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**The surficial sediments of Assawoman Bay and Isle of
Wight Bay in Maryland: physical and chemical
characteristics**

by

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The surficial sediments of Assawoman Bay and Isle of Wight Bay in Maryland: physical and chemical characteristics

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EXECUTIVE SUMMARY

The Maryland Geological Survey conducted a two year investigation of the shallow geological framework and near surface geochemical character of the sediments of Assawoman and Isle of Wight Bays located along Maryland's Atlantic coast. This report presents the results of the second year study which focused on the physical and chemical characteristics of the surficial sediments of Assawoman and Isle of Wight Bays. The objectives of the second year study were:

- 1) To map the chemical and sedimentological characteristics of the surficial sediments;
- 2) To delineate the vertical stratigraphic sequence of Assawoman and Isle of Wight Bays.

The study was funded through the Minerals Management Service (MMS)/University of Texas cooperative studies relating to continental margin.

In order to accomplish these objectives, 172 surficial sediment samples were collected in Isle of Wight and Assawoman Bays as well as the lower tidal reaches of the major tributaries. The sediments were analyzed for water content, textural properties, total nitrogen, carbon and sulfur contents, and for six metals: Cr, Cu, Fe, Mn, Ni, and Zn. Results from these analyses were used to map the distribution of sediment type, nitrogen, carbon and sulfur contents and relative enrichment of the six metals in the surficial sediments. Seismic data collected during the previous year's study (Wells and others, 1994) along with data from a series of borings collected by the Army Corps of Engineers were used to estimate thicknesses of the SAND, SILT and CLAY components in the two coastal bays.

Based on the textural analyses of 171 surficial sediment samples, the average textural composition of the bay bottom sediments is 54% SAND, 28% SILT and 18% CLAY. The SAND to MUD (SAND + CLAY components) ratio is nearly 1:1. SAND sediments (i.e. SAND > 75%), which cover approximately 44% of the bottom of the two bays, are found primarily along the eastern side of the bays. The SANDS vary in thickness from several cm to more than 8 meters, gradually thinning toward the west. CLAYEY SILTS, which cover approximately 14% of the study area, are found in the tributaries and in isolated pockets associated with marshy shorelines. SILTY CLAYS are restricted to upstream areas of the tributaries. SILTY SAND, SANDY SILT and SAND-SILT-CLAY are found in isolated pockets along marshy shorelines and along the boundaries between SAND and CLAYEY SILTS. Based on seismic data collected during the previous year study, the CLAYEY SILT deposits are estimated to be up to 5 meters thick in area east of the mouth of St. Martin River (due south of Isle of Wight Bay). This area corresponds to the thalweg of the St. Martin paleochannel.

Water content is strongly associated with the CLAY component of the sediment as reflected by the high correlation coefficient between percent water and CLAY content ($r = 0.95$). Water contents of SAND sediments average 21.6% while SILTY CLAY sediments have the highest water contents (maximum value = 79%).

Total carbon contents measured in the surficial sediments range from 0 to 9.86% with a mean value of 2.08%. Correlation analysis reveals strong associations between carbon content and % water ($r = 0.89$), and carbon content and CLAY ($r = 0.88$), indicating that carbon content is associated with the fine grained fraction. In general, the carbon content distribution closely follows the sediment distribution. The highest carbon values (>7%) were obtained from SILTY CLAY sediments collected in the upstream areas of Roy and Greys Creek and St. Martin river.

Nitrogen contents in surficial sediments range from 0 to 0.59%, and average 0.16%. The highest nitrogen contents are associated with SILTY CLAYS found in upstream areas of the tributaries (St. Martin River, Greys Creek and Roy Creek). Nitrogen content of the sediments is strongly associated with carbon content ($r = 0.915$) reflecting the fact that nitrogen comes primarily from organic geopolymers found in the sediment. N/C values are generally low (mean = 0.065) for sediments in the tributaries and along the marsh island areas between Greys Creek and Roy Creek, suggesting that nitrogen in sediments comes primarily from terrestrial organic material, probably as cellulose plant tissue. N/C values are higher, averaging 0.177, for the sediments collected in the central portions of Isle of Wight and Assawoman Bays. In these areas plankton is most likely the primary source of nitrogen in sediments.

Total sulfur contents of the surficial sediments of the coastal bays range from 0 to 3.16% about a mean of 0.63%. Distribution pattern for sulfur contents are similar to those for nitrogen and carbon. Sulfur contents is greatly influenced by sediment texture. Correlation analyses show a strong association between sulfur and CLAY content ($r = 0.91$) and water content ($r = 0.88$). SILTY CLAYS collected in the tributaries yielded the highest sulfur contents, ranging from 1.41 to 3.16%. The ratio of carbon to sulfur (C/S) averages 3.56 ± 1.32 for all samples. This value is much higher than the C/S ratio of $2.8 (\pm 1.5)$ for modern marine sediments reported by Berner and Raiswell (1984). The higher C/S values may reflect the origin and nature of the carbon contained in the sediments. A significant portion of the total carbon measured in many of the coastal bay sediments may be non-reactive carbon, perhaps in the form of plant material or inorganic carbon secretions in worm tubes.

Correlations between metal contents and carbon, nitrogen, and sulfur contents are moderate to strong ($r > 0.7$). The highest correlations are between Fe and Cr ($r = 0.984$), Fe and Mn ($r = 0.956$) and Cr and Zn ($r = 0.953$). There are also high correlations between CLAY content and Cr, Fe, and Ni, and between water content and all six metals. These metals typically are associated with clay minerals as they are either components of the mineral lattice structure or absorbed onto clay surfaces. Because of the strong relationship between metal content and grain size, several techniques were used to normalize the metal data so the comparisons could be made between the different sediment types.

One technique correlated metal content with the grain size composition. Metal concentrations in sediments below 30 cm in the sediment column were interpreted to represent

the historical norms for the coastal bays. These deeper sediments were used to obtain the relationship between grain size and metal contents to determine background metal concentrations. Background levels were calculated for all surficial samples based on grain size, and compared to the measured metal levels. Variation from background levels were then mapped.

Variation levels for Cr, Fe, and Mn are not significant for most areas within the two bays; *i.e.*, variation level values fall within the normal dispersion of background level values. On the other hand, variation levels for Cu and Zn indicate that the surficial sediments contain twice the amount of Cu and Zn than background levels (historical levels). Variation levels for Zn and Cu were mapped revealing distribution patterns that reflect anthropogenic influences within the two bays. High variation levels of both Cu and Zn are seen in the St. Martin River and in isolated pockets adjacent to developments and marinas. The developed shorelines contain dead-end canals and narrow boat slips, and thus by design, have poor water circulation, which contribute to the accumulation of these metals. Likewise, the St. Martin River acts as a sink for these metals as well as other pollutants, due in part, to the fine grained nature of the sediments. The variation levels for metals also reflect the relatively high pollutant input into the St. Martin River compared to other tributaries.

INTRODUCTION

The Maryland coastal bay system consists of four bays: Assawoman Bay, Isle of Wight Bay, Sinepuxent Bay and Chincoteague Bay. These coastal bays are considered very valuable resources not only from a geological viewpoint, but from an environmental perspective. During the last two decades, development pressures along the shoreline around the bays have raised concerns about the "health" of the bays. Yet, there is a paucity of environmental data available to adequately assess and monitor the bays. Little is understood about the hydrodynamics and sedimentation processes. An understanding of the hydrodynamics of the bays is critical in dealing with dredging and disposal of polluted sediments. Because the bays are very shallow, bottom sediments are often resuspended, mixing with the overlying water column. Therefore, the bottom sediments play an important role in bay water quality. Sedimentological studies are important to the understanding of the relationship between bottom sediments and bay hydrodynamics as well as to the general health of the bays.

During the past seven years of the Mineral Management Service-Association of American State Geologists (MMS/AASG) Continental Margins Program, the Maryland Geological Survey has mapped the surficial sediments and defined the shallow geological framework of the inner continental shelf of Maryland (Kerhin and Williams, 1987; Toscano and others, 1989). The area of study had been limited to the inner continental shelf of Maryland, and did not include the adjacent coastal bay systems. These coastal bays mark the leading edge boundary of the present transgression and overlie sedimentary sequences that link the onshore to offshore stratigraphy. Therefore, studies of the geologic framework of these bays would contribute to the understanding of the relationship between offshore and onshore stratigraphy and the history of the holocene transgression.

For the eighth year of the MMS/AASG Continental Margins Program, the Maryland Geological Survey initiated a preliminary investigation of the shallow geological framework and near surface geochemical character of the sediments of Assawoman and Isle of Wight Bays located along Maryland's Atlantic coast. The purpose of this study was two-fold: 1) The information from this study would "fill in" some of the gaps in reconstructing the shallow stratigraphy and Quaternary history of Maryland's inner continental shelf. 2) The study would provide some preliminary base-line sedimentological and chemical data for future studies of these back-bay areas.

The eighth year study was design as a reconnaissance investigation of the shallow geology of the two bays. Due to funding and time constraints, tasks were kept simple with seismic profiling being the primary tool of study. In addition to seismic profiling, a series of shallow sediment cores were collected along various transect with the two bays. Analyses of these sediment cores provided important geochemical behavior and history of the shallow sediment column in the bays (Wells and others, 1994).

For the ninth year of the MMS/AASG Continental Margins Program, the Maryland Geological Survey continued the investigation of the geological framework of Assawoman and Isle of Wight Bays with the emphasis on the physical and chemical characteristics of the surficial

sediments. The objectives of the continuation of the Coastal Bays study were:

- 1) To map the chemical and sedimentological characteristics of the surficial sediments;
- 2) To delineate the vertical stratigraphic sequence of Assawoman and Isle of Wight Bays;

Presented in this report are the results and preliminary interpretation of the data from the continuation of the Isle of Wight and Assawoman Bays Study. Results include the textural and chemical data from analyses of 171 surficial sediment samples collected in the two bays.

PREVIOUS STUDIES

Early studies focused primarily on water quality monitoring in the bays (Sieling 1958, 1959, 1960; Cerco and others, 1978; Allison 1975; and Fang and others, 1977). Water column studies conducted by Allison (1975) measured pH, salinity, water temperature, dissolved oxygen (DO), nutrients, chlorophyll-a, total iron, heavy metal and pesticide concentrations, turbidity, and fecal coliform bacteria. At twelve (12) sites within Isle of Wight and Assawoman Bays, Allison analyzed bottom sediments for six metals: Cu, Cr, Pb, Zn, Cd, and Hg. Although Allison concluded that the metals concentrations in the sediments were not significantly high, he did not elaborate on any relationship between sediment and water quality data.

Several studies examined the physical character of sediments from Chincoteague Bay (Bartberger and Biggs, 1970; Bartberger, 1976). These studies involved the analyses of 150 Chincoteague Bay sediments for grain size characteristics in order to determine the origin, distribution, and rates of accumulation of sediments in Chincoteague Bay. Results showed that the sandy sediments were found on the eastern margins of the Chincoteague Bay. Fine-grained sediments were located in the deeper areas and along the western shore areas. The primary source of sand was from Assateague Island in the form of overwash, aeolian transport, and sediment run-off. By comparison, sediment input from streams was minor. Based on estimated volumes of annual sediment input into Chincoteague Bay, the average sedimentation rate was calculated to be 0.3 mm per year.

Folger (1972) compiled existing data on the texture and composition of bottom sediments from 45 estuaries, lagoons, bays, and deltas of the United States. Seventeen of the study areas were on the Atlantic coast, but did not include any embayments between Chesapeake Bay and New York Harbor. Sediment characteristics examined by Folger included appearance, texture, mineral composition, and organic content. Folger correlated sediment characteristics with geologic, bathymetric, and hydrologic characteristics of the specific study basins. Folger concluded that sediment textures and distribution patterns are controlled by sediment supply and tidal range.

More recently, an assessment of Maryland's coastal bay aquatic ecosystem and terrestrial pollutant loadings into the bays was completed (UM and CESI, 1993). The assessment, based on existing information, examined data for trends in the overall quality of the bays ecosystem. Objectives of the study were to identify water quality problems and to develop strategies for the

effective management of the bay system. The study identified the upper bays (Assawoman and Isle of Wight bays), and particularly the St. Martin River, as areas exhibiting serious water quality problems as a result of several factors including poor flushing, development along the shorelines, and high nutrient loadings. Estimates of nutrient loading rates for total nitrogen, total phosphorous, total suspended solids, zinc, lead and biochemical oxygen demand were calculated to be very high for Turville/Herring Creek and St. Martin River compared to those observed for selected portions of the Chesapeake Bay and other coastal bays. However, the study pointed out that there is a general lack of information regarding the toxic contamination in the upper bays and recommended developing a baseline for priority pollutants in sediments and biota.

STUDY AREA

GEOLOGIC SETTING

The study area is located on the Atlantic coast of the Delmarva Peninsula (Figure 1a). Isle of Wight and Assawoman Bays are the two northern-most coastal bays in Maryland. Fenwick Island, part of the barrier Island/southern spit unit of the Delmarva coastal compartment (Fisher, 1967), separates the coastal bays from the Atlantic Ocean. The bays are underlain by unconsolidated Coastal Plain sediments, the upper-most 60 m of which are Cenozoic in age. Sediments of the Sinepuxent Formation are exposed along much of Maryland's coastal area from Bethany Beach, Delaware, southward to the Maryland-Virginia border and directly underlie the study area (Figure 1b). The Sinepuxent Formation was described by Owens and Denny (1979) based on information from drill holes along Sinepuxent Neck, the designated type locality for the Formation. The Sinepuxent Formation is composed of dark colored, poorly sorted, silty fine to medium sand with thin beds of peaty sand and black clay. Heavy minerals are abundant and consist of both amphibole and pyroxene minerals. All of the major clay mineral groups: kaolinite, montmorillonite, illite and chlorite, are represented. The sand consists of quartz, feldspar and abundant mica (muscovite, biotite, and chlorite). The high mica content makes the Sinepuxent Formation lithologically distinct from underlying older units (Owens and Denny, 1979).

The Sinepuxent Formation is interpreted to be a marginal marine deposit. Owens and Denny (1979) had assigned a mid-Wisconsin age (24-30 ka) to the formation based on C¹⁴ data. Later studies correlated the Sinepuxent Formation to the offshore Q2 deposits which were determined to be of oxygen-isotope Stage 5 age (between 80 to 120 ka) based on amino-acid racemization (Toscano, 1992; Toscano and others, 1989; Toscano and York, 1992).

Within the study area, the Sinepuxent is underlain by the Beaverdam Sand Formation which is Pliocene in age (Owens and Denny, 1979) (Figure 1b). The western edge of the Sinepuxent formation lies against the Ironshire Formation which consists of pale yellow to white sand and gravelly sand. Although the Ironshire Formation sits unconformably on top of the Beaverdam, at no point does it underlie the Sinepuxent Formation (Owens and Denny, 1979).

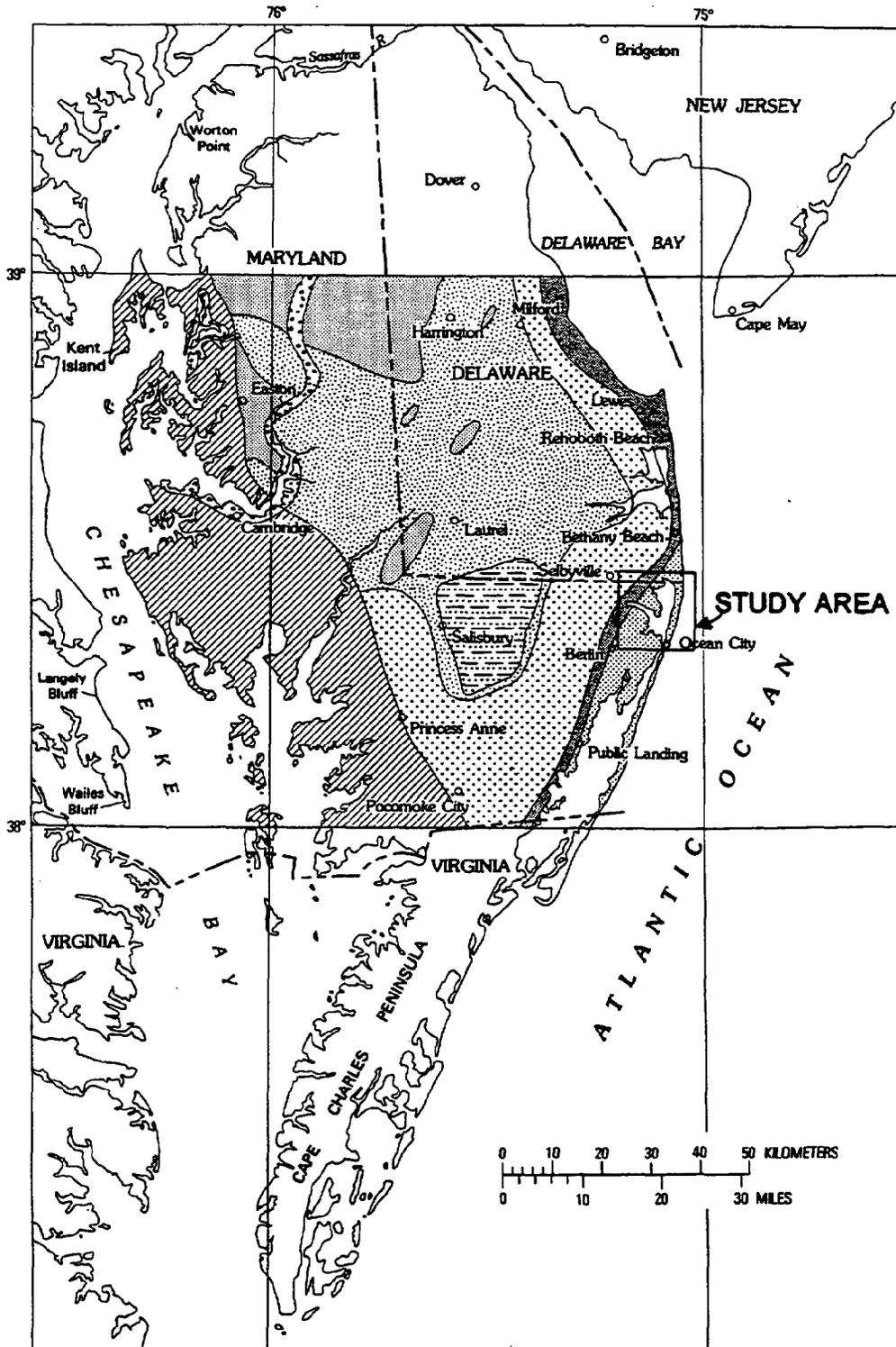


Figure 1. A) Generalized geologic map of central Delmarva Peninsula (from Owens and Denny, 1979). See Figure 1B for pattern key.

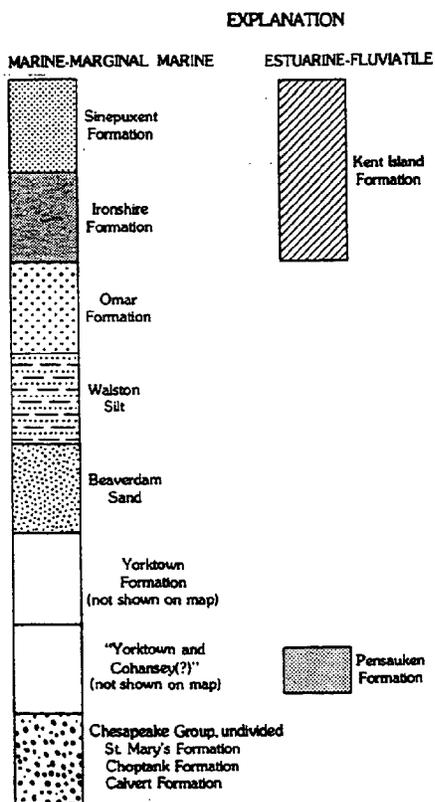
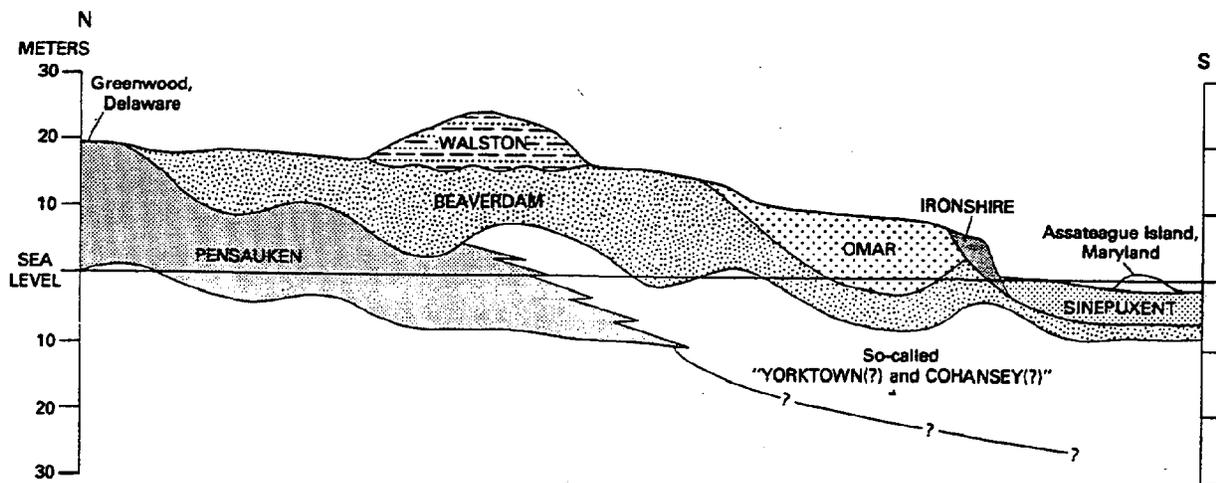


Figure 1. B) Cross-section showing stratigraphic relationship of formations (from Owens and Denny, 1979), with pattern key.

PHYSICAL CHARACTERISTICS

Assawoman Bay and Isle of Wight Bay are microtidal (<2 m tidal range) coastal lagoons and are contiguous with each other. For this discussion, the boundary between Assawoman Bay and Isle of Wight Bay is the Rt. 90 bridge which spans Fenwick Island (Ocean City at 60th Street) and Isle of Wight (Figure 2). Table I lists the basic morphometric data for both bays. The surface area statistics presented in Table I differ from those presented in the previous year (Wells and others, 1994). The differences are attributed to 1) differences in methods used to calculate areas, and 2) extent of surface areas included in the statistics. For this study, surface areas include the areal extent of the sampling which covers the lower tidal reaches of the tributaries as well as the bays themselves.

Table I. Morphometric data for Isle of Wight and Assawoman Bays. Dimension and area statistics were compiled from data from this study. Surface areas include the lower tidal reaches (i.e.- to the first major bifurcation) of the major tributaries. Drainage area values are from UM and CESI (1993).

	Assawoman Bay	Isle of Wight Bay	Two Bay System
Surface area	21.5 km ²	24.1 km ²	45.6 km ²
Maximum length	7.9 km	6.7 km	14.5 km
Maximum width	3.3 km	4.3 km	—
Drainage area	24.7 km ²	146 km ²	170.7 km ²

Assawoman Bay, the northern-most bay, has a water surface area of 19.5 km² and is elongated in north-south direction. The length of Assawoman Bay, measured from the mouth of Roy Creek to Rt. 90 bridge, is 7.9 km. Maximum width of Assawoman Bay is 3.3 km. Greys Creek and Roy Creek have a combined surface area of 1.9 km². Isle of Wight Bay has a surface area of 17.2 km². The length of this bay, from Rt. 90 Bridge to the west end of the north jetty at the inlet, is 6.7 km. Maximum width is 4.3 km. The surface area of the St. Martin River, from the mouth (at Ocean Pines) to the juncture of the Bishopville Prong and Shingle Landing Prong, is 5.4 km². The combine surface area of Turville/Herring Creek and Manklin Creek is 1.5 km².

The St. Martin River is the major tributary, accounting for 62% of the total drainage area for the bays (Bartberger and Biggs, 1970; UM and CESI, 1993). Drainage area for Isle of Wight Bay is about 6 times the area of the bay itself (Table I). On the other hand, the drainage area of Assawoman Bay is about equal (1.1 times) to its surface area. In all, the drainage area for both bays is about 4 times as large as their open water areas. For comparison, the watershed basin for the Chesapeake Bay is 28 times its open water area. As a result of the relatively small drainage area combined with flat topography, fresh water input into the two coastal bays is small. The limited fresh water input and restricted access to open ocean contribute to poor flushing of the bays (Bartberger and Biggs, 1970; UM and CESI, 1993).

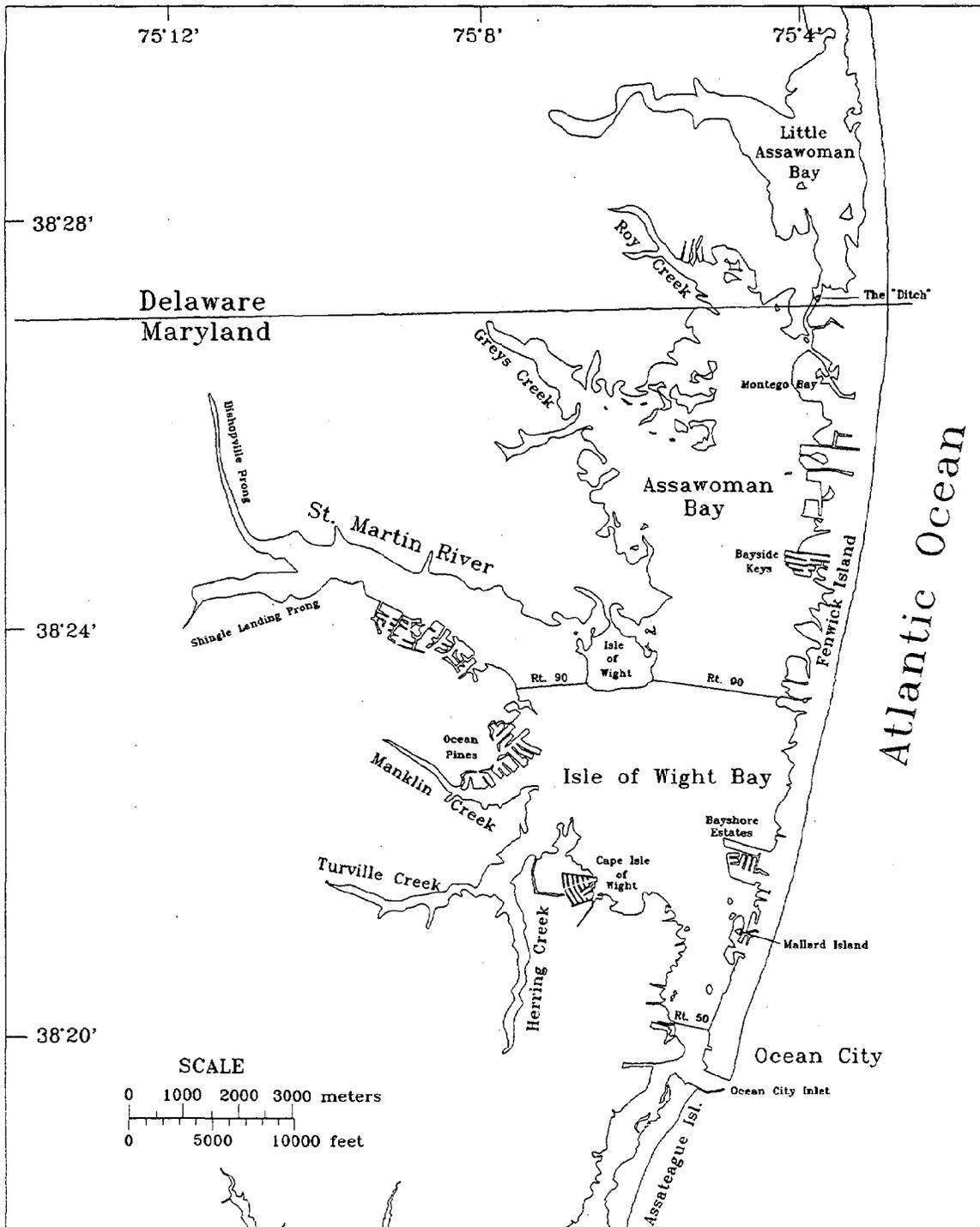


Figure 2. Study area.

The two bays are connected to the Atlantic Ocean through a single outlet, Ocean City Inlet, located at the extreme south end of Isle of Wight Bay. Ocean City Inlet had formed during a hurricane in 1933 and was immediately stabilized by jetties to keep it opened.

Historically, several other inlets have been documented along Fenwick Island (Truitt, 1968). These inlets also formed during storms as did the Ocean City Inlet, but were eventually filled in as a result of natural processes. During the March 1962 storm, also known as the Ash Wednesday Storm, Fenwick Island was breached near 71st street. A channel approximately 50 ft wide was cut through to the bay (U.S. Army Corps of Engineers, 1962a). The Army Corps of Engineers immediately filled in the inlet with sand dredged from Assawoman Bay.

The bays are very shallow, the average depth less than 2 m (Figure 3). Generally, areas with depths greater than 3 m are a result of dredging. Some of the deepest areas are within the Federal Navigation Channel, which is maintained at -10 m. These deep areas are located in the southern end of Isle of Wight Bay. Other artificially deep areas include numerous dredged holes in Assawoman Bay and along the east side of Isle of Wight Bay. The material dredged from these holes were used to fill in low-lying areas on Fenwick Island for development, or used as beach fill to replenish the beach in Ocean City after the March 1962 storm. These holes vary in depth from 4.9 to 9.8 m. Another artificially deep area is within a canal known as "The Ditch", the depths of which average 4.5 m. This canal connects Assawoman Bay to Little Assawoman Bay (in Delaware).

Circulation patterns and tidal ranges in the two bays are dependent on proximity to the inlet and wind conditions. Near the inlet, currents are primarily an effect of tidal cycles. Currents over 200 cm/sec are common near the inlet and within the Federal Navigation channel. Tidal amplitudes, based on data from NOS tide stations located in southern Isle of Wight Bay, range from 0.78 to 0.55 m. Tidal influence diminishes rapidly with increasing distance from the inlet. Along the western and northern margins of the bays, wind conditions have a greater effect on water levels and current velocities.

Salinity in the two bays decreases slightly with increasing distance from Ocean City Inlet. Maximum salinity measured during the summer (Casey and Wesche, 1981) ranged from 30 ppt near the inlet to 26 ppt in Assawoman Bay just north of the Rt. 90 bridge. Salinity tends to be higher in the summer due to limited freshwater input and high evaporation.

Bordering the bays are wetlands and marshes, found mainly along the western margin. Much of the bay side of Fenwick Island has been developed at the expense of wetlands (Dolan and others, 1980). Large areas have been filled in and built up, and much of natural shoreline has been armored by bulkheads or rip-rap.

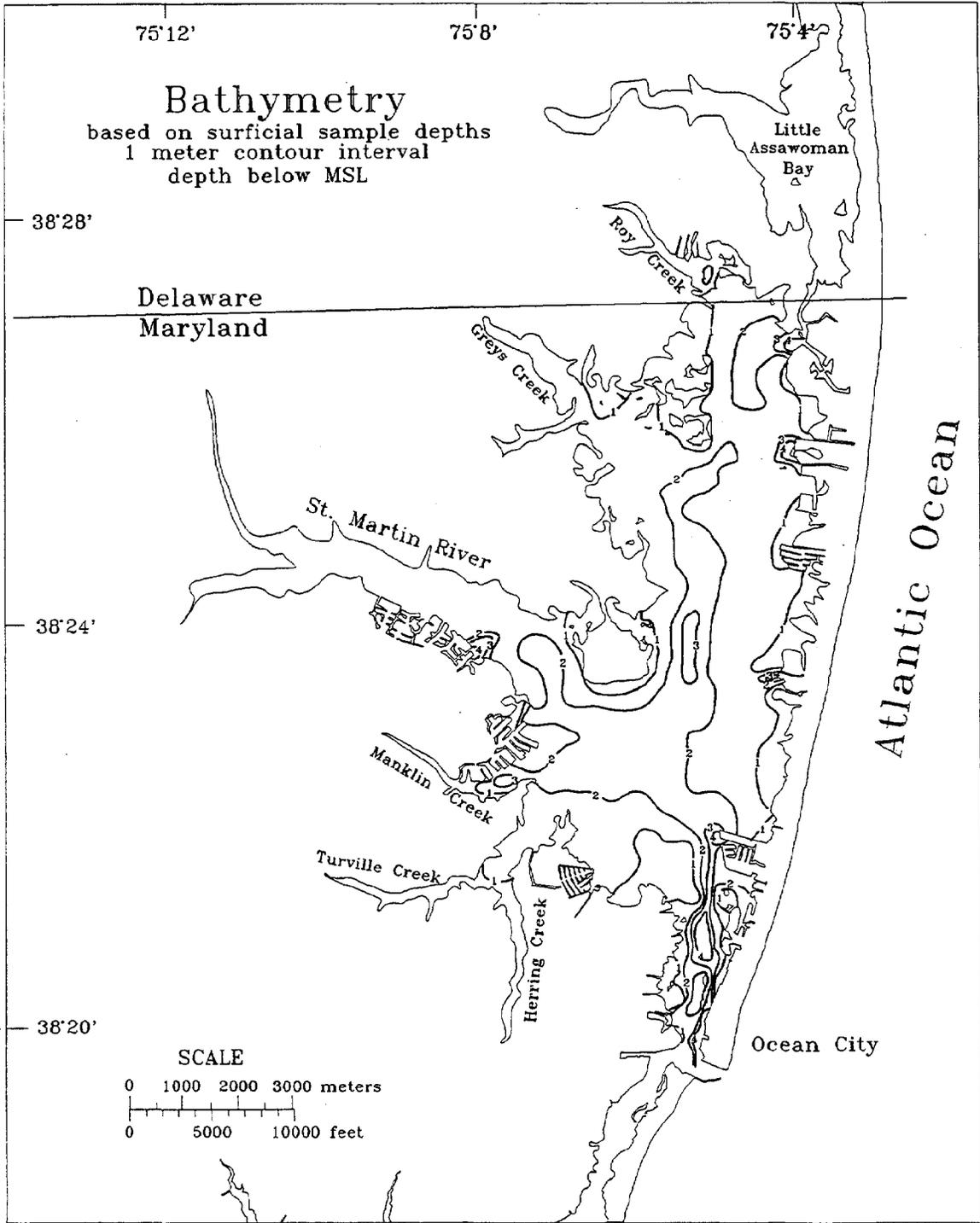


Figure 3. Bathymetry of Isle of Wight and Assawoman Bays based on surficial sample depths.

METHODS

SURFICIAL SAMPLE COLLECTION

Surficial sample collection was conducted onboard an 18 ft whaler. A Magnavox MX300 GPS system with MX 50R DGPS Beacon (U.S. Coast Guard) Receiver was used for navigation. The accuracy of the system is ± 3 to 5 meters.

A sampling grid based on 500 by 1000 meter spacing was used to determine sample locations. Sample spacing east-west across the bays was 500 meters. Longitudinally down the bays the samples were spaced 1000 meters. Bottom sediments were expected to show the greatest textural variation laterally (east-west) across the bay as opposed to longitudinally along the bays axes. In order to adequately document these changes, the tighter spacing laterally across the bays was adopted. An even tighter sampling spacing was used in the southern end of Isle of Wight Bay where abrupt changes in textural composition of sediments were anticipated due to the flood tidal delta feature and the Federal navigation channel. Samples were collected in the major tributaries approximately every 500 meters and as far upstream as the first stream bifurcation. Sample locations are shown in Figure 4. Latitude and longitude for each stations are presented in Appendix I (Table X).

Sediment samples were collected using a hand operated stainless-steel dredge sampler which sampled a bottom surface area of 19 cm x 14 cm. Upon collection, the samples were visually described and then placed in Whirl-Pak™ bags. Field descriptions of the samples are presented in Appendix I (Table XI).

LABORATORY ANALYSES

Textural Analyses

Sediment samples were analyzed for water content and grain size (SAND, SILT, CLAY content). Water content was calculated as the percentage of water weight to the weight of the wet sediment using equation 1.

$$\% \text{Water} = \frac{W_w}{W_t} * 100 \quad (1)$$

where: W_w is the weight of water; and

W_t is the weight of wet sediment.

Water content was determined by weighing 30 to 50 grams of sediment, drying the sediment at 65°C, and then reweighing the dried sediment. Dried sediments were saved for chemical analyses (see **Chemical Analyses** section).

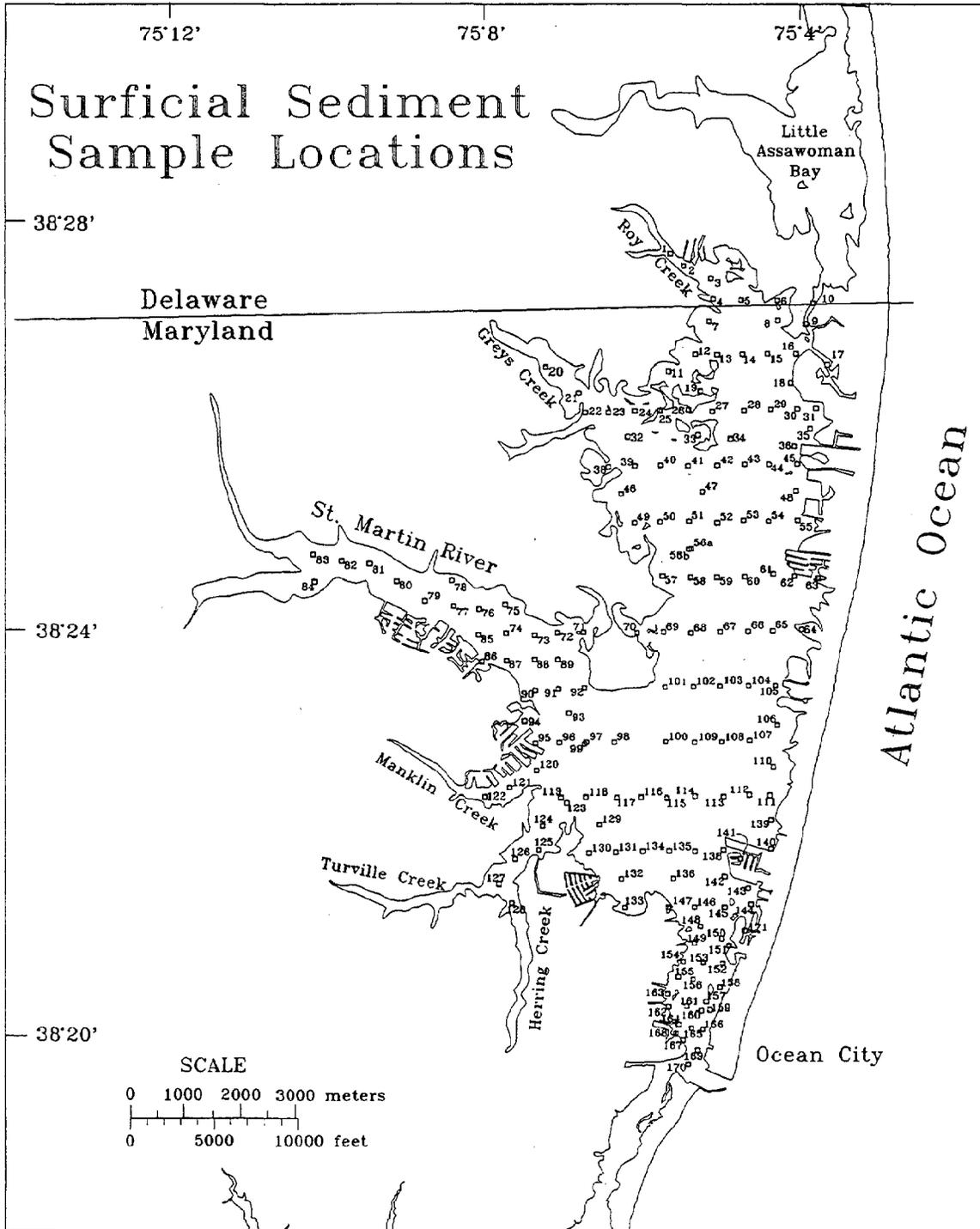


Figure 4. Surficial sample locations.

SAND, SILT and CLAY contents were determined using the textural analysis detailed in Kerhin and others (1988). Sediment samples were first treated with 10% solution of hydrochloric acid (HCl) to remove carbonate material such as shells and then treated with a 6 to 15% solution of hydrogen peroxide (H₂O₂) to remove organic material. The sediments were then passed through a 62 micron mesh sieve separating SAND from the mud (SILT + CLAY) fraction.

Mud fractions were analyzed using a pipette technique to determine SILT and CLAY contents. Weights of the SAND, SILT and CLAY fractions were converted to relative proportions (weight percentages). The sediments were categorized according to Shepard's (1954) classification based on percent SAND, SILT and CLAY components.

The results of the textural analyses are listed in Appendix II (Table XII).

Chemical Analyses

Sediments dried for water content determination were analyzed for total elemental nitrogen, carbon and sulfur contents and six metals. The dried sediments were pulverized in tungsten-carbide vials using a ball mill, then placed in Whirl-Pak™ bags, and stored in a desiccator.

Nitrogen, Carbon, and Sulfur Analyses

The sediments were analyzed for total nitrogen, carbon and sulfur (NCS) contents using a Carlo Erba NA1500 analyzer. Approximately 10 to 15 mg of dried sediment were weighed into a tin capsule. The exact weight (to the nearest µg) of the sample was recorded. To enhance complete combustion during the analysis, 15 to 20 mg of vanadium pentoxide (V₂O₅) were added to the sediment.

The sediment sample, contained in a tin capsule, was dropped into a combustion chamber where the sample was oxidized in an atmosphere of pure oxygen. The resulting combustion gases, along with pure helium used as a carrier gas, were passed through a reduction furnace to remove free oxygen and then through a sorption trap to remove water. Separation of the gas components was achieved by passing the gas mixture through a chromatographic column. A thermal conductivity detector was used to measure the relative concentrations of the gases.

The NA1500 Analyzer was configured for NCS analysis using the manufacturer's recommended settings. As a primary standard, 5-chloro- 4-hydroxy- 3-methoxy-benzylisothiourea phosphate was used. Blanks (tin capsules containing only vanadium pentoxide) were run at the beginning of the analyses and after 12 to 15 unknowns (samples) and standards. Replicates of every fifth sample were run. As a secondary standard, a NIST reference material (NIST SRM #1646 - Estuarine Sediment) was run after every 6 to 7 sediment samples. Table II presents the comparisons of the MGS results and the certified values for total carbon, nitrogen and sulfur contents for the NIST standard. There is excellent agreement between the NIST values and MGS's results.

Table II. Results of nitrogen, carbon, and sulfur analyses of NIST-SRM #1646 (Estuarine Sediment) compared to the certified or known values. MGS values were obtained by averaging the results of all SRM analyses run during this study.

Element Analyzed	Certified Values* (% by weight)	MGS Results (this study)
Nitrogen	0.211	0.18 ±0.04
Carbon	1.72	1.67 ±0.08
Sulfur	0.96	0.99 ±0.08

* The value for carbon is certified by NIST. The sulfur value is the non-certified value reported by NIST. The value of nitrogen was obtained from repeated analyses inhouse and by other laboratories (Haake Buchler Labs and U.S. Dept. of Agriculture).

Metal Analyses

Sediments were analyzed for six metals: chromium (Cr), copper (Cu), iron (Fe), manganese (Mn), nickel (Ni), and zinc (Zn). These metals were selected for several reasons. 1) These metals are non-volatile. As opposed to volatile metals, these metals are less likely to be lost during analytical procedures used in this study. 2) Studies have shown that these metals can be used as environmental indicators (Hennessee and others, 1990; Hill, 1984; Cantillo, 1982; Sinex and Helz, 1981). 3) Comparable data for these metals are available for the Chesapeake Bay (Cantillo, 1982; Helz and others, 1982; Hill and others, 1985; and Sommer and Pyzik, 1974) and for other estuaries (Sinex and Helz, 1981).

Concentrations for the six metals were determined using a microwave digestion technique, followed by analyses of the digestate on an Inductively Coupled Argon Plasma unit (ICAP). The microwave digestion technique is detailed in Wells and others (1994).

A Thermo Jarrel-Ash Atom Scan 25 sequential ICAP was used for the metal analyses. The wavelengths and conditions selected for the metals of interest were determined using digested bottom sediments from the selected sites in the Chesapeake Bay and reference materials from the National Institute of Standards and Technology (NIST SRM #1646 - Estuarine Sediment; NIST SRM #2704 - Buffalo River Sediment) and the National Research Council of Canada (PACS-1 - Marine Sediment).

The wavelengths and conditions were optimized for the expected metal levels and the sample matrix. Quality control was maintained by comparing unknown samples to the 3 standard reference materials (SRM's): NIST #1646, NIST #2704, and PACS-1. SRMs and blanks were run with each set (10 to 15 samples) of unknowns. Check (calibration) standards were also run every 15 to 20 samples or approximately every hour of run time to check instrument drift. Replicates of every tenth unknown (sample) were run.

Results of the analyses of the three standard reference materials are compared to the certified values in Table III. The MGS's results indicate better than 90% recovery for all of the metals except Mn. The lower recovery values for Mn (for NIST SRM #1646 and PACS-1) may be due to incomplete digestion during sample preparation.

Table III. Results of metal analyses of standard reference materials compared to the certified values.

Metals	Certified Values			MGS Results					
	BR*	ES*	PAC*	BR*	% recovery	ES*	% recovery	PAC*	% recovery
Cr ($\mu\text{g/g}$)	135 ± 5	76 ± 3	113 ± 8	133 ± 3.9	98.3	79 ± 2.2	104.0	107 ± 2.94	94.5
Cu ($\mu\text{g/g}$)	98.6 ± 5	18 ± 3	452 ± 16	96 ± 2.2	96.8	15 ± 0.6	82.5	440 ± 8.08	97.2
Fe (%)	4.11 ± 0.1	3.35 ± 0.1	4.87 ± 0.12	3.90 ± 0.3	95.9	3.20 ± 0.3	95.8	4.45 ± 0.38	91.4
Mn ($\mu\text{g/g}$)	555 ± 19	375 ± 20	470 ± 12	572 ± 41.8	103.1	329 ± 33.2	87.8	370 ± 37.3	78.7
Ni ($\mu\text{g/g}$)	44.1 ± 3	32 ± 3	44.1 ± 2	37 ± 2.6	83.2	27 ± 2.2	85.0	36 ± 1.6	81.2
Zn ($\mu\text{g/g}$)	438 ± 12	138 ± 6	824 ± 22	420 ± 3.8	95.9	120 ± 0.7	86.8	800 ± 8.69	97.1

*BR = NIST-SRM #2704 - Buffalo River Sediment

*ES = NIST SRM #1646 - Estuarine Sediment

*PAC= National Research Council of Canada PACS-1 - Marine Sediment

Data Reduction

All statistical analyses of textural and chemical data were performed using Statgraphics Plus, Version 6.0 (Manugistics, Inc., 1992).

RESULTS AND DISCUSSION

SEDIMENT TEXTURE

Based on the textural analyses of 171 surficial sediment samples, the average textural composition of the bay bottom sediments is 54% SAND, 28% SILT and 18% CLAY. The SAND to mud ratio is nearly 1:1, similar to the findings for Chincoteague sediments reported by Bartberger (1976).

Bottom sediments include seven of the ten Shepard's (1954) classifications. Most of the samples fall in the SAND and the CLAYEY SILT classifications. The third most common sediment type represented is SILTY SAND. Table IV presents a summary of the classification of the surficial sediments.

Table IV. Summary of sediment classification and areal extent for each classification mapped in Isle of Wight Bay and Assawoman Bay.			
SHEPARD'S (1954) CLASSIFICATION	Number of samples	Percent of total samples	Areal extent of class mapped (km ²)
SAND	73	43	19.3
SILTY SAND	20	12	6.5
CLAYEY SAND	2	1	--- ^a
SANDY SILT	6	4	0.9
SAND SILT CLAY	7	4	0.3
CLAYEY SILT	52	30	14.4
SILTY CLAY	11	6	2.5
TOTAL	171	100	43.8 ^b

^a Areal extent was not calculated; less than 0.1 km².
^b Totals may not add due to rounding .

Distribution of sediment type is shown in Figure 5. The trend is an eastward (seaward) increase in grain size of bottom sediments. Sandy sediments (i.e. SAND > 75%), which cover approximately 44% of the bottom of the two bays, are found primarily along the eastern side of the bays. CLAYEY SILTS, which cover approximately 14% of the study area, are found in the tributaries and in isolated pockets associated with marshy shorelines. SILTY CLAYS are restricted to upstream areas of the tributaries. SILTY SANDS, SANDY SILTS and SAND-SILT-CLAYS are found in isolated pockets along marshy shorelines and along the boundaries between SANDS and CLAYEY SILTS. The boundary areas represent zones of mixing between

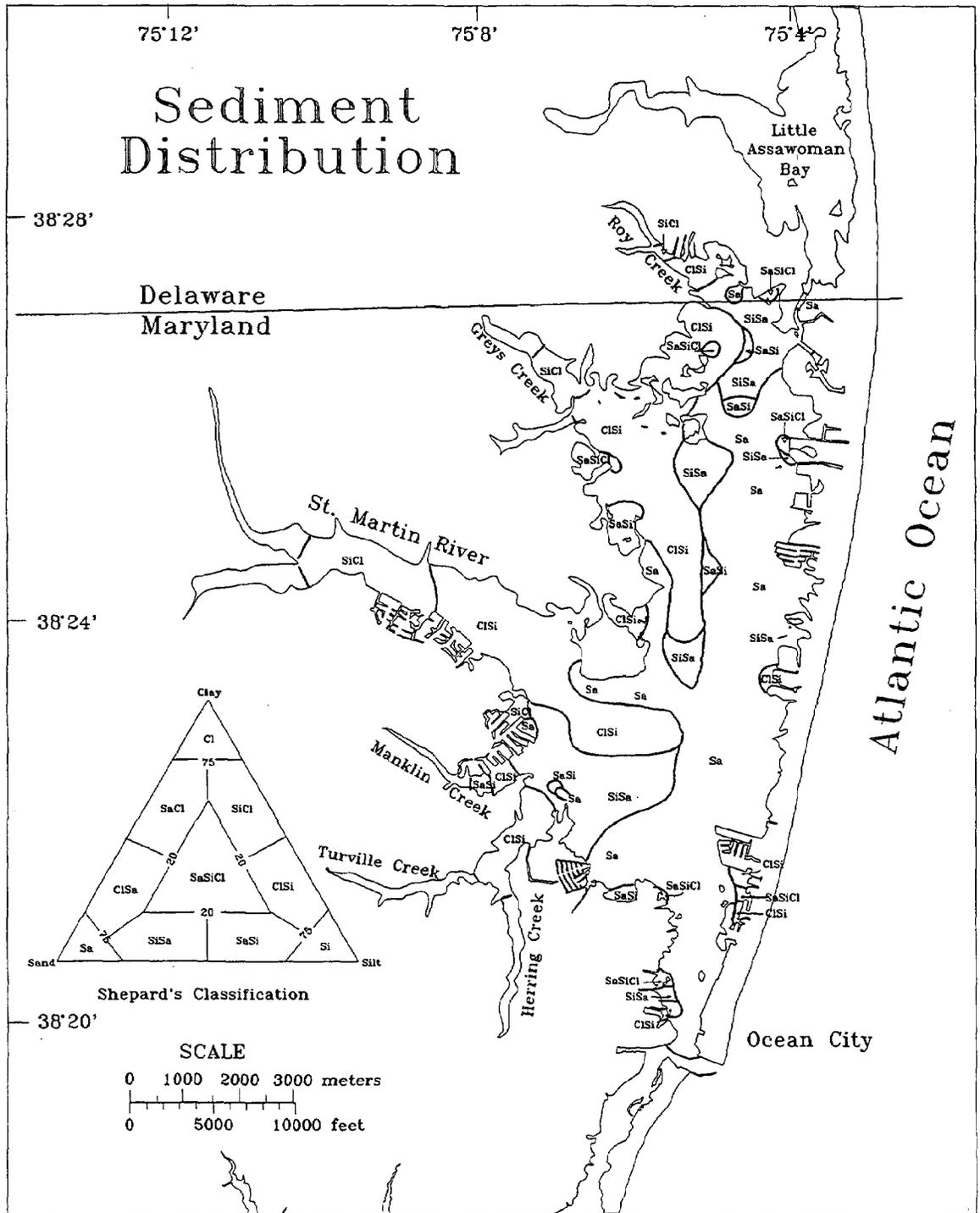


Figure 5. Distribution of sediment type based on Shepard's (1954) classification.

the coarse (SAND) and fine grained end members (SILTY CLAY and CLAYEY SILT) of the sediment distribution. However, the transition between mud and SAND dominated areas is quite abrupt for most of the bays.

Sediment distributions reflect energy environments as well as proximity to source of sediments. SAND found along the western side of the bays represents material carried across the barrier island (Fenwick Island) as washover or eolian deposits, or carried through the inlet. These areas are shallower and exposed to a relatively large fetch. The bottom in these areas are subject to higher energies from wind generated waves. Fine grained sediments either are not being deposited or are actively being winnowed from these higher energy areas. At the southern end of Isle of Wight Bay, large SAND shoals have been deposited as part of the flood tidal delta associated with the inlet at Ocean City. Based on vibracores collected on these shoals in 1981/82, the central flood tidal delta is estimated to be 4.2 m (14 ft) thick and contains medium to fine SAND (Wells and Kerhin, 1982).

The SAND dominated area around Isle of Wight is interpreted to be reworked SAND from the exposed pre-transgression surface which seismic data show outcropping in this area. This exposed surface is interpreted to represent a former footprint of a larger Isle of Wight.

Along the main stem of the bays, SAND sediments vary in thickness from several cm to more than 8 meters, gradually thinning toward the west. Estimates of thickness are based on data from a series of borings collected in 1962 by the U.S. Army Corps of Engineers (1962b). Locations of the 1962 borings are shown in Figure 6. Figure 7 shows the approximate thickness of the sandy sediments (sediments having median diameter of greater than 0.1 mm) based these borings. The boring data did not differentiate the modern SAND deposits from underlying older SAND deposits (i.e. Pleistocene sands).

Surface portions of the SAND deposits had been dredged for material to repair the beach in Ocean City after the Ash Wednesday Storm in 1962. Approximately 870,000 m³ (1.03 x 10⁶ yds³) of SAND were removed from the back bays for beach reparation (Evert, 1985; U.S. Army Corps of Engineers, 1980). Figure 8 depicts changes in bathymetry since 1962 for selected areas along the eastern side of the bays. Bathymetric changes are based on comparisons of water depths reported for the 1962 borings to those for the surficial samples collected for this study. Since 1962, selected areas, particularly along the central axis of the bays, have been deepened by dredging. Some of these areas correspond those areas where surface SAND deposits were greater than 6 m (20 ft) thick. It is assumed that most of the material excavated from the bays to repair the beach in 1962 were taken from these deepened areas. Since 1962, additional material has been dredged from the back bays, either to be used for fill to build up low lying areas for development in Ocean City, or to create channels for boat access to marinas and private boat slips.

SILTY CLAYS, and CLAYEY SILTS are confined primarily to marsh areas and tributaries. CLAYEY SILT dominated sediments are found at the lower reaches of the tributaries and at "lobes" extending from the tributaries into the main bay areas (Figure 5). SILTY CLAY sediments are found in the upper reaches of the tributaries. Sources of the fine-grained deposits are from sediments contained in surface run-off and from shoreline erosion. The study area is

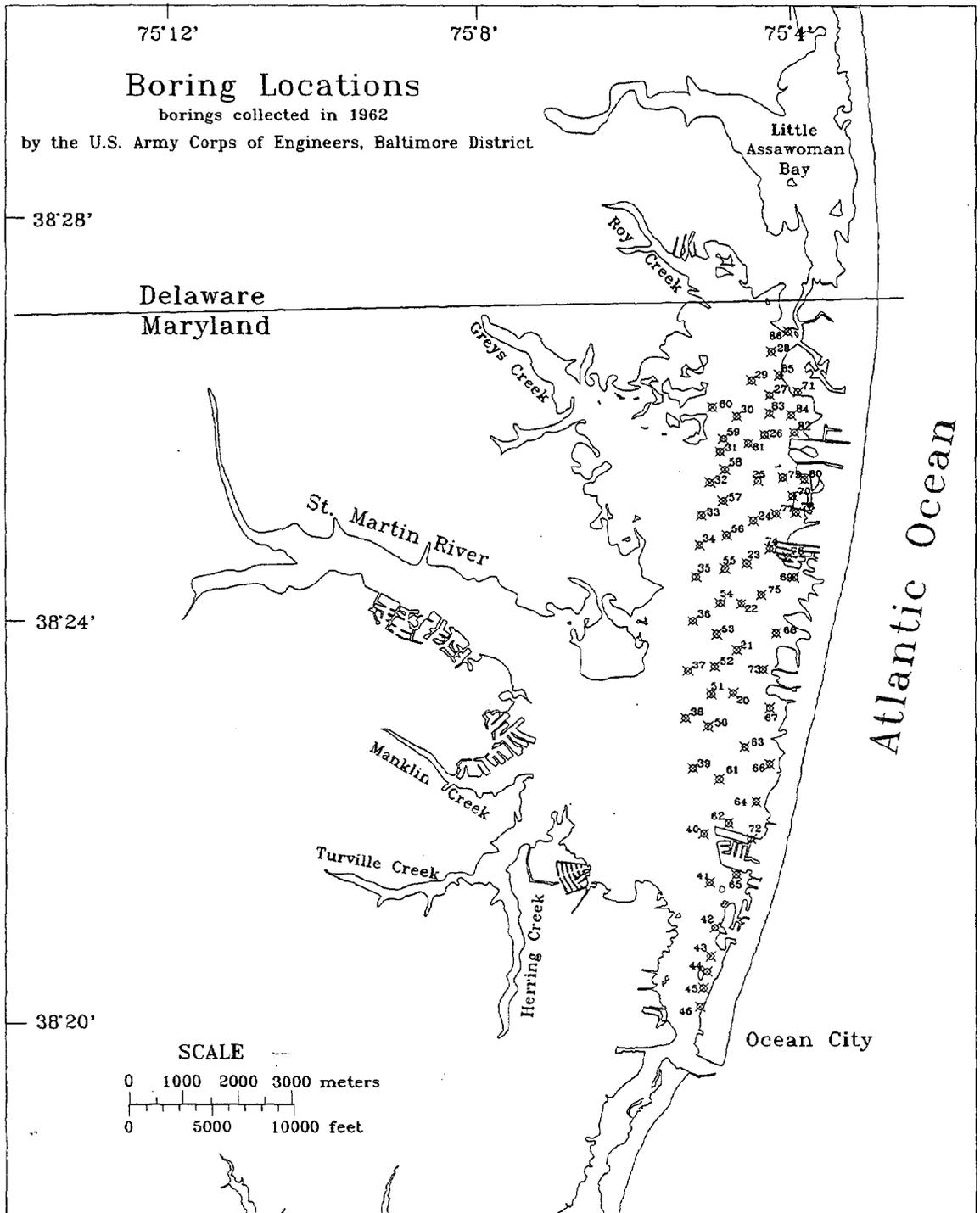


Figure 6. Location of borings collected in 1962 by the U.S. Army Corps of Engineers.

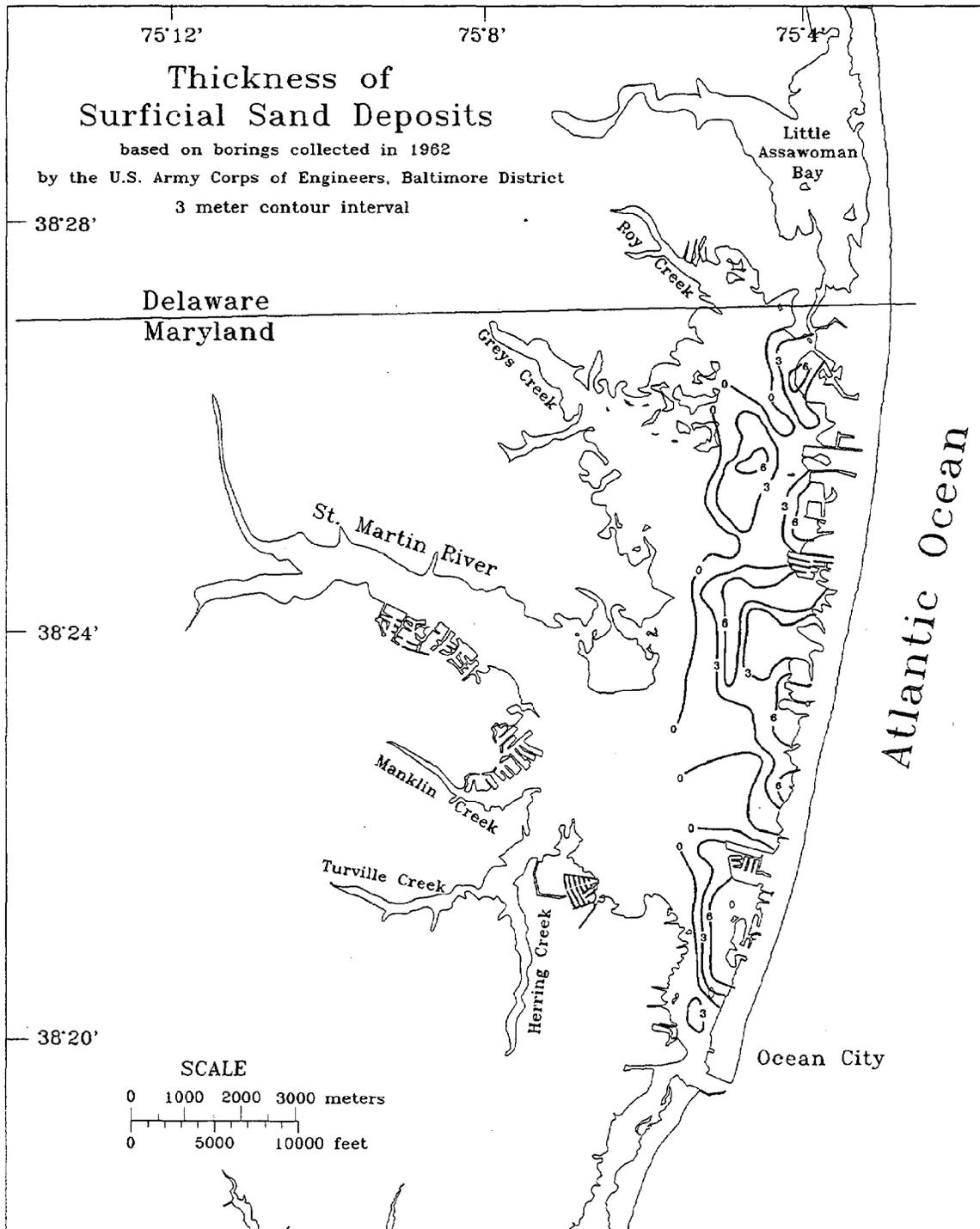


Figure 7. Thickness of the SAND sediments based the 1962 borings.

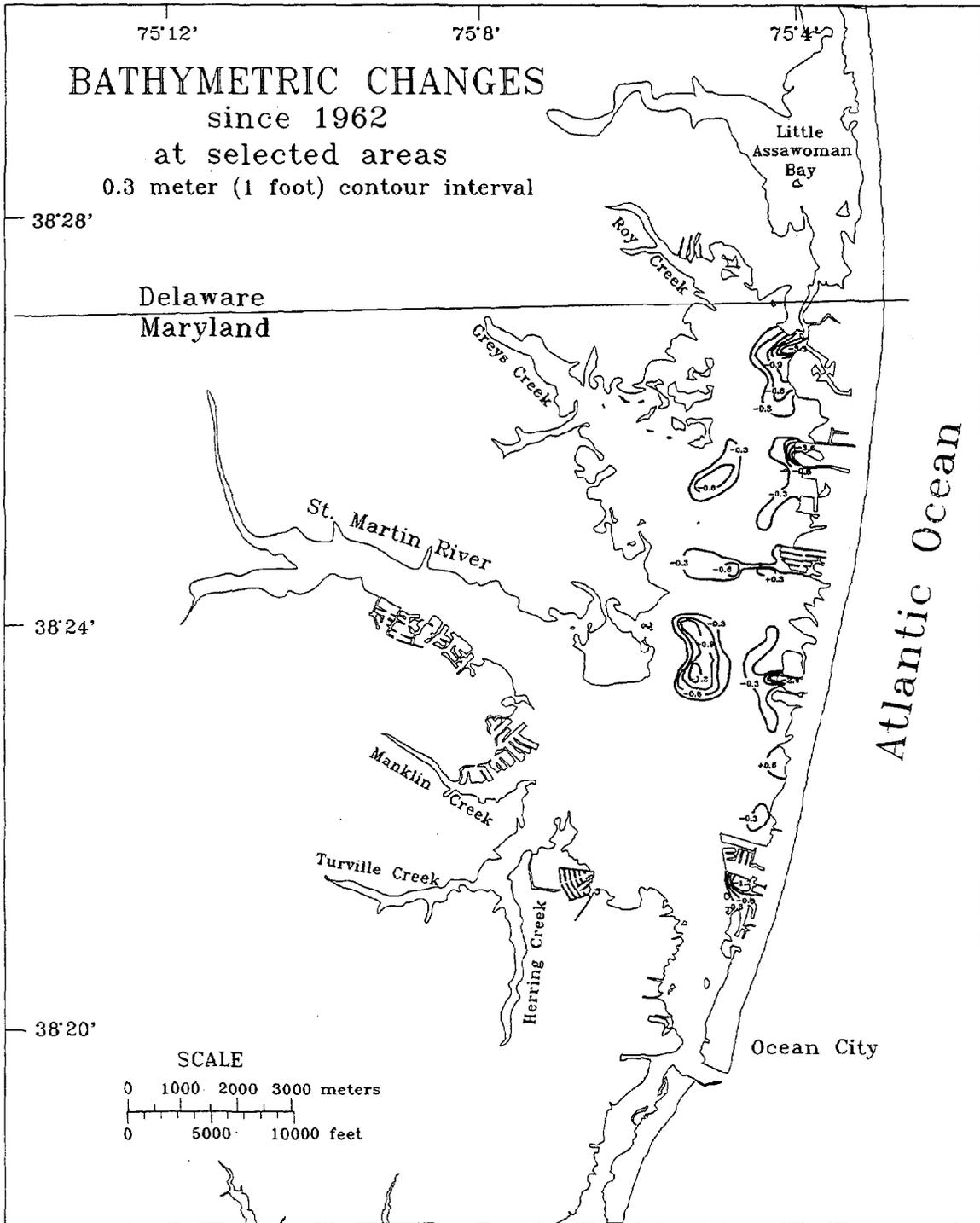


Figure 8. Bathymetric changes since 1962 at selected areas in Isle of Wight and Assawoman Bays.

underlain by the Sinepuxent Formation which was described by Owens and Denny (1979) as being sandy with layers of black clay and peat beds. During shore erosion processes, the finer grained material is selectively removed, suspended, and deposited in areas where wave action is minimal, such as in the protected marshy areas (*i.e.*- areas of limited fetch) and in deeper mid-channel areas (*i.e.*- below wave base). Based on seismic data collected during the previous year's study (Wells and others, 1994), the CLAYEY SILT deposits are estimated to be up to 5 meters thick in the area east of the mouth of the St. Martin River (due south of Isle of Wight Bay). This area corresponds to the thalweg of the St. Martin paleochannel.

WATER CONTENT

Correlation analyses of water contents as well as SAND, SILT, CLAY, carbon, nitrogen and sulfur contents for all sediment samples were performed to detect any significant associations between variables. The correlations were done using Pearson product-moment technique (Johnson and Wichern, 1982). The resulting correlation matrix is presented in Table V.

Table V. Correlation matrix for nitrogen, carbon, sulfur contents and sediment textural data based on all surficial sediment samples. Correlation analysis was conducted pairwise to include all samples and to utilize all non-missing values for each parameter whenever possible. BDL entries were treated as missing parameter values. Values listed in the table are Pearson correlation coefficients (r). Significant levels for all values are less than 0.01 (critical value of r at 99% = 0.479).

	%Carbon	%Nitrogen	%Sulfur	%H ₂ O
%Carbon	1.000	-	-	-
%Nitrogen	0.915	1.000	-	-
%Sulfur	0.964	0.852	1.000	-
%H ₂ O	0.887	0.796	0.879	1.000
%SAND	-0.814	-0.698	-0.840	-0.956
%SILT	0.665	0.541	0.698	0.873
%CLAY	0.884	0.792	0.911	0.946

The amount of water a sediment holds is strongly influenced by grain size, with fine grained sediment holding more water. The correlation coefficient values presented in Table V confirm this relationship. Water contents are strongly associated with the CLAY component of the sediment as reflected by the high correlation coefficient between percent water and CLAY content ($r = 0.95$). By the same token, water contents show a strong inverse relationship with SAND content ($r = -0.96$). Association between water content and SILT content ($r = 0.87$) is weaker.

The relationship between water contents and grain size is further exemplified in Table VI which summarizes mean values for water, nitrogen, carbon and sulfur contents for each sediment type. Water contents of SAND sediments average 21.6% while SILTY CLAY sediments have the highest water contents (maximum value = 79%).

Table VI. Summary of water content, percent nitrogen, carbon and sulfur for each sediment type.					
Sediment Type [Shepard's (1954) Classification]	Number of samples	Mean			
		Water (% wet weight)	Nitrogen (% dry weight)	Carbon (% dry weight)	Sulfur (% dry weight)
SAND	73	21.6 ±4.7	0.06* ±0.06	0.31* ±0.25	0.03* ±0.05
SILTY SAND	20	38.5 ±8.0	0.09 ±0.09	1.21 ±0.62	0.28 ±0.12
CLAYEY SAND	2	47.1 ±5.9	0.1 ±0.21	0.81 ±1.15	0.15 ±0.22
SANDY SILT	6	47.7 ±5.7	0.11 ±0.09	1.91 ±1.03	0.60 ±0.26
SAND SILT CLAY	7	55.9 ±6.7	0.24 ±0.07	2.76 ±1.03	0.72 ±0.35
CLAYEY SILT	52	59.9 ±6.7	0.25 ±0.13	3.60 ±1.49	1.17 ±0.42
SILTY CLAY	11	69.9 ±3.3	0.44 ±0.11	6.49 ±1.83	2.21 ±0.57

*Number of SAND samples used to calculate means for nitrogen, carbon, and sulfur values is 63. Ten SAND samples were not analyzed for chemistry due to the difficulty in grinding the coarser SAND particles in preparation for analyses.

GEOCHEMISTRY

Carbon

The carbon found in sediments consists of both inorganic and organic components. Studies of the Chesapeake Bay sediments have shown that inorganic carbon component is minor, contributing less than 18% to the total carbon content (Hennessee and others, 1986; Hobbs, 1983). Shell fragments accounted for the bulk of inorganic carbon measured in Chesapeake Bay sediments. Although shell fragments were often noted in the surficial samples (refer to Appendix

I for field descriptions of the sediments), they were not as abundant compared to Chesapeake Bay sediments. Therefore, it is assumed that inorganic carbon contributes little to the total carbon measured in the coastal bay sediments.

Total carbon contents measured in the surficial sediments range from 0 to 9.86% with a mean value of 2.08% which are similar to those values reported for the Chesapeake Bay (range = 0 to 10.5%; mean = 2.1%; Hennessee and others, 1986) and for other pristine estuaries (Folger, 1972). Folger observed that organic carbon contents for fine-grained sediments from estuaries not subjected to high pollution seldom exceeded 5% and were often less than 3%. However, in this study, the high carbon values (>7%) were obtained from silty clay sediments collected in the upstream areas of Roy and Greys Creek and St. Martin River. Sample 83 which was collected in Bishopville Prong of the St. Martin River contained 9.86% carbon. This sample did not contain obvious peat material or any other material that would account for the high carbon value. Some of the carbon most likely came from sources containing high organics such as run-off associated with the poultry industry and agriculture practices and discharge from sewage treatment plants (Bishopville) into the St. Martin River.

Correlation analysis reveals strong associations between carbon content and % water ($r = 0.89$) and CLAY ($r = 0.88$) (Table V), indicating that carbon content is associated with the fine grained fraction. This relationship is well illustrated in Figure 9 which presents the areal distribution of carbon content. Carbon content distribution closely follows the sediment distribution.

Nitrogen

Nitrogen contents in surficial sediments range from 0 to 0.59%, and average 0.16%. These values are lower than the mean and maximum values obtained from the cores samples from the first year study (Wells and others, 1994). The core sediments included samples containing peat which yielded very high nitrogen values (maximum contents = 1.39%). None of the surficial samples analyzed for this study contained appreciable peat material.

Results of correlation analysis of nitrogen, carbon, and sulfur contents with textural data show that nitrogen is moderately associated with CLAY content ($r = 0.792$). The highest nitrogen contents are associated with SILTY CLAYS found in upstream areas of the tributaries (St. Martin River, Greys Creek and Roy Creek).

Nitrogen content of the sediments is strongly associated with carbon content ($r = 0.915$). The strong relationship between nitrogen and carbon reflects the fact that nitrogen comes primarily from organic geopolymers found in the sediment (Hill and others, 1992). Therefore, nitrogen is expected to maintain a fairly constant proportionality with carbon content depending on the nature of the organic source. Ratios of nitrogen to carbon (N/C) range from 0.007 to 0.916 with a mean value of 0.142 ± 0.16 . The mean is slightly higher than the mean ratio of 0.113 obtained from sediment cores collected in the Chesapeake Bay (Hill and others, 1992), but is lower than the Redfield's (1963) ratio of 0.176 for planktonic organisms. The intermediate value for the ratio of nitrogen to carbon seen in the coastal bay sediments reflects a combination

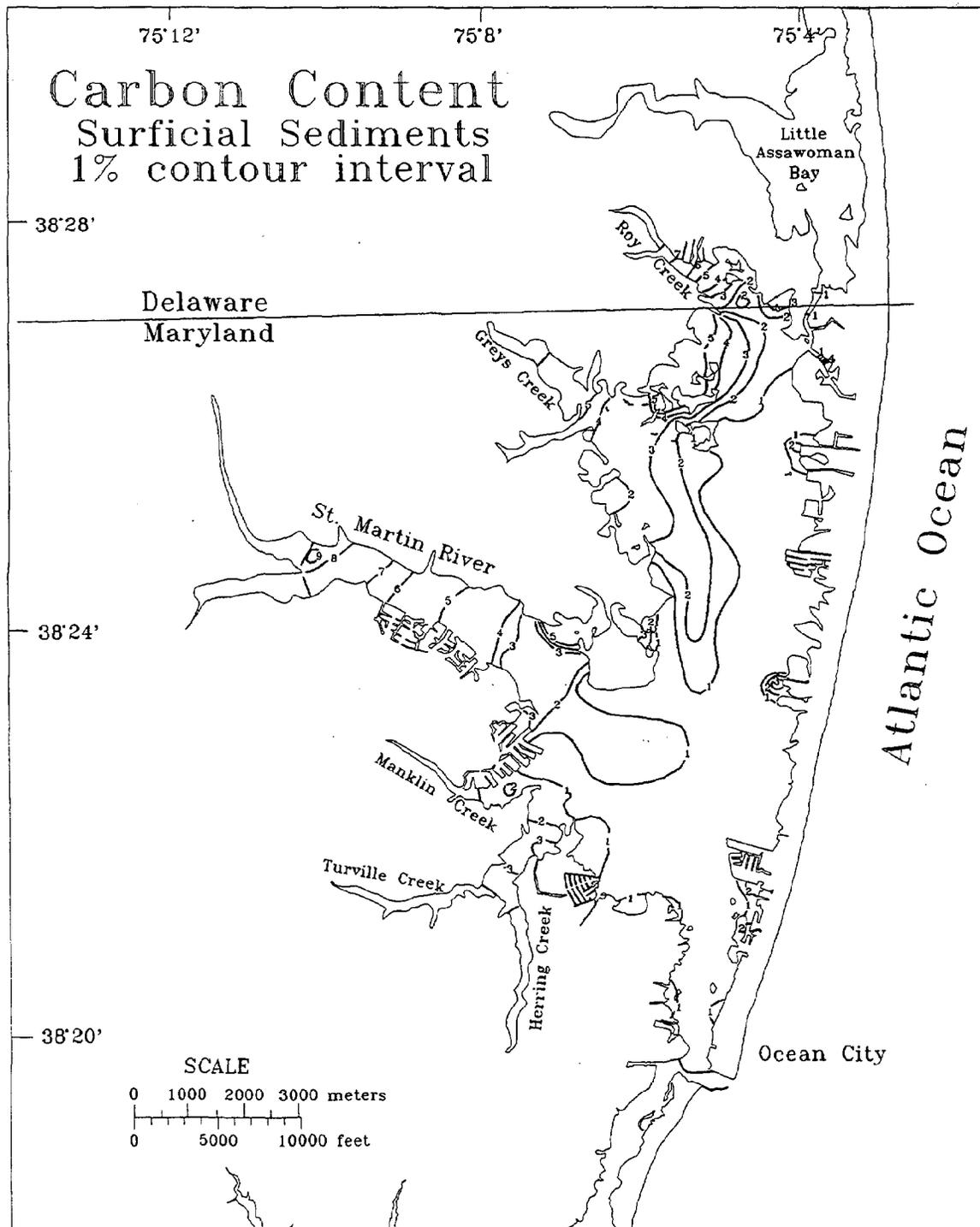


Figure 9. Distribution of total carbon content in surficial sediments for Isle of Wight and Assawoman Bays.

of organic material types contained in the sediments. N/C values for terrestrial derived carbon sources are lower than those for marine sources (Jeffrey Cornwell, Horn Point Environmental Lab- unpublished data). In the two coastal bays, N/C values are generally low (mean = 0.065) for sediments in the tributaries and along the marsh island areas between Greys Creek and Roy Creek, suggesting that nitrogen in sediments comes from terrestrial organic material, probably as cellulose plant tissue. N/C values are higher, averaging 0.177, for the sediments collected in the central portions of Isle of Wight and Assawoman Bays. In these areas plankton is most likely the primary source of nitrogen in sediments.

Nitrogen loadings into the St. Martin River were estimated to be 10 to 18 times the loadings into Assawoman and Isle of Wight Bays (UM and CESI, 1993). Although some of the highest nitrogen values were obtained from St. Martin River sediments, nitrogen contents for the river sediments average 0.36%, 2 to 3 times those values obtained from sediments collected in other portions of the study area. Furthermore, nitrogen content values are lower than expected given the high carbon content in the sediments (*i.e.*- mean N/C = 0.060). The relatively low N/C ratios may be attributed, in part, to the terrigenous source of organic material. In other words, the river sediments do not contain excessive amounts of nitrogen. This suggests that, in spite of the high nitrogen loadings for St. Martin River, very little nitrogen is being preserved in the sediments.

Sulfur

Sulfur in sediments is found primarily as inorganic metal sulfides and elemental sulfur. These sulfur species form as a result of a bacterially mediated reaction during which organic carbon is oxidized using dissolved sulfate (SO_4^{2-}) from seawater as an oxidant (Berner, 1967, 1972; Goldhaber and Kaplan, 1974). During the process that occurs under anaerobic conditions, sulfate is reduced to sulfide. The sulfide reacts with ferrous iron (Fe^{+2}) forming an iron monosulfide precipitant which further reacts with elemental sulfur to form FeS_2 (pyrite and its polymorph, marcasite) (Berner, 1970).

Total sulfur contents of the surficial sediments of the two coastal bays range from 0 to 3.16% about a mean of 0.63%. The range and mean are slightly higher than those values reported for sediments from Maryland's portion of the Chesapeake Bay (range = 0-2.0%, mean = 0.56% ;Hennessee and others, 1986) and Virginia's portion of the Chesapeake Bay (range = 0-2.0%; mean = 0.35% ; Hobbs, 1983). As with nitrogen and carbon contents, SILTY CLAYS collected in the tributaries yielded the highest sulfur contents, ranging from 1.41 to 3.16%. Distribution of total sulfur content in surficial sediments is shown in Figure 10.

Correlation analyses show a strong association between sulfur and CLAY content ($r = 0.91$) and water content ($r = 0.88$). Correlation between sulfur and SILT is weaker ($r = 0.70$). The strong correlation between sulfur and CLAY content suggests that sulfur is best preserved in clayey sediments as opposed to silty sediments. Clayey sediments typically have high water contents which accounts for the strong correlation between sulfur and water content. These results are consistent with those of the Chesapeake Bay (Hennessee and others, 1986).

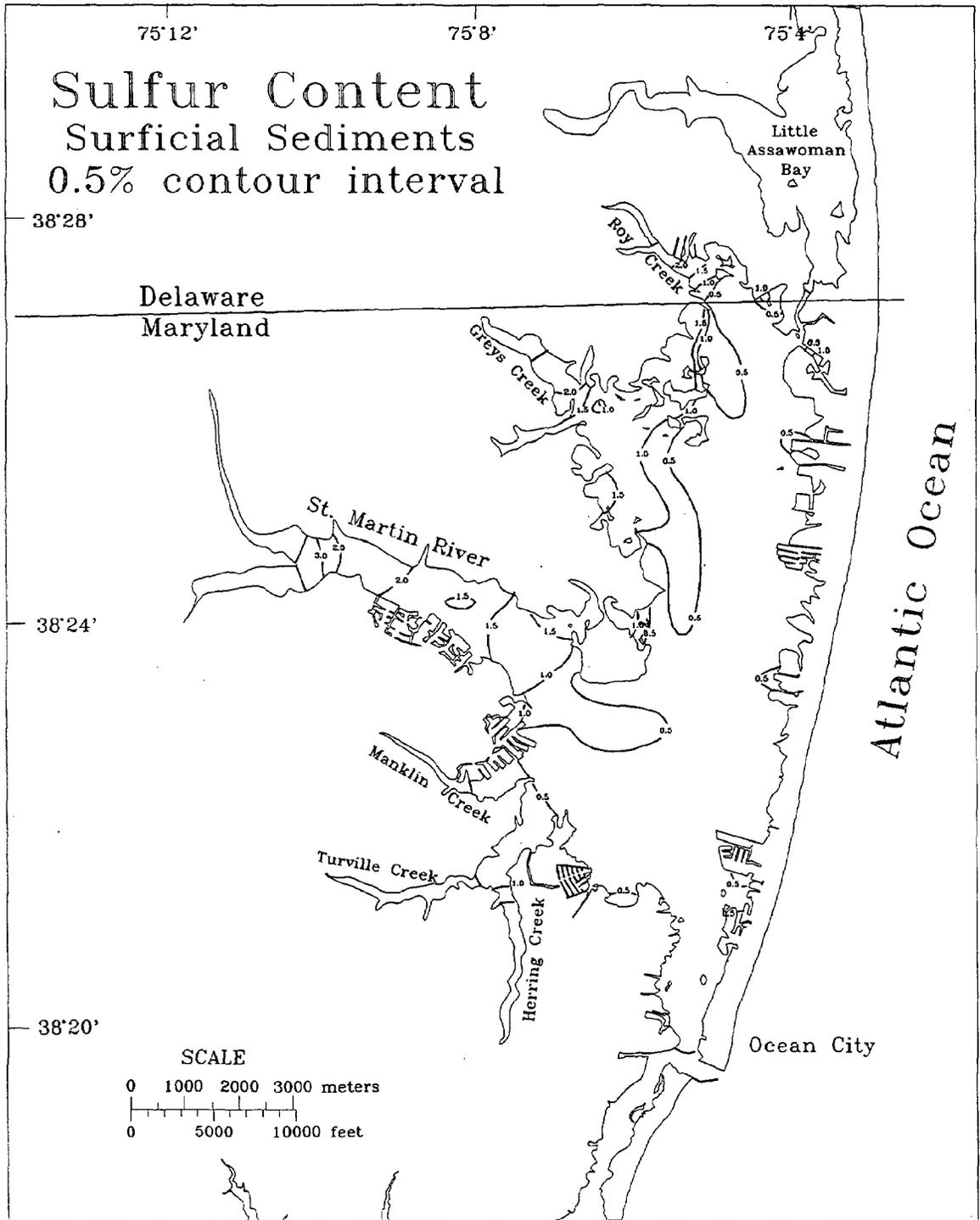


Figure 10. Distribution of total sulfur content in surficial sediments.

The ratio of carbon to sulfur (C/S) averages 3.56 ± 1.32 for all samples. This value is much higher than the C/S ratio of 2.8 (± 1.5) for modern marine sediments reported by Berner and Raiswell (1984). The higher C/S values may be related to the nature of the carbon contained in the sediments. A significant portion of the total carbon measured in many of the coastal bay sediments may be non-reactive carbon, perhaps in the form of plant detritus. Plant detritus is less susceptible to bacterial decay compared to algal debris and therefore is more likely to be preserved (Goldhaber and Kaplan, 1975). However, there is no apparent distribution pattern of the C/S ratio values as there is with N/C ratio values. If abundant plant material contributed to higher C/S values, then one would expect sediments collected in the tributaries to have high C/S values. The mean of 3.29 for C/S values for sediments collected in the marsh and tributaries is slightly lower than the mean (3.72) for main bay sediments. Abundant worm tubes as well as algae mats were noted in many of the surficial samples collected in the main bay areas. These tubes and algae may have contributed to the amount of non-reactive carbon, thus accounting for the proportionately high carbon content in these sediments.

Metals

Correlation matrix for metal concentrations, carbon, nitrogen and sulfur contents, and sediment texture is presented in Table VII. Most correlations between the variables are moderate to strong ($r > 0.7$). These correlations are similar to those calculated for the core sediments (refer to Wells and other, 1994). The highest correlations are between Fe and Cr ($r = 0.984$), Fe and Mn ($r = 0.956$) and Cr and Zn ($r = 0.953$). There are also high correlations between CLAY content and Cr, Fe, and Ni, and between water content and all six metals. These metals typically are associated with clay minerals as they are either components of the mineral lattice structure or absorbed onto clay surfaces (Cantillo, 1982). Clay minerals comprise a significantly large portion of the fine (CLAY size) sediment fraction. Likewise, all metal concentrations except Cu show a strong inverse relationship with SAND contents ($r > 0.89$).

Metal concentrations for surficial sediments are within the range of those obtained from an earlier study in the two bays (Allison, 1975). For comparison, average Zn concentrations for fine grained sediments from the Baltimore Harbor (Sinex and others, 1981; Sinex and Helz, 1982) are twice the highest concentration (see sample 83) measured in this study. Cr levels in Baltimore Harbor sediments are three times as much as the highest values obtained in this study. Therefore, it is in the opinion of the authors of this report that the levels of metal concentrations measured in the coastal bay sediments are not excessive. Unfortunately, there are no EPA action levels or threshold limits for metal in sediments at this time. Nor is there any standard method for determining significance of trace metal content in sediments. It is not within the scope of this study to determine if metal levels in sediments are detrimental to the environment. Instead, the objective is to document the existing levels of metals in the sediment, establishing a baseline with which future comparisons may be made. Because of the wide range of sediment types analyzed in the study, comparisons of absolute metal concentrations between the surficial sediments are very difficult. Therefore, several techniques for the treatment of metal data are used to account for the differences in metal concentration due to textural composition of the sediments. Once metal data are "normalized" with respect to textural differences, trends in the spatial distribution of metals are easier to realize and interpret.

Table VII. Correlation matrix for trace metal concentrations and sediment textural data based on all surficial sediment samples. Correlation analysis was conducted pairwise, to include all samples and utilize all non-missing values for each parameter whenever possible. BDL entries were treated as missing parameter values. Values listed in table are Pearson correlation coefficients (r). Significant levels for all values are less than 0.01 (critical value of r at 99% = 0.479).

	Cr	Cu	Fe	Mn	Ni	Zn
Cr	1.000	-	-	-	-	-
Cu	0.830	1.000	-	-	-	-
Fe	0.984	0.791	1.000	-	-	-
Mn	0.940	0.679	0.956	1.000	-	-
Ni	0.928	0.808	0.921	0.843	1.000	-
Zn	0.953	0.896	0.933	0.859	0.931	1.000
% SAND	-0.972	-0.760	-0.971	-0.933	-0.892	-0.910
% SILT	0.888	0.554	0.899	0.888	0.752	0.776
% CLAY	0.960	0.874	0.945	0.861	0.930	0.965
%H ₂ O	0.960	0.833	0.963	0.907	0.895	0.928
% Nitrogen	0.745	0.759	0.732	0.653	0.720	0.815
% Carbon	0.835	0.786	0.834	0.751	0.813	0.905
% Sulfur	0.868	0.789	0.863	0.768	0.840	0.927

Enrichment Factors

To reduce the effect of grain size, metal concentrations may be discussed in terms of enrichment factors (EF). The use of enrichment factors also allows for comparisons of sediments from different environments and the comparisons of sediments whose trace metal contents were obtained by different analytical techniques (Cantillo, 1982; Hill and others, 1990; Sinex and Helz, 1981).

Enrichment factor is defined as:

$$EF_{(X)} = \frac{(X/Fe)_{sample}}{(X/Fe)_{reference}} \quad (2)$$

where:

$EF_{(X)}$ is the enrichment factor for the metal X;

$X/Fe_{(sample)}$ is the ratio of the concentrations of metal X to Fe in the sample; and

$X/Fe_{(reference)}$ is the ratio of the concentrations of metal X to Fe in a reference material, such as an average crustal rock.

Fe is chosen as the element for normalizing because anthropogenic sources for Fe are small compared to natural sources (Helz, 1976). Taylor's (1964) average continental crust is used as the reference material. Average crustal abundance data may not be representative of the coastal bay sediments because there is a higher proportion of SAND in the bay sediments compared to the average crustal rock. However, abundance data is useful as a relative indicator.

Enrichment factors for the five metals in the surficial sediments are listed in Appendix II (Table XIV). The average enrichment factor values are almost identical to those calculated for the core samples for the first year study (Wells and others, 1994) and are within those values obtained for other coastal bays not subjected to industry (Sinex and Helz, 1981). The surficial bay sediments are enriched in Cr and Zn with respect to crustal rock. The average enrichment factor values for Cr and Zn are 1.31 and 2.54, respectively. Distributions of EF values for Cr indicate no discernable pattern. However, distribution for EF values for Zn show areas of higher enrichments in the tributaries ($EF > 3$).

Surficial sediments generally are not enriched in Cu, Mn, and Ni relative to average crustal rock. EF values average less than one for Cu and Ni (0.51 and 0.61, respectively) and one for Mn. The low values for Cu and Ni do not necessarily signify the area is depleted in these metals, but instead reflect the unsuitability of the reference material with respect to this particular study area (Wells and others, 1994).

Variation from Historical Norms

The "degree" of metal enrichment in sediments relative to a regional norm or historical levels can be assessed by correlating trace metal concentrations with grain size composition (Hennessee and others, 1990; Hill and others, 1990). During the first year study of Isle of Wight and Assawoman Bays, a series of shallow sediment cores were collected and analyzed for metals.

Based on the downcore decrease in enrichment factor values, metal concentrations of sediments below 30 cm in the sediment column were interpreted to represent the historical norm for the coastal bays (Wells and others, 1994). Metal concentration values for these sediments (*i.e.* sediments below -30 cm) were fitted to the following equation:

$$X = a(\text{SAND}) + b(\text{SILT}) + c(\text{CLAY}) \quad (3)$$

where:

X is the metal of interest;

a , b , and c are the proportionality coefficients determined for the SAND, SILT and CLAY components, respectively; and

SAND , SILT , and CLAY are grain size fractions of the sediment sample.

Using an algorithm developed by Marquardt (1963), least square coefficients were estimated. The results are presented in Table VIII. The correlations are excellent for all of the metals. The values for the coefficients indicate that CLAY fractions account for a significant amount of the metal concentrations.

Table VIII. Least squares coefficients for metal data. Metal concentration values for sediments sampled below 30 cm in cores collected during the first year study were fitted to Equation 3.						
	Estimates of coefficients					
	Cr	Cu	Fe	Mn	Ni	Zn
SAND	5.4905	0.97712	0.12284	37.682	3.43225	5.158017
SILT	32.8062	5.83	1.24878	166.7049	13.37438	25.15979
CLAY	173.0266	14.374	7.8523	691.4095	50.4597	127.3579
R ²	0.9505	0.9042	0.9536	0.823282	0.9006	0.92221

By substituting the least squares coefficients from Table VIII in equation 3, "predicted" metal concentrations were calculated for the 171 surficial sediments. These predicted metal concentration values represent the expected historical or background levels of metals based on grain size composition of the sediment. To determine variations from historical norms, the predicted metal concentrations were compared to the measured values using the following equation.

$$\text{Variation}_x = \left(\frac{\text{Measured}_x - \text{Predicted}_x}{\text{Predicted}_x} \right) \quad (4)$$

Negative values indicate depletion and positive values indicate enrichment relative to background levels.

Variation values calculated for core sediments below 30 cm in the sediment column were analyzed according to Gaussian statistics. Variation values for all metals exhibited near-normal distributions with mean values close to zero. Mean variation values and standard deviations for each metal are presented in Table IX. The standard deviation (σ), a measure of dispersion of values, provides a convenient means to identify significantly high or low variation values calculated for the surficial sediments. For example, in a normal distribution, 68% of the values fall within 1σ of the mean; 95.5% of the values fall within 2σ of the mean. Values greater than 3σ (3 sigma levels), are considered significant beyond the natural population dispersion.

Table IX. Mean and standard deviation (σ) of the variation values calculated for sediments below 30 cm in the sediment column. The mean and 3σ values are used to identify significantly low or high variation values.				
Metal	Mean	σ	2σ	3σ
Cr	0.01	± 0.17	± 0.34	± 0.50
Cu	-0.02	± 0.23	± 0.46	± 0.69
Fe	0.05	± 0.28	± 0.57	± 0.85
Mn	0.00	± 0.21	± 0.43	± 0.65
Ni	0.02	± 0.27	± 0.54	± 0.82
Zn	0.01	± 0.20	± 0.39	± 0.60

Variation values for each metal were calculated for the surficial sediments and are presented in Appendix II (Table XV). Variation values for Cu and Zn average close to one indicating that surficial sediments contain twice the amount of Cu and Zn over background levels (historical levels). Most variation values for Cu and Zn for surficial sediments exceed 3σ levels, and are interpreted to be significantly high values. These results agree with the results of the previous years study (Wells and other, 1994). Both zinc and copper are ubiquitous in that these two metals are commonly used in marine related industries. Zn is widely used as a sacrificial anodizing coat or plate applied to a variety of metal products that will be subjected to salt water corrosion. Copper is in the chemical compound used to impregnate wood for maine use and is used as an anti-biofouling agent in marine paints.

Distribution of Variation Levels

Variation values for Zn were mapped in terms of sigma levels and are presented in Figure 11. The distribution reveals a very interesting pattern, one that does not follow the sediment distribution. Instead, the distributions reflect anthropogenic influences within the two bays. The distribution also demonstrates the degree of sensitivity of this technique for assessing metal enrichment within the study area. For most of Isle of Wight Bay and southern Assawoman Bay, zinc is between 3 and 6 sigma levels above background. There are a few areas characterized by lower sigma level (between 0 and -3) along the eastern side of Assawoman Bay and in "the Ditch". These areas correspond to dredged areas where modern sediments have been removed, exposing older material that has not been enriched with zinc.

Another area marked by low sigma levels is evident near the inlet. The zero-sigma level contour outlines the Federal navigation channel. In this area, relative enrichment of zinc is minimized by several factors. 1) The Federal channel is periodically dredged by the Army Corps, removing sediment contaminated with zinc. 2) Strong tidal currents flush the area, preventing the deposition of zinc contaminated sediments.

High variation levels for zinc were calculated for sediments collected in the St. Martin River. Values fall between 6 and 9 sigma levels. Sediment sample #83, collected in the Bishopville Prong of the river, yielded a variation value 11.8 sigma levels above background. These variation values indicate that the fine-grained sediments in the St. Martin River act as a sink for zinc. Other studies have identified the St. Martin River as receiving a considerable Zn loading (as well as other pollutants) (UM and CESI, 1993).

There are several other areas characterized by high Zn variation values ($>6 \sigma$ levels) but the sediments are not as fine-grained as those found in the St. Martin River. These areas are adjacent to marinas and developments having a large number of boat slips (*i.e.*- Cape Isle of Wight and Bayside Key - refer to Figure 2 for locations). The elevated zinc levels in sediments are most likely related to the high boat activity in these areas. These developments usually contain dead-end canals and marina basins which normally have restricted circulation, thus allowing contaminants to accumulate in the sediments. Interestingly, the sediments in most of these areas are not particularly fine grained, but are SAND and SAND-mud mixtures. There are two "hot spots", characterized by exceedingly high variation levels (up to 12-15 σ levels). One hot spot (defined by samples 107, 111, 113, 139 and 140) is located north of Bayshore Estates and bayside of the Ocean City Convention Center. The second (defined by samples 154, 155, and 156) is located on the west side of Isle of Wight Bay, opposite of Mallard Island. The sediments at both of these "hot spots" are classified as SAND. Variation levels for the other metals are also significantly high in sediments from these two areas. Run-off enriched in metals from the large parking lot at the Convention Center may contribute to the "hot spot" north of Bayshore Estates. At this time there is no obvious explanation for the hot spot opposite of Mallard Island. The authors theorize that there may be a local source for the metals, such as a buried barge or automobile (or auto parts).

Distribution of variation levels for Cu reveals a somewhat similar pattern (Figure 12). Variation levels generally are within 3 sigma levels for large portions of the bays. Variation

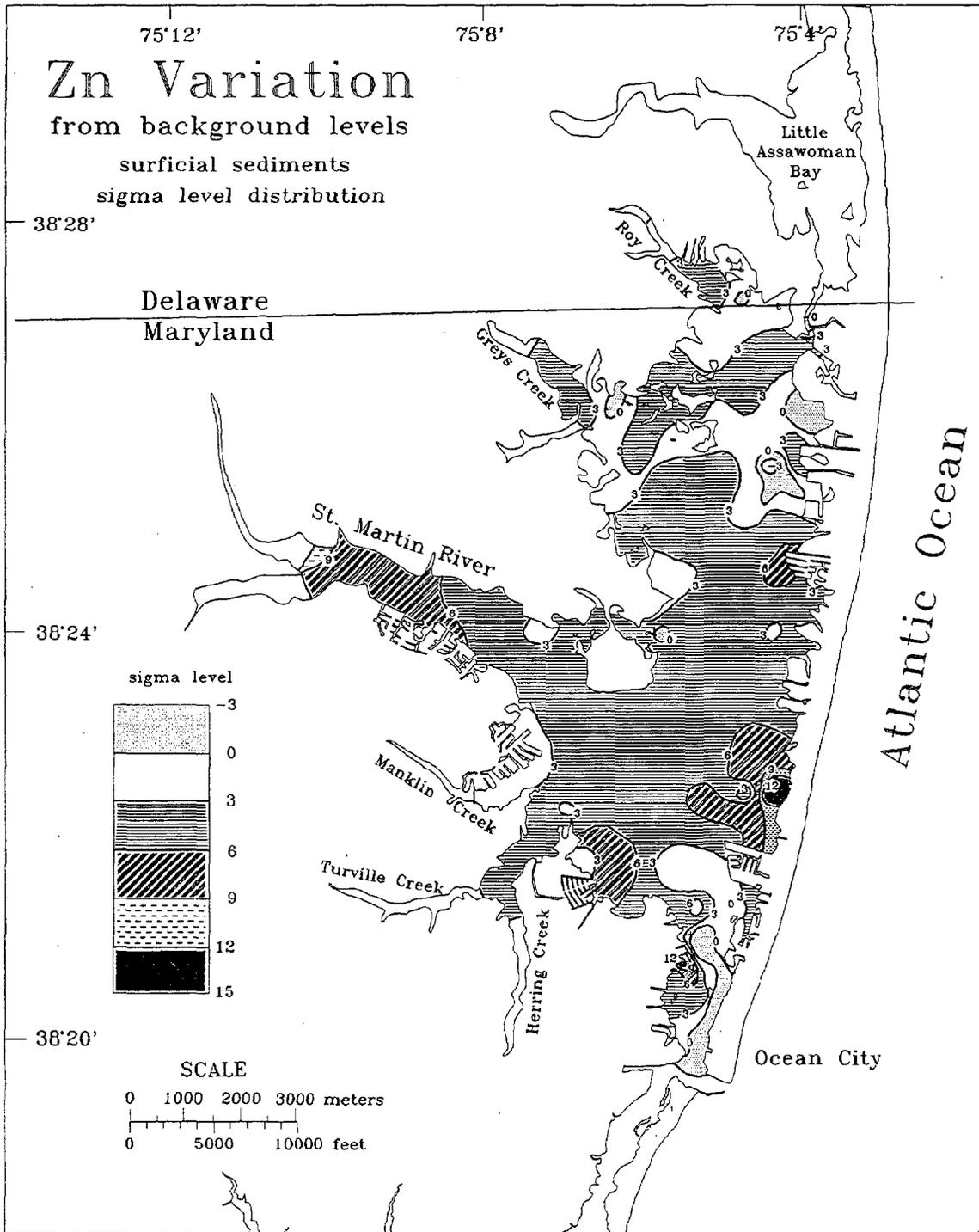


Figure 11. Distribution of sigma levels for Zn variation from background levels in surficial sediments.

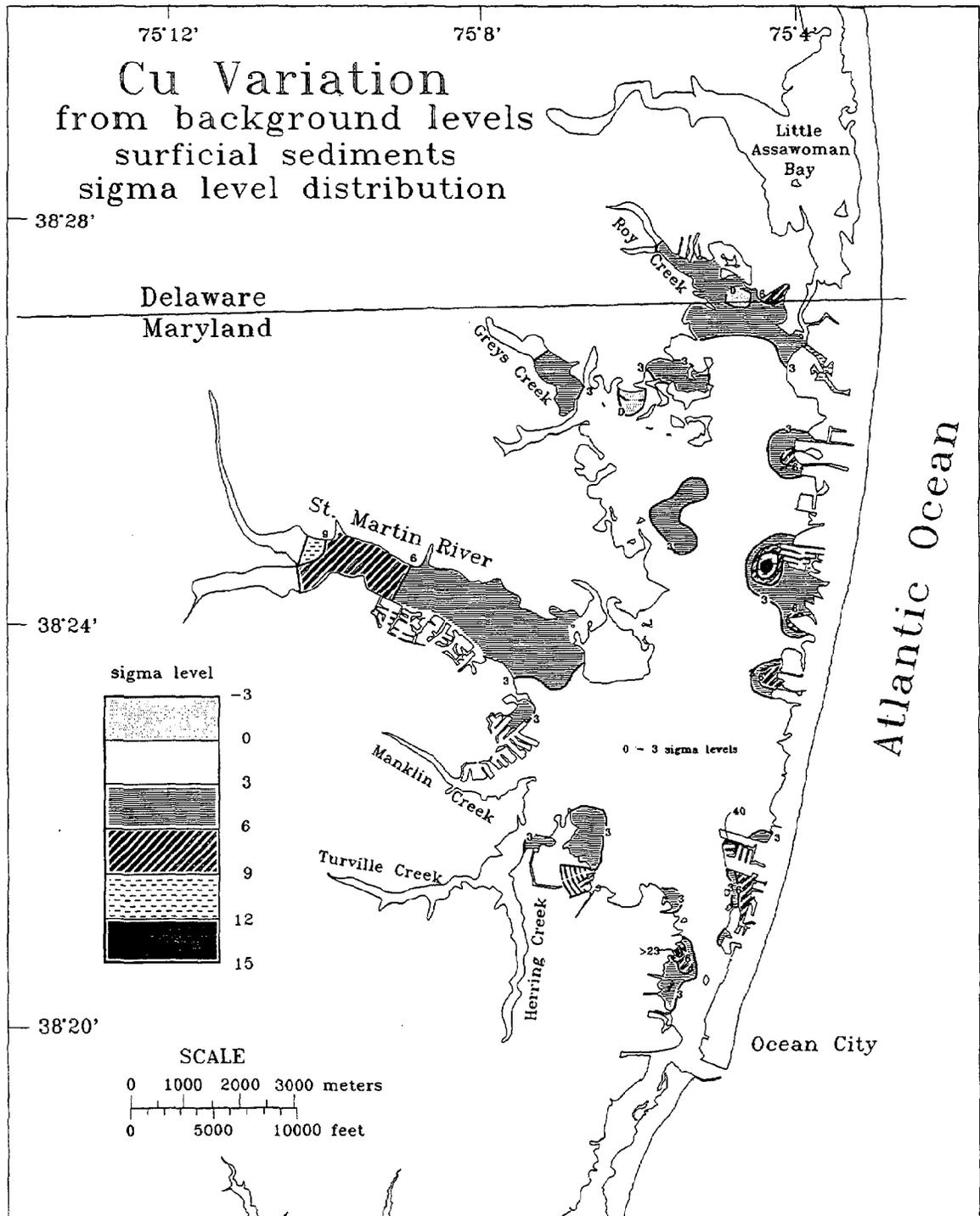


Figure 12. Distribution of sigma levels for Cu variation from background levels in surficial sediments.

levels are greater than 3 sigma levels for the fine-grained sediments collected in Greys and Roy Creeks and are even higher (6 to 9 σ levels) in the upstream area of the St. Martin River. Along the bay side of Fenwick Island and in southern Isle of Wight Bay are several pockets of high Cu variation levels, several of which correspond to the high Zn areas. Many of these pockets are adjacent to developed shorelines with man-made canals and a large number of boat slips. Copper leachates from marine paint and wooden bulkheads (constructed with chromated-copper-arsenate treated wood) accumulate in the sediments at the bottom of these poorly flushed canals. Some of the highest sigma levels were obtained from sediments collected either in canals (stations 17, 141, and 171), or within a meter from wooden bulkheads (stations 63 and 140).

The sigma levels for Cr, Fe, and Mn are less than 3 σ levels for most stations. Sigma levels for Ni are even lower, within 1 to 2 σ levels. However, sediments collected at 17 stations yielded significantly high variation values (>3 σ levels) for both Fe and Mn. Some of these sediments (stations 101, 104, 107, 111, 112, 154, 156, and 159) are located within the "hot spots" previously described. The variation levels for Cr, Cu and Zn are also high for these samples. The high variation values for the metals are attributed to contamination from a local source. The rest of the sediments having high variation levels for Fe and Mn are either randomly located (stations 18, 60, 63, 66 and 114), or concentrated along the shoaling areas in southern Isle of Wight Bay (stations 131, 134, 136, 137, 140, 146, and 148). All of these samples are classified as SAND. The SAND fractions from these samples contain higher amounts of heavy minerals compared to other surficial sediment and compared to the core sediments used in calculating the background levels. Conceivably, heavy minerals transported into the bay through the inlet would be found in concentrated pockets along the tidal shoal. The relatively higher heavy mineral concentrations contained in these sediments would account for the high variation levels of Fe and Mn over background levels.

CONCLUSIONS

The distribution of sediment types in Isle of Wight and Assawoman Bays is very similar to that for Chincoteague Bay (Bartberger, 1976) and Rehoboth and Indian river Bays (Chrzastowski, 1986). These bays correspond to Folger's (1972) category of bays having small tidal range and limited sediment input from landward sources. In these bays, the bottom is dominated by sand transported in by overwash processes, inlet related delta formations and from winnowing action by wave in shallow areas. Finer grained sediments (SILT and CLAY) are restricted to deeper channel areas and in tributaries.

Carbon, nitrogen and sulfur contents for most of the surficial coastal bay sediments are within the range expected for marine sediments. Carbon, nitrogen, and sulfur contents are strongly related to the texture of the sediments, with higher values associated with finer grained sediments. The highest values were obtained from SILTY CLAYS collected in the upstream areas of the tributaries. Very high values for carbon were obtained from several sediment samples collected in the upstream area of the St. Martin River. These high values are thought to be excessive and reflect high nutrient input in the river.

This is one of the first studies to measure total nitrogen in the sediments. Data from this

study provide some clues as to the nature of nitrogen and its cycling within the bay ecosystem. Nitrogen contents relative to carbon, expressed as N/C ratios, suggest that much of the nitrogen measured in sediments collected in the tributaries comes from terrestrial derived organic matter while nitrogen in sediments collected in main stem of the bays comes from planktonic matter. The low N/C values obtained from St. Martin River sediments suggested that, in spite of the high nitrogen loadings into St. Martin River Basin (UM and CESI, 1993), relatively little nitrogen is preserved in the sediments.

Conversely, carbon to sulfur (C/S) ratios indicate a more complex nature of the organic matter found in the sediments. C/S ratios are higher than expected for marine sediments, particularly for those sediments collected in the main stem of the bay. The high C/S ratios are attributed to sediments having a disproportionately high amount of non-reactive carbon. This carbon is not metabolized during sulfate reduction, and thus is preserved in the sediments. The non-reactive carbon is attributed to the abundance worm tubes and algae mats collected with the surficial sediments. Further analysis is recommended to quantify the amount of non-reactive carbon contained in the sediments.

Results of metal analyses yield no excessively high metal concentrations. Enrichment factor (EF) values relative to average crustal rock were calculated to be greater than one for Zn and Cr and less than one for Cu, Mn, and Ni. EF values for both Zn and Cu are highest in tributaries where fine grained sediments are deposited. The highest values are found in the upstream areas of the St. Martin River.

The low EF values, particularly for Mn, suggest that the reference material used to calculate the EF values probably does not adequately represent the sediments found in the study area. Although the reference material used is questionable, the calculated enrichment factors for Isle of Wight and Assawoman Bays are similar to enrichment factors for other Atlantic coast bays in non-industrial regions (Sinex and Helz, 1981). These results agree with those obtained from core sediment analyzed during the previous year study (Wells and others, 1994).

A second technique used to assess and compare metal levels correlates metal concentrations to textural composition. By comparing predicted metal levels based on textural composition with metal levels actually measured in the sediments, variation or enrichment over background levels may be quantified. This technique has been very successful in monitoring subtle increases in metals in bottom sediments around the Hart-Miller Island dredge disposal site in the Chesapeake Bay (Hennessee and others, 1992; Hill and others, 1990). Likewise, results from this technique has proven particularly sensitive in defining areas in Isle of Wight and Assawoman Bays that are enriched in Zn and Cu over background levels. Because Zn and Cu are used in a variety of products, particularly those related to the marine industry, these two metals are ubiquitous in many of the coastal bays (Sinex and Helz, 1981; UM and CESI, 1993). So, it is not unusual to find the surficial sediments in the bays enriched in these two metals. Although high variation levels for Zn and Cu are generally associated with fine grained sediments, even higher levels are seen in several SAND dominated areas adjacent to developed shorelines. These areas are subjected to high boating activity and usually are bulkheaded along most of the shoreline. The developed shoreline contains dead-end canals and narrow boat slips, and thus by design, have poor water circulation, which contribute to the accumulation of these

metals.

Results from this study indicate that the St. Martin River acts as a natural sink for many pollutants. Variation levels for Zn and Cu, as well as carbon, sulfur and nitrogen contents, are higher for sediments in the St. Martin River compared to those from other areas in the two bays. These higher levels may be attributed, in part, to the fine grained nature of the sediments (SILTS and CLAYS) found in the St. Martin River. On the other hand, these levels also reflect the relatively high pollutant input into the river compared to other tributaries. Studies have indicated that Isle of Wight (via the St. Martin River) receives a particularly high proportion of combined pollutant loads of the four coastal bays: 57% of current metal loadings and 50% of projected loads contributed by the Maryland Coastal Bays watershed (UM and CESI, 1993). The drainage area for Isle of Wight is 32% of the total watershed for Maryland's coastal bay system.

Assawoman Bay, by comparison, appears to be more pristine with regard to Zn and Cu enrichments. Because the watershed area of Assawoman Bay is very small compared to its surface water area, input of pollutants are minimal. Also, much of the shoreline along Assawoman Bay is natural and not developed or armored. These factors plus the fact that large areas within the main bay have been dredged, removing recently deposited (and likely enriched) sediments, result in Assawoman Bay sediments being less enriched with metals or contaminated with other pollutants.

The variation technique for assessing and evaluating metal contamination in sediment provides a useful tool in identifying areas that are sensitive to anthropogenic activities. Although results from this method cannot determine the degree of impact on other components in the bay ecosystem such as benthic population, the results may be used as indicators of where contaminated materials are being deposited. These areas may be targeted for further, more intense investigation.

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Appendix I.
Location data and field descriptions of sediment samples.

Table X. Coordinates (latitude and longitude) for surficial sediment sample locations. Coordinates are based on 1927 North American datum.

Station #	Latitude			Longitude			Comments
	DD	MM	SS.S	DD	MM	SS.S	
1	38	27	35.4	75	5	43.3	Roy Creek
2	38	27	28.2	75	5	33.1	Roy Creek
3	38	27	20.3	75	5	12.7	Roy Creek
4	38	27	8.4	75	5	10.8	Roy Creek
5	38	27	7.5	75	4	50.6	Roy Creek
6	38	27	7.1	75	4	23.3	
7	38	25	55.6	75	5	14.6	
8	38	26	55.5	75	4	22.9	
9	38	26	52.9	75	4	1.7	Station in the "Ditch", a canal connecting to Little Assawoman Bay
10	38	27	5.1	75	3	56.3	Station in the "Ditch"
11	38	26	26.2	75	5	46.1	
12	38	26	36.2	75	5	25.3	
13	38	26	35.6	75	5	9.3	
14	38	26	35.8	75	4	50.2	
15	38	26	35.6	75	4	31.3	
16	38	26	35.5	75	4	9.5	
17	38	26	28.8	75	3	46.0	In canal behind Montego Bay Trailer Park
18	38	26	18.8	75	4	13.8	Station <1 m from bulkhead at Montego Bay
19	38	26	14.6	75	5	21.9	
20	38	26	29.8	75	7	19.5	Greys Creek; station in small cove with mixed shorelines- some rip-rap, marsh and bulkheads

Station #	Latitude			Longitude			Comments
	DD	MM	SS.S	DD	MM	SS.S	
21	38	26	14.5	75	6	55.0	Greys Creek
22	38	26	2.7	75	6	50.3	Greys Creek
23	38	26	2.5	75	6	32.5	Greys Creek
24	38	26	3.3	75	6	12.4	Greys Creek
25	38	26	3.4	75	5	53.5	Station ~6 m from island
26	38	26	3.7	75	5	31.4	
27	38	26	2.2	75	5	13.4	
28	38	26	2.8	75	4	49.7	
29	38	26	3.1	75	4	29.8	
30	38	26	3.2	75	4	9.3	
31	38	26	3.2	75	3	55.1	
32	38	25	48.2	75	6	17.9	Greys Creek
33	38	25	48.8	75	5	24.5	
34	38	25	46.4	75	5	0.1	
35	38	25	51.4	75	3	59.8	
36	38	25	41.4	75	4	11.9	
38	38	25	30.4	75	6	33.3	
39	38	25	30.7	75	6	13.1	
40	38	25	31.0	75	5	53.5	
41	38	25	30.7	75	5	32.3	
42	38	25	30.5	75	5	10.3	
43	38	25	31.1	75	4	50.0	
44	38	25	30.8	75	4	31.6	
45	38	25	30.8	75	4	10.0	Station in dredged hole; 6 m water depth
46	38	25	14.3	75	6	23.9	
47	38	25	15.3	75	5	21.9	

Station #	Latitude			Longitude			Comments
	DD	MM	SS.S	DD	MM	SS.S	
48	38	25	14.8	75	4	11.4	
49	38	24	57.8	75	6	13.9	
50	38	24	34.0	75	5	54.4	
51	38	24	58.4	75	5	32.4	
52	38	24	57.2	75	5	11.0	
53	38	24	58.3	75	4	51.4	
54	38	24	57.7	75	4	32.5	
55	38	24	57.8	75	4	10.3	
56	38	24	41.8	75	5	32.4	
56	38	24	42.2	75	5	31.1	
57	38	24	14.9	75	5	53.4	
58	38	24	25.4	75	5	32.0	
59	38	24	24.9	75	5	12.1	
60	38	24	25.1	75	4	51.1	
61	38	24	26.2	75	4	29.6	
62	38	24	25.0	75	4	13.4	At Bayside Keys (88th St.); station between boat piers, ~. 0.6 m from wooden bulkhead
63	38	24	23.5	75	3	55.7	In canal at Bayside Keys; station ~ 1 m from wooden bulkhead
64	38	24	53.6	75	4	8.7	
65	38	23	53.2	75	4	30.7	
66	38	23	53.1	75	4	49.6	
67	38	23	53.0	75	5	10.1	
68	38	23	52.7	75	5	32.4	
69	38	23	53.1	75	5	53.2	
70	38	23	53.0	75	6	13.6	

Station #	Latitude			Longitude			Comments
	DD	MM	SS.S	DD	MM	SS.S	
71	38	23	53.7	75	6	54.4	St. Martin River
72	38	23	53.8	75	7	13.9	St. Martin River
73	38	23	52.6	75	7	31.2	St. Martin River
74	38	23	53.7	75	7	52.7	St. Martin River
75	38	24	10.5	75	7	53.0	St. Martin River
76	38	24	8.3	75	8	12.7	St. Martin River
77	38	24	10.0	75	8	32.3	St. Martin River
78	38	24	24.9	75	8	33.4	St. Martin River
79	38	24	13.1	75	8	54.2	St. Martin River
80	38	24	25.1	75	9	14.8	St. Martin River
81	38	24	35.7	75	9	35.3	St. Martin River
82	38	24	37.4	75	9	56.1	St. Martin River
83	38	24	41.6	75	10	17.2	St. Martin River; at junction of Bishopville Prong
84	38	24	25.4	75	10	16.5	St. Martin River; at junction of Shingle Landing Prong
85	38	23	52.9	75	8	13.7	St. Martin River
86	38	23	37.6	75	8	11.4	St. Martin River
87	38	23	38.0	75	7	52.6	St. Martin River
88	38	23	38.1	75	7	31.6	St. Martin River
89	38	23	38.0	75	7	13.9	St. Martin River
90	38	23	20.0	75	7	31.4	
91	38	23	20.6	75	7	13.9	
92	38	23	21.1	75	6	54.3	
93	38	23	6.2	75	7	6.4	
94	38	23	2.2	75	7	40.0	
95	38	22	48.8	75	7	32.0	
96	38	22	48.8	75	7	13.5	

Station #	Latitude			Longitude			Comments
	DD	MM	SS.S	DD	MM	SS.S	
97	38	22	48.8	75	6	53.6	
98	38	22	48.7	75	6	32.6	
99	38	22	47.9	75	6	55.0	
100	38	22	48.5	75	5	52.7	
101	38	23	20.9	75	5	52.6	
102	38	23	21.1	75	5	31.3	
103	38	23	21.1	75	5	11.0	
104	38	23	21.2	75	4	49.9	
105	38	23	21.1	75	4	29.4	
106	38	22	57.9	75	4	28.5	
107	38	22	48.9	75	4	49.4	
108	38	22	48.2	75	5	10.7	
109	38	22	48.2	75	5	30.8	
110	38	22	32.7	75	4	32.2	Bayside of approx. 45th St.
111	38	22	15.8	75	4	34.9	Bayside of Convention Center
112	38	22	16.1	75	4	50.6	
113	38	22	15.3	75	5	31.1	
114	38	22	15.8	75	5	31.1	
115	38	22	14.9	75	5	52.9	
116	38	22	15.4	75	6	12.4	
117	38	22	15.4	75	6	31.1	
118	38	22	15.8	75	6	54.5	
119	38	22	15.8	75	7	13.2	
120	38	22	32.5	75	7	31.3	
121	38	22	22.1	75	7	52.0	Manklin Creek
122	38	22	17.0	75	8	10.9	Manklin Creek
123	38	22	12.7	75	7	9.0	

Station #	Latitude			Longitude			Comments
	DD	MM	SS.S	DD	MM	SS.S	
124	38	21	59.3	75	7	27.2	Turville/Herring Creeks
125	38	21	45.1	75	7	30.7	Turville/Herring Creeks
126	38	21	40.1	75	7	48.7	Turville/Herring Creeks
127	38	21	25.7	75	8	1.0	Turville/Herring Creeks
128	38	21	14.6	75	7	51.4	Herring Creek
129	38	21	59.3	75	6	44.8	
130	38	21	42.7	75	6	53.0	
131	38	21	43.1	75	6	32.4	
132	38	21	27.3	75	6	28.4	
133	38	21	10.9	75	6	26.2	
134	38	21	43.3	75	6	11.6	
135	38	21	43.3	75	5	51.5	
136	38	21	27.2	75	5	48.8	
137	38	21	43.3	75	5	32.0	
138	38	21	43.6	75	5	10.6	Station ~1 m from wooden bulkhead
139	38	22	1.0	75	4	34.8	Bayside of Convention Center
140	38	21	41.7	75	4	34.8	Station within 1.5 m from green wooden bulkhead at Bayshore Estates (~32 nd St.)
141	38	21	38.4	75	4	58.1	Dead-end canal in Bayshore Estates, ~0.5 m from wooden bulkhead
142	38	21	28.3	75	5	10.0	
143	38	21	21.4	75	4	52.6	
144	38	21	12	75	4	50.6	
145	38	21	10.4	75	5	10.1	
146	38	21	10.9	75	5	32.9	
147	38	21	10.7	75	5	52.4	

Station #	Latitude			Longitude			Comments
	DD	MM	SS.S	DD	MM	SS.S	
148	38	20	59.7	75	5	28.7	Fed. Channel; 6 m water depth
149	38	20	49.9	75	5	33.4	
150	38	20	52.1	75	5	12.8	
151	38	20	48.1	75	5	7.4	
152	38	20	37.9	75	5	12.8	
153	38	20	38.5	75	5	27.2	
154	38	20	39.4	75	5	42.1	
155	38	20	30.1	75	5	46.1	
156	38	20	28.4	75	5	35.0	
157	38	20	15.4	75	5	25.2	
158	38	20	23.7	75	5	15.1	
159	38	20	10.6	75	5	22.5	
160	38	20	10.0	75	5	28.9	
161	38	20	12.9	75	5	40.1	Station on west edge of flood delta; very shallow
162	38	20	12.2	75	5	53.9	
163	38	20	19.9	75	5	54.4	
164	38	20	1.7	75	5	46.2	
165	38	19	59.6	75	5	36.8	
166	38	19	58.7	75	5	28.3	Station north of Rt 50 Bridge; on edge of Fed. Channel
167	38	19	52.7	75	5	43.2	
168	38	19	56.4	75	5	48.7	Station next to Shanty Town
169	38	19	46.6	75	5	32.3	
170	38	19	38.3	75	5	39.8	Southern most station
171	38	20	56.4	75	4	55.6	

Table XI. Field descriptions for surficial sediment samples collected in Isle of Wight and Assawoman Bays. Samples were collected on April 26, 27, 28, 29 and 30, 1993.

<u>Station #</u>	<u>Water Depth</u>	<u>Description</u>
1	0.8 m (2.5 ft)	Very thin flocculent layer on top very dark grey, almost black, thick mud; some plant material; very strong H ₂ S odor
2	0.8 m (2.5 ft)	Very thin flocculent layer on top very dark grey, almost black, thick mud; some plant material; very strong H ₂ S odor
3	1.2 m (4 ft)	Dark brown flocculent layer on dark grey mud; worm tubes; no H ₂ S odor
4	1.1 m (3.5 ft)	Brown gelatinous flocculent layer over mottled dark grey to brown sandy mud with lots of plant material
5	1.1 m (3.5 ft)	Thin brown flocculent layer on mottled grey and black muddy sand; worm tubes
6	1.4 m (4.5 ft)	Layer of green algae on flocculent layer; mottled grey-brown to black, soft, smooth mud; some plant material; slight H ₂ S odor
7	0.8 m (2.5 ft)	Dark brown flocculent layer with worm tubes; mottled black to dark grey, gelatinous mud; no odor
8	1.8 m (6 ft)	Layer of green algae on flocculent layer; mottled grey-brown to black, soft, slightly gritty mud; some plant material; worm tubes; slight H ₂ S odor
9	2.7 m (9 ft)	Layer of calcified(?) worm tubes on light brown muddy sand with some clay balls
10	3.4 m (11 ft)	Thick layer of calcified(?) worm tubes on light brown muddy sand with some clay balls
11	0.8 m (2.5 ft)	Thin grey-brown flocculent layer on dark brown-grey to black thick mud; worms

Table XI (cont.) Field descriptions for surficial sediment samples.

<u>Station #</u>	<u>Water Depth</u>	<u>Description</u>
12	0.8 m (2.5 ft)	Thin grey-brown flocculent layer on top of dark grey to black (mottled) thick mud; plant material
13	1.1 m (3.5 ft)	Dark brown flocculent layer with worm tubes; mottled black to dark grey, gelatinous mud; no odor
14	1.8 m (6 ft)	Brown flocculent layer on dark olive grey, smooth mud
15	1.8 m (6 ft)	Brown flocculent layer with algae on dark olive grey, soft mud; worm tubes; no H ₂ S odor
16	4.3 m (14 ft)	Greenish-brown algae on dark brown, gritty, soupy mud; lots of worm tubes
17	5.2 m (17 ft)	No flocculent layer; black mud; very strong H ₂ S odor
18	0.8 m (2.5 ft)	Grey-brown and dark grey, slightly muddy sand; some shell fragments; worm tubes
19	0.8 m (2.5 ft)	Thin brown flocculent layer on sticky, dark brown-grey to black mud; some tube worms; strong H ₂ S odor
20	0.6 m (2 ft)	Thin brown flocculent layer on top; dark grey, cohesive, gritty mud; slight H ₂ S odor
21	0.9 m (3 ft)	Thin, speckled brown flocculent layer; dark grey, watery mud; no H ₂ S odor
22	0.9 m (3 ft)	Thin brown speckled flocculent layer on top dark grey, almost black, gelatinous, watery mud; worms; very strong H ₂ S odor
23	0.8 m (2.5 ft)	Thin grey-brown flocculent layer on top with small, live clams; grey gritty mud with brown peat; lots of plant material; H ₂ S odor
24	0.9 m (3 ft)	Thin brown flocculent layer on dark grey to black, mottled, smooth mud; oxidized worm tubes
25	0.9 m (3 ft)	Dark green, very soupy mud with lots of plant material; no detectable H ₂ S odor

Table XI (cont.). Field descriptions for surficial sediment samples.

<u>Station #</u>	<u>Water Depth</u>	<u>Description</u>
26	0.6 m (2 ft)	Thin dark brown flocculent layer over dark grey cohesive mud; worm tubes; H ₂ S odor
27	1.2 m (4 ft)	Thick dark brown-grey flocculent layer with worm tubes; mottled black to dark grey mud with sand; no H ₂ S odor
28	1.8 m (6 ft)	Dark reddish-brown flocculent layer on mottled brown-grey to black mud; plant material; no H ₂ S odor
29	1.8 m (6 ft)	Dark brown to dark grey-black muddy sand; worm tubes; small crabs and one oysterdrill (gastropod)
30	1.1 m (3.5 ft)	Medium brown, medium to fine sand; some dark grey sand mixed in
31	0.5 m (1.5 ft)	Brown-grey, medium to fine sand; worms and worm tubes
32	1.2 m (4 ft)	Very thin flocculent layer; dark olive-grey, very watery, somewhat gritty mud; H ₂ S odor
33	0.6 m (2 ft)	Brown flocculent layer on top; mottled dark grey and brown-grey sandy mud; worm tubes; no H ₂ S odor
34	1.5 m (5 ft)	Brown flocculent layer on brown muddy sand; zones of reduced black muddy sand around plant matter; worm tubes
35	0.6 m (2 ft)	Brown oxidized sand on top of medium grey, slightly muddy sand; algae strings
36	2.7 m (9 ft)	Brown gelatinous flocculent layer on dark green sandy mud; strong H ₂ S odor; worm tubes
38	0.9 m (3 ft)	Speckled, grey to brown flocculent layer on top; dark grey, almost black, very watery mud; oxidized worm tubes throughout giving mud a mottled appearance
39	1.5 m (5 ft)	Dark grey, almost black, gelatinous mud; first grab had SAV (grass) and large worm tubes on top; no H ₂ S odor

Table XI (cont.) Field descriptions for surficial sediment samples.

<u>Station #</u>	<u>Water Depth</u>	<u>Description</u>
40	1.5 m (5 ft)	Brown flocculent layer on top; dark grey, almost black, cohesive mud; worm tubes sticking out of the top surface; no H ₂ S odor
41	1.5 m (5 ft)	Brown flocculent layer on dark green-brown sandy mud; oxidized worm tubes
42	1.8 m (6 ft)	Brown flocculent layer on medium grey sandy mud; worm tubes; no odor
43	1.8 m (6 ft)	Brown flocculent layer on dark olive-grey sandy mud
44	1.1 m (3.5 ft)	Light brown grading down to medium grey fine sand; worm tubes; slight H ₂ S odor
45	5.5 m (18 ft)	Dark brown flocculent layer on dark grey gritty mud; slight H ₂ S odor; some plant material
46	1.2 m (4 ft)	Very thin flocculent layer on top; dark grey, slightly gritty, cohesive mud; worm tubes and live worms; no H ₂ S odor
47	2.1 m (7 ft)	Brown flocculent layer on dark brown-grey mud with fine sand; some black reduced areas; no odor
48	1.5 m (5 ft)	Brown flocculent layer with worm tubes; grey and black fine sand; worm tubes and algae; very slight H ₂ S odor
49	1.2 m (4 ft)	Brown flocculent layer on top; dark green-grey mud; brown peat at bottom; mud has some shell fragments; worm tubes; H ₂ S odor
50	1.5 m (5 ft)	Very thin flocculent layer on top; dark olive-grey, gelatinous mud; no odor
51	1.8 m (6 ft)	Very thin flocculent layer on top; dark olive-grey, smooth mud; no odor
52	1.5 m (5 ft)	Dark brown flocculent layer on brown-grey fine sand
53	1.2 m (4 ft)	Brown fine sand on top of grey, very fine sand; worm tubes and algae; slight H ₂ S odor

Table XI (cont.). Field descriptions for surficial sediment samples.

<u>Station #</u>	<u>Water Depth</u>	<u>Description</u>
54	1.5 m (5 ft)	Brown flocculent layer on grey-brown muddy sand
55	0.6 m (2 ft)	Clean tan to brown fine sand; worm tubes
56a	2.1 m (7 ft)	Dark grey mud with some fine sand; worm tubes; no odor
56b	1.8 m (6 ft)	Brown flocculent layer with collapsed worm tubes; dark grey to olive-grey, slightly gritty mud; no H ₂ S odor; cottage cheese texture
57	1.5 m (5 ft)	Brown flocculent layer on top; grey-brown sandy mud; worm tubes; no H ₂ S odor
58	1.8 m (6 ft)	Dark brown flocculent layer; dark olive grey, smooth, gelatinous mud; live worms (polychaetes); no H ₂ S odor
59	2.1 m (7 ft)	Dark brown flocculent layer on top; dark olive-grey, slightly gritty mud; gelatinous worm tubes; no H ₂ S odor
60	1.2 m (4 ft)	Brown flocculent layer on top; dark grey to brown, fine sand; some organic material; worm tubes; H ₂ S odor
61	1.1 m (3.5 ft)	Grey-brown fine sand; several worm tubes
62	1.5 m (5 ft)	Brown flocculent layer over mottled, grey to black, muddy sand; grass clippings and plant material (station is in between boat piers and approximately 0.6 meter from wooden bulkhead)
63	0.5 m (1.8 ft)	Fine brown sand mottled with black sand; algae and cut grass; no odor (station is approximately 1 meter from wooden bulkhead)
64	0.5 m (1.5 ft)	Brown flocculent layer over brown-grey, slightly sandy mud; lots of plant material; strong H ₂ S odor
65	1.2 m (4 ft)	Brown, fine sand over dark grey fine sand; worm tubes; slight H ₂ S odor
66	1.5 m (5 ft)	Brown, fine sand over dark grey fine sand; worm tubes; slight H ₂ S odor

Table XI (cont.). Field descriptions for surficial sediment samples.

<u>Station #</u>	<u>Water Depth</u>	<u>Description</u>
67	1.8 m (6 ft)	Brown flocculent layer over brown-grey muddy sand; some algae; lots of worm tubes
68	2.7 m (9 ft)	Olive-brown flocculent layer over grey, sticky mud
69	1.5 m (5 ft)	Brown to grey fine sand; worm tubes
70	0.8 m (2.5 ft)	Light brown flocculent layer on top of light grey and dark grey to black mud; some plant material; worm tubes; H ₂ S odor
71	0.9 m (3 ft)	Dark brown flocculent layer over dark grey-black gelatinous mud; worm tubes; H ₂ S odor
72	1.5 m (5 ft)	Very dark brown flocculent layer on top of black to dark grey, slightly gritty mud; abundant organic matter; worm tubes; H ₂ S odor
73	*	Dark green-grey, gritty mud
74	1.5 m (5 ft)	Dark grey, slightly gritty, cohesive mud; worm tubes; odorless
75	*	Dark grey, almost black, slightly gritty mud; worm tubes; juvenile blue crab
76	*	Dark green-grey soft mud; slight H ₂ S odor; lots of worm tubes; thin layer of red algae on top
77	*	Dark green-grey soft mud; strong H ₂ S odor; lots of worm tubes; thin layer of red algae on top
78	1.2 m (4 ft)	Dark green-grey soft mud; strong H ₂ S odor; lots of worm tubes; thin layer of red algae on top
79	*	Dark green-grey soft mud; thin brown flocculent layer; red algae polychaete tubes
80	*	Dark brown-grey mud; H ₂ S odor

* Lorange (depth finder) malfunctioned; no depth sounding

Table XI (cont.). Field descriptions for surficial sediment samples.

<u>Station #</u>	<u>Water Depth</u>	<u>Description</u>
81	1.2 m (4 ft)	Dark greenish-grey, slightly gritty mud; some plant material; worm tubes; H ₂ S odor
82	*	Dark greenish-grey, slightly gritty mud; some plant material; worm tubes; H ₂ S odor
83	*	Dark grey, slightly gritty mud; lots of plant material; slight H ₂ S odor
84	*	Very dark grey, slightly gritty firm mud; strong H ₂ S odor
85	*	Dark green-grey, gritty, cohesive mud; odorless
86	5.8 m (19 ft)	Black gelatinous mud; strong H ₂ S odor; some red worms
87	1.5 m (5 ft)	Dark brown flocculent layer on top of dark olive-grey mud; worm and worm tubes; odorless
88	1.8 m (6 ft)	Dark brown flocculent layer containing collapsed worm tubes, on top of dark grey to black gelatinous mud; H ₂ S odor
89	2.1 m (7 ft)	Brown flocculent layer on top of medium grey, gelatinous, slightly gritty (fine sand) mud; worm tubes; odorless
90	1.5 m (5 ft)	Dark brown flocculent layer on top of dark grey gritty mud; some worms; H ₂ S odor
91	2.1 m (7 ft)	Dark brown flocculent layer on top of dark olive-grey, slightly gritty, mud; some worms
92	1.2 m (4 ft)	Fluffy brown flocculent layer on top of brown to grey muddy fine sand; odorless; worm tubes
93	1.8 m (6 ft)	Medium brown flocculent layer containing worm tubes, on top of firm medium brown-grey mud

* Loran (depth finder) malfunctioned; no depth sounding

Table XI (cont.) Field descriptions for surficial sediment samples.

<u>Station #</u>	<u>Water Depth</u>	<u>Description</u>
94	4.6 m (15 ft)	Reddish-brown flocculent layer on top of black gelatinous mud; strong H ₂ S odor
95	1.8 m (6 ft)	Reddish-brown flocculent layer on top of mottled grey and black fine sand; hard (calcified?) worm tubes
96	1.8 m (6 ft)	Reddish-brown flocculent layer on top of fine sandy mud; worms and worm tubes; odorless
97	1.8 m (6 ft)	Very thin brown flocculent layer on top of mottled dark grey and black mud; worms and oxidized worm tubes; odorless
98	2.1 m (7 ft)	Brown-grey flocculent layer on top of medium brown to olive thick (firm) mud with black streaks; odorless
99	2.1 m (7 ft)	Brown-grey flocculent layer on top of olive-grey mud; some grit
100	2.1 m (7 ft)	Reddish-brown flocculent layer over cohesive, dark grey mud; odorless
101	1.5 m (5 ft)	Dark brown to dark grey fine sand; slight H ₂ S odor
102	2.7 m (9 ft)	Grey-brown flocculent layer with collapsed worm tubes, over brown-grey, soft, gritty mud; grass shrimp
103	1.5 m (5 ft)	Dark brown fine sand over dark grey, almost black, fine sand; slight H ₂ S odor; few worm tubes and shell fragments; grass shrimp
104	1.1 m (3.5 ft)	Layer of dark brown, very fine sand over dark grey, very fine sand; plant material; small clam; odorless
105	3.0 m (10 ft)	Dark brown flocculent layer over mottled black and dark grey mud; plant material; H ₂ S odor; dead algae and seaweed
106	1.1 m (3.5 ft)	Medium brown fine sand over medium grey fine sand; odorless; rooted SAV on top; worm tubes; polychaetes; grass shrimp; oyster drill eggs

Table XI (cont.). Field descriptions for surficial sediment samples.

<u>Station #</u>	<u>Water Depth</u>	<u>Description</u>
107	1.4 m (4.5 ft)	Patchy reddish-brown flocculent layer on top of mottled grey and black, gritty mud; oyster drill (gastropod); odorless
108	1.2 m (4 ft)	Layered dark brown over dark grey, very fine sand; grass (SAV)
109	1.8 m (6 ft)	Brown flocculent layer containing red algae, over grey to dark grey, gritty sand; abundant worm tubes; odorless
110	0.8 m (2.5 ft)	Clean medium brown, medium to fine sand; slight H ₂ S odor
111	0.8 m (2.5 ft)	Medium brown to grey, medium to fine sand with small oxidized (lighter brown) areas; plant material; grass shrimp
112	1.5 m (5 ft)	Thin layer of reddish-brown flocculent overlying mottled medium and dark grey, gritty mud; oxidized burrows; shell fragments; worms
113	1.8 m (6 ft)	Brown flocculent layer containing jelly(fish?) masses and collapsed worm tubes, over very dark grey, gritty mud; deeper layer of medium grey mud with oxidized worm burrows
114	1.8 m (6 ft)	Medium brown muddy, very fine sand; lots of heavy minerals
115	2.1 m (7 ft)	Brown flocculent layer containing worm tubes over mottled medium to dark grey, gritty mud
116	1.8 m (6 ft)	Light grey, watery flocculent layer over medium grey-brown, slightly sandy, cohesive mud; worm burrows and casts (some oxidized); odorless
117	2.1 m (7 ft)	Light grey, watery flocculent layer over medium grey-brown, slightly sandy, cohesive mud; worm burrows and casts (some oxidized); odorless
118	1.8 m (6 ft)	Firm grey muddy sand; worm tubes, some collapsed, and live worms

Table XI (cont.). Field descriptions for surficial sediment samples.

<u>Station #</u>	<u>Water Depth</u>	<u>Description</u>
119	1.8 m (6 ft)	Reddish-brown flocculent on top of mottled dark grey and very black, slightly gritty, mud; oxidized burrows; odorless
120	1.5 m (5 ft)	Thin reddish-brown flocculent layer on top of mottled brown, grey, and black sandy mud; oxidized worm tubes
121	2.7 m (9 ft)	Brown flocculent layer with worm tubes, over medium grey-brown, slightly gritty mud; slight H ₂ S odor; worm tubes
122	0.9 m (3 ft)	Thin brown flocculent layer on top of thin (approx. 1 mm thick) black layer of mud overlying brownish-grey mud; H ₂ S odor; worms and oxidized burrows
123	1.2 m (4 ft)	Mottled dark brown to black muddy sand; worm tubes; odorless
124	1.5 m (5 ft)	Brown flocculent layer with collapsed worm tubes, juvenile clams and some live worms, on top of very dark brown to black firm, slightly gritty, mud; odorless
125	1.2 m (4 ft)	Reddish-brown flocculent layer over thin black layer over brown-grey mud; worms and worm tubes
126	1.2 m (4 ft)	Brown to medium grey flocculent on top of very thin black layer of mud, then medium grey mud; slight H ₂ S odor; worm tubes
127	1.1 m (3.5 ft)	Reddish-brown flocculent layer on top of mottled grey and black mud; collapsed worm tubes; H ₂ S odor
128	0.8 m (2.5 ft)	Patches of brown flocculent with jelly(fish?) masses on top of brown-grey, slightly gritty, soft mud; odorless
129	1.5 m (5 ft)	Olive-grey flocculent layer over olive-grey gritty mud; oyster drill; collapsed worm tubes; odorless
130	1.4 m (4.5 ft)	Brown-grey flocculent layer containing collapsed worm tubes, over dark brown-grey, slightly gritty mud; odorless

Table XI (cont.). Field descriptions for surficial sediment samples.

<u>Station #</u>	<u>Water Depth</u>	<u>Description</u>
131	1.5 m (5 ft)	Light brown fine sand over dark grey-brown fine sand; worm tubes; strong H ₂ S odor; grass shrimp
132	1.8 m (6 ft)	Thin dark brown flocculent layer over grey-brown muddy sand; some shell fragments
133	0.8 m (2.5 ft)	Light grey flocculent layer on top of dark grey, gritty mud; green leafy SAV; H ₂ S odor
134	0.6 m (2 ft)	Clean medium brown fine sand with grey streaks; shell fragments
135	0.9 m (3 ft)	Clean medium brown fine sand with grey streaks; very few shell fragments
136	0.6 m (2 ft)	Clean medium brown fine sand with grey streaks; shell fragments
137	0.9 m (3 ft)	Brown to dark grey medium sand; plant material; few shell fragments
138	3.7 m (12 ft)	Brownish-grey medium to fine sand with some silt; some shell fragments; odorless
139	1.2 m (4 ft)	Reddish-brown flocculent layer over clean mottled medium grey muddy sand
140	0.6 m (2 ft)	Light brown, fine sand; worm tubes
141	1.2 m (4 ft)	Dark brown flocculent layer over dark grey, gravelly, sandy, mud; shell fragments; algae fibers; odorless
142	1.8 m (6 ft)	Medium brown to dark grey, almost black, medium sand; H ₂ S odor
143	2.1 m (7 ft)	Medium brown flocculent layer over dark grey, smooth mud; oxidized burrows; skunk odor
144	1.5 m (5 ft)	Brown flocculent layer over dark grey, slightly gritty mud; razor clams (<i>Ensis</i>); tube worms
145	0.8 m (2.5 ft)	Medium brown-grey fine sand; some shell fragments

Table XI (cont.). Field descriptions for surficial sediment samples.

<u>Station #</u>	<u>Water Depth</u>	<u>Description</u>
146	0.5 m (1.5 ft)	Clean medium brown sand; some heavy minerals
147	0.6 m (2 ft)	Reddish-brown flocculent layer over brownish-grey, slightly gritty mud; plant material; oxidized burrows; worms; slight H ₂ S odor
148	5.8 m (19 ft)	Light brown, fine sand with some heavy minerals; fine shell hash on top
149	2.7 m (9 ft)	Light brown, medium to fine sand with some coarse, clear quartz gravel; fine shell fragments
150	2.7 m (9 ft)	Light brown, fine sand; few shell fragments
151	0.6 m (2 ft)	Dark brown flocculent layer over dark grey, gritty mud; algae; slight H ₂ S odor; shell fragments
152	5.2 m (17 ft)	Brown medium sand; abundant shell fragments (primarily mussels)
153	3.7 m (12 ft)	Light brown, slightly muddy, very poorly sorted sand; shell fragments
154	1.5 m (5 ft)	Brown, medium to coarse sand; shell fragments; worms
155	0.8 m (2.5 ft)	Brownish-grey, gritty flocculent layer containing seaweed and worms on surface, over medium grey, sandy mud; worm tubes; fishy odor; mussel shell on top
156	2.1 m (7 ft)	Grey flocculent layer over muddy fine sand, sand browner on top and gradually becoming grey toward the bottom; plant material (roots); hermit crab; shell fragments; fishy odor
157	0.3 m (1 ft)	Fine, clean sand
158	1.5 m (5 ft)	Brown medium sand; shell fragments and whole mussel shells
159	2.7 m (9 ft)	Light brown, medium sand with gravel; live clams and shell fragments (including an oyster shell); calcareous (limy?) worm tubes

Table XI (cont.). Field descriptions for surficial sediment samples.

<u>Station #</u>	<u>Water Depth</u>	<u>Description</u>
160	0.3 m (1 ft)	Mottled grey to brown fine sand; shell fragments
161	0.3 m (1 ft)	Grey-brown with black streaks muddy fine sand; roots; worm tubes and worms; fishy odor
162	0.5 m (1.5 ft)	Brown flocculent layer with green algae on top of dark grey mud; mud contains abundant algae; no odor
163	0.9 m (3 ft)	Reddish-brown flocculent layer on top of thin layer of brown gelatinous mud, over grey to black gelatinous mud; gritty grey mud at bottom of grab (-10 cm); strong H ₂ S odor; algae masses throughout sample; skunk-like odor
164	2.1 m (7 ft)	Black sandy mud; H ₂ S odor; flocculent layer on top (in spite of current); live mussels
165	5.5 m (18 ft)	Light brown, fine to medium, sand; live mussels and a few mussel shells
166	5.8 m (19 ft)	Light brown, fine to medium sand; shell fragments
167	0.5 m (1.5 ft)	Light brown, clean medium sand; shell fragments
168	2.1 m (7 ft)	Light brown, fine to medium, clean sand; shell fragments
169	4.6 m (15 ft)	Light brown, clean, medium sand; shell fragments
170	2.1 m (7 ft)	Light brown, clean, medium sand; some gravel and shell fragments
171	2.1 m (7 ft)	Dark brown flocculent layer over medium grey, smooth mud; strong H ₂ S odor

Appendix II.
Textural and geochemical data for sediment samples.

Table XII. Textural data for surficial sediment samples.

Station #	Water Content (%)	Textural Component (percent by weight)					Shepard's (1954) Class.*
		Gravel	Sand	Silt	Clay	Mud Si + Cl	
1	73.97	0.00	4.66	42.49	52.85	95.34	SiCl
2	71.46	0.00	4.38	52.15	43.48	95.63	ClSi
3	65.01	0.00	5.43	65.71	28.86	94.57	ClSi
4	51.01	0.00	71.99	18.78	9.23	28.01	SiSa
5	19.28	0.00	95.45	3.30	1.25	4.55	Sa
6	59.36	0.00	33.21	43.05	23.74	66.79	SaSiCl
7	65.72	0.00	11.22	56.89	31.90	88.79	ClSi
8	32.99	0.06	74.61	18.75	6.58	25.33	SiSa
9	17.52	0.00	74.39	20.77	4.85	25.62	SiSa
10	21.19	0.20	99.80	0.00	0.00	0.00	Sa
11	69.19	0.00	1.21	57.14	41.65	98.79	ClSi
12	67.52	0.00	4.21	57.86	37.93	95.79	ClSi
13	64.60	0.00	31.17	45.80	23.02	68.82	SaSiCl
14	57.82	0.00	5.21	67.34	27.45	94.79	ClSi
15	48.21	0.00	60.62	26.60	12.79	39.39	SiSa
16	43.14	0.00	71.95	15.45	12.60	28.05	SiSa
17	79.28	0.00	2.48	39.44	58.09	97.53	SiCl
18	30.07	12.53	85.75	1.29	0.44	1.73	Sa
19	69.18	0.00	3.32	59.66	37.03	96.69	ClSi
20	68.46	0.00	17.75	39.87	42.38	82.25	SiCl
21	68.92	0.00	1.28	48.02	50.71	98.73	SiCl
22	68.75	0.00	0.70	58.17	41.12	99.29	ClSi
23	60.87	0.00	18.12	62.38	19.51	81.89	ClSi
24	58.59	0.00	5.73	65.51	28.76	94.27	ClSi

Station #	Water Content (%)	Textural Component (percent by weight)					Shepard's (1954) Class.*
		Gravel	Sand	Silt	Clay	Mud Si + Cl	
25	60.27	0.00	15.79	49.46	34.75	84.21	ClSi
26	63.66	0.00	7.83	58.17	34.00	92.17	ClSi
27	36.38	0.00	79.43	13.56	7.01	20.57	Sa
28	49.05	0.00	35.19	46.85	17.96	64.81	SaSi
29	25.49	0.00	81.17	9.83	9.01	18.84	Sa
30	18.85	0.00	96.27	0.57	3.16	3.73	Sa
31	28.21	0.00	93.08	1.77	5.15	6.92	Sa
32	60.67	0.00	14.17	53.71	32.12	85.83	ClSi
33	27.37	0.00	85.62	7.09	7.29	14.38	Sa
34	26.07	0.00	88.16	5.78	6.06	11.84	Sa
35	22.02	0.00	90.44	2.60	6.96	9.56	Sa
36	49.31	0.00	49.44	27.91	22.65	50.56	SaSiCl
38	64.10	0.00	25.73	39.11	35.16	74.27	SaSiCl
39	61.30	0.00	2.17	59.08	38.75	97.83	ClSi
40	56.19	0.00	2.25	66.99	30.76	97.75	ClSi
41	37.38	0.00	63.61	23.12	13.27	36.39	SiSa
42	35.70	0.00	69.89	17.46	12.64	30.10	SiSa
43	21.61	0.00	86.38	5.98	7.64	13.62	Sa
44	19.56	0.00	91.80	0.63	7.57	8.20	Sa
45	43.39	0.00	67.59	18.54	13.87	32.41	SiSa
46	53.75	0.00	15.22	55.46	29.32	84.78	ClSi
47	40.14	0.00	71.70	18.09	10.21	28.30	SiSa
48	23.25	0.00	96.19	1.60	2.21	3.81	Sa
49	57.25	0.00	28.48	51.66	19.86	71.52	SaSi
50	59.68	0.00	5.95	64.49	29.57	94.06	ClSi
51	51.70	0.00	14.77	58.80	26.42	85.22	ClSi

Station #	Water Content (%)	Textural Component (percent by weight)					Shepard's (1954) Class.*
		Gravel	Sand	Silt	Clay	Mud Si + Cl	
52	18.76	0.00	98.52	1.16	0.31	1.47	Sa
53	20.46	0.00	98.44	1.02	0.55	1.57	Sa
54	22.56	0.00	92.86	4.54	2.60	7.14	Sa
55	19.18	0.00	98.81	0.96	0.23	1.19	Sa
56.1	54.48	0.00	11.50	60.58	27.92	88.50	ClSi
56.2	54.56	0.00	7.62	62.41	29.97	92.38	ClSi
57	24.94	0.00	86.80	8.28	4.92	13.20	Sa
58	54.87	0.00	10.05	62.01	27.94	89.95	ClSi
59	46.37	0.00	38.14	45.63	16.23	61.86	SaSi
60	20.70	0.00	97.34	1.84	0.83	2.67	Sa
61	30.39	0.00	89.94	5.37	4.69	10.06	Sa
62	26.48	0.00	99.34	0.47	0.18	0.65	Sa
63	20.80	0.00	98.07	1.13	0.80	1.93	Sa
64	46.45	0.00	72.21	19.97	7.82	27.79	SiSa
65	19.50	0.00	99.72	0.43	0.00	0.43	Sa
66	18.53	0.00	98.72	1.03	0.25	1.28	Sa
67	30.63	0.00	88.76	6.38	4.87	11.25	Sa
68	55.08	0.00	16.16	53.03	30.81	83.84	ClSi
69	20.46	0.00	98.29	0.90	0.81	1.71	Sa
70	55.62	0.00	3.50	63.47	33.02	96.49	ClSi
71	68.65	0.00	16.68	52.64	30.68	83.32	ClSi
72	75.19	0.00	7.68	52.42	39.91	92.33	ClSi
73	60.93	0.00	3.12	66.32	30.55	96.87	ClSi
74	61.04	0.00	3.94	56.43	39.62	96.05	ClSi
75	70.39	0.00	2.28	57.92	39.80	97.72	ClSi
76	68.53	0.00	1.94	54.88	43.17	98.05	ClSi

Station #	Water Content (%)	Textural Component (percent by weight)					Shepard's (1954) Class.*
		Gravel	Sand	Silt	Clay	Mud Si + Cl	
77	68.49	0.00	1.96	51.83	46.21	98.04	ClSi
78	64.36	0.00	2.13	50.68	47.19	97.87	ClSi
79	67.23	0.00	4.96	46.17	48.87	95.04	SiCl
80	70.25	0.00	2.71	44.07	53.22	97.29	SiCl
81	70.85	0.00	5.94	42.02	52.04	94.06	SiCl
82	74.19	0.00	3.77	35.66	60.57	96.23	SiCl
83	71.64	0.00	13.48	39.69	46.83	86.52	SiCl
84	71.10	0.00	2.74	35.30	61.96	97.26	SiCl
85	61.41	0.00	6.41	50.90	42.69	93.59	ClSi
86	74.51	0.00	4.53	48.19	47.27	95.46	ClSi
87	62.14	0.00	5.14	55.47	39.38	94.85	ClSi
88	58.25	0.00	2.64	58.61	38.75	97.36	ClSi
89	57.49	0.00	2.84	63.71	33.44	97.15	ClSi
90	53.49	0.00	12.57	61.60	25.82	87.42	ClSi
91	55.13	0.00	7.94	62.56	29.50	92.06	ClSi
92	30.25	0.00	82.41	11.74	5.86	17.60	Sa
93	52.54	0.00	4.51	67.71	27.78	95.49	ClSi
94	72.81	0.00	1.06	48.84	50.11	98.95	SiCl
95	19.67	0.00	93.79	4.16	2.05	6.21	Sa
96	30.18	0.00	61.38	29.94	8.68	38.62	SiSa
97	49.86	0.00	12.39	67.51	20.09	87.60	ClSi
98	48.14	0.00	9.58	67.10	23.32	90.42	ClSi
99	54.15	0.00	10.93	65.63	23.44	89.07	ClSi
100	55.22	0.00	14.33	55.64	30.03	85.67	ClSi
101	25.76	0.00	98.05	1.50	0.45	1.95	Sa
102	38.28	0.00	58.17	25.16	16.66	41.82	SiSa

Station #	Water Content (%)	Textural Component (percent by weight)					Shepard's (1954) Class.*
		Gravel	Sand	Silt	Clay	Mud Si + Cl	
103	19.85	0.00	99.10	0.88	0.02	0.90	Sa
104	21.13	0.00	98.47			1.53	Sa
105	69.10	0.00	14.94	43.16	41.90	85.06	ClSi
106	23.35	0.00	99.15			0.85	Sa
107	22.39	0.00	91.70	5.72	2.57	8.29	Sa
108	18.27	0.00	98.40	1.53	0.08	1.61	Sa
109	28.07	0.00	78.70	12.72	8.58	21.30	Sa
110	17.81	0.00	99.37			0.63	Sa
111	19.83	0.00	100.00			0.00	Sa
112	19.96	0.00	90.18	6.63	3.19	9.82	Sa
113	32.18	0.00	78.22	13.78	8.00	21.78	Sa
114	21.80	0.00	90.10	7.04	2.86	9.90	Sa
115	42.04	0.00	56.96	29.55	13.49	43.04	SiSa
116	35.67	0.00	53.27	33.16	13.57	46.73	SiSa
117	41.63	0.00	50.84	35.19	13.98	49.17	SiSa
118	45.50	0.00	58.33	27.90	13.76	41.66	SiSa
119	42.62	0.00	32.37	53.26	14.37	67.63	SaSi
120	25.80	0.00	65.81	28.04	6.15	34.19	SiSa
121	55.46	0.00	19.35	52.49	28.16	80.65	ClSi
122	49.18	0.00	25.15	56.02	18.84	74.86	SaSi
123	18.20	0.00	87.75	8.88	3.37	12.25	Sa
124	53.00	0.00	12.72	58.73	28.55	87.28	ClSi
125	69.51	0.00	2.83	57.90	39.27	97.17	ClSi
126	61.84	0.00	11.79	58.71	29.49	88.20	ClSi
127	66.28	0.00	4.59	59.19	36.22	95.41	ClSi
128	68.49	0.00	1.46	54.24	44.31	98.55	ClSi

Station #	Water Content (%)	Textural Component (percent by weight)					Shepard's (1954) Class.*
		Gravel	Sand	Silt	Clay	Mud Si + Cl	
129	45.60	0.00	66.32	22.36	11.32	33.68	SiSa
130	38.50	0.00	67.11	20.52	12.37	32.89	SiSa
131	21.71	0.00	95.43	3.95	0.61	4.56	Sa
132	22.78	0.39	91.33	5.54	2.74	8.28	Sa
133	41.51	0.00	37.44	51.38	11.18	62.56	SaSi
134	18.90	0.02	99.43			0.55	Sa
135	19.38	0.00	99.48			0.52	Sa
136	16.88	0.04	99.17			0.78	Sa
137	18.66	0.00	98.73			1.27	Sa
138	17.73	0.00	95.93	2.77	1.30	4.07	Sa
139	23.33	0.00	94.38	3.41	2.22	5.63	Sa
140	18.63	0.95	98.44			0.60	Sa
141	47.11	8.60	60.31	14.47	16.62	31.09	ClSa
142	24.61	0.03	98.87	0.79	0.31	1.10	Sa
143	63.39	0.00	16.06	43.50	40.44	83.94	ClSi
144	54.20	0.00	47.92	27.28	24.80	52.08	SaSiCl
145	18.72	0.00	97.66	1.47	0.87	2.34	Sa
146	21.24	0.00	97.90	1.61	0.49	2.10	Sa
147	49.21	0.00	36.90	40.91	22.19	63.10	SaSiCl
148	19.35	0.00	99.89			0.11	Sa
149	20.83	0.22	99.45			0.34	Sa
150	19.53	0.00	99.59			0.41	Sa
151	31.36	0.00	82.53	9.45	8.02	17.47	Sa
152	16.45	0.07	99.77			0.16	Sa
153	14.91	8.67	89.25	1.38		1.38	Sa
154	16.91	0.80	98.94	0.26		0.26	Sa

Station #	Water Content (%)	Textural Component (percent by weight)					Shepard's (1954) Class.*
		Gravel	Sand	Silt	Clay	Mud Si + Cl	
155	30.50	0.00	85.19	8.07	6.74	14.81	Sa
156	24.70	0.00	89.73	6.49	3.78	10.27	Sa
157	18.92	0.00	99.69	0.31		0.31	Sa
158	19.76	0.71	98.98	0.31		0.31	Sa
159	17.89	2.73	97.21	0.07		0.07	Sa
160	14.17	0.18	99.63	0.19		0.19	Sa
161	20.31	0.00	95.14	2.96	1.90	4.86	Sa
162	40.85	0.00	58.87	22.21	18.92	41.13	SiSa
163	50.69	0.00	45.30	29.41	25.29	54.70	SaSiCl
164	38.79	0.00	71.55	12.62	15.82	28.44	ClSa
165	19.59	0.00	99.59	0.41		0.41	Sa
166	13.96	1.31	98.63	0.06		0.06	Sa
167	13.84	0.34	99.60	0.06		0.06	Sa
168	16.06	0.05	99.57	0.38		0.38	Sa
169	15.37	0.11	99.87	0.02		0.02	Sa
170	17.14	0.69	99.29	0.02		0.02	Sa
171	62.17	0.00	3.16	56.53	40.32	96.85	ClSi

*Key for sediment classification in Table , based on Shepard's (1954) nomenclature:

Sa = SAND

Si = SILT

Cl = CLAY

SaSi = SANDY SILT

SiSa = SILTY SAND

ClSa = CLAYEY SAND

SaCl = SANDY CLAY

SiCl = SILTY CLAY

ClSi = CLAYEY SILT

SaSiCl = SAND-SILT-CLAY

Table XIII. Chemical data for surficial sediment samples. BDL indicates below detection limit.

Sta. #	Nitrogen	Carbon	Sulfur	Metal concentrations					
	Percent by weight			Cr (ug/g)	Cu (ug/g)	Fe (%)	Mn (ug/g)	Ni (ug/g)	Zn (ug/g)
1	0.52	7.71	2.10	77.4	17.9	3.00	312.94	22.7	100.0
2	0.47	6.72	2.22	81.5	19.7	3.33	481.84	23.8	127.7
3	0.36	4.91	1.46	68.4	18.2	2.66	281.04	16.7	103.8
4	0.21	2.63	0.55	28.2	6.9	1.20	141.06	9.1	37.7
5	0.10	0.59	0.00	8.7	2.0	0.43	90.47	5.9	7.9
6	0.32	3.71	1.10	55.9	15.7	2.45	223.01	14.3	80.6
7	0.43	5.46	1.58	81.2	16.7	3.31	331.88	22.0	108.8
8	0.10	1.26	0.24	22.4	5.3	0.96	132.65	8.4	29.3
9	0.00	0.46	0.00	2.0	BDL	0.13	117.06	BDL	4.0
10	0.00	1.16	0.00	3.2	BDL	0.12	195.50	BDL	BDL
11	0.45	5.94	1.61	86.2	17.6	3.47	383.80	24.2	125.9
12	0.45	5.83	1.68	77.8	13.5	3.24	381.10	24.1	103.8
13	0.35	4.08	0.87	58.5	10.3	2.44	248.07	17.0	75.6
14	0.31	3.21	1.00	69.1	12.9	2.83	299.06	21.6	95.5
15	0.17	1.63	0.34	39.6	6.2	1.62	214.78	10.4	54.2
16	0.16	1.35	0.22	37.6	6.3	1.46	224.68	13.7	49.1
17	0.38	4.56	1.41	86.4	35.3	3.44	268.79	31.8	151.2
18	0.03	0.24	0.10	7.0	BDL	0.32	83.35	BDL	7.9
19	0.42	5.24	1.70	78.0	15.1	3.31	370.43	24.1	112.7
20	0.43	5.30	2.26	85.2	17.4	3.61	322.68	22.2	134.8
21	0.37	5.42	2.04	96.2	18.7	4.02	413.93	27.3	144.5
22	0.40	5.09	1.86	84.6	16.7	3.21	305.40	19.7	137.1
23	0.19	3.81	0.86	42.7	4.5	3.76	364.07	10.1	44.3

Sta. #	Nitrogen	Carbon	Sulfur	Metal concentrations					
	Percent by weight			Cr (ug/g)	Cu (ug/g)	Fe (%)	Mn (ug/g)	Ni (ug/g)	Zn (ug/g)
24	0.24	3.67	1.11	68.1	10.7	2.92	288.87	16.2	95.5
25	0.44	5.60	1.19	76.5	15.3	2.93	334.24	19.4	108.3
26	0.26	4.22	1.36	73.6	12.9	3.15	309.04	19.5	104.9
27	0.09	1.02	0.19	18.6	2.5	0.87	135.74	4.1	25.1
28	0.17	1.84	0.54	48.0	7.9	1.98	248.20	12.9	65.2
29	0.09	0.65	0.11	18.4	2.8	0.76	114.82	7.0	24.0
30	0.03	0.22	0.00	4.4	BDL	0.17	44.61	BDL	3.1
31	0.00	0.25	0.04	6.2	BDL	0.29	63.80	BDL	6.4
32	0.24	3.46	1.23	70.0	11.5	2.78	289.91	21.0	98.0
33	0.04	0.66	0.15	14.9	BDL	0.74	141.29	6.3	19.1
34	0.04	0.51	0.12	13.2	BDL	0.65	133.04	3.0	16.7
35	0.01	0.45	0.08	11.1	1.4	0.47	103.87	3.7	10.7
36	0.16	2.02	0.65	55.4	12.6	2.30	261.09	17.0	77.6
38	0.25	3.75	1.21	66.1	12.5	3.91	332.29	29.9	88.1
39	0.25	3.58	1.20	82.9	15.0	3.54	385.80	22.5	117.5
40	0.15	2.65	0.96	76.4	13.0	2.76	306.35	19.3	99.3
41	0.08	1.32	0.47	35.7	5.5	1.54	196.61	7.1	44.4
42	0.05	1.09	0.31	31.6	4.7	1.26	180.09	9.0	41.5
43	0.29	0.46	0.13	17.7	1.8	0.68	102.47	3.9	22.5
44	0.00	0.15	0.05	6.2	BDL	0.24	64.30	BDL	5.3
45	0.09	1.47	0.46	40.0	9.4	1.51	165.97	12.2	51.8
46	0.18	2.76	1.77	76.1	9.7	3.49	330.10	20.1	74.9
47	0.05	0.99	0.30	34.8	5.4	1.35	182.14	8.1	42.5
48	0.02	0.24	0.09	9.3	1.5	0.36	74.79	2.1	9.0
49	0.24	3.95	1.07	53.6	8.6	2.34	272.33	15.0	68.3
50	0.22	3.13	1.04	77.6	13.7	3.10	335.73	20.9	109.4
51	0.17	2.14	0.69	64.4	11.0	2.68	291.19	11.8	86.6
52	Sand sample- was not analyzed for chemistry								
53	0.02	0.11	0.04	7.4	BDL	0.30	92.87	3.2	9.5

Sta. #	Nitrogen	Carbon	Sulfur	Metal concentrations					
	Percent by weight			Cr (ug/g)	Cu (ug/g)	Fe (%)	Mn (ug/g)	Ni (ug/g)	Zn (ug/g)
54	0.03	0.42	0.09	15.8	1.6	0.59	102.64	4.2	20.2
55	Sand sample- was not analyzed for chemistry								
56.1	0.29	2.29	0.65	73.2	13.2	2.82	308.43	21.5	95.1
56.2	0.18	2.51	0.81	74.4	14.0	2.90	304.14	21.4	100.2
57	0.06	0.60	0.11	17.4	2.3	0.69	123.89	4.3	20.3
58	0.28	2.40	0.73	74.1	11.5	2.73	306.44	19.6	89.3
59	0.12	1.36	0.42	53.9	8.7	2.17	284.98	14.0	66.6
60	0.09	0.28	0.00	12.1	1.2	0.51	108.00	BDL	13.1
61	0.07	0.60	0.06	20.7	8.4	0.73	117.96	2.4	29.0
62	0.09	0.27	0.00	6.2	BDL	0.32	88.67	BDL	5.9
63	0.12	0.31	0.00	10.1	2.3	0.45	110.95	BDL	11.4
64	0.28	2.85	0.39	28.4	7.7	1.06	162.43	6.0	39.7
65	0.11	0.19	0.00	5.9	BDL	0.29	64.40	BDL	7.6
66	0.06	0.18	0.00	10.1	BDL	0.58	157.38	3.5	11.3
67	0.08	0.67	0.01	21.4	3.2	0.87	135.05	4.3	27.1
68	0.20	2.37	0.83	80.1	13.2	2.87	315.16	20.0	96.3
69	0.08	0.17	0.00	5.4	BDL	0.34	88.92	BDL	7.0
70	0.31	3.81	1.20	73.6	11.9	2.86	282.10	21.3	97.4
71	0.35	5.53	1.63	71.1	13.7	2.90	253.61	21.8	99.1
72	0.59	8.02	1.90	72.9	18.3	2.85	243.24	23.1	123.8
73	0.18	2.97	1.28	76.2	10.3	3.04	279.58	21.0	88.7
74	0.23	3.61	1.28	86.0	15.4	3.28	314.02	24.2	121.0
75	0.40	5.77	1.61	80.0	16.9	3.03	264.23	25.8	121.9
76	0.38	4.57	1.48	87.4	19.3	3.42	329.92	26.0	139.0
77	0.36	4.67	1.50	94.2	19.5	3.58	334.48	31.9	146.5
78	0.35	5.59	1.84	89.6	21.2	3.53	322.01	33.5	160.0
79	0.38	5.14	1.77	94.5	22.5	3.71	371.58	35.1	163.1
80	0.47	6.11	2.15	100.3	25.1	3.85	357.48	35.8	187.7
81	0.50	7.79	2.38	86.4	26.4	3.36	294.60	29.3	173.6

Sta. #	Nitrogen	Carbon	Sulfur	Metal concentrations					
	Percent by weight			Cr (ug/g)	Cu (ug/g)	Fe (%)	Mn (ug/g)	Ni (ug/g)	Zn (ug/g)
82	0.59	7.80	2.52	94.6	27.2	3.61	315.33	30.5	193.9
83	0.59	9.86	3.10	77.5	30.9	3.31	238.30	29.4	235.0
84	0.56	7.91	3.16	97.3	32.2	3.69	289.09	32.2	214.2
85	0.25	4.48	1.67	92.5	19.4	3.43	308.11	27.7	133.0
86	0.30	4.24	1.62	101.9	22.2	3.59	329.02	11.1	125.8
87	0.04	2.74	1.31	87.4	17.7	3.29	306.51	28.5	122.2
88	0.11	2.65	1.08	91.0	16.9	3.32	313.51	26.1	123.0
89	0.13	2.66	1.05	86.3	15.3	3.23	311.78	28.3	112.8
90	0.07	2.22	1.07	68.4	11.6	2.61	267.67	20.1	92.4
91	0.16	2.35	0.87	72.6	15.2	2.95	297.83	22.6	99.0
92	0.00	0.42	0.18	21.6	3.2	0.88	118.62	4.6	29.6
93	0.09	1.84	0.83	71.4	11.1	2.98	318.95	16.7	88.2
94	0.25	3.82	1.43	90.8	18.4	3.79	348.02	26.6	117.5
95	0.00	0.03	0.08	12.3	BDL	0.51	97.36	BDL	12.6
96	0.07	0.43	0.21	32.6	3.7	1.38	226.85	8.4	37.1
97	0.09	1.48	0.58	62.9	10.7	2.48	289.53	5.7	77.4
98	0.07	1.54	0.69	65.8	10.3	2.57	300.58	15.8	82.3
99	0.11	1.59	0.48	66.8	10.1	2.70	338.25	17.0	78.8
100	0.18	1.64	0.77	70.9	12.0	2.84	319.18	16.2	91.2
101	0.00	0.24	0.00	10.9	BDL	0.46	132.10	3.5	11.9
102	0.08	1.23	0.24	42.6	5.7	1.76	271.04	8.7	58.2
103	0.12	0.20	0.00	8.2	BDL	0.41	118.35	4.3	8.8
104	0.00	0.13	0.00	9.4	BDL	0.36	80.74	BDL	10.5
105	0.42	3.56	0.79	80.1	21.5	3.24	301.90	26.1	119.0
106	0.21	0.02	0.00	4.9	BDL	0.29	65.57	BDL	8.3
107	0.11	0.54	0.00	17.2	1.5	0.76	129.12	4.2	22.7
108	Sand sample- was not analyzed for chemistry								
109	0.10	0.66	0.00	25.9	4.1	1.08	154.38	10.7	37.8
110	Sand sample- was not analyzed for chemistry								

Sta. #	Nitrogen	Carbon	Sulfur	Metal concentrations					
	Percent by weight			Cr (ug/g)	Cu (ug/g)	Fe (%)	Mn (ug/g)	Ni (ug/g)	Zn (ug/g)
111	0.07	0.05	0.00	14.5	1.5	0.65	117.81	BDL	20.0
112	0.09	0.27	0.00	3.3	BDL	0.17	39.23	BDL	5.1
113	0.14	0.67	0.00	28.9	4.1	1.23	177.12	7.8	39.7
114	0.18	0.31	0.06	19.8	2.0	0.87	137.87	2.9	28.1
115	0.00	0.85	0.23	44.3	4.4	1.85	265.58	12.8	53.1
116	0.00	0.74	0.21	41.5	6.4	1.71	241.61	12.6	51.9
117	0.01	0.88	0.27	40.9	6.2	1.73	219.44	13.6	53.5
118	0.00	0.91	0.21	41.2	6.7	1.76	247.17	14.4	53.3
119	0.00	1.10	0.30	46.0	7.5	1.97	263.64	15.6	57.1
120	0.00	0.52	0.13	19.4	2.8	0.91	125.15	6.3	28.3
121	0.00	2.10	0.92	58.6	8.4	2.67	278.43	18.5	66.3
122	0.02	1.77	0.64	44.2	8.3	1.94	208.69	17.6	60.3
123	0.00	0.32	0.08	11.5	2.3	0.59	95.04	6.1	17.0
124	0.17	2.01	0.57	61.2	11.4	2.63	288.13	22.5	85.3
125	0.14	3.18	0.93	75.5	16.3	3.23	311.76	25.0	108.4
126	0.07	2.65	0.62	64.2	12.7	2.82	284.80	19.3	91.6
127	0.28	3.30	0.98	73.6	16.8	3.15	296.94	24.1	118.5
128	0.22	3.85	1.21	84.7	20.1	3.47	328.51	24.0	139.9
129	0.10	1.11	0.30	41.3	7.1	1.73	246.52	13.2	53.6
130	0.10	1.09	0.29	36.6	6.8	1.54	211.99	10.6	41.8
131	0.02	0.18	0.11	12.8	BDL	0.61	100.17	7.8	18.0
132	0.03	0.35	0.13	15.7	2.1	0.75	111.93	8.8	23.7
133	0.10	1.45	0.62	40.8	6.5	1.81	230.64	16.5	54.4
134	0.00	0.15	0.00	6.0	BDL	0.38	103.22	5.2	9.0
135	0.05	0.07	0.00	5.7	BDL	0.36	97.85	4.5	8.2
136	0.10	0.11	0.00	4.4	BDL	0.30	78.91	5.3	7.4
137	0.00	0.10	0.00	3.7	BDL	0.24	61.23	3.1	6.3
138	0.07	0.26	0.00	8.5	BDL	0.45	100.88	5.2	13.5
139	0.08	0.39	0.00	12.2	2.2	0.57	109.34	3.5	16.1

Sta. #	Nitrogen	Carbon	Sulfur	Metal concentrations					
	Percent by weight			Cr (ug/g)	Cu (ug/g)	Fe (%)	Mn (ug/g)	Ni (ug/g)	Zn (ug/g)
140	0.07	0.09	0.00	6.0	2.0	0.32	72.15	4.1	14.8
141	0.31	1.62	0.31	38.8	39.9	1.31	134.18	11.1	63.5
142	0.14	0.26	0.00	5.8	1.3	0.22	48.56	BDL	6.9
143	0.32	2.77	0.57	83.2	22.4	3.31	417.99	27.3	115.1
144	0.20	1.88	0.42	60.7	14.0	2.32	258.47	19.8	81.0
145	0.05	0.17	0.00	7.1	1.3	0.38	79.39	BDL	9.3
146	0.00	0.21	0.00	11.4	BDL	0.56	140.62	3.8	13.5
147	0.24	1.94	0.50	55.1	12.6	2.11	230.36	15.7	75.0
148	0.00	0.02	0.00	5.6	BDL	0.32	101.62	BDL	4.6
149	0.00	0.09	0.00	2.3	1.2	0.13	32.41	BDL	2.1
150	0.00	0.15	0.00	4.9	BDL	0.28	83.67	3.1	6.5
151	0.07	0.73	0.17	22.4	4.3	0.93	127.01	6.3	30.7
152	Sand sample- was not analyzed for chemistry								
153	0.00	0.14	0.00	3.9	1.6	0.24	77.61	BDL	5.1
154	0.00	0.02	0.00	17.6	6.2	0.78	126.23	6.6	23.7
155	0.05	0.64	0.00	24.3	4.6	1.04	144.60	7.9	31.6
156	0.11	0.54	0.00	19.2	5.1	0.81	127.14	4.6	24.7
157	0.00	0.13	0.00	3.1	BDL	0.19	46.92	4.7	4.4
158	Sand sample- was not analyzed for chemistry								
159	0.11	0.19	0.00	1.6	1.4	0.13	29.83	7.3	2.2
160	0.00	0.01	0.00	5.8	BDL	0.32	94.79	3.6	5.1
161	0.04	0.22	0.00	11.6	1.4	0.58	97.98	BDL	14.9
162	0.26	1.30	0.17	47.7	10.0	1.93	230.06	15.0	61.0
163	0.19	1.92	0.29	60.2	13.3	2.52	288.91	16.7	78.1
164	0.01	0.00	0.00	31.8	6.4	1.37	172.17	7.8	39.6
165	0.00	0.01	0.00	3.5	BDL	0.17	38.64	BDL	3.2
166	0.00	0.08	0.00	3.4	BDL	0.14	36.91	2.5	2.4
167	Sand sample- was not analyzed for chemistry								
168	Sand sample- was not analyzed for chemistry								

Sta. #	Nitrogen	Carbon	Sulfur	Metal concentrations					
	Percent by weight			Cr (ug/g)	Cu (ug/g)	Fe (%)	Mn (ug/g)	Ni (ug/g)	Zn (ug/g)
169	Sand sample- was not analyzed for chemistry								
170	Sand sample- was not analyzed for chemistry								
171	0.24	2.65	0.83	87.1	27.2	3.66	386.68	26.4	125.7

Table XIV. Enrichment factors, relative to average continental crust, for metals analyzed in surficial sediments.

Station #	Enrichment factors relative to average continental crust (Taylor, 1964)				
	Cr	Cu	Mn	Ni	Zn
1	1.45	0.61	0.62	0.57	2.68
2	1.38	0.61	0.86	0.54	3.08
3	1.45	0.70	0.63	0.47	3.14
4	1.33	0.59	0.70	0.57	2.54
5	1.14	0.47	1.25	1.03	1.48
6	1.29	0.66	0.54	0.44	2.65
7	1.38	0.52	0.59	0.50	2.64
8	1.32	0.57	0.82	0.66	2.46
9	0.88		5.29		2.48
10	1.56		10.02		
11	1.40	0.52	0.65	0.52	2.92
12	1.35	0.43	0.70	0.56	2.58
13	1.35	0.43	0.60	0.52	2.50
14	1.37	0.47	0.63	0.57	2.71
15	1.38	0.40	0.79	0.48	2.70
16	1.45	0.44	0.91	0.70	2.70
17	1.41	1.05	0.46	0.69	3.54
18	1.25		1.57		2.01
19	1.33	0.47	0.66	0.55	2.74
20	1.33	0.49	0.53	0.46	3.00
21	1.35	0.48	0.61	0.51	2.89
22	1.48	0.53	0.56	0.46	3.43

Station #	Enrichment factors relative to average continental crust (Taylor, 1964)				
	Cr	Cu	Mn	Ni	Zn
23	0.64	0.12	0.57	0.20	0.95
24	1.31	0.37	0.59	0.42	2.63
25	1.47	0.54	0.68	0.50	2.98
26	1.32	0.42	0.58	0.47	2.68
27	1.21	0.29	0.93	0.35	2.32
28	1.36	0.41	0.74	0.49	2.65
29	1.37	0.38	0.90	0.69	2.54
30	1.44		1.52		1.44
31	1.21		1.32		1.81
32	1.42	0.42	0.62	0.57	2.83
33	1.13		1.12	0.64	2.06
34	1.14		1.21	0.34	2.06
35	1.32	0.31	1.30	0.58	1.82
36	1.35	0.56	0.67	0.55	2.71
38	0.95	0.33	0.50	0.57	1.81
39	1.32	0.43	0.65	0.48	2.67
40	1.56	0.48	0.66	0.52	2.89
41	1.31	0.37	0.76	0.34	2.32
42	1.41	0.38	0.85	0.54	2.65
43	1.47	0.27	0.90	0.43	2.67
44	1.48		1.62		1.80
45	1.50	0.64	0.65	0.61	2.77
46	1.23	0.28	0.56	0.43	1.73
47	1.45	0.41	0.80	0.45	2.53
48	1.45	0.41	1.22	0.43	1.99
49	1.29	0.38	0.69	0.48	2.35

Station #	Enrichment factors relative to average continental crust (Taylor, 1964)				
	Cr	Cu	Mn	Ni	Zn
50	1.41	0.45	0.64	0.51	2.84
51	1.35	0.42	0.64	0.33	2.60
52	Sand sample- was not analyzed for chemistry				
53	1.40		1.84	0.80	2.56
54	1.49	0.27	1.02	0.53	2.73
55	Sand sample- was not analyzed for chemistry				
56.1	1.46	0.48	0.65	0.57	2.71
56.2	1.44	0.49	0.62	0.55	2.78
57	1.41	0.34	1.06	0.46	2.35
58	1.53	0.43	0.67	0.54	2.63
59	1.40	0.41	0.78	0.48	2.47
60	1.32	0.23	1.24		2.04
61	1.59	1.18	0.95	0.24	3.18
62	1.10		1.66		1.49
63	1.26	0.51	1.45		2.02
64	1.51	0.75	0.91	0.43	3.01
65	1.17		1.34		2.13
66	0.99		1.62	0.46	1.58
67	1.39	0.38	0.92	0.37	2.50
68	1.57	0.47	0.65	0.52	2.70
69	0.90		1.55		1.65
70	1.45	0.42	0.58	0.56	2.74
71	1.38	0.49	0.52	0.56	2.75
72	1.44	0.66	0.51	0.61	3.49
73	1.41	0.35	0.55	0.52	2.35
74	1.48	0.48	0.57	0.55	2.97

Station #	Enrichment factors relative to average continental crust (Taylor, 1964)				
	Cr	Cu	Mn	Ni	Zn
75	1.49	0.57	0.52	0.64	3.24
76	1.44	0.58	0.57	0.57	3.27
77	1.48	0.56	0.55	0.67	3.29
78	1.43	0.62	0.54	0.71	3.65
79	1.43	0.62	0.59	0.71	3.54
80	1.47	0.67	0.55	0.70	3.93
81	1.45	0.81	0.52	0.66	4.16
82	1.47	0.77	0.52	0.63	4.32
83	1.32	0.96	0.43	0.67	5.72
84	1.48	0.89	0.46	0.66	4.67
85	1.52	0.58	0.53	0.61	3.12
86	1.60	0.63	0.54	0.23	2.82
87	1.50	0.55	0.55	0.65	2.99
88	1.54	0.52	0.56	0.59	2.98
89	1.50	0.49	0.57	0.66	2.81
90	1.47	0.45	0.61	0.58	2.84
91	1.39	0.53	0.60	0.58	2.70
92	1.37	0.37	0.80	0.39	2.69
93	1.35	0.38	0.63	0.42	2.38
94	1.35	0.50	0.54	0.53	2.50
95	1.36		1.14		1.99
96	1.33	0.27	0.97	0.45	2.16
97	1.43	0.44	0.69	0.17	2.51
98	1.44	0.41	0.69	0.46	2.58
99	1.39	0.38	0.74	0.47	2.35
100	1.41	0.43	0.67	0.43	2.59

Station #	Enrichment factors relative to average continental crust (Taylor, 1964)				
	Cr	Cu	Mn	Ni	Zn
101	1.33		1.71	0.57	2.09
102	1.36	0.33	0.91	0.37	2.65
103	1.13		1.71	0.78	1.73
104	1.46		1.32		2.33
105	1.39	0.68	0.55	0.61	2.96
106	0.97		1.36		2.33
107	1.28	0.20	1.01	0.42	2.42
108	Sand sample- was not analyzed for chemistry				
109	1.34	0.39	0.84	0.74	2.80
110	Sand sample- was not analyzed for chemistry				
111	1.26	0.24	1.07		2.47
112	1.07		1.34		2.39
113	1.33	0.34	0.85	0.48	2.60
114	1.28	0.23	0.94	0.25	2.60
115	1.34	0.24	0.85	0.52	2.31
116	1.37	0.38	0.84	0.55	2.44
117	1.33	0.37	0.75	0.59	2.48
118	1.32	0.39	0.83	0.61	2.44
119	1.31	0.39	0.79	0.59	2.33
120	1.20	0.32	0.82	0.52	2.50
121	1.24	0.32	0.62	0.52	2.00
122	1.28	0.44	0.64	0.68	2.50
123	1.09	0.39	0.95	0.78	2.31
124	1.31	0.44	0.65	0.64	2.61
125	1.31	0.52	0.57	0.58	2.70
126	1.28	0.46	0.60	0.51	2.61

Station #	Enrichment factors relative to average continental crust (Taylor, 1964)				
	Cr	Cu	Mn	Ni	Zn
127	1.31	0.55	0.56	0.57	3.02
128	1.38	0.59	0.56	0.52	3.25
129	1.35	0.42	0.85	0.58	2.49
130	1.34	0.45	0.81	0.52	2.18
131	1.18		0.97	0.95	2.37
132	1.18	0.28	0.89	0.88	2.55
133	1.27	0.36	0.75	0.68	2.42
134	0.88		1.60	1.02	1.89
135	0.91		1.63	0.94	1.85
136	0.82		1.54	1.31	1.95
137	0.87		1.51	0.96	2.10
138	1.07		1.33	0.87	2.41
139	1.21	0.41	1.15	0.46	2.29
140	1.05	0.64	1.33	0.96	3.71
141	1.67	3.13	0.61	0.64	3.91
142	1.49	0.60	1.32		2.53
143	1.42	0.69	0.75	0.62	2.80
144	1.47	0.62	0.66	0.64	2.81
145	1.06	0.34	1.24		1.98
146	1.13		1.48	0.51	1.92
147	1.47	0.61	0.65	0.56	2.86
148	0.98		1.89		1.17
149	1.03	0.96	1.53		1.33
150	0.97		1.76	0.82	1.85
151	1.36	0.47	0.81	0.51	2.67
152	Sand sample- was not analyzed for chemistry				

Station #	Enrichment factors relative to average continental crust (Taylor, 1964)				
	Cr	Cu	Mn	Ni	Zn
153	0.94	0.69	1.95		1.76
154	1.26	0.81	0.95	0.63	2.43
155	1.31	0.45	0.82	0.57	2.44
156	1.33	0.65	0.93	0.42	2.44
157	0.91		1.45	1.85	1.83
158	Sand sample- was not analyzed for chemistry				
159	0.68	1.15	1.38	4.29	1.39
160	1.01		1.73	0.84	1.26
161	1.14	0.25	1.01		2.08
162	1.39	0.53	0.70	0.58	2.54
163	1.34	0.54	0.68	0.50	2.49
164	1.31	0.48	0.75	0.43	2.33
165	1.18		1.37		1.51
166	1.32		1.53	1.29	1.33
167	Sand sample- was not analyzed for chemistry				
168	Sand sample- was not analyzed for chemistry				
169	Sand sample- was not analyzed for chemistry				
170	Sand sample- was not analyzed for chemistry				
171	1.34	0.76	0.63	0.54	2.76

Table XV. Variation values for metal concentrations relative to background (or historical) levels. Variation values were calculated using equations 3 and 4 (see explanation in text).

Station #	Variation from background levels (calculated using equations 3 and 4 - see text for explanation)					
	Cr	Cu	Fe	Mn	Ni	Zn
1	-0.27	0.77	-0.36	-0.29	-0.30	0.28
2	-0.12	1.11	-0.18	0.24	-0.18	0.86
3	-0.05	1.27	-0.14	-0.10	-0.29	0.94
4	0.08	1.20	0.14	0.15	-0.05	0.87
5	0.03	0.51	0.67	0.81	0.36	0.08
6	-0.02	1.51	0.00	-0.10	-0.24	0.88
7	0.09	1.08	0.03	0.04	-0.09	0.96
8	0.04	0.91	0.14	0.26	0.00	0.73
9	-0.89		-0.82	0.22		-0.73
10	-0.42		-0.06	4.20		
11	-0.05	0.89	-0.13	0.00	-0.16	0.87
12	-0.08	0.52	-0.12	0.06	-0.11	0.65
13	0.03	0.64	0.01	0.00	-0.10	0.78
14	-0.01	0.63	-0.06	-0.02	-0.06	0.83
15	0.16	0.57	0.14	0.38	-0.14	1.08
16	0.22	0.83	0.15	0.61	0.26	1.08
17	-0.24	2.31	-0.32	-0.43	-0.08	0.80
18	0.19		1.02	1.22		0.49
19	-0.07	0.71	-0.09	0.04	-0.10	0.81
20	-0.03	1.02	-0.06	-0.12	-0.19	1.08
21	-0.07	0.85	-0.12	-0.04	-0.15	0.88

Station #	Variation from background levels (calculated using equations 3 and 4 - see text for explanation)					
	Cr	Cu	Fe	Mn	Ni	Zn
22	-0.06	0.79	-0.19	-0.20	-0.31	1.04
23	-0.23	-0.31	0.61	0.48	-0.46	0.07
24	-0.05	0.34	-0.05	-0.07	-0.31	0.79
25	-0.01	0.91	-0.13	0.02	-0.21	0.88
26	-0.06	0.55	-0.08	-0.08	-0.22	0.80
27	-0.11	-0.03	0.06	0.34	-0.50	0.52
28	-0.01	0.40	-0.03	0.15	-0.22	0.79
29	-0.21	0.05	-0.18	0.05	-0.19	0.32
30	-0.59		-0.53	-0.24		-0.66
31	-0.58		-0.47	-0.13		-0.45
32	-0.05	0.46	-0.13	-0.09	-0.12	0.78
33	-0.24		-0.03	0.50	-0.16	0.23
34	-0.23		-0.01	0.57	-0.57	0.22
35	-0.38	-0.31	-0.32	0.20	-0.48	-0.25
36	0.08	1.35	0.05	0.18	0.01	1.02
38	-0.12	0.65	0.19	0.04	0.25	0.58
39	-0.04	0.65	-0.06	0.05	-0.18	0.83
40	0.01	0.56	-0.15	-0.06	-0.22	0.77
41	0.05	0.43	0.09	0.27	-0.41	0.71
42	0.01	0.33	-0.03	0.26	-0.19	0.72
43	-0.11	-0.21	-0.13	0.07	-0.49	0.43
44	-0.66		-0.67	-0.27		-0.64
45	0.18	1.53	0.07	0.09	0.04	1.01
46	0.09	0.28	0.16	0.10	-0.12	0.44
47	0.27	0.69	0.21	0.43	-0.19	1.00
48	-0.03	0.08	0.16	0.38	-0.55	0.10

Station #	Variation from background levels (calculated using equations 3 and 4 - see text for explanation)					
	Cr	Cu	Fe	Mn	Ni	Zn
49	0.01	0.40	0.05	0.16	-0.16	0.72
50	0.07	0.70	-0.01	0.07	-0.12	1.02
51	-0.02	0.49	-0.05	0.02	-0.46	0.76
52	Sand sample- was not analyzed for chemistry					
53	0.11		0.69	1.18	-0.16	0.58
54	0.42	0.02	0.59	0.70	-0.17	1.19
55	Sand sample- was not analyzed for chemistry					
56.1	0.06	0.72	-0.05	0.03	-0.05	0.85
56.2	0.02	0.74	-0.08	-0.03	-0.10	0.85
57	0.09	0.13	0.16	0.54	-0.35	0.58
58	0.07	0.49	-0.08	0.02	-0.14	0.73
59	0.19	0.62	0.15	0.41	-0.11	0.95
60	0.64	-0.02	1.48	1.37		1.00
61	0.40	3.51	0.34	0.57	-0.62	1.42
62	0.04		1.23	1.25		0.08
63	0.42	0.98	1.30	1.50		0.80
64	0.18	1.58	0.11	0.42	-0.34	1.12
65	0.06		1.23	0.68		0.44
66	0.64		2.75	2.87	-0.03	1.00
67	0.39	0.67	0.52	0.74	-0.32	1.18
68	0.12	0.72	-0.07	0.02	-0.14	0.80
69	-0.24		0.73	1.01		0.10
70	-0.06	0.40	-0.16	-0.16	-0.16	0.67
71	0.00	0.80	-0.06	-0.17	-0.06	0.86
72	-0.16	1.06	-0.25	-0.34	-0.16	0.92
73	0.02	0.24	-0.06	-0.13	-0.14	0.59

Station #	Variation from background levels (calculated using equations 3 and 4 - see text for explanation)					
	Cr	Cu	Fe	Mn	Ni	Zn
74	-0.01	0.70	-0.14	-0.15	-0.13	0.86
75	-0.09	0.85	-0.21	-0.29	-0.08	0.86
76	-0.06	1.05	-0.16	-0.16	-0.11	1.02
77	-0.03	1.02	-0.16	-0.18	0.05	1.03
78	-0.09	1.17	-0.19	-0.22	0.09	1.19
79	-0.06	1.30	-0.16	-0.11	0.13	1.20
80	-0.06	1.45	-0.19	-0.19	0.09	1.38
81	-0.17	1.65	-0.27	-0.32	-0.09	1.25
82	-0.19	1.52	-0.31	-0.34	-0.14	1.25
83	-0.18	2.37	-0.21	-0.40	0.00	2.34
84	-0.18	1.93	-0.30	-0.41	-0.11	1.44
85	0.02	1.12	-0.14	-0.19	-0.03	0.97
86	0.04	1.30	-0.17	-0.20	-0.63	0.73
87	0.01	0.98	-0.13	-0.16	0.04	0.90
88	0.05	0.88	-0.12	-0.14	-0.05	0.92
89	0.09	0.79	-0.06	-0.08	0.11	0.92
90	0.04	0.56	-0.07	-0.06	-0.07	0.88
91	0.01	0.91	-0.05	-0.04	-0.04	0.84
92	0.16	0.37	0.25	0.30	-0.38	1.02
93	0.01	0.39	-0.02	0.04	-0.28	0.68
94	-0.12	0.83	-0.17	-0.19	-0.17	0.54
95	0.22		0.55	0.72		0.48
96	0.16	0.02	0.22	0.70	-0.20	0.70
97	0.09	0.54	0.02	0.13	-0.71	0.79
98	0.05	0.40	-0.04	0.09	-0.25	0.75
99	0.07	0.39	0.01	0.23	-0.19	0.68

Station #	Variation from background levels (calculated using equations 3 and 4 - see text for explanation)					
	Cr	Cu	Fe	Mn	Ni	Zn
100	0.00	0.56	-0.08	0.04	-0.30	0.72
101	0.63		1.63	2.10	-0.09	0.98
102	0.06	0.30	0.04	0.51	-0.37	0.90
103	0.43		2.05	2.04	0.21	0.64
104	0.73		2.00	1.18		1.07
105	-0.08	1.47	-0.16	-0.18	-0.05	0.83
106	-0.09		1.35	0.75		0.62
107	0.51	-0.07	0.96	1.09	-0.19	1.41
108	Sand sample- was not analyzed for chemistry					
109	0.11	0.50	0.17	0.40	0.23	1.08
110	Sand sample- was not analyzed for chemistry					
111	1.64	0.54	4.29	2.13		2.87
112	-0.74		-0.61	-0.42		-0.50
113	0.28	0.49	0.37	0.64	-0.09	1.24
114	0.62	0.17	1.05	1.11	-0.47	1.79
115	0.22	0.03	0.24	0.62	0.01	0.93
116	0.11	0.46	0.11	0.43	-0.04	0.83
117	0.06	0.37	0.08	0.26	0.00	0.83
118	0.14	0.60	0.17	0.51	0.14	0.93
119	0.04	0.37	0.08	0.32	0.01	0.71
120	-0.17	-0.11	-0.01	0.10	-0.31	0.55
121	-0.12	0.15	-0.08	-0.04	-0.15	0.32
122	-0.16	0.33	-0.12	-0.10	-0.02	0.53
123	-0.15	0.21	0.23	0.34	0.04	0.54
124	-0.12	0.49	-0.12	-0.04	-0.01	0.65
125	-0.13	0.80	-0.15	-0.16	-0.09	0.67

Station #	Variation from background levels (calculated using equations 3 and 4 - see text for explanation)					
	Cr	Cu	Fe	Mn	Ni	Zn
126	-0.09	0.63	-0.08	-0.07	-0.16	0.73
127	-0.11	0.94	-0.12	-0.15	-0.09	0.93
128	-0.10	1.11	-0.17	-0.17	-0.19	0.99
129	0.35	0.98	0.38	0.75	0.21	1.28
130	0.15	0.88	0.18	0.46	-0.06	0.72
131	0.69		1.85	1.14	0.89	1.69
132	0.35	0.29	0.88	0.79	0.67	1.47
133	0.07	0.30	0.16	0.30	0.19	0.87
134	0.09		2.13	1.75	0.52	0.76
135	0.05		1.91	1.61	0.31	0.59
136	-0.18		1.50	1.11	0.56	0.44
137	-0.31		0.98	0.65	-0.09	0.23
138	0.01		0.76	1.03	0.21	0.84
139	0.20	0.56	0.70	0.93	-0.28	0.88
140	0.11	1.08	1.65	0.95	0.21	1.92
141	0.05	9.45	-0.16	-0.17	-0.10	1.27
142	-0.07	0.20	0.40	0.19		0.20
143	-0.02	1.63	-0.12	0.17	0.02	0.82
144	0.11	1.50	-0.01	0.10	0.11	0.98
145	-0.03	0.08	0.83	0.75		0.43
146	0.68		2.15	2.27	0.00	1.22
147	0.02	1.13	-0.08	-0.02	-0.12	0.85
148	0.02		1.60	1.70		-0.10
149	-0.58	0.21	0.03	-0.14		-0.59
150	-0.11		1.31	1.23	-0.10	0.26
151	0.04	0.71	0.09	0.24	-0.23	0.82

Station #	Variation from background levels (calculated using equations 3 and 4 - see text for explanation)					
	Cr	Cu	Fe	Mn	Ni	Zn
152	Sand sample- was not analyzed for chemistry					
153	-0.27	0.68	0.86	1.16		0.04
154	2.18	5.34	5.28	2.35	0.91	3.58
155	0.28	1.04	0.42	0.57	0.07	1.11
156	0.41	1.85	0.67	0.80	-0.22	1.23
157	-0.44		0.51	0.23	0.36	-0.16
158	Sand sample- was not analyzed for chemistry					
159	-0.71	0.51	0.07	-0.19	1.19	-0.56
160	0.05		1.60	1.50	0.06	-0.02
161	0.22	0.04	0.90	0.82		0.84
162	0.10	1.19	0.05	0.21	0.03	0.86
163	0.08	1.29	0.05	0.20	-0.09	0.86
164	-0.10	0.74	-0.08	0.09	-0.36	0.47
165	-0.37		0.31	0.01		-0.40
166	-0.38		0.18	-0.01	-0.27	-0.54
167	Sand sample- was not analyzed for chemistry					
168	Sand sample- was not analyzed for chemistry					
169	Sand sample- was not analyzed for chemistry					
170	Sand sample- was not analyzed for chemistry					
171	-0.02	1.98	-0.05	0.03	-0.06	0.91

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