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SECOND CREEK RESTORATION

ECOLOGICAL RESOURCES REPORT

COMMERCE CITY, COLORADO

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SECOND CREEK RESTORATION
ECOLOGICAL RESOURCES REPORT
COMMERCE CITY, COLORADO

Prepared for:

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Commerce City, CO 80022

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August 9, 2019

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1.0 INTRODUCTION

Smith Environmental and Engineering (SMITH) performed an ecological assessment for approximately 120 acres located in Commerce City, Adams County, Colorado (Study Area). SMITH assessed the soil conditions, existing vegetation, and presence of black-tailed prairie dogs (*Cynomys ludovicianus*) in order to determine the feasibility and recommended approach for restoring this open space property.

1.1 STUDY AREA

The Study Area (Figure 1) is located adjacent to Second Creek between E 104th Avenue and E 96th Avenue in Sections 16 and 17, Township 2 South, Range 66 West of the 6th Principal Meridian on the Brighton US Geological Survey (USGS) quadrangle. The center of the Study Area is located at 39.879197 degrees north, 104.795585 degrees west at an elevation of approximately 5,150 feet. The Study Area is managed as a City-owned open space property. Land use to the east and west is primarily residential. The Rocky Mountain Arsenal National Wildlife Refuge is located south of E 96th Avenue. Other surrounding lands are either vacant or are in agricultural production; however, most are zoned as Planned Urban Development (PUD) and will likely be developed in the future.

The Natural Resources Conservation Service (NRCS) uses the concept of Ecological Sites to describe the ecological potential and ecosystem dynamics of land areas. An Ecological Site is defined as a "distinctive kind of land with specific soil and physical characteristics that differ from other kinds of land in its ability to produce a distinctive kind and amount of vegetation and its ability to respond similarly to management actions and natural disturbances" (NRCS 2011). There are three Ecological Sites identified within the Study Area: Salt Meadow, Salt Flat, and Sandy Plains. The NRCS publishes Ecological Site Descriptions (ESD) for each identified Ecological Site. Appendix B includes the ESDs for each of the identified sites within the Study Area.


Area of Interest
Adams County, CO
E 104th Ave
Landmark Dr
E 96th Ave
Legend
Study Area
Second Creek
Smith Environmental and Engineering
250 Perry Lane
Dacono, Colorado 80514
(720) 887-4928, (720) 887-4680 (fax)
N
W
E
S
SECOND CREEK
RESTORATION
0 500 1,000
Feet
Figure 1
Study Area
Adams County, Colorado
July 2019

2.0 SOILS

SMITH investigated the specific characteristics of the soils within the Study Area to gain a better understanding of how they are influencing current site conditions and how they will affect ecological restoration potential. The soil investigation consisted of Order 1 soil mapping, according to the standards of the National Cooperative Soil Survey. Existing Order 2 soil mapping and literature (Soil Conservation Service 1974) indicates that over 90 percent of the Study Area is comprised of salt-affected soils. However, Order 1 soil mapping is conducted on a smaller scale (typically 1:6,000 vs. 1:24,000 for Order 2) and provides more detailed information for local restoration projects.

Soil map units were delineated on an aerial photograph to the series (sixth) taxonomic level. Soil borings were completed to depths of up to 40 inches to observe standard physical, biological, and chemical characteristics. The most important characteristics included sodium adsorption ratio (inferred from soil structure, dominance of salt tolerant species, and the presence of visible salt crystals), percent organic matter (inferred by soil color), electrical conductivity (inferred by the presence of visible salt crystals and dominance of salt tolerant species), depth to water table, and presence of redoximorphic features (indicative of a high water table). Dominant plant species at each soil boring location were also recorded as they may be useful during restoration.

Four soil series were identified in the Study Area: Vona, Avar, Mosher, and Longmont (Figure 2). Vona and Avar soils are well-drained, deep, and medium to coarse textured. Mosher is moderately well-drained to somewhat poorly drained and fine textured. A medium-textured version of Mosher was observed during mapping but was included with the delineations of Mosher. Longmont soils are poorly drained and fine textured. Avar, Longmont, and Mosher are most common in the Study Area and are saline and sodic. Vona is neither saline nor sodic. In the Vona and Avar soils, depth to the water table is typically greater than 40 in. below ground surface during the growing season. In the Mosher soil, the water table is typically 25 to 50 in. below ground surface, and in the Longmont soil it is typically less than 20 in. below ground surface. Mosher and Longmont soils support the Salt Meadow Ecological Site, Avar soils support the Salt Flat Ecological Site, and Vona soils support the Sandy Plains Ecological Site (NRCS 2011).

2.1 SALT-AFFECTED SOILS

When there are enough salt(s) in the soil to retard plant growth, injure plant tissue, and/or decrease yields, the soil is referred to as salt affected. Salt-affected soils contain excess soluble salts (saline), excess exchangeable sodium (sodic), or both. Western states typically have mostly saline soils with some saline-sodic soils and isolated occurrences of sodic soils (NRCS 2002). The Study Area is dominated by saline, sodic, and saline-sodic soils.

2.1.1 Saline Soils

Electrical conductivity (EC), which is usually measured in decisiemens per meter (dS/m), provides an overall measure of soil salinity. The higher the number, the higher the salt concentration. Soil salinity affects plant nutrient availability, soil osmotic potential, and populations of essential soil microorganisms, which in turn affect the yield and survival of plants. Salinity levels greater than 4 dS/m can be toxic to many plants, though every species has a different tolerance to soil salinity.

Smith Environmental and Engineering 250 Perry Lane Dacono, Colorado 80514 (720) 887-4928, (720) 887-4680 (fax)	SECOND CREEK RESTORATION 0 500 1,000 Feet	Figure 2 Soils Map Adams County, Colorado July 2019

Four salinity classes are recognized by the NRCS (2019) as it relates to the tolerance of plants to withstand the effects of soil salinity: none (tolerant to a soil with an electrical conductivity of 0-2 dS/m), low (tolerant to 2.1-4.0 dS/m), medium (tolerant to 4.1-8.0 dS/m), and high (tolerant to greater than 8.0 dS/m). These salinity classes are reflected in Table 1.

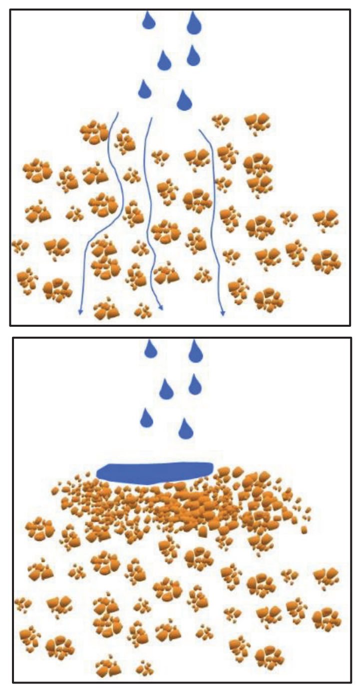
Some native species observed in the Study Area will tolerate salinity levels higher than 8 dS/m, including fourwing saltbush (*Atriplex canescens)*, alkali sacaton (*Sporobolus airoides*), western wheatgrass (*Pascopyrum smitii*), and inland saltgrass (*Distichlis stricta)*. Pure stands of these species suggest an area is highly saline. Other native species such as rubber rabbitbrush (*Ericameria nauseosa*) tolerate salinity levels greater than 8 dS/m but are clearly adversely affected (i.e. growth is stunted) at these levels.

SMITH observed several invasive and noxious weed species within the Study Area that are surviving, and in many cases thriving, in highly saline soils, including Russian olive (*Elaeagnus angustifolia*), kochia (*Kochia scoparia),* musk thistle (*Carduus nutans*), Canada thistle (*Cirsium arvense*), Russian thistle (*Salsola* spp.), lambsquarters (*Chenopodium album)*, and Russian knapweed (*Acroptilon repens*). The implementation of planting plans that do not consider the local soil salinity conditions may result not only in plant mortality of desirable species that are not salt tolerant, but also in vulnerability to infestation by undesirable species.

2.1.2 Sodic Soils

Sodic soils are characterized by a disproportionately high concentration of exchangeable sodium. This is evaluated using two metrics: sodium adsorption ratio (SAR) and exchangeable sodium percentage (ESP). Sodium adsorption ratio is a ratio of soluble sodium to soluble calcium and magnesium in a soil. An SAR value greater than 13 is characteristic of sodic soils; an ESP of 15 or greater indicates a sodic soil.

Exchangeable sodium causes soil particles to de-flocculate or disperse, resulting in decreased pore space within the soil (see diagrams at right). Whereas flocculated or aggregated soil particles form flow pathways for water and air through the soil profile, the loss of permeability in sodic soils can severely restrict water movement. Sodic soils tend to develop poor structure and drainage over time. Sodic soils are sometimes referred to as "black alkali" or "slick spots" due to the dissolved organic matter in the soil solution. They are hard and cloddy when dry and tend to crust.



Top: a flocculated soil with suitable flow pathways.
Bottom: a de-flocculated soil with poor drainage conditions.
(Walworth 2006).

Sodic soils can have significant impacts on plant growth. Reduced infiltration into the root zone can cause plant stress, and surface crusting can limit seedling emergence. Additionally, as seen in saline soils, high levels of sodium can be toxic to sensitive plants or lead to nutrient deficiencies or imbalances. Sodic soils can also have a high pH (Davis et. al 2012).

3.0 VEGETATION

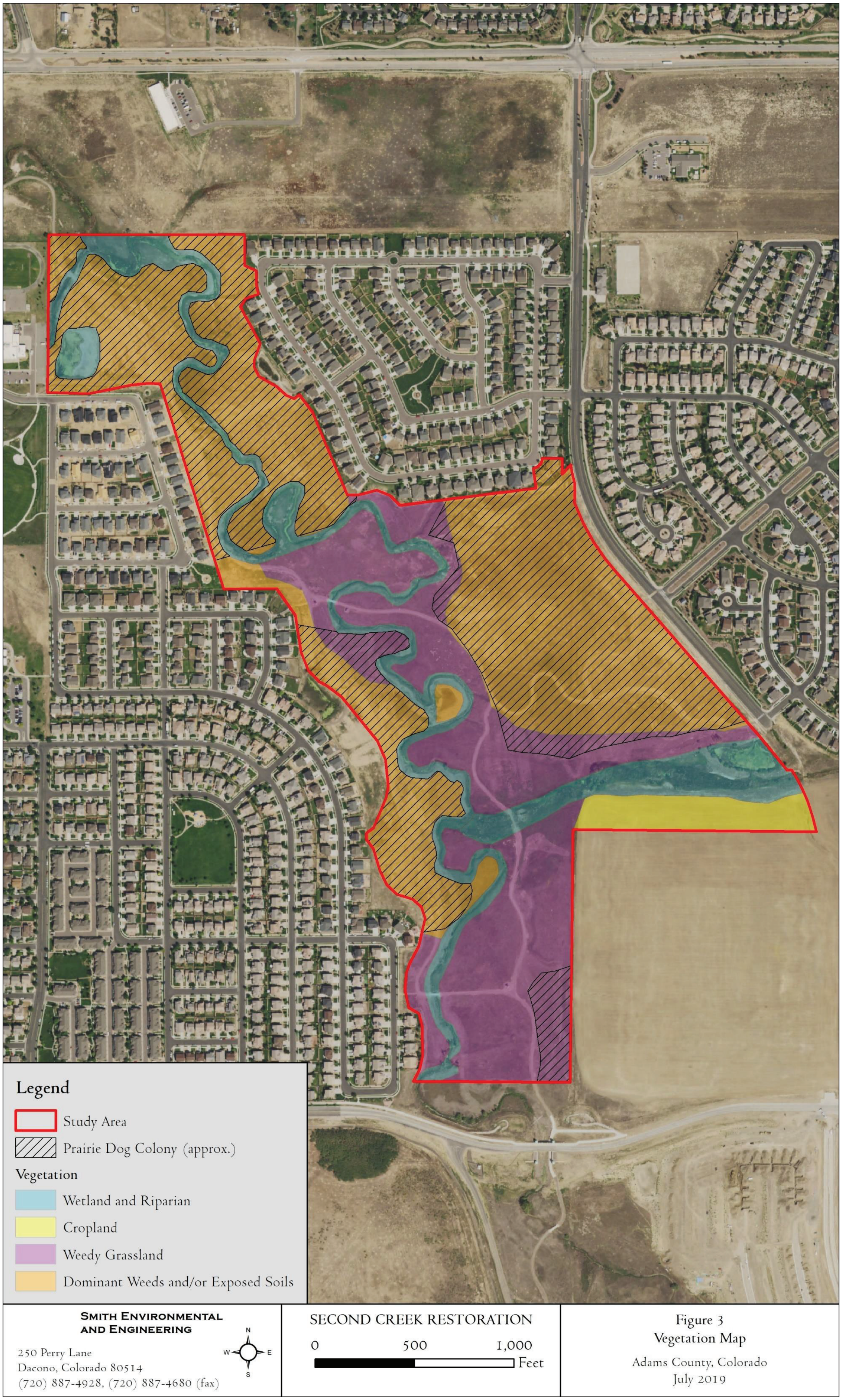
The vegetation on a site, which is often assessed both in terms of species composition and percent cover, depends on the combined effects of soil, topography, and climate. Where climate and topography are similar, differences in vegetation are a function of the soil type. Therefore, Ecological Sites (discussed previously) are directly interpreted from soil types. In a relatively undisturbed area, the vegetation would closely resemble the ESD. However, disturbances caused by humans or wildlife (including prairie dogs) can alter the condition or quality of the existing vegetation. The Ecological Site designation remains unchanged, and it can be used as a guide for restoration. But the observed vegetation will differ significantly from what the ESD predicts.

Remnants of the Ecological Sites were observed within the Study Area, but in general, the vegetation is typical of a significantly disturbed and human-modified system. Like much of the eastern Front Range, the land use history of the Study Area includes extensive agricultural use. Google Earth imagery indicates that as late as the 1990s, portions of the Study Area were still actively being farmed. Indeed, the field immediately southeast of the Study Area is still being used in wheat production. In the 2000s, agricultural land uses in the area were largely phased out as residential developments were constructed. Although the Study Area has now been placed into passive recreational use as an open space, the legacy of human impacts is evident in the prevalence of nonnative plant species, including both forage grasses such as smooth brome (*Bromus inermis*) and weedy species.

SMITH has categorized the Study Area into four different vegetative units (Figure 3) based on the cover, composition, and structural characteristics that were observed: Cropland, Wetland and Riparian, Weedy Grassland, and Dominant Weeds and/or Exposed Soils. Two of these units (Cropland and Wetland/Riparian) will have little implications on any proposed restoration activities. The wheat field to the southeast of the Study Area extends slightly into the Study Area. SMITH assumes that this will remain in production for the time being, and the City is not currently proposing to restore this site.

The wetland and riparian vegetation that occurs along Second Creek, a detention pond, and a stormwater drainage constitute a second unit (Photos 1 and 2). Some of the species observed are included in Table 1, specifically in the Aquatic Plants section. SMITH understands that the City will be focusing restoration efforts on the upland areas within the Study Area. There are opportunities for restoration along this riparian corridor, but continued development within the watershed will lead to changes in the hydrologic regime of Second Creek. A long-term, sustainable restoration effort in this area will be more successful when development within the local area has largely ceased.

The remaining two vegetative units are distinguished primarily by their surface cover and overall levels of disturbance. The areas labeled Weedy Grassland on Figure 3 (in purple) have relatively high percentages of plant cover and low percentages of bare ground (Photos 3 and 4). These areas are located primarily east of Second Creek and in the southern extent of the Study Area. Prairie dogs are generally absent in these areas or occur at low densities. As the name implies, the vegetation in these areas is a mix of grass species (native and nonnative) and weedy forbs. Western wheatgrass, crested wheatgrass (*Agropyron cristatum*), smooth brome, inland saltgrass, and alkali sacaton (*Sporobolus airoides*) were the most common grass species. Kochia was the most abundant weedy species in these areas, but pennycress (*Thlaspi arvense*), lambsquarters, sweetclover (*Melilotus officinale*), and prickly lettuce (*Lactuca serriola*) were also observed.



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SECOND CREEK RESTORATION

Figure 3
Vegetation Map
Adams County, Colorado
July 2019

Table 1. Plant Species Observed at Second Creek[1]

Scientific Name	Common Name	Native Status	Salinity Tolerance[2]
TREES AND SHRUBS			
Atriplex canescens	Fourwing saltbush	Native	High
Elaeagnus angustifolia	Russian-olive	Noxious – List C	High
Ericameria nauseosa	Rubber rabbitbrush	Native	Medium
Salix exigua	Sandbar willow	Native	Low
Symphoricarpos spp.	Snowberry	Native	Low/Medium
Yucca glauca	Yucca	Native	Medium
FORBS			
Acroptilon repens	Russian knapweed	Noxious – List B	---
Argemone spp.	Prickly poppy	Native	Low
Asclepias spp.	Milkweed	Native	None
Carduus nutans	Musk thistle	Noxious – List B	---
Chenopodium album	Lambsquarters	Introduced	---
Cirsium arvense	Canada thistle	Noxious – List B	---
Cleome serrulata	Rocky Mountain beeplant	Native	None
Convolvulus arvensis	Field bindweed	Noxious – List C	---
Conyza canadensis	Horseweed	Introduced	None
Kochia scoparia	Kochia	Introduced	Low
Lactuca serriola	Prickly lettuce	Introduced	---
Melilotus officinale	Sweetclover	Introduced	High
Mentha arvensis	Wild mint	Native	None
Portulaca oleracea	Purslane	Introduced	---
Rumex crispus	Curly dock	Introduced	---
Salsola spp.	Russian thistle/tumbleweed	Introduced	---
Solanum triflorum	Cutleaf nightshade	Native	---
Thlaspi arvense	Field pennycress	Introduced	---
Verbascum thapsus	Common mullein	Noxious – List C	---
GRASSES			
Agropyron cristatum	Crested wheatgrass	Introduced	Medium
Bromus inermis	Smooth brome	Introduced	Medium
Bromus japonicus	Japanese brome	Introduced	None
Distichlis stricta	Saltgrass	Native	High
Hordeum jubatum	Foxtail barley	Native	---
Pascopyrum smitii	Western wheatgrass	Native	High
Sporobolus airoides	Alkali sacaton	Native	High
AQUATIC PLANTS			
Typha spp.	Cattail	Native	Low/Medium
Schoenoplectus pungens	Common threesquare	Native	Medium
Schoenoplectus tabernaemontani	Softstem bulrush	Native	Low

1. Not a comprehensive plant inventory.
2. NRCS assigns salinity tolerance ratings to select species based on a less than 10 percent reduction in plant growth at a particular electrical conductivity level.

The final vegetative unit described is labeled Dominant Weeds and/or Exposed Soils in Figure 3 (in orange). These areas do vary in species composition and overall cover, but they are generally characterized by high levels of disturbance and a drastic deviation from historical conditions. Prairie dog activity is common in nearly all of these areas, and in some areas, there is also evidence of surface disturbance activities. The area east of Stuart Middle School is dominated by kochia, which is a nonnative, weedy species (Photo 5). There is little bare ground, but there are also few desirable species, including grasses. The areas farther south and adjacent to Second Creek have more grasses and native species present, including alkali sacaton, western wheatgrass, inland saltgrass, fourwing saltbush, Rocky Mountain beeplant (*Cleome serrulata*), and cutleaf nightshade (*Solanum triflorum*). However, these species are intermittent, and there are large patches of bare ground with salt deposits at the surface (Photos 6 and 7).

The eastern segment nearest to the housing development is the most starkly denuded in the entire Study Area. There is almost no surface vegetation in much of this area, and the species that are present are primarily weeds such as field bindweed (*Convolvulus arvensis*), Russian thistle, or kochia (Photo 8). SMITH suspects there may have been an herbicide application in this area that led to the complete lack of vegetation. The exposed soil is now at a high risk for wind and water erosion.

4.0 BLACK-TAILED PRAIRIE DOGS

Black-tailed prairie dogs are an important species in a natural prairie ecosystem. They provide prey for raptors, coyotes, and other predators, and their abandoned burrows provide habitat for a number of species, including Burrowing Owls, Mountain Plover, and rattlesnakes. However, prairie dogs can also have negative effects on a landscape, especially one that has a history of disturbance.

Prairie dogs “clip” vegetation during grazing and to enhance their ability to detect predators and other threats. A natural prairie ecosystem is typically populated with robust, native vegetation that can withstand this clipping behavior. In areas where there is already an abundance of nonnative or undesirable species, constant herbivory pressure from prairie dogs can lead to a weedy or nearly barren site. This problem is often exacerbated in urban and suburban colonies that do not allow for natural colony expansion. This vegetation pattern was clearly observed in the Study Area as many of the areas occupied by prairie dogs were characterized by an abundance of weeds and bare ground (Figure 3).

Additionally, prairie dogs are exacerbating the problems associated with the saline and sodic soils. When prairie dogs excavate their burrows, subsurface soils are often deposited on the surface. In natural settings, this can provide a vital ecosystem service by aiding in soil aeration and nutrient cycling. In the Study Area, however, prairie dogs are bringing soil to the surface from the most saline and sodic horizons in the soil profile. This has resulted in even higher salinity and sodicity conditions at the surface in areas where prairie dog burrows (active or inactive) currently exist. These high salinity and sodicity levels have a pronounced effect on vegetation, and in some areas, plant cover is almost nonexistent (Photo 7).

5.0 RESTORATION RECOMMENDATIONS

Grassland restoration can be a lengthy, expensive, and difficult process under the best conditions. Complicating factors such as overgrazing, poor soils, and infestations of invasive plant species only exacerbate the inherent challenges. As Commerce City prepares to face these challenges, SMITH first recommends that the community answer the following questions:

1. What are the community's goals for this open space? Should prairie dogs be part of the landscape at a sustainable and healthy carrying capacity? What degree of bare ground is acceptable? Is native vegetation a priority, or are nonnative species acceptable provided they are not noxious?
2. What is the timeline for when these goals should be achieved? Is that timeline realistic considering that large-scale grassland restoration can decades? Will the community remain committed to this project if results are not immediately evident?
3. How should restoration be approached for a site over 120 acres? Should the entirety property be restored in a single effort, or phased into priority areas? Are there opportunities for small-scale research plots?
4. What will be the budget for this project? Is the community, its decision makers, and its staff prepared to commit annual funding towards monitoring and maintenance to ensure that restoration gains are maintained? Or is one-time funding all that is available?
5. What resources are available for the planning and implementation of the restoration effort? Does the City plan to contract with restoration professionals? What role will City staff play?
6. How will success be determined? Will specific success criteria be outlined? Will plant cover and composition, soils, or both be assessed? Will staff and/or public input be incorporated?

The answers to these questions will guide the decision makers and staff members in determining what actions are feasible in the short, intermediate, and long-term. Once the community has agreed upon a vision and committed to providing the funding and resources necessary, only then should the restoration effort begin in earnest. SMITH has prepared the following recommendations on the actual process of ecological restoration. They are listed in increasing order of cost and complexity.

5.1 PREPARE A RESTORATION PLAN

A comprehensive restoration plan that addresses vegetation, soils, and wildlife should be developed by a qualified individual or entity with experience in ecological restoration. The plan should have a narrative component that outlines the answers to the questions described above, including the overall goals of the restoration. It should also include detailed design plans and specifications for the agreed-upon restoration approach. A monitoring plan and success criteria (if desired) should also be incorporated into the restoration plan. This plan should be considered a living document that can be revised if new restoration strategies are developed or if attempted strategies are found to be inappropriate for the site.

5.2 PREPARE AND IMPLEMENT A WEED MANAGEMENT PLAN

If funding is limited, the implementation of an aggressive weed management plan can be a good introductory or foundational action for ecological restoration. Not only does such a plan address the regulatory requirements of the Colorado Noxious Weed Act, but if designed and implemented properly, it can work in conjunction with the expansion of desirable native species.

The first step for a weed management plan is to determine the species of concern and map their presence within the Study Area. The plan should identify if the target species will be only state-listed noxious weed species, or whether other nonnatives will also be included. Once the map is complete, an integrated treatment approach should be developed for each species. For instance, some species are best managed with a chemical treatment early in the spring, whereas others respond best to a late fall application. Some species can be effectively mowed or hand pulled, but other species reproduce vegetatively so this can be counterproductive. Biological controls (i.e. insects or fungi) are available from the State for some species.

Once the plan has been developed, diligent implementation and monitoring is essential. SMITH recommends that weed management activities occur at least twice per year, ideally in the spring and fall. In the early years of plan implementation, these will be significant efforts. It may seem like progress is not being made. Many noxious weed species have seeds that remain viable in the soil for several years. To ensure an efficient and targeted approach, the weed map should be updated annually, and the plan modified as necessary.

While weed management alone is a worthwhile endeavor, it should be noted that its successes will be maximized if the efforts are completed in concert with other restoration efforts. For example, if the vegetative cover of an area is almost exclusively weedy species, revegetating those areas following treatment would be wise to ensure there are desirable species present to recolonize the area. Similarly, once an area has been revegetated, aggressive weed management is often required to ensure desired species have a competitive advantage in becoming established. Additionally, without prairie dog management, significant reduction in weed cover will not be achieved, as discussed below.

5.3 PREPARE AND IMPLEMENT A PRAIRIE DOG MANAGEMENT PLAN

The presence of prairie dogs on an open space property involves more than simply an ecological discussion. Within most communities, prairie dogs find both strong support and often equally strong opposition. While no policy or management proposal will please everyone, all opinions are valid and should be taken into consideration during the planning process. Attempting to circumvent these issues or avoid the public on these matters rarely succeeds.

Nonetheless, a hard truth remains. Ecological restoration activities in urban and semi-urban areas, specifically efforts to restore native vegetation, will have a very low rate of success with active prairie dog colonies on site. In a degraded site with limited food availability, native seed and/or planted or emerging seedlings would be heavily grazed upon. Additionally, seeding efforts would require significant disturbance of the colony, either through drill seeding operations and possibly during the installation of tackifiers or blankets. Even weed management activities can have effects on existing colonies by reducing available food sources or exposing the animals to herbicides. For these reasons, most natural resource managers in the Front Range do not attempt large-scale site restoration where prairie dogs occur.

SMITH recommends that City staff and decision makers, with input from the public, classify the Study Area into three categories: Prairie Dog Areas, Expansion Areas, and Exclusion Areas. This should reflect long-term goals, not the existing conditions (unless those are the desired conditions). Expansion Areas should be located adjacent to Prairie Dog Area and allow for natural colony expansion.

Prairie dogs will not be permitted to expand into Exclusion Areas, which may occur within a buffer adjacent to private properties or within desirable native plant areas. Active management (i.e. trapping or burrow fumigation) may be required to keep Exclusion Areas unoccupied.

Based on the extent of acreage that is to be dedicated to each area, the City should seek advice from Colorado Parks and Wildlife (CPW) to determine an appropriate carrying capacity for prairie dogs. If these pre-determined carrying capacities are exceeded, the Expansion Areas would be targeted first for population reduction efforts. If may seem counterintuitive to remove prairie dogs from a property where they are allowed, but managing the colony size will prevent overpopulation issues, including excessive herbivory on desired vegetation. It is critical to remember that even a restored property is still a human-altered environment, with landscape restraints and a lack of true predator controls.

Once a long-term vision for prairie dogs in the Study Area is established, actions should be taken to begin implementation. If an area is occupied with prairie dogs but has been designated an Exclusion Area, those prairie dogs could be trapped and donated to raptor rehabilitation or black-footed ferret recovery, or burrow fumigation could be conducted. Conversely, if prairie dogs do not currently occur in an area designated as a Prairie Dog Area, they could be translocated within the property limits without requiring a permit from CPW.

The most significant challenge will be accounting for prairie dogs as other components of the site restoration are implemented. If an area necessitates aggressive revegetation, the prairie dogs will likely need to be removed until the desired vegetation has established. It could take years before the area is suitable for the reintroduction of prairie dogs. If the restoration activities are phased, a population of prairie dogs could be maintained on the property and reallocated when restoration success has been achieved in certain areas. Another long-term option for maintaining prairie dogs on the site post-restoration would be to accept relocated prairie dogs from other properties in Adams County.

Balancing site restoration and prairie dog management will require flexibility and creativity. There is no perfect solution. But as with restoration as a whole, beginning with a vision of where you want to end up will help determine how you get there.

5.4 REVEGETATE WITH SALT-TOLERANT SPECIES

A critical component to restoring any site is the establishment of vegetation that is native to the area and adapted for local site conditions. Though a simple concept, many projects are set back when the selected plants cannot survive due to toxic soil conditions, inadequate soil moisture, nutrient deficiencies, etc.

As discussed previously, the saline-sodic soil conditions prevalent in the Study Area absolutely must be taken into account for any revegetation efforts. Taxpayer dollars could be easily wasted if salt-intolerant species are utilized and do not establish. Table 2 below lists some native species having salt tolerance that could be utilized; additional species can be found in the ESDs. Grasses represent the lowest risk for such sites, with many native species having a high salinity tolerance. Forbs would need to be selected carefully and potentially tested in small areas. Shrubs should be used sparingly, as they represent a higher cost and are not the dominant plant stratum in this ecological setting.

Table 2. Selected Native Plants with Salinity and Sodicty Tolerance

		Tolerance of the Plant to Salinity (dS/m)/Sodicity (SAR)*				Upper Tolerance Limit Salinity (dS/m)/ Sodicity (SAR)*
Scientific Name	Common Name	<2/ <3	2-4/ 3-6	4-8/ 6-13	>8/ >13	
SHRUBS						
Atriplex canescens	Fourwing saltbush	High	High	High	Low	12/13
Ericameria nauseosa	Rubber rabbitbrush	High	High	Medium	No	8/10
Rosa woodsii	Woods' rose	High	Low	No	No	4/3
Symphoricarpos occidentalis	Western snowberry	High	High	Low	No	4/6
FORBS						
Artemisia fridiga	Fringed sage	High	High	Medium	No	8/10
Glycyrrhiza lepidota	Wild licorice	High	Low	No	No	4/3
Heterotheca villosa	Hairy false goldenaster	High	Low	No	No	4/3
Ratibida columnifera	Coneflower	High	Low	No	No	4/3
Sphaeralcea coccinea	Scarlet globemallow	High	High	Medium	No	8/10
Vicia americana	American vetch	High	Low	No	No	4/3
GRASSES						
Distichlis stricta	Inland saltgrass	High	High	High	Low	12/13
Elymus canadensis	Canada wildrye	High	High	Low	No	8/10
Elymus trachycaulus	Slender wheatgrass	High	High	Low	No	8/10
Elymus lanceolatus	Thickspike wheatgrass	High	High	Low	No	8/10
Panicum virgatum	Switchgrass	High	High	Low	No	8/10
Pascopyrum smitii	Western wheatgrass	High	High	Low	No	8/10
Puccinellia nuttalliana	Nuttall's alkali grass	High	High	High	Low	12/13
Sporobolus airoides	Alkali sacaton	High	High	High	Low	12/13

*According to Ogle and St. John (2010), NRCS (2002 & 2019), Tober et. al (2007), and SMITH.

Because the Study Area is so large, selective seeding is the most effective way to implement large scale revegetation. Seed mixes using the species in Table 2 could be developed and applied to meet specific revegetation goals throughout the Study Area. For instance, the section of the Study Area that is almost completely devoid of vegetation would need to be entirely reseeded at a heavy rate. Drill seeding and application of a mulch tackifier would also be recommended to avoid having seed and topsoil blow or wash away. However, hand broadcasting methods would be more appropriate in areas where the existing vegetation includes some desirable species and surface disturbance would be undesirable. Either method could be incorporated after weed management activities, depending on how aggressive the weed removal action is.

Some containerized shrubs could also be incorporated into the planting plan, as large quantities would not be necessary. However, any planted shrubs should be provided supplemental irrigation for the first growing season as their root systems establish. Smaller containerized plants (i.e. wildflowers or grass plugs) could be utilized as well but are much more costly. These may be best utilized in smaller, high value areas (such as a native plant demonstration plot). There could also be opportunities for small research plots, especially on species whose salt tolerance is unknown.

5.5 RECLAIM AREAS OF HIGHLY SALINE AND/OR SODIC SOILS.

If the ultimate long-term goal for this site is to reestablish a sustainable, native, upland plant community, the reclamation of sodic soils will be required. This involves the application of gypsum, leaching of salts, covering affected areas with one to two feet of non-saline, non-sodic soils, or a combination of these treatments. This is more expensive than prairie dog management or revegetation efforts but may provide more long-term success.

When soils are high in sodium, the goal is to replace the sodium on the soil particle exchange sites with calcium, then leach the sodium out of the profile to at least a depth of 30 in. below ground surface. SMITH recommends mixing gypsum (calcium sulfate) into the soil, and then irrigating with water high in calcium to leach out the sodium. This will reduce the sodicity but leave a saline soil. Subsequently irrigating with normal water (rainwater) will leach out some the calcium and reduce the salinity.

The general rule-of-thumb for recovering a one-foot depth of sodic soil on one acre requires approximately 1.7 tons of pure gypsum for each milliequivalent of sodium reduction (Davis et al. 2012). Additional soil testing would be needed to determine the existing ESP and identify the desired target. The cost of one ton of gypsum is about $300-400.

The water table is less than 6 ft below ground surface across most of the Study Area, and occasionally high sodium water ascends in the soil profile through capillary rise during high-water table events. Before the reclamation of sodic soil can be undertaken in the Study Area, a drain system would need to be installed to keep the water table at or below 5 ft. Mosher, Longmont and Avar soils are all sodic within the Study Area. Because the installation of a drain system is not feasible in areas where the water table is high (less than 40 in.), reclamation of Longmont soil areas is not feasible. It is recommended sodic soil reclamation be attempted only in Avar and Mosher soils.

6.0 LITERATURE CITED

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APPENDIX A – PHOTOGRAPHS

Photo 1. View looking downstream along Second Creek. Longmont soils are typical along the creek and support riparian vegetation that includes sandbar willow. The transition to Mosher soils and upland plant species (especially kochia) is abrupt.

Photo 2. View looking west along a wetland drainage dominated by cattails. Salt crusting is evident in the Mosher soils (left of the red line). Longmont soils occur in the wetland area (right of the red line).

Photo 3. View looking west at an area with Avar soils supporting some native grasses but also an abundance of weeds. The dark green plant is kochia, and the lighter green forb in the foreground is lambsquarters.

Photo 4. View looking southwest towards an area of Avar (central area) and Mosher soils (foreground and background). These areas have a mix of native grasses and weeds. The dark vegetation in the background is kochia.

Photo 5. View looking east from near Stuart Middle School across an area with Avar soils and dominated by kochia.

Photo 6. View looking south in an area east of Second Creek with Avar soils, intermittent native grasses (mostly inland saltgrass), and fourwing saltbush (shown above). Prairie dogs are present in this area, and there is a significant amount of bare ground.

Photo 7. View looking east on Avar soils west of Second Creek with bare ground and weeds, primarily field bindweed and Russian thistle. Prairie dogs were present in this area.

Photo 8. View looking east at Vona soils on the hillside on the eastern edge of the Study Area. Where vegetation is present, it is primarily field bindweed. Prairie dogs were present in this area.

Photo 9. A large infestation of Canada thistle, a state-listed noxious weed.

Photo 10. Avar soils supporting a large infestation of Russian knapweed, a state-listed noxious weed.