Therefore, oxygen cannot be used as the final electron acceptor in respiration. Instead, the sulfur in the sulfate is used as the final electron acceptor and the sulfate is reduced to sulfide in the form of H_2S . This is analogous to the reduction of oxygen to form H_2O in aerobic organisms.

The activity of the SRB is dependent on the supply of sulfate and nutrients in the environment. The nutritional requirements of these bacteria are complex. They cannot metabolize simple sugars such as glucose and fructose, requiring instead carbon in the form of short-chained fatty acids and carboxylic acids such as acetate, lactate, malate, succinate, and oxalate. SRB cannot utilize simple sugars because they do not possess all the enzymes of glycolysis and the Krebs Cycle (Postgate, 1984).

1.4 The SRB Process

The treatment of AMD by the use of SRB is based upon the ability of SRB to produce sulfide from sulfate and to generate alkalinity. The sulfide generated binds rapidly and readily with most metals to form a metal sulfide precipitate. The reduction of sulfate consumes protons, thereby decreasing acidity. Furthermore, the metabolism of carbon nutrients results in the formation of CO_2 . The hydration of CO_2 produces carbonate which can contribute towards increasing the alkalinity of the water. The overall increased alkalinity may result in the removal of metals (e.g. Al and Mn) that are not precipitated by sulfide. SRB activity can, therefore, lower sulfate and metal concentrations and the acidity of the AMD.

The formation of metal sulfides and specifically pyrite (FeS_2) represents one of the advantages of the SRB process over liming. The formation of pyrite results in the storage of sulfur and a removal of acidity in a stable form. Metal sulfides have much lower solubilities in water than metal hydroxides and will precipitate readily. Metal sulfides are stable as long as the environment remains anoxic and reduced. It would therefore, be best to leave the precipitate undisturbed. Another advantage is that the process is based upon the activity of bacteria found in the immediate environment and, therefore, lends itself to passive treatment.

1.5 Passive vs Active Treatment

The treatment of AMD by lime is described as "active" since treatment is accomplished by a process that can only be maintained by a continuous intervention for the desired results to occur. These processes are not self-sustaining, requiring continuous input and maintenance.

The use of SRB in reactor units is considered as active treatment. The utilization of SRB in unit processes to treat industrial effluents with high concentrations of sulfate has been studied and successfully implemented around the world. Such industrial effluents would include pulp mill spent sulfite liquor, metal extraction raffinate, spent sulfuric acid

and acid mine drainage.

The "passive" treatment of AMD that is encountered in systems such as wetlands, occur as a consequence of on-going processes in the environment. Passive treatment systems do not require much maintenance and are potentially self-sustaining. Also, the end products of treatment require little or no further processing or disposal. Therefore, they are usually lower in cost and more desirable than an active treatment process. The objective of this project is to investigate the implementation of SRB in a passive treatment process.

1.6 The Feasibility of Using SRB to Treat AMD

As mentioned previously, the SRB are strict anaerobes with complex nutritional requirements. In addition, the sulfate reducing activity of pure cultures of SRB such as *Desulfovibrio desulfuricans* occurs only when the ORP is less than -200 mV and when the pH is greater than 5.5 (Postgate, 1984). The critical ORP for sulfate reduction in soil was about -150 mV, while a pH in the 6.5 to 8.5 range was required (Connell and Patrick, Jr, 1968).

These environmental conditions could be satisfied in reactor systems where parameters can be controlled. The use of SRB to treat AMD in a passive system would, however, appear not to be feasible especially since the typical pH of AMD is in the 2 to 3 range. Nevertheless, further investigation is warranted and is based in part on the following observations:

- i. Active SRB have been found in acidic environments where the pH was about 3; i.e. much less than 5 (Satake, 1977; Gyure *et al*, 1990);
- ii. Active SRB can be found in the oxygenated zones of soils and sediments (Jorgensen, 1977).

These observations indicate that the bacteria were able to survive and be active in what would be considered adverse environmental conditions. This may be a reflection of the fact that investigations on the conditions required for sulfate-reducing activity were performed under laboratory conditions and that different variables were controlled. The key

to an explanation may lie in a third observation.

- iii. SRB congregate on and around particles and organic matter (Wakao and Furusaka, 1976; Jorgensen, 1977).

Microelectrodes that measured dissolved oxygen levels and oxidation-reduction potentials (ORP) over small distances were used to examine the environment at the surface of soil particles (Zausig *et al*, 1993). Steep gradients of these parameters were observed over distances of only several microns from the surface. The gradients were generated and maintained by the metabolism of the bacteria around the particles. In essence, a microenvironment that was conducive to the growth and activity of the bacteria was being propagated on the particle by the bacteria themselves. The composition of these microenvironments were very different from that of the bulk environment.

Microscopic examination of particles by scanning electron microscopy demonstrated that bacteria were clustered in areas where surface features could harbour the bacteria (Weise and Rheinheimer, 1978; Meyer-Reil, 1994). The ability of bacteria to inhabit microniches on the surface of particles and propagate a microenvironment would therefore, explain the survival of the bacteria in adverse environmental conditions. This may be the key as to how the SRB process can be implemented for the treatment of AMD. A bed of particulate matter such as gravel should be provided as a physical substrate on which the SRB can establish themselves. Initial experiments have demonstrated the importance of having such a bed in a system for treatment of AMD.

The role of the bed of particulate material on the activity of SRB must be considered. Since the congregation of SRB on particles is important, is sulfate reducing activity and treatment of AMD related to the total surface area that the particles offered? Does the nature of the particles itself have any effect on SRB activity? What effects do other parameters of the bed have on SRB activity and the overall treatment process? If the effective use of SRB in the treatment of AMD is to be accomplished, these questions must be answered. Currently, no work on this topic has been found in the literature.

1.7 Objectives

In cases where an open mine site has been decommissioned, the open mine pit itself can be used to collect and contain the AMD. The objective of this study was to provide information for the potential implement of the SRB process in the containment pit. This is desirable since no impoundment and treatment facilities need to be constructed.

Towards this end, the general objectives of this study were to identify and characterize the process parameters of a system for treating AMD comprising a population of SRB established in a gravel bed. This information would be useful for the implementation and operation of such a process as part of an on-site passive treatment system for AMD.

The specific objectives were:

1. To design a reactor in which a continuous flow of AMD could be easily maintained over a gravel bed;
2. To characterize the hydrodynamic of the reactor in the absence of SRB;
3. To establish a population of SRB in a gravel bed in the reactor;
4. To identify the key process parameters under continuous flow conditions.

The results of this work indicated that process parameters within the gravel bed itself demanded closer investigation since the gravel bed is the active site in the system.

The set of objectives for this part of the study were:

1. To design a reactor in which events occurring in the gravel bed could be easily monitored;
2. To devise a series of experiments in which the effects of differences in physical parameters of the gravel could be investigated;
3. To characterize and quantify the effects of various physical parameters of a gravel bed on the sulfate-reducing activity of SRB.
4. To characterize and quantify the relationship between the physical parameters of a gravel bed with respect to the sulfate-reducing activity of SRB.

The information obtained will help to:

1. Establish design criteria for constructing an AMD treatment system based on SRB.
2. Establish a population of SRB at the mine site for the purposes of treating AMD.

2. LITERATURE REVIEW

The literature review is divided into four main parts. The first is a short historical perspective which describes various studies and observations leading to the use of SRB in the treatment of AMD. The second and third parts examine the role of SRB in active and passive treatment systems respectively. The fourth section discusses the question of nutrition which is an important consideration in this field of research. A short encapsulation will conclude the literature review and provide the context in which the objectives of this study should be considered.

While this review will present the activity of SRB as being beneficial and something to be encouraged and optimized, the deleterious effects of such activity should also be commented on, albeit briefly. The SRB play an important role in biocorrosion, biofouling, plugging, the production of sour gases, and in decreased crop yield in flooded fields (Senez, 1969; Postgate, 1984). In these cases, the activity of SRB is a nuisance to industry, entailing enormous economic losses. The curbing of SRB activity, if not the total eradication of a local SRB population, is the desired goal in these situations.

2.1 Historical Perspective

The literature on the use of SRB in the treatment of AMD and especially that on passive treatment, is sparse. This may be due to the fact that this process was deemed not to be economically feasible, considering the nutritional and environmental requirements of the SRB. And it was only with the research into the use of wetlands over the last twenty years that a practical solution to this problem has become possible.

A role for SRB in the treatment of AMD was first documented by Tuttle *et al* (1969). This was a fortuitous development since this was not a directed attempt at specifically using SRB in the process. A pile of wood dust was placed across the path of a stream

heavily polluted with acid mine drainage. The dam caused pools to be formed before and after the pile. The quality of the water after seeping through the wood dust pile was improved: the pH increased from 3.0 to 4.3, the sulfate concentration decreased from 10 $\mu\text{moles/mL}$ to 3.825 $\mu\text{mole/mL}$ and the iron concentration also decreased from 1.4 μmoles to 0.681 $\mu\text{moles/mL}$. A black precipitate was observed at the bottom of the pool after the dam. Investigation of the wood dust pile and the effluent stream revealed that a population of SRB had established itself in the wood dust and was the cause of the observed changes.

The impact of this paper does not appear to have been immediate. The second paper of note was written ten years later when a second group of investigators examined the potential use of SRB in the passive treatment of AMD (Wakao *et al.*, 1979). The main focus of this study was on how the nutritional requirements of SRB could be met in a system such as that described by Tuttle, where wood was the main source of carbon. Wakao demonstrated in laboratory cultures that supplementing with glucose and fructose was not useful but the addition of peptone yielded good results. This will be further discussed in Section 2.3.

This line of study was still not further pursued until the use of wetlands to treat AMD was being implemented in the 1980's. In the course of these studies, the critical role of SRB in the treatment of AMD by these ecosystems became evident. At this point attempts were made to specifically encourage the activity of these bacteria by providing the appropriate environment. This will be discussed in Section 2.2.2.

2.2 Treatment Systems

2.2.1 The Use of SRB in Unit Processes to Treat Effluents

Much research has been done on the use of SRB in active treatment processes though not necessarily only for AMD. SRB have been used in the treatment of a number of industrial wastewaters that have high concentrations of sulfate and while this is outside of the scope of this study it is instructive to consider them. The use of SRB in active treatment

processes should not be dismissed out of hand and should always be considered as a possible alternative to the passive treatment process depending on the circumstances. This is especially true when the SRB process can be used to generate a product which can be marketed.

Cork and Cusanovich (1978) designed a system for the removal of sulfate from industrial effluents to produce elemental sulfur. The process was based on the activity of two anaerobic bacteria of the sulfur cycle: *Desulfovibrio desulfuricans* and *Chlorobium thiosulfatophilum*. The system consisted of two air-tight anaerobic stirred reactors in series. In the first reactor, sulfate in the effluent was reduced to hydrogen sulfide by a culture of *D. desulfuricans*. The hydrogen sulfide was purged from this reactor by the sparging of an inert carrier gas comprising 75% Ar and 25% CO₂ through the medium. This gas stream was passed into the second reactor where it was bubbled through a culture of *C. thiosulfatophilum*. These bacteria oxidized the sulfide to elemental sulfur which was recovered as a product.

In subsequent developments, the system was operated on a continuous basis in which there was a constant flow of fresh medium into and spent medium out of both reactors (Cork and Cusanovich, 1979). Also nitrogen was used as a carrier gas instead of the Ar-CO₂ mix though it is unclear how this would affect the growth of *C. thiosulfatophilum* since it would need a source of CO₂. In these studies, well-defined laboratory media specific for the growth of the two different bacteria were used and lactic acid was the carbon source used for *D. desulfuricans*. No carbon source was needed for *C. thiosulfatophilum* because it is photosynthetic. The pH was adjusted to 7 in all cases.

Hydrometallurgical solvent extraction effluents or raffinates containing high concentrations of sulfate (646 mM) were used in one part of the study (Cork and Cusanovich, 1978). The raffinate was supplemented with lactic acid and yeast extract. The pH of the raffinate was not reported and it is unclear if the pH was adjusted. The raffinate was fed into the first reactor displacing the defined medium on which the *Desulfovibrio* had been growing. The SRB were unable to grow in the raffinate unless it was diluted to at least 25%. The claim that such a system could be used to treat AMD was not investigated.

The work by Cork and Cusanovich served as the prototype or basis for processes proposed by future groups of researchers in this field. A similar two stage system was proposed by Maree and his colleagues to treat wastewaters containing high levels of sulfate such as pulp mill effluent and AMD (Maree and Strydom, 1985, 1987; Maree *et al*, 1987; Maree, Gerber and Hill, 1987). The basic concept of using *Desulfovibrio* and *Chlorobium* to consume sulfate and produce elemental sulfur is the same as that of Cork and Cusanovich. The difference lies in the use of (i) an upflow packed bed reactor for *Desulfovibrio*, and (ii) a recirculation loop on this reactor to optimize sulfate removal. A packed bed or solid medium was used in an attempt to increase the rate of sulfate reduction and decrease the retention time.

Of interest to this dissertation was the investigation into the type of solid medium used in the bed. The substrates considered were: (i) 1 cm hard stone; (ii) crushed hard stone; (iii) 2 mm quartz sand; and (iv) plastic (Maree and Strydom, 1985). Unfortunately, no further information about the substrate was provided. The difference between the hard stone and crushed hard stone and the size and shape of the plastic were not discussed. No sulfate reduction was observed in the case of sand and plastic while 90% sulfate removal was obtained for the two stone media. This is to be compared to 40% sulfate removal for a sludge blanket reactor where no physical substrate is present. The poor performance of sand and plastic substrates was ascribed to a lack of trace minerals in these cases. In subsequent experiments dolomite pebbles with a diameter of 2 to 3 mm were used (Maree and Strydom, 1987).

AMD supplemented with a carbon source and adjusted to pH 7 was used. A variety of carbon sources including sugar, sulphite pulp mill effluent and sewage sludge were tested. All were shown to be capable of acting as carbon sources for the SRB and the use of molasses was decided upon since it contained a variety of sugars and was cheap. Good removal of sulfate and metals, especially lead and nickel was attained.

Couillard *et al* (1988) investigated the use of a two stage and a single stage system for the biological treatment of spent sulphite liquor (SSL) from a pulp mill. In the pulping process lignin is removed from the pulp by using sulfite to sulphonate the lignin.

This solubilizes the lignin and results in the formation of lignosulphonates which is discharged as part of the effluent from the pulp mill. In this study, *D. desulfuricans* was used to remove the sulfur from lignosulphonates to produce hydrogen sulfide and lignin. The hydrogen sulfide could be purged and sent to a sulphur burner to be recycled for use in the pulping process and the lignin could be precipitated, collected and burnt to produce steam.

A novel aspect of this study was the use of *Lactobacillus bulgaricus* to ferment the sugars in the SSL to produce hydrogen and the lactic acid required as a carbon source by the SRB. A two stage system was designed in which the SSL was first fed into a reactor containing the *Lactobacillus*. The effluent from this reactor containing the lactic acid was passed into the second reactor containing the *Desulfovibrio*.

A single stage system in which both *Lactobacillus* and *Desulfovibrio* were present in the same reactor was also examined. This arrangement did not prove to be successful since the optimal pH ranges for the two bacteria were different. Also the *Lactobacillus* tends to acidify its environment which negatively affects the SRB. A constant manipulation of the pH was required.

A full scale two stage system using SRB was implemented by Budelco in the Netherlands for the purpose of treating groundwater contaminated with sulfate and heavy metals from a zinc refinery (Barnes *et al*, 1992; Scheeren *et al*, 1992). Wells were situated in the flow path of groundwater from the refinery site to collect the contaminated water. About 5,000 m³/d were collected. The water had high levels of sulfate (1300 mg/L) and zinc (135 mg/L) and has a pH of 4.5. Prior to the first stage, the pH of the water was adjusted and ethanol was added as a carbon source for the SRB.

In the first stage, an upflow anaerobic sludge blanket (UASB) reactor was used to support a mixed population of SRB. Sulfate in the influent is reduced and sulfide is produced. The sulfide can (i) precipitate the heavy metals in the water, (ii) escape into the head space and be trapped in the scrubbers, and (iii) remain in solution. The effluent from this reactor is passed into a second reactor which is a submerged fixed-film (SFF) reactor packed with Pall rings. Aerobic bacteria growing in this reactor oxidizes any

hydrogen sulfide remaining in the water to produce sulfur. This system was designed to treat about 7,000 m³/d. The system was tested in two trial runs and the effluent met all environmental standards for water discharge.

Stucki *et al* (1993) proposed a system for treating spent sulfuric acid from chemical processing plants. This system was based on a fixed bed reactor with a recycle stream that was passed through a stripper in which the hydrogen sulfide generated by SRB activity is purged by a stream of N₂. The influent stream entered the fixed bed reactor from the bottom. Acetate was used as a carbon source for the SRB and the pH of influent into the fixed bed reactor was adjusted. Three different types of packing were used: (i) porous glass spheres, (ii) lava beads, and (iii) polyurethane pellets. The types of packing used affected the diffusion of gas through the system in the case of glass spheres and the lava beads.

A recent novel development in the active treatment of AMD using SRB was the Biosulfide Process (Rowley *et al*, 1994). The reduction of sulfate by SRB and the precipitation of metals by hydrogen sulfide occurred in separate parts of the system rather than within the same unit. This was accomplished by passing the raw AMD through a series of three precipitators prior to its entry into the bioreactor where the SRB were situated. The metals were precipitated by the hydrogen sulfide generated by the SRB in the bioreactor. The hydrogen sulfide was stripped from the bioreactor by sparging the reactor with N₂ and was directed to the precipitators. The metals can be selectively precipitated and the metal sulfides can be collected.

By the time the AMD reached the bioreactor the metals have been removed and only high levels of sulfate were present. Consequently no metal sulfide precipitate occurred in the bioreactor. The effluent stream from the bioreactor can be either discharged or used to adjust the pH of the influent stream of AMD. Thus, the adjustment of pH was achieved by using the alkalinity generated in the bioreactor and did not require the addition of a chemical base. A 100 L pilot scale system was built and operated continuously for 75 hours with AMD and good results were obtained: the pH of the effluent was consistently over 7 and good metal and sulfate removals were achieved.

The SRB have, therefore, an important role in treatment processes for effluents rich

in sulfate. There are many feasible processes appropriate for a variety of conditions and applications. High rates of reduction of sulfate can be obtained under optimal environmental conditions. The sulfide generated can either be used to precipitate metals or be converted to elemental sulfur. However, there are several disadvantages. First the pH must be adjusted. The Biosulfide Process does address this problem with success. Second, a source of carbon must be provided. Other problems are the removal of the metal precipitate or hydrogen sulfide and the cost of maintaining optimal operating conditions.

2.2.2 SRB in Passive Treatment Systems for AMD

2.2.2.1 Wetlands

Wetlands are areas where the soil or substrate is waterlogged at least periodically, and may be covered by shallow waters (Gorham *et al*, 1984). This simple definition belies the fact that there are several types of wetlands. A major division is whether or not the wetland is freshwater or marine. The vegetation, geology and climate around a wetland will affect its character and composition. The wetlands referred to in this section are freshwater wetlands such as bogs, fens, and marshes.

Wetlands are known to affect the quality of water passing through them, acting as sinks for sulfate and nitrate (Bayley *et al*, 1986). This role of wetlands was of interest to researchers investigating the response of bodies of waters to acid precipitation. This focus widened to include the infiltration of acid mine drainage as a result of a study by Wieder and Lang (1984).

Wieder and Lang (1984) were investigating the effect of wetlands on water chemistry of streams draining similar types of watersheds in West Virginia. The water chemistry of three streams were monitored and compared: the first drained a forested area, the second drained a forested area containing a *Sphagnum*-dominated wetland, and the third stream drained a forested area containing an abandoned coal mine and a bog wetland. The third stream was contaminated with AMD from the coal mine. On comparison of the data, they concluded that the presence of a wetland does have a significant effect on

water chemistry and in the case of the AMD contaminated stream, the wetland lowered the H^+ , Ca^{2+} , Mg^{2+} , Fe^{2+} , and SO_4^{2-} levels in the water. These observations suggested that wetlands could be used to treat AMD contaminated waters.

Several processes have been identified as being potentially involved in the treatment of AMD by wetlands. These are adsorption, ion exchange, bioaccumulation, bacterial and abiotic oxidation, sedimentation, neutralization, sulfate reduction and formation of carbonate materials (Kleinman and Hedin, 1989). Adsorption and ion exchange can cause the pH of the water to decrease (Eger, 1994). The increased acidity is due to the exchange of protons for metals ions. As the pH decreases, the efficiency of the process decreases (Lapakko and Eger, 1988; Eger, 1994). Similarly, the oxidation and hydrolysis of metals causes the release of protons leading to the acidification of the wetland (Brodie *et al*, 1993).

The major anaerobic process is sulfate reduction by the SRB. The SRB play an important role in the response of wetlands to infiltration by AMD and acid rain (Mills and Herlihy, 1985; Eger, 1994). Unlike the aerobic process, the activity of the SRB brings about not only the removal of metals but also the removal of acidity and the generation of alkalinity. The reduction of sulfate consumes protons and the carbon metabolism of the SRB leads to the production of carbonate alkalinity. Sulfate reduction has been documented to be one of the major biological source of alkalinity in acidified lakes and wetlands.

Other biological sources of alkalinity are the reduction of nitrate and the reduction of ferric iron [Fe(III)]. The biologically-mediated reduction of Fe(III) to Fe(II) may in fact be the major generator of alkalinity in wetland rather than sulfate reduction per se (Vile and Wieder, 1993). However, this conclusion is not incompatible with the central role of SRB since the reduction of Fe(III) may occur through the activity of the SRB.

In the wetland ecosystem, a cycling between the reduced and oxidized forms of the sulfur is observed. This occurs as a result of changes in the oxygen levels when water levels fluctuate. When the water level is high, the substrate of the wetland is anaerobic and the metal sulfides are stable. However, when water levels drop, as can happen in late summer and in drought conditions, the substrate becomes oxygenated and the sulfide can

be reoxidized to sulfate. When water levels increase, the sulfate is reduced again. This cycling has also been observed in lakes. Despite this cycling, a net reduction and removal of sulfate in the overall sulfur balance, is usually observed.

A wetland can, therefore, act as a source of alkalinity and as a sink for metals and sulfate. That this does occur in wetlands is a result of several mechanisms, the foremost of which is the activity of SRB. Wetlands can thus treat AMD.

2.2.2.2 Constructed Wetlands

The use of wetlands to treat AMD is, however, not an acceptable practice since wetlands are important and valued ecosystems that are habitats for a wide variety of animal and plant life. The area of wetlands is rapidly shrinking as they are being drained and developed for either agricultural or urban use (Nichols, 1988). As a result, investigations in this field have been directed at the use of artificial or constructed wetlands. The construction of wetlands for the treatment of AMD is a relatively new field, starting only in the 1980's. The bulk, if not all, of the pioneering work was done in the U.S.A. Such research is ongoing and is being done primarily in the U.S.A., Canada and Australia.

Wetlands have been constructed for the treatment of not only AMD but also for a variety of industrial, municipal and agricultural wastewaters (Hammer, 1989; Moshiri, 1993). Wetlands are being used to remove nitrates, phosphorus, and to lower the BOD in wastes such as municipal sewage, pulp and paper effluents, dairy effluents and waste from the petrochemical industry. The characteristics of AMD are, however, very different from these other effluents. AMD has very little organic content and low alkalinity. The high levels of metals and high acidity poses considerable problems to plant and aquatic life. The effect on wetlands receiving these waters can, therefore, be negative if the wetland is not designed properly.

Initial attempts were for the most part not successful. This was due primarily to a lack of basic information and experience. Consequently, all results, negative and positive, have been of value in helping to advance the knowledge base in the design and operation of constructed wetlands. However, conflicting results and unexplainable successes and failures still are features of this field of research.

Observations indicate that fluctuations can occur in the performance of wetlands. There is some evidence that the monitoring protocol itself may play a role in such fluctuations (Wieder, 1994). The measurement of performance is done by taking samples at the points of influx and efflux. The difference in the water qualities of these sample is the basis for determining the degree of treatment attained. Also, samples are usually taken only once and usually during the day. An hourly sampling of water taken from the efflux point of wetlands indicated that there were large fluctuations in the iron content taken at night and during the day. This deserves more attention.

Much of the initial work was done on a small scale and had been designed in a number of different forms (barrels, trenches, ponds) for a variety of applications. Despite this, several general conclusions have emerged on how to build a wetland for the treatment of AMD. The most important being that the flow rate should be slow enough so that the residence or contact time of the AMD in the wetland is sufficient.

The sizing and configuration of the wetlands have to take into account (i) the expected amounts of AMD to be treated, (ii) the flow rates that must be attained to allow for the appropriate residence or contact time for treatment to occur, (iii) the amount and types of biomass and substrate that must be present for treatment to be attained, (iv) seasonal fluctuations in water quantity and quality.

Furthermore, since sustainability is a desired goal, a balanced ecosystem must be established in the wetland. The types of vegetation and substrate to be used in the constructed wetland were the initial focus of much attention. The types of aquatic plants that could be used were limited since there are not many plants that are tolerant of metals and acidity. Attention centered on plants such as typha and sphagnum since they were found in waters contaminated with metals. Possible mechanisms involved in the treatment of AMD by these plants were bioaccumulation of metals and oxygenation of the sediment. However, while the plants were tolerant to relatively elevated levels of metals, there was a limit to the amount that could be tolerated and accumulated before the plants were adversely affected. The harvesting of these plants to remove the metals was not feasible since most of the metal was accumulated in the roots rather than in the leaves (Dunbabin and Bowmer, 1992).

Peat and sphagnum have good adsorbent properties which would result in metal removal. However, metals sequestered by this mechanism are easily remobilized and the capacity for the adsorption of metals is finite. As mentioned in the previous section, the removal of metals by adsorption tended to acidify the environment which limits the efficiency of adsorption (Lapakko and Eger, 1988). The removal of metals by adsorption is limited and is only for the short term.

The types of vegetation and substrate used in the wetlands do not seem to be important as there were no significant differences in treatment when different combinations of vegetation and substrates were used (Brodie *et al*, 1988). The role of plants is, therefore, primarily to: (i) oxygenate the substrate, (ii) provide buffering capacity, (iii) add organic matter to the system, and (iv) provide a root system to counter erosion (Brodie *et al*, 1988; Dunbabin and Bowmer, 1992).

The main sink for metals and sulfate in wetlands is the sediment and not the plants (Dunbabin and Bowmer, 1992). Observations suggest that adsorption occurred first to bind the metal to the substrate, followed by precipitation with sulfide generated by SRB activity (Machemer and Wildeman, 1992). The removal of metals by this process does not contribute to increased acidity. As mentioned above, sulfate reduction is a major source of alkalinity in acidified lakes (Giblin *et al*, 1990; Schindler *et al*, 1986).

Sulfate reduction was always identified as potentially playing a role in the remediation of AMD in constructed wetlands. However, initial wetlands were not designed to optimize the use of SRB activity. As mentioned earlier, the main focus had been on the types of vegetation and substrate to be used. The question of whether the flow should be surface or subsurface is therefore, an important consideration. Since an active SRB population is essential for both the long term removal and storage of sulfate and metals and for the generation of alkalinity, the flow of water should be directed to the sediment or substrate.

2.2.2.3 SRB and Sediments

As was described in Chapter 1, the sediment is the habitat of the SRB and these bacteria are capable of surviving in what would be considered adverse conditions as a result of

the formation of microenvironments by bacterial activity on soil particles and other surfaces. The formation of the microenvironment is due to the propensity of bacteria to aggregate on and to colonize surfaces. The formation of the microenvironments has been described as follows: "Biomass accumulation in biofilms or aggregates can result in the development of microenvironments, due to diffusional resistance of reactants within the biomass layer" (Lens *et al*, 1995). The actual attachment of bacteria to the surface does not seem to be a pre-requisite for the formation of these micromilieus.

Most microorganisms in nature (i.e. out of the laboratory) are thought to exist as attached to surfaces rather than as free-swimming (Costerton, Irvin and Cheng, 1981). This occurs even though the bacteria are mobile and such is the case of some SRB such as *Desulfovibrio desulfuricans*. The standard use of liquid cultures in laboratories may, therefore, produce misleading artifacts that do not reflect the actual activity of bacteria in their natural environments. This would explain discrepancies between the required laboratory culture conditions necessary for the bacteria to grow and be active and the conditions under which bacteria are actually found in the environment.

Why do bacteria tend to colonize surfaces? This may be due in large part to the tendency of nutrient molecules to accumulate on surfaces as a result of electrostatic forces. The sediment-water interface is, therefore, a nutrient rich zone. It would therefore, be in the interest of the microorganisms to maintain themselves in this niche. The surface may also provide some physical protection.

The colonization of surfaces by bacteria can result in the formation of large structures called biofilms. The generation of biofilms is due to the activity of a group of bacteria, the primary colonizers, that are able to produce an extracellular polysaccharide which forms a large polymeric structure called the glycocalyx. The glycocalyx is a permeable matrix in which in the primary colonizers grow and reproduce. As new cells are formed, the older cells remain next to the solid surface.

As the glycocalyx becomes more extensive, aerobic and anaerobic zones are established within the mat. The level of the biofilm closest to the surface becomes anaerobic due to both the metabolism of aerobic bacteria at and near the surface of the biofilm and to the slow diffusion of oxygen into the biofilm. Anaerobic microorganisms are able to

penetrate into the mat and establish themselves in these anoxic zones. Other aerobic bacteria may also colonize the biofilm. Consequently, a community or consortium of diverse microorganisms including both aerobic and anaerobic microorganisms can be harboured in the biofilm. The biofilm confers some physical protection, and can act as a barrier to biocidal agents such as antibiotics, accounting for the persistence of bacteria in spite of attempts to sterilize. The occurrence of SRB in biofilms was found to be independent of environmental conditions (Lens *et al.*, 1995).

The concept of the microenvironment has far-reaching consequences and implications for environmental scientists and engineers. The use of fixed-film and sludges in reactors rely in large part on the immobilization of bacteria on a surfaces and on particulate matter.

2.2.2.4 Anoxic Limestone Drains

A promising development in recent years has been the use of anoxic limestone drains (ALD) in conjunction with wetlands as proposed by Turner and McCoy in 1990 (Hedin *et al.*, 1994). An underground drainage system to collect and drain the AMD from the waste rock pile was installed. A bed of limestone gravel was buried and placed in the flow path of the drain before the AMD surfaces into the wetland. The bed or ALD served as a source of alkalinity. No precipitation of the metal occurred because of the anaerobic condition that exist within the drain. Consequently no armouring of the limestone occurred. Upon surfacing and contact with oxygen, the metals were oxidized and precipitated, and the alkalinity was consumed as a result of the liberation of protons in this process. Most of the Fe was removed at this stage.

The effluent from the ALD was passed through a staged constructed wetland where further metal removal and generation of alkalinity occurred. The final stage of the wetland can be a polishing pond in which SRB activity is high. Any remaining metals can be removed and the alkalinity of the water is increased prior to discharge. These passive treatment systems achieve high metal removal and neutralization of the acidity on a consistent basis. Several are presently in operation in the Pittsburgh area. These systems have only been constructed in the last few years and the long-term operation has yet to

be seen. The lifetime of such an ALD-wetland system is estimated to be about 25 years. This depends in large part on the quantity of limestone present in the ALD.

The use of ALDs should only be considered in cases where the alkalinity of the water is very low (<80 mg/L) and iron content is high (> 20 mg/L). Otherwise, a conventional constructed wetland should be used (Brodie *et al*, 1993). If the alkalinity is high, a constructed wetland should be sufficient to treat the water.

2.3 The Question of Nutrition

The key to the economic feasibility and the self-sustaining aspect of using SRB to treat AMD centers on the question of nutrition. This is because AMD is an organic-poor environment and the SRB have specific nutritional requirements. The SRB cannot utilize simple sugars such as glucose and fructose, instead more complex carbon compounds are needed.

In active treatment processes where the SRB are the only bacteria present, they must be supplied with a carbon source that they can readily metabolize. As was described in section 2.2.1 on active treatment processes, pure chemical carbon sources such as lactic acid and methanol were used. These carbon sources can be expensive and may render the process economical unfeasible, especially if large quantities of AMD are to be treated.

With respect to passive treatment by SRB, the search for an inexpensive and readily available source of nutrition has been of concern from the beginning. The papers by Tuttle *et al* (1969) and Wakao *et al* (1979) are ultimately about the nutritional aspects of the treatment of AMD by SRB.

These studies demonstrated that (i) the extent of SRB activity is restricted by carbon and nitrogen limitations, and (ii) the carbon and nitrogen requirements of the SRB can be provided by the metabolism of other microorganisms present in the immediate environment in a commensal relationship. The first point suggests that a major constraint on SRB activity in nature is carbon and nitrogen limitation.

The second point is important since it means that, in theory, it is not necessary to provide the SRB directly with a carbon source if the SRB are part of a consortium or

community of different microorganisms (Tezuka, 1966). This is more than likely how the SRB are sustained in nature. A self-sustaining process would depend on such a relationship. Consequently, a wider range of carbon sources such as wood, straw, hay and other waste organic materials can be considered.

The possibility of using wood as proposed by Tuttle *et al* (1969) or other plant material such as straw and hay has been the basis of much study since they are plentiful and are considered as waste. The degradation of such materials to provide the carbon in an appropriate form for the SRB depends on the activity of aerobic microorganisms.

The degradation of the cellulosic components of wood by aerobic bacteria and fungi was shown to result in a decrease in the acidity of the water (Jongejan, 1986). The activity of these microorganisms can prepare or condition the environment for the SRB to establish themselves by: (i) metabolizing and producing the required nutrients for SRB; (ii) decreasing the acidity of the water, and (iii) depleting or lowering the oxygen as a result of their aerobic metabolism. The rate of degradation must be sufficiently fast to support the rates of sulfate-reduction required for successful treatment of AMD. Unfortunately, this is generally not the case and the ligno-cellulosic material must be supplemented with simple sugars such as sucrose (Bechard *et al*, 1994).

Sewage sludge has been considered. The use of sewage sludge was originally investigated from the point of view of producing sulfur. The sludge was supplemented with sulfate to stimulate the activity of SRB present in the sludge. The sulfide that was generated could be collected and oxidized to produce sulfur (Butlin *et al*, 1956; Burgess and Wood, 1961). At the time of these studies, the demand and prices for sulfur was high. The sludge was, therefore, used as a source of both the bacteria and the nutrients. The sludge at the end of the process could be safely handled and disposed, since it was more easily dewatered and the effluent was of good quality.

Similarly, the use of cattle manure as a supplement to AMD was investigated. In these studies, anaerobic digester slurry was found to be able to support sulfate-reducing activity (Ueki *et al*, 1986). Furthermore, the slurry and its supernatant were good sources of alkalinity and could be used to neutralize the AMD and precipitate metals. The addition of 5% (v/v) digester slurry to the neutralized AMD resulted in the reduction of

sulfate at a maximum rate of $120 \text{ mgL}^{-1}\text{d}^{-1}$ (Ueki *et al.*, 1988).

The use of sewage sludge as a carbon source for SRB activity to treat AMD is appealing since two different wastes can be used to treat each other. The AMD would take the place of the sulfate supplement and the sulfide generated would precipitate the metals in the AMD. However, this has not been pursued despite the fact that it has been mentioned as a possible carbon source in several publications. This may be due to (i) environmental concerns about the use of sewage, and (ii) transportation problems of sewage sludge to outlying areas.

Presently spent mushroom compost, a combination of straw and horse manure is the most common substrate used in constructed wetlands whenever SRBs are to be used. The question of nutrition is outside the scope of this study and is consequently not addressed here.

2.4 Concluding Remarks

The SRB occupy an important niche in the sulfur cycle in the environment which make them ideally suited for the treatment of AMD. The activity of these bacteria can result in the removal of significant quantities of sulfate, metals, and acidity from AMD, to effectively treat the water. The active and passive treatment of AMD by SRB are feasible alternatives to chemical treatment.

In active treatment processes, culture conditions are manipulated to provide optimal conditions for SRB activity. For example, the pH of the AMD is usually adjusted to lower the acidity of the water prior to its contact with the SRB. Also an anaerobic environment and nutrition have to be provided and maintained.

Direct intervention should be minimal in passive treatment processes. Such manipulations would add to expenditure and would indicate that the system is not operating well. In passive treatment systems, the SRB are not provided directly with the culture conditions required for their growth and activity. This should evolve from the system itself. Constructed wetlands are being used to treat AMD, however, this field of research is still in its infancy. Most constructed wetlands are not more than a decade old and their

long term performance have still to be ascertained.

The key to the use of SRB in passive treatment systems is to provide a physical substrate on which the bacteria can establish and maintain an environment appropriate for their survival. A gravel bed can be used as a physical substrate. The specific goal of this study is to obtain data that would be useful for determining the size and composition of the gravel bed. This information can also be useful in the sizing of the substrate bed for wetlands.

3. PRELIMINARY WORK

When first conceived, the ultimate objective of this study was to establish a population of SRB in an open mine pit for the purpose of treating the AMD accumulating in it. To achieve this goal, a fundamental understanding of key parameters operating in this system was required. Consequently a reactor was designed in an attempt to simulate conditions at an open mine pit. This reactor was used to determine the key physical and biological parameters and to study the behaviour of such a system under various conditions to help in the implementation at the site.

As this work progressed, the importance of the gravel bed and the lack of information about the role of the gravel bed in the system became evident. Attention in the literature has focused on the biological needs of the SRB, however, scant regard has been given to a description of the role of the physical environment on the activity of the SRB. Thus, the characterization of the physical parameters of the gravel bed became the main focus of this study and, as such, resulted in a redefinition of the objectives as presented in Section 1.7. Similarly, a different concept was achieved for the implementation of an AMD treatment system using SRB and this is discussed in Chapter 6.

This initial work is presented in its entirety in this chapter despite the fact that it was not completed as originally intended. These experiments were, therefore, of a preliminary nature. However, the results do offer an insight into the development of the project as a whole and give some understanding of the limitations that might be encountered in the implementation of SRB in passive treatment systems.

3.1 Reactor Design and Materials

A reactor was designed primarily to simulate the treatment conditions that would occur at the mine site where a continuous flow of AMD over a sediment containing SRB was

expected. The hydrodynamics of the reactor were an important feature of this system. A gravel bed at the bottom of the reactor was used as a sediment.

Considerations in the design of this reactor were: (i) the depth of the water column, (ii) a continuous flow regime simulating the flow of water through a pit, and (iii) the localization of the active site for the bacteria at the bottom of the reactor. The depth of the water column was considered to be an important parameter since a sufficient depth was believed to be important for the development of gradients of metals, sulfates, acidity and dissolved oxygen.

The design and dimensions of the reactor are illustrated in Figure 3.1. The reactor was made of clear 0.635 cm (1/4") Plexiglas. All fittings were 0.635 cm (1/4") except for the fittings in the bottom plate of the shaft which were 1.27 cm (1/2"). The larger fittings in the bottom plate helped to facilitate rapid draining of the reactor.

The reactor was composed of three parts: (i) a head tank, (ii) a shaft, and (iii) a side tank. The shaft was a column comprised of cylindrical units. The design allowed for the volume and depth of the water column to be varied depending on the number and size of cylindrical units composing the column.

The head tank and the shaft opened directly into one another. The side tank was separated from the head tank and communicated only with the shaft via 1/4" latex tubing that connected spigots arranged at periodic intervals on the side of the shaft to fittings located in the bottom of the side tank. A 15.24 cm (6") layer of gravel was located at the bottom of the shaft.

The shaft was composed of Plexiglas cylinder units. The individual cylinder units had an inner diameter of 15.24 cm (6") and a height of 45.72 cm (18"). The units were joined together using flanges attached around the top and bottom of the unit. Viton O-rings (15.24 cm [6"] i.d. by 0.95 cm [3/8"] thick) were used to seal the joints between the cylindrical units and between the shaft and the head tank. A bottom plate covered the end of the shaft. A 1.27 cm (1/2") nipple was located at the center of the plate, to which was attached an elbow and a ball valve with a hose connector. The size of all fitting attached to the bottom plate were 1.27" and were used to drain the reactor.

Two nipples were inserted along one side of each unit. The first fitting was

located 7.62 cm (3") from the top of the unit and the second was placed 15.24 cm (6") from the bottom. The two nipples were 22.86 cm (9") apart. As a result of this design, when the column units were joined together and attached to the head tank, the arrangement of the fittings was such that: (i) the nipples were spaced at 22.86 cm (9") intervals; (ii) the top-most nipple was 7.62 cm (3") from the bottom of the head tank; and (iii) the bottom-most nipple was 15.24 cm (6") from the bottom of the reactor and was flush with the top of the gravel bed.

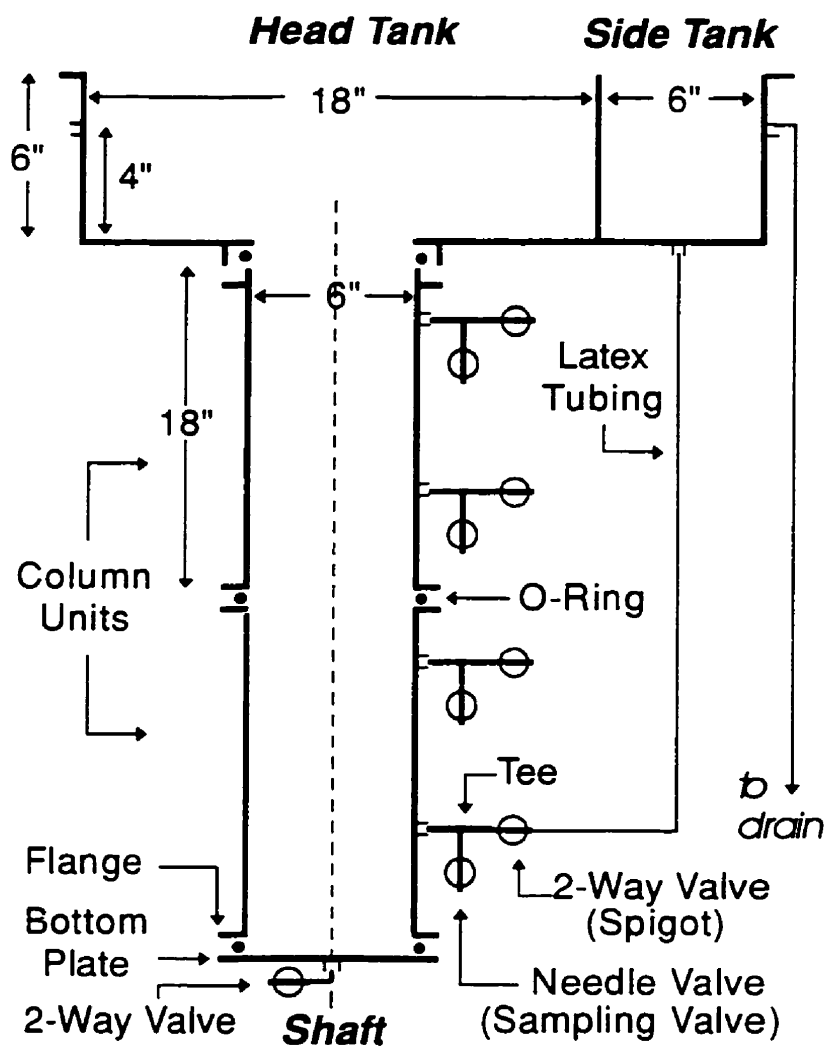


Figure 3.1 Design of the continuous flow reactor; sideview. Not drawn to scale.

A tee was attached to each of the nipples. A needle valve was connected to one arm of the tee, and a stopcock with a hose connector was placed on the other arm. The stopcock was connected to a 0.635 cm (1/4") hose connector in the bottom of the side tank via 0.635 cm (1/4") latex tubing. The needle valve was used for taking water samples. The stopcock was used to regulate the flow of water to the side tank. The placement of the sampling needle valve before the stopcock allowed for water samples to be taken even if there was no flow to the side tank through that stopcock.

The 0.635 cm (1/4") fittings on the side of the head and side tanks were for the influx and efflux of water from the system. Fresh water was pumped into the head tank using a peristaltic pump and water was displaced passively from the reactor due to the difference in hydrostatic head between the head and side tanks. Both 0.635 cm (1/4") fittings were placed 10.16 cm (4") from the bottom of the head and side tanks, therefore, this was the level to which the water could accumulate in the two tanks. This height could be increased by attaching a piece of tubing to the efflux fitting and looping the tubing upwards before it descended to the collection bottle. Therefore, the height of the upward loop of the tubing determined the height of the water level within the two tanks.

The reactor was designed in this configuration not to simulate the contours of the pit but to simulate gross flow conditions within the mine pit. Also, the design ensured that a constant level of AMD existed within the reactor and that this could be maintained by the use of only one pump. The configuration directed the flow of water through the reactor along the following path: fresh AMD entered the system in the head tank, passed down into the shaft, over the gravel bed, and up into the side tank. This simulated the flow of water into the pit and out by infiltration through the pit walls.

The final configuration that was used throughout the investigation was that illustrated in Figure 3.1. A photograph of the constructed reactor in operation is shown in Figure 3.2. Using two cylindrical units resulted in a total volume of about 38 L. Unless otherwise specified, only the bottom-most spigot was opened for the passage of AMD to the side tank. Not shown in Figures 3.1 and 3.2 is the cover constructed for the reactor. The cover had a rubber seal and could be secured onto the reactor by bolting onto the flange located around the top of the reactor.



Figure 3.2 Sideview of the constructed operational reactor with a 15.24 cm (6") deep gravel bed at the bottom of the shaft inoculated with SRB.

A special bottom plate was designed for the purposes of inserting a dissolved oxygen probe upwards into the shaft of the reactor. The probe was centrally located in the plate and allowed for the height of the probe in the reactor to be adjustable without (i) leakage, (ii) slippage, and (iii) having to dismantle the reactor. This was accomplished by a simple design that used two O-rings and a Plexiglas ring (tightening ring) which was tightened down onto the O-rings by three screws (Figure 3.3). The O-rings fitted snugly around the probe and the flattening of the O-rings by the Plexiglas ring squeezed the O-

rings tighter against the probe effectively clamping the probe into place and ensuring a water-tight seal.

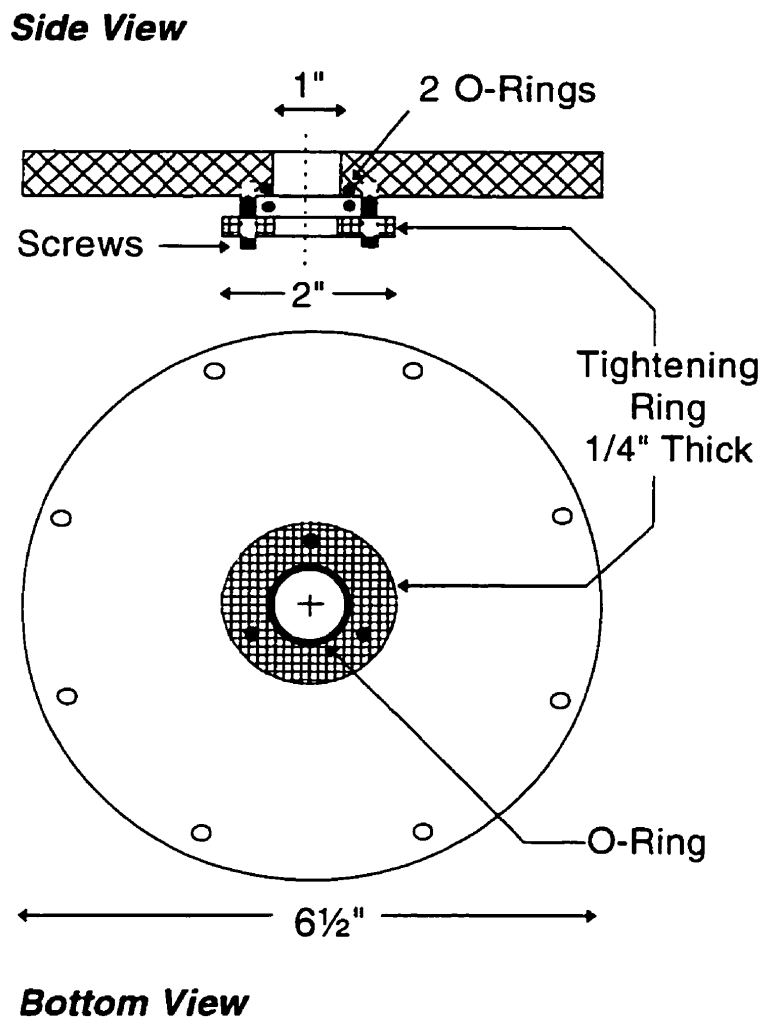


Figure 3.3 Design of the bottom-plate for dissolved oxygen probe.

3.1.1 Gravel Bed

Unsorted limestone gravel with a nominal size of 1/4" was used to form the gravel bed at the bottom of the column. It was not clear how much gravel should be used. The main consideration was that the depth be sufficient for SRB to be established, however, a definition of "sufficient" was not available. Moreover, the height of the water column was thought to be a more important parameter than that of the gravel bed. The decision to use a 6" gravel bed was made with the understanding that this would be a starting point and that it could be changed.

The gravel was washed to remove sand, clay, dust and other small particles and air dried. The dried gravel was introduced into the reactors up to the desired height. The void volume was measured directly by pouring in water until the surface of the gravel bed was reached.

3.1.2 Measurements

The pH was measured using a pH electrode with a double junction (Cole Palmer, Model No. 203). This type of electrode is less sensitive to sulfide poisoning. The ORP was measured using a platinum band redox electrode (Cole Palmer, Model No. 207). The level of dissolved oxygen was measured using a 420 mm (16.5") polarographic dissolved oxygen (DO) probe (Cole Palmer) connected to a power supply and meter (Cole Palmer, Model No. 01971-00).

Metal concentrations were measured by inductively-coupled plasma spectrophotometry (ICP) (Polyscan 61E Thermo Jarrell Ash) at the Noranda Technology Centre, Pointe Claire, Quebec. Water samples were acidified to 3% HCl prior to metal analysis by ICP.

The concentration of sulfate in the water samples taken during the part of the study prior to the inoculation of the column with SRB was measured by a turbidometric method which is described in detailed in Appendix A (American Public Health Association, 1989). The sulfate concentration in water samples taken after the SRB were

established in the reactor was calculated based on the S concentration measured by ICP. All S present was assumed to be present in the form of sulfate. This assumption was made on the basis of the following arguments. First, sulfate is the major, if not the only sulfur-bearing solute in AMD. This is justifiable from what is known about the characteristics of AMD. Second, when sulfate is reduced by the SRB, the sulfur in the sulfate appears either in the precipitate as metal sulfide or as hydrogen sulfide gas, that is, the sulfur is no longer in solution. Therefore, sulfur was not likely to be found in any other form than sulfate in the water and a decrease in sulfur concentration was interpreted as a decrease in sulfate concentration.

3.2 Experimental Design and Protocol

3.2.1 Characterization of the Hydrodynamics of the Continuous Flow Reactor

3.2.1.1 Sulfate

The hydrodynamics of the reactor in the absence of SRB activity were investigated under different operating conditions. Sulfate was used as a tracer since it is the most abundant component of AMD and is essential for the activity of SRB. The use of sulfate in the form of sulfuric acid and sodium sulfate was investigated.

The use of sulfuric acid as a tracer was abandoned after observing that the tap water had a buffering capacity. Attempts made to overcome or exhaust this buffering capacity by acidifying the water with HCl in the reactor prior to the start of the experiment proved to be impractical because of the amount of acid required and the low final pH attained. It was decided that it would be more practical to follow changes in the concentration of sulfate rather than protons (pH).

The basic protocol followed for the characterization of the hydrodynamics of the reactor was as follows. The reactor was filled with tap water and a 100 mL 0.1 M solution of sodium sulfate was pumped into the head tank. The addition of the sulfate solution was followed by either a continuous flow of fresh tap water into the reactor or

by no further influx of water (no-flow conditions). A flow rate of 3.8 mL/min gave a hydraulic retention time (HRT) of 7 d. The actual HRT that would be found in a treatment system at the mine site was unknown. A HRT of 7 d was used as a starting point, being not too long so as to be impractical for experimentation yet probably long enough for treatment to have occurred.

During this study only the bottom spigot of the reactor was opened, all the other spigots were kept closed. Water samples were taken periodically from (i) the head tank near the entry point of water, (ii) the needle valve on the bottom spigot, and (iii) the side tank near the exit point of water from the reactor. The concentration of sulfate was measured. The concentration of sulfate in tap water was about 22 mg/L and was taken into account in the calculation of sulfate concentrations.

3.2.1.2 Temperature Gradient

The effect of a temperature gradient on the hydrodynamics of the reactor was investigated. Two scenarios were studied: (1) the top of the reactor was heated while the bottom was cooled, (2) the bottom was heated while the top was cooled. The first case was examined under continuous flow and no-flow conditions while the second was examined only under no-flow conditions.

The heating and cooling of the head tank and the gravel bed at the bottom of the column was accomplished by the use of a glass coil immersed in the head tank and by a copper tubing coiled around the bottom of the cylinder. Glass was used because it was inert and resistant to the acidity of the AMD and had good thermal conductivity. Fiberglass insulation (2" thickness) was wrapped around the bottom of the reactor where the copper tubing was located. Heated water from a hot water-bath and cooled water from a refrigerated water-bath were circulated through the coils to heat or cool either the top or bottom of the reactor.

3.2.1.3 Oxygen

Since SRB are anaerobic and are not active when oxygen is present, the characterization of the distribution of dissolved oxygen (DO) in the reactor was a necessary step.

The bottom plate was replaced with the specially designed bottom plate for the DO probe. The DO probe was inserted with tip facing upwards into the shaft of the reactor. The height of the DO probe tip above the bottom of the reactor was 15.24 cm (6"), which corresponds to the height of the gravel bed. The water column was first sparged with air and the DO probe was calibrated to 100% air saturation. The column was then sparged with N₂ gas and the DO probe was calibrated to 0%. This could not be achieved unless the reactor was covered. Once the DO probe was zeroed, the N₂ gas was turned off and the DO level was monitored continuously using a chart recorder under no-flow conditions over three different temperature ranges: (i) 12-13°C, (ii) 15-16°C, and (iii) 18-20°C.

3.2.1.4 Effect of Activity of Aerobic Bacteria on Oxygen Levels

The activity of aerobic bacteria is thought to be important in providing SRB with nutrients. Also, the consumption of oxygen by the metabolism of these bacteria will deplete oxygen in the water. This would facilitate the generation and maintenance of an anaerobic environment in the gravel bed. To test the effect of the aerobic bacterial metabolism on oxygen levels in the water, the following experiment was performed.

A 15.24 cm (6") bed of limestone gravel was introduced around the DO probe such that the tip of the probe was just above the level of the gravel. The reactor was filled with Mattabi mine water and 94 g of organic material consisting of 13 g brewer's dried grain, 63 g wood pulp, and 18 g manure. The aerobic bacteria present on the organic material were the bacteria used in this experiment. This experiment was done under no-flow conditions.

The DO probe was raised an additional 5.08 cm (2") to clear the surface of the layer of organic material. The settling of the organic material occurred slowly and the tip of the probe was cleared periodically of any debris that should happen to settle on it. The DO was monitored continuously and the pH was measured in water samples taken periodically from the bottom of the reactor.

3.2.2 Establishment of an SRB Population

The inoculation and establishment of a population of SRB in the gravel bed of the reactor was accomplished in two stages. In the first stage, the bottom unit of the reactor was detached and fitted with a cover. A 15.24 cm (6") gravel bed of limestone (6.35 mm [1/4"] diameter) was deposited in the reactor and the void volume was measured.

The gravel bed was inoculated with a mixed population of SRB that was isolated at the Noranda Technology Centre (Pointe Claire, Quebec) from sediment samples taken at the Brunswick Mine site near Bathurst, New Brunswick. AMD supplemented with 4 g/L sodium lactate (carbon source) and 0.5 g/L ammonium chloride (nitrogen source) was introduced slowly until the unit was filled. These concentrations were those used in the isolation and enrichment medium of SRB from sediment samples (Gerhardt *et al.*, 1981). The cover was put in place and bolted down. The filling and covering of the unit were measures taken to exclude as much air as possible from the system so as to allow for the establishment of an anaerobic environment.

The establishment of the SRB was encouraged by the use of a centrifugal pump which continuously circulated AMD in the water column above the gravel bed. The criteria for "establishment" were when the water taken from the bottom spigot had a pH above 5.5 and an ORP of less than -100 mV. Other positive indicators of SRB activity were the presence of a black precipitate within the gravel bed and a sulfurous odour in the water sample.

In the second stage, the unit was reattached to the main body of the reactor after the SRB population was established in the gravel bed. The reactor was filled incrementally with AMD from the Matabi Mine site (Ignace, Ontario) over a period of 16 days to a final volume of 38 L. The concentrations of metals and the pH of this water are given in Table 3.1. The AMD was supplemented with sodium lactate and ammonium chloride in the concentrations given above.

The filling of the reactor was followed by an acclimatization period of 18 days. In this period, the SRB reestablished a neutral pH and a reduced environment in the gravel bed under no-flow conditions.

Table 3.1: pH and Composition of Mattabi Mine Water (determined by ICP) and Comparison with Recommended Levels in Water for Aquatic Life.

	Barrel 1 (M1)	Barrel 2 (M2)	Recommended levels for aquatic life ¹
pH	4	2.5-3.0	6.5-9
Elements (mg/L)			
Al	56	131	0.005-0.1
Cu	17	45	0.002-0.004
Fe	18	209	0.3
Mg	122	203	none
Mn	20	37	none
S	933	1324	none
Zn	188	349	0.03

¹ Environment Canada, 1995. Recommendation on Water Quality.

3.2.3 Continuous Flow Experiments

The treatment of a continuous flow of AMD through the reactor was investigated in a series of experiments in which the rate of flow was varied. The basic protocol for these experiments was as follows. Fresh AMD was pumped into the head tank of the reactor using the peristaltic pump used in the previous experiments. The treated AMD was passively displaced into the side tank and out of the reactor. Water samples were taken periodically from the bottom spigot. The ORP and pH were measured immediately and the sample was stored and prepared for metal and sulfate analysis by ICP.

Three flow rates were used. The flow rates and their corresponding hydraulic retention times were 3.8 mL/min (7 d), 3 mL/min (10 d), and 1.85 mL/min (14 d). During the course of these experiments, the first barrel of Mattabi water was depleted and a second barrel of AMD was obtained. The compositions of both batches of AMD were given in Table 3.1.

3.3 Results and Discussion

3.3.1 Characterization of Hydrodynamic Behaviour in the Reactor

A knowledge of the hydrodynamic behaviour of the system in the absence of SRB activity was important for a correct interpretation of results obtained in the presence of the SRB. This was especially important since a control column where SRB are not present would not be available. The hydrodynamics of the system were characterized under different operating conditions before the SRB were established in the reactor. This was done by observing the movement and distribution of sulfate over time.

3.3.1.1 Tracer Experiments

The use of 100 mL sulfate solutions with concentrations of 0.01, 0.1 and 1M were investigated. When a 1 M sulfate solution was used, the sulfate accumulated within 6 h at the bottom of the reactor (Figure 3.4). The results for 0.01 and the 0.1 M sulfate solutions were similar. Sulfate appeared simultaneously at the bottom of the reactor and in the side tank, 10-12 h after being introduced into the system.

The rapid accumulation of sulfate at the bottom of the reactor in the case of the 1 M sulfate solution was due to the high concentration of the sulfate making the solution denser than the water in the reactor. This conclusion was supported by the observation that at the point of entry of the 1 M sulfate solution, a stream within the water column could be seen falling to the floor of the head tank.

A 100 mL solution of 0.1 M sodium sulfate was used in all subsequent experiments since it gave results similar to that of the 0.01 M solution and the sulfate was easier to detect. Furthermore, the concentration of sulfate in the AMD used in this study was about 0.03 M (3000 ppm). A 0.1 M sulfate solution was, therefore, representative of the strength of sulfate found in the AMD.

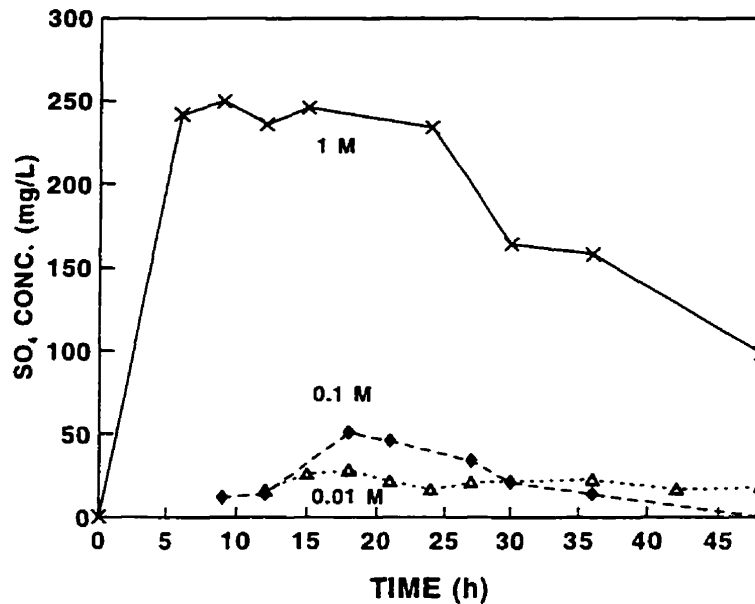


Figure 3.4 Changes in sulfate concentrations over time at the bottom of the reactor under continuous flow (3.8 mL/min) after the introduction of Na₂SO₄ solutions of different strengths into the head tank.

The movement of sulfate through the reactor occurred in a time frame that was much shorter than the hydraulic retention time: 10-12 h vs 7 d. This indicated that the rate of movement of sulfate was not controlled by the rate of pumping. The movement or migration of sulfate through the reactor appeared to be affected more by density or concentration gradients rather than the bulk flow of the water. The presence of such a gradient should appear when the system is operational as a result of (i) SRB activity which would consume sulfate at the bottom of the reactor, and (ii) the localisation of the SRB in the gravel bed. Consequently, this would favour the movement of sulfate to the active site regardless of the flow rate, and thereby facilitating the treatment process.

3.3.1.2 Effect of Temperature Gradient

The existence and effects of temperature gradients in shallow lakes has been well documented. In summer, the top layer of water is warmer while the bottom is cooler. This leads to a stratification of the lake water where there is a bottom layer of water which is

very different in composition than that of the water column above it. Exchange of solutes occurs at the interface between the two layers. In autumn and spring, the thermal gradient is inverted and mixing occurs between the layers, breaking the stratification in the body of water. The effect of temperature gradients on the movement of sulfate was investigated since such gradients may be important in the holding pit.

The presence of a temperature gradient in the reactor had a dramatic effect on the movement and distribution of sulfate in the system. When the bottom was cooled and the top warmed, a temperature gradient of about 10°C could be produced and easily maintained. However, when the bottom was heated and the top cooled, a temperature gradient of only about 1-2°C could be attained and was maintained with difficulty due to convection currents. In this case, there could be no flow of water through the system since this disrupted the temperature gradient. Therefore, this second scenario could be examined only under no-flow conditions.

When the top was heated and the bottom was cooled and a continuous flow (3.8 mL/min) of water was in effect, a steady migration of sulfate from the head tank to the bottom was observed (Figure 3.5). The concentration of sulfate at the bottom of the reactor increased constantly from the start of the experiment, peaked at 30 h, and declined thereafter. The sulfate first appeared in the side tank after 15 h and increased steadily over time, and continued to do so as the sulfate concentration at the bottom decreased. This indicated that the sulfate would be eventually washed out of the system.

When the experiment was performed under no-flow conditions, the behaviour was different (Figures 3.6). Most of the sulfate migrated to the bottom within 3-6 h, and remained there over the course of the experiment. Some sulfate remained in the head tank and some migrated into the side tank within 3-6 h. The levels of sulfate in the head and side tanks were similar. This distribution of sulfate was attained within 6-12 h and remained stable over the duration of the experiment.

These results indicated that the temperature gradient induced a difference in the buoyancy or density of the water between the top and bottom of the reactor. The density of the sulfate solution became an important factor in determining the distribution and movement of sulfate through the system. The sulfate solution would accumulate in the

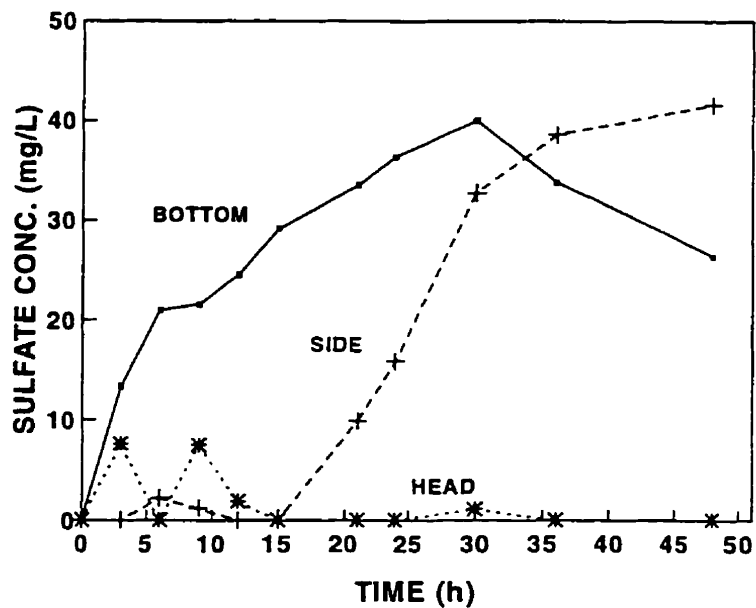


Figure 3.5 Distribution of sulfate in the presence of a temperature gradient: top heated, bottom cooled, and a continuous flow rate of 3.8 mL/min.

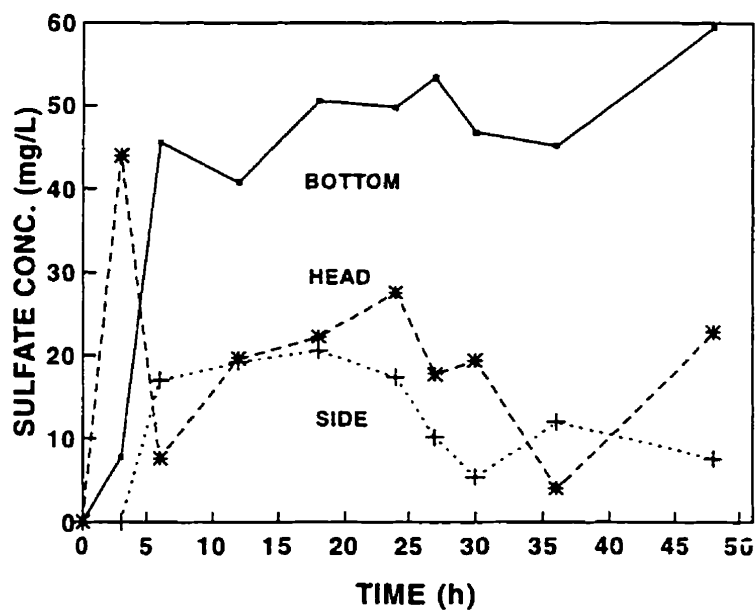


Figure 3.6 Changes in sulfate concentrations in different parts of the reactor with the top heated and the bottom cooled (temperature gradient of 10°C), and under no-flow conditions.

part of the reactor where the density or buoyancy of the water was similar to its own buoyancy. Consequently, the bottom acted as a sink for sulfate as was seen for both continuous flow and no-flow operating conditions. The difference in the distribution of sulfate between the continuous flow and no-flow conditions was due to the flow regime itself. A continuous flow displaced sulfate through the system and little or no diffusion of sulfate back up into the head tank was observed. Under no-flow conditions, a dynamic equilibrium was attained in the diffusion of sulfate between the bottom and the other parts of the reactor.

When the temperature gradient was inverted, the sulfate concentrations in the head tank and the bottom of the reactor became similar within 3-6 h (Figure 3.7). Little or no sulfate was seen in the side tank. This should be compared with the previous experiment which was also performed under no-flow conditions.

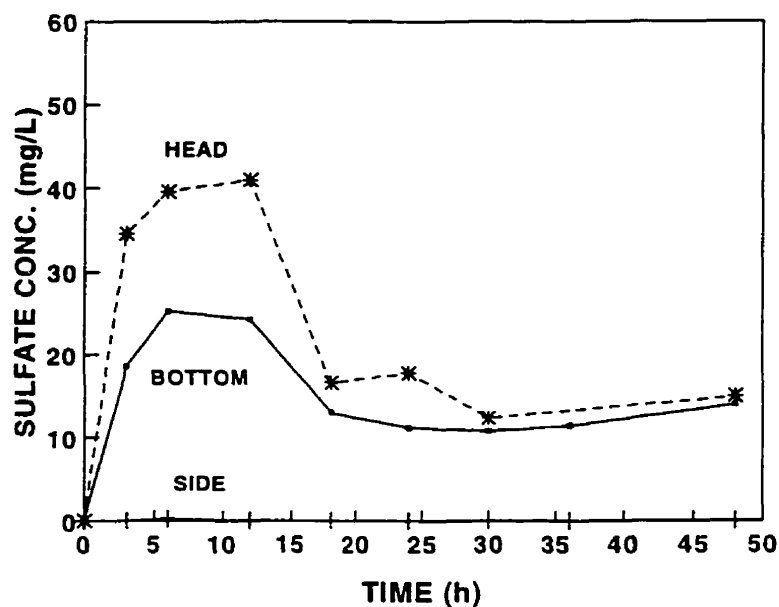


Figure 3.7 Changes in sulfate concentrations in different parts of the reactor with the top cooled and the bottom heated (temperature gradient of 2°C), and under no-flow conditions.

The equilibration of sulfate levels between the top and bottom of the reactor was probably due to mixing induced by the temperature gradient and resulting convection currents. The cooled water at the top of the reactor would be less buoyant than the

warmed water at the bottom of the reactor. Consequently, the cooled water would have a tendency to sink while the warmed water would rise. This would result in a mixing of the water in the reactor which explains not only why the sulfate became evenly distributed between the head tank and column but also why the temperature gradient was difficult to attain and maintain under these conditions. The lack of movement of sulfate to the side tank cannot be explained.

These results show that temperature gradients have an effect on the movement and distribution of sulfate through the system. In all cases, the movement of sulfate to the bottom of the reactor was not impeded. This is important since the active site of the system is located at the bottom of the reactor and ultimately the pit itself.

3.3.1.3 Diffusion of Oxygen

The effect of temperature on the rate of diffusion of dissolved oxygen to the bottom of the reactor is presented in Figure 3.8. The rates of diffusion of oxygen to the bottom of the reactor were about 2.5 times more rapid at 18-20°C than at 12-13°C.

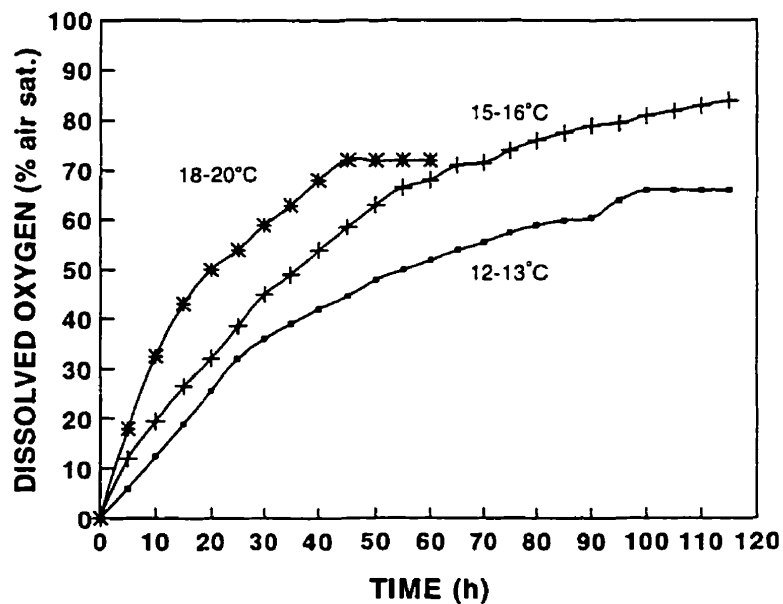


Figure 3.8 Effect of temperature on movement of dissolved oxygen to the bottom of the reactor

This information was also to be used a part of the investigation on the effects of temperature on the treatment process. The slower rate of diffusion of oxygen at lower temperatures would suggest that aerobic digestion of organic materials may be diminished accordingly, and that an anaerobic environment would be easier to maintain. However, the effect of temperature itself on both aerobic and anaerobic bacterial activity must also be taken into account since lowered temperature would result in decreased activity.

3.3.1.4 Effect of Aerobic Bacterial Activity on Dissolved Oxygen Levels

The influence of bacteria activity on dissolved oxygen levels at the top of the sediment was investigated in the presence of AMD and under no-flow conditions. The results are presented in Figure 3.9. After the introduction of 94 g organic material, the DO level decreased from 65-70% of saturation to 0% within 4 days. After day 4, the DO levels rose and reached a plateau at 30-40% of saturation by day 7. The fact that the new level of DO was lower than the initial DO level may be due to continuing bacterial activity.

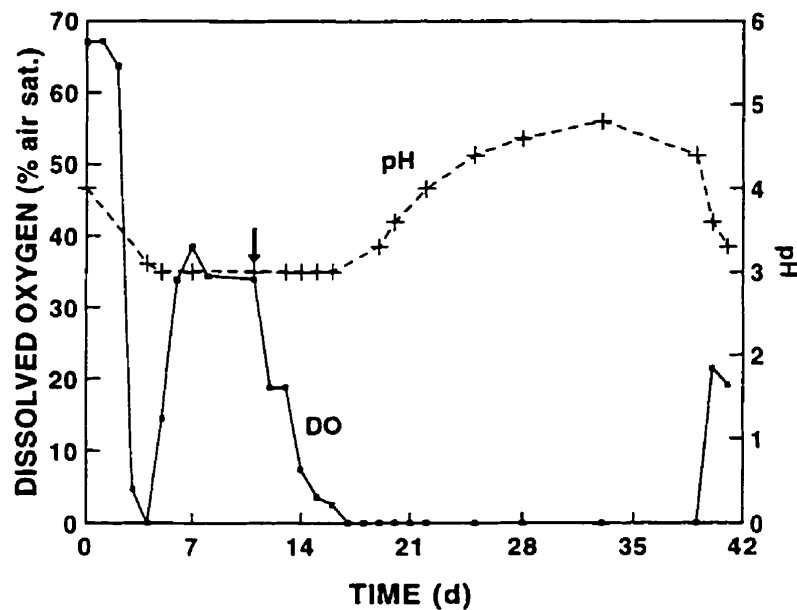


Figure 3.9 Effect of aerobic bacterial activity on dissolved oxygen content at the bottom of the water column. The arrow indicates when the second batch of organic material was added to the reactor.

Another 100 g of organic material was added on day 10. The DO content decreased to 0% of saturation within 6 days and remained at this level for 3 weeks. This long period of low DO was probably due to sustained bacterial activity. At the end of the 3 weeks, the DO level rose to about 20% of saturation.

The pH was also monitored during the course of the experiment. After the introduction of the first load of organic material the pH decreased from 4 to 3. Following the second addition of organic material, the pH increased from 3 to 4.8 during the 3 week period when the DO level was 0%. At the end of the 3 week period, the pH decreased to 3.3 as the DO increased to about 20% of saturation.

The concomitant changes in pH and DO can be attributed to the activity of bacteria present on the organic material. The decline in DO would indicate that these bacteria were aerobic and that their biological activity was sufficient to consume and deplete the oxygen in the water at the bottom of the reactor.

The decline in DO levels after the first load was introduced was probably due to a short flush of bacterial activity. The short duration of this drop in DO may be a result of either the rapid exhaustion of the readily available nutrients in the organic mix or the acidity generated by the bacteria themselves. The readily available carbon fraction would be provided by the manure. The degradation of lignin and cellulose in the wood pulp and grain is a slow process.

The second drop in DO was of a longer duration than the first one. The addition of a second load of organic material may have increased the population of aerobes and boosted the activity of the aerobic bacteria already present. Also, the degradation of the ligno-cellulosic material from the first load of organic material may have become advanced enough to start contributing to the nutrition of the aerobes. This conclusion was supported by the fact that the pH increased during this period. Jongejan (1986) demonstrated that bacterial degradation of cellulose by aerobic bacteria resulted in an increase in pH.

3.3.2 Establishment of SRB

The establishment of a population of SRB in the gravel bed at the bottom of the column was accomplished in 4 to 5 weeks after inoculation. Zones of black precipitate were evident in the gravel bed within 3 weeks and these expanded and coalesced until the gravel was completely black. The walls of the reactor around the water column became coated with a black precipitate. The pH and ORP attained at the bottom of the water column were 7.1 and -390 mV respectively (Figure 3.10).

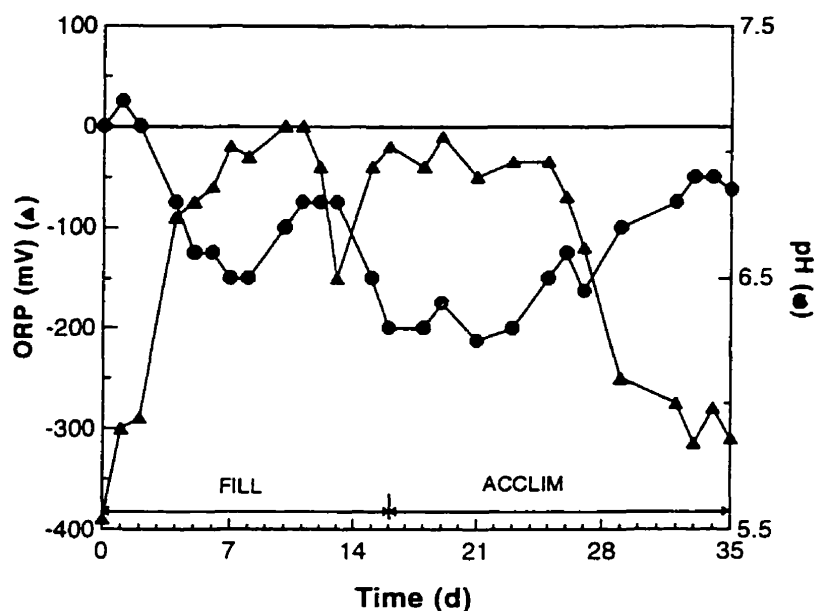


Figure 3.10 Changes in pH and ORP over the Fill and Acclimatization periods. Continuous flow was started on day 35.

The reactor was slowly filled with AMD over 16 days. During this period, the pH decreased from 7.1 to 6.5 and the ORP increased from -390 mV to 0 mV. The sulfate concentration increased from about 120 ppm to 2125 ppm by day 11, however the concentration had decreased to about 1550 ppm by day 16.

The system was allowed to acclimatize under no-flow conditions once the reactor was filled to the desired level. After a period of 18 days, the pH had increased to 6.8 and the ORP had decreased to -300 mV.

3.3.3 Treatment of AMD under Continuous Flow Conditions

The treatment of a continuous flow of AMD through the reactor was investigated in a series of experiments using different flow rates. The pH and ORP were monitored over the length of the study. Metal and sulfate analyses were done on water samples taken from the surface of the gravel bed.

3.3.3.1 Changes in pH and ORP

In the first experiment, a flow rate corresponding to a hydraulic retention time of 7 days was used since it was considered to be a reasonable length of time that would allow for sufficient contact between the water and the SRB for treatment to occur without detriment to the bacteria. By day 3 the pH had decreased from 6.9 to 6.5 and the ORP had increased from -300 mV to -100 mV (Experiment 1 in Figure 3.11). The flow was stopped at this time since the critical ORP for sulfate reduction to occur has been reported in the literature as being -100 to -150 mV. Subsequently, the pH increased to 6.8 and the ORP decreased to -330 mV within the next three days under stagnant conditions.

A hydraulic retention time of 10 days was used in the next experiment. After 3 days, the pH had decreased to 6.5 and the ORP had risen to -70 mV (Experiment 2 in Figure 3.11). The flow was stopped, and the SRB culture recovered rapidly under no-flow conditions. The pH increased to 7 and the ORP decreased to -265 mV during the next four days.

A third experiment with a hydraulic retention time of 14 days was initiated. As had occurred on the previous two occasions there was a rapid decrease in pH and increase in ORP. By day 4, the pH had decreased from 7 to 6.4 and the ORP had increased from -265 mV to -110 mV (Experiment 3a in Figure 3.11). This time the flow was not stopped so as to investigate the possibility that the culture would recover after a period of adaptation.

In the second week of Experiment 3a, the ORP peaked at 0 mV and the pH stabilized at 6.2-6.3. A layer of black precipitate had accumulated on top of the gravel bed and on the bottom of the head tank. Water samples taken from the bottom spigot

were invariably black and had a strong sulfurous odour. The black colour was due to a precipitate which settled as a thin layer when the sample was allowed to stand. The water above the precipitate was clear and colourless. Water taken from the top spigot was cloudy, yellow and had no odour.

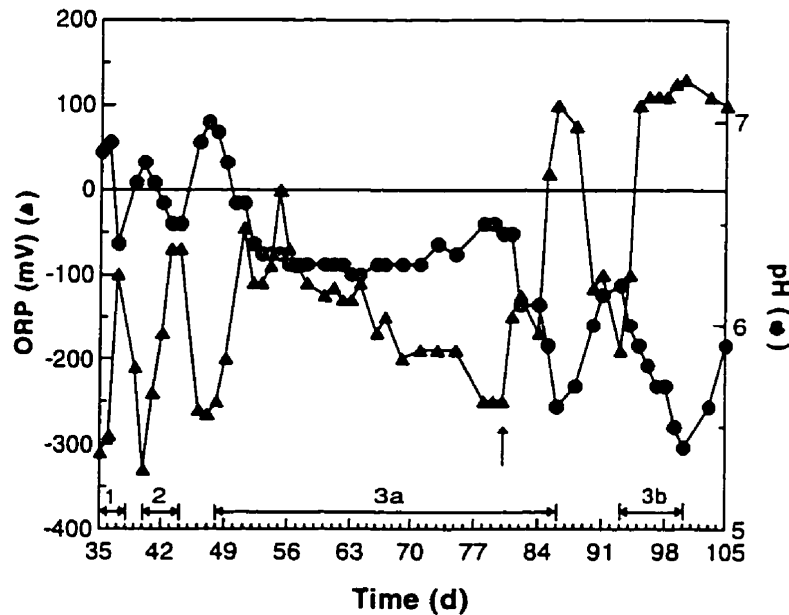


Figure 3.11 Changes in pH and ORP over the continuous flow experiments. 1: 7d hydraulic retention time (HRT); 2: 10d HRT; 3a,b: 14d HRT. The arrow indicates when new AMD was used (Day 80).

Differences in the ORP and pH were observed between water samples taken from the top and the bottom of the water column. The difference in ORP was about 200 mV: -150 at the bottom vs. +50 mV at the top. The pH difference was about 0.05 to 0.1 pH unit: 6.3 at the bottom vs. 6.2 to 6.25 at the top.

The effect of increasing the flow rate so as to decrease the hydraulic retention time from 14 days to 10 days was to be investigated in the next step. Prior to increasing the flow rate, it was decided to continue the present experiment until 3 reactor volumes had passed through the system before changing to a faster flow rate. This should have allowed for a steady state to be achieved within the SRB culture. The general definition of a steady state is when no changes in culture conditions occur for a given time period.

In the case of a continuous flow reactor with mixing, the definition of a steady state is when no change in biomass concentration occurs over a given time period. However, in a reactor without mixing, the biomass will tend to increase if the bacteria are attached to surfaces. The best indication of a steady state would, therefore, be when no further changes in bacterial activity as measured by pH, ORP and sulfate levels could be detected under the given operating conditions. The passage of 3 reactor volumes would assure that the replacement of the water column had occurred.

During the course of the third reactor volume, the stock of AMD being used was depleted and a fresh batch of AMD was obtained from Mattabi Mines. The new batch of AMD was more acidic than that of the previous batch. The difference was of the magnitude of 1 pH unit, i.e. the new batch was 10 times more acidic than the old batch. There were also differences in the concentrations of metals (Table 3.1). The new batch of AMD was used starting on day 80 (Figure 3.11).

The SRB culture was affected by the change in AMD. Within 6 days of using the new AMD, the ORP increased rapidly from -250 mV to +90 mV and the pH decreased from 6.45 to 5.7. The flow was stopped to allow the culture to recover and this occurred rapidly; after 7 days the ORP was -190 mV and the pH was 6.25.

A continuous flow of AMD giving a 14 day hydraulic retention time as in the previous experiment was started again (Experiment 3b in Figure 3.11). The culture did not respond well: the pH decreased and the ORP increased sharply. The flow of AMD was continued so as to investigate the possibility that the culture would stabilize after a period of adaptation, as had occurred before in experiment 3a. However, after 7 days the ORP had risen to +145 mV and the pH had decreased to 5.4. The flow was stopped and the culture was allowed to recover.

The source of the problem was probably the higher acidity of the new batch of AMD. Several strategies were considered to overcome this predicament. The first was to further decrease the flow rate, the second was to adjust the pH of the AMD, and the third was to add more gravel to the reactor. A slower flow rate would increase the hydraulic retention time beyond 14 days. This approach would greatly increase the length of each experiment. Adjustment of the pH was not considered as a feasible alternative.

It was decided to add 1" of fresh washed limestone gravel. The addition of fresh gravel should provide both buffering capacity to the system and more surface area on which the SRB could establish themselves. Buffering could result from the dissolution of the limestone. The addition of a new layer of gravel could also provide a solution for what to do with the precipitate that accumulates at the bottom of the reactor. By covering it with fresh gravel it will be less likely to be reoxidized and remobilized.

Prior to the addition of fresh gravel, the culture was not recovering as rapidly under no-flow conditions as on the previous occasions. The addition of 1" of fresh gravel to the reactor brought about a rapid response. The ORP was -235 mV and the pH was 6.8 after 7 days under no-flow conditions. A flow was started with a hydraulic retention time of 14 days. The ORP increased to +105 mV and the pH decreased to 5.9 within 3 days. The flow of AMD was allowed to continue to see whether or not the system would be able to acclimatize to the conditions being imposed. This did not occur; over the following two weeks the pH steadily declined to 5.0 and the ORP stabilized at about +125 mV. The flow was stopped at this point.

Another 3" of fresh washed gravel was added to the bed and the flow was started again using the same retention time as before. The ORP decreased to -200 mV and the pH increased to about 6 over the first 7 days. However, the ORP increased to +100 mV and the pH decreased to 4.5 between days 7 and 30. The experiment was stopped.

3.3.3.2 Changes in Sulfate and Metal Concentrations

Sulfate and metal concentrations were measured in water samples collected from the surface of the gravel bed using the bottom-most spigot on the side of the reactor. The sulfate and metals data were interpreted using the concentrations of sulfate and metals in the untreated AMD as the basis for comparison.

3.3.3.2A Sulfate

Changes in sulfate concentration over experiments **1**, **2**, **3a** and **3b** are presented in Table 3.2 and illustrated in Figure 3.12.

Table 3.2: Sulfate concentration (mg/L) and % Removal of sulfate (% Rem) in water samples taken from the surface of the gravel bed (measured by ICP).

	Day	[SO ₄] mg/L	% Removal
M1¹		2691	
Expt 1	34	2367	12.4
	35	2134	21.0
	36	2175	19.4
	37	1898	29.7
Expt 2	40	1996	26.1
	41	2063	23.6
	42	2133	21.0
	43	2160	20.0
Expt 3a	47	2074	23.2
	52	2187	19.0
	57	2306	14.6
	62	2391	11.5
	67	2442	9.6
	73	2404	11.0
	78	2396	11.3
M2²		2700	
	80	2466	8.7
	82	2607	3.4
	84	2562	5.1
	86	2985	0.0
Interval	88	2793	0.0
	90	2655	1.7
Expt 3b	93	2472	8.4
	95	2631	2.6
	97	2703	0.0
	99	2817	0.0
	100	3057	0.0
End	104	2892	0.0

¹ First batch of Mattabi AMD; composition was used to calculate % removal for samples from day 0 to day 78.

² Second batch of Mattabi AMD; composition was used to calculate % removal for samples from day 80 to 104.

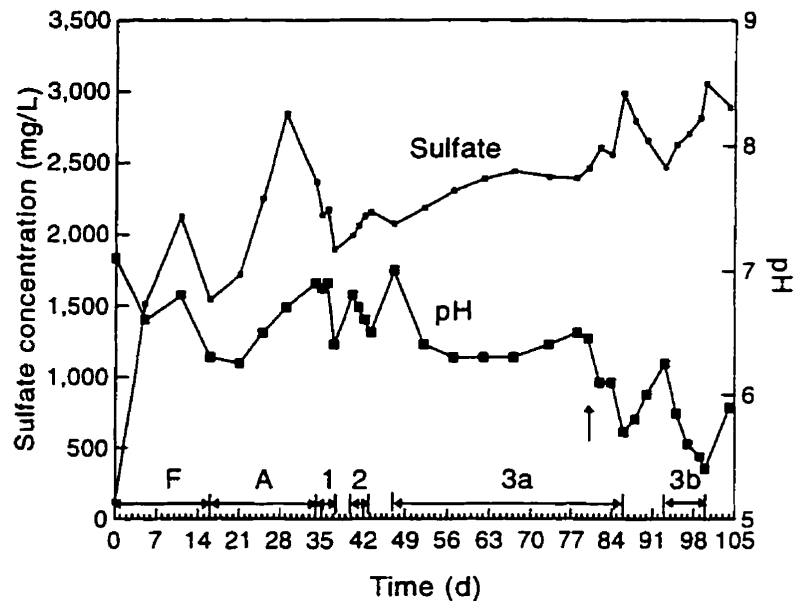


Figure 3.12 Changes in sulfate concentration and pH at the surface of the gravel bed over the course of the Fill (F) and Acclimatization (A) periods and during runs 1, 2, 3a and 3b.

Sulfate concentrations increased during experiments 1, 2 and 3a. This was caused by the influx of fresh AMD into the system. An increase in sulfate levels does not necessarily mean that the SRB were inactive. As stated at the beginning of this section, the analysis of sulfate data was done on the basis of the sulfate concentration in the untreated AMD. Therefore, despite the fact that sulfate concentrations increased during the experiments, the levels of sulfate were still lower than in the initial AMD and a percent removal could be calculated. The amount of sulfate removed was sufficient to account for the amounts of metals removed.

In experiment 3a, a steady increase in sulfate concentration from about 2,000 mg/L to 2,400 mg/L occurred in the first two weeks and became constant at about 2,400 mg/L during the third and fourth week of the experiment, just prior to the use of the new batch of AMD. This observation coupled with the steady pH measured in this period may indicate that a steady state with respect to one aspect of SRB activity had been achieved in the system during this period. This steady state results from a situation in which the reduction (consumption) of sulfate and the generation of alkalinity are in equilibrium with

the influx of fresh sulfate and acidity into the system.

3.3.3.2B Metals

Changes in Al, Cd, Cu, Fe, Mn and Zn concentrations are presented in Table 3.3. The removal of Al, Cd, Cu, Fe and Zn was generally greater than 98% in experiments 1, 2 and 3a. Little or no fluctuations in the percent removal were observed. The percent removal for Al, Cd, Fe and Zn decreased at the end of experiment 3b; Al and Fe were affected the most. Considerable variability was observed in the case of Mn, where removal ranged from 80% during experiment 1 to 0% at the end of experiment 3a and 3b. The results indicated that metal removal from SRB activity works best for Cu and Zn followed by Al, Cd and Fe and least well for Mn.

Following the use of the new batch of AMD, at the end of experiment 3a, sulfate and Mn removal were reduced to 0%, and removal of Cd and Zn had decreased to 66% and 45% respectively. At the end of experiment 3b, the percent removal of all the metals listed in Table 3.3 had decreased considerably with the exception of Cu. The percent removal of Al, Fe and Zn were about 5.5, 1 and 0% respectively.

The results presented here indicate that good removal of Al, Cd, Cu, Fe and Zn could be achieved by SRB activity under the flow and AMD conditions occurring in experiment 3a (Table 3.3). The removal of Mn appears to be affected by the acidity of the system. While it has been assumed that metal removal by SRB activity is due to the production of sulfide, the literature states that Al and Mn will be removed (by precipitation) primarily as either hydroxides or carbonates and not as sulfides. The removal of Al and Mn is, therefore, dependent on the alkalinity and acidity of the system. Consequently, the removal of metals by SRB activity is dependent on both the generation of sulfide and alkalinity.

Table 3.3: Concentrations and Percent Removal of Metals
 Concentrations of metals (mg/L) measured by ICP in water samples taken
 from the surface of the gravel bed and % removal of metals.

Day	Al	%	Cd	%	Cu	%	Fe	%	Mn	%	Zn	%
M1¹	32.5		0.8		1.73		41.8		17.9		184.3	
Experiment 1												
34	0.56	98.3	0.04	95.0	0.02	98.8	0.28	99.3	5.31	70.3	0.09	99.9
35	0.55	98.3	0.02	97.5	0.02	98.8	0.32	99.2	3.41	80.9	0.02	99.9
36	0.38	98.8	0.02	97.5	0.02	98.8	0.02	99.9	14.08	21.3	3.61	98.1
37	0.45	98.6	0.02	97.5	0.02	98.8	0.42	99.0	7.19	59.8	0.02	99.9
Experiment 2												
40	0.32	99.0	0.02	97.5	0.02	98.8	0.15	99.6	6.53	63.5	0.02	99.9
41	0.29	99.1	0.02	97.5	0.02	98.8	0.15	99.6	10.01	44.1	0.02	99.9
42	0.42	98.7	0.02	97.5	0.02	98.8	0.02	99.9	12.84	28.2	0.02	99.9
43	0.73	97.8	0.02	97.5	0.02	98.8	0.08	99.8	15.12	15.5	0.4	99.8
Experiment 3												
47	0.28	99.1	0.02	97.5	0.02	98.8	0.02	99.9	14.03	21.6	0.02	99.9
52	0.43	98.7	0.02	97.5	0.02	98.8	2.12	94.9	14.79	17.3	0.12	99.9
57	0.41	98.7	0.02	97.5	0.02	98.8	0.05	99.9	16.11	10.0	1.76	99.1
67	0.57	98.3	0.02	97.5	0.02	98.8	0.14	99.7	16.27	9.1	1.1	99.4
78	0.42	98.7	0.02	97.5	0.02	98.8	2.39	94.3	14.73	17.7	0.02	99.9
M2²	32.6		0.8		1.73		42.1		17.9		185.2	
80	0.25	99.2	0.03	96.9	0.03	98.6	0.17	99.6	16.8	6.1	23.4	87.3
82	0.25	99.2	0.25	68.9	0.07	95.9	0.2	99.5	18.5	0.0	50.7	72.6
84	0.25	99.2	0.03	96.9	0.03	98.6	0.23	99.5	18.5	0.0	39.4	78.7
86	0.28	99.1	0.27	66.5	0.1	94.2	0.41	99.0	21.4	0.0	101	45.3
Interval												
88	0.25	99.2	0.16	80.1	0.03	98.6	0.2	99.5	20	0.0	45.3	75.5
90	0.25	99.2	0.03	96.9	0.03	98.6	0.22	99.5	19.05	0.0	36.5	80.2
Experiment 3b												
93	0.25	99.2	0.03	96.9	0.03	98.6	0.15	99.6	16.8	6.1	26.6	85.6
95	8.46	73.9	0.11	86.3	0.03	98.6	1.89	95.5	18.9	0.0	43.7	76.3
97	15.4	52.7	0.16	80.1	0.03	98.6	10.6	74.7	19.9	0.0	63.2	65.8
99	24	26.2	0.13	83.9	0.03	98.6	29.3	30.2	20.4	0.0	57.5	68.9
100	30.7	5.6	0.16	80.1	0.04	97.5	41.5	1.1	22	0.0	70	62.1
End												
104	0.56	98.3	0.03	96.9	0.03	98.6	8.97	78.6	21.1	0.0	23.3	87.4

¹ First batch of Mattabi AMD.

² Second batch of Mattabi AMD.

Analyses of sulfate and metals concentrations of water samples, taken from the top and the bottom of the water column, showed that slight concentration gradients existed (Table 3.4). The concentrations were generally higher at the top than at the bottom. The observed gradients could act as driving forces for the diffusion of sulfate and metals to the gravel bed. This is desirable since the active site of the system is in the sediment.

The percent removals of metals at the top of the water column were already quite high. The removal of metals from this location can be explained by the presence of a black layer of precipitate that had accumulated on the floor of the head tank in which SRB can be present. This layer was about 2.5 cm thick. The activity of SRB at this level of the reactor could account for the metal and sulfate removal far from the bottom of the reactor where the principal active site is located. The establishment of SRB in the precipitate in the top of the reactor could have been initiated during periods when the entire water column became anoxic which occurred when the flow was stopped.

Table 3.4 Concentration of Sulfate and Metals at Different Depths in the Water Column.

Sample Location*	Day	ORP (mV)	pH	Concentrations (mg/L)				
				SO ₄	Al	Fe	Mn	Zn
Top	34	-275	6.9	2474	0.5	0.08	7.8	0.02
Bottom	34	-280	6.9	2367	0.56	0.28	5.31	0.09
Top	47	70	6.9	2088	0.37	0.16	13.83	0.26
Bottom	47	-265	7	2074	0.28	0.02	14.03	0.02
Top	62	50	6.2	2453	1.81	1.01	16.42	13.86
Bottom	62	-130	6.3	2391	0.36	0.03	16.49	0.65
Top	78	-115	6.4	2580	1.27	0.26	15.86	0.21
Bottom	78	-250	6.5	2396	0.42	2.39	14.73	0.02

* **Top:** at the surface of the water column;
Bottom: at the surface of the gravel bed

3.4 Summary and Conclusions

This study was undertaken to identify and characterize the basic physical and biological parameters of a reactor system using SRB so as to help predict and design the operating conditions in a large-scale *in situ* treatment system. The preliminary phase of this investigation was performed under continuous flow conditions over a 6" gravel bed.

Prior to the introduction of SRB into the reactor, a characterization of the hydrodynamics of the reactor was done. This would be of use in the interpretation of results obtained in the presence of AMD since there would be no control used during the course of this experiment.

The characterization of the hydrodynamics of the reactor showed that the rate of movement of solutes within the reactor was not controlled by the rate of flow of water through the system. The movement of solutes through the system occurred within 48 h as compared to a 7 day hydraulic retention time. The migration of sulfate was affected by density gradients, thermal gradients, and convective mixing. The distribution of sulfate was also influenced by density differences between the sulfate solution being added and the water in the tank. The role of density gradients in the water column in the distribution and movement of solutes was accentuated when temperature gradients were imposed on the system.

A population of SRB was established in a 6" deep limestone gravel bed in the presence of AMD. The reactor was filled slowly with AMD over a period of 16 days. This was followed by an acclimatization period under stagnant conditions. The acclimatization period lasted 18 days, at the end of which, the pH and ORP had reached levels suitable for SRB activity.

The treatment of a continuous flow of AMD by SRB was examined. A flow rate resulting in a hydraulic retention time of 14 days was found to be compatible with sustaining SRB activity after a 7-day period of adaptation. Good removal (>95%) of Al, Cd, Cu, Fe and Zn was achieved. The percent removal of sulfate was comparatively low (10-11%) and the concentration of sulfate was elevated (2400 mg/L), however, the amount of sulfate removed was sufficient to account for the amount of metals removed.

Comparison of results obtained in the absence and the presence of SRB indicated that SRB activity affected the migration and distribution of sulfate and oxygen in the reactor. The characterization of the distribution of sulfate in the absence of SRB indicated that sulfate would readily and rapidly accumulate at the bottom of the reactor. However, in the presence of SRB the concentration of sulfate was higher at the top of the water column than at the bottom. This was due to SRB activity which reduced the sulfate at the bottom. The gradient established in the presence of SRB favoured the diffusion of this solute to the bottom of the reactor. Therefore, any concerns about the transport of these solutes and especially sulfate to the sediment are not warranted. No sulfate limitation should occur at the bottom of the pit since fresh AMD is denser than water that would accumulate in the pit.

It is debatable that a steady state was achieved during any of the experiments. One definition of a steady state in a continuous flow reactor is when a constant biomass concentration occurs. However, this definition applies to a reactor that is well mixed. A definite conclusion could not be reached since it was difficult to monitor the amount of biomass in the system. This was due to the fact that the SRB are (i) anaerobic and (ii) associated with particulate material. The bacteria were essentially immobilized in the gravel bed. A steady state with respect to SRB activity could be considered since the ORP, pH and sulfate concentrations are indicators of SRB activity. A constant ORP or pH could be taken together with a constant sulfate concentration to be indicative of a steady state. Such a state was achieved during the latter part of experiment 3a.

The system was unable to accommodate a change in the composition of the AMD being used. When a fresh batch of AMD from the Mattabi mines was introduced, the SRB could not sustain activity under the given operating conditions. It appeared that either a longer retention time or an increase in alkalinity was required. As an alternative to decreasing the flow rate, fresh limestone had been added to the system in an effort to increase both the alkalinity and the area of SRB activity in the system. This approach was not successful.

This preliminary study underscored the limitations of the treatment system presented here. The inability of the system to accommodate changes in AMD composition sug-

gested that this system was not flexible enough to tolerate such differences, and until these aspects are satisfactorily addressed, such a treatment system would have limited application. A reconsideration of the objectives of this study was necessary.

Over the course of this work, it was apparent that there was a lack of information concerning the design of a physical support for the SRB population, i.e. the gravel bed, for the implementation of a practical treatment system. A sediment or support on which the SRB can be established is understood to be a necessary feature, however, a characterization of the relationship between the type of support and the performance of the system has not been done. Such information would be very useful in the design of passive treatment systems using SRB. Furthermore, it was apparent that it would be useful to directly monitor changes occurring within the gravel bed.

A study on the characterization of the physical parameters of the gravel bed with respect to SRB activity would necessitate a different approach using a series of columns containing gravel of different composition and different size classes. The experiments with the continuous flow reactors were, therefore, not continued and no investigation into the effect of temperature gradients on the treatment of AMD was done.

4. MATERIALS AND METHODS

4.1 Reactor Design and Materials

The prime considerations in the design of these reactors were (i) depth of the gravel bed, (ii) in-situ measurement of pH and ORP at any level in the gravel bed, and (iii) the withdrawal of water samples from any depth in the gravel bed.

The design and dimensions of one reactor are illustrated in Figure 4.1. The design was simple and the reactors were constructed using 0.635 cm (1/4") Plexiglas. The column was composed of two identical cylinder units with an inner diameter of 14 cm (5.5") and a height of 45.7 cm (18"). The total height of the column was 91.4 cm (36"). The units were joined by flanges which were positioned at the top and bottom of the unit. The bottom of the column was covered by a bottom plate with a 1.27 cm (1/2") nipple in the centre. A 1.27 cm (1/2") elbow and a 1.27 cm (1/2") ball valve with a hose fitting were attached to the nipple. Viton O-rings with an inner diameter of 15.24 cm (6") and a thickness of 0.95 cm (3/8") were used to seal the joints between the cylinder units and between the cylinder unit and the bottom plate.

A unique feature of the reactor system was a central PVC pipe with an inner diameter of 2.54 cm (1") and a height of 91.4 cm (36"). The pipe was perforated with rows of small holes drilled at 1.27 cm (1/2") intervals along its length. The pipe was not attached to the reactor, and was held in place by the gravel bed. Either a pH or an ORP electrode could be lowered down the pipe to measure pH and ORP at any level in the bed. Water samples were taken by lowering a tube in the pipe and pumping out a volume of sample from the desired depth using a variable speed peristaltic pump (Masterflex Model 7520-35, Cole Palmer Instrument Co., Chicago, Ill.). Seven such reactor columns were constructed.

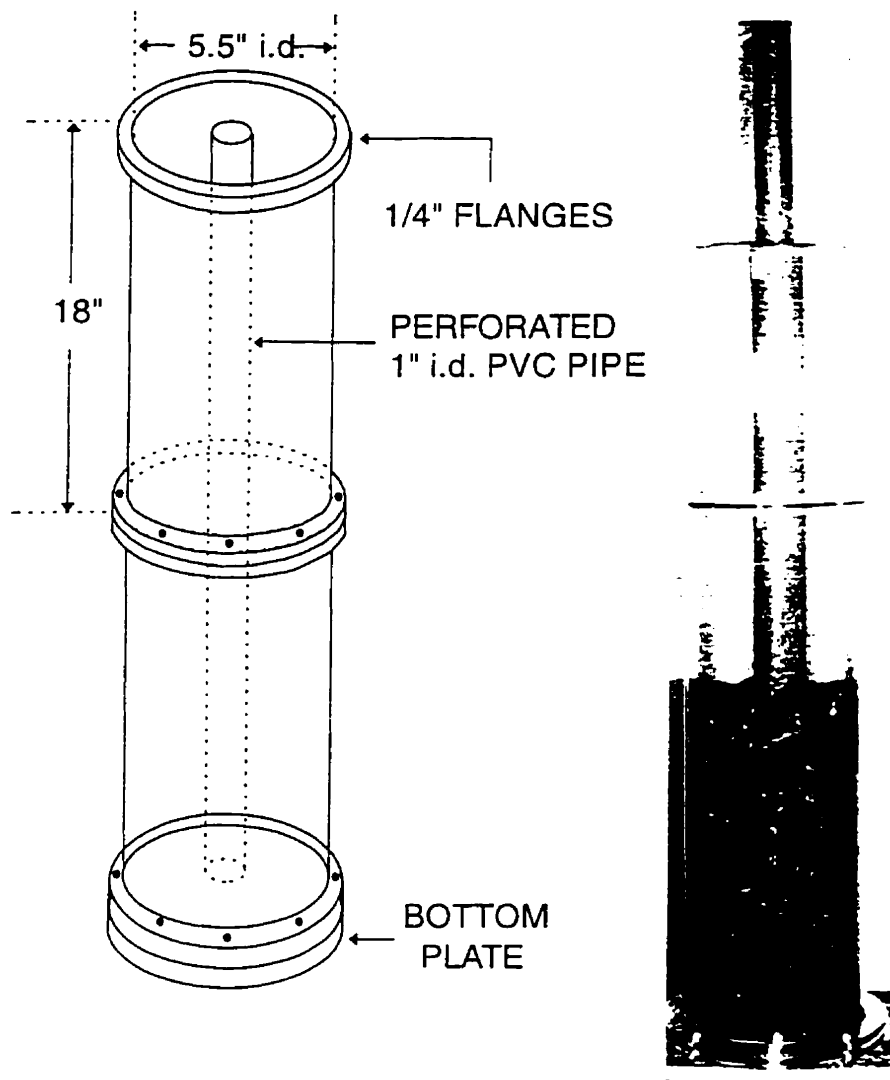


Figure 4.1 Design and picture of the column reactor, sideview.
Not drawn to scale.

4.2 Gravel Bed

The gravel bed in the continuous flow reactor was composed of a heterogeneous mix of limestone aggregates that was described as 1/4" gravel. The limestone and granite gravel used in the column reactors were sorted by American Standard Sieves into 1/4" (1/4-3/8"), 1/2" (1/2-3/4"), and 3/4" size groups. The gravel was washed to remove sand, clay, dust and other small particles and air dried. Glass marbles with a diameter of 1/2" (1/2-3/4")

were also used.

The dried gravel was introduced into the reactors up to a height of 30.48 cm (12"). The void volume was measured directly by pouring in water until the surface of the gravel bed was reached. The volume within the central PVC pipe was taken into consideration by subtracting the calculated volume within a 12" length of the pipe from the measured void volume for the bed. It was this corrected void volume that was used in subsequent calculations.

4.3 Experimental Design and Protocol

4.3.1 Measurements

The pH was measured using a pH electrode with a double junction (Cole Palmer, Model No. 203). This type of electrode is less sensitive to sulfide poisoning. The ORP was measured using a platinum band redox electrode (Cole Palmer, Model No. 207). The level of dissolved oxygen was measured using a 420 mm (16.5") Cole Palmer dissolved oxygen (DO) probe.

Metal concentrations were measured by inductively-coupled plasma spectrophotometry (ICP) (Polyscan 61E Thermo Jarrell Ash) at the Noranda Technology Centre, Pointe Claire, Quebec. Water samples were acidified to 3% HCl prior to metal analysis by ICP. A sulfate concentration was calculated based on the S concentration measured by ICP. All S present was assumed to be present in the form of sulfate. This assumption was made on the basis of the following arguments. First, sulfate is the major, if not the only sulfur-bearing solute in AMD. This is justifiable from what is known about the characteristics of AMD. Second, when sulfate is reduced by the SRB, the sulfur in the sulfate appears either in the precipitate as metal sulfide or as hydrogen sulfide gas, that is, the sulfur is no longer in solution. Therefore, sulfur is no not likely to be found in any other form than sulfate in the water and a decrease in sulfur concentration is a decrease in sulfate concentration.

Conductivity measurements were performed in two of the seven columns (indicated in Table 4.1) using 12 electrodes placed at 1" intervals starting from the top of the gravel bed down to a depth of 11" in the bed. The top electrode was flush with the surface of the gravel bed. These were attached with silicon glue to the wall of the reactor. The electrodes were made from 12 gauge (0.029 cm) stainless steel (302) wires and were coated with a thermoshrink plastic. The bottom 0.635 cm (1/4") of the electrode was left bare. An uncoated stainless steel wire was placed down the central pipe and served as the common electrode. These electrodes were connected to a Hewlett Packard data acquisition/control unit (Model No. 3421A) which was controlled by a Hewlett Packard 87XM computer.

The conductivity was measured in the following manner. The data acquisition unit measured a two-wire resistance on an hourly basis in which readings were performed ten times in rapid succession and averaged. The average was converted to give the conductivity and recorded. In the initial phase of the study, when SRB were being established in the gravel beds, a gradual increase in conductivity in both experimental and control columns was observed. This phenomenon was due to a build up of a voltage between the electrodes as the effect was negated when the electrodes were depolarized. Consequently, it was necessary to depolarize the electrodes between readings and this was accomplished by programming the data acquisition unit to leave the channels open during the quiescent period.

4.3.2 Experimental Setup for the Column Reactors

The initial and final setups for the columns are given in Table 4.1. Three sizes (1/4", 1/2", 3/4") and types (granite, limestone, glass) of gravel were initially included. Over the course of the study, the setup changed and two sizes (1/4" and 1/2") and types (granite and limestone) were used. The conductivity electrodes in columns 5 and 6 were installed prior to the introduction of the gravel bed. The appropriate gravel beds as described in Table 4.1 were placed in the corresponding column around the central pipe to a height of 30.48 cm (12").

The bed volumes (V_b) were calculated from the bed height and column diameter. The void volumes (V_v) were measured directly and recorded (Table 4.2). The bed and void volumes were corrected for the volume in the central PVC pipe (0.154 L) and the corrected volumes were used in the calculation of other parameters.

The total surface areas (tSA) of the gravel in the bed were calculated based on the assumption that the particles were spherical by the following equation (Geankoplis, 1983):

$$tSA = a V_b \quad (1)$$

where:

tSA = total surface area (m^2),

a = ratio of total surface area in the bed to total volume of the bed (m^{-1}), and

V_b = bed volume (m^3).

The a was calculated by:

$$a = a_v (1 - \epsilon) \quad (2)$$

where:

a_v = specific surface area of a spherical particle (m^{-1}),

ϵ = void fraction

The void fraction, ϵ , was calculated by (V_v/V_b). The specific surface area of the particle, a_v , was the surface to volume ratio of the particle and was calculated by:

$$a_v = \frac{\pi D^2}{\frac{\pi D^3}{6}} = \frac{6}{D_p} \quad (3)$$

where D_p is the effective diameter of the particle, (m).

The general and specific column parameters are given in Table 4.2. The tSA of the gravel bed containing 1/4" gravel was two times that of the 1/2" gravel. The difference in tSA is only two times and not higher since, as shown in equation 3, the specific surface area was obtained by the ratio of the area of a sphere and the volume of a sphere

and consequently, the relationship between a_v and D is linear.

The assumption of sphericity was not an accurate one as can be seen from the difference in the measured void volumes between the beds containing 1/2" gravel and the bed containing 1/2" glass balls (Table 4.2). However, since the results were used on a comparative basis and the assumption was applied consistently throughout, the use of the assumption was valid.

Table 4.1: Description of Columns

A: INITIAL SETUP OF COLUMNS

<u>Column #</u>	<u>Content</u>	<u>Experimental Status</u>
1	1/4" granite	Inoculated with SRB
2	1/4" granite	Control, no SRB
3	1/4" limestone	Inoculated with SRB
4	1/2" granite	Inoculated with SRB, conductivity
5	1/2" granite	Control, no SRB, conductivity
6	1/2" limestone	Inoculated with SRB
7	1/2" glass	Inoculated with SRB
8	3/4" granite	Inoculated with SRB

B. FINAL SETUP OF COLUMNS

<u>Column #</u>	<u>Content</u>	<u>Experimental Status</u>
1	1/4" granite	Inoculated with SRB
2	1/4" granite	Control, no SRB
3	1/4" limestone	Inoculated with SRB
7	1/4" limestone	Control, no SRB
4	1/2" granite	Inoculated with SRB, conductivity
5	1/2" granite	Control, no SRB, conductivity
6	1/2" limestone	Inoculated with SRB

Table 4.2: Column Parameters

A. GENERAL COLUMN DIMENSIONS

Diameter:	13.97 cm (5.5")
Cross Section Area:	153.28 cm ²
Height of Gravel Bed:	30.48 cm (12")
Vol. of Gravel Bed:	4.67 L
Vol. of Central Pipe (1" i.d.):	0.154 L
Vol. of Bed Corrected for Central Pipe:	4.52 L

B. VOID VOLUMES AND SURFACE AREAS OF INITIAL COLUMN SETUP

Col #	Description	Measured Void Vol (V _v), L	Corrected Void Vol ¹ (V _v), L	Void Fraction (ε)	Total S.A. m ²
1	1/4" Granite	2.10	1.95	0.43	1.95
2	1/4" Granite	2.12	1.97	0.44	1.93
3	1/4" Limestone	2.13	1.98	0.44	1.92
4	1/2" Granite	2.35	2.20	0.49	0.877
5	1/2" Granite	2.33	2.18	0.48	0.884
6	1/2" Limestone	2.29	2.13	0.47	0.901
7	1/2" Glass	2.06	1.91	0.42	0.986
8	3/4" Granite	2.71	2.45	0.47	0.647

C. VOID VOLUMES AND SURFACES AREAS OF FINAL COLUMN SETUP

Col #	Description	Measured Void Vol (V _v), L	Corrected Void Vol ¹ (V _v), L	Void Fraction (ε)	Total S.A. m ²
1	1/4" Granite	2.10	1.95	0.43	1.95
2	1/4" Granite	2.12	1.96	0.44	1.93
3	1/4" Limestone	2.13	1.98	0.44	1.92
7	1/4" Limestone	2.18	2.03	0.45	1.88
4	1/2" Granite	2.35	2.20	0.49	0.877
5	1/2" Granite	2.33	2.18	0.48	0.884
6	1/2" Limestone	2.29	2.13	0.47	0.901

¹ Corrected for volume in the central PVC pipe.

4.3.3 The Establishment of SRB in the Columns

Initially, columns 1, 3, 4, 6, 7 and 8 were each inoculated with 250 mL of a mixed culture of SRB taken from the continuous flow reactor. The SRB culture was slowly poured into the gravel bed. No SRB were added to columns 2 and 5. All the columns were filled to the 8 L level with AMD, giving a volume of approximately 6 L in the water column above the gravel bed. The AMD was supplemented with 4 g/L sodium lactate and 0.5 g/L ammonium chloride and was diluted by one half with water to promote the establishment of the SRB.

Because it was difficult to establish the SRB in the columns, the columns were inoculated several times. The columns were not covered and there was no circulation of the water column. Columns 7 (1/2" glass) and 8 (3/4" granite) were discontinued when no change in pH or ORP were observed in these columns. Column 7 was used as a 1/4" limestone control as indicated in part B, Table 4.1.

4.3.4 Column Experiments

After the bacteria were established, part of the water column was "cycled". This term was used to describe the replacement of part of the 6 L of water column with fresh full strength AMD. Volumes of 1, 2, 4 and 6 L of the water column were cycled in a series of experiments. The number of repetitions and the order in which the volumes were cycled are presented in Table 4.3:

Table 4.3: Volumes Cycled (L)

Column #	Cycle #		
	<u>1-4</u>	<u>5-7</u>	<u>8-9</u>
1,2,3,7	2	4	1
4,5,6	2	4	6

The protocol used was as follows. If we take as an example the case of the 2 L experiment, water was removed from the top of the water column by siphoning down to

the 4 L mark. Two liters of fresh AMD were then poured slowly into the column to bring the volume back to the 6 L mark. A total volume of 6 L was maintained.

The first three cycles were performed using AMD from the Mattabi mines and the composition of this water is given in Table 3.1 (Barrel 2). The supply of Mattabi AMD was depleted after the third cycle and a synthetic AMD was used in all subsequent experiments. The composition of this water was based on the Mattabi AMD in barrel 2. The composition and the procedure for the preparation of this synthetic AMD are given in Appendix B.

The response of the columns to this disturbance was monitored over 28 days under stagnant conditions. The pH and ORP were measured periodically by lowering the probes down the center pipe. The ORP readings were always obtained before the pH. Readings were taken at 1" intervals starting from the top (0") of the gravel bed down to the bottom (12") of the bed. To prevent possible inoculation of the control columns with SRB, measurements were always taken in the control columns before the columns containing SRB. The pH and ORP were measured prior to and immediately after cycling was started (day 0). Subsequent measurements were taken on day 1, 3, 5, 7, 14, 21, and 28.

Water samples were withdrawn periodically using a peristaltic pump with the tubing lowered down the central pipe. Aliquots of about 35 mL were taken at 3" intervals starting from the top of the gravel bed (0"). Day 0 samples were taken soon after a cycle was started. Subsequent samples were taken at days 3, 7, 14, 21 and 28. All samples were stored at 4°C. Selected water samples were prepared for metal analysis by ICP at the Noranda Technology Centre (Pointe Claire, Quebec). A 25 mL portion of the sample was acidified to a final concentration of 3% HCl.

The electrical conductivities in Columns 4 and 5 were monitored continuously over the course of each experiment. Conductivity measurements were performed and recorded automatically on an hourly basis using the data acquisition/control unit and computer system described in Section 4.3.1.

5. RESULTS AND DISCUSSION

The design of the column reactors allowed for the measurement of pH and ORP at all levels within the system without the need to take water samples. This was important since large numbers of readings were taken over the course of each experiment and the removal of a large number of water samples would have led to significant changes in the volume of the water column. Also, the *in situ* measurement of the ORP is better than measurement of the ORP of a water sample since the ORP is sensitive to disturbances. Consequently, the ORP was always measured prior to measuring the pH.

The setup of the columns was based on the theory that differences in aggregate size and composition would affect SRB activity.

5.1 Establishment of SRB in Gravel Beds

The establishment of the SRB in the gravel beds in the presence of AMD was difficult and took longer than the 18 days required in the continuous flow reactor. The beds had to be inoculated several times. The difference may have been due to the fact that the water in the water column was not circulated as had been done with the continuous flow reactor. Also, AMD with a different composition and lower pH was being used.

The SRB were established in four of the six inoculated columns after a period of three months (Table 5.1). The SRB were considered to be established when the ORP was lower than -100 mV, the pH was greater than 5.5, a black precipitate was present, and a sulfurous odour was detectable in water samples. This occurred first in the limestone columns starting with the 1/4" size and then the 1/2" size gravel. The establishment of the SRB in the granite columns required an additional one to four weeks to be accomplished. This would suggest that limestone was the preferred substrate with respect to the start-up of the system. Neither black precipitate nor sulfurous odour were detected at any time in the control columns.

Table 5.1: Establishment of SRB Populations in the Columns

Column	Days*	pH _i	pH _r	ORP _i (mV)	ORP _r (mV)
1/4" Limestone	54	4.4	7.2	190	-380
1/2" Limestone	103	4.3	7.3	210	-390
1/4" Granite	110	4.25	7.1	220	-365
1/2" Granite	134	4	6.3	230	-290

*Period over which SRB were established in the columns after inoculation.

No changes in ORP or pH indicating SRB activity were observed in the columns containing 1/2" glass or 3/4" granite beds. These columns were discontinued after 145 days. One column was subsequently used as a limestone control, and contained a 1/2" limestone gravel bed in which no SRB were inoculated.

The bed containing 1/2" glass balls had been used to investigate the assumption of sphericity that was made to calculate the total surface area of each gravel bed. The glass balls gave a much better approximation of sphericity than the gravel and consequently, the surface area was more exactly calculated. Results from this column were to be compared with the results generated from the 1/2" granite and 1/2" limestone columns. Unfortunately, an SRB population could not be established in the bed of glass balls.

The failure of SRB to be established in the 1/2" glass and 3/4" granite columns suggested that surface features were important and that either a critical minimum surface area or a critical maximum void volume exists. If, as in the case of the glass balls, the surface was too smooth with no irregularities in which the bacteria could be lodged, then establishment of the SRB was difficult, if not impossible, under the culture conditions that were being used.

5.2 Cycling of the Water Column

The response of the columns to replacement or "cycling" of part of the water column with fresh AMD was studied under batch conditions rather than under continuous flow conditions. In effect, the columns were operated in a manner similar to a sequential batch reactor where the volume in the draw period was varied in a series of experiments. The implications of this mode of operation on the implementation of treatment processes that use SRB will be discussed in Chapter 6. The parameters that were used to monitor the status of the system were the ORP and pH. The reestablishment of the ORP and pH either to levels prior to the cycling, or to a steady state was the criterion used for termination of a cycle and the addition of fresh AMD.

A batch mode of operation was also useful in facilitating the interpretation of the data. The interpretation and comparison of the final steady states of each cycle were less ambiguous under batch conditions than under continuous flow conditions since identifiable and possible equivalent endpoints could be reached. To address the concern with the equivalency of the steady states obtained at the end of each cycle replications were performed of each experiment.

The 2L cycle was repeated three times. The first three cycles used AMD from the second batch of Mattabi water. This batch of water was exhausted at this point. A decision was made to use a synthetic AMD with a composition and pH based on the second batch of Mattabi water instead of obtaining a new batch of Mattabi water. As previously observed, the composition and nature of a new batch of AMD from the Mattabi mine could be very different. The advantage of using synthetic AMD was that the composition of the water was constant from experiment to experiment. This allowed for better comparison of the results obtained over the course of the study. The synthetic AMD was used in the third repetition of the 2L cycle. No difference was observed between this cycle and the previous cycle, therefore, the synthetic AMD was used in all subsequent experiments.

5.2.1 Metal and Sulfate Removal

5.2.1.1 Focus of Metal and Sulfate Analyses

The first step of the study was to determine the distribution of bacterial activity within the gravel bed and the changes occurring over time. This would indicate where the focus of the metal and sulfate analyses should be directed and the window of time in which most of these changes would be occurring. Such information would circumvent the need for analyses of a large number of samples. The investigation was done during cycle 2 on the 1/2" granite columns. These columns were chosen since they were thought to represent the case where SRB activity would be the poorest. Results from the 1/2" granite bed would, therefore, be the best indicator of the limitations of the study.

As mentioned in the Materials and Methods section, the concentration of sulfate in the water samples had been calculated on the assumption that all the S measured by ICP over the course of the study was in the form of sulfate. This assumption was made on the basis of the following arguments. First, only sulfate salts of metals were used in the preparation of the artificial AMD. Also, it is important to bear in mind that sulfate is the major, if not the only solute containing sulfur in real AMD. Second, over the course of each experiment when sulfate is reduced by the SRB, the sulfur in the sulfate appears either in the precipitate as metal sulfide or as hydrogen sulfide gas, that is, the sulfur is no longer in solution. Sulfur was, therefore, unlikely to be found in any other form than sulfate in the water and a decrease in sulfur concentration was interpreted as a decrease in sulfate concentration.

Measurements of metal and sulfate concentrations were done on samples taken at different periods and from different depths within the 1/2" granite gravel beds. The results showed that most of the metal and sulfate removal occurred within the first 7 to 14 days and that removals were greatest in the top 3 inches of the gravel (Tables 5.2 and 5.3, Figures 5.1 to 5.4). The pH and ORP measurements also indicated that most of the changes were localized in the top 3 inches of the gravel (Section 5.4). Consequently, in order to provide meaningful comparisons between the columns, the analysis of data

presented here focuses on samples taken from the interface (0") at day 7 (unless otherwise indicated) and the duration of each cycle was at least 28 days.

Focusing on the gravel-water interface is logical since it is the area of exchange between the active site, i.e, the sediment, and the water column. The literature also indicated that accumulation of nutrients and microorganisms occurs at the sediment-water interface and supports the decision reached here.

Table 5.2: Changes in Metal and Sulfate Concentrations Over Time at the Top of the Gravel Bed (0") when $V_c = 2L$ (Cycle 3).

Time (d)	1/2" Granite, inoculated with SRB Concentrations (mg/L)					1/2" Granite, control Concentrations (mg/L)				
	Al	Fe	Mn	Zn	SO ₄	Al	Fe	Mn	Zn	SO ₄
0	11.6	33.9	3.2	2.6	1823	73.2	185.8	35.2	302.6	3510
7	3.1	3.9	2.1	2.2	1673	72.7	177.0	34.5	298.2	3450
14	1.9	3.2	1.3	1.9	1546	71.4	170.4	34.7	296.4	3420
28	1.1	2.7	0.8	1.1	1280	70.9	165.4	34.7	295.5	3390

Table 5.3: Depth Profile of % Removal of Metals and Sulfate in 1/2" Granite Columns at day 28 and for $V_c = 2L$ (Cycle 2).

Depth (")	1/2" Granite, inoculated with SRB % Removal					1/2" Granite, control % Removal				
	Al	Fe	Mn	Zn	SO ₄	Al	Fe	Mn	Zn	SO ₄
0	94	99	99	96	39	23	63	4	5	0
3	97	100	99	100	38	24	63	4	5	0
6	98	100	99	100	36	3	18	4	4	2
9	99	100	20	100	32	1	11	4	4	2
12	92	95	39	67	34	4	13	5	5	3

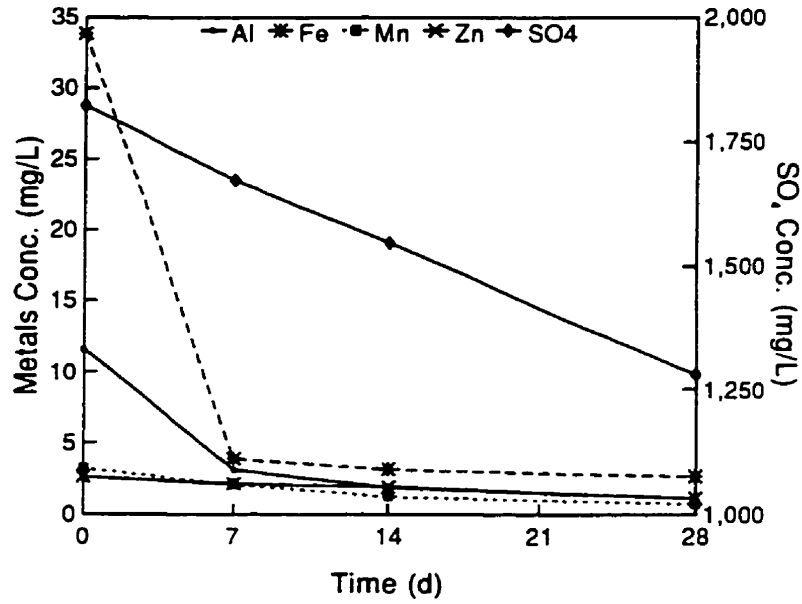


Figure 5.1 Changes in metals and sulfate concentrations over time at the surface of the bed (0'') in column containing 1/2'' granite gravel inoculated with SRB. Cycle volume is 2L.

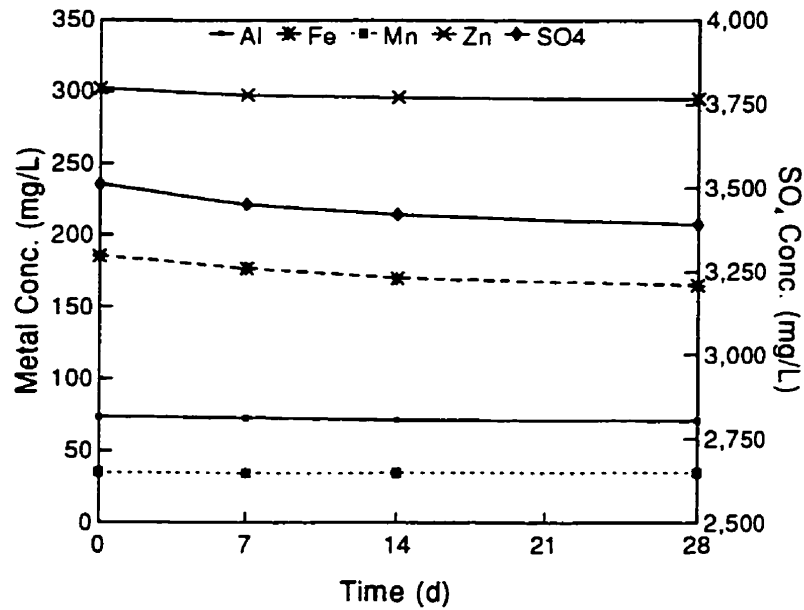


Figure 5.2 Changes in metals and sulfate concentrations over time at the surface of the bed (0'') in control column (no SRB) containing 1/2'' granite gravel. Cycle volume is 2L.

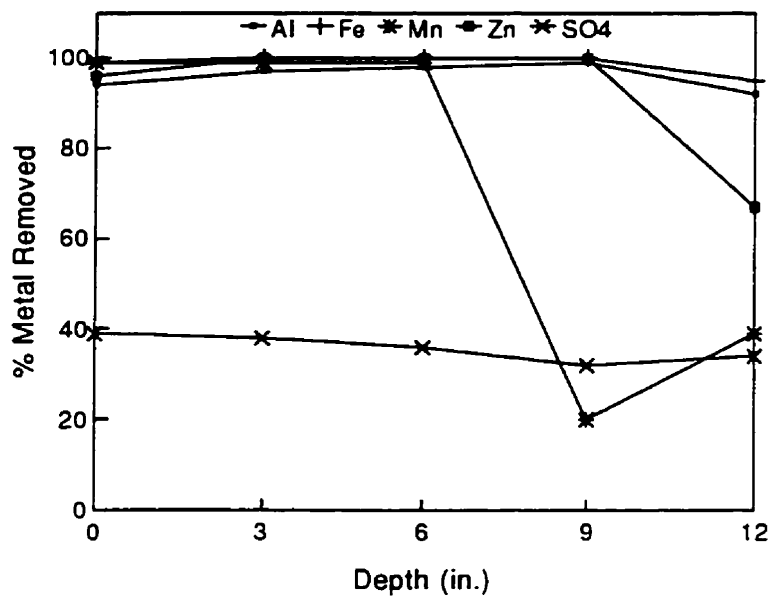


Figure 5.3 % Metal removal as a function of depth (in.) in 1/2" granite column inoculated with SRB after 28 d. Cycle volume is 2L.

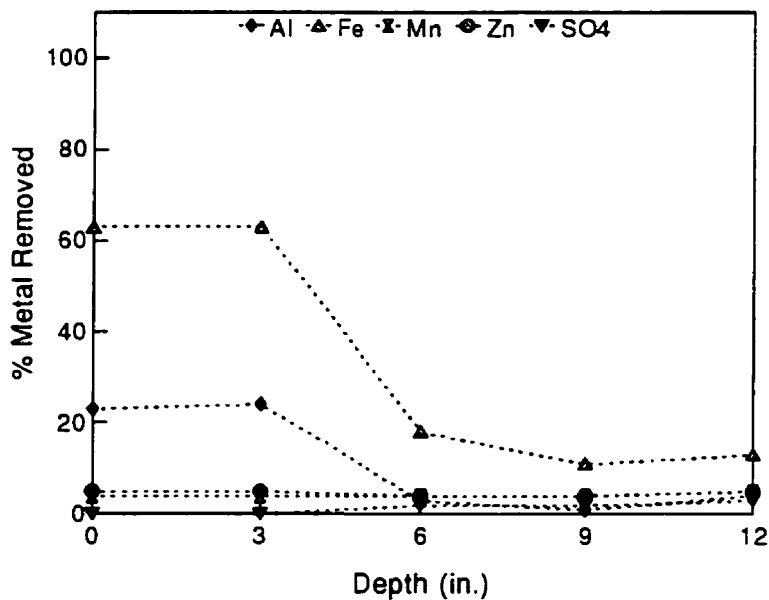


Figure 5.4 % Metal removal as a function of depth (in.) in control 1/2" granite column after 28 d. Cycle volume is 2L.

5.2.1.2 Analysis of Metal and Sulfate Removal Data

All data for metal and sulfate concentrations are presented in Appendix C. The 95% confidence limits were calculated for sulfate concentrations on days 0 and 28 from all experiments (Appendix D). The confidence interval gives the range within which the initial and final sulfate concentrations can be found. Overall, the variability in sulfate concentrations at day 0 was less than at day 28. In the case of the 1/4" gravel beds the confidence intervals were considerably larger for the 28 day data than for the 0 day data, whereas, differences between the size of the confidence intervals for 0 and 28 day were slight for the 1/2" gravel beds. This indicated that there was some basis for assuming that the initial states of the cultures were comparable from experiment to experiment.

The analysis of the results for the removal of Al, Fe, Mn, Zn and sulfate after 7 days is presented in Table 5.4 and are the averages of at least two experiments. Removal is given in this table as "Proportion of Metal and Sulfate Removed" and is the difference between the initial and final concentrations divided by the initial concentration. This method of presenting the data was useful in overcoming the problem evident in Table 5.3 where the initial concentrations of metals and sulfate in the column inoculated with SRB were much lower than that in the control column. This was due to the fact that the metal removal had occurred in the experimental column while little or no removal had occurred in the control columns. Therefore, when part of the water column was replaced with fresh AMD, a dilution of this fresh AMD occurred in columns containing SRB while little or no dilution occurred in control columns. The effect of pH should also be taken into account. The higher pH of the receiving water in the columns containing SRB favoured the precipitation of metals as metal hydroxides. Such an event would cause a decrease in pH since this results in the release of protons. This does occur at the start of every cycle, however, this was assumed to be due to the acidity in the fresh AMD. The difference in initial concentrations could also be overcome if the data were analysed as "rates of removal". This analysis was done and will be presented in Section 5.2.2.2.

Presumably, these differences in the initial concentrations of metals and sulfates between the SRB and control columns would not occur if the entire water column (6L) was replaced with fresh AMD at the beginning of the cycle. However, this was not the

case. When a cycle volume of 6L was used in columns 4, 5 and 6, the concentrations of metals were generally higher in the control column than in the columns containing SRB. This could be due to the on-going production of sulfide by the SRB and to the fact that the void volume (2L) was not replaced.

Table 5.4: Proportion of Metals and Sulfate Removed after Day 7

Volume Cycled (L)	Metal	1/4"				1/2"		
		G Exp	G Ctl	L Exp	L Ctl	G Exp	G Ctl	L Exp
1	Al	0.75	0.65	0.66	0.75			
2	Al	0.72	0.32	0.63	0.59	0.80	0.02	0.87
4	Al	0.59	0.43	0.62	0.33	0.65	0	0.48
6	Al					0.68	0	0.69
1	Cu	0.79	0.18	0.5	0.43			
2	Cu	0.88	0.30	0.83	0.81	0.79	0.17	0
4	Cu	0.87	0.23	0.67	0.57	0.98	0.01	0.87
6	Cu					0.91	0	0.87
1	Fe	0.87	0.71	0.79	0.51			
2	Fe	0.89	0.13	0.91	0.93	0.90	0.06	0.98
4	Fe	0.48	0.04	0.45	0.1	0.59	0.01	0.28
6	Fe					0.57	0	0.18
1	Mn	0.26	0	0.25	0.015			
2	Mn	0.81	0.02	0.88	0.37	0.9	0.01	0.42
4	Mn	0.15	0.03	0.28	0.01	0.11	0.02	0.02
6	Mn					0	0.02	0
1	Zn	0.80	0.04	0.80	0.10			
2	Zn	0.97	0.05	0.84	0.51	0.98	0	0.34
4	Zn	0.75	0.02	0.78	0.03	0.88	0	0.67
6	Zn					0.81	0	0.85
1	SO ₄	0.07	0.01	0.089	0.024			
2	SO ₄	0.184	0.042	0.186	0.095	0.144	0.01	0.133
4	SO ₄	0.182	0.013	0.181	0.018	0.121	0.00	0.08
6	SO ₄					0.08	0.00	0.062

G: granite; L: limestone; Exp: inoculated with SRB; Ctl: control, not inoculated with SRB

The results show that good overall removals of metal and sulfate were attained in a batch mode of operation within 7 days. The following observations can be made from examination of Table 5.4.

- i. Good removal of Zn was attained in the columns containing 1/4" gravel and in the column with 1/2" granite under all conditions. Removal was highest (84 and 97%) when a cycle volume of 2L was used. Comparatively low percent removals were observed in the 1/2" limestone column: only 34% and 67% removal occurred for cycle volumes of 2L and 4L, respectively. Little or no removal of Zn was observed in the control columns except in the 1/4" limestone control column.
- ii. Removal of Al and Fe was observed in all columns inoculated with SRB for all volumes cycled. Comparative levels of removal of Al were also observed in the 1/4" granite and limestone control columns but not the 1/2" granite control column. Similarly, high levels of Fe removal occurred in the 1/4" control columns after 7 days for the 1L and 2L cycles and 28 days for the 4L cycle.
- iii. Good removal of Cu was observed, however, in several cases high removal was also observed in the control columns. The removal of Cu was observed to be better in the granite columns than in the limestone columns.
- iv. The removal of Mn in columns inoculated with SRB fluctuated depending on the quantity of water cycled. Higher proportions of Mn were removed when 1L and 2L cycle volumes were used as compared to that for 4L and 6L. The highest removal occurred when the cycle volume was 2L, whereas no removal occurred when 6L were cycled. Little or no Mn removal was observed in the control columns, except for the 1/4" limestone control column.
- v. Good removal of sulfate was attained in columns with SRB when 2L and 4L were cycled. Poor removal was observed when 1L was cycled and little or no removal occurred when 6L were cycled.
- vi. The performance of the granite beds with respect to metal and sulfate removal was equal to if not better than that of the limestone beds.

5.2.1.3 Possible Mechanisms for Metal Removal

Comparison of the results from the experimental columns containing SRB and the control columns suggested that the removal of various metals from AMD could be accounted for by SRB activity. The SRB process would appear to be most effective in the removal of Zn from AMD.

The results for Al and Fe showed that removal occurred in the control columns in the 1/4" gravel columns when cycle volumes of 1L and 2L were used. However, no such removal was observed either in the 1/2" granite control column or when 4L was used. Similar results were obtained for Cu in the controls, however, high levels of removal were also observed when 4L was cycled. This was not due to contamination of the 1/4" control columns with SRB since no black precipitate occurred, no sulfurous odours were detected and sulfate levels remained elevated. This would indicate that Al, Cu, and Fe were removed by mechanisms other than sulfate reduction/sulfide production.

Aluminium can be removed by complexing with hydroxide rather than with sulfide, and consequently, the pH and alkalinity of the water play important roles in the removal of Al. Cu and Fe can also be precipitated as an hydroxide (e.g. $\text{Cu}(\text{OH})_2$, $\text{Fe}(\text{OH})_3$). The pHs in the 1/4" control columns for both granite and limestone were consistently between 5 and 6 while the pH in the 1/2" control column for granite was around 4. The higher pH in the 1/4" control columns may account for the removal of Al, Cu and Fe observed in these columns as hydroxides.

The formation of MnS is not common and MnS is soluble in water. The removal of Mn occurs as a result of either oxidation or adsorption onto amorphous FeS (Arakakis and Morse, 1993; Stark *et al*, 1995). The oxidation of Mn is dependent on pH and ORP and results in the formation of MnO and MnCO_3 . Under reduced conditions, manganese is in solution, and if the pH is less than 6.0, Mn^{2+} is stable and will remain in solution regardless of the ORP (Stark *et al*, 1995). The removal of Mn can occur through the adsorption of Mn^{2+} onto amorphous FeS such as mackinawite to form an Fe-Mn-S complex (Arakakis and Morse, 1993). Furthermore, the amorphous FeS can be converted to pyrite, a stable form of FeS, trapping the Mn with it. The adsorption of Mn onto FeS would appear to be the most likely mechanism by which Mn is removed in the columns

since the environment is highly reduced. So while the production of sulfide does not lead directly to the removal of Mn *per se*, the complexation of the sulfide with iron to form amorphous FeS can eventually lead to Mn removal.

The removal of Al and Mn in the presence of SRB would, therefore, be due to the generation of alkalinity by the SRB while the removal of Fe could be due to complexation with either sulfide or hydroxide. In ecosystems where sulfate levels are high and where sulfate reduction is an important source of alkalinity, the presence of Fe is essential for sulfate reduction to occur. Iron acts as a trap for the sulfide that is produced, removing the sulfide in a stable form that does not inhibit the further activity of the SRB.

5.2.1.4 Sulfate Removal

Good removal of sulfate was obtained when cycle volumes of 2L and 4L were used. However, sulfate removal was lower when cycle volumes of 1L and 6L were used. These two volumes represented the extremes of loading of AMD on the columns. Sulfate reduction is stimulated by sulfate. A low load of sulfate as represented by a 1L cycle volume would, therefore, not evoke the same response as either a 2L or 4L volume, resulting in comparatively lower SRB activity. This would account for the poor response to a 1L cycle volume despite the low load of metals and acidity on the system. In the case where a 6L cycle volume was used, the entire water column was replaced causing oxygenation, oxidation, and acidification in the bed. Consequently SRB activity was disrupted, resulting in the low degree of sulfate removal.

The results did not support the expectation that the performance of SRB in the limestone beds would be superior to that in granite beds. The hypothesis was that limestone could act as a source of alkalinity releasing carbonate as the limestone was dissolved. Meanwhile, granite was considered to be comparatively inert and would not make any contributions to increasing the alkalinity of the system. The limestone beds should, therefore, have provided a more conducive environment with respect to pH for the SRB and SRB activity. However, such does not appear to have been the case. Further analyses of the data will still consider the two types of gravel separately to determine the importance, if any, of gravel type in other aspects of the system.

The correlation of bacterial activity and AMD treatment with other physical parameters of the systems was investigated next.

5.2.2 Relationships Between System Parameters and SRB Activity

Relationships between the total surface area (tSA), the void volume (V_v) of the bed, the volume cycled (V_c) and SRB activity were investigated. The analyses were done separately for the granite and the limestone columns to ascertain whether or not the nature of the gravel was important in the overall process.

A parameter that could be used as an indicator of SRB activity was required for such an analysis to take place. The best indicator of SRB activity would be the removal of sulfate rather than the removal of a metal or metals since sulfate removal can be directly related to the sulfate reducing activity of the SRB. This was supported by the data obtained from the control columns, where SRB were absent and where changes in sulfate levels were negligible yet metal removal occurred to some degree. Therefore, sulfate removal was used as an indicator of SRB activity. The removal of sulfate can be expressed either as the total proportion of sulfate removed after a particular period of time, or as the average rate of sulfate removal. Both possibilities were investigated.

5.2.2.1 Proportion of Sulfate Removed

The proportion of sulfate removed is the fraction of sulfate removed and has no units. This was calculated as the amount of sulfate removed over a given period of time ($\Delta[\text{SO}_4]$) divided by the initial concentration of sulfate ($[\text{SO}_4]_0$). In this study, the period of time of interest was 7 days since, as was shown in Section 5.2.1, most metal removal occurred within the first seven days. The proportions of sulfate removed for each cycle volume and for each column are given in Table 5.5. These values are the average of at least two experiments under each condition.

Plots of the proportion of sulfate removed against the total surface area and the void volume demonstrated the following general relationships: (i) sulfate removal increased as the total surface area of the gravel increased (Figure 5.5) and, (ii) sulfate removal decreased as the void volume increased (Figure 5.6). The r^2 values for the linear cor-

relation between sulfate removal and tSA were 0.74 and 0.80 for granite and limestone, respectively. These results supported the basic assertion that SRB congregate on and inhabit the surfaces of particles. Consequently, the larger the surface area, the greater are the potential population of SRB and the amounts of sulfate being removed.

Therefore, a system with a large surface area and a small void volume would be desired for greater levels of sulfate reduction. This could be achieved by using smaller sized particles in the gravel bed. Presumably, the proportion of sulfate removed would approach 1 (within 7 days) as the surface area becomes very large and as the void volume becomes very small. However, the diffusion of sulfate and nutrients into the bed may be affected if the void volume is too small and the accumulation of metal sulfide precipitate in the void volume must be taken into account.

Table 5.5: Sulfate Removal

Column	tSA (m ²)	V _v (m ³)	Proportion of SO ₄ Removed (7d)				Rate of SO ₄ Removal (ppm/d)			
			1L	2L	4L	6L	1L	2L	4L	6L
Cycle Vol.										
1/4" G	1.940	1.95	0.07	0.18	0.18		23.8	44.2	66.3	
1/4" G-Ctl	1.925	1.97	0.01	0.03	0.01		0.5	7.6	2.9	
1/4" L	1.918	1.98	0.09	0.19	0.18		27.3	33.3	51	
1/4" L-Ctl	1.880	2.03	0.025	0.1	0.14		9.8	13.0	7.7	
1/2" G	0.876	2.2		0.14	0.12	0.08		23.9	29.9	38.6
1/2" G-Ctl	0.883	2.18		0.01	0.01	0		6.4	0	0
1/2" L	0.899	2.14		0.13	0.08	0.06		12.3	33.8	30

G: granite; L: limestone; Ctl: control; tSA: total surface area; V_v: void volume.

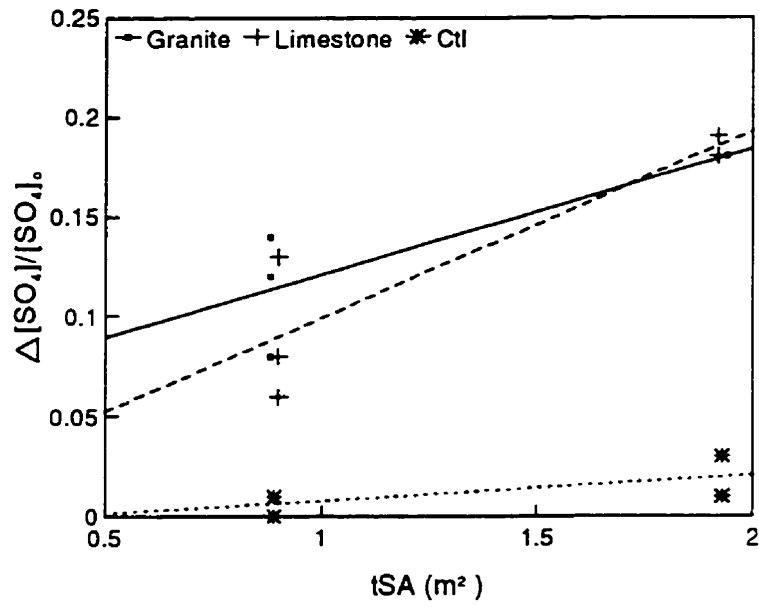


Figure 5.5 Sulfate removal as a function of total surface area (tSA) of the gravel bed, day 7. Solid line: granite; dashed line: limestone; dotted line: controls.

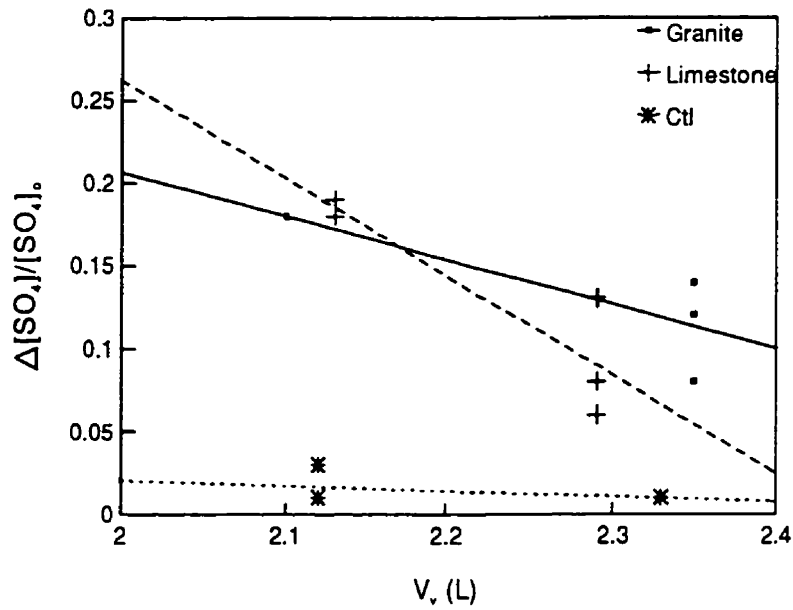


Figure 5.6 Sulfate removal as a function of the void volume (V_v) of the gravel bed, day 7. Solid line: granite; dashed line: limestone; dotted line: controls.

As was shown in the previous section, sulfate removal was lower when the V_c was 1L and 6L. This was attributed to decreased SRB activity due to low sulfate levels in the case of 1L and to aeration and increased acidity in the case of 6L. An analysis of the data without the 1L and 6L data was done. Stronger correlations between the proportion of sulfate removed and V_v and tSA were obtained. The r^2 values were 0.93 and 0.83 for granite and limestone, respectively.

Changes in V_c must, therefore, be taken into account in the analysis of the data. This could be accomplished by the use of ratios. The cycle volume to void volume ratio (V_c/V_v) and the cycle volume to total surface area ratio (V_c/tSA) were investigated. The V_c/V_v ratio can be interpreted as the amount of loading of fresh AMD on the void volume in the gravel bed. Likewise, the V_c/tSA ratio can be interpreted as the amount of loading of fresh AMD for a given total surface area of gravel in the bed.

The use of the V_c/V_v ratio did not yield any useful information about relationships between the void volume and bacterial activity (Figure 5.7). However, a relationship was evident when the V_c/tSA ratio was used (Figure 5.8).

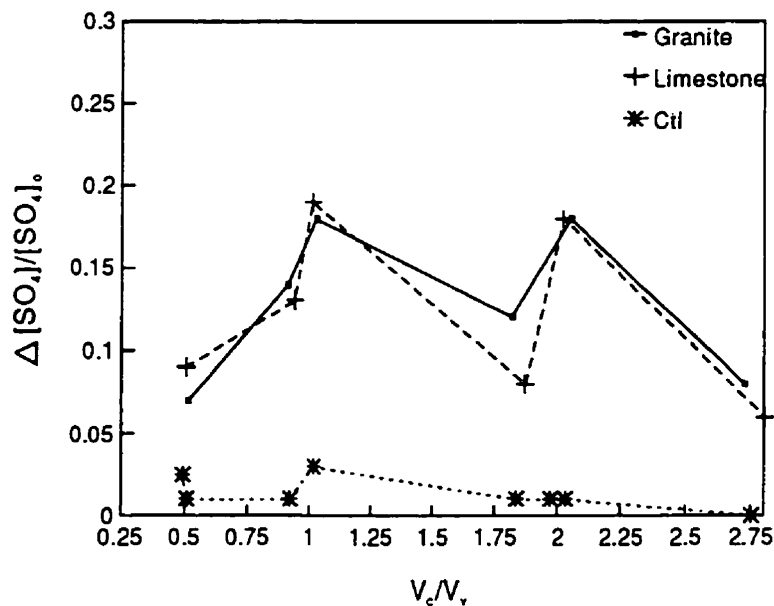


Figure 5.7 The proportion of sulfate removed as a function of V_c/V_v . Solid line: granite; dashed line: limestone; dotted line: controls. No correlation is evident.

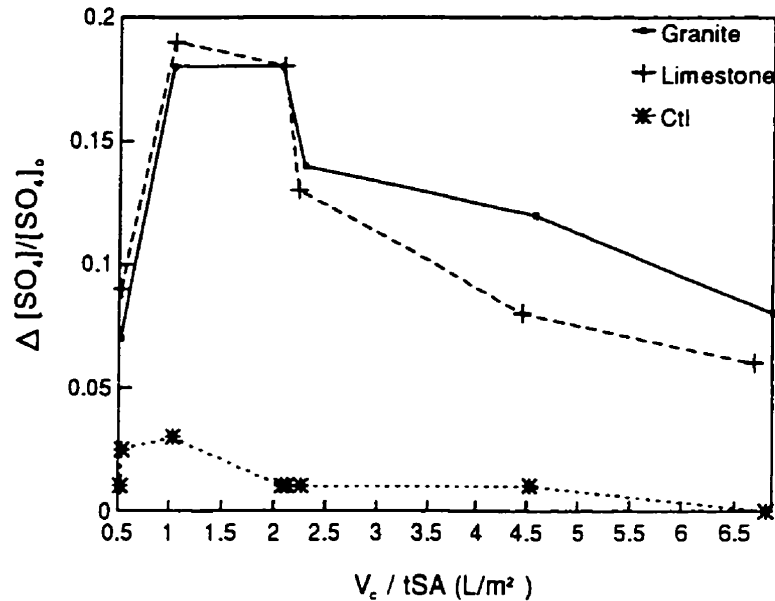


Figure 5.8 The proportion of sulfate removed as a function of V_c / tSA . Solid line: granite; dashed line: limestone; dotted line: controls.

The curves in Figure 5.8 were similar for both granite and limestone and both described a range of values for the V_c / tSA ratio in which sulfate removal was optimal. This range was between 1 and 2 L/m² and the optimum level of sulfate removal achieved was 18 to 19%. This analysis takes into account the response of the culture to cycle volumes of 1L and 6L in a manner which was not evident in Figures 5.5 and 5.6.

5.2.2.2 The Rate of Sulfate Removal

The analysis of the data using rates of sulfate removal as a function of the V_c / V_v and the V_c / tSA ratios was done. The calculated rates are given in Table 5.5. The general observations were: (i) no clear relationship was seen between the rate of sulfate removal and the V_c / V_v ratio, however, there was an overall increase in the rate of sulfate removal as the V_c / V_v ratio increased (Figure 5.9); and (ii) the relationship between rate of removal and the V_c / tSA ratio followed a pattern similar to that observed for the proportion of sulfate removed (Figure 5.10); an optimum rate of removal occurred when the V_c / tSA ratio had a value between 1 to 2 L/m². An abrupt decrease in the rate of removal was

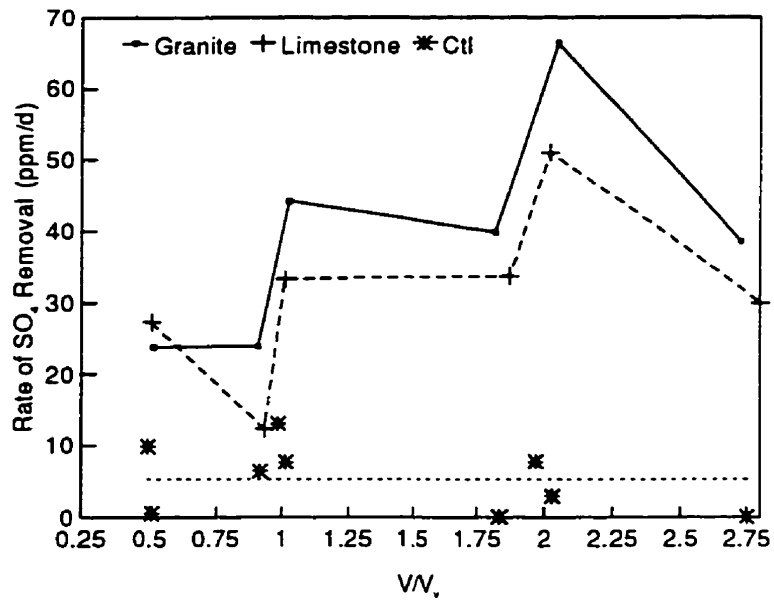


Figure 5.9 Rates of sulfate removal as a function of V_c / V_v . Solid line: granite; dashed line: limestone; dotted line: controls.

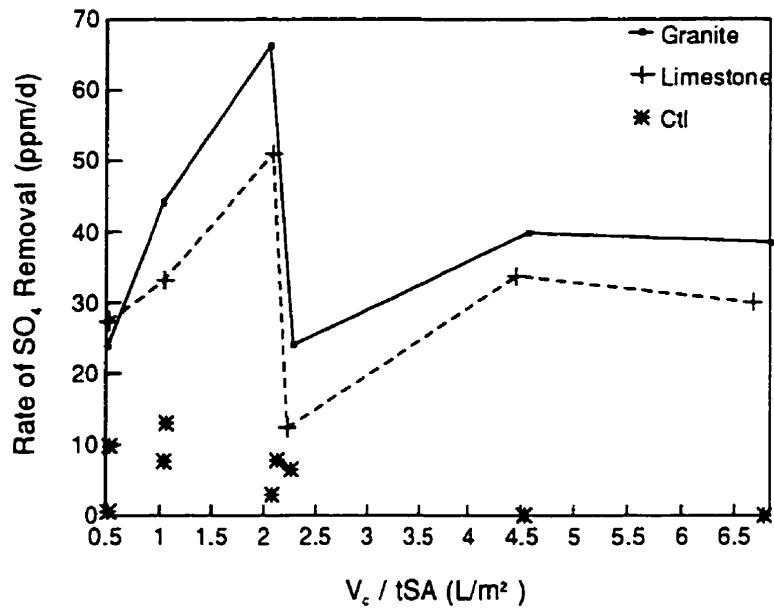


Figure 5.10 Rates of sulfate removal as a function of V_c / tSA . Solid line: granite; dashed line: limestone; dotted line: controls.

observed after the optimum which was not observed in the case when the proportion of sulfate removed was used in the analysis.

The analysis of the data would be greatly facilitated by the use of an entity that encompassed and described the relationship between various bed parameters instead of using individual bed parameters. Dimensionless numbers were constructed to fulfil such a role.

5.2.3 Construction and Evolution of a Dimensionless Number

Dimensionless numbers were constructed to describe relationships among various parameters of the system that could be correlated with SRB activity based on the data on sulfate removal. Parameters to be considered and the arrangement of these parameters were decided upon in the following manner.

The system was divided into the water column, the gravel bed and the interface. The parameters describing the water column were the total volume of the water column, V , which does not including the void volume, and the volume of the water column that was cycled (V_c). The V_c represented the load of sulfate, metals and acidity on the system. The parameters describing the gravel bed were the particle size of the gravel (diameter), the total surface area of the gravel (tSA), the void volume (V_v), and the depth of the bed. The interface between the two compartments was represented by the superficial surface area (sSA) of the gravel bed and was the area over which exchange between the water column and the gravel bed occurred. The sSA was constant in this study and was assumed to be the same as the cross-sectional area of the column. Relationships had been observed between sulfate removal and the void volume (V_v) and between sulfate removal and the total surface area (tSA) in the Section 5.2.2.1..

Four parameters were used to describe the system: V_c , V_v , tSA and sSA . The particle size was not included directly but was present since it was used in the calculation of the tSA . The four possible dimensionless numbers comprised of these four variables were:

$$D = \frac{V_c * sSA}{V_v * tSA}$$

$$F = \frac{V_v * sSA}{V_c * tSA}$$

$$E = \frac{V_v * tSA}{V_c * sSA}$$

$$G = \frac{V_c * tSA}{V_v * sSA}$$

The numbers were designated D , E , F , and G . The construction of the numbers was simplistic since neither coefficients nor other mathematical manipulations were implemented. Dimensionless number E is the inverse of D and similarly G is the inverse of F . Despite the fact that the sSA is a constant in this study, it was included in the dimensionless number since it can vary from system to system and has important practical implications.

The numbers can best be interpreted in the following manner. The dimensionless numbers are composed of two ratios. If D is taken as an example, it can be presented as:

$$D = \frac{V_c}{V_v} * \frac{sSA}{tSA}$$

The V_c/V_v ratio represented the amount or load of fresh AMD on the gravel bed. The sSA/tSA ratio was an aspect ratio which took into account the height of the gravel bed since a large sSA/tSA ratio implied a thin gravel layer while a small sSA/tSA ratio implied a thick gravel bed. Overall, this number represented a loading to support (substrate) ratio: L/S , which may be considered to be the name for this dimensionless number.

The arrangement of parameters in D was such that the parameters describing the water column were grouped in the numerator while those describing the gravel bed were placed in the denominator. The difference between D and F was that the V_c/V_v ratio was inverted in F . The arrangement of the variables in F reflected the observations made in the previous section that sulfate removal has a direct relationship with the total surface area in the gravel bed and an inverse relationship with the void volume.

5.2.3.1 The Proportion of Sulfate Removed as a Function of D and E

This analysis was done in two parts. In the first part only data from the 2L and 4L cycles were considered, and in the second part, data from all cycle volumes were used. This was done since this was the sequence of events that occurred during this study. The data obtained using 2L and 4L cycle volumes were obtained and analysed first. The results indicated that certain trends would occur, as shown in previous sections. This directly influenced the direction of the latter part of the study using cycle volumes of 1L and 6L. The inclusion of data obtained using 1L and 6L cycle volumes affected the trends predicted by the 2L and 4L data. This train of events is, therefore, presented here to both explain the development of the work and to help understand the trends indicated by the data.

The proportions of sulfate removed after 7 days when 2L and 4L volumes were cycled were plotted against D (Figure 5.11). For the purposes of comparison, separate curves were drawn for the two types of gravel. The results from the two control columns were pooled together in one general curve.

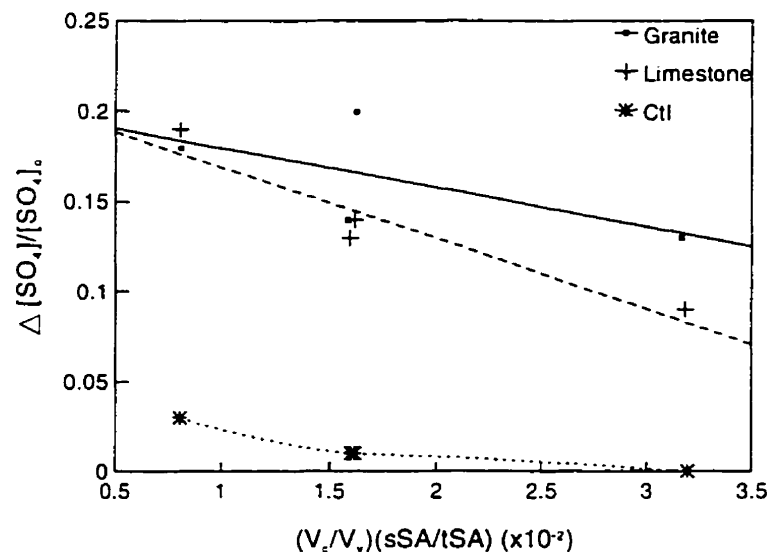


Figure 5.11 Sulfate removal for 2L and 4L volumes cycled as a function of the dimensionless number D , day 7. Granite: solid line; limestone: dashed line; control: dotted line.

The overall trend observed was that as the tSA increased and as the V_c decreased, the proportion of sulfate removed decreased. The curves in Figure 5.11 suggest that: (i) higher sulfate removal would occur with lower values of D , and (ii) sulfate removal would continue to decrease with higher values of D . This implied that the maximum level of sulfate removal would occur when $D = 0$.

D can equal 0 if either V_c or $sSA = 0$. When $V_c = 0$, no new sulfate is being introduced into the reactor. Any sulfate removal observed at this point would be due to sulfate already present in the system and would be expected to be low. The only conceivable situation where $sSA = 0$ would be if the interface between the gravel bed and the water column should become covered or sealed such that there is no contact between the AMD and the SRB. However, this would be a situation where no sulfate removal would be expected to occur.

D can approach 0 if either tSA or V_c approaches ∞ , which means that the tSA and the V_c become very large. A large surface area should lead to increased SRB activity and to greater sulfate removal. However, an inverse relationship exists between the surface area and the void volume of a packed bed. If the total surface area becomes very large, the void volume would become very small, and vice versa. Any change in one of these two parameters would then be negated by a change in the other. Consequently, it is unlikely that D would approach 0 in these circumstances.

The response of the system with respect to the removal of sulfate to higher and lower values of D was investigated in the subsequent series of experiments. In this study, V_c was varied to attain changes in D since changes in the other three parameters would necessitate changes in column and bed sizes. To obtain a lower value of D , a cycle volume of 1L was used in the columns containing 1/4" gravel and to obtain a higher value of D , 6L was cycled in the columns containing 1/2" gravel. Since no new information would be obtained by cycling 1L in the 1/2" columns and 6L in the 1/4" columns, these experiments were not performed.

The accumulated data for sulfate removal for all cycles were plotted separately for limestone and granite against D (Figure 5.12).

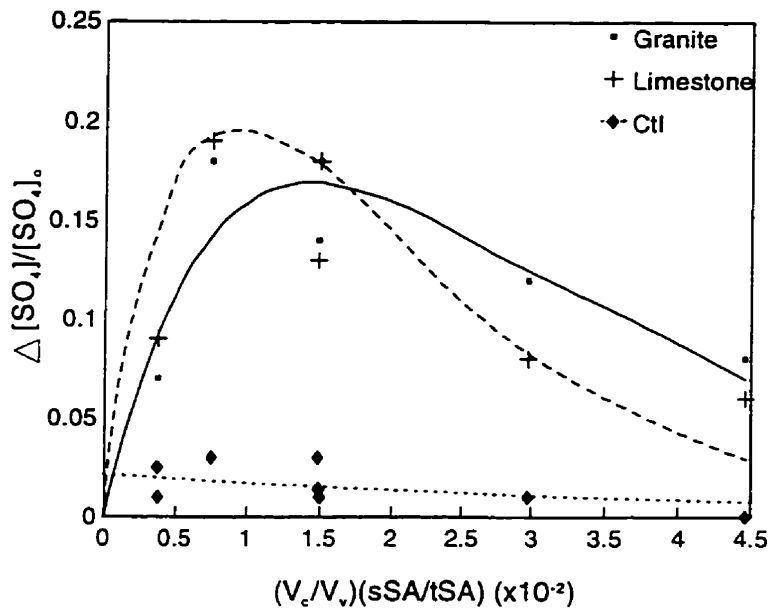


Figure 5.12 Sulfate removal for all volumes cycled as a function of the dimensionless number D , day 7. Granite: solid line; limestone: dashed line; control: dotted line.

The curves were fitted to the data using the following equation:

$$y = ax^be^{cx} \quad (1)$$

where a , b , and c are coefficients. The values of a , b , and c for the curve for granite were 26.38, 0.967, and -65.717 respectively and for limestone the values were 35.38, 0.92 and -95 respectively.

The trends observed in Figure 5.11 using the data from the 2L and 4L cycles had suggested that higher removal of sulfate would occur at lower values of D . This was not the case; low sulfate removal occurred when a 1L cycle volume was used. The graph described a range of values for D from about 0.0075 to 0.015 in which sulfate removal was at an optimum. This behaviour was also predicted by the curve in Figure 5.10 where the proportion of sulfate removed was plotted as a function of V_c/tSA .

The dilution of the 1L of fresh AMD in the water column could also be an important factor in this case. However, the dilution of the volume cycled in the water column was not taken into consideration in the analysis of the results since the actual response

of the system to various loads of sulfate was being investigated. In either case, the sulfate concentration at the level of the gravel bed would not have stimulated as much SRB activity as for the 2L and 4L cycles.

The low sulfate removal was expected when a 6L cycle volume was used since it was predicted by the trends observed in Figures 5.8 and 5.12. This represented a severe stress on the system since the total volume of the water column was replaced with fresh AMD. It should be noted that the data refers to a 7-day treatment period and while the removal of sulfate was low at day 7, the system was able to eventually cope and recover by day 28 to 35 as indicated by the pH, ORP and conductivity data (Appendices E and F: Cycles 8 and 9 for Columns 4, 5 and 6). A longer time was, therefore, required for bacterial activity and treatment to occur. The curve also suggested that if larger cycle volumes were used, the performance of the columns inoculated with SRB would approach that of the control columns, i.e. SRB activity would not longer occur.

An analysis of the data using dimensionless number E was done (Figure 5.13). As was observed for D , the resulting curve clearly defined a range for E in which sulfate

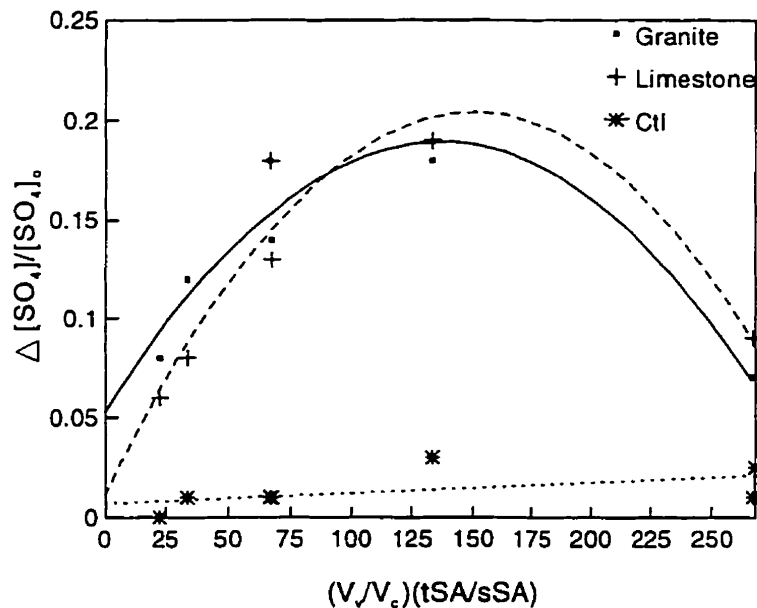


Figure 5.13 Sulfate removal for all volumes cycled as a function of the dimensionless number E , day 7. Granite: solid line; limestone: dashed line; control: dotted line.

removal was at an optimum. The curves were fitted using the following equation:

$$y = a(x-b)^2 - c \quad (2)$$

where a , b , and c are coefficients. The values for a , b , and c for granite were -7.251×10^{-6} , 137.2, and -0.1893 respectively and for limestone the values were -8.514×10^{-6} , 150.5, -0.2038 respectively. The proportion of sulfate removed increased steadily for both granite and limestone as the dimensionless number E increased. This trend occurred until E reached a value between 125 and 150, after which sulfate removal decreased.

5.2.3.2 Granite vs Limestone

A visual comparison of the limestone and granite curves would seem to indicate that at low values of D the sulfate removal in the limestone columns was either similar or superior to that in the granite columns. As the value of D increased, sulfate removal in the limestone columns decreased below that of the granite columns. A student t-test with a confidence interval of 95% was done to statistically compare the limestone and granite data. The t-test indicated that there was no difference between the two gravel types with respect to sulfate removal. Consequently, the data for both types of gravel can be combined to construct one curve for gravel in general (Figures 5.14 and 5.15).

The curve in Figure 5.14 was drawn using Equation 1 where the values for coefficients a , b , and c were 19.59, 0.894 and -69.56, respectively. The curve in Figure 5.15 was drawn using Equation 2 where the values for coefficients a , b , and c were -7.88×10^{-6} , 144.4, and -0.1962, respectively.

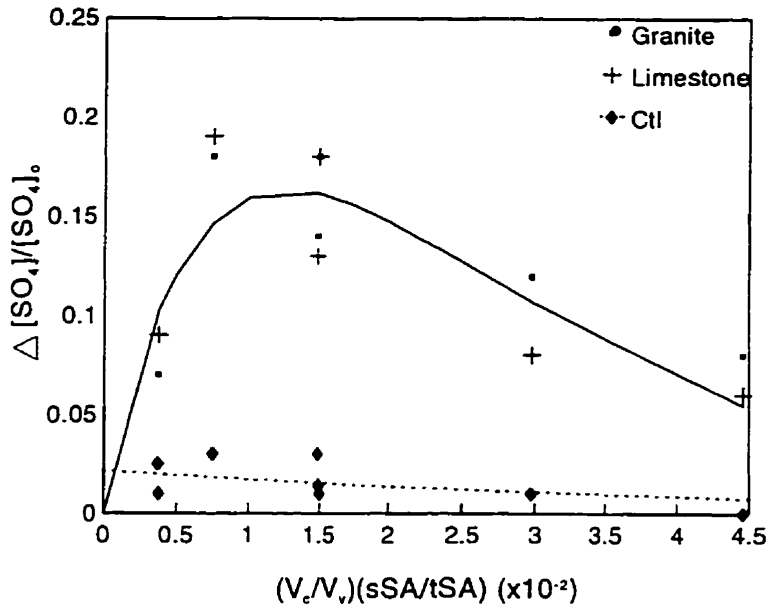


Figure 5.14 General curve for gravel combining granite and limestone data as a function of dimensionless number D .

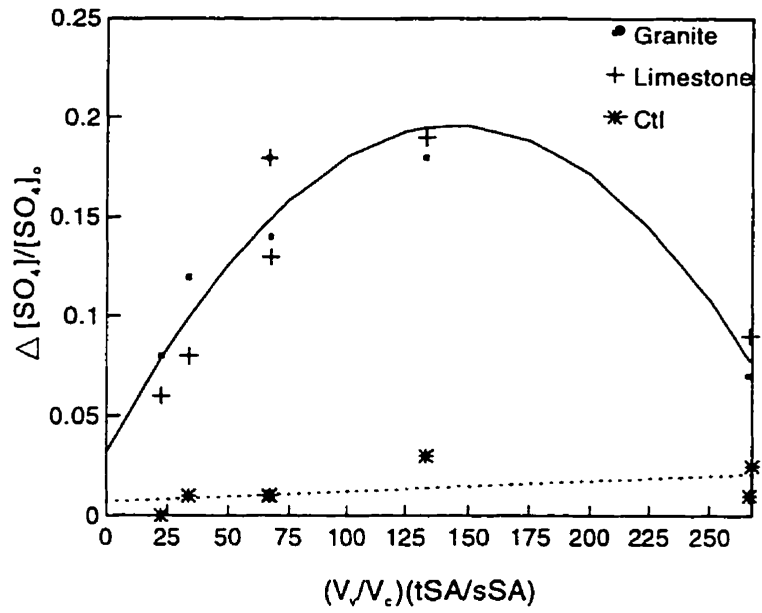


Figure 5.15 General curve for gravel combining granite and limestone data as a function of dimensionless number E .

5.2.3.3 Proportion of Sulfate Removed as a Function of F and G

No clear relationship was obtained when the sulfate removal data was analyzed using dimensionless number F (Figure 5.16). Several maxima and minima were observed for both types of gravel. The r^2 values were 0.115 and 0.047 for granite and limestone respectively. Consequently, the use of dimensionless numbers F and G for analyzing the sulfate removal data was not further pursued.

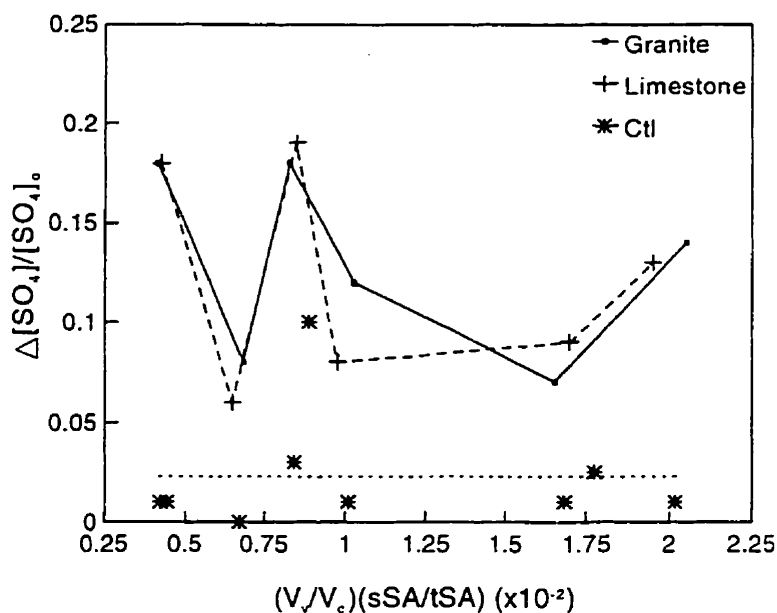


Figure 5.16 The removal of sulfate for granite limestone as a function of the dimensionless number F , day 7. Granite: solid line; limestone: dashed line; control: dotted line.

5.2.3.4 Rate of Sulfate Removal as a Function of D

The possible existence of relationships between the rate of sulfate removal and the dimensionless numbers was investigated. The rates of sulfate removal were calculated as an average for the first 7 days since most of the metal removal occurred within this time as shown in Section 5.2.1. A plot of the rate of sulfate removal as a function of D is shown in Figure 5.17 and was very different from that obtained between the proportion of sulfate removed and D (Figure 5.12). No apparent relationships or overall trends were seen. The r^2 values were 0.011 and 0.001 for granite and limestone respectively.

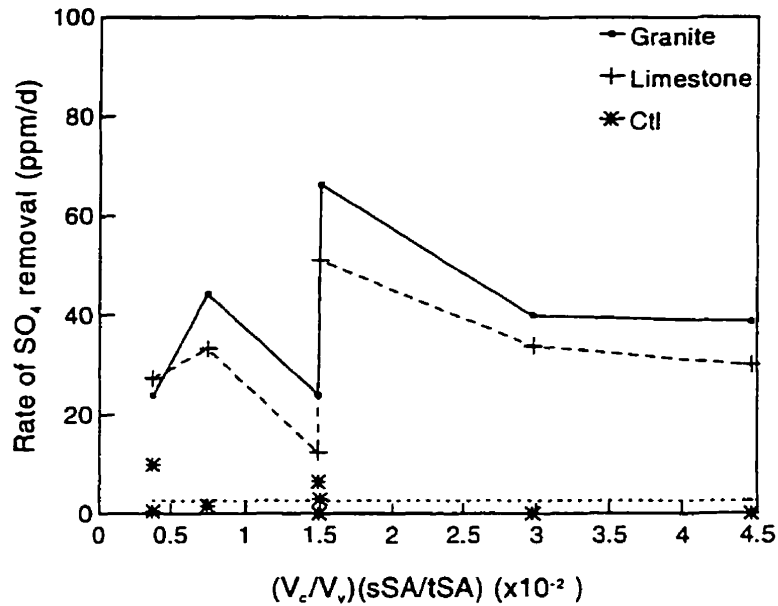


Figure 5.17 The rate of sulfate removal for granite and limestone gravel as a function of dimensionless number D , day 7. Granite: solid line; limestone: dashed line; control: dotted line.

This would suggest that with respect to rates of sulfate removal, the dimensionless number D was (i) not useful in that it does not aptly describe the relationships between the parameters involved and; (ii) not complete in that some other factor or parameter is involved and has not been included in its construction.

5.2.3.5 Rate of Sulfate Removal as a Function of F

A plot of the rate of sulfate removal and F resulted in a curve (Figure 5.18) in which the rate decreased smoothly as F increased (i.e. as V_v increased and tSA decreased). This trend was observed for both limestone and granite. The line was fitted to the data using the following equation:

$$y = \frac{a}{x^b} - c \quad (3)$$

where a , b and c are coefficients. The values of a , b , and c were 0.548, 0.843, and 9.15 respectively for granite and 0.827, 0.728, and 4.98 respectively for limestone.

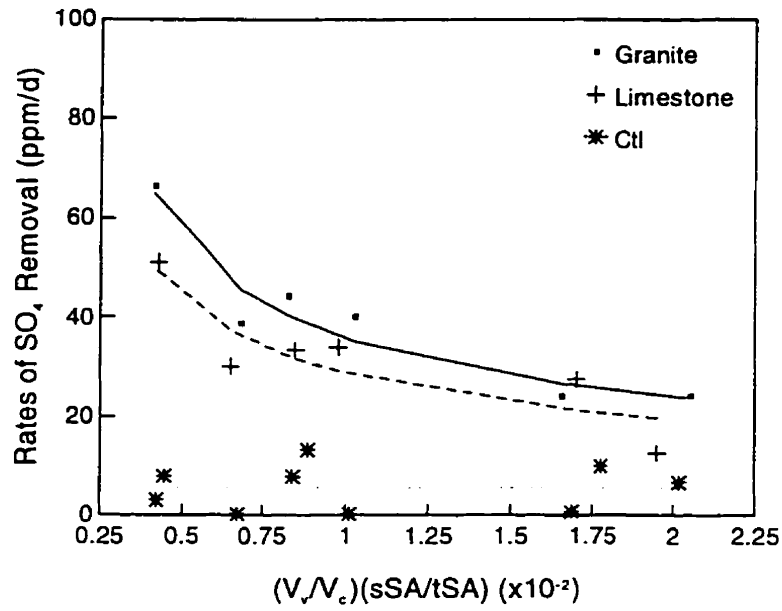


Figure 5.18 The rate of sulfate removal for granite and limestone as a function of dimensionless number F . Granite: solid line; limestone: dashed line; control: dotted line.

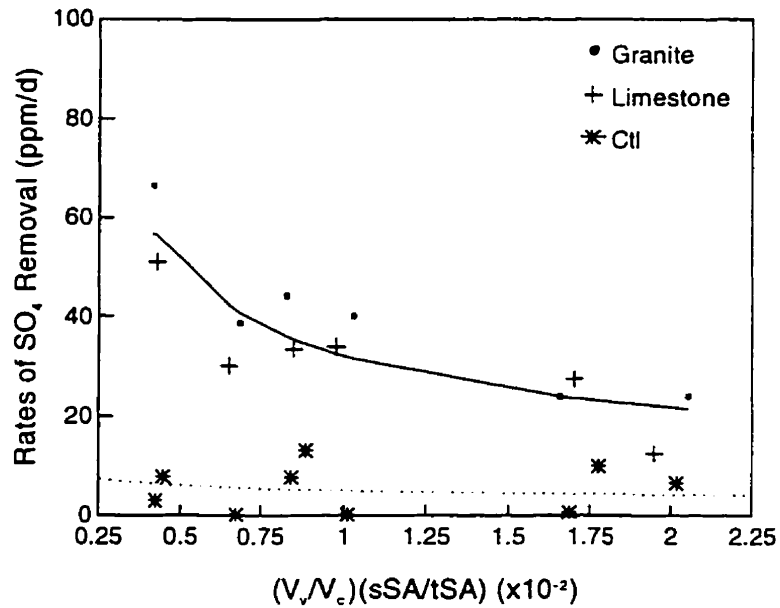


Figure 5.19 General curve for gravel combining granite and limestone data as a function of dimensionless number F .

A general curve can be drawn combining the data from both granite and limestone since the difference between the sets of data had been shown to be insignificant (Figure 5.19). The curve was fitted to the data using equation (3). The values of a , b , and c were 0.496, 0.838, and 8.61 respectively.

This was very different from what has been obtained when the proportion of sulfate removal data was used with F , the resulting graph had demonstrated a series of maxima and minima (Figure 5.16). There was, therefore, a difference in how the proportion of sulfate removed data and the rate of removal data are best presented. Dimensionless number D gave a cogent representation of the proportion of sulfate removed data while F gave the best presentation of the rate of removal data.

Why does this disparity between the two representation of the data exist and what does it mean? The only difference between D and F was that V_c/V_v was inverted. Examination of the curves suggested that the rate of sulfate removal was directly related to the amount of sulfate (V_c) introduced into the system while the amount of sulfate removed was related to the V_v . A possible explanation for this difference was that the rate of sulfate reduction was dependent on the amount of sulfate present while the amount of sulfate removed was dependent on the number of bacteria present. In the first case, the initial amount of sulfate was important while in the second case, the total surface area of the gravel bed and access to this surface was the major consideration. In the latter case, the amount of sulfate present in the V_v was more critical than the initial amount of sulfate present in the system (V_c).

The distinction between the quantity of sulfate removed and the rate of sulfate removal is subtle but has important implications. Depending on both the physical parameters of the gravel bed and the mode of operation, the rate of sulfate removal can be high while the actual amount of sulfate removed can be low. Or conversely, the amount of sulfate removed can be high while the rate of removal can be low.

5.2.3.6 Metal Removal vs Dimensionless Numbers

The analysis of the data presented in the previous sections was focused on the removal of sulfate since this, rather than metal removal, would be a direct measure of SRB activity. The existence of possible relationships between the dimensionless numbers constructed in the previous sections and metal removal is examined in this section.

This analysis should consider the following factors. Comparison of results from the experimental and the control columns suggest that mechanisms for metal removal other than sulfide precipitation were also occurring since high metal removals were observed in some of the control columns. Sulfate removal appeared to be due almost entirely to SRB activity as can be seen by comparing the results from the experimental and control columns (Table 5.5).

Furthermore, the reactions of different metals with sulfide differ in their stoichiometries. For example, Cu, Fe, and Zn can be precipitated as CuS (covellite), FeS (ferrous sulfide), and ZnS (sphalerite) respectively, binding only one sulfide. However, Cu₂S (chalcocite) and Cu₉S₅ (digenite) can also be formed. Similarly, Fe can complex with S to form either FeS₂ (pyrite) or Fe₄S₅ (pyrrhotite) among others. Also, more than one metal may complex with sulfide at one time. Examples of this are Cu₅FeS₄ (bornite) and CuFeS₂ (chalcopyrite).

The use of a "total metal removal" parameter would help to overcome the need to account for these different factors. Nevertheless, the concept of "total metal removal" is nebulous since many metals are involved, including ones not considered in this analysis such as Ca, Mg, and Na. Also, it would be more informative to perform this analysis for individual metals, specifically Al, Cu, Fe, Mn, and Zn, to investigate the behaviour of each metal with respect to the physical parameters of the system. The data for the proportions of metal removed were presented in Table 5.4. The rates of metal removal are given in Table 5.6. Graphical representation of the relationships between the removal of individual metals and dimensionless number D and between the rates of metal removal and dimensionless number F are presented in Figures 5.20 to 5.29.

Table 5.6 Rates of Metal Removal

Volume Cycled (L)	Metal	Rate of Metal Removal (ppm/d)						
		1/4"				1/2"		
		G Exp	G Ctl	L Exp	L Ctl	G Exp	G Ctl	L Exp
1	Al	0.87	0.37	0.75	1.08			
2	Al	0.98	1.33	0.35	1.06	0.68	0.20	1.24
4	Al	6.33	1.45	5.63	1.88	6.65	0.00	4.82
6	Al					5.81	0.00	6.21
1	Cu	0.17	0.06	0.06	0.47			
2	Cu	0.02	0.22	0.01	0.02	0.01	0.16	0
4	Cu	1.16	0.44	1.21	0.3	0.65	0.02	1.72
6	Cu					0.71	0	0.68
1	Fe	5.26	0.71	2.94	1.44			
2	Fe	5.63	4.06	9.56	6.41	4.47	1.49	8.45
4	Fe	11.02	0.94	9.64	1.57	12.43	0.26	5.60
6	Fe					4.76	0.00	0.98
1	Mn	0.37	0.00	0.41	0.06			
2	Mn	1.15	0.10	1.00	0.66	1.53	0.04	0.76
4	Mn	0.54	0.14	1.04	0.04	0.39	0.09	0.07
6	Mn					0.00	0.09	0.00
1	Zn	3.80	0.95	1.22	3.10			
2	Zn	0.18	1.62	0.85	3.47	0.27	0.21	0.81
4	Zn	21.68	0.77	21.01	1.08	24.44	0.00	18.06
6	Zn					19.90	0.00	21.69

G: granite; L: limestone; Exp: inoculated with SRB; Ctl: control, not inoculated with SRB.

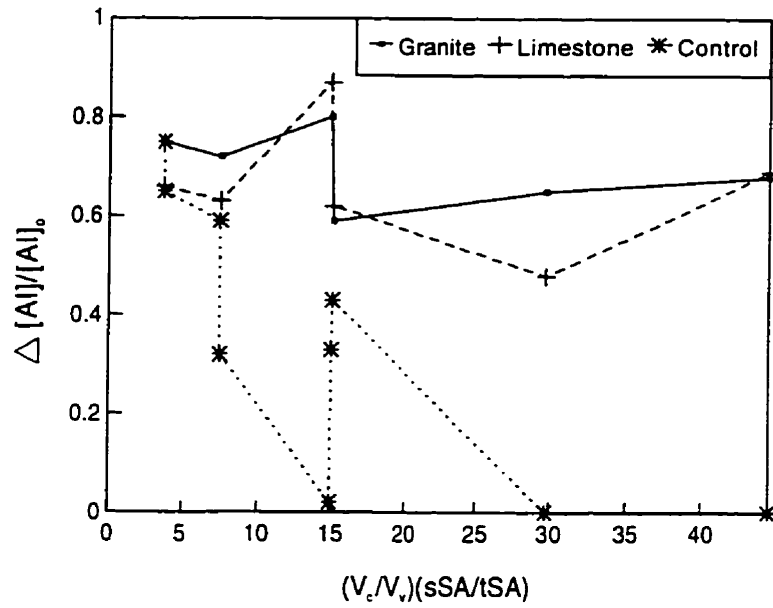


Figure 5.20 Proportion of Al removed as a function of the dimensionless number D . Solid line: granite; dashed line: limestone; dotted line: control.

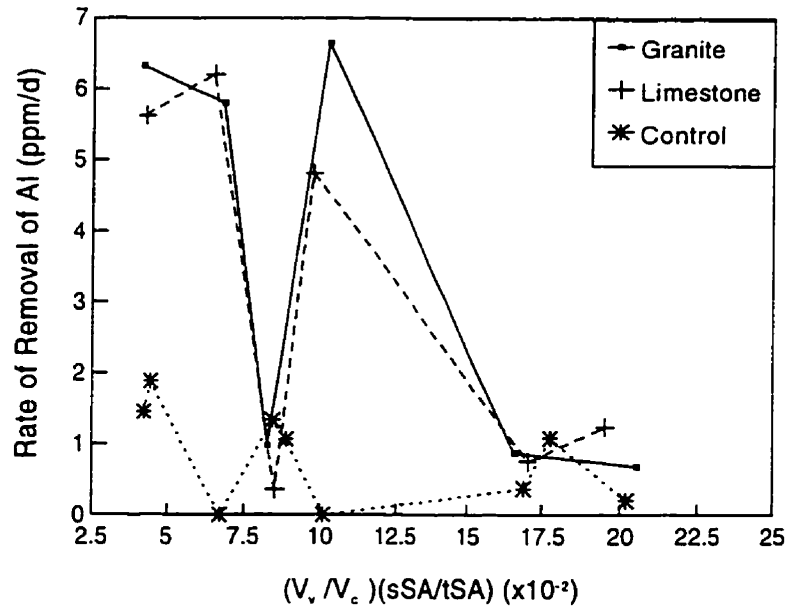


Figure 5.21 Rate of Al removal as a function of the dimensionless number F . Solid line: granite; dashed line: limestone; dotted line: control.

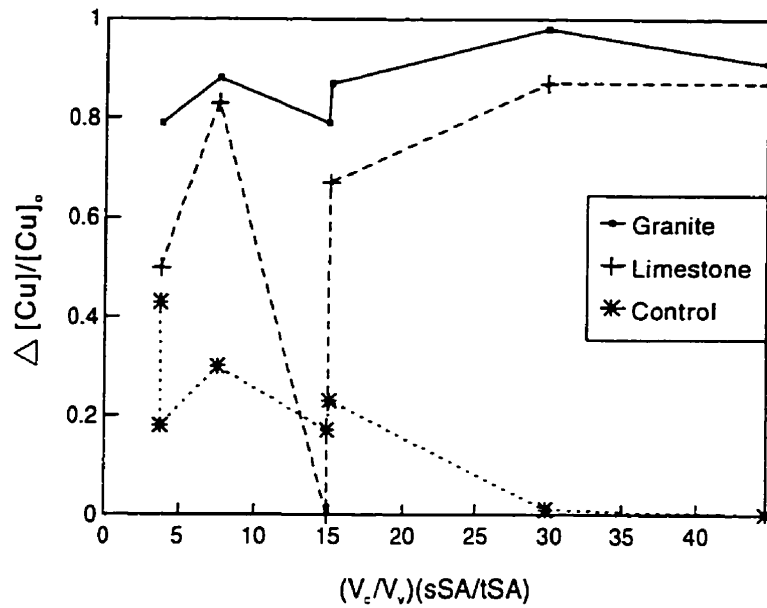


Figure 5.22 Proportion of Cu removed as a function of the dimensionless number D . Solid line: granite; dashed line: limestone; dotted line: control.

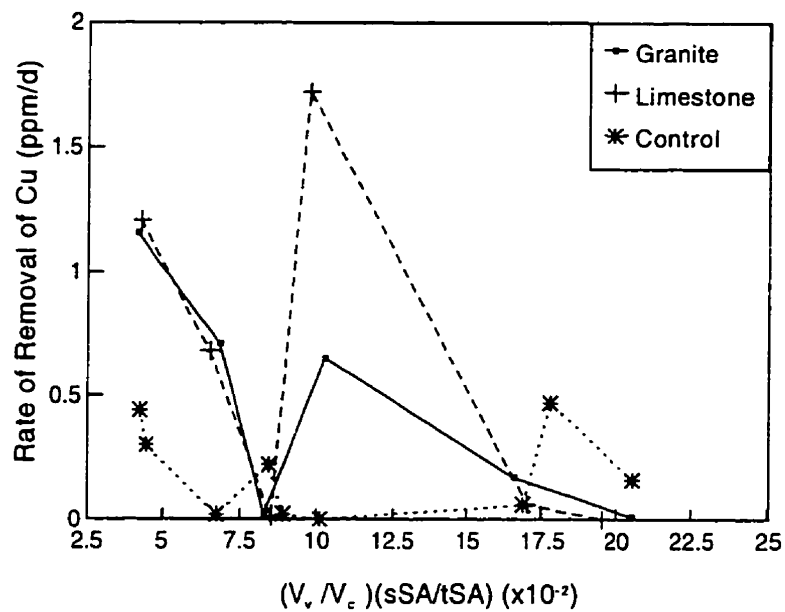


Figure 5.23 Rate of Cu removal as a function of the dimensionless number F . Solid line: granite; dashed line: limestone; dotted line: control.

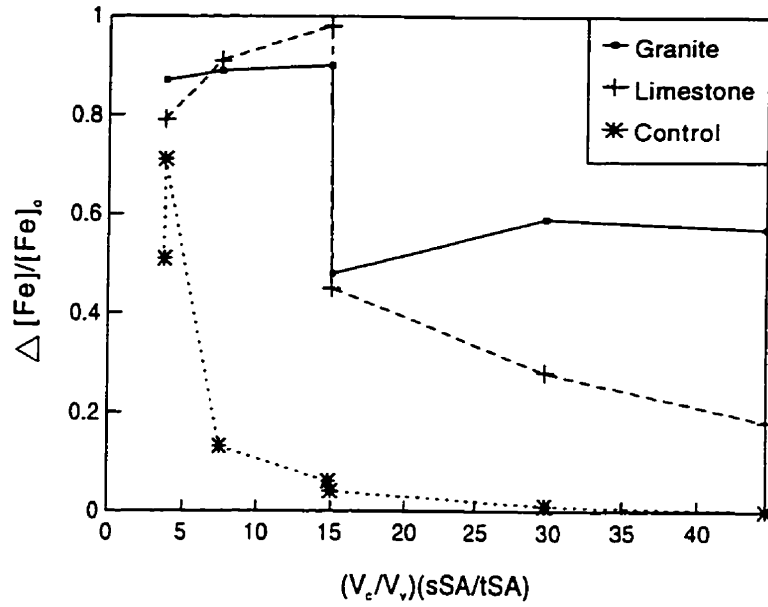


Figure 5.24 Proportion of Fe removed as a function of the dimensionless number D . Solid line: granite; dashed line: limestone; dotted line: control.

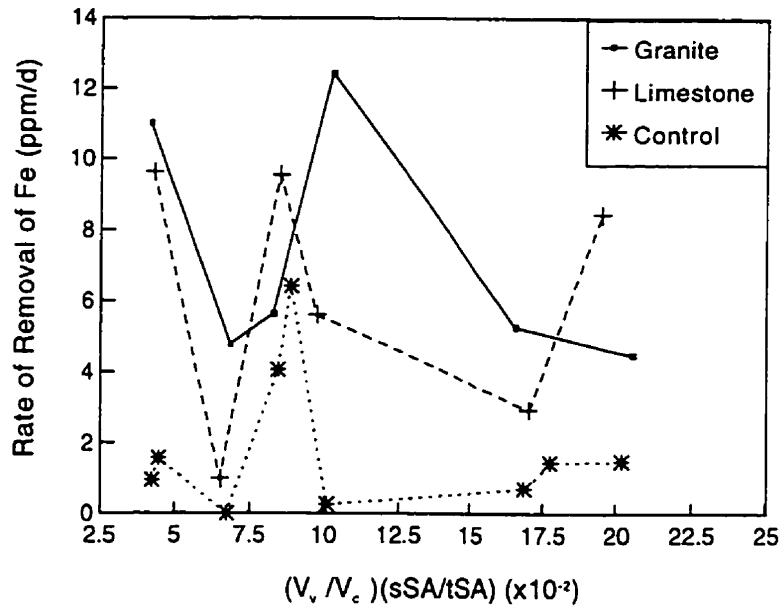


Figure 5.25 Rate of Fe removal as a function of the dimensionless number F . Solid line: granite; dashed line: limestone; dotted line: control.

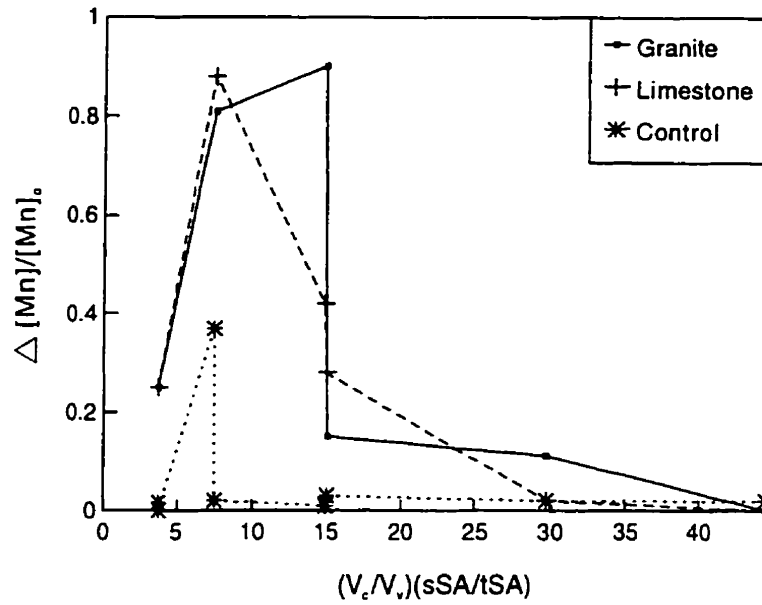


Figure 5.26 Proportion of Mn removed as a function of the dimensionless number D . Solid line: granite; dashed line: limestone; dotted line: control.

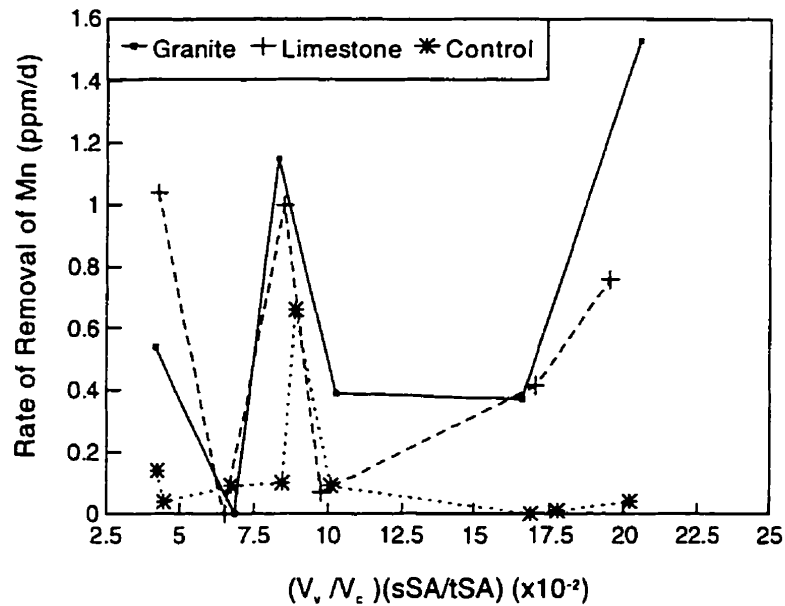


Figure 5.27 Rate of Mn removal as a function of the dimensionless number F . Solid line: granite; dashed line: limestone; dotted line: control.

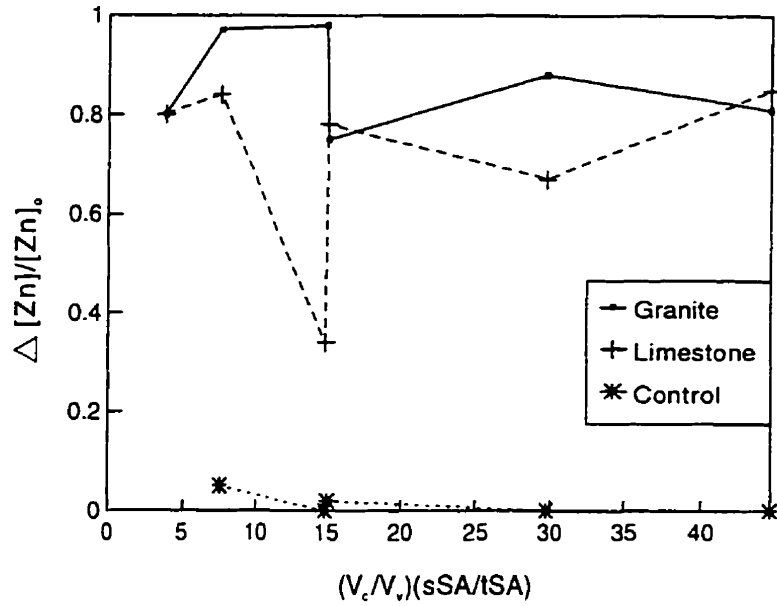


Figure 5.28 Proportion of Zn removed as a function of the dimensionless number D . Solid line: granite; dashed line: limestone; dotted line: control.

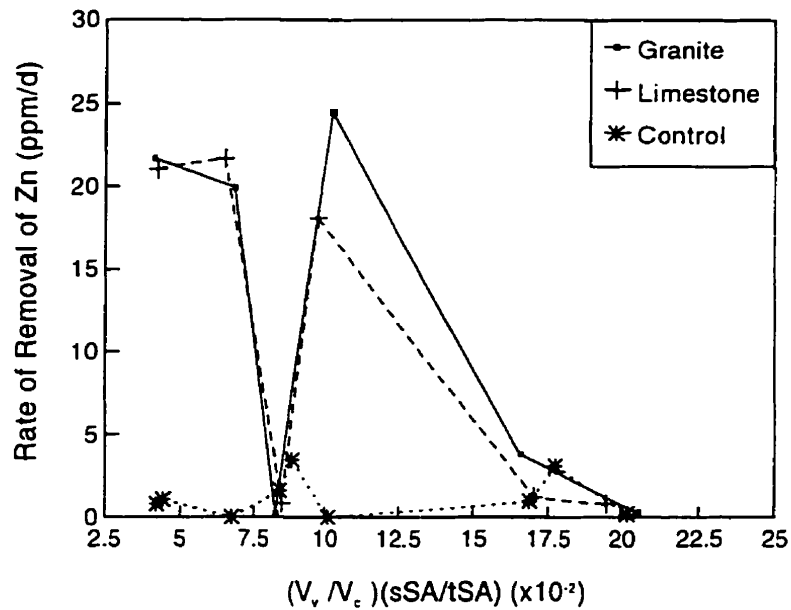


Figure 5.29 Rate of Zn removal as a function of dimensionless number F . Solid line: granite; dashed line: limestone; dotted line: control.

Two general trends can be discerned for relationships between the proportion of metal removed and the dimensionless number D . The first trend was one in which the proportion of metal removed remained relatively constant with some exceptions over all values of D . This was the case for Al (Figure 5.20), Cu (Figure 5.22), and Zn (Figure 5.28). The second was one in which a maximum level of removal occurred for values of D lower than 15 and which rapidly decreased to a lower level for values higher than 15. Such was the case for Fe (Figure 5.24) and Mn (Figure 5.26). This second trend was similar to that observed for sulfate and reflects the close relationship between sulfate reduction and removal of Fe as iron sulfide and removal of Mn as a co-precipitate with the iron sulfide.

The plots demonstrated that little or no relationships were observed between the rate of metal removal and F , as had been seen for sulfate. This suggested that the rate of metal removal cannot be appropriately described using F . However, when the graphs for all the metals were examined together there was an overall pattern in which a minimum in the rate of removal occurred consistently for all metals and for both types of gravel when F had a value between 6×10^{-2} and 9×10^{-2} . This recurring pattern seemed to suggest that there was some underlying relationship between the rate of metal removal and the physical parameters of the bed which is not adequately described by the dimensionless number. However, as was previously seen, F does present a cogent description of the rate of sulfate removal data. The difference is probably due to the fact that a number of mechanisms are involved in metal removal which are not involved in sulfate removal. Sulfate removal in the system under study is a process that is dependent entirely on a biological process whereas metal removal is dependent on both biological and physical processes.

5.2.4 Conductivity, pH and ORP

5.2.4.1 Conductivity Measurements

The measurement of electrical conductivity was investigated for its usefulness in monitoring SRB activity in the gravel bed. The basis of this method was that bacterial activity caused a decrease in the impedance and an increase in the conductivity of the culture medium. This phenomenon was due to the metabolism of bacteria which may (i) generate charged, mobile metabolites such as organic acids, and (ii) decompose large molecules into a number of smaller ones. Consequently, changes in impedance have been correlated with bacterial activity and successfully applied in the medical field and in the food industry to detect and enumerate contaminant bacteria (Firstenberg-Eden and Eden, 1984). The measurement of electrical conductivity has also been used to detect for bacterial activity in soils (Silverman and Munoz, 1974).

Impedance is the opposition to a current that is encountered specifically in an alternating current circuit and is composed of two parts, the resistance and the reactance. They are both forces that act against the flow of electrons, however, resistance causes power to be dissipated, while reactance does not. Reactance is related to the capacitance and inductance in a circuit and varies with the frequency of the current.

Conductivity is the inverse of the resistance and is the ease with which a current can be established when either a direct or alternating current is used as a power source. Conductivity measurements using a direct current power source would be preferred since, unlike impedance, there would be no need to account for reactance.

The measurement of conductivity is advantageous since it is relatively simple, rapid, does not require the isolation of bacteria, and is non-destructive. This method could be especially useful in the case of anaerobes such as SRB since anaerobic techniques are not required. Also, when bacteria either cluster around particles or grow on surfaces it is difficult to dislodge them to obtain an accurate enumeration. Consequently, it could be used as an on-line method of monitoring bacterial activity.

Measurement of changes in impedance had previously been used to detect SRB activity in sediment (Oremland and Silverman, 1979) but not electrical conductivity. In

this study, the measurement of electrical conductivity was implemented as a relatively easy and non-intrusive method of detecting and monitoring bacterial activity at different depths in the gravel bed. The evaluation of this method was done on the basis of comparison with the pH, ORP and sulfate measurements.

An increase in the conductivity was the expected behaviour of the system, however, a second possible scenario was also considered prior to the start of the experiment. The aqueous milieu, the AMD, has high concentrations of ions such as protons, metals and sulfate, suggesting that initially, the conductivity would be elevated. The removal of these molecules by the activity of SRB could, therefore, result in a decrease rather than an increase in the conductivity. This would be contrary to the expected behaviour. However, this second scenario was not observed. In the establishment phase, the initial conductivities were low. No changes were observed until the SRB were established, after which the conductivity increased. The conductivity in the control column remained low and relatively constant over this same time period and this was the case over the length of the entire study.

The recorded conductivity measurements for each cycle are included in the Appendices (Appendix F). Changes in conductivity as a function of both the depth in the gravel bed and the time for each of the cycles are presented graphically in Figures 5.30 to 5.38. Changes in conductivity measurements obtained in the control column for cycles 1 and 8 are given in Figures 5.39 and 5.40. Only these two examples were given since, as stated previously, conductivity in the control column remained low and relatively constant over the course of the study.

In the analysis of the conductivity data, the conductivity measured in the control column was subtracted from the corresponding conductivity measured in the SRB column. All conductivity data reported in Figures 5.30 to 5.38 have been treated in this manner. Comparison of changes in conductivity for each cycle demonstrated a wide range of behaviour, however, several general trends were observed.

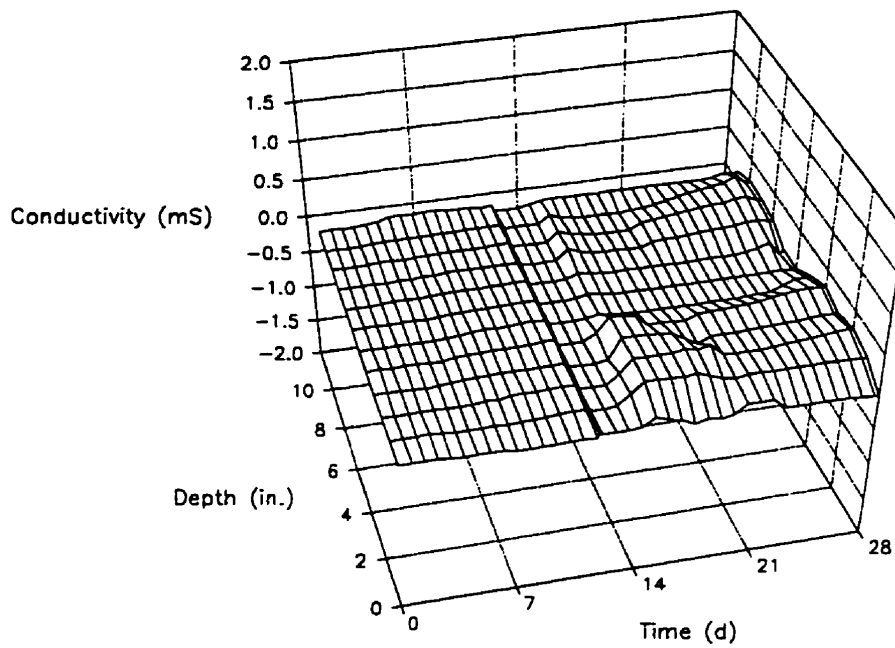


Figure 5.30 Changes in conductivity over time and depth in a bed composed of 1/2" granite, inoculated with SRB: Cycle 1. $V_c = 4L$.

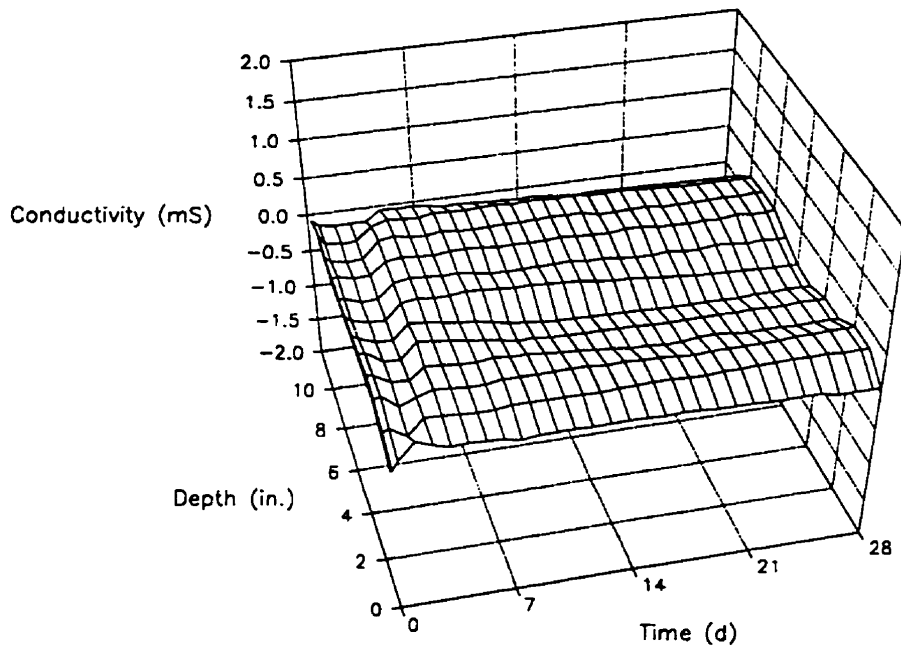


Figure 5.31 Changes in conductivity over time and depth in a bed composed of 1/2" granite, inoculated with SRB: Cycle 2. $V_c = 4L$.

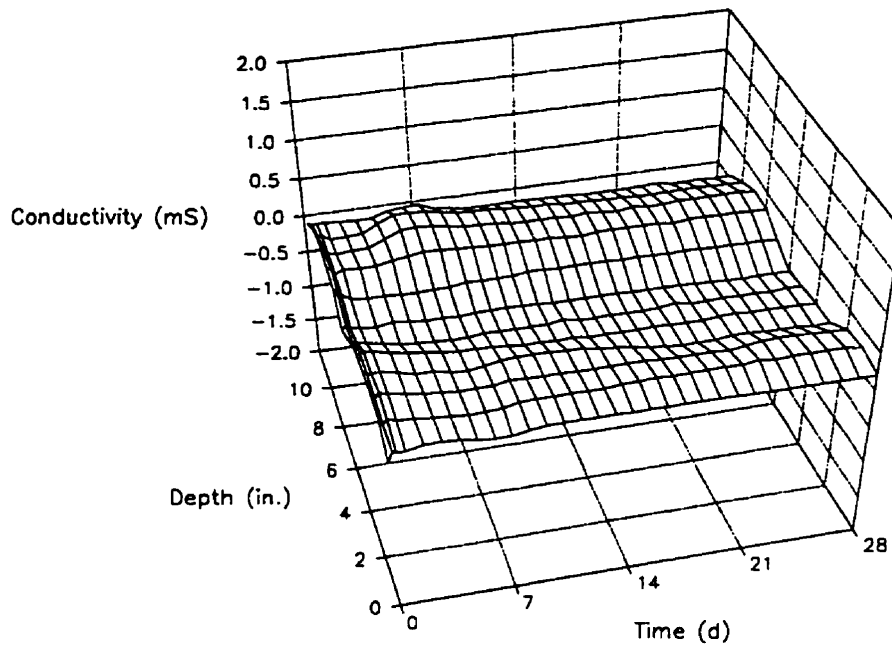


Figure 5.32 Changes in conductivity over time and depth in a bed composed of 1/2" granite inoculated with SRB: Cycle 3. $V_c = 4L$.

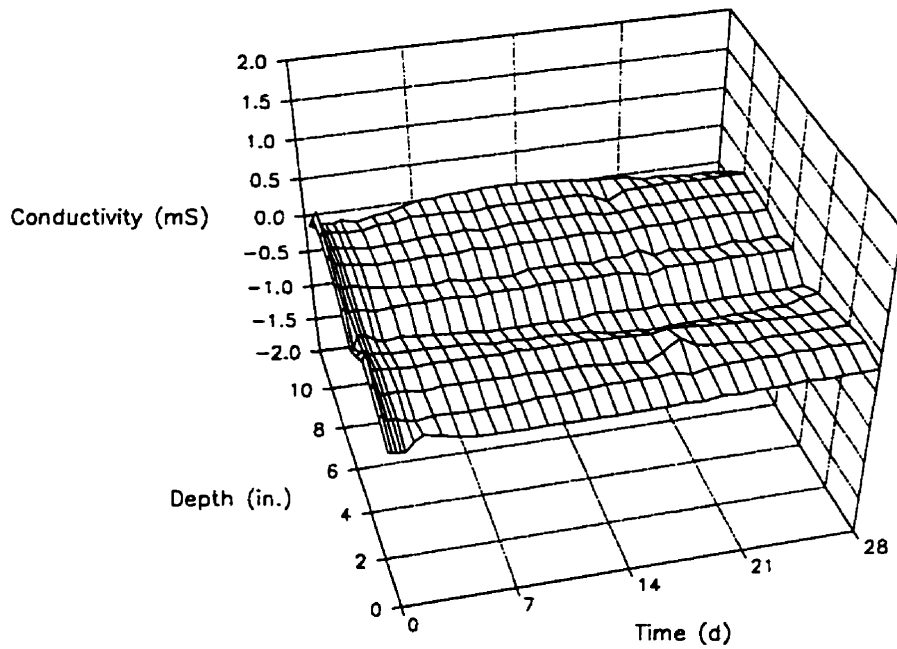


Figure 5.33 Changes in conductivity over time and depth in a bed composed of 1/2" granite inoculated with SRB: Cycle 4. $V_c = 4L$.

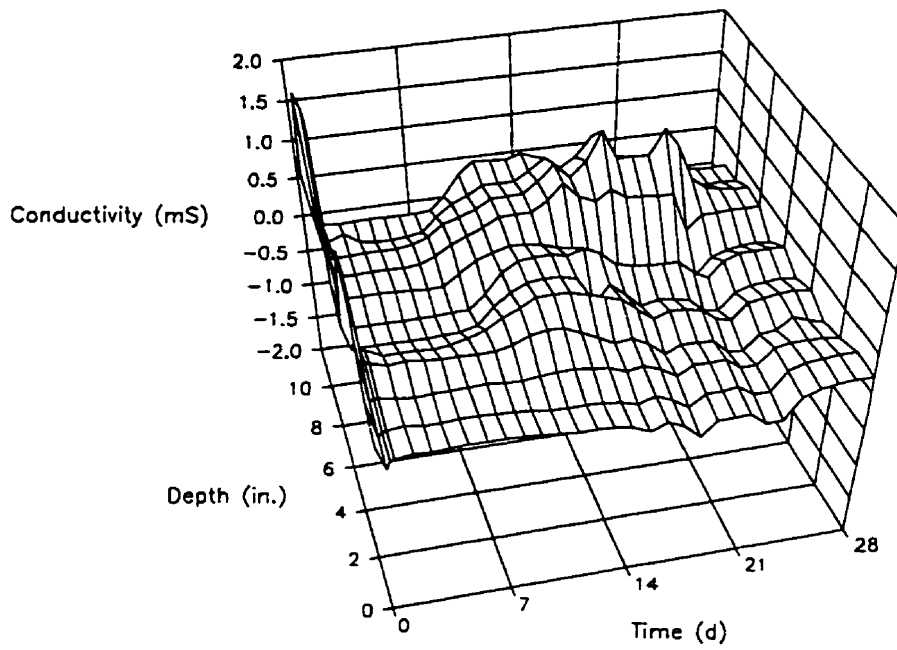


Figure 5.34 Changes in conductivity over time and depth in a bed composed of 1/2" granite, inoculated with SRB. Cycle 5, $V_c = 2L$.

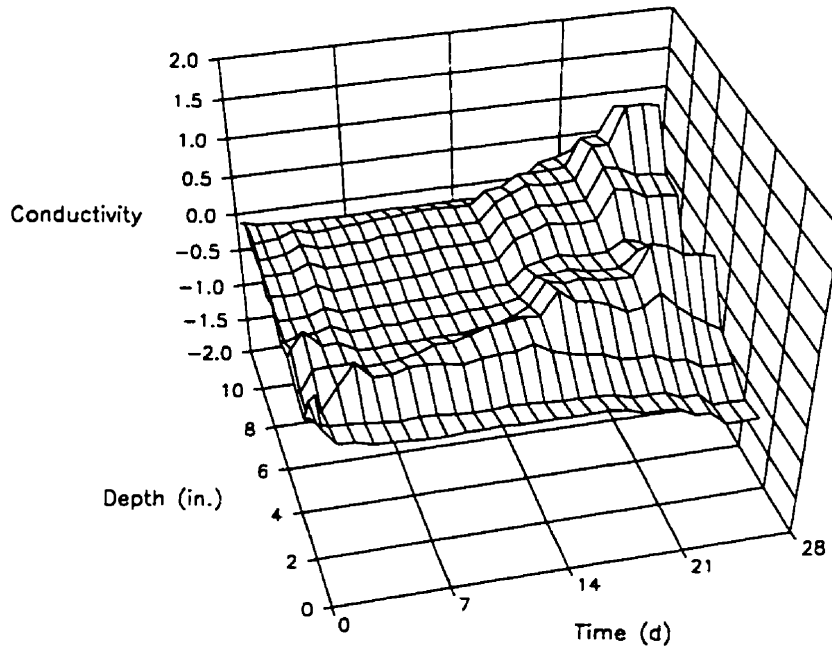


Figure 5.35 Changes in conductivity over time and depth in bed composed of 1/2" granite, inoculated with SRB: Cycle 6, $V_c = 2L$.

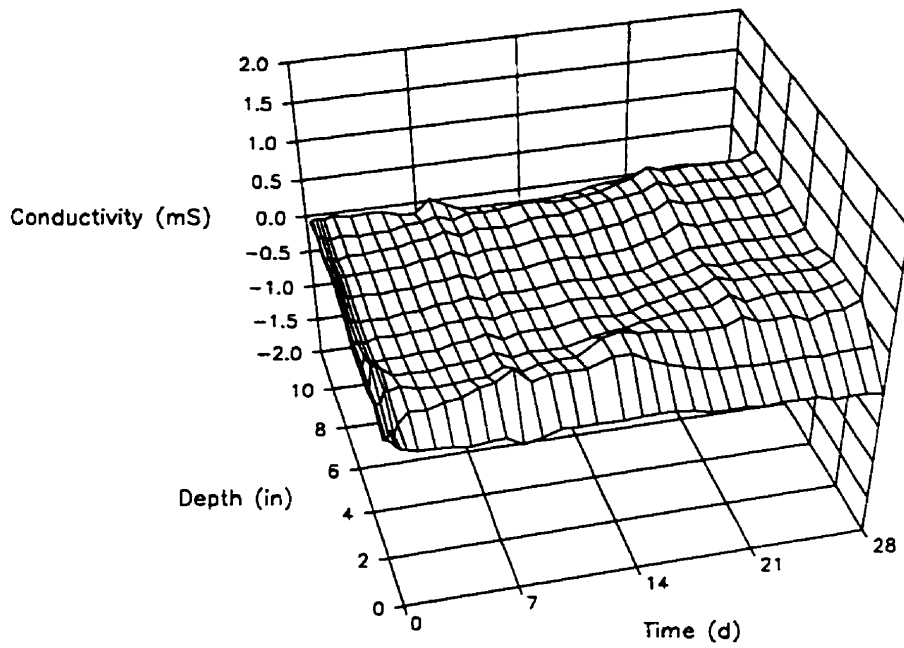


Figure 5.36 Changes in conductivity over time and depth in a bed composed of 1/2" granite, inoculated with SRB: Cycle 7, $V_c = 2L$.

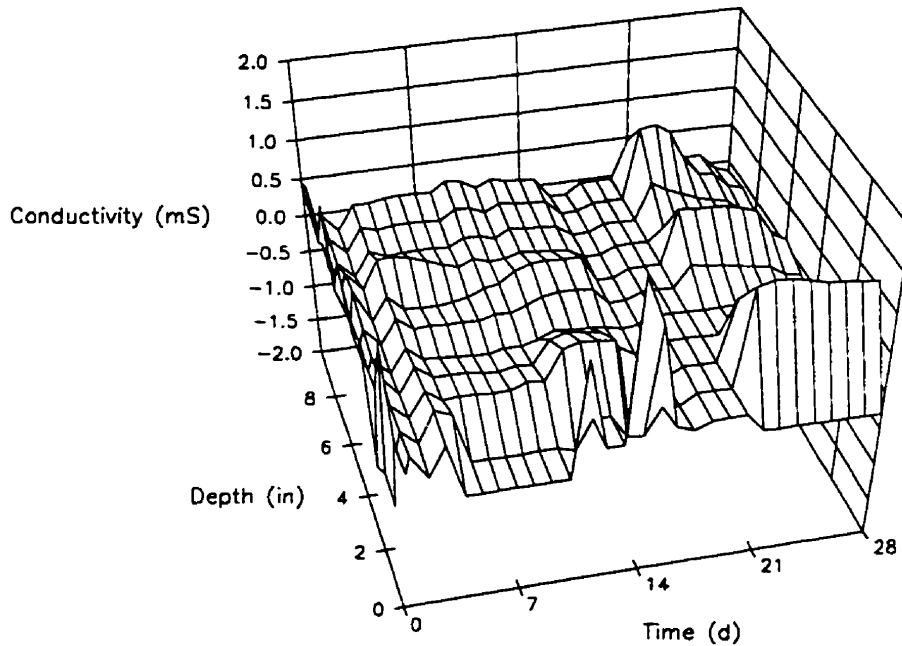


Figure 5.37 Changes in conductivity over time and depth in a bed composed of 1/2" granite, inoculated with SRB: Cycle 8, $V_c = 6L$.

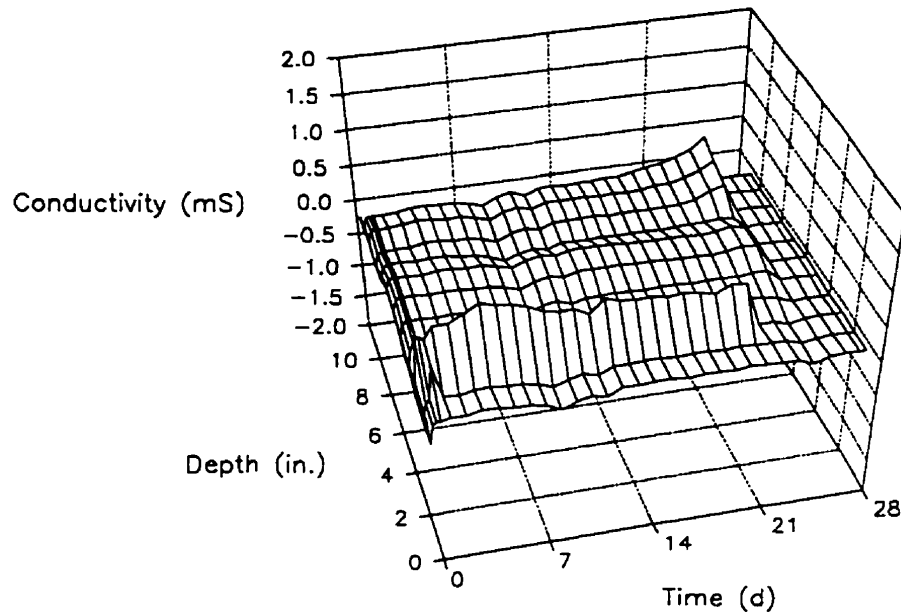


Figure 5.38 Changes in conductivity over time and depth in a bed composed of 1/2" granite, inoculated with SRB: Cycle 9. $V_c = 6L$.

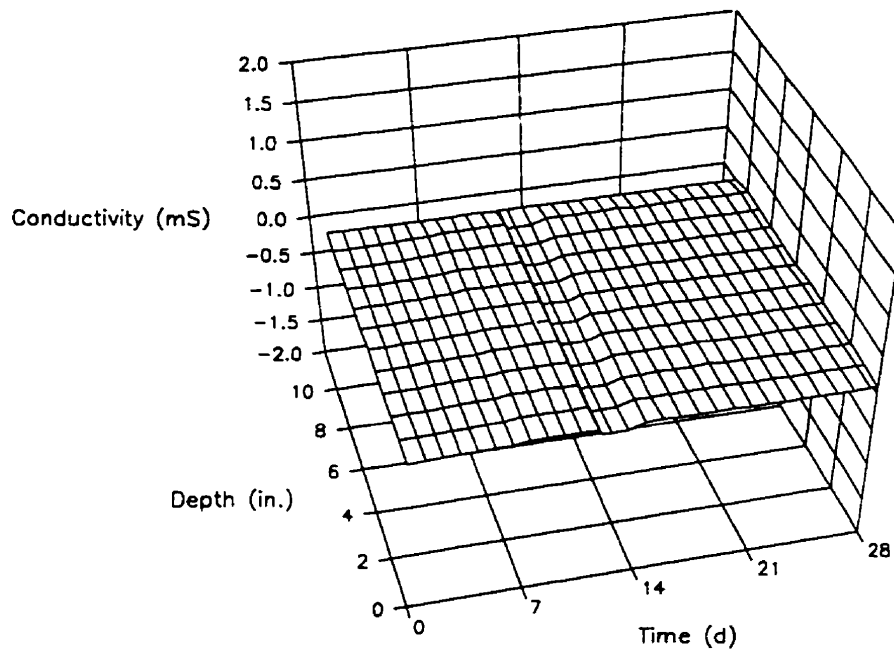


Figure 5.39 Changes in conductivity over time and depth in a bed composed of 1/2" granite with no SRB: Cycle 1. $V_c = 4L$.

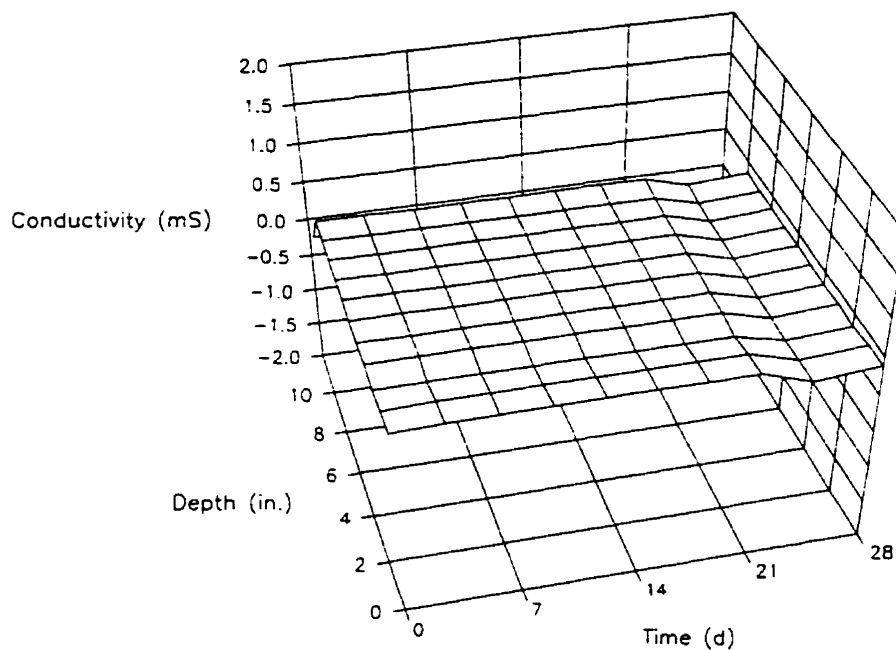


Figure 5.40 Changes in conductivity over time and depth in a bed composed of 1/2" granite with no SRB: Cycle 8. $V_c = 6L$.

These trends were:

i. Abrupt changes in conductivity throughout the gravel bed usually occurred at the beginning when the fresh AMD was first introduced into the system. The conductivity usually decreased rapidly within the first day. The conductivity started to increase after a lag period that varied from cycle to cycle.

ii. Following this initial activity, there were two broad patterns of distribution of conductivity in the gravel bed. In the first case, peaks of activity were observed in the 0-4" and the 9-11" layers. These peaks were separated by a region where the conductivity was lower. Cycles 1, 2, 3, 4 and 7 fall into this category. Cycle 3 is a good example. In the second case, activity became concentrated over time in the lower regions of the bed while little activity is evident in the top 0-1". Several peaks or zones of activity were observed and the most consistent peak or zone was in the bottom 7-11". Cycle 5, 6, 8, and 9 fall into this category.

iii. These patterns broadly reflect the amount of volume cycled. In cycles 1 to 4, the volume cycled was 2L, while in cycles 5 to 7 and in cycles 8 to 9, the volumes cycl-

ed were 4L and 6L respectively. This would suggest that when the load of fresh AMD on the system was greater than 2L, SRB activity became localized in the lower regions of the gravel bed. The exception to this was cycle 7.

The conductivity measurements indicated that the bottom of the bed was a second major site of SRB activity in the gravel bed. Water samples taken from the bottom two to three inches always had a sulfurous odour and were black due to the presence of precipitates. This region acted as a reservoir of SRB. This may be due in part to the fact that this region was the best suited for SRB activity since it would have been both the most reduced and most anaerobic region in the reactor.

5.2.4.2 pH and ORP Measurements

The pH and ORP measurements for each column and for all the cycles are given in Appendix E. Graphical representations of this data are also included in Appendix E.

In columns inoculated with SRB, the general observation was that changes in pH and ORP were confined to the top three to four inches of the gravel bed while in the lower eight to nine inches the pH and ORP remained uniform, stable, and favourable for SRB activity. Little or no transition zones were observed between the two regions. While no pH or ORP gradients were seen in the lower part of the bed, changes in conductivity were observed. Differences in pH and ORP between the top and bottom of the gravel bed disappeared by the end of each cycle. The exception to this trend was when a cycle volume of 6L was used. In this case, the pH and ORP were affected to a depth of 10 to 11 inches and differences were still evident at the end of the cycle (day 28).

In the control columns where SRB were not inoculated, gradients in ORP and pH between the top and the bottom of the bed were observed. However, no gradients or changes in conductivity were seen. This suggested that bacterial activity disrupted the formation of pH and ORP gradients in the bed and that the differences in pH, ORP and conductivity profiles in the gravel bed between the SRB and the control columns were due to SRB activity. The use of conductivity to gauge bacterial activity in the beds has, therefore, been demonstrated to an important tool, especially when pH and ORP measurements are not possible or when no gradients in pH and ORP are detected.

6. STRATEGY FOR IMPLEMENTATION

This chapter discusses potential strategies for implementation of the results of this study in the design of biological systems for the treatment of AMD. The original scenario for the on-site use of SRB in the treatment of AMD will be reviewed and an alternative approach will be proposed.

6.1 Treatment of AMD Directly in the Open Mine Pit

The specific circumstance considered at the beginning of the study was one where an open mine operation had been decommissioned and the open mine pit was being used as a holding pit to accumulate the AMD being generated. The original objective of this study was to use SRB within the holding pit itself to treat both the AMD already in it and any fresh AMD entering the pit. This was to be accomplished prior to the pit being filled, after which it was anticipated that a flow of water out of the pit to a neighbouring stream and lake would occur. The preliminary work presented in Chapter 3 was directed at the elucidation of such a system. The results demonstrated that the treatment of a continuous flow of AMD was possible under certain conditions, however, it was incapable of adapting to abrupt changes in water quality. The volume and strength of AMD being produced can fluctuate greatly over short periods of time since it is dependent in large part on the amount of precipitation, and a robust treatment system must be able to accommodate changes in the quantity and quality of AMD.

Another problem was the lack of control over the process. Possible methods of regulating the exposure of the SRB to the AMD were not immediately apparent. This would make it difficult, if not impossible, to intervene and salvage the system should a critical event arise. Consequently such an approach was not entirely satisfactory.

6.2 Treatment of AMD Using a "Reactor" Pit

Another strategy would be to use a separate and smaller pit in which the actual treatment process will take place (Figure 6.1). A population of SRB can be established in a gravel bed in this "reactor" pit without having to deal immediately with a large volume of AMD over a large area. Consequently, the establishment and acclimatization of the SRB can be accomplished easier in the absence of these factors.

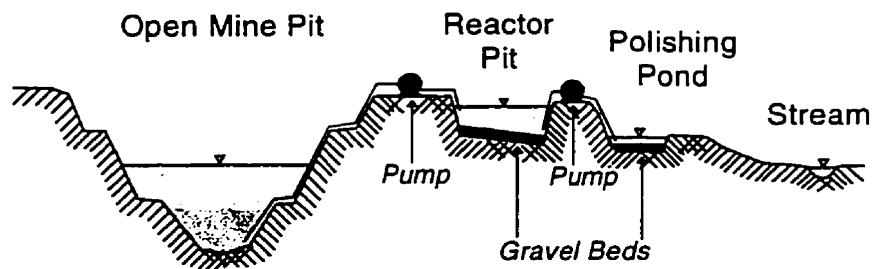


Figure 6.1 Schematic of possible treatment system using a second or reactor pit in which treatment by SRB takes place. SRB would be found in the gravel bed at the bottom of the reactor pit and the polishing pond. Not drawn to scale.

The open mine pit would serve as an equalization tank for the "reactor" pit. The amount of AMD pumped into the "reactor" pit can, therefore, be regulated. This approach gives some control over the treatment process and is, therefore, an improvement over the direct implementation of the SRB in the holding pit.

The size of the pit and the gravel bed and the operation of the system will be discussed with respect to the data and experience obtained in the work discussed in Chapter 5. A sizing of the gravel bed can be done using the dimensionless numbers proposed in this thesis.

6.2.1 Sizing of the Treatment System

The dimensionless numbers were constructed to describe the relationship between various physical parameters of the gravel bed and sulfate removed by SRB activity, in a form that

would be useful for the sizing of a full scale treatment system. The constraints were that the dynamics and the operating conditions of the final system should be the same. The parameters used were the void volume, cycle volume, total surface area of gravel in the bed and the superficial surface area.

If the dimensionless numbers proposed in this thesis are used to size the gravel bed then a bed with parameters that yield a value for D in the range of 0.0075 to 0.015 and a value for F of about 0.005 is desired with a treatment period of 7 days. The proportion of sulfate removed and the rate of sulfate removal were highest for these values of D and F respectively. The inclusion of the cycle volume in the dimensionless numbers takes into account the volume of fresh AMD introduced into the system and this, along with any time constraints, will help to determine the final capacity of the pit.

6.2.2 Operation of the "Reactor" Pit

The reactor pit can be operated as either a continuous flow reactor or a sequential batch reactor (SBR). Since these dimensionless numbers were obtained for a system operating in a batch mode, the operation of the reactor pit will be considered only from this point of view. In a SBR, at the end of the batch reaction, a portion of the water column is removed and replaced with fresh influent and the batch process occurs again. This procedure can be repeated for as long as necessary. This type of reactor has been successfully used to treat wastewaters from the agricultural and food processing industries (Lo *et al.*, 1988; Hadjinicolaou, 1989; Fernandes and McKyes, 1991).

There are five stages, or periods, in each cycle of the operation of an SBR. These are "Fill", "React", "Settle", "Draw" and "Idle". Fresh wastewater is introduced into the reactor in the Fill period. In the React and Settle period, the treatment process occurs until completion and separation of biomass and water takes place. The treated water is removed from the reactor in the Draw period and the sludge and biomass is left behind. The Idle period is the time between the Draw and the next Fill period and may not exist, depending on the operation (Irvine, 1979).

Mixing occurs in the fill period as the fresh wastewater effluent is introduced into

the reactor. This facilitates the exchange between the active site and fresh AMD and nutrients. Mixing also causes aeration which could be detrimental to SRB activity since SRB are anaerobes. However, as was observed in the work presented in this thesis, the SRB are able to survive short exposure to aerobic conditions.

The volume of the water column removed and replaced in the Draw and Fill stages would be 50 to 67% of the water column present in the reactor pit. The filling of the pit would be accomplished by a pump to move the AMD out of the mine pit and into the reactor pit (Figure 6.1). The removal of water from the reactor would probably also be done by a pump though it is possible that this could also be achieved by gravity.

The React period would be 7 days since the dimensionless numbers were obtained from data obtained over the first 7 days of the process. The React period can be readily extended or shortened in the SBR mode of operation. This can be controlled by on-line monitoring water conditions over the course of the React stage. The pH and ORP are parameters indicating water condition that can be easily measured and monitored. The use of electrical conductivity may be a more sensitive on-line monitoring method, but this remains to be investigated and developed further. The best monitoring of water quality would be a method for rapid on-line measurement of metal and sulfate concentrations. The length of the React period may depend ultimately on the desired level of sulfate concentration in the treated water. Although most of the metals have been precipitated and the acidity lowered, the sulfate is still relatively elevated at the end of 7 days.

The Idle period could either be eliminated entirely or be used to remove precipitates if the accumulation of particulates should interfere with the functioning of the system.

A number of pits in parallel could be used if the volume of water involved is great or if the window of time in which treatment must be accomplished for a given site is restricted. The efflux stream from the pits could be discharged through a polishing pond containing SRB to scavenge and remove any metals left in the water (Figure 6.1). In any case, it would be useful to have at least two pits operating at the same time so that if one should fail the other would still be available.

6.3 Concluding Remarks

The use of a second smaller pit would permit for some control over the treatment process that would not be possible if the SRB process were to be implemented directly in the holding pit. The operation of the pit as a sequential batch reactor (SBR) rather than as a continuous flow reactor was proposed. The SBR mode of operation has several advantages which are: (i) no requirement for low flow rates allowing for sufficient contact time between the AMD and the SRB which now occurs under stagnant conditions in the React period; (ii) little or no wash out of biomass from the system; (iii) the system possesses some adaptability with respect to contact time should there be any abrupt changes in the quality of the AMD. The flexibility of the system lies in the capacity to adjust the length of the React period to ensure that there is sufficient contact time. This is accomplished by either delaying or expediting the drawing of water from the pit and filling it with fresh AMD.

7. CONCLUSIONS

This study investigated the relationships between the physical parameters of the gravel bed and SRB activity in a sequential batch mode of operation. Several conclusions were reached.

The initial phase was the inoculation of the gravel bed with a population of SRB. The results showed that the bacteria were able to establish and maintain themselves in the presence of AMD when the diameter of the particles did not exceed 1/2" and if the particles were not smooth. SRB were not established in the beds composed of 3/4" granite gravel or of 1/2" glass balls. This suggested that a void volume to total surface area relationship and the nature of the gravel were key parameters affecting the ability of SRB to establish themselves successfully in the beds.

The establishment of SRB occurred earlier in the limestone beds than in the granite beds. However, no significant difference was observed with respect to the performance of the different gravel beds in the treatment of AMD. This could be explained in the following manner. During the establishment phase, the contribution of alkalinity to the system by the gravel itself may be important, however, once the SRB are established, SRB activity is the major source of alkalinity in the system and is no longer dependent on any contributions by the gravel itself. Also, the coating of the gravel by the bacteria may physically interfere with and limit any further role of the gravel as a source of alkalinity to the system.

The investigation demonstrated clear relationships between gravel bed parameters and SRB activity. Furthermore, the effects of varying loads of fresh AMD on the system could best be described using dimensionless numbers. These numbers are loading-to-sediment ratios (L/S). Two such numbers, D and F were constructed and proposed. D was useful for describing the relationships between gravel bed parameters, AMD (sulfate) loading and bacterial activity with respect to the proportion of sulfate removal while F

was useful with respect to the rate of sulfate removal. The difference appears to be related to the volume cycled to void volume ratio, (V_c/V_v), wherein, the proportion of sulfate removed was related to the V_v , while the rate of sulfate removal was related to V_c , the amount of sulfate introduced into the system. The relationships were that the amount of sulfate removed increased as V_v increased, and the rate of sulfate removal increased as V_c increased. The rate of sulfate reduction was, therefore, dependent on the amount of sulfate present while the amount of sulfate removed was dependent on the number of bacteria present. Consequently, with respect to the proportion of sulfate removed, the initial amount of sulfate was important while in the case of rate of sulfate removal, the total surface area of the gravel bed and access to this surface was the major consideration. Thus, for a given combination of physical parameters of the gravel bed and operating conditions, the rate of sulfate removal can be high while the amount of sulfate removed can be low, and conversely, the amount of sulfate removed can be high while the rate of removal can be low. The results indicated that a gravel bed with a D value of about 1×10^{-2} to 1.5×10^{-2} provided the optimal conditions for sulfate removal over 7 days. The bed with an F value of 0.5×10^{-2} and lower would be desirable as the rates of sulfate removal were highest for this range of F values.

The operation of the columns as sequential batch reactors eliminated the need for slow flow rates while allowing for sufficiently long retention times. Also, the use of a batchwise mode instead of a continuous mode simplified the interpretation of the data with respect to a steady state, and allowed for the comparison of the results obtained from various cycles. The results of the study indicated that a draw volume that was two-thirds (67%) of the water column volume yielded good results with respect to sulfate removal with a hydraulic retention time of 7 days. The level of sulfate removal and elevation of pH attained in these 7 days were sufficient to remove greater than 90% of the metals.

The removal of the treated water can be done rapidly as possible since it is unlikely to have an effect on the performance of the system. The introduction of the fresh AMD can be done rapidly since no adverse effects were observed as a result of such an action. The rapid addition of AMD would also provide some mixing. The Draw and

Fill periods can, therefore, be relatively short as compared to the React period.

The use of electrical conductivity measurements to monitor bacterial activity in the gravel bed was shown to be possible and warrants further research. A correlation between the changes in conductivity and the SRB activity was tentatively established. This was accomplished by the use of control columns where no SRB were introduced into the system. Little or no changes in conductivity measurements were observed in the control columns. However, further examination is required for the proper interpretation of the traces obtained in this study. This work is worth pursuing since it will allow for a rapid on-line method for monitoring bacterial activity in a gravel bed without disturbing the sediment for taking samples.

Overall, the study demonstrated that relationships do exist between various physical aspects of a gravel bed and the biological activity of SRB in the system and that they can be quantified and described using dimensionless numbers. The use of the dimensionless numbers to size gravel beds and pits in the field for the treatment of AMD by SRB has to be further investigated as the values for the dimensionless numbers may vary under different operating and bed conditions. However, the basic relationships contained in the dimensionless numbers should remain applicable.

8. RECOMMENDATIONS

The column reactors was operated with the knowledge that certain limitations existed in the system. Such limitations should be investigated in future studies since they may have important consequences on the dimensionless numbers. The limitations were:

- i. The assumption that nutritional requirements are satisfied.
- ii. The systems were operated only at room temperature.
- iii. The superficial surface area was a constant.
- iv. The assumption that the void volume does not change over the course of the experiment.

The results obtained in the study with the column reactors were obtained under conditions where they were not nutrient limited. The nutritional requirements of the SRB were met by using ammonium chloride as a nitrogen source, and sodium lactate, an easily accessible carbon source. It is unlikely that such abundant concentrations of lactate would be found in AMD which is nutrient poor. However, the examination of nutrient limitation was considered to be outside the immediate scope of this study. Likewise, the operation of the reactors was only at room temperature whereas on site a wide range of temperatures will be experienced. This needs to be addressed in future studies.

The dimensionless number should be tested by varying the superficial surface area while maintaining a constant total surface area. This should provide more information on the limitations of the dimensionless number and more information for the proper sizing of the gravel bed. Similarly, different geometries of the gravel bed should be examined to see if this will have any affect on the relationships between the dimensionless numbers and sulfate removal.

The effect of precipitate on the system has not been considered. This may have the effect of diminishing the void volume but it may also increase the total surface area on which the SRB can establish themselves. The question of what to do with the precipitate also needs to be addressed. Presently it would seem to be best to leave it undisturbed.

The start-up period should be studied in more detail since any information obtained on this particular phase of the process would be of use in optimizing and facilitating the establishment of the SRB on site.

The use of supports other than limestone which may contribute towards the alkalinity of the system should be examined and compared with the results obtained in this study. This should also confirm the hypothesis that coating of the limestone results in the negation of any possible advantage offered by the limestone during the course of the run.

9. ORIGINALITY AND CONTRIBUTIONS TO KNOWLEDGE

The original aspects of this thesis and contributions to knowledge are:

- 1. The design of a reactor system in which environmental conditions in the gravel bed and water column could be easily monitored *in situ*.** This was achieved by using a central perforated PVC pipe down which pH and ORP electrodes could be lowered to any depth and from which water samples could be withdrawn at any level in the reactor. The consequences of this design were that: (i) there was no need to withdraw a large number of water samples from the reactor, (ii) disturbances to the system were minimized, and (iii) only the minimum number of electrodes were required.
- 2. The construction of dimensionless numbers to describe relationships between various physical parameters of the gravel bed reactor system.** The dimensionless numbers basically described the loading of sulfate (AMD) on a gravel bed with a specific configuration and can, therefore, be considered to be L/S (Loading/Sediment) ratios. The relationship between the dimensionless numbers and the amount and rate of sulfate removal provides information about the sizing and implementation of gravel beds for the treatment of AMD by SRB.
- 3. An investigation into the use of electrical conductivity to monitor SRB activity in a gravel bed.** The SRB are anaerobic bacteria that tend to aggregate on surfaces which make them difficult to culture and enumerate. The measurement of electric conductivity may, therefore, provide a simple and rapid method of monitoring SRB activity in gravel beds. Previous attempts had been to use the measurement of impedance as a means of monitoring SRB activity in soil samples.

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APPENDIX

APPENDIX A

Sulfate Analysis - Turbidometric Method

The turbidometric method is that described in *Standard Methods for the Examination of Wastewater*, 17th edition.

I. Reagents

1. Buffer Solution

<u>Ingredients</u>	<u>Quantity</u>
MgCl ₂ · 6H ₂ O	30 g
CH ₃ COONa · 3H ₂ O	5 g
KNO ₃	1 g
Acetic Acid (99%)	20 mL

Mix in 500 mL distilled H₂O and make up to 1000 mL.

2. Barium chloride crystals, 20-30 mesh

3. Standard sulfate solutions (1.00 mL = 100 µg SO₄²⁻)

1) 10.4 mL 0.0200 N H₂SO₄ in 100 mL distilled H₂O

2) 0.1479 g Na₂SO₄ in 1000 mL distilled H₂O

The working range of the sulfate analysis: 1-40 mg sulfate/L.

II. Procedure

1. Put 100 mL of sample with an appropriate concentration in a 250 mL Erlenmeyer flask.
2. Add 20 mL of the buffer solution.
3. Mix and add a spoonful (0.2-0.3 mL) BaCl₂ and begin timing 60 s immediately while stirring at a constant speed.
4. Pour solution into a cuvette and measure the turbidity at 420 nm after 5 ± 0.5 min.

A standard curve was first constructed using samples with known concentrations of sulfate.

This method was adapted for smaller volumes of samples and buffer solutions. All volumes were divided by 10. Standard curves were made using both the standard volumes as described above in the Procedure and with the smaller volumes. No difference was observed between the two curves.

The slope of the standard curve was 0.011 and the y-intercept was -0.055. The equation of the line was therefore: $y = 0.011x - 0.055$, where x is the concentration of sulfate and y is the absorbance at 420 nm. This equation was used to calculate the concentration of sulfate from the absorbance.

APPENDIX B

The Protocol for the Preparation of Synthetic AMD

The desired quantity of distilled water was acidified using hydrochloric acid to a final pH of 3. The following metal salts were added to the water to obtain concentrations of metals similar to that found in the second batch of Mattabi water.

Chemical	Desired Conc. of Metal (mg/L)	Amount required to make 1 L (mg)	Amount Sulfate added/ 1 L (mg)
Al ₂ (SO ₄) ₃ .16H ₂ O	131.1	1530	699.2
CaSO ₄ .2H ₂ O	590.2	2540	1416.48
CuSO ₄ .5H ₂ O	45.2	178	68.33
FeSO ₄ .5H ₂ O	208.6	1036	357.6
MgSO ₄	203.1	1019	812.4
MnSO ₄ .H ₂ O	36.7	113	64.06
ZnSO ₄ .7H ₂ O	348.6	1542	514.86
		Total sulfate added	3934.17

The pH of the water after addition of the metals was measured and recorded. Sodium lactate (4 g/L) and ammonium chloride (0.5 g/L) were added and the pH was measured and recorded.

APPENDIX C
ELEMENTAL ANALYSIS DATA

CYCLE 1

All samples are from 0", surface of gravel bed.

Column 1: 1/4" granite, with SRB

Day	Metal Concentrations (mg/L)					
	Al	Fe	Mn	Zn	S	SO4
1	33	110	19	6	685	2055
28	1	1	12	0	466	1397

Column 2: 1/4" granite, no SRB

Day	Metal Concentrations (mg/L)					
	Al	Fe	Mn	Zn	S	SO4
1	21	103	26	164	810	2430
28	9	66	26	135	813	2440

Column 3: 1/4" limestone, with SRB

Day	Metal Concentrations (mg/L)					
	Al	Fe	Mn	Zn	S	SO4
1	4	74	10	33	456	1368
28	0	1	0	0	187	560

CYCLE 1

All samples are from 0", surface of gravel bed.

Column 4: 1/2" granite, with SRB

Day	Depth (")	Metal Concentrations (mg/L)					
		Al	Fe	Mn	Zn	S	SO4
1	0	8	96	21	15	783	2348
	3	9	105	22	14	795	2384
	6	15	129	23	25	830	2489
	9	24	151	23	44	867	2601
	12	34	171	29	49	888	2663
28	0	1	1	0	1	477	1431
	3	0	1	0	0	494	1481
	6	0	0	0	0	528	1584
	9	0	0	19	0	594	1781
	12	3	9	18	16	586	1759

Column 5: 1/2" granite, no SRB

Day	Depth (")	Metal Concentrations (mg/L)					
		Al	Fe	Mn	Zn	S	SO4
1	0	61	144	28	240	953	2858
	3	64	152	28	244	972	2916
	6	65	158	29	247	994	2982
	9	68	163	29	251	1010	3030
	12	69	166	29	253	1020	3060
28	0	47	53	27	227	951	2853
	3	49	56	27	231	976	2927
	6	63	130	28	238	979	2938
	9	67	145	28	242	991	2974
	12	67	144	28	241	989	2966

Column 6: 1/2" limestone, with SRB

Day	Metal Concentrations (mg/L)					
	Al	Fe	Mn	Zn	S	SO4
1	12	6	13	2	583	1748
28	1	0	5	0	456	1368

CYCLE 2

All samples are from 0", surface of gravel bed.

Column 1: 1/4" granite, with SRB

Day	Metal Concentrations (mg/L)					
	Al	Ca	Fe	Mn	Zn	SO4
0	14.6	400.9	116.7	17.5	3.2	2074.0
7	4.9	346.1	19.6	6.4	1.6	1811.2
14	1.0	244.3	2.5	2.5	0.0	1574.0
28	0.3	108.9	0.1	0.0	0.0	1138.5

Column 2: 1/4" granite, no SRB

Day	Metal Concentrations (mg/L)					
	Al	Ca	Fe	Mn	Zn	SO4
0	23.4	614.0	154.1	31.3	187.3	2824.3
7	14.2	658.7	116.6	31.5	183.2	2896.1
14	9.6	602.6	90.4	28.2	156.9	2545.6
28	11.3	675.0	72.6	31.2	176.3	2849.8

Column 3: 1/4" limestone, with SRB

Day	Metal Concentrations (mg/L)					
	Al	Ca	Fe	Mn	Zn	SO4
0	4.3	193.8	102.6	9.5	6.6	1389.6
7	0.5	77.1	16.6	0.4	2.1	1136.6
14	0.3	99.7	0.1	1.0	0.0	865.1
28	0.3	9.4	0.0	0.0	0.0	475.9

CYCLE 2

All samples are from 0", surface of gravel bed.

Column 4: 1/2" granite, with SRB

Day	Metal Concentrations (mg/L)					
	Al	Ca	Fe	Mn	Zn	SO4
0	0.5	56.0	0.1	0.1	0.2	1443.3
2	3.4	315.9	60.9	14.1	2.8	2152.1
14	0.3	137.6	0.0	0.2	0.0	1672.2
28	0.3	54.7	0.0	0.0	0.0	1446.9

Column 5: 1/2" granite, no SRB

Day	Metal Concentrations (mg/L)					
	Al	Ca	Fe	Mn	Zn	SO4
0	61.6	444.2	68.3	32.5	288.6	3475.3
2	64.8	462.3	191.1	35.1	295.2	3450.7
14	67.9	473.9	179.4	36.4	307.5	3634.2
28	65.8	480.0	161.7	36.2	308.0	3630.8

Column 6: 1/2" limestone, with SRB

Day	Metal Concentrations (mg/L)					
	Al	Ca	Fe	Mn	Zn	SO4
0	0.4	107.7	0.0	0.5	0.3	1156.1
2	8.0	317.0	99.7	14.2	15.6	1873.6
14	0.3	213.7	0.1	0.2	0.0	1559.9
28	0.3	171.9	0.0	0.3	0.0	1425.9

CYCLE 4

All samples are from 0", the surface of the gravel bed.

Column 1: 1/4" granite, with SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	Zn	SO ₄
0	5.67	246.93	0.25	13.52	11.87	1.81	1477.32
7	1.33	142.13	0.03	0.54	1.42	0.03	1121.19
14	1.46	90.07	0.13	1.32	0.74	0.30	1015.77
28	1.25	145.55	0.12	1.45	2.08	0.55	917.16

Column 2: 1/4" granite, no SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	Zn	SO ₄
0	55.77	417.74	10.19	237.32	26.18	250.50	2626.44
7	49.78	431.87	7.10	226.76	25.70	242.87	2566.83
14	50.62	417.86	8.74	227.20	25.77	244.08	2560.89
28	46.66	437.12	8.46	208.92	26.01	242.09	2544.84

Column 3: 1/4" limestone, with SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	Zn	SO ₄
0	2.75	179.82	0.18	49.13	9.76	7.60	1214.67
7	1.05	157.87	0.03	1.33	6.10	0.03	954.36
14	1.50	116.73	0.03	0.96	1.56	0.03	782.32
	1.01	74.87	0.03	0.49	0.38	0.03	615.09

Column 7: 1/4" limestone, no SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	Zn	SO ₄
0	3.37	239.93	0.26	66.41	12.34	38.01	1945.86
7	0.84	204.24	0.05	4.70	3.23	1.48	1582.26
14	1.07	263.47	0.05	4.73	7.25	2.55	1510.47
28	0.93	209.39	0.03	3.52	2.71	2.14	1259.55

CYCLE 4

All samples are from 0", the surface of the gravel bed.

Column 4: 1/4" granite, with SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	Zn	SO ₄
0	3.66	298.46	0.14	3.78	9.33	0.98	1478.76
7	0.91	209.61	0.03	0.68	1.76	0.03	1293.48
14	0.80	186.77	0.03	0.73	1.27	0.03	1155.69
28	0.44	251.47	0.03	0.44	3.38	0.03	1188.24

Column 5: 1/4" granite, no SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	Zn	SO ₄
0	75.40	478.39	13.20	159.58	35.35	320.19	3510.00
7	71.76	482.83	10.99	148.75	35.19	325.78	3480.00
14	72.06	483.75	11.78	145.51	35.36	324.28	3510.00
28	70.41	486.18	11.83	136.41	35.41	324.18	3510.00

Column 6: 1/4" limestone, with SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	Zn	SO ₄
0	45.42	485.50	8.23	158.17	23.05	210.35	2512.50
7	41.69	499.22	8.24	148.04	23.16	208.94	2501.49
14	38.03	516.65	9.16	133.68	22.86	207.74	2481.36
28	28.18	564.66	7.65	91.89	23.02	201.57	2494.62

CYCLE 5

All samples are from 0", the surface of the gravel bed.

Column 1: 1/4" granite, with SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	Zn	SO ₄
0	51.43	394.35	0.66	137.98	22.91	125.97	2498.37
7	13.2	360.52	0.19	59.86	17.41	6.13	2018.64
28	2.91	295.48	0.47	3.98	7.6	4.62	1662

Column 2: 1/4" granite, no SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	Zn	SO ₄
0	73.25	588.6	15.67	201.24	32.93	338.48	3330
7	59.94	638.44	9.34	191.76	32.78	331.49	3360
28	33.86	674.92	6.02	120.9	30.56	301.72	3150

Column 3: 1/4" limestone, with SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	Zn	SO ₄
0	17.19	319.92	0.36	108.76	18.31	88.72	2120.16
7	6.06	303.45	0.31	62.71	13.6	12.81	1851.39
28	2.39	249.91	0.38	5.34	6.94	5.52	1354.59

Column 7: 1/4" limestone, no SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	Zn	SO ₄
0	27.78	760.34	0.61	104.21	28.38	240.98	3120
7	27.17	750.8	3.98	97.57	27.63	218.29	3120
28	5.87	733.62	1.37	43.83	25.12	161.48	2850.96

CYCLE 5

All samples are from 0", the surface of the gravel bed.

Column 4: 1/2" granite, with SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	Zn	SO ₄
0	56.44	394.58	8.18	129.44	21.01	187.98	2595.3
7	11.9	425.58	0.22	37.23	18.35	14.23	2380.59
28	3.72	464.91	0.08	5.15	12.64	1.49	1961.64

Column 5: 1/2" granite, no SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	Zn	SO ₄
0	94.4	545.08	21.61	175.93	38.32	373.69	3840
7	94.42	546.59	21.19	172.07	37.28	385.13	3900
28	99.2	537.28	21.25	171.92	37.86	380.9	3840

Column 6: 1/2" limestone, with SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	Zn	SO ₄
0	58.77	427.78	4.19	129.22	21.39	156.4	2654.97
7	21.91	437.27	0.23	69.84	19.99	6.36	2362.38
28	2.78	399.1	0.28	7	12.79	9.86	1942.62

CYCLE 6

Column 1: 1/4" granite, with SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	Zn	SO ₄
0	95.59	515.31	13.43	181.01	29.68	257.36	3210
7	36.18	472.06	1.1	98.6	23.89	63.38	2522.73
28	12.16	487.13	0.09	13.1	20.64	2.81	2299.65

Column 2: 1/4" granite, no SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	Zn	SO ₄
0	63.5	706.26	10.22	142.83	36.34	354.16	3450
7	50.62	695.61	7.31	132.63	33.97	344.89	3390
28	19.76	795.76	6.73	65.73	35.45	314.3	3300

Column 3: 1/4" limestone, with SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	Zn	SO ₄
0	78.49	442.36	8.13	156.73	25.15	206.3	2877.43
7	31.58	422.71	0.79	99.45	19.51	51.34	2431.56
28	8.18	339.31	0.25	7.05	13.45	5.3	2000.94

Column 7: 1/4" limestone, no SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	Zn	SO ₄
0	42.15	720.3	6.37	113.22	30.21	220.62	3150
7	31.63	779.64	4.33	125.16	33.39	263.37	3330
28	11.87	729.28	2.65	67.62	29.99	214.09	2903.64

CYCLE 6

All samples are from 0", the surface of the gravel bed.

Column 4: 1/2" granite, with SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	Zn	SO ₄
0	86.28	520.56	5.88	167.73	29.94	242.78	3330
7	29.07	522.28	0.11	73.61	26.32	13.29	2761.26
28	2.23	491.89	0.78	3.19	19.96	4.62	2081.7

Column 5: 1/2" granite, no SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	Zn	SO ₄
0	116.4	553.48	25.52	199.99	38.41	401.92	3870
7	120.66	569.97	32.75	206.31	38.83	414.93	4020
28	111.8	532.3	28.54	189.01	36.25	388.31	3750

Column 6: 1/2" limestone, with SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	Zn	SO ₄
0	76.23	536.69	3.2	148.9	27.81	214.19	3090
7	44.05	584.55	0.33	115.8	27.8	96.37	2913.81
28	14.05	656.67	0.18	44.94	27.43	19.77	2619.33

CYCLE 7

All samples are from 0", the surface of the gravel bed.

Column 1: 1/4" granite, with SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	SO ₄	Zn
0	87.46	526.41	12.04	171.80	28.21	1.07 g/L	253.99
7	52.09	545.63	0.40	100.87	28.42	920.73	112.45
28	27.97	556.26	0.15	48.19	27.41	839.24	43.69

Column 2: 1/4" granite, no SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	SO ₄	Zn
0	46.67	699.05	7.19	89.87	36.26	1.11 g/L	354.24
7	42.37	697.97	8.27	105.58	35.79	1.10 g/L	355.45
28	21.47	731.61	7.41	57.07	35.49	1.04 g/L	321.78

Column 3: 1/4" limestone, with SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	SO ₄	Zn
0	98.40	551.08	18.60	180.28	31.78	1.13 g/L	284.87
7	38.15	496.34	0.56	81.19	20.22	834.06	74.58
28	19.36	536.04	0.34	27.12	17.62	794.54	12.28

Column 7: 1/4" limestone, no SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	SO ₄	Zn
0	38.61	682.31	5.33	107.92	30.58	1.01 g/L	236.97
7	10.29	742.47	1.15	81.53	32.98	974.26	251.29
28	22.52	723.82	4.89	71.78	32.35	1.01 g/L	262.03

CYCLE 7

All samples are from 0", the surface of the gravel bed.

Column 4: 1/2" granite, with SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	SO ₄	Zn
0	77.25	535.86	1.19	150.27	27.81	1.04 g/L	141.40
7	39.36	556.15	1.96	72.79	25.95	925.72	31.31
28	18.96	739.44	0.35	74.56	32.66	960.99	31.61

Column 5: 1/2" granite, no SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	SO ₄	Zn
0	114.97	557.42	26.83	199.47	36.79	1.27 g/L	394.22
7	116.27	547.78	39.39	197.85	35.98	1.25 g/L	394.15
28	115.06	557.24	32.25	196.62	36.52	1.25 g/L	393.06

Column 6: 1/2" limestone, with SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	SO ₄	Zn
0	74.62	621.86	6.79	144.25	30.13	1.09 g/L	224.69
7	44.49	668.99	1.62	119.21	31.05	1.01 g/L	113.29
28	6.99	572.33	0.40	7.18	24.36	793.14	6.52

CYCLE 8

All samples are from 0", the surface of the gravel bed.

Column 1: 1/4" granite, with SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	SO ₄	Zn
0	8.10	579.06	1.64	43.41	21.63	814.93	34.68
7	2.55	585.24	0.35	8.96	19.82	770.88	5.32
28	1.64	555.28	0.39	2.77	13.23	675.98	7.09

Column 2: 1/4" granite, no SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	SO ₄	Zn
0	4.58	752.64	1.49	9.35	35.52	970.66	235.21
7	2.54	780.03	2.53	4.32	36.19	990.00	226.30
28	0.72	794.51	1.38	1.16	35.98	964.98	147.00

Column 3: 1/4" limestone, with SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	SO ₄	Zn
0	5.11	457.53	0.68	8.17	10.91	708.90	7.78
7	2.56	491.37	0.25	2.69	9.95	685.59	2.27
28	0.98	369.80	0.17	0.84	3.26	604.38	2.53

Column 7: 1/4" limestone, no SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	SO ₄	Zn
0	17.13	711.40	8.20	32.56	31.95	988.44	221.24
7	6.34	756.77	2.62	20.62	31.38	959.00	181.65
28	2.31	771.94	1.12	11.56	31.18	954.24	152.87

CYCLE 8

All samples are from 0", the surface of the gravel bed.

Column 4: 1/2" granite, with SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	Zn	SO ₄
0	92.24	535.22	5.98	177.76	32.64	1.09 g/L	201.81
7	53.20	599.32	0.44	147.96	34.92	1.00 g/L	73.24
28	5.46	636.47	0.31	7.10	31.96	874.82	3.53

Column 5: 1/2" granite, no SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	Zn	SO ₄
0	120.61	532.62	32.38	195.69	37.42	1.21 g/L	351.16
7	128.82	538.31	37.89	205.65	36.82	1.23 g/L	360.89
28	129.64	551.46	41.90	202.76	37.17	1.25 g/L	360.44

Column 6: 1/2" limestone, with SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	Zn	SO ₄
0	96.85	600.74	4.82	184.51	34.74	1.10 g/L	214.21
7	48.49	689.39	0.87	207.11	39.83	1.05 g/L	61.41
28	12.76	742.01	0.14	117.64	40.57	961.78	2.02

CYCLE 9

All samples are from 0", the surface of the gravel bed.

Column 1: 1/4" granite, with SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	SO ₄	Zn
0	8.33	530.74	1.38	44.58	18.35	785.37	32.03
7	1.67	550.02	0.29	5.40	14.98	718.32	8.14

Column 2: 1/4" granite, no SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	SO ₄	Zn
0	4.60	769.99	2.15	8.40	35.75	970.83	151.57
7	1.47	786.11	1.39	3.51	35.71	949.33	147.14

Column 3: 1/4" limestone, with SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	SO ₄	Zn
0	9.00	415.87	0.90	36.37	12.00	717.48	13.14
7	1.10	384.71	0.58	0.66	7.16	613.58	1.55

Column 7: 1/4" limestone, no SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	SO ₄	Zn
0	10.08	716.49	5.09	19.50	31.11	958.32	177.94
7	5.74	724.46	4.16	11.33	30.88	941.82	174.11

Column 4: 1/2" granite, with SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	SO ₄	Zn
0	102.30	591.81	4.79	179.28	35.13	1.14 g/L	261.26
7	59.93	638.71	0.48	142.41	40.31	1.05 g/L	111.18

Column 5: 1/2" granite, no SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	SO ₄	Zn
0	127.36	571.98	35.49	203.30	37.96	1.25 g/L	364.36
7	130.60	566.29	42.24	206.06	37.25	1.24 g/L	366.18

Column 6: 1/2" limestone, with SRB

Day	Metal Concentrations (mg/L)						
	Al	Ca	Cu	Fe	Mn	SO ₄	Zn
0	105.90	611.73	6.09	192.61	36.61	1.15 g/L	266.57
7	67.32	656.45	0.53	178.88	40.50	1.06 g/L	115.67

APPENDIX D

Intervals of Confidence (95%) for Sulfate Concentrations on Days 0 and 28.

	1/4" G Exp	1/4" G Ctl	1/4" L Exp	1/4" L Ctl	1/2" G Exp	1/2" G Ctl	1/2" L Exp
Day 0							
Average	2301.7	2971.1	1989.2	2832.7	2536.5	3583.7	2536.4
Std. Dev.	645.8	340.8	765.3	415.6	802.4	311.7	836.4
Std. Err.	215.3	113.6	255.1	157.1	267.5	103.9	278.8
Conf. Limit	496.4	262.0	588.2	384.3	616.8	239.6	642.9
% Conf.	21.6	8.8	29.6	13.6	24.3	6.7	25.3
Interval							
Avg.-Conf.	1805.4	2709.1	1401.0	2448.3	1919.7	3344.1	1893.5
Avg.+Conf.	2798.1	3233.1	2577.5	3217.0	3153.3	3823.4	3179.3
Day 28							
Average	1625.4	2862.4	1226.5	2589.7	1862.2	3559.3	2041.6
Std. Dev.	602.8	314.0	761.8	664.3	636.1	321.3	642.2
Std. Err.	213.1	111.0	269.3	271.2	224.9	113.6	227.1
Confidence	504.0	262.6	637.0	697.2	531.9	268.6	537.0
% Conf.	31.0	9.2	51.9	26.9	28.6	7.5	26.3
Interval:							
Avg.-Conf.	1121.4	2599.8	589.5	1892.4	1330.3	3290.6	1504.6
Avg.+Conf.	2129.4	3124.9	1863.5	3286.9	2394.0	3827.9	2578.6

G: Granite; L: Limestone; Exp: Inoculated with SRB; Ctl: Control, no SRB; Std. Dev: Standard Deviation; Std. Err.: Standard Error; Avg.: Average; Conf.: Confidence.

APPENDIX E

pH AND OXIDATION REDUCTION POTENTIAL MEASUREMENTS

CYCLE 1

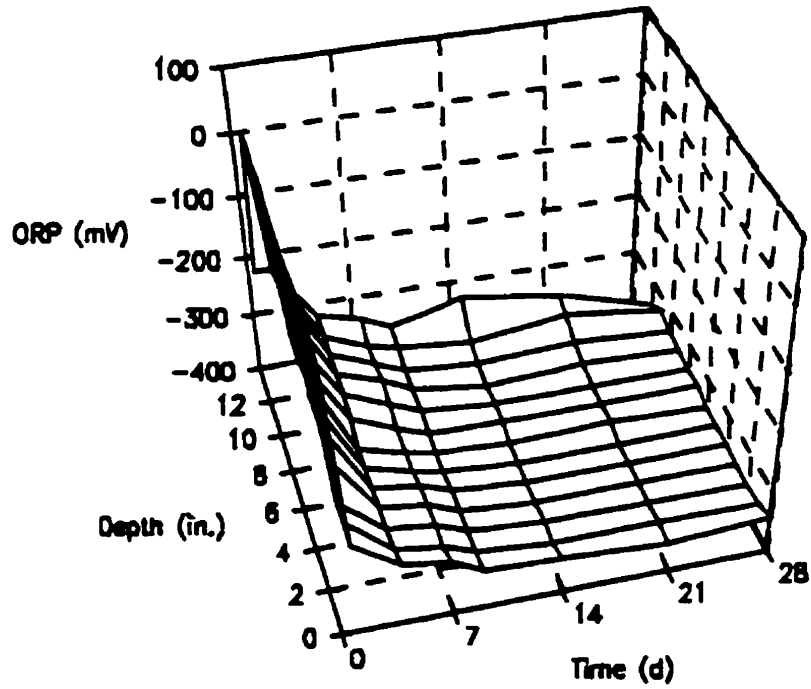
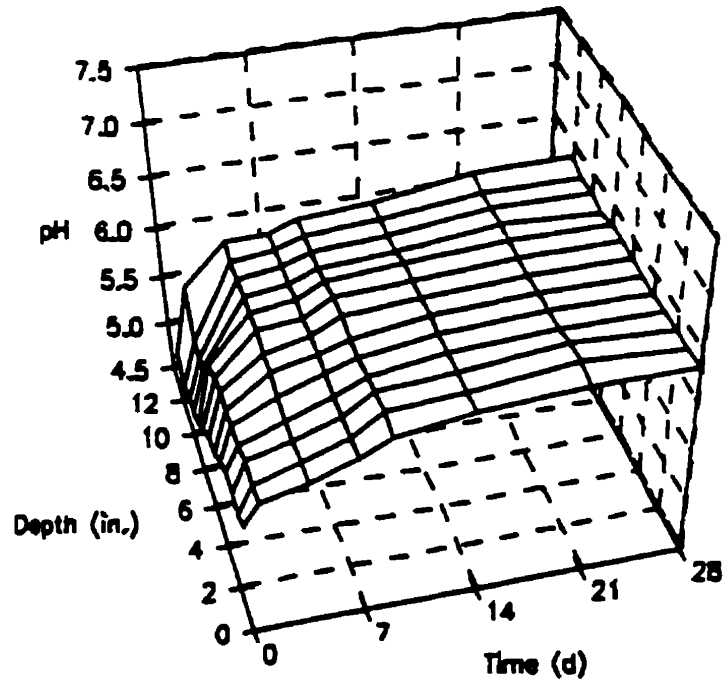
Column 1: 1/4" granite, with SRB

pH

Depth (")	Day -2	0	1	4	7	9	14	21	28
0	6.95	5.6	5.8	5.9	6.05	6.2	6.3	6.35	6.35
1	6.95	5.5	5.75	5.9	6.05	6.25	6.3	6.4	6.35
2	6.9	5.5	5.8	5.9	6.05	6.25	6.3	6.4	6.35
3	6.7	5.5	5.75	5.9	6.05	6.2	6.3	6.35	6.35
4	6.7	5.4	5.75	5.95	6.1	6.2	6.3	6.35	6.35
5	6.65	5.3	5.7	6	6.1	6.2	6.3	6.35	6.35
6	6.65	5.25	5.7	6	6.1	6.25	6.3	6.35	6.35
7	6.7	5.15	5.65	6.05	6.1	6.25	6.3	6.35	6.35
8	6.7	5	5.6	6.05	6.1	6.25	6.3	6.35	6.35
9	6.7	4.95	5.4	6.05	6.1	6.2	6.25	6.35	6.3
10	6.7	4.9	5.3	6.05	6.1	6.2	6.25	6.35	6.35
11	6.5	4.85	5.3	6.05	6.1	6.2	6.25	6.35	6.35
12	6.4	5	5.7	6.1	6.1	6.2	6.25	6.4	6.4

ORP (mV)

Depth (")	Day -2	0	1	4	7	9	14	21	28
0	-380	45	-250	-300	-310	-335	-340	-350	-340
1	-380	60	-250	-310	-320	-340	-350	-350	-350
2	-380	65	-250	-310	-320	-340	-350	-350	-350
3	-380	65	-210	-310	-320	-340	-350	-350	-350
4	-375	55	-190	-310	-320	-340	-350	-350	-345
5	-375	55	-180	-310	-330	-340	-350	-350	-345
6	-375	60	-175	-310	-330	-340	-345	-340	-345
7	-370	60	-175	-290	-320	-340	-340	-340	-340
8	-370	70	-170	-280	-310	-330	-340	-340	-340
9	-370	70	-150	-275	-300	-325	-340	-330	-335
10	-370	75	-140	-270	-300	-320	-330	-320	-330
11	-350	70	-145	-270	-300	-310	-320	-300	-320
12	-200	-170	-170	-260	-280	-300	-270	-295	-340



Changes in pH and ORP over time and depth.
 Column 1: 1/4" granite inoculated with SRB. Cycle 1: $V_c = 4L$.

CYCLE 1

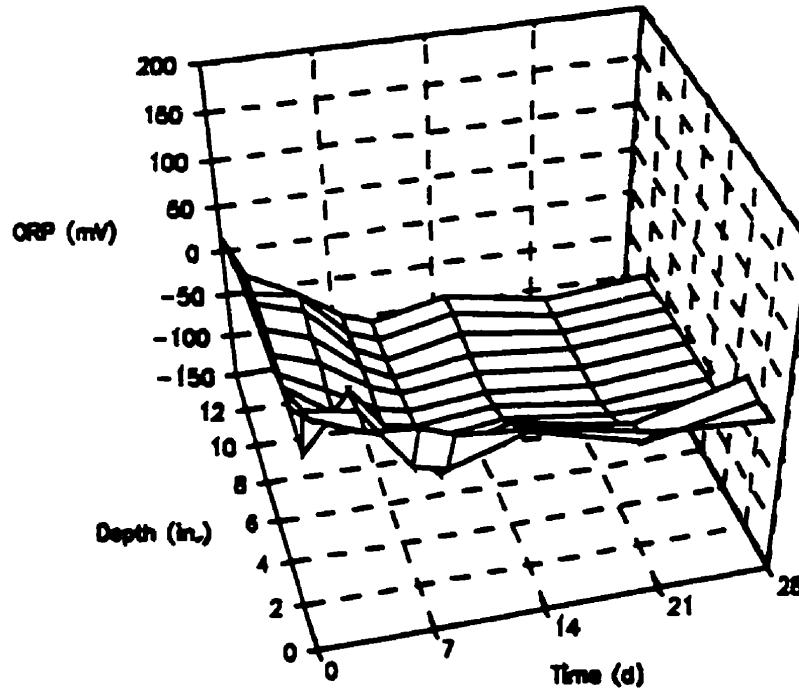
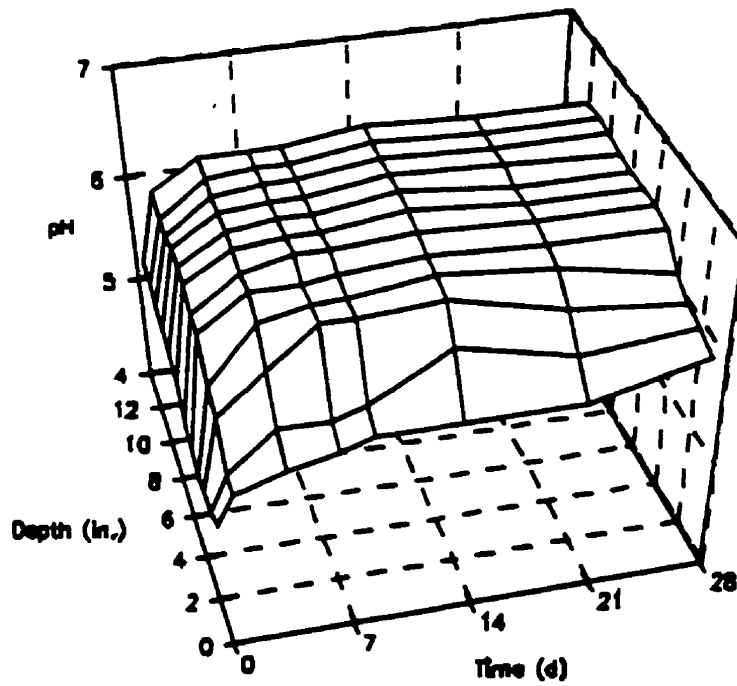
Column 2: 1/4" granite, no SRB

pH

Depth (")	Day -2	0	1	4	7	9	14	21	28	34	35
0	6.7	5	5.25	5.4	5.5	5.6	5.6	5.6	5.85	5.7	5.2
1	6.7	4.9	5.25	5.6	5.6	5.7	6.1	5.85	5.95	5.7	5.2
2	6.65	4.9	5.6	5.95	6.3	6.3	6.35	6.1	6	6.1	5.2
3	6.6	4.85	5.7	6.2	6.3	6.3	6.4	6.3	6.1	6.3	5.2
4	6.6	4.9	6	6.3	6.3	6.35	6.4	6.35	6.35	6.3	5.2
5	6.6	5	6	6.3	6.4	6.4	6.45	6.4	6.4	6.3	5.2
6	6.6	5.2	6.1	6.35	6.4	6.4	6.5	6.4	6.4	6.3	5.2
7	6.6	5.3	6.1	6.35	6.4	6.4	6.5	6.4	6.4	6.35	5.2
8	6.6	5.35	6.1	6.35	6.4	6.4	6.5	6.45	6.4	6.3	5.15
9	6.6	5.4	6.05	6.35	6.4	6.4	6.5	6.45	6.45	6.3	5.15
10	6.6	5.45	6.05	6.35	6.4	6.4	6.5	6.45	6.45	6.3	5.2
11	6.6	5.5	6.15	6.4	6.4	6.4	6.5	6.45	6.45	6.35	5.25
12	6.6	5.5	6.2	6.4	6.4	6.4	6.5	6.5	6.45	6.35	5.5

ORP (mV)

Depth (")	Day -2	0	1	4	7	9	14	21	28	34	35
0	160	130	115	90	85	70	60	30	20	190	90
1	160	130	100	90	10	0	30	-10	20	40	90
2	140	130	20	90	10	-35	10	-10	25	40	90
3	100	135	20	30	-10	-40	-10	-40	-60	-15	90
4	90	135	30	-10	-30	-45	-30	-50	-50	-20	95
5	90	130	30	-15	-40	-50	-40	-60	-50	-25	100
6	90	105	20	-10	-45	-55	-45	-60	-50	-30	105
7	90	95	20	0	-40	-55	-45	-60	-50	-30	105
8	90	90	30	10	-40	-60	-45	-60	-50	-30	110
9	95	80	40	20	-40	-60	-40	-60	-50	-30	110
10	95	70	30	20	-40	-55	-35	-60	-50	-35	115
11	100	70	30	0	-40	-55	-35	-60	-50	-35	110
12	100	80	15	5	-40	-50	-35	-55	-45	-35	60



Changes in pH and ORP over time and depth.
 Column 2: 1/4" granite with no SRB, control. Cycle 1: $V_c = 4L$.

CYCLE 1

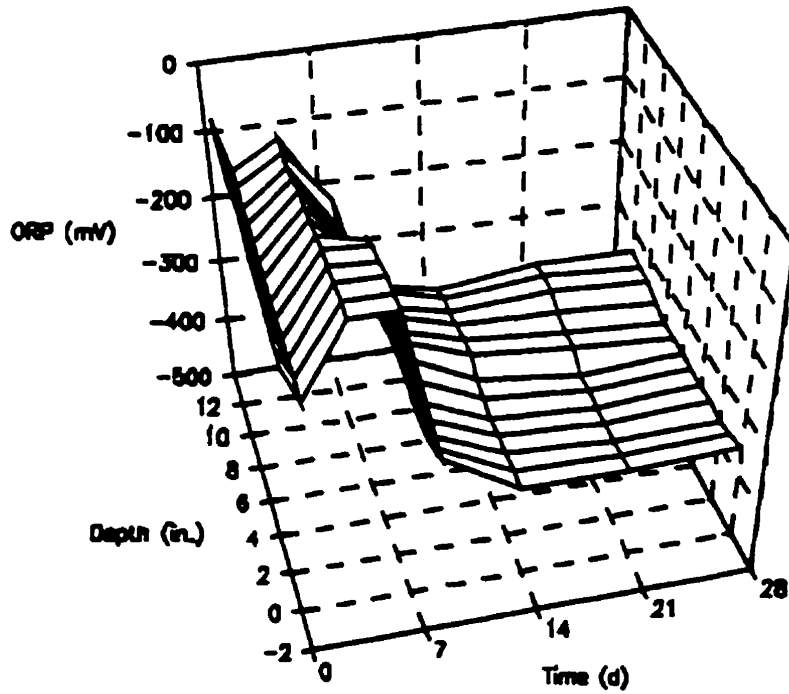
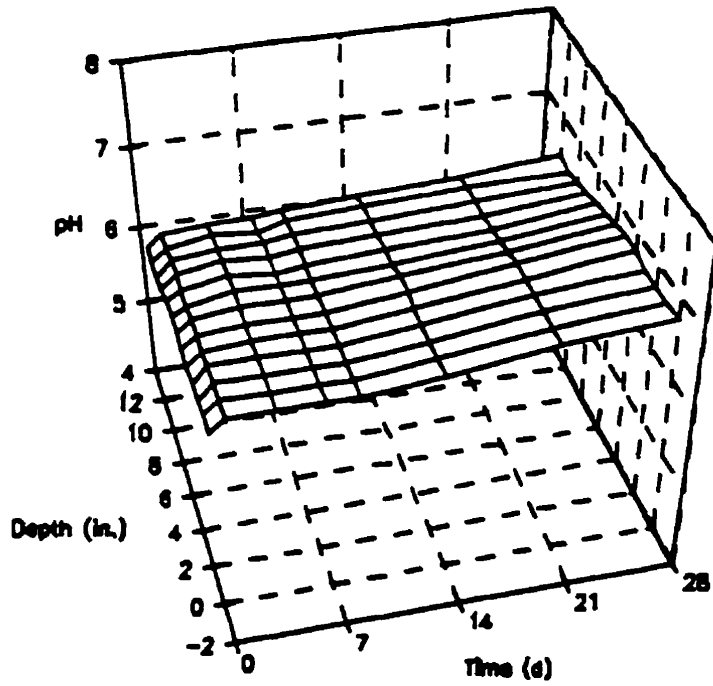
Column 3: 1/4 limestone, with SRB

pH

Depth (")	Day -2	0	1	4	7	9	14	21	28	34	35
0	7.3	6.25	6.4	6.4	6.4	6.4	6.5	6.65	6.75	6.9	6.3
1	7.3	6.25	6.4	6.4	6.4	6.4	6.5	6.65	6.75	6.9	6.3
2	7.25	6.2	6.4	6.4	6.4	6.4	6.5	6.65	6.75	6.9	6.3
3	7.25	6.2	6.4	6.4	6.4	6.4	6.5	6.65	6.75	6.9	6.3
4	7.25	6.2	6.35	6.4	6.4	6.4	6.5	6.65	6.8	6.9	6.3
5	7.25	6.2	6.35	6.4	6.4	6.4	6.5	6.65	6.8	6.9	6.3
6	7.25	6.2	6.35	6.4	6.4	6.4	6.5	6.6	6.75	6.9	6.3
7	7.25	6.2	6.3	6.4	6.4	6.4	6.45	6.55	6.7	6.9	6.3
8	7.2	6.2	6.3	6.4	6.35	6.4	6.45	6.5	6.65	6.85	6.25
9	7.2	6.15	6.3	6.4	6.35	6.4	6.45	6.5	6.6	6.8	6.25
10	7	6.1	6.3	6.35	6.35	6.4	6.45	6.5	6.55	6.7	6.25
11	6.85	6.1	6.25	6.35	6.3	6.4	6.45	6.5	6.5	6.65	6.2
12	6.8	6.1	6.25	6.3	6.3	6.35	6.4	6.45	6.55	6.65	6.35

ORP (mV)

Depth (")	Day -2	0	1	4	7	9	14	21	28	34	35
0	-370	-115	-170	-60	-60	-290	-360	-360	-355	-370	-70
1	-370	-110	-160	-60	-60	-300	-360	-365	-360	-375	-80
2	-370	-100	-160	-60	-60	-310	-360	-370	-365	-380	-80
3	-375	-95	-155	-60	-65	-310	-360	-370	-360	-380	-80
4	-375	-90	-150	-60	-65	-310	-360	-370	-360	-380	-80
5	-375	-80	-150	-65	-80	-300	-355	-370	-360	-380	-80
6	-375	-70	-140	-65	-140	-290	-350	-370	-360	-380	-80
7	-375	-65	-140	-70	-150	-290	-335	-350	-360	-380	-80
8	-375	-65	-135	-70	-170	-300	-335	-350	-360	-380	-75
9	-375	-65	-130	-75	-180	-300	-335	-340	-350	-380	-70
10	-360	-50	-130	-80	-180	-310	-340	-330	-340	-370	-70
11	-355	-45	-120	-80	-160	-305	-340	-330	-340	-365	-70
12	-350	-40	-120	-80	-185	-325	-350	-335	-335	-360	-150



Changes in pH and ORP over time and depth.
 Column 3: 1/4" limestone inoculated with SRB. Cycle 1: $V_c = 4L$.

CYCLE 1

Column 7: 1/4 limestone, no SRB

pH

Depth (")	Day	-2	0	1	4	7	9	14	21	28	34	35
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0 No data for Cycles 1 and 2

1

2

3

4

5

6

7

8

9

10

11

12

ORP (mV)

Depth (")	Day	-2	0	1	4	7	9	14	21	28	34	35
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0 No data for Cycles 1 and 2

1

2

3

4

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11

12

CYCLE 1

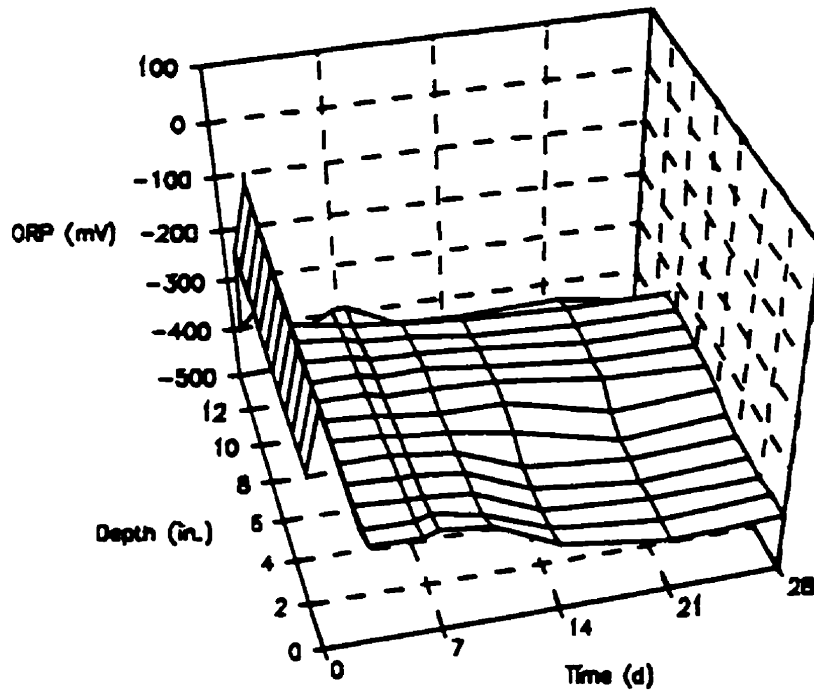
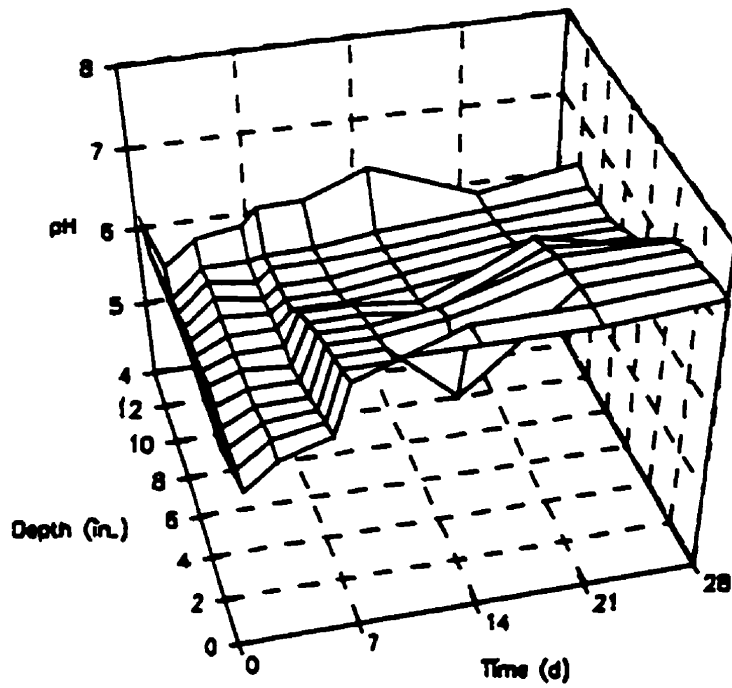
Column 4: 1/2" granite, with SRB

pH

Depth (")	Day -2	1	3	6	7	10	14	21	28
0	7.7	6	6.3	6.5	7.1	7.3	7.3	7.3	7.4
1	7.7	6	6.3	6.4	7	7	7.3	7.3	7.4
2	7.7	6	6.25	6.3	6.9	6.9	6.2	7.3	7.35
3	7.65	6	6.2	6.2	6.8	6.8	6.9	7.25	7.3
4	7.65	6	6.15	6.15	6.7	6.7	6.8	7.2	7.2
5	7.65	6	6.15	6.1	6.6	6.6	6.5	7.1	7
6	7.65	5.95	6.1	6.1	6.5	6.5	6.4	7	6.7
7	7.65	5.9	6.1	6.1	6.3	6.3	6.35	6.55	6.6
8	7.65	5.85	6.1	6.05	6.2	6.2	6.3	6.5	6.5
9	7.6	5.8	6.1	6	6.15	6.15	6.25	6.4	6.4
10	7.6	5.75	6.1	6	6.15	6.15	6.2	6.35	6.4
11	7.6	5.7	6.05	6.05	6.1	6.1	6.2	6.3	6.4
12	7.6	5.9	6.2	6.3	6.5	6.5	6.8	6.3	6.5

ORP (mV)

Depth (")	Day -2	1	3	6	7	10	14	21	28
0	-385	-40	-310	-310	-300	-310	-370	-400	-390
1	-385	-45	-320	-320	-310	-330	-380	-400	-390
2	-385	-50	-315	-320	-320	-330	-385	-400	-395
3	-390	-50	-315	-320	-320	-330	-385	-405	-395
4	-390	-50	-315	-315	-320	-330	-380	-400	-390
5	-390	-50	-310	-315	-320	-330	-350	-400	-385
6	-390	-50	-310	-315	-320	-330	-330	-380	-370
7	-390	-50	-310	-310	-320	-320	-325	-350	-360
8	-390	-40	-310	-310	-320	-315	-330	-350	-355
9	-390	-40	-305	-310	-320	-320	-330	-350	-350
10	-390	-30	-300	-310	-320	-325	-340	-350	-350
11	-390	-25	-300	-315	-320	-330	-340	-350	-350
12	-390	-300	-370	-320	-320	-365	-370	-365	-400



Changes in pH and ORP over time and depth.
 Column 4: 1/2" granite inoculated with SRB. Cycle 1: $V_c = 4L$.

CYCLE 1

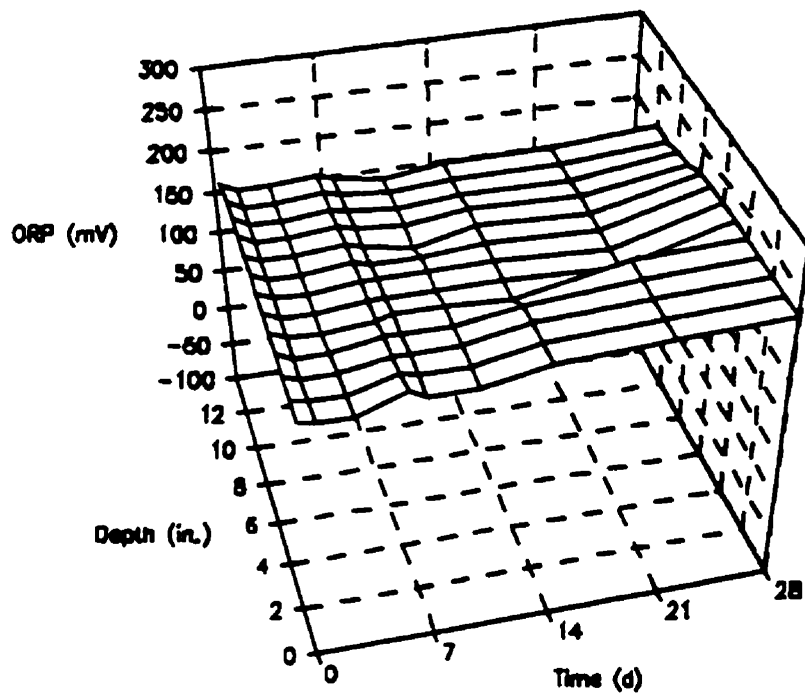
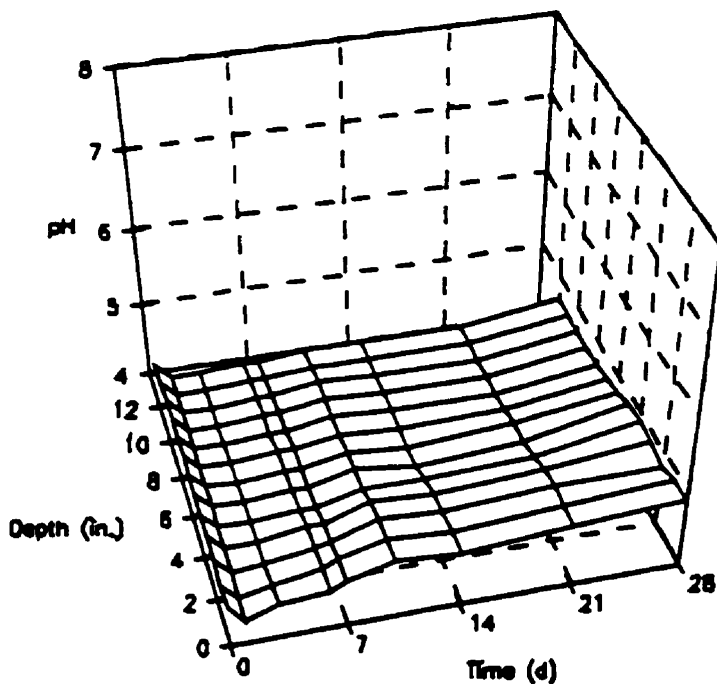
Column 5: 1/2" granite, no SRB

pH

Depth (")	Day -2	1	3	6	7	10	14	21	28
0	4.95	4.3	4.45	4.5	4.6	4.75	4.7	4.8	4.9
1	4.95	4.3	4.4	4.5	4.6	4.75	4.7	4.8	4.9
2	4.95	4.35	4.4	4.5	4.55	4.75	4.7	4.8	4.8
3	4.95	4.4	4.4	4.5	4.5	4.7	4.65	4.75	4.9
4	4.95	4.4	4.4	4.45	4.45	4.6	4.6	4.65	4.9
5	5	4.4	4.4	4.45	4.45	4.6	4.5	4.6	4.9
6	5	4.4	4.4	4.45	4.45	4.55	4.5	4.6	4.8
7	5	4.4	4.4	4.45	4.45	4.55	4.5	4.55	4.75
8	5	4.4	4.4	4.45	4.45	4.55	4.5	4.5	4.7
9	5	4.4	4.4	4.45	4.45	4.55	4.5	4.5	4.7
10	5	4.4	4.4	4.45	4.45	4.55	4.5	4.5	4.7
11	5	4.4	4.4	4.45	4.45	4.5	4.5	4.5	4.7
12	5	4.4	4.4	4.45	4.45	4.5	4.5	4.5	4.7

ORP (mV)

Depth (")	Day -2	1	3	6	7	10	14	21	28
0	200	190	190	210	200	200	215	220	225
1	200	190	190	205	200	200	215	220	225
2	210	190	190	200	200	200	215	220	225
3	215	190	190	200	200	200	210	220	225
4	215	190	190	195	200	200	195	220	225
5	215	190	190	195	195	195	195	190	225
6	215	190	190	195	195	195	195	190	225
7	215	190	190	195	190	190	195	190	225
8	215	190	190	195	190	180	195	190	220
9	220	190	190	195	190	185	195	190	210
10	220	190	190	195	190	185	190	190	205
11	220	190	190	195	190	185	190	190	200
12	220	190	190	195	190	180	190	190	200



Changes in pH and ORP over time and depth.
 Column 5: 1/2" granite with no SRB, control. Cycle 1: $V_c = 4L$.

CYCLE 1

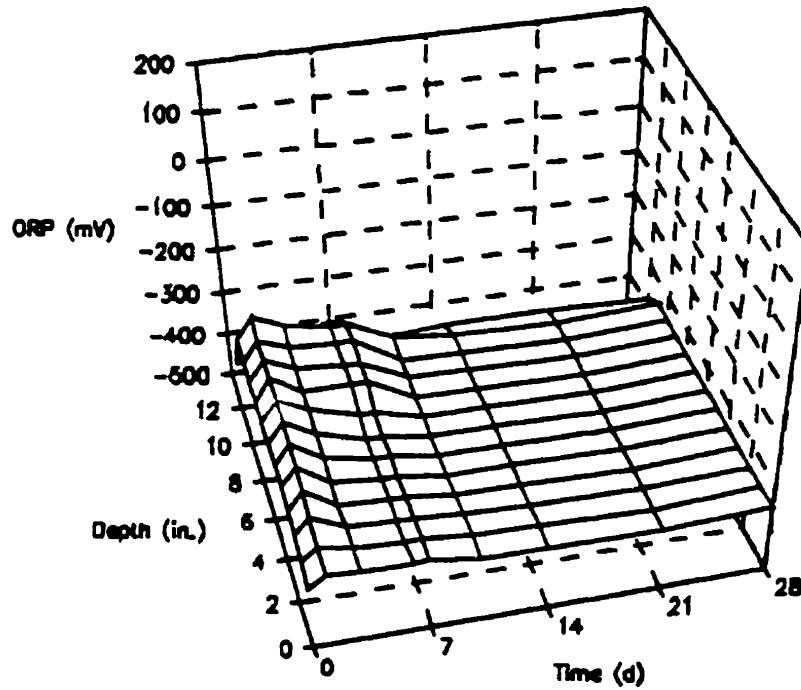
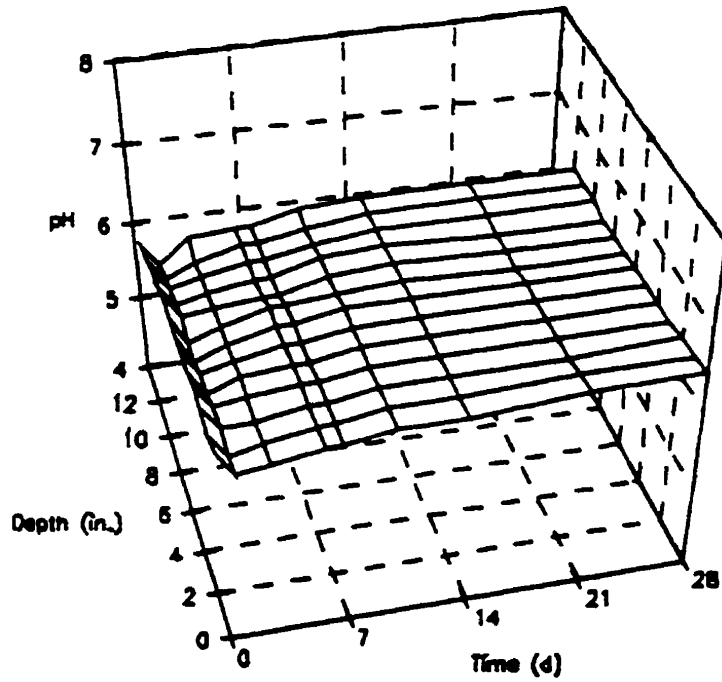
Column 6: 1/2" limestone, with SRB

pH

Depth (")	Day								
	-2	1	3	6	7	10	14	21	28
0	7	6.15	6.2	6.3	6.3	6.4	6.4	6.5	6.5
1	7	6.1	6.2	6.3	6.3	6.4	6.4	6.45	6.45
2	7	6.2	6.2	6.3	6.3	6.4	6.4	6.4	6.45
3	7	6.2	6.25	6.3	6.3	6.4	6.4	6.4	6.4
4	7	6.1	6.25	6.3	6.3	6.4	6.4	6.4	6.4
5	7	6.1	6.2	6.3	6.3	6.4	6.4	6.4	6.4
6	7.05	6	6.15	6.3	6.3	6.4	6.4	6.4	6.4
7	7.05	6	6.15	6.3	6.3	6.35	6.4	6.35	6.35
8	7	6.1	6.15	6.2	6.2	6.35	6.4	6.35	6.35
9	6.8	6	6.1	6.2	6.2	6.35	6.4	6.35	6.35
10	6.7	6	6.1	6.2	6.2	6.3	6.4	6.4	6.4
11	6.65	5.9	6.05	6.2	6.2	6.3	6.4	6.4	6.4
12	6.65	5.85	6.15	6.2	6.2	6.35	6.4	6.4	6.4

ORP (mV)

Depth (")	Day								
	-2	1	3	6	7	10	14	21	28
0	-405	-335	-340	-340	-340	-355	-355	-360	-350
1	-405	-320	-335	-340	-340	-350	-355	-360	-350
2	-405	-300	-335	-340	-340	-350	-355	-360	-350
3	-405	-290	-335	-340	-340	-355	-355	-360	-350
4	-405	-280	-330	-340	-340	-355	-355	-360	-350
5	-405	-275	-320	-340	-340	-355	-355	-360	-350
6	-405	-270	-310	-340	-340	-355	-355	-360	-350
7	-405	-265	-300	-330	-330	-355	-355	-360	-350
8	-405	-260	-300	-300	-300	-355	-355	-360	-350
9	-395	-260	-290	-300	-300	-350	-355	-360	-350
10	-390	-260	-285	-290	-290	-350	-355	-360	-350
11	-390	-245	-275	-290	-290	-340	-355	-360	-350
12	-390	-390	-420	-325	-325	-380	-370	-370	-380



Changes in pH and ORP over time and depth.
 Column 6: 1/2" limestone inoculated with SRB. Cycle 1: $V_c = 4L$.

CYCLE 2

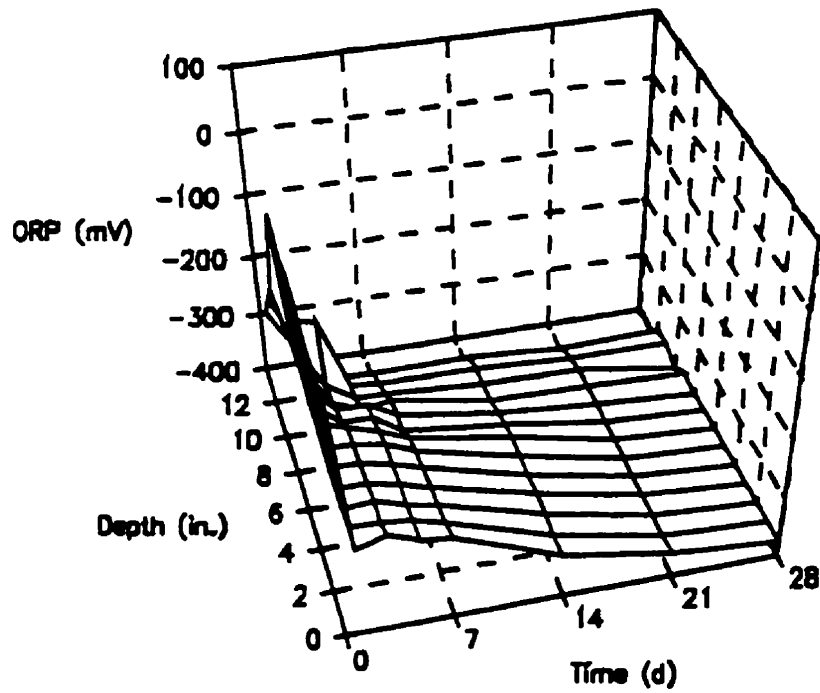
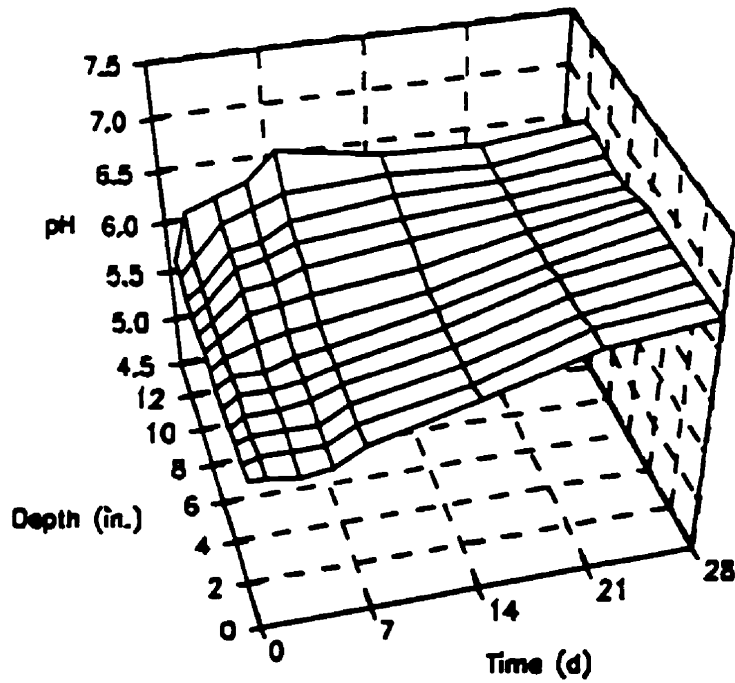
Column 1: 1/4" granite, with SRB

pH

Depth (")	Day -1	0	1	3	5	7	14	21	28	35
0	6.6	6	6	5.95	6	6.15	6.4	6.7	6.8	6.8
1	6.6	5.95	6	6	6	6.15	6.35	6.7	6.8	6.8
2	6.55	5.95	6	6	6	6.15	6.35	6.65	6.8	6.8
3	6.55	5.9	6	6	6.05	6.15	6.35	6.65	6.8	6.8
4	6.5	5.9	6	6	6.05	6.15	6.35	6.65	6.8	6.8
5	6.45	5.9	6	6	6.1	6.15	6.35	6.6	6.8	6.8
6	6.45	5.9	6	6.1	6.15	6.2	6.35	6.6	6.8	6.8
7	6.45	5.9	6	6.2	6.25	6.3	6.4	6.6	6.75	6.75
8	6.45	5.9	6	6.25	6.3	6.4	6.5	6.6	6.7	6.7
9	6.5	5.9	6	6.3	6.35	6.45	6.55	6.6	6.7	6.7
10	6.5	5.9	6	6.3	6.35	6.5	6.6	6.6	6.7	6.7
11	6.6	5.95	6.1	6.4	6.5	6.6	6.65	6.6	6.75	6.7
12	6.65	5.95	6.4	6.5	6.6	6.85	6.7	6.65	6.75	6.7

ORP (mV)

Depth (")	Day -1	0	1	3	5	7	14	21	28	35
0	-380	-40	-255	-240	-260	-265	-330	-360	-375	-375
1	-380	-35	-255	-255	-260	-275	-330	-365	-375	-380
2	-380	-35	-260	-255	-270	-280	-330	-365	-375	-380
3	-380	-35	-260	-260	-270	-285	-330	-365	-375	-380
4	-380	-30	-260	-260	-270	-285	-330	-365	-375	-380
5	-370	-20	-260	-260	-270	-290	-330	-365	-375	-380
6	-360	-10	-250	-265	-280	-300	-330	-365	-375	-380
7	-360	-10	-250	-290	-290	-320	-340	-365	-375	-380
8	-360	-5	-245	-300	-300	-325	-350	-365	-375	-375
9	-360	0	-240	-320	-340	-330	-360	-365	-370	-375
10	-360	-145	-240	-320	-350	-350	-360	-365	-390	-375
11	-365	-190	-230	-240	-360	-365	-365	-375	-375	-375
12	-380	-240	-280	-350	-375	-375	-375	-385	-380	-380



Changes in pH and ORP over time and depth.
 Column 1: 1/4" granite inoculated with SRB. Cycle 2: $V_c = 4L$.

CYCLE 2

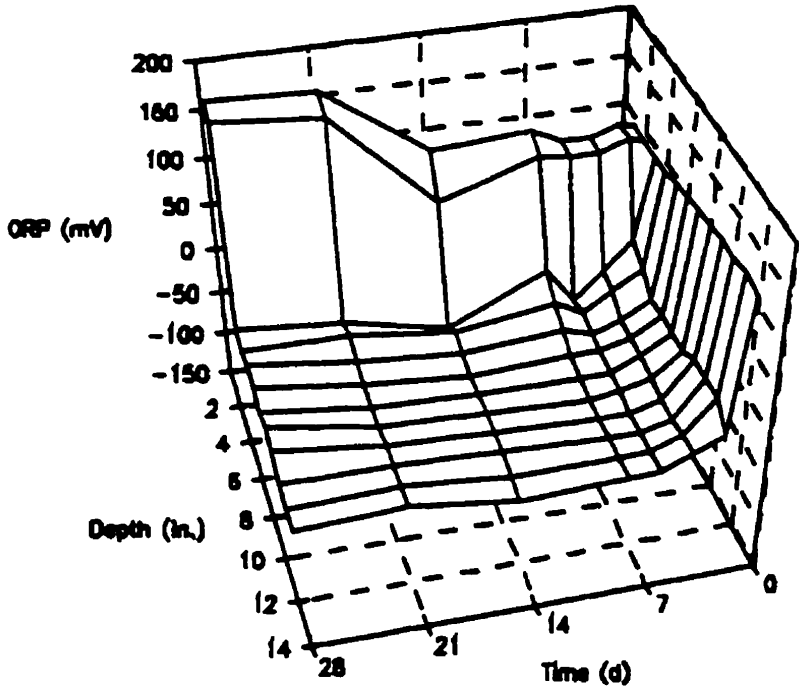
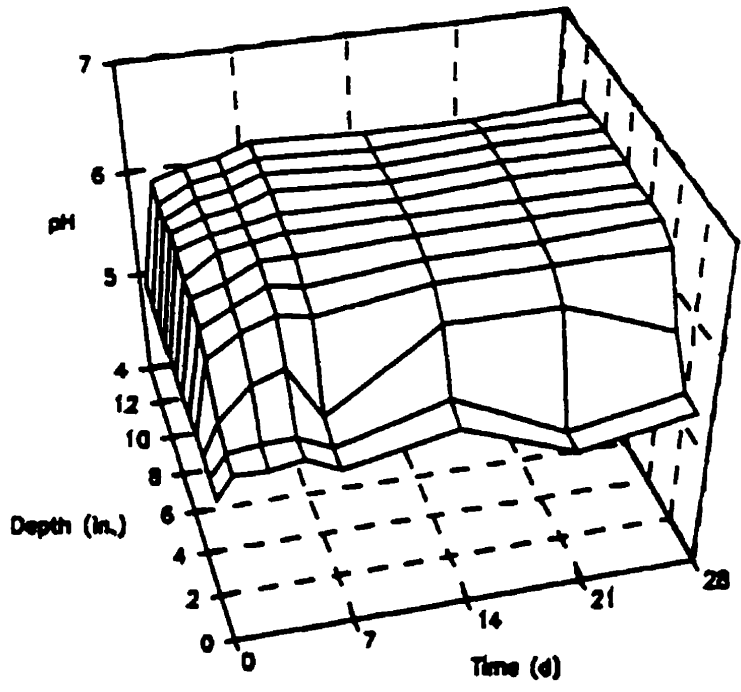
Column 2: 1/4" granite, no SRB

pH

Depth (")	Day -1	0	1	3	5	7	14	21	28	35
0	5.7	5.2	5.4	5.4	5.45	5.3	5.5	5.1	5.3	5.3
1	5.7	5.2	5.4	5.45	5.45	5.3	5.6	5.1	5.3	5.2
2	6.1	5.2	5.5	5.8	5.9	5.4	6.1	6.1	5.7	5.3
3	6.3	5.2	5.9	6.1	6.2	6.15	6.3	6.3	6.3	6
4	6.3	5.2	6	6.15	6.3	6.25	6.35	6.35	6.4	6.3
5	6.3	5.2	6.1	6.2	6.35	6.35	6.4	6.4	6.4	6.3
6	6.3	5.2	6.1	6.3	6.35	6.4	6.4	6.4	6.4	6.35
7	6.35	5.2	6.2	6.3	6.35	6.4	6.4	6.45	6.45	6.4
8	6.3	5.15	6.2	6.3	6.35	6.45	6.4	6.45	6.45	6.4
9	6.3	5.15	6.15	6.3	6.35	6.45	6.4	6.45	6.45	6.4
10	6.3	5.2	6.15	6.3	6.35	6.45	6.4	6.45	6.45	6.4
11	6.35	5.25	6.2	6.3	6.35	6.45	6.4	6.4	6.45	6.4
12	6.35	5.5	6.25	6.3	6.35	6.4	6.4	6.4	6.4	6.4

ORP (mV)

Depth (")	Day -1	0	1	3	5	7	14	21	28	35
0	190	90	95	85	85	100	95	170	175	170
1	40	90	95	85	85	90	55	160	170	170
2	40	90	0	-30	-60	-20	-70	-45	-35	170
3	-15	90	-15	-35	-55	-40	-55	-40	-40	-25
4	-20	95	-30	-50	-60	-50	-60	-50	-35	-20
5	-25	100	-30	-50	-60	-60	-65	-55	-40	-20
6	-30	105	-30	-50	-65	-65	-65	-60	-45	-30
7	-30	105	-30	-55	-65	-70	-65	-60	-40	-35
8	-30	110	-20	-60	-70	-70	-65	-60	-45	-35
9	-30	110	-20	-60	-70	-70	-65	-60	-60	-35
10	-35	115	-20	-55	-70	-70	-70	-60	-65	-40
11	-35	110	-40	-55	-70	-70	-75	-60	-65	-40
12	-35	60	-40	-55	-70	-70	-75	-60	-75	-50



Changes in pH and ORP over time and depth.
 Column 2: 1/4" granite with no SRB, control. Cycle 2: $V_c = 4L$.

CYCLE 2

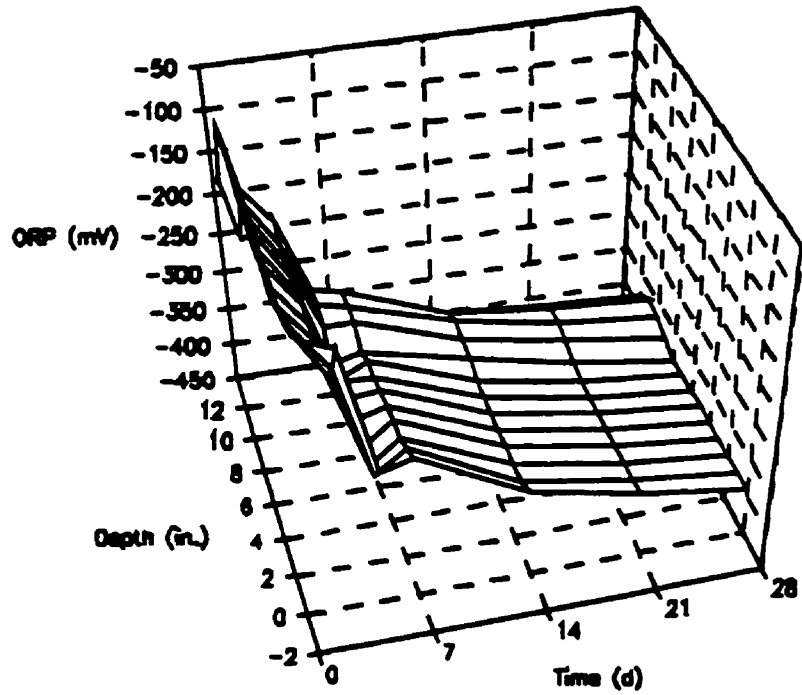
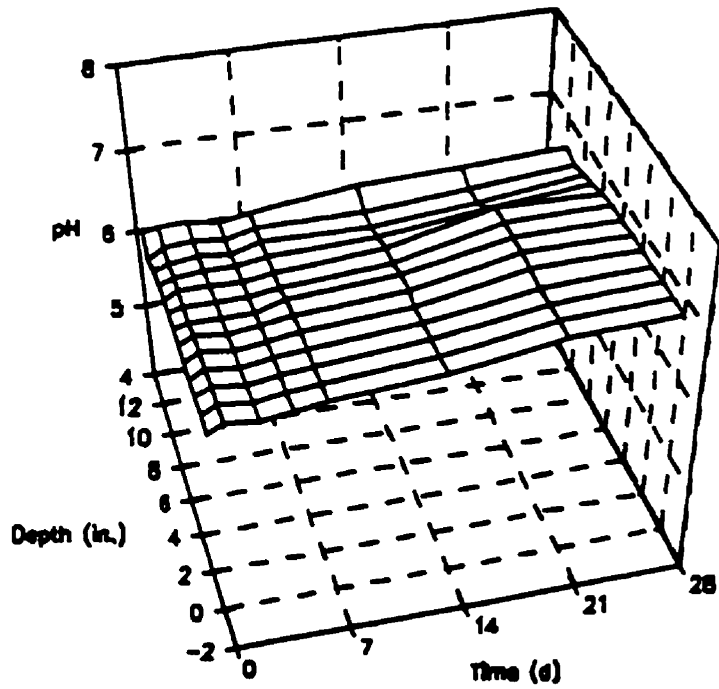
Column 3: 1/4" limestone, with SRB

pH

Depth (")	Dat -1	0	1	3	5	7	14	21	28	35
0	6.9	6.3	6.4	6.35	6.4	6.45	6.55	6.75	6.8	6.85
1	6.9	6.3	6.4	6.35	6.4	6.45	6.55	6.75	6.8	6.85
2	6.9	6.3	6.4	6.35	6.4	6.45	6.55	6.75	6.8	6.85
3	6.9	6.3	6.4	6.35	6.4	6.45	6.55	6.75	6.8	6.85
4	6.9	6.3	6.4	6.35	6.4	6.45	6.55	6.8	6.8	6.85
5	6.9	6.3	6.4	6.35	6.4	6.45	6.55	6.8	6.8	6.85
6	6.9	6.3	6.35	6.35	6.35	6.45	6.55	6.8	6.8	6.85
7	6.9	6.3	6.35	6.35	6.35	6.4	6.5	6.8	6.8	6.85
8	6.85	6.25	6.35	6.35	6.35	6.4	6.5	6.8	6.75	6.8
9	6.8	6.25	6.3	6.35	6.35	6.4	6.45	6.6	6.7	6.7
10	6.7	6.25	6.3	6.35	6.3	6.4	6.4	6.5	6.65	6.6
11	6.65	6.2	6.3	6.35	6.3	6.4	6.4	6.5	6.6	6.55
12	6.65	6.35	6.4	6.4	6.35	6.4	6.55	6.6	6.65	6.6

ORP (mV)

Depth (")	Day -1	0	1	3	5	7	14	21	28	35
0	-370	-70	-110	-125	-280	-270	-340	-370	-390	-370
1	-375	-80	-120	-170	-310	-280	-350	-375	-390	-375
2	-380	-80	-140	-200	-320	-290	-350	-375	-390	-375
3	-380	-80	-150	-210	-320	-290	-350	-375	-390	-375
4	-380	-80	-150	-200	-305	-295	-350	-375	-390	-375
5	-380	-80	-150	-200	-300	-295	-350	-375	-390	-375
6	-380	-80	-145	-195	-300	-300	-350	-375	-390	-380
7	-380	-80	-145	-200	-320	-300	-350	-375	-390	-380
8	-380	-75	-145	-200	-320	-310	-340	-370	-390	-380
9	-380	-70	-145	-200	-290	-290	-335	-360	-380	-380
10	-370	-70	-145	-200	-280	-290	-330	-355	-370	-370
11	-365	-70	-145	-190	-280	-290	-340	-355	-365	-365
12	-360	-150	-225	-210	-320	-350	-360	-370	-380	-365



Changes in pH and ORP over time and depth.
 Column 3: 1/4" limestone inoculated with SRB. Cycle 2: $V_c = 4L$.

CYCLE 2

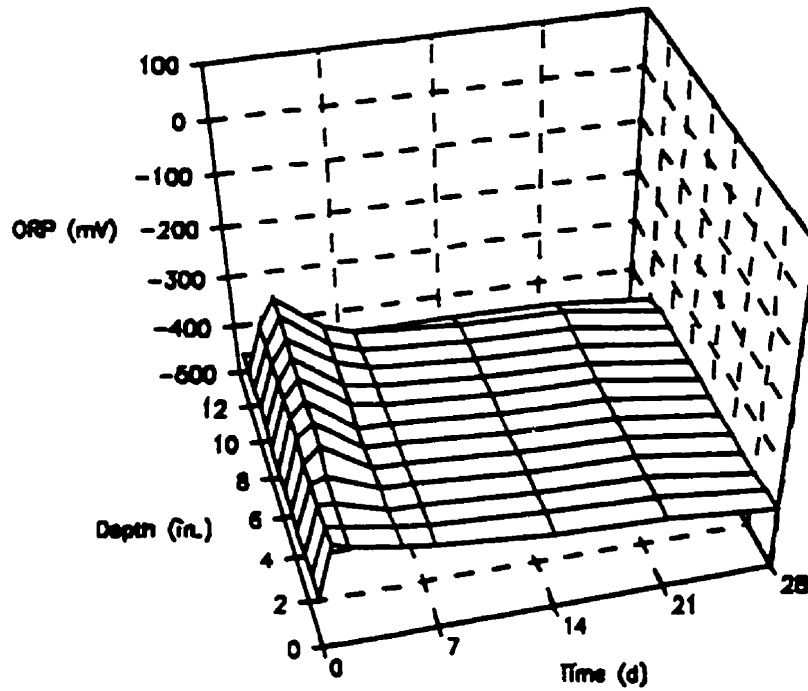
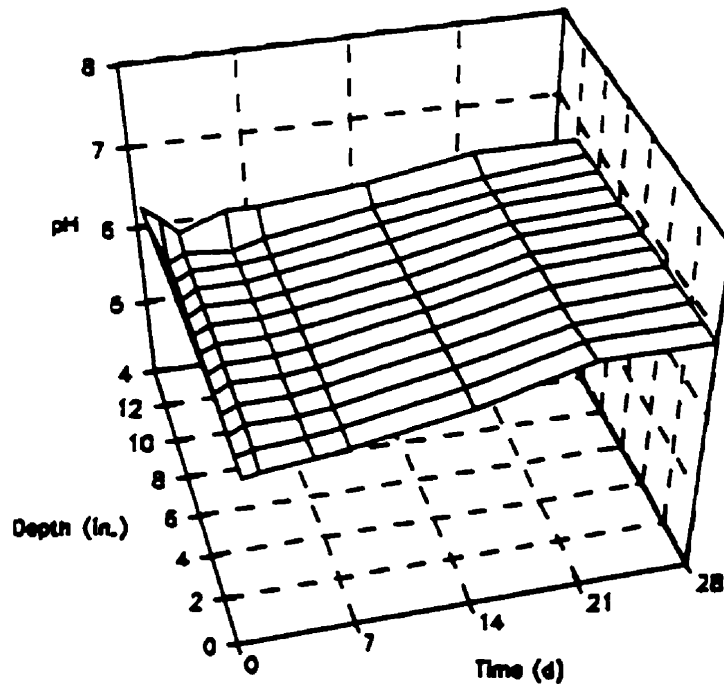
Column 4: 1/2" granite, with SRB

pH

Depth (")	Day 0	1	2	5	7	14	21	28	35
0	7.1	6.15	6.2	6.25	6.3	6.55	6.9	6.9	7
1	7.1	6.15	6.2	6.25	6.3	6.55	6.9	6.9	7
2	7.1	6.15	6.25	6.25	6.3	6.55	6.85	6.9	7
3	7.1	6.15	6.25	6.25	6.3	6.55	6.85	6.9	7
4	6.9	6.15	6.25	6.25	6.3	6.55	6.85	6.9	7
5	6.9	6.15	6.25	6.25	6.3	6.55	6.85	6.9	7
6	6.8	6.15	6.25	6.25	6.3	6.5	6.8	6.85	6.85
7	6.8	6.15	6.25	6.25	6.3	6.5	6.8	6.85	6.95
8	6.75	6.15	6.25	6.25	6.3	6.5	6.75	6.8	6.9
9	6.7	6.15	6.25	6.25	6.3	6.5	6.75	6.8	6.85
10	6.65	6.15	6.25	6.25	6.3	6.5	6.7	6.8	6.85
11	6.65	6.15	6.25	6.2	6.3	6.5	6.7	6.8	6.9
12	6.65	6.5	6.3	6.5	6.5	6.6	6.8	6.8	6.85

ORP (mV)

Depth (")	Day 0	1	2	5	7	14	21	28	35
0	-400	-300	-310	-325	-335	-355	-360	-380	-380
1	-400	-310	-315	-330	-340	-350	-360	-385	-385
2	-405	-310	-310	-340	-340	-355	-360	-390	-385
3	-400	-310	-300	-340	-340	-355	-360	-390	-385
4	-400	-310	-280	-340	-340	-355	-360	-390	-390
5	-400	-300	-275	-340	-340	-355	-360	-390	-390
6	-400	-300	-270	-340	-340	-355	-360	-390	-390
7	-395	-300	-265	-330	-340	-355	-360	-390	-390
8	-390	-305	-260	-330	-340	-355	-360	-390	-390
9	-390	-305	-260	-320	-340	-355	-360	-390	-390
10	-390	-305	-250	-320	-340	-355	-360	-390	-390
11	-390	-300	-250	-320	-340	-355	-360	-390	-390
12	-390	-395	-375	-380	-375	-375	-380	-400	-390



Changes in pH and ORP over time and depth.
 Column 4: 1/2" granite inoculated with SRB. Cycle 2: $V_c = 4L$.

CYCLE 2

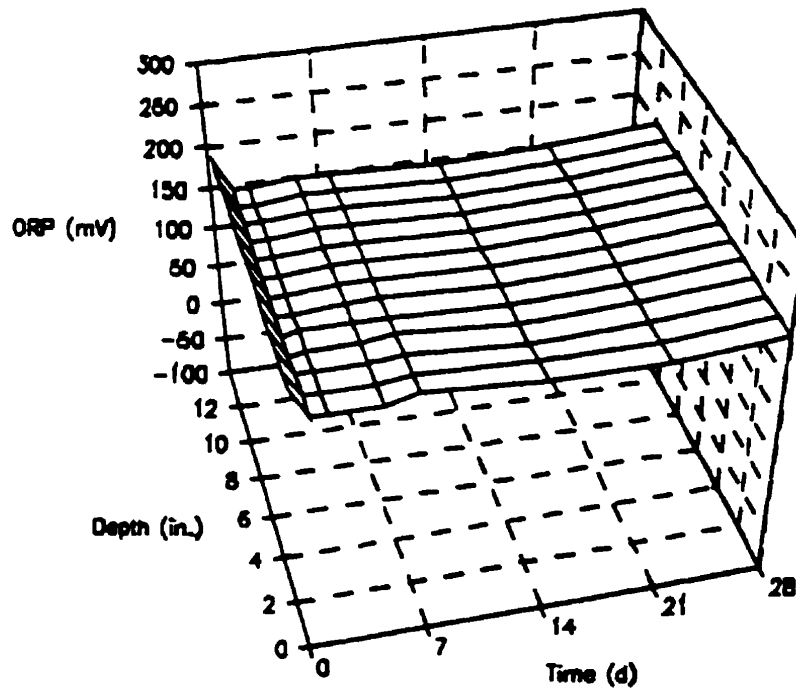
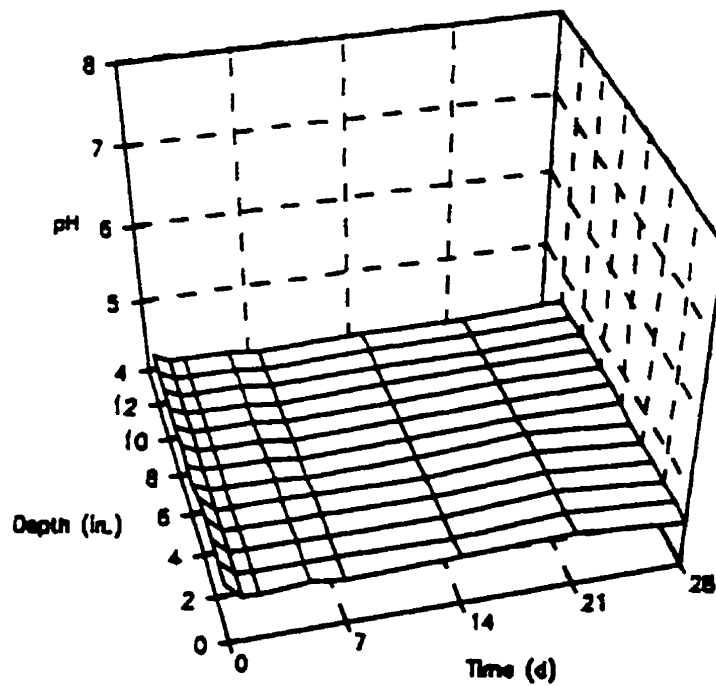
Column 5: 1/2" granite, no SRB

pH

Depth (")	Day 0	1	2	5	7	14	21	28	35
0	4.8	4.6	4.6	4.65	4.6	4.65	4.7	4.6	4.7
1	4.8	4.6	4.6	4.6	4.6	4.6	4.7	4.6	4.7
2	4.8	4.6	4.6	4.6	4.6	4.6	4.7	4.6	4.7
3	4.8	4.6	4.6	4.6	4.6	4.6	4.7	4.6	4.7
4	4.8	4.6	4.6	4.6	4.6	4.6	4.7	4.6	4.7
5	4.7	4.6	4.6	4.6	4.55	4.6	4.7	4.6	4.7
6	4.7	4.6	4.6	4.6	4.55	4.6	4.65	4.65	4.6
7	4.7	4.6	4.6	4.6	4.55	4.6	4.65	4.65	4.6
8	4.7	4.6	4.6	4.6	4.55	4.6	4.65	4.65	4.6
9	4.7	4.6	4.6	4.6	4.55	4.6	4.65	4.65	4.6
10	4.7	4.6	4.6	4.6	4.55	4.6	4.6	4.65	4.6
11	4.7	4.6	4.6	4.6	4.55	4.6	4.6	4.65	4.6
12	4.7	4.6	4.6	4.6	4.55	4.6	4.6	4.65	4.6

ORP (mV)

Depth (")	Day 0	1	2	5	7	14	21	28	35
0	225	190	190	190	200	190	190	200	200
1	220	190	190	190	195	190	190	200	200
2	220	190	190	190	195	185	190	200	200
3	220	185	190	190	195	185	190	200	205
4	220	185	190	190	190	185	190	200	205
5	220	185	185	190	190	185	190	200	205
6	220	185	185	190	190	185	190	200	205
7	220	185	185	190	190	185	190	200	205
8	220	185	185	190	190	185	190	200	205
9	220	185	185	190	190	185	190	200	200
10	220	185	185	190	190	185	190	200	200
11	220	185	185	190	190	185	190	200	200
12	220	185	185	190	190	185	190	200	200



Changes in pH and ORP over time and depth.
 Column 5: 1/2" granite with no SRB, control. Cycle 2: $V_c = 4L$.

CYCLE 2

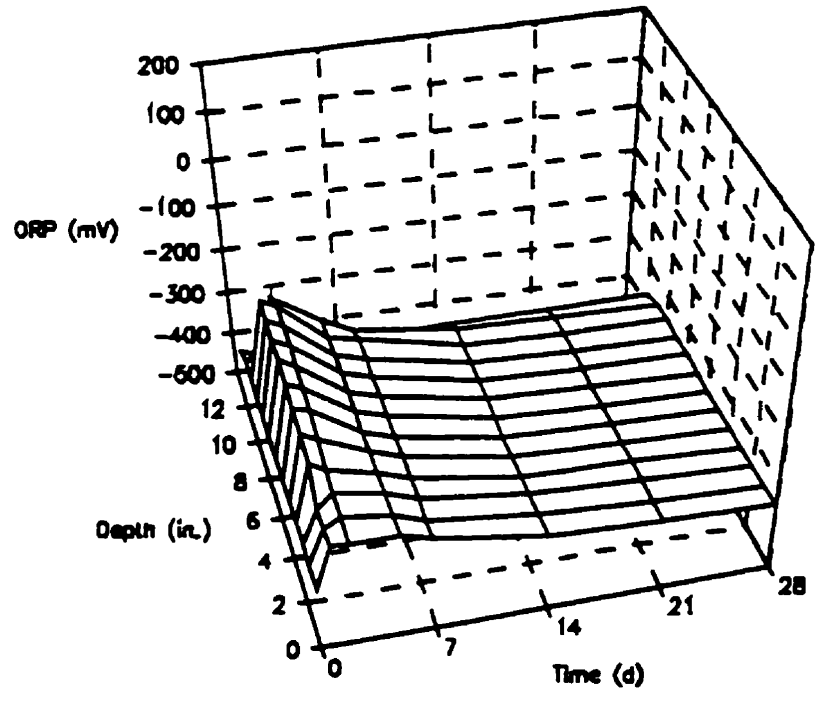
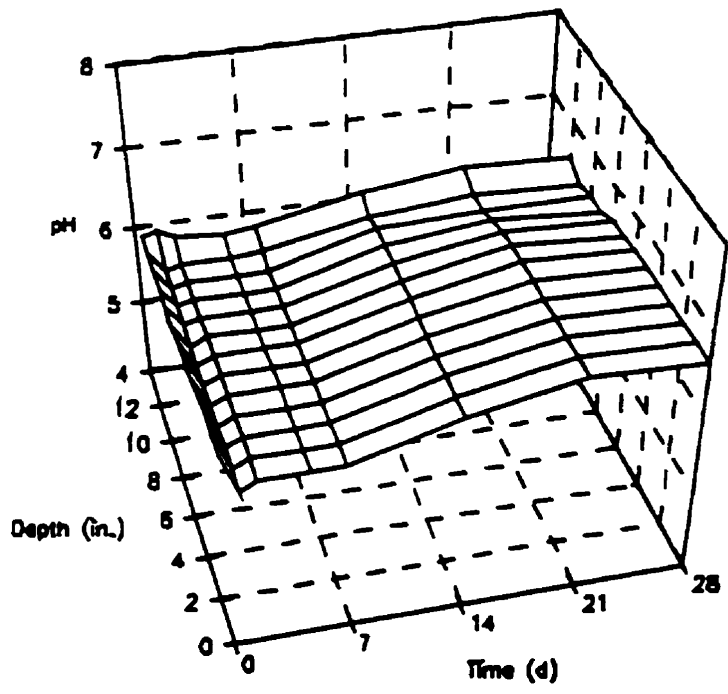
Column 6: 1/2" limestone, with SRB

pH

Depth (")	Day 0	1	2	5	7	14	21	28	35
0	6.5	6	6.1	6.1	6.1	6.45	6.7	6.65	6.7
1	6.5	6	6.1	6.1	6.1	6.45	6.7	6.65	6.7
2	6.5	6	6.1	6.1	6.1	6.45	6.7	6.65	6.7
3	6.45	6	6.1	6.1	6.1	6.45	6.7	6.65	6.7
4	6.4	6	6.1	6.1	6.1	6.45	6.7	6.65	6.7
5	6.4	6	6.1	6.1	6.1	6.45	6.7	6.65	6.7
6	6.35	6	6.1	6.1	6.1	6.45	6.7	6.65	6.7
7	6.3	6	6.1	6.1	6.1	6.45	6.7	6.6	6.7
8	6.3	6.05	6.1	6.1	6.1	6.45	6.65	6.6	6.6
9	6.3	6.05	6.1	6.1	6.1	6.45	6.6	6.5	6.5
10	6.3	6.05	6.1	6.1	6.1	6.45	6.5	6.5	6.5
11	6.3	6.05	6.1	6.1	6.15	6.4	6.5	6.45	6.45
12	6.3	6.35	6.25	6.2	6.25	6.5	6.65	6.6	6.6

ORP (mV)

Depth (")	Day 0	1	2	5	7	14	21	28	35
0	-360	-270	-270	-270	-290	-330	-340	-350	-365
1	-360	-280	-260	-275	-300	-330	-345	-355	-370
2	-360	-285	-255	-275	-300	-330	-345	-355	-370
3	-360	-230	-250	-275	-300	-340	-345	-360	-370
4	-360	-210	-230	-275	-300	-340	-350	-360	-370
5	-360	-200	-210	-275	-300	-340	-350	-360	-370
6	-355	-190	-205	-275	-295	-340	-350	-360	-370
7	-350	-180	-200	-275	-295	-340	-350	-360	-370
8	-350	-175	-195	-275	-295	-340	-350	-355	-370
9	-350	-170	-190	-275	-295	-340	-350	-355	-365
10	-350	-170	-185	-275	-290	-340	-350	-350	-360
11	-350	-320	-210	-275	-310	-340	-350	-355	-360
12	-365	-375	-350	-350	-380	-370	-370	-370	-380



Changes in pH and ORP over time and depth.
 Column 6: 1/2" limestone inoculated with SRB. Cycle 2: $V_c = 4L$.

CYCLE 3

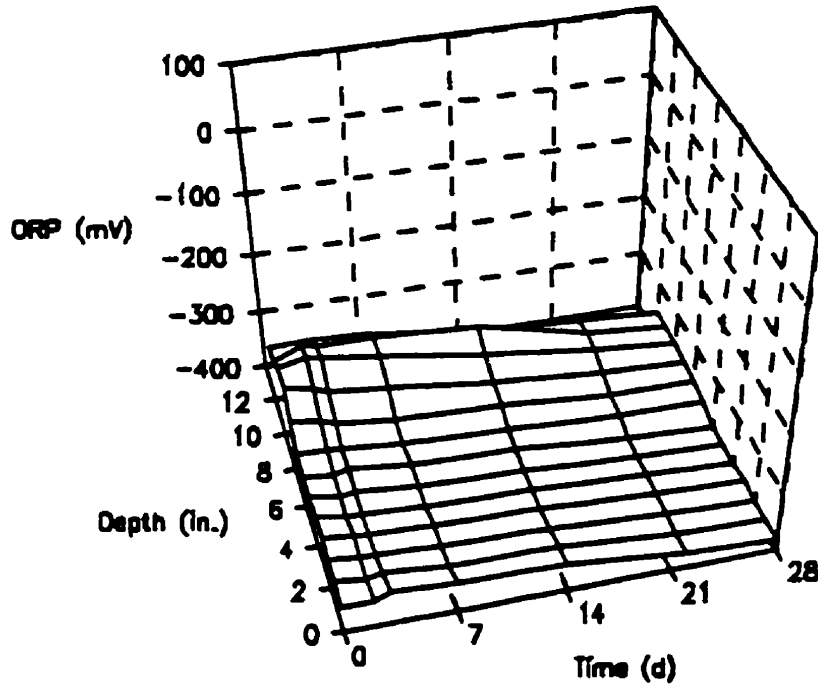
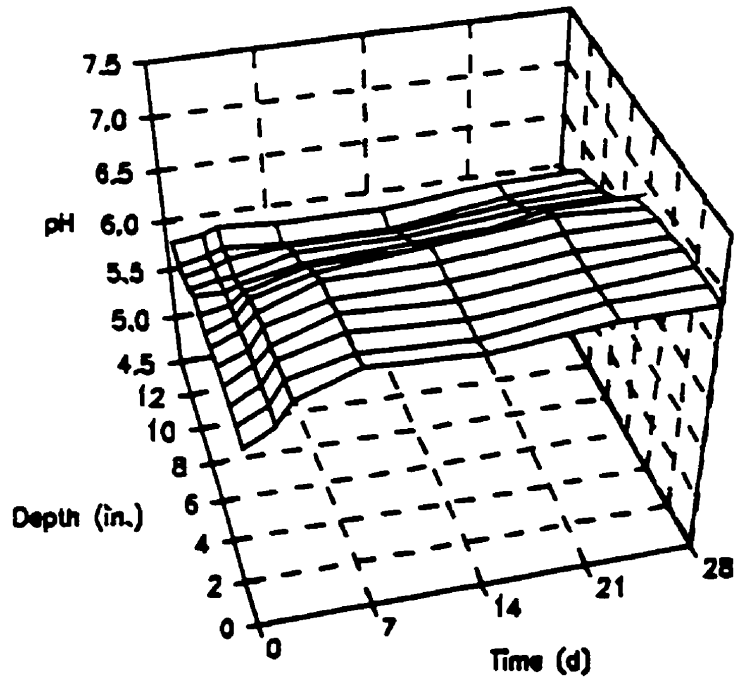
Column 1: 1/4" granite, with SRB

pH

Depth (")	Day								
	-1	0	2	3	7	14	22	28	35
0	7	6.3	6.45	6.65	6.85	6.8	6.9	6.9	6.85
1	7	6.3	6.45	6.65	6.8	6.75	6.9	6.9	6.85
2	7	6.3	6.45	6.65	6.8	6.75	6.85	6.9	6.85
3	7	6.3	6.45	6.6	6.8	6.75	6.85	6.9	6.85
4	7	6.3	6.4	6.6	6.75	6.75	6.85	6.85	6.85
5	7	6.3	6.4	6.55	6.75	6.75	6.85	6.85	6.85
6	7	6.25	6.35	6.5	6.65	6.75	6.85	6.8	6.85
7	6.95	6.25	6.3	6.4	6.55	6.55	6.75	6.75	6.75
8	6.9	6.25	6.25	6.3	6.4	6.45	6.5	6.55	6.55
9	6.85	6.15	6.2	6.2	6.35	6.35	6.45	6.45	6.45
10	6.85	6.1	6.15	6.2	6.25	6.25	6.35	6.35	6.4
11	6.85	6.05	6.1	6.15	6.1	6.1	6.25	6.3	6.25
12	6.8	6.1	6.15	6.2	6.15	6.15	6.25	6.25	6.2

ORP (mV)

Depth (")	Day								
	-1	0	2	3	7	14	22	28	35
0	-390	-355	-355	-345	-350	-355	-375	-380	-380
1	-390	-350	-355	-350	-360	-360	-375	-380	-385
2	-395	-350	-355	-355	-360	-365	-375	-380	-385
3	-395	-350	-355	-355	-360	-365	-375	-380	-385
4	-395	-345	-355	-355	-360	-365	-375	-380	-385
5	-395	-345	-355	-350	-360	-365	-375	-380	-385
6	-395	-345	-350	-345	-355	-360	-375	-380	-385
7	-395	-340	-340	-340	-350	-355	-365	-365	-385
8	-390	-315	-320	-330	-340	-345	-360	-360	-360
9	-390	-285	-295	-305	-315	-335	-350	-355	-355
10	-385	-280	-270	-275	-290	-315	-340	-350	-350
11	-385	-300	-280	-285	-285	-295	-340	-350	-350
12	-385	-305	-305	-305	-310	-335	-345	-355	-345



Changes in pH and ORP over time and depth.
 Column 1: 1/4" granite inoculated with SRB. Cycle 3: $V_c = 4L$.

CYCLE 3

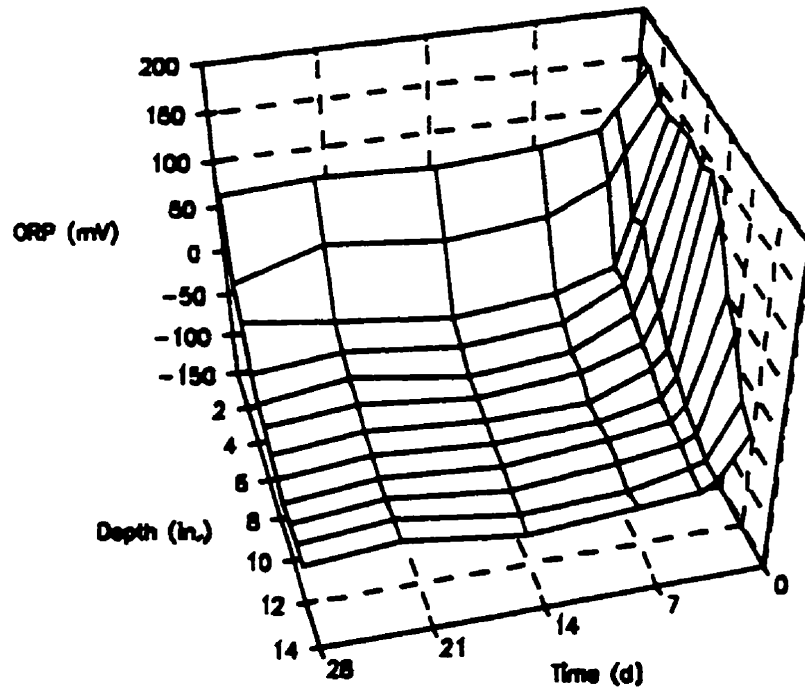
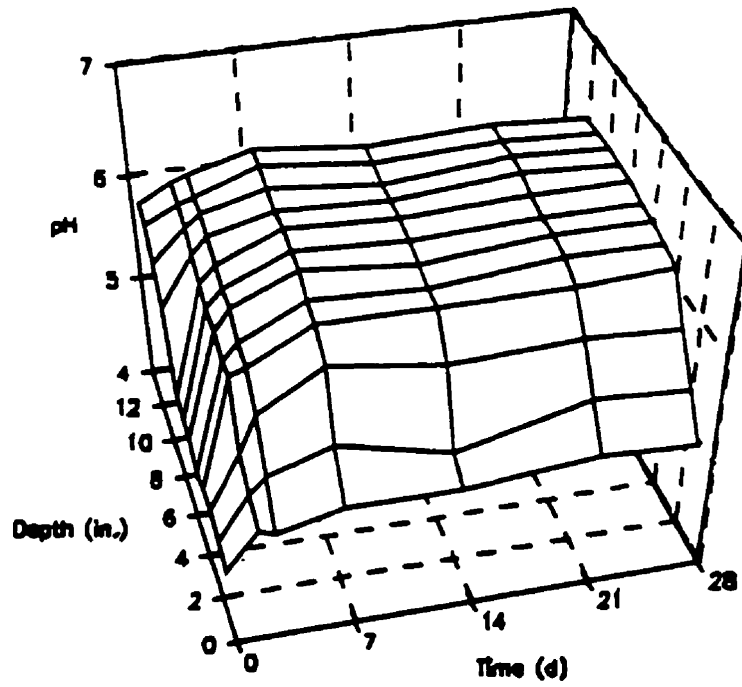
Column 2: 1/4" granite, no SRB

pH

Depth (")	Day -1	0	2	3	7	14	22	28	35
0	5.1	4.5	4.85	4.8	4.95	4.95	5.05	5	5.05
1	5.4	4.6	5	5.15	5.35	5.1	5.4	5.35	5.4
2	5.9	4.7	5.2	5.55	5.9	5.75	5.8	5.75	5.75
3	6.15	4.7	5.75	5.8	6.1	6.1	6.1	6.15	6.1
4	6.25	4.65	5.7	5.85	6.15	6.1	6.2	6.2	6.2
5	6.25	4.8	5.8	6	6.25	6.15	6.25	6.25	6.25
6	6.3	4.8	5.85	6	6.25	6.2	6.25	6.25	6.25
7	6.35	4.85	5.9	6.05	6.3	6.25	6.3	6.3	6.3
8	6.35	5.55	6	6.15	6.3	6.25	6.35	6.3	6.3
9	6.35	5.8	6.1	6.2	6.35	6.25	6.35	6.3	6.3
10	6.35	6	6.15	6.2	6.4	6.3	6.35	6.3	6.3
11	6.35	6.05	6.2	6.25	6.4	6.3	6.35	6.3	6.3
12	6.35	6.15	6.25	6.25	6.4	6.3	6.35	6.3	6.3

ORP (mV)

Depth (")	Day -1	0	2	3	7	14	22	28	35
0	105	155	115	95	85	80	85	80	75
1	50	135	85	55	25	15	30	0	15
2	-35	135	30	-25	-45	-55	-40	-25	-45
3	-60	140	40	-25	-60	-70	-55	-65	-70
4	-80	145	5	-40	-75	-85	-65	-80	-80
5	-90	135	-20	-55	-80	-90	-75	-85	-95
6	-100	145	-45	-65	-95	-95	-85	-95	-95
7	-100	115	-55	-80	-95	-100	-90	-100	-105
8	-100	55	-70	-85	-95	-105	-95	-105	-105
9	-100	30	-80	-90	-100	-110	-95	-105	-110
10	-100	-25	-90	-95	-110	-115	-95	-105	-115
11	-100	-40	-90	-100	-105	-115	-95	-105	-115
12	-100	-60	-95	-105	-110	-115	-100	-105	-115



Changes in pH and ORP over time and depth.
 Column 2: 1/4" granite with no SRB, control. Cycle 3: $V_c = 4L$.

CYCLE 3

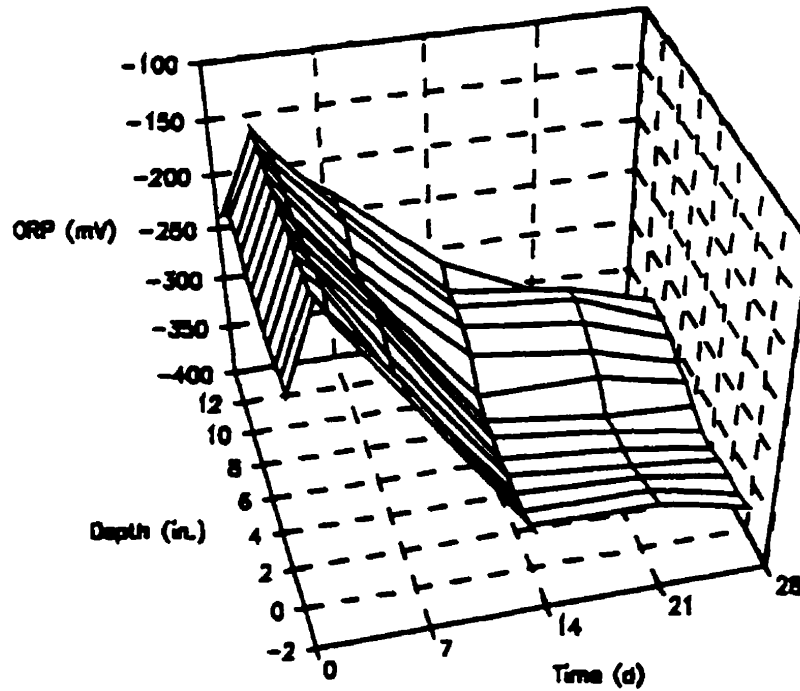
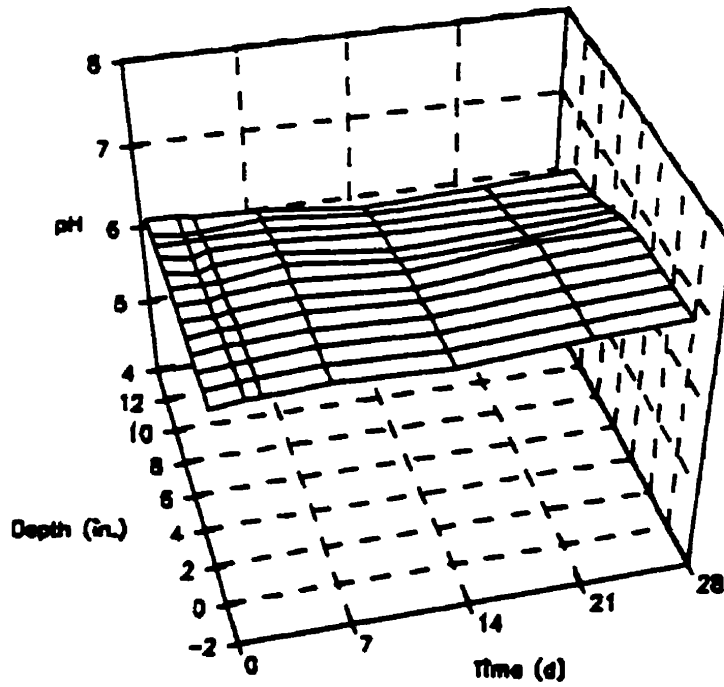
Column 3: 1/4" limestone, with SRB

pH

Depth (")	Day -1	0	2	3	7	14	22	28	35
0	7.35	6.55	6.6	6.6	6.65	6.6	6.7	6.75	6.75
1	7.35	6.55	6.6	6.6	6.65	6.6	6.7	6.75	6.75
2	7.35	6.55	6.6	6.6	6.65	6.6	6.7	6.75	6.75
3	7.35	6.55	6.6	6.6	6.65	6.6	6.7	6.75	6.75
4	7.35	6.55	6.6	6.6	6.65	6.6	6.7	6.75	6.75
5	7.35	6.55	6.55	6.6	6.65	6.55	6.7	6.75	6.75
6	7.35	6.55	6.55	6.6	6.65	6.55	6.7	6.7	6.75
7	7.3	6.55	6.55	6.55	6.65	6.5	6.55	6.65	6.65
8	7.3	6.55	6.5	6.55	6.6	6.45	6.5	6.55	6.55
9	7.25	6.55	6.5	6.55	6.55	6.45	6.45	6.45	6.45
10	7.1	6.5	6.5	6.5	6.5	6.4	6.4	6.4	6.4
11	6.9	6.45	6.4	6.4	6.45	6.35	6.35	6.35	6.35
12	6.85	6.45	6.45	6.4	6.4	6.25	6.3	6.35	6.3

ORP (mV)

Depth (")	Day -1	0	2	3	7	14	22	28	35
0	-380	-195	-115	-140	-215	-355	-355	-375	-375
1	-380	-195	-125	-145	-215	-360	-360	-380	-375
2	-380	-200	-125	-140	-230	-360	-365	-380	-380
3	-385	-200	-125	-140	-225	-360	-370	-380	-380
4	-385	-200	-125	-145	-215	-360	-370	-385	-380
5	-385	-195	-125	-145	-215	-355	-370	-385	-380
6	-385	-195	-125	-145	-215	-355	-370	-375	-380
7	-385	-195	-125	-150	-220	-345	-345	-365	-365
8	-385	-190	-125	-145	-220	-320	-335	-360	-360
9	-375	-190	-125	-145	-215	-305	-320	-350	-355
10	-370	-185	-125	-145	-205	-300	-310	-345	-345
11	-370	-195	-125	-145	-205	-300	-315	-340	-345
12	-370	-210	-145	-165	-205	-285	-340	-355	-350



Changes in pH and ORP over time and depth.
 Column 3: 1/4" limestone inoculated with SRB. Cycle 3: $V_c = 4L$.

CYCLE 3

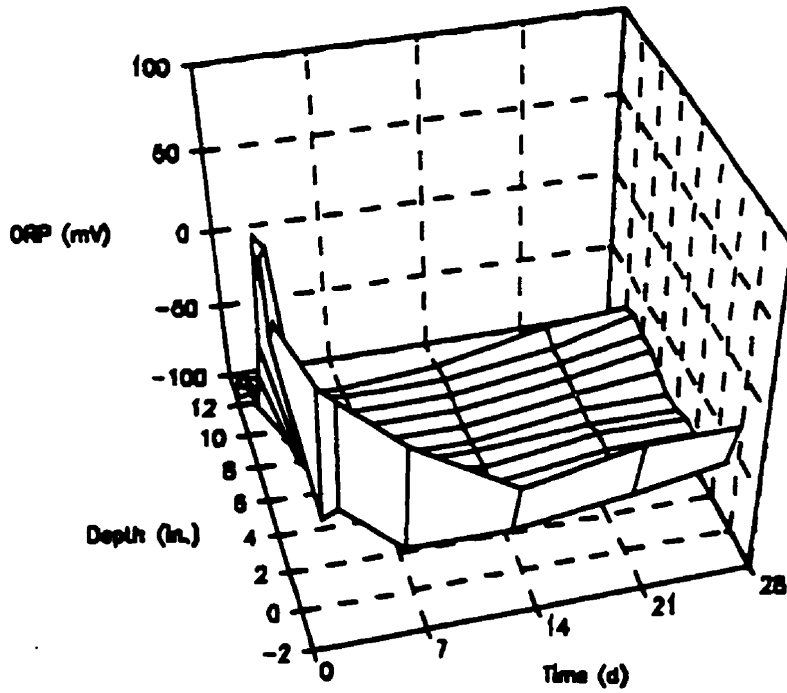
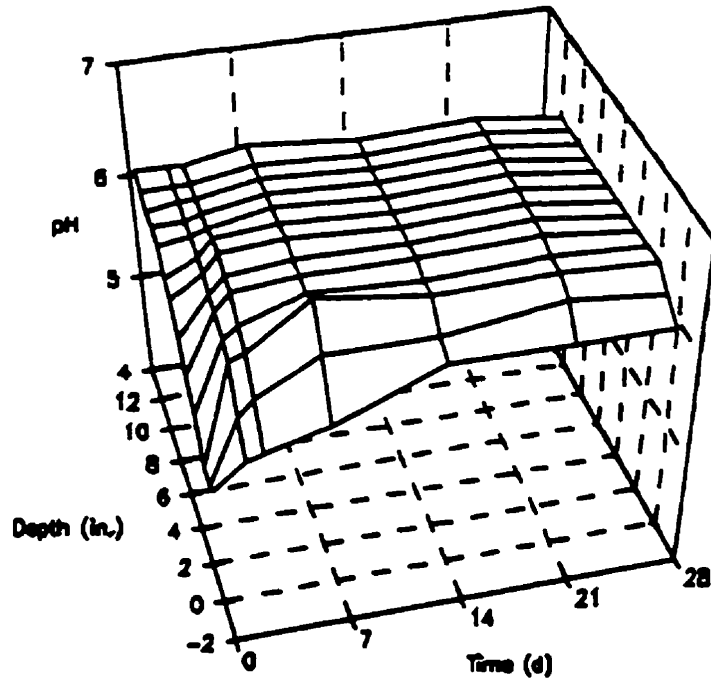
Column 7: 1/4" limestone, no SRB

pH

Depth (")	Day -1	0	2	3	7	14	22	28	35
0	5.85	5.15	5.35	5.4	5.55	5.95	5.95	5.95	5.8
1	6	5	5.6	5.75	6.05	6.05	6.2	6.1	6.05
2	6.2	3	5.95	6	6.4	6.26	6.3	6.25	6.2
3	6.15	5.35	6	6.1	6.3	6.25	6.3	6.25	6.25
4	6.2	5.55	6.1	6.25	6.3	6.3	6.35	6.25	6.25
5	6.2	5.75	6.1	6.25	6.3	6.3	6.35	6.25	6.25
6	6.2	5.95	6.15	6.3	6.35	6.3	6.35	6.25	6.25
7	6.2	6	6.15	6.3	6.35	6.3	6.35	6.25	6.25
8	6.2	6.15	6.2	6.25	6.35	6.3	6.35	6.25	6.25
9	6.2	6.2	6.2	6.25	6.35	6.3	6.35	6.25	6.25
10	6.2	6.2	6.25	6.25	6.35	6.3	6.35	6.25	6.2
11	6.2	6.25	6.25	6.25	6.35	6.3	6.35	6.25	6.2
12	6.25	6.3	6.3	6.3	6.4	6.3	6.35	6.25	6.2

ORP (mV)

Depth (")	Day -1	0	2	3	7	14	22	28	35
0	110	80	40	30	-5	-45	-30	-30	-55
1	60	60	-55	-50	-85	-85	-75	-65	-85
2	25	135	-40	-55	-80	-90	-80	-75	-90
3	-20	90	-40	-70	-80	-90	-85	-75	-90
4	-30	25	-55	-70	-80	-90	-80	-80	-90
5	-35	-5	-65	-75	-85	-90	-80	-80	-90
6	-35	-35	-65	-75	-90	-90	-85	-85	-90
7	-35	-40	-75	-80	-95	-95	-85	-85	-90
8	-35	-40	-70	-80	-95	-95	-85	-80	-85
9	-35	-55	-70	-80	-95	-95	-85	-75	-80
10	-30	-65	-75	-85	-95	-95	-85	-75	-75
11	-30	-70	-75	-90	-95	-95	-85	-70	-75
12	-45	-95	-90	-100	-100	-95	-80	-75	-80



Changes in pH and ORP over time and depth.
 Column 7: 1/4" limestone with no SRB, control. Cycle 3: $V_c = 4L$.

CYCLE 3

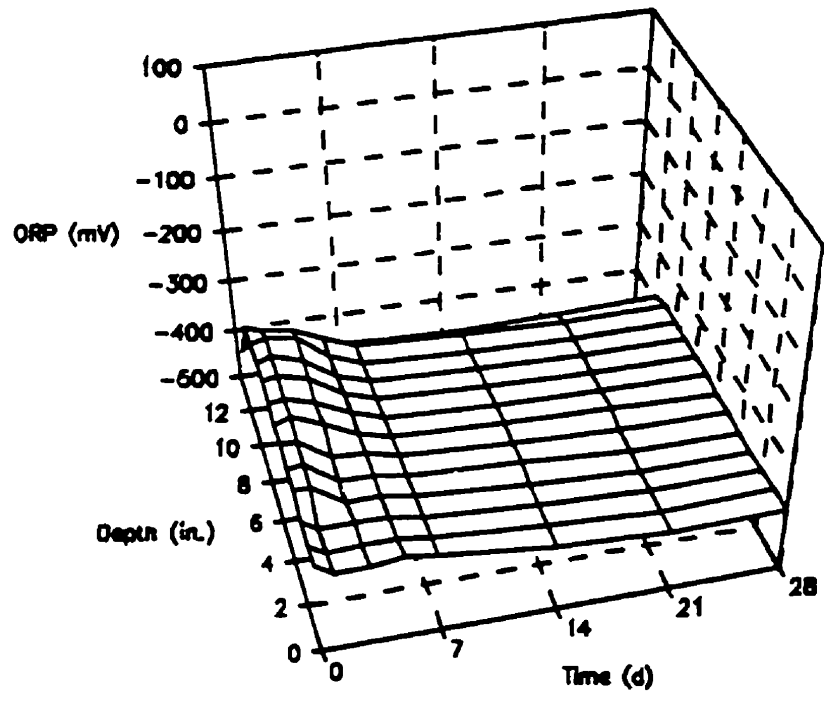
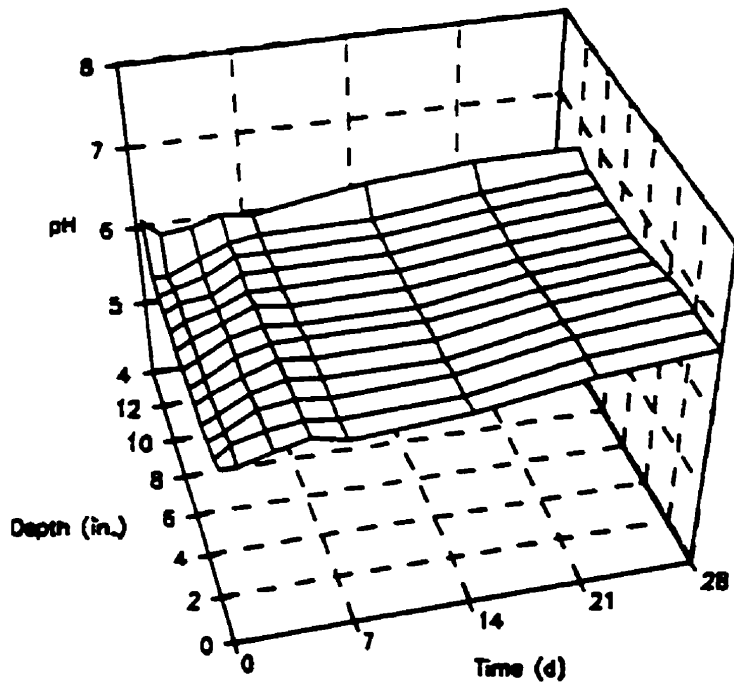
Column 4: 1/2" granite, with SRB

pH

Depth (")	Day	0	1	3	5	7	14	21	28
0	7.2	6.3	6.3	6.4	6.5	6.4	6.5	6.7	6.8
1	7.2	6.15	6.3	6.4	6.45	6.4	6.45	6.7	6.8
2	7.2	6.1	6.2	6.4	6.45	6.4	6.45	6.7	6.8
3	7.2	6.05	6.15	6.35	6.45	6.4	6.4	6.65	6.8
4	7.2	6.05	6.15	6.3	6.45	6.4	6.4	6.65	6.75
5	7.1	6	6.1	6.3	6.4	6.4	6.4	6.6	6.7
6	7.1	6	6.1	6.3	6.4	6.35	6.35	6.55	6.65
7	7	6	6.1	6.25	6.4	6.35	6.35	6.5	6.6
8	7	6	6.1	6.2	6.35	6.35	6.35	6.5	6.6
9	6.95	6	6.1	6.15	6.35	6.35	6.35	6.5	6.6
10	6.9	6	6.05	6.15	6.35	6.35	6.35	6.5	6.6
11	6.9	6	6	6.15	6.3	6.35	6.35	6.5	6.6
12	6.9	6.5	6.3	6.35	6.45	6.4	6.6	6.7	6.7

ORP (mV)

Depth (")	Day	0	1	3	5	7	14	21	28
0	-380	-330	-350	-350	-340	-350	-375	-385	-380
1	-385	-335	-355	-350	-350	-360	-375	-385	-380
2	-390	-330	-350	-350	-350	-360	-375	-385	-380
3	-390	-310	-310	-350	-350	-360	-375	-385	-385
4	-390	-310	-305	-350	-350	-360	-370	-385	-385
5	-390	-300	-300	-340	-345	-360	-370	-380	-380
6	-390	-300	-290	-315	-345	-360	-370	-375	-380
7	-390	-295	-290	-310	-340	-360	-370	-375	-375
8	-390	-290	-285	-300	-340	-360	-370	-375	-375
9	-385	-290	-280	-300	-340	-360	-370	-375	-375
10	-390	-290	-280	-290	-335	-360	-370	-375	-375
11	-390	-290	-300	-310	-335	-360	-370	-375	-375
12	-395	-370	-350	-360	-375	-390	-400	-395	-390



Changes in pH and ORP over time and depth.
 Column 4: 1/2" granite inoculated with SRB. Cycle 3: $V_c = 4L$.

CYCLE 3

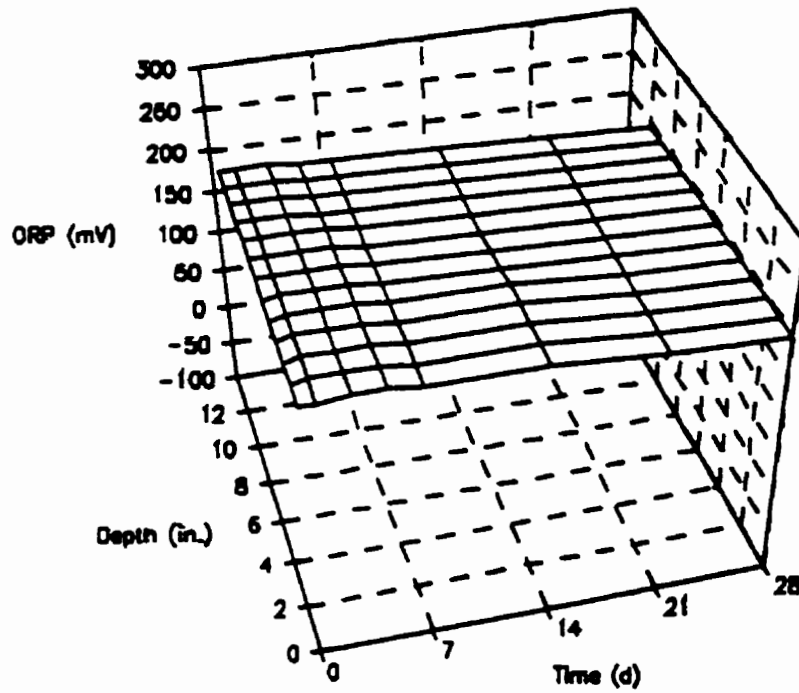
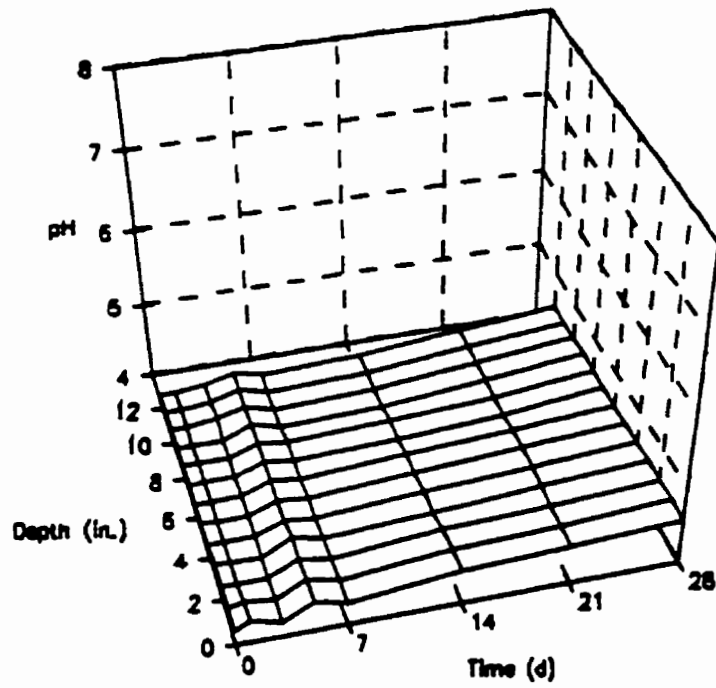
Column 5: 1/2" granite, no SRB

pH

Depth (")	Day -2	0	1	3	5	7	14	21	28
0	4.7	4.2	4.3	4.2	4.4	4.3	4.45	4.5	4.6
1	4.7	4.2	4.25	4.2	4.4	4.3	4.45	4.5	4.6
2	4.7	4.2	4.2	4.2	4.4	4.3	4.45	4.5	4.6
3	4.7	4.2	4.2	4.2	4.4	4.3	4.4	4.5	4.6
4	4.7	4.2	4.2	4.2	4.35	4.3	4.4	4.5	4.6
5	4.7	4.2	4.2	4.2	4.35	4.3	4.4	4.5	4.6
6	4.7	4.2	4.2	4.2	4.35	4.3	4.4	4.5	4.6
7	4.7	4.2	4.2	4.2	4.35	4.3	4.35	4.45	4.6
8	4.7	4.2	4.2	4.2	4.35	4.3	4.35	4.45	4.6
9	4.7	4.2	4.2	4.2	4.35	4.25	4.3	4.45	4.6
10	4.7	4.2	4.2	4.25	4.35	4.25	4.3	4.45	4.6
11	4.7	4.2	4.2	4.25	4.35	4.25	4.3	4.45	4.55
12	4.7	4.2	4.2	4.25	4.35	4.25	4.3	4.45	4.55

ORP (mV)

Depth (")	Day -2	0	1	3	5	7	14	21	28
0	200	210	210	215	215	210	210	200	195
1	200	210	215	215	215	210	210	200	195
2	200	210	215	215	215	210	210	200	195
3	200	210	215	215	215	210	210	200	195
4	200	210	215	215	215	210	210	200	195
5	200	210	215	215	215	210	205	200	195
6	200	215	215	215	215	210	205	200	195
7	200	215	215	215	215	210	205	200	195
8	200	215	215	215	215	210	205	200	195
9	200	215	215	215	210	210	205	200	195
10	200	215	215	215	210	210	205	200	195
11	200	215	215	215	210	210	205	200	195
12	200	215	215	215	210	210	205	200	195



Changes in pH and ORP over time and depth.
 Column 5: 1/2" granite with no SRB, control. Cycle 3: $V_c = 4L$.

CYCLE 3

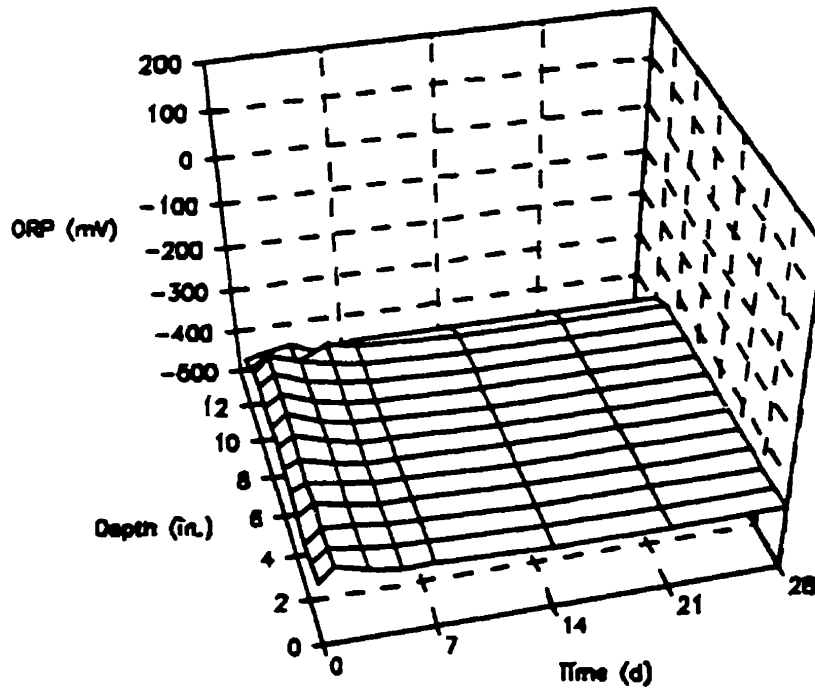
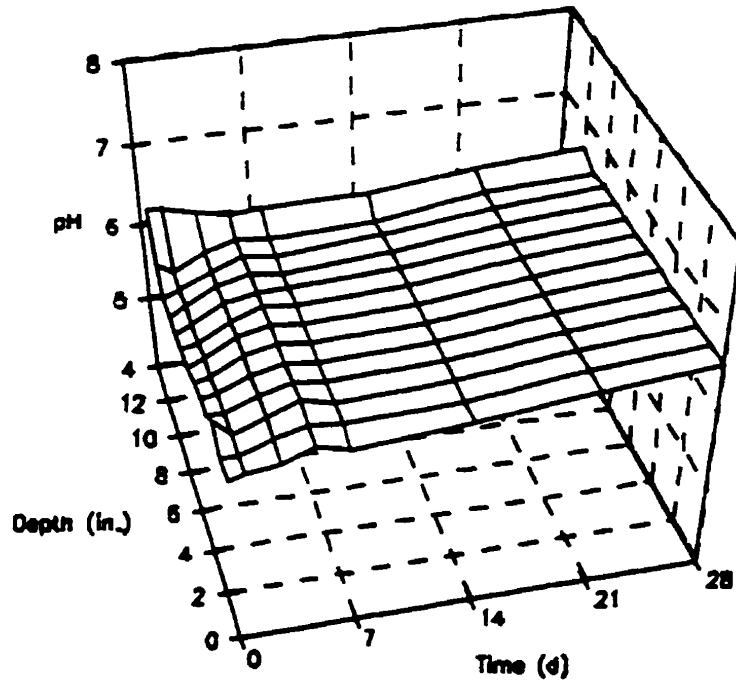
Column 6: 1/2" limestone, with SRB

pH

Depth (")	Day -2	0	1	3	5	7	14	21	28
0	6.9	6.1	6.15	6.2	6.35	6.25	6.35	6.5	6.6
1	6.9	6.1	6.1	6.25	6.35	6.3	6.35	6.5	6.6
2	6.9	6.3	6.1	6.25	6.4	6.3	6.35	6.5	6.6
3	6.9	6.1	6.1	6.25	6.35	6.3	6.35	6.5	6.6
4	6.9	6.05	6.1	6.25	6.35	6.3	6.35	6.5	6.6
5	6.9	6	6.05	6.25	6.35	6.3	6.35	6.5	6.6
6	6.9	5.95	6.05	6.25	6.35	6.3	6.35	6.5	6.6
7	6.9	5.95	6	6.2	6.35	6.3	6.35	6.5	6.6
8	6.85	5.9	6	6.2	6.3	6.3	6.35	6.5	6.6
9	6.8	5.9	6	6.2	6.3	6.25	6.35	6.5	6.6
10	6.7	5.9	6	6.15	6.3	6.25	6.35	6.5	6.6
11	6.65	6.1	6	6.2	6.3	6.25	6.3	6.5	6.55
12	6.7	6.6	6.6	6.5	6.4	6.45	6.45	6.6	6.7

ORP (mV)

Depth (")	Day -2	0	1	3	5	7	14	21	28
0	-375	-350	-320	-340	-350	-350	-360	-360	-355
1	-380	-360	-330	-340	-350	-350	-360	-360	-360
2	-380	-365	-335	-340	-350	-350	-360	-360	-360
3	-380	-350	-325	-340	-350	-350	-360	-360	-360
4	-380	-340	-325	-340	-350	-350	-360	-360	-360
5	-380	-335	-320	-340	-350	-350	-360	-360	-360
6	-380	-335	-310	-335	-350	-350	-360	-360	-360
7	-380	-330	-305	-335	-345	-350	-360	-360	-360
8	-380	-330	-305	-330	-345	-350	-360	-360	-360
9	-380	-325	-300	-330	-340	-350	-360	-360	-360
10	-370	-335	-300	-325	-340	-350	-360	-360	-360
11	-370	-370	-350	-370	-335	-350	-360	-360	-360
12	-385	-390	-380	-370	-400	-380	-380	-380	-380



Changes in pH and ORP over time and depth.
 Column 6: 1/2" limestone inoculated with SRB. Cycle 3: $V_c = 4L$.

CYCLE 4

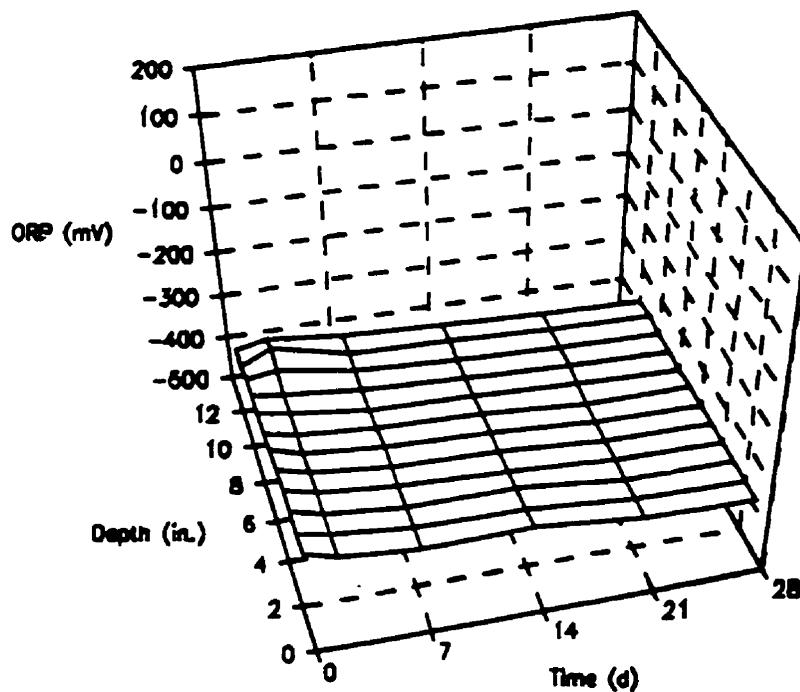
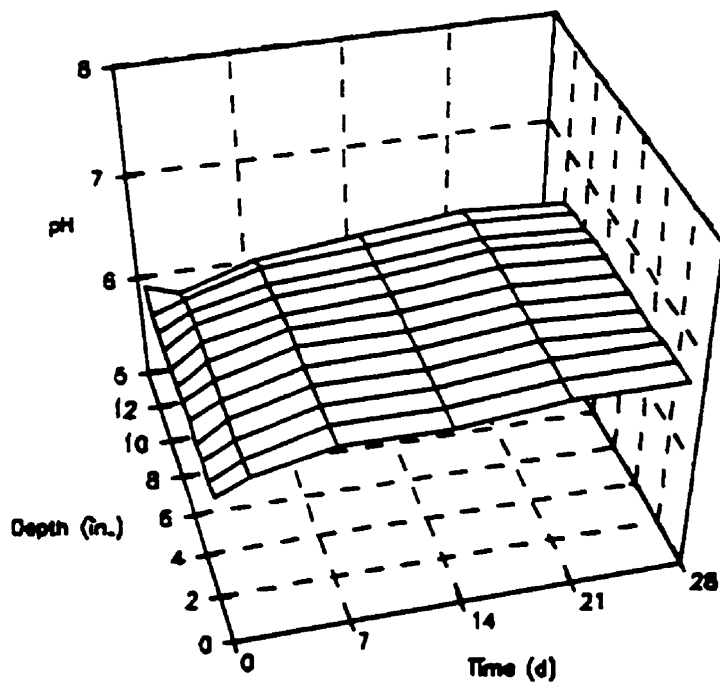
Column 1: 1/4" granite, with SRB

pH

Depth (")	Day -2	0	2	7	14	21	28
0	7.05	6.25	6.4	6.55	6.55	6.65	6.65
1	7.05	6.2	6.35	6.55	6.55	6.65	6.65
2	7.05	6.2	6.35	6.55	6.55	6.65	6.65
3	7.05	6.15	6.35	6.55	6.55	6.65	6.6
4	7	6.2	6.35	6.55	6.55	6.65	6.6
5	7	6.2	6.35	6.55	6.55	6.65	6.6
6	7	6.15	6.35	6.55	6.55	6.65	6.6
7	6.9	6.15	6.35	6.5	6.55	6.65	6.6
8	6.85	6.15	6.35	6.5	6.55	6.65	6.6
9	6.65	6.15	6.3	6.45	6.5	6.6	6.55
10	6.55	6.15	6.25	6.45	6.5	6.6	6.55
11	6.45	6.25	6.15	6.35	6.45	6.55	6.5
12	6.4	6.35	6.35	6.45	6.5	6.5	6.55

ORP (mV)

Depth (")	Day -2	0	2	7	14	21	28
0	-390	-325	-345	-360	-355	-375	-380
1	-390	-330	-345	-360	-360	-380	-380
2	-390	-325	-345	-360	-360	-380	-380
3	-390	-325	-345	-360	-365	-380	-380
4	-390	-325	-345	-360	-365	-380	-380
5	-395	-325	-345	-360	-365	-380	-380
6	-395	-330	-345	-360	-365	-380	-380
7	-380	-330	-340	-360	-365	-375	-380
8	-375	-330	-340	-355	-365	-375	-380
9	-365	-335	-325	-355	-365	-375	-380
10	-360	-345	-315	-355	-360	-370	-375
11	-360	-350	-335	-355	-365	-375	-380
12	-360	-340	-360	-375	-375	-385	-385



Changes in pH and ORP over time and depth.
 Column 1: 1/4" granite inoculated with SRB. Cycle 4: $V_c = 4L$.

CYCLE 4

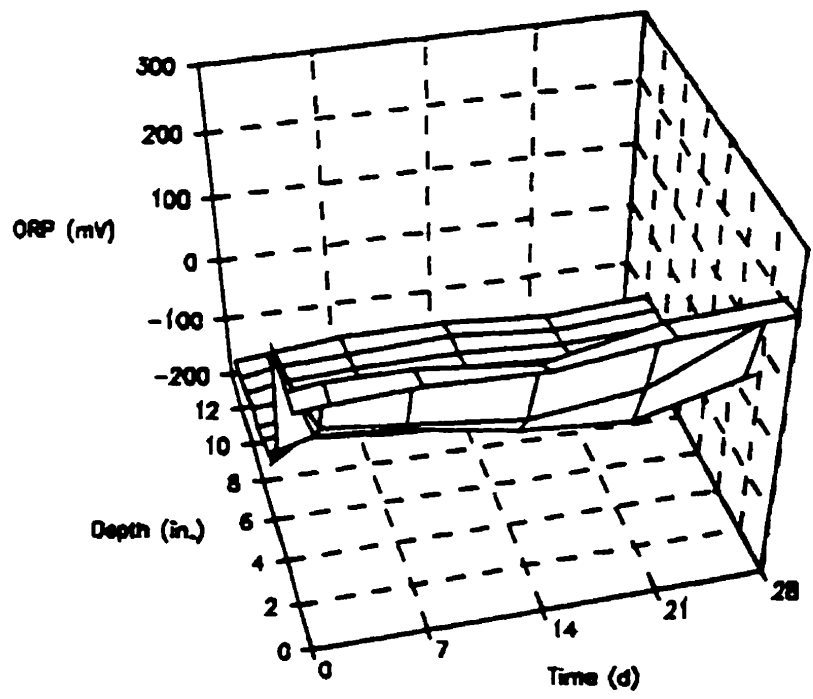
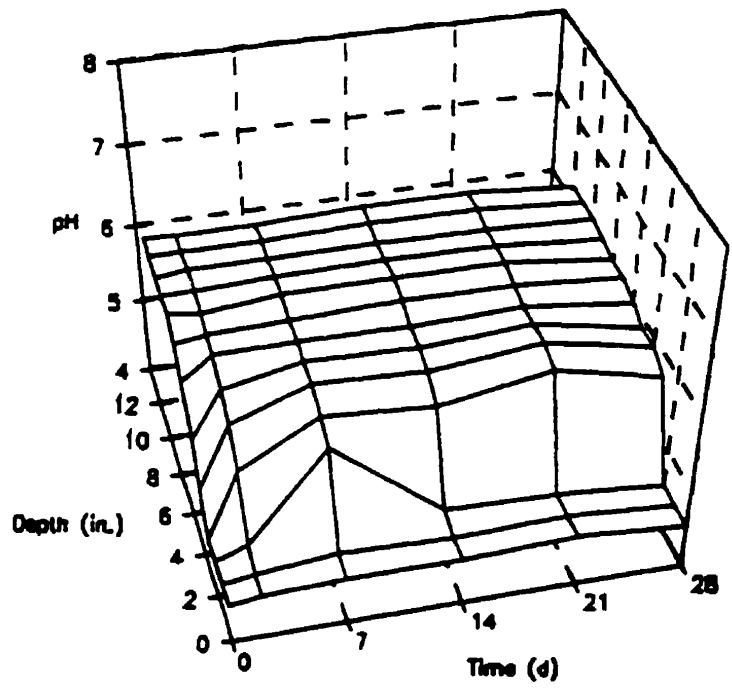
Column 2: 1/4" granite, no SRB

pH

Depth (")	Day -2	0	2	7	14	21	28
0	5.3	4.5	4.55	4.6	4.6	4.65	4.55
1	5.65	4.5	4.55	4.65	4.6	4.65	4.55
2	5.85	4.5	4.65	5.75	4.7	4.65	4.55
3	6.05	4.5	5.35	5.9	5.8	6.05	5.75
4	6.1	4.9	5.7	6.05	6	6.15	5.9
5	6.15	5.3	5.9	6.1	6.05	6.15	5.9
6	6.2	5.8	6.1	6.1	6.1	6.15	6
7	6.2	6.05	6.1	6.15	6.2	6.2	6.1
8	6.2	6.2	6.15	6.25	6.25	6.25	6.1
9	6.2	6.2	6.2	6.25	6.25	6.25	6.15
10	6.2	6.2	6.25	6.25	6.25	6.25	6.2
11	6.2	6.25	6.25	6.25	6.3	6.3	6.2
12	6.25	6.25	6.25	6.25	6.3	6.3	6.2

ORP (mV)

Depth (")	Day -2	0	2	7	14	21	28
0	45	175	180	185	180	200	210
1	-25	175	180	180	160	195	205
2	-75	175	80	65	45	65	145
3	-95	175	35	25	-5	-20	25
4	-105	-15	0	-15	-25	-45	-10
5	-105	-65	-30	-40	-35	-55	-30
6	-115	-85	-60	-55	-65	-70	-65
7	-120	-95	-90	-75	-75	-85	-65
8	-120	-105	-100	-85	-85	-100	-80
9	-125	-105	-100	-85	-90	-100	-95
10	-125	-110	-100	-95	-95	-105	-100
11	-125	-115	-105	-100	-95	-110	-100
12	-125	-115	-110	-100	-100	-115	-105



Changes in pH and ORP over time and depth.
 Column 2: 1/4" granite with no SRB, control. Cycle 4: $V_c = 4L$.

CYCLE 4

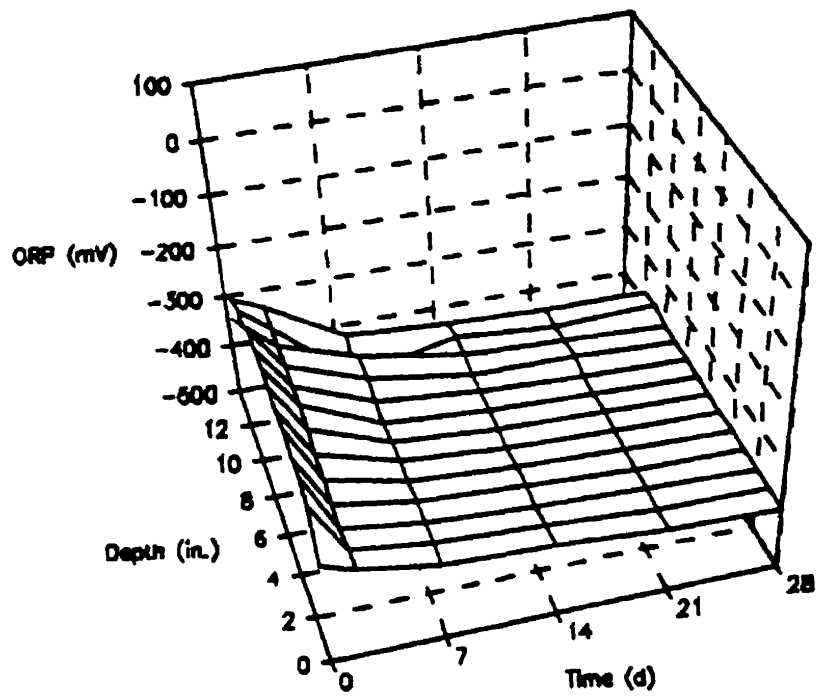
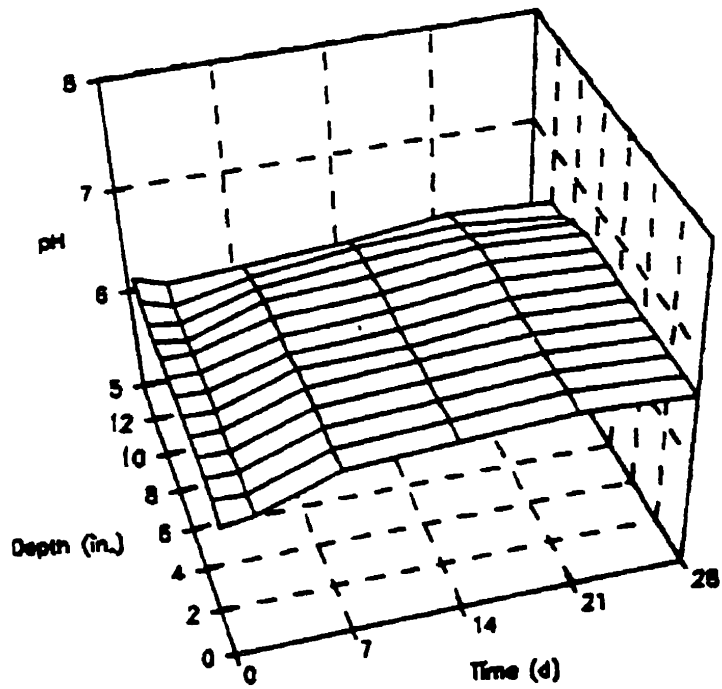
Column 3: 1/4" limestone, with SRB

pH

Depth (")	Day	0	2	7	14	21	28
0	7.05	6.3	6.35	6.6	6.65	6.7	6.65
1	7.05	6.35	6.35	6.6	6.65	6.7	6.65
2	7	6.35	6.35	6.6	6.65	6.7	6.65
3	7	6.35	6.35	6.6	6.65	6.7	6.65
4	7	6.35	6.35	6.6	6.65	6.7	6.65
5	7	6.35	6.35	6.6	6.6	6.7	6.65
6	7	6.35	6.35	6.55	6.6	6.7	6.65
7	6.95	6.35	6.35	6.55	6.6	6.7	6.65
8	6.8	6.35	6.35	6.55	6.6	6.7	6.65
9	6.65	6.35	6.3	6.55	6.6	6.7	6.65
10	6.55	6.35	6.3	6.5	6.6	6.65	6.6
11	6.5	6.4	6.3	6.45	6.55	6.6	6.5
12	6.45	6.45	6.35	6.4	6.45	6.55	6.5

ORP (mV)

Depth (")	Day	0	2	7	14	21	28
0	-385	-305	-325	-350	-360	-375	-380
1	-385	-230	-330	-350	-360	-375	-380
2	-385	-215	-330	-350	-365	-375	-380
3	-390	-220	-325	-350	-365	-375	-380
4	-390	-205	-315	-350	-365	-375	-380
5	-390	-205	-305	-350	-365	-375	-380
6	-390	-200	-295	-350	-365	-375	-380
7	-385	-200	-285	-350	-365	-375	-380
8	-365	-200	-285	-345	-365	-375	-380
9	-365	-200	-280	-335	-365	-370	-380
10	-360	-225	-275	-325	-360	-370	-380
11	-360	-230	-275	-400	-360	-375	-370
12	-365	-240	-265	-350	-365	-375	-375



Changes in pH and ORP over time and depth.
 Column 3: 1/4" limestone inoculated with SRB. Cycle 4: $V_c = 4L$.

CYCLE 4

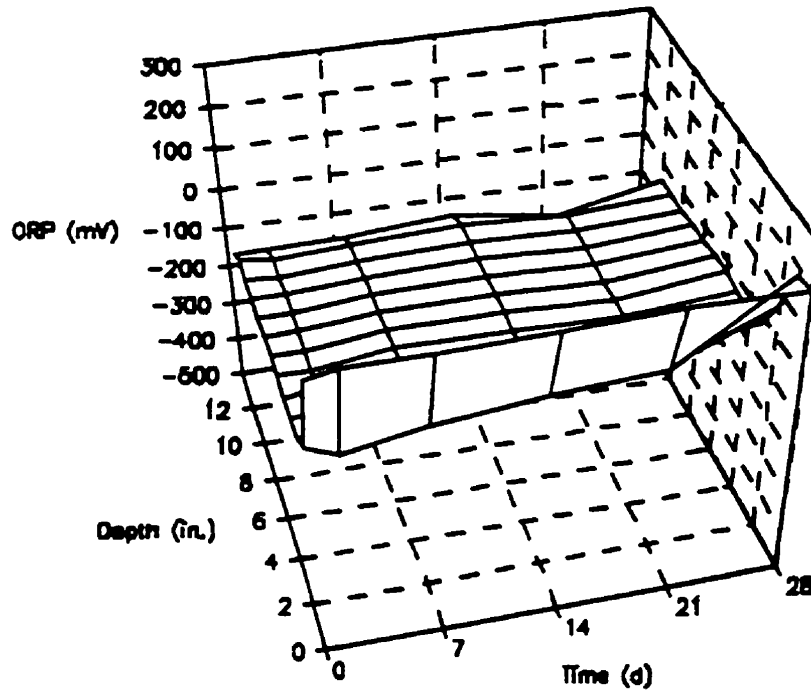
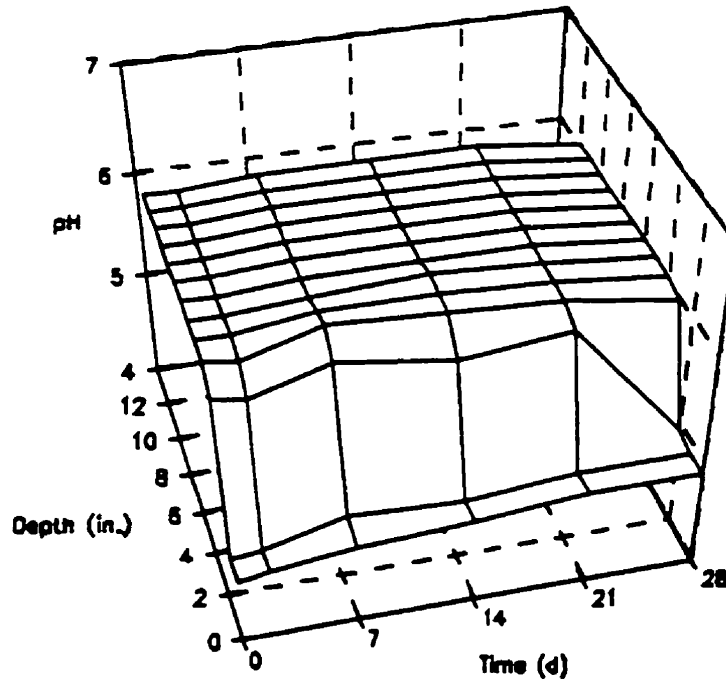
Column 7: 1/4" limestone, no SRB

pH

Depth (")	Day						
	-2	0	2	7	14	21	28
0	6.05	4.6	4.65	4.75	4.8	4.9	4.9
1	6.1	4.6	4.65	4.85	4.8	4.9	4.9
2	6.2	5.95	5.9	6.1	5.95	6.05	4.95
3	6.2	6.1	6.05	6.25	6.2	6.15	6
4	6.2	6.1	6.1	6.2	6.2	6.15	6.05
5	6.2	6.1	6.1	6.15	6.2	6.15	6.05
6	6.15	6.1	6.1	6.15	6.15	6.15	6.05
7	6.15	6.1	6.1	6.15	6.15	6.15	6.05
8	6.15	6.1	6.1	6.15	6.15	6.15	6.05
9	6.15	6.1	6.1	6.15	6.15	6.15	6.05
10	6.15	6.1	6.1	6.15	6.15	6.15	6.05
11	6.15	6.1	6.1	6.15	6.15	6.15	6.05
12	6.15	6.1	6.1	6.15	6.15	6.15	6.05

ORP (mV)

Depth (")	Day						
	-2	0	2	7	14	21	28
0	-50	170	185	185	190	200	195
1	-70	-35	-65	-30	-5	10	185
2	-95	-65	-70	-45	-45	-45	65
3	-95	-70	-55	-50	-45	-50	-15
4	-90	-70	-55	-45	-45	-45	-35
5	-85	-65	-65	-40	-45	-50	-30
6	-80	-65	-65	-45	-45	-55	-25
7	-75	-65	-65	-45	-45	-55	-30
8	-70	-65	-65	-50	-45	-55	-35
9	-65	-65	-65	-50	-45	-55	-35
10	-65	-60	-65	-55	-45	-55	-40
11	-60	-55	-65	-55	-45	-55	-40
12	-90	-85	-85	-80	-60	-100	-45



Changes in pH and ORP over time and depth.
 Column 7: 1/4" limestone with no SRB, control. Cycle 4: $V_c = 4L$.

CYCLE 4

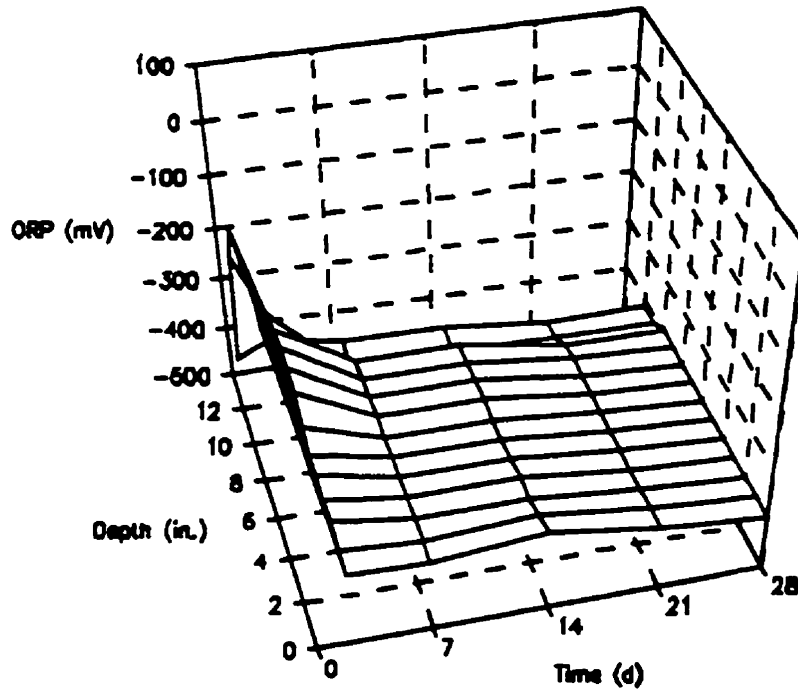
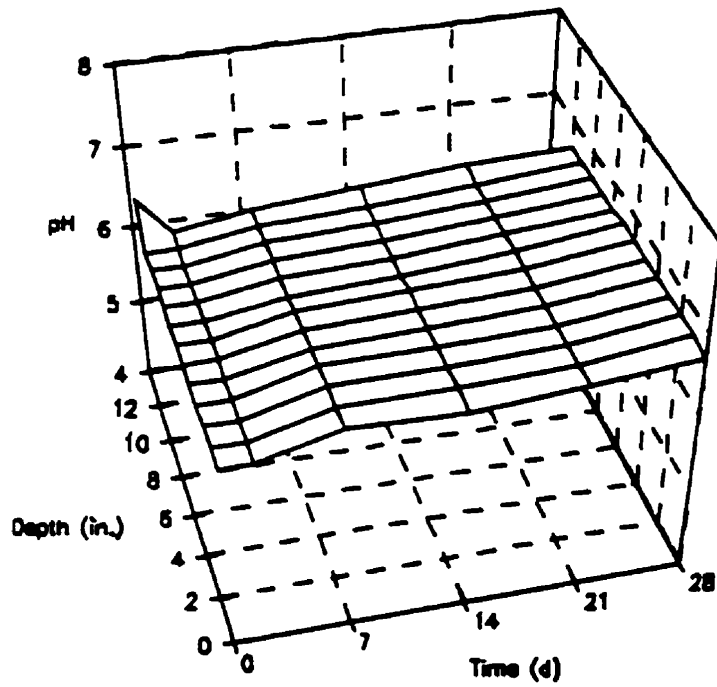
Column 4: 1/2" granite, with SRB

pH

Depth (")	Day -2	0	2	7	14	21	28
0	7.3	6.3	6.3	6.55	6.5	6.6	6.7
1	7.2	6.3	6.3	6.55	6.55	6.6	6.75
2	7.2	6.3	6.3	6.55	6.55	6.6	6.75
3	7.15	6.3	6.3	6.55	6.55	6.6	6.75
4	7.1	6.3	6.3	6.5	6.55	6.6	6.75
5	7.05	6.3	6.3	6.5	6.55	6.6	6.75
6	7	6.3	6.3	6.5	6.55	6.6	6.75
7	6.9	6.3	6.3	6.45	6.5	6.6	6.75
8	6.9	6.3	6.3	6.45	6.5	6.6	6.7
9	6.9	6.3	6.3	6.45	6.5	6.6	6.7
10	6.9	6.3	6.3	6.45	6.5	6.6	6.7
11	6.85	6.3	6.3	6.45	6.5	6.6	6.7
12	6.85	6.75	6.3	6.45	6.55	6.65	6.7

ORP (mV)

Depth (")	Day -2	0	2	7	14	21	28
0	-375	-80	-365	-370	-350	-380	-395
1	-375	-85	-360	-370	-355	-380	-395
2	-375	-85	-345	-365	-365	-385	-395
3	-385	-85	-345	-365	-365	-385	-395
4	-395	-85	-335	-365	-365	-385	-395
5	-400	-85	-335	-365	-365	-385	-395
6	-405	-80	-320	-365	-365	-385	-395
7	-405	-80	-290	-360	-360	-385	-395
8	-405	-80	-280	-360	-360	-385	-395
9	-405	-80	-275	-360	-360	-385	-395
10	-405	-80	-275	-360	-360	-395	-395
11	-405	-160	-280	-420	-410	-415	-415
12	-405	-395	-370	-390	-395	-415	-415



Changes in pH and ORP over time and depth.
 Column 4: 1/2" granite inoculated with SRB. Cycle 4: $V_c = 4L$.

CYCLE 4

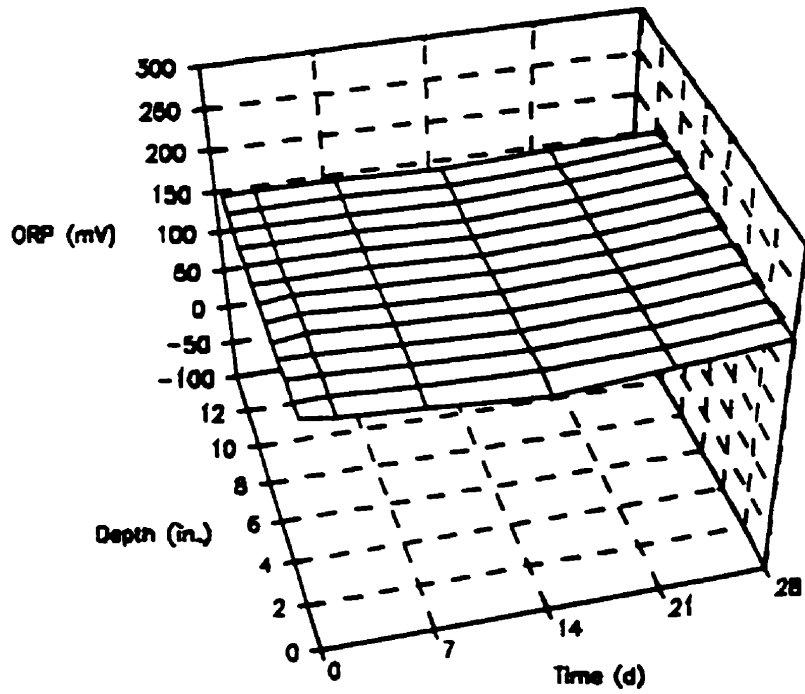
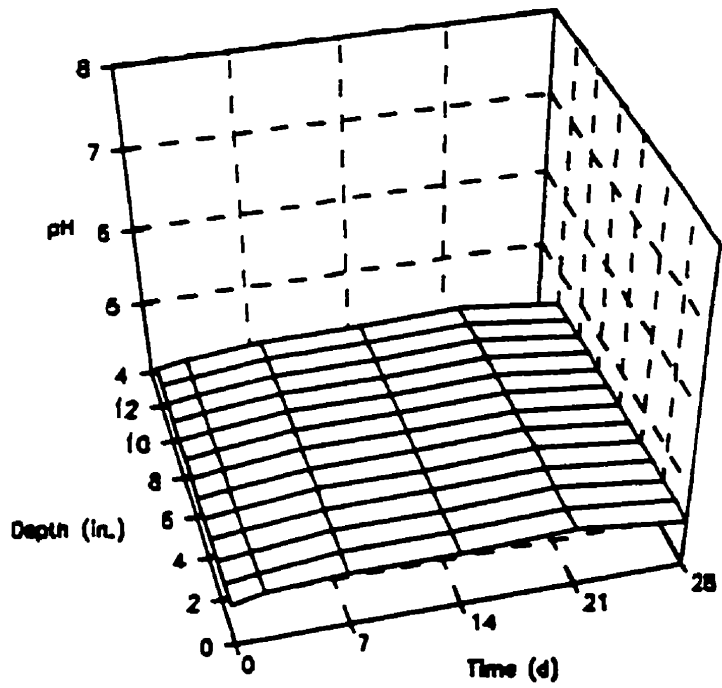
Column 5: 1/2" granite, no SRB

pH

Depth (")	Day -2	0	2	7	14	21	28
0	4.9	4.55	4.65	4.7	4.7	4.75	4.6
1	4.9	4.55	4.6	4.7	4.7	4.75	4.6
2	4.9	4.55	4.6	4.7	4.7	4.75	4.6
3	4.9	4.55	4.6	4.7	4.7	4.75	4.6
4	4.9	4.55	4.6	4.7	4.7	4.75	4.6
5	4.9	4.55	4.6	4.7	4.7	4.75	4.6
6	4.9	4.55	4.6	4.7	4.7	4.75	4.6
7	4.9	4.55	4.6	4.7	4.7	4.75	4.6
8	4.9	4.55	4.6	4.7	4.7	4.75	4.6
9	4.9	4.55	4.6	4.7	4.7	4.75	4.6
10	4.9	4.55	4.6	4.7	4.7	4.75	4.6
11	4.9	4.55	4.6	4.7	4.7	4.75	4.6
12	4.9	4.55	4.6	4.7	4.7	4.75	4.6

ORP (mV)

Depth (")	Day -2	0	2	7	14	21	28
0	150	195	190	185	175	185	195
1	155	190	190	185	180	185	195
2	155	190	190	185	180	185	195
3	155	190	190	185	180	185	195
4	155	185	190	185	180	185	195
5	155	185	190	185	180	185	195
6	155	185	190	185	180	185	195
7	155	185	185	185	180	185	195
8	155	185	185	185	180	185	195
9	155	185	185	185	180	185	195
10	155	185	185	185	180	185	195
11	155	185	185	185	180	185	195
12	155	185	185	185	180	185	190



Changes in pH and ORP over time and depth.
 Column 5: 1/2" granite with no SRB, control. Cycle 4: $V_c = 4L$.

CYCLE 4

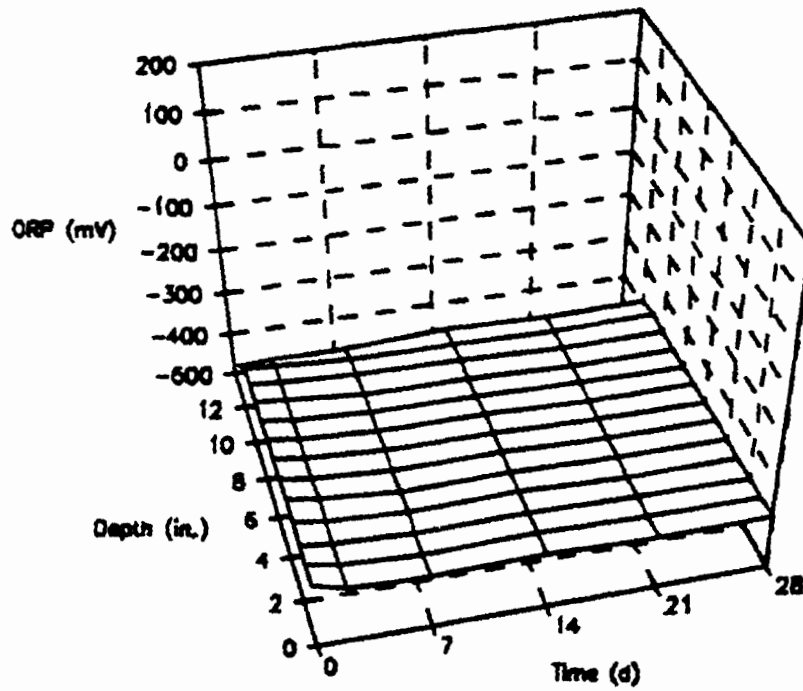
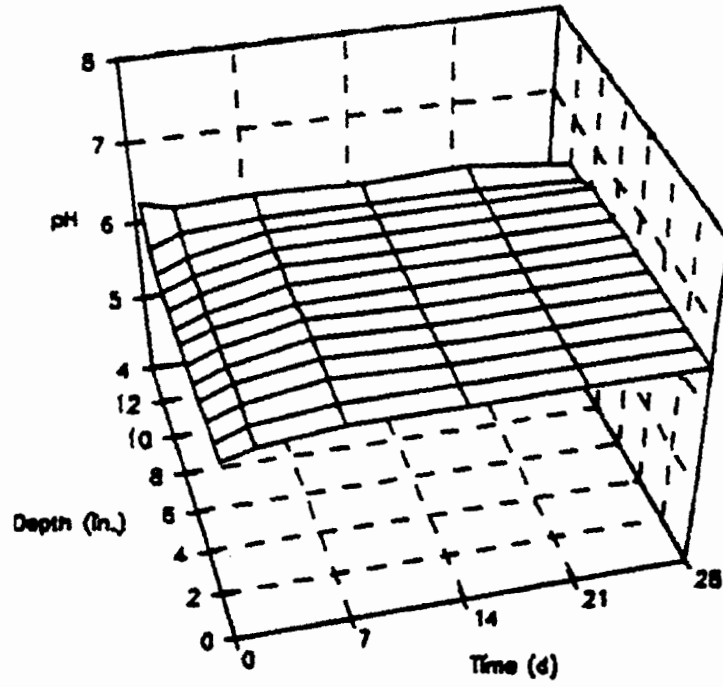
Column 6: 1/2" limestone, with SRB

pH

Depth (")	Day	0	2	7	14	21	28
0	7	6.35	6.45	6.55	6.55	6.55	6.55
1	7	6.3	6.45	6.55	6.55	6.55	6.55
2	7	6.3	6.45	6.6	6.55	6.55	6.55
3	7	6.3	6.45	6.6	6.55	6.55	6.55
4	7	6.25	6.4	6.6	6.55	6.55	6.55
5	7	6.25	6.4	6.6	6.55	6.55	6.55
6	7	6.25	6.4	6.55	6.55	6.55	6.55
7	7	6.2	6.35	6.55	6.55	6.55	6.55
8	7	6.2	6.35	6.55	6.55	6.55	6.55
9	6.85	6.2	6.35	6.55	6.55	6.55	6.55
10	6.8	6.2	6.35	6.55	6.55	6.55	6.55
11	6.75	6.3	6.45	6.5	6.5	6.5	6.45
12	6.7	6.65	6.55	6.6	6.55	6.6	6.45

ORP (mV)

Depth (")	Day	0	2	7	14	21	28
0	-395	-355	-375	-380	-375	-380	-375
1	-400	-360	-375	-380	-375	-380	-380
2	-400	-365	-375	-380	-375	-380	-380
3	-400	-360	-370	-380	-375	-380	-380
4	-400	-355	-365	-380	-375	-380	-380
5	-400	-355	-365	-375	-375	-380	-380
6	-400	-355	-365	-375	-375	-380	-380
7	-400	-355	-365	-375	-375	-380	-380
8	-400	-355	-365	-375	-375	-380	-380
9	-395	-355	-360	-375	-375	-380	-380
10	-390	-355	-360	-370	-370	-380	-380
11	-390	-360	-365	-375	-375	-380	-375
12	-400	-395	-390	-390	-380	-385	-385



Changes in pH and ORP over time and depth.
 Column 6: 1/2" limestone inoculated with SRB. Cycle 4: $V_c = 4L$.

CYCLE 5

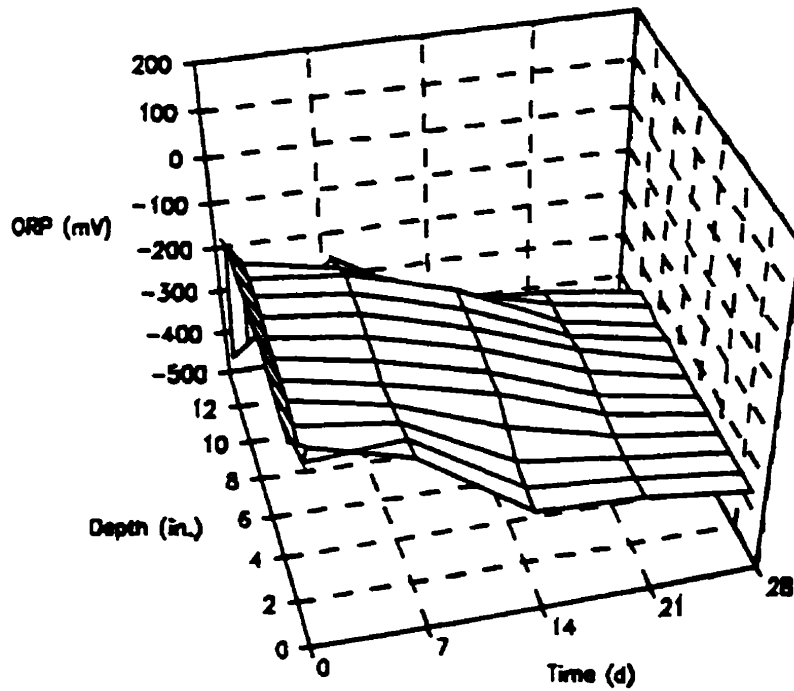
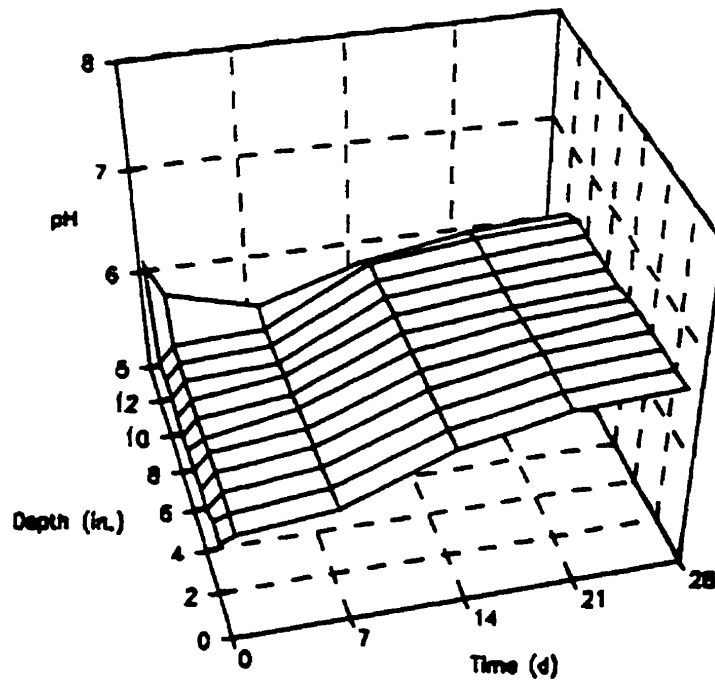
Column 1: 1/4" granite, with SRB

pH

Depth (")	Day -1	0	1	7	14	21	28	35
0	6.95	5.75	5.8	5.9	6.3	6.5	6.55	6.65
1	6.95	5.75	5.8	5.9	6.3	6.5	6.55	6.65
2	6.95	5.65	5.8	5.9	6.3	6.5	6.55	6.65
3	6.95	5.65	5.8	5.9	6.3	6.5	6.55	6.65
4	6.95	5.65	5.8	5.9	6.3	6.45	6.55	6.65
5	6.95	5.65	5.75	5.9	6.3	6.45	6.5	6.65
6	6.95	5.6	5.75	5.85	6.3	6.4	6.45	6.65
7	6.95	5.6	5.75	5.85	6.3	6.4	6.45	6.6
8	6.9	5.6	5.75	5.8	6.3	6.4	6.45	6.55
9	6.9	5.6	5.75	5.8	6.3	6.4	6.45	6.55
10	6.9	5.6	5.75	5.8	6.3	6.4	6.45	6.5
11	6.85	6.4	6.1	5.85	6.15	6.3	6.35	6.45
12	6.85	6.8	6.75	6.2	6.2	6.4	6.35	6.45

ORP (mV)

Depth (")	Day -1	0	1	7	14	21	28	35
0	-395	-85	-100	-160	-325	-335	-365	-375
1	-400	-75	-180	-165	-320	-335	-365	-380
2	-400	-70	-145	-175	-305	-335	-365	-380
3	-400	-65	-135	-180	-270	-330	-365	-380
4	-400	-60	-135	-180	-240	-325	-365	-380
5	-400	-60	-130	-170	-235	-325	-365	-380
6	-400	-60	-130	-160	-225	-315	-365	-375
7	-400	-60	-125	-150	-220	-305	-365	-375
8	-400	-60	-120	-145	-215	-315	-360	-375
9	-400	-60	-120	-140	-210	-320	-365	-375
10	-400	-80	-125	-165	-255	-320	-360	-375
11	-400	-375	-350	-180	-320	-330	-365	-375
12	-405	-395	-400	-375	-380	-365	-385	-390



Changes in pH and ORP over time and depth.
 Column 1: 1/4" granite inoculated with SRB. Cycle 5: $V_c = 2L$.

CYCLE 5

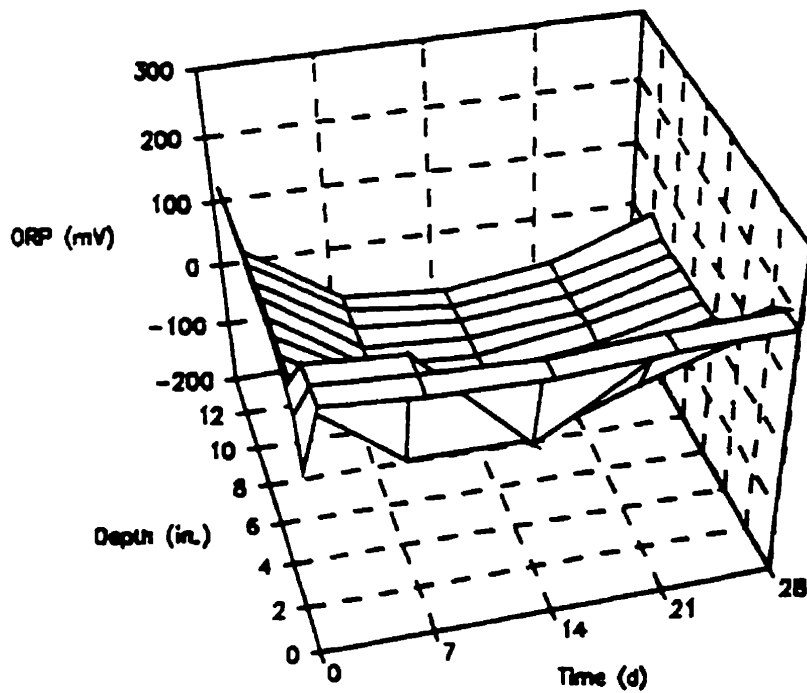
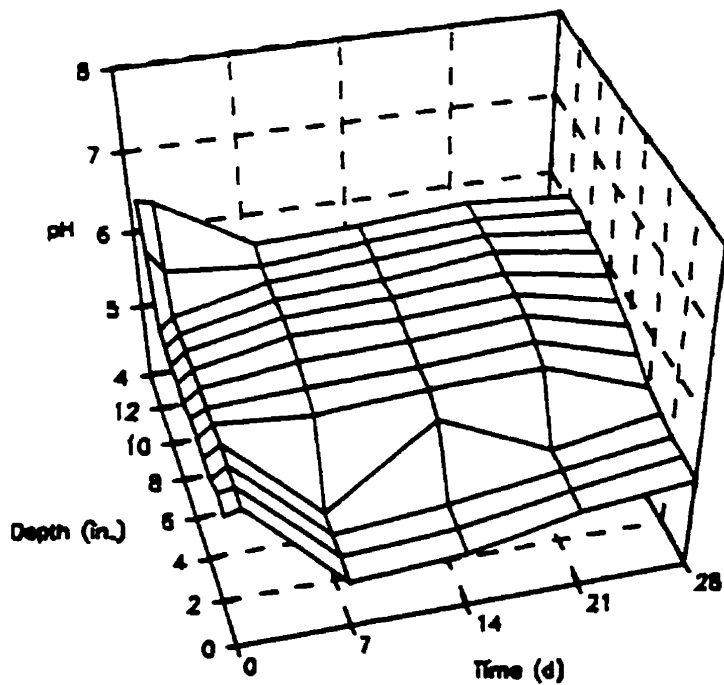
Column 2: 1/4" granite, ctl

pH

Depth (")	Day -1	0	1	7	14	21	28	35
0	6.95	5.75	5.8	4.6	4.7	5	5.15	5.3
1	6.95	5.75	5.8	4.65	4.75	5	5.2	5.35
2	6.95	5.65	5.8	4.65	4.8	5	5.2	5.35
3	6.95	5.65	5.8	4.65	5.65	5	5.25	5.4
4	6.95	5.65	5.8	5.7	5.8	5.85	5.35	5.6
5	6.95	5.65	5.75	5.8	5.85	5.95	5.55	5.85
6	6.95	5.6	5.75	5.9	5.95	6.05	5.7	5.95
7	6.95	5.6	5.75	6	6	6.1	5.8	6
8	6.9	5.6	5.75	6	6.05	6.15	5.9	6.1
9	6.9	5.6	5.75	6	6.05	6.2	6	6.1
10	6.9	5.6	5.75	6	6.1	6.2	6.05	6.15
11	6.85	6.4	6.1	6	6.1	6.2	6.1	6.15
12	6.85	6.8	6.75	6.05	6.1	6.2	6.1	6.15

ORP

Depth (")	Day -1	0	1	7	14	21	28	35
0	215	95	185	175	170	180	185	190
1	215	145	185	175	170	180	185	190
2	90	155	185	175	5	110	160	175
3	25	170	90	-20	-20	40	90	140
4	-20	175	80	-20	-30	20	60	120
5	-45	175	75	-15	-35	0	45	75
6	-70	175	75	-20	-35	-15	30	60
7	-80	175	75	-15	-35	-15	25	55
8	-90	175	75	-25	-35	-10	25	60
9	-110	175	80	-25	-35	-20	25	70
10	-105	175	75	-20	-35	-20	20	55
11	-105	175	75	-20	-40	-20	20	65
12	-110	175	70	-25	-40	-20	35	60



Changes in pH and ORP over time and depth.
 Column 2: 1/4" granite with no SRB, control. Cycle 5: $V_c = 2L$.

CYCLE 5

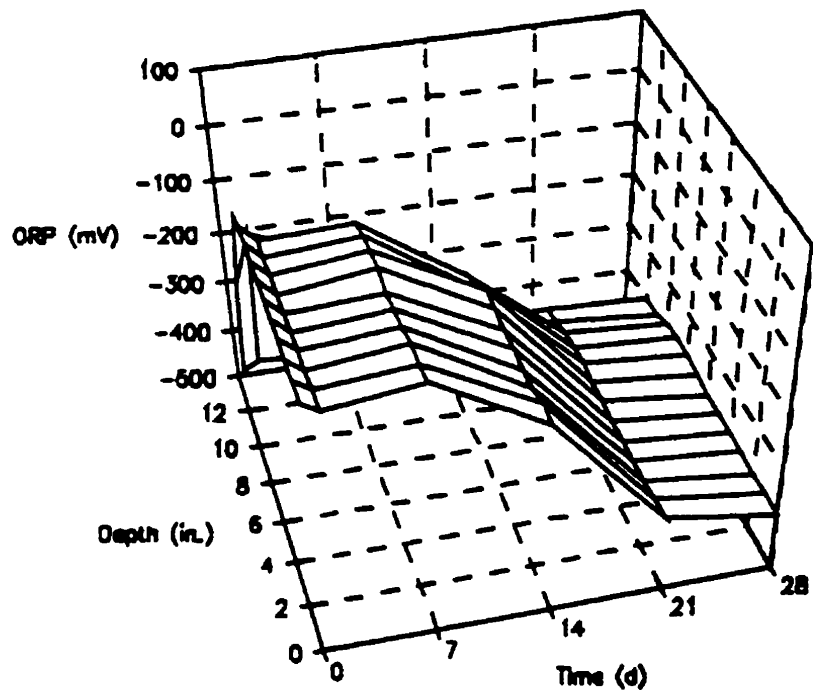
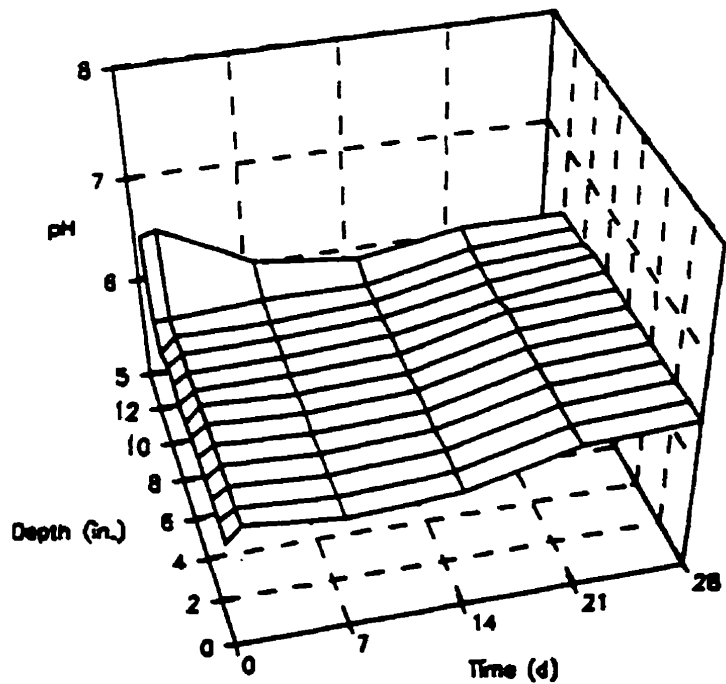
Column 3: 1/4" limestone, with SRB

pH

Depth (")	Day -1	0	1	7	14	21	28	35
0	7.3	6.05	6.2	6.1	6.15	6.4	6.45	6.55
1	7.3	6.05	6.15	6.1	6.15	6.4	6.45	6.55
2	7.3	6.05	6.15	6.1	6.15	6.4	6.45	6.55
3	7.3	6.05	6.15	6.1	6.15	6.4	6.45	6.55
4	7.3	6.05	6.15	6.1	6.15	6.4	6.45	6.55
5	7.3	6.05	6.15	6.1	6.15	6.4	6.45	6.55
6	7.3	6	6.15	6.1	6.15	6.4	6.45	6.55
7	7.3	6	6.1	6.1	6.15	6.4	6.45	6.55
8	7.3	6	6.1	6.1	6.15	6.35	6.45	6.55
9	7.25	6	6.1	6.1	6.15	6.35	6.45	6.5
10	7.05	5.95	6.1	6.1	6.15	6.35	6.4	6.45
11	6.95	6.1	6.1	6.15	6.15	6.35	6.4	6.45
12	6.8	6.75	6.8	6.35	6.25	6.4	6.4	6.45

ORP

Depth (")	Day -1	0	1	7	14	21	28	35
0	-410	-30	-50	-30	-140	-355	-390	-390
1	-410	-30	-50	-35	-140	-360	-390	-390
2	-410	-30	-55	-35	-150	-365	-390	-390
3	-410	-30	-55	-40	-155	-365	-385	-390
4	-410	-30	-60	-45	-150	-365	-385	-390
5	-410	-30	-60	-50	-150	-365	-385	-390
6	-410	-30	-60	-40	-145	-360	-385	-390
7	-410	-30	-60	-40	-145	-360	-380	-390
8	-410	-30	-60	-45	-175	-355	-375	-385
9	-410	-30	-60	-55	-185	-360	-375	-380
10	-400	-45	-130	-220	-210	-365	-380	-380
11	-395	-205	-110	-195	-370	-375	-395	-390
12	-395	-415	-400	-410	-390	-385	-395	-390



Changes in pH and ORP over time and depth.
 Column 3: 1/4" limestone inoculated with SRB. Cycle 5: $V_c = 2L$.

CYCLE 5

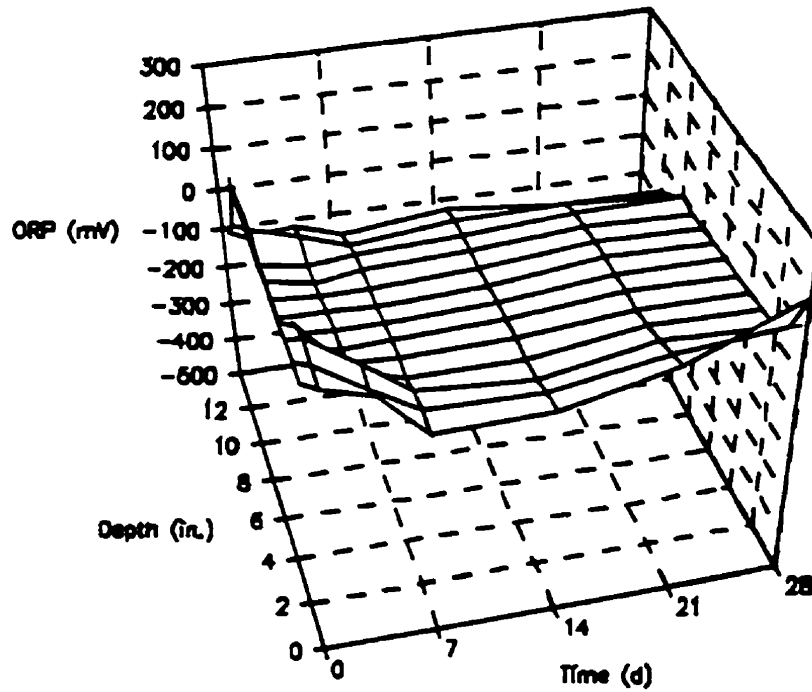
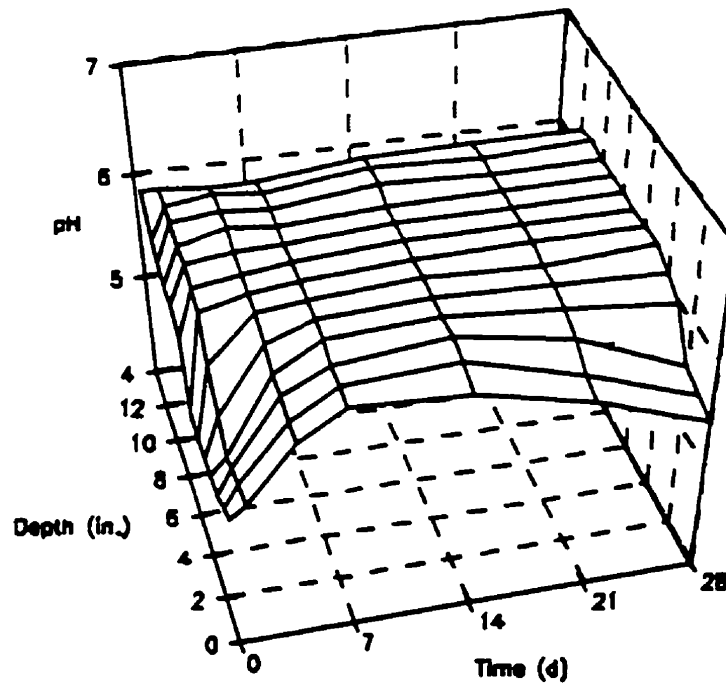
Column 7: 1/4" limestone, ctl

pH

Depth (")	Day -1	0	1	7	14	21	28	35
0	6.15	5.8	5.75	5.35	5.55	5.8	5.75	5.8
1	6.2	5.8	5.75	5.35	5.6	5.85	5.8	5.85
2	6.2	5.85	5.8	5.45	5.65	5.9	5.85	5.9
3	6.2	5.85	5.9	5.8	5.8	6.05	5.95	6
4	6.2	5.9	6	5.95	5.9	6.15	6	6.1
5	6.2	5.9	6.1	6.05	6.05	6.2	6.05	6.15
6	6.2	5.85	6.15	6.05	6.1	6.2	6.1	6.2
7	6.2	5.85	6.2	6.1	6.1	6.2	6.15	6.2
8	6.2	5.8	6.2	6.1	6.1	6.2	6.15	6.2
9	6.15	5.8	6.2	6.1	6.1	6.2	6.15	6.2
10	6.15	5.8	6.2	6.1	6.1	6.2	6.2	6.2
11	6.2	5.85	6.2	6.1	6.1	6.2	6.2	6.2
12	6.15	6.2	6.25	6.1	6.1	6.2	6.2	6.2

ORP (mV)

Depth (")	Day -1	0	1	7	14	21	28	35
0	0	120	85	125	90	95	125	135
1	-5	125	80	120	90	85	110	130
2	-15	135	-15	-30	-15	75	75	80
3	-10	130	-15	-45	-25	-5	50	0
4	-10	130	-25	-45	-45	-25	-25	-15
5	-5	140	-30	-55	-60	-35	-25	-15
6	-5	140	-35	-65	-60	-40	-25	-25
7	0	140	-35	-65	-55	-45	-40	-20
8	0	135	-40	-65	-55	-40	-40	-25
9	5	130	-40	-65	-60	-45	-40	-25
10	5	130	-40	-65	-45	-45	-45	-30
11	-10	20	-40	-70	-75	-45	-50	-30
12	-35	-25	-45	-70	-110	-65	-60	-25



Changes in pH and ORP over time and depth.
 Column 7: 1/4" limestone with no SRB, control. Cycle 5: $V_c = 2L$.

CYCLE 5

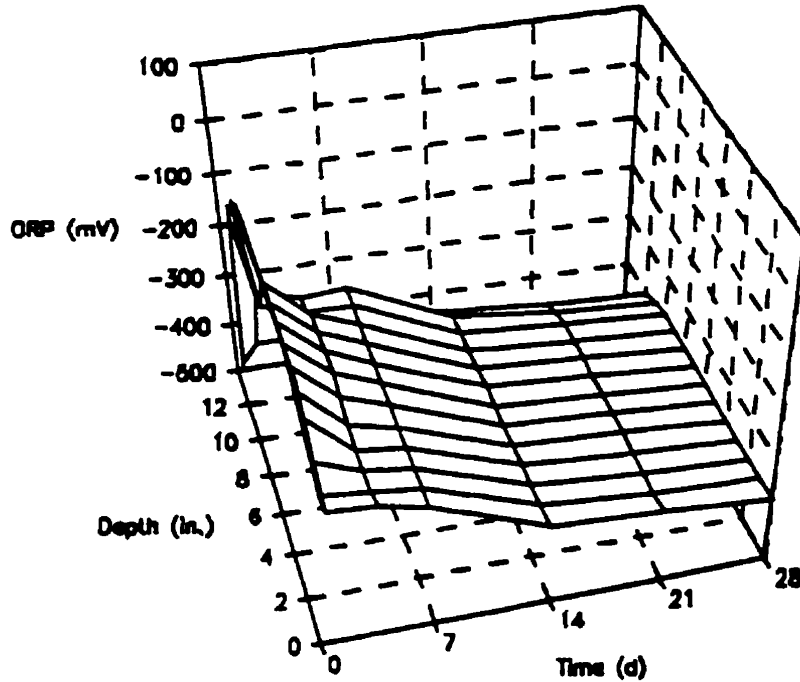
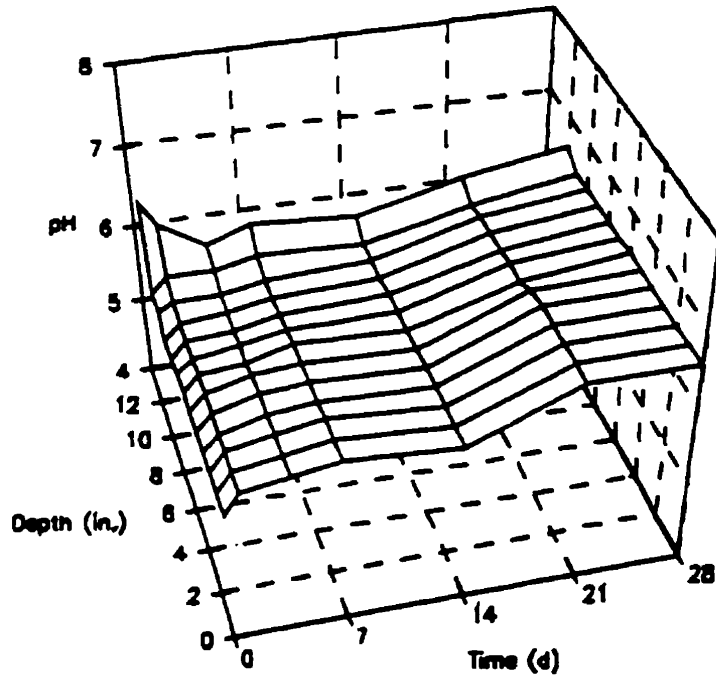
Column 4: 1/2" granite, with SRB

pH

Depth (")	Day -1	0	1	4	7	14	21	28	35
0	6.95	5.65	5.9	6	6.1	6	6.55	6.55	6.7
1	6.95	5.65	5.9	6	6.1	6	6.55	6.55	6.7
2	6.95	5.65	5.9	6	6.1	6	6.55	6.55	6.7
3	6.95	5.65	5.85	6	6.05	6	6.55	6.55	6.7
4	6.95	5.65	5.85	6	6.05	6	6.55	6.55	6.7
5	6.95	5.65	5.85	6	6.05	6	6.5	6.55	6.65
6	6.95	5.65	5.85	5.9	6.05	6	6.4	6.55	6.65
7	6.95	5.65	5.8	5.9	6	6	6.4	6.5	6.6
8	6.95	5.6	5.8	5.85	5.95	6	6.35	6.5	6.6
9	6.95	5.6	5.8	5.85	5.95	6	6.35	6.5	6.6
10	6.95	5.75	5.85	5.85	5.95	6	6.35	6.5	6.55
11	6.95	5.75	5.95	5.95	6.05	6	6.3	6.5	6.6
12	6.95	6.7	6.4	6.05	6.25	6.15	6.45	6.65	6.65

ORP (mV)

Depth (")	-1	0	1	4	7	14	21	28	35
0	-400	-5	-245	-250	-270	-350	-360	-375	-385
1	-400	-5	-255	-265	-275	-350	-365	-375	-385
2	-400	-5	-230	-265	-275	-350	-365	-375	-385
3	-400	-5	-185	-265	-275	-350	-365	-375	-385
4	-400	-5	-175	-255	-275	-350	-360	-375	-385
5	-405	-5	-165	-240	-270	-350	-360	-375	-385
6	-405	-5	-160	-230	-265	-350	-360	-375	-380
7	-405	-5	-155	-225	-265	-345	-360	-375	-380
8	-405	-5	-155	-225	-260	-345	-360	-375	-380
9	-410	-5	-150	-225	-260	-345	-360	-375	-380
10	-410	-35	-230	-255	-255	-345	-360	-375	-380
11	-410	-85	-240	-260	-255	-345	-370	-385	-380
12	-410	-410	-375	-375	-355	-370	-390	-400	-390



Changes in pH and ORP over time and depth.
 Column 4: 1/2" granite inoculated with SRB. Cycle 5: $V_c = 2L$.

CYCLE 5

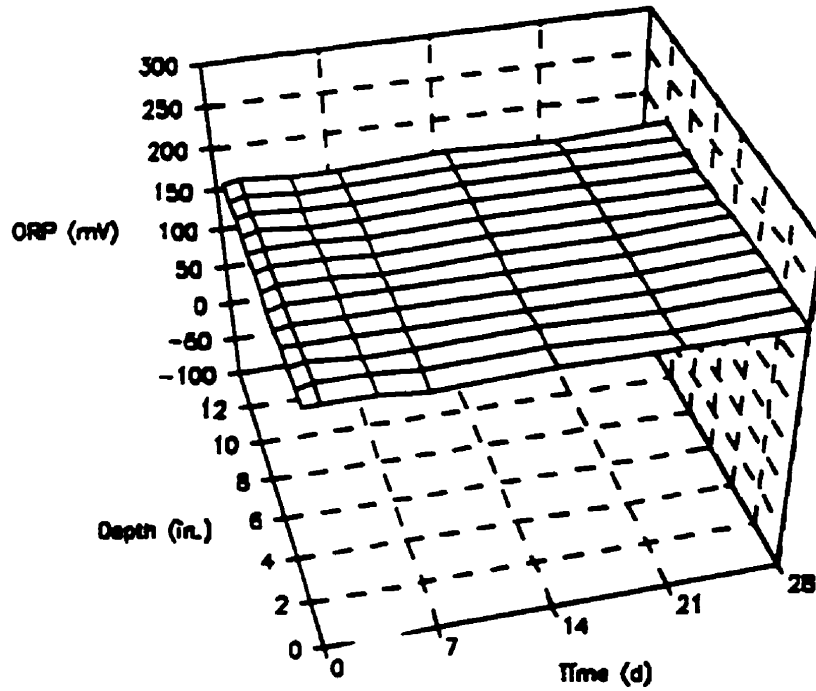
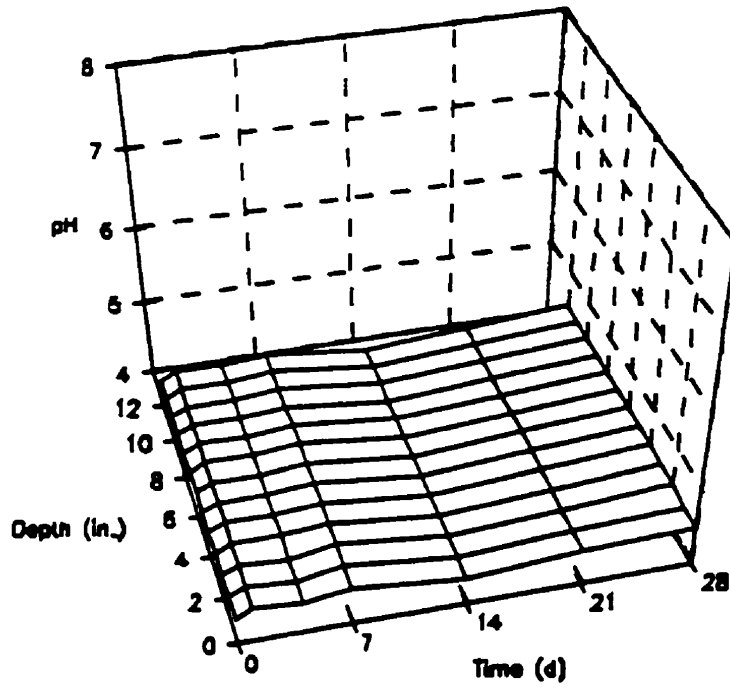
Column 5: 1/2" granite, no SRB

pH

Depth (")	Day -1	0	1	4	7	14	21	28	35
0	4.7	4.35	4.45	4.4	4.5	4.35	4.45	4.5	4.65
1	4.7	4.35	4.45	4.4	4.5	4.35	4.45	4.5	4.65
2	4.75	4.35	4.45	4.4	4.5	4.35	4.45	4.55	4.65
3	4.75	4.35	4.45	4.45	4.5	4.35	4.45	4.55	4.65
4	4.75	4.35	4.45	4.45	4.5	4.35	4.45	4.55	4.65
5	4.75	4.35	4.45	4.45	4.5	4.35	4.45	4.55	4.65
6	4.75	4.35	4.45	4.45	4.5	4.35	4.45	4.55	4.65
7	4.75	4.35	4.45	4.45	4.5	4.35	4.45	4.55	4.65
8	4.75	4.35	4.45	4.45	4.5	4.35	4.45	4.55	4.65
9	4.75	4.35	4.45	4.45	4.5	4.35	4.45	4.55	4.65
10	4.75	4.35	4.45	4.45	4.5	4.35	4.45	4.55	4.65
11	4.75	4.35	4.45	4.45	4.5	4.35	4.45	4.55	4.65
12	4.75	4.35	4.45	4.45	4.5	4.35	4.45	4.55	4.65

ORP (mV)

Depth (")	Day -1	0	1	4	7	14	21	28	35
0	170	205	205	205	200	205	205	205	210
1	170	200	205	205	200	205	200	205	210
2	170	200	205	200	200	205	200	205	210
3	170	200	200	200	200	200	200	205	210
4	170	195	200	200	200	200	200	205	210
5	170	195	200	200	200	200	200	205	210
6	170	195	200	200	195	200	200	205	210
7	170	195	200	200	195	200	200	200	210
8	170	195	200	200	195	200	200	200	210
9	170	195	200	195	195	200	200	200	210
10	170	195	200	195	195	200	200	200	210
11	170	195	200	195	195	200	200	200	210
12	170	195	200	195	195	200	195	200	210



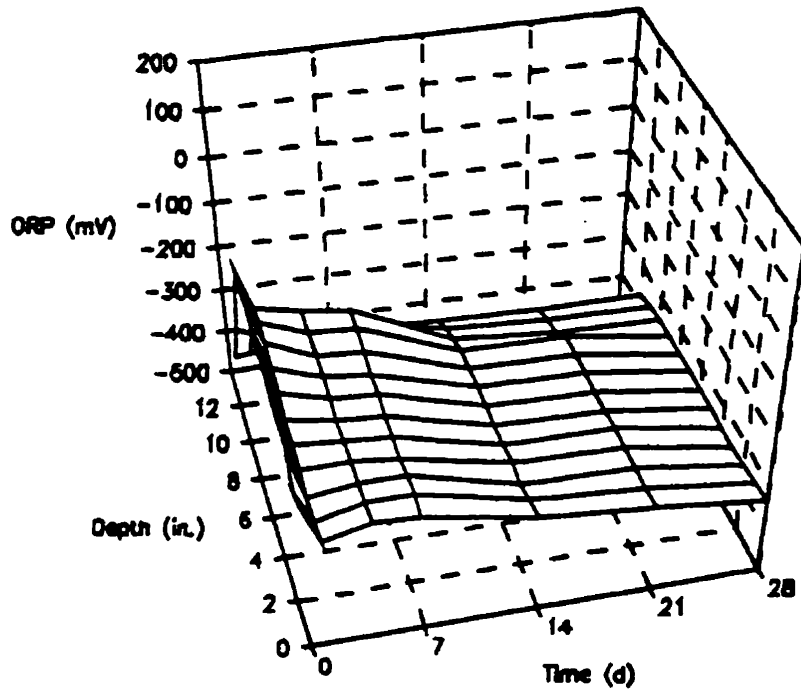
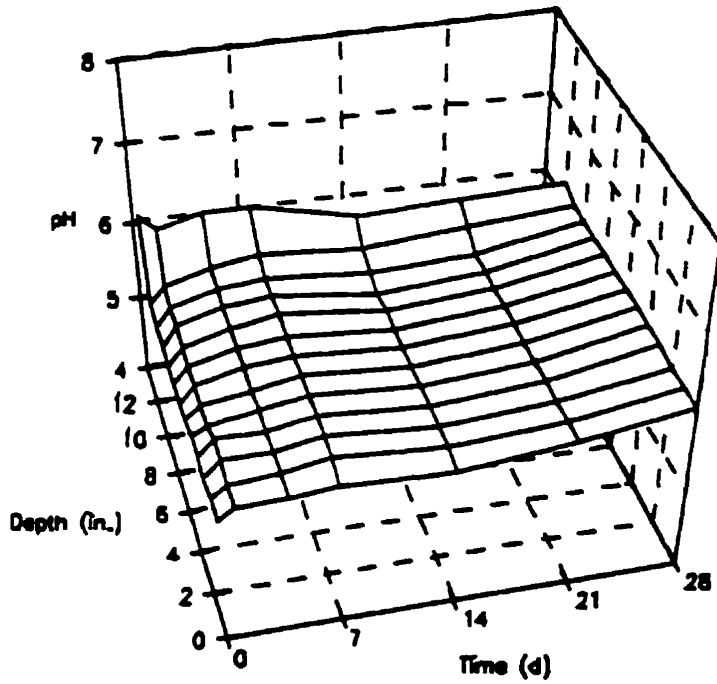
Changes in pH and ORP over time and depth.
 Column 5: 1/2" granite with no SRB, control. Cycle 5: $V_c = 2L$.

CYCLE 5

Column 6: 1/2" Limestone, no SRB

pH										
Depth	Day									
(")	-1	0	1	4	7	14	21	28	35	
0	6.8	5.6	5.75	5.75	5.8	5.75	5.9	6.1	6.25	
1	6.8	5.6	5.75	5.8	5.9	5.8	5.9	6.1	6.25	
2	6.8	5.6	5.8	5.8	5.9	5.8	5.9	6.1	6.25	
3	6.8	5.6	5.8	5.8	5.9	5.8	5.9	6.15	6.25	
4	6.8	5.6	5.7	5.8	5.9	5.8	5.9	6.15	6.25	
5	6.8	5.55	5.7	5.8	5.9	5.8	5.9	6.15	6.25	
6	6.8	5.5	5.7	5.85	5.9	5.8	5.9	6.15	6.25	
7	6.8	5.5	5.7	5.85	5.9	5.8	5.9	6.15	6.25	
8	6.8	5.5	5.7	5.85	5.95	5.8	5.9	6.15	6.25	
9	6.75	5.5	5.75	5.9	5.95	5.8	5.9	6.15	6.2	
10	6.75	5.5	5.75	5.9	5.95	5.85	5.9	6.15	6.25	
11	6.7	5.6	5.8	5.95	6.05	5.95	6.05	6.15	6.35	
12	6.7	6.5	6.3	6.45	6.45	6.15	6.2	6.25	6.35	

ORP (mV)										
Depth	Day									
(")	-1	0	1	4	7	14	21	28	35	
0	-385	-175	-260	-235	-240	-285	-305	-335	-335	
1	-385	-195	-265	-240	-240	-295	-310	-340	-345	
2	-390	-140	-260	-245	-245	-305	-310	-345	-345	
3	-390	-130	-245	-245	-255	-305	-310	-350	-345	
4	-390	-125	-235	-245	-250	-310	-310	-350	-340	
5	-390	-115	-225	-245	-250	-310	-315	-350	-340	
6	-390	-110	-210	-240	-245	-310	-315	-350	-340	
7	-390	-105	-200	-235	-245	-310	-315	-350	-340	
8	-390	-100	-185	-230	-235	-310	-315	-350	-340	
9	-390	-100	-180	-220	-225	-310	-315	-350	-340	
10	-385	-100	-190	-210	-225	-325	-345	-350	-340	
11	-385	-275	-290	-275	-295	-340	-355	-360	-355	
12	-390	-380	-375	-365	-355	-365	-370	-370	-360	



Changes in pH and ORP over time and depth.
 Column 6: 1/2" limestone inoculated with SRB. Cycle 5: $V_c = 2L$.

CYCLE 6

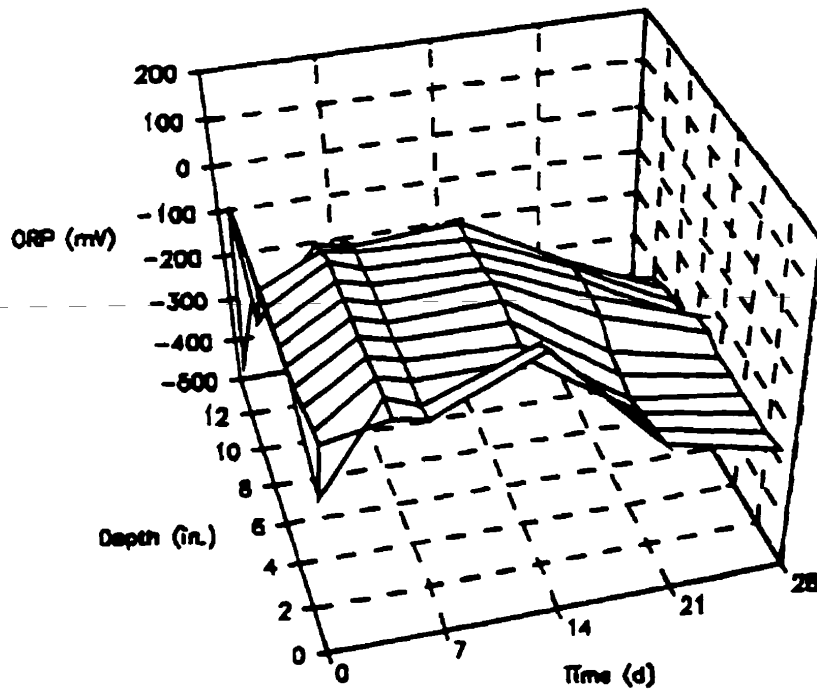
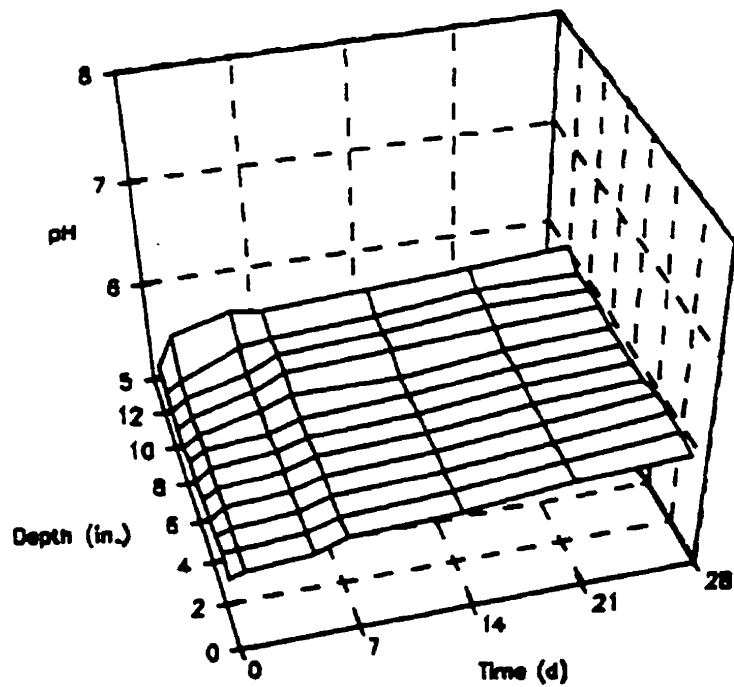
Column 1: 1/4" granite, with SRB

pH

Depth (")	Day 0	1	5	7	14	21	28
0	5.5	5.55	5.6	5.7	5.75	5.85	5.9
1	5.55	5.55	5.6	5.7	5.75	5.85	5.95
2	5.5	5.55	5.6	5.7	5.75	5.85	5.95
3	5.45	5.55	5.6	5.7	5.75	5.85	5.95
4	5.45	5.55	5.6	5.7	5.75	5.85	5.9
5	5.45	5.55	5.6	5.7	5.75	5.85	5.9
6	5.45	5.55	5.6	5.7	5.75	5.85	5.9
7	5.4	5.5	5.65	5.75	5.75	5.85	5.9
8	5.4	5.5	5.65	5.8	5.85	5.9	5.95
9	5.4	5.5	5.65	5.8	5.85	5.95	5.95
10	5.4	5.5	5.75	5.8	5.85	5.95	5.95
11	5.5	5.8	5.95	5.9	5.95	6	6.05
12	6.35	6.3	6.25	6.15	6.1	6.25	6.25

ORP (mV)

Depth (")	Day 0	1	5	7	14	21	28
0	35	-80	-55	-70	30	-215	-275
1	30	-250	-55	-85	0	-225	-280
2	25	-155	-55	-75	-75	-235	-280
3	35	-145	-55	-75	-85	-245	-280
4	30	-140	-55	-75	-75	-235	-280
5	30	-135	-55	-75	-70	-225	-280
6	30	-135	-55	-75	-70	-185	-265
7	30	-135	-55	-75	-80	-180	-265
8	30	-130	-55	-80	-85	-180	-305
9	30	-130	-65	-80	-90	-190	-310
10	20	-240	-90	-105	-90	-215	-315
11	-370	-220	-335	-130	-275	-310	-330
12	-400	-420	-360	-350	-325	-340	-355



Changes in pH and ORP over time and depth.
 Column 1: 1/4" granite inoculated with SRB. Cycle 6: $V_c = 2L$.

CYCLE 6

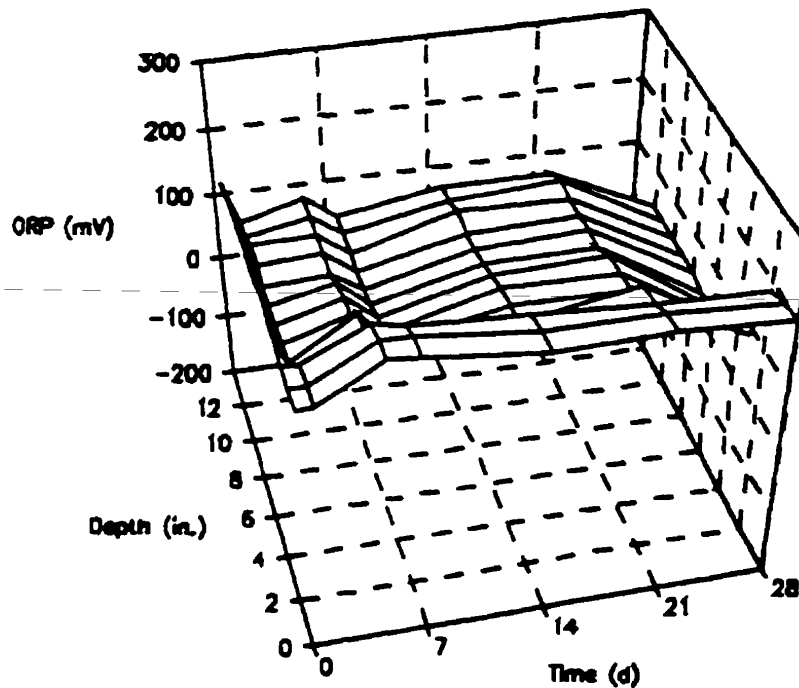
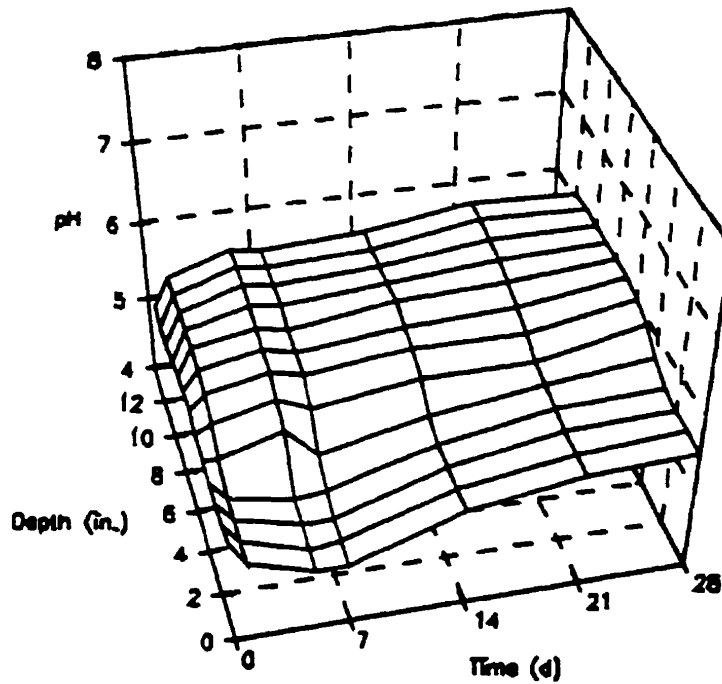
Column 2: 1/4" granite, ctl

pH

Depth (")	Day 0	1	5	7	14	21	28
0	5.3	5	4.75	4.75	5.25	5.45	5.5
1	5.25	5	4.75	4.8	5.25	5.45	5.55
2	5.25	5	4.8	4.8	5.25	5.5	5.55
3	5.25	5	4.85	4.9	5.3	5.55	5.6
4	5.25	5.25	5.5	5.1	5.4	5.6	5.75
5	5.35	5.45	5.65	5.45	5.65	5.65	5.95
6	5.4	5.6	5.75	5.65	5.8	5.8	6.05
7	5.4	5.65	5.8	5.7	5.85	5.9	6.1
8	5.35	5.7	5.85	5.75	5.95	6	6.1
9	5.3	5.7	5.9	5.85	5.95	6.05	6.1
10	5.3	5.7	5.95	5.9	5.95	6.1	6.1
11	5.3	5.7	5.95	5.9	5.95	6.15	6.1
12	5.35	5.7	5.95	5.9	5.95	6.15	6.1

ORP

Depth (")	Day 0	1	5	7	14	21	28
0	175	175	230	225	205	210	200
1	175	175	225	225	205	205	195
2	175	175	220	210	200	190	185
3	180	130	185	140	160	190	90
4	180	115	175	125	155	155	70
5	185	115	145	110	155	150	55
6	180	115	140	105	145	150	45
7	180	115	135	95	135	135	40
8	180	115	120	90	130	135	45
9	180	120	125	90	125	130	45
10	180	125	125	90	135	130	45
11	175	110	125	95	125	135	45
12	170	105	130	95	120	120	45



Changes in pH and ORP over time and depth.
 Column 2: 1/4" granite with no SRB, control. Cycle 6: $V_c = 2L$.

CYCLE 6

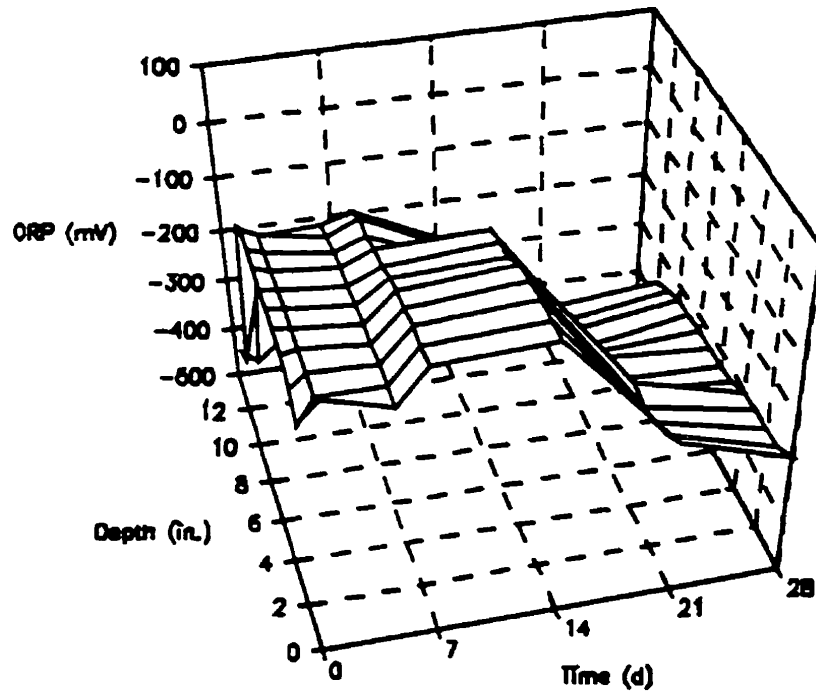
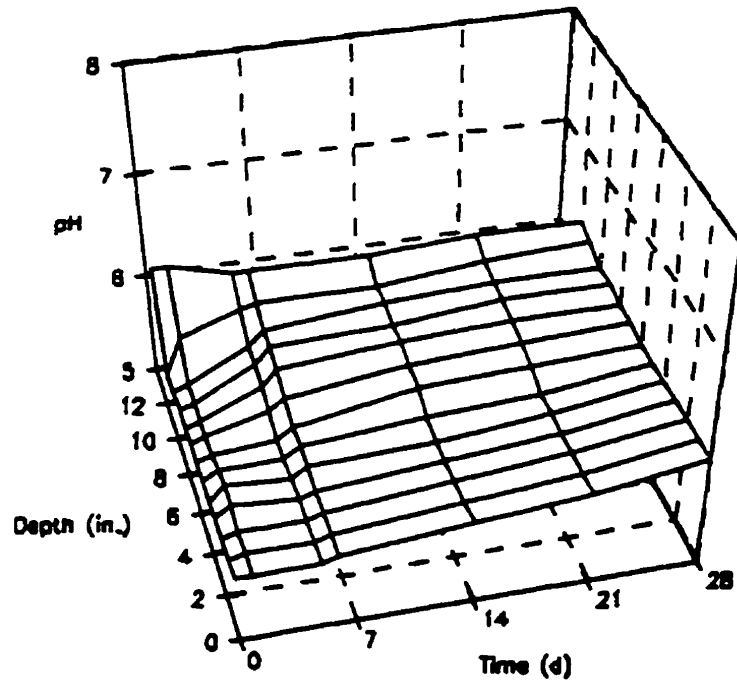
Column 3: 1/4" limestone, with SRB

pH

Depth (")	Day 0	1	5	7	14	21	28
0	5.65	5.65	5.65	5.7	5.8	5.9	6.05
1	5.6	5.65	5.65	5.7	5.8	5.9	6.05
2	5.6	5.65	5.65	5.7	5.8	5.9	6.05
3	5.6	5.7	5.65	5.7	5.8	5.9	6.05
4	5.55	5.7	5.65	5.75	5.8	5.9	6.05
5	5.55	5.65	5.65	5.75	5.85	5.9	6.05
6	5.55	5.6	5.65	5.75	5.95	6	6.05
7	5.55	5.6	5.75	5.85	6	6.05	6.1
8	5.5	5.55	5.8	5.95	6.05	6.1	6.1
9	5.5	5.55	5.85	6	6.05	6.15	6.15
10	5.5	5.55	5.85	6	6.1	6.15	6.15
11	5.5	5.85	6.05	6.1	6.1	6.2	6.25
12	6.4	6.4	6.25	6.25	6.25	6.3	6.3

ORP

Depth (")	Day 0	1	5	7	14	21	28
0	-60	-30	-65	-5	5	-210	-275
1	-110	-65	-65	-5	5	-235	-295
2	-85	-60	-65	-5	5	-250	-300
3	-60	-55	-65	-10	5	-260	-300
4	-50	-55	-65	-15	0	-250	-305
5	-50	-55	-65	-25	-20	-305	-320
6	-50	-55	-65	-40	-25	-320	-325
7	-45	-55	-65	-40	-35	-310	-325
8	-45	-55	-70	-50	-135	-335	-325
9	-40	-55	-75	-50	-145	-360	-325
10	-65	-90	-85	-70	-160	-360	-330
11	-360	-230	-225	-250	-345	-375	-345
12	-380	-405	-310	-355	-365	-380	-360



Changes in pH and ORP over time and depth.
 Column 3: 1/4" limestone inoculated with SRB. Cycle 6: $V_c = 2L$.

CYCLE 6

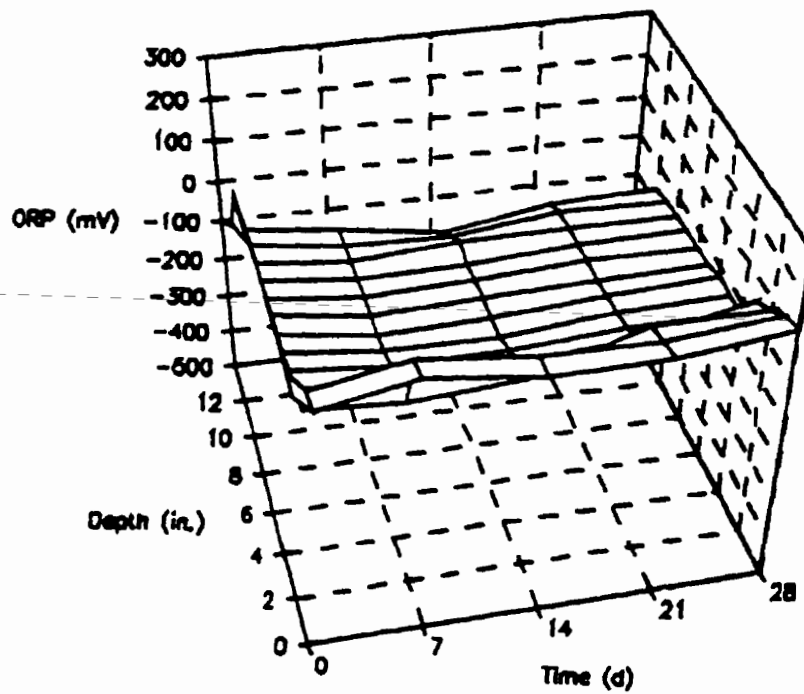
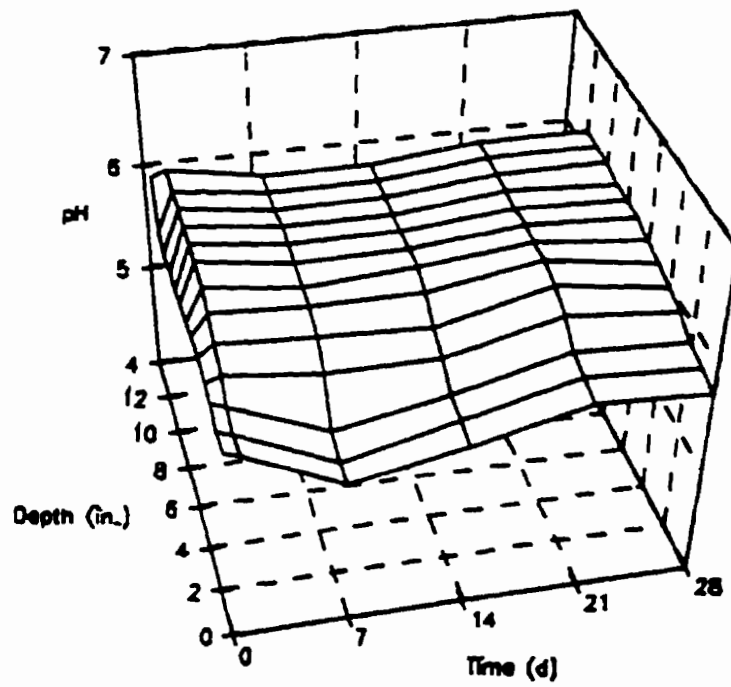
Column 7: 1/4" limestone, ctl

pH

Depth (")	Day 0	1	5	7	14	21	28
0	5.75	5.65	5.6	5.6	5.6	5.75	5.7
1	5.75	5.65	5.6	5.6	5.65	5.8	5.8
2	5.7	5.65	5.6	5.65	5.7	5.9	5.9
3	5.8	5.7	5.7	5.75	5.85	5.95	6.05
4	5.7	5.7	5.95	5.95	6.05	6.05	6.1
5	5.65	5.65	6.1	6	6.1	6.15	6.15
6	5.6	5.6	6.15	6.05	6.15	6.2	6.2
7	5.55	5.6	6.15	6.05	6.15	6.2	6.2
8	5.45	5.55	6.15	6.1	6.2	6.2	6.2
9	5.4	5.55	6.15	6.1	6.2	6.25	6.2
10	5.35	5.55	6.2	6.15	6.2	6.25	6.25
11	5.3	5.85	6.2	6.15	6.2	6.25	6.25
12	5.3	6.4	6.15	6.15	6.15	6.2	6.2

ORP

Depth (")	Day 0	1	5	7	14	21	28
0	130	-30	135	145	155	140	80
1	110	-65	130	145	145	120	55
2	130	-60	130	140	50	100	45
3	150	-55	10	0	10	95	25
4	150	-55	5	10	-10	95	20
5	155	-55	-5	-20	-15	85	20
6	155	-55	-10	-30	-15	85	10
7	155	-55	-15	-35	-15	75	10
8	155	-55	-20	-40	-15	80	10
9	155	-55	-25	-40	-25	75	10
10	155	-90	-20	-45	-30	55	-5
11	155	-230	-25	-45	-35	50	-5
12	-40	-405	-45	-55	-40	0	-20



Changes in pH and ORP over time and depth.
 Column 7: 1/4" limestone with no SRB, control. Cycle 6: $V_c = 2L$.

CYCLE 6

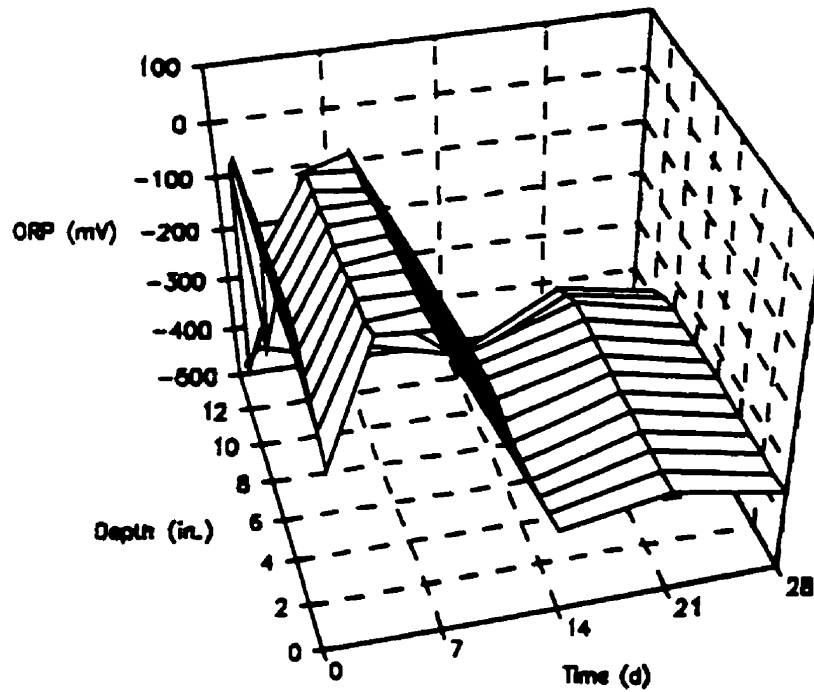
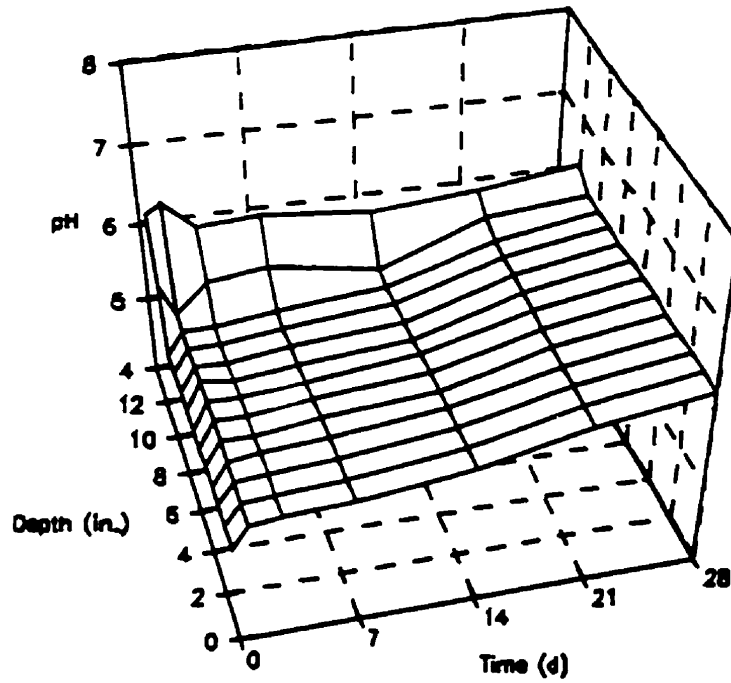
Column 4: 1/2" granite, with SRB

pH

Depth (")	Day							
	35	0	1	3	7	14	21	28
0	6.7	5.25	5.5	5.55	5.6	5.75	6.05	6.25
1	6.7	5.25	5.5	5.55	5.6	5.75	6.05	6.25
2	6.7	5.25	5.5	5.55	5.6	5.75	6.05	6.25
3	6.7	5.2	5.5	5.55	5.6	5.75	6.05	6.25
4	6.7	5.2	5.5	5.5	5.6	5.7	6.05	6.25
5	6.65	5.15	5.5	5.5	5.6	5.7	6.05	6.25
6	6.65	5.15	5.5	5.5	5.55	5.7	6.05	6.25
7	6.6	5.15	5.5	6.45	5.55	5.65	6.05	6.25
8	6.6	5.15	5.45	5.45	5.55	5.65	6.05	6.25
9	6.6	5.15	5.45	5.45	5.55	5.65	6.05	6.25
10	6.55	5.15	5.45	5.45	5.55	5.65	6.05	6.25
11	6.6	5.85	5.45	5.8	5.9	5.65	6.15	6.25
12	6.65	6.55	6.65	6.3	6.35	6.2	6.3	6.45

ORP (mV)

Depth (")	Day							
	35	0	1	4	7	14	21	28
0	-385	85	-155	60	55	-345	-305	-345
1	-385	85	-125	50	55	-350	-305	-350
2	-385	80	-115	50	50	-360	-305	-350
3	-385	80	-110	50	50	-370	-305	-350
4	-385	80	-105	40	50	-370	-305	-350
5	-385	85	-100	40	45	-370	-305	-350
6	-380	85	-100	40	45	-365	-305	-350
7	-380	80	-95	40	40	-360	-305	-350
8	-380	80	-95	40	30	-355	-305	-350
9	-380	80	-95	40	35	-360	-305	-350
10	-380	40	-300	10	35	-370	-305	-350
11	-380	-380	-300	-130	-270	-425	-325	-360
12	-390	-405	-375	-400	-395	-450	-345	-380



Changes in pH and ORP over time and depth.
 Column 4: 1/2" granite inoculated with SRB. Cycle 6: $V_c = 2L$.

CYCLE 6

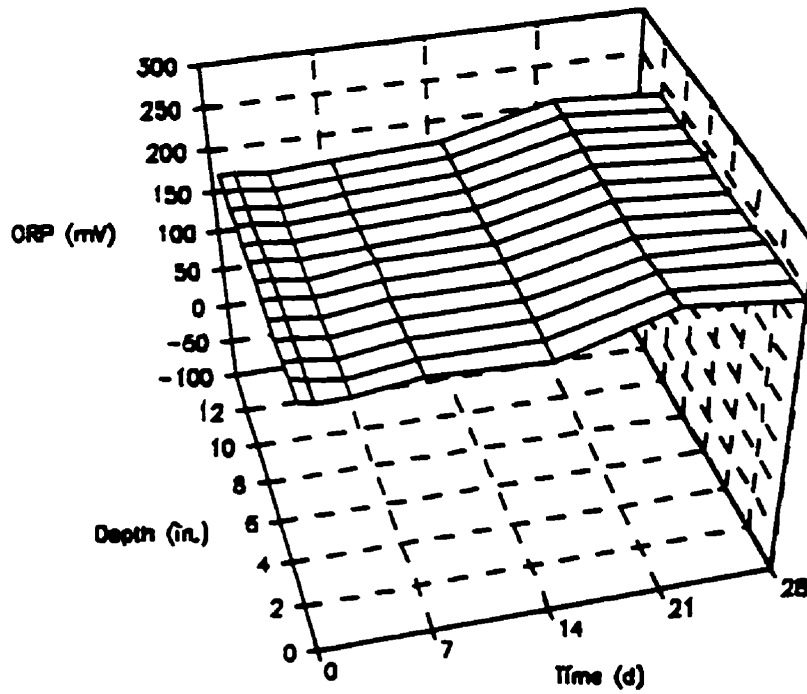
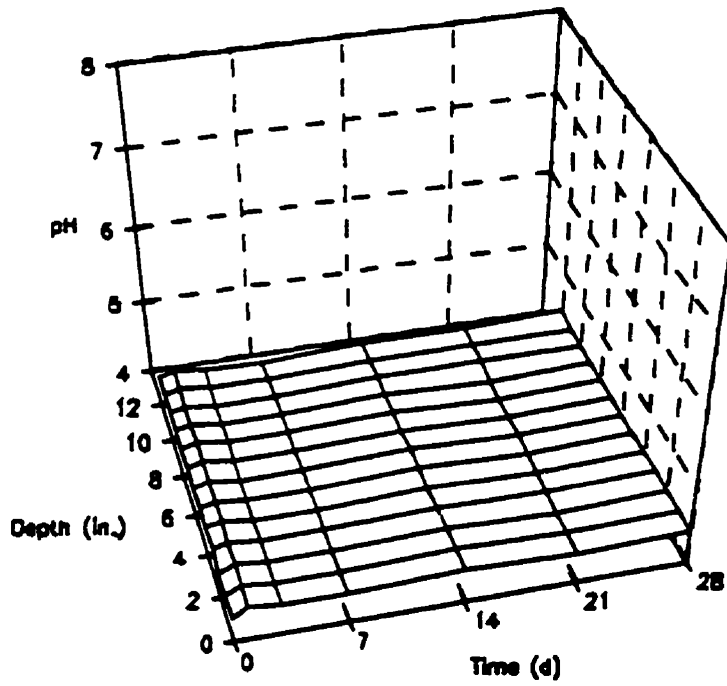
Column 5: 1/2" granite, no SRB

pH

Depth (")	Day 35	0	1	3	7	14	21	28
0	4.65	4.35	4.45	4.4	4.4	4.45	4.4	4.45
1	4.65	4.35	4.45	4.4	4.4	4.45	4.4	4.45
2	4.65	4.35	4.45	4.4	4.4	4.45	4.4	4.45
3	4.65	4.4	4.45	4.4	4.4	4.45	4.4	4.45
4	4.65	4.4	4.45	4.4	4.4	4.45	4.4	4.45
5	4.65	4.4	4.45	4.4	4.4	4.45	4.4	4.45
6	4.65	4.4	4.45	4.4	4.4	4.45	4.4	4.45
7	4.65	4.4	4.45	4.4	4.4	4.45	4.4	4.45
8	4.65	4.4	4.45	4.4	4.4	4.45	4.4	4.45
9	4.65	4.4	4.45	4.4	4.4	4.45	4.4	4.45
10	4.65	4.4	4.45	4.4	4.4	4.45	4.45	4.45
11	4.65	4.4	4.45	4.4	4.4	4.45	4.45	4.45
12	4.65	4.4	4.45	4.4	4.4	4.45	4.45	4.5

ORP (mV)

Depth (")	Day 35	0	1	3	7	14	21	28
0	210	215	210	210	220	215	255	240
1	210	215	210	205	215	215	250	240
2	210	210	210	205	215	215	250	240
3	210	210	210	205	215	215	245	240
4	210	210	210	205	215	215	245	235
5	210	210	210	205	215	215	245	235
6	210	210	210	205	215	215	245	235
7	210	210	210	205	210	215	245	235
8	210	210	210	205	210	215	245	235
9	210	210	210	205	210	215	245	235
10	210	210	210	205	210	215	245	235
11	210	210	210	205	210	215	245	235
12	210	210	210	205	210	215	245	235



Changes in pH and ORP over time and depth.
 Column 5: 1/2" granite with no SRB, control. Cycle 6: $V_c = 2L$.

CYCLE 6

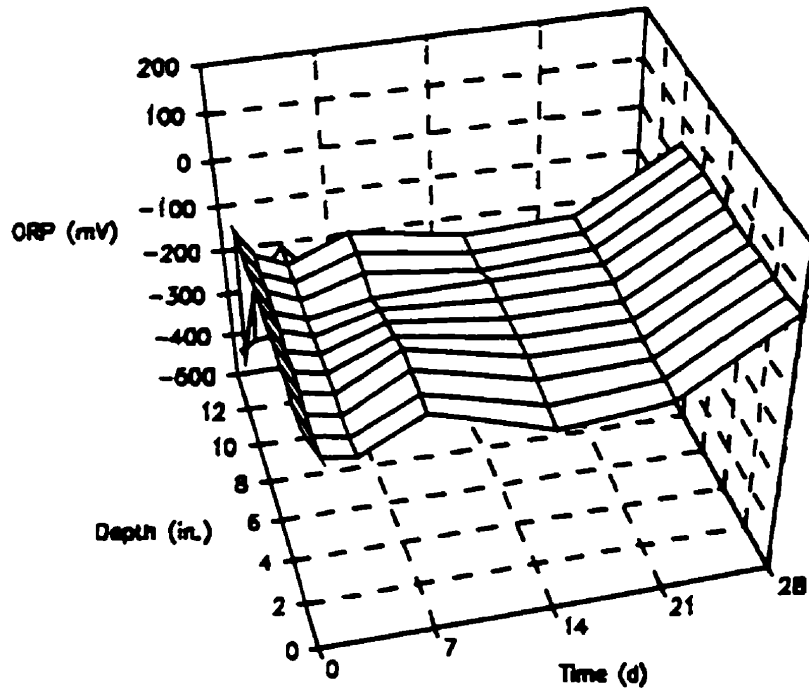
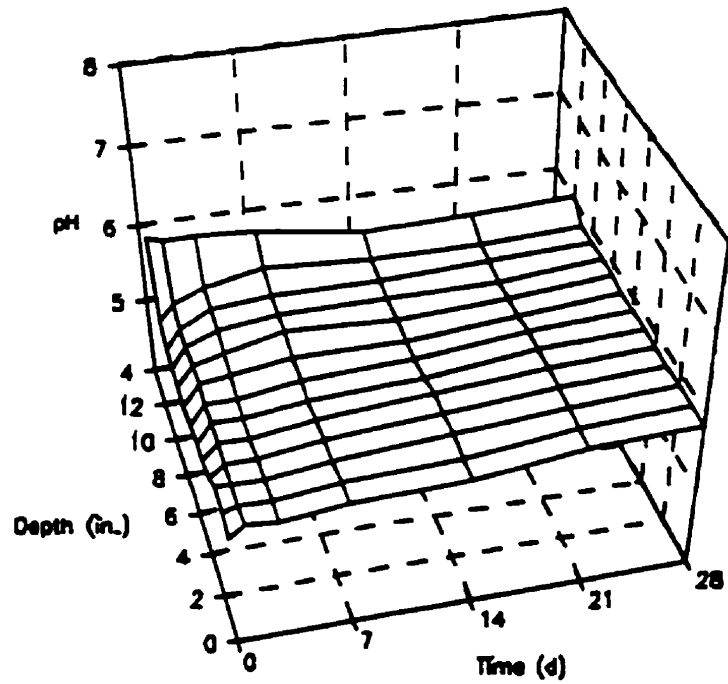
Column 6: 1/2" limestone, with SRB

pH

Depth (")	Day 35	0	1	3	7	14	21	28
0	6.25	5.4	5.55	5.5	5.6	5.65	5.8	5.85
1	6.25	5.45	5.5	5.5	5.6	5.65	5.8	5.85
2	6.25	5.5	5.5	5.5	5.6	5.7	5.8	5.85
3	6.25	5.35	5.5	5.5	5.6	5.7	5.8	5.85
4	6.25	5.3	5.5	5.5	5.6	5.7	5.8	5.85
5	6.25	5.25	5.5	5.5	5.6	5.65	5.8	5.85
6	6.25	5.25	5.5	5.5	5.6	5.65	5.8	5.85
7	6.25	5.25	5.5	5.55	5.65	5.65	5.75	5.85
8	6.25	5.25	5.5	5.6	5.75	5.7	5.75	5.85
9	6.2	5.25	5.5	5.65	5.75	5.75	5.75	5.85
10	6.25	5.25	5.5	5.7	5.75	5.75	5.8	5.85
11	6.35	5.4	5.6	5.75	5.9	5.8	5.8	5.85
12	6.35	6.25	6.2	6.2	6.15	5.95	6	6.05

ORP (mV)

Depth (")	Day 35	0	1	3	7	14	21	28
0	-335	0	-70	-80	-15	-90	-70	65
1	-345	0	-70	-85	-20	-85	-70	60
2	-345	0	-70	-85	-15	-75	-70	60
3	-345	-5	-70	-85	-15	-70	-70	60
4	-340	-5	-70	-85	-30	-70	-70	55
5	-340	-5	-70	-85	-40	-70	-70	55
6	-340	-10	-70	-90	-55	-70	-70	55
7	-340	-10	-70	-95	-70	-70	-70	55
8	-340	-10	-65	-95	-55	-85	-75	55
9	-340	-10	-65	-95	-50	-85	-75	55
10	-340	-10	-65	-95	-45	-85	-75	50
11	-355	-325	-175	-90	-260	-200	-145	-195
12	-360	-355	-340	-330	-330	-325	-350	-300



Changes in pH and ORP over time and depth.
 Column 6: 1/2" limestone inoculated with SRB. Cycle 6: $V_c = 2L$.

CYCLE 7

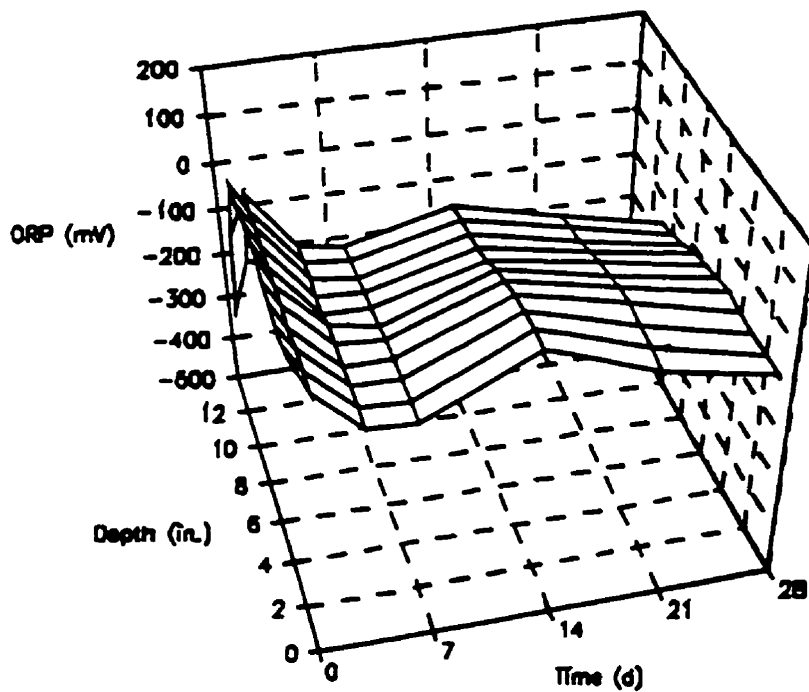
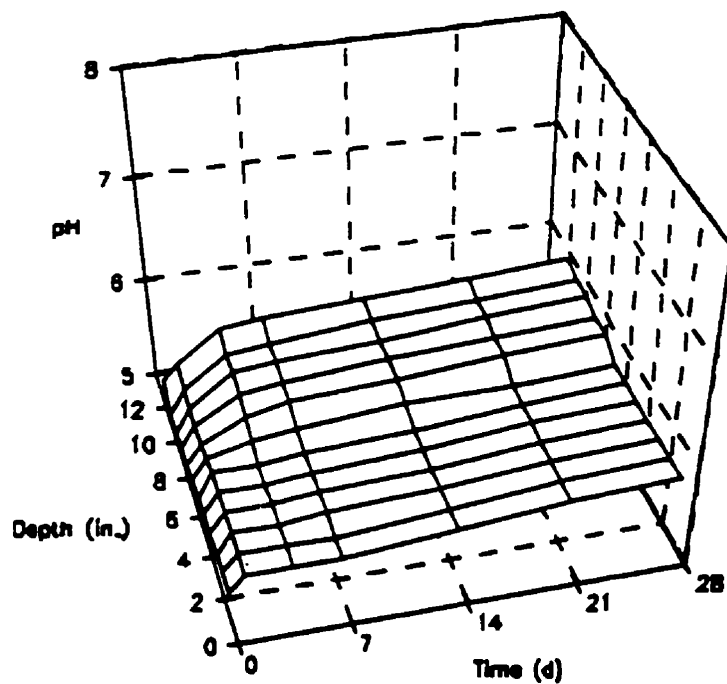
Column 1: 1/4" granite, with SRB

pH

Depth (")	Day -1	0	1	4	7	14	21	28
0	6.4	5.3	5.45	5.45	5.45	5.55	5.65	5.7
1	6.35	5.3	5.45	5.45	5.45	5.55	5.65	5.7
2	6.35	5.25	5.45	5.45	5.5	5.55	5.65	5.7
3	6.35	5.25	5.45	5.45	5.5	5.55	5.65	5.7
4	6.35	5.25	5.45	5.45	5.5	5.55	5.65	5.7
5	6.35	5.2	5.45	5.45	5.5	5.55	5.65	5.7
6	6.3	5.2	5.4	5.5	5.55	5.65	5.65	5.7
7	6.25	5.15	5.35	5.55	5.65	5.7	5.8	5.85
8	6.15	5.15	5.35	5.6	5.65	5.75	5.8	5.85
9	6.15	5.1	5.35	5.65	5.7	5.75	5.85	5.9
10	6.15	5.1	5.35	5.65	5.7	5.8	5.85	5.9
11	6.15	5.3	5.45	5.75	5.8	5.85	5.9	5.95
12	6.3	6.2	6.2	6.1	6	6.1	5.95	6

ORP (mV)

Depth (")	Day -1	0	1	4	7	14	21	28
0	-315	95	20	-70	-75	35	-50	-95
1	-315	80	20	-70	-75	35	-40	-95
2	-315	75	25	-70	-70	30	-35	-90
3	-315	80	25	-70	-70	25	-30	-85
4	-315	85	30	-65	-70	15	-35	-80
5	-315	100	30	-65	-85	0	-50	-90
6	-310	95	30	-85	-85	-20	-60	-100
7	-305	90	35	-85	-90	-30	-75	-110
8	-305	90	35	-85	-100	-40	-90	-130
9	-310	95	35	-90	-100	-45	-95	-145
10	-310	-50	35	-90	-105	-50	-105	-155
11	-315	-250	-145	-200	-205	-270	-250	-295
12	-340	-340	-360	-345	-350	-335	-325	-325



Changes in pH and ORP over time and depth.
 Column 1: 1/4" granite inoculated with SRB. Cycle 7: $V_c = 2L$.

CYCLE 7

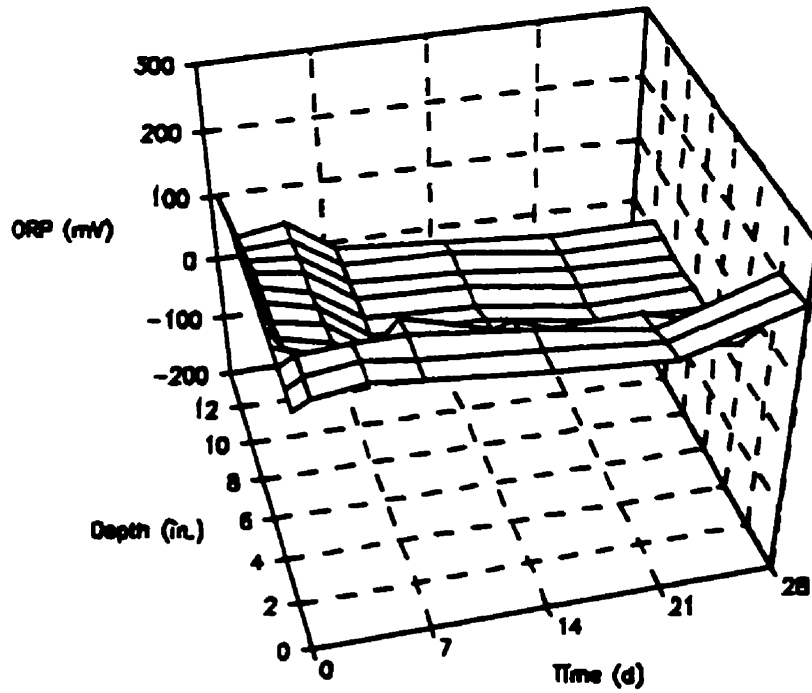
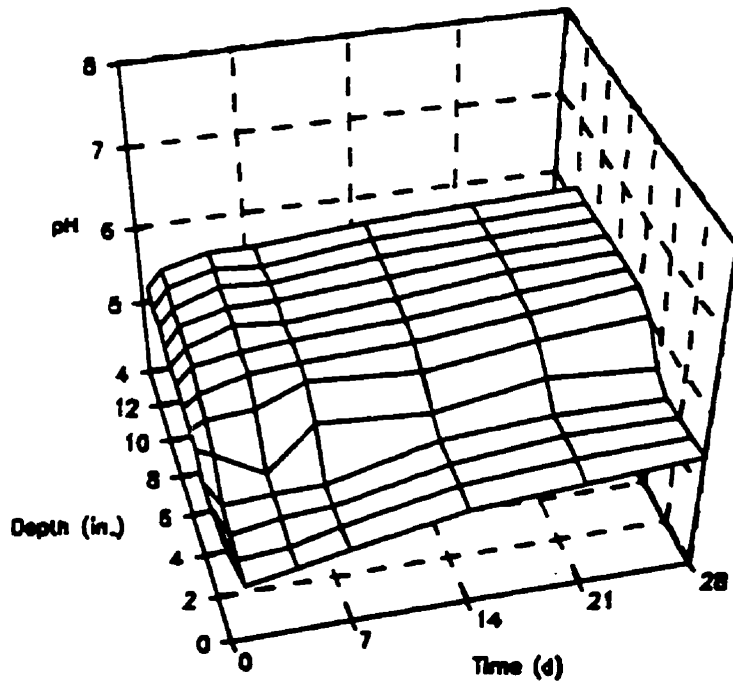
Column 2: 1/2" granite, no SRB

pH

Depth (")	Day -1	0	1	4	7	14	21	28
0	6.2	5.35	4.75	4.85	5	5.25	5.35	5.45
1	6.2	5.35	4.8	4.85	5	5.3	5.4	5.45
2	6.2	5.25	4.85	4.95	5	5.3	5.45	5.45
3	6.2	5.3	4.95	5	5	5.35	5.45	5.45
4	6.25	5.45	5.35	5	5.55	5.45	5.7	5.6
5	6.25	5.45	5.55	5.6	5.85	5.75	5.95	6.05
6	6.3	5.5	5.65	5.8	5.85	5.9	6.05	6.2
7	6.3	5.55	5.75	5.85	5.9	5.95	6.1	6.2
8	6.35	5.55	5.75	5.95	5.9	6	6.15	6.2
9	6.35	5.55	5.8	5.95	5.95	6.05	6.15	6.2
10	6.4	5.6	5.8	6	5.95	6.1	6.15	6.2
11	6.4	5.6	5.85	6	5.95	6.1	6.15	6.2
12	6.4	5.65	5.85	6	6	6.1	6.15	6.2

ORP (mV)

Depth (")	Day -1	0	1	4	7	14	21	28
0	225	175	190	200	190	175	165	215
1	225	175	190	200	190	175	160	210
2	225	175	190	195	195	175	150	205
3	225	175	165	110	190	140	145	90
4	225	175	140	110	75	130	65	40
5	220	175	125	105	65	75	55	25
6	220	175	120	105	50	50	15	10
7	220	175	120	100	45	45	15	10
8	220	170	115	95	45	35	10	15
9	220	170	110	100	45	40	15	10
10	220	165	100	95	45	35	15	10
11	220	155	90	95	45	40	15	15
12	225	150	85	95	45	30	15	15



Changes in pH and ORP over time and depth.
 Column 2: 1/4" granite with no SRB, control. Cycle 7: $V_c = 2L$.

CYCLE 7

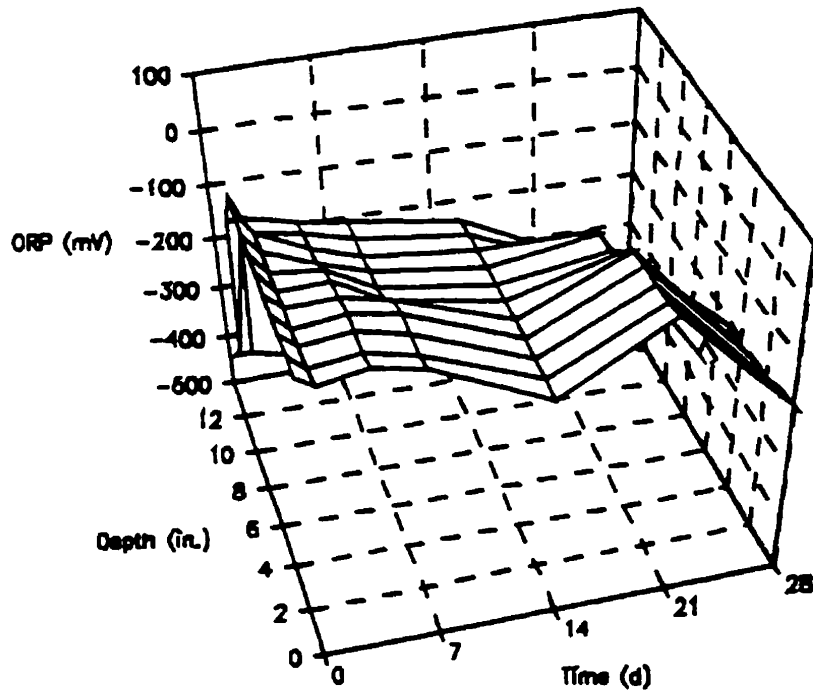
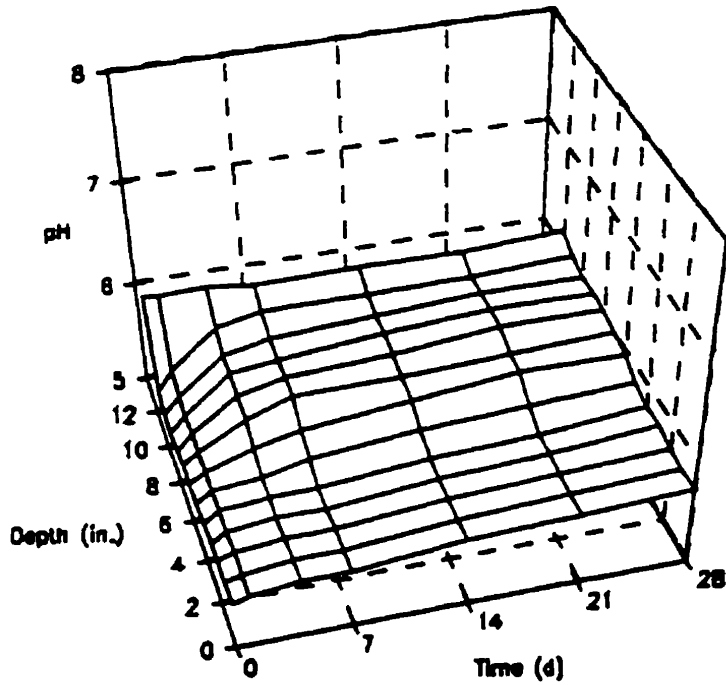
Column 3: 1/4" limestone, with SRB

pH

Depth (")	Day -1	0	1	4	7	14	21	28
0	6.6	5.45	5.5	5.55	5.55	5.65	5.7	5.75
1	6.6	5.45	5.5	5.55	5.55	5.65	5.7	5.75
2	6.6	5.45	5.5	5.55	5.55	5.65	5.7	5.75
3	6.55	5.4	5.5	5.55	5.55	5.65	5.7	5.8
4	6.55	5.4	5.5	5.55	5.55	5.65	5.7	5.8
5	6.55	5.4	5.5	5.55	5.65	5.75	5.8	5.85
6	6.5	5.4	5.5	5.65	5.75	5.85	5.95	5.95
7	6.4	5.4	5.5	5.75	5.9	5.9	5.95	6
8	6.3	5.35	5.5	5.8	5.9	5.95	6.05	6.05
9	6.3	5.35	5.5	5.85	5.9	6	6.05	6.05
10	6.25	5.35	5.5	5.85	5.95	6	6.05	6.05
11	6.25	5.4	5.6	5.95	6.05	6.05	6.05	6.1
12	6.25	6.2	6.2	6.2	6.15	6.15	6.15	6.2

ORP (mV)

Depth (")	Day -1	0	1	4	7	14	21	28
0	-330	20	0	15	-5	-95	15	-180
1	-335	20	-5	5	-15	-95	5	-185
2	-335	20	-5	5	-15	-95	0	-200
3	-335	20	-10	0	-15	-95	0	-200
4	-335	20	-10	-5	-25	-95	-5	-210
5	-335	25	-15	-10	-60	-95	-40	-210
6	-325	25	-15	-25	-70	-100	-70	-225
7	-325	25	-10	-45	-75	-100	-70	-335
8	-325	35	-10	-50	-80	-100	-100	-335
9	-325	30	-40	-55	-80	-105	-190	-325
10	-325	-45	-45	-65	-80	-110	-205	-350
11	-325	-325	-95	-325	-315	-250	-320	-360
12	-330	-370	-370	-395	-355	-295	-340	-370



Changes in pH and ORP over time and depth.
 Column 3: 1/4" limestone inoculated with SRB. Cycle 7: $V_c = 2L$.

CYCLE 7

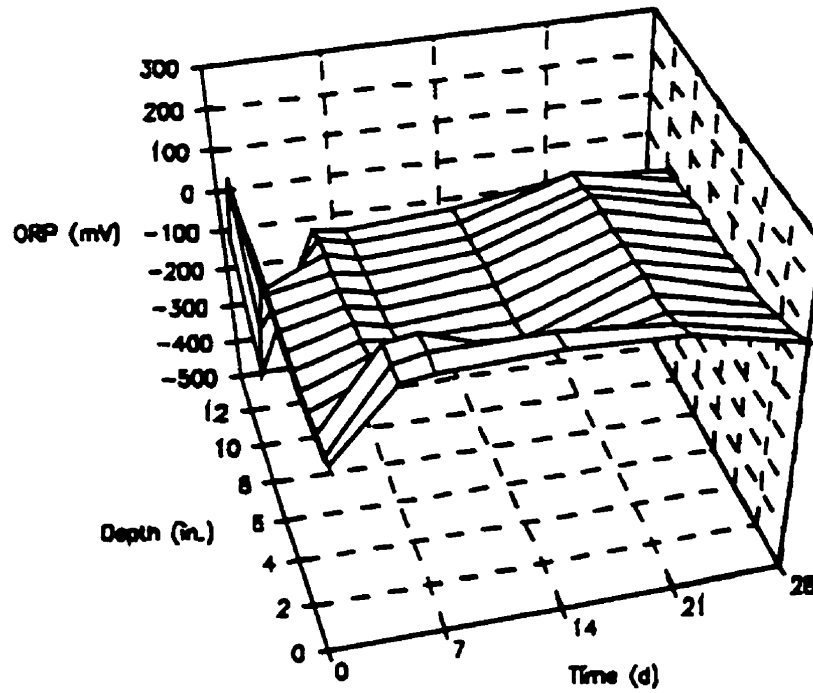
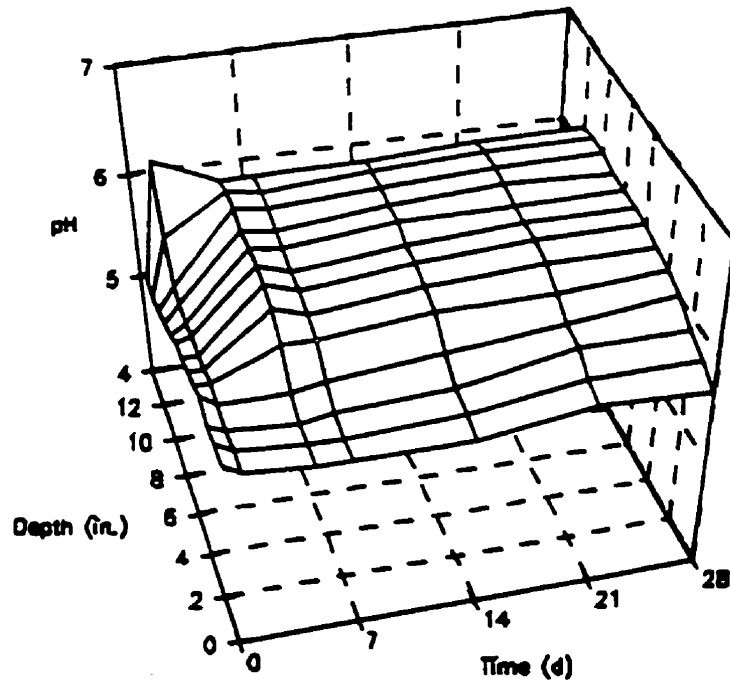
Column 7: 1/4" limestone, no SRB

pH

Depth (")	Day -1	0	1	4	7	14	21	28
0	5.8	5.25	5.35	5.85	6.1	6.05	5.8	5.45
1	5.8	5.15	5.35	5.85	6.1	6.15	5.85	5.5
2	5.85	5.05	5.3	5.9	6.1	6.2	6	5.6
3	5.95	5.05	5.2	5.9	6.15	6.2	6.1	6
4	6	5	5.4	6	6.15	6.2	6.15	6.1
5	6.05	5	5.7	6.1	6.15	6.2	6.15	6.2
6	6.1	5.1	6	6.1	6.15	6.2	6.2	6.2
7	6.15	5.6	6.05	6.1	6.15	6.2	6.2	6.2
8	6.15	5.75	6.1	6.15	6.15	6.2	6.2	6.2
9	6.15	5.75	6.1	6.2	6.15	6.2	6.2	6.2
10	6.2	5.8	6.15	6.2	6.15	6.25	6.2	6.2
11	6.2	5.85	6.15	6.2	6.15	6.25	6.2	6.25
12	6.2	6.15	6.15	6.1	6.1	6.2	6.2	6.2

ORP (mV)

Depth (")	-1	0	1	4	7	14	21	28
0	220	165	145	110	5	10	70	180
1	100	165	150	75	10	5	50	70
2	50	165	165	85	5	-15	35	25
3	40	160	145	15	-15	-15	25	20
4	35	165	-5	-10	-15	-10	15	15
5	30	165	-15	-25	-20	-10	15	10
6	25	170	-20	-25	-25	-15	10	10
7	20	170	-25	-25	-30	-20	10	5
8	15	170	-25	-35	-30	-20	5	0
9	-5	170	-25	-45	-30	-20	0	-5
10	-10	170	-30	-45	-35	-25	-5	-5
11	-20	35	15	-15	-55	-30	-25	-45
12	-40	-25	-45	-35	-70	-40	-70	-70



Changes in pH and ORP over time and depth.
 Column 7: 1/4" limestone with no SRB, control. Cycle 7: $V_c = 2L$.

CYCLE 7

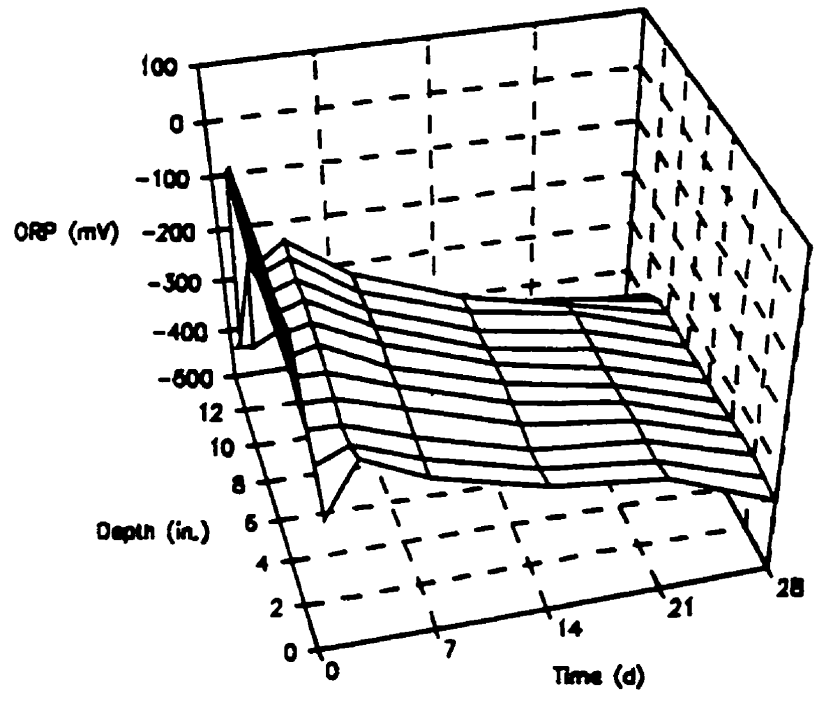
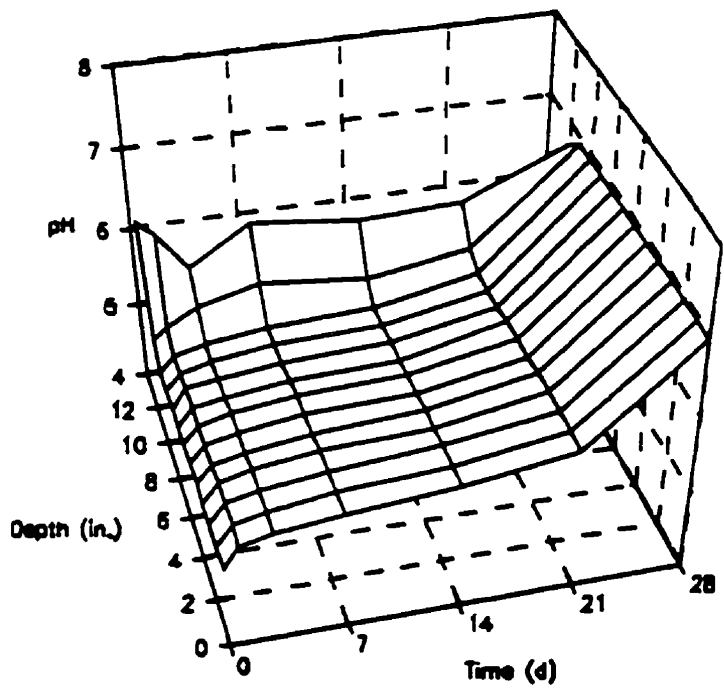
Column 4: 1/2" granite, with SRB

pH

Depth (")	Day -2	0	1	3	7	14	21	28
0	6.5	5.05	5.3	5.4	5.5	5.6	5.8	6
1	6.5	5.05	5.3	5.4	5.5	5.6	5.8	6
2	6.5	5.05	5.3	5.4	5.5	5.6	5.8	6
3	6.5	5.05	5.3	5.4	5.5	5.55	5.8	6
4	6.45	5.05	5.25	5.35	5.45	5.55	5.8	6
5	6.4	5.05	5.25	5.35	5.45	5.5	5.75	6
6	6.4	5.05	5.25	5.35	5.45	5.5	5.75	6
7	6.35	5	5.25	5.3	5.4	5.45	5.75	6
8	6.35	5	5.25	5.3	5.4	5.45	5.7	6
9	6.35	5	5.2	5.3	5.4	5.45	5.7	6
10	6.35	5	5.2	5.3	5.4	5.45	5.7	6
11	6.35	5.2	5.35	5.55	5.75	5.6	5.8	6
12	6.7	6.5	6.3	5.85	6.3	6.15	6.2	6.35

ORP (mV)

Depth (")	Day -2	0	1	3	7	14	21	28
0	-370	85	-245	-145	-200	-255	-280	-310
1	-370	75	-185	-160	-205	-260	-285	-310
2	-370	70	-160	-160	-205	-265	-285	-310
3	-365	70	-150	-150	-190	-255	-285	-310
4	-365	70	-140	-140	-185	-250	-285	-305
5	-360	70	-140	-125	-185	-250	-290	-305
6	-360	70	-135	-120	-180	-250	-290	-305
7	-360	70	-135	-115	-180	-255	-290	-305
8	-365	70	-130	-110	-185	-255	-290	-305
9	-360	65	-130	-105	-185	-255	-290	-305
10	-360	30	-150	-105	-185	-260	-305	-305
11	-370	-320	-170	-195	-265	-310	-330	-335
12	-390	-365	-370	-340	-345	-355	-370	-365



Changes in pH and ORP over time and depth.
 Column 4: 1/2" granite inoculated with SRB. Cycle 7: $V_c = 2L$.

CYCLE 7

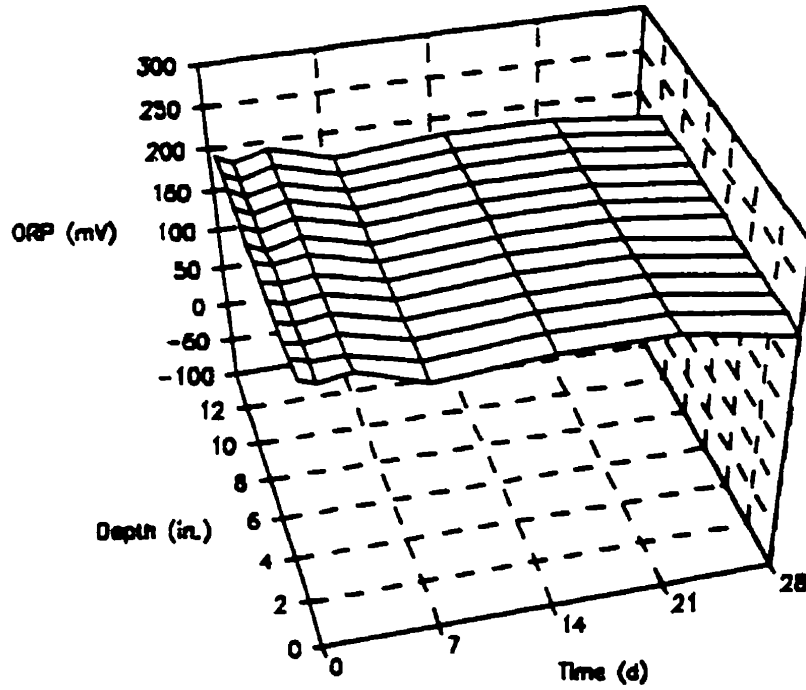
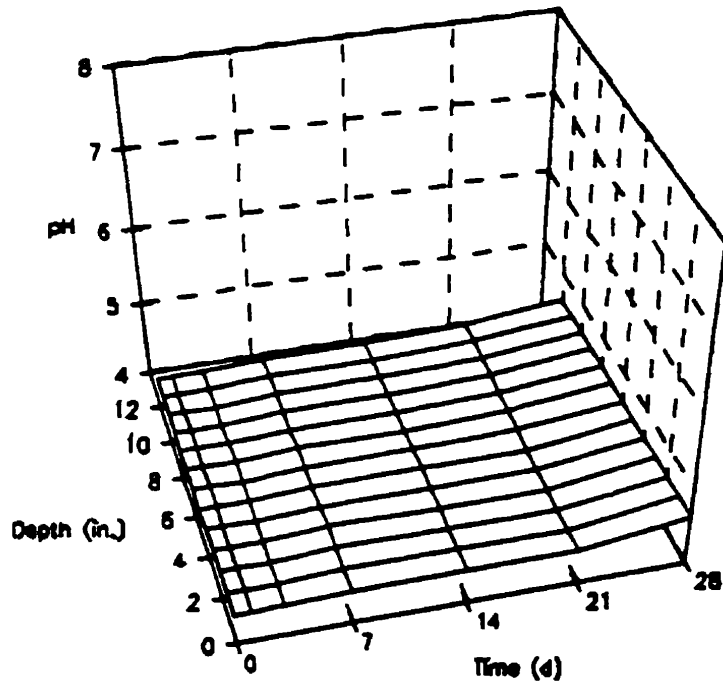
Column 5: 1/2" granite, no SRB

pH

Depth (")	Day -2	0	1	3	7	14	21	28
0	4.55	4.4	4.4	4.4	4.45	4.45	4.45	4.5
1	4.55	4.4	4.4	4.4	4.45	4.45	4.45	4.5
2	4.55	4.4	4.4	4.4	4.45	4.45	4.45	4.5
3	4.55	4.4	4.4	4.4	4.45	4.45	4.45	4.5
4	4.55	4.4	4.4	4.4	4.45	4.45	4.45	4.5
5	4.55	4.4	4.4	4.4	4.45	4.45	4.45	4.5
6	4.55	4.4	4.4	4.4	4.45	4.45	4.5	4.5
7	4.55	4.4	4.4	4.4	4.45	4.45	4.5	4.5
8	4.55	4.4	4.4	4.4	4.45	4.45	4.5	4.5
9	4.55	4.4	4.4	4.4	4.45	4.45	4.5	4.5
10	4.55	4.4	4.4	4.4	4.45	4.45	4.5	4.5
11	4.55	4.4	4.4	4.4	4.45	4.45	4.5	4.5
12	4.55	4.4	4.4	4.4	4.45	4.45	4.5	4.5

ORP (mV)

Depth (")	Day -2	0	1	3	7	14	21	28
0	230	235	230	235	210	220	220	230
1	225	235	230	230	210	220	220	230
2	225	230	225	230	210	220	220	230
3	225	230	225	230	210	220	220	230
4	225	230	225	230	210	220	220	230
5	225	230	225	230	210	220	220	230
6	225	230	225	230	210	220	220	225
7	225	230	220	230	210	220	220	225
8	225	230	220	230	210	220	220	225
9	225	230	220	230	210	220	220	225
10	220	230	220	230	210	220	220	225
11	220	230	220	230	210	220	220	225
12	220	230	220	230	210	220	220	225



Changes in pH and ORP over time and depth.
 Column 5: 1/2" granite with no SRB, control. Cycle 7: $V_c = 2L$.

CYCLE 7

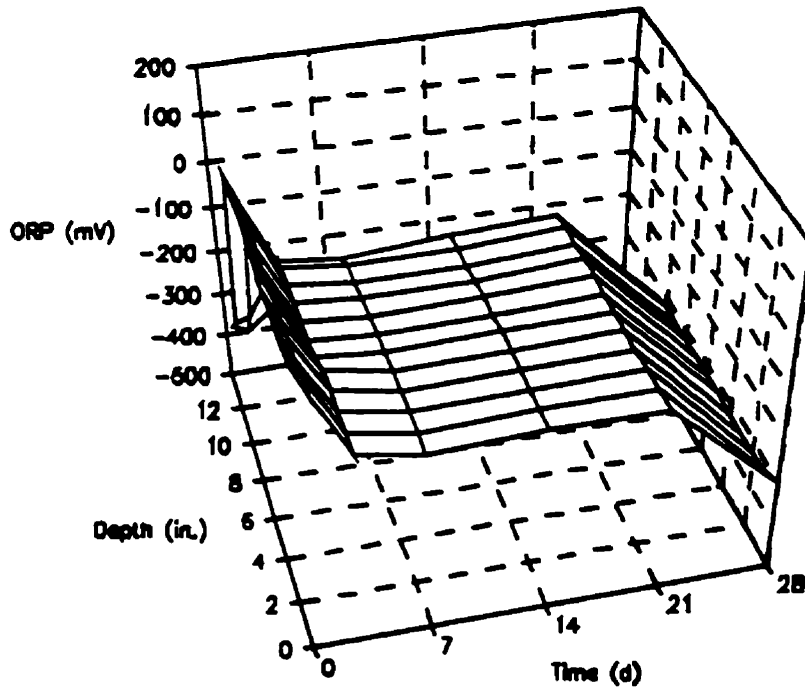
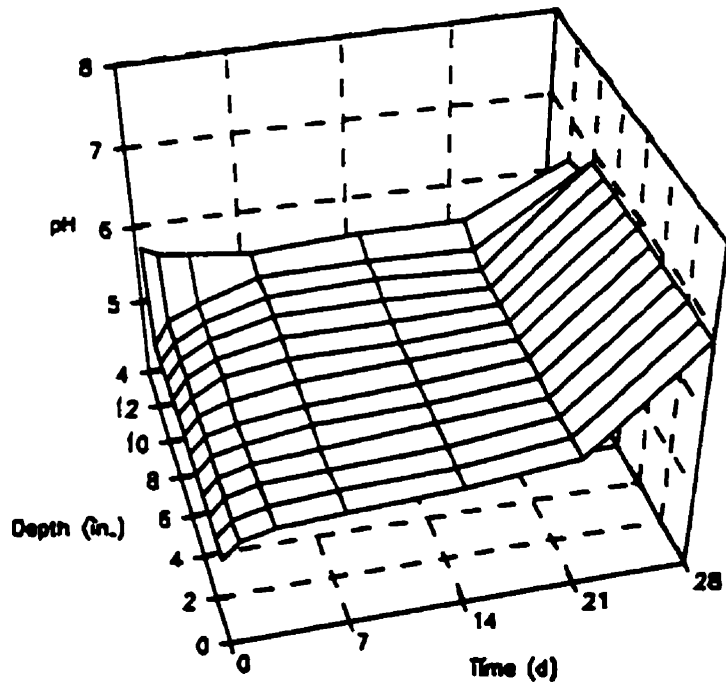
Column 6: 1/2" limestone, with SRB

pH

Depth (")	Day -2	0	1	3	7	14	21	28
0	6.15	5.15	5.35	5.45	5.5	5.55	5.7	5.7
1	6.15	5.15	5.35	5.45	5.5	5.55	5.7	5.75
2	6.15	5.15	5.35	5.45	5.5	5.55	5.7	5.75
3	6.15	5.15	5.35	5.45	5.5	5.6	5.7	5.75
4	6.15	5.15	5.35	5.45	5.55	5.6	5.7	5.75
5	6.15	5.15	5.35	5.45	5.55	5.6	5.7	5.75
6	6.15	5.15	5.35	5.5	5.6	5.65	5.7	5.75
7	6.15	5.15	5.35	5.55	5.65	5.65	5.7	5.75
8	6.15	5.1	5.35	5.55	5.7	5.7	5.7	5.75
9	6.15	5.1	5.35	5.55	5.75	5.75	5.7	5.75
10	6.15	5.1	5.35	5.55	5.75	5.8	5.7	5.75
11	6.15	5.1	5.4	5.55	5.8	5.8	5.75	5.75
12	6.2	6.15	6.05	6	5.9	5.95	5.95	5.95

ORP (mV)

Depth (")	Day -2	0	1	3	7	14	21	28
0	-345	120	50	-80	-105	-95	-95	-300
1	-345	115	45	-80	-105	-95	-95	-320
2	-345	115	40	-80	-105	-100	-95	-325
3	-345	110	40	-80	-105	-100	-95	-325
4	-340	105	35	-80	-105	-100	-95	-325
5	-340	110	35	-95	-105	-100	-95	-320
6	-340	115	30	-100	-110	-105	-95	-325
7	-340	120	25	-100	-110	-105	-95	-320
8	-340	120	25	-100	-110	-110	-95	-320
9	-340	110	35	-100	-115	-115	-100	-320
10	-340	110	35	-100	-115	-115	-100	-320
11	-345	-250	-240	-125	-140	-120	-110	-330
12	-355	-300	-315	-265	-250	-170	-205	-350



Changes in pH and ORP over time and depth.
 Column 6: 1/2" limestone inoculated with SRB. Cycle 7: $V_c = 2L$.

CYCLE 8

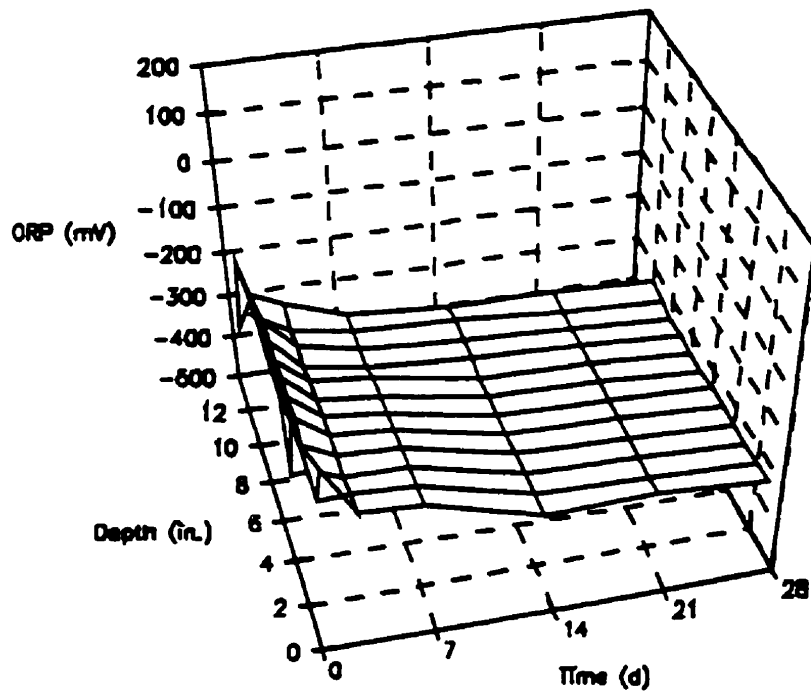
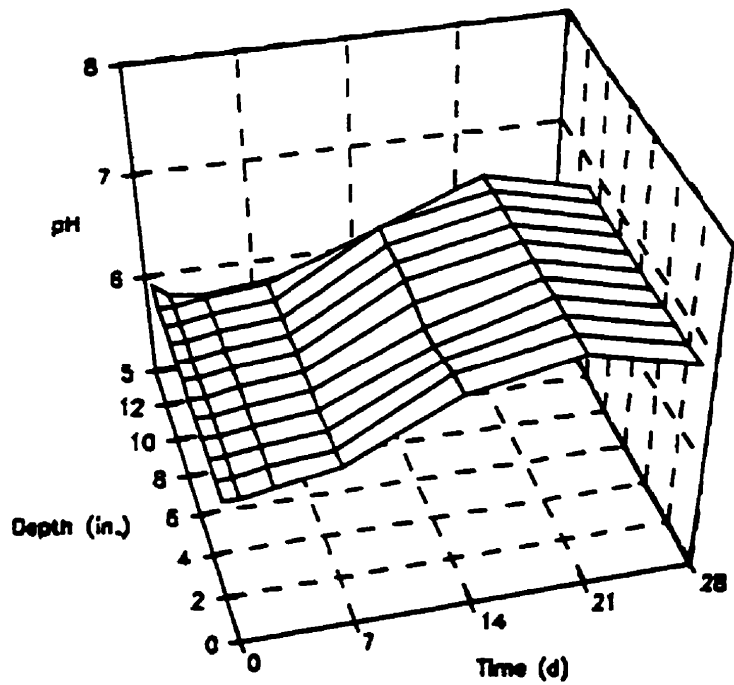
Column 1: 1/4" granite, with SRB

pH

Depth (")	Day							
	-5	0	1	3	7	14	21	28
0	6.9	6.2	6.2	6.25	6.35	6.85	7.05	6.8
1	6.9	6.2	6.2	6.25	6.3	6.85	7.05	6.8
2	6.85	6.2	6.2	6.25	6.3	6.8	7.05	6.8
3	6.85	6.2	6.2	6.25	6.3	6.75	7.05	6.8
4	6.85	6.2	6.2	6.25	6.3	6.75	7.05	6.8
5	6.85	6.2	6.2	6.25	6.3	6.8	7.05	6.8
6	6.85	6.2	6.2	6.25	6.3	6.85	7.05	6.8
7	6.75	6.2	6.2	6.25	6.3	6.85	7.05	6.8
8	6.4	6.2	6.2	6.25	6.3	6.85	7.05	6.8
9	6.3	6.2	6.2	6.25	6.3	6.85	7.05	6.8
10	6.3	6.2	6.2	6.25	6.3	6.65	7.05	6.8
11	6.2	6.25	6.15	6.1	6.15	6.3	6.5	6.5
12	6.25	6.3	6.25	6.15	6.15	6.3	6.35	6.45

ORP (mV)

Depth (")	Day							
	-5	0	1	3	7	14	21	28
0	-300	-80	-140	-250	-255	-325	-320	-335
1	-325	-75	-260	-255	-260	-325	-330	-340
2	-320	-245	-240	-265	-265	-325	-330	-340
3	-320	-110	-230	-265	-270	-325	-330	-340
4	-320	-110	-215	-265	-275	-325	-330	-340
5	-320	-105	-210	-265	-280	-325	-330	-340
6	-320	-90	-210	-270	-285	-325	-330	-345
7	-305	-90	-215	-270	-285	-325	-330	-345
8	-305	-90	-215	-280	-305	-320	-330	-345
9	-305	-100	-210	-275	-305	-320	-330	-345
10	-300	-110	-240	-280	-305	-310	-330	-340
11	-310	-300	-230	-260	-305	-320	-320	-330
12	-320	-310	-310	-325	-315	-320	-330	-345



Changes in pH and ORP over time and depth.
 Column 1: 1/4" granite inoculated with SRB. Cycle 8: $V_c = 1L$.

CYCLE 8

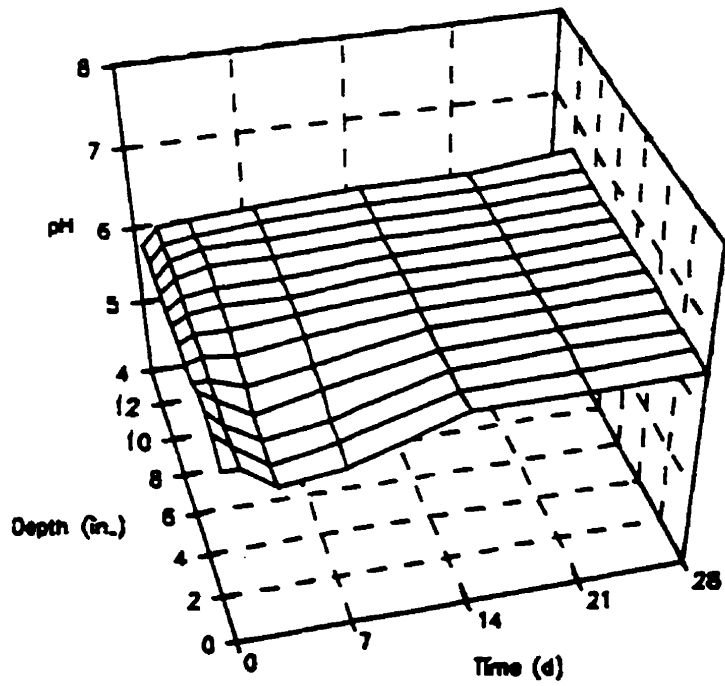
Column 2: 1/4" granite, no SRB

pH

Depth (")	Day -5	0	1	3	7	14	21	28
0	6.5	6.25	6.25	5.95	6.05	6.5	6.5	6.5
1	6.55	6.45	6.25	5.95	6.1	6.5	6.5	6.55
2	6.55	6.45	6.25	6	6.1	6.5	6.55	6.55
3	6.55	6.45	6.3	6.05	6.25	6.5	6.55	6.55
4	6.55	6.3	6.3	6.15	6.3	6.55	6.55	6.6
5	6.55	6.3	6.35	6.3	6.4	6.55	6.55	6.6
6	6.55	6.3	6.4	6.4	6.45	6.55	6.55	6.6
7	6.55	6.3	6.4	6.45	6.45	6.55	6.55	6.6
8	6.55	6.25	6.4	6.45	6.45	6.55	6.55	6.6
9	6.55	6.25	6.4	6.5	6.5	6.55	6.55	6.6
10	6.55	6.2	6.4	6.5	6.5	6.55	6.55	6.6
11	6.55	6.2	6.4	6.45	6.5	6.55	6.55	6.6
12	6.6	6.2	6.4	6.45	6.5	6.55	6.55	6.65

ORP (mV)

Depth (")	Day -5	0	1	3	7	14	21	28
0	100	170	180	235	250	165	190	185
1	100	170	170	225	240	165	190	185
2	105	170	165	215	200	165	190	180
3	100	170	165	180	190	160	190	175
4	95	170	160	165	185	160	190	175
5	90	170	150	165	185	160	190	175
6	90	165	150	165	180	160	190	170
7	85	170	155	165	175	160	190	175
8	80	170	155	165	175	160	185	175
9	75	170	150	165	175	160	185	175
10	70	165	155	165	175	165	185	175
11	65	165	150	165	175	165	185	175
12	65	170	155	165	170	160	185	170



Changes in pH and ORP over time and depth.
 Column 2: 1/4" granite with no SRB, control. Cycle 8: $V_c = 1L$.

CYCLE 8

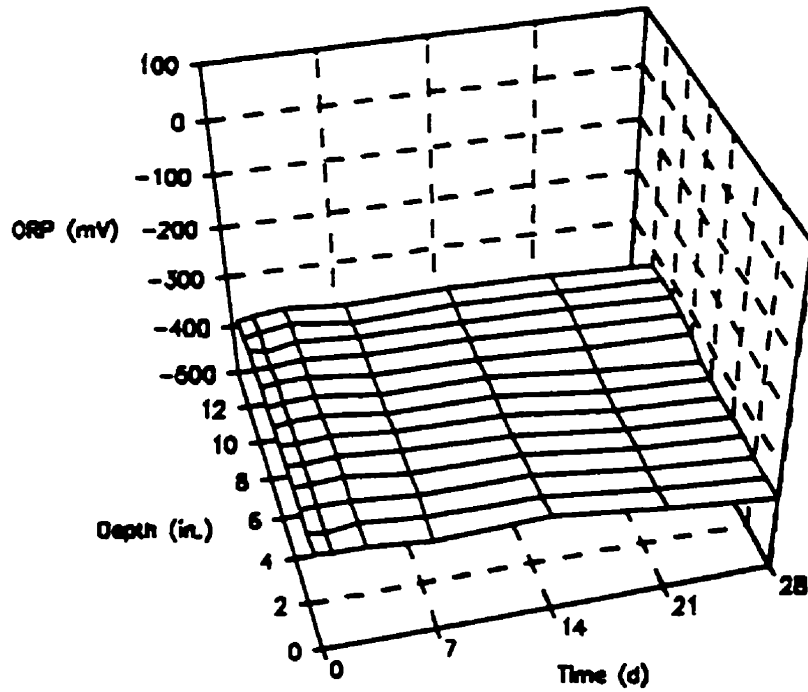
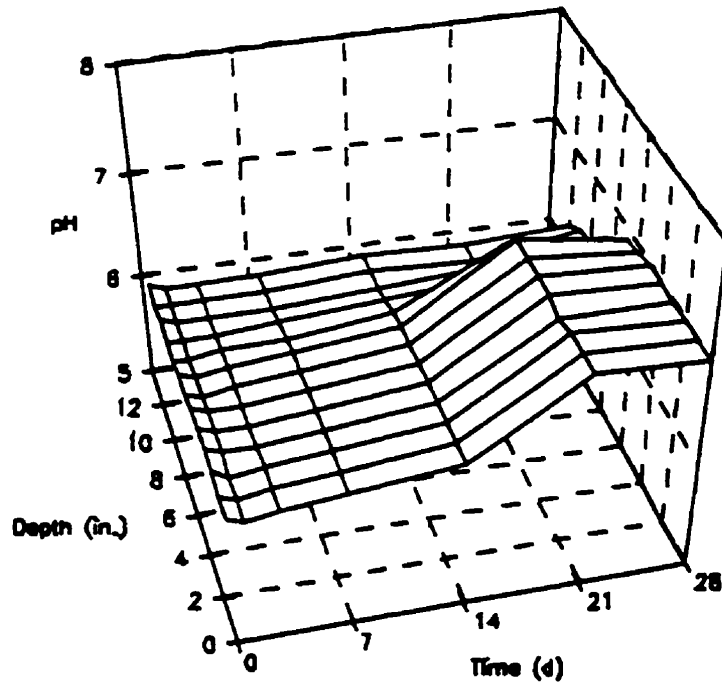
Column 3: 1/4" limestone, with SRB

pH

Depth (")	-5	0	1	3	7	14	21	28
0	6.75	6.25	6.2	6.25	6.3	6.4	7.05	7
1	6.75	6.25	6.2	6.25	6.3	6.4	7.05	7
2	6.75	6.3	6.2	6.25	6.3	6.4	7.05	7
3	6.75	6.3	6.25	6.25	6.3	6.4	7	7
4	6.75	6.3	6.25	6.25	6.3	6.4	7.05	7
5	6.75	6.3	6.25	6.25	6.3	6.4	7.05	7
6	6.7	6.25	6.2	6.25	6.3	6.4	7.05	6.95
7	6.55	6.25	6.2	6.25	6.3	6.4	7.05	6.9
8	6.35	6.2	6.2	6.25	6.25	6.35	6.85	6.75
9	6.25	6.2	6.2	6.2	6.25	6.3	6.4	6.6
10	6.25	6.25	6.2	6.2	6.2	6.25	6.3	6.4
11	6.25	6.2	6.2	6.2	6.2	6.25	6.2	6.35
12	6.25	6.25	6.2	6.2	6.2	6.25	6.2	6.25

ORP (mV)

Depth (")	-5	0	1	3	7	14	21	28
0	-340	-310	-315	-315	-325	-315	-340	-360
1	-340	-315	-320	-310	-320	-320	-345	-360
2	-340	-310	-310	-310	-320	-320	-345	-360
3	-340	-310	-310	-305	-320	-320	-345	-355
4	-340	-310	-310	-305	-315	-320	-345	-355
5	-330	-310	-310	-305	-315	-320	-345	-355
6	-320	-310	-305	-305	-320	-320	-345	-355
7	-315	-310	-305	-305	-320	-320	-340	-355
8	-315	-310	-305	-305	-320	-320	-330	-335
9	-315	-310	-310	-305	-315	-315	-325	-330
10	-320	-310	-315	-305	-315	-315	-320	-330
11	-320	-320	-315	-305	-320	-315	-320	-325
12	-320	-320	-315	-310	-320	-315	-320	-330



Changes in pH and ORP over time and depth.
 Column 3: 1/4" limestone inoculated with SRB. Cycle 8: $V_c = 1L$.

CYCLE 8

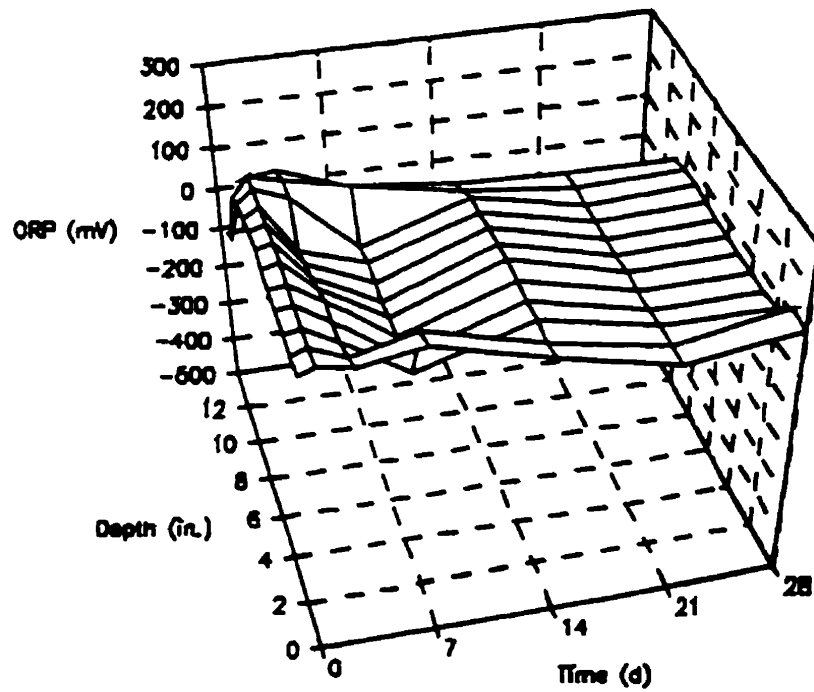
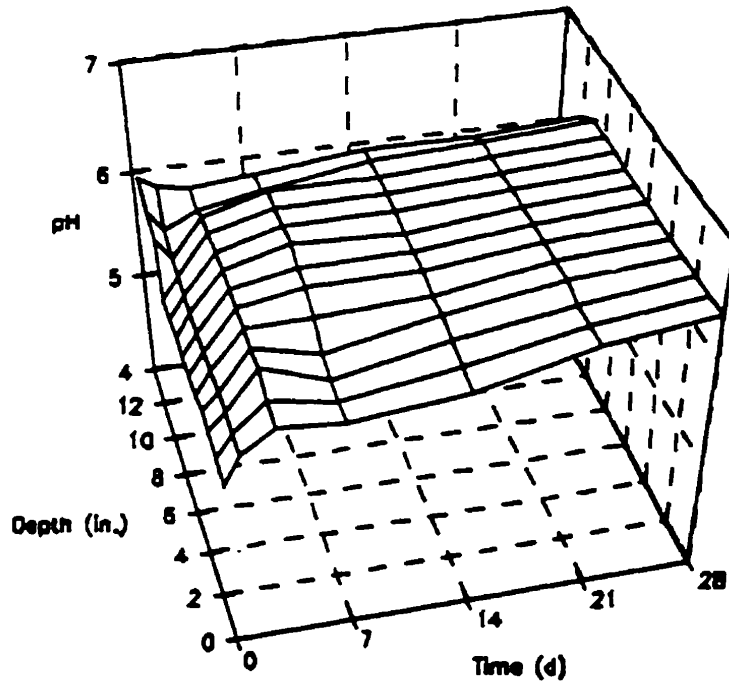
Column 7: 1/4" limestone, no SRB

pH

Depth (")	Day -5	0	1	3	7	14	21	28
0	6.2	5.55	5.8	6	5.95	6.05	6.3	6.4
1	6.2	5.6	5.8	6.05	5.95	6.1	6.3	6.4
2	6.2	5.65	5.8	6.15	5.95	6.15	6.3	6.4
3	6.25	5.65	5.8	6.15	6	6.2	6.35	6.4
4	6.25	5.6	5.8	6.15	6.15	6.2	6.35	6.4
5	6.25	5.6	5.8	6.15	6.25	6.25	6.35	6.4
6	6.25	5.6	5.8	6.15	6.25	6.25	6.35	6.4
7	6.2	5.6	5.8	6.15	6.3	6.25	6.35	6.4
8	6.2	5.6	5.8	6.15	6.3	6.3	6.35	6.4
9	6.2	5.6	5.8	6.15	6.3	6.3	6.35	6.4
10	6.15	6	5.8	6.15	6.3	6.3	6.35	6.4
11	6.1	6.1	5.9	6.05	6.15	6.3	6.35	6.4
12	6.25	6.25	6.15	6.1	6.15	6.25	6.25	6.3

ORP (mV)

Depth (")	Day -5	0	1	3	7	14	21	28
0	155	180	195	180	205	135	75	110
1	145	175	190	155	190	120	70	115
2	125	175	185	140	45	125	70	70
3	140	185	190	140	35	125	60	65
4	145	185	190	140	35	125	60	65
5	145	185	195	125	35	130	60	65
6	165	185	195	105	25	125	55	65
7	170	185	195	95	25	120	55	65
8	170	170	195	80	30	115	55	65
9	170	165	195	165	25	110	55	70
10	165	140	185	165	130	85	55	65
11	30	0	140	150	90	65	55	50
12	-20	-30	-25	15	0	-50	-30	-20



Changes in pH and ORP over time and depth.
 Column 7: 1/4" limestone with no SRB, control. Cycle 8: $V_c = 1L$.

CYCLE 8

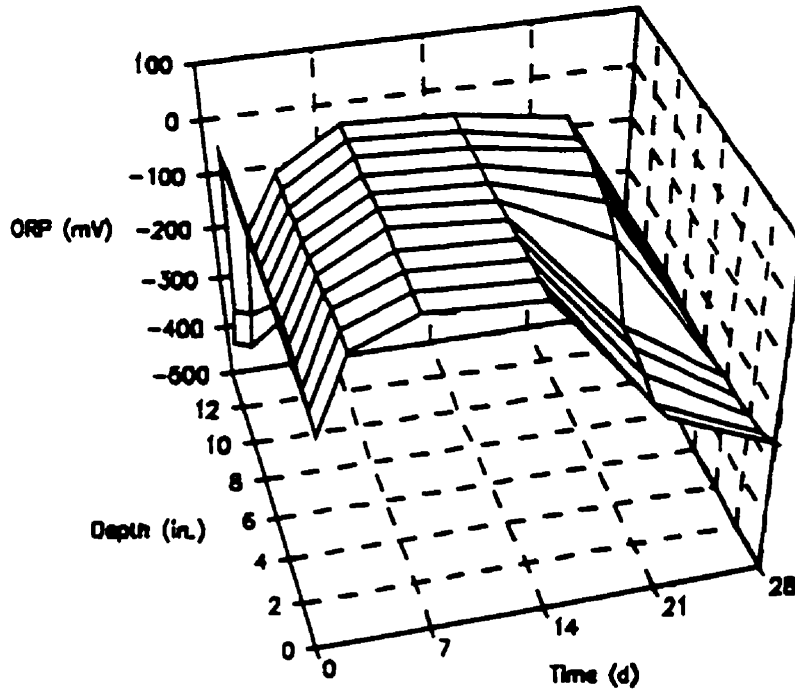
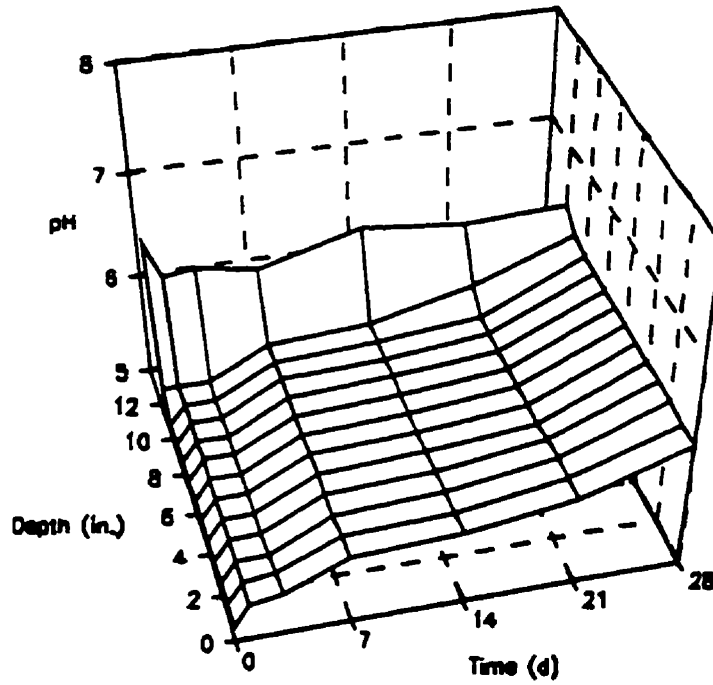
Column 4: 1/2" granite, with SRB

pH

Depth (")	Day -5	0	1	3	7	14	21	28
0	6.95	5.15	5.35	5.4	5.65	5.7	5.85	6.2
1	6.95	5.15	5.35	5.4	5.65	5.7	5.85	6.2
2	6.95	5.15	5.35	5.35	5.65	5.7	5.85	6.25
3	6.95	5.15	5.35	5.35	5.65	5.7	5.85	6.25
4	6.95	5.15	5.35	5.35	5.65	5.7	5.8	6.25
5	6.95	5.15	5.35	5.35	5.65	5.7	5.8	6.25
6	6.95	5.15	5.35	5.35	5.65	5.7	5.8	6.25
7	6.95	5.15	5.35	5.35	5.65	5.7	5.8	6.25
8	6.95	5.15	5.35	5.35	5.65	5.7	5.8	6.25
9	6.95	5.15	5.35	5.35	5.65	5.7	5.8	6.25
10	6.95	5.15	5.35	5.35	5.65	5.7	5.8	6.25
11	6.95	5.35	5.35	5.35	5.65	5.7	5.95	6.3
12	6.75	6.65	6.3	6.35	6.25	6.5	6.4	6.45

ORP (mV)

Depth (")	Day -5	0	1	3	7	14	21	28
0	-360	70	-100	35	80	70	-165	-250
1	-355	65	-95	35	80	70	-180	-270
2	-350	60	-95	35	80	70	-165	-275
3	-350	55	-95	30	80	70	-150	-275
4	-355	55	-95	25	85	70	-145	-275
5	-355	55	-95	20	85	70	-25	-280
6	-355	55	-90	15	80	70	10	-280
7	-355	55	-90	15	80	70	25	-280
8	-355	55	-90	10	80	70	40	-280
9	-355	55	-90	10	80	70	30	-280
10	-355	50	-90	10	80	70	40	-275
11	-365	-265	-275	-260	-220	-330	-300	-335
12	-385	-365	-375	-335	-340	-365	-350	-365



Changes in pH and ORP over time and depth.
 Column 4: 1/2" granite inoculated with SRB. Cycle 8: $V_c = 6L$.

CYCLE 8

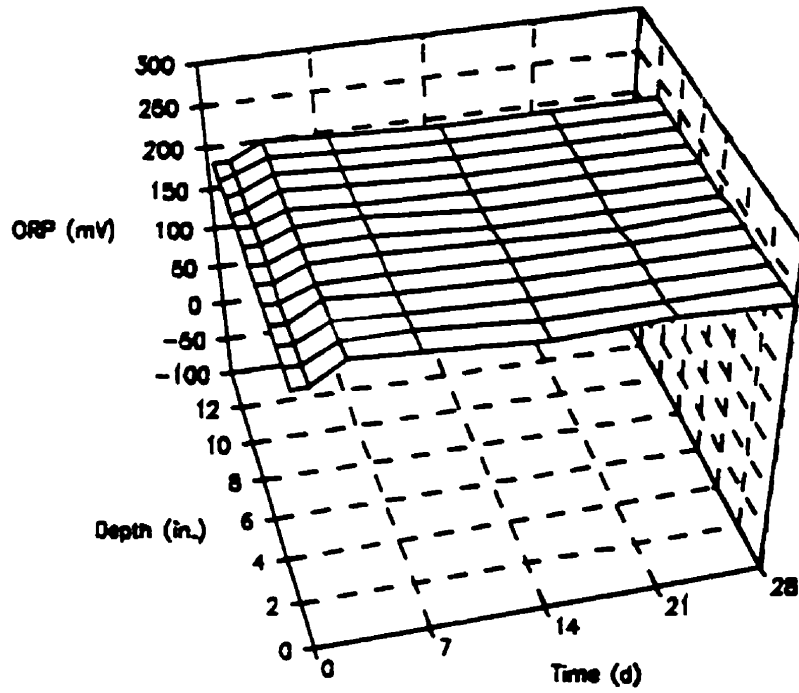
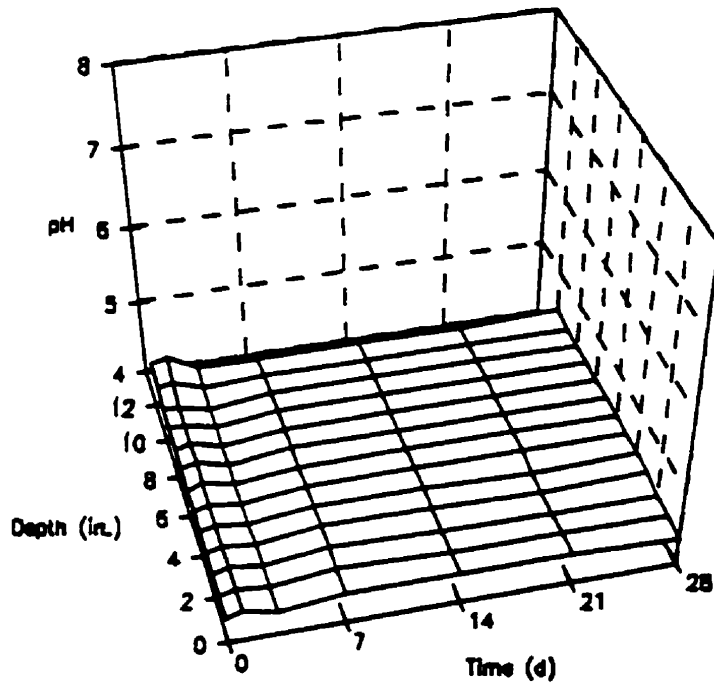
Column 5: 1/2" granite, no SRB

pH

Depth (")	Day -5	0	1	3	7	14	21	28
0	4.65	4.35	4.4	4.3	4.4	4.4	4.4	4.35
1	4.65	4.35	4.4	4.35	4.45	4.4	4.4	4.4
2	4.65	4.35	4.4	4.35	4.45	4.4	4.4	4.4
3	4.65	4.35	4.4	4.35	4.45	4.45	4.4	4.45
4	4.65	4.35	4.4	4.35	4.45	4.45	4.4	4.45
5	4.65	4.35	4.4	4.35	4.45	4.45	4.45	4.45
6	4.65	4.35	4.45	4.35	4.45	4.45	4.45	4.45
7	4.65	4.4	4.45	4.35	4.45	4.45	4.45	4.45
8	4.65	4.4	4.45	4.35	4.45	4.45	4.45	4.45
9	4.65	4.45	4.45	4.35	4.45	4.45	4.45	4.45
10	4.65	4.45	4.45	4.35	4.45	4.45	4.45	4.45
11	4.65	4.5	4.55	4.4	4.45	4.45	4.45	4.45
12	4.65	4.6	4.65	4.45	4.45	4.45	4.45	4.5

ORP (mV)

Depth (")	Day -5	0	1	3	7	14	21	28
0	195	225	225	250	245	235	240	235
1	200	225	225	245	245	235	235	235
2	200	225	225	245	240	235	235	235
3	200	225	225	245	240	235	235	235
4	200	225	225	240	240	235	235	235
5	200	225	225	240	240	235	230	235
6	205	225	225	240	240	230	230	230
7	205	225	225	240	240	230	230	230
8	205	225	225	240	235	230	230	230
9	205	220	225	240	235	230	230	230
10	205	220	225	240	235	230	230	230
11	205	220	225	240	235	230	230	230
12	205	220	220	240	235	230	230	230



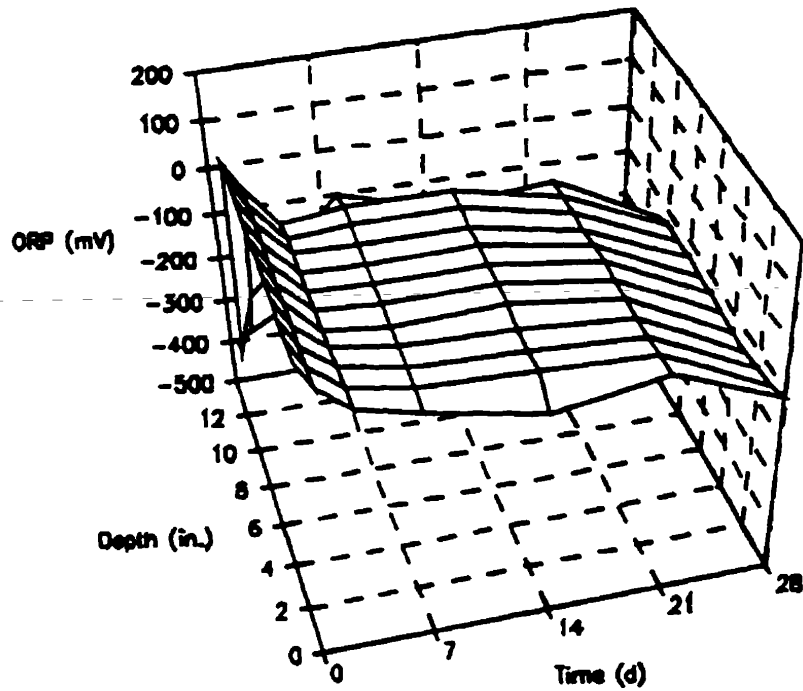
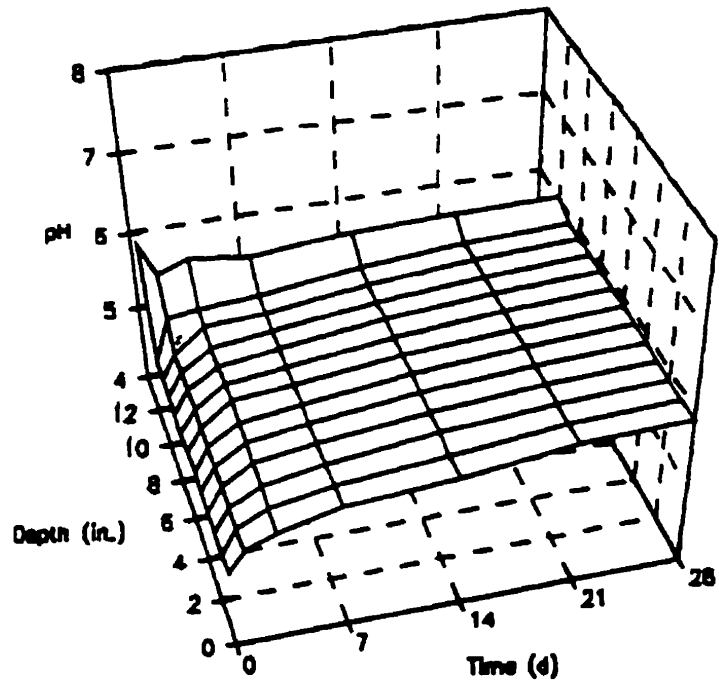
Changes in pH and ORP over time and depth.
 Column 5: 1/2" granite with no SRB, control. Cycle 8: $V_c = 6L$.

CYCLE 8

Column 6: 1/2" limestone, with SRB

Depth (")	Day -5	0	1	3	7	14	21	28
0	6.9	5	5.25	5.4	5.6	5.7	5.85	5.9
1	6.9	4.95	5.25	5.45	5.6	5.7	5.85	5.9
2	6.9	4.95	5.25	5.45	5.6	5.75	5.85	5.9
3	6.9	4.95	5.25	5.5	5.6	5.75	5.85	5.9
4	6.9	4.95	5.25	5.5	5.6	5.75	5.85	5.9
5	6.9	4.95	5.25	5.5	5.6	5.75	5.85	5.9
6	6.9	4.95	5.25	5.55	5.6	5.75	5.85	5.9
7	6.9	4.95	5.25	5.5	5.6	5.75	5.85	5.9
8	6.9	4.95	5.25	5.5	5.6	5.75	5.85	5.9
9	6.9	4.95	5.25	5.5	5.6	5.75	5.85	5.9
10	6.9	4.95	5.25	5.55	5.6	5.75	5.85	5.9
11	6.6	4.95	5.5	5.55	5.6	5.75	5.85	5.9
12	6.55	6.25	5.85	6	5.9	6	6.05	6.05

ORP (mV) Depth (")	-5	0	1	3	7	14	21	28
0	-300	135	80	25	-5	-55	-20	-110
1	-320	135	80	25	0	-10	-20	-130
2	-325	135	75	25	0	-10	-25	-135
3	-325	135	75	20	0	-5	-25	-140
4	-325	140	80	15	0	5	-25	-140
5	-320	140	80	15	5	10	-25	-135
6	-325	135	80	15	10	10	-25	-135
7	-320	140	85	15	10	15	-25	-135
8	-320	145	90	20	15	15	-30	-130
9	-320	145	90	10	20	20	-30	-130
10	-320	145	90	5	20	20	-30	-130
11	-330	-300	-180	-115	10	-50	-30	-145
12	-350	-320	-300	-265	-250	-290	-285	-310



Changes in pH and ORP over time and depth.
 Column 6: 1/2" limestone inoculated with SRB. Cycle 8: $V_c = 6L$.

CYCLE 9

Column 1: 1/4" granite, with SRB

pH

Depth (")	Day -7	0	1	3	7	14	21	28
0	6.8	6	6.15	6.45	6.65	7	7	7.2
1	6.8	6	6.15	6.45	6.6	6.95	7	7.2
2	6.8	6.05	6.15	6.45	6.6	6.95	6.95	7.2
3	6.8	6.05	6.15	6.45	6.6	6.95	6.95	7.2
4	6.8	6.05	6.15	6.45	6.6	6.95	6.95	7.2
5	6.8	6	6.15	6.4	6.6	6.95	6.95	7.2
6	6.8	5.95	6.15	6.4	6.6	6.95	7	7.2
7	6.8	5.95	6.15	6.4	6.6	7	7	7.2
8	6.8	5.95	6.15	6.4	6.6	7	7	7.2
9	6.8	5.95	6.15	6.35	6.6	7	7	7.2
10	6.8	5.95	6.15	6.35	6.6	7	7	7.2
11	6.5	5.9	6	6.15	6.25	6.35	6.5	6.7
12	6.45	6.45	6.45	6.35	6.3	6.45	6.5	6.65

ORP (mV)

Depth (")	Day -7	0	1	3	7	14	21	28
0	-335	-310	-350	-290	-325	-320	-330	-300
1	-340	-310	-360	-295	-325	-320	-335	-300
2	-340	-310	-375	-295	-325	-320	-335	-315
3	-340	-225	-380	-310	-325	-325	-335	-320
4	-340	-200	-375	-315	-325	-325	-335	-320
5	-340	-185	-375	-310	-320	-325	-335	-320
6	-345	-180	-370	-300	-320	-325	-335	-320
7	-345	-175	-375	-305	-320	-330	-335	-320
8	-345	-175	-380	-305	-320	-330	-335	-320
9	-345	-225	-360	-295	-320	-330	-335	-320
10	-340	-220	-385	-295	-320	-320	-330	-325
11	-330	-350	-335	-320	-335	-330	-335	-330
12	-345	-390	-400	-345	-350	-340	-345	-340

CYCLE 9

Column 2: 1/4" granite, no SRB

pH

Depth (")	Day	0	1	3	7	14	21	28
0	6.5	6.3	6.45	6.5	6.6	6.6	6.6	6.65
1	6.55	6.25	6.45	6.45	6.55	6.6	6.6	6.65
2	6.55	6.25	6.4	6.45	6.55	6.55	6.6	6.65
3	6.55	6.2	6.4	6.4	6.5	6.55	6.6	6.6
4	6.6	6.15	6.3	6.4	6.5	6.55	6.6	6.6
5	6.6	6.1	6.2	6.35	6.5	6.55	6.6	6.6
6	6.6	6.05	6.15	6.3	6.45	6.55	6.6	6.6
7	6.6	5.9	6.05	6.2	6.2	6.4	6.6	6.6
8	6.6	5.8	5.9	6.1	6.2	6.35	6.4	6.6
9	6.6	5.4	5.75	6	6.2	6.25	6.35	6.4
10	6.6	5.3	5.7	6	6.15	6.25	6.3	6.35
11	6.6	5.4	5.75	6	6.15	6.25	6.3	6.35
12	6.65	5.35	5.85	6	6.15	6.25	6.3	6.35

ORP (mV)

Depth (")	Day	0	1	3	7	14	21	28
0	185	155	180	170	165	175	180	150
1	185	160	185	180	165	170	180	150
2	180	165	190	180	165	170	180	150
3	175	165	150	180	165	165	180	150
4	175	155	150	180	160	165	180	150
5	175	155	145	150	155	145	135	150
6	170	155	145	155	150	105	85	150
7	175	160	130	135	135	80	60	150
8	175	170	160	150	120	65	35	150
9	175	175	160	150	100	50	15	20
10	175	185	115	120	80	25	10	10
11	175	190	85	75	45	15	15	10
12	170	190	80	60	35	10	10	10

CYCLE 9

Column 3: 1/4" limestone, with SRB

pH

Depth (")	Day	0	1	3	7	14	21	28
0	7	6.05	6.15	6.35	6.5	6.65	6.7	6.75
1	7	6.05	6.15	6.35	6.5	6.65	6.7	6.75
2	7	6.05	6.15	6.35	6.5	6.65	6.7	6.75
3	7	6.1	6.15	6.35	6.5	6.65	6.7	6.75
4	7	6	6.15	6.35	6.5	6.65	6.7	6.75
5	7	6	6.15	6.3	6.45	6.6	6.65	6.75
6	6.95	5.95	6.15	6.25	6.35	6.5	6.55	6.55
7	6.9	5.95	6.15	6.2	6.3	6.35	6.4	6.45
8	6.75	5.95	6.05	6.15	6.2	6.25	6.35	6.4
9	6.6	5.95	6	6.15	6.15	6.25	6.3	6.35
10	6.4	5.85	6	6.1	6.15	6.2	6.25	6.35
11	6.35	5.8	5.95	6.1	6.1	6.2	6.25	6.3
12	6.25	6.2	6.2	6.15	6.15	6.2	6.25	6.3

ORP (mV)

Depth (")	Day	0	1	3	7	14	21	28
0	-360	-365	-350	-315	-335	-330	-350	-335
1	-360	-465	-355	-325	-335	-330	-345	-335
2	-360	-480	-360	-325	-335	-335	-345	-340
3	-355	-485	-360	-325	-335	-335	-345	-340
4	-355	-480	-355	-320	-330	-330	-345	-340
5	-355	-390	-345	-320	-335	-330	-345	-340
6	-355	-375	-340	-305	-330	-325	-335	-335
7	-355	-365	-335	-305	-325	-320	-330	-330
8	-335	-350	-335	-305	-315	-320	-330	-325
9	-330	-405	-335	-305	-315	-315	-325	-325
10	-330	-350	-370	-305	-315	-315	-325	-325
11	-325	-430	-320	-285	-325	-315	-325	-320
12	-330	-420	-380	-325	-335	-320	-330	-325

CYCLE 9

Column 7: 1/4" limestone, no SRB

pH

Depth (")	Day -7	0	1	3	7	14	21	28
0	6.4	5.75	5.95	6	6	6.2	6.3	6.3
1	6.4	5.75	5.95	6	6.05	6.2	6.35	6.35
2	6.4	5.75	5.95	6	6.1	6.2	6.35	6.35
3	6.4	5.75	5.95	6	6.1	6.2	6.35	6.35
4	6.4	5.8	5.95	6	6.1	6.2	6.35	6.35
5	6.4	5.8	5.95	6	6.1	6.2	6.35	6.35
6	6.4	5.8	6	6	6.15	6.25	6.35	6.35
7	6.4	5.85	6.05	6.15	6.2	6.25	6.35	6.45
8	6.4	6.05	6.2	6.25	6.3	6.25	6.35	6.45
9	6.4	6.05	6.2	6.3	6.35	6.3	6.35	6.45
10	6.4	6.05	6.2	6.3	6.35	6.3	6.35	6.4
11	6.4	6.1	6.2	6.35	6.35	6.25	6.35	6.35
12	6.3	6.25	6.25	6.25	6.35	6.2	6.3	6.3

ORP (mV)

Depth (")	Day -7	0	1	3	7	14	21	28
0	110	135	230	235	160	175	210	170
1	115	150	220	230	160	170	210	165
2	70	150	220	230	170	165	210	165
3	65	155	220	230	170	160	210	165
4	65	155	215	225	170	155	210	165
5	65	160	215	110	130	150	205	165
6	65	160	205	100	100	40	195	165
7	65	165	140	80	90	15	185	165
8	65	165	130	65	70	-10	60	165
9	70	165	80	25	40	-15	0	160
10	65	175	35	0	10	-30	20	-5
11	50	45	30	15	10	-40	-40	-5
12	-20	0	-40	-20	10	-60	-55	-40

CYCLE 9

Column 4: 1/2" granite, with SRB

pH

Depth (")	Day -1	0	1	3	7	14	21	28	35
0	6.75	4.8	5.15	5.2	5.35	5.4	5.5	5.6	5.95
1	6.75	4.75	5.15	5.2	5.35	5.4	5.5	5.6	5.95
2	6.75	4.75	5.15	5.2	5.35	5.4	5.5	5.6	5.95
3	6.75	4.7	5.15	5.2	5.35	5.4	5.5	5.6	5.95
4	6.75	4.7	5.15	5.2	5.35	5.4	5.5	5.6	5.95
5	6.75	4.7	5.15	5.2	5.35	5.4	5.5	5.6	5.95
6	6.7	4.7	5.15	5.2	5.35	5.4	5.5	5.6	5.95
7	6.7	4.7	5.1	5.2	5.35	5.4	5.5	5.6	5.95
8	6.65	4.65	5.1	5.2	5.35	5.4	5.5	5.6	5.95
9	6.6	4.65	5.1	5.2	5.35	5.4	5.5	5.6	5.95
10	6.6	4.65	5.1	5.2	5.35	5.4	5.5	5.6	5.95
11	6.6	5.05	5.2	5.3	5.5	5.4	5.7	5.95	6.1
12	6.65	6.6	6.45	6.5	6.2	6.45	6.55	6.25	6.35

ORP (mV)

Depth (")	Day -1	0	1	3	7	14	21	28	35
0	-340	165	55	95	125	120	135	50	-205
1	-340	165	45	90	115	120	135	60	-235
2	-340	155	40	90	115	120	130	75	-235
3	-340	150	40	90	115	125	130	80	-225
4	-340	150	45	95	115	125	135	80	-215
5	-340	155	50	95	115	125	135	80	-215
6	-340	155	50	95	115	125	135	80	-210
7	-340	155	45	95	115	125	135	75	-210
8	-340	160	40	95	115	125	135	75	-210
9	-340	160	35	95	115	125	135	80	-220
10	-340	160	30	95	115	125	130	80	-220
11	-350	-335	-250	-225	-250	-295	-275	-290	-315
12	-365	-370	-365	-360	-355	-370	-355	-365	-335

CYCLE 9

Column 5: 1/2" granite, no SRB

pH

Depth (")	Day -1	0	1	3	7	14	21	28	35
0	4.45	4.2	4.25	4.25	4.25	4.35	4.35	4.4	4.4
1	4.45	4.25	4.25	4.3	4.3	4.35	4.35	4.4	4.4
2	4.45	4.25	4.25	4.3	4.3	4.35	4.4	4.4	4.4
3	4.45	4.25	4.3	4.3	4.3	4.35	4.4	4.45	4.45
4	4.45	4.3	4.3	4.3	4.3	4.35	4.4	4.45	4.45
5	4.45	4.3	4.3	4.3	4.3	4.35	4.4	4.45	4.45
6	4.5	4.3	4.3	4.3	4.3	4.35	4.4	4.45	4.45
7	4.5	4.3	4.3	4.3	4.3	4.4	4.4	4.45	4.45
8	4.5	4.3	4.3	4.3	4.3	4.4	4.4	4.45	4.45
9	4.5	4.3	4.3	4.3	4.35	4.4	4.4	4.45	4.45
10	4.5	4.3	4.3	4.3	4.35	4.4	4.4	4.45	4.45
11	4.5	4.3	4.3	4.3	4.35	4.4	4.4	4.45	4.45
12	4.5	4.3	4.3	4.3	4.35	4.4	4.4	4.45	4.45

ORP (mV)

Depth (")	Day -1	0	1	3	7	14	21	28	35
0	230	240	235	240	240	240	240	240	250
1	230	240	235	235	235	240	235	240	250
2	230	235	235	235	235	235	235	240	250
3	230	235	235	235	235	235	235	240	250
4	230	235	235	235	235	235	235	240	245
5	225	235	235	235	235	235	235	235	245
6	225	235	235	235	235	235	235	235	245
7	225	235	235	235	235	235	235	235	245
8	225	235	235	235	235	235	235	235	245
9	225	235	235	235	235	235	230	235	245
10	225	235	235	235	235	235	230	235	245
11	225	235	235	235	235	235	230	235	245
12	225	235	235	235	235	230	230	235	245

CYCLE 9

Column 6: 1/2" limestone, with SRB

pH

Depth (")	Day -1	0	1	3	7	14	21	28	35
0	6.1	4.6	4.95	5.1	5.25	5.45	5.5	5.55	5.65
1	6.1	4.6	4.95	5.1	5.25	5.45	5.55	5.55	5.65
2	6.1	4.55	4.95	5.1	5.25	5.45	5.55	5.55	5.65
3	6.1	4.5	4.95	5.1	5.25	5.45	5.55	5.55	5.65
4	6.1	4.5	4.95	5.1	5.25	5.45	5.55	5.55	5.65
5	6.1	4.45	4.95	5.1	5.25	5.45	5.55	5.55	5.65
6	6.1	4.45	4.95	5.1	5.25	5.45	5.55	5.55	5.65
7	6.1	4.45	4.95	5.1	5.25	5.45	5.55	5.55	5.65
8	6.1	4.45	4.95	5.1	5.25	5.45	5.55	5.55	5.65
9	6.1	4.45	4.95	5.1	5.25	5.45	5.55	5.55	5.65
10	6.1	4.45	4.95	5.1	5.25	5.45	5.5	5.55	5.65
11	6.1	5.1	5.05	5.1	5.3	5.45	5.5	5.6	5.65
12	6.25	6.15	6	6	6.05	5.95	6.05	6.05	6.05

ORP (mV)

Depth (")	Day -1	0	1	3	7	14	21	28	35
0	-290	200	105	105	60	10	20	30	80
1	-295	190	110	105	65	30	35	35	85
2	-295	185	115	105	70	45	40	45	85
3	-290	180	115	105	70	55	45	45	80
4	-290	180	115	110	75	60	50	45	80
5	-290	175	115	110	75	60	55	50	80
6	-290	180	115	110	75	65	55	50	80
7	-290	185	115	110	75	70	55	50	80
8	-290	190	120	110	80	70	55	50	80
9	-290	190	120	110	80	75	60	50	80
10	-290	185	120	110	80	75	60	50	85
11	-290	-5	-20	-100	-115	-125	-210	-265	-280
12	-335	-340	-315	-320	-295	-295	-315	-315	-300

APPENDIX F

CONDUCTIVITY MEASUREMENTS

Changes in conductivity (mS)
 Cycle 1: Column 4 (EXP)

Time		Depth (in.)		2	3	4	5	6	7	8	9	10	11
h	d	0	1										
0	0	0.0319	0.1036	0.1269	0.1195	0.1489	0.135	0.1224	0.1201	0.1049	0.1146	0.1166	0.0842
1	0.042	0.0332	0.1043	0.1279	0.1206	0.151	0.137	0.1241	0.1207	0.1052	0.1149	0.117	0.0851
2	0.083	0.0347	0.0297	0.0383	0.0354	0.0771	0.0658	0.0669	0.0674	0.0564	0.0619	0.066	0.0575
3	0.125	0.0289	0.014	0.0145	0.0151	0.0152	0.0152	0.0148	0.0148	0.0129	0.0135	0.0143	0.0119
4	0.167	0.0178	0.0178	0.0172	0.0149	0.0167	0.0271	0.0197	0.0156	0.0131	0.013	0.0145	0.011
5	0.208	0.0141	0.0151	0.0146	0.0131	0.0144	0.0224	0.0162	0.0136	0.0123	0.0121	0.0131	0.0105
6	0.25	0.0128	0.0145	0.0138	0.0124	0.0138	0.021	0.0156	0.0128	0.0119	0.0116	0.0126	0.0102
12	0.5	0.0105	0.0117	0.0101	0.0094	0.0117	0.0136	0.0136	0.0105	0.0095	0.0093	0.0098	0.0088
18	0.75	0.0084	0.0097	0.0086	0.0085	0.0107	0.0118	0.0122	0.0092	0.0083	0.0084	0.0086	0.0081
24	1	0.0076	0.0092	0.0083	0.0083	0.0102	0.0108	0.0111	0.0086	0.008	0.0081	0.0082	0.0079
30	1.25	0.0075	0.0093	0.0083	0.0083	0.0102	0.0105	0.0106	0.0084	0.008	0.0081	0.0081	0.0078
36	1.5	0.0074	0.0107	0.0083	0.0083	0.0107	0.0102	0.0102	0.0083	0.0079	0.008	0.008	0.0077
42	1.75	0.0073	0.0361	0.0087	0.0086	0.0123	0.0103	0.0099	0.0083	0.008	0.008	0.008	0.0076
48	2	0.0071	0.0814	0.0333	0.0342	0.0295	0.0246	0.0238	0.0223	0.0215	0.0217	0.0216	0.0203
54	2.25	0.0285	0.1364	0.0739	0.0419	0.0459	0.0378	0.0367	0.0343	0.0316	0.0328	0.0317	0.0304
60	2.5	0.0489	0.1876	0.1626	0.0604	0.1402	0.0524	0.0449	0.0424	0.0357	0.036	0.0361	0.0326
66	2.75	0.0412	0.3721	0.3769	0.3247	0.3613	0.1547	0.1321	0.1018	0.0749	0.0713	0.0711	0.0641
72	3	0.1011	0.3751	0.384	0.3696	0.3727	0.1325	0.1284	0.1375	0.1449	0.1123	0.0987	0.0632
78	3.25	0.2084	0.3696	0.3828	0.3629	0.3616	0.1269	0.1132	0.1352	0.2079	0.1985	0.1796	0.0668
84	3.5	0.2137	0.3678	0.3748	0.3565	0.3541	0.1131	0.1053	0.1213	0.1763	0.155	0.1411	0.0696
90	3.75	0.106	0.3686	0.3717	0.3548	0.3512	0.1001	0.0977	0.1162	0.1623	0.1436	0.122	0.0708
96	4	0.1424	0.369	0.3744	0.3568	0.3506	0.0876	0.0925	0.1132	0.1552	0.1373	0.1164	0.0716
102	4.25	0.1408	0.3663	0.3732	0.3541	0.3443	0.0694	0.0845	0.1069	0.142	0.1296	0.1057	0.0699
108	4.5	0.1393	0.3686	0.3768	0.3555	0.3394	0.0729	0.0714	0.1021	0.1282	0.1257	0.0941	0.0708
114	4.75	0.1054	0.3708	0.3818	0.3555	0.3281	0.0757	0.0698	0.0996	0.1273	0.1246	0.0893	0.0697
120	5	0.105	0.3658	0.3775	0.3479	0.2748	0.0789	0.0714	0.0971	0.1252	0.1161	0.0859	0.068
126	5.25	0.1388	0.3742	0.3852	0.3507	0.1939	0.0787	0.0761	0.0946	0.1184	0.1067	0.0853	0.0685
132	5.5	0.035	0.3605	0.3786	0.3378	0.1813	0.0755	0.0714	0.0913	0.1097	0.093	0.0853	0.0668
138	5.75	0.0589	0.3649	0.386	0.3349	0.1837	0.0742	0.0717	0.0899	0.1067	0.0884	0.0871	0.0661
144	6	0.0682	0.3653	0.3869	0.3245	0.1823	0.0749	0.0706	0.0898	0.105	0.0878	0.0868	0.0654
150	6.25	0.0823	0.3817	0.4135	0.327	0.1905	0.0759	0.0708	0.0908	0.1073	0.0893	0.0884	0.0658
156	6.5	0.0681	0.3647	0.3945	0.2976	0.1833	0.0717	0.071	0.0898	0.1033	0.0893	0.0883	0.065
162	6.75	0.0589	0.3489	0.3824	0.2707	0.1781	0.0702	0.0701	0.0885	0.1009	0.0892	0.0865	0.0647
168	7	0.0521	0.3252	0.3723	0.2389	0.1735	0.0698	0.0696	0.0875	0.0987	0.0886	0.0854	0.0646
174	7.25	0.0688	0.3232	0.3991	0.2214	0.1835	0.0703	0.0706	0.0886	0.1032	0.0909	0.0869	0.0655
180	7.5	0.1011	0.3227	0.4707	0.198	0.2087	0.0899	0.0911	0.1066	0.12	0.1033	0.0989	0.0825
186	7.75	0.1011	0.2776	0.4187	0.1493	0.1852	0.0788	0.085	0.1068	0.1066	0.0911	0.086	0.0735
192	8	0.1899	0.2508	0.4004	0.1634	0.188	0.0722	0.0722	0.0884	0.1059	0.0932	0.086	0.0673
198	8.25	0.1989	0.2681	0.3222	0.1869	0.2086	0.0695	0.0689	0.0848	0.125	0.1071	0.087	0.0638
204	8.5	0.1955	0.2377	0.2564	0.2048	0.2287	0.0694	0.069	0.0865	0.1501	0.1627	0.092	0.0658
210	8.75	0.1935	0.2334	0.2434	0.2084	0.2307	0.0683	0.069	0.0862	0.1538	0.1757	0.0958	0.0668
216	9	0.1929	0.2728	0.2356	0.2126	0.2362	0.068	0.067	0.0856	0.1592	0.1808	0.0955	0.0673
222	9.25	0.1923	0.2579	0.2407	0.216	0.2393	0.0691	0.0672	0.0862	0.1618	0.1919	0.0999	0.0681
228	9.5	0.1917	0.2699	0.2382	0.2169	0.2429	0.0693	0.0669	0.0861	0.1641	0.1984	0.1062	0.0678
234	9.75	0.1905	0.2696	0.2375	0.2167	0.2431	0.0691	0.0667	0.0865	0.1644	0.2031	0.1149	0.0683
240	10	0.1899	0.2654	0.2382	0.2165	0.2438	0.0692	0.0656	0.0866	0.1664	0.2078	0.1284	0.0681
246	10.25	0.0735	0.2615	0.242	0.2258	0.2499	0.0697	0.0661	0.088	0.1748	0.2125	0.1477	0.0689
252	10.5	0.0731	0.2614	0.251	0.2247	0.2638	0.0726	0.0678	0.0888	0.1808	0.2258	0.1635	0.0708
258	10.75	0.0637	0.2442	0.2473	0.2234	0.2617	0.0713	0.0668	0.088	0.1779	0.2333	0.1689	0.0773
264	11	0.0636	0.2475	0.2435	0.2254	0.2641	0.0719	0.0664	0.0883	0.1799	0.2406	0.1798	0.0785
270	11.25	0.0635	0.256	0.2468	0.2277	0.2695	0.0715	0.0663	0.0892	0.1833	0.24	0.1856	0.0776
276	11.5	0.0633	0.2599	0.2503	0.2271	0.2718	0.0713	0.0664	0.0893	0.1852	0.245	0.1944	0.0711
282	11.75	0.0633	0.2581	0.2491	0.2287	0.2735	0.0732	0.0657	0.091	0.1888	0.2569	0.2084	0.0699
288	12	0.0635	0.2585	0.2543	0.2349	0.2823	0.0725	0.0661	0.092	0.1921	0.2699	0.2243	0.0716
294	12.25	0.0632	0.2587	0.2635	0.234	0.2882	0.073	0.0659	0.0927	0.1947	0.2697	0.2292	0.0703
300	12.5	0.0629	0.2559	0.2685	0.2355	0.2934	0.0743	0.0654	0.0934	0.1978	0.2712	0.2355	0.07
306	12.75	0.0631	0.2358	0.2736	0.2364	0.295	0.0774	0.0652	0.0957	0.199	0.2748	0.242	0.0695
312	13	0.0631	0.2646	0.2773	0.2412	0.3109	0.0771	0.0658	0.0975	0.2063	0.2797	0.2492	0.0694

h	d	0	1	2	3	4	5	6	7	8	9	10	11
318	13.25	0.0631	0.2598	0.2754	0.2438	0.3127	0.0819	0.0665	0.104	0.2142	0.2866	0.2562	0.0742
324	13.5	0.0632	0.261	0.288	0.2483	0.3235	0.0828	0.0674	0.1095	0.2169	0.2829	0.2626	0.0701
330	13.75	0.063	0.2618	0.3006	0.2517	0.3331	0.0849	0.0686	0.1125	0.2201	0.2857	0.2693	0.0708
336	14	0.063	0.2599	0.3058	0.2536	0.336	0.0937	0.0687	0.1186	0.2241	0.2912	0.2816	0.0735
342	14.25	0.0631	0.2447	0.2986	0.2522	0.3275	0.1087	0.0693	0.1378	0.2359	0.3103	0.2911	0.0772
348	14.5	0.0635	0.2572	0.311	0.261	0.3479	0.1539	0.0701	0.1491	0.2455	0.3159	0.3041	0.081
354	14.75	0.063	0.2483	0.32	0.263	0.3514	0.1876	0.0708	0.1565	0.2434	0.3139	0.3003	0.0854
360	15	0.0628	0.2468	0.3281	0.2659	0.3579	0.2099	0.0715	0.1681	0.2495	0.3204	0.3137	0.0967
366	15.25	0.0478	0.2487	0.3355	0.2699	0.3616	0.2195	0.0732	0.1855	0.258	0.3262	0.317	0.1097
372	15.5	0.0405	0.2451	0.3765	0.2817	0.3666	0.1888	0.074	0.1571	0.2219	0.2813	0.2757	0.0908
378	15.75	0.0397	0.2479	0.365	0.2798	0.3573	0.1969	0.0742	0.1598	0.2185	0.2714	0.267	0.0925
384	16	0.0391	0.2493	0.3568	0.2787	0.3535	0.2128	0.074	0.166	0.2207	0.2701	0.2703	0.0988
390	16.25	0.0406	0.2546	0.3506	0.2785	0.3498	0.219	0.0758	0.1758	0.2281	0.2808	0.2792	0.1129
396	16.5	0.0404	0.2569	0.3489	0.281	0.3539	0.2307	0.0791	0.182	0.2293	0.2798	0.2827	0.1331
402	16.75	0.0403	0.2576	0.3415	0.2788	0.3481	0.2336	0.0776	0.1887	0.2332	0.2843	0.2885	0.1455
408	17	0.0403	0.2623	0.3398	0.2817	0.3533	0.2415	0.079	0.1947	0.2369	0.2801	0.2822	0.1533
414	17.25	0.0388	0.2642	0.3537	0.2858	0.3546	0.2495	0.0803	0.2028	0.2393	0.2852	0.2846	0.1665
420	17.5	0.0384	0.2643	0.3433	0.2938	0.3676	0.2557	0.0833	0.206	0.2401	0.2841	0.2855	0.186
426	17.75	0.0381	0.2617	0.3396	0.2966	0.3834	0.2684	0.0892	0.2063	0.2381	0.2789	0.2856	0.2053
432	18	0.0381	0.2597	0.3492	0.2899	0.3666	0.2656	0.0985	0.2183	0.2448	0.2897	0.2916	0.2161
438	18.25	0.0382	0.2609	0.3418	0.2859	0.3522	0.2553	0.1008	0.2242	0.2524	0.2968	0.2945	0.2232
444	18.5	0.0383	0.2608	0.3424	0.2911	0.3602	0.2608	0.1137	0.2227	0.2493	0.2917	0.2932	0.2282
450	18.75	0.0381	0.2573	0.3433	0.2961	0.3743	0.271	0.1632	0.2231	0.2493	0.2873	0.2954	0.2322
456	19	0.0379	0.2548	0.3316	0.2878	0.3553	0.2606	0.168	0.2346	0.2574	0.2984	0.2957	0.2364
462	19.25	0.0382	0.2548	0.3274	0.2882	0.3495	0.2549	0.1786	0.2374	0.2675	0.3096	0.2985	0.235
468	19.5	0.0382	0.2535	0.3257	0.2893	0.3503	0.2563	0.189	0.2387	0.276	0.3063	0.2956	0.2306
474	19.75	0.0389	0.2609	0.3321	0.3006	0.3708	0.272	0.2289	0.2524	0.2898	0.3165	0.3091	0.2486
480	20	0.0391	0.2639	0.3359	0.3034	0.3753	0.2753	0.2446	0.2607	0.2918	0.3202	0.3123	0.2511
486	20.25	0.0393	0.2657	0.3411	0.3057	0.3822	0.28	0.2542	0.2615	0.2868	0.317	0.3111	0.2511
492	20.5	0.0392	0.2655	0.3435	0.3057	0.3838	0.2806	0.2604	0.2651	0.2861	0.3178	0.3135	0.258
498	20.75	0.0389	0.2635	0.3425	0.3039	0.3803	0.2759	0.2648	0.2767	0.2863	0.3185	0.3123	0.2589
504	21	0.0392	0.2653	0.3332	0.3133	0.4018	0.2838	0.2771	0.2823	0.2955	0.3258	0.3237	0.2713
510	21.25	0.039	0.2651	0.3337	0.3123	0.4056	0.2839	0.2822	0.2729	0.2889	0.3196	0.3173	0.2692
516	21.5	0.0373	0.2562	0.322	0.2997	0.3945	0.2738	0.2703	0.2701	0.2912	0.3178	0.3139	0.2507
522	21.75	0.0344	0.2603	0.3395	0.3057	0.3995	0.2759	0.2878	0.2809	0.2936	0.32	0.3165	0.2709
528	22	0.0371	0.2505	0.3335	0.3109	0.4458	0.2913	0.3185	0.271	0.2832	0.3134	0.3111	0.2442
534	22.25	0.0365	0.2439	0.3333	0.3086	0.4374	0.2895	0.3556	0.2816	0.2856	0.317	0.3166	0.2461
540	22.5	0.0364	0.2359	0.3355	0.2993	0.3983	0.2628	0.3344	0.2916	0.2825	0.3055	0.3028	0.2424
546	22.75	0.0375	0.2442	0.345	0.2997	0.3955	0.2436	0.3266	0.3004	0.314	0.3266	0.3201	0.2645
552	23	0.0367	0.241	0.3414	0.2999	0.3901	0.2498	0.3325	0.2893	0.3038	0.3176	0.3106	0.2518
558	23.25	0.0367	0.2389	0.3445	0.3002	0.3832	0.2505	0.3426	0.292	0.2979	0.3163	0.3124	0.25
564	23.5	0.0383	0.2421	0.3597	0.3064	0.3948	0.261	0.3497	0.3058	0.3047	0.3207	0.3183	0.2759
570	23.75	0.0397	0.2485	0.374	0.3134	0.398	0.2555	0.3552	0.3196	0.3222	0.335	0.331	0.2933
576	24	0.0392	0.2462	0.3719	0.315	0.3952	0.2635	0.3602	0.314	0.3221	0.3342	0.3303	0.2929
582	24.25	0.0394	0.2461	0.3758	0.3215	0.3994	0.2707	0.3722	0.3159	0.3226	0.3352	0.3316	0.2925
588	24.5	0.0395	0.2449	0.278	0.3255	0.3963	0.2727	0.376	0.3209	0.3191	0.3339	0.3295	0.2905
594	24.75	0.0392	0.2423	0.3754	0.3253	0.3858	0.266	0.3724	0.3244	0.32	0.3299	0.3271	0.2867
600	25	0.04	0.2439	0.382	0.3322	0.3911	0.269	0.3857	0.3293	0.3228	0.3342	0.3309	0.2885
606	25.25	0.0399	0.2404	0.3784	0.3307	0.3886	0.2709	0.3936	0.3278	0.3172	0.3343	0.3312	0.2889
612	25.5	0.0377	0.2253	0.3547	0.3142	0.3653	0.2642	0.4021	0.3272	0.3197	0.3326	0.3279	0.2763
618	25.75	0.0389	0.2267	0.3649	0.3173	0.3598	0.2525	0.3841	0.3301	0.3197	0.3301	0.3272	0.291
624	26	0.0386	0.227	0.3576	0.311	0.3506	0.2568	0.395	0.3312	0.3179	0.3304	0.3266	0.2881
630	26.25	0.0387	0.233	0.3433	0.3046	0.3396	0.2574	0.4028	0.3291	0.3195	0.3282	0.3263	0.2884
636	26.5	0.0384	0.2332	0.3416	0.3023	0.3225	0.2483	0.3892	0.3295	0.3187	0.3263	0.324	0.2854
642	26.75	0.0386	0.2278	0.3477	0.3021	0.3199	0.2434	0.3874	0.3357	0.324	0.3323	0.3296	0.2929
648	27	0.0388	0.2283	0.3465	0.3021	0.322	0.2559	0.397	0.3353	0.3275	0.3377	0.3354	0.298
654	27.25	0.0371	0.2267	0.332	0.2973	0.2952	0.2618	0.4061	0.3307	0.3213	0.3291	0.3241	0.2693
660	27.5	0.0379	0.2296	0.3396	0.3029	0.3376	0.276	0.3965	0.335	0.3276	0.3347	0.3294	0.2714
666	27.75	0.0385	0.2269	0.3449	0.3011	0.3124	0.2657	0.404	0.3369	0.3238	0.3334	0.3309	0.2912
672	28	0.0373	0.2292	0.3315	0.2988	0.3371	0.2813	0.3988	0.3351	0.3288	0.3366	0.3343	0.2765
678	28.25	0.0372	0.2292	0.3333	0.3012	0.3345	0.2877	0.4184	0.3405	0.3264	0.3335	0.3291	0.2681
684	28.5	0.0374	0.2312	0.3344	0.3028	0.3358	0.2847	0.4105	0.3398	0.3275	0.3346	0.3298	0.2672

h	d	0	1	2	3	4	5	6	7	8	9	10	11
690	28.75	0.0374	0.2263	0.3395	0.3001	0.3123	0.2729	0.4077	0.3346	0.3285	0.3386	0.3359	0.2719
696	29	0.0365	0.2191	0.3291	0.2931	0.3079	0.2938	0.4998	0.3902	0.3764	0.3864	0.3828	0.2941
702	29.25	0.0362	0.2224	0.321	0.2944	0.2932	0.2972	0.4968	0.3937	0.3657	0.3732	0.3711	0.2717
708	29.5	0.0359	0.2178	0.3239	0.2933	0.2976	0.2925	0.4502	0.3594	0.3345	0.3444	0.3429	0.2529
714	29.75	0.0366	0.2192	0.3297	0.295	0.308	0.2978	0.4454	0.3483	0.3426	0.3557	0.3539	0.2601
720	30	0.0367	0.2199	0.3305	0.2987	0.3172	0.3034	0.4575	0.3492	0.3504	0.3637	0.3619	0.2627
726	30.25	0.0359	0.2219	0.3206	0.2984	0.2967	0.3034	0.4633	0.3651	0.3434	0.3551	0.3503	0.249
732	30.5	0.0354	0.2204	0.3195	0.2983	0.2907	0.2976	0.4466	0.3527	0.3439	0.3521	0.3485	0.2433
738	30.75	0.0359	0.2176	0.325	0.2965	0.3036	0.3003	0.436	0.3387	0.3433	0.3588	0.358	0.2478
744	31	0.0358	0.218	0.3253	0.2995	0.3048	0.3029	0.4406	0.3401	0.3454	0.3629	0.3621	0.245
750	31.25	0.0358	0.2242	0.323	0.3058	0.2924	0.3052	0.4436	0.3549	0.3453	0.3594	0.3567	0.2365
756	31.5	0.0353	0.2235	0.3218	0.3029	0.302	0.2999	0.431	0.3497	0.3432	0.3582	0.3548	0.2372
762	31.75	0.0363	0.2212	0.3301	0.306	0.3056	0.3081	0.432	0.3418	0.3481	0.3685	0.3681	0.2388
768	32	0.0375	0.2256	0.3416	0.3178	0.3252	0.319	0.449	0.3722	0.3785	0.4047	0.4026	0.263
774	32.25	0.0359	0.2187	0.3278	0.3075	0.3176	0.3108	0.4423	0.3417	0.348	0.3727	0.3702	0.2327
780	32.5	0.0366	0.2267	0.3276	0.3154	0.311	0.3161	0.4397	0.3506	0.3519	0.3767	0.3731	0.2297
786	32.75	0.0369	0.2276	0.3279	0.3175	0.3118	0.3157	0.4326	0.3365	0.351	0.3769	0.372	0.2272
792	33	0.0364	0.2224	0.3302	0.314	0.3238	0.3159	0.432	0.3388	0.3541	0.3828	0.3786	0.2311
798	33.25	0.0364	0.226	0.3268	0.3151	0.3269	0.317	0.4401	0.3351	0.3518	0.3787	0.3765	0.226
804	33.5	0.036	0.2202	0.327	0.3123	0.3201	0.314	0.4306	0.3399	0.3482	0.3774	0.3705	0.2219
810	33.75	0.0371	0.2286	0.3292	0.3224	0.3206	0.3195	0.4326	0.3284	0.3513	0.3827	0.375	0.2219
816	34	0.0364	0.2268	0.326	0.3182	0.3313	0.3153	0.4282	0.3262	0.3523	0.3825	0.3757	0.2203
822	34.25	0.0359	0.2203	0.3268	0.3181	0.327	0.3146	0.435	0.3315	0.3452	0.3783	0.3695	0.2165
828	34.5	0.0362	0.2258	0.3251	0.3243	0.3146	0.3171	0.4297	0.3307	0.3489	0.38	0.371	0.2144
834	34.75	0.0365	0.2234	0.334	0.3253	0.3254	0.3142	0.4298	0.3205	0.3484	0.3816	0.3715	0.2144
840	35	0.0359	0.2262	0.3227	0.3228	0.3125	0.3134	0.4227	0.3106	0.3417	0.3718	0.3626	0.2086
846	35.25	0.0357	0.2254	0.3232	0.3237	0.3063	0.3109	0.4221	0.3093	0.3385	0.3711	0.3572	0.2027
852	35.5	0.0362	0.2275	0.3257	0.3272	0.3074	0.3112	0.4187	0.3144	0.3424	0.3756	0.3637	0.1997
846	35.75	0.0371	0.2256	0.3378	0.329	0.322	0.3147	0.4348	0.3104	0.3571	0.3967	0.3859	0.2055
864	36	0.036	0.2258	0.3253	0.3264	0.3127	0.3123	0.4187	0.2952	0.3411	0.3766	0.3647	0.1921
870	36.25	0.0366	0.2235	0.3299	0.3316	0.3448	0.3192	0.4038	0.2771	0.3256	0.3622	0.3518	0.1772
876	36.5	0.0363	0.2228	0.3257	0.3267	0.3451	0.3142	0.3847	0.2698	0.3225	0.3585	0.3488	0.1676
882	36.75	0.0366	0.2305	0.3299	0.3327	0.3137	0.3039	0.39	0.2739	0.3292	0.3673	0.358	0.1668
888	37	0.0366	0.2331	0.3318	0.3275	0.3282	0.3104	0.4307	0.2989	0.3629	0.4049	0.393	0.1853
894	37.25	0.0368	0.2315	0.3331	0.3364	0.3221	0.3132	0.4322	0.2916	0.3576	0.4001	0.3913	0.1833
900	37.5	0.0367	0.2322	0.3317	0.3381	0.3183	0.3106	0.4048	0.2687	0.3292	0.3678	0.3613	0.1643
906	37.75	0.0368	0.2345	0.3337	0.3392	0.3194	0.3109	0.4319	0.2924	0.3558	0.3975	0.3914	0.1771

Changes in Conductivity (mS)
 Cycle 1: Column 5 (CTL)

Time		Depth (in.)		2	3	4	5	6	7	8	9	10	11
h	d	0	1										
0	0	0.0697	0.0676	0.0646	0.0652	0.0645	0.0641	0.063	0.0626	0.0626	0.0622	0.0617	0.0054
1	0.042	0.0698	0.0676	0.0646	0.0651	0.0644	0.064	0.0629	0.0626	0.0626	0.0621	0.0617	0.0054
2	0.083	0.0374	0.0372	0.0364	0.037	0.037	0.0369	0.0366	0.0365	0.0368	0.0366	0.0364	0.0053
3	0.125	0.0095	0.0097	0.0096	0.0089	0.0098	0.0098	0.0097	0.0097	0.0099	0.0099	0.0098	0.006
4	0.167	0.0097	0.0099	0.0098	0.0101	0.01	0.01	0.0099	0.0099	0.0101	0.01	0.0099	0.0069
5	0.208	0.0097	0.01	0.0098	0.0101	0.0101	0.01	0.0099	0.0099	0.0101	0.01	0.0099	0.007
6	0.25	0.0097	0.01	0.0098	0.0102	0.0101	0.0101	0.0099	0.0099	0.0101	0.01	0.0099	0.007
12	0.5	0.0106	0.0109	0.0107	0.0111	0.011	0.011	0.0108	0.0108	0.0111	0.011	0.0109	0.0075
18	0.75	0.0106	0.0109	0.0108	0.0111	0.011	0.011	0.0108	0.0108	0.0111	0.011	0.0109	0.0075
24	1	0.0106	0.0109	0.0107	0.0111	0.011	0.011	0.0108	0.0108	0.0111	0.011	0.0109	0.0074
30	1.25	0.0107	0.0109	0.0108	0.0112	0.0111	0.0111	0.0109	0.0109	0.0112	0.011	0.0109	0.0075
36	1.5	0.0107	0.011	0.0109	0.0113	0.0112	0.0112	0.0109	0.0109	0.0112	0.0111	0.011	0.0075
42	1.75	0.0108	0.0111	0.0109	0.0113	0.0113	0.0112	0.011	0.011	0.0113	0.0112	0.011	0.0076
48	2	0.0274	0.0276	0.0273	0.028	0.0278	0.0278	0.0272	0.0272	0.0278	0.0276	0.0273	0.0064
54	2.25	0.0389	0.0392	0.0386	0.0395	0.0393	0.0392	0.0385	0.0385	0.039	0.0387	0.0385	0.0055
60	2.5	0.0391	0.0394	0.0388	0.0398	0.0396	0.0396	0.039	0.039	0.0395	0.0393	0.0391	0.0054
66	2.75	0.0786	0.0776	0.0754	0.0766	0.0758	0.0756	0.0744	0.0739	0.0741	0.0736	0.0732	0.0053
72	3	0.0788	0.0777	0.0756	0.0766	0.0759	0.0757	0.0744	0.074	0.0742	0.0737	0.0732	0.0053
78	3.25	0.0796	0.0784	0.0762	0.0772	0.0766	0.0762	0.075	0.0745	0.0747	0.0742	0.0737	0.0054
84	3.5	0.0799	0.0786	0.0765	0.0774	0.0768	0.0764	0.0751	0.0746	0.0749	0.0743	0.0738	0.0054
90	3.75	0.08	0.0787	0.0765	0.0776	0.0767	0.0764	0.0751	0.0746	0.0748	0.0743	0.0737	0.0054
96	4	0.0802	0.0788	0.0766	0.0776	0.0768	0.0764	0.0752	0.0746	0.0749	0.0743	0.0738	0.0054
102	4.25	0.0803	0.0788	0.0765	0.0776	0.0767	0.0764	0.0752	0.0746	0.0748	0.0742	0.0737	0.0054
108	4.5	0.0805	0.0789	0.0766	0.0777	0.0768	0.0764	0.0752	0.0746	0.0749	0.0743	0.0737	0.0054
114	4.75	0.0806	0.0789	0.0766	0.0777	0.0768	0.0765	0.0752	0.0747	0.0749	0.0743	0.0737	0.0054
120	5	0.0807	0.079	0.0766	0.0778	0.0768	0.0765	0.0753	0.0747	0.0749	0.0743	0.0737	0.0054
126	5.25	0.0807	0.079	0.0766	0.0777	0.0768	0.0764	0.0752	0.0746	0.0748	0.0742	0.0736	0.0054
132	5.5	0.0807	0.079	0.0765	0.0778	0.0765	0.0763	0.0751	0.0745	0.0747	0.0741	0.0735	0.0054
138	5.75	0.0808	0.079	0.0765	0.0776	0.0766	0.0763	0.0751	0.0745	0.0747	0.0741	0.0735	0.0054
144	6	0.081	0.0791	0.0766	0.0778	0.0767	0.0764	0.0752	0.0746	0.0747	0.0741	0.0735	0.0054
150	6.25	0.0815	0.0797	0.0772	0.0782	0.0773	0.0769	0.0757	0.075	0.0751	0.0744	0.0738	0.0054
156	6.5	0.0816	0.0797	0.0771	0.0782	0.0772	0.0768	0.0756	0.075	0.0751	0.0744	0.0738	0.0054
162	6.75	0.0815	0.0795	0.0769	0.078	0.077	0.0767	0.0755	0.0748	0.0749	0.0743	0.0737	0.0054
168	7	0.0814	0.0794	0.0768	0.0779	0.0768	0.0765	0.0753	0.0747	0.0747	0.0741	0.0735	0.0054
174	7.25	0.0818	0.0798	0.0772	0.0783	0.0773	0.0769	0.0757	0.075	0.0751	0.0745	0.0739	0.0055
180	7.5	0.1013	0.0987	0.0955	0.1113	0.0962	0.0959	0.0948	0.094	0.0943	0.0936	0.093	0.0053
186	7.75	0.0908	0.0884	0.0854	0.0867	0.0857	0.0854	0.0842	0.0834	0.0836	0.0829	0.0823	0.0054
192	8	0.0829	0.0806	0.0777	0.0787	0.0779	0.0773	0.0762	0.0754	0.0754	0.0748	0.0741	0.0055
198	8.25	0.0779	0.0756	0.0728	0.0735	0.0727	0.0721	0.071	0.0703	0.0702	0.0695	0.0688	0.0057
204	8.5	0.0779	0.0755	0.0727	0.0734	0.0726	0.0721	0.0708	0.0701	0.07	0.0694	0.0687	0.0056
210	8.75	0.0778	0.0754	0.0725	0.0733	0.0725	0.0719	0.0707	0.0699	0.0699	0.0692	0.0685	0.0056
216	9	0.0778	0.0754	0.0725	0.0733	0.0725	0.0719	0.0707	0.0699	0.0699	0.0692	0.0685	0.0056
222	9.25	0.078	0.0756	0.0727	0.0735	0.0727	0.0721	0.0709	0.0701	0.0701	0.0694	0.0687	0.0057
228	9.5	0.0779	0.0755	0.0726	0.0734	0.0726	0.072	0.0708	0.07	0.0699	0.0693	0.0685	0.0056
234	9.75	0.0777	0.0753	0.0724	0.0732	0.0724	0.0717	0.0706	0.0698	0.0697	0.0691	0.0683	0.0056
240	10	0.0776	0.0752	0.0723	0.073	0.0722	0.0716	0.0704	0.0697	0.0696	0.0689	0.0682	0.0056
246	10.25	0.0776	0.0752	0.0723	0.0732	0.0723	0.0717	0.0705	0.0697	0.0696	0.069	0.0683	0.0056
252	10.5	0.0781	0.0757	0.0727	0.0736	0.0727	0.0721	0.0709	0.0701	0.07	0.0694	0.0686	0.0057
258	10.75	0.0775	0.0751	0.0721	0.073	0.072	0.0715	0.0703	0.0695	0.0694	0.0688	0.068	0.0056
264	11	0.0772	0.0748	0.0718	0.0727	0.0717	0.0712	0.07	0.0692	0.0691	0.0685	0.0678	0.0056
270	11.25	0.0773	0.0749	0.0719	0.0728	0.0718	0.0713	0.0701	0.0693	0.0692	0.0686	0.0678	0.0056
276	11.5	0.077	0.0746	0.0716	0.0725	0.0715	0.0709	0.0698	0.069	0.0689	0.0683	0.0675	0.0056
282	11.75	0.0767	0.0743	0.0713	0.0722	0.0712	0.0707	0.0696	0.0688	0.0686	0.068	0.0673	0.0056
288	12	0.077	0.0745	0.0715	0.0724	0.0714	0.0709	0.0698	0.069	0.0688	0.0682	0.0675	0.0056
294	12.25	0.0768	0.0744	0.0714	0.0723	0.0713	0.0707	0.0696	0.0688	0.0687	0.068	0.0673	0.0056
300	12.5	0.0767	0.0742	0.0712	0.0721	0.0711	0.0706	0.0694	0.0686	0.0685	0.0679	0.0671	0.0055
306	12.75	0.0766	0.0742	0.0712	0.0721	0.0711	0.0705	0.0694	0.0686	0.0684	0.0678	0.0671	0.0055
312	13	0.0766	0.0742	0.0711	0.0721	0.0711	0.0705	0.0694	0.0686	0.0684	0.0678	0.0671	0.0055
318	13.25	0.0738	0.0743	0.0712	0.0722	0.0712	0.0706	0.0695	0.0687	0.0685	0.0679	0.0672	0.0056

h	d	0	1	2	3	4	5	6	7	8	9	10	11
324	13.5	0.0768	0.0744	0.0713	0.0722	0.0712	0.0706	0.0695	0.0687	0.0685	0.0679	0.0672	0.0056
330	13.75	0.0768	0.0743	0.0712	0.0721	0.0711	0.0706	0.0695	0.0686	0.0685	0.0679	0.0671	0.0056
336	14	0.0766	0.0741	0.071	0.072	0.071	0.0704	0.0693	0.0684	0.0683	0.0677	0.067	0.0055
342	14.25	0.0768	0.0744	0.0713	0.0722	0.0712	0.0707	0.0695	0.0687	0.0685	0.0679	0.0672	0.0056
348	14.5	0.0772	0.0748	0.0716	0.0726	0.0716	0.071	0.0698	0.069	0.0688	0.0682	0.0675	0.0056
354	14.75	0.0771	0.0747	0.0715	0.0725	0.0714	0.0709	0.0697	0.0689	0.0687	0.0681	0.0674	0.0056
360	15	0.0769	0.0745	0.0713	0.0723	0.0712	0.0706	0.0695	0.0687	0.0685	0.0679	0.0672	0.0056
366	15.25	0.0772	0.0748	0.0716	0.0726	0.0715	0.071	0.0698	0.0689	0.0688	0.0682	0.0674	0.0056
372	15.5	0.0827	0.0802	0.0767	0.0781	0.0768	0.0763	0.0752	0.0744	0.0742	0.0737	0.0729	0.0054
378	15.75	0.0827	0.0802	0.0767	0.0781	0.0767	0.0763	0.0752	0.0743	0.0742	0.0736	0.0729	0.0054
384	16	0.0826	0.0802	0.0767	0.078	0.0767	0.0763	0.0752	0.0743	0.0742	0.0736	0.0729	0.0054
390	16.25	0.0824	0.08	0.0765	0.0779	0.0767	0.0763	0.0752	0.0744	0.0743	0.0737	0.073	0.0054
396	16.5	0.0823	0.0799	0.0764	0.0778	0.0765	0.0761	0.0751	0.0742	0.0741	0.0735	0.0728	0.0054
402	16.75	0.0821	0.0797	0.0762	0.0776	0.0763	0.0759	0.0749	0.0741	0.0739	0.0734	0.0727	0.0054
408	17	0.0823	0.08	0.0764	0.0778	0.0765	0.0761	0.0751	0.0742	0.0741	0.0735	0.0728	0.0054
414	17.25	0.083	0.0806	0.0769	0.0783	0.0769	0.0765	0.0754	0.0745	0.0744	0.0738	0.073	0.0054
420	17.5	0.0832	0.0808	0.0771	0.0785	0.0771	0.0767	0.0756	0.0747	0.0745	0.0739	0.0731	0.0055
426	17.75	0.0829	0.0806	0.0768	0.0782	0.0768	0.0764	0.0753	0.0744	0.0742	0.0736	0.0729	0.0054
432	18	0.0823	0.0801	0.0763	0.0776	0.0763	0.0759	0.0749	0.074	0.0738	0.0732	0.0725	0.0054
438	18.25	0.0822	0.0799	0.0762	0.0775	0.0762	0.0757	0.0747	0.0738	0.0736	0.073	0.0723	0.0054
444	18.5	0.0821	0.0798	0.0761	0.0774	0.076	0.0756	0.0746	0.0737	0.0736	0.073	0.0723	0.0054
450	18.75	0.0816	0.0795	0.0757	0.077	0.0757	0.0753	0.0743	0.0734	0.0733	0.0727	0.072	0.0054
456	19	0.0814	0.0793	0.0755	0.0767	0.0755	0.0751	0.0741	0.0732	0.073	0.0725	0.0718	0.0054
462	19.25	0.0816	0.0794	0.0757	0.0769	0.0756	0.0752	0.0742	0.0733	0.0731	0.0726	0.0719	0.0054
468	19.5	0.0814	0.0792	0.0755	0.0767	0.0754	0.075	0.0741	0.0732	0.073	0.0724	0.0717	0.0054
474	19.75	0.082	0.0798	0.076	0.0772	0.0759	0.0755	0.0745	0.0736	0.0734	0.0728	0.0721	0.0054
480	20	0.0823	0.0801	0.0763	0.0775	0.0761	0.0757	0.0747	0.0738	0.0736	0.073	0.0723	0.0054
486	20.25	0.0823	0.0801	0.0763	0.0775	0.0761	0.0757	0.0747	0.0738	0.0736	0.073	0.0723	0.0054
492	20.5	0.0821	0.0799	0.0761	0.0773	0.076	0.0755	0.0745	0.0736	0.0734	0.0729	0.0721	0.0054
498	20.75	0.0828	0.0806	0.0767	0.0779	0.0765	0.0761	0.075	0.0741	0.0739	0.0733	0.0726	0.0054
504	21	0.0833	0.081	0.0772	0.0784	0.077	0.0765	0.0754	0.0745	0.0743	0.0737	0.0729	0.0054
510	21.25	0.0833	0.081	0.0772	0.0784	0.0769	0.0765	0.0754	0.0745	0.0743	0.0737	0.0729	0.0054
516	21.5	0.0906	0.0882	0.0842	0.0963	0.0843	0.084	0.083	0.0821	0.082	0.0815	0.0808	0.0054
522	21.75	0.0837	0.0813	0.0775	0.0787	0.0772	0.0768	0.0757	0.0748	0.0745	0.0739	0.0731	0.0055
528	22	0.1022	0.0995	0.0949	0.1107	0.0952	0.095	0.094	0.093	0.093	0.0923	0.0916	0.0053
534	22.25	0.1016	0.0991	0.0946	0.0961	0.0947	0.0945	0.0935	0.0926	0.0925	0.0919	0.0911	0.0053
540	22.5	0.0903	0.0882	0.0843	0.0855	0.0839	0.0837	0.0827	0.0818	0.0817	0.0811	0.0804	0.0054
546	22.75	0.0913	0.0891	0.085	0.086	0.0846	0.0842	0.0832	0.0822	0.082	0.0815	0.0807	0.0054
552	23	0.0909	0.0887	0.0847	0.0768	0.0843	0.084	0.083	0.0821	0.0819	0.0813	0.0806	0.0054
558	23.25	0.0905	0.0884	0.0844	0.0765	0.084	0.0837	0.0827	0.0818	0.0817	0.0811	0.0804	0.0054
564	23.5	0.083	0.081	0.0771	0.0778	0.0764	0.0759	0.0748	0.0739	0.0736	0.073	0.0722	0.0054
570	23.75	0.0835	0.0815	0.0776	0.0783	0.0768	0.0763	0.0752	0.0743	0.074	0.0734	0.0726	0.0054
576	24	0.0838	0.0819	0.0779	0.0786	0.0771	0.0766	0.0755	0.0746	0.0743	0.0737	0.0729	0.0055
582	24.25	0.0838	0.0818	0.0779	0.0786	0.077	0.0766	0.0754	0.0745	0.0742	0.0736	0.0728	0.0055
588	24.5	0.0836	0.0816	0.0777	0.0784	0.0769	0.0764	0.0752	0.0744	0.0741	0.0735	0.0727	0.0054
594	24.75	0.0835	0.0816	0.0777	0.0784	0.0768	0.0764	0.0752	0.0744	0.0741	0.0735	0.0727	0.0054
600	25	0.0836	0.0817	0.0778	0.0785	0.0769	0.0764	0.0753	0.0744	0.0741	0.0735	0.0727	0.0054
606	25.25	0.0832	0.0814	0.0775	0.0782	0.0766	0.0762	0.075	0.0742	0.0739	0.0733	0.0725	0.0054
612	25.5	0.0896	0.0878	0.084	0.0952	0.0833	0.083	0.082	0.0812	0.0811	0.0806	0.0799	0.0053
618	25.75	0.0818	0.0801	0.0765	0.0769	0.0755	0.075	0.0739	0.0731	0.0728	0.0723	0.0715	0.0054
624	26	0.0815	0.0798	0.0763	0.0767	0.0752	0.0748	0.0737	0.0729	0.0727	0.0721	0.0714	0.0053
630	26.25	0.0809	0.0793	0.0759	0.0762	0.0747	0.0743	0.0733	0.0725	0.0723	0.0718	0.071	0.0053
636	26.5	0.0808	0.0791	0.0757	0.076	0.0745	0.0741	0.0731	0.0723	0.0721	0.0716	0.0708	0.0053
642	26.75	0.0812	0.0796	0.0761	0.0764	0.0749	0.0745	0.0734	0.0726	0.0724	0.0719	0.0711	0.0053
648	27	0.0816	0.0799	0.0764	0.0767	0.0752	0.0748	0.0737	0.0729	0.0726	0.0721	0.0713	0.0053
654	27.25	0.0885	0.0869	0.0834	0.0841	0.0825	0.0823	0.0813	0.0806	0.0805	0.08	0.0793	0.0053
660	27.5	0.0883	0.0866	0.0832	0.0749	0.0822	0.082	0.0811	0.0804	0.0802	0.0789	0.0791	0.0053
666	27.75	0.0812	0.0796	0.0763	0.0764	0.0749	0.0745	0.0734	0.0727	0.0724	0.0719	0.0711	0.0053
672	28	0.0889	0.0873	0.0838	0.0845	0.0828	0.0826	0.0816	0.0809	0.0808	0.0803	0.0796	0.0053
678	28.25	0.0886	0.087	0.0836	0.0843	0.0826	0.0824	0.0814	0.0807	0.0806	0.0801	0.0794	0.0053
684	28.5	0.0885	0.0868	0.0835	0.0841	0.0824	0.0822	0.0812	0.0805	0.0804	0.0799	0.0792	0.0053
690	28.75	0.09	0.0883	0.0848	0.0853	0.0835	0.0832	0.0821	0.0814	0.0812	0.0807	0.0799	0.0053

h	d	0	1	2	3	4	5	6	7	8	9	10	11
696	29	0.1166	0.1139	0.1093	0.0957	0.108	0.1078	0.1067	0.1057	0.1055	0.1048	0.104	0.0052
702	29.25	0.1157	0.1132	0.1088	0.0954	0.1076	0.1075	0.1064	0.1055	0.1054	0.1047	0.1039	0.0052
708	29.5	0.1012	0.0992	0.0955	0.11	0.0941	0.0939	0.0929	0.0921	0.092	0.0914	0.0907	0.0053
714	29.75	0.1017	0.0997	0.0961	0.1105	0.0946	0.0943	0.0933	0.0925	0.0923	0.091	0.091	0.0053
720	30	0.1021	0.1001	0.0965	0.111	0.0949	0.0947	0.0935	0.0927	0.0926	0.092	0.0912	0.0053
726	30.25	0.1018	0.0998	0.0963	0.0855	0.0947	0.0943	0.0933	0.0925	0.0923	0.0918	0.0909	0.0053
732	30.5	0.1007	0.0988	0.0954	0.11	0.0941	0.0936	0.0926	0.0918	0.0917	0.0912	0.0904	0.0053
738	30.75	0.1011	0.0992	0.0957	0.0964	0.0942	0.0938	0.0927	0.092	0.0918	0.0913	0.0905	0.0053
744	31	0.1016	0.0997	0.0962	0.0968	0.0945	0.0941	0.093	0.0922	0.0921	0.0915	0.0907	0.0053
750	31.25	0.1012	0.0994	0.096	0.1107	0.0944	0.094	0.0929	0.0921	0.092	0.0914	0.0907	0.0053
756	31.5	0.1008	0.099	0.0956	0.0963	0.0942	0.0935	0.0924	0.0917	0.0916	0.091	0.0902	0.0053
762	31.75	0.1008	0.099	0.0956	0.0967	0.0941	0.0936	0.0925	0.0918	0.0916	0.0911	0.0903	0.005
768	32	0.103	0.1009	0.0972	0.0981	0.0954	0.0947	0.0933	0.0924	0.0922	0.0916	0.0907	0.0053
774	32.25	0.1018	0.1	0.0965	0.1116	0.095	0.0943	0.0932	0.0924	0.0923	0.0917	0.0909	0.0053
780	32.5	0.1013	0.0995	0.0962	0.1112	0.0947	0.094	0.0929	0.0921	0.092	0.0914	0.0906	0.0053
786	32.75	0.1014	0.0996	0.0963	0.1114	0.949	0.0941	0.093	0.0922	0.0921	0.0915	0.0907	0.0053
792	33	0.1018	0.1	0.0966	0.0976	0.951	0.0943	0.0931	0.0924	0.0922	0.0917	0.0908	0.0053
798	33.25	0.1017	0.0999	0.0966	0.1118	0.952	0.0943	0.0932	0.0924	0.0923	0.0917	0.0909	0.0053
804	33.5	0.1004	0.0988	0.0956	0.1108	0.0944	0.0934	0.0924	0.0917	0.0916	0.0911	0.0903	0.0053
810	33.75	0.1007	0.0991	0.096	0.1112	0.0948	0.0938	0.0926	0.0919	0.0918	0.0913	0.0905	0.0053
816	34	0.1009	0.0993	0.0962	0.1114	0.0949	0.0939	0.0927	0.092	0.0919	0.0914	0.0905	0.0053
822	34.25	0.1005	0.099	0.0959	0.1112	0.0947	0.0936	0.0925	0.0919	0.0917	0.0912	0.0904	0.0053
828	34.5	0.1	0.0985	0.0955	0.1107	0.0945	0.0932	0.0921	0.0915	0.0913	0.0908	0.09	0.0052
834	34.75	0.1004	0.0988	0.0956	0.0973	0.0948	0.0934	0.0923	0.0916	0.0915	0.091	0.0901	0.0053
840	35	0.1005	0.099	0.0958	0.0973	0.095	0.0935	0.0924	0.0917	0.0916	0.0911	0.0902	0.0053
846	35.25	0.1001	0.0986	0.0955	0.111	0.0947	0.0932	0.0921	0.0915	0.0913	0.0909	0.09	0.0052
852	35.5	0.0993	0.0978	0.0947	0.0964	0.094	0.0925	0.0914	0.0908	0.0906	0.0901	0.0893	0.0052
858	35.75	0.101	0.0993	0.096	0.0976	0.095	0.0933	0.0921	0.0914	0.0912	0.0907	0.0898	0.0052
864	36	0.1001	0.0987	0.0956	0.0971	0.0948	0.0931	0.0921	0.0914	0.0912	0.0907	0.0899	0.0052
870	36.25	0.0887	0.0874	0.0847	0.0861	0.0838	0.0823	0.0811	0.0806	0.0804	0.08	0.0791	0.0053
876	36.5	0.0878	0.0865	0.0838	0.076	0.0831	0.0817	0.0804	0.0798	0.0796	0.0793	0.0785	0.0052
882	36.75	0.089	0.0877	0.0849	0.077	0.0841	0.0825	0.0812	0.0806	0.0804	0.08	0.0791	0.0053
888	37	0.1004	0.0988	0.0955	0.0973	0.0948	0.093	0.0916	0.091	0.0907	0.0903	0.0893	0.0052
894	37.25	0.1005	0.0989	0.0957	0.0975	0.095	0.0931	0.0917	0.0911	0.0908	0.0904	0.0894	0.0052
900	37.5	0.089	0.0877	0.085	0.0865	0.0843	0.0825	0.0813	0.0807	0.0805	0.0801	0.0793	0.0053
906	37.75	0.1006	0.0989	0.0956	0.0976	0.0951	0.0931	0.0917	0.0911	0.0908	0.0903	0.0894	0.0052

Changes in Conductivity (mS)
 Cycle 1: Column 4 - Column 5: (EXP - CTL)

Time		Depth (in.)		2	3	4	5	6	7	8	9	10	11
h	d	0	1										
0	0	-0.0378	0.036	0.0623	0.0543	0.0844	0.0709	0.0594	0.0575	0.0423	0.0524	0.0549	0.0788
1	0.042	-0.0366	0.0367	0.0633	0.0555	0.0866	0.073	0.0612	0.0581	0.0426	0.0528	0.0553	0.0797
2	0.083	-0.0027	-0.0075	0.0019	-0.0016	0.0401	0.0289	0.0303	0.0309	0.0196	0.0253	0.0296	0.0522
3	0.125	0.0194	0.0043	0.0049	0.0062	0.0054	0.0054	0.0051	0.0051	0.003	0.0036	0.0045	0.0059
4	0.167	0.0081	0.0079	0.0074	0.0048	0.0067	0.0171	0.0098	0.0057	0.003	0.003	0.0046	0.0041
5	0.208	0.0044	0.0051	0.0048	0.003	0.0043	0.0124	0.0063	0.0037	0.0022	0.0021	0.0032	0.0035
6	0.25	0.0031	0.0045	0.004	0.0022	0.0037	0.0109	0.0057	0.0029	0.0018	0.0016	0.0027	0.0032
12	0.5	-0.0001	0.0008	-0.0006	-0.0017	0.0007	0.0026	0.0028	-0.0003	-0.0016	-0.0017	-0.0011	0.0013
18	0.75	-0.0022	-0.0012	-0.0022	-0.0026	-0.0003	0.0008	0.0014	-0.0016	-0.0028	-0.0026	-0.0023	0.0006
24	1	-0.003	-0.0017	-0.0024	-0.0028	-0.0008	-0.0002	0.0003	-0.0022	-0.0031	-0.0029	-0.0027	0.0005
30	1.25	-0.0032	-0.0016	-0.0025	-0.0029	-0.0009	-0.0006	-0.0003	-0.0025	-0.0032	-0.0029	-0.0028	0.0003
36	1.5	-0.0033	-0.0003	-0.0026	-0.003	-0.0005	-0.001	-0.0007	-0.0026	-0.0033	-0.0031	-0.003	0.0002
42	1.75	-0.0035	0.025	-0.0022	-0.0027	0.001	-0.0009	-0.0011	-0.0027	-0.0033	-0.0032	-0.003	0
48	2	-0.0203	0.0538	0.006	0.0062	0.0017	-0.0032	-0.0034	-0.0049	-0.0063	-0.0059	-0.0057	0.0139
54	2.25	-0.0104	0.0972	0.0353	0.0024	0.0066	-0.0014	-0.0018	-0.0042	-0.0074	-0.0059	-0.0068	0.0249
60	2.5	0.0098	0.1482	0.1238	0.0206	0.1006	0.0128	0.0059	0.0034	-0.0038	-0.0033	-0.003	0.0272
66	2.75	-0.0374	0.2945	0.3015	0.2481	0.2855	0.0791	0.0577	0.0279	0.0008	-0.0023	-0.0021	0.0588
72	3	0.0223	0.2974	0.3084	0.293	0.2968	0.0568	0.054	0.0635	0.0707	0.0386	0.0255	0.0579
78	3.25	0.1288	0.2912	0.3066	0.2857	0.285	0.0507	0.0382	0.0607	0.1332	0.1243	0.1059	0.0614
84	3.5	0.1338	0.2892	0.2983	0.2791	0.2773	0.0367	0.0302	0.0467	0.1014	0.0807	0.0673	0.0642
90	3.75	0.026	0.2899	0.2952	0.2772	0.2745	0.0237	0.0226	0.0416	0.0875	0.0693	0.0483	0.0654
96	4	0.0622	0.2902	0.2978	0.2792	0.2738	0.0112	0.0173	0.0386	0.0803	0.063	0.0426	0.0662
102	4.25	0.0605	0.2875	0.2967	0.2765	0.2676	-0.007	0.0093	0.0323	0.0672	0.0554	0.032	0.0645
108	4.5	0.0588	0.2897	0.3002	0.2778	0.2626	-0.0035	-0.0038	0.0275	0.0533	0.0514	0.0204	0.0654
114	4.75	0.0248	0.2919	0.3052	0.2778	0.2513	-0.0008	-0.0054	0.0249	0.0524	0.0503	0.0156	0.0643
120	5	0.0243	0.2868	0.3009	0.2701	0.198	0.0024	-0.0039	0.0224	0.0503	0.0418	0.0122	0.0626
126	5.25	0.0581	0.2952	0.3086	0.273	0.1171	0.0023	0.0009	0.02	0.0436	0.0325	0.0117	0.0631
132	5.5	-0.0457	0.2815	0.3021	0.26	0.1048	-0.0008	-0.0037	0.0168	0.035	0.0189	0.0118	0.0614
138	5.75	-0.0219	0.2859	0.3095	0.2573	0.1071	-0.0021	-0.0034	0.0154	0.032	0.0143	0.0136	0.0607
144	6	-0.0128	0.2862	0.3103	0.2467	0.1056	-0.0015	-0.0046	0.0152	0.0303	0.0137	0.0133	0.06
150	6.25	0.0008	0.302	0.3363	0.2488	0.1132	-0.001	-0.0049	0.0158	0.0322	0.0149	0.0146	0.0604
156	6.5	-0.0135	0.285	0.3174	0.2194	0.1061	-0.0051	-0.0046	0.0148	0.0282	0.0149	0.0145	0.0596
162	6.75	-0.0226	0.2694	0.3055	0.1927	0.1011	-0.0065	-0.0054	0.0137	0.026	0.0149	0.0128	0.0593
168	7	-0.0293	0.2458	0.2955	0.161	0.0967	-0.0067	-0.0057	0.0128	0.024	0.0145	0.0119	0.0592
174	7.25	-0.013	0.2434	0.3219	0.1431	0.1062	-0.0066	-0.0051	0.0136	0.0281	0.0164	0.013	0.06
180	7.5	-0.0002	0.224	0.3752	0.0867	0.1125	-0.006	-0.0037	0.0126	0.0257	0.0097	0.0059	0.0772
186	7.75	0.0103	0.1892	0.3333	0.0626	0.0995	-0.0066	0.0008	0.0234	0.023	0.0082	0.0037	0.0681
192	8	0.107	0.1702	0.3227	0.0847	0.1101	-0.0051	-0.004	0.013	0.0305	0.0184	0.0119	0.0618
198	8.25	0.121	0.1925	0.2494	0.1134	0.1359	-0.0026	-0.0021	0.0145	0.0548	0.0376	0.0182	0.0581
204	8.5	0.1176	0.1622	0.1837	0.1314	0.1561	-0.0027	-0.0018	0.0164	0.0801	0.0933	0.0233	0.0602
210	8.75	0.1157	0.158	0.1709	0.1351	0.1582	-0.0036	-0.0017	0.0163	0.0839	0.1065	0.0273	0.0612
216	9	0.1151	0.1974	0.1631	0.1393	0.1637	-0.0039	-0.0037	0.0157	0.0893	0.1116	0.027	0.0617
222	9.25	0.1143	0.1823	0.168	0.1425	0.1666	-0.003	-0.0037	0.0161	0.0917	0.1225	0.0312	0.0624
228	9.5	0.1138	0.1944	0.1656	0.1435	0.1703	-0.0027	-0.0039	0.0161	0.0942	0.1291	0.0377	0.0622
234	9.75	0.1128	0.1943	0.1651	0.1435	0.1707	-0.0026	-0.0039	0.0167	0.0947	0.134	0.0466	0.0627
240	10	0.1123	0.1902	0.1659	0.1435	0.1716	-0.0024	-0.0048	0.0169	0.0968	0.1389	0.0602	0.0625
246	10.25	-0.0041	0.1863	0.1697	0.1526	0.1776	-0.002	-0.0044	0.0183	0.1052	0.1435	0.0794	0.0633
252	10.5	-0.005	0.1857	0.1783	0.1511	0.1911	0.0005	-0.0031	0.0187	0.1108	0.1564	0.0949	0.0651
258	10.75	-0.0138	0.1691	0.1752	0.1504	0.1897	-0.0002	-0.0035	0.0185	0.1085	0.1645	0.1009	0.0717
264	11	-0.0136	0.1727	0.1717	0.1527	0.1924	0.0007	-0.0036	0.0191	0.1108	0.1721	0.112	0.0729
270	11.25	-0.0138	0.1811	0.1749	0.1549	0.1977	0.0002	-0.0038	0.0199	0.1141	0.1714	0.1178	0.072
276	11.5	-0.0137	0.1853	0.1787	0.1546	0.2003	0.0004	-0.0034	0.0203	0.1163	0.1767	0.1269	0.0655
282	11.75	-0.0134	0.1838	0.1778	0.1565	0.2023	0.0025	-0.0039	0.0222	0.1202	0.1889	0.1411	0.0643
288	12	-0.0135	0.184	0.1828	0.1625	0.2109	0.0016	-0.0037	0.023	0.1233	0.2017	0.1568	0.066
294	12.25	-0.0136	0.1843	0.1921	0.1617	0.2169	0.0023	-0.0037	0.0239	0.126	0.2017	0.1619	0.0647
300	12.5	-0.0138	0.1817	0.1973	0.1634	0.2223	0.0037	-0.004	0.0248	0.1293	0.2033	0.1684	0.0645
306	12.75	-0.0135	0.1616	0.2024	0.1643	0.2239	0.0069	-0.0042	0.0271	0.1306	0.207	0.1749	0.064
312	13	-0.0135	0.1904	0.2062	0.1691	0.2398	0.0066	-0.0036	0.0289	0.1379	0.2119	0.1821	0.0639
318	13.25	-0.0107	0.1855	0.2042	0.1716	0.2415	0.0113	-0.003	0.0353	0.1457	0.2187	0.189	0.0686

h	d	0	1	2	3	4	5	6	7	8	9	10	11
324	13.5	-0.0136	0.1866	0.2167	0.1761	0.2523	0.0122	-0.0021	0.0408	0.1484	0.215	0.1954	0.0645
330	13.75	-0.0138	0.1875	0.2294	0.1796	0.262	0.0143	-0.0009	0.0439	0.1516	0.2178	0.2022	0.0652
336	14	-0.0136	0.1858	0.2348	0.1816	0.265	0.0233	-0.0006	0.0502	0.1558	0.2235	0.2146	0.068
342	14.25	-0.0137	0.1703	0.2273	0.18	0.2563	0.038	-0.0002	0.0691	0.1674	0.2424	0.2239	0.0716
348	14.5	-0.0137	0.1824	0.2394	0.1884	0.2763	0.0829	0.0003	0.0801	0.1767	0.2477	0.2366	0.0754
354	14.75	-0.0141	0.1736	0.2485	0.1905	0.28	0.1167	0.0011	0.0876	0.1747	0.2458	0.2329	0.0798
360	15	-0.0141	0.1723	0.2568	0.1936	0.2867	0.1393	0.002	0.0994	0.181	0.2525	0.2465	0.0911
366	15.25	-0.0294	0.1739	0.2639	0.1973	0.2901	0.1485	0.0034	0.1167	0.1898	0.2588	0.3114	0.1041
372	15.5	-0.0422	0.1649	0.2998	0.2036	0.2898	0.1125	-0.0012	0.0827	0.1477	0.2076	0.2028	0.0854
378	15.75	-0.043	0.1677	0.2883	0.2017	0.2806	0.1206	-0.001	0.0855	0.1443	0.1978	0.1941	0.0871
384	16	-0.0435	0.1691	0.2801	0.2007	0.2768	0.1365	-0.0012	0.0917	0.1465	0.1965	0.1974	0.0934
390	16.25	-0.0418	0.1746	0.2741	0.2006	0.2731	0.1427	0.0006	0.1014	0.1538	0.2071	0.2062	0.1075
396	16.5	-0.0419	0.177	0.2725	0.2032	0.2774	0.1546	0.004	0.1078	0.1552	0.2063	0.2099	0.1277
402	16.75	-0.0418	0.1779	0.2653	0.2012	0.2718	0.1577	0.0027	0.1146	0.1593	0.2109	0.2158	0.1401
408	17	-0.042	0.1823	0.2634	0.2039	0.2768	0.1654	0.0039	0.1205	0.1628	0.2066	0.2094	0.1479
414	17.25	-0.0442	0.1836	0.2768	0.2075	0.2777	0.173	0.0049	0.1283	0.1649	0.2114	0.2116	0.1611
420	17.5	-0.0448	0.1835	0.2662	0.2153	0.2905	0.179	0.0077	0.1313	0.1656	0.2102	0.2124	0.1805
426	17.75	-0.0448	0.1811	0.2628	0.2184	0.3066	0.192	0.0139	0.1319	0.1639	0.2053	0.2127	0.1999
432	18	-0.0442	0.1796	0.2729	0.2123	0.2903	0.1897	0.0236	0.1443	0.171	0.2165	0.2191	0.2107
438	18.25	-0.044	0.181	0.2656	0.2084	0.276	0.1796	0.0261	0.1504	0.1788	0.2238	0.2222	0.2178
444	18.5	-0.0438	0.181	0.2663	0.2137	0.2842	0.1852	0.0391	0.149	0.1757	0.2187	0.2209	0.2228
450	18.75	-0.0435	0.1778	0.2676	0.2191	0.2986	0.1957	0.0889	0.1498	0.1766	0.2153	0.29	0.2268
456	19	-0.0435	0.1755	0.2561	0.2111	0.2798	0.1855	0.0939	0.1761	0.2143	0.2229	0.1604	0.231
462	19.25	-0.0434	0.1754	0.2517	0.2113	0.2739	0.1797	0.1044	0.1641	0.1944	0.237	0.2266	0.2296
468	19.5	-0.0432	0.1743	0.2502	0.2126	0.2749	0.1813	0.1149	0.1655	0.203	0.2339	0.2239	0.2252
474	19.75	-0.0431	0.1811	0.2561	0.2234	0.2949	0.1965	0.1544	0.1788	0.2164	0.2437	0.237	0.2432
480	20	-0.0432	0.1838	0.2596	0.2259	0.2992	0.1996	0.1699	0.1869	0.2182	0.2472	0.24	0.2457
486	20.25	-0.043	0.1856	0.2648	0.2282	0.3061	0.2043	0.1795	0.1877	0.2132	0.244	0.2388	0.2457
492	20.5	-0.0429	0.1856	0.2674	0.2284	0.3078	0.2051	0.1859	0.1915	0.2127	0.2449	0.2414	0.2526
498	20.75	-0.0439	0.1829	0.2658	0.226	0.3038	0.1998	0.1898	0.2026	0.2124	0.2452	0.2397	0.2535
504	21	-0.0441	0.1843	0.256	0.2349	0.3248	0.2073	0.2017	0.2078	0.2212	0.2521	0.2508	0.2659
510	21.25	-0.0443	0.1841	0.2565	0.2339	0.3287	0.2074	0.2068	0.1984	0.2146	0.2459	0.2444	0.2638
516	21.5	-0.0533	0.168	0.2378	0.2034	0.3102	0.1898	0.1873	0.188	0.2092	0.2363	0.2331	0.2453
522	21.75	-0.0493	0.179	0.262	0.227	0.3223	0.1991	0.2121	0.2061	0.2191	0.2461	0.2434	0.2654
528	22	-0.0651	0.151	0.2386	0.2002	0.3506	0.1963	0.2245	0.178	0.1902	0.2211	0.2195	0.2389
534	22.25	-0.0651	0.1448	0.2387	0.2125	0.3427	0.195	0.2621	0.189	0.1931	0.2251	0.2255	0.2408
540	22.5	-0.0539	0.1477	0.2512	0.2138	0.3144	0.1791	0.2517	0.2098	0.2008	0.2244	0.2224	0.237
546	22.75	-0.0538	0.1551	0.26	0.2137	0.3109	0.1594	0.2434	0.2182	0.232	0.2451	0.2394	0.2591
552	23	-0.0542	0.1523	0.2567	0.2231	0.3058	0.1658	0.2495	0.2072	0.2219	0.2363	0.23	0.2464
558	23.25	-0.0538	0.1505	0.2601	0.2237	0.2992	0.1668	0.2599	0.2102	0.2162	0.2352	0.232	0.2446
564	23.5	-0.0447	0.1611	0.2826	0.2286	0.3184	0.1851	0.2749	0.2319	0.2311	0.2477	0.2461	0.2705
570	23.75	-0.0438	0.167	0.2964	0.2351	0.3212	0.1792	0.28	0.2453	0.2482	0.2616	0.2584	0.2879
576	24	-0.0446	0.1643	0.294	0.2364	0.3181	0.1869	0.2847	0.2394	0.2478	0.2605	0.2574	0.2874
582	24.25	-0.0444	0.1643	0.2979	0.2429	0.3224	0.1941	0.2968	0.2414	0.2484	0.2616	0.2588	0.287
588	24.5	-0.0441	0.1633	0.2003	0.2471	0.3194	0.1963	0.3008	0.2465	0.245	0.2604	0.2568	0.2851
594	24.75	-0.0443	0.1607	0.2977	0.2469	0.309	0.1896	0.2972	0.25	0.2459	0.2564	0.2544	0.2813
600	25	-0.0436	0.1622	0.3042	0.2537	0.3142	0.1926	0.3104	0.2549	0.2487	0.2607	0.2582	0.2831
606	25.25	-0.0433	0.159	0.3009	0.2525	0.312	0.1947	0.3186	0.2536	0.2433	0.261	0.2587	0.2835
612	25.5	-0.0519	0.1375	0.2707	0.219	0.282	0.1812	0.3201	0.246	0.2386	0.252	0.248	0.271
618	25.75	-0.0429	0.1466	0.2884	0.2404	0.2843	0.1775	0.3102	0.257	0.2469	0.2578	0.2557	0.2856
624	26	-0.0429	0.1472	0.2813	0.2343	0.2754	0.182	0.3213	0.2583	0.2452	0.2583	0.2552	0.2828
630	26.25	-0.0422	0.1537	0.2674	0.2284	0.2649	0.1831	0.3295	0.2566	0.2472	0.2564	0.2553	0.2831
636	26.5	-0.0424	0.1541	0.2659	0.2263	0.248	0.1742	0.3161	0.2572	0.2466	0.2547	0.2532	0.2801
642	26.75	-0.0426	0.1482	0.2716	0.2257	0.245	0.1689	0.314	0.2631	0.2516	0.2604	0.2585	0.2876
648	27	-0.0428	0.1484	0.2701	0.2254	0.2468	0.1811	0.3233	0.2624	0.2549	0.2656	0.2641	0.2927
654	27.25	-0.0514	0.1398	0.2486	0.2132	0.2127	0.1795	0.3248	0.2501	0.2408	0.2491	0.2448	0.264
660	27.5	-0.0504	0.143	0.2564	0.228	0.2554	0.194	0.3154	0.2546	0.2474	0.2558	0.2503	0.2661
666	27.75	-0.0427	0.1473	0.2686	0.2247	0.2375	0.1912	0.3306	0.2642	0.2514	0.2615	0.2598	0.2859
672	28	-0.0516	0.1419	0.2477	0.2143	0.2543	0.1987	0.3172	0.2542	0.248	0.2563	0.2547	0.2712
678	28.25	-0.0514	0.1422	0.2497	0.2169	0.2519	0.2053	0.337	0.2598	0.2458	0.2534	0.2497	0.2628
684	28.5	-0.0511	0.1444	0.2509	0.2187	0.2534	0.2025	0.3293	0.2593	0.2471	0.2547	0.2506	0.2619
690	28.75	-0.0526	0.138	0.2547	0.2148	0.2288	0.1897	0.3256	0.2532	0.2473	0.2579	0.256	0.2666

h	d	0	1	2	3	4	5	6	7	8	9	10	11
696	29	-0.0801	0.1052	0.2198	0.1974	0.1999	0.186	0.3931	0.2845	0.2709	0.2816	0.2788	0.2889
702	29.25	-0.0795	0.1092	0.2122	0.199	0.1856	0.1897	0.3904	0.2882	0.2603	0.2685	0.2672	0.2665
708	29.5	-0.0653	0.1186	0.2284	0.1833	0.2035	0.1986	0.3573	0.2673	0.2425	0.253	0.2522	0.2476
714	29.75	-0.0651	0.1195	0.2336	0.1845	0.2134	0.2035	0.3521	0.2558	0.2503	0.2639	0.2629	0.2548
720	30	-0.0654	0.1198	0.234	0.1877	0.2223	0.2087	0.364	0.2565	0.2578	0.2717	0.2707	0.2574
726	30.25	-0.0659	0.1221	0.2243	0.2129	0.202	0.2091	0.37	0.2726	0.2511	0.2633	0.2594	0.2437
732	30.5	-0.0653	0.1216	0.2241	0.1883	0.1966	0.204	0.354	0.2609	0.25225	0.2609	0.2581	0.238
738	30.75	-0.0652	0.1184	0.2293	0.2001	0.2094	0.2065	0.3433	0.2467	0.2515	0.2675	0.2675	0.2425
744	31	-0.0658	0.1183	0.2291	0.2027	0.2103	0.2088	0.3476	0.2479	0.2533	0.2714	0.2714	0.2397
750	31.25	-0.0654	0.1248	0.227	0.1951	0.198	0.2112	0.3507	0.2628	0.2533	0.268	0.266	0.2312
756	31.5	-0.0655	0.1245	0.2262	0.2066	0.2078	0.2064	0.3386	0.258	0.2516	0.2672	0.2646	0.2319
762	31.75	-0.0645	0.1222	0.2345	0.2093	0.2115	0.2145	0.3395	0.25	0.2565	0.2774	0.2778	0.2335
768	32	-0.0655	0.1247	0.2444	0.2197	0.2298	0.2243	0.3557	0.2798	0.2863	0.3131	0.3119	0.2577
774	32.25	-0.0659	0.1187	0.2313	0.1959	0.2226	0.2165	0.3491	0.2493	0.2557	0.281	0.2793	0.2274
780	32.5	-0.0647	0.1272	0.2314	0.2042	0.2163	0.2221	0.3468	0.2585	0.2599	0.2853	0.2825	0.2244
786	32.75	-0.0645	0.128	0.2316	0.2061	-0.6372	0.2216	0.3396	0.2443	0.2589	0.2854	0.2813	0.2219
792	33	-0.0654	0.1224	0.2336	0.2164	-0.6272	0.2216	0.3389	0.2464	0.2619	0.2911	0.2878	0.2258
798	33.25	-0.0653	0.1261	0.2302	0.2033	-0.6251	0.2227	0.3469	0.2427	0.2595	0.287	0.2856	0.2207
804	33.5	-0.0644	0.1214	0.2314	0.2015	0.2257	0.2206	0.3382	0.2482	0.2566	0.2863	0.2802	0.2166
810	33.75	-0.0636	0.1295	0.2332	0.2112	0.2258	0.2257	0.34	0.2365	0.2595	0.2914	0.2845	0.2166
816	34	-0.0645	0.1275	0.2298	0.2068	0.2364	0.2214	0.3355	0.2342	0.2604	0.2911	0.2852	0.215
822	34.25	-0.0646	0.1213	0.2309	0.2069	0.2323	0.221	0.3425	0.2396	0.2535	0.2871	0.2791	0.2112
828	34.5	-0.0638	0.1273	0.2296	0.2136	0.2201	0.2239	0.3376	0.2392	0.2576	0.2892	0.281	0.2092
834	34.75	-0.0639	0.1246	0.2384	0.228	0.2306	0.2208	0.3375	0.2289	0.2569	0.2906	0.2814	0.2091
840	35	-0.0646	0.1272	0.2269	0.2255	0.2175	0.2199	0.3303	0.2189	0.2501	0.2807	0.2724	0.2033
846	35.25	-0.0644	0.1268	0.2277	0.2127	0.2116	0.2177	0.33	0.2178	0.2472	0.2802	0.2672	0.1975
852	35.5	-0.0631	0.1297	0.231	0.2308	0.2134	0.2187	0.3273	0.2236	0.2518	0.2855	0.2744	0.1945
858	35.75	-0.0639	0.1263	0.2418	0.2314	0.227	0.2214	0.3427	0.219	0.2659	0.306	0.2961	0.2003
864	36	-0.0641	0.1271	0.2297	0.2293	0.2179	0.2192	0.3266	0.2038	0.2499	0.2859	0.2748	0.1869
870	36.25	-0.0521	0.1361	0.2452	0.2455	0.261	0.2369	0.3227	0.1965	0.2452	0.2822	0.2727	0.1719
876	36.5	-0.0515	0.1363	0.2419	0.2507	0.262	0.2325	0.3043	0.19	0.2429	0.2792	0.2703	0.1624
882	36.75	-0.0524	0.1428	0.245	0.2557	0.2296	0.2214	0.3088	0.1933	0.2488	0.2873	0.2789	0.1615
888	37	-0.0638	0.1343	0.2363	0.2302	0.2334	0.2174	0.3391	0.2079	0.2722	0.3146	0.3037	0.1801
894	37.25	-0.0637	0.1326	0.2374	0.2389	0.2271	0.2201	0.3405	0.2005	0.2668	0.3097	0.3019	0.1781
900	37.5	-0.0523	0.1445	0.2467	0.2516	0.234	0.2281	0.3235	0.188	0.2487	0.2877	0.282	0.159
906	37.75	-0.0638	0.1356	0.2381	0.2416	0.2243	0.2178	0.3402	0.2013	0.265	0.3072	0.302	0.1719

Changes in Conductivity (mS)
 Cycle 2: Column 4 (EXP)

Time (h)	Time (d)	Depth (in.)		2	3	4	5	6	7	8	9	10	11
		0	1										
-4		0.035	0.2251	0.3687	0.3965	0.3825	0.3289	0.332	0.2456	0.2893	0.3395	0.3479	0.1737
-3		0.0348	0.2249	0.3632	0.3944	0.3797	0.3294	0.3342	0.2476	0.2938	0.3379	0.3491	0.1743
-2		0.0347	0.2245	0.3615	0.3895	0.3745	0.3281	0.3333	0.2476	0.2919	0.3377	0.3491	0.1728
-1		0.035	0.2257	0.3643	0.3898	0.3733	0.3292	0.3354	0.2502	0.2958	0.3417	0.3551	0.1739
0	0	0.0353	0.2276	0.3676	0.3889	0.3722	0.3331	0.339	0.2508	0.2978	0.3448	0.3581	0.1744
1	0.04	0.0346	0.2229	0.3672	0.3859	0.3673	0.3315	0.3386	0.2521	0.3	0.3459	0.3596	0.175
2	0.08	0.0321	0.2194	0.3284	0.3576	0.3702	0.3258	0.3371	0.2469	0.3102	0.3582	0.3671	0.1808
3	0.125	0.0388	0.2186	0.3355	0.3557	0.321	0.2915	0.2573	0.2032	0.2327	0.2512	0.2797	0.1567
4	0.17	0.152	0.2985	0.4278	0.3958	0.3744	0.3402	0.309	0.2342	0.2783	0.2784	0.2481	0.1568
5	0.21	0.138	0.2841	0.3974	0.3667	0.3604	0.3131	0.2968	0.2308	0.2515	0.217	0.2016	0.1306
6	0.25	0.144	0.2682	0.3867	0.3695	0.3822	0.3113	0.2981	0.2395	0.2402	0.2037	0.1824	0.1157
9	0.375	0.1408	0.2496	0.3531	0.3245	0.3239	0.2622	0.23297	0.2349	0.229	0.1879	0.1687	0.104
12	0.5	0.1379	0.2537	0.359	0.332	0.3278	0.2375	0.1899	0.2148	0.2363	0.1837	0.1602	0.0937
18	0.75	0.1993	0.2421	0.2838	0.2536	0.2913	0.2243	0.1868	0.1998	0.2442	0.187	0.159	0.0872
24	1	0.2435	0.2192	0.2517	0.2461	0.3087	0.2295	0.178	0.1835	0.2466	0.1852	0.1546	0.0823
30	1.25	0.3107	0.1739	0.2091	0.2137	0.2208	0.1746	0.1576	0.16	0.2005	0.166	0.1444	0.0802
36	1.5	0.3635	0.129	0.1955	0.2136	0.1978	0.1632	0.1486	0.1504	0.1931	0.1552	0.1381	0.073
42	1.75	0.3723	0.1097	0.1851	0.2043	0.1893	0.1629	0.1509	0.1526	0.1907	0.1569	0.1448	0.075
48	2	0.3769	0.1046	0.1904	0.1925	0.1878	0.1642	0.1533	0.1571	0.198	0.16	0.1503	0.0749
54	2.25	0.3374	0.2469	0.237	0.1917	0.1881	0.1556	0.1443	0.1533	0.2053	0.1559	0.1483	0.0676
60	2.5	0.2903	0.3231	0.283	0.2134	0.1964	0.1585	0.1451	0.1582	0.2119	0.1679	0.1558	0.0669
66	2.75	0.2853	0.335	0.313	0.2676	0.2363	0.1716	0.1493	0.1667	0.2213	0.1839	0.1678	0.0658
72	3	0.2767	0.3715	0.3499	0.3467	0.3666	0.2667	0.1759	0.2076	0.293	0.2488	0.2118	0.0604
78	3.25	0.2486	0.3451	0.3492	0.3559	0.3956	0.3297	0.272	0.2792	0.3162	0.286	0.2432	0.0733
84	3.5	0.2384	0.3226	0.347	0.358	0.3965	0.3501	0.344	0.3396	0.3623	0.3707	0.3173	0.0739
90	3.75	0.2174	0.3018	0.3335	0.3446	0.3934	0.3518	0.3626	0.3592	0.3756	0.3932	0.3634	0.1569
96	4	0.2448	0.2951	0.3319	0.3434	0.3851	0.3445	0.3694	0.3712	0.3823	0.404	0.3824	0.233
102	4.25	0.2423	0.2999	0.326	0.3419	0.3737	0.3336	0.3677	0.3678	0.3815	0.3995	0.3859	0.2392
108	4.5	0.2478	0.2988	0.3368	0.348	0.3717	0.3325	0.3744	0.3764	0.3884	0.4046	0.3878	0.2086
114	4.75	0.2229	0.3008	0.3278	0.3416	0.3655	0.3199	0.3637	0.3627	0.3822	0.4054	0.3888	0.1825
120	5	0.2382	0.3007	0.3364	0.3455	0.3593	0.316	0.3752	0.3723	0.3787	0.4088	0.3871	0.1808
126	5.25	0.237	0.3065	0.3178	0.3301	0.3465	0.3004	0.3558	0.3613	0.3686	0.3762	0.368	0.1896
132	5.5	0.2418	0.3007	0.3225	0.3294	0.3431	0.2948	0.3564	0.3629	0.3665	0.3744	0.366	0.1953
138	5.75	0.2449	0.3054	0.3267	0.3318	0.3412	0.2913	0.3612	0.3662	0.3708	0.3762	0.3708	0.199
144	6	0.2334	0.3046	0.3204	0.3269	0.3256	0.2786	0.3572	0.3588	0.3662	0.3712	0.367	0.1992
150	6.25	0.2389	0.3093	0.3317	0.3323	0.3252	0.2784	0.3647	0.3653	0.3702	0.3773	0.3709	0.1985
156	6.5	0.2323	0.3027	0.329	0.3271	0.3117	0.2689	0.3583	0.3577	0.364	0.3688	0.3629	0.1948
162	6.75	0.2375	0.3111	0.3332	0.3307	0.3123	0.2705	0.366	0.3643	0.3702	0.3743	0.3688	0.1914
168	7	0.2312	0.3056	0.3277	0.3241	0.3009	0.2672	0.3596	0.3574	0.3641	0.37	0.364	0.1888
174	7.25	0.1699	0.3493	0.3905	0.3735	0.3158	0.2759	0.407	0.3853	0.4148	0.4276	0.417	0.1936
180	7.5	0.1938	0.3447	0.3774	0.3661	0.309	0.2722	0.4018	0.3752	0.4116	0.422	0.4121	0.1782
186	7.75	0.2072	0.3411	0.3716	0.3595	0.2895	0.2497	0.3914	0.3556	0.4063	0.4196	0.409	0.168
192	8	0.2229	0.3449	0.3843	0.3654	0.2947	0.2496	0.3941	0.3568	0.4094	0.4395	0.4348	0.1671
198	8.25	0.2227	0.3424	0.3762	0.359	0.2804	0.2378	0.3857	0.3399	0.403	0.4154	0.4096	0.1525
204	8.5	0.228	0.3476	0.373	0.3546	0.2731	0.2285	0.3821	0.3333	0.4017	0.3956	0.4034	0.1437
210	8.75	0.2344	0.3464	0.3723	0.3513	0.269	0.2196	0.388	0.3339	0.3955	0.3945	0.4069	0.1414
216	9	0.2335	0.3458	0.3701	0.3448	0.2594	0.208	0.3782	0.3229	0.4012	0.3902	0.4046	0.1388
222	9.25	0.231	0.3413	0.3799	0.3378	0.2454	0.1958	0.3842	0.3237	0.3898	0.3982	0.3937	0.1371
228	9.5	0.2295	0.3439	0.3697	0.328	0.2327	0.1815	0.3776	0.3168	0.3964	0.3857	0.3922	0.1417
234	9.75	0.2295	0.3417	0.3595	0.3169	0.2204	0.1709	0.3698	0.3067	0.3897	0.3844	0.3947	0.1475
240	10	0.2294	0.3392	0.3574	0.3131	0.2184	0.163	0.3657	0.306	0.3706	0.3861	0.3944	0.1413
246	10.25	0.2274	0.335	0.3545	0.3069	0.2108	0.1523	0.3603	0.3008	0.3659	0.3839	0.3932	0.1381
252	10.5	0.2263	0.3336	0.3614	0.3119	0.2294	0.1579	0.3508	0.2993	0.364	0.3861	0.3959	0.1386
258	10.75	0.2286	0.3267	0.358	0.3061	0.2213	0.1495	0.344	0.2942	0.3604	0.3817	0.3897	0.1162
264	11	0.2275	0.3326	0.3528	0.3091	0.2231	0.1429	0.3601	0.332	0.3746	0.3817	0.3815	0.1125
270	11.25	0.2244	0.3245	0.3621	0.3011	0.2079	0.1359	0.3583	0.3176	0.3753	0.38	0.3974	0.1224
276	11.5	0.2139	0.3231	0.3594	0.2917	0.2004	0.1313	0.3473	0.3053	0.3657	0.3796	0.3929	0.1173
282	11.75	0.2156	0.3214	0.356	0.2907	0.1978	0.1262	0.3449	0.3062	0.3676	0.3837	0.3894	0.1164
288	12	0.2184	0.3244	0.3626	0.2903	0.1988	0.1232	0.344	0.3101	0.3688	0.3744	0.3907	0.126

294	12.25	0.2147	0.3253	0.36	0.2856	0.1975	0.1174	0.3383	0.3114	0.3674	0.379	0.3758	0.1146
300	12.5	0.2116	0.3225	0.356	0.2742	0.1947	0.1124	0.3308	0.3044	0.3625	0.3795	0.3758	0.1163
306	12.75	0.2112	0.3183	0.3498	0.2576	0.1884	0.1064	0.3226	0.2919	0.3581	0.392	0.3773	0.123
312	13	0.2174	0.3073	0.3303	0.2511	0.1882	0.1044	0.3163	0.2874	0.3592	0.3866	0.3775	0.1214
318	13.25	0.2176	0.3116	0.33	0.2481	0.1885	0.1037	0.3138	0.2937	0.3593	0.3793	0.3919	0.1205
324	13.5	0.2169	0.3245	0.3371	0.2479	0.1871	0.1029	0.3108	0.2961	0.3587	0.3795	0.3893	0.1178
330	13.75	0.2215	0.324	0.329	0.2413	0.187	0.1018	0.3059	0.3034	0.3605	0.3751	0.3871	0.12
336	14	0.2047	0.3136	0.3418	0.2289	0.1851	0.0995	0.2983	0.2848	0.3587	0.3887	0.3898	0.1077
342	14.25	0.2046	0.3266	0.3565	0.2326	0.1936	0.0997	0.3025	0.2879	0.3662	0.378	0.391	0.1057
348	14.5	0.2143	0.3298	0.346	0.2282	0.1868	0.0981	0.2982	0.3003	0.3651	0.3919	0.3912	0.1231
354	14.75	0.2176	0.3207	0.3353	0.2144	0.1793	0.0959	0.2868	0.2927	0.359	0.3906	0.3882	0.1219
360	15	0.2049	0.3162	0.337	0.2021	0.1766	0.0948	0.2781	0.2737	0.3537	0.3927	0.3785	0.109
372	15.5	0.2041	0.3307	0.3342	0.1954	0.176	0.0935	0.2708	0.2733	0.3532	0.3922	0.377	0.1025
384	16	0.212	0.3286	0.3223	0.1912	0.1762	0.0911	0.2558	0.2735	0.3489	0.3868	0.3842	0.1118
396	16.5	0.2106	0.3423	0.3327	0.1977	0.1776	0.089	0.2496	0.2772	0.3459	0.3906	0.386	0.107
408	17	0.2023	0.3294	0.3205	0.1853	0.1739	0.0863	0.2349	0.2557	0.3315	0.345	0.3596	0.0921
420	17.5	0.201	0.3314	0.3148	0.1862	0.1692	0.0741	0.246	0.2491	0.3333	0.3393	0.3535	0.0887
432	18	0.1954	0.329	0.3025	0.1807	0.1676	0.0728	0.2315	0.2384	0.329	0.3627	0.3613	0.0948
444	18.5	0.1894	0.3304	0.2982	0.187	0.168	0.0734	0.2223	0.2319	0.3634	0.3505	0.3577	0.0909
456	19	0.1912	0.3294	0.2977	0.2058	0.1713	0.0739	0.2131	0.2373	0.3302	0.358	0.355	0.088
468	19.5	0.1829	0.34	0.3078	0.2203	0.1707	0.0729	0.2006	0.2362	0.365	0.3527	0.3616	0.0844
480	20	0.1877	0.3365	0.3058	0.2251	0.1766	0.0731	0.1914	0.2471	0.3304	0.3617	0.3564	0.0855
492	20.5	0.1842	0.3416	0.3127	0.2261	0.1752	0.0735	0.1848	0.2502	0.3316	0.3635	0.3532	0.0837
504	21	0.1827	0.3438	0.3121	0.2183	0.1727	0.0743	0.1798	0.2474	0.37	0.3561	0.3547	0.081
516	21.5	0.1768	0.3459	0.3137	0.205	0.1716	0.0746	0.1702	0.2291	0.3307	0.3369	0.3301	0.0715
528	22	0.1765	0.3523	0.3152	0.1953	0.1719	0.0753	0.165	0.2275	0.3306	0.3379	0.33	0.0718
540	22.5	0.1745	0.3594	0.3247	0.1875	0.1741	0.0757	0.1614	0.2341	0.3268	0.3369	0.3261	0.072
552	23	0.177	0.362	0.3331	0.1898	0.1758	0.0774	0.1539	0.2337	0.3274	0.3416	0.3276	0.075
564	23.5	0.1788	0.3665	0.3242	0.189	0.1766	0.0692	0.1504	0.2497	0.3335	0.3367	0.3233	0.0735
576	24	0.1771	0.3609	0.3351	0.1966	0.1885	0.0838	0.1459	0.2442	0.3327	0.3406	0.3222	0.0746
588	24.5	0.1745	0.3616	0.3428	0.1884	0.1826	0.0834	0.14	0.2367	0.3311	0.3373	0.3162	0.0754
600	25	0.17	0.3662	0.341	0.1749	0.1717	0.0805	0.1344	0.2183	0.3658	0.3481	0.3217	0.0812
612	25.5	0.1316	0.3668	0.3428	0.1756	0.175	0.0806	0.131	0.2183	0.3596	0.3463	0.319	0.0794
624	26	0.1328	0.3666	0.3389	0.1799	0.1783	0.0837	0.1303	0.218	0.3275	0.3594	0.3238	0.0788
636	26.5	0.1329	0.3621	0.3472	0.1928	0.1884	0.0897	0.1271	0.2334	0.3288	0.3411	0.3118	0.07
648	27	0.1351	0.3681	0.3477	0.1919	0.1901	0.0946	0.1253	0.2209	0.3688	0.357	0.3239	0.0746
660	27.5	0.1349	0.3626	0.3522	0.1983	0.1918	0.0955	0.1218	0.2229	0.3302	0.3511	0.3134	0.0677
672	28	0.1329	0.3636	0.3583	0.197	0.189	0.0925	0.119	0.2194	0.3624	0.3578	0.3225	0.0732
684	28.5	0.1342	0.3579	0.3667	0.2008	0.1906	0.0912	0.1156	0.2287	0.3662	0.3599	0.3229	0.0718
696	29	0.1376	0.3612	0.3691	0.2031	0.186	0.074	0.1141	0.2278	0.368	0.3624	0.3308	0.0718
708	29.5	0.137	0.366	0.3652	0.2209	0.1949	0.0971	0.1123	0.2207	0.3679	0.365	0.3207	0.0705

Changes in Conductivity (mS)
Cycle 2: Column 5 (CTL)

Time (h)	Time (d)	Depth (in.)	0	1	2	3	4	5	6	7	8	9	10	11
-4	-0.17	0.0911	0.0897	0.0867	0.0885	0.0864	0.0852	0.0834	0.0825	0.0821	0.0816	0.0807	0.0803	0.0053
-3	-0.125	0.0908	0.0895	0.0865	0.0883	0.0861	0.0849	0.0832	0.0822	0.0819	0.0814	0.0804	0.0803	0.0053
-2	-0.08	0.0894	0.0885	0.0859	0.0876	0.0855	0.0844	0.0829	0.0818	0.0815	0.0812	0.0802	0.0803	0.0053
-1	-0.04	0.0886	0.088	0.0856	0.0878	0.0853	0.0842	0.0829	0.0818	0.0815	0.0812	0.0802	0.0803	0.0053
0	0	0.0884	0.0877	0.0854	0.0873	0.0851	0.0842	0.0827	0.0817	0.0815	0.0811	0.0802	0.0803	0.0053
1	0.04	0.0884	0.0877	0.0854	0.0778	0.0851	0.0842	0.0827	0.0817	0.0815	0.0812	0.0802	0.0803	0.0053
2	0.08	0.0815	0.0808	0.0786	0.0799	0.078	0.0769	0.0755	0.0745	0.0741	0.0737	0.0727	0.0727	0.0054
3	0.125	0.0813	0.0807	0.0786	0.0799	0.078	0.077	0.0757	0.0747	0.0744	0.074	0.073	0.073	0.0054
4	0.17	0.1002	0.0993	0.0967	0.0869	0.0968	0.0957	0.0944	0.0931	0.0929	0.0925	0.0914	0.0914	0.0053
5	0.21	0.0899	0.0892	0.0869	0.0884	0.0867	0.0856	0.0843	0.0832	0.0828	0.0825	0.0815	0.0815	0.0054
6	0.25	0.0829	0.0822	0.0799	0.0809	0.0794	0.0782	0.0769	0.0758	0.0754	0.075	0.074	0.074	0.0055
9	0.375	0.0826	0.0819	0.0797	0.0808	0.0792	0.0782	0.077	0.0758	0.0755	0.075	0.0741	0.0741	0.0055
12	0.5	0.0781	0.0775	0.0753	0.0762	0.0748	0.0737	0.0725	0.0714	0.071	0.0705	0.0697	0.0697	0.0062
18	0.75	0.0776	0.077	0.0749	0.0757	0.0744	0.0734	0.0723	0.0712	0.0708	0.0704	0.0696	0.0696	0.0131
24	1	0.0779	0.0773	0.0752	0.0761	0.0748	0.0739	0.0728	0.0716	0.0714	0.0709	0.0701	0.0701	0.0163
30	1.25	0.0845	0.0837	0.0813	0.0824	0.0809	0.08	0.0788	0.0776	0.0773	0.0768	0.076	0.076	0.0055

36	1.5	0.0848	0.084	0.0816	0.0828	0.0812	0.0803	0.0791	0.0779	0.0776	0.0771	0.0763	0.0056
42	1.75	0.0908	0.09	0.0875	0.0795	0.0874	0.0866	0.0854	0.0842	0.0839	0.0835	0.0827	0.0054
48	2	0.093	0.092	0.0894	0.0908	0.0892	0.0883	0.087	0.0856	0.0854	0.0849	0.084	0.0055
54	2.25	0.0861	0.0853	0.0829	0.0841	0.0826	0.0817	0.0804	0.0791	0.0789	0.0784	0.0775	0.0056
60	2.5	0.0862	0.0854	0.083	0.0841	0.0826	0.0818	0.0805	0.0792	0.0789	0.0784	0.0776	0.0056
66	2.75	0.0866	0.0859	0.0835	0.0847	0.0832	0.0823	0.081	0.0797	0.0795	0.079	0.0781	0.0057
72	3	0.0809	0.0804	0.0785	0.0796	0.0784	0.0777	0.0764	0.0752	0.0751	0.0747	0.0739	0.0114
78	3.25	0.0938	0.093	0.0904	0.1028	0.0902	0.0895	0.0882	0.0868	0.0867	0.0862	0.0854	0.0065
84	3.5	0.0867	0.086	0.0836	0.0849	0.0834	0.0826	0.0813	0.08	0.0799	0.0794	0.0786	0.0128
90	3.75	0.0874	0.0867	0.0844	0.0858	0.0842	0.0834	0.0821	0.0807	0.0806	0.0801	0.0792	0.0057
96	4	0.0869	0.0863	0.084	0.0852	0.0837	0.0829	0.0816	0.0803	0.0802	0.0797	0.0789	0.0108
102	4.25	0.0875	0.0869	0.0846	0.0859	0.0843	0.0836	0.0823	0.0809	0.0808	0.0803	0.0794	0.0057
108	4.5	0.087	0.0864	0.0841	0.0853	0.0837	0.0831	0.0818	0.0805	0.0803	0.0799	0.079	0.0109
114	4.75	0.0944	0.0936	0.0909	0.0825	0.0907	0.09	0.0887	0.0873	0.0872	0.0867	0.0858	0.0055
120	5	0.0954	0.0946	0.0919	0.0935	0.0916	0.0909	0.0896	0.0881	0.088	0.0875	0.0866	0.0056
126	5.25	0.0877	0.0873	0.0851	0.0866	0.0849	0.0843	0.0831	0.0817	0.0817	0.0812	0.0804	0.0076
132	5.5	0.0871	0.0866	0.0844	0.0859	0.0842	0.0836	0.0823	0.081	0.081	0.0805	0.0797	0.0095
138	5.75	0.087	0.0864	0.0841	0.0854	0.0838	0.0832	0.0819	0.0806	0.0805	0.0801	0.0792	0.0109
144	6	0.0875	0.087	0.0848	0.0864	0.0847	0.0841	0.0828	0.0815	0.0814	0.081	0.0802	0.0058
150	6.25	0.0876	0.0871	0.0848	0.0862	0.0846	0.084	0.0827	0.0814	0.0813	0.0809	0.08	0.0095
156	6.5	0.0873	0.0868	0.0846	0.0861	0.0844	0.0838	0.0825	0.0812	0.0812	0.0807	0.0799	0.0057
162	6.75	0.0871	0.0864	0.0842	0.0854	0.0939	0.0833	0.082	0.0806	0.0806	0.0801	0.0793	0.0109
168	7	0.0865	0.086	0.0838	0.0852	0.0835	0.0829	0.0816	0.0803	0.0803	0.0798	0.079	0.0094
174	7.25	0.1048	0.1036	0.1006	0.1026	0.1005	0.0999	0.0985	0.097	0.0969	0.0963	0.0954	0.0054
180	7.5	0.1047	0.1035	0.1006	0.1025	0.1004	0.0998	0.0984	0.0969	0.0968	0.0962	0.0953	0.0054
186	7.75	0.0947	0.0938	0.0912	0.0929	0.0909	0.0903	0.0889	0.0875	0.0874	0.0869	0.086	0.0056
192	8	0.1054	0.1043	0.1013	0.1035	0.1012	0.1007	0.0993	0.0978	0.0978	0.0973	0.0964	0.0071
198	8.25	0.1046	0.1035	0.1006	0.0902	0.1005	0.0999	0.0985	0.097	0.0969	0.0964	0.0955	0.0054
204	8.5	0.1036	0.1025	0.0997	0.1164	0.0996	0.0991	0.0977	0.0963	0.0962	0.0958	0.0949	0.0059
210	8.75	0.1034	0.1024	0.0996	0.1163	0.0996	0.099	0.0977	0.0962	0.0962	0.0957	0.0949	0.0064
216	9	0.1037	0.1026	0.0998	0.1165	0.0997	0.0992	0.0979	0.0963	0.0964	0.0959	0.095	0.0059
222	9.25	0.104	0.1029	0.1	0.0897	0.0999	0.0993	0.0979	0.0964	0.0964	0.0959	0.095	0.0054
228	9.5	0.1039	0.1028	0.0999	0.0896	0.0997	0.0991	0.0978	0.0962	0.0962	0.0957	0.0948	0.0054
234	9.75	0.1036	0.1025	0.0997	0.1013	0.0996	0.099	0.0977	0.0962	0.0962	0.0957	0.0948	0.0059
240	10	0.0942	0.0933	0.0906	0.0921	0.0903	0.0896	0.0883	0.0868	0.0867	0.0862	0.0853	0.006
246	10.25	0.094	0.0931	0.0904	0.0919	0.0901	0.0895	0.0882	0.0867	0.0866	0.0861	0.0852	0.006
252	10.5	0.0933	0.0923	0.0897	0.0914	0.0894	0.0889	0.0875	0.0861	0.086	0.0855	0.0847	0.0055
258	10.75	0.0862	0.0855	0.0833	0.0845	0.0829	0.0823	0.081	0.0797	0.0796	0.0791	0.0783	0.0108
264	11	0.087	0.0863	0.0842	0.0856	0.0839	0.0833	0.0819	0.0807	0.0806	0.0802	0.0793	0.0129
270	11.25	0.0869	0.0863	0.0841	0.0854	0.0838	0.0833	0.082	0.0806	0.0806	0.0801	0.0793	0.0084
276	11.5	0.0872	0.0867	0.0845	0.0859	0.0843	0.0837	0.0824	0.081	0.081	0.0804	0.0796	0.0057
282	11.75	0.0871	0.0865	0.0842	0.0856	0.0841	0.0835	0.0822	0.0808	0.0808	0.0802	0.0794	0.0057
288	12	0.0866	0.086	0.0837	0.085	0.0834	0.0829	0.0816	0.0803	0.0802	0.0797	0.0789	0.0083
294	12.25	0.0867	0.0861	0.0838	0.0853	0.0836	0.0831	0.0818	0.0805	0.0804	0.0799	0.0791	0.0075
300	12.5	0.0865	0.0859	0.0836	0.0851	0.0834	0.0829	0.0815	0.0802	0.0802	0.0797	0.0789	0.0083
306	12.75	0.0808	0.0806	0.0788	0.0801	0.0789	0.0784	0.0772	0.076	0.076	0.0755	0.0747	0.0071
312	13	0.0808	0.0806	0.0788	0.0803	0.0789	0.0784	0.0772	0.076	0.076	0.0756	0.0748	0.0115
318	13.25	0.0807	0.0805	0.0788	0.0803	0.0789	0.0784	0.0772	0.076	0.0761	0.0756	0.0748	0.0215
324	13.5	0.0806	0.0803	0.0786	0.0801	0.0787	0.0782	0.0769	0.0758	0.0758	0.0754	0.0746	0.0215
330	13.75	0.0807	0.0805	0.0787	0.0803	0.0789	0.0784	0.0771	0.076	0.0761	0.0756	0.0748	0.0215
336	14	0.0814	0.0813	0.0795	0.0809	0.0798	0.0794	0.0782	0.077	0.077	0.0766	0.0758	0.006
342	14.25	0.0817	0.0816	0.0799	0.0815	0.0803	0.0799	0.0787	0.0775	0.0776	0.0771	0.0764	0.0066
348	14.5	0.0807	0.0806	0.0788	0.0804	0.079	0.0785	0.0772	0.0761	0.0761	0.0757	0.0749	0.0167
354	14.75	0.0806	0.0805	0.0787	0.0802	0.0788	0.0784	0.0771	0.0759	0.076	0.0755	0.0747	0.0215
360	15	0.0814	0.0813	0.0796	0.0811	0.08	0.0796	0.0784	0.0773	0.0773	0.0768	0.0761	0.0072
372	15.5	0.081	0.0809	0.0791	0.0805	0.0794	0.079	0.0778	0.0766	0.0767	0.0762	0.0754	0.0065
384	16	0.0814	0.0814	0.0797	0.0814	0.0802	0.0799	0.0787	0.0776	0.0777	0.0772	0.0765	0.0217
396	16.5	0.076	0.076	0.0746	0.0764	0.0752	0.075	0.0739	0.073	0.0734	0.0731	0.0724	0.0343
408	17	0.076	0.0759	0.0743	0.0759	0.075	0.0747	0.0737	0.0728	0.0731	0.0728	0.0722	0.0146
420	17.5	0.0756	0.0755	0.0739	0.0755	0.0745	0.0742	0.0732	0.0723	0.0726	0.0723	0.0717	0.0342
432	18	0.0755	0.0754	0.0737	0.0753	0.0743	0.0741	0.073	0.0722	0.0724	0.0721	0.0715	0.034
444	18.5	0.0755	0.0753	0.0736	0.0752	0.0743	0.074	0.073	0.0721	0.0723	0.072	0.0714	0.0179
456	19	0.076	0.0759	0.0742	0.0759	0.0749	0.0747	0.0737	0.0729	0.0732	0.0729	0.0723	0.0343
468	19.5	0.0757	0.0755	0.0738	0.0754	0.0745	0.0743	0.0733	0.0724	0.0727	0.0724	0.0717	0.0179
480	20	0.0757	0.0755	0.0738	0.0754	0.0745	0.0742	0.0732	0.0724	0.0727	0.0724	0.0717	0.0343

492	20.5	0.0754	0.0752	0.0734	0.075	0.0741	0.0738	0.0728	0.0719	0.0722	0.0719	0.0712	0.0341
504	21	0.0758	0.0756	0.0737	0.0754	0.0745	0.0742	0.0732	0.0724	0.0727	0.0724	0.0717	0.0342
516	21.5	0.0756	0.0754	0.0735	0.0751	0.0742	0.074	0.0729	0.0721	0.0723	0.072	0.0714	0.0235
528	22	0.076	0.0759	0.0741	0.0757	0.0749	0.0747	0.0737	0.0728	0.0731	0.0728	0.0722	0.0236
540	22.5	0.0759	0.0757	0.0738	0.0755	0.0746	0.0744	0.0734	0.0726	0.0728	0.0725	0.0718	0.0236
552	23	0.0765	0.0764	0.0746	0.0763	0.0756	0.0753	0.0744	0.0736	0.0739	0.0736	0.073	0.0237
564	23.5	0.076	0.0759	0.074	0.0757	0.0748	0.0746	0.0736	0.0728	0.0731	0.0729	0.0722	0.0342
576	24	0.0757	0.0755	0.0735	0.0752	0.0743	0.074	0.073	0.0722	0.0725	0.0723	0.0716	0.034
588	24.5	0.0754	0.0752	0.0732	0.0748	0.074	0.0737	0.0727	0.0719	0.0721	0.0719	0.0712	0.034
600	25	0.0754	0.0751	0.0732	0.0747	0.0739	0.0736	0.0726	0.0718	0.072	0.0717	0.071	0.0235
612	25.5	0.0755	0.0753	0.0733	0.0749	0.0741	0.0737	0.0727	0.072	0.0722	0.0719	0.0712	0.034
624	26	0.0764	0.0762	0.0743	0.076	0.0752	0.0749	0.074	0.0732	0.0735	0.0733	0.0726	0.0339
636	26.5	0.0759	0.0757	0.0737	0.0754	0.0746	0.0743	0.0733	0.0725	0.0728	0.0726	0.0719	0.034
648	27	0.0763	0.076	0.0742	0.0758	0.075	0.0747	0.0737	0.073	0.0733	0.0731	0.0724	0.0339
660	27.5	0.0759	0.0756	0.0736	0.0752	0.0744	0.0742	0.0732	0.0724	0.0726	0.0724	0.0717	0.034
672	28	0.0762	0.0759	0.0739	0.0756	0.0748	0.0745	0.0735	0.0728	0.073	0.0728	0.0721	0.0341
684	28.5	0.0758	0.0754	0.0735	0.075	0.0742	0.0739	0.0729	0.0722	0.0724	0.0722	0.0715	0.034
696	29	0.0762	0.076	0.0741	0.0758	0.075	0.0747	0.0738	0.073	0.0733	0.0731	0.0724	0.0341
708	29.5	0.0758	0.0755	0.0735	0.075	0.0742	0.0739	0.0629	0.0722	0.0724	0.0722	0.0715	0.034

Changes in Conductivity (mS)

Cycle 2: Column 4 - Column 5: (EXP - CTL)

Time (h)	Time (d)	Depth (in.)											
		0	1	2	3	4	5	6	7	8	9	10	11
-4	-0.17	-0.0561	0.1354	0.282	0.308	0.2961	0.2437	0.2486	0.1631	0.2072	0.2579	0.2672	0.1684
-3	-0.125	-0.056	0.1354	0.2767	0.3061	0.2936	0.2445	0.251	0.1654	0.2119	0.2565	0.2687	0.169
-2	-0.08	-0.0547	0.136	0.2756	0.3019	0.289	0.2437	0.2504	0.1658	0.2104	0.2565	0.2689	0.1675
-1	-0.04	-0.0536	0.1377	0.2787	0.3118	0.288	0.245	0.2525	0.1684	0.2143	0.2605	0.2749	0.1686
0	0	-0.0531	0.1399	0.2822	0.3016	0.2871	0.2489	0.2563	0.1691	0.2163	0.2637	0.2779	0.1691
1	0.04	-0.0538	0.1352	0.2818	0.3081	0.2822	0.2473	0.2559	0.1704	0.2185	0.2647	0.2794	0.1697
2	0.08	-0.0494	0.1386	0.2498	0.2777	0.2922	0.2489	0.2616	0.1724	0.2361	0.2845	0.2944	0.1754
3	0.125	-0.0425	0.1379	0.2569	0.2758	0.243	0.2145	0.1816	0.1285	0.1583	0.1772	0.2067	0.1513
4	0.17	0.0518	0.1992	0.3311	0.3089	0.2776	0.2445	0.2146	0.1411	0.1854	0.1859	0.1567	0.1515
5	0.21	0.0481	0.1949	0.3105	0.2783	0.2737	0.2275	0.2125	0.1476	0.1687	0.1345	0.1201	0.1252
6	0.25	0.0611	0.186	0.3068	0.2886	0.3028	0.2331	0.2212	0.1637	0.1648	0.1287	0.1084	0.1102
9	0.375	0.0582	0.1677	0.2734	0.2437	0.2447	0.184	0.15597	0.1591	0.1535	0.1129	0.0946	0.0985
12	0.5	0.0598	0.1762	0.2837	0.2558	0.253	0.1638	0.1174	0.1434	0.1653	0.1132	0.0905	0.0875
18	0.75	0.1217	0.1651	0.2089	0.1779	0.2169	0.1509	0.1145	0.1286	0.1734	0.1166	0.0894	0.0741
24	1	0.1656	0.1419	0.1765	0.17	0.2339	0.1556	0.1052	0.1119	0.1752	0.1143	0.0845	0.066
30	1.25	0.2262	0.0902	0.1278	0.1313	0.1399	0.0946	0.0788	0.0824	0.1232	0.0892	0.0684	0.0747
36	1.5	0.2787	0.045	0.1139	0.1308	0.1166	0.0829	0.0695	0.0725	0.1155	0.0781	0.0618	0.0674
42	1.75	0.2815	0.0197	0.0976	0.1248	0.1019	0.0763	0.0655	0.0684	0.1068	0.0734	0.0621	0.0696
48	2	0.2839	0.0126	0.101	0.1017	0.0986	0.0759	0.0663	0.0715	0.1126	0.0751	0.0663	0.0694
54	2.25	0.2513	0.1616	0.1541	0.1076	0.1055	0.0739	0.0639	0.0742	0.1264	0.0775	0.0708	0.062
60	2.5	0.2041	0.2377	0.2	0.1293	0.1138	0.0767	0.0646	0.079	0.133	0.0895	0.0782	0.0613
66	2.75	0.1987	0.2491	0.2295	0.1829	0.1531	0.0893	0.0683	0.087	0.1418	0.1049	0.0897	0.0601
72	3	0.1958	0.2911	0.2714	0.2671	0.2882	0.189	0.0995	0.1324	0.2179	0.1741	0.1379	0.049
78	3.25	0.1548	0.2521	0.2588	0.2531	0.3054	0.2402	0.1838	0.1924	0.2295	0.1998	0.1578	0.0668
84	3.5	0.1517	0.2366	0.2634	0.2731	0.3131	0.2675	0.2627	0.2596	0.2824	0.2913	0.2387	0.0611
90	3.75	0.13	0.2151	0.2491	0.2588	0.3092	0.2684	0.2805	0.2785	0.295	0.3131	0.2842	0.1512
96	4	0.1579	0.2088	0.2479	0.2582	0.3014	0.2616	0.2878	0.2909	0.3021	0.3243	0.3035	0.2222
102	4.25	0.1548	0.213	0.2414	0.256	0.2894	0.25	0.2854	0.2869	0.3007	0.3192	0.3065	0.2335
108	4.5	0.1608	0.2124	0.2527	0.2627	0.288	0.2494	0.2926	0.2959	0.3081	0.3247	0.3088	0.1977
114	4.75	0.1285	0.2072	0.2369	0.2591	0.2748	0.2299	0.275	0.2754	0.295	0.3187	0.303	0.177
120	5	0.1428	0.2061	0.2445	0.252	0.2677	0.2251	0.2856	0.2842	0.2907	0.3213	0.3005	0.1752
126	5.25	0.1493	0.2192	0.2327	0.2435	0.2616	0.2161	0.2727	0.2796	0.2869	0.295	0.2876	0.182
132	5.5	0.1547	0.2141	0.2381	0.2435	0.2589	0.2112	0.2741	0.2819	0.2855	0.2939	0.2863	0.1858
138	5.75	0.1579	0.219	0.2426	0.2464	0.2574	0.2081	0.2793	0.2856	0.2903	0.2961	0.2916	0.1881
144	6	0.1459	0.2176	0.2356	0.2405	0.2409	0.1945	0.2744	0.2773	0.2848	0.2902	0.2868	0.1934
150	6.25	0.1513	0.2222	0.2469	0.2461	0.2406	0.1944	0.282	0.2839	0.2889	0.2964	0.2909	0.189
156	6.5	0.145	0.2159	0.2444	0.241	0.2273	0.1851	0.2758	0.2765	0.2828	0.2881	0.283	0.1891
162	6.75	0.1504	0.2247	0.249	0.2453	0.2184	0.1872	0.284	0.2837	0.2901	0.295	0.2895	0.1805

168	7	0.1447	0.2196	0.2439	0.2389	0.2174	0.1843	0.278	0.2771	0.2838	0.2902	0.285	0.1794
174	7.25	0.0651	0.2457	0.2899	0.2709	0.2153	0.176	0.3085	0.2883	0.3179	0.3313	0.3216	0.1882
180	7.5	0.0891	0.2412	0.2768	0.2636	0.2086	0.1724	0.3034	0.2783	0.3148	0.3258	0.3168	0.1728
186	7.75	0.1125	0.2473	0.2804	0.2666	0.1986	0.1594	0.3025	0.2681	0.3189	0.3327	0.323	0.1624
192	8	0.1175	0.2406	0.283	0.2619	0.1935	0.1489	0.2948	0.259	0.3116	0.3422	0.3384	0.16
198	8.25	0.1181	0.2389	0.2756	0.2688	0.1799	0.1379	0.2872	0.2429	0.3061	0.319	0.3141	0.1471
204	8.5	0.1244	0.2451	0.2733	0.2382	0.1735	0.1294	0.2844	0.237	0.3055	0.2998	0.3085	0.1378
210	8.75	0.131	0.244	0.2727	0.235	0.1694	0.1206	0.2903	0.2377	0.2993	0.2988	0.312	0.135
216	9	0.1298	0.2432	0.2703	0.2283	0.1597	0.1088	0.2803	0.2266	0.3048	0.2943	0.3096	0.1329
222	9.25	0.127	0.2384	0.2799	0.2481	0.1455	0.0965	0.2863	0.2273	0.2934	0.3023	0.2987	0.1317
228	9.5	0.1256	0.2411	0.2698	0.2384	0.133	0.0824	0.2798	0.2206	0.3002	0.29	0.2974	0.1363
234	9.75	0.1259	0.2392	0.2598	0.2156	0.1208	0.0719	0.2721	0.2105	0.2935	0.2887	0.2999	0.1416
240	10	0.1352	0.2459	0.2668	0.221	0.1281	0.0734	0.2774	0.2192	0.2839	0.2999	0.3091	0.1353
246	10.25	0.1334	0.2419	0.2641	0.215	0.1207	0.0628	0.2721	0.2141	0.2793	0.2978	0.308	0.1321
252	10.5	0.133	0.2413	0.2717	0.2205	0.14	0.069	0.2633	0.2132	0.278	0.3006	0.3112	0.1331
258	10.75	0.1424	0.2412	0.2747	0.2216	0.1384	0.0672	0.263	0.2145	0.2808	0.3026	0.3114	0.1054
264	11	0.1405	0.2463	0.2686	0.2235	0.1392	0.0596	0.2782	0.2513	0.294	0.3015	0.3022	0.0996
270	11.25	0.1375	0.2382	0.278	0.2157	0.1241	0.0526	0.2763	0.237	0.2947	0.2999	0.3181	0.114
276	11.5	0.1267	0.2364	0.2749	0.2058	0.1161	0.0476	0.2649	0.2243	0.2853	0.3	0.3133	0.1116
282	11.75	0.1285	0.2349	0.2718	0.2051	0.1137	0.0427	0.2627	0.2254	0.2868	0.3035	0.31	0.1107
288	12	0.1318	0.2384	0.2789	0.2053	0.1154	0.0403	0.2624	0.2298	0.2886	0.2947	0.3118	0.1177
294	12.25	0.128	0.2392	0.2762	0.2003	0.1139	0.0343	0.2296	0.2869	0.2986	0.2959	0.2967	0.1071
300	12.5	0.1251	0.2366	0.2724	0.1891	0.1113	0.0295	0.2493	0.2242	0.2823	0.2998	0.2969	0.108
306	12.75	0.1304	0.2377	0.271	0.1775	0.1095	0.028	0.2454	0.2159	0.2821	0.3165	0.3026	0.1159
312	13	0.1366	0.2267	0.2515	0.1708	0.1093	0.026	0.2391	0.2114	0.2832	0.311	0.3027	0.1099
318	13.25	0.1369	0.2311	0.2512	0.1678	0.1096	0.0253	0.2366	0.2177	0.2832	0.3163	0.3171	0.099
324	13.5	0.1363	0.2442	0.2585	0.1678	0.1084	0.0247	0.2339	0.2203	0.2829	0.3041	0.3147	0.0963
330	13.75	0.1408	0.2435	0.2503	0.161	0.1081	0.0234	0.2288	0.2274	0.2844	0.2995	0.3123	0.0985
336	14	0.1233	0.2323	0.2623	0.148	0.1053	0.0201	0.2201	0.2078	0.2817	0.3121	0.314	0.1017
342	14.25	0.1229	0.245	0.2766	0.1511	0.1133	0.0198	0.2238	0.2104	0.2886	0.3009	0.3146	0.0991
348	14.5	0.1336	0.2492	0.2672	0.1478	0.1078	0.0196	0.221	0.2242	0.2894	0.317	0.3163	0.1064
354	14.75	0.137	0.2402	0.2566	0.1342	0.1005	0.0175	0.2097	0.2168	0.283	0.3151	0.3135	0.1004
360	15	0.1235	0.2349	0.2574	0.121	0.0966	0.0152	0.1997	0.1964	0.2764	0.3159	0.3024	0.1018
372	15.5	0.1231	0.2498	0.2551	0.1149	0.0966	0.0145	0.193	0.1967	0.2765	0.316	0.3016	0.096
384	16	0.1306	0.2472	0.2426	0.1098	0.096	0.0112	0.1771	0.1959	0.2712	0.3096	0.3077	0.0901
396	16.5	0.1346	0.2663	0.2581	0.1213	0.1024	0.014	0.1757	0.2042	0.2725	0.3175	0.3136	0.0727
408	17	0.1263	0.2535	0.2462	0.1094	0.0989	0.0116	0.1612	0.1829	0.2584	0.2722	0.2874	0.0775
420	17.5	0.1254	0.2559	0.2409	0.1107	0.0947	-0.0001	0.1728	0.1768	0.2607	0.267	0.2818	0.0545
432	18	0.1199	0.2536	0.2288	0.1054	0.0933	-0.0013	0.1585	0.1662	0.2566	0.2906	0.2898	0.0608
444	18.5	0.1139	0.2551	0.2246	0.1118	0.0937	-0.0006	0.1493	0.1598	0.2911	0.2785	0.2863	0.073
456	19	0.1152	0.2535	0.2235	0.1299	0.0964	-0.0008	0.1394	0.1644	0.257	0.2851	0.2827	0.0537
468	19.5	0.1072	0.2645	0.234	0.1449	0.0962	-0.0014	0.1273	0.1638	0.2923	0.2803	0.2899	0.0665
480	20	0.112	0.261	0.232	0.1497	0.1021	-0.0011	0.1182	0.1747	0.2577	0.2893	0.2847	0.0512
492	20.5	0.1088	0.2664	0.2393	0.1511	0.1011	-0.0003	0.112	0.1783	0.2594	0.2916	0.282	0.0496
504	21	0.1069	0.2682	0.2384	0.1429	0.0982	0.0001	0.1066	0.175	0.2973	0.2837	0.283	0.0468
516	21.5	0.1012	0.2705	0.2402	0.1299	0.0974	0.0006	0.0973	0.157	0.2584	0.2649	0.2587	0.048
528	22	0.1005	0.2764	0.2411	0.1196	0.097	0.0006	0.0913	0.1547	0.2575	0.2651	0.2578	0.0482
540	22.5	0.0986	0.2837	0.2509	0.112	0.0995	0.0013	0.088	0.1615	0.254	0.2644	0.2543	0.0484
552	23	0.1005	0.2856	0.2585	0.1135	0.1002	0.0021	0.0795	0.1601	0.2535	0.268	0.2546	0.0513
564	23.5	0.1028	0.2906	0.2502	0.1133	0.1018	-0.0054	0.0768	0.1769	0.2604	0.2638	0.2511	0.0393
576	24	0.1014	0.2854	0.2616	0.1214	0.1142	0.0098	0.0729	0.172	0.2602	0.2683	0.2506	0.0406
588	24.5	0.0991	0.2864	0.2696	0.1136	0.1086	0.0097	0.0673	0.1648	0.259	0.2654	0.245	0.0414
600	25	0.0946	0.2911	0.2678	0.1002	0.0978	0.0069	0.0618	0.1465	0.2938	0.2764	0.2507	0.0577
612	25.5	0.0561	0.2915	0.2695	0.1007	0.1009	0.0069	0.0583	0.1463	0.2874	0.2744	0.2478	0.0454
624	26	0.0564	0.2904	0.2646	0.1039	0.1031	0.0088	0.0563	0.1448	0.254	0.2861	0.2512	0.0449
636	26.5	0.057	0.2864	0.2735	0.1174	0.1138	0.0154	0.0538	0.1609	0.256	0.2685	0.2399	0.036
648	27	0.0588	0.2921	0.2735	0.1161	0.1151	0.0199	0.0516	0.1479	0.2955	0.2839	0.2515	0.0407
660	27.5	0.059	0.287	0.2786	0.1231	0.1174	0.0213	0.0486	0.1505	0.2576	0.2787	0.2417	0.0337
672	28	0.0567	0.2877	0.2844	0.1214	0.1142	0.018	0.0455	0.1466	0.2894	0.285	0.2504	0.0391
684	28.5	0.0584	0.2825	0.2932	0.1258	0.1164	0.0173	0.0427	0.1565	0.2938	0.2877	0.2514	0.0378
696	29	0.0614	0.2852	0.295	0.1273	0.111	-0.0007	0.0403	0.1548	0.2947	0.2893	0.2584	0.0377
708	29.5	0.0612	0.2905	0.2917	0.1459	0.1207	0.0232	0.0494	0.1485	0.2955	0.2928	0.2492	0.0365

Changes in Conductivity (mS)
 Cycle 3: Column 4 (EXP)

Time (h)	Time (d)	Depth (in.)		2	3	4	5	6	7	8	9	10	11
		0	1										
-6	-0.25	0.0795	0.3793	0.4712	0.3918	0.3864	0.2263	0.0892	0.3226	0.3602	0.4026	0.3432	0.1451
-3	-0.125	0.1184	0.3616	0.4117	0.354	0.3651	0.2091	0.109	0.3476	0.3741	0.4297	0.3541	0.1325
0	0	0.1191	0.3706	0.4442	0.3866	0.4007	0.2237	0.098	0.3564	0.3791	0.4046	0.3476	0.145
3	0.125	0.1518	0.317	0.3784	0.3632	0.348	0.203	0.1192	0.3312	0.3609	0.3999	0.3405	0.1429
6	0.25	0.2514	0.2908	0.3413	0.3453	0.334	0.2007	0.1304	0.2674	0.3642	0.3555	0.2767	0.1348
9	0.375	0.2543	0.3542	0.4111	0.3602	0.3299	0.1889	0.0986	0.302	0.3335	0.2909	0.2713	0.1545
12	0.5	0.2334	0.3559	0.3881	0.3533	0.3456	0.1808	0.0993	0.271	0.2904	0.3077	0.2755	0.1463
18	0.75	0.2281	0.3322	0.376	0.3465	0.3268	0.17	0.0797	0.2227	0.3339	0.3014	0.2389	0.1385
24	1	0.2373	0.3202	0.3631	0.3563	0.3403	0.1739	0.0899	0.2084	0.3322	0.2854	0.2281	0.1316
30	1.25	0.2719	0.2877	0.3208	0.3163	0.3011	0.1562	0.0836	0.2506	0.3148	0.2968	0.23	0.1215
36	1.5	0.263	0.3287	0.3587	0.3497	0.3108	0.1449	0.0795	0.196	0.3193	0.2977	0.2356	0.1276
42	1.75	0.2492	0.3293	0.3509	0.3366	0.2971	0.1347	0.0771	0.1926	0.3739	0.3345	0.2507	0.1184
48	2	0.281	0.3127	0.3322	0.3171	0.2818	0.127	0.0747	0.1898	0.3213	0.2945	0.2323	0.1171
54	2.25	0.295	0.306	0.3227	0.3058	0.2745	0.1224	0.0731	0.1904	0.327	0.2975	0.2331	0.1135
60	2.5	0.306	0.2993	0.3155	0.2946	0.2694	0.1179	0.0726	0.1913	0.3285	0.2965	0.2304	0.1086
66	2.75	0.3065	0.2942	0.3073	0.2824	0.2629	0.0978	0.0983	0.1908	0.3311	0.3011	0.2364	0.106
72	3	0.2878	0.2863	0.2944	0.2651	0.25	0.0932	0.0961	0.1888	0.3334	0.3177	0.2486	0.1042
78	3.25	0.2784	0.286	0.2938	0.2609	0.252	0.0902	0.0952	0.1906	0.3457	0.3455	0.2834	0.1012
84	3.5	0.2773	0.2662	0.278	0.2721	0.2294	0.085	0.0926	0.1856	0.3542	0.3754	0.3137	0.0994
90	3.75	0.2783	0.2696	0.2783	0.2708	0.2271	0.0818	0.0912	0.185	0.3586	0.3631	0.3325	0.1058
96	4	0.2842	0.2802	0.2882	0.2799	0.2302	0.0808	0.092	0.1873	0.3771	0.4038	0.3667	0.1174
102	4.25	0.2689	0.2932	0.2941	0.2522	0.2373	0.0794	0.0918	0.1902	0.3925	0.417	0.3845	0.1184
108	4.5	0.2609	0.2916	0.2958	0.2468	0.2314	0.0791	0.0926	0.1945	0.4078	0.4503	0.4107	0.1297
114	4.75	0.2596	0.2921	0.2973	0.2458	0.226	0.0771	0.0917	0.1962	0.4175	0.4654	0.4239	0.1464
120	5	0.2767	0.287	0.2969	0.2504	0.2232	0.0765	0.0918	0.1985	0.4227	0.5165	0.4723	0.1752
126	5.25	0.2696	0.3096	0.3122	0.2772	0.23	0.0785	0.0955	0.2096	0.4634	0.5719	0.5207	0.1815
132	5.5	0.2731	0.2954	0.3007	0.2788	0.2236	0.0784	0.0957	0.2113	0.4617	0.586	0.5304	0.1988
138	5.75	0.2569	0.298	0.2978	0.2603	0.2096	0.0767	0.0933	0.2082	0.4541	0.5266	0.4704	0.1826
144	6	0.2591	0.2986	0.2962	0.2617	0.2056	0.0762	0.092	0.2108	0.4548	0.5285	0.4718	0.1937
150	6.25	0.2609	0.3043	0.2997	0.2724	0.2072	0.0759	0.0926	0.2159	0.4636	0.575	0.5174	0.2204
156	6.5	0.2605	0.2864	0.2879	0.2501	0.1948	0.0747	0.09	0.2067	0.4518	0.5195	0.4609	0.2028
162	6.75	0.2698	0.2933	0.2973	0.2709	0.2029	0.0762	0.0899	0.2151	0.4532	0.526	0.4616	0.2034
168	7	0.2599	0.3039	0.2989	0.2716	0.1997	0.0756	0.0883	0.2143	0.4518	0.5167	0.4528	0.2033
174	7.25	0.2807	0.3554	0.345	0.2939	0.197	0.0681	0.0909	0.2356	0.4967	0.6353	0.5442	0.2439
180	7.5	0.2744	0.3432	0.3415	0.3261	0.2129	0.0772	0.0899	0.2394	0.4899	0.5994	0.5219	0.2267
186	7.75	0.2683	0.3239	0.325	0.3003	0.1892	0.0762	0.0856	0.2206	0.4373	0.496	0.4278	0.1749
192	8	0.2694	0.3269	0.3108	0.282	0.1759	0.0735	0.0824	0.2186	0.4173	0.4591	0.3889	0.122
198	8.25	0.274	0.3244	0.3061	0.2723	0.1671	0.071	0.0799	0.2134	0.4066	0.4471	0.3789	0.1183
204	8.5	0.2716	0.3115	0.2944	0.2541	0.1525	0.0682	0.0774	0.2014	0.4025	0.4365	0.3758	0.106
210	8.75	0.277	0.3107	0.2883	0.2619	0.1467	0.067	0.0755	0.202	0.3938	0.4164	0.356	0.1118
216	9	0.2806	0.3249	0.2937	0.2886	0.1464	0.0669	0.0747	0.2059	0.3966	0.4171	0.3569	0.1108
222	9.25	0.2813	0.3191	0.2917	0.2933	0.1424	0.0664	0.0731	0.2039	0.3933	0.4125	0.3537	0.1092
228	9.5	0.2802	0.3182	0.2894	0.2937	0.1378	0.0659	0.0718	0.204	0.3868	0.405	0.3487	0.1081
234	9.75	0.2777	0.318	0.2872	0.2905	0.1347	0.0655	0.0705	0.2025	0.3791	0.3993	0.3453	0.107
240	10	0.2799	0.3189	0.286	0.2841	0.1312	0.0648	0.0696	0.2025	0.3763	0.4044	0.3498	0.1026
246	10.25	0.2849	0.3333	0.2923	0.2856	0.1304	0.0649	0.0696	0.2035	0.3829	0.4017	0.347	0.1003
252	10.5	0.2876	0.3342	0.2901	0.2761	0.1271	0.0652	0.0687	0.2036	0.383	0.3999	0.3437	0.0991
258	10.75	0.2866	0.3338	0.2895	0.2819	0.1242	0.0649	0.0674	0.2036	0.3789	0.3979	0.3415	0.0976
264	11	0.2839	0.3317	0.2885	0.2793	0.1208	0.0639	0.066	0.2012	0.3717	0.3978	0.3328	0.1049
270	11.25	0.2781	0.3144	0.2773	0.2635	0.1154	0.0633	0.0642	0.2482	0.3547	0.3732	0.3199	0.0934
276	11.5	0.2793	0.3201	0.2824	0.2708	0.1173	0.0638	0.0631	0.2524	0.3535	0.3734	0.3193	0.0915
282	11.75	0.2793	0.3211	0.2844	0.268	0.1147	0.0633	0.0614	0.2479	0.3529	0.3696	0.3172	0.0894
288	12	0.282	0.3236	0.2851	0.2633	0.1128	0.0625	0.0598	0.2453	0.3716	0.3718	0.3172	0.0957
294	12.25	0.281	0.3304	0.2826	0.2607	0.112	0.0641	0.0592	0.2408	0.3502	0.3679	0.3096	0.0868
300	12.5	0.2799	0.331	0.2803	0.2535	0.1115	0.0633	0.0581	0.2383	0.354	0.3675	0.3097	0.0856
306	12.75	0.2801	0.3337	0.2822	0.2525	0.1095	0.0628	0.0568	0.2368	0.3699	0.3667	0.3102	0.0904
312	13	0.2796	0.3218	0.2771	0.2746	0.13	0.0983	0.0557	0.2291	0.3677	0.3638	0.3073	0.0878
318	13.25	0.2821	0.3212	0.2727	0.2659	0.1287	0.0949	0.0553	0.2264	0.3678	0.363	0.3031	0.0878

Time (h)	Time (d)	Depth (m.)											
		0	1	2	3	4	5	6	7	8	9	10	11
324	13.5	0.278	0.3215	0.274	0.2643	0.1274	0.092	0.0544	0.2245	0.3659	0.3601	0.3023	0.0863
330	13.75	0.2828	0.3291	0.2809	0.2695	0.1257	0.0871	0.0535	0.2315	0.3702	0.363	0.3019	0.0851
336	14	0.2806	0.336	0.2784	0.2339	0.1007	0.0597	0.0524	0.2244	0.3665	0.3581	0.298	0.083
342	14.25	0.2792	0.36	0.2925	0.2435	0.1144	0.0608	0.053	0.2347	0.3645	0.3984	0.3132	0.0852
348	14.5	0.2833	0.3635	0.2991	0.2455	0.1132	0.0616	0.0523	0.245	0.3643	0.3985	0.3116	0.0835
354	14.75	0.284	0.3619	0.2976	0.2356	0.111	0.062	0.0513	0.2418	0.3582	0.397	0.3094	0.0824
360	15	0.2791	0.3525	0.291	0.2215	0.1072	0.0617	0.0501	0.2338	0.3469	0.3653	0.29	0.075
366	15.25	0.2782	0.3513	0.2897	0.2155	0.1101	0.0621	0.0492	0.2381	0.3435	0.3544	0.278	0.0745
372	15.5	0.2746	0.3474	0.2835	0.1975	0.1058	0.0614	0.0482	0.2254	0.3612	0.3506	0.2776	0.079
378	15.75	0.2769	0.3507	0.2846	0.1901	0.1059	0.0612	0.0476	0.227	0.36	0.3464	0.2718	0.0782
384	16	0.2822	0.3554	0.2856	0.1863	0.1105	0.0611	0.0471	0.2354	0.3418	0.3426	0.2611	0.0736
390	16.25	0.2795	0.3514	0.2797	0.172	0.1068	0.061	0.0465	0.2238	0.3584	0.3436	0.265	0.0784
396	16.5	0.283	0.3553	0.2829	0.1713	0.11	0.0612	0.0466	0.2328	0.3451	0.3373	0.2546	0.0719
402	16.75	0.2811	0.3517	0.2762	0.1575	0.1068	0.0607	0.0456	0.2218	0.3564	0.337	0.2552	0.0767
408	17	0.2841	0.3546	0.2747	0.1503	0.1071	0.0605	0.0454	0.2212	0.3588	0.3664	0.2697	0.0845
414	17.25	0.2834	0.3533	0.2732	0.143	0.1091	0.0615	0.0457	0.2192	0.3603	0.3687	0.2706	0.0828
420	17.5	0.2834	0.3569	0.2802	0.1439	0.1126	0.0624	0.0457	0.2263	0.3456	0.332	0.244	0.0697
426	17.75	0.2815	0.354	0.2756	0.1361	0.114	0.0617	0.0449	0.2214	0.3614	0.3397	0.2526	0.073
432	18	0.2815	0.3523	0.2711	0.1295	0.1106	0.0611	0.0444	0.2164	0.3588	0.361	0.2613	0.0783
438	18.25	0.285	0.3575	0.2755	0.1293	0.112	0.0617	0.045	0.221	0.3686	0.342	0.2502	0.0706
444	18.5	0.2863	0.3616	0.2801	0.1294	0.1133	0.0621	0.0445	0.2245	0.3656	0.3422	0.2503	0.0705
450	18.75	0.284	0.3594	0.2791	0.1262	0.1126	0.0621	0.0435	0.2243	0.3648	0.341	0.2503	0.069
456	19	0.2854	0.359	0.2757	0.1227	0.1117	0.0619	0.0432	0.2212	0.3641	0.3387	0.2463	0.0687
462	19.25	0.2869	0.3612	0.2734	0.1198	0.1122	0.0622	0.0432	0.2182	0.3675	0.3435	0.2472	0.0685
468	19.5	0.2824	0.3581	0.2702	0.116	0.0977	0.1089	0.0427	0.2123	0.3603	0.3598	0.2536	0.0735
474	19.75	0.2874	0.3657	0.2777	0.1201	0.1117	0.0618	0.0422	0.2223	0.3682	0.3685	0.2589	0.0724
480	20	0.2855	0.3625	0.2699	0.114	0.0978	0.1024	0.0416	0.2133	0.3618	0.3613	0.2497	0.0712
486	20.25	0.2717	0.3626	0.2635	0.1186	0.1122	0.0606	0.0418	0.2106	0.3645	0.3669	0.2508	0.071
492	20.5	0.2698	0.3629	0.2635	0.1215	0.1124	0.0638	0.0417	0.2098	0.3625	0.3657	0.2504	0.0699
498	20.75	0.2728	0.3805	0.2766	0.1242	0.1177	0.0589	0.0418	0.2182	0.3662	0.3669	0.2583	0.0696
504	21	0.2765	0.3649	0.257	0.1235	0.1128	0.0664	0.0415	0.2068	0.3635	0.3366	0.2277	0.0634
510	21.25	0.2782	0.3963	0.2617	0.146	0.1261	0.0626	0.0425	0.2257	0.3468	0.3264	0.2234	0.062
516	21.5	0.2804	0.3919	0.261	0.1409	0.1247	0.0639	0.0417	0.2119	0.3402	0.3416	0.2302	0.0662
522	21.75	0.275	0.39	0.2794	0.1484	0.1306	0.0656	0.0411	0.2276	0.3362	0.3395	0.2299	0.0648
528	22	0.2724	0.3853	0.2929	0.1459	0.1304	0.0648	0.0406	0.2238	0.3393	0.3414	0.2327	0.0651
534	22.25	0.2746	0.3857	0.3129	0.1448	0.1298	0.0649	0.0401	0.2199	0.3682	0.3651	0.2509	0.0686
540	22.5	0.2785	0.3841	0.3264	0.1464	0.1317	0.0649	0.0273	0.2221	0.3679	0.3659	0.2521	0.0685
546	22.75	0.2772	0.3807	0.3358	0.1451	0.1327	0.0654	0.0207	0.2157	0.3663	0.3636	0.2496	0.0677
552	23	0.2778	0.3705	0.3218	0.1499	0.1382	0.0746	0.0206	0.2091	0.3675	0.365	0.2397	0.0666
558	23.25	0.2822	0.3684	0.3249	0.1555	0.1421	0.075	0.0166	0.2135	0.3685	0.3279	0.2274	0.0613
564	23.5	0.281	0.3693	0.3204	0.1474	0.1391	0.0739	0.0166	0.2063	0.3663	0.3671	0.2405	0.0649
570	23.75	0.2835	0.3803	0.3356	0.1402	0.1214	0.0735	0.0164	0.2112	0.3651	0.3683	0.25	0.0632
576	24	0.2834	0.3805	0.3307	0.1379	0.1204	0.0727	0.0138	0.2052	0.3636	0.3656	0.2473	0.0636
582	24.25	0.2849	0.3687	0.3182	0.1437	0.141	0.0715	0.0138	0.199	0.3638	0.3666	0.2393	0.0642
588	24.5	0.2728	0.365	0.3243	0.146	0.1482	0.0701	0.0137	0.1988	0.3608	0.328	0.2264	0.0583
594	24.75	0.2779	0.3676	0.3335	0.1526	0.1505	0.0698	0.0137	0.207	0.3654	0.3328	0.2318	0.0586
600	25	0.2759	0.3791	0.3389	0.1354	0.1243	0.0688	0.0138	0.2028	0.3615	0.3641	0.2478	0.0611
606	25.25	0.2849	0.3811	0.3459	0.1396	0.1282	0.0673	0.0139	0.2065	0.366	0.3679	0.2501	0.0618
612	25.5	0.267	0.3802	0.3555	0.143	0.1309	0.0669	0.0138	0.2102	0.3647	0.3702	0.2529	0.0607
618	25.75	0.2722	0.3671	0.3263	0.153	0.1558	0.0659	0.0137	0.2106	0.3633	0.3281	0.2317	0.0565
624	26	0.2687	0.3791	0.3263	0.1343	0.1254	0.0657	0.0137	0.2069	0.3584	0.3646	0.2483	0.0592
630	26.25	0.2716	0.3703	0.317	0.1394	0.1282	0.1017	0.0139	0.1983	0.3598	0.3679	0.2399	0.0588
636	26.5	0.2704	0.3708	0.3271	0.1459	0.1541	0.0649	0.0139	0.2045	0.3598	0.3679	0.2432	0.0583
642	26.75	0.2678	0.3792	0.3309	0.1308	0.1127	0.0976	0.0137	0.2025	0.3522	0.3607	0.2448	0.0571
648	27	0.2703	0.3807	0.3202	0.1155	0.1304	0.0931	0.0117	0.201	0.353	0.3649	0.2434	0.0574
654	27.25	0.2741	0.3679	0.3198	0.1393	0.1276	0.088	0.0118	0.1955	0.3529	0.3296	0.2299	0.0534
660	27.5	0.2723	0.3685	0.3228	0.1335	0.1247	0.0853	0.0136	0.1934	0.3482	0.3611	0.2354	0.0552
666	27.75	0.2718	0.3675	0.3152	0.1295	0.1228	0.0832	0.0117	0.1857	0.3428	0.3579	0.233	0.0542
672	28	0.2765	0.3703	0.3145	0.1297	0.122	0.0818	0.0117	0.1888	0.3445	0.3607	0.2356	0.0538

Changes in Conductivity (mS)
Cycle 3: Column 5 (CTL)

Time (h)	Time (d)	Depth (in.)	0	1	2	3	4	5	6	7	8	9	10	11
-6	-0.25	0.08	0.0793	0.0769	0.0783	0.077	0.0764	0.0752	0.0743	0.0743	0.0738	0.0731	0.0731	0.007
-3	-0.125	0.0795	0.0788	0.0764	0.0778	0.0765	0.0759	0.0746	0.0738	0.0738	0.0734	0.0726	0.0726	0.0165
0	0	0.0795	0.0789	0.0766	0.078	0.0766	0.0761	0.0749	0.074	0.0741	0.0737	0.0729	0.0729	0.0135
3	0.125	0.0821	0.082	0.0799	0.0817	0.0805	0.0802	0.0791	0.0783	0.0786	0.0783	0.0775	0.0775	0.0227
6	0.25	0.0824	0.0823	0.0804	0.0822	0.0811	0.0808	0.0798	0.079	0.0792	0.0789	0.0782	0.0782	0.0226
9	0.375	0.0826	0.0823	0.0805	0.0824	0.0812	0.081	0.08	0.0791	0.0794	0.0789	0.0783	0.0783	0.0224
12	0.5	0.0826	0.0822	0.0804	0.0822	0.0811	0.0808	0.0798	0.0789	0.0792	0.0788	0.0781	0.0781	0.0223
18	0.75	0.0889	0.0885	0.0862	0.0879	0.0867	0.0863	0.0853	0.0842	0.0844	0.084	0.0832	0.0832	0.0133
24	1	0.0886	0.0882	0.0858	0.0875	0.0863	0.0859	0.0848	0.0838	0.084	0.0836	0.0828	0.0828	0.0132
30	1.25	0.082	0.0818	0.0797	0.0812	0.0802	0.0799	0.0789	0.078	0.0783	0.0779	0.0772	0.0772	0.0222
36	1.5	0.089	0.0886	0.0863	0.0881	0.0869	0.0866	0.0855	0.0845	0.0847	0.0843	0.0835	0.0835	0.0133
42	1.75	0.0822	0.082	0.08	0.0816	0.0807	0.0804	0.0795	0.0786	0.0788	0.0785	0.0778	0.0778	0.0222
48	2	0.089	0.0886	0.0862	0.088	0.0869	0.0865	0.0855	0.0844	0.0847	0.0843	0.0835	0.0835	0.0133
54	2.25	0.0891	0.0887	0.0864	0.0881	0.087	0.0866	0.0856	0.0846	0.0848	0.0844	0.0837	0.0837	0.0133
60	2.5	0.0892	0.0887	0.0863	0.088	0.0869	0.0865	0.0855	0.0844	0.0847	0.0843	0.0835	0.0835	0.0133
66	2.75	0.0889	0.0884	0.0859	0.0876	0.0864	0.0861	0.085	0.084	0.0842	0.0838	0.083	0.083	0.0113
72	3	0.0891	0.0885	0.086	0.0878	0.0866	0.0862	0.0852	0.0841	0.0844	0.084	0.0832	0.0832	0.0065
78	3.25	0.0894	0.0888	0.0864	0.0879	0.0869	0.0865	0.0854	0.0844	0.0846	0.0843	0.0835	0.0835	0.0072
84	3.5	0.0895	0.0889	0.0864	0.0881	0.0869	0.0866	0.0855	0.0845	0.0847	0.0844	0.0836	0.0836	0.0065
90	3.75	0.0979	0.0969	0.0938	0.0957	0.0942	0.0937	0.0925	0.0914	0.0915	0.0911	0.0902	0.0902	0.0058
96	4	0.0967	0.0958	0.0928	0.106	0.0932	0.0927	0.0915	0.0904	0.0906	0.0902	0.0894	0.0894	0.0094
102	4.25	0.0967	0.0958	0.0927	0.0949	0.0931	0.0926	0.0915	0.0904	0.0905	0.0901	0.0893	0.0893	0.0108
108	4.5	0.1077	0.1062	0.1026	0.0922	0.103	0.1024	0.1012	0.1	0.1001	0.0996	0.0987	0.0987	0.0061
114	4.75	0.1074	0.1058	0.1021	0.0918	0.1025	0.1019	0.1007	0.0995	0.0996	0.0991	0.0982	0.0982	0.0066
120	5	0.1231	0.1209	0.1162	0.1191	0.1167	0.1161	0.1147	0.1133	0.1134	0.1128	0.1118	0.1118	0.0079
126	5.25	0.1402	0.1375	0.1321	0.1628	0.1331	0.1327	0.1314	0.1299	0.1301	0.1295	0.1285	0.1285	0.0064
132	5.5	0.142	0.139	0.1332	0.1645	0.1341	0.1337	0.1323	0.1307	0.1308	0.1301	0.1291	0.1291	0.007
138	5.75	0.1215	0.1194	0.1147	0.1373	0.1152	0.1147	0.1134	0.112	0.1121	0.1115	0.1105	0.1105	0.0059
144	6	0.1212	0.119	0.1143	0.1369	0.1149	0.1143	0.113	0.1117	0.1118	0.1112	0.1102	0.1102	0.0065
150	6.25	0.1411	0.1382	0.1324	0.1631	0.1334	0.1329	0.1315	0.13	0.1302	0.1295	0.1284	0.1284	0.0054
156	6.5	0.1215	0.1194	0.1146	0.1174	0.1151	0.1145	0.1132	0.1119	0.112	0.1114	0.1104	0.1104	0.0055
162	6.75	0.1216	0.1194	0.1146	0.1372	0.1151	0.1145	0.1133	0.1119	0.112	0.1114	0.1104	0.1104	0.0055
168	7	0.1215	0.1194	0.1146	0.1173	0.115	0.1144	0.1132	0.1118	0.1119	0.1113	0.1103	0.1103	0.0059
174	7.25	0.1704	0.1659	0.1584	0.134	0.1599	0.1595	0.1581	0.1563	0.1565	0.1556	0.1544	0.1544	0.0053
180	7.5	0.1703	0.1657	0.1581	0.1339	0.1597	0.1593	0.1579	0.156	0.1562	0.1553	0.1541	0.1541	0.0053
186	7.75	0.1228	0.1205	0.1156	0.1182	0.1158	0.1151	0.1139	0.1125	0.1126	0.112	0.1109	0.1109	0.0055
192	8	0.0886	0.0877	0.0846	0.086	0.0847	0.084	0.0828	0.082	0.0821	0.0817	0.0808	0.0808	0.0161
198	8.25	0.0884	0.0876	0.0844	0.0859	0.0845	0.0838	0.0826	0.0818	0.0819	0.0815	0.0806	0.0806	0.0132
204	8.5	0.0816	0.081	0.0782	0.0795	0.0784	0.0778	0.0768	0.076	0.0761	0.0757	0.0749	0.0749	0.009
210	8.75	0.0811	0.0805	0.0777	0.0791	0.0779	0.0773	0.0763	0.0755	0.0756	0.0752	0.0744	0.0744	0.022
216	9	0.081	0.0804	0.0777	0.0791	0.078	0.0774	0.0763	0.0755	0.0756	0.0753	0.0745	0.0745	0.0102
222	9.25	0.0809	0.0803	0.0775	0.0789	0.0778	0.0772	0.0761	0.0753	0.0755	0.0751	0.0743	0.0743	0.0219
228	9.5	0.0809	0.0802	0.0775	0.0789	0.0777	0.0771	0.0761	0.0753	0.0754	0.0751	0.0743	0.0743	0.0219
234	9.75	0.0808	0.0801	0.0774	0.0787	0.0776	0.077	0.076	0.0752	0.0753	0.0749	0.0741	0.0741	0.0219
240	10	0.0754	0.0746	0.072	0.0733	0.0723	0.0718	0.0708	0.0702	0.0705	0.0702	0.0695	0.0695	0.0341
246	10.25	0.0755	0.0747	0.0721	0.0734	0.0724	0.0719	0.0709	0.0703	0.0706	0.0703	0.0696	0.0696	0.0341
252	10.5	0.0754	0.0746	0.0719	0.0732	0.0722	0.0717	0.0707	0.0701	0.0704	0.0702	0.0694	0.0694	0.0341
258	10.75	0.0753	0.0744	0.0718	0.073	0.072	0.0715	0.0706	0.07	0.0702	0.07	0.0692	0.0692	0.0341
264	11	0.0751	0.0743	0.0716	0.0729	0.0719	0.0714	0.0704	0.0698	0.0701	0.0698	0.0691	0.0691	0.0341
270	11.25	0.0753	0.0744	0.0717	0.073	0.072	0.0715	0.0705	0.0699	0.0702	0.0699	0.0692	0.0692	0.0339
276	11.5	0.075	0.074	0.0714	0.0726	0.0716	0.0711	0.0701	0.0695	0.0698	0.0695	0.0688	0.0688	0.0233
282	11.75	0.0747	0.0738	0.0711	0.0723	0.0713	0.0707	0.0697	0.0691	0.0694	0.0691	0.0684	0.0684	0.0177
288	12	0.0744	0.0735	0.0708	0.072	0.0709	0.0704	0.0694	0.0688	0.069	0.0688	0.068	0.068	0.0339
294	12.25	0.0746	0.0737	0.071	0.0722	0.0712	0.0706	0.0697	0.0691	0.0693	0.0691	0.0683	0.0683	0.0341
300	12.5	0.0745	0.0736	0.0709	0.0721	0.0711	0.0705	0.0695	0.0689	0.0691	0.0689	0.0681	0.0681	0.0232
306	12.75	0.0743	0.0733	0.0706	0.0718	0.0708	0.0702	0.0692	0.0686	0.0688	0.0686	0.0678	0.0678	0.0232
312	13	0.0743	0.0733	0.0706	0.0717	0.0707	0.0701	0.0692	0.0685	0.0687	0.0685	0.0677	0.0677	0.0143
318	13.25	0.0743	0.0734	0.0707	0.0718	0.0708	0.0703	0.0693	0.0687	0.0689	0.0686	0.0679	0.0679	0.0233

Time (h)	Time (d)	Depth (in.)		2	3	4	5	6	7	8	9	10	11
		0	1										
324	13.5	0.0743	0.0733	0.0706	0.0717	0.0707	0.0701	0.0692	0.0685	0.0687	0.0685	0.0678	0.0143
330	13.75	0.074	0.073	0.0703	0.0714	0.0704	0.0698	0.0688	0.0682	0.0684	0.0681	0.0674	0.034
336	14	0.0741	0.0731	0.0704	0.0714	0.0705	0.0698	0.0688	0.0682	0.0684	0.0681	0.0674	0.0176
342	14.25	0.0745	0.0735	0.0708	0.0718	0.0709	0.0703	0.0693	0.0687	0.0689	0.0686	0.0679	0.012
348	14.5	0.0741	0.0731	0.0704	0.0715	0.0705	0.0699	0.069	0.0693	0.0696	0.0683	0.0676	0.0176
354	14.75	0.074	0.073	0.0703	0.0714	0.0704	0.0698	0.0688	0.0682	0.0684	0.0681	0.0674	0.0176
360	15	0.0739	0.0729	0.0702	0.0713	0.0703	0.0697	0.0687	0.0681	0.0682	0.068	0.0672	0.0142
366	15.25	0.0737	0.0727	0.07	0.071	0.07	0.0694	0.0684	0.0678	0.068	0.0677	0.067	0.0175
372	15.5	0.0738	0.0728	0.07	0.071	0.0701	0.0695	0.0685	0.0679	0.068	0.0677	0.067	0.0119
378	15.75	0.0737	0.0727	0.0699	0.0709	0.07	0.0694	0.0684	0.0678	0.0679	0.0676	0.0669	0.0119
384	16	0.0734	0.0724	0.0696	0.0707	0.0697	0.0691	0.0681	0.0675	0.0677	0.0674	0.0667	0.023
390	16.25	0.0736	0.0726	0.0698	0.0708	0.0699	0.0692	0.0682	0.0677	0.0678	0.0675	0.0668	0.0141
396	16.5	0.0734	0.0724	0.0697	0.0708	0.0698	0.0691	0.0681	0.0675	0.0677	0.0674	0.0667	0.0231
402	16.75	0.0735	0.0725	0.0697	0.0707	0.0698	0.0691	0.0681	0.0675	0.0677	0.0674	0.0667	0.0175
408	17	0.0735	0.0725	0.0697	0.0708	0.0699	0.0692	0.0682	0.0676	0.0678	0.0675	0.0668	0.0232
414	17.25	0.0739	0.0729	0.0702	0.0713	0.0703	0.0697	0.0687	0.0681	0.0683	0.068	0.0673	0.0341
420	17.5	0.0738	0.0727	0.07	0.0711	0.0701	0.0695	0.0685	0.0679	0.0681	0.0678	0.0671	0.0231
426	17.75	0.0736	0.0726	0.0698	0.0709	0.0699	0.0693	0.0683	0.0677	0.0679	0.0676	0.0669	0.0339
432	18	0.0736	0.0726	0.0699	0.0709	0.07	0.0693	0.0683	0.0677	0.0679	0.0676	0.0669	0.0341
438	18.25	0.0739	0.0729	0.0702	0.0713	0.0703	0.0697	0.0687	0.0681	0.0683	0.068	0.0673	0.034
444	18.5	0.0737	0.0727	0.0699	0.071	0.07	0.0694	0.0684	0.0678	0.068	0.0677	0.067	0.0231
450	18.75	0.0735	0.0724	0.0697	0.0708	0.0698	0.0691	0.0681	0.0675	0.0677	0.0675	0.0667	0.0231
456	19	0.0734	0.0723	0.0696	0.0707	0.0697	0.069	0.068	0.0674	0.0676	0.0673	0.0666	0.0339
462	19.25	0.0737	0.0726	0.0699	0.071	0.07	0.0693	0.0683	0.0678	0.0679	0.0677	0.0669	0.0231
468	19.5	0.0736	0.0725	0.0698	0.0708	0.0699	0.0692	0.0682	0.0676	0.0678	0.0675	0.0668	0.0176
474	19.75	0.0732	0.0722	0.0695	0.0705	0.0695	0.0689	0.0679	0.0673	0.0674	0.0672	0.0664	0.0339
480	20	0.0732	0.0721	0.0694	0.0704	0.0695	0.0688	0.0678	0.0672	0.0673	0.0671	0.0664	0.034
486	20.25	0.0735	0.0724	0.0697	0.0707	0.0698	0.0691	0.0681	0.0675	0.0677	0.0674	0.0667	0.0232
492	20.5	0.0733	0.0723	0.0695	0.0705	0.0696	0.0689	0.0679	0.0673	0.0675	0.0672	0.0665	0.0175
498	20.75	0.0728	0.0719	0.0692	0.0703	0.0693	0.0686	0.0677	0.067	0.0671	0.0669	0.0662	0.0339
504	21	0.0733	0.0722	0.0695	0.0705	0.0695	0.0689	0.0679	0.0673	0.0674	0.0671	0.0664	0.0231
510	21.25	0.0734	0.0723	0.0696	0.0706	0.0696	0.069	0.0679	0.0674	0.0675	0.0673	0.0665	0.0231
516	21.5	0.0734	0.0724	0.0696	0.0705	0.0696	0.069	0.068	0.0673	0.0674	0.0672	0.0664	0.0118
522	21.75	0.073	0.0719	0.0692	0.0702	0.0692	0.0685	0.0675	0.0669	0.0671	0.0668	0.0661	0.0339
528	22	0.0729	0.0719	0.0691	0.0701	0.0691	0.0685	0.0675	0.0669	0.067	0.0667	0.066	0.0174
534	22.25	0.0726	0.0717	0.069	0.07	0.069	0.0684	0.0674	0.0668	0.0668	0.0666	0.0659	0.0174
540	22.5	0.0725	0.0716	0.0689	0.0699	0.0689	0.0683	0.0673	0.0667	0.0668	0.0666	0.0658	0.0338
546	22.75	0.0726	0.0717	0.069	0.07	0.069	0.0683	0.0674	0.0667	0.0668	0.0666	0.0658	0.0174
552	23	0.073	0.0719	0.0691	0.0701	0.0692	0.0685	0.0674	0.0668	0.067	0.0667	0.0659	0.0118
558	23.25	0.0729	0.0718	0.069	0.07	0.069	0.0683	0.0673	0.0667	0.0669	0.0666	0.0658	0.0229
564	23.5	0.073	0.0719	0.0691	0.0701	0.0691	0.0685	0.0674	0.0668	0.067	0.0667	0.0659	0.0141
570	23.75	0.0729	0.0718	0.069	0.07	0.0691	0.0684	0.0674	0.0667	0.0669	0.0666	0.0659	0.0338
576	24	0.0731	0.0719	0.0691	0.0701	0.0691	0.0685	0.0675	0.0668	0.067	0.0667	0.0659	0.0338
582	24.25	0.0733	0.0722	0.0693	0.0704	0.0694	0.0688	0.0678	0.0672	0.0673	0.067	0.0663	0.034
588	24.5	0.0733	0.0722	0.0693	0.0704	0.0694	0.0688	0.0678	0.0672	0.0673	0.067	0.0662	0.0231
594	24.75	0.0732	0.072	0.0692	0.0702	0.0693	0.0686	0.0676	0.067	0.0671	0.0669	0.0661	0.0338
600	25	0.0732	0.0721	0.0692	0.0703	0.0693	0.0686	0.0677	0.067	0.0672	0.0669	0.0661	0.0339
606	25.25	0.0734	0.0723	0.0695	0.0705	0.0695	0.0689	0.0679	0.0673	0.0675	0.0672	0.0664	0.0339
612	25.5	0.0733	0.0721	0.0692	0.0703	0.0693	0.0687	0.0677	0.067	0.0672	0.067	0.0662	0.0339
618	25.75	0.0731	0.072	0.0691	0.0701	0.0691	0.0685	0.0675	0.0669	0.067	0.0667	0.066	0.0174
624	26	0.073	0.0718	0.0689	0.07	0.069	0.0683	0.0674	0.0667	0.0669	0.0666	0.0658	0.023
630	26.25	0.0732	0.0721	0.0692	0.0703	0.0693	0.0687	0.0676	0.067	0.0672	0.0669	0.0661	0.0175
636	26.5	0.073	0.0719	0.069	0.07	0.069	0.0684	0.0674	0.0668	0.0669	0.0666	0.0659	0.0174
642	26.75	0.0728	0.0717	0.0688	0.0698	0.0688	0.0681	0.0672	0.0665	0.0667	0.0664	0.0656	0.0229
648	27	0.0728	0.0716	0.0687	0.0698	0.0688	0.0681	0.0671	0.0665	0.0666	0.0663	0.0655	0.0338
654	27.25	0.073	0.0718	0.0689	0.07	0.069	0.0683	0.0673	0.0667	0.0668	0.0665	0.0657	0.0338
660	27.5	0.0728	0.0717	0.0688	0.0698	0.0688	0.0682	0.0672	0.0665	0.0667	0.0664	0.0656	0.0174
666	27.75	0.0729	0.0717	0.0688	0.0698	0.0688	0.0681	0.0671	0.0665	0.0666	0.0663	0.0655	0.014
672	28	0.0727	0.0716	0.0686	0.0697	0.0687	0.068	0.067	0.0664	0.0665	0.0662	0.0654	0.023

Changes in Conductivity (mS)
 Cycle 3: Column 4 - Column 5: (EXP-CTL)

Time (h)	Time (d)	Depth (m.)											
		0	1	2	3	4	5	6	7	8	9	10	11
-6	-0.25	-0.0005	0.3	0.3943	0.3135	0.3094	0.1499	0.014	0.2483	0.2859	0.3288	0.2701	0.1381
-3	-0.125	0.0389	0.2828	0.3353	0.2762	0.2886	0.1332	0.0344	0.2738	0.3003	0.3563	0.2815	0.116
0	0	0.0396	0.2917	0.3676	0.3086	0.3241	0.1476	0.0231	0.2824	0.305	0.3309	0.2747	0.1315
3	0.125	0.0697	0.235	0.2985	0.2815	0.2675	0.1228	0.0401	0.2529	0.2823	0.3216	0.263	0.1202
6	0.25	0.169	0.2085	0.2609	0.2631	0.2529	0.1199	0.0506	0.1884	0.285	0.2766	0.1985	0.1122
9	0.375	0.1717	0.2719	0.3306	0.2778	0.2487	0.1079	0.0186	0.2229	0.2541	0.212	0.193	0.1321
12	0.5	0.1508	0.2737	0.3077	0.2711	0.2645	0.1	0.0195	0.1921	0.2112	0.2289	0.1974	0.124
18	0.75	0.1392	0.2437	0.2898	0.2586	0.2401	0.0837	-0.0056	0.1385	0.2495	0.2174	0.1557	0.1252
24	1	0.1487	0.232	0.2773	0.2688	0.254	0.088	0.0051	0.1246	0.2482	0.2018	0.1453	0.1184
30	1.25	0.1899	0.2059	0.2411	0.2351	0.2209	0.0763	0.0047	0.1726	0.2365	0.2189	0.1528	0.0993
36	1.5	0.174	0.2401	0.2724	0.2616	0.2239	0.0583	-0.006	0.1115	0.2346	0.2134	0.1521	0.1143
42	1.75	0.167	0.2473	0.2709	0.255	0.2164	0.0543	-0.0024	0.114	0.2951	0.256	0.1729	0.0962
48	2	0.192	0.2241	0.246	0.2291	0.1949	0.0405	-0.0108	0.1054	0.2366	0.2102	0.1488	0.1038
54	2.25	0.2059	0.2173	0.2363	0.2177	0.1875	0.0358	-0.0125	0.1058	0.2422	0.2131	0.1494	0.1002
60	2.5	0.2168	0.2106	0.2292	0.2066	0.1825	0.0314	-0.0129	0.1069	0.2438	0.2122	0.1469	0.0953
66	2.75	0.2176	0.2058	0.2214	0.1948	0.1765	0.0117	0.0133	0.1068	0.2469	0.2173	0.1534	0.0947
72	3	0.1987	0.1978	0.2084	0.1773	0.1634	0.007	0.0109	0.1047	0.249	0.2337	0.1654	0.0977
78	3.25	0.189	0.1972	0.2074	0.173	0.1651	0.0037	0.0098	0.1062	0.2611	0.2612	0.1999	0.094
84	3.5	0.1878	0.1773	0.1916	0.184	0.1425	-0.0016	0.0071	0.1011	0.2695	0.291	0.2301	0.0929
90	3.75	0.1804	0.1727	0.1845	0.1751	0.1329	-0.0119	-0.0013	0.0936	0.2671	0.272	0.2423	0.1
96	4	0.1875	0.1844	0.1954	0.1739	0.137	-0.0119	0.0005	0.0969	0.2865	0.3136	0.2773	0.108
102	4.25	0.1722	0.1974	0.2014	0.1573	0.1442	-0.0132	0.0003	0.0998	0.302	0.3269	0.2952	0.1076
108	4.5	0.1532	0.1854	0.1932	0.1546	0.1284	-0.0233	-0.0086	0.0945	0.3077	0.3507	0.312	0.1236
114	4.75	0.1522	0.1863	0.1952	0.154	0.1235	-0.0248	-0.009	0.0967	0.3179	0.3663	0.3257	0.1398
120	5	0.1536	0.1661	0.1807	0.1313	0.1065	-0.0396	-0.0229	0.0852	0.3093	0.4037	0.3605	0.1673
126	5.25	0.1294	0.1721	0.1801	0.1144	0.0969	-0.0542	-0.0359	0.0797	0.3333	0.4424	0.3922	0.1751
132	5.5	0.1311	0.1564	0.1675	0.1143	0.0895	-0.0553	-0.0366	0.0806	0.3309	0.4559	0.4013	0.1918
138	5.75	0.1354	0.1786	0.1831	0.123	0.0944	-0.038	-0.0201	0.0962	0.342	0.4151	0.3599	0.1767
144	6	0.1379	0.1796	0.1819	0.1248	0.0907	-0.0381	-0.021	0.0991	0.343	0.4173	0.3616	0.1872
150	6.25	0.1198	0.1661	0.1673	0.1093	0.0738	-0.057	-0.0389	0.0859	0.3334	0.4455	0.389	0.215
156	6.5	0.139	0.167	0.1733	0.1327	0.0797	-0.0398	-0.0232	0.0948	0.3398	0.4081	0.3505	0.1973
162	6.75	0.1482	0.1739	0.1827	0.1337	0.0878	-0.0383	-0.0234	0.1032	0.3412	0.4146	0.3512	0.1979
168	7	0.1384	0.1845	0.1843	0.1543	0.0847	-0.0388	-0.0249	0.1025	0.3399	0.4054	0.3425	0.1974
174	7.25	0.1103	0.1895	0.1866	0.1599	0.0371	-0.0914	-0.0672	0.0793	0.3402	0.4797	0.3898	0.2386
180	7.5	0.1041	0.1775	0.1834	0.1922	0.0532	-0.0821	-0.068	0.0834	0.3337	0.4441	0.3678	0.2214
186	7.75	0.1455	0.2034	0.2094	0.1821	0.0734	-0.0389	-0.0283	0.1081	0.3247	0.384	0.3169	0.1694
192	8	0.1808	0.2392	0.2262	0.196	0.0912	-0.0105	-0.0004	0.1366	0.3352	0.3774	0.3081	0.1059
198	8.25	0.1856	0.2368	0.2217	0.1864	0.0826	-0.0128	-0.0027	0.1316	0.3247	0.3656	0.2983	0.1051
204	8.5	0.19	0.2305	0.2162	0.1746	0.0741	-0.0096	0.0006	0.1254	0.3264	0.3608	0.3009	0.097
210	8.75	0.1959	0.2302	0.2106	0.1828	0.0688	-0.0103	-0.0008	0.1265	0.3182	0.3412	0.2816	0.0898
216	9	0.1996	0.2445	0.216	0.2095	0.0684	-0.0105	-0.0016	0.1304	0.321	0.3418	0.2824	0.1006
222	9.25	0.2004	0.2388	0.2142	0.2144	0.0646	-0.0108	-0.003	0.1286	0.3178	0.3374	0.2794	0.0873
228	9.5	0.1993	0.238	0.2119	0.2148	0.0601	-0.0112	-0.0043	0.1287	0.3114	0.3299	0.2744	0.0862
234	9.75	0.1969	0.2379	0.2098	0.2118	0.0571	-0.0115	-0.0055	0.1273	0.3038	0.3244	0.2712	0.0851
240	10	0.2045	0.2443	0.214	0.2108	0.0579	-0.0075	-0.0022	0.1323	0.3058	0.3342	0.2803	0.0685
246	10.25	0.2094	0.2586	0.2202	0.2122	0.058	-0.007	-0.0013	0.1332	0.3123	0.3314	0.2774	0.0662
252	10.5	0.2122	0.2596	0.2182	0.2029	0.0549	-0.0065	-0.002	0.1335	0.3126	0.3297	0.2743	0.065
258	10.75	0.2113	0.2594	0.2177	0.2089	0.0522	-0.0066	-0.0032	0.1336	0.3087	0.3279	0.2723	0.0635
264	11	0.2088	0.2574	0.2169	0.2064	0.0489	-0.0075	-0.0044	0.1314	0.3016	0.328	0.2637	0.0708
270	11.25	0.2028	0.24	0.2056	0.1905	0.0434	-0.0082	-0.0063	0.1783	0.2845	0.3033	0.2507	0.0595
276	11.5	0.2043	0.2461	0.211	0.1982	0.0457	-0.0073	-0.007	0.1829	0.2837	0.3039	0.2505	0.0682
282	11.75	0.2046	0.2473	0.2133	0.1957	0.0434	-0.0074	-0.0083	0.1788	0.2835	0.3005	0.2488	0.0717
288	12	0.2076	0.2501	0.2143	0.1913	0.0419	-0.0079	-0.0096	0.1765	0.3026	0.303	0.2492	0.0618
294	12.25	0.2064	0.2567	0.2116	0.1885	0.0408	-0.0065	-0.0105	0.1717	0.2809	0.2988	0.2413	0.0527
300	12.5	0.2054	0.2574	0.2094	0.1824	0.041	-0.0062	-0.0108	0.1692	0.2851	0.2994	0.2416	0.0624
306	12.75	0.2058	0.2604	0.2116	0.1807	0.0387	-0.0064	-0.0118	0.168	0.3013	0.2989	0.2424	0.0672
312	13	0.2053	0.2485	0.2065	0.2029	0.0593	0.0282	-0.0135	0.1606	0.299	0.2953	0.2396	0.0735

Time (h)	Time (d)	Depth (m.)		2	3	4	5	6	7	8	9	10	11
		0	1										
318	13.25	0.2078	0.2478	0.202	0.1941	0.0579	0.0246	-0.014	0.1577	0.2989	0.2944	0.2352	0.0645
324	13.5	0.2037	0.2482	0.2034	0.1926	0.0567	0.0219	-0.0148	0.156	0.2972	0.2916	0.2345	0.072
330	13.75	0.2088	0.2561	0.2106	0.1981	0.0553	0.0173	-0.0153	0.1633	0.3018	0.2949	0.2345	0.0511
336	14	0.2065	0.2629	0.208	0.1625	0.0302	-0.0101	-0.0164	0.1562	0.2981	0.29	0.2306	0.0654
342	14.25	0.2047	0.2865	0.2217	0.1717	0.0435	-0.0095	-0.0163	0.166	0.2956	0.3298	0.2453	0.0732
348	14.5	0.2092	0.2904	0.2287	0.174	0.0427	-0.0083	-0.0167	0.1757	0.2947	0.3302	0.244	0.0659
354	14.75	0.21	0.2889	0.2273	0.1642	0.0406	-0.0078	-0.0175	0.1736	0.2898	0.3289	0.242	0.0648
360	15	0.2052	0.2796	0.2208	0.1502	0.0369	-0.008	-0.0186	0.1657	0.2787	0.2973	0.2228	0.0608
366	15.25	0.2045	0.2786	0.2197	0.1445	0.0401	-0.0073	-0.0192	0.1703	0.2755	0.2867	0.211	0.057
372	15.5	0.2008	0.2746	0.2135	0.1265	0.0357	-0.0081	-0.0203	0.1575	0.2932	0.2829	0.2106	0.0671
378	15.75	0.2032	0.278	0.2147	0.1192	0.0359	-0.0082	-0.0208	0.1592	0.2921	0.2788	0.2049	0.0663
384	16	0.2088	0.283	0.216	0.1156	0.0408	-0.008	-0.021	0.1679	0.2741	0.2752	0.1944	0.0506
390	16.25	0.2059	0.2788	0.2099	0.1012	0.0369	-0.0082	-0.0217	0.1561	0.2906	0.2761	0.1982	0.0643
396	16.5	0.2096	0.2829	0.2132	0.1005	0.0402	-0.0079	-0.0215	0.1653	0.2774	0.2699	0.1879	0.0488
402	16.75	0.2076	0.2792	0.2065	0.0868	0.037	-0.0084	-0.0225	0.1543	0.2887	0.2696	0.1885	0.0592
408	17	0.2106	0.2821	0.205	0.0795	0.0372	-0.0087	-0.0222	0.1534	0.2913	0.2996	0.2029	0.0613
414	17.25	0.2095	0.2804	0.203	0.0717	0.0388	-0.0082	-0.023	0.1511	0.292	0.3007	0.2033	0.0487
420	17.5	0.2096	0.2842	0.2102	0.0728	0.0425	-0.0071	-0.0228	0.1584	0.2775	0.2642	0.1769	0.0466
426	17.75	0.2079	0.2814	0.2058	0.0652	0.0441	-0.0076	-0.0234	0.1537	0.2935	0.2721	0.1857	0.0391
432	18	0.2079	0.2797	0.2012	0.0586	0.0406	-0.0082	-0.0239	0.1487	0.2909	0.2934	0.1944	0.0442
438	18.25	0.2111	0.2846	0.2053	0.058	0.0417	-0.008	-0.0237	0.1529	0.3003	0.274	0.1829	0.0366
444	18.5	0.2126	0.2889	0.2102	0.0584	0.0433	-0.0073	-0.0239	0.1567	0.2976	0.2745	0.1833	0.0474
450	18.75	0.2105	0.287	0.2094	0.0554	0.0428	-0.007	-0.0246	0.1568	0.2971	0.2735	0.1836	0.0459
456	19	0.212	0.2867	0.2061	0.052	0.042	-0.0071	-0.0248	0.1538	0.2965	0.2714	0.1797	0.0348
462	19.25	0.2132	0.2886	0.2035	0.0488	0.0422	-0.0071	-0.0251	0.1504	0.2996	0.2758	0.1803	0.0454
468	19.5	0.2088	0.2856	0.2004	0.0452	0.0278	0.0397	-0.0255	0.1447	0.2925	0.2923	0.1868	0.0559
474	19.75	0.2142	0.2935	0.2082	0.0496	0.0422	-0.0071	-0.0257	0.155	0.3008	0.3013	0.1925	0.0385
480	20	0.2123	0.2904	0.2005	0.0436	0.0283	0.0336	-0.0262	0.1461	0.2945	0.2942	0.1833	0.0372
486	20.25	0.1982	0.2902	0.1938	0.0479	0.0424	-0.0085	-0.0263	0.1431	0.2968	0.2995	0.1841	0.0478
492	20.5	0.1965	0.2906	0.194	0.051	0.0428	-0.0051	-0.0262	0.1425	0.295	0.2985	0.1839	0.0524
498	20.75	0.2	0.3086	0.2074	0.0539	0.0484	-0.0097	-0.0259	0.1512	0.2991	0.3	0.1921	0.0357
504	21	0.2032	0.2927	0.1875	0.053	0.0433	-0.0025	-0.0264	0.1395	0.2961	0.2695	0.1613	0.0403
510	21.25	0.2048	0.324	0.1921	0.0754	0.0565	-0.0064	-0.0254	0.1583	0.2793	0.2591	0.1569	0.0389
516	21.5	0.207	0.3195	0.1914	0.0704	0.0551	-0.0051	-0.0263	0.1446	0.2728	0.2744	0.1638	0.0544
522	21.75	0.202	0.3181	0.2102	0.0782	0.0614	-0.0029	-0.0264	0.1607	0.2691	0.2727	0.1638	0.0309
528	22	0.1995	0.3134	0.2238	0.0758	0.0613	-0.0037	-0.0269	0.1569	0.2723	0.2747	0.1667	0.0477
534	22.25	0.202	0.314	0.2439	0.0748	0.0608	-0.0035	-0.0273	0.1531	0.3014	0.2985	0.185	0.0512
540	22.5	0.206	0.3125	0.2575	0.0765	0.0628	-0.0034	-0.04	0.1554	0.3011	0.2993	0.1863	0.0347
546	22.75	0.2046	0.309	0.2668	0.0751	0.0637	-0.0029	-0.0467	0.149	0.2995	0.297	0.1838	0.0503
552	23	0.2048	0.2986	0.2527	0.0798	0.069	0.0061	-0.0468	0.1423	0.3005	0.2983	0.1738	0.0548
558	23.25	0.2093	0.2966	0.2559	0.0855	0.0731	0.0067	-0.0507	0.1468	0.3016	0.2613	0.1616	0.0384
564	23.5	0.208	0.2974	0.2513	0.0773	0.07	0.0054	-0.0508	0.1395	0.2993	0.3004	0.1746	0.0508
570	23.75	0.2106	0.3085	0.2638	0.0712	0.0514	0.0044	-0.052	0.1438	0.2984	0.3014	0.1841	0.0294
576	24	0.2103	0.3086	0.2616	0.0678	0.0513	0.0042	-0.0537	0.1384	0.2966	0.2989	0.1814	0.0298
582	24.25	0.2116	0.2965	0.2489	0.0733	0.0716	0.0027	-0.054	0.1318	0.2965	0.2996	0.173	0.0302
588	24.5	0.1995	0.2928	0.255	0.0756	0.0788	0.0013	-0.0541	0.1316	0.2935	0.261	0.1602	0.0352
594	24.75	0.2047	0.2956	0.2643	0.0824	0.0812	0.0012	-0.0539	0.14	0.2983	0.2659	0.1657	0.0248
600	25	0.2027	0.307	0.2697	0.0651	0.055	0.0002	-0.0539	0.1358	0.2943	0.2972	0.1817	0.0272
606	25.25	0.2115	0.3088	0.2764	0.0691	0.0587	-0.0016	-0.054	0.1392	0.2985	0.3007	0.1837	0.0279
612	25.5	0.1937	0.3081	0.2863	0.0727	0.0616	-0.0018	-0.0539	0.1432	0.2975	0.3032	0.1867	0.0268
618	25.75	0.1991	0.2951	0.2572	0.0829	0.0867	-0.0026	-0.0538	0.1437	0.2963	0.2614	0.1657	0.0391
624	26	0.1957	0.3073	0.2574	0.0643	0.0564	-0.0026	-0.0537	0.1402	0.2915	0.298	0.1825	0.0362
630	26.25	0.1984	0.2982	0.2478	0.0691	0.0589	0.033	-0.0537	0.1313	0.2926	0.301	0.1738	0.0413
636	26.5	0.1974	0.2989	0.2581	0.0759	0.0851	-0.0035	-0.0535	0.1377	0.2929	0.3013	0.1773	0.0409
642	26.75	0.195	0.3075	0.2621	0.061	0.0439	0.0295	-0.0535	0.136	0.2855	0.2943	0.1792	0.0342
648	27	0.1975	0.3091	0.2515	0.0457	0.0616	0.025	-0.0554	0.1345	0.2864	0.2986	0.1779	0.0236
654	27.25	0.2011	0.2961	0.2509	0.0693	0.0586	0.0197	-0.0555	0.1288	0.2861	0.2631	0.1642	0.0196
660	27.5	0.1995	0.2968	0.254	0.0637	0.0559	0.0171	-0.0536	0.1269	0.2815	0.2947	0.1698	0.0378
666	27.75	0.1989	0.2958	0.2464	0.0597	0.054	0.0151	-0.0554	0.1192	0.2762	0.2916	0.1675	0.0402
672	28	0.2038	0.2987	0.2459	0.06	0.0533	0.0138	-0.0553	0.1224	0.278	0.2945	0.1702	0.0308

Changes in Conductivity (mS)
 Cycle 4: Column 4 (EXP)

Time (d)	Time (h)	Depth (in.)		2	3	4	5	6	7	8	9	10	11
		0	1										
15 March													
0	0	0.251	0.3753	0.446	0.5121	0.2951	0.0787	0.3201	0.3792	0.4734	0.5148	0.5146	0.1131
0.125	3	0.234	0.4011	0.4812	0.564	0.3095	0.0897	0.3421	0.399	0.5093	0.5653	0.5589	0.1069
0.25	6	0.2505	0.4287	0.5194	0.6209	0.3315	0.0966	0.3557	0.4106	0.5198	0.5897	0.6006	0.1022
0.375	9	0.2293	0.4037	0.4214	0.4461	0.2853	0.2474	0.3397	0.3711	0.4662	0.4633	0.4056	0.1014
0.5	12	0.2242	0.3457	0.381	0.3863	0.2784	0.2486	0.3068	0.343	0.3986	0.3734	0.3124	0.1069
0.625	15	0.2282	0.3392	0.3694	0.382	0.2765	0.2404	0.3088	0.3378	0.3912	0.3531	0.2995	0.1153
0.75	18	0.2329	0.3423	0.3551	0.3737	0.2786	0.25	0.3065	0.3554	0.3852	0.3546	0.302	0.1091
0.875	21	0.2228	0.332	0.349	0.376	0.2757	0.2303	0.3079	0.3373	0.3839	0.3452	0.2968	0.1091
1	24	0.224	0.3356	0.356	0.3731	0.2816	0.2409	0.3011	0.3537	0.3804	0.35	0.3009	0.1092
1.25	30	0.294	0.3019	0.3584	0.3741	0.2864	0.2285	0.2959	0.3508	0.376	0.3448	0.2973	0.1062
1.5	36	0.3337	0.2882	0.3605	0.3677	0.2764	0.1738	0.2802	0.3351	0.3594	0.3308	0.2875	0.108
1.75	42	0.3723	0.2731	0.3559	0.3655	0.2731	0.1678	0.275	0.3322	0.3721	0.3331	0.2863	0.1305
2	48	0.415	0.2731	0.3523	0.3559	0.2589	0.1341	0.2562	0.3109	0.3518	0.3147	0.2721	0.137
2.5	60	0.3796	0.3101	0.3465	0.3527	0.2541	0.1345	0.2658	0.2911	0.3139	0.2716	0.222	0.1198
3	72	0.3577	0.3049	0.3312	0.3496	0.2555	0.1535	0.2771	0.28	0.3195	0.2892	0.2783	0.0977
3.5	84	0.3422	0.3204	0.3634	0.3724	0.2616	0.1466	0.2906	0.2747	0.3344	0.3093	0.321	0.1125
4	96	0.3241	0.3101	0.3608	0.3683	0.2578	0.1395	0.2944	0.2593	0.3283	0.304	0.3274	0.1383
4.5	108	0.3089	0.3026	0.357	0.3636	0.2524	0.1313	0.2969	0.2499	0.3237	0.2991	0.316	0.1474
5	120	0.2973	0.3008	0.3546	0.3609	0.2468	0.1239	0.3006	0.2424	0.3215	0.3088	0.3297	0.1592
5.5	132	0.2908	0.3039	0.3578	0.3626	0.2441	0.1177	0.3059	0.2375	0.3344	0.3293	0.347	0.1805
6	144	0.2884	0.3085	0.3604	0.3681	0.2428	0.1131	0.3058	0.2281	0.3395	0.338	0.3694	0.2081
6.5	156	0.2789	0.3056	0.3581	0.365	0.2386	0.1078	0.3045	0.2665	0.3311	0.3444	0.3654	0.2155
7	168	0.2863	0.3069	0.3531	0.3631	0.235	0.1037	0.3043	0.2663	0.3376	0.349	0.3701	0.2575
7.5	180	0.2962	0.3304	0.3695	0.3863	0.2334	0.0799	0.2869	0.2371	0.3733	0.3742	0.3835	0.2423
8	192	0.3044	0.3342	0.3628	0.3671	0.2214	0.0931	0.2894	0.2321	0.3537	0.3564	0.3768	0.2633
8.5	204	0.3049	0.342	0.3658	0.3683	0.2131	0.0938	0.2997	0.2318	0.354	0.3592	0.3735	0.2812
9	216	0.3018	0.3496	0.3668	0.3792	0.2177	0.0838	0.3075	0.2308	0.3757	0.3739	0.3686	0.3037
9.5	228	0.2995	0.3542	0.3642	0.3689	0.2078	0.0926	0.3178	0.2283	0.356	0.3634	0.3788	0.3134
10	240	0.2992	0.3512	0.3558	0.3637	0.2061	0.0893	0.3152	0.2211	0.3497	0.3513	0.362	0.3089
10.5	252	0.2964	0.3604	0.362	0.369	0.2022	0.0883	0.3073	0.2201	0.3506	0.3564	0.3775	0.3193
11	264	0.2943	0.362	0.358	0.3652	0.1948	0.0843	0.3126	0.2166	0.3472	0.352	0.3692	0.3171
11.5	276	0.2944	0.367	0.3565	0.366	0.1915	0.0797	0.3166	0.2627	0.3589	0.3715	0.357	0.3142
12	288	0.2946	0.3736	0.3563	0.3678	0.1881	0.0772	0.3228	0.2621	0.3592	0.3677	0.3717	0.3268
12.5	300	0.2852	0.3822	0.3525	0.3697	0.1768	0.0659	0.3204	0.2628	0.3545	0.3657	0.365	0.3187
13	312	0.2852	0.3819	0.3448	0.3682	0.1751	0.0685	0.3199	0.2626	0.3555	0.3657	0.3639	0.3149
13.5	324	0.2847	0.3685	0.3255	0.3551	0.1734	0.0771	0.3153	0.2163	0.3721	0.3697	0.3552	0.2972
14	336	0.2927	0.3718	0.3217	0.3543	0.1776	0.0817	0.3205	0.2653	0.3593	0.3701	0.3723	0.3111
14.5	348	0.2855	0.3856	0.3123	0.3555	0.1323	0.0788	0.3245	0.2179	0.373	0.3693	0.3726	0.3053
15	360	0.2903	0.3838	0.2962	0.3516	0.1149	0.1126	0.3177	0.2643	0.3568	0.3676	0.37	0.2992
15.5	372	0.2873	0.3857	0.2835	0.3424	0.1087	0.1042	0.3032	0.2219	0.3719	0.3676	0.368	0.2872
16	384	0.3007	0.387	0.2741	0.3372	0.1065	0.0979	0.3187	0.2184	0.3702	0.3663	0.369	0.2871
16.5	396	0.3084	0.3935	0.3161	0.3324	0.104	0.0925	0.3185	0.2182	0.373	0.3702	0.3685	0.2788
17	408	0.3054	0.3973	0.3676	0.3277	0.1009	0.0868	0.3171	0.2632	0.358	0.3694	0.3703	0.2729
17.5	420	0.3054	0.3851	0.4569	0.3826	0.0779	0.082	0.3118	0.2612	0.341	0.3522	0.3544	0.2565
18	432	0.2954	0.3509	0.5226	0.3699	0.0773	0.0713	0.2958	0.2512	0.3199	0.3286	0.3311	0.2376
18.5	444	0.3108	0.3562	0.4303	0.3554	0.093	0.0688	0.2983	0.2503	0.3193	0.3294	0.3316	0.2324
19	456	0.3292	0.3962	0.4076	0.3587	0.1014	0.0966	0.3176	0.262	0.3366	0.3491	0.3528	0.2355
19.5	468	0.3284	0.4197	0.3737	0.3414	0.1065	0.0864	0.3193	0.2608	0.3409	0.3517	0.3556	0.2307
20	480	0.3194	0.4195	0.3649	0.3361	0.1052	0.0799	0.3162	0.2177	0.3546	0.3507	0.3551	0.2224
20.5	492	0.3292	0.4208	0.3639	0.3314	0.1054	0.0757	0.3131	0.2247	0.3553	0.3532	0.3574	0.2143
21	504	0.3263	0.4227	0.3659	0.3321	0.1064	0.0733	0.3198	0.2639	0.3463	0.3578	0.3608	0.2093
21.5	516	0.3193	0.4293	0.3714	0.3298	0.1141	0.0717	0.3147	0.2267	0.3733	0.3732	0.3597	0.1802
22	528	0.3368	0.4283	0.3367	0.3232	0.1159	0.0702	0.3117	0.2265	0.3485	0.3542	0.3641	0.1561
22.5	540	0.3271	0.4288	0.3643	0.316	0.1183	0.0782	0.3198	0.2648	0.3585	0.3682	0.358	0.1472
23	552	0.3417	0.419	0.3585	0.3078	0.118	0.0729	0.3135	0.2273	0.3729	0.3693	0.3716	0.1642
23.5	564	0.3548	0.4466	0.3589	0.2992	0.1173	0.0658	0.3167	0.2638	0.351	0.3621	0.3641	0.1528
24	576	0.3617	0.4453	0.3567	0.2873	0.1164	0.0707	0.3188	0.2217	0.3673	0.3647	0.3665	0.1498
24.5	588	0.3534	0.4426	0.3602	0.2806	0.1219	0.0719	0.3187	0.221	0.3707	0.3708	0.3699	0.1445
25	600	0.3346	0.4191	0.3497	0.2743	0.1417	0.0732	0.3242	0.2641	0.3592	0.3723	0.359	0.1217

25.5	612	0.3321	0.4157	0.3408	0.265	0.1433	0.0733	0.3195	0.2301	0.3536	0.3588	0.3661	0.1193
26	624	0.3554	0.4429	0.3586	0.2772	0.148	0.0652	0.3183	0.2285	0.3685	0.3648	0.3654	0.129
26.5	636	0.3429	0.4158	0.3572	0.2811	0.2149	0.0651	0.3209	0.2327	0.3537	0.3572	0.367	0.1136
27	648	0.351	0.4167	0.3529	0.2851	0.2159	0.0754	0.3231	0.2381	0.3538	0.3537	0.3643	0.1101
27.5	660	0.3499	0.4155	0.3565	0.2892	0.2301	0.0876	0.3275	0.2435	0.3564	0.3591	0.3687	0.1077
28	672	0.3598	0.42	0.3586	0.3049	0.2445	0.0961	0.3316	0.2516	0.3594	0.3601	0.367	0.1042

Changes in Conductivity (mS)
 Cycle 4: Column 5 (CTL)

Time (d)	Time (h)	Depth (in.)		2	3	4	5	6	7	8	9	10	11
		0	1										
0	1	0.0705	0.0704	0.068	0.0692	0.0685	0.0681	0.067	0.0666	0.0669	0.0666	0.0659	0.0054
0.125	3	0.0742	0.0739	0.071	0.0724	0.0715	0.0709	0.0697	0.0692	0.0694	0.069	0.0682	0.0061
0.25	6	0.0739	0.0738	0.071	0.0725	0.0716	0.071	0.0699	0.0694	0.0696	0.0692	0.0684	0.0163
0.375	9	0.074	0.0737	0.0709	0.0723	0.0715	0.071	0.0698	0.0693	0.0695	0.0692	0.0684	0.0075
0.5	12	0.0739	0.0737	0.0709	0.0722	0.0714	0.0709	0.0698	0.0693	0.0695	0.0692	0.0684	0.0067
0.625	15	0.0738	0.0735	0.0707	0.0721	0.0713	0.0708	0.0696	0.0692	0.0693	0.069	0.0682	0.0061
0.75	18	0.0699	0.0694	0.0665	0.0677	0.0669	0.0664	0.0652	0.0648	0.065	0.0647	0.0639	0.0098
0.875	21	0.0698	0.0693	0.0664	0.0676	0.0668	0.0663	0.0651	0.0647	0.0649	0.0646	0.0638	0.0098
1	24	0.0697	0.0692	0.0663	0.0675	0.0667	0.0662	0.065	0.0646	0.0648	0.0645	0.0637	0.0098
1.25	30	0.0696	0.0691	0.0662	0.0674	0.0666	0.066	0.0649	0.0645	0.0646	0.0643	0.0636	0.0086
1.5	36	0.0695	0.069	0.066	0.0673	0.0665	0.0659	0.0648	0.0643	0.0645	0.0642	0.0634	0.0085
1.75	42	0.0694	0.0688	0.0659	0.0671	0.0663	0.0658	0.0646	0.0642	0.0643	0.0641	0.0633	0.0076
2	48	0.0697	0.0692	0.0662	0.0675	0.0667	0.0662	0.0651	0.0646	0.0648	0.0645	0.0638	0.0098
2.5	60	0.0695	0.0689	0.066	0.0673	0.0664	0.0659	0.0647	0.0643	0.0645	0.0642	0.0634	0.0086
3	72	0.0702	0.0696	0.0666	0.068	0.0672	0.0667	0.0655	0.0652	0.0654	0.0651	0.0644	0.0227
3.5	84	0.074	0.0736	0.0707	0.072	0.0712	0.0708	0.0696	0.0691	0.0693	0.069	0.0682	0.0056
4	96	0.0737	0.0734	0.0704	0.0717	0.071	0.0705	0.0694	0.0689	0.0691	0.0687	0.068	0.0056
4.5	108	0.0737	0.0733	0.0703	0.0717	0.0709	0.0704	0.0693	0.0688	0.069	0.0687	0.0679	0.0056
5	120	0.0735	0.0731	0.0702	0.0715	0.0708	0.0703	0.0691	0.0687	0.0688	0.0685	0.0677	0.0056
5.5	132	0.0735	0.0732	0.0702	0.0715	0.0708	0.0703	0.0691	0.0687	0.0688	0.0685	0.0677	0.0056
6	144	0.0739	0.0735	0.0705	0.0718	0.0711	0.0705	0.0694	0.0689	0.0691	0.0688	0.068	0.0056
6.5	156	0.0795	0.0792	0.0761	0.0779	0.0773	0.0769	0.0759	0.0755	0.0758	0.0756	0.0749	0.0056
7	168	0.0744	0.074	0.071	0.0722	0.0715	0.071	0.0698	0.0693	0.0695	0.0692	0.0684	0.0061
7.5	180	0.0809	0.0805	0.0772	0.0788	0.078	0.0776	0.0764	0.0759	0.0762	0.0759	0.0751	0.0061
8	192	0.0891	0.0887	0.0853	0.0873	0.0867	0.0864	0.0853	0.0849	0.0853	0.0851	0.0843	0.0092
8.5	204	0.0892	0.0888	0.0853	0.0873	0.0866	0.0863	0.0852	0.0848	0.0852	0.085	0.0842	0.0081
9	216	0.0806	0.0801	0.0768	0.0784	0.0777	0.0772	0.0761	0.0757	0.0759	0.0756	0.0749	0.0066
9.5	228	0.0803	0.0798	0.0766	0.0782	0.0774	0.077	0.0759	0.0755	0.0757	0.0755	0.0747	0.0061
10	240	0.0887	0.0882	0.0848	0.0868	0.0862	0.0859	0.0848	0.0844	0.0849	0.0846	0.0839	0.0081
10.5	252	0.0801	0.0796	0.0763	0.0779	0.0772	0.0768	0.0756	0.0752	0.0755	0.0752	0.0744	0.0056
11	264	0.0797	0.0792	0.076	0.0776	0.0769	0.0765	0.0754	0.075	0.0753	0.075	0.0743	0.0055
11.5	276	0.0796	0.0792	0.0759	0.0775	0.0768	0.0764	0.0753	0.0749	0.0752	0.075	0.0742	0.0055
12	288	0.0736	0.0731	0.07	0.0712	0.0705	0.07	0.0688	0.0683	0.0685	0.0681	0.0674	0.0056
12.5	300	0.0736	0.0731	0.0699	0.0712	0.0705	0.0699	0.0688	0.0683	0.0684	0.0681	0.0673	0.0056
13	312	0.0739	0.0734	0.0703	0.0715	0.0708	0.0702	0.0691	0.0686	0.0687	0.0684	0.0676	0.0056
13.5	324	0.0794	0.0791	0.0758	0.0775	0.0769	0.0765	0.0754	0.0751	0.0754	0.0752	0.0745	0.006
14	336	0.0739	0.0734	0.0703	0.0716	0.0709	0.0704	0.0692	0.0688	0.0689	0.0686	0.0678	0.0061
14.5	348	0.0738	0.0733	0.0701	0.0714	0.0707	0.0701	0.0689	0.0685	0.0686	0.0683	0.0675	0.0056
15	360	0.0738	0.0733	0.0701	0.0714	0.0706	0.0701	0.0689	0.0684	0.0686	0.0683	0.0675	0.0056
15.5	372	0.0735	0.073	0.0698	0.0711	0.0704	0.0698	0.0686	0.0682	0.0683	0.068	0.0672	0.0056
16	384	0.0737	0.0732	0.07	0.0713	0.0706	0.07	0.0688	0.0684	0.0685	0.0682	0.0674	0.0056
16.5	396	0.0735	0.073	0.0698	0.0711	0.0704	0.0698	0.0686	0.0682	0.0683	0.068	0.0672	0.0056
17	408	0.0731	0.0727	0.0695	0.0708	0.0701	0.0695	0.0684	0.0679	0.0681	0.0677	0.067	0.0056
17.5	420	0.0733	0.0727	0.0695	0.0708	0.0701	0.0695	0.0683	0.0678	0.068	0.0677	0.0669	0.0055
18	432	0.0732	0.0727	0.0694	0.0708	0.07	0.0695	0.0683	0.0677	0.0679	0.0676	0.0668	0.0055
18.5	444	0.073	0.0725	0.0693	0.0707	0.0699	0.0694	0.0682	0.0677	0.0679	0.0675	0.0668	0.0055
19	456	0.0728	0.0723	0.0691	0.0706	0.0698	0.0693	0.0681	0.0676	0.0678	0.0675	0.0667	0.0055
19.5	468	0.0727	0.0722	0.069	0.0703	0.0696	0.0691	0.0679	0.0675	0.0677	0.0673	0.0666	0.0055
20	480	0.0726	0.0722	0.069	0.0703	0.0696	0.0691	0.0679	0.0675	0.0677	0.0673	0.0666	0.0055
20.5	492	0.0726	0.0721	0.0689	0.0703	0.0696	0.0691	0.0679	0.0675	0.0676	0.0673	0.0665	0.0055
21	504	0.073	0.0726	0.0694	0.0707	0.07	0.0695	0.0683	0.0679	0.0681	0.0678	0.067	0.0056
21.5	516	0.079	0.0786	0.0753	0.077	0.0765	0.0762	0.0751	0.0748	0.0752	0.075	0.0743	0.0055
22	528	0.0738	0.0732	0.0699	0.0712	0.0704	0.0699	0.0687	0.0682	0.0684	0.068	0.0673	0.0056
22.5	540	0.0732	0.0726	0.0693	0.0707	0.0699	0.0694	0.0682	0.0677	0.0679	0.0676	0.0668	0.0055
23	552	0.0739	0.0733	0.07	0.0713	0.0706	0.07	0.0688	0.0684	0.0686	0.0682	0.0674	0.0056
23.5	564	0.0693	0.0685	0.0652	0.0664	0.0657	0.0651	0.0639	0.0635	0.0636	0.0633	0.0626	0.0068
24	576	0.0697	0.0688	0.0654	0.0666	0.066	0.0654	0.0642	0.0638	0.064	0.0637	0.0629	0.0076
24.5	588	0.0693	0.0685	0.0651	0.0663	0.0656	0.065	0.0638	0.0635	0.0636	0.0633	0.0626	0.0068
25	600	0.0691	0.0682	0.0649	0.066	0.0654	0.0648	0.0636	0.0632	0.0634	0.0631	0.0623	0.0068

25.5	612	0.0692	0.0683	0.0649	0.0661	0.0655	0.0649	0.0637	0.0633	0.0635	0.0632	0.0624	0.0068
26	624	0.0693	0.0685	0.065	0.0662	0.0656	0.065	0.0638	0.0635	0.0636	0.0633	0.0626	0.0068
26.5	636	0.0693	0.0685	0.0651	0.0662	0.0656	0.065	0.0638	0.0635	0.0636	0.0633	0.0626	0.0068
27	648	0.0695	0.0686	0.0652	0.0664	0.0658	0.0652	0.064	0.0636	0.0638	0.0635	0.0628	0.0085
27.5	660	0.0693	0.0684	0.065	0.0663	0.0656	0.0651	0.0638	0.0635	0.0637	0.0634	0.0627	0.0085
28	672	0.0693	0.0685	0.0652	0.0664	0.0658	0.0653	0.064	0.0637	0.0639	0.0637	0.0629	0.0136

Changes in Conductivity (mS)
 Cycle 4: Column 4 - Column 5: (EXP-CTL)

Time (d)	Time (h)	Depth (in.)											
		0	1	2	3	4	5	6	7	8	9	10	11
0	1	0.1805	0.3049	0.378	0.4429	0.2266	0.0106	0.2531	0.3126	0.4065	0.4482	0.4487	0.1077
0.125	3	0.1598	0.3272	0.4102	0.4916	0.238	0.0188	0.2724	0.3298	0.4399	0.4963	0.4907	0.1008
0.25	6	0.1766	0.3549	0.4484	0.5484	0.2599	0.0256	0.2858	0.3412	0.4502	0.5205	0.5322	0.0859
0.375	9	0.1553	0.33	0.3505	0.3738	0.2138	0.1764	0.2699	0.3018	0.3967	0.3941	0.3372	0.0939
0.5	12	0.1503	0.272	0.3101	0.3141	0.207	0.1777	0.237	0.2737	0.3291	0.3042	0.244	0.1002
0.625	15	0.1544	0.2657	0.2987	0.3099	0.2052	0.1696	0.2392	0.2686	0.3219	0.2841	0.2313	0.1092
0.75	18	0.163	0.2729	0.2886	0.306	0.2117	0.1836	0.2413	0.2906	0.3202	0.2899	0.2381	0.0993
0.875	21	0.153	0.2627	0.2826	0.3084	0.2089	0.164	0.2428	0.2726	0.319	0.2806	0.233	0.0993
1	24	0.1543	0.2664	0.2897	0.3056	0.2149	0.1747	0.2361	0.2891	0.3156	0.2855	0.2372	0.0994
1.25	30	0.2244	0.2328	0.2922	0.3067	0.2198	0.1625	0.231	0.2863	0.3114	0.2805	0.2337	0.0976
1.5	36	0.2642	0.2192	0.2945	0.3004	0.2099	0.1079	0.2154	0.2708	0.2949	0.2666	0.2241	0.0995
1.75	42	0.3029	0.2043	0.29	0.2984	0.2068	0.102	0.2104	0.268	0.3078	0.269	0.223	0.1229
2	48	0.3453	0.2039	0.2861	0.2884	0.1922	0.0679	0.1911	0.2463	0.287	0.2502	0.2083	0.1272
2.5	60	0.3101	0.2412	0.2805	0.2854	0.1877	0.0686	0.2011	0.2268	0.2494	0.2074	0.1586	0.1112
3	72	0.2875	0.2353	0.2646	0.2816	0.1883	0.0868	0.2116	0.2148	0.2541	0.2241	0.2139	0.075
3.5	84	0.2682	0.2468	0.2927	0.3004	0.1904	0.0758	0.221	0.2056	0.2651	0.2403	0.2528	0.1069
4	96	0.2504	0.2367	0.2904	0.2966	0.1868	0.069	0.225	0.1904	0.2592	0.2353	0.2594	0.1327
4.5	108	0.2352	0.2293	0.2867	0.2919	0.1815	0.0609	0.2276	0.1811	0.2547	0.2304	0.2481	0.1418
5	120	0.2238	0.2277	0.2844	0.2894	0.176	0.0536	0.2315	0.1737	0.2527	0.2403	0.262	0.1536
5.5	132	0.2173	0.2307	0.2876	0.2911	0.1733	0.0474	0.2368	0.1688	0.2656	0.2608	0.2793	0.1749
6	144	0.2145	0.235	0.2899	0.2963	0.1717	0.0426	0.2364	0.1592	0.2704	0.2692	0.3014	0.2025
6.5	156	0.1994	0.2264	0.282	0.2871	0.1613	0.0309	0.2286	0.191	0.2553	0.2688	0.2905	0.2099
7	168	0.2119	0.2329	0.2821	0.2909	0.1635	0.0327	0.2345	0.197	0.2681	0.2798	0.3017	0.2514
7.5	180	0.2153	0.2499	0.2923	0.3075	0.1554	0.0023	0.2105	0.1612	0.2971	0.2983	0.3084	0.2362
8	192	0.2153	0.2455	0.2775	0.2798	0.1347	0.0067	0.2041	0.1472	0.2684	0.2713	0.2925	0.2541
8.5	204	0.2157	0.2532	0.2805	0.281	0.1265	0.0075	0.2145	0.147	0.2688	0.2742	0.2893	0.2731
9	216	0.2212	0.2695	0.29	0.3008	0.14	0.0066	0.2314	0.1551	0.2998	0.2983	0.2937	0.2971
9.5	228	0.2192	0.2744	0.2876	0.2907	0.1304	0.0156	0.2419	0.1528	0.2803	0.2879	0.3041	0.3073
10	240	0.2105	0.263	0.271	0.2769	0.1199	0.0034	0.2304	0.1367	0.2648	0.2667	0.2781	0.3008
10.5	252	0.2163	0.2808	0.2857	0.2911	0.125	0.0115	0.2317	0.1449	0.2751	0.2812	0.3031	0.3137
11	264	0.2146	0.2828	0.282	0.2876	0.1179	0.0078	0.2372	0.1416	0.2719	0.277	0.2949	0.3116
11.5	276	0.2148	0.2878	0.2806	0.2885	0.1147	0.0033	0.2413	0.1878	0.2837	0.2965	0.2828	0.3087
12	288	0.221	0.3005	0.2863	0.2966	0.1176	0.0072	0.254	0.1938	0.2907	0.2996	0.3043	0.3212
12.5	300	0.2116	0.3091	0.2826	0.2985	0.1063	-0.004	0.2516	0.1945	0.2861	0.2976	0.2977	0.3131
13	312	0.2113	0.3085	0.2745	0.2967	0.1043	-0.0017	0.2508	0.194	0.2868	0.2973	0.2963	0.3093
13.5	324	0.2053	0.2894	0.2497	0.2776	0.0965	0.0006	0.2399	0.1412	0.2967	0.2945	0.2807	0.2912
14	336	0.2188	0.2984	0.2514	0.2827	0.1067	0.0113	0.2513	0.1965	0.2904	0.3015	0.3045	0.305
14.5	348	0.2117	0.3123	0.2422	0.2841	0.0616	0.0087	0.2556	0.1494	0.3044	0.301	0.3051	0.2997
15	360	0.2165	0.3105	0.2261	0.2802	0.0443	0.0425	0.2488	0.1959	0.2882	0.2993	0.3025	0.2936
15.5	372	0.2138	0.3127	0.2137	0.2713	0.0383	0.0344	0.2346	0.1537	0.3036	0.2996	0.3008	0.2816
16	384	0.227	0.3138	0.2041	0.2659	0.0359	0.0279	0.2499	0.15	0.3017	0.2981	0.3016	0.2815
16.5	396	0.2349	0.3205	0.2463	0.2613	0.0336	0.0227	0.2499	0.15	0.3047	0.3022	0.3013	0.2732
17	408	0.2323	0.3246	0.2981	0.2569	0.0308	0.0173	0.2487	0.1953	0.2899	0.3017	0.3033	0.2673
17.5	420	0.2321	0.3124	0.3874	0.3118	0.0078	0.0125	0.2435	0.1934	0.273	0.2845	0.2875	0.251
18	432	0.2222	0.2782	0.4532	0.2991	0.0073	0.0018	0.2275	0.1835	0.252	0.261	0.2643	0.2321
18.5	444	0.2378	0.2837	0.361	0.2847	0.0231	-0.0006	0.2301	0.1826	0.2514	0.2619	0.2648	0.2269
19	456	0.2564	0.3239	0.3385	0.2881	0.0316	0.0273	0.1822	0.2517	0.2616	0.2641	0.1657	0.23
19.5	468	0.2557	0.3475	0.3047	0.2711	0.0369	0.0173	0.2514	0.1933	0.2732	0.2844	0.289	0.2252
20	480	0.2468	0.3473	0.2959	0.2658	0.0356	0.0108	0.2483	0.1502	0.2869	0.2834	0.2885	0.2169
20.5	492	0.2566	0.3487	0.295	0.2611	0.0358	0.0066	0.2452	0.1572	0.2877	0.2859	0.2909	0.2088
21	504	0.2533	0.3501	0.2965	0.2614	0.0364	0.0038	0.2515	0.196	0.2782	0.29	0.2938	0.2037
21.5	516	0.2403	0.3507	0.2961	0.2528	0.0376	-0.0045	0.2396	0.1519	0.2981	0.2982	0.2854	0.1747
22	528	0.263	0.3551	0.2668	0.252	0.0455	0.0003	0.243	0.1583	0.2801	0.2862	0.2968	0.1505
22.5	540	0.2539	0.3562	0.295	0.2453	0.0484	0.0088	0.2516	0.1971	0.2906	0.3006	0.2912	0.1417
23	552	0.2678	0.3457	0.2885	0.2365	0.0474	0.0029	0.2447	0.1589	0.3043	0.3011	0.3042	0.1586
23.5	564	0.2855	0.3781	0.2937	0.2328	0.0516	0.0007	0.2528	0.2003	0.2874	0.2988	0.3015	0.146
24	576	0.292	0.3765	0.2913	0.2207	0.0504	0.0053	0.2546	0.1579	0.3033	0.301	0.3036	0.1422
24.5	588	0.2841	0.3741	0.2951	0.2143	0.0563	0.0069	0.2549	0.1575	0.3071	0.3075	0.3073	0.1377
25	600	0.2655	0.3509	0.2848	0.2083	0.0763	0.0084	0.2606	0.2009	0.2958	0.3092	0.2967	0.1149

25.5	612	0.2629	0.3474	0.2759	0.1989	0.0778	0.0084	0.2558	0.1668	0.2901	0.2953	0.3029	0.0569
26	624	0.2861	0.3744	0.2936	0.211	0.0824	0.0002	0.2545	0.165	0.3049	0.3015	0.3028	0.1222
26.5	636	0.2736	0.3473	0.2921	0.2149	0.1493	0.0001	0.2571	0.1692	0.2901	0.2939	0.3044	0.1068
27	648	0.2815	0.3481	0.2877	0.2187	0.1501	0.0102	0.2591	0.1745	0.29	0.2902	0.3015	0.1016
27.5	660	0.2806	0.3471	0.2915	0.2229	0.1645	0.0225	0.2637	0.18	0.2927	0.2957	0.306	0.0992
28	672	0.2905	0.3515	0.2934	0.2385	0.1787	0.0308	0.2676	0.1879	0.2955	0.2964	0.3041	0.0906

Changes in Conductivity (mS)
Cycle 5: Column 4 (EXP)

Time (d)	Time (h)	Depth (in.)		2	3	4	5	6	7	8	9	10	11
		0	1										
-0.25	-6	0.284	0.345	0.771	1.486	1.48	0.712	0.898	1.614	2.051	2.289	1.756	0.7
0	0	0.794	0.995	1.41	1.996	1.96	0.778	1.024	2.131	3.048	3.087	2.428	0.787
0.04	1	0.967	1.081	1.571	2.287	2.22	0.818	1.099	2.402	3.09	3.02	1.587	0.616
0.08	2	0.654	1.042	1.535	2.2	2.132	0.802	1.01	2.153	1.767	1.485	1.212	0.51
0.13	3	0.391	0.937	1.394	1.926	1.863	0.749	0.824	1.711	1.409	1.245	1.024	0.463
0.17	4	0.331	0.683	1.299	1.788	1.717	0.709	0.715	1.511	1.244	1.133	0.944	0.446
0.21	5	0.295	0.528	1.227	1.692	1.618	0.673	0.625	1.282	1.141	1.062	0.896	0.435
0.25	6	0.266	0.422	1.149	1.586	1.477	0.608	0.521	1.104	1.072	1.002	0.857	0.428
0.29	7	0.257	0.38	0.909	1.502	1.355	0.552	0.47	1.03	1.026	0.964	0.829	0.424
0.33	8	0.247	0.36	0.661	1.406	1.249	0.516	0.46	0.965	0.986	0.938	0.802	0.419
0.38	9	0.242	0.333	0.574	1.35	1.184	0.484	0.457	0.918	0.96	0.918	0.784	0.416
0.42	10	0.235	0.321	0.508	1.297	1.14	0.462	0.453	0.881	0.934	0.903	0.766	0.414
0.46	11	0.224	0.296	0.452	0.991	0.811	0.286	0.268	0.561	0.592	0.576	0.507	0.251
0.5	12	0.223	0.29	0.441	0.815	0.635	0.21	0.192	0.416	0.439	0.428	0.384	0.183
0.75	18	0.217	0.267	0.364	0.524	0.398	0.12	0.104	0.237	0.255	0.248	0.223	0.099
1	24	0.22	0.269	0.365	0.483	0.376	0.106	0.09	0.21	0.229	0.223	0.197	0.085
1.25	30	0.232	0.277	0.343	0.428	0.271	0.101	0.082	0.198	0.22	0.214	0.183	0.077
1.5	36	0.239	0.283	0.343	0.43	0.264	0.103	0.082	0.201	0.226	0.22	0.182	0.077
1.75	42	0.238	0.276	0.33	0.424	0.257	0.101	0.083	0.2	0.226	0.22	0.177	0.076
2	48	0.237	0.271	0.316	0.427	0.252	0.101	0.081	0.198	0.224	0.22	0.17	0.075
2.25	54	0.236	0.267	0.307	0.448	0.276	0.113	0.092	0.219	0.247	0.241	0.179	0.084
2.5	60	0.237	0.264	0.303	0.453	0.273	0.112	0.092	0.218	0.246	0.24	0.165	0.084
2.75	66	0.236	0.26	0.301	0.442	0.268	0.111	0.091	0.215	0.242	0.238	0.147	0.083
3	72	0.236	0.258	0.301	0.463	0.272	0.112	0.091	0.218	0.244	0.239	0.132	0.083
3.25	78	0.237	0.257	0.302	0.463	0.27	0.112	0.09	0.218	0.247	0.239	0.124	0.083
3.5	84	0.24	0.258	0.307	0.444	0.264	0.111	0.09	0.214	0.242	0.237	0.119	0.083
3.75	90	0.242	0.259	0.31	0.448	0.265	0.111	0.09	0.213	0.242	0.239	0.116	0.083
4	96	0.245	0.259	0.312	0.437	0.266	0.112	0.09	0.213	0.243	0.239	0.115	0.083
4.25	102	0.24	0.254	0.305	0.457	0.269	0.113	0.089	0.212	0.245	0.241	0.113	0.083
4.5	108	0.242	0.255	0.306	0.461	0.272	0.113	0.089	0.211	0.25	0.244	0.112	0.082
4.75	114	0.241	0.253	0.302	0.415	0.241	0.099	0.078	0.185	0.223	0.223	0.099	0.072
5	120	0.246	0.255	0.304	0.409	0.244	0.1	0.078	0.182	0.223	0.224	0.098	0.073
5.25	126	0.249	0.257	0.308	0.414	0.252	0.101	0.079	0.18	0.229	0.229	0.098	0.073
5.5	132	0.247	0.256	0.312	0.451	0.291	0.114	0.089	0.196	0.263	0.264	0.113	0.082
5.75	138	0.247	0.254	0.31	0.406	0.258	0.101	0.079	0.169	0.237	0.24	0.102	0.073
6	144	0.246	0.252	0.311	0.397	0.268	0.103	0.079	0.166	0.246	0.25	0.105	0.073
6.25	150	0.244	0.248	0.306	0.394	0.272	0.103	0.08	0.163	0.258	0.263	0.107	0.073
6.5	156	0.246	0.253	0.318	0.405	0.281	0.106	0.085	0.166	0.276	0.284	0.112	0.073
6.75	162	0.251	0.254	0.317	0.4	0.294	0.109	0.092	0.17	0.295	0.305	0.122	0.073
7	168	0.245	0.252	0.321	0.391	0.318	0.114	0.097	0.181	0.33	0.338	0.14	0.073
7.25	174	0.262	0.276	0.354	0.429	0.342	0.131	0.105	0.212	0.382	0.394	0.168	0.084
7.5	180	0.245	0.251	0.322	0.442	0.372	0.139	0.111	0.248	0.419	0.43	0.216	0.096
7.75	186	0.242	0.244	0.309	0.413	0.362	0.145	0.103	0.271	0.393	0.444	0.248	0.082
8	192	0.245	0.243	0.311	0.406	0.4	0.18	0.119	0.323	0.466	0.491	0.331	0.083
8.25	198	0.26	0.242	0.304	0.403	0.435	0.221	0.15	0.373	0.486	0.519	0.396	0.099
8.5	204	0.243	0.236	0.303	0.423	0.464	0.266	0.203	0.419	0.5	0.555	0.458	0.13
8.75	210	0.244	0.234	0.302	0.428	0.499	0.33	0.245	0.442	0.552	0.562	0.487	0.2
9	216	0.25	0.238	0.317	0.47	0.543	0.41	0.311	0.485	0.559	0.554	0.495	0.256
9.25	222	0.245	0.228	0.324	0.493	0.655	0.521	0.435	0.558	0.646	0.635	0.573	0.331
9.5	228	0.25	0.235	0.333	0.548	0.649	0.55	0.515	0.564	0.651	0.644	0.586	0.388
9.75	234	0.249	0.231	0.354	0.564	0.663	0.572	0.559	0.575	0.662	0.653	0.6	0.463
10	240	0.251	0.238	0.358	0.563	0.663	0.583	0.58	0.577	0.665	0.657	0.607	0.517
10.25	246	0.252	0.232	0.362	0.568	0.786	0.688	0.697	0.677	0.79	0.779	0.747	0.635
10.5	252	0.256	0.243	0.371	0.643	0.789	0.692	0.71	0.672	0.792	0.783	0.723	0.656
10.75	258	0.257	0.248	0.402	0.659	0.797	0.698	0.723	0.675	0.798	0.792	0.735	0.674
11	264	0.258	0.251	0.405	0.66	0.803	0.702	0.73	0.673	0.799	0.795	0.736	0.676
11.25	270	0.254	0.242	0.404	0.659	0.802	0.698	0.734	0.668	0.797	0.792	0.736	0.673
11.5	276	0.257	0.245	0.406	0.658	0.975	0.88	0.887	0.796	0.975	0.967	0.886	0.798
11.75	282	0.262	0.256	0.406	0.649	0.799	0.732	0.74	0.661	0.801	0.794	0.737	0.664

12	288	0.262	0.258	0.408	0.646	0.797	0.731	0.742	0.654	0.801	0.798	0.742	0.663
12.25	294	0.257	0.248	0.383	0.569	0.792	0.73	0.742	0.648	0.801	0.965	0.89	0.784
12.5	300	0.262	0.258	0.383	0.566	0.784	0.721	0.737	0.637	0.796	0.793	0.737	0.653
12.75	306	0.255	0.25	0.407	0.572	0.96	0.875	0.895	0.76	0.977	0.97	0.89	0.77
13	312	0.257	0.251	0.381	0.562	0.792	0.73	0.751	0.635	0.802	0.797	0.74	0.64
13.25	318	0.264	0.263	0.406	0.562	0.792	0.73	0.755	0.634	0.98	0.976	0.897	0.754
13.5	324	0.261	0.264	0.407	0.558	0.791	0.726	0.756	0.628	0.983	1.236	1.121	0.906
13.75	330	0.255	0.254	0.381	0.504	0.778	0.718	0.749	0.615	0.979	1.229	1.112	0.88
14	336	0.264	0.266	0.404	0.505	0.776	0.714	0.752	0.607	0.977	0.977	0.895	0.703
14.25	342	0.281	0.29	0.456	0.647	1.271	1.113	1.188	0.902	1.844	1.825	1.576	1.092
14.5	348	0.26	0.272	0.401	0.503	0.786	0.712	0.763	0.585	1.246	1.257	1.12	0.739
14.75	354	0.248	0.259	0.375	0.486	0.775	0.698	0.753	0.565	0.968	0.975	0.888	0.561
15	360	0.253	0.27	0.379	0.477	0.784	0.401	0.889	0.636	1.234	1.244	1.105	0.619
15.25	366	0.253	0.274	0.391	0.482	0.771	0.692	0.883	0.593	1.234	1.024	1.102	0.508
15.5	372	0.252	0.273	0.373	0.443	0.77	0.689	0.89	0.566	1.24	1.251	1.105	0.444
15.75	378	0.249	0.263	0.363	0.434	0.65	0.583	0.739	0.45	0.963	0.974	0.879	0.331
16	384	0.255	0.272	0.362	0.424	0.65	0.576	0.731	0.433	0.956	0.971	0.876	0.311
16.25	390	0.254	0.275	0.363	0.421	0.644	0.569	0.732	0.415	0.964	1.237	1.094	0.372
16.5	396	0.254	0.278	0.366	0.418	0.642	0.562	0.737	0.403	0.971	1.236	1.094	0.361
16.75	402	0.246	0.265	0.353	0.404	0.571	0.496	0.636	0.355	0.952	1.218	1.075	0.352
17	408	0.247	0.265	0.347	0.395	0.564	0.486	0.633	0.341	0.947	1.221	1.075	0.349
17.25	414	0.252	0.277	0.351	0.388	0.56	0.481	0.637	0.329	0.954	1.223	1.073	0.343
17.5	420	0.256	0.281	0.352	0.389	0.56	0.476	0.727	0.353	0.968	1.235	1.077	0.338
17.75	426	0.257	0.284	0.353	0.386	0.562	0.469	0.724	0.33	1.23	1.728	1.453	0.444
18	432	0.261	0.29	0.359	0.387	0.569	0.465	0.736	0.32	1.232	1.752	1.46	0.442
18.25	438	0.256	0.284	0.347	0.373	0.549	0.441	0.639	0.275	0.961	1.239	1.067	0.329
18.5	444	0.249	0.272	0.333	0.351	0.499	0.396	0.619	0.264	0.948	1.223	1.044	0.324
18.75	450	0.25	0.271	0.331	0.335	0.489	0.378	0.561	0.234	0.944	1.221	1.036	0.323
19	456	0.255	0.281	0.335	0.322	0.482	0.364	0.557	0.226	0.941	1.218	1.023	0.322
19.25	462	0.258	0.284	0.337	0.334	0.488	0.361	0.618	0.247	0.945	1.236	1.033	0.324
19.5	468	0.259	0.287	0.336	0.328	0.488	0.35	0.615	0.242	0.945	1.238	1.023	0.323
19.75	474	0.257	0.283	0.331	0.326	0.443	0.327	0.541	0.212	0.778	1.208	0.997	0.32
20	480	0.259	0.287	0.333	0.317	0.474	0.333	0.552	0.21	0.935	1.221	0.993	0.322
20.25	486	0.262	0.289	0.339	0.328	0.447	0.321	0.549	0.21	0.939	1.231	0.986	0.32
20.5	492	0.264	0.292	0.336	0.31	0.467	0.321	0.548	0.204	0.928	1.218	0.956	0.321
20.75	498	0.266	0.298	0.331	0.299	0.459	0.313	0.545	0.202	0.921	1.214	0.921	0.319
21	504	0.269	0.303	0.338	0.311	0.434	0.299	0.537	0.203	0.908	1.213	0.87	0.316
21.25	510	0.286	0.332	0.359	0.308	0.475	0.31	0.603	0.231	1.157	1.699	1.062	0.422
21.5	516	0.315	0.356	0.379	0.316	0.506	0.327	0.675	0.27	1.55	1.756	0.949	0.429
21.75	522	0.299	0.345	0.363	0.295	0.448	0.29	0.572	0.235	1.417	1.707	0.83	0.423
22	528	0.3	0.331	0.347	0.281	0.438	0.286	0.53	0.214	1.068	1.67	0.781	0.42
22.25	534	0.299	0.332	0.336	0.265	0.422	0.27	0.498	0.216	0.838	1.621	0.74	0.421
22.5	540	0.3	0.335	0.345	0.275	0.394	0.26	0.465	0.201	0.695	1.554	0.704	0.42
22.75	546	0.299	0.333	0.341	0.267	0.38	0.251	0.447	0.2	0.674	1.495	0.681	0.42
23	552	0.303	0.335	0.34	0.259	0.388	0.251	0.429	0.195	0.573	1.413	0.664	0.419
23.25	558	0.301	0.335	0.333	0.248	0.381	0.246	0.42	0.194	0.522	1.037	0.513	0.322
23.5	564	0.299	0.334	0.326	0.236	0.371	0.24	0.407	0.191	0.505	0.977	0.511	0.32
23.75	570	0.299	0.334	0.321	0.231	0.363	0.236	0.4	0.19	0.497	0.798	0.427	0.268
24	576	0.3	0.335	0.318	0.227	0.357	0.232	0.394	0.19	0.505	0.759	0.433	0.272
24.25	582	0.301	0.337	0.314	0.22	0.349	0.228	0.389	0.19	0.461	0.644	0.379	0.236
24.5	588	0.301	0.337	0.309	0.214	0.34	0.224	0.397	0.196	0.47	0.634	0.381	0.235
24.75	594	0.302	0.337	0.303	0.21	0.331	0.22	0.387	0.194	0.452	0.553	0.342	0.205
25	600	0.303	0.338	0.3	0.209	0.323	0.221	0.397	0.191	0.442	0.547	0.345	0.206
25.25	606	0.304	0.337	0.302	0.221	0.321	0.224	0.388	0.198	0.453	0.55	0.352	0.213
25.5	612	0.306	0.34	0.297	0.216	0.312	0.221	0.397	0.196	0.437	0.495	0.317	0.189
25.75	618	0.306	0.341	0.288	0.207	0.342	0.229	0.377	0.195	0.432	0.484	0.314	0.188
26	624	0.309	0.34	0.283	0.307	0.342	0.229	0.379	0.194	0.435	0.48	0.316	0.19
26.25	630	0.309	0.34	0.285	0.216	0.312	0.223	0.396	0.206	0.441	0.479	0.319	0.193
26.5	636	0.313	0.345	0.281	0.211	0.344	0.232	0.382	0.198	0.449	0.486	0.328	0.198
26.75	642	0.313	0.345	0.272	0.202	0.337	0.227	0.376	0.196	0.418	0.442	0.298	0.178
27	648	0.314	0.344	0.27	0.204	0.334	0.225	0.377	0.197	0.42	0.44	0.298	0.178
27.25	654	0.315	0.343	0.266	0.204	0.333	0.224	0.377	0.197	0.42	0.44	0.298	0.179
27.5	660	0.316	0.344	0.257	0.196	0.327	0.219	0.372	0.196	0.415	0.43	0.293	0.176
27.75	666	0.316	0.346	0.251	0.191	0.319	0.215	0.368	0.194	0.411	0.434	0.295	0.178
28	672	0.321	0.351	0.25	0.194	0.324	0.217	0.377	0.197	0.436	0.455	0.314	0.19

Changes in Conductivity (mS)
Cycle 5: Column 5 (CTL)

Time (d)	Time (h)	Depth (in.)		2	3	4	5	6	7	8	9	10	11
		0	1										
-0.25	-6	0.475	0.438	0.398	0.411	0.402	0.404	0.399	0.391	0.391	0.386	0.382	0.001
0	0	0.491	0.457	0.422	0.447	0.442	0.447	0.444	0.436	0.438	0.433	0.429	0.001
0.04	1	0.496	0.461	0.425	0.449	0.443	0.448	0.445	0.437	0.439	0.435	0.431	0.001
0.08	2	0.499	0.463	0.427	0.45	0.442	0.447	0.443	0.435	0.437	0.432	0.429	0.001
0.13	3	0.5	0.463	0.426	0.45	0.442	0.446	0.443	0.434	0.436	0.431	0.428	0.001
0.17	4	0.5	0.462	0.426	0.449	0.441	0.445	0.442	0.434	0.435	0.43	0.427	0.001
0.21	5	0.501	0.463	0.427	0.45	0.443	0.447	0.444	0.435	0.436	0.431	0.427	0.001
0.25	6	0.5	0.462	0.425	0.448	0.441	0.444	0.442	0.433	0.434	0.429	0.425	0.001
0.29	7	0.5	0.462	0.425	0.447	0.44	0.444	0.442	0.433	0.434	0.429	0.425	0.001
0.33	8	0.499	0.461	0.424	0.447	0.44	0.444	0.442	0.433	0.434	0.429	0.425	0.001
0.38	9	0.499	0.46	0.423	0.446	0.44	0.444	0.442	0.432	0.434	0.429	0.425	0.001
0.42	10	0.5	0.464	0.426	0.448	0.441	0.444	0.442	0.432	0.433	0.428	0.425	0.001
0.46	11	0.305	0.292	0.274	0.285	0.282	0.284	0.283	0.279	0.28	0.278	0.276	0.001
0.5	12	0.219	0.212	0.201	0.208	0.207	0.208	0.207	0.205	0.206	0.205	0.203	0.001
0.75	18	0.12	0.117	0.111	0.099	0.113	0.113	0.112	0.111	0.112	0.112	0.111	0.001
1	24	0.106	0.104	0.099	0.089	0.099	0.099	0.098	0.097	0.097	0.097	0.096	0.001
1.25	30	0.095	0.093	0.088	0.09	0.089	0.088	0.088	0.087	0.087	0.086	0.085	0.001
1.5	36	0.095	0.092	0.088	0.089	0.088	0.088	0.087	0.086	0.086	0.086	0.085	0.001
1.75	42	0.094	0.092	0.087	0.089	0.088	0.087	0.087	0.086	0.086	0.086	0.085	0.001
2	48	0.094	0.092	0.087	0.089	0.088	0.087	0.086	0.086	0.086	0.085	0.084	0.001
2.25	54	0.106	0.103	0.098	0.1	0.099	0.098	0.098	0.097	0.097	0.096	0.095	0.001
2.5	60	0.106	0.104	0.098	0.1	0.099	0.099	0.098	0.097	0.097	0.097	0.096	0.001
2.75	66	0.106	0.103	0.098	0.1	0.099	0.098	0.097	0.096	0.097	0.096	0.095	0.001
3	72	0.107	0.104	0.098	0.101	0.099	0.099	0.098	0.097	0.097	0.097	0.096	0.001
3.25	78	0.107	0.105	0.099	0.101	0.1	0.099	0.098	0.097	0.097	0.097	0.096	0.001
3.5	84	0.107	0.104	0.098	0.101	0.099	0.099	0.098	0.097	0.097	0.097	0.096	0.001
3.75	90	0.107	0.104	0.098	0.101	0.099	0.099	0.098	0.097	0.097	0.097	0.096	0.001
4	96	0.106	0.104	0.098	0.101	0.1	0.099	0.099	0.098	0.098	0.098	0.097	0.001
4.25	102	0.108	0.105	0.099	0.102	0.1	0.1	0.099	0.098	0.098	0.098	0.097	0.001
4.5	108	0.107	0.104	0.099	0.101	0.1	0.1	0.099	0.098	0.098	0.097	0.096	0.001
4.75	114	0.095	0.092	0.088	0.089	0.088	0.088	0.087	0.086	0.086	0.086	0.085	0.001
5	120	0.095	0.092	0.087	0.089	0.088	0.088	0.087	0.086	0.086	0.086	0.085	0.001
5.25	126	0.095	0.093	0.088	0.09	0.089	0.088	0.087	0.086	0.086	0.086	0.085	0.001
5.5	132	0.107	0.104	0.098	0.101	0.099	0.099	0.098	0.097	0.097	0.097	0.096	0.001
5.75	138	0.094	0.092	0.087	0.089	0.088	0.087	0.086	0.086	0.086	0.085	0.084	0.001
6	144	0.095	0.093	0.088	0.08	0.088	0.088	0.087	0.086	0.086	0.086	0.085	0.001
6.25	150	0.095	0.093	0.088	0.08	0.089	0.088	0.087	0.086	0.086	0.086	0.085	0.001
6.5	156	0.095	0.092	0.087	0.089	0.088	0.088	0.087	0.086	0.086	0.086	0.085	0.001
6.75	162	0.094	0.092	0.087	0.089	0.088	0.088	0.087	0.086	0.086	0.086	0.085	0.001
7	168	0.095	0.093	0.088	0.08	0.089	0.088	0.087	0.086	0.087	0.086	0.085	0.001
7.25	174	0.107	0.104	0.099	0.115	0.1	0.1	0.099	0.098	0.098	0.098	0.097	0.001
7.5	180	0.122	0.119	0.112	0.115	0.114	0.114	0.113	0.112	0.112	0.112	0.111	0.001
7.75	186	0.107	0.104	0.099	0.101	0.1	0.099	0.098	0.097	0.098	0.097	0.096	0.001
8	192	0.107	0.104	0.099	0.089	0.1	0.1	0.099	0.098	0.098	0.098	0.096	0.001
8.25	198	0.123	0.12	0.113	0.136	0.115	0.115	0.114	0.113	0.113	0.113	0.111	0.001
8.5	204	0.123	0.12	0.113	0.116	0.115	0.115	0.114	0.113	0.113	0.113	0.111	0.001
8.75	210	0.122	0.119	0.112	0.1	0.114	0.114	0.113	0.112	0.112	0.112	0.111	0.001
9	216	0.122	0.119	0.113	0.1	0.114	0.114	0.113	0.112	0.112	0.112	0.111	0.001
9.25	222	0.145	0.14	0.132	0.164	0.135	0.135	0.133	0.132	0.133	0.132	0.131	0.001
9.5	228	0.145	0.14	0.132	0.116	0.135	0.134	0.133	0.132	0.132	0.132	0.131	0.001
9.75	234	0.144	0.14	0.132	0.115	0.135	0.134	0.133	0.132	0.132	0.132	0.131	0.001
10	240	0.145	0.14	0.132	0.116	0.135	0.135	0.133	0.132	0.133	0.132	0.131	0.001
10.25	246	0.176	0.169	0.159	0.136	0.163	0.163	0.162	0.16	0.161	0.16	0.159	0.001
10.5	252	0.176	0.169	0.159	0.136	0.163	0.163	0.162	0.161	0.161	0.161	0.159	0.001
10.75	258	0.176	0.17	0.16	0.165	0.164	0.164	0.163	0.161	0.162	0.161	0.16	0.001
11	264	0.176	0.169	0.16	0.164	0.164	0.164	0.162	0.161	0.162	0.161	0.159	0.001
11.25	270	0.176	0.169	0.16	0.164	0.164	0.164	0.162	0.161	0.161	0.161	0.159	0.001
11.5	276	0.224	0.213	0.2	0.207	0.206	0.207	0.206	0.204	0.205	0.204	0.202	0.001
11.75	282	0.176	0.169	0.16	0.164	0.163	0.163	0.162	0.161	0.161	0.161	0.159	0.001

12	288	0.175	0.169	0.159	0.164	0.163	0.163	0.162	0.16	0.161	0.161	0.159	0.001
12.25	294	0.222	0.212	0.199	0.206	0.205	0.206	0.205	0.203	0.204	0.203	0.201	0.001
12.5	300	0.174	0.168	0.158	0.163	0.162	0.162	0.161	0.16	0.16	0.16	0.158	0.001
12.75	306	0.222	0.212	0.199	0.206	0.205	0.206	0.205	0.202	0.204	0.203	0.201	0.001
13	312	0.176	0.169	0.159	0.164	0.163	0.163	0.162	0.16	0.161	0.16	0.159	0.001
13.25	318	0.223	0.213	0.2	0.207	0.206	0.206	0.205	0.203	0.204	0.203	0.201	0.001
13.5	324	0.306	0.287	0.268	0.28	0.279	0.281	0.28	0.277	0.279	0.277	0.275	0.001
13.75	330	0.305	0.286	0.267	0.279	0.279	0.281	0.279	0.276	0.278	0.276	0.274	0.001
14	336	0.221	0.212	0.199	0.206	0.206	0.206	0.205	0.203	0.204	0.204	0.202	0.001
14.25	342	0.496	0.448	0.411	0.437	0.436	0.443	0.442	0.436	0.439	0.436	0.432	0.001
14.5	348	0.303	0.286	0.267	0.279	0.278	0.28	0.279	0.276	0.277	0.276	0.273	0.001
14.75	354	0.219	0.209	0.197	0.204	0.203	0.204	0.203	0.201	0.202	0.201	0.199	0.001
15	360	0.301	0.284	0.265	0.277	0.276	0.278	0.277	0.274	0.275	0.274	0.271	0.001
15.25	366	0.303	0.285	0.266	0.278	0.277	0.279	0.278	0.275	0.276	0.275	0.272	0.001
15.5	372	0.303	0.285	0.266	0.278	0.277	0.279	0.278	0.274	0.276	0.274	0.272	0.001
15.75	378	0.219	0.209	0.197	0.204	0.203	0.204	0.203	0.201	0.202	0.201	0.199	0.001
16	384	0.219	0.209	0.196	0.204	0.203	0.203	0.202	0.2	0.201	0.201	0.199	0.001
16.25	390	0.302	0.284	0.265	0.277	0.276	0.278	0.277	0.274	0.275	0.273	0.271	0.001
16.5	396	0.302	0.285	0.266	0.278	0.276	0.278	0.277	0.274	0.275	0.274	0.271	0.001
16.75	402	0.302	0.285	0.266	0.278	0.276	0.278	0.277	0.274	0.275	0.274	0.271	0.001
17	408	0.302	0.285	0.266	0.278	0.276	0.278	0.277	0.274	0.275	0.273	0.271	0.001
17.25	414	0.302	0.285	0.266	0.277	0.276	0.278	0.277	0.274	0.275	0.273	0.271	0.001
17.5	420	0.303	0.285	0.266	0.278	0.276	0.278	0.277	0.274	0.275	0.273	0.271	0.001
17.75	426	0.493	0.445	0.408	0.433	0.431	0.437	0.435	0.428	0.429	0.425	0.421	0.001
18	432	0.494	0.445	0.409	0.434	0.432	0.437	0.436	0.429	0.43	0.426	0.423	0.001
18.25	438	0.304	0.286	0.267	0.278	0.277	0.279	0.278	0.274	0.276	0.274	0.272	0.001
18.5	444	0.304	0.286	0.266	0.278	0.277	0.279	0.277	0.274	0.275	0.274	0.271	0.001
18.75	450	0.303	0.285	0.265	0.277	0.276	0.278	0.277	0.273	0.274	0.273	0.27	0.001
19	456	0.304	0.285	0.266	0.277	0.276	0.278	0.277	0.274	0.275	0.274	0.271	0.001
19.25	462	0.306	0.286	0.267	0.278	0.277	0.279	0.278	0.275	0.276	0.275	0.272	0.001
19.5	468	0.305	0.286	0.266	0.278	0.277	0.278	0.277	0.274	0.275	0.274	0.271	0.001
19.75	474	0.304	0.286	0.266	0.278	0.276	0.278	0.277	0.274	0.275	0.273	0.271	0.001
20	480	0.306	0.287	0.267	0.278	0.277	0.279	0.278	0.275	0.276	0.274	0.272	0.001
20.25	486	0.307	0.287	0.267	0.279	0.278	0.279	0.278	0.275	0.276	0.275	0.272	0.001
20.5	492	0.305	0.286	0.266	0.278	0.277	0.278	0.277	0.274	0.275	0.274	0.271	0.001
20.75	498	0.303	0.285	0.266	0.277	0.276	0.277	0.276	0.273	0.274	0.272	0.27	0.001
21	504	0.303	0.287	0.267	0.279	0.277	0.279	0.278	0.275	0.276	0.274	0.271	0.001
21.25	510	0.495	0.448	0.41	0.435	0.431	0.438	0.436	0.43	0.432	0.428	0.425	0.001
21.5	516	0.494	0.448	0.41	0.436	0.432	0.438	0.437	0.431	0.434	0.43	0.427	0.001
21.75	522	0.492	0.446	0.409	0.434	0.43	0.436	0.434	0.427	0.429	0.425	0.422	0.001
22	528	0.492	0.445	0.407	0.433	0.429	0.436	0.434	0.428	0.43	0.426	0.423	0.001
22.25	534	0.491	0.445	0.408	0.434	0.429	0.435	0.433	0.426	0.427	0.423	0.419	0.001
22.5	540	0.49	0.444	0.407	0.433	0.428	0.434	0.432	0.425	0.426	0.421	0.418	0.001
22.75	546	0.49	0.444	0.407	0.432	0.428	0.434	0.432	0.425	0.426	0.421	0.417	0.001
23	552	0.489	0.443	0.406	0.431	0.427	0.433	0.432	0.424	0.425	0.421	0.417	0.001
23.25	558	0.301	0.284	0.265	0.277	0.275	0.277	0.276	0.272	0.273	0.272	0.269	0.001
23.5	564	0.301	0.283	0.264	0.276	0.274	0.276	0.275	0.272	0.272	0.271	0.268	0.001
23.75	570	0.218	0.209	0.196	0.203	0.201	0.202	0.201	0.199	0.2	0.199	0.197	0.001
24	576	0.219	0.208	0.195	0.202	0.201	0.201	0.201	0.199	0.199	0.198	0.196	0.001
24.25	582	0.171	0.165	0.155	0.132	0.158	0.158	0.158	0.156	0.157	0.156	0.155	0.001
24.5	588	0.172	0.166	0.155	0.132	0.158	0.158	0.158	0.156	0.156	0.156	0.154	0.001
24.75	594	0.142	0.137	0.129	0.159	0.131	0.13	0.13	0.128	0.129	0.128	0.127	0.001
25	600	0.143	0.138	0.13	0.16	0.131	0.131	0.13	0.129	0.129	0.128	0.127	0.001
25.25	606	0.145	0.14	0.131	0.162	0.132	0.132	0.131	0.13	0.13	0.129	0.128	0.001
25.5	612	0.123	0.12	0.112	0.134	0.113	0.112	0.112	0.11	0.11	0.11	0.109	0.001
25.75	618	0.122	0.119	0.111	0.114	0.112	0.112	0.111	0.11	0.11	0.11	0.108	0.001
26	624	0.123	0.119	0.112	0.114	0.113	0.112	0.111	0.11	0.11	0.11	0.108	0.001
26.25	630	0.123	0.12	0.112	0.1	0.113	0.112	0.112	0.11	0.111	0.11	0.109	0.001
26.5	636	0.124	0.12	0.112	0.1	0.113	0.113	0.112	0.111	0.111	0.11	0.109	0.001
26.75	642	0.108	0.105	0.098	0.089	0.099	0.098	0.097	0.096	0.096	0.096	0.095	0.001
27	648	0.109	0.106	0.099	0.089	0.099	0.099	0.098	0.097	0.097	0.097	0.095	0.001
27.25	654	0.109	0.106	0.099	0.115	0.099	0.099	0.098	0.097	0.097	0.097	0.095	0.001
27.5	660	0.108	0.105	0.098	0.114	0.099	0.098	0.097	0.096	0.096	0.096	0.095	0.001
27.75	666	0.108	0.105	0.098	0.1	0.099	0.098	0.097	0.096	0.096	0.096	0.095	0.001
28	672	0.122	0.119	0.112	0.133	0.113	0.113	0.112	0.111	0.111	0.111	0.11	0.001

Changes in Conductivity (mS)
 Cycle 5: Column 4 - Column 5: (EXP-CTL)

Time (d)	Time (h)	Depth (m.)											
		0	1	2	3	4	5	6	7	8	9	10	11
-0.25	-6	-0.191	-0.093	0.373	1.075	1.078	0.308	0.499	1.223	1.66	1.903	1.374	0.699
0.00	0	0.303	0.538	0.988	1.549	1.518	0.331	0.58	1.695	2.61	2.654	1.999	0.786
0.04	1	0.471	0.62	1.146	1.838	1.777	0.37	0.654	1.965	2.651	2.585	1.156	0.506
0.08	2	0.155	0.579	1.108	1.75	1.69	0.355	0.567	1.718	1.33	1.053	0.783	0.383
0.13	3	-0.109	0.474	0.968	1.476	1.421	0.303	0.381	1.277	0.973	0.814	0.596	0.222
0.17	4	-0.169	0.221	0.873	1.339	1.276	0.264	0.273	1.077	0.809	0.703	0.517	0.196
0.21	5	-0.206	0.065	0.8	1.242	1.175	0.226	0.181	0.847	0.705	0.631	0.469	0.434
0.25	6	-0.234	-0.04	0.724	1.138	1.036	0.164	0.079	0.671	0.638	0.573	0.432	0.427
0.29	7	-0.243	-0.082	0.484	1.055	0.915	0.108	0.028	0.597	0.592	0.535	0.404	0.423
0.33	8	-0.252	-0.101	0.237	0.959	0.809	0.072	0.018	0.532	0.552	0.509	0.377	0.418
0.38	9	-0.257	-0.127	0.151	0.904	0.744	0.04	0.015	0.486	0.526	0.489	0.359	0.415
0.42	10	-0.265	-0.143	0.082	0.849	0.699	0.018	0.011	0.449	0.501	0.475	0.341	0.413
0.46	11	-0.081	0.004	0.178	0.706	0.529	0.002	-0.015	0.282	0.312	0.298	0.231	0.25
0.5	12	0.004	0.078	0.24	0.607	0.428	0.002	-0.015	0.211	0.233	0.223	0.181	0.182
0.75	18	0.097	0.15	0.253	0.425	0.285	0.007	-0.008	0.126	0.143	0.136	0.112	0.098
1	24	0.114	0.165	0.266	0.394	0.277	0.007	-0.008	0.113	0.132	0.126	0.101	0.084
1.25	30	0.137	0.184	0.255	0.338	0.182	0.013	-0.006	0.111	0.133	0.128	0.098	0.076
1.5	36	0.144	0.191	0.255	0.341	0.176	0.015	-0.005	0.115	0.14	0.134	0.097	0.076
1.75	42	0.144	0.184	0.243	0.335	0.169	0.014	-0.004	0.114	0.14	0.134	0.092	0.075
2	48	0.143	0.179	0.229	0.338	0.164	0.014	-0.005	0.112	0.139	0.136	0.169	0.074
2.25	54	0.13	0.164	0.209	0.348	0.177	0.015	-0.005	0.122	0.151	0.146	0.178	0.083
2.5	60	0.131	0.16	0.205	0.353	0.174	0.013	-0.006	0.121	0.149	0.143	0.069	0.083
2.75	66	0.13	0.157	0.203	0.342	0.169	0.013	-0.006	0.119	0.145	0.142	0.052	0.082
3	72	0.129	0.154	0.203	0.362	0.173	0.013	-0.007	0.121	0.147	0.142	0.036	0.082
3.25	78	0.13	0.152	0.203	0.362	0.17	0.013	-0.008	0.121	0.15	0.142	0.028	0.082
3.5	84	0.133	0.154	0.209	0.343	0.165	0.012	-0.008	0.117	0.145	0.14	0.023	0.082
3.75	90	0.135	0.155	0.212	0.347	0.166	0.012	-0.008	0.116	0.145	0.142	0.02	0.082
4	96	0.139	0.155	0.214	0.336	0.166	0.013	-0.009	0.115	0.145	0.141	0.018	0.082
4.25	102	0.132	0.149	0.206	0.355	0.169	0.013	-0.01	0.114	0.147	0.143	0.016	0.082
4.5	108	0.135	0.151	0.207	0.36	0.172	0.013	-0.01	0.113	0.152	0.147	0.016	-0.014
4.75	114	0.146	0.161	0.214	0.326	0.153	0.011	-0.009	0.099	0.137	0.137	0.014	0.071
5	120	0.151	0.163	0.217	0.32	0.156	0.012	-0.009	0.096	0.137	0.138	0.013	0.072
5.25	126	0.154	0.164	0.22	0.324	0.163	0.013	-0.008	0.094	0.143	0.143	0.013	0.072
5.5	132	0.14	0.152	0.214	0.35	0.192	0.015	-0.009	0.099	0.166	0.167	0.017	0.081
5.75	138	0.153	0.162	0.223	0.317	0.17	0.014	-0.007	0.083	0.151	0.155	0.018	0.072
6	144	0.151	0.159	0.223	0.317	0.18	0.015	-0.008	0.08	0.16	0.164	0.02	0.072
6.25	150	0.149	0.155	0.218	0.314	0.183	0.015	-0.007	0.077	0.172	0.177	0.022	0.072
6.5	156	0.151	0.161	0.231	0.316	0.193	0.018	-0.002	0.08	0.19	0.198	0.027	0.072
6.75	162	0.157	0.162	0.23	0.311	0.206	0.021	0.005	0.084	0.209	0.219	0.037	0.072
7	168	0.15	0.159	0.233	0.311	0.229	0.026	0.01	0.095	0.243	0.252	0.055	0.072
7.25	174	0.155	0.172	0.255	0.314	0.242	0.031	0.006	0.114	0.284	0.296	0.071	0.083
7.5	180	0.123	0.132	0.21	0.327	0.258	0.025	-0.002	0.136	0.307	0.318	0.105	0.095
7.75	186	0.135	0.14	0.21	0.312	0.262	0.046	0.005	0.174	0.295	0.347	0.152	0.081
8	192	0.138	0.139	0.212	0.317	0.3	0.08	0.02	0.225	0.368	0.393	0.235	0.082
8.25	198	0.137	0.122	0.191	0.267	0.32	0.106	0.036	0.26	0.373	0.406	0.285	0.098
8.5	204	0.12	0.116	0.19	0.307	0.349	0.151	0.089	0.306	0.387	0.442	0.347	0.129
8.75	210	0.122	0.115	0.19	0.328	0.385	0.216	0.132	0.33	0.44	0.45	0.376	0.199
9	216	0.128	0.119	0.204	0.37	0.429	0.296	0.198	0.373	0.447	0.442	0.384	0.255
9.25	222	0.1	0.088	0.192	0.329	0.52	0.386	0.302	0.426	0.513	0.503	0.442	0.33
9.5	228	0.105	0.095	0.201	0.432	0.514	0.416	0.382	0.432	0.519	0.512	0.455	0.387
9.75	234	0.105	0.091	0.222	0.449	0.528	0.438	0.426	0.443	0.53	0.521	0.469	0.462
10	240	0.106	0.098	0.226	0.447	0.528	0.448	0.447	0.445	0.532	0.525	0.476	0.516
10.25	246	0.076	0.063	0.203	0.432	0.623	0.525	0.535	0.517	0.629	0.619	0.588	0.634
10.5	252	0.08	0.074	0.212	0.507	0.626	0.529	0.548	0.511	0.631	0.622	0.564	0.655
10.75	258	0.081	0.078	0.242	0.494	0.633	0.534	0.56	0.514	0.636	0.631	0.575	0.673
11	264	0.082	0.082	0.245	0.496	0.639	0.538	0.568	0.512	0.637	0.634	0.577	0.675
11.25	270	0.078	0.073	0.244	0.495	0.638	0.534	0.572	0.507	0.636	0.631	0.577	0.672
11.5	276	0.033	0.032	0.206	0.451	0.769	0.673	0.681	0.592	0.77	0.763	0.684	0.797
11.75	282	0.086	0.087	0.246	0.485	0.636	0.569	0.578	0.5	0.64	0.633	0.578	0.663

12	288	0.087	0.089	0.249	0.482	0.634	0.568	0.58	0.494	0.64	0.637	0.583	0.662
12.25	294	0.035	0.036	0.184	0.363	0.587	0.524	0.537	0.445	0.597	0.762	0.689	0.783
12.5	300	0.088	0.09	0.225	0.403	0.622	0.559	0.576	0.477	0.636	0.633	0.579	0.652
12.75	306	0.033	0.038	0.208	0.366	0.755	0.669	0.69	0.558	0.773	0.767	0.689	0.769
13	312	0.081	0.082	0.222	0.398	0.629	0.567	0.589	0.475	0.641	0.637	0.581	0.639
13.25	318	0.041	0.05	0.206	0.355	0.586	0.524	0.55	0.431	0.776	0.773	0.696	0.733
13.5	324	-0.045	-0.023	0.139	0.278	0.512	0.445	0.476	0.351	0.704	0.959	0.846	0.905
13.75	330	-0.05	-0.032	0.114	0.225	0.499	0.437	0.47	0.339	0.701	0.953	0.838	0.879
14	336	0.043	0.054	0.205	0.299	0.57	0.508	0.547	0.404	0.773	0.773	0.693	0.702
14.25	342	-0.215	-0.158	0.045	0.21	0.835	0.67	0.746	0.466	1.405	1.389	1.144	1.091
14.5	348	-0.043	-0.014	0.134	0.224	0.508	0.432	0.484	0.309	0.969	0.981	0.847	0.738
14.75	354	0.029	0.05	0.178	0.282	0.572	0.494	0.55	0.364	0.766	0.774	0.689	0.56
15	360	-0.048	-0.014	0.114	0.2	0.508	0.123	0.612	0.362	0.959	0.97	0.834	0.618
15.25	366	-0.05	-0.011	0.125	0.204	0.494	0.413	0.605	0.318	0.958	-0.151	0.833	0.507
15.5	372	-0.051	-0.012	0.107	0.165	0.493	0.41	0.612	0.292	0.964	0.977	0.833	0.443
15.75	378	0.03	0.054	0.166	0.23	0.447	0.379	0.536	0.249	0.761	0.773	0.68	0.33
16	384	0.036	0.063	0.166	0.22	0.447	0.373	0.529	0.233	0.755	0.77	0.677	0.31
16.25	390	-0.048	-0.009	0.098	0.144	0.368	0.291	0.455	0.141	0.689	0.964	0.823	0.371
16.5	396	-0.048	-0.007	0.1	0.14	0.366	0.284	0.46	0.129	0.696	0.962	0.823	0.36
16.75	402	-0.056	-0.02	0.087	0.126	0.295	0.218	0.359	0.081	0.677	0.944	0.804	0.351
17	408	-0.055	-0.02	0.081	0.117	0.288	0.208	0.356	0.067	0.672	0.948	0.804	0.348
17.25	414	-0.05	-0.008	0.085	0.111	0.284	0.203	0.36	0.055	0.679	0.95	0.802	0.342
17.5	420	-0.047	-0.004	0.086	0.111	0.284	0.198	0.45	0.079	0.693	0.962	0.806	0.337
17.75	426	-0.236	-0.161	-0.055	-0.047	0.131	0.032	0.289	-0.098	0.801	1.303	1.032	0.443
18	432	-0.233	-0.155	-0.05	-0.047	0.137	0.028	0.3	-0.109	0.802	1.326	1.037	0.441
18.25	438	-0.048	-0.002	0.08	0.095	0.272	0.162	0.361	0.001	0.685	0.965	0.795	0.328
18.5	444	-0.055	-0.014	0.067	0.073	0.222	0.117	0.342	-0.01	0.673	0.949	0.773	0.323
18.75	450	-0.053	-0.014	0.066	0.058	0.213	0.1	0.284	-0.039	0.67	0.948	0.766	0.322
19	456	-0.049	-0.004	0.069	0.045	0.206	0.086	0.28	-0.048	0.666	0.944	0.752	0.321
19.25	462	-0.048	-0.002	0.07	0.056	0.211	0.082	0.34	-0.028	0.669	0.961	0.761	0.323
19.5	468	-0.046	0.001	0.07	0.05	0.211	0.072	0.338	-0.032	0.67	0.964	0.752	0.322
19.75	474	-0.047	-0.003	0.065	0.048	0.167	0.049	0.264	-0.062	0.503	0.935	0.726	0.319
20	480	-0.047	0	0.066	0.039	0.197	0.054	0.274	-0.065	0.659	0.947	0.721	0.321
20.25	486	-0.045	0.002	0.072	0.049	0.169	0.042	0.271	-0.065	0.663	0.956	0.714	0.319
20.5	492	-0.041	0.006	0.07	0.032	0.19	0.043	0.271	-0.07	0.653	0.944	0.685	0.32
20.75	498	-0.037	0.013	0.065	0.022	0.183	0.036	0.269	-0.071	0.647	0.942	0.651	0.318
21	504	-0.034	0.016	0.071	0.032	0.157	0.02	0.259	-0.072	0.632	0.939	0.599	0.315
21.25	510	-0.209	-0.116	-0.051	-0.127	0.044	-0.128	0.167	-0.199	0.725	1.271	0.637	0.421
21.5	516	-0.179	-0.101	-0.031	-0.12	0.074	-0.111	0.238	-0.161	1.116	1.326	0.522	0.428
21.75	522	-0.193	-0.101	-0.046	-0.139	0.018	-0.146	0.138	-0.192	0.988	1.282	0.408	0.422
22	528	-0.192	-0.114	-0.06	-0.152	0.009	-0.15	0.096	-0.214	0.638	1.244	0.358	0.419
22.25	534	-0.192	-0.113	-0.072	-0.169	-0.007	-0.165	0.065	-0.21	0.411	1.198	0.321	0.42
22.5	540	-0.19	-0.109	-0.062	-0.158	-0.034	-0.174	0.033	-0.224	0.269	1.133	0.286	0.419
22.75	546	-0.191	-0.111	-0.066	-0.165	-0.048	-0.183	0.015	-0.225	0.248	1.074	0.264	0.419
23	552	-0.186	-0.108	-0.066	-0.172	-0.039	-0.182	-0.003	-0.229	0.148	0.992	0.247	0.418
23.25	558	0	0.051	0.068	-0.029	0.106	-0.031	0.144	-0.078	0.249	0.765	0.244	0.321
23.5	564	-0.002	0.051	0.062	-0.04	0.097	-0.036	0.132	-0.081	0.233	0.706	0.243	0.319
23.75	570	0.081	0.125	0.125	0.028	0.162	0.034	0.199	-0.009	0.297	0.599	0.23	0.267
24	576	0.081	0.127	0.123	0.025	0.156	0.031	0.193	-0.009	0.306	0.561	0.237	0.271
24.25	582	0.13	0.172	0.159	0.088	0.191	0.07	0.231	0.034	0.304	0.488	0.224	0.235
24.5	588	0.129	0.171	0.154	0.082	0.182	0.066	0.239	0.04	0.314	0.478	0.227	0.234
24.75	594	0.16	0.2	0.174	0.051	0.2	0.09	0.257	0.066	0.323	0.425	0.215	0.204
25	600	0.16	0.2	0.17	0.049	0.192	0.09	0.267	0.062	0.313	0.419	0.218	0.205
25.25	606	0.159	0.197	0.171	0.059	0.189	0.092	0.257	0.068	0.323	0.421	0.224	0.212
25.5	612	0.183	0.22	0.185	0.082	0.199	0.109	0.285	0.086	0.327	0.385	0.208	0.188
25.75	618	0.184	0.222	0.177	0.093	0.23	0.117	0.266	0.085	0.322	0.374	0.206	0.187
26	624	0.186	0.221	0.171	0.193	0.229	0.117	0.268	0.084	0.325	0.37	0.208	0.189
26.25	630	0.186	0.22	0.173	0.116	0.199	0.111	0.284	0.096	0.33	0.369	0.21	0.192
26.5	636	0.189	0.225	0.169	0.111	0.231	0.119	0.27	0.087	0.338	0.376	0.219	0.197
26.75	642	0.205	0.24	0.174	0.113	0.238	0.129	0.279	0.1	0.322	0.346	0.203	0.177
27	648	0.205	0.238	0.171	0.115	0.235	0.126	0.279	0.1	0.323	0.343	0.203	0.177
27.25	654	0.206	0.237	0.167	0.089	0.234	0.125	0.279	0.1	0.323	0.343	0.203	0.178
27.5	660	0.208	0.239	0.159	0.082	0.228	0.121	0.275	0.1	0.319	0.334	0.198	0.175
27.75	666	0.208	0.241	0.153	0.091	0.22	0.117	0.271	0.098	0.315	0.338	0.2	0.177
28	672	0.199	0.232	0.138	0.061	0.211	0.104	0.265	0.086	0.325	0.344	0.204	0.189

Changes in Conductivity (mS)
 Cycle 6: Column 4 (EXP)

Time (h)	Time (d)	Depth (in.)											
		0	1	2	3	4	5	6	7	8	9	10	11
-6	-0.25	0.414	0.39	0.071	0.118	0.236	0.174	0.353	0.212	0.388	0.392	0.268	0.132
-3	-0.125	0.414	0.383	0.07	0.117	0.229	0.171	0.351	0.21	0.387	0.392	0.267	0.131
0	0	0.984	0.6	0.059	0.144	0.293	0.213	0.413	0.25	0.56	0.577	0.425	0.115
3	0.125	0.904	0.524	0.067	0.138	0.269	0.194	0.29	0.219	0.371	0.214	0.194	0.127
6	0.25	0.557	0.333	0.075	0.122	0.406	0.209	0.205	0.249	0.27	0.201	0.171	0.127
12	0.5	0.342	0.244	0.084	0.413	0.362	0.209	0.183	0.228	0.23	0.199	0.163	0.118
24	1	0.332	0.24	0.131	0.368	0.59	0.249	0.185	0.216	0.228	0.202	0.163	0.078
36	1.5	0.328	0.195	0.395	0.39	0.402	0.267	0.2	0.225	0.244	0.215	0.172	0.072
48	2	0.312	0.227	0.413	0.389	0.369	0.249	0.199	0.222	0.24	0.219	0.172	0.064
60	2.5	0.276	0.225	0.487	0.351	0.336	0.266	0.227	0.252	0.266	0.252	0.205	0.058
72	3	0.249	0.212	0.692	0.389	0.372	0.314	0.275	0.303	0.323	0.316	0.267	0.05
84	3.5	0.24	0.198	0.705	0.394	0.364	0.305	0.268	0.291	0.318	0.321	0.271	0.048
96	4	0.237	0.185	0.468	0.322	0.247	0.212	0.187	0.203	0.231	0.239	0.195	0.049
108	4.5	0.237	0.18	0.465	0.328	0.246	0.215	0.189	0.207	0.233	0.238	0.2	0.048
120	5	0.229	0.173	0.469	0.326	0.238	0.211	0.186	0.205	0.229	0.233	0.208	0.047
132	5.5	0.224	0.195	0.544	0.384	0.269	0.238	0.211	0.235	0.26	0.263	0.239	0.046
144	6	0.213	0.186	0.532	0.342	0.246	0.221	0.197	0.22	0.24	0.247	0.229	0.045
156	6.5	0.211	0.183	0.554	0.373	0.241	0.218	0.193	0.216	0.235	0.242	0.226	0.045
168	7	0.209	0.171	0.541	0.399	0.245	0.217	0.192	0.216	0.237	0.245	0.229	0.045
180	7.5	0.22	0.161	0.541	0.438	0.249	0.223	0.196	0.221	0.245	0.26	0.239	0.046
192	8	0.232	0.149	0.517	0.468	0.262	0.234	0.206	0.234	0.262	0.284	0.258	0.047
204	8.5	0.235	0.15	0.511	0.469	0.265	0.237	0.207	0.237	0.263	0.28	0.261	0.048
216	9	0.235	0.139	0.47	0.467	0.265	0.238	0.208	0.239	0.267	0.288	0.265	0.047
228	9.5	0.239	0.149	0.522	0.521	0.27	0.241	0.211	0.246	0.271	0.293	0.273	0.048
240	10	0.239	0.142	0.518	0.539	0.27	0.241	0.211	0.247	0.274	0.301	0.276	0.048
252	10.5	0.236	0.151	0.54	0.565	0.268	0.239	0.209	0.247	0.267	0.283	0.268	0.048
264	11	0.225	0.165	0.532	0.612	0.301	0.267	0.232	0.278	0.3	0.313	0.296	0.047
276	11.5	0.226	0.16	0.534	0.633	0.305	0.267	0.231	0.28	0.296	0.308	0.293	0.047
288	12	0.225	0.151	0.539	0.637	0.311	0.268	0.231	0.282	0.295	0.306	0.29	0.047
300	12.5	0.222	0.147	0.611	0.654	0.342	0.27	0.234	0.285	0.293	0.301	0.287	0.046
312	13	0.222	0.144	0.607	0.671	0.404	0.281	0.243	0.291	0.297	0.3	0.286	0.046
324	13.5	0.22	0.137	0.538	0.669	0.454	0.301	0.252	0.296	0.302	0.302	0.284	0.046
336	14	0.217	0.132	0.478	0.656	0.505	0.343	0.265	0.314	0.321	0.315	0.286	0.05
348	14.5	0.224	0.136	0.467	0.953	0.726	0.512	0.39	0.476	0.486	0.487	0.428	0.049
360	15	0.228	0.128	0.419	0.946	0.798	0.59	0.446	0.556	0.56	0.534	0.454	0.049
372	15.5	0.231	0.126	0.402	0.948	0.865	0.66	0.516	0.658	0.65	0.662	0.499	0.049
384	16	0.231	0.123	0.377	0.777	0.742	0.597	0.495	0.621	0.615	0.633	0.483	0.05
396	16.5	0.234	0.127	0.371	0.78	0.779	0.634	0.548	0.693	0.674	0.711	0.57	0.058
408	17	0.232	0.127	0.359	0.773	0.807	0.652	0.576	0.733	0.716	0.748	0.652	0.085
420	17.5	0.231	0.128	0.35	0.767	0.957	0.761	0.679	0.888	0.883	0.915	0.809	0.156
432	18	0.229	0.128	0.339	0.765	0.81	0.657	0.591	0.752	0.756	0.779	0.709	0.235
444	18.5	0.227	0.128	0.333	0.765	0.811	0.656	0.592	0.755	0.765	0.787	0.727	0.33
456	19	0.222	0.128	0.321	0.657	0.794	0.641	0.584	0.742	0.758	0.777	0.726	0.424
468	19.5	0.225	0.132	0.321	0.764	0.805	0.649	0.592	0.756	0.773	0.789	0.738	0.46
480	20	0.219	0.131	0.314	0.646	0.797	0.646	0.591	0.752	0.77	0.789	0.739	0.476
492	20.5	0.223	0.146	0.313	0.76	0.981	0.775	0.695	0.95	0.978	1.008	0.941	0.502
504	21	0.232	0.144	0.334	0.945	1.294	0.967	0.847	1.248	1.289	1.335	1.21	0.542
516	21.5	0.224	0.154	0.315	0.756	0.983	0.772	0.67	0.953	0.977	1.299	1.194	0.48
528	22	0.228	0.155	0.313	0.75	1.242	0.936	0.79	1.212	1.252	1.317	1.203	0.416
540	22.5	0.232	0.149	0.321	0.748	1.254	0.939	0.77	1.228	1.271	1.89	1.688	0.455
552	23	0.24	0.153	0.33	0.759	1.266	0.944	0.736	1.249	1.294	1.941	1.718	0.428
564	23.5	0.239	0.151	0.326	0.734	1.255	0.933	0.683	1.244	1.288	1.938	1.707	0.411
576	24	0.242	0.153	0.325	0.634	1.246	0.927	0.622	1.25	1.289	1.943	1.701	0.401
588	24.5	0.242	0.151	0.319	0.548	1.212	0.906	0.561	1.23	1.266	1.92	1.675	0.397
600	25	0.243	0.147	0.31	0.511	1.191	0.887	0.524	1.222	1.254	1.912	1.654	0.396
612	25.5	0.246	0.145	0.306	0.461	1.166	0.869	0.496	1.223	1.251	1.917	1.644	0.396
624	26	0.247	0.143	0.302	0.431	1.143	0.843	0.475	1.636	1.698	1.931	1.625	0.397
636	26.5	0.251	0.144	0.302	0.414	1.119	0.822	0.461	1.642	1.694	1.96	1.624	0.4
648	27	0.256	0.147	0.307	0.398	0.891	0.654	0.38	1.626	1.669	1.97	1.588	0.403
660	27.5	0.258	0.144	0.303	0.38	0.73	0.535	0.325	1.579	1.609	1.957	1.546	0.405

672	28	0.259	0.143	0.303	0.374	0.594	0.458	0.289	1.513	1.523	1.943	1.492	0.404
684	28.5	0.262	0.141	0.303	0.367	0.51	0.419	0.268	1.444	1.408	1.953	1.439	0.405

Changes in Conductivity (mS)
Cycle 6: Column 5 (CTL)

Time (h)	Time (d)	Depth (in.)		2	3	4	5	6	7	8	9	10	11
		0	1										
-6	-0.25	0.074	0.072	0.068	0.069	0.068	0.067	0.067	0.066	0.066	0.066	0.065	0.003
-3	-0.125	0.074	0.072	0.068	0.069	0.068	0.067	0.067	0.066	0.066	0.066	0.065	0.004
0	0	0.08	0.079	0.074	0.075	0.074	0.074	0.073	0.072	0.072	0.072	0.071	0.003
3	0.125	0.087	0.086	0.081	0.082	0.081	0.081	0.08	0.079	0.079	0.079	0.078	0.003
6	0.25	0.096	0.095	0.089	0.091	0.09	0.09	0.089	0.088	0.088	0.088	0.087	0.004
12	0.5	0.096	0.094	0.089	0.091	0.09	0.089	0.089	0.088	0.088	0.088	0.087	0.004
24	1	0.074	0.072	0.068	0.069	0.068	0.068	0.067	0.066	0.067	0.066	0.066	0.004
36	1.5	0.074	0.072	0.068	0.069	0.068	0.068	0.067	0.066	0.067	0.066	0.066	0.004
48	2	0.074	0.072	0.068	0.069	0.068	0.067	0.067	0.066	0.066	0.066	0.065	0.004
60	2.5	0.074	0.072	0.068	0.069	0.068	0.067	0.067	0.066	0.066	0.066	0.065	0.004
72	3	0.074	0.072	0.068	0.069	0.068	0.067	0.067	0.066	0.066	0.066	0.065	0.004
84	3.5	0.074	0.072	0.068	0.069	0.068	0.067	0.067	0.066	0.066	0.066	0.065	0.004
96	4	0.073	0.072	0.067	0.068	0.067	0.067	0.066	0.066	0.066	0.066	0.065	0.004
108	4.5	0.073	0.071	0.067	0.068	0.067	0.067	0.066	0.065	0.066	0.066	0.065	0.004
120	5	0.073	0.071	0.067	0.068	0.067	0.067	0.066	0.065	0.065	0.065	0.065	0.004
132	5.5	0.073	0.071	0.067	0.068	0.067	0.067	0.066	0.065	0.065	0.065	0.064	0.004
144	6	0.073	0.071	0.067	0.068	0.067	0.066	0.066	0.065	0.065	0.065	0.064	0.004
156	6.5	0.073	0.071	0.067	0.068	0.067	0.066	0.066	0.065	0.065	0.065	0.064	0.004
168	7	0.073	0.071	0.067	0.068	0.067	0.066	0.066	0.065	0.065	0.065	0.064	0.004
180	7.5	0.073	0.071	0.066	0.068	0.067	0.066	0.065	0.065	0.065	0.065	0.064	0.005
192	8	0.073	0.071	0.067	0.068	0.067	0.066	0.066	0.065	0.065	0.065	0.064	0.005
204	8.5	0.073	0.071	0.067	0.068	0.067	0.066	0.066	0.065	0.065	0.065	0.064	0.005
216	9	0.073	0.071	0.067	0.068	0.067	0.066	0.066	0.065	0.065	0.065	0.064	0.005
228	9.5	0.073	0.071	0.067	0.068	0.067	0.067	0.066	0.065	0.066	0.066	0.065	0.005
240	10	0.073	0.071	0.067	0.068	0.067	0.067	0.066	0.065	0.066	0.066	0.065	0.005
252	10.5	0.073	0.071	0.067	0.068	0.067	0.067	0.066	0.065	0.066	0.066	0.065	0.006
264	11	0.073	0.071	0.067	0.068	0.067	0.066	0.066	0.065	0.065	0.065	0.064	0.006
276	11.5	0.073	0.071	0.067	0.068	0.067	0.066	0.066	0.065	0.065	0.065	0.064	0.006
288	12	0.073	0.071	0.066	0.067	0.067	0.066	0.065	0.065	0.065	0.065	0.064	0.006
300	12.5	0.073	0.071	0.066	0.067	0.067	0.066	0.065	0.065	0.065	0.065	0.064	0.006
312	13	0.072	0.071	0.066	0.067	0.067	0.066	0.065	0.065	0.065	0.065	0.064	0.006
324	13.5	0.072	0.071	0.066	0.067	0.067	0.066	0.065	0.065	0.065	0.065	0.064	0.006
336	14	0.078	0.077	0.072	0.074	0.073	0.072	0.072	0.071	0.071	0.071	0.07	0.006
348	14.5	0.079	0.077	0.073	0.074	0.073	0.073	0.072	0.071	0.071	0.071	0.07	0.007
360	15	0.079	0.077	0.072	0.074	0.073	0.072	0.071	0.071	0.071	0.071	0.07	0.006
372	15.5	0.079	0.077	0.073	0.074	0.073	0.073	0.072	0.071	0.071	0.071	0.07	0.006
384	16	0.079	0.078	0.073	0.074	0.074	0.073	0.072	0.072	0.072	0.072	0.071	0.006
396	16.5	0.087	0.085	0.08	0.082	0.081	0.08	0.079	0.079	0.079	0.079	0.078	0.006
408	17	0.108	0.106	0.1	0.102	0.101	0.101	0.1	0.099	0.1	0.099	0.098	0.006
420	17.5	0.173	0.17	0.16	0.166	0.166	0.167	0.166	0.165	0.165	0.165	0.163	0.006
432	18	0.174	0.17	0.16	0.166	0.166	0.166	0.165	0.164	0.165	0.165	0.163	0.006
444	18.5	0.174	0.17	0.16	0.166	0.165	0.166	0.165	0.164	0.165	0.164	0.163	0.006
456	19	0.174	0.169	0.16	0.165	0.165	0.165	0.165	0.163	0.164	0.164	0.162	0.006
468	19.5	0.174	0.17	0.16	0.165	0.165	0.165	0.164	0.163	0.164	0.164	0.162	0.006
480	20	0.175	0.169	0.159	0.136	0.164	0.164	0.163	0.162	0.162	0.162	0.16	0.006
492	20.5	0.222	0.214	0.2	0.208	0.207	0.208	0.207	0.206	0.206	0.206	0.204	0.007
504	21	0.308	0.291	0.272	0.286	0.285	0.287	0.286	0.284	0.285	0.283	0.281	0.007
516	21.5	0.308	0.292	0.272	0.286	0.285	0.287	0.287	0.284	0.285	0.283	0.281	0.007
528	22	0.308	0.291	0.271	0.286	0.285	0.287	0.286	0.283	0.284	0.283	0.28	0.007
540	22.5	0.499	0.454	0.417	0.447	0.444	0.451	0.45	0.443	0.445	0.441	0.437	0.007
552	23	0.498	0.454	0.417	0.447	0.444	0.451	0.45	0.444	0.445	0.441	0.438	0.007
564	23.5	0.499	0.454	0.417	0.446	0.443	0.45	0.449	0.442	0.444	0.44	0.436	0.007
576	24	0.499	0.454	0.417	0.447	0.444	0.45	0.449	0.443	0.444	0.44	0.436	0.007
588	24.5	0.498	0.454	0.417	0.446	0.443	0.449	0.448	0.442	0.443	0.439	0.435	0.007
600	25	0.498	0.453	0.416	0.446	0.443	0.449	0.448	0.442	0.443	0.439	0.435	0.007
612	25.5	0.498	0.453	0.416	0.446	0.442	0.448	0.447	0.441	0.442	0.438	0.434	0.007

624	26	0.497	0.452	0.415	0.444	0.44	0.446	0.445	0.439	0.439	0.435	0.431	0.007
636	26.5	0.5	0.455	0.417	0.447	0.443	0.449	0.448	0.442	0.443	0.439	0.436	0.007
648	27	0.5	0.455	0.417	0.447	0.443	0.449	0.448	0.442	0.443	0.439	0.434	0.007
660	27.5	0.5	0.453	0.416	0.445	0.442	0.447	0.446	0.441	0.441	0.437	0.433	0.007
672	28	0.5	0.454	0.417	0.446	0.442	0.448	0.447	0.442	0.442	0.438	0.434	0.007
684	28.5	0.501	0.453	0.416	0.446	0.442	0.449	0.448	0.442	0.443	0.44	0.436	0.007

Changes in Conductivity (mS)
Cycle 6: Column 4 - Column 5: EXP-CTL

Time (h)	Time (d)	Depth (in.)	0	1	2	3	4	5	6	7	8	9	10	11
-6	-0.25	0.34	0.318	0.003	0.049	0.168	0.107	0.286	0.146	0.322	0.326	0.203	0.129	
-3	-0.125	0.34	0.311	0.002	0.048	0.161	0.104	0.284	0.144	0.321	0.326	0.202	0.127	
0	0	0.904	0.521	-0.015	0.069	0.219	0.139	0.34	0.178	0.488	0.505	0.354	0.112	
3	0.125	0.817	0.438	-0.014	0.056	0.188	0.113	0.21	0.14	0.292	0.135	0.116	0.124	
6	0.25	0.461	0.238	-0.014	0.031	0.316	0.119	0.116	0.161	0.182	0.113	0.084	0.123	
12	0.5	0.246	0.15	-0.005	0.322	0.272	0.12	0.094	0.14	0.142	0.111	0.076	0.114	
24	1	0.258	0.168	0.063	0.299	0.522	0.181	0.118	0.15	0.161	0.136	0.097	0.074	
36	1.5	0.254	0.123	0.327	0.321	0.334	0.199	0.133	0.159	0.177	0.149	0.106	0.068	
48	2	0.238	0.155	0.345	0.32	0.301	0.182	0.132	0.156	0.174	0.153	0.107	0.06	
60	2.5	0.202	0.153	0.419	0.282	0.268	0.199	0.16	0.186	0.2	0.186	0.14	0.054	
72	3	0.175	0.14	0.624	0.32	0.304	0.247	0.208	0.237	0.257	0.25	0.202	0.046	
84	3.5	0.166	0.126	0.637	0.325	0.296	0.238	0.201	0.225	0.252	0.255	0.206	0.044	
96	4	0.164	0.113	0.401	0.254	0.18	0.145	0.121	0.137	0.165	0.173	0.13	0.045	
108	4.5	0.164	0.109	0.398	0.26	0.179	0.148	0.123	0.142	0.167	0.172	0.135	0.044	
120	5	0.156	0.102	0.402	0.258	0.171	0.144	0.12	0.14	0.164	0.168	0.143	0.043	
132	5.5	0.151	0.124	0.477	0.316	0.202	0.171	0.145	0.17	0.195	0.198	0.175	0.042	
144	6	0.14	0.115	0.465	0.274	0.179	0.155	0.131	0.155	0.175	0.182	0.165	0.041	
156	6.5	0.138	0.112	0.487	0.305	0.174	0.152	0.127	0.151	0.17	0.177	0.162	0.041	
168	7	0.136	0.1	0.474	0.331	0.178	0.151	0.126	0.151	0.172	0.18	0.165	0.041	
180	7.5	0.147	0.09	0.475	0.37	0.182	0.157	0.131	0.156	0.18	0.195	0.175	0.041	
192	8	0.159	0.078	0.45	0.4	0.195	0.168	0.14	0.169	0.197	0.219	0.194	0.042	
204	8.5	0.162	0.079	0.444	0.401	0.198	0.171	0.141	0.172	0.198	0.215	0.197	0.043	
216	9	0.162	0.068	0.403	0.399	0.198	0.172	0.142	0.174	0.202	0.223	0.201	0.042	
228	9.5	0.166	0.078	0.455	0.453	0.203	0.174	0.145	0.181	0.205	0.227	0.208	0.043	
240	10	0.166	0.071	0.451	0.471	0.203	0.174	0.145	0.182	0.208	0.235	0.211	0.043	
252	10.5	0.163	0.08	0.473	0.497	0.201	0.172	0.143	0.182	0.201	0.217	0.203	0.042	
264	11	0.152	0.094	0.465	0.544	0.234	0.201	0.166	0.213	0.235	0.248	0.232	0.041	
276	11.5	0.153	0.089	0.467	0.565	0.238	0.201	0.165	0.215	0.231	0.243	0.229	0.041	
288	12	0.152	0.08	0.473	0.57	0.244	0.202	0.166	0.217	0.23	0.241	0.226	0.041	
300	12.5	0.149	0.076	0.545	0.587	0.275	0.204	0.169	0.22	0.228	0.236	0.223	0.04	
312	13	0.15	0.073	0.541	0.604	0.337	0.215	0.178	0.226	0.232	0.235	0.222	0.04	
324	13.5	0.148	0.066	0.472	0.602	0.387	0.235	0.187	0.231	0.237	0.237	0.22	0.04	
336	14	0.139	0.055	0.406	0.582	0.432	0.271	0.193	0.243	0.25	0.244	0.216	0.044	
348	14.5	0.145	0.059	0.394	0.879	0.653	0.439	0.318	0.405	0.415	0.416	0.358	0.042	
360	15	0.149	0.051	0.347	0.872	0.725	0.518	0.375	0.485	0.489	0.463	0.384	0.043	
372	15.5	0.152	0.049	0.329	0.874	0.792	0.587	0.444	0.587	0.579	0.591	0.429	0.043	
384	16	0.152	0.045	0.304	0.703	0.668	0.524	0.423	0.549	0.543	0.561	0.412	0.044	
396	16.5	0.147	0.042	0.291	0.698	0.698	0.554	0.469	0.614	0.595	0.632	0.492	0.052	
408	17	0.124	0.021	0.259	0.671	0.706	0.551	0.476	0.634	0.616	0.649	0.554	0.079	
420	17.5	0.058	-0.042	0.19	0.601	0.791	0.594	0.513	0.723	0.718	0.75	0.646	0.15	
432	18	0.055	-0.042	0.179	0.599	0.644	0.491	0.426	0.588	0.591	0.614	0.546	0.229	
444	18.5	0.053	-0.042	0.173	0.599	0.646	0.49	0.427	0.591	0.6	0.623	0.564	0.324	
456	19	0.048	-0.041	0.161	0.492	0.629	0.476	0.419	0.579	0.594	0.613	0.564	0.418	
468	19.5	0.051	-0.038	0.161	0.599	0.64	0.484	0.428	0.593	0.609	0.625	0.576	0.454	
480	20	0.044	-0.038	0.155	0.51	0.633	0.482	0.428	0.59	0.608	0.627	0.579	0.47	
492	20.5	0.001	-0.068	0.113	0.552	0.774	0.567	0.488	0.744	0.772	0.802	0.737	0.495	
504	21	-0.076	-0.147	0.062	0.659	1.009	0.68	0.561	0.964	1.004	1.052	0.929	0.535	
516	21.5	-0.084	-0.138	0.043	0.47	0.698	0.485	0.383	0.669	0.692	1.016	0.913	0.473	
528	22	-0.08	-0.136	0.042	0.464	0.957	0.649	0.504	0.929	0.968	1.034	0.923	0.409	
540	22.5	-0.267	-0.305	-0.096	0.301	0.81	0.488	0.32	0.785	0.826	1.449	1.251	0.448	
552	23	-0.258	-0.301	-0.087	0.312	0.822	0.493	0.286	0.805	0.849	1.5	1.28	0.421	

564	23.5	-0.26	-0.303	-0.091	0.288	0.812	0.483	0.234	0.802	0.844	1.498	1.271	0.404
576	24	-0.257	-0.301	-0.092	0.187	0.802	0.477	0.173	0.807	0.845	1.503	1.265	0.394
588	24.5	-0.256	-0.303	-0.098	0.102	0.769	0.457	0.113	0.788	0.823	1.481	1.24	0.39
600	25	-0.255	-0.306	-0.106	0.065	0.748	0.438	0.076	0.78	0.811	1.473	1.219	0.389
612	25.5	-0.252	-0.308	-0.11	0.015	0.724	0.421	0.049	0.782	0.809	1.479	1.21	0.389
624	26	-0.25	-0.309	-0.113	-0.013	0.703	0.397	0.03	1.197	1.259	1.496	1.194	0.39
636	26.5	-0.249	-0.311	-0.115	-0.033	0.676	0.373	0.013	1.2	1.251	1.521	1.188	0.393
648	27	-0.244	-0.308	-0.11	-0.049	0.448	0.205	-0.068	1.184	1.226	1.531	1.154	0.396
660	27.5	-0.242	-0.309	-0.113	-0.065	0.288	0.088	-0.121	1.138	1.168	1.52	1.113	0.398
672	28	-0.241	-0.311	-0.114	-0.072	0.152	0.01	-0.158	1.071	1.081	1.505	1.058	0.397
684	28.5	-0.239	-0.312	-0.113	-0.079	0.068	-0.03	-0.18	1.002	0.965	1.513	1.003	0.398

Changes in Conductivity
Cycle 7: Column 4 (EXP)

Time (h)	Time (d)	Depth (in.)											
		0	1	2	3	4	5	6	7	8	9	10	11
-3	-0.125	0.345	0.099	0.27	0.114	0.096	0.086	0.174	0.36	0.289	0.27	0.301	0.142
0	0	0.812	0.059	0.298	0.134	0.12	0.106	0.202	0.444	0.363	0.353	0.381	0.14
3	0.125	0.54	0.1	0.261	0.168	0.171	0.166	0.215	0.366	0.356	0.242	0.271	0.18
6	0.25	0.477	0.087	0.237	0.418	0.384	0.196	0.204	0.334	0.365	0.219	0.27	0.207
9	0.375	0.342	0.099	0.289	0.477	0.316	0.226	0.227	0.312	0.34	0.254	0.296	0.196
12	0.5	0.322	0.106	0.42	0.506	0.292	0.222	0.219	0.294	0.314	0.248	0.292	0.217
15	0.625	0.306	0.165	0.448	0.461	0.245	0.196	0.187	0.253	0.267	0.217	0.256	0.201
18	0.75	0.287	0.255	0.437	0.456	0.229	0.2	0.183	0.247	0.259	0.219	0.253	0.199
21	0.875	0.277	0.311	0.432	0.427	0.221	0.201	0.179	0.24	0.252	0.222	0.247	0.195
24	1	0.274	0.37	0.435	0.422	0.22	0.206	0.179	0.24	0.252	0.226	0.249	0.197
36	1.5	0.263	0.466	0.489	0.356	0.254	0.252	0.204	0.271	0.285	0.271	0.283	0.211
48	2	0.251	0.434	0.457	0.334	0.232	0.234	0.184	0.244	0.26	0.256	0.25	0.186
60	2.5	0.241	0.429	0.41	0.315	0.235	0.231	0.186	0.241	0.26	0.254	0.242	0.177
72	3	0.241	0.429	0.41	0.315	0.235	0.231	0.186	0.241	0.26	0.254	0.242	0.177
84	3.5	0.233	0.513	0.409	0.322	0.267	0.258	0.235	0.269	0.29	0.299	0.272	0.19
96	4	0.224	0.534	0.429	0.337	0.271	0.261	0.235	0.27	0.296	0.297	0.282	0.185
108	4.5	0.218	0.542	0.416	0.332	0.27	0.256	0.233	0.265	0.296	0.298	0.275	0.174
120	5	0.239	0.74	0.538	0.455	0.385	0.356	0.322	0.372	0.415	0.428	0.384	0.209
132	5.5	0.211	0.614	0.411	0.336	0.3	0.281	0.255	0.289	0.32	0.327	0.301	0.115
144	6	0.21	0.626	0.394	0.33	0.297	0.276	0.248	0.281	0.313	0.326	0.299	0.094
156	6.5	0.21	0.626	0.394	0.33	0.297	0.276	0.248	0.281	0.313	0.326	0.299	0.094
168	7	0.239	0.923	0.629	0.531	0.486	0.438	0.429	0.447	0.51	0.536	0.483	0.282
180	7.5	0.239	0.923	0.629	0.531	0.486	0.438	0.429	0.447	0.51	0.536	0.483	0.282
192	8	0.239	0.923	0.629	0.531	0.486	0.438	0.429	0.447	0.51	0.536	0.483	0.282
204	8.5	0.216	0.623	0.455	0.336	0.313	0.29	0.272	0.292	0.33	0.357	0.327	0.168
216	9	0.215	0.632	0.455	0.335	0.313	0.29	0.27	0.292	0.33	0.363	0.329	0.089
228	9.5	0.216	0.632	0.466	0.329	0.312	0.29	0.269	0.291	0.33	0.367	0.33	0.082
240	10	0.213	0.626	0.466	0.32	0.302	0.285	0.263	0.285	0.32	0.354	0.32	0.079
252	10.5	0.212	0.626	0.476	0.318	0.302	0.284	0.261	0.283	0.319	0.345	0.319	0.077
264	11	0.212	0.626	0.476	0.318	0.302	0.284	0.261	0.283	0.319	0.345	0.319	0.077
276	11.5	0.212	0.626	0.476	0.318	0.302	0.284	0.261	0.283	0.319	0.345	0.319	0.077
288	12	0.241	1.581	1.56	1.122	1.016	0.848	0.835	0.905	1.066	1.106	1.03	0.381
300	12.5	0.211	0.741	0.669	0.409	0.368	0.335	0.317	0.34	0.386	0.413	0.376	0.083
312	13	0.208	0.729	0.678	0.404	0.361	0.332	0.31	0.337	0.38	0.403	0.37	0.076
324	13.5	0.211	0.735	0.708	0.405	0.357	0.334	0.309	0.34	0.38	0.407	0.368	0.075
336	14	0.216	0.728	0.732	0.439	0.363	0.339	0.313	0.345	0.384	0.417	0.371	0.074
348	14.5	0.22	0.723	0.759	0.506	0.381	0.355	0.324	0.367	0.41	0.455	0.39	0.075
360	15	0.22	0.617	0.664	0.455	0.33	0.307	0.279	0.317	0.361	0.397	0.333	0.077
372	15.5	0.22	0.624	0.774	0.56	0.42	0.373	0.336	0.379	0.443	0.488	0.4	0.076
384	16	0.219	0.539	0.671	0.506	0.36	0.33	0.292	0.329	0.397	0.45	0.352	0.083
396	16.5	0.215	0.537	0.667	0.535	0.394	0.353	0.307	0.341	0.416	0.476	0.365	0.085
408	17	0.212	0.489	0.656	0.557	0.443	0.383	0.323	0.357	0.438	0.499	0.38	0.103
420	17.5	0.208	0.483	0.653	0.582	0.498	0.422	0.349	0.389	0.48	0.542	0.417	0.135
432	18	0.207	0.479	0.657	0.602	0.532	0.465	0.385	0.424	0.514	0.571	0.456	0.165
444	18.5	0.202	0.444	0.652	0.61	0.57	0.494	0.43	0.463	0.547	0.592	0.496	0.176
456	19	0.203	0.439	0.65	0.62	0.58	0.511	0.459	0.491	0.57	0.608	0.529	0.185
468	19.5	0.203	0.44	0.655	0.631	0.598	0.53	0.496	0.525	0.59	0.618	0.562	0.198
480	20	0.203	0.44	0.658	0.632	0.607	0.538	0.52	0.543	0.599	0.625	0.58	0.206
492	20.5	0.203	0.431	0.656	0.637	0.627	0.551	0.545	0.569	0.618	0.635	0.597	0.216
504	21	0.206	0.441	0.784	0.777	0.755	0.662	0.61	0.698	0.755	0.767	0.723	0.252
516	21.5	0.201	0.425	0.652	0.649	0.634	0.567	0.568	0.594	0.639	0.646	0.618	0.232
528	22	0.2	0.421	0.657	0.66	0.646	0.576	0.579	0.605	0.65	0.656	0.626	0.249
540	22.5	0.196	0.421	0.661	0.668	0.655	0.583	0.587	0.613	0.659	0.665	0.639	0.266
552	23	0.196	0.416	0.655	0.665	0.652	0.582	0.584	0.612	0.657	0.661	0.636	0.274
564	23.5	0.199	0.427	0.668	0.681	0.669	0.595	0.602	0.628	0.673	0.677	0.653	0.288
576	24	0.199	0.427	0.668	0.68	0.668	0.594	0.601	0.629	0.674	0.674	0.651	0.289
588	24.5	0.135	0.409	0.577	0.657	0.649	0.579	0.583	0.611	0.653	0.654	0.632	0.28
600	25	0.134	0.407	0.576	0.656	0.648	0.578	0.58	0.609	0.651	0.653	0.63	0.274
612	25.5	0.136	0.416	0.659	0.67	0.658	0.586	0.586	0.618	0.662	0.662	0.642	0.267
624	26	0.133	0.427	0.661	0.669	0.656	0.585	0.584	0.617	0.662	0.663	0.643	0.26

636	26.5	0.135	0.425	0.66	0.668	0.654	0.582	0.583	0.618	0.661	0.662	0.644	0.25
648	27	0.134	0.422	0.658	0.665	0.651	0.581	0.58	0.616	0.66	0.66	0.641	0.24
660	27.5	0.136	0.43	0.669	0.677	0.662	0.591	0.589	0.628	0.673	0.674	0.655	0.234
672	28	0.136	0.465	0.783	0.789	0.768	0.676	0.677	0.729	0.786	0.786	0.763	0.24
684	28.5	0.214	0.538	1.274	1.309	1.259	1.037	1.055	1.18	1.311	1.309	1.25	0.2
696	29	0.209	0.483	0.975	0.994	0.96	0.823	0.816	0.903	0.992	0.987	0.951	0.141
708	29.5	0.21	0.521	1.252	1.279	1.216	1.012	1.009	1.144	1.273	1.272	1.217	0.122
720	30	0.141	0.474	0.968	0.976	0.935	0.81	0.787	0.887	0.975	0.974	0.941	0.116
732	30.5	0.219	0.54	1.292	1.313	1.242	1.038	1.012	1.179	1.321	1.322	1.262	0.108
744	31	0.216	0.528	1.271	1.29	1.215	1.025	0.982	1.159	1.302	1.302	1.246	0.105
756	31.5	0.218	0.524	1.268	1.286	1.204	1.024	0.96	1.152	1.301	1.303	1.244	0.099
768	32	0.218	0.518	1.266	1.287	1.196	1.02	0.932	1.15	1.303	1.822	1.732	0.095
780	32.5	0.216	0.505	1.246	1.263	1.168	1.004	0.889	1.126	1.28	1.285	1.226	0.096
792	33	0.216	0.473	1.237	1.255	1.145	0.997	0.833	1.114	1.275	1.277	1.218	0.093
804	33.5	0.22	0.507	1.245	1.254	1.137	0.997	0.747	1.111	1.274	1.283	1.221	0.093
816	34	0.216	0.463	1.225	1.231	1.108	0.984	0.628	1.09	1.258	1.264	1.201	0.089
828	34.5	0.224	0.509	1.258	1.259	1.115	1.004	0.563	1.112	1.287	1.296	1.229	0.089
840	35	0.223	0.512	1.75	1.771	1.523	1.319	0.65	1.536	1.833	1.828	1.713	0.086
852	35.5	0.224	0.515	1.763	1.776	1.502	1.325	0.614	1.532	1.843	1.84	1.72	0.085
864	36	0.222	0.498	1.735	1.73	1.438	1.305	0.584	1.484	1.81	1.806	1.683	0.083
876	36.5	0.223	0.465	1.703	1.708	1.377	1.291	0.569	1.45	1.795	1.783	1.659	0.082
888	37	0.221	0.452	1.237	1.222	0.955	0.99	0.428	1.034	1.27	1.748	1.626	0.08
900	37.5	0.221	0.447	1.234	1.218	0.825	0.987	0.425	1.018	1.271	1.741	1.612	0.079
912	38	0.219	0.423	1.207	1.186	0.64	0.967	0.42	0.973	1.244	1.244	1.15	0.079

Cycle 7

Col 5: Control

Time		0	1	2	3	4	5	6	7	8	9	10	11
(h)	(d)												
-3	-0.125	0.074	0.072	0.066	0.068	0.067	0.066	0.065	0.065	0.065	0.065	0.064	0.008
0	0	0.074	0.072	0.067	0.068	0.067	0.067	0.066	0.066	0.066	0.065	0.065	0.008
3	0.125	0.087	0.085	0.08	0.081	0.08	0.08	0.079	0.078	0.078	0.078	0.077	0.007
6	0.25	0.096	0.094	0.088	0.09	0.089	0.089	0.088	0.087	0.088	0.087	0.086	0.007
9	0.375	0.107	0.105	0.099	0.09	0.101	0.1	0.1	0.099	0.099	0.099	0.098	0.007
12	0.5	0.123	0.12	0.113	0.101	0.115	0.115	0.114	0.114	0.114	0.114	0.113	0.007
15	0.625	0.107	0.105	0.098	0.09	0.1	0.1	0.099	0.099	0.099	0.099	0.098	0.007
18	0.75	0.107	0.105	0.098	0.089	0.1	0.1	0.099	0.098	0.099	0.098	0.097	0.007
21	0.875	0.107	0.105	0.098	0.089	0.1	0.099	0.099	0.098	0.098	0.098	0.097	0.007
24	1	0.107	0.105	0.098	0.115	0.1	0.099	0.099	0.098	0.098	0.098	0.097	0.006
36	1.5	0.124	0.12	0.112	0.135	0.114	0.114	0.113	0.112	0.113	0.112	0.111	0.006
48	2	0.108	0.105	0.098	0.1	0.099	0.099	0.098	0.097	0.097	0.097	0.096	0.006
60	2.5	0.108	0.105	0.098	0.1	0.099	0.099	0.098	0.097	0.097	0.097	0.096	0.006
72	3	0.108	0.105	0.098	0.1	0.099	0.099	0.098	0.097	0.097	0.097	0.096	0.006
84	3.5	0.123	0.12	0.112	0.115	0.114	0.114	0.114	0.113	0.113	0.113	0.112	0.005
96	4	0.123	0.12	0.112	0.1	0.113	0.113	0.112	0.112	0.112	0.112	0.11	0.006
108	4.5	0.123	0.12	0.112	0.1	0.113	0.113	0.112	0.111	0.112	0.111	0.11	0.006
120	5	0.175	0.169	0.158	0.164	0.163	0.163	0.163	0.162	0.162	0.162	0.16	0.001
132	5.5	0.097	0.094	0.088	0.089	0.088	0.087	0.087	0.086	0.086	0.086	0.085	0.004
144	6	0.08	0.078	0.073	0.074	0.073	0.072	0.072	0.071	0.071	0.071	0.07	0.005
156	6.5	0.08	0.078	0.073	0.074	0.073	0.072	0.072	0.071	0.071	0.071	0.07	0.005
168	7	0.223	0.216	0.201	0.21	0.208	0.209	0.208	0.207	0.207	0.206	0.204	0.001
180	7.5	0.223	0.216	0.201	0.21	0.208	0.209	0.208	0.207	0.207	0.206	0.204	0.001
192	8	0.223	0.216	0.201	0.21	0.208	0.209	0.208	0.207	0.207	0.206	0.204	0.001
204	8.5	0.145	0.141	0.131	0.116	0.135	0.135	0.134	0.133	0.134	0.133	0.132	0.004
216	9	0.081	0.079	0.073	0.075	0.073	0.073	0.072	0.071	0.071	0.071	0.07	0.004
228	9.5	0.076	0.074	0.069	0.07	0.069	0.068	0.067	0.067	0.067	0.067	0.066	0.005
240	10	0.075	0.073	0.068	0.069	0.068	0.068	0.067	0.066	0.066	0.066	0.065	0.005
252	10.5	0.075	0.073	0.068	0.069	0.069	0.068	0.067	0.067	0.067	0.066	0.065	0.004
264	11	0.075	0.073	0.068	0.069	0.069	0.068	0.067	0.067	0.067	0.066	0.065	0.004
276	11.5	0.075	0.073	0.068	0.069	0.069	0.068	0.067	0.067	0.067	0.066	0.065	0.004
288	12	0.497	0.456	0.413	0.44	0.434	0.438	0.435	0.428	0.429	0.424	0.42	0.001
300	12.5	0.081	0.079	0.073	0.075	0.073	0.073	0.072	0.071	0.071	0.071	0.07	0.001
312	13	0.076	0.074	0.069	0.07	0.069	0.068	0.067	0.067	0.067	0.067	0.066	0.002

324	13.5	0.076	0.074	0.069	0.07	0.069	0.068	0.068	0.067	0.067	0.067	0.066	0.002
336	14	0.076	0.074	0.069	0.07	0.069	0.068	0.068	0.067	0.067	0.067	0.066	0.002
348	14.5	0.076	0.074	0.069	0.07	0.069	0.069	0.068	0.067	0.067	0.067	0.066	0.002
360	15	0.076	0.074	0.069	0.07	0.069	0.068	0.068	0.067	0.067	0.067	0.066	0.002
372	15.5	0.076	0.074	0.068	0.07	0.069	0.068	0.067	0.067	0.067	0.067	0.066	0.003
384	16	0.081	0.079	0.073	0.075	0.074	0.073	0.072	0.072	0.072	0.072	0.071	0.004
396	16.5	0.081	0.079	0.074	0.075	0.074	0.073	0.072	0.072	0.072	0.072	0.071	0.004
408	17	0.097	0.094	0.088	0.09	0.088	0.088	0.087	0.086	0.086	0.086	0.085	0.004
420	17.5	0.124	0.121	0.112	0.101	0.114	0.114	0.113	0.112	0.112	0.112	0.111	0.004
432	18	0.144	0.14	0.131	0.115	0.134	0.134	0.133	0.132	0.132	0.132	0.131	0.004
444	18.5	0.143	0.139	0.13	0.162	0.133	0.133	0.132	0.131	0.132	0.131	0.13	0.004
456	19	0.144	0.139	0.13	0.115	0.133	0.133	0.132	0.131	0.132	0.131	0.13	0.004
468	19.5	0.145	0.14	0.131	0.115	0.133	0.133	0.132	0.132	0.132	0.132	0.13	0.004
480	20	0.144	0.14	0.13	0.115	0.133	0.133	0.132	0.132	0.132	0.132	0.13	0.004
492	20.5	0.145	0.14	0.131	0.115	0.134	0.133	0.133	0.132	0.132	0.132	0.13	0.004
504	21	0.175	0.169	0.158	0.135	0.162	0.162	0.162	0.161	0.161	0.161	0.159	0.004
516	21.5	0.145	0.14	0.131	0.115	0.134	0.134	0.133	0.132	0.132	0.132	0.131	0.004
528	22	0.144	0.14	0.13	0.162	0.133	0.133	0.132	0.132	0.132	0.132	0.13	0.004
540	22.5	0.145	0.14	0.131	0.163	0.133	0.133	0.132	0.132	0.132	0.132	0.13	0.004
552	23	0.145	0.141	0.131	0.115	0.134	0.133	0.133	0.132	0.132	0.132	0.13	0.004
564	23.5	0.147	0.142	0.132	0.116	0.134	0.134	0.133	0.132	0.133	0.132	0.131	0.004
576	24	0.146	0.141	0.132	0.116	0.134	0.134	0.133	0.132	0.132	0.132	0.131	0.004
588	24.5	0.146	0.141	0.131	0.116	0.134	0.134	0.133	0.132	0.132	0.132	0.131	0.004
600	25	0.145	0.141	0.131	0.115	0.134	0.134	0.133	0.132	0.132	0.132	0.131	0.004
612	25.5	0.145	0.141	0.131	0.115	0.134	0.134	0.133	0.132	0.132	0.132	0.131	0.004
624	26	0.145	0.14	0.131	0.163	0.133	0.133	0.132	0.132	0.132	0.132	0.13	0.004
636	26.5	0.146	0.141	0.132	0.116	0.134	0.134	0.133	0.132	0.132	0.132	0.131	0.004
648	27	0.146	0.141	0.131	0.115	0.134	0.133	0.133	0.132	0.132	0.132	0.13	0.004
660	27.5	0.146	0.142	0.132	0.116	0.134	0.134	0.133	0.132	0.132	0.132	0.131	0.004
672	28	0.177	0.172	0.16	0.167	0.165	0.165	0.165	0.164	0.164	0.163	0.161	0.004
684	28.5	0.178	0.171	0.16	0.165	0.164	0.163	0.162	0.161	0.161	0.161	0.159	0.004
696	29	0.11	0.107	0.099	0.102	0.1	0.099	0.099	0.098	0.098	0.097	0.096	0.004
708	29.5	0.098	0.096	0.089	0.091	0.089	0.088	0.088	0.087	0.087	0.087	0.085	0.004
720	30	0.089	0.086	0.08	0.082	0.081	0.08	0.079	0.078	0.078	0.078	0.077	0.004
732	30.5	0.083	0.08	0.075	0.076	0.075	0.074	0.074	0.073	0.073	0.073	0.072	0.004
744	31	0.082	0.08	0.074	0.076	0.075	0.074	0.073	0.073	0.072	0.072	0.071	0.004
756	31.5	0.077	0.074	0.069	0.07	0.069	0.069	0.068	0.068	0.067	0.067	0.066	0.004
768	32	0.076	0.074	0.069	0.07	0.069	0.069	0.068	0.067	0.067	0.067	0.066	0.004
780	32.5	0.076	0.074	0.069	0.07	0.069	0.068	0.067	0.067	0.067	0.067	0.066	0.004
792	33	0.076	0.074	0.068	0.07	0.069	0.068	0.067	0.067	0.067	0.067	0.066	0.004
804	33.5	0.076	0.074	0.069	0.07	0.069	0.068	0.068	0.067	0.067	0.067	0.066	0.004
816	34	0.076	0.074	0.068	0.07	0.069	0.068	0.067	0.067	0.067	0.066	0.065	0.004
828	34.5	0.076	0.074	0.069	0.07	0.069	0.068	0.068	0.067	0.067	0.067	0.066	0.004
840	35	0.076	0.074	0.069	0.07	0.069	0.069	0.068	0.068	0.067	0.067	0.066	0.004
852	35.5	0.077	0.075	0.069	0.071	0.07	0.069	0.068	0.068	0.068	0.067	0.066	0.004
864	36	0.076	0.074	0.069	0.07	0.069	0.068	0.068	0.067	0.067	0.067	0.066	0.004
876	36.5	0.076	0.074	0.069	0.07	0.069	0.068	0.068	0.067	0.067	0.067	0.066	0.004
888	37	0.076	0.074	0.068	0.07	0.069	0.068	0.067	0.067	0.067	0.066	0.065	0.004
900	37.5	0.076	0.073	0.068	0.07	0.069	0.068	0.067	0.067	0.067	0.066	0.065	0.004
912	38	0.075	0.073	0.068	0.069	0.068	0.067	0.067	0.066	0.066	0.066	0.065	0.004

Changes in Conductivity (mS)

Cycle 7: Column 4 - Column 5: (EXP - CTL)

Time (h)	Time (d)	Depth (in.)											
		0	1	2	3	4	5	6	7	8	9	10	11
-3	-0.125	0.271	0.027	0.204	0.046	0.029	0.02	0.109	0.295	0.224	0.205	0.237	0.134
0	0	0.738	-0.013	0.231	0.066	0.053	0.039	0.136	0.378	0.297	0.288	0.316	0.132
3	0.125	0.453	0.015	0.181	0.087	0.091	0.086	0.136	0.288	0.278	0.164	0.194	0.173
6	0.25	0.381	-0.007	0.149	0.328	0.295	0.107	0.116	0.247	0.277	0.132	0.184	0.2
9	0.375	0.235	-0.006	0.19	0.387	0.215	0.126	0.127	0.213	0.241	0.155	0.198	0.189
12	0.5	0.199	-0.014	0.307	0.405	0.177	0.107	0.105	0.18	0.2	0.134	0.179	0.21
15	0.625	0.199	0.06	0.35	0.371	0.145	0.096	0.088	0.154	0.168	0.118	0.158	0.194

18	0.75	0.18	0.15	0.339	0.367	0.129	0.1	0.084	0.149	0.16	0.121	0.156	0.192
21	0.875	0.17	0.206	0.334	0.338	0.121	0.102	0.08	0.142	0.154	0.124	0.15	0.188
24	1	0.167	0.265	0.337	0.307	0.12	0.107	0.08	0.142	0.154	0.128	0.152	0.191
36	1.5	0.139	0.346	0.377	0.221	0.14	0.138	0.091	0.159	0.172	0.159	0.172	0.205
48	2	0.143	0.329	0.359	0.234	0.133	0.135	0.086	0.147	0.163	0.159	0.154	0.18
60	2.5	0.133	0.324	0.312	0.215	0.136	0.132	0.088	0.144	0.163	0.157	0.146	0.171
72	3	0.133	0.324	0.312	0.215	0.136	0.132	0.088	0.144	0.163	0.157	0.146	0.171
84	3.5	0.11	0.393	0.297	0.207	0.153	0.144	0.121	0.156	0.177	0.186	0.16	0.185
96	4	0.101	0.414	0.317	0.237	0.158	0.148	0.123	0.158	0.184	0.185	0.172	0.179
108	4.5	0.095	0.422	0.304	0.232	0.157	0.143	0.121	0.154	0.184	0.187	0.165	0.168
120	5	0.064	0.571	0.38	0.291	0.222	0.193	0.159	0.21	0.253	0.266	0.224	0.208
132	5.5	0.114	0.52	0.323	0.247	0.212	0.194	0.168	0.203	0.234	0.241	0.216	0.111
144	6	0.13	0.548	0.321	0.256	0.224	0.204	0.176	0.21	0.242	0.255	0.229	0.089
156	6.5	0.13	0.548	0.321	0.256	0.224	0.204	0.176	0.21	0.242	0.255	0.229	0.089
168	7	0.016	0.707	0.428	0.321	0.278	0.22	0.239	0.303	0.329	0.277	0.078	0
180	7.5	0.016	0.707	0.428	0.321	0.278	0.229	0.221	0.24	0.303	0.33	0.279	0.281
192	8	0.016	0.707	0.428	0.321	0.278	0.229	0.221	0.24	0.303	0.33	0.279	0.281
204	8.5	0.071	0.482	0.324	0.22	0.178	0.155	0.138	0.159	0.196	0.224	0.195	0.164
216	9	0.134	0.553	0.382	0.26	0.24	0.217	0.198	0.221	0.259	0.292	0.259	0.085
228	9.5	0.14	0.558	0.397	0.259	0.243	0.222	0.202	0.224	0.263	0.3	0.264	0.077
240	10	0.138	0.553	0.398	0.251	0.234	0.217	0.196	0.219	0.254	0.288	0.255	0.074
252	10.5	0.137	0.553	0.408	0.249	0.233	0.216	0.194	0.216	0.252	0.279	0.254	0.073
264	11	0.137	0.553	0.408	0.249	0.233	0.216	0.194	0.216	0.252	0.279	0.254	0.073
276	11.5	0.137	0.553	0.408	0.249	0.233	0.216	0.194	0.216	0.252	0.279	0.254	0.073
288	12	-0.256	1.125	1.147	0.682	0.582	0.41	0.4	0.477	0.637	0.682	0.61	0.38
300	12.5	0.13	0.662	0.596	0.334	0.295	0.262	0.245	0.269	0.315	0.342	0.306	0.082
312	13	0.132	0.655	0.609	0.334	0.292	0.264	0.243	0.27	0.313	0.336	0.304	0.074
324	13.5	0.135	0.661	0.639	0.335	0.288	0.266	0.241	0.273	0.313	0.34	0.302	0.073
336	14	0.14	0.654	0.663	0.369	0.294	0.271	0.245	0.278	0.317	0.35	0.305	0.072
348	14.5	0.144	0.649	0.69	0.436	0.312	0.286	0.256	0.3	0.343	0.388	0.324	0.073
360	15	0.144	0.543	0.595	0.385	0.261	0.239	0.211	0.25	0.294	0.33	0.267	0.075
372	15.5	0.144	0.55	0.706	0.49	0.351	0.305	0.269	0.312	0.376	0.421	0.334	0.073
384	16	0.138	0.46	0.598	0.431	0.286	0.257	0.22	0.257	0.325	0.378	0.281	0.079
396	16.5	0.134	0.458	0.593	0.46	0.32	0.28	0.235	0.269	0.344	0.404	0.294	0.081
408	17	0.115	0.395	0.568	0.467	0.355	0.295	0.236	0.271	0.352	0.413	0.295	0.099
420	17.5	0.084	0.362	0.541	0.481	0.384	0.308	0.236	0.277	0.368	0.43	0.306	0.131
432	18	0.063	0.339	0.526	0.487	0.398	0.331	0.252	0.292	0.382	0.439	0.325	0.161
444	18.5	0.059	0.305	0.522	0.448	0.437	0.361	0.298	0.332	0.415	0.461	0.366	0.172
456	19	0.059	0.3	0.52	0.505	0.447	0.378	0.327	0.36	0.438	0.477	0.399	0.181
468	19.5	0.058	0.3	0.524	0.516	0.465	0.397	0.364	0.393	0.458	0.486	0.432	0.194
480	20	0.059	0.3	0.528	0.517	0.474	0.405	0.388	0.411	0.467	0.493	0.45	0.202
492	20.5	0.058	0.291	0.525	0.522	0.493	0.418	0.412	0.437	0.486	0.503	0.467	0.212
504	21	0.031	0.272	0.626	0.642	0.593	0.5	0.448	0.537	0.594	0.606	0.564	0.248
516	21.5	0.056	0.285	0.521	0.534	0.5	0.433	0.435	0.462	0.507	0.514	0.487	0.228
528	22	0.056	0.281	0.527	0.498	0.513	0.443	0.447	0.473	0.518	0.524	0.496	0.245
540	22.5	0.051	0.281	0.53	0.505	0.522	0.45	0.455	0.481	0.527	0.533	0.509	0.262
552	23	0.051	0.275	0.524	0.55	0.518	0.449	0.451	0.48	0.525	0.529	0.506	0.27
564	23.5	0.052	0.285	0.536	0.565	0.535	0.461	0.469	0.496	0.54	0.545	0.522	0.284
576	24	0.053	0.286	0.536	0.564	0.534	0.46	0.468	0.497	0.542	0.542	0.52	0.285
588	24.5	-0.011	0.268	0.446	0.541	0.515	0.445	0.45	0.479	0.521	0.522	0.501	0.276
600	25	-0.011	0.266	0.445	0.541	0.514	0.444	0.447	0.477	0.519	0.521	0.499	0.27
612	25.5	-0.009	0.275	0.528	0.555	0.524	0.452	0.453	0.486	0.53	0.53	0.511	0.263
624	26	-0.012	0.287	0.53	0.506	0.523	0.452	0.452	0.485	0.53	0.531	0.513	0.256
636	26.5	-0.011	0.284	0.528	0.552	0.52	0.448	0.45	0.486	0.529	0.53	0.513	0.246
648	27	-0.012	0.281	0.527	0.55	0.517	0.448	0.447	0.484	0.528	0.528	0.511	0.236
660	27.5	-0.01	0.288	0.537	0.561	0.528	0.457	0.456	0.496	0.541	0.542	0.524	0.23
672	28	-0.041	0.293	0.623	0.622	0.603	0.511	0.512	0.565	0.622	0.623	0.602	0.236
684	28.5	0.036	0.367	1.114	1.144	1.095	0.874	0.893	1.019	1.15	1.148	1.091	0.196
696	29	0.099	0.376	0.876	0.892	0.86	0.724	0.717	0.805	0.894	0.89	0.855	0.137
708	29.5	0.112	0.425	1.163	1.188	1.127	0.924	0.921	1.057	1.186	1.185	1.132	0.118
720	30	0.052	0.388	0.888	0.894	0.854	0.73	0.708	0.809	0.897	0.896	0.864	0.112
732	30.5	0.136	0.46	1.217	1.237	1.167	0.964	0.938	1.106	1.248	1.249	1.19	0.104
744	31	0.134	0.448	1.197	1.139	1.14	0.951	0.909	1.086	1.23	1.23	1.175	0.101
756	31.5	0.141	0.45	1.199	1.216	1.135	0.955	0.892	1.084	1.234	1.236	1.178	0.095
768	32	0.142	0.444	1.197	1.217	1.127	0.951	0.864	1.083	1.236	1.755	1.666	0.091

780	32.5	0.14	0.431	1.177	1.193	1.099	0.936	0.822	1.059	1.213	1.218	1.16	0.092
792	33	0.14	0.399	1.169	1.185	1.076	0.929	0.766	1.047	1.208	1.21	1.152	0.089
804	33.5	0.144	0.433	1.176	1.184	1.068	0.929	0.679	1.044	1.207	1.216	1.155	0.089
816	34	0.14	0.389	1.157	1.161	1.039	0.916	0.561	1.023	1.191	1.198	1.136	0.085
828	34.5	0.148	0.435	1.189	1.189	1.046	0.936	0.495	1.045	1.22	1.229	1.163	0.085
840	35	0.147	0.438	1.681	1.701	1.454	1.25	0.582	1.468	1.766	1.761	1.647	0.082
852	35.5	0.147	0.44	1.694	1.705	1.432	1.256	0.546	1.464	1.775	1.773	1.654	0.081
864	36	0.146	0.424	1.666	1.66	1.369	1.237	0.516	1.417	1.743	1.739	1.617	0.079
876	36.5	0.147	0.391	1.634	1.638	1.308	1.223	0.501	1.383	1.728	1.716	1.593	0.078
888	37	0.145	0.378	1.169	1.152	0.886	0.922	0.361	0.967	1.203	1.682	1.561	0.076
900	37.5	0.145	0.374	1.166	1.148	0.756	0.919	0.358	0.951	1.204	1.675	1.547	0.075
912	38	0.144	0.35	1.139	1.117	0.572	0.9	0.353	0.907	1.178	1.178	1.085	0.075

Changes in Conductivity (mS)
 Cycle 8: Column 4 (EXP)

Time (h)	Time (d)	Depth (in.)											
		0	1	2	3	4	5	6	7	8	9	10	11
-3	-0.125	0.416	1.251	0.645	0.71	0.562	0.709	0.458	0.797	0.427	0.473	0.457	1.985
0	0	-0.05	-0.01	-0.35	1.031	0.769	1.34	0.68	1.458	0.68	0.812	0.906	6.963
3	0.125	0.921	2.151	0.759	0.711	0.595	0.788	0.55	0.866	0.617	0.717	0.817	3.016
6	0.25	0.877	1.648	0.71	0.699	0.561	0.672	0.532	0.783	0.624	0.716	0.822	2.855
9	0.375	0.772	1.106	0.653	0.645	0.515	0.604	0.502	0.701	0.592	0.667	0.768	2.234
12	0.5	0.556	0.505	0.392	0.42	0.327	0.371	0.329	0.473	0.298	0.337	0.385	2.086
15	0.625	0.434	0.336	0.288	0.314	0.237	0.272	0.249	0.36	0.199	0.227	0.259	2.018
18	0.75	0.394	0.302	0.262	0.284	0.209	0.246	0.225	0.327	0.173	0.198	0.225	2.018
21	0.875	0.37	0.291	0.249	0.267	0.191	0.23	0.21	0.305	0.155	0.179	0.201	2.04
24	1	0.422	0.352	0.296	0.317	0.224	0.274	0.46	0.375	0.204	0.231	0.263	1.402
36	1.5	0.334	0.324	0.252	0.256	0.165	0.217	0.192	0.304	0.156	0.179	0.203	2.041
48	2	0.3	0.333	0.241	0.234	0.145	0.199	0.174	0.286	0.14	0.164	0.182	2.018
60	2.5	0.304	0.364	0.254	0.24	0.144	0.202	0.172	0.307	0.143	0.169	0.189	0.674
72	3	0.312	0.398	0.266	0.246	0.145	0.203	0.172	0.337	0.148	0.176	0.197	0.692
84	3.5	-0.03	0.815	0.538	0.505	0.345	0.439	0.384	0.775	0.459	0.525	0.616	2.436
96	4	-0.029	0.627	0.419	0.39	0.272	0.346	0.288	0.667	0.36	0.412	0.496	2.381
108	4.5	-0.028	0.664	0.429	0.384	0.267	0.344	0.275	0.637	0.372	0.431	0.53	2.475
120	5	-0.027	-0.036	0.431	0.389	0.258	0.351	0.268	0.62	0.38	0.442	0.549	2.441
132	5.5	-0.027	-0.034	0.421	0.383	0.249	0.349	0.266	0.592	0.381	0.444	0.555	2.484
144	6	-0.028	-0.034	0.419	0.376	0.242	0.347	0.269	0.549	0.383	0.449	0.555	2.437
156	6.5	-0.028	-0.033	0.415	0.362	0.233	0.341	0.295	0.508	0.381	0.446	0.556	2.375
168	7	-0.025	-0.032	0.409	0.352	0.226	0.337	0.299	0.473	0.381	0.446	0.555	2.302
180	7.5	-0.028	-0.032	0.404	0.335	0.218	0.326	0.303	0.432	0.372	0.433	0.538	2.21
192	8	-0.028	-0.031	0.405	0.327	0.214	0.326	0.324	0.412	0.373	0.434	0.54	2.173
204	8.5	-0.028	-0.031	0.483	0.389	0.263	0.393	0.413	0.495	0.474	0.554	0.674	2.067
216	9	-0.028	-0.03	0.477	0.38	0.261	0.393	0.423	0.489	0.474	0.555	0.673	2.031
228	9.5	-0.028	-0.03	0.475	0.368	0.258	0.387	0.435	0.461	0.471	0.552	0.663	1.972
240	10	-0.028	-0.03	0.453	0.351	0.254	0.38	0.451	0.428	0.463	0.539	0.642	1.828
252	10.5		-0.356	0.606	0.441	0.151	0.29	0.388	0.302	0.313	0.375	0.468	1.297
264	11	1.211	-0.354	0.624	0.424	0.078	0.215	0.356	0.208	0.176	0.23	0.286	1.031
276	11.5	-0.029	-0.029	0.611	0.406	0.179	0.316	0.438	0.321	0.36	0.418	0.511	0.844
288	12	-0.029	-0.029	0.607	0.401	0.094	0.225	0.347	0.194	0.204	0.255	0.313	0.649
300	12.5	-0.029	-0.029	0.64	0.389	0.076	0.225	0.327	0.17	0.18	0.227	0.276	0.588
312	13	-0.029	-0.029	0.595	0.377	0.068	0.265	0.361	0.159	0.168	0.219	0.262	0.665
324	13.5	-0.029	-0.029	-0.036	0.362	0.066	0.256	0.334	0.161	0.175	0.218	0.265	0.654
336	14	2.029	-0.335	0.574	0.349	0.061	0.247	0.34	0.156	0.172	0.212	0.253	0.681
348	14.5	-0.029	-0.029	-0.035	0.344	0.064	0.265	0.343	0.15	0.169	0.209	0.247	0.68
360	15	1.467	-0.34	-0.64	0.143	0.07	0.257	0.374	0.147	0.174	0.227	0.246	0.779
372	15.5	-0.029	-0.028	-0.032	0.126	0.077	0.314	0.429	0.173	0.251	0.522	0.549	1.319
384	16	-0.026	-0.025	-0.028	-0.035	-0.052	-0.034	-0.033	-0.038	-0.036	-0.034	-0.033	-0.032
396	16.5	-0.026	-0.025	-0.027	-0.03	-0.045	-0.032	-0.032	-0.034	-0.033	-0.031	-0.032	-0.03
408	17	-0.026	-0.025	-0.027	-0.029	-0.038	-0.032	-0.031	-0.033	-0.032	-0.031	-0.032	-0.03
420	17.5	-0.028	-0.027	-0.028	-0.032	-0.033	-0.03	-0.029	-0.031	-0.03	-0.029	-0.029	-0.028
432	18	-0.028	-0.026	-0.028	-0.031	-0.03	-0.029	-0.029	-0.03	-0.029	-0.029	-0.029	-0.028
444	18.5	-0.027	-0.026	-0.028	-0.03	-0.03	-0.029	-0.028	-0.03	-0.029	-0.028	-0.028	-0.028
456	19	-0.028	-0.026	-0.027	-0.03	-0.029	-0.028	-0.028	-0.03	-0.028	-0.028	-0.028	-0.028
468	19.5	-0.028	-0.027	-0.028	-0.03	-0.029	-0.029	-0.028	-0.029	-0.028	-0.028	-0.028	-0.028
480	20	-0.029	-0.028	-0.029	-0.031	-0.03	-0.029	-0.029	-0.03	-0.029	-0.028	-0.029	-0.028
492	20.5	-0.03	-0.029	-0.03	-0.033	-0.032	-0.031	-0.03	-0.032	-0.031	-0.03	-0.03	-0.03
504	21	0.253	1.71	1.206	0.419	0.39	0.683	1.108	0.552	0.864	1.318	0.911	1.721
516	21.5	0.241	1.724	1.194	0.445	0.394	0.645	1.065	0.548	0.781	1.315	0.846	1.798
528	22	0.23	1.76	1.244	0.466	0.398	0.64	1.085	0.547	0.76	1.344	0.791	1.913
540	22.5	0.235	1.737	1.226	0.48	0.394	0.628	1.078	0.55	0.72	1.297	0.675	1.968
552	23	0.232	1.729	1.192	0.49	0.396	0.62	1.085	0.561	0.68	1.221	0.624	2.03
564	23.5	0.229	1.699	1.166	0.489	0.397	0.602	1.069	0.56	0.628	1.057	0.604	2.07
576	24	0.226	1.689	1.144	0.488	0.4	0.586	1.062	0.555	0.591	0.834	0.586	2.124
588	24.5	0.221	1.652	1.125	0.484	0.404	0.564	1.039	0.546	0.57	0.656	0.576	2.123
600	25	0.218	1.631	1.112	0.482	0.408	0.547	1.008	0.524	0.55	0.616	0.577	2.109
612	25.5	0.215	1.608	1.095	0.476	0.4	0.53	0.969	0.513	0.518	0.598	0.579	2.085
624	26	0.218	1.61	1.089	0.471	0.386	0.517	0.939	0.502	0.502	0.586	0.583	2.012

636	26.5	0.214	1.582	1.065	0.463	0.272	0.433	0.731	0.411	0.394	0.465	0.455	2.074
648	27	0.215	1.575	1.052	0.456	0.213	0.385	0.62	0.36	0.335	0.399	0.385	2.086
660	27.5	0.219	1.575	1.042	0.449	0.15	0.336	0.517	0.316	0.275	0.331	0.31	2.11
672	28	0.217	1.562	1.034	0.446	0.15	0.338	0.515	0.313	0.277	0.333	0.316	2.076
684	28.5	0.223	1.572	1.048	0.441	0.136	0.332	0.499	0.304	0.261	0.316	0.3	2.048
696	29	0.227	1.549	1.028	0.436	0.124	0.32	0.484	0.304	0.261	0.315	0.301	2.019

Changes in Conductivity (mS)
Cycle 8: Column 5 (CTL)

Time (h)	Time (d)	Depth (in.)											
		0	1	2	3	4	5	6	7	8	9	10	11
-3	-0.125	0.5	0.466	0.421	0.453	0.442	0.447	0.442	0.434	0.435	0.43	0.444	0.001
0	0	0.477	0.467	0.426	0.461	0.452	0.459	0.455	0.449	0.451	0.447	0.463	0.001
3	0.125	0.503	0.477	0.432	0.465	0.452	0.458	0.454	0.447	0.449	0.444	0.46	0.001
6	0.25	0.504	0.48	0.433	0.465	0.452	0.456	0.451	0.444	0.445	0.44	0.455	0.001
9	0.375	0.51	0.48	0.432	0.464	0.45	0.455	0.45	0.443	0.444	0.439	0.454	0.001
12	0.5	0.515	0.481	0.431	0.462	0.448	0.452	0.448	0.44	0.441	0.436	0.451	0.001
15	0.625	0.513	0.478	0.429	0.46	0.447	0.451	0.446	0.439	0.44	0.435	0.451	0.001
18	0.75	0.513	0.478	0.428	0.459	0.446	0.451	0.446	0.439	0.44	0.435	0.451	0.001
21	0.875	0.514	0.477	0.428	0.459	0.447	0.452	0.448	0.44	0.441	0.437	0.452	0.001
24	1	0.317	0.306	0.28	0.297	0.29	0.292	0.29	0.287	0.288	0.286	0.297	0.001
36	1.5	0.512	0.476	0.427	0.459	0.446	0.451	0.447	0.439	0.441	0.436	0.452	0.001
48	2	0.513	0.475	0.427	0.459	0.447	0.452	0.449	0.441	0.443	0.438	0.453	0.001
60	2.5	0.148	0.144	0.133	0.138	0.136	0.136	0.135	0.134	0.134	0.134	0.14	0.001
72	3	0.148	0.144	0.133	0.139	0.137	0.136	0.136	0.135	0.136	0.135	0.141	0.001
84	3.5	0.507	0.475	0.428	0.46	0.448	0.452	0.449	0.44	0.44	0.435	0.45	0.001
96	4	0.508	0.473	0.427	0.459	0.448	0.453	0.45	0.442	0.442	0.437	0.452	0.001
108	4.5	0.506	0.47	0.425	0.457	0.447	0.452	0.449	0.441	0.442	0.436	0.452	0.001
120	5	0.504	0.467	0.423	0.456	0.446	0.451	0.449	0.44	0.441	0.436	0.452	0.001
132	5.5	0.503	0.466	0.422	0.456	0.446	0.451	0.449	0.441	0.441	0.436	0.452	0.001
144	6	0.504	0.465	0.422	0.455	0.446	0.451	0.45	0.441	0.442	0.437	0.453	0.001
156	6.5	0.503	0.464	0.421	0.454	0.445	0.451	0.45	0.441	0.441	0.437	0.453	0.001
168	7	0.508	0.474	0.429	0.46	0.45	0.454	0.451	0.443	0.444	0.439	0.455	0.001
180	7.5	0.504	0.467	0.423	0.455	0.445	0.45	0.449	0.44	0.441	0.436	0.452	0.001
192	8	0.504	0.465	0.421	0.453	0.444	0.45	0.449	0.44	0.442	0.436	0.452	0.001
204	8.5	0.504	0.464	0.421	0.453	0.444	0.45	0.449	0.441	0.442	0.437	0.453	0.001
216	9	0.505	0.464	0.421	0.453	0.445	0.45	0.45	0.442	0.443	0.438	0.454	0.001
228	9.5	0.505	0.464	0.421	0.453	0.445	0.451	0.45	0.442	0.444	0.439	0.454	0.001
240	10	0.513	0.468	0.423	0.454	0.446	0.451	0.45	0.442	0.444	0.439	0.455	0.001
252	10.5	0.318	0.298	0.274	0.29	0.285	0.287	0.287	0.284	0.285	0.283	0.294	0.001
264	11	0.233	0.22	0.204	0.213	0.209	0.209	0.209	0.207	0.208	0.207	0.215	0.001
276	11.5	0.231	0.219	0.203	0.287	0.209	0.209	0.209	0.207	0.207	0.206	0.215	0.001
288	12	0.152	0.146	0.135	0.119	0.137	0.136	0.136	0.134	0.135	0.134	0.14	0.001
300	12.5	0.129	0.125	0.116	0.104	0.117	0.116	0.116	0.114	0.115	0.114	0.119	0.001
312	13	0.151	0.146	0.135	0.14	0.137	0.136	0.136	0.134	0.135	0.134	0.14	0.001
324	13.5	0.151	0.146	0.135	0.14	0.137	0.136	0.136	0.134	0.135	0.134	0.14	0.001
336	14	0.15	0.147	0.137	0.142	0.139	0.139	0.139	0.138	0.138	0.138	0.144	0.002
348	14.5	0.151	0.146	0.136	0.141	0.138	0.137	0.137	0.136	0.136	0.136	0.141	0.001
360	15	0.182	0.175	0.163	0.17	0.167	0.166	0.166	0.165	0.165	0.164	0.171	0.001
372	15.5	0.313	0.296	0.274	0.291	0.286	0.288	0.288	0.285	0.286	0.284	0.295	0.001
384	16	0.03	0.131	0.139	0.123	0.092	0.092	0.097	0.092	0.09	0.096	0.149	0.001
396	16.5	0.033	0.132	0.139	0.135	0.091	0.091	0.096	0.092	0.09	0.096	0.148	0.001
408	17	0.111	0.155	0.141	0.141	0.092	0.093	0.098	0.091	0.094	0.097	0.149	0.002
420	17.5	0.013	0.013	0.013	0.013	0.01	0.01	0.01	0.01	0.01	0.01	0.012	0.004
432	18	0.013	0.013	0.013	0.013	0.01	0.01	0.01	0.009	0.01	0.01	0.012	0.004
444	18.5	0.012	0.013	0.014	0.013	0.01	0.01	0.01	0.009	0.01	0.01	0.012	0.004
456	19	0.012	0.014	0.014	0.013	0.01	0.01	0.01	0.009	0.01	0.01	0.012	0.004
468	19.5	0.012	0.014	0.014	0.013	0.01	0.009	0.01	0.009	0.01	0.01	0.011	0.004
480	20	0.012	0.014	0.015	0.013	0.01	0.009	0.01	0.009	0.009	0.01	0.011	0.004
492	20.5	0.012	0.014	0.015	0.013	0.01	0.009	0.01	0.009	0.009	0.01	0.011	0.004
504	21	0.522	0.497	0.454	0.475	0.449	0.452	0.449	0.44	0.442	0.436	0.451	0.001
516	21.5	0.517	0.489	0.448	0.47	0.447	0.451	0.448	0.44	0.442	0.436	0.451	0.001
528	22	0.515	0.486	0.446	0.468	0.446	0.45	0.449	0.44	0.442	0.437	0.452	0.001

540	22.5	0.514	0.483	0.444	0.467	0.446	0.45	0.449	0.441	0.443	0.437	0.452	0.001
552	23	0.514	0.483	0.444	0.466	0.446	0.451	0.449	0.441	0.444	0.438	0.453	0.001
564	23.5	0.512	0.481	0.443	0.464	0.445	0.45	0.448	0.44	0.443	0.437	0.452	0.001
576	24	0.512	0.482	0.444	0.465	0.447	0.452	0.45	0.442	0.444	0.439	0.454	0.001
588	24.5	0.511	0.48	0.442	0.463	0.445	0.45	0.448	0.44	0.443	0.437	0.452	0.001
600	25	0.511	0.481	0.443	0.464	0.447	0.452	0.45	0.442	0.445	0.439	0.455	0.001
612	25.5	0.511	0.48	0.443	0.464	0.446	0.451	0.449	0.441	0.444	0.438	0.453	0.001
624	26	0.511	0.48	0.442	0.463	0.446	0.451	0.45	0.442	0.444	0.439	0.453	0.001
636	26.5	0.51	0.479	0.442	0.463	0.446	0.451	0.449	0.441	0.443	0.438	0.453	0.001
648	27	0.51	0.479	0.442	0.463	0.447	0.451	0.45	0.442	0.444	0.438	0.453	0.001
660	27.5	0.51	0.478	0.441	0.462	0.446	0.451	0.449	0.441	0.443	0.438	0.453	0.001
672	28	0.515	0.488	0.449	0.468	0.45	0.453	0.451	0.442	0.444	0.438	0.452	0.001
684	28.5	0.51	0.478	0.44	0.46	0.444	0.449	0.447	0.438	0.44	0.435	0.449	0.001
696	29	0.509	0.474	0.438	0.459	0.443	0.448	0.447	0.439	0.441	0.435	0.449	0.001

Changes in Conductivity (mS)
Cycle 8: Column 4 - Column 5: (Exp-Ctl)

Time (h)	Time (d)	Depth (in.)	0	1	2	3	4	5	6	7	8	9	10	11
-3	-0.125	-0.084	0.785	0.224	0.257	0.12	0.262	0.016	0.363	-0.008	0.043	0.013	1.984	
0	0	-0.527	-0.477	-0.776	0.57	0.317	0.881	0.225	1.009	0.229	0.365	0.443	6.962	
3	0.125	0.418	1.674	0.327	0.246	0.143	0.33	0.096	0.419	0.168	0.273	0.357	3.015	
6	0.25	0.373	1.168	0.277	0.234	0.109	0.216	0.081	0.339	0.179	0.276	0.367	2.854	
9	0.375	0.262	0.626	0.221	0.181	0.065	0.149	0.052	0.258	0.148	0.228	0.314	2.233	
12	0.5	0.041	0.024	-0.039	-0.042	-0.121	-0.081	-0.119	0.033	-0.143	-0.099	-0.066	2.085	
15	0.625	-0.079	-0.142	-0.141	-0.146	-0.21	-0.179	-0.197	-0.079	-0.241	-0.208	-0.192	2.017	
18	0.75	-0.119	-0.176	-0.166	-0.175	-0.237	-0.205	-0.221	-0.112	-0.267	-0.237	-0.226	2.017	
21	0.875	-0.144	-0.186	-0.179	-0.192	-0.256	-0.222	-0.238	-0.135	-0.286	-0.258	-0.251	2.039	
24	1	0.105	0.046	0.016	0.02	-0.066	-0.018	0.17	0.088	-0.084	-0.055	-0.034	1.401	
36	1.5	-0.178	-0.152	-0.175	-0.203	-0.281	-0.234	-0.255	-0.135	-0.285	-0.257	-0.249	2.04	
48	2	-0.213	-0.142	-0.186	-0.225	-0.302	-0.253	-0.275	-0.155	-0.303	-0.274	-0.271	2.017	
60	2.5	0.156	0.22	0.121	0.102	0.008	0.066	0.037	0.173	0.009	0.035	0.049	0.673	
72	3	0.164	0.254	0.133	0.107	0.008	0.067	0.036	0.202	0.012	0.041	0.056	0.691	
84	3.5	-0.537	0.34	0.11	0.045	-0.103	-0.013	-0.065	0.335	0.019	0.09	0.166	2.435	
96	4	-0.537	0.154	-0.008	-0.069	-0.176	-0.107	-0.162	0.225	-0.082	-0.025	0.044	2.38	
108	4.5	-0.534	0.194	0.004	-0.073	-0.18	-0.108	-0.174	0.196	-0.07	-0.005	0.078	2.474	
120	5	-0.531	-0.503	0.008	-0.067	-0.188	-0.1	-0.181	0.18	-0.061	0.006	0.097	2.44	
132	5.5	-0.53	-0.5	-0.001	-0.073	-0.197	-0.102	-0.183	0.151	-0.06	0.008	0.103	2.483	
144	6	-0.532	-0.499	-0.003	-0.079	-0.204	-0.104	-0.181	0.108	-0.059	0.012	0.102	2.436	
156	6.5	-0.531	-0.497	-0.006	-0.092	-0.212	-0.11	-0.155	0.067	-0.06	0.009	0.103	2.374	
168	7	-0.533	-0.506	-0.02	-0.108	-0.224	-0.117	-0.152	0.03	-0.063	0.007	0.1	2.301	
180	7.5	-0.532	-0.499	-0.019	-0.12	-0.227	-0.124	-0.146	-0.008	-0.069	-0.003	0.086	2.209	
192	8	-0.532	-0.496	-0.016	-0.126	-0.23	-0.124	-0.125	-0.028	-0.069	-0.002	0.088	2.172	
204	8.5	-0.532	-0.495	0.062	-0.064	-0.181	-0.057	-0.036	0.054	0.032	0.117	0.221	2.066	
216	9	-0.533	-0.494	0.056	-0.073	-0.184	-0.057	-0.027	0.047	0.031	0.117	0.219	2.03	
228	9.5	-0.533	-0.494	0.054	-0.085	-0.187	-0.064	-0.015	0.019	0.027	0.113	0.209	1.971	
240	10	-0.541	-0.498	0.03	-0.103	-0.192	-0.071	0.001	-0.014	0.019	0.1	0.187	1.827	
252	10.5	-0.318	-0.654	0.332	0.151	-0.134	0.003	0.101	0.018	0.028	0.092	0.174	1.296	
264	11	0.978	-0.574	0.42	0.211	-0.131	0.006	0.147	0.001	-0.032	0.023	0.071	1.03	
276	11.5	-0.26	-0.248	0.408	0.119	-0.03	0.107	0.229	0.114	0.153	0.212	0.296	0.843	
288	12	-0.181	-0.175	0.472	0.282	-0.043	0.089	0.211	0.06	0.069	0.121	0.173	0.648	
300	12.5	-0.158	-0.154	0.524	0.285	-0.041	0.109	0.211	0.056	0.065	0.113	0.157	0.587	
312	13	-0.18	-0.175	0.46	0.237	-0.069	0.129	0.225	0.025	0.033	0.085	0.122	0.664	
324	13.5	-0.18	-0.175	-0.171	0.222	-0.071	0.12	0.198	0.027	0.04	0.084	0.125	0.653	
336	14	1.879	-0.482	0.437	0.207	-0.078	0.108	0.201	0.018	0.034	0.074	0.109	0.679	
348	14.5	-0.18	-0.175	-0.171	0.203	-0.074	0.128	0.206	0.014	0.033	0.073	0.106	0.679	
360	15	1.285	-0.515	-0.803	-0.027	-0.097	0.091	0.208	-0.018	0.009	0.063	0.075	0.778	
372	15.5	-0.342	-0.324	-0.306	-0.165	-0.209	0.026	0.141	-0.112	-0.035	0.238	0.254	1.318	
384	16	-0.056	-0.156	-0.167	-0.158	-0.144	-0.126	-0.13	-0.13	-0.126	-0.13	-0.182	-0.033	
396	16.5	-0.059	-0.157	-0.166	-0.165	-0.136	-0.123	-0.128	-0.126	-0.123	-0.127	-0.18	-0.031	
408	17	-0.137	-0.18	-0.168	-0.17	-0.13	-0.125	-0.129	-0.124	-0.126	-0.128	-0.181	-0.032	
420	17.5	-0.041	-0.04	-0.041	-0.045	-0.043	-0.04	-0.039	-0.041	-0.04	-0.039	-0.041	-0.032	
432	18	-0.041	-0.039	-0.041	-0.044	-0.04	-0.039	-0.039	-0.039	-0.039	-0.039	-0.041	-0.032	

444	18.5	-0.039	-0.039	-0.042	-0.043	-0.04	-0.039	-0.038	-0.039	-0.039	-0.038	-0.04	-0.032
456	19	-0.04	-0.04	-0.041	-0.043	-0.039	-0.038	-0.038	-0.039	-0.038	-0.038	-0.04	-0.032
468	19.5	-0.04	-0.041	-0.042	-0.043	-0.039	-0.038	-0.038	-0.038	-0.038	-0.038	-0.039	-0.032
480	20	-0.041	-0.042	-0.044	-0.044	-0.04	-0.038	-0.039	-0.039	-0.038	-0.038	-0.04	-0.032
492	20.5	-0.042	-0.043	-0.045	-0.046	-0.042	-0.04	-0.04	-0.041	-0.04	-0.04	-0.041	-0.034
504	21	-0.269	1.213	0.752	-0.056	-0.059	0.231	0.659	0.112	0.422	0.882	0.46	1.72
516	21.5	-0.276	1.235	0.746	-0.025	-0.053	0.194	0.617	0.108	0.339	0.879	0.395	1.797
528	22	-0.285	1.274	0.798	-0.002	-0.048	0.19	0.636	0.107	0.318	0.907	0.339	1.912
540	22.5	-0.279	1.254	0.782	0.013	-0.052	0.178	0.629	0.109	0.277	0.86	0.223	1.967
552	23	-0.282	1.246	0.748	0.024	-0.05	0.169	0.636	0.12	0.236	0.783	0.171	2.029
564	23.5	-0.283	1.218	0.723	0.025	-0.048	0.152	0.621	0.12	0.185	0.62	0.152	2.069
576	24	-0.286	1.207	0.7	0.023	-0.047	0.134	0.612	0.113	0.147	0.395	0.132	2.123
588	24.5	-0.29	1.172	0.683	0.021	-0.041	0.114	0.591	0.106	0.127	0.219	0.124	2.122
600	25	-0.293	1.15	0.669	0.018	-0.039	0.095	0.558	0.082	0.105	0.177	0.122	2.108
612	25.5	-0.296	1.128	0.652	0.012	-0.046	0.079	0.52	0.072	0.074	0.16	0.126	2.084
624	26	-0.293	1.13	0.647	0.008	-0.06	0.066	0.489	0.06	0.058	0.147	0.13	2.011
636	26.5	-0.296	1.103	0.623	0	-0.174	-0.018	0.282	-0.03	-0.049	0.027	0.002	2.073
648	27	-0.295	1.096	0.61	-0.007	-0.234	-0.066	0.17	-0.082	-0.109	-0.039	-0.068	2.085
660	27.5	-0.291	1.097	0.601	-0.013	-0.296	-0.115	0.068	-0.125	-0.168	-0.107	-0.143	2.109
672	28	-0.298	1.074	0.585	-0.022	-0.3	-0.115	0.064	-0.129	-0.167	-0.105	-0.136	2.075
684	28.5	-0.287	1.094	0.608	-0.019	-0.308	-0.117	0.052	-0.134	-0.179	-0.119	-0.149	2.047
696	29	-0.282	1.075	0.59	-0.023	-0.319	-0.128	0.037	-0.135	-0.18	-0.12	-0.148	2.018

Changes in Conductivity (mS)
 Cycle 9: Column 4 (RXP)

Time (h)	Time (d)	Depth (in.)											
		0	1	2	3	4	5	6	7	8	9	10	11
-3	-0.125	0.216	0.384	0.444	0.11	0.26	0.342	0.354	0.265	0.255	0.317	0.282	0.483
0	0	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.034	-0.035	-0.037	-0.028
3	0.125	-0.01	-0.014	-0.03	0.114	0.268	0.381	0.434	0.274	0.223	0.331	0.267	0.97
6	0.25	-0.037	-0.486	0.736	0.1	0.226	0.324	0.362	0.236	0.174	0.266	0.21	0.78
9	0.375	-0.033	-0.032	0.597	0.098	0.202	0.291	0.318	0.218	0.159	0.24	0.188	0.662
12	0.5	-0.034	-0.035	0.555	0.097	0.21	0.286	0.29	0.209	0.151	0.225	0.175	0.598
15	0.625	-0.035	-0.038	0.553	0.094	0.208	0.275	0.292	0.212	0.14	0.21	0.159	0.58
18	0.75	-0.037	0.441	0.5	0.093	0.202	0.263	0.278	0.205	0.136	0.2	0.153	0.59
21	0.875	-0.037	0.44	0.503	0.091	0.201	0.258	0.271	0.203	0.134	0.196	0.15	0.576
24	1	-0.032	-0.036	0.575	0.091	0.189	0.281	0.283	0.211	0.137	0.202	0.16	0.556
36	1.5	-0.01	-0.031	0.666	0.092	0.201	0.273	0.282	0.218	0.144	0.216	0.155	0.573
48	2	-0.01	-0.031	0.613	0.092	0.176	0.26	0.272	0.216	0.146	0.224	0.159	0.577
60	2.5	-0.008	-0.03	0.683	0.09	0.2	0.247	0.273	0.215	0.148	0.227	0.162	0.568
72	3	-0.008	-0.03	0.636	0.086	0.193	0.238	0.277	0.208	0.147	0.231	0.162	0.58
84	3.5	-0.01	-0.029	0.749	0.079	0.179	0.233	0.267	0.192	0.154	0.229	0.172	0.521
96	4	-0.007	-0.016	0.894	0.074	0.177	0.235	0.268	0.187	0.156	0.22	0.174	0.52
108	4.5	-0.007	-0.016	0.877	0.074	0.17	0.237	0.273	0.181	0.159	0.218	0.179	0.526
120	5	-0.006	-0.015	0.863	0.071	0.168	0.239	0.278	0.177	0.161	0.22	0.183	0.538
132	5.5	-0.006	-0.015	0.842	0.063	0.166	0.24	0.281	0.173	0.163	0.22	0.186	0.587
144	6	-0.006	-0.015	0.826	0.061	0.166	0.241	0.283	0.169	0.165	0.222	0.189	0.593
156	6.5	-0.005	-0.015	0.817	0.061	0.167	0.245	0.29	0.165	0.167	0.226	0.194	0.618
168	7	-0.006	-0.015	0.798	0.06	0.162	0.234	0.277	0.157	0.164	0.218	0.189	0.597
180	7.5	-0.004	-0.015	0.802	0.06	0.172	0.248	0.296	0.159	0.17	0.229	0.199	0.711
192	8	-0.004	-0.015	0.781	0.06	0.176	0.249	0.298	0.157	0.172	0.23	0.202	0.689
204	8.5	-0.003	-0.005	0.777	0.061	0.192	0.269	0.326	0.16	0.182	0.249	0.216	0.819
216	9	-0.003	-0.005	0.671	0.062	0.195	0.266	0.32	0.161	0.196	0.256	0.233	0.697
228	9.5	-0.003	-0.005	0.663	0.062	0.19	0.27	0.325	0.158	0.199	0.258	0.236	0.704
240	10	-0.003	-0.005	0.649	0.061	0.19	0.268	0.321	0.154	0.199	0.254	0.231	0.631
252	10.5	-0.003	-0.005	0.638	0.061	0.189	0.265	0.318	0.151	0.199	0.247	0.232	0.63
264	11	-0.003	-0.005	0.572	0.062	0.194	0.273	0.329	0.151	0.204	0.257	0.232	0.606
276	11.5	-0.003	-0.004	0.566	0.067	0.167	0.288	0.336	0.143	0.191	0.246	0.215	0.675
288	12	-0.003	-0.004	0.511	0.068	0.161	0.298	0.353	0.152	0.213	0.278	0.231	0.678
300	12.5	-0.003	-0.01	0.675	0.062	0.13	0.242	0.286	0.13	0.179	0.227	0.19	0.482
312	13	-0.003	-0.01	0.674	0.063	0.126	0.241	0.286	0.131	0.179	0.215	0.188	0.485
324	13.5	-0.003	-0.006	0.608	0.064	0.128	0.25	0.3	0.134	0.188	0.223	0.195	0.482
336	14	-0.003	-0.006	0.6	0.064	0.127	0.248	0.295	0.133	0.185	0.229	0.19	0.468
348	14.5	-0.003	-0.006	0.598	0.064	0.125	0.247	0.291	0.132	0.185	0.227	0.189	0.461
360	15	-0.003	-0.008	0.583	0.063	0.123	0.234	0.27	0.126	0.173	0.218	0.181	0.419
372	15.5	-0.003	-0.008	0.586	0.063	0.12	0.235	0.271	0.125	0.174	0.215	0.188	0.429
384	16	-0.003	-0.008	0.582	0.063	0.119	0.234	0.269	0.124	0.174	0.214	0.186	0.422
396	16.5	-0.005	-0.006	0.567	0.062	0.118	0.233	0.267	0.124	0.171	0.216	0.196	0.414
408	17	-0.003	-0.008	0.572	0.062	0.118	0.231	0.263	0.123	0.171	0.214	0.195	0.403
420	17.5	-0.003	-0.008	0.568	0.062	0.118	0.228	0.261	0.122	0.173	0.206	0.202	0.4
432	18	-0.003	-0.008	0.56	0.062	0.118	0.224	0.257	0.121	0.174	0.206	0.201	0.394
444	18.5	-0.007	-0.008	0.55	0.061	0.118	0.215	0.247	0.119	0.167	0.205	0.201	0.375
456	19	-0.007	-0.008	0.546	0.061	0.116	0.213	0.245	0.118	0.163	0.211	0.207	0.373
468	19.5	-0.005	-0.005	0.511	0.063	0.121	0.226	0.264	0.124	0.175	0.233	0.245	0.401
480	20	-0.005	-0.005	0.511	0.062	0.12	0.222	0.261	0.124	0.179	0.248	0.257	0.388
492	20.5	-0.006	-0.01	0.592	0.059	0.113	0.197	0.235	0.115	0.161	0.233	0.261	0.356
504	21	-0.026	-0.026	0.574	0.057	0.109	0.186	0.216	0.113	0.159	0.226	0.252	0.382
516	21.5	-0.014	-0.025	0.579	0.058	0.113	0.193	0.225	0.118	0.17	0.245	0.292	0.403
528	22	-0.025	-0.025	0.576	0.057	0.117	0.203	0.229	0.123	0.186	0.264	0.311	0.422
540	22.5	-0.015	-0.025	-0.037	0.055	0.116	0.219	0.251	0.132	0.215	0.3	0.371	0.421
552	23	-0.026	-0.025	-0.035	0.055	0.126	0.243	0.284	0.145	0.265	0.319	0.407	0.442
564	23.5	-0.026	-0.025	-0.034	0.055	0.141	0.267	0.307	0.163	0.319	0.386	0.458	0.472
576	24	-0.026	0.025	-0.033	0.059	0.178	0.279	0.291	0.176	0.387	0.459	0.504	0.495
588	24.5	-0.027	-0.026	-0.032	0.057	0.213	0.312	0.325	0.2	0.444	0.56	0.667	0.61
600	25	-0.024	-0.023	-0.028	-0.062	-0.034	-0.034	-0.036	-0.035	-0.032	-0.03	-0.03	-0.033

612	25.5	-0.024	-0.024	-0.028	-0.046	-0.033	-0.033	-0.035	-0.034	-0.034	-0.03	-0.03	-0.033
624	26	-0.026	-0.025	-0.029	-0.036	-0.034	-0.034	-0.035	-0.034	-0.032	-0.031	-0.031	-0.034
636	26.5	-0.026	-0.025	-0.029	-0.042	-0.034	-0.034	-0.035	-0.034	-0.032	-0.031	-0.031	-0.034
648	27	-0.027	-0.026	-0.03	-0.039	-0.035	-0.034	-0.035	-0.035	-0.033	-0.032	-0.033	-0.034
660	27.5	-0.029	-0.027	-0.031	-0.04	-0.035	-0.035	-0.036	-0.036	-0.034	-0.034	-0.034	-0.035
672	28	-0.026	-0.025	-0.028	-0.034	-0.032	-0.032	-0.032	-0.032	-0.031	-0.031	-0.031	-0.032
684	28.5	-0.027	-0.026	-0.029	-0.036	-0.033	-0.033	-0.033	-0.034	-0.032	-0.032	-0.032	-0.033

Changes in Conductivity (mS)

Cycle 9: Column 5: (CTL)

Time (h)	Time (d)	Depth (in.)											
		0	1	2	3	4	5	6	7	8	9	10	11
-3	-0.125	0.127	0.123	0.114	0.118	0.115	0.114	0.114	0.113	0.114	0.113	0.116	0.001
0	0	0.116	0.143	0.132	0.127	0.09	0.089	0.093	0.088	0.09	0.095	0.114	0.001
3	0.125	0.528	0.493	0.445	0.466	0.446	0.449	0.445	0.436	0.437	0.432	0.443	0.001
6	0.25	0.323	0.311	0.287	0.299	0.289	0.29	0.289	0.285	0.286	0.284	0.291	0.001
9	0.375	0.233	0.227	0.212	0.22	0.214	0.214	0.214	0.211	0.212	0.211	0.217	0.001
12	0.5	0.182	0.178	0.167	0.173	0.168	0.168	0.168	0.167	0.168	0.167	0.171	0.001
15	0.625	0.182	0.178	0.167	0.172	0.168	0.168	0.168	0.166	0.167	0.166	0.171	0.001
18	0.75	0.182	0.177	0.165	0.142	0.166	0.166	0.166	0.165	0.165	0.165	0.169	0.001
21	0.875	0.182	0.177	0.165	0.141	0.166	0.166	0.166	0.164	0.165	0.164	0.169	0.001
24	1	0.182	0.178	0.167	0.172	0.168	0.168	0.168	0.166	0.167	0.166	0.171	0.001
36	1.5	0.182	0.177	0.166	0.172	0.167	0.167	0.167	0.166	0.166	0.166	0.17	0.001
48	2	0.182	0.176	0.165	0.17	0.166	0.165	0.165	0.164	0.165	0.164	0.168	0.001
60	2.5	0.183	0.177	0.165	0.17	0.166	0.165	0.165	0.164	0.164	0.163	0.167	0.001
72	3	0.182	0.177	0.165	0.142	0.167	0.167	0.167	0.166	0.166	0.165	0.169	0.001
84	3.5	0.152	0.146	0.136	0.12	0.137	0.136	0.136	0.134	0.135	0.134	0.137	0.001
96	4	0.151	0.146	0.136	0.12	0.136	0.135	0.135	0.134	0.134	0.133	0.137	0.001
108	4.5	0.151	0.146	0.136	0.12	0.136	0.135	0.135	0.134	0.134	0.134	0.137	0.001
120	5	0.151	0.146	0.136	0.119	0.136	0.135	0.135	0.134	0.134	0.133	0.136	0.001
132	5.5	0.182	0.175	0.163	0.168	0.164	0.163	0.163	0.162	0.162	0.162	0.166	0.001
144	6	0.183	0.176	0.163	0.169	0.165	0.164	0.164	0.163	0.163	0.162	0.166	0.001
156	6.5	0.182	0.175	0.163	0.169	0.164	0.164	0.164	0.162	0.163	0.162	0.166	0.001
168	7	0.183	0.178	0.167	0.173	0.169	0.168	0.168	0.167	0.167	0.166	0.17	0.001
180	7.5	0.232	0.223	0.207	0.216	0.21	0.21	0.21	0.208	0.209	0.207	0.213	0.001
192	8	0.231	0.222	0.206	0.215	0.21	0.21	0.21	0.208	0.209	0.208	0.212	0.001
204	8.5	0.318	0.301	0.278	0.292	0.285	0.286	0.286	0.282	0.283	0.28	0.287	0.001
216	9	0.231	0.221	0.205	0.214	0.209	0.209	0.209	0.208	0.208	0.207	0.212	0.001
228	9.5	0.231	0.221	0.205	0.214	0.209	0.209	0.209	0.207	0.208	0.206	0.211	0.001
240	10	0.182	0.175	0.163	0.169	0.164	0.164	0.164	0.162	0.163	0.162	0.166	0.001
252	10.5	0.182	0.175	0.162	0.168	0.164	0.163	0.163	0.162	0.162	0.161	0.165	0.001
264	11	0.183	0.176	0.163	0.169	0.165	0.164	0.164	0.162	0.162	0.161	0.165	0.001
276	11.5	0.231	0.221	0.205	0.214	0.209	0.209	0.209	0.207	0.207	0.206	0.211	0.001
288	12	0.231	0.221	0.205	0.214	0.209	0.209	0.209	0.207	0.208	0.206	0.211	0.001
300	12.5	0.131	0.126	0.117	0.12	0.117	0.116	0.115	0.114	0.114	0.113	0.116	0.001
312	13	0.13	0.125	0.116	0.12	0.116	0.115	0.115	0.114	0.114	0.113	0.115	0.001
324	13.5	0.13	0.125	0.116	0.104	0.116	0.115	0.115	0.114	0.114	0.113	0.115	0.001
336	14	0.13	0.125	0.117	0.104	0.116	0.115	0.115	0.114	0.114	0.113	0.115	0.001
348	14.5	0.13	0.125	0.116	0.104	0.116	0.115	0.115	0.114	0.114	0.113	0.115	0.001
360	15	0.113	0.11	0.102	0.105	0.102	0.101	0.101	0.1	0.1	0.1	0.102	0.001
372	15.5	0.113	0.11	0.102	0.105	0.102	0.101	0.101	0.1	0.1	0.099	0.101	0.001
384	16	0.114	0.11	0.102	0.105	0.102	0.101	0.101	0.1	0.1	0.099	0.101	0.001
396	16.5	0.129	0.125	0.116	0.104	0.116	0.115	0.115	0.114	0.114	0.114	0.116	0.001
408	17	0.113	0.11	0.102	0.104	0.102	0.1	0.1	0.099	0.099	0.099	0.1	0.001
420	17.5	0.113	0.109	0.102	0.104	0.101	0.1	0.1	0.099	0.099	0.098	0.1	0.001
432	18	0.113	0.109	0.102	0.104	0.101	0.1	0.1	0.099	0.099	0.098	0.1	0.001
444	18.5	0.113	0.109	0.102	0.104	0.101	0.1	0.1	0.099	0.099	0.099	0.1	0.001
456	19	0.113	0.11	0.102	0.105	0.102	0.101	0.1	0.099	0.099	0.099	0.101	0.001
468	19.5	0.129	0.124	0.116	0.139	0.116	0.115	0.115	0.114	0.114	0.113	0.116	0.001
480	20	0.129	0.124	0.116	0.14	0.116	0.115	0.115	0.114	0.114	0.113	0.116	0.001
492	20.5	0.101	0.097	0.091	0.093	0.09	0.089	0.089	0.088	0.088	0.087	0.089	0.001
504	21	0.091	0.088	0.082	0.084	0.081	0.08	0.08	0.079	0.079	0.079	0.08	0.001

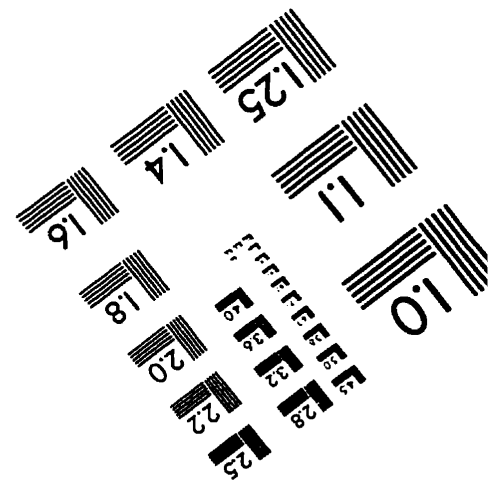
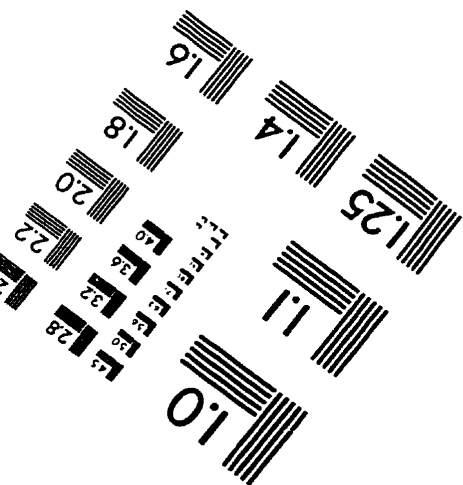
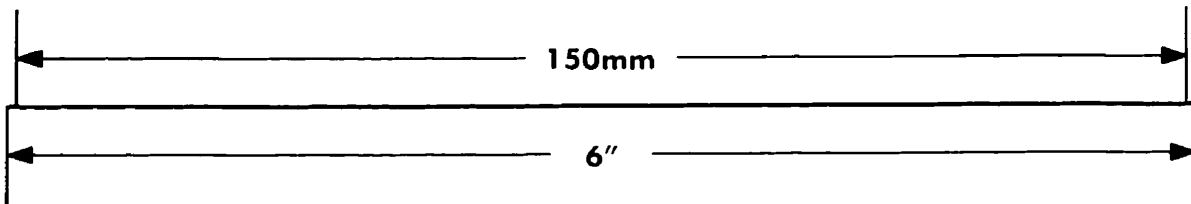
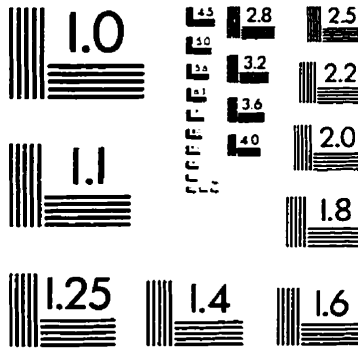
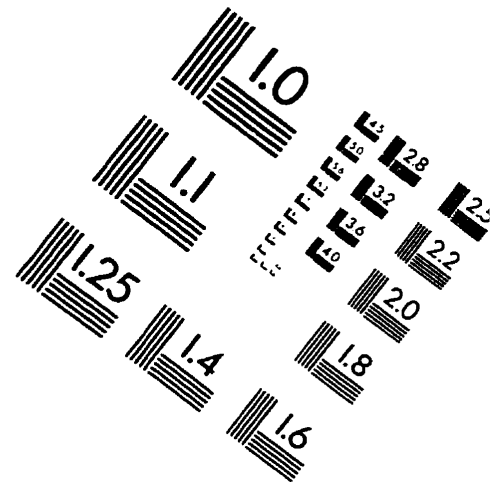
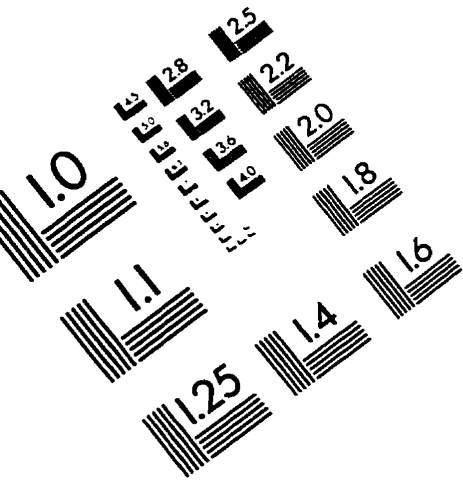
516	21.5	0.1	0.097	0.091	0.093	0.09	0.089	0.089	0.088	0.088	0.087	0.089	0.001
528	22	0.101	0.098	0.091	0.093	0.09	0.089	0.089	0.088	0.088	0.088	0.089	0.001
540	22.5	0.112	0.109	0.101	0.092	0.101	0.1	0.1	0.099	0.099	0.098	0.1	0.001
552	23	0.113	0.109	0.102	0.105	0.102	0.101	0.1	0.099	0.099	0.099	0.101	0.001
564	23.5	0.113	0.109	0.102	0.104	0.101	0.1	0.1	0.099	0.099	0.099	0.1	0.001
576	24	0.129	0.124	0.116	0.14	0.116	0.115	0.115	0.114	0.114	0.114	0.116	0.001
588	24.5	0.182	0.175	0.162	0.14	0.165	0.164	0.164	0.163	0.164	0.163	0.166	0.001
600	25	0.107	0.13	0.115	0.128	0.082	0.082	0.086	0.08	0.084	0.083	0.097	0.001
612	25.5	0.108	0.131	0.115	0.128	0.081	0.082	0.085	0.08	0.084	0.083	0.097	0.001
624	26	0.117	0.148	0.125	0.148	0.09	0.09	0.095	0.088	0.093	0.091	0.109	0.001
636	26.5	0.092	0.11	0.098	0.109	0.074	0.074	0.078	0.073	0.076	0.076	0.087	0.001
648	27	0.1	0.121	0.109	0.12	0.082	0.082	0.087	0.081	0.085	0.085	0.099	0.001
660	27.5	0.097	0.117	0.107	0.116	0.082	0.082	0.086	0.08	0.085	0.084	0.097	0.001
672	28	0.109	0.134	0.124	0.132	0.092	0.092	0.098	0.09	0.094	0.094	0.112	0.001
684	28.5	0.099	0.117	0.108	0.115	0.081	0.081	0.086	0.08	0.083	0.083	0.096	0.001

Changes in Conductivity (mS)
Cycle 9: Column 4 - Column 5: Exp-Ctl

Time (h)	Time (d)	Depth (")											
		0	1	2	3	4	5	6	7	8	9	10	11
-3	-0.125	0.089	0.261	0.33	-0.008	0.145	0.228	0.24	0.152	0.141	0.204	0.166	0.482
0	0	-0.119	-0.146	-0.135	-0.13	-0.093	-0.092	-0.096	-0.091	-0.124	-0.13	-0.151	-0.029
3	0.125	-0.538	-0.507	-0.475	-0.352	-0.178	-0.068	-0.011	-0.162	-0.214	-0.101	-0.176	0.969
6	0.25	-0.36	-0.797	0.449	-0.199	-0.063	0.034	0.073	-0.049	-0.112	-0.018	-0.081	0.779
9	0.375	-0.266	-0.259	0.385	-0.122	-0.012	0.077	0.104	0.007	-0.053	0.029	-0.029	0.661
12	0.5	-0.216	-0.213	0.388	-0.076	0.042	0.118	0.122	0.042	-0.017	0.058	0.004	0.597
15	0.625	-0.217	-0.216	0.386	-0.078	0.04	0.107	0.124	0.046	-0.027	0.044	-0.012	0.579
18	0.75	-0.219	0.264	0.335	-0.049	0.036	0.097	0.112	0.04	-0.029	0.035	-0.016	0.589
21	0.875	-0.219	0.263	0.338	-0.05	0.035	0.092	0.105	0.039	-0.031	0.032	-0.019	0.575
24	1	-0.214	-0.214	0.408	-0.081	0.021	0.113	0.115	0.045	-0.03	0.036	-0.011	0.555
36	1.5	-0.192	-0.208	0.5	-0.08	0.034	0.106	0.115	0.052	-0.022	0.05	-0.015	0.572
48	2	-0.192	-0.207	0.448	-0.078	0.01	0.095	0.107	0.052	-0.019	0.06	-0.009	0.576
60	2.5	-0.191	-0.207	0.518	-0.08	0.034	0.082	0.108	0.051	-0.016	0.064	-0.005	0.567
72	3	-0.19	-0.207	0.471	-0.056	0.026	0.071	0.11	0.042	-0.019	0.066	-0.007	0.579
84	3.5	-0.162	-0.175	0.613	-0.041	0.042	0.097	0.131	0.058	0.019	0.095	0.035	0.52
96	4	-0.158	-0.162	0.758	-0.046	0.041	0.1	0.133	0.053	0.022	0.087	0.037	0.519
108	4.5	-0.158	-0.162	0.741	-0.046	0.034	0.102	0.138	0.047	0.025	0.084	0.042	0.525
120	5	-0.157	-0.161	0.727	-0.048	0.032	0.104	0.143	0.043	0.027	0.087	0.047	0.537
132	5.5	-0.188	-0.19	0.679	-0.105	0.002	0.077	0.118	0.011	0.001	0.058	0.02	0.586
144	6	-0.189	-0.191	0.663	-0.108	0.001	0.077	0.119	0.006	0.002	0.06	0.023	0.592
156	6.5	-0.187	-0.19	0.654	-0.108	0.003	0.081	0.126	0.003	0.004	0.064	0.028	0.617
168	7	-0.189	-0.193	0.631	-0.113	-0.007	0.066	0.109	-0.01	-0.003	0.052	0.019	0.596
180	7.5	-0.236	-0.238	0.595	-0.156	-0.038	0.038	0.086	-0.049	-0.039	0.022	-0.014	0.71
192	8	-0.235	-0.237	0.575	-0.155	-0.034	0.039	0.088	-0.051	-0.037	0.022	-0.01	0.688
204	8.5	-0.321	-0.306	0.499	-0.231	-0.093	-0.017	0.04	-0.122	-0.101	-0.031	-0.071	0.818
216	9	-0.234	-0.226	0.466	-0.152	-0.014	0.057	0.111	-0.047	-0.012	0.049	0.021	0.696
228	9.5	-0.234	-0.226	0.458	-0.152	-0.019	0.061	0.116	-0.049	-0.009	0.052	0.025	0.703
240	10	-0.185	-0.18	0.486	-0.108	0.026	0.104	0.157	-0.008	0.036	0.092	0.065	0.63
252	10.5	-0.185	-0.18	0.476	-0.107	0.025	0.102	0.155	-0.011	0.037	0.086	0.067	0.629
264	11	-0.186	-0.181	0.409	-0.107	0.029	0.109	0.165	-0.011	0.042	0.096	0.067	0.605
276	11.5	-0.234	-0.225	0.361	-0.147	-0.042	0.079	0.127	-0.064	-0.016	0.04	0.004	0.674
288	12	-0.234	-0.225	0.306	-0.146	-0.048	0.089	0.144	-0.055	0.005	0.072	0.02	0.677
300	12.5	-0.134	-0.136	0.558	-0.058	0.013	0.126	0.171	0.016	0.065	0.114	0.074	0.481
312	13	-0.133	-0.135	0.558	-0.057	0.01	0.126	0.171	0.017	0.065	0.102	0.073	0.484
324	13.5	-0.133	-0.131	0.492	-0.04	0.012	0.135	0.185	0.02	0.074	0.11	0.08	0.481
336	14	-0.133	-0.131	0.483	-0.04	0.011	0.133	0.18	0.019	0.071	0.116	0.075	0.467
348	14.5	-0.133	-0.131	0.482	-0.04	0.009	0.132	0.176	0.018	0.071	0.114	0.074	0.46
360	15	-0.116	-0.118	0.481	-0.042	0.021	0.133	0.169	0.026	0.073	0.118	0.079	0.418
372	15.5	-0.116	-0.118	0.484	-0.042	0.018	0.134	0.17	0.025	0.074	0.116	0.087	0.428
384	16	-0.117	-0.118	0.48	-0.042	0.017	0.133	0.168	0.024	0.074	0.115	0.085	0.421
396	16.5	-0.134	-0.131	0.451	-0.042	0.002	0.118	0.152	0.01	0.057	0.102	0.08	0.413
408	17	-0.116	-0.118	0.47	-0.042	0.016	0.131	0.163	0.024	0.072	0.115	0.095	0.402

420	17.5	-0.116	-0.117	0.466	-0.042	0.017	0.128	0.161	0.023	0.074	0.108	0.102	0.399
432	18	-0.116	-0.117	0.458	-0.042	0.017	0.124	0.157	0.022	0.075	0.108	0.101	0.393
444	18.5	-0.12	-0.117	0.448	-0.043	0.017	0.115	0.147	0.02	0.068	0.106	0.101	0.374
456	19	-0.12	-0.118	0.444	-0.044	0.014	0.112	0.145	0.019	0.064	0.112	0.106	0.372
468	19.5	-0.134	-0.129	0.395	-0.076	0.005	0.111	0.149	0.01	0.061	0.12	0.129	0.4
480	20	-0.134	-0.129	0.395	-0.078	0.004	0.107	0.146	0.01	0.065	0.135	0.141	0.387
492	20.5	-0.107	-0.107	0.501	-0.034	0.023	0.108	0.146	0.027	0.073	0.146	0.172	0.355
504	21	-0.117	-0.114	0.492	-0.027	0.028	0.106	0.136	0.034	0.08	0.147	0.172	0.381
516	21.5	-0.114	-0.122	0.488	-0.035	0.023	0.104	0.136	0.03	0.082	0.158	0.203	0.402
528	22	-0.126	-0.123	0.485	-0.036	0.027	0.114	0.14	0.035	0.098	0.176	0.222	0.421
540	22.5	-0.127	-0.134	-0.138	-0.037	0.015	0.119	0.151	0.033	0.116	0.202	0.271	0.42
552	23	-0.139	-0.134	-0.137	-0.05	0.024	0.142	0.184	0.046	0.166	0.22	0.306	0.441
564	23.5	-0.139	-0.134	-0.136	-0.049	0.04	0.167	0.207	0.064	0.22	0.287	0.358	0.471
576	24	-0.155	-0.099	-0.149	-0.081	0.062	0.164	0.176	0.062	0.273	0.345	0.388	0.494
588	24.5	-0.209	-0.201	-0.194	-0.083	0.048	0.148	0.161	0.037	0.28	0.397	0.501	0.609
600	25	-0.131	-0.153	-0.143	-0.19	-0.116	-0.116	-0.122	-0.115	-0.116	-0.113	-0.127	-0.034
612	25.5	-0.132	-0.155	-0.143	-0.174	-0.114	-0.115	-0.12	-0.114	-0.118	-0.113	-0.127	-0.034
624	26	-0.143	-0.173	-0.154	-0.184	-0.124	-0.124	-0.13	-0.122	-0.125	-0.122	-0.14	-0.035
636	26.5	-0.118	-0.135	-0.127	-0.151	-0.108	-0.108	-0.113	-0.107	-0.108	-0.107	-0.118	-0.035
648	27	-0.127	-0.147	-0.139	-0.159	-0.117	-0.116	-0.122	-0.116	-0.118	-0.117	-0.132	-0.035
660	27.5	-0.126	-0.144	-0.138	-0.156	-0.117	-0.117	-0.122	-0.116	-0.119	-0.118	-0.131	-0.036
672	28	-0.135	-0.159	-0.152	-0.166	-0.124	-0.124	-0.13	-0.122	-0.125	-0.125	-0.143	-0.033
684	28.5	-0.126	-0.143	-0.137	-0.151	-0.114	-0.114	-0.119	-0.114	-0.115	-0.115	-0.128	-0.034

IMAGE EVALUATION TEST TARGET (QA-3)



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