Chapter 4

SOIL ANALYSIS OF THE BERKELEY NORTH WATERFRONT PARK

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In 1983 the Berkeley City Dump was closed, and the process of creating the North Waterfront Park began. A landscape architect was hired, and the filling of soil over the garbage was started. Two years later the time has come to decide what vegetation should be planted. Because the City of Berkeley could not afford to buy a uniform layer of topsoil, the City allowed anyone with clean fill to dump their soil free of charge (Hemmann, 1985, personal communication). This resulted in a wide variety of soils being used as topsoil for the new park. As an aid to the park planning process this study examines the fertility of the top layer of fill for the purpose of giving quantitative information on nutrient levels and pH to persons interested in developing a vegetation plan for the park. The results should be helpful as this is the first study done on the fertility of the soil at the park.

Background

The 90-acre North Waterfront Park (see map, p.viii) located directly north of the Berkeley marina, is divided into five sections (Figure 1). Phase I has already been developed and is an existing park. Phases III, IV, and an unnamed area comprising over half the North Waterfront Park, are not completely filled. This study focuses on Phase II, an area of approximately 11 acres, which at the time of this study was the only area completely filled and ready to be planted. For more information about the park see Brian Moore's paper in this report. The different soils received at Phase II from around the Bay Area have their own specific characteristics concerning plant growth, some good, others poor.

Methodology

Fifteen sample sites were chosen to cover the area uniformly (Figure 2 and Table 1). Approximately three kilograms of soil from a depth of six to twelve inches were taken from each site. The soil was air-dried, ground with a mortar and pestle, and then passed through a 2-millimeter sieve in preparation for chemical analysis. Two replicates were tested during each analysis of a site. The following soil fertility characteristics were tested for:

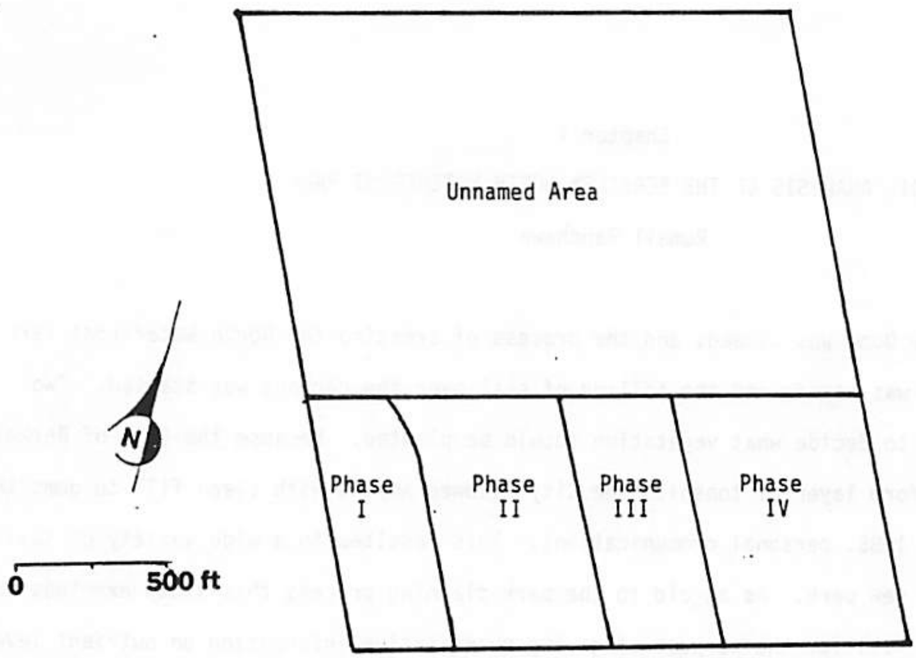

Figure 1: Diagram of North Waterfront Park phases.
Source: City of Berkeley, Department of Public Works,

1. pH
2. Nutrients
   a. Ca = Calcium
   b. Mg = Magnesium
   c. Na = Sodium
   d. K = Potassium
3. Percent organic matter (% OM)
4. Exchangeable Sodium Percentage (ESP)
5. Cation Exchange Capacity (CEC)

The pH is measured by analyzing a saturated soil paste with an electronic pH meter. The paste is made by adding water to the soil until the soil paste glistens as it reflects light, flows slightly when the container is tipped, and slides freely and cleanly off a spatula (Doner, 1985).

The Cation Exchange Capacity (CEC) is determined by adding together the amounts of the four nutrients tested for above using the equation: $CEC\ (meq/100\ g) = Ca^{+2} + Mg^{+2} + K^{+} + Na^{+}$, with all nutrient amounts expressed in meq/100 g. The CEC values calculated in this study will be slightly high for the following reason: There are two forms in which a nutrient can exist in the soil. A cation is called exchangeable if it adheres to a clay particle; if the cation is in the soil solution between soil particles,then it is called a soluble salt. The extractable amount of a cation is equal to the total amount of the soluble salt. This study measures only extractable cations and summed these values

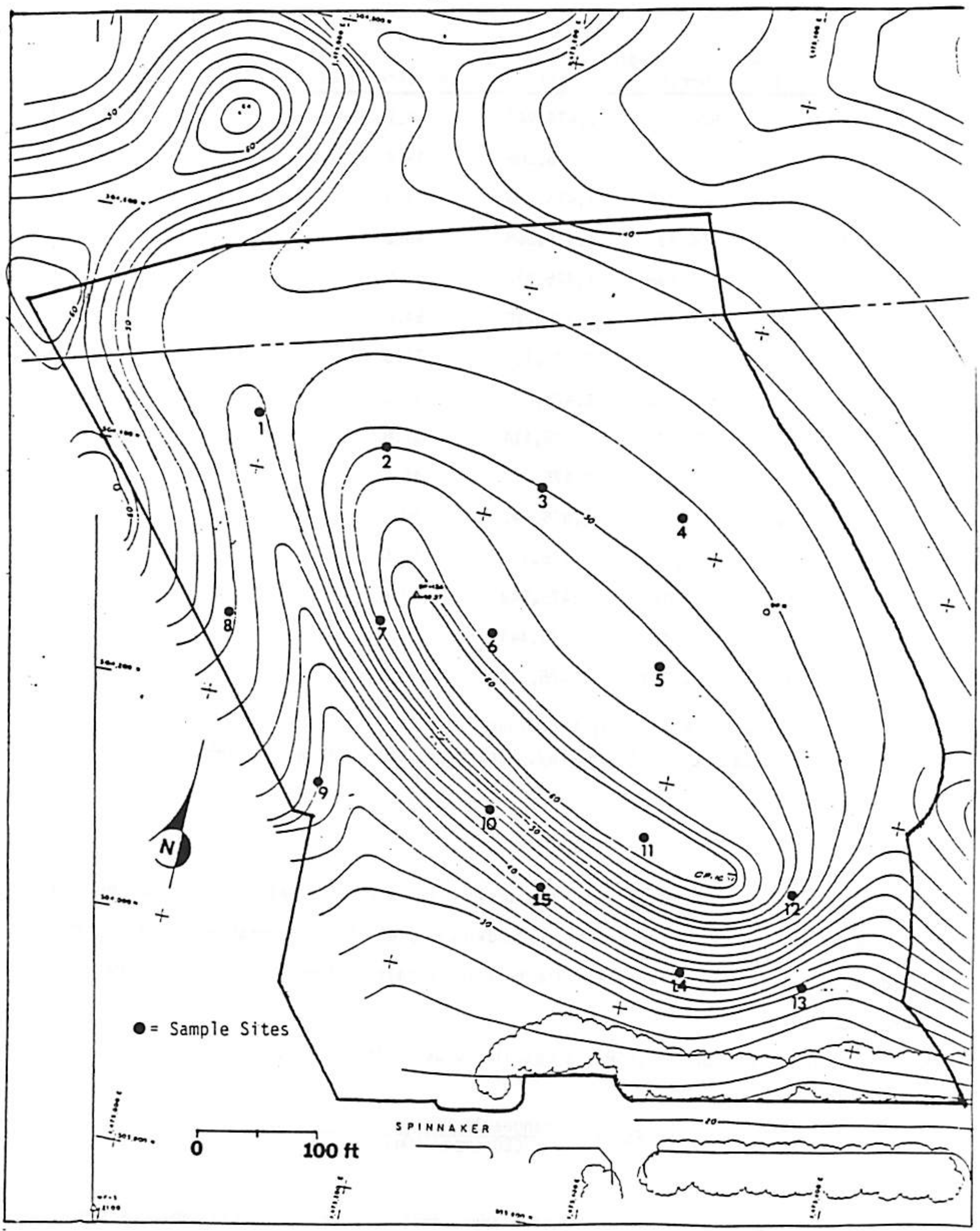

Figure 2: Phase II Sample Site Locations.
Source: City of Berkeley, Department of Public Works, 1985.

Sample Site	Coordinates North	East	Elevation (feet)
1	504,448	1,474,949	49.1
2	504,442	1,475,106	49.9
3	504,436	1,475,245	49.9
4	504,431	1,475,368	48.2
5	504,298	1,475,373	51.9
6	504,296	1,475,228	54.8
7	504,292	1,475,127	51.6
8	504,273	1,475,003	47.8
9	504,143	1,475,114	37.8
10	504,146	1,475,257	46.6
11	504,148	1,475,391	59.8
12	504,125	1,475,523	52.0
13	504,044	1,475,549	33.0
14	504,038	1,475,444	37.5
15	504,089	1,475,314	39.1

Table 1. Exact Site Locations.
Source: City of Berkeley, Department of Public Works, 1985.

to calculate the CEC, on the assumption that the amount of the soluble salt is much smaller than the exchangeable amount. Thus, extractable cation approximately equals exchangeable cation. This assumption is valid because the ratio of exchangeable to soluble salt cations is 10 to 1 or greater (Igbene, 1985, personal communication).

Exchangeable Sodium Percentage (ESP) is calculated using the equation:

$$ESP = \frac{\text{exchangeable Na (meq/100g)}}{\text{CEC (meq/100g)}} \times 100$$

This measurement also uses the extractable cation approximately equal to exchangeable cation assumption.

Percent organic matter is found by oven-drying the soil and weighing. The soil is then burned in an oven at 900° C to determine the difference in weight due to organic material being burned (McColl, 1984).

Results

Examining percent organic matter, nutrient amounts, cation exchange capacity, and exchangeable sodium percentage, one finds that these values are anomalous for sites 3 and 5. Site 3 has the highest value measured for five of the eight parameters tested, % OM, Ca, Mg, K, and CEC, and the lowest value for ESP. Site 5 is the opposite, having the lowest values for six of eight parameters tested, % OM, Ca, Mg, K, Na, and CEC. pH values for all sites were fairly uniform. More detailed results are given in Table 2.

Percent organic matter - Site 3 has the highest value, 14.0%, site 5 the lowest, 1.8%. The range of the thirteen other sites is from 2.3% to 6.0%.

Calcium (Ca^{+2}) - Site 3 has the highest value, 25.7 meq/100g, site 5 the lowest, 4.7 meq/100g. The range for the thirteen other sites is from 8.6 meq/100g to 19.1 meq/100g.

Magnesium (Mg^{+2}) - Again site 3 and site 5 have the high and low values, respectively. However, these values are close enough to values at other sites that the range will include both sites 3 and 5 with the range being 5.6 meq/100g at site 5 to 9.3 meq/100g at site 3.

Sample Site	% OM	pH	Extractable cations (meq/100g soil) Ca^{+2}	Mg^{+2}	K^{+}	Na^{+}	CEC (meq/100g)	ESP %
1	2.3	6.9	8.6	9.2	1.4	1.1	20.4	5.5
2	6.0	7.4	17.0	7.8	1.6	1.5	27.9	5.3
3	14.0	7.2	25.7	9.3	3.5	0.9	39.4	2.1
4	2.8	7.6	10.4	8.4	1.3	1.3	21.4	5.9
5	1.8	7.3	4.7	5.6	1.2	0.5	11.9	4.0
6	2.2	7.3	12.4	6.8	1.3	1.2	21.6	5.3
7	3.7	7.6	15.0	5.9	1.8	1.3	23.4	5.5
8	4.0	7.7	15.5	6.8	1.4	0.8	24.5	3.4
9	3.3	7.7	14.3	6.8	1.4	0.9	23.4	3.9
10	4.1	7.7	17.9	6.7	1.3	1.0	26.9	3.5
11	2.8	7.3	10.5	8.8	1.2	1.1	21.5	5.0
12	3.1	7.1	16.6	8.1	1.3	0.8	26.8	2.9
13	4.0	6.5	14.3	7.1	1.2	0.9	23.6	3.9
14	3.4	7.2	13.5	8.1	1.3	0.9	23.8	3.6
15	3.2	7.6	19.1	8.0	1.2	1.0	29.3	3.4

Table 2: Soil Analysis Values

Potassium (K^+) - Site 3 has the high value, 3.5 meq/100g. Site 5 shares the low value, 1.2 meq/100g, with sites 11, 13 and 15. The range is 1.2 meq/100g to 1.8 meq/100g.

Sodium (Na^+) - Site 5 has the low value, 0.5 meq/100g. For this parameter site 3 has an intermediate value, and the range is from 0.5 meq/100g at site 5 to 1.5 meq/100g at site 2.

Cation Exchange Capacity (CEC) - Due to the consistent high and low nutrient values of sites 3 and 5, respectively, their CEC values were also the highest and lowest by a substantial amount. Site 3 has the highest CEC value, 39.4 meq/100g, site 5 the lowest, 11.9 meq/100g. The thirteen other sites range from 20.4 meq/100g to 29.3 meq/100g.

Exchangeable Sodium Percentage (ESP) - Site 3 has the lowest value by a substantial margin with a value of 2.1%. The other values range from 3.4% to the high of 5.9% at site 4.

pH - Values are fairly uniform, ranging from a low of 6.5 at site 13 to a high of 7.7 at sites 8, 9, and 10.

Discussion of Results

The pH of the soil has an effect on plants through dissolution and precipitation of nutrients and other compounds in the soil. Below pH 5.5 aluminum becomes soluble and can be taken up by plant roots where it has a toxic effect; the hydrogen ion itself starts to have toxic effects on some plants below pH 4 (Bohn et al., 1979). Above pH 7 the availability of micronutrients such as iron, manganese, zinc, copper, and cobalt, starts to decrease due to precipitation. Phosphorous, a major soil nutrient is available only from pH 6 to 8 (Brady, 1974). At the sites tested, aluminum and hydrogen toxicity to plants will not occur since all sites were above pH 6. However, micronutrient deficiencies may occur at sites 4, 7, 8, 9, 10, 11, and 15, which all have pH values greater than 7.5 where the lowest availability for these micronutrients occurs. The eight other sites are suitable in their pH values for plant growth.

The amount of organic matter present in the soil, as measured by the percent organic matter parameter, is an important factor in producing physical and chemical conditions in the soil. Physically, organic matter promotes a process called aggregation, in which individual soil particles are bound together into a clump known as an aggregate, improving drainage in clayey soils (Brady, 1974). Chemically, organic matter has a very high CEC, typically 150 to 300 meq/100g (Brady, 1974). A small amount of this material mixed with the mineral soil will therefore raise the CEC, in some cases quite significantly.

The influence of organic matter is shown in the CEC values. Increasing CEC correlates with increasing organic matter content, except at a few sites. Taking into account that the actual CEC values are slightly lower than measured, because the extractable cation only approximately equals the exchangeable cation, it is found that all sites, except site 5, have CEC values at or above the average for California agricultural soils, 20.3 meq/100g (Bear, 1964, p. 167), with site 3 being substantially above average.

Although CEC is a good general measurement of fertility the amount of sodium contributing to the CEC must also be known. For example, consider a soil with a high CEC with the dominant cation being sodium; the CEC would be high yet the vegetation could suffer from sodium toxicity. The soil would be considered infertile, even though it had a high CEC value. The exchangeable sodium percentage provides a measure of the sodium hazard. If the ESP is greater than 15%, then the soil is considered sodic, and a sodium hazard exists to most plants. No sodium hazard is indicated, as all sites were substantially below 15%. However, this situation may change over time due to sodium influx from sea spray caused by close proximity to the Bay, requiring that plants be monitored for signs of sodium toxicity.

Calcium, magnesium, and potassium values are all at or above the average values for California agricultural soils (as given by Bear, 1964, p. 167), except for sites 4 and 11 which have slightly lower Ca values, and sites 1 and 5, which have substantially lower Ca values. A calcium deficiency may develop at sites 1 and 5. The low values of calcium at these two sites may possibly indicate serpentinitic soil.

Conclusion

This study found that 12 of the 15 sites had soils with fertilities about the same as the average agricultural soil in California. Sites 1 and 5 had lower fertilities due to low calcium levels, possibly because the soils are serpentinitic. Site 3 had a significantly higher fertility because it had a very high organic matter content. No sodium hazard was found to exist at any of the sites, however one may develop due to close proximity to the San Francisco Bay. In determining what vegetation should be planted, the possibility of a sodium hazard developing must be examined. Perhaps an ecological study area could be created displaying salt-resistant coastal vegetation along with serpentine endemic plants which could be planted on areas of serpentine soil at the park. To plant vegetation with a low tolerance to sodium may entail great future expense to keep the soil free from a sodium hazard. In light of Berkeley's current financial situation this may not be possible.

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