AN ANALYSIS OF THE SOIL SAMPLING NEEDS ON THE BENTON LAKE WILDLIFE REFUGE

Objectives

To monitor changes in the soil due to flooding and management as wetland and to evaluate how different water management systems affect the soil.

Present Management System

Aquatic and terrestrial conditions are alternated to increase the productivity of the aquatic phase. Water management is practiced to keep dissolved oxygen levels high enough to control botulism.

Soil Changes Induced by Flooding Naturally Well-Drained Soils

There are two major areas of change in the soil environment due to flooding:

1. A change from aerobic to anaerobic conditions. This change can be predicted to cause the following changes in soil properties:

   a. The chemical reduction of chemical compounds present in the soil; for example, carbon dioxide to methane, sulphate to hydrogen sulfide and sulphur, ferrous iron to ferric iron, and nitrate to ammonia and gaseous nitrogen. Certain reduced states of metallic iron can become toxic in acid soils, but there shouldn't be any problem in the alkaline soils present in the Refuge.

   b. Reduced oxidation rates of organic matter resulting in accumulation of organic matter. The end products of organic decomposition will change. Nitrification will cease, and the end products of nitrogen compound decomposition will become ammonia, gaseous nitrogen, and amines. Certain organic acid intermediate decomposition products may become toxic under extremely stagnate conditions. These effects are unlikely to cause management problems unless extremely stagnant conditions are allowed to persist.

2. A second major source of change in the soil is the accumulation of solids carried in the water which are left behind by evaporation. Two major kinds of solids are involved:

   a. Suspended solids, probably consisting mostly of colloidal organic matter and clay. This accumulation will increase the clay content of the soil surface but shouldn't be a problem in wetland management.

   b. Dissolved solids, consisting mostly of chemical salts. The accumulation of these salts will increase soil salinity and possibly alkalinity, depending upon ratios of calcium and magnesium to sodium. The effect on management will be the change in the amount and kinds of vegetation capable of growing on a drained pond. Extremely high salinity levels could result in the drained ponds becoming barren salt flats with resulting reductions in productivity of the aquatic systems.

Soil Testing Needs

From the above analysis, I conclude that the accumulation of soluble salts is the most likely effect of flooding to become critical in your future management decisions and, therefore, is the most important effect to monitor.

A sampling program to monitor the total effects upon the soil of wetland management is more of the nature of a research project because of the very complex changes induced by this practice. Commercial soil laboratories are oriented toward measuring those soil parameters important to agricultural and engineering uses of the soil and are not likely to have the capability to measure all the qualities affected by flooding.

A sampling program set up to monitor only those changes likely to be important to your future management decisions can be accomplished through commercial laboratory facilities since soil salinity and alkalinity are parameters commonly measured for soils managed for irrigated crop land. This type of program seems to me to be most adapted to your future needs.

Analysis of Current Testing Program

The data gathered in your present program is representative of a rather detailed chemical characterization of soils used for irrigated agriculture. Those parameters which define the fertility status of the soils do not seem to me to be important to your management objectives, unless fertilization and growing domestic plant species is contemplated. You have indicated that this is not the case and I, therefore, recommend that you discontinue measuring organic matter, phosphorous, potassium, sulphur, zinc, iron, copper, and manganese. Should you decide to fertilize at some future time, the fertility testing should be done immediately prior to fertilization because most of these parameters are very dynamic in soils. Testing for calcium, magnesium, and sodium concentration in the saturation extract, ph of the soil paste, and electrical conductivity of the saturation extract should be continued. These parameters are necessary to define the salinity and exchangeable sodium status of the soil. The SAR or sodium absorption ratio is computed from the concentrations of sodium, calcium, and magnesium in the saturation extract.

I also recommend that deep soil testing be discontinued. If your objective is to monitor changes in the soil alkalinity and salinity, these parameters are most variable in the soil surface under the type of management you are practicing, and it is the soil surface where seedlings germinate and most plant roots occur. Analyzing the effects of changes in these parameters on plant growth is, of course, your ultimate goal.

Recommended Sampling Program

Since the soil only becomes important in your management during the period the ponds are drained and salinity and alkalinity are most limiting to plant growth during germination and seedling establishment, I recommend sampling the first spring after the ponds are drained. Samples should be taken from the surface inch and at six inches. Surface salt crust which may be present should be sampled separately. The samples should be taken to characterize the major soil salinity conditions present in the pond. Most commonly, there are a variety of conditions present depending upon depth to ground water. Salt crusts, moisture content, and native vegetation can be used as surface evidence of these various conditions. The sample locations should be permanently marked and dominant native vegetation at each sample site recorded so that major changes in plant communities can be monitored.

Water samples should be taken to characterize water quality at various times of the year for several years, probably during maximum and minimum flow periods. After the water quality is characterized, sampling intervals can probably be reduced to once a year depending upon the amount of variation encountered.

The water quality parameters important to the recommended soil salinity monitoring program are calcium, magnesium, sodium, bicarbonate, and carbonate in milliequivalents per liter, specific conductance and sodium absorption ratios.

Analysis of Available Data

I checked with the Soil Conservation Service for soil classification data for the area. The ponded areas were not mapped. A variety of soils surround the ponds. They are all heavy silty clays--some have exchangeable sodium percentages exceeding 15 in the subsoil. Gypsum crystals are also present in the deep substrata.

The water sample analysis indicates a water with a low sodium hazard and moderate salinity hazard. Waters of this quality are considered suitable for irrigation of all but very salinity sensitive crops.

The soils sampled appear to be saline soils with slight to moderate salinity hazards. These hazards are not presently limiting to adapted native plants. Exchangeable sodium percentages are all below 15, well below for most samples, and black alkali is not presently a hazard. The relatively high calcium and magnesium concentrations in the saturation extract indicate that bicarbonate is not present in the soil solution. Those samples with calcium concentrations in excess of 20 milliequivalents probably contain gypsum and are, therefore, self-reclaiming as far as sodium saturation is concerned.

The available data indicates that there is little danger of soil alkalinity increasing much above 8.2, and the major future limiting factor to plant growth within the ponds will be soil salinity. The more salinity-tolerant native plants can tolerate salinity levels around 16 mmhos. Although, as mentioned earlier, concentrations during the germination and seedling establishment period are most often limiting and tolerance may be lower during this period.

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RESULTS OF DEEP SOIL SAMPLE ANALYSIS

FROM:
Montana Testing Laboratories,
P. O. Box [illegible]48
Great Falls, Montana 59404

FOR: (Grower) Benton Lake

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Ava H (Inc
3860 Pool	1	0-6	7.3	2.0	1.25		73.0	612	13.3	12.9	1.9	2.1	SiCL+	
3861 Pool	2	0-6	6.8	2.7	1.25		83.0	437	16.0	7.5	1.2	1.3	SiC-	
3862 Pool	3	0-6	7.9	2.4	1.25		113.0	887	19.4	17.2	4.8	2.9	SiC	
3863 Pool	4A	0-6	7.4	2.8	0.50		131.0	887	18.5	19.1	6.2	4.6	SiCL+	
3864 Pool	4A	6-12	7.9	0.5	1.25		92.5	675	27.1	14.9	6.2	5.3	SiCL+	
3865 Pool	4D	Native grass 2:1 salt only												
3866 Pool	4D	Foxtail 2:1 salt only												
3867 Pool	5	0-6	8.1	1.9	3.75		100.0	812	+35.0	19.1	6.2	5.0	SiCL+	
3868 Pool	5	6-12	8.4	0.8	0.25		73.0	525	+35.0	13.8	2.7	2.2	SiC-	
3869 Pool	6	0-6	7.9	2.9	0.25		135.5	837	24.1	18.4	4.2	2.9	SiC-	
3870 Pool	6	6-12	8.0	1.1	0.25		186.0	862	29.7	16.8	4.0	3.4	SiCL+	

OTHER TESTS REQUIRED

	Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others
3860	+137.5	2.2	191.0	7.0	170.0				S-					
3861	+137.5	3.1	283.0	10.0	126.0				0					
3862									0					
3863	+137.5	3.8	187.5	7.6	8.2				0					
3864	+137.5								S-					
									S-					
									0					
3867	+137.5	21.8	+30.0	+10.0	24.8				S-					
3868	+137.5	1.18	137.5	9.0	29.0				S					
3869	+137.5	3.1	195.0	9.4	11.4				0					
3870	+137.5	2.6	+30.0	8.9	8.9				0					

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RESULTS OF DEEP SOIL SAMPLE ANALYSIS

FROM:
Montana Testing Laboratories,
P. O. Box [illegible]28
Great Falls, Montana 59404

FOR: (Grower) Benton Lake
Pool 4-C

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Avai H (Inc
3852		0-6	7.7	2.2	1.25		122.0	887	24.1	16.6	6.2	5.6	SiCL+	
3853		6-12	7.9	1.1	0.50		100.0	837	27.1	15.4	5.0	3.0	SiCL	
3854		12-24	7.8	0.3	0.50		73.0	812	+35.0	17.2	6.2	6.2	SiC-	
3855		24-36	8.0	0.1	0.50		88.0	725	+35.0	20.5	7.5	4.5	SiC-	
3856		30-48	7.7	0.1	0.25		51.5	612	+35.0	20.2	7.2	5.3	SiC-	
3857		48-60	7.8	0.1	0.25		83.0	725	+35.0	18.0	7.0	6.4	SiCL+	
3858		60-72	7.8	0.1	0.25		92.5	787	+35.0	20.5	8.2	10.6	SiC-	
3859		72-96	7.9	0.1	0.50		54.8	637	+35.0	18.2	7.88	7.1	SiCL	

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others
+137.5								0					
+137.5	3.3	+30.0	5.8	6.7				0					
+137.5	2.2	+30.0	4.5	4.4				0					
+137.5	1.7	+30.0	3.4	2.8				0					
+137.5	1.5	73.3	2.8	1.8				0					
+137.5	1.5	+30.0	3.4	1.8				S-					
+137.5	3.6	+30.0	3.7	1.8				S-					
+137.5	1.1	97.5	2.8	4.2				M-					

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RESULTS OF DEEP SOIL SAMPLE ANALYSIS

FROM:

Montana Testing Laboratories, In[illegible]
P. O. Box 3048
Great Falls, Montana 59404

FOR: (Grower) Benton Lake
Check

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Available H_2O (Inches)
3846		0-6	7.4	2.5	1.25		32.0	912	34.1	14.2	2.1	1.4	SiC	
3847		6-12	8.0	1.5	0.25		29.5	725	+35.0	20.2	2.2	1.8	SiCL+	
3848		12-24	8.0	1.3	0.50		23.5	500	+35.0	17.0	3.6	2.4	SiCL	
3849		24-36	8.2	0.7	0.25		37.5	412	+35.0	15.9	3.7	3.8	SiC-	
3850		36-48	8.1	1.1	1.25		17.5	412	+35.0	16.4	4.4	3.4	SiCL+	
3851		48-72	8.0	0.9	10.40		21.0	587	+35.0	12.4	2.9	3.6	SiCL	

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others
104.5	1.6	97.5	4.0	13.8				S-					
+137.5	0.5	97.5	2.8	7.0				M-					
+137.5	0.4	26.0	2.0	4.2				M					
+137.5	0.2	15.5	2.4	6.2				M					
+137.5	1.0	27.8	2.5	6.2				M					
+137.5	1.0	07.5	2.8	6.2				M					

Table 1 Chemical Properties of Soil
Benton Lake

Lab No.	Depth inches	pH Paste	Sat'n. %	Elect. Cond. mmhos/cm	Saturation Extract Cations Ca	Mg	Na	SAR
					- - - -meq/liter- - -			
Check								
3846	0-6	6.8	68.7	2.2	9.1	7.1	7.0	2.46
3847	6-12	7.3	66.1	3.0	19.0	20.1	10.3	2.33
3848	12-24	7.5	68.2	4.5	26.0	17.5	17.8	3.82
3849	24-36	7.7	60.2	5.4	27.5	21.7	28.7	5.76
3850	36-48	7.6	64.7	5.7	29.5	21.3	23.0	4.55
3851	48-72	7.5	70.8	5.0	38.5	18.6	17.7	3.31
Pool 4-C								
3852	0-6	7.5	73.8	6.8	29.5	30.4	36.1	6.59
3853	6-12	7.5	76.8	4.9	17.0	40.2	26.6	4.97
3854	12-24	7.7	78.7	6.9	27.5	29.9	35.1	6.55
3855	24-36	7.7	78.0	7.0	18.8	32.6	39.1	7.70
3856	36-48	7.6	70.5	7.5	27.5	34.0	31.3	5.64
3857	48-60	7.5	72.4	7.5	25.5	35.0	45.1	8.19
3858	60-72	7.5	72.5	7.5	24.8	34.4	54.1	9.93
3859	72-96	7.7	71.0	8.2	24.8	36.9	50.6	9.12

Table 2 Chemical Properties of Soil
Benton Lake

				Saturation Extract				
					Cations			
Lab No.	Depth	pH Paste	Sat'n. %	Elect. Cond. mmhos/cm	Ca	Mg	Na	SAR
					- - - -meq/liter- - -			
Pool 1								
3860	0-6	6.8	60.5	2.9	5.2	5.8	4.6	1.96
Pool 2								
3861	0-6	6.3	56.4	4.0	26.0	20.5	10.0	2.77
Pool 3								
3862	0-6	7.4	73.2	4.3	11.0	14.3	24.0	6.72
Pool 4A								
3863	0-6	6.9	68.5	6.1	23.0	27.1	32.0	6.37
3864	6-12	7.5	61.8	6.8	24.0	20.9	36.1	7.60
Pool 4B								
3865 Native gr.	0-6	6.6	63.0	2.7	10.0	8.4	8.2	2.70
3866 Foxtail	0-6	6.8	72.8	5.3	21.5	25.8	24.0	4.93
Pool 5								
3867	0-6	7.3	75.6	6.3	22.5	25.9	32.7	6.65
3868	6-12	8.0	74.6	2.4	5.5	5.3	13.0	5.58
Pool 6								
3869	0-6	7.1	80.6	4.8	16.5	16.8	23.0	5.62
3870	6-12	7.5	78.5	3.7	15.5	11.0	16.0	4.38