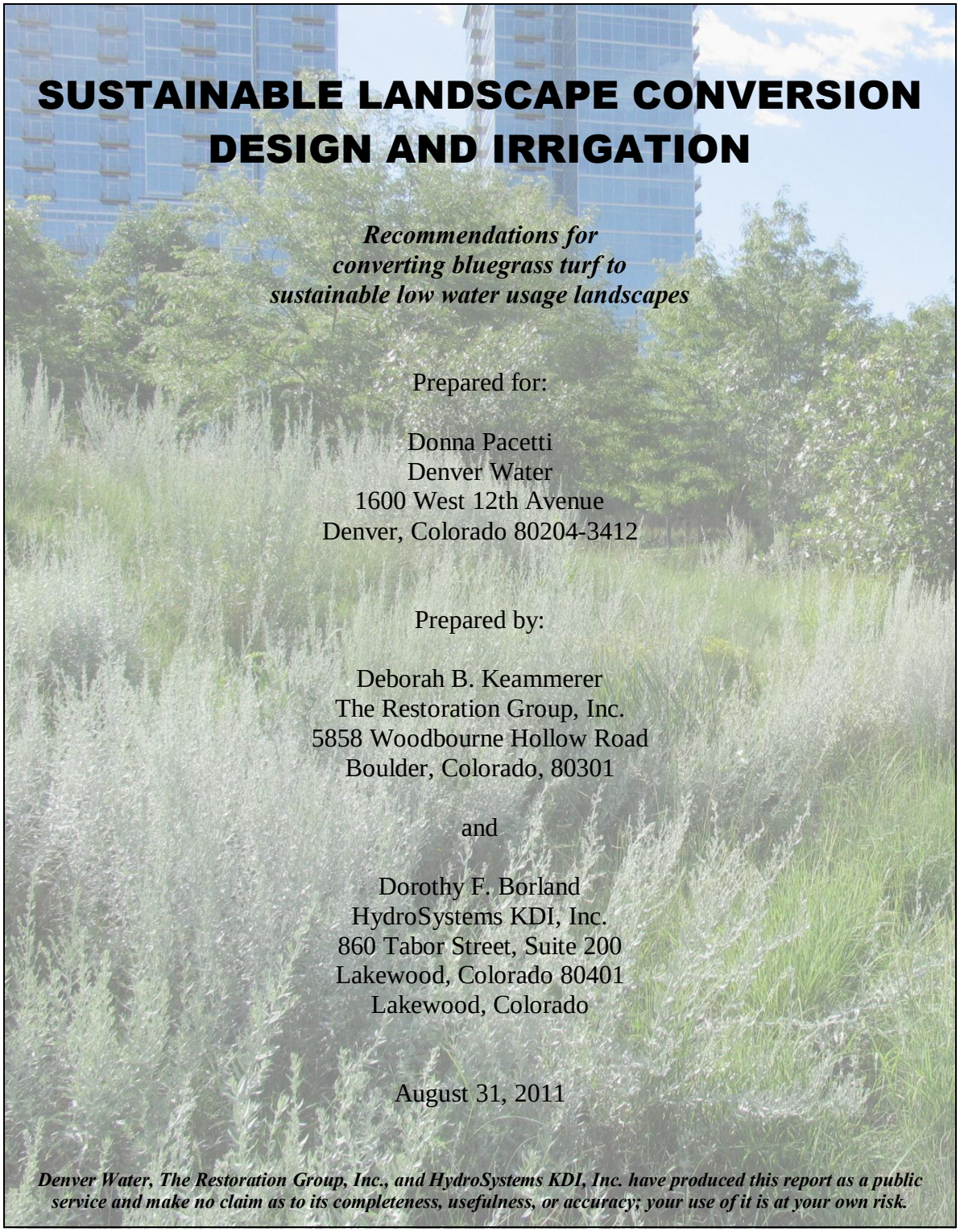

SUSTAINABLE LANDSCAPE CONVERSION DESIGN AND IRRIGATION

Recommendations for converting bluegrass turf to sustainable low water usage landscapes

Prepared for:

Donna Pacetti
Denver Water
1600 West 12th Avenue
Denver, Colorado 80204-3412

Prepared by:

Deborah B. Keammerer
The Restoration Group, Inc.
5858 Woodbourne Hollow Road
Boulder, Colorado, 80301

and

Dorothy F. Borland
HydroSystems KDI, Inc.
860 Tabor Street, Suite 200
Lakewood, Colorado 80401
Lakewood, Colorado

August 31, 2011

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Figure 1.1 Attractive use of drought tolerant ornamental grasses in a Front Range streetscape.

Executive Summary

This report has been prepared to assist those seeking to reduce water consumption in Front Range high plains communities. It is designed to help evaluate and identify locations with potential for conversion to more sustainable low water usage landscape types. Advantages and disadvantages of conversion are presented with information regarding site selection and design relative to site specific conditions and intended final usage. The report describes a range of proven drought tolerant treatment alternatives including turf grasses, mulched beds, unmowed grasslands, and native plant communities suitable for consideration in a range of local situations from urban to rural. Appendices provide technical recommendations for seed mixtures, conversion methods, irrigation and maintenance programs. Recommendations are also included for reducing water use on existing bluegrass turf. Since new technologies and new grass varieties are being actively developed, a discussion of future trends is also provided.

Topics addressed in this report:

- Modified Kentucky bluegrass irrigation and maintenance program
- Alternative turfgrasses for mowed lawns
- Alternative grasslands or prairie conversions for unmowed areas
- Seed mixtures and plant material sources for conversions
- Conversion methods
- Establishment irrigation and maintenance recommendations
- Long term irrigation and maintenance recommendations
- Future trends and future needs recommendations

Figure 1.2 Mowed and unmowed fine leaved fescues can provide water savings of 40 percent or greater. This installation is located at Flatirons Crossings Mall in Broomfield.

1.0 Introduction

National and regional landscape design trends and how these relate to sustainable landscape conversion.

Sustainable landscape designs have improved greatly over the last two decades. This trend in alternative landscape creation is attuned to regional environments and driven by an interest in resource conservation. Within the Front Range corridor newer developments, malls and streetscapes have created beautiful landscapes which address the paired needs to reduce water consumption and maintenance efforts (Figures 1.1, 1.2 and 1.3). This forward-looking trend has already found wide application, offering a diverse and attractive regional setting for newer urban and suburban developments.

Figure 1.3 Drought tolerant median landscape along east 104th Ave in Thornton.

The current challenge is to further expand these benefits by exploring the potential for conversion of existing conventional landscape treatments into more sustainable landscapes. Conversion of high water usage turfgrass areas to less water consumptive and lower maintenance treatments is possible and can provide significant savings in water

usage. Such conversions can also provide an opportunity for older landscapes to better serve the current or projected use patterns. Opportunities for more drought tolerant redesign include the use of alternative turf grasses, restoration of regional native grasslands, and conversion of portions of traditional landscapes to mulched beds with ornamental grasses or shrubs for greater visual diversity.

There are many advantages for conversion to more sustainable landscapes. Primary to these is water savings. Once an area is established with more drought tolerant vegetation and the irrigation schedule is set to match the mature plant requirements, significant savings can be realized (Figure 5.18). Conversion to an alternative turfgrass can yield 40 percent or greater water savings over conventionally irrigated Kentucky bluegrass. Achievement of these savings always depends on having a well trained staff that can monitor and adjust irrigation schedules and long term maintenance activities to maximize the goals of the conversion site.

Other conversion benefits will follow. Changes in landscape maintenance programs can provide a further savings over conventional maintenance costs. In general, mowing frequencies, fertilizer applications and herbicide use can all be reduced, depending on the conversion type selected.

> All projected percent water savings given in this report are comparisons of conventional Kentucky bluegrass irrigation at a rate of 37 inches per year average water use based on the results of a recent Denver Water Department (DWD) audit of 256 home owner associations.

If a more natural appearance is desirable, conversions to naturalized non-native grasslands or a variety of native prairie types can result in a 70 percent or greater water savings. These hardy grasslands can look attractive and healthy with a small amount of regular irrigation and one annual mowing (Figure 1.2). Restoration of native landscape elements provides relief from an otherwise generic urban/suburban landscape, lending the area greater regional character (Figure 1.4).

Figure 1.4 Early summer condition of mixed grass prairie planted in Erie Commons Open Space.

Native areas support passive recreation, exploration, creative play, and wildlife habitat, which greatly enrich our metropolitan areas. Personal health and well being and educational benefits can be enhanced by access to functional native or naturalized open spaces. Multi-use benefits of native restoration in drainages and riparian corridors are recognized by the recent trend in Low Impact Development (LID) designs for storm water nationwide. Such sustainable green infrastructure areas are being intentionally featured in urban designs because they provide a range of important ecological services, including: erosion protection, water quality improvement, run off reduction, oxygen production, carbon dioxide sequestration, air cooling, while serving as natural aesthetic features for passive recreation and wildlife habitat.

While beneficial in the long term, there are immediate costs to the implementation of sustainable landscape designs. Even though water conservation is a primary emphasis of sustainable landscape conversion, most conversions in the Front Range area will still require a permanent irrigation system in order to maintain plant health. Redesign and installation of sustainable landscapes can be as simple as removing and replacing bluegrass turf with a more drought tolerant turfgrass utilizing the same irrigation zones and system. However, many projects could require a new irrigation system.

In addition to funds for redesign and installation, it is critical that maintenance costs be considered. This element of the conversion program is critical and must not be overlooked. During the first one or two years of growth, new conversion areas will require more intensive monitoring and specialized maintenance. At this time it will be essential to inform the public of the goals and expectations for the area and to begin a process of retraining and/or adding specialized maintenance personnel. **Conversion sites cannot be managed like conventional turfgrass and achieve their water savings goals.** Maintenance will require a staff with a new range of skills. These personnel must be aware of the proper methods for water conservation irrigation and maintenance of the new conversion areas. At this time staff must become thoroughly familiar with a new irrigation system (controllers, schedules) and the different requirements of the new landscape to prevent both under or over-watering, both of which can be damaging to establishing conversion vegetation.

This report provides guidance on selection of areas with good potential for conversion in Section 2.0. Critical environmental considerations which should inform selection of a conversion type are discussed in Section 3.0. A full discussion of methods to improve drought tolerance of Kentucky bluegrass turf is provided in Section 4. Section 5 describes a number of conversion vegetation choices suitable for use in a variety of settings in the Front Range area. Important considerations for conversion are discussed in Section 6. Establishment and long term maintenance requirements are presented in Sections 7 and 8. Section 9 discusses future trends and needs. Thorough technical supporting information for implementing conversion is provided in the Appendices.

2.0 Sustainable Landscape Conversion Areas

Kentucky bluegrass has long been used as a durable turfgrass. It is still a good option for heavily used active play areas (Section 4.0). However, many conventional bluegrass installations are under-utilized or not intended for active play. The following discussion has been prepared to assist with identifying areas with good potential for conversion.

2.1 Under-Utilized Conventional Turf

Many lawns function mainly as a green landscape setting. Some of these areas can be considered for conversion to a less demanding, more drought tolerant form of landscape, such as alternative turfgrass, native grasslands, or mulched beds of ornamental grasses or shrubs. Replacement with alternative vegetation could yield significant water conservation while still providing an attractive landscaped setting.

Areas which might be underutilized and suitable for conversion may include:

- Portions of business or school campuses
- Drainages, detention and retention ponds
- Passive use trail areas
- Areas with changing demographics; decreasing need for lawns
- Golf course roughs or outlying areas (many such areas may have already been converted)
- Sloping areas within the landscape

2.2 Restricted Access Turf

Some irrigated areas are situated along roads and in parking lots and are not suitable for active play (Figure 2.1). Water savings can be achieved by conversion of these areas to alternative turfgrass, native or naturalized grasslands, or mulched ornamental grass or shrub beds.

Areas with restricted use which can be considered for conversion include:

- Parkways and neighborhood streetscapes
- Roadside, medians, tree lawns
- Shopping malls and parking lot islands

Figure 2.1 Blue grama used in parking lot islands as drought tolerant planting.

2.3 Problem Maintenance Areas

A variety of turf maintenance difficulties can be reduced by conversion to sustainable alternative vegetation. Areas of deep shade under trees or near buildings can be converted to mulched beds with shade and drought tolerant groundcover. Wet drainage areas which are difficult to mow could be converted to native moist meadow or wetland vegetation. This conversion could also improve water quality, habitat, and add visual diversity to a site. Steep slopes, which may be challenging and dangerous to maintain can be considered for native or naturalized grassland or shrubland conversions. Areas with nuisance animals, such as waterfowl, might be converted to taller grasses or shrubs to discourage waterfowl grazing (Section 7.9.2).

Problem maintenance areas which could be converted to achieve water savings include:

- Heavy shade
- Wet drainages
- Steep slopes
- Waterfowl grazing areas

2.4 Redesign Areas

Changing demographic patterns may lead to obsolete landscapes which could benefit from redesign. Irrigation renovations are often part of redesign planning and offer an opportunity to consider a more sustainable alternative landscape.

Redesign of these areas can offer the opportunity to adopt more sustainable landscapes:

- Brown fields or redevelopment areas
- Open space or park conversions
- Older threadbare park areas
- Large under-utilized conventional turf areas and other sites with little aesthetic diversity
- Areas requiring irrigation renovation

2.5 Active Play Turf

Kentucky bluegrass is the most common turfgrass for athletic fields and other active play areas. Where Kentucky bluegrass turf remains the desired vegetation on a site, up to a 20 percent water savings may be achieved by implementing adjustments in the irrigation and maintenance programs to encourage deeper rooting (Section 4.0).

Conversion of active play turf to other more drought tolerant varieties of grass is increasingly possible to consider. Cold tolerant varieties of bermudagrass and inland saltgrass both look very promising, but are still somewhat experimental. From limited trials of these species, it appears that these two alternative warm season turfgrasses could provide a water savings of close to 80 percent over conventionally maintained bluegrass turf (Section 5.0). The response of these two alternative turfgrasses to heavy play field use still needs to be studied. More heavily used areas could yield a lower percent water savings.

Conventional turfgrass areas to consider for conversion to more drought tolerant grass turf include:

- Park play lawns with few or no trees
- Portions of business or campus settings
- Park entry areas

3.0 Existing Site Condition Evaluation

Before a potential conversion area is selected, evaluation of site specific physical characteristics and desired uses should inform the redesign. Some potential uses and vegetation types are not suited to physically challenging sites. There can be significant costs associated with forcing an ill-suited use or impractical conversion vegetation type on an area. This can result in higher installation costs, as well as increased long term irrigation needs and/or maintenance requirements. This section is intended to assist with identification of best suited conversions for specific physical settings. Problem areas which cannot be readily corrected should receive re-evaluation regarding suitable use and conversion design. More than one of the challenges discussed below may be present on a conversion site.

3.1 Intended Uses

The intended use of the area should influence the selection of conversion vegetation. Certain sustainable landscape conversion types may be better suited for specific uses (Table 3.1).

Table 3.1. Potential conversion types based on desired site uses.

Intended use	Potential Conversion Types
Lawns or play fields	Kentucky bluegrass with a deeper rooting program, drought tolerant alternative turfgrasses
Passive use open spaces for walking or hiking	Native grasslands, shrublands, riparian areas, wetlands
Entry areas and passive use urban settings	Mulched ornamental grass, perennials, shrub or tree beds
Streetscapes, malls, campus areas	Drought tolerant turf, native grasslands, mulched ornamental grass, perennials, shrub or tree beds

3.2 Outdated Irrigation Systems

Many conversion sites have an existing older irrigation system. While this is not a *natural* site characteristic, it is a primary characteristic and should be considered along with other physical elements of the site.

A reprogrammed irrigation controller or improved/updated irrigation system in conjunction with implementation of a modified maintenance program can achieve 10-30% water savings (Appendix D).

When considering conversion to an alternative grass, the existing irrigation system should first be evaluated to determine whether reprogramming the controller, or upgrading to a newer system (redesign, new controllers and/or irrigation heads) will be necessary to meet the needs and intent of the redesigned area and conversion vegetation. Older systems may not be designed properly for the siteôs characteristics and the needs of the new vegetation type. If existing zones are not separated on upper and lower slope locations or are not installed on the contour, there could be unnecessary runoff and water loss.

Installation of newer, more water efficient irrigation components will include more advanced features which aid in matching water needs to the water applied. Newer, more advanced controllers have multiple programs, so irrigation zones can be assigned separate programs based on specific vegetation requirements. The new controllers generally have multiple cycles or a ñcycle and soakò feature which is useful to reduce runoff when watering for deeper rooting conversion vegetation, especially on clay soils.

Renovation of an existing irrigation system can support adjustments in a landscape design. Conversion area installations may require a separation of irrigation programs and zones from non-converted areas. If only part of an irrigated turf area is to be converted, creation of a dedicated irrigation zone could be an essential requirement. Also, with a renovated irrigation system, conversion vegetation can be selected and located to better match soils, slope and aspect, and intended use. During redesign, consider separation of conversion areas from conventional turf or mulched tree beds using sidewalks, trails, roads, or concrete mow strips, which will help delineate the visual differences between leaf textures or colors of the grasses.

When pre-existing shrub and tree beds will be maintained as part of the conversion redesign, a separate irrigation system must be provided to maintain health for the woody vegetation. Very few conversion grasses need as much water as most trees and shrubs. Either the grasses will be over irrigated or the woody plants will be dry. In either case, neither grasses nor trees will be properly irrigated. A new zone of rotor (large area) heads could be installed at the outer edge of the bed, which sprays into the mulched tree area. Where dense shrubs prevent even spray distribution, it may be possible to place a bubbler or drip irrigation system at the surface and mulch to cover. A bubbler system can also be trenched in, but care must be taken to avoid damage to tree and shrub roots.

3.3 Soils

When converting a landscape, the existing soil characteristics should be considered to assure a good match to the requirements of the desired alternative vegetation. Most regional soils are adequate for turf or native grassland conversions. If they historically supported a relatively successful turfgrass, they are probably adequate to support conversion vegetation. However, in a few locations pre-existing soil problems may present challenges. These possible problems are discussed below (Sections 3.3.1 - 3.3.4).

3.3.1 Topsoil

If topsoil salvage and reapplication did not occur during initial development of a site, or if the topsoil is very shallow, it can be challenging to obtain desired plant cover or necessary rooting depth for drought tolerance (Figure 3.1). Areas lacking topsoil may be improved by importing topsoil (costly) or by amending soils to better support healthy turf or native grasslands. Cover soil over buried bedrock or concrete should be at least 18 inches thick to provide adequate soil moisture and rooting depth for drought tolerant vegetation. Soils with less than 2 percent organic matter can benefit from incorporation of composted organic soil amendments. Clay or sandy soils can sometimes be improved with incorporation of organic matter. **All soil amendments must be very well mixed into the soil to be effective.** Residual patches of organic matter on the soil surface will not support seedling grass establishment. In areas of clay soils, sand should not be used as a soil amendment.

Figure 3.1 Vegetation has not successfully established in this area of exposed subsoil. Salvage and reapplication of topsoil would have improved seeding results.

3.3.2 Nutrient Levels

In general, cool season grasses tolerate higher nutrient levels than warm season grasses, which include many regional native grass species. The intended use of an area should influence the grasses selected for turf or cover. Cool season grasses are a better choice in areas with frequent dog use. Excessive nutrient loading from fertilization or dog waste will lead to degradation of both warm and cool season turfgrass areas as well as native grasslands. Over time, warm season grasses may become thin and weedy with elevated levels of nitrogen. The increased development of dog parks can provide relief to park areas heavily used by dogs. Designated crusher fines ñdog reliefò locations placed at park entries can help reduce nutrient loading on turf areas. Dog waste bags and disposal cans should be provided and regularly maintained.

3.3.3 Texture

The soil texture in an area should be considered when selecting a potential conversion type. Active use turf conversion areas can be more successful on sandy loam soils, which do not compact readily. Because infiltration is more rapid in sand, turfgrasses in these areas require shorter, more frequent irrigation cycles. Soil textures at the far ends of the texture spectrum (heavy clay soils and very sandy soils) may be better designed as passive use areas. Clay rich soils compact readily with active play or concentrated foot traffic. Compacted clay soils have slower infiltration rates. If irrigated too frequently, compacted clay soils can become anaerobic, slowing turf growth and recovery due to low soil oxygen levels and the physical difficulty of root growth. Some degree of soil improvement can be affected with the thorough incorporation of organic soil amendments during the conversion process. However, very clay rich soils can be extremely challenging to amend effectively on a long term basis.

Soil texture is less problematic in passive use areas such as trail corridors, open space areas, streetscapes and portions of business or school campuses. Native plant communities can be matched to the full range of native soil types (Section 5.3). Compaction issues on clay soils and disturbance of sandy soils are less problematic when trails and sidewalks are provided to direct foot traffic away from vegetation. Mid-range clay loam, loam, and sandy loam soils can support a variety of turfgrasses or native grassland stands.

3.3.4 Salinity

Elevated salt levels (electrical conductivity or EC of 4 mmhos/cm or greater) can be a problem along sidewalks and roads where saline treatments are regularly applied for winter ice removal (Figure 3.2). Application of reuse water with a slight salt content could eventually lead to elevated soil salinity. Naturally occurring areas of elevated soil salinity occur occasionally throughout the Front Range region, where shallow surface soils overlay the Pierre Shale (a marine deposit). In these locations, salts leached from the underlying shale forms a white powder at the soil surface, which is visible in late

winter and early spring. Drainage can be a problem in shallow soils over shale or other hard pan layers, which function as barriers to water infiltration.

Figure 3.2 Elevated salinity levels inhibit grass cover along road edges, which leaves them more vulnerable to weediness and erosion.

Most turf type grasses are better suited to soils with low or no salinity (EC of 3 mmhos/cm or less) and can become thin and weedy in saline areas. Tall fescue, fine fescue, and perennial ryegrass are adapted non-native turfgrasses which, in established stands can tolerate moderate soil salinities (EC up to 6 mmhos/cm). Halophytic (salt tolerant) native and adapted species may also be installed in slightly saline areas (Section 5.0). Inland saltgrass, a native species, has good potential for use as turfgrass. Colorado State University is engaged in trials for selection of suitable inland saltgrass varieties. As of this report, no improved inland saltgrass varieties have been commercially released.

Alkali sacaton (*Sporobolus airoides*), great basin wild rye (*Elymus cinereus aka Leymus*), western wheatgrass (*Pascopyrum smithii*), and alkali cordgrass (*Spartina gracilis*) are all salt tolerant native grass species. These species can be used in grassland conversions in

saline areas (EC 4-6 mmhos/cm). Seedling establishment, even with salt tolerant species requires lower soil salinities (EC of 4 mmhos/cm or less). Flushing an area with water prior to seeding can improve establishment.

Where healthy streetscape vegetation is critical, physical protection for vegetated medians and street edges can be enhanced with elevated medians which provide splash guards to reduce damage from salt spray (Figure 3.3). To create a successful streetscape, it may be necessary to leach accumulated salts or replace existing saline soils with fresh topsoil. By installing an irrigation system, heavy winter salt contamination can be flushed from the area each spring. Saline street areas or roadsides, where installation of irrigation flushing systems would be impractical, should be considered for hardscape treatment.

Figure 3.3 Splash guards and vegetated elevated medians can help reduce salt impact to plantings along road edges.

3.4 Shade

Stands of warm season conversion turfgrass species may thin in shaded areas due to a lack of direct sunshine and competition with existing tree or shrub roots. Heavily shaded areas can be converted to mulched beds. For the best water savings and improved woody vegetation maintenance, the irrigation for mulched tree and ornamental grass of shrub beds should be separate from grass areas. Separate zones permit optimal irrigation programs for shady locations and adjacent sunny exposures, or for vegetation types with differing irrigation requirements (Figure 3.4).

Figure 3.4 Mulched ornamental grass bed in tree lawn. Note use of drip irrigation line in foreground.

Most evergreens can be more drought tolerant than deciduous trees and shrubs and can adjust to a somewhat reduced watering schedule. An exception is the Colorado blue spruce which is a riparian evergreen and requires regular irrigation for good health. If tree and shrub beds are being converted from a heavier turf-type irrigation program to a less frequent irrigation schedule within a mulched bed, it may take several years for the plants to adapt to reduced irrigation frequency by developing deeper rooting. To

encourage rooting at depth, adequate water should be applied in less frequent cycles to moisten soils to 12 inches or more. Repeated back to back cycles (cycle and soak) or deep watering two nights in a row can reduce run off and recharge moisture at depth.

Shady areas should not be selected for conversion to warm season turf or native short grasses, which benefit from exposure to full sun. Cool season alternative turf grasses (Section 5.0) can be used to create drought tolerant turf in lightly shaded areas.

3.5 Topography

Slopes tend to shed water quickly and thus tend to be drier. South and west facing slopes can become very dry, particularly during the winter, due to the combined effects of slope and direct low winter sun angles. Drought tolerant turf or native prairie mixtures are well suited to slopes, and should have irrigation zones which separate them from level or moister locations. Native grassland mixtures are well adapted to most slopes and exposures. High ridges and south or west facing slopes are good sites for shortgrass prairie mixes. Midgrass prairie mixtures are suited to east and north-facing locations, and gentler or slightly less exposed slopes. Tall grass mixtures are well suited to lower and moister locations. Additional irrigation can improve establishment of these native grasslands and must be provided if tall grasses are to be maintained in drier exposed sites. In very steep areas, retaining walls can help reduce the slope gradient, thus improving infiltration and making maintenance easier and safer (Figure 3.5).

Figure 3.5 Retaining walls reduce the gradient and improve infiltration of this fine fescue grassland.

3.6 Hydrology

Elevated levels of soil moisture can occur where runoff is concentrated as it drains from hard surfaces (roofs or pavement) or irrigated areas. Drainages and detention basins can also be wet or anaerobic at times. Turfgrass are weakened or killed by periods of long saturation. Maintenance mowing presents problems in wet soils because mowers can leave ruts. Fortunately, moist sites present an opportunity for improved landscape diversity and reduced maintenance. Gravel mulched rain gardens can replace turfgrasses in confined urban settings (Figure 3.6). Narrow, well designed rain gardens can provide a colorful living detail which conveys drainage from roof or pavement across an urban landscape. (For additional information, see the Urban Drainage and Flood Control District Urban Storm Drainage Criteria Manual, Volume 3ï Bioretention).

Drainage areas can often be converted to include riparian plant communities. With no additional water, low areas can support diverse local native vegetation including: tallgrass prairies, moist meadows, and wetlands. Where space allows, native woody species can be added to improve community structure and habitat value, including plains cottonwood, peach-leaved willow, wild plum, chokecherry, golden currant, red osier dogwood, woodbine, netleaf hackberry, virgins bower, western snowberry and other attractive species. Planted in the proper locations for the individual speciesô soil moisture requirements, these native plants need little or no irrigation after establishment. These riparian species can provide erosion protection, summer cooling, structural and aesthetic diversity as well as critical wildlife habitat.

Figure 3.6 A colorful rain garden which receives roof runoff and is supplemented by a drip irrigation system during dry spells.

3.7 Weeds

Areas with long established weed populations may require focused weed control for a period of time before and after conversions, depending on the weed species and extent of the local infestation. It is best to reduce the vigor of an extensive weed population prior

to seeding or converting an area. Once an area is selected for conversion, existing troublesome and noxious weeds should be identified and controlled. (Colorado State listed noxious weeds and weed control recommendations are available at http://www.colorado.gov/ag/weeds.)

Control strategies for the critical weed species should be initiated as soon as they can be effective. Broadleaved noxious weeds can be controlled relatively easily before and after grass conversion since the herbicides required generally do not harm established grasses. Always follow the label instructions. Weedy grasses may be more challenging to manage, since the control agents may be effective against both the weedy grasses and the desired grass cover, especially during the period of active growth. In this situation, careful pre-treatment for control of weedy grasses can help reduce later maintenance efforts. Weed roots and seeds, which can remain viable in the soil for years, are activated by irrigation and may compete with the desired conversion species during establishment.

During the first year of establishment, regular mowing will help control annual weeds. Spot application of selected herbicides for biennial and perennial weed control can begin once the seedling grasses have developed some size, later in the first summer. Boom application of herbicides should generally not be used in native grasslands but can be effective in some turfgrass areas, with caution. Consistent control of weed competition is essential for establishment of the desired species. Ineffective weed management can rapidly lead to conditions which can be far more costly to correct.

Supporting materials are provided in Appendix C.

4.0 Kentucky Bluegrass Reconsidered

> Nearly a 20 percent water savings can be realized relatively quickly by implementing modifications of the irrigation and maintenance programs for conventionally maintained Kentucky bluegrass turf. An even greater savings may be possible with monthly adjustments of irrigation based on seasonally changing ET rates.

The rate of irrigation for conventionally maintained Kentucky bluegrass turf in the Front Range area varies widely. A typical irrigation rate determined by the Denver Water Department audit (Section 1.0) of 37 inches of irrigation per year is used in this report for comparison purposes. In support of regional water conservation, the Denver Water Department has been carefully evaluating the potential for developing a lower recommended irrigation rate for bluegrass turf (Section 4.1 below). Colorado State University studies have shown that an ñevery third dayò schedule may be adequate to keep most bluegrass areas healthy, especially when the amount of water applied matches the water used, based on evapotranspiration (ET) rates. Bluegrass turf will generally respond well and maintain good visual quality with an irrigation program supplying just 90 percent of the local rate of evapotranspiration. Changes in irrigation and maintenance of conventional bluegrass turf, alone, can yield some water savings even without conversion to alternative vegetation.

A further means for achieving water savings recommended by Denver Water can be obtained with monthly monitoring and appropriate irrigation schedule adjustments. Their calculations, based on variations in ET demand throughout the year, suggest that as much an additional 25 percent water savings could be possible by adjusting application rates monthly based on the local ET rate (Section 4.2).

Figure 4.1 Conventionally maintained Kentucky bluegrass areas can yield close to a 20 percent water savings if placed on a modified irrigation and maintenance program.

4.1 Modified Kentucky Bluegrass Irrigation Program

There is a range of philosophies on how many inches of irrigation are really necessary for maintaining Kentucky bluegrass (Figure 4.1). While conventional irrigation of bluegrass turf may use 37 inches of irrigation water, considerable water savings may be possible by developing a modified irrigation program based on actual water requirements. Denver Water estimates that the evapotranspiration rate (ET) for Denver is 34 inches per growing season. If bluegrass is irrigated to replace 90 percent of ET losses, this is approximately 30.6 inches of water. Adjusting for the calculated ñeffective rainfallò of 8 inches per growing season (Irrigation Association Standard 2003-2008), 22 inches of irrigation water is required. However, due to inefficiencies in water delivery, Denver Water recommends applying a 75 percent system efficiency factor. Therefore, a modified irrigation program for Kentucky bluegrass, replacing 90 percent of ET will require about 30 inches of water per growing season. This is a 19 percent water savings compared to

37 inches of irrigation per year for a conventional bluegrass irrigation program (Figure 5.1.8).

4.2 Irrigation Considerations for Greater Water Savings

Water savings from irrigation scheduling depends on the person operating the irrigation controller. ñWhoever controls the controller controls the water and water savings.ò **Field staff in charge of the irrigation must understand and support modified irrigation schedule, whether for bluegrass or another conversion vegetation type.** The run times per zone will be based on the type of irrigation head (Section 7.3) and the historic ET for the site. Long term or maintenance irrigation programs are discussed in greater detail in report Section 8 and typical schedules are provided in Appendix D as a starting point for obtaining water savings results.

The ET for an area is provided on most water districts web pages. Some controllers can access current weather data or may be programmed with local historic ET curve data. Water demands in spring are often lower and increase to the period of peak demand during late summer. Peak season evapotranspiration rates occur in July, when it can require about 7 inches of irrigation (1.75 inches per week) to compensate for losses. By September, as the ET rates decline with cooler daily temperatures, irrigation rate can again be reduced. Many controllers offer a ñglobal adjustò feature. The peak season, July/August, schedule can be the ñbaselineò schedule in the controller. From there, the global adjust feature will reduce the zone run times by the percent programmed into the controller for each month until July/August when the program will be at 100%. In the late summer, the percentage can adjust again until irrigation is discontinued. During especially hot or cool periods, the ñglobal adjustò feature allows a quick adjustment to the irrigation schedule without manually changing the run times on each zone. It is important to remember to change the global adjust back to ñnormalò when unusual conditions are over. If possible, it is better to retain an infrequent watering schedule and increase the application rate with additional cycles. This will encourage deeper rooting and greater drought tolerance.

When irrigating conversion turf infrequently, such as once every two weeks, care must be taken to avoid conflicts with regular turf irrigation. The alternative grasses irrigation zones should be located on a different program on the controller than the conventional bluegrass zones. The irrigation nights should be the nights when the bluegrass is not irrigated.

The ñcycle and soakò feature on many controllers allows irrigation in several shorter cycles. This can reduce runoff, especially with pop-up spray heads, and will result in deeper water penetration. For ñcycle and soakò the desired amount of water for a cycle is divided into several ñsplit cyclesò or fractions. These fractional cycles are applied over one or two consecutive nights for areas receiving infrequent irrigation.

Another effective method for reducing water use is to ensure the required rain sensor is connected to the controller, is operational and is calibrated to override scheduled irrigation when a pre-determined amount of rain has been received. The rain shut off device will prevent irrigation until the moisture from the rain has been used by the plants.

4.3 Modified Bluegrass Maintenance

Bluegrass irrigation can be gradually adjusted from higher range of irrigation to the modified irrigation program of about 30 inches per year, with associated changes in maintenance and a year of a transitional irrigation. This will require some advance planning. Turf which has been generously irrigated for some time can have very shallow roots. By incrementally reducing irrigation frequency and modifying the maintenance program, Kentucky bluegrass turf can be encouraged to root more deeply and thus require less frequent watering.

For best results, the modified program should be implemented in late September beginning with thorough aeration to reduce soil compaction and stimulate root growth. Follow aeration with a light application of fertilizer and drag the area with a metal mat to break up the plugs. The fragmented plugs will serve as organic topdressing. The

following spring, as the grass begins to grow, irrigation should be adjusted to less frequent but longer cycles, which should maintain deep soil moisture.

With frequent monitoring, the times between irrigation can be gradually extended. The lesser frequency should allow uppermost soils to dry somewhat between waterings. With these modifications, a single deep watering per week may be adequate to maintain bluegrass turf. With regular observation of turf conditions, irrigation can be adjusted to occur when the grass just begins to show stress as a slight darkening of the grass blades. The gradual development of deeper rooting and improved drought tolerance can require a full season to accomplish. With patience and some additional monitoring and irrigation adjustment efforts, this process may occur with minimal browning or discoloration of the bluegrass turf. Clay soils are harder for roots to penetrate and can require additional time for conversion to lower irrigation levels.

Once adjusted to this modified irrigation program, Kentucky bluegrass turf can also benefit from less generous and less frequent fertilization. Less fertility means less growth stimulation. Slower growth demands less water. Frequency of mowing can also be slightly reduced and grass may be cut higher to support deeper rooting.

Supporting materials are provided in Appendices A and D.

4.4 Modified Maintenance of Lighter Use Athletic Fields

Kentucky bluegrass has been the standard for turf athletic fields for many years because it can recover from heavy use. Where Kentucky bluegrass turf remains the desired vegetation on an athletic field, some water savings may be achieved by implementing adjustments in the irrigation and maintenance programs to encourage deeper rooting. Regular aeration programs with light fertilizer applications can help reduce compaction. Lighter use athletic fields may respond more readily to this modified program. Because of frequent compaction, heavy use athletic fields are more challenging to convert to this program. When creating a new athletic field, non-clay soils can sometimes be amended with organic matter to improve rooting depth and drought tolerance.

Supporting materials are provided in Appendix D.

5.0 Sustainable Landscape Conversion Options: Vegetation Types

In order to select the best conversion type for a site, potential uses should be identified and the specific site characteristics evaluated (Section 3.0). Once these have been identified, it will be possible to select an appropriate conversion type from those described in this section. Each conversion option is described below, with comments about suitable uses, relative drought tolerance, preferred soil type, vegetation characteristics, and maintenance requirements.

5.1 Adapted (Non-Native) Grasses and Grass Mixtures

The following drought tolerant non-native grasses and grass mixtures can be useful to create mowed turfgrass areas or naturalized, un-mowed grasslands.

5.1.1 Fine Fescue Mixture

A mixture of Fescue (Festuca) species and varieties, non-native cool season grass species.

Possible water savings of 41 to 43% for mowed fescue turfgrass
Possible water savings of 70% for unmowed fescue grasslands
Seed mixture A.4
Establishment irrigation program C.2.1
Long term irrigation programs D.2 1, D.3.1

Recommended for:

- Casual play areas, picnicking and other low-use lawns
- Tree lawns or parking strips (between sidewalk and curb)
- Unmowed grasslands in naturalized areas

Fine leaved fescue species combine well to provide a drought and shade tolerant turf well suited to planting as tree lawns. The recommended mixture of species (Appendix A) includes: hard fescue, creeping red fescue, sheep and blue fescues, which have a slight sod forming component and can be mowed for turf or left unmowed for a more natural appearance (Figure 5.1). These cool season grasses grow well in clay loam to sandy loam soils with consistent low level irrigation. Fine fescues can be encouraged to root deeply and thus require less frequent watering. With a program of careful irrigation management, significant water savings are possible. Once established, a well managed fine fescue turf can yield up to 43 percent water savings as compared with conventionally

maintained Kentucky bluegrass. Installations of unmowed fescue grasslands can realize a 68 to 78 percent water savings. Over-watering or under-watering can result in damage, which can require overseeding for restoration. For best results, a regular irrigation schedule at reduced application rates is best to maintain an even and dense stand of grass.

Figure 5.1 An un-mowed fine fescue grassland provides a soft cover for this shady slope. An area of mowed tall fescue turf is under the trees on the right. The lighter mowed grass just above the fine fescue slope is a mowed portion of fine fescue turf.

Dense seeding of this fine-leaved fescue mix will produce a thick turf (Figure 5.2), while a lighter seeding rate may be used to established un-mowed grasslands. Unmowed, these grasses will become twelve to fourteen inches tall by early summer. The slender grass blades may be only half that height. The species of fescue in this mixture range in color from deep green to blue green and have a leaf width much narrower than that of Kentucky bluegrass. Further savings can be achieved through less frequent mowing and fertilization. Fine fescue turf can be mowed on a seven to ten day mowing cycle to produce a smooth turf appearance. The fertilizer rate and frequency are lower than those for conventionally maintained Kentucky bluegrass turf. If excessively fertilized or over-

irrigated, fine fescue areas can thin and become patchy. If weed control is required, always check labels prior to chemical application, fine fescues can be sensitive to some herbicides.

Figure 5.2 Several varieties of fine fescue turfgrass at the CSU turfgrass test plots show the variations in color which are possible within a fescue mixture.

5.1.2 Hardy Bermudagrass

Bermudagrass (Cynodon dactylon) improved varieties, non-native warm season grass.

Possible water savings of 78%
Source of plants or seed A.3
Establishment irrigation program C.2.2
Long term irrigation program D.2.2

Recommended for:

- Tree lawns or parking strips (between sidewalk and curb)
- Low maintenance turf areas with minimal irrigation
- Passive use irrigated turf areas
- Light use athletic fields

Bermudagrass is an introduced, warm season grass with aggressive stolons (above ground runners and stems) and rhizomes that is somewhat experimental, but beginning to see

some application for turfgrass in the Front Range of Colorado. The unimproved variety, also called ócommonô bermudagrass is known as a weedy aggressive turf and garden invader in southern and western Colorado. The improved varieties are reported to be less invasive and are becoming more commonly used as a drought tolerant, low growing turfgrass (Figure 5.3). As with other warm season grasses, this species turns tan colored with the onset of dormancy about mid-September and greens up late in mid-May. Newer varieties have narrow (0.125 inch) deep green leaves. They are available as seed or may be propagated from plugs dug from existing stands.

Figure 5.3 A trial area of winter hardy bermudagrass turf at the CSU test plots.

Because it grows so fast, bermudagrass is able to recover from heavy use and may be useful in lighter use athletic fields. As a warm season grass, it will perform well on about 78 percent less water and is more tolerant of heat in the summer than bluegrass. It is a shorter grass and it will perform best if mowed at one inch in height. Because of its aggressive growth, verticutting or power raking may be needed to keep the grass in good health. Because of fall dormancy, it is recommended to complete annual aeration, verticutting and fertilization before the end of July.

Hardy bermudagrass varieties include: ôRivieraô, ôMidlawnô and ôYukonô. For a vegetative (sodded) variety, ôPatriotô is available. These have been tested and used in the Front Range.

5.1.3 Unimproved Tall Fescue and Meadow Fescue

Festuca arundinacea and Festuca pratensis, non-native cool season grass species.

Possible water savings of 43% or greater when naturally sub-irrigated
Seed mixture A.2
Establishment irrigation program C.2.1
Long term irrigation program D.1.2 (reduction possible after 2 years with deeper rooting to water table)

Recommended for:

- Casual play lawns in low lying areas
- Sub-irrigated turf grass (water within 2-3 feet of the surface).

Unimproved tall and meadow fescues are very similar and have been used for casual lawns for a number of years. They are cool season bunch grasses with deep green coarse leaves and moderately good turf potential. In upland areas these species can require nearly as much water as conventional Kentucky bluegrass. However, in very specific areas they can be a good choice for drought tolerant lawns. Where a lawn occurs in a low lying area, with soil surface within two to three feet of the summer water table, tall and meadow fescues can be seeded and encouraged through a program similar to that recommended for encouraging greater rooting depths for Kentucky bluegrass. In the proper location and with careful management these species will root into the moist soil above the water table. Depending upon the soil this can take two or three years. Once deeply rooted, these fescue species can remain green and healthy with only limited irrigation. While these bunchgrasses form a somewhat rough turf, the coarse leaves will tolerate heavy traffic. This grass grows best in loam to clay loam soils and is somewhat salt tolerant. Tall fescue will not do well in areas with ground water pooling at the surface. More information on vegetation which can tolerate saturated soils is provided below in Moist Meadow and Wetland (Section 5.3.5).

Tall and meadow fescue leaf blades (0.25-0.5 inches) are wider than those of Kentucky bluegrass. The turf created by these species is not as soft as bluegrass, but may be used for lawns and casual play areas. It is not recommended for athletic fields. The leaves of the fescues are tough and mower blades need to be sharp for the cleanest cut. Growth starts in April. Provide weekly mowing until after the first week of June, when the frequency of mowing could be reduced to every 10 days or two weeks. These tough grasses can be very useful in low lying lawn areas where they can provide a very durable drought tolerant turf which requires less maintenance.

5.1.4 Improved Turf-Type Tall Fescue

Festuca arundinacea, a cool season grass.

- Not recommended due to high irrigation requirement.

In recent years a number of improved varieties of tall fescue have been developed to reduce the width the leaf blade to more closely resemble the Kentucky bluegrass and improve the uniformity of the turf. Unfortunately, the deeper rooting trait of the older unimproved varieties was lost as the narrower leaf width was favored by plant selection and breeding. The improved tall fescue varieties can have a higher irrigation requirement than some Kentucky bluegrass varieties. These improved varieties are not recommended for alternative turfgrass conversions.

5.1.5 Wheatgrass Turf or Unmowed Wheatgrass Grassland Mixture

Mixture of native and non-native wheatgrasses, a cool season grass species.

Possible water savings of 41 to 43% for mowed wheatgrass turf
Possible water savings of 70% for un-mowed wheatgrass grassland
Seed mixture A.5
Establishment irrigation program C.2.1
Long term irrigation program D.2.1, D.3.1

Recommended for:

- Tree lawns or parking strips (grass between sidewalk and curb)
- Low maintenance turf areas with minimal irrigation
- Passive use irrigated turf areas

This grass mixture can be used to provide a range of cover from dense turfgrass to unmowed naturalized grassland stand (Figure 5.4). It has been used successfully

throughout the Front Range of Colorado. It is useful in mowed tree lawns or parking strips where a coarser (wider) leaf texture is acceptable. This mixture of species can provide a very durable drought tolerant turf which requires less maintenance than conventional Kentucky bluegrass. It includes both native and introduced cool season wheatgrasses with moderately good turf potential. Unmowed grasslands can germinate and establish fairly easily on 15 inches of precipitation or irrigation per year. Establishment irrigation will improve seeding results. If not mowed the seed heads can reach 24 inches in height and are interesting but not striking. Except for slender wheatgrass, these grass species are sod formers. This cool season mixture of grasses will grow well in clay loam to loam soils. Two different seeding rates are included in Appendix A: one for turf, at a heavier seeding rate, and one for naturalized grasslands, at a lower seeding rate.

Figure 5.4 A new wheatgrass installation late in the first year after seeding. This installation shows the late summer appearance of the unmowed wheatgrass grassland. A six foot band of mowed wheatgrass turf appears in the lower left photo adjacent to the sidewalk. A small section bluegrass lawn appears on the left and at the top of the photo. The thin spots filled in the following year.

Leaf colors for the grasses in this mixture range from medium green to bluish green with a width of about 0.25 inches, and are not as soft or uniform in color or leaf widths as a single species planting of Kentucky bluegrass. This mixture will provide a good turf with about half the irrigation water of conventional bluegrass.

These wheatgrass species will start to grow actively in April. Turf areas can be mowed on a weekly schedule for a month and then frequency of mowing can extend from 10 to 14 days. Since the leaf blades and culms are coarse, mower blades must be sharp to avoid shredding the edges of the leaf blades, which will increase moisture stress. For best summer appearance, naturalized wheatgrass grasslands should be mowed only once, in early June, to prevent seed head development. If mowed after mid June, wheatgrass stands which are not irrigated may not recover and can look like stubble until fall. If the appearance of the flowering stalks is acceptable, these grasslands can remain unmowed all summer. During the summer, non-irrigated areas will tend to go dormant, becoming a tan color. The grasses will green up again in fall when the temperatures typically cool and soil moisture increases. Irrigated turf wheatgrass areas can receive up to two fertilizer applications a year, but should receive about half the fertilizer used on Kentucky bluegrass. For non-irrigated areas, no supplemental fertilization is needed.

5.2 Native Turfgrass Species

The following drought tolerant native grasses and grass mixtures can be useful to create mowed turfgrass areas or native prairie grasslands. Several native warm season grass species have been utilized in single or dual species turfgrass plantings for many years. Buffalograss and blue grama are the most frequently used regional native species for this application. Once established, these species can yield as much as 78 percent water savings over conventionally maintained Kentucky bluegrass lawns. Due to winter dormancy of these warm season species, heavy winter time use can lead to a worn appearance and may contribute to weed invasion.

5.2.1 Buffalograss Turf

Buchloe dactyloides, a warm season native grass.

Possible water savings of 78%
Source of plants or seed mixture A.6, A.8
Establishment irrigation program C.2.2
Long term irrigation program D.2.2

Recommended for:

- Sunny tree lawns or parking strips (areas between sidewalk and curb)
- Low use turf areas with minimal irrigation
- Passive use irrigated turf areas
- Low lying passive use drainage areas, roadside ditches, or curb-less roadside areas

Buffalograss is a warm season native grass which spreads by above ground runners (stolons) and has been utilized for a number of years as an alternative turfgrass. Buffalograss provides a light green drought tolerant low growing turf. Once established, it will grow well with 78 percent less irrigation than conventionally maintained Kentucky bluegrass. In Front Range urban settings, application of 2 inches of irrigation or less per month is adequate to keep this tough, deep rooting grass species green all summer. This native species is well adapted to medium to heavy clay soils. Buffalograss grows best in full sun locations and should not be used in partial or full shade locations. If tree areas are to be present they should be in mulched beds with separate irrigation zones.

Buffalograss leaf blades are narrower than those on bluegrass and slightly hairy. Leaf tips on some varieties curl. Buffalograss is dioecious, producing male and female plants and flowers. Male flowers rise just above the foliage and the female flowers are on shorter stalks that are seldom noticed. This warm season grass species greens up in mid May and will become tan in mid September as it enters dormancy in the fall. It will maintain that color all winter. Most buffalograss varieties tolerate low to moderate foot traffic and can be left unmowed, reaching a height of only 6 inches or less. Monthly mowing will make a buffalograss turf look more uniform. Fertilization should be infrequent (every few years) and should use a slow release product, such as Biosol® or equivalent. Chemical fertilizers should be avoided as they can thin or weaken the turf and lead to weed invasion. Early spring weed control for broadleaf species or residual

cool season grasses is essential. Careful application of broadleaf or broad spectrum herbicides may be safe during the late dormancy period in March, prior to warm season green up in May. Always follow herbicide label directions.

Figure 5.5 Legacy variety buffalograss turf display in July, shows a rich medium green color.

Newer varieties of buffalograss have improved turf density and color. Front Range installations can use ôTop Gunô as a seed variety of buffalograss to produce a dense turf. Some varieties are produced only from cuttings and therefore available as plugs, which can be useful in small lawn settings or as sod. ôLegacyô buffalograss has a deeper green leaf color with an earlier spring green-up time than other warm season turf-grasses and is a commercially available vegetative variety available as plugs or sod (Figure 5.5, and Appendix A).

5.2.2 Blue Grama Turf

Chondrosum gracile, aka Bouteloua gracilis, a warm season native grass

Possible water savings of 78%
Source of plants or seed mixture A.7, A.8
Establishment irrigation program C.2.2
Long term irrigation program D.2.2

Recommended for:

- Sunny tree lawns or parking strips (between sidewalk and curb)
- Low use turf areas with minimal irrigation
- Passive use irrigated turf areas
- Low lying passive use drainage areas, roadside ditches, or curb-less roadside areas

Blue grama, the designated ñColorado State grassò, is a warm season native bunchgrass which has some sod forming tendencies, spreading slowly by tillers. Blue grama can be planted alone or in a mixture with buffalograss. It is very drought tolerant, requiring up to 78 percent less water than conventionally irrigated bluegrass. Once established, it stays green with 2 inches of irrigation or less per month through the summer. It is well adapted to denser soil types and will tolerate clay. Blue grama will do best in full sun locations and will thin in shady conditions or if overwatered.

Leaf blades of blue grama are similar to buffalograss, slightly narrower and softer than Kentucky bluegrass. Blue grama turf can be left unmowed for a tousled appearance (Figure 5.6), or mowed monthly during the summer to a 3 to 4 inch height, for a smoother appearance. Unmowed stands will develop the familiar ñeyelashò grass flowers which can reach 15 inches in height, while the foliage is typically only 6 to 8 inches high. Blue grama is a warm season grass which has a delayed spring green up in May. Like buffalograss, this grass will become dormant in the fall with the start of cooler night temperatures and shorter days, becoming buff colored until spring green up. Fertilization should be infrequent (every few years) and should use a slow release product, such as Biosol® or equivalent. Chemical or synthetic fertilizers should be avoided as they can thin or weaken the turf and lead to weed invasion. Early spring weed control for broadleaf species or residual cool season grasses is essential. Careful application of

broadleaf or broad spectrum herbicides can be safe during the late dormancy period in March or early April, prior to warm season green up in May.

Figure 5.6 Blue grama turf with flowering heads near REI, in Denver. This area is a bit too shady; fine fescues might be better.

5.2.3 Inland Saltgrass Turf

Distichlis stricta, a native warm season grass species

Possible water savings of 78%
Source of plants or seed A.9
Establishment irrigation program C.2.2
Long term irrigation program D.2.2

Inland salt grass has great potential for use in settings similar to buffalograss and blue grama. This low growing, salt and drought tolerant native grass is rhizomatous and will develop into a dense sod as it establishes. For several years Colorado State University has been involved with the United States Golf Association and the University of Arizona with field trials of inland saltgrass for turfgrass use (Figure 5.7). Some of the trial selections of inland saltgrass at the CSU test plots in Fort Collins are a mid-green color

with excellent turfgrass density. **Unfortunately, improved varieties have not yet been commercially released from test trials.**

Figure 5.7 An inland saltgrass turf trial area at the CSU test plots.

Seed from the native (unimproved) inland saltgrass is available commercially. Germination rates, which are low due to lengthy seed dormancy, can be increased by pre-treating the seed (Appendix A.9.1). Nurseries sometimes carry pots or plugs of inland saltgrass. Close plant spacing, 6 inches on center, is recommended as the in-fill rate is slow. Establishment period weed control is recommended. Once established, inland saltgrass is a durable and very drought tolerant turfgrass which is usually less than 6 to 8 inches tall and looks groomed even without mowing. It is tolerant of some soil salinity and is mostly not palatable to prairie dogs. At this time, sod or plug sources are limited. Small sites could be sprigged from a native donor site.

5.3 Native Grasslands and Prairies

Native grasslands are characteristic of the semi-arid Front Range region. These attractive grasslands typify the diverse regional aesthetic while requiring far less irrigation and

maintenance. They are adapted to the local annual precipitation, requiring far less moisture than conventional turf types. Various native grassland types are suitable for planting in soils ranging from heavy clay to sandy soils, dry southern and western exposures to moist or saturated soils. Some species also tolerate saline soils. They can be useful in a variety of sustainable conversion designs. Prairie areas with public access should be provided with trails to concentrate foot traffic.

Native grassland types are well suited for passive use areas of:

- Parks, open space, and trail areas
- School and business campuses
- Mall or development entryways and streetscapes
- Storm water drainage areas, detention basins, or floodways along natural streams

Native grassland options include a wide range of plant communities. Grassland types described in this report include: upland short and midgrass prairies, sand prairie, tallgrass prairie, saline grasslands, as well as moist meadows, wetlands, and mixes adapted to roadside and trail edge conditions. Native woody vegetation can be included in many of these conversion types. A variety of native drought tolerant shrubs are suited to inclusion in many areas of upland grasslands. Moister sites, drainages, detention and retention pond areas can support native riparian trees and shrubs. Careful selection of planting locations will greatly reduce irrigation requirements for these large woody native plants.

Native grassland plantings in highly visible locations, such as parks, along streets, or other in other urban settings will perform better with a permanent irrigation system, which can provide establishment watering and long term access to irrigation to help maintain a healthy dense native stand. Native grassland conversions will benefit even from temporary irrigation during the first growing season.

When a native prairie or grassland is too large or remote it may be impractical for permanent irrigation. Native grasslands which lack irrigation systems (open space and natural areas) can be slower to establish and will be improved if fall seeded and well mulched, to help retain soil moisture during germination. If the spring soil conditions are very dry these non-irrigated grasslands may not germinate very well, initially. However,

if the seedbed is not disturbed or eroded by the wind, the seeds can remain dormant until an adequate precipitation event. The first heavy precipitation event should initiate growth in native grasslands, even in mid to late summer.

In prairie conversion areas, pre-existing or newly installed shrubs and trees may require a separate irrigation zone of emitters or bubblers within a mulched bed. Single zones of overhead spray irrigation for both grasslands and woody vegetation should be avoided, as grasslands generally require less irrigation than most shrubs and trees. The exception is tallgrass prairie, which can sometimes be irrigated in the same overhead zone and schedule as some native woody plants, including ponderosa pines, Rocky Mountain juniper, and three-leaf sumac.

Annual maintenance activities for native grasslands differ greatly from those required for conventional turf. Native grasslands are adapted to low soil nutrient levels and can become weedy if fertilized. Once established, little or no additional fertilizer is required for areas on native topsoil. To prevent high nutrient loading provide signage, bags, and disposal receptacles for dog waste. Inclusion of a designated crusher fines dog ówalking/reliefô area near trail entrances will further reduce nutrient loading in the grasslands.

Unmowed native grasses add color and visual interest in the fall and winter, particularly after a snow. If desired, mowing can be done once a year, in late winter, to remove standing dead vegetation before the spring green up. Regular control of noxious or troublesome weeds is an essential annual activity in native grassland plantings. Many regional weeds readily invade these areas, especially where soils are moist or receiving supplemental irrigation.

In taller native prairies, seeding a band of low growing shortgrass species along trails or roadsides can further reduce the need for maintenance mowing and create a more open trailside corridor.

5.3.1 Shortgrass Prairie

A mixture of native shortgrass prairie species

Possible water savings of 81 to 86%
Seed mixture A.10
Establishment irrigation program C.2.2
Long term irrigation program D.3.2

Recommended for:

- Sunny locations
- High exposed ridges
- Upper west and south-facing slopes
- Trail edges and roadsides
- Native streetscapes
- Passive use park and campus areas
- Open space areas
- Areas with low irrigation requirements

Figure 5.8 Native shortgrass prairie east of Denver in late June with yucca and orange flowering Indian paintbrush.

Shortgrass prairie species occur widely in native areas east of the Front Range. This grassland type is very drought tolerant. Sunny exposed locations can support this low

growing grassland type. This drought tolerant grassland type is generally dominated by buffalograss (*Buchloe dactyloides*) and blue grama (*Chondrosum gracile*), but can include many other species as well (Figure 5.8). Regional shortgrass prairies can include shrubs such as yucca (*Yucca glauca*) and rabbitbrush (*Chrysothamnus nauseosus* ssp. *nauseosus*) and many colorful wildflower species. Shortgrass prairies are well adapted to clay, clay loam soils, and to a lesser degree, sandy loam soils. Very sandy soils need a different seed mix.

As discussed in the introductory section above, maintenance will be far less than required for a conventional lawn, but should include a regular weed control program, one annual winter mowing, and no regular fertilization. Shortgrass areas in urban settings benefit from irrigation once or twice a month to support continued green summer growth, maintain a denser cover, and compensate for the warmer urban environment (Appendix D.3.2).

5.3.2 Midgrass Prairie

A mixture of native midgrass prairie species

Possible water savings of 73 to 78%
Height: less than 24 inches
Seed mixture A.11
Establishment irrigation program C.2.2
Long term irrigation program D.3.3

Recommended for:

- Mid slopes
- North and east-facing exposures
- Passive use park and campus areas
- Native streetscapes
- Open space areas
- Areas with low irrigation requirements

Midgrass prairies are widely distributed in this region and tend to occur in more mesic sites than the shortgrass areas. Midgrass prairies have blue grama and buffalograss, but have more western wheatgrass (*Pascopyrum smithii*), sideoats grama (*Bouteloua curtipendula*), and little bluestem (*Schizachyrium scoparium*). Shrub species, such as Yucca and rabbitbrush, and wildflowers can also be present (Figure 5.9). This grassland

community can be planted on the same range of native soils as shortgrass prairies, including clay loam, loam or sandy loam soils. Less severe areas such as east or north facing exposures, intermediate south-facing and west-facing slopes, flatter uplands sites are well suited to this grassland type.

Figure 5.9 Native midgrass prairie with yucca near Aurora reservoir in late June.

Maintenance efforts will be less than required for a conventional lawn, but should include a regular weed control program, annual late winter mowing, but no regular fertilization. In urban settings, where irrigation can be installed, midgrass areas can be irrigated twice a month to improve the grass density and color during the summer. This watering helps to augment higher rates of evapotranspiration typical in regional urban areas (Appendix D.3.3).

5.3.3 Tallgrass Prairie

A mixture of native tallgrass prairie species.

Possible water savings of 57 to 68%
Height: 24 inches to 40 inches
Seed mixture A.12
Establishment irrigation program C.2.2
Long term irrigation program D.3.4

Recommended for:

- Lower slopes and swales
- North and east-facing exposures
- Passive use park and campus areas (with irrigation)
- Native restoration in moist or lower open space areas
- Grass buffer areas
- Drainages
- Detention basins
- Native streetscapes with irrigation

Figure 5.10 A seeded tall grass prairie in Fishback Landing Park west of downtown Denver showing fall color in late September.

Tallgrass prairies naturally occur along the base of the western foothills, where natural precipitation rates are somewhat higher. Dominant tallgrass species include switchgrass (*Panicum virgatum*), Indian grass (*Sorghastrum avenaceum*), big bluestem (*Andropogon gerardii*), green needlegrass (*Stipa viridula, aka Nasella*) as well as midgrass and shortgrass prairie species. These taller grasses are well suited to provide erosion control and water quality improvements as grass buffers and detention basin vegetation. Tallgrass species are best adapted to richer loamy soils. Denser stands of tall grasses can develop on lower slopes and valley floors near stream channels and detention basins with access to greater soil moisture. During late summer, tall grass species develop interesting grass flowers which stand above the leaves. With the onset of fall, many of the tallgrass species will change to shades of gold, orange or red. If unmowed, the burnished fall color will persist well into winter, providing an attractive landscape feature (Figure 5.10).

As with other native grasslands, tallgrass areas require less maintenance input than a conventional lawn, but must have a regular weed control program, annual late winter mowing, and no regular fertilization. Installations in drier upland or urban settings should have irrigation and will do best if watered regularly from June to August. By deeply irrigating every two weeks these areas can be maintained with good grass density and color throughout the summer Appendix D.3.4).

5.3.4 Sand Prairie

Mixture of native sand prairie species

Percent savings: For use in non-irrigated open space
Height: 22 inches to 36+ inches
Seed mixture A.14
No establishment irrigation necessary

Recommended for:

- Sandy loam and sandy soil areas
- Open space areas
- Portions of parks or campus settings
- Permeable Landscape Detention (PLD) areas with modified sandy growth media

Sand prairie vegetation is adapted to the harsh dry conditions typical in natural sandy soil deposits along Cherry Creek and some locations east of Denver (Figure 5.11). These

locations are typically dominated by midgrass to tallgrass species including sandreed (*Calamovilfa longifolia*), sand bluestem (*Andropogon hallii*), Needle-and-Thread grass (*Stipa viridula* aka *Nasella*) and sand dropseed (*Sporobolus cryptandrus*). These species are also recommended to be included when reseeding porous landscape detention (PLD) areas, since these areas use sand enhanced growth media. Sand prairies can be planted wherever sandy soil conditions permit, however, the taller sand prairie species will be better developed on lower slopes and valley floor locations with higher levels of soil moisture.

Figure 5.11 Native sand prairie with needle-and-thread grass, east of Denver.

Since vegetation growing in sandy soils can be easily disturbed by foot traffic, passive recreational activities are recommended for these areas. Where foot traffic is anticipated, trails should be provided to concentrate pedestrian traffic and protect vegetated areas. Sand prairie areas should be very drought tolerant and irrigation is generally not required. Once established, sand prairies should not require mowing, since mowers can disturb light sandy soil and vegetation. As with other native grasslands, regular weed control may be necessary and fertilization is not generally required.

5.3.5 Moist Meadows and Wetlands

A mixture of native tallgrass and wetland species.

Percent savings: For use in non-irrigated lowlands with naturally moist soils
Height: 24 inches to 48 inches or taller
Seed mixture A.13
No establishment irrigation necessary

Recommended for:

- Wet drainage areas
- Streamsides and low lying floodway areas
- Constructed wetland detention basins
- Wetland mitigation areas
- Moist soil areas of parks and campus settings
- Low lying, moist native restoration sites
- Low lying open space areas

Figure 5.12 Moist meadow vegetation dominated by prairie cordgrass near South Boulder Creek.

Moist meadow and wetland vegetation is adapted to grow in occasionally or consistently saturated soils. Natural drainage areas, detention basins, seeps or low wet areas, such as

at the base of irrigated slopes, can be challenging to maintain as regularly mowed turf. These wet areas can support interesting native vegetation with erosion control, water quality, and habitat value. Dominant moist meadow species may include prairie cordgrass (*Spartina pectinata*), woolly sedge (*Carex lanuginosa*), Nebraska sedge (*Carex nebrascensis*), Baltic rush (*Juncus balticus*), bulrush (*Scirpus* spp., *Schoenoplectus* spp), and several attractive tall wildflowers, such as smooth blue aster (*Aster laevis*), Nuttallôs and Maximillianôs sunflowers (*Helianthus nuttallii*, *H. maximiliani*) and blue vervain (*Verbena hastata*). Moist areas will also support a number of attractive native riparian trees and shrubs, generally without any additional irrigation. These additions to the area are of great importance as wildlife habitat. Among these are plains cottonwood (*Populus deltoides*, ssp. *monilifera*), peach-leaved willow (*Salix amygdaloides*), box elder (*Acer negundo*), net-leaf hackberry (*Celtis reticulata*), wild plum (*Prunus americana*), chokecherry (*Padus virginiana* aka *Prunus*), golden current (*Ribes aureum*), red osier dogwood (*Swida sericea* aka *Cornus*), western snowberry (*Symphoricarpos occidentalis*), and sandbar willow (*Salix exigua*). Species-rich woody riparian areas offer respite from the summer heat for hikers, critical food and nesting sites for wildlife species, valuable cooling for neighborhood areas and long term carbon sequestration. As with other native areas, the maintenance program should include regular weed control, occasional winter mowing, and no fertilization.

5.4 Additional Conversion Vegetation Types

5.4.1 Salt Tolerant Grasses

A mixture of native halophytic grass species.

For use in non-irrigated saline areas
Height: less than 18 inches
Seed mixture A.15
Establishment irrigation generally unnecessary

Recommended for:

- Native areas with naturally elevated soil salinities
- Roadsides or sidewalk edges in grassland areas which receive some saline runoff or spray from ice management
- **Not for use in heavy salt application areas which exceed an EC of 6 to 8 mmhos/cm.**

Figure 5.13 Native inland saltgrass on roadside in north Boulder.

Elevated salt levels naturally occur in the Denver area, due to exposed regional marine sediments. The splash zone in roadside areas can also have elevated salt content where salt products are used for de-icing. If a grassland or native prairie mixture has been planted within a streetscape, a salt tolerant mixture can be over-seeded on top of the basic seed mixture to provide salt tolerant grasses (Figures 5.13 and 5.14). However, all native species have an upper limit of salt tolerance. Mature salt tolerant species can tolerate twice the levels (EC of 6-8 mmhos/cm) necessary for their seedlings to successfully establish (EC of 3-4 mmhos/cm). The edges of highways, where magnesium chloride is regularly applied, may already exceed the acceptable salinity levels tolerated by these native species. It can be very difficult to keep vegetation alive in these areas. If roadside areas have an irrigation system, it can be helpful to thoroughly irrigate in early spring in order to flush the salts from the soil.

Figure 5.14 Alkali sacaton, a salt tolerant grass in roadside planting east of Longmont.

5.4.2 Mulched Beds

Ornamental grasses, flowers, shrubs, or trees

Possible water savings 25 to 50% or greater, depending upon selected plant materials and irrigation requirements
Height: various

Recommended for:

- Mall and development landscapes
- Streetscapes and parking lot islands
- Detail areas in parks and campuses
- Trail entry areas
- Sod conversion areas with pre-existing or newly planted woody plant or ornamental grass beds

Landscapes designed in the last decade increasingly have utilized edged beds for dramatic effect with graded gravel or wood chip mulches. Ornamental grasses, shrubs, flowering plants and trees are all used to create these landscape features. Irrigation application rates and maintenance requirements in mulched beds can be lower than those

for traditional turf, depending upon the selected vegetation. Conversion turfgrass or native grassland conversions which have pre-existing tree or shrubs can preserve the shrubs and trees by installing mulched beds around the woody plantings. The beds should extend to the tree or shrub drip line (outer extent of the tree or shrub canopy). Separate irrigation must be provided for the mulched beds and adjacent grass areas.

Figure 5.15 Native Oregon grape in shady woodchip mulched bed under pines.

Organic chip mulches and cobble or gravel mulches function differently. Organic bark or wood chip mulch can be used under shrubs or large trees to retain moisture and help control weed establishment. Pine needles blend well in bark mulched areas (Figure 5.15). Annual weeds can be less troublesome in organic mulch but regular spot treatment to control annual and perennial weeds is essential. Organic mulches tend to tie up nitrogen due to decomposition, robbing nutrients from the mulched vegetation. More frequent fertilization and replacement of lost mulch will be required in beds with organic mulches.

Stone mulches (gravel and cobble) can be a better choice in some areas. Exposed windy sites, such as roadside beds and medians, are better mulched with stone, which wonôt

readily blow away. Flower, shrub and ornamental grass beds with stone mulch can be more easily blown free of leaves and organic debris (Figures 5.16 and 5.17). There is less frequent call for fertilizer application in gravel mulched beds, since there is little decomposition.

Figure 5.16 Flowering shrubs in gravel mulched beds along 28th Street in Boulder. Gravel stays in place better than wood chips along windy road edges.

Irrigation rates must be adequate but not excessive. Organic mulches may require slightly more water during each cycle to compensate for absorption by the mulch. All types of mulched beds will become weedy unless regularly spot treated with pre-emergent herbicides and/or broadleaved herbicides to control weeds between the plants. Herbaceous plants in mulched beds may lose shape or become weak and collapse with excessive watering or shade. Periodic pruning can shape woody vegetation. Herbaceous plants should be trimmed back in the fall (flowers) or later winter (ornamental grasses) to improve appearance for spring re-growth. Mulches should be replenished as needed, possibly yearly.

Figure 5.17 Ornamental grasses in gravel mulched bed.

5.4.3 Low Impact Development (LID) Designs

Ornamental grasses, flowers, shrubs, or trees.

Possible water savings 25 to 50% or greater, depending upon selected plant materials and supplemental irrigation requirements
Height: various

Recommended for:

- Portions of confined urban landscapes
- Parking lot islands
- Business and campus settings
- Streetscapes with Low Impact Development (LID) drainage areas
- Bioretention areas or rain gardens

Low Impact Development (LID) is a recent drainage design concept for urban/suburban settings. Designs employing LID concepts include vegetated drainages and detention areas including rain gardens and bioretention areas (Figure 3.6). In these alternative designs, stormwater is directed to porous planted beds and drainages. Within an urban setting these vegetated areas serve multiple purposes including: filtration and water

quality improvement (sediment filtering and pollutant uptake), water storage with delayed release, and an opportunity for creating an aesthetic vegetated landscape enhancement with limited supplemental irrigation. For these areas to be effective they must be carefully designed and constructed with the site adapted plant materials and growth medium (for proper drainage). With care and planning, these urban drainage sites can be transformed into attractive landscape assets.

Many species of native and adapted plants are well suited to these areas. Ornamental grasses, flowers and small shrubs can all be featured in LID areas. To keep this vegetation healthy during dry spells, a permanent irrigation system should be provided to supply occasional supplemental water. Gravel mulch can be a better choice for areas with surface water flows, since bark will tend to float. Maintenance for these areas should include annual leaf litter removal and weed control. Depending on the growth medium and mulch choice, occasional fertilization may be necessary, which can be applied as a foliar spray to reduce flushing with storm water or leaching to the ground water.

5.4.4 Synthetic turf

Possible water savings of 85 to 90% (some water is necessary for periodic flushing)
Many brands and varieties available
Regular irrigation for flushing

Recommended with reservations for:

- Municipal ball fields, with some reservations

Another option for athletic fields that is becoming more common is the use of synthetic turf. Once called óAstroturfô®, there are many systems and grass/mat choices available. Synthetic turf fields offer the advantage of year round use and a reduced, although very different, maintenance program. All synthetic turf systems require specific subsurface soil or gravel layers with a drainage system. These fields are expensive to install, but can be installed on otherwise unusable land, such as capped landfills. Most of the fields have crumb filler to add cushioning, which is made from recycled tires.

There are disadvantages to synthetic turf. Current research is investigating the potential release of lead and zinc from crumb rubber. Athletes carry home some of the filler on their socks and clothes, which can be deposited on carpets. Another significant disadvantage to synthetic turf fields is the heat build-up. Studies have shown that synthetic fields can be 20 degrees hotter than turf fields, creating possible problems during the summer.

Standard maintenance requires refreshing the crumb rubber or other filler on a regular basis. Sweeping equipment is needed to redistribute the crumb filler after use. Watering is necessary to wash down the fields after play to remove sweat and other body fluids which can support harmful bacteria. Currently reuse water is approved for this application as long as the turf dries before players return to the field. Special disinfectants can also be applied to help keep the fields clean.

5.4.5 Dog parks

Maintaining healthy grass cover in dog parks is difficult. Unless a dog park is large and the usage is relatively light, most grasses will eventually die due to compaction, wear, and excessive nitrogen accumulation. Even with collection and disposal of solid wastes, grasses do not respond favorably to heavy nutrient concentrations which affect these areas. Natural ground cover options beyond turf and soil are limited to wood chips or naturally rounded gravels. Crushed coarse gravels are not recommended due to sharp edges which can injure a dogôs foot pads. Outlying areas can sometimes be vegetated with a wheatgrass mix (Appendix A-5) which has some tolerance for traffic and nutrient loading. Following reseeding, dogs will need to be excluded from any seeded areas for at least a full year.

Synthetic turf has been used in dog parks. However, these non-natural surfaces can become too hot for dogs to use comfortably in the summer and are difficult to clean. Odor can become a problem over time and the area will still require regular irrigation in order to flush wastes off. In natural soil surfaced dog parks, soil organisms naturally

decompose wastes to control odors. Groundwater or storm water contamination can be a concern.

5.4.6 Water Savings Summary

Conversion of conventional Kentucky bluegrass turf to other turfgrass or prairies types can result in water savings ranging from approximately 19 percent for modified Kentucky bluegrass turf to 100 percent savings for non-irrigated prairies (Figure 5.18). Conversion to midgrass and shortgrass prairie types can result in savings greater than 70 percent, and conversions to other turfgrass and prairie types can show savings between 40 and 70 percent. These values suggest that a wide range of alternatives exist to the degree that a variety of management options can be considered when contemplating conversion from conventional Kentucky bluegrass turf to less consumptive vegetation covers.

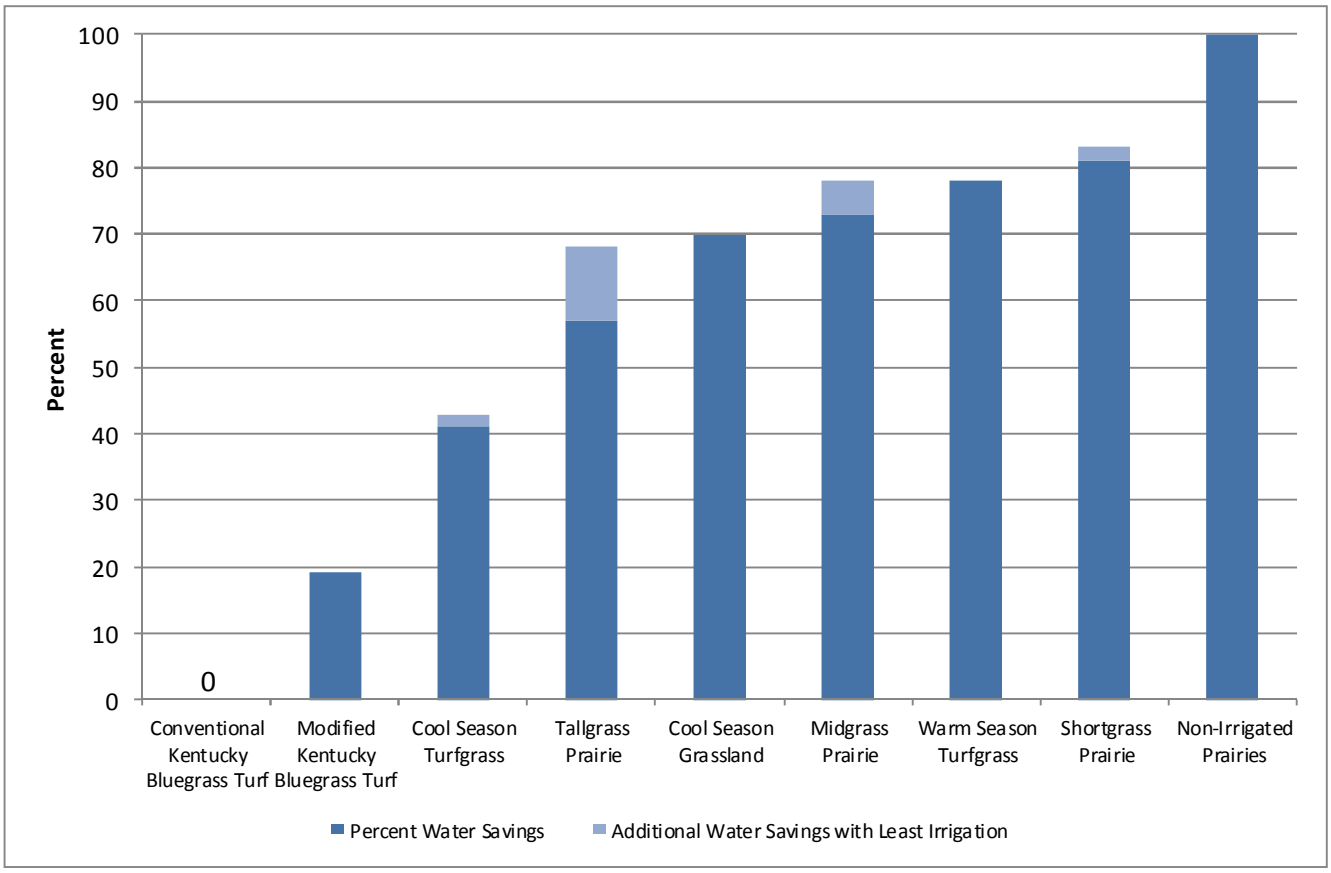

Figure 5.18 Percent of water savings for eight alternatives to conventional Kentucky bluegrass turf compared to a typical irrigation rate of 37 inches per year.

6.0 Conversion Methods

This section provides background to assist with planning and selection of conversion methods. Detailed conversion methods are provided, in Appendix B, which address a number of specific site situations, conversion goals, and other requirements. Methods suitable for large and small sites, native grassland or turfgrass conversions and chemically assisted or mechanical control methods are provided.

Conversion Methods provided in Appendix B include:

1. Vegetation removal with broad spectrum herbicide, aeration and seeding
2. Vegetation removal with broad spectrum herbicide, tilling and seeding
3. Vegetation removal by sod stripping, tilling and seeding
4. Vegetation removal followed by planting of plugs
5. Vegetation removal by solarization using plastic sheeting
6. Vegetation removal by sheet mulching or composting

6.1 Pre-Conversion Vegetation Control

Many conversions to a more drought tolerant turfgrass or grassland type require that the existing vegetation be removed by chemical and/or physical means. Broad spectrum or total vegetation herbicides (such as Roundup® or an equivalent) may be applied to the existing turf or weeds to eliminate the existing vegetation on the site. At least two applications of herbicide are generally required for an adequate kill of the existing vegetation. If herbicide use is not desired, the vegetation may be removed by sod stripping or smothered under plastic or heavy mulch applications and tilled or aerated to create a seedbed (Appendix B).

6.2 Timing

The success of establishment of new grass conversions and the water consumption required for establishment can be greatly influenced by seeding time. Planning ahead to allow adequate time for the vegetation removal phase can assure that the existing vegetation is entirely controlled (dead) by desired seeding date. **A buffer of at least two**

weeks should be factored into any schedule to accommodate additional efforts for a more complete pre-conversion vegetation control. Preparation for fall, winter, or early spring seeding times can require starting the vegetation control phase by the previous mid-July, to assure a good kill on preexisting vegetation. Spring seeding can offer a further water savings due to the residual benefits of winter moisture and potential cooler temperatures during spring germination.

Fall seeding is particularly important for conversions to native grassland types where no supplemental irrigation is available, and for any sites where the conversion requires tilling the seedbed or otherwise working the soil extensively. Tilling mixes air into the soil, which dries the soil. Winter precipitation has the dual benefits of moistening the soil and recompaction of the seedbed, thus improving seed/soil contact for spring germination. Fall and winter seeding must occur when the soil is frost and snow free. When seeding occurs between March and August, rolling the seedbed prior to irrigation will help re-compact the soil and improve germination results.

Early seeding can save water. Irrigated conversion sites can be seeded as late as April 15th, with good results. Seeding after April 15th can require significantly more establishment water due to increasingly warm weather. To assure adequate time for establishment prior to the first hard frost, irrigated conversion areas should be seeded on or before August 15th. This will allow about 6 weeks before irrigation systems are turned off and winterized. When a bare winter seedbed is unacceptable, turf can be eliminated in early spring and reseeded once the turf removal is complete.

6.3 Seedbed Preparation

Conversion methods are included in this report in Appendix B ranging from those with limited surface disturbance using aeration, to methods with extensive surface disturbance utilizing vegetation stripping or tilling. Newly germinated seedlings are very sensitive to seedbed conditions. Adequate seedbed preparation can improve conversion vegetation establishment. Heavily compacted sites should be de-compacted by deep ripping or tilling (six to twelve inches) or thoroughly aerating in preparation for seeding. Loosening

a seedbed and slightly recompacting by irrigation, rolling, or allowing time and precipitation (over the fall and winter) to accomplish this, will improve results.

6.4 Soils and Soil Amendments

For best results, soil conditions should be evaluated prior to conversion to assure a good match of the selected conversion type. The seedbed preparation phase also offers an opportunity to improve less than satisfactory soils. While costly, conversion sites with poor soils, such as those which have been overlot graded or are otherwise lacking topsoil should be improved prior to seeding. If the subsoil is very poor it should be amended with 3 to 6 cubic yards of organic matter per 1000 square feet, a synthetic fertilizer (such as diammonium phosphate) or a slow release fertilizer, (such as Biosol® or equivalent), and ripped deeply. **Composted organic matter applications must be very thoroughly incorporated**. Following subsoil improvement the seedbed should be topdressed with a minimum of 2 to 4 inches of a high quality topsoil to improve seeding results. This minor amount of topsoil will greatly improve the seedbed conditions for germination. These treatments will encourage deeper root penetration which can help reduce long term watering requirements.

Surface soil conditions where regional rock formations (shale, sandstone, or decomposed granite) are exposed at the surface are not suitable for conversion sites without the addition of 18 inches of cover soil, including 2 to 4 inches of high quality topsoil. This amount of soil is necessary to provide an adequate soil moisture reservoir and rooting depth to sustain the vegetation.

6.4.1 Fertilizers

Turfgrass conversion sites will benefit from application of a fertilizer with at least 25 percent slow release nitrogen in a ratio of 4-1-1 (nitrogen-phosphorus-potassium). The application rate should be one pound of nitrogen per 1000 square feet. A higher application rate, 1.5 pounds of nitrogen per 1000 square feet is recommended for conversion areas where aerated dead turf serves as a seedbed, to aid with decomposition of the dead thatch.

Conversion sites seeded to native warm season turfgrass or native grassland types will generally benefit from the use of a low fertility slow release granular organic fertilizer (such as Biosol® or equivalent) for improved establishment results. Application rates of 800 to 1200 pounds per acre of granular organic fertilizer are recommended, depending upon the condition of the soil. High nitrogen synthetic fertilizers can stimulate annual weeds and should not be used on native grasslands. Organic fertilizers can be broadcast before or after seeding, but should be applied prior to hydromulching. Organic fertilizers which are prepared from processed animal wastes and by-products, are not recommended, as they are generally fast release and can be relatively "hot" when applied.

6.5 Irrigation Considerations for Conversions

Germination is a risky time for newly seeded areas. Irrigation should deliver consistent moisture to improve establishment results. Sites with available irrigation can be successfully seeded almost any time during the growing season, allowing for a minimum of six weeks for establishment. Most conversion sites will benefit from a well managed irrigation program, during both establishment and long term management. If seeding can be timed for late March or early April, germination will occur in the spring, when cooler temperatures may permit some establishment period water savings. Non-irrigated areas often establish better if seeded between late fall and early spring in order to take full advantage of any precipitation events which will help to firm the seedbed and improve the soil moisture for more thorough germination.

Irrigation programs for establishment should be carefully managed. **It is critical to program initial irrigation based on the actual requirements of the seedbed soils and conversion type; monitoring and fine tuning according to needs of the site and weather conditions.** Too much or too little water can be damaging to seedlings. Some municipalities may have irrigation ordinances which are in conflict with recommended establishment irrigation programs. Since the establishment irrigation lasts only for the first growing season, it may be possible to receive a variance for that time period.

6.6 Plugs and Sod

Alternative turfgrass species are generally sod forming grasses which produce a tight sod. These grasses can be rolled or lifted in the field and have potential to be marketed as commercial turfgrass. Establishment irrigation programs for sod can be shorter than for a seeded project. The cost for this rapid conversion is generally greater than for a seeded installation.

Sod forming grasses are characterized by their ability to spread with rhizomes, which propagate further grass plants from underground stems. Unfortunately, regional availability for vegetative conversion sod grasses is still limited. Some of the alternative sod forming grasses have extended dormancies or do not produce adequate seed and therefore are best propagated vegetatively from rooted materials. Some commercially available grass species and varieties, which are grown as sod or plugs, are produced from cuttings or sprigs. ôPrestigeô and ôLegacyô are two commercially produced improved buffalograss varieties which can be obtained as sod or plugs from regional suppliers. Improved winter hardy varieties of bermudagrass (*Cynodon dactylon*), a non-native species, are also available as sod, but probably will need to be purchased from out of state sources and shipped in. Zone hardiness should be checked before ordering bermudagrass, since many varieties are adapted only to warmer locations.

It is hoped that more commercial suppliers will respond to water conservation needs and offer additional alternative grass varieties as sod. When ordering alternative sod grass, always check the recommended planting zones or inquire with the CSU Cooperative Extension Service for suitability for this area.

At this time, the only drought tolerant turfgrass species reliably available as plugs in the Front Range area is buffalograss. Other species could be contract grown for a specific project. The same alternative grasses which show promise for sod production are well suited for plugs: buffalograss, bermudagrass, and inland saltgrass. Plugs provide more rapid establishment of sod forming grasses at lesser cost than sod, but at a higher cost

than seeding. Weed invasion can be a problem in the gaps between the plugs. Establishment irrigation will be similar to that for sod.

6.7 Drill Seeding and Broadcast Seeding

Grass seed can be planted in several ways. Drilling and broadcasting seed are the two most common seeding methods. Drills vary widely and should be selected to match the demands of the particular grass mix being seeded. Most drills have cutting wheels which open a furrow and drop seed into it. These machines are equipped with depth bands for delivering the seed to the proper depth, cutter and packer wheels. Native grass drills have separate seed boxes for fine seeds and larger seeds and agitators within the boxes to keep chaffy and small seeds in the mixture well combined during the seeding operation. Turfgrass drills have closer spaced seed rows (2 to 3 inches) than do rangeland or native grass drills (7 inch spacing). Cross drilling (double drilling) is a method which reduces the appearance of drill rows by dividing the seed between two operations, drilling the second seed application perpendicular to the first.

Broadcast seeding can produce a more uniform germination pattern than drill seeding. Seed can be broadcast by hand with a rotary spreader in smaller areas, or a with a drop spreader equipped with a seed box agitator (to mix fine and chaffy seeds) in larger areas. For the best results, the seed should be divided into two portions. Apply the first portion across the entire area in parallel passes. Overseed the entire area with the reserved seed, with passes perpendicular to the first operation. Do not broadcast seed on days with winds over five miles per hour. Broadcast seeded installations should be harrowed or raked immediately following seeding to cover the seed before mulching. A combination of broadcast and drilling can also be used to create a uniform seeding result.

6.8 Hydroseeding

Hydroseeding is a broadcast seeding method which applies the seed in a light hydromulch slurry (250 pounds hydromulch plus seed per acre). Following installation of all the seed, a second heavier application of the remaining hydromulch (2250 pounds

per acre) secures the seed in place. This method of seeding requires several irrigation cycles per day during germination to keep the seed hydrated and prevent desiccation.

Hydroseeding should not be confused with hydromulching which is hydraulically applied fibrous wood mulch containing no seed. Hydroseeding can be useful for seeding steep slopes or narrow turfgrass areas. In this region, hydroseeding can be used in turfgrass installations where an irrigation system is available and can apply the frequent watering cycles required to keep the seed moist during germination.

Native seeding operations seldom use hydroseeding, even if they can be irrigated, because hydroseeding leaves the seed at the surface where it can dry out between irrigation cycles or precipitation events. Drill seeding or broadcast seeding are generally the preferred native seeding methods. Most small and steep sites can be hand broadcast with seed and raked to cover, before mulch or erosion control fabric is installed. Where severely inaccessible sites (wetland areas or slopes 2:1 or steeper) prevent the use of the other seeding methods, hydroseeding can be an acceptable alternative method. If hydroseeding a native mixture, seeding rates can be increased (1.5 to 2 times the normal rate) to improve the results for this method.

6.9 Mulches and Fabrics for Seeded Areas

Mulches and erosion control fabrics are employed to protect seedbeds (of turfgrass or native grasslands) from wind and water erosion and to conserve soil moisture for more uniform germination results. They are recommended for conversion areas where the seedbed has been tilled, stripped of sod, or is otherwise is bare of vegetation. Areas to be seeded following aeration, of a dead sod, do not generally require mulch to secure the seed and retain water. However, on more extensively disturbed seedbeds, some form of mulch should be applied following seeding and application of fertilizers.

Mulching is essential to maximize efficiency of establishment irrigation. Mulches retain the soil moisture longer at the surface where the seed is located. Once the seed is hydrated, it should not be permitted to dry. Hydromulch applications (or other mulches)

retain the seedbed moisture and allow longer intervals between watering cycles. **Mulching rates should be carefully monitored to assure effective coverage and to prevent smothering of seedlings.**

A number of different mulches are available and can be selected based on cost effectiveness and appearance. Hydraulic fiber mulches (hydromulch) are readily applied with specialized equipment. They can create a uniform soil cover, which binds closely to the soil surface. They are useful in highly visible settings with good access for the equipment in urban or suburban areas such as parks, streetscapes, parking lot islands, business or school campuses, and residential yards.

Hydraulically applied mulches vary from light weight products, such as virgin wood fiber hydromulch, to heavier and more costly products including polymer enhanced bonded fiber matrix or flexible fiber matrix products. Wood fiber hydromulch will function well on level areas up to slopes of 3:1. When applied correctly, with the proper tackifier, wood fiber mulches generally stay in place if not broken by foot or vehicle traffic. Bonded or flexible fiber matrix mulches are generally used on slopes steeper than 3:1 as a more readily installed alternative to fabric mulches. Less costly recycled paper product mulches (egg carton-like material) can be tricky to apply evenly and risk smothering seedlings.

Application rates for hydromulch should be no less than 2000 to 2500 pounds per acre. Bonded or flexible fiber matrix mulches are generally applied at about 3000 pounds per acre rates. After application, there should be little or no bare soil visible. Excessively heavy rates of application should also be avoided since they may inhibit vegetation establishment or water penetration.

Fabric mulches are mid-range in cost and are available in a wide variety of fabric types. Biodegradable products are a better choice, as they will breakdown over time and integrate with the soils. Products containing synthetic netting are not recommended. These products do not break down readily, can become entangled in mowers or ensnare snakes or other wildlife and become a tripping hazard. Over time, synthetic netting can loosen and ófloatô above the vegetation complicating mowing operations.

Jute is a soft, coarsely woven hemp fabric which is one of the least costly fabric mulches. It is suitable for gentle slopes in either turfgrass or native installations, to reinforce swales, and to prevent rill development in the center of concave slopes in hydromulch installations. Because it is very flexible, it lies directly on the soil and is particularly effective at preventing rill development along sidewalk edges. A variety of tough woven coconut fiber blankets (coir) are commonly used for bank stabilizations along drainages or streams where the mulch must resist water erosion and contain loose soils and vegetation for several years during establishment. The best seedbed protection is provided by products that are soft or flexible enough to relax and lie directly on the soil surface, thus encouraging infiltration of surface water and preventing rill development.

All fabric mulches must be applied on a smooth soil surface with no roots, rocks, or clods to lift the fabric away from the soil surface. Frequency of staking is also critical for keeping the fabric in contact with the soil. Stream bank installations of coir generally use 18 to 24 inch diagonally cut wooden 2 X 4 stakes installed two feet on center or closer, near the waterôs edge. Upland sites, with less concentrated risk of water erosion may use steel staples or smaller wooden pins to hold the fabric. Sloping installations 3:1 or steeper are improved by frequent staking and horizontal check slots to assure good soil contact and interrupt any surface erosion. Added care and closer staking must be used when installing blankets which incorporate straw (or other stiffer materials) within them to assure tight soil contact.

Crimped straw is generally the least costly mulch treatment. It can be useful on larger sites and native grassland installations, but is not used in turf areas. Because straw will blow with the wind, it can be a nuisance in urban and suburban settings or along roadsides where fugitive straw may become a problem. Crimping must be done with a specialized crimping devise, not a disk, which cuts the straws. Longer straws (75 % over 10 inches long) should be used for better crimping results. It is possible to use a hydraulically applied tackifier to help secure the straw and reduce wind loss. **Hay, which contains exotic grass seed, should never be used.**

7.0 Establishment Maintenance

Specialized maintenance is critical for the best results in establishing drought tolerant turf or native prairie/grassland areas. During the first year after seeding, commitment to frequent site monitoring, irrigation management, and consistent weed control is essential. Specialized training in the use of new irrigation controllers and maintenance requirements of unfamiliar vegetation types must be provided to protect the considerable investment of conversion. These new maintenance skills must be learned by the existing staff or specialized staff members should be employed. This must be considered a component of the conversion program in order to realize the goals of developing a healthy new landscape area with potential for water savings.

Maintenance of conversion areas differs from conventional maintenance in many ways. Careful training and development of the maintenance crew responsible for these tasks is strongly recommended.

7.1 Irrigation Monitoring and Adjustments

Establishment irrigation schedules generally begin with shorter more frequent cycles to keep the seedbed moist throughout germination. The early establishment irrigation programs should be adjusted every few weeks for the first summer to be less frequent, but longer in duration. The frequency of watering required in the establishment phase can sometimes necessitate applying for a variance from municipal ordinance requirements. Extremely hot dry weather can prompt the need for further short term adjustments in an establishment irrigation program. Irrigation requirements can differ depending upon what grasses are being established. Irrigation for cool season grass establishment can be started in late April or early May. Warm season grasses, which do not germinate until the soil temperatures are warmer, will not require irrigation until later, starting in mid to late May, after day temperatures exceed 70 degrees and surface soils start to dry out. Maintenance staff must resist the temptation to overwater these grasslands. **Overwatering of warm season grasses can eventually drown them or weaken the stand, resulting in invasion by weeds.**

7.2 Irrigation Programs: Establishment

7.2.1 Phase One Irrigation

Germination: weeks 1 to 4 after seeding (Appendix C).

During germination frequent monitoring and adjustment of irrigation cycles is required. Irrigation run times will be based on the type of irrigation head. Preliminary irrigation cycles should be frequent and short in duration, maintaining moisture in the upper inch or two of the seedbed. The most favorable time for establishing grasses is spring, when temperatures are cooler and some natural precipitation may occur. If soil conditions are dry before germination, an initial deeper watering with several split cycles can help recharge the soil moisture. Monitoring is essential as sunny or windy days can rapidly dry a seedbed surface, especially in locations with southern or western exposures. Check seedbed regularly for depth of soil moisture following irrigation cycles.

During the initial three or four week germination period, the irrigation should be scheduled in two or three short cycles in morning and evening, with an additional cycle mid day for turfgrass installations. This additional irrigation cycle is particularly critical in hydroseeded areas. Native grassland areas can establish successfully with two short cycles, morning and evening, as long as the areas have been adequately mulched. Adjustments in irrigation may be necessary with very dry hot weather. The surface of the mulch can dry daily, but if the upper half inch of soil in the seedbed becomes dry during this critical time, the germinating seeds and small seedlings could die. By 21 days, numerous seedlings should be visible emerging from the soil, giving a green haze to the seeded area.

7.2.2 Phase Two Irrigation

Weeks 5 to 6 after seeding (Appendix C).

At the end of three to four weeks, as seedlings develop more leaves, their roots will penetrate deeper into the soil. Less frequent, but longer watering cycles will provide moisture at depths that will encourage seedlings to continue to develop. It is important at

this time to allow the surface soils to dry slightly between watering to encourage deeper rooting.

During weeks five and six, the irrigation frequency for turfgrass conversion areas can be reduced to a daily ócycle and soakô feature, applying slightly more water per split cycle. This cycle can be applied in the evening. Irrigated native grassland conversions may be reduced to two to three watering nights per week with the slightly longer split irrigation cycles. Check seedbed following irrigation cycles to see that enough water is delivered to maintain soil moisture to a depth of two inches or greater. Adequate mulch cover will help extend the period of adequate soil moisture between watering.

7.2.3 Phase Three Irrigation

Weeks 7 to 8 for turfgrass.
Weeks 7-12 for warm season grasses including native prairie or grassland mixtures.
(Appendix C)

During this time the irrigation cycles can become less frequent. Surface soils should continue to dry somewhat between irrigation cycles; however, soil moisture should remain reliable at a two to three inch depth. The irrigation frequency for turfgrass conversion areas can be reduced further to every other night. Irrigated native grassland conversions may be reduced to one to two watering nights per week for weeks seven to twelve, with the slightly longer split irrigation cycles. Continue to monitor soil moisture.

7.2.4 Late Phase Irrigation

Week 9 to the end of the season for turfgrass.
Weeks 13 to 16 for native prairie or grassland.
(Appendix C)

Further reduction in irrigation cycle frequency, while adjusting the amount of water applied for the desired soil moisture depth should occur as grasses begin to mature. Turfgrass conversions should be irrigated every two or three nights to the end of the irrigation season, maintaining moisture at the 3 to 6 inch depth or deeper. Native grassland conversions can continue to be irrigated one night per week until September. In early September, reduce native grasslands irrigation frequency to every other week to

harden the plants off as they go dormant. Check seed bed for soil moisture at six to twelve inches following irrigation cycles.

7.3. Irrigation Run Times: Establishment

(Appendix C)

Rotor or large area irrigation heads will apply approximately 0.3 inches to 0.5 inches of water per hour. During the first four weeks of establishment, each irrigation cycle should be long enough to water to at least a one inch depth, without creating runoff. Split cycles or the ócycle and soakô feature must be employed to reduce rilling or run off. During mid to late germination, the run times for rotors will be increased to 45 to 60 minutes per water day. For accurate and specific precipitation rate information, refer to the irrigation head manufacturerôs catalog or contact the irrigation equipment distributor.

Pop-up spray heads, used in smaller areas of 20 feet or less, will generally apply about 1.5 inches of water per hour. For the first four weeks of establishment, apply 0.5 inches with split cycles or use the ócycle and soakô feature. To reduce possible run off or rilling, the multiple cycles should be less than five minutes each. During later establishment each multiple cycle run time should not exceed 7 to 10 minutes, with several cycles per water night, up to three times per week. For accurate and specific precipitation rate information, refer to the irrigation head manufacturerôs catalog or contact the irrigation equipment distributor.

7.4 Soil Moisture Monitoring: Establishment

Monitoring should focus on assessing soil moisture levels and depth, making adjustments to the irrigation cycles, duration and repairing of any damaged areas in the seed bed. It will be necessary to monitor and correct for site specific conditions.

The most critical criterion to monitor for establishment program success is depth of soil moisture. Individual site conditions and weather can require adjustments in any recommended irrigation program. Frequent soil moisture monitoring and irrigation adjustments are strongly recommended.

Grass seedlings of most conversion vegetation are sensitive not only to drought, but also to saturated soil conditions. During early establishment, it is important to watch for signs of puddling or standing water or overly moist (muddy) surface soils, which are indicative of developing saturated (anaerobic) soil conditions. This condition may occur in low spots, which are poorly drained. Overwatering is possible especially in clay soil areas or conversions where the treated dead sod is left in place as mulch. These sites will require close monitoring to guard against saturated soil conditions, which can lead to seedling death.

7.5 Reuse Water: Establishment

Soil and water quality are critical during the early establishment phase. Seedling grasses are more sensitive than mature grasses to elevated salinity levels. In areas with very low soil salinities (EC of < 2 mmhos/cm), it is generally acceptable to irrigate with reuse water (as long as the reuse water has a low salinity level). Soils with elevated salinity levels EC > 2 mmhos/cm) should be irrigated with reuse water only with caution for establishment. It can be challenging to establish salt tolerant species from seed in areas with moderate soil salinity levels (EC of > 4 mmhos/cm). To help remedy this it may be possible to leach some excess salts from saline soils by flushing with water containing very low or no salts. Alternative methods of plant establishment using rooted materials could bypass some of these problems. Consider sprigging or plugging a salt tolerant species such as inland saltgrass into moderately saline soil areas or areas with more saline reuse water.

7.6 Seedbed Repair

Seedbed areas may be eroded or damaged due to concentrated drainage on concave slopes or from runoff draining from hard surfaces (pavement, sidewalks, or roofs). Mowing equipment may cause rutting in wet soil areas. Damaged areas should be repaired promptly, reseeded and re-mulched. Good quality amended topsoil may be imported to fill ruts, rills, or gullies. After seeding, hydromulch, hand broadcast pelletized mulch or jute netting should be applied to help secure the repaired area.

7.7 Mowing: Establishment

Regular establishment mowing is necessary to develop a dense turfgrass stand. For first growing season, turfgrass areas may be mowed to a three inch height when the grasses (and weeds) are five inches tall. This may require weekly mowing. Establishing native prairies or grasslands will benefit from monthly mowing during the first year to reduce competition with annual weeds starting in late May or early June. Mowing should occur before the annual weeds set viable seed. If the clippings are heavy and could smother seedling grasses, they should be collected and disposed of off site. Mow after soils have dried for a day or more following irrigation or precipitation to avoid creating ruts. If possible, use a relatively small mower for the first mowing to reduce the weight of the equipment and avoid crushing the new seedlings or creating ruts in the soft seedbed. If the irrigation program was interrupted to allow seedbed to dry, be sure to restart irrigation following mowing. Weed free stands of establishing native grass do not require mowing.

7.8 Weed Control: Establishment

Conversion vegetation will always establish more successfully with proper and effective weed management. Weed growth should be observed carefully during the conversion establishment so that proper weed control is addressed in a timely manner.

The disturbance associated with conversion seeding will stimulate germination of annual weed seeds in the soil. During the first year, many annual weed species can be controlled by mowing before weed seeds become viable (their green color fading to tan or brown). Regular turfgrass mowing schedules should control annual weeds. After three months, careful broadleaf herbicide applications can also be used on turfgrass areas to assist with annual weed control. Always read the herbicide label and apply a small test application before general use. In native grasslands or prairies, establishment mowing for annual weed control can occur monthly, starting in late May. Mowing of native prairie areas should be discontinued after the first year. Avoid the use of large tractor mounted

mowers during the first month or two after germination. Heavy mowers can damage tender grass seedlings and may leave deep ruts in moist seedbeds. The mowing should not damage the perennial grasses or any wildflowers or shrub seedlings which may be present.

Pre-emergent herbicides should not be applied before or during establishment of any seeded area as these herbicides will inhibit not only weeds, but any desirable seeded grasses as well. Some pre-emergent herbicides have a 4 to 6 month period of soil activity. Always consult the labels for species sensitivities and proper application rates.

In most conversion areas, it is generally safe to begin careful application of broadleaf herbicides to control perennial weeds two months after seeding. Perennial noxious weeds can be treated with careful spot application directly on the weeds, using broadleaf herbicides. Fall herbicide treatments can be helpful to control residual perennial weeds. Certain herbicides can be used as a pre-emergent to reduce winter or spring annual weed growth. Use care whenever applying a general spray or boom spray to turf or native areas. Always check the labels for applicability to the targeted weed species and sensitivity of grass seedlings. Test herbicides and application rates in a less visible location.

Weed populations in areas near a conversion site may introduce weed seeds or may invade an area by vegetative growth (rhizomes). If possible, develop a ócross-boundaryô weed control agreement with adjacent property managers to prevent weed seed contamination or invasion.

7.9 Site Protection: Establishment

7.9.1 Human Impact Controls

Newly seeded turf or native areas are sensitive to misuse. Signage and fencing can enlist support from the pubic to avoid trampling the newly installed area. Generally one growing season of protection is adequate for discouraging off sidewalk foot traffic. If a

social trail appears to be developing, and signage and closure do not eliminate the trail use, a crusher fines path or sidewalk may be called for in this area.

7.9.2 Waterfowl Impact Control

Waterfowl grazing can rapidly degrade a newly seeded area. Fencing strategies can help prevent access and discourage grazing. A proven method for discouraging geese includes fencing the perimeter with a 3 to 4 foot high woven wire fence to prevent walk in access. Fly-in access can be discouraged by placing metal ǿTô posts in a 15 foot grid pattern within the protected area and hanging flagging ribbons from plastic cording stretched between the posts. After a year, once vegetation is well established, fencing can be removed. Other means may be needed to help discourage over-use by water fowl. Consult the Colorado Division of Wildlife.

7.9.3 Prairie Dog Impact Control

Prairie dog grazing pressure is incompatible with revegetation. Areas with an uncontrolled population of prairie dogs generally lose most grass cover and trend toward noxious weeds (in the summer) and bare, blowing soils (in the winter**).** If regular population control and well managed fencing are installed, it may be possible to retain a small population of prairie dogs on a portion of an open space area (Figure 7.1). **Generally, conversion areas should not be installed in areas with existing or nearby prairie dog populations.**

Prairie dog fencing can help exclude prairie dogs where they are not wanted. These fences are sturdy constructions of wire and plastic which can be effective visual barriers, discouraging neighboring prairie dogs from entering and grazing a newly seeded area. Some installations include a 6 foot section of chicken wire for further protection. The chicken wire is folded down the middle. Half (3 feet high) is wired to posts along the prairie dog colony side of the plastic fencing to protect this fencing from chewing. The remaining three foot section extends toward the colony and is buried under 4 to 6 inches of soil, which discourages under-burrowing at the fence. It is also possible to install the

lower three feet of chicken wire in a three foot deep trench. In this case, it is critical that the upper section of fence is at least three feet high.

It is essential that any newly seeded areas near existing prairie dog colonies be monitored. Encroaching prairie dogs should be controlled or removed immediately to prevent costly reseeding. Several years of grazing exclusion are essential to allow for good root development. Heavy grazing will eventually degrade conversion sites.

Figure 7.1 Prairie dogs require large areas of grassland and careful management to prevent overcrowding and degradation of the landscape.

8.0 Long Term Maintenance

Maintenance recommendations for the second year and thereafter.

Conversion area maintenance is different from conventional maintenance. By the second year after seeding, most turfgrass and native grassland maintenance programs should be shifting toward a long term program. Irrigation should be adjusted to the prescribed lower levels and periodically monitored to determine whether any further adjustment is required. If the season is unusually wet or dry, the irrigation schedule could need temporary modification (Appendix D). Mow heights, herbicide treatments, fertilizer rates and frequencies can also be different, depending on the conversion type. Adaptive management principles will apply.

During the second year**,** native grassland and turfgrass conversions should begin to fill in and the grass plants to attain more mature stature, as they continue to develop deeper roots. Irrigation programs should begin to realize water savings with less frequent cycles. **Regular irrigation and grass establishment monitoring is recommended, as rooting depths will continue to improve with proper irrigation management.** Monitoring and controlling weed populations should be an ongoing and critical yearly task.

> Adaptive management is a flexible program which responds to seasonal weather, site use patterns, weed invasions, and any other changes which may occur. A **well trained maintenance crew, familiar with the needs of conversion vegetation** should be responsible for the regular monitoring and maintenance efforts of the landscape.

8.1 Irrigation: Long Term

Once established, irrigated turf or native grasslands areas should be on their respective long term irrigation programs of less frequent but longer duration watering cycles (Appendix D). Irrigation should be applied in multiple shorter cycles, over successive nights if necessary, to prevent water loss from runoff. Compared to a conventionally irrigated lawn with 37 inches of irrigation per year, the modified bluegrass irrigation program associated with deep root training (Section 4) can achieve a 19 percent water savings. Alternative turfgrasses can achieve a 41 to 57 percent water savings and

occasionally irrigated grasslands or prairies can realize as much as 70 to 86 percent water savings over conventional turfgrass irrigation.

8.2 Mowing: Long Term

Conversion turfgrass can be mowed to 3 inches every week to 10 days. Some bermudagrass varieties can be mowed shorter. Clippings may remain uncollected, unless annual weeds are numerous. If desired, clippings can be collected and disposed of off-site to reduce weed seed contamination. It is recommended that mowing occur at least two days after an irrigation event. Wheatgrass and fine fescue grasslands can be left unmowed, or mowed once in early June to prevent seed head production and retain greener summer aspect. Recovery from summer mowing (after mid June) can be slow. Loss of leaves in early summer may cause dieback of the roots, which makes the plants less efficient at accessing deeper reserves of soil moisture and thus more vulnerable to drought.

Summer mowing is not recommended for native prairie areas except for spot mowing to control weed seeds. When allowed to mature without mowing, native grasses will develop interesting seed heads in late summer, which will provide texture and color through the fall and winter. During late February, native grasslands can be mowed to reduce the previous yearôs dead stalks and improve the appearance of the area for spring growth with no impact on rooting depth. Thick cuttings should be raked and removed to prevent smothering of spring growth. It is recommended to use different mowing equipment for native or naturalized areas than for turfgrass areas to prevent dulling of cutting blades.

8.3 Weed Control: Long Term

Annual weeds can generally be controlled with mowing or careful light herbicide applications. **Annual and perennial weeds can be treated in <u>warm season turfgrasses</u> by application of a broad spectrum herbicide (Roundup® or equivalent) before the grasses green up in the spring.** For best results apply the broad spectrum herbicide in late March or early April to avoid damage to the grasses. Do not use this in cool season

grass areas. Annual weeds in native areas or grasslands can generally be controlled by a combination of mowing and selective, timely mowing and spot herbicide applications.

A noxious perennial weed treatment program should be developed for each individual conversion area based on the weeds present and potential herbicides and treatment strategies. If needed, by the second year, application of herbicides is possible in most turfgrass areas. Always check labels for species sensitivities, rates and timing recommendations to prevent inadvertent damage. Fine leaved and native fescues are sensitive to some herbicides. Fall herbicide treatments for broadleaved weeds can be made in late September or early October.

It is critical that weeds in native grasslands be actively managed each year. All herbicide applications should be supervised by someone with state weed control certification. Native grasslands maintenance staff should have a current certification from Colorado Department of Agriculture for commercial applicator in rangeland (107), aquatic (108), and possibly Industrial and Right of Way (109). Herbicide should not be applied with a boom sprayer in diverse native grassland mixes to preserve any shrubs or wildflowers included in the seed mixture. Targeted spot herbicide application with hand sprayers should be used for control of biennial and perennial weeds. Biennial or perennial noxious weeds will continue to require spot herbicide applications at least twice a year, generally in late spring and late summer/early fall.

Different weeds require different chemicals, applications times, and rates. Appropriate herbicides, application methods, times and rates should be researched carefully. Rotation through a series of appropriate herbicides can reduce the risk of developing herbicide tolerance in surviving weed populations. Do not apply herbicides by boom or broadcast methods until they have been tested on a small area for species sensitivity. A summary report of weed control actions should be compiled annually to assist with planning future programs. Weeds know no boundaries; part of an adaptive management program should include development of a cross boundary weed control agreements with neighboring properties.

8.4 Aeration: Long Term

Heavily used conversion turfgrass areas, such as bermudagrass athletic fields, should be aerated once a year in early spring with a hollow tine core aerator that pulls a 3 inch plug. Plugs should be left on site. The area can be dragged with a metal drag mat to break up the plugs and work the soil from the plugs into the aeration holes. Aerated turf should be watered more frequently to reduce visible signs of moisture stress until roots fill the aeration holes. Aeration can also be done immediately before or after periods of expected heavy use.

Native grasslands seldom require decompaction unless construction access or other unusually heavy use occurs. Trails should be developed on native grassland areas where the public will be utilizing the area for hiking.

8.5 Fertilization: Long Term

Conversion turfgrasses, mixed wheatgrass or fine fescue mixes can benefit from a reduced but regular fertilizer program, applied every year or two in the fall. One pound actual nitrogen per 1000 square feet can be applied about October 1st. Native grass areas growing on average native soils generally do not require additional fertilizer after initial seeding and fertilizer applications. If a native site is thin or the grasses appear stunted, apply no more than 800 pounds per acre of low fertility slow release granular organic fertilizer (such as Biosol® or equivalent). Do not use a rapid release organic or synthetic fertilizer on native non-irrigated stands because it can stimulate weed growth.

Addition of nitrogen encourages weeds and can contribute to degradation of native prairies or other warm season grass areas. In metropolitan areas, nitrogen can build up in soils due to elevated nitrogen from exhaust fumes in the air. Heavy use of an area by dogs can also elevate soil fertility due to wastes. Designated crusher fines areas with dog waste bags and trash cans should be provided at entry areas to public parks and trails. Signage can request that dog owners walk their dogs within those designated areas prior to exercising them in parks or other public spaces.

9.0 Future Trends/Future Needs

Water demands from on going population growth along the Front Range will continue to apply heavy pressure to the available water supply. At this time, most turfgrass areas remain as water consumptive conventional Kentucky bluegrass. Up to this time drought tolerant landscape designs have focused largely on installation of mulched beds with drip systems, and grasslands. **Conversion methods need to be more widely demonstrated on public landscapes** (Figure 9.1). While buffalograss and blue grama have seen some use as alternative lawns, excellent alternative turfgrasses such as cold hardy bermudagrass and inland saltgrass have seen very limited application. They should receive more visible application in the public landscape. Modified irrigation and maintenance programs for Kentucky bluegrass should also be publicly demonstrated (Section 4).

Figure 9.1 Midgrass prairie conversion area in fall condition on Ruby Hill, Denver.

One reason for the dearth of alternative turfgrass demonstration projects is the relative lack of commercial sod sources. Within the Front Range, these species have limited or no commercial production. Buffalograss and blue grama turfgrasses are still

most readily available as seed. Programs which support conversions should be implemented. With greater public interest, conversion sod sources would develop. It may be necessary to óprime the pumpô a bit with demonstration projects.

Increased commercial sod production of conversion grasses for the Front Range could be quickly initiated. Improved varieties of cold hardy bermudagrass, buffalograss and blue grama are already commercially available and could be brought to greater local production levels. Naturally occurring dense, fast growing selections of inland saltgrass already exist throughout the region and could be collected for trials prior to wider production as commercial sod. Aside from this, implementation of long term trials on these and other drought tolerant species could contribute to our regional understanding of the best irrigation management. Short term and long term effects of moisture stress on Kentucky bluegrass and conversion species should be studied.

Finally, and by no means lastly, a training program for maintenance of alternative drought tolerant landscapes needs to be developed. Landscape management companies and homeowners need access to specialized training in order to acquire the specific and distinctively different skills necessary to properly install and successfully maintain the range of proposed conversion landscapes. This training program in conversion landscape installation, irrigation, and maintenance could be set up as a certification program for commercial landscapers. This program could be similar to the state certification program for weed control. It should supply the necessary understanding to support the wide variety of choices which are needed for successful conversion projects. The modified management program for Kentucky bluegrass should be taught in this program, as well.

10.0 The Authors

Deborah B. Keammerer

Ms. Keammerer has over 35 years experience in consulting focused on ecological restoration and sustainable design of open space areas and alternative native vegetation in rural and urban settings. Her work includes collaboration with engineering and landscape architectural teams to integrate ecological principles into overall site planning. The focus of her efforts has been to restore regional native landscapes with improved ecological function to help to reduce long term maintenance requirements. She has co-designed and provided installation and maintenance guidance for many award winning regional sustainable landscape projects including Commons Park along the South Platte River in Denver and the Riverwalk in Breckenridge.

Dorothy F. Borland

Ms. Borland is an expert in turfgrass and dryland grass mixes and irrigation design. Ms. Borland has been a turfgrass consultant since 1983, providing seed mix recommendations and maintenance guidelines for landscape maintenance firms and landscape architects. In 1999, Ms. Borland joined HydroSystems*KDI as a Commercial Irrigation Designer and Project Manager. Dorothyôs personal passion for this topic led her to earn her Masters Degree in Horticulture specializing in Turfgrass Science from Colorado State University. Her thesis examined buffalograss, blue grama and crested wheatgrass as lawn grasses. Dorothy brings a unique expertise in turfgrass management and the use of low water use and native seed mixes in an urban setting.

APPENDICES

APPENDIX A

Conversion Vegetation Sources: Seed Mixtures, Sod and Plug Recommendations
(Refer also to Sections 4.0 and 5.0)

APPENDIX A. Conversion Sources: Seed Mixtures, Sod and Plug Recommendations

A.1 Drought Tolerant Kentucky Bluegrass and Texas Hybrid Bluegrass Turf Varieties (non-native species)

All varieties of bluegrass and Texas hybrid bluegrasses may respond better to a modified management program with less frequent irrigation. These varieties can be useful where Kentucky bluegrass is still desired (as on athletic play fields). Most varieties are available as seed, some as sod and a very few as plugs. If seeding, use a mix of at least three improved varieties. Sod should also contain at least three varieties. Varieties are listed below, but others are also available. New ones enter the market frequently; check with the seed companies (Section 4.0).

Table A.1

DROUGHT TOLERANT BLUEGRASS VARIETIES		GRASS SEASON	VARIETIES	% OF MIX BY WT.	PLS* #/ACRE	PLS* #/1000 SQ. FT.
Kentucky bluegrass X Texas bluegrass	Hybrid cross	cool season	Bandera, Spitfire, Thermal Blue and others	33 for each of 3 varieties	43	1
Kentucky Bluegrass	*Poa pratensis*	cool season	Bella and other varieties	plugs and sod		
Seeding rate for bluegrass turf	**Total**				**130**	**3**
* PLS - Pure live seed (weight given is only seed, not chaff).						

A.2 Common Tall Fescue Turf Mixture (non-native species)

Older unimproved varieties of tall fescue which have turf potential for low lying areas within 2 to 4 feet of the summer ground water level (Section 5.0).

Select a single variety mix or a 50/50 mixture of two varieties.

Table A.2

COMMON TALL FESCUE MIXTURE		GRASS SEASON	VARIETIES	% OF MIX BY WT.	PLS* #/ACRE	PLS* #/1000 SQ. FT.
Tall fescue	*Festuca arundinacea*	cool season	Alta, Kentucky 31	50/50 or 100	200	4.5
Seeding rate for tall fescue	**Total PLS* #/Acre**				**200**	**4.5**

* PLS - Pure live seed (weight given is only seed, not chaff).

A.3 **Bermudagrass Turf Varieties** (non-native species)

Winter hardy bermudagrass seed and sod/plug varieties have been tried in the Front Range. Other trial varieties at CSU show promise, but have not been released commercially as of this date (Section 5.0, Figure 5.3).

Select a single source and variety below.

Table A.3

WINTER HARDY BERMUDAGRASS VARIETIES		GRASS TYPE	VARIETIES	SOURCE	PLS* #/ACRE	PLS* #/1000 SQ. FT.
Improved bermudagrass	*Cynodon dactylon*	warm season	Patriot, Midland	Seed, plugs or sprigs from local turf	60	
Improved bermudagrass	*Cynodon dactylon*	warm season	Riviera, Yukon	seed	60	1.5
Improved bermudagrass	*Cynodon dactylon*	warm season	CSU trials	Unavailable at this time		
Seeding rate for bermudagrass turf	**Total PLS* #/acre**				**60**	**1.5**
* PLS - Pure live seed (weight given is only seed, not chaff).						

A.4 **Fine Leaved Fescue Turf or Grasslands Mixture** (non-native species)

This non-native mixture can be used for minimally irrigated passive use turf areas, such as tree lawns, or un-mowed minimally irrigated grasslands. Some varieties are listed below, but many are available. New ones enter the market frequently, check with the seed companies (Section 5.0, Figure 5.2).

Table A.4

FINE LEAVED FESCUE MIXTURE		GRASS SEASON	VARIETIES	SOURCE	% OF MIX BY WT.	PLS#*/ ACRE
Hard fescue	*Festuca trachyphylla*	cool season	Durar, Rhino	seed	28	25
Sheep fescue	*Festuca ovina*	cool season	Covar	seed	22	20
Blue fescue	*Festuca ovina*	cool season	SR 3200, SR 3210	seed	22	20
Creeping red fescue	*Festuca rubra*	cool season	Shadow II SR 5100, Aruba	seed	28	25
Seeding rate for irrigated fine fescue turf	**Total PLS* #/acre**				**90 #/ Ac**	**90**
Seeding rate for minimally irrigated or non-irrigated, un-mowed fine fescue grassland	**Total PLS* #/acre**				**25#/Ac**	
* PLS - Pure live seed (weight given is only seed, not chaff).						

A.5 Wheatgrass Turf or Grasslands Mixture (Mixture of selected native and non-native wheatgrass species.)

This mixture can be used for minimally irrigated passive use turf areas, or un-mowed minimally irrigated grasslands (Section 5.0, Figure 5.4).

Table A.5

WHEATGRASS MIXTURE		GRASS SEASON	VARIETIES	SOURCE	% OF MIX BY WT.
Pubescent wheatgrass	*Agropyron intermedium*	cool season	Luna	seed	40
Western wheatgrass	*Pascopyrum smithii*	cool season	Arriba	seed	23
Streambank wheatgrass	*Agropyron riparium*	cool season	Sodar	seed	18
Slender wheatgrass	*Agropyron trachycaulum*	cool season	Primar or Pryor	seed	19
Seeding rate for irrigated wheatgrass turf	**Total PLS* #/acre**				**350 #/Ac**
Seeding rate for minimally irrigated un-mowed wheatgrass grassland	**Total PLS* #/acre**				**100 #/Ac**
* PLS - Pure live seed (weight given is only seed, not chaff).					

A.6 Buffalograss Turf Varieties (native species)

Buffalograss, a native shortgrass prairie species, can be used as a single species turfgrass in exposed sunny locations under 6500ô elevation. Do not plant in very sandy areas. Varieties are available as seed, sod or plugs. Some varieties are listed below, but many are available. New ones enter the market frequently, check with the seed companies (Section 5.0, Figure 5.5).

Select one source and variety.

Table A.6

BUFFALOGRASS TURF		GRASS SEASON	VARIETIES	SOURCE	PLS* #/ACRE	PLS* #/1000 SQ. FT.
Buffalograss	*Buchloe dactyloides*	warm season	Topgun or Texoka	seed	130	3.00
Buffalograss	*Buchloe dactyloides*	warm season	Legacy, Topgun or Texoka	plugs or sod		
Seeding rate for buffalograss turf					130	3.00
For non-turf areas use Shortgrass Prairie Mixture, below.						
* PLS - Pure live seed (weight given is only seed, not chaff).						

A.7 Blue Grama Turf Varieties (native species)

This species can be planted as a single species turf in sunny exposed sites less than 7500ô elevation. Plant plugs on 4-6 inch centers. Do not plant in very sandy areas (Section 5.0, Figure 5.6).

Table A.7

BLUE GRAMA TURF		GRASS SEASON	VARIETIES	SOURCE	PLS* #/ACRE	PLS* #/1000 SQ. FT.
Blue grama	*Chondrosum gracile*	warm season	Hachita	seed	100	2
Blue grama	*Chondrosum gracile*	warm season	Hachita	Plugs or sod		
Seeding rate for blue grama turf					**100**	**2**
For non-turf areas use Shortgrass Prairie Mixture, below.						
* PLS - Pure live seed (weight given is only seed, not chaff).						

A.8 **Buffalograss and Blue grama Turf Mixture** (native species)

These two native shortgrass species can be planted together as a turf in sunny exposed sites below 6500ô elevation.
The 85/15 percent mix by seed weight, provided below, will yield approximately a 50/50 mix by seed count (Section 5.0).

Table A.8

BUFFALOGRASS/ BLUE GRAMA TURF MIXTURE		GRASS SEASON	VARIETIES	% OF MIX BY WT.	PLS #/ACRE	PLS #/1000 SQ. FT.
Buffalograss	*Buchloe dactyloides*	warm season	Topgun, Texoka, Sharps improved or others	85	127.5	3
Blue grama	*Chondrosum gracile*	warm season	Hachita	15	22.5	0.5
Seeding rate for buffalograss and blue grama turf					**150**	**3.5**
For non-turf areas use Shortgrass Prairie Mixture, below.						
* PLS - Pure live seed (weight given is only seed, not chaff).						

A.9 Inland Saltgrass Turf (native species)

Inland saltgrass shows great promise, but improved sod varieties are not currently available. Current sources of sod or plugs sources are limited. It is challenging to establish seed readily. Small sites could be sprigged from a native donor sites. Native, unimproved seed is currently the most reliable source. However, native seed must be pre-treated to break dormancy and improve germination rates. Pre treatment instructions are included below. CSU currently has this species in turf trials, but no commercial varieties have been released as of publication of this report (Section 5.0, Figure 5.7).

Table A.9

INLAND SALTGRASS TURF		GRASS SEASON	VARIETIES	SOURCE	PLS* #/ACRE	PLS* #/1000 SQ. FT.
Inland saltgrass	*Distichlis stricta*	warm season	Native	seed	60	1.40
Inland saltgrass	*Distichlis stricta*	warm season	Native	Sod or plugs		
Inland saltgrass	*Distichlis stricta*	warm season	CSU trials	Unavailable at this time		
Seeding rate for inland saltgrass turf					**60**	**1.40**
For non-turf areas use Salt Tolerant Seed Mixture, below.						
* PLS - Pure live seed (weight given is only seed, not chaff).						

A.9.1 Inland Saltgrass Stratification

Pretreatment instructions to help break seed dormancy and improve seed establishment.

In order to break the natural dormancy of native saltgrass seed a pre-treatment of the seed is required. Pre-treated saltgrass seed will yield a higher percentage of germination.

1. Place seed into fabric bags (pillow cases can be used). Do not overfill bags as seed will swell and bags must fit into a 5 gallon bucket.
2. Place bagged seed into 5 gallon buckets.
3. Mix water and hydrogen peroxide (2:1 water to 3% peroxide solution) to cover seed. Weight to keep bagged seeds submerged.
4. Soak for 6 hours.
5. Rinse very well. Drain but do not dry seed.
6. Divide seed into large zippered plastic bags and put 1/4 cup water and a plastic drinking straw in corner to aerate seed.
7. Refrigerate at 36-41° F for 30 days. Check bags for moisture content. Add water if the seed begins to dry.
8. **Do not allow seed to dry out before it is seeded.**
9. Prepared seed can be mixed with moist sand to improve ease of distribution. Hand broadcast on prepared seedbed. Rake to cover seed immediately.
10. Mulch with hydromulch.

A.10 **Shortgrass Prairie Mixture** (native species)

Native shortgrass prairies are adapted to exposed areas, ridges and upland sites. The list below is a basic native grassland matrix to which additional native short grasses, wildflowers, and shrub species can be added for greater diversity and structure. A list of optional wildflowers is provided. In rural sites this prairie requires 10 to 18 inches of natural precipitation per year. Urban settings require additional irrigation to compensate for hotter local conditions (Section 5.0, Figure 5.8).

Table A.10

SHORTGRASS PRAIRIE MIXTURE		GRASS SEASON	VARIETIES	% OF MIX BY WT.	PLS*** #/ACRE	PLS*** #/1000 SQ. FT.
GRASSES						
Buffalograss*	*Buchloe dactyloides*	warm season	Sharp's	47	14	0.32
Blue grama*	*Chondrosum gracile*	warm season	Hachita	37	11	0.25
Junegrass	*Koeleria macrantha*	cool season	Native	10	3	0.07
Western wheatgrass*	*Pascopyrum smithii*	cool season	Arriba	6	2	0.06
Seeding rate for basic mixture	Seeding rate may be doubled for a denser stand				**30**	**0.7**
OPTIONAL WILDFLOWERS					OZ/ACRE**	
Fringed sage	*Artemisia frigida*		Native		1	
Blanketflower	*Gaillardia aristata*		Native		1	
Bluebells	*Campanula rotundifolia*		Native		1	
Showy locoweed	*Oxytropis lambertii*		Native		2	
Silky locoweed	*Oxytropis sericea*		Native		3	
Sidebells penstemon	*Penstemon secundiflorus*		Native		3	
Blue mist penstemon	*Penstemon virens*		Native		3	
Scarlet globemallow	*Sphaeralcea coccinea*		Native		3	
Total oz/acre for wildflowers					**17 oz/acre**	
*always include these key species, maintain at least a 30 #/acre rate						
** 1/4# minimum order for each species						
*** PLS - Pure live seed (weight given is only seed, not chaff).						

A.11 **Midgrass Prairie Mixture** (native species)

Midgrass prairies occur on less exposed sites, with deeper soils and greater soil moisture than shortgrass prairies. In rural sites this prairie requires 15 to 18 inches of precipitation per year. Irrigation can compensate for hotter local conditions (Section 5.0, Figure 5.9).

Table A.11

MIDGRASS PRAIRIE MIXTURE		GRASS SEASON	VARIETIES	% OF MIX BY WT.	PLS*** #/ACRE	PLS*** #/1000 SQ. FT.
GRASSES						
Buffalograss	*Buchloe dactyloides*	warm season	Topgun	13	4	0.10
Sideoats grama*	*Bouteloua curtipendula*	warm season	Butte	20	6	0.14
Blue grama*	*Chondrosum gracile*	warm season	Hachita	13	4	0.10
Western wheatgrass*	*Pascopyrum smithii*	cool season	Arriba	20	6	0.14
Little bluestem*	*Schizachyrium scoparium*	warm season	Pastura	7	2	0.05
Sand dropseed*	*Sporobolus cryptandrus*	warm season	Native	7	2	0.05
Green needlegrass	*Stipa viridula*	cool season	Lordorn	20	6	0.14
Rate for basic mixture	Seeding rate may be doubled for a denser stand.				**30**	**0.72**
OPTIONAL WILDFLOWERS					OZ/ACRE**	
Fringed sage	*Artemisia frigida*	X	Native		1	
Smooth aster	*Aster laevis*	X	Native		2	
Blanketflower	*Gaillardia aristata*	X	Native		4	
Showy goldeneye	*Viguiera multiflora*	X	Native		2	
Sidebells penstemon	*Penstemon secundiflorus*	X	Native		2	
Scarlet globemallow	*Sphaeralcea coccinea*	X	Native		3	
Seeding rate for wildflowers					**14 oz/acre**	
*always include these key species, maintain at least a 30 #/acre rate for mix						
** 1/4 # minimum per species order						
*** PLS - Pure live seed (weight given is only seed, not chaff).						

A.12 **Tallgrass Prairie Mixture** (native species)

Tallgrass prairies occur in more mesic (moister) sites than the other grasslands. Lowland areas along drainages support these tallgrass species. In rural sites this prairie requires 18 or 30 inches of precipitation per year. Irrigation can compensate for hotter local conditions. This vegetation offers erosion protection and wildlife habitat (Section 5.0, Figure 5.10).

Table A.12

TALLGRASS PRAIRIE MIXTURE		GRASS SEASON	VARIETIES	% OF MIX BY WT.	PLS #/ACRE	PLS #/1000 SQ. FT.
GRASSES						
Big bluestem*	*Andropogon gerardii*	warm season	Pawnee	10	3	0.07
Sideoats grama*	*Bouteloua curtipendula*	warm season	Butte	10	3	0.07
Blue grama	*Chondrosum gracile*	warm season	Hachita	7	2	0.05
Switchgrass*	*Panicum virgatum*	warm season	Blackwell	17	5	0.12
Western wheatgrass*	*Pascopyrum smithii*	cool season	Arriba	17	5	0.12
Little bluestem	*Schizachyrium scoparium*	warm season	Blaze or Pastura	13	4	0.10
Indiangrass*	*Sorghastrum avenaceum*	warm season	Cheyenne	13	4	0.10
Sand dropseed*	*Sporobolus cryptandrus*	warm season	Native	3	1	0.02
Green needlegrass*	*Stipa viridula*	cool season	Lordorn	10	3	0.07
Seeding rate for basic mixture (double for denser stand)					**30**	**0.72**
OPTIONAL WILDFLOWERS					**OZ/AC**	
Smooth aster	*Aster laevis*		Native		2	
Louisiana sage	*Artemisia ludoviciana*		Native		1	
Blanketflower	*Gaillardia aristata*		Native		4	
Showy goldeneye	*Viguiera multiflora*		Native		2	
Large flowered penstemon	*Penstemon grandiflorus*		Native		4	
Wand penstemon	*Penstemon virgatus*		Native		4	
Seeding rate for wildflowers					**17 oz/ac**	
*always include these key species, maintain at least a 30 #/acre rate for mix						
** 1/4 # minimum per species order						
*** PLS - Pure live seed (weight given is only seed, not chaff).						

A.13 **Wet Meadow or Wetland Mixture** (native species)

Wet meadows and wetlands occur along drainages and in detention ponds. These sites can have saturated soils and require moisture tolerant vegetation. The taller species should only be mowed annually in mid winter. Correctly located, these species should require no additonal irrigation (Section 5.0, Figure 5.12).

Table A.13

WET MEADOW OR WETLAND MIXTURE		GRASS SEASON	VARIETIES	% OF MIX BY WT.	PLS #/ ACRE	PLS #/1000 SQ. FT.
GRASSES						
Woolly sedge*	*Carex lanuginosa*	cool season	Native	7	2	0.05
Nebraska sedge*	*Carex nebrascensis*	cool season	Native	7	2	0.05
Blue grama	*Chondrosum gracile*	warm season	Hachita	2	1	0.02
Inland saltgrass	*Distichlis stricta*	warm season	Native	7	2	0.05
Baltic rush*	*Juncus balticus*	cool season	Native	7	2	0.05
Prairie cordgrass*	*Spartina pectinata*	cool season	Native	13	4	0.09
Switchgrass*	*Panicum virgatum*	warm season	Blackwell	20	6	0.14
Western wheatgrass*	*Pascopyrum smithii*	cool season	Arriba	20	6	0.14
Green needlegrass*	*Stipa viridula (aka Nasella)*	cool season	Lodorn	17	5	0.12
Seeding rate for basic mixture (double for denser stand)					**30**	**0.71**
OPTIONAL WILDFLOWERS					OZ./ACRE**	
Yarrow	*Achillea millefolium*		Common		1	
Showy milkweed	*Asclepias speciosa*		Native		2	
Wild Bergamot	*Monarda fistulosa*		Native		3	
Nuttall's sunflower	*Helianthus nuttallii*		Native		3	
Blue vervain	*Verbena hastata*		Native		3	
Seeding rate for wildflowers					**12 oz/acre**	
*always include these key species, maintain at least a 30 #/acre rate for mix						
**1/4# min order per wildflower species						
*** PLS - Pure live seed (weight given is only seed, not chaff).						

A.14 Sand Prairie Seed Mixture

This mixture will provide native grassland cover for non-mowed sandy sites. This type is unsuitable for heavily used urban areas, unless trails area provided. Irrigation should be limited, if at all (Section 5.0, Figure 5.11).

Table A.14

SAND PRAIRIE MIXTURE		GRASS TYPE	VARIETIES	% OF MIX	PLS #/ACRE	PLS #/1000 SQ. FT.
GRASSES						
Sand bluestem*	*Andropogon hallii*	warm season	Garden	7	2	0.05
Sideoats grama*	*Bouteloua curtipendula*	warm season	Butte	10	3	0.07
Prairie sandreed*	*Calamovilfa longifolia*	warm season	Goshen	13	4	0.09
Blue grama*	*Chondrosum gracile*	warm season	Hachita	13	4	0.09
Indian ricegrass	*Oryzopsis hymenoides*	warm season	Nezpar	3	1	0.02
Switchgrass*	*Panicum virgatum*	warm season	Blackwell	26	8	0.19
Western Wheatgrass	*Pascopyrum smithii*	cool season	Arriba	7	2	0.05
Sand bluestem*	*Schizachyrium hallii*	warm season	Goldstrike	7	2	0.05
Sand dropseed*	*Sporobolus cryptandrus*	warm season	Native	7	2	0.05
Green needlegrass*	*Stipa viridula*	cool season	Lodorn	7	2	0.05
Seeding rate for basic mixture (double for denser stand)					**30**	**0.71**
OPTIONAL WILDFLOWERS					OZ/ACRE**	
Pasture sage	*Artemisia frigida*				2	
Scarlet gilia	*Ipomopsis aggregata*				3	
Blanket flower	*Gaillardia aristata*				4	
Tansy aster	*Machaeranthera tanacetifolia*				2	
Seeding rate for wildflowers					**11 oz/acre**	
OPTIONAL SHRUBS						
Dwarf rabbitbrush	*Chrysothamnus nauseosus, subsp. nau.*				2	
Yucca	*Yucca glauca*				4	
Seeding rate for shrubs					**6 oz/acre**	
*always include these key species, maintain at least a 30 #/acre rate for mix						
**1/4# min order per wildflower species						
*** PLS - Pure live seed (weight given is only seed, not chaff).						

A.15 Salt Tolerant Seed Mixture

Salt tolerant native grasses are adapted to natural exposures of saline soils, often in moist areas over shale. This variable height mixture (short, mid, and tall species) can be used in non-mowed, slightly saline road ditches. Shorter species may be selected to plant (ƶ) in areas where lower grasses or mowing is desired. Areas with heavy exposure to salts may exceed the range of tolerance of native grasses (upper range for germination <4 mmhos/cm, upper range for healthy mature vegetation <8 mmhos/cm). Irrigation can be used to periodically conduct a spring flush of winter salt accumulations from these areas. For improved results, pre-treat saltgrass seed (See A.9.1, Section 5.0, Figures 5.13 and 5.14)

Table A.15

SALT TOLERANT SEED MIXTURE		GRASS SEASON	VARIETIES	% OF MIX BY WT.	PLS**# /ACRE	PLS** # /1000 SQ. FT.
GRASSES						
Buffalograss ƶ	*Buchloe dactyloides*	warm season	Topgun	9	3	0.07
Blue gramaƶ	*Chondrosum gracile*	warm season	Hachita	6	2	0.05
Inland saltgrass*ƶ	*Distichlis stricta*	warm season	Native	6	2	0.05
Green needlegrass	*Stipa viridula (aka Nasella)*	cool season	Native	19	6	0.14
Switchgrass	*Panicum virgatum*	warm season	Native	13	4	0.09
Western wheatgrass*	*Pascopyrum smithii*	cool season	Arriba	25	8	0.19
Alkali sacaton*	*Sporobolus airoides*	warm season	Salado	16	5	0.12
Sand dropseed	*Sporobolus cryptandrus*	warm season	Native	6	2	0.05
Seeding rate for basic mixture	Seeding rate may be doubled for denser stand.				**32 #**	**0.76 #**
*always include these key species, maintain at least a 30 #/acre rate for mix						
** PLS - Pure live seed (weight given is only seed, not chaff).						
ƶ : Shorter species for less mowing on saline road edges. Adjust seeding rate to 30 # PLS or greater.						

APPENDIX B

Conversion Methods

(Refer also to Section 6.0)

B.1 Conversion Method 1: Vegetation Removal with Broad Spectrum Herbicide Followed by Aeration

Dense turfgrass areas can be killed with repeated broad spectrum herbicide applications. Organic alternatives to herbicide controls are provided in Conversion Methods B.3, B.5 and B.6.

Recommended for conversion of:

- Conventional turfgrass to alternate turfgrass
- Conventional turfgrass to fescue or wheatgrass grassland (requires thorough aeration)
- Areas with acceptable soil (few amendments required)
- Conversions in areas with irrigation
- De-compacting and inter-seeding degraded turf

Not recommended for conversion of:

- Conventional turfgrass to native grassland

Methods

1. Initiate conversion when vegetation is actively growing. Do not start this when the vegetation is dormant in late fall, winter, or early spring. Completing turf-kill by mid September prepares a site for an earlier start on spring seeding of cool season turf or wheatgrass grasslands.
2. Irrigate conversion area well for two or more weeks ahead of herbicide treatment. Do not mow. Lush vegetation with long leaf blades, in good growing condition at time of herbicide treatment will absorb more of the herbicide, resulting in a more complete kill. Allow more time and irrigation cycles for this phase if the area is very dry and the vegetation is summer dormant.
3. Thoroughly treat the conversion area with a broad spectrum herbicide, (Roundup® or other glyphosate product), following label rates and directions. After grasses begin to yellow (1 to 2 weeks) re-apply herbicide a second time, to provide a complete kill of any remaining green grasses or weeds. Treated turf will turn yellow/orange and then tan. Any remaining areas of green turf or weeds should be treated with an additional herbicide application. This process can take 4 to 6 weeks for a complete kill.
4. Mow dead grass as short as possible, raking and removing all the debris.
5. Flag all irrigation heads to avoid damaging in following steps.
6. Aerate using a hollow tine core aerator that pulls a three inch plug.

   A. Turfgrass Conversion:

Make at least three passes, at different angles across the conversion area for turf to turf conversions.

B. Grassland Conversions:

Aerate repeatedly five or six times to open the turf for a denser grassland establishment.

7. Seed turfgrass using a rotary spreader, a drop spreader with a seed box agitator, or a Brillion drill seeder. Divide the seed mixture into two portions. First sow half the seed in one direction, in parallel passes across the entire area. Next, repeat the seeding operation perpendicular to the first application with the reserved portion of seed. Do not seed on days with winds over five miles per hour.
8. Fertilize cool season turf grass conversions with a slow release fertilizer containing at least 25 percent slow release nitrogen in a ratio of 4-1-1, (nitrogen to phosphorus to potassium). The application rate should be one pound actual nitrogen per 1000 square feet. Use a slightly heavier rate of fertilizer for conversion areas that had very thick turf to aid in the breakdown the dead organic matter.
9. Harrow (rake) the seeded area using a metal drag mat or similar device immediately following seeding. This will shake the seed and fertilizer into the aeration holes and help break up the aerator plugs to create a top-dressing.
10. Irrigation should begin in spring or, if planted later, immediately following seed and mulch installation. See typical establishment irrigation schedules in Appendix C.

B.2 Conversion Method 2: Vegetation Removal with Broad Spectrum Herbicide Followed by Tilling

This method can be useful in areas of degraded turf where a new irrigation system is to be installed. Organic alternatives to herbicide control provided in Conversion Methods B-3, B-5 and B-6 can also be utilized for turf removal.

Recommended for conversion of:

- Degraded/thin turfgrass to native prairies, fescue or wheatgrass grasslands
- Conversion areas where the addition of soil amendments and organic matter would be beneficial

Not recommended for conversion of:

- Areas with an existing irrigation system to be used in the future
- Conventional turfgrass to drought tolerant turfgrass

Methods

1. Initiate conversion when vegetation is actively growing. Do not start this when the vegetation is dormant in late fall, winter, or early spring. Completing turf-kill by mid September prepares a site for an earlier start on spring seeding. This can yield some water savings due to establishment during a cooler season.
2. Irrigate conversion area well for two or more weeks ahead of herbicide treatment. Do not mow. Lush vegetation with long leaf blades, in good growing condition at time of herbicide treatment will absorb more of the herbicide, resulting in a more complete kill. Allow more time and irrigation cycles for this phase if the area is very dry and the vegetation is summer dormant.
3. Thoroughly treat the conversion area with a broad spectrum herbicide, (Roundup® or other glyphosate product), following label rates and directions. After grasses begin to yellow (1 to 2 weeks) re-apply herbicide a second time, to provide a complete kill of any remaining green grasses or weeds. Treated turf will turn yellow/orange and then tan. Any remaining areas of green turf or weeds should be treated with an additional herbicide application. This process can take 4 to 6 weeks for a complete kill.
4. When the kill is acceptable, mow the dead grass as short as possible, raking and removing all the debris.
5. Fertilizer Application

   A. Cool Season Fescue or Wheatgrass Grasslands:

Fertilize with a product containing at least 25 percent slow release nitrogen in a ratio of 4-1-1, (nitrogen to phosphorus to potassium). The application rate shall be one pound actual nitrogen per 1000 square feet.

B. Native Prairie Seeding:

Fertilize the area with 20 pounds Biosol® per 1000 square feet (or equivalent organic fertilizer) to assist with decomposition of the dead grass. Native prairies can be degraded by application of excessive nitrogen. Avoid the use of synthetic fertilizers with high nitrogen content. Slow release organic fertilizers will provide adequate nutrients for establishment.

6. Till the conversion area to finely shred all remaining vegetation and roots and to evenly incorporate dead sod and fertilizer into the soil to a depth of at least 6 inches. **It is essential that the tilling be very thorough.** Rake off and remove excess ófloatingô organic matter from a heavy turf.
7. Remove rocks and clods over two inches in diameter from the seedbed for native grassland or grassland conversions. Some roughness of the seedbed is acceptable in these areas.
8. Re-compact the seedbed prior to seeding by deeply irrigating to settle the soil or by compacting with a turf roller. Seedbed compaction should not exceed 85 percent Standard Proctor Density. If irrigation is used to re-compact, water deeply and allow a couple days for the seedbed to settle and dry somewhat before seeding. Do not use a sheepôs foot compactor.
9. Re-install irrigation, carefully over trenching and around heads.
10. Seeding

A. Broadcast Method:

Recommended for irregular, steep, or small areas under 1000 square feet.

Divide the seed mixture for the area into two portions. Broadcast the desired seed mixture using a rotary spreader or a drop spreader with a seed box agitator (to mix fine or chaffy seeds), applying seed in repeated parallel passes across the entire area. Repeat the broadcast seeding with the remaining half of the seed, seeding perpendicular to the first application. Do not seed on days with winds over five mph.

Harrow or rake all broadcast seeded areas, to cover the seed, using a spring tooth or metal drag mat or similar device immediately following seeding.

B. Drill Seeding Method:

Recommended for areas with good access.

Drill rows should be no greater than seven inches apart. To disguise the drill rows, double drill (seed the area twice) in perpendicular directions (cross drill) or broadcast half of the seed first and then drill the remaining half of the seed. If drill seeded, native prairie and grassland mixtures must be installed by a grassland drill with separate seed boxes with agitators. The drill depth bands should be set at 0.3 to 0.5 inch depth.

11. Hydromulch with 2500 pounds per acre mechanically defibrated virgin wood fiber mixed with 150-200 pounds per acre organic (*Psillium* seed based) or polymer tackifier. Hydromulch helps prevent wind and water erosion, securing the soil and seed; it also is critical for soil moisture retention during germination. Fall or winter seeded areas must be hydromulched with a heavy tackifier rate (200 pounds per acre) to reduce seed loss during winter winds.
12. Irrigation should begin in early spring or, if planted later, immediately following seed and mulch installation. See typical establishment irrigation schedules in Appendix C.

B.3 Conversion Method 3: Vegetation Removal by Sod Stripping Followed by Tilling

This method works well in areas with dense healthy turf and few shallow tree roots where a new irrigation system is to be installed. If desired, good quality stripped sod can be salvaged for use elsewhere.

Recommended for conversion of:

- Dense turfgrass conversion to seeded alternative turf or seeded grasslands or native prairies
- Sod areas to be salvaged for use elsewhere
- Areas with prohibitions for herbicide use. (Some limited herbicide use can be helpful to spot manage any remaining turf or perennial noxious weeds.)
- Good topsoil areas, which do not require the addition of organic matter
- Areas with few trees to be converted to native prairies or seeded grasslands

Not recommended for:

- Areas with thin or patchy turfgrass or bunchgrass
- Areas under trees or shrubs (root damage can occur)

Methods

1. Initiate this treatment during the frost-free period, just before intended seedbed preparation and seeding. Spring and early fall are recommended due to cooler moister conditions.
2. Spot treat any weeds with a broadleaf herbicide two weeks prior to sod removal.
3. Irrigate a day or two before stripping to moisten sod for easier stripping, rolling and reinstallation.
4. If present, remove irrigation or flag heads to avoid damaging during in later steps in the conversion.
5. Strip sod with a power stripper. Use an alternative turf-kill method under trees to prevent damage to tree roots.
6. Apply desired soil amendments before tilling the site to have them incorporated well into the soil.
7. Fertilizer Application:

   A. Cool Season Turfgrass, Fescue or Wheatgrass Grasslands:

Fertilize with a product containing at least 25 percent slow release nitrogen in a ratio of 4-1-1, (nitrogen to phosphorus to potassium). The application rate shall be one pound actual nitrogen per 1000 square feet.

B. Native Prairies:

Fertilize the area with 20 pounds Biosol® per 1000 square feet (or equivalent organic fertilizer) to assist with decomposition of the dead grass. Native prairies can be degraded by application of excessive nitrogen. Avoid use of synthetic fertilizers with high nitrogen content. Slow release organic fertilizers will provide adequate nutrients for establishment.

8. Till the conversion area to a depth of at least 6 inches to incorporate fertilizer and any other amendments thoroughly.
9. Seedbed preparation
   A. Turfgrass Conversions:

   Rake and remove rocks or clods over one inch in diameter to create a smooth seedbed.

   B. Grassland or Native Prairie Conversions:

   Rake and remove rocks and clods over two inches in diameter for native grassland or wheatgrass conversions. Some roughness of the seedbed is acceptable in these areas.
10. Re-compact the seedbed prior to seeding by deeply irrigating to settle the soil or by compacting with a turf roller. Seedbed compaction should not exceed 85 percent Standard Proctor Density. If irrigation is used to re-compact, water deeply and allow a couple days for the seedbed to settle and dry somewhat before seeding. Do not use a sheepôs foot compactor. Recompaction by irrigation is recommended clay loam or clay soils.
11. Seeding
    A. Broadcast Method:

    Recommended for seeding dense turfgrass stands or irregular, steep, or small areas under 1000 square feet.

    Divide the seed mixture for the area into two portions. Broadcast the desired seed mixture using a rotary spreader or a drop spreader with a seed box agitator (to mix fine or chaffy seeds), applying seed in repeated parallel passes across the entire area.

Repeat the broadcast seeding with the remaining half of the seed, seeding perpendicular to the first application. Do not seed on days with winds over five mph. Harrow or rake all broadcast seeded areas, to cover the seed, using a spring tooth or metal drag mat or similar device immediately following seeding. Raking or harrowing should mix the seed into the soil, not rake it off. This places the seeds in the soil where their moisture content can be kept more uniform between irrigation cycles, enhancing germination success. Harrowing or raking saves water by requiring less frequent irrigation cycles

B. Drill Seeding Method:

Recommended for larger grasslands or prairies where some appearance of drill rows may be acceptable. Brillion seeders (see below) can be used for seeding large areas of turfgrass.

Drill rows should be no greater than seven inches apart. To disguise the drill rows, double drill (seed the area twice) in perpendicular directions (cross drill) or broadcast half of the seed first and then drill the remaining half of the seed. If drill seeded, native prairie and grassland mixtures must be installed by a grassland drill with separate seed boxes with agitators. The drill depth bands should be set at 0.3 to 0.5 inch depth. A Brillion seeder, which has very close drill rows can also be used when seeding large areas of turfgrass, sow half the seed in one direction and then cross seed with the second portion. Harrow or rake immediately to cover seed. Do not use a Brillion seeder on days with winds over five miles per hour.

12. Hydromulch with 2500 pounds per acre mechanically defibrated virgin wood fiber mixed with 150 to 200 pounds per acre organic (*Psillium* seed based) or polymer tackifier. Hydromulch will secure soil and seed and will help retain soil moisture during germination. Fall or winter seeded areas must be hydromulched with a heavy tackifier rate (200 pounds per acre) to reduce seed loss during winter winds.
13. Irrigation should begin in early spring or, if planted later, immediately following seed and mulch installation. See typical establishment irrigation schedules in Appendix C.

B.4 Conversion Method 4: Vegetation Removal Followed by Planting of Plugs or Sod

Recommended for conversion of:

- Degraded/thin turfgrass to drought tolerant cool season turfgrass
- Degraded/thin turfgrass to drought tolerant warm season turfgrass

Not recommended for:

- Dense turfgrass conversions
- Conversions to native grasslands

Methods

1. Select a method below and remove original vegetation
    - Broad-spectrum herbicide and tilling: follow Conversion Method B.2, items 1 to 9. Rake site to remove all rocks and clods over 0.5 inches. Moisten and allow surface to dry slightly.
    - Sod stripping: follow Conversion Method B.3, items 1 to 10.
    - Solarization: follow Conversion Method B.5, items 1 to 11.
2. Sodding: Freshly cut sod should be delivered to the site and protected from drying out until planted. Install sod over moistened surface with edges tightly butted together, staggering sod pieces. Roll sod after installation and irrigate.
3. Plugging: Use only sod-forming grasses for plugging (bermudagrass, buffalograss, or inland saltgrass). Depending on the grass to be planted, determine spacing for the plugs. Typical spacing is 12ò on center. Create a grid or place the plugs in a grid, with triangular spacing. Plant plugs no deeper than found in the container. Weed control is necessary between the plugs until ground cover has been achieved. Be sure to read the herbicide label to determine compatibility with plugged conversion species.
4. Irrigation should begin immediately following sod or plug installation. Application of a pre-emergent can reduce annual weed competition. See typical establishment irrigation schedules in Appendix C.

B.5 Conversion Method 5: Vegetation Removal by Solarization Followed by Aeration

Organic vegetation removal option, suitable for sites with little public access.

Instead of herbicide treatment, turfgrass areas can be smothered under tightly applied clear plastic. Days should be fairly consistently over 80 degrees. Full sun exposure is required for the area for 6 to 8 hours a day. June is usually a good time to initiate this treatment. The turf should be in active growing condition at start of treatment for best results. Allow 6 to 8 weeks for a full kill. In areas with legume such as clover, additional herbicide treatment will be necessary to kill vegetation in this plant family (legumes). Limited follow up treatment with a broad spectrum herbicide can be used to help eliminate any remaining living vegetation.

Recommended for conversion of:

- Sites where organic alternative is desirable or necessary
- Smaller irrigated sites
- Conventional turfgrass to alternate turfgrass
- Conventional turfgrass to wheatgrass mix (use very thorough aeration)
- Conventional turfgrass to native turfgrass
- Areas with good soil (few amendments required)
- Private home landscapes

Not recommended for conversion of:

- Large public areas with frequent use and good access.
- Areas under trees and shrubs (Note: solarization may damage shallow roots and will prevent oxygen and moisture access for several weeks during the summer; it can kill trees.)
- Exposed sites which may be damaged in the wind
- Site shaded by structures several hours a day

1. Install separate irrigation zone for all pre-existing shrub and tree beds prior to conversion. Designate areas under trees and five feet beyond canopy edge for conversion to a mulched bed. Remove turf under trees and shrubs with broad spectrum herbicide (Roundup® or equivalent chemical, see Conversion Method B.1). Irrigation under trees should continue or be only briefly interrupted. Complete mulch installation once turf is dead.
2. For turf areas, remove all sticks or objects which can puncture the plastic.
3. Mow the site closely (low) to reduce grass stubble, if present.
4. Dig a 6 inch trench around perimeter of entire treatment area.

5. Water site well to moisten to a depth of 6 inches or greater. Be sure to water trees and shrubs thoroughly at this time.
6. Wait about two days to allow the site to dry enough for solid footing, if necessary.
7. Spread clear UV resistant plastic sheeting (3 to 6 mil thickness) over the site, pull tight.
8. Overlap seams at least 6 inches and secure with 8 inch landscape staples 12 to 18 inches on center to hold seam tightly to soil surface. Cover staples and seam edge with duct tape to cover puncture holes and seams to reduce moisture loss.
9. Extend the plastic at least 8 inches beyond the outer trench and refill the trench with soil or sand to hold plastic edge securely.
10. If the area has public access, place a construction fence with public signage around margin to prevent foot traffic across plastic, as any tears will diminish the success of this treatment. Repair any tears promptly with duct tape.
11. Remove plastic after 6 to 8 weeks. For better weed control, do not till the area to reseed, but use an aerator/seed method (Conversion Method B.1). Weed seeds which are more than 4 inches underground (and any clover or other legume family species) may still be viable.
12. Completion Methods:
    A. For aeration and seeding method follow items 5 to 10 in Conversion Method B.1. (Aeration method is better if seeding will occur under any tree canopies.)
    B. For tilling and seeding method follow Conversion Method B.2, items 5 to 12. Do not till under trees and shrubs, as damage to roots can occur. If permanent mulch beds are not to be installed, use aeration under tree and shrub canopies to prepare for seeding. If possible install separate irrigation zones and permanent mulch beds in tree and shrub areas.

B.6 Conversion Method 6: Vegetation Removal by Sheet Mulching or Composting

Organic vegetation removal option, suitable for smaller sites with little public access.

Sheet mulching or composting is another possible means of non-toxic vegetation removal. Where herbicide use is not desirable, turf can be smothered under a thick cover of mulch. This method is well suited to smaller areas such as private landscapes or where organic or textural soil amendments would be beneficial. This mulching treatment requires several layers of paper or cardboard and an ample supply of organic compostable materials. June is usually a good time to initiate this treatment. The turf should be in active growing condition at start of treatment for best results. Allow at least 4 to 6 weeks for a full turf-kill. Limited follow up treatment with a broad spectrum herbicide can help eliminate any remaining living vegetation. Areas under the tree and shrub canopies can be killed with a broad spectrum herbicide or mulched to kill turfgrass, but should be watched carefully. Use a lesser depth of mulch (6 inches) in areas under trees and be sure to continue occasional irrigation.

Recommended for conversion of:

- Smaller irrigated or non-irrigated sites
- Sites where soils would benefit from significant amendment (clay or sandy soils)
- Sites where a non-chemical alternative is desirable or necessary
- Areas under trees and shrubs (these areas must be treated somewhat differently than turf areas, see below)
- Private home landscapes
- Areas with access to large amounts of organic matter

Not recommended for conversion of:

- Larger public areas with frequent use and good public access.
- Exposed sites which are exposed to strong winds
- Linear areas such as tree lawns (mulch is more likely to blow free from narrow sites)

1. Designate areas under trees and five feet beyond canopy edge for final conversion to mulched bed. Turf under trees and shrubs can be mulched with a lighter mulch layer (6 inches) with careful monitoring or turf can be removed with a broad spectrum herbicide (Roundup® or equivalent chemical, see Conversion Method B.1). Irrigation under trees should continue or be only briefly interrupted. Complete mulch installation once turf is dead.
2. The turf must be in active growing condition, and recently irrigated, but not soggy or saturated at initiation of this treatment.

3. On a windless day, place at least five layers of overlapping moist newspapers, craft paper or two layers of overlapping non-waxed corrugated cardboard over the entire lawn to be removed. Wetting the papers helps reduce the tendency for them to blow away and speeds their decomposition. Overlapping the layers assures more complete removal of the underlying turf.
4. Cover the papers with alternating layers of nitrogen rich materials such as lawn clippings or composted manure, with coarser layers of straw, pine needles or shredded leaves. Avoid use of fresh manure, clippings from lawns with stolons (buffalograss or bermudagrass), weedy grasses such as quackgrass with roots, hay or weedy clippings with seed heads, or larger coarse sticks and branches, which decompose slowly. Application of an organic fertilizer will aid in decomposition, if manure or grass clippings are limited. The pile should be 12 to 24 inches thick at the start of decomposition.
5. Surrounding the area with construction or snow fence will help reduce wind velocities across the mulch pile, and help to keep it in place.
6. Occasional overhead irrigation will remoisten the pile and keep the decomposition process active.
7. Allow 4 to 6 weeks for a full kill. Check the much pile for level of decomposition; the organic matter should be moist, darker in color, and soft. If the mulch is not decomposing, top-dress the pile with an organic nitrogen fertilizer and irrigate very well to soak thoroughly. Sand may be added to the top to help hold down the mulch pile, retain moisture in the organic layers, and improve the soil.
8. Once the materials in the mulch pile are turning dark and breaking down, follow Conversion Method B-2; items 5 to 12 after the turf-kill for tilling and seeding.
9. Do not till under trees and shrubs, as damage to roots can occur. If possible install separate irrigation zones and permanent mulch beds for tree and shrub areas. If areas are to be seeded, use aeration under tree and shrub canopies to prepare for seeding.

APPENDIX C

Establishment Irrigation Programs

APPENDIX C Establishment Irrigation Programs

Germination and first year irrigation programs

(Long term irrigation schedules are presented in Appendix D. Further establishment period information is presented in Section 8.0.)

During early establishment, irrigation frequency should be greater than that for mature established areas. The different irrigation programs provided below are designed to assist with germination and encourage deeper root development as the seedling plants develop. Establishment irrigation schedules sometimes exceed municipal watering ordinances. If this is the case, it may require application for a short term variance for the period of establishment. Proper seedbed preparation will improve infiltration rates and reduce runoff water loss. An adequate mulch application after seeding will help retain soil moisture longer between watering cycles.

Seedling germination occurs very near the soil surface. Maintaining adequate surface soil moisture during the first few weeks of growth is the goal of early establishment irrigation programs. Regular adjustments in frequency and duration of irrigation cycles throughout the first growing season are necessary to encourage continued development of greater rooting depths. This will help achieve a drought tolerant landscape. Incremental irrigation adjustments will result in reduced water consumption. **Failure to monitor and adjust irrigation cycles to the needs of the developing grasses over time can result in a less successful conversion project.**

Soil moisture depth is the critical variable during establishment irrigation. Frequency and duration of the cycles should result in the targeted soil moisture depth. During the first year (or two), irrigation frequencies will be gradually decreased. Widely spaced irrigation cycles allow the surface soils to dry out between applications, encouraging roots to follow the soil moisture to greater depths. Each watering cycle needs to be longer in order to recharge deeper soil moisture reserves. Application of the necessary quantity of water, through two to three shorter cycles or ósplitô cycles, allows time for infiltration. This should reduce run off and water loss. The

irrigation schedule run time per zone may need to be adjusted to reduce or increase the water applied to obtain the recommended results.

Irrigation technicians may need to fine tune the typical schedules provided below depending upon the individual siteôs characteristics, which include: degree of slope, aspect, soil type, ambient temperature (in urban settings), and seasonal weather differences.

C.1 Irrigation Head Types

Effect on irrigation zone run time

Generally, **rotor** (large area) heads apply approximately 0.3ò to 0.5ò of water per hour. During initial establishment of a seeded area (germination), each cycle should be 20 to 30 minutes in duration. This should be long enough to keep the soil surface moist, but not create runoff. Later, long term maintenance run times may be 45 to 60 minutes three times per week, depending on the irrigation head model and nozzle. For accurate and specific precipitation rate information for each head and nozzle, refer to the irrigation head manufacturerôs catalog or contact the irrigation distributor.

The **pop-up spray heads** used in smaller areas will generally apply about 1.5ò of water per hour. For establishment, the multiple cycles should be less than 5 minutes each to avoid runoff. Later, long term maintenance run times should not exceed 7 to 10 minutes, with 2 or 3 cycles per water night, three times or less per week. For accurate and specific precipitation rate information on each nozzle, refer to the irrigation head manufacturerôs catalog or contact the irrigation distributor.

C.2 Establishment Irrigation Programs

These tables assume the following:

- Cool season seed installation will occur by late March or early April.
- Warm season or native prairie/grassland seed mixture installation will occur by May 15th.

- Irrigation zone run times will be adjusted depending on irrigation head and nozzle type (See C.1.0).
- Irrigation program can be adjusted for site specific conditions, including high spring soil moisture or dry spring conditions, site exposure, soil type, precipitation, current day time high temperatures and wind conditions, ambient reflected heat from adjacent buildings and/or pavement. If the program is modified due to unusually dry or wet conditions, be sure to monitor closely and adjust as conditions change.

C.2.1 Cool Season Grass Establishment Irrigation Program

Germination and first year irrigation program for fine fescue, tall fescue, and wheatgrass mixtures.

Cool season grasses can initiate growth readily in early spring if seeded by mid March. Earlier seeding (fall through winter, as conditions permit) will permit the seed bed to resettle and encourage earlier germination with less water usage. For best water savings do not hydroseed; instead, drill or broadcast and harrow separately and then apply adequate hydromulch for longer soil moisture retention.

Table C.2.1

COOL SEASON SEEDED TURF AND GRASSLAND ESTABLISHMENT IRRIGATION SCHEDULE (FINE FESCUE, TALL FESCUE, WHEATGRASS MIXTURES)			
DATE	FREQUENCY	TARGETED SOIL MOISTURE DEPTH	IRRIGATION START TIMES AND DURATION
April 1 to 30 (until substantial germination)	3 times per day for 3 to 4 weeks	Maintain moisture at surface and in upper inch of soil; check moisture depth daily, do not saturate or puddle	6 AM, 12 noon, 8 PM (single short cycles)
May 1 to 15	nightly for 2 weeks	Maintain moisture to 2 inches; check moisture depth twice weekly	10 PM or later, 1 split cycle* per watering night, slightly increased run time to provide moisture to depth
May 16 to 31	Alternate nights for 2 weeks	Maintain moisture at 3 inches; check moisture depth twice weekly, surface soils can dry somewhat between waterings	10 PM or later, 1 split cycle* per watering night, slightly increased run time to provide moisture to desired depth
June 1 to September 30 (until end of irrigation season)	3 nights per week	Moisture to 6ò; check moisture depth weekly, surface soils can dry between waterings	10 PM or later, 1 split cycle* per watering night. Adjust zone run times to provide moisture to desired depth. Run times can increase with high summer temperatures.
*split cycle is a cycle divided into 2 or 3 shorter portions which jointly deliver the desired full run time for the cycle, but allow at least 2 hours between the divided cycle segments for infiltration, in order to reduce run off water loss. The ócycle and soakô feature of newer irrigation controllers can accomplish this.			

C.2.2 Warm Season Grass Establishment Irrigation Program

Germination and first year irrigation program for buffalograss, blue grama, bermudagrass, inland saltgrass, and native prairie mixtures.

Warm season grasses initiate growth as soils warm in May and June. Like cool season grasses, warm season grasses can be seeded later, but it is possible to save establishment water if areas are seeded between October and mid-March. Earlier seeding (fall through winter, as conditions permit) will permit the seed bed to resettle with winter and precipitation, supporting germination with less water usage. Do not use hydroseeding to install seed, as this leaves it on or above the soil surface and vulnerable to desiccation. Always apply adequate hydromulch to extend the time of adequate soil moisture between watering cycles, resulting in less water consumption.

Native prairie or native grassland seeded areas can be irrigated during establishment to improve densities and infill rates. Adjust irrigation cycle times based on irrigation head and nozzle size (Appendix C.1.0). An irrigation program following the table below will improve seeding results, especially in the event of a dry establishment year. Native seeded areas in urban settings have higher evapotranspiration rates than rural prairie areas. It is recommended that permanent irrigation systems be installed to provide establishment and long term maintenance irrigation. (Appendix D).

Table C.2.2

WARM SEASON SEEDED TURF AND NATIVE PRAIRIE OR GRASSLAND ESTABLISHMENT IRRIGATION SCHEDULE (BUFFALOGRASS AND OR BLUE GRAMA, AND OTHER NATIVE WARM SEASON GRASS DOMINATED MIXTURES)			
DATE	FREQUENCY	TARGETED SOIL MOISTURE DEPTH	IRRIGATION START TIMES AND DURATION
May 15 to June 15 (until substantial germination)	2 times per day for 3 to 4 weeks	Maintain moisture at surface and in upper inch of soil; check moisture depth daily, do not saturate or puddle	8 AM, 8 PM (single short cycles)
June 16 to 30	2 to 3 watering nights per week	Moisture to 2 inches; check moisture depth twice weekly, surface soils can dry slightly between waterings	10 PM or later, 1 split cycle* per watering night. Adjust zone run times to provide moisture to desired depth. Run times can increase with high summer temperatures.
July 1 to 31	1 to 2 watering nights per week	Moisture to 3 inches; check soil moisture twice weekly, surface soils can dry between waterings	10 PM or later, 1 split cycle* per watering night. Adjust zone run times to provide moisture to desired depth. Run times can increase with high summer temperatures.
August 1 to 31	1 watering night per week	Moisture to 6ò; check moisture depth weekly, surface soils can dry between waterings	10 PM or later, 1 split cycle* per watering night. Adjust zone run times to provide moisture to desired depth. Run times can increase with high summer temperatures.
September 1 to 15	1 watering night alternate weeks as nights cool	Maintain deep moisture to 6ò; check moisture depth weekly	10 PM or later, 1 split cycle* per watering night. Adjust zone run times to provide moisture to desired depth. Run times can decrease with cooler temperatures.
September 16 or later (as nights cool below 40 degrees F)	Withhold further irrigation		
*split cycle is a cycle divided into 2 or 3 shorter portions which jointly deliver the desired full run time for the cycle, but allow at least 2 hours between the divided cycle segments for infiltration, in order to reduce run off water loss. The ócycle and soakô feature of newer irrigation controllers can accomplish this.			

APPENDIX D

Long Term Irrigation Schedules

APPENDIX D Long Term Irrigation Schedules

Maintenance irrigation programs

The modified Kentucky bluegrass irrigation program and several typical long term irrigation schedules are provided below. These tables should be used as a starting point for the year after establishment for each conversion area or type. Individual sites and seasonal weather conditions can require some adjustment of these irrigation schedules. This level of adaptive management based on site requirements will provide better results. Adjust irrigation cycle times based on irrigation head and nozzle size (Section 7.3 and Appendix C.1.0).

D.1 Modified Kentucky Bluegrass Turf Irrigation Programs

The following two irrigation programs are provided to assist with achieving water savings on conventionally irrigated Kentucky bluegrass turf. Turf areas accustomed to 37 inches of water per year can apply the fully modified long term irrigation program (D.1.2). Areas exceeding 40 inches or more of irrigation may want to apply the transitional turf irrigation schedule for at least one year to reduce stress on the turf. These programs are designed to encourage deeper rooting of the existing bluegrass, which will improve drought tolerance and water use efficiency. For best results the bluegrass turf selected for the modified long term irrigation program should first be well aerated and fertilized. Late fall or very early spring are the preferred times for aeration and root recovery. Heavily irrigated turf on clay soils may require a longer transition time for roots to penetrate to depth. A second transitional year with fall aeration and light fertilization and may improve results in clay soil areas.

Water requirement for each program and potential water savings are also provided. Modified irrigation rates are based on Denver Waterôs calculations, which are discussed in Section 4.1.

D.1.1 Transitional Kentucky Bluegrass Turf Irrigation Schedule

For gradually weaning heavily irrigated bluegrass (accustomed to 40 irrigation or more)

Water required: 39” per year

This one year transitional irrigation program is provided to help ease conventional bluegrass turf toward the modified irrigation program in D.1.2, below. For best results, this program requires adjustment of the irrigation program twice during the summer (July 1 and September 1). Implementation of the transitional irrigation program will help wean existing turfgrass off heavier watering rates of 50ò or more per year, thereby reducing the shock and brown out phase of going directly to a modified bluegrass irrigation program, provided below.

Table D.1.1

TRANSITIONAL KENTUCKY BLUEGRASS IRRIGATION SCHEDULE (YEAR 1 OF REDUCED IRRIGATION)			
DATES	FREQUENCY	WATER QUANTITY	IRRIGATION START TIMES AND DURATION
April 1 - June 30	2 watering nights per week	0.75"/cycle	10 PM or later, apply in 1 or 2 split cycles.
July 1- August 31	2 watering nights per week	1.0"/cycle	10 PM or later, may apply as a split cycle.
Sept 1 - Sept 30	1 watering night per week	1.25ò per cycle	10 PM or later, may apply in 2 or 3 split cycles.
October 1	discontinue irrigation for the winter		
*split cycle is a cycle divided into 2 or 3 shorter portions which jointly deliver the desired full run time for the cycle, but allow at least 2 hours between the divided cycle segments for infiltration, in order to reduce run off water loss. The ócycle and soakô feature of newer irrigation controllers can accomplish this.			

D.1.2 Modified Kentucky Bluegrass Turf Long Term Irrigation Schedule

Irrigation water required: 30 to 32" per year
Potential water savings 19%

The modified Kentucky bluegrass irrigation program is provided to achieve water savings on existing Kentucky bluegrass turf. For best results this conversion to a more drought tolerant bluegrass turf should be initiated in the fall and followed by a full year of transitional irrigation (see D.1.1 above). Annual fall aeration and light fertilization can help encourage continued deeper rooting. Under this schedule, if the bluegrass turf shows water stress as darkening of the grass blades, the transitional program can be returned to for a short time. During the first few years, the application of the optional irrigation program for July and August (see D.1.2) may be necessary to prevent discoloration of the turf in mid summer. Re-adjustment of the program in early September is essential to continue to encourage deeper rooting.

Table D.1.2

MODIFIED KENTUCKY BLUEGRASS LONG TERM IRRIGATION SCHEDULE			
DATES	FREQUENCY	WATER QUANTITY	IRRIGATION START TIMES AND DURATION
April 1 - Sept 31 (See optional adjustment below)	1 watering night per week	1.25"/cycle	10 PM or later, apply as 2 or 3 split cycles*, on 1-2 consecutive l nights.
Optional adjustment July 1- August 31	*1 watering night per week*	*1.5 - 1.75"/cycle*	*Optional increase for peak ET in July and August. 10 PM or later, apply as 3 split cycles on 1 or 2 sequential nights. Reduce back to 1.25" per cycle for September.*
October 1	discontinue irrigation for the winter		
*split cycle is a cycle divided into 2 or 3 shorter portions which jointly deliver the desired full run time for the cycle, but allow at least 2 hours between the divided cycle segments for infiltration, in order to reduce run off water loss. The ócycle and soakô feature of newer irrigation controllers can accomplish this.			

D.2 Alternative Mowed Turfgrass Long Term Irrigation Programs

D.2.1 Cool Season Mowed Turfgrass Long Term Irrigation Program

Typical irrigation program for mowed fine fescue, tall fescue and wheatgrass turfgrass.

Irrigation water required: 22 to 26" per year.
Potential water savings of 41 to 43%

Cool season grasses differ from conventional turfgrass in rooting depths, evapotranspiration rates (ET), and thus water requirements. A typical program is provided below as a starting point. Each species and particular location can require slightly more or less irritation. Regular monitoring should check for soil moisture at a 6 to 12 inch depth. If soils are not maintaining moisture at this depth, adjust the program to apply slightly more water on the watering night. Add additional water by increasing duration of overall watering time, which could require adding a third cycle (split cycle) on watering nights. Two consecutive watering nights can be used, if necessary to apply the split cycles. For best drought tolerance, do not increase cycle frequencies.

Table D.2.1

COOL SEASON TURFGRASS LONG TERM IRRIGATION SCHEDULE (MOWED LAWNS)			
DATES	FREQUENCY	WATER QUANTITY	IRRIGATION START TIMES AND DURATION
April 15- May 15 (as turfgrasses begin to green up)(See optional adjustment below)	1 watering night per week	1.0ò per cycle	10 PM or later Apply as 1 or 2 split cycles* per watering night. (Run times may increase with unusually dry/hot spring conditions.)
May 16 to October 1)(See optional July/August adjustment below)	2 watering nights per week	0.5ò per cycle (1.0ò per week)	10 PM or later 1 cycle per watering night with zone run times based on site specific water needs. (Run times may increase with unusually dry/hot summer conditions.)
Optional adjustment *July 1- August 31*	*2 watering nights per week*	*1.0" per cycle*	*Optional increase for peak ET July/August. 10 PM or later, apply as 2 split cycles Reduce in September.*
October	discontinue irrigation for the winter		

*split cycle is a cycle divided into 2 or 3 shorter portions which jointly deliver the desired full run time for the cycle, but allow at least 2 hours between the divided cycle segments for infiltration, in order to reduce run off water loss. The ócycle and soakô feature of newer irrigation controllers can accomplish this.

D.2.2 Warm Season Mowed Turfgrass Long Term Irrigation Program

Irrigation program for mowed buffalograss, bermudagrass, blue grama, inland saltgrass.

Irrigation water required: 16" per year
Potential water savings: 57%

Warm season grasses initiate spring green up later than cool season grasses. Good soil moisture encourages spring leaf growth. In dry spring years, the recommended irrigation rate might double to charge the deeper soil levels with moisture. In wet springs, no irrigation may be required until June. The summer program can be infrequent but generous enough to keep the deeper soil levels moist. A typical program is provided below as a starting point. Each species and particular location can require slightly more or less irrigation. Regular monitoring should check for soil moisture at a 6 to 12 inch depth. If soils are not remaining moist at this depth, apply slightly more water on the watering nights. Do this by increasing duration of the zone run time or adding a third cycle (split cycle) on watering nights. The irrigation frequency should not be increased. In the case of a cool or wet summer season, it is possible to reduce irrigation frequency. Restore the original program when dry or hot conditions return.

Table D.2.2

WARM SEASON TURFGRASS LONG TERM MAINTENANCE IRRIGATION SCHEDULE			
MONTH	FREQUENCY	WATER QUANTITY	IRRIGATION START TIMES and SCHEDULE
May 15- Sept 15	2 water nights per month.	1.0" per cycle	10 PM or later Apply as 1 or 2 split cycles* per watering night with zone run times based on site specific water needs. (Run times may increase with unusually dry/hot summer conditions, decreasing again with cooling fall weather.)
September 16	discontinue irrigation for the winter		

*split cycle is a cycle divided into 2 or 3 shorter portions which jointly deliver the desired full run time for the cycle, but allow at least 2 hours between the divided cycle segments for infiltration, in order to reduce run off water loss. The ócycle and soakô feature of newer irrigation controllers can accomplish this.

D.3 Alternative Unmowed Grassland and Prairie Long Term Maintenance Irrigation Programs

D.3.1 Cool Season Grassland Long Term Maintenance Irrigation Program

Typical irrigation program for low maintenance unmowed fine fescue and wheatgrass mixtures.

Irrigation water required: 11" per year
Potential water savings: 70%

Low maintenance or infrequently mowed grasslands require less irrigation and maintenance to remain healthy. Without the stress due to mowing, this vegetation can be very drought tolerant.

Table D.3.1

COOL SEASON GRASSLAND LONG TERM MAINTENANCE IRRIGATION SCHEDULE			
MONTH	FREQUENCY	WATER QUANTITY	IRRIGATION START TIMES AND DURATION
April 1 to Sep 15	2 watering nights per month	1ò per cycle	10 PM or later Apply as 1 or 2 split cycle* per watering night with zone run times based on site specific water needs. (Run times may increase with unusually dry/hot summer conditions.)
September 16	discontinue irrigation for the winter		

*split cycle is a cycle divided into 2 or 3 shorter portions which jointly deliver the desired full run time for the cycle, but allow at least 2 hours between the divided cycle segments for infiltration, in order to reduce run off water loss. The ócycle and soakô feature of newer irrigation controllers can accomplish this.

D.3.2 Native Shortgrass Prairie Long Term Maintenance Irrigation Program

Typical irrigation program for native shortgrass prairie or salt tolerant grasses.

Irrigation water required: 5.25 to 7" per year
Potential water savings: 81 to 86%

Shortgrass prairies can survive with no additional water in rural open space settings. However, in urban and suburban settings these grasses can be irrigated on a limited program to maintain a greener appearance throughout the summer heat. Water should be applied infrequently, but in adequate quantities to soak deeply into the soil (6ò or more). Sandy soil areas will need the same amount of water applied in more frequent, but shorter cycles, as water infiltrates into the sandy soil faster than through loam or clay soils.

Table D.3.2

NATIVE SHORTGRASS PRAIRIE MAINTENANCE IRRIGATION SCHEDULE			
MONTH	FREQUENCY	WATER QUANTITY	PREFERRED TIMES OF DAY
May 15 to Sept 15	2 watering nights per month.	0.75 to 1.0" per cycle	10 PM or later Apply as 1 or 2 split cycles* per watering night with zone run times based on site specific water needs. (Run times may increase with unusually dry/hot summer conditions, decreasing again with cooling fall weather.)
September 16	discontinue irrigation for the winter		

*split cycle is a cycle divided into 2 or 3 shorter portions which jointly deliver the desired full run time for the cycle, but allow at least 2 hours between the divided cycle segments for infiltration, in order to reduce run off water loss. The ócycle and soakô feature of newer irrigation controllers can accomplish this.

D.3.3 Native Midgrass Prairie Long Term Maintenance Irrigation Program

Irrigation water required: 8 to 10” per year
Potential water savings: 73 to 78%

Midgrass prairies can survive with no irrigation. However, a limited irrigation program will maintain denser growth through the summer heat. This is critical for seeded prairies in urban/suburban settings, which are hotter and drier that rural open space areas. Irrigation should not be overdone, as this encourages weediness. Water should be applied infrequently, but in adequate quantities to soak deeply into the soil (6ò or more). Sandy soil areas will need the same amount of water applied in more frequent, but shorter cycles.

Table D.3.3

NATIVE MIDGRASS PRAIRIE MAINTENANCE IRRIGATION SCHEDULE			
MONTH	FREQUENCY	WATER QUANTITY	PREFERRED TIMES OF DAY
May 15 to Sept 15	2 watering nights per month.	1.0 to 1.25" per cycle	10 PM or later Apply as 2 or 3 split cycles* per watering night with zone run times based on site specific water needs. (Run times may increase with unusually dry/hot summer conditions, decreasing again with cooling fall weather.)
September 16	discontinue irrigation for the winter		

*split cycle is a cycle divided into 2 or 3 shorter portions which jointly deliver the desired full run time for the cycle, but allow at least 2 hours between the divided cycle segments for infiltration, in order to reduce run off water loss. The ócycle and soakô feature of newer irrigation controllers can accomplish this.

D.3.4 Native Tallgrass Prairie Maintenance Irrigation Program

Irrigation water required: 12 to 16" per year
Potential water savings: 57 to 68%

Native tallgrass prairies are adapted to lowland areas or sites close to the foothills where more moisture is available. Urban and suburban tallgrass should be irrigated to maintain denser growth through the summer heat. To avoid encouraging weeds, tallgrass prairies should not be excessively irrigated. Water should be applied infrequently, but in adequate quantities to keep soils moist 6 to 12ò deep). Sandy soil areas will need the same amount of water applied in more frequent, but shorter cycles.

Table D.3.4

NATIVE TALLGRASS PRAIRIE LONG TERM IRRIGATION SCHEDULE			
MONTH	FREQUENCY	WATER QUANTITY	PREFERRED TIMES OF DAY
May 15 to Sept 15	2 watering nights per month.	2ò per cycle	10 PM or later Apply as 2-3 split cycles* on 1 or 2 consecutive nights with zone run times based on site specific water needs. (Run times may increase with unusually dry/hot summer conditions, decreasing again with cooling fall weather.)
September 16	discontinue irrigation for the winter		

*split cycle is a cycle divided into 2 or 3 shorter portions which jointly deliver the desired full run time for the cycle, but allow at least 2 hours between the divided cycle segments for infiltration, can be delivered on consecutive nights in order to reduce run off water loss. The ócycle and soakô feature of newer irrigation controllers can accomplish this.

APPENDIX E

GLOSSARY

GLOSSARY

Accession: The seed or cutting source of a plant collection. Species vary slightly in their genetic make up over their area of natural distribution. A particular collection may have different characteristics, which make it better suited to a particular site or use.

Active recreational use: Uses which have more intensive impact on the vegetation in an area; including: picnicking, casual play, games, sports, and gatherings; as opposed to **passive recreational use** of a site, such as viewing while hiking on trails or sidewalks.

Adaptive management: A flexible management program developed by a well trained and skilled maintenance staff, based on regular monitoring and program adjustments in response to current and developing site conditions. **Not a set management program.** Adaptive management programs are necessary for successful maintenance of conversion areas.

Alternative turf: A species or mixture of species which require 24 to 58 percent less water and less mowing than required by a conventionally maintained Kentucky bluegrass lawn. Alternative turf types for this region can include: fine leaved fescue mix, wheatgrass mix, buffalograss and/or blue grama, improved varieties of bermudagrass, and inland saltgrass.

Anaerobic Soils: Soils which are lacking in oxygen**,** including saturated or wet soils**.**

Bioretention areas: Vegetated infiltration areas which receive runoff from roads and parking lots. These areas filter pollutants and sediment from the water. This water may be used to recharge the groundwater or be collected transported to a storm drainage system. These are often included as part of a Low Impact Development design (LID).

Broad-spectrum herbicide: An herbicide which, when applied to leaves, will kill most plants. These herbicides are often glyphosate based and are sold under a number of product names, including, but not limited to Roundup® and Rodeo®.

Bunchgrass: A grass species growth form characterized by growing as individual plants and not spreading by roots and rhizomes. Bunchgrasses reproduce by seed and generally have fibrous root systems lacking strong lateral roots and root sprouts. Bunchgrasses include: blue grama, switchgrass, and many species of fescue.

Chemical scarification: One method of breaking seed dormancy. Chemical scarification is a pre-treatment process which weakens the seed coat, speeding or improving seed germination rates. This process is usually accomplished by soaking the seed in an acid or oxidizing agent.

Conversion area: An area of conventional landscape selected for modification to a less water consumptive vegetation cover.

Conveyance capacity: The volume of water a drainage area is capable of moving (cubic feet per second or cfs) during high water events. The cross section of the drainage, as well as the vegetation within that area, affects the efficiency of drainage, or conveyance capacity.

Cool season and warm season grasses: Grasses can be divided into two groups depending upon when they initiate growth and revert to dormancy.

Cool season grasses initiate growth or ógreen upô early in the spring (March or April). If not mowed, they produce flowering stalks in May or early June. Without regular irrigation, they can become dormant in the heat of the summer. Cool season grasses will re-initiate growth in late summer or early fall as the weather cools and moisture is more available. Cool season grasses include some species of introduced turf grasses such as Kentucky bluegrass, fine fescues, as well as some native grasses, including, but not limited to: western wheatgrass, green needlegrass, and Indian ricegrass.

Warm season grasses initiate growth later than cool season grasses, generally in May. If unmowed, they produce flowering stalks in late summer. They will continue to grow and remain green through the heat of the summer. In fall, these grasses enter dormancy based on day length and soil temperature. Warm season grasses include some species of introduced

turfgrasses such as bermudagrass, as well as local native grasses such as buffalograss, blue grama, little bluestem, big bluestem and switchgrass.

Cross boundary weed control: A program of weed management created by adjacent property managers in order to share weed management goals and provide mutually beneficial weed control results.

Cycle and soak: A feature on irrigation controllers which divides the total irrigation cycle into two or more shorter cycles. This helps reduce runoff and generally results in deeper penetration of the water into the soil. This feature calculates automatically the required shorter run times to apply the required water. Before the ócycle and soakô feature was added to controllers, the same effect was possible by scheduling shorter cycles and using two or more irrigation start times.

Dioecious: A plant which produces either male or female flowers on separate plants; as opposed to **monecious** plants which bear male and female flowering parts on the same plant. Buffalograss and inland saltgrass are examples of dioecious plants. Plants with monecious flowers are more common.

Dormancy: The natural characteristic of seeds which prevents germination until the seeds have gone through a period of moist and cool conditions. Many seeds have dormancy requirements in order to prevent germination at unfavorable times for establishment.

Ecological services: Functions provided by native plant communities which include but are not limited to soil development, wildlife habitat (including food, cover, breeding areas, and nesting sites), erosion protection, water quality improvement, run off reduction, cooling, shade, oxygen production, and carbon sequestration.

Effective rainfall: Total rainfall that is available in the root zone.

Electrical conductivity (EC): A measure of soil salinity, generally reported in soils test as mmhos/cm.

Ephemeral: Short term nature, as with a small stream which flows only after showers or during snow melt and is otherwise dry.

Evapotranspiration rate (ET): The loss of water from soil by evaporation and transpiration from plants. Transpiration accounts for most of the water lost by evapotranspiration from dense turf stands. Evapotranspiration is influenced by light duration, temperature, wind, solar radiation, and air pressure.

Functional open space, functional grassland: A restored or native area which recovers from minor disturbances by self seeding or natural vegetative propagation through rhizomes and root sprout and suckering.

Groundwater: Water beneath the soil surface which forms a zone of saturated soil, which may be accessed by wells. Springs occur where the groundwater level intercepts the soil surface.

Hydromulch/hydromulching: Generally a finely ground organic product applied in a slurry with tackifier and sprayed on a seedbed after the seed is placed in the ground. Hydromulch reduces soil erosion and soil water loss.

Hydroseeding: The process of applying seed in water based slurry, which sprays the seed onto the surface of the soil. Generally, during hydroseeding a small amount of hydromulch material is mixed with the seed and water (150 pounds per acre). It is recommended to double the seeding rates when hydroseeding. This seeding method is more frequently used in turfgrass seeding.

Marine sediments (Pierre shale): A dark gray sedimentary deposit, laid down 70 to 80 million years ago. Under Denver this formation can be up to 5000 feet thick. When it occurs near the surface, salts leached from this formation may accumulate on the soil surface due to evaporation.

Mesic: Referring to soil conditions intermediate in moisture availability; as apposed to xeric (dry) or hydric (wet).

Native species: Species that were historically present in the Colorado high plains region and are adapted to a particular set of conditions characteristic of the Front Range physical environment. True native plants are those which have not been intentionally bred or modified. Nurseries and seed companies carry native species, but these plant materials may have been selected for specific or improved characteristics.

Parking strips: The small divider islands within parking lots which are sometimes vegetated.

Passive recreational uses: (See **Active recreational uses, above.**)

Porous landscape detention (PLD): A storm water collection feature or system which has a special coarse growth medium, or formulated soil, to encourage rapid infiltration of storm water. These areas can be vegetated to promote improved water quality through sediment deposit and pollutant uptake by plants. Urban Drainage and Flood Control District encourages inclusion of these and other similar infiltration systems in new development and urban renewal designs.

Rain garden: A porous vegetated landscape feature which conveys stormwater, captures pollutants and reduces run off in urban landscape design. This is a type of low impact development (LID) design.

Restoration (as in *ecological restoration*)*:* The process of actively encouraging the recovery of native plant and animal communities by reversing damage to soils, hydrology, and vegetation.

Reuse water: Post-treatment processed wastewater which may be used for landscape irrigation. This water generally has slightly elevated levels of salts, nutrients, metals and other chemicals.

Rhizome: An underground lateral stem which produces further shoots and roots at nodes. Most sod forming grasses spread by rhizomes.

Riparian: Referring to land directly adjacent to streams or lakes, often with contact to elevated groundwater conditions.

Sheet mulching: A non-chemical method for turfgrass removal, involving layering compost and other materials over existing turfgrass in order to kill it without chemical means. This method can be useful in smaller conversion areas where organic means are desirable and soil amendments would be helpful.

Sod: A grass species growth form characterized by growing from underground rhizomes and roots or above ground stolons. Sod forming grasses may reproduce by vegetative propagation from lateral rhizomes and root sprouts, as well as by seeds. Dense turfgrass species such as buffalograss, inland saltgrass, bermudagrass and Kentucky bluegrass are considered to be sod forming grasses.

Solarization: The application of heavy clear plastic sheeting to kill existing vegetation and surface seeds prior to seeding or planting conversion areas.

Split cycle: A water saving feature often found on newer irrigation controllers which helps reduce run off. This feature divides the desired irrigation run time into 2 or 3 shorter segments, separated by a lapse time to allow for water infiltration.

Sprigging: A vegetative method of plant propagation using segments of grass stolons or rhizomes. This method can be employed with inland saltgrass and bermudagrass, but is not widely used in Colorado at this time.

Stolons: Lateral horizontal stems, just above the soil surface, which form roots and other small plants at nodes. Buffalograss, bermudagrass and strawberries vegetatively propagate and spread by this method.

Stratification: The process of chemically or physically eroding the seed coat which permits moisture to enter (re-hydrate) in preparation for germination. After re-hydrating, a seed may require a further period of cool temperatures in order to ôbreakô dormancy and germinate.

Sub irrigation, (naturally occurring): A condition of vegetation which is rooted into the moist soil just above **the groundwater or water table.**

System efficiency factor: A correction or adjustment for uneven water distribution as it is applied to a site with the goal of a nearly equal amount of water deposited on each square foot of surface area. For irrigation systems, this is based on the expected uniformity of distribution pattern from the sprinkler nozzles (information generally available from the manufacturer) and the spacing of irrigation heads. Depending on the type of head, rotor vs. spray head, the nozzle efficiency can range from 45% to 75%. Precipitation is considered to be 100% efficient.

Tree lawns: The narrow landscaped area between street curb and sidewalk, similar to parking strips.

Verticutting/vertical mowing: The use of a mower with vertically operated blades or wire tines (power rake) that cut or pull into the turf perpendicular to the soil surface. This is used to remove heavy thatch on dense grasses, such as bermudagrass. Power raking and verticutting are not recommended for use on bluegrass.

Warm season grasses: (See **cool season grasses)**

Water table: The sub-surface water level below which soils become saturated by groundwater.