Chapter 5

# SOIL QUALITY OF BUCHANAN STREET MARSH: SOIL FACTORS IMPORTANT TO SALT MARSH CREATION

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## Introduction

The Buchanan Street salt marsh is a 2.0 acre tidal salt marsh between Golden Gate Fields racetrack and the Buchanan Street extension. Part of the proposed operational improvements to routes I-80 and I-180 in Alameda County includes destroying approximately 1.6 acres of this marsh to realign the Buchanan Street extension (DOT et al., 1984). The Caltrans project also consists of developing a new salt marsh just north of the existing one, where the present Buchanan Street extension now exists (Figure 1). Under Executive Order 119900, Protection of Wetlands, requiring compensation for the destruction, Caltrans will attempt to create conditions comparable to those of the existing marsh (such as drainage and vegetation) in the new marsh.

The establishment of marsh vegetation is one of the primary objectives of marsh creation (Josselyn and Buchholz, 1984), for wetland vegetation is the foundation of the salt marsh ecosystem. A productive, stable plant population secures other wildlife habitats. There are many environmental factors that should be considered to assure successful establishment of marsh vegetation. Some of these important variables are elevation, climate, soil salinity and pH, nutrient availability, length of inundation, and drainage patterns (Josselyn and Buchholz, 1984; Harvey et al., 1982). Most of the factors ultimately affect the salinity of the soil which is known to be the major condition influencing marsh vegetation. It is evident that the soil conditions in the new marsh soil will be a main determinant of the fate of the attempt to establish marsh vegetation. It is the purpose of this study to measure the various soil factors in the existing Buchanan Street marsh that need to be taken into consideration in creating comparable conditions in the proposed new salt marsh. No previous soil studies have been made of this marsh.

## Past Studies

For implementation of Executive Order 119900, an interagency field review was made on the Buchanan Street marsh (DOT et al., 1984). It consisted of determining the habitat value of the marsh, the impacts of the proposed mitigation project, and determining compensation measures. The review also included suggestions of ways to prevent impacts during construction and mitigation and of ways to establish

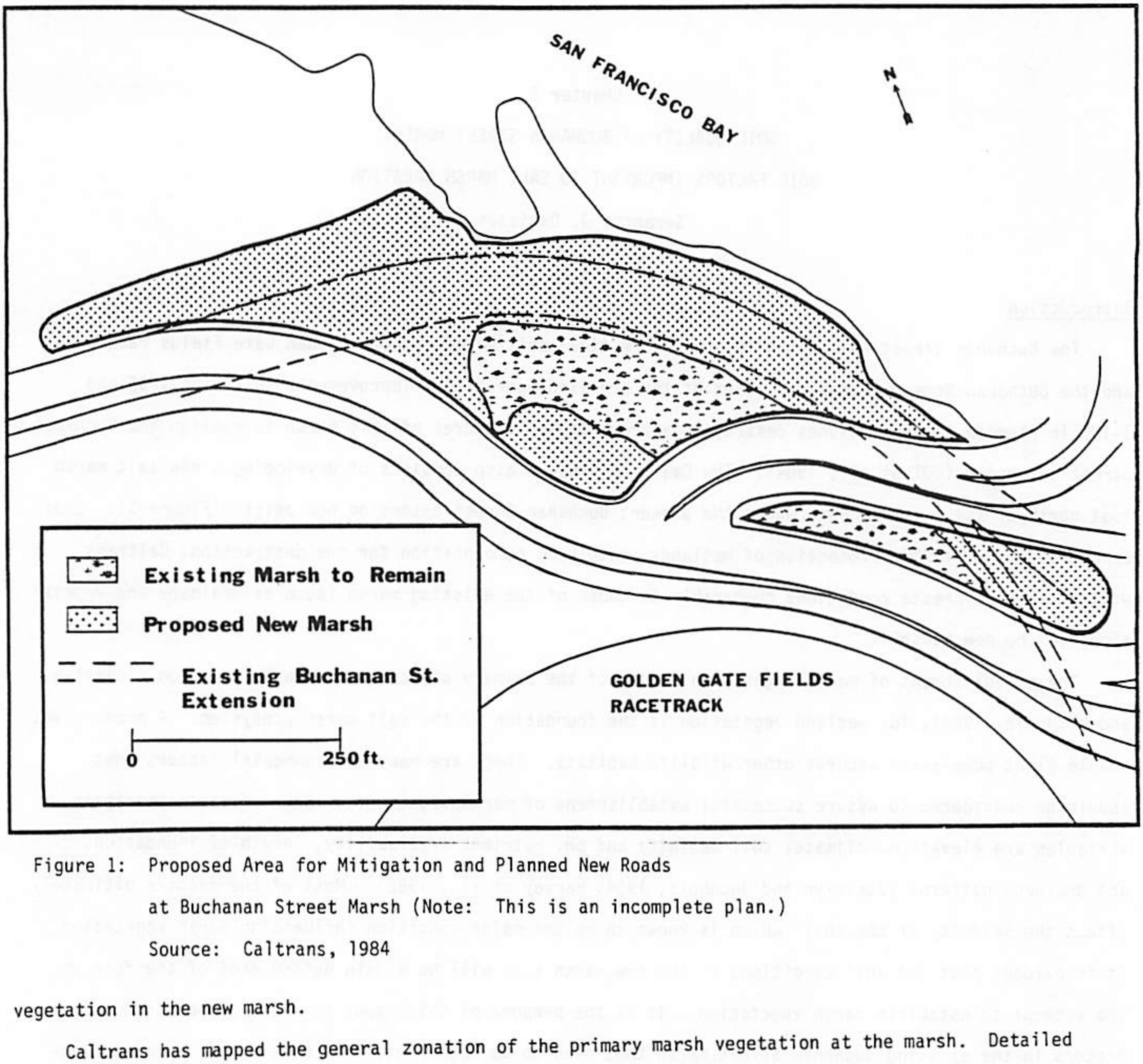


Figure 1: Proposed Area for Mitigation and Planned New Roads at Buchanan Street Marsh (Note: This is an incomplete plan.) Source: Caltrans, 1984

vegetation in the new marsh.

Caltrans has mapped the general zonation of the primary marsh vegetation at the marsh. Detailed maps of the elevation of the marsh were also made by the same agency. This information is used in this report to study the soil factors at different elevations.

Methods

The time available for this study limited the amount of research that could be done on the salt marsh. Only a portion of a complete soil chemical analysis, relevant to the maintenance of marsh vegetation, was completed for this study. Additional chemical analyses will be done in April and May, 1985 by the author.

The time available also limited the collection of soil samples to one time of the year and to one tide height. Various soil parameters, such as salinity, may vary during a year (Chapman, 1960); therefore the results of this study are not representative of marsh soil conditions throughout an entire year.

The sample sites were chosen along three of the transects studied by Caltrans (Caltrans, 1984, Figure 2). Sites whose elevation was measured by Caltrans were chosen and were found using a map of the elevation of the marsh, transect markings in the marsh, and a tape measure. Sites were selected at elevations from 1.3 to 2.5 feet to include any variation in the soil factors due to elevation. Sites were chosen where vegetation was present. Two samples were collected at each site to assure that the soil parameters determined are representative of that specified site.

Soil samples were collected in February of 1985 at low tide. With the use of a shovel, 1 to 2 kilograms of soil were taken within the top 25 centimeters for each sample, to assure that the volume of soil represented the primary source of nutrients available to the marsh vegetation. The root zone of marsh vegetation is within this soil depth (Chapman, 1960). The soil samples were placed immediately in plastic bags and were closed tightly to minimize aeration of the soil. The samples were refrigerated to reduce chemical changes in the soil.

As a preparation for the analysis, a saturation paste was made for each sample, using standard methods (Doner, 1985). The soil solution from the saturation paste was used to determine the soil salinity (the total soluble cation concentration).

Electrical Conductivity (EC) of the Saturation Extract

The electrical conductivity of the soil solution was measured to obtain an approximation of the soil salinity. An Orion conductivity meter was used to measure this property, with 0.01 molar potassium chloride as a reference solution. Readings from the meter were recorded in units of mmhos/cm and converted to parts per thousand (ppt) to give a concentration of salts.

There are two steps involved which convert the conductance reading (mmhos/cm) to units of concentration (ppt). The first approximates a relationship among conductance, charge of the cations, and milliequivalents of cations in order to convert the reading to milliequivalents per liter (meq/L) (Doner, 1985). The approximation is

$$\text{meq/L} = 10 \times \text{EC reading (mmhos/cm)}.$$

Units of ppt require the weighted equivalent weight of the solutes in a solution (in this case the salts NaCl, KCl, $MgCl_2$, $CaCl_2$). An estimation of the composition of the salts in the soil solution is the composition of salts in ocean water. The weighted equivalent weight of the salts in ocean water is 57.16 grams per equivalent (g/eq) (Mall, 1969). To obtain a more accurate value of the weighted equivalent weight of the salts, specific to this marsh, a measurement of the concentration of the four salts

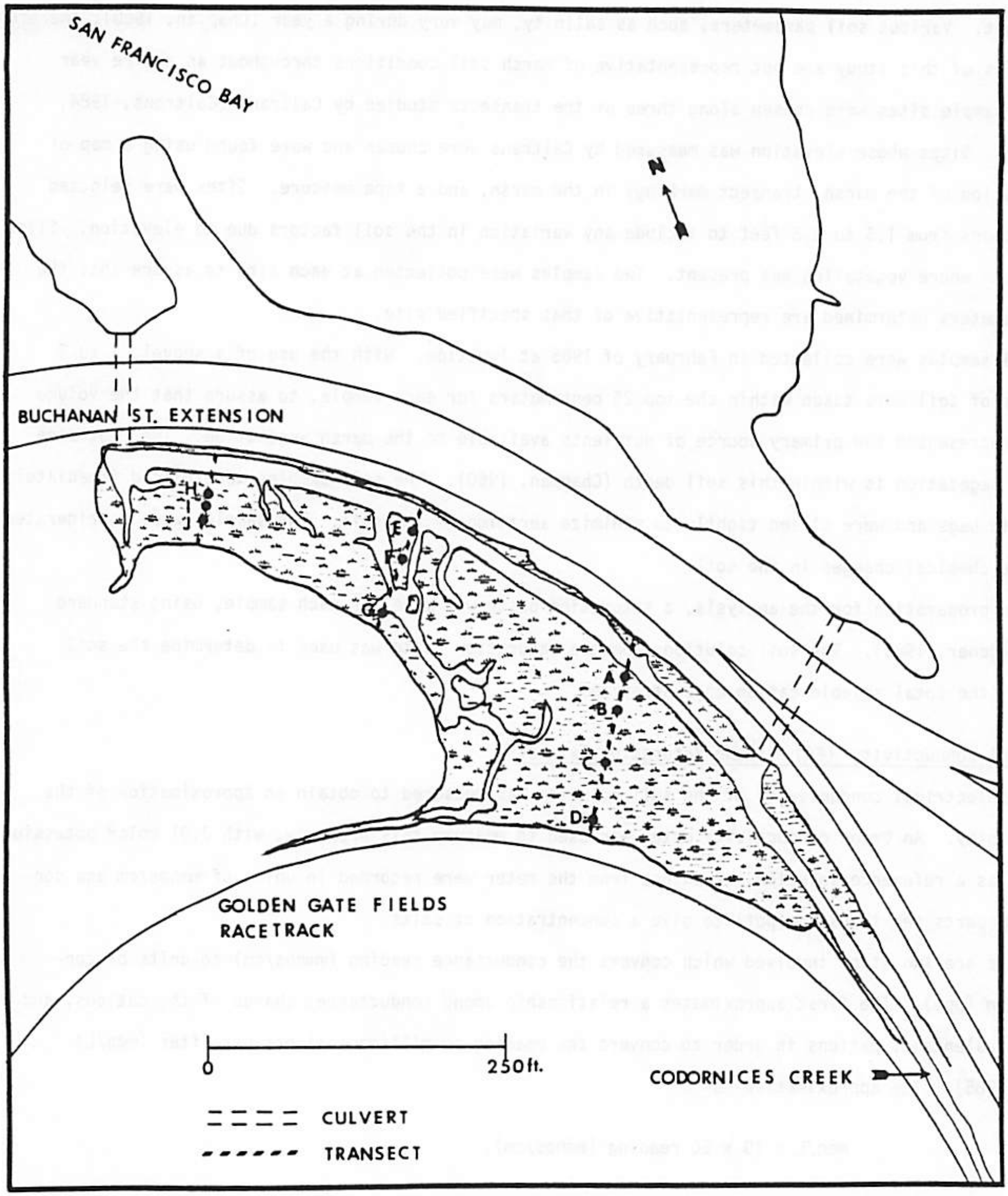


Figure 2. Map of Buchanan Street Marsh showing sample sites.
Source: Caltrans, 1984

in the soil solution would be needed. The following equation converts meq/L to ppt, using the weighted equivalent weight of the salts in ocean water:

$$ppt = (meq/L)(1eq/1000meq)(57.16g/eq)(1000mg/g)(1L/1000mL)(1mL/g).$$

Soil pH

A saturation paste of each soil sample was used to measure the pH of the soil by the electrometric method (Page et al., 1982). The electrodes were moved around in the paste and then allowed to equilibrate to obtain a representative value of pH.

Results

The pH measurements of samples from the top 25 cm of soil range from 6.3 to 7.1 (Table 1). Although the pH difference between replicates at most sites is small, there is at least a 0.3 unit difference in pH between replicates taken at sites A, E, and H.

The salinity measurements range from 17.7 to 23.3 ppt. The range for sample sites that consisted of pickleweed is 17.7 to 22.7 ppt. The sites with cordgrass have salinities ranging from 21.4 to 23.3 ppt (Table 1).

No correlation of salinity with elevation was discovered for the measurements made (Table 1). For example, the salinity at site C, at 2.2 ft., is higher than site B at 2.5 ft., whereas site A at 1.7 ft. has a lower salinity. Three of the study sites are at 2.3 ft., and have soil salinities ranging from 18.0 to 22.7 ppt.

Discussion

The pH values are within the tolerance range for halophytes (pH 4 to 9). The values are also in the pH range for optimal nutrient uptake by halophytes (pH 6 to 8) (Harvey et al., 1982). It is important that the pH of the soil remains within these ranges. At high pH values, the availability of nutrients such as potassium, phosphorus, and iron may be diminished. This decrease in availability is due partly to competition for sites (by the nutrients) in the ion exchange structure of the soil. At low pH values, the solubilities of various metallic cations increase, which may have toxic effects on the vegetation. At pH 7 an increase in solubility of other metallic cations may occur (Ranwell, 1972; Chapman, 1960). Stevenson and Emory (1958) found that pH of salt marshes is determined by bacterial action, organic matter, grain size and sorting of the soil, proximity to creek, and soil depth. Considering these factors with regard to establishing an optimal pH in the new marsh may be worthwhile.

The soil salinities found from this study are within the salinity tolerance ranges for the two dominant types of vegetation in the marsh. The soil salinities of sites consisting of pickleweed are at the lower end of the tolerance range for this type of plant (15 to 50 ppt) (Harvey et al., 1982).

However, the salinity at sites where cordgrass exists is higher than the values for optimal growth (less than 15 ppt) (Josselyn, 1983). Cordgrass is able to exist in soil salinity of up to 35 ppt, but grows at reduced rates above 15 ppt.

The soil salinities found in this study represent values preferred by the established marsh vegetation. Salinity requirements for establishing marsh vegetation have been found to be different from those of adult marsh vegetation (Chapman, 1960; Harvey et al., 1982). Harvey and others (1982) have suggested planting pickleweed at a salinity level between 30 and 60 ppt in order to reduce competition with other species of marsh vegetation. This salinity level is higher than values found in Buchanan Street marsh. Pacific cordgrass should be established below a salinity of 30 ppt (Harvey et al., 1982). Salinities at Buchanan Street sites with cordgrass are below 30 ppt. It has been determined that seed germination of Pacific cordgrass requires a lowered salinity and pretreatment with freshwater to enhance germination (Zedler, 1984).

Sediment salinity generally increases with increasing elevation because of longer periods of exposure to air, therefore more evaporation (Josselyn, 1983). Since this pattern was not found at Buchanan Street marsh, other factors may be affecting soil salinity, such as proximity to Codornices Creek (which feeds into the marsh) and to the marsh channels. Sites nearer the creek may have lower salinity as a result. Sites A through C are on a transect closest to where the creek feeds into the marsh. The transect runs from the channel connected to the creek, and directly away from it (Figure 2). There appears to be a gradient of increasing salinity with increasing distance from the channel at sites A through C (Table 1). The other two transects run directly away from the same channel, and have a similar gradient, but not as great a change in salinity (possibley because these transects are shorter than the other). The salinity gradient for all three transects cannot be confirmed on the few soil salinities measured in this study.

The salinity of salt marsh soils greatly depends on the season, salinity of the tidal waters, and duration of inundation (Chapman, 1960; Mahall and Park, 1976). The salinity values found may be lower than the annual average salinity, as the samples were collected in February. The amount of rainfall and the reduced evaporation rate at this time of year would contribute to low soil salinity. The soil samples were taken at a low tide, which may also result in low salinity. Water at high tides in estuaries tend to be more saline than at low tides due to the larger portion of ocean water (Lindbergh and Harriss, 1973). The time period of inundation is dependent on the height of the tide. A high tide will reach higher elevations in a marsh, allowing more soil solution to exchange with the tidal water. The period of inundation causes the soil salinity to be closer to that of the tidal water.

The variance in pH and salinity of the Buchanan Street sites mentioned could be due to the sampling technique used. Some replicate samples for a site were taken from a lower depth than the first (but within the top 25 cm), causing only one sample to include the top oxidized layer of soil.

A salinity gradient can exist from high to low values with increasing depth, within the top 25 cm of marsh soil. This is primarily due to surface evaporation, but depends on the amount of rainfall, time of inundation, and temperature (Chapman, 1960). The gradient may reverse during the winter. Salinity measurements need to be taken at various depths to verify that this gradient exists. The oxidized layer of a marsh soil may be lower in pH as a result of oxidation of compounds such as hydrogen sulfide (Josselyn and Buchholz, 1984).

The type of soil determines the salinity and nutrient conditions for marsh vegetation. A dominant clay content is needed to provide the large ion exchange surface for a source of nutrients to plants (Harvey et al., 1982). The abundant surface gives a large concentration of cations in the soil solution, i.e., a greater salinity, due to an equilibrium established between the solution and the exchange surface. A high clay content gives the marsh soil its water retentive capacity. As a result, leaching of salts is reduced (Chapman, 1960).

Suggestions

There are various conditions that should be considered for establishing marsh vegetation at the new proposed marsh. The salinity results from this study and the zonation found by Caltrans (1984) for the marsh show that a plan for an overall lower soil salinity for established cordgrass would optimize its

| Sample (site-replicate#) | Elevation above NGVD (ft.) | pH | Salinity (mmhos/cm) | Salinity (ppt) | Type of vegetation at site |
|---|---|---|---|---|---|
| A-1<br>A-2 | 1.7 | 6.5<br>6.8 | 27.8<br>24.3 | 15.9<br>13.9 | pickleweed |
| B-1<br>B-2 | 2.5 | 6.8<br>6.8 | 36.3<br>31.0 | 20.7<br>17.7 | pickleweed |
| C-1<br>C-2 | 2.2 | 7.1<br>7.1 | 40.8<br>40.4 | 23.3<br>23.1 | cordgrass |
| D-1<br>D-2 | 1.3 | 6.3<br>6.4 | ----<br>---- | ----<br>---- | pickleweed |
| E-1<br>E-2 | 2.3 | 6.4<br>6.7 | 31.9<br>31.5 | 18.2<br>18.0 | pickleweed |
| F-1<br>F-2 | 2.0 | 6.8<br>6.8 | ----<br>---- | ----<br>---- | pickleweed |
| G-1<br>G-2 | 1.6 | 6.7<br>6.9 | 37.5<br>40.2 | 21.4<br>22.9 | cordgrass |
| H-1<br>H-2 | 2.3 | 6.4<br>6.8 | 38.4<br>37.2 | 21.9<br>21.3 | pickleweed |
| I-1<br>I-2 | 2.0 | 7.0<br>7.0 | ----<br>---- | ----<br>---- | pickleweed |
| J-1<br>J-2 | 2.3 | 7.0<br>6.9 | 39.8<br>39.3 | 22.7<br>22.5 | pickleweed |

Table 1: pH and Salinity Measurements of Soil Samples from Buchanan Street Marsh
Elevations are with reference to the National Geodetic Vertical Datum 1929 (NGVD) standard (Source: Caltrans, 1984).

growth. The influx of freshwater from Codornices Creek into the marsh, as well as increased tidal flow, will contribute to a low salinity (Caltrans, 1984). In addition to establishing salinities for adult vegetation, the salinity requirements for young vegetation at the time of establishing the new marsh should be observed. The importance of the different salinity requirements were mentioned previously. Factors determining salinity, that can be controlled in marsh creation, are tidal flow, elevation, and the period of inundation.

Soil salinity is not the only aspect of the soil that should be considered in establishing marsh vegetation at the proposed new marsh. The well-established vegetation at the Buchanan Street marsh requires a minimum specific nutrient level. Even though salinity is a measure of the total cation concentration in solution, which are nutrients for plants, it does not give the distribution of the amount of each cation. There are important nutrients that are not in the form of cations, therefore are not accounted for in the salinity measurements. Nitrogen and phosphorus are usually the limiting nutrients in salt marshes (Long and Mason, 1983); knowing their concentrations would be beneficial in achieving a stable plant population.

It is important that a careful decision be made about the type of soil used for creating the new marsh. The type of soil appears to be a controlling factor determining the success of vegetation establishment. It is suggested in the 1984 Environmental Impact Statement (DOT et al., 1984) that the proposed project use the soil from the existing marsh for the new marsh. This seems to be an ideal plan as long as the following precautions are taken. Compaction of the soil should be avoided during the moving of the soil, as this factor reduces the amount of pore space in the soil, which reduces water movement and air space. Any drying of the soil during mitigation must be avoided, as some of the minerals of the clay soil prohibit a complete rehydration. These minerals bind strongly together when water is removed, and cause the soil to shrink (Josselyn, 1983).

Many marsh restoration experts stress the importance of obtaining scientific data on various factors determining marsh conditions and on habitat requirements. The environmental factors cited in this study can contribute to the successful creation of a new marsh.

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