Abstract

Title of Thesis HYDROMORPHOLOGY OF ANOMALOUS BRIGHT LOAMY SOILS ON THE MID-ATLANTIC COASTAL PLAIN

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Some loamy textured soils along the Mid-Atlantic coastal plain undergo extended periods of saturation or ponding, yet lack the hydromorphology that identifies them as hydric by any of the currently approved Field Indicators of Hydric Soils (FI). Termed Anomalous Bright Loamy Soils (ABLS), these were identified at four research sites on the Delmarva Peninsula. The hydrologic and biogeochemical status of these soils was monitored for three years along a hydrosequence at each site. A series of field and lab experiments were run to investigate the possible causes for the ABLS-phenomenon. The most likely cause is a combination of low hydrologic gradient coupled with the length of time since saturation. Using observed morphology, a newly developed Field Indicator successfully discriminated between five hydric soils that lacked an approved indicator and those that were not hydric. This indicator has now been approved as an official FI of Hydric Soils (F20).

HYDROMORPHOLOGY OF ANOMALOUS BRIGHT LOAMY SOILS ON THE MID-ATLANTIC COASTAL PLAIN

by

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Dedication

I dedicate this thesis to my parents, Gisela and Klaus:

The support you have offered me, not only during the years spent completing this project, but throughout all of my life as well, has been unwavering and constant, and without any doubts.

There is no way I could repay what you have given me.

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There may be no other time of the year when it would be more appropriate for me to acknowledge my appreciation and thanks for all who have participated in any way to the successful completion of this project, than on this Thanksgiving Day of 2008.

I would like to extend my gratitude to the U.S. Environmental Protection Agency, in cooperation with the Maryland Department of the Environment, for proving the funds to carry out this project; to all the members of the Mid-Atlantic Hydric Soils Committee and to the National Technical Committee for Hydric Soils who gave their time and thoughts, and who provided many insightful recommendations over the years.

Thank you to all the professors of my classes who made it possible for me to realize my own excitement and joy for soils. To all the people who helped me with my work, when two hands and one mind were simply not enough: John Wah, Steve Burch, Suzy Park, Cary Coppock, Brian Strong, Karen Vaughan and Rob Vaughan, Carol Gordon, Danielle Balduff, and David Win of the University of MD; Carla Baker, Charlie Hanner, Phillip King, and Al Rizzo of the NRCS.

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1) Thesis Introduction

As population growth continues to transform the dwindling acreage of available rural spaces and open farm land into housing communities, shopping strips, and light industry, development boundaries are being pushed to the fringes of environmentally fragile areas such as wetlands and related transitional zones. Not until recent decades has the value of these zones been recognized (Dennison and Berry, 1993; Troeh et al., 1999). Floodwaters that may otherwise inundate communities are attenuated by wetland soils and vegetation. Rainwater washed off roads, agricultural fields, and construction sites carrying pollutants such as fertilizers, chemicals, and sediment is mediated by the various wetland processes yielding higher-quality outgoing surface and ground waters. In times of drought, wetlands moderate local hydrology by steadily supplying a continuous base flow to first order creeks and streams (Berry, 1993).

While wetlands provide people and their communities with these and other beneficial features, they are also highly productive wildlife habitats and home to a diverse community of plants and animals (National Research Council, 1995). A recurring sense of urgency to protect these vital areas continues to play a major role in how current environmental issues are approached and resolved. To protect these important wetlands, effective ways of systematically distinguishing between those areas that are wetlands and those that are not must be developed. This concept of a comprehensive method of wetland identification is founded on a three-parameter approach that considers the characteristics of wetland soils, wetland hydrology, and wetland vegetation. The official definition of a wetland states that: Wetlands are "…those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal conditions do support, a prevalence of vegetation typically adapted for life in saturated soil conditions" (Environmental Laboratory, 1987). All three parameters must be present in some capacity before an area qualifies as a wetland, with each parameter having specific criteria (National Research Council (NRC), 1995).

Hydrology

Water is the primary driving factor in the existence of a wetland (Mitsch and Gosselink, 2000). If the local water table comes close enough to the soil surface for long enough periods of time during the year, biogeochemical reactions take place that over time result in a variety of wetland processes. The definition of the terms "timing", "frequency", and "duration" of saturation varies between several regulatory agencies in the United States. The 1987 Corps of Engineers (COE) Wetland Delineation Manual requires continuous inundation and/or saturation to the soil surface for 5 to 12.5% of the time (duration) during the regional "growing season" (timing). The commonly accepted duration of an event necessary to bring about anaerobic and reducing conditions in the soil is 7 days (inundation) or 14 (saturation) (National Research Council (NRC), 1995). Under "normal" weather conditions (occurrence of monthly precipitation amounts between the 30th and 70th percentile) the frequency of wetland hydrological conditions is expected to be at least 50% of the time or at least 50 out of 100 years.

Vegetation

Vegetation communities differ from wetland to upland sites. Plants can be divided into five categories, distinguished by the probability of their occurrence in a wetland under natural conditions (Mitsch and Gosselink, 2000). Obligate wetland plants (OBL) are estimated to occur > 99% of time in wetlands and < 1% in non-wetlands; facultative wetland plants (FACW) are estimated to occur 67-99% of the time in wetlands and 1-33% in non-wetlands; facultative plants (FAC) share an equal chance (33-67%) of living in either wetland and/or non-wetland environments; facultative upland plants (FACU) are estimated to occur 1-33% of the time in wetlands and 67-99% in non-wetlands, while upland plants (UPL) occur almost exclusively (>99%) in non-wetlands (Mitsch and Gosselink, 2000). Wetland vegetation communities are normally dominated by FAC, FACW, or OBL plants (Tiner, 1993).

Hydric Soils

The phenomenon of regular cycling between anaerobic and aerobic conditions over the years has a distinctive effect on the appearance of a soil (Richardson et al., 2001). Morphological features that develop are indications of processes that occur in soils under saturated conditions containing adequate organic matter and facultative anaerobic bacteria (Mausbach and Parker, 2001; Rabenhorst, 2004).

The currently accepted definition of a hydric soil was published in the *Federal Register,* July 13, 1994 and states: "A hydric soil is a soil that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part."

The phrase "…formed under conditions" refers to the original environment (hydrological/pedological conditions) under which the soil developed. The hydric soil component in the definition of a wetland is based on morphological characteristics that form as a result of wetland hydrology. Due to the persistent nature of redoximorphic features, the soil does not necessarily have to be saturated, flooded, or ponded at the time of its description. Based on the definition, drained hydric soils are still considered "hydric", however they cannot contribute to an area qualifying as a wetland due to the lacking hydrological component.

The phrase "…saturation, flooding, or ponding" alludes to the wet conditions that are necessary to induce the anaerobic conditions characteristic of typical hydric soils.

The phrase "…during the growing season" refers to the time of year when temperatures are warm enough for soil microbes to be active. The concept of biologic zero (5°C at 50-cm soil depth) is based on the notion that "metabolic processes of microorganisms, plant roots, and animals are negligible" at lower temperatures (Environmental Laboratory, 1987). However, soils in Alaska have demonstrated the ability of certain bacteria to reduce Fe at temperatures that fall below biological zero (Clark and Ping, 1997; Gregorich and Janzen, 2000; Rivkina et al., 2000; Vasilas, 2004). The National Technical Committee for Hydric Soils (NTCHS) continues to deliberate on this issue (NTCHS, 2003).

The phrase "…anaerobic conditions" involves the soil experiencing saturation long enough for soil microbes to deplete the oxygen. In relation to a hydric soil, the

NTCHS has understood this condition to be demonstrated by a level of reduction, adequate to transform Fe (III) to Fe (II).

Ideally, the process of hydric soil identification would be straightforward enough so that consistent and accurate delineations with few complications could be achieved by relatively non-specialized personnel. This is unfortunately not the case. Over recent decades the process has become a precise and an increasingly detail-oriented procedure. The easily recognizable and common characteristics that hydric soils exhibit are the first traits soil scientists look for. Fundamental to typical wetland soils are the accumulation of organic matter at the surface and gray soil colors mottled with iron redox concentrations. To help soil scientists reach a higher degree of accuracy in delineating wetlands, it is imperative to recognize the highly variable nature that exists in a soil's morphological expression of hydric conditions.

Field Indicators of Hydric Soils

Field Indicators of Hydric Soils (FI) have been developed to be used to systematically identify hydric soils in the field. This guide provides field soil scientists with a list of soil morphological features that can be used to conclude, proof-positive, that a soil is hydric. Field Indicators are used throughout the United States; however, not every *Indicator* is applicable in every part of the Nation. Using soils, geological, and land-use properties, the U.S. is separated into regions (Land Resource Regions (LRA) or Major Land Resource Areas (MLRA)). Within each region particular *Field Indicators* may be applied (USDA-NRCS, 2006b). *Indicators* were developed to be "proof-positive" in that a soil is considered hydric if it meets any of the approved *Indicators*.

Although occasionally a soil may be suspected of being hydric, based on professional judgment, it is possible that it may not meet any of the approved *Field Indicators*; the absence of an indicator, however, does not automatically exclude it from being hydric. These hydric soils that lack an approved indicator may be considered “problematic” in the sense that they do not show morphological characteristics typical for their degree of wetness. If the problematic soil is of significant geographic extent, research and field studies may be undertaken to identify new field indicators to accommodate these new situations (USDA-NRCS, 2006a).

The ABLS phenomenon

Anecdotal observations from field soil scientists in the Mid-Atlantic region (Fig. 1-1) indicated that there were hydric soils in close proximity to tidal waters or marshes that did not possess morphological features that were commonly associated with hydric soils. Although they seemed to have high water tables for extended periods of time and were in proximity to tidal wetlands, they often had the morphology of better-drained (SWPD or MWD) soils. Some problematic hydric soils have been identified that are predominantly sandy in texture (Kuehl et al., 1997). Because the soils of this study are largely loams, sandy loams, and silt loams, they have been termed Anomalous Bright Loamy Soils or ABLS.

As we began to study the soils, one of our opening speculations was the absence of saturated conditions. A water table that comes to, or near, the soil surface for extended periods of time during the year is the driving force behind the onset of anaerobic conditions. We therefore questioned whether these sites were simply not wet enough to induce anaerobiosis.

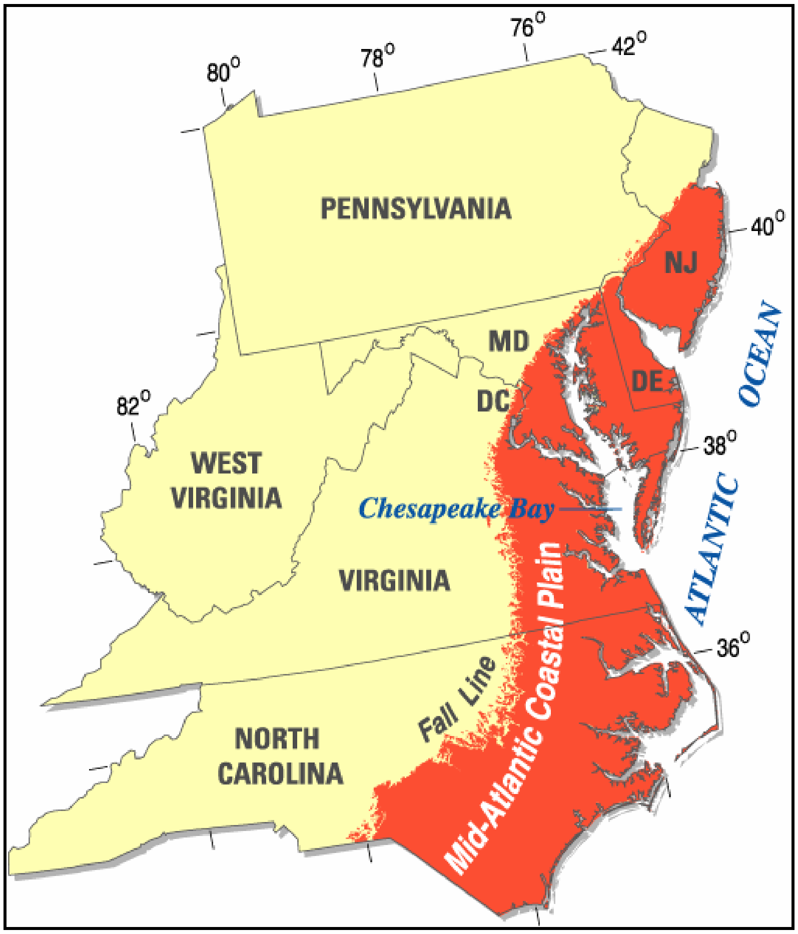


Figure 1-1: Map showing the Mid-Atlantic region of the United States. Area colored in red depicts the Mid-Atlantic coastal plain.
(Source: http://md.water.usgs.gov/publications/fs-157-00/html/index.htm).

A second, possible explanation was that wetland hydrology did exist at the sites, but that the soils did not develop the anaerobic conditions that were required for the production of the morphological features indicative of wetland conditions. Factors that might affect the microbial population or that might keep soils from becoming anaerobic included elevated levels of dissolved salts (or other chemical components of the soil-water), temperatures too low for microbes to be active, low amounts of decomposable organic matter, or oxyaquic conditions (saturation of the soil with oxygenated water).

If both saturation and reduction occur in the soil, yet the soil still does not develop morphological evidence of such conditions, complications may lie in the particles that make up the soil itself. Over time, repeated cycles of soil reduction and aeration in most mineral soils causes the segregation of iron oxides into areas where there are fewer iron coatings (gray areas – "redox depletions") and into areas where there more iron coatings (red areas – "redox concentrations"). Thus, a third possible explanation for ABLS-soils could be that the mineral grains of the soil itself may be resistant to the development of gray colors during times of reduction. This could either be a result of the iron species in the soil being resistant to reducing conditions, or that the uncoated soil mineral grains themselves are inherently brown.

Hypotheses

In most soils of the Mid-Atlantic coastal plain, when water tables come close enough to the surface to significantly affect how land-development is approached, these hydrological conditions are manifested in the form of recognizable soil morphological features. In the case of ABLS, this relationship is not so straightforward. We have described a number of processes that could possibly be responsible for the phenomenon. These are restated below as research hypotheses which can be tested and accepted or rejected.

1. Soils in areas suspected to be wetlands may in fact not be saturated for long enough periods of time to develop typical wetland morphology.

2. Soils may indeed be saturated, but not reducing due to factors affecting microbial activity. Such factors include low amounts of decomposable organic matter, temperatures too low for adequate metabolic activity, salinity of the water. Additionally, the soil may experience oxyaquic conditions (oxygenated water).

3. Soils may be saturated and reducing but do not show typical redoximorphic features due to parent material characteristics. These include mineral grains that, although stripped of their iron coating, appear brown because of the inherent mineralogy. Also, the species of iron oxide that coats the grains may be more resistant to reduction.

Objectives

Therefore, the objectives of this study were: 1) to document the ABLS-phenomenon; 2) to understand the cause of the ABLS-phenomenon (various hypotheses tested); 3) to develop an approach for identifying these problematic soil-landscape settings (determining which soils in these landscapes are in fact hydric soils); 4) to evaluate the present *Hydric Soil Field Indicators* with respect to these ABLS-soils, and 5) if necessary, to propose an alternate FI that will facilitate in the identification of problem hydric soils on the Mid-Atlantic coastal plain.

2) Background

Wetlands

Up until recent decades, wetlands were considered problem parts of the landscape that were sources of disease and a hindrance to the development of agricultural lands (National Research Council, 1995). Practices of wetland destruction through drainage and filling were accepted and encouraged by some government policies over the past 120 years, up until as recently as the mid 1970's (Mitsch and Gosselink, 2000). By the mid 1980's approximately half of the original wetlands in the United States were lost by either draining or filling. A greater concern developed for more comprehensive wetland protection practices and federal policies began to take effect by the mid 1970's. Since then, awareness and education of the values and benefits of wetlands has dramatically increased (Mitsch and Gosselink, 2000; National Research Council, 1995; Tiner, 1993), and the practice of constructing new wetlands has improved while increasing momentum (Shisler, 1990). Some of the many milestone conservation directives or statutes include the Federal Water Pollution Control Act (1972, 1977), Section 404 of the Clean Water Act (1982), the Food Security Act (including the "Swampbuster" provision) (1985), and the Corps of Engineers Wetlands Delineation Manual (1987) (Mitsch and Gosselink, 2000). Within the United States, wetlands are the only type of ecosystem that is subject to comprehensive regulation across all public and private lands (National Research Council, 1995). Continuing efforts to refine how wetlands are recognized and identified across landscapes are applied by agencies such as the U.S. Army Corps of Engineers (Wakeley et al., 1996).

Wetlands can be considered transitional zones between areas that are aquatic and those that are terrestrial, taking on some attributes of each (National Research Council, 1995). The characteristics of a wetland are attributed to several factors which include climate, soil type, topography, geology, and the various hydrologic flow-paths into and out of the area. This last factor is the most influential on how successfully a wetland functions (Mitsch and Gosselink, 2000; National Research Council, 1995; Braddock, 1995; Finlayson and Moser, 1991).

Importance of Wetlands

Wetlands are a vital component of the landscape that act in many ways to help maintain ecosystem health. Vegetation growing along shorelines and stream banks helps to attenuate wave action and prevent soil erosion (Mitsch and Gosselink, 2000). Marshes along tidal waters help to buffer the impact of storm surges that otherwise may threaten local developments (Kusler, 1983). Run-off water from these developments is slowed and filtered by wetland vegetation and soils. Particulates in run-off waters settle in this environment and chemicals are adsorbed and/or transformed by soil minerals (Jeffords et al., 1992; Dennison and Berry, 1993). Although wetlands can function as nutrient “sinks” or “sources” (depending on the seasonal, hydrologic flow-path), wetlands improve water quality through biogeochemical transformations (National Research Council, 1995; Braddock, 1995). The quality of water that flows out of a wetland and into surface or ground waters is greatly improved, containing fewer particulate and chemical contaminants (Kusler, 1983). During drier times of the year, wetlands add to the base-flow of streams and local surface waters, or during draught, maintain a base-flow (Braddock, 1995). The wetland habitat provides for a diverse population of plants and animals. They are considered sanctuaries for wildlife where native plants, animals, fungi, and bacteria thrive. Of all ecosystems occurring in temperate zones of the world, wetlands are considered the most productive (Jeffords et al., 1992).

Components of Wetlands

Since the implementation of Section 404 of the Clean Water Act, open waters and wetlands of the United States have been protected against acts of unregulated dredging and/or filling. The U.S. Corps of Engineers (Federal Register, 1982) in cooperation with the Environmental Protection Agency (Federal Register, 1980) has defined wetlands as: "Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal conditions do support, a prevalence of vegetation typically adapted for life in saturated soil conditions; Wetlands generally include swamps, marshes, bogs, and similar areas." (Environmental Laboratory, 1987). In order for an area to qualify as a jurisdictional wetland, there are three components that must be simultaneously present. These are the hydrologic component, the vegetative component, and the soil component. Each of these contributes to the comprehensive functioning of a wetland.

"Hydrology is probably the single most important determinant of the establishment and maintenance of specific types of wetlands and wetland processes" (Mitsch and Gosselink, 2000) and "…the influence of water is the key parameter in the presence or absence of wetlands" (Hurt and Carlisle, 2001). The effects of wetland hydrology are apparent in the type of plants growing in that area (adaptation of hydrophytic plants) and in the soil morphology that develops (hydric soils), largely due to the anaerobic conditions that commonly follow saturation (Tiner, 1999). Factors that influence hydrology are precipitation, flooding, stratigraphy, soil type (clayey vs. sandy), and plant cover (type and amount) (Environmental Laboratory, 1987; Richardson et al., 2001; Mitsch and Gosselink, 2000). Primary indicators of wetland hydrology include drainage patterns, drift lines, sediment deposition, water marks, and visual observation of saturation or inundation. Secondary indicators are oxidized rhizospheres occurring within the upper 30 cm or the soil, water-stained leaves, and hydrologic data from a soil survey report (Environmental Laboratory, 1987). In the event that a primary indicator is not able to be identified, two secondary indicators may be substituted. Where wetlands occur in the landscape is largely determined by landscape characteristics and the wetland's positions in the landscape (Braddock, 1995). Areas such as depressions, foot-slope seeps, and low-lying areas adjacent to tidal waters are some examples. These areas experience wetness conditions that are primarily driven by seasonal water table fluctuations, precipitation events, flooding, or a combination of these (Mitsch and Gosselink, 2000).

Hydrophytic plants are the second requirement for wetlands. The COE defines hydrophytic vegetation as "the sum total of macrophytic plant life that occurs in areas where the frequency and duration of inundation or soil saturation produce permanently or periodically saturated soils of sufficient duration to exert a controlling influence on the plant species present (may consist of more than one plant community (species association))” (Environmental Laboratory, 1987). These plants are physiologically better-suited to live in moist-to-wet soils, compared to non-hydrophytes, and are sustained only by the hydrologic component of a wetland (Tiner, 1993). Besides hydrology, other influencing factors are light, temperature, soil (texture/permeability), and physical disturbance (Environmental Laboratory, 1987). Indicators of hydrophytic vegetation being the dominant plant type are the presence of at least 50% of a combination of OBL, FACW, or FAC species, or morphological adaptations. These adaptations are a physiological response of the plants exposure to sustained wetness conditions and include adventitious roots, buttressed trunks, and pneumatophores (Mitsch and Gosselink, 2000; National Research Council (NRC), 1995; Tiner, 1993).

The third requirement of a wetland is hydric soils. The currently accepted, technical definition of a hydric soil states that they “…formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part” (Federal Register, 1994). These soils form morphological characteristics as a direct result of their being saturated and reducing for an extended period of the year (Genthner et al., 1998). Although morphological features remain when the hydrological component is removed or altered (through drainage), they reflect the conditions under which that soil formed (Vasilas, 2004). In general, fundamental indicators of the presence of a hydric soil are gray, low-chroma matrix colors, iron concentrations/depletions, and/or a thick, dark-colored surface horizon (Vepraskas, 2001). The list of Field Indicators of Hydric Soils was developed and is maintained by the National Technical Committee for Hydric Soils (USDA-NRCS, 2006a).

Identification of Wetlands

Identifying an area as a wetland involves a three-parameter approach which recognizes the hydrological, vegetative, and soil components of a functioning wetland (Tiner, 1999). Identifying at least one indicator from each of the three parameters assures the presence of a wetland (Environmental Laboratory, 1987).

Although wetland hydrology may be considered the definitive aspect of the existence of a wetland, it is also the most difficult of the three parameters to interpret for identification purposes (National Research Council (NRC), 1995; Mitsch and Gosselink, 2000; Vepraskas, 2001). Water tables in a wetland commonly fluctuate slightly on a daily or weekly basis; however, the greatest changes to a wetland's hydroperiod occur seasonally (Richardson et al., 2001), and is dependant on the contours of the land, as well as characteristics of sub-surface aspects such as soil, geology, and groundwater (Vasilas, 2004). During drier times of the year, water tables drop significantly and may not be readily evident at that time. During the wet season, water tables are closer to the soil surface and are more likely to be observed. With respect to wetland delineation efforts, to accurately determine the frequency and duration of when soil is saturated, without the use of instrumentation, is extremely difficult (Hurt and Carlisle, 2001). Wetland hydrology can be inferred indirectly by considering the expression of the soil and vegetative components. Because hydrology has a direct effect on these two components, they may be considered indicators of the degree of the hydrological influence on the area.

If the vegetative and soil components of delineating a wetland are met, it is likely (but not certain) that the hydrological component is also met (Environmental Laboratory, 1987).

Hydrophytic vegetation has developed ways to successfully survive under hydrologic conditions that periodically saturate or pond the soil throughout the year. Depending on the frequency and duration of these saturation events, the dominance of the plant community type reflects either that of a wetland or an upland area. The plant community in less-obvious wetland areas may be made up of both upland and wetland species; however, for the vegetation component to qualify for a wetland, at least 50% of the vegetation community must be considered wetland vegetation (Federal Register, 1994; Tiner, 1993).

Hydric soils develop as a direct result of a saturated and reducing soil environment (Megonigal et al., 1993). When these conditions persist for long enough periods of time, morphological features form in soils that are characteristically found in wetland areas (Veneman et al., 1998). Whether a hydric soil has been drained or not, its hydromorphology persists over long periods of time, and is an indication of the wet conditions under which it formed (Vasilas, 2004).

Delineating wetlands can involve uncertainties about how accurately the hydrological or vegetative components represent the overall, long-term wetland status of an area. For example, hydrologic conditions in a wetland are heavily influenced by annual precipitation amounts; therefore, water table heights in a wetland can vary significantly from one year to the next, consequently affecting vegetation (Richardson et al., 2001). The inconsistent nature of the hydrological and vegetative components of a wetland may not allow for an accurate representation of the long-term wetland status of that area.

Because morphological characteristics of wetland soils develop over a span of decades to centuries, the expression of their features is a result of the long-term, average hydrological conditions that occur in that area (Rabenhorst, 2004). The morphological features persist over time and are altered very slowly, unaffected by isolated wet or dry years. Therefore, because of the persistent nature of the hydromorphology of a soil, the focus of this project is on the hydric soils component of wetland identification.

Processes leading to hydric soil morphology

Seasonal Saturation by Groundwater

Soil saturation in most Mid-Atlantic wetlands commonly occurs during the cooler months of the year (November – March). During this time, evapotranspiration rates are lowest, thereby allowing groundwater to accumulate and to rise closest to the surface in wetland areas. Water tables fluctuate minimally during this time until vegetation leaf-out occurs and significant evapotranspiration rates resume.

Statistical analyses are performed on long-term precipitation data gathered from sites nationally to determine a typical rainfall amount for a given area. The data are assembled into WETS tables that list a range of monthly precipitation amounts for an area that is considered "normal". In a year when normal precipitation falls, water table data recorded on-site may be considered applicable to wetland assessment efforts.

The hydroperiod of a wetland can be generally defined as the pattern of seasonal water table fluctuations. Factors that influence the hydroperiod of a wetland are the balance between the in- and out-flows of water, the surface contours of the landscape, and the sub-surface soil conditions (Mitsch and Gosselink, 2000). Groundwater levels, and therefore times when the soil is saturated, are dynamic. Short-term fluctuations in water table levels that occur as a result of precipitation events are evident throughout the year. These are usually characterized by spikes and troughs in the hydrograph. These individual events are not considered significant contributors to the overall wetland hydrological conditions (Richardson et al., 2001). Seasonal changes in water tables occurring over the course of a year are a result of a balance between precipitation amounts and the seasonal changes in evapotranspiration.

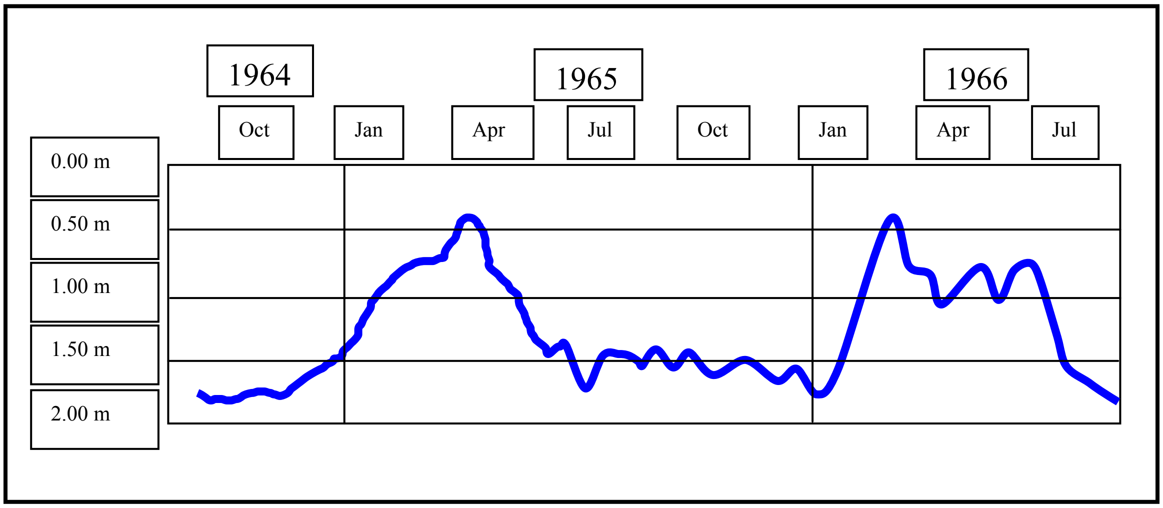


Figure 2-1: Example of a hydrograph of a Woodstown soil in Worcester County, MD, illustrating fluctuations in water table levels that are directly related to influences of precipitation and evapotranspiration (Figure modified from Fig. A2.2 in Fanning and Fanning, 1989)

Although evapotranspiration has a pronounced effect on soil moisture content and groundwater levels during the growing season (Dunne and Leopold, 1998), it is precipitation that most influences water tables throughout the year.

Development of anaerobic (Fe-reducing) conditions

For anaerobic conditions to develop in a soil, several conditions need to be met. Oxygen needs to be excluded from the soil, enough labile organic matter needs to be available as an energy source for the respiration of anaerobic microbes (Germida and Siciliano, 2000), and temperatures need to be warm enough to sustain biologic soil activities (National Research Council, 1995; Tiner, 1993; Vepraskas and Sprecher, 1997). Although the factors that affect the development of anaerobic conditions in the soil depend on one another, the overriding influence of soil saturation is most significant. When a soil becomes saturated, oxygen exchange between the air and the soil is significantly reduced (Gambrell and Patrick, 1978). Oxygen diffuses through water at a rate that is 10^4 times slower than through air, therefore any remaining oxygen levels in the soil or dissolved in the water are rapidly exhausted (Craft, 2001; Ponnamperuma, 1972). The aerobic soil microbial population, at this point, either dies out or goes dormant, and anaerobic microbes begin to respire (Craft, 2001; Rowell, 1981). Both the anaerobic and aerobic microbes require enough decomposable organic matter (OM) to respire. When microbes oxidize organic matter during respiration, electrons are transferred to an electron-acceptor. In an aerobic environment, these electrons are applied to oxygen which reduces to water. Since oxygen is not available as an electron-acceptor in anaerobic soils, electrons are transferred to other oxidants in the soil, such as NO_3^-, Mn^{4+}, Fe^{3+}, SO_4^{2-}, and C^{4+} species (Vepraskas and Faulkner, 2001). As reducing conditions persist and become increasingly stronger, the more easily reduced NO_3^-

and Mn^{4+} species are exhausted. Ferric iron (Fe^{3+}) is the next dominant mineral species in the soil to become an electron-acceptor and becomes reduced to its ferrous state (Fe^{2+}) (Rowell, 1981).

Because microbes are the impetus behind the development of reducing conditions in the soil, temperatures need to be warm enough to sustain respiration (Craft, 2001; National Research Council (NRC), 1995). The concept of biologic zero (5°C at 50-cm soil depth) is based on the idea that when temperatures are too cold, “metabolic processes of microorganisms, plant roots, and animals are negligible” (Environmental Laboratory, 1987). The notion of biologic zero in soils, thereby determining the length of the growing season and wetland determinations, is highly debated (Rabenhorst, 2005). Studies in Alaska have shown soil microbial respiration to occur at temperatures below 5°C (Clark and Ping, 1997; Gregorich and Janzen, 2000; Tiner, 1993). Generally speaking, temperatures that are too low (<4°C) tend to dramatically slow down their activity, while warmer temperatures (> 9°C) show accelerated microbial rates. Moderate temperatures (4°C - 9°C) lend themselves to sustained microbial respiration (Rabenhorst and Castenson, 2005). On average, microbial respiration rates double for every increase of 10°C in temperature (National Research Council (NRC), 1995).

The degree to which a soil is reducing can be quantified by using relatively simple methods and materials that are easily available. Commonly, platinum-tipped electrodes are used in conjunction with a calomel reference electrode and a voltmeter to measure redox potentials in the soil (Fiedler et al., 2007). Oxidizing conditions are prevalent when Eh values are between +700 mV and +400 mV, while conditions ranging from initially anaerobic to extremely reducing are represented by Eh values from +400 mV to -

400 mV (Mitsch and Gosselink, 2000; Sparks, 2003). The redox potentials at which mineral species are reduced are not a static threshold because they are dependant on the pH of the soil (Mitsch and Gosselink, 2000; National Research Council (NRC), 1995; Ponnamperuma, 1972; Vepraskas and Sprecher, 1997). Figure 2-2 shows this relationship in which lower redox potentials are required to reduce a mineral species as the soil pH increases. Here, the Fe-minerals goethite and hematite are plotted relative to criteria set forth by the National Technical Committee for Hydric Soils (black line) (NTCHS, 2000). Soils in which redox potentials plot above the Technical Standard-line are assumed oxidizing (Fe(III)), while those that plot below the TS-line are assumed reducing (Fe(II), relative to the criteria set forth by the NTCHS.

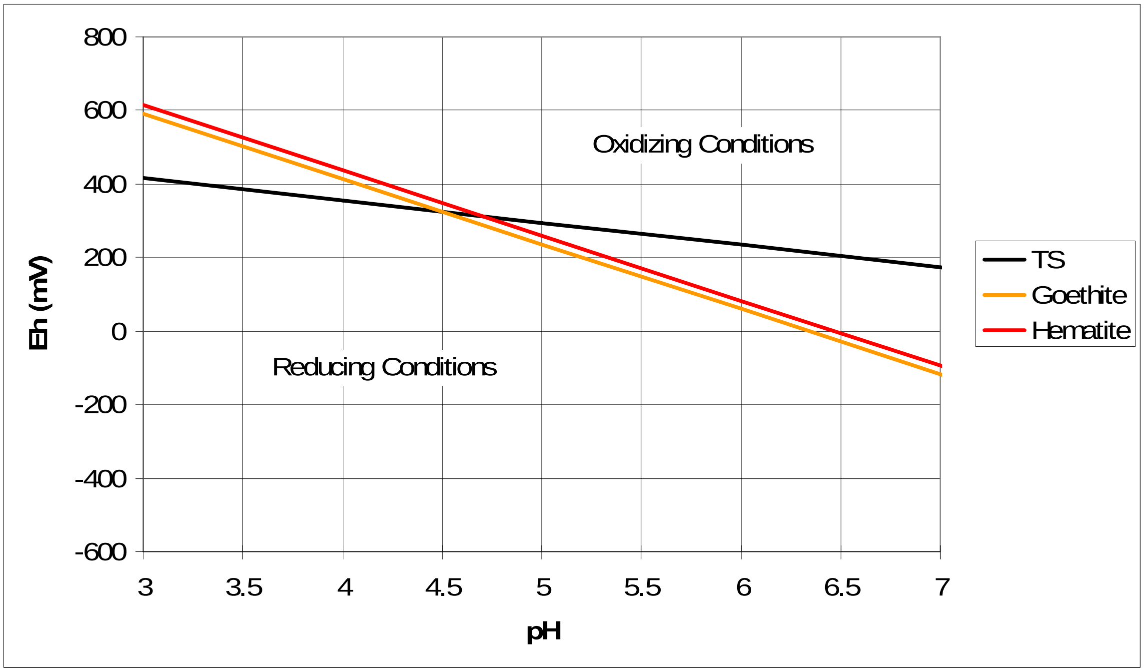


Figure 2-2: Eh/pH stability diagram showing lines representing boundaries between reducing and oxidizing conditions in the soil (relative to criteria set forth by the National Technical Committee for Hydric Soils (NTCHS, 2000)). The orange and red lines represent the stability fields of the minerals goethite (FeOOH) and hematite ($Fe_2O_{3)}$, respectively; and the black line represents the Technical Standard (TS). Goethite and hematite lines were calculated based on Fe-activity of 10^{-6}M.

Segregation of Iron leads to RMF

The repeated cycle of Fe-reduction and Fe-oxidation leads to the formation of redoximorphic features (RMFs) in the soil (National Research Council (NRC), 1995). Redoximorphic features, as related to iron, are considered either Fe-concentrations or Fe-depletions. Iron concentrations are redder areas in the soil where iron (Fe III) has accumulated relative to the surrounding soil matrix, whereas iron depletions are paler zones containing less iron (Fe III) (Vepraskas, 2001). Because ferrous iron (Fe II) is soluble, water movement in the soil influences the formation of RMFs (Vepraskas, 1992). These water vectors in the soil can be either vertical fluctuations due to water tables, lateral movement through the soil because of subtle topographical differences, or also can occur as a consequence of evapotranspiration (Mitsch and Gosselink, 2000). In each of these cases, reduced iron (Fe II) that is present in the soil will follow the flow of any of the water vectors present. When water tables drop and oxygen is introduced into the soil, pore-water containing ferrous iron is oxidized in-place, perpetuating the development of iron concentrations (Fe III) (National Research Council (NRC), 1995; Vepraskas, 2001; Vepraskas and Sprecher, 1997). The root system of most hydrophytic plants brings oxygen into the rhizosphere. This zone directly adjacent to the roots can become oxidized creating iron oxide pore linings (Vepraskas, 1992).

Soil textures also influence the formation of RMFs. Coarse-textured soils are often oxidized more readily compared to finer-textured soils. Textural boundaries can either slow or accelerate water movement through the soil, resulting in zones where either iron depletions or iron concentrations form (Clothier et al., 1978).

The strongly reducing zone that occurs directly around decaying organic matter results in higher concentrations of ferrous iron in this area relative to the surrounding soil matrix. The resulting concentration gradient that occurs between these two areas causes a diffusion of soluble components through the soil over short distances. The movement of these components occurs from areas of higher concentration to areas of lower concentration (Wild, 1981). The zone immediately surrounding decaying OM usually becomes rapidly deficient of iron (Fe-depletion) that grades outwardly into a more iron-rich zone (Fe-concentration) (Vepraskas, 1992).

The degree to which a soil is saturated is expressed in the soil's morphology. Soils that experience occasional saturation may only have Fe-concentrations. Increased saturation times develop Fe-depletions. When soils experience prolonged periods of saturation and reducing conditions the soil matrix color is often gray with few concentrations of iron. In this case, almost all of the iron occurring as soil coatings has been reduced and removed from the system revealing the gray, uncoated soil mineral grains. This depleted matrix is a strong indication of extremely wet soil conditions (Ponnamperuma, 1972; Rabenhorst, 2004; Vepraskas, 2001).

Hydric Soils

Since the implementation of section 404 of the Clean Water act, wetland delineation has become an increasingly active area of interest. The hydric soils component of a wetland is defined as: "…a soil that formed under conditions of saturation, flooding, or ponding, long enough during the growing season to develop anaerobic conditions in the upper part" (Federal Register, 1994). The parts of the definition are further defined; *Formed under* means that the soil’s morphology is a result of the representative, long-term hydrological conditions under which the soil developed. Because of the persistent nature of soil morphology, it is not necessary for a soil with hydromorphology to be saturated or even wet at the time it is described. In some cases, a drained hydric soil is still considered to be “hydric”, although it cannot be termed a wetland due to the lack of the hydrologic component. *Saturation, flooding, or ponding* means that a hydrological component is necessary for the soil to develop the reducing conditions that lead to the formation redoximorphic features. *Long enough* is a time period that a soil needs to experience saturation so that reducing conditions can develop. The length of time it takes for iron-reduction to occur in the soil depends on several factors; however once the soil is sufficiently saturated, temperature is commonly considered one of the primary issues (National Research Council, 1995; Vepraskas, 2001). The 1987 COE Wetlands Delineation Manual suggests a period of continuous soil saturation lasting for a minimum of 5% of the growing season. *During the growing season* is a phrase that refers to the time of year when soil temperatures are warm enough for soil microbes to actively respire. Although research conducted in Alaska supports that soil microbes are somewhat active under temperatures down to 0°C (Clark and Ping, 1997; Rabenhorst, 2005; Tiner, 1999), the National Technical Committee for Hydric Soils (NTCHS) continues to deliberate on this issue (NTCHS, 2003). Many consider the minimum soil temperature at which microbial respiration occurs is 5°C (Megonigal et al., 1996). *To develop anaerobic conditions* means that the soil’s hydric status is conditional on its ability to become anaerobic. Oxyaquic soil conditions occur when enough dissolved oxygen is maintained in the soil water to prevent the soil from developing anaerobic conditions. Under these oxyaquic conditions, a hydric soil cannot develop (Vepraskas and Sprecher, 1997; Vepraskas and Faulkner, 2001). *In the upper part* typically refers to the top 30 cm of the mineral material that has a texture of loamy fine sand (or finer), and for soils with coarser textures, it refers to the upper 15 cm (NRCS, 2006)).

Characteristic morphological features of a hydric soil include concentrations and depletions of iron, a reduced or depleted soil matrix, accumulations of organic matter on the soil surface, and organic staining/streaking of the matrix (Mitsch and Gosselink, 2000; National Research Council (NRC), 1995; Vepraskas, 1992; Vepraskas, 2001). The degree to which each of these features is expressed depends directly on how long the soil is saturated and reduced (Rabenhorst, 2004).

The ability to recognize a soil as being “hydric” relies heavily on the identification of specific morphological features that are directly related to the degree of saturation and reducing conditions that occur in the soil. Field Indicators of Hydric Soils (FI) were developed by The National Technical Committee for Hydric Soils (NTCHS) to help positively identify a hydric soil. The presence of a FI is considered “proof-positive” evidence of the soil having undergone simultaneous saturation and reduction, thereby meeting the definition of a hydric soil (Federal Register, 1994).

All soils that are hydric may not necessarily have an Indicator. Some wetlands that qualify by means of the hydrologic (saturated and reducing) and vegetative components can have hydric soils that lack an approved indicator. A standard for identifying these hydric soils was developed by the National Technical Committee for Hydric Soils (NTCHS). This *Technical Standard* (TS) is based on several criteria involving collecting quantitative field data, including water table data and either redox potential data or the use of *alpha-alpha Dipyridyl* dye, or the use of IRIS tubes (Castenson and Rabenhorst, 2006) (NTCHS, 2000). The TS is used in-lieu of a FI or when evaluating a new FI. The shortcoming of using the TS as a means of determining the hydric status of a soil is the time-investment. However, when investigating "problematic" wet soils that are considered hydric, yet lacking a currently accepted FI, invoking the TS is necessary.

In some cases, when delineating wetlands, the hydrologic and vegetative components may be identifiable, however the area may not qualify if the hydric soil component is lacking. In these cases, the soils may be considered problematic hydric soils. The primary difficulty in identifying problematic hydric soils is that they do not meet any of the currently accepted FI. Just because a soil does not meet any of the current FI, however, does not mean that the soil is not hydric. Further investigation utilizing the TS can resolve the status of questionable hydric soils. Problematic hydric soils include some soils that formed from parent material which proved resistant to developing redox features under reducing conditions. Examples are the soils that formed in Triassic ("Red Parent Material") and Permian ("Delta Ochric") red bed materials (Rabenhorst and Parikh, 2000; Elless, 1992; Elless et al., 1996; Faulkner et al., 1991). Other problematic hydric soils are young soils or soils forming on active flood plains (Castenson, 2004; Lindbo, 1997), soils with dark parent material such as Mollisols (Bell and Richardson, 1997) and Vertisols (Jacob et al., 1997)), and sandy soils (Kuehl et al., 1997).

3) Soil Water Tables and Redox Data in ABLS Soils

INTRODUCTION

This chapter addresses the relationship between soil saturation and the length of time that is needed to develop reducing conditions strong enough to mobilize iron in ABLS-soils.

Oxidation-reduction (redox) measurements are made in soils to theoretically determine when redox sensitive chemical species would be stable in a soil environment (Austin and Huddleston, 1999; James and Bartlett, 2000; Rowell, 1981). A voltage measurement is made when a completed circuit is created by a platinum-tipped electrode, a calomel reference electrode, and a voltmeter (Bohn, 1971; Vepraskas and Faulkner, 2001). Potentials developed between electrodes inserted into the soil are measured in millivolts (mV); relatively positive values infer more oxidizing conditions while relatively negative values suggest more reducing conditions (Cogger et al., 1992; Faulkner et al., 1989).

In most seasonally saturated wetland soils, water tables rise close to (or even above) the surface during the wet season and fall during drier (higher evapotranspiration rates) times of the year (Mitsch and Gosselink, 2000). Elevated water tables physically exclude air that once filled pore spaces in the soil. Under saturated conditions, oxygen-diffusion into the soil is reduced by a factor of 10^4 (Craft, 2001; Ponnamperuma, 1972). Residual oxygen in this saturated environment is quickly consumed by the remaining respiring aerobic microbes (National Research Council (NRC), 1995). The oxidation of soil organic matter (SOM) continues by anaerobic respiration with the reduction of other chemical species in place of oxygen. Common soil minerals acting as electron sinks in this process include manganese and iron oxides. Once reduced, these become soluble and are able to move through the soil (Vepraskas, 1992). Warmer temperatures and greater amounts of SOM accelerate microbial activities and result in lower redox potentials occurring in shorter periods of time. Cooler temperatures tend to slow down microbial respiration (Vaughan, 2008). Some have suggested that soil microbial activity ceases at biological zero (5°C) (Vepraskas, 2001). Microbial respiration may continue at temperatures below 5°C, although at a slower rate (Clark and Ping, 1997; Gregorich and Janzen, 2000; Tiner, 1993). In some special cases, some soils that are saturated may be recharged continuously by oxygenated water (oxyaquic conditions) and will not become anaerobic and therefore not exhibit low redox potentials (Vepraskas and Sprecher, 1997; Vepraskas and Faulkner, 2001). The degree to which each of these individual factors is expressed greatly affects how strongly reduced a saturated soil may become.

The objectives of this study were: 1) to document water tables and redox potentials in selected hydric soil landscapes, 2) to monitor the length of time required to develop anaerobic conditions in saturated soils, and 3) to evaluate the impact of soil temperature on the development of anaerobic conditions in saturated ABLS-soils.

MATERIALS AND METHODS

Field Methodology

Site Locations

Four study sites were chosen as part of a larger effort to examine typical soil-landscape settings where the ABLS problem condition exists. At each of the four sites, a three-point transect was identified that spanned a range of conditions (based on prior observations) from more poorly drained soils (probably hydric) to better drained soils (probably non-hydric), including an intermediate transitional site that was generally thought to be a typical ABLS hydric soil. Sites were selected to ensure that human impacts on hydrology and drainage were minimal, and that access to the sites was limited to minimize the potential for vandalism. Sites were located on the Delmarva Peninsula (Fig. 3-1), with three in Maryland and one in Delaware. The Maryland sites were at the Blackwater National Wildlife Refuge in Dorchester County, at the Isle of Wight Wildlife Management Area in Worcester County, and at the Eastern Neck Island National Wildlife Refuge in Kent County. The Delaware site was located at the Ted Harvey Wildlife Area in Kent County.

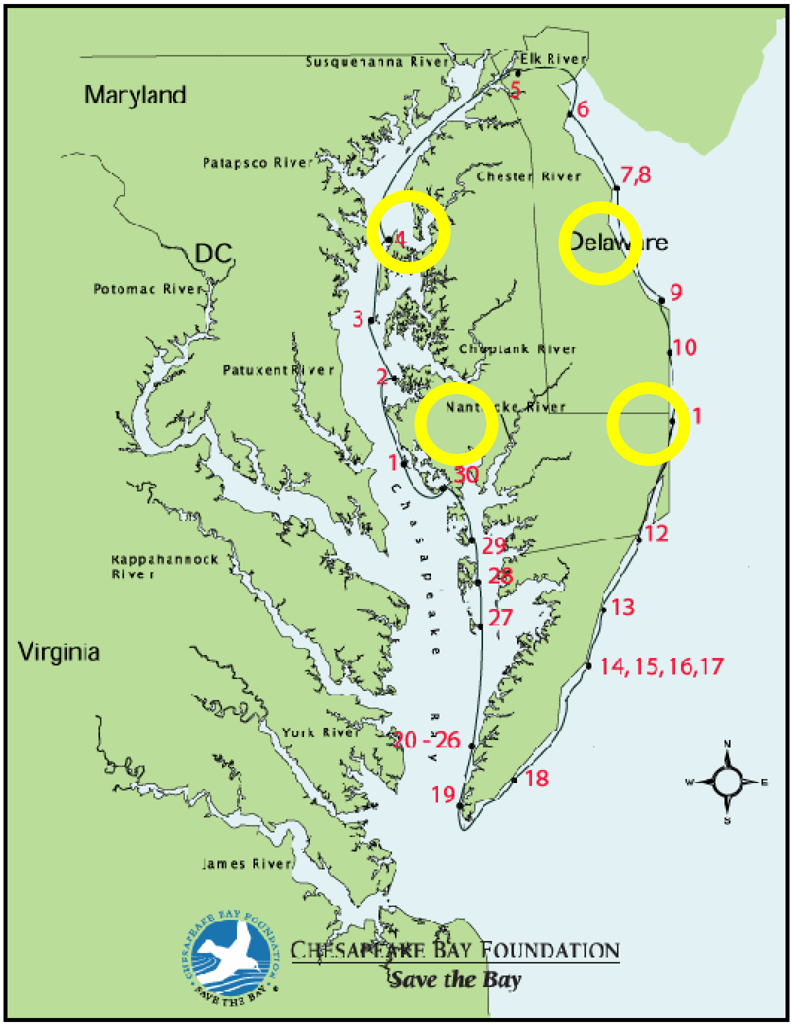


Figure 3-1: Approximate locations of the four ABLS research sites on the Delmarva Peninsula. (Source:http://www.cbf.org/images/content/pagebuilder/118028.gif).

Water Tables

Water tables were monitored using automated recording wells (RDS WL80) installed to an approximate depth of 1.5 m and programmed to record data twice daily. At each of the four study sites, these wells were located at the three points representing the lower, middle, and upper portions of the transect (Sprecher, 2008). Data were downloaded periodically using a hand-held Hewlett-Packard calculator with an infrared interface. Water levels in open wells were observed occasionally to verify the proper operation of the recording wells.

Oxidation-Reduction Potentials and pH

At each of the transect points and within one meter of the monitoring wells, redox potentials were measured using six replicate platinum-tipped electrodes, calomel reference electrodes, and voltmeters. The Pt electrodes were inserted into the soil at depths of 10, 20, 30, 40, and 50 cm and voltages recorded after permitting some reasonable time for equilibration (typically, 2-5 minutes). During the wet season (approximately November through April) redox potentials were measured bi-weekly. They were measured at monthly intervals during the drier times of the year. pH was measured on the same occasions and at the same depths as redox potential. To measure pH, a 16 mm soil corer was used to extract a small soil sample which was made into a 1:1 slurry with de-ionized water. Measurements were taken in the field with a portable pH meter.

Soil Temperatures

Soil temperatures were recorded at the research sites using automated data loggers. At each of the four sites, three recorders were buried adjacent to the middle well, one each at 10, 30, and 50 cm depth. Loggers were programmed to take measurements every four hours. Data were downloaded at the end of three years using an optical interface and desktop computer.

Soil Description and Sampling

Adjacent to each well, a pit was dug by hand to one to two meters. Soils were described in detail using protocols of the National Cooperative Soil Survey (NCSS) (Soil Survey Staff, 1993; Schoeneberger, 2002) and then sampled by horizon. At the base of some pits, if conditions permitted, a hand auger was used to further describe soils to depths that ranged from 129 cm to 335 cm. Soils were subsequently classified (Soil Survey Staff, 2006)

Laboratory Methodology

Organic carbon content was determined on duplicate, ground soil samples from each pedogenic horizon. Analyses were run by dry combustion (950°C) using a LECO CNH analyzer (Nelson and Sommers, 1982; Tabatabai and Bremner, 1991).

RESULTS AND DISCUSSION

Water Tables

Water table data collected at all four research sites for a period of approximately three years, from February, 2001 through February, 2004 are shown in figures 3-2 through 3-5. Within this period, two complete wet (November - April) and dry (May - October) seasonal cycles were captured for analysis.

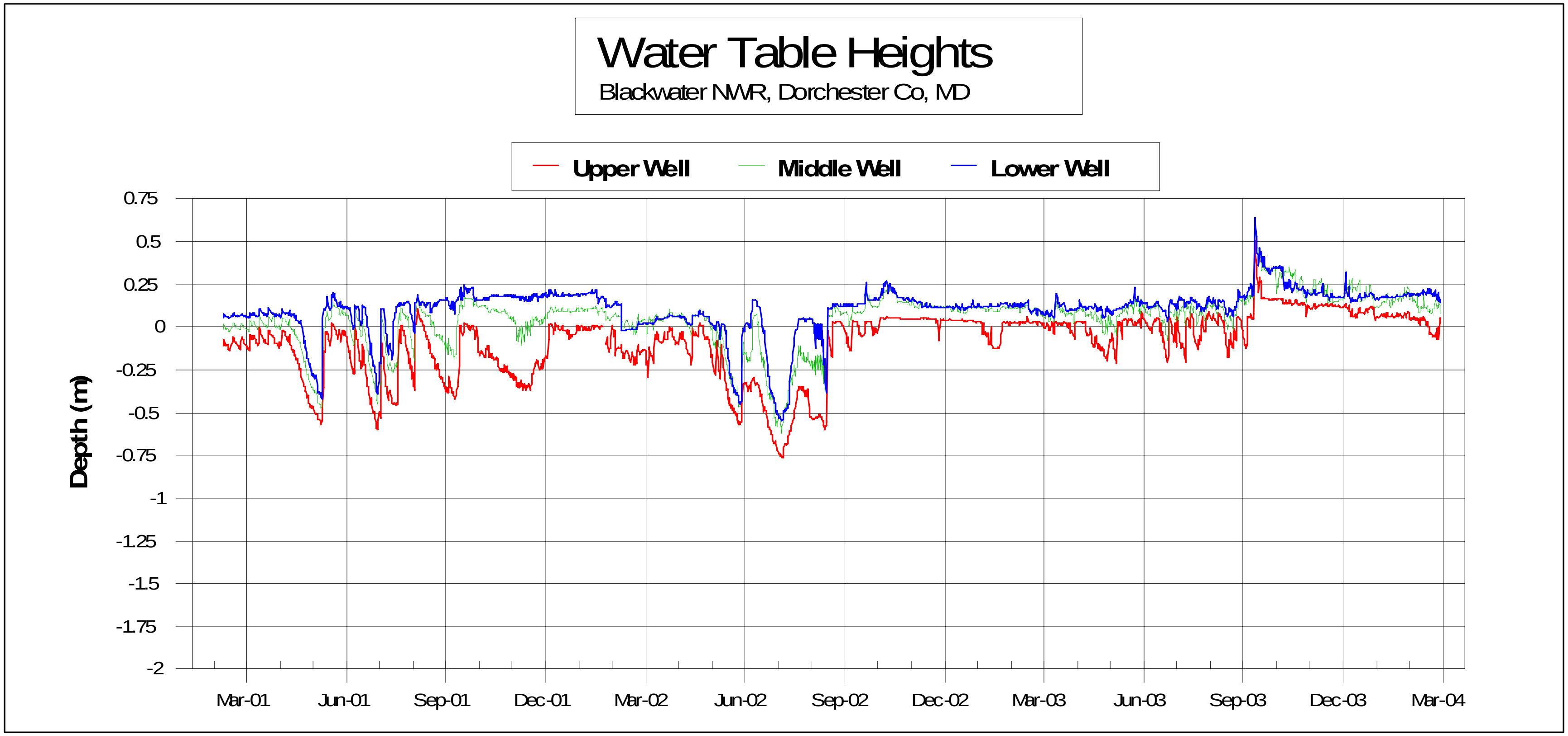


Figure 3-2: Complete water table data (Feb 2001 – Feb 2004). Lower, middle, and upper well positions at Blackwater are represented by blue, green, and red lines, respectively.

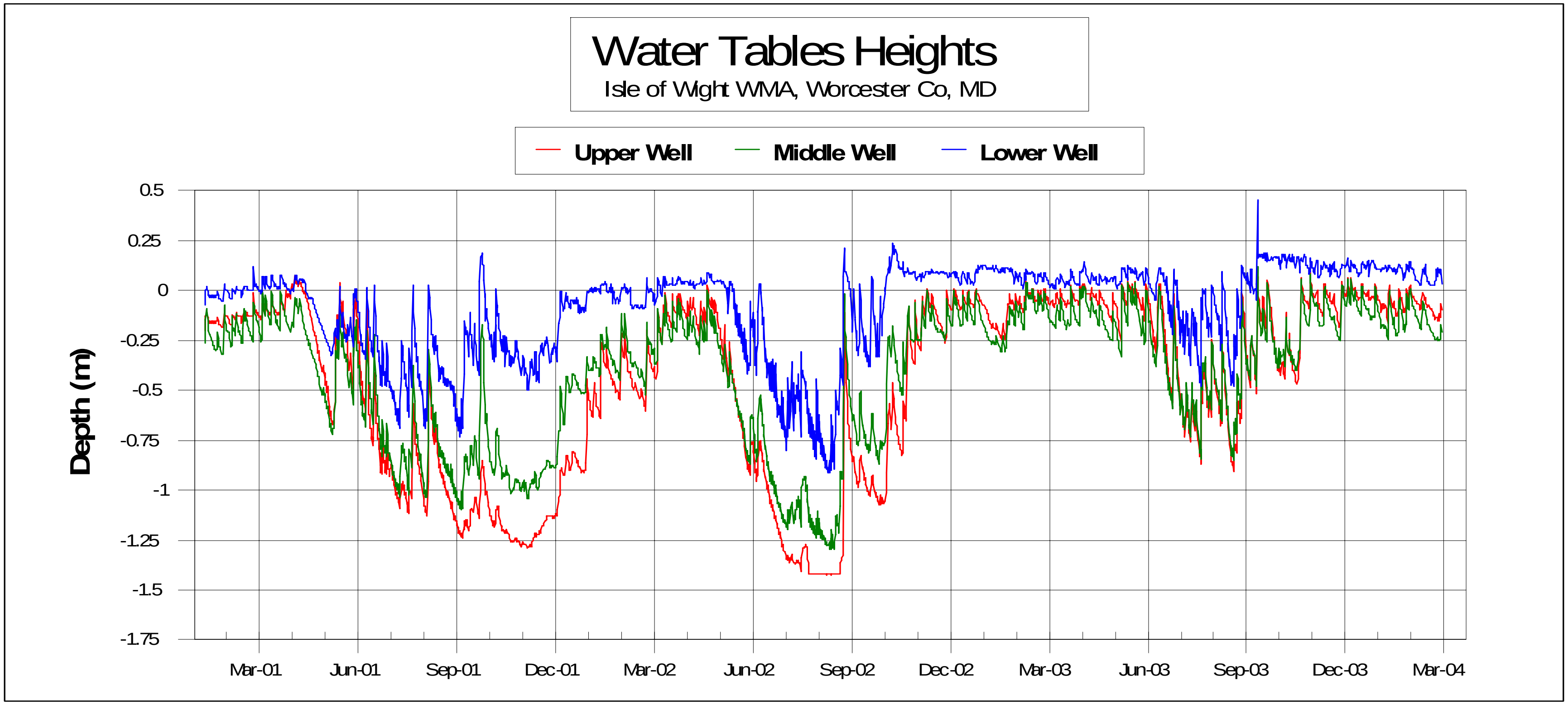


Figure 3-3: Complete water table data (Feb 2001 – Feb 2004). Lower, middle, and upper well positions at Isle of Wight are represented by blue, green, and red lines, respectively.

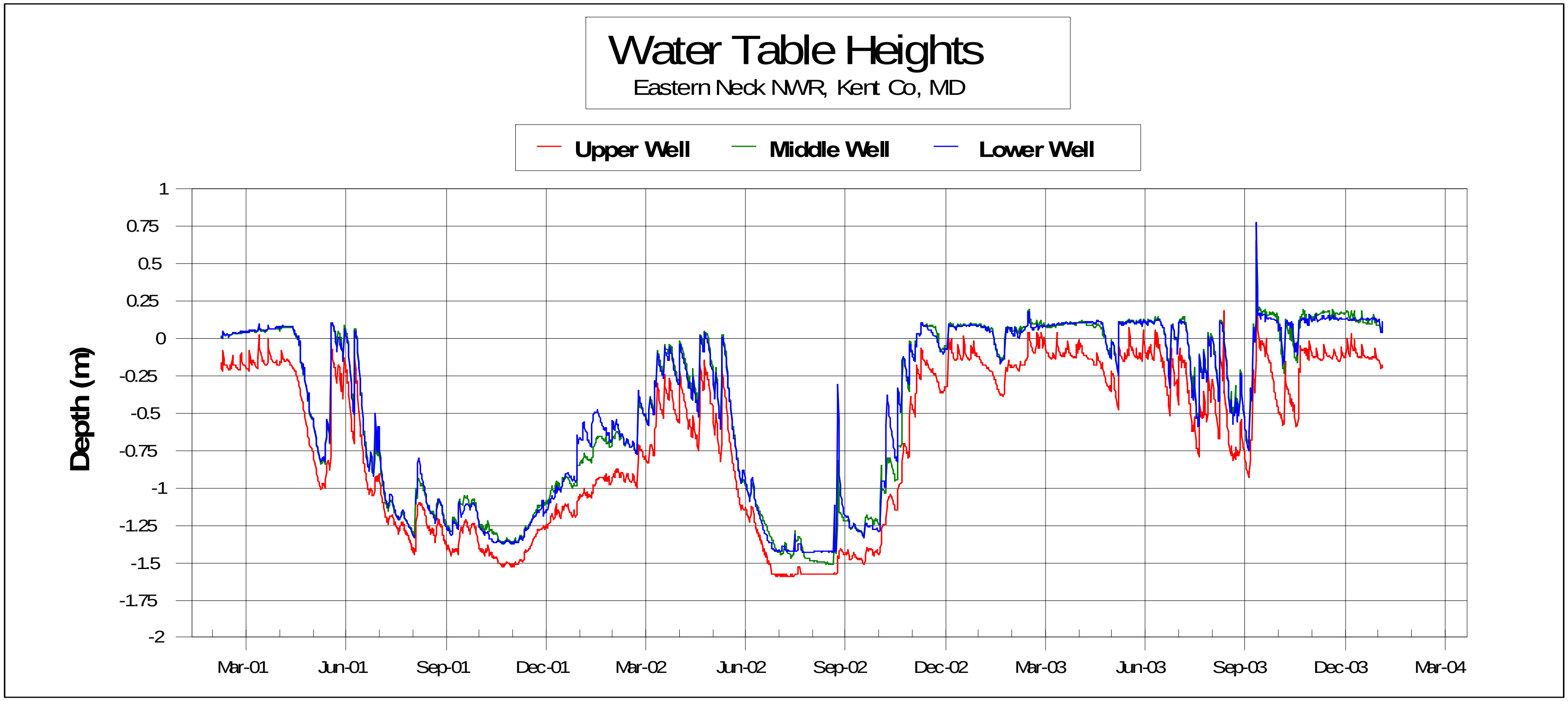


Figure 3-4: Complete water table data (Feb 2001 – Feb 2004). Lower, middle, and upper well positions at Eastern Neck Island are represented by blue, green, and red lines, respectively.

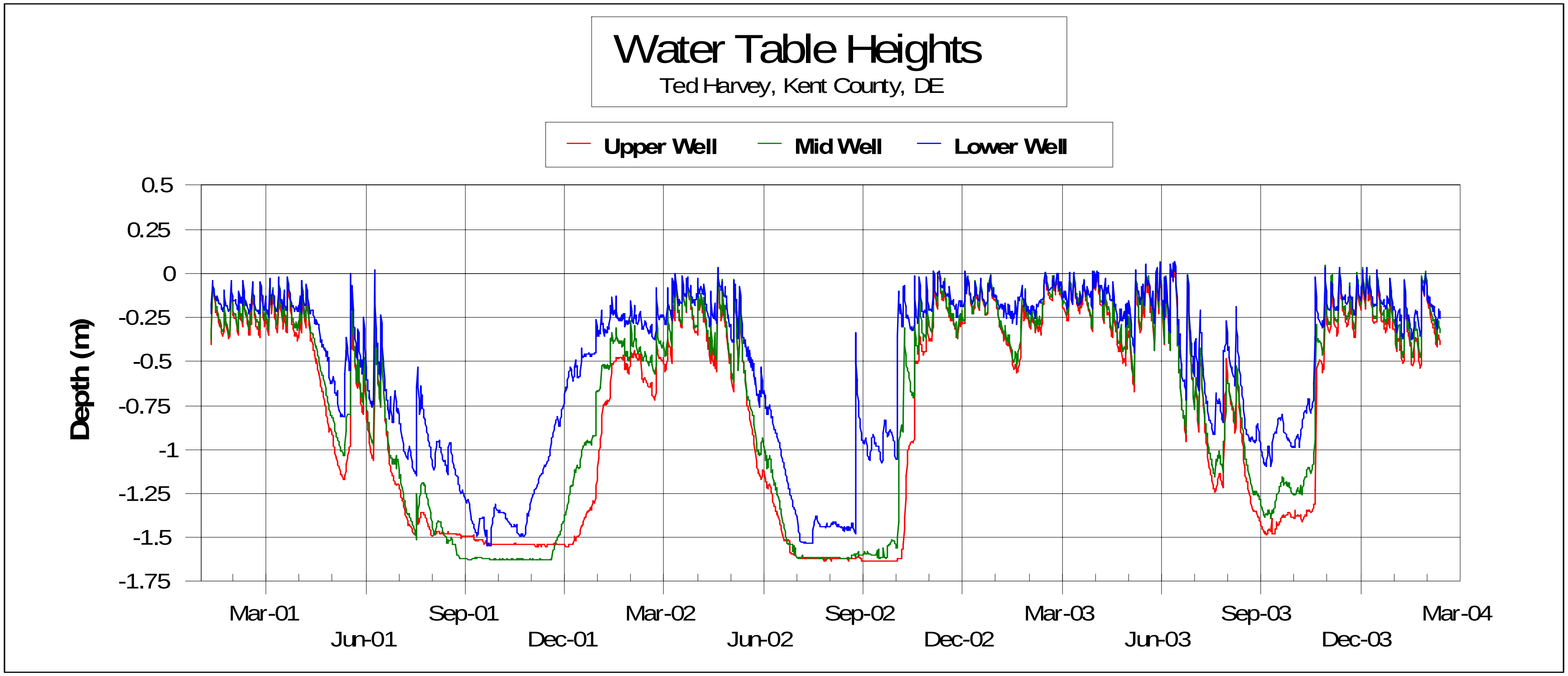


Figure 3-5: Complete water table data (Feb 2001 – Feb 2004). Lower, middle, and upper well positions at Ted Harvey are represented by blue, green, and red lines, respectively.

Not surprisingly, soils on the “upper” end of the transects had water tables that were generally deeper than those at the lower of each end of the transect. Soils at the midpoint of each transect commonly showed intermediate water table levels. Soils on the transects were continuously saturated to within 30 cm of the soil surface for periods ranging from 204 days (Ted Harvey site) to 361 days (Blackwater site) on the “lower” end of transects and from 62 days (Ted Harvey site) to 361 days (Blackwater site) on the “upper” end of transects. For the period of study (two hydrologic years: February 2001 – February 2003), the cumulative time that a soil was saturated was calculated as a percentage of the year; Figures 3-6 and 3-7 show average percentages of the year that each soil was saturated to 30 cm and at the surface, respectively. Proximity of water tables relative to the soil surface differed somewhat from site to sites. Soils at the Blackwater site were saturated much more often and for longer periods compared to those at the other sites. Water tables at the remaining three sites were more similar to one another, although the Ted Harvey site stands out as being less wet than the Eastern Neck and Isle of Wight sites (Fig. 3-7).

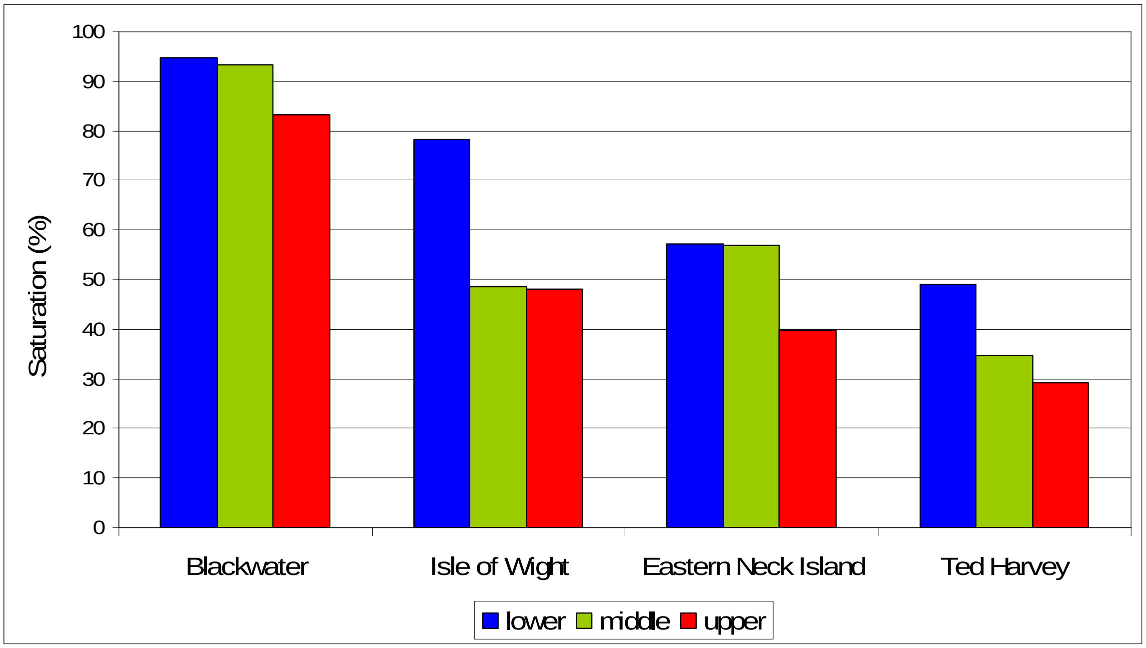


Figure 3-6: Average percentage of the year that the ground water levels reached 30 cm in the lower, middle, and upper soils at each of the four research sites (February 2001-February 2004).

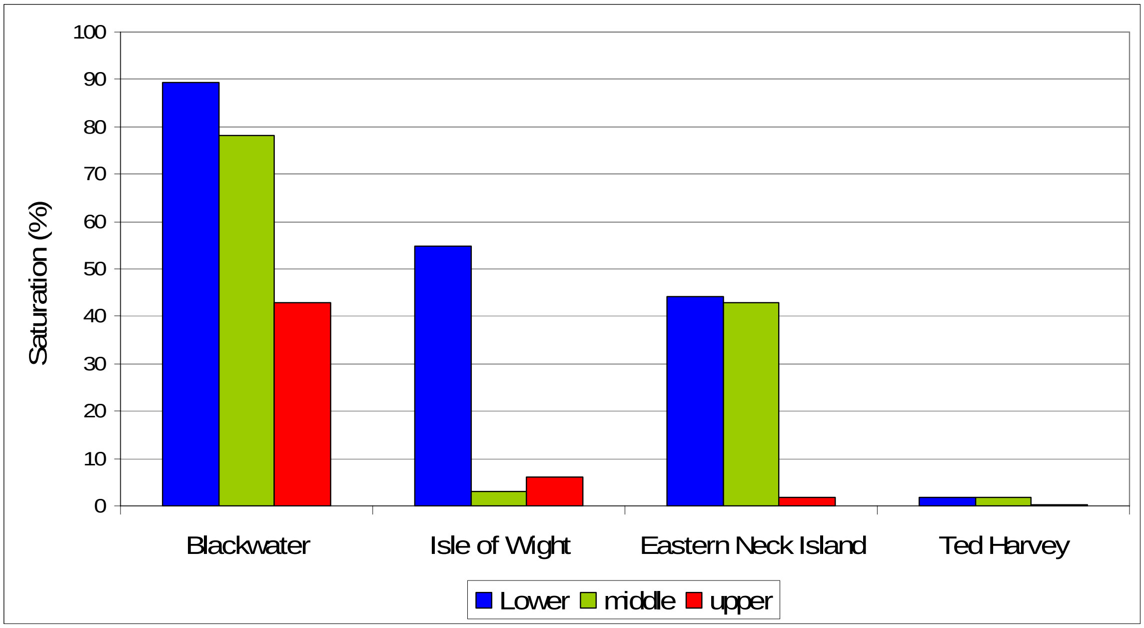


Figure 3-7: Average percentage of the year that the ground water levels reached the soil surface in the lower, middle, and upper soils at each of the four research sites (February 2001- February 2004).

Redox Potential and pH

The reduction of iron from its insoluble, oxidized form (Fe(III)), to its more-soluble, reduced state (Fe(II)) is dependent on both the Eh and pH of the soil. Attempts to predict the reduction of iron oxides in wet soils have been made by using thermodynamic data and plotting mineral stability fields on an Eh/pH diagram (Karathanasis, 2002). Taking a more empirical approach, the National Technical Committee for Hydric Soils (NTCHS) developed a Technical Standard (TS) for hydric soils that includes criteria for documenting reduced soil conditions. Measured data are plotted on an Eh/pH diagram, where the equation $Eh = 595 - 60 (pH)$ defines the threshold between oxidizing and reducing conditions (Fig. 3-8). When the measured Eh and pH plot above the line, the soil is considered oxidized and when the data plot below the line, the soil environment is considered reducing. Therefore, both Eh and pH were measured. Soil pH was observed to change only gradually over time. Therefore, some missing pH data were interpolated from measurements taken on earlier and later dates.

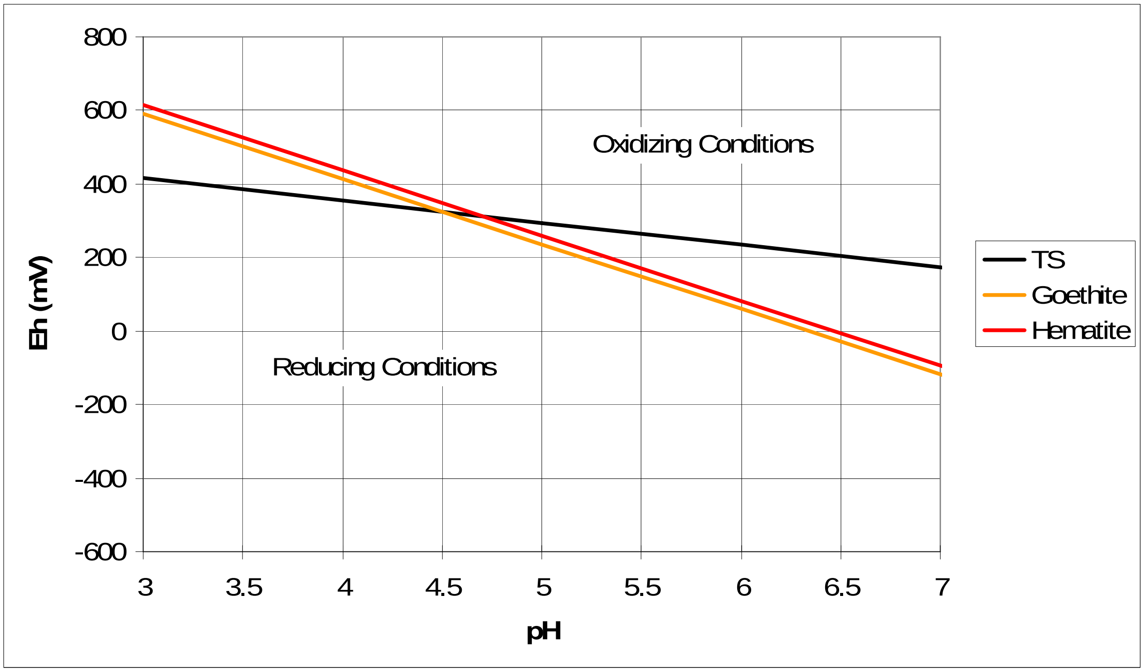
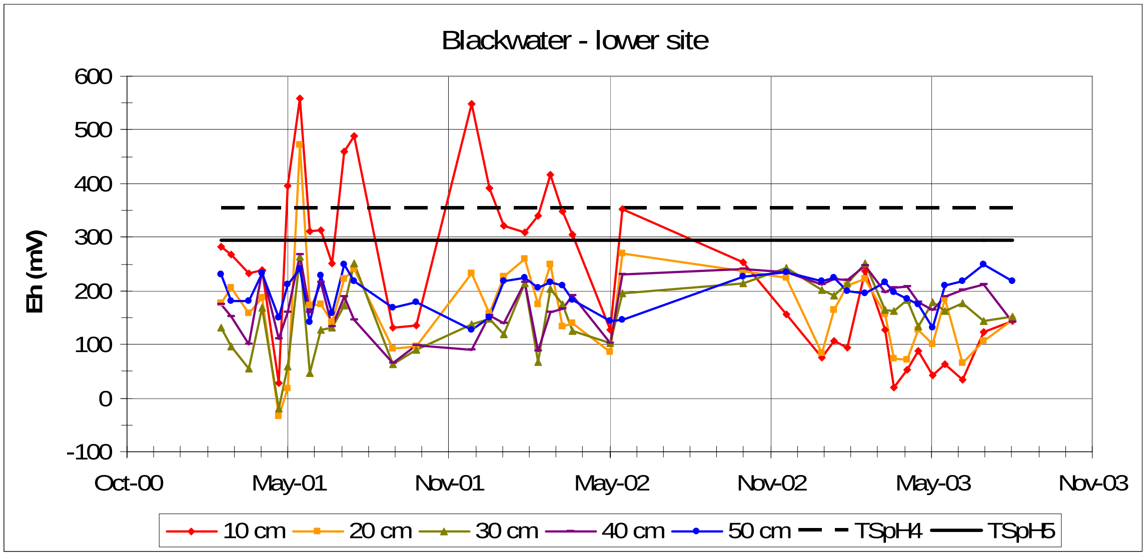


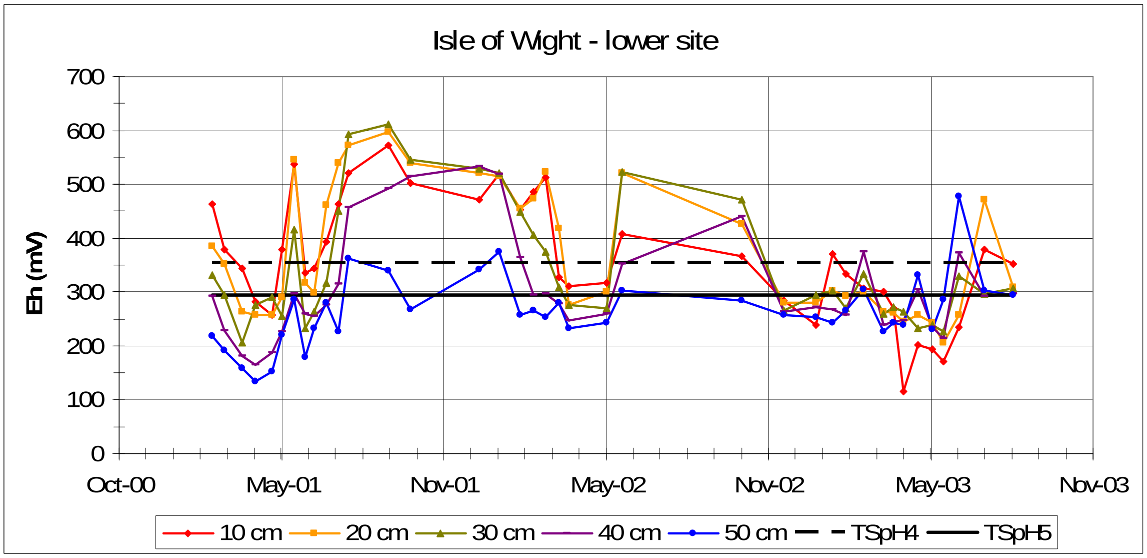
Figure 3-8: Eh/pH stability diagram showing lines representing boundaries between reducing and oxidizing conditions in the soil (relative to criteria set forth by the National Technical Committee for Hydric Soils (NTCHS, 2000)). The orange and red lines represent the stability fields of the minerals goethite (FeOOH) and hematite ($Fe_2O_{3)}$, respectively; and the black line represents the Technical Standard (TS). Goethite and hematite lines were calculated based on Fe-activity of 10^{-6}M.

Lower Landscape Positions

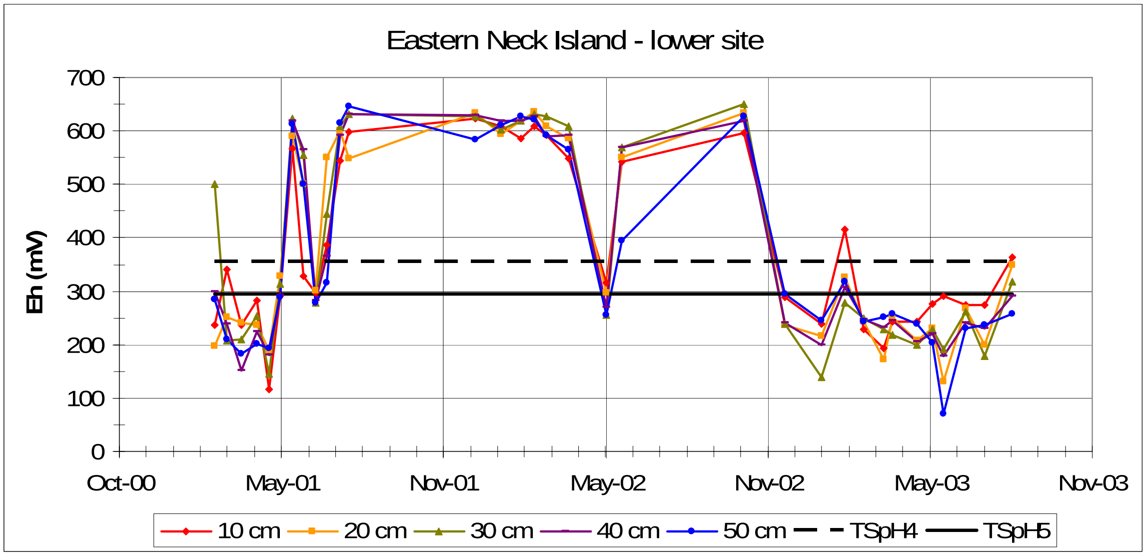
Redox potentials measured in soils at the lower (wet) end of the transects were generally lower, and reducing conditions lasted longer than in soils at the "middle" and "upper" sections of the transect. Redox potentials measured at 20-cm depths and below at the Blackwater site remained below the Technical Standard line (indicating reducing conditions) for essentially the entire time that Eh was recorded (Feb. 2001 – Aug. 2003). Although this site was saturated to the surface for most of the year, redox potentials at 10 cm sometimes were oxidizing, perhaps due to movement of oxygenated rainwater into the upper part of the soil. Contributing to this was a thick, highly porous hemi-to-fibric surface horizon which physically made it more difficult to obtain accurate redox potential measurements closer to the surface (0-10 cm). At the Isle of Wight site, reducing conditions (based on the Technical Standard) persisted at depths of 20 cm and below for periods ranging from 1 to 10 consecutive weeks and at the 30 cm depth from 3.5 to 10 consecutive weeks. The Eastern Neck Island site showed reducing conditions at the 20-cm depth from 1 to 20 consecutive weeks and at the 30-cm depth from 1 to 23 consecutive weeks; while at the Ted Harvey site, reducing conditions occurred regularly only at depths of 30 cm and below for periods ranging from 1 to almost 10 consecutive weeks (Figs. 3-9a, b, c, and d).



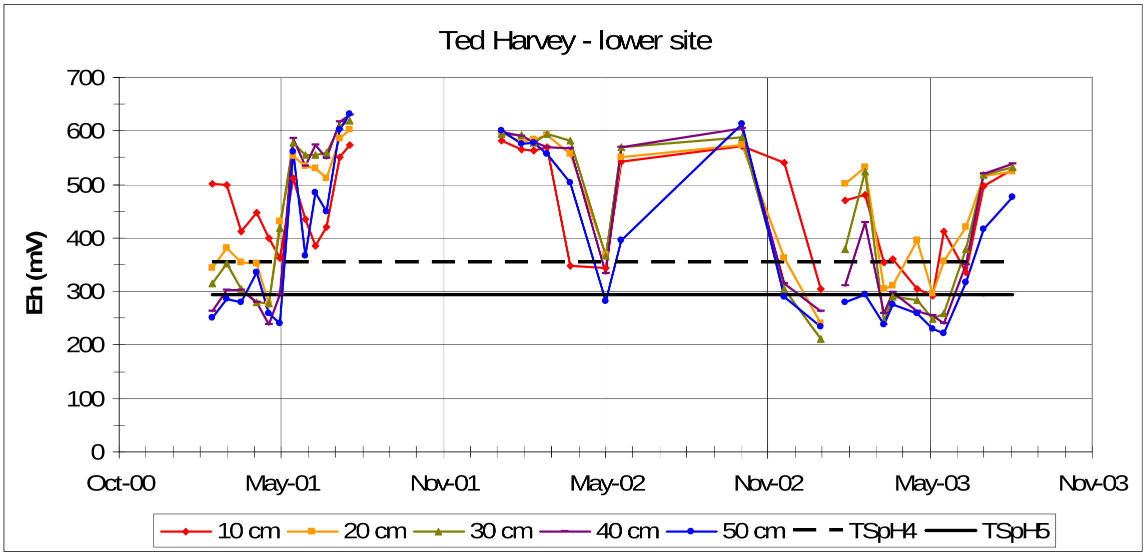
(Figure 3-9a)



(Figure 3-9b)



(Figure 3-9c)

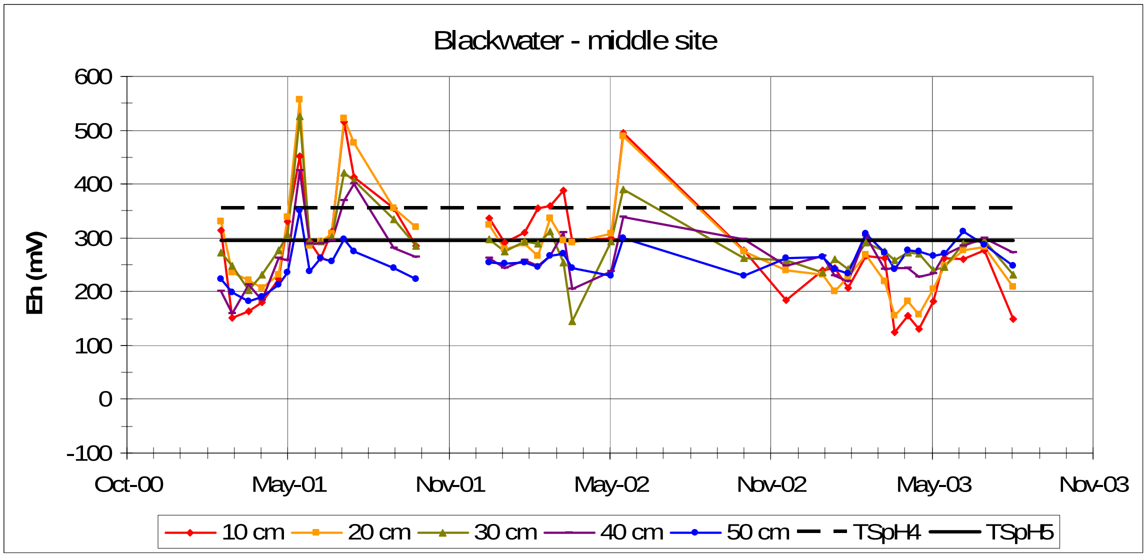


(Figure 3-9d)

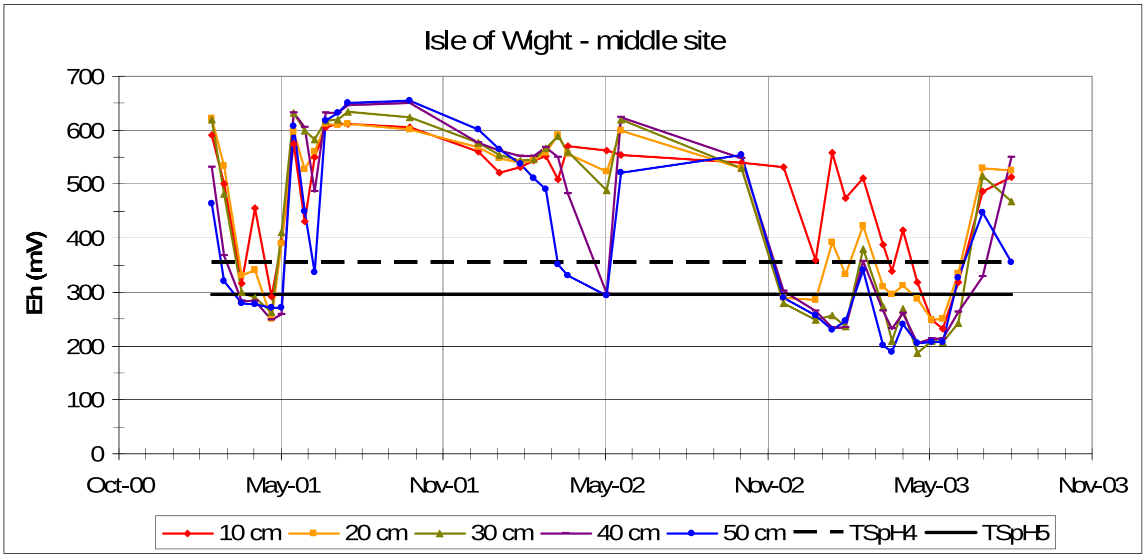
Figure 3-9 a-d: Redox potentials measured in soils at the lower transect points. Data are means of six replicate measurements at 10, 20, 30, 40, and 50 cm depths below the soil surface. The two black, horizontal lines represent a range within which iron becomes reduced based on the Technical Standard at pH 4 (upper horizontal line) and at pH 5 (lower horizontal line), as the pH values in the soils generally ranged between 4 and 5.

Middle Landscape Positions

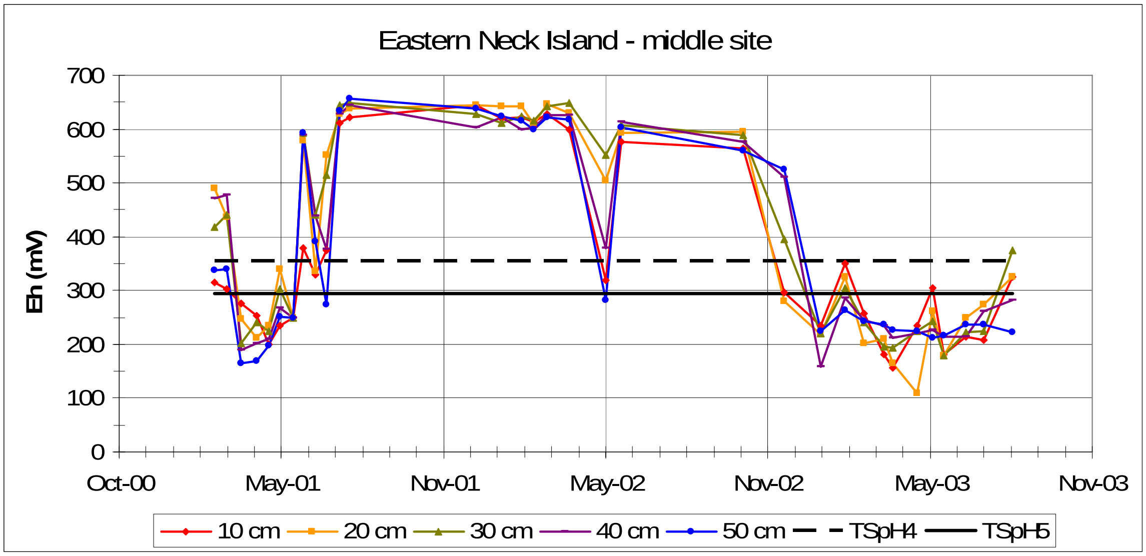
Relative to soils at the low end, soils at the middle positions at each site generally showed shorter periods of reducing conditions, and the reducing conditions generally were at greater depths in the soil profile. Only the Blackwater site showed little difference in redox potentials between the lower and middle positions of the transect, where reducing conditions persisted for approximately 44 weeks to within 20 cm of the surface, and for nearly 102 weeks at the 30-cm depth and below. At the Isle of Wight site, both redox and water table data indicated that the middle position is actually slightly drier, than the upper position on that transect. Reducing conditions were observed at the depth of 20 cm only for 4 consecutive weeks and then again on two other individual occasions. At 30 cm, however, the period of reduction was longer, and ranged from 5 to 12 consecutive weeks. At the Eastern Neck Island site, soils at the middle point had water tables and redox potentials much like soils at that site's low position. At the Ted Harvey site, soils at the mid-part only showed evidence of reducing conditions at the 20 cm depth on three, non-sequential occasions. Based on calculations using interpolated pH data, redox potentials around 30 cm appear to fall below the Technical Standard line for reducing conditions for approximately 11 weeks (Figs. 3-10a, b, c, and d).



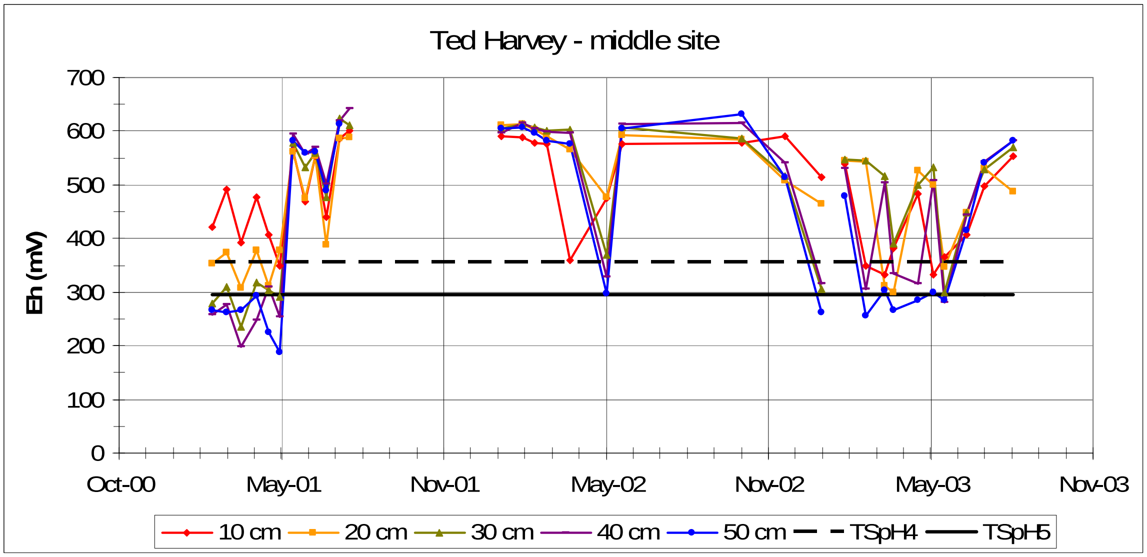
(Figure 3-10a)



(Figure 3-10b)



(Figure 3-10c)

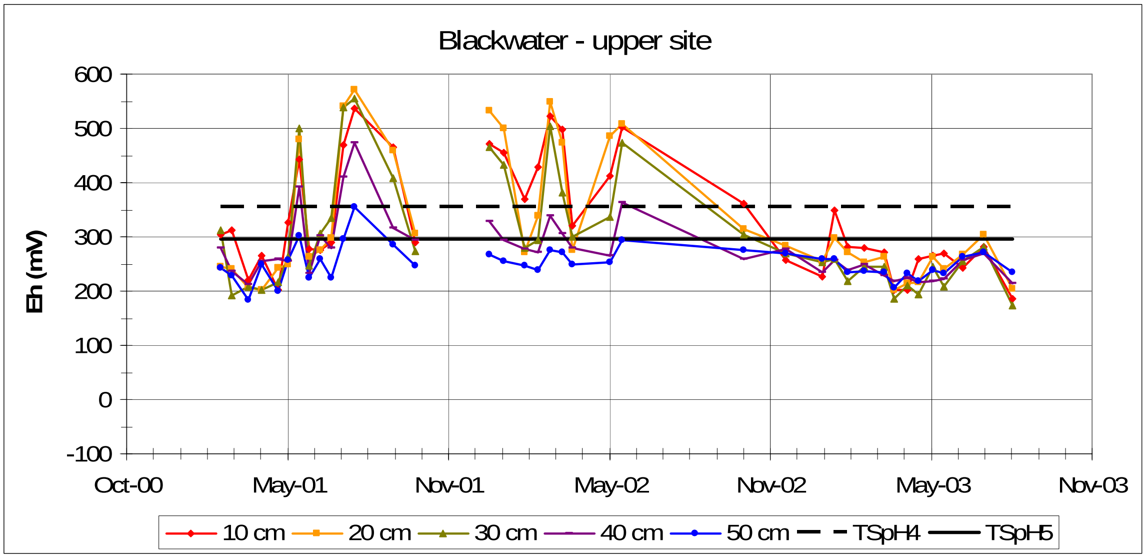


(Figure 3-10d)

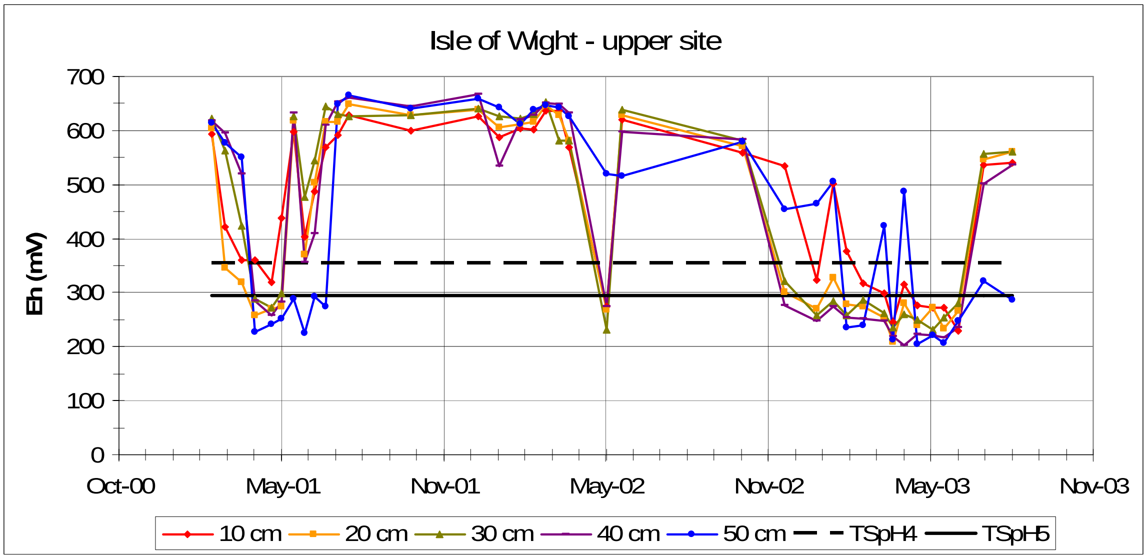
Figure 3-10 a-d: Redox potentials measured in soils at the mid-points of the transect. Data are means of six replicate measurements at 10, 20, 30, 40, and 50 cm depths below the soil surface. The two black horizontal lines represent a range within which iron reduces based on the Technical Standard at pH 4 (upper horizontal line) and at pH 5 (lower horizontal line), as the pH values in the soils ranged from 4 to 5.

Upper Landscape Positions

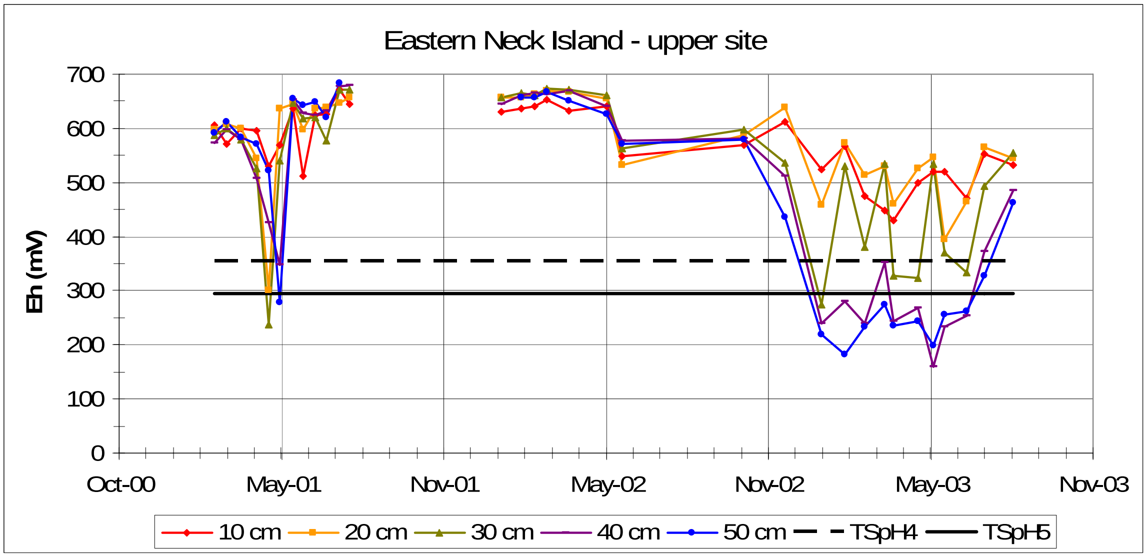
In general, soils located toward the upper end of the transect generally did not experience the wetness conditions that are required to induce iron reduction in the upper part of the soil. Although conditions for iron reduction appeared to be present at most sites at depths of 40 and 50 cm, the Blackwater site was the exception with soils experiencing saturation close to the soil surface throughout the year; even at the upper position. This was partly due to the site's low elevation and the minimal topographic variation across the transect. For these reasons, reducing conditions were observed at the Blackwater site for extended periods ranging from 4 to 27 consecutive weeks at the 20-cm depth, and from 4 to 44 consecutive weeks at the 30-cm depth. Redox measurements at 10 cm showed that the soil at this depth occasionally became oxidized. At the upper end of the transect of the Isle of Wight site, soils were slightly wetter than those at the middle position; redox potentials therefore paralleled these conditions accordingly. Measurements at 20 cm indicated reducing conditions for up to 18 weeks, while at the 30-cm depth, periods of reduction occurred more frequently and lasted longer (up to 23 weeks). The Eastern Neck Island site showed trends that were more as expected. Reducing conditions were documented at 30-cm depths occasionally only during the wet seasons, and for a four-consecutive-week period only once. The soils at the upper end of the transect at Ted Harvey site proved to be the driest of all sites. Reducing conditions at 30 cm were not observed on only three non-consecutive visits (Figs. 3-11a, b, c, and d).



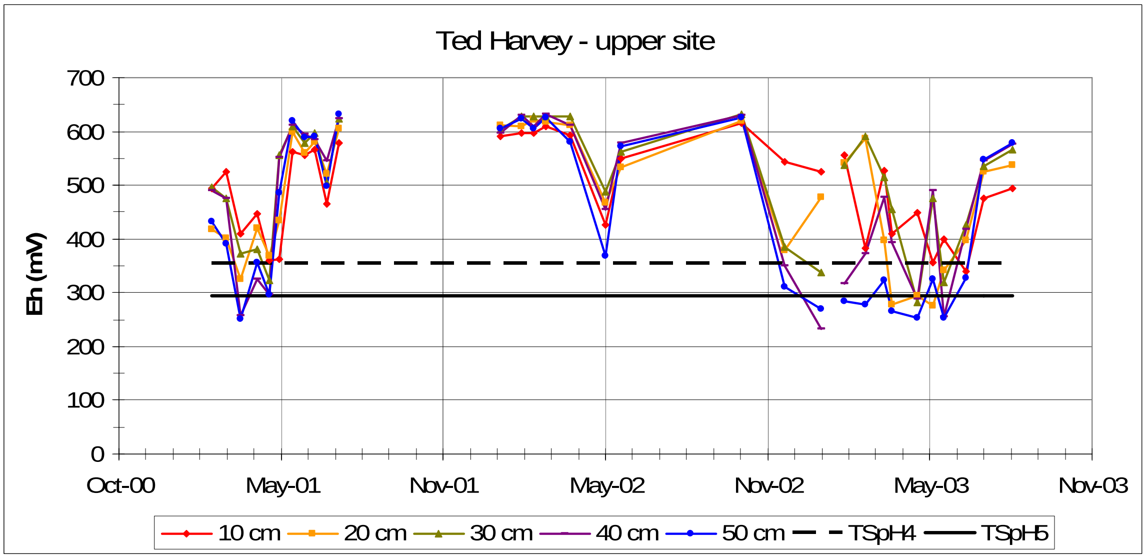
(Figure 3-11a)



(Figure 3-11b)



(Figure 3-11c)



(Figure 3-11d)

Figure 3-11 a-d: Redox potentials measured in soils at the upper points of the transect. Data are means of six replicate measurements at 10, 20, 30, 40, and 50 cm depths below the soil surface. The two black horizontal lines represent a range within which iron reduces based on the Technical Standard at pH 4 (upper horizontal line) and at pH 5 (lower horizontal line), as the pH values in the soils ranged from 4 to 5.

Soil Temperatures

Distinct, seasonal temperature fluctuations in the soil were evident. Figure 3-12 illustrates soil temperature data at 30 cm from three out of the four research sites; data loggers buried at the Eastern Neck Island site were not recovered.

Comparing temperatures at soil depths of 10 cm, 30 cm, and 50 cm at a single site (Isle of Wight), it was apparent that seasonal temperature fluctuations were increasingly moderated with soil-depth (Fig. 3-13).

Because soil temperatures were relatively similar from the three research sites, data were averaged at the three depths to represent soil temperature data for the Eastern Neck Island site. Furthermore, because redox data, pH data, and water table data were gathered at 10-, 20-, 30-, 40-, and 50-cm depths, it was desirable to also have temperature data at all depths. Therefore, soil temperatures at depths at 20 cm and 40 cm were determined by interpolation.

Each of the four sites showed noticeable temperature differences at 10 cm. Considering the number of days that soil temperatures dropped below 5°C, as well as the lowest temperatures that were logged at the 10-cm depth, Ted Harvey was the coolest of the four sites. Oppositely, the soils at the Blackwater site appeared to be warmest, possibly due to the insulating effects of the thick, organic surface horizon covering the soil surface or to the extreme wetness they experience. The Isle of Wight site showed soil temperatures intermediate to Ted Harvey and Blackwater.

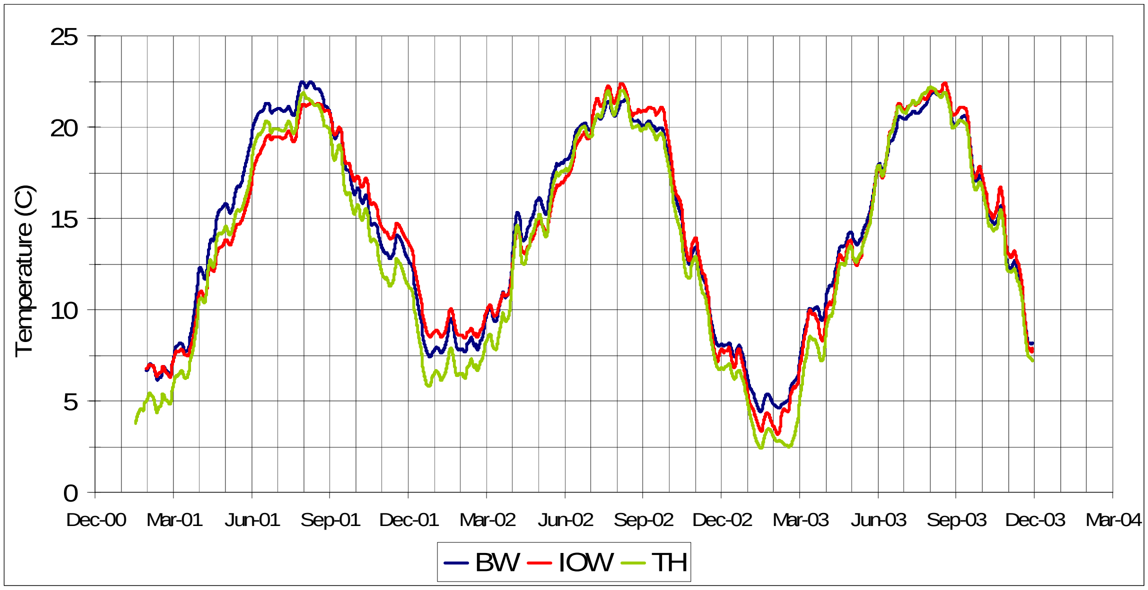


Figure 3-12: Soil temperatures measured at 30 cm at the Blackwater, Isle of Wight, and Ted Harvey sites are plotted as seven-day running averages. Data loggers at the Eastern Neck Island site were not recovered.

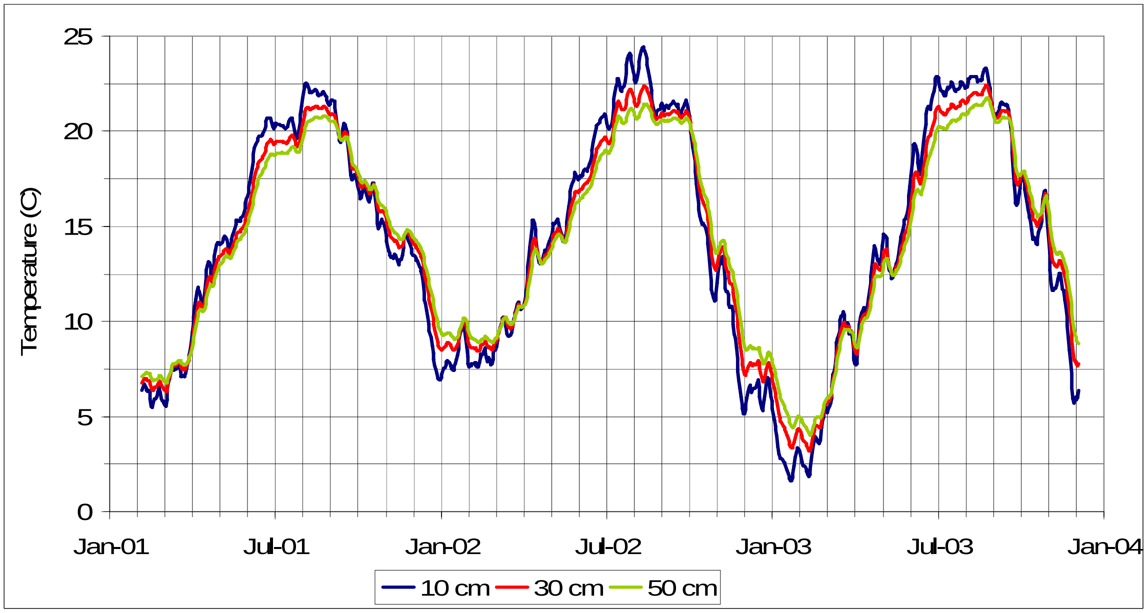


Figure 3-13: Soil temperatures measured at 10 cm, 30 cm, and 50 cm depths at the Isle of Wight site show how seasonal temperature fluctuations are moderated with depth. Data are plotted as seven-day running averages.

Soil Redox Properties vs. Length of Saturation

Redox potentials are affected by a number of factors inherent to the soil environment. Of these factors, saturation due to elevated water tables is one of the main driving forces behind the development of anaerobic conditions in the soil. We know that, generally, soils first become saturated, and then after some period of time, they become reducing. The length of time required for saturated soils to become reducing has not been thoroughly investigated, however has been documented (Vaughan, 2009). We know from experience that it is a much simpler and less-expensive process to measure soil water tables than it is to measure soil redox potentials. Therefore, it would be helpful if we could describe the relationship between saturation and the onset of reducing conditions. By developing a model that describes the relationship between soil saturation and the time it takes for soils to develop reducing conditions, available water table data might then be used to infer a soil's redox status.

In order to limit the variability in the soil properties that might affect the development of reducing conditions, certain portions of the soil data set were removed based on the following reasons:

1. Soil horizons that were saturated for extremely long periods of time (>200 days) were usually continuously and strongly reduced, such as the soils at the Blackwater site. Under these conditions, those horizons did not adequately transition between oxidizing and reducing conditions, and therefore would not contribute any significant information to our model.

2. The upper 10 cm of pedons had highly variable organic carbon (OC) contents that ranged from 24.5 g/kg to 106.5 g/kg, which also affected the physical properties of

these horizons (high porosity) in some soils (Nelson and Sommers, 1982). This led to difficulties in obtaining reliable Eh measurements and therefore these horizons were excluded from analyses (Tab. 3-1).

3. The redox data from the 50-cm depth at the upper site at the Isle of Wight were not included because a coarse sand lens was encountered precisely at that depth causing the Eh data to be abnormally high there.

Table 3-1: Organic carbon content (g/kg) of ABLS-soils in horizons (excluding surface horizons) to approximately 50 cm (depths based on horizon breaks).

	Landscape Position	
	Depth	Carbon Content
Site	Lower	
	cm	g/kg
Blackwater	16-24	5.04
Blackwater	25-39	4.09
Blackwater	39-53	4.52
Isle of Wight	27-45	2.60
Isle of Wight	45-61	2.75
Eastern Neck Island	15-32	2.55
Eastern Neck Island	32-42	2.54
Eastern Neck Island	42-62	1.75
Ted Harvey	14-26	22.64
Ted Harvey	26-39	6.43
Ted Harvey	39-63	3.82
	Middle	
Blackwater	22-51	3.16
Isle of Wight	20-33	3.81
Isle of Wight	33-49	3.65
Eastern Neck Island	15-28	3.25
Eastern Neck Island	28-45	1.96
Eastern Neck Island	45-69	1.62
Ted Harvey	14-26	12.47
Ted Harvey	26-40	3.75
Ted Harvey	40-68	3.44
	Upper	
Blackwater	16-33	4.51
Blackwater	33-63	3.32
Isle of Wight	18-31	2.17
Isle of Wight	31-55	1.24
Eastern Neck Island	14-38	2.91
Eastern Neck Island	38-56	1.63
Ted Harvey	20-33	6.41
Ted Harvey	33-52	5.42

Using this modified data set, the soil Eh and pH were compared with the water table records at the same depth where Eh was measured. On each day when Eh was measured, it was determined whether or not the soil was saturated, and if so, for how long it had been saturated. These data are plotted in figure 3-14. There is a great deal of natural variability in this system, and that there are factors other than the length of saturation that are affecting soil redox potentials. Nevertheless, a best-fit line can be placed in the data that shows that approximately 49% of the variability can be accounted for by the length of time the soil was saturated.

The soil pH at these sites generally ranged between values of 4 and 5. Based on the equation for the TS-line (Fig. 3-4), the Eh corresponding to pH values of 4 and 5 are 355 mV and 295 mV, respectively. The best-fit line calculated for the data intersects these values (355 mV and 295 mV) at 20 days and at 63 days, respectively, suggesting that in general, these soils become reducing sometime between 20 and 63 days of continuous saturation.

Relating measured redox potentials to a static pH-range likely obscures our understanding. Therefore the data set was reevaluated in a way that takes all pH values into account, resulting in more focused results. Each data point was individually recalculated using field pH measurements, where Eh and pH (measured at each depth and at each site) were compared to the TS-line. The difference in mV between measured field Eh values and the Eh corresponding to the TS at the pH in the soil was then plotted as "Eh *relative* to the TS" (Eh=0=TS). These data are shown in figure 3-15. This approach eliminated variability associated with soil pH and resulted in a slightly better fit, with $r^2 = 0.54$ (Fig. 3-15). This best-fit line intersects the x-axis (TS-line) at approximately 43 days, indicating that after approximately 43 days of continuous saturation, soils became reducing as defined by the TS.

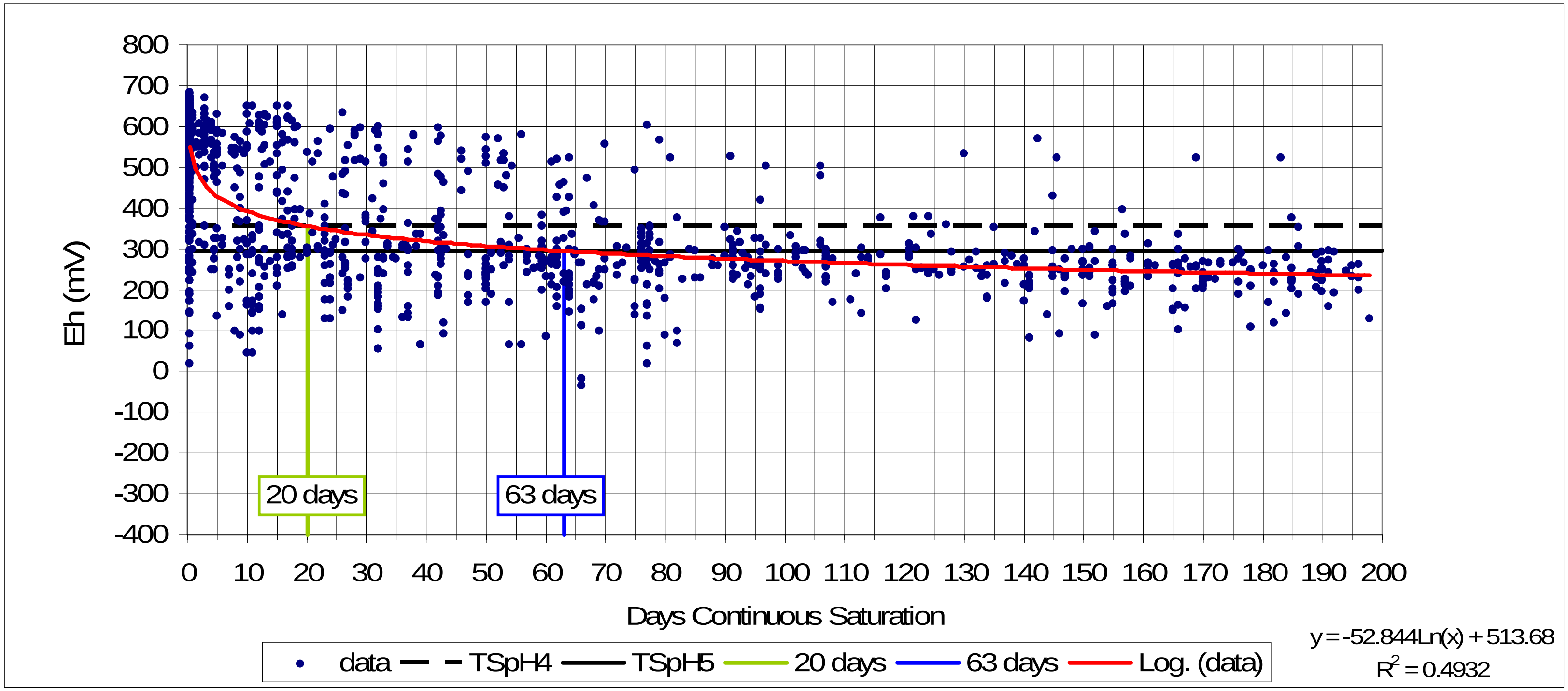


Figure 3-14: Graph showing soil environment reaching the *Technical Standard* (qualifying as a "hydric soil") under continually saturated conditions between soil pH ranges of 4 (dotted horizontal black line) and 5 (solid horizontal black line). Where the least-squares (red) line (best-fit logarithmic regression of the data) crosses the TSpH4 line, soils qualify as "hydric" after approximately 20 days of continuous saturation and where the yellow line crosses the TSpH5 line, soils qualify as hydric after approximately 63 days of continuous saturation. All soil temperatures are included in this data set.

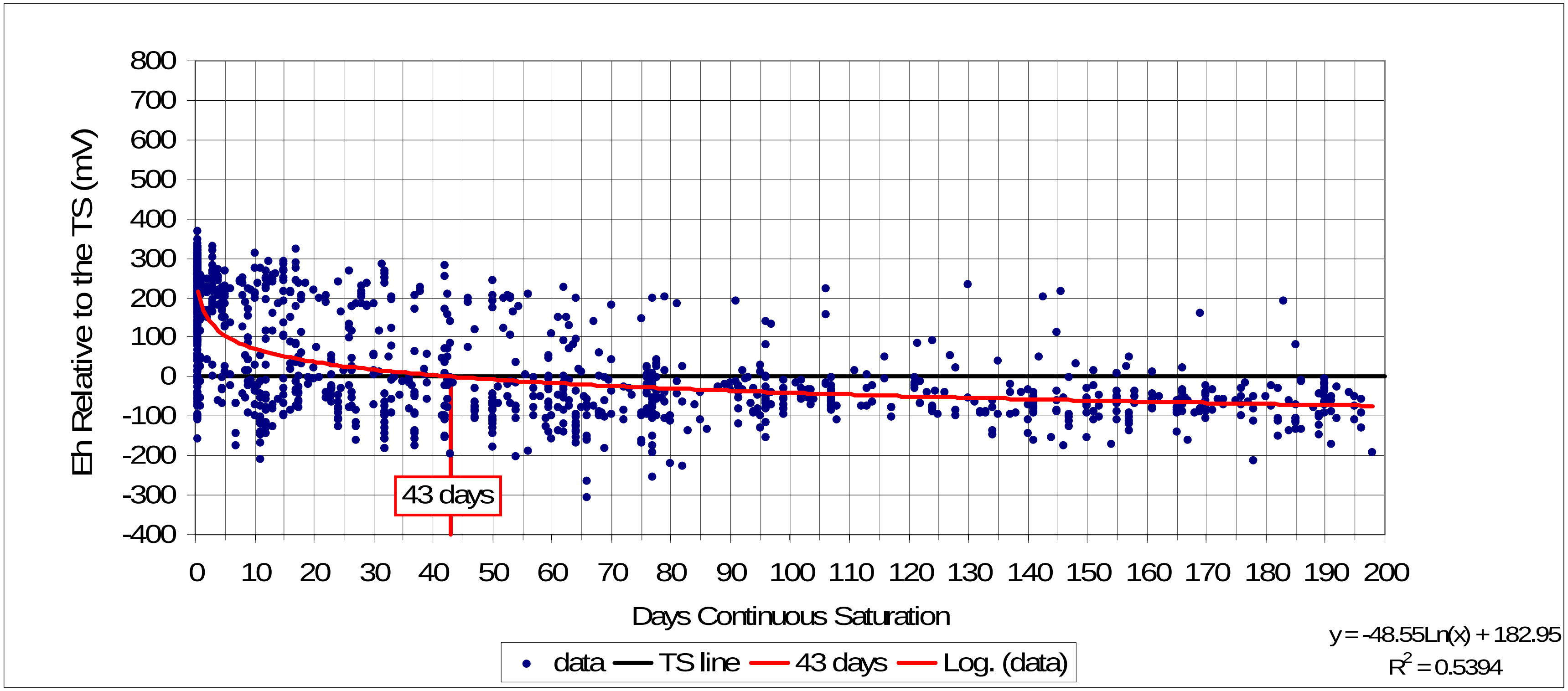


Figure 3-15: Graph showing measured redox/pH data relative to the *Technical Standard*. A least squares (red) line (best-fit logarithmic regression of the data) follows the general trend of the data. The soil environment at or below the TS-line is assumed to qualify as "hydric" under continually saturated conditions. Taking all temperature data into account, soils reach "hydric" status where the yellow line crosses the TS-line (after approximately 43 days of continuous saturation).

Temperature Effects on Redox Potentials

Although soil saturation is considered one of the primary driving forces behind the onset of reducing conditions, we know that microbial respiration is also affected by soil temperature. Soils usually experience the coldest temperatures of the year during times when water tables are closest to the surface. Although fully saturated, soil microbial processes could be expected to be very slow during these times. Therefore, the redox potentials plotted relative to the Technical Standard in figure 3-15 were subsequently separated into temperature groups.

Fourteen-day running averages for temperature (calculated for the particular depth at which the Eh measurements were taken) were used to minimize the effect of short-termed temperature fluctuations. Redox potentials were assembled into 5°C temperature ranges (<5.0, 5.0-9.9, 10.0-14.9, and >15.0) and plotted against days of continuous saturation (Fig. 3-16). Data included in each of these temperature ranges reflected a relatively even distribution of data; the concept of *biological zero* (5°C) was taken into consideration when selecting the ranges.

A least-squares best-fit line was calculated and plotted for the data in each temperature range. These data are shown in figure 3-16. The point where each of the lines crosses the TS-line (x-intercept) represents the approximate number of days the soils were continuously saturated when the soils developed reducing conditions (within that particular temperature range).

It is evident in figure 3-16, that as the temperature of the saturated soil increases, it takes less time for reducing conditions to develop. The x-intercepts for the four best-fit lines were plotted in figure 3-17 to show how differences in soil temperature can affect redox processes. A best-fit power-function was fit to the points and demonstrates the relationship between length of saturation, soil temperature, and the onset of reducing conditions. The slope of the curve in figure 3-17 illustrates that as temperatures drop from 10°C to 5°C, the curve becomes much steeper indicating that microbial activity slows dramatically. Conversely, at temperatures above 10°C, the curve begins to level out, indicating at these temperatures microbes are active and are less affected by soil temperatures.

It is important to note, however, that this data set is comprised wholly of field-data and therefore includes a great deal of variability as is usually associated with such research practices. Fine-scale variations in organic matter content, the presence of plant roots, the amount of active C contributed seasonally during plant senescence, and soil macro-pores are among the factors, likely contributed to the variability.

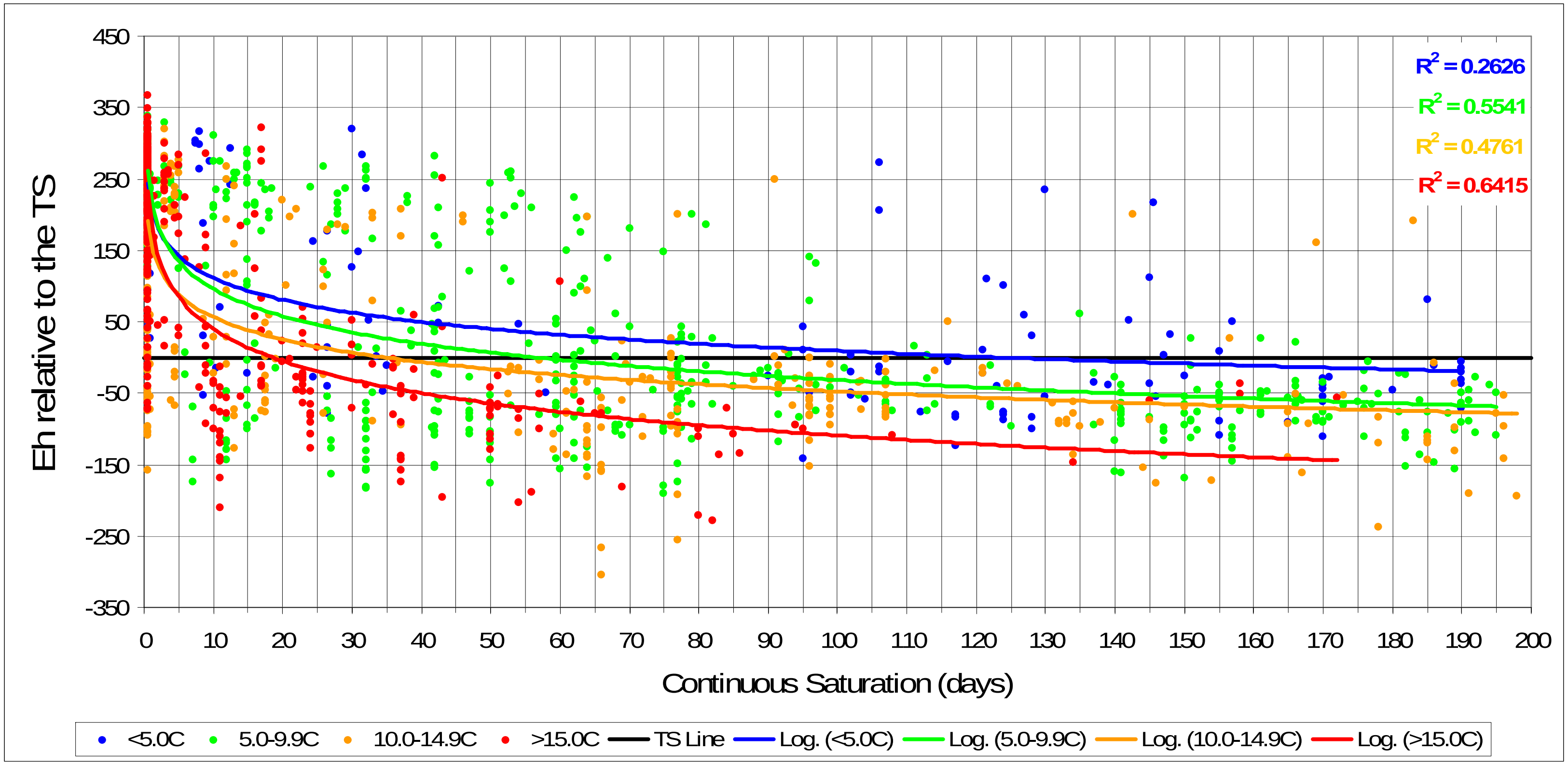


Figure 3-16: Graph showing soil temperatures grouped into 5°C ranges and their effects on redox rates in the soil. Where colored lines (best-fit logarithmic regression of the data) cross the *Technical Standard* (horizontal black line) it is assumed that the soil has reached a reduced state (according to the Technical Standard) after x-days of continuous saturation.

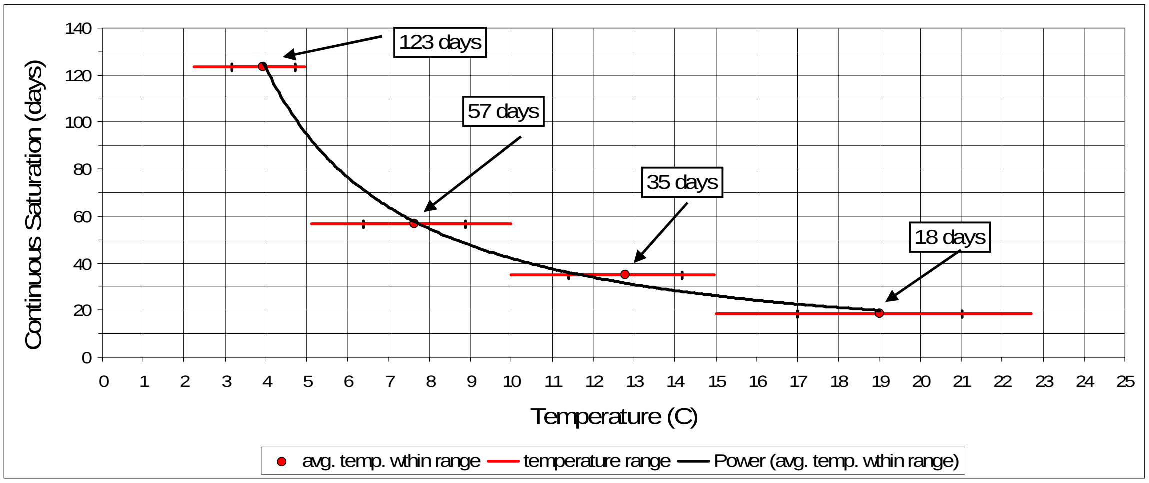


Figure 3-17: Graph shows the x-intercepts of least-squares best-fit (power regression of the data) temperature range lines from Figure 3-16. Data follow a best-fit power function. Horizontal red lines represent temperature ranges with black +/- standard error bars (of means).

CONCLUSIONS

Soils on the Delmarva Peninsula, representing the ABLS phenomenon, did experience reducing conditions after being saturated for extended periods of time. An initial assessment comparing Eh and the period of soil saturation indicated that the soil became reducing with respect to iron somewhere between 20 and 63 days. This assessment was refined by including measured soil pH values into the calculations and comparing each data point to the TS-line [Eh = 595-60(pH)].
Using this approach, we found that ABLS-soils became reducing (relative to the TS) after approximately 43 days of saturation.

Because soil temperature affects the rates of microbial activity, the calculations were further refined by separating the data according to measured soil temperature. These data showed that, although reducing conditions will develop under cold conditions, the required period of saturation is longer when soil temperatures are colder. At 4°C, soils needed to be saturated for approximately 123 days in order to become reducing, whereas at 19°C soils only needed to be saturated for approximately 18 days to become reducing.

In light of these conclusions, we can reject the first and second hypotheses.

4) Relationship between Soil Morphology and Length of Saturation

INTRODUCTION

Wetland soils that experience seasonal saturation due to fluctuating water tables commonly undergo chemical and morphological changes (Rabenhorst, 2004). Water tables that saturate the soil exclude soil air and dramatically decrease soil aeration. If allowed to remain saturated for a long enough period of time when temperatures are warm enough for microorganisms to respire, the soil environment becomes anaerobic (Meek et al., 1968). Under these conditions, thermodynamically predicted mineral transformations take place (James and Bartlett, 2000; Rowell, 1981). Although several mineral species in the soil are affected, the focus of this chapter is on iron oxides. In their oxidized state, these minerals are insoluble and act as strong soil pigmenting agents (Bigham et al., 2002). However, if sufficiently reducing conditions in the soil persist for long enough periods of time, ferric iron (Fe^{3+}) is reduced to its ferrous state (Fe^{2+}). Ferrous iron is colorless, soluble, and highly mobile in the soil, and able to move with soil pore water and groundwater along hydrologic flow paths.

The degree to which a soil experiences saturation and reduction is closely related to, and expressed by, its morphology (Daniels et al., 1971; Franzmeier et al., 1983; He et al., 2003; Jacobs et. al., 2002; Pickering and Veneman, 1984; Rabenhorst, 2004). In soils that repeatedly experience cycles of reducing and oxidizing conditions, Fe accumulates in some areas, forming iron “concentrations”, while leaving adjacent areas gray and depleted of iron (iron “depletions”) (D’Amore et al., 2004; Boersma et al., 1972; Faulkner and Patrick, 1992).

There have been numerous studies that relate soil morphology to the duration of saturation and include work by Galusky et al. (1998), Jacobs et al. (2002), Morgan and Stolt (2006), West et al. (1998), and Castenson (2004). Galusky's PhD research correlated precipitation data to water tables in soils on the Maryland coastal plain. The studies conducted by Jacobs et al., Morgan and Stolt, and West et al. investigated the relationship between soil morphology and seasonal water tables of soils on the Middle Coastal plain in Georgia, the southern coast of Rhode Island, and in the Dougherty Plain of southwest Georgia, respectively. In general, these studies found similar results: Fe-concentrations developed when soils were saturated for short periods of time, usually for between 2 and 20% of the year. Iron depletions formed as the length of saturation increased to approximately 17 to 40% of the year; and a depleted matrix occurred when soils were saturated for 42 to 57% of the year. Castenson's MS thesis project reported on soils on Mid-Atlantic piedmont floodplains and their reticence to express what was thought of as typical hydromorphology, probably due to the young age of the parent material in the alluvial floodplain settings. These piedmont floodplain soils needed significantly longer saturation times to form the types and abundance of redoximorphic features similar to those in soils in other settings.

A group of soils on the Mid Atlantic coastal plain was observed that did not express morphological indicators considered typical for soils experiencing this same degree of saturation and thus, in this sense, they have been referred to as "problematic". This group of soils has been termed "Anomalous Bright Loamy Soils" (ABLS). These soils have been observed to occur mostly along low-lying coastal areas with a subtle, convex shape to their landscapes, and nearly always are within 100-200 meters of the marsh or water's edge. The objectives of this study were (1) to compare the morphology of ABLS with water tables occurring at these sites and (2), to compare these findings with those of similar studies in other pedological settings.

MATERIALS AND METHODS

Study Sites

Four study sites were selected on the Delmarva Peninsula to study Anomalous Bright Loamy Soils (ABLS) of the Mid Atlantic coastal plain. These were identified with the assistance of members of the Mid Atlantic Hydric Soils Committee (MAHSC), who had field experience with ABLS-soils. Three of the sites were located in Maryland, in Dorchester, Worcester, and Kent Counties, and the fourth site was located in Kent County, Delaware (Fig. 4-1).

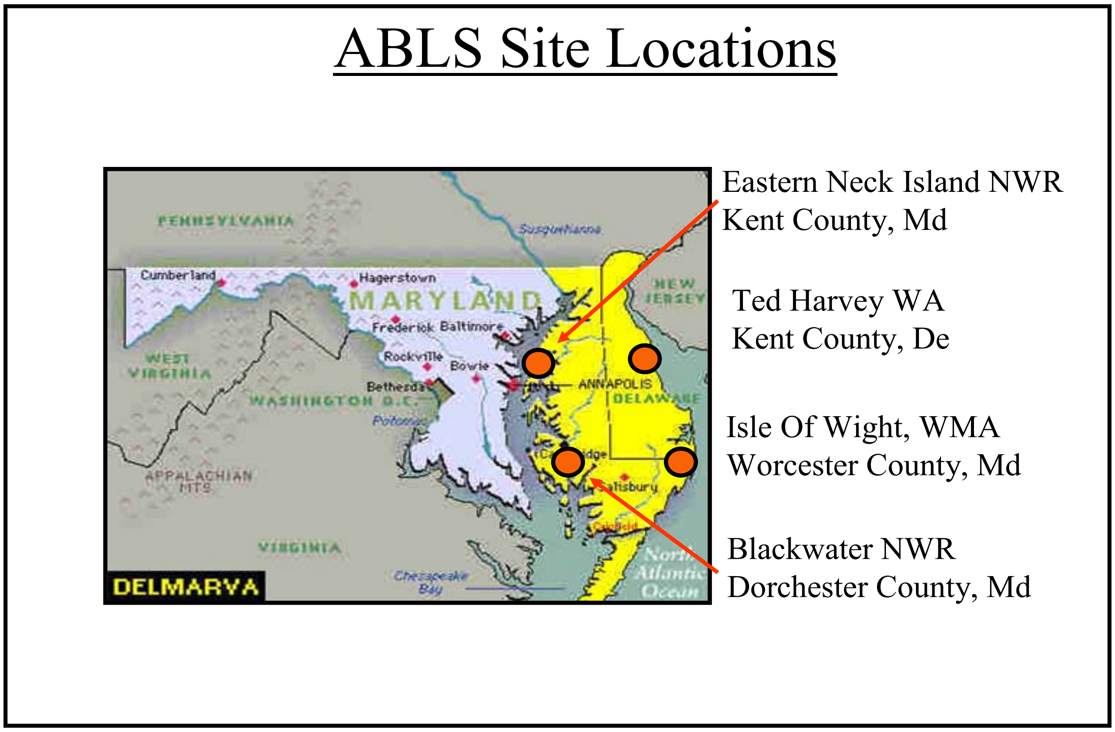


Figure 4-1: Four study site locations (circles) on the Delmarva Peninsula where ABLS-soils were examined.

Each of the sites was thought to be representative of typical soil-landscape settings where the problem ABLS-conditions exists. Sites were selected with several criteria in mind to ensure the success of the study. In particular, sites were selected to ensure that present drainage and hydrological conditions had not been significantly altered (such as by drainage structures), and also that public access to the sites was limited to reduce possible vandalism of equipment placed at the sites. At each site, a transect was identified along a hydrosequence where soils ranged from more poorly drained (probably hydric) to better drained (probably not hydric) conditions.

Water Tables

Water tables were monitored using Remote Data Systems automated recording wells (RDS, Inc., Wilmington, NC), capturing water table levels twice daily to a maximum depth of approximately 1.5 m. At each site, three wells were installed along the transect to confirm the presence of a hydrosequence (Sprecher, 2008). Well data were periodically downloaded using a hand-held Hewlett-Packard calculator with infrared interface, and then were off-loaded to a computer for processing.

Soils

Soil pits were dug by hand and described to depths ranging from 88 cm to 170 cm, depending on the depth to water table levels present at the time when soils were described. Starting at the base of most pits, soils were further described by augering to depths that ranged from 129 cm to 335 cm. Soil descriptions were made following standard protocols (Soil Survey Staff, 1993), while focusing detailed attention on the identification and description of redoximorphic features. The percentages of redoximorphic features were estimated to the nearest percent by comparing with standard reference charts.

Soil samples were collected from each horizon. In the lab, samples were air-dried and crushed to pass through a 2-mm sieve. Samples were analyzed for particle size (PSA) using the pipette-method (Gee and Bauder, 1986). Samples were also analyzed for organic carbon in the mineral fraction by dry-combustion at 950°C (Nelson and Sommers, 1982; Tabatabai and Bremner, 1991).

Precipitation

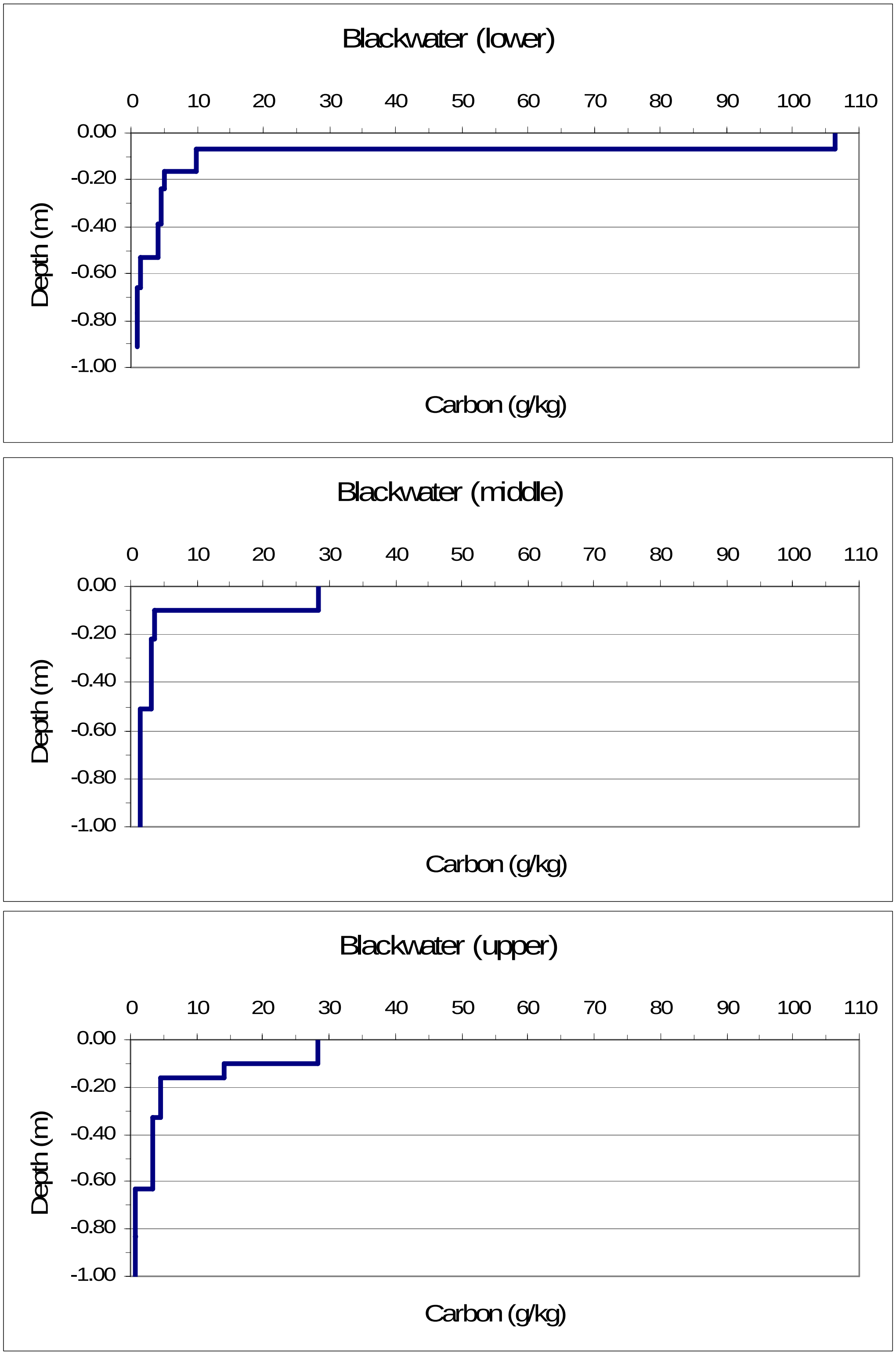
Precipitation data were initially collected for the Isle of Wight, the Eastern Neck Island, and the Ted Harvey sites using tipping-bucket rain gauges (the Blackwater site was not instrumented). However, technical difficulties were encountered using these gauges including mechanical failure and animal (insect) intrusion that made it impractical to rely solely on these data for analysis. Therefore, the data from local weather stations positioned relatively close to each of the sites were identified and utilized for substitute precipitation data. The weather station in Vienna, MD (Dorchester County: latitude/longitude: 38°29'N / 75°49'W) was referenced for the Blackwater research site (approximately 19 km (12 mi) away); the weather station at the Ocean City Airport (Worcester County: latitude/longitude: 38°19'N / 75°07'W) located in Ocean City, MD was referenced for the Isle of Wight research site (approximately 8 km (5 mi) away); the weather station in Chestertown, MD (Kent County, MD: latitude/longitude: 39°13'N / 76°03'W) was referenced for the Eastern Neck Island research site (approximately 20 km

(12 mi) away); and the weather station in Dover, DE (Kent County, DE: latitude/longitude: 39°16'N / 75°31'W) was referenced for the Ted Harvey research site (approximately 7 km (4 mi) away).

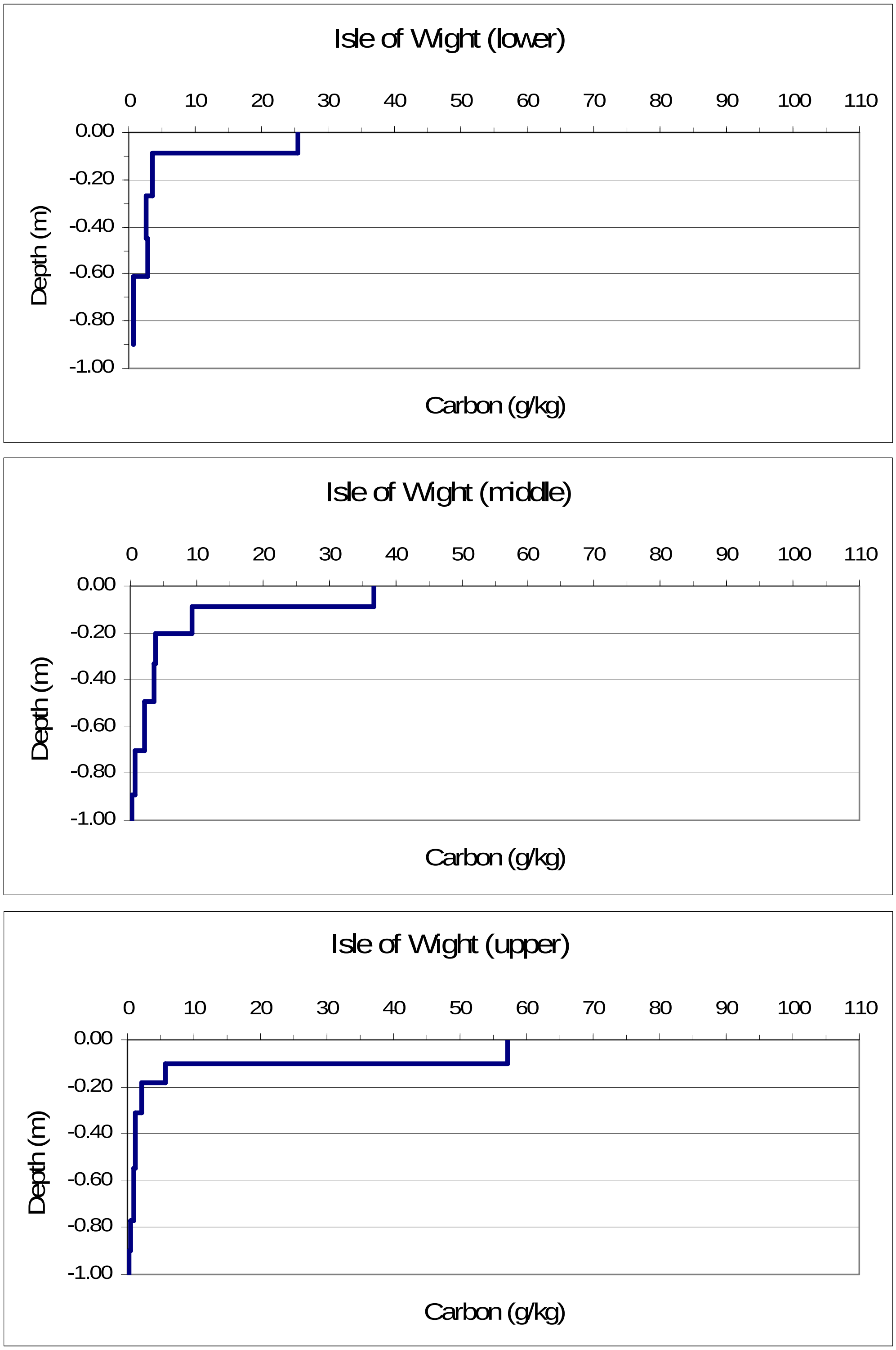
RESULTS AND DISCUSSION

Soils

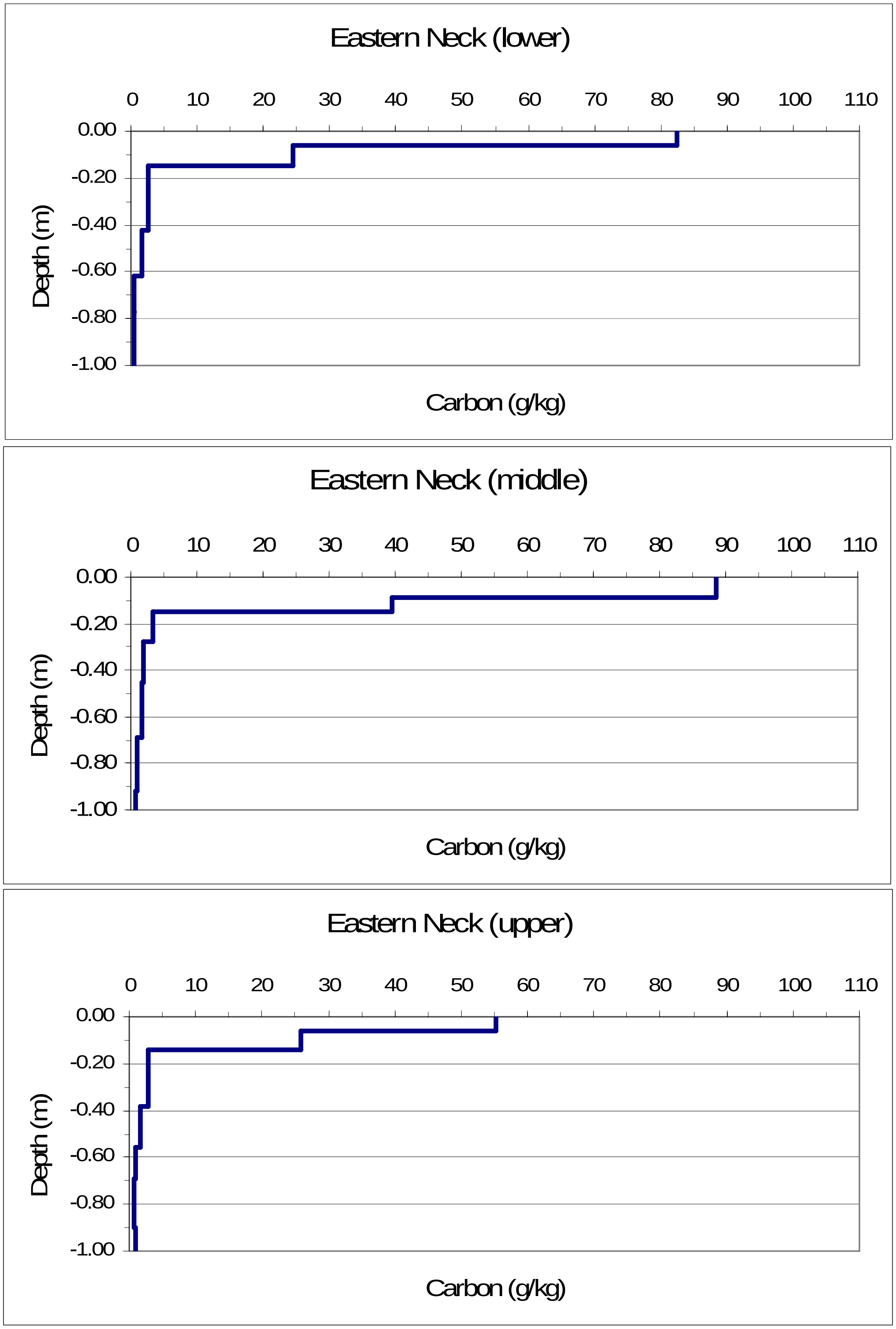
Organic carbon content of ABLS-soils was generally found to be within the range of Coastal Plain soils with similar drainage found on the Delmarva Peninsula (Figs. 4-2a, b, c, and d) (Foss et al., 1969, Soil Survey Staff, 2008). Maximum carbon content in these soils occurred at the surface, in O- and A-horizons. Below these horizons, the amount of carbon tapered off quickly, generally to less than approximately 5g/kg, within 20 cm of the surface. The distribution of carbon is similar to that commonly found in older, more stable soils on the Delmarva Peninsula which are well-developed enough and possess an argillic horizon (Foss et al., 1969, Soil Survey Staff, 2008). Soil textures in the Bt horizons ranged from silt loams and fine sandy loams to sandy loams. A lithologic discontinuity occurred at the Blackwater, Eastern Neck Island, and Ted Harvey sites, distinguishable by a relatively coarser texture below the discontinuity. Twelve pedon descriptions from the soils examined at the four research sites are listed in Tables 4-2 (a-c) through 4-5 (a-c). Particle Size Analysis results for these pedons are reported in Appendix C.


Blackwater (lower)
0
10
20
30
40
50
60
70
80
90
100
110
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
Depth (m)
Carbon (g/kg)
Blackwater (middle)
0
10
20
30
40
50
60
70
80
90
100
110
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
Depth (m)
Carbon (g/kg)
Blackwater (upper)
0
10
20
30
40
50
60
70
80
90
100
110
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
Depth (m)
Carbon (g/kg)

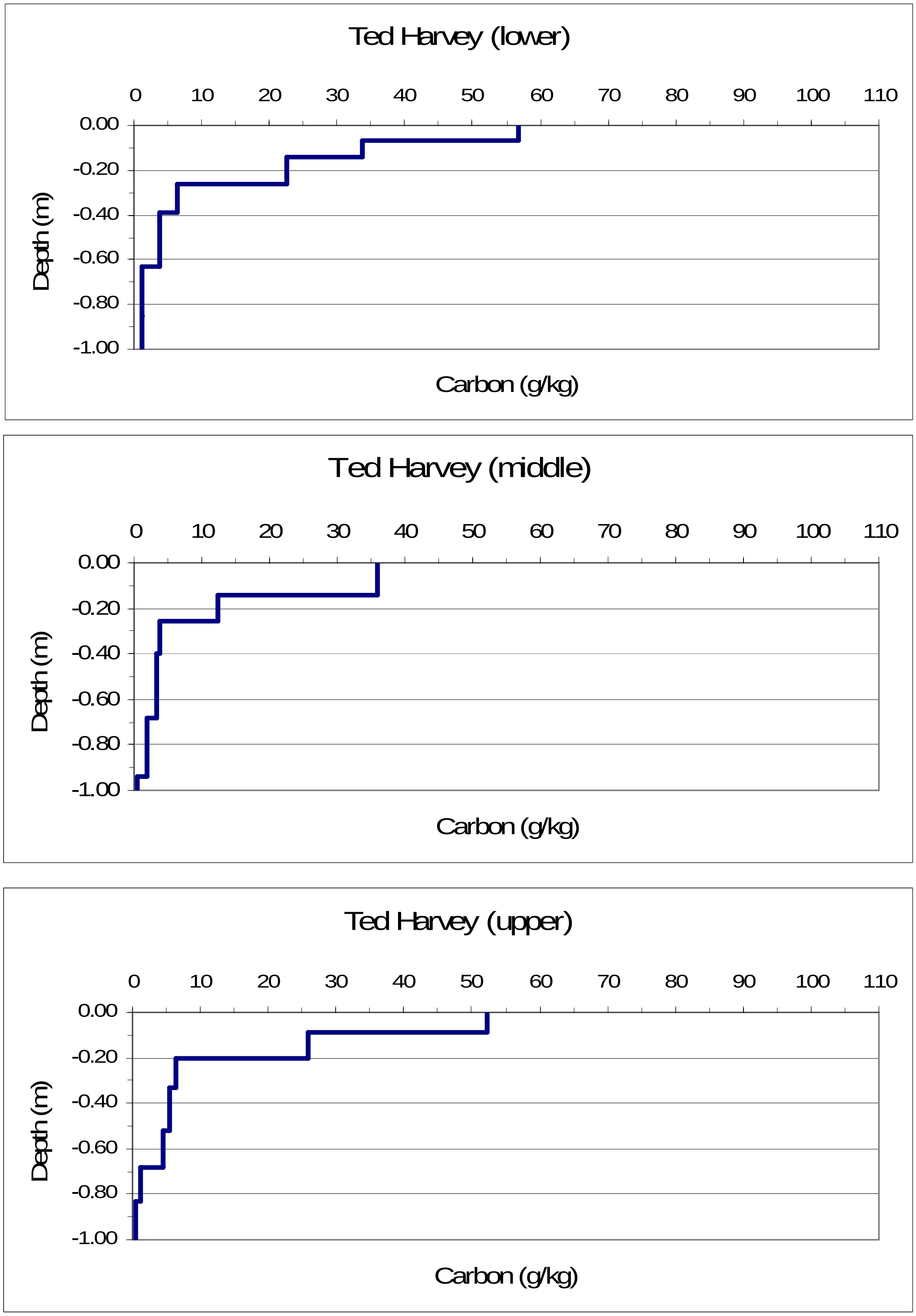
(Figure 4-2a)


Isle of Wight (lower)
0
10
20
30
40
50
60
70
80
90
100
110
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
Depth (m)
Carbon (g/kg)
Isle of Wight (middle)
0
10
20
30
40
50
60
70
80
90
100
110
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
Depth (m)
Carbon (g/kg)
Isle of Wight (upper)
0
10
20
30
40
50
60
70
80
90
100
110
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
Depth (m)
Carbon (g/kg)

(Figure 4-2b)


Eastern Neck (lower)
0
10
20
30
40
50
60
70
80
90
100
110
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
Depth (m)
Carbon (g/kg)
Eastern Neck (middle)
0
10
20
30
40
50
60
70
80
90
100
110
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
Depth (m)
Carbon (g/kg)
Eastern Neck (upper)
0
10
20
30
40
50
60
70
80
90
100
110
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
Depth (m)
Carbon (g/kg)

(Figure 4-2c)



(Figure 4-2d)

Figures 4-2 a-d: Total soil carbon content (g/kg) within the upper 100 cm at the Blackwater (a), Isle of Wight (b), Eastern Neck Island (c), and Ted Harvey (d) research sites. Sampling depths based on horizon breaks.

Precipitation

Summarized precipitation data for ABLS sites appear in Table 4-1. Generally speaking for the Mid-Atlantic area, precipitation amounts in 2001 were considered average compared to long-term data, with 2002 being a "dry" year (precipitation totals significantly below average) and 2003 a "wet" year (precipitation totals significantly above average). Precipitation at all four research sites was within 5 to 17% of the long-term average throughout the three-year study; with 2003 clearly being a wetter-than-average year.

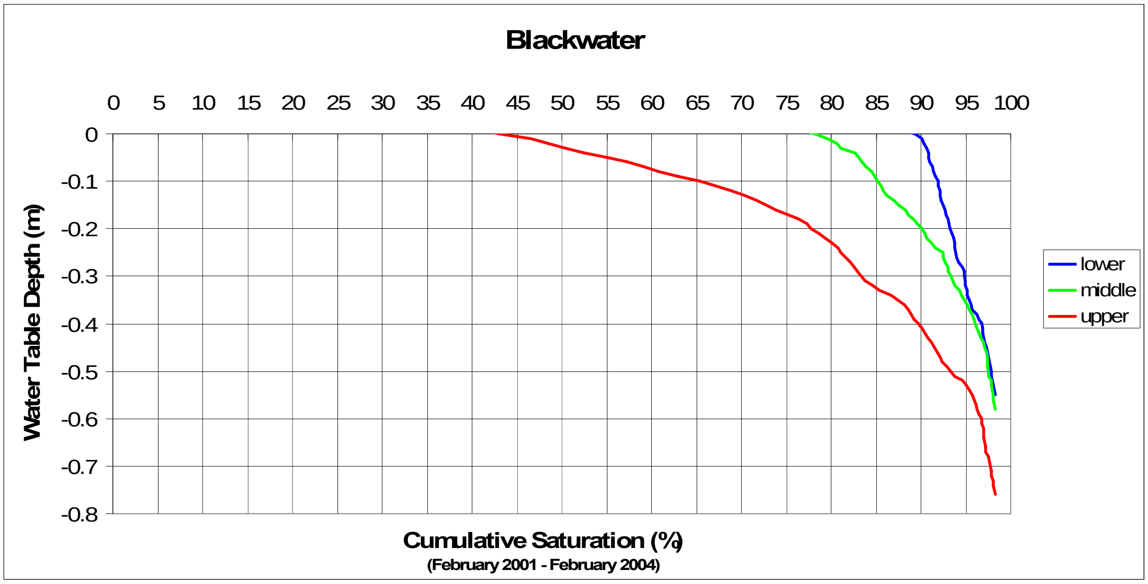
Table 4-1: Precipitation data for years 2000-2003 as compared to long-term averages (*long-term average).

	Year								
	2001		2002		2003		LTA	2001-2003 (3-yr avg.)	
Site	mm	% of LTA*	mm	% of LTA*	mm	% of LTA*	mm	mm	% of LTA*
Blackwater	1025	93	874	80	1560	142	1097	1153	105
Isle of Wight	669	61	838	76	1221	111	1100	909	83
Eastern Neck Island	1017	89	1088	96	1611	141	1139	1239	109
Ted Harvey	984	84	1308	112	1599	136	1172	1297	111

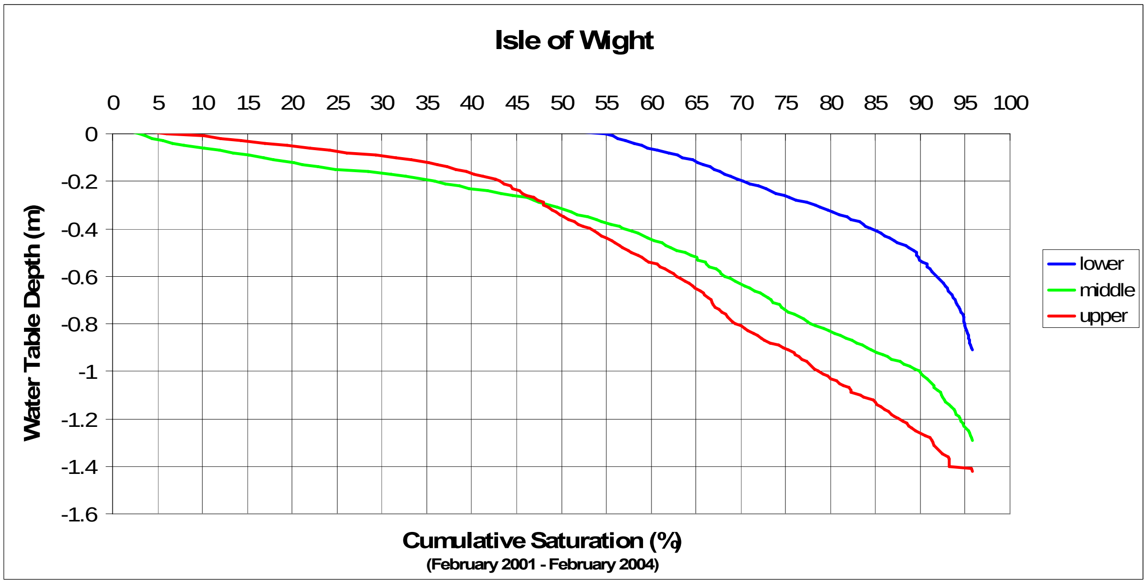
Water Tables

At each of the four sites, at least some of the soils (the lower lying ones) had sufficiently high water tables so that they were saturated to the surface or ponded for extended periods of time. Water tables followed typical patterns and were higher during winter and early spring (November – March) and dropped significantly during late spring and summer (April – October); these trends are mostly driven by evapotranspiration rates that are low in the winter and high in the summer.

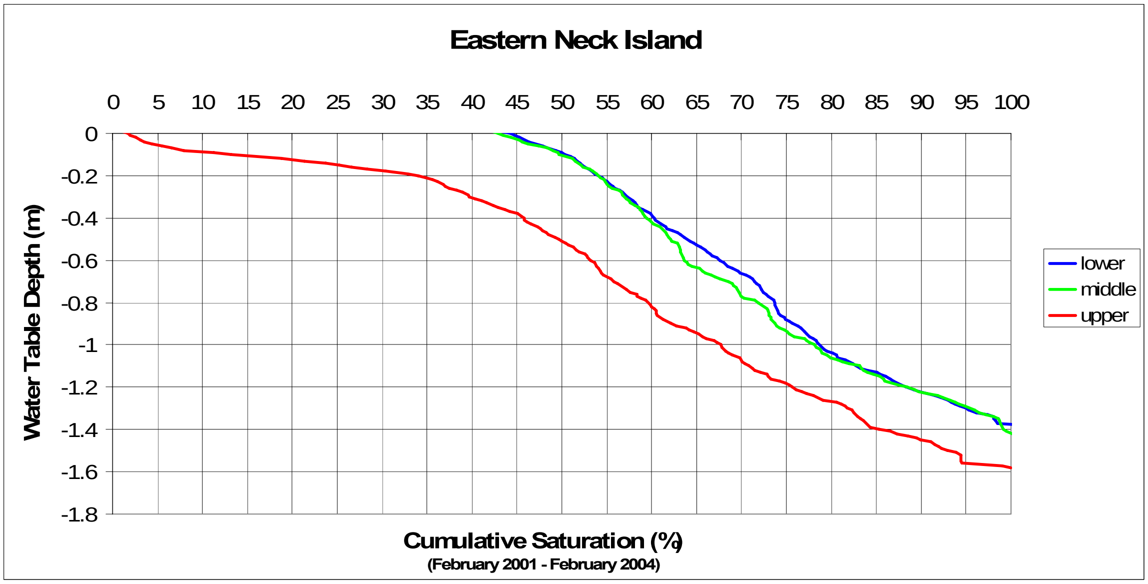
Cumulative frequency distribution curves of water tables were calculated using a three-year data set that was collected between February 20, 2001 and February 20, 2004. Results include data of years that were drier than long-term averages (2001 and 2002) and of years that were wetter than long-term averages (2003). As would be expected, water tables were generally closer to the surface for longer periods along the lower points of the transect (blue lines in Figs. 4-3a, b, c, and d) and lower in the soil along the upper end of the transect (red lines in Figs. 4-3a, b, c, and d). Exceptions to this generalization were noted at the Eastern Neck Island and at the Isle of Wight sites. At Eastern Neck Island, the lower and middle positions experienced almost identical water table levels (Fig. 4-3c), which is not surprising as the elevation of these two sites was nearly identical. At Isle of Wight site, soils at the upper end of the transect were slightly wetter than those at the middle position (Fig. 4-3b). This observation at Isle of Wight was likely the effect of a seasonally ponded area, less than fifty meters away that occurred above the upper site. The Blackwater site was by far the wettest of all four sites. Water tables were at or above the mineral soil surface for between 45 and 90% of the year (Fig. 4-3a). Conversely, the Ted Harvey site was the driest with the water tables occurring at or above the surface for less than 2% of the year (Fig. 4-3d).



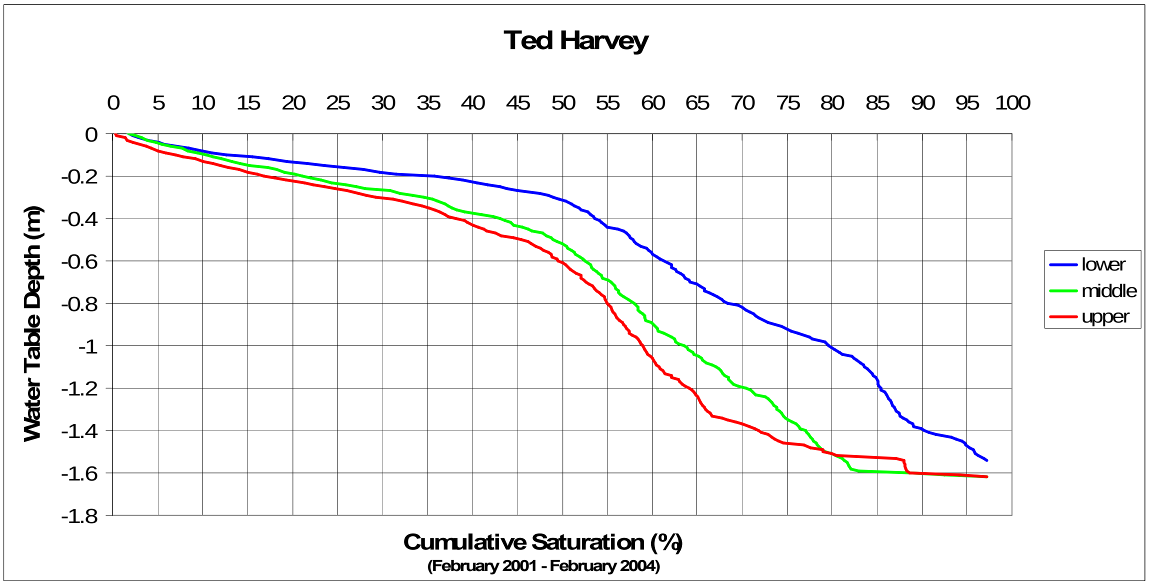
(Figure 4-3a)



(Figure 4-3b)



(Figure 4-3c)



(Figure 4-3d)

Figures 4-3 a-d: Cumulative frequency distribution curves for water tables at the Blackwater (a), Isle of Wight (b), Eastern Neck Island (c), and Ted Harvey (d) research sites.

Soil Morphology as a function of Cumulative Saturation

Soil morphological descriptions for the pedons analyzed in this study are shown in Tables 4-2 (a-c) through 4-5 (a-c).

Tables 4-2 a-c: Pedon descriptions at the lower (a), middle (b), and upper (c) positions of the Blackwater research site (Blackwater National Wildlife Refuge, Dorchester County, MD).

Table 4-2a - Soil Description: Blackwater National Wildlife Refuge, Dorchester County, MD
Site Position: Lower Well
Date: August 21, 2002
Water Table Height (pit): 37 cm
Pit Depth: 0-105 cm
Described by: Philip Zurheide and John Wah
NOTES: Some mixing of A into E horizon (root mat lenses); redox in 5th horizon shows sharper boundaries than in horizon above.

Horizon	Depth (cm)	Description
Oe	**14-0**	dark reddish brown (5YR 2.5/2) mucky peat; clear smooth boundary.
A	**0-7**	black (7.5YR 2.5/1) mucky silt loam (11% clay); weak medium sub-angular blocky structure; very friable; abrupt wavy boundary.
Eg	**7-16**	gray (2.5Y 6/1) silt loam (14% clay) with common (15%) medium distinct olive (5Y 5/3) and common (3%) fine prominent yellowish brown (10YR 5/6) soft masses; moderate medium sub-angular blocky parting to weak medium platy structure; friable; clear smooth boundary.
BEg	**16-26**	gray (2.5Y 6/1) silt loam (15% clay) with many (34%) medium distinct light olive brown (2.5Y 5/6) and common (15%) medium prominent yellowish brown (10YR 5/6) and few (1%) fine prominent yellowish brown (10YR 5/8) soft masses; weak medium sub-angular blocky structure; friable; clear smooth boundary.
Btg1	**26-39**	gray (2.5Y 6/1) silt loam (21% clay) with common (13%) medium distinct light olive brown (2.5Y 5/6) and common (18%) medium prominent yellowish brown (10YR 5/8) soft masses; weak coarse sub-angular blocky structure; friable; clear smooth boundary.
Btg2	**39-53**	gray (N5) silt loam (25% clay) with common (17%) medium prominent yellowish brown (10YR 5/8) soft masses; weak coarse sub-angular blocky structure; friable; clear smooth boundary.
Bt1	**53-66**	yellowish brown (10YR 5/6) with many (21%) medium distinct strong brown (7.5YR 5/8) soft masses and common (5%) fine to medium distinct yellowish red (5YR 5/6) as clay skins and many (25%) medium prominent gray (5Y 5/1) iron depletions;

		weak coarse prismatic parting to moderate medium to thick platy structure; friable; clear smooth boundary.
Bt2	**66-77**	olive (5Y 5/4) loam (26% clay) with common (13%) fine to medium prominent strong brown (7.5YR 5/8) soft masses with common (7%) medium prominent and fine to medium distinct yellowish red (5YR 5/6) as clay skins and common (10%) medium faint olive gray (5Y 5/2) and common (15%) medium distinct gray (N5) iron depletions; weak coarse prismatic parting to moderate medium thick platy structure; friable (brittle); clear smooth boundary.
2BC	**77-91**	light olive brown (2.5Y 5/4) sandy loam (13% clay) with common 15%) medium to coarse prominent yellowish brown (10YR 5/8) and common (15%) fine to medium prominent strong brown (7.5YR 5/8) soft masses and common (18%) medium prominent grayish brown (2.5Y 5/2) iron depletions; weak to moderate thick platy and weak coarse prismatic structure; friable.

Table 4-2b - Soil Description: Blackwater National Wildlife Refuge, Dorchester County, MD
Site Position: Middle Well
Date: Jan 24, 2002
Pit Depth: 0-114 cm
Auger Depth: 114 cm - 140+ cm
Described by: Philip Zurheide, Martin C. Rabenhorst, Phillip King; assisted by, Carla Baker, Steve Burch, Charlie Hanner, John Wah, and David Win.
NOTES: No iron concentrations in A horizon; Redox depletions pronounced around decaying roots/channels and along prism faces.

Horizon	Depth (cm)	Description
Oe	**11-0**	very dusky red (2.5YR 2.5/2) mucky peat; abrupt smooth boundary.
A	**0-10**	dark reddish gray to weak red (2.5YR 4/1.5) silt loam (11% clay); weak medium sub-angular blocky structure; friable; abrupt smooth boundary.
Bt (BE)	**10-22**	light olive brown (2.5Y 5/6) (40%) and olive yellow (2.5Y 6/6) (40%) silt loam (21% clay) with common (2%) very fine prominent strong brown (7.5YR 4/6) and common (2%) yellowish brown (10YR 5/6) soft masses and common (16%) medium distinct gray (2.5Y 6/1) iron depletions; weak medium sub-angular blocky structure parting to weak fine sub-angular blocky structure; friable; clear smooth boundary.
Btg	**22-51**	gray (5Y 6/1) (70%) and light brownish gray (2.5Y 6/2) (10%) silty clay loam (31% clay) with common (20%) medium distinct reddish yellow (7.5YR 6.5/8) soft masses; weak medium sub-angular blocky structure; friable; clear smooth boundary.
2Bt	**51-103**	light olive brown (2.5Y 5/6) (25%) and yellowish brown (10YR 5/8) (50%) loam to sandy clay loam (21% clay) to fine sandy loam with common (5%) reddish yellow (7.5YR 6.5/8) soft masses and common (20%) greenish gray (10Y 6/1) and gray (N5) iron depletions; weak very coarse prismatic parting to moderate medium platy parting to moderate fine to medium sub-angular blocky structure; firm; clear smooth boundary.
2BC	**103-129**	yellowish brown (10YR 5/6) sandy loam with common medium distinct reddish yellow (7.5YR 6/8) soft masses.
2C	**129+**	light olive brown (2.5Y 5/4) fine sandy loam.

Table 4-2c - Soil Description: Blackwater National Wildlife Refuge, Dorchester County, MD
Site Position: Upper Well
Date: Jan 24, 2002
Pit Depth: 0-88 cm
Auger Depth: 88 cm - 212 cm

Described by: Philip Zurheide, Martin C. Rabenhorst, Phillip King; assisted by, Carla Baker, Steve Burch, Charlie Hanner, John Wah, and David Win.
NOTES: Redox depletions pronounced around decaying roots/channels and along prism faces.

Horizon	Depth (cm)	Description
Oe	**5-0**	black (5YR 2.5/1) mucky peat; abrupt smooth boundary.
A	**0-10**	very dark grayish brown to dark grayish brown (10YR 3.5/2) (97%) silt loam (9% clay) with common (3%) fine dark brown (7.5YR 3/3) soft masses around roots; weak medium subangular blocky structure; friable; clear smooth boundary.
EA	**10-16**	dark grayish brown to olive brown (2.5Y 4/2.7) (93%) silt loam (9% clay) with common (7%) fine dark brown (7.5YR 3/3) soft masses; weak fine to medium subangular blocky structure; friable; abrupt smooth boundary.
Bt1	**16-33**	light olive brown (2.5Y 5/4) (80%) silt loam (17.5% clay) with common (7%) strong brown (7.5YR 4/6) and common (3%) dark brown (7.5YR 3/4) soft masses and common (5%) light olive brown (2.5Y 5/3.2) and common (5%) light brownish gray (2.5Y 6/2) iron depletions; weak medium subangular blocky structure; friable; clear to gradual smooth boundary.
Bt2	**33-63**	light olive brown (2.5Y 5/4) (65%) loam (23% clay) with common (10%) fine strong brown (7.5YR 4/6) soft masses and common (10%) light olive brown (2.5Y 5/3) and common (15%) grayish brown (2.5Y 5/2) iron depletions; weak fine subangular blocky structure; friable; clear smooth boundary.
2BC1	**63-83**	yellowish brown (10YR 5/6) (65%) sandy loam (15% clay) with many (25%) medium faint dark yellowish brown (10YR 4/6) soft masses and common (10%) grayish brown (2.5Y 5/2) iron depletions; weak medium platy parting to weak medium subangular blocky structure; friable; clear smooth boundary.
2BC2	**83-173**	Yellowish brown (10YR 5/6) loamy sand with strong brown (7.5YR 4/6) soft masses and light brownish gray (2.5Y 6/2) iron depletions.

2BC3	**173-207**	yellowish brown (10YR 5/4) sandy loam with strong brown (7.5YR 4/6) soft masses and gray (2.5Y 6/1) iron depletions.

Tables 4-3 a-c: Pedon descriptions at the lower (a), middle (b), and upper (c) positions of the Isle of Wight research site (Isle of Wight Wildlife Management Area, Worcester County, MD).

Table 4-3a - Soil Description: Isle of Wight Wildlife Management Area, Worcester County, MD
Site Position: Lower Well
Date: July 22, 2002
Pit Depth: 0-96+ cm
Described by: Philip Zurheide, Martin C. Rabenhorst; Steve Burch, Karen Castenson, Cary Coppock, and Robert Vaughan

Horizon	Depth (cm)	Description
Oe	**6-0**	very dusky red (2.5YR 2.5/2) mucky peat; abrupt smooth boundary.
A	**0-9**	very dark gray (2.5Y 3/1) (92%) sandy loam to loam (8% clay) with common (8%) distinct fine dark reddish brown (5YR 3/3) pore linings of iron; weak fine sub-angular blocky structure; friable; clear wavy boundary.
B/A	**9-27**	light olive brown (2.5Y 5/4) (60%) and very dark grayish brown to dark grayish brown (2.5Y 3.5/2) (15%) sandy loam (14% clay) with common (15%) medium distinct strong brown (7.5YR 4/6) soft masses and pore linings of iron and common (5%) fine prominent yellowish red (5YR 4/6) pore linings of iron and common (5%) medium to coarse faint very dark grayish brown to dark grayish brown (2.5Y 3.5/2) iron depletions; moderate medium sub-angular blocky structure; friable; clear smooth boundary.
Bt1	**27-45**	light olive brown (2.5Y 5/4) loam (18% clay) with many (25%) medium distinct strong brown (7.5YR 4/6) soft masses and pore linings of iron and common (5%) fine prominent yellowish red (5YR 4/6) pore linings of iron and common (5%) medium to coarse faint grayish brown (2.5Y 5/2) iron depletions; moderate medium sub-angular blocky structure; friable; clear smooth boundary.
Bt2	**45-60**	dark yellowish brown (10YR 4/4) fine sandy loam (15% clay) with common (20%) medium to coarse faint strong brown (7.5YR 5/6) soft masses of iron and common (5%) fine distinct strong brown (7.5YR 4/6) pore linings of iron and common (5%) moderate to coarse gray (2.5Y 5/1) iron depletions; weak moderate to coarse sub-angular blocky structure; friable; clear smooth boundary.
BC	**60-90+**	light olive brown (2.5Y 5/4) loamy sand (6% clay) with common (20%) very coarse prominent yellowish brown (10YR 5/6) soft masses of iron and common (5%) medium to coarse prominent yellowish red (5YR 4/6) pore linings of iron and common (20%) very coarse faint dark grayish brown (2.5Y 5/2) iron depletions; structureless massive; very friable.

Table 4-3b - Soil Description: Isle of Wight Wildlife Management Area, Worcester County, MD
Site Position: Middle Well
Date: July 22, 2002
Pit Depth: 0-96+ cm
Described by: Philip Zurheide, Martin C. Rabenhorst; Steve Burch, Karen Castenson, Cary Coppock, and Robert Vaughan

Horizon	Depth (cm)	Description
A	**0-9**	very dark brown (7.5YR 2.5/2) loam to sandy loam (10% clay) with few (1%) fine distinct dark reddish brown (5YR 5/4) pore linings of iron; moderate medium granular structure; very friable; clear smooth boundary.
AE	**9-20**	olive brown (2.5Y 4/4) loam to fine sandy loam (11% clay) with common (4%) fine to medium distinct yellowish red (5YR 4/6) pore linings of iron; weak fine sub-angular blocky parting to weak fine to medium granular structure; friable; clear smooth boundary.
EB	**20-33**	yellowish brown (10YR 5/6) sandy loam (9% clay) with common (6%) fine to medium distinct yellowish red (5YR 4/6) pore linings of iron and common (5%) medium to coarse faint light olive brown (2.5Y 5/4) iron depletions; weak medium sub-angular blocky structure; friable; clear smooth boundary.
Bt1	**33-49**	dark yellowish brown (10YR 4/6) sandy loam (16% clay) with common (5%) fine distinct yellowish red (5YR 5/8) pore linings of iron and common (15%) medium to coarse distinct light olive brown (2.5Y 5/3) iron depletions; moderate medium to coarse sub-angular blocky structure; friable; clear smooth boundary.
Bt2	**49-70**	dark yellowish brown (10YR 4/6) sandy loam (19% clay) with common (10%) coarse distinct strong brown (7.5YR 4/6) soft masses of iron and common (2%) fine prominent yellowish red (5YR 5/8) pore linings of iron and light olive brown (2.5Y 5/3) iron depletions; moderate medium to coarse sub-angular blocky structure; friable; clear smooth boundary.
C1	**70-89**	yellowish brown (10YR 5/4) sandy loam to loamy sand (8% clay) with common (20%) coarse to very coarse faint yellowish brown (10YR 5/6) soft masses of iron and common (3%) fine to medium prominent yellowish red (5YR 5/8) pore linings of iron and common (5%) medium to coarse faint light yellowish brown (2.5Y 6/4) iron depletions; very weak coarse sub-angular blocky structure; very friable; gradual smooth boundary.
C2	**89-125+**	light olive brown (2.5Y 5/4) loamy sand to sand (4% clay) with common (5%) medium prominent yellowish red (5YR 5/8) pore linings of iron and many (25%) very coarse faint grayish brown (2.5Y 5/2) iron depletions; structureless single grain

lose; very friable.

Table 4-3c - Soil Description: Isle of Wight Wildlife Management Area, Worcester County, MD
Site Position: Upper Well
Date: July 22, 2002
Pit Depth: 0-96+ cm
Auger Depth: 96-270+ cm
Described by: Philip Zurheide, Martin C. Rabenhorst; Steve Burch, Karen Castenson, Cary Coppock, and Robert Vaughan

Horizon	Depth (cm)	Description
A	**0-10**	dark brown (7.5YR 3/2) loam to fine sandy loam (10% clay); moderate medium granular structure; friable; abrupt wavy boundary.
AB	**10-18**	brown (10YR 4/3) fine sandy loam (12% clay) with common (10%) medium distinct strong brown (7.5YR 4/6) and common (5%) medium prominent dark reddish brown (5YR 3/4) soft masses of iron and common (3%) fine dark grayish brown (2.5Y 4/2) iron depletions; weak medium sub-angular blocky structure; friable; clear wavy boundary.
BA	**18-31**	light olive brown (2.5Y 5/4) fine sandy loam (13% clay) with many (35%) medium to coarse faint yellowish brown (10YR 5/6) soft masses of iron and common (3%) fine distinct strong brown (7.5YR 4/6) pore linings of iron; weak medium sub-angular blocky structure; friable; clear smooth boundary.
Bt1	**31-55**	yellowish brown (10YR 5/6) fine sandy loam (14% clay) with common (2%) fine prominent strong brown (7.5YR 5/8) pore linings of iron and common (8%) coarse distinct light olive brown (2.5Y 5/3) iron depletions around roots and common (10%) medium to coarse faint light olive brown (2.5Y 5/4) iron depletions; weak coarse sub-angular blocky structure; friable; clear smooth boundary. yellowish brown (10YR 5/6) sandy loam (11% clay) with common (15%) medium distinct strong brown (7.5YR 4/6) soft masses and pore linings of iron and common (15%) medium to coarse distinct light yellowish brown (2.5Y 6/4) iron depletions; weak medium to coarse sub-angular blocky structure; friable; clear smooth boundary.
Bt2	**55-77**	yellowish brown (10YR 5/6) sandy loam (11% clay) with common (15%) medium distinct strong brown (7.5YR 4/6) soft masses and pore linings of iron and common (15%) medium to coarse distinct light yellowish brown (2.5Y 6/4) iron depletions; weak medium to coarse sub-angular blocky structure; friable; clear smooth boundary.
BC	**77-90**	brownish yellow (10YR 6/6) loamy sand (6% clay) with common (20%) medium to coarse distinct strong brown (7.5YR 4/6) soft masses of iron and common (3%) fine distinct strong brown (7.5YR 5/8) pore linings of iron and many (25%) coarse to very coarse distinct light yellowish brown (2.5Y 6/4) iron depletions; very weak medium to coarse sub-angular blocky

		structure; very friable; clear smooth boundary.
C1	**90-137**	light olive brown (2.5Y 5/3) sand (4% clay) with common (15%) fine to medium prominent strong brown (7.5YR 5/8) pore linings of iron and common (10%) coarse to very coarse distinct light olive brown (2.5Y 5/6) soft masses of iron and many (30%) coarse to very coarse faint light brownish gray (2.5Y 6/2) iron depletions; structureless single grain lose; very friable; clear wavy boundary.
C2	**137-150**	gray (2.5Y 6/1) (30%) and yellowish brown (10YR 5/4) (60%) fine sand to loamy fine sand with common (10%) medium to coarse distinct strong brown (7.5YR 4/6) soft masses of iron.
2Cg	**150-183**	gray (5Y 6/1) fine sandy loam (14% clay) with many (30%) coarse to very coarse prominent yellowish brown (10YR 5/6) and common (10%) medium to coarse prominent strong brown (7.5YR 5/8) soft masses of iron.
3C'1	**183-225**	light olive brown (2.5Y 5/3) loam (26% clay) with common (15%) medium prominent strong brown (7.5YR 4/6) and common (5%) medium prominent strong brown (7.5YR 5/8) and common (5%) fine to medium prominent dusky red (2.5YR 3/2) soft masses of iron and many (30%) medium to very coarse prominent gray (5Y 6/1) iron depletions; firm.
4C'2	**225-259**	light olive brown (2.5Y 5/3) fine sandy loam (10% clay) with common (10%) coarse prominent strong brown (7.5YR 4/6) and common (20%) very coarse prominent strong brown (7.5YR 5/8) soft masses of iron.
5C'3	**259-270+**	dark yellowish brown (10YR 4/4) fine sand with many (25%) very coarse prominent strong brown (7.5YR 4/6) soft masses of iron.

Tables 4-4 a-c: Pedon descriptions at the lower (a), middle (b), and upper (c) positions of the Eastern Neck Island research site (Eastern Neck Island National Wildlife Refuge, Kent County, MD).

Table 4-4a - Soil Description: Eastern Neck Island National Wildlife Refuge, Kent County, MD
Site Position: Lower Well
Date: November 28, 2001
Pit Depth: 0-170 cm
Auger Depth: 170 cm – 310 cm
Described by: Philip Zurheide, Martin C. Rabenhorst, Phillip King; John Wah, Steve Burch, and Suzy Park.

Horizon	Depth (cm)	Description
Oe	**3-2**	dark brown (7.5YR 3/2) mucky peat; abrupt smooth boundary.
A	**0-6**	very dark gray (10YR 3/1) silt loam (8% clay); moderate fine to medium granular structure; friable; common (10%) fine to medium roots; abrupt smooth boundary.
EA	**6-15**	brown (10YR 4/3) silt loam (10% clay) with few (1%) strong brown (7.5YR 4/6) soft masses; moderate very fine sub-angular blocky structure; friable; common (10%) fine to medium roots; clear wavy boundary.
BE	**15-32**	light yellowish brown (2.5Y 6/4) (40%) and (2.5Y 6/3) (25%) silt loam (13% clay) with common (5-10%) yellowish brown (10YR 5/8) and common (10%) dark yellowish brown (10YR 4/6) soft masses and many (25%) light yellowish brown (2.5Y 6/3) iron depletions; weak course sub-angular blocky structure; friable to firm (brittle); common (5%) fine roots; clear smooth boundary.
Bt1	**32-42**	pale brown (10YR 6/3) silt loam (19% clay) with common (5%) dark reddish brown (5YR 3/4) soft masses and many (30%) yellowish brown (10YR 5/6) iron depletions; weak course platy and moderate fine to medium sub-angular blocky structure; friable; common (5-10%) fine to medium roots; clear smooth boundary.
Bt2	**42-62**	yellowish brown (10YR 5/8) loam (22% clay) with many (25%) strong brown (7.5YR 5/6) and common (5%) dark reddish brown (5YR 3/4) soft masses and many (30%) pale brown (10YR 6/3) iron depletions; weak course platy and moderate fine to medium sub-angular blocky structure; friable; common (6%) fine to medium roots; clear smooth boundary.
2Bt	**62-77**	yellowish brown (10YR 5/6) very fine sandy loam/loam (19% clay) with many (25%) strong brown (7.5YR 5/6) soft masses and common (15%) light brownish gray (2.5Y 6/2) and many (25%) light yellowish brown (2.5Y 6/4) iron depletions; weak

		very coarse prismatic and moderate medium to course platy and moderate fine to medium sub-angular blocky structure; friable to firm (slightly brittle); few fine to medium roots; clear smooth boundary.
2BC1	**77-112**	yellowish brown (10YR 5/4) fine sandy loam (19% clay) with many (25%) strong brown (7.5YR 4/6) soft masses and common (10%) gray (2.5Y 6/1) iron depletions in areas of loamy fine sand and common (20%) light yellowish brown (2.5Y 6/4) mottles; weak to moderate very course prismatic and moderate to strong course platy structure; friable; very few fine roots; clear smooth boundary.
2BC2	**112-143**	light olive brown (2.5Y 5/6) fine sandy loam (16% clay) with common (20%) yellowish brown (10YR 5/6) soft masses and common (20%) yellowish brown (2.5Y 6/4) and common (10%) gray (2.5Y 6/1) iron depletions; strong very course sub-angular blocky structure; friable; gradual smooth boundary.
2BC3	**143-167**	yellowish brown (10YR 5/6) fine sandy loam (14% clay) with common (10%) strong brown (7.5YR 5/6) soft masses and many (25%) greenish gray (10Y 6/1) iron depletions; strong very course sub-angular blocky structure; friable; clear smooth boundary.
2BC4	**167-179**	light gray (2.5Y 7/1) fine sandy loam (7% clay) with common (10%) light yellowish brown (2.5YR 6/3) and common (20%) reddish yellow (7.5YR 6/8) soft masses.
2C1	**179-199**	light olive brown (2.5Y 5/3-4) fine sandy loam (12% clay) with common (20%) red (2.5YR 4/6) soft masses and common (5%) gray (2.5Y 6/1) iron depletions.
2C2	**199-215**	light gray (2.5Y 7/1) fine sandy loam (9% clay) with common (5%) yellowish brown (10YR 5/6) soft masses and many (40%) light yellowish brown (2.5Y 6/3) iron depletions.
2C3	**215-257**	light olive brown (2.5Y 5/3) very fine sandy loam (6% clay) with common (7%) strong brown (7.5YR 5/6) soft masses and common (5%) light gray (2.5Y 7/1) iron depletions.
2C4	**257-307**	light olive brown (2.5Y 5/4) very fine sandy loam (9% clay) with common (10%) strong brown (7.5 YR 5/6) soft masses.

Table 4-4b - Soil Description: Eastern Neck Island National Wildlife Refuge, Kent County, MD
Site Position: Middle Well
Date: November 28, 2001
Pit Depth: 0-150 cm
Auger Depth: 150 cm – 240 cm
Described by: Philip Zurheide, Martin C. Rabenhorst, Phillip King; John Wah, Steve Burch, and Suzy Park.

Horizon	Depth (cm)	Description
Oe	**3-0**	mucky peat; abrupt smooth boundary.
A	**0-9**	very dark gray (10YR 3/1) silt loam (8% clay); moderate fine to medium granular structure; very friable; clear wavy boundary; common fine to medium roots.
AE	**9-15**	brown (10YR 4/3) silt loam (10% clay); moderate fine to medium sub-angular blocky structure; very friable; clear wavy boundary; common fine to medium roots.
BE	**15-28**	light yellowish brown (2.5Y 6/4) silt loam (14% clay) with many (30%) yellowish brown (10YR 5/6) soft masses of iron; weak medium to coarse sub-angular blocky structure; friable; clear smooth boundary; common fine to medium roots.
Bt1	**28-45**	strong brown (7.5YR 5/6) silt loam (21% clay) with many (30%) yellowish brown (10YR 5/8) soft masses of iron and common (20%) light yellowish brown (2.5Y 6/4) and common (10%) light yellowish brown (2.5Y 6/3) iron depletions; moderate fine to medium sub-angular blocky structure; friable; clear smooth boundary; common fine to medium roots.
Bt2	**45-69**	light brown (7.5YR 6/4) (30%) and yellowish brown (10YR 5/6) (30%) loam (18% clay) with many (25%) strong brown (7.5YR 5/8) soft masses of iron and common (5%) brown (10YR 5/3) and common (10%) light gray (2.5Y 7/2) iron depletions; moderate medium to coarse sub-angular blocky structure; friable gradual smooth boundary; common medium roots.
2Bt3	**69-92**	yellowish brown (10YR 5/6) fine sandy loam (15% clay) with common (5%) yellowish red (5YR 4/6) and many (25%) strong brown (7.5YR 5/8) and many (30%) light yellowish brown (2.5Y 6/4) soft masses of iron and light brownish gray (2.5Y 6/2) and light brownish gray (10YR 6/2) iron depletions; moderate coarse sub-angular blocky with some weak medium to coarse prismatic structure; friable to firm; slightly brittle; clear smooth boundary; common fine to medium roots.

2BC1	**92-137**	gray (10YR 5/1) fine sandy loam (13% clay) with common (15%) yellowish brown (10YR 5/8) soft masses of iron and common (15%) light yellowish brown (2.5Y 6/3) occurring in loamy sand textures and common (20%) light gray (2.5Y 7/2) and common (5%) greenish gray (5GY 6/1) occurring in heavy sandy loam textures as iron depletions; weak medium to very coarse prismatic parting to moderate medium to coarse platy structure; friable; clear smoother boundary.
2BC2	**137-157**	light yellowish brown (2.5Y 6/4) sandy clay loam (23% clay) with common (10%) yellowish brown (10YR 5/8) soft masses of iron and many (30%) gray (10YR 6/1) iron depletions.
2C1	**157-192**	light yellowish brown (2.5Y 6/4) very fine sandy loam (14% clay) with many (40%) yellowish (10YR 5/6) soft masses of iron and common (10%) light gray (2.5Y 7/1) iron depletions.
2C2	**192-237**	light yellowish brown (2.5Y 6/3) very fine sandy loam with common (5%) strong brown (7.5YR 5/8) soft masses of iron.

Table 4-4c - Soil Description: Eastern Neck Island National Wildlife Refuge, Kent County, MD
Site Position: Upper Well
Date: August 22, 2002
Pit Depth: 0-155 cm
Described by: Philip Zurheide, John Wah, and Robert Vaughan.

Horizon	Depth (cm)	Description
A	**0-6**	dark brown (10YR 3/3) loam/silt loam (9% clay); weak fine granular structure; very friable; clear smooth boundary.
AE	**6-14**	dark yellowish brown (10YR 4/4) silt loam/loam (11% clay); weak fine sub-angular blocky structure; very friable; clear wavy boundary.
EB	**14-38**	light yellowish brown (2.5Y 6/4) silt loam (12% clay) with few (1%) fine faint strong brown (7.5 YR 5/6) pore linings of iron and common (5%) medium distinct yellowish brown (10YR 5/6) soft masses; moderate medium sub-angular blocky structure; friable; clear smooth boundary.
Bt1	**38-56**	olive yellow (2.5Y 6/6) loam-silt loam (14% clay) with common (8%) medium distinct yellowish brown (10YR 5/8) soft masses and many (25%) medium to coarse faint light yellowish brown (2.5Y 6/4) iron depletions; moderate medium sub-angular blocky structure; friable; clear smooth boundary.
Bt2	**56-69**	yellowish brown (10YR 5/8) loam-fine sandy loam (12% clay) with many (25%) medium distinct strong brown (7.5YR 5/6) soft masses and many (25%) medium prominent light brownish gray (2.5Y 6/2) iron depletions; weak coarse prismatic parting to moderate medium sub-angular blocky structure; friable; clear smooth boundary.
BCt	**69-90**	yellowish brown (10YR 5/6) fine sandy loam (8% clay) with common (10%) medium faint yellowish brown (10YR 5/8) soft masses and light yellowish brown (2.5Y 6/4) and light yellowish gray (2.5Y 6/2) iron depletion as 1-inch diameter root channel through horizon; weak coarse prismatic parting to moderate medium platy structure; friable; abrupt smooth boundary.
2Bt	**90-104**	light yellowish brown (2.5Y 6/4) clay loam (33% clay) with many (25%) medium prominent strong brown (7.5YR 5/8) soft masses and common (19%) medium prominent gray (2.5Y 6/1) iron depletions; weak coarse prismatic parting to weak to moderate medium sub-angular blocky structure; friable; clear smooth boundary.
2BC1	**104-**	olive yellow (2.5Y 6/6) fine sandy loam (8% clay) with common (8%) medium distinct yellowish brown (10YR 5/8) and few

	121	(1%) fine prominent strong brown (7.5YR 4/6) pore linings of iron and common (8%) coarse prominent light olive gray (5Y 6/2) iron depletions; weak coarse prismatic parting to moderate medium sub-angular blocky structure; friable clear smooth boundary.
2BC2	**121-155**	light olive brown (2.5Y 5/4) sandy loam (8% clay) with many (40%) coarse to very coarse gray (5Y 6/1) iron depletions as discontinuous lenses to 3 inches thick and common (10%) medium distinct yellowish brown (10YR 5/6) soft masses around depleted lenses as noted above; weak medium sub-angular blocky and weak medium platy structure; friable.

Tables 4-5 a-c: Pedon descriptions at the lower (a), middle (b), and upper (c) positions of the Ted Harvey research site (Ted Harvey Wildlife Area, Kent County, DE).

Table 4-5a - Soil Description: Ted Harvey Wildlife Area, Kent County, DE
Site Position: Lower Well
Date: July 24, 2002
Pit Depth: 0-170 cm
***Auger Depth:** 170 cm – 332+ cm
Described by: Philip Zurheide, Martin C. Rabenhorst; Steve Burch, Karen Castenson and Robert Vaughan.

Horizon	Depth (cm)	Description
A1	**0-7**	black (7.5YR 2.5/1) mucky silt loam (12% clay) with common (3%) fine distinct dark reddish brown (5YR 3/3) pore linings of iron; weak fine granular structure; very friable; clear smooth boundary.
A2	**7-14**	black (7.5YR 2/2) silt loam (13% clay) with common (10%) fine to medium distinct dark reddish brown (5YR 3/3) pore linings of iron; moderate medium granular structure; very friable; clear smooth boundary.
AE	**14-26**	dark olive brown (2.5Y 3/3) lilt loam (14% clay) with common (15%) fine to very fine dark brown (7.5YR 3/4) pore linings of iron; moderate medium sub-angular blocky parting to moderate medium granular structure; friable; clear smooth boundary.
EB	**26-39**	light yellowish brown (2.5Y 6/3) silt loam to loam (14% clay) with many (35%) coarse to very coarse faint yellowish brown (10YR 5/4) soft masses of iron and common (8%) fine distinct dark brown (7.5YR 3/4) pore linings of iron; weak medium sub-angular blocky structure; friable clear smooth boundary.
Bt	**39-63**	yellowish brown (10YR 5/6) loam (24% clay) with common (15%) medium to coarse distinct strong brown (7.5YR 5/8) soft masses of iron and common (4%) fine to medium distinct dark brown (7.5YR 3/4) pore linings of iron and common (15%) medium to coarse distinct light olive brown (2.5Y 5/3) iron depletions (around root channels); moderate medium to coarse sub-angular blocky structure; friable; abrupt smooth boundary. NOTE: 15% crotovinas consisting of A material and decaying roots in areas ranging from 2-5cm.
2BC1	**63-85**	yellowish brown (10YR 5/8) sandy loam (12% clay) with many (25%) medium strong brown (7.5YR 5/8) soft masses of iron and common (5%) brown (7.5YR 4/4) as clay films and common (15%) medium to coarse distinct light olive brown (2.5Y 5/3) iron depletions (around root channels) and many (30%) coarse to very coarse 2.5Y 5/8 iron depletions; weak

		coarse platy and weak medium sub-angular blocky structure; friable and very friable; abrupt wavy boundary.
3BC2	**85-124**	light olive brown (2.5Y 5/4) silt loam (13% clay) with many (25%) coarse to very coarse prominent strong brown (7.5YR 5/8) soft masses of iron around depletions and common (15%) coarse to very coarse distinct gray (5Y 6/1) iron depletions (on ped faces); moderate coarse to very coarse prismatic parting to moderate medium to coarse platy structure; firm; clear wavy boundary.
3BCg	**124-170**	light olive brown (2.5Y 5/4) silt loam (16% clay) with many (25%) coarse to very coarse prominent strong brown (7.5YR 5/8) soft masses of iron and many (30%) very coarse gray (5Y 6/1) iron depletions (along prism faces); moderate medium to coarse prismatic parting to moderate coarse sub-angular blocky structure; firm.
*****	**170-235**	dark grayish brown (10YR 4/2) clay with common (20%) fine prominent dark yellowish brown (10YR 4/6) and strong brown (7.5 YR 5/8) soft masses of iron. NOTE: 230-235cm; dark reddish brown (5YR 3/4).
*****	**235-280**	very dark gray (7.5YR 3/1) clay with common (10%) very coarse distinct strong brown (7.5YR 4/6) soft masses of iron and grayish brown (2.5Y 5/2) iron depletions.
*****	**280-310**	gray (2.5Y 6/1) clay with common (5%) fine prominent strong brown (7.5YR 4/6) soft masses of iron.
*****	**310-335+**	gray (5Y 6/1) clay with many (25%) fine to medium prominent strong brown (7.5YR 4/6) and common (5%) fine to medium prominent strong brown (7.5YR 5/8) soft masses of iron.

Table 4-5b - Soil Description: Ted Harvey Wildlife Area, Kent County, DE
Site Position: Middle Well
Date: July 24, 2002
Pit Depth: 0-148 cm
Described by: Philip Zurheide, Martin C. Rabenhorst; Steve Burch, Karen Castenson and Robert Vaughan.

Horizon	Depth (cm)	Description
A	**0-14**	very dark brown (10YR 2/2) silt loam to loam (14% clay); moderate medium granular structure; very friable; clear smooth boundary.
AE	**14-26**	brown (10YR 4/3) loam to silt loam (14% clay) with common (3%) fine distinct strong brown (7.5YR 4/6) pore linings of iron; weak medium sub-angular blocky structure; very friable; clear wavy boundary. NOTE: 15% crotovinas consisting of A material throughout.
BE	**26-40**	light olive brown (2.5Y 5/4) loam (16% clay) with common fine distinct strong brown (7.5YR 4/6) pore linings of iron and common (5%) medium to coarse faint light olive brown (2.5Y 5/3) iron depletions; weak coarse sub-angular blocky structure; friable; clear smooth boundary. NOTE: 8% crotovinas consisting of A material throughout
Bt1	**40-68**	yellowish brown (10YR 5/6) loam (21% clay) with common (10%) medium to coarse distinct strong brown (7.5YR 5/8) soft masses of iron and common (3%) fine to medium distinct yellowish red (5YR 4/6) pore linings of iron and common (15%) medium to coarse distinct light olive brown (2.5Y 5/3) iron depletions (on ped faces); moderate medium to coarse sub-angular blocky structure; friable; gradual wavy boundary.
Bt2	**68-94**	yellowish brown (10YR 5/6) (25%) and (10YR 5/8) (25%) loam (19% clay) with common (5%) medium to very coarse distinct yellowish red (5YR 4/6) and common (15%) medium to very coarse distinct strong brown (7.5YR 4/6) soft masses of iron and many (30%) coarse to very coarse prominent light brownish gray (2.5Y 6/2) iron depletions; moderate medium to coarse sub-angular blocky structure; friable; abrupt smooth boundary.
2BC1	**94-118**	yellowish brown (10YR 4/5) sandy loam (11% clay) with common (5%) medium to coarse distinct strong brown (7.5YR 4/6) and common (5%) medium to coarse distinct strong brown (7.5YR 5/6) soft masses of iron and many (25%) coarse to very coarse prominent gray (2.5Y 6/1) iron depletions; weak coarse sub-angular blocky structure; friable; abrupt wavy boundary.

3BC2	**118-130**	light olive brown (2.5Y 5/4) silt loam (23% clay) with many (25%) medium to coarse distinct strong brown (7.5YR 4/6) soft masses and pore linings of iron and many (35%) coarse to very coarse prominent gray (5Y 6/1) iron depletions; moderate medium sub-angular blocky structure; firm; abrupt wavy boundary.
4BC3	**130-148+**	dark yellowish brown (10YR 4/6) loamy sand (5% clay) with common (5%) medium to coarse distinct strong brown (7.5YR 4/6) soft masses of iron and common (15%) coarse to very coarse prominent light brownish gray (2.5Y 6/2) iron depletions; weak coarse sub-angular blocky structure; friable to very friable.

Table 4-5c - Soil Description: Ted Harvey Wildlife Area, Kent County, DE
Site Position: Upper Well
Date: July 24, 2002
Coordinates: N 39° 05’ 16.13”   W 75° 24’ 23.13”
Pit Depth: 0-142 cm
Described by: Philip Zurheide, Martin C. Rabenhorst; Steve Burch, Karen Castenson and Robert Vaughan.

Horizon	Depth (cm)	Description
A	**0-9**	very dark grayish brown (10YR 3/2) silt loam (11% clay); moderate medium granular structure; friable; clear smooth boundary.
AE	**9-20**	brown (10YR 4/3) silt loam (13% clay) with common (10%) fine to medium faint dark brown (7.5YR 3/4) soft masses of iron; weak medium sub-angular blocky structure; friable; clear wavy boundary.
EB	**20-33**	light olive brown (2.5Y 5/4) silt loam (16% clay) with few (1%) medium faint dark yellowish brown (10YR 4/4) pore linings of iron and common (5%) medium faint light olive brown (2.5Y 5/3) iron depletions; weak medium to coarse platy parting to weak medium to coarse sub-angular blocky structure; friable; clear smooth boundary. NOTE: 5% inclusions of A-material as crotovinas.
Bt1	**33-53**	yellowish brown (10YR 5/6) silt loam (22% clay) with common (3%) fine distinct strong brown (7.5YR 4/6) soft masses of iron and common (15%) medium to very coarse prominent dark yellowish brown (10YR 3/4) pore linings of iron and common (8%) medium prominent light brownish gray (2.5Y 6/2) iron depletions along root channels; moderate medium to coarse prismatic parting to moderate medium to coarse sub-angular blocky structure; friable; clear smooth boundary.
Bt2	**52-68**	yellowish brown (10YR 5/6) silt loam (21% clay) with common (10%) medium to coarse prominent dark yellowish brown (10YR 3/4) pore linings of iron and common (10%) medium to coarse distinct strong brown (7.5YR 5/6) soft masses of iron and many (25%) medium prominent light brownish gray (2.5Y 6/2) iron depletions along root channels and ped faces; moderate medium to coarse sub-angular blocky structure; friable; clear wavy boundary.
2Bt3	**68-83**	yellowish brown (10YR 5/6) fine sandy loam (14% clay) with common (20%) medium to coarse distinct strong brown (7.5YR 5/6) and common (20%) medium to coarse distinct yellowish brown (10YR 5/4) soft masses of iron and common (15%) medium to very coarse distinct light yellowish brown (2.5Y 6/3) and common (5%) medium to very coarse prominent light yellowish gray (2.5Y 6/2) iron depletions; moderate medium sub-angular blocky structure; friable; abrupt smooth

		boundary.
2BC1	**83-105**	strong brown (7.5YR 5/6) (20%) and yellowish brown (10YR 5/6) (40%) sandy loam to loamy sand (8% clay) with faint medium to coarse strong brown (7.5YR 4/6) soft masses of iron and common (5%) distinct pale brown (10YR 6/3) and common (5%) distinct light olive brown (2.5Y 5/3) iron depletions; weak very coarse platy parting to weak coarse sub-angular blocky structure; friable; clear wavy boundary.
2BC2	**105-125**	light olive brown (2.5Y 5/6) sandy loam (15% clay) with common (10%) medium to coarse strong brown (7.5YR 4/6) soft masses of iron and common (5%) coarse to very coarse prominent gray (2.5Y 6/1) and common (10%) coarse to very coarse faint light olive brown (2.5Y 5/4) iron depletions; weak medium to coarse sub-angular blocky structure; friable; abrupt wavy boundary. NOTE: horizon extends down on right side.
3BC3	**125-142**	light olive brown (2.5Y 5/4) silty clay loam (28% clay) with common (15%) medium to coarse distinct yellowish brown (10YR 5/6) iron concentrations and many (25%) coarse to very coarse distinct gray (2.5Y 5/1) iron depletions; moderate medium sub-angular blocky structure; firm. NOTE: representative material more on left side of pit.

Surface Horizons

The degree of development of organic surface horizons (O-horizons) was influenced by how long the soil experienced saturation. The Blackwater site was the wettest of all sites and had highly developed organic horizons at all three site positions. Organic horizon thickness increased from 5 cm (upper position) to 14 cm (lower position).

The Ted Harvey site was considered the driest of all four sites where water tables remained below the soil surface for nearly the entire year. Here, no organic horizons were described. Organic matter accumulation in soil surface horizons as O-horizons, was directly related to the degree that these soils experienced water tables to the surface; as the frequency and duration of saturation events increased, so did the amount of organic matter in these horizons. Figure 4-4 illustrates this relationship between the thickness of O-horizons in ABLS soils and their cumulative length of saturation at the mineral soil surface.

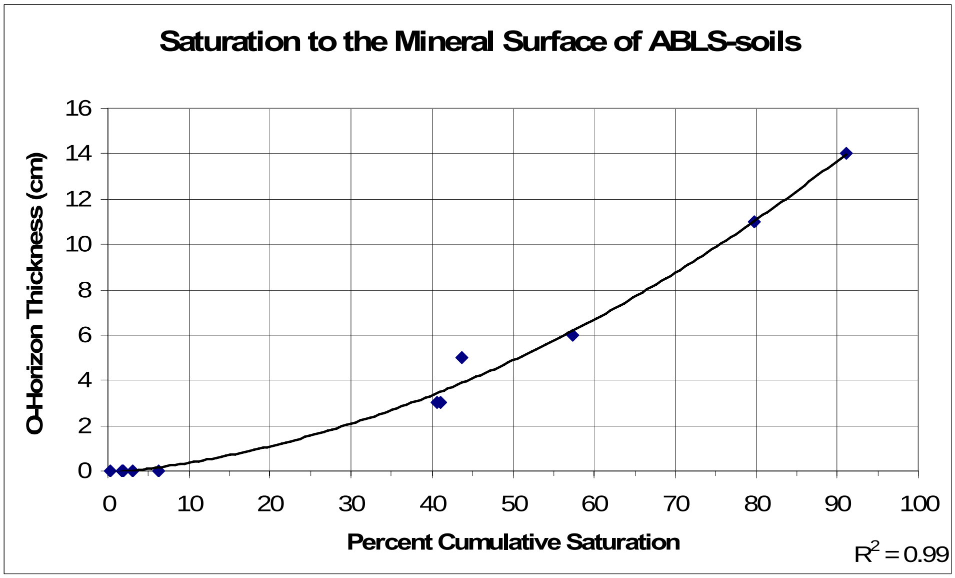


Figure 4-4: O-horizon thickness of twelve ABLS pedons as a function of the length of time the soil experienced saturation to the mineral surface.

Iron Concentrations

No distinct or prominent redoximorphic features were described in horizons that were saturated for less than 22% of the year. Distinct and prominent redoximorphic iron concentrations were observed in ABLS-soils (excluding horizons that had redox depletions of chroma ≤ 2) when the duration of saturation ranged between 22-82%, with an average of 54%. The abundance of these features was positively related to the length of time the soil was saturated (Fig. 4-5) and increased to an average maximum of approximately 17% when the soils were saturated for approximately 64% of the time.

These data were compared with data from several other studies that also related the duration of saturation to the development of distinct and prominent Fe-concentrations without depletions of chroma ≤ 2 (Fig. 4-6). In these other studies, soils containing horizons with distinct and prominent concentrations (without 2-chroma depletions), the average time that these horizons were saturated ranged between 2% and 44%. In contrast, in ABLS-soils, the average length of saturation for horizons with concentrations (without low-chroma depletions) was 56%.

An Analysis of Variance (ANOVA) was run on these data to determine whether or not the differences observed between ABLS-soils and other studies were significant; these results are shown in figure 4-7. Results tended to segregate into two groups; the studies by Jacobs et al. (2002), Morgan and Stolt (2006), Galusky (1997), and West et al. (1998) generally reported results rather similar to one another. The second group included the results of the Castenson (2004) study and the ABLS-soils study, which were not significantly different from one another, but were significantly different from the results of the other studies in that they required significantly longer saturation periods to exhibit redox concentrations.

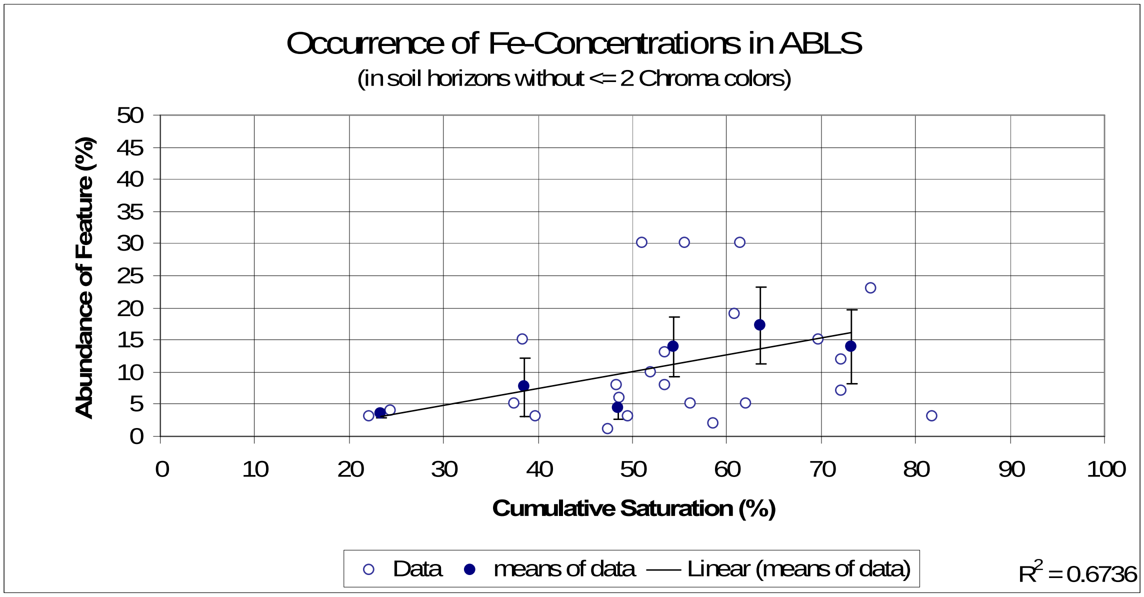


Figure 4-5: Abundance of iron concentrations in ABLS-soils (without depletions ≤ 2 chroma) increases with increasing saturation. Solid dots show means of 10% cumulative saturation increments and bars show SE of the means.

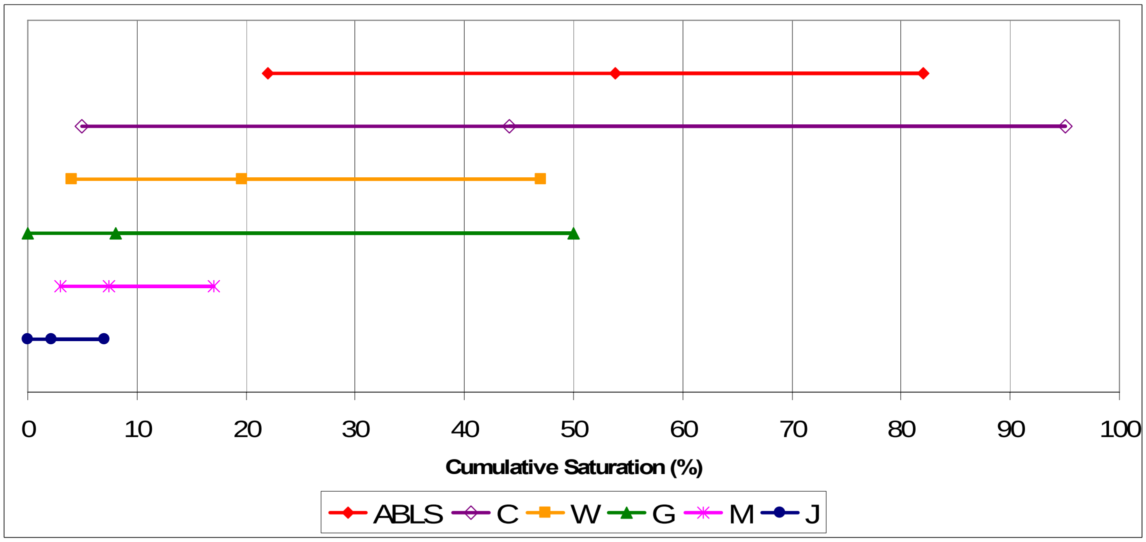


Figure 4-6: Means (center points) and ranges (end points) of cumulative saturation data of soil horizons with iron concentrations, but without chroma ≤ 2 depletions, for the ABLS-soils and for soils reported in other studies. ABLS=this study, C=Castenson, 2004 (PFP-study); G=Galusky, 1997; J=Jacobs et al., 2002; M=Morgan and Stolt, 2006; W=West et al., 1998.

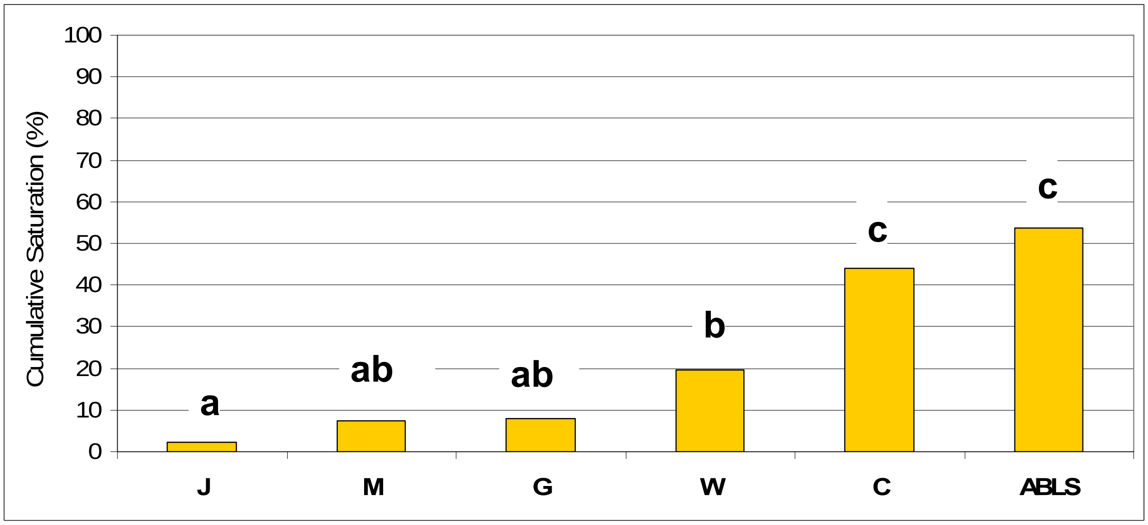


Figure 4-7: Results from Analysis of Variance (ANOVA) showing differences between studies that are significant. Values are for soil horizons with Fe-concentrations (without chroma ≤ 2 depletions). Values identified with the same letter are not significantly different from one another (p=0.05). ABLS=this study, C=Castenson, 2004 (PFP-study); G=Galusky, 1997; J=Jacobs et al., 2002; M=Morgan and Stolt, 2006; W=West et al., 1998.

Depletions

When the duration of saturation and reduction is increased, the mobilization and segregation of Fe-oxides may then become sufficient to produce low-chroma depletions (Vepraskas and Sprecher, 1997). Figure 4-8 illustrates the relationship between the cumulative percent saturation and the development of Fe-depletions in ABLS-soils. No Fe-depletions were observed when cumulative saturation was less than 41% of the year. As the percentage of saturation increased between 41% and 100%, there was a general increase in percentage of ≤2 chroma depletions, with the mean percentage of the abundance of depletions increasing from 6% (when saturated 40-50% of the time) to 43% (when saturated 90-100% of the time). ABLS-horizons that were saturated for greater than 80% of the time fell out generally into two different groups. One group (n=17) had brown matrix colors with common to many depletions of ≤ 2 chroma. A smaller group (n=8) had depleted matrices with 50% to 80% chroma ≤ 2. Figure 4-9 shows the means and ranges of cumulative percentage of saturation in soil horizons showing depletions with chroma ≤ 2 for similar projects in other pedological settings. In three out of four of the projects (Galusky et al., 1998; Jacobs et al., 2002; Morgan and Stolt, 2006), Fe-depletions were present when the mean cumulative percentage of saturation was approximately 20%. The study by West et al. (1998) showed Fe-depletions in horizons that were saturated between 10% and 62% of the time (mean saturation of 42%). Work by Castenson (2004), focusing on problematic soils of the Mid-Atlantic Piedmont floodplains, showed that these soils required a greater length of saturation to develop depletions of chroma ≤ 2. The average percentage of saturation for PFP-soils showing common Fe-depletions was 71% (range 26-95%). An analysis of variance (ANOVA) was run on these data to determine whether or not differences between ABLS-soils and other soils were significant. Figure 4-10 shows that the studies by Jacobs (2002), Morgan and Stolt (2006), and Galusky (1997), and West (1998) were all relatively similar to one another. The results of the problematic PFP-soils (Castenson, 2004) and the ABLS-soils were similar to one another but different from the other studies requiring significantly longer saturation to show comparable expression of redox depletions.

For the ABLS-soils, the mean percent saturation for horizons with a depleted matrix was 96% with a range of 82-100%. Most of the studies indicate soils showing a depleted matrix have a mean cumulative saturation percentage that ranged from 40% to 60% (Fig. 4-11). Only the study by Castenson, which focused on problematic soils of

Piedmont floodplains, showed significantly higher cumulative saturation percentages for horizons with depleted matrices, with a means of 93% saturation (range of 40-100%).

An Analysis of Variance (ANOVA) was run on these data to determine whether or not the differences observed between ABLS-soils and other studies were significant. Figures 4-12 shows how results tended to segregate into two groups. The first group (Jacobs, 2002, Morgan and Stolt, 2006, Galusky, 1997, West, 1998) had results that were generally similar to one another. The second group included the PFP-study (Castenson, 2004) and the ABLS-study, which were similar to one another but statistically different from the other studies, requiring significantly longer saturation to show a depleted matrix.

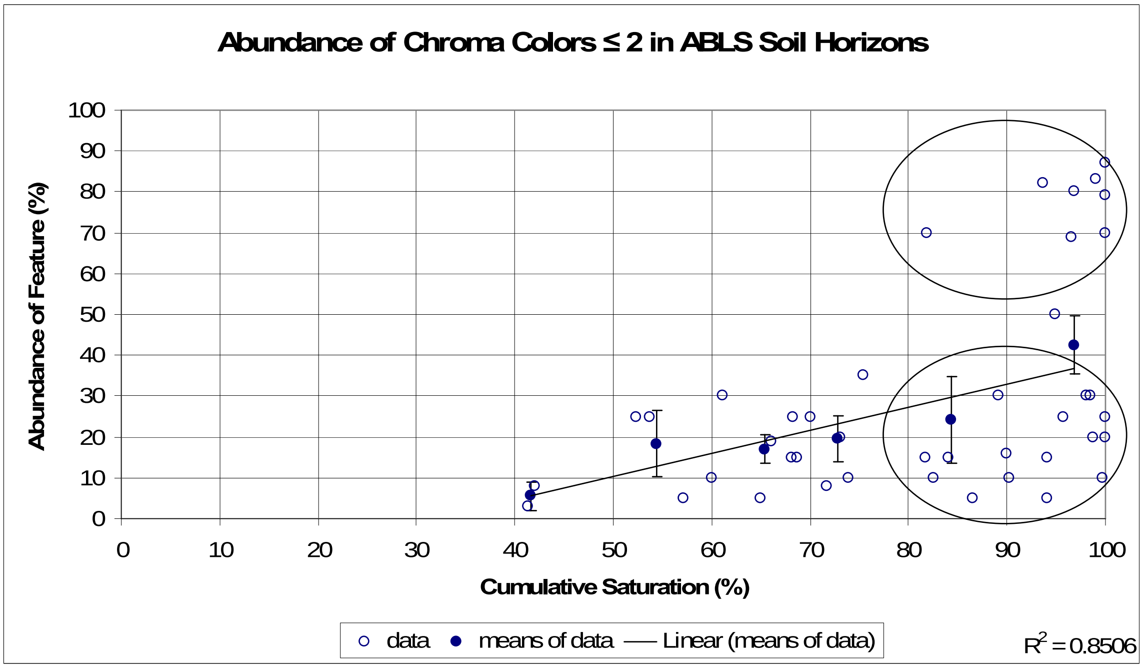


Figure 4-8: Data showing abundance of depletions (≤ 2 chroma) in ABLS-soils as a function of percentage of time the horizon was saturated. Open circles represent data from individual soil horizons, while solid circles represent means for horizons falling within a ten percentage point range for cumulative saturation ranges (40-50, 50-60, 60-70, 70-80, 80-90, and 90-100). When cumulative saturation was > 80%, soil horizons fell out into two groups;

one with a depletion abundance of approximately 20% (lower circle) and the other group with an abundance of approximately 80% (upper circle).

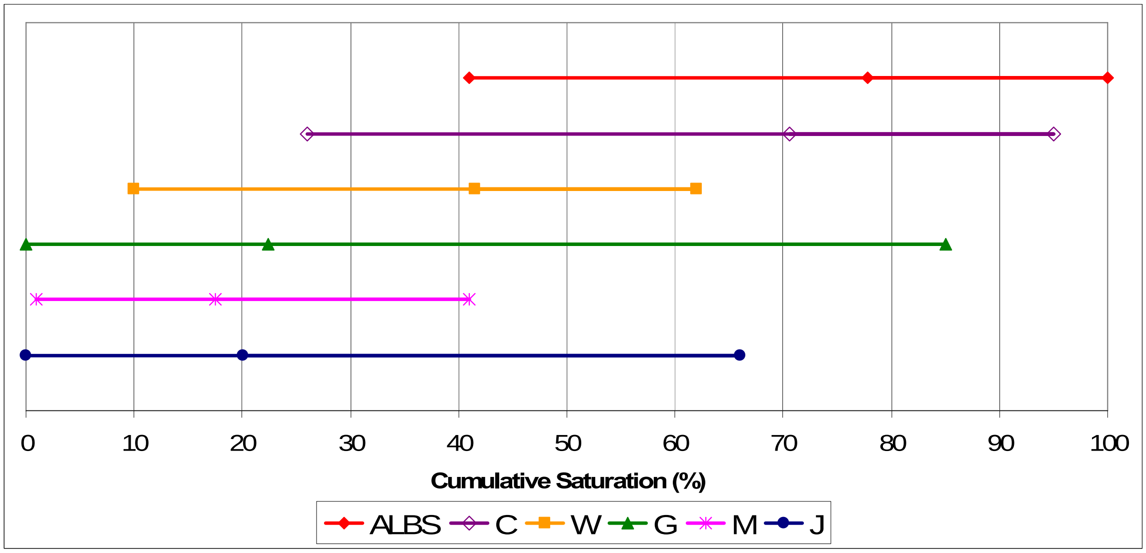


Figure 4-9: Means and ranges of cumulative percent saturation in horizons containing depletions of chroma ≤ 2 (but not a depleted matrix) from this (ABLS) study and other published studies. ABLS=this study, C=Castenson, 2004 (PFP-study); G=Galusky, 1997; J=Jacobs et al., 2002; M=Morgan and Stolt, 2006; W=West et al., 1998.

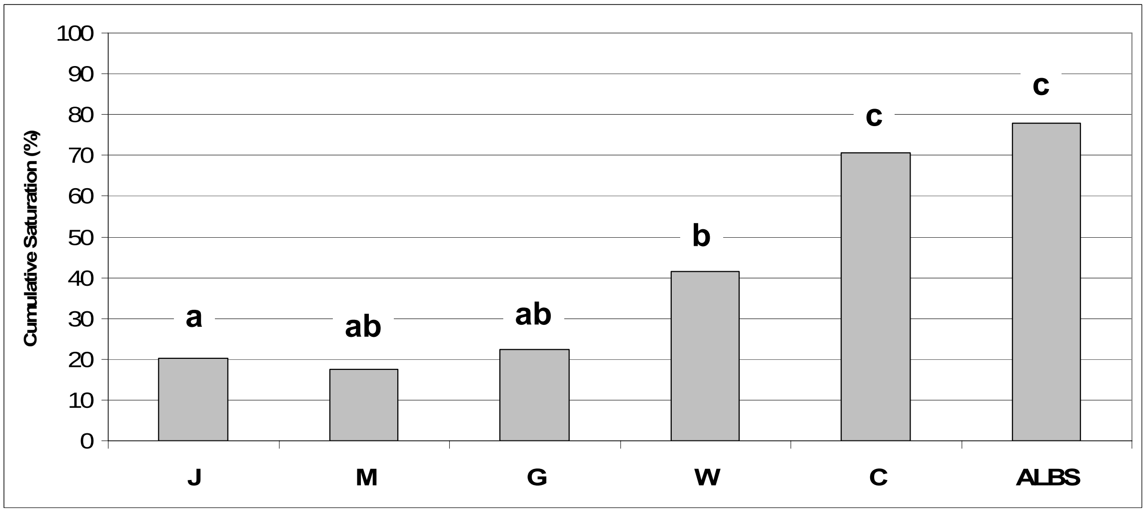


Figure 4-10: Mean cumulative saturation percentage for horizons containing depletions of chroma ≤ 2 (but not a depleted matrix) for this (ABLS) study an other published studies. Bars identified with the same letter are not significantly different from each other (p=0.05). ABLS=this study, C=Castenson, 2004 (PFP-study); G=Galusky, 1997; J=Jacobs et al., 2002; M=Morgan and Stolt, 2006; W=West et al., 1998.

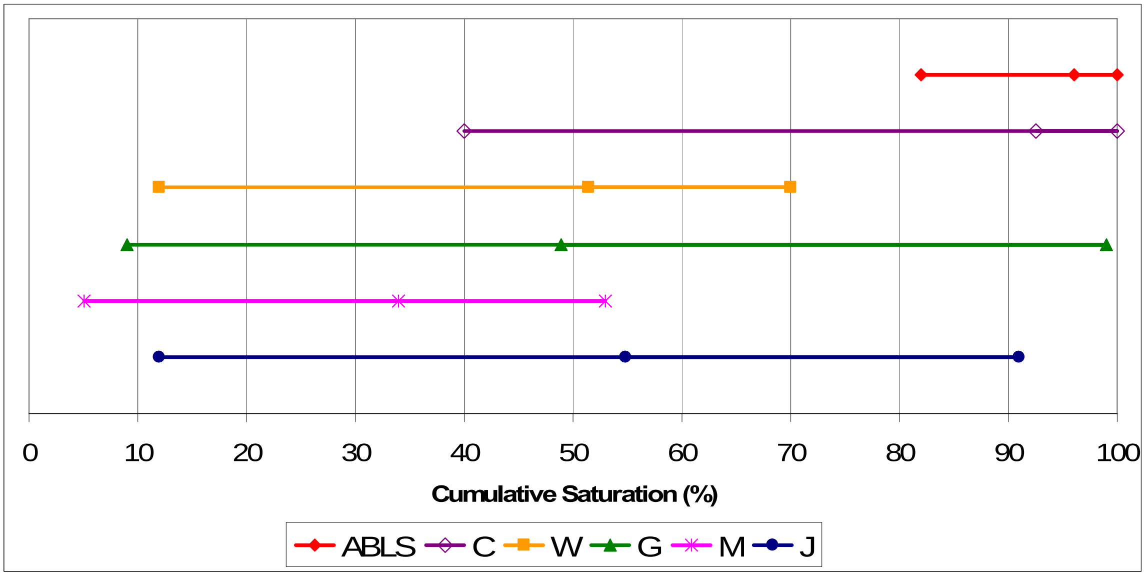


Figure 4-11: Means (center points) and ranges (end points) of cumulative saturation percentages for soil horizons in this (ABLS) study and in other similar studies that have a depleted matrix. ABLS=this study, C=Castenson, 2004 (PFP-study); G=Galusky, 1997; J=Jacobs et al., 2002; M=Morgan and Stolt, 2006; W=West et al., 1998.

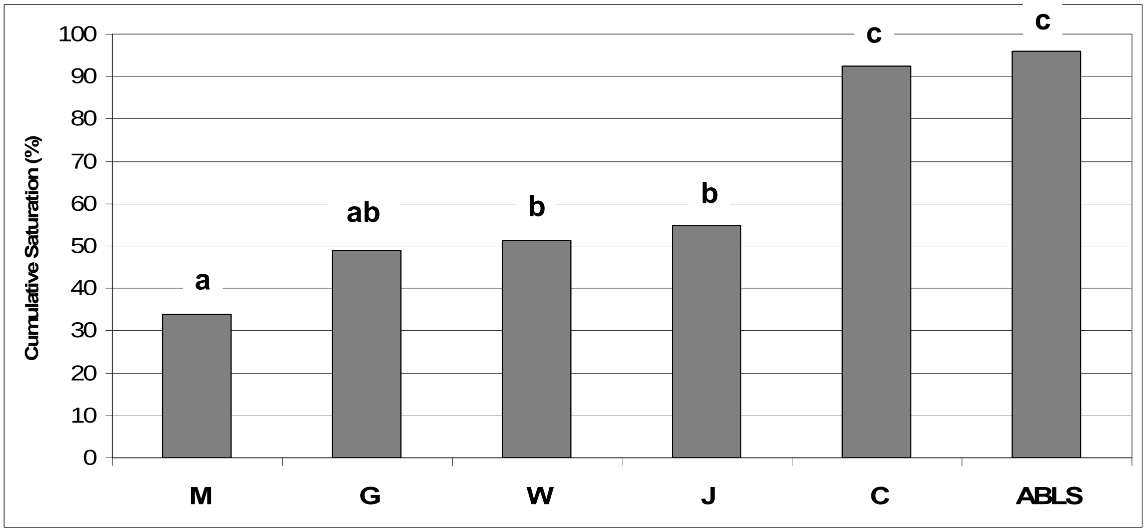


Figure 4-12: Mean cumulative saturation of horizons with a depleted matrix in this (ABLS) study and in other published studies. Bars identified with the same letter are not significantly different from each other (p=0.05). ABLS=this study, C=Castenson, 2004 (PFP-study); G=Galusky, 1997; J=Jacobs et al., 2002; M=Morgan and Stolt, 2006; W=West et al., 1998.

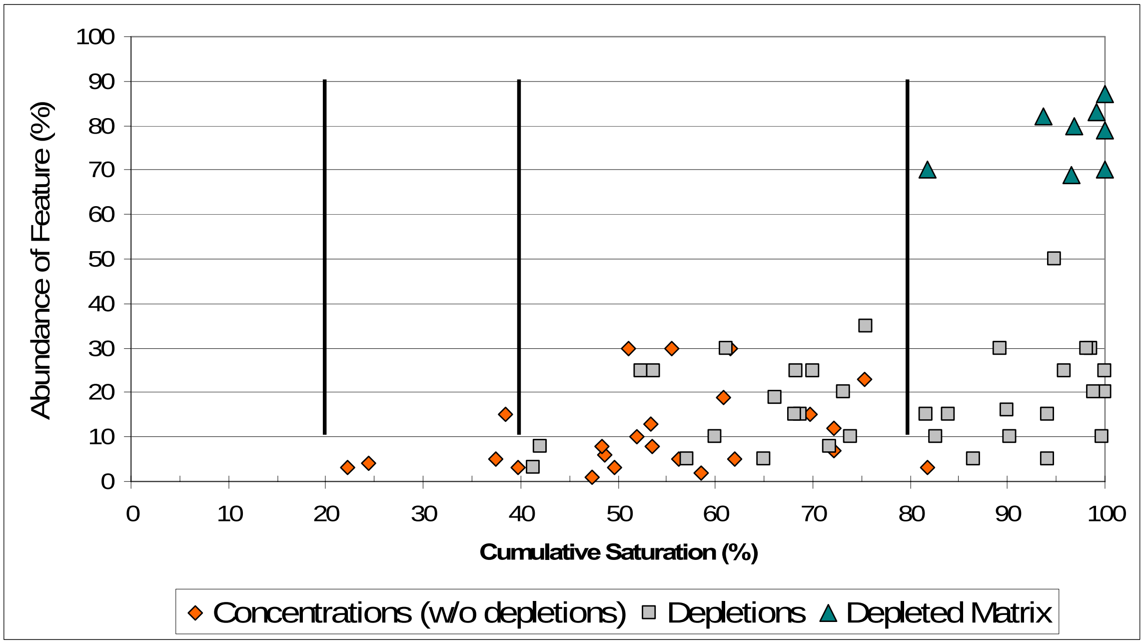


Figure 4-13: Cumulative saturation of ABLS-horizons showing various types of redoximorphic features. Black, vertical bars indicate approximate percent saturation where a transition of redox feature-expression in the soil occurs.

To summarize, horizons in ABLS-soils that were saturated for less than 20% of the time showed no distinct or prominent redoximorphic features of any kind. Horizons that were saturated for between 20% and 40% of the time contained only distinct or prominent concentrations, but no depletions. Horizons that were saturated for between 40% and 80% of the time may contain either concentrations (without depletions) or both concentrations and depletions. Horizons that were saturated for greater than 80% of the time would likely have depletions or a depleted matrix (usually with concentrations) (Fig. 4-13).

From a predictive standpoint (predicting saturation from redoximorphic features), the morphological data are less specific. If no concentrations or depletions were observed, then one would expect that the ABLS-soil was saturated for less than 20% of the year (or approximately ten weeks). If concentrations were observed without depletions, one would expect that the cumulative saturation percentages ranged from somewhere between 20 and 80%. If depletions were observed, but not a depleted matrix, one would then expect the soil to be saturated for between 40 and 100% of the time. If a depleted matrix was observed, one would expect the soil to be saturated for between 80 and 100% of the time.

CONCLUSIONS

Anomalous Bright Loamy Soils (ABLS) of the Mid-Atlantic coastal plain require significantly longer saturation times to develop hydromorphological redox features when compared to those observed in most other soils. Distinct or prominent iron concentrations are present only in ABLS-soils that are saturated for a minimum of approximately 20% of the time, and on average are saturated for of 54% of the year. Other studies report iron concentrations being formed when mean saturation ranged between 2% and 25%. ABLS-soils that are saturated for a minimum of 42% of the year, and on average are saturated for 78% of the year, contain redox depletions with chroma ≤ 2. In most other soils with depletions of chroma ≤ 2, mean saturation ranged from 18% to 40%. Depleted matrices in ABLS-soils are only present when the percentage of time saturated exceeded 80% and averaged 96%, while in other soils, mean saturation periods ranged from 42% to 57%. Only the problematic soils of piedmont floodplains (Castenson, 2004) showed a similar saturation period for comparable redoximorphic features. Generally speaking, soils lower on the transect showed indications of wetter conditions through greater accumulations of organic matter at the surface and a higher occurrence of lower-chroma iron depletions or depleted matrices compared to soils higher on the transect. A significant correlation was also observed between the length of time that the water table was present at or above the mineral soil surface, and the thickness of accumulated organic horizons. Field technicians identifying and delineating hydric soils should seek to recognize ABLS-soils in appropriate, near-coastal settings. Failure to do so could lead to inaccurate soil and land use evaluations when relying upon more traditional interpretations of hydrology based on soil redoximorphic features.

5) The ABLS Phenomenon

INTRODUCTION

When soils are saturated continually for an extended period, they can become reducing and undergo biogeochemical transformations (Ponnamperuma, 1972; Vepraskas, 1992; National Research Council, 1995; Mitsch and Gosselink, 2000). For this to happen, soil temperatures must be warm enough to sustain actively respiring microbes. After aerobic microbes have depleted dissolved oxygen, anaerobic soil microorganisms continue to oxidize available organic matter resulting in a reduced soil environment. Soil mineral species in their oxidized state, such as Fe (III) and Mn (IV), act as soil pigmenting agents. In soils that remain anaerobic for long periods of time, ferric iron (Fe^{3+}) can be reduced to ferrous iron (Fe^{2+}) (Collins and Buol, 1970). This reduced form of iron is colorless and highly mobile in the soil, and can be transported in solution by local hydraulic gradients (Vepraskas, 2001). Seasonal cycles of alternating oxidizing and reducing conditions create color patterns in the soil known as redoximorphic (redox) features. These features are areas where colors are either stronger (redder or browner) where iron is more concentrated (Fe-concentrations) or weaker (more faded) where iron is less concentrated (Fe-depletions), relative to the surrounding soil matrix color. To a certain degree, the longer a soil remains saturated and reduced, the greater will be the abundance of these redox features (Franzmeier et al., 1983; Hseu and Chen, 1996; Simonson and Boersma, 1972). If saturation and reduction continue for more extended periods, eventually the iron oxides that pigment the soil are reduced, solubilized, and removed, revealing the gray colors of the soil's uncoated mineral grains.

A gray-colored soil matrix is a common indicator that the soil has formed under especially wet or poorly drained conditions.

Some soils on the Mid-Atlantic coastal plain have been recognized as "problematic" in the sense that these soils have developed under conditions of extended seasonal saturation, but they do not express a morphology that normally would be interpreted as representing wet conditions. Because of this phenomenon, and because they are loamy rather than sandy in texture, they have been termed Anomalous Bright Loamy Soils (ABLS). These problematic soils are commonly found adjacent to estuarine marshes or waters, and have mostly been observed to occur within one meter of mean sea level. Landforms on which they occur are linear or slightly (subtly) convex. The morphology of these poorly drained, hydric soils more closely resembles that of moderately well-drained soils, which complicates wetland delineations and land-use evaluations under current practices. Having recognized that these soils seem to be much wetter that their morphology would suggest, several alternative hypotheses were developed as possible explanations for this phenomenon.

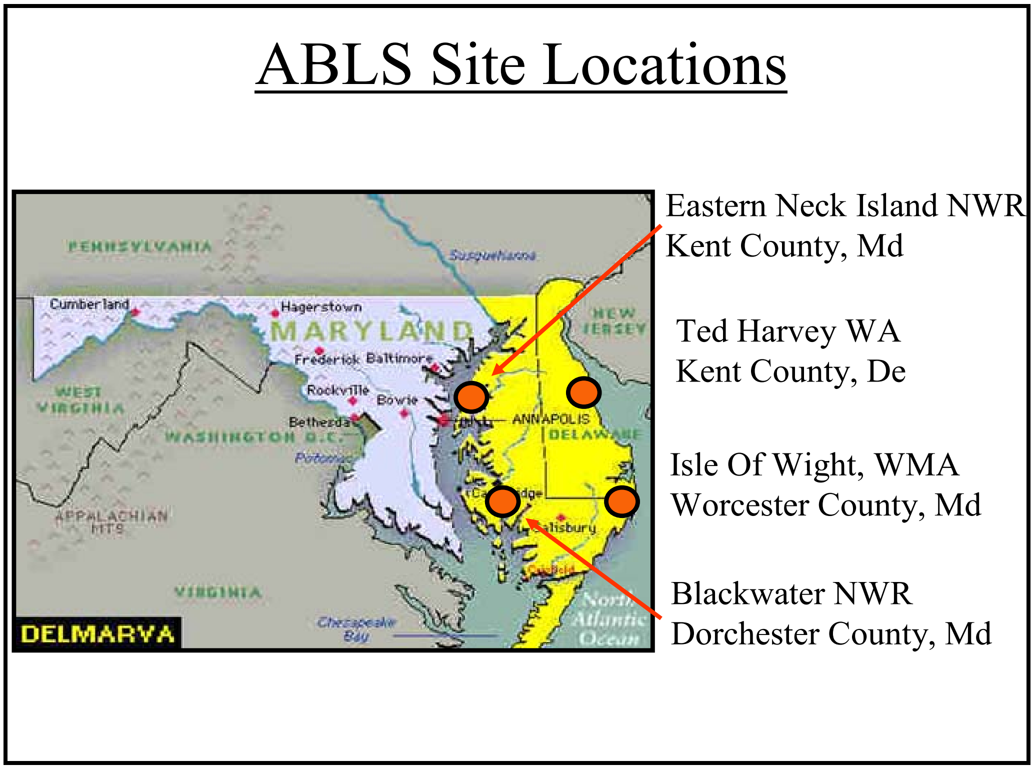
During this investigation of the ABLS phenomenon, each of these hypotheses was evaluated. The hypotheses included: 1) ABLS-soils are not actually as wet as they are thought to be and thus their morphology does in fact accurately reflect their hydrology; 2) The soils are saturated but, for some reason, they do not develop reducing conditions; and 3) The soils are both saturated and reducing, however due to the mineralogy or some other inherent characteristic of their parent material, they are resistant to the development of typical hydric soil morphology.

The objective of this study was to: Test the various hypotheses in order to understand what is responsible for this ABLS-phenomenon.

MATERIALS AND METHODS

Study Sites

Four sites were identified on the Delmarva Peninsula with help from members of the Mid-Atlantic Hydric Soils Committee (MAHSC), who had field experience in identifying these problematic ABLS-soils. Site selection was based on criteria that a site 1) represents typical soil-landscape settings where the problem condition exist, 2) includes a transition between more poorly drained soils (probably hydric) and better drained soils (probably non-hydric), 3) is minimally impacted by altered hydrology, and 4) is minimally accessible to limit potential vandalism of instrumentation. Three of the four selected sites were located in Maryland (Dorchester, Worcester, and Kent Counties) and one was located in Kent County, Delaware (Fig. 5-1).



ABLS Site Locations

Eastern Neck Island NWR
Kent County, Md

Ted Harvey WA
Kent County, De

Isle Of Wight, WMA
Worcester County, Md

Blackwater NWR
Dorchester County, Md

Figure 5-1: Four study site locations (circles) on the Delmarva Peninsula where ABLS-soils were examined.

Water Tables

Water tables were monitored using WL-80 Remote Data Systems automated recording wells (RDS, Inc., Wilmington, NC). Three wells were installed at each of the four sites to a depth of approximately 1.5 m, leaving 0.5 m above-ground to record possible flooding events (Sprecher, 2008). Wells were positioned along a transect to confirm the presence of a hydrosequence. Data were recorded twice daily and downloaded periodically using a hand-held Hewlett-Packard calculator with an infrared interface. Data were off-loaded to a computer and processed.

Soil Oxidation-Reduction Potentials

Soil oxidation-reduction, “redox” potentials (Eh), and pH measurements were made approximately bi-weekly when water tables were near to the soil surface (late fall through spring), and less frequently during summer months when water tables were deep. Redox measurements were taken at five depths (10cm, 20cm, 30cm, 40cm, and 50cm) using six replicate platinum-tipped electrodes inserted into the soil, allowing documentation of the redox depth-profile. Calomel reference electrodes and standard voltmeters completed the circuit.

Soil pH

The pH measurements were made at the same depths and on the same dates as when Eh was measured, using a portable field pH meter. Each soil sample was made into a slurry (approximately 1:1) using distilled water and measurements were made after 15 minutes.

Color Change Propensity Index (CCPI)

To determine if mineralogy or some other property of the soil parent material caused soils to be resistant to color-change under reducing conditions, the Color Change Propensity Index (CCPI) was calculated for these soils using the procedure of Rabenhorst and Parikh (2000). Thirty-three soil samples were analyzed from the B-horizons of the four research sites. After the prescribed treatments, colors (hue, value, and chroma) were measured to the nearest 0.1 unit using a digital colorimeter (Minolta CR-300 - Osaka, Japan). The CCPI was calculated following the parameters in Rabenhorst and Parikh (2000) where soils with a CCPI ≤ 30 would be considered problematic (resistant to color-change under reducing conditions) and those with a CCPI of ≥ 40 were considered not problematic, or “normal”.

RESULTS AND DISCUSSION

Water Tables

To evaluate the first hypothesis (that the soils were not as wet as had been thought), we compared water table levels with soil morphology. Water table data were collected continually over a three-year period and were observed to follow typical patterns for the Mid-Atlantic region where water tables were highest during winter and early spring (November – March) and dropped significantly during late spring and summer (April – October) (refer to Chapter 4, Figsures 4-3 (a-d) for complete hydrographs). Seasonal trends are mostly driven by evapotranspiration rates that are low in the winter and high in the summer.

A cumulative frequency of the water table depths was calculated using data from hydrographs extending from February 2001 to February 2004. For loamy hydric soils, the focus is usually on the upper 25 cm or 30 cm of the soil, referred to in the definition of a hydric soil as “the upper part”. The percentage of time each of the soils was saturated at or above 30 cm is shown in Table 5-1. The data demonstrate that water tables were in fact near the soil surface for extended periods of time throughout the study. The Blackwater site was the wettest of all sites, being saturated to the surface at the low well for approximately 90% of the time. The Ted Harvey site was the least wet of all sites, however the lower soils at the site still remained saturated to within 30 cm of the soil surface for approximately 30 to 50% of the three-year period. The Isle of Wight and Eastern Neck Island sites were saturated for periods that were intermediate between the Blackwater and Ted Harvey sites.

Table 5-1: Length of time (% and weeks/yr) when the lower, middle, and upper soils at each of the four research sites were saturated to 50 cm below the ground surface.

		Cumulative Saturation					
		Site Position					
	Depth	Lower		Middle		Upper	
Site	(m)	%	weeks	%	weeks	%	weeks
Blackwater	0.0	67	35	57	30	36	19
	-0.1	89	46	80	41	60	31
	-0.2	92	48	85	44	73	38
	-0.3	94	49	92	48	80	41
	-0.4	95	50	96	50	88	46
	-0.5	98	51	98	51	93	48
Isle of Wight	0.0	47	25	6	3	15	8
	-0.1	61	32	21	11	33	17
	-0.2	66	34	39	20	40	21
	-0.3	73	38	48	25	44	23
	-0.4	82	43	54	28	48	25
	-0.5	89	46	57	30	53	27
Eastern Neck	0.0	32	16	32	17	41	21
	-0.1	39	20	39	20	37	19
	-0.2	42	22	43	22	33	17
	-0.3	45	23	46	24	28	15
	-0.4	47	24	47	25	19	10
	-0.5	51	26	50	26	3	2
Ted Harvey	0.0	6	3	5	3	3	1
	-0.1	23	12	15	8	12	6
	-0.2	41	21	26	13	22	12
	-0.3	51	27	35	18	31	16
	-0.4	54	28	44	23	37	19
	-0.5	58	30	49	26	46	24

These data demonstrate that water tables in the soils at all four sites were elevated within the soil profile and caused saturation for long periods of time; but compared to other comparatively wet soils, they showed very weak expression of redoximorphic features (see Chapter 4: Relationship between Soil Morphology and Length of Saturation). Therefore, we rejected the first hypothesis.

Soil Eh and pH

To evaluate the second hypothesis, we examined the Eh and pH values of the soils at times when the water tables were high and the soils were saturated. Figure 5-2 illustrates an example of how redox potentials respond to soil saturation (mid-portion of the transect at the Eastern Neck Island site). Here, Eh was plotted relative to the Technical Standard (TS). Comprehensive Eh-data are presented in figures 3-5 a-d (Chapter 3), where a detailed discussion of the relationship between the length of saturation and the onset of reducing conditions can be found.

In general, when the soil became saturated, the Eh began to drop. Usually, with sustained saturation, the Eh would continue to drop to within the range where Fe-reduction was predicted, according to the NTCHS. Because the water tables persisted near the surface of the soil for long periods, reducing conditions also persisted as is common for many hydric soils. Therefore, we rejected the second hypothesis.

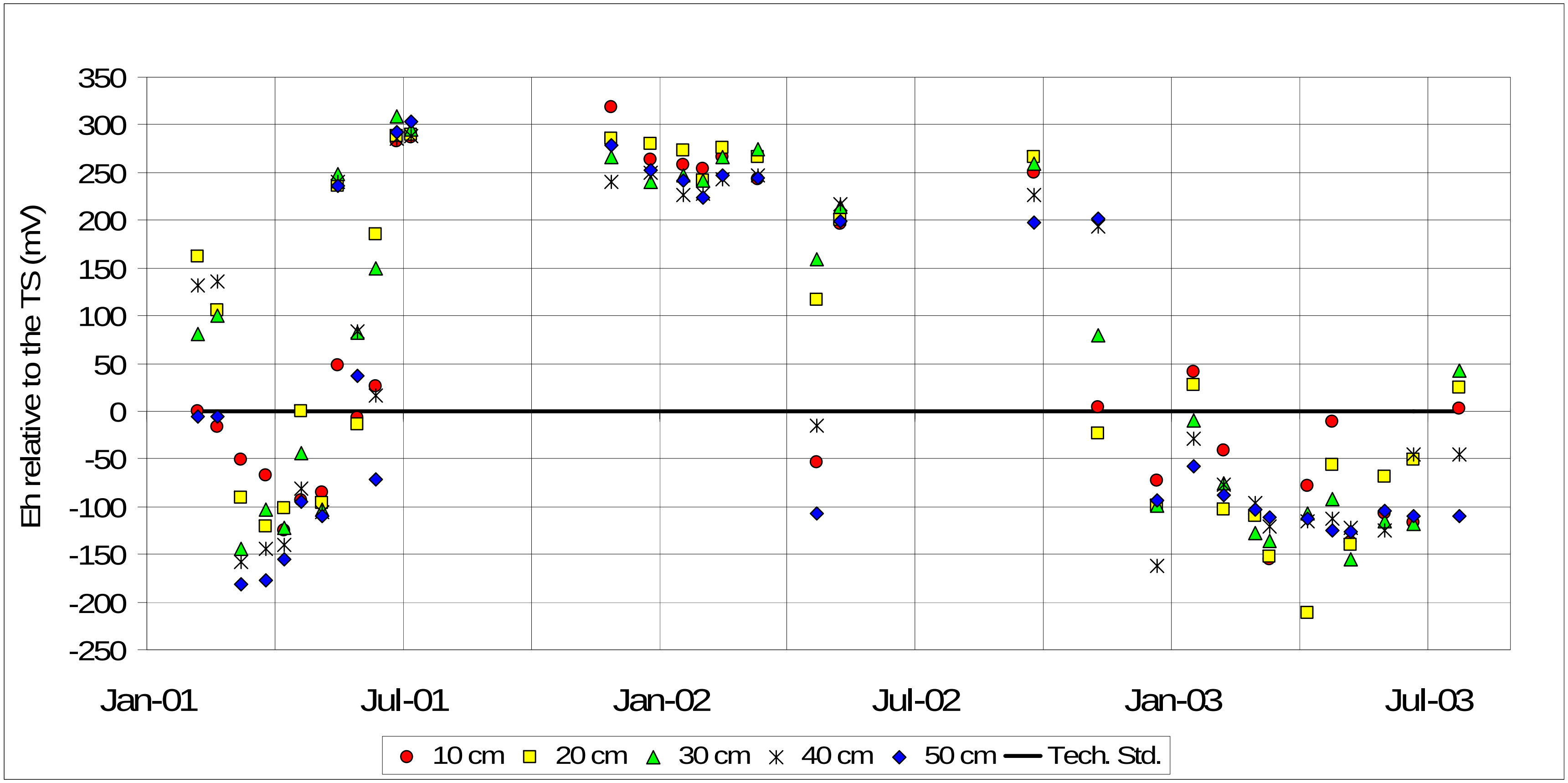


Figure 5-2: Soil redox potentials at the mid-transect position at the Eastern Neck Island site between 2001 and 2003. The horizontal black line represents the threshold where the soil is considered either oxidizing (above the line) or reducing (below the line) with respect to iron, according to the Technical Standard. Redox potentials dropped below the Technical Standard (reduced) at times when seasonal water tables were near the soil surface.

Color Change Propensity Index (CCPI)

To evaluate the third hypothesis (that soils were saturated and reduced, yet resistant to develop hydric soil morphology), we examined the propensity of soil horizons to develop gray colors under reducing conditions as evaluated by the CCPI.

Based on the work of Rabenhorst and Parikh (2000), soils that showed difficulties in turning gray under naturally reducing conditions have a CCPI of less than 30. Examples of these kinds of soils include those that formed from the red Triassic shales of the Piedmont physiographic province (Elless and Rabenhorst, 1994; Elless et al., 1996) or from the red Paleozoic shales in the Ridge and Valley province. Those soils with a CCPI of greater than 40 were more typical showing no difficulty turning gray and were considered to be non-problematic. Indices between 30 and 40 were considered to be intermediate. Most of the 33 samples of ABLS-soils had CCPI values that ranged between 53 and 75, with a small number samples having CCPI values as high as 84 to 141 (overall mean of 71). The CCPI values for the ABLS-soils showed that they were in a range that could be considered as non-problematic (Table 5-2). This means that ABLS parent materials do not appear to be resistant to color change under reducing conditions. In light of these results, we rejected the third hypothesis.

Table 5-2: All thirty-three samples of ABLS-soils fell into the "non-problematic" (CCPI>40) range on the Color Change Propensity Index (CCPI) scale, implying that the parent materials of these soils showed no difficulties turning gray under reducing conditions. (Pos.= position at site; Hor.= horizon).

Research Site											
Blackwater			Isle of Wight			Eastern Neck			Ted Harvey		
Pos.	Hor.	CCPI	Pos.	Hor.	CCPI	Pos.	Hor.	CCPI	Pos.	Hor.	CCPI
low	BEg	119.5	low	B/A	63.1	low	BE	63.3	low	AE	95.4
low	Btg1	74.8	low	Bt1	58.2	low	Bt1	55.4	low	EB	84.3
mid	BE-Btg	108.1	low	Bt2	53.6	low	Bt2	57	low	Bt1	57
mid	2Bt	55.8	mid	EB	70.2	mid	BE	60.6	mid	AE	93.7
up	Bt1	66.7	mid	Bt1	64.4	mid	Bt1	57.1	mid	BE	74.8
up	Bt2	60.8	up	AB	141	mid	2Bt3	75.5	mid	Bt1	63.4
up	2BC1	55.1	up	BA	70.6	up	AE	89.1	up	EB	65.9
			up	Bt1	59.6	up	EB	66.4	up	Bt1	58.7
						up	Bt1	57.5	up	Bt2	53.1

CONCLUSIONS

Some hydric soils encountered on the Mid Atlantic coastal plain have proven to be reticent in expressing morphological indicators typical for their degree of saturation and reduction. These Anomalous Bright Loamy Soils (ABLS) were studied to investigate and identify the cause behind this phenomenon. Our observations indicate that the water tables present in these soils were close to the surface during the wetter parts of the year. Cumulative saturation data indicate that on average, water tables persist within 30 cm of the soil surface for between 17 weeks (Ted Harvey site – upper soil) and 49 weeks (Blackwater site – lower soil) out of each year. These soils are, in fact, quite wet. Oxidation-reduction measurements showed extended periods when reducing conditions occurred when the soils were saturated. During periods of high water tables, redox values in ABLS-soils were often low enough to reduce ferric iron to ferrous iron. These soils were clearly saturated long enough for them to develop anaerobic conditions in the upper part (see chapter 3). In examining the propensity of these soils to turn gray under reducing conditions, the CCPI values of ABLS-soils ranged from 53 to 141 with a mean value of 71. These indices plotted well in the range of where soils were considered to be non-problematic. The parent material of ABLS-soils was therefore not considered to be a cause for their not being more dominantly gray-colored. During the course of this research, we were able to reject all three of the hypotheses posed as possible explanations of the ABLS phenomenon.

Therefore, as a result of the work completed up to this point, we are forced to identify a possible fourth hypothesis to explain the anomalous hydromorphology of ABLS-soils: This alternate hypothesis states that the reticence of ABLS-soils to exhibit typical redoximorphic features may be attributed to a low, lateral hydrologic gradient due to their low relief and proximity to sea level, which slows the movement and removal of the reduced, ferrous iron from the soil-system. This hypothesis was investigated further in Chapter 6. When considered in conjunction with recent sea level rise, the period of time for which the soils have been saturated and reducing may not have been long enough for the morphology to develop low chroma matrix colors commonly associated with hydric soils.

6) Morphological Changes Induced by Leaching of Iron under Anaerobic Conditions - A Mesocosm Study

INTRODUCTION

The driving force behind anaerobiosis in the soil is saturation of the soil which limits diffusion of oxygen (Callebaut et al., 1982; Clothier et al., 1978). The oxygen diffusion rate through a saturated soil is 10^{-4} that of the rate when the soil pores are filled with air (Ponnamperuma, 1972, Richardson et al., 2001). Once a soil is subjected to saturated, flooded, or ponded conditions, and any remaining dissolved oxygen is consumed, a shift occurs in the mechanism by which the soil microbial population respires. Under these anoxic conditions, anaerobic soil bacteria respire by transferring electrons gained by the oxidation of soil organic matter to electron acceptors other than oxygen, such as nitrate, manganese, or iron. Although a soil is generally considered anaerobic once oxygen levels are depleted below a level of 0.1 ppm (Angle, 2000), it may not be sufficiently reduced to induce noticeable morphological changes. If reducing conditions persist for long enough periods of time, however, ferric iron (Fe^{3+}) becomes the primary electron acceptor and is reduced to the ferrous state (Fe^{2+}), which is both colorless and highly soluble (Ponnamperuma, 1972; Gambrell and Patrick, 1978; Vepraskas and Faulkner, 2001; Mitsch and Gosselink, 1993; Craft, 2001). Regular cycling between aerobic and anaerobic conditions (sufficiently reducing to mobilize iron) causes iron to segregate into areas containing relatively greater amounts of iron (concentrations) and areas with lesser amounts of iron (depletions), compared to the surrounding soil matrix.

Soil color often is controlled by various iron oxide and organic matter coatings, typically distributed unevenly throughout the soil (Couto et al., 1985; Fanning and Fanning, 1989). Segregation of the iron oxides in soils affected by fluctuating water tables and periodic reducing conditions, renders a mottled appearance to the soil. By observing the color, size, and quantity of redoximorphic features (concentrations and depletions of Fe), and the depth at which these features develop, soil scientists are able to assess the hydric status of a soil (Vepraskas, 2001). Once formed, redoximorphic features persist over time, which makes them reliable indicators when identifying hydric soils even during periods when the soil is no longer saturated (Hurt and Carlisle, 2001).

Occasionally, landscapes are observed that readily indicate the presence of a wetland, although the morphology of the soils suggests a better-drained environment (Franzmeier et al., 1983; Vepraskas and Wilding, 1983). Hydromorphological features in these soils are either not present or they inaccurately represent the hydrological conditions of the soil. One such type of problem-soil that is found on the Mid-Atlantic coastal plain is Anomalous Bright Loamy Soils (ABLS). Initially, it was postulated that these soils did not experience adequate saturation for long enough periods of time, or, that the soils were saturated but did not become reducing due to some inherent site characteristics. After it was shown that these soils were both saturated and also developed reducing conditions, a third possible explanation was postulated for their lack of hydric morphology related to the parent material itself. Assessment of the soil's Color Change Propensity Index (CCPI) however, demonstrated that this was not the case (Rabenhorst and Parikh, 2000) (Fig. 6-1). Thus, through several years of field and laboratory research, the initial three hypotheses that were posed to explain the ABLS phenomenon were systematically rejected, and the need for further evaluation of the problem was sustained. It was therefore further hypothesized that soils in these particular landforms may experience low lateral hydraulic gradients, which do not allow ferrous iron to be removed from the system. Evaluation of this hypothesis was conducted through a laboratory mesocosm study. The proposed experiment was designed to determine the effects of an altered (greater) hydrological gradient on undisturbed ABLS soil-cores, as simulated by enhanced leaching. Therefore, the objective of this mesocosm study was to determine whether enhanced leaching from saturated and reduced ABLS soil-cores affects soil morphology.

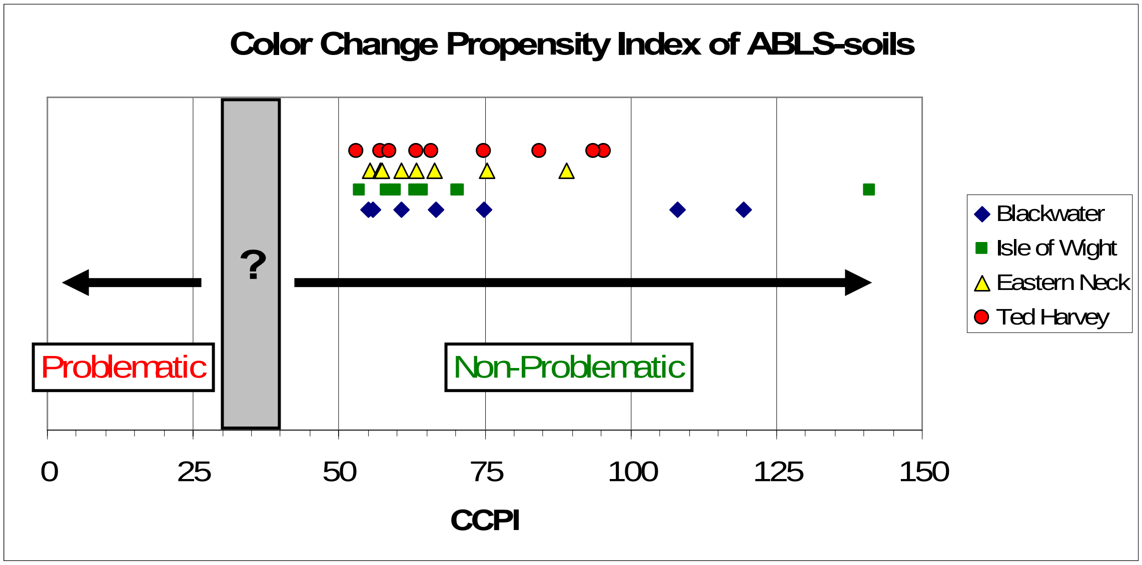


Figure 6-1: The CCPI of 34 ABLS-soil samples plotted in the "non-problematic" range, indicating that the parent material of ABLS-soils did not show difficulties turning gray under reducing conditions.

MATERIALS AND METHODS

Field

The soil used in this study was collected from the Isle of Wight (N 38 213 41.47, W 75 06 42.06), Worcester County, MD, which is surrounded by Assawoman Bay on the North-East, by the Isle of Wight Bay on the South, and by the Saint Martin River on the West. This area of the Isle of Wight is approximately one meter above sea level and was identified as an ABLS site.

Twelve undisturbed soil cores were extracted from this site using 50-cm sections of 15-cm, schedule 40 polyvinyl chloride (PVC) pipe (sharpened with an outside bevel of 60-degrees so that it could be easily driven into the soil but would minimize sample compaction). Each of the PVC pipes was hammered 40 cm into the ground and then excavated with the PVC pipe containing the soil as a mesocosm. All twelve cores were extracted from within approximately one-square-meter area to minimize variation among samples.

Laboratory

After the cores were transported to the laboratory, PVC end-caps (drilled with a one-inch drainage hole) were glued to the bottom end of each soil core. Fine gravel was used as a support medium between two layers of filter fabric inside each end-cap. Leachate from the bottom of the mesocosm was collected through 0.125-inch inside diameter clear, flexible tubing secured using a rubber stopper and regulated by a metal, screw-type hose clamp.

Mesocosms

The twelve mesocosms were randomly separated into four treatment groups, each consisting of three cores. Three groups of three cores were leached and one group of three control cores was not leached (Unleached Control (ULC)). The nine cores that were leached were kept saturated and ponded with a 1mM solution of $CaCl_2$ in distilled water. The small amount of calcium chloride was added to prevent dispersion of the soil during leaching.

Of the nine mesocosms that were saturated and leached, three cores were treated as a control ("Leached Control" (LC)), to which no carbon was added. The second set of three cores received a solution of 36mg/L dextrose ("Dextrose" (D)) (carbon source) in distilled water, and the final set of three cores received a surface treatment of 9.2g/week (approximately 0.5 kg/m^2/wk) of dried, ground leaves ("Leaves" (L)) (carbon source). Carbon was supplied to these cores to mainly ensure that redox reactions were not carbon-limited during the six-month experiment. The leaves were collected at the IOW-site where the mesocosms were collected, and mainly were leaves of *Quercus bicolor* (Swamp White Oak), *Carya glabra* (Pignut Hickory), *Liquidambar styraciflua* (Sweet Gum), *Quercus alba* (White Oak), and *Nyssa sylvatica* (Black Gum). Three-hundred mL of solution was supplied at the surface and also collected from the bottom of each mesocosm daily, which was equivalent to approximately 1.7 cm of precipitation per day (thus, the D-mesocosms received approximately 1.7 g C/m^2/wk as dextrose). To minimize the risk of the possible oxidation of ferrous iron during the leaching period, the flow rate was adjusted to collect the sample over approximately a six-hour time period. A 50-mL sub-sample of the 300-mL of leachate was acidified with one drop of 12 M HCl and refrigerated until they could be analyzed for soluble Fe. Leachate samples were diluted with distilled water (1:21) and analyzed bi-weekly for total dissolved iron by atomic absorption spectroscopy.

Redox potentials and pH

Redox potentials in each core were monitored periodically throughout the six-month span of the experiment. Six platinum electrodes were permanently installed in each core (three at a depth of 15 and three at 25 cm) (Austin and Huddleston, 1999; Owens et al, 2005). The redox potential from each electrode was measured using a Calomel reference electrode and a voltmeter. In addition, [alpha], [alpha]'-dipyridyl dye was used periodically as a test of the presence of ferrous iron in the leachate. The pH values were recorded twice, once at each the beginning and then at the end of the six-month experiment. For this, a 2-cm soil sample (plug) was extracted from each core at an approximate depth of 20 cm and mixed to form a 1:1 water-soil slurry using distilled water.

Disassembly of Cores

At the end of the six-month experiment, each core was bisected lengthwise. A circular saw was used to cut the PVC cap off the bottom end of each core and subsequently to cut the length of each side of the PVC sleeve. With the core upright, a carpenter’s saw was then used to cut down the center, dividing each core into two equal halves. One half of each core was described while the second half was cut into horizontal sections for determining bulk density values and extractable iron. Bulk density calculations were based on measured volumes and dry weights of 5-cm thick sections. Iron in each section was extracted using sodium dithionite in a citrate buffer (DCB) and analyzed by atomic absorption spectrometry (Jenne et al., 1974).

RESULTS AND DISCUSSION

Redox Potentials and pH

Over the course of the first several weeks, redox potentials in the mesocosms decreased steadily. Within three days they reached levels low enough to theoretically reduce iron (typically, several hundred mV below the Fe^{3+}/Fe^{2+} stability lines). Potentials continued to drop over time and remained low for the duration of the experiment (Fig. 6-2). This assumption was substantiated by observing positive reactions of the leachate with alpha, alpha-dipyridyl within one week of starting the experiment. The persistence of reduced conditions inside the mesocosms resulted in pH values that rose from 4.1 to 6.0 during the course of the experiment.

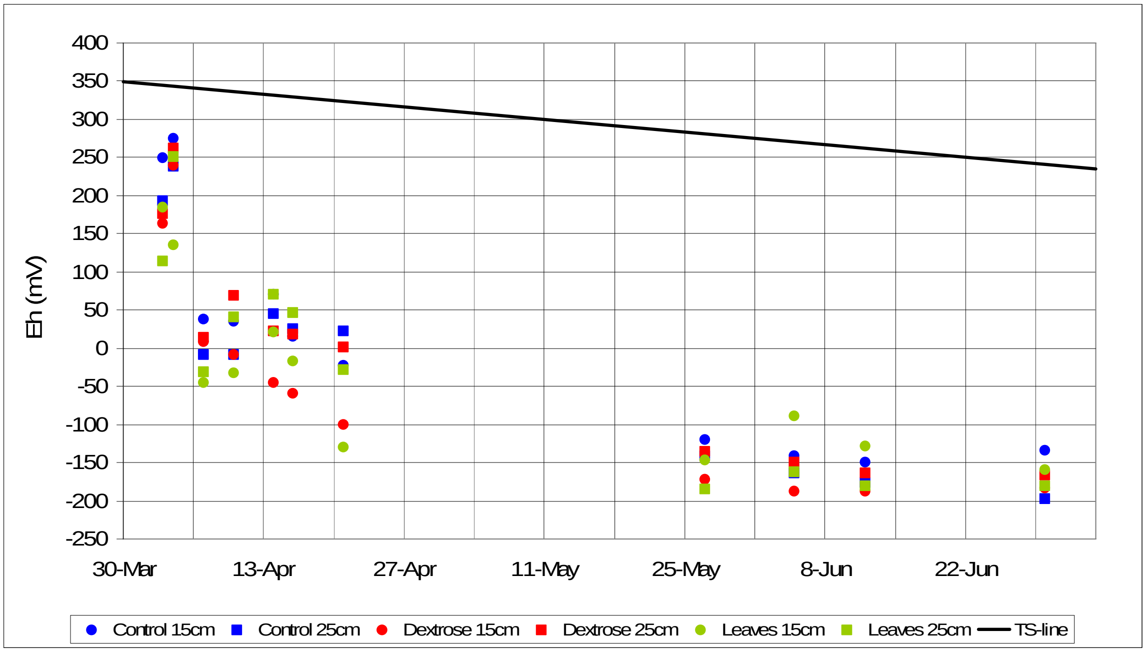


Figure 6-2: Redox potentials (Eh) of eight, saturated soil-mesocosms measured in triplicate at 15 cm and 25 cm. Averages from each depth were calculated per treatment (three cores per treatment). Note: Essentially all observations were substantially below the Eh-threshold for the Fe-reduction as specified in the Technical Standard for hydric soils (black line).

Leached Iron

The amount of reduced iron leached from the cores differed markedly between treatments (Figs. 6-3 and 6-4). The total quantity of iron removed under each treatment by leaching was 3.92 g, 2.18 g, and 5.30 g, respectively for the leached control-, dextrose-, and leaves-treatments (Table 6-1). It should be noted that one of the three leaves mesocosms failed to transmit adequate leachate to be retained in the experiment. The cause of this is uncertain, but it is assumed that water flow was restricted in some manner within the core. This could have been caused by something inherent to the soil sample, by something that happened during assembly/capping of the core (such as surface-sealing or slumping), or by something that developed over the course of the experiment (such as dispersion of the soil leading to clogged flow-paths).

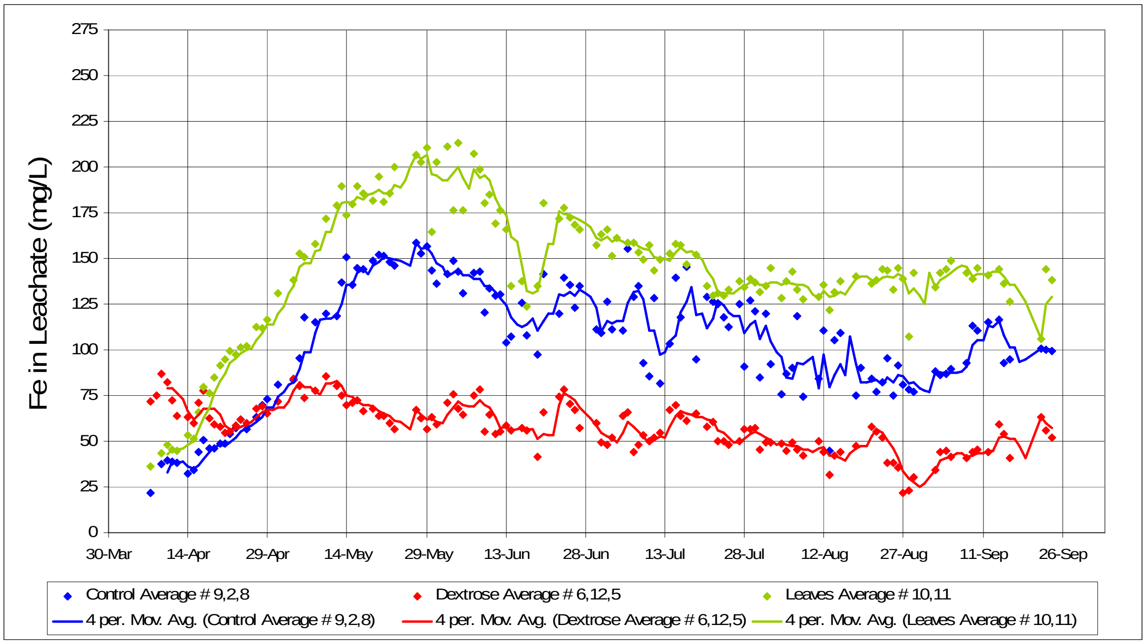


Figure 6-3: Ferrous iron concentrations in mesocosm leachate during a six-month period. Points represent the average concentration of iron in the leachate of each treatment group, at each time of sampling. Colored lines show a four-sampling moving average for the data.

The reason for adding additional carbon (C) (as leaves or dextrose) to two of the mesocosm treatments was to ensure that available C did not become limiting to microbial activity as solution was passed through the mesocosm. Data in figures 6-3 and 6-4 show that the greatest amount of Fe was leached from the mesocosm with added leaves (L) and the least was removed from those mesocosms to which dextrose (D) was added. During the six months of leaching, all three treatments achieved and maintained a steady-state of Fe-removal, and significant amounts of Fe were still being collected at the end of six months (Fig. 6-3). Notably, the leached control mesocosms showed no evidence of becoming carbon-limited for iron reduction and leaching; iron was still being reduced and removed in the Leached Control mesocosms (LC) at the end of six months at a level of approximately 100µg/mL.

Because such large quantities of organic carbon (6.8 kg/m^2 over six months) were being added in the leaves-treatments, it is not surprising that the greatest amounts of Fe were leached from the mesocosms in this treatment. What was surprising was that both the Fe-removal rate and the cumulative total Fe leached from the control mesocosms were greater than in those that had additional carbon added as dextrose; even though carbon additions were rather modest (44 g C/m^2 over six months). It is unclear to us what the cause of this phenomenon was. One possible explanation is that the addition of dextrose favors and stimulates a portion of the microbial population which may suppress the actions of other microbes that are more efficient reducers of iron. An alternate explanation might be that some of the iron removed from the mesocosms was chelated by decomposition products of the leaves and soil organic matter. Addition of an easily oxidized carbon source such as dextrose might suppress the decomposition of the leaves and soil organic matter, which normally produces organic compounds that can chelate iron. Further support for this second postulation was the color of the leachate which, in general, resembled the color and clarity of tea. The leachate from cores that were treated with leaves was the darkest liquid while leachate from the cores treated with dextrose was almost colorless. The leachate color from the control cores was intermediate between the other two treatments. The lighter colors may reflect fewer complex organic compounds derived from the decomposition of leaves and soil organic matter.

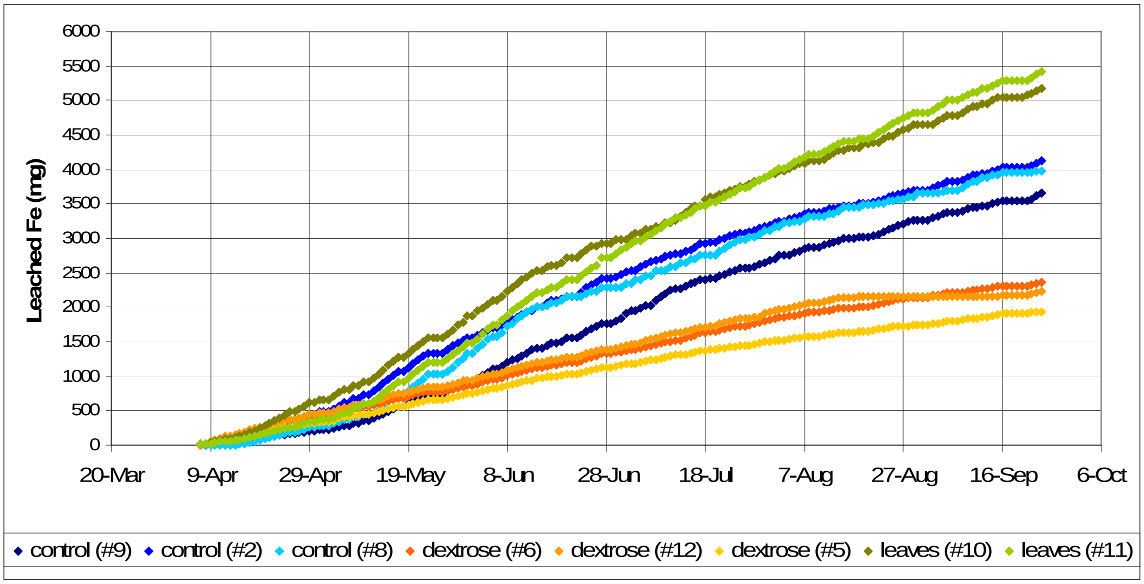


Figure 6-4: Cumulative leached iron (mg) for each core, three cores per treatment. One of the three cores treated with leaves was removed early in the experiment due to a significantly reduced leachate flow rate.

Iron Remaining in the Mesocosms after leaching

As expected, post-experiment total extractable iron corresponded to the magnitude of iron in the leachate. Unleached Control cores (ULC), not part of the leaching process, were used to document iron quantities prior to leaching. The total cumulative DCB-extractable iron data are presented in table 6-1. The quantities of Fe remaining in the mesocosms were inversely proportional to the quantities of Fe leached from the mesocosms.

Table 6-1: Calculated Fe lost from the mesocosms (based on DCB extractable Fe present in the mesocosms at the conclusion of the study) compared with Fe leached from the mesocosms. Values within columns with the same letter are not significantly different at the 0.05 level.

Treatment	Fe remaining in mesocosm	Change (relative to ULC)	Fe leached from mesocosm
	------------------------------------	(g)	------------------------------------
Unleached Control (ULC)	25.18 (a)	---	---
Leached Control (LC)	21.45 (ab)	-3.73 (ab)	3.73 (a)
Dextrose (D)	23.17 (ab)	-2.00 (a)	2.18 (b)
Leaves (L)	17.53 (b)	-7.65 (b)	5.30 (c)

The data in figures 6-5 through 6-7 demonstrate that for the leached control and leaves treatment, the iron was removed relatively evenly from throughout the cores. In the dextrose-cores, it appears that iron was mostly removed from upper portions of these cores and that relatively little Fe was leached from the lower portions. This is demonstrated by the quantity of extractable iron in the lower sections of dextrose cores being comparable in amount to the mesocosms that were not leached. One possible explanation is that iron, reduced in the upper zone, moves unhindered through and out of the mesocosm, while iron in the lower sections may not be as strongly affected by redox processes. A second possible explanation is that iron reduction occurs throughout the core. But, iron is removed from the upper sections passing through the lower zones, becomes immobilized and accumulates there. Thus, iron in the soil may only have shifted in location. In either case, the final results show iron quantities in the lower one-third of cores treated with dextrose to be more similar to those quantities in cores that were not leached.

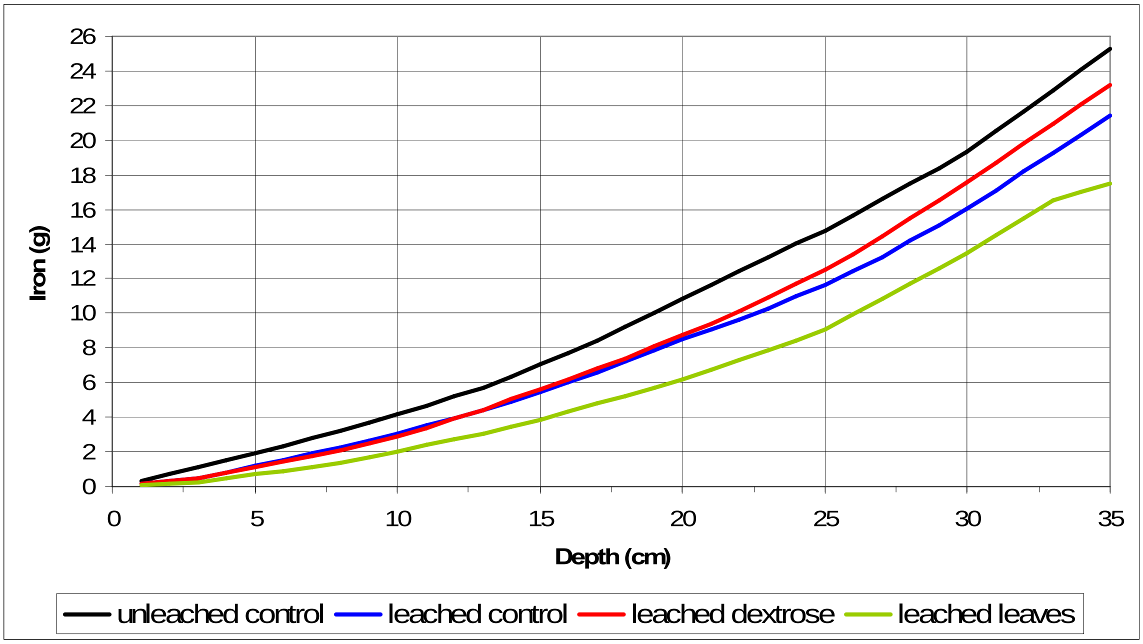


Figure 6-5: Cumulative DCB-extractable iron from 11 mesocosms following the leaching experiment. Values represent the means of three replicate cores from each of the four treatment groups. The leaves-treatment consisted of only two cores.

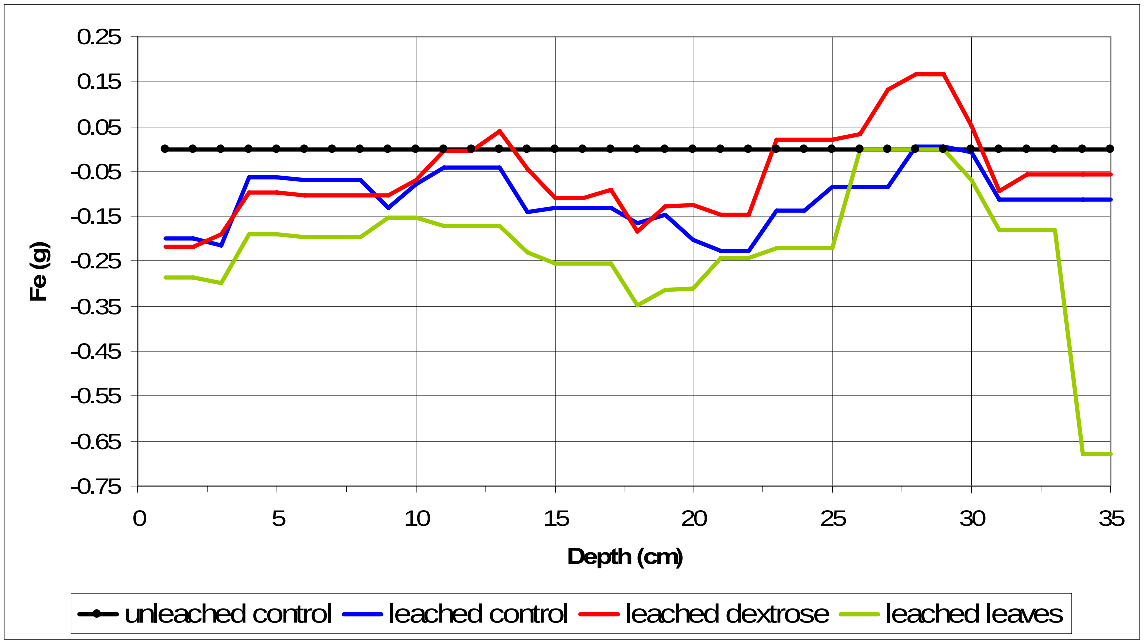


Figure 6-6: DCB-extractable iron-per-cm from the 11 mesocosms following the leaching experiment. Data from the eight, leached soils were plotted relative to the three, unleached (control) soils. Values are means of three replicate cores from each of the four treatment groups. The leaves-treatment consisted of only two cores.

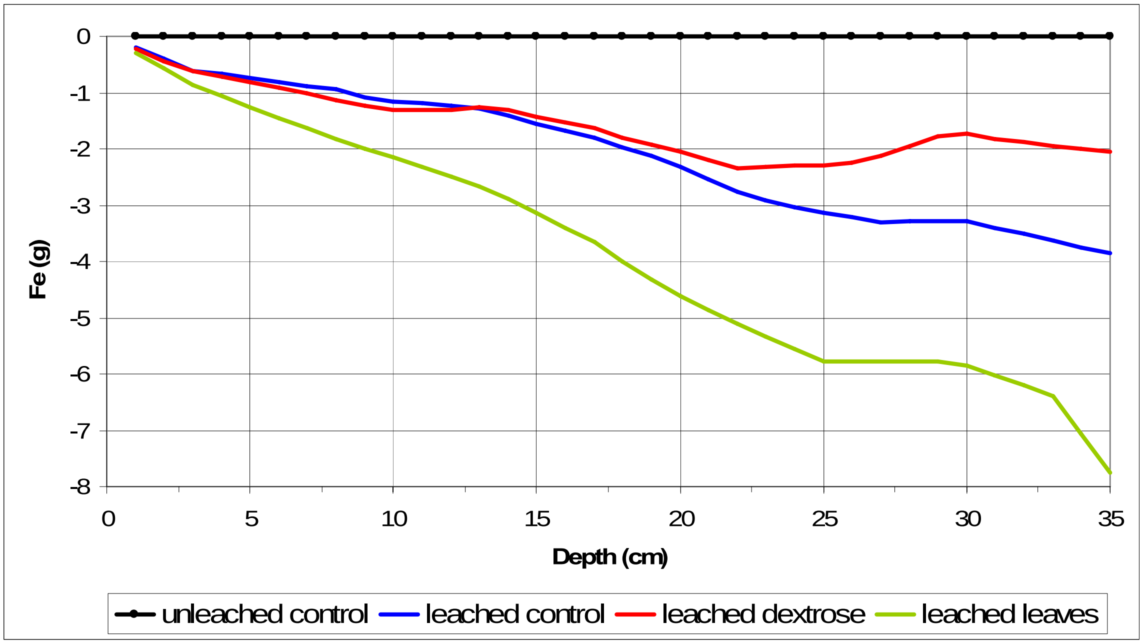


Figure 6-7: Cumulative DCB-extractable iron from 11 soil mesocosms following the leaching experiment; data are plotted relative to the unleached (control) soils. Values are means of three replicate cores from each of the four treatment groups. The leaves-treatment consisted of only two cores.

Soil Morphology

Color Analysis

Distinctive, morphological changes were observed in the soil-cores in which anaerobic conditions were induced and leaching was maintained. The most evident morphological change observed in mesocosms under this reducing and leaching regime was the chroma of the matrix color relative to their color before leaching. Visually, the slight changes that occurred in matrix colors were evident between the leached treatments (Fig. 6-8). Matrix colors changed from 2.5Y 5/4 to 2.5Y 5/3^{+} (Tab. 6-2); hues and values essentially remained unaffected. Additionally, it is noteworthy to mention, when visually comparing the features present in the leached cores to those in the cores that were not leached, that this leaching experiment contributed to neither the formation nor the elimination of any redoximorphic features in the soils.

Table 6-2: Changes in soil matrix colors of leached mesocosms relative to unleached mesocosms. Colors are averages per treatment.

	Munsell Color
Treatment	Hue Value/Chroma
Unleached Control	2.5YR 5/4
Leached Control	2.5YR 5/3$^+$
Dextrose	2.5YR 5/3$^+$
Leaves	2.5YR 5/3$^+$

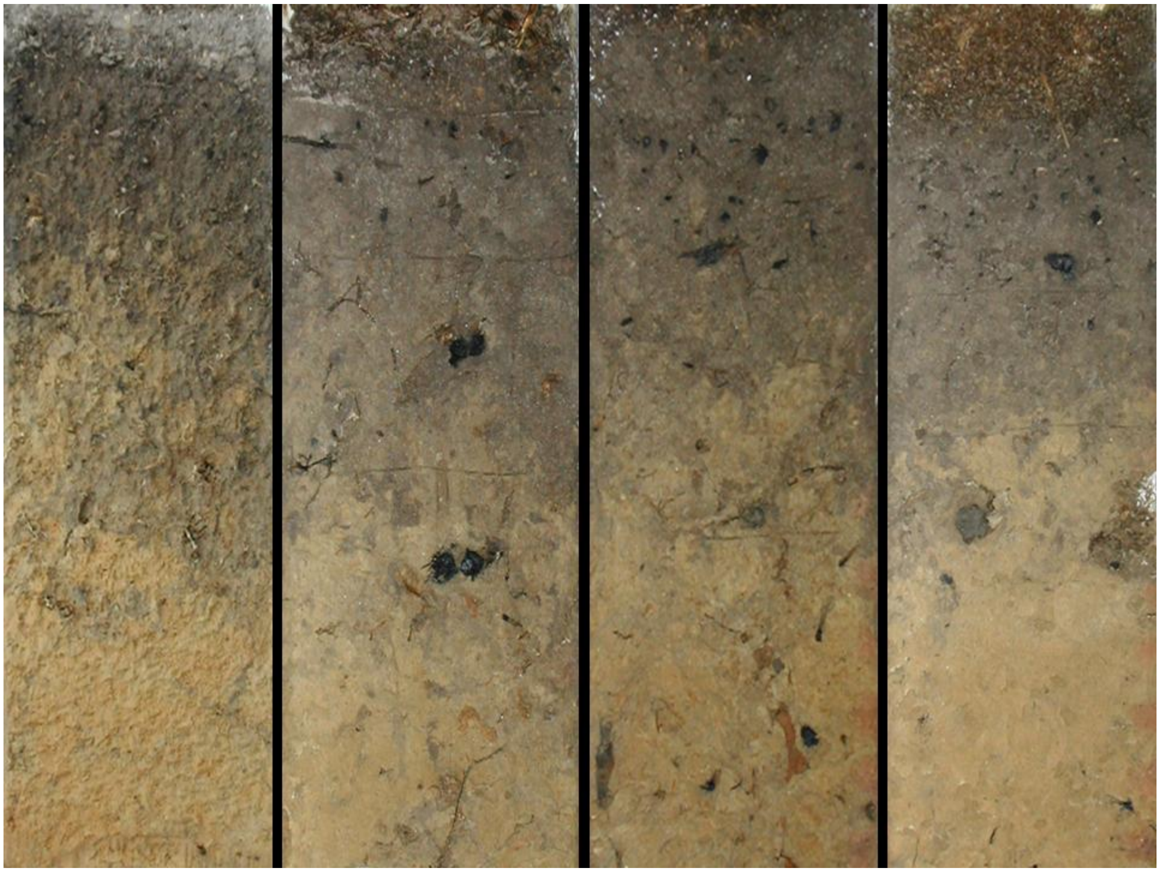


Figure 6-8: Photographs of mesocosm soils representing each of the four leaching treatments (left to right: "unleached control", "leached control", "dextrose", and "leaves"). The leached cores showed a definite "paling" in color, with matrix chromas changing from 4 to 3.

CONCLUSIONS

After six months of leaching under anaerobic conditions, soil cores showed distinctive differences across treatment groups relative to leached iron (Figs. 6-3 and 6-4), and extractable iron (Figs. 6-5 through 6-7). Removing Fe by reduction and leaching results in noticeable, morphological matrix color changes.

The quantity of iron removed from each core by reduction and leaching was dependent on the quantity and type of OM added to the system. With the addition of unusually high levels of leaves to the soil we found elevated Fe-removal rates relative to the control, while adding relatively modest quantities of dextrose caused a decrease in the quantity of Fe removed. It is not entirely clear why the cores that were treated with dextrose leached less Fe than the control cores, however speculations have been that dextrose may be preferentially metabolized by certain anaerobic bacteria.

Extending the results of this laboratory experiment into the field helps us to develop possible explanations as to why ABLS-soils exist. The anomalous hydromorphology of ABLS may be a combination of two processes: Soils in these particular landforms are likely to experience local hydrology with a weak lateral gradient. This phenomenon may result in reduced iron remaining in the soil system and eventually being reoxidized locally instead of being flushed away.

This experiment was of limited duration, but still resulted in an observable change in matrix color. Had this been extended for a longer period such that a greater proportion of Fe was removed from the soil, it is reasonable to surmise that color changes would become even more dramatic; eventually reflecting more typical colors associated with hydric soils.

7) Development of a Field Indicator for Identifying Anomalous Bright Loamy Hydric Soils in the Mid-Atlantic Coastal Plain

INTRODUCTION

The importance of accurate wetland identification and delineation has increasingly been recognized over recent years. Wetlands and their functions have been accepted as invaluable to sustaining good environmental quality, and to contributing to healthy wildlife ecosystems and clean water resources. Discharging dredge or fill materials into open waters without permit was made illegal with the implementation of section 404 of the Clean Water Act (Public Law 92-500, 33 U.S. Congress 1251). Impacted wetland areas were defined by the Act as "…areas that are inundated or saturated by surface water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions; Wetlands generally include swamps, marshes, bogs, and similar areas" (Environmental Laboratory, 1987).

Hydric soils are defined as soils that are "…saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part" (Federal Register, 1994). These types of soils are commonly found in wetland settings and typically show distinctive morphological characteristics that developed as a result of anaerobic, biogeochemical influences. Hydric soils are one of the three necessary parameters for identifying and delineating wetlands (wetland hydrology, wetland vegetation, and wetland ("hydric") soils). Soil morphology is not rapidly altered and is considered to reflect the relatively long-term effect of hydrological conditions under which the soil developed. Wetland vegetation and wetland hydrology may be more transient and less consistent indicators of wetland from one year to the next, but the more persistent morphological features of a hydric soil can be utilized regardless of the hydrological conditions under which the soil evaluation is made.

To help identify the hydric soil component of a landscape, the Natural Resources Conservation Service (NRCS) developed a set of Field Indicators of Hydric Soils, in cooperation with the U.S. Fish and Wildlife Service (USFWS), the U.S. Army Corps of Engineers (USCOE), and the U.S. Environmental Protection Agency (USEPA), along with support from universities and local agencies. Field Indicators are approved for use by the National Technical Committee for Hydric Soils (NTCHS). These Indicators were designed to recognize specific soil morphological features that are known to demonstrate that a soil meets the definition of a hydric soil. Indicators were developed to be regionally specific, taking into consideration the variability of conditions under which hydric soils form. Twenty Land Resource Regions (LRRs) and 170 Major Land Resource Areas (MLRAs) have been identified in the United States. The locations of LRRs and MLRAs, and their boundaries, are defined in the U.S. Department of Agriculture Handbook 296 (USDA-NRCS, 2006b). Hydric soil field indicators were designed to be applied as a guide to help the user identify the components of a hydric soil and not intended as a replacement for the definition of a hydric soil. Shortcomings of the indicators become evident when none of the currently accepted indicators can be applied to a soil that is suspected to be hydric. The list of Field Indicators is therefore dynamic and regularly subject to re-evaluation whenever new data is acquired. Proposed new Indicators and suggested changes to current Indicators are reviewed by the Technical Committee for Hydric Soils (NTCHS). The Indicators are designed to be "proof-positive" in that the identification of an Indicator guarantees the presence of a hydric soil (Hurt et al., 2006).

To help evaluate a proposed indicator or to test a soil that is suspected of being hydric, a national standard was developed by the NTCHS. This standard, known as the Technical Standard (TS), utilizes hydrological and biogeochemical measurements in a soil to determine if it is hydric (NTCHS, 2000). Soils that are evaluated using the TS must meet two conditions to be hydric: 1) continuous saturation lasting a minimum of 14 days and 2) (during continuous saturation) the development of redox potentials low enough to reduce ferric iron. Both of these two conditions must occur during a year with "normal" rainfall. The latter of the two conditions can be met by either a positive reaction to alpha, alpha'-dipyridyl (a dye that changes color, becoming pink, when reacting with ferrous iron), by a means of measured redox potentials (five Pt-electrodes at 0.25 m) and pH measurements, or can also be demonstrated by way of installing IRIS tubes (3 of 5 IRIS tubes have iron removed from 30% of a zone 15 cm long). The equation for the TS-line ($Eh = -60\ pH + 595$) considers both the soil's redox potential (Eh) and pH to determine if it is reducing (Fig. 7-1). A soil with Eh values that plot below the TS-line is considered reducing with respect to iron.

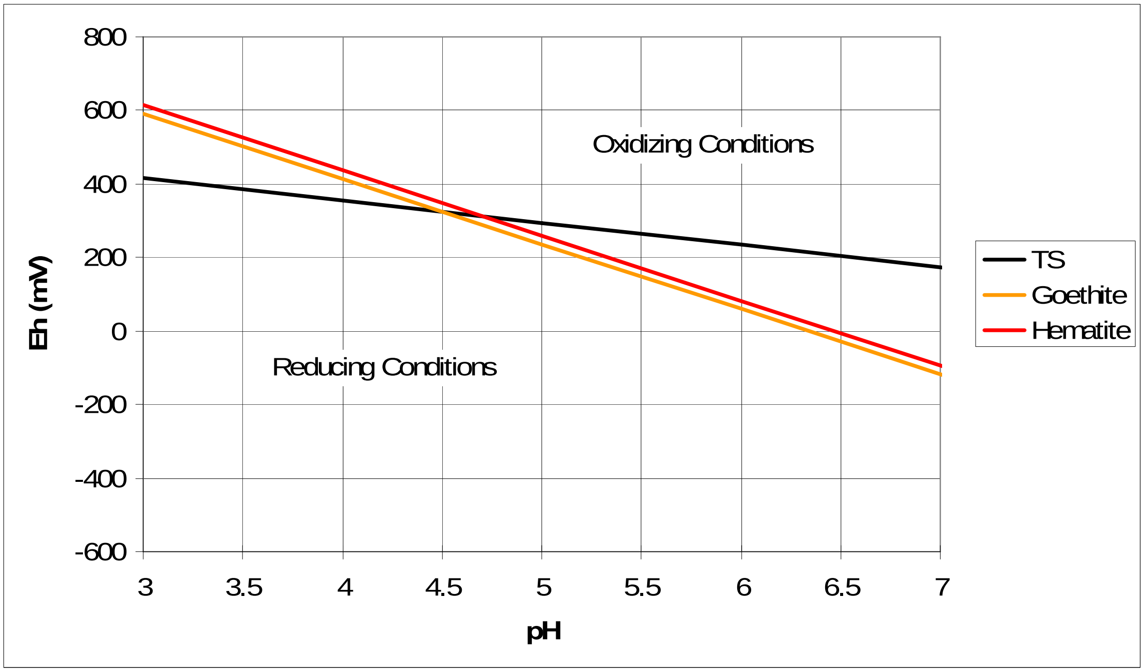


Figure 7-1: Eh/pH stability diagram showing lines representing boundaries between reducing and oxidizing conditions in the soil (relative to criteria set forth by the National Technical Committee for Hydric Soils (NTCHS, 2000)). The orange and red lines represent the stability fields of the minerals goethite (FeOOH) and hematite (Fe_2O_3)), respectively; and the black line represents the Technical Standard (TS). Goethite and hematite lines were calculated based on Fe-activity of 10^{-6}M.

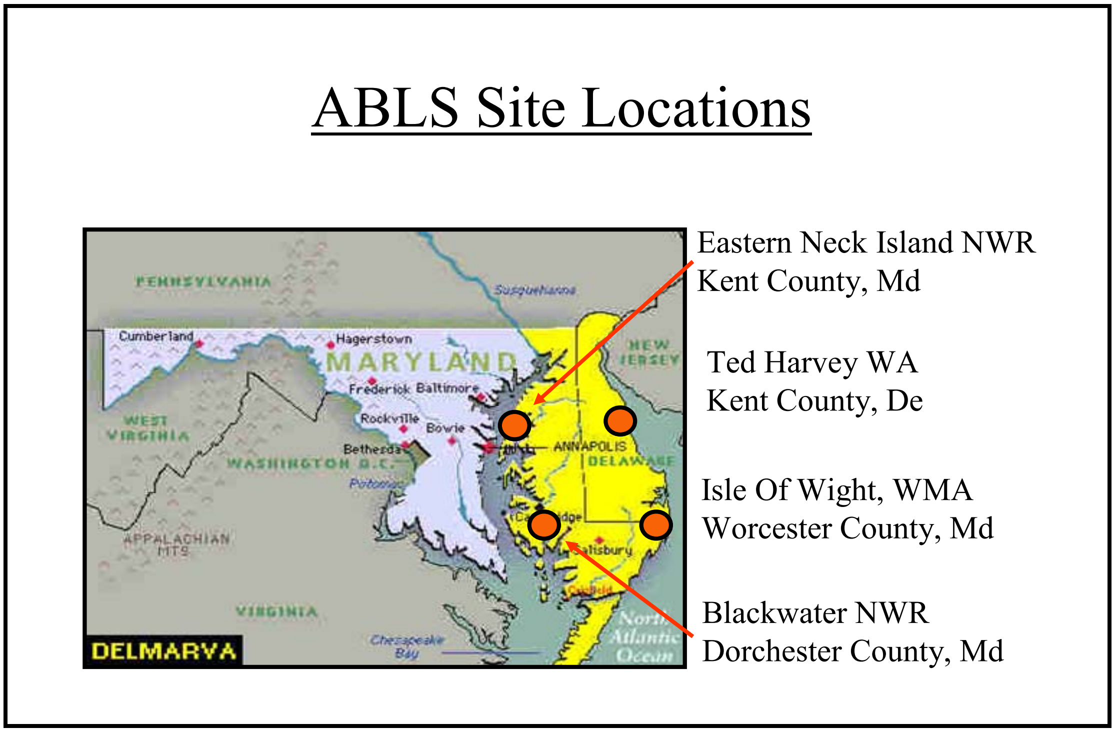
In recent years, soil scientists have encountered wetland soils in particular settings of the Mid-Atlantic coastal plain that possessed morphological features that seemed inconsistent with pedogenesis under wetland conditions. These “problematic” wetland soils could not be identified as hydric by using the currently approved FI. This lack of a suitable FI could cause wetland consultants to omit significant areas when delineating the hydric soil component of wetland landscapes. One group of these problematic soils have been identified on low-lying (<2 m) landscapes that were subtly linear-to-convex in form, and usually within 100-200 m of the marsh or water’s edge. These have been termed Anomalous Bright Loamy Soils (ABLS).

Research was conducted to evaluate the hydrologic and hydro-geomorphic components of these problem-soils. Consequently, a number of these Anomalous Bright Loamy Soils were thought to be hydric soils based on the TS; however there was no currently accepted field indicator that identified ABLS-soils as hydric. Therefore, the objective of this study was to either modify an existing Field Indicator or to develop a new FI that could be used to effectively identify ABLS-soils as hydric soils.

MATERIALS AND METHODS

Study Sites

Four study sites were selected on the Delmarva Peninsula that were representative of the ABLS soil-landscape setting. At each of the four sites, a lower, middle, and upper position was identified on a transect. Each transect covered a range of wetness conditions with the lower (and the wettest - assumed to be hydric) positions being closest to the water's edge, and the upper (and the driest - assumed to be non-hydric) positions being farthest from the water. Sites were chosen where the hydrology and drainage were unaltered or minimally impacted by human activities, and where access to the sites was limited to minimize disturbance and vandalism. Sites are located on the Delmarva Peninsula (Fig. 7-2), with three in Maryland and one in Delaware. The Maryland sites were at the Blackwater National Wildlife Refuge in Dorchester County, at the Isle of Wight Wildlife Management Area in Worcester County, and at the Eastern Neck Island National Wildlife Refuge in Kent County. The Delaware site was located at the Ted Harvey Wildlife Area in Kent County.



ABLS Site Locations

Eastern Neck Island NWR
Kent County, Md

Ted Harvey WA
Kent County, De

Isle Of Wight, WMA
Worcester County, Md

Blackwater NWR
Dorchester County, Md

Figure 7-2: Four study site locations on the Delmarva Peninsula (yellow area) marked by orange circles.

Water Tables

To determine whether these soils met the saturation requirement of the TS, automated recording wells (RDS WL80) were installed at each of the twelve point-locations of the transects. Two-meter wells were installed to an approximate depth of 1.5 m (so that any possible ponding or flooding events could also be recorded) (Sprecher, 2008). They were programmed to record water tables twice daily. Data were downloaded from the wells using a hand-held Hewlett-Packard calculator with an infrared interface at monthly intervals. To ensure that the automated wells were operating properly, open auger holes were maintained so that water table levels could be observed and compared with the data from the recording wells.

Soils

Morphological descriptions of the soil were made at each of the twelve point-locations to evaluate whether or not these soils met any of the current hydric soil field indicators. Soil pits were excavated by hand to depths ranging from 88 cm 170 cm (depending on where the water table was at the time of sampling), and were then described and sampled by horizon (Soil Survey Staff, 1993). At the base of some of the pits, auger borings were made in order to describe the soil at greater depths ranging from 129 cm to 335 cm. Particular attention in the descriptions was given to soil matrix colors and redoximorphic features. Redox features were estimated to the nearest percent using standard charts as guides (Schoeneberger et al., 2002).

Soil Eh and pH

Oxidation-reduction (“redox”) potentials were measured every two weeks during the wet season (approximately November through April), then once every 4-6 weeks during the drier times of the year. Measurements were made using six replicate platinum-tipped (Pt) electrodes, paired with six calomel reference electrodes, and six voltmeters. The Pt electrodes were inserted into the soil at five depths (10cm, 20cm, 30cm, 40cm, and 50cm) and allowed to equilibrate for a short period of time (2-5 minutes) before voltages were recorded. Soil pH was also measured on the same dates and at the same depths where redox potentials were measured. A 16-mm soil corer was used to extract samples that were made into a 1:1 slurry using de-ionized water. Measurements were made with a portable field pH meter.

Precipitation

Precipitation data were originally intended to be collected on-site at all four locations. Data-recording tipping-bucket rain gauges were installed at the Isle of Wight, the Eastern Neck Island, and the Ted Harvey sites (the Blackwater site was not instrumented). However, due to regular mechanical failure and animal (insect) intrusion, these data were soon considered unreliable. Because of the inconsistent data from the rain gauges, rainfall data from nearby weather stations were obtained. A weather station in Vienna, Md (Dorchester County: latitude/longitude: 38°29'N / 75°49'W) was referenced for the Blackwater research site (approximately 19 km (12 mi) away); the weather station at the Ocean City Airport (Worcester County: latitude/longitude: 38°19'N / 75°07'W) located in Ocean City, Md was referenced for the Isle of Wight research site (approximately 8 km (5 mi) away); a weather station in Chestertown, Md (Kent County, Md: latitude/longitude: 39°13'N / 76°03'W) was referenced for the Eastern Neck Island research site (approximately 20 km (12 mi) away); and a weather station in Dover, De (Kent County, De: latitude/longitude: 39°16'N / 75°31'W) was referenced for the Ted Harvey research site (approximately 7 km (4 mi) away).

RESULTS AND DISCUSSION

Water Tables and Redox Potentials

Soils at all four sites experienced water tables near or to the surface for extended periods of time during some parts of every year. Based on cumulative frequency distribution data of water tables, Fig. 7-3 illustrates the degree to which

ABLS-soils were saturated to within 0.25 m of the mineral soil surface. The Blackwater site was clearly the wettest of all four sites with saturation to -0.25 m at the lower well occurring for nearly 95% of the three-year monitoring period. The soils at the Ted Harvey site were the least wet with saturation to -0.25 m occurring for less than 45% of the time at the lower well. Wetness conditions at the Isle of Wight and Eastern Neck Island sites were intermediate.

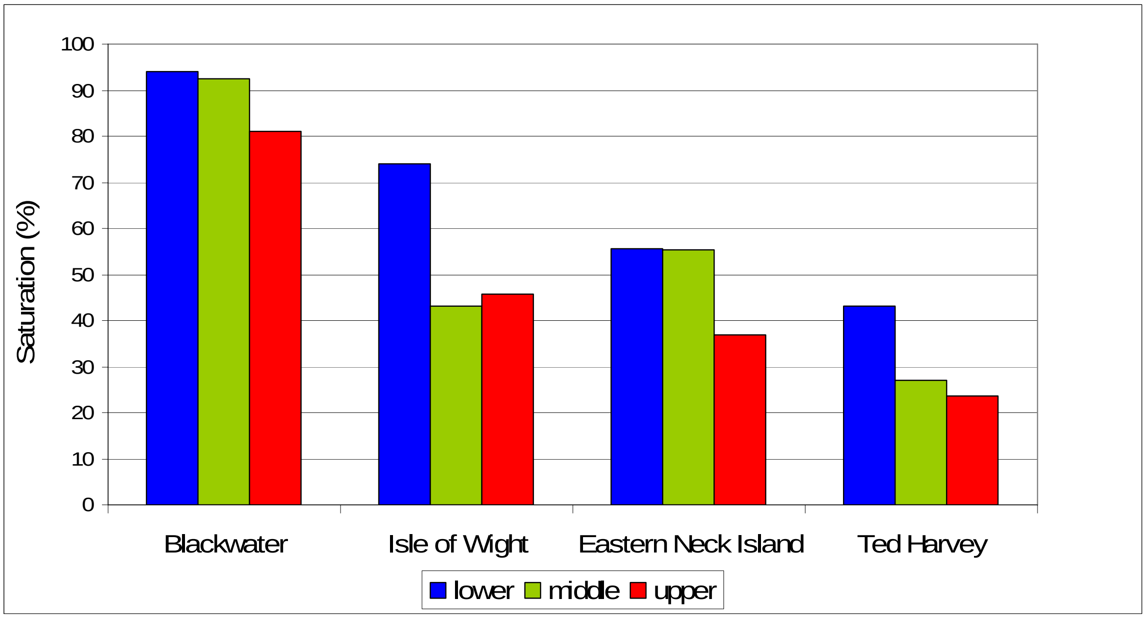


Figure 7-3: Percentage of the year that water tables were within 25 cm of the soil surface in the recording wells at the four research sites in this study (February, 2001 - February 2004).

Redox data presented in Figures 7-4, 7-5, 7-6, and 7-7 illustrate the oxidation-reduction potential that occurs in ABLS-soils when they become saturated. Redox potentials (Eh) were plotted relative to the TS so that Eh-values below the TS-line are shown as “negative” and soils were considered to be “reducing”. Where Eh-values plotted above the TS-line, they are shown as “positive” and soils were considered to be “not-reducing”.

The Blackwater site was excessively saturated, with water tables remaining close to the surface essentially all year long. Because of this, redox potentials at this site were similar among the lower, middle, and upper positions, differing only slightly in the upper 20 cm between the lower and the upper positions (Figs. 7-3 and 7-4). At the Isle of Wight site, the only notable anomaly that occurred in the relationship between site positions and wetness conditions was at the middle and upper wells. The water tables at the upper well appeared to be affected by the hydrology of a seasonally ponded area approximately 50 m away. This resulted in the soil at the upper well being slightly wetter than the soil at the middle well, which also affected redox potentials accordingly (Figs 7-3 and 7-5). At the Eastern Neck Island site, the lower and middle positions experienced nearly identical water tables and redox potentials (Figures 7-3 and 7-6). The Ted Harvey site was the driest of all four sites, experiencing minimal occurrence of surface ponding (Figures 7-3 and 7-7).

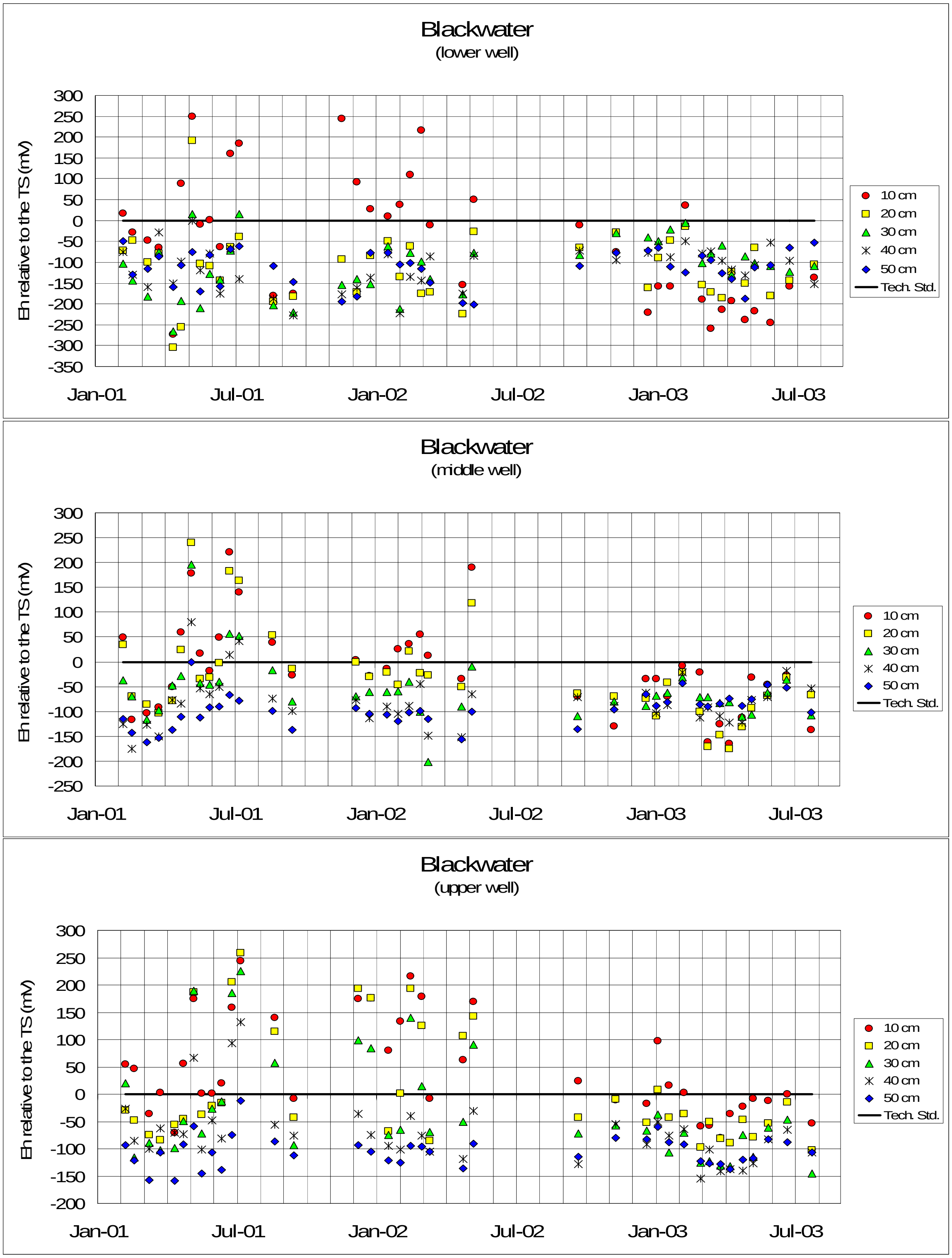


Figure 7-4: Soil redox potentials measured at 10 cm – 50 cm at the Blackwater site (lower, middle, and upper site positions), plotted relative to the Technical standard (black, horizontal line at 0 mV). Positive values would be oxidizing with respect to Fe and negative values would be considered reducing with respect to Fe.

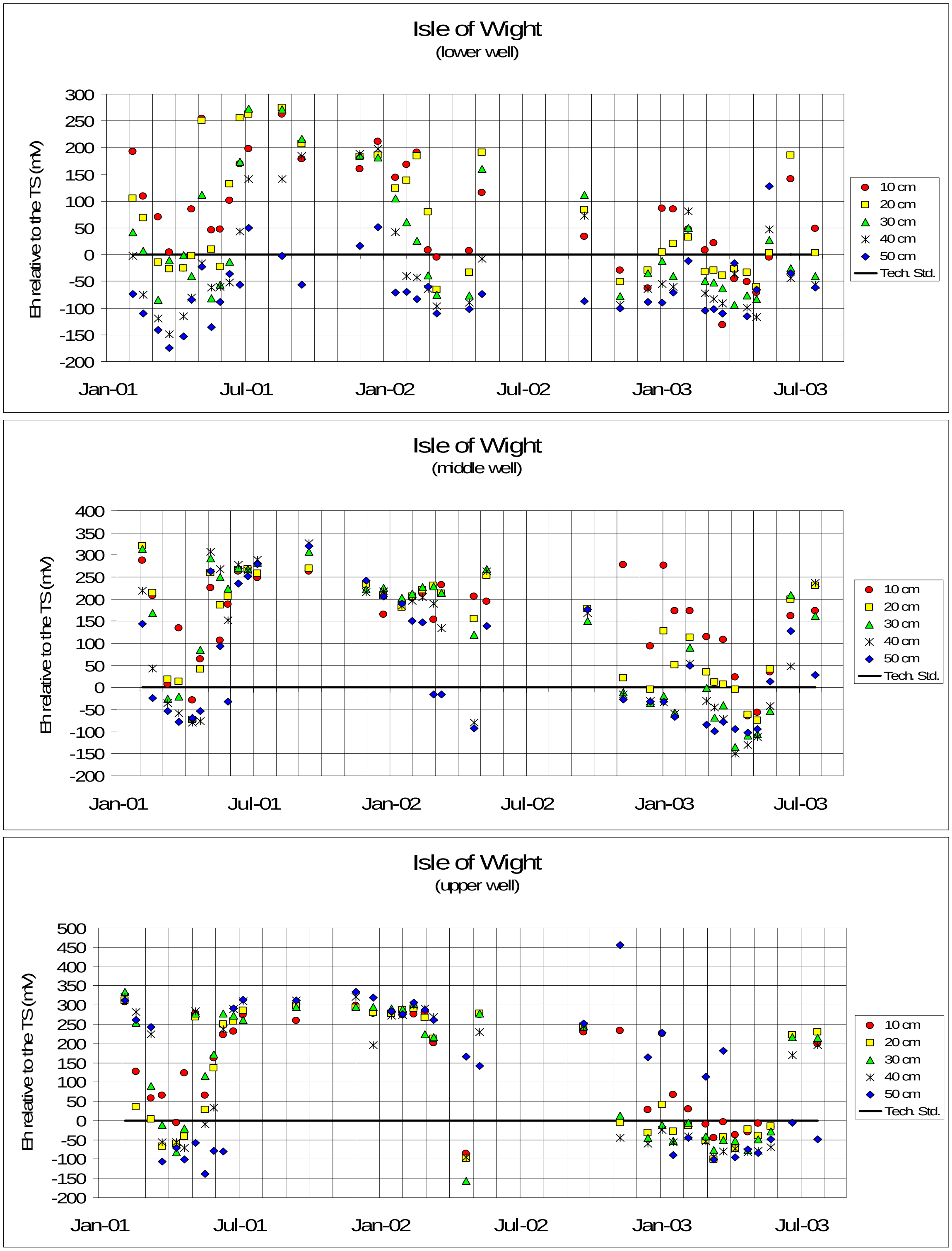


Figure 7-5: Soil redox potentials measured at 10 cm – 50 cm at the Isle of Wight site (lower, middle, and upper site positions), plotted relative to the Technical standard (black, horizontal line at 0 mV). Positive values would be oxidizing with respect to Fe and negative values would be considered reducing with respect to Fe.

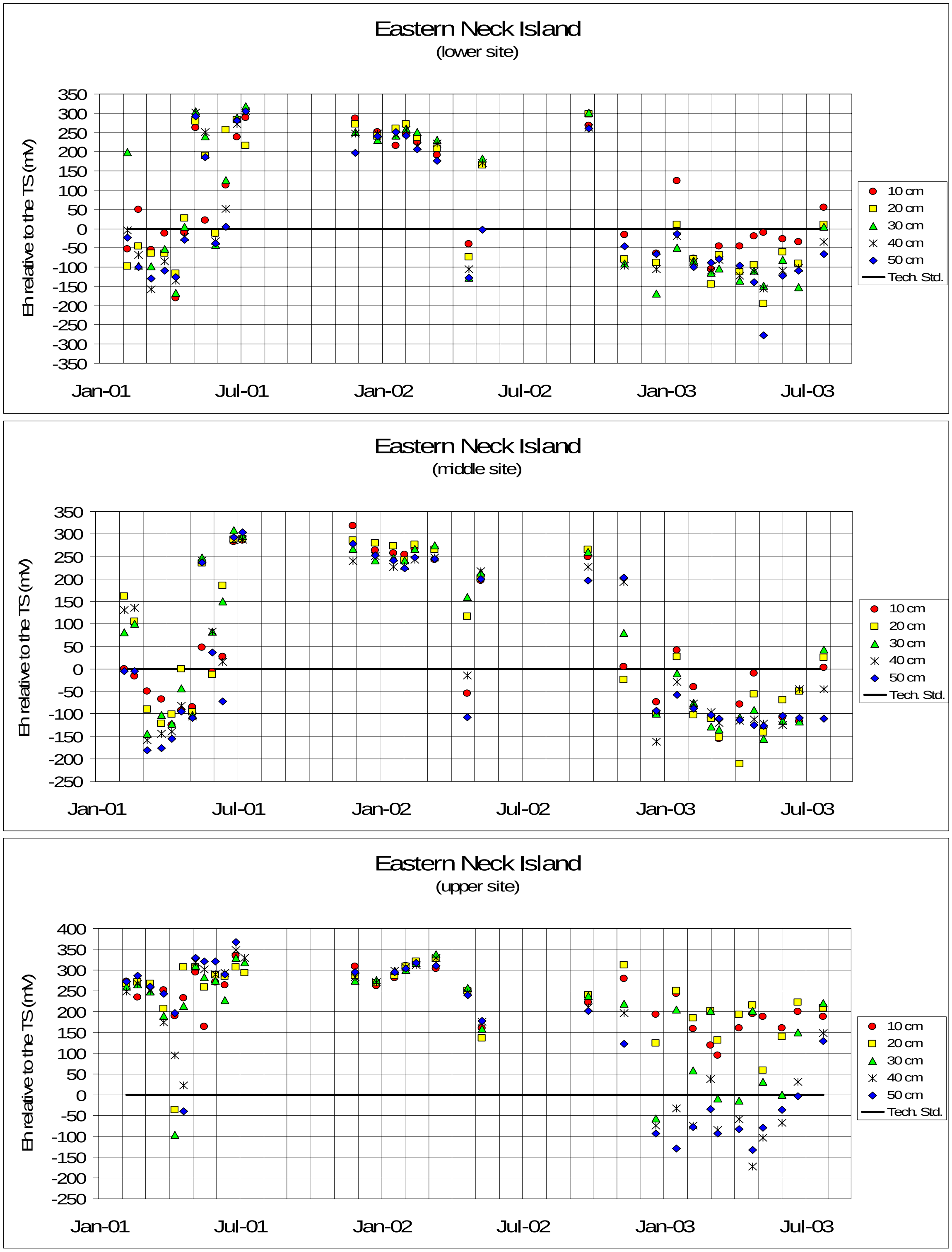


Figure 7-6: Soil redox potentials measured at 10 cm – 50 cm at the Eastern Neck Island site (lower, middle, and upper site positions), plotted relative to the Technical standard (black, horizontal line at 0 mV). Positive values would be oxidizing with respect to Fe and negative values would be considered reducing with respect to Fe.

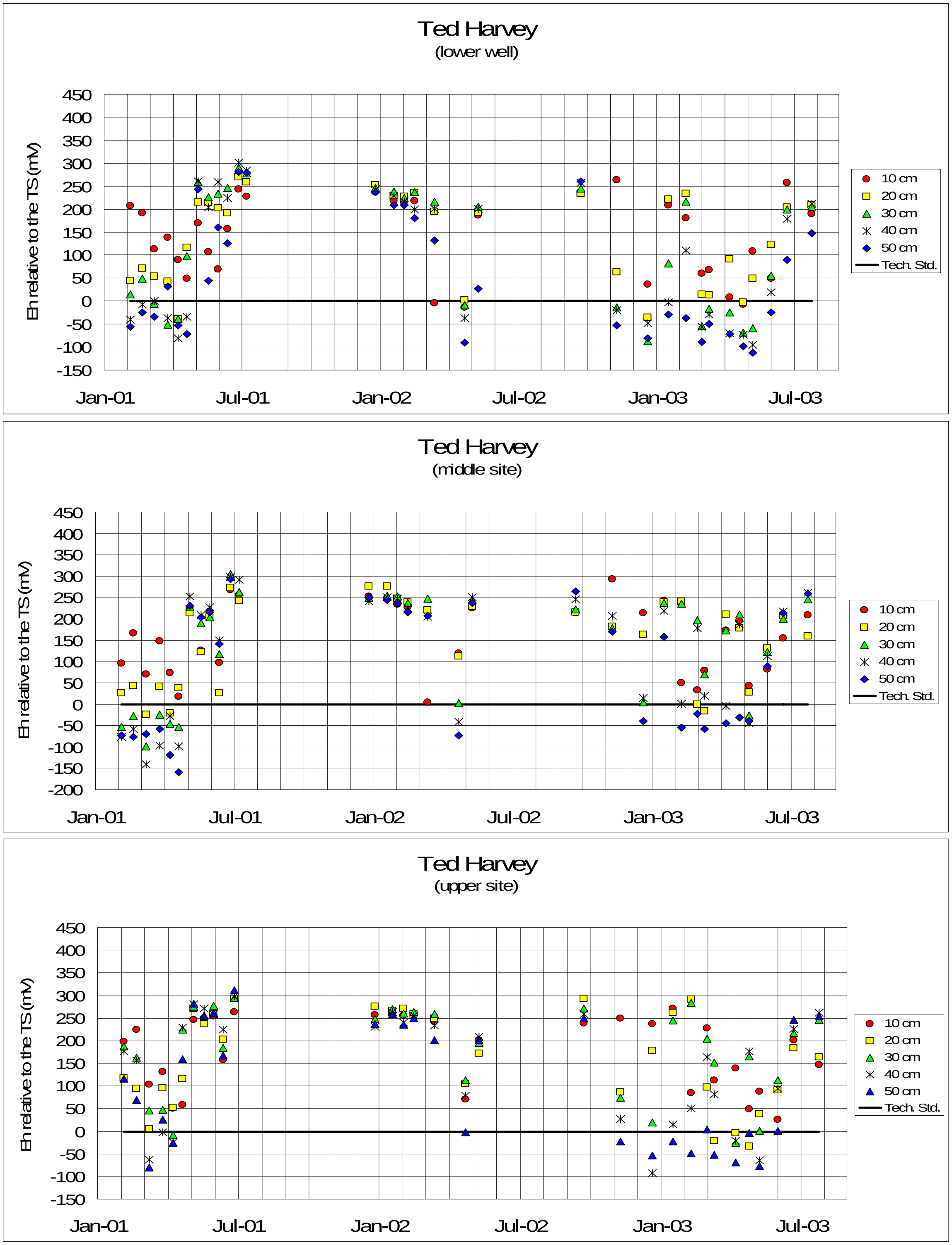


Figure 7-7: Soil redox potentials measured at 10 cm – 50 cm at the Ted Harvey site (lower, middle, and upper site positions), plotted relative to the Technical standard (black, horizontal line at 0 mV). Positive values would be oxidizing with respect to Fe and negative values would be considered reducing with respect to Fe.

Precipitation

According to the TS, for a soil to be considered “hydric”, it must meet water table and redox requirements during a period of “normal” precipitation. Rainfall is considered to be “normal” when the quantity falls within the range of the 30th to the 70th percentiles of the long-term local averages. For the ABLS-study, these statistics were available also from the same stations that supplied monthly precipitation averages. The precipitation data recorded at weather stations near to each of the research sites are illustrated in Figures 7-8 through 7-11.

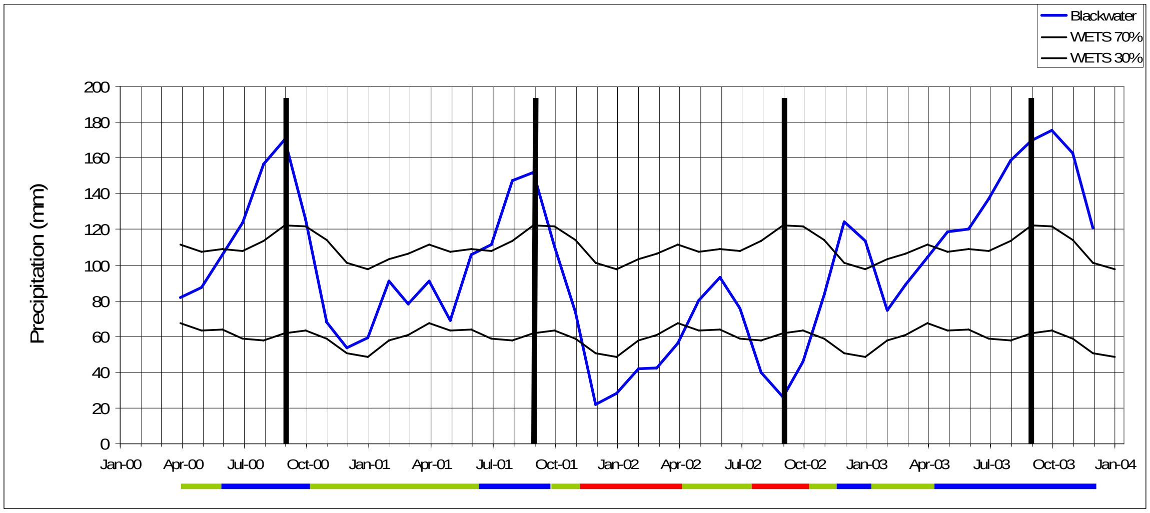


Figure 7-8: Precipitation data collected at Vienna, Md for the Blackwater site. The three-month running average of data is shown in reference to the 30th and 70th percentiles. The colored horizontal line along the bottom of the graph shows periods when the precipitation is above average (blue), average (green), and below average (red).

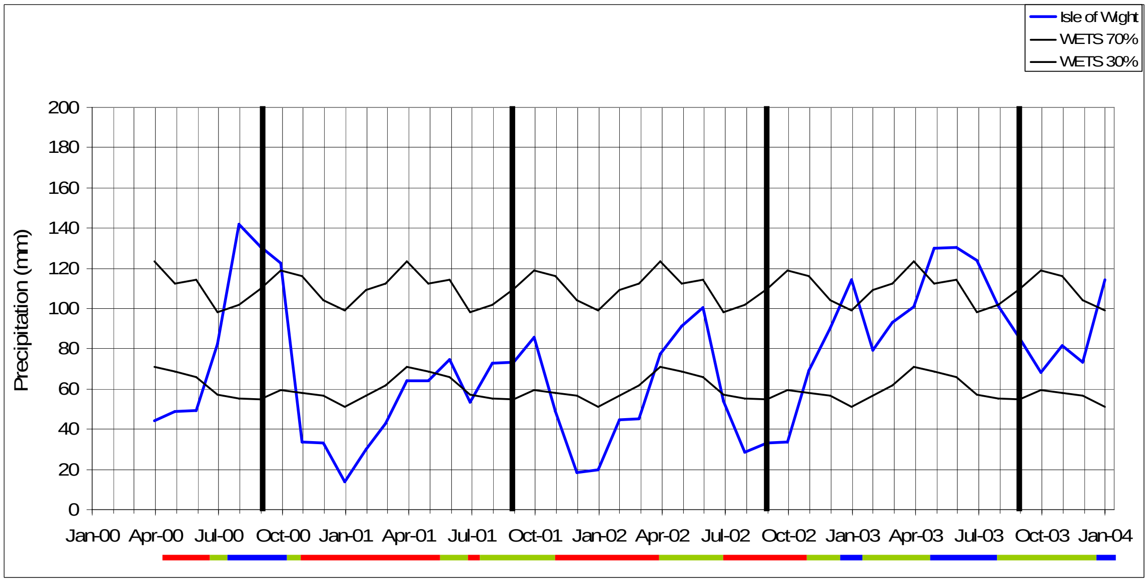


Figure 7-9: Precipitation data collected at the Ocean City Airport, Md for the Isle of Wight site. The three-month running average is shown in reference to the 30th and 70th percentiles. The colored horizontal line along the bottom of the graph shows periods when precipitation is above average (blue), average (green), and below average (red).

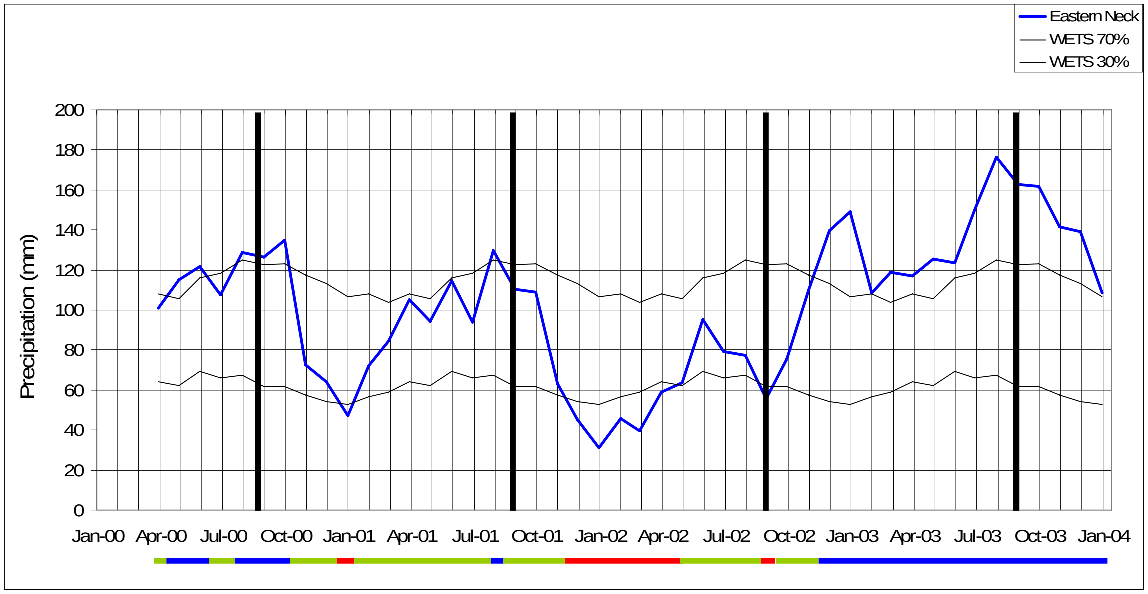


Figure 7-10: Precipitation data collected at Chestertown, Md for the Eastern Neck Island site. The three-month running average is shown in reference to the 30th and 70th percentiles. The colored horizontal line along the bottom of the graph shows periods when precipitation is above average (blue), average (green), and below average (red).

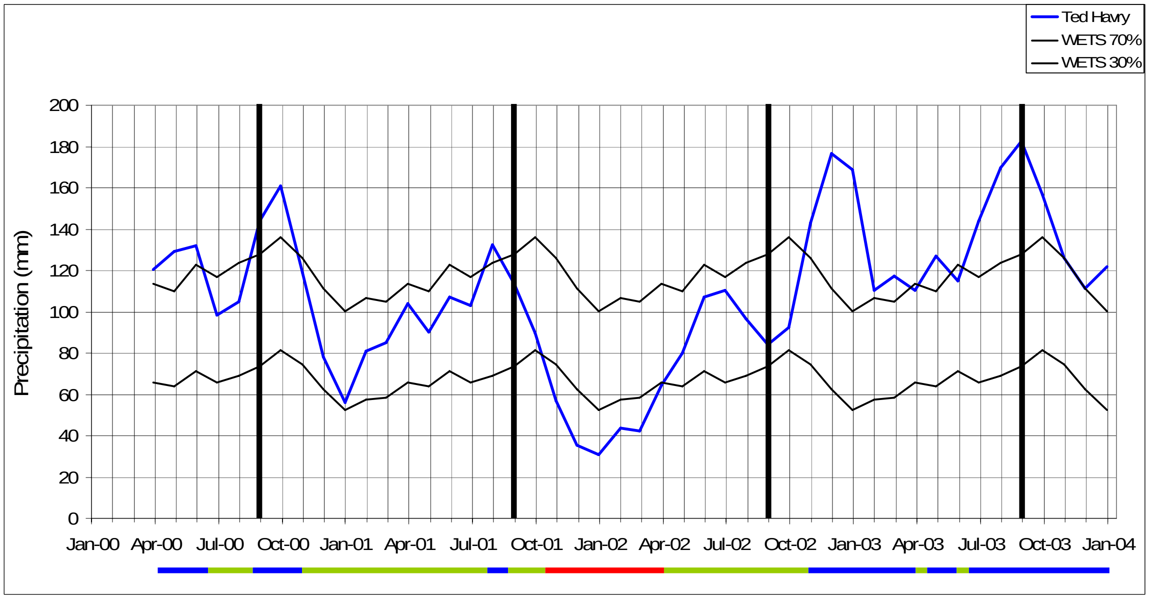


Figure 7-11: Precipitation data collected at Dover, De for the Ted Harvey site. The three-month running average is shown in reference to the 30th and 70th percentiles. The colored horizontal line along the bottom of the graph shows periods when precipitation is above average (blue), average (green), and below average (red).

Table 7-1: Amount of precipitation during the periods from November through May during three hydrological years. In general, the 2000-2001 period was normal (although it was dryer than normal at the IOW-site). The 2001-2002 period was dryer than normal at all sites, and the 2002-2003 period was wetter than normal at all sites.

	Annual Wet Season		
Site	11/2000 – 5/2001	11/2001 – 5/2002	11/2002 – 5/2003
Blackwater	Normal	Dry	Wet
Isle of Wight	Dry	Dry	Slightly Wet
Eastern Neck	Normal	Dry	Wet
Ted Harvey	Normal	Dry	Wet

Soil Saturation and Reduction

For a soil to be considered "hydric" by the TS, it must experience simultaneous saturation and reduction for a period of at least 14 consecutive days. Figures 7-12 through 7-15 show the periods when water tables occurred at 20 cm and 30 cm below the soil surface (thick, colored lines) and, also (at these depths), periods when soils were reducing with respect to iron (thin, colored lines with markers). Water tables and reduced conditions were then correlated to show periods when simultaneous saturation and reduction occurred in the soil at 20 cm and 30 cm (thin, black lines). These data are summarized in Table 7-2 showing the length individual events (days) when soils were simultaneously saturated and reduced.

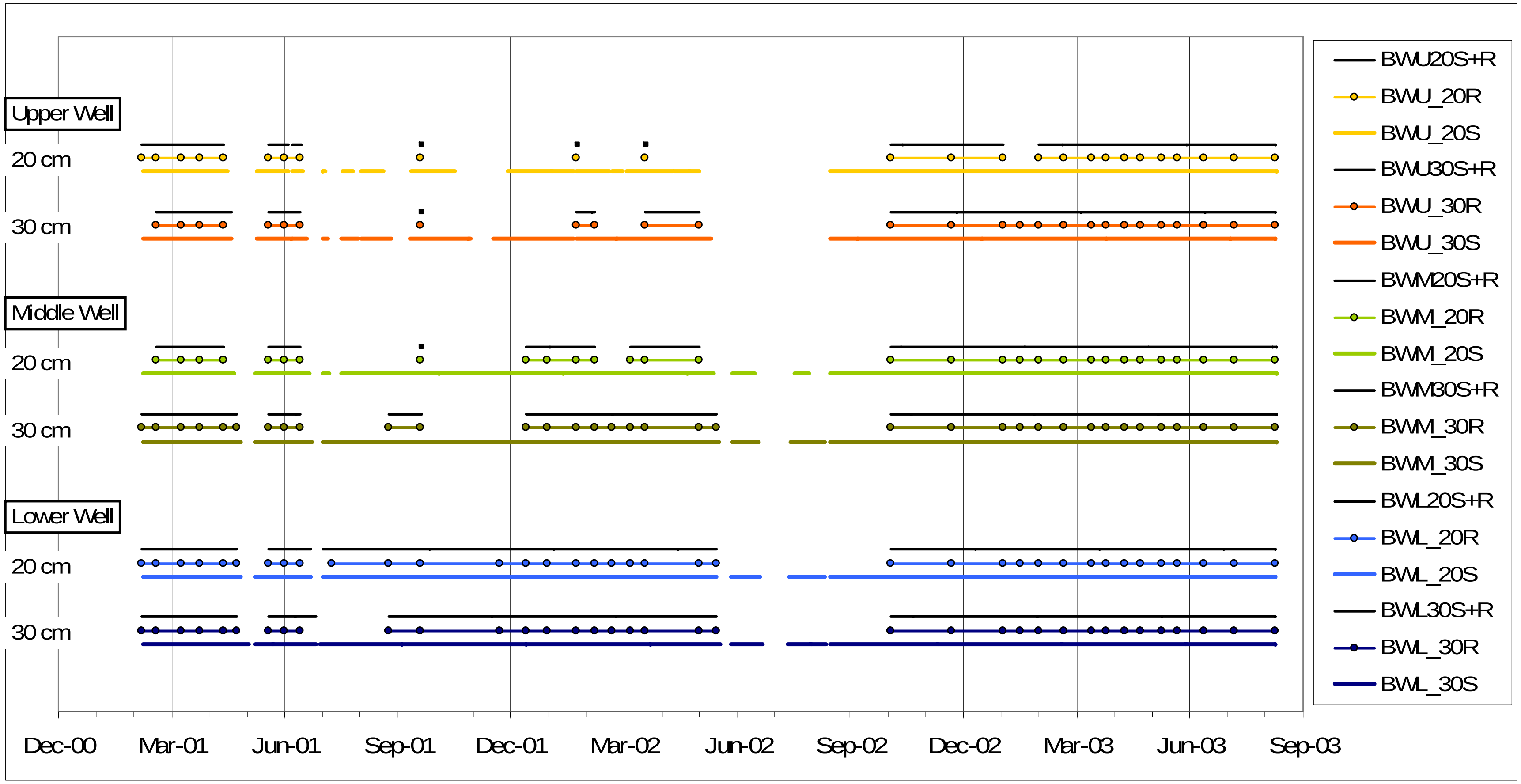


Figure 7-12: Periods when soils at the Blackwater site were saturated and reducing at depths of 20 cm and 30 cm. Thick, colored lines represent periods of saturation (S); thin, colored lines with markers represent reduced conditions (R); thin black lines represent periods of simultaneous saturation and reduction (S+R).

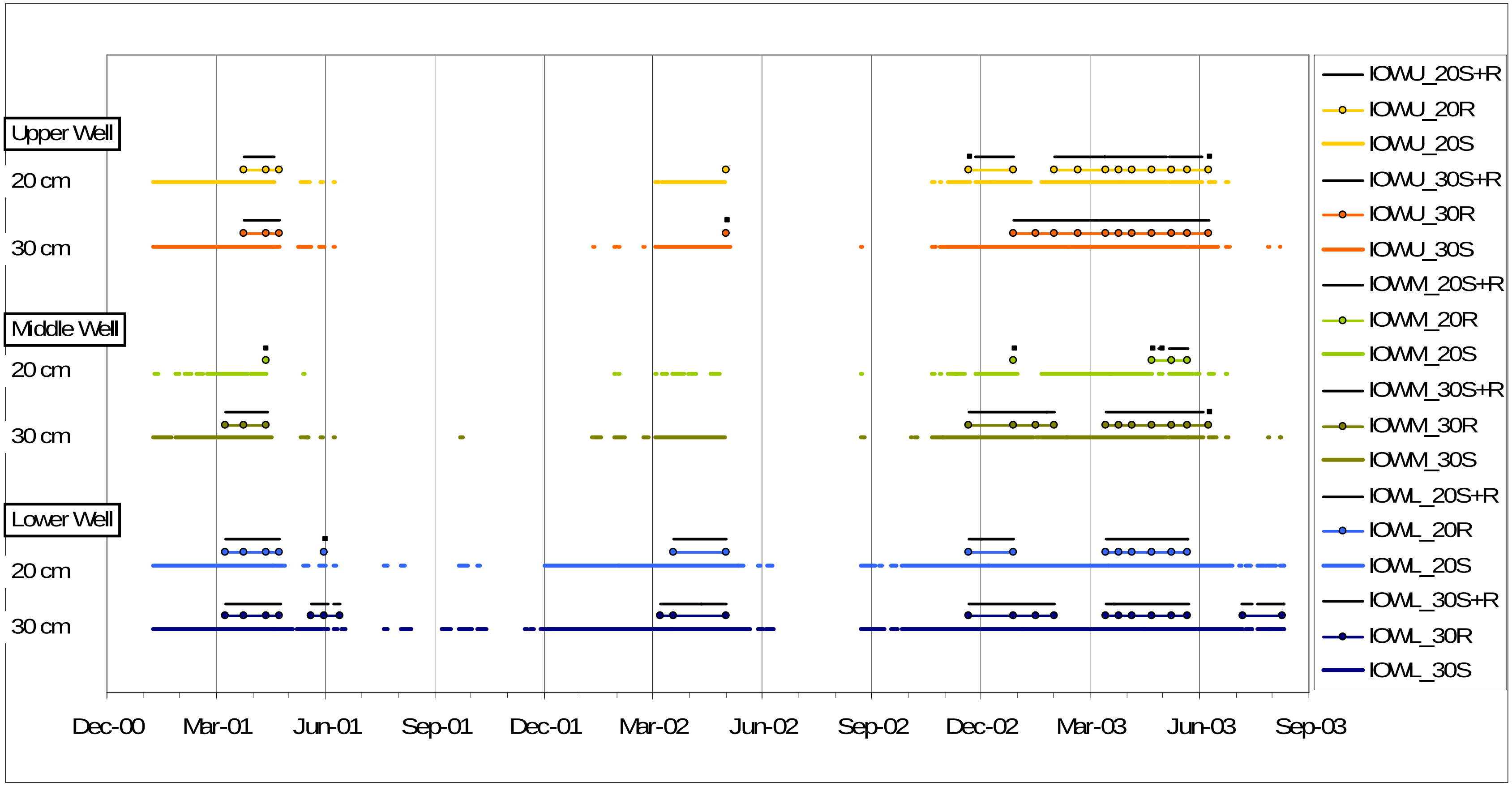


Figure 7-13: Periods when soils at the Isle of Wight site were saturated and reducing at depths of 20 cm and 30 cm. Thick, colored lines represent periods of saturation (S); thin, colored lines with markers represent reduced conditions (R); thin black lines represent periods of simultaneous saturation and reduction (S+R).

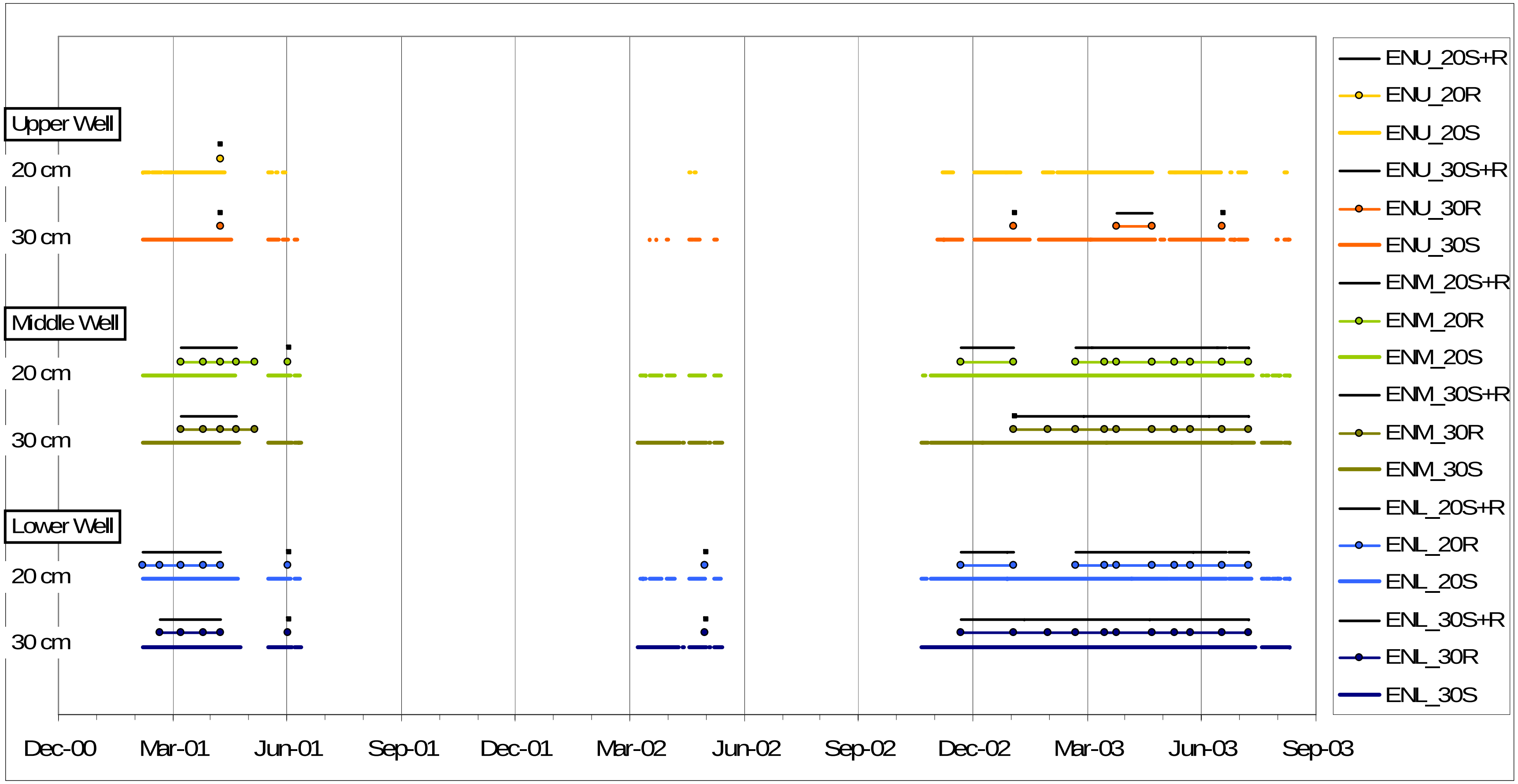


Figure 7-14: Periods when soils at the Eastern Neck Island site were saturated and reducing at depths of 20 cm and 30 cm. Thick, colored lines represent periods of saturation (S); thin, colored lines with markers represent reduced conditions (R); thin black lines represent periods of simultaneous saturation and reduction (S+R).

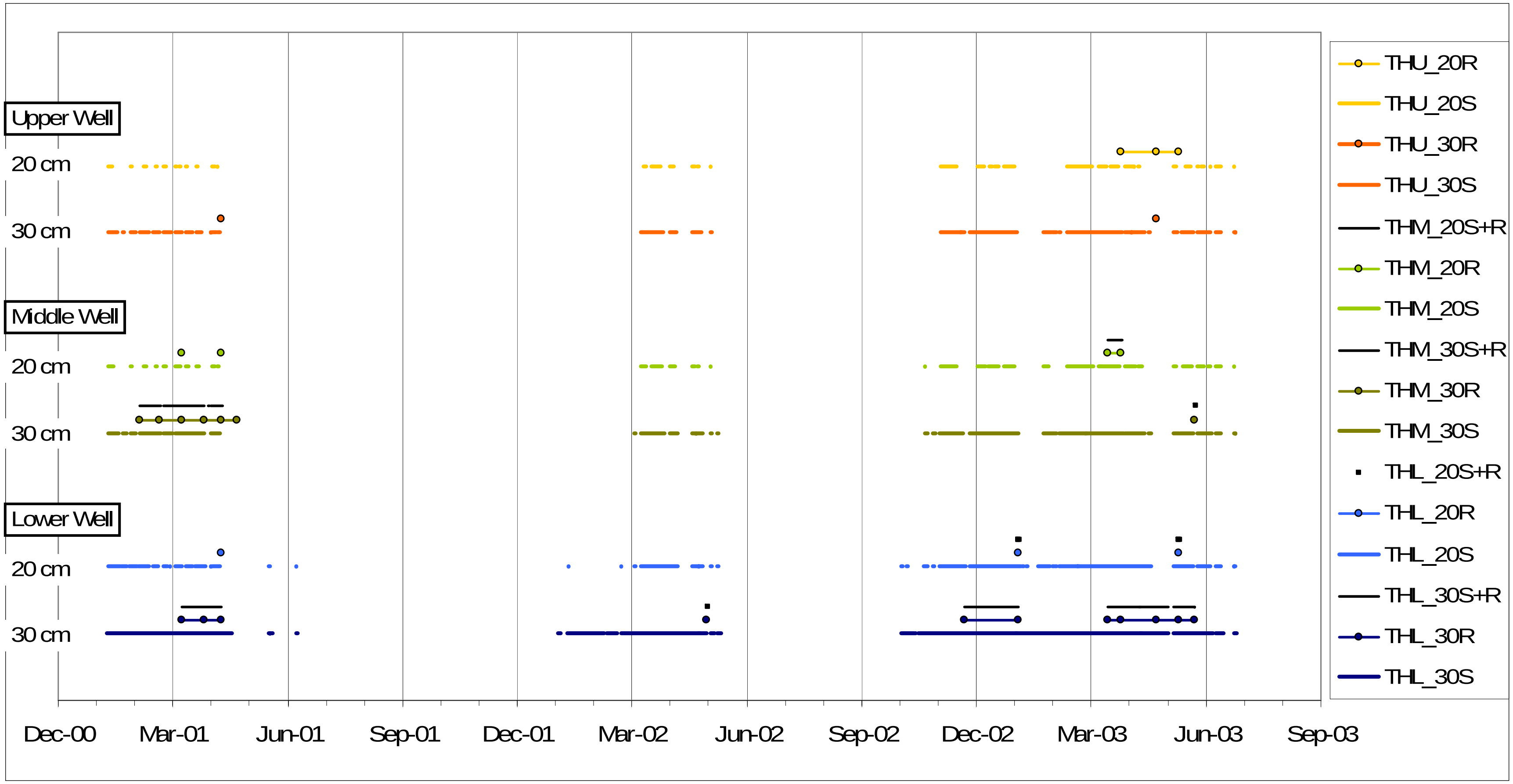


Figure 7-15: Periods when soils at the Ted Harvey site were saturated and reducing at depths of 20 cm and 30 cm. Thick, colored lines represent periods of saturation (S); thin, colored lines with markers represent reduced conditions (R); thin black lines represent periods of simultaneous saturation and reduction (S+R).

Table 7-2: Length of duration (days) of individual events when soils show simultaneous saturation and reduction at depths of 20 cm and 30 cm at the Blackwater, Isle of Wight, Eastern Neck Island, and Ted Harvey research sites. Numbers in bold indicate a period lasting for a minimum of 14 consecutive days. Paired numbers in italics represent a continuous episode of saturation across years.

		Site Position					
		Lower		Middle		Upper	
Site	Year	20 cm	30 cm	20 cm	30 cm	20 cm	30 cm
Blackwater	2001	**77** **35**	**77** **39**	**54** **26** 7	**77** **26** **27**	**66** **16** 7 7	**61** **26** 7
	2002	***173*** ***144***	***120*** ***144***	***9*** ***15*** **55**	***9*** ***144***	7 7	**15** **44**
	2003	***80*** ***230***	***80*** ***230***	***80*** ***231***	***80*** ***231***	***80*** ***10*** **191**	***80*** ***230***
Isle of Wight	2001	**45** 7	**45** **14** 6	7	**35**	**26**	**30**
	2002	**44**	**55**			7	7
	2003	***31*** ***5*** **70**	***31*** ***39*** **70** 9 **22**	7 7 **16**	***30*** ***40*** **82** 7	**32** **94** **28** 7	**163**
Eastern Neck Island	2001	**63** 7	**49** 7	**44** 7	**44**	7	7
	2002	7	7				
	2003	***30*** ***11*** **120** **16**	***30*** ***198***	***30*** ***11*** **120** **16**	**187**		7 **28** 7
Ted Harvey	2001		**32**		**17** **32** 10		
	2002		7				
	2003	7 7	***30*** ***11*** **48** **17**	11	7		

Those soils that were shown to be simultaneously reducing and saturated for 14 days during a "normal" (or dry) year were identified as hydric, according to the TS. The morphology of all soils was then evaluated to see whether or not they met a current FI. This was compared with whether or not they were hydric according to the TS.

Of the twelve soils that were evaluated, three met one of the currently approved Field Indicators of Hydric Soils. These soils were at the lower and middle positions of the Blackwater site and at the lower position of the Ted Harvey site. The two soils at Blackwater met the requirements of Field Indicator F3 (*Depleted Matrix)*, and the one soil at Ted Harvey met Field Indicator F6 (*Redox Dark Surface)*. All three of these also met the requirements of the TS. Of the remaining nine soils that did not meet one of the approved Field Indicators, five soils were hydric based on the TS and four were not hydric according to the TS (Tab. 7-3).

Table 7-3: Summary evaluations of soils at the study sites showing whether or not they are hydric soils according to the Technical Standard and whether or not they meet a currently approved Field Indicator for hydric soils. Labels in bold indicate where the soil was shown to be hydric according to the TS, but was lacking a currently approved FI.

Site	Site Position	Technical Standard	Currently Approved Field Indicator
Blackwater	Lower	Hydric	F3 (Depleted Matrix)
	Middle	Hydric	F3 (Depleted Matrix)
	Upper	Hydric	X
Isle of Wight	Lower	Hydric	X
	Middle	NH	X
	Upper	Hydric	X
Eastern Neck Island	Lower	Hydric	X
	Middle	Hydric	X
	Upper	NH	X
Ted Harvey	Lower	Hydric	F6 (Redox Dark Surface)
	Middle	NH	X
	Upper	NH	X

Hydric ABLS-Soils

The morphology of hydric ABLS-soils on the Mid-Atlantic coastal plain was not typical when compared to other soils that experienced similar wetness conditions. These soils may be considered problematic in that they misrepresent their wetness status by appearing (morphologically) as though water tables occurred lower in the soil profile. Matrix colors in ABLS-soils were recorded as commonly having 2.5Y hues and chromas of 3-5, depending on how wet the soils were. Pedons that experienced wetter conditions were more likely to have a matrix color with chromas of 3 and 4; whereas those pedons that experienced water tables lower in the profile, had chroma colors greater than 4 (complete soil descriptions are listed in chapter 4: "Relationship of Soil Morphology and Water Tables").

In examining these five soils that were hydric according to the TS, but did not meet a FI, it was noted that, in general, they had an abundance of redox concentrations in the upper part, but typically had brighter matrix colors of chroma 4. By carefully comparing the morphology and distinguishing between those soils that were, or were not hydric according to the TS, we were able to formulate a draft Field Indicator.

The proposed indicator requires the soils to have a mineral layer at least 10 cm (4 inches) thick starting within 20 cm (8 inches) of the soil surface with matrix (60 percent or more of the volume) chroma of less than 5 and 10 percent or more distinct or prominent redox concentrations occurring as soft masses or pore linings and/or depletions. When this draft indicator was initially applied to these five hydric ABLS-soils that were missed by the current Indicators, the proposed indicator captured all five as hydric. In addition, when compared with the four pedons that were not hydric according to the TS, none of the soils met the proposed indicator. Evaluation of ABLS-soils using the Technical Standard criteria, the currently approved Field Indicators of Hydric Soils, and the proposed indicator for ABLS-soils, the proposed indicator captured (as hydric) all five of those soils that met the TS, but none of the fours soils that did not meet the TS. Therefore, this proposed indicator was found to be “proof-positive”, as is required of all Indicators (Tab. 7-4).

Table 7-4: Evaluation of 12 soils in the ABLS-study using the proposed Field Indicator for ABLS-soils. All five of the hydric soils (according to the TS) that did not meet an approved FI, were identified with the proposed FI. None of the four non-hydric soils were identified using the proposed indicator. NH= not hydric; X=does not meet indicator.

Site	Site Position	Technical Standard	Currently Approved Indicator	Proposed Indicator
Blackwater	Lower	Hydric	F3 (Depleted Matrix)	Hydric
	Middle	Hydric	F3 (Depleted Matrix)	X
	Upper	Hydric	X	Hydric
Isle of Wight	Lower	Hydric	X	Hydric
	Middle	NH	X	X
	Upper	Hydric	X	Hydric
Eastern Neck Island	Lower	Hydric	X	Hydric
	Middle	Hydric	X	Hydric
	Upper	NH	X	X
Ted Harvey	Lower	Hydric	F6 (Redox Dark Surface)	Hydric
	Middle	NH	X	X
	Upper	NH	X	X

EPILOGUE

The data and draft indicator that were presented in this paper were submitted to the National Technical Committee on Hydric Soils (NTCHS) for review early in 2005. Following the review, the NTCHS approved this proposed Field Indicator in January of 2006 as a new Field Indicator of Hydric Soils (USDA-NRCS, 2006). This new Field Indicator is identified as “F20: Anomalous Bright Loamy Soils”. Soils that are identified as hydric using the F20 Indicator are common to landscapes that are linear to slightly convex, occurring within 200 meters from estuarine marshes or waters, and within 1 meter of mean high water. The F20 Indicator for identifying hydric ABLS-soils was approved for use in Major Land Resource Area (MLRA) 149A of Land Resource Region (LRR) S and MLRAs 153C and 153D of LRR T; and for testing in MLRA 153B in LRR T.

8) Thesis Conclusions

Water tables that come close to the soil surface for extended periods of time affect the biogeochemistry of the soil. The stability and solubility of soil minerals such as manganese and iron are determined by the redox potentials that develop under saturated and reduced conditions. According to the Technical Standard of the NTCHS, on average ABLS-soils developed reducing conditions sufficient to reduce iron after 43 days of continuous saturation. It was also shown that the rate at which saturated ABLS-soils develop reducing conditions is a function of soil temperature and thus could be as short as 18 days (at approximately 19°C) or as long as 123 days (at approximately 4°C).

Research conducted on the Delmarva Peninsula proved that ABLS-soils were simultaneously saturated and reduced, yet did not develop redoximorphic features consistent with their saturation. No distinct or prominent redoximorphic features were described in horizons that were saturated for less than 22% of the three-year study period. For iron concentrations to form in horizons without 2-chroma depletions, an average saturation of 54% (ranging from 22 to 82%) was required. Iron depletions formed in horizons that were saturated for an average of 78% (ranging from 41 to 100%), while depleted matrices developed only when saturation rates averaged 96% (ranging from 82 to 100%). Comparing these result to those of similar studies in other pedological settings, ABLS-soils required significantly longer saturation periods to develop comparable redoximorphic features. Only the study conducted by Castenson (2004), investigating the problematic Piedmont floodplain soils, reported similar results.

Four research sites on the Delmarva Peninsula, representing ABLS-soils, showed that soils were saturated at 30 cm for between 17 weeks (Ted Harvey site – upper soil) and 49 weeks (Blackwater site – lower soil) out of the year. During these periods of saturation, redox potentials were sufficiently low to develop anaerobic and reducing conditions to reduce ferric to ferrous iron. Because the observed soil morphology was inconsistent with the degree of wetness they experienced, the propensity of these soils to form redoximorphic features was investigated in the lab. Measured CCPI values were shown to range from 53 to 141, with a mean of 71, which demonstrated that these soils were within the "non-problematic" range of the CCPI-scale. Therefore, the soil parent material was ruled out as a significant factor in causing the soils to show uncharacteristic hydromorphology.

To determine whether hydrological flow and limits to leaching of reduced iron might be a determining factor contributing to the ABLS-phenomenon, soil cores from the Isle of Wight site were leached under continuously saturated and reduced conditions in the lab. An average of 3.92 g of iron was leached from the control cores, while the cores treated with dextrose and the cores treated with leaves lost an average of 2.18 g and 5.30 g of iron, respectively. The addition of ground leaves resulted in increased Fe-leaching. It was surprising, however, that the cores treated with dextrose had notably lower leaching rates of Fe compared to the leached control group. It was unclear what caused this; however speculations have been made relating these results to the effects of dextrose on anaerobic bacterial populations. After approximately six months of leaching, distinct changes in matrix colors were observed in all cores regardless of treatment. Matrix chroma colors changed from 2.5Y 5/4 to 2.5Y 5/3+, while matrix hues and values essentially remained unaffected. The continual leaching iron from all cores appeared to have no influence on either the formation or removal of redoximorphic features that were present. Results of this leaching experiment suggest that the explanation of the ABLS-phenomenon may be related to a low, lateral hydrologic gradient that inhibits soluble, reduced Fe from being moved out of the system and is instead allowed to re-oxidize, in-situ. An alternate, actually related explanation for this phenomenon may be that these soils have not experienced saturated and reducing conditions long enough (years/decades) for the morphology to reflect that of a hydric soil.

Anomalous Bright Loamy Soils on the Delmarva Peninsula represent a group of soils found in a distinctive, pedological setting in the Mid-Atlantic coastal plain. Many of these soils are saturated and reducing, and therefore would be considered hydric by the Technical Standard, yet they do not meet any of the Field Indicators of Hydric Soils (USDA-NRCS, 2002). A proposed Field Indicator was developed to assist in identifying these unusual hydric soils. This Indicator requires a mineral layer at least 10 cm (4 inches) thick starting within 20 cm (8 inches) of the soil surface with matrix (60 percent) or more of the volume) chroma of less than 5 and 10 percent or more distinct or prominent redox concentrations occurring as soft masses or pore linings and/or depletions. This indicator identified five ABLS-soils as hydric that were previously missed because of a lacking Indicator and succeeded in discriminating against four soils that did not meet the TS. Based on the work presented in this thesis, the National Technical Committee on Hydric Soils (NTCHS) approved this proposed Field Indicator, which was accepted in January of 2006. The Field Indicator is identified as “F20: Anomalous Bright Loamy Soils”.

Appendix A: Soil Descriptions

Soil Description: Blackwater National Wildlife Refuge, Dorchester County, MD
Site Position: Lower Well
Coordinates:
Date; Time: August 21, 2002; 9:00 am
Water Table Height (pit or open auger hole): 37 cm
Pit Depth: 0-105 cm
Auger Depth: none
Described by: Philip Zurheide and John Wah
NOTES: Some mixing of A into E horizon (root mat lenses); redox in 5th horizon shows sharper boundaries than in horizon above.

Horizon	Depth (cm)	Description
Oe	**14-0**	dark reddish brown (5YR 2.5/2) mucky peat; clear smooth boundary.
A	**0-7**	black (7.5YR 2.5/1) mucky silt loam (11% clay); weak medium sub-angular blocky structure; very friable; abrupt wavy boundary.
Eg	**7-16**	gray (2.5Y 6/1) silt loam (14% clay) with common (15%) medium distinct olive (5Y 5/3) and common (3%) fine prominent yellowish brown (10YR 5/6) soft masses; moderate medium sub-angular blocky parting to weak medium platy structure; friable; clear smooth boundary.
BEg	**16-26**	gray (2.5Y 6/1) silt loam (15% clay) with many (34%) medium distinct light olive brown (2.5Y 5/6) and common (15%) medium prominent yellowish brown (10YR 5/6) and few (1%) fine prominent yellowish brown (10YR 5/8) soft masses; weak medium sub-angular blocky structure; friable; clear smooth boundary.
Btg1	**26-39**	gray (2.5Y 6/1) silt loam (21% clay) with common (13%) medium distinct light olive brown (2.5Y 5/6) and common (18%) medium prominent yellowish brown (10YR 5/8) soft masses; weak coarse sub-angular blocky structure; friable; clear smooth boundary.
Btg2	**39-53**	gray (N5) silt loam (25% clay) with common (17%) medium prominent yellowish brown (10YR 5/8) soft masses; weak coarse sub-angular blocky structure; friable; clear smooth boundary.

Bt1	**53-66**	yellowish brown (10YR 5/6) with many (21%) medium distinct strong brown (7.5YR 5/8) soft masses and common (5%) fine to medium distinct yellowish red (5YR 5/6) as clay skins and many (25%) medium prominent gray (5Y 5/1) iron depletions; weak coarse prismatic parting to moderate medium to thick platy structure; friable; clear smooth boundary.
Bt2	**66-77**	olive (5Y 5/4) loam (26% clay) with common (13%) fine to medium prominent strong brown (7.5YR 5/8) soft masses with common (7%) medium prominent and fine to medium distinct yellowish red (5YR 5/6) as clay skins and common (10%) medium faint olive gray (5Y 5/2) and common (15%) medium distinct gray (N5) iron depletions; weak coarse prismatic parting to moderate medium thick platy structure; friable (brittle); clear smooth boundary.
2BC	**77-91**	light olive brown (2.5Y 5/4) sandy loam (13% clay) with common 15%) medium to coarse prominent yellowish brown (10YR 5/8) and common (15%) fine to medium prominent strong brown (7.5YR 5/8) soft masses and common (18%) medium prominent grayish brown (2.5Y 5/2) iron depletions; weak to moderate thick platy and weak coarse prismatic structure; friable.

Soil Description: Blackwater National Wildlife Refuge, Dorchester County, MD
Site Position: Middle Well
Date; Time: Jan 24, 2002; 9:00 am
Water Table Height (pit or open auger hole): N/A
Pit Depth: 0-114 cm
Auger Depth: 114 cm - 140+ cm
Described by: Martin C. Rabenhorst and Phillip King; assisted by Philip Zurheide, Carla Baker, Steve Burch, Charlie Hanner, John Wah, and David Win.
NOTES: No iron concentrations in A horizon; Redox depletions pronounced around decaying roots/channels and along prism faces.

Horizon	Depth (cm)	Description
Oe	**11-0**	very dusky red (2.5YR 2.5/2) mucky peat; abrupt smooth boundary.
A	**0-10**	dark reddish gray to weak red (2.5YR 4/1.5) silt loam (11% clay); weak medium sub-angular blocky structure; friable; abrupt smooth boundary.
Bt (BE)	**10-22**	light olive brown (2.5Y 5/6) (40%) and olive yellow (2.5Y 6/6) (40%) silt loam (21% clay) with common (2%) very fine prominent strong brown (7.5YR 4/6) and common (2%) yellowish brown (10YR 5/6) soft masses and common (16%) medium distinct gray (2.5Y 6/1) iron depletions; weak medium sub-angular blocky structure parting to weak fine sub-angular blocky structure; friable; clear smooth boundary.
Btg	**22-51**	gray (5Y 6/1) (70%) and light brownish gray (2.5Y 6/2) (10%) silty clay loam (31% clay) with common (20%) medium distinct reddish yellow (7.5YR 6.5/8) soft masses; weak medium sub-angular blocky structure; friable; clear smooth boundary.
2Bt	**51-103**	light olive brown (2.5Y 5/6) (25%) and yellowish brown (10YR 5/8) (50%) loam to sandy clay loam (21% clay) to fine sandy loam with common (5%) reddish yellow (7.5YR 6.5/8) soft masses and common (20%) greenish gray (10Y 6/1) and gray (N5) iron depletions; weak very coarse prismatic parting to moderate medium platy parting to moderate fine to medium sub-angular blocky structure; firm; clear smooth boundary.
2BC	**103-129**	yellowish brown (10YR 5/6) sandy loam with common medium distinct reddish yellow (7.5YR 6/8) soft masses.
2C	**129+**	light olive brown (2.5Y 5/4) fine sandy loam.

Soil Description: Blackwater National Wildlife Refuge, Dorchester County, MD
Site Position: Upper Well
Date; Time: Jan 24, 2002; 12:00 pm
Water Table Height (pit or open auger hole): N/A
Pit Depth: 0-88 cm
Auger Depth: 88 cm - 212 cm
Described by: Martin C. Rabenhorst and Phillip King; assisted by Philip Zurheide, Carla Baker, Steve Burch, Charlie Hanner, John Wah, and David Win.
NOTES: Redox depletions pronounced around decaying roots/channels and along prism faces.

Horizon	Depth (cm)	Description
Oe	**5-0**	black (5YR 2.5/1) mucky peat; abrupt smooth boundary.
A	**0-10**	very dark grayish brown to dark grayish brown (10YR 3.5/2) (97%) silt loam (9% clay) with common (3%) fine dark brown (7.5YR 3/3) soft masses around roots; weak medium subangular blocky structure; friable; clear smooth boundary.
EA	**10-16**	dark grayish brown to olive brown (2.5Y 4/2.7) (93%) silt loam (9% clay) with common (7%) fine dark brown (7.5YR 3/3) soft masses; weak fine to medium subangular blocky structure; friable; abrupt smooth boundary.
Bt1	**16-33**	light olive brown (2.5Y 5/4) (80%) silt loam (17.5% clay) with common (7%) strong brown (7.5YR 4/6) and common (3%) dark brown (7.5YR 3/4) soft masses and common (5%) light olive brown (2.5Y 5/3.2) and common (5%) light brownish gray (2.5Y 6/2) iron depletions; weak medium subangular blocky structure; friable; clear to gradual smooth boundary.
Bt2	**33-63**	light olive brown (2.5Y 5/4) (65%) loam (23% clay) with common (10%) fine strong brown (7.5YR 4/6) soft masses and common (10%) light olive brown (2.5Y 5/3) and common (15%) grayish brown (2.5Y 5/2) iron depletions; weak fine subangular blocky structure; friable; clear smooth boundary.
2BC1	**63-83**	yellowish brown (10YR 5/6) (65%) sandy loam (15% clay) with many (25%) medium faint dark yellowish brown (10YR 4/6) soft masses and common (10%) grayish brown (2.5Y 5/2) iron depletions; weak medium platy parting to weak medium subangular blocky structure; friable; clear smooth boundary.
2BC2	**83-173**	Yellowish brown (10YR 5/6) loamy sand with strong brown (7.5YR 4/6) soft masses and light brownish gray (2.5Y 6/2) iron depletions.

2BC3	**173-207**	yellowish brown (10YR 5/4) sandy loam with strong brown (7.5YR 4/6) soft masses and gray (2.5Y 6/1) iron depletions.

Soil Description: Isle of Wight Wildlife Management Area, Worcester County, MD
Site Position: Lower Well
Date; Time: July 22, 2002; 1:00 pm
Water Table Height (pit or open auger hole): N/A
Pit Depth: 0-96+ cm
Auger Depth: N/A
Described by: Martin C. Rabenhorst and Philip Zurheide, assisted by Steve Burch, Karen Castenson, Cary Coppock, and Robert Vaughan
NOTES:

Horizon	Depth (cm)	Description
Oe	**6-0**	very dusky red (2.5YR 2.5/2) mucky peat; abrupt smooth boundary.
A	**0-9**	very dark gray (2.5Y 3/1) (92%) sandy loam to loam (8% clay) with common (8%) distinct fine dark reddish brown (5YR 3/3) pore linings of iron; weak fine sub-angular blocky structure; friable; clear wavy boundary.
B/A	**9-27**	light olive brown (2.5Y 5/4) (60%) and very dark grayish brown to dark grayish brown (2.5Y 3.5/2) (15%) sandy loam (14% clay) with common (15%) medium distinct strong brown (7.5YR 4/6) soft masses and pore linings of iron and common (5%) fine prominent yellowish red (5YR 4/6) pore linings of iron and common (5%) medium to coarse faint very dark grayish brown to dark grayish brown (2.5Y 3.5/2) iron depletions; moderate medium sub-angular blocky structure; friable; clear smooth boundary.
Bt1	**27-45**	light olive brown (2.5Y 5/4) loam (18% clay) with many (25%) medium distinct strong brown (7.5YR 4/6) soft masses and pore linings of iron and common (5%) fine prominent yellowish red (5YR 4/6) pore linings of iron and common (5%) medium to coarse faint grayish brown (2.5Y 5/2) iron depletions; moderate medium sub-angular blocky structure; friable; clear smooth boundary.
Bt2	**45-60**	dark yellowish brown (10YR 4/4) fine sandy loam (15% clay) with common (20%) medium to coarse faint strong brown (7.5YR 5/6) soft masses of iron and common (5%) fine distinct strong brown (7.5YR 4/6) pore linings of iron and common (5%) moderate to coarse gray (2.5Y 5/1) iron depletions; weak moderate to coarse sub-angular blocky structure; friable; clear smooth boundary.
BC	**60-90+**	light olive brown (2.5Y 5/4) loamy sand (6% clay) with common (20%) very coarse prominent yellowish brown (10YR 5/6) soft masses of iron and common (5%) medium to coarse prominent yellowish red (5YR 4/6) pore linings of iron and common

(20%) very coarse faint dark grayish brown (2.5Y 5/2) iron depletions; structureless massive; very friable.

Soil Description: Isle of Wight Wildlife Management Area, Worcester County, MD
Site Position: Middle Well
Date; Time: July 22, 2002; 1:00 pm
Water Table Height (pit or open auger hole): N/A
Pit Depth: 0-96+ cm
Auger Depth: N/A
Described by: Martin C. Rabenhorst and Philip Zurheide, assisted by Steve Burch, Karen Castenson, Cary Coppock, and Robert Vaughan

Horizon	Depth (cm)	Description
A	**0-9**	very dark brown (7.5YR 2.5/2) loam to sandy loam (10% clay) with few (1%) fine distinct dark reddish brown (5YR 5/4) pore linings of iron; moderate medium granular structure; very friable; clear smooth boundary.
AE	**9-20**	olive brown (2.5Y 4/4) loam to fine sandy loam (11% clay) with common (4%) fine to medium distinct yellowish red (5YR 4/6) pore linings of iron; weak fine sub-angular blocky parting to weak fine to medium granular structure; friable; clear smooth boundary.
EB	**20-33**	yellowish brown (10YR 5/6) sandy loam (9% clay) with common (6%) fine to medium distinct yellowish red (5YR 4/6) pore linings of iron and common (5%) medium to coarse faint light olive brown (2.5Y 5/4) iron depletions; weak medium sub-angular blocky structure; friable; clear smooth boundary.
Bt1	**33-49**	dark yellowish brown (10YR 4/6) sandy loam (16% clay) with common (5%) fine distinct yellowish red (5YR 5/8) pore linings of iron and common (15%) medium to coarse distinct light olive brown (2.5Y 5/3) iron depletions; moderate medium to coarse sub-angular blocky structure; friable; clear smooth boundary.
Bt2	**49-70**	dark yellowish brown (10YR 4/6) sandy loam (19% clay) with common (10%) coarse distinct strong brown (7.5YR 4/6) soft masses of iron and common (2%) fine prominent yellowish red (5YR 5/8) pore linings of iron and light olive brown (2.5Y 5/3) iron depletions; moderate medium to coarse sub-angular blocky structure; friable; clear smooth boundary.
C1	**70-89**	yellowish brown (10YR 5/4) sandy loam to loamy sand (8% clay) with common (20%) coarse to very coarse faint yellowish brown (10YR 5/6) soft masses of iron and common (3%) fine to medium prominent yellowish red (5YR 5/8) pore linings of iron and common (5%) medium to coarse faint light yellowish brown (2.5Y 6/4) iron depletions; very weak coarse sub-angular blocky structure; very friable; gradual smooth boundary.

C2	**89- 125+**	light olive brown (2.5Y 5/4) loamy sand to sand (4% clay) with common (5%) medium prominent yellowish red (5YR 5/8) pore linings of iron and many (25%) very coarse faint grayish brown (2.5Y 5/2) iron depletions; structureless single grain lose; very friable.

Soil Description: Isle of Wight Wildlife Management Area, Worcester County, MD
Site Position: Upper Well
Date; Time: July 22, 2002; 1:00 pm
Water Table Height (pit or open auger hole): N/A
Pit Depth: 0-96+ cm
Auger Depth: N/A
Described by: Martin C. Rabenhorst and Philip Zurheide, assisted by Steve Burch, Karen Castenson, Cary Coppock, and Robert Vaughan

Horizon	Depth (cm)	Description
A	**0-10**	dark brown (7.5YR 3/2) loam to fine sandy loam (10% clay); moderate medium granular structure; friable; abrupt wavy boundary.
AB	**10-18**	brown (10YR 4/3) fine sandy loam (12% clay) with common (10%) medium distinct strong brown (7.5YR 4/6) and common (5%) medium prominent dark reddish brown (5YR 3/4) soft masses of iron and common (3%) fine dark grayish brown (2.5Y 4/2) iron depletions; weak medium sub-angular blocky structure; friable; clear wavy boundary.
BA	**18-31**	light olive brown (2.5Y 5/4) fine sandy loam (13% clay) with many (35%) medium to coarse faint yellowish brown (10YR 5/6) soft masses of iron and common (3%) fine distinct strong brown (7.5YR 4/6) pore linings of iron; weak medium sub-angular blocky structure; friable; clear smooth boundary.
Bt1	**31-55**	yellowish brown (10YR 5/6) fine sandy loam (14% clay) with common (2%) fine prominent strong brown (7.5YR 5/8) pore linings of iron and common (8%) coarse distinct light olive brown (2.5Y 5/3) iron depletions around roots and common (10%) medium to coarse faint light olive brown (2.5Y 5/4) iron depletions; weak coarse sub-angular blocky structure; friable; clear smooth boundary. yellowish brown (10YR 5/6) sandy loam (11% clay) with common (15%) medium distinct strong brown (7.5YR 4/6) soft masses and pore linings of iron and common (15%) medium to coarse distinct light yellowish brown (2.5Y 6/4) iron depletions; weak medium to coarse sub-angular blocky structure; friable; clear smooth boundary.
Bt2	**55-77**	yellowish brown (10YR 5/6) sandy loam (11% clay) with common (15%) medium distinct strong brown (7.5YR 4/6) soft masses and pore linings of iron and common (15%) medium to coarse distinct light yellowish brown (2.5Y 6/4) iron depletions; weak medium to coarse sub-angular blocky structure; friable; clear smooth boundary.
BC	**77-90**	brownish yellow (10YR 6/6) loamy sand (6% clay) with common (20%) medium to coarse distinct strong brown (7.5YR 4/6) soft masses of iron and common (3%) fine distinct strong brown (7.5YR 5/8) pore linings of iron and many (25%) coarse to

		very coarse distinct light yellowish brown (2.5Y 6/4) iron depletions; very weak medium to coarse sub-angular blocky structure; very friable; clear smooth boundary.
C1	**90-137**	light olive brown (2.5Y 5/3) sand (4% clay) with common (15%) fine to medium prominent strong brown (7.5YR 5/8) pore linings of iron and common (10%) coarse to very coarse distinct light olive brown (2.5Y 5/6) soft masses of iron and many (30%) coarse to very coarse faint light brownish gray (2.5Y 6/2) iron depletions; structureless single grain lose; very friable; clear wavy boundary.
C2	**137-150**	gray (2.5Y 6/1) (30%) and yellowish brown (10YR 5/4) (60%) fine sand to loamy fine sand with common (10%) medium to coarse distinct strong brown (7.5YR 4/6) soft masses of iron.
2Cg	**150-183**	gray (5Y 6/1) fine sandy loam (14% clay) with many (30%) coarse to very coarse prominent yellowish brown (10YR 5/6) and common (10%) medium to coarse prominent strong brown (7.5YR 5/8) soft masses of iron.
3C’1	**183-225**	light olive brown (2.5Y 5/3) loam (26% clay) with common (15%) medium prominent strong brown (7.5YR 4/6) and common (5%) medium prominent strong brown (7.5YR 5/8) and common (5%) fine to medium prominent dusky red (2.5YR 3/2) soft masses of iron and many (30%) medium to very coarse prominent gray (5Y 6/1) iron depletions; firm.
4C’2	**225-259**	light olive brown (2.5Y 5/3) fine sandy loam (10% clay) with common (10%) coarse prominent strong brown (7.5YR 4/6) and common (20%) very coarse prominent strong brown (7.5YR 5/8) soft masses of iron.
5C’3	**259-270+**	dark yellowish brown (10YR 4/4) fine sand with many (25%) very coarse prominent strong brown (7.5YR 4/6) soft masses of iron.

Soil Description: Eastern Neck Island National Wildlife Refuge, Kent County, MD
Site Position: Lower Well
Date; Time: November 28, 2001; 9:00 am
Water Table Height (pit or open auger hole): N/A
Pit Depth: 0-170 cm
Auger Depth: 170 cm – 310 cm
Described by: Martin C. Rabenhorst, Phillip King, and Philip Zurheide, and assisted by John Wah, Steve Burch, and Suzy Park.

Horizon	Depth (cm)	Description
Oe	**3-2**	dark brown (7.5YR 3/2) mucky peat; abrupt smooth boundary.
A	**0-6**	very dark gray (10YR 3/1) silt loam (8% clay); moderate fine to medium granular structure; friable; common (10%) fine to medium roots; abrupt smooth boundary.
EA	**6-15**	brown (10YR 4/3) silt loam (10% clay) with few (1%) strong brown (7.5YR 4/6) soft masses; moderate very fine sub-angular blocky structure; friable; common (10%) fine to medium roots; clear wavy boundary.
BE	**15-32**	light yellowish brown (2.5Y 6/4) (40%) and (2.5Y 6/3) (25%) silt loam (13% clay) with common (5-10%) yellowish brown (10YR 5/8) and common (10%) dark yellowish brown (10YR 4/6) soft masses and many (25%) light yellowish brown (2.5Y 6/3) iron depletions; weak course sub-angular blocky structure; friable to firm (brittle); common (5%) fine roots; clear smooth boundary.
Bt1	**32-42**	pale brown (10YR 6/3) silt loam (19% clay) with common (5%) dark reddish brown (5YR 3/4) soft masses and many (30%) yellowish brown (10YR 5/6) iron depletions; weak course platy and moderate fine to medium sub-angular blocky structure; friable; common (5-10%) fine to medium roots; clear smooth boundary.
Bt2	**42-62**	yellowish brown (10YR 5/8) loam (22% clay) with many (25%) strong brown (7.5YR 5/6) and common (5%) dark reddish brown (5YR 3/4) soft masses and many (30%) pale brown (10YR 6/3) iron depletions; weak course platy and moderate fine to medium sub-angular blocky structure; friable; common (6%) fine to medium roots; clear smooth boundary.
2Bt	**62-77**	yellowish brown (10YR 5/6) very fine sandy loam/loam (19% clay) with many (25%) strong brown (7.5YR 5/6) soft masses and common (15%) light brownish gray (2.5Y 6/2) and many (25%) light yellowish brown (2.5Y 6/4) iron depletions; weak very coarse prismatic and moderate medium to course platy and moderate fine to medium sub-angular blocky structure;

		friable to firm (slightly brittle); few fine to medium roots; clear smooth boundary.
2BC1	**77-112**	yellowish brown (10YR 5/4) fine sandy loam (19% clay) with many (25%) strong brown (7.5YR 4/6) soft masses and common (10%) gray (2.5Y 6/1) iron depletions in areas of loamy fine sand and common (20%) light yellowish brown (2.5Y 6/4) mottles; weak to moderate very course prismatic and moderate to strong course platy structure; friable; very few fine roots; clear smooth boundary.
2BC2	**112-143**	light olive brown (2.5Y 5/6) fine sandy loam (16% clay) with common (20%) yellowish brown (10YR 5/6) soft masses and common (20%) yellowish brown (2.5Y 6/4) and common (10%) gray (2.5Y 6/1) iron depletions; strong very course sub-angular blocky structure; friable; gradual smooth boundary.
2BC3	**143-167**	yellowish brown (10YR 5/6) fine sandy loam (14% clay) with common (10%) strong brown (7.5YR 5/6) soft masses and many (25%) greenish gray (10Y 6/1) iron depletions; strong very course sub-angular blocky structure; friable; clear smooth boundary.
2BC4	**167-179**	light gray (2.5Y 7/1) fine sandy loam (7% clay) with common (10%) light yellowish brown (2.5YR 6/3) and common (20%) reddish yellow (7.5YR 6/8) soft masses.
2C1	**179-199**	light olive brown (2.5Y 5/3-4) fine sandy loam (12% clay) with common (20%) red (2.5YR 4/6) soft masses and common (5%) gray (2.5Y 6/1) iron depletions.
2C2	**199-215**	light gray (2.5Y 7/1) fine sandy loam (9% clay) with common (5%) yellowish brown (10YR 5/6) soft masses and many (40%) light yellowish brown (2.5Y 6/3) iron depletions.
2C3	**215-257**	light olive brown (2.5Y 5/3) very fine sandy loam (6% clay) with common (7%) strong brown (7.5YR 5/6) soft masses and common (5%) light gray (2.5Y 7/1) iron depletions.
2C4	**257-307**	light olive brown (2.5Y 5/4) very fine sandy loam (9% clay) with common (10%) strong brown (7.5 YR 5/6) soft masses.

Soil Description: Eastern Neck Island National Wildlife Refuge, Kent County, MD
Site Position: Middle Well
Date; Time: November 28, 2001; 9:00 am
Water Table Height (pit or open auger hole): N/A
Pit Depth: 0-150 cm
Auger Depth: 150 cm – 240 cm
Described by: Martin C. Rabenhorst, Phillip King, and Philip Zurheide, and assisted by John Wah, Steve Burch, and Suzy Park.

Horizon	Depth (cm)	Description
Oe	**3-0**	mucky peat; abrupt smooth boundary.
A	**0-9**	very dark gray (10YR 3/1) silt loam (8% clay); moderate fine to medium granular structure; very friable; clear wavy boundary; common fine to medium roots.
AE	**9-15**	brown (10YR 4/3) silt loam (10% clay); moderate fine to medium sub-angular blocky structure; very friable; clear wavy boundary; common fine to medium roots.
BE	**15-28**	light yellowish brown (2.5Y 6/4) silt loam (14% clay) with many (30%) yellowish brown (10YR 5/6) soft masses of iron; weak medium to coarse sub-angular blocky structure; friable; clear smooth boundary; common fine to medium roots.
Bt1	**28-45**	strong brown (7.5YR 5/6) silt loam (21% clay) with many (30%) yellowish brown (10YR 5/8) soft masses of iron and common (20%) light yellowish brown (2.5Y 6/4) and common (10%) light yellowish brown (2.5Y 6/3) iron depletions; moderate fine to medium sub-angular blocky structure; friable; clear smooth boundary; common fine to medium roots.
Bt2	**45-69**	light brown (7.5YR 6/4) (30%) and yellowish brown (10YR 5/6) (30%) loam (18% clay) with many (25%) strong brown (7.5YR 5/8) soft masses of iron and common (5%) brown (10YR 5/3) and common (10%) light gray (2.5Y 7/2) iron depletions; moderate medium to coarse sub-angular blocky structure; friable gradual smooth boundary; common medium roots.
2Bt3	**69-92**	yellowish brown (10YR 5/6) fine sandy loam (15% clay) with common (5%) yellowish red (5YR 4/6) and many (25%) strong brown (7.5YR 5/8) and many (30%) light yellowish brown (2.5Y 6/4) soft masses of iron and light brownish gray (2.5Y 6/2) and light brownish gray (10YR 6/2) iron depletions; moderate coarse sub-angular blocky with some weak medium to coarse prismatic structure; friable to firm; slightly brittle; clear smooth boundary; common fine to medium roots.

2BC1	**92-137**	gray (10YR 5/1) fine sandy loam (13% clay) with common (15%) yellowish brown (10YR 5/8) soft masses of iron and common (15%) light yellowish brown (2.5Y 6/3) occurring in loamy sand textures and common (20%) light gray (2.5Y 7/2) and common (5%) greenish gray (5GY 6/1) occurring in heavy sandy loam textures as iron depletions; weak medium to very coarse prismatic parting to moderate medium to coarse platy structure; friable; clear smoother boundary.
2BC2	**137-157**	light yellowish brown (2.5Y 6/4) sandy clay loam (23% clay) with common (10%) yellowish brown (10YR 5/8) soft masses of iron and many (30%) gray (10YR 6/1) iron depletions.
2C1	**157-192**	light yellowish brown (2.5Y 6/4) very fine sandy loam (14% clay) with many (40%) yellowish (10YR 5/6) soft masses of iron and common (10%) light gray (2.5Y 7/1) iron depletions.
2C2	**192-237**	light yellowish brown (2.5Y 6/3) very fine sandy loam with common (5%) strong brown (7.5YR 5/8) soft masses of iron.

Soil Description: Eastern Neck Island National Wildlife Refuge, Kent County, MD
Site Position: Upper Well
Date; Time: August 22, 2002; 9:00 am
Water Table Height (pit or open auger hole): N/A
Pit Depth: 0-155 cm
Auger Depth: N/A
Described by: Philip Zurheide, John Wah, and Robert Vaughan.

Horizon	Depth (cm)	Description
A	**0-6**	dark brown (10YR 3/3) loam/silt loam (9% clay); weak fine granular structure; very friable; clear smooth boundary.
AE	**6-14**	dark yellowish brown (10YR 4/4) silt loam/loam (11% clay); weak fine sub-angular blocky structure; very friable; clear wavy boundary.
EB	**14-38**	light yellowish brown (2.5Y 6/4) silt loam (12% clay) with few (1%) fine faint strong brown (7.5 YR 5/6) pore linings of iron and common (5%) medium distinct yellowish brown (10YR 5/6) soft masses; moderate medium sub-angular blocky structure; friable; clear smooth boundary.
Bt1	**38-56**	olive yellow (2.5Y 6/6) loam-silt loam (14% clay) with common (8%) medium distinct yellowish brown (10YR 5/8) soft masses and many (25%) medium to coarse faint light yellowish brown (2.5Y 6/4) iron depletions; moderate medium sub-angular blocky structure; friable; clear smooth boundary.
Bt2	**56-69**	yellowish brown (10YR 5/8) loam-fine sandy loam (12% clay) with many (25%) medium distinct strong brown (7.5YR 5/6) soft masses and many (25%) medium prominent light brownish gray (2.5Y 6/2) iron depletions; weak coarse prismatic parting to moderate medium sub-angular blocky structure; friable; clear smooth boundary.
***BCt**	**69-90**	yellowish brown (10YR 5/6) fine sandy loam (8% clay) with common (10%) medium faint yellowish brown (10YR 5/8) soft masses and light yellowish brown (2.5Y 6/4) and light yellowish gray (2.5Y 6/2) iron depletion as 1-inch diameter root channel through horizon; weak coarse prismatic parting to moderate medium platy structure; friable; abrupt smooth boundary.
***2Bt**	**90-104**	light yellowish brown (2.5Y 6/4) clay loam (33% clay) with many (25%) medium prominent strong brown (7.5YR 5/8) soft masses and common (19%) medium prominent gray (2.5Y 6/1) iron depletions; weak coarse prismatic parting to weak to moderate medium sub-angular blocky structure; friable; clear smooth boundary.

2BC1	**104-121**	olive yellow (2.5Y 6/6) fine sandy loam (8% clay) with common (8%) medium distinct yellowish brown (10YR 5/8) and few (1%) fine prominent strong brown (7.5YR 4/6) pore linings of iron and common (8%) coarse prominent light olive gray (5Y 6/2) iron depletions; weak coarse prismatic parting to moderate medium sub-angular blocky structure; friable clear smooth boundary.
2BC2	**121-155**	light olive brown (2.5Y 5/4) sandy loam (8% clay) with many (40%) coarse to very coarse gray (5Y 6/1) iron depletions as discontinuous lenses to 3 inches thick and common (10%) medium distinct yellowish brown (10YR 5/6) soft masses around depleted lenses as noted above; weak medium sub-angular blocky and weak medium platy structure; friable.

Soil Description: Ted Harvey Wildlife Area, Kent County, DE
Site Position: Lower Well
Date; Time: July 24, 2002; 2:00 pm
Water Table Height (pit or open auger hole): N/A
Pit Depth: 0-170 cm
***Auger Depth:** 170 cm – 332+ cm
Described by: Martin C. Rabenhorst and Philip Zurheide, assisted by Steve Burch, Karen Castenson and Robert Vaughan.

Horizon	Depth (cm)	Description
A1	**0-7**	black (7.5YR 2.5/1) mucky silt loam (12% clay) with common (3%) fine distinct dark reddish brown (5YR 3/3) pore linings of iron; weak fine granular structure; very friable; clear smooth boundary.
A2	**7-14**	black (7.5YR 2/2) silt loam (13% clay) with common (10%) fine to medium distinct dark reddish brown (5YR 3/3) pore linings of iron; moderate medium granular structure; very friable; clear smooth boundary.
AE	**14-26**	dark olive brown (2.5Y 3/3) lilt loam (14% clay) with common (15%) fine to very fine dark brown (7.5YR 3/4) pore linings of iron; moderate medium sub-angular blocky parting to moderate medium granular structure; friable; clear smooth boundary.
EB	**26-39**	light yellowish brown (2.5Y 6/3) silt loam to loam (14% clay) with many (35%) coarse to very coarse faint yellowish brown (10YR 5/4) soft masses of iron and common (8%) fine distinct dark brown (7.5YR 3/4) pore linings of iron; weak medium sub-angular blocky structure; friable clear smooth boundary.
Bt	**39-63**	yellowish brown (10YR 5/6) loam (24% clay) with common (15%) medium to coarse distinct strong brown (7.5YR 5/8) soft masses of iron and common (4%) fine to medium distinct dark brown (7.5YR 3/4) pore linings of iron and common (15%) medium to coarse distinct light olive brown (2.5Y 5/3) iron depletions (around root channels); moderate medium to coarse sub-angular blocky structure; friable; abrupt smooth boundary. NOTE: 15% crotovinas consisting of A material and decaying roots in areas ranging from 2-5cm.
2BC1	**63-85**	yellowish brown (10YR 5/8) sandy loam (12% clay) with many (25%) medium strong brown (7.5YR 5/8) soft masses of iron and common (5%) brown (7.5YR 4/4) as clay films and common (15%) medium to coarse distinct light olive brown (2.5Y 5/3) iron depletions (around root channels) and many (30%) coarse to very coarse 2.5Y 5/8 iron depletions; weak coarse platy and weak medium sub-angular blocky structure; friable and very friable; abrupt wavy boundary.

3BC2	**85-124**	light olive brown (2.5Y 5/4) silt loam (13% clay) with many (25%) coarse to very coarse prominent strong brown (7.5YR 5/8) soft masses of iron around depletions and common (15%) coarse to very coarse distinct gray (5Y 6/1) iron depletions (on ped faces); moderate coarse to very coarse prismatic parting to moderate medium to coarse platy structure; firm; clear wavy boundary.
3BCg	**124-170**	light olive brown (2.5Y 5/4) silt loam (16% clay) with many (25%) coarse to very coarse prominent strong brown (7.5YR 5/8) soft masses of iron and many (30%) very coarse gray (5Y 6/1) iron depletions (along prism faces); moderate medium to coarse prismatic parting to moderate coarse sub-angular blocky structure; firm.
*	**170-235**	dark grayish brown (10YR 4/2) clay with common (20%) fine prominent dark yellowish brown (10YR 4/6) and strong brown (7.5 YR 5/8) soft masses of iron. NOTE: 230-235cm; dark reddish brown (5YR 3/4).
*	**235-280**	very dark gray (7.5YR 3/1) clay with common (10%) very coarse distinct strong brown (7.5YR 4/6) soft masses of iron and grayish brown (2.5Y 5/2) iron depletions.
*	**280-310**	gray (2.5Y 6/1) clay with common (5%) fine prominent strong brown (7.5YR 4/6) soft masses of iron.
*	**310-335+**	gray (5Y 6/1) clay with many (25%) fine to medium prominent strong brown (7.5YR 4/6) and common (5%) fine to medium prominent strong brown (7.5YR 5/8) soft masses of iron.

Soil Description: Ted Harvey Wildlife Area, Kent County, DE
Site Position: Middle Well
Date; Time: July 24, 2002; 12:00 pm
Water Table Height (pit or open auger hole): N/A
Pit Depth: 0-148 cm
Auger Depth: N/A
Described by: Martin C. Rabenhorst and Philip Zurheide, assisted by Steve Burch, Karen Castenson and Robert Vaughan.

Horizon	Depth (cm)	Description
A	**0-14**	very dark brown (10YR 2/2) silt loam to loam (14% clay); moderate medium granular structure; very friable; clear smooth boundary.
AE	**14-26**	brown (10YR 4/3) loam to silt loam (14% clay) with common (3%) fine distinct strong brown (7.5YR 4/6) pore linings of iron; weak medium sub-angular blocky structure; very friable; clear wavy boundary. NOTE: 15% crotovinas consisting of A material throughout.
BE	**26-40**	light olive brown (2.5Y 5/4) loam (16% clay) with common fine distinct strong brown (7.5YR 4/6) pore linings of iron and common (5%) medium to coarse faint light olive brown (2.5Y 5/3) iron depletions; weak coarse sub-angular blocky structure; friable; clear smooth boundary. NOTE: 8% crotovinas consisting of A material throughout
Bt1	**40-68**	yellowish brown (10YR 5/6) loam (21% clay) with common (10%) medium to coarse distinct strong brown (7.5YR 5/8) soft masses of iron and common (3%) fine to medium distinct yellowish red (5YR 4/6) pore linings of iron and common (15%) medium to coarse distinct light olive brown (2.5Y 5/3) iron depletions (on ped faces); moderate medium to coarse sub-angular blocky structure; friable; gradual wavy boundary.
Bt2	**68-94**	yellowish brown (10YR 5/6) (25%) and (10YR 5/8) (25%) loam (19% clay) with common (5%) medium to very coarse distinct yellowish red (5YR 4/6) and common (15%) medium to very coarse distinct strong brown (7.5YR 4/6) soft masses of iron and many (30%) coarse to very coarse prominent light brownish gray (2.5Y 6/2) iron depletions; moderate medium to coarse sub-angular blocky structure; friable; abrupt smooth boundary.
2BC1	**94-118**	yellowish brown (10YR 4/5) sandy loam (11% clay) with common (5%) medium to coarse distinct strong brown (7.5YR 4/6) and common (5%) medium to coarse distinct strong brown (7.5YR 5/6) soft masses of iron and many (25%) coarse to very

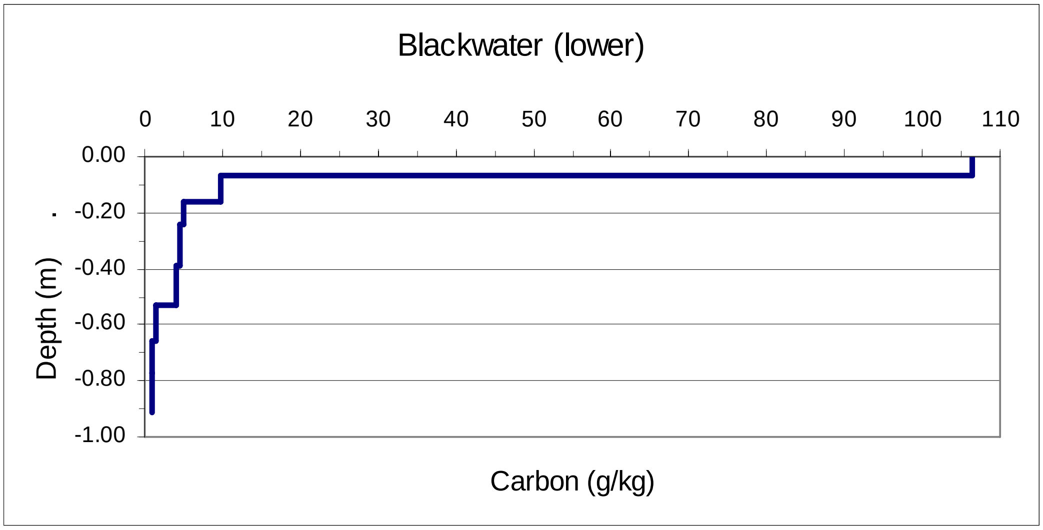
		coarse prominent gray (2.5Y 6/1) iron depletions; weak coarse sub-angular blocky structure; friable; abrupt wavy boundary.
3BC2	**118-130**	light olive brown (2.5Y 5/4) silt loam (23% clay) with many (25%) medium to coarse distinct strong brown (7.5YR 4/6) soft masses and pore linings of iron and many (35%) coarse to very coarse prominent gray (5Y 6/1) iron depletions; moderate medium sub-angular blocky structure; firm; abrupt wavy boundary.
4BC3	**130-148+**	dark yellowish brown (10YR 4/6) loamy sand (5% clay) with common (5%) medium to coarse distinct strong brown (7.5YR 4/6) soft masses of iron and common (15%) coarse to very coarse prominent light brownish gray (2.5Y 6/2) iron depletions; weak coarse sub-angular blocky structure; friable to very friable.

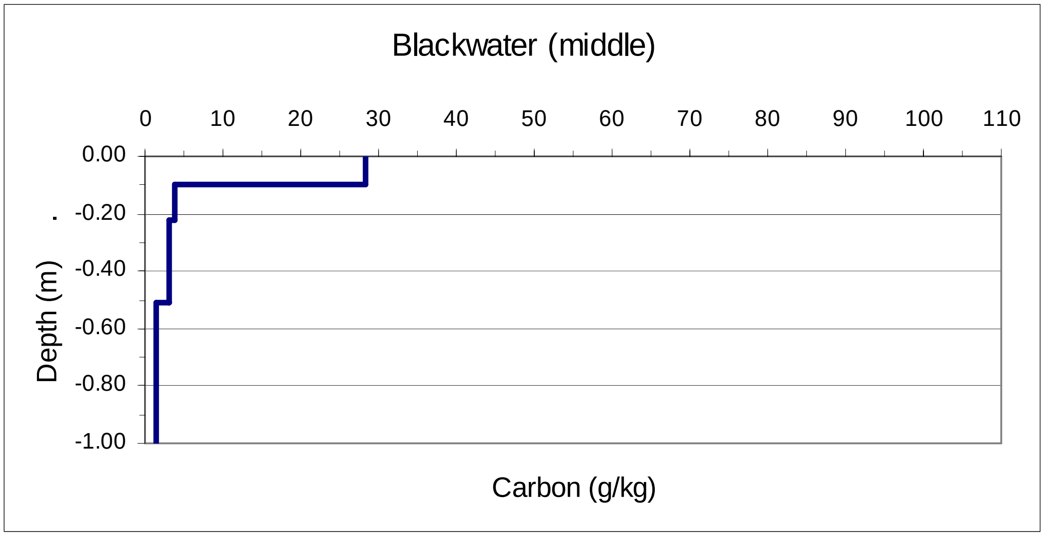
Soil Description: Ted Harvey Wildlife Area, Kent County, DE
Site Position: Upper Well
Coordinates: N 39° 05’ 16.13”   W 75° 24’ 23.13”
Water Table Height (pit or open auger hole): N/A
Pit Depth: 0-142 cm
Auger Depth: N/A
Described by: Martin C. Rabenhorst and Philip Zurheide, assisted by Steve Burch, Karen Castenson and Robert Vaughan.

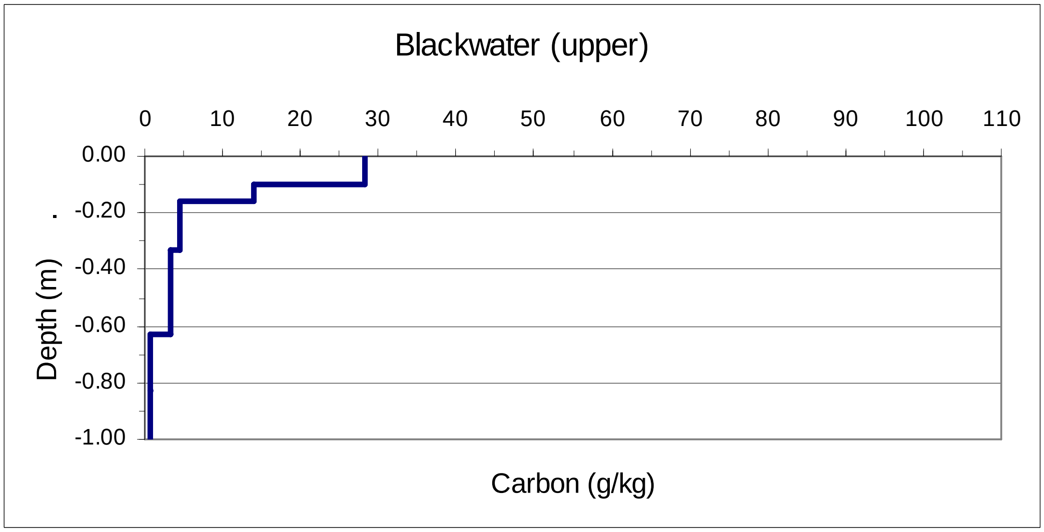
Horizon	Depth (cm)	Description
A	**0-9**	very dark grayish brown (10YR 3/2) silt loam (11% clay); moderate medium granular structure; friable; clear smooth boundary.
AE	**9-20**	brown (10YR 4/3) silt loam (13% clay) with common (10%) fine to medium faint dark brown (7.5YR 3/4) soft masses of iron; weak medium sub-angular blocky structure; friable; clear wavy boundary.
EB	**20-33**	light olive brown (2.5Y 5/4) silt loam (16% clay) with few (1%) medium faint dark yellowish brown (10YR 4/4) pore linings of iron and common (5%) medium faint light olive brown (2.5Y 5/3) iron depletions; weak medium to coarse platy parting to weak medium to coarse sub-angular blocky structure; friable; clear smooth boundary. NOTE: 5% inclusions of A-material as crotovinas.
Bt1	**33-53**	yellowish brown (10YR 5/6) silt loam (22% clay) with common (3%) fine distinct strong brown (7.5YR 4/6) soft masses of iron and common (15%) medium to very coarse prominent dark yellowish brown (10YR 3/4) pore linings of iron and common (8%) medium prominent light brownish gray (2.5Y 6/2) iron depletions along root channels; moderate medium to coarse prismatic parting to moderate medium to coarse sub-angular blocky structure; friable; clear smooth boundary.
Bt2	**52-68**	yellowish brown (10YR 5/6) silt loam (21% clay) with common (10%) medium to coarse prominent dark yellowish brown (10YR 3/4) pore linings of iron and common (10%) medium to coarse distinct strong brown (7.5YR 5/6) soft masses of iron and many (25%) medium prominent light brownish gray (2.5Y 6/2) iron depletions along root channels and ped faces; moderate medium to coarse sub-angular blocky structure; friable; clear wavy boundary.
2Bt3	**68-83**	yellowish brown (10YR 5/6) fine sandy loam (14% clay) with common (20%) medium to coarse distinct strong brown (7.5YR 5/6) and common (20%) medium to coarse distinct yellowish brown (10YR 5/4) soft masses of iron and common (15%) medium to very coarse distinct light yellowish brown (2.5Y 6/3) and common (5%) medium to very coarse prominent

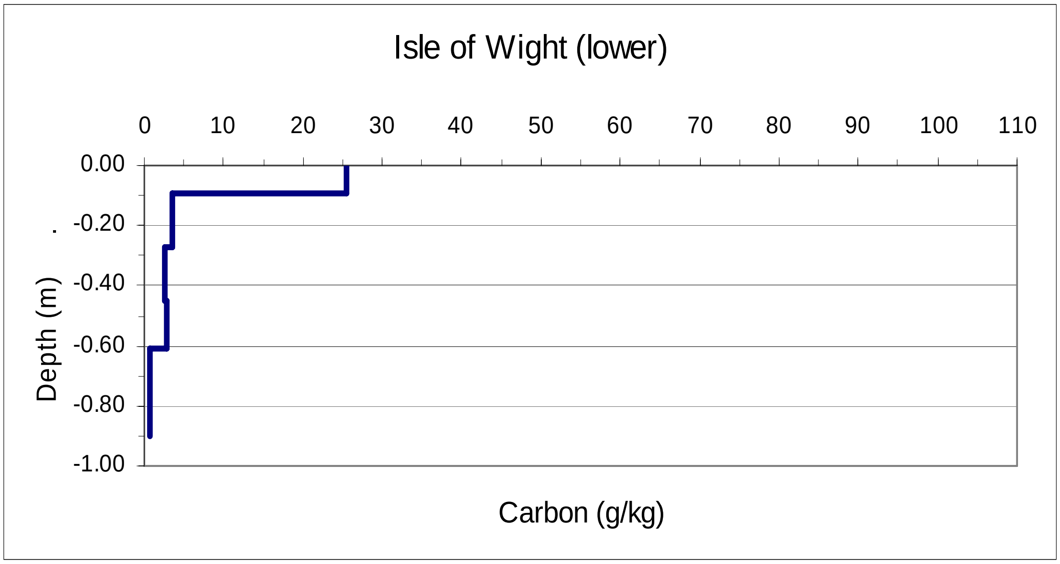
		light yellowish gray (2.5Y 6/2) iron depletions; moderate medium sub-angular blocky structure; friable; abrupt smooth boundary.
2BC1	**83-105**	strong brown (7.5YR 5/6) (20%) and yellowish brown (10YR 5/6) (40%) sandy loam to loamy sand (8% clay) with faint medium to coarse strong brown (7.5YR 4/6) soft masses of iron and common (5%) distinct pale brown (10YR 6/3) and common (5%) distinct light olive brown (2.5Y 5/3) iron depletions; weak very coarse platy parting to weak coarse sub-angular blocky structure; friable; clear wavy boundary.
2BC2	**105-125**	light olive brown (2.5Y 5/6) sandy loam (15% clay) with common (10%) medium to coarse strong brown (7.5YR 4/6) soft masses of iron and common (5%) coarse to very coarse prominent gray (2.5Y 6/1) and common (10%) coarse to very coarse faint light olive brown (2.5Y 5/4) iron depletions; weak medium to coarse sub-angular blocky structure; friable; abrupt wavy boundary. NOTE: horizon extends down on right side.
3BC3	**125-142**	light olive brown (2.5Y 5/4) silty clay loam (28% clay) with common (15%) medium to coarse distinct yellowish brown (10YR 5/6) iron concentrations and many (25%) coarse to very coarse distinct gray (2.5Y 5/1) iron depletions; moderate medium sub-angular blocky structure; firm. NOTE: representative material more on left side of horizon.

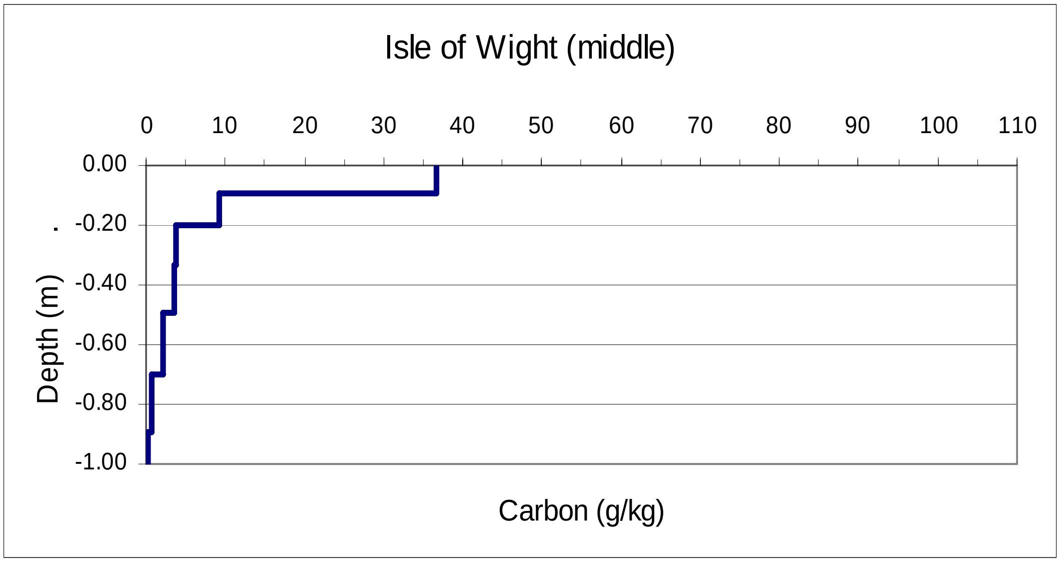
Appendix B: Organic Carbon Data

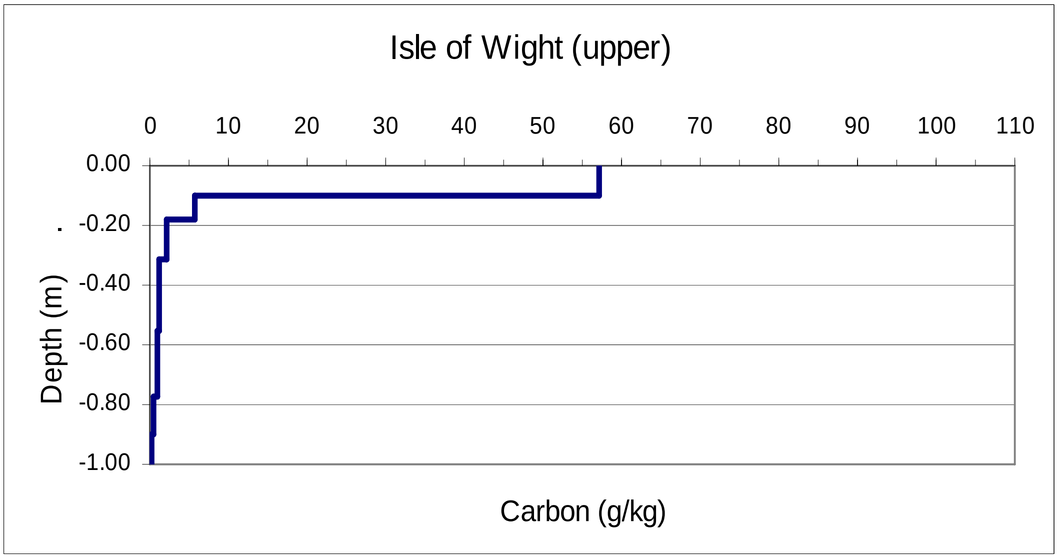


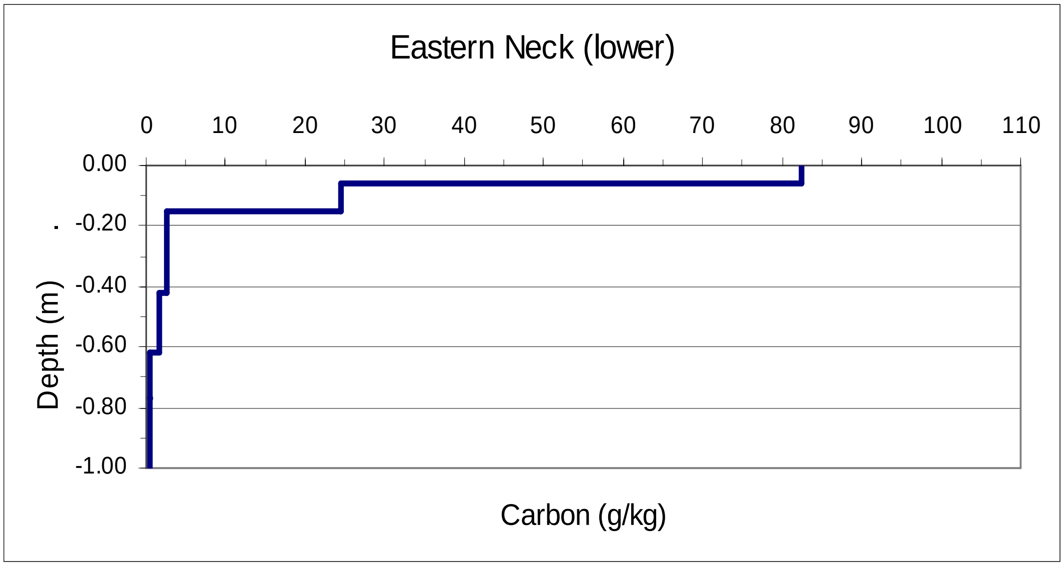


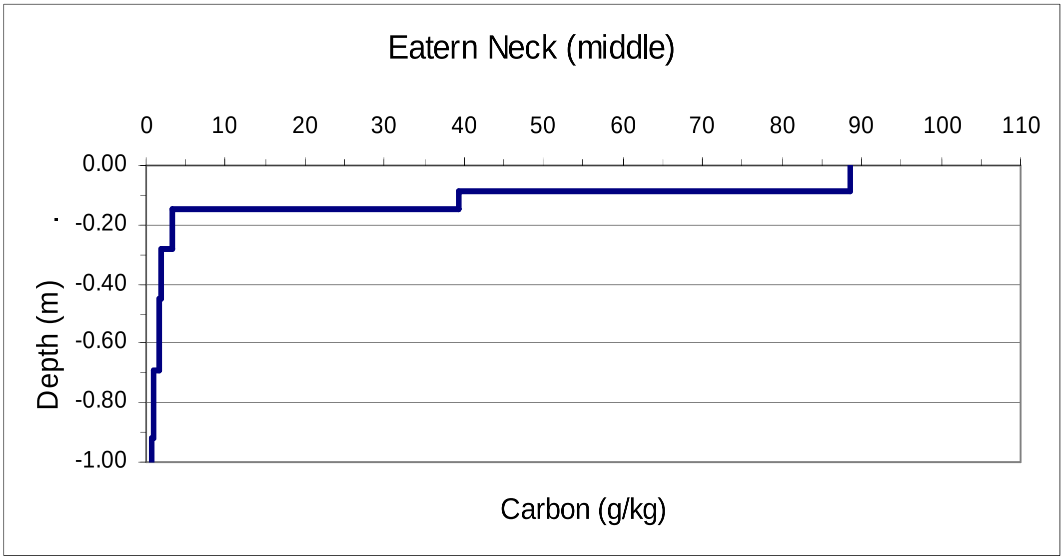


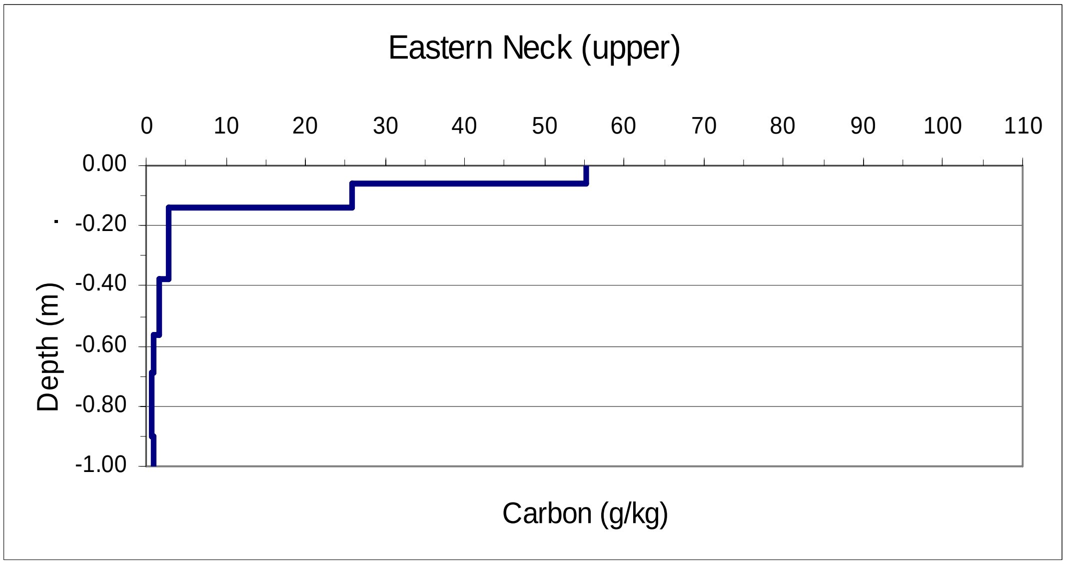

Isle of Wight (lower)
0
10
20
30
40
50
60
70
80
90
100
110
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
Depth (m)
Carbon (g/kg)

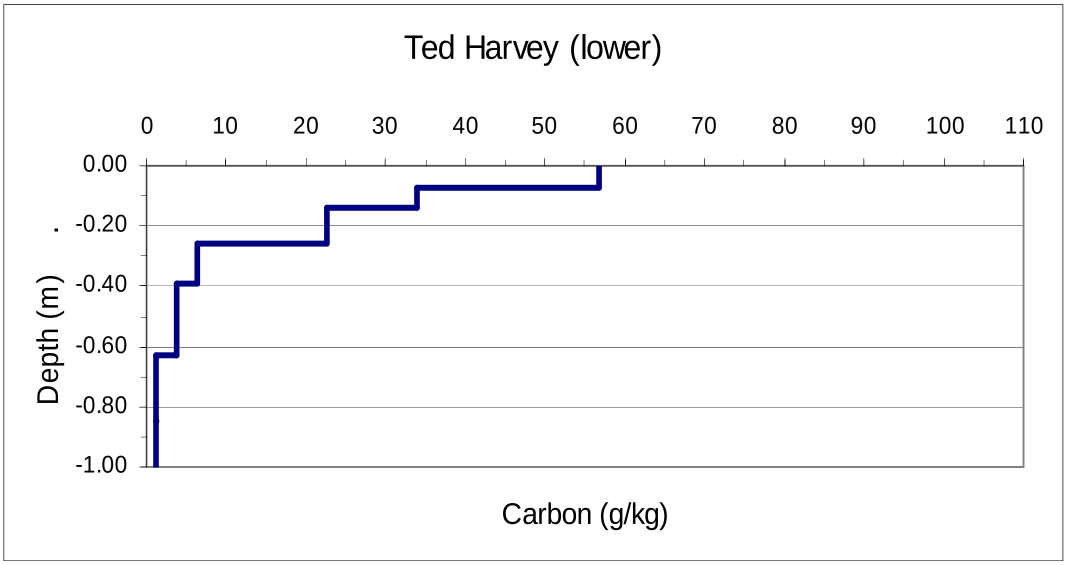

Isle of Wight (middle)
0
10
20
30
40
50
60
70
80
90
100
110
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
Depth (m)
Carbon (g/kg)

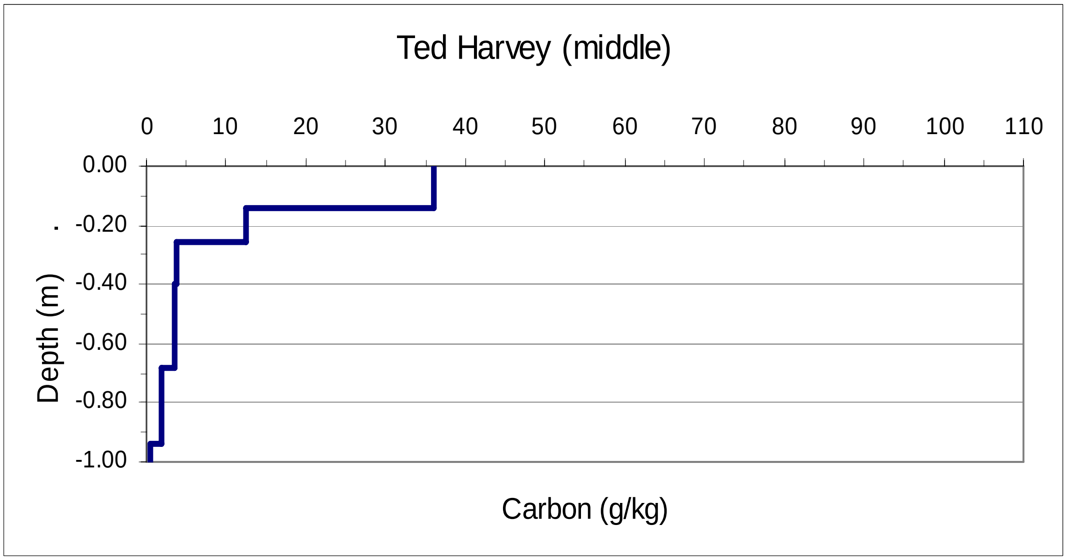

Isle of Wight (upper)
0
10
20
30
40
50
60
70
80
90
100
110
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
Depth (m)
Carbon (g/kg)

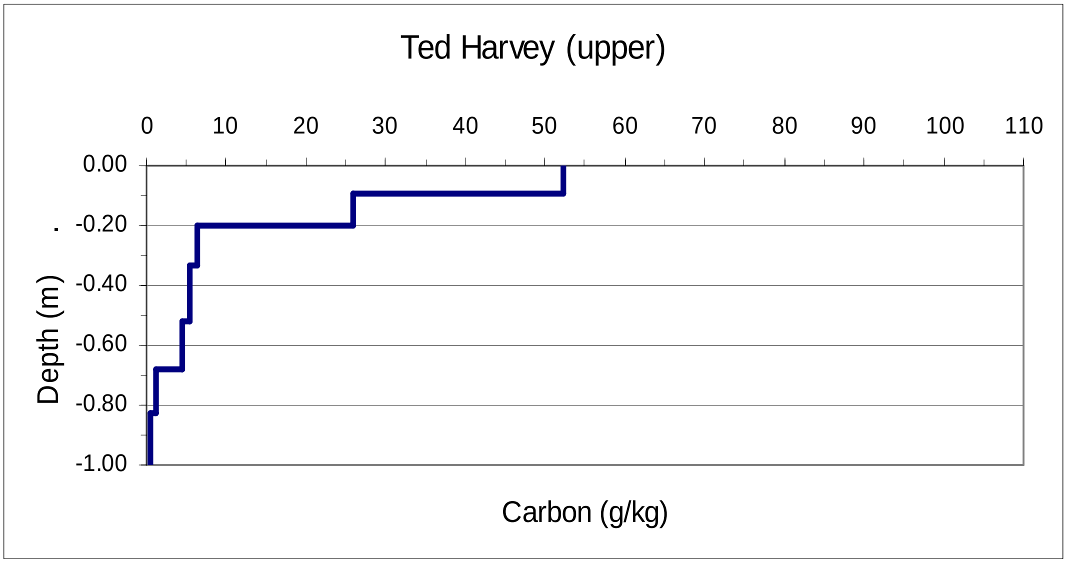

Eastern Neck (lower)
0
10
20
30
40
50
60
70
80
90
100
110
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
Depth (m)
Carbon (g/kg)


Eatern Neck (middle)
0
10
20
30
40
50
60
70
80
90
100
110
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
Depth (m)
Carbon (g/kg)


Eastern Neck (upper)
0
10
20
30
40
50
60
70
80
90
100
110
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
Depth (m)
Carbon (g/kg)


Ted Harvey (lower)
0
10
20
30
40
50
60
70
80
90
100
110
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
Depth (m)
Carbon (g/kg)


Ted Harvey (middle)
0
10
20
30
40
50
60
70
80
90
100
110
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
Depth (m)
Carbon (g/kg)


Ted Harvey (upper)
0
10
20
30
40
50
60
70
80
90
100
110
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
Depth (m)
Carbon (g/kg)

SITE	Depth (cm)	Average %C	SITE	Depth (cm)	Average %C
BWL	0-7	10.65	IOWL	0-9	2.55
BWL	7-16	0.98	IOWL	9-27	0.35
BWL	16-24	0.50	IOWL	27-45	0.26
BWL	24-39	0.41	IOWL	45-61	0.27
BWL	39-53	0.45	IOWL	61-90+	0.07
BWL	53-66	0.14			
BWL	66-77	0.10	IOWM	0-9	3.67
BWL	77-91	0.09	IOWM	9-20	0.93
			IOWM	20-33	0.38
BWM	0-10	2.83	IOWM	33-49	0.37
BWM	10-22	0.37	IOWM	49-70	0.22
BWM	22-51	0.32	IOWM	70-89	0.07
BWM	51-103	0.15	IOWM	89-125	0.02
BWM	103-129	0.05			
			IOWU	0-10	5.72
BWU	0-10	2.82	IOWU	10-18	0.57
BWU	10-16	1.41	IOWU	18-31	0.22
BWU	16-33	0.45	IOWU	31-55	0.12
BWU	33-63	0.33	IOWU	55-77	0.10
BWU	63-83	0.07	IOWU	77-90	0.05
BWU	83-173	0.07	IOWU	90-137	0.02
BWU	173-207	0.06	IOWU	137-150	0.06
			IOWU	150-183	0.05
			IOWU	183-225	0.06
			IOWU	225-259	0.04
			IOWU	259-270	0.02

SITE	Depth (cm)	Average %C	SITE	Depth (cm)	Average %C
ENL	0-6	8.24	THL	0-7	5.67
ENL	6-15	2.45	THL	7-14	3.38
ENL	15-32	0.26	THL	14-26	2.26
ENL	32-42	0.25	THL	26-39	0.64
ENL	42-62	0.17	THL	39-63	0.38
ENL	62-77	0.06	THL	63-85	0.13
ENL	77-112	0.04	THL	85-124	0.11
ENL	112-143	0.05	THL	124-170	0.07
ENL	143-167	0.07	THL	170-235	0.14
ENL	167-179	0.06	THL	235-280	0.23
ENL	179-199	0.07	THL	280-310	0.21
ENL	199-215	0.05	THL	310-335	0.23
ENL	215-257	0.02			
ENL	257-307	0.03	THM	0-14	3.60
			THM	14-26	1.25
ENM	0-9	8.85	THM	26-40	0.37
ENM	9-15	3.94	THM	40-68	0.34
ENM	15-28	0.32	THM	68-94	0.19
ENM	28-45	0.20	THM	94-118	0.05
ENM	45-69	0.16	THM	118-130	0.09
ENM	69-92	0.10	THM	130-148+	0.03
ENM	92-137	0.06			
ENM	137-157	0.06	THU	0-9	5.23
ENM	157-192	0.06	THU	9-20	2.59
ENM	192-237	0.03	THU	20-33	0.64
			THU	33-52	0.54
ENU	0-6	5.52	THU	52-68	0.45
ENU	6-14	2.58	THU	68-83	0.12
ENU	14-38	0.29	THU	83-105	0.05
ENU	38-56	0.16	THU	105-125	0.05
ENU	56-69	0.09	THU	125-142	0.12
ENU	69-90	0.07			
ENU	90-104	0.09			
ENU	104-121	0.07			
ENU	121-155	0.06			

Appendix C: Particle Size Analysis

Blackwater National Wildlife Refuge – Dorchester County, MD

Pedon	Hor.	Depth (cm)	< 2 mm ------- % -------				> 2 mm (sands) -------------- % -------------					
			S	Si	C	FC	VC	C	M	F	VF	CF
Lower	A	0-7	6.5	62.0	31.5	N/A	0.1	0.7	2.1	1.6	2.0	0.0
	Eg	7-16	7.8	74.7	17.5	N/A	0.5	1.1	2.0	1.5	2.6	0.0
	BEg	16-24	6.3	71.3	22.4	N/A	0.5	1.1	2.0	1.5	2.6	0.0
	Btg1	24-39	5.2	62.8	32.0	N/A	0.3	0.7	1.6	1.2	2.4	0.0
	Btg2	39-52	4.8	55.1	40.1	N/A	0.1	0.5	1.3	0.9	2.4	0.0
	Bt1	53-66	8.3	62.3	29.3	N/A	0.3	0.3	0.8	0.8	2.5	0.0
	Bt2	66-77	29.8	48.7	21.5	N/A	0.1	0.6	1.9	2.0	3.7	0.0
	2BC	77-91	55.3	30.0	14.8	N/A	0.2	2.6	11.5	9.6	5.8	0.0
Middle	A	0-10	9.8	79.3	10.9	N/A	0.2	1.2	2.8	2.3	3.2	0.0
	BE/Bt	10-22	7.3	71.9	20.8	N/A	0.3	0.7	1.8	1.6	2.8	0.0
	Btg	22-51	5.9	59.4	34.6	N/A	0.0	0.2	1.4	1.4	3.0	0.0
	2Bt	51-103	42.1	41.7	16.2	N/A	0.5	2.6	14.4	15.3	9.3	0.0
	2BC	103-129	86.7	7.2	6.1	N/A	1.8	3.3	22.2	39.9	19.4	0.5
Upper	A	0-10	26.2	63.3	10.5	N/A	1.0	3.1	10.8	7.3	4.2	0.0
	EA	10-16	24.5	64.1	11.4	N/A						
	Bt1	16-33	23.7	59.9	16.3	N/A	0.5	2.5	9.8	7.0	3.9	0.0
	Bt2	33-63	31.6	48.0	20.3	N/A	0.4	3.0	14.2	9.9	4.1	0.0
	2BC1	63-83	64.2	22.3	13.5	N/A	0.6	7.3	31.6	18.9	5.8	0.1
	2BC2	83-173	85.4	5.7	8.9	N/A	1.8	6.8	33.1	35.5	8.1	1.1
	2BC3	173-207	87.7	5.8	6.5	N/A	15.0	20.4	37.5	13.5	1.3	5.2

Isle of Wight Wildlife Management Area – Worcester County, MD												
Pedon	Hor.	Depth (cm)	< 2 mm ------- % -------				> 2 mm (sands) -------------- % -------------					
			S	Si	C	FC	VC	C	M	F	VF	CF
Lower	A	0-9	60.6	29.5	9.8	N/A	0.7	3.6	10.8	29.5	12.3	0.0
	B/A	9-27	57.0	32.7	10.3	N/A	0.7	3.6	10.8	29.5	12.3	0.0
	Bt1	27-45	55.0	30.5	14.5	N/A	0.4	2.6	10.1	29.6	12.2	0.0
	Bt2	45-61	77.7	9.5	12.8	N/A	0.5	3.8	14.4	46.2	12.7	0.0
	BC	61-90+	93.1	1.4	5.5	N/A	0.9	3.2	16.9	57.9	14.2	0.1
Middle	A	0-9	70.4	21.5	8.1	N/A	0.8	5.2	15.6	37.7	11.1	0.0
	AE	9-20	68.8	24.6	6.6	N/A	0.8	4.6	14.6	37.3	11.6	0.0
	EB	20-33	67.4	24.9	7.7	N/A	0.8	4.3	14.1	36.6	11.6	0.0
	Bt1	33-49	63.4	23.9	12.7	N/A	0.9	4.6	13.5	32.5	11.8	0.0
	Bt2	49-70	72.2	14.4	13.4	N/A	0.7	4.5	14.6	40.7	11.8	0.0
	C1	70-89	89.9	4.0	6.0	N/A	1.6	6.1	19.2	52.5	10.5	0.1
	C2	89-125+	95.2	1.7	3.1	N/A	0.3	4.2	16.8	59.4	14.5	0.0
Upper	A	0-10	70.5	20.6	8.9	N/A	0.4	6.6	13.8	38.5	11.1	0.0
	AB	10-18	68.0	24.4	7.6	N/A	0.5	6.4	13.1	37.1	10.9	0.0
	BA	18-31	64.1	26.9	8.9	N/A	0.8	5.7	12.4	35.0	10.2	0.0
	Bt1	31-55	67.3	24.9	7.8	N/A	1.3	5.2	14.3	32.4	14.2	0.1
	Bt2	55-77	84.0	7.7	8.3	N/A	2.2	8.2	18.9	41.7	13.0	0.2
	BC	77-90	93.4	2.6	4.0	N/A	1.1	4.7	18.9	54.5	14.2	0.2
	C1	90-137	97.7	1.8	0.5	N/A	0.2	3.4	18.3	58.1	17.7	0.0
	C2	137-150	88.0	5.4	6.5	N/A	0.3	3.2	14.5	49.2	20.9	0.0
	2Cg	150-183	70.1	19.2	10.7	N/A	0.8	3.7	12.4	32.4	20.7	0.1
	3C'1	183-225	36.0	39.7	24.3	N/A	0.3	1.3	4.2	8.5	21.7	0.0
	4C'2	225-259	66.7	26.5	6.8	N/A	0.2	1.0	5.2	21.7	38.6	0.0
	5C3	259-270+	86.6	12.8	0.6	N/A	0.1	0.2	3.2	29.4	53.7	0.0

Eastern Neck Island National Wildlife Refuge – Kent County, MD

Pedon	Horizon	Depth (cm)	< 2 mm ------- % -------				> 2 mm (sands) -------------- % -------------					
			S	Si	C	FC	VC	C	M	F	VF	CF
Lower	A	0-6	29.1	49.2	21.7	9.5	1.5	0.8	2.3	9.7	14.8	1.1
	EA	6-15	34.3	51.0	14.7	3.8	0.2	0.8	2.7	12.0	18.5	-0.4
	BE	15-32	36.3	49.9	13.8	N/A	0.5	0.8	2.7	11.6	20.7	0.3
	Bt1	32-42	38.8	44.3	16.9	5.2	0.4	0.8	2.7	11.6	23.3	0.4
	Bt2	42-62	44.7	37.7	17.6	6.5	0.6	1.1	2.8	12.3	27.9	2.1
	2Bt3	62-77	60.3	21.2	18.5	5.3	0.1	0.3	1.4	12.2	46.3	0.1
	2BC1	77-112	67.5	12.1	20.4	6.4	0.2	1.1	5	32.1	29.2	0
	2BC2	112-143	75.0	10.7	14.3	4.4	0.3	1.7	6.7	46.5	19.8	0.2
	2BC3	143-167	69.9	11.6	18.4	7.2	0.2	1.1	4.4	36.2	28	0.7
	2BC4	167-179	78.6	11.8	9.7	2.9	0.1	1.2	4	31.2	42.1	0
	2C1	179-199	82.1	8.3	9.5	3.2	0.1	0.4	1.5	33	47.1	0
	2C2	199-215	83.3	8.4	8.3	3.2	0.1	0.7	2.4	40.5	39.5	0
	2C3	215-257	82.7	8.4	8.9	4.1	0.2	0.7	2.3	33.5	46	0
	2C4	257-307	78.0	13.9	8.1	2.7	0	0.3	0.9	11.1	65.7	0
Middle	A	0-9	31.5	47.9	20.6	8.9	1.1	0.9	2.7	13.0	13.7	0.9
	AE	9-15	35.1	47.6	17.3	6.6	0.5	1.1	3.2	13.1	17.2	-0.8
	BE	15-28	38.0	48.6	13.4	N/A	0.3	0.9	3.0	14.0	19.7	0.1
	Bt1	28-45	37.2	46.4	16.4	5.5	0.2	0.8	2.7	13.3	20.2	0.2
	Bt2	45-69	45.3	38.5	16.2	7.2	0.3	0.8	3.2	16.4	24.6	0.1
	2Bt3	69-92	59.3	23.2	17.5	6.6	0.1	0.3	2.2	16.1	40.5	-0.1
	2BC1	92-137	72.1	9.7	18.3	8.6	0.1	1.7	7.3	44.7	18.3	0.5
	2BC2	137-157	69.9	13.9	16.1	7.6	0.1	0.9	3.6	28.2	37.1	0.2
	2C1	157-192	68.4	12.1	19.5	8.9	0.2	1.1	4.4	32.6	30.1	0.1
	2C2	192-237	91.9	5.4	2.7	0.7	0.1	0.3	1.8	40.5	49.2	0
Upper	A	0-6	37.4	47.4	15.2	6.3	0.5	1.2	3.5	14.0	18.2	0.0
	AE	6-14	34.8	51.2	14.0	4.2	0.4	1.0	3.3	13.0	17.1	0.0
	EB	14-38	34.8	53.7	11.5	3.1	0.1	0.8	3.0	13.3	17.5	0.0
	Bt1	38-56	33.4	49.9	16.8	5.5	0.2	0.9	3.1	12.3	16.8	0.0
	Bt2	56-69	53.8	30.6	15.6	6.4	0.2	1.6	5.1	20.5	26.4	0.0
	BCt	69-90	76.6	11.1	12.4	6.6	0.1	1.7	7.7	37.7	29.4	0.0
	2Bt	90-104	52.0	23.6	24.4	9.8	0.1	0.3	1.1	7.6	42.9	0.0
	2BC1	104-121	65.9	14.7	19.4	8.1	0.1	0.7	3.7	26.8	34.5	0.0
	2BC2	121-155	71.6	10.0	18.4	8.3	0.2	1.6	6.6	46.8	16.4	0.1

Ted Harvey Wildlife Area – Kent County, DE

Pedon	Hor	Depth (cm)	< 2 mm ------- % -------				> 2 mm (sands) -------------- % -------------					
			S	Si	C	FC	VC	C	M	F	VF	CF
Lower	A1	0-7	31.3	49.5	19.2	N/A	0.9	5.5	10.7	9.6	4.5	0.0
	A2	7-14	34.6	*	*	N/A	0.6	6.5	12.1	10.4	5.1	0.1
	AE	14-26	33.5	53.3	13.2	N/A	0.6	6.0	11.3	10.4	5.1	0.0
	EB	26-39	33.3	55.1	11.5	3.3	0.5	3.6	12.1	10.3	6.8	0.0
	Bt	39-63	41.8	*	*	N/A	0.9	4.6	15.2	13.3	7.7	0.5
	2BC1	63-85	78.4	14.9	6.6	3.1	1.2	12.1	35.5	25.5	4.1	0.0
	3BC2	85-124	25.2	63.0	11.8	3.6	0.6	2.7	5.6	5.7	10.6	0.0
	3BCg	124-170	8.8	69.2	22.0	9.6	0.2	0.8	1.7	2.0	4.1	0.0
	**	170-235	43.3	28.5	28.2	8.2	3.0	6.4	17.0	13.4	3.5	5.6
	**	235-280	28.4	34.4	37.2	9.4	1.5	3.9	12.2	8.8	1.9	1.2
	**	280-310	6.9	36.2	56.9	19.4	0.3	0.8	2.1	2.1	1.5	0.1
	**	310-335+	11.8	33.4	54.9	19.3	1.4	3.0	3.5	2.7	1.2	0.1
Middle	A	0-14	40.9	43.9	15.2	6.2	1.7	6.9	14.8	12.4	5.1	0.1
	AE	14-26	44.9	44.7	10.5	3.9	1.4	6.7	16.6	14.3	5.8	0.1
	BE	26-40	45.1	45.4	9.5	N/A	1.6	6.1	16.2	14.7	6.5	0.7
	Bt1	40-68	44.4	41.8	13.9	6.1	2.2	6.8	15.8	13.4	6.1	0.7
	Bt2	68-94	40.8	33.5	25.7	5.2	1.3	4.9	13.2	12.8	8.6	0.2
	2BC1	94-118	62.5	29.2	8.3	N/A	3.1	11.4	22.8	19.0	6.2	N/A
	3BC3	118-130	21.2	60.8	18.0	N/A	1.1	3.3	6.8	5.8	4.3	N/A
	4BC3	130-148+	74.0	16.2	9.8	N/A	4.5	13.0	26.6	23.5	6.4	N/A
Upper	A	0-9	17.9	62.1	19.9	8.3	0.8	2.9	5.7	5.0	3.6	0.1
	AE	9-20	18.6	65.4	16.0	6.0	0.5	2.7	5.7	5.3	4.3	0.1
	EB	20-33	18.8	67.5	13.8	N/A	0.3	1.9	5.2	5.1	6.3	0.0
	Bt1	33-52	14.6	67.1	18.3	N/A	0.3	1.5	3.7	3.9	5.2	N/A
	Bt2	52-68	17.7	62.2	20.0	N/A	0.3	1.4	4.1	4.5	7.4	N/A
	2Bt3	68-83	36.0	50.0	14.0	N/A	0.7	3.1	10.2	11.6	10.4	N/A
	2BC1	83-105	74.2	18.0	7.8	N/A	4.9	14.4	25.8	20.4	8.7	N/A
	2BC2	105-125	74.5	16.4	9.0	N/A	3.9	13.8	27.9	22.7	6.2	N/A
	3BC3	125-142+	12.8	47.0	40.2	N/A	0.3	1.7	4.1	4.0	2.7	N/A

* sample lost

** auger sample

Appendix D: Color Change Propensity Index (CCPI)

Color-Change Propensity Index (CCPI) – part 1:3
5g of air-dried soil
in 70 ml of sodium citrate buffer (0.0 hours @ room temperature)

Site	Horizon	Depth (cm)	Measure	Hue	Hue (numerical scale)	Value	Chroma
BWL	BEg	30-40	1	2.8Y	22.8	5.1	3.2
			2	2.7Y	22.7	5.0	3.0
			3	2.7Y	22.7	5.0	3.1
BWL	Btg1	40-53	1	2.4Y	22.4	5.1	3.2
			2	2.5Y	22.5	5.0	3.4
			3	2.4Y	22.4	4.8	3.1
BWM	BE-Btg	21-33	1	2.1Y	22.1	5.0	3.7
			2	2.0Y	22.0	4.9	3.6
			3	1.9Y	21.9	4.9	3.6
BWM	2Bt	62-114	1	0.5Y	20.5	4.9	4.0
			2	0.5Y	20.5	4.9	4.0
			3	0.5Y	20.5	4.9	4.0
BWU	Bt1	21-38	1	1.1Y	21.1	4.8	3.4
			2	1.1Y	21.1	4.8	3.3
			3	1.0Y	21.0	4.8	3.3
BWU	Bt2	38-68	1	0.7Y	20.7	4.9	3.9
			2	0.7Y	20.7	4.8	3.8
			3	0.7Y	20.7	4.9	3.9
BWU	2BC1	68-88	1	0.1Y	20.1	5.0	4.7
			2	0.1Y	20.1	4.9	4.4
			3	0.1Y	20.1	4.6	4.2
IOWL	B/A	15-33	1	0.7Y	20.7	4.6	3.5
			2	0.7Y	20.7	4.6	3.4
			3	0.6Y	20.6	4.5	3.4
IOWL	Bt1	33-51	1	0.6Y	20.6	4.8	3.8
			2	0.7Y	20.7	4.7	3.9
			3	0.2Y	20.2	4.6	3.8
IOWL	Bt2	51-66	1	0.4Y	20.4	4.5	3.4
			2	0.2Y	20.2	4.5	3.4
			3	0.3Y	20.3	4.5	3.8
IOWM	EB	20-33	1	0.4Y	20.4	4.7	3.2
			2	0.4Y	20.4	4.5	3.2
			3	0.3Y	20.3	4.4	3.1

IOWM	Bt1	33-49	1	0.1Y	20.1	4.5	3.7
			2	0.1Y	20.1	4.5	3.7
			3	0.1Y	20.1	4.5	3.7
IOWM	Bt2	49-70	1	0.1Y	20.1	4.6	4.1
			2	0.1Y	20.1	4.7	4.1
			3	0.1Y	20.1	4.3	3.9
IOWU	AB	10-18	1	0.6Y	20.6	3.7	2.2
			2	0.7Y	20.7	3.7	2.2
			3	0.7Y	20.7	3.8	2.3
IOWU	BA	18-31	1	0.5Y	20.5	4.4	3.3
			2	0.5Y	20.5	4.5	3.4
			3	0.4Y	20.4	4.5	3.4
IOWU	Bt1	31-55	1	0.9Y	20.9	4.8	3.8
			2	0.7Y	20.7	4.7	3.6
			3	0.5Y	20.5	4.7	3.8
THL	AE	14-26	1	9.5YR	19.5	3.3	1.5
			2	9.7YR	19.7	3.3	1.5
			3	9.6YR	19.6	3.3	1.5
THL	EB	26-39	1	0.1Y	20.1	3.7	4.6
			2	0.1Y	20.1	4.5	2.9
			3	0.1Y	20.1	4.4	2.9
THL	Bt1	39-63	1	0.1Y	20.1	4.6	3.7
			2	0.1Y	20.1	4.5	3.6
			3	0.1Y	20.1	4.3	3.6
THM	AE	14-26	1	0.1Y	20.1	3.7	2.2
			2	0.1Y	20.1	3.7	2.2
			3	0.1Y	20.1	3.7	2.2
THM	BE	26-40	1	0.3Y	20.3	4.6	3.1
			2	0.3Y	20.3	4.4	3.1
			3	0.2Y	20.2	4.5	3.1
THM	Bt1	40-68	1	0.1Y	20.1	4.7	3.8
			2	0.1Y	20.1	4.8	3.9
			3	0.1Y	20.1	4.8	3.9
THU	EB	20-33	1	0.1Y	20.1	4.6	3.1
			2	0.1Y	20.1	4.7	3.1
			3	0.1Y	20.1	4.5	3.1

THU	Bt1	33-52	1	0.1Y	20.1	4.7	3.7
			2	0.1Y	20.1	4.7	3.8
			3	0.1Y	20.1	4.6	3.5
THU	Bt2	52-68	1	0.1Y	20.1	4.8	3.8
			2	0.1Y	20.1	4.6	3.8
			3	0.1Y	20.1	4.6	3.7
ENL	BE	18-35	1	0.9Y	20.9	5.1	3.8
			2	0.9Y	20.9	5.0	3.8
			3	0.8Y	20.8	4.8	3.7
ENL	Bt1	35-45	1	0.4Y	20.4	4.9	4.1
			2	0.4Y	20.4	4.7	4.0
			3	0.1Y	20.1	4.9	4.1
ENL	Bt2	45-65	1	0.1Y	20.1	4.9	4.2
			2	0.1Y	20.1	4.8	4.1
			3	0.1Y	20.1	4.9	4.2
ENM	BE	18-31	1	1.4Y	21.4	5.1	3.5
			2	1.5Y	21.5	5.1	3.5
			3	1.5Y	21.5	5.1	3.4
ENM	Bt1	31-48	1	1.0Y	21.0	5.2	4.2
			2	1.0Y	21.0	5.1	4.2
			3	0.9Y	20.9	4.9	4.1
ENM	2Bt3	72-95	1	1.2Y	21.2	5.3	4.2
			2	1.4Y	21.4	5.0	4.1
			3	1.2Y	21.2	5.1	4.1
ENU	AE	6-14	1	0.1Y	20.1	3.6	2.0
			2	0.1Y	20.1	3.6	2.1
			3	0.1Y	20.1	3.3	2.0
ENU	EB	14-38	1	1.0Y	21.0	5.1	3.6
			2	1.0Y	21.0	4.9	3.6
			3	0.9Y	20.9	4.9	3.6
ENU	Bt1	38-56	1	0.8Y	20.8	5.1	4.1
			2	0.6Y	20.6	5.1	4.1
			3	0.6Y	20.6	5.1	4.1

Color-Change Propensity Index (CCPI) – part 2:3
5.0 g of air-dried soil + 5.0 g sodium dithionite
in 70 ml of sodium citrate buffer (1.0 hours @ room temperature)

Site	Horizon	Depth (cm)	Measure	Hue	Hue (numerical scale)	Value	Chroma
BWL	BEg	30-40	1	4.6Y	24.6	5.0	1.5
			2	4.7Y	24.7	4.9	1.5
			3	4.8Y	24.8	5.1	1.5
BWL	Btg1	40-53	1	6.7Y	26.7	4.9	1.2
			2	6.7Y	26.7	4.8	1.2
			3	6.4Y	26.4	4.7	1.2
BWM	BE-Btg	21-33	1	4.4Y	24.4	5.1	1.3
			2	4.3Y	24.3	4.9	1.3
			3	4.1Y	24.1	4.9	1.3
BWM	2Bt	62-114	1	3.3Y	23.3	4.7	1.3
			2	3.2Y	23.2	4.8	1.3
			3	3.4Y	23.4	4.7	1.3
BWU	Bt1	21-38	1	3.1Y	23.1	4.6	1.9
			2	3.1Y	23.1	4.7	1.9
			3	3.1Y	23.1	4.5	1.8
BWU	Bt2	38-68	1	3.7Y	23.7	4.8	1.6
			2	3.7Y	23.7	4.7	1.7
			3	3.7Y	23.7	4.7	1.7
BWU	2BC1	68-88	1	2.0Y	20.0	4.6	1.8
			2	1.9Y	21.9	4.7	1.8
			3	2.2Y	22.2	4.7	1.7
IOWL	B/A	15-33	1	2.5Y	22.5	4.3	1.7
			2	2.5Y	22.5	4.4	1.7
			3	2.5Y	22.5	4.3	1.7
IOWL	Bt1	33-51	1	2.9Y	22.9	4.6	1.8
			2	2.8Y	22.8	4.4	1.8
			3	2.8Y	22.8	4.2	1.8
IOWL	Bt2	51-66	1	2.8Y	22.8	4.3	1.7
			2	2.8Y	22.8	4.2	1.7
			3	2.3Y	22.3	4.0	1.7
IOWM	EB	20-33	1	2.2Y	22.2	4.3	1.7
			2	2.3Y	22.3	4.3	1.8
			3	2.2Y	22.2	4.1	1.8

IOWM	Bt1	33-49	1	2.5Y	22.5	4.5	1.6
			2	2.4Y	22.4	4.6	1.6
			3	2.4Y	22.4	4.4	1.5
IOWM	Bt2	49-70	1	2.7Y	22.7	4.6	1.7
			2	2.8Y	22.8	4.4	1.7
			3	2.7Y	22.7	4.6	1.7
IOWU	AB	10-18	1	2.2Y	22.2	3.7	1.4
			2	2.2Y	22.2	3.8	1.4
			3	2.1Y	22.1	3.8	1.4
IOWU	BA	18-31	1	2.9Y	22.9	4.2	1.9
			2	2.8Y	22.8	4.4	1.9
			3	2.8Y	22.8	4.1	1.8
IOWU	Bt1	31-55	1	3.0Y	23.0	4.5	1.8
			2	3.0Y	23.0	4.4	1.9
			3	3.0Y	23.0	4.5	2.0
THL	AE	14-26	1	0.9Y	20.9	3.4	1.1
			2	0.8Y	20.8	3.4	1.1
			3	1.2Y	21.2	3.3	1.1
THL	EB	26-39	1	2.4Y	22.4	4.5	1.5
			2	2.6Y	22.6	4.4	1.6
			3	2.6Y	22.6	4.1	1.5
THL	Bt1	39-63	1	3.1Y	23.1	4.7	1.5
			2	3.1Y	23.1	4.6	1.5
			3	2.8Y	22.8	4.5	1.4
THM	AE	14-26	1	1.7Y	21.7	3.7	1.4
			2	1.8Y	21.8	3.8	1.4
			3	1.7Y	21.7	3.7	1.4
THM	BE	26-40	1	2.9Y	22.9	4.3	1.5
			2	2.7Y	22.7	4.4	1.5
			3	2.7Y	22.7	4.4	1.6
THM	Bt1	40-68	1	3.3Y	23.3	4.8	1.5
			2	3.5Y	23.5	4.8	1.5
			3	3.5Y	23.5	4.7	1.5
THU	EB	20-33	1	2.4Y	22.4	4.5	1.7
			2	2.4Y	22.4	4.3	1.7
			3	2.4Y	22.4	4.5	1.7

THU	Bt1	33-52	1	2.7Y	22.7	4.6	1.7
			2	2.8Y	22.8	4.5	1.7
			3	3.0Y	23.0	4.5	1.7
THU	Bt2	52-68	1	3.5Y	23.5	4.6	1.4
			2	3.4Y	23.4	4.7	1.4
			3	3.4Y	23.4	4.5	1.4
ENL	BE	18-35	1	3.1Y	23.1	5.0	2.2
			2	3.1Y	23.1	5.0	2.1
			3	3.2Y	23.2	4.8	2.0
ENL	Bt1	35-45	1	2.8Y	22.8	4.9	2.0
			2	2.7Y	22.7	4.9	2.0
			3	2.7Y	22.7	4.9	2.0
ENL	Bt2	45-65	1	3.0Y	23.0	4.8	1.9
			2	3.1Y	23.1	4.7	2.0
			3	3.0Y	23.0	4.9	1.9
ENM	BE	18-31	1	3.0Y	23.0	4.9	2.1
			2	3.1Y	23.1	4.8	2.0
			3	3.1Y	23.1	4.9	2.0
ENM	Bt1	31-48	1	3.5Y	23.5	4.9	2.1
			2	3.5Y	23.5	4.9	2.1
			3	3.4Y	23.4	4.9	2.1
ENM	2Bt3	72-95	1	7.3Y	27.3	5.1	1.2
			2	7.1Y	27.1	5.0	1.2
			3	6.9Y	26.9	5.1	1.2
ENU	AE	6-14	1	1.7Y	21.7	3.6	1.6
			2	1.7Y	21.7	3.7	1.6
			3	1.5Y	21.5	3.5	1.5
ENU	EB	14-38	1	3.3Y	23.3	4.8	2.0
			2	3.4Y	23.4	4.8	2.0
			3	3.5Y	23.5	4.7	2.0
ENU	Bt1	38-56	1	4.0Y	24.0	4.8	2.1
			2	4.1Y	24.1	4.6	2.0
			3	4.2Y	24.2	4.9	2.1

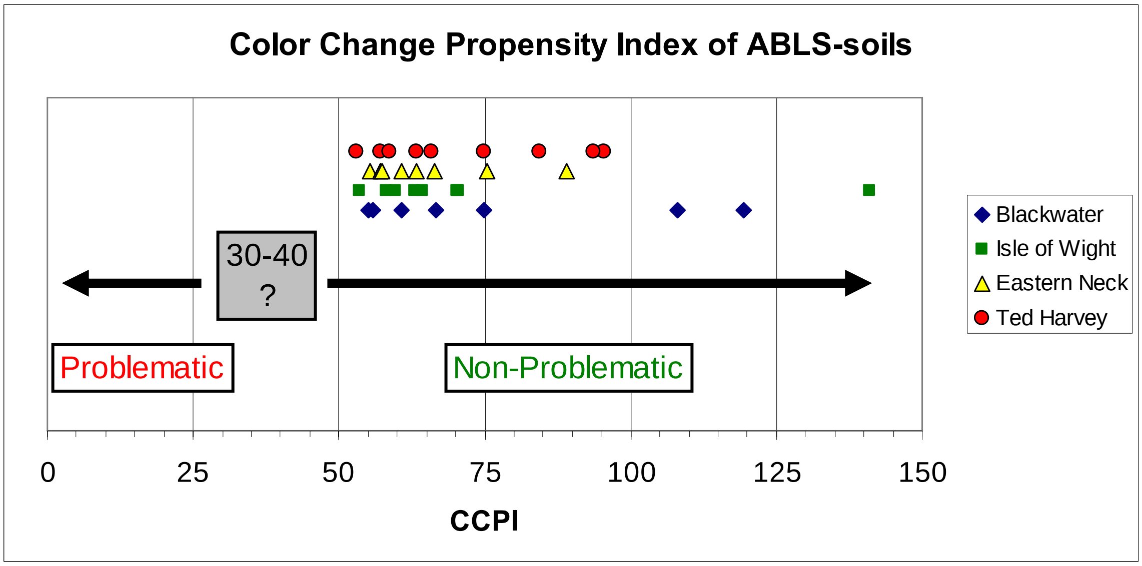
Color-Change Propensity Index (CCPI) – part 3:3
5.0 g of air-dried soil + 5.0 g sodium dithionite
in 70 ml of sodium citrate buffer (2 x 2.0 hours @ 80°C)

Site	Horizon	Depth (cm)	Measure	Hue	Hue (numerical scale)	Value	Chroma
BWL	BEg	30-40	1	4.8Y	24.8	5.1	0.6
			2	4.7Y	24.7	5.1	0.6
			3	4.8Y	24.8	5.1	0.6
BWL	Btg1	40-53	1	1.1GY	31.1	5.0	0.4
			2	1.5GY	31.5	5.0	0.4
			3	1.2GY	31.2	5.1	0.4
BWM	BE-Btg	21-33	1	5.0Y	25.0	4.9	0.6
			2	4.7Y	24.7	4.9	0.6
			3	5.1Y	25.1	4.8	0.6
BWM	2Bt	62-114	1	4.1GY	34.1	4.9	0.4
			2	5.1GY	35.1	4.9	0.4
			3	4.8GY	34.8	4.8	0.4
BWU	Bt1	21-38	1	5.7Y	25.7	5.0	0.7
			2	5.7Y	25.7	4.8	0.6
			3	5.6Y	25.6	4.9	0.6
BWU	Bt2	38-68	1	1.0GY	31.0	4.9	0.4
			2	.6GY	30.6	5.0	0.5
			3	1.0GY	31.0	4.8	0.4
BWU	2BC1	68-88	1	7.5Y	27.5	5.0	0.5
			2	7.3Y	27.3	5.0	0.5
			3	6.6Y	26.6	4.9	0.5
IOWL	B/A	15-33	1	5.7Y	25.7	4.7	0.7
			2	5.2Y	25.2	4.5	0.6
			3	5.5Y	25.5	4.6	0.7
IOWL	Bt1	33-51	1	8.5Y	28.5	4.7	0.5
			2	8.8Y	28.8	5.0	0.5
			3	8.7Y	28.7	4.8	0.5
IOWL	Bt2	51-66	1	9.6Y	29.6	4.5	0.5
			2	9.1Y	29.1	4.7	0.5
			3	8.3Y	28.3	4.6	0.5
IOWM	EB	20-33	1	4.0Y	24.0	4.4	0.8
			2	4.1Y	24.1	4.4	0.8

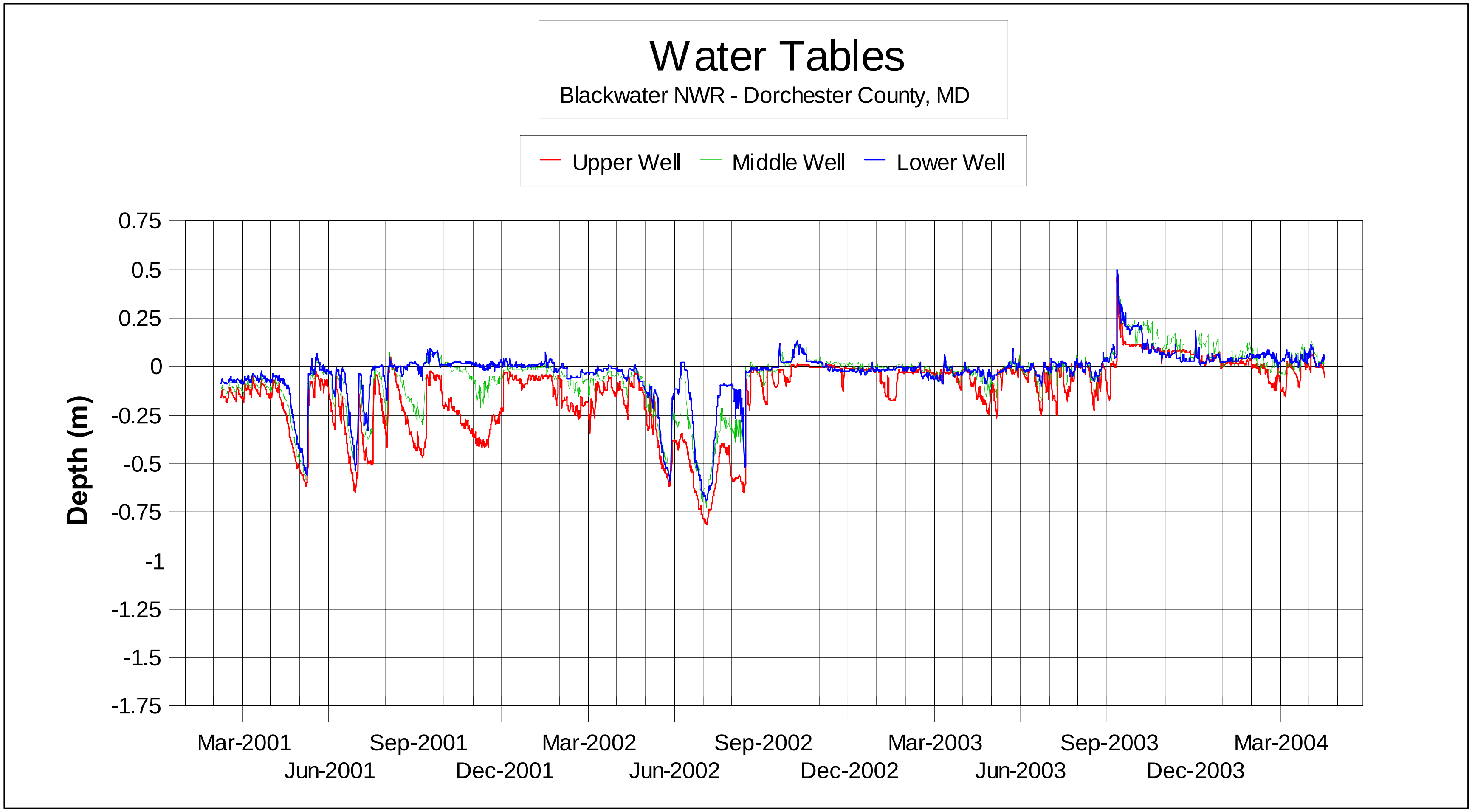
			3	4.3Y	24.3	4.5	0.8
IOWM	Bt1	33-49	1	6.8Y	26.8	4.7	0.6
			2	6.7Y	26.7	4.7	0.5
			3	7.0Y	27.0	4.7	0.5
IOWM	Bt2	49-70	1				
			2				
			3				
IOWU	AB	10-18	1	1.9Y	21.9	3.7	0.8
			2	1.9Y	21.9	3.8	0.8
			3	1.7Y	21.7	3.8	0.8
IOWU	BA	18-31	1	5.4Y	25.4	4.7	0.7
			2	5.2Y	25.4	4.6	0.7
			3	5.4Y	25.4	4.6	0.7
IOWU	Bt1	31-55	1	7.8Y	27.8	4.7	0.5
			2	7.8Y	27.8	4.8	0.6
			3	8.0Y	28.0	4.6	0.5
THL	AE	14-26	1	1.1Y	21.1	3.3	0.7
			2	1.4Y	21.4	3.2	0.8
			3	0.9Y	20.9	3.3	0.7
THL	EB	26-39	1	4.4Y	24.4	4.2	0.8
			2	4.3Y	24.3	4.3	0.7
			3	4.2Y	24.2	4.2	0.7
THL	Bt1	39-63	1	0.9GY	30.9	4.7	0.4
			2	0.7GY	30.7	4.6	0.4
			3	1.3GY	31.3	4.7	0.4
THM	AE	14-26	1	2.1Y	22.1	3.8	0.8
			2	2.1Y	22.1	3.7	0.8
			3	2.1Y	22.1	3.7	0.8
THM	BE	26-40	1	5.0Y	25.0	4.6	0.7
			2	5.2Y	25.2	4.5	0.7
			3	4.8Y	24.8	4.5	0.8
THM	Bt1	40-68	1	0.9GY	30.9	4.7	0.4
			2	1.1GY	31.1	4.8	0.4
			3	0.8GY	30.8	4.7	0.5
THU	EB	20-33	1	5.1Y	25.1	4.6	0.7
			2	5.2Y	25.2	4.5	0.7

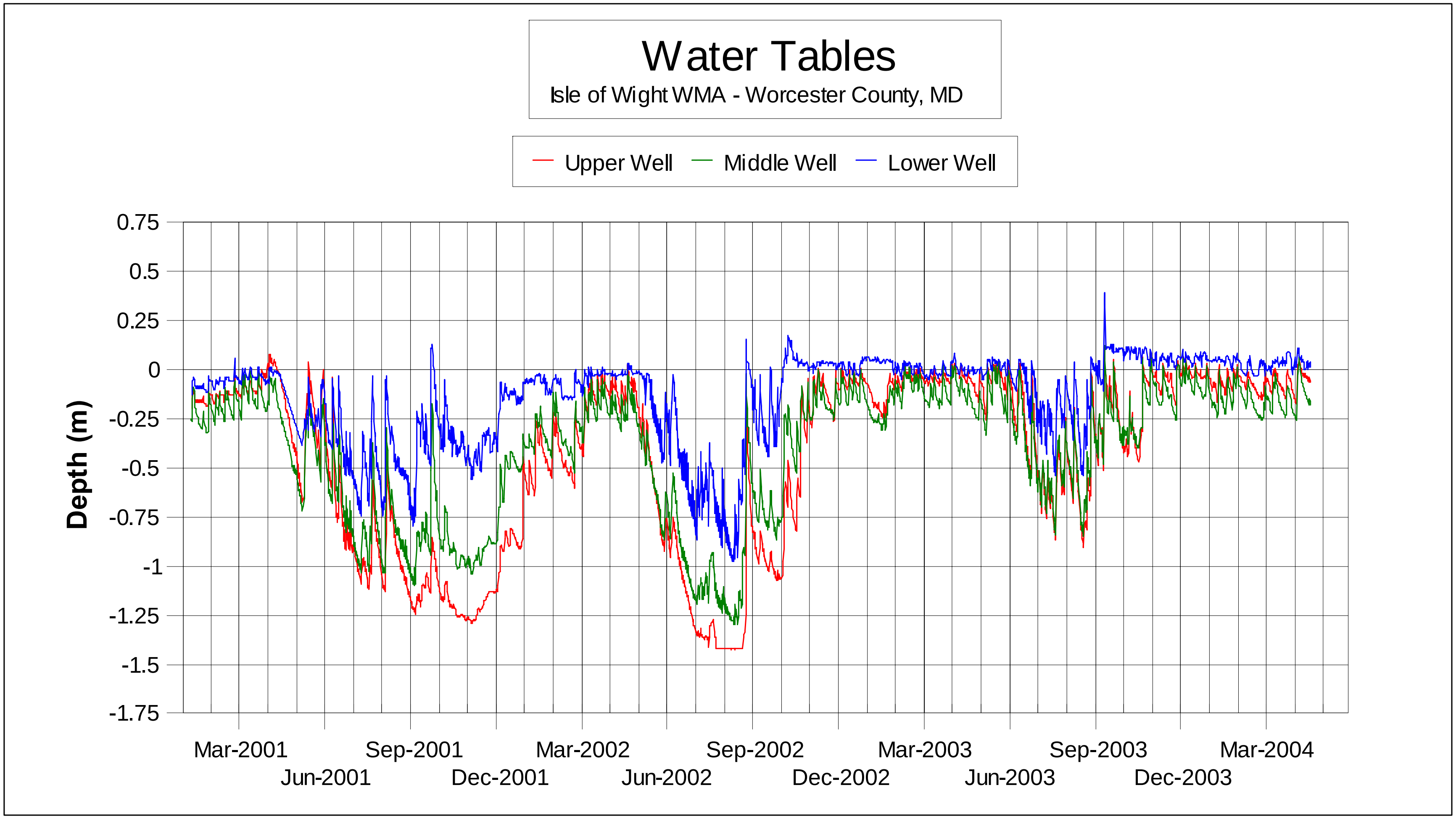
			3	5.3Y	25.3	4.6	0.7
THU	Bt1	33-52	1	9.0Y	29.0	4.8	0.5
			2	9.1Y	29.1	4.6	0.5
			3	9.3Y	29.3	4.6	0.5
THU	Bt2	52-68	1	6.2GY	36.2	4.6	0.4
			2	6.0GY	36.0	4.6	0.4
			3	6.5GY	36.5	4.6	0.4
ENL	BE	18-35	1	6.8Y	26.8	5.1	0.7
			2	7.1Y	27.1	5.1	0.6
			3	6.8Y	26.8	5.1	0.7
ENL	Bt1	35-45	1	.2GY	30.2	5.2	0.5
			2	.3GY	30.3	5.2	0.5
			3	.1GY	30.1	5.4	0.5
ENL	Bt2	45-65	1	1.9GY	31.9	5.1	0.5
			2	1.7GY	31.7	5.0	0.5
			3	2.6GY	32.6	4.9	0.5
ENM	BE	18-31	1	5.7Y	25.7	5.0	0.7
			2	5.6Y	25.6	5.1	0.7
			3	5.7Y	25.7	5.0	0.7
ENM	Bt1	31-48	1	1.0GY	31.0	5.4	0.5
			2	.2GY	30.2	5.3	0.5
			3	.7GY	30.7	5.3	0.5
ENM	2Bt3	72-95	1	6.8GY	36.8	5.3	0.5
			2	6.9GY	36.9	5.1	0.5
			3	6.8GY	36.8	5.2	0.5
ENU	AE	6-14	1	2.2Y	22.2	3.8	0.9
			2	1.8Y	21.8	3.8	0.9
			3	2.0Y	22.0	3.7	0.8
ENU	EB	14-38	1	6.7Y	26.7	5.0	0.7
			2	6.7Y	26.7	5.1	0.7
			3	6.9Y	26.9	5.0	0.7
ENU	Bt1	38-56	1	3.6GY	33.6	5.2	0.4
			2	3.8GY	33.8	5.3	0.4
			3	3.5GY	33.5	5.1	0.4

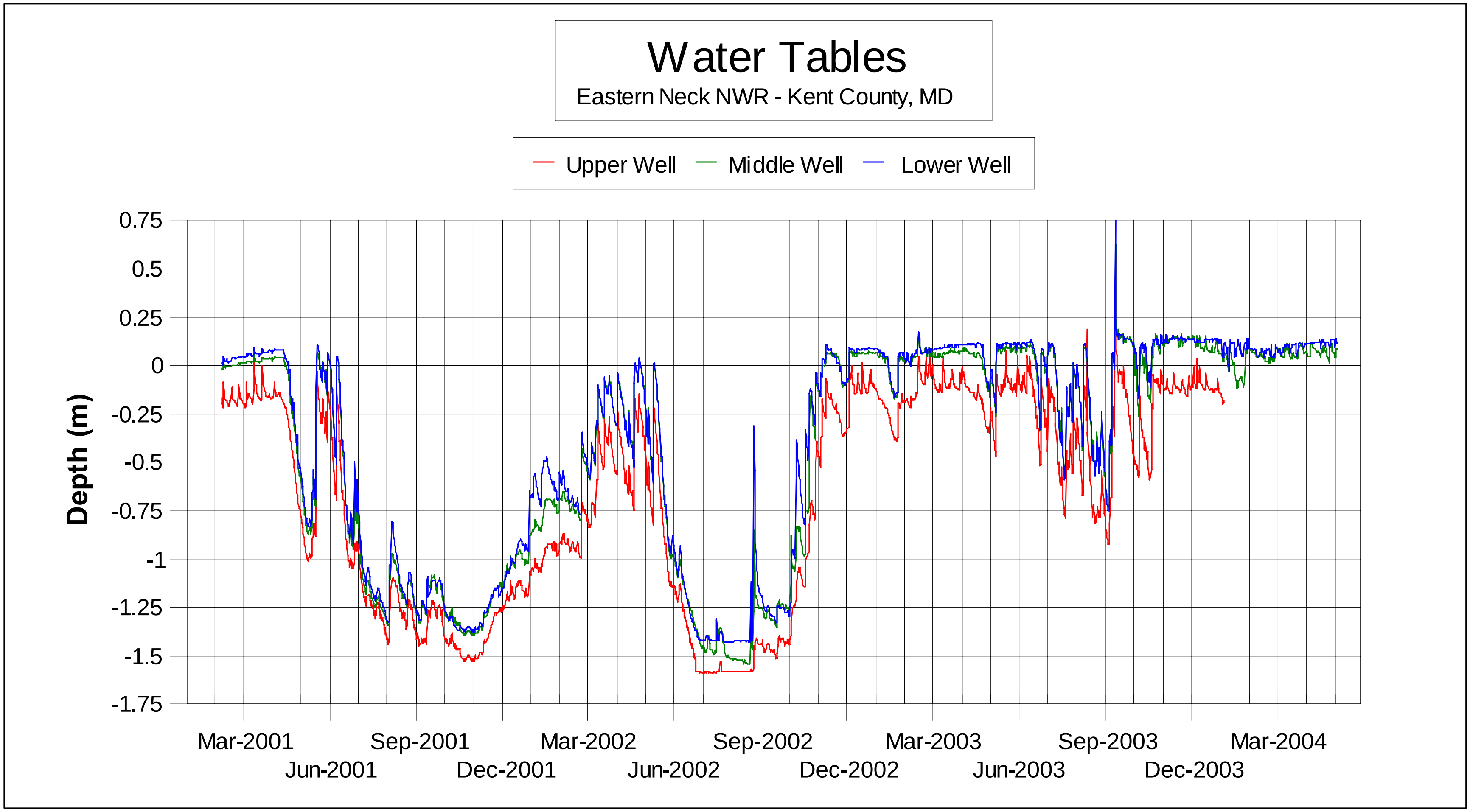
Research Site											
Blackwater			Isle of Wight			Eastern Neck			Ted Harvey		
Pos.	Hor.	CCPI	Pos.	Hor.	CCPI	Pos.	Hor.	CCPI	Pos.	Hor.	CCPI
up	2BC1	55.1	low	Bt2	53.6	low	Bt1	55.4	up	Bt2	53.1
mid	2Bt	55.8	low	Bt1	58.2	low	Bt2	57.0	low	Bt1	57.0
up	Bt2	60.8	up	Bt1	59.6	mid	Bt1	57.1	up	Bt1	58.7
up	Bt1	66.7	low	B/A	63.1	up	Bt1	57.5	mid	Bt1	63.4
low	Btg1	74.8	mid	Bt1	64.4	mid	BE	60.6	up	EB	65.9
mid	BE-Btg	108.1	mid	EB	70.2	low	BE	63.3	mid	BE	74.8
low	BEg	119.5	up	BA	70.6	up	EB	66.4	low	EB	84.3
			up	AB	141.0	mid	2Bt3	75.5	mid	AE	93.7
						up	AE	89.1	low	AE	95.4

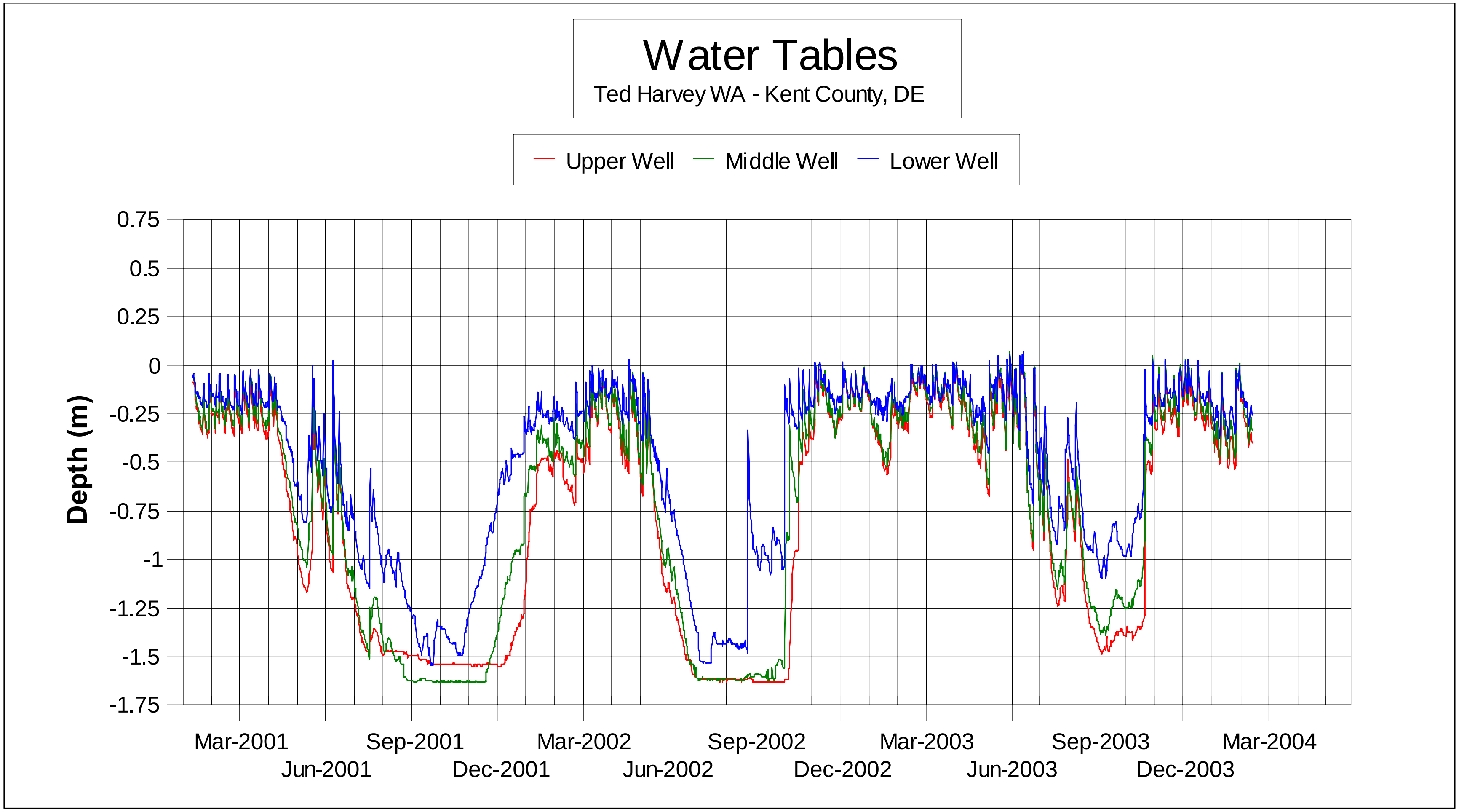


Appendix E: Water Tables Graphs (relative to the soil surface)




Water Tables
Isle of Wight WMA - Worcester County, MD
Upper Well
Middle Well
Lower Well
Depth (m)
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
-1.25
-1.5
-1.75
Mar-2001
Jun-2001
Sep-2001
Dec-2001
Mar-2002
Jun-2002
Sep-2002
Dec-2002
Mar-2003
Jun-2003
Sep-2003
Dec-2003
Mar-2004

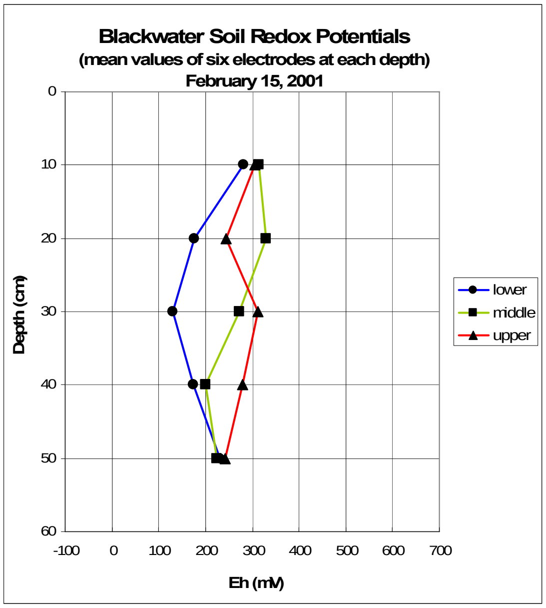

Water Tables
Eastern Neck NWR - Kent County, MD
Upper Well
Middle Well
Lower Well
Depth (m)
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
-1.25
-1.5
-1.75
Mar-2001
Jun-2001
Sep-2001
Dec-2001
Mar-2002
Jun-2002
Sep-2002
Dec-2002
Mar-2003
Jun-2003
Sep-2003
Dec-2003
Mar-2004


Water Tables
Ted Harvey WA - Kent County, DE
Upper Well
Middle Well
Lower Well
Depth (m)
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
-1.25
-1.5
-1.75
Mar-2001
Jun-2001
Sep-2001
Dec-2001
Mar-2002
Jun-2002
Sep-2002
Dec-2002
Mar-2003
Jun-2003
Sep-2003
Dec-2003
Mar-2004

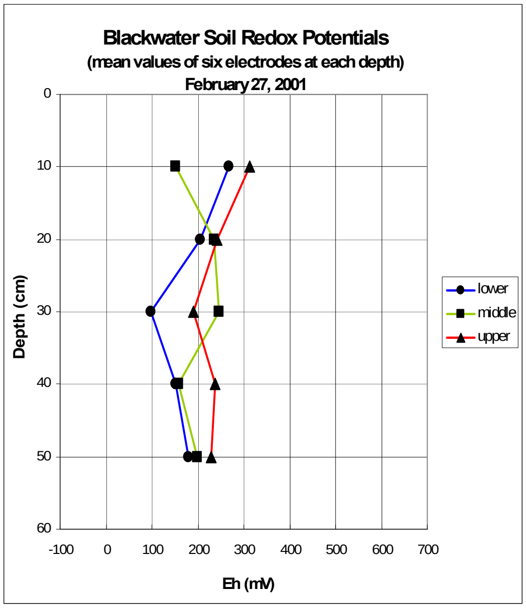
Appendix F: Redox Potential Data

Blackwater			--------------	cm	--------------	
15-Feb-01		10	20	30	40	50
	circuit		----------	Eh (mV)	----------	
Lower	1	329	290	124	201	227
Well	2	168	146	134	16	226
	3	313	180	154	223	253
	4	265	163	146	206	221
	5	335	227	199	234	228
	6	282	56	31	162	224
mean (mV)		**282**	**177**	**131**	**174**	**230**
Middle	1	407	400	378	355	262
Well	2	320	312	289	256	262
	3	274	254	239	66	219
	4	354	336	256	222	222
	5	305	365	245	115	183
	6	225	311	231	184	198
mean (mV)		**314**	**330**	**273**	**200**	**224**
Upper	1	232	218	362	343	281
Well	2	285	213	309	269	253
	3	296	344	253	278	225
	4	343	212	375	304	233
	5	411	284	276	236	213
	6	261	196	295	248	255
mean (mV)		**305**	**245**	**312**	**280**	**243**

Blackwater			--------------	cm	--------------	
27-Feb-01		10	20	30	40	50
	circuit		----------	Eh (mV)	----------	
Lower	1	346	112	84	91	179
Well	2	128	158	20	172	198
	3	244	205	161	175	134
	4	308	319	142	180	191
	5	291	294	91	147	205
	6	283	147	84	140	173
mean (mV)		**267**	**206**	**97**	**151**	**180**
Middle	1	101	301	339	97	194
Well	2	-26	198	12	224	217
	3	117	122	121	149	125
	4	310	282	456	-11	177
	5	304	259	246	179	221
	6	99	248	308	316	256
mean (mV)		**151**	**235**	**247**	**159**	**198**
Upper	1	341	365	254	288	258
Well	2	345	256	163	251	235
	3	226	121	110	124	72
	4	270	188	172	279	287
	5	360	246	181	228	251
	6	331	270	268	254	263
mean (mV)		**312**	**241**	**191**	**237**	**228**



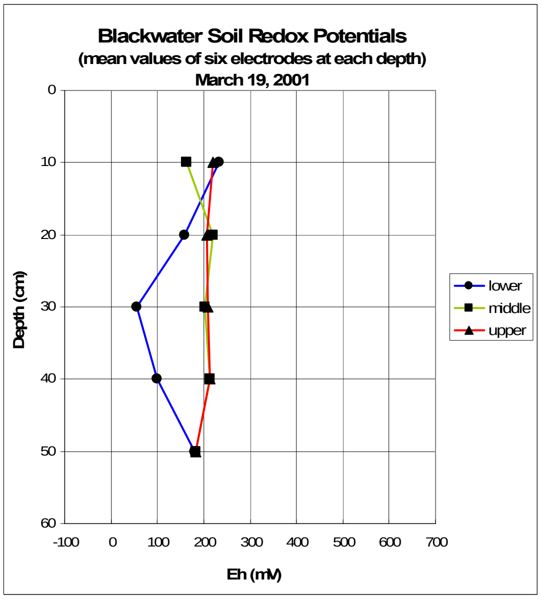
Blackwater Soil Redox Potentials
(mean values of six electrodes at each depth)
February 15, 2001

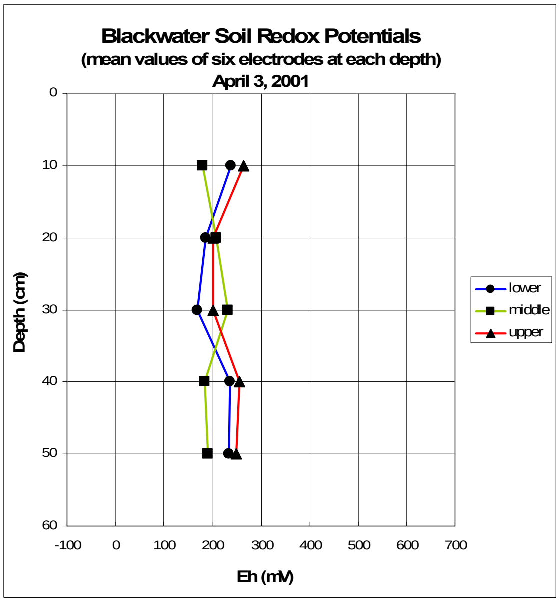


Blackwater Soil Redox Potentials
(mean values of six electrodes at each depth)
February 27, 2001

Blackwater		--------------		cm		--------------
19-Mar-01		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	239	174	161	135	241
Well	2	179	285	89	174	209
	3	217	174	-43	-6	78
	4	254	73	-30	111	183
	5	254	161	16	124	146
	6	254	89	137	61	222
mean (mV)		**233**	**159**	**55**	**100**	**180**
Middle	1	272	263	227	239	219
Well	2	119	197	251	220	299
	3	134	272	120	147	60
	4	272	178	188	193	144
	5	135	143	142	155	67
	6	53	275	286	321	311
mean (mV)		**164**	**221**	**202**	**213**	**183**
Upper	1	187	183	155	239	219
Well	2	169	260	219	220	299
	3	165	200	148	147	60
	4	294	227	287	193	144
	5	192	132	182	155	67
	6	313	234	261	321	311
mean (mV)		**220**	**206**	**209**	**213**	**183**

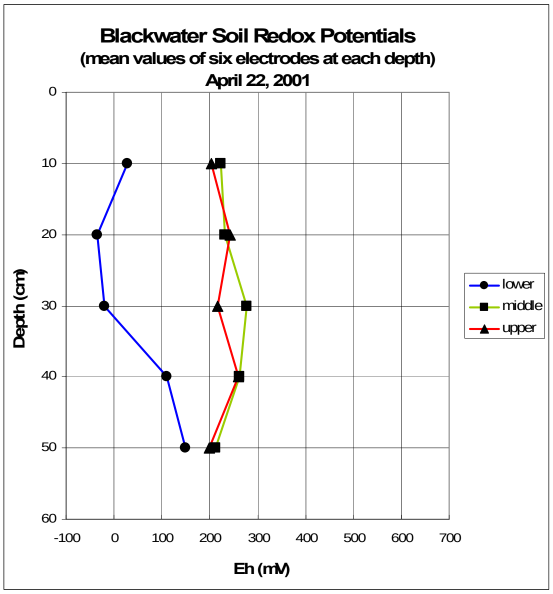
Blackwater		--------------		cm		--------------
3-Apr-01		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	99	134	20	161	152
Well	2	275	254	190	316	314
	3	133	58	121	96	113
	4	333	241	247	298	298
	5	244	223	229	227	227
	6	347	204	207	321	294
mean (mV)		**239**	**186**	**169**	**237**	**233**
Middle	1	217	229	244	302	194
Well	2	183	258	276	89	228
	3	98	79	127	83	69
	4	187	256	314	275	220
	5	200	195	149	123	154
	6	195	224	273	234	283
mean (mV)		**180**	**207**	**231**	**184**	**191**
Upper	1	255	234	217	277	242
Well	2	275	254	190	316	314
	3	133	58	121	96	113
	4	333	241	247	298	298
	5	244	223	229	227	227
	6	347	204	207	321	294
mean (mV)		**265**	**202**	**202**	**256**	**248**

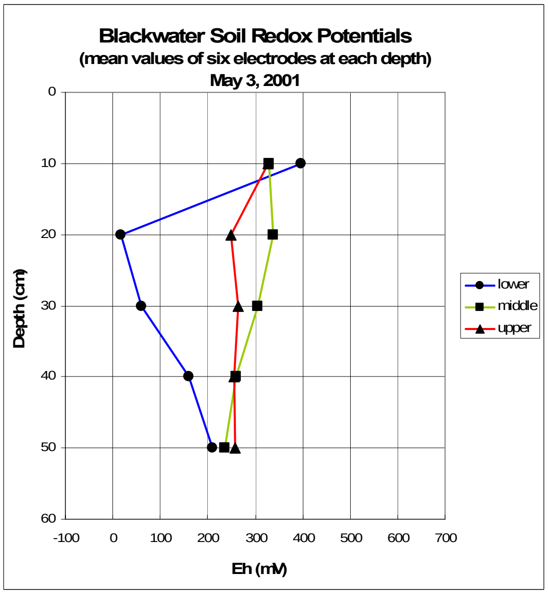




Blackwater		--------------		cm		--------------
22-Apr-01		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	70	-83	-48	30	171
Well	2	45	-61	-40	158	174
	3	85	24	12	115	78
	4	104	5	-28	127	125
	5	-110	-43	16	158	170
	6	-27	-46	-27	79	182
mean (mV)		**28**	**-34**	**-19**	**111**	**150**
Middle	1	224	222	230	305	217
Well	2	268	286	282	330	239
	3	266	263	277	212	189
	4	147	237	238	221	161
	5	242	169	407	300	276
	6	195	217	230	212	193
mean (mV)		**224**	**232**	**277**	**263**	**213**
Upper	1	175	259	213	318	205
Well	2	208	279	209	252	210
	3	222	255	242	241	204
	4	194	237	192	200	171
	5	176	218	252	361	219
	6	242	204	193	186	191
mean (mV)		**203**	**242**	**217**	**260**	**200**

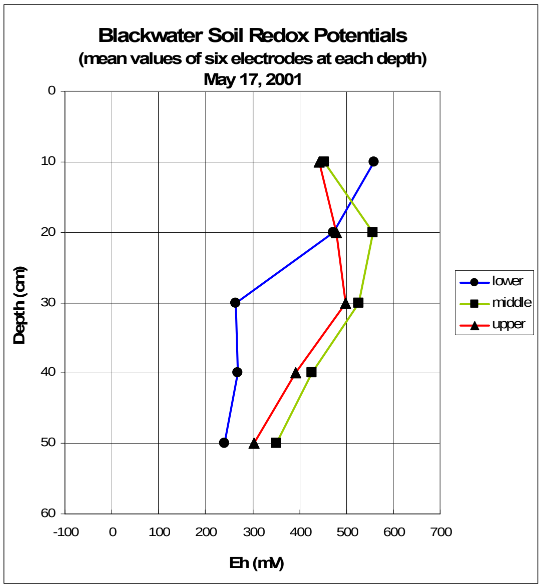
Blackwater		--------------		cm		--------------
3-May-01		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	541	2	77	141	213
Well	2	180	-104	-14	161	222
	3	390	24	95	212	221
	4	522	135	92	48	165
	5	202	75	87	220	247
	6	540	-23	20	177	200
mean (mV)		**396**	**18**	**60**	**160**	**211**
Middle	1	394	335	339	163	257
Well	2	436	409	406	351	293
	3	71	267	228	218	227
	4	486	359	260	241	162
	5	414	432	368	340	272
	6	179	223	234	241	199
mean (mV)		**330**	**338**	**306**	**259**	**235**
Upper	1	343	280	274	274	301
Well	2	214	288	289	238	244
	3	430	238	242	252	262
	4	435	216	239	233	214
	5	335	277	327	319	293
	6	204	200	214	215	226
mean (mV)		**327**	**250**	**264**	**255**	**257**

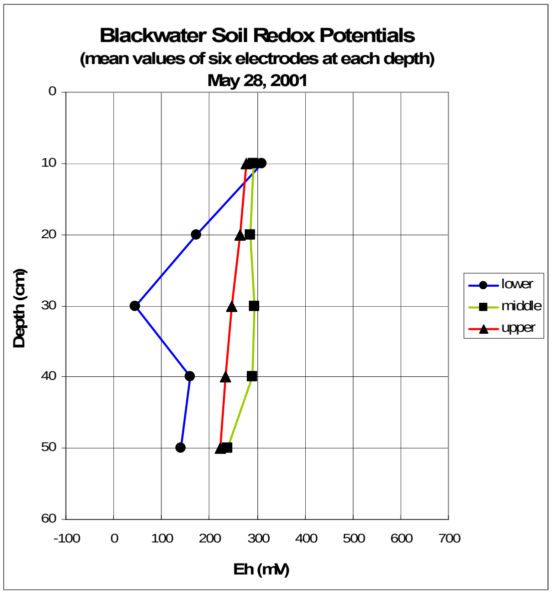




Blackwater		--------------		cm		--------------
17-May-01		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	560	530	331	273	278
Well	2	605	363	373	287	262
	3	526	494	237	316	264
	4	514	354	249	230	166
	5	582	549	340	278	234
	6	564	544	56	226	239
mean (mV)		**559**	**472**	**264**	**268**	**241**
Middle	1	543	570	574	380	398
Well	2	489	543	458	432	268
	3	492	561	530	366	304
	4	400	548	489	516	328
	5	557	565	565	379	297
	6	230	549	542	482	510
mean (mV)		**452**	**556**	**526**	**426**	**351**
Upper	1	551	559	544	382	320
Well	2	389	439	280	349	254
	3	266	563	544	364	362
	4	513	496	521	329	220
	5	383	266	536	340	305
	6	552	549	568	590	355
mean (mV)		**442**	**479**	**499**	**392**	**303**

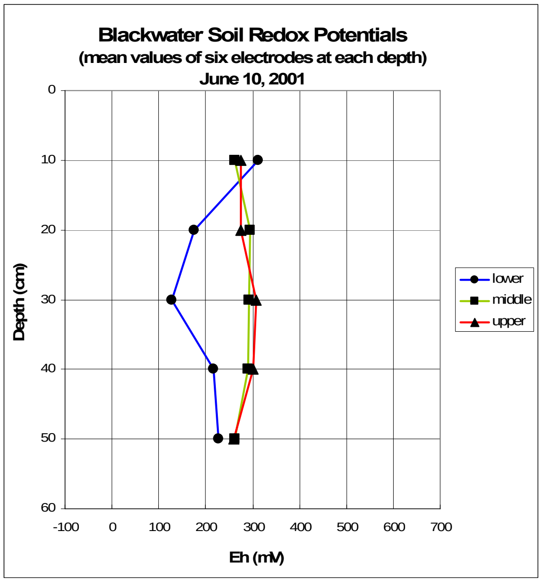
Blackwater		--------------		cm		--------------
28-May-01		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	278	150	73	184	173
Well	2	271	-151	16	163	174
	3	340	207	63	161	134
	4	291	226	44	172	61
	5	352	272	30	186	155
	6	327	336	49	93	147
mean (mV)		**310**	**173**	**46**	**160**	**141**
Middle	1	289	276	244	253	260
Well	2	212	263	264	291	211
	3	350	285	288	288	204
	4	327	251	293	185	157
	5	313	321	338	384	273
	6	269	313	334	339	320
mean (mV)		**293**	**285**	**294**	**290**	**238**
Upper	1	227	278	215	184	204
Well	2	280	259	263	241	251
	3	264	339	238	268	234
	4	264	201	187	224	145
	5	337	219	294	225	239
	6	298	288	283	257	272
mean (mV)		**278**	**264**	**247**	**233**	**224**

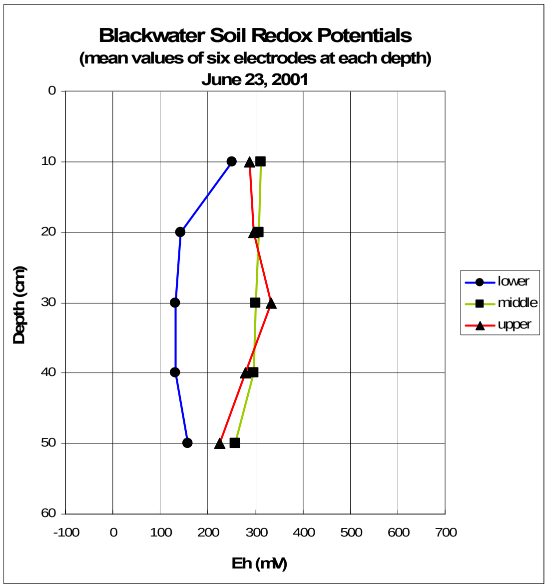




Blackwater			--------------	cm	--------------	
10-Jun-01		10	20	30	40	50
	circuit		----------	Eh (mV)	----------	
Lower	1	297	72	149	212	214
Well	2	321	-31	173	207	229
	3	238	334	173	267	259
	4	320	234	102	185	186
	5	359	351	203	295	276
	6	337	90	-33	130	202
mean (mV)		**312**	**175**	**128**	**216**	**228**
Middle	1	160	274	299	325	258
Well	2	158	197	219	179	195
	3	350	401	379	308	261
	4	251	233	307	330	291
	5	324	358	391	318	288
	6	328	300	165	279	283
mean (mV)		**262**	**294**	**293**	**290**	**263**
Upper	1	280	308	322	315	266
Well	2	132	211	231	216	179
	3	303	321	301	338	267
	4	280	238	324	258	203
	5	331	356	360	332	354
	6	326	224	303	350	291
mean (mV)		**275**	**276**	**307**	**302**	**260**

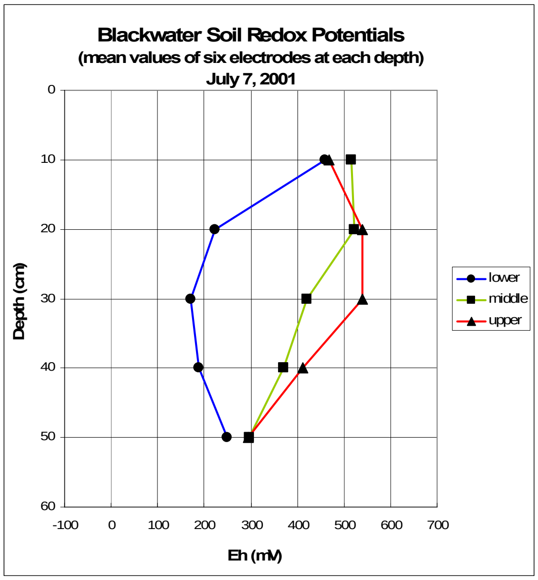
Blackwater			--------------	cm	--------------	
23-Jun-01		10	20	30	40	50
	circuit		----------	Eh (mV)	----------	
Lower	1	279	126	94	234	106
Well	2	401	193	80	208	186
	3	182	241	241	106	249
	4	88	29	146	51	141
	5	181	276	116	88	40
	6	381	-15	113	112	232
mean (mV)		**252**	**142**	**132**	**133**	**159**
Middle	1	298	336	333	271	184
Well	2	456	314	254	358	263
	3	262	328	306	298	284
	4	301	269	262	210	234
	5	291	334	372	349	330
	6	262	262	278	288	247
mean (mV)		**312**	**307**	**301**	**296**	**257**
Upper	1	274	335	327	261	223
Well	2	217	273	242	251	211
	3	238	308	316	271	248
	4	303	326	540	353	188
	5	455	279	306	286	242
	6	249	259	271	251	236
mean (mV)		**289**	**297**	**334**	**279**	**225**

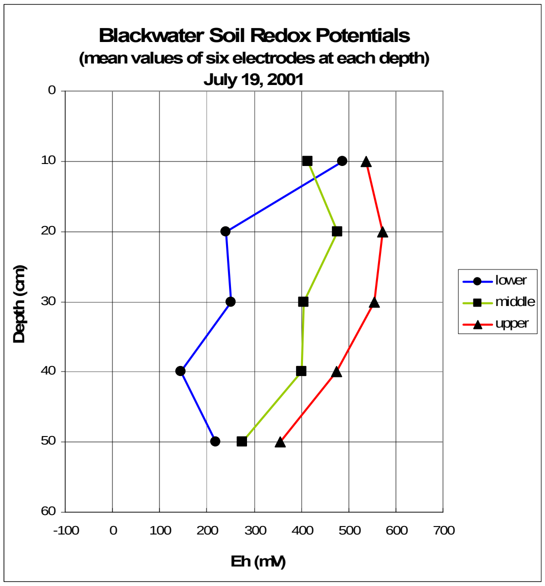




Blackwater		-------------- cm --------------				
7-Jul-01		10	20	30	40	50
	circuit	---------- Eh (mV) ----------				
Lower	1	273	30	37	184	228
Well	2	308	197	202	248	263
	3	623	450	295	295	337
	4	503	486	204	257	270
	5	503	167	219	65	167
	6	550	8	76	87	224
mean (mV)		**460**	**223**	**172**	**189**	**248**
Middle	1	503	390	320	282	219
Well	2	448	522	312	323	310
	3	566	580	443	383	314
	4	516	553	437	378	300
	5	538	550	448	323	302
	6	522	536	560	532	335
mean (mV)		**516**	**522**	**420**	**370**	**297**
Upper	1	403	424	380	222	222
Well	2	529	553	560	371	330
	3	564	576	573	395	355
	4	518	580	567	391	263
	5	255	537	581	553	273
	6	544	572	574	533	324
mean (mV)		**469**	**540**	**539**	**411**	**295**

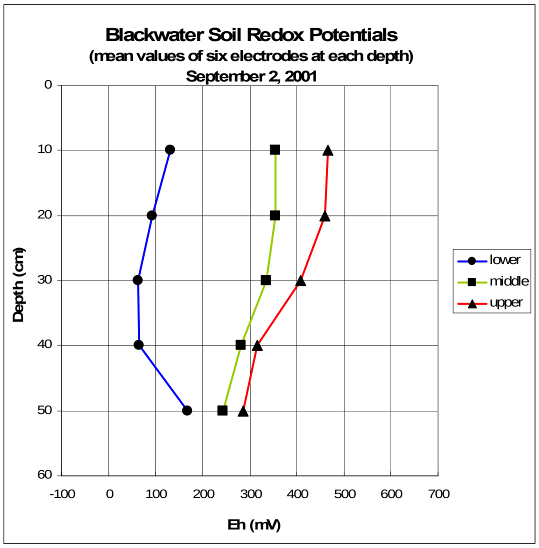
Blackwater		-------------- cm --------------				
19-Jul-01		10	20	30	40	50
	circuit	---------- Eh (mV) ----------				
Lower	1	473	16	166	23	223
Well	2	505	229	325	153	244
	3	529	317	233	161	182
	4	522	279	321	195	202
	5	383	282	189	81	179
	6	518	323	269	259	275
mean (mV)		**488**	**241**	**251**	**145**	**218**
Middle	1	227	417	323	392	266
Well	2	284	465	414	346	269
	3	431	529	448	351	290
	4	438	410	461	461	318
	5	544	482	358	490	212
	6	554	555	430	361	296
mean (mV)		**413**	**476**	**406**	**400**	**275**
Upper	1	517	500	459	399	280
Well	2	504	581	540	453	327
	3	574	599	565	484	325
	4	529	583	573	543	434
	5	511	600	612	404	433
	6	586	571	582	558	330
mean (mV)		**537**	**572**	**555**	**474**	**355**

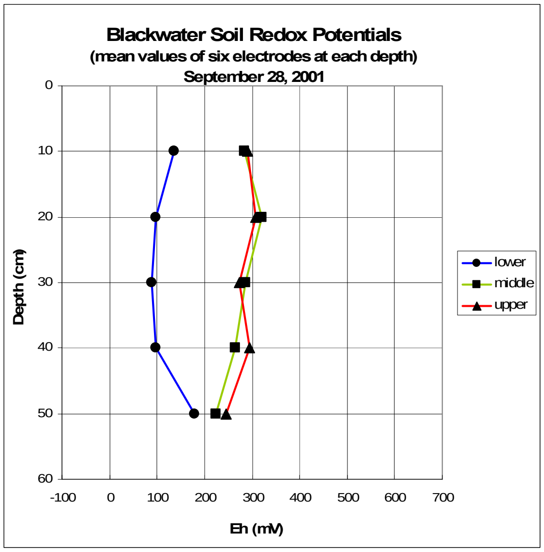




Blackwater		--------------		cm		--------------
2-Sep-01		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	247	-2	25	18	70
Well	2	53	84	121	139	129
	3	213	227	0	159	233
	4	140	218	145	49	226
	5	121	34	30	1	193
	6	20	-1	65	32	165
mean (mV)		**132**	**93**	**64**	**66**	**169**
Middle	1	308	280	302	244	241
Well	2	247	264	292	237	260
	3	433	348	324	239	265
	4	311	291	297	281	187
	5	356	380	410	316	234
	6	468	563	382	366	272
mean (mV)		**354**	**354**	**335**	**281**	**243**
Upper	1	491	384	258	230	232
Well	2	523	470	321	334	293
	3	536	413	327	293	287
	4	384	528	487	374	337
	5	494	443	536	336	275
	6	367	517	523	335	283
mean (mV)		**466**	**459**	**409**	**317**	**285**

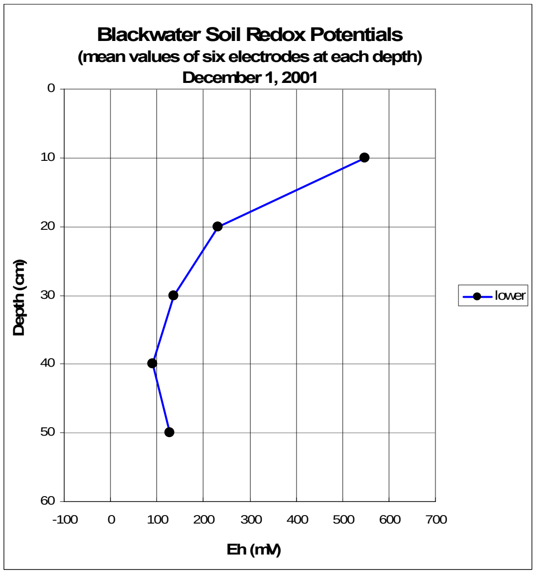
Blackwater		--------------		cm		--------------
28-Sep-01		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	-7	236	55	70	215
Well	2	295	102	183	200	233
	3	254	74	26	51	142
	4	117	61	164	56	211
	5	65	55	37	65	67
	6	89	53	70	148	204
mean (mV)		**136**	**97**	**89**	**98**	**179**
Middle	1	254	337	311	277	217
Well	2	280	282	239	229	226
	3	269	296	290	276	216
	4	290	267	314	263	241
	5	335	436	311	264	197
	6	278	307	250	283	244
mean (mV)		**284**	**321**	**286**	**265**	**224**
Upper	1	287	286	275	316	262
Well	2	206	196	205	229	221
	3	348	311	271	351	226
	4	287	343	307	294	240
	5	311	301	272	272	267
	6	299	406	313	302	257
mean (mV)		**290**	**307**	**274**	**294**	**246**

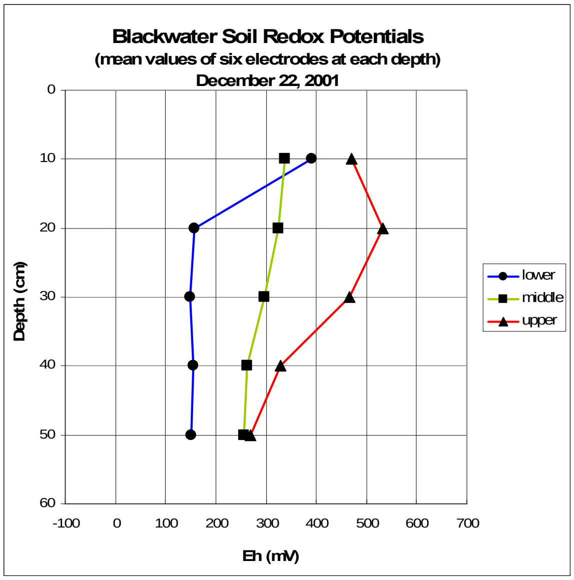




Blackwater		--------------		cm		--------------
1-Dec-01		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	582	301	173	138	66
Well	2	536	154	20	-4	126
	3	582	326	227	183	120
	4	485	307	215	148	269
	5	516	-16	-26	-72	-28
	6	592	319	215	155	215
mean (mV)		549	232	137	91	128
Middle	1					
Well	2					
	3					
	4					
	5					
	6					
mean (mV)						
Upper	1					
Well	2					
	3					
	4					
	5					
	6					
mean (mV)						

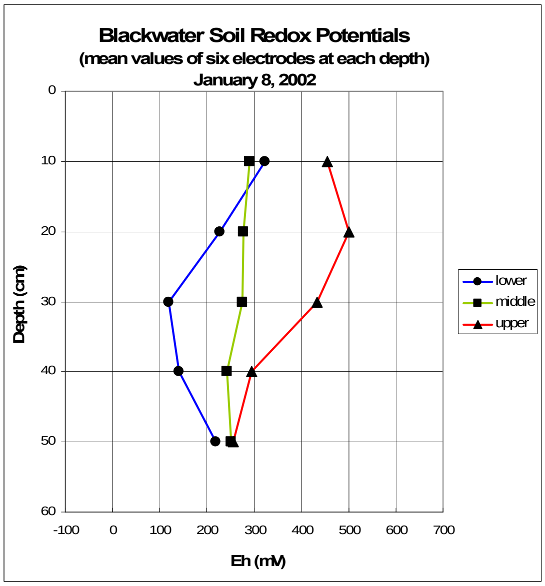
Blackwater		--------------		cm		--------------
22-Dec-01		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	464	168	180	186	73
Well	2	371	211	154	178	20
	3	384	230	219	206	343
	4	371	287	148	157	90
	5	409	2	36	92	178
	6	345	47	149	111	195
mean (mV)		**391**	**158**	**148**	**155**	**150**
Middle	1	349	300	314	247	329
Well	2	299	411	282	287	279
	3	302	307	268	287	247
	4	320	300	260	238	244
	5	300	317	264	243	196
	6	452	312	395	277	232
mean (mV)		**337**	**325**	**297**	**263**	**255**
Upper	1	316	512	489	312	275
Well	2	529	573	506	373	293
	3	465	475	310	303	272
	4	520	553	566	331	255
	5	473	575	371	313	256
	6	525	512	555	343	259
mean (mV)		**471**	**533**	**466**	**329**	**268**

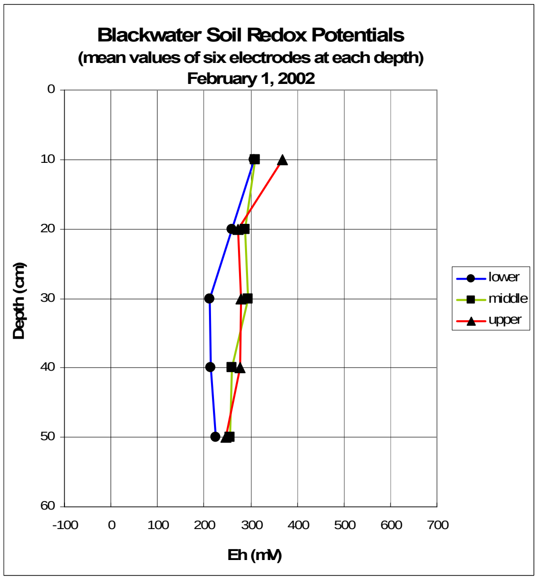




Blackwater				cm		
8-Jan-02		10	20	30	40	50
	circuit			Eh (mV)		
Lower	1	283	308	133	145	244
Well	2	359	272	208	223	249
	3	341	275	141	208	247
	4	344	298	156	58	232
	5	260	94	115	50	120
	6	345	114	-40	156	221
mean (mV)		**322**	**227**	**119**	**140**	**219**
Middle	1	281	279	316	270	270
Well	2	258	283	287	246	249
	3	305	287	283	256	258
	4	238	265	245	236	262
	5	383	289	227	247	243
	6	283	265	287	200	231
mean (mV)		**291**	**278**	**274**	**243**	**252**
Upper	1	480	542	398	293	269
Well	2	473	503	322	280	251
	3	304	383	304	247	244
	4	450	529	702	297	259
	5	504	481	451	295	255
	6	526	563	419	353	259
mean (mV)		**456**	**500**	**433**	**294**	**256**

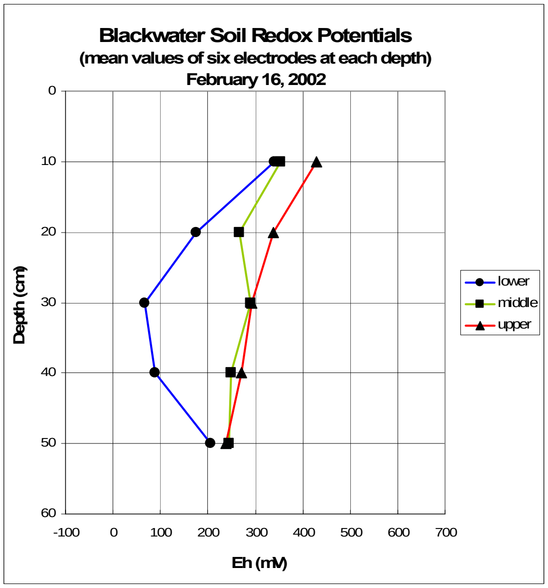
Blackwater				cm		
1-Feb-02		10	20	30	40	50
	circuit			Eh (mV)		
Lower	1	349	283	205	205	229
Well	2	373	330	222	239	269
	3	249	247	225	216	225
	4	361	233	211	189	243
	5	263	236	229	232	235
	6	253	233	183	207	150
mean (mV)		**308**	**260**	**213**	**215**	**225**
Middle	1	352	357	377	295	277
Well	2	382	332	341	286	285
	3	242	244	243	236	235
	4	397	334	324	281	284
	5	243	231	244	224	216
	6	235	238	234	232	234
mean (mV)		**309**	**289**	**294**	**259**	**255**
Upper	1	370	243	270	259	257
Well	2	416	337	354	320	273
	3	317	244	241	242	229
	4	491	355	352	324	273
	5	330	222	238	247	227
	6	290	231	225	267	215
mean (mV)		**369**	**272**	**280**	**277**	**246**

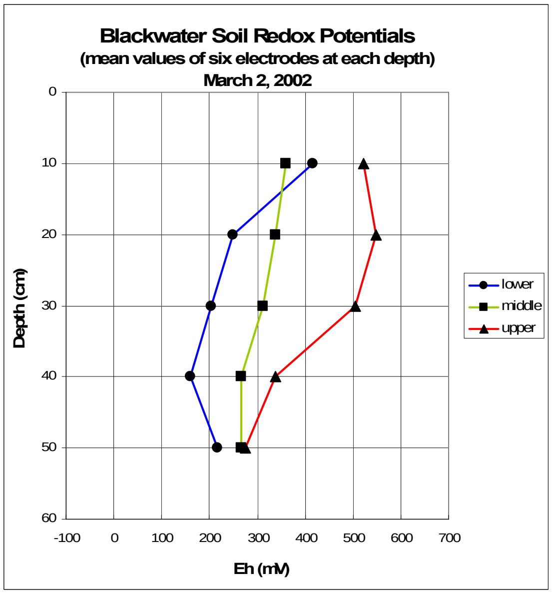




Blackwater		-------------- cm --------------				
16-Feb-02		10	20	30	40	50
	circuit	---------- Eh (mV) ----------				
Lower Well	1	346	304	119	3	198
	2	244	302	208	175	250
	3	373	336	-164	18	197
	4	333	15	86	81	183
	5	375	1	141	115	215
	6	369	89	13	138	189
mean (mV)		**340**	**175**	**67**	**88**	**205**
Middle Well	1	358	279	245	276	269
	2	300	230	271	257	252
	3	355	298	286	263	267
	4	397	310	247	239	245
	5	380	263	419	225	217
	6	336	220	271	225	221
mean (mV)		**354**	**267**	**290**	**248**	**245**
Upper Well	1	407	320	301	289	256
	2	412	417	288	260	236
	3	468	273	295	312	251
	4	467	322	282	259	211
	5	485	444	328	296	268
	6	335	257	264	211	211
mean (mV)		**429**	**339**	**293**	**271**	**239**

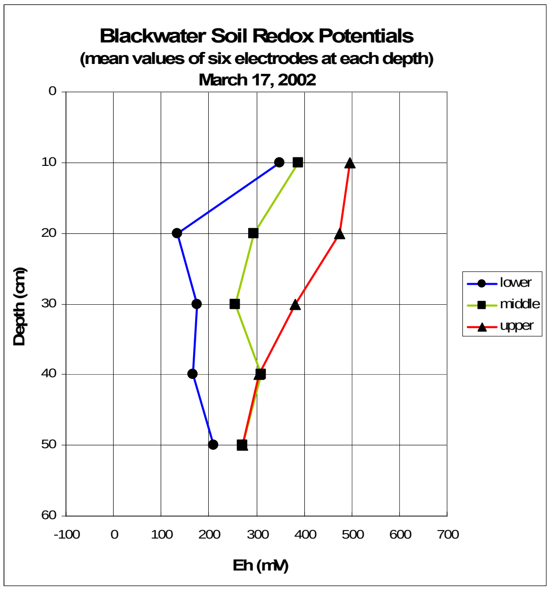
Blackwater		-------------- cm --------------				
2-Mar-02		10	20	30	40	50
	circuit	---------- Eh (mV) ----------				
Lower Well	1	429	284	310	265	190
	2	483	282	200	195	261
	3	487	378	247	235	256
	4	361	307	158	57	147
	5	414	171	189	139	231
	6	329	67	115	70	209
mean (mV)		**417**	**248**	**203**	**160**	**216**
Middle Well	1	459	351	359	285	294
	2	283	267	289	239	267
	3	382	316	327	278	257
	4	377	336	280	244	227
	5	320	408	300	283	286
	6	341	345	315	269	263
mean (mV)		**360**	**337**	**312**	**266**	**266**
Upper Well	1	511	563	528	338	295
	2	502	540	342	274	245
	3	537	547	565	359	316
	4	533	553	560	357	255
	5	541	557	528	383	285
	6	512	526	502	321	253
mean (mV)		**523**	**548**	**504**	**339**	**275**

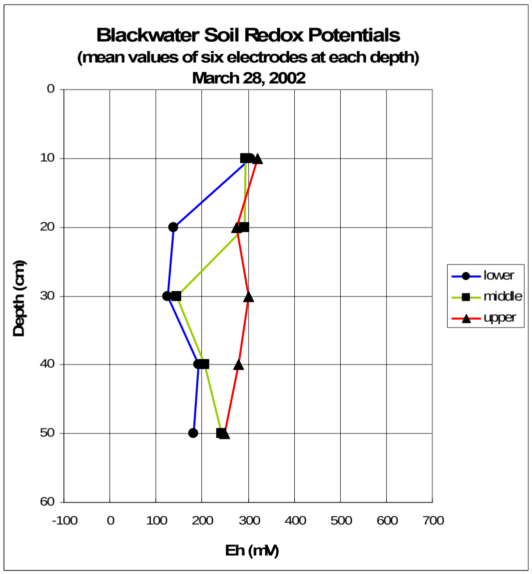




Blackwater		-------------		cm		-------------
Mar 17, 2002		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	361	220	159	162	203
Well	2	384	103	216	139	164
	3	388	190	182	207	222
	4	346	164	210	117	219
	5	301	90	165	159	226
	6	305	38	119	216	219
mean (mV)		**348**	**134**	**175**	**167**	**209**
Middle	1	359	300	279	297	308
Well	2	370	301	273	303	296
	3	371	332	229	269	306
	4	436	275	267	325	243
	5	414	277	224	351	249
	6	369	286	258	316	224
mean (mV)		**387**	**295**	**255**	**310**	**271**
Upper	1	496	506	332	285	253
Well	2	506	432	506	330	283
	3	536	552	409	329	281
	4	469	474	380	296	256
	5	482	435	332	305	278
	6	495	446	335	293	272
mean (mV)		**497**	**474**	**382**	**306**	**271**

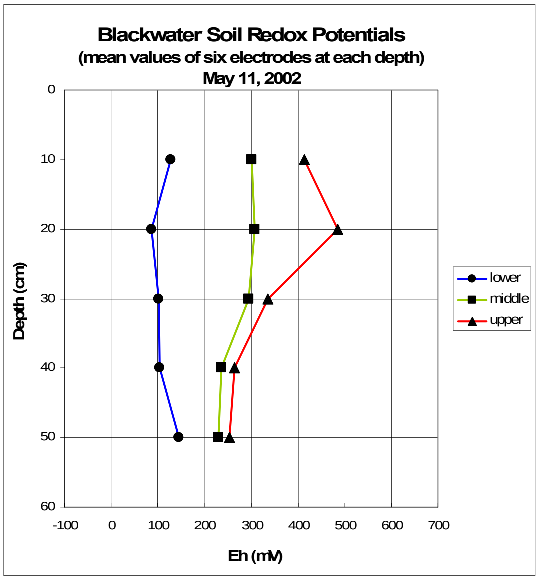
Blackwater		-------------		cm		-------------
28-Mar-02		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	365	97	149	250	210
Well	2	392	354	129	237	230
	3	359	173	79	237	215
	4	311	56	137	77	48
	5	153	91	139	171	219
	6	250	60	123	178	169
mean (mV)		**305**	**139**	**126**	**192**	**182**
Middle	1	305	326	281	268	252
Well	2	326	309	120	180	232
	3	287	281	3	141	238
	4	302	257	-11	184	231
	5	281	303	259	266	269
	6	265	277	212	190	236
mean (mV)		**294**	**292**	**144**	**205**	**243**
Upper	1	332	323	261	256	248
Well	2	364	267	328	291	237
	3	350	244	288	299	280
	4	277	238	324	279	235
	5	300	294	295	266	253
	6	305	285	310	285	249
mean (mV)		**321**	**275**	**301**	**279**	**250**

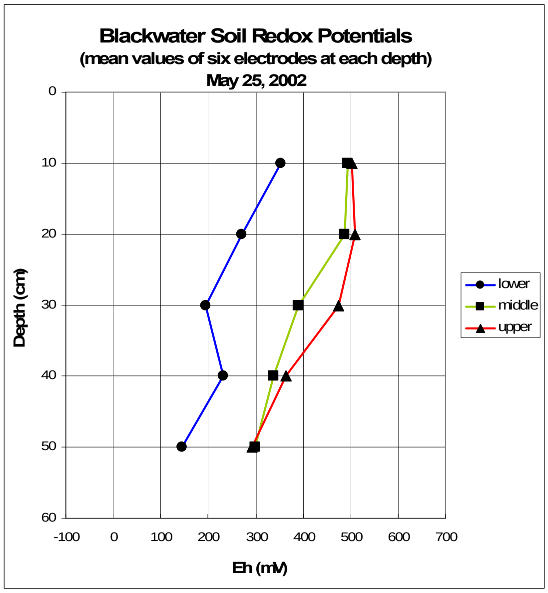




Blackwater				cm		
11-May-02		10	20	30	40	50
	circuit			Eh (mV)		
Lower Well	1	69	135	169	91	137
	2	220	81	116	21	117
	3	0	9	35	219	115
	4	127	65	81	123	159
	5	164	52	103	94	163
	6	179	174	109	69	172
mean (mV)		**127**	**86**	**102**	**103**	**144**
Middle Well	1	311	335	320	273	275
	2	310	388	340	252	249
	3	320	269	313	225	254
	4	295	253	227	186	174
	5	264	276	304	268	232
	6	301	320	262	217	197
mean (mV)		**300**	**307**	**294**	**237**	**230**
Upper Well	1	534	552	345	304	274
	2	471	365	330	256	245
	3	319	504	340	246	252
	4	339	425	325	248	231
	5	373	529	332	290	283
	6	443	540	343	247	240
mean (mV)		**413**	**486**	**336**	**265**	**254**

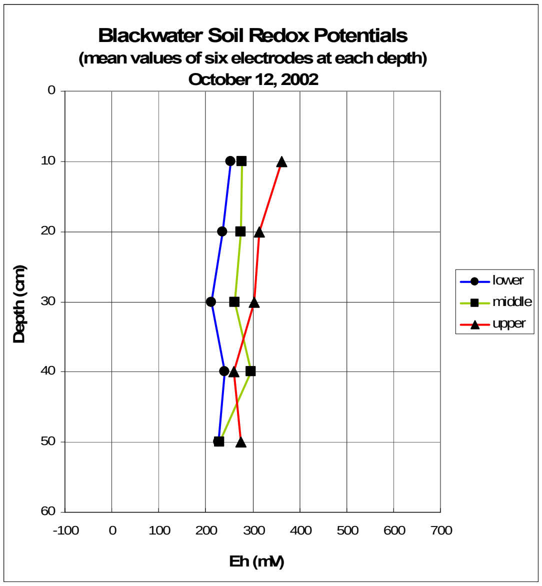
Blackwater				cm		
25-May-02		10	20	30	40	50
	circuit			Eh (mV)		
Lower Well	1	474	305	190	207	169
	2	358	306	217	238	123
	3	422	324	194	237	94
	4	285	261	200	244	149
	5	293	249	204	210	186
	6	285	176	162	251	157
mean (mV)		**353**	**270**	**195**	**231**	**146**
Middle Well	1	537	480	375	342	289
	2	482	457	389	333	287
	3	486	507	394	408	279
	4	461	482	396	313	341
	5	513	501	404	351	309
	6	485	499	382	278	287
mean (mV)		**494**	**488**	**390**	**338**	**299**
Upper Well	1	529	486	344	434	303
	2	491	509	585	454	311
	3	495	510	464	327	289
	4	454	492	404	319	295
	5	526	535	494	313	279
	6	519	521	554	329	281
mean (mV)		**502**	**509**	**474**	**363**	**293**

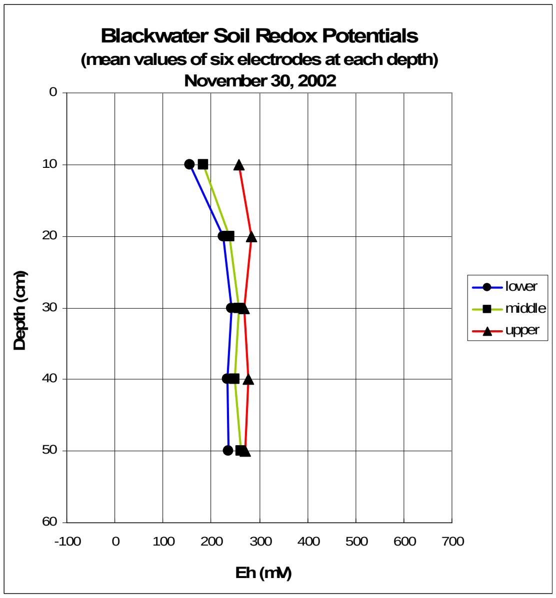




Blackwater				cm		
12-Oct-02		10	20	30	40	50
	circuit			Eh (mV)		
Lower	1	279	211	205	230	224
Well	2	217	233	213	224	198
	3	243	250	243	251	243
	4	276	251	202	247	226
	5	285	278	182	249	222
	6	222	190	231	246	246
mean (mV)		**254**	**236**	**213**	**241**	**227**
Middle	1	271	262	255	308	226
Well	2	296	286	270	298	238
	3	261	247	261	283	234
	4	276	305	259	292	224
	5	284	270	267	295	228
	6	273	275	263	304	232
mean (mV)		**277**	**274**	**263**	**297**	**230**
Upper	1	308	292	293	226	230
Well	2	363	297	349	251	267
	3	408	292	304	194	283
	4	354	299	272	272	285
	5	414	362	332	268	291
	6	325	342	274	349	302
mean (mV)		**362**	**314**	**304**	**260**	**276**

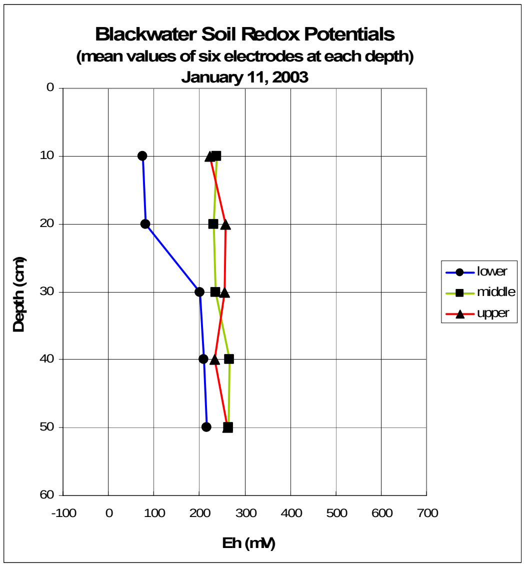
Blackwater				cm		
30-Nov-02		10	20	30	40	50
	circuit			Eh (mV)		
Lower	1	170	223	220	235	237
Well	2	87	208	217	192	225
	3	293	239	247	240	240
	4	121	227	254	244	231
	5	148	235	243	235	235
	6	115	215	272	255	243
mean (mV)		**156**	**225**	**242**	**234**	**235**
Middle	1	223	224	267	247	289
Well	2	131	235	240	223	291
	3	190	249	250	248	278
	4	155	247	252	249	221
	5	152	231	251	239	244
	6	250	250	288	279	251
mean (mV)		**184**	**239**	**258**	**248**	**262**
Upper	1	262	286	251	307	252
Well	2	211	261	245	296	286
	3	232	313	300	273	304
	4	300	266	288	268	260
	5	244	267	242	225	231
	6	291	307	287	294	287
mean (mV)		**257**	**283**	**269**	**277**	**270**



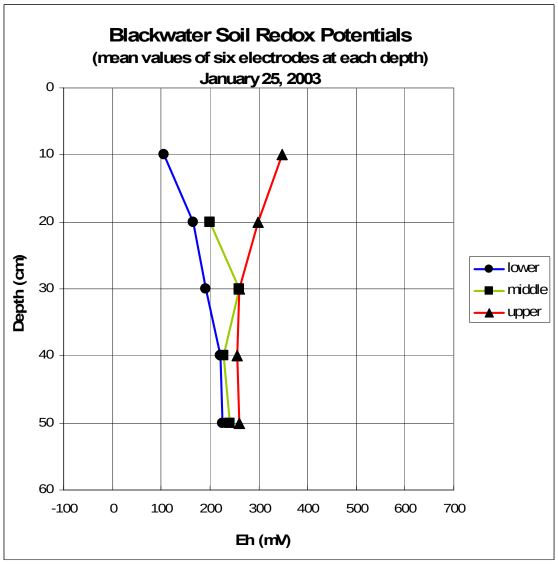


Blackwater		--------------		cm		--------------
11-Jan-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	105	216	186	197	212
Well	2	142	-74	191	214	224
	3	85	96	204	202	221
	4	66	98	227	229	210
	5	27	78	186	237	220
	6	22	85	209	189	215
mean (mV)		**75**	**83**	**201**	**211**	**217**
Middle	1	277	306	231	307	332
Well	2	289	265	245	198	263
	3	231	213	243	252	244
	4	231	199	227	247	226
	5	193	206	242	305	267
	6	213	194	229	284	259
mean (mV)		**239**	**231**	**236**	**266**	**265**
Upper	1	204	253	234	236	274
Well	2	108	239	264	243	257
	3	220	274	261	230	255
	4	282	247	243	204	241
	5	306	276	272	255	285
	6					
mean (mV)		**224**	**258**	**255**	**234**	**262**

Blackwater		--------------		cm		--------------
25-Jan-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	156	199	221	233	231
Well	2	90	141	221	223	222
	3	159	160	243	232	231
	4	125	195	236	231	229
	5	59	127	177	225	234
	6	46	169	52	187	201
mean (mV)		**106**	**165**	**192**	**222**	**225**
Middle	1		182	244	118	249
Well	2		201	218	183	243
	3		248	274	271	262
	4		193	231	243	230
	5		206	276	301	259
	6		167	316	258	211
mean (mV)			**200**	**260**	**229**	**242**
Upper	1	296	233	251	245	247
Well	2	370	353	277	267	275
	3	478	300	277	300	294
	4	348	340	251	234	243
	5	214	307	271	264	256
	6	380	256	234	233	243
mean (mV)		**348**	**298**	**260**	**257**	**260**



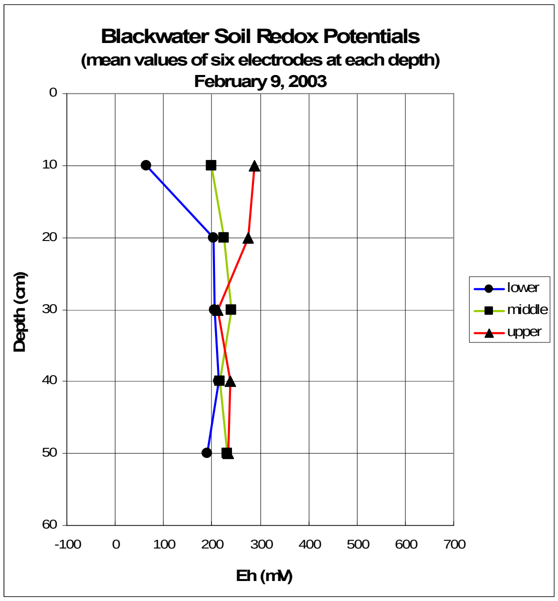
Blackwater Soil Redox Potentials
(mean values of six electrodes at each depth)
January 11, 2003

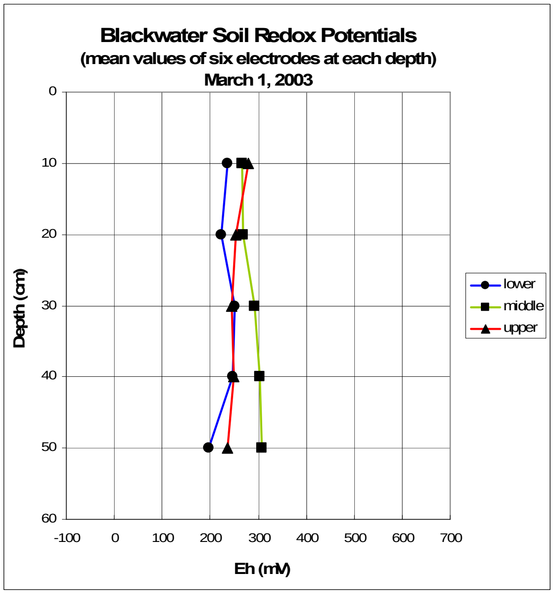


Blackwater Soil Redox Potentials
(mean values of six electrodes at each depth)
January 25, 2003

Blackwater		-------------- cm --------------				
9-Feb-03		10	20	30	40	50
	circuit	---------- Eh (mV) ----------				
Lower Well	1	29	231	208	224	211
	2	49	230	200	224	216
	3	96	197	172	166	109
	4	94	187	224	228	211
	5	59	169	228	233	207
	6					
mean (mV)		**65**	**203**	**206**	**215**	**191**
Middle Well	1	256	250	251	211	209
	2	162	243	266	234	244
	3	188	167	154	164	233
	4	132	227	263	219	239
	5	259	236	272	250	228
	6					
mean (mV)		**199**	**225**	**241**	**216**	**231**
Upper Well	1	299	269	203	235	247
	2	239	211	215	229	231
	3	380	370	203	186	198
	4	268	251	210	279	247
	5	256	281	234	262	243
	6					
mean (mV)		**288**	**276**	**213**	**238**	**233**

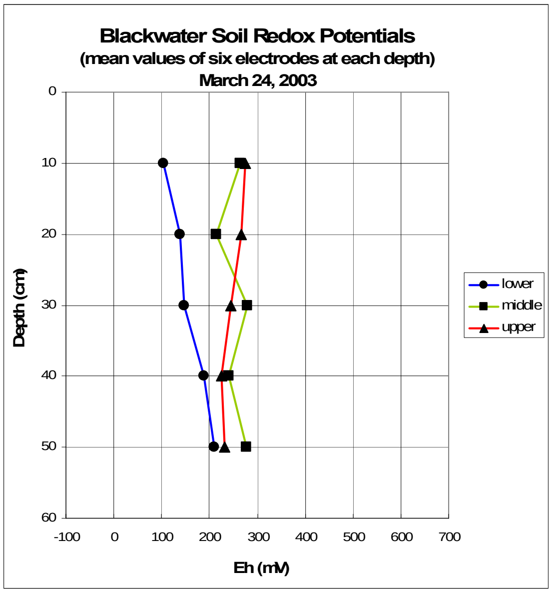
Blackwater		-------------- cm --------------				
1-Mar-03		10	20	30	40	50
	circuit	---------- Eh (mV) ----------				
Lower Well	1	249	251	241	255	226
	2	152	228	259	242	223
	3	291	261	256	256	234
	4	262	244	253	251	230
	5	202	129	234	216	99
	6	261	225	265	261	166
mean (mV)		**236**	**223**	**251**	**247**	**196**
Middle Well	1	265	272	296	287	283
	2	265	241	295	302	333
	3	304	279	316	318	291
	4	278	294	288	334	249
	5	224	239	257	295	338
	6	260	289	301	284	346
mean (mV)		**266**	**269**	**292**	**303**	**307**
Upper Well	1	297	267	244	247	251
	2	312	209	242	263	181
	3	266	259	252	256	254
	4	298	292	252	259	248
	5	273	249	235	238	242
	6	230	246	243	239	245
mean (mV)		**279**	**254**	**245**	**250**	**237**

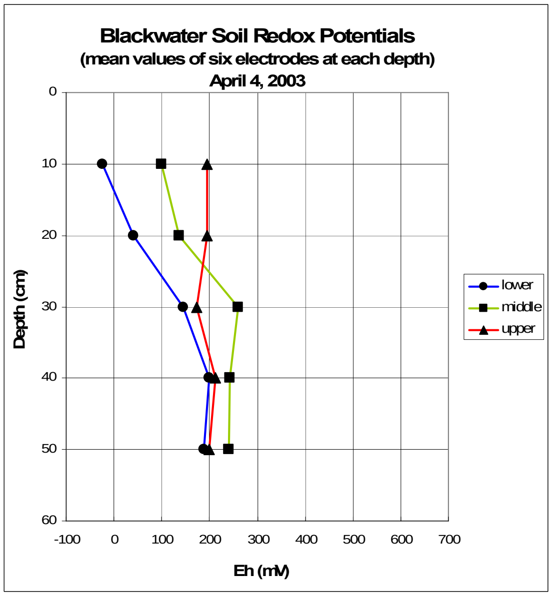

Blackwater Soil Redox Potentials
(mean values of six electrodes at each depth)
February 9, 2003


Blackwater Soil Redox Potentials
(mean values of six electrodes at each depth)
March 1, 2003

Blackwater		--------------		cm		--------------
24-Mar-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	96	132	90	184	200
Well	2					
	3	152	174	174	219	237
	4	62	69	153	167	178
	5	59	156	148	170	204
	6	147	163	173	204	229
mean (mV)		**103**	**139**	**148**	**189**	**210**
Middle	1	253	289	260	252	307
Well	2					
	3	265	309	320	237	244
	4	254	229	262	233	285
	5	283	137	286	237	279
	6	272	109	270	244	277
mean (mV)		**265**	**215**	**280**	**241**	**278**
Upper	1	279	271	214	205	209
Well	2					
	3	241	238	236	210	222
	4	263	269	234	231	247
	5	312	312	281	242	233
	6	286	244	259	244	246
mean (mV)		**276**	**267**	**245**	**226**	**231**

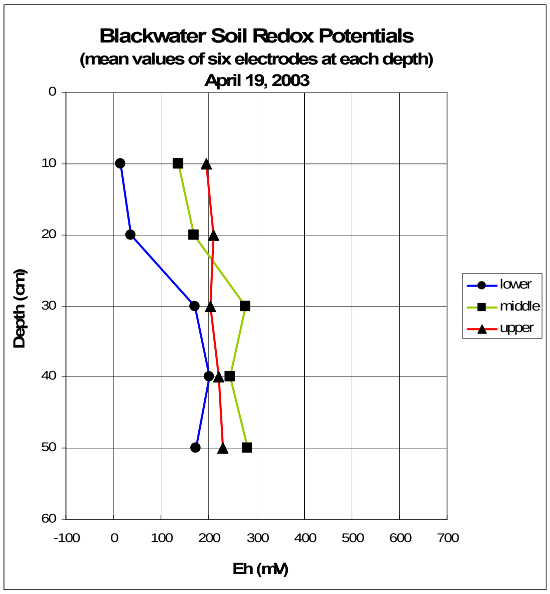
Blackwater		--------------		cm		--------------
4-Apr-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	-54	-23	154	188	194
Well	2					
	3	4	50	192	221	228
	4	-43	1	175	205	121
	5	9	91	77	185	199
	6	-40	81	133	195	204
mean (mV)		**-25**	**40**	**146**	**199**	**189**
Middle	1	75	128	248	216	277
Well	2					
	3	35	141	277	304	271
	4	32	105	257	200	199
	5	185	165	244	244	218
	6	173	145	275	250	237
mean (mV)		**100**	**137**	**260**	**243**	**240**
Upper	1	186	218	174	211	190
Well	2					
	3	245	290	190	223	199
	4	179	108	159	194	195
	5	176	181	181	217	209
	6	184	177	164	221	205
mean (mV)		**194**	**195**	**174**	**213**	**200**

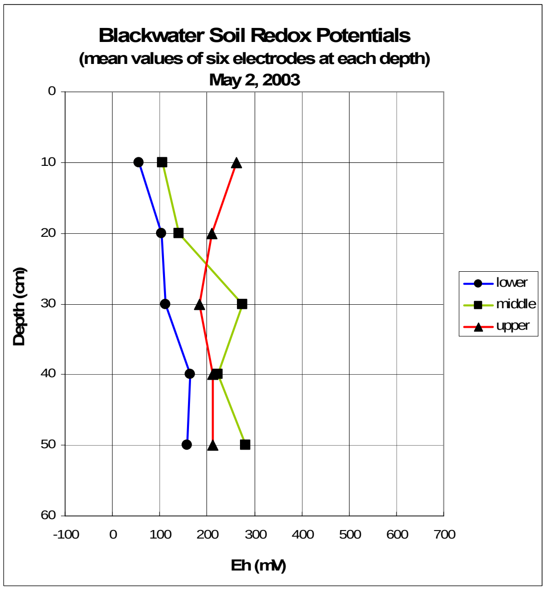

Blackwater Soil Redox Potentials
(mean values of six electrodes at each depth)
March 24, 2003


Blackwater Soil Redox Potentials
(mean values of six electrodes at each depth)
April 4, 2003

Blackwater		--------------		cm		--------------
19-Apr-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	22	72	176	188	189
Well	2	-8	31	70	166	52
	3	42	61	223	229	205
	4	10	24	224	228	221
	5	10	-7	157	194	196
	6					
mean (mV)		**15**	**36**	**170**	**201**	**173**
Middle	1	196	227	316	281	270
Well	2	130	123	265	238	311
	3	84	122	242	212	326
	4	93	163	295	247	272
	5	183	212	270	244	233
	6					
mean (mV)		**137**	**169**	**278**	**244**	**282**
Upper	1	203	244	195	196	208
Well	2	207	226	191	222	224
	3	155	228	223	234	250
	4	214	109	198	224	229
	5	189	236	212	227	234
	6					
mean (mV)		**194**	**209**	**204**	**221**	**229**

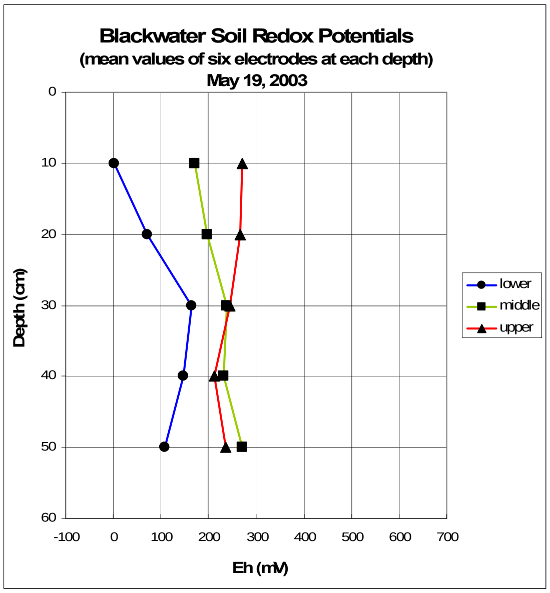
Blackwater		--------------		cm		--------------
2-May-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	63	129	160	199	177
Well	2	98	126	73	188	178
	3	54	145	151	92	106
	4	61	73	81	200	192
	5	7	44	97	146	144
	6					
mean (mV)		**57**	**103**	**112**	**165**	**159**
Middle	1	91	73	268	236	252
Well	2	281	252	319	196	290
	3	56	83	278	229	251
	4	92	208	258	241	295
	5	16	84	255	215	318
	6					
mean (mV)		**107**	**140**	**276**	**223**	**281**
Upper	1	239	229	201	185	180
Well	2	325	103	184	219	206
	3	238	235	201	232	231
	4	302	282	157	186	204
	5	207	200	171	237	240
	6					
mean (mV)		**262**	**210**	**183**	**212**	**212**



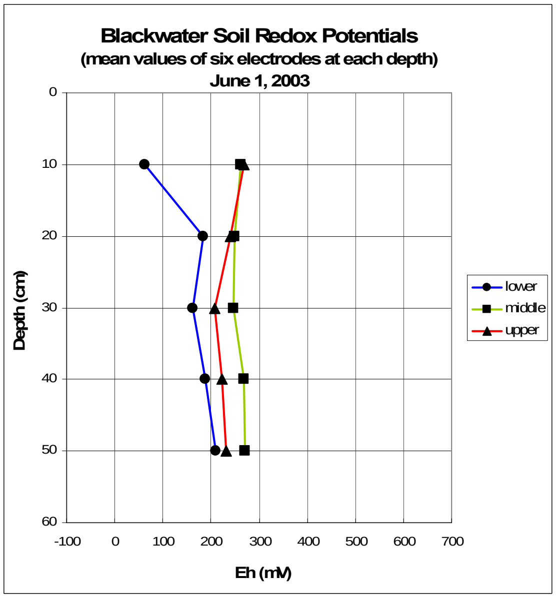


Blackwater		--------------		cm		--------------
19-May-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	-22	80	189	180	95
Well	2	31	96	199	153	41
	3	12	60	178	170	152
	4	-45	53	60	94	139
	5	35	66	198	142	116
	6					
mean (mV)		**2**	**71**	**165**	**148**	**109**
Middle	1	131	169	240	243	282
Well	2	185	208	260	226	268
	3	186	209	245	279	273
	4	162	212	233	224	295
	5	188	189	210	182	233
	6					
mean (mV)		**170**	**197**	**238**	**231**	**270**
Upper	1	304	216	245	219	244
Well	2	264	265	244	233	219
	3	262	252	241	241	228
	4	249	371	271	206	255
	5	275	231	224	166	239
	6					
mean (mV)		**271**	**267**	**245**	**213**	**237**

Blackwater		--------------		cm		--------------
1-Jun-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	11	174	151	189	196
Well	2	41	158	109	186	173
	3	50	328	150	181	191
	4	61	86	172	127	221
	5	88	165	194	218	233
	6	128	193	203	230	242
mean (mV)		**63**	**184**	**163**	**189**	**209**
Middle	1	236	240	235	264	263
Well	2	258	217	190	244	267
	3	196	230	213	251	221
	4	259	283	277	271	291
	5	296	199	266	277	292
	6	334	316	292	306	293
mean (mV)		**263**	**248**	**246**	**269**	**271**
Upper	1	234	203	180	169	178
Well	2	240	210	165	202	192
	3	237	191	178	184	218
	4	282	300	226	258	262
	5	289	256	217	262	267
	6	334	284	279	257	274
mean (mV)		**269**	**241**	**208**	**222**	**232**



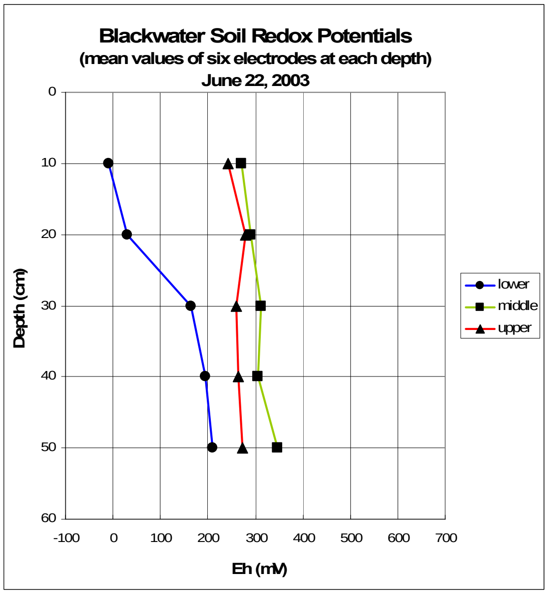
Blackwater Soil Redox Potentials
(mean values of six electrodes at each depth)
May 19, 2003

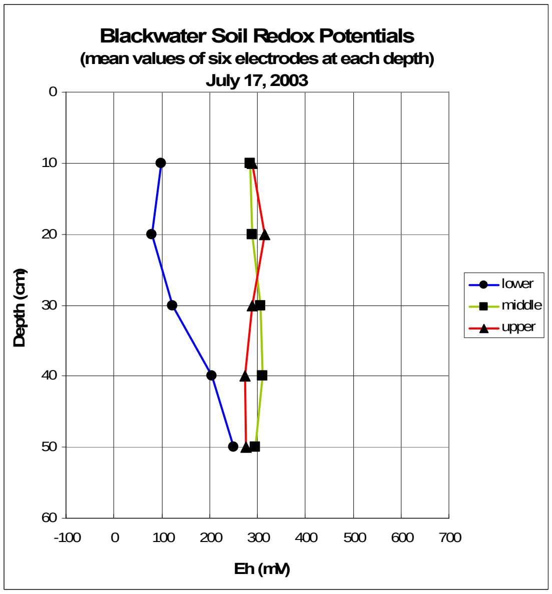


Blackwater Soil Redox Potentials
(mean values of six electrodes at each depth)
June 1, 2003

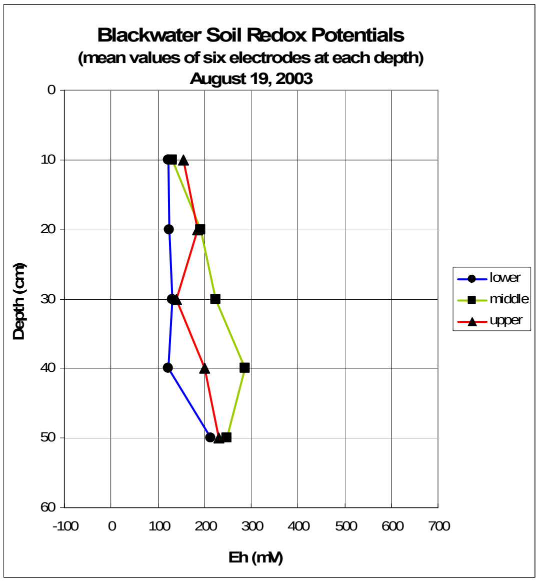
Blackwater		cm				
22-Jun-03		10	20	30	40	50
	circuit	Eh (mV)				
Lower Well	1					
	2	13	8	173	181	204
	3	3	28	169	178	198
	4	-12	58	164	193	205
	5	17	49	153	222	230
	6	-60	4	161	196	220
mean (mV)		**-8**	**29**	**164**	**194**	**211**
Middle Well	1					
	2	241	233	247	248	297
	3	242	273	289	284	340
	4					
	5	264	307	353	346	392
	6	332	352	362	345	356
mean (mV)		**270**	**291**	**313**	**306**	**346**
Upper Well	1					
	2	202	240	204	212	227
	3	248	267	241	242	256
	4					
	5	235	296	287	287	282
	6	284	318	308	320	323
mean (mV)		**242**	**280**	**260**	**265**	**272**

Blackwater		cm				
17-Jul-03		10	20	30	40	50
	circuit	Eh (mV)				
Lower Well	1					
	2	59	13	17	121	192
	3	37	32	130	184	214
	4	187	139	176	244	290
	5	36	14	73	182	233
	6	172	195	215	294	324
mean (mV)		**98**	**79**	**122**	**205**	**251**
Middle Well	1					
	2	248	232	254	239	274
	3	249	269	275	250	259
	4	230	236	274	310	284
	5	332	286	333	342	290
	6	360	422	397	410	371
mean (mV)		**284**	**289**	**307**	**310**	**296**
Upper Well	1					
	2	208	289	253	181	230
	3	314	353	265	273	262
	4	270	256	246	302	265
	5	372	353	330	286	271
	6	279	327	356	332	351
mean (mV)		**289**	**316**	**290**	**275**	**276**



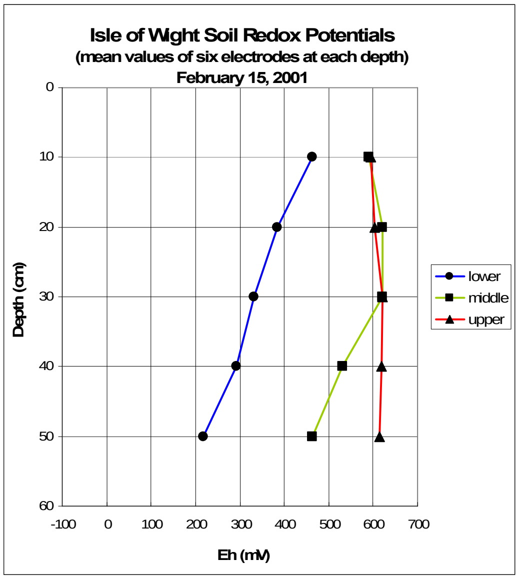


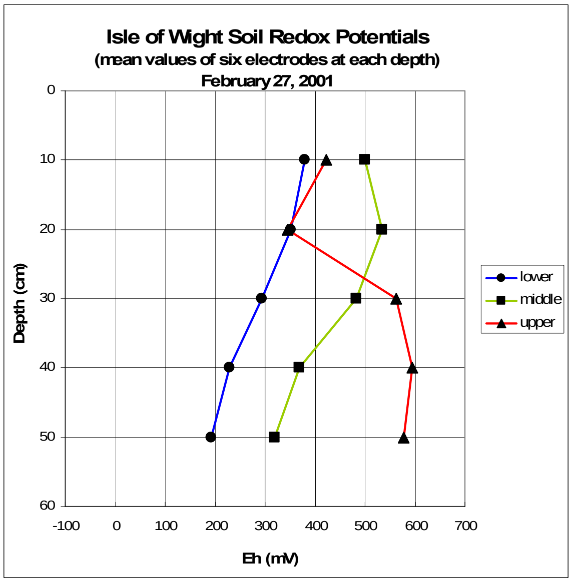
Blackwater		--------------		cm		--------------
19-Aug-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1					
Well	2	17	22	67	36	53
	3	93	54	112	50	202
	4	129	139	133	115	246
	5	190	193	156	200	285
	6	187	216	191	208	285
mean (mV)		**123**	**125**	**132**	**122**	**214**
Middle	1					
Well	2	122	217	217	294	240
	3	115	174	253	276	284
	4	93	160	185	299	244
	5	110	214	244	276	225
	6	216				
mean (mV)		**131**	**191**	**225**	**286**	**248**
Upper	1					
Well	2	164	178	125	199	243
	3	182	170	172	193	204
	4	167	204	120	223	238
	5	110	188	137	188	233
	6					
mean (mV)		**156**	**185**	**139**	**201**	**230**



Isle of Wight		--------------		cm		--------------
15-Feb-01		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	492	389	328	364	238
Well	2	451	375	324	270	279
	3	459	417	301	222	209
	4	475	361	271	272	161
	5	442	381	430	337	202
	6					
mean (mV)		**464**	**385**	**331**	**293**	**218**
Middle	1	621	619	618	592	518
Well	2	635	635	621	598	522
	3	639	616	609	553	479
	4	613	620	626	516	426
	5	449	619	626	400	369
	6					
mean (mV)		**591**	**622**	**620**	**532**	**463**
Upper	1	556	585	626	616	617
Well	2	592	611	626	608	627
	3	609	590	620	627	610
	4	578	620	627	620	625
	5	635	614	612	617	597
	6					
mean (mV)		**594**	**604**	**622**	**618**	**615**

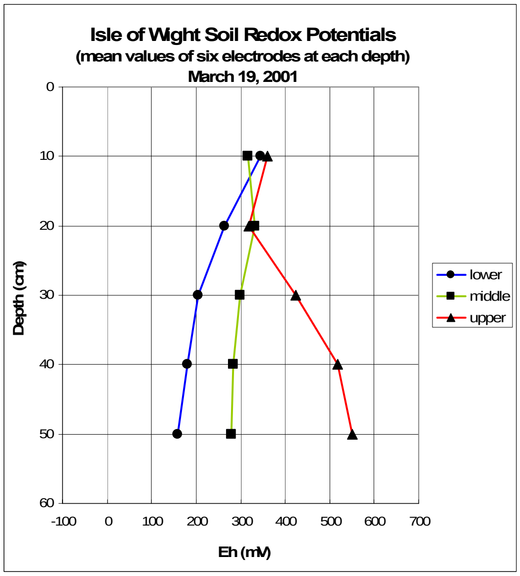
Isle of Wight		--------------		cm		--------------
27-Feb-01		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	355	299	442	214	221
Well	2	357	317	254	159	256
	3	293	259	189	131	88
	4	418	404	381	302	179
	5	409	395	231	267	194
	6	444	437	264	300	211
mean (mV)		**379**	**352**	**294**	**229**	**192**
Middle	1	591	572	585	544	521
Well	2	551	585	574	422	324
	3	501	521	503	309	277
	4	441	495	381	264	222
	5	486	524	487	351	300
	6	430	508	359	320	273
mean (mV)		**500**	**534**	**482**	**368**	**320**
Upper	1	423	361	591	594	568
Well	2	385	318	569	605	558
	3	402	451	564	599	600
	4	419	352	533	588	581
	5	396	306	543	593	561
	6	505	282	569	592	596
mean (mV)		**422**	**345**	**562**	**595**	**577**

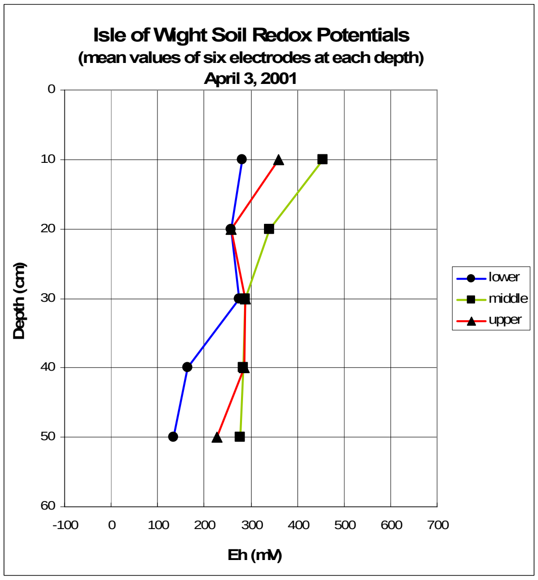




Isle of Wight		--------------		cm	--------------	
19-Mar-01		10	20	30	40	50
	circuit	----------		Eh (mV)	----------	
Lower Well	1	395	253	274	204	251
	2	373	257	210	87	86
	3	229	155	116	107	115
	4	369	307	227	273	160
	5	324	227	129	138	72
	6	372	383	272	278	264
mean (mV)		**344**	**264**	**205**	**181**	**158**
Middle Well	1	397	514	410	349	325
	2	346	390	325	318	310
	3	210	173	190	196	194
	4	378	322	312	310	340
	5	250	242	244	230	206
	6	316	346	311	303	306
mean (mV)		**316**	**331**	**299**	**284**	**280**
Upper Well	1	369	335	403	506	554
	2	448	313	497	524	597
	3	308	259	408	474	500
	4	349	322	297	490	539
	5	373	355	427	538	549
	6	318	329	511	584	567
mean (mV)		**361**	**319**	**424**	**519**	**551**

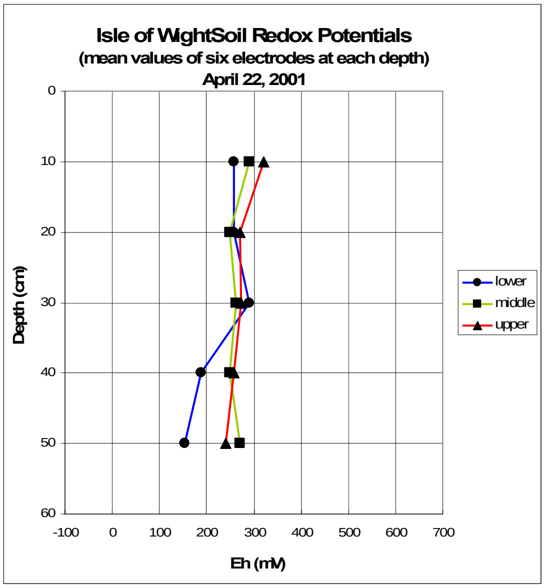
Isle of Wight		--------------		cm	--------------	
3-Apr-01		10	20	30	40	50
	circuit	----------		Eh (mV)	----------	
Lower Well	1	326	329	346	146	256
	2	344	266	362	115	92
	3	57	124	93	159	34
	4	306	276	271	187	67
	5	284	239	219	156	136
	6	375	310	366	219	217
mean (mV)		**282**	**257**	**276**	**164**	**134**
Middle Well	1	594	415	307	297	301
	2	598	441	333	312	317
	3	263	182	161	127	179
	4	485	364	339	334	277
	5	405	286	278	290	281
	6	390	357	317	339	313
mean (mV)		**456**	**341**	**289**	**283**	**278**
Upper Well	1	422	286	312	291	389
	2	397	236	310	295	179
	3	188	123	180	195	113
	4	382	335	340	319	260
	5	385	244	285	275	175
	6	384	316	308	332	253
mean (mV)		**360**	**257**	**289**	**285**	**228**

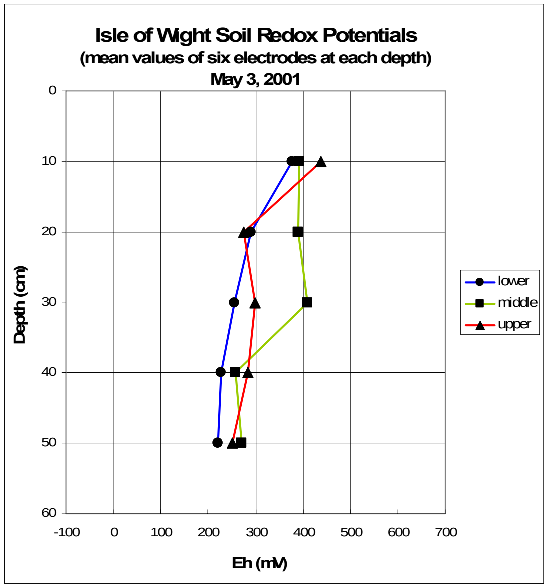




Isle of Wight				cm		
22-Apr-01		10	20	30	40	50
	circuit			Eh (mV)		
Lower	1	281	258	304	165	125
Well	2	199	224	271	167	143
	3	287	308	287	199	174
	4	292	277	272	167	142
	5	322	334	336	247	206
	6	163	143	277	184	128
mean (mV)		**257**	**257**	**291**	**188**	**153**
Middle	1	313	239	277	252	244
Well	2	255	262	298	264	320
	3	362	287	312	273	318
	4	332	272	260	261	234
	5	304	303	323	309	319
	6	179	136	105	136	187
mean (mV)		**291**	**250**	**263**	**249**	**270**
Upper	1	423	291	301	296	308
Well	2	339	318	276	270	269
	3	354	332	319	294	269
	4	235	169	220	213	178
	5	344	328	340	325	283
	6	224	187	179	152	139
mean (mV)		**320**	**271**	**273**	**258**	**241**

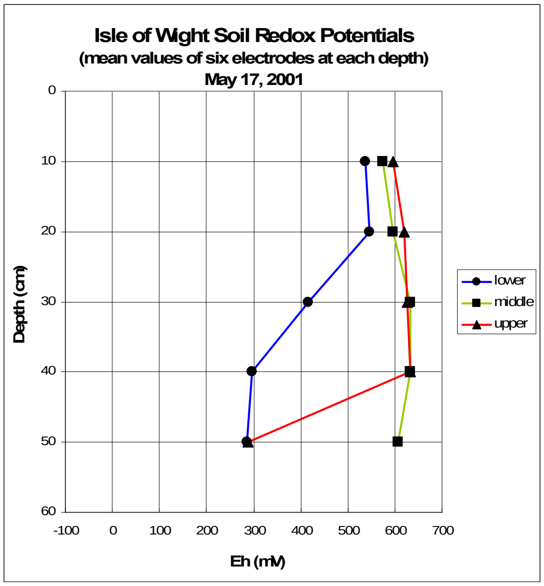
Isle of Wight				cm		
3-May-01		10	20	30	40	50
	circuit			Eh (mV)		
Lower	1	337	288	287	250	241
Well	2	355	232	184	196	177
	3	483	281	272	249	238
	4	296	334	231	204	179
	5	313	305	309	266	253
	6	481	299	250	199	231
mean (mV)		**378**	**290**	**256**	**227**	**220**
Middle	1	395	314	280	256	274
Well	2	167	414	458	242	281
	3	349	282	247	254	229
	4	501	208	528	214	286
	5	515	526	609	305	325
	6	427	598	337	276	233
mean (mV)		**392**	**390**	**410**	**258**	**271**
Upper	1	574	119	272	300	280
Well	2	329	258	277	263	182
	3	363	280	280	237	281
	4	353	372	326	272	241
	5	514	337	327	330	280
	6	487	280	304	297	244
mean (mV)		**437**	**274**	**298**	**283**	**251**

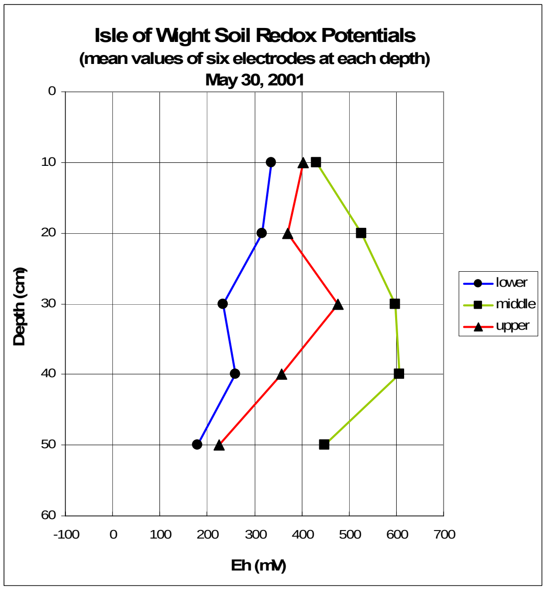




Isle of Wight				cm		
17-May-01		10	20	30	40	50
	circuit			Eh (mV)		
Lower	1	560	578	538	312	345
Well	2	529	524	339	297	380
	3	529	572	479	315	258
	4	534	533	474	261	207
	5	547	537	345	315	270
	6	531	530	312	283	255
mean (mV)		**538**	**546**	**415**	**297**	**286**
Middle	1	611	624	638	624	559
Well	2	563	600	630	628	546
	3	551	538	625	650	628
	4	567	590	623	638	641
	5	559	607	636	652	650
	6	592	620	641	604	615
mean (mV)		**574**	**597**	**632**	**633**	**607**
Upper	1	616	622	628	599	306
Well	2	592	606	628	642	229
	3	593	619	648	653	262
	4	610	623	642	617	213
	5	556	618	551	624	316
	6	613	624	659	661	404
mean (mV)		**597**	**619**	**626**	**633**	**288**

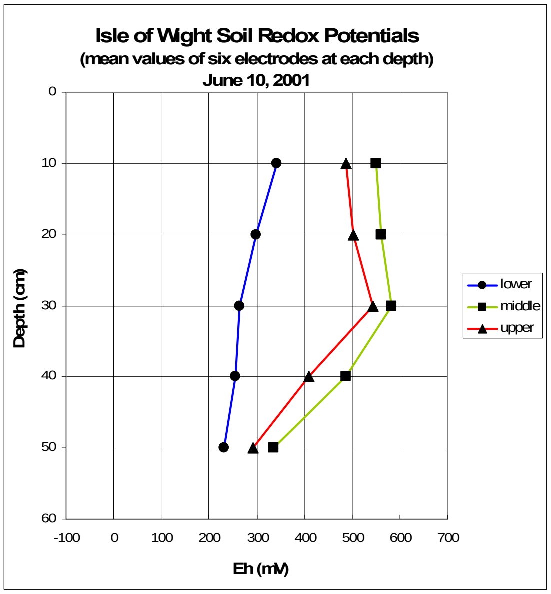
Isle of Wight				cm		
30-May-01		10	20	30	40	50
	circuit			Eh (mV)		
Lower	1	314	306	236	267	163
Well	2	315	334	262	258	175
	3	356	330	283	314	201
	4	337	308	207	234	146
	5	368	321	188	290	236
	6	319	303	223	196	160
mean (mV)		**335**	**317**	**233**	**260**	**180**
Middle	1	574	514	596	623	361
Well	2	366	529	580	584	366
	3	479	552	614	606	401
	4	366	526	595	615	582
	5	426	563	615	623	447
	6	375	477	596	586	536
mean (mV)		**431**	**527**	**599**	**606**	**449**
Upper	1	412	288	562	384	192
Well	2	357	283	590	272	174
	3	388	355	568	350	209
	4	382	454	368	285	291
	5	462	495	322	299	204
	6	415	343	451	550	285
mean (mV)		**403**	**370**	**477**	**357**	**226**

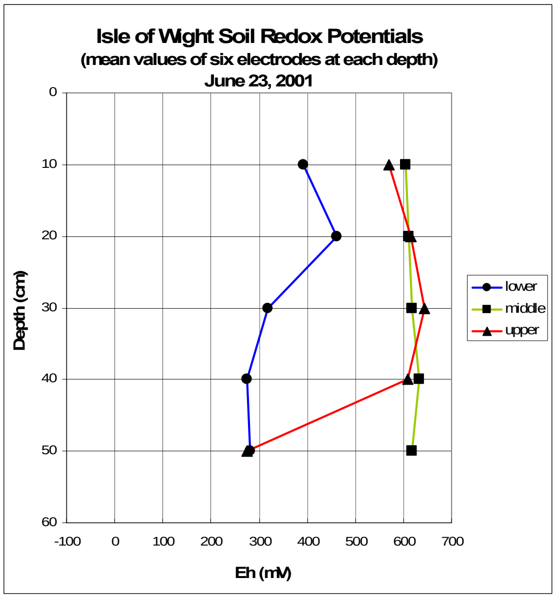




Isle of Wight		--------------	cm	--------------		
10-Jun-01		10	20	30	40	50
	circuit	----------	Eh (mV)	----------		
Lower	1	347	283	281	298	220
Well	2	337	323	226	192	228
	3	284	294	316	296	273
	4	394	312	167	252	206
	5	369	306	287	242	254
	6	324	275	306	248	210
mean (mV)		**343**	**299**	**264**	**255**	**232**
Middle	1	560	555	573	551	361
Well	2	541	586	549	319	261
	3	583	575	568	519	325
	4	621	488	596	403	336
	5	457	579	621	581	396
	6	535	583	583	548	335
mean (mV)		**550**	**561**	**582**	**487**	**336**
Upper	1	650	585	576	500	426
Well	2	545	609	621	594	377
	3	501	380	578	401	335
	4	457	467	480	348	230
	5	424	451	420	263	185
	6	349	527	590	353	199
mean (mV)		**488**	**503**	**544**	**410**	**292**

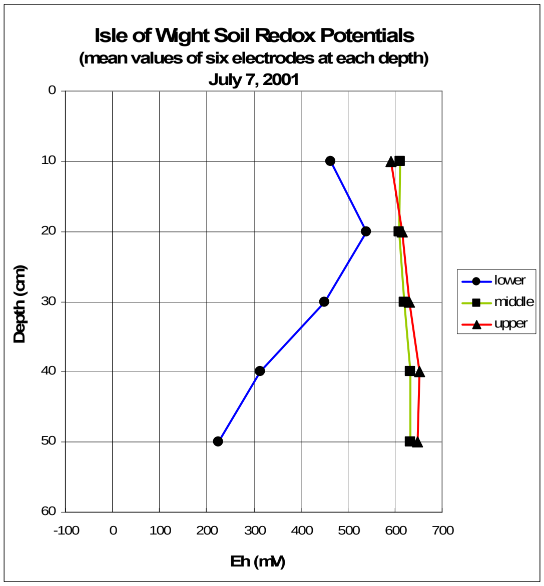
Isle of Wight		--------------	cm	--------------		
23-Jun-01		10	20	30	40	50
	circuit	----------	Eh (mV)	----------		
Lower	1	555	488	281	278	254
Well	2	318	558	329	309	249
	3	517	318	431	303	281
	4	249	387	248	206	297
	5	180	502	316	311	278
	6	537	513	300	248	329
mean (mV)		**393**	**461**	**318**	**276**	**281**
Middle	1	642	632	641	651	663
Well	2	573	617	618	625	617
	3	604	598	610	636	617
	4	614	620	620	637	617
	5	601	614	603	619	622
	6	597	584	613	626	567
mean (mV)		**605**	**611**	**618**	**632**	**617**
Upper	1	601	629	664	657	312
Well	2	580	641	668	456	307
	3	571	630	656	662	254
	4	582	615	633	638	251
	5	542	599	626	647	244
	6	540	584	614	594	283
mean (mV)		**569**	**616**	**644**	**609**	**275**

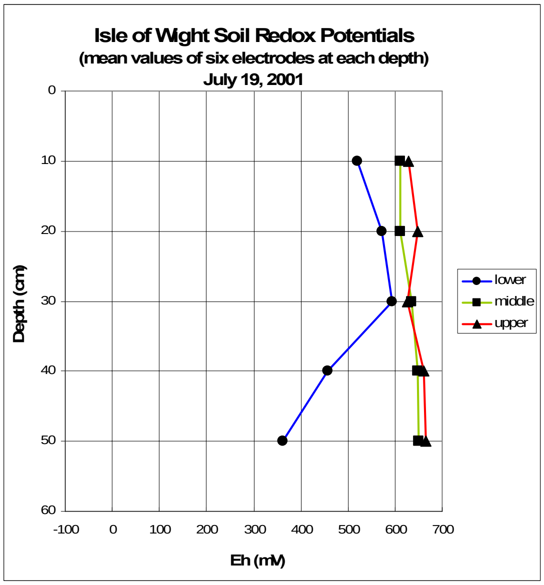




Isle of Wight		--------------	cm	--------------		
7-Jul-01		10	20	30	40	50
	circuit	----------	Eh (mV)	----------		
Lower	1	471	499	301	230	161
Well	2	548	528	465	317	236
	3	288	565	528	345	252
	4	507	543	443	397	244
	5	435	546	472	309	214
	6	535	560	498	291	251
mean (mV)		**464**	**540**	**451**	**315**	**226**
Middle	1	591	563	572	584	566
Well	2	633	627	637	642	623
	3	628	620	640	652	655
	4	613	621	597	630	654
	5	594	622	640	650	649
	6	606	606	625	642	648
mean (mV)		**611**	**610**	**619**	**633**	**633**
Upper	1	577	599	627	652	648
Well	2	607	646	659	670	670
	3	609	628	657	660	655
	4	591	595	625	648	646
	5	591	629	641	650	624
	6	575	601	579	632	652
mean (mV)		**592**	**616**	**631**	**652**	**649**

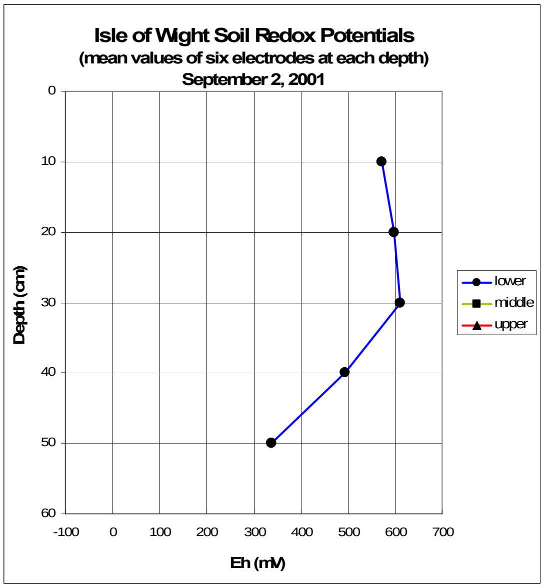
Isle of Wight		--------------	cm	--------------		
19-Jul-01		10	20	30	40	50
	circuit	----------	Eh (mV)	----------		
Lower	1	507	545	584	568	513
Well	2	498	569	572	356	256
	3	527	589	601	594	327
	4	509	563	603	314	258
	5	551	570	596	344	261
	6	535	602	604	569	554
mean (mV)		**521**	**573**	**593**	**458**	**362**
Middle	1	604	571	618	612	640
Well	2	643	643	643	661	625
	3	625	638	643	661	642
	4	600	624	630	649	663
	5	596	613	637	652	665
	6	603	576	636	644	669
mean (mV)		**612**	**611**	**635**	**647**	**651**
Upper	1	634	660	665	686	665
Well	2	639	657	664	676	670
	3	644	654	656	678	660
	4	606	610	515	599	628
	5	633	645	588	651	677
	6	611	660	669	681	688
mean (mV)		**628**	**648**	**626**	**662**	**665**

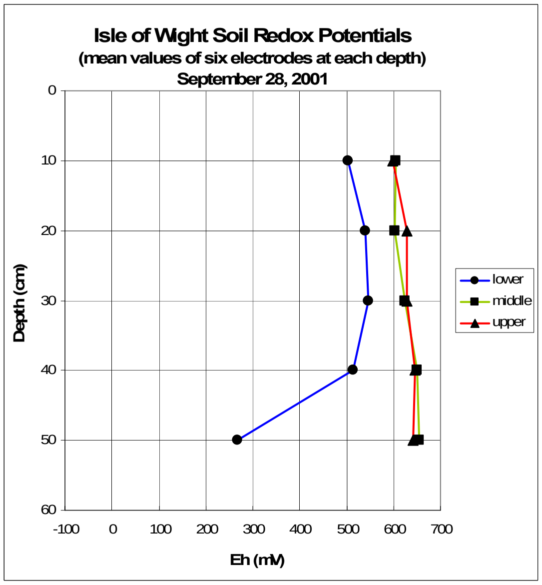




Isle of Wight				cm		
2-Sep-01		10	20	30	40	50
	circuit			Eh (mV)		
Lower	1	564	582	606	450	388
Well	2	557	573	598	612	379
	3	564	604	623	600	337
	4	559	594	607	310	312
	5	597	618	624	377	302
	6	593	619	615	611	315
mean (mV)		**572**	**598**	**612**	**493**	**339**
Middle	1					
Well	2					
	3					
	4					
	5					
	6					
mean (mV)						
Upper	1					
Well	2					
	3					
	4					
	5					
	6					
mean (mV)						

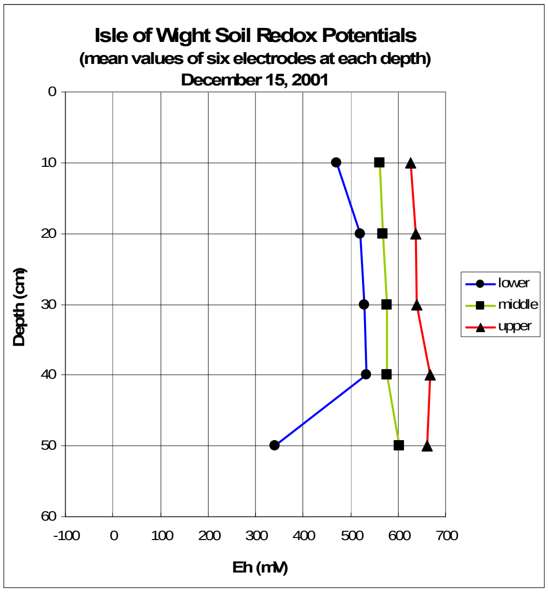
Isle of Wight				cm		
28-Sep-01		10	20	30	40	50
	circuit			Eh (mV)		
Lower	1	467	525	544	562	217
Well	2			563	588	261
	3	523	548	573	512	249
	4	503	547	488	556	280
	5	493	526	536	346	315
	6	531	554	571	519	277
mean (mV)		**503**	**540**	**546**	**514**	**267**
Middle	1	582	600	600	642	651
Well	2	632	530	615	649	648
	3	618	619	635	656	657
	4	597	617	625	648	651
	5	591	629	626	652	656
	6	610	619	641	659	666
mean (mV)		**605**	**602**	**624**	**651**	**655**
Upper	1	586	611	622	625	617
Well	2					
	3					
	4					
	5					
	6	612	646	636	664	665
mean (mV)		**599**	**629**	**629**	**645**	**641**

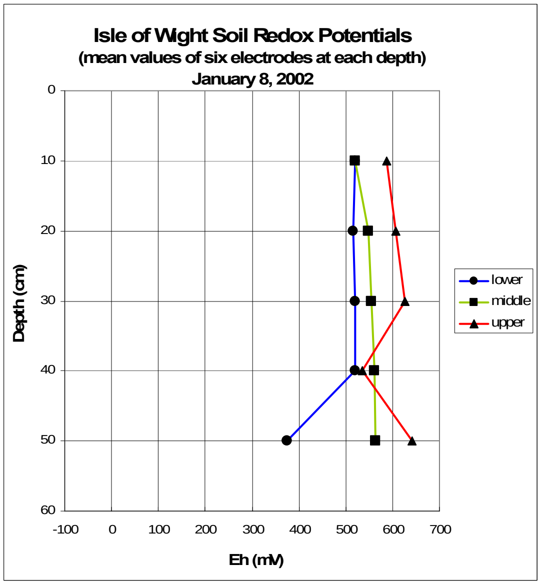




Isle of Wight		--------------		cm		--------------
15-Dec-01		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	507	522	542	539	302
Well	2	461	528	535	530	311
	3	473	531	555	546	360
	4	435	513	538	543	547
	5	438	514	467	532	308
	6	512	516	534	507	221
mean (mV)		**471**	**521**	**529**	**533**	**342**
Middle	1	547	559	573	580	596
Well	2	569	546	566	596	605
	3	561	576	572	537	590
	4	559	593	586	565	602
	5	559	551	573	582	607
	6	573	590	583	596	611
mean (mV)		**561**	**569**	**576**	**576**	**602**
Upper	1	626	661	664	689	675
Well	2	639	639	603	662	654
	3	633	655	651	668	662
	4	630	661	657	667	655
	5	619	641	664	677	671
	6	615	569	602	636	642
mean (mV)		**627**	**638**	**640**	**667**	**660**

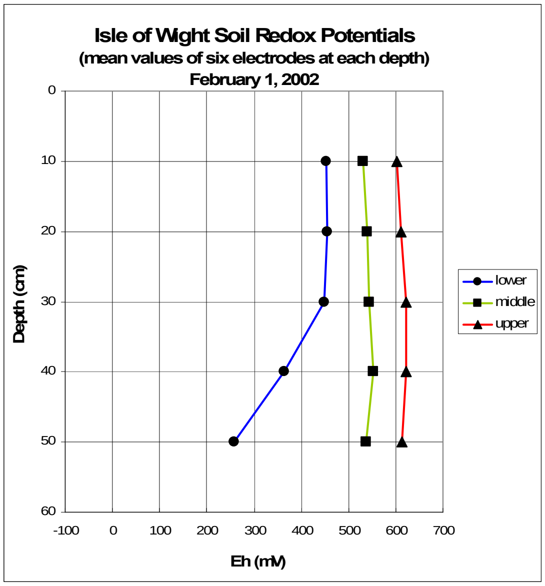
Isle of Wight		--------------		cm		--------------
8-Jan-02		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	521	539	549	526	495
Well	2	533	536	540	549	423
	3	503	416	398	383	347
	4	532	532	546	554	310
	5	503	525	537	554	427
	6	524	543	549	550	244
mean (mV)		519	515	520	519	374
Middle	1	548	559	571	573	592
Well	2	550	572	583	583	583
	3	395	445	459	467	444
	4	550	567	578	582	582
	5	535	561	569	580	581
	6	546	581	561	585	599
mean (mV)		521	548	554	562	564
Upper	1	611	569	615	604	632
Well	2	616	608	642	672	662
	3	473	525	530	538	569
	4	622	639	657	647	662
	5	616	644	659	373	661
	6	591	652	651	378	664
mean (mV)		588	606	626	535	642

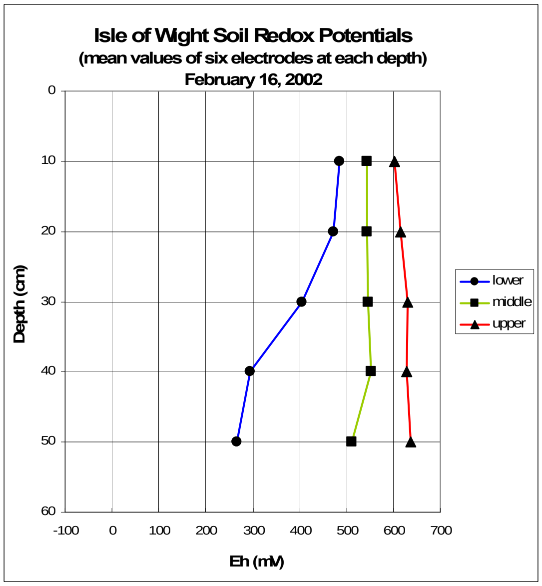




Isle of Wight		-------------- cm --------------				
1-Feb-02		10	20	30	40	50
	circuit	---------- Eh (mV) ----------				
Lower Well	1	470	466	390	337	266
	2	524	502	426	395	265
	3	402	486	432	268	201
	4	504	513	505	360	284
	5	426	410	453	365	257
	6	393	351	479	457	273
mean (mV)		**453**	**455**	**448**	**364**	**258**
Middle Well	1	515	515	510	511	490
	2	569	557	561	568	559
	3	484	505	506	505	489
	4	559	575	565	584	575
	5	521	536	549	568	562
	6	536	553	568	578	555
mean (mV)		**531**	**540**	**543**	**552**	**538**
Upper Well	1	579	594	596	590	584
	2	633	637	628	646	630
	3	525	554	563	577	564
	4	638	622	648	628	632
	5	625	641	653	658	644
	6	615	622	649	626	623
mean (mV)		**603**	**612**	**623**	**621**	**613**

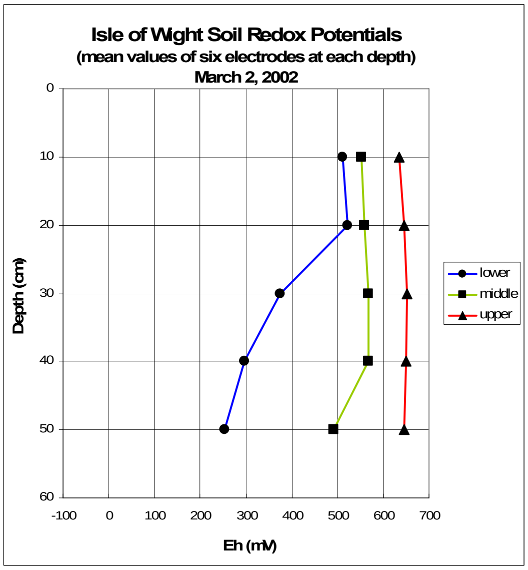
Isle of Wight		-------------- cm --------------				
16-Feb-02		10	20	30	40	50
	circuit	---------- Eh (mV) ----------				
Lower Well	1	494	452	324	287	255
	2	427	377	269	250	252
	3	514	512	361	321	284
	4	511	477	485	360	284
	5	519	503	497	287	253
	6	443	515	493	267	266
mean (mV)		**485**	**473**	**405**	**295**	**266**
Middle Well	1	562	585	581	563	514
	2	475	501	446	462	395
	3	569	568	579	576	536
	4	545	480	545	567	531
	5	548	563	561	566	550
	6	559	565	566	577	541
mean (mV)		**543**	**544**	**546**	**552**	**511**
Upper Well	1	628	644	648	647	657
	2	530	551	543	559	563
	3	607	568	640	617	652
	4	589	645	648	640	633
	5	627	639	652	656	654
	6	630	650	654	656	666
mean (mV)		**602**	**616**	**631**	**629**	**638**

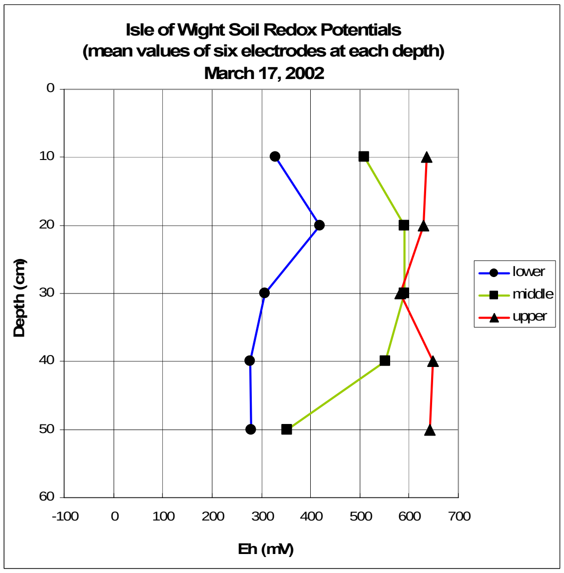




Isle of Wight		--------------		cm		--------------
2-Mar-02		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	524	537	353	319	270
Well	2	499	531	337	279	244
	3	515	505	343	304	269
	4	508	507	444	269	236
	5	529	533	347	296	260
	6	497	518	425	313	247
mean (mV)		**512**	**522**	**375**	**297**	**254**
Middle	1	573	584	573	564	429
Well	2	459	471	474	466	404
	3	570	582	585	584	524
	4	572	572	576	596	546
	5	565	571	596	595	497
	6	575	574	595	601	543
mean (mV)		**552**	**559**	**567**	**568**	**491**
Upper	1	647	651	672	669	648
Well	2	636	646	656	648	656
	3	620	638	631	655	646
	4	642	633	639	645	644
	5	638	654	658	640	635
	6	635	652	656	646	645
mean (mV)		**636**	**646**	**652**	**651**	**646**

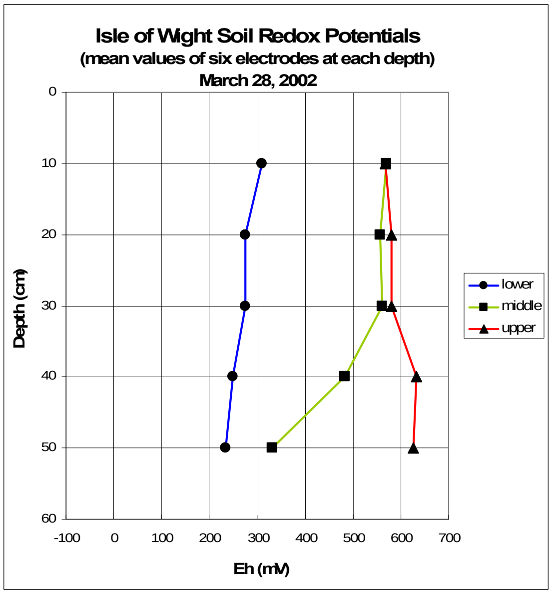
Isle of Wight		--------------		cm		--------------
17-Mar-02		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	322	402	299	265	274
Well	2	338	435	312	285	281
	3	321	428	302	282	283
	4	318	420	318	276	279
	5	332	415	310	288	285
	6	335	407	307	273	276
mean (mV)		**328**	**418**	**308**	**278**	**280**
Middle	1	502	595	591	556	382
Well	2	505	581	582	546	333
	3	488	603	597	556	346
	4	524	588	595	543	332
	5	521	596	583	554	355
	6	514	583	593	552	363
mean (mV)		**509**	**591**	**590**	**551**	**352**
Upper	1	630	624	660	657	648
Well	2	640	633	640	651	650
	3	640	625	249	646	636
	4	632	628	643	643	633
	5	636	635	644	650	640
	6	635	629	656	645	644
mean (mV)		**636**	**629**	**582**	**649**	**642**

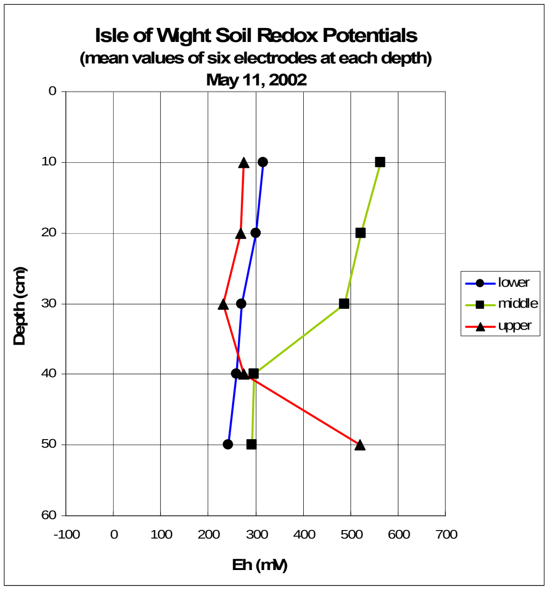




Isle of Wight		--------------	--------------	cm	--------------	--------------
28-Mar-02		10	20	30	40	50
	circuit	----------	----------	Eh (mV)	----------	----------
Lower	1	304	268	273	247	227
Well	2	294	265	263	241	240
	3	325	288	293	264	245
	4	325	272	270	251	224
	5	300	283	277	229	226
	6	313	280	272	254	234
mean (mV)		**310**	**276**	**275**	**248**	**233**
Middle	1	574	534	545	354	309
Well	2	570	565	577	409	364
	3	589	585	595	559	334
	4	590	571	584	557	344
	5	544	539	529	524	329
	6	554	545	534	496	303
mean (mV)		**570**	**557**	**561**	**483**	**331**
Upper	1	559	599	579	635	638
Well	2	536	613	591	629	624
	3	627	628	571	631	623
	4	570	634	561	646	641
	5	525	488	595	634	625
	6	588	523	588	619	609
mean (mV)		**568**	**581**	**581**	**632**	**627**

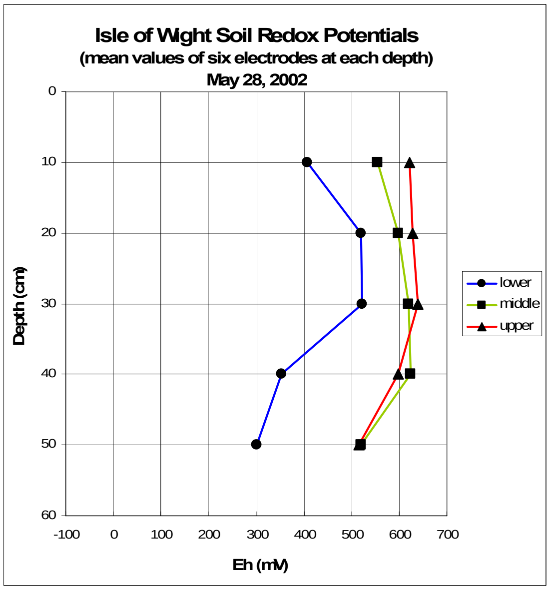
Isle of Wight		--------------	--------------	cm	--------------	--------------
May 11, 2002		10	20	30	40	50
	circuit	----------	----------	Eh (mV)	----------	----------
Lower	1	340	297	301	288	263
Well	2	285	310	279	276	283
	3	327	291	275	270	252
	4	319	278	235	222	201
	5	345	331	280	274	256
	6	288	295	248	230	197
mean (mV)		**317**	**300**	**270**	**260**	**242**
Middle	1	603	585	497	310	286
Well	2	503	449	583	300	294
	3	540	550	572	301	294
	4	571	442	381	281	263
	5	595	567	553	302	318
	6	564	542	343	289	303
mean (mV)		**563**	**523**	**488**	**297**	**293**
Upper	1	282	283	193	271	563
Well	2	272	280	227	267	349
	3	288	326	263	239	518
	4	271	215	238	233	545
	5	264	292	291	307	564
	6	275	220	174	334	572
mean (mV)		**275**	**269**	**231**	**275**	**519**

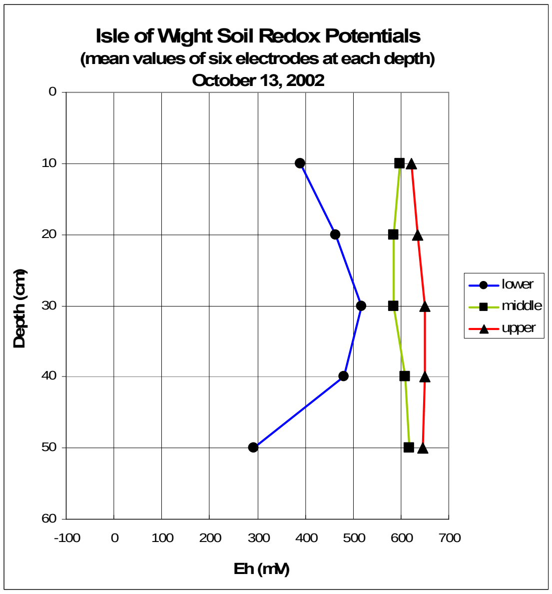




Isle of Wight				cm		
28-May-02		10	20	30	40	50
	circuit			Eh (mV)		
Lower	1	326	507	513	394	314
Well	2	314	501	565	314	298
	3	511	529	528	324	290
	4	506	533	495	341	306
	5	504	534	517	424	321
	6	287	523	514	323	285
mean (mV)		**408**	**521**	**522**	**353**	**302**
Middle	1	559	599	635	632	532
Well	2	550	607	617	642	535
	3	550	591	618	630	518
	4	556	599	605	625	505
	5	566	601	620	606	499
	6	543	595	623	613	535
mean (mV)		**554**	**599**	**620**	**625**	**521**
Upper	1	626	636	627	633	403
Well	2	626	617	640	642	585
	3	612	627	643	579	619
	4	621	625	642	468	550
	5	616	640	643	640	530
	6	626	630	638	625	402
mean (mV)		**621**	**629**	**639**	**598**	**515**

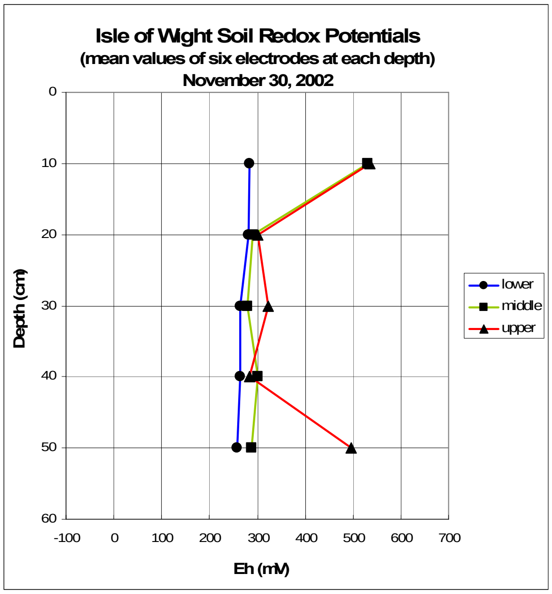
Isle of Wight				cm		
13-Oct-02		10	20	30	40	50
	circuit			Eh (mV)		
Lower	1	449	493	505	360	267
Well	2					
	3	371	492	529	504	284
	4	372	485	513	516	297
	5	400	483	535	502	309
	6	364	367	507	522	302
mean (mV)		**391**	**464**	**518**	**481**	**292**
Middle	1	580	591	578	603	614
Well	2					
	3	617	620	601	612	598
	4	612	559	595	583	614
	5	594	582	575	628	635
	6	589	579	581	626	627
mean (mV)		**598**	**586**	**586**	**610**	**618**
Upper	1	596	626	638	616	607
Well	2					
	3	641	657	665	667	652
	4	626	611	644	652	651
	5	631	649	662	664	671
	6	613	636	640	652	646
mean (mV)		**621**	**636**	**650**	**650**	**645**

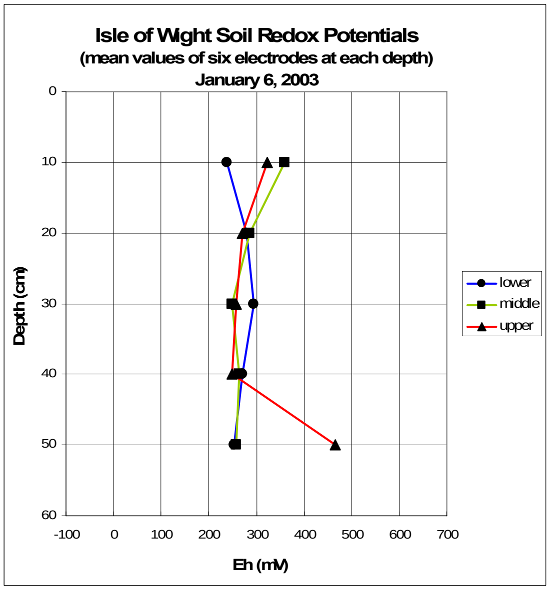




Isle of Wight		--------------		cm		--------------
30-Nov-02		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower Well	1	246	266	290	269	270
	2	286	264	308	273	255
	3	318	289	302	277	270
	4	277	289	264	258	258
	5	252	246	234	238	235
	6	323	334	194	270	260
mean (mV)		**284**	**281**	**265**	**264**	**258**
Middle Well	1	593	327	293	302	285
	2	593	275	285	293	274
	3	475	301	290	308	312
	4	536	293	255	311	299
	5	436	235	253	264	252
	6	553	310	295	328	310
mean (mV)		**531**	**290**	**279**	**301**	**289**
Upper Well	1	554	317	339	282	535
	2	556	314	355	285	525
	3	488	306	312	281	438
	4	614	301	302	273	478
	5	404	261	315		
	6	595	305	308	294	510
mean (mV)		**535**	**301**	**322**	**283**	**497**

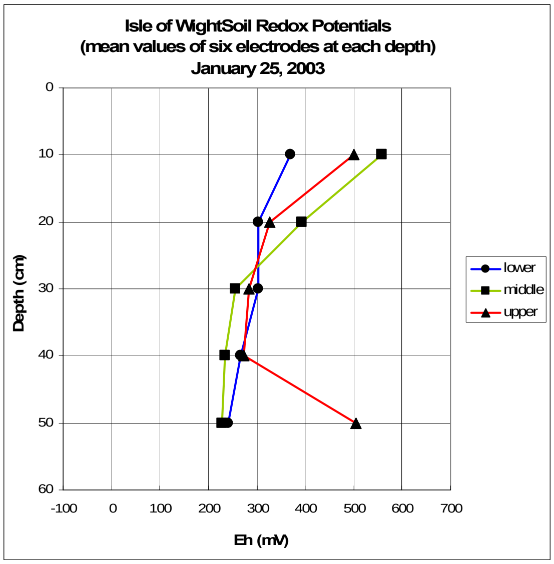
Isle of Wight		--------------		cm		--------------
6-Jan-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower Well	1	202	286	298	280	264
	2	285	300	308	297	282
	3	147	253	306	281	257
	4	292	330	300	282	264
	5	262	259	303	239	208
	6	244	249	249	245	244
mean (mV)		**239**	**280**	**294**	**271**	**253**
Middle Well	1	329	277	243	281	293
	2	462	300	286	301	271
	3	372	298	192	235	178
	4	387	315	283	301	294
	5	340	273	239	225	264
	6	263	247	243	244	244
mean (mV)		**359**	**285**	**248**	**265**	**257**
Upper Well	1	349	275	306	260	465
	2	319	244	281	279	479
	3	301	273	205	261	546
	4	377	293	281	262	508
	5	329	289	235	187	495
	6	260	244	242	241	294
mean (mV)		**323**	**270**	**258**	**248**	**465**

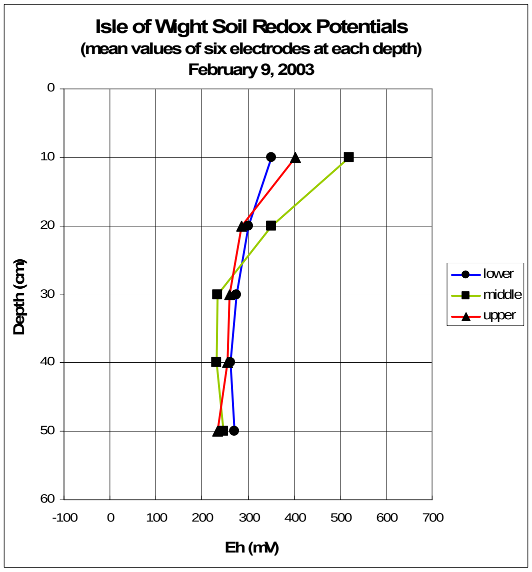




Isle of Wight				-------------- cm --------------		
25-Jan-03		10	20	30	40	50
	circuit			---------- Eh (mV) ----------		
Lower	1	473	302	296	269	242
Well	2	278	279	381	279	266
	3	310	277	324	277	260
	4	448	321	276	246	237
	5	432	325	284	272	262
	6	279	315	258	257	187
mean (mV)		**370**	**303**	**303**	**267**	**242**
Middle	1	540	257	241	207	228
Well	2	531	344	235	225	226
	3	531	355	280	248	234
	4	581	281	224	219	212
	5	602	578	277	277	256
	6	570	542	286	231	216
mean (mV)		**559**	**393**	**257**	**235**	**229**
Upper	1	594	300	269	254	581
Well	2	346	294	271	255	535
	3	610	356	310	284	363
	4	524	374	295	299	478
	5	613	316	302	289	558
	6	316	324	254	265	514
mean (mV)		**501**	**327**	**284**	**274**	**505**

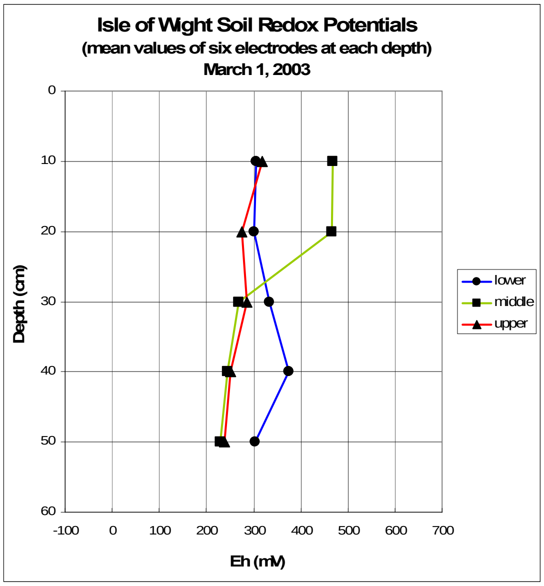
Isle of Wight				-------------- cm --------------		
9-Feb-03		10	20	30	40	50
	circuit			---------- Eh (mV) ----------		
Lower	1	343	281	279	242	274
Well	2	436	321	374	306	296
	3	324	288	186	228	221
	4	330	321	287	265	290
	5	323	298	250	265	272
	6					
mean (mV)		**351**	**302**	**275**	**261**	**271**
Middle	1	457	276	169	221	235
Well	2	496	305	249	252	262
	3	539	307	237	236	253
	4	567	455	244	260	237
	5	544	412	272	184	249
	6					
mean (mV)		**521**	**351**	**234**	**231**	**247**
Upper	1	393	295	286	268	316
Well	2	400	291	283	275	221
	3	375	244	197	229	200
	4	427	267	256	252	205
	5	417	334	273	252	224
	6					
mean (mV)		**402**	**286**	**259**	**255**	**233**



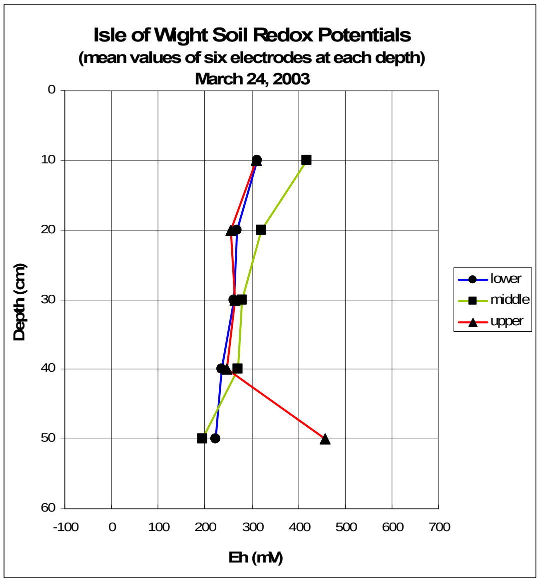


Isle of Wight		--------------		cm		--------------
1-Mar-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	292	294	284	258	244
Well	2	297	283	269	261	247
	3	338	335	350	326	298
	4	295	283	291	581	327
	5	298	276	406	456	271
	6	316	329	402	359	436
mean (mV)		**306**	**300**	**334**	**374**	**304**
Middle	1	361	396	248	227	237
Well	2	370	437	257	224	224
	3	436	466	292	273	248
	4	527	520	265	251	226
	5	567	491	286	250	214
	6	542	479	264	244	225
mean (mV)		**467**	**465**	**269**	**245**	**229**
Upper	1	349	289	428	295	261
Well	2	304	268	249	231	216
	3	360	314	293	286	275
	4	321	269	279	229	198
	5	274	218	246	243	274
	6	298	283	220	230	209
mean (mV)		**318**	**274**	**286**	**252**	**239**

Isle of Wight		--------------		cm		--------------
24-Mar-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	406	306	339	258	244
Well	2					
	3	277	218	249	236	212
	4	269	218	224	211	217
	5	293	288	233	235	199
	6	315	311	272	244	239
mean (mV)		**312**	**268**	**263**	**237**	**222**
Middle	1	459	320	219	244	252
Well	2					
	3	472	339	316	294	226
	4	311	301	259	241	138
	5	403	331	306	280	170
	6	444	316	297	289	183
mean (mV)		**418**	**321**	**279**	**270**	**194**
Upper	1	318	239	231	247	476
Well	2					
	3	303	255	290	292	432
	4	336	279	269	232	459
	5	291	257	253	231	525
	6	296	244	277	234	400
mean (mV)		**309**	**255**	**264**	**247**	**458**



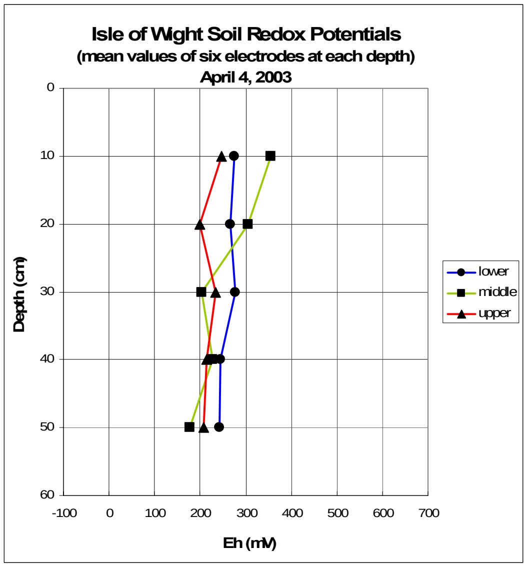
Isle of Wight Soil Redox Potentials
(mean values of six electrodes at each depth)
March 1, 2003

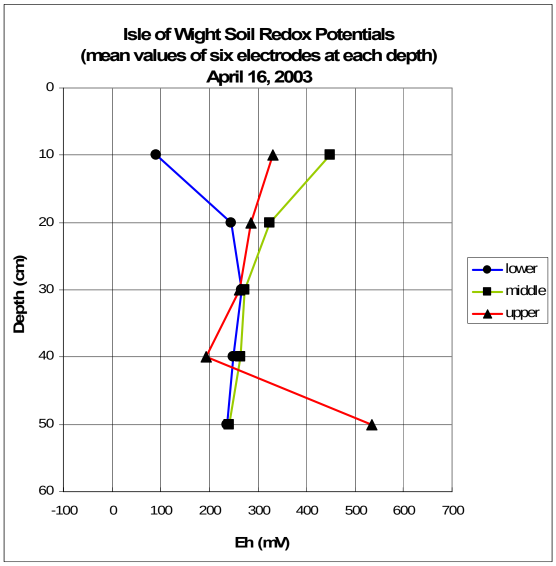


Isle of Wight Soil Redox Potentials
(mean values of six electrodes at each depth)
March 24, 2003

Isle of Wight		--------------		cm		--------------
4-Apr-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	314	232	271	205	194
Well	2					
	3	285	289	260	237	240
	4	180	266	290	256	257
	5	322	332	344	312	303
	6	277	209	223	217	216
mean (mV)		**276**	**266**	**278**	**245**	**242**
Middle	1	359	294	61	185	182
Well	2					
	3	386	273	194	211	198
	4	331	320	296	257	143
	5	321	316	256	268	251
	6	385	320	207	218	109
mean (mV)		**356**	**305**	**203**	**228**	**177**
Upper	1	173	142	204	211	190
Well	2					
	3	269	225	258	235	225
	4	299	207	246	205	220
	5	201	203	223	187	191
	6	292	225	241	239	209
mean (mV)		**247**	**200**	**234**	**215**	**207**

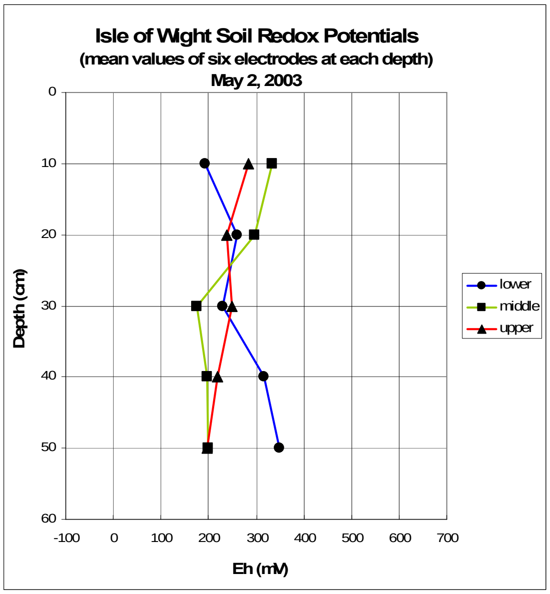
Isle of Wight		--------------		cm		--------------
16-Apr-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	114	213	251	234	221
Well	2	27	198	245	232	214
	3	258	303	311	281	267
	4	50	238	271	236	226
	5	2	277	253	263	253
	6					
mean (mV)		**90**	**246**	**266**	**249**	**236**
Middle	1	394	312	286	271	246
Well	2	416	329	267	275	228
	3	397	311	259	258	263
	4	654	326	257	262	225
	5	380	344	294	255	239
	6					
mean (mV)		**448**	**324**	**273**	**264**	**240**
Upper	1	315	244	244	52	566
Well	2	300	317	281	181	535
	3	329	295	244	243	544
	4	349	298	282	246	582
	5	360	279	265	250	448
	6					
mean (mV)		**331**	**287**	**263**	**194**	**535**

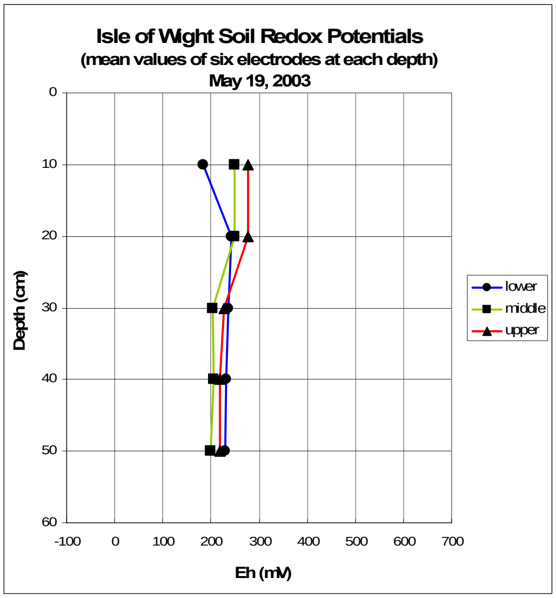




Isle of Wight		-------------- cm --------------				
2-May-03		10	20	30	40	50
	circuit	---------- Eh (mV) ----------				
Lower	1	258	265	255	400	420
Well	2	61	262	270	279	312
	3	139	199	192	261	247
	4	233	217	154	249	468
	5	274	357	276	392	297
	6					
mean (mV)		**193**	**260**	**229**	**316**	**349**
Middle	1	339	330	244	231	246
Well	2	332	314	64	209	215
	3	282	259	203	192	183
	4	300	305	172	194	182
	5	415	278	194	166	168
	6					
mean (mV)		**334**	**297**	**175**	**198**	**199**
Upper	1	289	242	255	225	194
Well	2	290	247	269	228	209
	3	272	213	244	223	205
	4	244	216	233	199	178
	5	324	279	248	216	200
	6					
mean (mV)		**284**	**239**	**250**	**218**	**197**

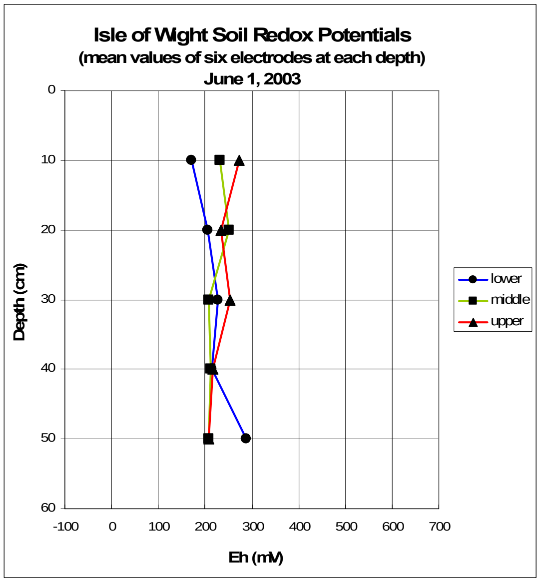
Isle of Wight		-------------- cm --------------				
19-May-03		10	20	30	40	50
	circuit	---------- Eh (mV) ----------				
Lower	1	137	198	209	205	197
Well	2	195	254	236	239	227
	3	167	248	233	221	221
	4	181	257	258	244	244
	5	237	251	251	253	255
	6					
mean (mV)		**183**	**242**	**237**	**232**	**229**
Middle	1	244	239	205	189	206
Well	2	217	233	213	232	207
	3	256	250	220	202	203
	4	272	254	186	203	195
	5	259	267	192	205	188
	6					
mean (mV)		**250**	**249**	**203**	**206**	**200**
Upper	1	256	276	237	219	165
Well	2	306	283	243	215	248
	3	276	281	230	227	240
	4	276	273	198	216	233
	5	271	272	233	213	203
	6					
mean (mV)		**277**	**277**	**228**	**218**	**218**

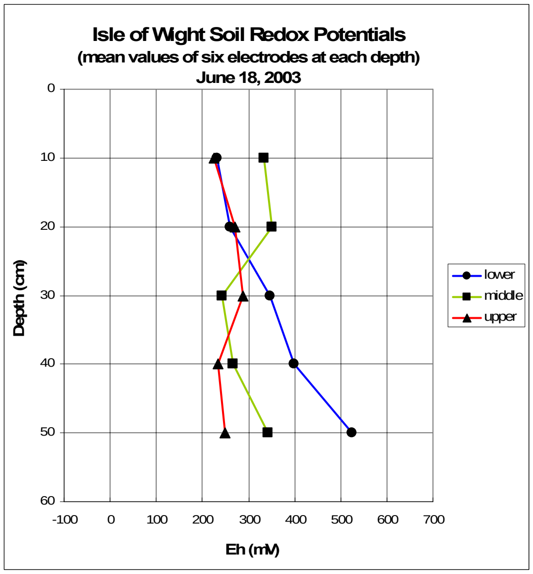




Isle of Wight		--------------	--------------	cm	--------------	--------------
1-Jun-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1	141	150	205	210	354
Well	2	123	166	184	170	449
	3	91	163	180	169	208
	4	242	223	254	216	224
	5	226	244	253	234	223
	6	201	282	288	286	263
mean (mV)		**171**	**205**	**227**	**214**	**287**
Middle	1	243	259	177	209	188
Well	2	215	241	202	186	165
	3	196	227	197	178	188
	4	205	234	170	236	255
	5	250	273	207	205	201
	6	281	273	289	265	252
mean (mV)		**232**	**251**	**207**	**213**	**208**
Upper	1	267	244	244	188	201
Well	2	221	190	194	170	172
	3	260	159	212	206	192
	4	277	262	277	239	231
	5	307	264	293	251	224
	6	302	286	300	243	222
mean (mV)		**272**	**234**	**253**	**216**	**207**

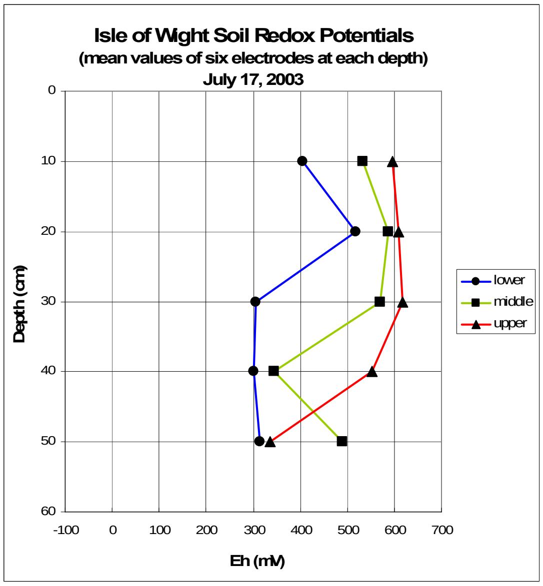
Isle of Wight		--------------	--------------	cm	--------------	--------------
18-Jun-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower	1					
Well	2	272	331	360	506	556
	3	190	289	303	397	535
	4	53	49	269	294	515
	5	271	266	387	375	507
	6	374	363	418	423	511
mean (mV)		**232**	**260**	**347**	**399**	**525**
Middle	1					
Well	2	367	318	229	273	612
	3	491	536	261	285	273
	4	297	351	200	224	243
	5	251	230	237	249	269
	6	263	322	289	299	316
mean (mV)		**334**	**351**	**243**	**266**	**343**
Upper	1					
Well	2	194	265	281	188	243
	3	154	235	241	205	222
	4	176	247	271	224	245
	5	327	286	325	242	244
	6	279	321	322	309	288
mean (mV)		**226**	**271**	**288**	**234**	**248**

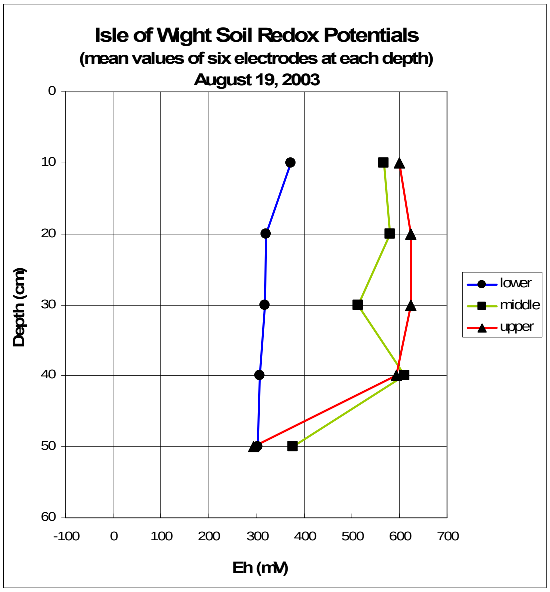




Isle of Wight		-------------- cm --------------				
17-Jul-03		10	20	30	40	50
	circuit	---------- Eh (mV) ----------				
Lower	1					
Well	2	403	502	242	239	256
	3	414	539	195	227	258
	4	473	521	404	355	332
	5	391	525	269	287	382
	6	351	500	420	398	343
mean (mV)		**406**	**517**	**306**	**301**	**314**
Middle	1					
Well	2	517	573	580	319	261
	3	503	571	601	301	610
	4	549	571	564	349	601
	5	567	582	543	458	623
	6	534	641	564	300	349
mean (mV)		**534**	**588**	**570**	**345**	**489**
Upper	1					
Well	2	567	603	620	523	326
	3	618	626	632	642	295
	4	604	611	606	616	336
	5	610	611	635	387	310
	6	579	589	599	595	415
mean (mV)		**596**	**608**	**618**	**553**	**336**

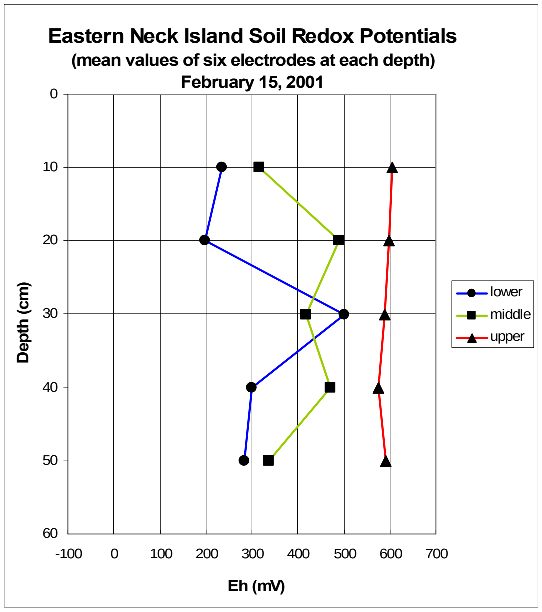
Isle of Wight		-------------- cm --------------				
19-Aug-03		10	20	30	40	50
	circuit	---------- Eh (mV) ----------				
Lower	1					
Well	2	297	335	365	336	295
	3	343	349	306	253	288
	4	509	299	285	283	308
	5	371	286	302	301	265
	6	346	335	331	364	361
mean (mV)		**373**	**321**	**318**	**307**	**303**
Middle	1					
Well	2	573	585	552	612	345
	3	554	589	494	617	402
	4	580	584	584	638	350
	5	569	572	487	607	388
	6	559	575	448	585	399
mean (mV)		**567**	**581**	**513**	**612**	**377**
Upper	1					
Well	2	530	623	606	583	252
	3	635	631	614	542	299
	4	614	614	633	648	325
	5	605	611	618	599	311
	6	615	641	651	600	287
mean (mV)		**600**	**624**	**624**	**594**	**295**

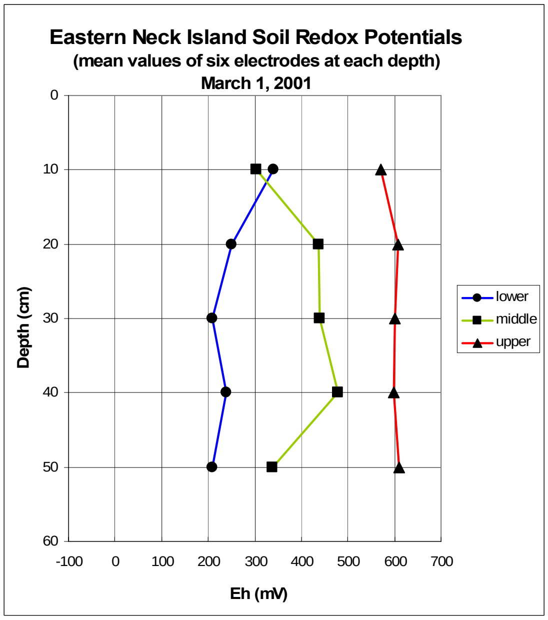




Eastern Neck		--------------		cm		--------------
15-Feb-01		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower site	1	290	199	560	502	499
	2	218	245	549	291	183
	3	258	189	510	227	170
	4	226	138	429	268	169
	5	173	151	450	-7	202
	6	251	264	505	520	482
mean (mV)		**236**	**198**	**501**	**300**	**284**
Middle Site	1	306	580	486	573	496
	2	350	586	587	570	526
	3	419	440	339	379	109
	4	252	558	511	536	318
	5	288	528	561	517	300
	6	279	248	22	253	275
mean (mV)		**316**	**490**	**418**	**471**	**337**
Upper site	1	646	631	601	613	627
	2	617	608	604	615	608
	3	549	508	528	519	516
	4	626	589	608	605	589
	5	571	609	559	525	602
	6	627	642	625	565	611
mean (mV)		**606**	**598**	**588**	**574**	**592**

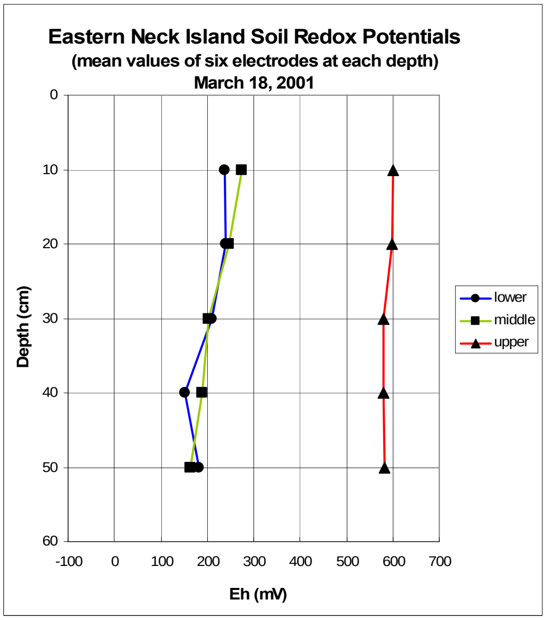
Eastern Neck		--------------		cm		--------------
1-Mar-01		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower site	1	322	290	114	204	201
	2	322	194	172	281	209
	3	374	164	143	182	152
	4	384	267	214	255	227
	5	312	286	372	236	214
	6	333	302	233	273	249
mean (mV)		**341**	**251**	**208**	**239**	**209**
Middle Site	1	332	357	339	523	434
	2	312	563	537	576	439
	3	294	516	517	555	383
	4	288	530	512	506	295
	5	267	359	452	433	222
	6	327	298	283	276	261
mean (mV)		**303**	**437**	**440**	**478**	**339**
Upper site	1	619	600	600	603	609
	2	583	621	604	598	608
	3	548	576	590	590	605
	4	617	627	622	627	622
	5	541	598	600	620	623
	6	517	622	586	551	598
mean (mV)		**571**	**607**	**600**	**598**	**611**

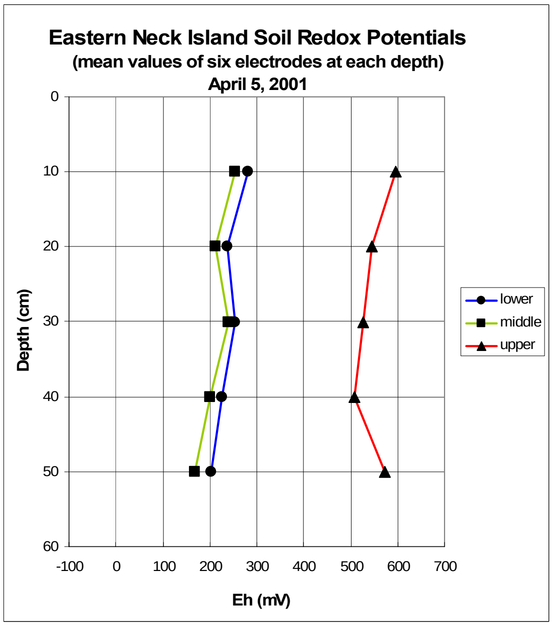




Eastern Neck		-------------- cm --------------				
Mar 18,2001		10	20	30	40	50
	circuit	---------- Eh (mV) ----------				
Lower site	1	201	257	280	222	229
	2	274	254	215	-141	142
	3	231	162	130	141	129
	4	168	269	300	294	267
	5	275	244	160	94	134
	6	274	252	177	301	190
mean (mV)		**237**	**240**	**210**	**152**	**182**
Middle Site	1	310	293	200	156	174
	2	214	268	366	264	197
	3	200	120	116	82	87
	4	318	297	224	211	178
	5	255	198	149	64	129
	6	350	303	158	361	220
mean (mV)		**275**	**247**	**202**	**190**	**164**
Upper site	1	641	618	555	574	599
	2	654	610	622	545	594
	3	630	611	600	598	608
	4	535	538	538	579	552
	5	497	609	559	575	574
	6	640	609	605	602	570
mean (mV)		**600**	**599**	**580**	**579**	**583**

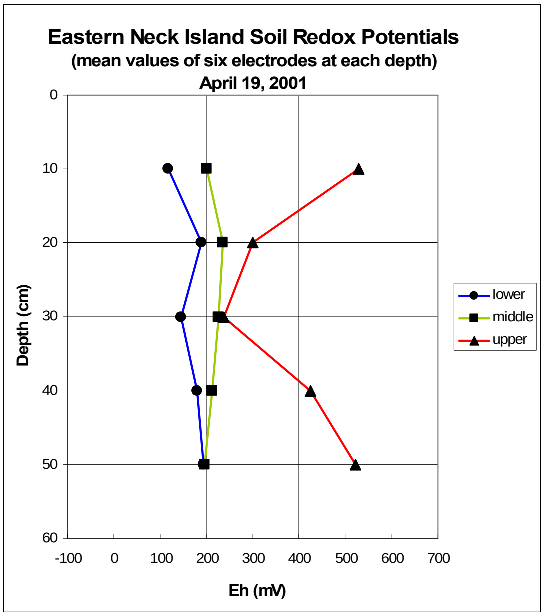
Eastern Neck		-------------- cm --------------				
5-Apr-01		10	20	30	40	50
	circuit	---------- Eh (mV) ----------				
Lower site	1	143	242	283	263	218
	2	326	285	296	227	213
	3	314	236	306	227	217
	4	332	235	222	215	171
	5	295	189	158	191	190
	6					
mean (mV)		**282**	**237**	**253**	**225**	**202**
Middle Site	1	267	224	251	265	254
	2	272	197	245	257	222
	3	257	204	251	100	88
	4	310	227	215	156	208
	5	164	211	236	225	73
	6					
mean (mV)		**254**	**213**	**240**	**201**	**169**
Upper site	1	614	578	487	572	597
	2	626	522	544	555	606
	3	585	567	516	547	583
	4	600	589	548	484	553
	5	548	466	541	380	520
	6					
mean (mV)		**595**	**544**	**527**	**508**	**572**

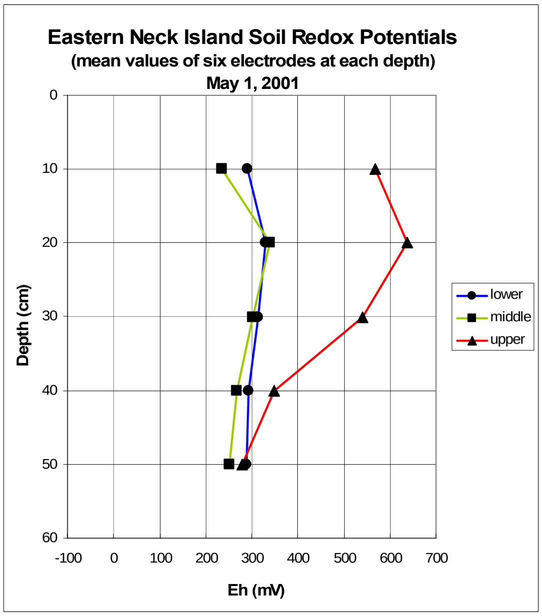




Eastern Neck				cm		
19-Apr-01		10	20	30	40	50
	circuit			Eh (mV)		
Lower site	1	166	251	262	211	207
	2	128	228	237	251	244
	3	32	33	65	73	73
	4	257	261	50	163	204
	5	158	212	76	180	206
	6	-39	153	179	202	224
mean (mV)		**117**	**190**	**145**	**180**	**193**
Middle Site	1	143	251	264	215	238
	2	302	230	242	227	261
	3	110	151	117	74	15
	4	123	255	263	245	214
	5	304	248	249	283	235
	6	220	276	214	219	216
mean (mV)		**200**	**235**	**225**	**211**	**197**
Upper site	1	550	373	265	485	532
	2	492	258	295	502	535
	3	546	282	66	154	492
	4	569	313	336	427	570
	5	547	309	304	512	473
	6	478	262	162	472	529
mean (mV)		**530**	**300**	**238**	**425**	**522**

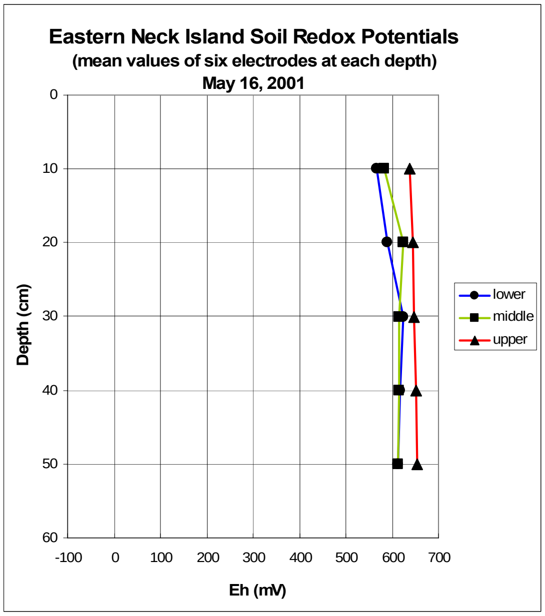
Eastern Neck				cm		
1-May-01		10	20	30	40	50
	circuit			Eh (mV)		
Lower site	1	257	363	349	314	338
	2	349	290	330	353	285
	3	242	370	309	285	242
	4	279	371	301	260	225
	5	287	309	306	240	290
	6	325	272	284	302	348
mean (mV)		**290**	**329**	**313**	**292**	**288**
Middle Site	1	174	393	326	335	332
	2	396	350	314	314	297
	3	141	480	314	109	200
	4	188	276	234	204	204
	5	126	273	320	306	252
	6	383	268	302	336	229
mean (mV)		**235**	**340**	**302**	**267**	**252**
Upper site	1	565	635	486	536	518
	2	587	640	478	281	286
	3	561	629	615	139	229
	4	503	608	478	129	310
	5	570	647	559	495	137
	6	629	660	631	505	194
mean (mV)		**569**	**637**	**541**	**348**	**279**

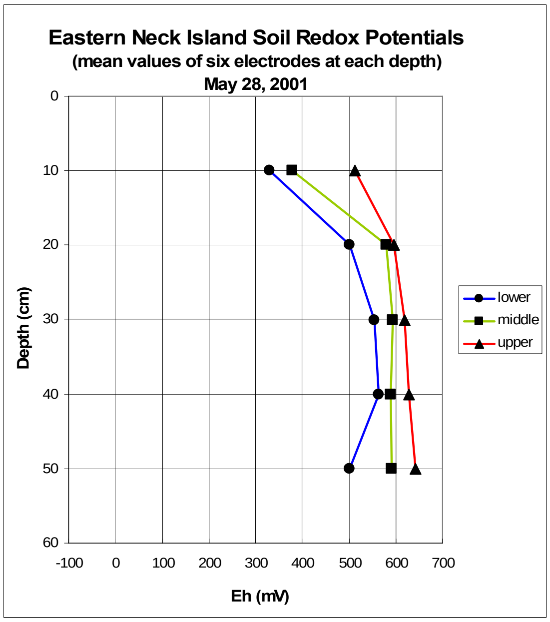




Eastern Neck		cm				
16-May-01		10	20	30	40	50
	circuit	Eh (mV)				
Lower site	1	576	610	626	626	628
	2	589	603	632	626	632
	3	575	578	618	624	610
	4	551	569	623	617	604
	5	546	575	627	594	593
	6	564	599	612	618	605
mean (mV)		**567**	**589**	**623**	**618**	**612**
Middle Site	1	601	639	638	604	631
	2	599	630	608	610	616
	3	580	624	638	627	600
	4	562	612	604	606	574
	5	549	616	600	619	622
	6	600	630	602	620	633
mean (mV)		**582**	**625**	**615**	**614**	**613**
Upper site	1	633	664	678	678	679
	2	645	627	657	661	668
	3	610	651	656	644	664
	4	620	649	638	646	609
	5	679	650	639	651	656
	6	636	620	608	632	655
mean (mV)		**637**	**644**	**646**	**652**	**655**

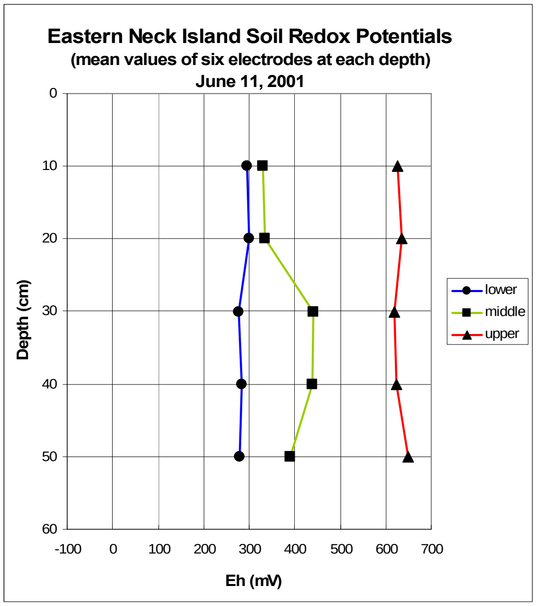
Eastern Neck		cm				
28-May-01		10	20	30	40	50
	circuit	Eh (mV)				
Lower site	1	334	608	621	638	549
	2	327	290	485	578	408
	3	346	544	598	605	554
	4	353	566	568	584	574
	5	321	569	566	601	559
	6	292	426	494	378	358
mean (mV)		**329**	**501**	**555**	**564**	**500**
Middle Site	1	380	609	619	610	557
	2	465	602	616	603	581
	3	532	593	630	620	645
	4	248	598	586	602	605
	5	381	601	616	617	652
	6	270	468	492	481	510
mean (mV)		**379**	**579**	**593**	**589**	**592**
Upper site	1	441	623	656	658	676
	2	559	648	595	642	663
	3	598	634	671	657	661
	4	501	633	635	650	662
	5	612	663	662	643	658
	6	363	381	496	525	534
mean (mV)		**512**	**597**	**619**	**629**	**642**

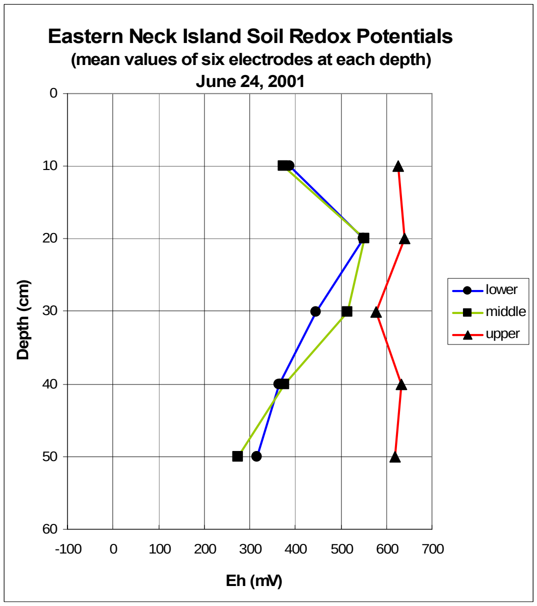




Eastern Neck		-------------- cm --------------				
11-Jun-01		10	20	30	40	50
	circuit	---------- Eh (mV) ----------				
Lower site	1	342	342	263	302	326
	2	297	265	255	275	267
	3	272	350	345	318	310
	4	300	244	229	248	180
	5	306	305	295	277	298
	6	261	301	278	278	295
mean (mV)		**296**	**301**	**278**	**283**	**279**
Middle Site	1	389	363	570	568	561
	2	278	310	567	552	556
	3	365	329	378	341	473
	4	315	295	307	280	148
	5	373	365	326	395	332
	6	262	350	494	492	276
mean (mV)		**330**	**335**	**440**	**438**	**391**
Upper site	1	595	643	637	606	675
	2	639	648	623	575	634
	3	642	632	639	646	635
	4	623	603	609	617	639
	5	633	655	596	655	655
	6	620	636	616	642	658
mean (mV)		**625**	**636**	**620**	**624**	**649**

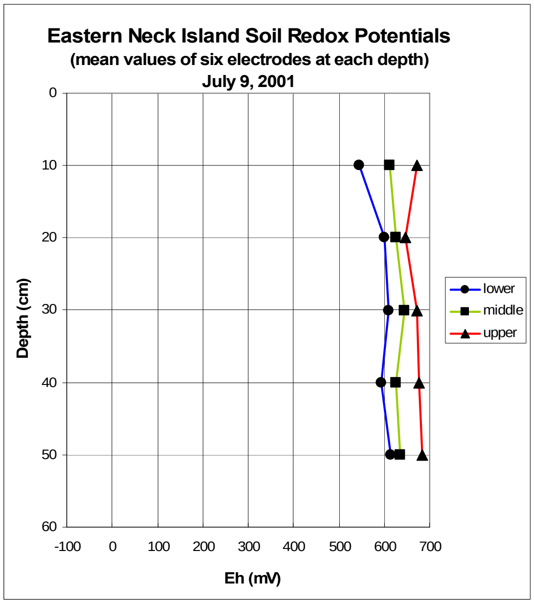
Eastern Neck		-------------- cm --------------				
24-Jun-01		10	20	30	40	50
	circuit	---------- Eh (mV) ----------				
Lower site	1	332	478	322	286	246
	2	314	545	570	395	360
	3	311	575	551	431	382
	4	305	550	391	296	295
	5	545	574	394	367	273
	6	517	580	442	415	342
mean (mV)		**387**	**550**	**445**	**365**	**316**
Middle Site	1	472	528	567	515	360
	2	262	548	568	398	218
	3	321	513	535	340	252
	4	340	559	315	314	261
	5	390	561	518	282	283
	6	458	604	585	411	271
mean (mV)		**374**	**552**	**515**	**377**	**274**
Upper site	1	626	603	599	614	611
	2	621	629	653	619	588
	3	609	640	282	641	622
	4	638	646	640	643	624
	5	623	654	642	632	635
	6	647	664	647	642	642
mean (mV)		**627**	**639**	**577**	**632**	**620**

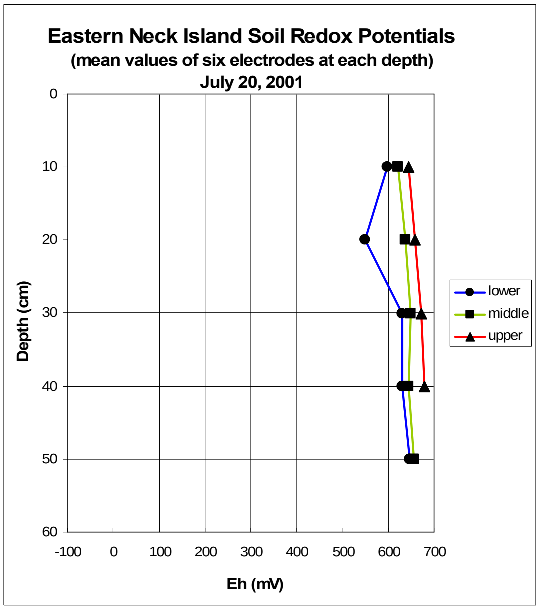




Eastern Neck		-------------- cm --------------				
9-Jul-01		10	20	30	40	50
	circuit	---------- Eh (mV) ----------				
Lower site	1	570	569	586	604	606
	2	557	615	646	630	634
	3	559	608	619	623	614
	4	440	595	542	485	573
	5	591	603	645	591	625
	6	555	615	617	623	632
mean (mV)		**545**	**601**	**609**	**593**	**614**
Middle Site	1	603	621	642	615	642
	2	564	623	642	651	655
	3	631	635	651	583	644
	4	621	618	632	638	595
	5	619	636	648	651	634
	6	629	630	647	622	641
mean (mV)		**611**	**627**	**644**	**627**	**635**
Upper site	1	660	662	673	678	699
	2	680	613	664	659	682
	3	681	636	669	683	684
	4	658	637	659	674	682
	5	671	661	678	680	698
	6	683	664	687	692	654
mean (mV)		**672**	**646**	**672**	**678**	**683**

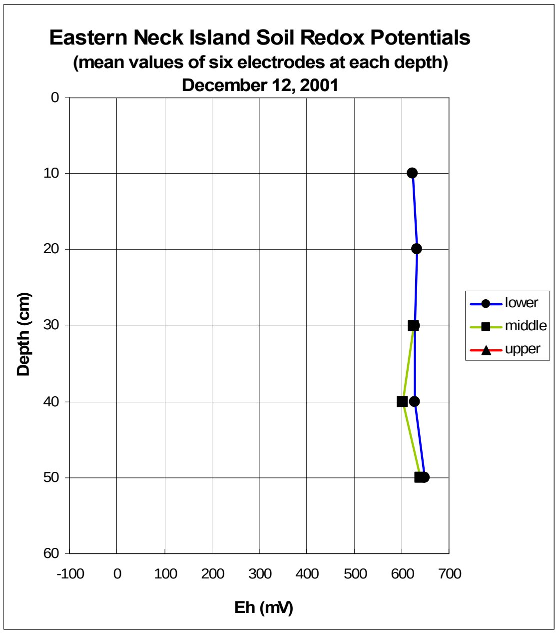
Eastern Neck		-------------- cm --------------				
20-Jul-01		10	20	30	40	50
	circuit	---------- Eh (mV) ----------				
Lower site	1	594	626	639	620	642
	2	597	257	663	642	666
	3	596	588	626	620	645
	4	591	561	620	616	628
	5	616	632	643	634	646
	6	601	630	593	653	649
mean (mV)		**599**	**549**	**631**	**631**	**646**
Middle Site	1	612	651	660	634	663
	2	621	647	664	657	669
	3	627	637	659	642	653
	4	628	642	638	621	642
	5	621	631	618	652	651
	6	621	618	655	658	660
mean (mV)		**622**	**638**	**649**	**644**	**656**
Upper site	1	648	656	669	685	
	2	653	673	679	662	
	3	670	659	677	679	
	4	636	655	660	668	
	5	634	661	678	696	
	6	622	642	667	681	
mean (mV)		**644**	**658**	**672**	**679**	

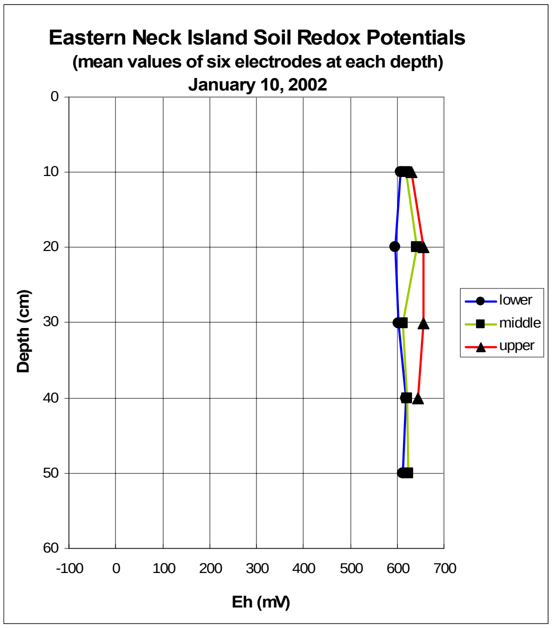




Eastern Neck		--------------	cm	--------------		
12-Dec-01		10	20	30	40	50
	circuit	----------	Eh (mV)	----------		
Lower site	1	641	627	631	636	642
	2	642	640	636	636	656
	3	641	642	638	614	636
	4	609	632	642	642	664
	5	610	642	635	643	654
	6	602	621	585	603	
mean (mV)		**624**	**634**	**628**	**629**	**650**
Middle Site	1			627	638	642
	2			644	633	
	3			644	581	625
	4			556	575	
	5					
	6			644	551	635
mean (mV)				**627**	**604**	**639**
Upper site	1					
	2					
	3					
	4					
	5					
	6					
mean (mV)						

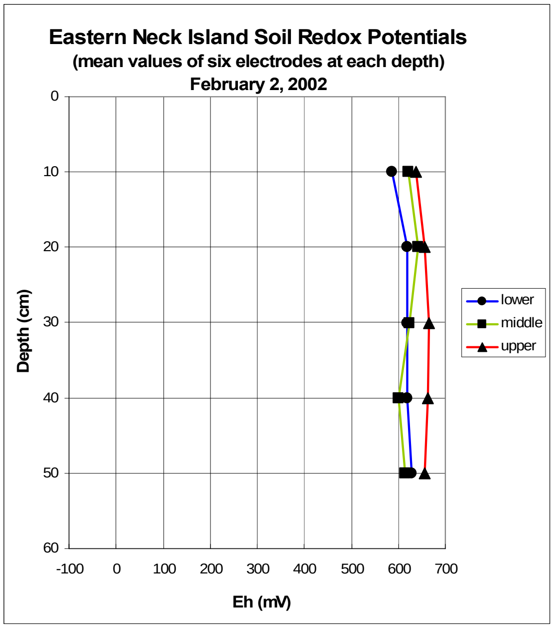
Eastern Neck		--------------	cm	--------------		
10-Jan-02		10	20	30	40	50
	circuit	----------	Eh (mV)	----------		
Lower site	1	603	576	586	603	603
	2	606	574	593	610	595
	3	611	591	615	622	607
	4	615	600	608	624	619
	5	605	604	602	621	616
	6	609	623	612	625	623
mean (mV)		**608**	**595**	**603**	**618**	**611**
Middle Site	1	618	635	615	616	623
	2	612	644	607	631	630
	3	632	646	613	629	632
	4	638	644	616	625	620
	5	615	640	609	620	616
	6	604	644	614	605	619
mean (mV)		**620**	**642**	**612**	**621**	**623**
Upper site	1	645	655	653	642	
	2	655	665	664	644	
	3	626	661	660	650	
	4	616	648	654	635	
	5	615	650	657	641	
	6	621	657	656	650	
mean (mV)		**630**	**656**	**657**	**644**	

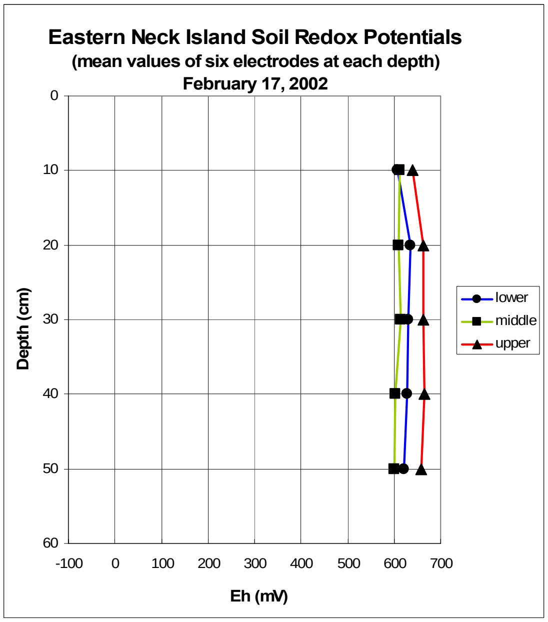

Eastern Neck Island Soil Redox Potentials
(mean values of six electrodes at each depth)
December 12, 2001


Eastern Neck Island Soil Redox Potentials
(mean values of six electrodes at each depth)
January 10, 2002

Eastern Neck		cm				
2-Feb-02		10	20	30	40	50
	circuit	Eh (mV)				
Lower site	1	570	626	623	607	632
	2	620	644	655	633	644
	3	544	585	608	592	583
	4	610	619	638	644	648
	5	611	632	588	619	638
	6	561	610	602	625	621
mean (mV)		**586**	**619**	**619**	**620**	**628**
Middle Site	1	638	644	605	590	605
	2	643	624	635	622	627
	3	598	610	594	579	581
	4	651	670	659	612	630
	5	632	658	644	622	624
	6	566	652	600	575	620
mean (mV)		**621**	**643**	**623**	**600**	**615**
Upper site	1	624	640	639	644	645
	2	643	664	671	651	650
	3	588	659	665	664	655
	4	659	672	676	668	658
	5	648	663	676	679	669
	6	657	640	669	665	663
mean (mV)		**637**	**656**	**666**	**662**	**657**

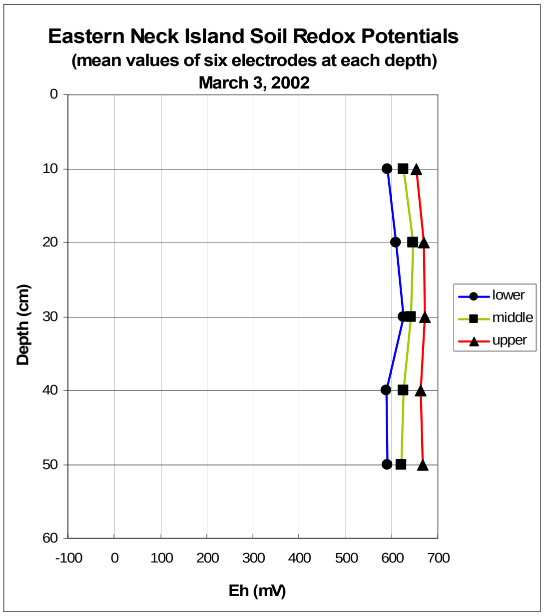
Eastern Neck		cm				
17-Feb-02		10	20	30	40	50
	circuit	Eh (mV)				
Lower site	1	617	639	642	641	624
	2	601	626	634	640	631
	3	605	626	638	635	621
	4	610	655	648	648	639
	5	601	632	626	606	617
	6	613	631	599	595	598
mean (mV)		**608**	**635**	**631**	**628**	**622**
Middle Site	1	619	646	637	622	608
	2	629	621	636	627	626
	3	622	621	611	601	620
	4	602	631	624	616	617
	5	640	516	551	527	518
	6	563	618	631	633	611
mean (mV)		**613**	**609**	**615**	**604**	**600**
Upper site	1	652	676	667	666	662
	2	633	659	654	654	651
	3	638	659	669	673	657
	4	637	663	673	667	663
	5	646	671	651	663	656
	6	641	653	656	670	661
mean (mV)		**641**	**664**	**662**	**666**	**658**

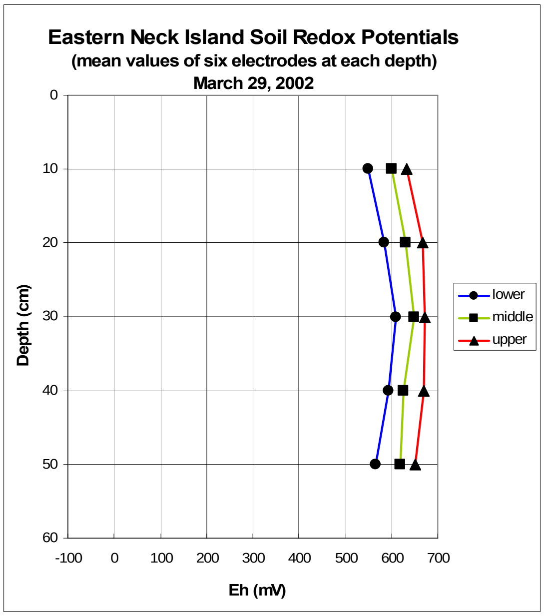




Eastern Neck		--------------		cm		--------------
3-Mar-02		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower site	1	562	623	650	601	609
	2	558	563	628	575	558
	3	612	629	628	603	598
	4	592	614	625	589	609
	5	603	608	613	583	609
	6	624	619	620	585	566
mean (mV)		**592**	**609**	**627**	**589**	**592**
Middle Site	1	640	646	646	626	621
	2	625	645	643	623	615
	3	620	652	642	626	634
	4	634	637	633	629	625
	5	621	651	646	622	607
	6	624	646	640	621	621
mean (mV)		**627**	**646**	**642**	**625**	**621**
Upper site	1	652	669	672	670	669
	2	658	677	674	664	661
	3	651	668	677	679	676
	4	659	672	675	666	654
	5	661	669	665	634	667
	6	635	662	675	673	675
mean (mV)		**653**	**670**	**673**	**664**	**667**

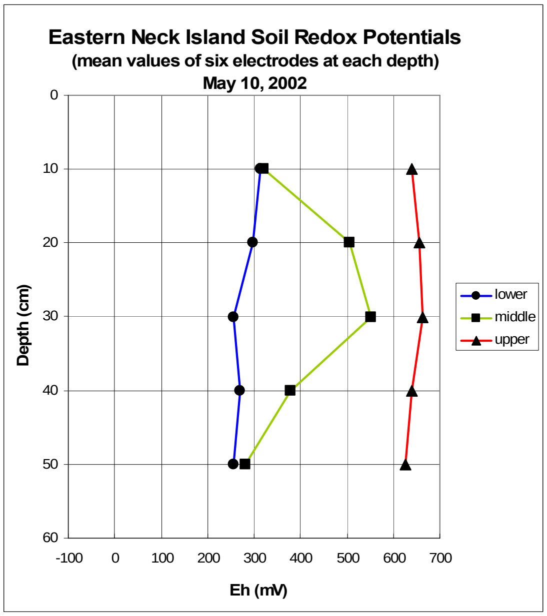
Eastern Neck		--------------		cm		--------------
29-Mar-02		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower site	1	538	589	546	585	561
	2	535	583	635	584	573
	3	566	558	635	590	572
	4	558	609	620	611	557
	5					
	6					
mean (mV)		**549**	**585**	**609**	**593**	**566**
Middle Site	1	590	624	646	620	611
	2	603	634	654	632	623
	3	618	631	648	627	625
	4	590	633	642	623	613
	5					
	6					
mean (mV)		**600**	**631**	**648**	**626**	**618**
Upper site	1	611	667	676	668	658
	2	650	667	664	661	642
	3	635	672	674	679	653
	4	631	664	672	673	650
	5					
	6					
mean (mV)		**632**	**668**	**672**	**670**	**651**

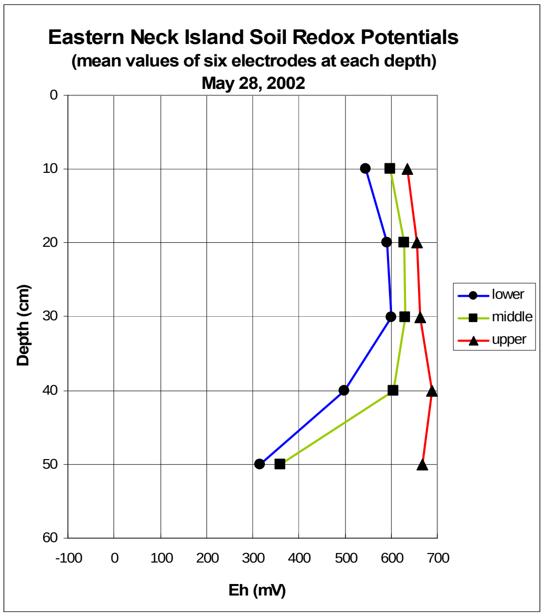




Eastern Neck		--------------		cm		--------------
10-May-02		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower site	1	307	290	261	309	314
	2	320	330	279	305	292
	3	319	280	214	292	235
	4	348	268	262	257	259
	5	303	341	272	213	164
	6	292	274	249	249	268
mean (mV)		**315**	**297**	**256**	**271**	**255**
Middle Site	1	354	468	519	428	311
	2	291	453	614	347	280
	3	346	597	597	375	318
	4	280	401	504	281	248
	5	328	564	493	497	264
	6	321	547	583	340	271
mean (mV)		**320**	**505**	**552**	**378**	**282**
Upper site	1	650	667	665	666	652
	2	666	670	676	663	660
	3	669	676	664	658	669
	4	603	601	641	631	616
	5	590	648	658	586	539
	6	659	667	668	640	621
mean (mV)		**640**	**655**	**662**	**641**	**626**

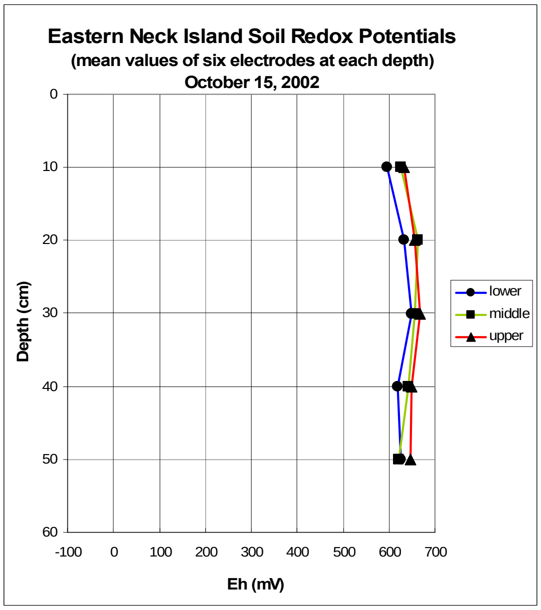
Eastern Neck		--------------		cm		--------------
28-May-02		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower site	1	576	608	628	601	342
	2	503	597	605	426	323
	3	560	564	582	411	353
	4	526	583	577	461	243
	5	578	609	616	506	308
	6	535	590	596	587	328
mean (mV)		**546**	**592**	**601**	**499**	**316**
Middle Site	1	605	642	644	612	381
	2	616	646	646	593	401
	3	593	624	623	627	336
	4	573	612	614	571	318
	5	585	621	625	612	356
	6	618	628	630	621	372
mean (mV)		**598**	**629**	**630**	**606**	**361**
Upper site	1	648	669	663	689	670
	2	622	653	665	701	679
	3	628	644	662	683	663
	4	642	665	667	682	665
	5	632	661	663	685	661
	6	644	646	664	691	666
mean (mV)		**636**	**656**	**664**	**689**	**667**

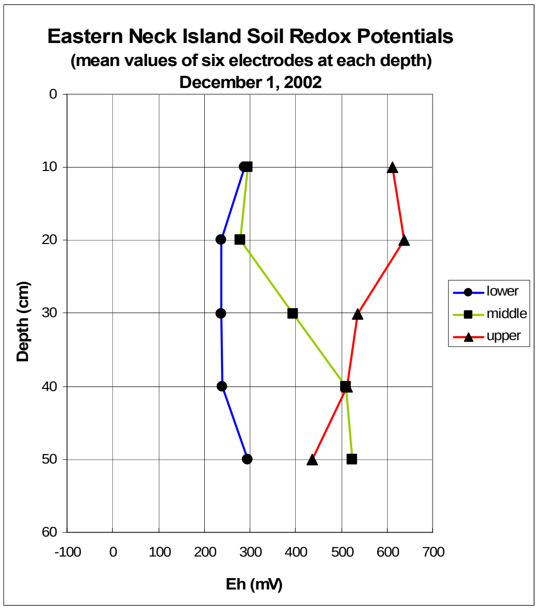




Eastern Neck		--------------		cm		--------------
15-Oct-02		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower site	1	579	619	648	624	628
	2	577	633	646	604	630
	3	606	625	658	617	629
	4	596	644	653	631	624
	5	621	642	651	621	632
	6	595	642	642	625	619
mean (mV)		**596**	**634**	**650**	**620**	**627**
Middle Site	1	623	668	641	652	617
	2	628	665	670	647	612
	3	646	672	675	624	610
	4					
	5	636	673	662	646	641
	6	604	640	634	641	631
mean (mV)		**627**	**664**	**656**	**642**	**622**
Upper site	1	622	635	654	638	645
	2	624	666	679	660	655
	3	610	654	663	633	653
	4					
	5	654	661	671	658	634
	6	652	667	670	652	649
mean (mV)		**632**	**657**	**667**	**648**	**647**

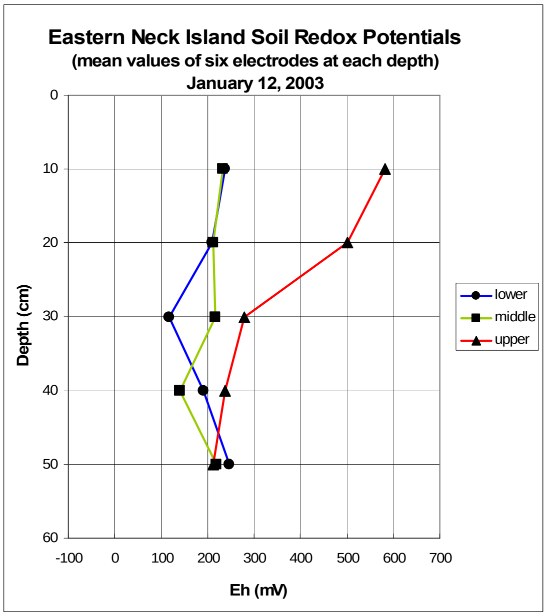
Eastern Neck		--------------		cm		--------------
1-Dec-02		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower site	1	320	288	224	281	283
	2	329	192	249	253	256
	3	259	234	254	215	224
	4	298	287	234	241	274
	5	245	154	206	182	415
	6	276	266	258	271	315
mean (mV)		**288**	**237**	**238**	**241**	**295**
Middle Site	1	288	289	335	538	576
	2	281	262	226	550	568
	3	248	233	231	373	353
	4	351	299	475	523	530
	5	253	241	519	466	499
	6	355	357	583	607	616
mean (mV)		**296**	**280**	**395**	**510**	**524**
Upper site	1	659	675	595	581	347
	2	548	652	604	597	587
	3	540	542	409	422	329
	4	661	673	611	623	557
	5	604	618	502	513	417
	6	668	669	495	337	379
mean (mV)		**613**	**638**	**536**	**512**	**436**

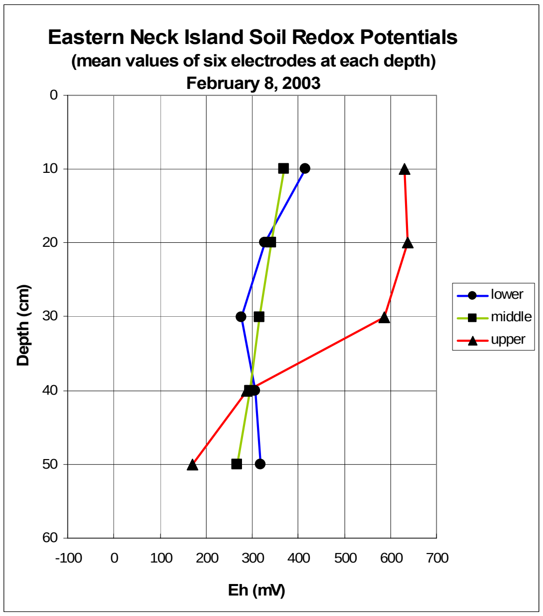




Eastern Neck		--------------		cm		--------------
12-Jan-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower site	1	214	241	-16	156	228
	2	198	239	175	209	232
	3	242	214	162	180	239
	4	251	255	168	182	245
	5	285	94	102	230	286
	6					
mean (mV)		**238**	**209**	**118**	**191**	**246**
Middle Site	1	219	195	193	170	218
	2	253	209	232	220	241
	3	231	183	214	55	149
	4	178	231	199	172	232
	5	277	245	243	90	262
	6					
mean (mV)		**232**	**213**	**216**	**141**	**220**
Upper site	1	589	562	252	201	195
	2	584	478	302	259	208
	3	585	449	277	243	205
	4	586	592	289	242	228
	5	563	430	282	246	231
	6					
mean (mV)		**581**	**502**	**280**	**238**	**213**

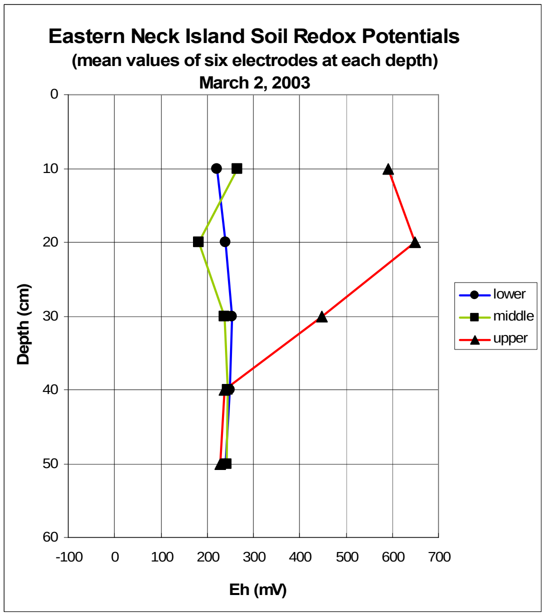
Eastern Neck		--------------		cm		--------------
8-Feb-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower site	1	508	402	372	350	331
	2	465	340	368	284	299
	3	422	326	174	285	300
	4	590	537	503	504	512
	5	186	266	247	245	255
	6	324	91	5	178	209
mean (mV)		**416**	**327**	**278**	**308**	**318**
Middle Site	1	370	287	254	249	226
	2	367	342	344	320	292
	3	429	389	344	326	296
	4	338	341	312	295	269
	5	346	344	333	290	257
	6					
mean (mV)		**370**	**341**	**317**	**296**	**268**
Upper site	1	654	655	617	361	277
	2	634	642	612	361	82
	3	619	626	471	335	199
	4	606	634	603	393	222
	5	642	634	630	-7	73
	6					
mean (mV)		**631**	**638**	**587**	**289**	**171**

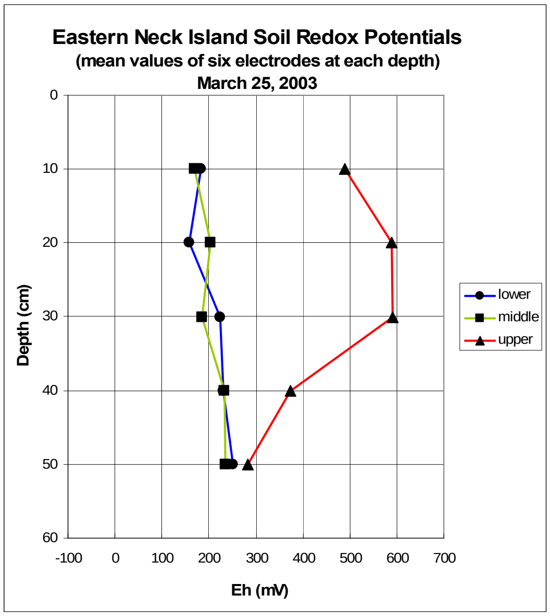




Eastern Neck		--------------		cm		--------------
2-Mar-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower site	1	223	245	255	263	257
	2	235	243	245	243	232
	3	220	247	263	246	244
	4	208	229	250	249	231
	5					
	6					
mean (mV)		**222**	**241**	**253**	**250**	**241**
Middle Site	1	291	231	245	244	245
	2	151	37	224	239	233
	3	332	261	259	247	245
	4	285	194	223	248	243
	5					
	6					
mean (mV)		**265**	**181**	**238**	**245**	**242**
Upper site	1	615	658	494	225	245
	2	547	637	332	229	219
	3	608	655	539	248	225
	4	593	642	431	247	222
	5					
	6					
mean (mV)		**591**	**648**	**449**	**237**	**228**

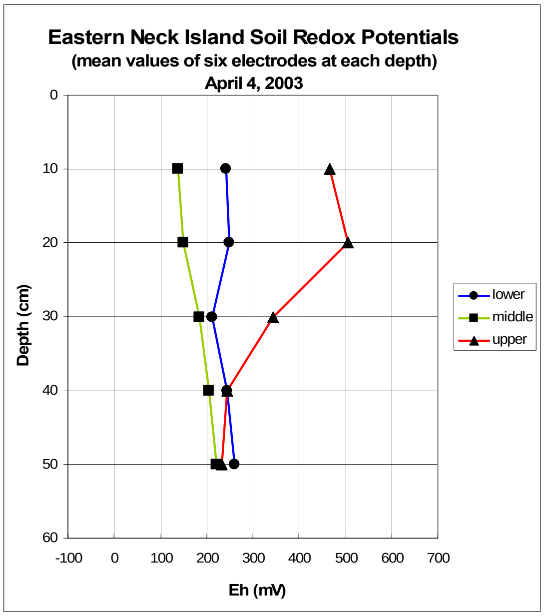
Eastern Neck		--------------		cm		--------------
25-Mar-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower site	1	254	232	265	233	251
	2					
	3	135	197	126	231	249
	4	184	108	204	224	224
	5	169	167	250	224	256
	6	173	89	281	239	281
mean (mV)		**183**	**159**	**225**	**230**	**252**
Middle Site	1	122	218	235	220	244
	2					
	3	272	194	193	269	269
	4	84	144	169	205	194
	5	181	241	157	235	237
	6	191	224	178	237	234
mean (mV)		**170**	**204**	**186**	**233**	**236**
Upper site	1	418	602	502	367	218
	2					
	3	374	604	606	351	278
	4	547	604	606	403	312
	5	564	515	618	395	319
	6	542	618	628	352	281
mean (mV)		**489**	**589**	**592**	**374**	**282**

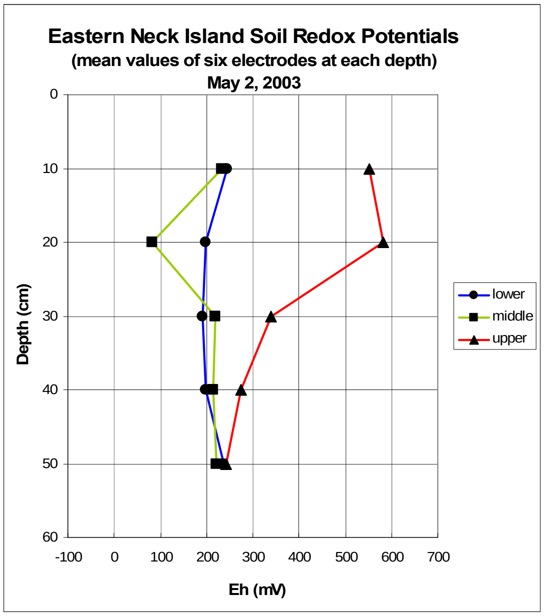




Eastern Neck		--------------	--------------	cm	--------------	--------------
4-Apr-03		10	20	30	40	50
	circuit	----------	----------	Eh (mV)	----------	----------
Lower site	1	263	218	238	229	244
	2					
	3	304	266	271	253	272
	4	78	226	173	229	243
	5	327	269	257	279	288
	6	239	270	123	235	259
mean (mV)		**242**	**250**	**212**	**245**	**261**
Middle Site	1	126	93	207	225	230
	2					
	3	233	230	253	256	220
	4	84	148	177	211	227
	5	126	191	163	109	207
	6	125	86	122	227	225
mean (mV)		**139**	**150**	**184**	**206**	**222**
Upper site	1	546	494	424	250	225
	2					
	3	412	388	359	274	243
	4	404	550	317	205	239
	5	402	551	281	232	226
	6	572	540	336	257	234
mean (mV)		**467**	**505**	**343**	**244**	**233**

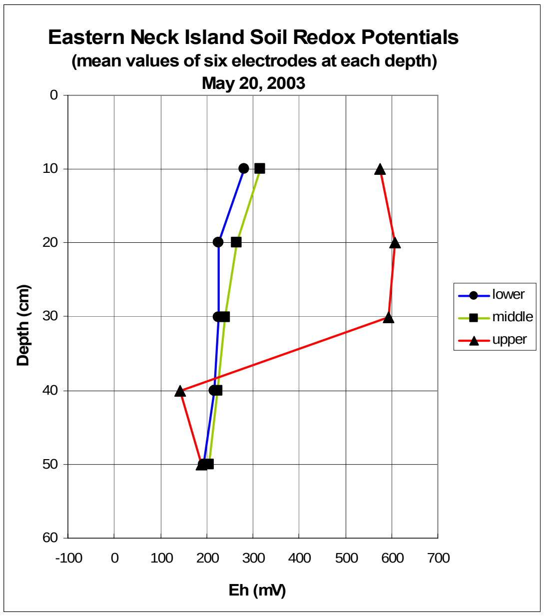
Eastern Neck		--------------	--------------	cm	--------------	--------------
2-May-03		10	20	30	40	50
	circuit	----------	----------	Eh (mV)	----------	----------
Lower site	1	232	244	201	166	218
	2	239	74	211	225	215
	3	264	235	279	264	253
	4	213	225	89	156	239
	5	271	219	173	178	259
	6					
mean (mV)		**244**	**199**	**191**	**198**	**237**
Middle Site	1	298	103	189	161	199
	2	141	60	229	237	231
	3	311	2	218	231	226
	4	128	38	240	251	232
	5	282	205	224	193	217
	6					
mean (mV)		**232**	**82**	**220**	**215**	**221**
Upper site	1	580	610	387	264	269
	2	581	586	393	304	310
	3	416	474	301	262	178
	4	588	617	291	271	167
	5	591	629	324	267	293
	6					
mean (mV)		**551**	**583**	**339**	**274**	**243**

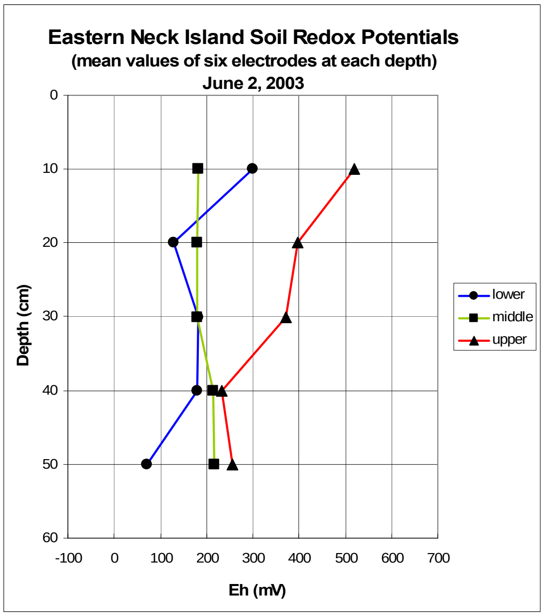




Eastern Neck		--------------		cm		--------------
20-May-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower site	1	338	175	254	248	228
	2	244	251	198	224	223
	3	335	270	241	239	103
	4	280	263	247	236	247
	5	212	176	184	136	171
	6					
mean (mV)		**282**	**227**	**225**	**217**	**194**
Middle Site	1	341	257	281	249	229
	2	415	352	215	233	217
	3	324	277	270	241	223
	4	277	222	265	239	214
	5	228	217	175	154	142
	6					
mean (mV)		**317**	**265**	**241**	**223**	**205**
Upper site	1	573	625	562	293	237
	2	605	617	546	114	125
	3	583	597	633	48	199
	4	555	597	630	120	244
	5	561	602	595	135	142
	6					
mean (mV)		**575**	**608**	**593**	**142**	**189**

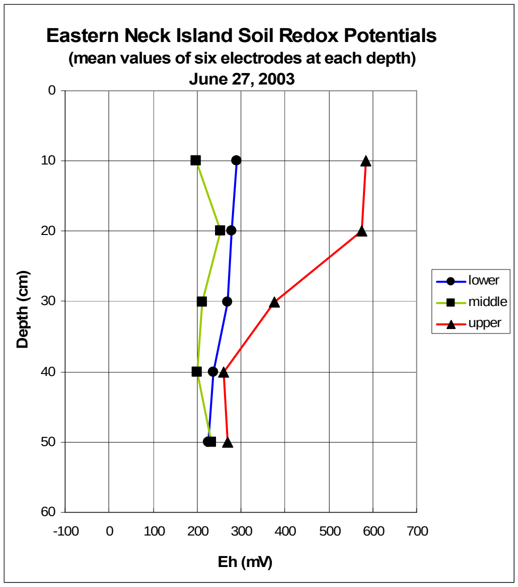
Eastern Neck		--------------		cm		--------------
2-Jun-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower site	1		134		142	-10
	2	297	150	150	152	-60
	3	254	172	225	166	-34
	4	294	53	86	164	98
	5	313	133	203	223	174
	6	337	138	243	229	256
mean (mV)		**299**	**130**	**181**	**179**	**71**
Middle Site	1	150	3	123	171	174
	2	127	214	134	193	207
	3	190	107	85	163	174
	4	198	233	235	243	228
	5	150	244	221	237	235
	6	278	281	283	284	275
mean (mV)		**182**	**180**	**180**	**215**	**216**
Upper site	1	515	448	375	345	304
	2	465	346	241	26	146
	3	456	348	269	153	211
	4	558	447	525	323	267
	5	580	414	451	268	279
	6	538	373	366	291	325
mean (mV)		**519**	**396**	**371**	**234**	**255**

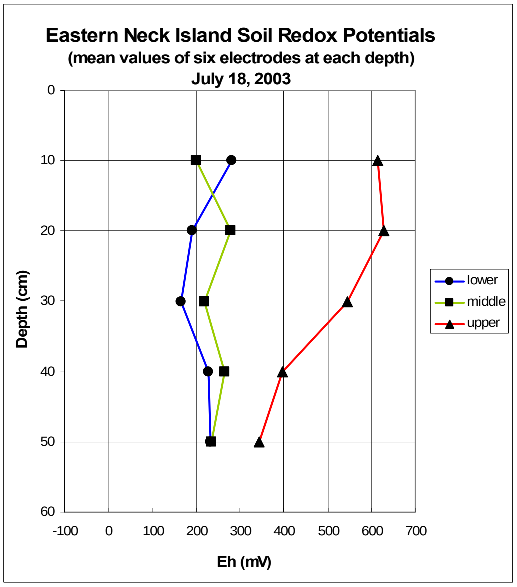




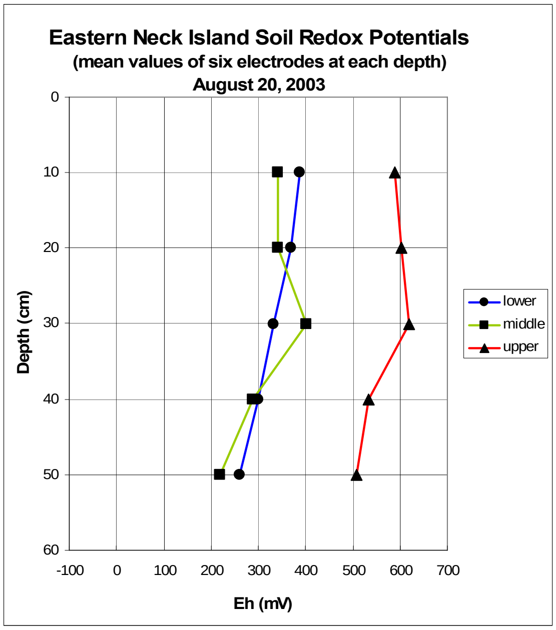
Eastern Neck		--------------		cm		--------------
27-Jun-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower site	1					
	2	302	232	241	221	176
	3	263	244	269	222	223
	4					
	5	280	295	277	218	223
	6	313	346	295	289	277
mean (mV)		**290**	**279**	**271**	**238**	**225**
Middle Site	1					
	2	60	208	166	158	168
	3	160	222	244	205	241
	4					
	5	273	281	223	193	213
	6	304	299	213	243	306
mean (mV)		**199**	**253**	**212**	**200**	**232**
Upper site	1					
	2	634	654	391	246	342
	3	629	584	419	270	256
	4					
	5	552	463	273	213	199
	6	523	593	425	309	279
mean (mV)		**585**	**574**	**377**	**260**	**269**

Eastern Neck		--------------		cm		--------------
18-Jul-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower site	1					
	2	251	30	172	172	199
	3	273	238	46	181	198
	4	272	79	44	224	225
	5	289	270	224	231	235
	6	321	340	342	330	314
mean (mV)		**281**	**191**	**166**	**228**	**234**
Middle Site	1					
	2	126	221	200	220	162
	3	189	203	237	244	162
	4	233	300	286	267	283
	5	198	318	188	251	244
	6	255	354	186	348	326
mean (mV)		**200**	**279**	**219**	**266**	**235**
Upper site	1					
	2	626	637	433	395	272
	3	637	646	665	459	368
	4	610	640	469	360	309
	5	630	647	652	396	374
	6	571	572	501	376	395
mean (mV)		**615**	**628**	**544**	**397**	**344**



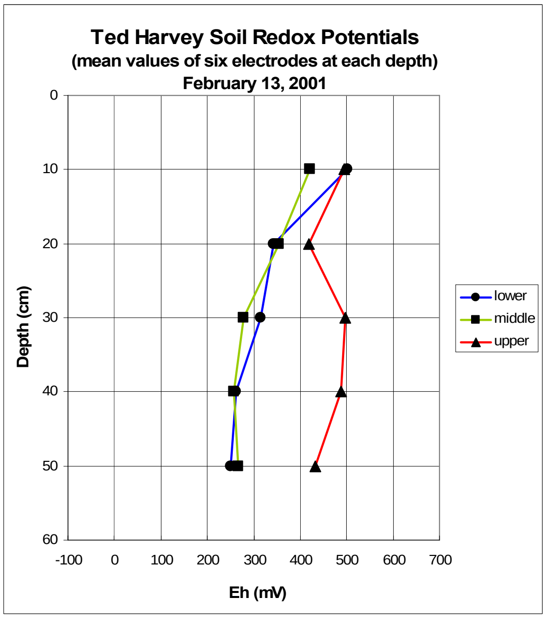


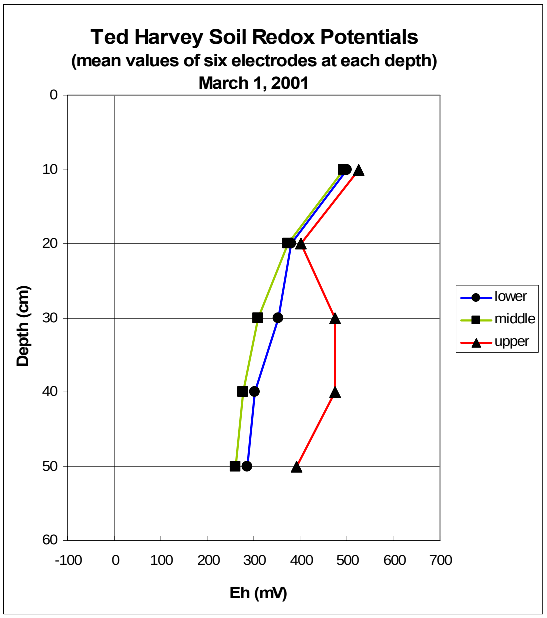
Eastern Neck		--------------	cm	--------------		
20-Aug-03		10	20	30	40	50
	circuit	----------	Eh (mV)	----------		
Lower site	1					
	2	385	340	320	302	231
	3	379	328	306	286	247
	4	373	383	351	271	252
	5	403	371	321	294	263
	6	395	422	361	340	309
mean (mV)		**387**	**369**	**332**	**299**	**260**
Middle Site	1					
	2	300	269	403	269	248
	3	361	403	392	277	210
	4	379	280	340	261	136
	5	373	374	419	313	246
	6	291	384	449	326	255
mean (mV)		**341**	**342**	**401**	**289**	**219**
Upper site	1					
	2	607	631	657	464	477
	3	571	595	628	591	540
	4	603	592	610	553	490
	5	587	604	600	528	495
	6	582	596	593	535	532
mean (mV)		**590**	**604**	**618**	**534**	**507**



Ted Harvey				cm		
13-Feb-01		10	20	30	40	50
	circuit			Eh (mV)		
Lower site	1	560	422	306	290	279
	2	525	333	427	271	237
	3	550	336	355	237	251
	4	490	327	239	285	280
	5	385	296	250	232	207
	6					
mean (mV)		**502**	**343**	**315**	**263**	**251**
Middle Site	1	394	529	351	303	276
	2	361	282	278	258	261
	3	453	272	264	287	280
	4	451	339	276	283	316
	5	445	350	220	161	196
	6					
mean (mV)		**421**	**354**	**278**	**258**	**266**
Upper site	1	531	420	517	555	521
	2	492	458	488	492	365
	3	432	318	510	513	445
	4	500	454	510	527	495
	5	513	438	459	359	335
	6					
mean (mV)		**494**	**418**	**497**	**489**	**432**

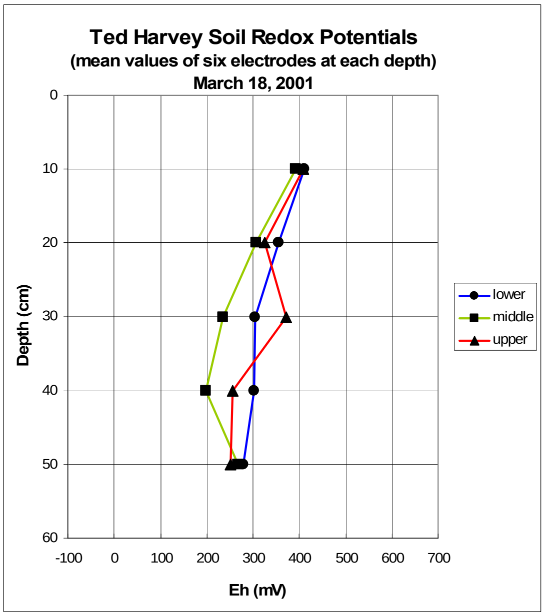
Ted Harvey				cm		
1-Mar-01		10	20	30	40	50
	circuit			Eh (mV)		
Lower site	1	549	385	394	311	325
	2	576	396	513	361	344
	3	539	521	370	278	191
	4	540	352	338	304	303
	5	309	284	187	241	260
	6	488	345	318	319	290
mean (mV)		**500**	**381**	**353**	**302**	**286**
Middle Site	1	581	478	395	323	297
	2	596	411	300	302	191
	3	474	347	262	213	186
	4	488	352	310	314	304
	5	397	323	287	229	321
	6	413	330	298	277	273
mean (mV)		**492**	**374**	**309**	**276**	**262**
Upper site	1	552	445	434	376	353
	2	520	367	492	473	334
	3	503	281	519	465	475
	4	580	483	520	544	456
	5	497	432	486	503	407
	6	504	406	399	488	324
mean (mV)		**526**	**402**	**475**	**475**	**392**

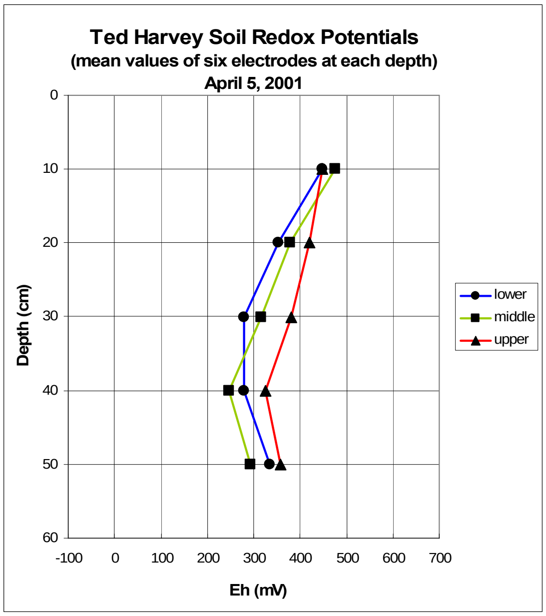




Ted Harvey				cm		
18-Mar-01		10	20	30	40	50
	circuit			Eh (mV)		
Lower site	1	402	349	283	434	306
	2	529	427	337	334	276
	3	365	258	258	234	224
	4	509	415	352	325	311
	5	269	302	276	289	286
	6	397	380	315	197	276
mean (mV)		**412**	**355**	**304**	**302**	**280**
Middle Site	1	485	335	286	207	262
	2	411	335	279	218	249
	3	301	168	184	149	333
	4	403	342	258	264	415
	5	355	281	85	79	61
	6	396	388	316	273	284
mean (mV)		**392**	**308**	**235**	**198**	**267**
Upper site	1	302	316	326	335	282
	2	486	382	530	434	329
	3	431	269	406	180	177
	4	382	276	335	270	316
	5	451	352	264	41	128
	6	400	356	368	283	276
mean (mV)		**409**	**325**	**372**	**257**	**251**

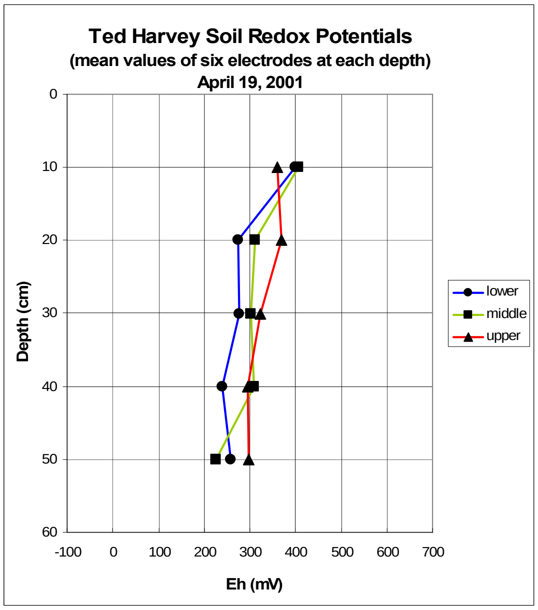
Ted Harvey				cm		
5-Apr-01		10	20	30	40	50
	circuit			Eh (mV)		
Lower site	1	460	351	316	340	374
	2	442	322	304	301	313
	3	507	437	339	264	357
	4	408	328	230	184	309
	5	425	325	208	305	323
	6					
mean (mV)		**448**	**353**	**279**	**279**	**335**
Middle Site	1	589	377	350	334	314
	2	487	359	353	100	410
	3	472	369	350	291	329
	4	350	408	208	152	76
	5	481	377	324	358	341
	6					
mean (mV)		**476**	**378**	**317**	**247**	**294**
Upper site	1	539	594	481	354	393
	2	392	345	397	372	379
	3	462	367	330	371	423
	4	385	388	328	238	212
	5	456	409	370	292	378
	6					
mean (mV)		**447**	**421**	**381**	**325**	**357**

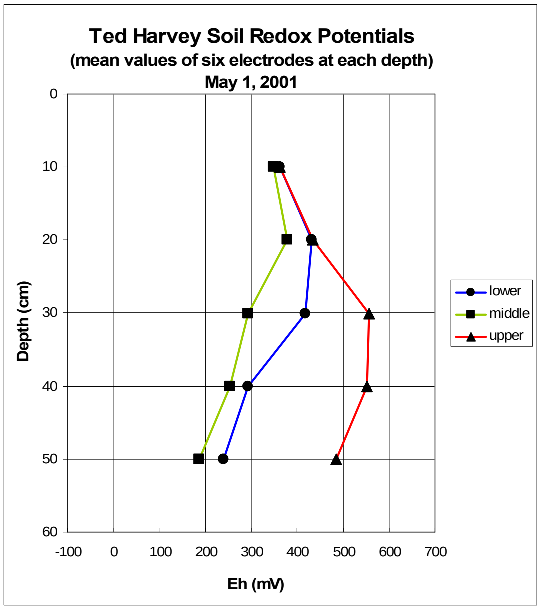

Ted Harvey Soil Redox Potentials
(mean values of six electrodes at each depth)
March 18, 2001


Ted Harvey Soil Redox Potentials
(mean values of six electrodes at each depth)
April 5, 2001

Ted Harvey		--------------		cm		--------------
19-Apr-01		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower site	1	442	287	366	296	378
	2	367	285	324	166	270
	3	419	276	263	184	117
	4	467	278	271	270	262
	5	379	268	262	302	266
	6	320	255	174	217	258
mean (mV)		**399**	**275**	**277**	**239**	**259**
Middle Site	1	540	349	353	268	282
	2	434	283	315	245	137
	3	388	317	317	324	266
	4	364	335	281	269	264
	5	424	324	299	363	425
	6	291	266	254	384	-27
mean (mV)		**407**	**312**	**303**	**309**	**225**
Upper site	1	249	393	333	358	298
	2	445	477	373	318	390
	3	428	403	334	301	221
	4	408	308	341	294	197
	5	375	410	305	279	437
	6	261	220	250	224	239
mean (mV)		**361**	**369**	**323**	**296**	**297**

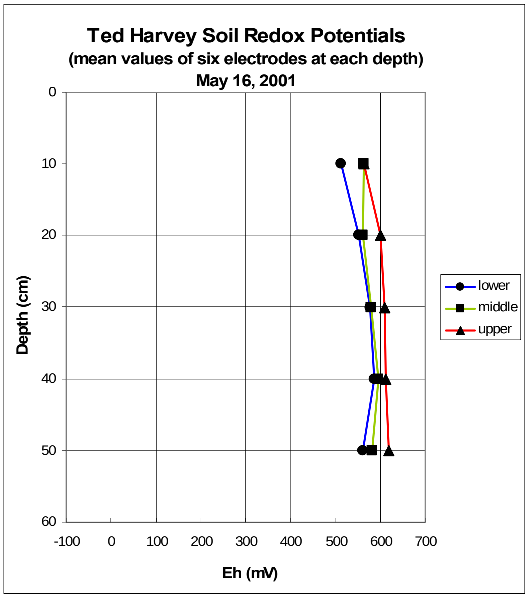
Ted Harvey		--------------		cm		--------------
1-May-01		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower site	1	346	563	526	316	265
	2	496	494	401	222	158
	3	244	420	430	231	266
	4	533	360	432	441	234
	5	274	326	388	280	288
	6	280	425	328	271	236
mean (mV)		**362**	**431**	**418**	**294**	**241**
Middle Site	1	371	374	324	276	304
	2	344	470	285	161	161
	3	263	340	239	318	215
	4	199	243	237	206	199
	5	387	424	299	295	192
	6	528	418	365	263	51
mean (mV)		**349**	**378**	**292**	**253**	**187**
Upper site	1	380	289	544	545	530
	2	533	556	566	542	468
	3	312	570	581	560	492
	4	343	442	552	561	400
	5	315	391	532	546	520
	6	291	358	559	557	498
mean (mV)		**362**	**434**	**556**	**552**	**485**

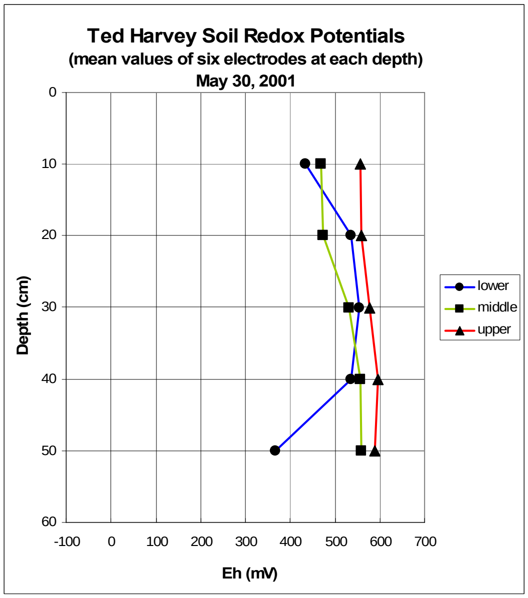




Ted Harvey		--------------	--------------	cm	--------------	--------------
16-May-01		10	20	30	40	50
	circuit	----------	----------	Eh (mV)	----------	----------
Lower site	1	531	582	594	603	567
	2	499	562	572	595	595
	3	503	583	585	589	570
	4	522	552	573	585	504
	5	499	496	567	582	570
	6	517	539	578	560	565
mean (mV)		**512**	**552**	**578**	**586**	**562**
Middle Site	1	582	588	581	592	607
	2	579	566	592	575	529
	3	581	560	561	600	595
	4	530	532	559	570	519
	5	551	550	587	594	611
	6	558	577	596	640	634
mean (mV)		**564**	**562**	**579**	**595**	**583**
Upper site	1	585	579	630	611	628
	2	544	628	593	624	636
	3	535	567	584	599	603
	4	540	573	594	570	578
	5	586	627	631	635	637
	6	587	623	621	631	632
mean (mV)		**563**	**600**	**609**	**612**	**619**

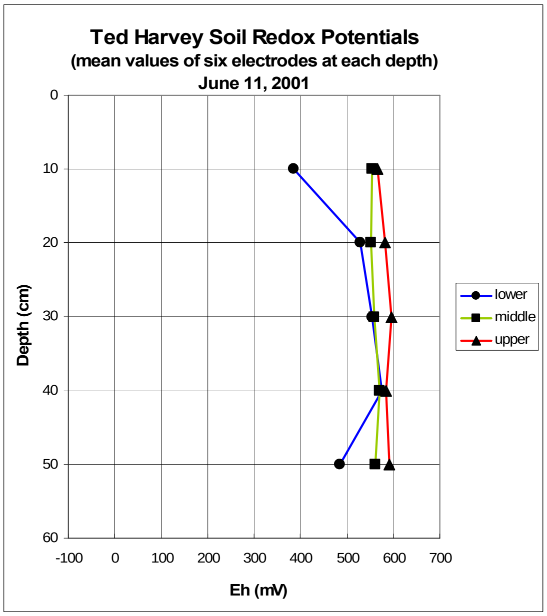
Ted Harvey		--------------	--------------	cm	--------------	--------------
30-May-01		10	20	30	40	50
	circuit	----------	----------	Eh (mV)	----------	----------
Lower site	1	501	569	567	593	370
	2	513	568	584	558	531
	3	409	543	604	573	513
	4	370	529	573	488	201
	5	397	521	538	531	162
	6	422	480	461	466	421
mean (mV)		**435**	**535**	**555**	**535**	**366**
Middle Site	1	562	402	560	581	587
	2	425	451	511	533	509
	3	517	515	565	537	510
	4	386	544	550	512	570
	5	475	424	515	580	578
	6	447	510	488	601	603
mean (mV)		**469**	**474**	**532**	**557**	**560**
Upper site	1	570	542	579	598	573
	2	550	548	555	596	595
	3	575	544	580	557	592
	4	542	555	593	592	541
	5	557	580	614	625	633
	6	543	586	547	602	596
mean (mV)		**556**	**559**	**578**	**595**	**588**

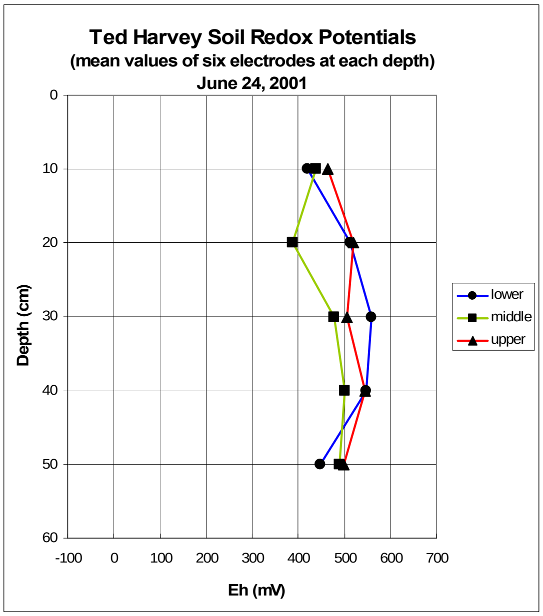




Ted Harvey				cm		
11-Jun-01		10	20	30	40	50
	circuit			Eh (mV)		
Lower site	1	365	565	574	581	576
	2	381	536	547	562	552
	3	458	547	587	591	532
	4	311	518	506	571	350
	5	486	527	551	568	523
	6	311	486	567	570	375
mean (mV)		**385**	**530**	**555**	**574**	**485**
Middle Site	1	566	552	574	569	593
	2	544	564	572	569	577
	3	559	563	551	565	593
	4	535	529	539	543	459
	5	560	570	574	586	574
	6	561	540	544	586	572
mean (mV)		**554**	**553**	**559**	**570**	**561**
Upper site	1	575	593	611	596	604
	2	557	573	610	598	612
	3	577	571	601	579	581
	4	545	582	587	571	568
	5	576	588	581	581	594
	6	573	581	590	584	584
mean (mV)		**567**	**581**	**597**	**585**	**591**

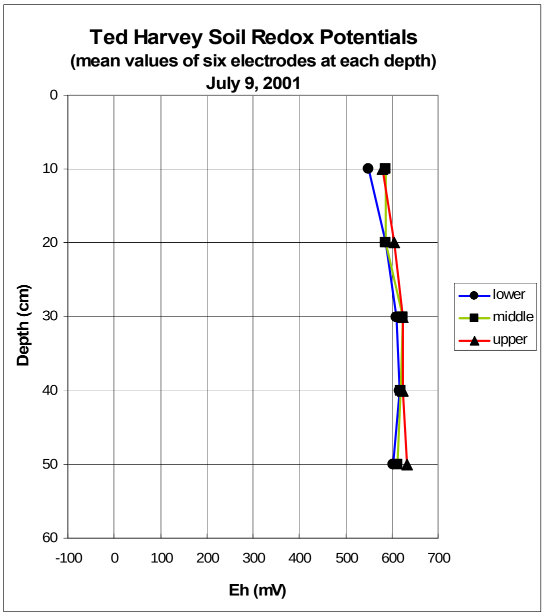
Ted Harvey				cm		
24-Jun-01		10	20	30	40	50
	circuit			Eh (mV)		
Lower site	1	375	518	544	531	562
	2	377	499	566	574	502
	3	449	525	568	492	507
	4	319	504	554	567	308
	5	586	539	568	552	453
	6	415	486	561	569	359
mean (mV)		**420**	**512**	**560**	**548**	**449**
Middle Site	1	420	277	463	503	409
	2	390	292	401	417	476
	3	420	324	494	527	510
	4	376	436	468	459	488
	5	495	477	506	537	471
	6	535	520	533	569	580
mean (mV)		**439**	**388**	**478**	**502**	**489**
Upper site	1	505	557	563	582	579
	2	411	404	533	518	491
	3	431	502	510	480	566
	4	450	548	274	580	303
	5	551	566	562	519	472
	6	441	543	589	592	583
mean (mV)		**465**	**520**	**505**	**545**	**499**

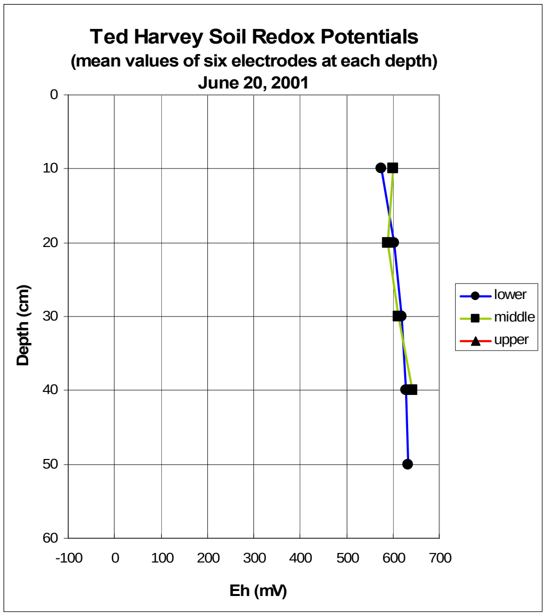




Ted Harvey		-------------- cm --------------				
9-Jul-01		10	20	30	40	50
	circuit	---------- Eh (mV) ----------				
Lower site	1	570	583	583	612	602
	2	568	590	619	623	634
	3	527	576	611	617	617
	4	497	573	593	612	609
	5	575	592	615	617	595
	6	565	610	632	622	562
mean (mV)		**550**	**587**	**609**	**617**	**603**
Middle Site	1	585	577	604	568	618
	2	594	594	631	636	634
	3	567	605	629	623	623
	4	596	602	611	606	595
	5	598	575	636	637	579
	6	582	570	632	643	626
mean (mV)		**587**	**587**	**624**	**619**	**613**
Upper site	1	591	599	633	632	638
	2	568	612	635	627	649
	3	599	616	632	641	645
	4	578	615	623	633	635
	5	562	592	613	587	596
	6	575	596	602	616	632
mean (mV)		**579**	**605**	**623**	**623**	**633**

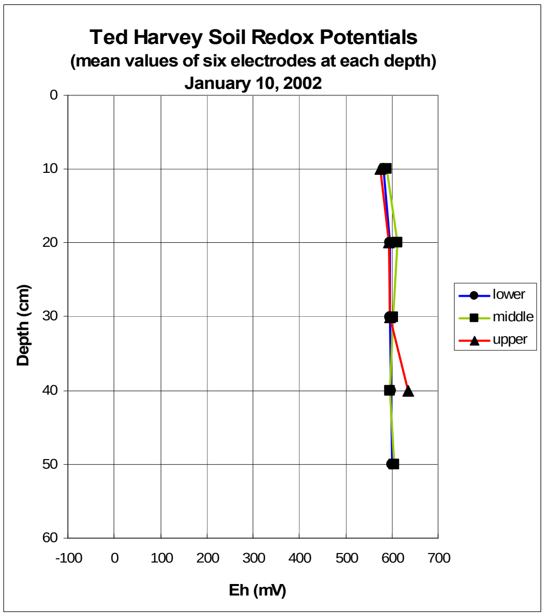
Ted Harvey		-------------- cm --------------				
20-Jul-01		10	20	30	40	50
	circuit	---------- Eh (mV) ----------				
Lower site	1	576	609	628	642	639
	2	557	600	629	643	618
	3	578	598	623	626	643
	4	581	596	597	604	621
	5	563	599	627	603	616
	6	590	618	617	655	655
mean (mV)		**574**	**603**	**620**	**629**	**632**
Middle Site	1	596	601	501		
	2	615	504	637		
	3	580	603	634	645	
	4	591	604	627		
	5	611	622	636		
	6	611	595	639	640	
mean (mV)		**601**	**588**	**612**	**643**	
Upper site	1					
	2					
	3					
	4					
	5					
	6					
mean (mV)						

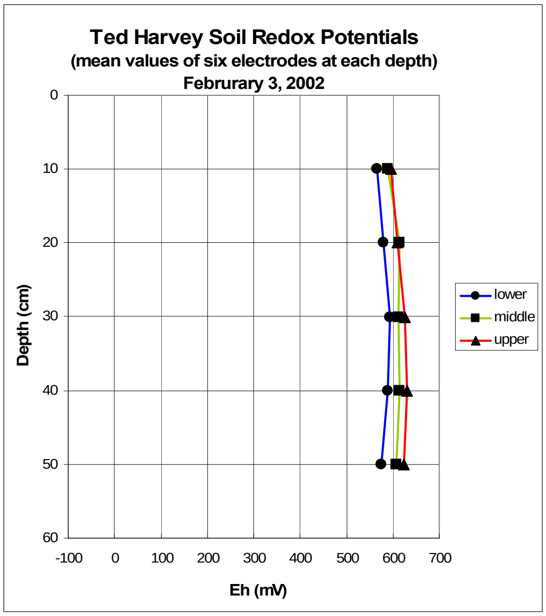




Ted Harvey		--------------		cm		--------------
10-Jan-02		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower site	1	578	590	603	604	587
	2	587	598	607	609	591
	3	574	584	594	599	601
	4	580	623	599	591	612
	5	583	590	589	598	612
	6	581	592	577	594	600
mean (mV)		**581**	**596**	**595**	**599**	**601**
Middle Site	1	585	598	614	609	618
	2	596	626	613	612	610
	3	601	622	611	571	594
	4	586	601	585	590	596
	5	601	611	598	590	591
	6	571	609	605	607	619
mean (mV)		**590**	**611**	**604**	**597**	**605**
Upper site	1	585	634	625		
	2	586	612	597	631	
	3	476	470	464		
	4	608	613	626	638	
	5	599	622	635		
	6	598	613	636	638	
mean (mV)		**575**	**594**	**597**	**636**	

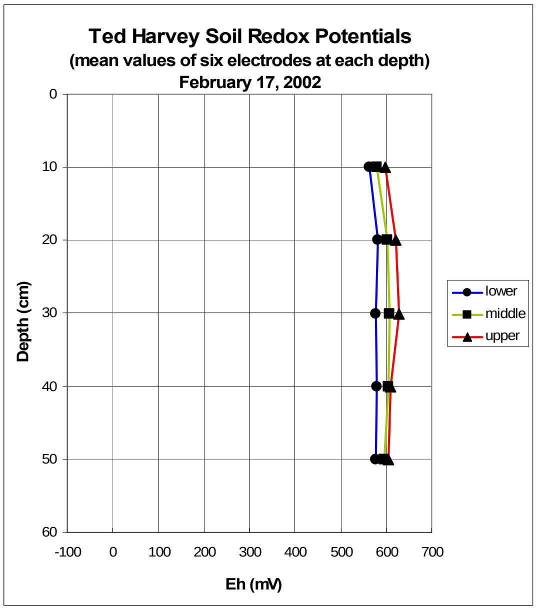
Ted Harvey		--------------		cm		--------------
3-Feb-02		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower site	1	567	582	592	578	512
	2	573	571	600	586	590
	3	568	579	587	594	589
	4	562	592	614	581	599
	5	559	575	586	606	585
	6	558	574	581	595	579
mean (mV)		**565**	**579**	**593**	**590**	**576**
Middle Site	1	569	593	608	600	605
	2	590	608	619	627	616
	3	590	615	614	617	607
	4	596	640	615	619	609
	5	591	612	616	613	603
	6	598	613	605	615	609
mean (mV)		**589**	**614**	**613**	**615**	**608**
Upper site	1	585	600	618	617	640
	2	595	621	639	646	621
	3	603	602	638	627	625
	4	597	606	625	629	615
	5	605	614	623	633	627
	6	596	608	620	634	612
mean (mV)		**597**	**609**	**627**	**631**	**623**

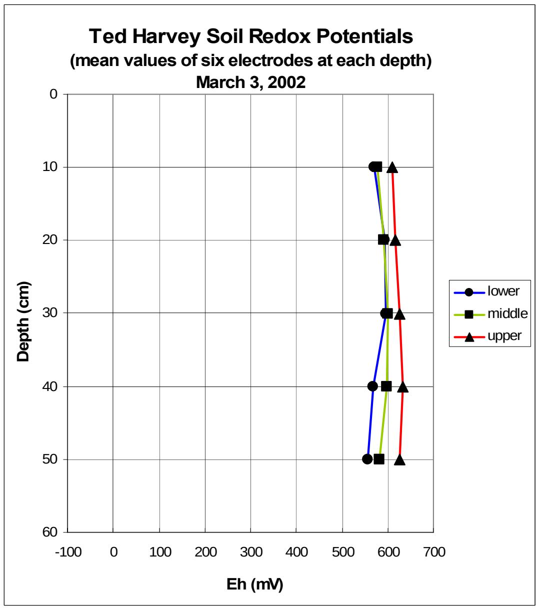




Ted Harvey				cm		
17-Feb-02		10	20	30	40	50
	circuit			Eh (mV)		
Lower site	1	574	594	598	591	590
	2	565	579	582	580	576
	3	562	586	593	587	565
	4	559	581	588	565	580
	5	562	585	508	575	577
	6	558	573	593	583	578
mean (mV)		**563**	**583**	**577**	**580**	**578**
Middle Site	1	591	596	611	614	591
	2	579	598	578	593	584
	3	570	593	603	575	586
	4	577	612	622	614	609
	5	579	601	605	617	598
	6	579	615	626	622	612
mean (mV)		**579**	**603**	**608**	**606**	**597**
Upper site	1	614	635	637	615	602
	2	599	608	605	614	604
	3	596	620	635	613	605
	4	594	625	633	623	616
	5	589	620	627	606	609
	6	597	616	629	589	596
mean (mV)		**598**	**621**	**628**	**610**	**605**

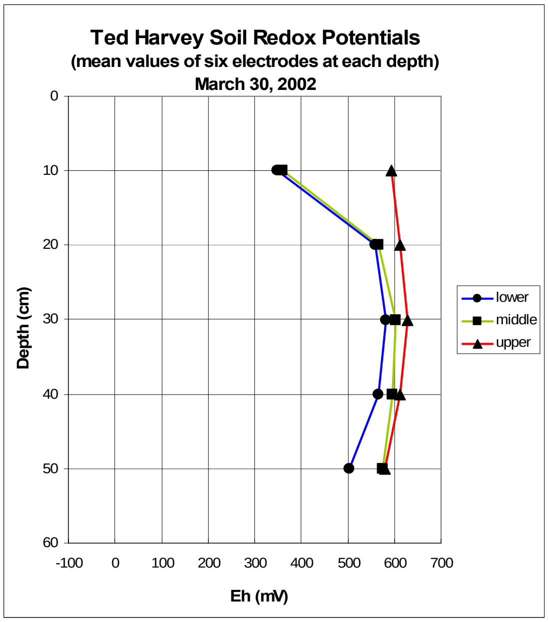
Ted Harvey				cm		
3-Mar-02		10	20	30	40	50
	circuit			Eh (mV)		
Lower site	1	577	587	586	550	563
	2	578	604	605	568	554
	3	571	593	592	583	561
	4	554	584	594	575	550
	5	565	592	602	573	548
	6	576	597	593	564	563
mean (mV)		**570**	**593**	**595**	**569**	**557**
Middle Site	1	576	586	589	583	575
	2	587	599	604	604	591
	3	580	599	609	603	588
	4	568	586	596	606	571
	5	573	585	606	604	586
	6	577	593	603	593	582
mean (mV)		**577**	**591**	**601**	**599**	**582**
Upper site	1	604	628	636	644	635
	2	619	611	633	636	633
	3	606	618	623	629	614
	4	601	606	619	623	619
	5	611	612	625	626	627
	6	615	625	627	633	623
mean (mV)		**609**	**617**	**627**	**632**	**625**

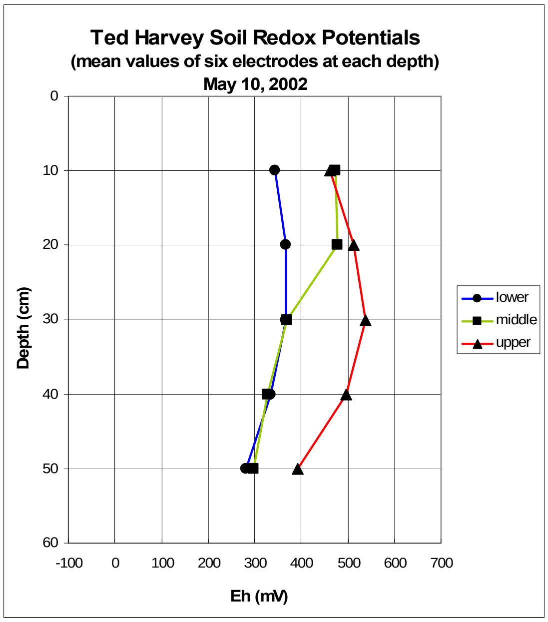




Ted Harvey			--------------	cm	--------------	
30-Mar-02		10	20	30	40	50
	circuit		----------	Eh (mV)	----------	
Lower site	1	342	571	581	590	528
	2	351	551	585	560	489
	3	360	565	584	556	525
	4	341	549	577	567	465
	5	346	555	583	564	515
	6					
mean (mV)		**348**	**558**	**582**	**567**	**504**
Middle Site	1	342	577	609	594	575
	2	373	560	603	602	575
	3	365	563	607	598	579
	4	359	562	595	604	573
	5	355	566	599	589	577
	6					
mean (mV)		**359**	**566**	**603**	**597**	**576**
Upper site	1	600	605	628	628	611
	2	585	621	641	633	605
	3	598	601	624	583	547
	4	595	609	626	615	573
	5	588	618	623	603	565
	6					
mean (mV)		**593**	**611**	**628**	**612**	**580**

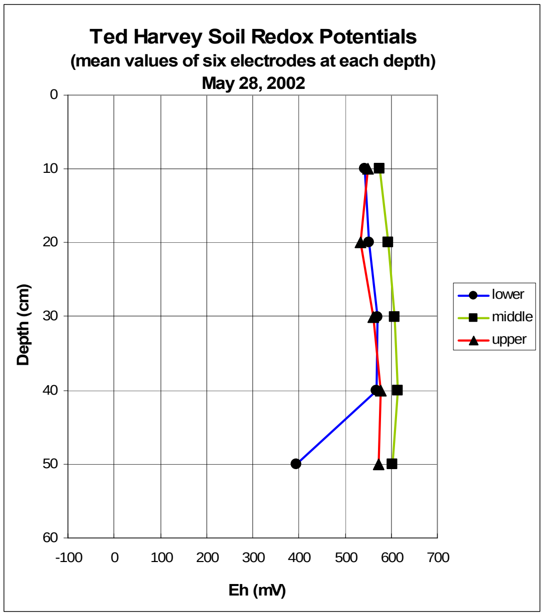
Ted Harvey			--------------	cm	--------------	
10-May-02		10	20	30	40	50
	circuit		----------	Eh (mV)	----------	
Lower site	1	336	464	312	289	289
	2	395	324	533	358	314
	3	389	334	333	320	311
	4	329	331	283	249	253
	5	313	452	513	509	292
	6	296	304	227	280	235
mean (mV)		**343**	**368**	**367**	**334**	**282**
Middle Site	1	499	585	403	303	310
	2	569	456	529	342	190
	3	547	499	487	430	410
	4	321	430	254	253	215
	5	409	453	273	355	336
	6	500	444	274	283	325
mean (mV)		**474**	**478**	**370**	**328**	**298**
Upper site	1	354	450	491	542	345
	2	393	510	572	491	449
	3	564	573	583	520	328
	4	491	499	496	485	394
	5					
	6	511	532	541	443	446
mean (mV)		**463**	**513**	**537**	**496**	**392**

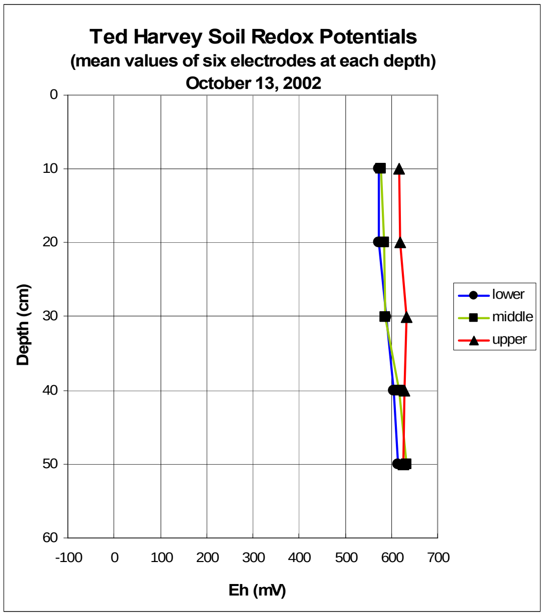

Ted Harvey Soil Redox Potentials
(mean values of six electrodes at each depth)
March 30, 2002


Ted Harvey Soil Redox Potentials
(mean values of six electrodes at each depth)
May 10, 2002

Ted Harvey		--------------		cm		--------------
28-May-02		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower site	1	521	559	584	564	447
	2	533	542	561	560	367
	3	523	552	581	567	355
	4	550	520	559	568	372
	5	555	565	552	571	462
	6	573	568	584	585	366
mean (mV)		**543**	**551**	**570**	**569**	**395**
Middle Site	1	584	595	608	621	599
	2	555	586	604	605	600
	3	571	592	610	599	593
	4	587	585	603	628	621
	5	575	595	607	616	605
	6	584	604	615	614	603
mean (mV)		**576**	**593**	**608**	**614**	**604**
Upper site	1	572	518	569	571	573
	2	521	525	559	571	550
	3	551	546	544	584	591
	4	563	512	576	585	575
	5	539	554	572	576	580
	6	545	543	554	581	561
mean (mV)		**549**	**533**	**562**	**578**	**572**

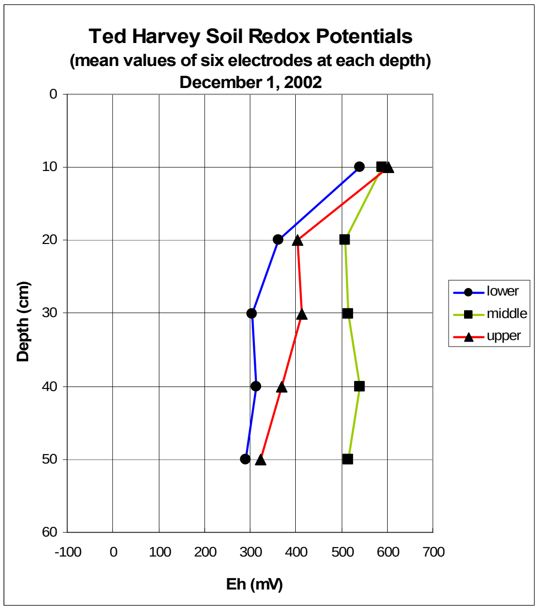
Ted Harvey		--------------		cm		--------------
13-Oct-02		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower site	1	554	580	570	603	622
	2	500	562	588	610	621
	3	588	573	586	608	610
	4	619	588	609	607	611
	5	573	574	580	593	605
	6	595	563	601	606	612
mean (mV)		**572**	**573**	**589**	**605**	**614**
Middle Site	1	580	593	589	624	634
	2	575	595	576	627	632
	3	597	596	613	621	636
	4	522	561	558	591	625
	5	592	576	604	625	630
	6	603	584	573	610	635
mean (mV)		**578**	**584**	**586**	**616**	**632**
Upper site	1	624	624	632	611	620
	2	604	613	627	635	622
	3	605	620	630	623	629
	4	617	630	642	642	625
	5	625	615	633	635	618
	6	621	619	632	630	635
mean (mV)		**616**	**620**	**633**	**629**	**625**

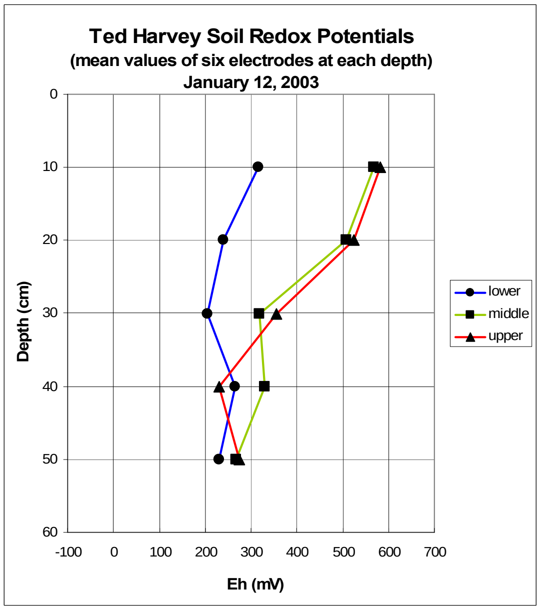




Ted Harvey		--------------		cm		--------------
1-Dec-02		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower site	1	569	365	300	306	286
	2	520	343	260	305	275
	3	537	347	330	323	285
	4	565	362	327	324	305
	5	491	395	280	319	276
	6	566	364	335	310	310
mean (mV)		**541**	**363**	**305**	**315**	**290**
Middle Site	1	614	599	551	582	548
	2	571	559	532	571	536
	3	614	424	450	461	446
	4	582	424	526	552	549
	5	584	471	520	526	491
	6	574	565	515	551	512
mean (mV)		**590**	**507**	**516**	**541**	**514**
Upper site	1	622	414	532	528	328
	2	616	418	519	399	389
	3	518	293	375	282	273
	4	624	523	335	342	315
	5					
	6	641	376	306	297	315
mean (mV)		**604**	**405**	**413**	**370**	**324**

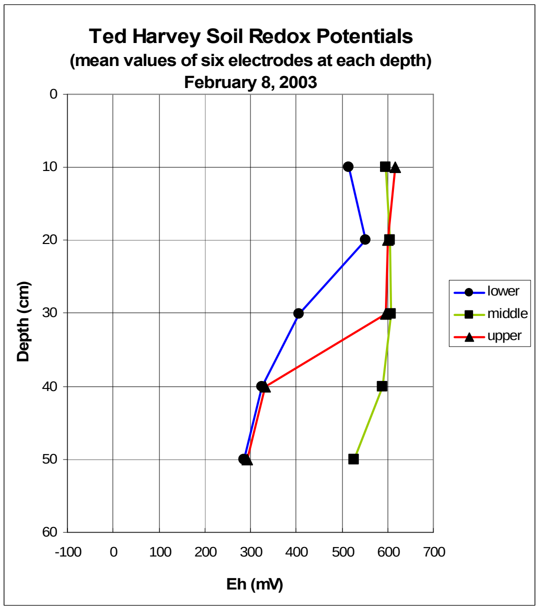
Ted Harvey		--------------		cm		--------------
12-Jan-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower site	1	269	233	170	236	250
	2	319	209	140	233	190
	3	320	250	174	259	244
	4	329	248	285	293	253
	5	346	255	258	307	215
	6					
mean (mV)		**317**	**239**	**205**	**266**	**230**
Middle Site	1	559	495	335	393	273
	2	579	514	310	273	288
	3	565	521	273	316	246
	4	552	476	310	279	244
	5	585	540	364	385	285
	6					
mean (mV)		**568**	**509**	**318**	**329**	**267**
Upper site	1	555	564	470	287	256
	2	589	506	356	212	232
	3	580	535	413	213	364
	4	567	499	271	232	244
	5	617	515	267	211	278
	6					
mean (mV)		**582**	**524**	**355**	**231**	**275**

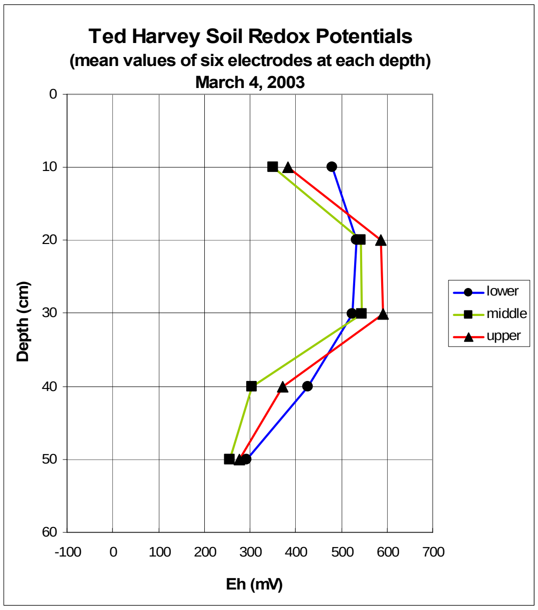




Ted Harvey		--------------	--------------	cm	--------------	--------------
8-Feb-03		10	20	30	40	50
	circuit	----------	----------	Eh (mV)	----------	----------
Lower site	1	214	241	-16	156	228
	2	198	239	175	209	232
	3	242	214	162	180	239
	4	251	255	168	182	245
	5	285	94	102	230	286
	6					
mean (mV)		**238**	**209**	**118**	**191**	**246**
Middle Site	1	219	195	193	170	218
	2	253	209	232	220	241
	3	231	183	214	55	149
	4	178	231	199	172	232
	5	277	245	243	90	262
	6					
mean (mV)		**232**	**213**	**216**	**141**	**220**
Upper site	1	589	562	252	201	195
	2	584	478	302	259	208
	3	585	449	277	243	205
	4	586	592	289	242	228
	5	563	430	282	246	231
	6					
mean (mV)		**581**	**502**	**280**	**238**	**213**

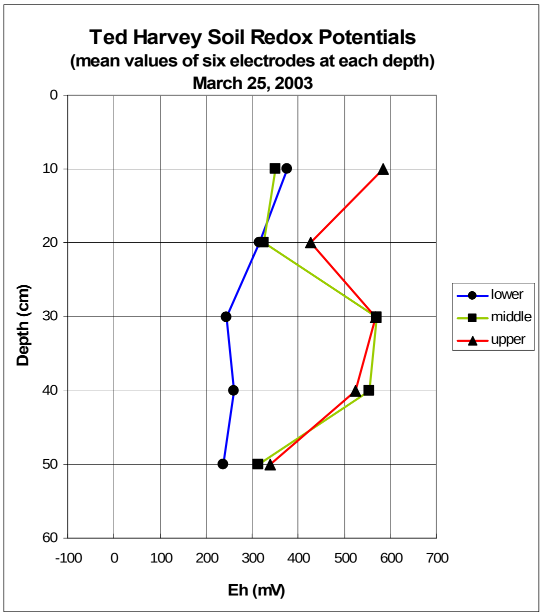
Ted Harvey		--------------	--------------	cm	--------------	--------------
4-Mar-03		10	20	30	40	50
	circuit	----------	----------	Eh (mV)	----------	----------
Lower site	1	463	506	506	301	269
	2	538	532	395	348	302
	3	487	460	534	333	259
	4	510	561	575	537	312
	5	517	565	585	497	289
	6	362	576	551	549	334
mean (mV)		**480**	**533**	**524**	**428**	**294**
Middle Site	1	365	550	507	303	219
	2	352	513	872	271	209
	3	330	539	425	273	254
	4	315	581	426	395	318
	5	368	522	458	271	276
	6	370	551	579	316	261
mean (mV)		**350**	**543**	**545**	**305**	**256**
Upper site	1	346	573	583	306	274
	2	412	566	590	529	297
	3	409	599	606	315	288
	4	404	610	610	458	279
	5	365	604	584	307	265
	6	364	567	571	315	261
mean (mV)		**383**	**587**	**591**	**372**	**277**

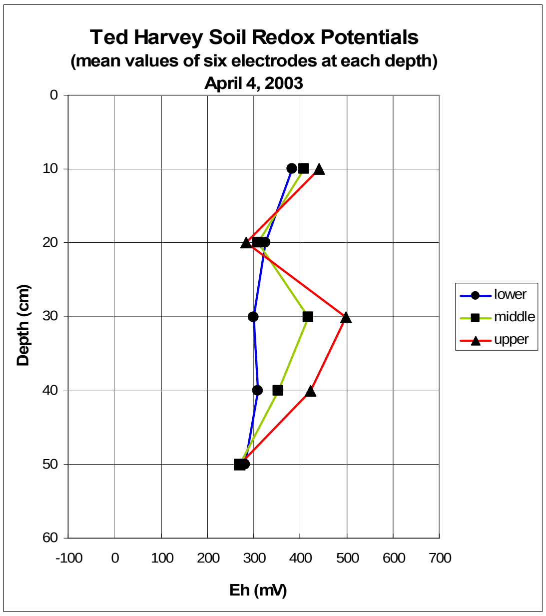




Ted Harvey				cm		
25-Mar-03		10	20	30	40	50
	circuit			Eh (mV)		
Lower site	1	393	314	255	258	224
	2					
	3	365	301	263	299	244
	4	376	314	282	281	232
	5	364	330	290	269	252
	6	384	320	134	199	234
mean (mV)		**376**	**316**	**245**	**261**	**237**
Middle Site	1	339	268	539	542	312
	2					
	3	374	332	589	567	306
	4	352	310	567	538	300
	5	325	366	572	562	354
	6	364	352	586	566	302
mean (mV)		**351**	**326**	**571**	**555**	**315**
Upper site	1	498	359	535	528	385
	2					
	3	637	459	577	556	345
	4	555	439	573	435	296
	5	616	433	584	558	343
	6	619	451	574	549	332
mean (mV)		**585**	**428**	**569**	**525**	**340**

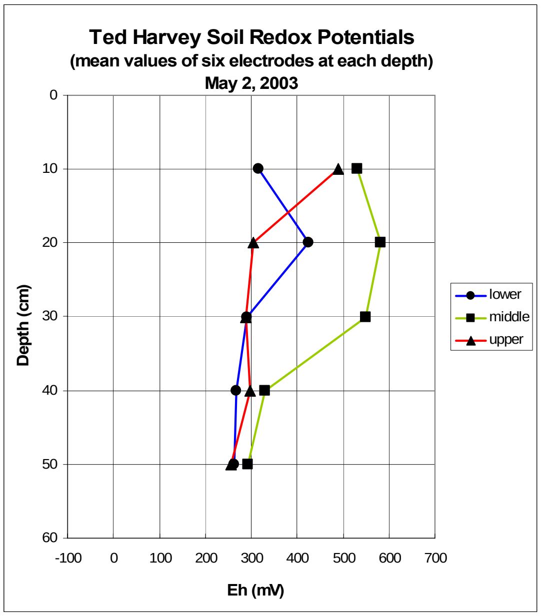
Ted Harvey				cm		
4-Apr-03		10	20	30	40	50
	circuit			Eh (mV)		
Lower site	1	491	335	294	328	323
	2					
	3	352	322	294	318	283
	4	420	333	317	322	264
	5	374	347	328	317	273
	6	276	286	265	262	269
mean (mV)		**383**	**325**	**300**	**309**	**282**
Middle Site	1	361	314	439	305	238
	2					
	3	385	322	519	356	239
	4	407	287	360	338	312
	5	567	366	430	488	337
	6	319	261	347	278	227
mean (mV)		**408**	**310**	**419**	**353**	**271**
Upper site	1	361	318	457	509	285
	2					
	3	426	260	529	482	302
	4	631	364	469	497	261
	5	419	200	534	317	254
	6	371	273	504	311	252
mean (mV)		**442**	**283**	**499**	**423**	**271**

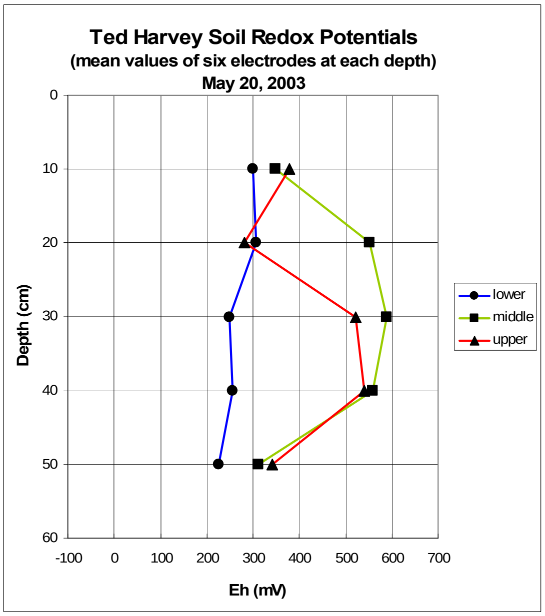




Ted Harvey				cm		
2-May-03		10	20	30	40	50
	circuit			Eh (mV)		
Lower site	1	318	361	261	270	281
	2	296	434	238	234	210
	3	317	450	309	249	273
	4	346	530	343	283	251
	5	303	354	306	304	293
	6					
mean (mV)		**316**	**426**	**291**	**268**	**262**
Middle Site	1	390	592	560	379	335
	2	504	534	532	273	248
	3	593	608	560	290	293
	4	571	581	538	351	291
	5	595	594	557	350	291
	6					
mean (mV)		**531**	**582**	**549**	**329**	**292**
Upper site	1	524	379	272	285	262
	2	554	155	216	209	200
	3	439	136	158	230	250
	4	424	355	302	283	256
	5	510	498	497	481	305
	6					
mean (mV)		**490**	**305**	**289**	**298**	**255**

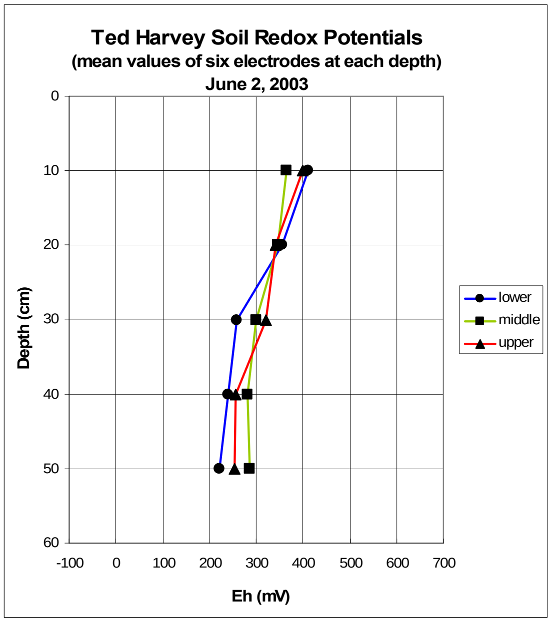
Ted Harvey				cm		
20-May-03		10	20	30	40	50
	circuit			Eh (mV)		
Lower site	1	258	265	256	259	213
	2	247	283	255	257	231
	3	449	477	275	235	229
	4	291	237	229	213	228
	5	254	270	227	321	236
	6					
mean (mV)		**300**	**306**	**248**	**257**	**227**
Middle Site	1	270	549	605	601	441
	2	343	591	619	611	320
	3	240	457	529	491	253
	4	526	581	602	552	238
	5	366	577	594	541	302
	6					
mean (mV)		**349**	**551**	**590**	**559**	**311**
Upper site	1	374	224	556	591	430
	2	384	300	545	549	318
	3	361	309	556	595	403
	4	317	257	387	400	215
	5	456	317	559	568	339
	6					
mean (mV)		**378**	**281**	**521**	**541**	**341**

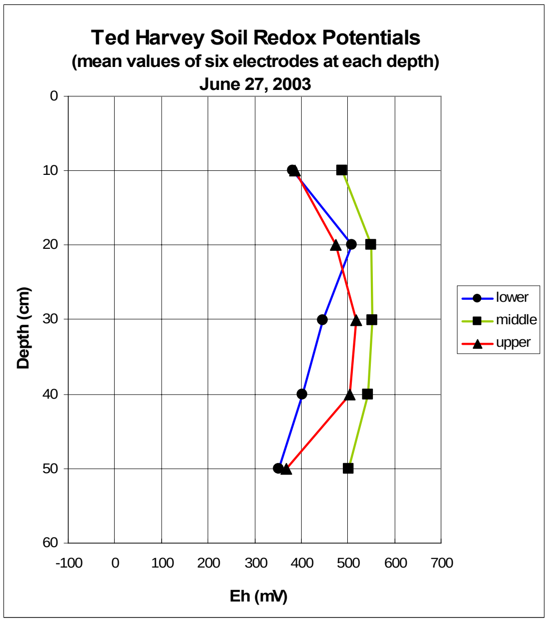




Ted Harvey		--------------		cm		--------------
2-Jun-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower site	1	455	350	274	333	279
	2	391	248	238	177	241
	3	517	386	310	249	241
	4	376	372	321	266	282
	5	342	499	338	320	126
	6	390	278	75	92	163
mean (mV)		**412**	**356**	**259**	**240**	**222**
Middle Site	1	430	377	358	287	277
	2	327	385	206	212	263
	3	217	265	260	258	255
	4	504	386	348	337	306
	5	378	328	307	275	293
	6	333	340	315	318	317
mean (mV)		**365**	**347**	**299**	**281**	**285**
Upper site	1	399	335	244	247	260
	2	270	203	217	182	185
	3	394	333	302	241	237
	4	584	504	319	254	250
	5	392	358	524	306	283
	6	357	320	314	301	307
mean (mV)		**399**	**342**	**320**	**255**	**254**

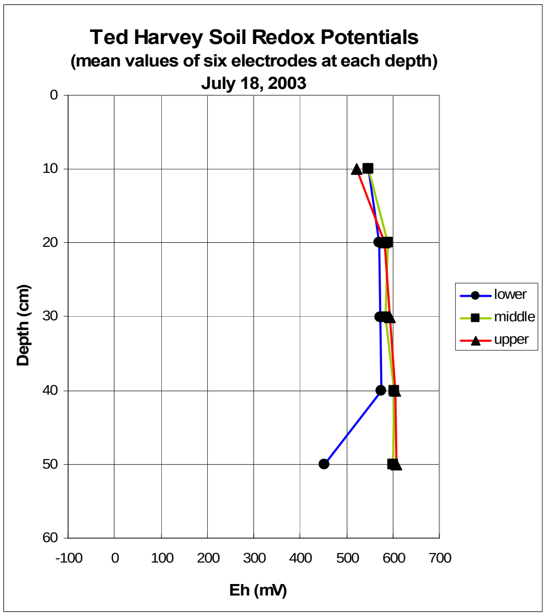
Ted Harvey		--------------		cm		--------------
27-Jun-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower site	1					
	2	533	550	493	500	428
	3	358	503	372	399	373
	4					
	5	327	569	459	371	296
	6	307	414	460	339	316
mean (mV)		**381**	**509**	**446**	**402**	**353**
Middle Site	1					
	2	500	567	581	573	578
	3	591	547	554	521	463
	4					
	5	400	546	544	554	429
	6	464	537	527	523	537
mean (mV)		**489**	**549**	**552**	**543**	**502**
Upper site	1					
	2	429	431	506	510	331
	3	449	395	552	514	406
	4					
	5	281	540	502	514	319
	6	390	531	510	474	416
mean (mV)		**387**	**474**	**518**	**503**	**368**

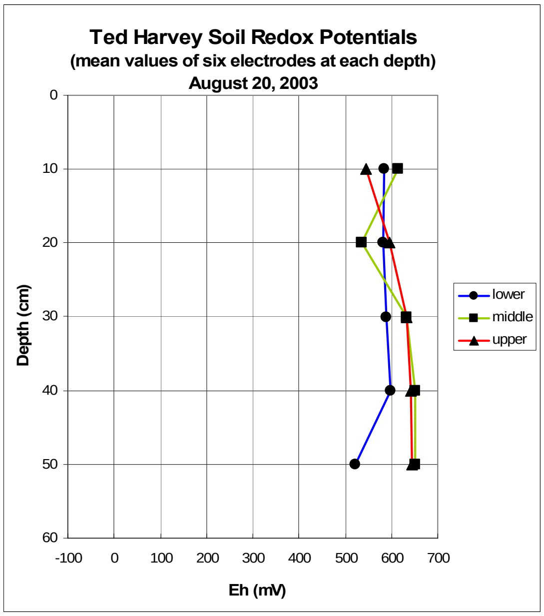




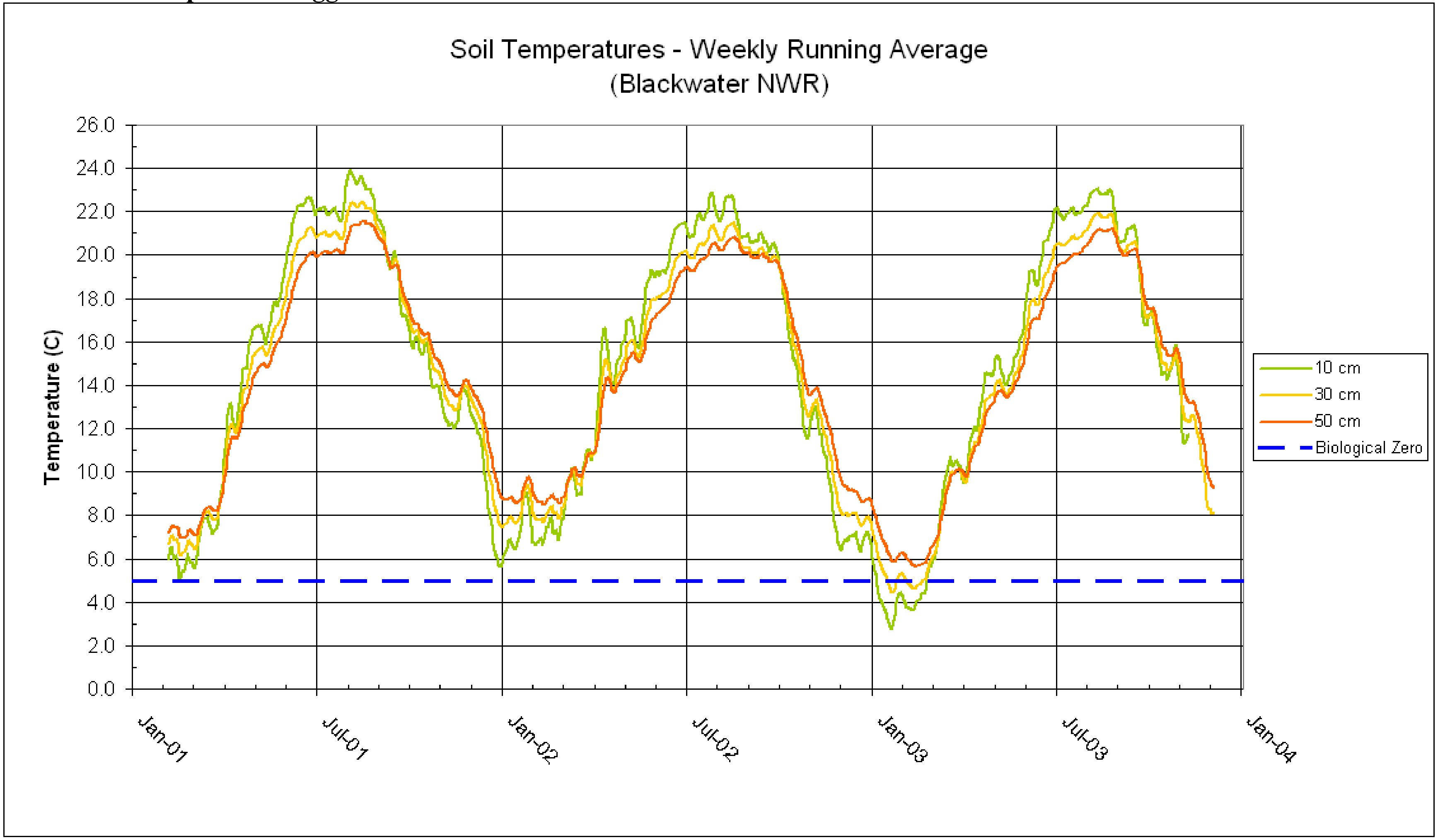
Ted Harvey		--------------		cm		--------------
18-Jul-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower site	1	571	578	586	559	510
	2	576	574	579	580	519
	3	557	594	586	571	327
	4	479	560	563	590	460
	5	553	545	552	573	442
	6					
mean (mV)		**547**	**570**	**573**	**575**	**452**
Middle Site	1					
	2	571	587	555	596	601
	3	571	592	601	612	593
	4	557	589	606	612	611
	5	483	589	599	606	619
	6	558	585	563	591	580
mean (mV)		**548**	**588**	**585**	**603**	**601**
Upper site	1					
	2	484	561	583	612	592
	3	480	592	601	610	641
	4	538	578	598	613	610
	5	544	602	608	612	611
	6	561	572	581	583	582
mean (mV)		**521**	**581**	**594**	**606**	**607**

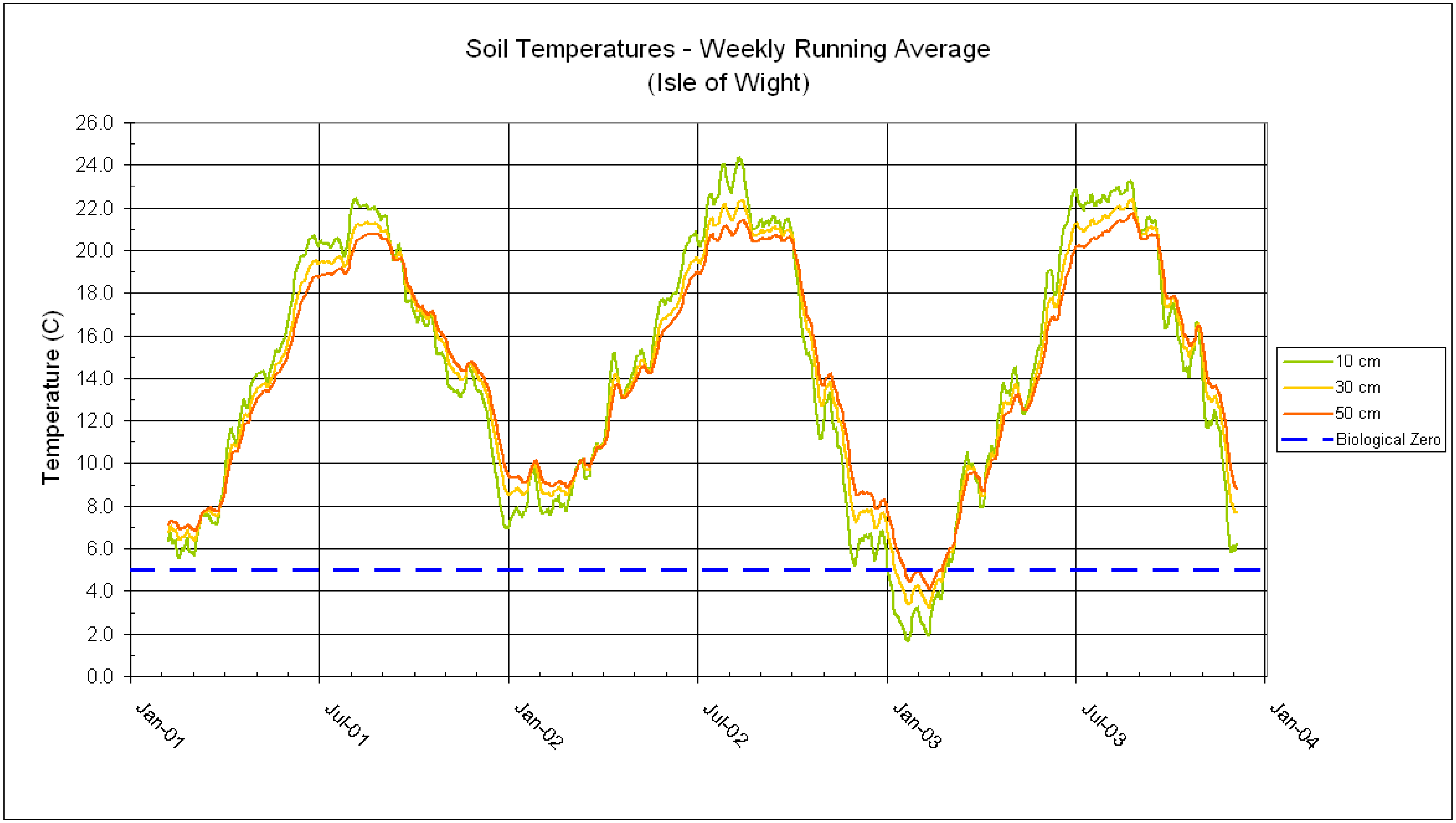
Ted Harvey		--------------		cm		--------------
20-Aug-03		10	20	30	40	50
	circuit	----------		Eh (mV)		----------
Lower site	1					
	2	617	603	615	632	601
	3	584	588	568	595	438
	4	571	560	593	603	591
	5	571	586	592	586	401
	6	580	567	579	573	583
mean (mV)		**585**	**581**	**589**	**598**	**523**
Middle Site	1					
	2	613	620	633	649	658
	3	622	248	644	671	656
	4	591	573	620	645	639
	5	621	636	652	648	668
	6	629	605	623	640	635
mean (mV)		**615**	**536**	**634**	**651**	**651**
Upper site	1					
	2	614	619	622	636	642
	3	532	590	632	648	656
	4	469	600	639	645	638
	5	569	581	637	645	645
	6	534	595	628	643	646
mean (mV)		**544**	**597**	**632**	**643**	**645**

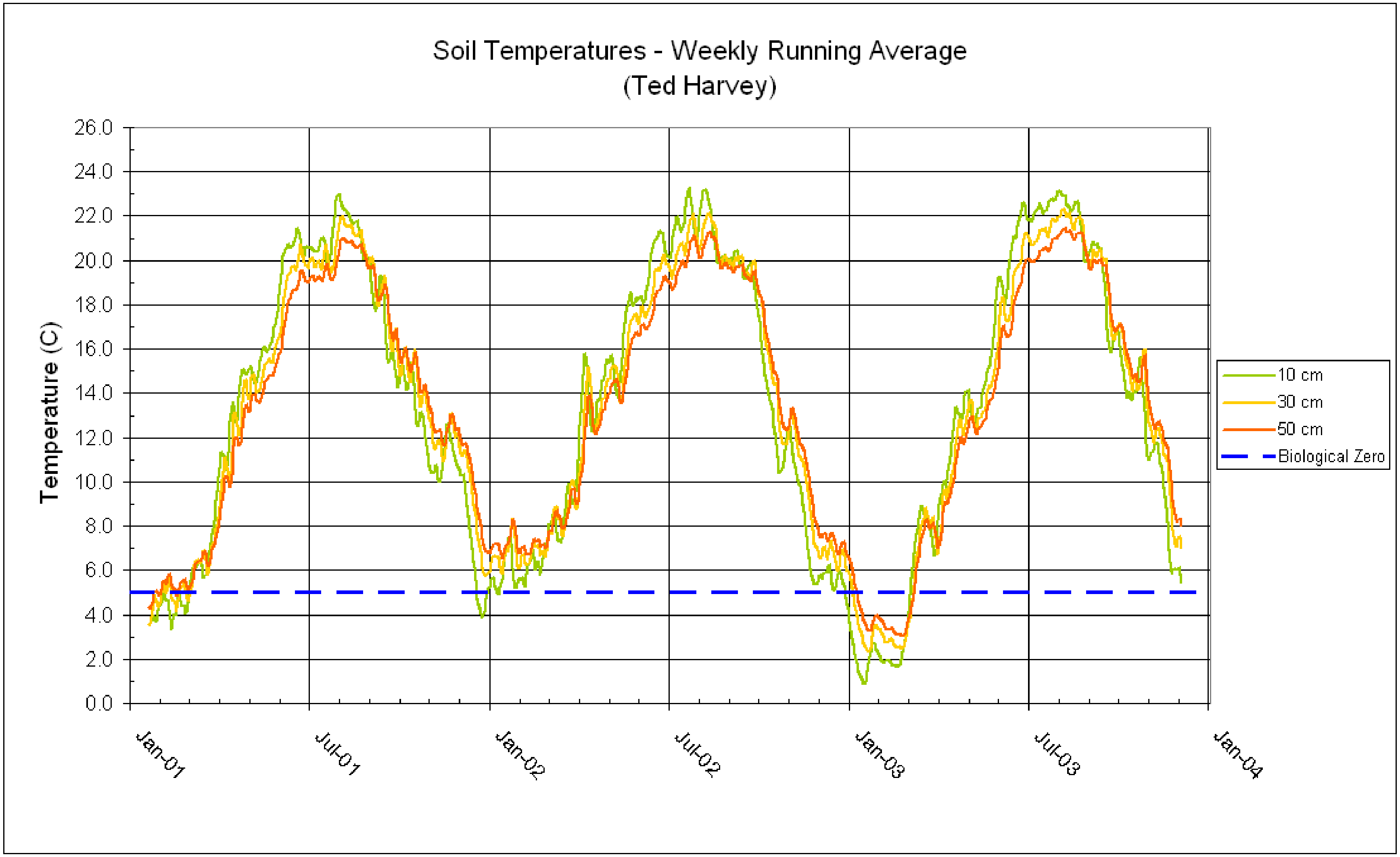

Ted Harvey Soil Redox Potentials
(mean values of six electrodes at each depth)
July 18, 2003


Ted Harvey Soil Redox Potentials
(mean values of six electrodes at each depth)
August 20, 2003

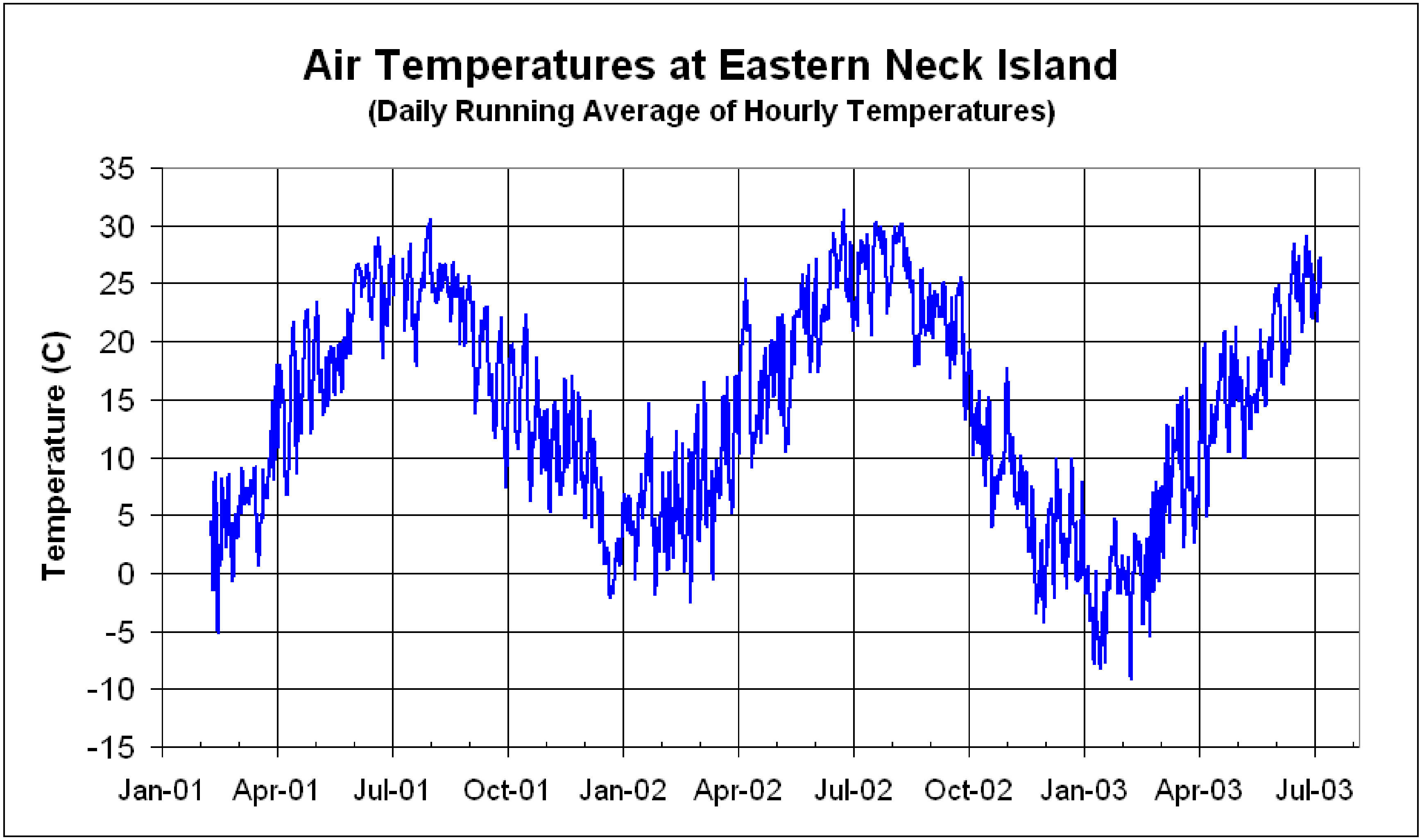
Appendix G: Soil Temperature Data at 10 cm, 30 cm, and 50 cm
NOTE: Soil temperature logger for the Eastern Neck Island site was not recovered




Soil Temperatures - Weekly Running Average
(Isle of Wight)
Temperature (C)
26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
10 cm
30 cm
50 cm
Biological Zero


Soil Temperatures - Weekly Running Average
(Ted Harvey)
Temperature (C)
26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
10 cm
30 cm
50 cm
Biological Zero

Appendix H: Air Temperatures at Eastern Neck Island site.
NOTE: Data from Blackwater and Isle of Wight sites not recovered; data from Ted Harvey site not shown.



Appendix I: Vegetation Analysis

Vegetation Analysis	August 22, 2002	
Site: Blackwater – middle		
Describers:		
Dr. Martin Rabenhorst		
Al Rizzo		
Philip Zurheide		
Karen Castenson		
Robert Vaughan		
Dominance of species by order of listing		
Tree stratum		**Status**
Loblolly Pine	*Pinus taeda*	FAC-
Sapling stratum		
(none)		
Shrub stratum		
Loblolly Pine	*Pinus taeda*	FAC-
Eastern Baccharis/High-Tide Bush	*Baccharis halimifolia*	FACW
Common Persimmon	*Diospyros virginiana*	FAC-
Herbaceous stratum		
Common Reed	*Phragmites australis*	FACW
Switchgrass	*Panicum virgatum*	FAC
Saltmarsh Fleabane	*Pluchea camphorata*	FACW
Sedge	*Cyperus sp.*	
Halberd-leaved Tearthumb	*Polygonum arifolium*	OBL
Softrush	*Juncus effusus*	FACW+
Woody Vine stratum		
Greenbriar	*Smilax rotundifolia*	FAC
Poison Ivy	*Toxicodendron radicans*	FAC

Vegetation Analysis	August 22, 2002	
Site: Blackwater – upper		
Describers:		
Dr. Martin Rabenhorst		
Al Rizzo		
Philip Zurheide		
Karen Castenson		
Robert Vaughan		
Dominance of species by order of listing		
Tree stratum		**Status**
Loblolly Pine	*Pinus taeda*	FAC-
Black Gum	*Nyssa sylvatica*	FAC
Sweet Gum	*Liquidambar styraciflua*	FAC
Willow Oak	*Quercus phellos*	FAC+
Sapling stratum		
Southern Red Oak	*Quercus falcata*	FACU-
Northern Red Oak	*Quercus rubra*	FACU-
Shrub stratum		
Wax Myrtle	*Myrica cerifera*	FAC
Willow Oak	*Quercus phellos*	FAC+
Eastern Baccharis/High-Tide Bush	*Baccharis halimifolia*	FACW
Loblolly Pine	*Pinus taeda*	FAC-
American Holly	*Ilex opaca*	FACU+
Common Persimmon	*Diospyros virginiana*	FAC-
Herbaceous stratum		
Spike Grass	*Distichlis spicata*	FACW+
Saltmarsh Fleabane	*Pluchea camphorata*	FACW
Blackberry		
Prickly Lettuce (disturbed area)	*Lactuca serriola*	FAC-
Woody Vine stratum		
Greenbriar	*Smilax rotundifolia*	FAC
Poison Ivy	*Toxicodendron radicans*	FAC

Vegetation Analysis	August 22, 2002	
Site: Isle of Wight – lower		
Describers:		
Dr. Martin Rabenhorst		
Al Rizzo		
Philip Zurheide		
Karen Castenson		
Robert Vaughan		
Dominance of species by order of listing		
Tree stratum		**Status**
Loblolly Pine	*Pinus taeda*	FAC-
Willow Oak	*Quercus phellos*	FAC+
Black Gum	*Nyssa sylvatica*	FAC
Sweet Gum	*Liquidambar styraciflua*	FAC
Swamp White Oak	*Quercus bicolor*	FACW+
Sapling stratum		
Sweet Gum	*Liquidambar styraciflua*	FAC
Wax Myrtle	*Myrica cerifera*	FAC
Shrub stratum		
Loblolly Pine	*Pinus taeda*	FAC-
Wax Myrtle	*Myrica cerifera*	FAC
Eastern Baccharis/High-Tide Bush	*Baccharis halimifolia*	FACW
Jesuit's Bark/Marsh-Elder	*Iva frutescens*	FACW+
Herbaceous stratum		
Common Reed	*Phragmites australis*	FACW
Switchgrass	*Panicum virgatum*	FAC
Saltmeadow Cordgrass	*Spartina patens*	FACW+
Seaside Goldenrod	*Solidago sempervirens*	FACW
Panic Grass	*Dichanthelium*	FAC
Soft Rush	*Juncus effusus*	FACW+
Woody Vine stratum		
Greenbriar	*Smilax rotundifolia*	FAC
Poison Ivy	*Toxicodendron radicans*	FAC

Vegetation Analysis	August 22, 2002	
Site: Isle of Wight – middle		
Describers:		
Dr. Martin Rabenhorst		
Al Rizzo		
Philip Zurheide		
Karen Castenson		
Robert Vaughan		
Dominance of species by order of listing		
Tree stratum		**Status**
Swamp White Oak	*Quercus bicolor*	FACW+
Pignut Hickory	*Carya glabra*	FACU-
Sweet Gum	*Liquidambar styraciflua*	FAC
White Oak	*Quercus alba*	FACU-
Black Gum	*Nyssa sylvatica*	FAC
Sapling stratum		
Sweet Gum	*Liquidambar styraciflua*	FAC
Swamp White Oak	*Quercus bicolor*	FACW+
Shrub stratum		
Loblolly Pine	*Pinus taeda*	FAC-
American Holly	*Ilex opaca*	FACU+
Sweet Gum	*Liquidambar styraciflua*	FAC
Southern Arrowwood	*Viburnum dentatum*	FAC
Highbush Blueberry	*Vaccinium corymbosum*	FACW-
Herbaceous stratum		
Swamp White Oak	*Quercus bicolor*	FACW+
Spike Grass/ (Inland Saltgrass?)	*Distichlis spicata*	FACW+
Sweetbay Magnolia	*Magnolia virginiana*	FACW+
Partridgeberry	*Mitchella repens*	FACU
Sassafras Lauraceae	*Sassafras albidum*	FACU-
Cinnamon Fern	*Osmunda cinnamomea*	FACW
Loblolly Pine	*Pinus taeda*	FAC-
Woody Vine stratum		
Greenbriar	*Smilax rotundifolia*	FAC
Fox Grape	*Vitis labrusca*	FACU
Japanese Honeysuckle	*Lonicera japonica*	FAC-

Vegetation Analysis	August 22, 2002	
Site: Isle of Wight - upper		
Describers:		
Dr. Martin Rabenhorst		
Al Rizzo		
Philip Zurheide		
Karen Castenson		
Robert Vaughan		
Dominance of species by order of listing		
Tree stratum		**Status**
Red Maple	*Acer rubrum*	FAC
Sweet Gum	*Liquidambar styraciflua*	FAC
Willow Oak	*Quercus phellos*	FAC+
Sapling stratum		
Black Gum	*Nyssa sylvatica*	FAC
Sweet Gum	*Liquidambar styraciflua*	FAC
Highbush Blueberry	*Vaccinium corymbosum*	FACW-
Shrub stratum		
American Holly	*Ilex opaca*	FACU+
Highbush Blueberry	*Vaccinium corymbosum*	FACW-
Loblolly Pine	*Pinus taeda*	FAC-
Southern Arrowwood	*Viburnum dentatum*	FAC
Serviceberry	*Amelanchier alnifolia*	N/A
Sweet Gum	*Liquidambar styraciflua*	FAC
Herbaceous stratum		
Partridgeberry	*Mitchella repens*	FACU
Woody Vine stratum		
Greenbriar	*Smilax rotundifolia*	FAC
Poison Ivy	*Toxicodendron radicans*	FAC
Japanese Honeysuckle	*Lonicera japonica*	FAC-

Vegetation Analysis	August 22, 2002	
Site: Eastern Neck Island - lower		
Describers:		
Dr. Martin Rabenhorst		
Al Rizzo		
Philip Zurheide		
Karen Castenson		
Robert Vaughan		
Dominance of species by order of listing		
Tree stratum		**Status**
Black Gum	*Nyssa sylvatica*	FAC
Red Maple	*Acer rubrum*	FAC
Northern Red Oak	*Quercus rubra*	FACU-
Willow Oak	*Quercus phellos*	FAC+
Sapling stratum		
Black Gum	*Nyssa sylvatica*	FAC
Sweet Gum	*Liquidambar styraciflua*	FAC
Red Maple	*Acer rubrum*	FAC
Northern Red Oak	*Quercus rubra*	FACU-
Willow Oak	*Quercus phellos*	FAC+
Pawpaw	*Asimina triloba*	FACU+
Shrub stratum (suppressed due to draught)		
American Holly	*Ilex opaca*	FACU+
Pawpaw	*Asimina triloba*	FACU+
Herbaceous stratum		
Spike Grass/ (Inland Saltgrass?)	*Distichlis spicata*	FACW+
Partridgeberry	*Mitchella repens*	FACU
Red Maple	*Acer rubrum*	FAC
Willow Oak	*Quercus phellos*	FAC+
Royal Fern	*Osmunda regalis*	OBL
Woody Vine stratum		
Greenbriar	*Smilax rotundifolia*	FAC
Japanese Honeysuckle	*Lonicera japonica*	FAC-

Vegetation Analysis	August 22, 2002	
Site: Eastern Neck Island - middle		
Describers:		
Dr. Martin Rabenhorst		
Al Rizzo		
Philip Zurheide		
Karen Castenson		
Robert Vaughan		
Dominance of species by order of listing		
Tree stratum		**Status**
Black Gum	*Nyssa sylvatica*	FAC
Red Maple	*Acer rubrum*	FAC
Northern Red Oak	*Quercus rubra*	FACU-
Willow Oak	*Quercus phellos*	FAC+
Sapling stratum		
Black Gum	*Nyssa sylvatica*	FAC
American Holly	*Ilex opaca*	FACU+
Sweet Gum	*Liquidambar styraciflua*	FAC
Shrub stratum		
(none)		
Herbaceous stratum		
Spike Grass/ (Inland Saltgrass?)	*Distichlis spicata*	FACW+
Black Gum	*Nyssa sylvatica*	FAC
Partridgeberry	*Mitchella repens*	FACU
Woody Vine stratum		
Greenbriar	*Smilax rotundifolia*	FAC

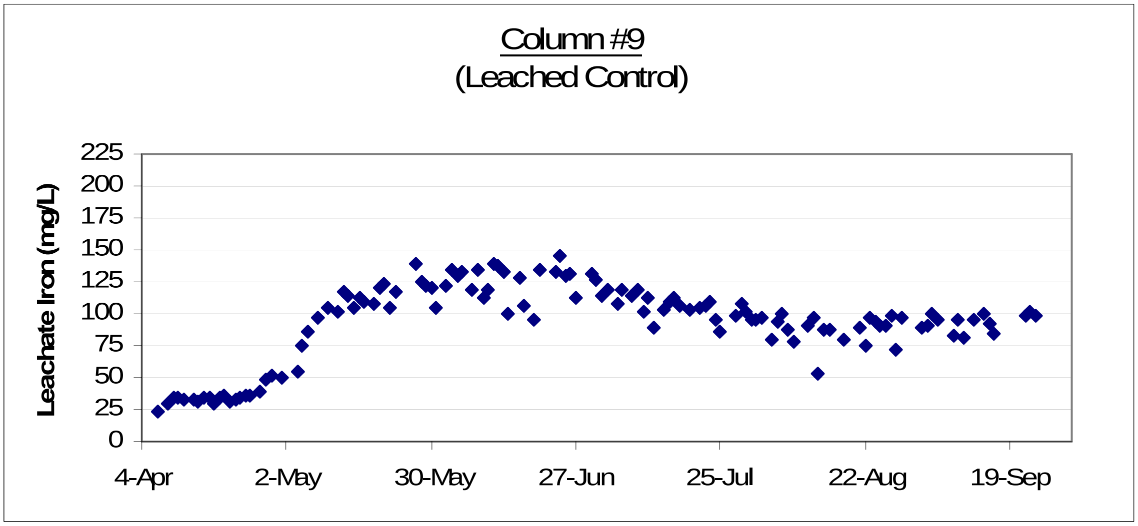
Vegetation Analysis	August 22, 2002	
Site: Eastern Neck Island - upper		
Describers:		
Dr. Martin Rabenhorst		
Al Rizzo		
Philip Zurheide		
Karen Castenson		
Robert Vaughan		
Dominance of species by order of listing		
Tree stratum		**Status**
White Oak	*Quercus alba*	FACU-
Tulip Popler	*Liriodendron tulipifera*	FACU
Sweet Gum	*Liquidambar styraciflua*	FAC
Pignut Hickory	*Carya glabra*	FACU-
Swamp White Oak	*Quercus bicolor*	FACW+
Sapling stratum		
Black Cherry	*Prunus serotina*	FACU
Pawpaw	*Asimina triloba*	FACU+
Shrub stratum		
(none)		
Herbaceous stratum		
False Solomon's Seal	*Smilacina racemosa*	FACU-
Woody Vine stratum		
Japanese Honeysuckle	*Lonicera japonica*	FAC-
NOTE: suppression of under-story plants by grazing		

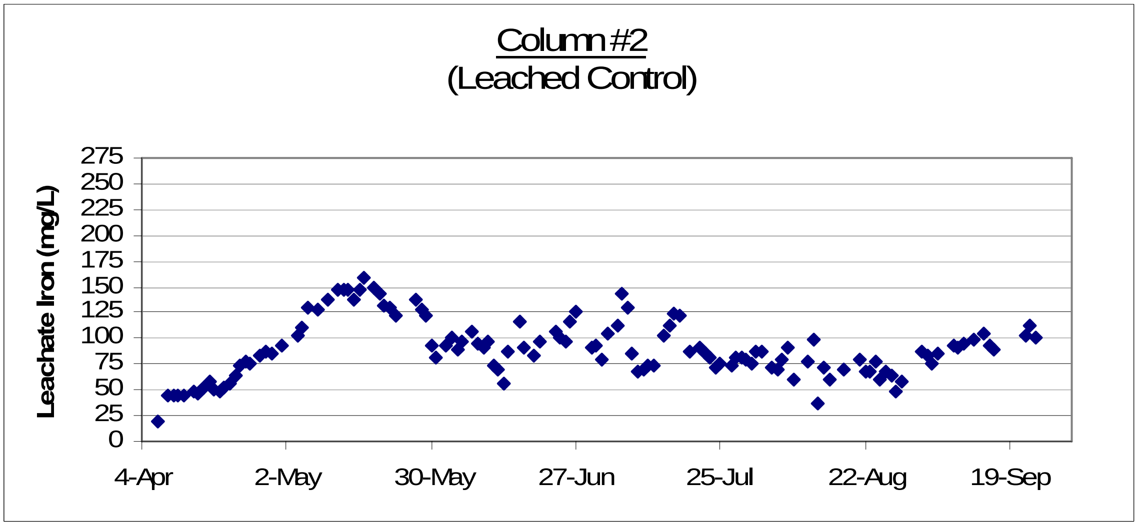
Vegetation Analysis	August 22, 2002	
Site: Ted Harvey - lower		
Describers:		
Dr. Martin Rabenhorst		
Al Rizzo		
Philip Zurheide		
Karen Castenson		
Robert Vaughan		
Dominance of species by order of listing		
Tree stratum		**Status**
Sweet Gum	*Liquidambar styraciflua*	FAC
Sapling stratum		
Common Persimmon	*Diospyros virginiana*	FAC-
Sweet Gum	*Liquidambar styraciflua*	FAC
Shrub stratum		
Eastern Baccharis/High-Tide Bush	*Baccharis halimifolia*	FACW
Southern Bayberry/Wax Myrtle	*Myrica cerifera (Morella cerifera)*	FAC
Winged Sumac	*Rhus copallinum*	N/A
Common Persimmon	*Diospyros virginiana*	FAC-
Staghorn Sumac	*Rhus hirta (L.) Sudworth/Rhus typhina*	N/A
Herbaceous stratum		
Sensitive Fern	*Onoclea sensibilis*	FACW
Rough-stemed Goldenrod/Wrinkle-leaf Goldenrod	*Solidago rugosa*	FAC
Switchgrass	*Panicum virgatum*	FAC
Dewberry		
Blackberry		
Partridgeberry	*Mitchella repens*	FACU
Common Reed	*Phragmites australis*	FACW
Seaside Goldenrod	*Solidago sempervirens*	FACW
Saltmarsh Fleabane	*Pluchea camphorata*	FACW
Dogbane (Climbing Dogbane)	*Trachelospermum difforme (Walt.) Gray*	FACW
Woody Vine stratum		
Coastalplain Tickseed	*Coreopsis gladiata Walt.*	FACW
Poison Ivy	*Toxicodendron radicans*	FAC

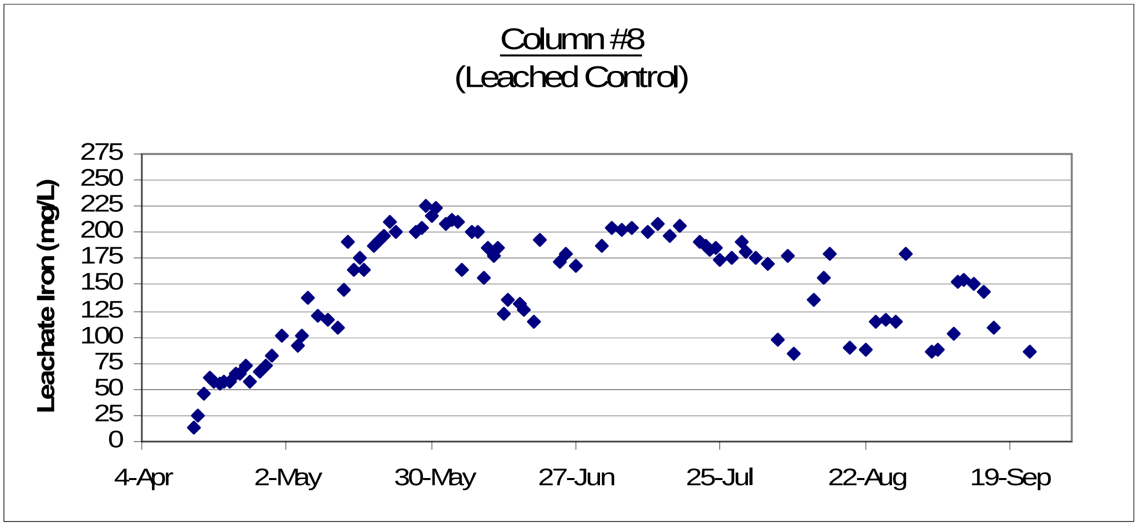
Vegetation Analysis	August 22, 2002	
Site: Ted Harvey - middle		
Describers:		
Dr. Martin Rabenhorst		
Al Rizzo		
Philip Zurheide		
Karen Castenson		
Robert Vaughan		
Dominance of species by order of listing		
Tree stratum		**Status**
Sweet Gum	*Liquidambar styraciflua*	FAC
Willow Oak	*Quercus phellos*	FAC+
Postoak	*Quercus stellata Wangenh.*	UPL
Sapling stratum		
Sweet Gum	*Liquidambar styraciflua*	FAC
Common Persimmon	*Diospyros virginiana*	FAC-
Shrub stratum		
Common Persimmon	*Diospyros virginiana*	FAC-
Herbaceous stratum		
Dewberry		
Switchgrass	*Panicum virgatum*	FAC
Poison Ivy	*Toxicodendron radicans*	FAC
Common Velvetgrass	*Holcus lanatus*	FACU
Seaside Goldenrod	*Solidago sempervirens*	FACW
Woody Vine stratum		
Japanese Honeysuckle	*Lonicera japonica*	FAC-
Poison Ivy	*Toxicodendron radicans*	FAC

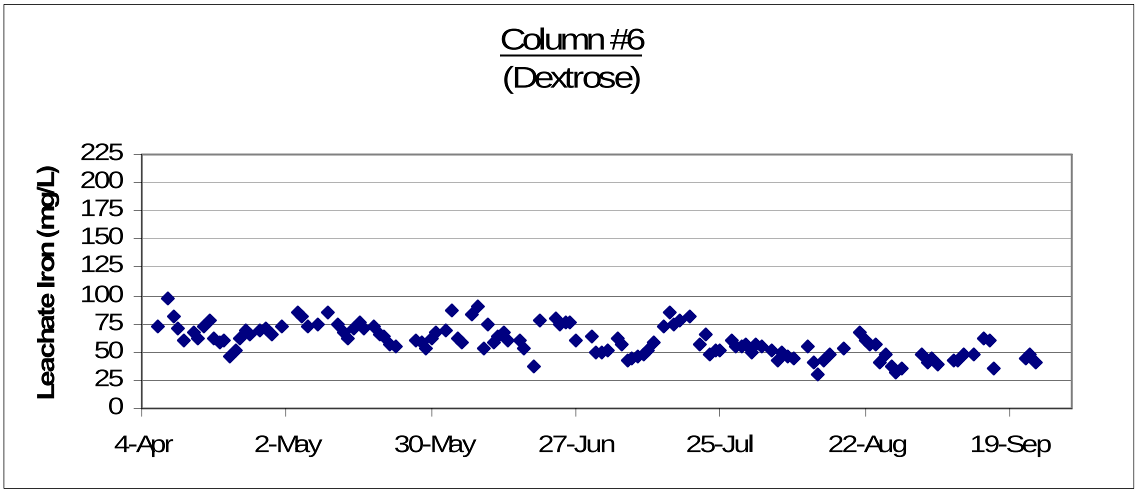
Vegetation Analysis	August 22, 2002	
Site: Ted Harvey - upper		
Describers:		
Dr. Martin Rabenhorst		
Al Rizzo		
Philip Zurheide		
Karen Castenson		
Robert Vaughan		
Dominance of species by order of listing		
Tree stratum		**Status**
Sweet Gum	*Liquidambar styraciflua*	FAC
Pin Oak	*Quercus palustis*	FACW
Black Gum	*Nyssa sylvatica*	FAC
Willow Oak	*Quercus phellos*	FAC+
Sapling stratum		
Staghorn Sumac	*Rhus hirta (L.) Sudworth/Rhus typhina*	N/A
Willow Oak	*Quercus phellos*	FAC+
Sweet Gum	*Liquidambar styraciflua*	FAC
Common Persimmon	*Diospyros virginiana*	FAC-
Shrub stratum		
Willow Oak	*Quercus phellos*	FAC+
Common Persimmon	*Diospyros virginiana*	FAC-
Eastern Baccharis/High-Tide Bush	*Baccharis halimifolia*	FACW
Southern Arrowwood	*Viburnum dentatum*	FAC
Herbaceous stratum		
Blackberry		
Switchgrass	*Panicum virgatum*	FAC
Deer tongue	*Dichanthelium clandestinum (L.) Gould*	FAC+
Seaside Goldenrod	*Solidago sempervirens*	FACW
Common Velvetgrass	*Holcus lanatus*	FACU
Common Persimmon	*Diospyros virginiana*	FAC-
Woody Vine stratum		
Japanese Honeysuckle	*Lonicera japonica*	FAC-
Poison Ivy	*Toxicodendron radicans*	FAC
Dewberry		
Cat Greenbrier	*Smilax glauca*	FACU

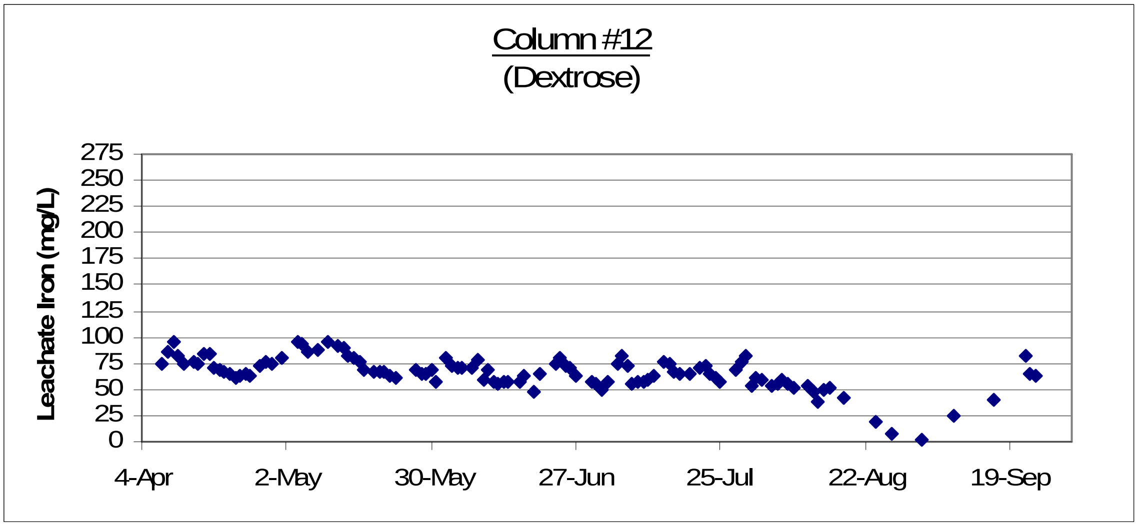
Appendix J: Mesocosm Leached Iron

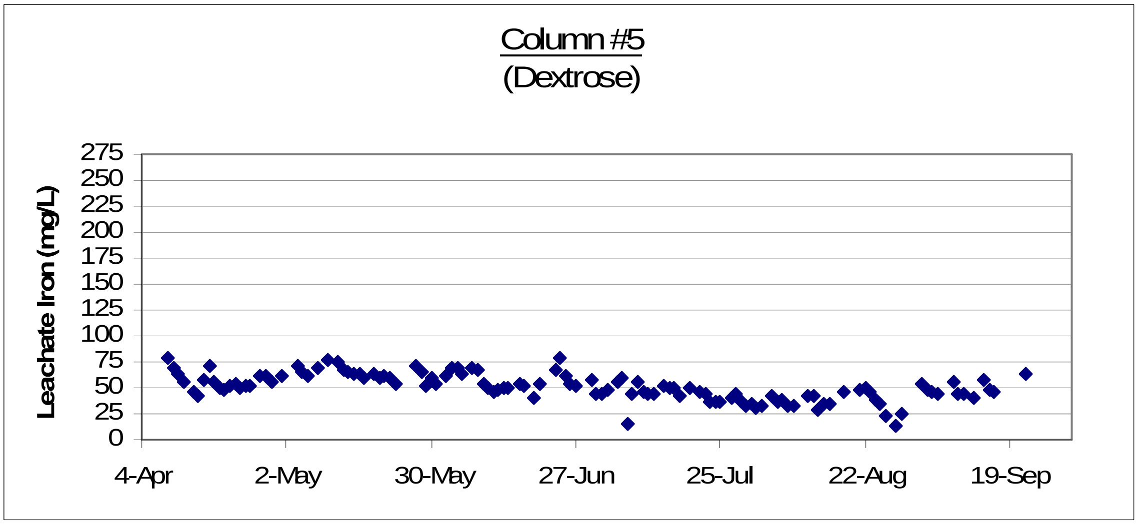


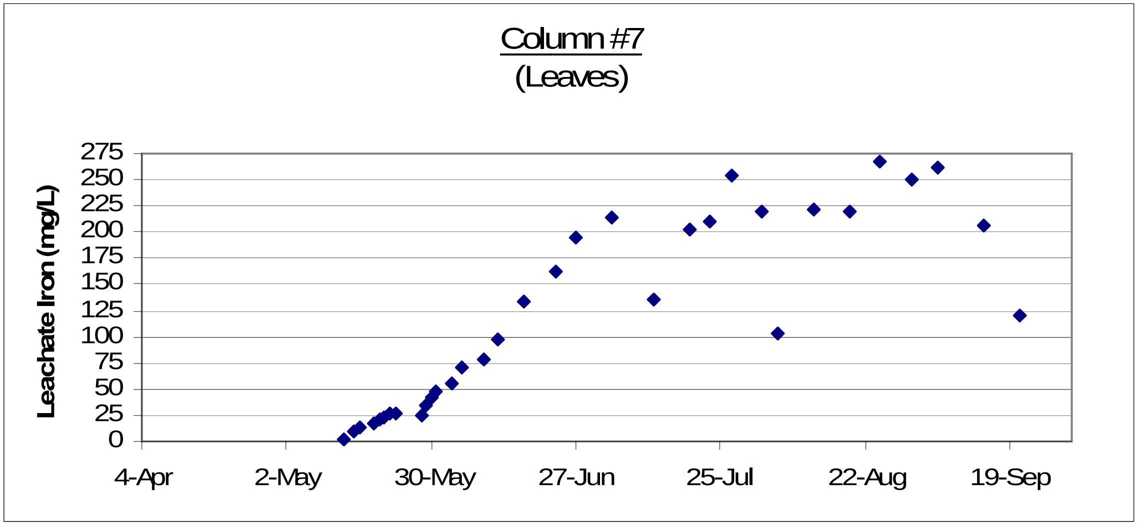


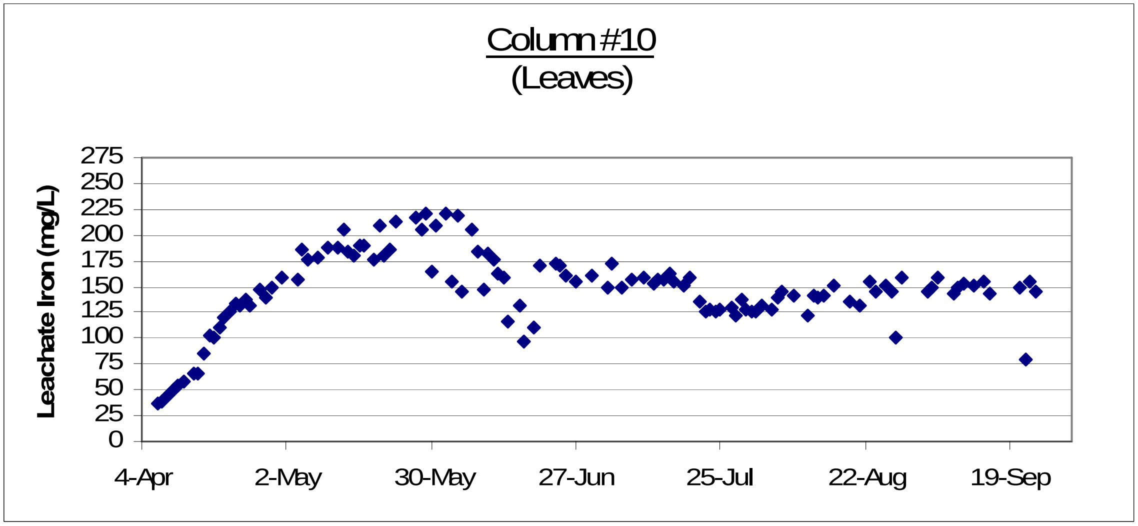


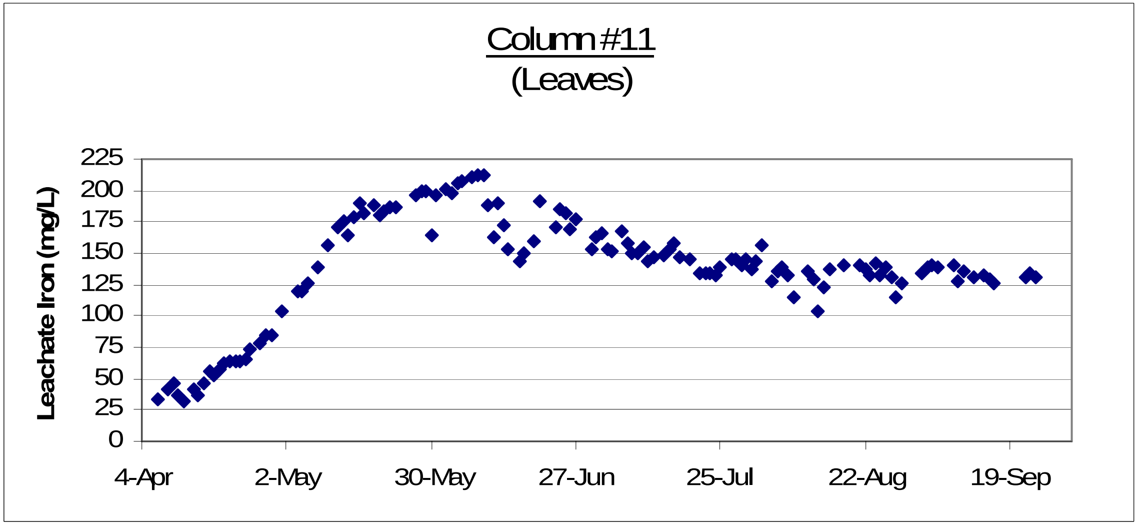

Column #6
(Dextrose)
Leachate Iron (mg/L)
225
200
175
150
125
100
75
50
25
0
4-Apr
2-May
30-May
27-Jun
25-Jul
22-Aug
19-Sep


Column #12
(Dextrose)
Leachate Iron (mg/L)
275
250
225
200
175
150
125
100
75
50
25
0
4-Apr
2-May
30-May
27-Jun
25-Jul
22-Aug
19-Sep

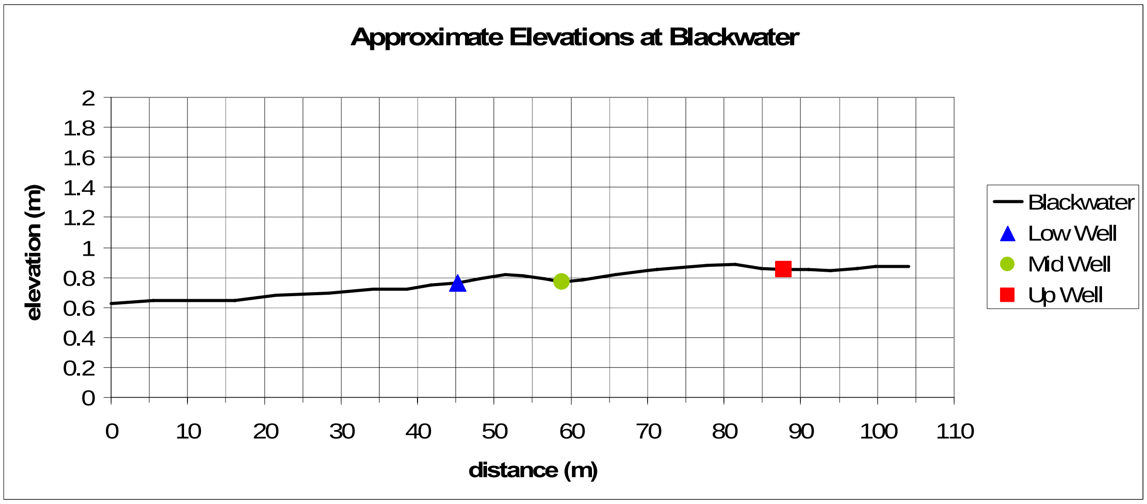

Column #5
(Dextrose)
Leachate Iron (mg/L)
275
250
225
200
175
150
125
100
75
50
25
0
4-Apr
2-May
30-May
27-Jun
25-Jul
22-Aug
19-Sep

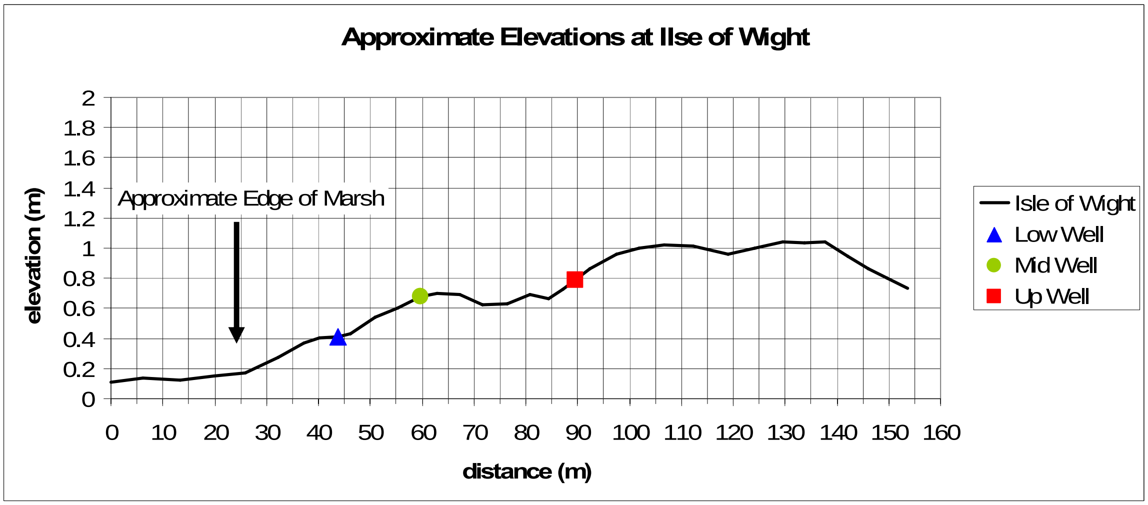

Column #7
(Leaves)
Leachate Iron (mg/L)
275
250
225
200
175
150
125
100
75
50
25
0
4-Apr
2-May
30-May
27-Jun
25-Jul
22-Aug
19-Sep

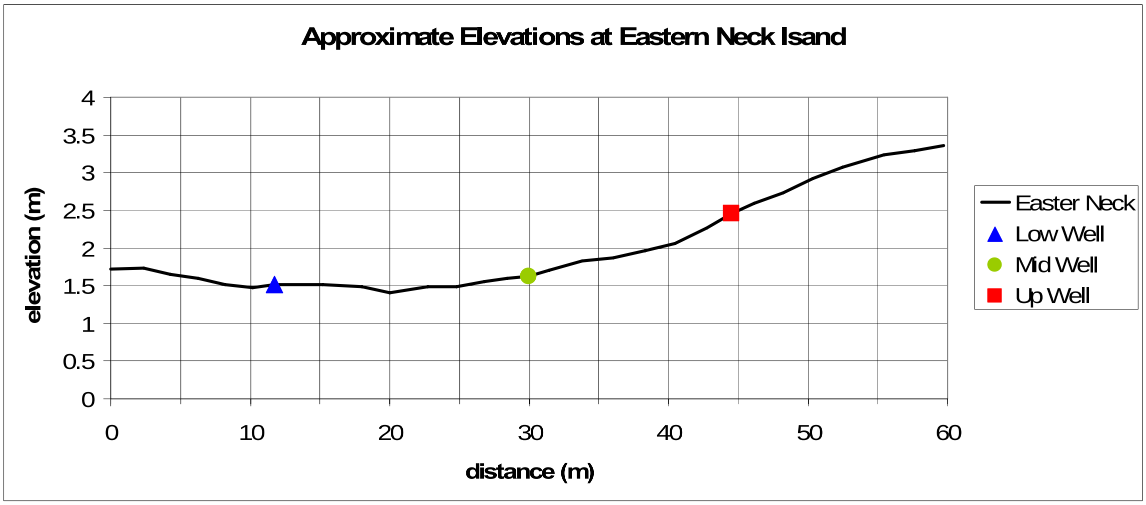

Column #10
(Leaves)
Leachate Iron (mg/L)
275
250
225
200
175
150
125
100
75
50
25
0
4-Apr
2-May
30-May
27-Jun
25-Jul
22-Aug
19-Sep

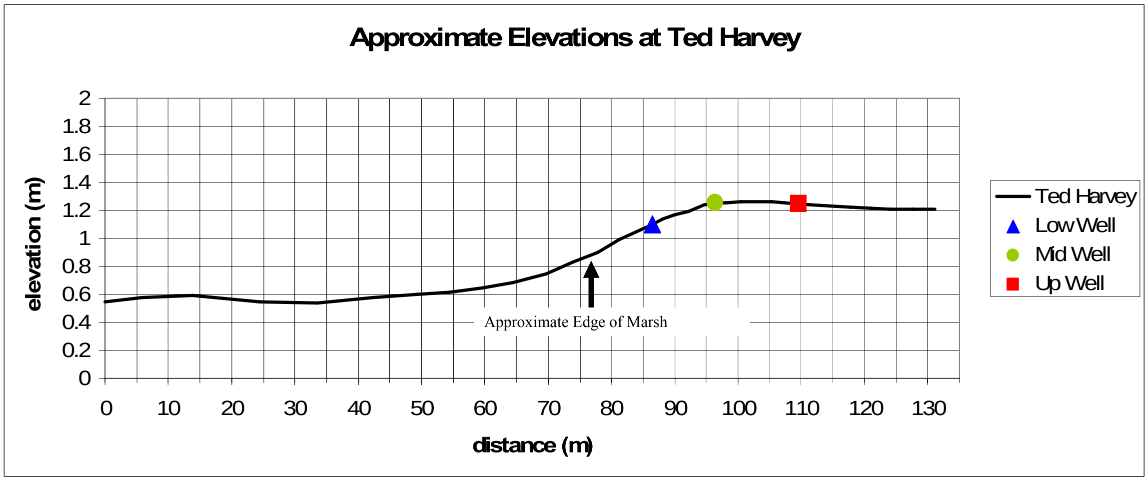

Column #11
(Leaves)
Leachate Iron (mg/L)
225
200
175
150
125
100
75
50
25
0
4-Apr
2-May
30-May
27-Jun
25-Jul
22-Aug
19-Sep

Appendix K: Site Elevation Graphs






Approximate Elevations at Eastern Neck Isand
elevation (m)
4
3.5
3
2.5
2
1.5
1
0.5
0
0
10
20
30
40
50
60
distance (m)
Easter Neck
Low Well
Mid Well
Up Well


Approximate Elevations at Ted Harvey
elevation (m)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
10
20
30
40
50
60
70
80
90
100
110
120
130
distance (m)
Approximate Edge of Marsh
Ted Harvey
Low Well
Mid Well
Up Well

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