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Memo

To: Mark Pifher, Southern Delivery System (SDS) Program

From: Joe Stevens and Renee Rondeau, Colorado Natural Heritage Program
David Buckner, ESCO Associates, Inc. (subcontractor to CNHP)

CC: Allison Mosser, Colorado Springs Utilities, SDS Program,
Alec Hart, MWH Americas, Inc.,
Ed Redente, Redente Ecological Consultants

Date: January 30, 2014

Re: Pueblo County Revegetation Cover Establishment Protocol for the Southern Delivery System Pipeline Project

Purpose

This memo describes the protocol to be used to assess and document revegetation success on the Southern Delivery System (SDS) pipeline alignment in Pueblo County. These protocols will serve as the basis for determining that revegetation meets the requirements of the stormwater permit issued by the Colorado Department of Public Health and Environment (CDPHE) and the 1041 permit issued by Pueblo County. Those permits require that revegetation of the disturbed areas contains at least 70 percent and 90 percent, respectively, of the cover existing on the site prior to construction, together with similar species diversity.

The protocol uses a point-intercept method with a stratified random sampling design to assess percent ground cover and species richness. The post-revegetation sampling will be stratified by work package and functional soil type, and will include ten (10) samples in work package/soil unit areas up to one mile in length, and fifteen (15) samples in areas greater than one mile in length. In areas with very limited total extent of a soil group (0.1 mile or less), best professional judgment will be used and three (3) to five (5) samples will be placed. Compiled data will be compared to the applicable standard (90 percent of pre-existing vegetation cover) using a one sample t-test to evaluate confidence level of the determination of revegetation success.

The memo includes a discussion of the underlying permit language, describes the management and sampling objectives of the protocol, explains the likely progression of vegetation development, describes how progress and sustainable growth will be evaluated over the two year revegetation period, and describes the methods for determining final revegetation success. In support of the protocol, three Technical Memos are attached describing the procedure for point-intercept cover and seedling density sampling (Technical Memo 1), the pre-disturbance sampling methods (Technical Memo 2), and the post revegetation sampling methods and statistical evaluation (Technical Memo 3).

During the first growing season following seeding, seedling density data will be collected. At the end of the first growing season (typically September) cover data will be collected for the purpose of assessing compliance with the CDPHE Stormwater Permit criterion of 70 percent of pre-existing cover. If in the judgment of the SDS Program, the extent of vegetation cover at that time might also satisfy the Pueblo County 90 percent of pre-existing cover criterion, the full sampling design described below will be implemented.

Introduction

The Southern Delivery System Program has conducted pre-disturbance vegetation surveys to document the density and type of vegetation that existed on the pipeline work packages (S1, S2 and S3) prior to construction-related work activities starting. These evaluations were completed by the Colorado Natural Heritage Program (CNHP), a research unit within the Warner College of Natural Resources at Colorado State University. The data were acquired for the purpose of establishing performance standards for post-construction revegetation.

CNHP used a point-intercept method developed by ESCO Associates for establishing percent vegetation cover by species and determining species richness. Pre-disturbance vegetation sampling was conducted by soil type within the SDS work packages. A copy of the methodology used is attached to this memo as Technical Memo 1. CNHP will use this same point-intercept protocol for evaluating reclamation progress and final reclamation success determination. Post-revegetation sampling will occur at randomly located and oriented transects to establish an estimate of the mean cover of plant species by soil types within work packages. CNHP has determined that sample size of ten (10) transects in each soil unit cumulatively less than one mile in length, or fifteen (15) transects in each soil unit cumulatively longer than one mile in length is sufficient to estimate the mean and variance to confidently determine post-restoration revegetation success in accordance with Pueblo County 1041 Permit number 2008-002. In areas with very limited total extent of a soil group (0.1 mile or less), best professional judgment will be used and three (3) to five (5) samples will be placed. The following describe in more detail the level of effort for both progress and final cover evaluations. A detailed description of the Pre-Construction vegetation survey and the establishment of Cover Performance Standards from those data are attached in Technical Memo 2.

Background

SDS Permit Language

In addition to the Bureau of Reclamation's 2009 Record of Decision (GP-2009-01), regulations requiring reclamation of disturbed lands by the SDS Project include the CDPHE Construction General Stormwater Permit (COR 030000) and Pueblo County Resolution P&D 09-22 approving 1041 Permit 2008-002.

The CDPHE General Stormwater Permit associated with construction activities stipulates, *"Final stabilization is reached when all ground surface disturbing activities at the site have been completed, and uniform vegetative cover has been established with an individual plant density of at least 70 percent of pre-disturbance levels..."*

Under the Pueblo County 1041 permit, SDS is required to conduct a pre-construction evaluation of existing vegetation to be disturbed during construction of the SDS project within Pueblo County and upon reclamation of the site, vegetative cover is required to be, *"... of the same seasonal variety native to the area of the disturbed land, or species that support the post-construction land use ..."*

The revegetated area will be considered acceptable if its cover is not less than 90 percent of the pre-construction vegetation cover with similar species diversity. SDS will achieve this objective by utilizing a seed mixture that reflects pre-construction species diversity and which, as more fully explained below, is anticipated to result in a re-establishment of the required percent vegetative cover which will, in turn, through time experience a natural succession in species dominance until the original conditions are duplicated.

Management Objectives and Sampling / Monitoring Objectives

The management objective of the revegetation effort in Pueblo County is to ensure that by the earliest opportunity the average cover of native and non-noxious opportunistic plant species occurring on each soil type within each work package is at least 90 percent of the vegetation cover that existed on those same soils prior to disturbance for construction.

The sampling objective is to quantitatively document whether revegetation has achieved the requirements of the permit standard of 90 percent of pre-disturbance vegetation cover. The monitoring objective is to quantitatively assess and document progress toward the management objective.

Likely Progression of Vegetation Development

The reality of revegetation in the arid west is that the period following seeding until treated areas are fully re-established with the same species mix, as compared to undisturbed areas, is generally longer than two years. Usually, a minimum of five years will pass before the main perennial plants comprise the bulk of cover and the prevalence of early successional species that initially colonized the disturbance area diminish. At the end of two years, even with irrigation, it is likely that species other than the target

shortgrass species will dominate the seeded community. As an example, slender wheatgrass (*Elymus trachycaulus*) was included in the seed mixture to perform the function of occupying space and pre-empting weeds while blue grama (*Bouteloua gracilis*), galleta (*Pleuraphis jamesii*), and other perennials slowly establish and begin to dominate. Slender wheatgrass is short-lived and will disappear from the community after three to four years, allowing the cover of the long-term desired warm season grasses to achieve dominance. This natural maturation of the ecosystem will allow for the re-planted areas to achieve the same seasonal variety with similar species diversity as required by Pueblo County.

In addition to the seeded species, it can be expected that opportunistic early-seral species will have colonized the area naturally and will establish at varying densities. The seeds of most of these species were in the soil prior to disturbance and were suppressed by perennial competition. Irrigation will enhance the seeded species, but it will also allow development of these naturally present opportunists. Most of these opportunistic plants are native species and do not represent the potential for long-term weed problems. Noxious weed species listed by the State or County, if identified on the work package alignment, will be controlled as detailed in each work packages' contract documents and specifications and in accordance with Colorado Department of Agriculture noxious weed management regulations. Typically, the non-noxious opportunistic species will not damage the growth of the long-term native species and will not be treated. It is inevitable that they will be present and visually conspicuous for two or more years as the perennial species expand their presence. As native perennial species increase, the opportunistic species will be suppressed by competition and will decline to insignificant levels. In recognition of the natural processes described here and their inherent rates of progress, all non-noxious perennial and native annual/biennial species will be included along with non-native annual/biennial species to the extent of their original presence in the assessment of cover during quantitative evaluations of revegetation success.

Protocol

Progress Evaluations

To ensure revegetation is progressing as planned and to communicate the status to the SDS Program, regular progress meetings will be held with the revegetation contractor(s) and periodic site inspections will be coordinated with Pueblo County, U.S. Bureau of Reclamation and other stakeholder representatives. The frequency of progress evaluations will be every other month (bi-monthly) during the growing season (April through September) and quarterly in the non-growing season (October through March). Quantitative sampling of the vegetation will be conducted during the first and second growing season to determine the progress of revegetation.

Quantitative sampling and evaluations (Seedling Density and Cover evaluations) for the SDS project pipeline work packages (S2 and S3) are expected to be undertaken as per the following schedule:

- July 2013 - Seedling Density assessment,

- September 2013 - Seedling density assessment and cover evaluation for CDPHE stormwater permit evaluation for determination of 70 percent of pre-existing cover,
- At the discretion of SDS, evaluation for assessment of 90 percent of pre-existing cover will also be completed during the September 2013 assessment,
- August/September 2014 - Evaluation for assessment of 90 percent of pre-existing cover if not achieved in 2013 and/or to demonstrate 90 percent cover is being maintained.

Quantitative sampling and evaluations for the SDS project S1 pipeline work package will have the same milestones on a schedule anticipated to be one year following those shown for the S2 and S3 work packages which were planted earlier. All evaluations (both seeding density and cover assessment) are somewhat dependent on soil and air temperature and occurrence of natural precipitation which drives the timing of each growing season.

Qualitative evaluations, using photo documentation, will be completed in conjunction with quantitative sampling events described above. Qualitative sampling will occur at the same locations of the randomly selected sampling points. GPS coordinates will be used to relocate photo points each year. The photos will serve to provide visual indication of the progress of plant community development.

For seedling density evaluation, CNHP will use a 0.5 square meter plot frame to assess and report seedling density (see Technical Memo 1, Seedling Density Sampling). For the separate cover evaluations, CNHP will use the same point-intercept protocol as the pre-disturbance survey (see Technical Memo 1, Cover Sampling Methods). A summary memorandum will be prepared with photographs to document the site conditions, findings, and percent cover established after each evaluation. For progress evaluations during the first growing season, three (3) transects from each soil type identified in the pre-disturbance report will be conducted within each work package. If in the judgment of the SDS Program, the extent of vegetation cover at that time might also satisfy the 90 percent of pre-existing cover criterion, the full sampling design described below will be implemented.

Milestones of specific interest for all Pueblo County pipeline work packages include:

- Initial application of irrigation water
- Successful germination and seedling stand establishment
- Revegetation reaches 70 percent of pre-existing cover
- Revegetation reaches 90 percent of pre-existing cover

As mentioned above, dates will vary by work package and irrigation schedule with the start of irrigation being driven by soil and air temperature. SDS staff will coordinate with Pueblo County representatives during assessment of achievement of 70 percent pre-existing cover. Under the CDPHE construction

stormwater permit program, the revegetation contractor(s) can be released from their construction stormwater permit once this percent of pre-existing cover has been reached.

Sustainable Growth

The seedling density data from the first growing season will be used as evidence of sustainable growth of the established community, as will cover and species diversity data from the second growing season. Pursuant to third party (CNHP) recommendations and contract specifications, the target to ensure sustainable growth will be the presence of an average of at least four seedlings per square foot of planted or otherwise desirable perennial species. At this density, the likelihood of continued development toward a mature shortgrass prairie vegetation cover is high. The progression of that target to a mature prairie grassland assumes management by landowners is not deleterious to long-term health of the plant community. The early presence of an adequate number of plants per square foot is the best available basis for predicting sustainability.

Final Cover Evaluations

To document re-establishment of cover across each work package, trained ecologists will randomly locate sample points within separate soil types utilizing the random point generating tool in the ESRI ArcMap GIS software application. CNHP will use the same point-intercept sampling protocol as the pre-disturbance surveys and will prepare a summary memorandum with photographs, tables, and calculations to document site conditions and findings concerning percent vegetation cover established.

To make this determination, CNHP will complete a minimum of 10 sample transects in work package/soil units that cumulatively comprise a small area (a length of one mile or less), and fifteen (15) transects in each soil unit that cumulatively comprise a larger area (greater than one mile in length). The completion of sampling in each work package/soil type identified during the pre-disturbance surveys will provide Pueblo County adequate data to determine whether the 90 percent of pre-existing cover standard has been met. Pueblo County, U.S. Bureau of Reclamation and other stakeholder representatives will be invited to participate in these evaluations and Pueblo County provided the opportunity to review and accept the report(s) and will eventually be required to certify compliance with the terms and conditions of the 1041 Permit. Details of the post-construction evaluation procedure are provided in Technical Memo 3.

Following receipt and acceptance of the Final Cover Evaluations document, Pueblo County representatives will provide SDS with a letter concurring with SDS's written request to close out 1041 Construction Conditions. A separate request will be submitted for each specific pipeline work package segment (S1, S2 or S3).

Species Diversity

Species diversity will be determined from simple counts of species present by plant-life form as obtained from the sampling data.

Technical Memo 1

Sampling Procedure for Point Intercept Cover and Seedling Density Data Collection

The following procedure establishes baseline levels of plant cover in areas affected by the Southern Delivery System Project and will be used to determine seedling density following revegetation.

Within an area that was disturbed, vegetation will be quantitatively sampled as described below to establish:

- 1) The percent cover by species as well as total vegetation cover and
- 2) Species richness

These data will provide a basis for assessment of the percent of vegetation cover re-established in post-revegetation evaluations.

Vegetation Unit Identification

As vegetation varies along the length of the proposed area of disturbance, variations in plant community at the “alliance” level of the US National Vegetation Classification system (FGDC 2008) will be documented. Association and alliance level classification is based on the premise that a vegetation type represents a group of stands that have similar plant composition and physiognomy enabling their recognition. Should such significant soil variation as might substantially affect plant cover growth potential be encountered within a single alliance in a particular reach, these will be subdivided and the number of sample measurements adjusted accordingly.

This mapping methodology addresses both the need to document natural variation in the pre-existing vegetation and the need to set plant cover standard levels consistent with the varying potentials of varying environments.

Sample Location

Samples will be placed in locations representative of the general vegetation type and condition.

Cover Sampling Methods

At each sample site, cover data will be collected using a point-intercept method in which data are tabulated as interceptions of a projected point with plant species, bare ground, litter, standing dead vegetation, or rock. The cover sampling points will be optically projected using a Cover-Point Optical Point Projection Device. Sampling will occur along 50 meter transects. At each meter from one to fifty along the transect, a point will be vertically projected from a location 50 centimeters (cm) to the left of the transect and a point will be vertically projected from a location 50 cm to the right of the transect (avoiding harm to vegetation along the tape itself). Thus, data from a total of 2 x 50, or 100 points will be recorded. Plant interceptions will be tallied by species upon interception of the projected point with any attached plant part produced during the current growing season. “First hit” data (the first interception of any of the

materials listed below) will be recorded. In addition to this, "additional hit" data (any additional live species intercepted between the first hit and the ground) will also be collected.

- Litter will be considered to be any organic material that had fallen, or had begun to fall to the soil surface.
- Standing dead vegetation will be any dead plant material that was produced in previous years but which was still standing and had not lodged or broken off to become litter.
- Rock will be considered to be any inorganic fragment with the largest diameter greater than or equal to 1 cm.
- Bare soil will be considered to be inorganic fragments with a diameter less than 1 cm largest diameter or organic debris too small to be of readily identifiable origin.

First hit interceptions will be used to calculate absolute top layer (first hit) foliar cover by dividing the number of interceptions for a particular species or material by the total number of points taken (100). First hit relative vegetation cover will be calculated by dividing first hit absolute cover for each species by the total first hit vegetation cover. All-layer absolute cover will be calculated by dividing all hits for particular species by the total number of points taken (100). In addition, all-layer relative cover will be calculated using all hits for particular species divided by the total vegetation hits accumulated during sampling of the transect.

Seedling Density Sampling (Post-Revegetation Analyses)

Seedlings of seeded or perennial plant species will be counted within randomly placed 0.5 square meters (5.37 square feet) circular plots. The results will be averaged and divided by 5.37 to obtain number of seedlings per square foot.

References

FGDC. 2008. Vegetation Classification Standard, Version 2. Federal Geographic Data Committee, Vegetation Subcommittee. FGDC Secretariat, U.S. Geological Survey. Reston, VA.
FGDC-STD-005-2008 (Version 2). 62p. plus Appendices.

Technical Memo 2

Pre-construction Survey

This Technical Memo describes the general conditions and methodology CNHP used to sample and assess pre-construction vegetation cover and describes the results.

Measurements of Pre-existing Vegetation Cover in Pueblo County

As per a pre-established Protocol (attached Technical Memo 1) pre-existing vegetation cover was measured along the planned alignment of the SDS raw water pipeline in Pueblo County, Colorado. Quantitative sampling was conducted at intervals along the alignment to document percent cover by live plants. All observations took place between October 5, 2011 and October 21, 2011. Locations of quantitative samples are indicated on Maps S1-1 and 2, S2-1 through 4 and S3-1 through 4 (see attached).

The study area is in the valley of the Arkansas River downstream (east) from its emergence from the mountain front. Along some reaches of the pipeline route, exposed shale and limestone are the predominant soil parent materials, while on other reaches recent alluvium predominates and on high terrace sites older deposits of Arkansas River alluvium in the form of sands and gravels predominate.

2010-2011 Drought

The study area receives on average about 12.5 inches of precipitation per year. During the 12 months prior to the observations reported here, precipitation in the subject area was less than 50 percent of the long term average (Western Regional Climate Center 2012).

Other Environmental Effects on Vegetation

There are two particularly important variables that locally affect the magnitude of live vegetation cover. These are soils and the presence of prairie dogs. The soil/geologic conditions with the least potential production of vegetation are likely those that are shallow (less than one foot) over limestone and shale bedrock in the south portion of the Pueblo County portion of the SDS pipeline (i.e. S1 and the southern portion of S2). Soils possessed of these characteristics include the Penrose, Manvel and Minnequa series. Soils of recent very fine grained and salt-rich alluvia along active drainages are of the Limon and Heldt series. Heavy clay texture, high salt content and frequent overbank flood disturbance are factors that affect vegetation growth on these soils. Haverson soils also developed on comparatively recent alluvium but are of more moderate texture and are much less salt-affected.

In the central and northern portions of S3, soils developed from shale are prevalent. On some areas (Midway- Shale complex), erosional removal of weathered material is sufficiently active that soils are shallow and poorly developed. On some other areas deeply weathered shale has remained in place and moderately deep soils with clay-rich texture and gypsum accumulations in the subsoil prevail (Razor series). In the far north portion of S3 are limited areas of early Pleistocene age alluvium with deep well-developed soils of moderate texture in the Stoneham series. These soils support the most well-developed vegetation growth of any upland areas included along the SDS in Pueblo County.

Recent history of grazing use of these areas can substantially limit the extent of vegetation cover in addition to drought and soil limitations. Especially in the S1 portion of the SDS alignment, very heavy grazing by prairie dogs (*Cynomys ludovicianus*) has strongly limited, and to a large degree destroyed, herbaceous perennial vegetation cover. In combination with soil limitations and drought the percent of the ground covered by perennial herbaceous vegetation in these areas is in the low single digits and much of what exists is fourwing saltbush (*Atriplex canescens*) that prairie dogs avoid. Historical season-long grazing of vegetation by livestock in the S3 portion of the route has also strongly limited the extent of vegetation cover.

Observance during pre-disturbance evaluations identified some sampled areas in Soil Groups A and B below that had experienced prior land use which degraded, and in some areas eliminated, vegetation cover. In these areas, what remained was deemed un-representative of healthy vegetation and cover and values from these areas were not included when CNHP developed the quantitative pre-existing percent cover base levels reported in 2011. Therefore, base values are biased high, representing healthy cover in those areas where over-grazing or previous land development/disturbance was observed.

Base Values for Evaluation of Revegetation Success

The following are suggested base vegetation cover values (to be multiplied by 0.9 in accordance with 1041 permit requirements for 90 percent revegetation). They are to apply to the listed soils wherever they occur (in S1, S2 and S3). For work on the Federal land associated with connection of the SDS project to the Pueblo Dam North Outlet Works (PDC1A and PDC1B), Juniper Pump Station (JPS) and the portion of S1 on Federal land, the base cover values will also be multiplied by 0.9 in accordance with governing documents and bonds for this work.

The various soils of the Pueblo County portion of the SDS pipeline have been grouped by functional similarity into the following Soil Groups. These Groups are judged to be similar in their revegetation potential. The distribution of these units is indicated on Maps S1-1 and -2, S2-1, -2, and -3, and S3-1, -2, -3, and -4. All tables referenced are in the 2011 pre-disturbance survey report.

A. Soils Shallow over Shale and Limestone (Penrose, Manvel and Minnequa series; Tables 4, 7, and Samples 5, 7 and 8 of Table 8): **17.2 percent**

B. Soils on Clay-rich, Salt-affected Alluvial Material (Limon and Heldt series; Tables 1, 5, and 11): **26.5 percent**

C. Soils Deep on Early Pleistocene Alluvium (Stoneham and Cascajo series; Tables 10 and 15): **35.0 percent**

D. Soils on Weathered Shale (with active erosional removal) (Midway – Shale complex; Shingle series; Tables 9 and 13): **17.0 percent**

E. Soils on Deeply Weathered Shale (without active erosional removal) (Razor series; Table 14): **23.3 percent**

F. Soils on Recent Alluvium of Moderate Texture and Salt Content (Haverson series and Ustic Torrifluvents; Table 6 and 16): **41.3 percent**

LITERATURE CITED

Western Regional Climate Center. 2012. <http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?co6765>

Pre Construction Cover Survey Maps for Work Packages S1, S2, and S3

The attached maps depict the locations of the preconstruction cover survey transects completed on work segments S1, S2, and S3. The maps are oriented with north at the top and are organized from south to north, starting at the connection point of S1 with Pueblo Dam and ending at the northern end of S3 at the El Paso County line. Each map depicts the location of the survey transects and the various functional soil groups within the pipeline alignment overlain on aerial photography of the surrounding landscape.

Technical Memo 3

Post-Revegetation Sampling

This Technical Memo describes the design and methodology CNHP will use to sample and quantitatively assess post-disturbance revegetation success. For the practicality of achieving an unbiased evaluation, the approach is based on random sampling and the use of resulting means to compare results to previously established performance standards. By the nature of plant growth in response to varying conditions along the length of the revegetated area, and by the nature of random sampling, variability in levels of plant abundance are to be expected both on the ground and in sample results. The use of 50 meter-long transects tends to encompass variability though a certain amount of variability can be expected at scales larger than this.

Creditable Vegetation Cover

Cover provided by plants included in the Colorado A-, B-, or C-list of noxious plant species, if any, will not be acceptable in the evaluation of cover. Cover by all other plants will be acceptable in assessment of adequate revegetation cover, except as follows: cover by non-native annual / biennial plants in excess of the relative cover by those plants in the pre-construction sample data will not be counted toward establishment of proof of successful revegetation (see below).

Maximum allowable relative cover by Introduced Annual and Biennial Species:

A. Soils Shallow over Shale and Limestone (Penrose, Manvel and Minnequa series; Tables 4, 7, and Samples 5, 7 and 8 of Table 8): **22.2 percent**

B. Soils on Clay-rich, Salt-affected Alluvial Material (Limon and Heldt series; Tables 1, 5, and 11): **2.6 percent**

C. Soils Deep on Early Pleistocene Alluvium (Stoneham and Cascajo series; Tables 10 and 15): **3.9 percent**

D. Soils on Weathered Shale (with active erosional removal) (Midway – Shale complex; Shingle series; Tables 9 and 13): **1.3 percent**

E. Soils on Deeply Weathered Shale (without active erosional removal) (Razor series; Table 14): **3.6 percent**

F. Soils on Recent Alluvium of Moderate Texture and Salt Content (Haverson series and Ustic Torrifluvents; Table 6 and 16): **16.7 percent**

Sampling Design

Cover Sampling Method

Sampling to assess compliance with the standard of 90 percent of pre-existing cover will proceed separately within each work package (S1, S2 and S3) and separately within each soil functional group as identified during the pre-construction vegetation survey (see Technical Memo 2). All sample locations will be randomly located by delineating the soil functional groups in each work package in ESRI ArcMap GIS application and using the random point generation tool to place the correct number of random points in that area.

For sample units with a total (cumulative) length of one mile or less, ten (10) segments of equal length will be established and a randomly located and oriented sample placed in each. For units greater than one mile in cumulative length, fifteen (15) segments of equal length will be identified and a sample randomly located within each. Sample points will be located in the field using hand-held GPS units with coordinates of the random points pre-loaded.

In areas with total Soil Group length less than 0.1 mile, three (3) to five (5) samples will be made. Professional judgment will be used in these small sample areas (e.g. Soil Groups B and F in S3) to determine the location and number of samples collected.

Orientation of the 50-meter transect will be randomly selected by using a random number ranging from 1 to 360 as an azimuth. Sampling transects will not extend outside the Permanent Easement (PE), Temporary Construction Easement (TCE) or work limits areas. Should a boundary be encountered, a new orientation that remains within these limits will be chosen in the same manner. Ineligible sites (see below) will be excluded from sampling.

Sampling to assess compliance with the CDPHE criterion of 70 percent of pre-existing cover will proceed within separate work packages and soil reaches. If the 70 percent cover standard alone is being assessed, the sample intensity will be five (5) samples in reaches of one mile or less in cumulative length and eight (8) samples in those greater than one mile in cumulative length. Professional judgment will be used in small sample areas (e.g. Soil Groups B and F in S3) to determine the location and number of samples collected.

Informational Cover Composition Sampling Method

Data on species composition will be collected for informational purposes outside the scope of the 1041 permit requirements. Ten (10) 1 x1 meter plots will be placed at 5-meter intervals along the right side of the cover sampling transect (as viewed from the origin) beginning at the 5-meter mark. Within each of the resulting ten plots the presence of desirable species will be noted by species. For this purpose, desirable species will mean any seeded species plus any other native annual, biennial, or perennial species plus any non-native perennial species. Native will mean species noted as native in and occurring in the Southeast ¼ of Colorado in Biota of North America Project distribution mapping. The resulting frequency data will be tabulated by species. For example, if Species A is noted as present in 7 of the 10 plots it will have a frequency value of 70 percent.

Frequency values from all transects within a given soil group will then be averaged. For these evaluations, average frequency values by species will be used as follows: The average frequencies of all acceptable species will be summed. A sum for all desirable species present that equals or exceeds 200 percent will be deemed adequate evidence of successful establishment of acceptable species. This supplemental criterion addresses the reality that vegetation at the time of evaluation will still be juvenile. Many planted or otherwise desirable species grow slowly and though they may be only a small percentage of the total plant cover at the time of measurement, will eventually become more abundant. This frequency evaluation allows documentation of the presence of the desirable species sought in the long term vegetation cover.

Seedling Density

Seedlings of seeded or perennial plant species will be counted within randomly placed 0.5 square meter (5.37 square foot) circular plots. The results will be averaged and divided by 5.37 to obtain number of seedlings per square foot.

Plots will be thirty per Work Package/Soil Group area. All sample points will be randomly located via GIS-generated coordinates.

Sites Ineligible for Sampling

Areas within the revegetation zone in which the vegetation cover has been negatively affected by land management of private owners after SDS construction or for which a waiver has been executed/granted will be excluded from the sample universe (i.e., no samples will be placed in these areas). Within the disturbed alignment no sampling will occur on access roads, trails, above-ground SDS infrastructure, other above-ground public or private infrastructure, waterways, or other areas where sampling is determined not to be practical, safe or meaningful. Such areas will be manually delineated in the GIS and excluded from the eligible sampling area when creating the random point coverage.

Sampling Schedule

During the first growing season following seeding, seedling density data will be collected. At the end of the first growing season (typically September) cover data will be collected for the purpose of assessing compliance with the CDPHE Stormwater Permit criterion of 70 percent of pre-existing cover. If in the judgment of the SDS Program, the extent of vegetation cover at that time might also satisfy the 90 percent of pre-existing cover criterion, the full sampling design described above will be implemented. If only the CDPHE criterion is being tested, sample intensity within a work package will be five samples in soil reaches one mile or less in cumulative length and eight in those greater than one mile in cumulative length. During the second growing season, sampling intensity will be ten (10) samples in soil reaches one mile or less in cumulative length and fifteen (15) samples in those greater than one mile in cumulative length.

Hypothesis Testing

Statistical evaluation of the success of revegetation for each soil functional group within a work package will be tested via a one-sample t-test of the following null hypothesis:

The (traditional) null hypothesis being tested would be that the revegetated area mean (\bar{x}) is indistinguishable from 90 percent of the pre-existing cover, stated as $H_0: \bar{x} = Q$. If t_c is less than or equal to the 1-tailed t -table value for alpha error probability of 0.05, at $(n-1)$ degrees of freedom, then H_0 is accepted, and revegetation is deemed successful (i.e., indistinguishable from 90 percent of the standard).

The sample data will be evaluated for normality and transformed if appropriate. The formula for the one sample t-test is:

$$t_c = \frac{Q - \bar{x}}{S_{\bar{x}}}$$

Where: \bar{x} = Revegetated Area Sample Mean
 Q = 90 percent of pre-existing cover
 $S_{\bar{x}}$ = Standard error of mean [s/\sqrt{n}]
 s = Sample standard deviation
 n = Sample size
 t_c = Calculated t -value
 t_t = Table t -value (alpha = 0.05)

Photographic Documentation

Photo documentation will be conducted during the growing seasons and in conjunction with the point-intercept cover sampling. Photos will be taken at each transect location during all sampling. Photo points will be relocated using a handheld GPS receiver.

Colorado Springs Utilities Southern Delivery System

Measurements of Post-restoration Seedling Density for Pueblo County Work Package S1



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October, 2013

Prepared in conjunction with:

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Cover Photo: Sample site 6 on Soil Group B in work package S1 (by ESCO Assoc. Inc.)



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Introduction

As the first look at success of seeding efforts in the Pueblo county portion of the Southern Delivery System (SDS) Pipeline, a quantitative evaluation of seedling density was carried out in late July, 2013. This report documents post-construction seedling densities during the first growing season along the S1 section of the Southern Delivery System (SDS) pipeline route in Pueblo County, Colorado. The Colorado Natural Heritage Program, in cooperation with ESCO Associates, completed the post-construction seedling density survey under contract to Colorado Springs Utilities.

The following includes the methods used, the results, and a discussion of the seedling density evaluation on the sites after any construction activities. Maps of Work Package S1 are contained in Appendix A.

The study area is in a tributary valley of the Arkansas River downstream (east) from its emergence from the mountain front. Along some reaches of the pipeline route, exposed shale and limestone are the predominant soil parent materials, while on other reaches recent alluvium predominates and on high terrace sites older deposits of Arkansas River alluvium in the form of sands and gravels predominate.

Given the important effect of soils on details of pre-existing vegetation and the outcome of revegetation efforts, pre-existing conditions and revegetation performance standards for plant cover were separated by soil group. These groups differ from each other in such characteristics as depth, texture, and salt content, all of which along with other variable factors have the potential to affect the extent and nature of the revegetation process as well as the rate of establishment and development. Within the “soil groups” identified in the Pueblo County portions of the SDS pipeline, three occurred in the portion of Work Package S1 that was irrigated beginning in the spring of 2013:

A. Soils Shallow over Shale and Limestone (Penrose, Manvel and Minnequa Series): 71.7% of Work Package S1

B. Soils on Clay-rich, Salt-affected Alluvial Material (Limon and Heldt Series): 17.9% of Work Package S1

D. Soils on Weathered Shales (with active erosional removal) (Midway – Shale Complex; Shingle Series): 10.4% of Work Package S1

The distribution of these Soil Groups (based on previous mapping in SCS (1979)) is indicated on the maps of S1 included in Appendix A

Although Soil Group C is present in Work Package S1, the seedling density of this soil group was not measured during this sampling effort as this portion of the pipeline had not yet been irrigated. Due to the recent string of drought years, vegetation in this region is dependent on irrigation for seedling germination. Consequently, without irrigation in place, seedling density values for this Soil Group would have been misrepresentative of the revegetation progress.

Methods

As per the Pueblo County Revegetation Cover Establishment Protocol (Protocol), within each Soil Group in Work Package S1, 30 points were randomly selected using GIS software. These computer-selected points were visited in the field using handheld GPS units during the period of July 29-31, 2013. At each point a 0.5 square meter circular plot was placed on the ground by blind drop at the point indicated by the GPS device. Within the plot, all seedlings of perennial plants were tallied. Acceptable species are those from the seed mix as well as all other non-noxious perennial plant species.

Data were tallied and converted from the number of seedlings per 0.5 sq. m. to the number per sq. ft., which is the unit of measure specified in construction specifications and the Protocol.

Results

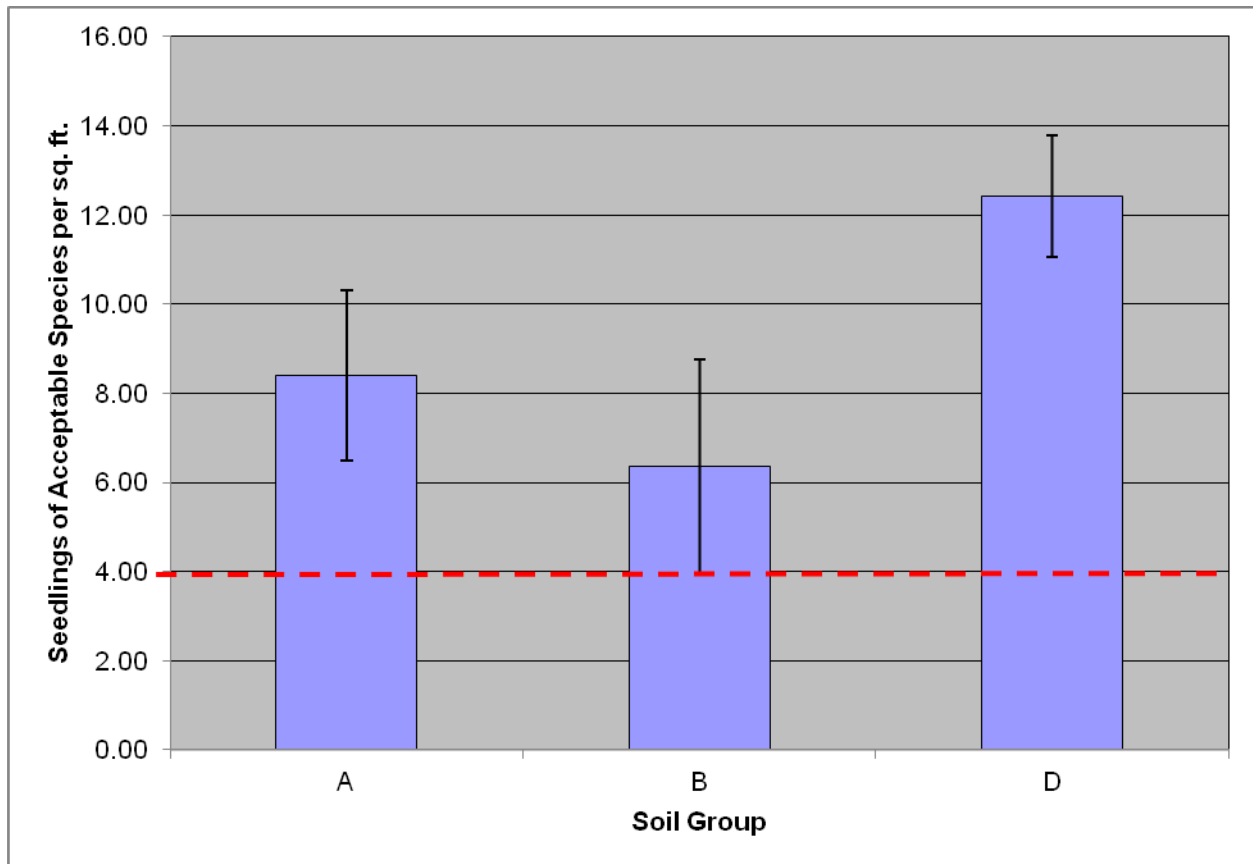
Sample data are presented in Table. 1. As can be seen in Figure 1, all Soil Groups within Work Package S1 have seedling density levels above 4 per sq. ft.

Table 1. Results of Seedling Density Sampling of Seeded Area in Southern Delivery System Work Package S1

Work Package	Soil Group	Mean Seedlings per sq. ft.*	90% Confidence Interval (+/-)	Sample Size (n)
S1	A	8.40	1.91	30
S1	B	13.62	2.40	14
S1	D	12.43	1.37	30

* Seedlings of acceptable species are defined as those included in the seed mix and any other non-noxious perennial species

Figure 1. Preliminary Seedling Density of Work Package S1



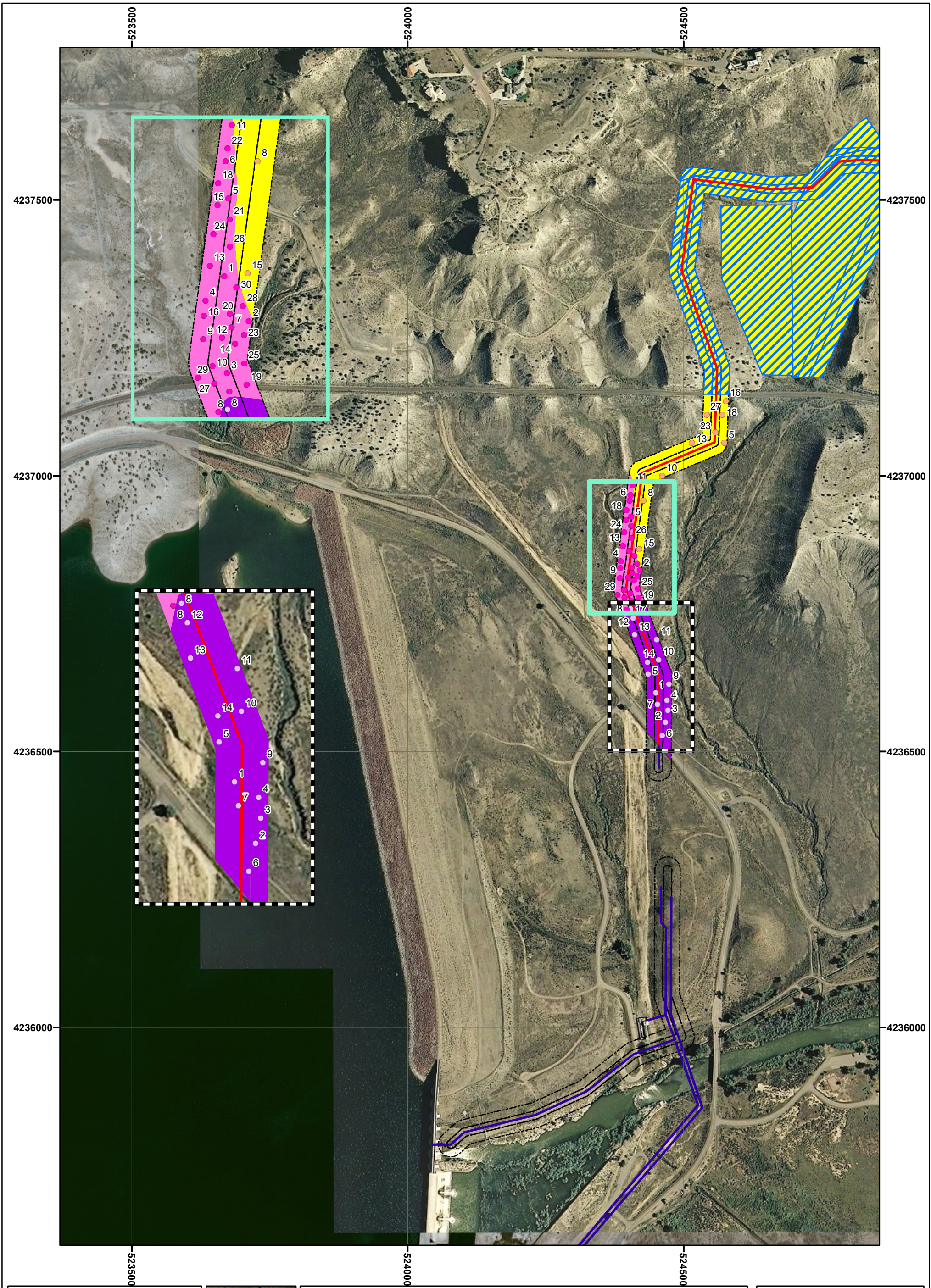
Discussion

The recent string of drought years in Pueblo County has continued in 2013. This scarcity of water has made the presence of irrigation on the seeded pipeline right-of-way essential for seed germination to occur. In addition to water availability, it is apparent from these data that soil characteristics have an effect on seedling density. In the earlier stages of the revegetation process, the seedling density metric is the most direct indicator of the progress of the seeded areas toward the ultimate goal of vigorous self-sustaining plant cover. The presence of (a minimum of) 4 seedlings per sq. ft. is the level that would be expected in irrigated areas after a full growing season. Since the seedling density in all Soil Groups in S1 surpassed the 4 seedlings per sq. ft. standard, the initial progress of vegetation regrowth in this Work Package is indicative that revegetation efforts are likely to be successful. Revegetation progress will continue to be monitored through future evaluations of vegetation cover as the planted vegetation begins to mature.

Literature Cited

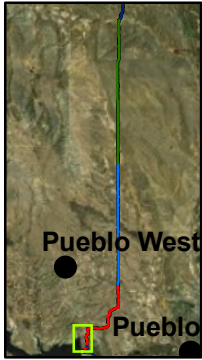
USDA Soil Conservation Service (SCS). 1979. Soil Survey of Pueblo Area, Colorado: Parts of Pueblo and Custer Counties. U.S. Dept. of Agric. Soil Conservation Service in cooperation with the Colorado Agricultural Experiment Station. 92 pp. plus maps.

Appendix A: Maps – Work Package S1



Map 1. S1-1
2013 Seedling Density
Monitoring Locations
S1 (Raw Water PC)
4.25 miles
Colorado Springs Utilities
Southern Delivery Systems

GRID: UTM NAD 83 z 13N



Soil Type A Sample Locations (n=30)

Soil Type B Sample Locations (n=14)

Soil Type D Sample Locations (n=30)

Areas Not Sampled

S1

S2

S3

Areas Not Irrigated

Pipeline Easement

Soils Groups

A
Soils Shallow over Shale and Limestone
(Penrose, Manvel and Minnequa series)

B
Soils on Clay-rich, Salt-affected Alluvial Material
(Limon and Heldt series)

C
Soils Deep on Early Pleistocene Alluvium
(Stoneham and Cascajo series)

D
Soils on Weathered Shales (with active erosional removal)
(Midway - Shale complex; Shingle series)

E
Soils on Deeply Weathered Shales (without active erosional removal)
(Razor series)

F
Soils on Recent Alluvium of Moderate Texture and Salt Content
(Haverson series and Ustic Torrifluvents)

Aerial Imagery NAIP 2009 Pueblo County, Colorado

1 in = 160 meters

0

80

160

Meters

N

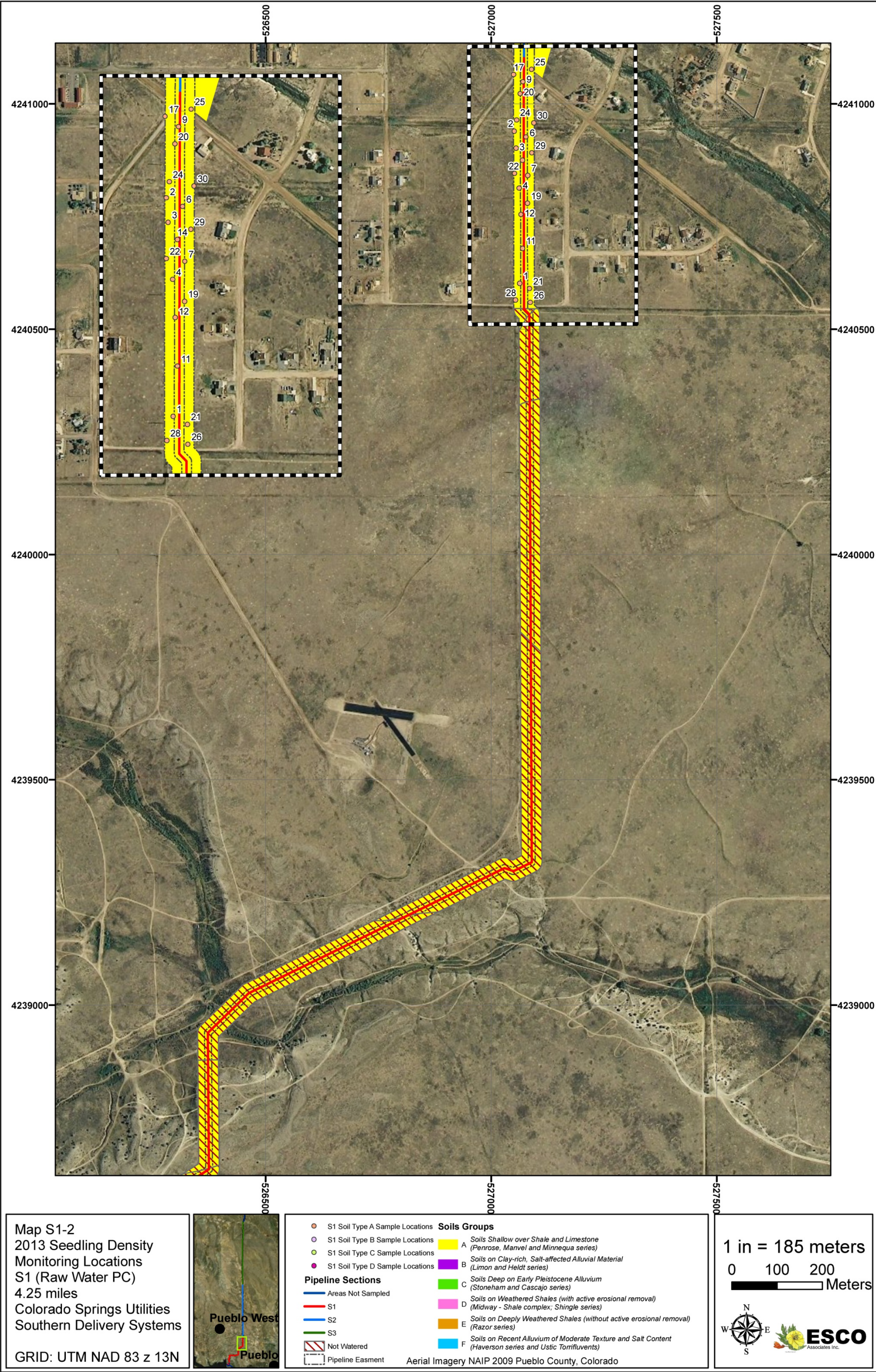
W

E

S

Colorado

ESCO



Colorado Springs Utilities Southern Delivery System

Measurements of Post-restoration Seedling Density for Pueblo County Work Package S2



Prepared for:
**Colorado Springs Utilities
Southern Delivery System
Colorado Springs, CO 80947**

Prepared by:
**Colorado Natural Heritage Program
Colorado State University
Fort Collins, CO 80523**

October, 2013

Prepared in conjunction with:

**ESCO Associates, Inc.
Boulder, CO**



Cover Photo: Sample site 14 on Soil Group A in work package S2 (by ESCO Assoc. Inc.)



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Introduction

As the first look at success of seeding efforts in the Pueblo county portion of the Southern Delivery System (SDS) Pipeline, a quantitative evaluation of seedling density was carried out in late July, 2013. This report documents post-construction seedling densities during the first growing season along the S2 section of the Southern Delivery System (SDS) pipeline route in Pueblo County, Colorado. The Colorado Natural Heritage Program, in cooperation with ESCO Associates, completed the post-construction seedling density survey under contract to Colorado Springs Utilities.

The following includes the methods used, the results, and a discussion of the seedling density evaluation on the sites after any construction activities. Maps of Work Package S2 are contained in Appendix A.

The study area is in a tributary valley of the Arkansas River downstream (east) from its emergence from the mountain front. Along some reaches of the pipeline route, exposed shale and limestone are the predominant soil parent materials, while on other reaches recent alluvium predominates and on high terrace sites older deposits of Arkansas River alluvium in the form of sands and gravels predominate.

Given the important effect of soils on details of pre-existing vegetation and the outcome of revegetation efforts, pre-existing conditions and revegetation performance standards for plant cover were separated by soil group. These groups differ from each other in such characteristics as depth, texture, and salt content, all of which along with other variable factors have the potential to affect the extent and nature of the revegetation process as well as the rate of establishment and development. Within the “soil groups” identified in the Pueblo County portions of the SDS pipeline, four occurred in Work Package S2:

A. Soils Shallow over Shale and Limestone (Penrose, Manvel and Minnequa Series): 66.4% of work package S2

B. Soils on Clay-rich, Salt-affected Alluvial Material (Limon and Heldt Series): (Note that this represents the level found on Limon soils in ungrazed S2): 24.0% of work package S2

D. Soils on Weathered Shales (with active erosional removal) (Midway – Shale Complex; Shingle Series): 5.6% of work package S2

F. Soils on Recent Alluvium of Moderate Texture and Salt Content (Haverson Series and Ustic Torrifluvents): 4.0 % of work package S2

The distribution of these Soil Groups (based on previous mapping in SCS (1979)) is indicated on the maps of S2 included in Appendix A

Methods

As per the Pueblo County Revegetation Cover Establishment Protocol (Protocol), within each Soil Group in Work Package S2, 30 points were randomly selected using GIS software. These computer-selected points were visited in the field using handheld GPS units during the period of July 29-31, 2013. At each point a 0.5 square meter circular plot was placed on the ground by blind drop at the point indicated by the GPS device. Within the plot, all seedlings of perennial plants

were tallied. Acceptable species are those from the seed mix as well as all other non-noxious perennial plant species.

Data were tallied and converted from the number of seedlings per 0.5 sq. m. to the number per sq. ft., which is the unit of measure specified in construction specifications and the Protocol.

Results

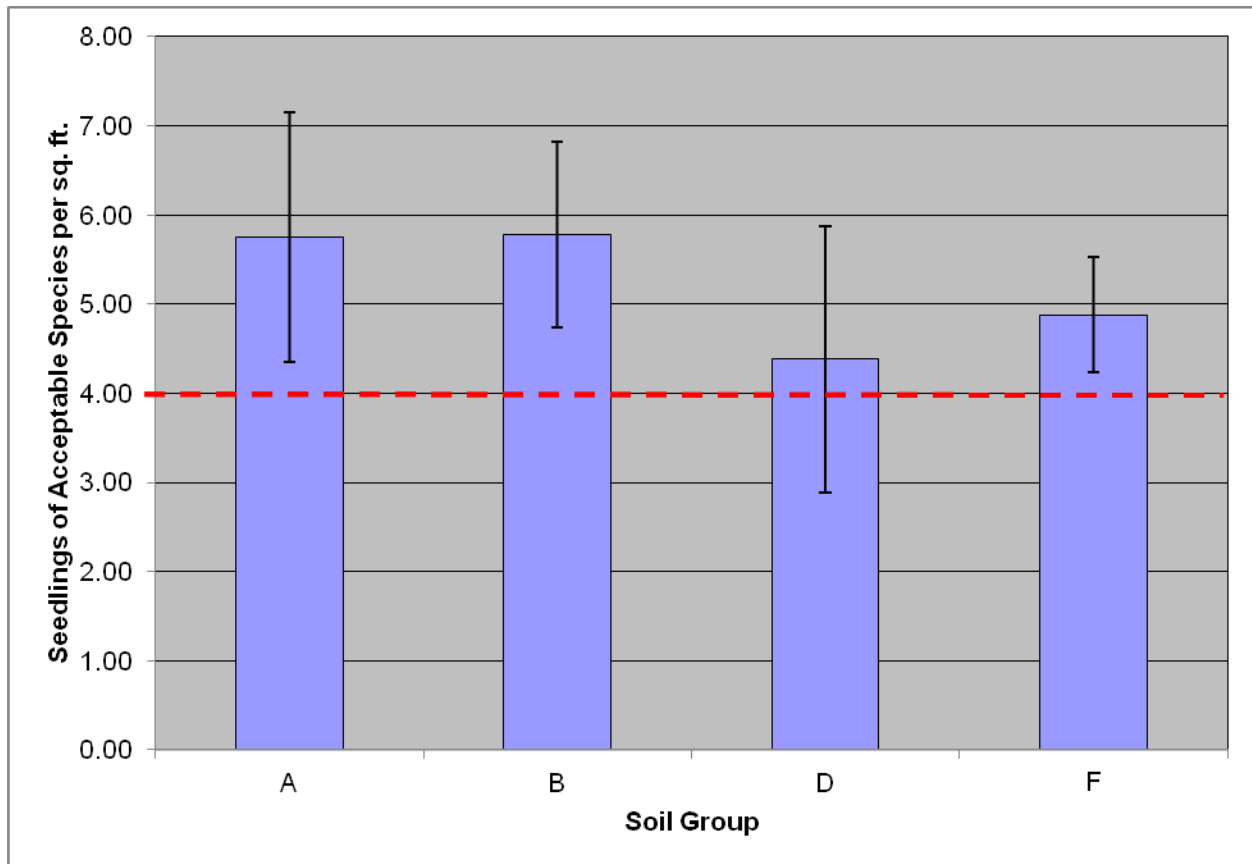
Sample data are presented in Table. 1. As can be seen in Figure 1, all Soil Groups within Work Package S2 have seedling density levels above 4 per sq. ft.

Table 1. Results of Seedling Density Sampling of Seeded Area in Southern Delivery System Work Package S2

Work Package	Soil Group	Mean Seedlings per sq. ft.*	90% Confidence Interval (+/-)	Sample Size (n)
S2	A	5.75	1.40	30
S2	B	5.78	1.04	30
S2	D	4.38	1.50	30
S2	F	4.88	0.65	30

* Seedlings of acceptable species are defined as those included in the seed mix and any other non-noxious perennial species

Figure 1. Preliminary Seedling Density of Work Package S2



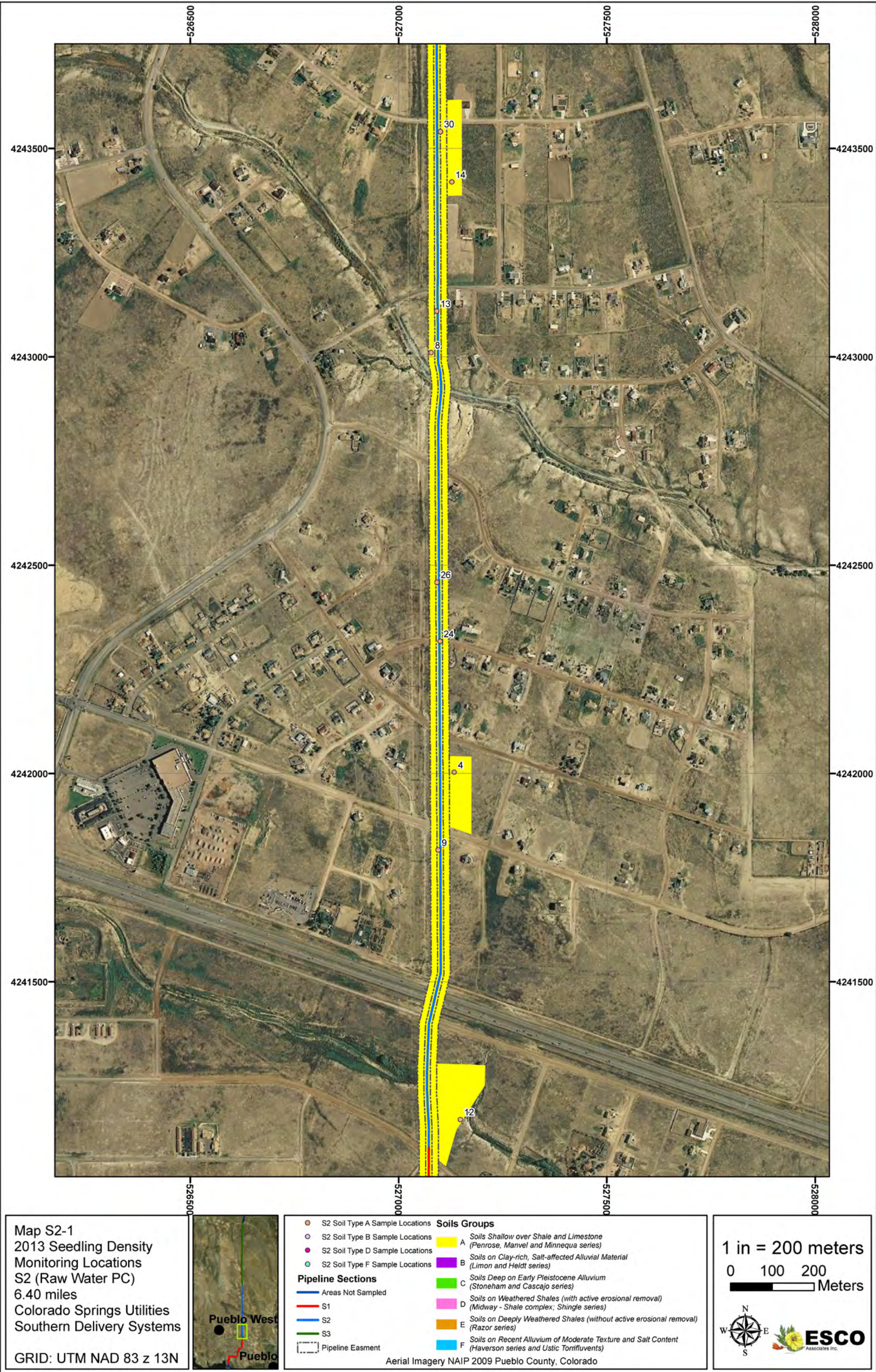
Discussion

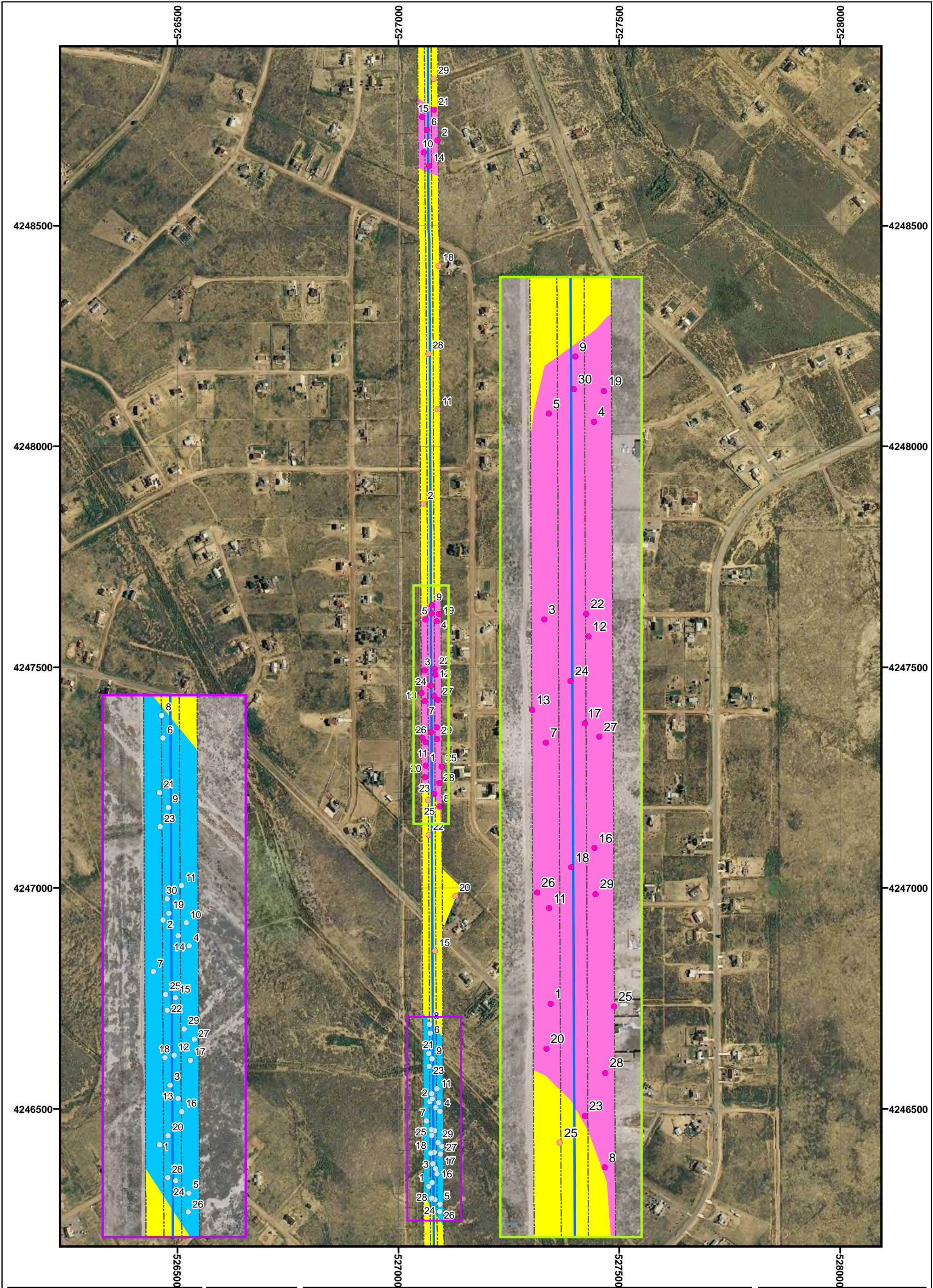
The recent string of drought years in Pueblo County has continued in 2013. This scarcity of water has made the presence of irrigation on the seeded pipeline right-of-way essential for seed germination to occur. In addition to water availability, it is apparent from these data that soil characteristics have an effect on seedling density. In the earlier stages of the revegetation process, the seedling density metric is the most direct indicator of the progress of the seeded areas toward the ultimate goal of vigorous self-sustaining plant cover. The presence of (a minimum of) 4 seedlings per sq. ft. is the level that would be expected in irrigated areas after a full growing season. Since the seedling density in all Soil Groups in S2 surpassed the 4 seedlings per sq. ft. standard, the initial progress of vegetation regrowth in this Work Package is indicative that revegetation efforts are likely to be successful. Revegetation progress will continue to be monitored through future evaluations of vegetation cover as the planted vegetation begins to mature.

Literature Cited

USDA Soil Conservation Service (SCS). 1979. Soil Survey of Pueblo Area, Colorado: Parts of Pueblo and Custer Counties. U.S. Dept. of Agric. Soil Conservation Service in cooperation with the Colorado Agricultural Experiment Station. 92 pp. plus maps.

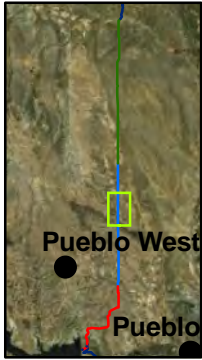
Appendix A: Maps – Work Package S2





Map 3. S2-3
2013 Seedling Density
Monitoring Locations
S2 (Raw Water PC)
6.40 miles
Colorado Springs Utilities
Southern Delivery Systems

GRID: UTM NAD 83 z 13N

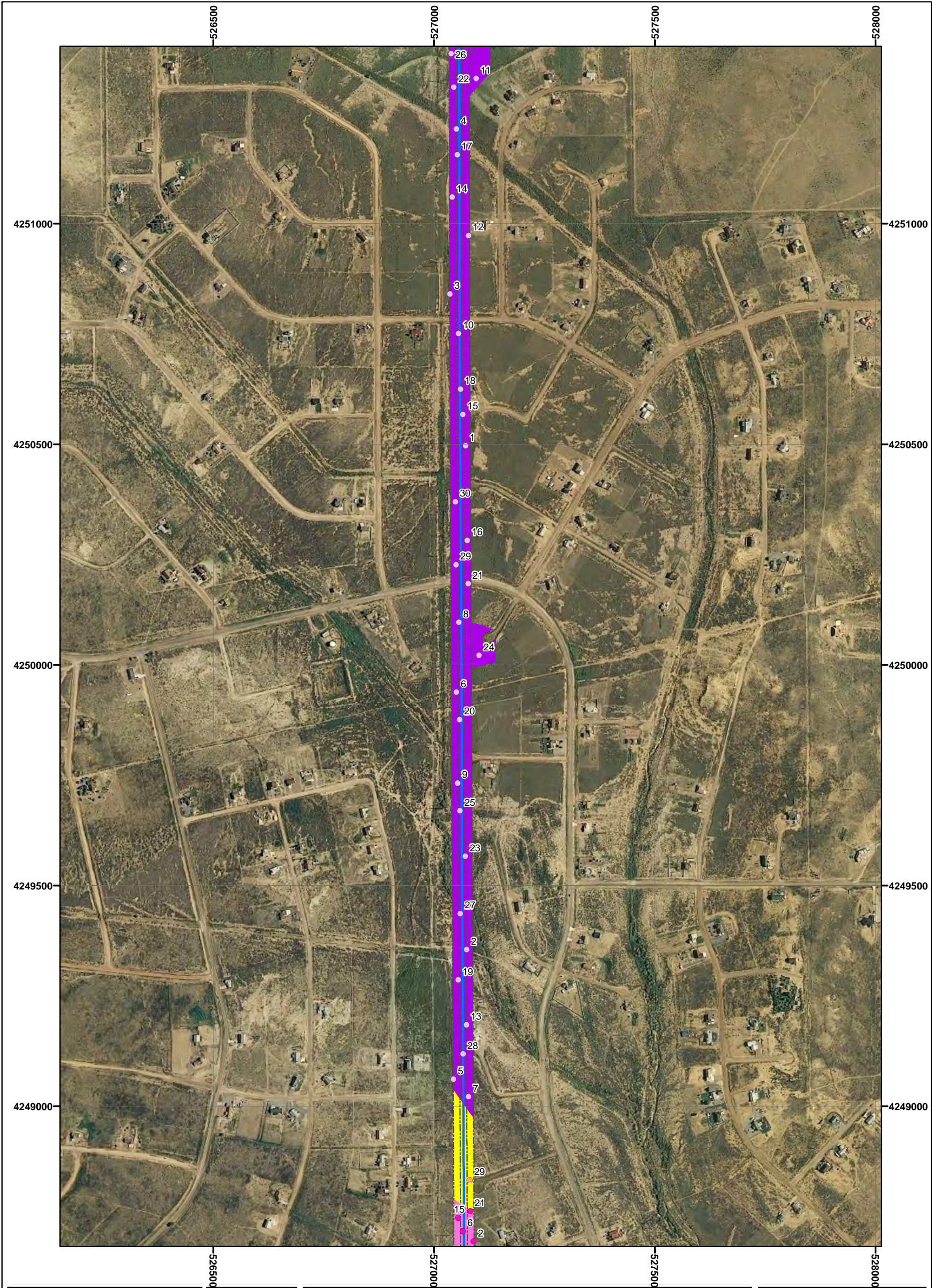


- Soil Type A Sample Locations (n=30)
 - Soil Type B Sample Locations (n=30)
 - Soil Type D Sample Locations (n=30)
 - Soil Type F Sample Locations (n=30)
- Pipeline Sections**
- Areas Not Sampled
 - S1
 - S2
 - S3
 - Pipeline Easment

- Soils Groups**
- A Soils Shallow over Shale and Limestone (Penrose, Manvel and Minnequa series)
 - B Soils on Clay-rich, Salt-affected Alluvial Material (Limon and Heldt series)
 - C Soils Deep on Early Pleistocene Alluvium (Stoneham and Cascajo series)
 - D Soils on Weathered Shales (with active erosional removal) (Midway - Shale complex; Shingle series)
 - E Soils on Deeply Weathered Shales (without active erosional removal) (Razor series)
 - F Soils on Recent Alluvium of Moderate Texture and Salt Content (Haverson series and Ustic Torrifluvents)
- Aerial Imagery NAIP 2009 Pueblo County, Colorado

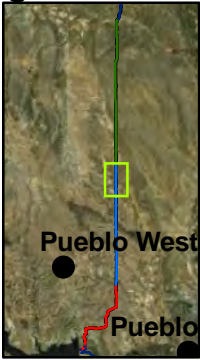
1 in = 200 meters
0 100 200 Meters

ESCO



Map 4. S2-4
2013 Seedling Density
Monitoring Locations
S2 (Raw Water PC)
6.40 miles
Colorado Springs Utilities
Southern Delivery Systems

GRID: UTM NAD 83 z 13N



● Soil Type A Sample Locations (n=30)

● Soil Type B Sample Locations (n=30)

● Soil Type D Sample Locations (n=30)

● Soil Type F Sample Locations (n=30)

Pipeline Sections

— Areas Not Sampled

— S1

— S2

— S3

--- Pipeline Easment

Soils Groups

A Soils Shallow over Shale and Limestone (Penrose, Marvel and Minnequa series)

B Soils on Clay-rich, Salt-affected Alluvial Material (Limon and Heldt series)

C Soils Deep on Early Pleistocene Alluvium (Stoneham and Cascajo series)

D Soils on Weathered Shales (with active erosional removal) (Midway - Shale complex; Shingle series)

E Soils on Deeply Weathered Shales (without active erosional removal) (Razor series)

F Soils on Recent Alluvium of Moderate Texture and Salt Content (Haverson series and Ustic Torrifluvents)

Aerial Imagery NAIP 2009 Pueblo County, Colorado

1 in = 200 meters

0 100 200

Meters

N

W E S

Mural Heritage Program

Colorado

ESCO

Associates Inc.

Colorado Springs Utilities Southern Delivery System

*Measurements of Post-restoration Seedling Density for Pueblo County
Work Package S3-12*



Prepared for:
**Colorado Springs Utilities
Southern Delivery System
Colorado Springs, CO 80947**

Prepared by:
**Colorado Natural Heritage Program
Colorado State University
Fort Collins, CO 80523**

October, 2013

Prepared in conjunction with:

**ESCO Associates, Inc.
Boulder, CO**



**Cover Photo: Sample site 9 on Soil Group A (Penrose, Manuel and Minnequa Series) in work package S3-12
(by ESCO Assoc. Inc.)**



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Introduction

As the first look at success of seeding efforts in the Pueblo county portion of the Southern Delivery System (SDS) Pipeline, a quantitative evaluation of seedling density was carried out in late July, 2013. This report documents post-construction seedling densities during the first growing season along the section of pipeline that was seeded and on which irrigation was initiated in 2012. This section is specifically labeled S3-12 and extends from Antelope Road northward to the end of work package S3. The Colorado Natural Heritage Program, in cooperation with ESCO Associates, completed the post-construction seedling density survey under contract to Colorado Springs Utilities.

The following includes the methods used, the results, and a discussion of the seedling density evaluation on the sites after any construction activities. Maps of Work Package S3-12 are contained in Appendix A.

The study area is in a tributary valley of the Arkansas River downstream (east) from its emergence from the mountain front. Along some reaches of the pipeline route, exposed shale and limestone are the predominant soil parent materials, while on other reaches recent alluvium predominates and on high terrace sites older deposits of Arkansas River alluvium in the form of sands and gravels predominate.

Given the important effect of soils on details of pre-existing vegetation and the outcome of revegetation efforts, pre-existing conditions and revegetation performance standards for plant cover were separated by soil group. These groups differ from each other in such characteristics as depth, texture, and salt content, all of which along with other variable factors have the potential to affect the extent and nature of the revegetation process as well as the rate of establishment and development. Within the "soil groups" identified in the Pueblo County portions of the SDS pipeline, five occurred in Work Package S3-12 :

A. Soils Shallow over Shale and Limestone (Penrose, Manvel and Minnequa Series): 13.1% of Work Package S3-12

B. Soils on Clay-rich, Salt-affected Alluvial Material (Limon and Heldt Series): 2.8% of Work Package S3-12

C. Soils Deep on Early Pleistocene Alluvium (Stoneham and Cascajo Series): 47.2% of Work Package S3-12

E. Soils on Deeply Weathered Shales (without active erosional removal) (Razor Series): 35.6% of Work Package S3-12

F. Soils on Recent Alluvium of Moderate Texture and Salt Content (Haverson Series and Ustic Torrifluvents): 1.3% of Work Package S3-12.

The distribution of these Soil Groups (based on previous mapping in SCS (1979)) is indicated on the maps of S3-12 included in Appendix A

Methods

As per the Pueblo County Revegetation Cover Establishment Protocol (Protocol), seedling density sample size was 30 per Soil Group for Work Package S3 in its entirety. Thus the samples in the S3-12 section represent only a portion of the total samples in S3. The area of Soil Group F (Haverson Series) in the S3 section of the pipeline is only approximately 1500 square feet, consequently, 30 samples could not be placed in this group. The computer-selected sample points were visited in the field using handheld GPS units during the period of July 29-31, 2013. At each point a 0.5 square meter circular plot was placed on the ground by blind drop at the point indicated by the GPS device. Within the plot, all seedlings of perennial plants were tallied. Acceptable species are those from the seed mix as well as all other non-noxious perennial plant species.

Data were tallied and converted from the number of seedlings per 0.5 sq. m. to the number per sq. ft., which is the unit of measure specified in construction specifications and the Protocol.

Results

Sample data are presented in Table. 1. As can be seen in Figure 1, all Soil Groups within Work Package S3-12, with the exception of Soil Group E (Razor Series) and F (Haverson Series), have seedling density levels above 4 per sq. ft.

Table 1. Results of Seedling Density Sampling of Seeded Area in Southern Delivery System Work Package S3-12

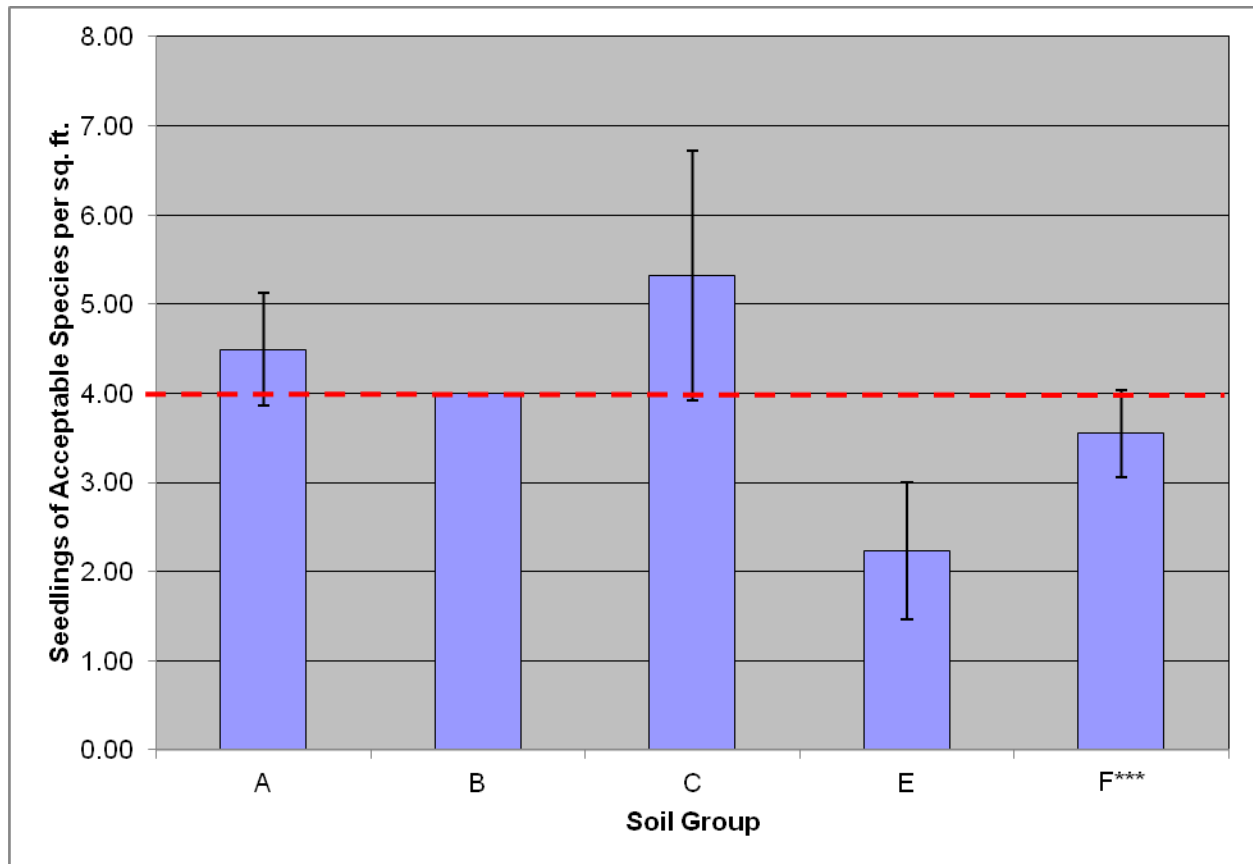
Work Package	Soil Group	Mean Seedling per sq. ft.*	90% Confidence Interval (+/-)	Sample Size (n)
S3 2012**	A	4.49	0.63	30
S3 2012**	B	4.00	0.00	1
S3 2012**	C	5.32	1.40	12
S3 2012**	E	2.23	0.77	9
S3 2012	F***	3.55	0.49	10

* Seedlings of acceptable species meaning those included in the Seed Mix and any other non-noxious perennials

** Note that as per the Pueblo County Protocol, Seedling Density sample size was 30 per Work Package / Soil Group. This is true of Work Package S3, but the separation shown reflects the fact that on the northernmost portion of S3 (north of Antelope Road) irrigation was initiated in fall 2012 while on the southern portion, irrigation was not initiated until part way into the 2013 growing season due to on-going work.

*** This unit of approximately 1500 square feet was too small to justify 30 samples.

Figure 1. Preliminary Seedling Density of Work Package S3-12



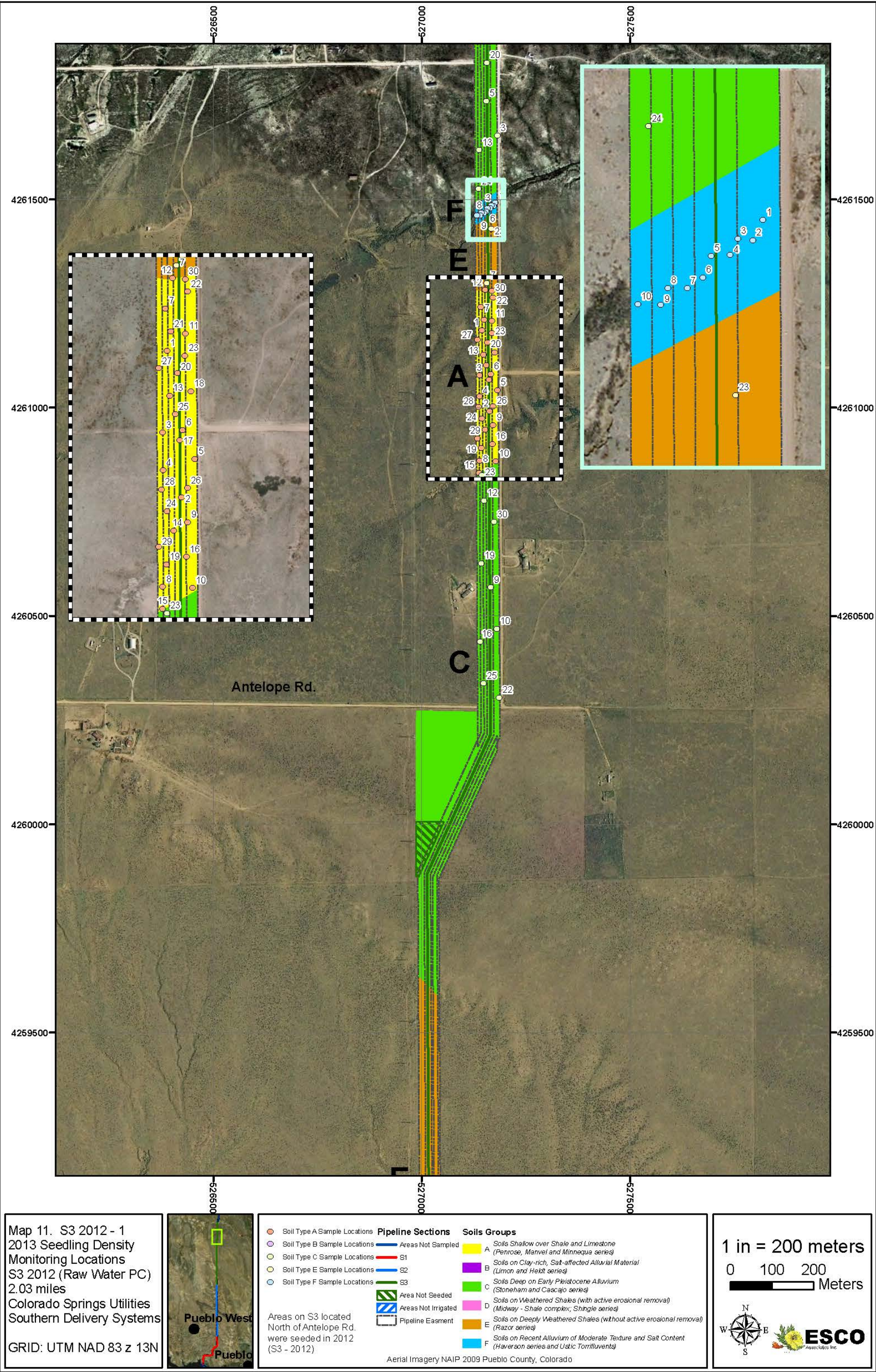
Discussion

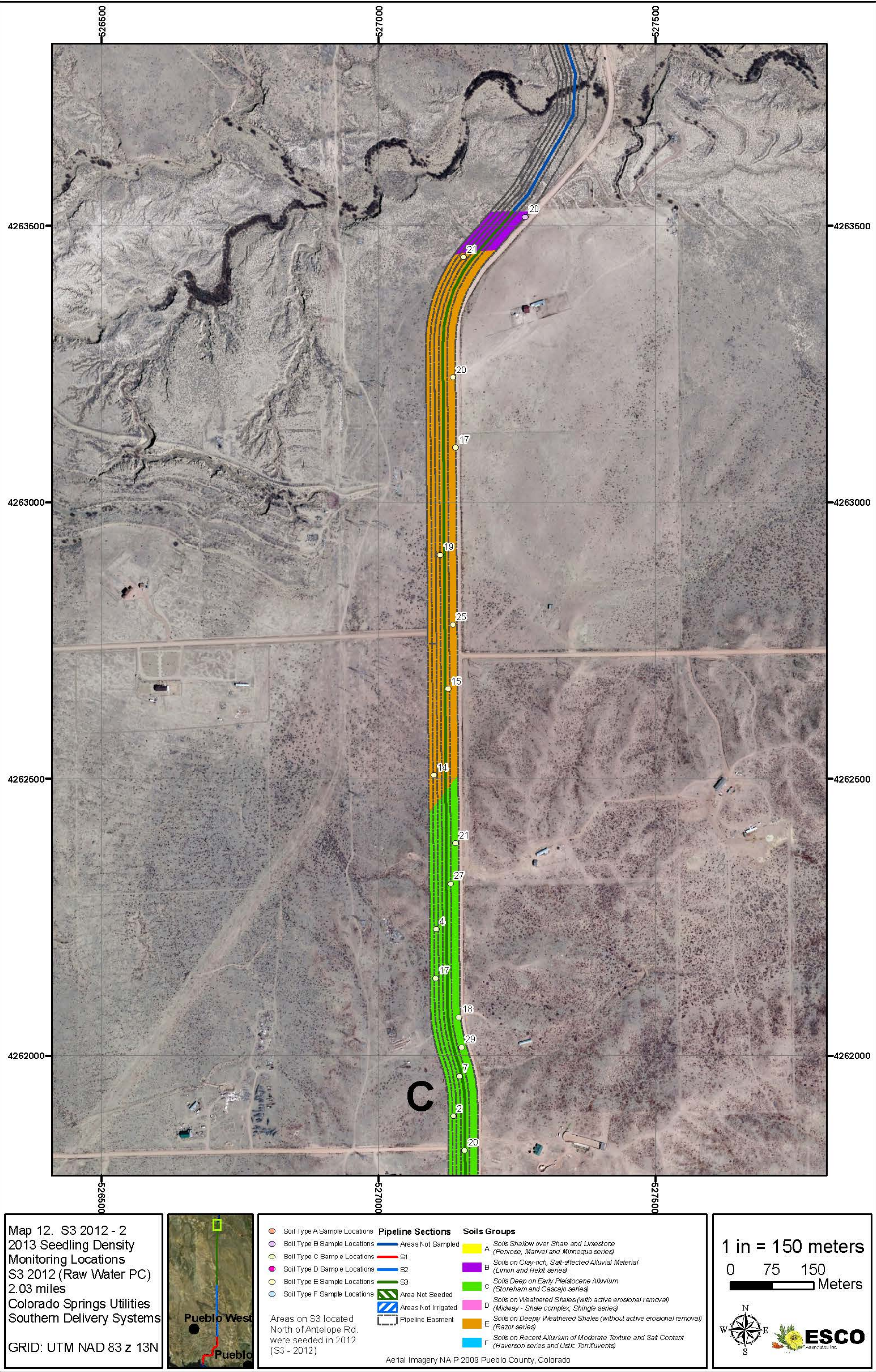
The recent string of drought years in Pueblo County has continued in 2013. This scarcity of water has made the presence of irrigation on the seeded pipeline right-of-way essential for seed germination to occur. The earlier implementation of irrigation on the S3-12 section resulted in higher seedling densities compared to sections irrigated later (See Seedling Density Report for S3-13). In addition to water availability, it is apparent from these data that soil characteristics have an effect on seedling density. In the earlier stages of the revegetation process, the seedling density metric is the most direct indicator of the progress of the seeded areas toward the ultimate goal of vigorous self-sustaining plant cover. The presence of (a minimum of) 4 seedlings per sq. ft. is the level that would be expected in irrigated areas after a full growing season. Since the seedling density in all but two (Groups E and F) of the Soil Groups in S3-12 surpassed the 4 seedlings per sq. ft. standard, the initial progress of vegetation regrowth in this Work Package is indicative that revegetation efforts are likely to be successful. Revegetation progress will continue to be monitored through future evaluations of vegetation cover as the planted vegetation begins to mature

Literature Cited

USDA Soil Conservation Service (SCS). 1979. Soil Survey of Pueblo Area, Colorado: Parts of Pueblo and Custer Counties. U.S. Dept. of Agric. Soil Conservation Service in cooperation with the Colorado Agricultural Experiment Station. 92 pp. plus maps.

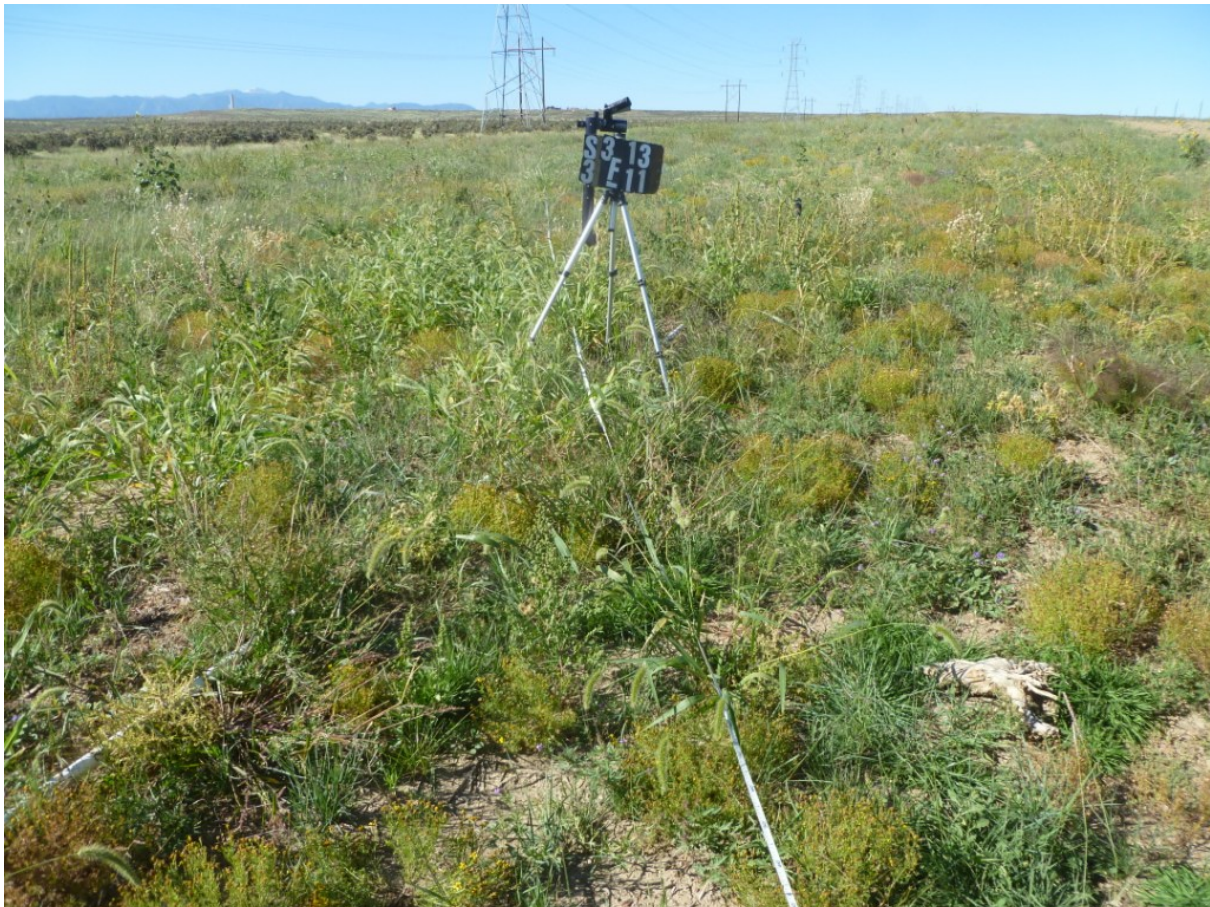
Appendix A: Map – Work Package S3-12





Colorado Springs Utilities Southern Delivery System

Measurements of Post-restoration Seedling Density for Pueblo County Work Package S3-13



Prepared for:
**Colorado Springs Utilities
Southern Delivery System
Colorado Springs, CO 80947**

Prepared by:
**Colorado Natural Heritage Program
Colorado State University
Fort Collins, CO 80523**

October, 2013

Prepared in conjunction with:

**ESCO Associates, Inc.
Boulder, CO**



Cover Photo: Sample Site 11 on Soil Group E (Razor Series) in work package S3-13 (by ESCO Assoc. Inc.)



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Introduction

As the first look at success of seeding efforts in the Pueblo county portion of the Southern Delivery System (SDS) Pipeline, a quantitative evaluation of seedling density was carried out in late July, 2013. This report documents post-construction seedling densities during the first growing season along the section of pipeline that was seeded and on which irrigation was initiated in June 2013. This section is specifically labeled S3-13 and extends from the southern end of the S3 work package north to Antelope Road. The Colorado Natural Heritage Program, in cooperation with ESCO Associates, completed the post-construction seedling density survey under contract to Colorado Springs Utilities.

The following includes the methods used, the results, and a discussion of the seedling density evaluation on the sites after any construction activities. Maps of Work Package S3-13 are contained in Appendix A.

The study area is in a tributary valley of the Arkansas River downstream (east) from its emergence from the mountain front. Along some reaches of the pipeline route, exposed shale and limestone are the predominant soil parent materials, while on other reaches recent alluvium predominates and on high terrace sites older deposits of Arkansas River alluvium in the form of sands and gravels predominate.

Given the important effect of soils on details of pre-existing vegetation and the outcome of revegetation efforts, pre-existing conditions and revegetation performance standards for plant cover were separated by soil group. These groups differ from each other in such characteristics as depth, texture, and salt content, all of which along with other variable factors have the potential to affect the extent and nature of the revegetation process as well as the rate of establishment and development. Within the “soil groups” identified in the Pueblo County portions of the SDS pipeline, four occurred in Work Package S3-13:

B. Soils on Clay-rich, Salt-affected Alluvial Material (Limon and Heldt Series): 44.0% of Work Package S3-13

C. Soils Deep on Early Pleistocene Alluvium (Stoneham and Cascajo Series): 7.8% of Work Package S3-13

D. Soils on Weathered Shales (with active erosional removal) (Midway – Shale Complex): 14.8% of Work Package S3-13

E. Soils on Deeply Weathered Shales (without active erosional removal) (Razor Series): 33.4% of Work package S3-13

The distribution of these Soil Groups (based on previous mapping in SCS (1979)) is indicated on the maps of S3-13 included in Appendix A

Methods

As per the Pueblo County Revegetation Cover Establishment Protocol (Protocol), seedling density sample size was 30 per Soil Group for Work Package S3 in its entirety. Thus the samples in the S3-13 section represent only a portion of the total samples in S3. The computer-selected sample points were visited in the field using handheld GPS units during the period of July 29-31, 2013. At each point a 0.5 square meter circular plot was placed on the ground by blind drop at the point indicated by the GPS device. Within the plot, all seedlings of perennial plants were tallied. Acceptable species are those from the seed mix as well as all other non-noxious perennial plant species.

Data were tallied and converted from the number of seedlings per 0.5 sq. m. to the number per sq. ft., which is the unit of measure specified in construction specifications and the Protocol.

Results

Sample data are presented in Table. 1. As can be seen in Figure 1, all Soil Groups within Work Package S3-13 fell short of the 4 seedlings per square foot target.

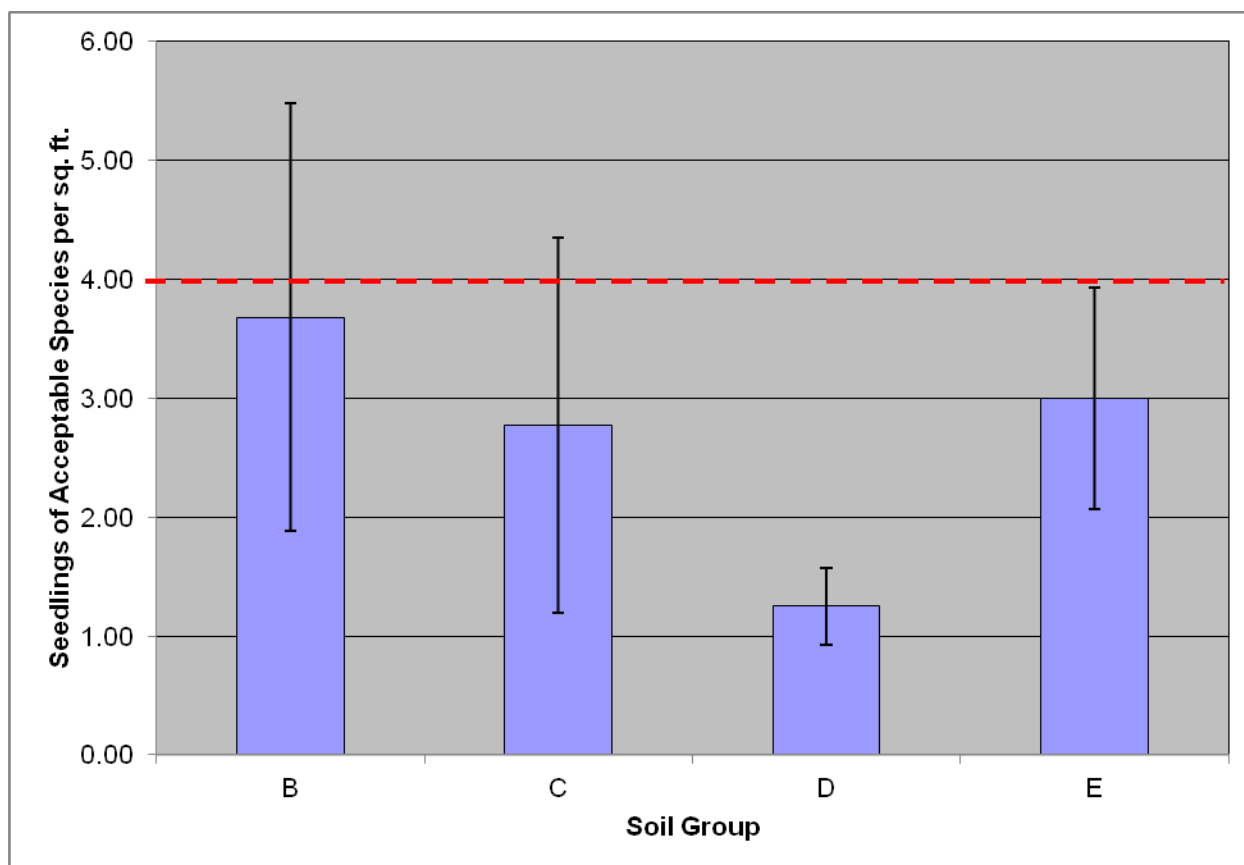
Table 1. Results of Seedling Density Sampling of Seeded Area in Southern Delivery System Work Package S3-13

Work Package	Soil Group	Mean Seedlings per sq. ft.*	90% Confidence Interval (+/-)	Sample Size (n)
S3 2013**	B	3.68	1.80	29
S3 2013**	C	2.77	1.58	18
S3 2013**	D	1.25	0.32	30
S3 2013**	E	3.00	0.93	21

* Seedlings of acceptable species meaning those included in the Seed Mix and any other non-noxious perennials

** Note that as per the Pueblo County Protocol, Seedling Density sample size was 30 per Work Package / Soil Group. This is true of Work Package S3, but the separation shown reflects the fact that on the northernmost portion of S3 (north of Antelope Road) irrigation was initiated in fall 2012 while on the southern portion, irrigation was not initiated until part way into the 2013 growing season due to on-going work.

Figure 1. Preliminary Seedling Density of Work Package S3-13



Discussion

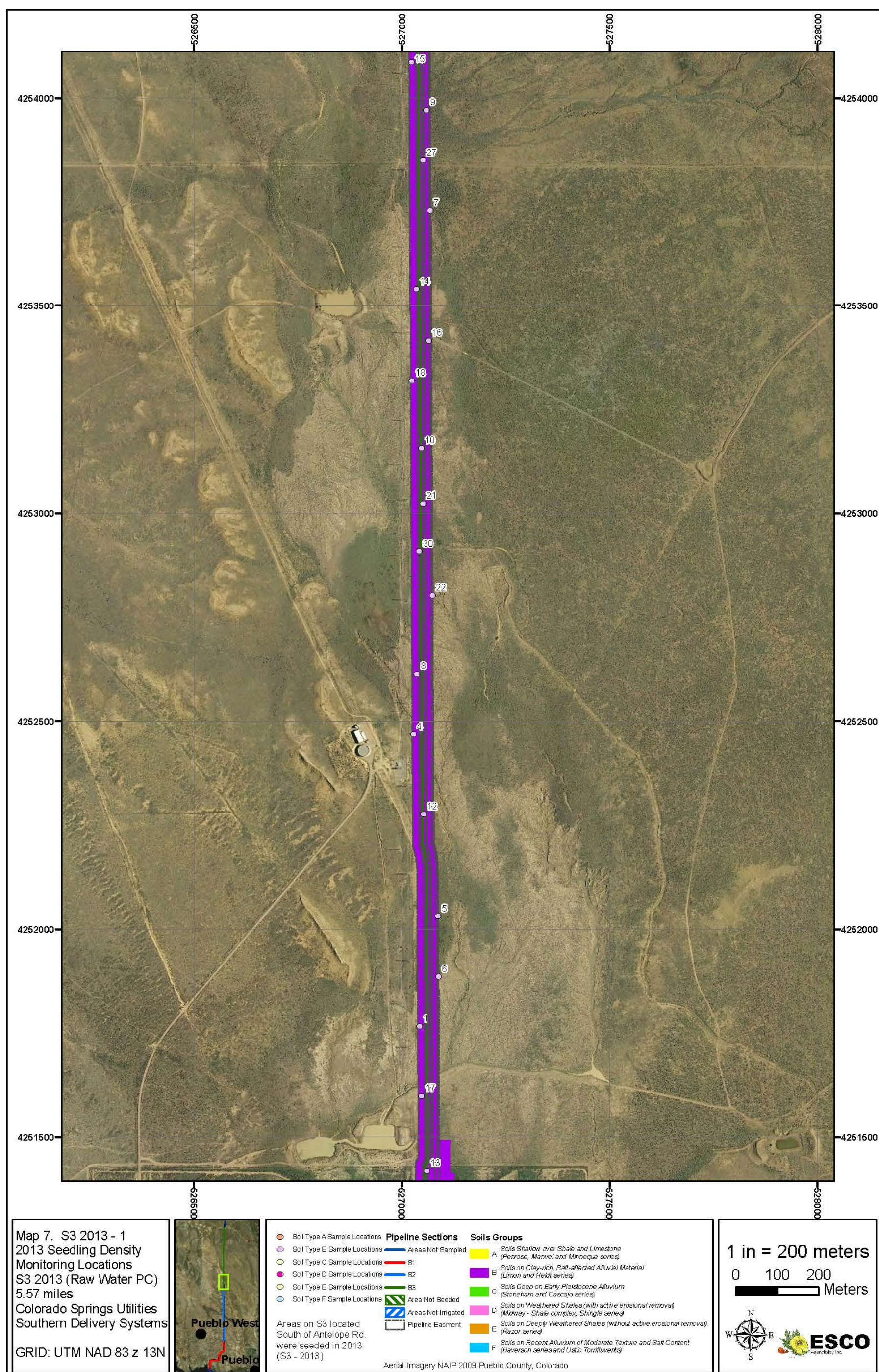
The recent string of drought years in Pueblo County has continued in 2013. This scarcity of water has made the presence of irrigation on the seeded pipeline right-of-way essential for seed germination to occur. Onset of irrigation on the S3-13 section was during the first half of June 2013 and thus by late July, a period of as little as four weeks had elapsed since moisture was first applied. This resulted in lower seedling densities compared to sections irrigated earlier (See for example Seedling Density Report for S3-12). The success of seedlings in the same Soil Groups in the S3-12 section suggests that the seedling densities of section S3-13 will eventually attain higher seedling densities. During data gathering, it was obvious that a very large portion of counted seedlings were comprised of shoots that had emerged from the ground surface very recently, suggesting that the germination process at that time was on-going. Consequently, the seedling density measurements below the goal of 4 seedlings per square feet should not be cause for alarm, it is clear from this sampling that germination is occurring and is expected to continue to progress from this early stage. It is likely that seedling density values will exceed the level of 4 per sq. ft. once full germination is accomplished.

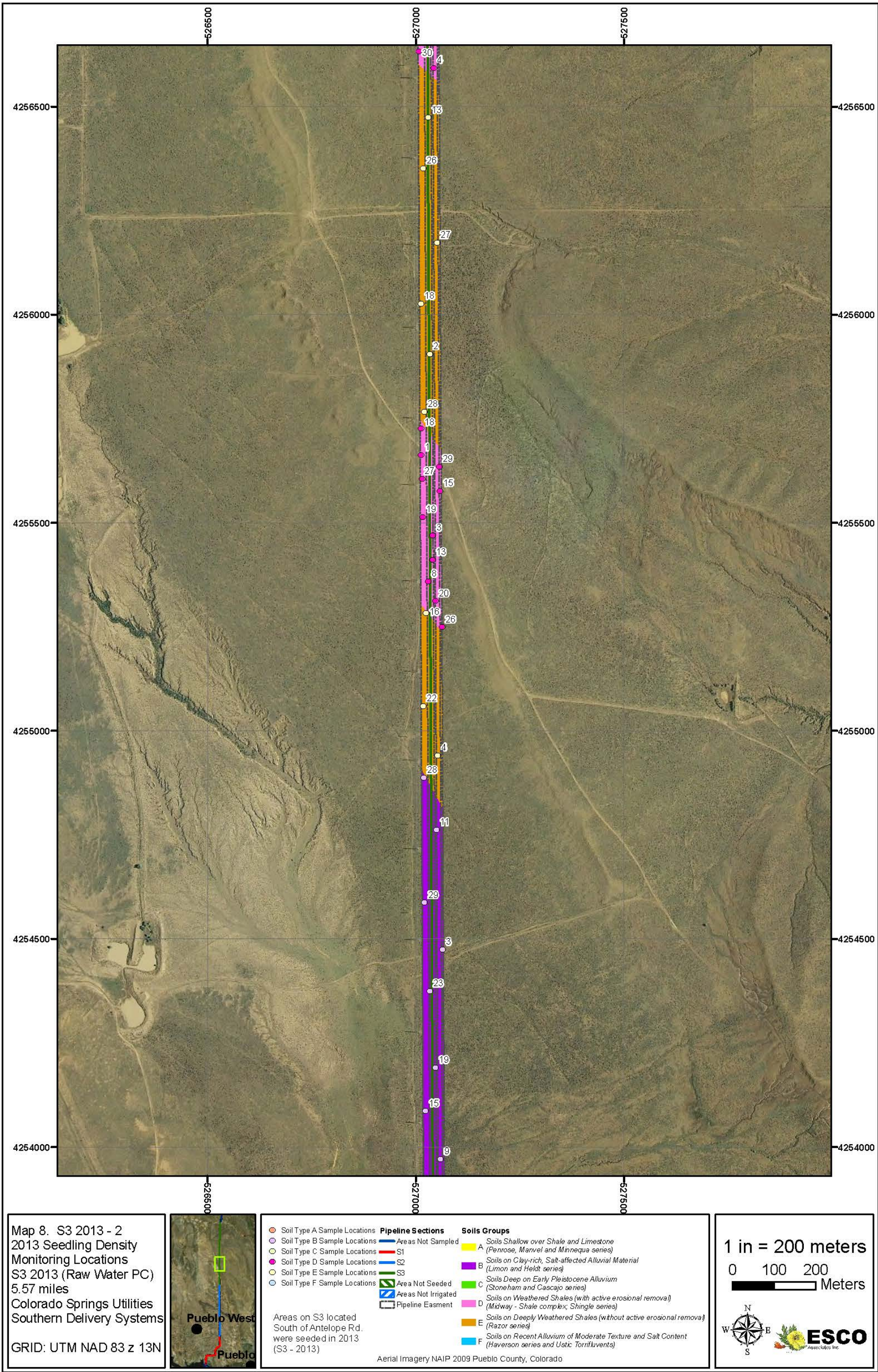
In addition to water availability, it is apparent from these data that soil characteristics have an effect on seedling density. In the earlier stages of the revegetation process, the seedling density metric is the most direct indicator of the progress of the seeded areas toward the ultimate goal of vigorous self-sustaining plant cover. The presence of (a minimum of) 4 seedlings per sq. ft. is the

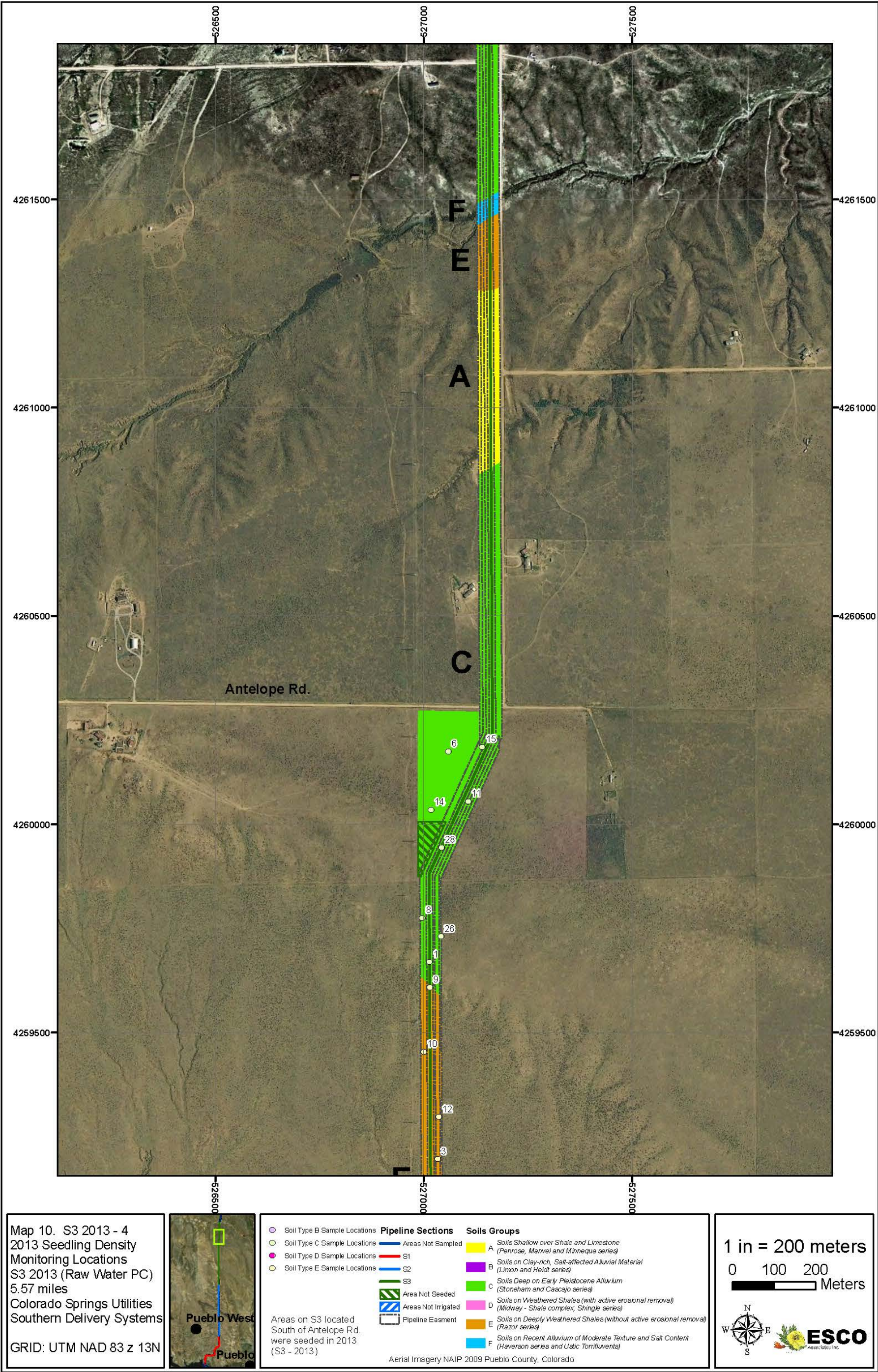
level that would be expected in irrigated areas after a full growing season. Revegetation progress will continue to be monitored through future evaluations of vegetation cover as the planted vegetation begins to mature.

Literature Cited

USDA Soil Conservation Service (SCS). 1979. Soil Survey of Pueblo Area, Colorado: Parts of Pueblo and Custer Counties. U.S. Dept. of Agric. Soil Conservation Service in cooperation with the Colorado Agricultural Experiment Station. 92 pp. plus maps.

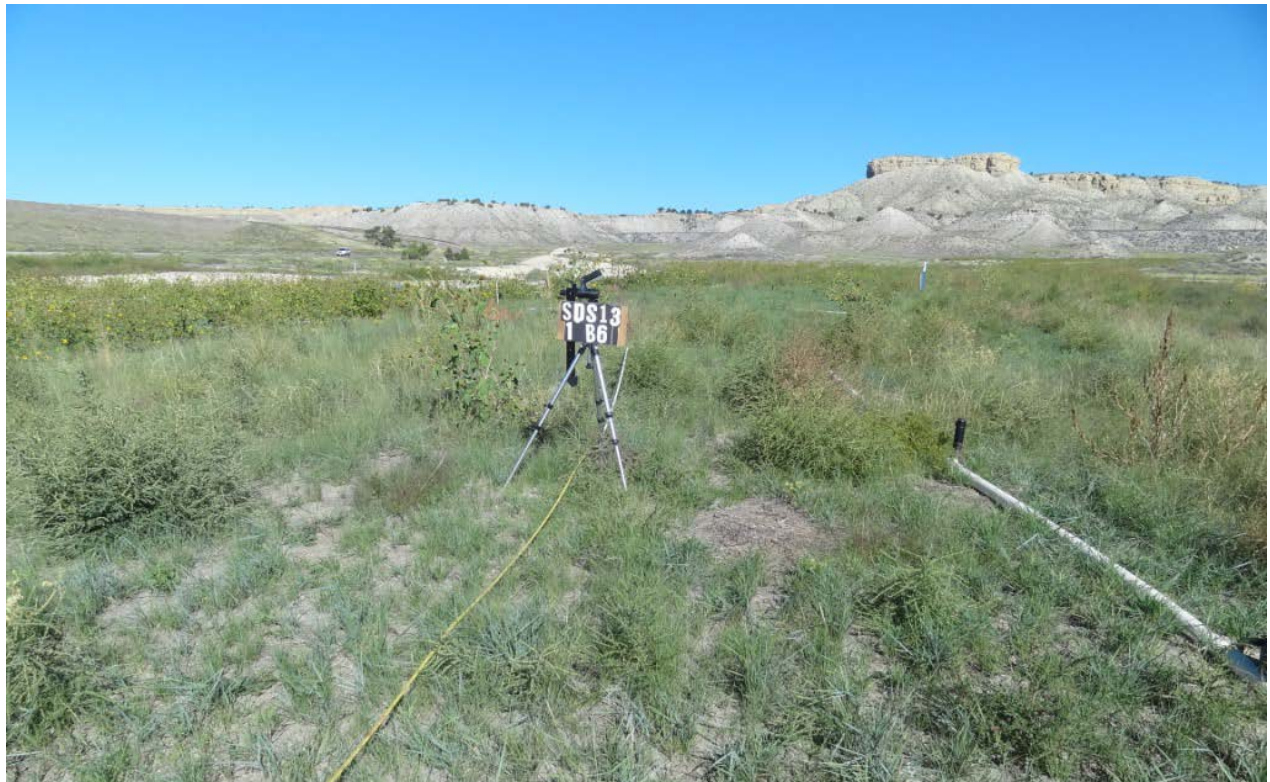






Colorado Springs Utilities Southern Delivery System

Measurements of Post-restoration Vegetation Cover for Pueblo County Work Package S1



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Cover Photo: Sample site 6 on Soil Group B (Limon and Heldt Series) in work package S1 (by ESCO Assoc. Inc.)



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Introduction

This report documents conditions of post-construction vegetation cover after the first growing season along the S1 section of the Southern Delivery System (SDS) pipeline route in Pueblo County, Colorado. The Colorado Natural Heritage Program, in cooperation with ESCO Associates, completed the post-construction survey under contract to Colorado Springs Utilities. This report compares post-construction vegetative cover values to the standards for revegetation prescribed by CDPHE Stormwater Regulations and the Pueblo County 1041 permit in order to evaluate revegetation success in this section. It also reports frequency-based quantitative measures of the presence of acceptable species in comparison to a pre-determined standard.

The following includes the methods used, the results, and a discussion of factors affecting vegetation cover on the sites after any construction activities. Maps, tabular data, and photographs of work package S1 are contained in separate Appendices A, B, and C, respectively. Appendix D includes applicable portions of the Pueblo County Revegetation Cover Establishment Protocol (Protocol).

The study area is in a tributary valley of the Arkansas River downstream (east) from its emergence from the mountain front. Along some reaches of the pipeline route, exposed shale and limestone are the predominant soil parent materials, while on other reaches recent alluvium predominates and on high terrace sites older deposits of Arkansas River alluvium in the form of sands and gravels predominate.

Methods

Assessment of Cover and the Presence of Acceptable Species in revegetated and irrigated areas along the SDS Pipeline in Pueblo County was completed in late September 2013 as per a formal Protocol developed for the project. Prior to this, in July 2013, the density of seedlings of acceptable species per square foot was assessed along these same reaches of revegetated right-of-way. The July assessment provided an early look into revegetation results, but the September 2013 effort included evaluation of two different parameters that were applicable to vegetation somewhat more mature than in July 2013.

The primary parameter assessed in the September work was percent cover by acceptable species as set forth in the protocol. This measure relates to the Pueblo County 1041 permit requirement that cover on revegetated areas comprise at least 90% of pre-existing levels. It also relates to the requirement under CDPHE Stormwater Regulations that cover attains at least 70% of pre-existing levels. Pre-existing levels of cover on the Pueblo County work package reaches were established by quantitative sampling in October 2011 prior to construction. Further details on this pre-construction effort can be found in the 2011 report.

Beyond the return of adequate plant cover (detailed in the Protocol document), measures intended to provide Pueblo County with an evaluation of the adequate presence of Acceptable Species in the reconstructed vegetation were also made as per provisions in the Protocol. Acceptable species had been determined in consultation with the Pueblo County vegetation representative to include all native species and all introduced perennial species other than those included on the current State of Colorado A, B or C-lists of noxious species.

Beginning with the pre-construction vegetation surveys, results of sampling in this work package have been grouped by broad soil types. These groups, established to simplify the process, include soil series of similar nature as plant growth media. Within each soil type, sample transects (See Protocol Technical Memos 1 and 3, Appendix D) were placed at random locations in an effort to capture the variability of vegetative cover present. At each representative sample location, vegetation cover and ground cover were measured via observation at 100 locations spaced at 1 meter intervals along the transect length. Maps showing the extent of the soil groups present within the alignment of the work package and the location of sample transect origin points are included in Appendix A.

Areas that were not seeded or irrigated as part of the revegetation effort were not sampled.

Results

A total of 30 transects were sampled in the work package S1 area during the post-construction survey. The various soils across the extent of the work package were grouped for simplicity into four units that differed in their nature as plant growth media and as to the means by which it will be necessary to salvage and replace them during construction. The four groups are as follows:

A. Soils Shallow over Shale and Limestone (Penrose, Manvel and Minnequa series; Table 1, Appendix B)

B. Soils on Clay-rich, Salt-affected Alluvial Material (Limon and Heldt series; Table 2, Appendix B)

C. Soils Deep on Early Pleistocene Alluvium (Stoneham and Cascajo series; Post-construction values not yet measured)

D. Soils on Weathered Shales (with active erosional removal) (Midway – Shale complex, Shingle series; Table 3, Appendix B)

The distribution of these Soil Groups is indicated on the maps of S1 included in Appendix A.

Although Soil Group C is present in Work Package S1, the vegetative cover of this soil group was not measured during this sampling effort as this portion of the pipeline had not yet been irrigated. Due to the recent string of drought years, vegetation in this region is dependent on irrigation for seedling germination. Consequently, without irrigation in place, vegetation cover values for this Soil Group would have been misrepresentative of the revegetation progress.

Plant cover observed during sampling was related to the above soil groups and used to establish base values from which revegetation performance standards were calculated.

Base Cover Values for Evaluation of Revegetation Success

The following are base vegetation cover values (to be multiplied by 0.9 in accordance with the Protocol) that were measured pre-construction.

A. Soils Shallow over Shale and Limestone (Penrose, Manvel and Minnequa series): **17.2%**

B. Soils on Clay-rich, Salt-affected Alluvial Material (Limon and Heldt series): **26.5%** (Note that this represents the level found on Limon soils in ungrazed S1)

D. Soils on Weathered Shales (with active erosional removal) (Midway – Shale complex, Shingle series): **17.0%**.

Post Construction Results

Table 1 (below) displays the base vegetation cover, revegetation cover values at the 90% and 70% levels (established under Pueblo Co. 1041 and CDPHE Stormwater Regulations, respectively), and the post-construction percent cover values by soil groups. Soil group C does not have an associated post-construction cover value as construction in this section was yet to be completed through a significant portion of the 2013 growing season. Vegetation sampling on soil group C will be initiated in 2014. Figure 1 (below) graphically represents this information. As can be seen in Figure 1 and Table 1, total cover by acceptable species exceeded the 70% and 90% levels (prescribed under Pueblo Co. 1041) for all of S1 as of late September 2013. Note, however, that CDPHE cover expectations include all species present (including introduced annual species deemed partially unacceptable in Pueblo Co. evaluations).

Table 1: Vegetation Cover by Soil Group for S1

Map Code	Soil Group	% of Work Unit	% Base Veg. Cover	90% Revegetation Cover Performance Std. (0.9 x Base)	70% Revegetation Cover Performance Std. (0.7 x Base)	% Cover by Acc. Spp
A	Soils shallow over shale and limestone (Penrose, Manvel and Minnequa series)	71.7	17.2	15.5	12.1	33.3
B	Soils on clay-rich, salt-affected alluvial material (Limon and Heldt Series)	17.9	26.5	23.9	18.6	30.2
D	Soils on Weathered Shales (with active erosional removal) (Midway – shale complex; Shingle series)	10.4	17.0	15.3	11.9	51.3

Figure 1: Fall 2013 S1 SDS Pueblo Co. Restoration Cover Levels vs. 2014 Standards

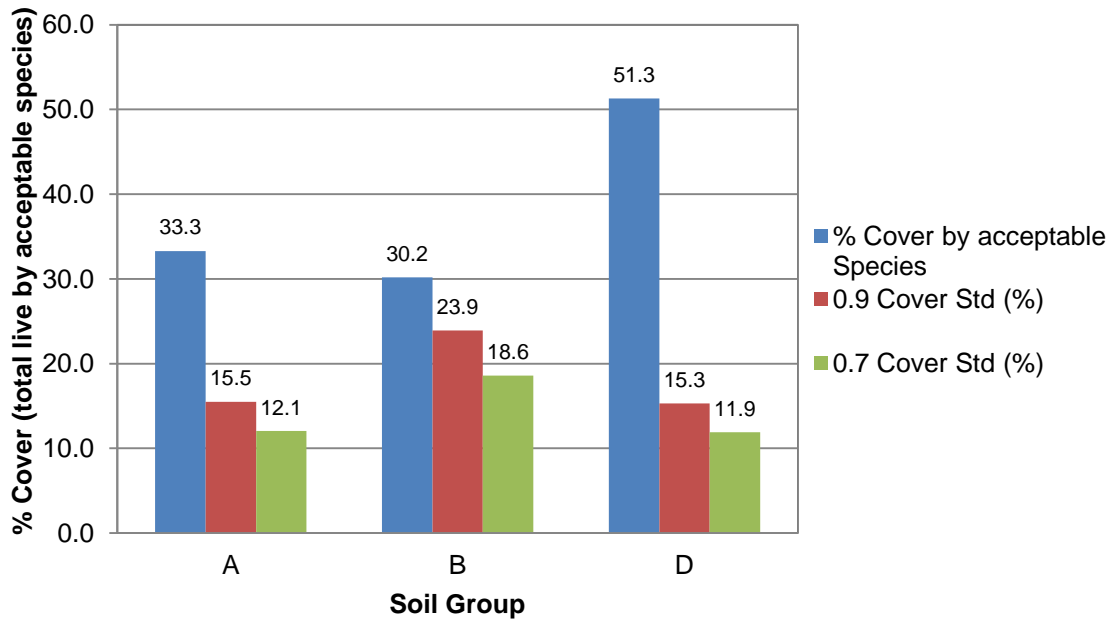


Figure 2: Fall 2013 S1 SDS Pueblo Co. Restoration Presence of Acceptable Species vs. 2014 Standards

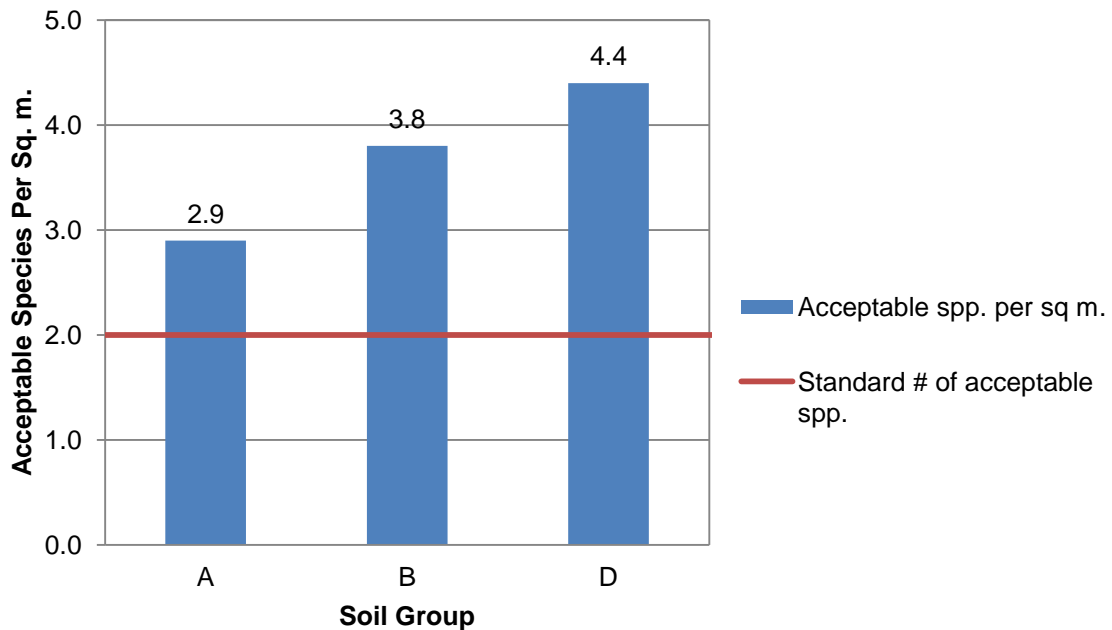


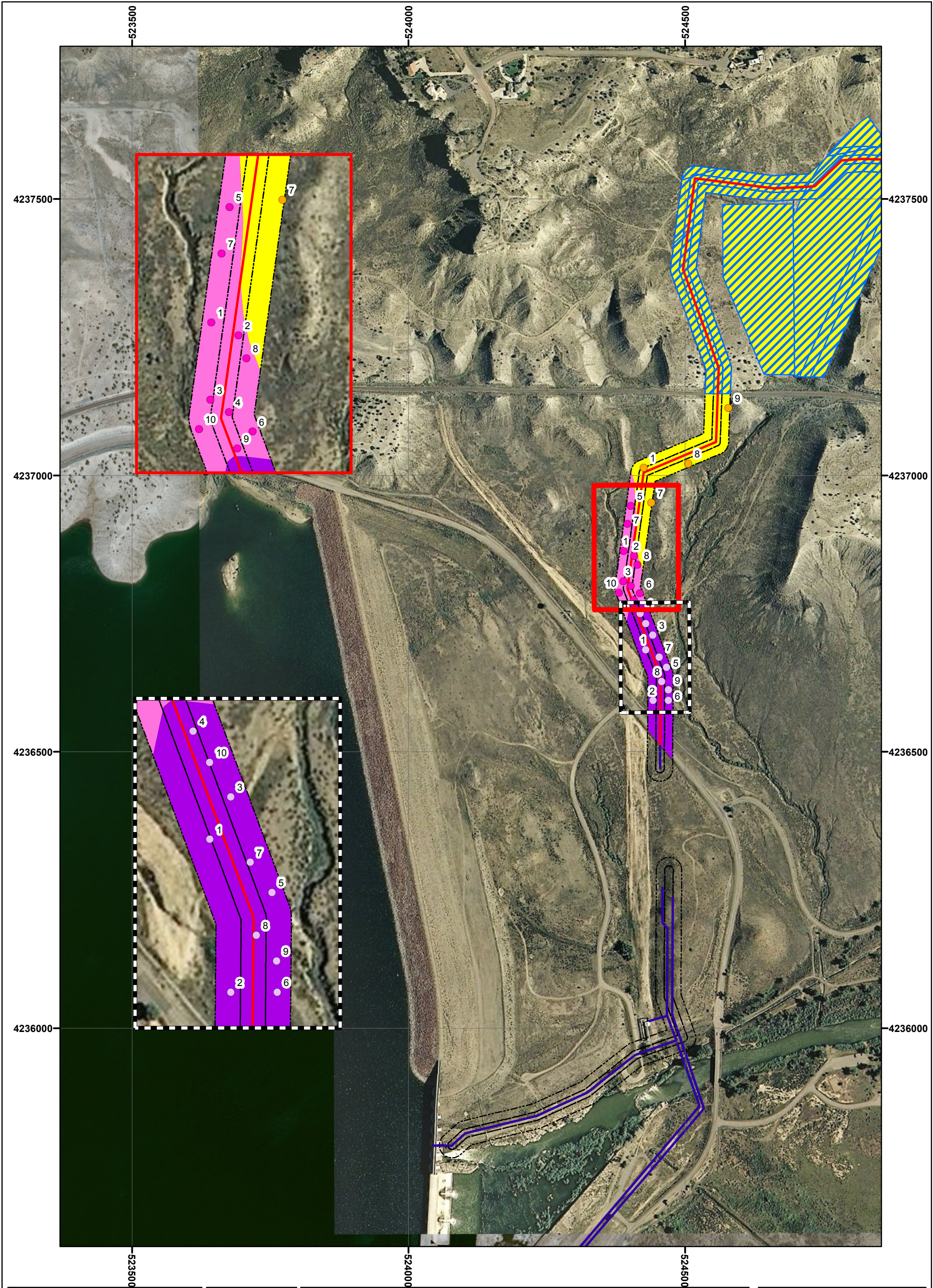
Figure 2 (above) displays the number of acceptable species present on each soil type in S1 compared to the pre-established standard of 2 species per square meter. In all soil groups, the number of acceptable species present surpassed the standard.

Discussion

Post-Construction Revegetation Performance

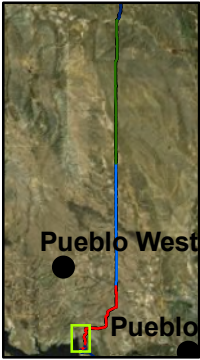
Vegetation cover by acceptable species in all soil groups in S1 sampled in 2013 surpassed both the Pueblo County 1041 permit standards and the CDPHE Stormwater Regulation standards. All areas of S1 sampled in 2013 surpassed the criterion of 2 acceptable species per square meter in the developing reconstructed vegetation (Figure 2). This supports a conclusion that all areas of the S1 work package have reached the pre-determined acceptable levels of post-construction vegetation cover as of the end of the first growing season. It should be noted that the 90% revegetation cover performance standards set forth in the Pueblo County 1041 permit are applicable over a two-year period. The fact that S1 measurements presented here, taken at the end of the first growing season (September 2013), have already exceeded the 90% standard values suggests that revegetation and post-construction species composition development are moving in the right direction.

Appendix A: Maps – Work Package S1



Map1. S1-1
2013 Cover Sampling
Monitoring Locations
S1 (Raw Water PC)
4.25 miles
Colorado Springs Utilities
Southern Delivery Systems

GRID: UTM NAD 83 z 13N



Soil Type A Sample Locations (n=10)

Soil Type B Sample Locations (n=10)

Soil Type D Sample Locations (n=10)

Pipeline Sections

- Areas Not Sampled
- S1
- S2
- S3
- Areas Not Irrigated
- SDS Easement

Soils Groups

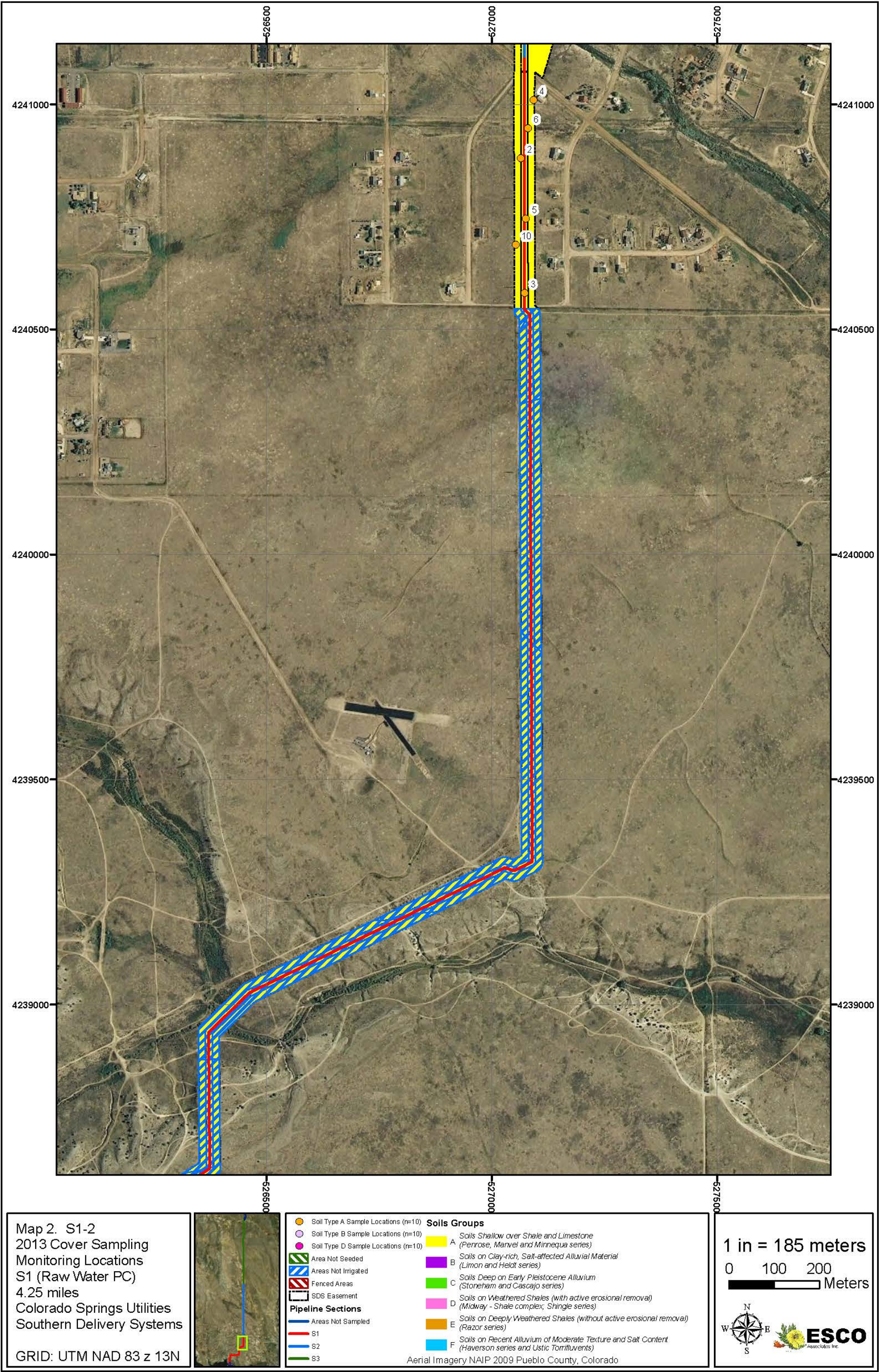
- A** Soils Shallow over Shale and Limestone (Penrose, Marvel and Minnequa series)
- B** Soils on Clay-rich, Salt-affected Alluvial Material (Limon and Heldt series)
- C** Soils Deep on Early Pleistocene Alluvium (Stoneham and Cascajo series)
- D** Soils on Weathered Shales (with active erosional removal) (Midway - Shale complex; Shingle series)
- E** Soils on Deeply Weathered Shales (without active erosional removal) (Razor series)
- F** Soils on Recent Alluvium of Moderate Texture and Salt Content (Haverson series and Ustic Torrifluvents)

Aerial Imagery NAIP 2009 Pueblo County, Colorado

1 in = 160 meters

0 80 160

Meters



Appendix B: Tabular Data – Work Package S1

Table 1: Work Package S1 on Penrose, Manvel and Minnequa Series Soils (Soil Group A)

PLANT SPECIES	FIRST HIT		ALL HIT		Percent Foliar Cover*											
	FIRST HIT		RELATIVE	ALL HIT	RELATIVE											
	AVERAGE		VEGETATION	AVERAGE	VEGETATION											
	COVER ^a	FREQUENCY ^b	COVER ^c	COVER ^d	COVER ^e	---Sample Number---										
	(%)	(%)	(%)	(%)	(%)	1	2	3	4	5	6	7	8	9	10	
NATIVE ANNUAL & BIENNIAL FORBS																
Amaranthus albus	0.00	10.00	0.00	0.00	0.00							P				
Ambrosia artemisiifolia var. elatior	0.00	30.00	0.00	0.00	0.00			P		P					P	
Chamaesyce sp.	0.60	80.00	1.28	0.70	1.30	1	P	3	P	2(1)	P			P	P	
Dyssodia aurea	0.60	40.00	1.28	0.60	1.12			1	P	3					2	
Dyssodia papposa	0.10	30.00	0.21	0.10	0.19		P		1		P					
Helianthus annuus	0.90	70.00	1.92	0.90	1.68	3	2	P				3	P	1	P	
Poinsettia dentata	0.00	20.00	0.00	0.00	0.00	P						P				
Polanisia dodecandra	0.00	10.00	0.00	0.00	0.00									P		
Solanum rostratum	0.20	90.00	0.43	0.40	0.74	1(1)	P	P	P	P	P	1(1)	P		P	
Solanum triflorum	0.10	20.00	0.21	0.10	0.19							P	1			
TOTAL NATIVE ANN. & BIEN. FORBS	2.5	100.0	5.3	2.8	5.2	5(1)	2	4	1	5(1)	P	4(1)	1	1	2	
INTRODUCED ANNUAL & BIENNIAL FORBS																
Amaranthus retroflexus	0.10	40.00	0.21	0.10	0.19			P	P		P		1			
Bassia sieversiana	7.70	70.00	16.45	8.60	16.01		10(1)	3	30(5)	8(1)	23(1)		P		3(1)	
Erodium cicutarium	0.00	10.00	0.00	0.00	0.00	P										
Lactuca serriola	0.00	20.00	0.00	0.00	0.00		P		P							
Salsola australis	6.30	100.00	13.46	6.70	12.48	8	9(1)	11	8	4	8(3)	1	2	1	11	
Salsola collina	1.20	10.00	2.56	1.40	2.61				12(2)							
Tribulus terrestris	0.00	20.00	0.00	0.00	0.00	P						P				
TOTAL INTRO. ANN. & BIEN. FORBS	15.3	100.0	32.7	16.8	31.3	8	19(2)	14	50(7)	12(1)	31(4)	1	3	1	14(1)	
NATIVE ANNUAL GRASSES																
Panicum capillare	0.10	30.00	0.21	0.10	0.19				P		1	P				
TOTAL NATIVE ANN. GRASSES	0.1	30.0	0.2	0.1	0.2	---	---	---	P	---	1	P	---	---	---	
INTRODUCED ANNUAL GRASSES																
Bromus tectorum	0.00	10.00	0.00	0.00	0.00			P								
Digitaria sanguinalis	0.10	60.00	0.21	0.10	0.19	P			1	P	P			P	P	
Eragrostis cilianensis	0.00	20.00	0.00	0.00	0.00				P		P					
Sorghum halepense	0.10	20.00	0.21	0.10	0.19	1							P			
Triticum aestivum	10.20	50.00	21.79	10.30	19.18		39		17(1)	4	38				4	
TOTAL INTRO. ANN. GRASSES	10.4	90.0	22.2	10.5	19.6	1	39	P	18(1)	4	38	---	P	P	4	
NATIVE PERENNIAL FORBS																
			FIRST HIT		ALL HIT											

FIRST HITALL HIT

PLANT SPECIES	FIRST HIT	RELATIVE		ALL HIT	RELATIVE	Percent Foliar Cover*									
	AVERAGE		VEGETATION	AVERAGE	VEGETATION										
	COVER ^a	FREQUENCY ^b	COVER ^c	COVER ^d	COVER ^e	---Sample Number---									
	(%)	(%)	(%)	(%)	(%)	1	2	3	4	5	6	7	8	9	10
Glandularia bipinnatifida	0.30	60.00	0.64	0.30	0.56		3	P	P	P	P				P
Asclepias speciosa	0.00	10.00	0.00	0.00	0.00					P					
Hedeoma drummondii	0.00	10.00	0.00	0.00	0.00				P						
Quincula lobata	0.10	30.00	0.21	0.10	0.19	1						P	P		
Solanum elaeagnifolium	0.00	10.00	0.00	0.00	0.00									P	
Sphaeralcea angustifolia	0.00	10.00	0.00	0.00	0.00							P			
Zinnia grandiflora	0.00	10.00	0.00	0.00	0.00										P
TOTAL NATIVE PERENNIAL FORBS	0.4	100.0	0.9	0.4	0.7	1	3	P	P	P	P	P	P	P	P
INTRODUCED PERENNIAL FORBS															
Convolvulus arvensis	0.10	50.00	0.21	0.10	0.19		P		1	P	P				P
Daucus carota	0.00	10.00	0.00	0.00	0.00							P			
Medicago sativa	0.20	10.00	0.43	0.30	0.56							2(1)			
Rumex crispus	0.00	30.00	0.00	0.00	0.00		P		P		P				
Taraxacum officinale	0.00	30.00	0.00	0.10	0.19				P		(1)				P
TOTAL INTRO. PERENNIAL FORBS	0.3	70.0	0.6	0.5	0.9	---	P	---	1	P	(1)	2(1)	---	P	P
NATIVE PERENNIAL GRASSES (cool)															
Pascopyrum smithii	8.40	100.00	17.95	11.10	20.67	6(3)	3(2)	3(1)	2(5)	4(2)	4(5)	25(5)	25(2)	11(1)	1(1)
TOTAL NATIVE PERENNIAL GRASSES (c)	8.4	100.0	17.9	11.1	20.7	6(3)	3(2)	3(1)	2(5)	4(2)	4(5)	25(5)	25(2)	11(1)	1(1)
INTRODUCED PERENNIAL GRASSES (cool)															
Echinochloa crus-galli	0.00	30.00	0.00	0.00	0.00					P		P			P
Eragrostis sp.	0.10	20.00	0.21	0.10	0.19		1				P				
Setaria viridis	0.30	30.00	0.64	0.30	0.56	1						P	2		
TOTAL INTRO. PERENNIAL GRASSES (c)	0.4	70.0	0.9	0.4	0.7	1	1	---	---	P	P	P	2	P	---
NATIVE PERENNIAL GRASSES (warm)															
Bouteloua curtipendula	0.10	60.00	0.21	0.20	0.37		(1)	P	1		P				P
Chondrosum gracile	2.40	90.00	5.13	3.10	5.77	5	P	P	1(3)	2	1(1)	2(2)	6(1)	7	
Muhlenbergia wrightii	0.10	40.00	0.21	0.10	0.19		P	P	P		1				
Pleuraphis jamesii	1.10	30.00	2.35	1.10	2.05			P						10	1
Sporobolus airoides	3.60	70.00	7.69	3.80	7.08	6	2		(1)		3	11(1)	6	8	
Sporobolus cryptandrus	1.50	70.00	3.21	2.10	3.91	6(1)		1(1)		2(3)		4	P	1	1(1)
TOTAL NATIVE PERENNIAL GRASSES (w)	8.8	100.0	18.8	10.4	19.4	17(1)	2(1)	1(1)	2(4)	4(3)	5(1)	17(3)	12(1)	26	2(1)
NATIVE SUBSHRUBS															
Ambrosia linearis	0.10	20.00	0.21	0.10	0.19								1		P
Atriplex confertifolia	0.00	30.00	0.00	0.10	0.19				P		(1)				P
TOTAL NATIVE SUBSHRUBS	0.1	40.0	0.2	0.2	0.4	---	---	---	P	---	(1)	---	1	P	---

FIRST HIT

ALL HIT

PLANT SPECIES	FIRST HIT		RELATIVE	ALL HIT	RELATIVE	Percent Foliar Cover*									
	AVERAGE	FREQUENCY ^b	VEGETATION	AVERAGE	VEGETATION										
	COVER ^a		COVER ^c	COVER ^d	COVER ^e	---Sample Number---									
	(%)	(%)	(%)	(%)	(%)	1	2	3	4	5	6	7	8	9	10
NATIVE SHRUBS															
Atriplex canescens	0.10	70.00	0.21	0.50	0.93		(1)	P	1(1)	P	(2)	P			P
TOTAL NATIVE SHRUBS	0.1	70.0	0.2	0.5	0.9	---	(1)	P	1(1)	P	(2)	P	---	---	P
NATIVE TREES															
Populus sp.	0.00	50.00	0.00	0.00	0.00	P	P					P	P		P
TOTAL NATIVE TREES	0.0	50.0	0.0	0.0	0.0	P	P	---	---	---	---	P	P	---	P
Standing dead	11.50	30.00		11.50				41		38					36
Litter	19.80	100.00		19.80		13	25	26	8	27	15	12	39	8	25
Bare soil	21.20	100.00		21.20		48	5	11	14	5	5	39	17	52	16
Rock	0.70	50.00		0.70			1		3	1	1			1	
TOTALS	100.0			106.9		100	100	100	100	100	100	100	100	100	100
TOTAL VEGETATION COVER	46.8 (s=21.0)		100.0	53.7 (s=25.5)	100.0	39(5)	69(6)	22(2)	75(18)	29(7)	79(14)	49(10)	44(3)	39(1)	23(3)
GROUND COVER (Litter+Rock+Veg+St. Dead)	78.8			85.7		52(5)	95(6)	89(2)	86(18)	95(7)	95(14)	61(10)	83(3)	48(1)	84(3)
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 18.4 Std.Dev.= 3.1)						16	19	17	25	16	22	20	15	17	17

^a First Hit Cover = Absolute percent cover in vertical view with no account of plants obscured by first (i.e. top) hit.

^b Frequency = Percent of the samples in which a species or lifeform occurred

^c First Hit Relative Cover = Percent of the First Hit vegetation cover comprised of this species or lifeform

^d All Hit Cover = Absolute percent cover in vertical view accounting for all cover by the species or lifeform, whether over-arched by other plants or not

^e All Hit Relative Cover = Percent of the All Hit vegetation cover comprised of the species or lifeform

***P=Present within 1m. on either side of cover transect, but not quantitatively encountered.**
()=Data in parentheses represent other hits that are used in conjunction with first hits for all hit cover statistics.

Table 2: Work Package S1 on Limon and Heldt Series (Soil Group B)

PLANT SPECIES	FIRST HIT		FIRST HIT	ALL HIT		Percent Foliar Cover*									
	AVERAGE		RELATIVE	AVERAGE	RELATIVE										
	COVER ^a	FREQUENCY ^b	VEGETATION	COVER ^d	VEGETATION	---Sample Number---									
	(%)	(%)	COVER ^c	(%)	COVER ^e	1	2	3	4	5	6	7	8	9	10
NATIVE ANNUAL & BIENNIAL FORBS															
Amaranthus albus	0.00	10.00	0.00	0.00	0.00						P				
Chamaesyce sp.	0.20	90.00	0.41	0.20	0.39	P	1	1	P		P	P	P	P	P
Descurainia pinnata	0.10	30.00	0.21	0.10	0.20	P		P	1						
Dyssodia aurea	0.20	40.00	0.41	0.20	0.39		P	2		P			P		
Erigeron strigosus	0.00	10.00	0.00	0.00	0.00			P							
Helianthus annuus	2.90	90.00	5.99	3.00	5.86	2	9	3(1)	4		1	1	1	P	8
Mentzlia multiflora	0.10	60.00	0.21	0.20	0.39	P	P					P	P	1	(1)
Polygonum douglasii	0.00	10.00	0.00	0.00	0.00									P	
Solanum rostratum	0.40	100.00	0.83	0.40	0.78	1	1	P	P	1	P	P	1	P	P
Ximenesia encelioides	0.00	10.00	0.00	0.00	0.00										P
TOTAL NATIVE ANN. & BIEN. FORBS	3.9	100.0	8.1	4.1	8.0	3	11	6(1)	5	1	1	1	2	1	8(1)
INTRODUCED ANNUAL & BIENNIAL FORBS															
Amaranthus hybridus	0.00	50.00	0.00	0.00	0.00		P	P		P	P	P			
Bassia sieversiana	11.40	100.00	23.55	11.80	23.05	18(1)	5	11(1)	3	12	8	18(1)	20	11	8(1)
Carduus sp.	0.00	10.00	0.00	0.00	0.00				P						
Euphorbia davidii	0.00	30.00	0.00	0.00	0.00							P		P	P
Halogeton glomeratus	0.00	10.00	0.00	0.00	0.00			P							
Melilotus officinalis	1.30	100.00	2.69	1.50	2.93	2	P	1	5	P	P	3(1)	(1)	P	2
Salsola australis	0.80	70.00	1.65	0.80	1.56		1	1		1	P	2		1	2
Salsola collina	5.80	90.00	11.98	5.90	11.52	4(1)	6	6		23	1	6	6	1	5
Tribulus terrestris	0.00	20.00	0.00	0.00	0.00			P						P	
TOTAL INTRO. ANN. & BIEN. FORBS	19.3	100.0	39.9	20.0	39.1	24(2)	12	19(1)	8	36	9	29(2)	26(1)	13	17(1)
NATIVE ANNUAL GRASSES															
Panicum capillare	1.40	90.00	2.89	1.40	2.73	2	2	1		3	4	P	1	P	1
TOTAL NATIVE ANN. GRASSES	1.4	90.0	2.9	1.4	2.7	2	2	1	---	3	4	P	1	P	1
INTRODUCED ANNUAL GRASSES															
Bromus tectorum	0.60	50.00	1.24	0.60	1.17		P	P			3		P	3	
Eragrostis cilianensis	0.00	20.00	0.00	0.00	0.00			P		P					
Sorghum halepense	0.00	10.00	0.00	0.00	0.00								P		
Triticum aestivum	0.20	30.00	0.41	0.20	0.39		P	1					1		
TOTAL INTRO. ANN. GRASSES	0.8	60.0	1.7	0.8	1.6	---	P	1	---	P	3	---	1	3	---
NATIVE PERENNIAL FORBS															

PLANT SPECIES	FIRST HIT		FIRST HIT	ALL HIT		Percent Foliar Cover*									
	AVERAGE		RELATIVE	AVERAGE											
	COVER ^a	FREQUENCY ^b	COVER ^c	COVER ^d	COVER ^e	---Sample Number---									
	(%)	(%)	(%)	(%)	(%)	1	2	3	4	5	6	7	8	9	10
Glandularia bipinnatifida	0.20	70.00	0.41	0.20	0.39	P	P	P	P		P		1	1	
Astragalus agrestis	0.00	20.00	0.00	0.00	0.00				P						P
Hedeoma drummondii	0.00	10.00	0.00	0.00	0.00								P		
Lomatium foeniculaceum	0.10	40.00	0.21	0.10	0.20		1				P		P	P	
Oligosporus dracunculus ssp. glaucus	0.00	10.00	0.00	0.00	0.00						P				
Quincula lobata	0.60	100.00	1.24	0.90	1.76	P	P	1	2	1(1)	P	1	(2)	P	1
Solidago sp.	0.00	40.00	0.00	0.00	0.00		P				P		P	P	
Sphaeralcea angustifolia	0.90	100.00	1.86	0.90	1.76	P	P	P	2	2	1	1	P	P	3
Sphaeralcea coccinea	0.00	10.00	0.00	0.00	0.00					P					
Vicia americana	0.00	10.00	0.00	0.00	0.00						P				
TOTAL NATIVE PERENNIAL FORBS	1.8	100.0	3.7	2.1	4.1	P	1	1	4	3(1)	1	2	1(2)	1	4
INTRODUCED PERENNIAL FORBS															
Rumex crispus	0.00	10.00	0.00	0.00	0.00					P					
Taraxacum officinale	0.00	20.00	0.00	0.00	0.00		P				P				
TOTAL INTRO. PERENNIAL FORBS	0.0	30.0	0.0	0.0	0.0	---	P	---	---	P	P	---	---	---	---
NATIVE PERENNIAL GRASSES (cool)															
Elymus trachycaulus	3.00	100.00	6.20	3.10	6.05	1	P	5	7(1)	1	4	2	6	4	P
Pascopyrum smithii	4.10	100.00	8.47	4.40	8.59	7	2	4(2)	3	2	8(1)	1	4	8	2
TOTAL NATIVE PERENNIAL GRASSES (c)	7.1	100.0	14.7	7.5	14.6	8	2	9(2)	10(1)	3	12(1)	3	10	12	2
INTRODUCED PERENNIAL GRASSES (cool)															
Echinochloa crus-galli	0.10	40.00	0.21	0.10	0.20			P	P			P			1
Setaria viridis	0.10	20.00	0.21	0.10	0.20		1				P				
Thinopyrum intermedium	0.10	10.00	0.21	0.10	0.20							1			
TOTAL INTRO. PERENNIAL GRASSES (c)	0.3	60.0	0.6	0.3	0.6	---	1	P	P	---	P	1	---	---	1
NATIVE PERENNIAL GRASSES (warm)															
Chondrosum gracile	8.00	100.00	16.53	8.80	17.19	7	9(1)	8(2)	11(1)	7(1)	10	9(1)	7(1)	10	2(1)
Muhlenbergia arenicola	0.10	10.00	0.21	0.10	0.20										1
Pleuraphis jamesii	0.40	30.00	0.83	0.40	0.78		1				1			2	
Sporobolus airoides	3.80	100.00	7.85	4.00	7.81	4(1)	5	4	3	3(1)	5	4	5	P	5
Sporobolus cryptandrus	1.50	80.00	3.10	1.70	3.32		6	P	P	3(1)	1	3(1)	P		2
TOTAL NATIVE PERENNIAL GRASSES (w)	13.8	100.0	28.5	15.0	29.3	11(1)	21(1)	12(2)	14(1)	13(3)	17	16(2)	12(1)	12	10(1)
NATIVE SUBSHRUBS															
Gutierrezia sarothrae	0.00	10.00	0.00	0.00	0.00								P		
TOTAL NATIVE SUBSHRUBS	0.0	10.0	0.0	0.0	0.0	---	---	---	---	---	---	---	P	---	---

PLANT SPECIES	FIRST HIT		FIRST HIT	ALL HIT	ALL HIT	Percent Foliar Cover*									
	AVERAGE		RELATIVE	AVERAGE	RELATIVE										
	COVER ^a	FREQUENCY ^b	COVER ^c	COVER ^d	COVER ^e	---Sample Number---									
	(%)	(%)	(%)	(%)	(%)	1	2	3	4	5	6	7	8	9	10
INTRODUCED SUBSHRUBS															
Lespedeza cuneata	0.00	10.00	0.00	0.00	0.00				P						
TOTAL INTRODUCED SUBSHRUBS	0.0	10.0	0.0	0.0	0.0	---	---	---	P	---	---	---	---	---	---
NATIVE SHRUBS															
Atriplex canescens	0.00	80.00	0.00	0.00	0.00		P	P	P	P	P		P	P	P
TOTAL NATIVE SHRUBS	0.0	80.0	0.0	0.0	0.0	---	P	P	P	P	P	---	P	P	P
NATIVE TREES															
Populus sp.	0.00	60.00	0.00	0.00	0.00		P	P	P		P		P	P	
TOTAL NATIVE TREES	0.0	60.0	0.0	0.0	0.0	---	P	P	P	---	P	---	P	P	---
Standing dead	0.30	20.00		0.30						2		1			
Litter	11.40	100.00		11.40		11	15	11	11	4	11	10	10	12	19
Bare soil	39.30	100.00		39.30		38	35	40	47	35	42	36	37	45	38
Rock	0.60	40.00		0.60		3			1			1		1	
TOTALS	100.0			102.8		100	100	100	100	100	100	100	100	100	100
TOTAL VEGETATION COVER	48.4 (s=5.5)		100.0	51.2 (s=6.7)	100.0	48(3)	50(1)	49(6)	41(2)	59(4)	47(1)	52(4)	53(4)	42	43(3)
GROUND COVER (Litter+Rock+Veg+St.Dead)	60.7			63.5		62(3)	65(1)	60(6)	53(2)	65(4)	58(1)	64(4)	63(4)	55	62(3)
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 23.2 Std.Dev.= 4.4)						16	28	28	20	19	28	20	26	25	22

^a First Hit Cover = Absolute percent cover in vertical view with no account of plants obscured by first (i.e. top) hit.

^b Frequency = Percent of the samples in which a species or lifeform occurred

^c First Hit Relative Cover = Percent of the First Hit vegetation cover comprised of this species or lifeform

^d All Hit Cover = Absolute percent cover in vertical view accounting for all cover by the species or lifeform, whether over-arched by other plants or not

^e All Hit Relative Cover = Percent of the All Hit vegetation cover comprised of the species or lifeform

*P=Present within 1m. on either side of cover transect, but not quantitatively encountered.
 ()=Data in parentheses represent other hits that are used in conjunction with first hits for all hit cover statistics.

Table 3: Work Package S1 on Midway-Shale Complex; Shingle Series Soils (Soil Group D)

PLANT SPECIES	FIRST HIT		FIRST HIT	ALL HIT		Percent Foliar Cover*									
	AVERAGE		RELATIVE	AVERAGE											
	COVER ^a	FREQUENCY ^b	VEGETATION	COVER ^d	VEGETATION	---Sample Number---									
	(%)	(%)	COVER ^c	(%)	COVER ^e	1	2	3	4	5	6	7	8	9	10
NATIVE ANNUAL & BIENNIAL FORBS															
Amaranthus albus	0.10	20.00	0.16	0.10	0.15					1		P			
Ambrosia artemisiifolia var. elatior	0.00	30.00	0.00	0.00	0.00	P						P	P		
Chamaesyce sp.	0.30	90.00	0.49	0.30	0.44	P	P	P	P		P	P	P	3	P
Chenopodium fremontii	0.70	40.00	1.14	0.70	1.02		P		P		1	6			
Chenopodium pratericola	0.10	40.00	0.16	0.10	0.15		1	P			P				P
Helianthus annuus	5.60	90.00	9.14	5.60	8.20	8	7	2	3	18	5		4	8	1
Lepidium densiflorum	0.00	10.00	0.00	0.00	0.00								P		
Oonopsis foliosa	0.10	20.00	0.16	0.10	0.15									P	1
Poinsettia dentata	0.10	60.00	0.16	0.10	0.15	P	P		P	1		P			P
Solanum rostratum	1.30	100.00	2.12	1.30	1.90	P	P	1	1	6	P	P	2	1	2
Solanum triflorum	0.00	20.00	0.00	0.00	0.00					P		P			
Ximenesia encelioides	0.00	20.00	0.00	0.00	0.00								P	P	
TOTAL NATIVE ANN. & BIEN. FORBS	8.3	100.0	13.5	8.3	12.2	8	8	3	4	26	6	6	6	12	4
INTRODUCED ANNUAL & BIENNIAL FORBS															
Amaranthus hybridus	0.00	40.00	0.00	0.00	0.00			P	P					P	P
Amaranthus retroflexus	0.10	30.00	0.16	0.10	0.15	P					P	1			
Ambrosia trifida	0.20	20.00	0.33	0.20	0.29		1							1	
Bassia sieversiana	1.50	80.00	2.45	1.80	2.64		1	3(1)	2	P	4		P	1(1)	4(1)
Chenopodium album	0.10	40.00	0.16	0.10	0.15					1	P	P			P
Erodium cicutarium	0.00	20.00	0.00	0.00	0.00									P	P
Halogeton glomeratus	0.00	10.00	0.00	0.00	0.00			P							
Lactuca serriola	0.00	10.00	0.00	0.00	0.00									P	
Melilotus officinalis	0.80	60.00	1.31	1.00	1.46		P		P		P		P	7(2)	1
Salsola australis	6.60	100.00	10.77	6.90	10.10	3	19(1)	5	5	3	20(2)	1	3	2	5
Salsola collina	0.90	50.00	1.47	0.90	1.32		1				1		1	4	2
Tribulus terrestris	0.10	20.00	0.16	0.10	0.15							1	P		
Xanthium strumarium	0.00	10.00	0.00	0.00	0.00	P									
TOTAL INTRO. ANN. & BIEN. FORBS	10.3	100.0	16.8	11.1	16.3	3	22(1)	8(1)	7	4	25(2)	3	4	15(3)	12(1)
NATIVE ANNUAL GRASSES															
Panicum capillare	0.80	90.00	1.31	0.90	1.32	P	P	1	P		1	P	1	2(1)	3
Uknown aveneae	0.00	20.00	0.00	0.00	0.00			P	P						
TOTAL NATIVE ANN. GRASSES	0.8	90.0	1.3	0.9	1.3	P	P	1	P	---	1	P	1	2(1)	3
INTRODUCED ANNUAL GRASSES															
Bromus tectorum	0.60	10.00	0.98	0.60	0.88	6									

PLANT SPECIES	FIRST HIT		FIRST HIT	ALL HIT		Percent Foliar Cover*									
	AVERAGE		RELATIVE	AVERAGE											
	COVER ^a	FREQUENCY ^b	VEGETATION COVER ^c	COVER ^d	VEGETATION COVER ^e	---Sample Number---									
						1	2	3	4	5	6	7	8	9	10
Eragrostis pilosa	0.00	20.00	0.00	0.00	0.00		P							P	
Digitaria sanguinalis	0.00	30.00	0.00	0.00	0.00	P							P		P
Panicum dichotomiflorum	0.00	30.00	0.00	0.00	0.00		P						P	P	
Sorghum halepense	0.10	30.00	0.16	0.10	0.15				1					P	P
Triticum aestivum	0.10	50.00	0.16	0.20	0.29			P	1				P	(1)	P
TOTAL INTRO. ANN. GRASSES	0.8	70.0	1.3	0.9	1.3	6	P	P	2	---	---	---	P	(1)	P
NATIVE PERENNIAL FORBS															
Astragalus agrestis	0.40	30.00	0.65	0.40	0.59						P			4	P
Engelmannia peristenia	0.00	10.00	0.00	0.00	0.00									P	
Glandularia bipinnatifida	0.30	90.00	0.49	0.30	0.44	P	P	P	P		P	P	2	1	P
Oenothera sp.	0.00	20.00	0.00	0.00	0.00						P			P	
Oligosporus dracunculus ssp. glaucus	0.00	10.00	0.00	0.00	0.00									P	
Quincula lobata	2.70	100.00	4.40	3.10	4.54	1	2(1)	1	2	1	1	4	4	4	7(3)
Sphaeralcea angustifolia	0.50	100.00	0.82	0.80	1.17	P	P	P	P	(2)	1(1)	1	P	2	1
Sphaeralcea coccinea	0.00	10.00	0.00	0.00	0.00			P							
Tithymalus brachyceras	0.00	10.00	0.00	0.00	0.00										P
TOTAL NATIVE PERENNIAL FORBS	3.9	100.0	6.4	4.6	6.7	1	2(1)	1	2	1(2)	2(1)	5	6	11	8(3)
INTRODUCED PERENNIAL FORBS															
Daucus carota	0.00	30.00	0.00	0.00	0.00	P	P							P	
Medicago sativa	0.10	20.00	0.16	0.10	0.15	1						P			
TOTAL INTRO. PERENNIAL FORBS	0.1	40.0	0.2	0.1	0.1	1	P	---	---	---	---	P	---	P	---
NATIVE PERENNIAL GRASSES (cool)															
Elymus trachycaulus	0.00	10.00	0.00	0.00	0.00									P	
Pascopyrum smithii	16.30	100.00	26.59	19.50	28.55	15(2)	21(3)	13(3)	16(5)	16(13)	10	20(1)	19(1)	13	20(4)
TOTAL NATIVE PERENNIAL GRASSES (c)	16.3	100.0	26.6	19.5	28.6	15(2)	21(3)	13(3)	16(5)	16(13)	10	20(1)	19(1)	13	20(4)
INTRODUCED PERENNIAL GRASSES (cool)															
Echinochloa crus-galli	0.00	20.00	0.00	0.00	0.00	P						P			
Phleum pratense	0.00	40.00	0.00	0.00	0.00		P				P			P	P
Setaria viridis	0.20	50.00	0.33	0.20	0.29	P				1	P	1		P	
TOTAL INTRO. PERENNIAL GRASSES (c)	0.2	70.0	0.3	0.2	0.3	P	P	---	---	1	P	1	---	P	P
NATIVE PERENNIAL GRASSES (warm)															
Bouteloua curtipendula	0.10	10.00	0.16	0.10	0.15						1				
Chondrosum gracile	6.30	100.00	10.28	7.20	10.54	4(1)	13(1)	7	4	9(6)	2	5	11	P	8(1)
Muhlenbergia wrightii	0.00	10.00	0.00	0.00	0.00						P				
Pleuraphis jamesii	0.30	60.00	0.49	0.40	0.59		1		P		1(1)	1	P		P

PLANT SPECIES	FIRST HIT		FIRST HIT	ALL HIT	ALL HIT	Percent Foliar Cover*									
	AVERAGE		RELATIVE	AVERAGE	RELATIVE										
	COVER ^a	FREQUENCY ^b	COVER ^c	COVER ^d	COVER ^e	---Sample Number---									
	(%)	(%)	(%)	(%)	(%)	1	2	3	4	5	6	7	8	9	10
Sporobolus cryptandrus	5.30	100.00	8.65	5.60	8.20	7(1)	1	8	4	7(1)	7(1)	1	P	8	10
Sporobolus airoides	8.30	100.00	13.54	9.10	13.32	11(1)	9(2)	11	6	12(4)	P	17	11	P	6(1)
TOTAL NATIVE PERENNIAL GRASSES (w)	20.3	100.0	33.1	22.4	32.8	22(3)	24(3)	26	14	28(11)	11(2)	24	22	8	24(2)
NATIVE SHRUBS															
Atriplex canescens	0.30	60.00	0.49	0.30	0.44	P	P		3	P			P		P
TOTAL NATIVE SHRUBS	0.3	60.0	0.5	0.3	0.4	P	P	---	3	P	---	---	P	---	P
NATIVE TREES															
Populus sp.	0.00	50.00	0.00	0.00	0.00	P	P			P			P	P	
TOTAL NATIVE TREES	0.0	50.0	0.0	0.0	0.0	P	P	---	---	---	P	---	P	P	---
Standing dead	0.20	20.00		0.20		1	1								
Litter	12.10	100.00		12.10		10	11	18	14	4	16	3	10	15	20
Bare soil	25.60	100.00		25.60		33	9	29	38	19	29	38	30	22	9
Rock	0.80	50.00		0.80			2	1		1			2	2	
TOTALS	100.0			107.0		100	100	100	100	100	100	100	100	100	100
TOTAL VEGETATION COVER	61.3 (s=10.0)		100.0	68.3 (s=15.8)	100.0	56(5)	77(8)	52(4)	48(5)	76(26)	55(5)	59(1)	58(1)	61(5)	71(10)
GROUND COVER (Litter+Rock+Veg+St.Dead)	74.4			81.4		67(5)	91(8)	71(4)	62(5)	81(26)	71(5)	62(1)	70(1)	78(5)	91(10)
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 24.5 Std.Dev.= 5.1)						24	26	19	22	16	27	23	25	34	29

^a First Hit Cover = Absolute percent cover in vertical view with no account of plants obscured by first (i.e. top) hit.

^b Frequency = Percent of the samples in which a species or lifeform occurred

^c First Hit Relative Cover = Percent of the First Hit vegetation cover comprised of this species or lifeform

^d All Hit Cover = Absolute percent cover in vertical view accounting for all cover by the species or lifeform, whether over-arched by other plants or not

^e All Hit Relative Cover = Percent of the All Hit vegetation cover comprised of the species or lifeform

*P=Present within 1m. on either side of cover transect, but not quantitatively encountered.
 ()=Data in parentheses represent other hits that are used in conjunction with first hits for all hit cover statistics.

Appendix C: Site Photos – Work Package S1



Photograph 1. S1 on Penrose, Manvel and Minnequa series, Sample 1 - 2013



Photograph 2. S1 on Penrose, Manvel and Minnequa series, Sample 2 - 2013



Photograph 3. S1 on Penrose, Manvel and Minnequa series, Sample 3 - 2013



Photograph 4. S1 on Penrose, Manvel and Minnequa series, Sample 4 - 2013



Photograph 5. S1 on Penrose, Manvel and Minnequa series, Sample 5 - 2013



Photograph 6. S1 on Penrose, Manvel and Minnequa series, Sample 6 - 2013



Photograph 7. S1 on Penrose, Manvel and Minnequa series, Sample 7 - 2013



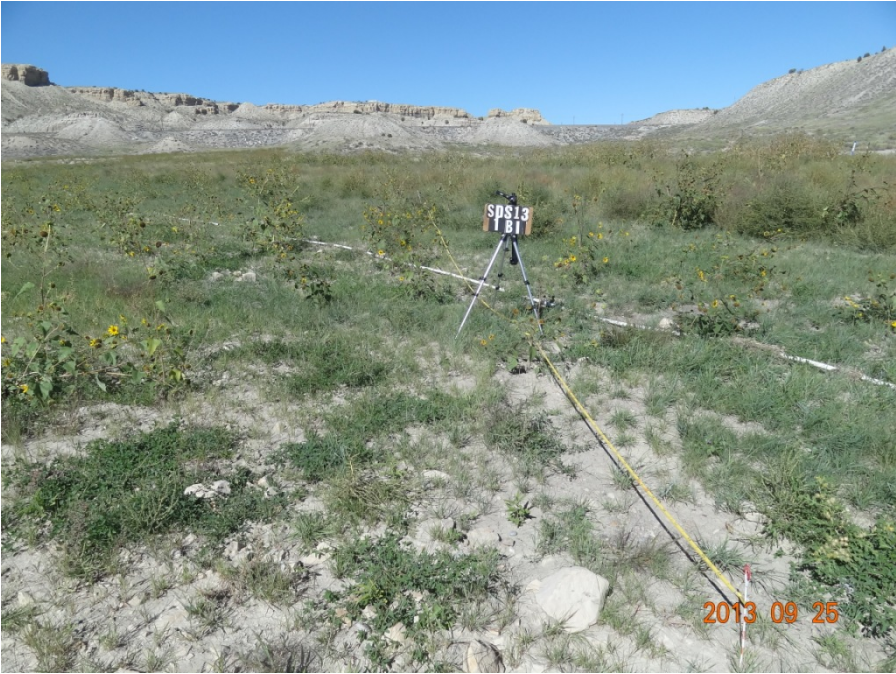
Photograph 8. S1 on Penrose, Manvel and Minnequa series, Sample 8 - 2013



Photograph 9. S1 on Penrose, Manvel and Minnequa series, Sample 9 - 2013



Photograph 10. S1 on Penrose, Manvel and Minnequa series, Sample 10 -2013



Photograph 11. S1 on Limon and Heldt series, Sample 1 - 2013



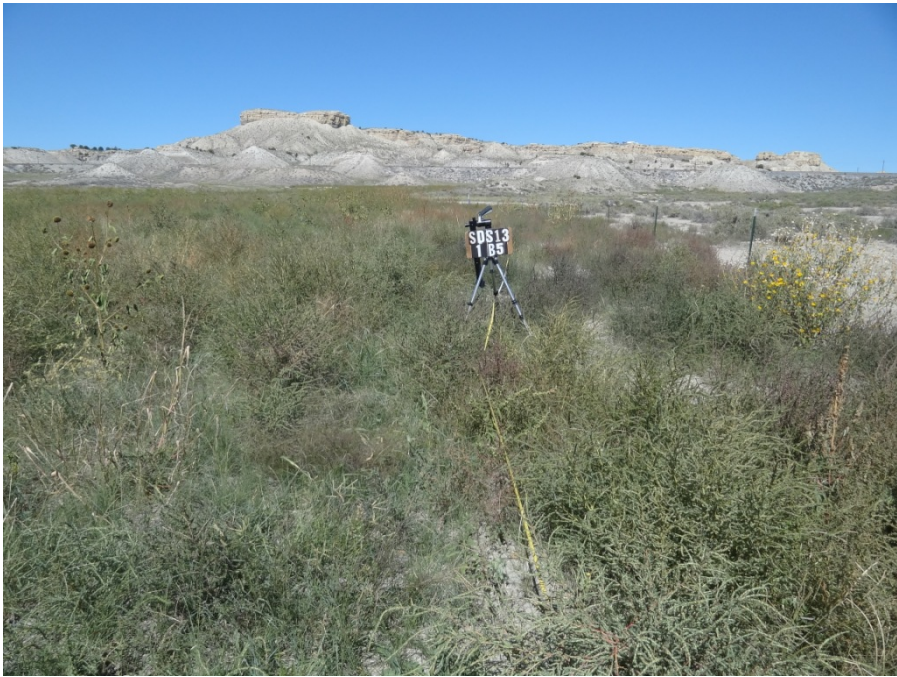
Photograph 12. S1 on Limon and Heldt series, Sample 2 - 2013



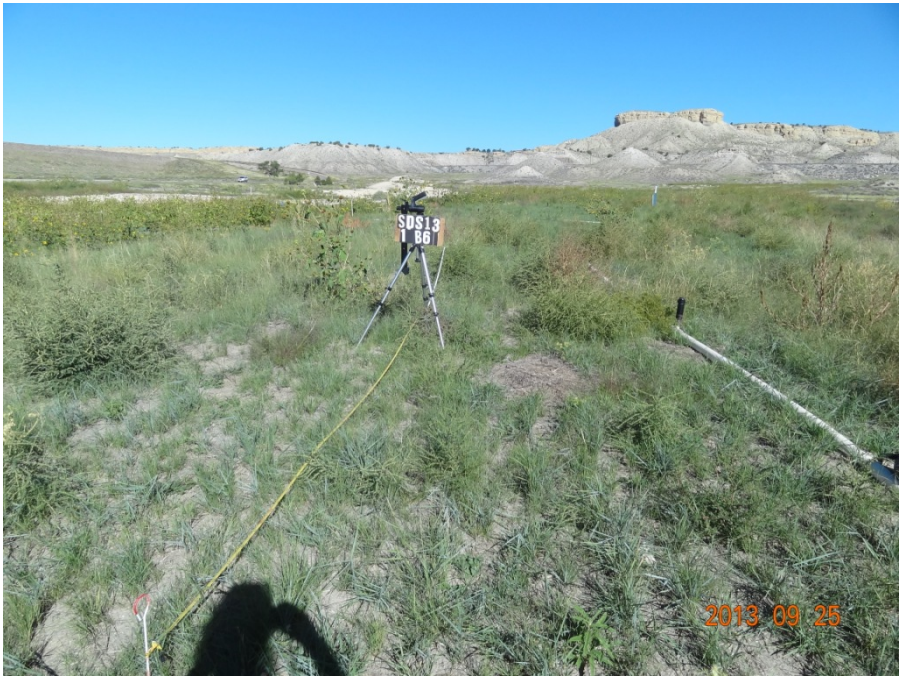
Photograph 13. S1 on Limon and Heldt series, Sample 3 - 2013



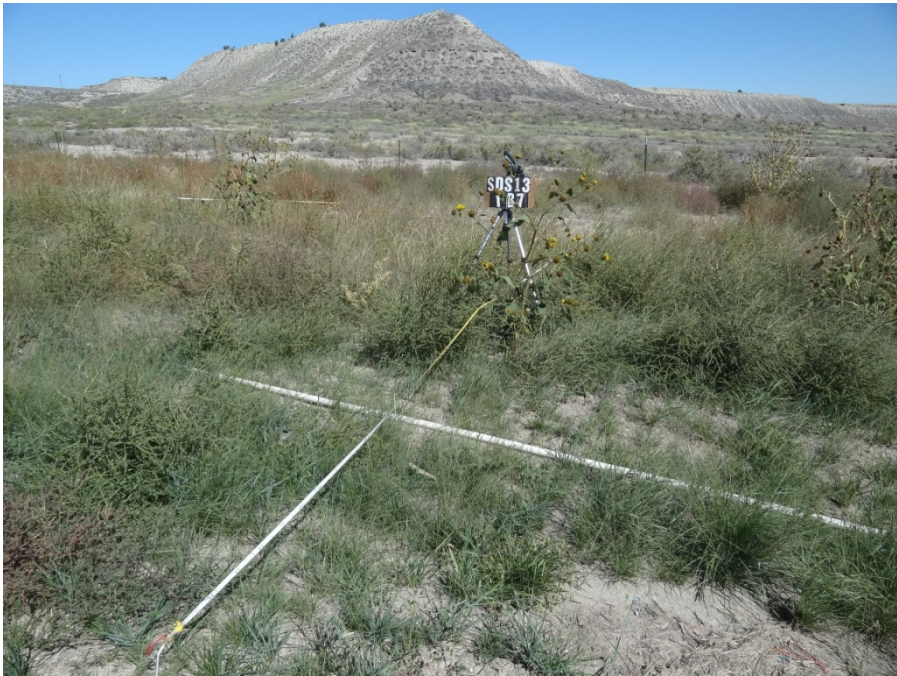
Photograph 14. S1 on Limon and Heldt series, Sample 4 - 2013



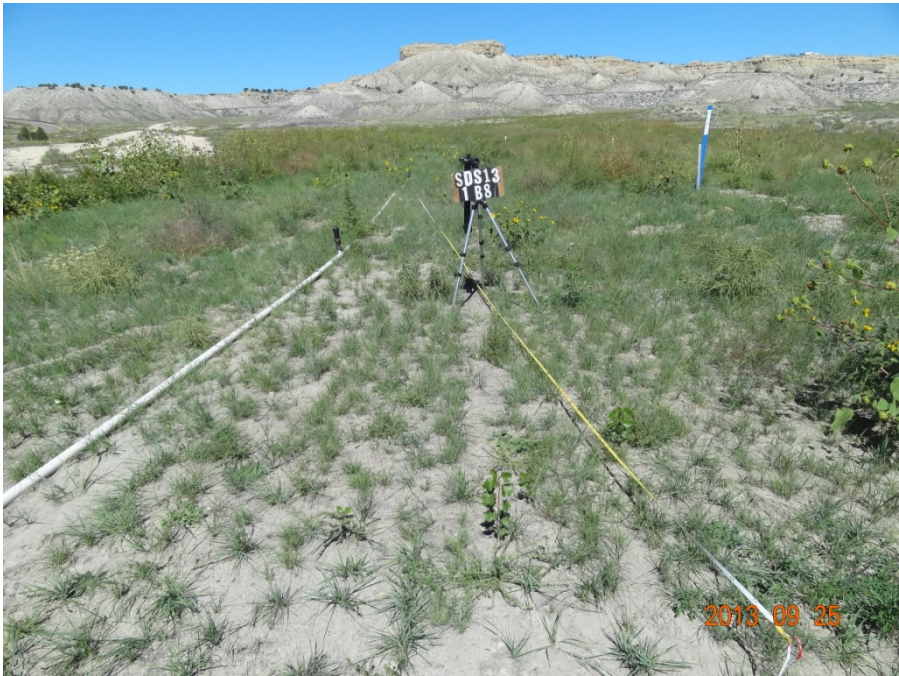
Photograph 15. S1 on Limon and Heldt series, Sample 5 - 2013



Photograph 16. S1 on Limon and Heldt series, Sample 6 - 2013



Photograph 17. S1 on Limon and Heldt series, Sample 7 - 2013



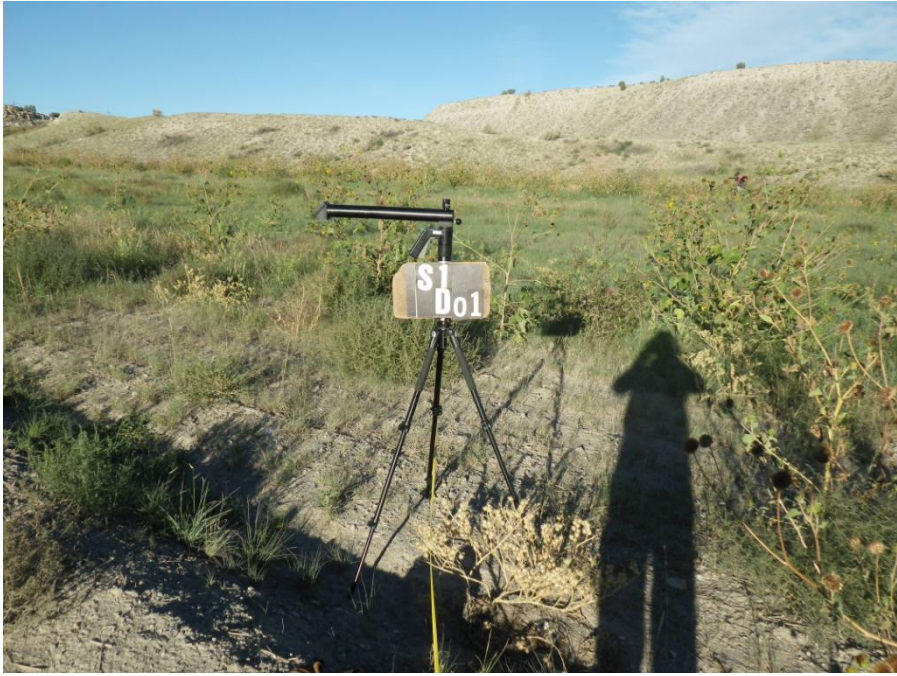
Photograph 18. S1 on Limon and Heldt series, Sample 8 - 2013



Photograph 19. S1 on Limon and Heldt series, Sample 9 - 2013



Photograph 20. S1 on Limon and Heldt series, Sample 10 - 2013



Photograph 21. S1 on Midway-Shale complex; Shingle series, Sample 1 - 2013



Photograph 22. S1 on Midway-Shale complex; Shingle series, Sample 2 - 2013



Photograph 23. S1 on Midway-Shale complex; Shingle series, Sample 3 - 2013



Photograph 24. S1 on Midway-Shale complex; Shingle series, Sample 4 - 2013



Photograph 25. S1 on Midway-Shale complex; Shingle series, Sample 5 - 2013



Photograph 26. S1 on Midway-Shale complex; Shingle series, Sample 6- 2013



Photograph 27. S1 on Midway-Shale complex; Shingle series, Sample 7 - 2013



Photograph 28. S1 on Midway-Shale complex; Shingle series, Sample 8 - 2013



Photograph 29. S1 on Midway-Shale complex; Shingle series, Sample 9 - 2013



Photograph 30. S1 on Midway-Shale complex; Shingle series, Sample10 – 2013

Appendix D: Established Vegetation Sampling Protocols

Technical Memo 1

Sampling Procedure for Point Intercept Cover and Seedling Density Data Collection

The following procedure establishes baseline levels of plant cover in areas affected by the Southern Delivery System Project and will be used to determine seedling density following revegetation.

Within an area that was disturbed, vegetation will be quantitatively sampled as described below to establish:

- 1) The percent cover by species as well as total vegetation cover and
- 2) Species richness

These data will provide a basis for assessment of the percent of vegetation cover re-established in post-revegetation evaluations.

Vegetation Unit Identification

As vegetation varies along the length of the proposed area of disturbance, variations in plant community at the “alliance” level of the US National Vegetation Classification system (FGDC 2008) will be documented. Association and alliance level classification is based on the premise that a vegetation type represents a group of stands that have similar plant composition and physiognomy enabling their recognition. Should such significant soil variation as might substantially affect plant cover growth potential be encountered within a single alliance in a particular reach, these will be subdivided and the number of sample measurements adjusted accordingly.

This mapping methodology addresses both the need to document natural variation in the pre-existing vegetation and the need to set plant cover standard levels consistent with the varying potentials of varying environments.

Sample Location

Samples will be placed in locations representative of the general vegetation type and condition.

Cover Sampling Methods

At each sample site, cover data will be collected using a point-intercept method in which data are tabulated as interceptions of a projected point with plant species, bare ground, litter, standing dead vegetation, or rock. The cover sampling points will be optically projected using a Cover-Point Optical Point Projection Device. Sampling will occur along 50 meter transects. At each meter from one to fifty along the transect, a point will be vertically projected from a location 50 centimeters (cm) to the left of the transect and a point will be vertically projected from a location 50 cm to the right of the transect (avoiding harm to vegetation along the tape itself). Thus, data from a total of 2 x 50, or 100 points will be recorded. Plant interceptions will be tallied by species upon interception of the projected point with any attached plant part

produced during the current growing season. "First hit" data (the first interception of any of the materials listed below) will be recorded. In addition to this, "additional hit" data (any additional live species intercepted between the first hit and the ground) will also be collected.

- Litter will be considered to be any organic material that had fallen, or had begun to fall to the soil surface.
- Standing dead vegetation will be any dead plant material that was produced in previous years but which was still standing and had not lodged or broken off to become litter.
- Rock will be considered to be any inorganic fragment with the largest diameter greater than or equal to 1 cm.
- Bare soil will be considered to be inorganic fragments with a diameter less than 1 cm largest diameter or organic debris too small to be of readily identifiable origin.

First hit interceptions will be used to calculate absolute top layer (first hit) foliar cover by dividing the number of interceptions for a particular species or material by the total number of points taken (100). First hit relative vegetation cover will be calculated by dividing first hit absolute cover for each species by the total first hit vegetation cover. All-layer absolute cover will be calculated by dividing all hits for particular species by the total number of points taken (100). In addition, all-layer relative cover will be calculated using all hits for particular species divided by the total vegetation hits accumulated during sampling of the transect.

Seedling Density Sampling (Post-Revegetation Analyses)

Seedlings of seeded or perennial plant species will be counted within randomly placed 0.5 square meters (5.37 square feet) circular plots. The results will be averaged and divided by 5.37 to obtain number of seedlings per square foot.

References

FGDC. 2008. Vegetation Classification Standard, Version 2. Federal Geographic Data Committee, Vegetation Subcommittee. FGDC Secretariat, U.S. Geological Survey. Reston, VA. FGDC-STD-005-2008 (Version 2). 62p. plus Appendices.

Technical Memo 3

Post-Revegetation Sampling

This Technical Memo describes the design and methodology CNHP will use to sample and quantitatively assess post-disturbance revegetation success. For the practicality of achieving an unbiased evaluation, the approach is based on random sampling and the use of resulting means to compare results to previously established performance standards. By the nature of plant growth in response to varying conditions along the length of the revegetated area, and by the nature of random sampling, variability in levels of plant abundance are to be expected both on the ground and in sample results. The use of 50 meter-long transects tends to encompass variability though a certain amount of variability can be expected at scales larger than this.

Creditable Vegetation Cover

Cover provided by plants included in the Colorado A-, B-, or C-list of noxious plant species, if any, will not be acceptable in the evaluation of cover. Cover by all other plants will be acceptable in assessment of adequate revegetation cover, except as follows: cover by non-native annual / biennial plants in excess of the relative cover by those plants in the pre-construction sample data will not be counted toward establishment of proof of successful revegetation (see below).

Maximum allowable relative cover by Introduced Annual and Biennial Species:

A. Soils Shallow over Shale and Limestone (Penrose, Manvel and Minnequa series; Tables 4, 7, and Samples 5, 7 and 8 of Table 8): **22.2 percent**

B. Soils on Clay-rich, Salt-affected Alluvial Material (Limon and Heldt series; Tables 1, 5, and 11): **2.6 percent**

C. Soils Deep on Early Pleistocene Alluvium (Stoneham and Cascajo series; Tables 10 and 15): **3.9 percent**

D. Soils on Weathered Shale (with active erosional removal) (Midway – Shale complex; Shingle series; Tables 9 and 13): **1.3 percent**

E. Soils on Deeply Weathered Shale (without active erosional removal) (Razor series; Table 14): **3.6 percent**

F. Soils on Recent Alluvium of Moderate Texture and Salt Content (Haverson series and Ustic Torrifluvents; Table 6 and 16): **16.7 percent**

Cover Sampling Method

Sampling to assess compliance with the standard of 90 percent of pre-existing cover will proceed separately within each work package (S1, S2 and S3) and separately within each soil functional group as identified during the pre-construction vegetation survey (see Technical Memo 2). All sample locations will be randomly located by delineating the soil functional groups in each work package in ESRI ArcMap GIS application and using the random point generation tool to place the correct number of random points in that area.

For sample units with a total (cumulative) length of one mile or less, ten (10) segments of equal length will be established and a randomly located and oriented sample placed in each. For units greater than one mile in cumulative length, fifteen (15) segments of equal length will be identified and a sample randomly located within each. Sample points will be located in the field using hand-held GPS units with coordinates of the random points pre-loaded.

In areas with total Soil Group length less than 0.1 mile, three (3) to five (5) samples will be made. Professional judgment will be used in these small sample areas (e.g. Soil Groups B and F in S3) to determine the location and number of samples collected.

Orientation of the 50-meter transect will be randomly selected by using a random number ranging from 1 to 360 as an azimuth. Sampling transects will not extend outside the Permanent Easement (PE), Temporary Construction Easement (TCE) or work limits areas. Should a boundary be encountered, a new orientation that remains within these limits will be chosen in the same manner. Ineligible sites (see below) will be excluded from sampling.

Sampling to assess compliance with the CDPHE criterion of 70 percent of pre-existing cover will proceed within separate work packages and soil reaches. If the 70 percent cover standard alone is being assessed, the sample intensity will be five (5) samples in reaches of one mile or less in cumulative length and eight (8) samples in those greater than one mile in cumulative length. Professional judgment will be used in small sample areas (e.g. Soil Groups B and F in S3) to determine the location and number of samples collected.

Informational Cover Composition Sampling Method

Data on species composition will be collected for informational purposes outside the scope of the 1041 permit requirements. Ten (10) 1 x1 meter plots will be placed at 5-meter intervals along the right side of the cover sampling transect (as viewed from the origin) beginning at the 5-meter mark. Within each of the resulting ten plots the presence of desirable species will be noted by species. For this purpose, desirable species will mean any seeded species plus any other native annual, biennial, or perennial species plus any non-native perennial species. Native will mean species noted as native in and occurring in the Southeast ¼ of Colorado in Biota of North America Project distribution mapping. The resulting frequency data will be tabulated by species. For example, if Species A is noted as present in 7 of the 10 plots it will have a frequency value of 70 percent.

Frequency values from all transects within a given soil group will then be averaged. For these evaluations, average frequency values by species will be used as follows: The average frequencies of all acceptable species will be summed. A sum for all desirable species present that equals or exceeds 200 percent will be deemed adequate evidence of successful establishment of acceptable species. This supplemental criterion addresses the reality that vegetation at the time of evaluation will still be juvenile. Many planted or otherwise desirable species grow slowly and though they may be only a small percentage of the total plant cover at the time of measurement, will eventually become more abundant. This frequency evaluation allows documentation of the presence of the desirable species sought in the long term vegetation cover.

Seedling Density

Seedlings of seeded or perennial plant species will be counted within randomly placed 0.5 square meter (5.37 square foot) circular plots. The results will be averaged and divided by 5.37 to obtain number of seedlings per square foot.

Plots will be thirty per Work Package/Soil Group area. All sample points will be randomly located via GIS-generated coordinates.

Sites Ineligible for Sampling

Areas within the revegetation zone in which the vegetation cover has been negatively affected by land management of private owners after SDS construction or for which a waiver has been executed/granted will be excluded from the sample universe (i.e., no samples will be placed in these areas). Within the disturbed alignment no sampling will occur on access roads, trails, above-ground SDS infrastructure, other above-ground public or private infrastructure, waterways, or other areas where sampling is determined not to be practical, safe or meaningful. Such areas will be manually delineated in the GIS and excluded from the eligible sampling area when creating the random point coverage.

Sampling Schedule

During the first growing season following seeding, seedling density data will be collected. At the end of the first growing season (typically September) cover data will be collected for the purpose of assessing compliance with the CDPHE Stormwater Permit criterion of 70 percent of pre-existing cover. If in the judgment of the SDS Program, the extent of vegetation cover at that time might also satisfy the 90 percent of pre-existing cover criterion, the full sampling design described above will be implemented. If only the CDPHE criterion is being tested, sample intensity within a work package will be five samples in soil reaches one mile or less in cumulative length and eight in those greater than one mile in cumulative length. During the second growing season, sampling intensity will be ten (10) samples in soil reaches one mile or less in cumulative length and fifteen (15) samples in those greater than one mile in cumulative length.

Hypothesis Testing

Statistical evaluation of the success of revegetation for each soil functional group within a work package will be tested via a one-sample t-test of the following null hypothesis:

The (traditional) null hypothesis being tested would be that the revegetated area mean (\bar{x}) is indistinguishable from 90 percent of the pre-existing cover, stated as $H_0: \bar{x} = Q$. If t_c is less than or equal to the 1-tailed t -table value for alpha error probability of 0.05, at $(n-1)$ degrees of freedom, then H_0 is accepted, and revegetation is deemed successful (i.e., indistinguishable from 90 percent of the standard).

The sample data will be evaluated for normality and transformed if appropriate. The formula for the one sample t-test is:

$$t_c = \frac{Q - \bar{x}}{S_{\bar{x}}}$$

Where: \bar{x} = Revegetated Area Sample Mean
 Q = 90 percent of pre-existing cover
 $S_{\bar{x}}$ = Standard error of mean [s/\sqrt{n}]
 s = Sample standard deviation
 n = Sample size
 t_c = Calculated t -value
 t_t = Table t -value (alpha = 0.05)

Photographic Documentation

Photo documentation will be conducted during the growing seasons and in conjunction with the point-intercept cover sampling. Photos will be taken at each transect location during all sampling. Photo points will be relocated using a handheld GPS receiver.

Colorado Springs Utilities Southern Delivery System

*Measurements of Post-restoration Vegetation Cover for Pueblo County
Work Package S2*



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Southern Delivery System
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October, 2013

Prepared in conjunction with:

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Boulder, CO**



Cover Photo: Sample site 14 on Soil Group A (Penrose, Manuel and Minnequa Series) in work package S2 (by ESCO Assoc. Inc.)



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Introduction

This report documents conditions of post-construction vegetation cover after the first growing season along the S2 section of the Southern Delivery System (SDS) pipeline route in Pueblo County, Colorado. The Colorado Natural Heritage Program, in cooperation with ESCO Associates, completed the post-construction survey under contract to Colorado Springs Utilities. This report compares post-construction vegetative cover values to the standards for revegetation prescribed by CDPHE Stormwater Regulations and the Pueblo County 1041 permit in order to evaluate revegetation success in this section. It also reports frequency-based quantitative measures of the presence of acceptable species in comparison to a pre-determined standard.

The following includes the methods used, the results, and a discussion of factors affecting vegetation cover on the sites after any construction activities. Maps, tabular data, and photographs of work package S2 are contained in separate Appendices A, B, and C, respectively. Appendix D includes applicable portions of the Pueblo County Revegetation Cover Establishment Protocols (Protocols).

The study area is in a tributary valley of the Arkansas River downstream (east) from its emergence from the mountain front. Along some reaches of the pipeline route, exposed shale and limestone are the predominant soil parent materials, while on other reaches recent alluvium predominates and on high terrace sites older deposits of Arkansas River alluvium in the form of sands and gravels predominate.

Methods

Assessment of Cover and the Presence of Acceptable Species in revegetated and irrigated areas along the SDS Pipeline in Pueblo County was completed in late September 2013 as per the Protocol developed for the project. Prior to this, in July 2013, the density of seedlings of acceptable species per square foot was assessed along these same reaches of revegetated right-of-way. The July assessment provided an early look into revegetation results, but the September 2013 effort included evaluation of two different parameters that were applicable to vegetation somewhat more mature than in July 2013.

The primary parameter assessed in the September work was percent cover by acceptable species as set forth in the Protocol. This measure relates to the Pueblo County 1041 permit requirement that cover on revegetated areas comprise at least 90% of pre-existing levels. It also relates to the requirement under CDPHE Stormwater Regulations that cover attains at least 70% of pre-existing levels. Pre-existing levels of cover on the Pueblo County work package reaches were established by quantitative sampling in October 2011 prior to construction. Further details on this pre-construction effort can be found in the 2011 report.

Beyond the return of adequate plant cover (detailed in the Protocol document), measures intended to provide Pueblo County with an evaluation of the adequate presence of Acceptable Species in the reconstructed vegetation were also made as per provisions in the protocol. Acceptable species had been determined in consultation with the Pueblo County vegetation representative to include all native species and all introduced perennial species other than those included on the current State of Colorado A, B or C-lists of noxious species.

Beginning with the pre-construction vegetation surveys, results of sampling in this work package have been grouped by broad soil types. These groups, established to simplify the process,

include soil series of similar nature as plant growth media. Within each soil type, sample transects (See Protocol Technical Memos 1 and 3, Appendix D) were placed at random locations in an effort to capture the variability of vegetative cover present. At each representative sample location, vegetation cover and ground cover were measured via observation at 100 locations spaced at 1 meter intervals along the transect length. Maps showing the extent of the soil groups present within the alignment of the work package and the location of sample transect origin points are included in Appendix A.

Results

A total of 50 transects were sampled in the work package S2 area during the post-construction survey. The various soils across the extent of the work package were grouped for simplicity into four units that differed in their nature as plant growth media and as to the means by which it will be necessary to salvage and replace them during construction. The four groups are as follows:

A. Soils Shallow over Shale and Limestone (Penrose, Manvel and Minnequa series; Table 1, Appendix B)

B. Soils on Clay-rich, Salt-affected Alluvial Material (Limon and Heldt series; Table 2, Appendix B)

D. Soils on Weathered Shales (with active erosional removal) (Midway – Shale complex, Shingle series; Table 3, Appendix B)

F. Soils on Recent Alluvium of Moderate Texture and Salt Content (Haverson series and Ustic Torrifluvents; Table 4, Appendix B)

The distribution of these Soil Groups is indicated on the maps of S2 included in Appendix A.

Plant cover observed during sampling was related to the above soil groups and used to establish base values from which revegetation performance standards were calculated.

Base Cover Values for Evaluation of Revegetation Success

The following are base vegetation cover values (to be multiplied by 0.9 in accordance with the Protocol) that were measured pre-construction.

A. Soils Shallow over Shale and Limestone (Penrose, Manvel and Minnequa series): **17.2%**

B. Soils on Clay-rich, Salt-affected Alluvial Material (Limon and Heldt series): **26.5%**
(Note that this represents the level found on Limon soils in ungrazed S2)

D. Soils on Weathered Shales (with active erosional removal) (Midway – Shale complex, Shingle series): **17.0%**.

F. Soils on Recent Alluvium of Moderate Texture and Salt Content (Haverson series and Ustic Torrifluvents): **41.3%**

Post Construction Results

Table 1 (below) displays the base vegetation cover, revegetation cover values at the 90% and 70% levels (established under Pueblo Co. 1041 and CDPHE Stormwater Regulations, respectively), and the post-construction percent cover values by the respective soil groups. In all soil groups, post-construction vegetation cover met or exceeded the 70% revegetation performance standards. Soil groups A, B and F surpassed the 90% revegetation performance standards, but soil group D did not. Note, however, that CDPHE cover expectations include all species present (including introduced annual species deemed partially unacceptable in Pueblo Co. evaluations). Figure 1 graphically represents this information.

Table 1: Vegetation Cover per Soil Group for S2

Map Code	Soil Group	% of Work Unit	% Base Veg. Cover	90% Revegetation Cover Performance Std. (0.9 x Base)	70% Revegetation Cover Performance Std. (0.7 x Base)	% Cover by Acc. Spp
A	Soils shallow over shale and limestone (Penrose, Manvel and Minnequa series)	68.3	17.2	15.5	12.1	29.2
B	Soils on clay-rich, salt-affected alluvial material (Limon and Heldt Series)	23.6	26.5	23.9	18.6	26.4
D	Soils on Weathered Shales (with active erosional removal) (Stoneham and Cascajo series)	4.0	17.0	15.3	11.9	13.1
F	Soils on recent alluvium of moderate texture and salt content (Haverson series and Ustic Torrifluvents)	4.1	41.3	37.2	28.9	38.6

Figure 1: Fall 2013 S2 SDS Pueblo Co. Restoration Cover Levels vs. 2014 Standards

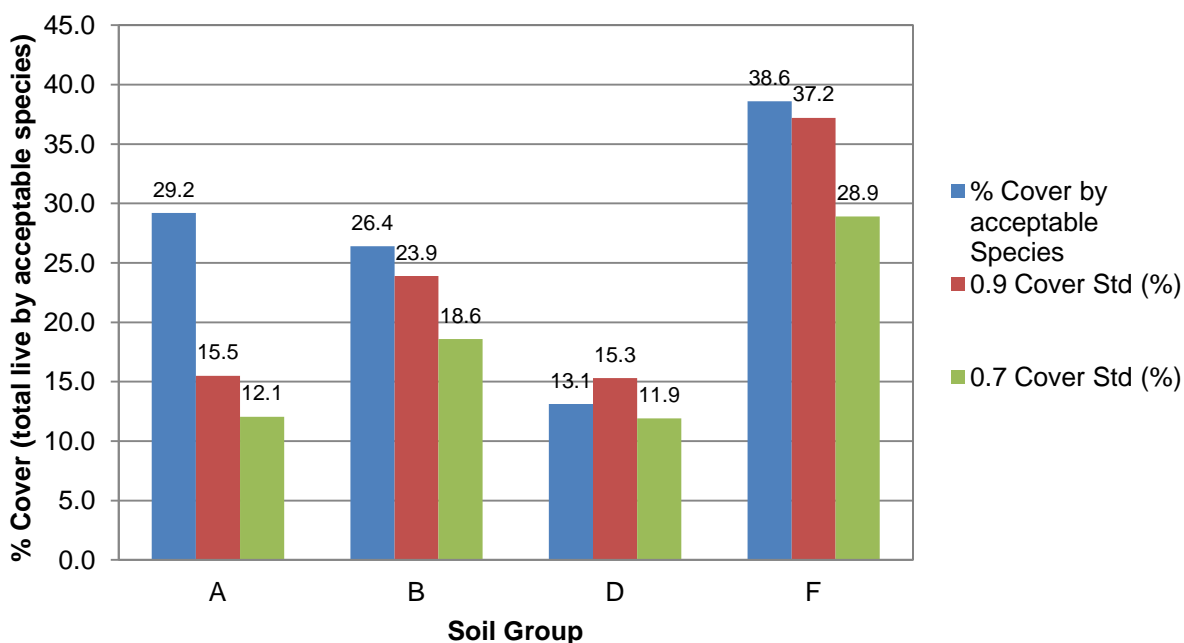


Figure 2: Fall 2013 S2 SDS Pueblo Co. Restoration Presence of Acceptable Species vs. 2014 Standards

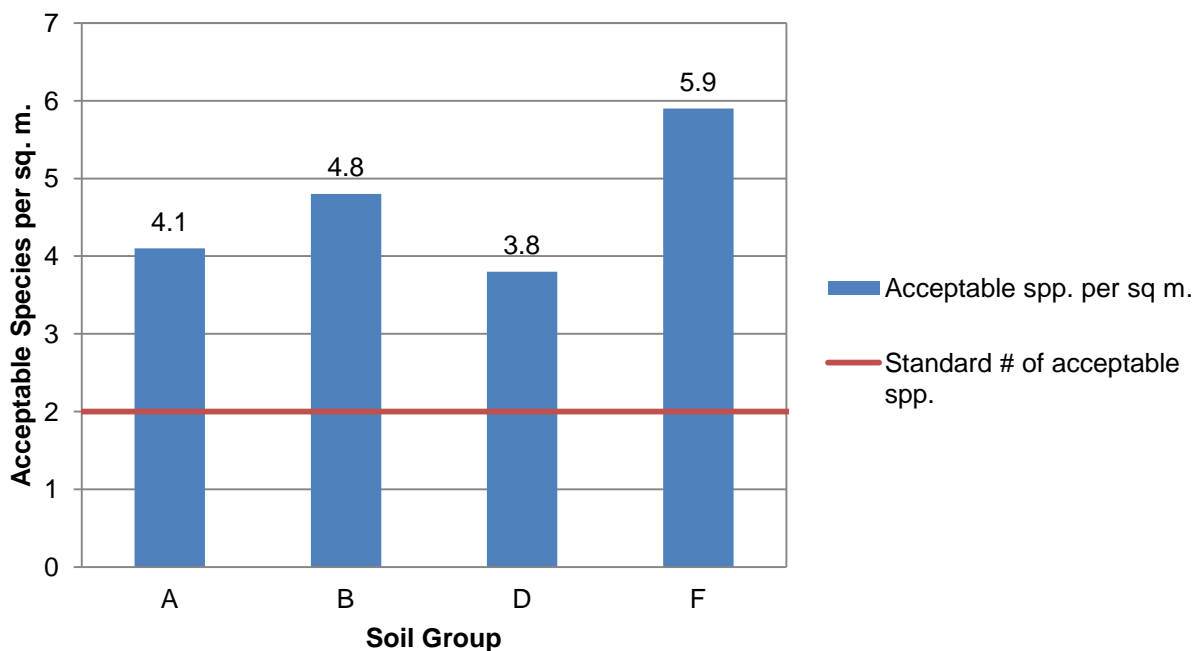


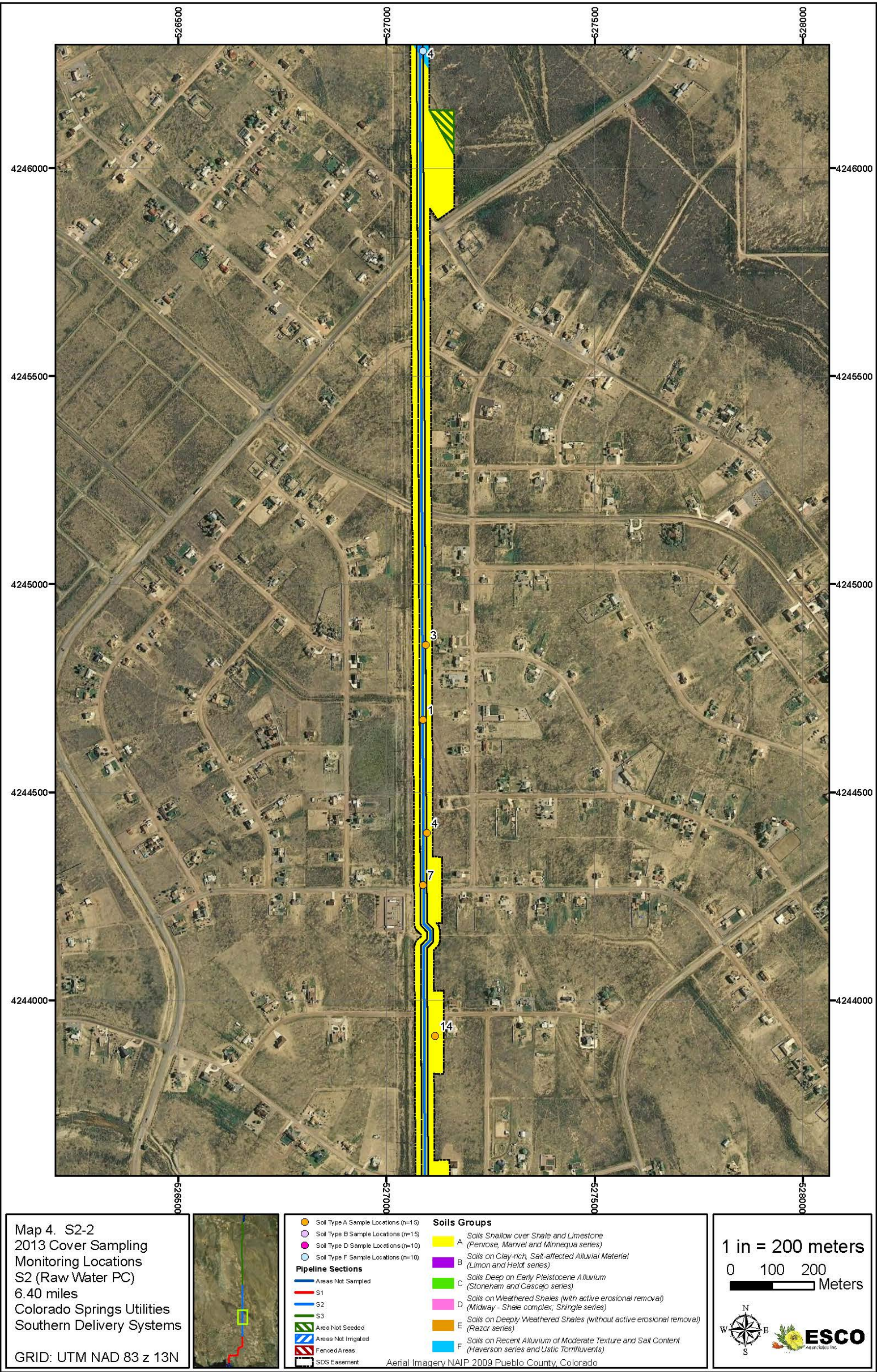
Figure 2 displays the number of acceptable species present on each soil type in S2 compared to the pre-established standard of 2 species per square meter. In all soil groups, the mean number of acceptable species present surpassed the standard.

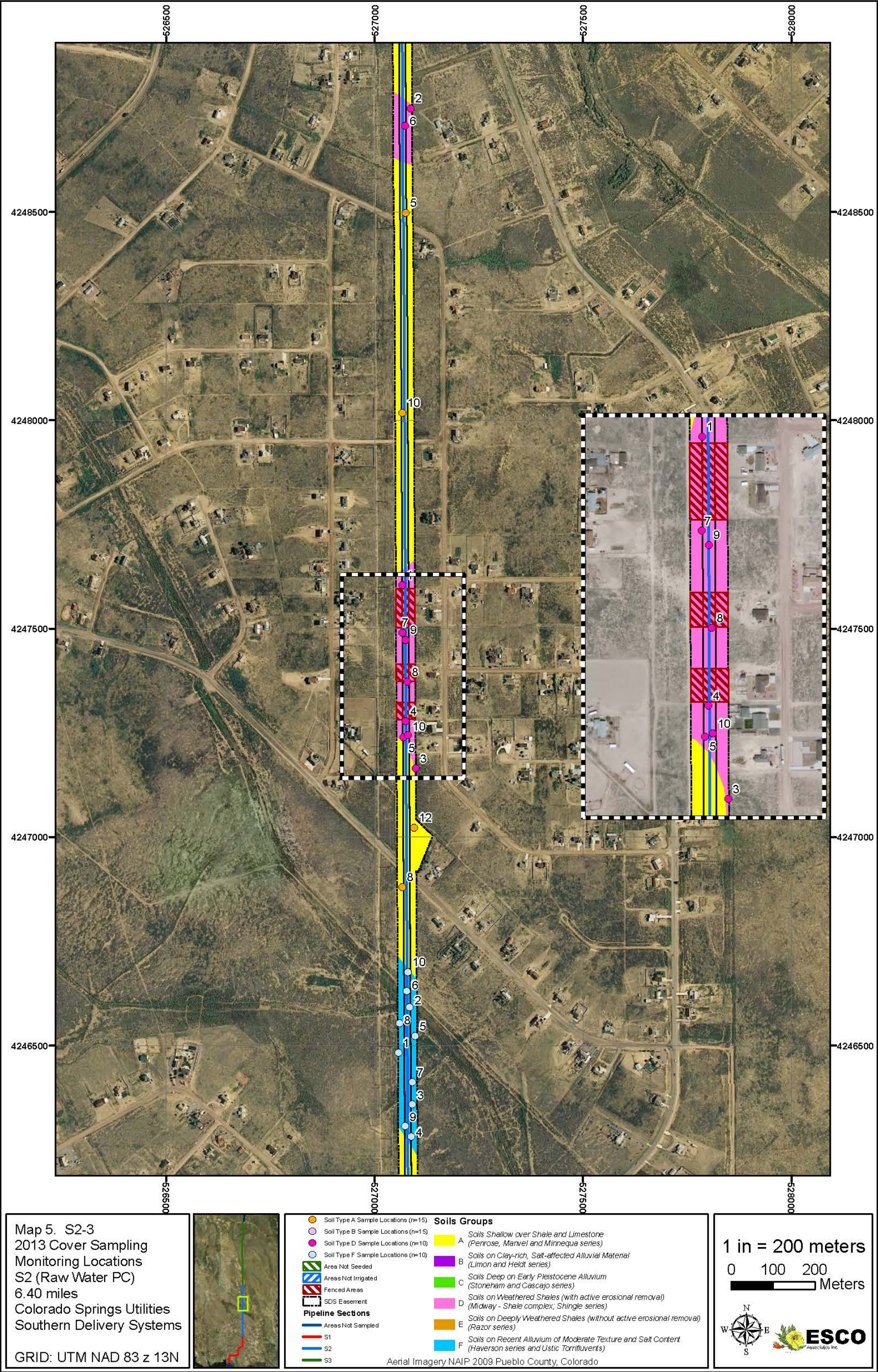
Discussion

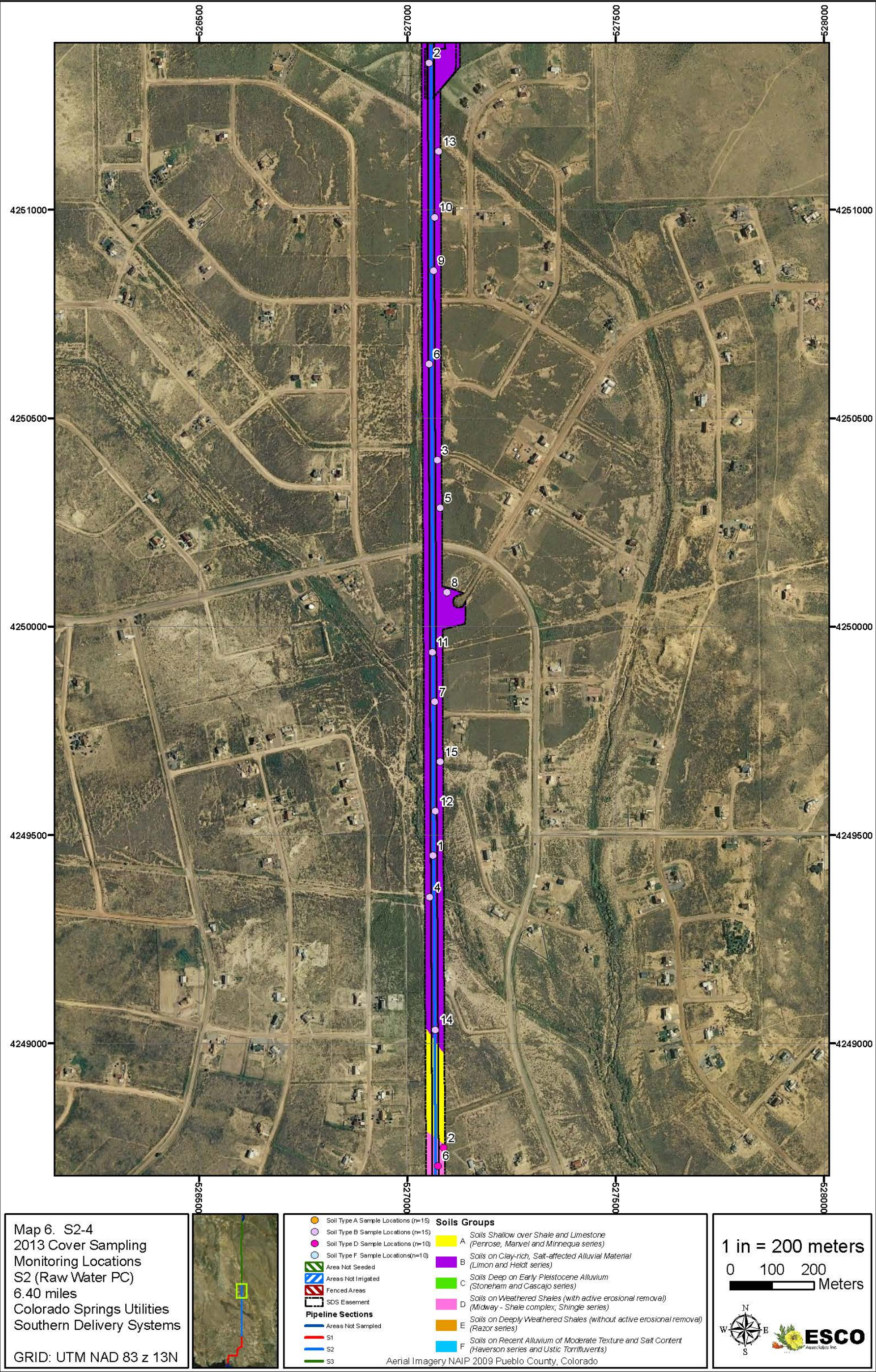
Post-Construction Revegetation Performance

The 70% revegetation CDPHE Stormwater Regulation standards were surpassed in all soil groups within work package S2; however soil group D did not meet the 90% Pueblo County permit 1041 standards. It should be noted that the 90% revegetation cover performance standards stated in the Pueblo County 1041 permit are applicable over a two-year period. The S2 measurements presented here were taken at the end of the first growing season (September 2013). If the currently observable revegetation trends continue in this area, the 90% standards should be met before the 2-year period. Additionally, all areas of S2 surpassed the criterion of 2 acceptable species per square meter in the developing reconstructed vegetation. This supports a projection that, even though not all areas of the S2 work package have reached the 90% revegetation standard levels, post-construction species composition development is moving in the right direction.

Appendix A: Maps – Work Package S2







Appendix B: Tabular Data – Work Package S2

Table 1: Work Package S2 on Penrose, Manvel and Minnequa Series Soils (Soil Group A)

PLANT SPECIES	FIRST HIT		FIRST HIT		ALL HIT		Percent Foliar Cover*														
	AVERAGE		RELATIVE		AVERAGE																
	COVER ^a	FREQUENCY ^b	COVER ^c		COVER ^d	COVER ^e	---Sample Number---														
	(%)	(%)	(%)		(%)	(%)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
NATIVE ANNUAL & BIENNIAL FORBS																					
Amaranthus albus	0.07	33.33	0.17		0.07	0.16			P	P		P	1						P		
Atriplex saccaria	0.00	6.67	0.00		0.00	0.00				P											
Chamaesyce sp.	0.93	80.00	2.39		1.20	2.95	P	P	2	P	4		1(1)	3(1)		3	P	1(1)		(1)	P
Dyssodia aurea	1.67	73.33	4.27		1.73	4.26	1	1	3	5	P	P	1			P		1(1)		13	P
Dyssodia papposa	0.27	26.67	0.68		0.27	0.66					P			3		1		P			
Helianthus annuus	0.00	40.00	0.00		0.00	0.00	P	P			P			P					P	P	
Lepidium densiflorum	0.00	13.33	0.00		0.00	0.00					P			P							
Monolepis nuttalliana	0.00	13.33	0.00		0.00	0.00	P										P				
Oenothera villosa	0.00	13.33	0.00		0.00	0.00								P				P			
Solanum rostratum	0.00	6.67	0.00		0.00	0.00		P													
Solanum triflorum	0.00	13.33	0.00		0.00	0.00			P										P		
Verbesina encelioides ssp. encelioides	0.33	20.00	0.85		0.33	0.82								4		P		1			
TOTAL NATIVE ANN. & BIEN. FORBS	3.3	93.3	8.4		3.6	8.9	1	1	5	5	4	P	3(1)	10(1)	---	4	P	3(2)	P	13(1)	P
INTRODUCED ANNUAL & BIENNIAL FORBS																					
Amaranthus hybridus	0.00	20.00	0.00		0.00	0.00							P		P				P		
Amaranthus retroflexus	0.00	6.67	0.00		0.00	0.00								P							
Bassia sieversiana	4.60	100.00	11.77		4.67	11.48	3	7	2	6(1)	4	1	4	5	5	P	4	P	9	5	14
Halogeton glomeratus	0.00	6.67	0.00		0.00	0.00											P				
Hibiscus trionum	0.07	6.67	0.17		0.07	0.16								1							
Lactuca serriola	0.00	20.00	0.00		0.00	0.00	P		P						P						
Malva neglecta	0.07	13.33	0.17		0.07	0.16	1												P		
Melilotus officinalis	0.00	13.33	0.00		0.00	0.00											P	P			
Salsola australis	2.20	73.33	5.63		2.20	5.41	3	4	2	3	2		1		1		9		4	3	1
Salsola collina	11.60	100.00	29.69		11.87	29.18	10	27	9	6(1)	8	15	1(1)	6	21	1	25	P	30(1)	6(1)	9
TOTAL INTRO. ANN. & BIEN. FORBS	18.5	100.0	47.4		18.9	46.4	17	38	13	15(2)	14	16	6(1)	12	27	1	38	P	43(1)	14(1)	24
NATIVE ANNUAL GRASSES																					
Munroa squarrosa	0.00	13.33	0.00		0.00	0.00								P						P	
Panicum capillare	0.20	46.67	0.51		0.20	0.49			P	1			P	P			P			1	1
TOTAL NATIVE ANN. GRASSES	0.2	46.7	0.5		0.2	0.5	---	---	P	1	---	---	P	P	---	---	P	---	---	1	1
INTRODUCED ANNUAL GRASSES																					
Bromus tectorum	0.00	6.67	0.00		0.00	0.00		P													
Digitaria sanguinalis	0.40	93.33	1.02		0.40	0.98		2	P	2	P	P	P	1	P	P	P	P	1	P	P

PLANT SPECIES	FIRST HIT		FIRST HIT	ALL HIT		Percent Foliar Cover*														
	AVERAGE		RELATIVE	AVERAGE																
	COVER ^a	FREQUENCY ^b	VEGETATION	COVER ^d	RELATIVE															
	(%)	(%)	COVER ^c	(%)	VEGETATION	---Sample Number---														
			(%)		COVER ^e	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Panicum dichotomiflorum	0.00	6.67	0.00	0.00	0.00								P							
Sorghum halepense	0.07	46.67	0.17	0.07	0.16	P		P	P	1			P	P				P		
Triticum aestivum	0.00	13.33	0.00	0.00	0.00		P												P	
TOTAL INTRO. ANN. GRASSES	0.5	100.0	1.2	0.5	1.1	P	2	P	2	1	P	P	1	P	P	P	P	1	P	P
NATIVE PERENNIAL FORBS																				
Abronia fragrans	0.00	6.67	0.00	0.00	0.00							P								
Astragalus shortianus	0.00	20.00	0.00	0.00	0.00				P				P							P
Astragalus sp.	0.00	13.33	0.00	0.00	0.00				P			P								
Chamaesaracha coronopus	1.67	60.00	4.27	1.67	4.10	1		2	2	1		P	1		17		P		1	
Cucurbita foetidissima	0.00	6.67	0.00	0.00	0.00								P							
Gaillardia pinnatifida	0.00	6.67	0.00	0.00	0.00			P												
Glandularia bipinnatifida	1.73	73.33	4.44	1.73	4.26	P		P	2	P	P	1	3			10	3		5	2
Lesquerella sp.	0.00	20.00	0.00	0.00	0.00					P			P		P					
Linum lewisii	0.00	13.33	0.00	0.00	0.00								P				P			
Oenothera sp.	0.00	20.00	0.00	0.00	0.00	P			P			P								
Quincula lobata	0.07	40.00	0.17	0.07	0.16		P	P		P				P	1			P		
Rorippa sp.	0.07	13.33	0.17	0.07	0.16					P					1					
Rudbeckia hirta	0.00	6.67	0.00	0.00	0.00									P						
Solanum elaeagnifolium	0.07	6.67	0.17	0.07	0.16											1				
Solidago sp.	0.00	13.33	0.00	0.00	0.00					P							P			
Sphaeralcea angustifolia	0.00	13.33	0.00	0.00	0.00								P					P		
Sphaeralcea coccinea	0.07	53.33	0.17	0.13	0.33	P			P	P		P	P		P		P		1(1)	
TOTAL NATIVE PERENNIAL FORBS	3.7	100.0	9.4	3.7	9.2	1	P	2	4	1	P	1	4	P	19	11	3	P	7(1)	2
INTRODUCED PERENNIAL FORBS																				
Acroptilon repens	0.00	6.67	0.00	0.00	0.00		P													
Convolvulus arvensis	0.00	13.33	0.00	0.00	0.00								P				P			
Rumex crispus	0.00	13.33	0.00	0.00	0.00									P					P	
Taraxacum officinale	0.00	6.67	0.00	0.00	0.00								P							
Trifolium pratense	0.00	6.67	0.00	0.00	0.00										P					
TOTAL INTRO. PERENNIAL FORBS	0.0	40.0	0.0	0.0	0.0	---	P	---	---	---	---	---	P	P	P	---	P	---	P	---
NATIVE PERENNIAL GRASSES (cool)																				
Aristida divaricata	0.00	13.33	0.00	0.00	0.00			P								P				
Elymus trachycaulus	0.00	13.33	0.00	0.00	0.00						P			P						
Pascopyrum smithii	1.67	100.00	4.27	1.80	4.43	P	1(1)	2	2	1	P	1	6	2	2	P	6(1)	P	1	1
TOTAL NATIVE PERENNIAL GRASSES (c)	1.7	100.0	4.3	1.8	4.4	P	1(1)	2	2	1	P	1	6	2	2	P	6(1)	P	2	1

PLANT SPECIES	FIRST HIT		FIRST HIT	ALL HIT		Percent Foliar Cover*														
	AVERAGE		RELATIVE	ALL HIT	RELATIVE															
	COVER ^a	FREQUENCY ^b	VEGETATION	AVERAGE	VEGETATION															
	(%)	(%)	COVER ^c	COVER ^d	COVER ^e	---Sample Number---														
						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
INTRODUCED PERENNIAL GRASSES (cool)																				
Echinochloa crus-galli	0.33	80.00	0.85	0.33	0.82	P	P	P		P	P		1	P	1		P	1	1	1
Setaria viridis	0.07	26.67	0.17	0.13	0.33		P				P			P		1(1)				
Thinopyrum intermedium	0.07	13.33	0.17	0.07	0.16		1											P		
TOTAL INTRO. PERENNIAL GRASSES (c)	0.5	86.7	1.2	0.5	1.3	P	1	P	---	P	P	---	1	P	1	1(1)	P	1	1	1
NATIVE PERENNIAL GRASSES (warm)																				
Bouteloua curtipendula	2.60	100.00	6.66	2.87	7.05	1	4	2	5	3(2)	2	4	1	P	P	3(1)	6	2	5(1)	1
Buchloe dactyloides	0.00	13.33	0.00	0.00	0.00			P				P								
Chondrosum gracile	3.60	100.00	9.22	3.80	9.34	3	3	6	5	4(1)	6	P	1	3	P	7(1)	6	1(1)	5	4
Leptochloa dubia	0.07	33.33	0.17	0.07	0.16		P	P				1						P		P
Muhlenbergia arenacea	0.07	13.33	0.17	0.07	0.16							P							1	
Pleuraphis jamesii	2.87	100.00	7.34	2.93	7.21	4	4	5	5(1)	1	1	2	P	P	1	1	7	5	3	4
Sporobolus airoides	1.20	66.67	3.07	1.33	3.28			1	P	5(1)	P	1	5		3	P	2(1)			1
Sporobolus cryptandrus	0.27	80.00	0.68	0.27	0.66	1	P	P	P		1	P	P	P	P	1	1			P
TOTAL NATIVE PERENNIAL GRASSES (w)	10.7	100.0	27.3	11.3	27.9	9	11	14	15(1)	13(4)	10	8	7	3	4	12(2)	22(1)	8(1)	13(1)	10
NATIVE SUBSHRUBS																				
Gutierrezia sarothrae	0.00	6.67	0.00	0.00	0.00									P						
TOTAL NATIVE SUBSHRUBS	0.0	6.7	0.0	0.0	0.0	---	---	---	---	---	---	---	---	P	---	---	---	---	---	---
INTRODUCED SUBSHRUBS																				
Lespedeza cuneata	0.00	6.67	0.00	0.00	0.00												P			
TOTAL INTRODUCED SUBSHRUBS	0.0	6.7	0.0	0.0	0.0	---	---	---	---	---	---	---	---	---	---	---	P	---	---	---
NATIVE SHRUBS																				
Atriplex canescens	0.07	20.00	0.17	0.07	0.16	P		1											P	
TOTAL NATIVE SHRUBS	0.1	20.0	0.2	0.1	0.2	P	---	1	---	---	---	---	---	---	---	---			P	---
INTRODUCED SHRUBS																				
Tamarix chinensis	0.00	6.67	0.00	0.00	0.00								P							
TOTAL INTRODUCED SHRUBS	0.0	6.7	0.0	0.0	0.0	---	---	---	---	---	---	---	P	---	---	---	---	---	---	---
NATIVE TREES																				
Populus sp.	0.00	6.67	0.00	0.00	0.00													P		
TOTAL NATIVE TREES	0.0	6.7	0.0	0.0	0.0	---	---	---	---	---	---	---	---	---	---	---	---	P	---	---
BRYOPHYTES																				

PLANT SPECIES	FIRST HIT		FIRST HIT	ALL HIT	ALL HIT	Percent Foliar Cover*														
	AVERAGE		RELATIVE	AVERAGE	RELATIVE															
	COVER ^a	FREQUENCY ^b	VEGETATION	COVER ^d	VEGETATION	---Sample Number---														
	(%)	(%)	(%)	(%)	(%)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Moss	0.07	6.67	0.17	0.07	0.16														1	
TOTAL BRYOPHYTES	0.1	6.7	0.2	0.1	0.2	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---
Standing dead	2.27	80.00		2.27		2	2	2	3	1	1	4		4		2		7	2	4
Litter	24.93	100.00		24.93		24	23	31	16	26	51	25	30	36	17	12	10	29	20	24
Bare soil	31.20	100.00		31.20		38	21	30	36	37	18	52	26	23	51	22	51	9	26	28
Rock	2.53	73.33		2.53		8			1	2	4		3	5	1	2	5	2		5
TOTALS	100.0			101.6		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
TOTAL VEGETATION COVER	39.1 (s=12.0)		100.0	40.7 (s=12.7)	100.0	28	54(1)	37	44(3)	34(4)	26	19(2)	41(1)	32	31	62(3)	34(4)	53(2)	52(4)	39
GROUND COVER (Litter+Rock+Veg+St.Dead)	68.8			70.4		62	79(1)	70	64(3)	63(4)	82	48(2)	74(1)	77	49	78(3)	49(4)	91(2)	74(4)	72
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 21.7 Std.Dev.= 4.2)						21	21	26	22	23	15	24	33	19	20	19	23	20	22	17

^a First Hit Cover = Absolute percent cover in vertical view with no account of plants obscured by first (i.e. top) hit.

^b Frequency = Percent of the samples in which a species or lifeform occurred

^c First Hit Relative Cover = Percent of the First Hit vegetation cover comprised of this species or lifeform

^d All Hit Cover = Absolute percent cover in vertical view accounting for all cover by the species or lifeform, whether over-arched by other plants or not

^e All Hit Relative Cover = Percent of the All Hit vegetation cover comprised of the species or lifeform

***P=Present within 1m. on either side of cover transect, but not quantitatively encountered.**
()=Data in parentheses represent other hits that are used in conjunction with first hits for all hit cover statistics.

Table 2: Work Package S2 on Limon and Heldt Series (Soil Group B)

PLANT SPECIES	FIRST HIT		ALL HIT		Percent Foliar Cover*															
	FIRST HIT		RELATIVE	ALL HIT	RELATIVE															
	AVERAGE		VEGETATION	AVERAGE	VEGETATION															
	COVER ^a	FREQUENCY ^b	COVER ^c	COVER ^d	COVER ^e	---Sample Number---														
	(%)	(%)	(%)	(%)	(%)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
NATIVE ANNUAL & BIENNIAL FORBS																				
Amaranthus albus	0.93	33.33	2.60	0.93	2.45			P		P				5	8			1		
Anoda cristata	0.07	6.67	0.19	0.07	0.18			1												
Atriplex saccaria	0.00	6.67	0.00	0.00	0.00									P						
Chamaesyce sp.	0.47	60.00	1.30	0.60	1.58			1	P	1			(1)	1	P	P			4	(1)
Chenopodium berlandieri	0.00	6.67	0.00	0.00	0.00															P
Chenopodium incanum	0.00	6.67	0.00	0.00	0.00							P								
Conyza canadensis	0.00	13.33	0.00	0.00	0.00	P													P	
Coreopsis tinctoria	0.00	6.67	0.00	0.00	0.00				P											
Descurainia incana	0.13	13.33	0.37	0.13	0.35					P	2									
Dyssodia aurea	0.47	80.00	1.30	0.53	1.40	P	P	1	P	5	P	P		(1)	1	P		P		P
Dyssodia papposa	0.00	20.00	0.00	0.00	0.00	P													P	P
Grindelia squarrosa	0.00	6.67	0.00	0.00	0.00							P								
Helianthus annuus	0.00	53.33	0.00	0.00	0.00		P	P	P		P		P	P	P			P		
Oenothera villosa	0.00	6.67	0.00	0.00	0.00														P	
Oonopsis foliosa	0.00	20.00	0.00	0.00	0.00			P		P	P									
Solanum rostratum	0.07	53.33	0.19	0.07	0.18		P	P		P			P	P		P		1		P
Ximenesia encelioides	0.80	93.33	2.23	0.80	2.10	P	P	3	P	1	1	P	P	2	1	P		P	2	2
TOTAL NATIVE ANN. & BIEN. FORBS	2.9	93.3	8.2	3.1	8.2	P	P	6	P	7	3	P	(1)	8(1)	10	P	---	2	6	2(1)
INTRODUCED ANNUAL & BIENNIAL FORBS																				
Alyssum desertorum	0.07	6.67	0.19	0.07	0.18			1												
Amaranthus hybridus	0.00	6.67	0.00	0.00	0.00									P						
Amaranthus retroflexus	0.00	6.67	0.00	0.00	0.00								P							
Bassia sieversiana	5.60	100.00	15.61	5.67	14.89	5	20	1	7	2(1)	4	16	1	4	1	15	P	1	P	7
Chenopodium album	0.00	66.67	0.00	0.00	0.00	P					P	P	P	P	P	P	P	P		P
Euphorbia davidii	0.00	13.33	0.00	0.00	0.00		P						P							
Halogeton glomeratus	0.80	93.33	2.23	0.93	2.45	P	5(1)	P	P	P	P	P		P	3	P	P	1(1)	P	3
Hibiscus trionum	0.00	6.67	0.00	0.00	0.00					P										
Lactuca serriola	0.07	6.67	0.19	0.07	0.18											1				
Lespedeza striata	0.00	13.33	0.00	0.00	0.00				P											P
Malva neglecta	0.00	6.67	0.00	0.00	0.00					P										
Melilotus officinalis	0.07	40.00	0.19	0.07	0.18	1			P	P					P		P			P
Plantago lanceolata	0.00	6.67	0.00	0.00	0.00								P							
Salsola australis	1.33	46.67	3.72	1.40	3.68		P	3		1	6			6(1)	P			4		
Salsola collina	1.47	73.33	4.09	1.53	4.03	P		12	1	2	2	1	(1)			1	2		P	1
TOTAL INTRO. ANN. & BIEN. FORBS	9.4	100.0	26.2	9.7	25.6	6	25(1)	17	8	5(1)	12	17	1(1)	10(1)	4	17	2	6(1)	P	11

PLANT SPECIES	FIRST HIT		FIRST HIT		ALL HIT		Percent Foliar Cover*														
	AVERAGE		RELATIVE		AVERAGE																
	COVER ^a		VEGETATION		COVER ^d																
	(%)	FREQUENCY ^b	(%)	(%)	(%)	(%)	---Sample Number---														
		(%)	(%)				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
NATIVE ANNUAL GRASSES																					
Leptochloa fusca ssp. fascicularis	0.00	20.00	0.00	0.00	0.00	0.00				P				P		P					
Munroa squarrosa	0.07	13.33	0.19	0.07	0.18	0.18									P				1		
Panicum capillare	0.00	13.33	0.00	0.00	0.00	0.00				P				P							
TOTAL NATIVE ANN. GRASSES	0.1	33.3	0.2	0.1	0.2	0.2	---	---	---	P	---	---	---	P	P	P	---	---	1	---	---
INTRODUCED ANNUAL GRASSES																					
Bromus japonicus	0.20	26.67	0.56	0.20	0.53	0.53	1					P	1	1							
Bromus tectorum	0.33	33.33	0.93	0.33	0.88	0.88		P	P			2		3				P			
Digitaria sanguinalis	0.27	40.00	0.74	0.27	0.70	0.70	1						1	1			P	P			1
Panicum dichotomiflorum	0.07	26.67	0.19	0.07	0.18	0.18	P			1			P				P				
Sorghum halepense	0.47	33.33	1.30	0.53	1.40	1.40		1				4			(1)	P			2		
Triticum aestivum	0.07	6.67	0.19	0.07	0.18	0.18								1							
TOTAL INTRO. ANN. GRASSES	1.4	86.7	3.9	1.5	3.9	3.9	2	1	P	1	---	6	2	6	(1)	P	P	P	2	---	1
NATIVE PERENNIAL FORBS																					
Achillea millefolium	0.00	6.67	0.00	0.00	0.00	0.00					P										
Astragalus agrestis	0.00	6.67	0.00	0.00	0.00	0.00				P											
Astragalus racemosus	0.13	53.33	0.37	0.13	0.35	0.35	P				P		P	1	P	P			1		P
Astragalus sp.	0.93	13.33	2.60	0.93	2.45	2.45				14										P	
Chamaesaracha coronopus	0.33	53.33	0.93	0.33	0.88	0.88		P	P	1	P					1		P	2	1	
Euphorbia sp.	0.00	6.67	0.00	0.00	0.00	0.00															P
Glandularia bipinnatifida	1.47	86.67	4.09	1.53	4.03	4.03		P	1	P	8	P	P	7(1)	1	2	1		P	2	P
Hedeoma drummondii	0.00	6.67	0.00	0.00	0.00	0.00				P											
Heterotheca villosa	0.00	6.67	0.00	0.00	0.00	0.00														P	
Lomatium foeniculaceum	0.00	6.67	0.00	0.00	0.00	0.00						P									
Oenothera sp.	0.00	6.67	0.00	0.00	0.00	0.00													P		
Oonopsis puebloensis	0.00	13.33	0.00	0.00	0.00	0.00														P	P
Physaria sp.	0.00	6.67	0.00	0.00	0.00	0.00														P	
Picradeniopsis oppositifolia	0.00	6.67	0.00	0.00	0.00	0.00				P											
Quincula lobata	0.67	80.00	1.86	0.87	2.28	2.28	P		(1)	P	4(1)	P	1	P	2	2(1)	P			P	1
Rorippa sp.	0.00	13.33	0.00	0.00	0.00	0.00								P						P	
Rudbeckia hirta	0.00	6.67	0.00	0.00	0.00	0.00													P		
Solidago sp.	0.00	20.00	0.00	0.00	0.00	0.00				P								P		P	
Sphaeralcea angustifolia	0.00	80.00	0.00	0.00	0.00	0.00		P	P		P	P	P	P	P	P	P		P	P	P
Sphaeralcea coccinea	0.07	60.00	0.19	0.07	0.18	0.18	P		P		P	P		1		P	P	P		P	
Vicia americana	0.00	6.67	0.00	0.00	0.00	0.00								P							
Zinnia grandiflora	0.00	6.67	0.00	0.00	0.00	0.00														P	

PLANT SPECIES	FIRST HIT		FIRST HIT	ALL HIT		Percent Foliar Cover*														
	AVERAGE		RELATIVE	AVERAGE																
	COVER ^a	FREQUENCY ^b	VEGETATION COVER ^c	COVER ^d	VEGETATION COVER ^e	---Sample Number---														
	(%)	(%)	(%)	(%)	(%)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
TOTAL NATIVE PERENNIAL FORBS	3.6	100.0	10.0	3.9	10.2	P	P	1(1)	15	12(1)	P	1	9(1)	3	5(1)	1	P	3	3	1
INTRODUCED PERENNIAL FORBS																				
Convolvulus arvensis	0.07	6.67	0.19	0.07	0.18	1														
Rumex crispus	0.00	40.00	0.00	0.00	0.00				P					P		P	P	P		P
Taraxacum officinale	0.00	6.67	0.00	0.00	0.00												P			
TOTAL INTRO. PERENNIAL FORBS	0.1	46.7	0.2	0.1	0.2	1	---	---	P	---	---	---	---	P	---	P	P	P	---	P
NATIVE PERENNIAL GRASSES (cool)																				
Elymus trachycaulus	0.07	6.67	0.19	0.07	0.18			1												
Pascopyrum smithii	4.93	100.00	13.75	5.47	14.36	5	3(1)	4	4	8(1)	2(1)	12	15(3)	3	4	3(1)	2	P	1	8(1)
TOTAL NATIVE PERENNIAL GRASSES (c)	5.0	100.0	13.9	5.5	14.5	5	3(1)	5	4	8(1)	2(1)	12	15(3)	3	4	3(1)	2	P	1	8(1)
INTRODUCED PERENNIAL GRASSES (cool)																				
Bromopsis inermis	0.00	13.33	0.00	0.00	0.00								P			P				
Echinochloa crus-galli	0.80	73.33	2.23	0.87	2.28	2	P	P	P	P		3		2		1(1)	2	P		2
Setaria viridis	0.40	33.33	1.12	0.40	1.05	1			2			1				2				P
Thinopyrum intermedium	0.27	26.67	0.74	0.27	0.70	P						P	2							2
TOTAL INTRO. PERENNIAL GRASSES (c)	1.5	80.0	4.1	1.5	4.0	3	P	P	2	P	---	4	2	2	---	3(1)	2	P	---	4
NATIVE PERENNIAL GRASSES (warm)																				
Aristida purpurea	0.07	40.00	0.19	0.07	0.18	1	P					P				P	P			P
Bouteloua curtipendula	4.07	100.00	11.34	4.40	11.56	1	2	7(2)	1	9	3	2	10(1)	8(2)	8	4	4	2	P	P
Buchloe dactyloides	0.00	6.67	0.00	0.00	0.00						P									
Chondrosum gracile	1.73	93.33	4.83	1.80	4.73	2	P	2(1)	1	3	3	P	5	3	2	1	P	4		P
Leptochloa dubia	0.07	53.33	0.19	0.07	0.18	P				P	P	P	1	P	P			P		
Pleuraphis jamesii	3.67	100.00	10.22	3.80	9.98	2	1	3	2	4	2	1	11	5(2)	6	5	1	7	P	5
Sporobolus airoides	1.53	100.00	4.28	1.73	4.55	P	1(1)	1	1	2	3(1)	2	1	1	P	2	2	2	1	4(1)
Sporobolus cryptandrus	0.27	66.67	0.74	0.27	0.70			P			P	1		1	P	P	P	2	P	P
TOTAL NATIVE PERENNIAL GRASSES (w)	11.4	100.0	31.8	12.1	31.9	6	4(1)	13(3)	5	18	11(1)	6	28(1)	18(4)	16	12	7	17	1	9(1)
INTRODUCED PERENNIAL GRASSES (warm)																				
Bothriochloa sp.	0.00	6.67	0.00	0.00	0.00								P							
TOTAL INTRO. PERENNIAL GRASSES (w)	0.0	6.7	0.0	0.0	0.0	---	---	---	---	---	---	---	P	---	---	---	---	---	---	---
INTRODUCED SUBSHRUBS																				
Lespedeza cuneata	0.20	40.00	0.56	0.20	0.53	P			P			P				P	P			3
TOTAL INTRODUCED SUBSHRUBS	0.2	40.0	0.6	0.2	0.5	P	---	---	P	---	---	P	---	---	---	P	P	---	---	3

PLANT SPECIES	FIRST HIT		FIRST HIT	ALL HIT	ALL HIT	Percent Foliar Cover*														
	AVERAGE		RELATIVE	AVERAGE	RELATIVE															
	COVER ^a	FREQUENCY ^b	VEGETATION	COVER ^d	VEGETATION	---Sample Number---														
	(%)	(%)	COVER ^c	(%)	COVER ^e	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
NATIVE SHRUBS																				
Atriplex canescens	0.33	66.67	0.93	0.33	0.88	P	P		P			P	3	P	1	1		P		P
TOTAL NATIVE SHRUBS	0.3	66.7	0.9	0.3	0.9	P	P	---	P	---	---	P	3	P	1	1	---	P	---	P
NATIVE TREES																				
Acacia sp.	0.00	6.67	0.00	0.00	0.00												P			
Populus sp.	0.00	13.33	0.00	0.00	0.00				P										P	
TOTAL NATIVE TREES	0.0	20.0	0.0	0.0	0.0	---	---	---	P	---	---	---	---	---	---	---	P	---	P	---
Standing dead	0.40	33.33		0.40		1			1					2		1	1			
Litter	18.73	100.00		18.73		18	8	12	16	28	15	25	22	17	30	12	20	16	25	17
Bare soil	42.73	100.00		42.73		55	58	46	44	22	46	31	14	35	30	50	57	53	56	44
Rock	2.27	53.33		2.27		3	1		4		5	2		2			9		8	
TOTALS	100.0			102.2		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
TOTAL VEGETATION COVER	35.9 (s=13.4)		100.0	38.1 (s=15.2)	100.0	23	33(3)	42(4)	35	50(3)	34(2)	42	64(7)	44(7)	40(1)	37(2)	13	31(1)	11	39(3)
GROUND COVER (Litter+Rock+Veg+St.Dead)	57.3			59.5		45	42(3)	54(4)	56	78(3)	54(2)	69	86(7)	65(7)	70(1)	50(2)	43	47(1)	44	56(3)
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 27.5 Std.Dev.= 3.2)						28	21	28	31	28	26	28	33	28	26	28	22	27	26	32

^a First Hit Cover = Absolute percent cover in vertical view with no account of plants obscured by first (i.e. top) hit.

^b Frequency = Percent of the samples in which a species or lifeform occurred

^c First Hit Relative Cover = Percent of the First Hit vegetation cover comprised of this species or lifeform

^d All Hit Cover = Absolute percent cover in vertical view accounting for all cover by the species or lifeform, whether over-arched by other plants or not

^e All Hit Relative Cover = Percent of the All Hit vegetation cover comprised of the species or lifeform

***P=Present within 1m. on either side of cover transect, but not quantitatively encountered.**
()=Data in parentheses represent other hits that are used in conjunction with first hits for all hit cover statistics.

Table 3: Work Package S2 on Midway-Shale Complex; Shingle Series Soils (Soil Group D)

PLANT SPECIES	FIRST HIT		FIRST HIT		ALL HIT		Percent Foliar Cover*									
	AVERAGE		RELATIVE		RELATIVE											
	COVER ^a	FREQUENCY ^b	VEGETATION	COVER ^c	AVERAGE	VEGETATION	---Sample Number---									
							1	2	3	4	5	6	7	8	9	10
NATIVE ANNUAL & BIENNIAL FORBS																
Amaranthus albus	0.00	50.00	0.00	0.00	0.00	0.00			P	P	P	P				P
Amaranthus blitoides	0.20	20.00	0.77	0.20	0.74	0.74			P							2
Atriplex saccaria	0.00	10.00	0.00	0.00	0.00	0.00										P
Chamaesyce sp.	0.40	80.00	1.53	0.40	1.49	1.49	P		1	P	P		P	3	P	P
Cryptantha sp.	0.10	10.00	0.38	0.10	0.37	0.37								1		
Descurainia incana	0.00	40.00	0.00	0.00	0.00	0.00			P	P			P			P
Descurainia pinnata	0.00	30.00	0.00	0.00	0.00	0.00	P							P	P	
Dyssodia aurea	0.30	40.00	1.15	0.30	1.12	1.12	2		P	1			P			
Dyssodia papposa	0.20	90.00	0.77	0.20	0.74	0.74	P	P	1	P	1	P		P	P	P
Helianthus annuus	0.00	10.00	0.00	0.00	0.00	0.00									P	
Linum puberulum	0.00	10.00	0.00	0.00	0.00	0.00								P		
Oenothera villosa	0.00	10.00	0.00	0.00	0.00	0.00			P							
Oonopsis foliosa	0.00	30.00	0.00	0.00	0.00	0.00			P	P						P
Ximenesia encelioides	0.10	60.00	0.38	0.10	0.37	0.37		P	P	P	P			P		1
TOTAL NATIVE ANN. & BIEN. FORBS	1.3	100.0	5.0	1.3	4.8	4.8	2	P	2	1	1	P	P	4	P	3
INTRODUCED ANNUAL & BIENNIAL FORBS																
Amaranthus hybridus	0.00	10.00	0.00	0.00	0.00	0.00										P
Amaranthus retroflexus	0.10	50.00	0.38	0.10	0.37	0.37			P		P		1	P		P
Bassia sieversiana	3.80	80.00	14.56	3.80	14.13	14.13	P	1	8	3	6	P			2	18
Halogeton glomeratus	0.00	20.00	0.00	0.00	0.00	0.00	P	P								
Lactuca serriola	0.00	10.00	0.00	0.00	0.00	0.00								P		
Lappula redowskii	0.00	30.00	0.00	0.00	0.00	0.00			P				P			P
Malva neglecta	0.00	10.00	0.00	0.00	0.00	0.00					P					
Melilotus officinalis	0.00	30.00	0.00	0.00	0.00	0.00			P				P	P		
Salsola australis	0.50	60.00	1.92	0.60	2.23	2.23		P	(1)	3	2	P				P
Salsola collina	8.70	100.00	33.33	8.80	32.71	32.71	8	23	3	5(1)	5	28	3	4	5	3
Tribulus terrestris	0.30	40.00	1.15	0.30	1.12	1.12			P	P	1					2
Verbascum thapsus	0.00	10.00	0.00	0.00	0.00	0.00									P	
TOTAL INTRO. ANN. & BIEN. FORBS	13.4	100.0	51.3	13.6	50.6	50.6	8	24	11(1)	11(1)	14	28	4	4	7	23
NATIVE ANNUAL GRASSES																
Panicum capillare	0.10	50.00	0.38	0.10	0.37	0.37		1	P		P	P			P	
TOTAL NATIVE ANN. GRASSES	0.1	50.0	0.4	0.1	0.4	0.4	---	1	P	---	P	P	---	---	P	---
INTRODUCED ANNUAL GRASSES																

PLANT SPECIES	FIRST HIT		FIRST HIT	ALL HIT		Percent Foliar Cover*									
	AVERAGE		RELATIVE	AVERAGE											
	COVER ^a	FREQUENCY ^b	COVER ^c	COVER ^d	COVER ^e	---Sample Number---									
	(%)	(%)	(%)	(%)	(%)	1	2	3	4	5	6	7	8	9	10
Digitaria sanguinalis	0.10	50.00	0.38	0.10	0.37	P			P	P	1				P
Sorghum halepense	0.00	30.00	0.00	0.00	0.00		P	P							P
TOTAL INTRO. ANN. GRASSES	0.1	70.0	0.4	0.1	0.4	P	P	P	P	P	1	---	---	---	P
NATIVE PERENNIAL FORBS															
Astragalus agrestis	0.00	10.00	0.00	0.00	0.00								P		
Astragalus racemosus	0.00	10.00	0.00	0.00	0.00							P			
Astragalus shortianus	0.00	20.00	0.00	0.00	0.00								P		P
Chamaesaracha coronopus	0.10	30.00	0.38	0.10	0.37	1		P				P			
Gaura coccinea	0.00	10.00	0.00	0.00	0.00								P		
Glandularia bipinnatifida	0.00	60.00	0.00	0.00	0.00	P		P		P			P	P	P
Linum lewisii	0.00	20.00	0.00	0.00	0.00			P				P			
Oxybaphus linearis	0.00	10.00	0.00	0.00	0.00										P
Packera plattensis	0.00	10.00	0.00	0.00	0.00		P								
Physaria sp.	0.00	60.00	0.00	0.10	0.37	P		P	(1)	P			P		P
Quincula lobata	0.00	10.00	0.00	0.00	0.00					P					
Rorippa sp.	0.00	40.00	0.00	0.00	0.00	P		P				P			P
Rumex sp.	0.00	10.00	0.00	0.00	0.00								P		
Solidago sp.	0.00	10.00	0.00	0.00	0.00	P									
Sphaeralcea angustifolia	0.00	20.00	0.00	0.00	0.00	P									P
Sphaeralcea coccinea	0.00	60.00	0.00	0.00	0.00	P		P	P				P	P	P
Zinnia grandiflora	0.00	20.00	0.00	0.00	0.00		P	P							
TOTAL NATIVE PERENNIAL FORBS	0.1	90.0	0.4	0.2	0.7	1	P	P	(1)	P	---	P	P	P	P
INTRODUCED PERENNIAL FORBS															
Taraxacum officinale	0.00	20.00	0.00	0.00	0.00	P								P	
Trifolium pratense	0.00	20.00	0.00	0.00	0.00					P	P				
TOTAL INTRO. PERENNIAL FORBS	0.0	40.0	0.0	0.0	0.0	P	---	---	---	P	P	---	---	P	---
NATIVE PERENNIAL GRASSES (cool)															
Pascopyrum smithii	3.10	100.00	11.88	3.30	12.27	3(1)	1	3	2	9(1)	2	1	6	3	1
TOTAL NATIVE PERENNIAL GRASSES (c)	3.1	100.0	11.9	3.3	12.3	3(1)	1	3	2	9(1)	2	1	6	3	1
INTRODUCED PERENNIAL GRASSES (cool)															
Echinochloa crus-galli	0.00	90.00	0.00	0.00	0.00	P	P	P	P	P	P	P	P		P
Setaria viridis	0.00	10.00	0.00	0.00	0.00									P	
Thinopyrum intermedium	0.00	30.00	0.00	0.00	0.00		P			P				P	
TOTAL INTRO. PERENNIAL GRASSES (c)	0.0	100.0	0.0	0.0	0.0	P	P	P	P	P	P	P	P	P	P

PLANT SPECIES	FIRST HIT		FIRST HIT	ALL HIT		Percent Foliar Cover*									
	AVERAGE		RELATIVE	AVERAGE											
	COVER ^a	FREQUENCY ^b	VEGETATION COVER ^c	COVER ^d	RELATIVE VEGETATION COVER ^e	---Sample Number---									
	(%)	(%)	(%)	(%)	(%)	1	2	3	4	5	6	7	8	9	10
NATIVE PERENNIAL GRASSES (warm)															
Aristida purpurea	0.00	20.00	0.00	0.00	0.00					P			P		
Bouteloua curtipendula	1.50	100.00	5.75	1.50	5.58	2	2	1	4	1	P	1	1	1	2
Chondrosum gracile	2.10	90.00	8.05	2.20	8.18	3(1)	2	3	7	1		1	1	P	3
Leptochloa dubia	0.00	10.00	0.00	0.00	0.00				P						
Pleuraphis jamesii	1.50	100.00	5.75	1.60	5.95	3	2	2	P	1	P	1	2	1	3(1)
Sporobolus airoides	2.20	100.00	8.43	2.30	8.55	P	1	1	2	5(1)	1	2	3	3	4
Sporobolus cryptandrus	0.40	80.00	1.53	0.40	1.49	P	P	3	P			1	P	P	P
TOTAL NATIVE PERENNIAL GRASSES (w)	7.7	100.0	29.5	8.0	29.7	8(1)	7	10	13	8(1)	1	6	7	5	12(1)
INTRODUCED PERENNIAL GRASSES (warm)															
Bothriochloa sp.	0.00	20.00	0.00	0.00	0.00			P							P
TOTAL INTRO. PERENNIAL GRASSES (w)	0.0	20.0	0.0	0.0	0.0	---	---	P	---	---	---	---	---	---	P
INTRODUCED SUBSHRUBS															
Lespedeza cuneata	0.00	10.00	0.00	0.00	0.00					P					
TOTAL INTRODUCED SUBSHRUBS	0.0	10.0	0.0	0.0	0.0	---	---	---	---	P	---	---	---	---	---
NATIVE SHRUBS															
Artemisia tridentata	0.00	10.00	0.00	0.00	0.00								P		
Atriplex canescens	0.00	20.00	0.00	0.00	0.00				P	P					
Eriogonum effusum	0.10	10.00	0.38	0.10	0.37								1		
Krascheninnikovia lanata	0.00	10.00	0.00	0.00	0.00				P						
TOTAL NATIVE SHRUBS	0.1	30.0	0.4	0.1	0.4	---	---	---	P	P	---	---	1	---	---
NATIVE TREES															
Populus sp.	0.00	10.00	0.00	0.00	0.00									P	
TOTAL NATIVE TREES	0.0	10.0	0.0	0.0	0.0	---	---	---	---	---	---	---	---	P	---
LICHENS															
Lichen	0.00	10.00	0.00	0.00	0.00								P		
TOTAL LICHENS	0.0	10.0	0.0	0.0	0.0	---	---	---	---	---	---	---	P	---	---
AGAVOIDS															
Yucca glauca	0.20	10.00	0.77	0.20	0.74									2	
TOTAL AGAVOIDS	0.2	10.0	0.8	0.2	0.7	---	---	---	---	---	---	---	2	---	---
Standing dead	0.20	20.00		0.20		1	1								

PLANT SPECIES	FIRST HIT		FIRST HIT	ALL HIT	ALL HIT	Percent Foliar Cover*									
	AVERAGE		RELATIVE	AVERAGE	RELATIVE										
	COVER ^a	FREQUENCY ^b	VEGETATION	COVER ^d	VEGETATION	---Sample Number---									
	(%)	(%)	COVER ^c	(%)	COVER ^e	1	2	3	4	5	6	7	8	9	10
Litter	26.50	100.00		26.50		24	28	10	27	34	26	33	35	30	18
Bare soil	45.40	100.00		45.40		51	37	61	45	33	42	55	40	51	39
Rock	1.80	90.00		1.80		2	1	3	1	1		1	1	4	4
TOTALS	100.0			100.8		100	100	100	100	100	100	100	100	100	100
TOTAL VEGETATION COVER	26.1 (s=8.5)		100.0	26.9 (s=8.8)	100.0	22(2)	33	26(1)	27(2)	32(2)	32	11	24	15	39(1)
GROUND COVER (Litter+Rock+Veg+St.Dead)	54.6			55.4		49(2)	63	39(1)	55(2)	67(2)	58	45	60	49	61(1)
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 23.6 Std.Dev.= 6.3)						23	18	33	24	25	14	18	29	20	32

^a First Hit Cover = Absolute percent cover in vertical view with no account of plants obscured by first (i.e. top) hit.

^b Frequency = Percent of the samples in which a species or lifeform occurred

^c First Hit Relative Cover = Percent of the First Hit vegetation cover comprised of this species or lifeform

^d All Hit Cover = Absolute percent cover in vertical view acccounting for all cover by the species or lifeform, whether over-arched by other plants or not

^e All Hit Relative Cover = Percent of the All Hit vegetation cover comprised of the species or lifeform

*P=Present within 1m. on either side of cover transect, but not quantitatively encountered.
()=Data in parentheses represent other hits that are used in conjunction with first hits for all hit cover statistics.

Table 4: Work Package S2 on Recent Alluvium, Moderate Texture and Salt Content (Soil Group F)

PLANT SPECIES	FIRST HIT		FIRST HIT	ALL HIT		Percent Foliar Cover*									
	AVERAGE		RELATIVE	AVERAGE											
	COVER ^a	FREQUENCY ^b	VEGETATION	COVER ^d	VEGETATION	---Sample Number---									
	(%)	(%)	(%)	(%)	(%)	1	2	3	4	5	6	7	8	9	10
NATIVE ANNUAL & BIENNIAL FORBS															
Ambrosia artemisiifolia var. elatior	0.00	10.00	0.00	0.00	0.00					P					
Anoda cristata	0.00	10.00	0.00	0.00	0.00			P							
Chamaesyce sp.	0.90	100.00	2.33	0.90	2.14	1	1	1	P	1	1	1	3	P	P
Descurainia incana	0.00	10.00	0.00	0.00	0.00						P				
Descurainia pinnata	0.00	20.00	0.00	0.00	0.00		P						P		
Dyssodia aurea	0.50	60.00	1.29	0.50	1.19	2			P	P	1	1			1
Dyssodia papposa	0.40	70.00	1.03	0.40	0.95		1	2	1		P		P	P	P
Helianthus annuus	0.20	50.00	0.52	0.20	0.48		P		1	P			P		1
Oenothera villosa	0.00	20.00	0.00	0.00	0.00						P				P
Oonopsis foliosa	0.00	20.00	0.00	0.10	0.24						P				(1)
Poinsettia dentata	0.00	40.00	0.00	0.00	0.00		P	P	P	P					
Solanum rostratum	0.20	90.00	0.52	0.20	0.48	P	P		1	P	P	P	P	P	1
Solanum triflorum	0.00	10.00	0.00	0.00	0.00	P									
Ximenesia encelioides	1.60	90.00	4.13	1.60	3.81	2	5	1	3	P	P	P	4	1	
TOTAL NATIVE ANN. & BIEN. FORBS	3.8	100.0	9.8	3.9	9.3	5	7	4	6	1	2	2	7	1	3(1)
INTRODUCED ANNUAL & BIENNIAL FORBS															
Amaranthus hybridus	0.00	10.00	0.00	0.00	0.00					P					
Amaranthus retroflexus	0.00	20.00	0.00	0.00	0.00		P				P				
Bassia sieversiana	3.10	100.00	8.01	3.40	8.10	1	5	2(1)	P	5	P	4	10	2(2)	2
Erodium cicutarium	0.00	10.00	0.00	0.00	0.00								P		
Halogeton glomeratus	0.00	20.00	0.00	0.00	0.00							P			P
Hibiscus trionum	0.00	10.00	0.00	0.00	0.00									P	
Lactuca serriola	0.00	40.00	0.00	0.00	0.00		P	P	P				P		
Melilotus officinalis	0.00	20.00	0.00	0.00	0.00	P				P					
Salsola australis	1.10	70.00	2.84	1.20	2.86	2		2	P	1(1)	P	2		4	
Salsola collina	1.00	80.00	2.58	1.10	2.62	1	1(1)			1	P	P	1	4	2
Sonchus asper	0.00	20.00	0.00	0.00	0.00			P	P						
Tragopogon dubius ssp. major	0.10	10.00	0.26	0.10	0.24						1				
Xanthium strumarium	0.00	10.00	0.00	0.00	0.00		P								
TOTAL INTRO. ANN. & BIEN. FORBS	5.3	100.0	13.7	5.8	13.8	4	6(1)	4(1)	P	7(1)	1	6	11	10(2)	4
NATIVE ANNUAL GRASSES															
Cenchrus longispinus	0.00	10.00	0.00	0.00	0.00				P						
Panicum capillare	0.20	60.00	0.52	0.20	0.48		P	P		P		1	P		1
TOTAL NATIVE ANN. GRASSES	0.2	70.0	0.5	0.2	0.5	---	P	P	P	P	---	1	P	---	1

PLANT SPECIES	FIRST HIT		FIRST HIT		ALL HIT		Percent Foliar Cover*									
	AVERAGE		RELATIVE		AVERAGE											
	COVER ^a	FREQUENCY ^b	COVER ^c		COVER ^d	COVER ^e	---Sample Number---									
	(%)	(%)	(%)		(%)	(%)	1	2	3	4	5	6	7	8	9	10
INTRODUCED ANNUAL GRASSES																
Digitaria sanguinalis	0.50	100.00	1.29		0.50	1.19	P	P	2	2	1	P	P	P	P	P
TOTAL INTRO. ANN. GRASSES	0.5	100.0	1.3		0.5	1.2	P	P	2	2	1	P	P	P	P	P
NATIVE PERENNIAL FORBS																
Astragalus agrestis	0.00	20.00	0.00		0.00	0.00				P					P	
Astragalus racemosus	0.20	30.00	0.52		0.20	0.48			P						2	P
Astragalus shortianus	0.00	10.00	0.00		0.00	0.00				P						
Astragalus sp.	0.00	10.00	0.00		0.00	0.00							P			
Berlandiera lyrata	0.00	10.00	0.00		0.00	0.00			P							
Chamaesaracha coronopus	0.10	10.00	0.26		0.10	0.24								1		
Gaillardia pinnatifida	0.00	10.00	0.00		0.00	0.00						P				
Glandularia bipinnatifida	1.50	100.00	3.88		1.60	3.81	P	3(1)	2	P	P	1	P	3	P	6
Hedeoma drummondii	1.40	80.00	3.62		1.50	3.57	2	7		P	2	P	1	2(1)		P
Linum lewisii	0.00	40.00	0.00		0.00	0.00		P				P		P		P
Lomatium foeniculaceum	0.00	10.00	0.00		0.00	0.00										P
Oenothera sp.	0.00	10.00	0.00		0.00	0.00		P								
Physaria sp.	0.00	10.00	0.00		0.00	0.00										P
Quincula lobata	0.70	100.00	1.81		0.80	1.90	P	P	1	P	P	1	P	3(1)	1	1
Rorippa sp.	0.00	20.00	0.00		0.00	0.00			P			P				
Rumex sp.	0.00	20.00	0.00		0.00	0.00				P	P					
Solanum elaeagnifolium	0.10	10.00	0.26		0.10	0.24										1
Sphaeralcea angustifolia	1.80	100.00	4.65		2.20	5.24	2(1)	1	6(2)	P	1	1(1)	3	P	3	1
Sphaeralcea coccinea	0.20	90.00	0.52		0.20	0.48	P	P	P	P	P	P	P		1	1
TOTAL NATIVE PERENNIAL FORBS	6.0	100.0	15.5		6.7	16.0	4(1)	11(1)	9(2)	P	3	3(1)	4	9(2)	7	10
INTRODUCED PERENNIAL FORBS																
Cirsium arvense	0.00	10.00	0.00		0.00	0.00									P	
Convolvulus arvensis	0.10	50.00	0.26		0.10	0.24	P	1			P		P	P		
Rumex crispus	0.00	40.00	0.00		0.00	0.00				P		P		P	P	
Taraxacum officinale	0.10	20.00	0.26		0.10	0.24				P					1	
Trifolium pratense	0.00	10.00	0.00		0.00	0.00				P						
TOTAL INTRO. PERENNIAL FORBS	0.2	80.0	0.5		0.2	0.5	P	1	---	P	P	P	P	P	1	---
NATIVE PERENNIAL GRASSES (cool)																
Pascopyrum smithii	6.90	100.00	17.83		8.20	19.52	4	7(1)	14(1)	11(3)	3(1)	4(1)	10(3)	5(2)	9	2(1)
TOTAL NATIVE PERENNIAL GRASSES (c)	6.9	100.0	17.8		8.2	19.5	4	7(1)	14(1)	11(3)	3(1)	4(1)	10(3)	5(2)	9	2(1)

PLANT SPECIES	FIRST HIT		FIRST HIT	ALL HIT		Percent Foliar Cover*									
	AVERAGE		RELATIVE	AVERAGE											
	COVER ^a	FREQUENCY ^b	VEGETATION COVER ^c	COVER ^d	RELATIVE VEGETATION COVER ^e	---Sample Number---									
	(%)	(%)	(%)	(%)	(%)	1	2	3	4	5	6	7	8	9	10
INTRODUCED PERENNIAL GRASSES (cool)															
Echinochloa crus-galli	0.80	90.00	2.07	1.00	2.38	1	1	3(2)	1	1	P	P	P	1	
Thinopyrum intermedium	0.20	10.00	0.52	0.20	0.48		2								
TOTAL INTRO. PERENNIAL GRASSES (c)	1.0	90.0	2.6	1.2	2.9	1	3	3(2)	1	1	P	P	P	1	---
NATIVE PERENNIAL GRASSES (warm)															
Aristida purpurea	0.20	10.00	0.52	0.20	0.48									2	
Bouteloua curtipendula	4.80	100.00	12.40	5.00	11.90	1	4	9	7	1(1)	6	7	3(1)	7	3
Chondrosum gracile	2.90	100.00	7.49	3.00	7.14	3	3	7	1(1)	3	1	4	4	2	1
Muhlenbergia arenicola	0.00	10.00	0.00	0.00	0.00									P	
Pleuraphis jamesii	2.40	100.00	6.20	2.40	5.71	P	P	6	P	2	5	1	3	6	1
Sporobolus airoides	2.20	100.00	5.68	2.20	5.24	3	4	6	1	P	3	P	2	1	2
Sporobolus cryptandrus	2.10	100.00	5.43	2.30	5.48	2	8(1)	1(1)	P	4	P	2	3	1	P
TOTAL NATIVE PERENNIAL GRASSES (w)	14.6	100.0	37.7	15.1	36.0	9	19(1)	29(1)	9(1)	10(1)	15	14	15(1)	19	7
INTRODUCED PERENNIAL GRASSES (warm)															
Bothriochloa sp.	0.00	10.00	0.00	0.00	0.00			P							
TOTAL INTRO. PERENNIAL GRASSES (w)	0.0	10.0	0.0	0.0	0.0	---	---	P	---	---	---	---	---	---	---
INTRODUCED SUBSHRUBS															
Lespedeza cuneata	0.00	10.00	0.00	0.00	0.00				P						
TOTAL INTRODUCED SUBSHRUBS	0.0	10.0	0.0	0.0	0.0	---	---	---	P	---	---	---	---	---	---
NATIVE SHRUBS															
Atriplex canescens	0.10	80.00	0.26	0.10	0.24	P		P	P	P	P		P	1	P
TOTAL NATIVE SHRUBS	0.1	80.0	0.3	0.1	0.2	P	---	P	P	P	P	---	P	1	P
NATIVE TREES															
Populus sp.	0.00	30.00	0.00	0.00	0.00			P	P	P					
TOTAL NATIVE TREES	0.0	30.0	0.0	0.0	0.0	---	---	P	P	P	---	---	---	---	---
SUCCULENTS															
Cylindropuntia imbricata	0.10	10.00	0.26	0.10	0.24									1	
TOTAL SUCCULENTS	0.1	10.0	0.3	0.1	0.2	---	---	---	---	---	---	---	---	1	---
Standing dead	0.30	30.00		0.30		1						1	1		
Litter	21.70	100.00		21.70		27	19	13	28	18	21	40	17	20	14

PLANT SPECIES	FIRST HIT		FIRST HIT	ALL HIT	ALL HIT	Percent Foliar Cover*									
	AVERAGE		RELATIVE	AVERAGE	RELATIVE										
	COVER ^a	FREQUENCY ^b	VEGETATION COVER ^c	COVER ^d	VEGETATION COVER ^e	---Sample Number---									
	(%)	(%)	(%)	(%)	(%)	1	2	3	4	5	6	7	8	9	10
Bare soil	36.70	100.00		36.70		43	25	21	39	56	47	20	33	27	56
Rock	2.60	90.00		2.60		2	2	1	4		7	2	2	3	3
TOTALS	100.0			103.3		100	100	100	100	100	100	100	100	100	100
TOTAL VEGETATION COVER	38.7 (s=14.3)		100.0	42.0 (s=15.6)	100.0	27(1)	54(4)	65(7)	29(4)	26(3)	25(2)	37(3)	47(5)	50(2)	27(2)
GROUND COVER (Litter+Rock+Veg+St.Dead)	63.3			66.6		57(1)	75(4)	79(7)	61(4)	44(3)	53(2)	80(3)	67(5)	73(2)	44(2)
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 28.7 Std.Dev.= 3.0)						24	30	28	34	30	31	24	28	29	29

^a First Hit Cover = Absolute percent cover in vertical view with no account of plants obscured by first (i.e. top) hit.

^b Frequency = Percent of the samples in which a species or lifeform occurred

^c First Hit Relative Cover = Percent of the First Hit vegetation cover comprised of this species or lifeform

^d All Hit Cover = Absolute percent cover in vertical view accounting for all cover by the species or lifeform, whether over-arched by other plants or not

^e All Hit Relative Cover = Percent of the All Hit vegetation cover comprised of the species or lifeform

*P=Present within 1m. on either side of cover transect, but not quantitatively encountered.
()=Data in parentheses represent other hits that are used in conjunction with first hits for all hit cover statistics.

Appendix C: Site Photos – Work Package S2



Photograph 1. S2 on Penrose, Manvel and Minnequa series, Sample 1 - 2013



Photograph 2. S2 on Penrose, Manvel and Minnequa series, Sample 2 - 2013



Photograph 3. S2 on Penrose, Manvel and Minnequa series, Sample 3 - 2013



Photograph 4. S2 on Penrose, Manvel and Minnequa series, Sample 4 - 2013



Photograph 5. S2 on Penrose, Manvel and Minnequa series, Sample 5 - 2013



Photograph 6. S2 on Penrose, Manvel and Minnequa series, Sample 6 - 2013



Photograph7. S2 on Penrose, Manvel and Minnequa series, Sample 7 - 2013



Photograph 8. S2 on Penrose, Manvel and Minnequa series, Sample 8 - 2013



Photograph 9. S2 on Penrose, Manvel and Minnequa series, Sample 9 - 2013



Photograph 10. S2 on Penrose, Manvel and Minnequa series, Sample 10 - 2013



Photograph 11. S2 on Penrose, Manvel and Minnequa series, Sample 11 - 2013



Photograph 12. S2 on Penrose, Manvel and Minnequa series, Sample 12 - 2013



Photograph 13. S2 on Penrose, Manvel and Minnequa series, Sample 13 - 2013



Photograph 14. S2 on Penrose, Manvel and Minnequa series, Sample14 - 2013



Photograph 15. S2 on Penrose, Marvel and Minnequa series, Sample 15 - 2013



Photograph 16. S2 on Limon and Heldt series, Sample 1 - 2013



Photograph 17. S2 on Limon and Heldt series, Sample 2 - 2013



Photograph 18. S2 on Limon and Heldt series, Sample 3 - 2013



Photograph 19. S2 on Limon and Heldt series, Sample 4 - 2013



Photograph 20. S2 on Limon and Heldt series, Sample 5 - 2013



Photograph 21. S2 on Limon and Heldt series, Sample 6 - 2013



Photograph 22. S2 on Limon and Heldt series, Sample 7 - 2013



Photograph 23. S2 on Limon and Heldt series, Sample 8 - 2013



Photograph 24. S2 on Limon and Heldt series, Sample 9 - 2013



Photograph 25. S2 on Limon and Heldt series, Sample 10 - 2013



Photograph 26. S2 on Limon and Heldt series, Sample 11 - 2013



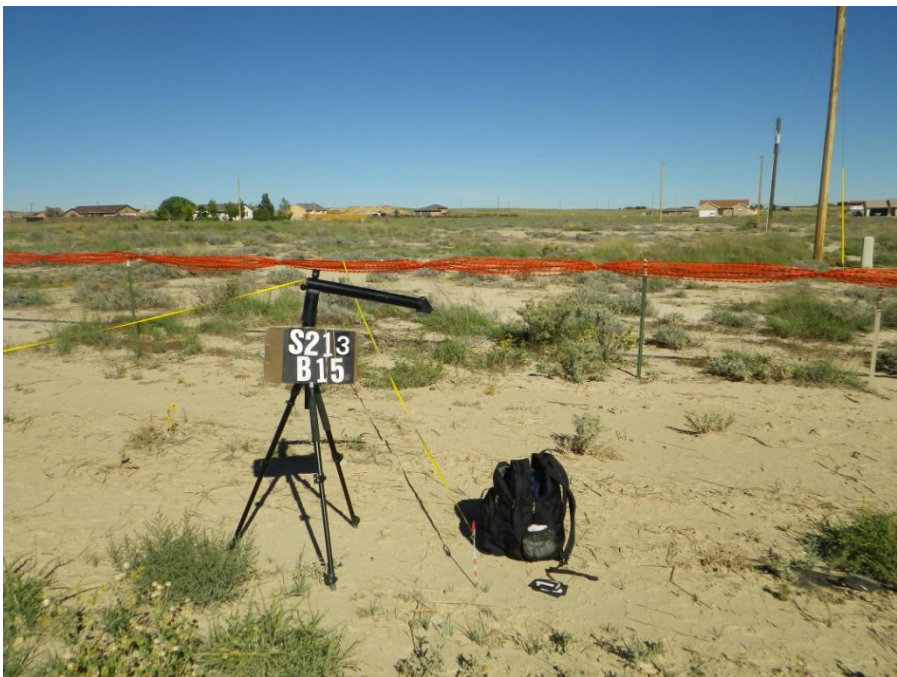
Photograph 27. S2 on Limon and Heldt series, Sample 12 - 2013



Photograph 28. S2 on Limon and Heldt series, Sample 13 - 2013



Photograph 29. S2 on Limon and Heldt series, Sample 14 - 2013



Photograph 30. S2 on Limon and Heldt series, Sample 15 - 2013



Photograph 31. S2 on Midway-Shale complex; Shingle series, Sample 1 - 2013



Photograph 32. S2 on Midway-Shale complex; Shingle series, Sample 2-2013



Photograph 33. S2 on Midway-Shale complex; Shingle series, Sample 3 - 2013



Photograph 34. S2 on Midway-Shale complex; Shingle series, Sample 4 - 2013



Photograph 35. S2 on Midway-Shale complex; Shingle series, Sample 5 - 2013



Photograph 36. S2 on Midway-Shale complex; Shingle series, Sample 6 - 2013



Photograph 37. S2 on Midway-Shale complex; Shingle series, Sample 7 - 2013



Photograph 38. S2 on Midway-Shale complex; Shingle series, Sample 8 - 2013



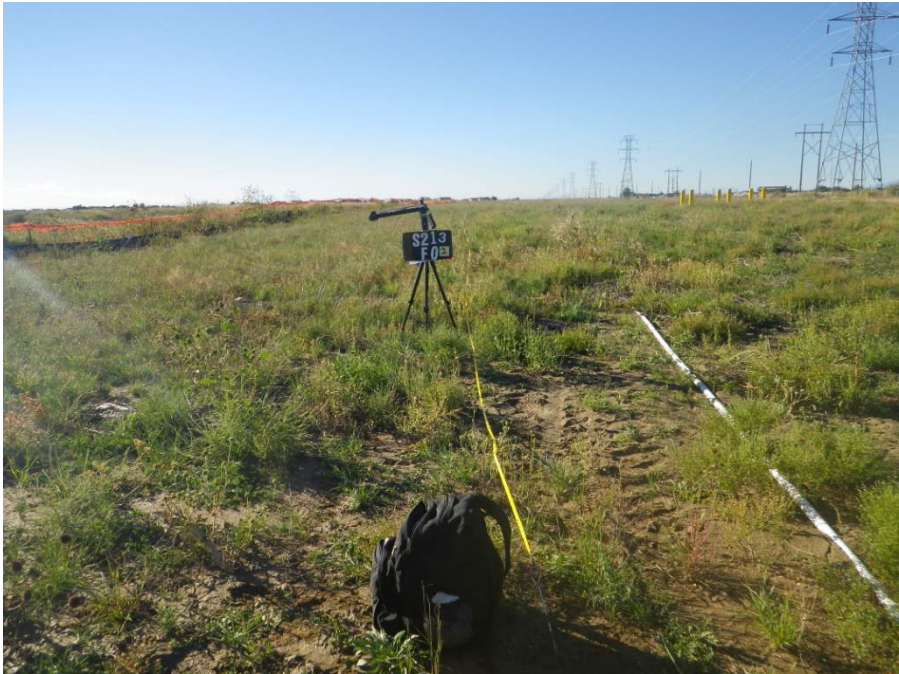
Photograph 39. S2 on Midway-Shale complex; Shingle series, Sample 9 - 2013



Photograph 40. S2 on Midway-Shale complex; Shingle series, Sample 10 - 2013



Photograph 41. S2 on Recent Alluvium, Moderate Texture and Salt, Sample 1



Photograph 42. S2 on Recent Alluvium, Moderate Texture and Salt, Sample 2



Photograph 43. S2 on Recent Alluvium, Moderate Texture and Salt, Sample 3



Photograph 44. S2 on Recent Alluvium, Moderate Texture and Salt, Sample 4



Photograph 45. S2 on Recent Alluvium, Moderate Texture and Salt, Sample 5



Photograph 46. S2 on Recent Alluvium, Moderate Texture and Salt, Sample 6



Photograph 47. S2 on Recent Alluvium, Moderate Texture and Salt, Sample 7



Photograph 48. S2 on Recent Alluvium, Moderate Texture and Salt, Sample 8



Photograph 49. S2 on Recent Alluvium, Moderate Texture and Salt, Sample 9



Photograph 50. S2 on Recent Alluvium, Moderate Texture and Salt, Sample 10

Appendix D: Established Vegetation Sampling Protocols

Technical Memo 1

Sampling Procedure for Point Intercept Cover and Seedling Density Data Collection

The following procedure establishes baseline levels of plant cover in areas affected by the Southern Delivery System Project and will be used to determine seedling density following revegetation.

Within an area that was disturbed, vegetation will be quantitatively sampled as described below to establish:

- 1) The percent cover by species as well as total vegetation cover and
- 2) Species richness

These data will provide a basis for assessment of the percent of vegetation cover re-established in post-revegetation evaluations.

Vegetation Unit Identification

As vegetation varies along the length of the proposed area of disturbance, variations in plant community at the “alliance” level of the US National Vegetation Classification system (FGDC 2008) will be documented. Association and alliance level classification is based on the premise that a vegetation type represents a group of stands that have similar plant composition and physiognomy enabling their recognition. Should such significant soil variation as might substantially affect plant cover growth potential be encountered within a single alliance in a particular reach, these will be subdivided and the number of sample measurements adjusted accordingly.

This mapping methodology addresses both the need to document natural variation in the pre-existing vegetation and the need to set plant cover standard levels consistent with the varying potentials of varying environments.

Sample Location

Samples will be placed in locations representative of the general vegetation type and condition.

Cover Sampling Methods

At each sample site, cover data will be collected using a point-intercept method in which data are tabulated as interceptions of a projected point with plant species, bare ground, litter, standing dead vegetation, or rock. The cover sampling points will be optically projected using a Cover-Point Optical Point Projection Device. Sampling will occur along 50 meter transects. At each meter from one to fifty along the transect, a point will be vertically projected from a location 50 centimeters (cm) to the left of the transect and a point will be vertically projected from a location 50 cm to the right of the transect (avoiding harm to vegetation along the tape itself). Thus, data from a total of 2 x 50, or 100 points will be recorded. Plant interceptions will be tallied by species upon interception of the projected point with any attached plant part

produced during the current growing season. "First hit" data (the first interception of any of the materials listed below) will be recorded. In addition to this, "additional hit" data (any additional live species intercepted between the first hit and the ground) will also be collected.

- Litter will be considered to be any organic material that had fallen, or had begun to fall to the soil surface.
- Standing dead vegetation will be any dead plant material that was produced in previous years but which was still standing and had not lodged or broken off to become litter.
- Rock will be considered to be any inorganic fragment with the largest diameter greater than or equal to 1 cm.
- Bare soil will be considered to be inorganic fragments with a diameter less than 1 cm largest diameter or organic debris too small to be of readily identifiable origin.

First hit interceptions will be used to calculate absolute top layer (first hit) foliar cover by dividing the number of interceptions for a particular species or material by the total number of points taken (100). First hit relative vegetation cover will be calculated by dividing first hit absolute cover for each species by the total first hit vegetation cover. All-layer absolute cover will be calculated by dividing all hits for particular species by the total number of points taken (100). In addition, all-layer relative cover will be calculated using all hits for particular species divided by the total vegetation hits accumulated during sampling of the transect.

Seedling Density Sampling (Post-Revegetation Analyses)

Seedlings of seeded or perennial plant species will be counted within randomly placed 0.5 square meters (5.37 square feet) circular plots. The results will be averaged and divided by 5.37 to obtain number of seedlings per square foot.

References

FGDC. 2008. Vegetation Classification Standard, Version 2. Federal Geographic Data Committee, Vegetation Subcommittee. FGDC Secretariat, U.S. Geological Survey. Reston, VA. FGDC-STD-005-2008 (Version 2). 62p. plus Appendices.

Technical Memo 3

Post-Revegetation Sampling

This Technical Memo describes the design and methodology CNHP will use to sample and quantitatively assess post-disturbance revegetation success. For the practicality of achieving an unbiased evaluation, the approach is based on random sampling and the use of resulting means to compare results to previously established performance standards. By the nature of plant growth in response to varying conditions along the length of the revegetated area, and by the nature of random sampling, variability in levels of plant abundance are to be expected both on the ground and in sample results. The use of 50 meter-long transects tends to encompass variability though a certain amount of variability can be expected at scales larger than this.

Creditable Vegetation Cover

Cover provided by plants included in the Colorado A-, B-, or C-list of noxious plant species, if any, will not be acceptable in the evaluation of cover. Cover by all other plants will be acceptable in assessment of adequate revegetation cover, except as follows: cover by non-native annual / biennial plants in excess of the relative cover by those plants in the pre-construction sample data will not be counted toward establishment of proof of successful revegetation (see below).

Maximum allowable relative cover by Introduced Annual and Biennial Species:

A. Soils Shallow over Shale and Limestone (Penrose, Manvel and Minnequa series; Tables 4, 7, and Samples 5, 7 and 8 of Table 8): **22.2 percent**

B. Soils on Clay-rich, Salt-affected Alluvial Material (Limon and Heldt series; Tables 1, 5, and 11): **2.6 percent**

C. Soils Deep on Early Pleistocene Alluvium (Stoneham and Cascajo series; Tables 10 and 15): **3.9 percent**

D. Soils on Weathered Shale (with active erosional removal) (Midway – Shale complex; Shingle series; Tables 9 and 13): **1.3 percent**

E. Soils on Deeply Weathered Shale (without active erosional removal) (Razor series; Table 14): **3.6 percent**

F. Soils on Recent Alluvium of Moderate Texture and Salt Content (Haverson series and Ustic Torrifluvents; Table 6 and 16): **16.7 percent**

Cover Sampling Method

Sampling to assess compliance with the standard of 90 percent of pre-existing cover will proceed separately within each work package (S1, S2 and S3) and separately within each soil functional group as identified during the pre-construction vegetation survey (see Technical Memo 2). All sample locations will be randomly located by delineating the soil functional groups in each work package in ESRI ArcMap GIS application and using the random point generation tool to place the correct number of random points in that area.

For sample units with a total (cumulative) length of one mile or less, ten (10) segments of equal length will be established and a randomly located and oriented sample placed in each. For units greater than one mile in cumulative length, fifteen (15) segments of equal length will be identified and a sample randomly located within each. Sample points will be located in the field using hand-held GPS units with coordinates of the random points pre-loaded.

In areas with total Soil Group length less than 0.1 mile, three (3) to five (5) samples will be made. Professional judgment will be used in these small sample areas (e.g. Soil Groups B and F in S3) to determine the location and number of samples collected.

Orientation of the 50-meter transect will be randomly selected by using a random number ranging from 1 to 360 as an azimuth. Sampling transects will not extend outside the Permanent Easement (PE), Temporary Construction Easement (TCE) or work limits areas. Should a boundary be encountered, a new orientation that remains within these limits will be chosen in the same manner. Ineligible sites (see below) will be excluded from sampling.

Sampling to assess compliance with the CDPHE criterion of 70 percent of pre-existing cover will proceed within separate work packages and soil reaches. If the 70 percent cover standard alone is being assessed, the sample intensity will be five (5) samples in reaches of one mile or less in cumulative length and eight (8) samples in those greater than one mile in cumulative length. Professional judgment will be used in small sample areas (e.g. Soil Groups B and F in S3) to determine the location and number of samples collected.

Informational Cover Composition Sampling Method

Data on species composition will be collected for informational purposes outside the scope of the 1041 permit requirements. Ten (10) 1 x1 meter plots will be placed at 5-meter intervals along the right side of the cover sampling transect (as viewed from the origin) beginning at the 5-meter mark. Within each of the resulting ten plots the presence of desirable species will be noted by species. For this purpose, desirable species will mean any seeded species plus any other native annual, biennial, or perennial species plus any non-native perennial species. Native will mean species noted as native in and occurring in the Southeast ¼ of Colorado in Biota of North America Project distribution mapping. The resulting frequency data will be tabulated by species. For example, if Species A is noted as present in 7 of the 10 plots it will have a frequency value of 70 percent.

Frequency values from all transects within a given soil group will then be averaged. For these evaluations, average frequency values by species will be used as follows: The average frequencies of all acceptable species will be summed. A sum for all desirable species present that equals or exceeds 200 percent will be deemed adequate evidence of successful establishment of acceptable species. This supplemental criterion addresses the reality that vegetation at the time of evaluation will still be juvenile. Many planted or otherwise desirable species grow slowly and though they may be only a small percentage of the total plant cover at the time of measurement, will eventually become more abundant. This frequency evaluation allows documentation of the presence of the desirable species sought in the long term vegetation cover.

Seedling Density

Seedlings of seeded or perennial plant species will be counted within randomly placed 0.5 square meter (5.37 square foot) circular plots. The results will be averaged and divided by 5.37 to obtain number of seedlings per square foot.

Plots will be thirty per Work Package/Soil Group area. All sample points will be randomly located via GIS-generated coordinates.

Sites Ineligible for Sampling

Areas within the revegetation zone in which the vegetation cover has been negatively affected by land management of private owners after SDS construction or for which a waiver has been executed/granted will be excluded from the sample universe (i.e., no samples will be placed in these areas). Within the disturbed alignment no sampling will occur on access roads, trails, above-ground SDS infrastructure, other above-ground public or private infrastructure, waterways, or other areas where sampling is determined not to be practical, safe or meaningful. Such areas will be manually delineated in the GIS and excluded from the eligible sampling area when creating the random point coverage.

Sampling Schedule

During the first growing season following seeding, seedling density data will be collected. At the end of the first growing season (typically September) cover data will be collected for the purpose of assessing compliance with the CDPHE Stormwater Permit criterion of 70 percent of pre-existing cover. If in the judgment of the SDS Program, the extent of vegetation cover at that time might also satisfy the 90 percent of pre-existing cover criterion, the full sampling design described above will be implemented. If only the CDPHE criterion is being tested, sample intensity within a work package will be five samples in soil reaches one mile or less in cumulative length and eight in those greater than one mile in cumulative length. During the second growing season, sampling intensity will be ten (10) samples in soil reaches one mile or less in cumulative length and fifteen (15) samples in those greater than one mile in cumulative length.

Hypothesis Testing

Statistical evaluation of the success of revegetation for each soil functional group within a work package will be tested via a one-sample t-test of the following null hypothesis:

The (traditional) null hypothesis being tested would be that the revegetated area mean (\bar{x}) is indistinguishable from 90 percent of the pre-existing cover, stated as $H_0: \bar{x} = Q$. If t_c is less than or equal to the 1-tailed t -table value for alpha error probability of 0.05, at $(n-1)$ degrees of freedom, then H_0 is accepted, and revegetation is deemed successful (i.e., indistinguishable from 90 percent of the standard).

The sample data will be evaluated for normality and transformed if appropriate. The formula for the one sample t-test is:

$$t_c = \frac{Q - \bar{x}}{S_{\bar{x}}}$$

Where: \bar{x} = Revegetated Area Sample Mean
 Q = 90 percent of pre-existing cover
 $S_{\bar{x}}$ = Standard error of mean [s/\sqrt{n}]
 s = Sample standard deviation
 n = Sample size
 t_c = Calculated t -value
 t_t = Table t -value (alpha = 0.05)

Photographic Documentation

Photo documentation will be conducted during the growing seasons and in conjunction with the point-intercept cover sampling. Photos will be taken at each transect location during all sampling. Photo points will be relocated using a handheld GPS receiver.

Colorado Springs Utilities Southern Delivery System

*Measurements of Post-restoration Vegetation Cover for Pueblo County
Work Package S3-12*



Prepared for:
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October, 2013

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**Cover Photo: Sample site 9 on Soil Group A (Penrose, Manuel and Minnequa Series) in work package S3-12
(by ESCO Assoc. Inc.)**



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Introduction

This report documents conditions of post-construction vegetation cover after the first growing season along the section of the Southern Delivery System (SDS) pipeline route in Pueblo County, Colorado, that was seeded and on which irrigation was initiated in 2012. This section is specifically labeled S3-12 and extends from Antelope Road northward to the end of work package S3.. The Colorado Natural Heritage Program, in cooperation with ESCO Associates, completed this post-construction survey under contract to Colorado Springs Utilities. This report compares post-construction vegetative cover values to the standards for revegetation prescribed by CDPHE Stormwater Regulations and the Pueblo County 1041 permit in order to evaluate revegetation success in this section. It also reports frequency-based quantitative measures of the presence of acceptable species in comparison to a pre-determined standard.

The following includes the methods used, the results, and a discussion of factors affecting vegetation cover on the sites after any construction activities. Maps, tabular data, and photographs of work package S3-12 are contained in separate Appendices A, B, and C, respectively. Appendix D includes applicable portions of the Pueblo County Revegetation Cover Establishment Protocols (Protocols).

The study area is in a tributary valley of the Arkansas River downstream (east) from its emergence from the mountain front. Along some reaches of the pipeline route, exposed shale and limestone are the predominant soil parent materials, while on other reaches recent alluvium predominates and on high terrace sites older deposits of Arkansas River alluvium in the form of sands and gravels predominate.

Methods

Assessment of Cover and the Presence of Acceptable Species in revegetated and irrigated areas along the SDS Pipeline in Pueblo County was completed in late September 2013 as per the Protocol developed for the project. Prior to this, in July 2013, the density of seedlings of acceptable species per square foot was assessed along these same reaches of revegetated right-of-way. The July assessment provided an early look into revegetation results, but the September 2013 effort included evaluation of two different parameters that were applicable to vegetation somewhat more mature than in July 2013.

The primary parameter assessed in the September work was percent cover by acceptable species as set forth in the Protocol. This measure relates to the Pueblo County 1041 permit requirement that cover on revegetated areas comprise at least 90% of pre-existing levels. It also relates to the requirement under CDPHE Stormwater Regulations that cover attains at least 70% of pre-existing levels. Pre-existing levels of cover on the Pueblo County work package reaches were established by quantitative sampling in October 2011 prior to construction. Further details on this pre-construction effort can be referenced in the 2011 report.

Beyond the return of adequate plant cover (detailed in the Protocol document), measures intended to provide Pueblo County with an evaluation of the adequate presence of Acceptable Species in the reconstructed vegetation were also made as per provisions in the Protocol. Acceptable species had been determined in consultation with the Pueblo County vegetation representative to include all native species and all introduced perennial species other than those included on the current State of Colorado A, B or C-lists of noxious species.

Beginning with the pre-construction vegetation surveys, results of sampling in this work package have been grouped by broad soil types. These groups, established to simplify the process, include soil series of similar nature as plant growth media. Within each soil type, sample transects (See Protocol Technical Memos 1 and 3, Appendix D) were placed at random locations in an effort to capture the variability of vegetative cover present. At each representative sample location, vegetation cover and ground cover were measured via observation at 100 locations spaced at 1 meter intervals along the transect length. Maps showing the extent of the soil groups present within the alignment of the work package and the location of sample transect origin points are included in Appendix A.

Results

A total of 31 transects were sampled in the work package S3-12 area during the post-construction survey. The various soils across the extent of the work package were grouped for simplicity into five units that differed in their nature as plant growth media and as to the means by which it will be necessary to salvage and replace them during construction. The five groups are as follows:

A. Soils Shallow over Shale and Limestone (Penrose, Manvel and Minnequa series; Table 1, Appendix B)

B. Soils on Clay-rich, Salt-affected Alluvial Material (Limon and Heldt series; Not Sampled)

C. Soils Deep on Early Pleistocene Alluvium (Stoneham and Cascajo series); Table 2, Appendix B)

E. Soils on Deeply Weathered Shales (without active erosional removal) (Razor series; Table 3, Appendix B)

F. Soils on Recent Alluvium of Moderate Texture and Salt Content (Haverson series and Ustic Torrifluvents; Not Sampled)

The distribution of these Soil Groups is indicated on the maps of S3-12 included in Appendix A.

Plant cover observed during sampling was related to the above soil groups and used to establish base values from which revegetation performance standards were calculated.

Base Cover Values for Evaluation of Revegetation Success

The following are base vegetation cover values (to be multiplied by 0.9 in accordance with the Protocol) that were measured pre-construction.

A. Soils Shallow over Shale and Limestone (Penrose, Manvel and Minnequa series): **17.2%**

B. Soils on Clay-rich, Salt-affected Alluvial Material (Limon and Heldt series): **Not Sampled**

C. Soils Deep on Early Pleistocene Alluvium (Stoneham and Cascajo series): **35.0%**

E. Soils on Deeply Weathered Shales (without active erosional removal) (Razor series): **23.3%**

F. Soils on Recent Alluvium of Moderate Texture and Salt Content (Haverson series and Ustic Torrifluvents): **Not Sampled**

Post Construction Results

Table 1 displays the base vegetation cover, revegetation cover values at the 90% and 70% levels (established under Pueblo Co. 1041 and CDPHE Stormwater Regulations, respectively), and the post-construction percent cover values by the respective soil groups. Figure 1 graphically represents this information. In soil groups A and E, post-construction vegetation cover exceeded the 90% revegetation performance standards. Soil Group C met neither the 70% nor the 90% revegetation standards. Note, however, that CDPHE cover expectations include all species present (including introduced annual species deemed partially unacceptable in Pueblo Co. evaluations). Soil Groups B and F constituted only 2.8% and 1.5%, respectively, of the S3-12 work package area. Sites within soil group F were flooded during the time of sampling and could not be assessed. The Soil Group B area at the far north end of S3 was partially disturbed by the tie-in to the S4AW work package and was not sampled in 2013.

Table 1: Vegetation Cover per Soil Group for S3-12

Map Code	Soil Group	% of Work Unit	% Base Veg. Cover	90% Revegetation Cover Performance Std. (0.9 x Base)	70% Revegetation Cover Performance Std. (0.7 x Base)	% Cover by Acc. Spp
A	Soils shallow over shale and limestone (Penrose, Manvel and Minnequa series)	13.1	17.2	15.5	12.1	42.0
B	Soils on clay-rich, salt affected alluvial material (Limon and Heldt Series)	2.8	NS	NS	NS	NS
C	Soils deep on early Pleistocene alluvium (Midway – shale complex; Shingle series)	47.2	35.0	31.5	24.5	23.2
E	Soils on deeply weathered shales (without active erosional removal) (Razor series)	35.6	23.3	21.0	16.3	28.6
F	Soils on recent alluvium of moderate texture and salt content (Haverson series and Ustic Torrifluvents)	1.3	NS	NS	NS	NS

NS = Not Sampled

Figure 1: Fall 2013 S3-12 SDS Pueblo Co. Restoration Cover Levels vs. 2014 Standards

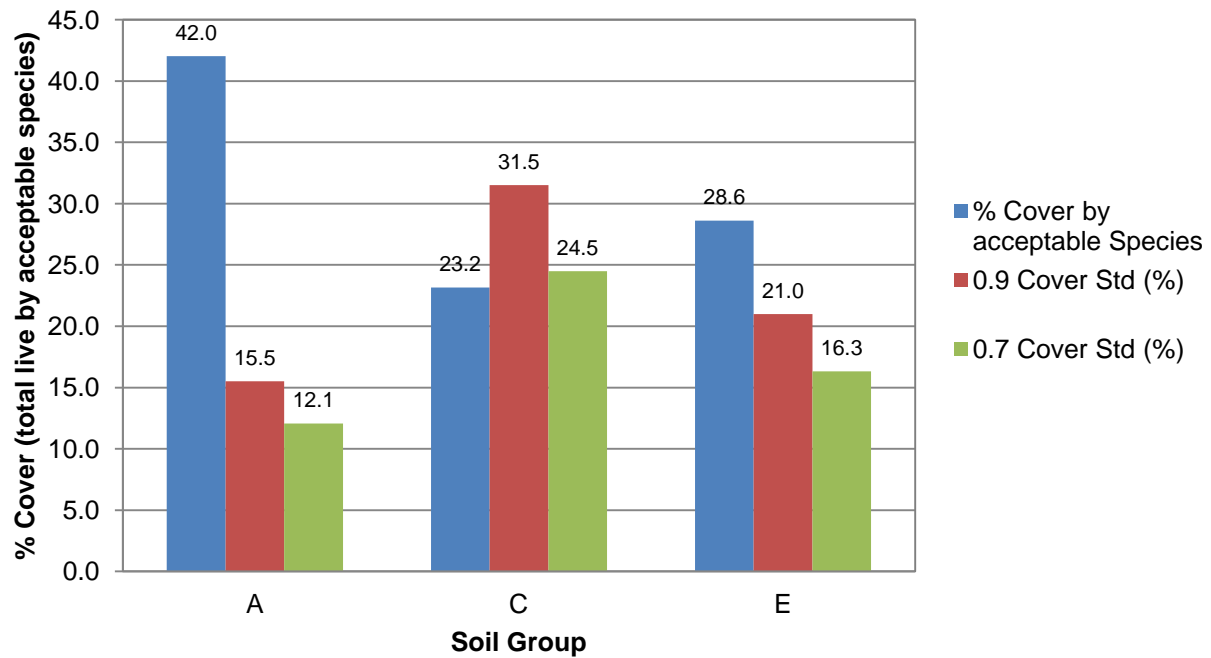


Figure 2: 2014 S3-12 SDS Pueblo Co. Presence of Acceptable Species

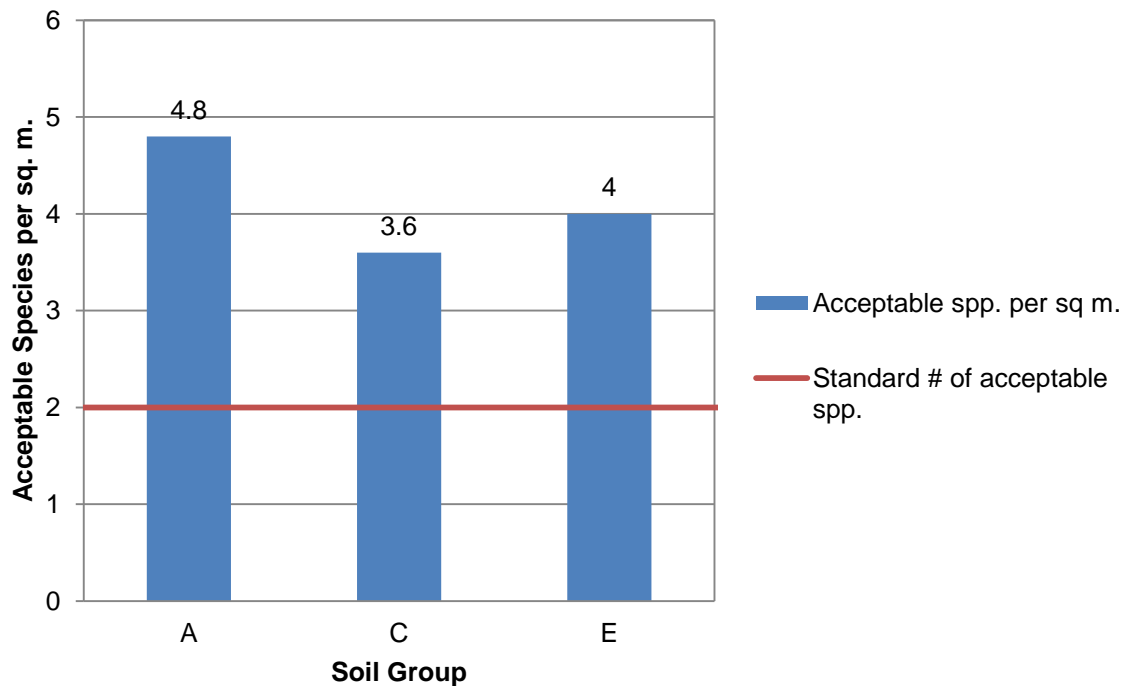


Figure 2 displays the number of acceptable species present on each soil type in S3-12 compared to the pre-established standard of 2 species per square meter. In all soil groups, the number of acceptable species present surpassed the standard.

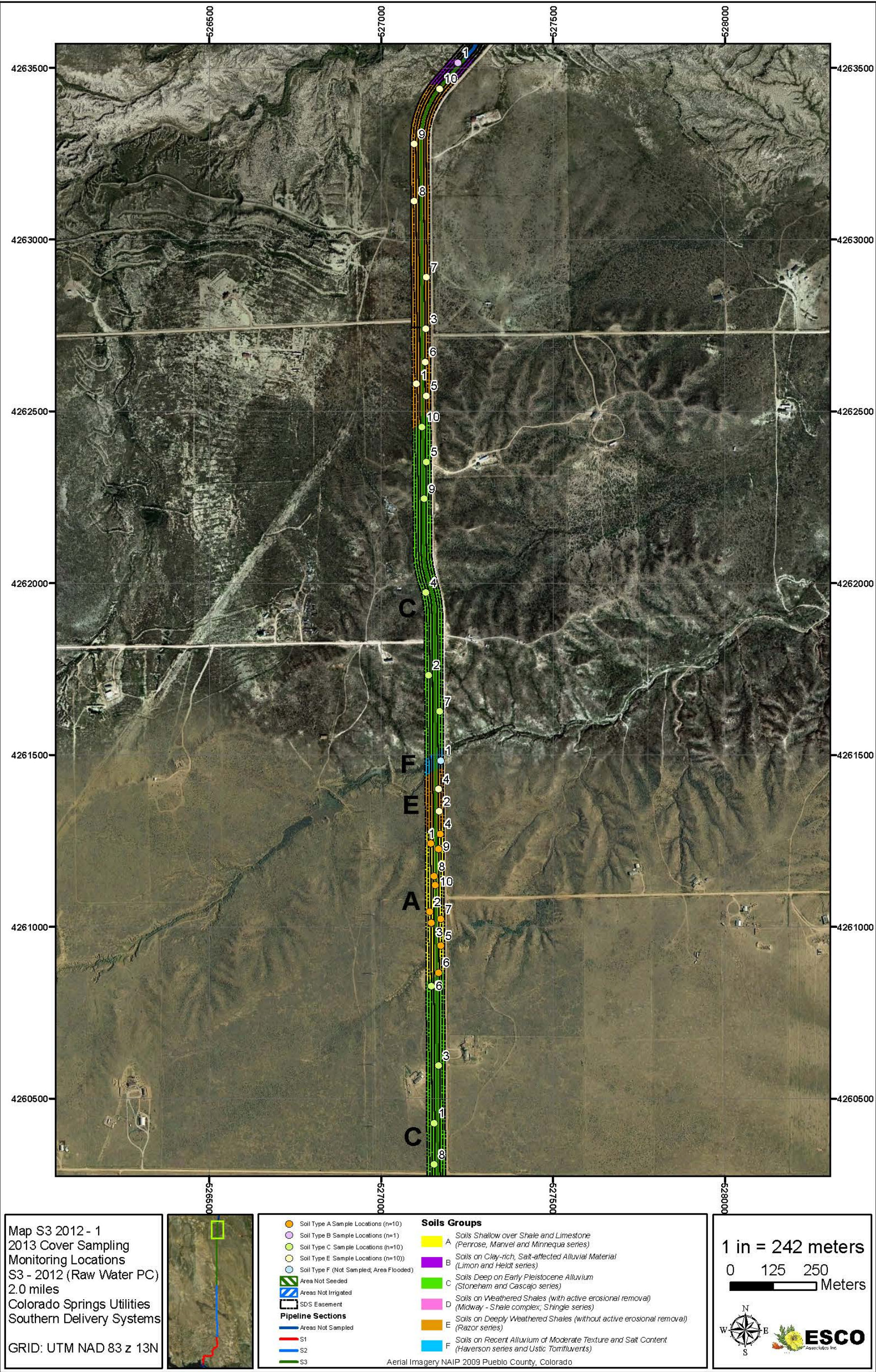
Discussion

Post-Construction Revegetation Performance

Not all sampled sites in S3-12 had reached the 70% CDPHE Stormwater Regulation standards or the 90% 1041 Pueblo County permit standards at the time of sampling. The portion not meeting the standard as of September 2013 was Soil Group C, comprised of well-developed soils that supported high total vegetation cover, but with much of this cover comprised of Russian thistle as of September 2013. Mean density of acceptable seedlings observed in July 2013 on these areas was greater than 5 per square foot. It is thought likely that the substantial grazing by local livestock has significantly reduced the presence of desirable species and allowed the Russian thistle to grow especially large. If the livestock grazing pressure can be controlled, the potential in 2014 for development of an adequate stand of vegetation here is present. If not, then the performance standards will not apply to this area as per provisions of the Protocols.

It should be noted that the 90% revegetation cover performance standards stated in the Pueblo County 1041 permit are applicable over a two-year period. The S3-12 measurements presented here were taken at the end of the first growing season (September 2013), and vegetation cover can be expected to increase over time. The number of acceptable species surpassed the standard (2 species) in all soil groups. This supports a conclusion that, even though not all areas of the S3-12 work package have reached the revegetation standard levels, species composition is moving in the right direction, though full achievement of target levels may be impossible if excessive livestock grazing continues in some of the areas.

Appendix A: Maps – Work Package S3-12



Appendix B: Tabular Data – Work Package S3-12

Table 1: Work Package S3-12 on Penrose, Manvel and Minnequa Series Soils (Soil Group A)

PLANT SPECIES	FIRST HIT		ALL HIT		Percent Foliar Cover*										
	AVERAGE COVER ^a (%)	FREQUENCY ^b (%)	RELATIVE VEGETATION COVER ^c (%)	AVERAGE COVER ^d (%)	RELATIVE VEGETATION COVER ^e (%)	---Sample Number---									
						1	2	3	4	5	6	7	8	9	10
NATIVE ANNUAL & BIENNIAL FORBS															
Amaranthus albus	2.70	90.00	5.48	2.80	5.05	7	P	1(1)	P	3		P	3	5	8
Amaranthus blitoides	0.20	60.00	0.41	0.20	0.36		P			P		P	P	2	P
Chamaesyce sp.	0.00	10.00	0.00	0.00	0.00							P			
Chenopodium incanum	0.00	30.00	0.00	0.00	0.00		P			P		P			
Conyza canadensis	0.00	10.00	0.00	0.00	0.00					P					
Cryptantha sp.	0.00	20.00	0.00	0.00	0.00				P						P
Dyssodia aurea	0.70	100.00	1.42	0.70	1.26	P	3	P	1	P	P	1	1	1	P
Dyssodia papposa	0.10	40.00	0.20	0.10	0.18		P			P	P	1			
Helianthus annuus	0.80	90.00	1.62	0.90	1.62		P	2	1	5	P	P	P	P	(1)
Mentzlia multiflora	0.40	50.00	0.81	0.50	0.90		P	1		2(1)		1			P
Polanisia dodecandra	0.00	90.00	0.00	0.00	0.00	P		P	P	P	P	P	P	P	P
Solanum rostratum	0.10	70.00	0.20	0.10	0.18		1	P	P	P	P	P	P		
Solanum triflorum	0.00	20.00	0.00	0.00	0.00					P				P	
Ximenesia encelioides	0.10	60.00	0.20	0.10	0.18	P			P			P	P	1	P
TOTAL NATIVE ANN. & BIEN. FORBS	5.1	100.0	10.3	5.4	9.7	7	4	4(1)	2	10(1)	P	3	4	9	8(1)
INTRODUCED ANNUAL & BIENNIAL FORBS															
Amaranthus hybridus	0.00	20.00	0.00	0.00	0.00									P	P
Amaranthus retroflexus	0.00	10.00	0.00	0.00	0.00	P									
Bassia sieversiana	1.20	60.00	2.43	1.40	2.52	1	4		2	1(1)	1	3(1)			
Chenopodium album	0.10	60.00	0.20	0.10	0.18	P		1	P				P	P	P
Malva neglecta	0.00	20.00	0.00	0.00	0.00			P		P					
Melilotus officinalis	0.80	80.00	1.62	0.90	1.62	P	P	P	1		7(1)	P	P		P
Salsola australis	1.40	10.00	2.84	1.50	2.70			14(1)							
Salsola collina	16.20	90.00	32.86	16.60	29.91	13	21(1)		36	17	13(1)	20(2)	15	9	18
TOTAL INTRO. ANN. & BIEN. FORBS	19.7	100.0	40.0	20.5	36.9	14	25(1)	15(1)	39	18(1)	21(2)	23(3)	15	9	18
NATIVE ANNUAL GRASSES															
Cenchrus longispinus	0.00	10.00	0.00	0.00	0.00										P
Munroa squarrosa	0.00	60.00	0.00	0.00	0.00	P	P	P				P	P		P
Panicum capillare	0.00	80.00	0.00	0.00	0.00	P	P			P	P	P	P	P	P
TOTAL NATIVE ANN. GRASSES	0.0	90.0	0.0	0.0	0.0	P	P	P	---	P	P	P	P	P	P
INTRODUCED ANNUAL GRASSES															
Bromus japonicus	0.00	10.00	0.00	0.00	0.00						P				
Digitaria ischaemum	0.00	10.00	0.00	0.00	0.00							P			
			FIRST HIT		ALL HIT										

FIRST HIT

ALL HIT

PLANT SPECIES	FIRST HIT		RELATIVE	ALL HIT	RELATIVE	Percent Foliar Cover*									
	AVERAGE	FREQUENCY ^b	VEGETATION	AVERAGE	VEGETATION										
	COVER ^a		COVER ^c	COVER ^d	COVER ^e	---Sample Number---									
	(%)	(%)	(%)	(%)	(%)	1	2	3	4	5	6	7	8	9	10
Digitaria sanguinalis	0.00	40.00	0.00	0.00	0.00				P				P	P	P
TOTAL INTRO. ANN. GRASSES	0.0	60.0	0.0	0.0	0.0	---	---	---	P	---	P	P	P	P	P
NATIVE PERENNIAL FORBS															
Ambrosia confertiflora	0.10	20.00	0.20	0.10	0.18					P					1
Astragalus agrestis	0.00	20.00	0.00	0.00	0.00	P			P						
Astragalus shortianus	0.00	20.00	0.00	0.00	0.00					P					P
Astragalus sp.	0.00	20.00	0.00	0.00	0.00				P						P
Berlandiera lyrata	0.00	20.00	0.00	0.00	0.00						P	P			
Chamaesaracha coronopus	0.00	20.00	0.00	0.00	0.00	P			P						
Glandularia bipinnatifida	0.00	60.00	0.00	0.00	0.00		P	P		P		P	P	P	
Hedeoma drummondii	0.00	10.00	0.00	0.00	0.00								P		
Heterotheca villosa	0.00	20.00	0.00	0.00	0.00		P				P				
Lesquerella montana	0.00	10.00	0.00	0.00	0.00							P			
Oligosporus dracunculus ssp. glaucus	0.10	50.00	0.20	0.10	0.18	P			P				P	1	P
Quincula lobata	0.00	40.00	0.00	0.00	0.00	P	P		P			P			
Solanum elaeagnifolium	0.10	10.00	0.20	0.10	0.18			1							
Solidago sp.	0.00	10.00	0.00	0.00	0.00					P					
Sphaeralcea coccinea	0.10	70.00	0.20	0.20	0.36	P		1		P	(1)	P	P	P	
TOTAL NATIVE PERENNIAL FORBS	0.4	100.0	0.8	0.5	0.9	P	P	2	P	P	(1)	P	P	1	1
INTRODUCED PERENNIAL FORBS															
Convolvulus arvensis	0.00	10.00	0.00	0.00	0.00					P					
Rumex crispus	0.00	10.00	0.00	0.00	0.00								P		
TOTAL INTRO. PERENNIAL FORBS	0.0	20.0	0.0	0.0	0.0	---	---	---	---	P	---	---	P	---	---
NATIVE PERENNIAL GRASSES (cool)															
Pascopyrum smithii	7.00	100.00	14.20	10.20	18.38	1(1)	6(6)	9(5)	6(4)	22(8)	14(2)	5(4)	1(1)	3(1)	3
TOTAL NATIVE PERENNIAL GRASSES (c)	7.0	100.0	14.2	10.2	18.4	1(1)	6(6)	9(5)	6(4)	22(8)	14(2)	5(4)	1(1)	3(1)	3
INTRODUCED PERENNIAL GRASSES (cool)															
Bromopsis inermis	0.00	10.00	0.00	0.00	0.00				P						
Echinochloa crus-galli	0.20	90.00	0.41	0.20	0.36	P		1	P	P	1	P	P	P	P
Setaria viridis	0.00	40.00	0.00	0.00	0.00		P			P	P	P			
Thinopyrum intermedium	0.20	10.00	0.41	0.20	0.36				2						
TOTAL INTRO. PERENNIAL GRASSES (c)	0.4	100.0	0.8	0.4	0.7	P	P	1	2	P	1	P	P	P	P
NATIVE PERENNIAL GRASSES (warm)															
Bouteloua curtipendula	3.90	100.00	7.91	4.50	8.11	2	1	4(4)	6(1)	4	8	5(1)	1	5	3
Buchloe dactyloides	0.00	20.00	0.00	0.00	0.00									P	P

FIRST HIT

ALL HIT

PLANT SPECIES	FIRST HIT		RELATIVE	ALL HIT	RELATIVE	Percent Foliar Cover*									
	AVERAGE		VEGETATION	AVERAGE	VEGETATION										
	COVER ^a	FREQUENCY ^b	COVER ^c	COVER ^d	COVER ^e	---Sample Number---									
	(%)	(%)	(%)	(%)	(%)	1	2	3	4	5	6	7	8	9	10
Pleuraphis jamesii	1.90	100.00	3.85	2.30	4.14	3(1)	2	1	(1)	1	P	1	3(1)	2	6(1)
Chondrosum gracile	7.70	100.00	15.62	8.20	14.77	13(1)	6	5(1)	11	1	5(1)	8(1)	4(1)	15	9
Sporobolus airoides	1.20	90.00	2.43	1.30	2.34	4(1)	P		P	P	P	P	2	2	4
Sporobolus cryptandrus	2.00	100.00	4.06	2.20	3.96	P	1	1(1)	P	1	P	9	1	4	3(1)
TOTAL NATIVE PERENNIAL GRASSES (w)	16.7	100.0	33.9	18.5	33.3	22(3)	10	11(6)	17(2)	7	13(1)	23(2)	11(2)	28	25(2)
NATIVE SHRUBS															
Atriplex canescens	0.00	40.00	0.00	0.00	0.00	P				P				P	P
TOTAL NATIVE SHRUBS	0.0	40.0	0.0	0.0	0.0	P	---	---	---	P	---	---	---	P	P
SUCCULENTS															
Opuntia polyacantha	0.00	20.00	0.00	0.00	0.00								P	P	
TOTAL SUCCULENTS	0.0	20.0	0.0	0.0	0.0	---	---	---	---	---	---	---	P	P	---
AGAVOIDS															
Yucca glauca	0.00	50.00	0.00	0.00	0.00	P	P	P	P						P
TOTAL AGAVOIDS	0.0	50.0	0.0	0.0	0.0	P	P	P	P	---	---	---	---	---	P
Standing dead	2.40	40.00		2.40		1		13		7				3	
Litter	9.40	100.00		9.40		15	8	2	8	17	8	13	11	6	6
Bare soil	37.50	100.00		37.50		38	47	43	26	19	42	33	51	37	39
Rock	1.40	40.00		1.40		2					1		7	4	
TOTALS	100.0			106.2		100	100	100	100	100	100	100	100	100	100
TOTAL VEGETATION COVER	49.3 (s=9.6)		100.0	55.5 (s=10.6)	100.0	44(4)	45(7)	42(13)	66(6)	57(10)	49(6)	54(9)	31(3)	50(1)	55(3)
GROUND COVER (Litter+Rock+Veg+St.Dead)	62.5			68.7		62(4)	53(7)	57(13)	74(6)	81(10)	58(6)	67(9)	49(3)	63(1)	61(3)
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 25.9 Std.Dev.= 3.4)						25	24	21	27	30	21	30	26	25	30

^a First Hit Cover = Absolute percent cover in vertical view with no account of plants obscured by first (i.e. top) hit.

^b Frequency = Percent of the samples in which a species or lifeform occurred

^c First Hit Relative Cover = Percent of the First Hit vegetation cover comprised of this species or lifeform

^d All Hit Cover = Absolute percent cover in vertical view accounting for all cover by the species or lifeform, whether over-arched by other plants or not

° All Hit Relative Cover = Percent of the All Hit vegetation cover comprised of the species or lifeform

***P=Present within 1m. on either side of cover transect, but not quantitatively encountered.**

()=Data in parentheses represent other hits that are used in conjunction with first hits for all hit cover statistics.

Table 2: Work Package S3-12 on Stoneham and Cascajo Series (Soil Group C)

PLANT SPECIES	FIRST HIT		FIRST HIT		ALL HIT		Percent Foliar Cover*									
	AVERAGE		RELATIVE VEGETATION		AVERAGE		---Sample Number---									
	COVER ^a	FREQUENCY ^b	COVER ^c		COVER ^d	COVER ^e										
	(%)	(%)	(%)		(%)	(%)	1	2	3	4	5	6	7	8	9	10
NATIVE ANNUAL & BIENNIAL FORBS																
Amaranthus albus	2.40	80.00	5.90		2.50	5.71	P	7	P	4(1)	1	P	6			6
Amaranthus blitoides	0.30	30.00	0.74		0.30	0.68	2			1				P		
Chamaesyce sp.	0.50	50.00	1.23		0.50	1.14	P		2			1	P	2		
Chenopodium berlandieri	0.10	10.00	0.25		0.10	0.23					1					
Chenopodium incanum	0.20	40.00	0.49		0.20	0.46	2	P	P			P				
Dyssodia aurea	1.90	100.00	4.67		2.10	4.79	4	P	4	1(1)	P	P	1	9(1)	P	P
Dyssodia papposa	1.40	70.00	3.44		1.40	3.20	2		2		P	P		8	P	2
Helianthus annuus	0.10	40.00	0.25		0.10	0.23	1			P		P			P	
Mentzlia multiflora	0.00	20.00	0.00		0.00	0.00			P		P					
Poinsettia dentata	0.00	20.00	0.00		0.00	0.00	P		P							
Polanisia dodecandra	0.00	60.00	0.00		0.00	0.00	P				P	P		P	P	P
Solanum rostratum	0.00	20.00	0.00		0.00	0.00								P		P
Ximenesia encelioides	0.20	70.00	0.49		0.20	0.46	P	P		P		P	P	2		P
TOTAL NATIVE ANN. & BIEN. FORBS	7.1	100.0	17.4		7.4	16.9	11	7	8	6(2)	2	1	7	21(1)	P	8
INTRODUCED ANNUAL & BIENNIAL FORBS																
Amaranthus retroflexus	0.50	50.00	1.23		0.50	1.14		2		P		P	3	P		
Bassia sieversiana	1.90	70.00	4.67		2.00	4.57	4		2(1)	1	1	P		8		3
Chenopodium album	0.40	60.00	0.98		0.40	0.91		3			P	P	1	P		P
Lactuca serriola	0.00	20.00	0.00		0.00	0.00	P		P							
Melilotus officinalis	0.40	50.00	0.98		0.50	1.14	1		1		P	2(1)		P		
Portulaca oleracea	0.00	20.00	0.00		0.00	0.00		P					P			
Salsola australis	5.90	70.00	14.50		6.10	13.93	P		P	15(1)	26(1)			P	10	8
Salsola collina	10.80	60.00	26.54		11.00	25.11	8(1)	17(1)	14			24	37	8		
Tragopogon dubius ssp. major	0.00	10.00	0.00		0.00	0.00						P				
TOTAL INTRO. ANN. & BIEN. FORBS	19.9	100.0	48.9		20.5	46.8	13(1)	22(1)	17(1)	16(1)	27(1)	26(1)	41	16	10	11
NATIVE ANNUAL GRASSES																
Munroa squarrosa	0.00	30.00	0.00		0.00	0.00				P		P	P			
Panicum capillare	0.00	30.00	0.00		0.10	0.23	P					(1)		P		
TOTAL NATIVE ANN. GRASSES	0.0	50.0	0.0		0.1	0.2	P	---	---	P	---	(1)	P	P	---	---
INTRODUCED ANNUAL GRASSES																
Bromus commutatus	0.00	30.00	0.00		0.00	0.00	P		P					P		
Bromus tectorum	0.00	10.00	0.00		0.00	0.00						P				
Digitaria ischaemum	0.10	30.00	0.25		0.10	0.23	1		P					P		
Digitaria sanguinalis	0.00	30.00	0.00		0.00	0.00		P		P			P			

PLANT SPECIES	FIRST HIT		FIRST HIT	ALL HIT		Percent Foliar Cover*									
	AVERAGE		RELATIVE	AVERAGE											
	COVER ^a	FREQUENCY ^b	VEGETATION COVER ^c	COVER ^d	VEGETATION COVER ^e	---Sample Number---									
	(%)	(%)	(%)	(%)	(%)	1	2	3	4	5	6	7	8	9	10
TOTAL INTRO. ANN. GRASSES	0.1	70.0	0.2	0.1	0.2	1	P	P	P	---	P	P	P	---	---
NATIVE PERENNIAL FORBS															
Ambrosia confertiflora	0.10	20.00	0.25	0.10	0.23		1					P			
Aster sp.	0.00	10.00	0.00	0.00	0.00						P				
Astragalus sp.	0.00	20.00	0.00	0.00	0.00					P				P	
Astragalus tridactylus	0.10	40.00	0.25	0.10	0.23	P		P			P		1		
Evolvulus nuttallianus	0.00	10.00	0.00	0.00	0.00		P								
Glandularia bipinnatifida	0.00	40.00	0.00	0.00	0.00	P	P					P	P		
Heterotheca villosa	0.00	10.00	0.00	0.00	0.00									P	
Ipomopsis sp.	0.00	10.00	0.00	0.00	0.00										P
Lygodesmia juncea	0.00	10.00	0.00	0.00	0.00		P								
Oligosporus dracunculus ssp. glaucus	0.00	10.00	0.00	0.00	0.00		P								
Psoralegium tenuiflorum	0.00	10.00	0.00	0.00	0.00						P				
Quincula lobata	0.00	10.00	0.00	0.00	0.00										P
Sphaeralcea coccinea	0.00	40.00	0.00	0.00	0.00		P	P				P	P		
Thelesperma sp.	0.00	20.00	0.00	0.00	0.00				P						P
Zinnia grandiflora	0.00	10.00	0.00	0.00	0.00							P			
TOTAL NATIVE PERENNIAL FORBS	0.2	100.0	0.5	0.2	0.5	P	1	P	P	P	P	P	1	P	P
INTRODUCED PERENNIAL FORBS															
Rumex crispus	0.00	20.00	0.00	0.00	0.00	P		P							
TOTAL INTRO. PERENNIAL FORBS	0.0	20.0	0.0	0.0	0.0	P	---	P	---	---	---	---	---	---	---
NATIVE PERENNIAL GRASSES (cool)															
Elymus elymoides	0.00	10.00	0.00	0.00	0.00						P				
Pascopyrum smithii	3.00	100.00	7.37	4.10	9.36	1	1	P	7(3)	1(3)	7(2)	P	5(1)	3	5(2)
TOTAL NATIVE PERENNIAL GRASSES (c)	3.0	100.0	7.4	4.1	9.4	1	1	P	7(3)	1(3)	7(2)	P	5(1)	3	5(2)
INTRODUCED PERENNIAL GRASSES (cool)															
Echinochloa crus-galli	0.00	50.00	0.00	0.00	0.00	P		P	P		P		P		
Setaria viridis	0.10	20.00	0.25	0.10	0.23	1							P		
TOTAL INTRO. PERENNIAL GRASSES (c)	0.1	50.0	0.2	0.1	0.2	1	---	P	P	---	P	---	P	---	---
NATIVE PERENNIAL GRASSES (warm)															
Aristida purpurea	0.00	30.00	0.00	0.00	0.00	P			P		P				
Bouteloua curtipendula	3.50	100.00	8.60	3.80	8.68	2	2	P	9(1)	4(1)	4(1)	1	P	11	2
Chondrosum gracile	5.20	100.00	12.78	5.70	13.01	4	9	3	7(1)	5(1)	9(2)	2	P	11(1)	2
Pleuraphis jamesii	0.80	70.00	1.97	0.90	2.05	1	1	P	2(1)		1	1		2	
Sporobolus airoides	0.10	60.00	0.25	0.10	0.23	P	1			P	P	P	P		
Sporobolus cryptandrus	0.50	90.00	1.23	0.60	1.37	2	P	P	P	1	P	(1)	2	P	

PLANT SPECIES	FIRST HIT		FIRST HIT	ALL HIT	ALL HIT	Percent Foliar Cover*									
	AVERAGE		RELATIVE	AVERAGE	RELATIVE										
	COVER ^a	FREQUENCY ^b	VEGETATION	COVER ^d	VEGETATION	---Sample Number---									
	(%)	(%)	(%)	(%)	(%)	1	2	3	4	5	6	7	8	9	10
TOTAL NATIVE PERENNIAL GRASSES (w)	10.1	100.0	24.8	11.1	25.3	9	13	3	18(3)	10(2)	14(3)	4(1)	2	24(1)	4
NATIVE SUBSHRUBS															
Ambrosia linearis	0.10	10.00	0.25	0.10	0.23										1
Gutierrezia sarothrae	0.10	10.00	0.25	0.10	0.23			1							
TOTAL NATIVE SUBSHRUBS	0.2	20.0	0.5	0.2	0.5	---	---	1	---	---	---	---	---	---	1
NATIVE SHRUBS															
Atriplex canescens	0.00	10.00	0.00	0.00	0.00				P						
TOTAL NATIVE SHRUBS	0.0	10.0	0.0	0.0	0.0	---	---	---	P	---	---	---	---	---	---
NATIVE TREES															
Acacia sp.	0.00	20.00	0.00	0.00	0.00	P		P							
TOTAL NATIVE TREES	0.0	20.0	0.0	0.0	0.0	P	---	P	---	---	---	---	---	---	---
SUCCULENTS															
Opuntia polyacantha	0.00	10.00	0.00	0.00	0.00									P	
TOTAL SUCCULENTS	0.0	10.0	0.0	0.0	0.0	---	---	---	---	---	---	---	---	P	---
AGAVOIDS															
Yucca glauca	0.00	10.00	0.00	0.00	0.00						P				
TOTAL AGAVOIDS	0.0	10.0	0.0	0.0	0.0	---	---	---	---	---	P	---	---	---	---
Standing dead	4.80	70.00		4.80			2		10	13		1	3	3	16
Litter	14.60	100.00		14.60		17	11	24	11	7	14	16	27	11	8
Bare soil	34.30	90.00		34.30			40	45	32	40	37	31	23	49	46
Rock	5.60	60.00		5.60		47	3	2			1		2		1
TOTALS	100.0			103.1		100	100	100	100	100	100	100	100	100	100
TOTAL VEGETATION COVER	40.7 (s=7.9)		100.0	43.8 (s=9.5)	100.0	36(1)	44(1)	29(1)	47(9)	40(6)	48(7)	52(1)	45(2)	37(1)	29(2)
GROUND COVER (Litter+Rock+Veg+St.Dead)	65.7			68.8		100(1)	60(1)	55(1)	68(9)	60(6)	63(7)	69(1)	77(2)	51(1)	54(2)
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 21.7 Std.Dev.= 6.1)						31	21	25	19	16	30	20	26	13	16

^a First Hit Cover = Absolute percent cover in vertical view with no account of plants obscured by first (i.e. top) hit.

^b Frequency = Percent of the samples in which a species or lifeform occurred

^c First Hit Relative Cover = Percent of the First Hit vegetation cover comprised of this species or lifeform

^d All Hit Cover = Absolute percent cover in vertical view accounting for all cover by the species or lifeform, whether over-arched by other plants or not

^e All Hit Relative Cover = Percent of the All Hit vegetation cover comprised of the species or lifeform

***P=Present within 1m. on either side of cover transect, but not quantitatively encountered.**
()=Data in parentheses represent other hits that are used in conjunction with first hits for all hit cover statistics.

Table 3: Work Package S3-12 on Razor Series (Soil Group E)

PLANT SPECIES	FIRST HIT		FIRST HIT	ALL HIT	RELATIVE	Percent Foliar Cover*									
	AVERAGE		VEGETATION	AVERAGE	VEGETATION										
	COVER ^a	FREQUENCY ^b	COVER ^c	COVER ^d	COVER ^e	---Sample Number---									
	(%)	(%)	(%)	(%)	(%)	1	2	3	4	5	6	7	8	9	10
NATIVE ANNUAL & BIENNIAL FORBS															
Amaranthus albus	3.50	60.00	8.29	3.60	8.00	11	4	4	4	6	6(1)				
Amaranthus blitoides	1.20	60.00	2.84	1.30	2.89			1		1	1	6(1)	1	2	
Ambrosia artemisiifolia var. elatior	0.00	10.00	0.00	0.00	0.00			P							
Chamaesyce sp.	0.30	60.00	0.71	0.30	0.67				P		P	1	1	P	1
Chenopodium berlandieri	0.00	10.00	0.00	0.00	0.00										P
Chenopodium incanum	1.70	80.00	4.03	1.90	4.22	7		P	P	1	2		1(2)	5	1
Chenopodium rubrum	0.20	20.00	0.47	0.20	0.44					P					2
Dyssodia aurea	5.70	100.00	13.51	6.30	14.00	1	P	P	1	3	P	5(1)	6	31	10(5)
Dyssodia papposa	3.40	80.00	8.06	3.60	8.00	P		3		2	3	7	3	4	12(2)
Helianthus annuus	0.20	50.00	0.47	0.20	0.44				P			P	1	P	1
Mentzlia multiflora	0.10	10.00	0.24	0.10	0.22									1	
Oligosporus pacificus	0.10	10.00	0.24	0.10	0.22			1							
Polanisia dodecandra	0.00	50.00	0.00	0.00	0.00		P				P		P	P	P
Solanum rostratum	0.10	60.00	0.24	0.10	0.22	P		P		P		1		P	P
Solanum triflorum	0.10	20.00	0.24	0.10	0.22								1	P	
Ximenesia encelioides	0.80	90.00	1.90	0.80	1.78	P	P	P		P	3	3	2	P	P
TOTAL NATIVE ANN. & BIEN. FORBS	17.4	100.0	41.2	18.6	41.3	19	4	9	5	12	15(1)	18(1)	21(3)	42	29(7)
INTRODUCED ANNUAL & BIENNIAL FORBS															
Amaranthus hybridus	0.00	30.00	0.00	0.00	0.00								P	P	P
Amaranthus retroflexus	0.70	80.00	1.66	0.80	1.78		P	P	P		P	7(1)	P	P	P
Bassia sieversiana	3.50	90.00	8.29	3.50	7.78	1	P	12		2	8	11	P	P	1
Chenopodium album	0.00	40.00	0.00	0.00	0.00		P		P					P	P
Euphorbia davidii	0.00	10.00	0.00	0.00	0.00		P								
Halogeton glomeratus	0.00	10.00	0.00	0.00	0.00				P						
Melilotus officinalis	0.20	40.00	0.47	0.20	0.44		1		1		P			P	
Portulaca oleracea	0.40	60.00	0.95	0.40	0.89		1			1	1		1	P	P
Salsola australis	0.00	20.00	0.00	0.00	0.00	P				P					
Salsola collina	10.60	100.00	25.12	10.80	24.00	1	31	P	34	3(1)	P	P	15(1)	14	8
Tribulus terrestris	0.00	10.00	0.00	0.00	0.00		P								
TOTAL INTRO. ANN. & BIEN. FORBS	15.4	100.0	36.5	15.7	34.9	2	33	12	35	6(1)	9	18(1)	16(1)	14	9
NATIVE ANNUAL GRASSES															
Munroa squarrosa	0.10	60.00	0.24	0.10	0.22			P		P	P		P	1	P
Panicum capillare	0.10	50.00	0.24	0.10	0.22					P		P	P	1	P
TOTAL NATIVE ANN. GRASSES	0.2	70.0	0.5	0.2	0.4	---	---	P	---	P	P	P	P	2	P

PLANT SPECIES	FIRST HIT		FIRST HIT	ALL HIT		Percent Foliar Cover*									
	AVERAGE		RELATIVE	AVERAGE											
	COVER ^a	FREQUENCY ^b	VEGETATION COVER ^c	COVER ^d	VEGETATION COVER ^e	---Sample Number---									
						1	2	3	4	5	6	7	8	9	10
INTRODUCED ANNUAL GRASSES															
Digitaria ischaemum	0.30	40.00	0.71	0.30	0.67						1		P	1	1
Digitaria sanguinalis	0.10	30.00	0.24	0.10	0.22		P		1			P			
TOTAL INTRO. ANN. GRASSES	0.4	70.0	0.9	0.4	0.9	---	P	---	1	---	1	P	P	1	1
NATIVE PERENNIAL FORBS															
Astragalus shortianus	0.00	30.00	0.00	0.00	0.00								P	P	P
Chamaesaracha coronopus	0.20	30.00	0.47	0.20	0.44			1			1			P	
Glandularia bipinnatifida	0.30	100.00	0.71	0.30	0.67	P	P	P	P	P	P	P	2	P	1
Hedeoma drummondii	0.00	10.00	0.00	0.00	0.00										P
Lesquerella montana	0.10	10.00	0.24	0.10	0.22									1	
Oligosporus dracunculus ssp. glaucus	0.00	10.00	0.00	0.00	0.00		P								
Quincula lobata	0.00	10.00	0.00	0.00	0.00									P	
Sphaeralcea angustifolia	0.00	20.00	0.00	0.00	0.00			P							P
Sphaeralcea coccinea	0.00	20.00	0.00	0.00	0.00					P					P
Thelesperma sp.	0.00	20.00	0.00	0.00	0.00	P				P					
TOTAL NATIVE PERENNIAL FORBS	0.6	100.0	1.4	0.6	1.3	P	P	1	P	P	1	P	2	1	1
NATIVE PERENNIAL GRASSES (cool)															
Elymus elymoides	0.00	30.00	0.00	0.00	0.00								P	P	P
Pascopyrum smithii	2.80	100.00	6.64	3.20	7.11	4	2	5	1(1)	5	2	2	1	4(1)	2(2)
TOTAL NATIVE PERENNIAL GRASSES (c)	2.8	100.0	6.6	3.2	7.1	4	2	5	1(1)	5	2	2	1	4(1)	2(2)
INTRODUCED PERENNIAL GRASSES (cool)															
Bromopsis inermis	0.00	10.00	0.00	0.00	0.00		P								
Echinochloa crus-galli	0.00	70.00	0.00	0.10	0.22		P		P	P	P		P	(1)	P
Setaria viridis	0.00	40.00	0.00	0.00	0.00				P			P		P	P
Thinopyrum intermedium	0.10	10.00	0.24	0.10	0.22				1						
TOTAL INTRO. PERENNIAL GRASSES (c)	0.1	80.0	0.2	0.2	0.4	---	P	---	1	P	P	P	P	(1)	P
NATIVE PERENNIAL GRASSES (warm)															
Bouteloua curtipendula	0.90	90.00	2.13	1.20	2.67	P	4(1)		4(2)	P	P	P	P	P	1
Buchloe dactyloides	0.00	10.00	0.00	0.00	0.00										P
Chondrosum gracile	1.70	80.00	4.03	2.10	4.67	P	7(1)	2	6(3)	2		P		P	P
Pleuraphis jamesii	0.20	30.00	0.47	0.20	0.44		2		P						P
Sporobolus airoides	0.40	40.00	0.95	0.40	0.89		P		P	2					2
Sporobolus cryptandrus	1.80	90.00	4.27	1.90	4.22	P	P	2	P		P	1	(1)	6	9
TOTAL NATIVE PERENNIAL GRASSES (w)	5.0	100.0	11.8	5.8	12.9	P	13(2)	4	10(5)	4	P	1	(1)	6	12
NATIVE SUBSHRUBS															

PLANT SPECIES	FIRST HIT		FIRST HIT	ALL HIT	ALL HIT	Percent Foliar Cover*									
	AVERAGE		RELATIVE	AVERAGE	RELATIVE										
	COVER ^a	FREQUENCY ^b	VEGETATION	COVER ^d	VEGETATION	---Sample Number---									
	(%)	(%)	COVER ^c	(%)	(%)	1	2	3	4	5	6	7	8	9	10
Gutierrezia sarothrae	0.10	20.00	0.24	0.10	0.22			1			P				
TOTAL NATIVE SUBSHRUBS	0.1	20.0	0.2	0.1	0.2	---	---	1	---	---	P	---	---	---	---
NATIVE SHRUBS															
Atriplex canescens	0.20	80.00	0.47	0.20	0.44	P		P	P	P	1	1		P	P
TOTAL NATIVE SHRUBS	0.2	80.0	0.5	0.2	0.4	P	---	P	P	P	1	1	---	P	P
PARASITE															
Cuscuta sp.	0.00	10.00	0.00	0.00	0.00			P							
TOTAL PARASITE	0.0	10.0	0.0	0.0	0.0	---	---	P	---	---	---	---	---	---	---
AGAVOIDS															
Yucca glauca	0.00	10.00	0.00	0.00	0.00									P	
TOTAL AGAVOIDS	0.0	10.0	0.0	0.0	0.0	---	---	---	---	---	---	---	---	P	---
Standing dead	10.70	70.00		10.70		24		20		14	17	23	7	2	
Litter	15.20	100.00		15.20		22	11	19	9	26	23	11	16	4	11
Bare soil	31.40	100.00		31.40		29	35	29	37	33	30	26	37	24	34
Rock	0.50	40.00		0.50			2		1		1				1
TOTALS	100.0			102.8		100	100	100	100	100	100	100	100	100	100
TOTAL VEGETATION COVER	42.2 (s=14.7)		100.0	45.0 (s=16.4)	100.0	25	52(2)	32	53(6)	27(1)	29(1)	40(2)	40(5)	70(2)	54(9)
GROUND COVER (Litter+Rock+Veg+St.Dead)	68.6			71.4		71	65(2)	71	63(6)	67(1)	70(1)	74(2)	63(5)	76(2)	66(9)
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 24.2 Std.Dev.= 6.4)						16	23	22	22	22	23	19	24	35	36

^a First Hit Cover = Absolute percent cover in vertical view with no account of plants obscured by first (i.e. top) hit.

^b Frequency = Percent of the samples in which a species or lifeform occurred

^c First Hit Relative Cover = Percent of the First Hit vegetation cover comprised of this species or lifeform

^d All Hit Cover = Absolute percent cover in vertical view accounting for all cover by the species or lifeform, whether over-arched by other plants or not

^e All Hit Relative Cover = Percent of the All Hit vegetation cover comprised of the species or lifeform

*P=Present within 1m. on either side of cover transect, but not quantitatively encountered.
 ()=Data in parentheses represent other hits that are used in conjunction with first hits for all hit cover statistics.

Appendix C: Site Photos – Work Package S3-12



Photograph 1. S3-12 on Penrose, Manvel and Minnequa series, Sample 1 - 2013



Photograph 2. S3-12 on Penrose, Manvel and Minnequa series, Sample 2 - 2013



Photograph 3. S3-12 on Penrose, Manvel and Minnequa series, Sample 3 - 2013



Photograph 4. S3-12 on Penrose, Manvel and Minnequa series, Sample 4 - 2013



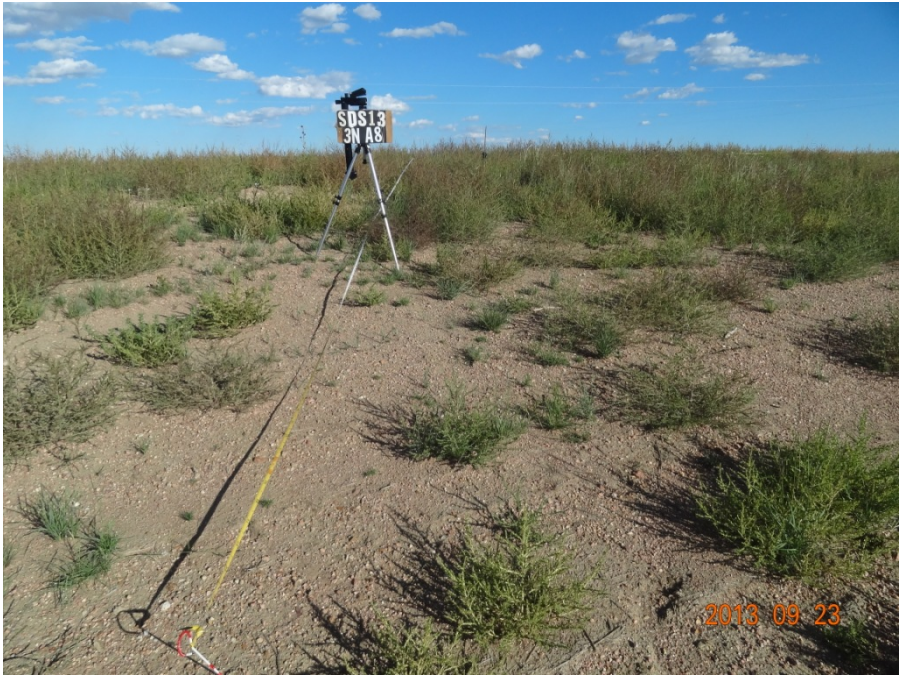
Photograph 5. S3-12 on Penrose, Manvel and Minnequa series, Sample 5 - 2013



Photograph 6. S3-12 on Penrose, Manvel and Minnequa series, Sample 6 - 2013



Photograph 7. S3-12 on Penrose, Manvel and Minnequa series, Sample 7 - 2013



Photograph 8. S3-12 on Penrose, Manvel and Minnequa series, Sample 8 - 2013



Photograph 9. S3-12 on Penrose, Manvel and Minnequa series, Sample 9 - 2013



Photograph 10. S3-12 on Penrose, Manvel and Minnequa series, Sample 10 - 2013



Photograph 11. S3-12 on Limon and Heldt series, Sample 1 - 2013



Photograph 12. S3-12 on Stoneham and Cascajo series, Sample 1 - 2013



Photograph 13. S3-12 on Stoneham and Cascajo series, Sample 2 - 2013



Photograph 14. S3-12 on Stoneham and Cascajo series, Sample 3 - 2013



Photograph 15. S3-12 on Stoneham and Cascajo series, Sample 4 - 2013



Photograph 16. S3-12 on Stoneham and Cascajo series, Sample 5 - 2013



Photograph 17. S3-12 on Stoneham and Cascajo series, Sample 6 - 2013



Photograph 18. S3-12 on Stoneham and Cascajo series, Sample 7 - 2013



Photograph 19. S3-12 on Stoneham and Cascajo series, Sample 8 - 2013



Photograph 20. S3-12 on Stoneham and Cascajo series, Sample 9 - 2013



Photograph 21. S3-12 on Stoneham and Cascajo series, Sample 10 - 2013



Photograph 22. S3-12 on Razor series, Sample 1 - 2013



Photograph 23. S3-12 on Razor series, Sample 2 - 2013



Photograph 24. S3-12 on Razor series, Sample 3 - 2013



Photograph 25. S3-12 on Razor series, Sample 4 - 2013



Photograph 26. S3-12 on Razor series, Sample 5 - 2013



Photograph 27. S3-12 on Razor series, Sample 6 - 2013



Photograph 28. S3-12 on Razor series, Sample 7 - 2013



Photograph 29. S3-12 on Razor series, Sample 8 - 2013



Photograph 30. S3-12 on Razor series, Sample 9 - 2013



Photograph 31. S3-12 on Razor series, Sample 10 - 2013

Appendix D: Established Vegetation Sampling Protocols

Technical Memo 1

Sampling Procedure for Point Intercept Cover and Seedling Density Data Collection

The following procedure establishes baseline levels of plant cover in areas affected by the Southern Delivery System Project and will be used to determine seedling density following revegetation.

Within an area that was disturbed, vegetation will be quantitatively sampled as described below to establish:

- 1) The percent cover by species as well as total vegetation cover and
- 2) Species richness

These data will provide a basis for assessment of the percent of vegetation cover re-established in post-revegetation evaluations.

Vegetation Unit Identification

As vegetation varies along the length of the proposed area of disturbance, variations in plant community at the “alliance” level of the US National Vegetation Classification system (FGDC 2008) will be documented. Association and alliance level classification is based on the premise that a vegetation type represents a group of stands that have similar plant composition and physiognomy enabling their recognition. Should such significant soil variation as might substantially affect plant cover growth potential be encountered within a single alliance in a particular reach, these will be subdivided and the number of sample measurements adjusted accordingly.

This mapping methodology addresses both the need to document natural variation in the pre-existing vegetation and the need to set plant cover standard levels consistent with the varying potentials of varying environments.

Sample Location

Samples will be placed in locations representative of the general vegetation type and condition.

Cover Sampling Methods

At each sample site, cover data will be collected using a point-intercept method in which data are tabulated as interceptions of a projected point with plant species, bare ground, litter, standing dead vegetation, or rock. The cover sampling points will be optically projected using a Cover-Point Optical Point Projection Device. Sampling will occur along 50 meter transects. At each meter from one to fifty along the transect, a point will be vertically projected from a location 50 centimeters (cm) to the left of the transect and a point will be vertically projected from a location 50 cm to the right of the transect (avoiding harm to vegetation along the tape itself). Thus, data from a total of 2 x 50, or 100 points will be recorded. Plant interceptions will be tallied by species upon interception of the projected point with any attached plant part

produced during the current growing season. "First hit" data (the first interception of any of the materials listed below) will be recorded. In addition to this, "additional hit" data (any additional live species intercepted between the first hit and the ground) will also be collected.

- Litter will be considered to be any organic material that had fallen, or had begun to fall to the soil surface.
- Standing dead vegetation will be any dead plant material that was produced in previous years but which was still standing and had not lodged or broken off to become litter.
- Rock will be considered to be any inorganic fragment with the largest diameter greater than or equal to 1 cm.
- Bare soil will be considered to be inorganic fragments with a diameter less than 1 cm largest diameter or organic debris too small to be of readily identifiable origin.

First hit interceptions will be used to calculate absolute top layer (first hit) foliar cover by dividing the number of interceptions for a particular species or material by the total number of points taken (100). First hit relative vegetation cover will be calculated by dividing first hit absolute cover for each species by the total first hit vegetation cover. All-layer absolute cover will be calculated by dividing all hits for particular species by the total number of points taken (100). In addition, all-layer relative cover will be calculated using all hits for particular species divided by the total vegetation hits accumulated during sampling of the transect.

Seedling Density Sampling (Post-Revegetation Analyses)

Seedlings of seeded or perennial plant species will be counted within randomly placed 0.5 square meters (5.37 square feet) circular plots. The results will be averaged and divided by 5.37 to obtain number of seedlings per square foot.

References

FGDC. 2008. Vegetation Classification Standard, Version 2. Federal Geographic Data Committee, Vegetation Subcommittee. FGDC Secretariat, U.S. Geological Survey. Reston, VA. FGDC-STD-005-2008 (Version 2). 62p. plus Appendices.

Technical Memo 3

Post-Revegetation Sampling

This Technical Memo describes the design and methodology CNHP will use to sample and quantitatively assess post-disturbance revegetation success. For the practicality of achieving an unbiased evaluation, the approach is based on random sampling and the use of resulting means to compare results to previously established performance standards. By the nature of plant growth in response to varying conditions along the length of the revegetated area, and by the nature of random sampling, variability in levels of plant abundance are to be expected both on the ground and in sample results. The use of 50 meter-long transects tends to encompass variability though a certain amount of variability can be expected at scales larger than this.

Creditable Vegetation Cover

Cover provided by plants included in the Colorado A-, B-, or C-list of noxious plant species, if any, will not be acceptable in the evaluation of cover. Cover by all other plants will be acceptable in assessment of adequate revegetation cover, except as follows: cover by non-native annual / biennial plants in excess of the relative cover by those plants in the pre-construction sample data will not be counted toward establishment of proof of successful revegetation (see below).

Maximum allowable relative cover by Introduced Annual and Biennial Species:

A. Soils Shallow over Shale and Limestone (Penrose, Manvel and Minnequa series; Tables 4, 7, and Samples 5, 7 and 8 of Table 8): **22.2 percent**

B. Soils on Clay-rich, Salt-affected Alluvial Material (Limon and Heldt series; Tables 1, 5, and 11): **2.6 percent**

C. Soils Deep on Early Pleistocene Alluvium (Stoneham and Cascajo series; Tables 10 and 15): **3.9 percent**

D. Soils on Weathered Shale (with active erosional removal) (Midway – Shale complex; Shingle series; Tables 9 and 13): **1.3 percent**

E. Soils on Deeply Weathered Shale (without active erosional removal) (Razor series; Table 14): **3.6 percent**

F. Soils on Recent Alluvium of Moderate Texture and Salt Content (Haverson series and Ustic Torrifluvents; Table 6 and 16): **16.7 percent**

Cover Sampling Method

Sampling to assess compliance with the standard of 90 percent of pre-existing cover will proceed separately within each work package (S1, S2 and S3) and separately within each soil functional group as identified during the pre-construction vegetation survey (see Technical Memo 2). All sample locations will be randomly located by delineating the soil functional groups in each work package in ESRI ArcMap GIS application and using the random point generation tool to place the correct number of random points in that area.

For sample units with a total (cumulative) length of one mile or less, ten (10) segments of equal length will be established and a randomly located and oriented sample placed in each. For units greater than one mile in cumulative length, fifteen (15) segments of equal length will be identified and a sample randomly located within each. Sample points will be located in the field using hand-held GPS units with coordinates of the random points pre-loaded. In areas with total Soil Group length less than 0.1 mile, three (3) to five (5) samples will be made. Professional judgment will be used in these small sample areas (e.g. Soil Groups B and F in S3) to determine the location and number of samples collected.

Orientation of the 50-meter transect will be randomly selected by using a random number ranging from 1 to 360 as an azimuth. Sampling transects will not extend outside the Permanent Easement (PE), Temporary Construction Easement (TCE) or work limits areas. Should a boundary be encountered, a new orientation that remains within these limits will be chosen in the same manner. Ineligible sites (see below) will be excluded from sampling.

Sampling to assess compliance with the CDPHE criterion of 70 percent of pre-existing cover will proceed within separate work packages and soil reaches. If the 70 percent cover standard alone is being assessed, the sample intensity will be five (5) samples in reaches of one mile or less in cumulative length and eight (8) samples in those greater than one mile in cumulative length. Professional judgment will be used in small sample areas (e.g. Soil Groups B and F in S3) to determine the location and number of samples collected.

Informational Cover Composition Sampling Method

Data on species composition will be collected for informational purposes outside the scope of the 1041 permit requirements. Ten (10) 1 x1 meter plots will be placed at 5-meter intervals along the right side of the cover sampling transect (as viewed from the origin) beginning at the 5-meter mark. Within each of the resulting ten plots the presence of desirable species will be noted by species. For this purpose, desirable species will mean any seeded species plus any other native annual, biennial, or perennial species plus any non-native perennial species. Native will mean species noted as native in and occurring in the Southeast ¼ of Colorado in Biota of North America Project distribution mapping. The resulting frequency data will be tabulated by species. For example, if Species A is noted as present in 7 of the 10 plots it will have a frequency value of 70 percent.

Frequency values from all transects within a given soil group will then be averaged. For these evaluations, average frequency values by species will be used as follows: The average frequencies of all acceptable species will be summed. A sum for all desirable species present that equals or exceeds 200 percent will be deemed adequate evidence of successful establishment of acceptable species. This supplemental criterion addresses the reality that vegetation at the time of evaluation will still be juvenile. Many planted or otherwise desirable species grow slowly and though they may be only a small percentage of the total plant cover at the time of measurement, will eventually become more abundant. This frequency evaluation allows documentation of the presence of the desirable species sought in the long term vegetation cover.

Seedling Density

Seedlings of seeded or perennial plant species will be counted within randomly placed 0.5 square meter (5.37 square foot) circular plots. The results will be averaged and divided by 5.37 to obtain number of seedlings per square foot.

Plots will be thirty per Work Package/Soil Group area. All sample points will be randomly located via GIS-generated coordinates.

Sites Ineligible for Sampling

Areas within the revegetation zone in which the vegetation cover has been negatively affected by land management of private owners after SDS construction or for which a waiver has been executed/granted will be excluded from the sample universe (i.e., no samples will be placed in these areas). Within the disturbed alignment no sampling will occur on access roads, trails, above-ground SDS infrastructure, other above-ground public or private infrastructure, waterways, or other areas where sampling is determined not to be practical, safe or meaningful. Such areas will be manually delineated in the GIS and excluded from the eligible sampling area when creating the random point coverage.

Sampling Schedule

During the first growing season following seeding, seedling density data will be collected. At the end of the first growing season (typically September) cover data will be collected for the purpose of assessing compliance with the CDPHE Stormwater Permit criterion of 70 percent of pre-existing cover. If in the judgment of the SDS Program, the extent of vegetation cover at that time might also satisfy the 90 percent of pre-existing cover criterion, the full sampling design described above will be implemented. If only the CDPHE criterion is being tested, sample intensity within a work package will be five samples in soil reaches one mile or less in cumulative length and eight in those greater than one mile in cumulative length. During the second growing season, sampling intensity will be ten (10) samples in soil reaches one mile or less in cumulative length and fifteen (15) samples in those greater than one mile in cumulative length.

Hypothesis Testing

Statistical evaluation of the success of revegetation for each soil functional group within a work package will be tested via a one-sample t-test of the following null hypothesis:

The (traditional) null hypothesis being tested would be that the revegetated area mean (\bar{x}) is indistinguishable from 90 percent of the pre-existing cover, stated as $H_0: \bar{x} = Q$. If t_c is less than or equal to the 1-tailed t -table value for alpha error probability of 0.05, at $(n-1)$ degrees of freedom, then H_0 is accepted, and revegetation is deemed successful (i.e., indistinguishable from 90 percent of the standard).

The sample data will be evaluated for normality and transformed if appropriate. The formula for the one sample t-test is:

$$t_c = \frac{Q - \bar{x}}{S_{\bar{x}}}$$

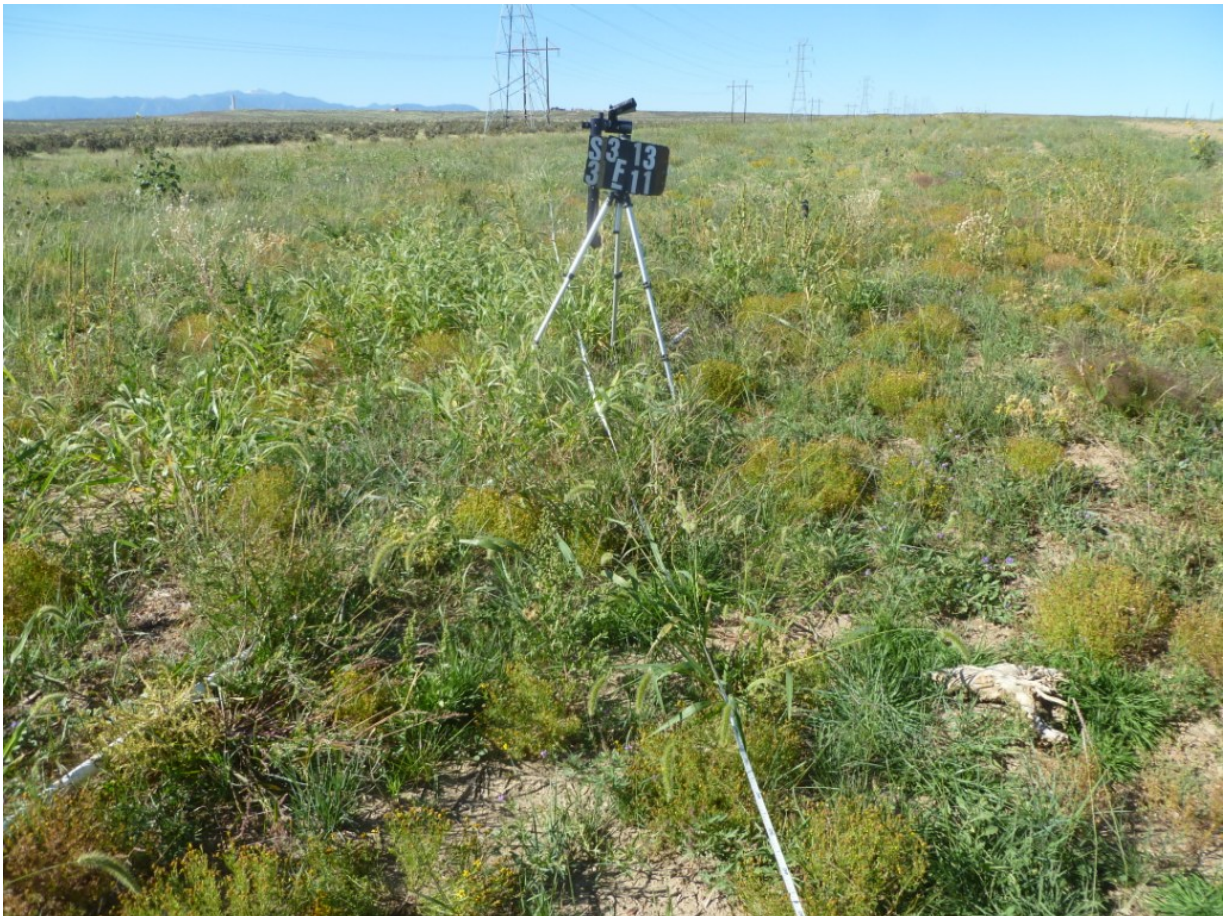
Where: \bar{x} = Revegetated Area Sample Mean
 Q = 90 percent of pre-existing cover
 $S_{\bar{x}}$ = Standard error of mean [s/\sqrt{n}]
 s = Sample standard deviation
 n = Sample size
 t_c = Calculated t -value
 t_t = Table t -value (alpha = 0.05)

Photographic Documentation

Photo documentation will be conducted during the growing seasons and in conjunction with the point-intercept cover sampling. Photos will be taken at each transect location during all sampling. Photo points will be relocated using a handheld GPS receiver.

Colorado Springs Utilities Southern Delivery System

*Measurements of Post-restoration Vegetation Cover for Pueblo County
Work Package S3-13*



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October, 2013

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Cover Photo: Sample Site 11 on Soil Group E (Razor Series) in work package S3-13 (by ESCO Assoc. Inc.)



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Introduction

This report documents conditions of post-construction vegetation cover after the first growing season along the portion of the S3 sections of the Southern Delivery System (SDS) pipeline route in Pueblo County, Colorado, that on which irrigation was initiated in 2013. This reach is labeled S3-13. It extends from the southern end of the S3 work package north to Antelope Road. The Colorado Natural Heritage Program, in cooperation with ESCO Associates, completed this post-construction survey under contract to Colorado Springs Utilities. This report compares post-construction vegetative cover values to the standards for revegetation prescribed by CDPHE Stormwater Regulations and the Pueblo county 1041 permit in order to evaluate revegetation success in this section. It also reports frequency-based quantitative measures of the presence of acceptable species in comparison to a pre-determined standard.

The following includes the methods used, the results, and a discussion of factors affecting vegetation cover on the sites after any construction activities. Maps, tabular data, and photographs of work package S3-13 are contained in separate Appendices A, B, and C, respectively. Appendix D includes applicable portions of the Pueblo County Revegetation Cover Establishment Protocols (Protocols).

The study area is in a tributary valley of the Arkansas River downstream (east) from its emergence from the mountain front. Along some reaches of the pipeline route, exposed shale and limestone are the predominant soil parent materials, while on other reaches recent alluvium predominates and on high terrace sites older deposits of Arkansas River alluvium in the form of sands and gravels predominate.

Methods

Assessment of Cover and the Presence of Acceptable Species in revegetated and irrigated areas along the SDS Pipeline in Pueblo County was completed in late September 2013 as per the Protocol developed for the project. Prior to this, in July 2013, the density of seedlings of acceptable species per square foot was assessed along these same reaches of revegetated right-of-way. The July assessment provided an early look into revegetation results, but the September 2013 effort included evaluation of two different parameters that were applicable to vegetation somewhat more mature than in July 2013.

The primary parameter assessed in the September work was percent cover by acceptable species as set forth in the protocol. This measure relates to the Pueblo County 1041 permit requirement that cover on revegetated areas comprise at least 90% of pre-existing levels. It also relates to the requirement under CDPHE Stormwater Regulations that cover attains at least 70% of pre-existing levels. Pre-existing levels of cover on the Pueblo County work package reaches were established by quantitative sampling in October 2011 prior to construction. Further details on this pre-construction effort can be referenced in the 2011 report.

Beyond the return of adequate plant cover (detailed in the Protocol document), measures intended to provide Pueblo County with an evaluation of the adequate presence of Acceptable Species in the reconstructed vegetation were also made as per provisions in the Protocol. Acceptable species had been determined in consultation with the Pueblo County vegetation representative to include all native species and all introduced perennial species other than those included on the current State of Colorado A, B or C-lists of noxious species.

Beginning with the pre-construction vegetation surveys, results of sampling in this work package have been grouped by broad soil types. These groups, established to simplify the process, include soil series of similar nature as plant growth media. Within each soil type, sample transects (See Protocol Technical Memos 1 and 3, Appendix D) were placed at random locations in an effort to capture the variability of vegetative cover present. At each representative sample location, vegetation cover and ground cover were measured via observation at 100 locations spaced at 1 meter intervals along the transect length. Maps showing the extent of the soil groups present within the alignment of the work package and the location of sample transect origin points are included in Appendix A.

Results

A total of 50 transects were sampled in the work package S3-13 area during the post-construction survey. The various soils across the extent of the work package were grouped for simplicity into five units that differed in their nature as plant growth media and as to the means by which it will be necessary to salvage and replace them during construction. The five groups are as follows:

B. Soils on Clay-rich, Salt-affected Alluvial Material (Limon and Heldt series; Table 1, Appendix B)

C. Soils Deep on Early Pleistocene Alluvium (Stoneham and Cascajo series; Table 2, Appendix B)

D. Soils on Weathered Shales (with active erosional removal) (Midway – Shale complex, Shingle series; Table 3, Appendix B)

E. Soils on Deeply Weathered Shales (without active erosional removal) (Razor series; Table 4, Appendix B)

F. Soils on Recent Alluvium of Moderate Texture and Salt Content (Haverson series and Ustic Torrifluvents; Not Sampled)

The distribution of these Soil Groups is indicated on the maps of S3-13 included in Appendix A.

Plant cover observed during sampling was related to the above soil groups and used to establish base values from which revegetation performance standards were calculated.

Base Cover Values for Evaluation of Revegetation Success

The following are base vegetation cover values (to be multiplied by 0.9 in accordance with the Protocols) that were measured pre-construction.

B. Soils on Clay-rich, Salt-affected Alluvial Material (Limon and Heldt series): **26.5%**

C. Soils Deep on Early Pleistocene Alluvium (Stoneham and Cascajo series): **35.0%.**

D. Soils on Weathered Shales (with active erosional removal) (Midway – Shale complex, Shingle series): **17.0%.**

E. Soils on Deeply Weathered Shales (without active erosional removal) (Razor series): **23.3%**

Post Construction Results

Table 1 (below) displays the base vegetation cover, revegetation cover values at the 90% and 70% levels (established under Pueblo Co. 1041 and CDPHE Stormwater Regulations, respectively), and the post-construction percent cover values for vegetation in their respective soil groups. Figure 1 graphically represents this information. In soil groups B, C, D and E post-construction vegetation cover exceeded the 90% revegetation performance standards. Note, however, that CDPHE cover expectations include all species present (including introduced annual species deemed partially unacceptable in Pueblo Co. evaluations. Sites within soil group F were flooded during the time of sampling and could not be assessed. Soil group F constituted only 0.4% of the S3-13 work package area, and had these areas been sampled they would have only yielded space for a single sampling transect.

Table 1: Vegetation Cover per Soil Group for S3-13

Map Code	Soil Group	% of Work Unit	% Base Veg. Cover	90% Revegetation Cover Performance Std. (0.9 x Base)	70% Revegetation Cover Performance Std. (0.7 x Base)	% Cover by Acc. Spp
B	Soils on clay-rich, salt-affected alluvial material (Limon and Heldt Series)	44.0	26.5	23.9	18.6	24.1
C	Soils deep on early Pleistocene alluvium (Stoneham and Cascajo series)	7.8	35.0	31.5	24.5	39.3
D	Soils on Weathered Shales (with active erosional removal) (Midway – shale complex; Shingle series)	14.8	17.0	15.3	11.9	16.9
E	Soils on recent alluvium of moderate texture and salt content (Haverson series and Ustic Torrifluvents)	33.4	23.3	21.0	16.3	30.9

Figure 1: Fall 2013 S3-13 SDS Pueblo Co. Restoration Cover Levels vs. 2014 Standards

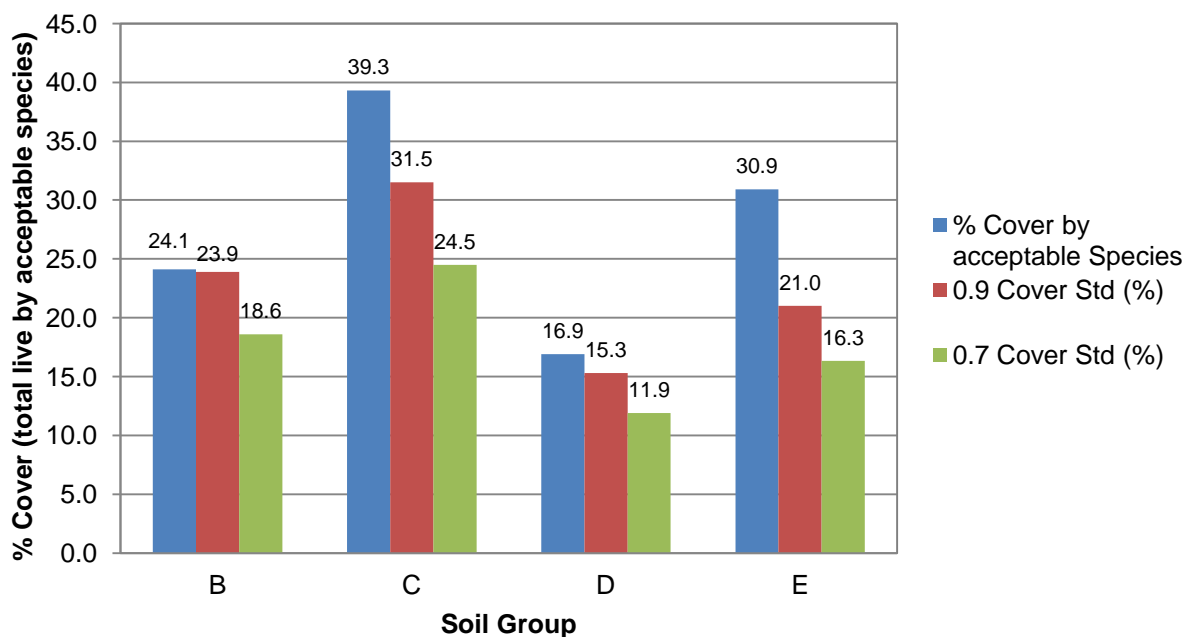


Figure 2: 2014 S3-13 SDS Pueblo Co. Presence of Acceptable Species

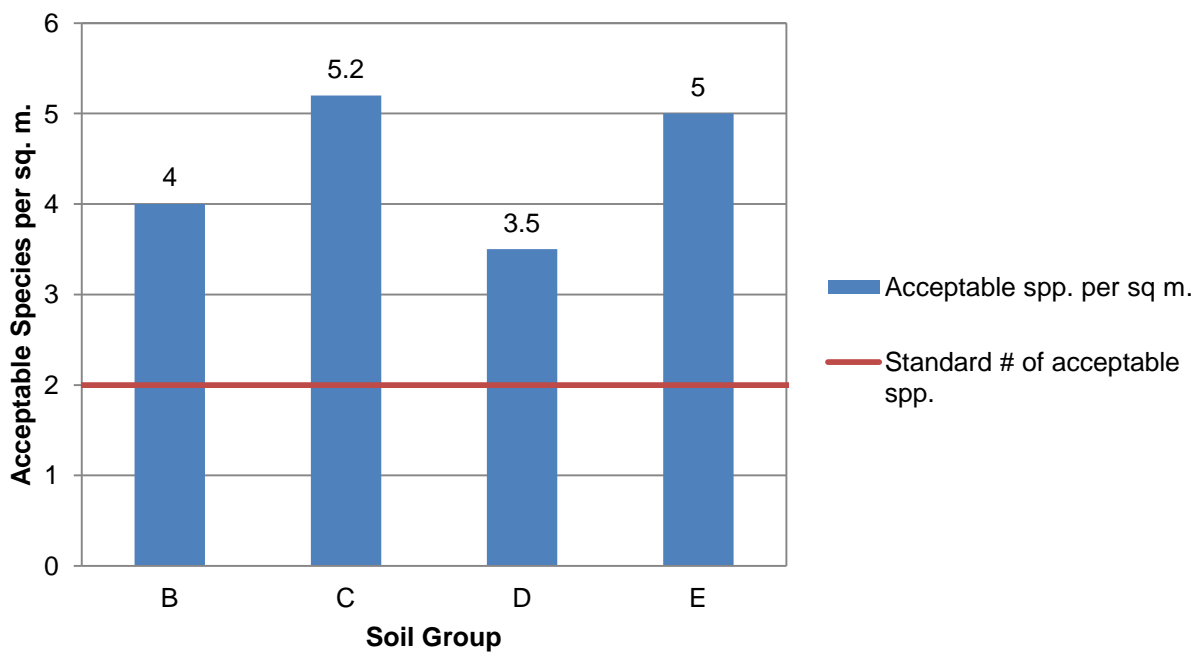


Figure 2 displays the number of acceptable species present on each soil type in S3-13 compared to the pre-established standard of 2 species per square meter. In all soil groups, the number of acceptable species present surpassed the standard.

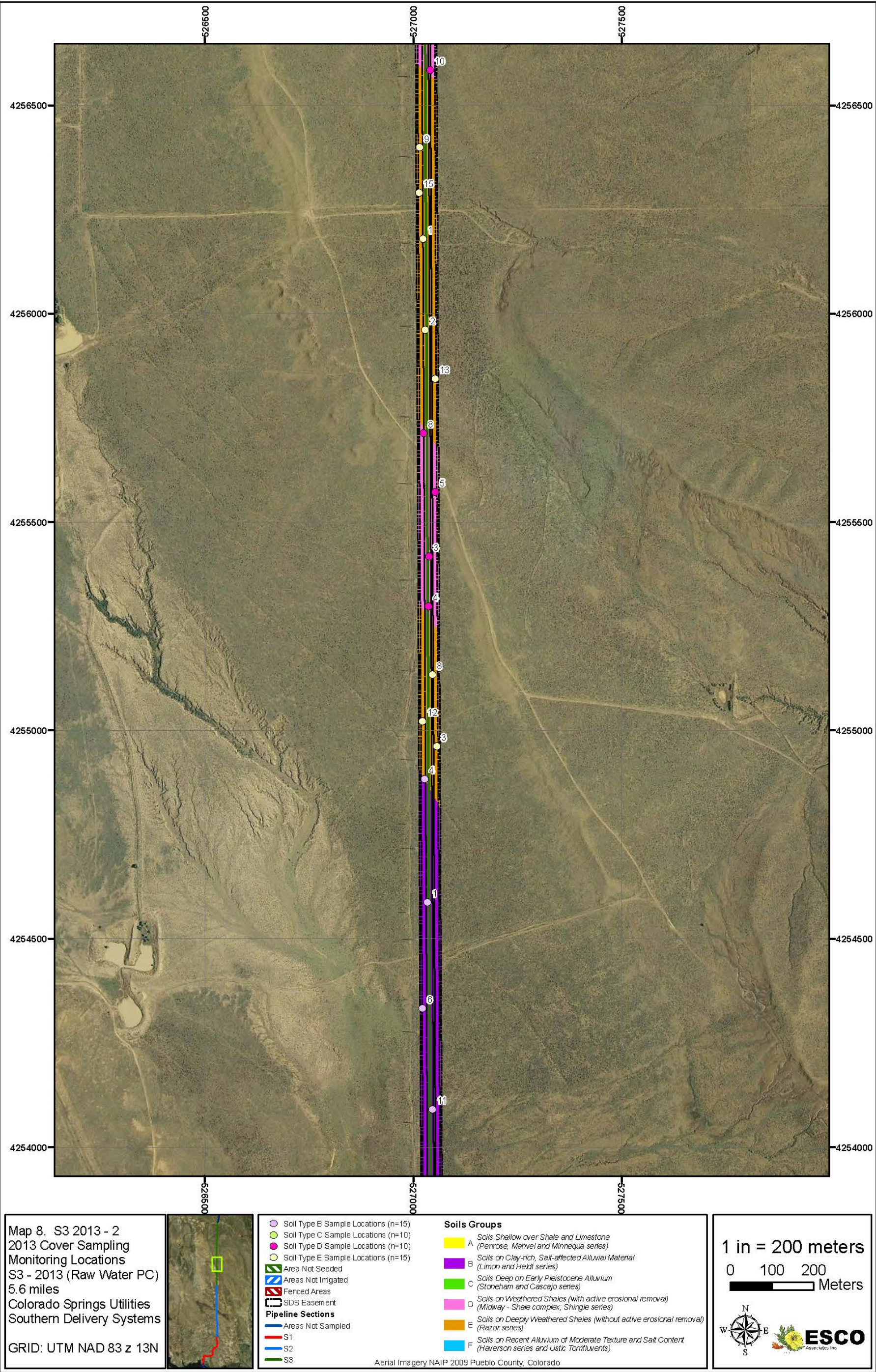
Discussion

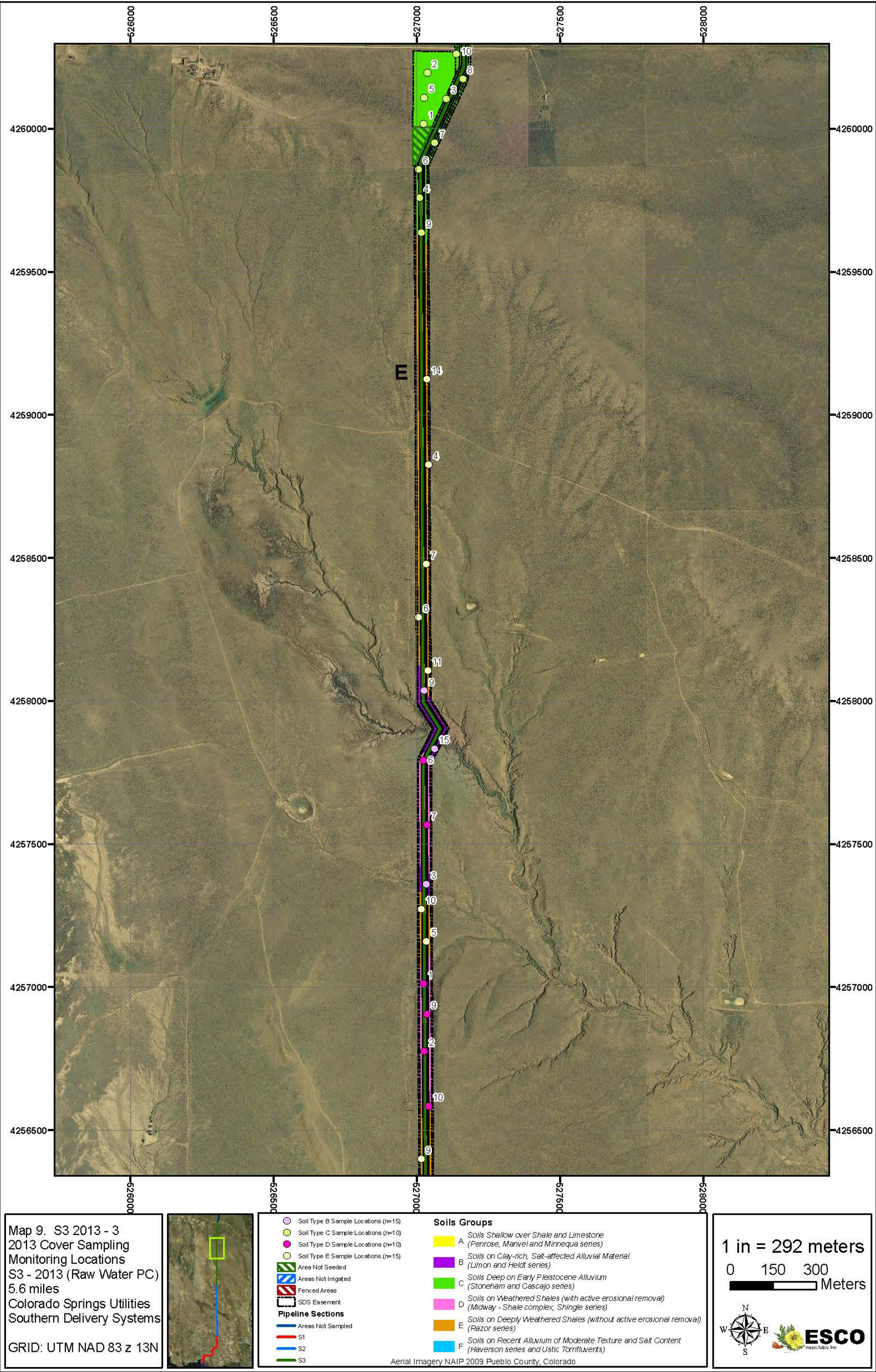
Post-Construction Revegetation Performance

None of the Soil Groups sampled in section S3-13 failed to equal or exceed the Pueblo County 1041 permit standard of 90%. Some areas within this unit had been damaged to varying degrees by broad-scale flooding associated with a large precipitation event in early September 2013. It is anticipated that reseeding the results will bring the low areas upward and the overall soil group B cover values in 2014 will be satisfactory.

However, it should be noted that the 90% revegetation cover performance standards stated in the Pueblo County 1041 permit are applicable over a two-year period. The S3-13 measurements presented here were taken at the end of the first growing season (September 2013), and vegetation cover can be expected to increase over time. The number of acceptable species surpassed the standard (2 species per square meter) in all soil groups. Despite damage that occurred in September 2013 on the Soil Group B sites, the cover data suggest that compliance with the 90% standard after the 2014 growing season is likely. From species presence data it can also be seen that species composition is also moving in the right direction.







Appendix B: Tabular Data – Work Package S3-13

Table 1: Work Package S3-13 on Limon and Heldt Series (Soil Group B)

PLANT SPECIES	FIRST HIT		FIRST HIT		ALL HIT		Percent Foliar Cover*														
	AVERAGE		RELATIVE		AVERAGE																
	COVER ^a		VEGETATION		COVER ^d		---Sample Number---														
	(%)	(%)	(%)	(%)	(%)	(%)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
NATIVE ANNUAL & BIENNIAL FORBS																					
Amaranthus albus	0.33	26.67	0.95	0.33	0.91			P	1						3				1		
Anoda cristata	0.00	6.67	0.00	0.00	0.00			P													
Atriplex saccaria	0.13	6.67	0.38	0.13	0.36														2		
Chamaesyce sp.	1.13	86.67	3.23	1.27	3.46	5(2)	P	3	P	1	P	3	3			1	P	P	1	P	
Chenopodium berlandieri	0.07	20.00	0.19	0.07	0.18					P	P						1				
Chenopodium incanum	0.00	20.00	0.00	0.00	0.00				P	P		P									
Chenopodium rubrum	0.00	13.33	0.00	0.00	0.00				P												P
Conyza canadensis	0.00	6.67	0.00	0.00	0.00										P						
Cryptantha sp.	0.00	6.67	0.00	0.00	0.00					P											
Descurainia incana	0.00	6.67	0.00	0.00	0.00						P										
Descurainia pinnata	0.13	13.33	0.38	0.13	0.36											2			P		
Dyssodia aurea	0.73	100.00	2.09	0.73	2.00	1	2	1	P	P	1	P	2	P	P	P	P	P	1	2	1
Dyssodia papposa	0.07	26.67	0.19	0.07	0.18		1					P					P				P
Erigeron divergens	0.00	6.67	0.00	0.00	0.00				P												
Grindelia squarrosa	0.00	6.67	0.00	0.00	0.00																P
Helianthus annuus	0.13	46.67	0.38	0.13	0.36	P	1			P	P				P	P			1		
Ipomopsis laxiflora	0.00	6.67	0.00	0.00	0.00							P									
Monolepis nuttalliana	0.27	26.67	0.76	0.27	0.73						P		4	P						P	
Polygonum douglasii	0.00	6.67	0.00	0.00	0.00											P					
Solanum rostratum	0.27	53.33	0.76	0.27	0.73			P	P			P	P			2	P	P	2		
Solanum triflorum	0.13	13.33	0.38	0.13	0.36			1	1												
Suaeda sp.	0.00	13.33	0.00	0.00	0.00												P				P
Ximenesia encelioides	0.60	60.00	1.71	0.60	1.64	1	1	P			P	P		P		P		P	7		
TOTAL NATIVE ANN. & BIEN. FORBS	4.0	100.0	11.4	4.1	11.3	7(2)	6	6	P	1	1	7	5	3	5	1	P		15	2	1
INTRODUCED ANNUAL & BIENNIAL FORBS																					
Abutilon theophrasti	0.00	6.67	0.00	0.00	0.00									P							
Amaranthus hybridus	0.40	53.33	1.14	0.40	1.09			P	1	4	P	1	P		P						P
Bassia sieversiana	1.80	33.33	5.13	1.80	4.92		1							1	P	25		P			
Carduus nutans ssp. macrolepis	0.00	6.67	0.00	0.00	0.00						P										
Carduus sp.	0.00	6.67	0.00	0.00	0.00			P													
Chenopodium album	0.00	13.33	0.00	0.00	0.00			P											P		
Euphorbia davidii	0.00	6.67	0.00	0.00	0.00											P					
Halogeton glomeratus	0.73	46.67	2.09	0.80	2.19		3				1			4		1(1)	P	P	2		

PLANT SPECIES	FIRST HIT		ALL HIT		Percent Foliar Cover*															
	AVERAGE		RELATIVE	AVERAGE	RELATIVE															
	COVER ^a	FREQUENCY ^b	VEGETATION	COVER ^d	VEGETATION	---Sample Number---														
	(%)	(%)	(%)	(%)	(%)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Lactuca serriola	0.07	6.67	0.19	0.07	0.18										1					
Malva neglecta	0.00	6.67	0.00	0.00	0.00			P												
Medicago lupulina	0.00	6.67	0.00	0.00	0.00	P														
Melilotus officinalis	0.13	46.67	0.38	0.13	0.36	P	1					P	P		P			P	1	
Portulaca oleracea	0.33	46.67	0.95	0.33	0.91	P	1		P			3				P			P	1
Salsola australis	4.53	53.33	12.93	4.60	12.57		18		6		1			P	7		28(1)	7	1	
Salsola collina	3.27	66.67	9.32	3.47	9.47	1	6(1)			15(1)	6	1	5		2	4		P	9(1)	
Solanum americanum	0.07	6.67	0.19	0.07	0.18			1												
Sonchus sp.	0.00	6.67	0.00	0.00	0.00												P			
TOTAL INTRO. ANN. & BIEN. FORBS	11.3	100.0	32.3	11.7	31.9	1	30(1)	2	10	16(1)	8	4	10	P	36(1)	4	28(1)	9	11(1)	1
NATIVE ANNUAL GRASSES																				
Munroa squarrosa	0.00	6.67	0.00	0.00	0.00						P									
Panicum capillare	0.27	46.67	0.76	0.27	0.73		1	P			1		P	1			1	P		
TOTAL NATIVE ANN. GRASSES	0.3	46.7	0.8	0.3	0.7	---	1	P	---	---	1	---	P	1	---	---	1	P	---	---
INTRODUCED ANNUAL GRASSES																				
Bromus tectorum	0.33	13.33	0.95	0.40	1.09					2							3(1)			
Digitaria ischaemum	0.07	6.67	0.19	0.07	0.18			1												
Digitaria sanguinalis	0.20	73.33	0.57	0.20	0.55	P	P		P	P	1	2			P	P	P	P	P	
Sorghum halepense	0.47	26.67	1.33	0.47	1.28		1								4		1	1		
Triticum aestivum	0.00	6.67	0.00	0.00	0.00										P					
TOTAL INTRO. ANN. GRASSES	1.1	80.0	3.0	1.1	3.1	P	1	1	P	2	1	2	---	---	4	P	4(1)	1	P	---
NATIVE PERENNIAL FORBS																				
Asclepias verticillata	0.00	6.67	0.00	0.00	0.00													P		
Astragalus crassicaarpus	0.00	6.67	0.00	0.00	0.00			P												
Astragalus racemosus	0.80	73.33	2.28	0.80	2.19		P	6		P	1	1	P	2			P	1	P	1
Astragalus shortianus	0.00	26.67	0.00	0.00	0.00	P			P		P						P			
Brickellia eupatorioides	0.00	13.33	0.00	0.00	0.00					P										P
Chamaesaracha coronopus	0.20	60.00	0.57	0.20	0.55	3	P	P	P		P				P	P	P		P	
Cryptantha jamesii	0.00	13.33	0.00	0.00	0.00		P								P					
Glandularia bipinnatifida	0.67	86.67	1.90	0.87	2.37	3	P	5(2)	P	P	P		P	P	1	P	P	1(1)	P	
Hedeoma drummondii	0.00	33.33	0.00	0.00	0.00		P	P		P					P			P		
Lomatium foeniculaceum	0.00	6.67	0.00	0.00	0.00										P					
Oenothera sp.	0.00	6.67	0.00	0.00	0.00													P		
Oxybaphus linearis	0.00	6.67	0.00	0.00	0.00														P	

PLANT SPECIES	FIRST HIT		FIRST HIT	ALL HIT		Percent Foliar Cover*														
	AVERAGE COVER ^a	FREQUENCY ^b	RELATIVE VEGETATION	AVERAGE COVER ^d	RELATIVE VEGETATION COVER ^e	---Sample Number---														
			COVER ^c	COVER ^d	COVER ^e	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Picradeniopsis oppositifolia	0.00	6.67	0.00	0.00	0.00	P														
Quincula lobata	0.20	53.33	0.57	0.20	0.55	P	1	1		P			P		1		P	P		
Rudbeckia hirta	0.00	6.67	0.00	0.00	0.00	P														
Solidago sp.	0.07	13.33	0.19	0.07	0.18		P								1					
Sphaeralcea angustifolia	0.00	46.67	0.00	0.00	0.00		P			P			P			P	P	P	P	
Sphaeralcea coccinea	0.07	60.00	0.19	0.07	0.18	P	1	P	P		P	P			P		P	P		
Vicia sp.	0.00	6.67	0.00	0.00	0.00															P
TOTAL NATIVE PERENNIAL FORBS	2.0	100.0	5.7	2.2	6.0	6	2	12(2)	P	P	1	1	P	2	3	P	P	2(1)	P	1
INTRODUCED PERENNIAL FORBS																				
Convolvulus arvensis	0.00	6.67	0.00	0.00	0.00								P							
Daucus carota	0.00	6.67	0.00	0.00	0.00	P														
Rumex crispus	0.00	6.67	0.00	0.00	0.00												P			
Taraxacum officinale	0.00	6.67	0.00	0.00	0.00										P					
Trifolium pratense	0.00	13.33	0.00	0.00	0.00					P									P	
TOTAL INTRO. PERENNIAL FORBS	0.0	40.0	0.0	0.0	0.0	P	---	---	---	P	---	---	P	---	P	---	P	---	P	---
NATIVE PERENNIAL GRASSES (cool)																				
Aristida divaricata	0.00	6.67	0.00	0.00	0.00					P										
Elymus trachycaulus	0.13	13.33	0.38	0.13	0.36	1								1						
Pascopyrum smithii	3.27	100.00	9.32	3.40	9.29	P	1	3	P	7	4	3	1	7(1)	2(1)	6	3	2	6	4
TOTAL NATIVE PERENNIAL GRASSES (c)	3.4	100.0	9.7	3.5	9.7	1	1	3	P	7	4	3	1	8(1)	2(1)	6	3	2	6	4
INTRODUCED PERENNIAL GRASSES (cool)																				
Echinochloa crus-galli	0.33	86.67	0.95	0.40	1.09	P	1	1	P	P	P	1		1	1	P	P	(1)		P
Setaria viridis	0.07	20.00	0.19	0.07	0.18			1		P									P	
Thinopyrum intermedium	0.07	6.67	0.19	0.07	0.18												1			
TOTAL INTRO. PERENNIAL GRASSES (c)	0.5	93.3	1.3	0.5	1.5	P	1	2	P	P	P	1	---	1	1	P	1	(1)	P	P
NATIVE PERENNIAL GRASSES (warm)																				
Aristida purpurea	0.00	6.67	0.00	0.00	0.00										P					
Bouteloua curtipendula	2.07	100.00	5.89	2.33	6.38	3	3(1)	2	4	2	3	P	1	P	3	1	2(2)	4(1)	P	3
Chondrosum gracile	1.60	100.00	4.56	1.67	4.55	P	P	3	2	1	2	2	P	3	2(1)	P	1	5	P	3
Leptochloa dubia	0.07	13.33	0.19	0.07	0.18												P	1		
Pleuraphis jamesii	3.00	100.00	8.56	3.27	8.93	4	2(1)	4	2	3	3	1	2	P	P	4	3(1)	4(1)	4	9(1)
Sporobolus airoides	5.07	100.00	14.45	5.07	13.84	2	2	8	4	1	3	7	P	27	P	5	1	1	P	15
Sporobolus cryptandrus	0.60	60.00	1.71	0.60	1.64	3	P	3	1	P	P		P		1	1				

PLANT SPECIES	FIRST HIT		FIRST HIT	ALL HIT		Percent Foliar Cover*														
	AVERAGE		RELATIVE	AVERAGE																
	COVER ^a	FREQUENCY ^b	VEGETATION	COVER ^d	VEGETATION	---Sample Number---														
	(%)	(%)	(%)	(%)	(%)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
TOTAL NATIVE PERENNIAL GRASSES (w)	12.4	100.0	35.4	13.0	35.5	12	7(2)	20	13	7	11	10	3	30	6(1)	11	7(3)	15(2)	4	30(1)
NATIVE SUBSHRUBS																				
Gutierrezia sarothrae	0.00	6.67	0.00	0.00	0.00												P			
TOTAL NATIVE SUBSHRUBS	0.0	6.7	0.0	0.0	0.0	---	---	---	---	---	---	---	---	---	---	---	P	---	---	---
INTRODUCED SUBSHRUBS																				
Lespedeza cuneata	0.00	20.00	0.00	0.00	0.00		P								P			P		
TOTAL INTRODUCED SUBSHRUBS	0.0	20.0	0.0	0.0	0.0	---	P	---	---	---	---	---	---	---	P	---	---	P	---	---
NATIVE SHRUBS																				
Atriplex canescens	0.13	60.00	0.38	0.13	0.36		P	P			P	1	1			P		P	P	P
TOTAL NATIVE SHRUBS	0.1	60.0	0.4	0.1	0.4	---	P	P	---	---	P	1	1	---	---	P	---	P	P	P
NATIVE TREES																				
Acacia sp.	0.00	13.33	0.00	0.00	0.00				P						P					
TOTAL NATIVE TREES	0.0	13.3	0.0	0.0	0.0	---	---	---	P	---	---	---	---	---	P	---	---	---	---	---
SUCCULENTS																				
Opuntia polyacantha	0.00	13.33	0.00	0.00	0.00		P								P					
Opuntia spp.	0.00	6.67	0.00	0.00	0.00				P											
TOTAL SUCCULENTS	0.0	20.0	0.0	0.0	0.0	---	P	---	P	---	---	---	---	---	P	---	---	---	---	---
Litter	12.00	100.00		12.00		7	9	6	13	7	14	4	9	26	14	3	13	20	5	30
Bare soil	52.07	100.00		52.07		66	42	48	62	60	59	67	71	29	29	75	39	30	72	32
Rock	0.87	26.67		0.87					2								4	6		1
TOTALS	100.0			101.5		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
TOTAL VEGETATION COVER	35.1 (s=11.7)		100.0	36.6 (s=12.9)	100.0	27(2)	49(3)	46(2)	23	33(1)	27	29	20	45(1)	57(3)	22	44(5)	44(4)	23(1)	37(1)
GROUND COVER (Litter+Rock+Veg+St.Dead)	47.9			49.5		34(2)	58(3)	52(2)	38	40(1)	41	33	29	71(1)	71(3)	25	61(5)	70(4)	28(1)	68(1)
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 25.9 Std.Dev.= 7.0)						25	40	30	23	29	25	19	22	17	37	21	29	33	21	17

^a First Hit Cover = Absolute percent cover in vertical view with no account of plants obscured by first (i.e. top) hit.

^b Frequency = Percent of the samples in which a species or lifeform occurred

^c First Hit Relative Cover = Percent of the First Hit vegetation cover comprised of this species or lifeform

^d All Hit Cover = Absolute percent cover in vertical view accounting for all cover by the species or lifeform, whether over-arched by other plants or not

^e All Hit Relative Cover = Percent of the All Hit vegetation cover comprised of the species or lifeform

***P=Present within 1m. on either side of cover transect, but not quantitatively encountered.**
()=Data in parentheses represent other hits that are used in conjunction with first hits for all hit cover statistics.

Table 2: Work Package S3-13 on Stoneham and Cascajo Series (Soil Group C)

PLANT SPECIES	FIRST HIT		FIRST HIT		ALL HIT	Percent Foliar Cover*										
	AVERAGE		RELATIVE		AVERAGE	RELATIVE										
	COVER ^a	FREQUENCY ^b	VEGETATION		COVER ^d	VEGETATION	---Sample Number---									
	(%)	(%)	COVER ^c		(%)	COVER ^e	1	2	3	4	5	6	7	8	9	10
NATIVE ANNUAL & BIENNIAL FORBS																
Amaranthus albus	3.50	100.00	6.58		4.00	6.53	4(1)	1	6	9(3)	1	5	2(1)	3	P	4
Amaranthus blitoides	0.00	20.00	0.00		0.00	0.00	P				P					
Chamaesyce sp.	1.40	100.00	2.63		1.70	2.77	P	1	(1)	2	1	2	3	2(2)	3	P
Chenopodium berlandieri	0.00	20.00	0.00		0.00	0.00		P								P
Chenopodium incanum	0.00	20.00	0.00		0.10	0.16	(1)				P					
Chenopodium leptophyllum	0.00	20.00	0.00		0.00	0.00									P	P
Chenopodium rubrum	0.00	20.00	0.00		0.00	0.00				P						P
Descurainia pinnata	0.10	10.00	0.19		0.10	0.16						1				
Dyssodia aurea	11.30	90.00	21.24		12.90	21.04	6(5)	20(1)		24(3)	10(1)	15(4)	12(1)	17(1)	2	7
Dyssodia papposa	4.40	70.00	8.27		4.90	7.99	12(2)	11	10(3)	3		3		1		4
Erigeron strigosus	0.00	10.00	0.00		0.00	0.00	P									
Helianthus annuus	0.10	10.00	0.19		0.10	0.16							1			
Nuttallia decapetala	0.00	10.00	0.00		0.00	0.00									P	
Solanum rostratum	0.00	20.00	0.00		0.00	0.00				P		P				
Ximenesia encelioides	3.80	90.00	7.14		3.80	6.20	8	1	2	11	3	3	8	2		P
TOTAL NATIVE ANN. & BIEN. FORBS	24.6	100.0	46.2		27.6	45.0	30(9)	34(1)	18(4)	49(6)	15(1)	29(4)	26(2)	25(3)	5	15
INTRODUCED ANNUAL & BIENNIAL FORBS																
Amaranthus retroflexus	2.00	90.00	3.76		2.30	3.75	15(1)	1	3(2)	P	P	P		P	P	1
Bassia sieversiana	1.50	60.00	2.82		1.80	2.94	8(1)		1(1)		3	P	P			3(1)
Chenopodium album	0.30	50.00	0.56		0.50	0.82		1(1)	1			P			1(1)	P
Hibiscus trionum	0.00	20.00	0.00		0.00	0.00				P			P			
Melilotus officinalis	0.80	80.00	1.50		1.10	1.79	1(1)	P	P		2	P	3(2)		P	2
Portulaca oleracea	0.10	30.00	0.19		0.20	0.33	(1)					1	P			
Salsola australis	1.70	70.00	3.20		1.80	2.94	5(1)		1	1	5	2		1	2	
Salsola collina	9.70	100.00	18.23		10.10	16.48	7	7	13(2)	4(1)	10	5	10	12	28(1)	1
Tribulus terrestris	0.30	20.00	0.56		0.30	0.49					1			2		
TOTAL INTRO. ANN. & BIEN. FORBS	16.4	100.0	30.8		18.1	29.5	36(5)	9(1)	19(5)	5(1)	21	8	13(2)	15	31(2)	7(1)
NATIVE ANNUAL GRASSES																
Munroa squarrosa	0.00	30.00	0.00		0.00	0.00					P			P	P	
Panicum capillare	0.00	40.00	0.00		0.00	0.00				P		P	P	P		
TOTAL NATIVE ANN. GRASSES	0.0	60.0	0.0		0.0	0.0	---	---	---	P	P	P	P	P	P	---
INTRODUCED ANNUAL GRASSES																

PLANT SPECIES	FIRST HIT		FIRST HIT	ALL HIT	ALL HIT	Percent Foliar Cover*									
	AVERAGE		RELATIVE	AVERAGE	RELATIVE										
	COVER ^a	FREQUENCY ^b	VEGETATION	COVER ^d	VEGETATION	---Sample Number---									
	(%)	(%)	(%)	(%)	(%)	1	2	3	4	5	6	7	8	9	10
Digitaria sanguinalis	0.10	70.00	0.19	0.20	0.33			P	1		P	P	P	P	(1)
Bromus tectorum	0.20	30.00	0.38	0.20	0.33		1				1				P
Sorghum halepense	0.00	10.00	0.00	0.10	0.16							(1)			
TOTAL INTRO. ANN. GRASSES	0.3	80.0	0.6	0.5	0.8	---	1	P	1	---	1	(1)	P	P	(1)
NATIVE PERENNIAL FORBS															
Ambrosia confertiflora	0.10	10.00	0.19	0.10	0.16						1				
Astragalus agrestis	0.10	10.00	0.19	0.20	0.33	1(1)									
Astragalus crassicaarpus	0.00	40.00	0.00	0.00	0.00		P	P						P	P
Astragalus racemosus	0.00	20.00	0.00	0.00	0.00	P			P						
Astragalus shortianus	0.00	20.00	0.00	0.00	0.00					P		P			
Astragalus sp.	0.00	10.00	0.00	0.00	0.00				P						
Chamaesaracha coronopus	0.70	90.00	1.32	0.80	1.31	P	(1)	3	3	P	P		1	P	P
Glandularia bipinnatifida	3.00	100.00	5.64	3.60	5.87	(3)	2	(1)	6	P	14(1)	8(1)	P	P	P
Hedeoma drummondii	0.00	10.00	0.00	0.10	0.16				(1)						
Psoralidium tenuiflorum	0.00	10.00	0.00	0.00	0.00									P	
Rumex sp.	0.00	10.00	0.00	0.10	0.16	(1)									
Solanum elaeagnifolium	0.10	10.00	0.19	0.20	0.33							1(1)			
Sphaeralcea angustifolia	0.00	10.00	0.00	0.00	0.00				P						
Sphaeralcea coccinea	0.00	50.00	0.00	0.00	0.00	P	P			P		P		P	
Vexibia nuttalliana	0.10	20.00	0.19	0.10	0.16								1		P
TOTAL NATIVE PERENNIAL FORBS	4.1	100.0	7.7	5.2	8.5	1(5)	2(1)	3(1)	9(1)	P	15(1)	9(2)	2	P	P
INTRODUCED PERENNIAL FORBS															
Cirsium arvense	0.00	10.00	0.00	0.00	0.00					P					
Rumex crispus	0.00	10.00	0.00	0.00	0.00		P								
TOTAL INTRO. PERENNIAL FORBS	0.0	20.0	0.0	0.0	0.0	---	P	---	---	P	---	---	---	---	---
NATIVE PERENNIAL GRASSES (cool)															
Elymus trachycaulus	0.10	30.00	0.19	0.10	0.16			P					P		1
Pascopyrum smithii	0.70	100.00	1.32	0.90	1.47	(1)	1	1	2	P	2	P	P	(1)	1
TOTAL NATIVE PERENNIAL GRASSES (c)	0.8	100.0	1.5	1.0	1.6	(1)	1	1	2	P	2	P	P	(1)	2
INTRODUCED PERENNIAL GRASSES (cool)															
Echinochloa crus-galli	0.00	20.00	0.00	0.00	0.00				P						P
Setaria viridis	0.50	60.00	0.94	0.50	0.82		1	1			1		P	1	1
TOTAL INTRO. PERENNIAL GRASSES (c)	0.5	70.0	0.9	0.5	0.8	---	1	1	P	---	1	---	P	1	1

PLANT SPECIES	FIRST HIT AVERAGE COVER ^a (%)	FREQUENCY ^b (%)	FIRST HIT RELATIVE VEGETATION COVER ^c (%)	ALL HIT AVERAGE COVER ^d (%)	ALL HIT RELATIVE VEGETATION COVER ^e (%)	Percent Foliar Cover*									
						---Sample Number---									
						1	2	3	4	5	6	7	8	9	10
NATIVE PERENNIAL GRASSES (warm)															
Bouteloua curtipendula	1.20	80.00	2.26	1.40	2.28		P	1	1	1		3	P	3	3(2)
Buchloe dactyloides	0.00	10.00	0.00	0.00	0.00							P			
Chondrosum gracile	2.50	90.00	4.70	2.80	4.57		2(1)	6(1)	(1)	1	3	1	1	2	9
Leptochloa dubia	0.10	40.00	0.19	0.10	0.16					P		P	P	1	
Panicum virgatum	0.00	10.00	0.00	0.00	0.00										P
Pleuraphis jamesii	0.90	90.00	1.69	1.00	1.63	3(1)		P	1	P	P	P	2	3	P
Sporobolus airoides	0.20	80.00	0.38	0.30	0.49	P	1	P	P	P	P	1	(1)		
Sporobolus cryptandrus	1.60	80.00	3.01	2.70	4.40		1(2)	P	6(4)		6(5)	P	P	2	1
TOTAL NATIVE PERENNIAL GRASSES (w)	6.5	100.0	12.2	8.3	13.5	3(1)	4(3)	7(1)	8(5)	2	9(5)	5	3(1)	11	13(2)
INTRODUCED SUBSHRUBS															
Lespedeza cuneata	0.00	10.00	0.00	0.00	0.00										P
TOTAL INTRODUCED SUBSHRUBS	0.0	10.0	0.0	0.0	0.0	---	---	---	---	---	---	---	---	---	P
NATIVE SHRUBS															
Atriplex canescens	0.00	20.00	0.00	0.10	0.16				(1)		P				
TOTAL NATIVE SHRUBS	0.0	20.0	0.0	0.1	0.2	---	---	---	(1)	---	P	---	---	---	---
AGAVOIDS															
Yucca glauca	0.00	10.00	0.00	0.00	0.00									P	
TOTAL AGAVOIDS	0.0	10.0	0.0	0.0	0.0	---	---	---	---	---	---	---	---	P	---
Litter	13.40	100.00		13.40		9	16	17	7	20	13	16	4	6	26
Bare soil	33.00	100.00		33.00		21	32	34	19	42	22	30	51	44	35
Rock	0.40	30.00		0.40								1		2	1
TOTALS	100.0			108.1		100	100	100	100	100	100	100	100	100	100
TOTAL VEGETATION COVER	53.2 (s=12.6)		100.0	61.3 (s=18.0)	100.0	70(21)	52(6)	49(11)	74(14)	38(1)	65(10)	53(7)	45(4)	48(3)	38(4)
GROUND COVER (Litter+Rock+Veg+St.Dead)	67.0			75.1		79(21)	68(6)	66(11)	81(14)	58(1)	78(10)	70(7)	49(4)	56(3)	65(4)
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 24.8 Std.Dev.= 2.3)						23	22	22	27	24	27	25	24	25	29

^a First Hit Cover = Absolute percent cover in vertical view with no account of plants obscured by first (i.e. top) hit.

^b Frequency = Percent of the samples in which a species or lifeform occurred

^c First Hit Relative Cover = Percent of the First Hit vegetation cover comprised of this species or lifeform

^d All Hit Cover = Absolute percent cover in vertical view accounting for all cover by the species or lifeform, whether over-arched by other plants or not

^e All Hit Relative Cover = Percent of the All Hit vegetation cover comprised of the species or lifeform

***P=Present within 1m. on either side of cover transect, but not quantitatively encountered.**
()=Data in parentheses represent other hits that are used in conjunction with first hits for all hit cover statistics.

Table 3: Work Package S3-13 on Midway-Shale Complex; Shingle Series Soils (Soil Group D)

PLANT SPECIES	FIRST HIT		FIRST HIT		ALL HIT	Percent Foliar Cover*										
	AVERAGE		VEGETATION		AVERAGE	---Sample Number---										
	COVER ^a	FREQUENCY ^b	COVER ^c		COVER ^d	COVER ^e										
	(%)	(%)	(%)		(%)	(%)	1	2	3	4	5	6	7	8	9	10
NATIVE ANNUAL & BIENNIAL FORBS																
Amaranthus albus	0.00	10.00	0.00		0.00	0.00	P									
Anoda cristata	0.00	10.00	0.00		0.00	0.00		P								
Atriplex saccaria	0.00	10.00	0.00		0.00	0.00					P					
Chamaesyce sp.	3.50	100.00	15.77		4.10	17.45	7	P	5(2)	3(1)	1	4(1)	4	5(2)	P	6
Chenopodium berlandieri	0.20	70.00	0.90		0.20	0.85	P	P	P	P		P		1	1	
Chenopodium incanum	0.10	40.00	0.45		0.10	0.43			P	P	P			1		
Chenopodium leptophyllum	0.00	30.00	0.00		0.00	0.00	P	P		P						
Dyssodia aurea	1.30	80.00	5.86		1.40	5.96			4	3(1)	1	P	2	3	P	P
Helianthus annuus	0.10	10.00	0.45		0.10	0.43								1		
Machaeranthera bigelovii	0.00	10.00	0.00		0.00	0.00	P									
Monolepis nuttalliana	0.10	70.00	0.45		0.10	0.43	P	1			P	P	P	P	P	
Solanum rostratum	0.00	20.00	0.00		0.00	0.00						P			P	
Verbesina encelioides ssp. encelioides	0.10	30.00	0.45		0.10	0.43				P				1	P	
TOTAL NATIVE ANN. & BIEN. FORBS	5.4	100.0	24.3		6.1	26.0	7	1	9(2)	6(2)	2	4(1)	6	12(2)	1	6
INTRODUCED ANNUAL & BIENNIAL FORBS																
Amaranthus hybridus	0.00	20.00	0.00		0.00	0.00			P	P						
Amaranthus retroflexus	0.00	20.00	0.00		0.00	0.00	P								P	
Bassia sieversiana	0.00	10.00	0.00		0.00	0.00								P		
Hibiscus trionum	0.00	20.00	0.00		0.00	0.00				P					P	
Malva neglecta	0.00	20.00	0.00		0.00	0.00						P			P	
Melilotus officinalis	0.00	40.00	0.00		0.00	0.00	P		P		P			P		
Portulaca oleracea	2.40	70.00	10.81		2.50	10.64	9	3		P		2		1	9(1)	P
Salsola australis	1.20	70.00	5.41		1.20	5.11		3	P	5	P			1	P	3
Salsola collina	0.40	70.00	1.80		0.40	1.70	2	P	P			1	1	P		P
Solanum americanum	0.00	10.00	0.00		0.00	0.00	P									
Tribulus terrestris	0.10	10.00	0.45		0.10	0.43	1									
TOTAL INTRO. ANN. & BIEN. FORBS	4.1	100.0	18.5		4.2	17.9	12	6	P	5	P	3	1	2	9(1)	3
NATIVE ANNUAL GRASSES																
Leptochloa fusca ssp. fascicularis	0.20	20.00	0.90		0.20	0.85						1	1			
Panicum capillare	0.50	40.00	2.25		0.50	2.13	1		1				1		2	
TOTAL NATIVE ANN. GRASSES	0.7	50.0	3.2		0.7	3.0	1	---	1	---	---	1	2	---	2	---
INTRODUCED ANNUAL GRASSES																

PLANT SPECIES	FIRST HIT AVERAGE COVER ^a (%)	FREQUENCY ^b (%)	FIRST HIT RELATIVE VEGETATION COVER ^c (%)	ALL HIT AVERAGE COVER ^d (%)	ALL HIT RELATIVE VEGETATION COVER ^e (%)	Percent Foliar Cover*									
						---Sample Number---									
						1	2	3	4	5	6	7	8	9	10
Digitaria sanguinalis	0.40	50.00	1.80	0.40	1.70		1	2	P			1		P	
Bromus tectorum	1.30	20.00	5.86	1.30	5.53						12		1		
Triticum aestivum	0.20	10.00	0.90	0.20	0.85						2				
TOTAL INTRO. ANN. GRASSES	1.9	70.0	8.6	1.9	8.1	---	1	2	P	---	14	1	1	P	---
NATIVE PERENNIAL FORBS															
Apocynum cannabinum	0.00	10.00	0.00	0.00	0.00									P	
Astragalus racemosus	0.20	40.00	0.90	0.20	0.85			P		P	P	2			
Astragalus shortianus	0.00	40.00	0.00	0.00	0.00		P	P		P		P			
Astragalus sp.	0.00	10.00	0.00	0.00	0.00									P	
Chamaesaracha coronopus	0.20	30.00	0.90	0.20	0.85			2		P			P		
Dalea candida var. oligophylla	0.00	10.00	0.00	0.00	0.00								P		
Glandularia bipinnatifida	0.30	80.00	1.35	0.30	1.28	P	1		1	P	P	P	1		P
Hedeoma drummondii	0.00	10.00	0.00	0.00	0.00				P						
Oenothera caespitosa	0.00	10.00	0.00	0.00	0.00		P								
Picradeniopsis oppositifolia	0.00	20.00	0.00	0.00	0.00				P	P					
Quincula lobata	0.00	70.00	0.00	0.00	0.00	P	P	P		P		P	P		P
Rudbeckia hirta	0.00	10.00	0.00	0.00	0.00								P		
Sphaeralcea angustifolia	0.00	20.00	0.00	0.00	0.00	P			P						
Sphaeralcea coccinea	0.10	70.00	0.45	0.30	1.28	P	P	(1)	1	P		P	(1)		
Vexibia nuttalliana	0.10	10.00	0.45	0.10	0.43								1		
Vicia americana	0.00	20.00	0.00	0.00	0.00	P									P
TOTAL NATIVE PERENNIAL FORBS	0.9	100.0	4.1	1.1	4.7	P	1	2(1)	2	P	P	2	2(1)	P	P
INTRODUCED PERENNIAL FORBS															
Rumex crispus	0.00	30.00	0.00	0.00	0.00						P		P		P
Taraxacum officinale	0.00	10.00	0.00	0.00	0.00						P				
Trifolium pratense	0.00	10.00	0.00	0.00	0.00					P					
TOTAL INTRO. PERENNIAL FORBS	0.0	40.0	0.0	0.0	0.0	---	---	---	---	P	P	---	P	---	P
NATIVE PERENNIAL GRASSES (cool)															
Elymus trachycaulus	0.10	20.00	0.45	0.10	0.43						1	P			
Pascopyrum smithii	0.80	80.00	3.60	0.90	3.83		1	2	2	P	1		1	1	(1)
Scleropogon brevifolius	0.00	20.00	0.00	0.00	0.00	P								P	
TOTAL NATIVE PERENNIAL GRASSES (c)	0.9	100.0	4.1	1.0	4.3	P	1	2	2	P	2	P	1	1	(1)
INTRODUCED PERENNIAL GRASSES (cool)															

PLANT SPECIES	FIRST HIT AVERAGE COVER ^a (%)	FREQUENCY ^b (%)	FIRST HIT RELATIVE VEGETATION COVER ^c (%)	ALL HIT AVERAGE COVER ^d (%)	ALL HIT RELATIVE VEGETATION COVER ^e (%)	Percent Foliar Cover*									
						---Sample Number---									
						1	2	3	4	5	6	7	8	9	10
Setaria viridis	0.40	30.00	1.80	0.50	2.13	P						1(1)			3
Echinochloa crus-galli	0.60	80.00	2.70	0.60	2.55		P	P	1		1	1	1	2	P
TOTAL INTRO. PERENNIAL GRASSES (c)	1.0	90.0	4.5	1.1	4.7	P	P	P	1	---	1	2(1)	1	2	3
NATIVE PERENNIAL GRASSES (warm)															
Aristida purpurea	0.00	10.00	0.00	0.00	0.00							P			
Bouteloua curtipendula	1.20	100.00	5.41	1.20	5.11	P	P	4	P	P	1	1	1	4	1
Chondrosum gracile	1.70	100.00	7.66	1.70	7.23	P	3	1	P	P	1	5	2	P	5
Pleuraphis jamesii	2.00	100.00	9.01	2.10	8.94	P	1	1	1	P	9	3	2(1)	P	3
Sporobolus airoides	1.50	80.00	6.76	1.50	6.38		P	7	1	P	3	2	1	1	
Sporobolus cryptandrus	0.90	100.00	4.05	0.90	3.83	P	P	4	P	P	P	1	3	P	1
TOTAL NATIVE PERENNIAL GRASSES (w)	7.3	100.0	32.9	7.4	31.5	P	4	17	2	P	14	12	9(1)	5	10
INTRODUCED SUBSHRUBS															
Lespedeza cuneata	0.00	20.00	0.00	0.00	0.00							P	P		
TOTAL INTRODUCED SUBSHRUBS	0.0	20.0	0.0	0.0	0.0	---	---	---	---	---	---	P	P	---	---
NATIVE SHRUBS															
Atriplex canescens	0.00	50.00	0.00	0.00	0.00	P					P	P	P		P
TOTAL NATIVE SHRUBS	0.0	50.0	0.0	0.0	0.0	P	---	---	---	---	P	P	P	---	P
SUCCULENTS															
Opuntia polyacantha	0.00	10.00	0.00	0.00	0.00										P
TOTAL SUCCULENTS	0.0	10.0	0.0	0.0	0.0	---	---	---	---	---	---	---	---	P	---
Litter	12.70	100.00		12.70		11	9	2	20	10	20	11	13	10	21
Bare soil	64.80	100.00		64.80		69	75	65	62	88	41	63	58	70	57
Rock	0.30	20.00		0.30			2						1		
TOTALS	100.0			101.3		100	100	100	100	100	100	100	100	100	100
TOTAL VEGETATION COVER	22.2 (s=10.3)		100.0	23.5 (s=11.0)	100.0	20	14	33(3)	18(2)	2	39(1)	26(1)	28(4)	20(1)	22(1)
GROUND COVER (Litter+Rock+Veg+St.Dead)	35.2			36.5		31	25	35(3)	38(2)	12	59(1)	37(1)	42(4)	30(1)	43(1)
SPECIES DENSITY (# of species/100 sq.m.)						25	21	22	23	20	25	23	30	24	17

(AVERAGE= 23.0 Std.Dev.= 3.5)		
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^a First Hit Cover = Absolute percent cover in vertical view with no account of plants obscured by first (i.e. top) hit.

^b Frequency = Percent of the samples in which a species or lifeform occurred

^c First Hit Relative Cover = Percent of the First Hit vegetation cover comprised of this species or lifeform

^d All Hit Cover = Absolute percent cover in vertical view accounting for all cover by the species or lifeform, whether over-arched by other plants or not

^e All Hit Relative Cover = Percent of the All Hit vegetation cover comprised of the species or lifeform

***P=Present within 1m. on either side of cover transect, but not quantitatively encountered.**
()=Data in parentheses represent other hits that are used in conjunction with first hits for all hit cover statistics.

Table 4: Work Package S3-13 on Razor Series (Soil Group E)

PLANT SPECIES	FIRST HIT		FIRST HIT		ALL HIT	Percent Foliar Cover*															
	AVERAGE		VEGETATION		AVERAGE	VEGETATION															
	COVER ^a	FREQUENCY ^b	COVER ^c		COVER ^d	COVER ^e	---Sample Number---														
	(%)	(%)	(%)		(%)	(%)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
NATIVE ANNUAL & BIENNIAL FORBS																					
Acrolasia dispersa	0.07	6.67	0.20		0.07	0.19														1	
Amaranthus albus	0.13	26.67	0.39		0.13	0.37							P	1	P		1				
Ambrosia sp.	0.07	20.00	0.20		0.07	0.19			P				P							1	
Anoda cristata	0.00	6.67	0.00		0.00	0.00								P							
Chamaesyce sp.	2.80	100.00	8.22		2.87	8.02	5(1)	3	1	1	3	2	1	3	1	8	3	2	5	2	2
Chenopodium berlandieri	0.00	46.67	0.00		0.00	0.00	P		P					P		P		P	P		P
Chenopodium incanum	0.20	53.33	0.59		0.20	0.56		P	2		P			P	P	1		P	P		
Chenopodium leptophyllum	0.00	13.33	0.00		0.00	0.00						P					P				
Croton texensis	0.00	6.67	0.00		0.00	0.00								P							
Cryptantha sp.	0.00	20.00	0.00		0.00	0.00	P		P										P		
Descurainia incana	0.00	13.33	0.00		0.00	0.00		P	P												
Descurainia pinnata	0.00	20.00	0.00		0.00	0.00			P			P								P	
Dyssodia aurea	4.73	100.00	13.89		5.33	14.93	2	1	1(1)	12(1)	9	10	5(1)	P	1	12(1)	2(2)	P	1	7(3)	8
Helianthus annuus	0.00	6.67	0.00		0.00	0.00							P								
Lepidium densiflorum	0.00	6.67	0.00		0.00	0.00			P												
Lepidium ramosissimum	0.00	6.67	0.00		0.00	0.00				P											
Machaeranthera bigelovii	0.00	6.67	0.00		0.00	0.00										P					
Monolepis nuttalliana	0.00	6.67	0.00		0.00	0.00										P					
Solanum rostratum	0.20	33.33	0.59		0.27	0.75				P		P	2(1)				1			P	
Solanum triflorum	0.00	6.67	0.00		0.00	0.00														P	
Ximenesia encelioides	1.20	73.33	3.52		1.33	3.73	5(2)	P	P	P				1	1	P		P	P	6	5
TOTAL NATIVE ANN. & BIEN. FORBS	9.4	100.0	27.6		10.3	28.7	12(3)	4	4(1)	13(1)	12	12	8(2)	4	4	21(1)	6(2)	3	6	17(3)	15
INTRODUCED ANNUAL & BIENNIAL FORBS																					
Amaranthus hybridus	0.00	33.33	0.00		0.00	0.00	P	P	P					P	P						
Amaranthus retroflexus	0.27	33.33	0.78		0.27	0.75				P		P	3				1			P	
Bassia sieversiana	0.07	6.67	0.20		0.07	0.19	1														
Brassica sp.	0.00	6.67	0.00		0.00	0.00								P							
Carduus nutans ssp. macrolepis	0.00	6.67	0.00		0.00	0.00													P		
Chenopodium album	0.00	20.00	0.00		0.00	0.00						P			P					P	
Descurainia sophia	0.00	6.67	0.00		0.00	0.00									P						
Euphorbia davidii	0.00	13.33	0.00		0.00	0.00							P							P	
Halogeton glomeratus	0.07	20.00	0.20		0.13	0.37					P	1(1)	P								
Hibiscus trionum	0.00	6.67	0.00		0.00	0.00				P											
Lactuca serriola	0.00	13.33	0.00		0.00	0.00						P	P								

PLANT SPECIES	FIRST HIT		FIRST HIT	ALL HIT		Percent Foliar Cover*														
	AVERAGE COVER ^a	FREQUENCY ^b	RELATIVE VEGETATION COVER ^c	AVERAGE COVER ^d	RELATIVE VEGETATION COVER ^e	---Sample Number---														
						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Medicago lupulina	0.00	6.67	0.00	0.00	0.00			P												
Malva neglecta	0.07	6.67	0.20	0.07	0.19											1				
Melilotus officinalis	0.13	66.67	0.39	0.13	0.37	P	P	1			P	P			P		P	P	P	1
Portulaca oleracea	0.13	40.00	0.39	0.13	0.37	1		P				1	P				P		P	
Salsola australis	1.33	80.00	3.91	1.47	4.10	P	P	2	P	P	(1)	1	8	1		2	4			2(1)
Salsola collina	1.07	100.00	3.13	1.07	2.99	P	1	P	1	1	1	2	1	1	1	3	2	P	1	1
Solanum americanum	0.00	6.67	0.00	0.00	0.00							P								
Tragopogon dubius ssp. major	0.00	6.67	0.00	0.00	0.00												P			
Xanthium strumarium	0.00	6.67	0.00	0.00	0.00				P											
TOTAL INTRO. ANN. & BIEN. FORBS	3.1	100.0	9.2	3.3	9.3	2	1	3	1	1	2(2)	7	9	2	1	7	6	P	1	4(1)
NATIVE ANNUAL GRASSES																				
Muhlenbergia minutissima	0.00	6.67	0.00	0.00	0.00		P													
Munroa squarrosa	0.00	6.67	0.00	0.00	0.00														P	
Panicum capillare	0.20	46.67	0.59	0.20	0.56	P		P				P	P				P	3		P
TOTAL NATIVE ANN. GRASSES	0.2	60.0	0.6	0.2	0.6	P	P	P	---	---	---	P	P	---	---	---	P	3	P	P
INTRODUCED ANNUAL GRASSES																				
Bromus tectorum	0.80	40.00	2.35	0.87	2.43	1		4						5			(1)	P		2
Digitaria sanguinalis	0.60	80.00	1.76	0.60	1.68	P		P	P	P	1	1	1		P	2	P	P	4	
TOTAL INTRO. ANN. GRASSES	1.4	93.3	4.1	1.5	4.1	1	---	4	P	P	1	1	1	5	P	2	(1)	P	4	2
NATIVE PERENNIAL FORBS																				
Astragalus crassicaarpus	0.00	33.33	0.00	0.00	0.00				P		P	P				P			P	
Astragalus racemosus	0.13	13.33	0.39	0.13	0.37						P					2				
Astragalus shortianus	0.00	60.00	0.00	0.00	0.00	P	P	P		P			P	P	P		P	P		
Astragalus sp.	0.13	20.00	0.39	0.13	0.37		P								P			2		
Chamaesaracha coronopus	0.53	80.00	1.57	0.53	1.49	2	2	P	3	1	P		P	P			P	P	P	P
Glandularia bipinnatifida	3.07	93.33	9.00	3.33	9.33	2	P	1	3(1)	P	7	3(1)		9(1)	2	4	1	1	11(1)	2
Hedeoma drummondii	0.00	13.33	0.00	0.00	0.00	P									P					
Oxybaphus linearis	0.00	6.67	0.00	0.00	0.00															
Physalis virginiana	0.00	6.67	0.00	0.00	0.00								P							
Picradeniopsis oppositifolia	0.07	20.00	0.20	0.07	0.19	P	P												1	
Quincula lobata	0.20	93.33	0.59	0.20	0.56	P	1	1	P	P	P	1	P	P	P	P	P	P	P	
Rudbeckia hirta	0.00	20.00	0.00	0.00	0.00				P									P	P	
Sphaeralcea angustifolia	0.00	26.67	0.00	0.00	0.00						P	P							P	P
Sphaeralcea coccinea	0.00	93.33	0.00	0.00	0.00	P	P	P		P	P	P	P	P	P	P	P	P	P	P

PLANT SPECIES	FIRST HIT AVERAGE COVER ^a (%)	FREQUENCY ^b (%)	FIRST HIT RELATIVE VEGETATION COVER ^c (%)	ALL HIT AVERAGE COVER ^d (%)	ALL HIT RELATIVE VEGETATION COVER ^e (%)	Percent Foliar Cover*														
						---Sample Number---														
						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Vexibia nuttalliana	0.07	6.67	0.20	0.07	0.19														1	
Verbena bracteata	0.00	6.67	0.00	0.00	0.00				P											
Vicia americana	0.00	6.67	0.00	0.00	0.00													P		
Vicia sp.	0.00	6.67	0.00	0.00	0.00									P						
TOTAL NATIVE PERENNIAL FORBS	4.2	100.0	12.3	4.5	12.5	4	3	2	6(1)	1	7	4(1)	P	9(1)	2	6	1	3	13(1)	2
INTRODUCED PERENNIAL FORBS																				
Cirsium arvense	0.00	6.67	0.00	0.00	0.00		P													
Nepeta cataria	0.00	6.67	0.00	0.00	0.00											P				
Rumex crispus	0.40	26.67	1.17	0.40	1.12	4		P											P	2
Sonchus uliginosus	0.00	6.67	0.00	0.00	0.00															P
Trifolium pratense	0.00	6.67	0.00	0.00	0.00														P	
TOTAL INTRO. PERENNIAL FORBS	0.4	40.0	1.2	0.4	1.1	4	P	P	---	---	---	---	---	---	---	P	---	---	P	2
NATIVE PERENNIAL GRASSES (cool)																				
Elymus trachycaulus	0.20	26.67	0.59	0.20	0.56		1		P										1	1
Pascopyrum smithii	1.87	86.67	5.48	1.87	5.22	1	2	1	1		P	4	2	2		6	2	1	2	4
TOTAL NATIVE PERENNIAL GRASSES (c)	2.1	86.7	6.1	2.1	5.8	1	3	1	1	---	P	4	2	2	---	6	2	1	3	5
INTRODUCED PERENNIAL GRASSES (cool)																				
Echinochloa crus-galli	0.40	60.00	1.17	0.40	1.12	P	P		P			2		1		1	P		P	2
Setaria viridis	0.67	53.33	1.96	0.67	1.87	1	P	P	1				1	1	1	5				
TOTAL INTRO. PERENNIAL GRASSES (c)	1.1	80.0	3.1	1.1	3.0	1	P	P	1	---	---	2	1	2	1	6	P	---	P	2
NATIVE PERENNIAL GRASSES (warm)																				
Aristida purpurea	0.00	6.67	0.00	0.00	0.00				P											
Bouteloua curtipendula	2.27	93.33	6.65	2.27	6.34		2	1	2	1	3	6	1	3	1	4	1	2	6	1
Chondrosum gracile	2.00	100.00	5.87	2.00	5.60	1	P	P	P	3	5	2	P	2	2	4	2	3	4	2
Distichlis stricta	0.07	6.67	0.20	0.07	0.19											1				
Muhlenbergia arenicola	0.00	6.67	0.00	0.00	0.00	P														
Pleuraphis jamesii	3.73	100.00	10.96	3.93	11.01	4(1)	2	1	7	3	4	2	8	1	4	3	4	4	6	3(2)
Sorghastrum avenaceum	0.00	6.67	0.00	0.00	0.00										P					
Sporobolus airoides	2.33	73.33	6.85	2.40	6.72			2	1		6	10	1	1	2	5(1)	1	2		4
Sporobolus compositus	0.07	6.67	0.20	0.07	0.19	1														
Sporobolus cryptandrus	1.67	100.00	4.89	1.67	4.66	4	1	6	1	P	P	P	P	2	1	P	3	2	P	5
TOTAL NATIVE PERENNIAL GRASSES (w)	12.1	100.0	35.6	12.4	34.7	10(1)	5	10	11	7	18	20	10	9	10	17(1)	11	13	16	15(2)

PLANT SPECIES	FIRST HIT		FIRST HIT	ALL HIT	ALL HIT	Percent Foliar Cover*														
	AVERAGE		RELATIVE	AVERAGE	RELATIVE															
	COVER ^a	FREQUENCY ^b	VEGETATION	COVER ^d	VEGETATION	---Sample Number---														
	(%)	(%)	(%)	(%)	(%)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
INTRODUCED SUBSHRUBS																				
Lespedeza cuneata	0.00	26.67	0.00	0.00	0.00				P			P				P			P	
TOTAL INTRODUCED SUBSHRUBS	0.0	26.7	0.0	0.0	0.0	---	---	---	P	---	---	P	---	---	---	P	---	---	P	---
NATIVE SHRUBS																				
Atriplex canescens	0.07	33.33	0.20	0.07	0.19				P	P	P				1		P			
TOTAL NATIVE SHRUBS	0.1	33.3	0.2	0.1	0.2	---	---	---	P	P	P	---	---	---	1	---	P	---	---	---
NATIVE TREES																				
Acacia sp.	0.00	20.00	0.00	0.00	0.00	P			P								P			
TOTAL NATIVE TREES	0.0	20.0	0.0	0.0	0.0	P	---	P	---	---	---	---	---	---	---	---	P	---	---	---
SUCCULENTS																				
Opuntia spp.	0.00	26.67	0.00	0.00	0.00			P			P	P							P	
TOTAL SUCCULENTS	0.0	26.7	0.0	0.0	0.0	---	---	P	---	---	P	P	---	---	---	---	---	---	P	---
Litter	15.00	100.00		15.00		12	29	27	11	11	10	6	23	19	21	9	17	16	6	8
Bare soil	50.67	100.00		50.67		53	55	47	56	68	49	48	50	48	43	41	60	58	39	45
Rock	0.27	20.00		0.27				2			1								1	
TOTALS	100.0			101.7		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
TOTAL VEGETATION COVER	34.1 (s=11.5)		100.0	35.7 (s=12.7)	100.0	35(4)	16	24(1)	33(2)	21	40(2)	46(3)	27	33(1)	36(1)	50(3)	23(1)	26	54(4)	47(3)
GROUND COVER (Litter+Rock+Veg+St.Dead)	49.3			51.0		47(4)	45	53(1)	44(2)	32	51(2)	52(3)	50	52(1)	57(1)	59(3)	40(1)	42	61(4)	55(3)
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 27.4 Std.Dev.= 4.6)						31	26	33	30	17	28	30	26	26	25	25	28	26	37	23

^a First Hit Cover = Absolute percent cover in vertical view with no account of plants obscured by first (i.e. top) hit.

^b Frequency = Percent of the samples in which a species or lifeform occurred

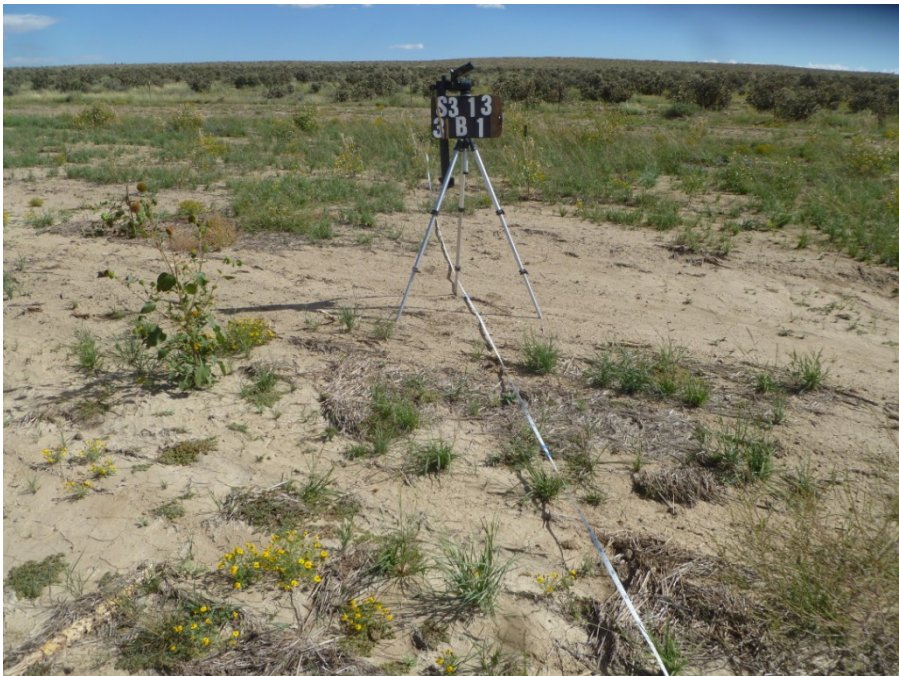
^c First Hit Relative Cover = Percent of the First Hit vegetation cover comprised of this species or lifeform

^d All Hit Cover = Absolute percent cover in vertical view accounting for all cover by the species or lifeform, whether over-arched by other plants or not

^e All Hit Relative Cover = Percent of the All Hit vegetation cover comprised of the species or lifeform

***P=Present within 1m. on either side of cover transect, but not quantitatively encountered.**
()=Data in parentheses represent other hits that are used in conjunction with first hits for all hit cover statistics.

Appendix C: Site Photos – Work Package S3-13



Photograph 1. S3-13 on Limon and Heldt series, Sample 1 - 2013



Photograph 2. S3-13 on Limon and Heldt series, Sample 2 - 2013



Photograph 3. S3-13 on Limon and Heldt series, Sample 3 - 2013



Photograph 4. S3-13 on Limon and Heldt series, Sample 4 - 2013



Photograph 5. S3-13 on Limon and Heldt series, Sample 5 - 2013



Photograph 6. S3-13 on Limon and Heldt series, Sample 6 - 2103



Photograph 87. S3-13 on Limon and Heldt series, Sample 7 - 2013



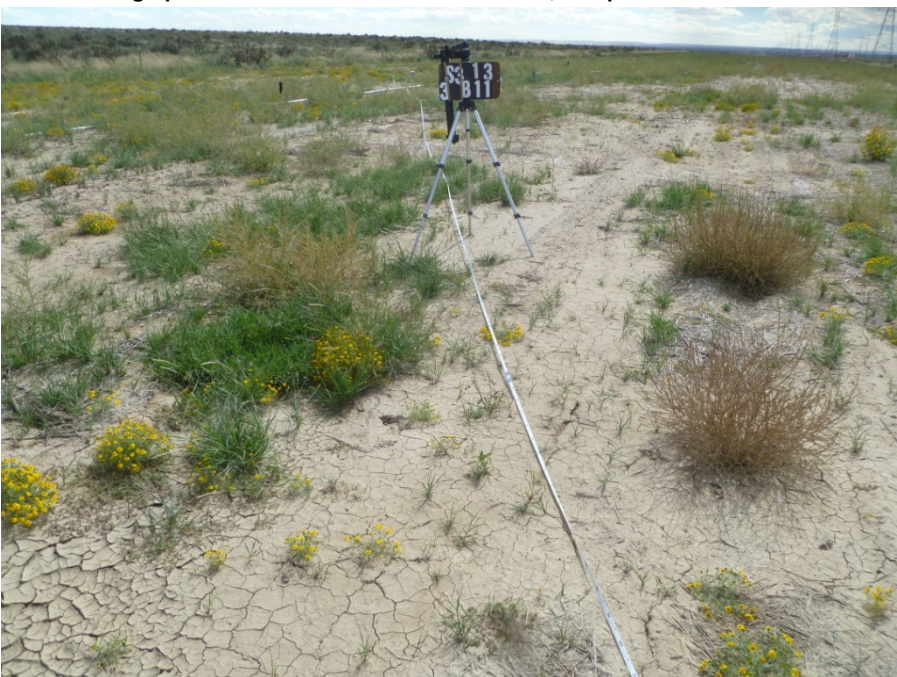
Photograph 8. S3-13 on Limon and Heldt series, Sample 8 - 2013



Photograph 9. S3-13 on Limon and Heldt series, Sample 9 - 2013



Photograph 10. S3-13 on Limon and Heldt series, Sample 10 - 2013



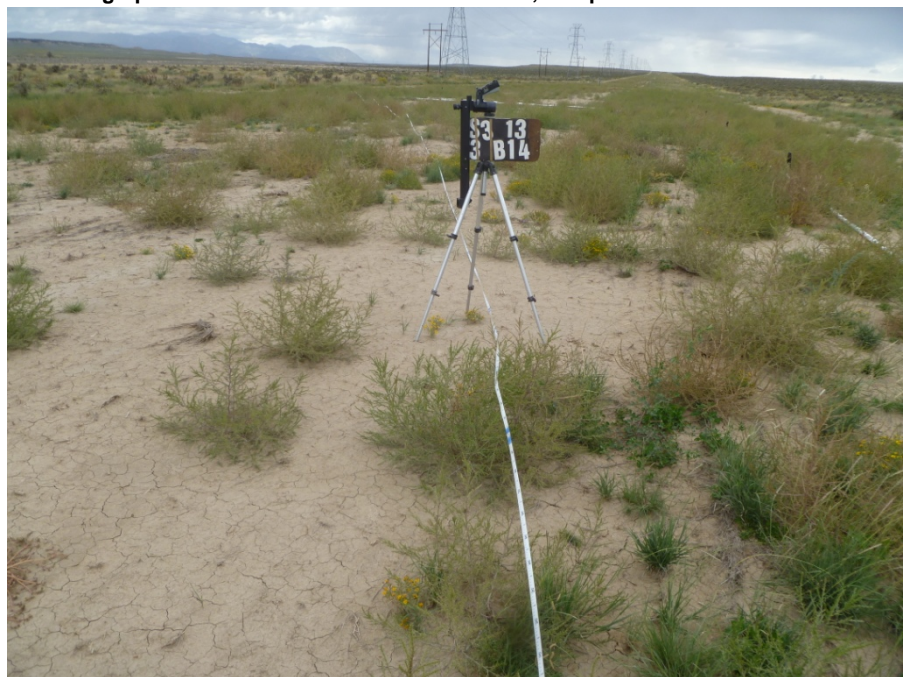
Photograph 11. S3-13 on Limon and Heldt series, Sample 11 - 2013



Photograph 12. S3-13 on Limon and Heldt series, Sample 12 - 2013



Photograph 13. S3-13 on Limon and Heldt series, Sample 13 - 2013



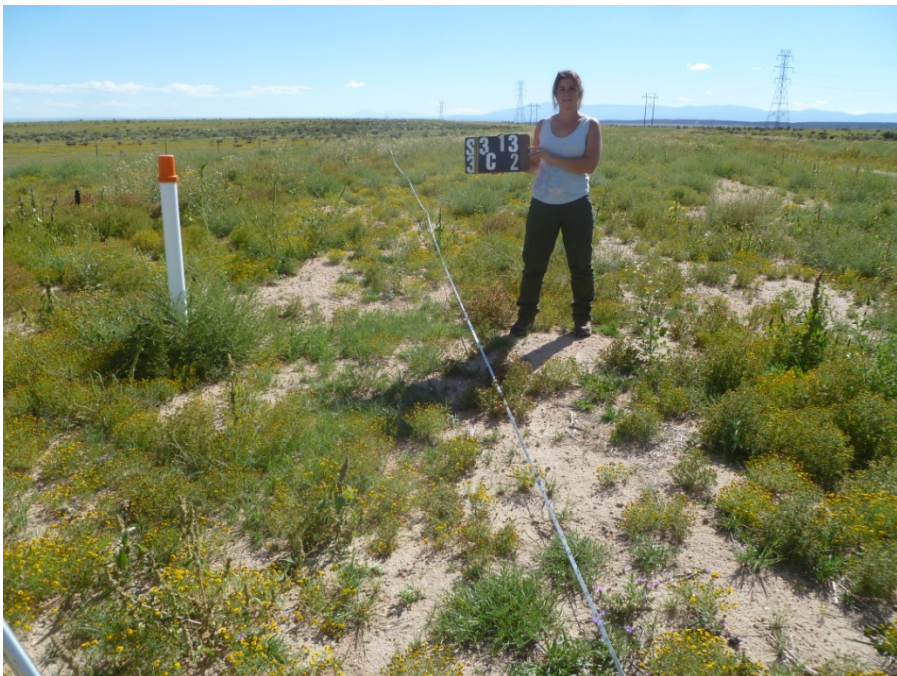
Photograph 14. S3-13 on Limon and Heldt series, Sample 14 - 2013



Photograph 15. S3-13 on Limon and Heldt series, Sample 15 - 2013



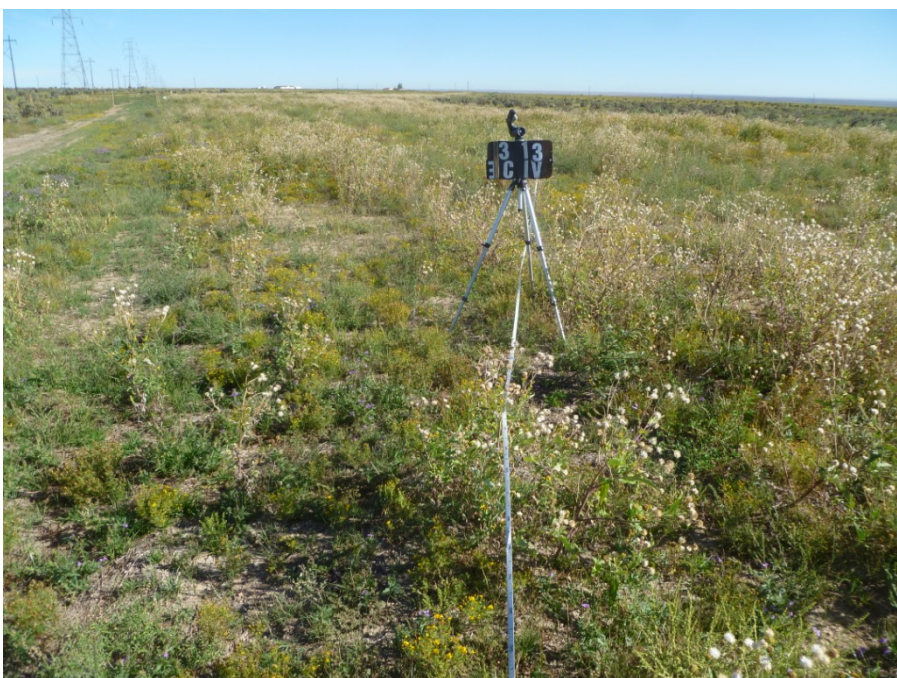
Photograph 16. S3-13 on Stoneham and Cascajo series, Sample 1 - 2013



Photograph 17. S3-13 on Stoneham and Cascajo series, Sample 2 - 2013



Photograph 18. S3-13 on Stoneham and Cascajo series, Sample 3 - 2013



Photograph 19. S3-13 on Stoneham and Cascajo series, Sample 4 - 2013



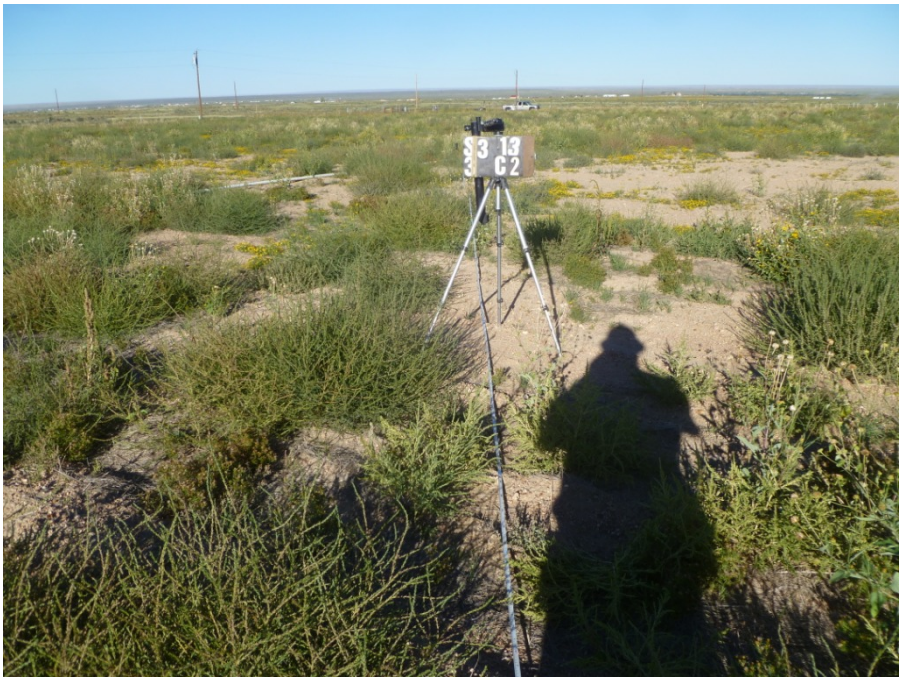
Photograph 20. S3-13 on Stoneham and Cascajo series, Sample 5 - 2013



Photograph 21. S3-13 on Stoneham and Cascajo series, Sample 6 - 2013



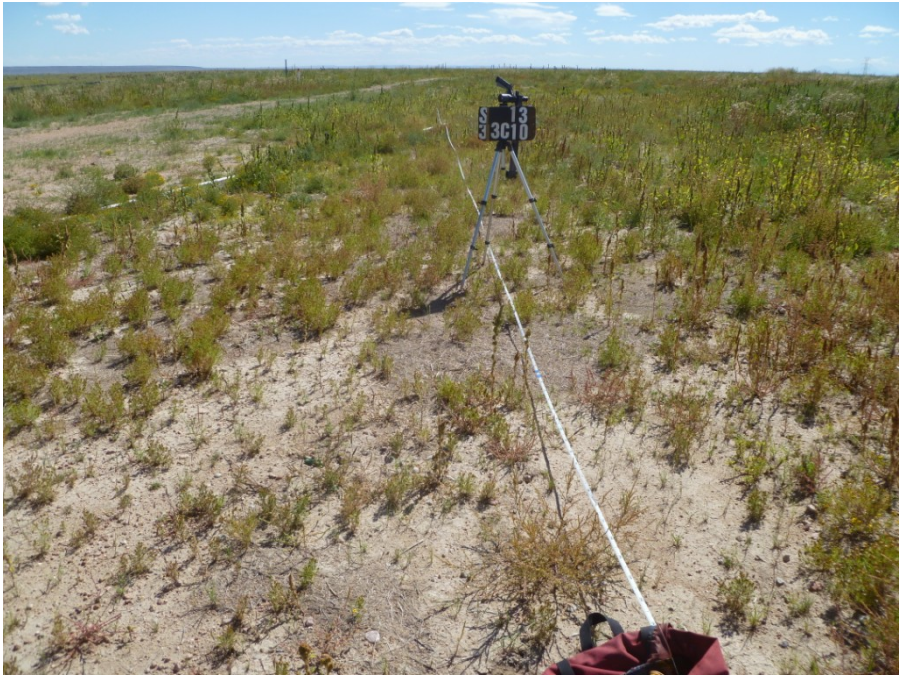
Photograph 22. S3-13 on Stoneham and Cascajo series, Sample 7 - 2013



Photograph 23. S3-13 on Stoneham and Cascajo series, Sample 8 - 2013



Photograph 24. S3-13 on Stoneham and Cascajo series, Sample 9 - 2013



Photograph 25. S3-13 on Stoneham and Cascajo series, Sample 10 - 2013



Photograph 26. S3-13 on Midway-Shale complex; Shingle series, Sample 1 - 2013



Photograph 27. S3-13 on Midway-Shale complex; Shingle series, Sample 2 - 2013



Photograph 28. S3-13 on Midway-Shale complex; Shingle series, Sample 3 - 2013



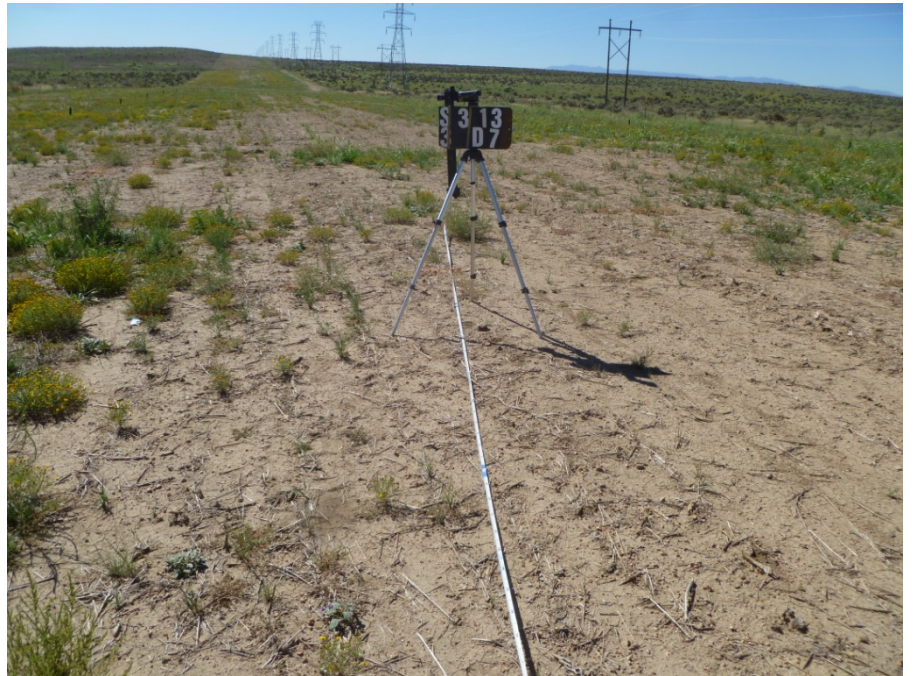
Photograph 29. S3-13 on Midway-Shale complex; Shingle series, Sample 4 - 2013



Photograph 30. S3-13 on Midway-Shale complex; Shingle series, Sample 5 - 2013



Photograph 31. S3-13 on Midway-Shale complex; Shingle series, Sample 6 - 2013



Photograph 32. S3-13 on Midway-Shale complex; Shingle series, Sample 7 - 2013



Photograph 33. S3-13 on Midway-Shale complex; Shingle series, Sample 8 - 2013



Photograph 34. S3-13 on Midway-Shale complex; Shingle series, Sample 9 - 2013



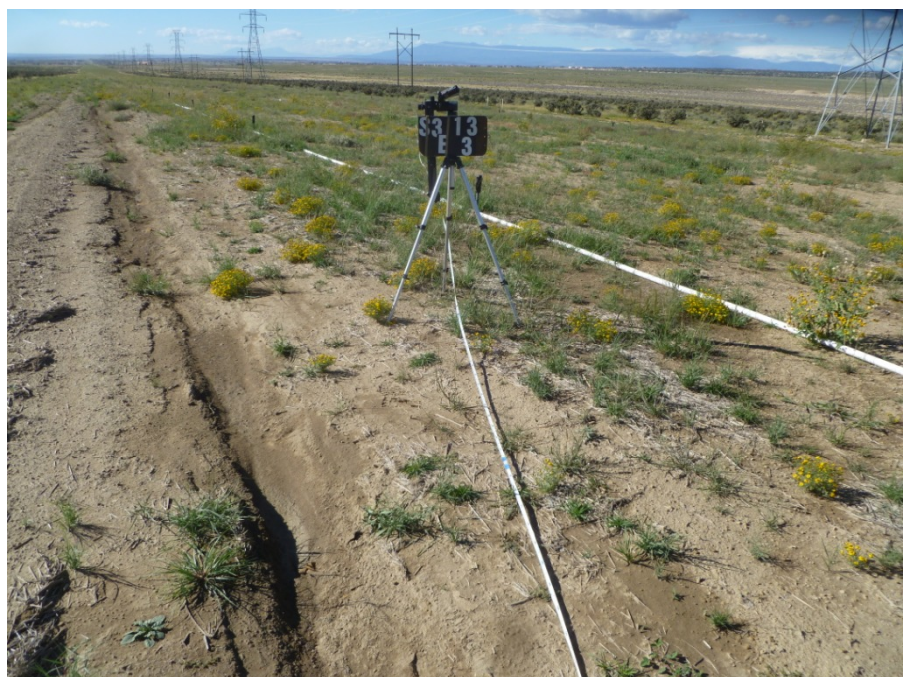
Photograph 35. S3-13 on Midway-Shale complex; Shingle series, Sample 10 - 2013



Photograph 36. S3-13 on Razor series, Sample 1 - 2013



Photograph 37. S3-13 on Razor series, Sample 2 - 2013



Photograph 38. S3-13 on Razor series, Sample 3 - 2013



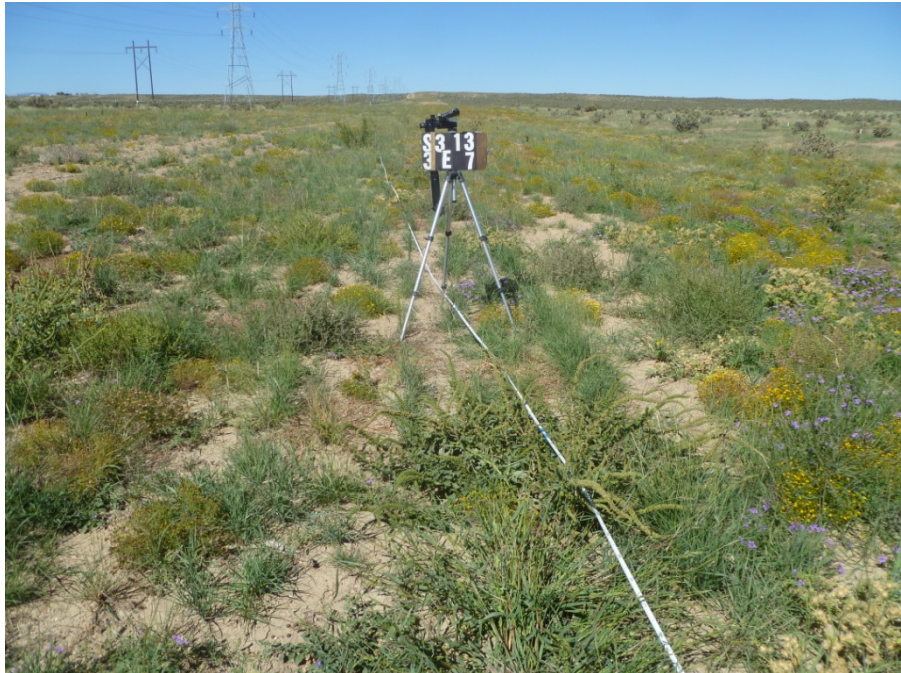
Photograph 39. S3-13 on Razor series, Sample 4 - 2013



Photograph 40. S3-13 on Razor series, Sample 5 - 2013



Photograph 41. S3-13 on Razor series, Sample 6 - 2013



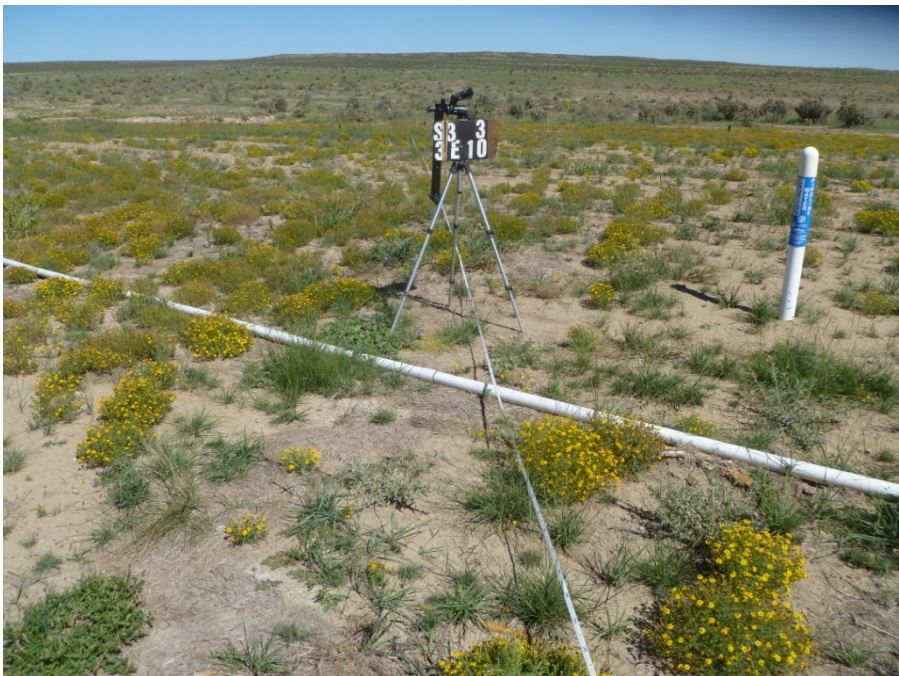
Photograph 42. S3-13 on Razor series, Sample 7 - 2013



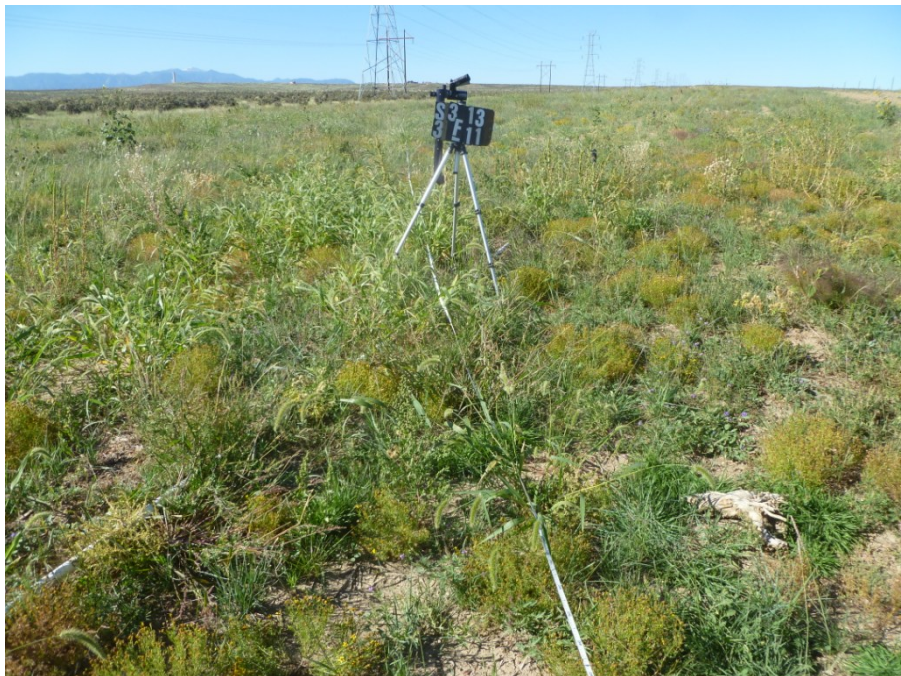
Photograph 43. S3-13 on Razor series, Sample 8 - 2013



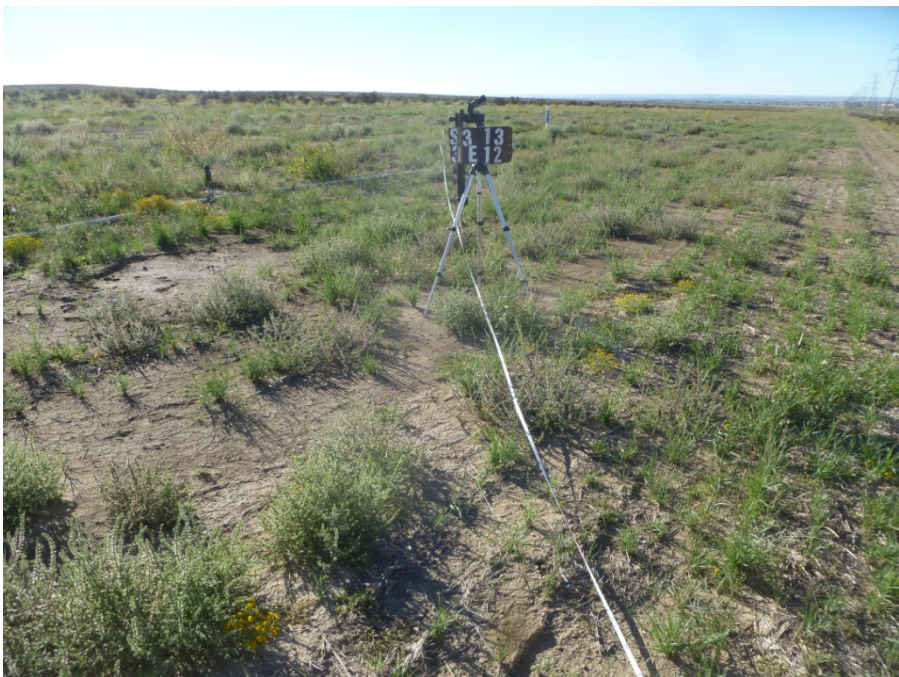
Photograph 44. S3-13 on Razor series, Sample 9 - 2013



Photograph 45. S3-13 on Razor series, Sample 10 - 2013



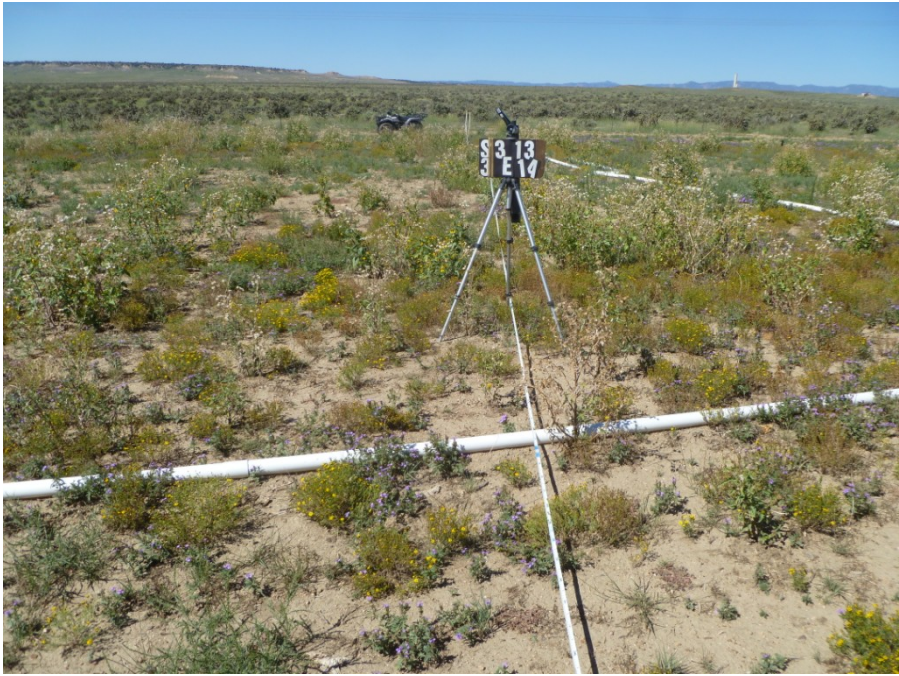
Photograph 46. S3-13 on Razor series, Sample 11 - 2013



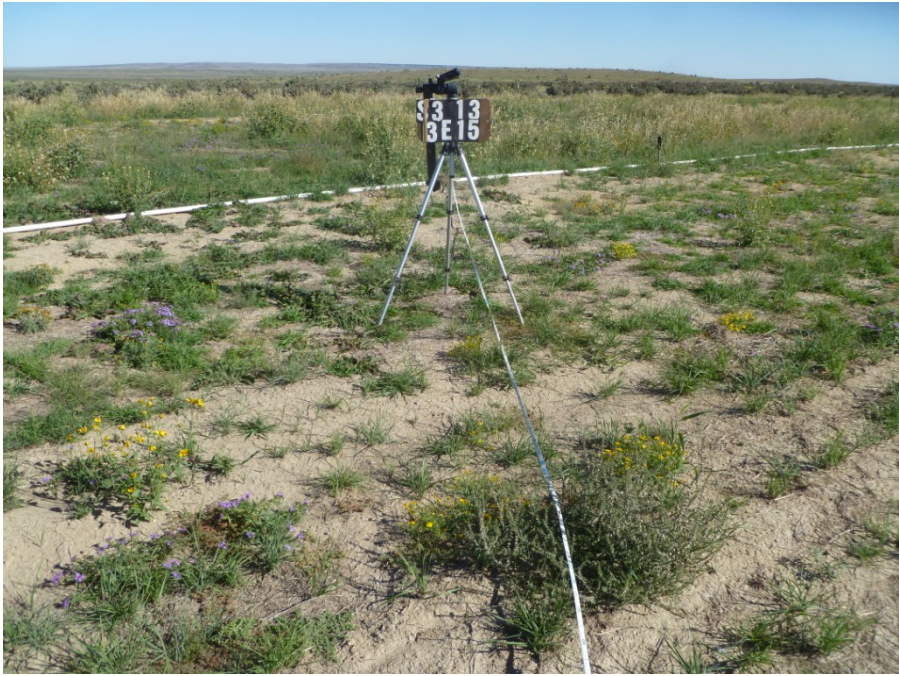
Photograph 47. S3-13 on Razor series, Sample 12 - 2013



Photograph 48. S3-13 on Razor series, Sample 13 - 2013



Photograph 49. S3-13 on Razor series, Sample 14 - 2013



Photograph 50. S3-13 on Razor series, Sample 15 – 2013

Appendix D: Established Vegetation Sampling Protocols

Technical Memo 1

Sampling Procedure for Point Intercept Cover and Seedling Density Data Collection

The following procedure establishes baseline levels of plant cover in areas affected by the Southern Delivery System Project and will be used to determine seedling density following revegetation.

Within an area that was disturbed, vegetation will be quantitatively sampled as described below to establish:

- 1) The percent cover by species as well as total vegetation cover and
- 2) Species richness

These data will provide a basis for assessment of the percent of vegetation cover re-established in post-revegetation evaluations.

Vegetation Unit Identification

As vegetation varies along the length of the proposed area of disturbance, variations in plant community at the “alliance” level of the US National Vegetation Classification system (FGDC 2008) will be documented. Association and alliance level classification is based on the premise that a vegetation type represents a group of stands that have similar plant composition and physiognomy enabling their recognition. Should such significant soil variation as might substantially affect plant cover growth potential be encountered within a single alliance in a particular reach, these will be subdivided and the number of sample measurements adjusted accordingly.

This mapping methodology addresses both the need to document natural variation in the pre-existing vegetation and the need to set plant cover standard levels consistent with the varying potentials of varying environments.

Sample Location

Samples will be placed in locations representative of the general vegetation type and condition.

Cover Sampling Methods

At each sample site, cover data will be collected using a point-intercept method in which data are tabulated as interceptions of a projected point with plant species, bare ground, litter, standing dead vegetation, or rock. The cover sampling points will be optically projected using a Cover-Point Optical Point Projection Device. Sampling will occur along 50 meter transects. At each meter from one to fifty along the transect, a point will be vertically projected from a location 50 centimeters (cm) to the left of the transect and a point will be vertically projected from a location 50 cm to the right of the transect (avoiding harm to vegetation along the tape itself). Thus, data from a total of 2 x 50, or 100 points will be recorded. Plant interceptions will be tallied by species upon interception of the projected point with any attached plant part

produced during the current growing season. "First hit" data (the first interception of any of the materials listed below) will be recorded. In addition to this, "additional hit" data (any additional live species intercepted between the first hit and the ground) will also be collected.

- Litter will be considered to be any organic material that had fallen, or had begun to fall to the soil surface.
- Standing dead vegetation will be any dead plant material that was produced in previous years but which was still standing and had not lodged or broken off to become litter.
- Rock will be considered to be any inorganic fragment with the largest diameter greater than or equal to 1 cm.
- Bare soil will be considered to be inorganic fragments with a diameter less than 1 cm largest diameter or organic debris too small to be of readily identifiable origin.

First hit interceptions will be used to calculate absolute top layer (first hit) foliar cover by dividing the number of interceptions for a particular species or material by the total number of points taken (100). First hit relative vegetation cover will be calculated by dividing first hit absolute cover for each species by the total first hit vegetation cover. All-layer absolute cover will be calculated by dividing all hits for particular species by the total number of points taken (100). In addition, all-layer relative cover will be calculated using all hits for particular species divided by the total vegetation hits accumulated during sampling of the transect.

Seedling Density Sampling (Post-Revegetation Analyses)

Seedlings of seeded or perennial plant species will be counted within randomly placed 0.5 square meters (5.37 square feet) circular plots. The results will be averaged and divided by 5.37 to obtain number of seedlings per square foot.

References

FGDC. 2008. Vegetation Classification Standard, Version 2. Federal Geographic Data Committee, Vegetation Subcommittee. FGDC Secretariat, U.S. Geological Survey. Reston, VA. FGDC-STD-005-2008 (Version 2). 62p. plus Appendices.

Technical Memo 3

Post-Revegetation Sampling

This Technical Memo describes the design and methodology CNHP will use to sample and quantitatively assess post-disturbance revegetation success. For the practicality of achieving an unbiased evaluation, the approach is based on random sampling and the use of resulting means to compare results to previously established performance standards. By the nature of plant growth in response to varying conditions along the length of the revegetated area, and by the nature of random sampling, variability in levels of plant abundance are to be expected both on the ground and in sample results. The use of 50 meter-long transects tends to encompass variability though a certain amount of variability can be expected at scales larger than this.

Creditable Vegetation Cover

Cover provided by plants included in the Colorado A-, B-, or C-list of noxious plant species, if any, will not be acceptable in the evaluation of cover. Cover by all other plants will be acceptable in assessment of adequate revegetation cover, except as follows: cover by non-native annual / biennial plants in excess of the relative cover by those plants in the pre-construction sample data will not be counted toward establishment of proof of successful revegetation (see below).

Maximum allowable relative cover by Introduced Annual and Biennial Species:

A. Soils Shallow over Shale and Limestone (Penrose, Manvel and Minnequa series; Tables 4, 7, and Samples 5, 7 and 8 of Table 8): **22.2 percent**

B. Soils on Clay-rich, Salt-affected Alluvial Material (Limon and Heldt series; Tables 1, 5, and 11): **2.6 percent**

C. Soils Deep on Early Pleistocene Alluvium (Stoneham and Cascajo series; Tables 10 and 15): **3.9 percent**

D. Soils on Weathered Shale (with active erosional removal) (Midway – Shale complex; Shingle series; Tables 9 and 13): **1.3 percent**

E. Soils on Deeply Weathered Shale (without active erosional removal) (Razor series; Table 14): **3.6 percent**

F. Soils on Recent Alluvium of Moderate Texture and Salt Content (Haverson series and Ustic Torrifluvents; Table 6 and 16): **16.7 percent**

Cover Sampling Method

Sampling to assess compliance with the standard of 90 percent of pre-existing cover will proceed separately within each work package (S1, S2 and S3) and separately within each soil functional group as identified during the pre-construction vegetation survey (see Technical Memo 2). All sample locations will be randomly located by delineating the soil functional groups in each work package in ESRI ArcMap GIS application and using the random point generation tool to place the correct number of random points in that area.

For sample units with a total (cumulative) length of one mile or less, ten (10) segments of equal length will be established and a randomly located and oriented sample placed in each. For units greater than one mile in cumulative length, fifteen (15) segments of equal length will be identified and a sample randomly located within each. Sample points will be located in the field using hand-held GPS units with coordinates of the random points pre-loaded.

In areas with total Soil Group length less than 0.1 mile, three (3) to five (5) samples will be made. Professional judgment will be used in these small sample areas (e.g. Soil Groups B and F in S3) to determine the location and number of samples collected.

Orientation of the 50-meter transect will be randomly selected by using a random number ranging from 1 to 360 as an azimuth. Sampling transects will not extend outside the Permanent Easement (PE), Temporary Construction Easement (TCE) or work limits areas. Should a boundary be encountered, a new orientation that remains within these limits will be chosen in the same manner. Ineligible sites (see below) will be excluded from sampling.

Sampling to assess compliance with the CDPHE criterion of 70 percent of pre-existing cover will proceed within separate work packages and soil reaches. If the 70 percent cover standard alone is being assessed, the sample intensity will be five (5) samples in reaches of one mile or less in cumulative length and eight (8) samples in those greater than one mile in cumulative length. Professional judgment will be used in small sample areas (e.g. Soil Groups B and F in S3) to determine the location and number of samples collected.

Informational Cover Composition Sampling Method

Data on species composition will be collected for informational purposes outside the scope of the 1041 permit requirements. Ten (10) 1 x1 meter plots will be placed at 5-meter intervals along the right side of the cover sampling transect (as viewed from the origin) beginning at the 5-meter mark. Within each of the resulting ten plots the presence of desirable species will be noted by species. For this purpose, desirable species will mean any seeded species plus any other native annual, biennial, or perennial species plus any non-native perennial species. Native will mean species noted as native in and occurring in the Southeast ¼ of Colorado in Biota of North America Project distribution mapping. The resulting frequency data will be tabulated by species. For example, if Species A is noted as present in 7 of the 10 plots it will have a frequency value of 70 percent.

Frequency values from all transects within a given soil group will then be averaged. For these evaluations, average frequency values by species will be used as follows: The average frequencies of all acceptable species will be summed. A sum for all desirable species present that equals or exceeds 200 percent will be deemed adequate evidence of successful establishment of acceptable species. This supplemental criterion addresses the reality that vegetation at the time of evaluation will still be juvenile. Many planted or otherwise desirable species grow slowly and though they may be only a small percentage of the total plant cover at the time of measurement, will eventually become more abundant. This frequency evaluation allows documentation of the presence of the desirable species sought in the long term vegetation cover.

Seedling Density

Seedlings of seeded or perennial plant species will be counted within randomly placed 0.5 square meter (5.37 square foot) circular plots. The results will be averaged and divided by 5.37 to obtain number of seedlings per square foot.

Plots will be thirty per Work Package/Soil Group area. All sample points will be randomly located via GIS-generated coordinates.

Sites Ineligible for Sampling

Areas within the revegetation zone in which the vegetation cover has been negatively affected by land management of private owners after SDS construction or for which a waiver has been executed/granted will be excluded from the sample universe (i.e., no samples will be placed in these areas). Within the disturbed alignment no sampling will occur on access roads, trails, above-ground SDS infrastructure, other above-ground public or private infrastructure, waterways, or other areas where sampling is determined not to be practical, safe or meaningful. Such areas will be manually delineated in the GIS and excluded from the eligible sampling area when creating the random point coverage.

Sampling Schedule

During the first growing season following seeding, seedling density data will be collected. At the end of the first growing season (typically September) cover data will be collected for the purpose of assessing compliance with the CDPHE Stormwater Permit criterion of 70 percent of pre-existing cover. If in the judgment of the SDS Program, the extent of vegetation cover at that time might also satisfy the 90 percent of pre-existing cover criterion, the full sampling design described above will be implemented. If only the CDPHE criterion is being tested, sample intensity within a work package will be five samples in soil reaches one mile or less in cumulative length and eight in those greater than one mile in cumulative length. During the second growing season, sampling intensity will be ten (10) samples in soil reaches one mile or less in cumulative length and fifteen (15) samples in those greater than one mile in cumulative length.

Hypothesis Testing

Statistical evaluation of the success of revegetation for each soil functional group within a work package will be tested via a one-sample t-test of the following null hypothesis:

The (traditional) null hypothesis being tested would be that the revegetated area mean (\bar{x}) is indistinguishable from 90 percent of the pre-existing cover, stated as $H_0: \bar{x} = Q$. If t_c is less than or equal to the 1-tailed t -table value for alpha error probability of 0.05, at $(n-1)$ degrees of freedom, then H_0 is accepted, and revegetation is deemed successful (i.e., indistinguishable from 90 percent of the standard).

The sample data will be evaluated for normality and transformed if appropriate. The formula for the one sample t-test is:

$$t_c = \frac{Q - \bar{x}}{S_{\bar{x}}}$$

Where: \bar{x} = Revegetated Area Sample Mean
 Q = 90 percent of pre-existing cover
 $S_{\bar{x}}$ = Standard error of mean [s/\sqrt{n}]
 s = Sample standard deviation
 n = Sample size
 t_c = Calculated t -value
 t_t = Table t -value (alpha = 0.05)

Photographic Documentation

Photo documentation will be conducted during the growing seasons and in conjunction with the point-intercept cover sampling. Photos will be taken at each transect location during all sampling. Photo points will be relocated using a handheld GPS receiver.