Protocol for Sustainable Roadsides

Williamson County

October 2010

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Preface

The purpose of the Williamson County Protocol on Sustainable Roadsides is to establish erosion and sedimentation principles and practices associated with the design and construction of Williamson County roadway projects. The guidelines, design criteria and technical specifications set forth in the Protocol address the issues of additional erosion and sedimentation controls, water quality management, protection of environmental features, and preservation of existing vegetation and existing soils not included in the standard Texas Department of Transportation (TxDOT) design criteria manual or technical specifications. The Protocol also addresses the inspection and maintenance of the items included herein by County professionals.

Best Management Practices (BMP) contained in this manual are not intended to limit the design responsibility of the design professional. Responsibility for actual roadway design remains with the design engineer.

The design factors, formulae, graphs and procedures contained in this manual are intended for use only as guides in the solution of erosion and sedimentation control during and after construction. Methods of design other than those indicated herein may be considered in those cases where experience indicates they are appropriate.

In addition to this manual, the design professional must review the Williamson County Design Criteria, TxDOT Erosion Control BMPs, standard TxDOT design criteria and technical specifications, and other documents as appropriate, to be sure they are adequate for the completed project based on the job site conditions, and the design professional is solely responsible for the designs submitted under their seal.

Williamson County Protocol for Sustainable Roadsides
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Chapter 1

Roadway Corridor Planning and Preliminary Design Protocol

CHAPTER 1

Introduction

During the commencement of a roadway project, right-of-way alignment considerations should include:

- Reduce long slopes
  Constructing roadways across steeply sloped areas increases soil disturbances, requires increased cut and fill, and contributes to high water velocities that cause erosion and sedimentation. Where possible, roadway layouts should avoid planning roads on steep slopes by designing roads to generally follow existing grades and run along ridge lines.

- Reduce disruptions to hydrological systems
  Constructing roadways across waterways increases the potential for water pollution caused by sedimentation. Where possible, roadway alignments should maintain the natural hydrological patterns.

The Sustainable Roadside Protocol includes five (5) recommended assessments and/or plans for submission to Williamson County during the preliminary planning and design phases of County roadway projects.

The five (5) assessments and/or plans for submission are:

Environmental Inventory

The Environmental Inventory guides the roadway design team to conduct an in-depth evaluation of the overall environmental conditions of the right-of-way. Environmental conditions include the drainage patterns and topography, soils, existing vegetation, site geology, aquatic features, and the land use of adjacent properties. This inventory will ensure that significant environmental features are properly considered during the design of the roadway and protected to the greatest extent possible. A thorough evaluation of the environmental features will reduce cost and time during the preparation of the roadway plans, as well as the construction and maintenance phases.

Low Impact Grading Design

The Low Impact Grading Design Plan is closely related to the Low Impact Drainage Design plan since grading impacts the overall drainage design of the right-of-way. The Best Management Practice (BMP) introduces low impact grading principles and techniques to minimize erosion and sedimentation along the right-of-way and helps roadway designers to reduce the amount of area disturbed by grading activities.

Low Impact Drainage Design

The Low Impact Drainage Design Plan is closely related to the Low Impact Grading Design Plan since the drainage design of the right-of-way must be graded to function. The BMP instructs the roadway designer to conduct a hydrology and hydraulic study of the roadside ditches and conveyance channels to determine the channel flow capacity and velocity. This BMP promotes channel design that keeps channel velocities under five feet per second (5 fps), thereby reducing

erosion potential. If velocities can not be reduced, then the appropriate BMPs should be incorporated into the roadway design.

Soils Management and Limits of Disturbance

The Soils Management and Limits of Disturbance Plan ensures that disturbance is minimized within the right-of-way to protect soils designated for vegetated cover. If areas must be disturbed, the BMP offers guidance on how to restore disturbed soils to ensure healthy plant growth.

Dynamic Erosion Control

The Dynamic Erosion Control Plan is an erosion and sedimentation methodology that corresponds to the ever changing conditions during construction activity. The goal of this BMP is a reduction of construction induced erosion and sedimentation into receiving waterways.

Roadway Schematic Design Phase

ITEM 10. ENVIRONMENTAL INVENTORY

Photo courtesy of TBG Partners

1.1 DESCRIPTION

An Environmental Inventory (EI) refers to the process whereby the design team conducts an in-depth evaluation of the overall environmental conditions of the roadway right-of-way prior to detailed roadway design. The assessment is a tool to ensure major site conditions are incorporated into the roadway design process.

1.2 DESIGN APPLICATION

A. INTENT

The goal of the Environmental Inventory is to broadly identify and evaluate the ecological systems influencing the roadway corridor to reduce cost and time impacts from a design, construction and maintenance prospective. Achieving cost reductions is a direct result of a comprehensive understanding of environmental characteristics and integrating the most appropriate construction, maintenance, and design techniques in response to those conditions.

An Environmental Inventory helps ensure environmental features and areas of ecological significance are identified to be incorporated into the design and protected to the greatest extent possible. The initial roadway design is the most appropriate time to conduct the environmental inventory. Environmental conditions adjacent to the roadway corridor should also be evaluated. The Environmental Inventory should build upon the Environmental Assessment and Environmental Impact Statement for the project.

When engineering a roadway under standard compliance requirements, environmental features are typically static. These features often include caves, springs, karst features, wetlands, and significant waterways. For the purpose of the Environmental Inventory minor drainage ways, significant tree clusters and prominent landforms should also be considered environmental features.

It is important to adequately investigate all ecological elements that contribute meaningful information to the design and function of a roadway site. An Environmental Inventory produced for a roadway project provides a broad understanding of existing environmental characteristics of the site and an opportunity for the designer to consider environmental protection and mitigation measures.

The Environmental Inventory will serve as a document identifying ecological resources and constraints that influence roadway design decisions. Additionally, the Environmental Inventory will help identify appropriate best management practices to mitigate environmental issues.

B. BENEFITS

The benefits of an Environmental Inventory:

1. Reduces financial and environmental costs by identifying and evaluating the roadway corridor's ecological systems. Cost reduction will come from a comprehensive understanding of the corridor's ecology and integrating the most appropriate construction, maintenance, and design techniques to address those conditions.
2. May reduce need for expensive and extensive erosion and sedimentation controls.
3. Enhances the aesthetic character of the roadside.
4. Potentially reduces construction time to mitigate environmental features.
5. Reduces cost and time of construction documentation to mitigate roadway impacts to environmental features.

C. LIMITATIONS

The limitation of an Environmental Inventory:

1. The Environmental Inventory should be conducted in the schematic design phase, which may add cost and time for performing the inventory, in addition to other environmental assessments currently required by TxDOT or other regulating agencies.

D. RELATED ITEMS

1. Item 11 "Low Impact Grading Design"
2. Item 12 "Low Impact Drainage Design"
3. Item 13 "Soils Management and Limits of Disturbance"
4. Item 14 "Dynamic Erosion Control Plan"
5. Item 28-1 "Maintaining Existing Vegetation"

E. REFERENCES

1. Federal Highway Administration National Environmental Policy Act
2. TxDOT Environmental Manual
3. TxDOT Stormwater Management Guidelines for Construction Activities

F. GUIDELINES

1. Pre-Design:
    a. Base Information:
        i. Conduct overlay analysis within the roadway right of way on aerial photograph(s) and topographic maps to identify potential features to investigate during the site visit.
        ii. Review aerial photograph(s), historical maps, and documents to identify environmental patterns or features. Types of maps include: Historic USGS Topographic maps, National Wetland Inventory Maps (NWI), etc.
    b. Review Environmental Compliance Documentation and Requirements:
        i. Environmental compliance documentation (i.e. TCEQ Water Pollution Abatement Plan) will often highlight individual features of merit as well as locations to assess in the field.
    c. Conduct Field Assessment:
        i. Walk the corridor with an ecologist, noting ecological conditions, features, and systems located on or related to the site and document GPS coordinates. Properly document and photograph environmental conditions. Note: Boundary survey and environmental compliance documentation does not provide the analytical data for an Environmental Inventory. However, this information can be a valuable resource in the assessment of existing corridor conditions.

2. Identify Environmental Resources and Constraints. A series of questions should be evaluated during the field assessment. Answers to these questions will provide the designers with useful information to make informed decisions in the design of the roadway and to properly incorporate appropriate Best Management Practices (BMPs) into the roadway design.

    a. Drainage Patterns and Topography:
        i. Evaluation:
            1. Do the actual site conditions correspond to the topographic and aerial information?
            2. Will roadway modifications to the topography impact offsite flow?
            3. Where does the majority of site runoff go? Is it received by a stream or lake? Does it drain across a field first?
            4. Are there opportunities for small scale storage and infiltration of roadside runoff?
            5. Is there adequate land area to mitigate high velocity and concentrated volume of runoff before releasing offsite?
            6. Is there significant incoming drainage that needs to be accommodated onsite?
        ii. BMPs associated with Drainage Patterns and Topography:
            1. Item 11 “Low Impact Grading Design”
            2. Item 12 “Low Impact Drainage Design”
            3. Item 13 “Soils Management and Limits of Disturbance”
            4. Item 14 “Dynamic Erosion Control Plan”
            5. Item 29-1 “Riparian Bioengineering”
            6. Item 32-1 “Biofiltration”

b. Site Soils:
    i. Performance
        1. Perform a general soil analysis, as specified in Item 13 “Soils Management and Limits of Disturbance”.
    ii. Evaluation:
        1. Does the site’s soil type and depth reflect the ecoregion(s) that the corridor is located?
        2. Are there areas of undisturbed native soils that can be preserved in place or stockpiled for later use?
    iii. BMPs associated with Site Soils:
        1. Item 13 “Soils Management and Limits of Disturbance”
        2. Item 14 “Dynamic Erosion Control Plan”
        3. Item 23-1 “Soil Ripping”
        4. Item 28-1 “Maintaining Existing Vegetation”
        5. Item 30-1 “Seeding for Erosion Control”
        6. Item 31-1 “Wildflower Seeding”
        7. Item 41 “Invasive Species Control”
        8. Item 42 “Reforestation”

c. Existing Vegetation:
    i. Analysis:
        1. Conduct an aerial analysis to identify areas within the right-of-way that contain stands of individual or clusters of significant trees.
        2. Walk the corridor with an ecologist or horticulturist and document dominant native species and invasive species present within the areas noted on the aerial analysis.
        3. Identify GPS coordinates of viable significant trees and record species and general health and size.
    ii. Evaluation:
        1. In what ecoregion(s) is the corridor located and how will this effect issues like infiltration, soil depth, ability of the site to recover from disturbance, rainfall patterns, etc.?
        2. How much of the corridor has native vegetation that can be preserved?
        3. How much of the corridor is dominated by invasive species?
        4. Are there significant forestry resources within the corridor that can be preserved?
    iii. BMPs associated with Existing Vegetation:
        1. Item 11 “Low Impact Grading Design”
        2. Item 13 “Soils Management and Limits of Disturbance”
        3. Item 14 “Dynamic Erosion Control Plan”
        4. Item 23-1 “Soil Ripping”
        5. Item 28-1 “Maintaining Existing Vegetation”
        6. Item 30-1 “Seeding for Erosion Control”
        7. Item 31-1 “Wildflower Seeding”
        8. Item 40 “Mowing”
        9. Item 41 “Invasive Species Control”
        10. Item 42 “Reforestation”

d. Site Geology:
    i. Evaluation:

1. Are there geologic features on or near the site that need to be preserved or protected from the impacts of construction?

ii. BMPs associated with Site Geology:
1. Item 11 "Low Impact Grading Design"
2. Item 12 "Low Impact Drainage Design"
3. Item 14 "Dynamic Erosion Control Plan"

e. Aquatic Features (Stock tanks, springs, creek crossings, etc.):
i. Evaluation:
1. What aquatic or riparian elements are on the site?
2. Does the stormwater directly enter these elements? If so, what can be done to maintain or improve water quality before it enters these features?

ii. BMPs associated with Aquatic Features:
1. Item 11 "Low Impact Grading Design"
2. Item 12 "Low Impact Drainage Design"
3. Item 14 "Dynamic Erosion Control Plan"
4. Item 29-1 "Riparian Bioengineering"
5. Item 32-1 "Biofiltration"
6. Item 41 "Invasive Species Control"
7. Item 42 "Reforestation"

f. Land Use of Adjacent Properties:
i. Evaluation:
1. What is the intended use of land adjacent to the property?
2. Will it be residential, commercial, park land, industrial, etc.?
3. How might the roadway corridor impact future uses?
4. How might future land uses impact the ecological conditions of the roadway corridor?

ii. BMPs associated with Land Use of Adjacent Properties:
1. Item 11 "Low Impact Grading Design"
2. Item 13 "Soils Management and Limits of Disturbance"
3. Item 14 "Dynamic Erosion Control Plan"
4. Item 28-1 "Maintaining Existing Vegetation"
5. Item 29-1 "Riparian Bioengineering"
6. Item 40 "Mowing"
7. Item 41 "Invasive Species Control"

G. Submittal
1. The Environmental Inventory shall be submitted to Williamson County. At a minimum the document should include the following:
a. A written summary of findings from 1.2 Design Application, F. Guidelines, 2. Identify Environmental Resources and Constraints.
b. A written summary of how these findings are intended to be addressed through the use of the Williamson County Protocol for Sustainable Roadsides.

H. Documentation on Roadway Plans
1. All significant environmental features shall be properly noted on roadway plans, profiles, SW3P, drainage plans and cross sections. Appropriate setbacks and/or protective measures shall also be properly defined.

ITEM 11. LOW IMPACT GRADING DESIGN

1.1 DESCRIPTION

Low impact grading techniques provide for optimum functionality, stormwater management, and erosion prevention capabilities of a roadway corridor.

1.2 DESIGN APPLICATION

A. INTENT

Grading impacts the rate, quantity and velocity of stormwater runoff. Conventional grading techniques often create large scale solutions that include conveying, managing and treating stormwater in large facilities located at the bottom of the macro-drainage areas. Low impact grading design promotes decentralized small-scale controls, allowing for infiltration capacity, storage and a longer time of concentration. The methods described in this section should be used in conjunction with the roadway safety requirements outlined by the Texas Department of Transportation (TXDOT) and all governing roadway authorities.

B. BENEFITS

The benefits of low impact grading include:

1. Reduces potential for erosion and sedimentation.
2. Minimizes corridor impact.
3. Enhances the appearance of the roadway corridor.
4. Reduces maintenance requirements.
5. Allows the constructed condition to better mimic the infiltration rate of pre-development conditions.

C. LIMITATIONS

The limitations of low impact grading include:

1. Potentially higher design and construction costs.
2. Constrained roadside width of a fixed right-of-way width.
3. Soil stability limitations due to slope.
4. Channel capacity will have to be verified to adequately meet the design flow.
5. May require embankment stabilizations, i.e. permanent soil retention blanket, rock gabions, or concrete.

D. RELATED ITEMS

1. Item 10 “Environmental Inventory”
2. Item 12 “Low Impact Drainage Design”
3. Item 13 “Soils Management and Limits of Disturbance”
4. Item 32-1 “Biofiltration”

E. REFERENCES

1. TCEQ Edwards Aquifer Rules
2. TXDOT Landscape and Aesthetics Design Manual
3. TXDOT Roadway Design Manual
4. Williamson County Design Criteria

F. GUIDELINES

1. Low Impact Grading Design:
   Create a grading and drainage plan that incorporates low impact grading principles. Low impact grading should reestablish the site's pre-development drainage pattern, infiltration rates, sediment loads, and outflow volumes after construction, where practical. When designing a roadway, all efforts should be made to:
   a. Incorporate small scale controls along the drainage shed to infiltrate, store and slow stormwater runoff.
   b. Design to minimize disturbance and impacts by identifying and preserving sensitive areas that affect the hydrology, including streams and their buffers, wetlands, steep slopes, highly-permeable soils, and woodlands.
   c. Minimize the amount of cut and fill required.
   d. Utilize existing flat conditions for infiltration, when possible.

2. Low Impact Grading Techniques:
   a. Reduce long drainage runs, where possible. The longer and steeper the slope, the greater the erosion potential. As a general rule, the erosion hazard will become critical if the slope lengths exceed the following values:
      i. 0% - 7% : 300 feet
      ii. 7% - 15% : 150 feet
      iii. 15% or over : 75 feet
   b. Break the drainage area into smaller, more frequent outfalls to reduce the volume of water entering receiving bodies of water.
   c. Ensure that drainage outfalls do not contribute to erosion and sedimentation on adjacent property.
   d. Minimize side slopes (cross slopes) to less than 6:1 (16%), where possible, or terrace side slope with stabilized embankments between level landings. Grade side slopes to collect runoff at the top of the slope and on each terrace level and convey to the bottom of the slope.
   e. Grade slopes to be rounded at the top and bottom of the slopes.
   f. The volume of flow in closed channels should be minimized to the greatest extent possible. Techniques that can affect and control the time of stormwater runoff concentration can be incorporated into the low impact grading design by managing flow and conveyance systems within the corridor.
   g. Swales and drainage channels should be designed with the following features:
      i. Increase surface roughness to slow velocity.
      ii. Maximize overland sheet flow conditions.
      iii. Use wider and flatter channels to avoid fast-moving channel flow.
      iv. Increase the channel flow path.
      v. Reduce channel gradients to decrease velocity.
      vi. Orient flows over pervious soils whenever possible to increase infiltration to maximize infiltration capacity.
   h. Incorporate grading techniques to slow water velocity:
      i. Channel Terracing
         Channel terracing is a method of establishing relatively flat channel runs with periodic drops to make up grade (i.e. stair steps), instead of a sustained even drop in grade. Channel terracing reduces erosion by decreasing the velocity of runoff and increasing infiltration. This increases the distance of runoff flow and translates to a higher infiltration rate.

Channel terraces are not effective on slopes comprised of sand or unstable soils. The following methodology should be followed:

(1.) Evaluate channel velocities reported in the channel hydrology and hydraulic study, refer to Item 12 "Low Impact Drainage Design."

(2.) A channel designed with a uniform slope resulting in velocities equal to or greater than five feet per second (5 fps) when vegetated should be evaluated to determine if terracing is appropriate to reduce velocities below five feet per second (5 fps). Maintain a minimum slope of 200:1 to 50:1 (0.5% - 2%).

(3.) Verify that terracing will fit within the right-of-way.

(4.) An example of terracing can be seen in Figure 1. In the example, a 3% slope has been terraced to reduce the flow of stormwater (See Williamson County Design Criteria Table 5.5b, Cross Section Elements). The 6 inch "lip" at the end of the gabion mattress creates a small stilling basin and allows for greater infiltration. The runoff will continue downstream because the gabion is permeable. A concrete or rock berm can also be used, as appropriate.

Figure 1. Channel Terracing

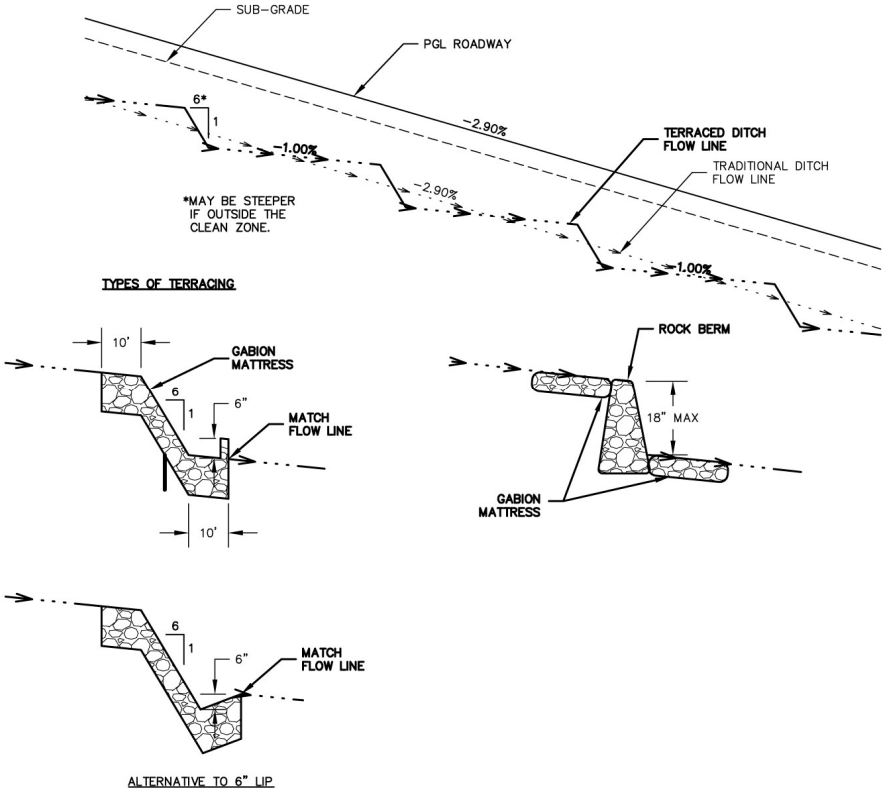


Figure by Pate Engineers, Inc.

ii. Sedimentation Features:
Capturing and holding stormwater runoff within smaller drainage basins reduces erosion and sedimentation by increasing infiltration and particle settlement and decreasing runoff volumes and velocities of water within

the drainage channels. The grading design should create micro-watersheds that allow for water holding capacity. Refer to Item 32-1 "Biofiltration." Strategies to achieve micro-watersheds include:

(1.) Temporary sediment traps that are maintained for sediment removal during construction. Sediment traps can be converted to permanent, vegetated biofiltration areas.
(2.) Depressed biofiltration areas in medians and in drainage channels.
(3.) Permanent, vegetated check dams in drainage channels.
(4.) Permanent constructed wetlands located upslope from receiving water bodies.

ITEM 12. LOW IMPACT DRAINAGE DESIGN

1.1 DESCRIPTION

Low impact drainage design includes an analysis for evaluating the hydraulic design of roadside ditch and conveyance channels, including channel flow capacity and channel velocity. Velocities equal to or greater than five feet per second (5 fps) cause erosion. Low impact drainage design analyzes the hydraulic design for opportunities to either modify the channel design to reduce the velocity or to implement appropriate BMPs to mitigate the high velocity flows.

1.2 DESIGN APPLICATION

A. INTENT

The purpose of the channel hydrology and hydraulic study is to determine the level of control required to achieve the stormwater management goals for the corridor. The required level of control may be achieved through the application of the Protocol.

Another purpose is to minimize stormwater impacts to the greatest extent practical. Maintaining the predevelopment site hydrology not only reduces downstream stormwater impacts, but also reduces and helps control localized small-scale impacts. The goal is to mimic the predevelopment hydrology by using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source.

A calculation of the water flow velocity of a channel in the design phase of a roadway project will determine if controls are needed to reduce erosion potential. If velocities are calculated at or above five feet/second (5 fps), evaluate the drainage and grading design in an effort to reduce velocities below the five feet/second (5 fps) threshold (refer to Item 11 “Low Impact Grading Design” for related information). For velocities five feet/second (5 fps) and above, incorporate appropriate temporary and permanent erosion and sedimentation control measures, as outlined in Chapter 2, “Structural Best Management Practices” to mitigate high velocity flows.

B. BENEFITS

The benefits of low impact drainage design include:

1. Early identification of areas likely to experience severe erosion problems.
2. The ability to design corrective measures to address erosion and sedimentation problems during the design phase.
3. Reduction of construction and maintenance costs by addressing erosive channel conditions within the design phase.
4. Ensuring maximum protection of the ecological integrity of the receiving waters.
5. Enhancing the local environment by managing runoff close to its source.
6. Minimizing the changes to the local hydrologic cycle.

C. LIMITATIONS

The limitations of low impact drainage design include:

1. Additional design during the roadway design phase.

D. RELATED ITEMS

1. Item 10 “Environmental Inventory”
2. Item 11 “Low Impact Grading Design”
3. Item 14 “Dynamic Erosion Control Plan “

E. REFERENCES
1. Texas Department of Transportation Hydraulic Design Manual
2. Texas Commission on Environmental Quality, Complying with the Edwards Aquifer Rules: Technical Guidance on Best Management Practices

F. GUIDELINES
1. The key to restoring the predevelopment hydrologic functions is to first minimize and then mitigate the hydrologic impacts of roadway development activities closer to the source of generation. Natural hydrologic functions such as interception, basin storage, and infiltration are uniformly distributed throughout an undeveloped site. Trying to control these functions using an end-of-pipe stormwater management approach creates substantial erosion and sedimentation issues. Hydrologic functions should be implemented using a distributed, at-source control strategy and is accomplished using micromanagement techniques throughout the site.

2. The time of concentration (Tc), in conjunction with the hydrologic site conditions, determines the peak discharge rate for a storm event. Site and infrastructure components that affect the time of concentration include:
   a. Travel distance (flow path)
   b. Slope of the ground surface
   c. Surface roughness
   d. Channel shape, pattern, and material components

3. Channel Hydrology and Hydraulic Study:
   a. Determine peak water flow rates along the channel using Rational Method or other appropriate methods as identified in the governing criteria.
   b. Divide each drainage area into sub-basins for roadside channels. Sub-basin divides should include the confluence of drainage areas and channels, driveways, pavement intersections, significant changes in slope and every 1,000 feet of drainage channel where no other sub-basin requirement exists.
   c. The design storm is the 10-year return frequency (or the channel capacity design storm required by Williamson County).
   d. Use peak flow rates to determine velocities in the channel:
      i. Use the channel slope, cross-section, and channel surface material with the peak flow rates determined above to calculate the velocity within each channel.
      ii. Use Manning's equation to determine velocity using Manning's roughness coefficients to determine both channel conditions:
         (1.) Unvegetated channel (interim condition)
         (2.) Vegetated channel (ultimate condition)
   e. Evaluate the velocities in the channel.
      i. If velocities of the vegetated channels are five feet/second (5 fps) or greater, evaluate the drainage and grading design in an effort to reduce velocities below the five feet/second (5 fps) threshold (refer to Item 11 "Low Impact Grading Design" for related information). For velocities five feet/second (5 fps) and above, use appropriate permanent erosion and sedimentation controls, preferably not vegetated channels, to permanently reduce or compensate for high velocities.

ii. If velocities of the unvegetated channels exceed four feet/second (4 fps), use appropriate temporary erosion and sedimentation controls to reduce or compensate for high velocities during revegetation.
iii. Grading design should maximize areas of sheet flow as much as possible to increase the time for runoff to reach each drainage outfall.

f. When draining runoff to offsite existing swales, channels or creeks, evaluate the effects of the runoff to minimize impacts:
i. Analyze the pre-development capacity of the receiving swale or drainage channel.
ii. Compare the pre-development capacity to the post-development capacity and flow.
iii. Incorporate appropriate BMPs to eliminate or minimize potential erosion and sedimentation on adjacent property.
iv. Determine the need for additional drainage easements, if necessary.
v. Flow velocities in areas directed to natural drainage patterns should mimic pre-development flow to minimize soil erosion potential. Methods for reducing flow velocities include installing a level spreader along the upland ledge of the natural drainage way, energy dissipaters, or by creating a flat vegetated area in the upland side of the buffer to promote sheet flow.

4. Low Impact Drainage Design Techniques:
a. Where possible, use trapezoidal channels with a flat bottom to maximize bottom width.
b. Use an array of low impact practices and best management practices to reduce velocity and cleanse stormwater runoff.
c. Design techniques implemented on small sub-catchments allow for an evenly distributed control of stormwater throughout the entire catchment area. This offers significant opportunities for maintaining the site's hydrologic functions including infiltration, basin storage, and interception, as well as a reduction in the time of concentration.

5. Submittals:
The submittal of the Low Impact Drainage Design documentation should include:
a. Drainage area map to include sub-basins with areas, flow rates and velocities. When draining to offsite areas, include the pre-development and post-development flow rates and velocities.
b. Erosion and sedimentation control plans to include location and limits of both temporary and permanent BMPs appropriate for interim and ultimate channel velocities. The BMPs recommended for Williamson County are listed in Chapter 2 in addition to the control measures outlined by TxDOT and TCEQ.
c. Roadway plans should include roadway cross sections, details and plan and profile sheets with road profile, channel profile, depth of flow, channel flow rate and channel velocity (both interim and ultimate) along the roadway and at significant grade changes.
d. Description of techniques used to minimize water velocity.

ITEM 13. SOILS MANAGEMENT AND LIMITS OF DISTURBANCE

Photo by Jim Richardson, National Geographic

1.1 DESCRIPTION

Undisturbed soils and soils restored to a healthy condition provide for effective stormwater management and erosion prevention capabilities of a roadway corridor.

1.2 DESIGN APPLICATION

A. INTENT

Healthy soils contribute to overall ecosystem health. Conventional grading and ROW preparation techniques often result in wholesale removal of vegetative cover within the ROW, often compacting and laying bare soils at the beginning of a roadway project and exposing the site to an extended period of erosion and sedimentation. Disturbed soils and vegetative cover directly impact the rate and quantity of erosion and sedimentation on a site. By designating limits of disturbance, both soils and vegetative cover are protected from construction activities. Proper management of soils in areas of disturbance results in soils restored to a healthy condition.

B. BENEFITS

The benefits of Soils Management and Limits of Disturbance include:

1. Reduces potential for erosion and sedimentation.
2. Reduces maintenance requirements.
3. Enhances the appearance of the roadway corridor.
4. Reduces costs associated with erosion and sedimentation control.
5. Increases infiltration.

6. Absorbs pollutants (grease, oil and other common hydrocarbon pollutants, pesticides, nutrients, etc.)
7. Reduces plant water usage.
8. Provides organic nutrients to plants, nutrient cycling, carbon storage and robust vegetative cover.
9. Promotes corridor impact minimization.

C. LIMITATIONS

The limitations of a Soils Management and Limits of Disturbance:

1. May require more coordination during construction activities.
2. Costs associated with tree protective structures and site disturbance protection measures.

D. RELATED ITEMS

1. Item 10 “Environmental Inventory”
2. Item 11 “Low Impact Grading Design”
3. Item 12 “Low Impact Drainage Design”
4. Item 14 “Dynamic Erosion Control Plan”
5. Item 23-1 “Soil Ripping”
6. Item 25-1 “Mulch Topdressing”
7. Item 26-1 “Compost”
8. Item 28-1 “Maintain Existing Vegetation”
9. Item 32-1 “Biofiltration”

E. GUIDELINES

1. Design:
   a. Soil testing should be conducted in the field every 1000 ft. (or more frequently as field conditions warrant) along the corridor to understand the existing soil characteristics, including data on nitrogen (N), phosphorus (P), organic matter and textural class.
   b. The Soils Management Plan should:
      i. Be created during the design phase of the project.
      ii. Indicate limits of construction disturbance to provide for the protection of healthy, intact soils and vegetated cover.
      iii. Specify the techniques and treatment of soils impacted by construction-related activities.
2. Establish the Limits of Construction / Disturbance
   a. Areas that will not be disturbed from grading and construction activities should be designated as a protected area. The protected area should be clearly marked with adequate protective fencing. Soils and existing vegetation within the area should be preserved and designated in the Soils Management Plan. Refer to Item 28-1 “Maintaining Existing Vegetation.”
3. Existing Soil Modification
   a. Construction activities will have an adverse effect on soil and plant health because of compaction and the removal of vegetative cover. When stripped of vegetation, soils are vulnerable to erosion forces and lead to silt-laden runoff during rains or storm events. To combat these effects, healthy topsoil in construction areas should:
      i. Be stockpiled and stored on-site at the beginning of construction activities, and redistributed on site after significant construction activities are completed. Refer to Item 20-1 “Topsoil.”

ii. If the soil has been compacted during construction activities, the soil may need to be ripped or structurally modified with organic matter in order to re-establish its effective soil performance. Refer to Item 23-1 'Soil Ripping."

4. Native Topsoil Retention
   a. Native undisturbed topsoil should be reused on-site, where possible. Refer to Item 20-1 "Topsoil" for stockpiling requirements. Topsoil layer and subsoil layers should be stored separately.
5. Soil Amendment and Improvements
   a. Soils adversely affected by construction related-activities should be amended to restore it to a healthy condition. Refer to Item 23-1 "Soil Ripping" and Item 26-1 "Compost."
      i. Amended soil should be protected from compaction after treatment.

ITEM 14. DYNAMIC EROSION CONTROL

1.1 DESCRIPTION

Dynamic erosion control is an erosion and sedimentation control plan that corresponds directly to construction sequencing on the site. The plan provides a methodology for controlling erosion and sedimentation for the sequential activities during the construction phase.

1.2 DESIGN APPLICATION

A. INTENT

Dynamic Erosion Control recognizes that erosion and sedimentation controls may need to vary during different phases of construction. This will ensure that erosion and sedimentation control measures are appropriate for each phase of the project.

B. BENEFITS

The benefits of a dynamic erosion control plan include:

1. Reduces the need for the installation of controls until these controls are required.
2. Increases effectiveness of the controls used by optimizing capture of runoff as drainage patterns and construction sequencing are modified.
3. Ensures appropriate protection of environmental features during construction.

C. LIMITATIONS

The limitations of a dynamic erosion control plan include:

1. Requires continuous attention and maintenance.
2. Erosion and Sedimentation Plans need to be adjusted to correspond to the construction sequence.

D. RELATED ITEMS

1. Item 23-1 “Soil Ripping”
2. Item 25-1 “Mulch Topdressing”
3. Item 26-1 “Compost”
4. Item 27-1 “Biodegradable Erosion Control Log”

E. REFERENCES

1. Texas Department of Transportation Roadway Design Manual
2. Texas Commission on Environmental Quality, Complying with the Edwards Aquifer Rules: Technical Guidance on Best Management Practices

F. GUIDELINES

1. Design:
   a. Identify construction sequencing.
   b. Limit control measures to those needed for each phase or sequence of construction.
   c. Evaluate the erosion and sedimentation control plan with respect to the construction sequence and timing. Use best management practices (BMPs) to control erosion and sedimentation during construction.
   d. Establish a phased erosion and sedimentation control plan utilizing BMPs.
   e. Actively monitor the erosion and sedimentation controls and make appropriate adjustments to conditions found on site.

2. Techniques:
    a. Designate construction staging areas and material storage areas on plans.
    b. Schedule grading and earthmoving operations to expose the smallest practical area of land for the shortest possible time. For example, one acre of exposed land will yield less sediment than two acres of exposed land, and an area exposed for three months will yield less sediment than an area exposed for six months.
    c. Apply soil erosion prevention and control practices as the first line of defense.
    d. Apply sediment control practices as a second line of defense.
    e. Staging of construction should involve stabilizing one part of the project before disturbing another.
    f. Stormwater runoff control practices. Dynamic erosion control measures should address runoff in one or a combination of the following ways:
        i. Reduction and detention of runoff
            (1.) Staging operations
        ii. Interception and diversion of runoff
            (1.) Diversion berm
            (2.) Drainage swales
            (3.) Vegetative buffers
        iii. Concentrated runoff flows
            (1.) Outlet stabilization
            (2.) Vegetative swales
            (3.) Sediment traps
            (4.) Rock berms
    g. Inspection and maintenance. A site cannot be controlled effectively without thorough, periodic checks of all erosion and sediment control practices. Modifications, repairs, cleaning or other maintenance operations should be performed expeditiously. Breaches in water handling structures should be repaired quickly.

Chapter 2

PS&E Phase Protocol: Best Management Practices Design Criteria

CHAPTER 2

Introduction

Temporary erosion controls are the first line of defense for the prevention of water pollution during construction activities. In addition, effective erosion prevention can result in cost savings, since repair of erosion damage can be minimized (TCEQ, 2005). The following temporary erosion and sedimentation controls should be used in conjunction with the Williamson County Protocol:

- **Brush Berms** - *See TCEQ, Complying with Edwards Aquifer Rules, 2005, Item 1.4.7.*
- **Check Dams** – *See Williamson County Design Criteria Manual, 2002, Item 4.3.7 and TCEQ, Complying with Edwards Aquifer Rules, 2005, Item 1.4.8.*
- **Diversion Dikes** - *See TCEQ, Complying with Edwards Aquifer Rules, 2005, Item 1.3.2.*
- **Interceptor Swales** - *See TCEQ, Complying with Edwards Aquifer Rules, 2005, Item 1.3.1.*
- **Interceptor and Perimeter Swales** - *See TxDOT, 4.0 Erosion Control BMPs, 2002, Item 4.6.*
- **Rock Berms** - *Also referred to as "Rock Filter Berms", See TxDOT, 2004 technical specification Item 506, "Temporary Erosion, Sedimentation and Environmental Controls", and TCEQ, Complying with Edwards Aquifer Rules, 2005, Item 1.4.5 and 1.4.6.*
- **Stone Outlet Sediment Trap** - *See TCEQ, Complying with Edwards Aquifer Rules, 2005, Item 1.4.12 and See TxDOT, 4.0 Erosion Control BMPs, 2002, Item 4.8.*
- **Sediment Basins** – *See TCEQ, Complying with Edwards Aquifer Rules, 2005, Item 1.4.13.*
- **Vegetative Buffers** - *See TCEQ, Complying with Edwards Aquifer Rules, 2005, Item 1.4.10.*

Permanent erosion and sedimentation controls are to be used to prevent severe erosion of the roadsides and water pollution after construction is complete. The following permanent erosion and sediment controls should be used in conjunction with the Williamson County Protocol:

- **Gabions and Gabion Mattresses** - *See TxDOT, 2004 technical specification Item 459, "Gabions and Gabion Mattresses"*
- **Riprap** - *See TxDOT, 2004 technical specification Item 432, "Riprap"*
- **Constructed Wetlands** – *See TCEQ, Complying with Edwards Aquifer Rules, 2005, Item 3.2.9.*
- **Sand Filter Systems** – *See TCEQ, Complying with Edwards Aquifer Rules, 2005, Item 3.2.6.*
- **Vegetative Filter Strips** - *See TCEQ, Complying with Edwards Aquifer Rules, 2005, Item 3.2.5.*
- **Wet Basins** – *See TCEQ, Complying with Edwards Aquifer Rules, 2005, Item 3.2.8.*

Applicability

The following best management practices (BMPs), or a combination of them, should be incorporated within the roadway design in the following conditions along Williamson County's roadsides:

1. **Applicable on all Williamson County Roadsides.** The below items should be used on all Williamson County roadways:
    a. Item 30-1 "Seeding for Erosion Control"
    Note: Seeding for Erosion Control should replace TxDOT, 2004 Technical Specification Item 164 "Seeding for Erosion Control."

2. **Applicable on all Creek/Riparian Crossings.** The below items should be used within floodplains, receiving water bodies and creek or riparian crossings, where possible:
    a. Item 27-1 "Biodegradable Erosion Control Log"
    Note: Biodegradable Erosion Control Logs should replace the use of silt fence within TxDOT, 2004 technical specification Item 506, "Temporary Erosion, Sedimentation and Environmental Controls".
    b. Item 28-1 "Maintaining Existing Vegetation"
    c. Item 29-1 "Riparian Bioengineering"

d. Item 32-1 "Biofiltration"
e. Rock Berms – *Also referred to as "Rock Filter Berms", See TxDOT, 2004 technical specification Item 506, "Temporary Erosion, Sedimentation and Environmental Controls", and TCEQ, Complying with Edwards Aquifer Rules, 2005, Item 1.4.5 and 1.4.6.*

3. **Applicable on Steep Cross Slopes.** A combination of the below items should be used to stabilize and reduce erosion on steep slopes:
    a. Item 24-1 "Soil Retention Blanket"
    b. Item 26-1 "Compost"
    c. Item 27-1 "Biodegradable Erosion Control Log"
    Note: Biodegradable Erosion Control Logs should replace the use of silt fence within TxDOT, 2004 technical specification Item 506, "Temporary Erosion, Sedimentation and Environmental Controls".
    d. Vegetative Filter Strips – *See TCEQ, Complying with Edwards Aquifer Rules, 2005, Item 3.2.5.*
    e. Interceptor Swales – *See TCEQ, Complying with Edwards Aquifer Rules, 2005, Item 1.3.1.*

4. **Suggested in High Velocity Channels.** A combination of the below items should be used to slow the velocity of water:
    a. Item 26-1 "Compost'
    b. Item 24-1 "Soil Retention Blanket"
    c. Channel Terracing – *Refer to Item 11 "Low Impact Grading Design," 1.2, F., 2., h., i.*
    d. Rock Berms – *Also referred to as "Rock Filter Berms", See TxDOT, 2004 technical specification Item 506, "Temporary Erosion, Sedimentation and Environmental Controls", and TCEQ, Complying with Edwards Aquifer Rules, 2005, Item 1.4.5 and 1.4.6.*
    e. Check Dams – *See TCEQ, Complying with Edwards Aquifer Rules, 2005, Item 1.4.8.*
    f. Brush Berms - *See TCEQ, Complying with Edwards Aquifer Rules, 2005, Item 1.4.7.*

5. **Suggested in Seeded Areas with Native Grasses.** It is recommended that the BMP below be used to promote the establishment of native grasses, particularly in locations over the Edward's Aquifer. Erosion control compost is one of the most effective erosion control measures:
    a. Item 26-1 "Compost"

6. **Suggested in Areas with Sensitive Environmental Features**. It is recommended that the below be used to protect sensitive environmental features, such as karst features, caves, springs, etc.:
    a. Item 28-1 "Maintaining Existing Vegetation"
    b. Item 27-1 "Biodegradable Erosion Control Log"
    Note: Biodegradable Erosion Control Logs should replace the use of silt fence within TxDOT, 2004 technical specification Item 506, "Temporary Erosion, Sedimentation and Environmental Controls".
    c. Diversion Dikes - *See TCEQ, Complying with Edwards Aquifer Rules, 2005, Item 1.3.2.*

Materials

ITEM 20-1. TOPSOIL

Source: Green Valley Recycling Corp.

1.1 DESCRIPTION

Topsoil is the upper layer of the soil surface which contains humus, minerals, available nutrients, and beneficial micro-organisms, resulting in a favorable condition for vegetative growth.

1.2 DESIGN APPLICATION

A. INTENT

Use topsoil as the media for revegetation.

B. BENEFITS

The benefits of topsoil include:

1. Encourages healthy and permanent vegetative growth.
2. Being readily available, whether on-site or imported.
3. Inexpensive.

C. LIMITATIONS

The limitations of topsoil include:

1. Variable quality of imported topsoil requires quality control monitoring.
2. Imported topsoil may have a seed bed of invasives.

D. REFERENCES

1. Article 7.19 “Preservation of Cultural and Natural Resources and the Environment”

E. GUIDELINES

1. Design Requirements:
   a. On-site supplied topsoil must complete the stockpiling and decomposition process before use.
   b. Specify four (4) inches of topsoil to be installed on all channels and areas with slopes from 10:1 to 3:1 that are to be revegetated. Erosion Control Compost (ECC) should be installed on top of this topsoil for erosion control. Compost manufactured topsoil (CMT) should be specified in lieu of topsoil on areas less than 10:1. Reference Item 26-1 “Compost”.

2. Materials:
   a. Use easily cultivated fertile topsoil, through fresh mining, that is free from objectionable material, such as weed seeds, roots, rhizomes, or stolons, has a high resistance to erosion, and is able to support plant growth.
      i. Obtain topsoil from the right of way at sites of proposed excavation or embankment when specified on the plans, or as directed.
      ii. Secure additional topsoil, if necessary, from approved sources outside the right of way in accordance with the requirements of Article 7.19, “Preservation of Cultural and Natural Resources and the Environment.”

3. Installation:
   a. Place excavated topsoil in stockpiles no less than three (3) feet by three (3) feet in size at designated locations within the right of way lines or as directed.
   b. From June 1 to October 15, completely turn the stockpile once per month. Internal temperature of the material should be 120-140F. Stockpile should continue to be turned and remain at this internal temperature for no less than one (1) month before use.
   c. From October 16 to May 31, if the average outdoor temperature is below 75F, remove and discard the top six (6) inches of the stockpile before use. It is not necessary to turn the stockpile during this time period.

ITEM 21-1. MULCH

Source: Hensons Mulch & More http://www.hensonsinc.charterinternet.com/hensonsinc/images/singlegrind.jpg

1.1 DESCRIPTION

Mulch is a shredded product derived from plants and available as wood chips, landscape clippings, or other locally available plant material.

1.2 DESIGN APPLICATION

A. INTENT

Mulch improves soils by adding organic matter as it decomposes, and protects soils from compaction and erosion during construction operations. Woody vegetation that is proposed to be removed from the site due to construction is the preferred source for mulch. Mulch can also be imported from off-site locations if on-site quantities are limited.

B. BENEFITS

The benefits of mulch include:

1. Serves as a recycled material of a construction activity waste product.
2. Being readily available, whether on-site or imported.
3. Inexpensive.

C. LIMITATIONS

The limitations of mulch include:

1. Difficult to calculate quantity of mulch that can be produced from on-site existing vegetation.

D. GUIDELINES

1. Design Requirements:
    a. During design phase, identify and designate areas containing on-site woody plant material which are scheduled for removal and are appropriate for mulch conversion.
    b. The Owner's Representative should conduct a field assessment of designated areas to determine whether specific areas containing invasive species or specific species found on-site should be excluded from mulching operations.
    c. Mulch stockpiles should be surrounded by biodegradable erosion control (BEC) logs to prevent runoff of material. Refer to Item 27-1, "Biodegradable Erosion Control Logs." Locations for stockpiling mulch should be approved by Engineer.
    d. Freshly shredded mulch must be stockpiled and undergo the decomposition process or the immature mulch will rob nutrients from the soil and inhibit vegetation growth.
    e. Three applications of mulch are Mulch Topdressing, BEC logs and as a component of Erosion Control Compost (ECC).

2. Materials:
    a. Mulch can be on-site shredded organic mulch or an imported organic mulch product.
        i. Mulch can be comprised of wood chips, shredded bark, shredded woody landscape trimmings, or coarse compost material originating from the 3-county Central Texas region (Williamson, Travis and Hays).
        ii. Mulch to be shredded with no pieces greater than three (3) inches in length and with all pieces passing through a two (2) to three (3) inch screen.
        iii. Invasive species should be excluded from mulch.
        iv. Color: natural wood.
        v. Contamination: less than 0.5% weight by volume.
        vi. Mulch to have undergone a decomposition process either on-site or at the supplier's location.

3. Preparation:
    a. Shred trees and vegetation to the specified size requirements.
    b. Apply Nitrogen at the rate of one (1) part Nitrogen to ten (10) parts mulch.
    c. Stockpile the mulch and allow to sit or cook for a period of no less than three (3) weeks if the temperature is above 70F. If the temperature is below 70F, extend the sitting or cooking time to five (5) to six (6) weeks.
    d. Turn the stockpile at least twice per week during the sitting or cooking period.
    e. Stockpiles should be surrounded by biodegradable erosion control logs within 24 hours of placement to prevent run-off of the material.

ITEM 22-1. VEGETATIVE WATERING

Source: TBG Partners

1.1 DESCRIPTION

Vegetative watering is temporary irrigation to aid in vegetation establishment.

1.2 DESIGN APPLICATION

A. INTENT

Vegetative watering assists in the establishment of temporary or permanent vegetation for erosion and sedimentation control. The success of vegetation establishment is dependent on adequate water application to encourage seed germination and plant growth during hot summer months or periods of drought. Irrigation water sources can be from on-site or transported from an off-site locations. Proper vegetative watering techniques avoid scouring and eroding of the roadside landscape caused by forceful watering, as can occur from a standard watering truck application.

B. BENEFITS

The benefits of applying vegetative watering:

1. Increases successfulness of vegetation establishment.
2. Decreases establishment time.
3. Drip irrigation can minimize ability of non-target species to establish.

C. LIMITATIONS

The limitations of using vegetative watering:

1. May be expensive depending on the application method used.
2. Irrigation systems may require significant maintenance.
3. Scouring damage to vegetative areas from forceful application of water truck water spray.
4. Compaction damage to vegetative areas from water truck tires.

D. RELATED ITEMS

1. Item 30-1 “Seeding for Erosion Control”
2. Item 31-1 “Wildflower Seeding”
3. Item 29-1 “Riparian Bioengineering”
4. Item 32-1 “Biofiltration”
5. Item 25-1 “Mulch Topdressing”
6. Item 26-1 “Compost”

E. GUIDELINES
1. Application:
   a. Determine vegetative watering technique most appropriate for the project, or within designated areas, of the project. If a technique is not specified, the Contractor will be responsible for determining the appropriate method:
      i. Preferred Irrigation Methods:
         (1) Temporary drip irrigation line, above ground
            (a) Application by drip irrigation allows water to be applied directly to the plant at a constant pressure and rate for each plant.
            (b) Determine the water source:
               (i) Tie into existing water supply.
               (ii) Pump water from nearby creek or river with the use of a generator.
               (iii) Tie temporary irrigation line to a water truck.
               (iv) Store water in a storage tank and locate at the highest elevation on the site. Determine if gravity flow is sufficient or if a pump is required.
            (c) Review submitted drawings prepared by Contractor to ensure full coverage of designated planted areas.
            (d) Ensure removal of the water lines and equipment after acceptance of the establishment period.

         (2) Temporary rotor or spray irrigation line, above ground
            (a) Rotor or spray irrigation to irrigate seed and/or plant stock in a large area at a constant pressure and rate to each plant or seeded area.
            (b) Determine the water source:
               (i) Tie into existing water supply.
               (ii) Pump water from nearby creek or river with the use of a generator.
               (iii) Tie temporary irrigation line to a water truck.
               (iv) Store water in a storage tank and locate at the highest elevation on the site. Determine if gravity flow is sufficient or if a pump is required.
            (c) Review submitted plans from Contractor to ensure full coverage of designated seeded or planted areas.
            (d) Ensure that the contractor removes the piping after the establishment period.

      ii. Standard Methods
         (1) Watering truck distribution

(a) Water truck distribution should be used in areas where other techniques are not feasible due to construction or cost constraints.
(b) Water truck tires should remain on the roadway pavement.
(c) Irrigation by water truck is appropriate for distribution in narrow vegetation areas.
(d) The water force should not scour or erode the soil or seeding bed or wash away seeds or plantings.
(e) The water spray should be directed upwards to distribute the water force and reduce potential erosion.

2. Materials:
   a. Review materials specified and provided by the Contractor.
   b. Measurement
      i. Vegetative watering should be quantified as its own bid item and should not be considered subsidiary to any other item.
      ii. Engineer should determine a total volume of water needed to meet the watering schedules provided in Tables 1 and 2. Irrigation application volume calculation is shown in Table 3.

Table 1: Vegetative Watering Schedule for Native Grass and Wildflower Seeding and Live Root Plantings

Time Period	Irrigation Application Amount*	Frequency**
Day of Installation	Minimum 1 inch	Min. 2 times per day
Phase 1 Next 10 days	Minimum 1 inch	Min. 1 time per day (no rain)
Phase 2 Next 14 days	Min. 1 inch or replace weekly ET	Min. 2 times per week (no rain or dew)
Phase 3 Until Plant Establishment	Min. 1.5 inch or replace weekly ET	Min. 1 time per every other week, or as necessary***

Source: Adapted from COA, 2009 & TCEQ, 2005.
Note 1: *5.6 gallons per square yard = 1 inch of applied water
Note 2: **Reduce irrigation frequency if during period of seasonal rains, since the watering frequency will greatly depend on the time of year. Deviations from the above watering schedule should be approved.
Note 3: ***Irrigation in Phase 3 should pause during the dormant season, beginning on December 15, and should be reinstated beginning February 15.
Note 4: Reference Item 30-1 "Seeding for Erosion Control" Maintenance Requirements for plant establishment specifications.

Table 2: Vegetative Watering Schedule for Planted Trees and Shrubs

Time Period	Irrigation Application Amount*	Frequency**
Day of Installation	Saturate Root Depth	Min. 1 time per day
Phase 1 - Next 14 days	Saturate Root Depth	Min. 1 time per every other day, or as necessary
Phase 2 - Until Plant Establishment	Saturate Root Depth	Min. 1 time per week, or as necessary***

Source: Adapted from COA, 2009 & TCEQ, 2005.
Note 1: *5.6 gallons per square yard = 1 inch of applied water
Note 2: **Reduce irrigation frequency if during period of seasonal rains, since the watering frequency will greatly depend on the time of year. Deviations from the above watering schedule should be approved.
Note 3: ***Irrigation in Phase 2 should pause during the dormant season, beginning on December 15, and should be reinstated beginning February 15.

Table 3: Irrigation Application Volume Calculation

Vegative Watering

Determination of Water Requirements for Grass Establishment

Summary of Assumptions:
1" of water over 1 s.y. = 5.61 gal.
Establishment period for vegetative after first 25 days = 4 months

Total S.Y. of Vegetation	X

Schedule	Amount per Application (in)	Gallons of Water Required
Day of Install	2	(X)*(2 in)*(5.61)
Next 10 Days (1x/day)	1	(X)*(1 in)*(5.61)
	1	(X)*(1 in)*(5.61)
	1	(X)*(1 in)*(5.61)
	1	(X)*(1 in)*(5.61)
	1	(X)*(1 in)*(5.61)
	1	(X)*(1 in)*(5.61)
	1	(X)*(1 in)*(5.61)
	1	(X)*(1 in)*(5.61)
	1	(X)*(1 in)*(5.61)
	1	(X)*(1 in)*(5.61)
Next 14 Days (2x/week)	1	(X)*(1 in)*(5.61)
	1	(X)*(1 in)*(5.61)
	1	(X)*(1 in)*(5.61)
	1	(X)*(1 in)*(5.61)
Until Plant Establishment (1x/2 weeks)	1.5	(X)*(1.5 in)*(5.61)
	1.5	(X)*(1.5 in)*(5.61)
	1.5	(X)*(1.5 in)*(5.61)
	1.5	(X)*(1.5 in)*(5.61)
	1.5	(X)*(1.5 in)*(5.61)
	1.5	(X)*(1.5 in)*(5.61)
	1.5	(X)*(1.5 in)*(5.61)
	1.5	(X)*(1.5 in)*(5.61)

Total Gallons	Y=(sum of gallons)

Total MG	(Y)/1000

Temporary Erosion and Sedimentation Controls

ITEM 23-1. SOIL RIPPING

Source: The Lady Bird Johnson Wildflower Center.

1.1 DESCRIPTION

Soil ripping is a treatment measure that loosens overly compacted soil.

1.2 DESIGN APPLICATION

A. INTENT

Soil ripping is the plowing or sub-soiling of the ground to alleviate compaction to allow for vegetative growth to prevent erosion in sheet flow conditions.

B. BENEFITS

The benefits of soil ripping include:

1. A low cost and practical means of reducing soil compaction.
2. Increases stormwater infiltration.
3. Provides areas suitable for vegetation to establish.
4. Can be performed on all slopes up to 3:1.

C. LIMITATIONS

The limitations of soil ripping include:

1. Ineffective on rocky slopes.
2. The maximum allowable slope for soil ripping is 3:1.

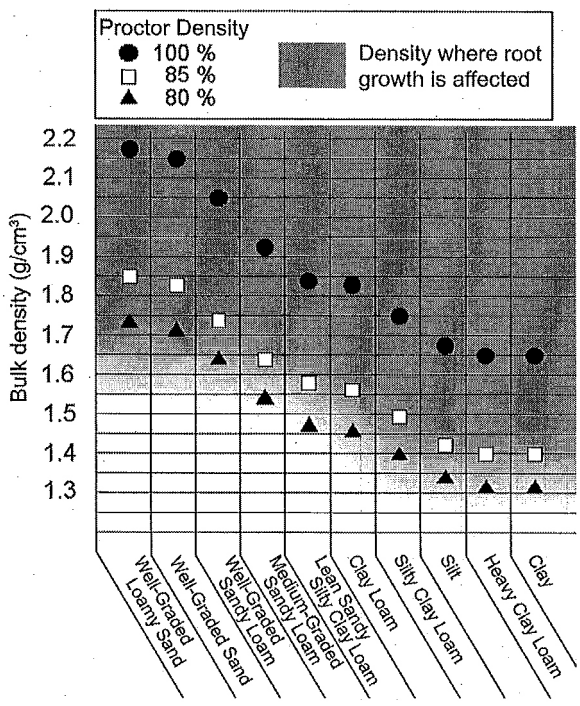
D. RELATED ITEMS

1. Item 10 “Environmental Inventory”
2. Item 11 "Dynamic Erosion Control Plan”
3. Item 25-1 “Mulch Topdressing”
4. Item 26-1 “Compost”
5. Item 27-1 “Biodegradable Erosion Control Log”
6. Item 30-1 “Seeding for Erosion Control”
7. Item 31-1 “Wildflower Seeding”

E. GUIDELINES

1. Design Requirements:
   a. Soil ripping is suitable for sloped site conditions up to 3:1.
   b. Grooves should be installed both parallel and perpendicular to slopes.
   c. Soil ripping is necessary when soil compaction levels exceed a standard proctor density of 80-85% in channels and 70-75% in non-channel areas (See Table 1). A soil density test is to be conducted and reviewed to ensure that areas are suitable for seeding in accordance with Item 30-1 "Seeding for Erosion Control."
   d. Spacing:
      Specify groove spacing on the plans depending on the slope of the area to be ripped.
      i. Slopes between 3:1 and 4:1, grooves should be sixteen (16) inches on center.
      ii. For slopes flatter than 4:1, grooves should be twelve (12) inches apart on center.
   e. Depth:
      Specify that compacted soils should be ripped to a depth of eighteen (18) inches to create a subsoil suitable for proper rooting of seeded vegetation. When embankment stabilization is a concern, ripping depth can be reduced to twelve (12) inches.
   f. Soil ripping should not be implemented within a drainage channel or in channel flow situations.

Table 1: Affects of Proctor Density on Root Growth



Note: Bulk density and levels affecting rooting compared to several Proctor densities. Note that soils to be used for most trees and shrubs should always be compacted to less than 85 percent of maximum dry density. There is limited research comparing bulk density to Proctor value, but a reasonable specification for compacting planting soil would be between 75 and 80 percent, with some settlement expected at that range. Sandier soils can be compacted up to 85 percent, with the exception of well-graded sandy soils. (Source: Data adapted from Daddow and Warrington 1983, Lichter and Lindsey 1994, and Brady et al. 1999)

2. Materials:
    a. Equipment
        i. Various types of equipment can be selected by the Contractor for soil ripping, such as a front-end loader equipped with disks, harrows or teeth.
        ii. Ensure that the Contractor is using equipment that will meet the design requirements, as stated above.

ITEM 24-1. SOIL RETENTION BLANKET

Source: TBG Partners

1.1 DESCRIPTION

Soil retention blankets are biodegradable (temporary) or permanent fabrics designed to protect soils on channels, slopes and other highly erosive areas from water and wind erosion.

1.2 DESIGN APPLICATION

A. INTENT

Soil retention blankets aid in the temporary or permanent armoring of soils in erosive channels as well as similar conditions, while assisting in the establishment of vegetation. Careful selection ensures a capability of resisting the calculated water velocities and the designed lifespan of the blanket material.

B. RELATED ITEMS

1. Item 12 “Low Impact Drainage Design”
2. Item 26-1 “Compost
3. Item 30-1 “Seeding for Erosion Control”
4. Item 31-1 “Wildflower Seeding”

C. REFERENCES

1. TxDOT/TTI, October 2009. General Product Material Descriptions, Final Performance Analysis.

D. GUIDELINES

1. Design
   a. Evaluate channel velocities as determined by the Hydrology and Hydraulic Study; refer to Item 12 “Low Impact Drainage Design,” in order to select an appropriate soil retention blanket.
   b. An application of erosion control compost (ECC) and seed mix on top of the soil retention blanket ensures the best establishment of vegetation; refer to Item 26-1 “Compost.”
   c. Specify a biodegradable (temporary) soil retention blanket in channels with water flows between two feet per second (2 fps) and five feet per second (5 fps) when vegetated.
   d. Permanent soil retention blankets are not an appropriate selection for areas that are mowed regularly and/or are mowed with a short mowing height less than six (6) inches.

2. Materials
   Specify from the following products:
   a. Biodegradable Soil Retention Blankets (TxDOT Type E)
      i. Western Excelsior Excel R-1
      ii. North American Green C125
      iii. Approved equal
   b. Permanent Soil Retention Blankets (TxDOT Type G)
      i. Landlok TRM 450
      ii. North American Green C350
      iii. Approved equal

3. Installation
   a. It is critical for the selected soil retention blanket to be installed per the manufacturer’s instructions.

ITEM 25-1. MULCH TOPDRESSING

Source: TBG Partners

1.1 DESCRIPTION

Mulch Topdressing is the application of mulch to exposed soil surfaces to protect the soils and existing vegetation from soil compaction, and to conserve soil moisture, and control soil temperature.

1.2 DESIGN APPLICATION

A. INTENT

Mulch Topdressing is used to promote infiltration, decrease runoff and protect soil surface from erosion caused by rainfall. Mulches applied to the ground surface conserve soil properties and promote vegetative growth (TXDOT Stormwater Management). Mulch applied around existing vegetation protects plant health and reduces compaction on exposed soils during construction. Mulch provides dust control and thereby assists in air quality.

B. BENEFITS

The benefits of mulch topdressing include:

1. Can be created from on-site woody vegetation scheduled for removal.
2. Effective temporary erosion control measure.
3. Reduces sheet flow velocity and soil transport from runoff.
4. Reduces dust and protects exposed soils from wind erosion.
5. Traps sediment and increases nitrogen removal from stormwater.

6. Reduces soil compaction from the impact of heavy rains and construction activities, better maintaining the health of preserved trees and other vegetation.
7. Insulates soils against extreme temperatures.
8. Reduces evaporation loss in exposed soils.
9. Suppresses weed growth.
10. Requires no removal, in most applications, because it naturally degrades.

C. LIMITATIONS

The limitations of mulch topdressing include:

1. It may delay seed germination.
2. May be dislodged by concentrated flows; should not be used in drainage channels.
3. May be dislodged on steep slopes; should not be used on slopes greater than 3:1.

D. RELATED ITEMS

1. Item 21-1 "Mulch"
2. Item 28-1 "Maintaining Existing Vegetation"

E. GUIDELINES

1. Design:
   a. Designate locations for stockpiling of mulch on plans or as directed. All fresh mulch must go through the stockpiling and decomposition process as specified in Item 21-1 "Mulch".
   b. Specify Mulch Topdressing in areas where native grass is inappropriate for establishment.
   c. Specify Mulch Topdressing under all driplines of existing trees with a caliper of six (6) inches or greater designated for preservation. Tree clusters should have mulch applied under the combined driplines of the trees.
   d. Specify Mulch Topdressing on construction drives.

2. Materials:
   a. On-site shredded mulch or imported organic mulch product. As specified in Item 21-1 "Mulch"

3. Installation:
   a. Apply mulch at a minimum of five (5) inches and with a maximum of eighteen (18) inches in depth under dripline of existing trees to remain with a caliper six (6) inch or greater.
   b. Apply mulch at a five (5) inch depth to inhibit invasive growth in areas where it is not feasible to establish vegetation.
   c. Apply mulch at eighteen (18) inch depth on vehicular drives.

ITEM 26-1. COMPOST

Source: H&H Wood Recyclers, http://www.hhwoodrecyclers.com/pics/Soils%20and%20Compost/Compost.jpg

1.1 DESCRIPTION

Compost is an organic material created by combining proper ratios of selected organic waste products; such as landscape trimmings, food wastes, and manures.

1.2 DESIGN APPLICATION

A. INTENT

Use compost as a soil amendment, a medium for revegetation, and a material for compost manufactured topsoil, erosion control compost, and biodegradable erosion control logs. A mix of fine and course grades of compost is best for controlling erosion.

1. The fine compost (passing through a 3/8 – ½ inch screen) will penetrate the soil surface and increase water infiltration and water holding capacity. In addition, the fine compost is essential for rapid vegetation establishment and long-term soil and plant health. The long-term nutrient value that compost supplies will come from the fine compost.
2. Coarse materials (passing through a 2 – 3 inch screen)although harder to plant into, help to prevent splashing of raindrops directly on the soil surface and are less likely to be disturbed by rainfall and storm runoff. The coarse materials also perform like filters by “stopping” or “catching” soil particles already in motion.

B. BENEFITS

The benefits of compost include:

1. Reduces the erosive impact of rainfall on exposed soil.
2. Improves water holding capacity of soil.
3. Improves the establishment of healthy, permanent vegetation that requires less maintenance.
4. Reduces pesticide use.
5. Reduces fertilizer use.

C. LIMITATIONS

The limitations of compost include:

1. May not be appropriate in situations where water quality is highly sensitive, due to the possibility of nutrient loading.
2. Variable quality of product requires quality control monitoring.
3. Limited number of vendors may result in higher transportation and material cost.

D. RELATED ITEMS

1. Item 20-1 "Topsoil"
2. Item 21-1 "Mulch"
3. Item 27-1 "Biodegradable Erosion Control Logs"

E. REFERENCES

1. United States of Federal Regulations (CFR), Title 40, Part 503 standards for Class A Biosolids.
2. Texas Commission on Environmental Quality (TCEQ) health and safety regulations, Texas Administrative Code (TAC), Chapter 332, including the time and temperature standards in Subchapter B, Part 23.
3. USCC Seal of Testing Assurance (STA) program.

F. GUIDELINES

1. Design Requirements:
   a. Determine erosion potential of soils and subsoils and slope for all areas to be revegetated.
   b. Use Compost Manufactured Topsoil (CMT) and Erosion Control Compost (ECC) for Item 30-1 "Seeding for Erosion Control".
   c. CMT should be specified for the establishment of vegetation in flat areas with a slope less than 10:1.
   d. ECC should be specified for temporary erosion control and to aid in the establishment of vegetation along road embankments, channels and all areas with slopes from 10:1 to 3:1. ECC is most effective as an erosion control measure in moderate to highly erosive soils. Specify ECC along rocky terrain, where other erosion control methods may be difficult to install (EPA, 2006). Specify ECC in areas compacted by construction activities to reduce soil compaction and assist in the establishment of vegetation.

2. Materials:
   a. Compost
      i. Furnish compost that has been produced by aerobic (biological) decomposition of organic matter and meets the requirements set forth by the United States Department of Agriculture and the United States Composting Council (USCC), "Test Methods for Examination of Composting and Compost" (TMECC), shown in 1.2F.2a (2).
      ii. Physical Requirements for Compost:

(1) Particle Size: 95% passing 5/8 in., 70% passing 3/8 in. in accordance with TMECC 02.02-B, "Sample Sieving for Aggregate Size Classification"
(2) Heavy Metals: Pass in accordance with TMECC 04.06, "Heavy Metals and Hazardous Elements"
  (a) 04.06-As, Arsenic
  (b) 04.06-Cd, Cadmium
  (c) 04.06-Cu, Copper
  (d) 04.06-Pb, Lead
  (e) 04.06-Hg, Mercury
  (f) 04.06-Mo, Molybdenum
  (g) 04.06-Ni, Nickel
  (h) 04.06-Se, Selenium
  (i) 04.06-Zn, Zinc
(3) Soluble Salts: 5.0 max.* dS/m in accordance with TMECC 04.10-A, "1:5 Slurry Method, Mass Basis" (*A soluble salt content up to 10.0 dS/m for compost used in CMT will be acceptable)
(4) pH: 5.5 – 8.5** in accordance with TMECC 04.11-A, "1:5 Slurry pH" (**A maximum pH of 9.5 will be acceptable for manure compost)
(5) Maturity: greater than 80% in accordance with TMECC 05.05-A, "Germination and Root Elongation"
(6) Organic Matter Content: 25-65%*** (dry mass) in accordance with TMECC 05.07-A, "Loss-On-Ignition Organic Matter Method" (***A minimum organic matter content of 10% will be acceptable for manure compost)
(7) Stability: less than 0.5 mg CO2 carbon/g compost carbon/day
(8) Fecal Coliform: Pass in accordance with TMECC 07.01-B, "Fecal Coliforms"

iii. Compost feedstock may include, but is not limited to, leaves and yard trimmings, biosolids, food scraps, food-processing residuals, manure or other agricultural residuals, forest residues, bark, and paper.

iv. Compost shall be reasonably free (less than 1% by dry weight) of manmade foreign matter. The organic matter shall not possess objectionable odor and shall not resemble the raw material from which it was derived. Particle size shall meet the following additional specifications: maximum particle length 0.5"

v. Ensure compost does not contain any visible refuse, other physical contaminants, or any substance considered to be harmful to plant growth, as approved by the engineer. Do not use materials that have been treated with chemical preservatives as a compost feedstock or as wood chips.

vi. Provide compost meeting all applicable United States Code of Federal Regulations (CFR), Title 40, Part 503 standards for Class A biosolids and Texas Commission on Environmental Quality (TCEQ) health and safety regulations as defined in the Texas Administrative Code (TAC), Chapter 332, including the time and temperature standards in Subchapter B, Part 23. Meet the requirements of the USCC Seal of Testing Assurance (STA) program. (TXDOT, 2004)

b. Compost Manufactured Topsoil (CMT)

CMT consists of blended compost, as specified in 1.2.F.2.a, and mineral soil. The Contractor shall determine the blend based on the compost supplier's nutrient analysis and the corresponding ratios in Table 1. The mineral soil should have a soil texture of less than 75% sand, and organic matter less than 2%. Measures must be taken to avoid weed contamination, through fresh mining, or complete cover or non-use of top six (6) inches of stockpiled material. Reference Item 160-WC 001 "Topsoil" for stockpiling specifications of on-site excavated topsoil. Material sources must be approved by the Owner's Representative. Dilution of compost must not be achieved with organic matter (mulch).

Table 1. Compost to mineral soil amendment ratios for Compost Manufactured Topsoil (CMT)

Compost Nutrient Analysis NO3, NH4, or P (available):	***Ratio (volume) compost: soil**
exceed 2000 ppm (0.2%)	1:25
are less than 2000 ppm (0.2%) but greater than 1000 ppm (0.1%)	1:20
are less than 1000 ppm (0.1%) but greater than 500 ppm (0.05%)	1:10
are less than 500 ppm (0.05%) but greater than 250 ppm (0.025%)	1:4
are less than 250 ppm (0.1%) but greater than 100 ppm (0.05%)	2:3

Source: Lady Bird Johnson Wildflower Center, 2010
*Note 1: Reference Table 2 for intended composition of CMT at final application achieved by mixing compost and topsoil at these ratios. Testing of composition at final application is not necessary. This table is for information only.

Table 2. CMT Composition at Final Application

Item	Units*	Range
Total Kjeldahl Nitrogen	$mg.kg^{-1}$	50 - 3000
Nitrate-N	$mg.kg^{-1}$	2** - 10
Ammonium-N	$mg.kg^{-1}$	2** - 10
Total Phosphorus	$mg.kg^{-1}$	5 - 1000
Available Phosphorus-P†	$mg.kg^{-1}$	5 - 50
pH		5 - 8
Salt concentration‡	$dS.m^{-1}$	<6

* $mg.kg^{-1}$ = ppm; 1% = 10,000 ppm

** Either Nitrate – N or Ammonium –N can be less than 2 mg kg^{-1} ppm provided the other form of available N (Nitrate or Ammonium) is greater than 2 mg kg^{-1}.

† P (available) by Mehlich-3 method, Bray or Olsen extraction and may underestimate actual bioavailable P. Either way P analysis must be stated.

‡ dS = deciSiemens (conductivity) = $mmhos.cm^{-1}$

Note 1: CMT composition should mimic natural soil conditions. Higher nutrient levels lead to invasives and algal blooms due to nutrient leaching and water contamination.

c. Erosion Control Compost (ECC)
ECC consists of compost, as specified in 1.2.F.2.a, blended with mulch in a ratio of three (3) parts compost to one (1) part mulch **(3:1)**. Mulch to be in accordance with Item 21-1 "Mulch."

d. Suppliers:
Compost shall be specified from one of the following approved vendors: (vendors that utilize static compost piling are preferred)
   i. Organics by Gosh, Austin TX
      512-276-1211
   ii. Gardenville, Austin TX
      1-888-655-6115
   iii. Geo Growers, Austin TX
      512-892-2722
   iv. Soil Express, Prosper TX
      972-347-2994

e. Installation
   i. CMT – Specify a four (4) inch depth for vegetation establishment on top of the subsoil. The CMT is the growing medium. Topsoil is not needed when using CMT.
   ii. ECC – Specify a three (3) inch depth for erosion control, for areas that will not be vegetated.
   iii. ECC – Specify a three (3) inch depth for erosion control and vegetation establishment on top of the specified depth of topsoil. The topsoil is the growing medium and the ECC is the topdressing.
   iv. Installation method of the CMT or ECC is to be determined by the Contractor and submitted for approval. Any of the following are acceptable methods of installation:
      (1) By hand raking
      (2) By mechanized spreader

(3) By a pneumatic blower – Seed can be mixed with compost during this application. Reference Item 30-1 "Seeding for Erosion Control".

v. Depending on slope, accessibility of location, and rockiness of the terrain, the Contractor is to select an approved installation method that is the least invasive to the adjacent areas.

ITEM 27-1. BIODEGRADABLE EROSION CONTROL LOGS

Source: Scott McCoy, Texas Department of Environmental Quality

1.1 DESCRIPTION

Biodegradable Erosion Control Logs (BEC logs) are tubular-shaped erosion and sedimentation control devices filled with natural core filling and wrapped with a containment mesh. BEC logs are used to intercept runoff, capture sediment, and release runoff as sheet flow. BEC logs are also referred to as filter logs, filter socks, filter rolls, and fiber rolls.

1.2 DESIGN APPLICATION

A. INTENT

BEC logs are designed for temporary erosion and sedimentation control. They are best adapted to areas of low sheer stress and are effective on slope conditions. BEC logs trap sediment and allow water flow to pass through, thus assisting in water quality. When installed in areas of low water volume conditions, BEC logs help maintain sheet flow. As the soil stabilizes with vegetative establishment, BEC logs may be left in place to biodegrade naturally.

B. BENEFITS

The benefits of BEC logs include:

1. Are easily installed and shaped to contours of a site.
2. Slows water velocity.
3. Do not have to be removed upon project completion, since they degrade naturally, reducing labor and disposal costs.
4. Does not interfere with seeding or mulch applications.
5. Can use on-site mulch.
6. Provide superior temporary sedimentation control instead of silt fence:

a. They have greater surface area, providing enhanced sediment capture and runoff release.
b. Produce less potential for rills.
c. Soil disturbance does not occur at project completion, since they are not removed.

C. LIMITATIONS

The limitations of BEC logs include:

1. BEC logs should not be used in channels with velocity flows over three feet per second (3 fps).
2. BEC logs have a limited sediment capture.
3. The use of a Type 2 BEC log (compost and mulch mixture) is limited in areas draining to a water body over the Edward's Aquifer.

D. RELATED ITEMS

1. Item 26-1 "Compost"
2. Item 21-1 "Mulch"
3. Item 30-1 "Seeding for Erosion Control'
4. Item 31-1 "Wildflower Seeding"

E. REFERENCES

1. References to be in accordance with Item 26-1 "Compost" 2.2.1, Section 2, 1.3 "References" A – C.

F. GUIDELINES

1. Design:
   a. Specify BEC logs as a temporary sedimentation control in the following conditions:
      i. Along road embankments, road cross slopes, or other areas with exposed soils not subject to high water velocities or volumes.
      ii. At the perimeter of a project site.
      iii. Around material stockpiles during construction.
      iv. Around drain inlets and environmental features for protection.
      v. Outside the tree protection fencing to prevent sediment from collecting within the root zone of preserved trees.
   b. Specify BEC logs to achieve both sedimentation and erosion control by slowing water velocity and maintaining sheet flow in the following conditions:
      i. At top edge of erosion control compost applications to prevent runoff from undermining underneath the erosion control compost blanket.
      ii. At the toe, top, along the face, or at-grade breaks of a slope.
      iii. Down slope of other exposed soil areas.
      iv. Use as a check dam in low volume channels with low water velocity (below 3 fps).
   c. BEC logs shall be in compliance with TCEQ, Complying with the Edwards Aquifer Rules, Technical Guidance for Best Management Practices, 2.5.1 'General Guidelines'.
   d. Specify containment mesh, Type 1 or Type 2 core filling material, log size (diameter), and log spacing.

2. Materials:
   BEC logs are composed of a degradable containment mesh and a core filling.

a. Containment Mesh:
   Specify a containment mesh based on the duration of time a fully functional BEC log will be required to achieve establishment of vegetation. Considering time of year and length of project construction.
   i. Filtrexx Soxx; 5 mil HDPE; Photodegradable; 3/8" Mesh opening; 26 psi; 23% UV Stability at 1000 hours; Functional longevity 9 month to 3 years.
   ii. Filtrexx Soxx; Multi-Filament Polypropylene (MFPP); Photodegradable; 3/8" Mesh opening; 44 psi; 100% UV Stability at 1000 hours; Functional longevity 1 year to 4 years.
   iii. Filtrexx Soxx; Multi-Filament Polypropylene Safety Soxx; Photodegradable; 1/8" Mesh opening; 202 psi; 100% UV Stability as 1000 hours; Functional longevity 2 years to 5 years.

b. Core Filling Types:
   Specify a Type 1 Mulch BEC log when used around highly sensitive riparian and environment features where nutrient loading is a concern. When nutrient loading is not a concern, Type 2 compost and mulch BEC logs are more effective at removing sediment, filtering pollutants, and slowing velocity. Mulch and compost filled BEC logs should also be specified when logs are intended to remain in place and be seeded.
   i. Type 1 – Mulch BEC log
      (1) Mulch BEC logs are composed of ground and shredded recycled wood. Mulch to be in accordance with Item 21-1 "Mulch."
   ii. Type 2 – Mulch and Compost BEC log
      (1) Mulch and compost to be uniformly blended at a ratio of 50/50 for a "living" BEC log that provides better support for vegetative growth.
      (2) Compost and Mulch to be in accordance with Item 20-1 "Compost" and Item 21-1 "Mulch."
      (3) Seed can be added to a Type 2 BEC log, though seeds at the bottom of the log will not germinate, thus, seeding the top and around the log will prove most effective.

c. BEC log Size
   i. Specify a standard size of 12", 18", 24", or 32" diameter.
   ii. Sizes should increase with higher water flows and velocities or steeper slopes.

d. Suppliers:
   Prefabricated BEC logs shall be specified from one of the following approved vendors:
   i. Hanes Geo Components. Austin, Texas, 512-670-2050
   ii. Soil Express. Prosper, Texas, 972-347-2994

3. Installation:
   a. Product data submitted by contractor to be approved.
   b. BEC logs can be prefabricated and brought to the site or constructed on-site with natural materials. BEC logs should be installed per manufacturer specifications.
   c. Spacing – Locate BEC logs on level contour spaces as follows:
      i. Slope inclination of 4:1 or flatter: BEC logs are to be installed at a maximum interval of twenty (20) ft.
      ii. Slope inclination between 4:1 and 2:1: BEC logs to be installed at maximum interval of fifteen (15) ft.

d. Staking – Ensure proper staking of the BEC logs:
    i. Install wood stakes in deep soils, at intervals of six (6) feet.
    ii. Install 3/8" steel reinforcement bar stakes in shallow, rocky soils, at intervals of six (6) feet.
e. At project completion, BEC logs may be left in-place or cut open and spread around the site at a depth of no more than one (1) inch.
f. Seeding of BEC logs
    i. Mulch BEC logs should not be seeded.
    ii. Compost BEC logs can be seeded. Seed can be incorporated into the compost prior to placement in the BEC log, or, seed can be added to the top of the BEC log. Apply seeding at the same rate as specified in Item 30-1 "Seeding for Erosion Control" or Item 31-1 "Wildflower Seeding."

Permanent Erosion and Sedimentation Controls

ITEM 28-1. MAINTAINING EXISTING VEGETATION

Source: TBG Partners

1.1 DESCRIPTION

Maintaining existing vegetation is the protection and non-disturbance of native plants within a designated area of the project.

1.2 DESIGN APPLICATION

A. INTENT

Retaining undisturbed vegetation and soils is an effective means of erosion and sedimentation control. Maintaining existing vegetation in areas adjacent to floodplains, wetlands, stream banks, or critical environmental features is particularly beneficial to preserve water quality..

B. BENEFITS

The benefits of maintaining existing vegetation include:

1. Reduces runoff quantity and velocity, and erosion and sedimentation rates.
2. Reduces costs associated with land clearing, revegetation and erosion and sedimentation controls.
3. Reduces maintenance costs associated with mowing.
4. Increases stormwater infiltration.
5. Provides a buffer against noise.
6. Provides visual interest for motorists and contributes to the regional character.
7. Provides fully developed habitat for fauna and flora.
8. Provides a healthy ecosystem since, on average, it takes twenty to thirty years for newly planted trees to provide the ecological functions and benefits of a mature tree stand (TCEQ, 2005).

C. LIMITATIONS

The limitations of maintaining existing vegetation include:

1. Potentially added time to incorporate existing vegetation into the grading and drainage design of the project.
2. Potentially added construction cost to accommodate existing vegetation into the grading and drainage construction activities.
3. Additional construction cost of protective fencing to ensure protection of existing vegetation.
4. Safety design will limit maintaining existing vegetation within safety clear zones and required view corridors.

D. RELATED ITEMS

1. Item 10 “Environmental Inventory”
2. Item 12 “Low Impact Grading Design”
3. Item 13 “Soils Management and Limits of Disturbance”
4. Item 29-1 “Riparian Bioengineering”

E. GUIDELINES

1. Design Requirements:
   a. Strategies to maintain existing vegetation should be developed during the design phase, prior to any construction activities.
   b. Prior to submitting construction plans for review, an aerial analysis should be conducted within the right-of-way to identify stands of individual or clusters of significant trees, as specified in Item 10, Environmental Inventory.
   c. When selecting vegetation to be maintained, the following factors should be considered:
      i. Location within the right-of-way: maintaining existing vegetation adjacent to floodplains, wetlands, stream banks, steep slopes, or critical environmental features provides effective erosion and sedimentation control and helps to preserve water quality. Refer to Item 29-1, Riparian Bioengineering for vegetation preservation within riparian areas.
      ii. Special attention should be given to the preservation of existing vegetation in locations which promote optimal erosion and sedimentation control, watershed protection, and pollution control.
      iii. Vegetative clusters: clusters of vegetation provide maximum benefits of erosion and sedimentation control. Isolated vegetation or small groups of trees should be considered, but provides fewer benefits.
      iv. Species of vegetation: Species that are native and well-suited to site conditions should remain.
      v. Health of vegetation: healthy vegetation should be selected over unhealthy vegetation because it will be less susceptible to damage, disease, and insects, as determined in Item 10, Environmental Inventory.
   d. Design grading to maximize the extent of retaining existing contours and maintaining preconstruction drainage patterns.
   e. Designate clearing within the right of way to be limited to those areas where it is necessary for roadway pavement, necessary grading and drainage and safety clear zone requirements. Refer to Item 13, Soils Management and Limits of Disturbance.
   f. The limits of clearing should be located outside of the drip lines of the preserved trees to the extent possible.

g. A Vegetation Preservation Plan should be created and included in the plans to identify the locations of trees, shrubs, and grasses which are potentially outside the limits of disturbance.
h. Delineate tree protection zones and protective fencing in the Plan to ensure the protection of the maintained existing vegetation.
    i. Specify protective fencing outside the critical root zones (CRZ) of trees and existing vegetation to be maintained. (CRZ radius = one (1) foot per inch of the trunk's diameter)
    ii. Specify trunk armoring for locations where construction activities may encroach on a portion of the CRZ. See Figure 1 for typical trunk armoring. If trunk armoring is used, the CRZ will still require protection. Nothing should ever be nailed to a tree.

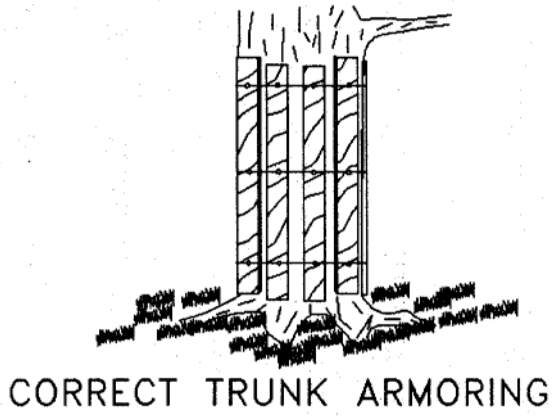


Figure 1: Trunk Armoring

    iii. Specify protective signage for posting at the edge of protection zones at a rate of one sign per 300 linear feet of fencing. Locate sign between six and eight (6-8) feet above grade in locations clearly visible from construction areas. Sign measurement should be eighteen (18) inch height by twenty-four (24) inch width with the following message: "Native Vegetation Protection Area. Do not Disturb"; include the County logo on the sign.
    iv. Incorporate a sedimentation control measure (Refer to Item 27-1 "Biodegradable Erosion Control Logs"), outside the tree protection fencing on upslope areas to prevent sediment from collecting within the root zone.
i. Significant alteration of existing hydrology should be avoided, where possible, as this may result in die-off of preserved vegetation.
j. Protect existing trees, shrubs and grass areas to be maintained within right-of-way from the following damage:
    i. Compaction of root area by equipment, vehicles or material storage;
    ii. Trunk damage by moving equipment material storage, nailing or bolting;
    iii. Strangling by tying ropes or guy wires to trunks or large branches;
    iv. Poisoning by pouring solvents, gas, paint or other chemicals on or around trees and roots, shrubs or grass areas;
    v. Cutting of roots by excavating or ditching;
    vi. Damage of branches by improper pruning;
    vii. Drought from failure to water or by cutting or changing normal drainage pattern near roots;

viii. Changes of soil pH factor by disposal of lime base materials such as concrete or plaster;
ix. Damage to roots 1-1/2" in diameter or over. Excavation and earthwork within drip line of trees should be done by hand.

k. Reference Tree and Plant Protection in the Special Conditions of the Project Construction Manual, to address payment for damages to protected trees, shrubs or grass areas that are destroyed, killed or damaged as a result of construction activities.

2. Materials:
   a. Protective fencing may be orange construction fencing (plastic) or cord fencing (wire) in accordance with TXDOT Item 506 "Temporary Erosion, Sedimentation, and Environmental Controls." Protective fencing may also be constructed of 4x4 posts and 2x4 stringers top and bottom.
   b. Trunk armoring should consist of 2x4 wood boards strapped vertically to the tree no more than two (2) inches apart and to a height of five (5) feet encircling the trunk.
   c. Protective signage should be composed of Corex or Coroplast and weather proofed with a dimension of 18" x 24". The sign should be yellow with black graphics that state: "Native Vegetation Protection Area. Do not Disturb"; include the County logo on the sign. Sign to be securely anchored on the protective fencing or mounted to a post.

3. Installation:
   a. As specified in TCEQ, Complying with the Edwards Aquifer Rules, Technical Guidance for Best Management Practices, 2.5.1 'General Guidelines' for tree protection installation.
   b. Install protective fencing prior to demolition or excavation operations. Leave protective fencing until construction operations are complete.
   c. Locate fencing and post signs at locations shown on plans or as directed.
   d. Ensure that the Contractor refrains from parking and storing construction equipment within the tree protection zones.
   e. Post signs to be visible to equipment operators.

ITEM 29-1. RIPARIAN BIOENGINEERING

Source: The Lady Bird Johnson Wildflower Center

1.1 DESCRIPTION

Riparian areas are waterway margins, the buffer of habitat between a stream channel and the upland areas that contribute to the stream. These are critical habitats for biodiversity and critical zones for the hydrology and biogeochemistry of the waterway. Riparian bioengineering is the stabilization of the riparian area through planting of appropriate plant material for the purpose of erosion control, storm water filtration of sediment and pollutants, and flood control.

1.2 DESIGN APPLICATION

A. INTENT

Riparian bioengineering aids in the stabilization of soils and banks adjacent to creeks, rivers and streams, while also improving ecological services, including water quality, natural habitat, and the health of aquatic ecosystems.

B. BENEFITS

The benefits of riparian bioengineering include:

1. Reduces sedimentation reaching receiving water bodies.
2. Creates fibrous root systems that stabilize soil particles.
3. Reduces the amount of pollutants transported into water systems.
4. Reduces water velocity and amount of surface runoff.
5. Increases soil infiltration rates.

6. Reduces soil erosion.
7. Effective flood control.
8. Reestablishes native wildlife habitat and biological diversity
9. Requires less maintenance than non-native plants due to adaptation to regional climate and soils.

C. LIMITATIONS

The limitations of riparian bioengineering include:

1. Riparian buffer width may be limited because of right-of-way and safety clear zone requirements.
2. Long establishment period for buffer plantings to be effective.
3. Vegetative watering may be necessary for establishment.
4. Disturbance of riparian buffer area necessary for plant establishment.

D. RELATED ITEMS

1. Item 10 “Environmental Inventory”
2. Item 13 “Soils Management and Limits of Disturbance’
3. Item 22-1 “Vegetative Watering”
4. Item 25-1 “Mulch Topdressing”
5. Item 26-1 “Compost”

E. REFERENCES

1. Item 192 “Landscape Planting”

F. GUIDELINES

1. Design Requirements:
   a. Specify riparian bioengineering treatments where a roadway intersects an existing receiving body of water or riparian area within the right-of-way.
   b. Identify the riparian bioengineering area. A riparian buffer area (the area perpendicular to the water course or drainage way) that is wide is more effective to filter and reduce pollutant levels, specifically nitrogen (Mayer et al, 2005).
   c. Determine the size and location of the riparian bioengineering area using the following:
      i. The width of the right-of-way.
      ii. Site conditions.
         (1) Environmental conditions. An environmental survey and site analysis is necessary to identify environmental features, as specified in Item 10 “Environmental Inventory.” The location and significance of environmental features will affect the width of the riparian buffer zone and the level of disturbance within the area.
         (2) The floodway and 100-year floodplain.
         (3) The velocity and volume of stormwater for each drainage run impacting the site.
         (4) Soil characteristics.
      iii. Estimated disturbance from construction activities.
      iv. Ecological sensitivity goals:
         (1) Degree of water quality protection.
         (2) Vegetation.
         (3) Wildlife and aquatic habitat.

d. Three vegetative zones should be established within the riparian buffer area (See Figure 1, below) and defined on the plan:
   i. The inner zone should be managed for control of invasive species. It should be allowed to develop into a climax community of shrubs and trees (See Table 1 and 2 plant lists).
   ii. The middle zone should be managed to promote shrub and tree growth (See Table 1 and 2 plant lists).
   iii. The outer zone should be managed to promote trees, grasses, wildflowers, and herbaceous plants. See Table 1 and 2 for trees and refer to Item 30-1 "Seeding for Erosion Control" for native grasses and wildflower species.
   iv. Allowable Uses: allowable uses near a riparian buffer should be established and defined on the plan. The zone nearest the water shall be most restrictive, while zones further from the water source should be more permissive. (Biohabitats Inc. 2007)

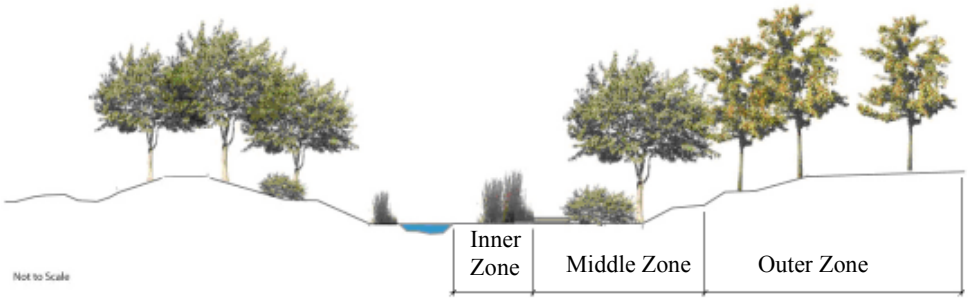


Figure 1: Riparian Vegetative Zones
Source: LBJWFC, 2009. Guadalupe Saldana Subdivision Pre-design Investigation Report

e. Characteristics of Vegetative Zones in Riparian Buffer Area

Characteristics	Inner Zone	Middle Zone	Outer Zone
Function	Protect the primary riparian habitat and ecosystem	Mitigate impact between land and water uses; filter and slow down runoff	Buffer encroachment of development; filter and slow down runoff
Width	20ft minimum; consider expansion due to environmental features or steep slopes	50ft minimum; depending on stream order, slope, floodplain, or presence of features	50ft minimum
Vegetation Type (Refer to Table 2 for recommended species)	Native shrubs, trees, aquatic vegetation that is unmanaged	Native shrubs and trees and grasses	Native grasses and herbaceous plants
Allowable Uses	Highly restricted; flood control, erosion control BMPs permitted	Restricted; flood control, erosion control BMPs permitted	Moderately Restricted footpaths, recreational uses permitted

Adapted from: Biohabitat Inc. 2007 & MSU, 1999

i. Recommend Plant Species for Inner Zone and Middle Zone of Riparian Buffer. Select a minimum of five (5) species from the woody species list (Table 1) and a minimum of ten (10) or more herbaceous species list (Table 2) below to be planted or seeded.
ii. No single species should constitute 1/3 or more of the total plant species. The greatest amount of species diversity should be obtained to produce a healthy habitat and prevent erosion.
iii. Woody species selected from Table 1, below, should be planted at a rate of eight (8) plants per 200 square feet.
iv. Herbaceous seeding or live root planting shall take place before woody species are planted.
v. Tree Saplings and container plants shall be installed after healthy establishment of herbaceous cover from seeding or live root planting to prevent erosion or die-off of trees and container plants.
vi. Part A and B of Table 2 is the primary seed mix for application in riparian areas.
vii. In the event that a species in Part A or B of the mix in Table 2 is not seasonally available, the Engineer should coordinate with the seed supplier to designate substitute species and quantities in the mix using Part C of Table 2. The Engineer may also allow a substitution if a particular species of seed becomes too costly due to seasonal fluctuations.
viii. Species from Part C of Table 2 may also be added on an optional basis to increase the amount of plant diversity at the site. If available and affordable, species in Part C are ideal to include in the seed mixes.
ix. Many of the species in Table 2 are also available in live root form. Live root plants are beneficial for quick establishment and can be used to supplement a seeded area. Live root plants should generally be installed at a ten (10) inch on center spacing. When using live root plants in an area where flooding is a concern, live root plants can be installed through a soil retention blanket.

Table 1: Native Trees and Shrubs (Woody Species) for Inner Zone and Middle Zone of Riparian Buffer - Williamson County

Species	Common name	Comments
Acer negundo	Box elder	For wet areas, waterside only.
Callicarpa americana	American beautyberry	
Carya illinoinensis	Pecan	
Cephalanthus occidentalis	Buttonbush	For wet areas, waterside only.
Cornus drummondii	Roughleaf Dogwood	For moist areas. Forms dense rhizomatous thickets.
Rhamnus (Frangula) caroliniana	Carolina buckthorn	
Fraxinus pennsylvanica	Green ash	For moist areas.
Ilex decidua	Possum haw	
Ilex vomitoria	Yaupon	
Morus rubra	Red mulberry	
Platanus occidentalis	Sycamore	

Populus deltoids	Eastern cottonwood	
Prunus Mexicana	Mexican plum	
Salix nigra	Black willow	For wet areas, waterside only.
Ulmus Americana	American elm	
Ulmus crassifolia	Cedar elm	
Amorpha fruticosa	False indigo	

Source: Lady Bird Johnson Wildflower Center, 2009

Table 2: Native Herbaceous Seed and Plants for Riparian Buffer (all Vegetative Zones) - Williamson County

Part A: Wildflowers			
Species	**Common name**	**lbs per acre**	**lbs per sq yd**
Centaurea americana	American basketflower	15.00	0.0020
Coreopsis tinctoria	Plains coreopsis	4.00	0.0008
Desmanthus illinoensis	Illinois bundle flower	15.00	0.0031
Engelmannia pinnatifida (Engelmannia peristenia)	Engelmann daisy (Cutleaf daisy)	27.00	0.0056
Helianthus maximiliani	*Maximillian sunflower	4.00	0.0008
Oenothera speciosa	Pink evening primrose	1.00	0.0012
Rudbeckia (Dracopis) amplexicaulis	Clasping coneflower	6.00	0.0002
		72.00	**0.0137**
Part B: Grasses			
Species	**Common name**	**lbs per acre**	**lbs per sq yd**
Bouteloua curtipendula	Sideoats grama	3.50	0.0007
Bouteloua gracilis	Blue grama	5.00	0.0010
Buchloe dactyloides	Buffalograss	12.00	0.0025
Elymus canadensis	*Prairie wild rye	15.00	0.0031
Leptochloa dubia	Green sprangletop	1.00	0.0002
Panicum virgatum (Upland)	*Switchgrass (Upland)	8.00	0.0017
Schizachyrium scoparium	Little bluestem	12.00	0.0025
Sorghastrum nutans	*Indian grass	12.00	0.0025
Tripsacum dactyloides	*Eastern gamagrass	12.00	0.0025
		80.50	**0.0167**
Part C: Replacement Species and/or Species for Increased Diversity			
Species	**Common name**	**lbs per acre**	**lbs per sq yd**
Andropogon gerardii	*Big bluestem grass	4.00	0.0008
Andropogon glomeratus	Bushy bluestem grass (for moist areas)	1.00	0.0002

Chasmanthium latifolium	Inland sea oats	6.00	0.0012
Physostegia intermedia	Obedient plant	1.00	0.0002
Salvia azurea	Pitcher sage	1.50	0.0003
Solidago altissima (S. canadensis)	*Tall goldenrod	1.50	0.0003
Solidago gigantea	Giant goldenrod	1.50	0.0003
"Midway Mix" (Native American Seeds)	Grasses 1'-2' tall	5.00	0.0010

Containerized

Species	Common name
Andropogon gerardii	*Big bluestem (grass)
Andropogon glomeratus	Bushy bluestem (grass) (for moist areas)
Carex blanda	Creek sedge (for moist areas)
Carex cherokeensis	Cherokee sedge (for moist areas)
Chasmanthium latifolium	Inland sea oats (grass)
Eleocharis palustris	Common spikerush (for moist areas)
Helianthus maximiliani	*Maximillian sunflower
Malvaviscus arboreus	Turk's Cap
Physostegia intermedia	Obedient plant
Solidago altissima (S. canadensis)	*Tall goldenrod
Solidago gigantea	Giant goldenrod
Sporobolus compositus var. compositus	Tall Dropseed (grass)
Tripsacum palustris	*Eastern Gamagrass

Source: Lady Bird Johnson Wildflower Center, 2009

***Note: These species are commonly available in Live Root material**

x. In addition to the above plant list, riparian native grass seeding and wildflower seeding should be specified for all vegetation zones. Refer to Item 30-1 "Seeding for Erosion Control."

f. Determine the revegetation technique. Two techniques to creating a riparian buffer include:
   i. Passive Revegetation – a technique best applied to an intact or partially intact riparian area. Repair and regeneration of existing vegetated buffers is accomplished through planting a succession of native plants, natural seed dispersal, reduction of invasive species and selective vegetation thinning.
   ii. Active Revegetation - A technique applied to a riparian area with little or no existing vegetated buffers, due to construction activities or other

destructive impacts. This technique involves the creation and implementation of a site specific plan detailing the species and location of proposed vegetation.

iii. Occasionally, a mix of the two techniques is appropriate for a riparian area.

g. A Riparian Habitat Plan (RHP) shall be prepared for the riparian area. The following are to be included:
   i. Riparian buffer boundaries and vegetative zones.
   ii. Specifications for the buffer width, existing species of vegetation, buffer uses, and management techniques.
   iii. Temporary sedimentation control(s) at the perimeter of the riparian bioengineering area to filter sediment before it enters the riparian buffer zone. Acceptable sediment controls include Biodegradable Erosion Control Logs (Refer to Item 27-1 "Biodegradable Erosion Control Logs"), rock filter dams (Item 506 "Temporary Erosion, Sedimentation, and Environmental Controls"), check dams (Refer to TCEQ, 2005 Item 1.4.8), and sediment basins (Refer to TCEQ, 2005, 1.4.13).
   iv. Other bank stabilization and erosion control techniques not included in this protocol that maintain existing vegetation. Bank stabilization and erosion control techniques (EPA, Napa, CA & EPA, 2006) may include:
      (1) Grass Revetment
      (2) Reed Planting
      (3) Tree & Shrub Planting
      (4) Toe Geotextile
      (5) Toe Rolls
      (6) Open Cell Revetments
      (7) Rip rap with vegetation/ joint planting
      (8) Brush Layering
      (9) Brush Mattressing
   v. The Vegetation Preservation Plan, as specified in Item 28-1 "Maintaining Existing Vegetation."
   vi. Vegetation establishment. Select the revegetation technique appropriate for site condition.
      (1) Active Revegetation Techniques
         (a) Active vegetation planting plans that should include woody species and herbaceous species per section F.1.d.(4) above.
      (2) Passive Revegetation Techniques
         (a) Plan for re-establishing, repairing, and establishing riparian vegetation.
         (b) The existing vegetation should be protected during construction with a barrier, as specified in Item 28-1 "Maintaining Existing Vegetation" and within the Erosion and Sedimentation plans.
         (c) Invasive species shall be removed prior to riparian bioengineering, as specified in Item 41 "Invasive Species Control."
         (d) Soil disturbance shall be minimized to reduce vegetation loss and erosion, as specified in Item 13 "Soils Management and Limits of Disturbance."

(e) Removal of existing vegetation shall be limited to the construction limits, defined in the Vegetation Preservation Plan, as specified in Item 28-1 "Maintaining Existing Vegetation."
(f) Erosion control techniques shall be used as indicated in the Vegetation Preservation Plan and the Erosion and Sedimentation Plans, to aid in erosion control adjacent to water sources.

2. Materials
   a. Seed:
      i. Provide seed as shown in the plans or as directed, and meeting the requirements of the Federal Seed Act and Texas Seed Law, including the testing and labeling for pure live seed (PLS= Purity and Germination). Minimum purity shall be 50%. The seed test to be conducted by the State Seed Laboratory, and a seed test report shall be submitted in accordance with 1.6, "Quality Control Submittals." Each type (mix) of seed shall be mixed by the supplier and delivered in labeled and unopened bags or containers, unless otherwise approved by the Owner's representative. The Contractor shall not blend the seed mixes on site. Use within twelve (12) months from that date of analysis. When Buffalograss is specified, use seed treated with KNO3 (potassium nitrate) to overcome dormancy.
      ii. Seeds shall be stored in a dry, well-ventilated location away from contaminants. Seed storage humidity level should be lower than 75%. Store any unused seed in a water resistant container. If seed will be stored longer than one (1) year, the optimal temperature range would be 40-60F.
      iii. During transit (from storage to sowing), seed should be protected from dramatic temperature fluctuations day after day; temperature cannot exceed 100F at any time. Seed must remain dry and protected from sun exposure. The transit period may not exceed ten (10) days.

   b. Growing Medium:
      i. Compost Manufactured Topsoil (CMT) or Erosion Control Compost (ECC) should be applied in conjunction with the native grass seed to facilitate grass establishment and provide an optimal growing medium. CMT and ECC will serve to control runoff and stabilize soils during non-growing seasons and vegetation establishment. Compost Manufactured Topsoil or Erosion Control Compost is to be specified for all seeded areas in accordance to Item 20-1 "Compost." Refer to Item 20-1 "Compost" to determine which growing medium is appropriate for a particular location.

3. Plant Installation:
   a. As specified in TxDOT Item 192.

ITEM 30-1. SEEDING FOR EROSION CONTROL

Source: http://www.al.nrcs.usda.gov/technical/photo/pas_hay/veg/NativeGrass%28645C%29.jpg

1.1 DESCRIPTION

Seeding for erosion control is the establishment of native grasses and wildflowers in a disturbed area to provide soil stabilization and to prevent erosion and the subsequent movement of sediment and pollutants into water systems.

1.2 DESIGN APPLICATION

A. INTENT

Native grasses have deep fibrous roots, endure regional climatic fluctuations and are effective for temporary and permanent control of soil erosion on roadside landscapes (Tinsley et. Al 2006).

B. BENEFITS

The benefits of using native grasses and wildflowers include:

1. Reduces erosion with dense soil cover
2. Reduces the velocity and amount of surface runoff.
3. Increases soil infiltration rates.
4. Stabilizes soil particles with fibrous roots.
5. Reduces the amount of pollutants transported into water systems.
6. Reestablishes native wildlife habitats, biological diversity, and regional character.
7. Requires less water, fertilizer and mowing than non-native plants due to adaptation to regional climate and soils.

C. LIMITATIONS

The limitations of using a native grass seed:

1. Perceived as having a less manicured appearance than some non-native grass species.
2. Some species may be more expensive due to seasonal fluctuations in availability, harvest requirements, etc.
3. Some species may require a longer time period for establishment from seed.
4. Some species may periodically not be commercially available.

D. RELATED ITEMS

1. Item 20-1 "Topsoil"
2. Item 22-1 "Vegetative Watering"
3. Item 26-1 "Compost"
4. Item 31-1 "Wildflower Seeding"

E. REFERENCES

1. Federal Seed Act
2. Texas Seed Law
3. Texas State Department of Agriculture (TDA)
4. Williamson County Agricultural Office
5. Item 636 "Aluminum Signs."
6. Item 644 "Small Roadside Sign Supports and Assemblies."

F. GUIDELINES

1. Design
   a. Identify the general location where the seed will be applied to identify the appropriate seed mix (see Figure 1: Seed Type Map of Williamson County).

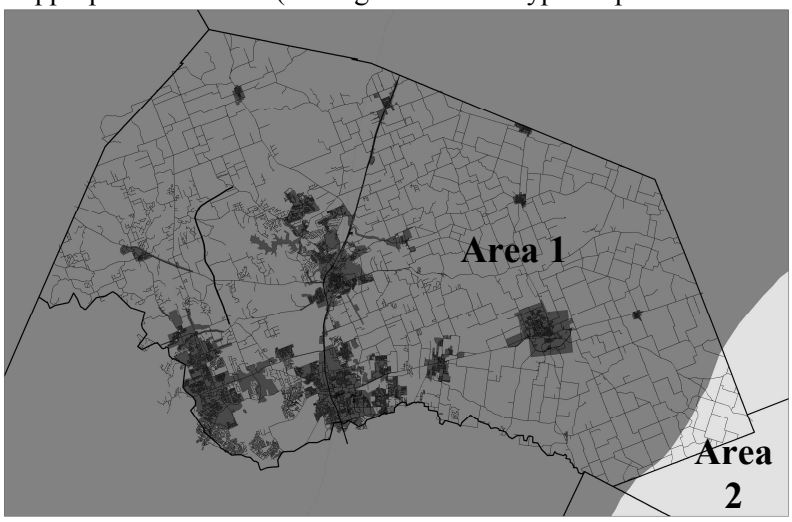


Figure 1: Seed Type Map of Williamson County

Area 1: Edward's Plateau & Blackland Prairie Eco-regions

Area 2: Post Oak Savanna Eco-region

b. Identify the location within the project where the seed will be applied to identify the appropriate seed mix. Types 1, 2, 3, 6, and 7 seed mixes contain a combination of grasses and wildflowers. Every effort should be made to schedule seeding during the fall or winter seeding periods according to Tables 8 and 9.
c. The following figure shows which seed mixes are appropriate for each of the eco-regions of Williamson County.

Figure 2: Area 1 & 2 Eco-regions and Corresponding Seed Mixes

Area 1 Edward's Plateau & Blackland Prairie	**Area 2** Post Oak Savanna
Type 1; Table 1: Standard Tall	**Type 2; Table 2:** Standard Tall
Type 3; Table 3: Riparian	**Type 3; Table 3:** Riparian
Type 4; Table 4: Cool Season Non-Native	**Type 4; Table 4:** Cool Season Non-Native
Type 5; Table 5: Spring Mix	**Type 6; Table 6:** Spring Mix
Type 7; Table 7: Standard Short	**Type 8; Table 8:** Standard Short

i. Use of the standard tall native seed mixes (Tables 1 & 2) are appropriate for most applications in Williamson County where native grasses are specified. Compared to the standard short native grass mixes (Tables 6 & 7) the standard tall mixes has the following attributes:
   (1) Establishes a stand of grass faster.
   (2) Has a greater range of adaptability to site conditions.
   (3) Has deeper root structure; provides greater soil stability.
   (4) Provides greater density of coverage.
   (5) Should not be mowed frequently and/or lower than six (6) inches.
ii. Use of the standard short native grass mixes (Tables 7 & 8) are appropriate for more urban applications where a more managed aesthetic is desired.
iii. Type 3 seed mix (Table 3) applies to riparian areas located throughout Williamson County. The riparian seed mix should be applied in areas that are periodically flooded or frequently wet, such as channels and margins of streams and drainageways.
iv. Type 4 seed mix (Table 4) is a cool season temporary cover seed mix amendment added to the standard or riparian seed mixes for installation during the cool season (Reference Table 10 & 11).
v. Type 9 seed mix (Table 9) is a repair mix for bare patches of soil that need to be seeded due to construction, roadway traffic, or other disturbances. Use of this mix should be limited to areas smaller than 100 square feet. If area of disturbance is larger, select one of the other seed mixes that is appropriate for the location and time of installation.

d. Parts A and B of tables 1,2,3,7, & 8 are the primary seed mixes for application.
e. In the event that a species in Part A or B of the mixes is not seasonally available, the Engineer should coordinate with the seed supplier to designate substitute species and quantities in the mix using Part C of the tables. The

Engineer may also allow a substitution if a particular species of seed becomes too costly due to seasonal fluctuations.

f. Species from Part C of the lists may also be added on an optional basis to increase the amount of plant diversity at the site. If available and affordable, species in Part C are ideal to include in the seed mixes.

g. The prepared seed mix shall come from one of the following three providers:
   i. Native American Seed Native American Seed, Junction TX. 1-800-728-4043
   ii. Wildseed Farms, Fredericksburg, TX. 1-800-848-0078
   iii. Douglass W. King Company, San Antonio, TX. 1-888-357-3337

Table 1: Type 1 – Standard Tall Native Grass Seed Mix
Native Seed Mix for Edward's Plateau and Blackland Prairie Eco-regions of Williamson County
Total Seed Rate of Type 1 Mix (Wildflowers and Grasses) = 0.0204 lbs/sq yd or 99.75 lbs/acre

Part A: Wildflowers			
Species	**Common Name**	**lbs per acre**	**lbs per sq yd**
Cassia (Chamaecrista) fasiculata	Partridge Pea	5.00	0.0010
Centaurea americana	American Basketflower	5.00	0.0010
Coreopsis tinctoria	Plains Coreopsis	2.00	0.0004
Desmanthus illinoensis	Illinois Bundleflower	3.75	0.0008
Engelmannia pinnatifida (Engelmannia peristenia)	Engelmann Daisy (Cutleaf Daisy)	9.00	0.0019
Gaillardia pulchella	Indian Blanket	7.50	0.0015
Helianthus maximiliani	Maximilian Sunflower	2.00	0.0004
Ipomopsis rubra	Standing Cypress	3.00	0.0006
Monarda citriodora	Lemon Mint	1.50	0.0003
Oenothera speciosa	Pink Evening Primrose	0.50	0.0001
Rudbeckia hirta	Black-eyed Susan	0.50	0.0001
Thelesperma filifolium	Greenthread	2.00	0.0004
		41.75	**0.0085**
Part B: Grasses			
Species	**Common Name**	**lbs per acre**	**lbs per sq yd**
Bouteloua curtipendula	Sideoats Grama	14.00	0.0029
Bouteloua gracilis	Blue Grama	15.00	0.0031
Buchloe dactyloides	Buffalograss	6.00	0.0012
Elymus canadensis	Canada (Prairie) Wildrye	10.00	0.0021
Leptochloa dubia	Green Sprangletop	4.00	0.0008
Panicum virgatum	Switchgrass (Upland)	2.00	0.0004
Schizachyrium scoparium	Little Bluestem	4.00	0.0008
Sorghastrum nutans	Indian Grass	3.00	0.0006
		58.00	**0.0119**

Part C: Replacement Species and/or Species added for Increased Diversity			
Species	**Common Name**	**lbs per acre**	**lbs per sq yd**
Andropogon gerardii	Big Bluestem	4.00	0.0008
Argemone albiflora	White Prickly Poppy	3.00	0.0006
**Bothriochloa laguroides*	Silver Bluestem		
Bouteloua rigidiseta	Texas Grama Grass	2.70	0.0006
Callirhoe leiocarpa	Annual Winecup	1.20	0.0002
Castilleja indivisa	Indian Paintbrush	0.15	0.0001
Dalea candida (Petalostemon candidus)	White Prairie Clover	1.00	0.0002
Eragrostis trichoides	Sand Lovegrass	0.50	0.0001
liatris mucronata	Gayfeather	2.50	0.0005
Lindheimera texana	Texas Yellow Star	3.00	0.0006
Oenothera missouriensis	Missouri Primrose	0.50	0.0001
Oenothera speciosa	Pink Evening Primrose	0.50	0.0001
Salvia azurea	Pitcher Sage	0.25	0.0001
Salvia farinacea	Mealy Blue Sage	1.50	0.0003
Simsia calva	Bush Sunflower	1.75	0.0004
Solidago nemoralis	Grey Goldenrod	1.75	0.0004
**Midway Mix (Native American Seed)*	Grasses 1'-2'	2.50	0.0005

Source: Lady Bird Johnson Wildflower Center, 2010

Table 2: Type 2 – Standard Tall Native Grass Seed Mix
Native Grass Mix for Post Oak Savanna Eco-region of Williamson County
Total Seed Rate of Type 2 Mix (Wildflowers and Grasses) = 0.0205 lbs/sq yd or 94.5 lbs/acre

Part A: Wildflowers			
Species	**Common Name**	**lbs per acre**	**lbs per sq yd**
Cassia (Chamaecrista) fasiculata	Partridge Pea	5.00	0.0010
Centaurea americana	American Basketflower	5.00	0.0020
Coreopsis tinctoria	Plains Coreopsis	1.00	0.0002
Desmanthus illinoensis	Illinois Bundleflower	3.75	0.0008
Engelmannia pinnatifida (Engelmannia peristenia)	Engelmann Daisy (Cutleaf Daisy)	9.00	0.0019
Ipomopsis rubra	Standing Cypress	3.00	0.0006
Monarda citriodora	Lemon Mint	1.50	0.0003
Oenothera speciosa	Pink Evening Primrose	0.25	0.0001
Rudbeckia hirta	Black-eyed Susan	0.50	0.0001
Thelesperma filifolium	Greenthread	2.00	0.0004
		31.00	**0.0074**
Part B: Grasses			
Species	**Common Name**	**lbs per acre**	**lbs per sq yd**
Bouteloua curtipendula	Sideoats Grama	14.00	0.0029
Bouteloua gracilis	Blue Grama	15.00	0.0031
Buchloe dactyloides	Buffalograss	6.00	0.0012
Elymus canadensis	Canada Wildrye	10.00	0.0021

Eragrostis trichoides	Sand Lovegrass	0.50	0.0001
Panicum virgatum	Switchgrass (Upland)	10.00	0.0021
Schizachyrium scoparium	Little bluestem (Native)	4.00	0.0008
Sporobolus cryptandrus	Sand Dropseed	1.00	0.0002
Sorghastrum nutans	Indian Grass	3.00	0.0006
		63.5	**0.0131**
Part C: Replacement Species and/or Species added for Increased Diversity			
Species	**Common Name**	**lbs per acre**	**lbs per sq yd**
Andropogon gerardii	Big Bluestem Grass	2.00	0.0004
Argemone albiflora	White Prickly Poppy	2.00	0.0004
Asclepias tuberosa	Butterfly Weed	2.50	0.0005
Bouteloua rigidiseta	Texas Grama Grass	2.25	0.0005
Callirhoe leiocarpa	Annual Winecup	1.00	0.0002
Castilleja indivisa	Indian Paintbrush	0.15	0.0000
Corydalis curvisiliqua	Scrambled Eggs	0.50	0.0001
liatris mucronata	Gayfeather	2.25	0.0005
Lindheimera texana	Texas Yellow Star	3.00	0.0006
Salvia azurea	Pitcher Sage	1.50	0.0003
Salvia farinacea	Mealy Blue Sage	1.50	0.0003
Simsia calva	Bush Sunflower	1.25	0.0003
Tridens flavus	Purpletop (Grass)	2.25	0.0005
"Midway Mix" (Native American Seed)	Grasses 1'-2' tall	2.00	0.0004

Source: Lady Bird Johnson Wildflower Center, 2010

Table 3: Type 3 – Riparian Native Grass Seed Mix
Native Seed Mix for Edward's Plateau, Blackland Prairie and Post Oak Savannah Eco-regions of Williamson County
Total Seed Rate of Type 3 Mix (Wildflowers and Grasses) = 0.0203 lbs/sq yd or 99 lbs/acre

Part A: Wildflowers			
Species	**Common Name**	**lbs per acre**	**lbs per sq yd**
Centaurea Americana	American Basketflower	5.00	0.0010
Coreopsis tinctoria	Plains Coreopsis	4.00	0.0008
Desmanthus illinoensis	Illinois Bundleflower	7.50	0.0015
Engelmannia pinnatifida (Engelmannia peristenia)	Engelmann Daisy (Cutleaf Daisy)	9.00	0.0019
Helianthus maximiliani	Maximilian Sunflower	2.00	0.0004
Oenothera speciosa	Pink Evening Primrose	0.50	0.0001
Rudbeckia (Dracopis) amplexicaulis	Clasping Coneflower	3.00	0.0006
		31.00	**0.0063**
Part B: Grasses			
Species	**Common Name**	**lbs per acre**	**lbs per sq yd**
Bouteloua curtipendula	Sideoats Grama	14.00	0.0029
Bouteloua gracilis	Blue Grama	15.00	0.0031
Buchloe dactyloides	Buffalograss	6.00	0.0012

Elymus canadensis	Canada (Prairie) Wildrye	10.00	0.0021
Leptochloa dubia	Green Sprangletop	4.00	0.0008
Panicum virgatum	Switchgrass (Upland)	2.00	0.0004
Schizachyrium scoparium	Little Bluestem	4.00	0.0008
Sorghastrum nutans	Indian Grass	3.00	0.0006
Tripsacum dactyloides	Eastern Gamagrass	10.00	0.0021
		68.00	**0.0140**
Part C: Replacement Species and/or Species added for Increased Diversity			
Species	**Common Name**	**lbs per acre**	**lbs per sq yd**
Andropogon gerardii	Big Bluestem	1.00	0.0002
Andropogon glomeratus	Bushy Bluestem Grass (for moist areas)	0.50	0.0001
Chasmanthium latifolium	Inland Sea Oats	1.50	0.0003
Physostegia intermedia	Obedient Plant	0.50	0.0001
**Solidago altissima (S. canadensis)*	Tall Goldenrod	0.75	0.0002
**Solidago gigantea*	Giant Goldenrod	0.75	0.0002
Salvia azurea	Pitcher Sage	0.75	0.0002
"Midway Mix" (Native American Seed)	Grasses 1'-2' tall	2.50	0.0005

Source: Lady Bird Johnson Wildflower Center, 2009

Table 4: Cool Season Native Grass Seed Mix
Cool Season Temporary Cover Seed Mix for Edward's Plateau, Blackland Prairie, and Post Oak Savannah Eco-Regions of Williamson County
Total Seed Rate of Type 4 Mix = 0.0046 lbs/sq yd or 22 lbs/acre

Species	Common Name	lbs per acre	Lbs per sq yd
Elymus canadensis	Prairie Wildrye	10.00	0.0021
Pascopyrum smithii	Western Wheatgrass	9.00	0.0019
Dalea candida (var. candida)	White Prairie Clover	3.00	0.0006
		22.00	**0.0046**

Source: Lady Bird Johnson Wildflower Center, 2009

Table 5: Type 5 – Spring Native Grass Seed Mix
Spring Native Seed Mix for Edward's Plateau and Blackland Prairie Eco-regions of Williamson County
Total Seed Rate of Type 5 Mix = 0.0098 lbs/sq yd or 58.00 lbs/acre

Species	Common Name	lbs per acre	lbs per sq yd
Bouteloua curtipendula	Sideoats grama	14.00	0.0029
Bouteloua gracilis	Blue grama	15.00	0.0031
Buchloe dactyloides	Buffalograss	6.00	0.0012
Elymus canadensis	Canada wildrye	10.00	0.0021
Leptochloa dubia	Green sprangletop	4.00	0.0008
Panicum virgatum	Switchgrass (upland variety)	2.00	0.0004
Schizachyrium scoparium	Little bluestem (native)	4.00	0.0008
Sorghastrum nutans	Indian grass	3.00	0.0006
		58.00	**0.0098**

Source: Lady Bird Johnson Wildflower Center, 2009

Table 6: Type – Spring Native Grass Seed Mix
Spring Native Seed Mix for the Post Oak Savanna Eco-regions of Williamson County
Total Seed Rate of Type 6 Mix = 0.0131 lbs/sq yd or 63.50 lbs/acre

Species	Common Name	lbs per acre	lbs per sq yd
Bouteloua curtipendula	Sideoats grama	14.00	0.0029
Bouteloua gracilis	Blue grama	15.00	0.0031
Buchloe dactyloides	Buffalograss	6.00	0.0012
Elymus canadensis	Canada wildrye	10.00	0.0021
Eragrostis trichoides	Sand lovegrass	0.50	0.0001
Panicum virgatum	Switchgrass (upland variety)	10.00	0.0021
Schizachyrium scoparium	Little bluestem (native)	4.00	0.0008
Sporobolus cryptandrus	Sand dropseed	1.00	0.0002
Sorghastrum nutans	Indian grass	3.00	0.0006
		63.50	**0.0131**

Source: Lady Bird Johnson Wildflower Center, 2009

Table 7: Type 7 – Standard Short Native Grass Seed Mix
Special Native Short Grass Mix for the Edward's Plateau & Blackland Prairie Eco-region of Williamson County
Total Seed Rate of Type 7 Mix (Wildflowers and Grasses) = 0.0318 lbs/sq yd or 154.5 lbs/acre

Part A: Wildflowers			
Species	**Common Name**	**lbs per acre**	**lbs per sq yd**
Cassia (Chamaecrista) fasiculata	Partridge Pea	5.00	0.0010
Coreopsis tinctoria	Plains Coreopsis	1.00	0.0002
Lupinus texensis	Bluebonnet	15.00	0.0031
Gaillardia pulchella	Indian Blanket	10.00	0.0021

Mondarda citriodora	Lemon Mint	3.00	0.0006
Oenothera speciosa	Pink Evening Primrose	0.50	0.0001
Rudbecia hirta	Black-eyed Susan	2.00	0.0004
Thelesperma filifolium	Greenthread	1.50	0.0003
		38.00	**0.0078**
Part B: Grasses			
Species	**Common Name**	**lbs per acre**	**lbs per sq yd**
Bouteloua curtipendula	Sideoats Grama	21.00	0.0043
Bouteloua gracilis	Blue Grama	35.00	0.0072
Buchloe dactyloides	Buffalograss	50.00	0.0103
Elymus Canadensis	Prairie Wildrye	10.00	0.0021
Eragrostis trichoides	Sand Lovegrass	0.50	0.0001
		116.5	**0.0240**
Part C: Replacement Species and/or Species added for Increased Diversity			
Species	**Common Name**	**lbs per acre**	**lbs per sq yd**
Bouteloua rigidiseta	Texas Gama Grass	2.25	0.0005
Callirhoe leiocarpa	Annual Winecup	1.00	0.0002
Castilleja indivisa	Indian Paintbrush	0.15	0.0000
Corydalis curvisiliqua	Scrambled Eggs	0.50	0.0001
liatris mucronata	Gayfeather	2.25	0.0005
Oenothera missouriensis	Missouri Primrose	1.75	0.0004
Dalea candida (Petalostemon candidus)	White Prairie Clover	0.75	0.0002
Salvia farinacea	Mealy Blue Sage	1.50	0.0003
Simsia calva	Bush Sunflower	1.75	0.0004
"Midway Mix" (Native American Seeds)	Grasses 1'-2' tall	2.50	0.0005

Source: Lady Bird Johnson Wildflower Center, 2010

Table 8: Type 8 – Standard Short Native Grass Seed Mix
Special Native Short Grass Mix for Post Oak Savanna Eco-region of Williamson County
Total Seed Rate of Type 8 Mix (Wildflowers and Grasses) = 0.0191 lbs/sq yd or 92.50 lbs/acre

Part A: Wildflowers			
Species	**Common Name**	**lbs per acre**	**lbs per sq yd**
Cassia (Chamaecrista) fasiculata	Partridge Pea	5.00	0.0010
Centaurea americana	American Basketflower	5.00	0.0010
Coreopsis tinctoria	Plains Coreopsis	2.00	0.0004
Desmanthus illinoensis	Illinois Bundleflower	3.75	0.0008
Engelmannia pinnatifida	Engelmann Daisy (Cutleaf Daisy)	9.00	0.0019
Gaillardia pulchella	Indian Blanket	7.50	0.0015
Ipomopsis rubra	Standying Cypress	3.00	0.0006
Mondardo citriodora	Lemon Mint	1.50	0.0003
Oenothera speciosa	Pink Evening Primrose	0.25	0.0001
Rudbecia herta	Black-eyed Susan	0.50	0.0001

Thelesperma filifolium	Greenthread	2.00	0.0004
		39.50	**0.0081**
Part B: Grasses			
Grasses	**Species**	**lbs per acre**	**lbs per sq yd**
Bouteloua curtipendula	Sideoats Grama	14.00	0.0029
Bouteloua gracilis	Blue Grama	15.00	0.0031
Buchloe dactyloides	Buffalograss	6.00	0.0012
Elymus canadensis	Canada Wildrye	10.00	0.0021
Schizachyrium scoparium	Little Bluestem (Native)	8.00	0.0017
		53.00	**0.0110**
Part C: Replacement Species and/or Species added for Increased Diversity			
Grasses	**Species**	**lbs per acre**	**lbs per sq yd**
Argemone albiflora	White Prickly Poppy	2.50	0.0005
Bouteloua rigidiseta	Texas Grama Grass	2.75	0.0006
Callirhoe leiocarpa	Annual Winecup	1.00	0.0002
Castilleja indivisa	Indian Paintbrush	0.15	0.0000
Eragrostis trichoides	Sand Lovegrass	0.50	0.0001
liatris mucronata	Gayfeather	2.50	0.0005
Lindheimera texana	Texas Yellow Star	3.00	0.0006
Oenothera missouriensis	Missouri Primrose	0.50	0.0001
Oenothera speciosa	Pink Evening Primrose	0.25	0.0001
Salvia azurea	Pitcher Sage	0.75	0.0002
Salvia farinacea	Mealy Blue Sage	1.50	0.0003
Simsia calva	Bush Sunflower	1.25	0.0003
"Midway Mix" (Native American Seeds)	Grasses 1'-2' tall	2.50	0.0005

Source: Lady Bird Johnson Wildflower Center, 2010

Table 9: Type 9 – Bare Patch Repair Mix
Bare Patch Repair Seed Mix for Edward's Plateau, Blackland Prairie, and Post Oak Savanna Eco-regions of Williamson County
Total Seed Rate of Type 9 Mix = 0.0094 lbs/sq yd or 45.00 lbs/acre

Species	Common Name	lbs per acre	lbs per sq yd
Bouteloua curtipendula	Sideoats grama	25.00	0.0052
Bouteloua gracilis	Blue grama	10.00	0.0021
Leptochloa dubia	Green sprangletop	10.00	0.0021
		45.00	**0.0094**

Source: Lady Bird Johnson Wildflower Center, 2009

h. Seeding Schedules
   i. The preferred seeding time is from September 21 to November 7 to take advantage of winter rains.
   ii. If seeding takes place in the spring, Engineer should require a fall seeding of Wildflowers according Item 31-1 "Wildflower Seeding" to increase species diversity.
   iii. If seeding time falls within the summer seeding period, Erosion Control Compost (ECC) should be applied to prevent erosion on areas to be

vegetated. Do no seed during this time. When the fall seeding period starts the specified seed mix shall be installed into the ECC.

Table 10: Type 1, 2, 7, 8 and 9 Seeding Schedule

	OPTIMUM PLANTING TIME			
	Fall Seeding	**Winter Seeding**	**Spring Seeding**	**Summer Seeding**
Seeding Dates	Sept. 21 - Nov. 7	Nov. 8 - Feb. 14	Feb. 15 - June 15	June 16 - Sept. 20
Grass Type	Type 1* Type 2* Type 7* Type 8* Type 9*	Type 1* Type 2* Type 6* Type 7* Type 9*	**TYPE 5 or 6***	**NO SEEDING**
	Standard Native Grass Mix	Standard Native Grass Mix	Spring Mix	Apply Erosion Control Compost (ECC)
		PLUS	**PLUS (Only if Directed)**	**PLUS**
Supplemental Grass		Table 4*		
		Cool Season Non-Native Grass Seed Mix	Apply the Table 2: Type 2** Wildflower Seed Mix in the next Fall Seeding Time Period	Apply the Type 1*- Standard Native Grass Mix in the Fall Seeding Time Period
* Reference Item 30-1 "Seeding for Erosion Control" for corresponding tables. ** Reference Item 31-1 "Wildflower Seeding" for corresponding tables.				

Table 11: Type 3 Seeding Schedule

	OPTIMUM PLANTING TIME			
	Fall Seeding	**Winter Seeding**	**Spring Seeding**	**Summer Seeding**
Seeding Dates	Sept. 21 - Nov. 7	Nov. 8 - Feb. 14	Feb. 15 - June 15	June 16 - Sept. 20
Grass Type	Type 3*	Type 3*	Type 3*	**NO SEEDING**
	Riparian Native Grass Seed Mix	Riparian Native Grass Seed Mix	Riparian Native Grass Seed Mix	Apply Erosion Control Compost (ECC)
		PLUS		**PLUS**
Supplemental Grass		Type 4*		
		Cool Season Non-Native Grass Seed Mix		Apply the Type 3*- Riparian Native Grass Seed Mix in the Fall Seeding Time Period
* Reference Item 30-1 "Seeding for Erosion Control" for corresponding tables.				

i. Sign – No Mow Area
   i. Specify protective signage for posting at the edge of native grass areas at a rate of one sign per 1,500 linear feet. Stake sign between four and five (4-5) feet above grade in locations clearly visible from mowing areas. Sign measurement should be twelve (12) inch height by eighteen (18) inch width with the following message: "Native Vegetation. No Mowing Area"; include the County logo on the sign.

2. Materials
   a. Seed:
      i. Provide seed as shown in the plans or as directed, and meeting the requirements of the Federal Seed Act and Texas Seed Law, including the testing and labeling for pure live seed (PLS= Purity and Germination). Minimum purity shall be 50%. The seed test to be conducted by the State Seed Laboratory, and a seed test report shall be submitted in accordance with 1.6, "Quality Control Submittals." Each type (mix) of seed shall be mixed by the supplier and delivered in labeled and unopened bags or containers, unless otherwise approved by the Owner's representative. The Contractor shall not blend the seed mixes on site. Use within twelve (12) months from that date of analysis. When Buffalograss is specified, use seed treated with KNO_3 (potassium nitrate) to overcome dormancy.
      ii. Seeds shall be stored in a dry, well-ventilated location away from contaminants. Seed storage humidity level should be lower than 75%. Store any unused seed in a water resistant container. If seed will be stored longer than one (1) year, the optimal temperature range would be 40-60F.

iii. During transit (from storage to sowing), seed should be protected from dramatic temperature fluctuations day after day; temperature cannot exceed 100F at any time. Seed must remain dry and protected from sun exposure until planted. The transit period may not exceed ten (10) days.

b. Growing Medium:
   i. Compost Manufactured Topsoil (CMT) or Erosion Control Compost (ECC) should be applied in conjunction with the native grass seed to facilitate grass establishment and provide an optimal growing medium. CMT and ECC will serve to control runoff and stabilize soils during non-growing seasons and vegetation establishment. Compost Manufactured Topsoil or Erosion Control Compost is to be specified for all seeded areas in accordance to Item 20-1 "Compost." Refer to Item 20-1 "Compost" to determine which growing medium is appropriate for a particular location.

c. Sign:
   i. Small Aluminum Sign (TxDOT Type A).

3. Installation
   a. A soil density test is to be conducted and reviewed to ensure that the correct seeding equipment and installation practice is being used to install the native grass seed. Native grass seed shall not be installed in areas with compacted soils until the soils have been ripped and meet compaction requirements in accordance with Item 23-1 "Soil Ripping."
   b. There are a variety of common seeding equipment and installation techniques. The preferred method for all installations is broadcast seeding. However, the Engineer may specify one of the following methods of seed installation when deemed necessary:
      i. Broadcast Seeding is the preferred method of installation and should especially be required for areas that are difficult to access or are highly sensitive to equipment damage or compaction.
      ii. No-till Drill Seeding is an acceptable method when seeding a large area or when overseeding an area of existing vegetation. For example, when the Type 5 Spring Seed mix is installed in the Spring, no-till drill seeding should be specified for the fall seeding of wildflowers in the same area.
      iii. Pre-mixing Seed with Compost and applying pneumatically should only be used when conditions do not allow for one of the other seeding methods. Depth of compost applied in this method should not exceed 2 inches.
   c. Sign Installation.
      i. Post signs at locations shown on the plans or as directed at Final Acceptance. Posted signs to be visible to mowing equipment operators.

ITEM 31-1. WILDFLOWER SEEDING

Source: http://images.google.com/imgres?imgurl=http://esperanto.wunderground.com

1.1 DESCRIPTION

Wildflower seeding is the seeding of wildflowers in existing vegetated areas to boost levels of seasonal wildflower displays in order to increase vegetative species diversity and aesthetic values.

1.2 DESIGN APPLICATION

A. INTENT

Wildflowers supplement native grasses in effective erosion control, due in part to their hardy drought tolerance. Wildflower species do not require fertilizers, pesticides, or herbicides. Vegetative watering is minimal, thus reducing establishment and maintenance costs, particularly when compared to grass turf maintenance. (EPA, 2008)

B. BENEFITS

The benefits of using a wildflower seed mix:

1. Reduces erosion by dense soil cover.
2. Reduces the velocity and amount of surface runoff.
3. Increases soil infiltration rates.
4. Creates fibrous root systems that stabilize soil particles.
5. Reduces the amount of pollutants transported into water systems.
6. Improves the regional character of a site, reestablish native wildlife habitats, and biological diversity.
7. Requires less water and mowing than non-native plants due to adaptation to regional climate and soils.

C. LIMITATIONS

The limitations of using a wildflower seeding:

1. Perceived as having a less manicured appearance after the blooming period than some non-native grass species.
2. Some species may be more expensive due to seasonal fluctuations in availability and harvest requirements.
3. Some species may periodically not be commercially available.
4. Some species may require a longer time period for establishment from seed.

D. RELATED ITEMS

1. Item 30-1 "Seeding for Erosion Control"

E. REFERENCES

1. Federal Seed Act
2. Texas Seed Law
3. Texas State Department of Agriculture (TDA)
4. Williamson County Agricultural Office
5. TxDOT, 2004. Item 636 "Aluminum Signs."
6. TxDOT, 2004. Item 644 "Small Roadside Sign Supports and Assemblies."

F. GUIDELINES

1. Design
   a. Identify the general location where the wildflower seed will be applied to identify the appropriate seed mix (see Figure 1: Wildflower Seed Type Map of Williamson County).

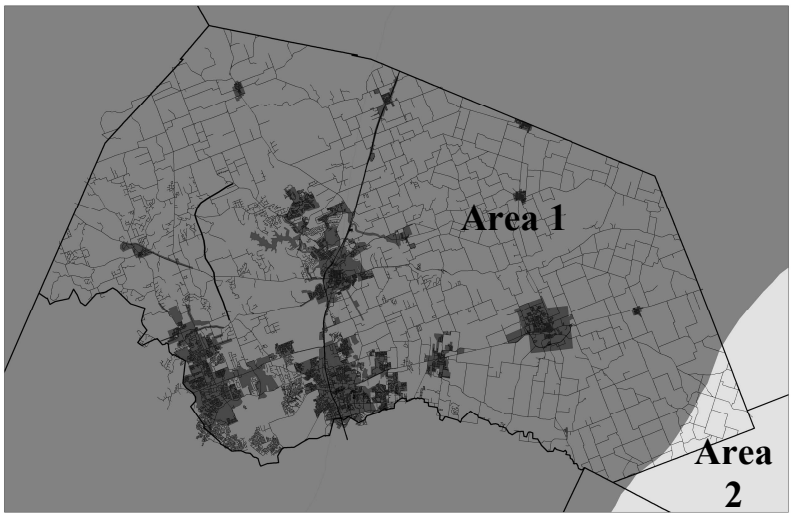


Figure 1: Wildflower Seed Type Map of Williamson County

Area 1 – Edward's Plateau & Blackland Prairie Eco-regions

Area 2 – Post Oak Savanna Eco-region

   b. Identify the location within the project where the wildflower seed will be applied to identify the appropriate seed mix. Each native mix contains a

combination of forbs (wildflowers). Use tables 1 through 5 to determine the appropriate seed mix and rates in the plans.

Figure 1: Area 1 & 2 Eco-regions and Corresponding Seed Mixes

Area 1 Edward's Plateau & Blackland Prairie	**Area 2** Post Oak Savanna
Type 1; Table 1: Standard Short	**Type 3; Table 3:** Standard Short
Type 2; Table 2: Standard Tall	**Type 4; Table 4:** Standard Tall
Type 4; Table 4: Cool Season Non-Native	**Type 4; Table 4:** Cool Season Non-Native
Type 5; Table 5: Riparian	**Type 5; Table 5:** Riparian

i. Use of the standard tall wildflower seed mixes (Tables 2 & 4) are appropriate for most applications in Williamson County where native grasses are specified.
ii. Use of the standard short wildflower mixes (Tables 1 & 2) are appropriate for more urban applications where a more managed aesthetic is desired.
iii. The Type 5 Riparian seed mix should be applied in areas that are periodically flooded or frequently wet, such as channels and margins of streams and drainageways.

c. Part A of tables 1 - 5 is the primary seed mix for application.
d. In the event that a species in Part A of the mixes is not seasonally available, the Engineer should coordinate with the seed supplier to designate substitute species and quantities in the mix using Part B of the tables. The Engineer may also allow a substitution if a particular species of seed becomes too costly due to seasonal fluctuations.
e. Species from Part B lists may also be added on an optional basis to increase the amount of plant diversity at the site. If available and affordable, species in Part B are ideal to include in the seed mixes.
f. Prepared seed mixes may be used as a substitute for creating a mix from the following tables. The prepared seed mix shall come from one of the three providers:
   i. Native American Seed, Junction TX. 1-800-728-4043
   ii. Wildseed Farms, Fredericksburg, TX. 1-800-848-0078
   iii. Douglas W. King Company, San Antonio, TX. 1-888-357-3337

Table 1: Type 1 Short Height Wildflower Seed Mix
Wildflower Seed Mix for Edward's Plateau and Blackland Prairie Eco-regions of Williamson County

Part A: Wildflowers			
Species	**Common name**	**lbs per acre**	**lbs per sq. yd.**
Cassia (Chamaecrista) fasciculata	Partridge Pea	5.00	0.0010
Coreopsis tintoria	Plains Coreopsis	2.00	0.0004
Desmanthus illinoensis	Illinois Bundleflower	7.50	0.0015

Engelmannia pinnatifida (Engelmannia peristenia)	Engelmann Daisy (Cutleaf Daisy)	9.00	0.0019
Gaillardia pulchella	Indian Blanket	10.00	0.0021
Lupinus texensis	Bluebonnet	15.00	0.0031
Mondarda citriodora	Lemon Mint	3.00	0.0006
Oenothera speciosa	Pink Evening Primrose	0.25	0.0001
Rudbeckia hirta	Black-eyed Susan	2.00	0.0004
Thelesperma filifolium	Greenthread	1.50	0.0003
		55.25	**0.0114**
Part B: Replacement Species and/or Species added for Increased Diversity			
Callirhoe leiocarpa	Annual Winecup	1.00	0.0002
Castilleja indivisia	Indian Paintbrush	0.15	0.0000
Corydalis curvisiliqua	Scrambled Eggs	0.50	0.0001
liatris mucronata	Gayfeather	2.50	0.0005
Oenothera missouriensis	Missouri Primrose	0.50	0.0001
Dalea candida (Petalostemon candidus)	White Prairie Clover	0.75	0.0002
Salvia farinacea	Mealy Blue Sage	1.50	0.0003
Simsia calva	Bush Sunflower	1.75	0.0004

Source: Lady Bird Johnson Wildflower Center, 2009

Table 2: Type 2 Tall Height Wildflower Seed Mix
Wildflower Seed Mix for Edward's Plateau and Blackland Prairie Eco-regions of Williamson County

Part A: Wildflowers			
Species	**Common name**	**lbs per acre**	**lbs per sq. yd.**
Cassia (Chamaecrista) fasciculata	Partridge Pea	5.00	0.0010
Centaurea americana	American Basketflower	5.00	0.0010
Coreopsis tintoria	Plains Coreopsis	1.00	0.0002
Desmanthus illinoensis	Illinois Bundleflower	3.00	0.0006
Engelmannia pinnatifida (Engelmannia peristenia)	Engelmann Daisy (Cutleaf Daisy)	9.00	0.0019
Gaillardia pulchella	Indian Blanket	7.50	0.0015
Helianthus maximiliani	Maximilian Sunflower	2.00	0.0004
Ipomopsis rubra	Standing Cypress	3.00	0.0006
Mondarda citriodora	Lemon Mint	1.50	0.0003
Oenothera speciosa	Pink Evening Primrose	0.25	0.0001
Rudbeckia hirta	Black-eyed Susan	0.50	0.0001
Thelesperma filifolium	Greenthread	1.50	0.0003
		39.25	**0.0080**
Part B: Replacement Species and/or Species added for Increased Diversity			
Callirhoe leiocarpa	Annual Winecup	1.00	0.0002
Castilleja indivisia	Indian Paintbrush	0.15	0.0000
Argemone albiflora	White Prickly Poppy	2.50	0.0005

Dalea candida (Petalostemon candidus)	White Prairie Clover	0.75	0.0002
liatris mucronata	Gayfeather	2.00	0.0004
Lindheimera texana	Texas Yellow Star	3.00	0.0006
Oenothera missouriensis	Missouri Primrose	1.75	0.0004
Oenothera speciosa	Pink Evening Primrose	0.50	0.0001
Salvia azurea	Pitcher Sage	0.75	0.0002
Salvia farinacea	Mealy Blue Sage	1.50	0.0003
Simsia calva	Bush Sunflower	1.75	0.0004
Solidago nemoralis	Grey Goldenrod	1.75	0.0004

Source: Lady Bird Johnson Wildflower Center, 2009

Table 3: Type 3 Short Height Wildflower Seed Mix
Wildflower Seed Mix for Post Oak Savanna Eco-region of Williamson County

Part A: Wildflowers			
Species	**Common name**	**lbs per acre**	**lbs per sq. yd.**
Cassia (Chamaecrista) fasciculate	Partridge Pea	5.00	0.0010
Coreopsis tintoria	Plains Coreopsis	1.00	0.0002
Gaillardia pulchella	Indian Blanket	10.00	0.0021
Lupinus texensis	Bluebonnet	15.00	0.0031
Mondarda citriodora	Lemon Mint	2.25	0.0005
Oenothera speciosa	Pink Evening Primrose	0.50	0.0001
Rudbeckia hirta	Black-eyed Susan	1.00	0.0002
Thelesperma filifolium	Greenthread	3.00	0.0006
		37.75	**0.0078**
Part B: Replacement Species and/or Species added for Increased Diversity			
Callirhoe leiocarpa	Annual Winecup	1.00	0.0002
Castilleja indivisia	Indian Paintbrush	0.15	0.0000
Asclepias tuberosa	Butterfly Weed	2.50	0.0005
Corydalis curvisiliqua	Scrambled Eggs	0.50	0.0001
liatris mucronata	Gayfeather	2.50	0.0005
Salvia farinacea	Mealy Blue Sage	1.50	0.0003
Simsia calva	Bush Sunflower	1.75	0.0004

Source: Lady Bird Johnson Wildflower Center, 2009

Table 4: Type 4 Tall Height Wildflower Seed Mix
Wildflower Seed Mix for Post Oak Savanna Eco-region of Williamson County

Part A: Wildflowers			
Species	**Common name**	**lbs per acre**	**lbs per sq. yd.**
Cassia (Chamaecrista) fasciculata	Partridge Pea	5.00	0.0010
Centaurea americana	American Basketflower	5.00	0.0010
Coreopsis tintoria	Plains Coreopsis	1.00	0.0002
Desmanthus illinoensis	Illinois Bundleflower	3.75	0.0008
Engelmannia pinnatifida (Engelmannia	Engelmann Daisy (Cutleaf Daisy)	9.00	0.0019

peristenia)			
Gaillardia pulchella	Indian Blanket	7.50	0.0015
Helianthus maximiliani	Maximilian Sunflower	2.00	0.0004
Ipomopsis rubra	Standing Cypress	3.00	0.0006
Mondarda citriodora	Lemon Mint	1.50	0.0003
Oenothera speciosa	Pink Evening Primrose	0.50	0.0001
Rudbeckia hirta	Black-eyed Susan	1.50	0.0003
Thelesperma filifolium	Greenthread	2.00	0.0004
		41.75	**0.0085**
Part B: Replacement Species and/or Species added for Increased Diversity			
Callirhoe leiocarpa	Annual Winecup	1.00	0.0002
Castilleja indivisia	Indian Paintbrush	0.15	0.0000
Argemone albiflora	White Prickly Poppy	2.50	0.0005
Dalea candida (Petalostemon candidus)	White Prairie Clover	0.75	0.0002
Asclepias tuberosa	Butterfly Weed	2.50	0.0005
Corydalis curvisiliqua	Scrambled Eggs	0.50	0.0001
liatris mucronata	Gayfeather	2.50	0.0005
Lindheimera texana	Texas Yellow Star	3.00	0.0006
Salvia azurea	Pitcher Sage	0.75	0.0002
Salvia farinacea	Mealy Blue Sage	1.50	0.0003
Simsia calva	Bush Sunflower	1.75	0.0004

Source: Lady Bird Johnson Wildflower Center, 2009

Table 5: Type 5 Riparian Wildflower Seed Mix

Wildflower Seed Mix for riparian areas of Williamson County

Part A: Wildflowers			
Species	**Common name**	**lbs per acre**	**lbs per sq. yd.**
Centaurea americana	American Basketflower	5.00	0.0010
Coreopsis tintoria	Plains Coreopsis	2.00	0.0004
Desmanthus illinoensis	Illinois Bundleflower	7.00	0.0014
Engelmannia pinnatifida (Engelmannia peristenia)	Engelmann Daisy (Cutleaf Daisy)	9.00	0.0019
Gaillardia pulchella	Indian Blanket	7.50	0.0015
Helianthus maximiliani	Maximilian Sunflower	2.00	0.0004
Oenothera speciosa	Pink Evening Primrose	0.50	0.0001
Rudbeckia (Dracopsis) amplexicaulis	Clasping Coneflower	3.00	0.0006
		36.00	**0.0073**
Part B: Replacement Species and/or Species added for Increased Diversity			
Physostegia intermedia	Obedient Plant	1.00	0.0002
Salvia azurea	Pitcher Sage	1.50	0.0003
Solidago altissima (S. canadensis)	Tall Goldenrod	2.50	0.0005
Solidago gigantea	Giant Goldenrod	2.50	0.0005

Source: Lady Bird Johnson Wildflower Center, 2009

g. Seeding Schedule
    i. September 21st to November 7th: apply wildflower seed mix
    ii. November 8th to September 20th: do not apply wildflower seed mix during this period.
h. Sign – No Mow Area
    i. Specify protective signage for posting at the edge of native grass areas at a rate of one sign per 1,500 linear feet. Stake sign between four and five (4-5) feet above grade in locations clearly visible from mowing areas. Sign measurement should be twelve (12) inch height by eighteen (18) inch width with the following message: "Native Vegetation. No Mowing Area"; include the County logo on the sign.

2. Materials
    a. Seed:
        i. Provide seed as shown in the plans or as directed, and meeting the requirements of the Federal Seed Act and Texas Seed Law, including the testing and labeling for pure live seed (PLS= Purity and Germination). Minimum purity shall be 50%. The seed test to be conducted by the State Seed Laboratory, and a seed test report shall be submitted in accordance with 1.6, "Quality Control Submittals." Each type (mix) of seed shall be mixed by the supplier and delivered in labeled and unopened bags or containers, unless otherwise approved by the Owner's representative. The Contractor shall not blend the seed mixes on site. Use within twelve (12) months from that date of analysis.
        ii. Seeds shall be stored in a dry, well-ventilated location away from contaminants. Seed storage humidity level should be lower than 75%. Store any unused seed in a water resistant container. If seed will be stored longer than one (1) year, the optimal temperature range would be 40-60F.
        iii. During transit (from storage to sowing), seed should be protected from dramatic temperature fluctuations day after day; temperature cannot exceed 100F at any time. Seed must remain dry and protected from sun exposure. The transit period may not exceed ten (10) days.
    b. Growing Medium:
    Wildflower seed may be installed following native grass establishment or in areas of naturally occurring native grass cover. Compost and added topsoil shall not be used as part of wildflower seeding.
    c. Sign
        i. Small Aluminum Sign (TxDOT Type A)

3. Installation
    a. There are a variety of common seeding equipment and installation techniques. The preferred method for all wildflower installations is broadcast seeding. However, the Engineer may specify one of the following methods of seed installation when deemed necessary:
        i. Broadcast Seeding is the preferred method of installation and should especially be required for areas that are difficult to access or are highly sensitive to equipment damage or compaction.
        ii. No-till Drill Seeding is an acceptable method when seeding a large area.
    b. Sign Installation.
    Post signs at locations shown on the plans or as directed at Final Acceptance. Posted signs to be visible to mowing equipment operators.

ITEM 32-1. BIOFILTRATION

1.1 DESCRIPTION

Biofiltration features are small, permanent landscaped basins typically located in-line with the drainage channels, providing stormwater management by using natural processes and low impact development principles.

1.2 DESIGN APPLICATION

A. INTENT

Biofiltration features assist in approaching the predevelopment hydrology by using these smaller, distributed features that rely on natural processes for water quality improvement (City of Austin Environmental Criteria Manual, 2009; EPA, 2009; and Low Impact Development Center, 2009).

These features lessen site runoff by accumulating water in a basin where it can infiltrate directly into the soil media (City of Austin Environmental Criteria Manual, 2009).

B. BENEFITS

The benefits of biofiltration include:

1. Improves water quality by treating the first flush of water.
2. Removes sediments and pollutants.
3. Comprehensive water quality control through use of chemical, biological, and physical properties of plants, microbes, and soil.

4. Reduces stormwater velocity.
5. Promotes sheet flow.
6. Provides base flow to rivers, creeks, and streams through infiltration; reducing flooding concerns downstream.
7. Provides a visual amenity.
8. Requires low maintenance once established.
9. Serves as a temporary sediment basin during construction, and then converting to a permanent biofiltration feature.

C. LIMITATIONS

The limitations of biofiltration include:

1. Limited to areas with relatively flat grades.
2. Maximum inflow velocity may be a constraint.
3. Inappropriate "end-of-pipe" solution.
4. Feature sizing capacity of right-of-way.
5. Inappropriate soil conditions:
   a. Existing toxicity and potential leaching of soil substrate.
   b. Inadequate soil volume.
   c. Subsurface drainage conditions.
   d. Soil type and infiltration rate.

D. RELATED ITEMS

1. Item 26-1 "Compost"
2. Item 25-1 "Mulch Topdressing"
3. Item 40 "Mowing"
4. Item 41 "Invasive Species Control"
5. Item 22-1 "Vegetative Watering"
6. Item 42 "Reforestation"

E. REFERENCES

1. Item 192, "Landscape Planting".
2. TCEQ, 2005, Complying with the Edward Aquifer Rules, Technical Guidance on Best Management Practices, Item 1.4.12 Stone Outlet Sediment Trap and Item 1.4.13 Sediment Basins, Item 3.4.8 Bioretention.

F. GUIDELINES

1. Design
   a. Locate biofiltration feature outside the roadway safety clear zone and in a location where road stability will not be impacted, or where there is potential to cause flooding of pavement.
   b. Drainage Area:
      i. Drainage areas are larger hydrologic flow systems that are divided into, and composed of, multiple smaller site specific drainage areas. Biofiltration features are best designed as part of a system of features treating a series of a sub basins, or micro-watersheds, within the larger drainage area. Provide multiple small drainage features rather than a single large feature. Smaller watersheds receive lower sediment loads and enhance pollutant removal (City of Austin Environmental Criteria manual, 2009).
      ii. Biofiltration features should have the same entry and exit flow path upon reaching pooling capacity (TCEQ-EAR).

c. Grading Design:
    i. Biofiltration feature should be located in an area with relatively flat slopes, no greater than five (5) percent (EPA, 2009).
    ii. Maximum inflow velocity to the basin should not exceed 3 ft/sec. Energy dissipation devices may be used for velocities greater than 3 ft/sec.
    iii. Top surface of the soil media bed should be flat.
    iv. The basin side slopes should be no steeper than 3:1.
d. Ground Water:
    i. Verify appropriate soil depth for infiltration to limit potential ground water mounding (Tsay and Hoopes 1998).
    ii. Define appropriate minimum depth of media and minimum distance from ground water. Ground water should be a minimum of three (3) feet below the bottom of the soil media.
e. Sizing Calculations:
    i. Determine the Water Quality Volume (WQV) by multiplying the first flush one (1) inch by the drainage area.
    ii. Divide the WQV by one (1) day infiltration rate = Area required for biofiltration feature.

2. Materials
    a. Soil media: Soil types influence biofiltration rates and the sizing of the feature.
        i. Conduct a field saturated conductivity test.
        ii. The soil media should allow water to infiltrate within 72 hours.
        iii. To increase the percolation rate of native soils, add 20-30% compost.
        iv. Soil media composition should include 50-60% sand, 20-30% compost, 20-30% topsoil, and less than 5% clay. Up to half of the sand content may be substituted with processed recycled glass.
    b. Underdrains: Underdrains are required for biofiltration features that are located in the Edwards Aquifer recharge and contributing zone. (TCEQ-EAR 3.4.8) However in other locations, underdrains are optional for most applications. In areas where underlying native soils have adequate saturated conductivity rates, underdrains are discouraged. However in locations where underlying native soils are not permeable, underdrains or other overflow features are encouraged.
        i. Piping should consist of a main collector pipe and two or more lateral branch pipes, each with a minimum diameter of four (4) inches.
        ii. Underdrains should be perforated with ¼ - ½ inch openings, six (6) inches center to center.
        iii. Piping should have a minimum slope of 1% (1/8 inch per foot).
        iv. Laterals should be spaced at intervals of no more than ten (10) feet.
        v. Each individual underdrain pipe should have a cleanout access location with a removable PVC cap (TCEQ-EAR).
    c. Liners: A biofiltration feature located within the Edwards Aquifer recharge zone must include a liner. Outside of the Edwards Aquifer recharge zone, liners are not required in a contributing zone, or other locations so that runoff is allowed to infiltrate. Reference TCEQ-EAR 3.4.8.8 for information regarding liner use and possible design considerations.
    d. Gravel blanket: Beneath the soil media, a gravel blanket is required that should include:
        i. ½" – 1 ½" diameter washed, rounded river gravel (COA-ECM) or processed recycled glass equivalent in size to gravel.

ii. A layer of filter fabric to separate the gravel layer from the soil media. No filter fabric is to be used on the side walls or invert of the feature (TCEQ-EAR).

e. Dry wells: In locations where infiltration is permitted, dry wells may be used to replace underdrains. Where subsurface compaction cannot be avoided, dry wells may be used to ensure adequate drainage from the biofiltration feature. Dry wells may also be installed in features after they have been installed if draw down times exceed predicted rates.
   i. A dry well is a minimum of a twelve (12) inch diameter hole that is filled with two to three (2 to 3) inch aggregate rock and sand to allow water infiltration down into the substrate where upper levels of infiltration are not sufficient to achieve desired draw down time.
   ii. Each dry well should penetrate a minimum of two (2) feet below compacted soil levels area. Some large biofiltration features may require more than one dry well.
   iii. Dry wells should be located at the low point in the subgrade.

3. Plant Selection: Biofiltration plant selection should be based on the function of the area, the expected inundation period, and the aesthetic qualities of the biofiltration features.
   a. Plants should be selected which:
      i. Are adapted to biofiltration feature hydrology.
      ii. Are adapted to the soil media type.
      iii. Are suitable for their specific function such as, erosion control and filtration.
      iv. Are durable, resilient and resistant to pests and disease.
      v. Are tolerant of the expected pollutant load in stormwater runoff.
      vi. Have a root system of the desired type, mass and depth.
      vii. Are resistant to weed invasion.
      viii. Require minimal maintenance.
      ix. Are not invasive.
   b. Plant Type
      i. Plant Density: Vegetated cover with herbaceous material should be at least 70% coverage within the biofiltration area once established.
      ii. Plant species should be selected from Table 1, below.
         (1) Part A and B of Table 1 is the primary seed mix for application in biofiltration features.
         (2) In the event that a species in Part A or B of the mix in Table 1 is not seasonally available, the Engineer should coordinate with the seed supplier to designate substitute species and quantities in the mix using Part C of Table 1. The Engineer may also allow a substitution if a particular species of seed becomes too costly due to seasonal fluctuations.
         (3) Species from Part C of Table 1 may also be added on an optional basis to increase the amount of plant diversity at the site. If available and affordable, species in Part C are ideal to include in the seed mixes.
         (4) The species listed in the "Container" tables should be installed after the seed mix has been installed and established.
         (5) Many of the species in Table 1 are available in live root form as well. Live root plants are beneficial for quick establishment and

can be used to supplement a seeded area. Live root plants should generally be installed at a ten (10) inch on center spacing.

Table 1: Native Plant Species Mix for Biofiltration Features
Native Plant Mix for Biofiltration Features in Williamson County
Total Seed Rate of Type 4 Mix = 0.0170 lbs/sq yd or 83 lbs/acre

Part A: Wildflowers			
Species	**Common name**	**lbs per acre**	**lbs per sq yd**
Coreopsis tintoria	Plains Coreopsis	4.00	0.0008
Desmanthus illinoensis	Illinois bundleflower	7.00	0.0014
Helianthus maximiliani	Maximilian sunflower	4.00	0.0008
Rudbecia(Dracopis) amplexicaulis	Clasping coneflower	3.00	0.0006
Oenothera speciosa	Pink evening primrose	0.50	0.0001
Rudbeckia hirta	Black-eyed Susan	0.50	0.0001
Rudbeckia (Dracopis) amplexicaulis	Clasping coneflower	3.00	0.0006
		22.00	**0.0044**
Part B: Grasses			
Species	**Common name**	**lbs per acre**	**lbs per sq yd**
Buchloe dactyloides	Buffalograss	6.00	0.0012
Elymus canadensis	*Prairie Wild Rye	15.00	0.0031
Panicum virgatum (Upland)	*Switchgrass (Upland)	8.00	0.0017
Sorghastrum nutans	*Indiangrass	12.00	0.0025
Tripsacum dactyloides	*Eastern Gamagrass	20.00	0.0041
		61.00	**0.0126**
Part C: Replacement Species and/or Species for Increased Diversity			
Species	**Common name**	**lbs per acre**	**lbs per sq yd**
Andropogon glomeratus	Bushy Bluestem (grass)	1.00	0.0002
Physostegia intermedia	Obedient Plant	1.00	0.0002

Containerized	
Species	**Common name**
Andropogon glomeratus	Bushy Bluestem (grass)
Carex blanda	Creek Sedge
Carex cherokeensis	Cherokee Sedge
Eleocharis palustris	Common Spikerush
Physostegia intermedia	Obedient Plant
Solidago altissima (S. canadensis)	*Tall Goldenrod

Solidago gigantea	Giant Goldenrod
Solidago juliae	Julia's Goldenrod

Source: Lady Bird Johnson Wildflower Center, 2009
*Note: These species are commonly available in Live Root material.

G. Installation:
   1. Soil media: Soil media will be used in a manner that will ensure adequate filtration.
      a. Scarify the sides and invert area of the excavated biofiltration feature (not required for biofiltration features that require liners).
      b. Place soil media in eight to twelve (8 – 12) inch lifts in order to reduce the possibility of excessive settlement.
      c. Lifts are not to be compacted, but may be slightly watered to encourage natural compaction.
      d. Rake soil media to level condition.
      e. Overfill above the proposed surface grade to accommodate natural settlement (TCEQ-EAR).
   2. It is important that the designer include maintenance considerations and the integrated pest management (IPM) during the design phase of the biofiltration project. The feature should be designed to allow for the maintenance access and maneuverability of maintenance equipment.
   3. Plants: Refer to Item 30-1 "Seeding for Erosion Control"; Item 41 "Invasive Species Control" and Item 22-1 "Vegetative Watering."

Chapter 3

PS&E Phase Protocol: Technical Specifications

CHAPTER 3

Introduction

The Williamson County Protocol special technical specifications are intended to supersede the applicable standard TxDOT technical specifications and be incorporated into contract plans for Williamson County roadway projects. The technical specifications relate to the Best Management Practices Design Criteria described in Chapter 2.

The technical specifications provided in this chapter are numbered and referenced for this protocol document. Within each technical specification, it will be the responsibility of the Design Engineer to edit the item numbers for all section titles, footers, and references that correspond to other technical specification items used in the project construction manual.

The following items to be included in the Special Conditions section of the Construction Manual:

XIV. Erosion Control:

Contractor shall comply with all laws prohibiting the pollution of any lake, stream, river, or wetland by the dumping of any refuse, rubbish, dredge material, or debris therein.

Contractor shall apply temporary and/or permanent erosion and sedimentation controls, as specified in the plans or directed to disturbed roadside areas, fifteen feet and beyond from road pavement, prior to initiating road base operations. Following asphalt paving of road pavement, apply temporary and/or permanent erosion and sedimentation controls to remaining disturbed areas, as specified in the plans or as directed.

Contractor shall be responsible for the maintenance of all temporary and permanent water quality and erosion control measures proposed under the Storm Water Pollution Prevention Plan (SWPPP) or the Water Pollution Abatement Plan (WPAP) for the duration of the project construction. Upon completion of construction and before the Construction Observer issues the "Certificate of completion", Contractor shall be responsible for the removal of all temporary measures and the cleaning and resetting of all permanent measures. All costs associated with this work shall be considered subsidiary to other bid items and no additional compensation shall be allowed.

Contractor shall take special precautions during all periods of heavy rainfall and at all locations where storm water, groundwater and/or mud and debris may enter the sewer systems. All mud, stones, and debris that enter the sewer systems due to Contractor's operations, or his neglect, shall be cleaned from the system by Contractor. It shall be Contractor's responsibility to see that such storm water, groundwater and debris do not enter the sewer system. All costs for such work shall be merged in the unit prices bid and no-additional compensation shall be allowed.

If it is necessary in the prosecution of the work to interrupt existing surface drainage, sewers, or under drainage, temporary drainage shall be provided until permanent drainage work is completed. The construction of all temporary drainage installations shall be considered as incidental to the construction of the work. Drainage ways shall be kept clear or other satisfactory provisions made for drainage.

Contractor shall be responsible for and shall take all reasonable and necessary precautions to preserve and protect all existing tile drains, sewers, and other subsurface drains, or parts thereof, which may be continued in service without change. Contractor shall repair at his own expense any and all damage to such facilities resulting from negligence or carelessness on the part of his operations.

XXXIII. Tree and Plant Protection:

Scope: Provide complete protection and maintenance of existing trees, shrubs **and grass areas designated to remain within construction limits and/or right-of-way**.

Coordination: Coordinate protection of existing trees, shrubs **and grass areas** with other trades so as to prevent damage to these items.

Payment for Damages: If existing trees, shrubs **or grass areas** are destroyed, killed or badly damaged as a result of construction observations, Contract sum will be reduced by the amount of assessed damages. Damages will be evaluated by the Construction Observer, using the following:

Trees: International Shade Tree Conference Standards and following formula – measurement of a cross section of tree trunk will be made at a point 2 feet above existing grade level to determine cross section area in square inches. Assessment for damage will be $27.00 per square inch.

Shrubs and Grass Areas: An initial fine of $1,000 shall be imposed for any unauthorized disturbance within the boundaries of the shrub and grass areas to remain within the right-of-way and outside the limits of disturbance. This disturbance includes but is not limited to: parking or intrusion of equipment or vehicles; storage of any materials, and any unauthorized damage and/or removal of vegetation. In addition to the initial fine, a base fine of $8.00 for every square foot of area of damaged vegetation within any areas designated to remain on the plans shall be imposed. The areas covered under this section include but are not limited to: areas designated to remain or no-work areas. In determining the amount of fine, the Construction Observer shall consider the degree and extent of harm caused by the violation, the cost of rectifying the damage, and whether the violation was committed willfully.

Materials: Tree Protection lumber dimensions shall be 4x4 and 2x4 sizes.

Protection: Protect existing trees, shrubs **and grass areas** within construction limits and/or designated to remain within the right-of-way from the following damage:

1. Compaction of root area by equipment, vehicles or material storage;
2. Trunk damage by moving equipment material storage, nailing or bolting;
3. Strangling by tying ropes or guy wires to trunks or large branches;
4. Poisoning by pouring solvents, gas, paint or other chemicals on or around trees and roots, shrubs or grass areas;
5. Cutting of roots by excavating or ditching;
6. Damage of branches by improper pruning;
7. Drought from failure to water or by cutting or changing normal drainage pattern past roots;

8. Changes of soil pH factor by disposal of lime base materials such as concrete or plaster;
9. Do not cut roots 1-1/2" in diameter or over. Excavation and earthwork within drip line of trees shall be done by hand.

Install barricade protection around trees and large shrubs, constructed of 4x4 posts and 2x4 stringers top and bottom. Install protection prior to demolition or excavation operations. Leave protection until construction operations are essentially complete.

Maintenance:

1. Water trees and shrubs within construction limits as required to maintain their health during course of construction operations.
2. Pruning will be performed by County.

Materials

Temporary Erosion and Sedimentation Controls

ITEM 20-2. TOPSOIL

SPECIAL PROVISION

160 – 20-2

TOPSOIL

For this project, Item 160, "Topsoil," of the Standard Specifications, is hereby voided and replaced in its entirety with the clauses and requirements below.

PART 1- GENERAL

1.1 DESCRIPTION
Furnish and apply topsoil as shown in the plans or as directed.

1.2 RELATED ITEMS
Item 26-2 "Compost"

1.3 MEASUREMENT
This item will be measured by the 100-ft. station along the baseline of each roadbed, by the square yard complete in place, or by the cubic yard in vehicles at the point of delivery.

1.4 PAYMENT
Unless topsoil is specified as a pay item, the work performed and materials furnished in accordance with this item will not be paid for directly but will be subsidiary to pertinent Items.

When topsoil is specified on the plans as a pay item, the work performed and topsoil furnished will be paid for at the unit price bid for "Furnishing and Placing Topsoil" of the depth specified on the plans (except for measurement by the cubic yard). This price is full compensation for securing necessary sources and royalties; furnishing topsoil; excavation, loading, hauling, stockpiling and placing; watering; rolling and equipment, labor, materials, tools and incidentals. Limits of excavation and embankment for payment are shown in Figure 1.

1.5 QUALITY CONTROL SUBMITTALS
A. Submit one (1) pound sample of on-site stockpiled topsoil for approval.
B. Submit imported topsoil and supplier information, including product composition, as well as a one (1) pound sample for approval.
C. A statement that the on-site stockpiled topsoil has met the decomposition process.

PART 2 – PRODUCTS

2.1 MATERIALS
A. Use easily cultivated fertile topsoil, through fresh mining, that is free from objectionable material, such as weed seeds, roots, rhizomes, or stolons, has a high resistance to erosion, and is able to support plant growth.
   1. Obtain topsoil from the right of way at sites of proposed excavation or embankment when specified on the plans, or as directed.

2. Secure additional topsoil, if necessary, from approved sources outside the right of way in accordance with the requirements of Article 7.19, "Preservation of Cultural and Natural Resources and the Environment." Ensure that the topsoil obtained from sites outside the right of way has a pH of 5.5 to 8.5.
3. Topsoil is subject to testing by the Engineer.
4. Use water that is clean and free of industrial wastes and other substances harmful to the growth of vegetation.

PART 3 – EXECUTION

3.1 SEQUENCING

A. Following removal of the existing vegetation from the site (if specified), excavate topsoil in specified areas and place in a stockpile on-site. Complete the decomposition process in stockpile prior to installation or use of topsoil at depths specified on plans. Install topsoil prior to installation of erosion control compost (ECC). Reference Item 26-2 "Compost" for installation specifications.

3.2 CONSTRUCTION

A. Installation
   1. Remove and dispose of objectionable material from the topsoil source before beginning the work.
   2. Place excavated topsoil in stockpiles no less than three (3) feet by three (3) feet by three (3) feet in size at designated locations along the right of way line or as directed.
   3. Keep source and stockpile areas drained during the period of topsoil removal and leave them in a neat condition when removal is complete.
   4. From June 1 to October 15, completely turn the stockpile once per month. Internal temperature of the material should be 120-140F. Stockpile should continue to be turned and remain at this internal temperature for no less than one (1) month before use.
   5. From October 16 to May 31, if the average outdoor temperature is below 75F, remove and discard the top six (6) inches of the stockpile. It is not necessary to turn the stockpile during this time period.
   6. Stockpiles should be surrounded by biodegradable erosion control logs to prevent run-off of material.
   7. X Uniformly blend topsoil per "Compost" if specified as Compost Modified Topsoil (CMT). Reference "Compost" for installation specifications.
   8. For subsoils that are not compacted, scarify or break the surface of the soil with a flexible tine harrow one (1) to two (2) inches in depth. Spread the topsoil to a uniform loose cover at the thickness specified. Place and shape the topsoil to no greater than 70-75% Proctor density. Soils compacted above the specified Proctor density must be ripped until they are within the desired percentages according to Item 23-2 "Soil Ripping." Apply the topsoil to the ripped soil and work into the lower soil horizons with a harrow.

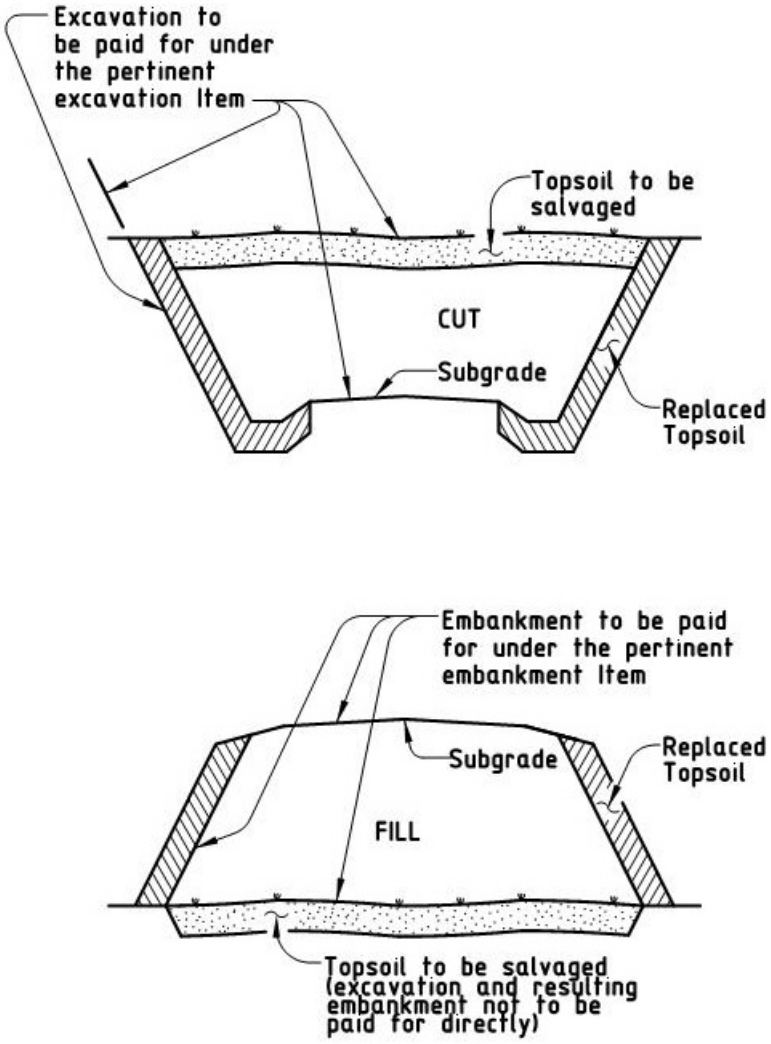


Figure 1
Roadway cross sections showing payment for excavation and embankment.

ITEM 21-2. MULCH

SPECIAL SPECIFICATION

21-2

MULCH

PART 1- GENERAL

1.1 DESCRIPTION
Furnish and install mulch as shown on the plans or as directed.

1.2 RELATED ITEMS
A. Item 5049 -27-2 "Biodegradable Erosion Control Logs"
B. Item 161-26-2 "Compost"
C. Item 25-2 "Mulch Topdressing"

1.3 MEASUREMENT & PAYMENT
Not measured or paid directly. This item is subsidiary to other items of the contract.

1.4 QUALITY CONTROL SUBMITTALS
A. Submit one (1) pound sample of on-site shredded mulch for approval.
B. Submit imported organic mulch product data and supplier information, including product composition, as well as a one (1) pound sample for approval.
C. A statement that the shredded mulch has met the decomposition process.

PART 2 – PRODUCTS

2.1 MATERIALS
A. Mulch can be on-site shredded organic mulch or an imported organic mulch product.
1. Mulch can be comprised of wood chips, shredded bark, shredded landscape trimmings, or coarse compost material originating from the 3-county Central Texas region (Williamson, Travis and Hays).
2. Mulch to be shredded with no pieces greater than three (3) inches in length and with all pieces passing through a two (2) to three (3) inch screen.
3. Invasive species should be excluded from mulch.
4. Color: natural wood.
5. Contamination: less than 0.5% weight by volume.
6. Mulch to have undergone a decomposition process either on site or at supplier's location.

PART 3 – EXECUTION

3.1 SEQUENCING
A. For mulch material that has not gone through the stockpiling and decomposition process: Following removal of the existing vegetation from the site, shred the material to the specified size, and place in a stockpile on-site. Complete the decomposition process in stockpile prior to installation or use of mulch at depths specified on plans. If using the mulch for dust control, compaction control, or on existing vegetation to remain, place immediately after the completion of the decomposition process.

3.2 CONSTRUCTION

A. Installation

1. Shred trees and vegetation to the specified size requirements.
2. Apply Nitrogen at the rate of one (1) part Nitrogen to ten (10) parts mulch.
3. Stockpile the mulch and allow to sit or cook for a period of no less than three (3) weeks if the temperature is above 70F. If the temperature is below 70F, extend the sitting or cooking time to five (5) to six (6) weeks.
4. Turn the stockpile at least twice per week during the sitting or cooking period.
5. Stockpiles should be surrounded by biodegradable erosion control logs within 24 hours of placement to prevent run-off of the material.

ITEM 22-2. VEGETATIVE WATERING

SPECIAL PROVISION

168 – 22-2

VEGETATIVE WATERING

For this project, Item 168, "Vegetative Watering," of the Standard Specifications, is hereby voided and replaced in its entirety with the clauses and requirements below.

PART 1- GENERAL

1.1 DESCRIPTION

Provide and distribute water to promote growth of vegetation as specified or as directed.

1.2 RELATED ITEMS

A. Item 29-1 "Riparian Bioengineering"
B. Item 164-30-1 "Seeding for Erosion Control"
C. Item 31-1 "Wildflower Seeding"
D. Item 32-1 "Biofiltration"

1.3 MEASUREMENT

This item will be measured by the 1000 gallons as applied.

1.4 PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Vegetative Watering". This price is full compensation for furnishing and operating watering equipment and measuring devices for furnishing and applying water, including hauling, equipment, labor, and incidentals.

1.5 QUALITY CONTROL SUBMITTALS

A. Submit water source and technique of application for approval.
B. Submit a layout drawing and shop drawings of the temporary irrigation system (drip or rotor/spray irrigation) for approval.
C. Submit a report of pH and soluble salt levels of the irrigation water for approval prior to installation.
D. Submit a weekly report for each delivery of water per water truck, if source of water is off-site.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Water

Use water that is clean and free of industrial wastes and other substances harmful to the growth of vegetation. Do not incorporate fertilizer into the water for irrigation. The pH should be between 6.5 – 8.4 to be acceptable for use as irrigation water (MSUES, 2009). Soluble salt levels between 0 – 1,500 mmhos/cm are acceptable for use (CTIP, 2008).

B. Temporary Irrigation
For materials, refer to Item 170 “Irrigation System”.

PART 3 – EXECUTION

3.1 SEQUENCING

A. Vegetative watering shall commence following installation of seeding and plants.

3.2 CONSTRUCTION

A. Schedule

1. Apply vegetative watering in the appropriate quantities and frequencies shown in Table 2 for native grass and wildflower seeded areas and Table 3 for planted trees and shrubs, or to replace moisture loss per evapotranspiration (ET) rate, whichever is greater. Significant on-site rainfall of ½ inch or greater allows the postponement of watering until the next scheduled irrigation.
2. Daily Evapotranspiration (ET) rates for the County may be found at this AgriLife Extension website:
http://texaset.tamu.edu/date.php?stn=3&spread=14
See an example as shown in Table 1.
How to use this table: Look at the first column, ETo, for the inches of water lost per day in evapotranspiration. Add the inches for the last 7 or 14 days (depending on your watering phase shown in Tables 2 and 3) of ETo to get the total number of inches lost by evapotranspiration. This is the amount of watering that needs to be applied to the vegetation at the frequency given in Tables 2 and 3.

Table 1: ET and Weather Data – 14 Day Table (for example only)

Georgetown II Weather Station
Station Sponsored by : Williamson County Extension

Date	ETo PET (in)	Tmax (F)	Tmin (F)	RHmin (%)	Solar (MJm2)	Rain (in)	Wind 4am (mph)	Wind 4pm (mph)
2010-08-26	0.20	90	76	35	15.47	0.00	4.91	4.15
2010-08-27	0.25	93	67	21	26.20	0.00	0.33	7.51
2010-08-28	0.24	95	62	23	26.05	0.00	0.10	4.28
2010-08-29	0.29	95	70	32	22.64	0.00	8.42	8.55
2010-08-30	0.30	96	78	38	20.19	0.00	8.73	8.46
2010-08-31	0.27	95	75	41	21.45	0.00	5.91	6.64
2010-09-01	0.28	95	77	38	21.56	0.00	5.55	6.35
2010-09-02	0.22	91	77	49	17.02	0.00	8.52	6.62
2010-09-03	0.16	84	71	49	11.92	0.18	1.34	9.83
2010-09-04	0.25	88	69	37	23.25	0.00	4.65	6.88
2010-09-05	0.24	91	67	32	23.00	0.00	0.49	6.55
2010-09-06	0.20	89	69	54	18.45	0.05	2.96	11.46
2010-09-07	0.06	77	72	84	2.64	4.74	4.73	14.46
2010-09-08	0.11	83	74	73	7.36	4.69	12.68	4.04
14 Day Summary	3.07	90	72	43	18.37	9.66	4.95	7.56

Note: Reported are the average hourly values, not the absolute highs and lows.
Source: AgriLIFE EXTENSION - Texas A&M System

Table 2: Vegetative Watering Schedule for Native Grass and Wildflower Seeding

Time Period	Irrigation Application Amount*	Frequency**
Day of Installation	Minimum 1 inch	Min. 2 times per day
Phase 1 Next 10 days	Minimum 1 inch	Min. 1 time per day (no rain)
Phase 2 Next 14 days	Min. 1 inch or replace weekly ET	Min. 2 time per week (no rain or dew)
Phase 3 Until Plant Establishment	Min. 1.5 inch or replace weekly ET	Min. 1 time per every other week, or as necessary***

Source: Adapted from COA, 2009 & TCEQ, 2005.
Note 1: *5.6 gallons per square yard = 1 inch of applied water
Note 2: **Reduce irrigation frequency if during period of seasonal rains, since the watering frequency will greatly depend on the time of year. Deviations from the above watering schedule should be approved.
Note 3: ***Irrigation in Phase 3 should pause during the dormant season, beginning on December 15, and should be reinstated beginning February 15.
Note 4: Reference Item 164-30-1 "Seeding for Erosion Control" Maintenance Requirements for plant establishment specifications.
Note 5: Stop irrigation if there is puddling.

Table 3: Vegetative Watering Schedule for Planted Trees and Shrubs

Time Period	Irrigation Application Amount*	Frequency**
Day of Installation	Saturate Root Depth	Min. 1 times per day
Phase 1 - Next 14 days	Saturate Root Depth	Min. 1 time per every other day, or as necessary
Phase 2 - Until Plant Establishment	Saturate Root Depth	Min. 1 time per week, or as necessary***

Source: Adapted from COA, 2009 & TCEQ, 2005.
Note 1: *5.6 gallons per square yard = 1 inch of applied water
Note 2: **Reduce irrigation frequency if during period of seasonal rains, since the watering frequency will greatly depend on the time of year. Deviations from the above watering schedule should be approved.
Note 3: ***Irrigation in Phase 2 should pause during the dormant season, beginning on December 15, and should be reinstated beginning February 15.
Note 4: Stop irrigation if there is puddling.

B. General Guidelines:
   1. Contractor should determine the vegetative watering technique (temporary drip irrigation, temporary rotor or spray irrigation or water truck) most appropriate for the project if not specified in the plans.
   2. After approval of drip or rotor/spray irrigation technique (if selected as the appropriate technique), produce shop drawings for these systems for approval by the Engineer.
   3. Apply water to all newly vegetated areas as shown on the plans or as directed.

4. Irrigation water should not cause excessive run-off.
5. Water should ensure 100% coverage on all seeded and planted areas.
6. Overspray onto pavement is not allowed.

C. Temporary drip irrigation guidelines:
   1. Install temporary drip irrigation lines per approved shop drawings.
   2. Irrigation system should provide coverage to 100% of plant establishment areas.
   3. Drip irrigation water should come from one of the following sources, submit water source for approval.
      a. Tie into existing water source or well.
      b. Pump water from nearby creek or river with the use of a generator. Obtain approval from Construction Observer prior to pumping.
      c. Tie temporary irrigation line to a water truck.
      d. Store water in a storage tank and locate at the highest elevation on the site to effectively move water to each emitter through pressure.
   4. Pressure compensating emitters should be used on hilly sites.
   5. Two emitters should be placed at each plant to ensure adequate watering in case one emitter becomes clogged.
   6. Drip system components may consist of barbed emitters in polyethylene tubing or in-line emitter tubing. Spaghetti tubing from multi-nozzle emitter heads should not be used due to ease of damage and numerous parts involved.
   7. Irrigation piping and all related equipment should be removed from site when directed by the Construction Observer after the acceptance of the establishment period.

D. Temporary rotor or spray irrigation guidelines:
   1. Install temporary rotor or spray irrigation lines per approved shop drawings.
   2. Irrigation system should provide coverage to 100% of plant establishment areas.
   3. Rotor or spray water should come from one of the following sources, submit water source to Owner's representative for approval.
      a. Tie into existing water source or well.
      b. Pump water from nearby creek or river with the use of a generator. Obtain approval from Construction Observer prior to pumping.
      c. Tie temporary irrigation line to a water truck.
      d. Store water in a storage tank and locate at the highest elevation on the site to effectively move water to each emitter through pressure.
   4. Pressure compensating emitters shall be used on hilly sites.
   5. Collect water lines and all irrigation equipment when directed by the Construction Observer after the acceptance of the establishment period.

E. Water truck distribution:
   1. Furnish and operate water truck equipment to apply water at a uniform and controllable rate that does not scour or erode the soil or seeding bed or wash away seeds or plantings. Applying water in multiple passes may be necessary to avoid scouring or erosion.
   2. The water truck operator should not drive within designated seeding or planting areas.
   3. The water spray should be directed upwards to distribute the water force and reduce potential erosion.

3.3 MAINTENANCE

A. The contractor should maintain the irrigation system, and inspect designated seeding or planting areas after each watering to ensure adequate water distribution. If erosion or seed washout occurs, soil and compost shall be restored to finished grade, and the area shall be reseeded (Refer to Item 164-30-1 "Seeding for Erosion Control").

B. Irrigation water lines should remain intact and functioning during the establishment period. The contractor should inspect equipment, including drip lines, connectors, and main lines on a regular basis to ensure that they are operable and do not leak. Broken water lines should be repaired immediately.

C. The site should be inspected after irrigation applications to ensure watering trucks have not eroded soil or compost or washed out seeds or plants. Soils compacted by water trucks are to be ripped. Refer to Item 23-1 "Soil Ripping". Damaged areas should be regraded and reseeded immediately.

ITEM 23-2. SOIL RIPPING

SPECIAL SPECIFICATION

23-2

SOIL RIPPING

PART 1- GENERAL

1.1 DESCRIPTION
Perform soil ripping on designated areas according to the plans or as directed.

1.2 RELATED ITEMS
A. Item 161-26-2 “Compost”
B. Item 21-2 “Mulch”
C. Item 164-30-2 “Seeding for Erosion Control”
D. Item 5049-27-2 “Biodegradable Erosion Control Logs”

1.3 MEASUREMENT
The process will be measured by the square yard.

1.4 PAYMENT
The work performed and furnished in accordance with this Item and Measured as provided under “Measurement” will be paid for at the unit price bid for “Soil Ripping”. This price is full compensation for labor, equipment, tools, supplies, and incidentals.

1.5 QUALITY CONTROL SUBMITTALS
Submit soil ripping equipment data for approval, prior to installation.

PART 2 – PRODUCTS

PART 3 – EXECUTION

3.1 SEQUENCING
A. Complete final grading in accordance with the plans or as directed.
B. Soil ripping should be performed prior to the installation of compost and/or topsoil, mulch, and/or native grass and wildflower seeding.

3.2 CONSTRUCTION
A. Installation:
1. Perform soil ripping parallel and perpendicular (in both directions) to the slope at location, groove spacing, and depth shown on the plans as well as any additional areas that have been compacted during construction activities to achieve a standard proctor density of 80-85% in channels and 70-75% in non-channel areas.
2. All soil surfaces with a slope of 3:1 or less that are compacted due to equipment traffic should be ripped.
3. If construction activities are on-going, repeat procedure as necessary.

3.3 MAINTENANCE

A. Routinely inspect the soil ripping weekly during construction and within 24 hours after every one-half (1/2) inch or greater rainfall event. Inspections should ensure that:
   1. No slumping of the rips has occurred.
   2. The ripping was installed at the appropriate depth and spacing.
   3. The contour rips are parallel and perpendicular to the slope.

B. If major slumping or slope failure occurs, the area should be regraded and reseeded. If minor slumping or rills occur, the specified topsoil and/or compost and seeding for the area in the plans may be applied, at the discretion of the Owner's Representative.

C. Continue to inspect the area on a weekly basis until vegetation has been established.

ITEM 24-2. SOIL RETENTION BLANKET

Reference Texas Department of Transportation, Technical Specifications, 2004, Item 169, Soil Retention Blankets for technical specifications.

ITEM 25-2. MULCH TOPDRESSING

SPECIAL SPECIFICATION

25-2

MULCH TOPDRESSING

PART 1- GENERAL

1.1 DESCRIPTION
Furnish and install mulch topdressing as shown in the plans or as directed.

1.2 RELATED ITEMS
A. Item 21-2 "Mulch"

1.3 MEASUREMENT
This item will be measured by the cubic yard.

1.4 PAYMENT
The work performed and the materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Mulch Topdressing." This price is full compensation for furnishing materials, including mowing, labor, equipment, maintenance, tools, supplies, and incidentals.

1.5 QUALITY CONTROL SUBMITTALS
A. Submit samples and product data in conformance with Item 21-2 "Mulch", Part 1, 1.4 "Quality Control Submittals."

PART 2 – PRODUCTS

2.1 MATERIALS
A. Mulch
As specified in Item 21-2 "Mulch"

PART 3 – EXECUTION

3.1 SEQUENCING
A. Apply mulch topdressing to vehicular drives, under driplines of existing trees, and to other designated locations, as specified on the plans or as directed after rough grading operations are complete.

3.2 CONSTRUCTION
A. Vegetation Removal
1. Remove vegetation as shown in the plans or as directed.
2. Conduct mulching operations at approved locations.
3. Stockpile mulch in locations shown on plans or as directed. Reference Item 21-2 "Mulch" for stockpiling specifications.

B. Site Preparation
   1. Grade and remove debris, unsatisfactory soil materials and obstructions from surface prior to mulch application.
   2. Remove top growth of vegetation to ensure that the mulch contacts the surface material.

C. Installation
   1. Apply mulch topdressing evenly at depths and locations as indicated in the drawings or as directed.
   2. Do not roll, tamp or compact mulch topdressing.
   3. Apply mulch topdressing under driplines of existing tree locations for moisture retention and inhibiting of invasive growth as shown on plans at a minimum depth of five (5) inches and a maximum depth of eighteen (18) inches. Do not pile the mulch against tree trunks or root flares.
   4. Spread mulch on vehicle drives for compaction reduction and dust abatement at a maximum eighteen (18) inch depth.
   5. Contractor should remove and dispose of mulch topdressing in areas designated for seeding prior to seed installation.

3.3 MAINTENANCE

A. Requirements
   1. Replace the mulch topdressing immediately if loosened or missing.
   2. After the completion of construction, mulch topdressing shall be spread out or removed to ensure the total depth surrounding the critical root zones of vegetation is between five (5) to six (6) inches. Depth should not exceed six (6) inches.

B. Schedule
   1. The mulch topdressing should be inspected weekly, in accordance with the Stormwater Pollution Prevention Plan and within 24 hours after every one half inch (½") or greater rain event until project completion to identify loosened or missing mulch cover.

ITEM 26-2. COMPOST

SPECIAL PROVISION

161 – 26-2

COMPOST

For this project, Item 161, "Compost," of the Standard Specifications, is hereby voided and replaced in its entirety with the clauses and requirements below.

PART 1- GENERAL

1.1 DESCRIPTION

Furnish and apply compost as shown in the plans or as directed.

1.2 RELATED ITEMS

A. Item 21-2 "Mulch"
B. Item 23-2 "Soil Ripping"
C. Item 164-30-2 "Seeding for Erosion Control"
D. Item 160-20-2 "Topsoil"
E. United States Code of Federal Regulations (CFR), Title 40, Part 503 standards for Class A biosolids
F. Texas Commission on Environmental Quality (TCEQ) health and safety regulations as defined in the Texas Administrative Code (TAC), Chapter 332, including the time and temperature standards in Subchapter B, Part 23
G. USCC Seal of Testing Assurance (STA) program

1.3 MEASUREMENT

This item will be measured by the square yard.

1.4 PAYMENT

Unless compost is specified as a pay item, the work performed and the materials furnished in accordance with this Item will not be paid for directly but will be subsidiary to pertinent items.

When compost is specified on the plans as a pay item, the work performed and the compost furnished will be paid for at the unit price bid for "Compost Manufactured Topsoil" or "Erosion Control Compost" of the depth specified. This price is full compensation for furnishing materials, labor, equipment, maintenance, tools, supplies, and incidentals.

1.5 QUALITY CONTROL SUBMITTALS

A. Prior to the delivery of the compost to the site, the following submittals are to be provided to the Owner's representative for approval:
    1. A statement that the compost meets federal and state health and safety regulations.
    2. A statement that the composting process has met time and temperature requirements.
    3. A copy of the producer's STA certification.

4. A copy of the lab analysis, performed by an STA-certified lab, verifying the compost meets the materials requirements for every 1000 c.y. of material. Test data should not be older than one (1) month old.
5. The compost installation method.
6. A copy of purchase receipt from approved vendor.
7. A copy of the current TCEQ compliance statement signed by the facility manager when furnishing biosolids compost.
8. A copy of the compost analysis from the compost supplier that lists NO3, NH4, and P levels (parts per million).

PART 2 – PRODUCTS

2.1 MATERIALS

A. Compost

1. Furnish compost that has been produced by aerobic (biological) decomposition of organic matter and meets the requirements set forth by the United States Department of Agriculture and the United States Composting Council (USCC), "Test Methods for Examination of Composting and Compost" (TMECC), shown in 2.1.A.2.
2. Physical Requirements for Compost:
    a. Particle Size: 95% passing 5/8 in., 70% passing 3/8 in. in accordance with TMECC 02.02-B, "Sample Sieving for Aggregate Size Classification"
    b. Heavy Metals: Pass in accordance with TMECC 04.06, "Heavy Metals and Hazardous Elements"
        i. 04.06-As, Arsenic
        ii. 04.06-Cd, Cadmium
        iii. 04.06-Cu, Copper
        iv. 04.06-Pb, Lead
        v. 04.06-Hg, Mercury
        vi. 04.06-Mo, Molybdenum
        vii. 04.06-Ni, Nickel
        viii. 04.06-Se, Selenium
        ix. 04.06-Zn, Zinc
    c. Soluble Salts: 5.0 max.* dS/m in accordance with TMECC 04.10-A, "1:5 Slurry Method, Mass Basis" (*A soluble salt content up to 10.0 dS/m for compost used in CMT will be acceptable)
    d. pH: 5.5 – 8.5** in accordance with TMECC 04.11-A, "1:5 Slurry pH" (**A maximum pH of 9.5 will be acceptable for manure compost)
    e. Maturity: greater than 80% in accordance with TMECC 05.05-A, "Germination and Root Elongation"
    f. Organic Matter Content: 25-65%*** (dry mass) in accordance with TMECC 05.07-A, "Loss-On-Ignition Organic Matter Method" (***A minimum organic matter content of 10% will be acceptable for manure compost)
    g. Stability: less than 0.5 mg CO_2 carbon/g compost carbon/day
    h. Fecal Coliform: Pass in accordance with TMECC 07.01-B, "Fecal Coliforms"
3. Compost feedstock may include, but is not limited to, leaves and yard trimmings, biosolids, food scraps, food-processing residuals, manure or other agricultural residuals, forest residues, bark, and paper.

4. Compost shall be reasonably free (less than 1% by dry weight) of manmade foreign matter. The organic matter shall not possess objectionable odor and shall not resemble the raw material from which it was derived. Particle size shall meet the following additional specifications: maximum particle length 0.5”
5. Ensure compost does not contain any visible refuse, other physical contaminants, or any substance considered to be harmful to plant growth, as approved by the engineer. Do not use materials that have been treated with chemical preservatives as a compost feedstock or as wood chips.
6. Provide compost meeting all applicable United States Code of Federal Regulations (CFR), Title 40, Part 503 standards for Class A biosolids and Texas Commission on Environmental Quality (TCEQ) health and safety regulations as defined in the Texas Administrative Code (TAC), Chapter 332, including the time and temperature standards in Subchapter B, Part 23. Meet the requirements of the USCC Seal of Testing Assurance (STA) program. (TXDOT, 2004)
7. Compost shall be obtained from any of the following approved vendors (vendors that utilize static compost piling are preferred):
    a. Organics by Gosh, Austin TX
    512-276-1211
    b. Garden-ville, Austin TX
    1-888-655-6115
    c. Geo Growers, Austin TX
    512-892-2722
    d. Soil Express, Prosper TX
    972-347-2994

B. Compost Manufactured Topsoil (CMT)
CMT consists of blended compost, as specified in 2.1.A, and mineral soil. The Contractor shall determine the blend based on the compost supplier’s nutrient analysis and the corresponding ratios in Table 1. The mineral soil should have a soil texture of less than 75% sand, and organic matter less than 2%. Measures must be taken to avoid weed contamination, through fresh mining, or complete cover or non-use of top six (6) inches of stockpiled material. Reference Item 160-20-2 “Topsoil” for stockpiling specifications of on-site excavated topsoil. Material sources must be approved by the Owner’s Representative. Dilution of compost must not be achieved with organic matter (mulch).

Table 1. Compost to mineral soil amendment ratios for Compost Manufactured Topsoil (CMT)

Compost Nutrient Analysis NO3, NH4, or P (available):	Ratio (volume) compost: soil
exceed 2000 ppm (0.2%)	1:25
are less than 2000 ppm (0.2%) but greater than 1000 ppm (0.1%)	1:20
are less than 1000 ppm (0.1%) but greater than 500 ppm (0.05%)	1:10
are less than 500 ppm (0.05%) but greater than 250 ppm (0.025%)	1:4
are less than 250 ppm (0.1%) but greater than 100 ppm (0.05%)	2:3

Source: Lady Bird Johnson Wildflower Center, 2010

C. Erosion Control Compost (ECC)
ECC consists of compost, as specified in 2.1.A, blended with mulch in a ratio of three (3) parts compost to one (1) part mulch **(3:1)**. Mulch to be in accordance with Item 21-2 "Mulch."

PART 3 – EXECUTION

3.1 SEQUENCING

A. CMT
Initiate site preparation, CMT and fine grading prior to any grass and wildflower seeding as specified in the plans or as directed to disturbed roadside areas and channels. If road base operations have not been completed, exclude site preparation and CMT installation fifteen (15) feet from the road pavement.

B. ECC
Initiate site preparation, topsoil installation, fine grading and ECC topdressing installation prior to any grass and wildflower seeding as specified in the plans or as directed to disturbed roadside areas and channels. If road base operations have not been completed, exclude site preparation and ECC topdressing installation fifteen (15) feet from the road pavement.

C. Following road pavement, initiate specified CMT or ECC installation prior to grass and wildflower seeding to remaining disturbed areas, as specified in the plans or as directed.

3.2 CONSTRUCTION

A. Site Preparation

1. Remove debris, unsatisfactory soil materials and obstructions from surface prior to CMT or ECC installation.
2. Remove top growth of vegetation to remain by mowing to a six (6) inch height to ensure that the CMT or ECC contacts the surface material.
3. CMT and ECC should not be installed onto compacted soil. Scarify or break the surface of the soil with a flexible tine harrow one (1) to two (2) inches in depth.

B. Installation

1. Apply CMT or ECC evenly at depths and locations as indicated in the drawings or as directed.
2. Installation method of the CMT or ECC is to be determined by the Contractor and submitted for approval. Any of the following are acceptable methods of installation:
   a. By hand raking
   b. By mechanized spreader
   c. By a pneumatic blower – Seed can be mixed with CMT or ECC during this application. Reference Item 164-30-2 "Seeding for Erosion Control".
3. Depending on slope, accessibility of location, and rockiness of the terrain, the Contractor is to select an approved installation method that is the least invasive to the adjacent areas.
4. Spread the CMT or ECC to a uniform loose cover at the thickness specified.
5. Till the Compost Manufactured Topsoil (CMT) to a depth no less than four (4) inches to integrate into the subsoil.
6. Lightly rake the Erosion Control Compost (ECC) to ensure good seed to compost contact.
7. Apply Erosion Control Compost (ECC) at least three (3) feet over the shoulder of a slope to prevent rill formation and erosion of compost.
8. Do not apply Erosion Control Compost (ECC) on surfaces with a slope greater than 4:1.
9. Do not apply on surfaces that are muddy, frozen or contain frost or ice.
10. Do not roll or tamp CMT or ECC.
11. Do not compact the CMT or ECC after application with heavy equipment or foot traffic.

3.3 MAINTENANCE

A. Requirements

1. Maintain CMT or ECC in a functional condition at all times and correct deficiencies immediately until acceptance of project.
2. Install additional CMT or ECC as directed by the Owner's Representative after inspection.
3. Protect areas from traffic and repair or re-establish if damaged or compacted.
4. Restore appearance, quality and condition to match adjacent work if damaged.

B. Schedule

1. The CMT or ECC should be inspected weekly until native grass is established, in accordance with the Stormwater Pollution Prevention Plan and then every week within 24 hours of every one half inch (½") or greater rain event until project completion.

ITEM 27-2. BIODEGRADABLE EROSION CONTROL LOGS

SPECIAL PROVISION

5049 – 27-2

BIODEGRADABLE EROSION CONTROL LOGS

For this project, Special Specification Item 5049, "Biodegradable Erosion Control Logs," of the Standard Specifications, is hereby voided and replaced in its entirety with the clauses and requirements below.

PART 1- GENERAL

1.1 DESCRIPTION
Furnish, install and maintain Biodegradable Erosion Control Logs (BEC log) as shown in the plans or as directed.

1.2 RELATED ITEMS
A. Item 21-2 "Mulch"
B. Item 161-26-2 "Compost"

1.3 MEASUREMENT
This item will be measured by the linear foot along the centerline of the top of the BEC log.

1.4 PAYMENT
The work performed and materials furnished in accordance with this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Biodegradable Erosion Control Log" of the sizes specified. This price is full compensation for furnishing, placing, maintaining and replacing, as required to facilitate construction operations, and for all materials, labor, tools equipment, and incidentals.

1.5 QUALITY CONTROL SUBMITTALS
A. Submit product data for approval in conformance with Item 161-26-2 "Compost" and Item 21-2 "Mulch".
B. Submit product data to the Owner's representative for the BEC log core material, containment mesh and size.

PART 2 – PRODUCTS

2.1 MATERIALS
A. Core Filling
Furnish core material as shown in the plans.
1. Type 1 – Mulch
As specified in Item 21-2 "Mulch"

2. Type 2 –Compost & Mulch
As specified in Item 161-26-2 "Compost" and Item 21-2 "Mulch". Compost and Mulch to be uniformly blended at a 50/50 ratio.

B. Containment Mesh
Furnish Filtrexx soxx (specified mesh type or approved equal) with diameters as shown on the plans or as directed.

C. Stakes
1. Wood stakes 1" x 2", tops to be flat. Length of stake varies with specified BEC log size, refer to 3.2.B. "Installation." Wood stakes to be used in deep soils.
2. 3/8" steel reinforcement bar. Length of stake varies with specified BEC log size, refer to 3.2.B. "Installation." Reinforcement bars to be used in shallow rocky soils.

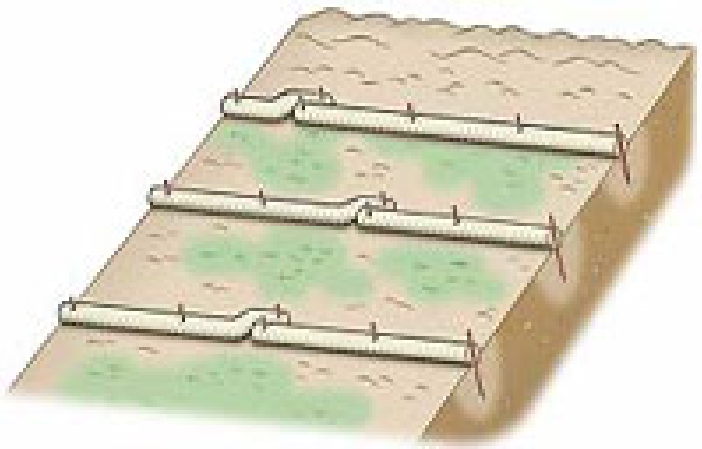
D. Suppliers:
1. BEC logs are either pre-filled with the core filling and delivered to the site, or are filled in place on site.
2. Pre-filled BEC logs to be obtained from one of the following vendors:
   a. Hanes Geo Components. Austin, Texas, 512-670-2050
   b. Soil Express. Prosper, Texas, 972-347-2994

PART 3 – EXECUTION

3.1 SEQUENCING
A. Install BEC logs before construction activities have initiated at perimeter of project site, around environmental features and other designated locations on plans or as directed to comply with Stormwater Pollution Prevention Plan.
B. Install BEC logs around designated material stockpiles within 24 hours after stockpiles have been established.
C. Following rough grading, install BEC logs as specified on the plans or directed to disturbed roadside areas. If roadbase operations have not been completed, exclude BEC log installation fifteen (15) feet from road pavement.
D. Following road pavement, install BEC logs to remaining disturbed areas, as specified in the plans or as directed.

3.2 CONSTRUCTION
A. Site Preparation
1. Remove debris and all unsatisfactory materials from the area.

B. Installation
1. Stuff core filling densely into BEC log containment mesh when adding core filling in the field. No more than 5% of the material is permitted to escape from the containment mesh during installation and maintenance.
2. Seal ends of BEC logs tightly and securely along extent of end opening with either metal staples or ties. Sealing fasteners should be a material that will not degrade before the intended lifespan of the log.
3. Lay BEC log on a level contour as shown on the plans or as directed. Spacing as specified is to be measured from centerline to centerline of BEC log.
4. Extend four (4) feet of each end of the BEC log to point upslope to prevent storm water from running around the end of the log.
5. When placing more than one BEC log in a single row, overlap end of logs a minimum of twelve (12) inches (See figure below).



Source: http://www.stormwaterenvironmental.com/images/Products/Wattles2.jpg

6. BEC logs to be securely staked in the ground. Staking to occur:
   a. At end of each log
   b. Along the length of the log at six (6) foot intervals
7. Size stake length to provide twelve (12) inches in the ground and roughly three to five (3-5) inches above the log.
8. Contact the Owner's Representative if the BEC log can not be correctly staked.
9. At final acceptance, BEC logs to remain in-place unless directed otherwise.

3.3 MAINTENANCE

A. Requirements

1. Inspect and maintain the BEC logs in good condition, including the core filling, containment mesh and staking until end of the maintenance period. No more than 5% of the material is permitted to escape from the containment mesh during installation and maintenance.
2. Maintain BEC log by keeping it clear of accumulated silt and debris. Remove accumulated sediment and debris when it is half the height of the log or more. Dispose of sediment and debris at an approved site in a manner that will not contribute to additional sedimentation.
3. Repair or replace damaged BEC logs immediately or as directed.

B. Schedule

1. BEC logs should be inspected in accordance with the Stormwater Pollution Prevention Plan to ensure BEC logs are securely in place and that excessive sediment has not accumulated and within 24 hours after every rain event of one half inch (½") or greater until project completion.
2. During a period of frequent rain events, BEC logs should be checked daily.

Permanent Erosion and Sedimentation Controls

ITEM 28-2. MAINTAINING EXISTING VEGETATION

SPECIAL SPECIFICATION

28-2

MAINTAINING EXISTING VEGETATION

PART 1- GENERAL

1.1 DESCRIPTION

A. Install native vegetation protective measures as indicated in the plans or as directed.
B. Post protection notice signs as indicated in the plans or as directed.

1.2 RELATED ITEMS

A. Item 29-2 "Riparian Bioengineering"

1.3 REFERENCES

A. Item 506 "Temporary Erosion, Sedimentation, and Environmental Controls"
B. Texas Commission on Environmental Quality (TCEQ), Complying with the Edwards Aquifer Rules, Technical Guidance on Best Management Practices, 2005 Section 2.5.1, Tree Protection.

1.4 MEASUREMENT

A. The fencing item will be measured by the linear foot (of protective fencing).
B. The trunk armoring will be measured per tree.
C. The sign item will be measured by the number of signs.

1.5 PAYMENT

The work performed and materials furnished in accordance with protective fencing and measured in accordance to "Measurement" will be paid for at the unit price for "Construction Perimeter Fence" per Item 506 "Temporary Erosion, Sedimentation, and Environmental Controls."

The work performed and materials furnished in accordance with trunk armoring and protection notice signs and measured in accordance to "Measurement" will be paid for at the unit price for "Trunk Armoring" or "Protection Notice Signs." This price is full compensation for installation, surveying, equipment, labor, materials, tools and incidentals.

Removal of trunk armoring and protection notice signs will not be paid for directly but is subsidiary to the installation item. When the Engineer directs that the armoring or signage or portions thereof be removed and replaced, payment will be made at the unit price bid for each item, which is full compensation for removal and reinstallation.

1.6 QUALITY CONTROL SUBMITTALS

A. Submit product data for type of protective fencing.
B. Submit information of native vegetation protection notice sign.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Native Vegetation Protection Fencing
As specified in the drawings and/or in accordance with TXDOT Item 506 "Temporary Erosion, Sedimentation, and Environmental Control" construction perimeter fencing.

B. Trunk Armoring
As specified in the drawings.

C. Protection Notice Sign
Protection notice signage should be composed of Corex or Coroplast and weather proofed with a dimension of 18" x 24". The sign should be yellow with black graphics that state: "Native Vegetation Protection Area. Do not Disturb"; include the County logo on the sign. Sign to be securely anchored on the protective fencing, affixed to an existing tree or mounted to a post.

PART 3 – EXECUTION

3.1 SEQUENCING

A. The notice signs, trunk armoring, and native vegetation protective fencing, in accordance with the Vegetation Preservation Plan, should be installed at the initiation of construction activities and remain in place until the final completion of the project. Fencing, trunk armoring, and signs should be removed at final site acceptance.

3.2 CONSTRUCTION

A. Install protective fencing and post signs at locations indicated on the Vegetation Preservation Plan or as directed to prevent encroachment and damage from construction activities in preserved areas.
   a. Embed fence posts 18 inches deep or adequately anchor in rock, with a spacing of 8 to 10 feet.
   b. Securely attach fencing material to posts as specified in the drawings.

B. Equipment, construction materials, topsoil, and fill dirt should not be placed not within the limit of preserved areas.

C. Parking of vehicles and equipment under the canopy of the existing trees should not be permitted.

D. Protective fencing should be removed as directed at final acceptance.

E. At final acceptance, posted signs to remain in-place unless directed otherwise.

3.3 MAINTENANCE

A. Inspection of designated preserved areas, as documented on the Vegetation Preservation Plan, should be conducted every 14 days, during construction and maintenance period.

B. Native vegetation fencing and signs should be replaced immediately if found to be damaged or missing.

C. See special conditions for penalties associated with damage to the existing vegetation, as set forth in the plans.

ITEM 29-2. RIPARIAN BIOENGINEERING

PART 1- GENERAL

1.1 DESCRIPTION

Provide, furnish and maintain plants, and related materials at designated locations shown in the plans.

1.2 RELATED ITEMS

A. Item 25-2 “Mulch Topdressing”
B. Item 26-2 “Compost”
C. Item 168-22-2 “Vegetative Watering”
D. Item 164-30-2 “Seeding for Erosion Control”
E. Item 31-2 “Wildflower Seeding”
F. Item 41 “Invasive Species Control”

1.3 REFERENCES

A. Item 192 “Landscape Planting.”

1.4 MEASUREMENT

This item will be measured by each plant. Other materials such as mulch, compost, seeding and vegetative watering shall be specified as separate items, and will be measured according to the requirements of each item.

1.5 PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Plant Material” of the size and type specified and in accordance with Item 192 “Landscape Planting.” This price is full compensation for furnishing the plant, mulch topdressing, plant soil mix, landscape edge, plant bed preparation, and vegetation barrier, unless much topdressing, plant soil mix, landscape edge, plant bed preparation, and vegetation barrier are specified as separate items. Other materials such as seeding and vegetative watering shall be specified as separate items.

When mulch topdressing, plant soil mix, landscape edge, plant bed preparation, and vegetation barrier are specified as separate pay items, the work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Mulch Topdressing,” “Plant Soil Mix,” “Landscape Edge,” “Plant Bed Preparation,” and “Vegetation Barrier.” Each price is full compensation for materials, equipment, labor, tools, and incidentals.

1.6 QUALITY CONTROL SUBMITTALS

A. Contractor to submit photo documentation representing quality of the plant material, for approval.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Mulch

As specified in Item 25-2 “Mulch Topdressing.”

B. Compost
As specified in Item 161-26-2 “Compost.”

C. Vegetative Watering
As specified in Item 168-22-2 “Vegetative Watering.”

D. Plants
As specified in the drawings and Item 192 “Landscape Planting”.

E. Native Grass Seed
As specified in Item 164-30-2 “Seeding for Erosion Control.”

F. Wildflower Seed
As specified in Item 31-2 “Wildflower Seeding.”

G. Fence Material
As specified in Item 28-2 “Maintaining Existing Vegetation.”

PART 3 – EXECUTION

3.1 SEQUENCING

A. Following fine grading initiate installation of riparian bioengineering treatments as specified in the plans or directed to disturbed roadside areas, fifteen feet and beyond from road pavement, prior to initiating road base operations.
B. Plant riparian bioengineering plant material after the removal of invasive species and after all erosion control measures have been installed in the area draining to, or near the water source.

3.2 CONSTRUCTION

A. Site Preparation
1. Invasive species shall be removed, reference Item 41 “Invasive Species Control.”
2. Erosion and sedimentation control techniques, such as compost, biodegradable erosion control logs, and rock berms shall be installed, as indicated in the plans.

B. Installation:
1. Locate and size buffer and planting areas as shown on the plans.
2. Woody plant species shall be planted as indicated on the plans and as specified in Item 192 “Landscape Planting”.
3. Container or live root stock shall be planted at a depth even with the root collar in holes that are large enough for the roots to fully extend. Soil shall be firmly packed around each plant.
4. Plant cuttings should be inserted into moist soil with a minimum of two to three (2 to 3) buds above the ground (NRCS, 1997 & EPA, 2006)
5. Native grass and wildflowers shall be seeded according to Item 164-30-2 “Seeding for Erosion Control” and Item 31-2 “Wildflower Seeding.”
6. Live Root Planting Schedule
   a. Live root planting may occur between September 21st and June 15th.
7. Container Grown Planting Schedule
   a. All year.

8. Supply planted or seeded area with temporary irrigation, immediately after installation, for healthy plant establishment, in accordance with Item 22-2 "Vegetative Watering."

3.3 MAINTENANCE

A. Inspect the buffer zone areas following construction to ensure:
   1. Buffer is free and clear of sediment, debris or other unacceptable material.
   2. Buffer is free of invasive species that may compromise growth of new vegetation.
   3. Buffer shall be inspected every seven (7) days until permanent vegetation is established.

B. The riparian area shall be maintained for one year following the final acceptance of all plants and seeds.

C. Inspect the riparian buffer area once a month, after vegetation has established, in addition to inspection within 24 hours after rain events over one half inch (½"). Inspection shall include documentation of any erosion, deposition, or damage to the buffer. (EPA, 2007) The Owner's representative shall be contacted if there is damage found during the maintenance period. Damage can be classified as missing plant material, erosion within the riparian area and sedimentation within the riparian area.

D. Upon inspection, erosion and sedimentation repairs should be made immediately.

ITEM 30-2. SEEDING FOR EROSION CONTROL

SPECIAL PROVISION

164 – 30-2

SEEDING FOR EROSION CONTROL

For this project, Item 164, "Seeding for Erosion Control," of the Standard Specifications, is hereby voided and replaced in its entirety with the clauses and requirements below.

PART 1- GENERAL

1.1 DESCRIPTION

Provide and install native grass seeding as shown in the plans or as directed.

1.2 RELATED ITEMS

A. Item 161-26-2 "Compost"
B. Item 168-22-2 "Vegetative Watering "
C. Item 160-20-2 "Topsoil"
D. Item 636 "Aluminum Signs"
E. Item 644 "Small Roadside Sign Supports and Assemblies"

1.3 REFERENCES

A. Federal Seed Act
B. Texas Seed Law

1.4 MEASUREMENT

This item will be measured by the square yard or by the acre.

1.5 PAYMENT

A. The work performed and the materials furnished in accordance with the seeding Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Seeding for Erosion Control (TY 1)", "Seeding for Erosion Control (TY 2)", "Seeding for Erosion Control (TY 3)", "Seeding for Erosion Control (TY 4)", "Seeding for Erosion Control (TY 5)", "Seeding for Erosion Control (TY 6)", and "Seeding for Erosion Control (TY 7)". This price is full compensation for furnishing materials, including seed, mowing, labor, equipment, maintenance, tools, supplies, and incidentals.

1.6 QUALITY CONTROL SUBMITTALS

A. Submit seeding product data, including plant tags and seed certification for native grass seed mix for approval.
B. Submit seed planting equipment method, manufacturer and data for approval.
C. Submit product data and sample for sign in accordance with Tex-726-I.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Native Grass Seed

Provide seed as shown in the plans or as directed, and meeting the requirements of the Federal Seed Act and Texas Seed Law, including the testing and labeling for pure live seed (PLS= Purity and Germination). Minimum purity shall be 50%. The seed test to be conducted by the State Seed Laboratory, and a seed test report shall be submitted in accordance with 1.6, "Quality Control Submittals." Each type (mix) of seed shall be mixed by the supplier and delivered in labeled and unopened bags or containers, unless otherwise approved by the Owner's representative. The Contractor shall not blend the seed mixes on site. Use within twelve (12) months from that date of analysis. When Buffalograss is specified, use seed treated with KNO3 (potassium nitrate) to overcome dormancy.

Seeds shall be stored in a dry, well-ventilated location away from contaminants. Seed storage humidity level should be lower than 75%. Store any unused seed in a water resistant container. If seed will be stored longer than one (1) year, the optimal temperature range would be 40-60F.

During transit (from storage to sowing), seed should be protected from dramatic temperature fluctuations day after day; temperature cannot exceed 100F at any time. Seed must remain dry and protected from sun exposure. The transit period may not exceed ten (10) days.

Native grass seed shall be obtained from any of the following three approved providers:
1. Native American Seed, Junction TX. 1-800-728-4043
2. Wildseed Farms, Fredericksburg, TX. 1-800-848-0078
3. Douglas W. King Company, San Antonio, TX. 1-888-357-3337

B. Cool Season Temporary Cover Seed
If native grass seed is to be installed during the winter period of November 8 – February 14, then Table 4 (temporary cool season mix) shall be incorporated into the native grass seed mix, as specified on the plans, or as directed.

C. Compost Manufactured Topsoil (CMT) and Erosion Control Compost (ECC)
As specified in Item 161-26-2 "Compost."

D. Topsoil
As specified in Item 160-20-2 "Topsoil."

E. Vegetative Watering
Clean, fresh and free of substances or matter that could inhibit vigorous growth of plants. As specified in Item 168-22-2 "Vegetative Watering".

F. No Mowing Notice Sign
As specified in Item 636 "Aluminum Signs."

G. Sign Support
As specified in Item 644 "Small Roadside Sign Supports and Assemblies."

PART 3 – EXECUTION

3.1 SEQUENCING

A. Following fine grading and topsoil or compost installation, initiate seed installation as specified in the plans or as directed to disturbed roadside areas and channels. If road base operations have not been completed, exclude seeding install fifteen (15) feet from the road pavement.

B. Following road pavement, initiate seed installation following grading and topsoil or compost installation to remaining disturbed areas, as specified in the plans or as directed.

C. Install no mowing notice signs in accordance with the plans or as directed at time of Final Acceptance.

3.2 CONSTRUCTION

A. Site Preparation

1. Remove all invasive species.
   a. Invasive weeds, either living plants or weed seed, shall be minimized at the site using appropriate herbicide application and/or weed-free soil amendments. Mow, burn, or apply herbicides as needed to control unwanted vegetation in accordance with Item 41 "Invasive Species Control" or as directed.
2. Seed should not be installed onto compacted soil. Scarify or break the surface of the soil with a flexible tine one (1) to two (2) inches in depth in the area to be seeded.
3. Apply specified compost and/or topsoil to the seeding surface (Refer to plans for required depth).
4. Seed area in accordance with the plans or as directed, with regard to installation specification below.

B. Installation

Apply the entire specified amount of seed to the area to be seeded. Application rates should be set to allow at least two complete passes over seeding area so the area is completely and evenly covered. Lightly rake compost and/or topsoil to ensure good seed contact. Seeds should not be buried at a depth over ¼".

1. Broadcast Seeding

   All areas shown to be seeded in the plans must be broadcast unless otherwise directed by the Engineer. Broadcast seed using hand or mechanical distribution in a uniform manner. Coordinate the application rate setting with the Owner's Representative prior to application. Apply seed on the surface of compost or topsoil. The seedbed should be culti-packed, or rolled, before and after seeding to ensure seed contact with the soil. Roll the seeding areas along slope contours. Wind speed should be fifteen (15) mph or less during seeding. Up to one-third of the seed may remain on top of the soil surface.

2. No-till Drill Seeding

   No-till drill seeding should only be used when directed by the Engineer. Use a no-till drill to reduce the risk of erosion and loss of seed. Ensure the drill opening size is adequate to allow free movement of full range of seed sizes being planted. Coordinate the application rate setting with the Owner's Representative prior to application. Plant seed parallel to the contour of the slopes.

3. Pre-mixing Seed with Compost (CMT and ECC)

Apply uniform dry mixture of seed and compost pneumatically only as directed by the Engineer in areas shown in the plans to a depth not to exceed two (2) inches. Pre-mixing the seed with compost will aid in a uniform application of seed.

C. Seeding Schedule

1. The preferred time to seed is from September 21 to November 7 to take advantage of winter rains.
2. Native Grass Seeding Schedule:

Table 1: Type 1, 2, 6, and 7 Seeding Schedule

	OPTIMUM PLANTING TIME			
	Fall Seeding	**Winter Seeding**	**Spring Seeding**	**Summer Seeding**
Seeding Dates	Sept. 21 - Nov. 7	Nov. 8 - Feb. 14	Feb. 15 - June 15	June 16 - Sept. 20
Grass Type	Type 1* Type 2* Type 6* Type 7*	Type 1* Type 2* Type 6* Type 7*	**TYPE 5***	**NO SEEDING**
	Standard Native Grass Mix	Standard Native Grass Mix	Spring Mix	Apply Erosion Control Compost (ECC)
		PLUS	**PLUS (Only if Directed)**	**PLUS**
Supplemental Grass		Table 4*		
		Cool Season Non-Native Grass Seed Mix	Apply the Table 2: Type 2* Wildflower Seed Mix in the next Fall Seeding Time Period	Apply the Type 1*-Standard Native Grass Mix in the Fall Seeding Time Period
* Reference plans for corresponding tables.				

Table 9: Type 3 Seeding Schedule

	OPTIMUM PLANTING TIME			
	Fall Seeding	**Winter Seeding**	**Spring Seeding**	**Summer Seeding**
Seeding Dates	Sept. 21 - Nov. 7	Nov. 8 - Feb. 14	Feb. 15 - June 15	June 16 - Sept. 20
Grass Type	Type 3*	Type 3*	Type 3*	**NO SEEDING**
	Riparian Native Grass Seed Mix	Riparian Native Grass Seed Mix	Riparian Native Grass Seed Mix	Apply Erosion Control Compost (ECC)
		PLUS		**PLUS**
Supplemental Grass		Type 4*		
		Cool Season Non-Native Grass Seed Mix		Apply the Type 3*- Riparian Native Grass Seed Mix in the Fall Seeding Time Period
* Reference plan for corresponding tables.				

D. Vegetative Watering
Provide vegetative watering to seeded areas shown on the plan immediately after seed installation for healthy vegetative establishment, in accordance with Item 168-22-2 "Vegetative Watering" or as directed.

E. No Mow Signs
At final acceptance, post signs at locations indicated on the plans or as directed to prevent mowing of established native grass stands.

3.3 MAINTENANCE

A. Requirements

1. Maintain the native grass areas during and after construction until the certificate of completion is issued.
2. Maintain the erosion control compost (ECC) if the seeding time falls in the summer period. Seed the specified grass mix when the fall seeding period begins.
3. Maintain native grass areas to establish vigorous growth and plant establishment of native grass mix. Establish an overall vegetative cover of 70-80% minimum with no single bare area larger than 100 SF. Areas should have at least 30% of species diversity and be four (4) to six (6) inches in height.
4. Watering of the native grass seed shall be in accordance with Item 168-22-2 "Vegetative Watering."
5. Posted signs should be repaired or replaced immediately if found to be damaged or missing.

B. Schedule
    1. Inspect the grass areas weekly and within 24 hours after each rain event of one half inch (1/2”) or more. Restore eroded areas to finished grade and reseed.
    2. Reseed areas that have not established if grass cover is less than 80% of coverage (TCEQ, 2005).
    3. Inspect seeded areas every two weeks during establishment phase to check for invasive species, refer to Invasive Species Control.

ITEM 31-2. WILDFLOWER SEEDING

SPECIAL SPECIFICATION

WC 104

WILDFLOWER SEEDING

PART 1- GENERAL

1.1 DESCRIPTION

Provide and install wildflower seeding as shown in the plans or as directed.

1.2 RELATED ITEMS

A. Item 164-30-2 "Seeding for Erosion Control"
B. Item 168-22-2 "Vegetative Watering"
C. Item 636 "Aluminum Signs"
D. Item 644 "Small Roadside Sign Supports and Assemblies"

1.3 REFERENCES

A. Federal Seed Act
B. Texas Seed Law

1.4 MEASUREMENT

A. Seeding items will be measured by the square yard or by the acre.

1.5 PAYMENT

A. The work performed and the materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Wildflower Seeding." This price is full compensation for furnishing materials, including seed, mowing, labor, equipment, maintenance, tools, supplies and incidentals.

1.6 QUALITY CONTROL SUBMITTALS

A. Submit product data including plant tags and seed certification for wildflower seed mix for approval.
B. Submit seeding equipment method, manufacturer and data for approval.
C. Submit product data and sample for sign in accordance with Tex-726-I.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Wildflower Seed

Provide seed as shown in the plans or as directed, meeting the requirements of the Federal Seed Act and Texas Seed Law, including the testing and labeling for pure live seed (PLS= Purity and Germination). Minimum purity shall be 50%. The seed test to be conducted by the State Seed Laboratory, and a seed test report shall be submitted in accordance with 1.6, "Quality Control Submittals." Each type (mix) of seed shall be mixed by the supplier and delivered in labeled and unopened bags or containers, unless otherwise approved by the Owner's representative. The Contractor shall not blend the seed mixes on site. Use within twelve (12) months from that date of analysis.

Seeds shall be stored in a dry, well-ventilated location away from contaminants. Seed storage humidity level should be lower than 75%. Store any unused seed in a water resistant container. If seed will be stored longer than one (1) year, the optimal temperature range would be 40-60F.

During transit (from storage to sowing), seed should be protected from dramatic temperature fluctuations day after day; temperature cannot exceed 100F at any time. Seed must remain dry and protected from sun exposure. The transit period may not exceed ten (10) days.

Wildflower seed shall be obtained from any of the following three approved providers:

1. Native American Seed, Junction TX. 1-800-728-4043
2. Wildseed Farms, Fredericksburg, TX. 1-800-848-0078
3. Douglas W. King Company, San Antonio, TX. 1-888-357-3337

B. No Mowing Notice Sign
As specified in Item 636 "Aluminum Signs."

C. Sign Support
As specified in Item 644 "Small Roadside Sign Supports and Assemblies."

PART 3 – EXECUTION

3.1 SEQUENCING

A. Install wildflower seed after native grass establishment.
B. Remove all invasive species.
C. Mow established grass and other low growing vegetation in wildflower seeding areas shown on plans to a maximum height of four (4) inches, or six (6) inches if in a location where permanent soil retention blanket exists, as specified in Item 40, "Mowing."

3.2 CONSTRUCTION

A. Site Preparation
1. Remove all invasive species. Invasive species, either living plants or weed seed, shall be minimized at the site using appropriate herbicide application and/or weed-free soil amendments. Mow, burn, or apply herbicides as needed to control unwanted vegetation in accordance with Invasive Species Control or as directed.
2. Mow established grass to four (4) inches if seeding into established vegetation.
3. Scarify the soil surface by dragging a harrow across the ground using equipement that will not compact or uproot existing vegetation. Tilling and compost application shall not be used in wildflower seeding.
4. Seed area in accordance with the plans or as directed, with regard to installation specification below.

B. Installation
Seeds should not be buried at a depth over ¼".
1. Broadcast Seeding
All areas shown to be seeded in the plans must be broadcast unless otherwise directed by the Engineer. Broadcast seed using hand or mechanical distribution in

a uniform manner. Coordinate the application rate setting with the Owner's Representative prior to application. Apply seed on the surface of compost or topsoil. The seedbed should be culti-packed, or rolled, before and after seeding to ensure seed contact with the soil. Roll the seeding areas along slope contours. Wind speed should be fifteen (15) mph or less during seeding. Up to one-third of the seed may remain on top of the soil surface.

2. No-till Drill Seeding
   No-till drill seed only as directed by the Engineer All areas shown in the plans to be seeded must be drill seeded unless directed by the Engineer. This method is appropriate in locations where compost modified topsoil is not specified. Use a no-till drill to reduce the risk of erosion and loss of seed. Ensure the drill opening size is adequate to allow free movement of full range of seed sizes being planted. Coordinate the application rate setting with the Owner's Representative prior to application. Plant seed parallel to the contour of the slopes.

C. Seeding Schedule
   1. September 21st to November 7th: apply wildflower seed mix
   2. November 8th to September 20th: do not apply wildflower seed mix during this period

D. Vegetative Watering
   Provide vegetative watering to seeded areas shown on the plan immediately after seed installation for healthy vegetative establishment, in accordance with Item 168-22-2 "Vegetative Watering" or as directed.

E. No Mow Signs
   At final acceptance, post signs at locations indicated on the plans or as directed to prevent mowing of established native grass stands.

3.3 MAINTENANCE

A. Requirements
   1. Maintain the wildflower areas during and after construction until the certificate of completion is issued.
   2. Maintain the wildflower areas to establish vigorous growth and plant establishment of wildflower mix. Establish an overall vegetative cover of 70-80% minimum with no single bare area larger than 100 SF. Areas should have at least 30% of species diversity and be four (4) to six (6) inches in height.
   3. Watering of the wildflower seed shall be in accordance with Item 168-22-2 "Vegetative Watering."
   4. Posted signs should be repaired or replaced immediately if found to be damaged or missing.

B. Schedule
   1. Inspect the wildflower areas weekly and within 24 hours after each rain event of one half inch (1/2") or more. Restore eroded areas to finished grade and reseed.
   2. Reseed areas that have not established if wildflower cover is less than 80% of coverage (TCEQ, 2005).
   3. Inspect seeded areas every two weeks during establishment phase to check for invasive species, refer to Invasive Species Control.

ITEM 32-2. BIOFILTRATION

PART 1- GENERAL

1.1 DESCRIPTION

Provide and install soils, gravel, seed mix, plants and related materials and maintain feature at designated locations as shown in the plans.

1.2 RELATED ITEMS

A. Item 161-26-2 “Compost”
B. Item 40 “Mowing”
C. Item 41 “Invasive Species Control”
D. Item 168-22-2 “Vegetative Watering”
E. Item 42 “Reforestation”

1.3 REFERENCES

A. Item 192 “Landscape Planting.”

1.4 MEASUREMENT

This item will be measured by square yard or acre of preparation and each container plant. Other materials such as soil media, gravel, compost, seed mix and vegetative watering shall be specified as separate items, and will be measured according to the requirements in the corresponding Items.

1.5 PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Plant Material” of the size and type specified and in accordance with Item 192 “Landscape Planting.” This price is full compensation for furnishing the plant, mulch topdressing, plant soil mix, landscape edge, plant bed preparation, and vegetation barrier, unless much topdressing, plant soil mix, landscape edge, plant bed preparation, and vegetation barrier are specified as separate items. Other materials such as seeding and vegetative watering shall be specified as separate items.

When mulch topdressing, plant soil mix, landscape edge, plant bed preparation, and vegetation barrier are specified as separate pay items, the work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Mulch Topdressing,” “Plant Soil Mix,” “Landscape Edge,” “Plant Bed Preparation,” and “Vegetation Barrier.” Each price is full compensation for materials, equipment, labor, tools, and incidentals.

The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Biofiltration Preparation” as specified. This price is full compensation for furnishing the soil media, underdrains, liners, gravel blankets, and dry wells. Payment for “Biofiltration Preparation” will be handled in the following manner:

When soil media, underdrains, liners, gravel blankets, and dry wells are specified as separate pay items, the work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid

for "Soil Media, Underdrains, Liners, Gravel Blankets, and Dry Wells." Each price is full compensation for materials, equipment, labor, tools, and incidentals.

1.6 QUALITY CONTROL SUBMITTALS

A. Contractor to submit soil media (for biofiltration) sample and soil analysis to Owner's representative for approval.
B. Contractor to conduct a field saturated conductivity test at the commencement of the project in the biofiltration area and submit results to Owner's representative.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Compost
As specified in Item 161-20-2 "Compost."

B. Vegetative Watering
As specified in Item 168-22-2 "Vegetative Watering."

C. Soil Media
The soil should allow water to infiltrate within seventy-two (72) hours. To increase the percolation rate of native soils add 20-30% compost. Soil make-up should be:
A. 50-60% sand. Up to ½ of the sand content may be substituted with processed recycled glass.
B. 20-30% compost
C. 20-30% topsoil
D. less than 5% clay

D. Underdrains
Underdrain piping should consist of a main collector pipe and two or more lateral branch pipes, each with a minimum diameter of 4 inches. Underdrains should be perforated with ¼ - ½ inch openings, 6 inches center to center. Piping should have a minimum slope of 1% (1/8 inch per foot). Laterals should be spaced at intervals of no more than ten (10) feet. Each individual underdrain pipe should have a cleanout access location with a removable PVC cap (TCEQ-EAR).

E. Liners
Install liners, as shown in the plans or as directed.

F. Gravel Blanket
A gravel blanket should include ½" – 1 ½" diameter washed, rounded river gravel below the soil media (COA-ECM). A layer of filter fabric shall be installed to separate the gravel layer from the soil media. No filter fabric is to be used on the side walls or invert of the biofiltration feature (TCEQ-EAR).

G. Dry Well
Install dry wells at the size and location shown on the plans. Fill each well with two to three (2-3) inch aggregate rock and sand.

H. Plants
As specified in the drawings and Item 192 "Landscape Planting."

PART 3 – EXECUTION

3.1 SEQUENCING

A. Following rough grading initiate installation of biofiltration features, as specified in the plans or directed to disturbed roadside areas, fifteen feet and beyond from road pavement, prior to initiating road base operations.

B. Following asphalt paving of road pavement, apply temporary and/or permanent erosion and sedimentation controls to remaining disturbed areas, as specified in the plans or as directed.

3.2 CONSTRUCTION

A. Site Preparation

1. Invasive species shall be removed, as specified in Item 41 "Invasive Species Control."
2. Rough excavation of the biofiltration feature.
3. Complete construction and stabilize all areas draining to the biofiltration basin. Permanent controls will be cleaned out and filter media will be installed after stabilization of the site.

B. Installation

1. Install gravel and filter fabric, and if specified, a liner and underdrains per drawings.
2. Soil media should be installed in a manner that will ensure adequate filtration.
   a. Scarify the sides and invert area of the excavated biofiltration feature (not required for biofiltration features that require liners)
   b. Place soil in eight to twelve inch (8" – 12") lifts in order to reduce the possibility of excessive settlement
   c. Lifts are not to be machine or tool compacted, but may be slightly watered to encourage natural compaction.
   d. Rake soil as needed to level out.
   e. Overfill above the proposed surface grade to accommodate natural settlement (TCEQ-EAR).
3. Minimize soil compaction of both the base of the biofiltration area and the required backfill.
   a. Avoid use of equipment with narrow tracks, narrow tires, rubber tires with large lugs, or high pressure tires.
   b. Alleviate compaction at the base of the biofiltration area.
4. The project Engineer or Landscape Architect should be present during installation of the soil media and plantings, and approve the installation.
5. Complete permanent erosion control and site restoration. Remove temporary erosion/sedimentation controls and tree protection. Restore any areas disturbed during removal of erosion/sedimentation controls.
6. Dry wells
   a. In locations where infiltration is permitted, install dry wells as specified or directed if draw down times exceed predicted rates.
   b. Excavate a twelve (12) inch minimum diameter hole and fill with two to three (2 to 3) inch aggregate rock and sand.
   c. Each dry well shall penetrate a minimum of two (2) feet below compacted soil levels.
   d. Dry wells shall be located at the low points in the subgrade.

e. If desired draw down times cannot be achieved, install additional dry wells as directed by the Engineer.

7. Plants
   a. Locate plants as shown on the plans.
   b. Provide and install plants per the size and locations shown on the plans.
   c. Woody plant species shall be planted as indicated on the plans as specified in Item 192 "Landscape Planting".
   d. Container or live root stock shall be planted at a depth even with the root collar in holes that are large enough for the roots to fully extend. Soil shall be firmly packed around each plant.
   e. Cuttings should be inserted into moist soil with a minimum of two to three (2 to 3) buds above the ground (NRCS, 1997 & EPA, 2006)
   f. Native grass and wildflower seed mixes shall be seeded according to Item 164-30-2 "Seeding for Erosion Control" and Item 31-2 "Wildflower Seeding."

3.3 MAINTENANCE

A. Inspect the biofiltration feature following construction to ensure:
   1. Limits of feature and location of plantings are in accordance with the drawings.
   2. Biofiltration feature is free and clear of sediment, debris or other unacceptable material.
   3. Biofiltration feature is free of invasive species that may compromise growth of new vegetation.
   4. Biofiltration feature shall be inspected every fourteen (14) days until permanent vegetation is established.

B. Inspect the biofiltration feature area once a month, after vegetation has established, in addition to inspecting within 24 hours after every one half (½) inch or greater rain event during the warranty period. Inspection shall include documentation of any erosion, deposition, or damage, followed by provisions for the correction of the problem. (EPA, 2007)

C. For biofiltration features planted with container grown material, a minimum of 95% of the vegetation shall be alive and viable for one year following installation. If vegetation in biofiltration feature is established from seed, then site must have at least 80% vegetative cover. In either case, no bare areas greater than ten (10) square feet may exist. These performance requirements apply to the entire pond including the biofiltration feature bottom, side slopes, and areas adjacent to the feature.

Chapter 4

PS&E Phase Protocol: County Inspection and Maintenance

CHAPTER 4

Introduction

The Williamson County Protocol County Inspection and Maintenance standards are intended to be used by County personnel to serve as a guide during the County inspection of the Best Management Practices (BMPs). Also, included is a maintenance guide for the BMPs following project acceptance. The County Inspections and Maintenance standards relate to the Best Management Practices Design Criteria, as described in Chapter 2, and the Special Technical Specifications, as described in Chapter 3.

Materials

ITEM 20-3. TOPSOIL

1.1 INSPECTION

A. Ensure that stockpile installation requirements have been met.

B. Inspect all topsoil areas weekly, in accordance with the Stormwater Prevention Pollution Plan, during construction and within 24 hours after every one half (1/2) inch or greater rain event to identify eroded or displaced topsoil. Designated areas missing topsoil should be reapplied immediately.

1. Location of topsoil is in accordance with designated areas on the drawings.
2. Topsoil is free and clear of debris or other unacceptable material.
3. Depth of topsoil is in accordance with the drawings.

C. Upon inspection, if areas of the topsoil have rills, undermining, or has eroded or displaced, a supplemental compost application should be installed.

ITEM 22-3. VEGETATIVE WATERING

1.1 INSPECTION

A. Inspect irrigation every seven (7) days during the first month to ensure the irrigation system runs properly and achieves 100% coverage in the designated areas. Inspect every thirty (30) days after the first month of irrigation until final acceptance. This includes monitoring for erosion, healthy vegetation establishment, and efficient irrigation systems.

B. Inspect vegetative watering efforts to ensure:
   1. Irrigation is not eroding or washing away soil and/or seeds.
   2. Irrigation levels and frequency are appropriate to establish healthy vegetation.
   3. Irrigation equipment is operating efficiently.

C. Water lines to remain intact and functioning efficiently.

D. Inspect drip lines, rotor or spray heads, connectors, and mainlines to ensure they are intact, functioning properly and not leaking water. Broken water lines to be repaired immediately.

E. Inspect the site after watering to ensure water trucks have not damaged finish grade or vegetation.

1.2 MAINTENANCE

A. The County does not need to irrigate any seeded or planted areas after vegetation establishes, except in extreme drought.

Temporary Erosion and Sedimentation Controls

ITEM 23-3. SOIL RIPPING

1.1 INSPECTION

A. Inspect all soil ripped areas for the following:
   1. No slumping of the rips has occurred.
   2. The ripping was installed at the correct locations and at the appropriate depth and spacing.
   3. The contour rips were made both parallel and perpendicular to the slope.

1.2 MAINTENANCE

A. If major slumping or slope failure occurs, the area should be re-graded and re-seeded.
B. Once vegetation is established, soil areas that have been ripped do not require maintenance.

ITEM 24-3. SOIL RETENTION BLANKET

1.1 INSPECTION

A. The soil retention blanket areas should be inspected for the following:

1. The correct product was installed in the location and size/width, as shown in the plans or as directed.
2. The correct anchoring method was used, as specified by the manufacturer.

1.2 MAINTENANCE

A. Requirements:

1. Do not regularly mow areas where soil retention blanket has been installed. If mowing is required, mow to a height greater than six (6) inches; refer to Item 40, "Mowing."
2. If vegetation is damaged and the soil retention blanket is ripped, it should be reinstalled. Additional compost, topsoil or seeding may be required.

B. Schedule

1. Inspect soil retention blankets located in channels and drainage ways every month to ensure that they have not been damaged by maintenance equipment, heavy rains or other means.

ITEM 25-3. MULCH TOPDRESSING

1.1 INSPECTION

A. Inspect all mulch topdressing areas weekly, in accordance with the Stormwater Prevention Pollution Plan, during construction and within 24 hours after every one half (1/2) inch or greater rain event to identify eroded or displaced mulch topdressing. Designated areas missing mulch topdressing should be reapplied immediately.

1. Location of mulch topdressing is in accordance with designated areas on the drawings.
2. Depth of mulch topdressing is in accordance with the drawings.
3. Mulch topdressing is properly removed in areas to receive seed installation.

ITEM 26-3. COMPOST

1.1 INSPECTION

A. Following construction, inspect application of compost to ensure:
   1. Location of Compost Manufactured Topsoil (CMT) or Erosion Control Compost (ECC) is in accordance with designated areas on the drawings.
   2. CMT and ECC is free and clear of debris or other unacceptable material.
   3. Depth of CMT and ECC is in accordance with the drawings.

B. Upon inspection, if areas of the CMT and ECC have rills, undermining, or has eroded or displaced, a supplemental compost application should be installed.
   1. If CMT or ECC failure occurs or vegetation does not establish within the germination parameters of the designated seed type, CMT or ECC and seed should be reapplied. If failure continues, additional erosion control practices should be considered.
   2. CMT and ECC shall be inspected until permanent vegetation is established.

ITEM 27-3. BIODEGRADABLE EROSION CONTROL LOGS

1.1 INSPECTION

A. Biodegradable Erosion Control (BEC) Logs should be inspected for the following:
   1. Proper trenching requirements have been met.
   2. Proper placement of the BEC Logs – along horizontal contour level.
   3. Correct spacing, as shown in the plans.
   4. Secured staking at intervals recommended by manufacturer.
   5. The containment mesh is densely filled.
   6. The ends of the BEC Logs have been turned upslope.
   7. The ends of the BEC Logs are overlapped, not abutted, when more than one roll is placed in a row.

1.2 MAINTENANCE

A. Requirements
   1. Remove any sediment accumulation on the upslope side of the fiber roll whenever the sediment reaches half the height of the roll.
   2. Split, torn, unraveled or slumping BEC Logs should be repaired or replaced if necessary.
   3. BEC Logs require minimal maintenance after the native plant revegetation is established, refer to Item 30-3 "Seeding for Erosion Control."

B. Schedule

   During construction, BEC Logs should be inspected every week and within 24 hours after every rain event greater than one half (½) inch. Frequent short-term inspection is recommended immediately after construction to ensure BEC Logs are securely in place and that excessive sediment has not accumulated.

Permanent Erosion and Sedimentation Controls

ITEM 28-3. MAINTAINING EXISTING VEGETATION

1.1 INSPECTION

A. Inspection of designated preserved areas, as documented on the Vegetation Preservation Plan, shall be conducted by the regulating authority and County arborist (or designated representative) every fourteen (14) days during construction and the maintenance period. Williamson County may choose to assign penalties to the contractor for damaging existing vegetation intended to be preserved. In such cases, this monetary penalty may be assigned based on either a square foot basis for herbaceous vegetation, or based on caliper inch for trees. The County may also choose to require similar vegetation be reestablished as was lost as part of the revegetation process, or may choose to allow standard revegetation practices to be used to replace lost vegetation.

B. County shall inspect any replacement vegetation planted by the contractor. Inspection shall ensure that the new vegetation is healthy and well established. Any vegetation that dies after the maintenance period has expired may be replaced by the County.

ITEM 29-3. RIPARIAN BIOENGINEERING

1.1 INSPECTION

A. Inspect the riparian buffer zone areas to ensure:
   1. The correct location and size of the riparian area.
   2. The correct erosion and sedimentation controls are in place.
   3. Riparian area is free and clear of sediment, debris or other unacceptable material.
   4. Riparian area is free of invasive species that may compromise or interfere with growth of new vegetation.
   5. Riparian area should be inspected every seven (7) days until permanent vegetation is established.

B. Inspect after significant storm events during construction and after the maintenance period. Inspect the riparian area every three months. Inspection shall include observation of any erosion, sedimentation, or damage to the buffer area, followed by provisions to correct the problem. (EPA, 2007)

1.2 MAINTENANCE

A. The riparian area should be maintained for a total of three (3) years after final acceptance, including maintenance provided by the Contractor. If erosion is found upon inspection, it should be repaired immediately. Vegetation should be replaced immediately.

B. Schedule
   Inspect the riparian buffer area every three months, in addition to inspecting after severe storm events, after the maintenance bond is released. The riparian area should be inspected weekly during bioengineering construction to ensure planting, seeding and installation is occurring in accordance to the plan.

ITEM 30-3. SEEDING FOR EROSION CONTROL

1.1 INSPECTION

A. Inspect the native grass seeded areas to ensure:
   1. The seed has established correctly, and has not washed away after rainfall events. The area shall be reseeded immediately if seed has washed away or has failed to establish. If the vegetated cover is less than 80% of the cover indicated on the plans after the establishment phase, the area should be reseeded.
   2. Erosion has not occurred. If erosion occurs, immediately restore the soil and compost to final grade and reseed.
   3. Refer to Item 41 "Invasive Species Control" for eradication methods.

1.2 MAINTENANCE

A. Maintenance of the native grass areas should include inspection to ensure that the grasses fulfill their role as an erosion control technique. Maintenance should include the control of invasive species and weeds to ensure the survival of the native grasses.

   Herbicide spraying of weeds should be applied on a "spot basis" to protect native vegetation. With proper supervision, periodic controlled burning is an effective method to control invasive species without the use of herbicides. Outside of the safety clear zone, maintenance can be reduced, under most circumstances, to one or fewer annual mowings for native grasses. Refer to Item 40, Mowing. (USDA, 2006).

B. Inspect the native grass quarterly to locate any eroded areas. Erosion should be addressed immediately by restoring the area to the finished grade and reseeding. If the vegetated cover is less than 80% of the amount of cover specified on the plans, the area should be reseeded. (TCEQ, 2005)

1.3 RELATED ITEMS:

A. Item 40 "Mowing"
B. Item 41 "Invasive Species Control"
C. Item 22-3 "Vegetative Watering"

ITEM 31-3. WILDFLOWER SEEDING

1.1 INSPECTION

A. Inspect the wildflower seeded areas to ensure:

1. The seed application has been installed correctly, and has not displaced or washed away after rainfall events. The area should be reseeded immediately if seed has washed away or has failed to establish. If the vegetated cover is less than 80% of the cover indicated on the plans, the area should be reseeded.
2. Erosion or sedimentation has not occurred. If erosion or sedimentation occurs, immediately restore the soil and compost application to finished grade and reseed.
3. Invasive species and weeds do not establish in the seeded area; refer to Item 41, Invasive Species Control, for eradication methods.

1.2 MAINTENANCE

A. Maintenance of the wildflower areas should include inspection to ensure that the wildflowers fulfill their role as an erosion control technique. Maintenance should include the control of invasive species and weeds to ensure the survival of the wildflowers.

Herbicide spraying of weeds should be applied on a "spot basis" to protect native vegetation. With proper supervision, periodic control burning is an effective method to control invasive species without the use of herbicides. Outside of the safety clear zone, maintenance can be reduced, under most circumstances, to less than one mowing annually for native grasses and wildflowers. Mow after wildflower seed heads have browned and dried. Refer to Item 40, Mowing. (USDA, 2006).

1.3 RELATED ITEMS:

A. Item 40 "Mowing"
B. Item 41 "Invasive Species Control"
C. Item 22-3 "Vegetative Watering"

ITEM 32-2. BIOFILTRATION

1.1 INSPECTION

Biofiltration Inspection Checklist:

A. Excavation of biofiltration area
   1. Suitable sub-grade materials.
   2. Presence of moisture or water.
   3. Dimensions and placement of excavation conforming with plans.
   4. Sediment and erosion control devices in place.

B. Installation Phase
   1. Correct placement of ground cover or mulch cover.
   2. Correct placement of drywells.
   3. Proper placement of plant materials (type, size, quantity).
   4. Proper grade establishment.
   5. Changes in grading, facility depth, size, soil medium, and plant materials should be approved prior to construction.

C. Final Inspection
   1. Drainage area conforms to plan.
   2. Drainage area completely stabilized.
   3. Biofiltration configuration, size and depth are in accordance with plans.
   4. All landscaping installed/landscape warrantee documentation received.
   (Prince George's County, Maryland, Bioretention Manual 2007)

1.2 MAINTENANCE

A. Mowing and/or Trimming: Mowing and/or trimming of vegetation are allowable with certain restrictions.
   1. Tall and Medium Grasses.
      a. Trimming activities must not impinge on the growing tips (basal crown) of the Bunchgrasses. Cutting these grasses below the basal crown will severely stress or kill them. These plants should not be cut lower than nine (9) inches from the ground.
   2. Short Grasses.
      a. Sod-forming grasses may be mown or trimmed to an appropriate height. These plants should not be scalped; cut no lower than six (6) inches from the ground.
      (City of Austin Environmental Criteria Manual, section 1.6.3, 2009)

B. Weed Management

Preventing the introduction of weeds is the most practical and cost-effective method for weed management. Eliminate bare soil with use of mulch or compost and reseeding. Remove weeds early in their growth stage, before they set seed. Allow the desired vegetation to out-compete the weeds.

1. Mulch: Control weeds by mulch application which blocks light and air space.
2. Cultivation: Cultivating cuts the weed roots below the soil to reduce root carbohydrates. May be done by hand tools only; using cultivating machines is not acceptable. Repeat cultivation at two to three (2-3) week intervals during the growing season. Bare areas must be re-seeded.
3. Organic herbicides: Be aware that organic herbicides must be used with caution and can be dangerous in concentrated form. Personal protective equipment must be used: rubber gloves, long pants, eye protection.

C. Wildlife Management.
Activities of animals should not interfere with biofiltration functions. Digging or burrowing in the filtration basin is particularly troublesome. Where problematic activity occurs, trapping or fencing or similar exclusionary method shall be considered.

D. Irrigation
1. Irrigation per Item 22-3 “Vegetative Watering” for plant establishment.
2. Overwatering is unacceptable as it will negatively impact the hydraulic performance and pollutant removal capabilities of the biofiltration system.

Chapter 5

Roadside Maintenance Protocol

CHAPTER 5

Introduction

The Williamson County Maintenance Protocol is a county-wide maintenance guide for roadsides, regardless of the roadway type or date that the roadway was constructed. The Maintenance Protocol focuses on three (3) Best Management Practices (BMPs) for roadside maintenance to reduce the potential for maintenance issues and reduce operations and maintenance costs over time.

Mowing

The Mowing BMP provides County guidance on effective mowing practices within specified zones within the right-of-way, maintain vegetation heights for safety, and control noxious and undesirable plants. Mowing at reduced rates allows native grass and/or wildflowers to establish, thrive and maintain a vigorous stand of vegetation on the roadsides, which prevents weed invasion and reduces soil erosion and sedimentation.

Invasive Species Control

The Invasive Species Control BMP provides the County with an effective approach to control invasive plant species along the roadside. These unwanted species often negatively impact or eliminate native plants, reduce plant species diversity, and harm native habitat and ecosystem functions. In addition, invasive species impact the regional or historic character of the landscape, threaten endangered species, reduce water quality, increase soil erosion, alter fire frequency, and spread pathogens. (NISC, 2005)

Reforestation

The Reforestation BMP provides County guidance on roadside reforestation to control erosion and sedimentation, restore healthy water resources and improve water quality. By using passive techniques, such as reducing mowing practices and installing bird perches along existing roadways, native woody plant material will establish.

Photographic Monitoring

The Photographic Monitoring BMP offers the County an additional approach to monitor the County's roadways to examine potential areas of erosion, sedimentation, as well as vegetation establishment within the right-of-way. By implementing the photographic monitoring technique, potential erosion and sedimentation problems can be identified before they jeopardize roadway stability or water quality. This BMP also serves as an effective means for evaluating the Protocol over time.

ITEM 40. MOWING

Source:http://itd.idaho.gov/highways/ops/maintenance/Roadside/Roadside%20Pictures/Roadside%20Mowing-2.jpg

1.1 DESCRIPTION

Appropriate mowing techniques maintain roadside safety requirements of proper safety clear zones and roadway visibility while retaining the purpose of the native vegetated roadsides for erosion control, biodiversity, improvement of water quality and a vernacular landscape. (Adapted from Idaho DOT)

1.2 DESIGN APPLICATION

A. INTENT

Provide a scheduled mowing strategy that reduces mowing practices in response to zones within the right-of-way, maintains vegetation heights for safety, and controls noxious and undesirable plants. Mowing at reduced rates allows native grass and/or wildflowers to establish, flourish and maintain a vigorous stand of vegetation on the roadsides, which prevents weed invasion and controls soil erosion and sedimentation. (Ehley, Alan M. 1990)

B. BENEFITS

The benefits of appropriate roadside mowing include:

1. Reduces maintenance costs, including manpower, fuel and equipment costs.
2. Improves soil stabilization on roadside slopes.
3. Improves water quality.

4. Reduces pesticide applications.
5. Increases wildlife habitat.
6. Increases biodiversity.
7. Controls noxious and invasive vegetation.
8. Creates an opportunity for public education on native habitats, including native grasses and wildflowers.

C. LIMITATIONS

The limitations of reducing roadside mowing:

1. May yield a less desirable aesthetic according to current public perception.
2. Adjacent landowners often desire a manicured aesthetic.

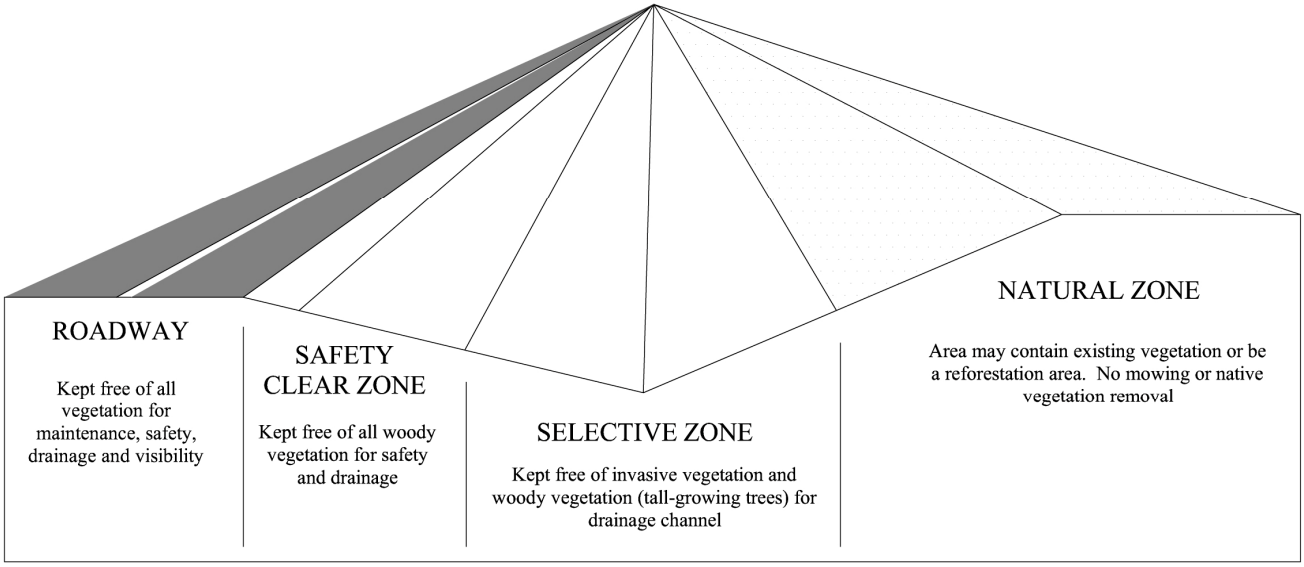
D. RELATED ITEMS

1. Item 28-1 "Maintaining Existing Vegetation"
2. Item 30-1 "Seeding for Erosion Control"
3. Item 31-1 "Wildflower Seeding"
4. Item 41 "Invasive Species Control"
5. Item 42 "Reforestation"

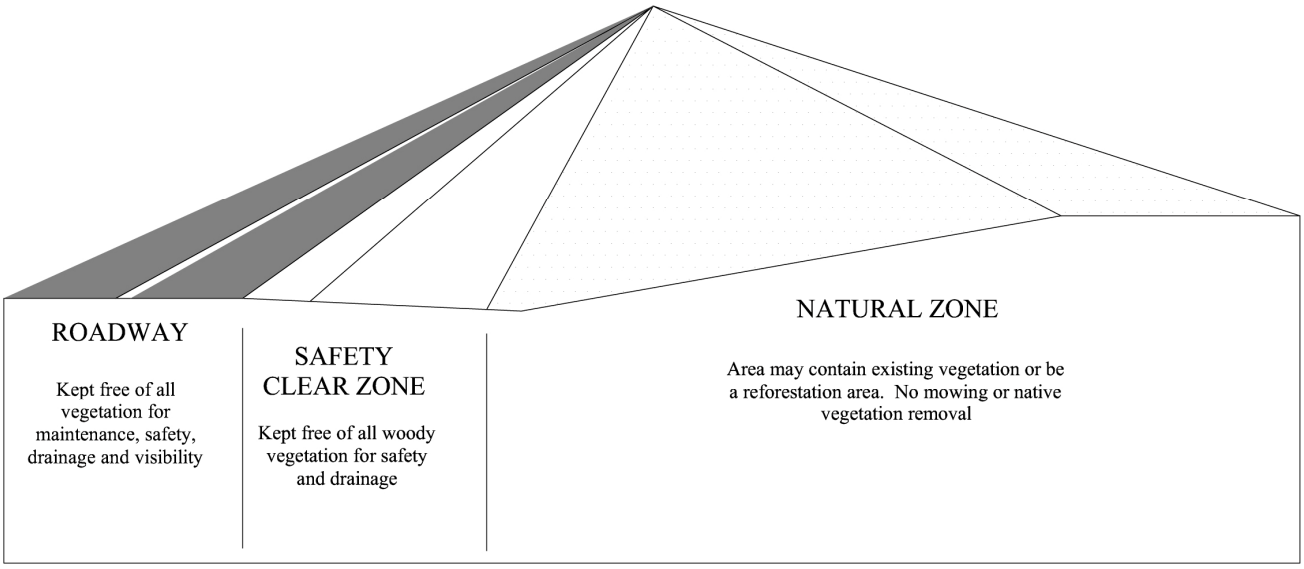
E. GUIDELINES

1. Instructions
   a. See Figure 1 for generalized location of safety clear zone, the selective zone and the natural zone.
   b. Safety Clear Zone
      i. Width and Location: To be in accordance with the Williamson County Design Criteria Manual for specific roadway type.
      ii. Mowing rate: Mow three (3) times per year in the following months: February, June and October, or as directed.
      iii. Mowing height: six inches (6").
      iv. Woody vegetation: Keep free of woody vegetation. Remove all trees or woody vegetation.
   c. Selective Zone
      i. Width and Location: This zone contains the drainage channel which is defined by the design depth of flow.
      ii. Mowing Rate: Mow once every two (2) years in October if invasive and woody vegetation is significant, or as directed.
      iii. Mowing height: Ten to twelve (10 – 12) inches. Mowing height should be monitored to ensure that soil retention blanket is not damaged by mowing operations.
      iv. Woody vegetation: Selectively remove woody vegetation within the base of the channel.
   d. Natural Zone
      i. Width and Location: Any area within right-of-way not meeting the requirements of the Safety Clear Zone or the Selective Zone.
      ii. Mowing Rate: This zone is a no-mow area, unless specifically directed.
      iii. Mowing height: Ten to twelve (10– 12) inches.
      iv. Woody vegetation: Do not remove native woody vegetation, unless as specifically directed. This zone is intended for maintaining existing vegetation or reforestation; refer to Item 42 "Reforestation."

Figure 1: Generalized cross-sections of roadside management zones



(Adapted from Penn State, 2000)



(Adapted from Penn State, 2000)

e. Mowing for Invasive Species Control
   i. Reference Item 41 "Invasive Species Control."
f. Other Mowing Guidelines:
   i. Mow to provide sight distance at horizontal curves, intersections, driveways and ramps to ensure roadway visibility.
   ii. Do not mow when soils are saturated or in a muddy condition as this may damage soil retention blankets and established vegetation, destabilize slopes, and promote erosion and sedimentation.
   iii. Slopes greater than 3:1 should not be mowed; these slopes should be identified with a marker, or a slope indicator should be attached to each tractor used for mowing to ensure safety.

iv. Slopes with permanent soil retention blanket should not be mowed. If mowing is required, mow at a minimum height of nine (9) inches or at an adequate height to not damage the soil retention blanket.
v. Areas not established with vegetation, or undergoing revegetation, should not be mowed to reduce erosion and sedimentation potential. Care should be taken to mow around biodegradable erosion control logs, when they are present.
vi. Areas with temporary irrigation should not be mowed until irrigation piping has been completely removed.
vii. Wildflower areas should be mowed only once – in October – to promote wildflower propagation and bloom. Wildflower seed heads should be matured (brown and dried) at time of mowing.
viii. Determine maintenance requirements for access, utility, or other easements within each zone.

2. Performance:
   a. Create a mowing schedule based on the guidelines set forth above.
   b. Perform mowing sequence as directed. Consider the following while mowing:
      i. Immediately remove debris ejected onto the roadway. Remove mowed grass from roadway when determined to be a hazard.
      ii. Hand trim around fixed objects within mowed area.
      iii. Restore appurtenances damaged by mowing operations, in accordance with TXDOT Article 7.12, "Contractor's Responsibility for Work".

ITEM 41. INVASIVE SPECIES CONTROL

Source:http://en.tourduvalat.org

1.1 DESCRIPTION

Invasive species control is the removal, management, and prevention of non-native and invasive plant species that cause environmental damage.

1.2 DESIGN APPLICATION

A. INTENT

Roadways are a prolific conduit for spreading weeds and invasive species. Invasive species negatively impact or eliminate native plants, reduce plant diversity, and harm native habitat and ecosystem functions. Invasive species reduce water quality and quantity, threaten endangered species, increase soil erosion, alter fire frequency, harm the regional and historic character of the landscape and can spread pathogens. (NISC, 2005)

Disturbed sites are especially vulnerable to the proliferation of invasive species since normally resistant, existing native species are reduced during the construction process. It is critically important to control invasive species on disturbed sites. The methods used to eradicate invasive species are physical, chemical or prescribed burn techniques.

B. BENEFITS

The benefits of invasive species control include:

1. Promotes the growth of native trees, shrubs, grasses and wildflowers.
2. Limits the spread of invasive species onto adjacent farm and ranch land.
3. Reduces soil erosion.
4. Increases plant diversity.
5. Reduces the spread of pathogens.

6. Contributes to the regional character.
7. Promotes a more interesting driving experience.

C. LIMITATIONS

The limitations of invasive species control include:

1. Increased labor and maintenance costs.
2. Requiring frequent monitoring.
3. Chemical techniques may impact water quality and existing native species.
4. Prescribed burning requires additional staffing and expertise.
5. May result in spread of more invasive species if not done properly.

D. RELATED ITEMS

1. Item 10 “Environmental Inventory”
2. Item 28-1 “Maintaining Existing Vegetation”
3. Item 29-1 “Riparian Bioengineering”
4. Item 30-1 “Seeding for Erosion Control”
5. Item 31-1 “Wildflower Seeding”
6. Item 32-1 “Biofiltration”
7. Item 42 “Reforestation”
8. Item 40 “Mowing”

E. REFERENCES

1. Federal Insecticide, Fungicide, and Rodenticide Act
2. Texas Pesticide and Right-to-Know Laws and Regulations (TDA)
3. Texas Structural Pest Control Board Act
4. Federal Seed Act
5. Texas Seed Law

F. GUIDELINES

1. Instructions
   a. Identify invasive plant species along a roadway corridor (see “Inspection” below)
   b. Specify which of the following invasive species controls would be best suited to control invasive plant species.
   c. Invasive species can be managed through the use of physical or chemical control, interspecies competition, and/or prescribed burning techniques. Determine which technique is most appropriate to control invasive species for a specific project site considering the following conditions:
      i. Level of disturbance of the site before and during construction.
      ii. Severity of the invasive species.
      iii. Topography of the site.
      iv. Environmental sensitivity of the site, refer to Item 10 “Environmental Inventory.”
      v. Identification of endangered or threatened species.
      vi. Amount of human development near site (rural, suburban, or urban).

2. Techniques:
   a. Interspecies competition involves the suppression of an invasive species through the encouraged growth of a competing, native species with similar biological qualities. This may be preferred to physical and chemical methods, in some cases, because it may cause less damage to non-target species, is a

self-perpetuating method upon establishment, and can be low-cost to the environment and budget (Simmons, 2005).

i. Determine which native species shall be used and the amount of seed necessary to effectively combat the invasive species by consulting a botanist or ecologist.
ii. Density of the native species shall be increased through oversowing
iii. Native species selected shall exhibit similar traits and shall germinate, flower, and seed within the same season as the invasive species
iv. Only high quality seed that meets the requirements of the federal and state laws, including the labeling requirements for pure live seed shall be used. The seed test shall be conducted by the State Seed Laboratory, and a seed test report shall be submitted.

b. Chemical techniques involve the use of herbicides. If an Environmental Inventory was conducted, determine if herbicide use is appropriate and suggest methods to minimize impact on non-target species, water quality and human health. Refer to Item 10 "Environmental Inventory." Herbicides are to be applied by a licensed applicator.
c. Physical techniques involve mechanical removal, eradication and alteration of growing conditions.
    i. Mechanical removal means may be used in large areas. Carefully timed mowing can control some species, particularly annual plants to reduce flowering and seed production, refer to Item 40, Mowing. This may take multiple years to achieve desired control levels and may require multiple treatments within a single year for species with a long flowering period. These treatments are most effective when combined with other treatment measures.
    ii. Selective physical techniques may be used in ecologically sensitive areas to reduce impact on the environment. These methods may require hand pulling of species and repeated efforts to ensure the invasive species have been eradicated.
d. Prescribed fires can be especially beneficial for controlling invasive species in Central Texas – a region that evolved with natural fire disturbance. Prescribed fires must be carefully planned and supervised by a professional fire manager to ensure that the prescribed fire will successfully eradicate invasive species. A prescribed fire plan must be developed by a professional fire manager and include the following:
    i. Invasive species objectives.
    ii. Ignition methods and smoke management procedures.
    iii. Weather parameters and public notification.
    iv. Specialized protective equipment and firefighting resources.
    v. Identification of plant, animal, and physical characteristics of the site.
    vi. Monitoring criteria and methods to protect the site from colonization of invasive species during the natural recovery after the burn.

    The professional fire manager should decide the season and intensity of the fire to be most effective and work with appropriate officials to ensure the safety of the burn along the roadside. Burn plots, fire breaks, and an ignition strategy must be developed by the ecologist and fire manager to ensure the most successful and controlled outcome. The professional fire manager shall create a monitoring program to ensure the prescribed burn has effectively reduced the invasive plant population. This program should review both pre and post burn

conditions to detect changes in population and coverage of both native and invasive species. (USFWS, 2009)

3. Materials:
   a. Physical technique:
      i. Mowing equipment.
      ii. Hand tools.
   b. Chemical technique:
      i. Herbicide used in accordance with all federal and state regulations.
   c. Interspecies competition:
      i. Refer to Item 30-1 "Seeding for Erosion Control."
      ii. Refer to Item 31-1 "Wildflower Seeding."
      iii. Consult a botanist or ecologist to recommend an increased seed rate appropriate for invasive plant species control.

4. Performance:
   a. Physical techniques may include:
      i. Pulling plants directly out of the soil by hand, always including the roots.
      ii. Hoeing or tilling areas to scrape seeds from the soil, or uproot plants just beneath the soil surface.
      iii. Mowing or cutting above ground plants to reduce them down to manageable levels to eradicate with herbicide, competing species, or other methods.
   b. Chemical technique:
      i. Herbicides must meet all federal and state requirements. Refer to "References."
      ii. Applicator must be certified by TXDOT and undergo training and testing as outlined in the Texas Department of Transportation and Texas Department of Agriculture Memorandum of Agreement 1995.
      iii. Submit copies of the herbicide product labels for approval.
      iv. Herbicide preparation, transportation, storage, and disposal shall follow the manufacturer's label and Federal requirements.
      v. Assess condition of vegetation in areas to be treated before, during, and after application to assess the effect on target and non-target species.
      vi. Discontinue use of herbicides that are ineffective or are causing significant undesirable effects.
      vii. Retain a record of the type of herbicide used, the time and date of application, application rate and the name of the person who applied the herbicide. (Adapted from USFWS, 2009 & TAES, 2005)
      viii. Do not apply herbicide in high wind conditions to minimize drift.
      ix. Do not apply herbicide when rainfall is predicted five hours or less before application.
      x. Avoid herbicide application during extended high temperatures or an extended drought, (TXDOT, 2009)
      xi. Mix herbicide with clean water, free of industrial wastes.
   c. Prescribed fires
      i. A professional fire manager should produce a burn plan that will identify all necessary materials and details.

5. Invasive Species:

a. Listed below are common woody, herbaceous, and aquatic invasive species in Williamson County. Invasive species control techniques should be used if any of the below species are found on site. The herbaceous species list is categorized by control categories to indicate the measures needed to control certain species. Category 1 species may be targeted and eliminated easily, while category 2 species may be difficult to completely eliminate. In category 2 cases the species population should be controlled within means, rather than complete eradication.

Invasive Woody Plant Species for Williamson County (A selective list of current or potential occurrence.)	
Scientific Name	**Common Name**
Ailanthus altissima	Tree-of-Heaven
Broussonetia papyrifera	Paper mulberry
Firmiana simplex	Chinese parasoltree
Ligustrum spp. (*L. japonicum, L. lucidum, L. quihoui , L. sinense, L. vulgare etc.*)	Ligustrum; privet
Lonicera japonica	Japanese Honeysuckle
Macfadyena unguis - cati	Catclaw Vine
Melia azedarach	Chinaberry
Nandina spp.	Nandina
Photinia spp. (*P. serratifolia ; P. x fraseri etc.*)	Chinese Photinia; red-tip photinia etc.
Pistacia chinensis	Chinese pistache
Pueraria lobata	Kudzu
Pyracantha coccinea	Pyracantha; Firethorn
Triadica sebifera (*Sapium sebiferum*)	Chinese Tallow Tree
Vitex agnus-castus	Chaste bush; Chastity tree
Hedera helix	English ivy
Morus alba	White Mulberry
Tamarix spp.	Saltcedar

Invasive Herbaceous Plant Species for Williamson County (A selective list of current or potential occurrence.)		**Control Category***
Scientific Name	**Common Name**	
Arundo donax	Giant reed, Giant cane	1
Centaurea melitensis; Centaurea solstitialis	Maltese star-thistle; Yellow star-thistle	1
Convolvulus arvensis	Field Bindweed	1
Cyrtomium falcatum	Asian hollyfern	1
Phyllostachys aurea	Golden bamboo	1
Rapistrum rugosum	Annual Bastardcabbage	1
Ruellia brittoniana	Mexican petunia; Britton ruellia	1
Sorghum halepense	Johnsongrass	1

Verbena brasiliensis	Brazilian vervain	1
Bothriochola ischaemum var. *songarica*	King Ranch Bluestem	2
Bromus arvensis; Bromus catharticus	Field brome; Rescuegrass	2
Cynodon dactylon	Bermudagrass	2
Dichanthium sericeum (also *D. annulatum; D. aristatum*)	Silky Bluestem (also other Old world bluestems such as Kleberg and Angleton bluestems)	2
Festuca arundinacea (Schedonorus phoenix)	Tall Fescue	2
Lolium perenne	Italian ryegrass	2
Medicago minima (also *Medicago arabica; Medicago lupulina etc.*)	Least burclover (and other burclovers)	2
Melilotus indicus (and *M. albus* etc.)	Yellow sweetclover (and other spp.)	2
Paspalum dilatatum	Dalllisgrass	2
Paspalum urvillei	Vaseygrass	2
*Category 1 species are relatively easy to target individual plants or clusters.		
*Category 2 species, although sometimes very problematic, are often widely and abundantly dispersed throughout the vegetative matrix, making them more difficult to target or to eliminate. Although elimination would be desirable, controlling populations to a less disruptive level is more realistic.		

Invasive Aquatic and Wetland Plant Species for Williamson County (A selective list of current or potential occurance.)	
Scientific Name	**Common Name**
Alternanthera philoxeroides	Alligatorweed
Colocasia esculenta (and *Xanthosoma sagittifolium*)	Elephant ear
Eichhornia crassipes	Water hyacinth
Hydrilla verticillata	Hydrilla
Myriophyllum spicatum	Eurasian watermilfoil
Pistia stratiotes	Water lettuce
Salvinia molesta and *Salvinia minima*	Giant salvinia and Common salvinia

G. INSPECTIONS AND MAINTENANCE

1. County roadway should be visited periodically to determine if invasive plant species are present. The County Arborist, County Agricultural Agent or an Ecologist should document the location and species of the invasive plants.

2. Interspecies competition: Inspect the native species vegetation after each significant rain event of a 1/2 inch or more. Locate and repair erosion or washout of seeds. Erosion should be addressed immediately by restoring the area to the finished grade and reseeding. If the vegetated cover is less than 80% of the amount of cover specified on the plans, the area should be reseeded. (TCEQ, 2005) A

monthly inspection should take place after the native species has established to ensure that the target species is being reduced by the competing native species. The monthly inspection should record the area with photographs to determine the effectiveness of the native species in eliminating the invasive. Specify sowing additional seed if the invasive species is not eliminated or reestablishes. Another technique, such as physical or chemical methods, may also be used at the discretion of the ecologist.

3. Chemical technique: The area where the herbicide is applied to control invasive species should be inspected every seven to ten (7-10) days for the first month after the herbicide is first applied. The inspection should ensure that the target species has been sufficiently damaged and eradicated. If the target species reestablishes, the technique should be repeated until the species is removed. In some cases, the herbicide application should be supplemented with a physical technique, such as mowing, to make the invasive species more vulnerable to herbicide. The area should be inspected monthly if the species is successfully eradicated after the first month, otherwise the area should continue to be inspected every seven (7) days.

4. Physical technique: Inspect every seven to ten (7-10) days for the first month after the physical technique is initiated. The inspection should ensure that the target species has been sufficiently damaged and eradicated. If the target species reestablishes, the technique should be repeated until the species is removed. In some cases, the physical technique should be supplemented with herbicide application to sufficiently eradicate the invasive species. The area should be inspected monthly if the species is successfully eradicated after the first month.

5. Prescribed burns: The area where prescribed burns take place should be inspected three (3) weeks after the first rain event following the prescribed fire, and every month following this rainfall for the first year. The inspection should ensure that the target species has been sufficiently damaged and eradicated. If the target species reestablishes, another technique should be used, such as herbicide application, interspecies competition, or a physical technique to effectively remove the target species. If the prescribed fire appears to have been successful in invasive species control, the area should be inspected quarterly after the first year to ensure it does not reoccur. A monitoring program should be directed by the ecologist, and should include the documentation of pre-burn and post-burn conditions. The ecologist should document the amount, or cover of the target species prior to the burn, and the rate of removal or die-off after the burn. The documentation should be in the form of photographs for County records.

ITEM 42. REFORESTATION

Source: TBG Partners

1.1 DESCRIPTION

Reforestation is the natural regeneration of native vegetation in a roadside area that has been previously disturbed by human activities or areas that have experienced severe erosion.

1.2 DESIGN APPLICATION

A. INTENT

Reforestation uses passive techniques, such as ceasing mowing operations and the installation of bird perches, along existing roadsides to encourage the establishment and growth of native woody plant material. Active planting is not addressed in this BMP.

B. BENEFITS

The benefits of reforestation include:

1. Re-establishing native tree composition, species diversity, and associated native wildlife habitat.
2. Eliminating non-native or invasive species that may disrupt natural forest regeneration.
3. Restoring healthy water resources, and improving water quality.
4. Reducing maintenance costs.
5. Reducing impacts to critical environmental features, as defined in Item 10 "Environmental Inventory."

C. LIMITATIONS

The limitations of reforestation include:

1. Not suitable for use within the Safety Clear Zone or designated visibility areas associated with horizontal curves, intersections, driveways, and ramps. Refer to Item 40 "Mowing."
2. Reforestation areas within future roadway expansion areas may require removal at a later date.
3. Vegetation from seed will take more than twenty to thirty (20-30) years to provide the ecological and aesthetic functions and benefits of a mature tree stand (TCEQ, 2005).

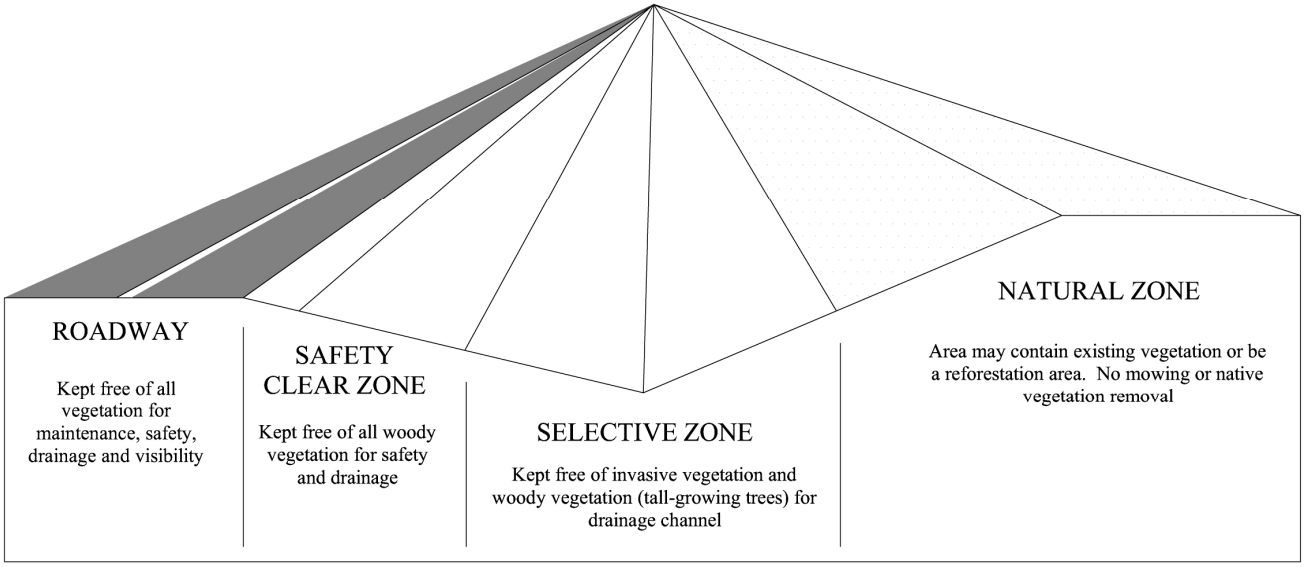
D. RELATED ITEMS

1. Item 28-1 "Maintaining Existing Vegetation"
2. Item 29-1 "Riparian Bioengineering"
3. Item 30-1 "Seeding for Erosion Control"
4. Item 40 "Mowing"
5. Item 41 "Invasive Species Control"
6. Item 43 "Photographic Monitoring"

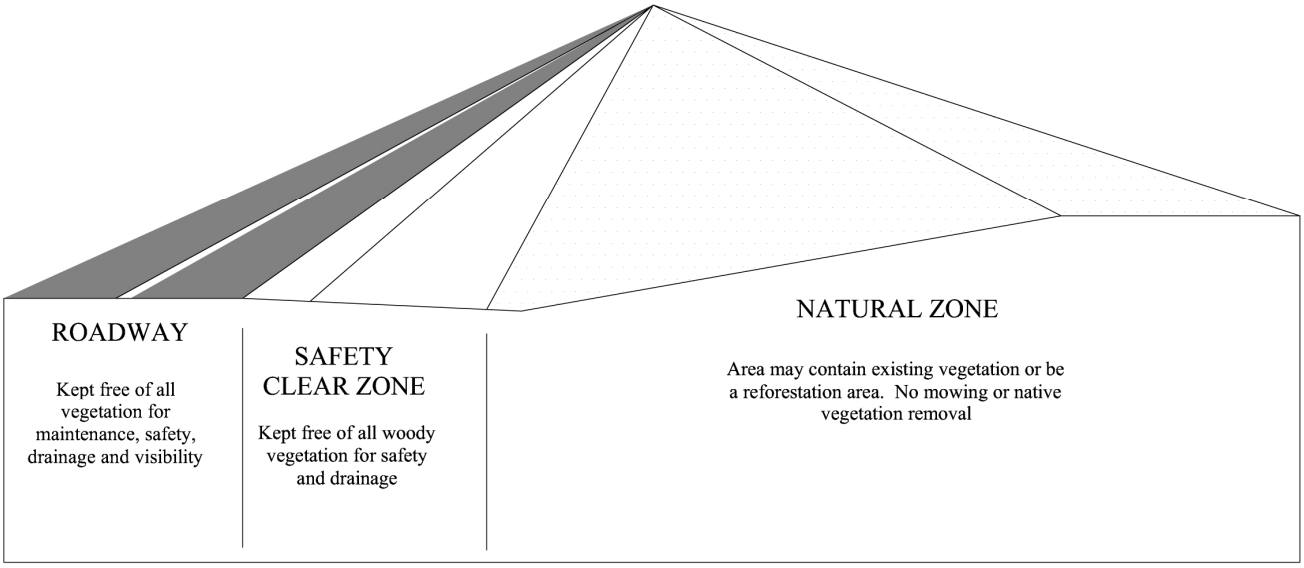
E. GUIDELINES

1. Instructions
   a. Designate areas with roadsides that would be candidates for reforestation. These areas may include:
      i. Creek crossings or riparian buffer areas.
      ii. Steep slopes (exceeding 3:1).
   b. Identify zones within the right-of-way where reforestation efforts are appropriate. Refer to Figure 1 and 2 below.
      i. Safety Clear Zone
         (1) Reference the Williamson County Design Criteria Manual for specific roadway type Clear Zone design criteria.
         (2) This area is not suitable for reforestation efforts.
      ii. Selective Zone
         (1) Contains the drainage channel which is defined by the design depth of flow.
         (2) This area is not suitable for reforestation efforts.
      iii. Natural Zone
         (1) Any area not meeting the requirements of the Safety Clear Zone or the Selective Zone.
         (2) This area is appropriate as a candidate for reforestation.
         (3) Determine maintenance requirements of access, utility, or other easements within the zone to assess easement impacts to reforestation area.

Figure 1: Generalized cross-sections of roadside management zones



(Adapted from Penn State, 2000)



(Adapted from Penn State, 2000)

c. Perform a ground survey to identify invasive species. Consult with the County Arborist, County Agricultural Agent or Ecologist to determine the presence of invasive species.
d. Invasive species in the reforestation area should be removed. Refer to Item 41 "Invasive Species Control."
    i. The continual removal of non-native species and competing vegetation will improve the ability of the areas to regenerate.
    ii. Mowing should not occur in "no-mow" areas designated in the plan for purposes of reforestation. Mowing for the purposes of invasive species control should take place only in areas where it will not interfere with growth of desired species.

iii. Consult with the County Arborist, County Agricultural Agent or Ecologist to determine the presence of competing vegetation and necessary procedures needed to establish and maintain a healthy reforestation area.

e. Indicate reforestation areas as "no mow areas" with County Maintenance staff. Refer to Item 40 "Mowing," and ensure areas are designated in maintenance mowing schedules and exhibits.

f. Clearly delineate "no mow areas" on roadsides with permanent signage and/or boundary markers.

g. Determine the most effective installation method, or combination of methods, for reforestation:

i. Passive method, leaving reforestation area undisturbed.

ii. Bird Perches

(1) Bird perches may be installed to encourage the deposition of seeds from species eaten by birds, such as Black Cherry, Persimmon Hackberry, and Juniper. (COA, 2008)

iii. Seed Harvesting.

(1) Native seeds may be harvested from a nearby ranch or field. Consult with County Agricultural Agent on availability of property owners, harvesters and other materials needed to harvest seed.

(2) Seed shall be stored in a dry, well ventilated location away from contaminants. Seed storage humidity level should be lower than 75%. Store any unused seed in a water resistant container. If seed will be stored longer than one (1) year, the optimal temperature range would be 40-60F.

iv. Seed Sourcing

(1) Native seeds may be purchased by local distributors, refer to Item 30-1, "Seeding for Erosion Control" for approved vendors.

2. Materials

a. Seed

i. Reference Item 30-1 "Seeding for Erosion Control" for materials

b. Bird Perches

i. Metal wire.

ii. Steel or wood poles.

3. Installation

a. Harvest Seed

i. Refer to Item 30-1 "Seeding for Erosion Control" for installation techniques.

b. Purchased Seed

i. Refer to Item 30-1 "Seeding for Erosion Control" for installation techniques.

c. Bird Perches

i. Perch sites consist of a metal wire strung between two or more wood or steel poles at the height of twelve (12) feet or greater. Perches should be installed in reforestation areas twenty (20) feet or wider to allow for adequate area for vegetative growth.

ii. Wire connecting bird perches should be installed at a minimum of twelve (12) feet above finish grade.

iii. The County Arborist, Agricultural Agent or Ecologist should determine location and number of perch sites to be established.

iv. Perch sites may be left in place or removed after vegetation has been established within the reforestation area. Establishment includes the following:
   (1) Tree heights of 48 inches or more.
   (2) Diversity of native plant species.

F. MAINTENANCE
1. The County Arborist, County Agricultural Agent or Ecologist should inspect reforested areas and perch sites once per year to determine the presence or absence of invasive species until native vegetation reaches 24 inches in height.
2. Invasive species removal should take place following its detection and follow the requirements as specified in Item 41, Invasive Species Control.
3. Repair or replace damaged perch sites within thirty (30) days. Refer to Item 43 "Photographic Monitoring" for instructions on monitoring the reforestation areas.

ITEM 43. PHOTOGRAPHIC MONITORING

Source: Photograph by Frederick C. Hall, USDA

1.1 DESCRIPTION

Photographic Monitoring is an effective method of documenting changes over time to environmental conditions within the roadside. Evidence from photographs provides spatial data that can be used to assess the health of roadside conditions, such as environmental features, riparian buffer areas, potential erosion areas and vegetation establishment. It also provides a mechanism for evaluating the Protocol for Sustainable Roadsides over time.

1.2 DESIGN APPLICATION

A. INTENT

Photographic monitoring is an appropriate technique to measure change over time, such as areas of potential erosion, vegetation establishment, or other conditions determined by the County.

B. BENEFITS

The benefits of photographic monitoring include:

1. Produces a lasting visual record of a site's level of progress, which can be used for technical or public educational purposes.
2. Monitoring sensitive areas or areas of concern that can provide desktop information to assess whether additional measures should be taken.
3. Provides informative data on measuring the effectiveness of the Protocol for Sustainable Roadsides or visual data to compare the Protocol to conventional roadside practices.

C. LIMITATIONS

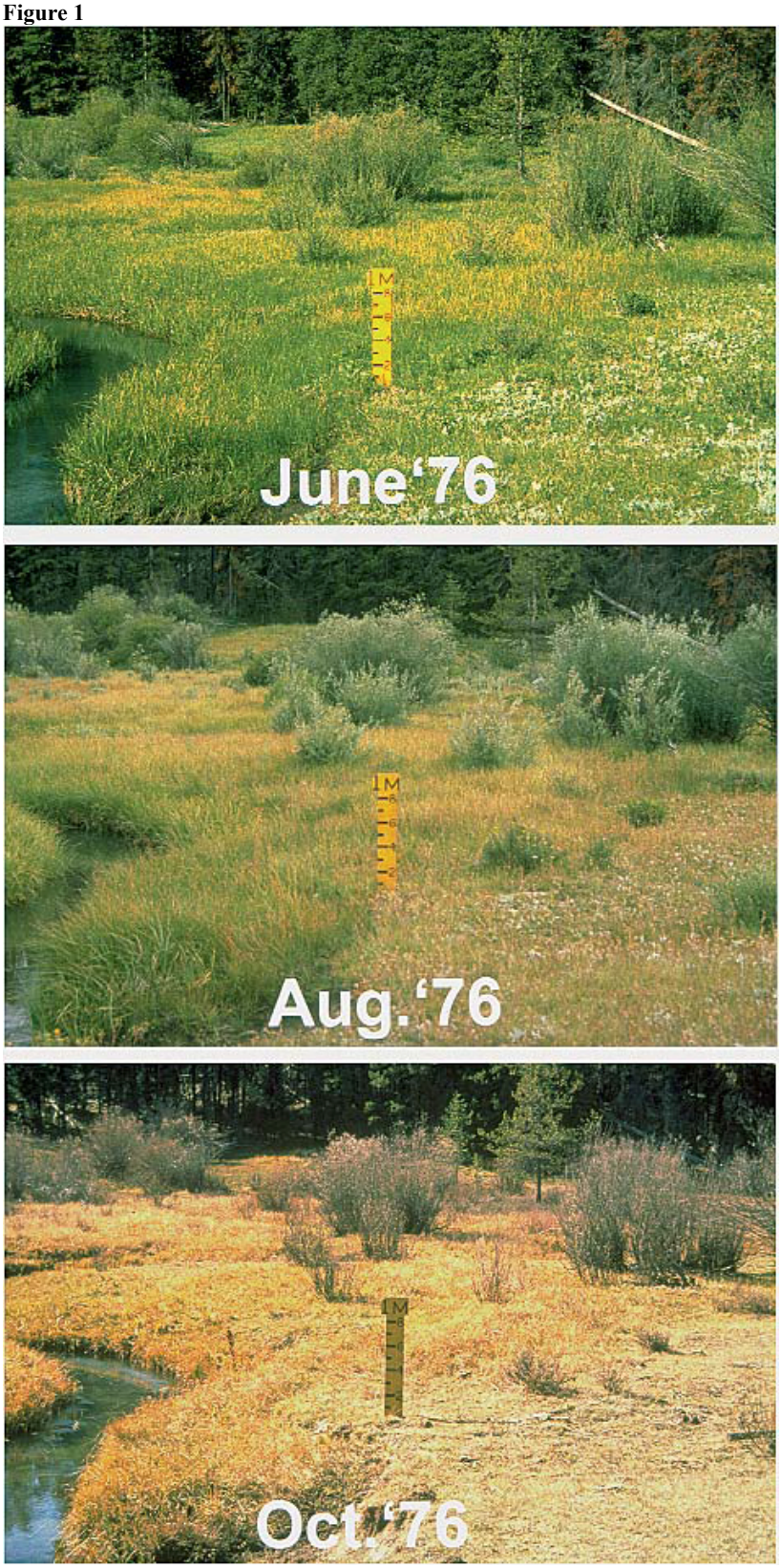
The limitations of photographic monitoring include:

1. Effort required to determine a fixed point for camera locations and photo points.
2. Requires organization to retain mapping and digital data over time.

D. GUIDELINES

1. Design Requirements: Photographic documentation of environmental topics of interest is an essential first step in photo monitoring. Monitoring implies the need to determine change. (USDA GTR526B1).
    a. In the initial planning, several steps are needed for photographic monitoring:
        i. Define the topics of interest such as reforestation, vegetation establishment, or riparian bioengineering.
        ii. Define the monitoring area and its limits.
        iii. Locate photo points to best document change based on the above directives. Locate a measuring stick at each of these photo points. Measuring sticks, or meter boards, identify the item being monitored, establish a camera orientation reference point for subsequent photography, set up a constant size-reference by which change can be documented, and provide a point on which to focus the camera (USDA GTR526A1) Refer to Figure 1 for photo and measuring stick examples.
        iv. Establish camera locations for optimum coverage of the subject. Coverage might require multiple photo points from the same location or multiple camera locations focusing on the same point (USDA GTR526A2). The camera locations must be properly documented so that subsequent photography provides consistent analysis.

Figure 1



Source: Photograph by Frederick C. Hall, USDA

2. Materials:
   a. A fixed lens digital camera that is 2.4 mega pixels or higher; the DPI (digital pixels per inch) should be set to the same value for each photograph. Preferably at no less than 150 DPI.
   b. A measuring stick, or meter board.
   c. T-posts or fence posts to mark camera positions.
   d. Compass and 100 foot tape for measurements.

3. Installation:
   a. The sequencing of photographic monitoring is based upon the desired goals. For instance, if the goal is to determine erosion patterns, then photographs would need to be taken before and after rainfall events. If the goal is to monitor vegetation establishment or reforestation, then the photographs might occur with each season. They must be marked by permanent features such as t-bar posts or fence posts.
   b. If any of the photographic observation areas are to be mowed, care should be taken so that T-post, fence post, and measuring stick locations are visible to maintenance crews. Failure to do so may result in the damage or loss of important data markers.
   c. Do not place camera in locations and photo points near stream edges or any other dynamic environs because the camera locations and photo points will not be discernable if there are any events such as erosion, flood, rock fall, etc. (USDA GTR526A2).

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Image below of contour ripping treated with compost and seed (from TAMU). Photo taken by Dennis Hoffman, Blackland Research Center senior research scientist.
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Or: http://forthoodreveg.tamu.edu/practices_contour-ripping.php

Front Image Source:
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