Attachment F

Evaluation of Agricultural Uses of Sediments

Final - November 25, 2002

Evaluation of Matilija Reservoir Sediments for Use on Agricultural Lands

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October 11, 2002

Introduction

Matilija Dam is a thin arch concrete dam built by Ventura County primarily for water storage capacity in 1947. Since that time the reservoir behind the dam has filled with sediment, reducing its flood control capacity to less than 10% of original. A coalition of private, state, and federal organizations is currently involved in studying the decommissioning of Matilija Dam and providing for restoration of the Matilija Creek ecosystem. Appraisal and Feasibility level geotechnical investigations have been carried out by the U.S. Bureau of Reclamation (Reclamation, 1 & 2) and the U.S. Army Corps of Engineers (USACE, 3).

A major aspect of the studies is sediment management and determining practical, economic, solutions to disposing of about 5.89 million cubic yards of sediment impounded behind Matilija Dam. One possible alternative in the sediment management program is the use of a large amount of this sediment for local agricultural applications.

Results of a surface geologic mapping and subsurface drilling program performed by Reclamation identified three major areas, each hosting different major sediment size fractions. These three areas were named the Reservoir, Delta, and Upstream Channel. The Reservoir area hosts a thick assemblage of fine grained sediment (predominantly silt), the Delta area hosts a complex mixture of fine to coarse sediment, and the Upstream Channel area hosts coarse sediment (predominantly gravel, cobbles, and boulders).

The present study explores the option of using about 2 million cubic yards of fine grained (fine textured) sediment present in the Reservoir area behind Matilija Dam for agricultural purposes. This could involve placing all the sediment on a single site, or possibly trucking the sediment to several local sites for use as a soil amendment to improve plow layer and active root zone soil characteristics of existing agricultural lands. Much of the sediment in the Reservoir area has a favorable silt loam texture that is well suited for agricultural crop production.

Summary

Based on this initial investigation, it is concluded that about 2 million cubic yards of fine grained sediment in the Reservoir area behind Matilija Dam has physical and chemical characteristics favorable for use as agricultural soils. However, if the use of this fine grained sediment for agricultural purposes is determined to be a practical option then additional detailed investigations need to be carried out. These additional investigations are listed in the "Recommendations" section.

Methods of Study

This report is based on a review and analysis of data contained in various appraisal and feasibility level reports published by Reclamation (1) & (2), and the US Army Corps of Engineers (USACE) (3). Additional geochemical and gradation analyses were performed by Colorado State University (CSU) on 16 samples of drill core obtained from Reclamation's

Feasibility Study, Geotechnical Field Investigations drilling program (2). These additional tests were used to determine the US Department of Agriculture (USDA) classification for the texture (gradation) of the sediment, obtain information on fertility and micro-nutrient content of the sediment, and to determine the carbonate content of the sediment.

Fertility tests were conducted on the Matilija Reservoir sediment by the Colorado State Cooperative Extension Service Soil, Water, and Plant Testing Laboratory. Nutrients were determined on an AB-DPTA extract. Soil salinity (ECe), and soluble boron were determined on a saturation extract. Soil reaction (pH) was determined on the saturated soil paste. Percent organic matter was determined with a modified Walkley-Black Method. A data summary is presented in Table 2. Hard copies of individual data sheets complete with interpretations for vegetable crops are attached to this report or can be faxed upon request. Percent lime on the data sheets is based on reaction to dilute HCL. Soil textures on the data sheets are estimates based on hand tests. Fertilizer recommendations on the individual data sheets are based on Colorado conditions but can be used as a general fertility index for the sediments. Due to possible incomplete oxidation of the samples, it is possible that forms of nitrogen, other than nitrate, are present in significant quantities in the sediment samples.

Samples of Drill Core

Reclamation drilled a total of eight Hollow Stem Flight Auger / Core holes from a barge in the Reservoir area. A total of 37 samples were collected for gradation (sediment particle size) testing, and 21 samples were collected for toxicity testing (chemical tests for 81 for metals, organics, sulfides, pesticides, PAHA's, PCB'S, Phthalates, Phenols, and Organotins as well as total solids, volatile solids, pH, and ammonia). The data for these analyses is presented in Reclamation's Geotechnical Field Investigations (2).

For the present investigation an additional 16 composite samples were collected from drill core in the Reservoir area. Eight composite samples were collected from the top half (shallower portion) of the drill holes and eight were collected from the bottom half (deeper portion) of the drill holes.

Soil particle size (texture or gradation) was determined by the hydrometer method, while an AB-DPTA extraction was used for determination of plant nutrients. Limited saturation extract testing was also completed to determine soil salinity, soil pH, and boron content. Calcium carbonate equivalent tests were performed to determine the ability of the soil to neutralize acid.

Volume of Fine Sediment

Reclamation's Geotechnical Field Investigations (2) determined that there are about 2 million cubic yards (about 1,240 acre-feet) of fine grained sediment in the Reservoir area that may be suitable for use on a wide range of agricultural lands. Additional lenses of clay/silt and sand are present in the Delta area interbedded within coarser sandy-gravely sediment. Sandy sediment in the Delta area, that is free of gravel and cobbles, could be useful for surface soil incorporation on medium and fine textured soils. However this material may be better suited for beach placement or other uses.

Physical Characteristics of the Sediment

Based on the USDA classification, soil textures of sediment in the Reservoir area range from light loam to light silty clay loam (Table 1). The most common texture of the samples is light silt loam with about 15- 20% clay. Water holding capacities, based on the soil texture (5), are estimated to range from 1.75 to 2.23 inches per foot and average about 2 inches per foot. The estimated saturated hydraulic conductivity ranges from 0.69 to 3.09 cm/hr and averages about 1.5 cm/hour.

Data presented in Table 1 indicates that deeper sediment in the Reservoir generally contains more clay than the shallower sediment. The textural data presented above were used to estimate water holding capacity and saturated hydraulic conductivity using a method developed by Saxton, 1986 (5).

Table 1. Particle Size Analysis

FIELD I.D.	DEPTH feet	SOIL TEXTURE USDA Classification	SAND %	SILT %	CLAY %
MDH 01-01 #1	13.3 - 35.0'	Silt Loam	14.4	70.0	15.6
MDH 01-01 #2	35.0 - 80.3'	Silt Loam	12.8	67.6	19.6
MDH 02-01 #1	13.0 - 44.0'	Silt Loam	26.6	64.0	9.4
MDH 02-01 #2	44.0 - 75.5'	Silt Loam	15.6	62.8	21.6
MDH 03-01 #1	13.3 - 36.0'	Silt Loam	16.8	64.6	18.6
MDH 03-01 #2	36.0 - 68.3'	Silt Loam	26.8	54.6	18.6
MDH 04-01 #1	13.0 - 23.0'	Loam	32.6	46.6	20.8
MDH 04-01 #2	23.0 - 33.0'	Silt Loam	7.6	67.6	24.8
MDH 05-01 #1	18.0 - 45.0'	Silt Loam	9.8	66.4	23.8
MDH 05-01 #2	45.0 - 72.8'	Silt Loam	30.4	54.8	14.8
MDH 06-01 #1	9.4 - 22.0'	Silt Loam	21.8	64.6	13.6
MDH 06-01 #2	22.0 - 33.0'	Loam	36.6	49	14.4
MDH 07-01 #1	8.3 - 23.0'	Silt Loam	29.2	60.4	10.4
MDH 07-01 #2	23.0 - 38.0'	Loam	40.6	46.2	13.2
MDH 15-01 #1	12.8 - 50.0'	Silt Loam	20.4	58	21.6
MDH 15-01 #2	50.0 - 85.0'	Silty Clay Loam	8.0	63.6	28.4

The soil gradations were determined by the hydrometer method as described in the USBR 5330-89. Textural designations and particle size classes are based on USDA criteria. Hydrometer reading times for the USDA soil types are: sand - 40 seconds and clay - 7 hours.

Sediment Fertility and Chemical Characteristics

Fine grained sediment in the Reservoir area is generally low in salt with electrical conductivity (ECe) values in the 1.5-2.3 ds/m range (Table 2). Soil reactions are typically slightly alkaline (pH about 7.3-7.7) and are well supplied with common micro-nutrients. However, staff at the soil-testing laboratory of Colorado State University (CSU) recommends about 120 pounds of nitrogen (N), 160 pounds of phosphate (P_2O_5), and about 60 pounds of potassium oxide (K_2O) per acre for optimum vegetable production.

Two tests were run on Reservoir sediment for calcium carbonate, one by the USACE and the other by CSU. Each test had a different protocol with different reaction times allowed between the sediment and hydrochloric acid. The test by CSU used a longer reaction time and determined the calcium carbonate (equivalent) content of the Reservoir sediment samples ranges from 1.8 to 8.6 percent and averages about 3.1 percent (Table 2). Tests by the USACE allowed a much shorter reaction time between the sediment and hydrochloric acid, and their results indicated calcium carbonate content of less than 0.5 percent on similar Reservoir samples.

Both tests may be correct since different protocols were used, and different reaction times were allowed for carbonate reaction with hydrochloric acid. It is believed that a significant portion of carbonate in the Reservoir sediment may be dolomite.

CSU lab found Reservoir sediment pH between 7.3-7.7 while the USACE lab, using a 1-1 soil / water extract, found pH of the Reservoir sediment between 6.7-7.2. Analysis of the acid/base data by Reclamation's Mid Pacific Region Environmental Monitoring Branch (MP-150) indicates that water draining through the Reservoir sediment would be neutral to slightly alkaline, and not acidic (6).

Organic matter in the samples ranges from 2.5- to 5.9%, and averaging about 3.5% (Table 2), which is favorable for agricultural applications. During the sample preparation process large pieces of bulk organic matter such as wood chips were removed from the samples prior to grinding. Consequently, most of the organic matter in the samples is probably more stable humus. Oxidation of sediments during the placement process will probably reduce sediment organic content somewhat.

Table 2. Geochemical Summary

FIELD I.D. #	Depth Feet	%OM	ECe ds/m	pH	NO3-N ppm	P ppm	K ppm	Zn ppm	Fe ppm	Mn ppm	Cu ppm	B ppm	*$CaCO_3$ % Eq
MDH 1-1	13.3-35.0	4.2	2.0	7.5	8	7.0	151	4.3	232.2	24.9	10.0	0.295	2.4
MDH 1-1	35.0-80.3	2.6	2.3	7.6	7	5.7	133	4.1	230.7	13.2	13.4	0 .219	2.3
MDH 2-1	13.0-44.0	3.7	2.3	7.5	9	6.3	102	3.0	191.0	9.7	9.3	0.252	1.9
MDH 2-1	44.0-75.5	2.7	2.1	7.6	2	6.5	131	4.1	224.3	15.0	13.4	0.233	4.1
MDH 3-1	13.3-36.0	5.1	2.3	7.5	18	8.7	141	3.8	242.9	12.1	9.0	0.345	5.7
MDH 3-1	36.0-68.3	2.5	1.9	7.7	8	6.3	103	3.3	205.9	6.5	10.7	0.184	2.2
MDH 4-1	13.0-23.0	2.8	1.6	7.6	7	6.3	122	2.4	209.2	8.5	9.0	0.205	2.2
MDH 4-1	23.0-33.0	5.9	2.2	7.5	10	8.6	198	5.1	290.0	24.3	12.2	0.301	2.3
MDH 5-1	18.0-45.0	3.2	1.7	7.5	1	6.2	117	3.3	258.2	18.9	11.4	0.264	3.5
MDH 5-1	45.0-72.8	2.8	2.0	7.5	2	5.4	86	2.9	219.0	9.8	9.5	0.521	3.1
MDH 6-1	9.4-22.0	3.3	2.0	7.5	1	4.8	98	3.0	234.6	13.3	9.7	0.307	2.8
MDH 6-1	22.0-33.0	5.5	1.5	7.5	2	8.2	126	3.9	248.3	22.7	8.7	0.363	8.6
MDH 7-1	8.3-23.0	4.0	2.1	7.5	1	4.8	105	3.0	238.7	7.6	10.0	0.283	3.2
MDH 7-1	23.0-38.0	4.4	1.9	7.3	3	5.2	80	3.3	181.3	1.8	7.8	0.378	2.6
MDH15-1	12.8-50.0	3.9	1.8	7.5	2	5.9	123	3.7	245.2	15.9	11.1	0.271	1.8
MDH15-1	50.0- 85.0	3.0	2.1	7.7	3	5.6	136	4.1	250.9	11.6	12.4	0.250	4.2

*Calcium Carbonate Equivalent is the percentage of total carbonate that is available for reaction with acidic water, reference (7).

Evaluation of Possible Phytotoxic Elements
Saturation extract boron was run on the 16 samples at the CSU soil testing laboratory and it was determined to be present in normal (non-toxic) concentrations (Table 2).

The soil extraction and testing methods used in the Reclamation (1) & (2), and USACE (3) reports are not specifically designed for plant phytotoxicity evaluation but do provide an indication of the elements that may be present in phytotoxic concentrations. The total element concentration test results presented in the existing Reclamation (1) & (2), and USACE (3) reports were based on the EPA3050 method which is not a complete soil digestion. This extraction procedure typically does not digest silicate minerals such as feldspars and any elements that are encapsulated within these minerals. The EPA3050 method approximates the biologically available element fractions in soils.

USACE (3) determined that the Reservoir sediment is suitable for fresh water disposal, and presented threshold data for NOAA criteria for marine sediment. Some of the sediment contained nickel and copper concentrations that slightly exceed "effective range low" for marine disposal. Data from Reclamation's appraisal report in 1999 indicate that the inorganic chemical concentrations in the sediment are below the average concentrations found in the Earth's crust, except that iron, arsenic, and selenium concentrations are moderately higher.

The USACE report (3) provides preliminary data on 39 sediment samples for organic compounds and pesticide residues as well as metals. The concentrations of a few organic compounds were measured in the samples near the detection limit, but these concentrations did not approach phytotoxic concentrations.

The USACE report (3) provides data for EPA3050 method extractions for several elements including selenium. The selenium values were measured with the EPA7742 hydride method and Reservoir samples from fine grained sediment averaged 0.62 mg/kg. The hydride method is the best method for selenium analysis and has detection limits of 0.1 to 1.0 mg/kg, depending on the sediment's matrix.

The USACE used EPA6020 method (ICP/MS) to measure the concentration of other metals, except they used EPA7471A method (cold vapor) for mercury.

Potential Uses for Sediments
Soil descriptions in the Ventura county soil survey (4) were reviewed to determine which soil series could benefit from application of Matilija sediments. A listing of the interpretations from this evaluation is about 95000 acres for the listed soils in Ventura County. Only soil mapping units with less than 10 percent slope were considered. The three-soil-survey maps nearest Matilija Dam show nearly 7000 acres of soil that could potentially benefit from the Reservoir sediment. These soil types are listed below by category.

<u>Low-water Holding Capacity</u>
Correltos
Huenene
Metz

Riverwash
Sandy alluvial land
Cortina
Anacapa
Garretson

Shallow Depth Soil
Castiac
Cibo
Diablo
Gilroy
Linne
Los Osos
Malibu

Acidic Soil
Aeule
Chesterson
Kimball
Ojai
Los Osos
Malibu

Sandy Soil
Riverwash
Metz
Correletos
Cortina
Arnold
Sandy alluvial land

Clay Soil
Diablo
Cropley
Los Osos
Cibo

High Ground Water Soil
Camarillo
Cropley
Fill land
Huenene
Pacheco

Soils Subject to Flooding
Riverwash
Sandy Alluvial land

Other
Pits and dumps
Irrigated fields with contrasting surface soil textures
Undulating and uneven lands where soil could be used to create a uniform gradient or reduce the existing gradient.

Interviews with Local Agricultural Experts
Telephone interviews with two local agricultural experts were conducted to confirm soil type evaluations and to determine the opportunities and problems associated with sediment placement on agricultural lands. A summary of the findings of these phone interviews with soil scientist Steve Jewett of the Natural Resources Conservation Service (NRCS) and Ben Faber of the University of California (UC) cooperative extension service is presented below.

Comments by NRCS Soil Scientist Steve Jewells:
- Placement of sediments in existing orchards will be very difficult. Sediments should not cover tree grafts and there is a potential to bury or damage irrigation systems.
- Existing orchards can receive green waste free from the Los Angeles area, therefore landowners would probably expect sediments to be delivered and spread free of charge.
- Low lying areas about 25 miles south of the Matilija site already can receive sediments from Callegos Creek. Dredgers often have a problem placing those sediments. We also may have to compete with dredging operations on other local streams for sediment disposal sites.
- Earthen slopes more than 9 percent are on the local counties erosion control list. Permits are required before any fill can be placed on these lands. This may be a significant impediment to sediment placement on some lands.
- Applications of sediments of contrasting textural characteristics may impede soil drainage, which could in turn cause root rot diseases. Sediments should be well incorporated into underlying layers to minimize this effect.

Comments by UC Extension Agent Ben Fabers:
- Placement of sediments in existing orchards would be difficult. A large area of potentially benefiting soil types is currently planted to orchards.
- Currently there are about 20,000 acres of Valencia orange orchards being removed in the Fillmore area because of economic issues. There may be an opportunity to apply sediments to these lands.
- About 2,000 acres of turfgrass are grown in the area. Every time turf is harvested about 1 inch of soil is removed with the turf. Eventually these turf growers will need to build lands back up.
- Use of sediments to neutralize soil acidity may be limited since most subtropical fruits generally prefer a slightly acid soil.
- The Oxnard plain contains many surface soils that would benefit from incorporating silt loam sediments into surface soils(E.G. Pacheco Silty Clay Loam).

- Some areas of Huemene soils on the Oxnard plain could be improved by raising the ground surface away from the water table by sediment applications.
- Application of sediments should provide a uniform surface soil layer with consistent infiltration rates. This would permit a high water application efficiency on gravity irrigated lands.
- There may be an opportunity to use sediment as fill material on rough, steep rangelands. Some lands of this type are located in the Ojai area.

Discussion

It appears that there are sufficient residual carbonates in the sediments to prevent acid conditions from forming following sediment oxidation at agricultural sites. Acid base accounting is very important since sulfides, organic sulfur, and other soil constituents can acidify the soil upon oxidation unless sufficient residual carbonates are present in the soil to buffer the reaction. Many elements are most soluble and toxic under acid soil conditions. Even though most potentially toxic metals are less soluble and less toxic in alkaline soil, elements like selenium are more soluble under the alkaline oxidized conditions that are common in the active root zone soils of many agricultural fields.

Existing data on selenium is inconclusive as far as hazard evaluation. USACE testing of 21 core samples of Reservoir sediment indicate a concentration of more than 0.6 ppm, using the EPA3050 extraction and EPA7742 extraction methods. While selenium is probably not present in levels directly toxic to plants it could be a problem in irrigation return flows originating from the lands or possibly cause elevated levels in food crops or livestock feed grown on the lands, therefore further testing of the sediments for soluble selenium is deemed appropriate.

The fine particle size of the Matilija Reservoir sediment makes it susceptible to both wind and water erosion. The large percentage of fine grained sand and silt are easily erodible. Any stockpiling of sediment, or upland placements, should have an erosion control plan. Handling and transport of dry sediments could also create dusty conditions.

Conclusions

- Based on the data available to date, it appears that about 2- to 3 million cubic yards (1,240- to 1,900 acre-feet) of the sediment in Matilija Reservoir is well suited for use on agricultural land.

- Based on all data examined to date, it appears that the carbonate content of Matilija Reservoir sediment is sufficiently elevated to prevent acidification of sediment and groundwater.

Recommendations

1. Conduct bench testing of sixteen sediment samples currently in Reclamation's Denver (D8570) laboratory. Monitor redox conditions, plant growth, $CaCO3$ content, and soil reaction (pH).
2. Conduct an ICP scan for multiple elements, as well as tests for selenium, arsenic, and mercury on saturation extracts prepared from the 16 samples currently in the laboratory.
3. Conduct an agricultural field examination of Matilija Reservoir and selected areas throughout Ventura County.

4. Visit the Ventura County agent, UC extension personnel, NRCS personnel, and other local experts to discuss sediment agricultural use proposals.
5. Locate greenhouse or other site for large-scale bench testing of sediment, including various treatment response evaluations.
6. Locate local site for field trials. Discuss field trial concept with USACE, UC cooperative extension, and other interested parties.
7. Develop method to obtain sufficient sediment (5-10 acre feet) from the Matilija Reservoir area for field trials.
8. Maintain existing sediment cores for future examination and interpretations.
9. Consult with USACE experts in Vicksburg, MS about agricultural use of the Matilija Reservoir sediment and organic constituents hazards upon oxidation of sediments, as well as suggested bench and field-testing methods.
10. Further investigations are needed to determine plant response, field-trials to determine sediment placement and management techniques and to demonstrate sediment productivity to local growers.
11. Due to the importance of the acid/base accounting to trace element toxicity potential as well as plant growth factors, it may be prudent to rerun these tests as well as the total sulfur content of the soils to insure we have the acid/ base account correct.

Attachments
The following attachments are attached to hard copies of the report only. For persons with only an electronic copy of this report the attachments may be mailed or faxed. Please contact Joseph Brummer at 303-445-2457 for copies of these attachments:

- Original CSU data sheets complete with fertility interpretations.
- Three NRCS soil survey sheets showing possible sediment application areas in the Matilija Dam vicinity.
- CSU laboratory method list.

References

(1) Appraisal Investigations Report for Matilija Dam Decommissioning, Ventura county California. February 2000, USBR

(2) Matilija Dam Ecosystem Restoration Feasibility Study, Final Geotechnical Field Investigations, Ventura County, California, USBR, July 2002.

(3) Impounded sediment characterization, Matilija Dam, Matilija Creek watershed, Ventura County, California. April 29, 2002, Draft USACE, Los Angeles District.

(4) Soil Survey Ventura Area California, USDA in cooperation with the University of California, issued April 1970.

(5) Estimating generalized soil-water characteristics from texture. Soil Sci. Soc. Amer. J. 50 (4) 1031-1036 K. E. Saxton et al, 1986.

(6) Review comments from Bruce Moore, Environmental Monitoring Branch (MP-157).

(7) Methods of Soil Analysis Part 2, Chemical and Microbiological Properties, American Society of Agronomy, C. A. Black, ed. 1965. Method 91-5.


1 590 000 FEET
R. 24 W.
LIMIT OF DETAILED NATIONAL SOIL SURVEY
FOREST
SoF
LkF
CrC
KmD2
SzC
SzD
AuC2
SoE2
SoE
OhD2
SzD
KmC2
OhC2
CyC
14
Santa
Ana
Valley
S A
Coyote
150
(Joins sheet 3)
1 590 000 FEET
5000
4000
3000
2000
1000
0

RNIA — SHEET NUMBER 2

2 Miles

Scale 1:24000

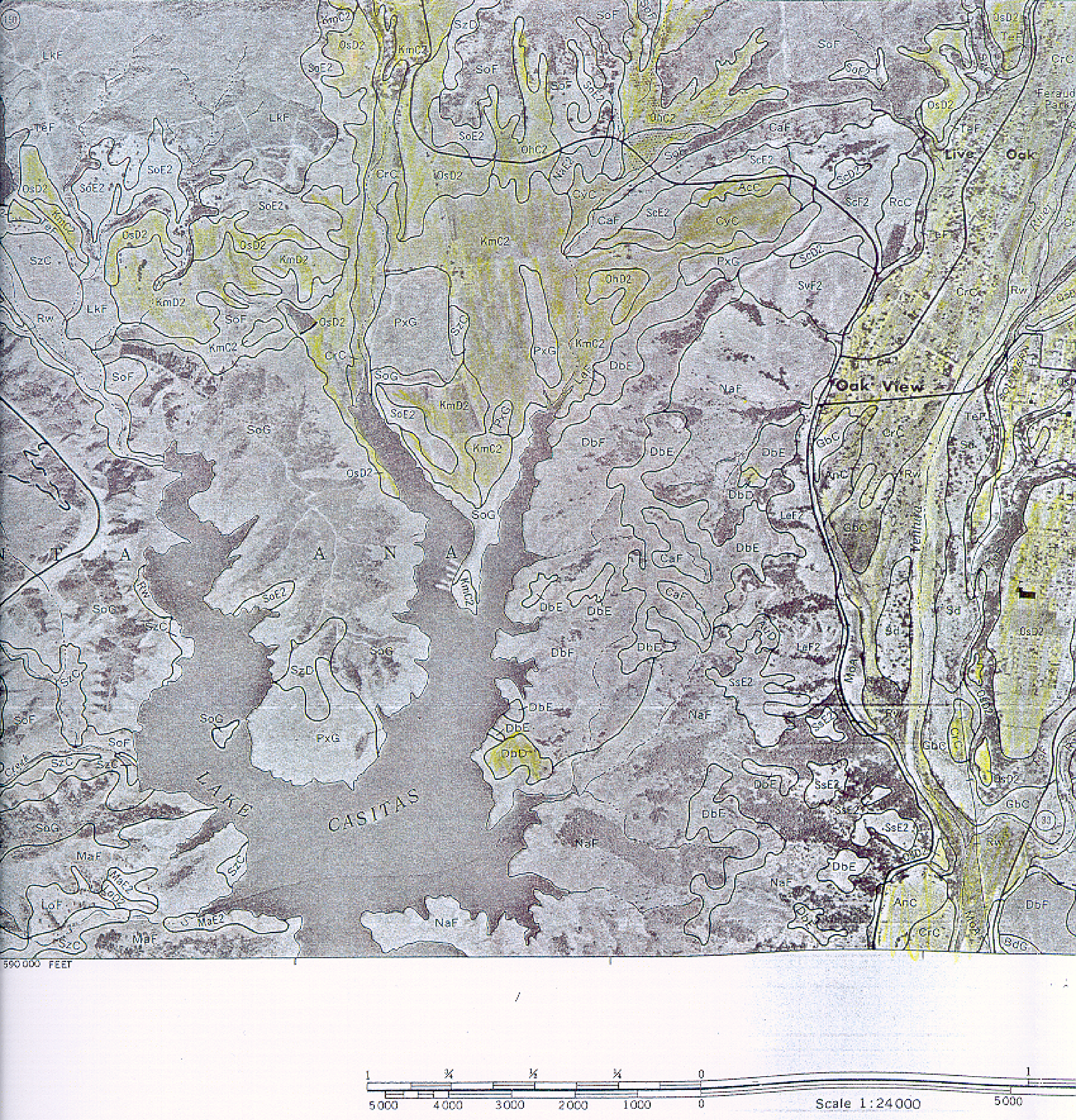
5000

10000 Feet

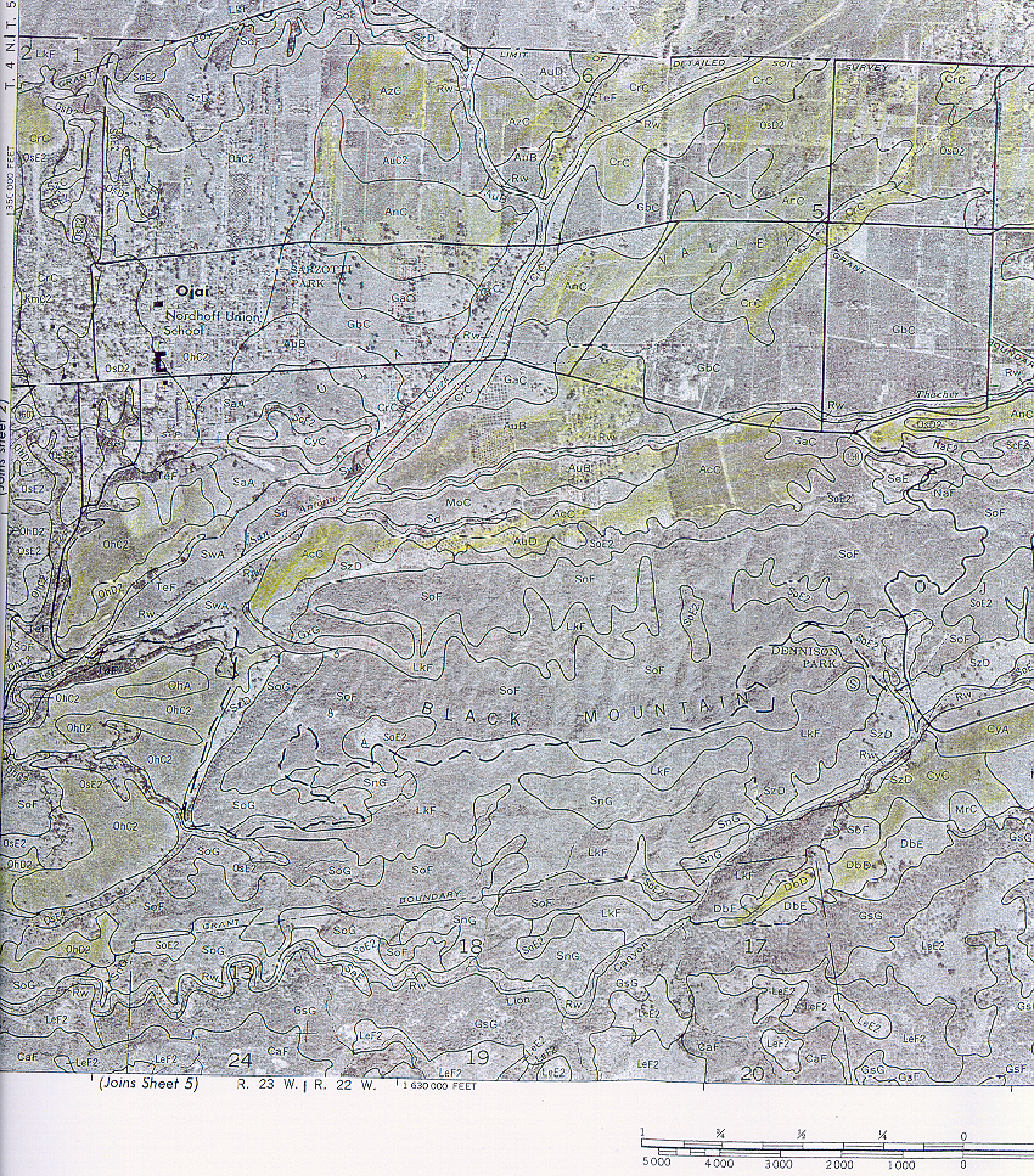
Plane coordinate project 5,000-foot grid ticks on Zone 5. Mosaic compiled

Yellow - land would benefit from Sediment

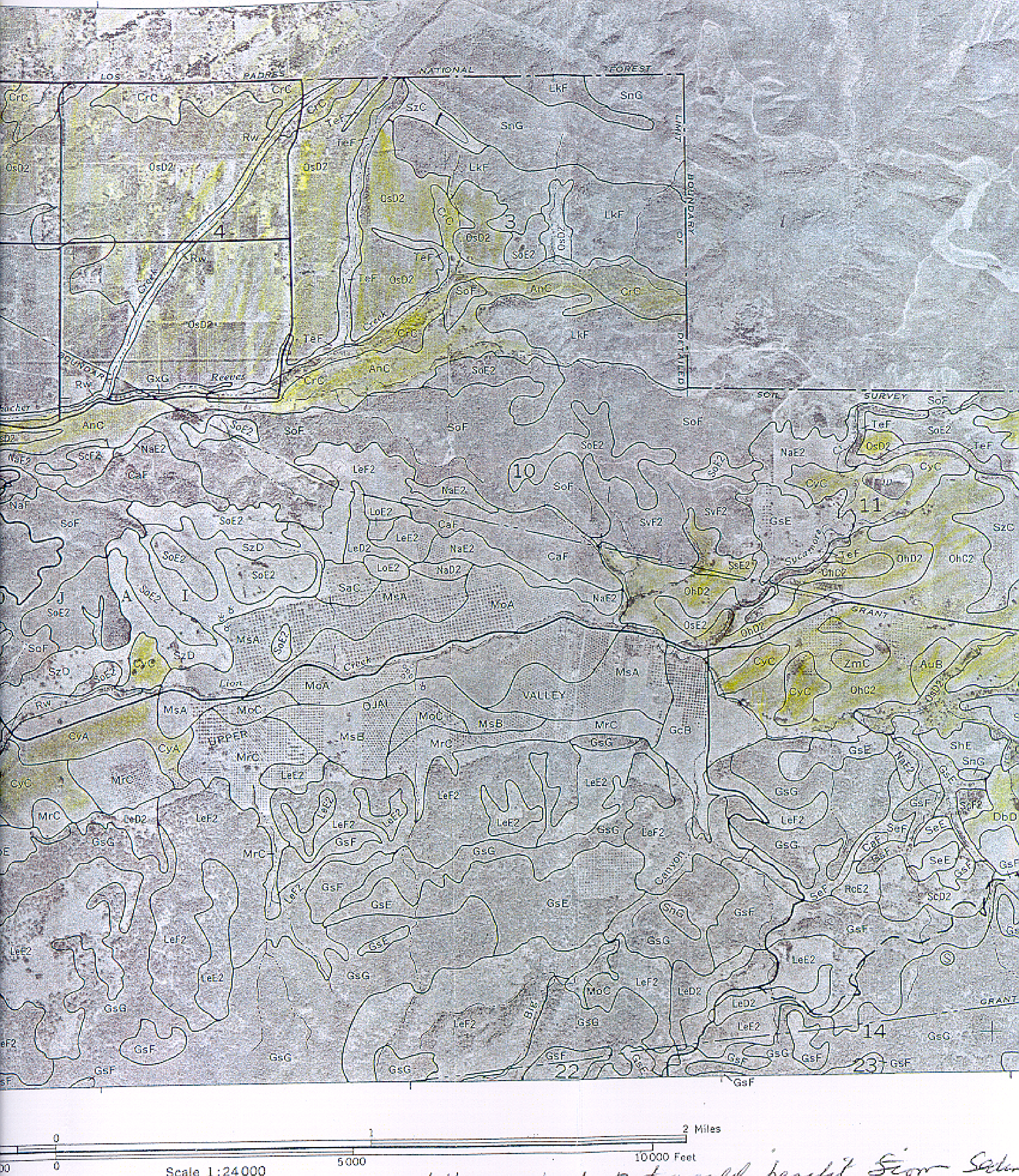
2500 acres


Live Oak
Oak View
LAKE
CASITAS
590 000 FEET
Scale 1:24000
1 ¾ ½ ¼ 0 1
5000 4000 3000 2000 1000 0 5000

Yellow – lands that would benefit from sediment.
~~1500~~ 2000 acres est



Ojai
Nordhoff Union School
SARZOTTI PARK
BLACK MOUNTAIN
DENNISON PARK
VALLEY
GRANT
GRANT BOUNDARY
DETAILED SOIL SURVEY
LIMIT OF
San Antonio Creek
Thacher
Lion Canyon
(Joins Sheet 5)
R. 23 W. | R. 22 W.
1 630 000 FEET
1 350 000 FEET
T. 4 N. | T. 5
5000
4000
3000
2000
1000
0



Yellow – Lands that would benefit from [illegible] application. 2400 acres

no. 0.502

Soil Test Explanation

by P.N. Soltanpour and R.H. Follett [1]

Quick Facts...

- Colorado State University routinely analyzes soil samples for pH, soluble salts, organic matter, nitrate nitrogen, phosphorus, potassium, zinc, iron, copper, manganese, lime and soil texture.
- Additional tests for gypsum and the sodium adsorption ratio (SAR) may be run in the laboratory.
- Nutrient levels are reported as parts per million (ppm) of the elemental nutrient.
- Included in a report from the Colorado State University Soil Testing Laboratory are interpretations that relate results to fertilizer and management suggestions.

Colorado State University routinely analyzes soil samples for pH, soluble salts, organic matter, nitrate nitrogen, phosphorus, potassium, zinc, iron, copper, manganese, lime and soil texture. This test replaces three separate tests previously used for extraction of these same nutrients. It is faster and more economical.

Routine Soil Tests

Soil pH, determined by the saturated paste method, indicates the acidity or alkalinity of soil based on a scale of 0 to 14. On the pH scale, 7.0 is neutral, values below 7.0 are acid, and those above are alkaline. Most Colorado soils are alkaline, having a pH between 7.0 and 8.0. A pH value above 8.5 indicates that the soil contains excess sodium.

Soluble salts are measured by the electrical conductivity of a soil extract from a saturated paste and are reported in mmhos/cm. Crops vary markedly in their tolerance to soluble salts. Therefore, the values must be interpreted in relation to the specific crop. (See Table 1.)

Organic matter (O.M.), reported as percent of total soil, contains about 95 percent of all soil nitrogen (N). About 30 pounds N per acre will be released (mineralized to nitrate) during the cropping season from each 1 percent O.M. present. Nitrogen release rates will be slower in mountain meadow and other high elevation soils.

Nitrate nitrogen, reported in ppm NO_3-N, is soluble and readily available for plant uptake and is therefore considered equally available as fertilizer N. To determine the approximate pounds of NO_3-N/acre-foot (1 acre to a depth of 1 foot), multiply the soil test value (ppm) by 3.6. For example, 10 ppm x 3.6 = 36 pounds NO_3-N/acre to a depth of one foot.

Phosphorus, potassium, zinc, iron, copper and manganese interpretations are given in Tables 2 through 7. When the soil test is very low to medium, fertilizer response is expected. Fertilizer recommended for high-testing soils is for maintenance (to maintain soil fertility at that desirable level). No fertilizer is recommended for soils testing high for dryland production. For the micronutrients, no fertilizer is recommended when the test indicates adequate. To date, there has been no confirmed field crop response to copper or manganese fertilization in Colorado. This test is an availability index. It does not measure the total amount in soil, but only that fraction extractable by the soil test.

Lime ($CaCO_3$) is reported as percent free lime. In the routine test, values are reported as low (0 to 1 percent), medium (1 to 2 percent), and high (above 2 percent). Specific values are determined and reported only when a sodium evaluation is requested on a sample. In this case, the percent freelime content is important in determining whether elemental sulfur will be an effective amendment in sodium reclamation. The lime content has no direct bearing on soil test interpretations for fertilizer recommendations by the Colorado State University Soil Testing Laboratory.

Texture is estimated by the hand-feel method. Nitrogen management suggestions are adjusted according to soil texture. It is important on sands, loamy sands and sandy loams that nitrogen applications be split to avoid mid- or late-season deficiency. It also is recommended that high nitrogen rates be split for many Crops.

Additional Soil Tests

Sodium adsorption ratio (SAR) is determined by saturated paste extraction and is reported as a special ratio of sodium to calcium plus magnesium.

This test evaluates the sodium content of soil. A value of 15 or greater indicates an excess of sodium will be adsorbed by the soil clay particles. Excess sodium can cause soil to be hard and cloddy when dry, to crust badly, and to take water very slowly.

The **gypsum test** is conducted in conjunction with the SAR test. Total gypsum is reported in meq. (milliequivalent) $CaSO_4$/100g. If sufficient native gypsum is present, sodium-affected soils may be successfully treated without addition of amendments such as gypsum or sulfur. The gypsum supplies soluble calcium to replace the adsorbed sodium. Reclamation can proceed if drainage of the land is possible.

Table 1: Tolerance levels of Crops for soluble salts.	
Test values in mmhos/cm	**Interpretation**
0-2	Satisfactory for Crops
2-4	Affects sensitive Crops
4-8	High for many Crops
above 8	Very high for most Crops

Table 2: Available phosphorus (ammonium bicarbonate-DTPA test).		
	Interpretation	
Test values* in ppm	**Irrigated production**	**Dryland production**
0-3	Very low	Low
4-7	Low	Medium
8-11	Medium	High
12-15	High	
above 15	Very high	

Table 3: Available potassium (ammonium bicarbonate-DTPA test).		
	Interpretation	
Test values* in ppm	**Irrigated production**	**Dryland production**
0-60	Low	Low-medium
61-120	Medium	High
121-180	High	
above 180	Very High	

Table 4: Available zinc (ammonium bicarbonate-DTPA test).		
	Interpretation	
Test values* in ppm	**Irrigated production**	**Dryland production**
0-0.50	Very low	Low
0.5-0.99	Low	Marginal
1.0-1.50	Marginal	Adequate
above 1.50	Adequate	

Table 5: Available iron (ammonium bicarbonate-DTPA test).	
Test values* in ppm[1]	**Irrigated and dryland production**
0-3.0	Low
3.1-5.0	Marginal
above 5.0	Adequate
[1]Values below 10.0 may be deficient for turf and many ornamentals.	

Table 6: Available manganese (ammonium bicarbonate-DTPA test).	
Test values* in ppm	**Interpretation**
0-0.5	May be low
above 5.0	Adequate

Table 7: Available copper (ammonium bicarbonate-DTPA test).	
Test values* in ppm	**Interpretation**
0-0.2	May be low
above 2.0	Adequate

[1] P.N. Soltanpour, Colorado State University professor, and R.H. Follett, former Cooperative Extension agronomist and professor; soil and crop sciences. 12/99.

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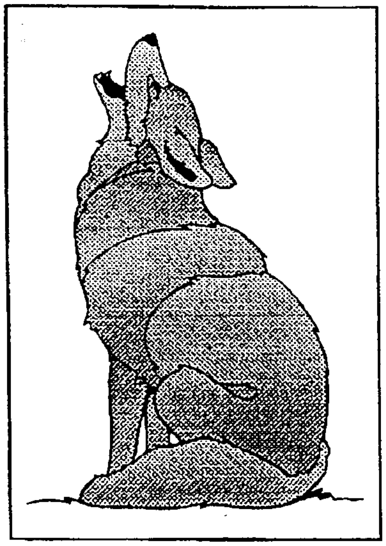

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DATE: 7-5-02 **NUMBER OF PAGES--COVER PLUS** 5

DELIVER MESSAGE TO: Joe Brummer
USDA

FROM: Mary Schumm

COMMENTS: Methods for Soil Analysis
Please see #1, #2 (sat paste),
#5, #3 (your Boron from sat paste extract),
#8 (AB-DTPA), #15, #20, #39 A.
If you have any other questions, please let us know.

If you have any problems receiving this document(s), please call us.

Methods for Soil Analysis

Analysis	Method	Reference
Chemical Analysis		
1. Soil pH	1:1 soil:water Saturated paste	Ref.2, p. 487 Ref. 3, Method 21a p. 102
2.Electrical Conductivity	1:1 soil:water Saturated paste	Ref. 2, pp.420-427 Ref. 3, method 4b p. 89 Ref. 2, pp.427-431
3. Sodium Adsorption Ratio (SAR)	From saturated paste extract Analyze Ca, Mg, Na by ICP	Ref. 2, pp. 1209-1210. Ref. 4, method 5E
4. Percent saturation	Gravimetric	Ref. 3, method 27.
5. Organic matter	Modified Walkely-Black method	Ref. 2, pp995-996
6. Weight loss on ignition	Ash at 550C, gravimetric determination	Ref. 4,method 6A3a
7. Ammonium-nitrogen	2M potassium chloride extract, automated phenate method by FIA	Ref.2 ,pp. 1146-1162
8. Nitrate-nitrogen	2M potassium chloride extract, or AB-DTPA extract, Zn reduction by FIA	Ref. 2,pp1146-1162
9. Nitrite-nitrogen	FIA	Ref.2, pp1146-1162
10. Sulfate-S	MCP extraction; analyze turbidimetrically	Ref. 2, pp.938-941
11. Anions (SO4, Cl, F, PO4) (water extracts)	Ion chromatography	EPA method 300.0. Ref. 5
12.CO3, HCO3	From water extract; determined by titration	EPA method 310.1. Ref. 6
13.Sodium bicarbonate P	Extract with Na2 CO3; analyze colorimetrically	Ref. 2,Pp.895-897

Analysis	Method	Reference
14. Mehlich P	Extract with Mehlich reagent; analyze colorimetrically	Ref.2, pp893-894.
15. Ammonium bicarbonate-DTPA phosphorus	Extract with AB-DTPA; analyze colorimetrically	Ref.2, pp897-898.
16. Bray P	Extract with dilute acid fluoride; analyze colorimetrically	Ref.2, pp894-895.
17. Organic P	Difference of total P-inorganic P	Ref. 2,pp.869-890.
18. Inorganic P by sequential extraction	Extract with ammonium fluoride, NaOH, sodium citrate-sodium dithionite, sodium bicarbonate	Ref. 2,pp.881-884.
19. Anion exchange (P fixation index)	ICP analysis of soluble P	Ref. 2, pp1231-1254.
20. Lime estimate	Qualitative fizz test with dilute acid	Ref. 4,method 6E2a.
21. Percent CaCO3 equiv.	Gravimetric	Ref. 4, method 6E1c.
22. Alkalinity (CO3+HCO3)	Soil-water extract; titrate for CO3 and HCO3	EPA method 310.1. Ref. 6.
23. Exchangeable acidity	Titration of potassium chloride extracts	Ref. 4, method 6H3.
24. Acid-base potential	The difference of CaCO3-total S	Ref. 7, pp233-258.
25. Gypsum	Difference of Ca and Mg from saturated paste and from high moisture determinations.	Ref. 3, method 22c.
26. Moisture determination	Dry soil at 105C; measure weight loss gravimetrically	Ref. 3, method 26.
27. Cation exchange capacity	Measure Na; account for entrained Na with nitrite	Ref. 2, pp 1201-1230.

Analysis	Method	Reference
28. Exchangeable Na	Extract with ammonium acetate, read by ICP; account for water soluble Na	Ref. 4, method 5D2.
29. Exchangeable Na percentage (ESP)	(Exchangeable Na/CEC) x 100	Ref. 2, pp1209-1210
30. Carbon/Nitrogen ratio	CHN furnace; subtract off CO3-C from total C to get TOC: C/N ratio= %TOC/%total N	Ref. 2, pp967-977.
31. Organic C	Total C from CHN furnace minus CO3-C	Ref. 2, pp.967-977.
32. Total C	CHN furnace	Ref. 2, pp967-977.
33. Redox potential	Platinum electrode	Ref. 2, pp1255-1273.
34. Pyritic S	Extraction with dilute hydrochloric acid and nitric acid. Read Fe by ICP. Convert Fe to FeS.	Ref. 7, pp 233-258.
35. Total S	SC132 Leco furnace	Ref. 2, pp933-938.
36. Silicon	Digestion with boric acid	Ref. 2, method 6V1.
37. Bromide	Water extract analyzed by ion chromatography	
38. Total Chloride	Water extract analyzed by ion chromatography	Ref. 4, method 6K1c
39. ICP elements: Ca, Mg, Na, K Zn, Fe, Mn, Cu, Ni, Pb, Cr, Cd, Mo, V, B, P, Ba, Sr, Ti, Al		
A. Extractable (water, dilute acid, AB-DTPA, etc)	ICP	Ref. 2, pp91-140

Analysis	Method	Reference
1.As	ICP-Hydride	Ref. 2, pp91-140.
2.Se	ICP-Hydride	" " "
B. Total		
1. Nitic-perchloric digest	ICP	" " "
2. Nitric-perchloric-HF digest	ICP	" " "
3. Total N	CHN furnace	Ref. 2, pp1085-1122.
	Kjeldahl	" " "
4. Mercury	Cold-vapor	Ref. 2, pp769-792.
5. As and Se	ICP-Hydride	Ref. 2, pp91-140.
40. Cyanide	Distillation	
Particle Size Analysis		
41. Hydrometer	Graduate cylinder; density by hydrometer	Ref. 1, method 15-4.
42. Pipet	Graduate cylinder; silt and clay fractions gravimetrically	Ref.1, method 15-4. Ref. 4, method 3A.
43. Sand fractions	Wet or dry sieve	Ref. 1, method 15-5.2.4.
44. Very fine sand	Wet or dry sieve; Collect fraction retained on #270 sieve	Ref. 1, method 15-5.2.4.
45. Gravel content	Collect fraction retained by 2mm sieve.	Ref. 4, method 3B.
46. Gravel fractions	Wet or dry sieve.	Ref.4, method 3B2
Physical characteristics		
47. Bulk density (clod method)	Weight of soil clod in water.	Ref. 1, method 13-4.
48. Bulk density (graduate cylinder)	Weight of known volume of soil.	Ref. 1, method 13-1.
49. Bulk density (intact cylinder)	Weight of known volume of soil from undisturbed soil core.	Ref. 1, method 13-2.
50. Hydraulic conductivity	Volume of water passing through a soil core in a certain amount of time.	Ref. 1, method 28-4

Analysis	Method	Reference
51. Porosity	From bulk density and particle density.	Ref. 1, method 18-2
52. Moisture tension	0-15 bar with appropriate pressure plates.	Ref. 1, method 26-1

References

1. Klute, A. 1986. Methods of Soil Analysis. Part 1. Physical and Mineralogical Methods. 2nd edition. Soil Science Society of America, Inc., Madison, Wisconsin.

2. Spark, D.L., (ed). 1996. Methods of Soil Analysis: Part 3. Chemical Methods. Soil Science Society of America, Inc., Madison, Wisconsin.

3. Diagnosis and Improvement of Saline and Alkali Soils. U.S. Salinity Laboratory Staff. U.S.D.A. Handbook No. 60. 1954.

4. Soil Survey Laboratory Methods Manual. Soil Survey Investigation Staff. Soil Survey Investigations Report No. 42. Version 1. October, 1991. U.S.D.A., SCS, National Soil Survey Center.

5. The Determination of Inorganic Anions in Water by Ion Chromatography. Method 300.0. USEPA. Environmental Monitoring and Systems Laboratory. Cincinnati, OH.

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7. Williams, R.D., and G.E. Schuman. 1987. Reclaiming Mine Soils and Overburden in the Western United States. Analytic Parameters and Procedures. Soil Conservation Society of America.

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IDENTIFICATION		ROUTINE SOIL TEST RESULTS													
Lab No.	Field Number	pH	Salts mmhos/cm	Lime %	Texture Estimate	SAR	Gypsum meq/100g	Organic Matter %	Nitrate N ppm	Phosphorus P ppm	Potassium K ppm	Zinc Zn ppm	Iron Fe ppm	Manganese Mn ppm	Copper Cu ppm
F430g	MDH 04-01 # 1	7.6	1.6	Medium	Clay Loam			2.8	7	6.3	122	2.4	209.2	8.5	9.0
F431h	MDH 04-01 # 2	7.5	2.2	Medium	Clay Loam			5.9	10	8.6	198	5.1	290.0	24.3	12.2

I. D.	FIELD INFORMATION					RECOMMENDED FERTILIZER (LBS/A)							OTHER		
Lab No.	Acres	Irrigation	Last Crop	Yield Last Crop	Manure T/A	Proposed Crop	Yield Goal	N	P_2O_5	K_2O	Zn	Fe (Iron)	Mn lbs/A	Cu lbs/A	Gypsum T/A
F430g		YES	None			vegetables		120	160	40	0	0	0	0	

Boron mg/L 0.205

F431h		YES	None			vegetables		120	160	0	0	0	0	0	

Boron mg/L 0.301

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F432i	MDH 05-01 # 1	7.5	1.7	Low	Clay Loam			3.2	1	6.2	117	3.3	258.2	18.9	11.4
F433j	MDH 05-01 # 2	7.5	2.0	Low	Clay Loam			2.8	2	5.4	86	2.9	219.0	9.8	9.5

I. D.	FIELD INFORMATION					RECOMMENDED FERTILIZER (LBS/A)							OTHER		
Lab No.	Acres	Irrigation	Last Crop	Yield Last Crop	Manure T/A	Proposed Crop	Yield Goal	N	P_2O_5	K_2O	Zn	Fe (Iron)	Mn lbs/A	Cu lbs/A	Gypsum T/A
F432i		YES	None			vegetables		120	160	40	0	0	0	0	

Boron mg/L 0.264

F433j		YES	None			vegetables		120	160	80	0	0	0	0	

Boron mg/L 0.521

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F434k	MDH 06-01 # 1	7.5	2.0	Medium	Clay Loam			3.3	1	4.8	98	3.0	234.6	13.3	9.7
F435l	MDH 06-01 # 2	7.5	1.5	Medium	Clay Loam			5.5	2	8.2	126	3.9	248.3	22.7	8.7

I. D.	FIELD INFORMATION					RECOMMENDED FERTILIZER (LBS/A)							OTHER		
Lab No.	Acres	Irrigation	Last Crop	Yield Last Crop	Manure T/A	Proposed Crop	Yield Goal	N	P_2O_5	K_2O	Zn	Fe (Iron)	Mn lbs/A	Cu lbs/A	Gypsum T/A
F434k		YES	None			vegetables		120	160	80	0	0	0	0	

Boron mg/L 0.307

F435l		YES	None			vegetables		120	160	40	0	0	0	0	

Boron mg/L 0.363

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Lab No.	Field Number	pH	Salts mmhos/cm	Lime %	Texture Estimate	SAR	Gypsum meq/100g	Organic Matter %	Nitrate N ppm	Phosphorus P ppm	Potassium K ppm	Zinc Zn ppm	Iron Fe ppm	Manganese Mn ppm	Copper Cu ppm
F436m	MDH 07-01 # 1	7.5	2.1	Low	Clay Loam			4.0	1	4.8	105	3.0	238.7	7.6	10.0
F437n	MDH 07-01 # 2	7.3	1.9	Low	Clay Loam			4.4	3	5.2	80	3.3	181.3	11.8	7.8

I. D.	FIELD INFORMATION					RECOMMENDED FERTILIZER (LBS/A)							OTHER		
Lab No.	Acres	Irrigation	Last Crop	Yield Last Crop	Manure T/A	Proposed Crop	Yield Goal	N	P_2O_5	K_2O	Zn	Fe (Iron)	Mn lbs/A	Cu lbs/A	Gypsum T/A
F436m		YES	None			vegetables		120	160	40	0	0	0	0	

Boron mg/L 0.283

F437n		YES	None			vegetables		120	160	80	0	0	0	0	

Boron mg/L 0.378

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Lab No.	Field Number	pH	Salts mmhos/cm	Lime %	Texture Estimate	SAR	Gypsum meq/100g	Organic Matter %	Nitrate N ppm	Phosphorus P ppm	Potassium K ppm	Zinc Zn ppm	Iron Fe ppm	Manganese Mn ppm	Copper Cu ppm
F438o	MDH 15-01 # 1	7.5	1.8	Low	Clay Loam			3.9	2	5.9	123	3.7	245.2	15.9	11.1
F439p	MDH 15-01 # 2	7.7	2.1	Low	Clay Loam			3.0	3	5.6	136	4.1	250.9	11.6	12.4

I. D.	FIELD INFORMATION					RECOMMENDED FERTILIZER (LBS/A)							OTHER		
Lab No.	Acres	Irrigation	Last Crop	Yield Last Crop	Manure T/A	Proposed Crop	Yield Goal	N	P_2O_5	K_2O	Zn	Fe (Iron)	Mn lbs/A	Cu lbs/A	Gypsum T/A
F438o		YES	None			vegetables		120	160	40	0	0	0	0	

Boron mg/L 0.271

F439p		YES	None			vegetables		120	160	40	0	0	0	0	

Boron mg/L 0.250

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Lab No.	Field Number	pH	Salts mmhos/cm	Lime %	Texture Estimate	SAR	Gypsum meq/100g	Organic Matter %	Nitrate N ppm	Phosphorus P ppm	Potassium K ppm	Zinc Zn ppm	Iron Fe ppm	Manganese Mn ppm	Copper Cu ppm
F440q	MDH 24-01 # 1	7.5	2.0	Medium	Clay Loam			2.8	2	6.1	127	3.8	221.0	15.7	12.3

I. D.	FIELD INFORMATION					RECOMMENDED FERTILIZER (LBS/A)							OTHER		
Lab No.	Acres	Irrigation	Last Crop	Yield Last Crop	Manure T/A	Proposed Crop	Yield Goal	N	P_2O_5	K_2O	Zn	Fe (Iron)	Mn lbs/A	Cu lbs/A	Gypsum T/A
F440q		YES	None			vegetables		120	160	40	0	0	0	0	

Boron mg/L 0.233

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Lab No.	Field Number	pH	Salts mmhos/cm	Lime %	Texture Estimate	SAR	Gypsum meq/100g	Organic Matter %	Nitrate N ppm	Phosphorus P ppm	Potassium K ppm	Zinc Zn ppm	Iron Fe ppm	Manganese Mn ppm	Copper Cu ppm
F424a	MDH 01-01- #1	7.5	2.0	Low	Silty Clay Loam			4.2	8	7.0	151	4.3	232.3	24.9	10.0
F425b	MDH 01-01- #2	7.6	2.3	Medium	Silty Clay			2.6	7	5.7	133	4.1	230.7	13.2	13.4

I. D.	FIELD INFORMATION					RECOMMENDED FERTILIZER (LBS/A)							OTHER		
Lab No.	Acres	Irrigation	Last Crop	Yield Last Crop	Manure T/A	Proposed Crop	Yield Goal	N	P_2O_5	K_2O	Zn	Fe (Iron)	Mn lbs/A	Cu lbs/A	Gypsum T/A
F424a		YES	None			vegetables		120	160	0	0	0	0	0	

Boron mg/L 0.295

F425b		YES	None			vegetables		120	160	40	0	0	0	0	

Boron mg/L 0.219

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Lab No.	Field Number	pH	Salts mmhos/cm	Lime %	Texture Estimate	SAR	Gypsum meq/100g	Organic Matter %	Nitrate N ppm	Phosphorus P ppm	Potassium K ppm	Zinc Zn ppm	Iron Fe ppm	Manganese Mn ppm	Copper Cu ppm
F426c	MDH 02-01 # 1	7.5	2.3	Medium	Clay Loam			3.7	9	6.3	102	3.0	191.0	9.7	9.3
F427d	MDH 02-01 # 2	7.6	2.1	Medium	Clay Loam			2.7	2	6.5	131	4.1	224.3	15.0	13.4

I. D.	FIELD INFORMATION					RECOMMENDED FERTILIZER (LBS/A)							OTHER		
Lab No.	Acres	Irrigation	Last Crop	Yield Last Crop	Manure T/A	Proposed Crop	Yield Goal	N	P_2O_5	K_2O	Zn	Fe (Iron)	Mn lbs/A	Cu lbs/A	Gypsum T/A
F426c		YES	None			vegetables		120	160	80	0	0	0	0	

Boron mg/L 0.252

F727d		YES	None			vegetables		120	160	40	0	0	0	0	

Boron mg/L 0.233

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SOIL, WATER & PLANT TESTING LABORATORY
COLORADO STATE UNIVERSITY
FORT COLLINS, COLORADO 80523-1120

DATE RECEIVED 05/21/2002

DATE REPORTED 05/31/2002

COUNTY N/A

SOIL TEST REPORT

MATILLDA

IDENTIFICATION		ROUTINE SOIL TEST RESULTS												
Lab No.	Field Number	pH	Salts mmhos/cm	Lime %	Texture Estimate	SAR	Gypsum meq/100g	Organic Matter %	Nitrate N ppm	Phosphorus P ppm	Potassium K ppm	Zinc Zn ppm	Iron Fe ppm	Manganese Mn ppm	Copper Cu ppm
F428e	MDH 03-01 # 1	7.5	2.3	Medium	Clay Loam			5.1	18	8.7	141	3.8	242.9	12.1	9.0
F429f	MDH 03-01 # 2	7.7	1.9	Medium	Clay Loam			2.5	8	6.3	103	3.3	205.9	6.5	10.7

I. D.	FIELD INFORMATION					RECOMMENDED FERTILIZER (LBS/A)							OTHER		
Lab No.	Acres	Irrigation	Last Crop	Yield Last Crop	Manure T/A	Proposed Crop	Yield Goal	N	P_2O_5	K_2O	Zn	Fe (Iron)	Mn lbs/A	Cu lbs/A	Gypsum T/A
F428e		YES	None			vegetables		120	160	40	0	0	0	0	

Boron mg/L 0.345

F429f		YES	None			vegetables		120	160	80	0	0	0	0	

Boron mg/L 0.184

IMPORTANT INFORMATION ATTACHED
Visit our web site at: http://www.colostate.edu/Depts/SoilCrop/soillab.html

APPROVED [signature] Ph.D.
TITLE Extension Soil Testing Specialist

ATTENTION GROWERS

The suggestions provided are based on the soil analysis results of our laboratory and the information you supplied on the Information Sheet. They are guides to obtaining your desired yield developed from the research of CSU scientists and extension personnel and may require some modification for your specific situation.

The fertilizer suggestions are given in pounds/acre on the oxide basis for phosphorus (P_2O_5) and potassium (K_2O). All other nutrients are suggested on the elemental basis (N, Zn, etc.) In the case of correcting sodium affected soils, gypsum (or other corrective materials) is suggested in tons/acre of material as a soil amendment (not a plant nutrient).

It is the policy of the CSU Soil Testing Laboratory to suggest only those nutrients that offer a reasonable possibility of increasing the yield of your crop and in those amounts as closely as we can determine that are necessary to achieve your yield goal. Remember, however, that a high yield goal can be obtained only when proper fertilization is used **IN COMBINATION** with a level of overall crop production management consistent with that yield goal.

Note 1 NITROGEN

Fertilizer nitrogen can easily be lost to the intended crop through leaching. Therefore, its management is of special importance. In cases of high N rates, sandy soils, or long-season crops, split applications will increase plant utilization of the fertilizer N, avoid late season deficiency, and reduce leaching loss.

a. SUGAR BEETS—Split nitrogen applications offer the opportunity to adjust the rate during the season in accordance with the yield prospect. This is especially important when fertilizing for a high yield since excessive nitrogen will reduce sugar yield. If the in-season yield prospect changes from the original goal, alter the nitrogen suggestion by 10 lbs. N/ton yield difference expected. Apply all nitrogen before July 1 on medium and heavy textured soils and before July 10 on coarse textured soils.

IMPORTANT: Much of the nitrogen from manure is released in the latter part of the season which tends to retard sugar accumulation. Therefore, manure would be best used on other crops in your rotation such as corn.

b. CORN AND SORGHUM (irrigated)—Split nitrogen applications prevent late season deficiency and offer the opportunity to adjust the rate of application in accordance with the yield prospect. If the in-season yield prospect changes from the original goal, alter the nitrogen rate by 40 lbs. N/25 bu grain or 10 T silage.

c. SMALL GRAINS:
WINTER WHEAT (dryland)—The suggestion is based on an "average" rainfall year. In years of exceptionally good soil moisture an additional 20 to 30 lbs. nitrogen applied in early spring over the suggested amount may increase yield and grain protein.

MALTING BARLEY—The nitrogen suggestion is based on avoiding unacceptably high grain protein yet obtaining a good yield.

d. PASTURE AND MEADOWS—Split nitrogen applications are necessary to maintain yield and protein content throughout the growing season. Applications should be split according to the number of harvests and yield potential of each harvest.

e. LEGUME CROPS (beans, alfalfa, etc.)—These crops utilize nitrogen from the air. When the roots are properly nodulated nitrogen fertilization will not be beneficial.

Note 2 PHOSPHORUS AND POTASSIUM

Phosphorus is a non-mobile nutrient, staying where it is placed in all but the sandiest soils. Therefore, plowdown or band applications which place it in the most active root-feeding zone are consistently superior to topdressing. In the case of established perennial crops such as alfalfa and pasture, topdressing has proven to be a satisfactory method of application. For most rapid benefit, topdress at the earliest possible date (fall application will give better first season response than spring application).

IMPORTANT: Excessive rates of phosphorus fertilization will reduce the availability of zinc and iron, which in the case of sensitive crops **(Note 3)** could cause an actual yield reduction

Potassium is more mobile in soil than phosphorus. However, there is little danger of leaching loss in all but the sandiest soils.

Note 3 MICRONUTRIENTS

Only zinc and iron deficiencies are common in Colorado. Crops grown in our state that are both zinc and iron sensitive (most likely to respond to fertilization with these nutrients) are corn, sorghum, beans, potatoes, and most fruit trees. Turfgrass and many ornamental shrubs and trees are iron (but not zinc) sensitive.

a. ZINC—The most effective application method for inorganic products, such as zinc sulfate, is generally broadcast-plowdown in which the zinc is mixed thoroughly in the plant rooting zone. * Banding is also effective and may be preferred in situations of shallow or minimum tillage. One application of 5 to 10 lbs. Zinc/A (15 to 30 lbs/A of zinc sulfate--36% Zn) should be sufficient for 2 to 4 years production.

Effective zinc chelates may be used at about 1/3 the rate of inorganic products. They may be banded or mixed. Application should be repeated for each subsequent zinc sensitive crop.

b. IRON—Soil application of iron generally is not effective in Colorado. Deficiency is best corrected by spraying the crop with a 2% Ferrous (iron) sulfate solution (1% SOLUTION FOR POTATOES) at the rate of 20 to 30 gallons/A 10-15 days after crop emergence. Repeat application at 10-day intervals if yellowing of foliage persists. A 2% solution is prepared by adding 16 lbs. iron sulfate (20% iron) to 100 gallons of water; include a surfactant (wetting agent).

c. MANGANESE—The most effective application method for inorganic products, such as manganese sulfate, is banding with an acid-forming fertilizer. Broadcast applications will likely require at least twice the suggested bonded rate to be effective. Do not reapply without a valid soil test.

d. COPPER—Copper may be broadcast and plowed down or band applied with good results. Do not reapply without a valid soil test.

Note 4 DRYLAND PRODUCTION

Response to fertilizer applications under dryland production situations is highly dependent on the annual available moisture. In regions that average less than 15 inches rainfall per year, it is doubtful that fertilization is an economical practice, regardless of the soil fertility level. Greater responses are usually obtained from the sandylands in comparison with the hardlands due to greater water utilization efficiency.

Note 5 SALT AND SODIUM

Saline soils contain an excess of soluble salts which inhibits seed germination and plant growth. The **ONLY** way to correct this condition and those cited below in your soil is to leach the salts from the plant root zone. Chemical amendments, conditioners, or fertilizers will not correct a salt problem. In order to leach the salts, the soil must have adequate internal drainage to allow water to pass through it. The amount of good quality irrigation water passing through a foot of soil will decrease the salt concentration by the approximate percentages listed below.

Acre-feet of Water/Acre	% Salt Reduction Expected
1/2	50
1	80
2	90

Our tests cannot determine if your field has adequate internal drainage or what steps are most practical in your specific situation. For this information, we suggest that you visit your local Soil Conservation Service office.

When it is not practical or possible to correct a salt problem, the only alternative is to plant a relatively salt tolerant crop such as tall wheatgrass or barley.

SODIC SOILS (black alkali) contain an excess of sodium which causes them to be hard and cloddy when dry, to crust badly, and take water very slowly . These soils must have a source of soluble calcium to correct the situation. This calcium may naturally occur in your soil or irrigation water or must be added as an amendment. Gypsum is the amendment most frequently used. In some cases, the soil already contains sufficient lime, then an acid or acid-forming amendment may be used to solubilize the calcium in the lime. Such amendments include sulfuric acid, elemental sulfur and lime-sulfur.

SALINE-SODIC SOILS contain large amounts of salt including sodium. This results in poor plant growth, although the physical condition of the soil and water intake may not be greatly impaired. Addition of a calcium furnishing amendment may or may not be necessary. Excess salts, including sodium, must be leached from the root zone as with saline soils.