SALINE-SODIC SOIL REMEDIATION PLAN
FLESSNER 9 FACILITY PAD

Introduction

Duraroot, LLC (Duraroot) and Great Western Oil & Gas Company (Great Western) have discussed and collaborated on developing a site-specific saline-sodic soil remediation plan to determine the appropriate methods for improving soil conditions and to quickly establish desired vegetation on the former Flessner 9 (Location ID: 316999) skim pit areas. This site-specific plan has incorporated several rounds of reported soil sample analysis from previous assessments and from Duraroot site visits. The most recent soil sample effort included collecting composited soil to analyze for saline-sodic soil parameters. Based on the results from those analyzed parameters, Duraroot developed a site-specific saline-sodic remediation plan designed to initiate and efficiently address decreasing the location's electrical conductivity (EC) and sodium adsorption ratio (SAR) levels below the Colorado Oil and Gas Conservation Commission (COGCC) Table 910-1 Concentration Levels. Duraroot developed this plan and then utilized H2 Enterprises, LLC to implement the construction portion of the remediation plan. Duraroot recommends monitoring the location for any land use changes and collecting additional soil samples for laboratory analysis to track saline-sodic soil conditions over the next several months.

Site Description

The Flesser 9 skim pit area (Project) location was field investigated by a Duraroot Certified Professional Soil Scientist (CPSS) on November 18, 2019. The Project area is located in the SW ¼ of the SE ¼ in Section 19, Township 1S, Range 56W in Washington County, Colorado (Figure 1). The approximate impacted area of the Project location is 6.5-acres. The current land use for the Project location is dryland wheat production. After discussions with Great Western and the landowner for this property, the planned land use is to convert the Project location to dryland corn for the 2020 harvest season. Agricultural fields are typically prepared for corn production in mid-April through early May in eastern Colorado. When developing this remediation plan, mulching and seeding the location were excluded due to the land use change and the upcoming soil surface turnover. Given corn's sensitivity to saline soils, it is recommended that barley be planted in the Project location for better vegetative cover success.

Soil Assessment Purpose

Duraroot's CPSS collected eight (8) discrete soil samples in the areas on the Project location where soil EC and SAR levels were initially reported as being the highest (Figure 2). Soils within the Project location are mapped primarily as the Weld silt loam (*Fine, smectitic, mesic Aridic Argiustolls*) soil series. The United States Department of Agriculture's (USDA) Natural Resource Conservation Services (NRCS) official series description of this soil type has been included in Attachment A.

Soil cores were collected from the surface to an 18.0-inch depth. Topsoil depths were determined from these cores and composited for sample analysis. The underlying soil horizons were also composited for sample analysis. Each sample point had two depths consisting of an average topsoil depth and the underlying subsoil. Samples were shipped first-class to Energy Laboratory in Helena, Montana, on November 18, 2019 for saline-sodic soil parameters, including soil pH, SAR, EC, and exchangeable sodium percentage (ESP). The results from these soil samples have been provided in Table 1. The results have assisted in identifying and recommending the most efficient methods for decreasing SAR and to prepare the land for corn production.

Previously collected soil samples from the Project location indicate that the soil is saline-sodic due to elevated SAR (≥ 13), EC values (> 4.0 mmoh/cm), and soil pH values less than 8.5. Duraroot's samples confirmed these findings in both the surface material and the underlying subsoil material. Treating saline-sodic soil in Colorado can pose several challenges when trying to decrease EC and SAR values in a timely manner. There are multiple factors needed to achieve desired EC and SAR levels in this type of environment. While Duraroot has recommended and implemented several techniques to the Project location to achieve EC levels below 4.0 mmhos/cm and SAR values below 12, it must be understood that this process takes time and the appropriate amount of precipitation to achieve the desired outcome.

Figure 1 - Flessner 9 Facility Location

Flessner 9 Areas

- Skim Pit Impacted Soils
- Well Pad
- Production Pad

Total: 9.25 Acres*

*Estimated acres

1:1,800

0 100 200 400 Feet

N W E S

Date: 3/9/2020
Aerial Imagery: Google Earth
Projection: WGS 1984 UTM Zone 13N
Produced by: Duraroot, LLC

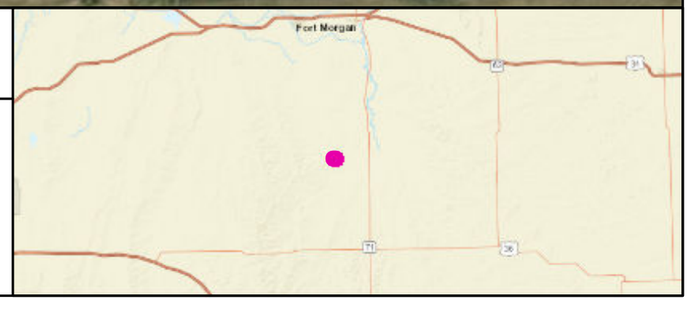

Figure 2. Surface soil conditions of the Project area at the time of the assessment.

Site Soil Analytics and Recommendations

Soil sample results from Energy Laboratory indicate elevated soil EC (5.3 – 13.5 mmhos/cm), SAR (31.8 – 59.0), and exchangeable sodium percentage (31.6 – 45.6%) in the Project location samples. To achieve desired EC and SAR values and to provide successful vegetative cover for final reclamation purposes on the Project location, the addition of elemental sulfur to decrease EC and gypsum to decrease SAR have been recommended. High salt content in soil can make it difficult for plant roots to find available water and can stress existing vegetation, leading to plant death. Duraroot has recommended an application rate of 2.0 tons per acre of elemental sulfur to decrease soil EC and an application rate of 16 tons per acre of gypsum to decrease SAR.

Saline-sodic soil conditions also exhibit reduced infiltration rates due to the dispersal of soil particles, which can create crusts on the soil surface. To aid in leaching sodium cations from soil particles in the soil profile, surface infiltration from annual precipitation is critical. Duraroot has recommended deep-ripping the soil surface down to an 18.0-inch depth to physically break up the soil profile. It was also recommended that 2.0 tons per acre of a physical deterrent, such as corn stalks, be incorporated into the upper 18.0-inches of the soil profile to increase infiltration rates. The addition of carbon into the soil profile can temporarily immobilize available nitrogen in the soil system, which is essential for plant growth. To help offset immobilization, Duraroot has recommended the addition of 100 pounds per acre of nitrogen.

Surface infiltration can be improved with the addition of mulch and vegetative cover. Improved infiltration increases the soil water content, which is critical for the soil chemical reactions with the elemental sulfur and gypsum to occur. The reclamation plan that Duraroot and Great Western used, involved deep-ripping the soil, disking the soil to create an irregular soil surface, and preparing the seedbed for planting corn. As spring precipitation permeates through the soil surface and the planted corn seeds begin to germinate, these chemical reactions will occur and will intiate the reduction of soil EC and SAR values.

Table 1. Saline-sodic soil sample results from Energy Laboratory

Flessner 9 Soil Sample Summary								
Sample ID (Depth)	CEC	pH	EC	Calcium	Magnesium	Sodium	SAR	ESP
	meq/100g	(s.u.)	mmhoss/cm	meq/L				%
S1 (0-6")	25.0	7.8	13.5	22.7	11.3	226	54.9	31.6
S1 (6-18")	34.8	8.0	9.4	4.21	4.13	120	59.0	32.8
S2 (0-6")	23.6	7.9	8.1	3.91	1.23	54.3	33.8	43.5
S2 (6-18")	31.4	8.4	5.3	0.73	0.41	31.0	40.9	43.4
S3 (0-6")	23.9	7.8	11.8	16.0	7.04	173	51.0	31.6
S3 (6-18")	34.7	7.7	9.0	4.51	2.78	60.8	31.8	42.3
S4 (0-6")	27.2	8.2	6.8	1.49	0.82	41.6	38.7	45.6
S4 (6-18")	34.6	8.3	6.6	1.47	1.49	39.6	32.5	38.4

Site Reclamation

H2 Enterprises, LLC commenced the saline-sodic soil remediation plan on the Project location on March 2, 2020 and completed the work on March 5, 2020 (Figures 3-6). Ground conditions were mostly frozen at the time of work. Weather conditions during this timeframe were sunny and warm (mid-60s°F). The Project area was first mowed to knock down existing vegetation and to use that material as additional physical deterrents for increased infiltration purposes. Crews utilized a manure spreader to spread the 16 tons of gypsum and a fertilizer cart to spread the elemental sulfur and nitrogen fertilizer. Crews also utilized 18.0-inch shanks to deep-rip the soil surface and a high-speed disc to incorporate the amendments into the soil surface.

It is recommended that Great Western implement a weed management program on this location while transitioning this property to dryland corn production. Bare soils are prone to weed infestations and the application of nitrogen fertilizer can accelerate the establishment of noxious and invasive weedy species. Addressing weed management early will help prevent weed populations from becoming a problem when corn has been established.

Figure 3. Crews deep-ripping the Project area after it had been mowed

Figure 4. Soil surface conditions after deep-ripping and gypsum and corn stalk incorporation.

Figure 5. Soil surface conditions after fertilizer and sulfur incorporation and then being high-speed disked.

Figure 6. Conditions of the Project area after crews completed the remediation plan.

Summary

Given the high levels of soil EC and SAR on the Project location, Duraroot provided several recommendations for achieving saline-sodic soil success. Even with the incorporation of all of these recommendations, this process will take time to monitor and maintain to ensure success. Successful remediation of saline-sodic soil can be achieved when the appropriate recommendations are implemented by a competent reclamation contractor with the physical capabilities to address each of the recommendations previously discussed.

The goal of this saline-soil remediation plan is to decrease the soil's EC (< 4.0 mmhos/cm) and SAR (<12) levels below the COGCC's Table 910-1 Concentration Levels. If Great Western determines that additional samples be collected for monitoring and tracking purposes, Duraroot can mobilize to the location, collect soil samples, and ship those samples to Energy Laboratory for analysis.

If you have any questions regarding this remediation plan, please feel free to reach out to Duraroot for further clarification. This remediation plan was prepared to increase the success of reducing saline-sodic conditions on the former Flessner 9 skim pit areas. Physical soil properties were evaluated using USDA-NRCS methods for soil classification. Further verification of these methods can be demonstrated in the field upon request.

Thank you,

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(1) Decompaction

Deep-rip surface soils to a minimum depth of 18.0-inches using a parabolic ripper or equivalent agricultural equipment to reduce soil compaction and improve drainage from sodic soil conditions that can create a soil crusting effect. The shanks on the back of a grader or dozer should NOT be used to reduce soil compaction. Given the fine soil textures on the Project location, corn stalks will need to be incorporated as deep as possible to ensure that soils have a physical deterrent to increase infiltration and porosity throughout the soil profile.

(2) Soil Amendments

Soil electrical conductivity (EC) and sodium adsorpotion ratios (SAR) levels were all elevated and can be treated with soil amendments. Apply 2.0 tons per acre of elemental sulfur to decrease soil EC levels. Sulfur aids in decreasing soluble salts in the soil and also decreases soil pH to a level that allows phosphorus to become plant available in the soil. Apply 16 tons per acre of gypsum to decrease SAR levels in the soil.

The application of organic matter is recommended to improve surface infiltration and organic matter content due to soil crusting conditions. Apply 2.0 tons per acre of cornstalks to the Project location. Improved surface infiltration with soil crust conditions will increase the chances of sodium leaching and will increase soil porosity which will allow water to move freely through the soil profile. Apply 100 pounds per acre of nitrogen to the soil to offset nitrogen immobilization from the inorporated corn stalks.

(3) Seedbed Preparation

These recommended site preparation steps will aid in successful reclamation. Steps may be omitted, conducted in different order, or changed to optimize success and efficiency depending on field conditions, sub-soil properties, and local terrain.

- Incorporate recommended gypsum and corn stalks, discussed above, to decrease SAR and to improve surface infiltration by deep-ripping 18.0-inches into the soil surface.
- Incorporate recommended elemental sulfur and nitrogen fertilizer, discussed above, to decrease soil EC and to offset nitrogen immobilization from organic carbon additions.
- Finally, disc the site to a depth of 4.0- to 6.0-inches to incorporate sulfur and nitrogen fertilizer and to create a seedbed conducive to seedling establishment (disk and harrow, field cultivator, vibra-shank, or other alternative suitable to site conditions).

(4) Weed Management

A site-specific Integrated Weed Management Plan (IWMP) should be developed once weedy species can be identified. Noxious, undesirable weedy species were not observed onsite. The site could be mowed prior to flowering and seed head production of weedy species. Mowing will reduce competition with desirable species and allow greater opportunity for reclamation success. In addition to mowing, herbicides appropriate for the identified weedy species could be applied to eradicate any problematic species. Application timing and rates for herbicides should follow the manufacturer's recommendations. At a minimum, weed management during the first two (2) seasons following reclamation should be diligent to improve establishment of seeded grasses and to prevent weedy species infestation.