Effects of Transmission Lines and Pipelines on Wetlands and Wildlife, and Best Management Practices–A Literature Review

by

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EFFECTIVENESS OF BEST MANAGEMENT PRACTICES IN RESTORING TEMPORARY IMPACTS IN NONTIDAL WETLANDS

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Effects of Transmission Lines and Pipelines on Wetlands and Wildlife and Best Management Practices—A Literature Review

1. INTRODUCTION

The types of utility rights-of-way included in this report are electrical transmission, gas pipelines, water, and sewer lines. Linear in nature, each of these is traverses the landscape often conflicting with wetland resources. Lowland areas such as river corridors and associated wetlands are often valued by the utility industry as desirable places to locate power transmission lines. These areas tend to be free from major obstructions, are low in price, away from the public view, and the long linear corridors simplify construction (Quidgley, 1978 Cited in Thibodeau, 1986). Sewer lines are often located near streams to accommodate gravity flow (MNCPPC, 1998).

Locating utility lines and access roads (temporary or permanent) in and around wetlands and waterways creates a challenge for natural resource managers. In some geographic locations, such as the Piedmont Plateau in Maryland, for example, most wetlands occur in the valley floors of streams (MNCPPC, 1998) and so utilities may impact a sizable portion of the resource. Streamside forests and wetlands are also influenced by the flooding regime of the adjoining stream which can be affected by these practices (Conner et al. 1981). Impacts to wetlands may occur by direct disturbance or indirectly through changes in the hydrology or sediment load.

Construction practices in general have a wide range of impacts to wetlands. The physical and chemical impacts may extend for many miles from the construction site. The most damaging effects of construction activities in wetland areas, in order of importance, are: direct habitat loss, addition of suspended solids and modification of water levels and flow regimes. Major construction-related impacts also derive from altered water temperature, pH, nutrient levels, oxygen, carbon dioxide, hydrogen sulfide, and certain pollutants such as heavy metals, radioactive isotopes, and pesticides (Darnell, 1976).

This literature review presents the current state of knowledge on the environmental impacts to wetlands from the construction and maintenance of a variety of utilities: electrical transmission, natural gas pipelines, and sewer lines and the roads necessary for construction and maintenance. Best management practices of these industries for the protection of land and water resources and wildlife are also presented as well as some findings about how vegetation recovers from perturbations as reported on sites that are not rights-of-way. Finally, included are also several case studies of best management practices in the industry and government.
2. IMPACTS ON WETLANDS BY LAND USE

Information on the long-term changes in wetland function due to construction of utility lines is poorly understood (Gaskin and Nutter, 1997; Thibodeau and Nickerson, 1986), though significant findings have been established within the last decade, especially where gas pipelines cross wetland habitats (FERC 2004; Van Dyke et al. 1994). For the purposes of this study, the investigator reviewed the literature about impacts from utilities, including electric transmission lines, gas pipelines, water, and sanitary sewer lines. In addition this investigation included two additional land uses—gravel and dirt roadways and forestry—recognizing that the development impacts of these land uses share some similarities with the construction impacts of utilities, such as vegetation clearing, stream crossings, and erosion.

2.1 Transmission Line and Pipeline Rights-of-Way

The Maryland Department of Natural Resources Power Plant Research Program evaluates how the design, construction, and operation of power plants, transmission lines and pipelines impact Maryland’s environmental, economic, and cultural resources. As part of their core function the program produces the Cumulative Environmental Impact Report biannually. The report summarizes impacts that transmission and pipeline rights-of-way impose on Maryland’s wetlands and forests during both construction and maintenance practices, with a focus on electric transmission lines (MDNR, 2008).

Maryland has more than 2,000 miles of electric power transmission line rights-of-way. There are 13 utilities distributing electricity to customers in Maryland. Four of these are large electric companies owned by three holding companies — Allegheny Power; Baltimore Gas and Electric; and Pepco Holdings, which owns Delmarva Power and Potomac Electric Power Company. These utilities serve approximately 90 percent of the customers in the state. The long, linear corridors of electric transmission lines span up to several hundred feet wide and sometimes align along or cross streams, rivers, floodplains, wetlands and other sensitive habitats, resulting in a variety of effects. Most transmission lines also cross some forested areas (MDNR, 2008).

The Office of Pipeline Safety (OPS), within the U. S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration (PHMSA), has overall regulatory responsibility for hazardous liquid and gas pipelines in the United States. Through certification by OPS, the state of Maryland regulates the operators having intrastate gas and liquid pipelines. This work is performed by the Pipeline Safety Division of the Maryland Public Service Commission (PHMSA 2010).

The pipeline network of Maryland consists of nearly 1,300 miles of pipelines (not including gas distribution lines to the end user) operated by over twenty different companies. Table 1 shows the breakdown by mileage among natural gas, refined products, and crude oil\(^1\). Refined products include materials such as gasoline, home heating oil, jet fuel, diesel, lubricants and the raw materials for fertilizer, chemicals and pharmaceuticals. Table 2 lists the operators (PHMSA 2010 and PSC 2005a and 2005b).

---

\(^1\) based on data generated from annual reports from 2009 to the Pipeline Hazardous Material Safety Administration of the U.S. Department of Transportation
Table 1

Maryland Pipeline Mileage Overview
(PHMSA 2010)

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Pipeline Miles</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>922</td>
<td>71.4%</td>
</tr>
<tr>
<td>Refined Products</td>
<td>317</td>
<td>24.5%</td>
</tr>
<tr>
<td>Crude Oil</td>
<td>52</td>
<td>4.0%</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>1,290</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Table 2

Maryland Pipeline Operators*
(PHMSA n.d. and Maryland Public Service Commission 2005)

<table>
<thead>
<tr>
<th>Pipeline Operator Name</th>
<th>Headquarters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baltimore Gas &amp; Electric Co</td>
<td>Baltimore, MD</td>
</tr>
<tr>
<td>Chesapeake Utilities</td>
<td>Dover, DE</td>
</tr>
<tr>
<td>Colonial Pipeline Co</td>
<td>Alpharetta, GA</td>
</tr>
<tr>
<td>Columbia Gas Cumberland</td>
<td>Cumberland</td>
</tr>
<tr>
<td>Columbia Gas Hagerstown</td>
<td>Hagerstown</td>
</tr>
<tr>
<td>Columbia Gas Of Maryland Inc</td>
<td>Canonsburg, PA</td>
</tr>
<tr>
<td>Columbia Gas Transmission Corp</td>
<td>Washington, PA</td>
</tr>
<tr>
<td>Dominion Transmission, Inc</td>
<td>Clarksburg, WV</td>
</tr>
<tr>
<td>Eastern Shore Natural Gas Co</td>
<td>Dover, DE</td>
</tr>
<tr>
<td>Easton Utilities*</td>
<td>Easton, MD</td>
</tr>
<tr>
<td>Elkton Gas, Div of NUI Corporation</td>
<td>Elkton, MD</td>
</tr>
<tr>
<td>Frederick Gas Div. of Washington Gas</td>
<td>Frederick, MD</td>
</tr>
<tr>
<td>Mirant Piney Point, LLC</td>
<td>Atlanta, GA</td>
</tr>
<tr>
<td>Nustar Terminals Operations Partnership</td>
<td>Dallas, TX</td>
</tr>
<tr>
<td>PPL Gas, Inc.</td>
<td></td>
</tr>
<tr>
<td>Petroleum Fuel And Terminal Company+</td>
<td>Chesapeake, VA</td>
</tr>
<tr>
<td>ST Services</td>
<td></td>
</tr>
<tr>
<td>Texas East</td>
<td>Houston, TX</td>
</tr>
<tr>
<td>Washington Gas Light Co</td>
<td>Washington, DC</td>
</tr>
<tr>
<td>Williams Gas Pipeline - Transco</td>
<td>Houston, TX</td>
</tr>
</tbody>
</table>

*Shaded rows are major gas utilities*
Pipelines in Maryland may include large-diameter lines carrying energy products to population centers, as well as small-diameter lines that may deliver natural gas to businesses and households. Most pipelines are located underground in rights-of-way (ROW)—consecutive property easements acquired by, or granted to, the pipeline company. The ROW provides sufficient space to perform pipeline maintenance and inspections, as well as a clear zone where encroachments can be monitored and prevented.

### 2.1.1 Construction Impacts

According to Maryland Department of Natural Resources, most of the construction impacts of transmission and pipeline rights-of-way involve short-term environmental damage that can be minimized with best management practices and mitigated by post-construction restoration. If there is unavoidable permanent damage, the utility company is required to provide environmental compensation by creating an equal or larger amount of equivalent habitat elsewhere (MDNR, 2008).

#### 2.1.1.1 Vegetation Removal During Construction

During the construction of pipeline and electrical transmission, the ROW is typically cleared of vegetation. The ROW may be 150 feet or more in width for electric transmission (Folga, 2007). Vegetation clearing for the construction of pipelines is typically around 85 feet wide, or in wetland areas may be limited to 75 feet if encroachment is unavoidable. Vegetation removal can result in immediate as well as long-term soil erosion that increases sediment loads in streams and wetlands and that can lead to changes in stream morphology and diminished water quality, ultimately degrading stream habitat. Removing vegetation from the riparian area also reduces the amount of shading, leaf litter, woody debris, and root structures, thereby also reducing critical habitat for many stream species (MDNR, 2008).

#### 2.1.1.2 Installation of Support Structures—Transmission Lines

A staging area is necessary to construct each support structure. At the site of each structure, holes are made with an auger or back hoe and blasting may be necessary for breaking large boulders or bedrock. The support structure is erected by a crane or by the use of helicopters (TEEIC, n.d.).

#### 2.1.1.3 Pipeline Construction

The gas industry usually transports natural gas via underground pipelines. Transmission pipelines are made of steel and generally measure from 6 to 48 inches in diameter (Folga, 2007). The major impact to natural resources occurs through construction practices such as trenching and backfilling, discussed below. Best management practices to minimize environmental impacts are discussed in section 3.2.3. Figure 1 illustrates the spatial arrangement of typical ROW disturbances during pipeline construction including trenching, temporary ROW during construction, temporary topsoil and spoil separation and storage.
2.1.1.3.1 Trenching

Trenches are dug around 4 feet wide in stable soils and around 2 ½ - 5 feet deep to the top of the pipe, allowing for the minimum 2 ½- 3 feet cover. Topsoil is separated and stock-piled. When soils are shallow or rocks are present, a ripper or rock trencher is used to break up the rock. If these tools are ineffective, blasting may be necessary (Folga, 2007). After trenching, sections of pipe are laid out along the trench. The pipe is assembled, and the joints are welded and coated with a protective epoxy coating before the pipe is lowered into the trench. The trench is backfilled, topsoil is emplaced and final grading and seeding performed.
When a pipeline crosses a stream, a conventional open-cut stream trench is often employed. Investigators reviewing practices across the country and in Canada found that open cut trenching is often performed without diverting stream flow around the trench and sediment loads are elevated during and shortly after construction. The magnitude and duration of sediment loading is influenced by the size and flow of the waterway, the specific in-stream activity and the particle size distribution of the stream bed. (Reid 1999). Maryland Department of the Environment, however, requires diversions and other practices in performing open-cut trenching.2

Reid (1999) reviewed 27 studies examining the effects of open-cut pipeline water crossings (where stream flow was often not diverted). Below is a summary of the findings. Section 2.1.3.4 discusses the impacts of open-cut stream crossings on aquatic life. Section 3.2.3.1 presents other management practices for crossing waterbodies to reduce impacts.

During open-cut trenching, peaks in sediment loads during construction decline rapidly, especially when the crossing is properly stabilized (Anderson et al. 1996 cited in Reid 1999). The method of excavation influences both the duration of in-stream activity and overall sediment load (Ritter 1981 and Terra 1996 cited in Reid 1999). The downstream extent and concentration of the sediment plume is also dependent on the particle sizes of the materials excavated.—small particles of clay or silt will be transported farther than sands and gravels (Julien 1995 cited in Reid 1999).

While the turbidity plume during construction may decline rapidly, excavated sediment deposited downstream and its effect on streambed conditions may be longer in duration. Coarser sediments such as sand may settle immediately downstream while silts and clays occur further downstream as a light coating on the streambed. In the studies examined by Reid (1999), the deposition of sediments downstream increased embeddedness (i.e. small material fill in the voids between larger particles) and change channel morphology and composition of the streambed. However, changes in streambed conditions in many conditions were short-term—lasting from 6 weeks to 2 years after construction (Crabtree et al 1978 and others cited in Reid 1999). Changes to channel morphology at the crossing location may be longer-term (Crabtree et al 1978 cited in Reid 1999). Increases in channel width and reduced water depth and meanders were observed 2-4 years after construction.

2.1.3.2 Hydrostatic Testing

Pipelines are tested for integrity by filling sections with water under pressure. The water used is from a local stream, river, or lake, a city water system, or trucked to the site. The same water is recycled for each section. At the end of the testing, the water is tested, treated if necessary to meet the requirements of the National Pollution Discharge Elimination System, and finally discharged (Folga 2007).

2 (COMAR) 26.17.04. governs, among other impacts, the change of the course, current, or cross section of a stream or water body. MDE may require a permit applicant to address, among other things: erosion of the construction site or stream bank; and impacts on nontidal wetlands, existing in-stream fisheries, wildlife habitat, or threatened or endangered species.
2.1.1.3.3 Hazardous Materials

Typical fuels, lubricants, and hazardous materials stored or used during construction include:

- Diesel and gasoline fuel
- Hydraulic oils and engine oil
- Lithium grease
- Anti-freeze
- Drilling mud

2.1.1.4 Sanitary Sewer Mains

Sanitary sewers remove wastewater from homes, businesses, and industry, transporting the sewerage to a sewage treatment plant. Conventional gravity flow systems are used in urban areas where possible however, systems may rely also on pressure and vacuum forces when necessary. The hierarchy of pipes includes a service lateral from the residence or business and local main sewer lines that feed to a regional trunk line (Figure 2).

Figure 2

Sanitary Sewer System

(City of Irving, n.d.)
Since gravity is used as much as possible, the largest part of the system—a trunk line or transmission main—tends to be located in the lowest topographic relief of the region. These areas, consequently, may also be adjacent to or within wetlands, streams, and floodplains (Figure 3). When pipelines are installed, the environmental disturbance depends on the design of the system, nature of the site, and the methods used for installation.

Figure 3
Sewer Line in Stream Channel
(Arlingtonians for a Clean Environment n.d.)

The physical components of a wastewater conveyance system are determined by design criteria dictated by the flow capacity as well as site constraints imposed by topography, soils, depth of water table, frost line and other existing conditions. Appurtenances include manholes, building connections, junction chambers or boxes, terminal cleanouts as well as other structures (EPA 2002 and WSSC 2008).

2.1.1.5 Water Supply System

A water supply system includes a diversity of engineered components designed to transport water from the collection source, such as a reservoir, or directly from groundwater, to the user. The entire supply system includes the water purification system, storage facilities, pumping stations and a network of pipes. According to the U.S. Environmental Protection Agency, a water system is “public” when it provides water to at least 15 service connections or serves an average of at least 25 people (EPA 2004). According to Maryland Department of the Environment, public water systems supply about 84% of Maryland resident’s water supply for nearly five million people (MDE 2009).
In a typical public water system, water is transported under pressure through a distribution network of buried pipes. Smaller pipes are attached to the main water lines to bring water from the distribution network to the user. For the purposes of this review, the pipe network (and the environmental impacts associated with pipe installation and maintenance) is the component of interest. The pipe network of a community water system is often expanded in order to connect with new development patterns and so may conflict with wetland resources.

Urban and suburban water service consists of three levels of distribution pipes:

- **Service Mains** designed and constructed to provide localized services.
- **Distribution Mains** designed and constructed to provide distribution from the major transmission mains to the service mains.
- **Transmission Mains** designed and constructed to provide a major water supply from the water treatment plant to the distribution main.

Unlike sewer lines, water service does not depend on gravity flow, but rather service is provided under pressure. Therefore, there is less of an inherent conflict between water lines and wetland resources, than the conflict often present between sewer lines and water and wetland resources.

### 2.1.1.6 Washington Suburban Sanitary Commission

The Washington Suburban Sanitary Commission (WSSC) is one of the major water and wastewater utilities in the State of Maryland. A bi-county agency (Montgomery and Prince Georges) WSSC services a 1,000 square mile area and 1.4 million people, making it the 8th largest water and sewer utility in the nation. Within this service area are over 4,700 miles of sewer pipe that feed into five wastewater treatment plants as well as more than 5,500 miles of fresh water pipelines that connect the Potomac and Patuxent Water Filtration Plants to end users (Figure 4).

WSSC design criteria (in conformance with State of Maryland guidelines) are used to size and direct the location of the water and sewer conveyance systems in that jurisdiction. As such, the criteria directly relate to the degree to which a site is disturbed during installation which may include impacts to wetlands, floodplains, waterways and other sensitive areas. Those WSSC design criteria that relate to the **space and location** requirements (thereby resulting in certain site disturbance) are presented here as a model of standard practices (WSSC 2008). Other jurisdictions in Maryland could be expected to vary from these criteria, within limits. The design criteria are discussed below and best management practices to limit and mitigate for the impacts of water and sewage conveyance systems are discussed in section 3.2.3.

WSSC design criteria for both water and wastewater are located within three sources which are used in conjunction with each other for any given project:

1. WSSC Pipeline Design Manual
2. WSSC Standard Details for Construction
3. WSSC General Conditions and Standard Specifications
Within each of these technical documents are provisions that are common to both water and sewer and other provisions that are particular to the each of these utilities.

**Figure 4**

**Washington Suburban Sanitary Commission Service Area**
(WSSC n.d.)

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### 2.1.1.6.1 Selected WSSC Design Criteria Common to both Water and Sewer Pipelines

**Rights-of-way and construction strips**

WSSC specifies the width of the right-of-way (ROW) for water and sewer based on pipeline diameter (Tables 1 and 2). The largest right-of-way is 75 feet for water pipes over 72 inches. The ROW dimensions in Tables 3 & 4 are for ROW’s containing one pipe. If multiple pipes are located in the ROW, additional spacing may be required as specified in the Manual. The
construction strip is also based on pipe diameter; however, the construction strip is determined by WSSC for pipes over 42 inches, based on site conditions. “Adequate” access points are required along the construction strips. For 48-inch and larger pipes, access points must be provided every 600 feet.

Table 3
Right-of-way and Construction Strip
Minimum Width Requirements for Water Pipelines
(WSSC 2008)

<table>
<thead>
<tr>
<th>Pipeline Diameter</th>
<th>Width of Right-of-way</th>
<th>Total Width of Construction Strips</th>
</tr>
</thead>
<tbody>
<tr>
<td>14-inch and smaller</td>
<td>20 feet</td>
<td>15 feet</td>
</tr>
<tr>
<td>16-inch to 24-inch</td>
<td>25 feet</td>
<td>20 feet</td>
</tr>
<tr>
<td>30-inch</td>
<td>30 feet</td>
<td>20 feet</td>
</tr>
<tr>
<td>36-inch to 42-inch</td>
<td>40 feet</td>
<td>To be determined by WSSC</td>
</tr>
<tr>
<td>48-inch to 66-inch</td>
<td>60 feet</td>
<td>To be determined by WSSC</td>
</tr>
<tr>
<td>72-inch and larger</td>
<td>75 feet</td>
<td>To be determined by WSSC</td>
</tr>
</tbody>
</table>

Table 4
Right-of-way and Construction Strip
Minimum Width Requirements for Sewer Pipelines*
(WSSC 2008)

<table>
<thead>
<tr>
<th>Pipeline Diameter</th>
<th>Width of Right-of-way</th>
<th>Total Width of Construction Strips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smaller than 15-inch</td>
<td>20 feet</td>
<td>20 feet</td>
</tr>
<tr>
<td>15-inch to 24-inch</td>
<td>45 feet</td>
<td>20 feet</td>
</tr>
<tr>
<td>30-inch to 36-inch</td>
<td>50 feet</td>
<td>To be determined by WSSC</td>
</tr>
<tr>
<td>42-inch and larger</td>
<td>55 feet</td>
<td>To be determined by WSSC</td>
</tr>
</tbody>
</table>

* [The manual requires greater ROW widths for depths of cover that are 22 feet or more by applying certain multipliers based on size of pipe].
Washington Suburban Sanitary Commission Trench Sizes

WSSC specifies maximum trench widths based on pipe diameter. Table 4 is a summary of maximum trench widths for two extremes of pipe sizes—one small and one very large.

Table 4

<table>
<thead>
<tr>
<th>Pipe diameter</th>
<th>Max. Trench Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 in.</td>
<td>27 in.</td>
</tr>
<tr>
<td>8 in.</td>
<td>28 in.</td>
</tr>
<tr>
<td>10 ft.</td>
<td>14 ft.</td>
</tr>
</tbody>
</table>

The minimum size for any trench is 27 inches wide. For an 8 inch pipe—the minimum dimension of a receiving pipe for gravity sewers—the minimum trench width is 28 inches. The maximum size trench for a 10-foot diameter, reinforced concrete pipe is 14 feet (Figure 5 a-c).

The maximum depth of pipe is normally 8-10 feet and any pipeline with a cover over 22 feet deep is considered a “deep sewer.” For pipes 24 inches and smaller, the pipe may lay on existing firm sub grade. For larger pipes, however, the trench is dug 6 to 12 inches deeper than the pipe inlet and the area below the pipe is filled with aggregate to support the pipe.

The embedment zone is the area immediately around the pipe, extending 0-12 inches below the pipe to firm subgrade, extending upward to one feet above the top of the pipe and sideways to the trench walls. This backfill material is typically aggregate brought from off site and graded to specifications. Above the embedment zone, backfill may be either native material from site or other specified material depending on the site constraints. Outside of wetland areas, the backfill must be free of organic material. In wetland areas, the backfill material may include organic material.
Figure 5
WSSC Standard Details—Trenches
Pipeline Stream Crossings

See section 3.2.3.1 for design criteria for protecting streams. Below are WSSC design criteria for protecting the pipe that affect the impact to streams.

Determination of Cover Depth

1) The design for the pipeline cover depth below the existing stream bed is to be determined after considering the factors below, which include the minimum required depth of cover, protection against frost penetration, pipe flotation and channel bed erosion. Measure the cover depth from the lowest point in the channel bed to the top of the pipe and show the required depth on the pipe profile...

d) Protection against channel bed erosion

(1) For pipelines 12-inch and smaller diameter. The required cover depth for protection against channel bed erosion may be assumed to be the same as the minimum cover depth [in upland areas]. ... However, calculations should be done to estimate this depth for cases where significant channel bottom erosion is anticipated due to stream channel configuration or other factors.

(2) For pipelines larger than 12" diameter. Protect the pipeline from exposure to direct stream flow and undermining of the channel bed beneath the pipeline due to erosion...

(d) If the cover depth is shallower than the depth calculated for the protection against channel bed erosion ... then provide special designs for protection against channel erosion as indicated below. Also verify that the depth of cover is adequate for protection against frost penetration and flotation. If the channel bed is not armored with erosion-resistant material, provide armoring of the channel bed downstream of the pipeline crossing. Standard Detail SC/3.1. (This Standard Detail is based on Maryland's Guidelines To Waterway Construction, January 1986, published by the former State of Maryland Water Resources Administration. For other methods of armoring the stream bed, see Maryland's Guidelines to Waterway Construction, January 1986.

2.1.1.6.2 Selected WSSC Design Criteria for Sewer Pipelines

WSSC contracts for the expansion if its service adding about 50 miles of new sewer main per year. Each drainage basin in its service area is associated with a major stream or river and each stream has one or more trunk sewers adjoining it.

The Development Services Group of WSSC provides conceptual guidelines for gravity sewers in the Pipeline Design Manual (2008). Those presented below have a direct relationship to the construction impacts that occur as the system is installed (bold font added for emphasis):

- Normal sewer is 8 to 10 feet deep. Sewers over 10 feet deep are considered extra depth and require additional working space and/or right-of-way.
- Sewers over 15 feet deep require substantially more construction space and/or right-of-way. Space requirements increase with increasing depth and ground slope. Sewers over
• ... By necessity, outfall sewers are located along drainage courses, where streams, wetlands, tree-save areas, parks and open space areas are likely to be located. The number of stream crossings is to be kept to a minimum and are to be perpendicular to the stream. ...

• Sewers along streams must be designed to be able to serve both sides of the stream. Therefore, the sewer cannot be placed too far from the stream or too far up the slope. A 25 foot minimum buffer between the stream bank and cleared construction area is to be provided.

Other WSSC design criteria in the Pipeline Design Manual (2008) affect the construction impacts on the environment because they dictate the size of the system. These criteria are included in the WSSC:

• Design the flow capacity…(especially for trunk sewers) to convey the ultimate flow within the area tributary to the sewer, unless the WSSC determines that a lesser requirement is suitable.

• Peak Wastewater Flow (PWF) is ... a step in determining the Design Flow for new sewers. It is the flow that can be expected during a 10-year storm. The Maryland Peaking Equation ... “Design Guidelines for Sewerage Facilities”, ...Department of Health and State of Maryland is used to calculate the PWF

• Normal depth for sewer pipelines is eight (8) to ten (10) feet measured from the lowest profile grade or ground line.

• Provide a minimum of three (3) feet of cover over sewer pipelines ..., 

• WSSC considers any sewer pipeline over twenty-two (22) feet of cover as a deep sewer.

• [Provide] ...additional right-of-way due to the excavation requirements for deep pipes...

Locational criteria in Rights-of-way and construction strips:

• All sewer infrastructure shall be located within the road/WSSC right-of-way with adequate access to allow for routine inspection and maintenance...

2.1.1.6.3 Selected WSSC Design Criteria for Water Pipelines

According to the Pipeline Design Manual (Manual), water lines should be located within roadways or roadway rights-of-way. Pipes over 12 inches may have other considerations. Water pipes should be located on the uphill side of the roadway (sewer lines are on the downhill side). The Pipeline Design Manual states the following in regards to environmental considerations:
When the pipeline alignment is located outside the road right of way, minimize disruption to environmental features and where possible avoid steep slopes, wetland areas, trees and other sensitive areas. Locate the alignment so that it follows the property lines as much as possible.

Cover Over Pipeline.

1) Minimum cover over the top of the pipe: (4) feet from the lowest profile grade or ground line.
2) Pipelines crossing under a stream, ditch, etc.
   a) Provide minimum four (4) feet cover over the top of the pipe...

2.1.1.5 Construction Impacts on Hydrology and Hydraulics

Streams and wetlands are complex systems that are strongly influenced by hydrology. The interaction of infiltration, soil moisture, groundwater, and runoff may be temporarily or permanently impacted by the construction of rights-of-way and access roads. Compaction decreases infiltration rates, increases runoff, and affects soil moisture content, and groundwater recharge (EPRI, 2002).

Hydraulics refers to the movement of flow patterns of water through the environment. Stable stream channels exist in a process of dynamic equilibrium where the hydraulics of the channel transports sediments and sediment inputs and sediment outputs remain stable. Stream crossings of access roads can change the hydraulics, causing sedimentation and erosion, and localized flooding, impacting stream dynamics that can impact aquatic habitat (EPRI, 2002).

2.1.2 Maintenance

The primary goals of electrical transmission rights-of-way maintenance are to retard the growth of woody vegetation to reduce power interruptions and safety hazards and also to assure access. According to the Maryland Power Plant Research Program, herbicides are frequently used and when properly applied, pose little danger to the terrestrial environment. Glyphosates, for example, persist in the environment for less than two months and are generally not toxic to wildlife. Improper use of herbicides, however, damages untargeted vegetation and wildlife. Mechanically cutting vegetation can also disturb and kill wildlife, and cause erosion and polluted waters and wetlands. Most Maryland utilities now use a combination of selective herbicide application and mechanical cutting (MDNR, 2008).

Generally, it is environmentally desirable to remove as few trees as possible. However, Maryland’s Public Service Commission estimates that fallen trees and branches are the largest cause of power outages in Maryland. The Maryland Department of Natural Resources Power Plant Research Program with the Maryland Electric Reliability Tree Trimming Council assembles tree data from utilities throughout the state to determine the causes of such outages. The data will be used to improve maintenance practices to remove hazardous trees while maintaining the maximum protection for valuable trees and forest habitat (MDNR, 2008). MDE
may require that trees be allowed to revegetate over the right-of-way, else require mitigation for
the permanent conversion of forest to emergent wetland. In rights-of-way for overhead
transmission lines, utilities may be required to establish and maintain a vegetative community of
shrubs or small trees instead of emergent wetlands. While this may be a permanent conversion
from forest, the impact is less than if the conversion were from forest to emergent wetland
(Clearwater, personal communication, 2010).

Other utilities have less intensive needs for vegetation management. Gas pipelines are allowed
by federal regulation to maintain a 10-foot wide corridor of herbaceous vegetation in their right-
of-way to allow inspection. In addition, trees greater than 15 feet in height may be selectively
removed within 15 feet of the pipeline.

Water and sewer mains traditionally do not perform regular vegetation maintenance on their
right-of-way as a function of their utility mission. In urban areas, however, maintenance
practices are dictated by the associated land uses. For example, streetscapes or parks will be
maintained to the cultural standards established by those uses.

2.1.3 Impacts to Wildlife

Utilities have multiple impacts on wildlife—both positive and negative. Depending on the
change in land use and the type of impact at time of construction, some impacts may be
temporary where the habitat is restored to its original integrity. Other impacts may be
permanent, especially where the change in land cover is permanent such as the removal of forest
habitat. Below is a discussion of:

- Impacts of maintaining rights-of-way with herbicide;
- Threats to birds from electrocution in electrical rights-of-way;
- Impacts to terrestrial biodiversity due to change in land cover; and
- Impacts of open cut trenching during stream and wetland crossings during the installation
  of underground pipes.

2.1.3.1 Impacts of Herbicide Applications on Wildlife

The Electric Power Research Institute (EPRI) investigated the risks to wildlife from the
application of herbicides commonly used in vegetation management. The investigator reviewed
impacts to avian, terrestrial, and aquatic species and modeled a margin of safety for nine
different chemicals:

- 2,4-D
- Fosamine Ammonium
- Glyphosate
- Imazapyr
- Metsulfuron Methyl
- Picloram
- Sulfometuron Methyl
- Triclopyr, amine and Triclopyr, ester
2.1.3.2.1 Avian and Terrestrial Species Risk Analysis

The risk to wildlife of using herbicides in vegetation management is based on the inherent toxicity of the herbicide to different species and the amount of exposure that each species may receive as a result of application (EPRI 2004). The EPRI investigation used the U.S. Environmental Protection Agency criteria to judge the risks to representative avian and terrestrial species:

“The USEPA criteria call for a comparison of an estimated environmental concentration (EEC) with a laboratory-determined LD$_{50}$ or LC$_{50}$ for the most closely related laboratory test species. Where the EEC exceeds one-fifth LD$_{50}$ or LC$_{50}$, USEPA deems it a significant risk that may be mitigated by restricting use of the herbicide.” (EPRI 2004)

The EPRI risk assessment used a “species total estimate dose” (rather than an EEC), comparing it with the laboratory toxicity level, because the dose in right-of-way applications comes from all exposure routes including dermal, ingestion, and inhalation—not just feeding.

2.1.3.1.1 Aquatic Wildlife Risk Analysis

In order to assess the risk to aquatic life, EPRI assumed that while spraying herbicides on foliage, drift may occur to aquatic habitats. In addition, they considered spills into a pond and accidental direct application to surface water. EPRI estimated the risk of adverse effects on aquatic species:

“The most sensitive toxicity value was compared to the typical and maximum estimated environmental concentrations. The ratio of the estimated environmental concentration (EEC) to the LD$_{50}$ is called the quotient value (Q value). USEPA [established risk criteria based on Q values].”

2.1.3.1.3 EPRI Findings of Impacts of Herbicides on Wildlife

Risk to wildlife was within acceptable range for all cases in typical applications. Six of the nine were within acceptable limits if applied at maximum rates. Three herbicides, however, 2,4-D and Triclopyr (amine and ester) did not have adequate margins of safety at maximum rates of application for the protection of wildlife.

For aquatic species, all herbicides provide an adequate margin of safety at typical application rates and maximum application rates. All herbicides, except Triclopyr had an acceptable margin of safety in case of an accidental direct application to water. All but two herbicides, Triclopyr ester and 2,4-D had an adequate margin of safety in the case of an accidental spill into a pond.

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3 LD$_{50}$ is the amount of a toxic agent (as a poison, virus, or radiation) that is sufficient to kill 50 percent of a population of animals usually within a certain time—called also median lethal dose. Miriam Webster Medical Dictionary. http://www.merriam-webster.com/medical/ld50

4 Lethal Concentration to 50%. i.e., a concentration that is lethal to 50% of a standard sample of human or animal subjects. http://www.plexoft.com/SBF/L.html
2.1.3.2 Bird Electrocutions

Bird electrocution occurs when a bird completes an electric circuit by simultaneously touching two energized parts or an energized part and a grounded part of the electrical equipment. Raptors in particular may perch and/or nest on utility poles in areas where there are few natural perches or nest sites. Most electrocutions occur on medium-voltage distribution lines (4 to 34.5 kV), in which the spacing between conductors may be small enough to be bridged by birds. Poles with energized hardware, such as transformers, can be especially hazardous, even to small birds, as they contain numerous closely-spaced energized parts (Edison Electric Institute et al., 2005).

Large, open-country birds, such as eagles and hawks, are typically at greatest risk for electrocution. In open habitats where few natural perches exist, such as grasslands, agricultural fields, and pastures, raptors will roost, nest or perch while hunting on utility poles. The large wingspans of raptors such as golden eagles, red-tailed hawks, osprey, and great horned owls enable them to simultaneously touch energized and/or grounded parts, potentially resulting in electrocution. Other smaller birds such as crows, ravens, magpies, small flocking birds and wading birds can also be electrocuted on closely-spaced exposed equipment, such as jumper wires on transformers. Wading birds, such as herons, egrets, ibis, or storks, are also at risk because of their height as it relates to the vertical spacing between lines (Edison Electric Institute et al., 2005). Section 3.2.2 of this document provides a brief summary of the Avian Protection Plan Guidelines written by the Avian Power Line Interaction Committee.

2.1.3.3 Impacts on Terrestrial Biological Diversity

The utility industry recognizes that issues related to biodiversity are relevant to management practices in their rights-of-way (Doucet, 1993). Investigators report on issues such as habitat fragmentation, species diversity and abundance, the "edge effect" and shrubland habitat value. This land use offers both challenges and opportunities for managing wildlife (Temple, 1996).

2.1.3.3.1 Impacts of Habitat Fragmentation

Many ecologists are concerned about the fragmentation of forested lands and other habitats in the eastern United States, its effects on biodiversity and the dynamics of species composition in forest fragments following deforestation (Forman, 1995 and Robbins et al., 1989, cited in Temple, 1996). According to the Electric Power Research Institute (EPRI), forest fragmentation is commonly an issue raised during siting of transmission rights-of-way (EPRI, 2003).

Ades and Temple assessed the extent of the problem of forest fragmentation caused by transmission rights-of-way in 54 forested sites in Wisconsin and found that the impacts on edge-sensitive forest-interior species can be severe (Ades, 1993, cited in Temple, 1996). The investigators examined sites that were either national forests or national wildlife refuges in Wisconsin, transected by transmission-line rights-of-way. In over half of these sites the fragmentation had significant negative impacts on the habitat of edge-sensitive species of plants and animals.

While transmission rights-of-way may have a negative affect on edge-sensitive species, in certain circumstances, they may offer an opportunity to link critical habitats that are isolated by...
development. For example, Pine Barrens once covered extensive portions of northwest Wisconsin. This habitat consisted of sparse prairie-like grassland with widely scattered pines. The rare sharp-tailed grouse depends on this habitat and wildlife specialists tried to manage the small patches of the remaining habitat to support the population. However, the remaining patches of habitat were too small. Shively and Temple (1994, 1995 cited in Temple, 1996) examined proposed routings of transmission rights-of-way and found potential to link the isolated grouse habitats if they were managed to provide appropriate grassland species.

2.1.3.3.2 Benefits of Herbaceous and Shrub Habitats on Wildlife

A significant source of information about the long-term impacts of mechanical and herbicidal maintenance on wildlife habitat and selected wildlife species is provided by the State Game Lands 33 Research and Demonstration Project that was initiated in 1952 (often called the Bramble and Byrnes study). The objectives of the long-term study are:

(1) compare the effectiveness of mechanical and herbicidal maintenance treatments on control of trees and development of tree-resistant plant cover types; and

(2) determine the effect of mechanical and herbicidal maintenance on wildlife habitat and selected wildlife species of high public interest.

Beginning in the 1980’s the right-of-way has been managed with the wire-zone border-zone method with low-lying vegetation in the wire zone and taller vegetation in the border zone (Figure 6). Studies along the right-of-way document impacts to bird populations, nesting ecology, small mammals, butterflies, reptiles and amphibians. According to Yahner the results show that habitat management with the use of herbicidal and hand-cut treatments, (i.e. wire zone-border zone management) creates an ecosystem that is very diverse in animals and plants (Yahner, 2004).

Bird Populations

Since 1982, researchers have studied bird populations along the right-of-way. Over 40 bird species have been noted, mostly those that nest in brushy or grassy vegetation. Later in the summer, family groups of forest bird species search for food in the brushy boarder. Overall, the abundance of birds along the right-of-way was seven times higher than the adjoining forest. The habitat of brushy and early successional plants benefits many bird species. This trend is particularly significant since early successional bird species as a group are declining faster than other groups such as forest or wetland birds (Askins 2001 cited by Yahner 2004).

Chasko and Gates (1982) performed another study on two rights-of-way (grassland versus shrubland) in Allegheny County Maryland adjoining a forest. The authors believe that a goal of nongame bird management along transmission-line corridors should be to maximize the number and diversity of successful breeding pairs. They observed that the Warrior Mountain shrubland corridor, maintained by selective basal herbicide spraying, provided excellent habitat for nesting
mixed-habitat birds. The grassland that was mowed annually showed minimal nesting, however, isolated shrub patches within the grassland were important for mixed-habitat species nesting.

Figure 6

Border Zone-Wire Zone Vegetation Management
Sacramento Municipal Utility District

Nesting Ecology

Researchers conducted a 2-year nesting ecology study of birds along the ROW (Bramble et al. 1994 cited by Yahner 2004). Most nests were found in border zones treated with herbicides with relatively few nests in hand cut areas. Overall, the nesting success (66%) was higher than success reported in other studies of songbirds (+/- 50%). Only one nest of 42 was parasitized by the brown-headed cowbird.

Small Mammal Population

During a 2-year study of small mammals, eight species were observed compared to only two in the adjacent forest. The ROW provided habitat for forest species such as the white-footed mouse in the border zone and habitat for early successional species such as the meadow vole in the wire zones (Bramble et al. 1992b cited in Yahner, 2004).
Butterfly Population

A 2-year study of the butterfly population identified nearly 30 species of butterflies. The use of herbicides in the wire zone resulted in many species of flowering herbaceous plants that benefited butterflies. Butterflies were much more common on herbicide-treated units than on hand-cut units (Bramble et al. 1999 cited in Yahner, 2004).

Amphibian and Reptiles

A 2-year study of amphibians and reptiles found a diverse population of amphibians and reptiles—more than four times the number of species in the ROW than in the adjacent forest. Herbicidal-treated units were more diverse in species and more abundant with individuals than the hand-cut units. The border zones of the ROW ensured moist habitats for salamanders and the wire zones provided suitable habitat for all species of amphibians and reptiles observed (Yahner et al. 2001).

2.1.3.3.3 The Edge Effect

Many of the responses measured in the section above report an increase in numbers of wildlife species and individuals in transmission rights-of-way maintained as brushy and herbaceous habitats. This pattern may be attributed to a natural response that wildlife managers and ecologists sometimes refer to as the “edge effect.” An edge is the junction of two different landscape elements such as plant community types (Giles 1978 and others cited in Yahner, 1988).

Increasing edge habitat can also have a negative impact to wildlife that planners should consider, especially as it relates to fragmentation of forest habitats (see 2.1.3.3.1 above). Yahner (1988) suggests a nuanced approach with regards to the edge effect:

“... managers... have traditionally considered edges as beneficial to wildlife because species diversity generally increases near habitat edges...However, edges can have negative consequences for wildlife by modifying distribution and dispersal and by increasing incidence of nest predation and parasitism. Edges also may be detrimental to species requiring large undisturbed areas because increases in edge generally result in concomitant reductions in size and possible isolation of patches and corridors. Thus ... managers... should be cautious when describing the benefits of edges to wildlife, particularly when dealing with species that require forest interiors...Based on our current understanding... we must not conclude that creation of more edge in landscapes will always have a positive effect on wildlife.”
2.1.3.3.4 Trends in Early Successional Shrubland Bird Habitat

In the last two decades, researchers have become concerned about the decline in birds that breed in early successional shrubland because of the decline in habitat. Transmission rights-of-way offer opportunities for these species if they can provide “source” habitats (habitats where reproductive output exceeds losses from mortality). King and Byers (2002) determined that a transmission right-of-way in Savoy State Forest, Massachusetts provided source habitat for the chestnut-sided warbler, a neo-tropical migrant. The investigators believe that these results are likely apply to other early-successional species, with similar life histories such as neo-tropical migrants.

2.1.3.4 Impacts of Open-cut Trenching on Aquatic Life

Reid (1999) reviewed 27 studies examining the effects of open-cut pipeline water crossings. Below is a summary of the findings. The studies reported on alterations to streambed conditions, reductions in the abundance and diversity of benthic invertebrates, and reductions in the abundance of fish populations.

Sediment released during in-stream construction can cause short-term changes to downstream aquatic life. The in-stream habitats usually recover within a year. In some crossings, streambed conditions actually improved as well as the productivity of benthic invertebrates. Additional study is needed on the effectiveness of alternate crossing techniques to minimize downstream sediment loading and establish effects of released sediment on fish.

The effects of open-cut trenching on benthic invertebrates include an increase in drift rates at the onset of construction and decline of densities post-construction. In addition, the diversity and structure of these communities changed in some studies to only sediment tolerant communities. Changes in the benthic communities tends to be short-term, however, as the stream recovers through flushing activity and sediment transport over time (Reid 1999).

“While there have been many assumptions about the potential effects of open-cut pipeline water crossings on fish and fish habitat, monitoring reports do not consistently document adverse effects. In cases where effects to fish communities and their habitat have been identified, changes are only short-term and recovery generally occurs within a year of construction. This conclusion is consistent with Yount and Niemi (1990) who found that stream ecosystems recovered from pipeline and road crossings within less than 2 years after construction. As well, an earlier EPA review of field studies documenting recovery from disturbances causing the death, or displacement of organisms found recovery from measured effects on invertebrates and fish within two years in 85 percent of the cases (USEPA 1991). These short-term impacts observed as a result of pipeline water crossings are minor and transitory when compared to the more chronic degradation of stream and river ecosystems caused by sediment loading from urban development and various agricultural, forestry, and mining practices (Waters 1995)...It is clear from this review [however,] that our understanding of the direct effects on fish is limited, or at least contradictory.”
2.1.4 Site Specific Findings

A utility company in North Reading, Massachusetts cleared all above-ground vegetation in order to install steel towers in a two square mile wooded wetland. The plant association was an open canopy with *Acer rubrum* and *Alnus rugosa* predominating and an understory of *Ilex verticillata*, *Rhododendron viscosum* and *Clethra alnifolia*. Researchers examined six measures of community composition: number of species, total stems count, diversity, species evenness, and species richness. The effects of both construction and maintenance did not have a substantial long-term impact on the vegetation, except in size and maturity. The vegetation recovered in two years from nearly total destruction. Periodically removing high-growing species during maintenance led to a different plant association that was similar in diversity and species richness (Thibodeau and Nickerson 1986).

A gravel road providing access for maintenance to a new power line blocked water flow across a shrub swamp in Tewksbury, Massachusetts, draining one section and impounding another. Within one year, the vegetation in the drained area shifted substantially toward a denser and more species-rich association. The study suggests that there is a ready supply of permanent colonizers that need only a short-term change in environment to establish. After three years the changes slowed, but they had not stopped after six. The authors suggest that many of these changes would likely not reverse themselves if a more normal flooding pattern established. Reversals may be possible, however, depending on the amount of flooding or sediment deposited (D. Clearwater personal communication 2010). In the newly flooded area there were few changes for the first three years, but after that time many species began to decline in numbers, with the most pronounced effect occurring after five years. The authors observed that draining had a more immediate and longer lasting effect than flooding (Thibodeau and Nickerson, 1985, 1986). MDE attempts to manage waterway and wetland crossings so that upstream and downstream are not altered in an adverse manner (Clearwater personal communication, 2010).

2.2 Impacts of Access Roads in Utility Rights-of-way

Roads provide access to utility lines during construction as well as for maintenance during normal operations. These roads range from temporary to permanent paths in a range of materials (EPRI, 2002). Transmission lines and pipelines have roads of about 15 feet in width that are typically made of gravel or dirt to provide access to rights-of-way for construction, inspection, and maintenance.

Grading access roads is one of the largest land disturbing activities associated with construction and maintenance of transmission lines (HDR, 2007). Access roads to critical support facilities, such as pump stations, compressor stations, and electric substations, are typically maintained in gravel throughout the operating life of the utility line (Tribal Energy and Environmental Information Clearinghouse). Temporary access roads established during construction are generally removed, re-graded, re-planted and stabilized, and sometimes mowed. (Clearwater 2010). Short gravel and dirt roads providing access for maintenance are not as serious an issue as longer dirt and gravel roads associated with other land uses such as forestry and rural areas (Clearwater 2010).
2.3 The Impacts of Forestry Practices to Wetlands

Forestry practices have a broad range of impacts to wetlands and waterways including inputs of sediment, nutrients, temperature, toxic chemicals and metals, organic matter, pathogens, herbicides, and pesticides. These impacts occur from harvesting activities and access roads that impact both the hydrology of the watershed, as well as water quality (USEPA, 2005). Forestry activities are the third leading cause of wetlands loss in the United States—behind urban development and agriculture—and accounted for 23 percent of wetland losses from 1986 to 1997 (Dahl, 2000). A review of forestry impacts is included in this review due to the similarities between harvesting timber and removal of trees in forested wetlands for utility line installation.

Potential effects of forestry operations in wetlands include:

- Loss and/or degradation due to discharges of dredged or fill material.
- Sediment production from road construction and use and equipment operation resulting in wetlands filling.
- Drainage alteration as a result of improper road construction and ditching. [An excellent discussion of the relationship between forest roads and drainage is contained in the U.S. Forest Service document Water/Road Interaction Technology Series (USDA-FS, 1998b)].
- Stream obstruction caused by failure to remove logging debris.
- Soil compaction caused by operation of logging vehicles during flooding periods or wet weather. Skid trails, haul roads, and log landings are areas where compaction is most severe.
- Contamination from improper application or use of pesticides.
- Loss of integrity of whole wetland landscapes (and the functions they serve) as a cumulative effect of incremental losses of small wetland tracts.

2.3.1 Hydrologic Impacts from Forestry Practices

Forestry practices impact the hydrology of the watershed in a variety of ways. The activities of road construction and road use, timber harvesting and site preparation in particular are all forestry activities that may also occur in the development of utility rights-of-way. Logging has the effect of both compacting and loosening soils due to the construction and use of roads, use of heavy machinery, logs being dragged over the ground, and vegetation being removed. Roads and road ditches, ruts on the ground, and areas cleared of leaf litter or other soil coverings may concentrate the water or divert flows, which can generate erosion. Stream crossings and roadways near streams exert the greatest impacts to water resources in forestry practices (USEPA 2005).

The biggest impact of forestry traffic is alteration of the physical properties of soil. Heavy-wheeled equipment creates ruts and churns soft wet soils which impede the movement of air and water and increases bulk density, or compaction. Rutting reduces porosity and saturates conductivity which may result in increased soil moisture retention and elevated water tables. Lower water holding capacity, and slower internal drainage is associated with ruts. Older ruts,
however, (two years or older) recover their drainage characteristics. When using wide-tired equipment, soil compaction is not the most significant impact on wet soils. (Aust et al. 1993 in Rummer 2004).

2.4 Plant Invasion from Linear Site Disturbance

Phragmites has been found to invade the landscape by following linear patterns established through disturbances such as highway and agricultural ditches. Due to the interconnectedness that occurs in the landscape, linear wetlands such as roadway and agricultural ditches can serve as corridors for the invading species, serving as “invasion foci” into other parts of the landscape. Maheu-Giroux and Sylvie de Blois (2005) found that riparian habitats along streams and rivers were invaded significantly less compared to the landscapes adjoining ditches, except when the streams intersected transportation rights-of-way. The study found that transportation rights-of-way were the best predictor of P. australis occurring in one of the landscapes studied. The authors suggest careful monitoring where transportation routes and other linear patterns of landscape disturbance cross wetlands of concern.

2.5 Water Contamination

Water contamination can be one of the most damaging environmental impacts from construction and is also difficult to mitigate. Contamination may occur from refueling equipment near wetland resources, storing hazardous material within a floodplain, direct contamination from machinery running in streams and wetlands or wet concrete spills (USFWS, 2008).

Soil erosion results in sedimentation. Sediments can smother aquatic insects, mussels, and other life, may negatively impact fish spawning areas, and damage fish gills (USFWS, 2008).
3. INDUSTRY STANDARDS AND BEST MANAGEMENT PRACTICES
FOR NATURAL RESOURCES PROTECTION

The Environmental Protection Agency defines Best Management Practices as:

_Procedures that have been determined by subject matter experts to be the most effective, low risk, economical and environmentally appropriate procedures for a specific situation_ (USEPA et al. 2006).

Maryland Department of the Environment, Nontidal Wetlands regulations also defines Best Management Practices⁵:

...conservation practices or systems of practices and management measures that:

(a) Control soil loss and reduce water quality degradation caused by nutrients, animal waste, toxics, and sediment; and

(b) Minimize adverse impacts to the surface water, ground water flow, and circulation patterns, and to the chemical, physical, and biological characteristics of nontidal wetlands.

The utility industry is responsible for minimizing impacts to wetlands and other natural resources. The incentive for engaging in BMP’s comes both from the regulatory community as well as the degree to which the industry voluntarily acts as an environmental steward. Practices that directly impact the environment first occur during vegetation clearing, followed by construction and finally, on-going maintenance practices. This discussion of standards and practices begins with a summary of the regulatory influences on vegetation clearing because of both its direct impact on the environment due to vegetation removal, but also the indirect impact of policies that dictate the size and location of rights-of-way. The widths of utility rights-of-way are strongly influenced by criteria developed to limit the interference of trees with power lines and so these criteria influence the encroachment on wetlands.

3.1 Overhead Transmission Line Standards for Vegetation Clearing

Clearing vegetation during the installation of transmission lines in rights-of-way and vegetation maintenance is governed by a range of regulatory and voluntary practices. The North American Electric Reliability Corporation (NERC) establishes the planning and operating rules that govern the electric utilities industry (NERC 2009). The responsibility over the construction and maintenance of power generating plants and transmission lines primarily resides with the state Public Utility Commissions (FERC n.d.). Maryland oversees the industry through the Public Service Commission, the Maryland Department of Natural Resources, and the Maryland Department of the Environment. Individual utilities also may voluntarily adopt standards for vegetation clearing and maintenance for both service reliability and environmental goals.

⁵ Code of Maryland Regulations (COMAR), Title 26, Subtitle 23 Nontidal Wetlands.
3.1.1 A Paradigm Shift in Regulating Vegetation Management-- from Voluntary to Mandatory Compliance

Trees contacting electric transmission powerlines contacting trees contributed to several major disturbances to electrical service, including the blackout of August 14, 2003 when an electric power blackout affected large portions of the Northeast and Midwest United States and Ontario, Canada. This event in particular heightened attention on regulating the interface between high-voltage powerlines and trees (Federal Energy Regulatory Commission 2004).

In 2004, a joint U.S.-Canada Power System Outage Task Force of representatives from the United States and Canada found that one of the four primary causes of the blackout was inadequate tree pruning and removal and that there was a wide range of vegetation management practices and procedures among transmission owners. For example, the study found that minimum right-of-way widths varied from company to company (Table 5).

<table>
<thead>
<tr>
<th>Size of Transmission Line</th>
<th>Minimum Width (ft)</th>
<th># of Companies</th>
<th>Minimum Width (ft)</th>
<th># of Companies</th>
<th>Minimum Width (ft)</th>
<th># of Companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 kV</td>
<td>&lt;125</td>
<td>4</td>
<td>&lt;75</td>
<td>6</td>
<td>&lt;75</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>126-175</td>
<td>21</td>
<td>76-125</td>
<td>36</td>
<td>76-125</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>≥176</td>
<td>&gt;13</td>
<td>≥126</td>
<td>30</td>
<td>≥126</td>
<td>&gt;30</td>
</tr>
<tr>
<td>345 kV</td>
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<td></td>
<td></td>
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<td>230 kV</td>
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<td></td>
</tr>
<tr>
<td>Less than 230 kV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.1.2 North American Electric Reliability Corporation

The Task Force recommended that the North American Energy Regulatory Commission (NERC) develop standards to maintain safe clearances of transmission lines from obstructions in the lines’ rights-of-way (Federal Energy Regulatory Commission 2004). The North American Electric Reliability Corporation is an international, independent, self-regulated, not-for-profit organization, whose mission is to ensure the reliability of the bulk power system in North America. The vegetation management provisions, FAC-003-1, are summarized in Table 6. In 2007 the standards became mandatory for high-voltage systems.

The Reliability Standards are the planning and operating rules that electric utilities follow to ensure a reliable system. Vegetation clearing for construction as well as on-going vegetation management, as it relates to their mission, are one of many provisions addressed in these
standards (Table 6) and any practices, such as environmental enhancements, must first be consistent with the standards (NERC, 2009).

The NERC standards apply only to high-voltage transmission lines of 200 kV or higher, or transmission lines of lower voltages if the regional entity deems the line critical to the reliability of bulk power system (NERC, 2008). The NERC standards allow companies to respond to local conditions in designing their practices. Institute of Electrical and Electronics Engineers (IEEE) Clearances specified by the standard are based on the Standard Guide for Maintenance Methods on Energized Power Lines\(^6\). Practices for working with trees are established by The American National Standards Institute (ANSI) Standards for Tree Care, section A-300(U.S.-Canada Power System Outage Task Force, 2006).

American National Standards Institute (ANSI) A300 Standards for Tree Care Operations are the tree care industry (i.e. professional arborists) performance standards for writing specifications to manage trees, shrubs, and other woody plants as well as guidelines for work specifications. The standards describe seven tree care practices (below). Volume 7, Integrated Vegetation Management, are standards for a managing plant communities in which compatible and incompatible vegetation is identified, action thresholds considered, control methods evaluated, and selected controls implemented to achieve a specific objective, including managing electric utility rights-of-way (Tree Care Industry Association n.d.).

- ANSI A300 (Part 1) - 2008 Pruning
- ANSI A300 (Part 2) - 2004 Fertilization
- ANSI A300 (Part 3) - 2006 Supplemental Support Systems (includes Cabling, Bracing, and Guying, and Propping)
- ANSI A300 (Part 4) - 2008 Lightning Protection Systems
- ANSI A300 (Part 5) - 2005 Management of Trees and Shrubs During Site Planning, Site Development, and Construction
- ANSI A300 (Part 6) - 2005 Transplanting (includes Planting)
- ANSI A300 (Part 7) - 2006 Integrated Vegetation Management (IVM)

According to the North American Electrical Reliability Corporation, the management of vegetation around major transmission lines remains a concern. In 2008, transmission lines were taken out of service for sustained periods 11 times due to contact with trees and vegetation management ranked in the top ten on NERC’s 2008 list of most frequently violated standards.

\(^6\) IEEE Standard #516-2009, available only through purchase from the Institute of Electrical and Electronics Engineers Standards, provides the general recommendations for performing maintenance work on energized power lines. Included are technical explanations for laboratory testing of tools and equipment, in-service inspection, maintenance and care of tools and equipment, and work methods of the maintenance of energized lines for persons working in vicinity of power lines.
### Table 6

**Selected Elements Adapted from:** NERC Standard FAC-003-1  
**Transmission Vegetation Management Program**  
**Effective Date:** April 7, 2006

**Purpose:** To improve the reliability of electric transmission systems by preventing outages from vegetation located on rights-of-way and minimizing outages from vegetation adjacent to ROW, maintaining clearances between transmission lines and vegetation on ROW, and reporting vegetation-related outages... to the Regional Reliability Organizations (RRO) and the North American Electric Reliability Council.

**Applicability:** This standard shall apply to all transmission lines operated at 200 kV and above and to any lower voltage lines designated by the RRO as critical to the reliability of the region's electric system.

**Requirements**

*R1.* The Transmission Owner shall prepare, and keep current, a formal transmission vegetation management program (TVMP) including objectives, practices, approved procedures, and specifications.

**R1.1.** The TVMP shall define a schedule for... vegetation inspections...based on the anticipated growth of vegetation and any other factors that could impact the relationship of vegetation to the transmission lines.

**R1.2.** The TVMP, shall ... document clearances between vegetation and ... supply conductors, considering transmission line voltage, the effects of temperature on conductor sag under design loading, and the effects of wind velocities ..., the Transmission Owner shall establish clearances to be ... and shall ...maintain a set of clearances to prevent flashover between vegetation and ... supply conductors.

**R1.2.1.** Clearance 1 — The Transmission Owner shall ... document appropriate clearance distances to be achieved at the time of transmission vegetation management work based upon local conditions and the ... time frame in which the Transmission Owner plans to return for future vegetation management work.....

**R1.2.2.** Clearance 2 — The Transmission Owner shall determine and document radial clearances to be maintained between vegetation and conductors under all operating conditions to prevent flashover between vegetation and conductors which will vary due to such factors as altitude and operating voltage.

**R2.** The Transmission Owner shall create and implement an annual plan for vegetation management work to ensure the reliability of the system. The plan shall describe the methods used, such as manual clearing, mechanical clearing, herbicide treatment, or other actions. The plan should be flexible enough to adjust to changing conditions, taking into consideration anticipated growth of vegetation and all other environmental factors that may have an impact on the reliability of the transmission systems.

**R3.** The Transmission Owner shall report quarterly to its RRO, or the RRO’s designee, sustained transmission line outages determined by the Transmission Owner to have been caused by vegetation.

**Additional Compliance Information:** The Transmission Owner shall demonstrate compliance through self-certification submitted to the ...RRO annually The RRO shall conduct an onsite audit every five years or more ... as deemed appropriate ....
3.2 Construction of Utility Rights-of-Way: Regulatory Oversight and Best Management Practices

After clearing vegetation in preparing new utility rights-of-way, various systems are in place to protect wetlands and other natural resources from the impacts of construction activities. The implementation of Best Management Practices is the result of various oversight activities of state environmental agencies and the stewardship practices of particular utility companies.

3.2.1 Maryland Public Service Commission and Department of Natural Resources Power Plant Recovery Program

In Maryland, electric utilities must obtain a Certificate of Public Convenience and Necessity (CPCN) from the Maryland Public Service Commission before constructing new transmission lines greater than 69,000 volts. Maryland’s Power Plant Research Program (PPRP) within the Department of Natural Resources develops the conditions issued with the CPCN to minimize effects to the State’s resources. Many general conditions are part of the utility’s standard operating practices and specific conditions provide additional protection to sensitive resource areas. In addition, the utilities also incorporate a variety of voluntary measures to restore and enhance environmental conditions within and adjacent to the transmission corridors (Patty et. al. 1997).

3.2.2 The State of Maryland Nontidal Wetlands Protection Program

The State of Maryland nontidal wetlands protection program has a goal of no net loss of nontidal wetlands acreage and function. The regulatory program is the most widely used program for controlling wetland impacts. The State of Maryland with the U.S. Army Corps of Engineers developed a joint processing procedure for the State Programmatic General Permit (SPGP) that granted authority to the Maryland Department of the Environment to issue many of the permits that are considered sufficient to satisfy § 404 of the Clean Water Act.

Under Maryland law, any land disturbing activity in excess of 5,000 square feet also requires that a sediment and erosion control plan be approved.\(^7\) The 1994 Maryland Standards and Specifications for Soil Erosion and Sediment Control\(^8\) are incorporated by reference into State regulations and serve as the official guide for erosion and sediment control practices. Construction activities disturbing one acre or more must acquire a permit for stormwater discharges.

\(^7\) Exceptions: State and federal projects are exempt from local approval, agricultural projects, or single-family residence on lots of 2 acres or more provided the earth disturbance is less than 0.5 acres. Plan approval is from soil conservation district.

\(^8\) MDE initiated a comprehensive review of the State's erosion and sediment control standards in early 2009 and developed a draft of the “2010 Maryland Standards and Specifications for Soil Erosion and Sediment Control” as part of the May 30, 2010 schedule for incorporation into regulation.
According to Maryland’s wetland regulatory program, all activities in nontidal wetlands (and their regulated buffers) require a permit or a letter of authorization, unless exempt by regulation (e.g., agricultural and forestry activities). In general, utility line installation qualifies for the expedited approval through a letter of authorization because they are often thought to result only in temporary impacts. A Letter of Authorization (LOA, sometimes also known as a letter of exemption) does not require an alternative site analysis or compensatory mitigation as part of the approval. However, in the cases of larger utility line installations, and those with permanent wetland losses, the proposed activity is part of a more comprehensive permit review and the alternative site analysis and mitigation is required. Loss generally occurs when one wetland type is converted to another, typically forested wetland to emergent.

Utility lines, among other projects, require best management practices that are specified by the Maryland Department of the Environment. The goals of the best management practices for working in nontidal wetlands, wetland buffers, waterways, and 100-year floodplains are contained in the Code of Maryland Regulations (Tables 7).9

Specific practices are typically required as conditions to nontidal wetlands authorizations, and included on construction plans (Table 8). The adherence to these conditions and their ability to result in wetlands being effectively restored after utility line installation is the subject of a field study by MDE as part of this overall grant.

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9 Title 26, Subtitle 23, Chapter 3.
Maryland Department of the Environment
Goals of Best Management Practices in Nontidal Wetlands

A. If a letter of exemption is granted, the Department may require an applicant to comply with best management practices, including one or more of the following:

1. Conduct the regulated activity so as not to harm a threatened or endangered species, or species in need of conservation, or alter or impair the critical habitat of these species;

2. Properly maintain the structure or fill;

3. Design the project to first avoid and then minimize any adverse impacts to the nontidal wetlands' existing topography, vegetation, fish and wildlife resources, and hydrologic conditions;

4. Conduct the regulated activity so as not to restrict or impede the:
   a. Movement of wildlife indigenous to the nontidal wetlands or adjacent water, or
   b. Passage of normal or expected high water flows;

5. Adhere to time-of-year restrictions as required by COMAR 26.08.02;

6. Avoid any disturbances in breeding areas for migratory waterfowl;

7. Maintain the hydrologic regime of the nontidal wetlands upstream, downstream, or adjacent to the exempted activity;

8. Remove excess fill or construction material or debris to an upland disposal area;

9. Place materials in a location and manner which does not adversely impact surface or subsurface water flow into or out of the nontidal wetland;

10. If backfill is obtained from sources other than the originally excavated material, use clean material free of waste metal products, unsightly debris, toxic material, or any other deleterious substance;

11. Place heavy equipment on mats or suitably design the equipment to prevent damage to the nontidal wetlands;

12. Repair and maintain any serviceable structures or fills so as not to result in a substantial deviation from the plans or specifications or the original structure or fill, although minor deviations due to changes in materials or construction techniques, and which are necessary for repair and maintenance, are permitted;

13. Rectify any nontidal wetlands temporarily impacted by any proposed repair and maintenance activity;

14. Repair and maintain any serviceable structure or fill so there is no permanent loss of nontidal wetlands in excess of nontidal wetlands lost under the original construction or fill;

15. Conduct the activity so as not to cause degradation of water quality as determined by the Department;

16. For installation of utility lines, make post-construction grades and elevations of nontidal wetlands the same as the original grades and elevations.
Table: 8

Best Management Practices for Working in Nontidal Wetlands, Wetland Buffers, Waterways, and 100-Year Floodplains

1. No excess fill, construction material, or debris shall be stockpiled or stored in nontidal wetlands, nontidal wetland buffers, waterways, or the 100-year floodplain.

2. Place materials in a location and manner which does not adversely impact surface or subsurface water flow into or out of nontidal wetlands, nontidal wetland buffers, waterways, or the 100-year floodplain.

3. Do not use the excavated material as backfill if it contains waste metal products, unsightly debris, toxic material, or any other deleterious substance. If additional backfill is required, use clean material free of waste metal products, unsightly debris, toxic material, or any other deleterious substance.

4. Place heavy equipment on mats or suitably operate the equipment to prevent damage to nontidal wetlands, nontidal wetland buffers, waterways, or the 100-year floodplain.

5. Repair and maintain any serviceable structure or fill so there is no permanent loss of nontidal wetlands, nontidal wetland buffers, or waterways, or permanent modification of the 100-year floodplain in excess of that lost under the originally authorized structure or fill.

6. Rectify any nontidal wetlands, wetland buffers, waterways, or 100-year floodplain temporarily impacted by any construction.

7. All stabilization in the nontidal wetland and nontidal wetland buffer shall consist of the following species: Annual Ryegrass (Lolium multiflorum), Millet (Setaria italica), Barley (Hordeum sp.), Oats (Uinia sp.), and/or Rye (Secale cereale). These species will allow for the stabilization of the site while also allowing for the voluntary revegetation of natural wetland species. Other non-persistent vegetation may be acceptable, but must be approved by the Nontidal Wetlands and Waterways Division. **Kentucky 31 fescue shall not be utilized in wetland or buffer areas.** The area should be seeded and mulched to reduce erosion after construction activities have been completed.

8. After installation has been completed, make post-construction grades and elevations the same as the original grades and elevations in temporarily impacted areas.

9. To protect aquatic species, in-stream work is prohibited as determined by the classification of the stream:

10. No excess fill, construction material, or debris shall be stockpiled or stored in nontidal wetlands, nontidal wetland buffers, waterways, or the 100-year floodplain.

11. Place materials in a location and manner which does not adversely impact surface or subsurface water flow into or out of nontidal wetlands, nontidal wetland buffers, waterways, or the 100-year floodplain.

12. Do not use the excavated material as backfill if it contains waste metal products, unsightly debris, toxic material, or any other deleterious substance. If additional backfill is required, use clean material free of waste metal products, unsightly debris, toxic material, or any other deleterious substance.

13. Place heavy equipment on mats or suitably operate the equipment to prevent damage to nontidal wetlands, nontidal wetland buffers, waterways, or the 100-year floodplain.
Table 8 Cont’d

14. Repair and maintain any serviceable structure or fill so there is no permanent loss of nontidal wetlands, nontidal wetland buffers, or waterways, or permanent modification of the 100-year floodplain in excess of that lost under the originally authorized structure or fill.

15. Rectify any nontidal wetlands, wetland buffers, waterways, or 100-year floodplain temporarily impacted by any construction.

16. All stabilization in the nontidal wetland and nontidal wetland buffer shall consist of the following species: Annual Ryegrass (*Lolium multiflorum*), Millet (*Setaria italica*), Barley (*Hordeum* sp.), Oats (*Uniola* sp.), and/or Rye (*Secale cereale*). These species will allow for the stabilization of the site while also allowing for the voluntary revegetation of natural wetland species. Other non-persistent vegetation may be acceptable, but must be approved by the Nontidal Wetlands and Waterways Division. *Kentucky 31 fescue shall not be utilized in wetland or buffer areas.* The area should be seeded and mulched to reduce erosion after construction activities have been completed.

17. After installation has been completed, make post-construction grades and elevations the same as the original grades and elevations in temporarily impacted areas.

18. To protect aquatic species, in-stream work is prohibited as determined by the classification of the stream:

   Use I waters: In-stream work shall not be conducted during the period March 1 through June 15, inclusive, during any year.

   Use III waters: In-stream work shall not be conducted during the period October 1 through April 30, inclusive, during any year.

   Use IV waters: In-stream work shall not be conducted during the period March 1 through May 31, inclusive, during any year.

19. Stormwater runoff from impervious surfaces shall be controlled to prevent the washing of debris into the waterway.

20. Culverts shall be constructed and any riprap placed so as not to obstruct the movement of aquatic species, unless the purpose of the activity is to impound water.

Under rare circumstances, utility lines are proposed and approved on designated Nontidal Wetlands of Special State Concern. These areas are listed in regulation and meet the following criteria under COMAR 26.23.01.04:

(a) Provide habitat or ecologically important buffers for the habitat of plant or animal species:

   (i) Listed as endangered or threatened by the U.S. Fish and Wildlife Service,

   (ii) Listed as endangered or threatened, or species listed as in need of conservation by the Department of Natural Resources, or
(iii) Considered to be a candidate for listing by the U.S. Fish and Wildlife Service, or considered to be locally unusual or rare by the Department of Natural Resources; or

(b) Are unique natural areas or contain ecologically unusual natural communities.

Additional BMP’s that may be applied to protect Nontidal Wetlands of Special State Concern are also listed in COMAR 26.23.06.03:

A. Protect against future disturbances to the nontidal wetland of special State concern by showing its surveyed boundary, expanded buffer, waterways, and 100-year floodplains on the property deed, and recording the information with the county;

B. Avoid impacts to regulated wetlands, buffers, expanded buffers, waterways, 100-year floodplains, and steep slopes or highly erodible soils as described in COMAR 26.23.01.04C that may cause an adverse impact to the nontidal wetland of special State concern;

C. Restrict regulated activities to the minimum area necessary to meet the project purpose;

D. Maintain existing groundwater recharge to the nontidal wetland of special State concern and tributaries to nontidal wetlands of special State concern by limiting impervious surfaces;

E. Use nonstructural stormwater management practices consistent with those in COMAR 26.17.02, to the extent practicable, such as infiltration, retention of forest, wetlands, and associated buffers, undisturbed floodplains, open space, and steep slopes, in association with structural stormwater management on properties with nontidal wetlands of special State concern or tributaries to nontidal wetlands of special State concern;

F. Manage runoff so that there is no direct discharge of stormwater into wetlands or waterways;

G. Restrict impervious surface on the project site to 15 percent or less, where practicable;

H. Install sediment controls such as super silt fences or comparable controls to completely surround all disturbed areas and maintain controls daily;

I. Stabilize disturbed areas daily with noninvasive native species;

J. Place vegetative waste, including yard waste, grass clippings, leaves, etc. or other debris outside of regulated wetlands, expanded buffers, waterways, and 100-year floodplains that are in the drainage area of the nontidal wetland of special State concern; or

K. Use other management practices listed in COMAR 26.23.03.02.
3.2.3 Water and Wastewater Conveyance—Regulatory Oversight and BMP’s

The construction of water and wastewater conveyance systems in Maryland is regulated by local authorities through the local building permit process. A state sewer construction permit is also required from the Maryland Department of the Environment for major community sewerage projects including sewer mains greater than 15 inches in diameter, pumping stations, and wastewater treatment plants.

3.2.3.1 WSSC BMP’s for Natural Resource Protection

WSSC has the organization’s minimal requirements for stream and wetland protection scattered throughout their Pipeline Design Manual, General Conditions and Standard Specifications, and Standard Details for Construction. Section 2.1.1.4 through 2.1.1.6 of this document discussed those WSSC design criteria that affect the degree to which the installation of sanitary sewer pipelines impact natural resources. Criteria that are designed to minimize the impacts to natural resource protection are summarized below by adapting relevant parts of the WSSC manual and specifications. The first provision describes the conflict that is at the heart of locating wastewater conveyance systems within sensitive riparian areas.

- Sewers are to be located to minimize disruption to environmental features. By necessity, outfall sewers are located along drainage courses, where streams, wetlands, tree-save areas, parks and open space areas are likely to be located. The number of stream crossings is to be kept to a minimum and are to be perpendicular to the stream. Wetlands are to be avoided as much as possible. Normally, the ground rises relatively sharply just beyond the floodplain. These slopes are to be avoided.

The Pipeline Design Manual gives further guidance on locating pipelines in sensitive areas.

- Pipelines going through environmentally sensitive areas such as streams, lakes and wetlands require special attention... Not only are complex environmental design and construction issues involved, but permitting issues and complying with different agency regulations create complications. Every effort should be made to avoid these areas. A thorough review and analysis of crossing these areas should be done during the conceptual design to minimize disruptions during construction. Resolution of environmental issues is often a very slow process. Therefore, these issues should be given top priority during the early stages of design.

WSSC guidelines for selecting stream crossing sites to minimize erosion and stabilization methods for streambanks is located in Part 3 of the Pipeline Design Manual10.

Selecting Crossing Alignment

1) Base the selection of the crossing alignment primarily on the consideration of channel stability and environmental and regulatory compliance.

2) Minimize the number of crossings, the total length of the crossing, and the disturbed area. Try to select an alignment that is perpendicular to the stream flow.

3) Determine requirements and constraints set forth by agencies having jurisdiction over the area of the crossing alignment, such as Maryland National Capital Park & Planning Commission (MNCPPC), Maryland Department of the Environment (MDE) and the Army Corps of Engineers.

4) Identify existing and potential long term channel instability problems at the alignment location, by the use of available topographic maps, land use information and field investigation. Channel instability can lead to failure/erosion of channel banks, shifting of channel positions and channel bed erosion.

5) Selecting stream crossing locations. Avoid locations with severe channel instability problems. Crossing alignments may be strategically located to minimize the adverse effects of channel instability. The following are guidelines for selecting locations of stream crossings.....

   a) At meandering channel bends, stream flow velocities can severely erode channel banks and scour holes on the channel bottom. The crossing can be placed approximately midway between two adjacent meandering bends or upstream of the meandering bend.

   b) Abrupt drop in channel bed, flow depth, riffles or localized scour holes indicate existing or potential channel bed instability. Alignment should not be placed in close proximity to and especially downstream of these locations.

   c) Where flow constriction occurs, e.g., due to bridge construction or channelization, the crossing should be placed upstream of the location of flow constriction, if possible.

   d) Stream channels which show noticeable increase in channel widths, meandering, steeply sloped channel banks, and lack of vegetation, indicate existing or potential problems of channel widening and changes in channel position. If the pipeline alignment parallels the stream channel, provide a buffer width between the nearest channel bank and the limit of disturbance. Determine the buffer width on a case by case basis. The minimum buffer width required by the State of Maryland, Department of Natural Resources, is twenty five (25) feet from the limit of construction area to the top of the nearest of stream bank.
e) Sediment traps and storm water control ponds can drastically reduce sediment supply and increase channel bed and bank erosion in downstream channels. Pipeline crossings should not be placed in close proximity downstream of these structures, if possible....

f) Activities such as channel dredging or cleaning can cause channel bed erosion due to decrease in flow depth and increases in flow velocity. Pipeline crossings should not be placed in close proximity upstream of these activities.

g) Alteration in stream flow path/direction by others, due to construction activities and channel work, can drastically affect stream hydraulics. Pipeline crossings should not be placed in close proximity upstream or downstream of these locations.

h) Select the crossing alignment such that the pipeline will be protected from impacts of construction of other utilities or structures.

**Post Construction Stabilization of Channel Banks.**

1) Stabilize channel banks to provide protection against surficial erosion of bank materials, slope instability and lateral movements of stream channel at the location of the stream crossing.

   a) Standard design. If the primary problem is surficial erosion and the maximum bankfull flow velocity is no greater than 10 feet per second (fps), provide riprap stabilization of channel banks, in accordance with Standard Detail SC/3.0 [See Figure 7]. ...

   b) Special design. If certain field conditions are considered to be not entirely applicable to the Standard Design SC/3.0, [ See Figure 6] consider alternative methods of channel bank stabilization, these may include modification to standard detail, use of geotextiles or vegetation, methods to reduce flow velocities, and/or directing flow path away from the banks. .... The following conditions may require special design:

   (1) Stream channels where maximum bankfull flow velocity is greater than or much lower than 10 fps. Riprap stone sizes other than Class 2 as indicated on Standard Detail SC/3.0 may be required under these cases ... 

   (2) Stream banks subject to potential risks of overall slope instability...

   (3) Channel banks that may be subject to direct impact of high flow velocities, or lateral movements, e.g., meandering channel bends or channel constrictions.

   (4) Channel banks with existing bank slopes much steeper than the maximum... 2:1 (H:V) slope
Figure 7

Streambank Stabilization
(WSSC 2009)
23. Pipeline Design in Wetlands.

a. General.

1) It is the WSSC's policy to avoid and protect environmentally sensitive areas such as nontidal wetlands whenever possible. Since it is not always practical to avoid wetland areas, the WSSC has developed the guidelines below in conjunction with the Maryland Department of the Environment (MDE) Nontidal Wetlands and Waterways Division for pipeline design and construction in wetlands.

b. Guidelines.

1) Every effort should be made to avoid crossing wetlands when selecting the pipeline alignment... When this is impossible, the crossing distance should be kept to a minimum. Indicate on the drawings, the limits of the nontidal wetland, nontidal wetland buffers (twenty five (25) feet, and one hundred (100) feet when slopes are greater than fifteen (15%) percent), and one hundred (100) year floodplain. Consider the following three main objectives when designing a pipeline in wetlands:

   a) Objective 1. Minimize the area of disturbance in wetlands during construction and backfill as much as possible with the native material that has been excavated.

   b) Objective 2. Provide proper bedding and side support materials for the pipe...

   c) Objective 3. Minimize seepage of ground water along the pipeline, which may drain the wetlands, by the proper selection of trench backfill and pipe bedding.

2) To achieve objective 1, WSSC and MDE have prepared the Standard Wetland Notes included in this section [i.e. Best Management Practices for Work in Nontidal Wetlands, Table below] for projects which will require excavation of nontidal wetlands. WSSC may request or provide additional notes, depending on the site conditions.

3) To achieve objectives 2 and 3, address these objectives on a case by case basis during the design. WSSC is designated to review this aspect of the design at the same time as the Sediment Control review for each project. WSSC will assist in determining whether special trench backfill and pipe bedding will be required for each project to prevent seepage along the pipeline.
Washington Suburban Sanitary Commission

Best Management Practices For Work In Nontidal Wetlands.

1. Place heavy equipment on mats or suitably operate the equipment to prevent damage to the nontidal wetlands.

2. Use previously excavated material as backfill unless it contains waste metal products, unsightly debris, toxic material or any other deleterious substance. Uses clean borrow material when excavated material is not suitable for use as backfill.

3. All excess fill, spoil material, debris, and construction material shall be disposed of outside the nontidal wetland, twenty (25) foot buffer area, and the one hundred (100) year floodplain, and in a location and manner which does not adversely impact surface or subsurface water flow into or out of the nontidal wetlands.

4. Temporary construction trailers or structures, staging areas, and stockpiles shall not be located within the nontidal wetlands, buffer areas or the one hundred (100) year floodplain unless specifically approved by the Maryland Department of the Environment, Nontidal Wetlands and Waterways Division.

5. All stabilization of disturbed areas within nontidal wetlands and buffer areas shall be with the following species: annual ryegrass (lolium multiflorum), millet (setaria italica), barley (hordeum sp.), oats (uniola sp.) and/or rye (secale cerale). These species will allow for the stabilization of the disturbed area while also allowing for the voluntary revegetation of natural wetland species. Other non-persistent vegetation may be acceptable, but must be approved by the Maryland Department of the Environment, Nontidal Wetlands and Waterways Division, prior to use. Kentucky 31 fescue shall not be utilized in the wetland or buffer areas. Seed and mulch disturbed areas to reduce erosion after construction activities have been completed.

6. Rectify any temporarily impacted areas by restoring to existing grades and elevations, and by performing appropriate vegetative stabilization. Wetlands and adjoining buffer areas shall not be mowed or otherwise managed to prevent the re-establishment of woody vegetation.

7. To protect important aquatic species, in-stream work is prohibited by the classification of the stream. Adhere to time-of-year restrictions as required by the Maryland Department of the Environment under COMAR 26.08.02.
Erosion and Sediment Control and Tree Protection.

a. General.

1) No land disturbance for the purpose of constructing or maintaining an underground utility may take place without first obtaining a Utility Erosion and Sediment Control Plan Approval and Permit from the Commission, and implementing soil erosion and sediment controls in accordance with an Erosion and Sediment Control Plan approved by the Commission....


1) Requirements for plan approval

   a) The Commission will review the plan to determine compliance with the WSSC Utility Erosion and Sediment Control Regulations and WSSC Specifications and Standard Details prior to approval....

2) Design Requirements....

   a) At a minimum, a Utility Erosion and Sediment Control plan should contain:

      (1) ...limits of disturbance (2) Location and type of erosion and sediment control devices to be installed...(3) WSSC Utility Erosion and Sediment Control Note and Standard Detail Sheet (4) ... access road and soil stockpile areas (5) Existing and proposed topography 100 feet either side of construction area...(6) ... waterways, streams, 100 year floodplain, and wetland boundaries for any water body within 100 feet of construction area (7) Total acreage of drainage area and direction of flow for any water body within 100 feet of construction area (8)... forested areas (9) ... environmentally sensitive areas such as Chesapeake Bay Critical Area, Class I and Class IV streams, parklands, steep slopes, ... etc. (10) Supporting documentation: i.e., County and/or Soil Conservation District approved sediment control plans

   b) Comply with the requirements and procedures set forth by the Maryland Department of the Environment (MDE), latest edition of the Maryland Standards and Specifications for Soil Erosion and Sediment Control and Water Resources Administration (WRA), latest edition of the Maryland Guideline to Waterway Construction, with specific jurisdiction requirements as modified in this section, and the Specifications and Standard Details...

   c) Sediment control design must conform to the latest edition of the Maryland Standards and Specifications for Soil Erosion and Sediment Control, Specifications and Standard Details.[ The WSSC Pipeline Design Manual also includes standard details for typical sediment and erosion control and tree protection elements].
Tunnels

a. General.

1) This section discusses the typical situations which require the use of a tunnel for the installation of a water or sewer pipeline.

2) Use of tunnels. Due to higher construction costs for a tunnel, the first choice of water and sewer pipeline construction is to use the cut and cover method... However, under certain circumstances ..., tunnel construction will be required... Tunneling may be required when crossing environmentally sensitive ... areas ... In general, the tunnel methods to be used ... are the jack and bore casing pipe installation or the earth balanced micro tunneling method.

3.2.3.2 Trenchless Technologies

Trenchless construction methods have been used in the United States for utility projects since the 1980's (no-dig construction.com n.d.). “Trenchless” refers to methods of installing underground utilities by various methods of digging underground without cutting a trench from above-ground and so can be an alternative in wetland and stream areas to avoid at-grade disturbance. Two of these methods include microtunneling and horizontal directional drilling. Microtunneling practice is well established in the installation of water and sewer lines; however, horizontal directional drilling (HDD) is more traditionally used in other industries such as telephone cable. Some members of the tunneling industry believe that HDD has significant potential for water and sewer projects (Griffin 1996; Construction Digest 2002).

3.2.3.2.1 Microtunneling

Microtunneling is used to install pipelines and conduits ranging between 8 inches to 10 feet in diameter and lengths up to 1,500 feet. Developed in Japan in 1976, the first project took place in the United States in 1984. The practice now makes up 10% of all new pipeline construction and the most common size ranges between 24 and 72 inches (8 feet) (Chung n.d.).

Microtunneling requires two vertical shafts at each end of the tunnel (Figure 8). The launch shaft drives the microtunneling machinery and the reception shaft issued to recover the tunneling machine. Because the procedure is operated remotely, the shafts can be located deeper and the launch shaft may be smaller than a jacking and boring operation where the contractors work at the face of the tunnel opening. Adequate space is still necessary for the launch shaft, however, requiring 20-40 feet wide by 75-150 feet length (Kortec n.d.).

There are many factors that are taken into consideration in planning a successful microtunneling project, including economics. Generally, when the invert of the pipe is deeper than 20 feet and the height of cover over the pipe is greater than 5 feet, the economics may be favorable for microtunneling, (Chung n.d.). Chung et al. designed a decision process for determining whether
or not to microtunnel (Figure 9). For the purposes of this review, only those considerations that relate to environmental impacts in streams and wetlands are introduced briefly below. Economic factors when protecting sensitive areas will be affected by the value of the natural system as measured by natural as well as cultural factors.

A range of geotechnical factors impact microtunneling projects. Some of the variables investigated at the planning phase include: grain size, moisture content, plasticity, compressibility, permeability and strength of the soil. In particular, the level of the groundwater significantly impacts the ability of the site to support the ground above the tunnel in order to avoid “loss-of-ground”. Groundwater is also a major consideration in selecting from the two methods of microtunneling: slurry and auger. The slurry method (using a natural clay or bentonite mixed with water) is the appropriate choice in areas with high groundwater (Chung n.d.). The magnitude of losses in a tunneling project can also be affected by the size and depth of the pipe, equipment capacity and the skill of the operator (Kleine and Essex 1995 cited in Chung n.d.).

While microtunneling can be a useful method to avoid disturbing the surface of sensitive areas, there remain risks involved that can impact these areas. Practitioners recommend contingency plans for a number of possibilities. Because the practice is performed without the benefit of seeing the face of the excavation, the most common contingency is the removal of the microtunnel boring machine because of unforeseen circumstance underground. In this situation, a rescue shaft is drilled at the site of the boring machine if it becomes necessary. Other contingencies may include:
Figure 9
Decision Model for Selecting Microtunneling Method
(Chung et al. n.d.)
- Slurry or lubricant reaching the surface;
- Sinkholes;
- Jacking pipe breaks;
- Inability to maintain line or grade;
- Jacking forces increasing to the point that the jacking system can’t complete the drive;
- Contaminated ground or groundwater;
- Hazardous/explosive conditions in the tunnel.

The risk for each of the above contingencies, as well as the down-time needed when a problem develops, can be reduced depending on the skill of the design engineer and the operator as well as the presence of well-thought contingency plans (Chung et al. n.d.).

3.2.3.2.2 Horizontal Directional Drilling

Horizontal directional drilling (HDD) uses a drilling rig on the surface to drill “horizontally” and install a pipe in a shallow underground arc. The drilling rig bores a pilot hole that’s filled with fluid and then uses a swiveling drill to enlarge the hole to the final size. The pipe is then pulled through the hole from the opposite end where the pipe is stored in a large staging area (Figure 10). Proponents promote HDD as a practice to limit environmental impacts in sensitive areas. However, like microtunneling, careful assessments, planning, design, and implementation is important to ensure first that it is the appropriate technology for the site and secondly that it is properly employed. Planning and implementation will require the skilled practice of regulators, engineers, environmental specialists and an HDD contractor (Canadian Association of Petroleum Producers 2004).

Water and sewer construction have been the smallest markets of the industries that use directional drilling to date, and HDD represents a small portion of public utilities work in general. One of the challenges is the difficulty in establishing the grades necessary with sanitary sewers using the HDD. In addition, agencies are sometimes concerned that the fluid used in the procedure could contaminate wet areas. Some in the trenchless technology industry, however, believe that eventually HDD will play a major role in installing sewerage projects and that limitations may be shortly overcome with new technology and as the industry develops more experience (Griffin 2002). The most common pipes installed through HDD include plastic pipes and communications cables. However, HDD can be used to install steel and cast-iron pipe (NASTT 2006).
Figure 10
Horizontal Directional Drilling
(CAPP 2004)
Equipment and supplies used in HDD include (NASTT 2006):

1. A rig, which provides the physical means – thrust and torque, to open the hole and pull in the product.
2. A transmitter/receiver system for tracking the location of the bore.
3. The down-hole equipment - drill pipe, drill bits, and reamers, which converts the physical properties of the rig to open the hole and pull in the product.
4. The drilling fluid, which serves to stabilize the hole, cool the down-hole equipment, and remove the spoils from the hole.
5. The drilling fluid delivery and recovery system made up of tanks, mixing systems, pumps; and, when recycling fluids, a system of screens, filters, shakers, cones, etc. to remove spoils brought to the surface from the fluid.

This combination of equipment and supplies requires a significant staging area which contributes to the upland impacts of HDD (Figure 11).

Figure 11

Horizontal Directional Drilling Schematic
(CAPP 2004)
Limitations of HDD

The use of HDD is limited by both the length of the span of pipe and the diameter as well as geotechnical factors. According to the Canadian Association of Petroleum Producers (CAPP), the longest drilled crossing in HDD practice as of the year 2000 was 6,000 feet with small diameter pipe. The largest diameter pipe was four feet and using such a large diameter is rare. These limitations are primarily due to the available technology. Underground, a high proportion of coarse grained gravels, cobbles and boulders and/or as well as hard bedrock will limit the use of HDD. Highly fractured or jointed rock may also present a problem (CAPP 2004).

Environmental Considerations

While HDD is an alternative to disturbing the surface of sensitive areas, there remain some environmental risks resulting from two primary factors (CAPP 2004):

1. Inadvertent returns of drilling fluids (Figure 12) into the aquatic or terrestrial environments\(^\text{11}\); and; to a lesser extent,
2. Disturbance of soils, vegetation and wildlife arising from either construction of drill sites, exit areas, access roads, and temporary vehicle crossings, or the HDD activity.

Inadvertent returns occur when drilling fluids disperse into surrounding soils, water, or the surface. Certain conditions have a higher potential for inadvertent returns including:

- fractured rock
- course grained permeable soils;
- considerable elevation change between the entry side and pipe side;
- insufficient depth of cover;
- artificial features such as existing exploratory bore holes

The primary adverse effects (listed as no. 1 and 2 above) may result in a variety of environmental impacts (CAPP 2004):

- Inadvertent introduction of drilling fluids into terrestrial and aquatic ecosystems resulting in: smothering and direct damage and/or mortality of parts of ecosystems.
- Damage to ecosystems during cleanup from inadvertent returns (Figure 12;
- Disturbance of soils, vegetation, wildlife at drill sites, access roads, and temporary road crossings;
- Poor surface runoff control from the drill site resulting in erosion and material entering a watercourse;

\(^{11}\) Inadvertent returns of drilling fluids are often hydro fractures that result “when the fluid pressures built up in the borehole exceed the overburden effect of the surrounding soil. Subsequently, the pressurized drilling fluid escapes from the borehole and migrates to the surface.” (Lueke and Ariaratmna 2005).
• Creation of a nearly impenetrable layer of clay on the surface preventing germination or colonization of new plants from inadvertent returns;

• Change in surface soil characteristics, thereby creating a change in vegetation communities;

• Disruption of aquifers that feed stream or wetland upwelling;

• Harmful alteration, disruption or destruction including instream, bank and riparian habitat at the crossing;

• Elevated turbidity and increased deposition of sediment downstream

• Interruption of fish movements up or downstream;

• Injury or mortality of fish associated with improper operation and screening of water pump intakes;

• Direct mortality of amphibians, reptiles, invertebrates and other less mobile wildlife from inadvertent returns;

• Incidental injury/mortality associated with accidental release of toxic substances through spills or, in some cases, additives to drilling mud.

• Bore instability or collapse during drilling of the pilot hole and subsequent reaming passes;

Table 9 shows some of the more common types of failures and their associated causes.

Figure 12

Drilling fluid on the Surface Resulting from Hydro Fracture
(Lueke and Ariaratnam 2005)
### Contingency Plans

HDD projects should always be accompanied by a contingency plan for unforeseen problems such as inadvertent returns of drilling fluid. The plan should include:

- General information that explaining the nature measurable parameters of an inadvertent release;
- Equipment and personnel needs for containment and clean-up;
- Emergency response procedures;
- Plans for continuance of drilling or alternative plans;

<table>
<thead>
<tr>
<th>Type</th>
<th>Cause</th>
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| Loss of drilling fluid / Loss of circulation |  - permeable deposits or jointed and/or fractured bedrock along the drill path  
  - excessive annular pressures for the bedrock formation or soils encountered |
| Drilling mud seepage directly into watercourse |  - permeable deposits or jointed and/or fractured bedrock along the drill path  
  - excessive annular pressures for the bedrock formation or soils encountered |
| Drilling mud seepage onto land and then into watercourse |  - permeable deposits or jointed and/or fractured bedrock along the drill path  
  - excessive annular pressures for the bedrock formation or soils encountered  
  - suggests inadequate monitoring along drill path |
| Collapsed hole |  - erosion or settling of the bore hole |
| Stuck drill stem or pipe string |  - collapse of hole along the drill path, due to swelling of highly plastic clays, boulders, bentonic shales, coal seams  
  - inadequate reaming to obtain optimal bore diameter for pull back |
| Lost tools and/or drill stands |  - twisting off of drill stem or metal failure of down hole tools |
| Damaged pipe or coating |  - inadequate reaming to obtain optimal bore diameter for pull back  
  - excessive entry or exit angle for bend radius of the pipe string  
  - sharp objects or casing present in bore  
  - collapse of hole along the drill path |
- Timelines of acceptable response and notification
- Clean-up methods and plans;
- Regulatory and stakeholder contacts;
- Monitoring plans;
- Disposal plans.

Further Research Needed

The variables inherent in planning for, designing, and implementing an HDD project require proper attention in order to insure success. However, investigators also point to the fact that more research is needed in order to understand such factors as hydro fractures and the relationship between specific tools and a successful outcome (Lueke and Ariaratnam 2005).

3.2.4 Federal Energy Regulatory Commission—Best Management Practices for Protecting Wetlands during Construction of Gas Pipelines

The Natural Gas Act of 1938 requires that interstate natural gas pipeline companies obtain a Certificate of Public Convenience and Necessity before constructing pipeline facilities. Under this process, the Federal Energy Regulatory Commission (FERC) enforces standards as established by their Wetland and Waterbody Construction and Mitigation Procedures (Procedures) (FERC, 2003). These guidelines were first established in 1994 to minimize the extent and duration of disturbances and later revised in 2003 (See Appendix 1).

While most of the Practices favor temporary impacts and wetland restoration, the Procedures do allow companies to maintain vegetation in a manner that allows for aerial surveys of the pipeline. The utility may maintain the ROW in an herbaceous state within a 10 foot wide corridor and remove or selectively cut trees greater than fifteen feet in height from within 15 feet of the pipeline, allowing for a total 30-foot corridor of maintained vegetation centered over the pipeline.

The Procedures addresses six major areas of concern:

1. Storm water pollution prevention;
2. Waterbody crossings;
3. Wetland crossings;
4. Restoration;
5. Post-construction maintenance and vegetation monitoring; and
6. Wetland protection during hydrostatic testing of the pipeline.

In 2004, the Federal Emergency Regulatory Commission undertook a study to evaluate the effectiveness of the 1994 version of the Procedures to determine whether natural gas pipeline companies were successful in restoring wetlands after construction. A summary of the findings is in section 6.1.1 of this report. Section 3.2.4.1 and 3.2.4.2, below, summarize the preferred practices for waterbody and wetland crossings.
3.2.4.1 Waterbody Crossings

Generally, the preferred method for crossing an actively-flowing waterbody with a pipeline is horizontal directional drilling as compared to open-cut trenching (Figure 10). With this method, a hole is dug below the stream crossing and pulling a prefabricated section of pipe through the hole. The goal is for no environmental impacts to banks, bed, or water of the stream or wetland (Folga, 2007).

Open-cut crossings involve cutting a trench across the waterbody while water flows through the trenching area. Where the water is shallow enough, it may be diverted by flumes and pumps. A flume pipe may be placed to divert the water around the trenching area. Pumps in combination with dams may also be used to divert the water during open-cut trenching. Regardless of the type of trenching method, construction staging areas are located a minimum of 50 feet from the water’s edge. In addition, prior to construction, temporary bridges are installed over all perennial water bodies and equipment access is limited to the bridge crossing (Folga, 2007).

3.2.4.2 Wetland Crossings

Methods used for constructing pipelines across wetlands will vary, depending on the nature of wetland hydrology and soils. Horizontal directional drilling may be used for crossing wetlands (see 3.2.3.2.2 above), however, more typically an open trench is dug with modifications to reduce impacts to wetland hydrology and soil structure (Folga, 2007).

FERC limits the construction ROW for gas pipelines to maximum 75 feet wide through wetlands during construction. Through the local, state and federal wetland permitting process, the utility will need to demonstrate that the encroachment is necessary. Temporary staging areas are located in uplands a minimum of 50 feet from the wetland edge. Construction equipment used while working in wetlands is limited to only those pieces that are essential. In areas where there is no reasonable access to the ROW except through wetlands, nonessential equipment is allowed only if the ground is firm enough or has been stabilized to avoid rutting. Otherwise, nonessential equipment is allowed to travel through wetlands only once (Folga, 2007).

Vegetation clearing in wetlands is limited to trees and shrubs, which are cut flush with the ground and removed. Stump removal, grading, and other disturbances are limited to the area immediately above the trench line to minimize disruption to wetland soils and the native seed and root stock. During clearing, sediment barriers such as silt fences and staked straw bales are installed and maintained adjacent to wetlands (Folga, 2007).

The method of pipeline construction used in wetlands depends on the stability of the soils. If wetland soils are not saturated and can support construction equipment on equipment mats, timber riprap, or straw mats, then construction occurs in a manner similar to upland construction with open-cut trenching. Topsoil is first removed and stored separately from the subsoil. Where wetland soils are saturated, segregating topsoil is not possible. Large timber mats placed ahead of the construction equipment can provide a stable working platform and protect wetland soils by spreading the weight of the construction equipment over a broad area (Folga, 2007).
The pipeline can be installed using the push-pull technique-- stringing and welding the pipeline outside of the wetland and excavating and backfilling the trench using a backhoe supported by equipment mats or timber riprap. The prefabricated pipeline is installed in the wetland by pushing or pulling it across the water-filled trench. After the pipeline is floated into place, the floats are removed and the pipeline sinks into place. The trench is backfilled to the proper grade to maintain wetland hydrology (Folga, 2007).

When the trench is backfilled, grades are restored to the original elevation. Trench breakers are installed where necessary to prevent water from draining away from the wetland. If topsoil was segregated from subsoil, then subsoil is backfilled first. If wetlands overlie rocky soils, the pipe is padded with rock-free soil or sand before backfilling with native bedrock and soil (Folga, 2007).

When a slope adjoins the wetland, sediment barriers are installed across the full width of the construction ROW at the base of slopes. These barriers are removed during the day when vehicle traffic is present and replaced each night. Sediment barriers also are installed along the edge of the ROW to minimize sediment run off into wetland areas outside the work area.

Temporary sediment barriers are installed until revegetation of adjacent upland. In wetlands where no standing water is present, the construction ROW is seeded in accordance with the recommendations of the local soil conservation authorities. Lime, mulch, and fertilizer are not used in wetlands (Folga, 2007).


The Electric Power Research Institute, Inc. (EPRI) is an independent, nonprofit organization that conducts research and development relating to the electricity industry. EPRI's members represent more than 90 percent of the electricity generated and delivered in the United States.

EPRI developed a technical report, Best Management Practices Manual for Access Road Crossings of Wetlands and Waterbodies (Manual). The document is intended for use by ROW managers, planner, and regulators and is applicable to transmission lines as well as other types of linear projects. Recommending avoidance of streams and wetlands wherever practicable, the Manual provides guidance for methods to minimize impacts when crossing is necessary (EPRI, 2002).

The Manual provides information on federal regulations, environmental consideration, project planning, a BMP selection process, and specific information on over 50 different practices. The BMP’s are appropriate for wetland and stream crossings and many are also applicable to other areas. The Manual is a compilation of practices from over a dozen technical reports from the United States, Canada, and the International Erosion Control Association. This summary of the Manual (below) begins with project planning.
3.2.5.1 EPRI Manual: Project Planning

According to EPRI, six practices should be considered in project planning:

1. **Avoidance.** Avoid the construction of a crossing or staging area by either choosing an alternative route or by using aerial or overhead equipment;

2. **Minimization.** Limit the number of crossings and the number of equipment trips to as few as possible. Limit the number of equipment staging areas and spoil storage areas.

3. **Use of Previously-disturbed Areas.** Use existing access roads, or staging areas.

4. **Selection of Crossing Location.** Consider criteria when locating crossing sites to minimize disturbance, such as shortest crossing point, avoiding unstable or steep banks, avoiding highly erodible soils, avoid unstable portions of stream channels.

5. **Scheduling.** Schedule construction during the season least damaging to the stream or wetland system and fisheries protection.

6. **Equipment Protection.** Equipment with low ground pressure spreads weight over a larger area, reducing impacts. The primary way to achieve low ground pressure is to use machines with wide tires (i.e. duals, tire tracks, bogies, tracks, and light weight equipment).

3.2.5.2 EPRI Manual: BMP Selection Process

The Manual outlines a 9-step process for selecting BMP’s (Figure 13):

Step 1 – Define Project Scope

Step 2 – Identification of Regulatory Permit Requirements

Step 3 – Site Characterization

Step 4 – Identification of Issues and Risks

Step 5 – Nominate and Screen Alternative BMPs

Step 6 – Select BMPs

Step 7 – Prepare Erosion and Sediment Control Plan

Step 8 – Implement Erosion and Sediment Control Plan

Step 9 – Operate, Monitor, and Maintain BMPs
Figure 10

Conceptual Approach for BMP Selection
(EPRI 2002)

BMP Selection Steps 3-7

Step 3: Characterize Site
- Physical
- Chemical
- Biological
- Land Use
- Other

Step 4: Identify Issues and Risks
- Identify potential risks for each site characteristic
- Evaluate consequences of identified issues on proposed project (may require expert advice)
- Prioritize issues that need to be addressed
- Combine similar issues

Step 5: Nominate and Screen BMPs
Develop a short list of applicable BMPs to avoid, minimize, and/or mitigate identified issues

Step 6: Select BMPs
Base selection upon such factors as:
- Permit requirements
- Effectiveness
- Longevity
- Durability
- Cost
- Availability

Step 7: Prepare Erosion and Sediment Control Plan
Plan should include:
- List of selected BMPs
- Location of BMPs
- BMP Construction Details and Specifications
- Implementation Schedule
- Monitoring and Maintenance Plan
3.2.5.3 Best Management Practice Details

The Manual provides a description of over fifty BMP’s to minimize environmental impacts from stream and wetland crossings in seven BMP categories including: crossing alternatives, erosion controls, sediment controls, runoff controls, water diversion, vegetation control, and non-storm water controls (Table 10). The Manual provides detailed descriptions of each of BMP including applications, limitations, specifications, maintenance requirements, costs, and product testing information. Appendix 2 of this report contains a brief description of each practice.

Table 10

<table>
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<th>Best Management Practices</th>
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**Crossing Alternatives**
- Fords
- Culverts
- Bridges

**Erosion Control**
- Preserving Existing Vegetation
- Temporary Seeding & Planting
- Permanent Seeding & Planting
- Sodding & Grass Plugging
- Vegetative Buffer Zone
- Soil Bioengineering
- Slope Roughening/Terracing/Rounding
- Soil Stabilizers
- Mulching
- Geotextiles, Mats, Plastic Covers, Blankets
- Rock Rip Rap
- Gabions
- Cellular Block Revetment
- Articulated Concrete Mattress
- Cellular Confinement System
- ROW Road Abandonment

**Sediment Control**
- Silt Fence
- Straw Bale Barrier
- Sand and Gravel Bag Barrier
- Brush or Rock Filter
- Turbidity Curtain
- Sediment Trap
- Sediment Basin
- Check Dams

**Water Diversion**
- Pump and Divert
- Stream Diversion
- Cofferdams

**Non-Storm Water Control**
- Paving Operations
- Structure Construction and Painting
- Material Delivery and Storage
- Material Use
- Solid Waste Management
- Hazardous Waste Management
- Contaminated Soil Management
- Concrete Waste Management
- Sanitary/Septic Waste Management
- Vehicle and Equipment Cleaning
- Stabilized Construction Entrance
- Vehicle and Equipment maintenance
- Stabilized Construction Roadway
- Entrance/Outlet Tire Wash
- Spill Prevention and Control

**Runoff Control**
- Earth Dikes, Drainage Swales, and Lined Ditches
- Slope and Subsurface Drains
- Outlet Protection/Velocity Dissipation Devices
- Flared Culvert End Sections
- Level Spreader
- Road Runoff Diversion

**Vegetation Control**
- Physical, Chemical, and Integrated Control
4. BEST MANAGEMENT PRACTICES FOR THE PROTECTION OF WILDLIFE IN UTILITY RIGHTS-OF-WAY

4.1 Avian Protection Plan Guidelines

The Avian Power Line Interaction Committee (APLIC) is made up of biologists from the utility industry, U.S. Fish and Wildlife Service, and the National Audubon Society and serves as a clearinghouse for information and communication on avian/powerline issues. In 2005 APLIC released the voluntary Avian Protection Plan Guidelines to reduce the risks to both electrical utility facilities as well as bird populations that result from their interaction with power transmission lines (Edison Electric Institute et al. 2005).

The Avian Protection Plan Guidelines (APPG) provides guiding principles and examples to help utilities develop their own individually-crafted avian protection plans to minimize avian mortality associated with utility structures. The guidelines provide a framework for addressing electrocution hazards, encouraging utilities to evaluate their power lines and work with USFWS to conserve federally protected migratory birds (Edison Electric Institute et al., 2005).

The APP guidelines are organized around 12 “principles”:

- Corporate Policy
- Training
- Permit Compliance
- Construction Design Standards
- Nest Management
- Avian Reporting System
- Risk Assessment Methodology
- Mortality Reduction Measures
- Avian Enhancement Options
- Quality Control
- Public Awareness
- Key Resources

Sections 4.1.1 through 4.1.12 below summarize each principle, as adapted from the APPG, with special emphasis on Construction Design Standards.

4.1.1 Corporate Policy

An APP typically includes a statement of company policy confirming [a] ... commitment to work cooperatively towards the protection of migratory birds....

4.1.2 Training

...All appropriate utility personnel, including managers, supervisors, line crews, engineering, dispatch, and design personnel, should be properly trained in avian issues. This training should encompass the reasons, need, and method by which employees should report an avian mortality,
4.1.3 Permit Compliance

Migratory birds of North America are protected by the Migratory Bird Treaty Act which is administered by the US Fish and Wildlife Service and eagles are protected by the Bald and Golden Eagle Protection Act. Under these acts, it is illegal to “take” these species (i.e. “pursue, hunt, shoot, wound, kill, trap, capture, or collect --MBTA--and also including molest or disturb in BGEPA). Threatened and endangered species are protected by the Endangered Species Act (EEI Avian Power Line Interaction Committee and US Fish and Wildlife Service 2005).

An APP can identify the process under which a company obtains and complies with all necessary permits related to avian issues. Particular attention should be given to specific activities that can require take permits including, but not limited to, nest relocation, temporary possession, depredation, salvage/disposal, and scientific collection. ...it is highly recommended that the utility make initial contact with the Migratory Bird Permit Examiner located in the USFWS Region where the utility is specifically planning to implement its APP.

4.1.4 Construction Design Standards

Avian interactions should be considered in the design and installation of new facilities, as well as the operation and maintenance of existing facilities. ... Construction standards for both new and retrofit techniques ... should be included in an APP... These standards should be used in areas where new construction should be avian-safe, as well as where existing infrastructure should be retrofitted to provide avian safety.

Construction methods for reducing bird injuries and fatalities vary. Two resources by the Avian Power Line Interaction Committee provide construction standards for avian protection:


4.1.4.1 Avian Protection Design Objectives and Construction Techniques

Presented below are design objectives, considerations and examples of construction techniques of best practices (APLIC and USFWS 2005).

New Construction

1. Separate by 60 inches energized conductors and grounded hardware or cover (insulate) energized parts and hardware if spacing is not available;
2. Avoid siting lines in areas where birds concentrate;
3. Where necessary, install devices to enhance visibility of lines;
4. In some situations, additional costs and risks to reliability may be justified by burying lines underground.

Modifications to Existing Facilities

Remedial actions may be necessary when “problem poles” are identified through bird mortality records or other sources. In order to reduce avian mortalities and/or outages related to birds collisions or nests, consider:

1. Numbers (1) and (3) above;
2. Discourage birds from perching on unsafe locations through perch guards or other methods;
3. Provide safe alternative locations for perching or nesting.

Site Specific Plans

Strategic planning to avoid or mitigate for birds at risk requires a site-specific approach. Variables include such factors as topography, avian populations, prey populations, land use practices, line configuration, adjacent wetlands, and historical bird use areas. A multi-disciplinary team of engineers, operators, and biologists assess the site conditions and develop a plan that may range from very local solutions to the need to address problems over a wide area.

Guidelines for New Structures

Risks to raptors are most often found on primary distribution lines where the distance between conductors is less than the bird’s height or wingspan. Figure 14 shows typical wingspan and height of mature eagles. In addition, problems can arise where grounded hardware are in close proximity to energized parts. Figure 15 shows a best practice for avian protection on both single phase and three phase poles with recommended minimum distances among live and grounded features. Where the minimum distances cannot be attained due to site constraints, an alternative method is to cover transformers, conductors, or other energized or grounded equipment with material available and acceptable to the utility industry to insulate the components from contact. Alternatively, a perch guard can be installed to prevent perching (Figure 16).
Figure: 14
Typical Wrist to Wrist and Head to Head Measurements of a Mature Eagle
(EEI and USFWS 2005)

Wrist to wrist measurement 54 inches

Wrist

Wrist

31 inches
Figure: 15
Typical avian safe structures: single phase (left), three-phase with lowered 8-foot crossarm (right)
(EEI and USFWS 2005)

Figure: 16
Perch Guard and Open Crossarm for Safe Perch
(EEI and USFWS 2005)
When transmission lines must be located in areas that conflict with local and migratory bird movements or where existing lines are found to conflict with bird movements, the lines may need to be marked to make them more visible. Figure 17 shows two marker devices that can be used to increase visibility.

![Swinging marker device (left) and bird flight diverter (right)](image)

(EEI and USFWS 2005)

4.1.5 Nest Management

An APP may include procedures for nest management on utility structures. These procedures should be explained to company employees during training to ensure uniform treatment of avian nest issues among personnel.

All active nests are protected by the Migratory Bird Treaty Act and so a permit may be required before managing an active nest. Problems may be avoided by moving a nest in the inactive season. Nesting platforms may provide an alternative in some cases, encouraging a bird to leave a nesting site on an active pole.

4.1.6 Avian Reporting System

Reporting avian mortalities may be required as a condition of Federal or State permits, however a utility may also choose to voluntarily monitor relevant avian interactions, including mortalities, through the development of an internal reporting system to pinpoint areas where mortalities may be occurring, as well as the extent. Data collected can be limited to avian mortalities or injuries, or could also include historical tracking of avian nest problems, particularly problematic poles or line configurations, as well as remedial actions taken. All data should be regularly entered into a searchable database....
4.1.7 Risk Assessment Methodology

An APP should include a method for evaluating the risks posed to migratory birds in a manner that identifies areas and issues of particular concern... [including] an assessment of available data... of areas of high avian use, avian mortality, nesting problems, established flyways, adjacent wetlands, prey populations, perch availability, effectiveness of existing procedures, remedial actions and other factors that can increase avian interactions with utility facilities.

4.1.8 Mortality Reduction Measures

...[Determine] ... whether an avian mortality reduction plan needs to be implemented ... [such as] where system monitoring should occur, where retrofit efforts should be focused, and where new construction warrants special attention to raptor and other bird issues.

4.1.9 Avian Enhancement

Include opportunities for a utility to enhance avian populations or habitat, including developing nest platforms, managing habitats to benefit migratory birds, or working cooperatively with agencies or organizations in such efforts.

4.1.10 Quality Control

An APP also may include a mechanism to review existing practices, ensuring quality control. For instance, a utility may conduct an independent assessment of its avian reporting system to ensure its effectiveness, or invest in research on the effectiveness of different techniques and technologies used to prevent collisions, electrocutions and problem nests.

4.1.11 Public Awareness

An APP should include a method to educate the public about the avian electrocution issue, the company’s avian protection program, as well as its successes in avian protection.

4.1.12 Key Resources

Identify key resources to address avian protection issues including, for example, a list of experts who may be called upon to aid in resolving avian issues. These could include consultants, State and Federal resource agencies, universities, or conservation groups. Engineers may find that internal personnel such as environmental specialists can aid in developing creative solutions to resolve avian interaction problems, and external organizations like APLIC can also serve as helpful resources by providing guidance, workshops, materials, and contact.
4.2 Landscape Pattern Analysis

The Electric Power Research Institute, sponsored a technical report to develop a methodology for using landscape metrics (e.g. habitat patch size, area, patch shape, and connectivity or distance) in assessing changes in landscape patterns, such as fragmentation. The resulting report, available for purchase from EPRI, presents general guidelines, an example analysis and an outline of procedure that can be applied to assessing changes in landscape patterns, such as fragmentation, in many landscape situations, including GIS modeling (EPRI, 2003).

4.3 Integrated Vegetation Management

According to EPA, integrated vegetation management (IVM) is:

*the practice of promoting desirable, stable, low-growing plant communities—that will resist invasion by tall-growing tree species—through the use of appropriate, environmentally sound, and cost-effective control methods. The methods include a combination of chemical, biological, cultural, mechanical, and/or manual treatments* (EPA 2010).

The practice of integrated vegetation management has been in development for many years in several disciplines including ROW management for both roads and utilities. Practices and expertise continue to evolve and change as understanding of the cause and effects among mechanical control, herbicidal control, natural control and plant communities grows.

The primary objective of a high voltage electric ROW is safe and reliable power. Toward this end, utilities develop objectives for maintaining vegetation so as not to conflict with the powerlines while maintaining the safety of their workers and the public. In addition, managers are regulated just as any other land use by applicable laws to protect the environment. Rowe managers may have secondary objectives for ecosystem management, such as enhancing wildlife habitat. Ideally, ROW managers would seek to provide safe and reliable power while also maximizing ecosystem values when developing IVM plans. Some utilities, in practice and in promotional literature, express that protecting natural resources are important priorities (EEI 1999).

While poor vegetation management on ROW can result in the loss of critical habitats, IVM can be used to create natural and diverse ecosystems, such as meadow and shrub edge habitats. These transition landscapes, in turn, may play a role in reducing wildlife habitat fragmentation, allowing species to remain in areas where the population might otherwise disappear. A variety of wildlife species (including threatened and endangered species) can thrive in a properly managed ROW, such as butterflies, songbirds, small mammals, and deer. These habitats can also be managed to increase plant diversity, protect endangered species and/or remove or reduce the presence of invasive and exotic species (EPA 2010-b).

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12 In this literature search, the earliest date referenced to IVM was in Priestly and Sullivan (2009): “*National Grid has the oldest IVM program in the Commonwealth of Massachusetts, adopting this multi-faceted approach to rights-of-way vegetation management in the late 1960’s.*”
4.3.1 Edison Electric Institute Environmental Stewardship Strategy

The Edison Electric Institute has members that represent 70% of the United States electric utilities (and 90% of the consumers) has been playing a leadership role in developing IVM practices for the industry. EEI offers a context for the public debate about the advantages and disadvantages of mechanical and herbicidal methods for controlling vegetation in rights-of-way (EEI n.d.-b):

There are several different ways of controlling vegetation around power line rights-of-way. These include both mechanical and chemical or herbicide methods.

While mechanical methods at first may seem the less harmful way to controlling vegetation, these methods, in fact, have many disadvantages. Cutting and mowing vegetation have the undesired effect of causing vegetation to grow back thicker and fuller, requiring repeated and often more frequent cutting and mowing. Mechanical methods also have many hidden risks, such as worker and environmental exposure to petroleum products that power mechanical equipment, physical injury from sharp tools and equipment, and the significant alteration of wildlife habitats.

Herbicide methods, on the other hand, can be used in a controlled and selective manner to focus just on those plants and trees that are problematic. Most herbicides used for vegetation control have low human and animal toxicity. Herbicides generally have lower toxicity than the petroleum products released by mechanical cutting equipment. These methods also can result in more desirable wildlife habitats.

In 1997 the Edison Electric Institute's Vegetation Management Task Force developed a pesticide “risk/use reduction strategy” to apply towards rights-of-way maintenance while participating in the Environmental Protection Agency’s Pesticide Environmental Stewardship Program. The strategy includes a reduction of traditional chemical methods and has seven objectives (EEI 1999):

- Select vegetation management practices which balance environmental concerns, public needs, safety and cost-effectiveness;
- Use Integrated Pest Management methods that are supported through scientific research as minimizing risk and increasing effectiveness for use in right-of-way vegetation management programs;
- Adopt Best Management Practices for herbicide applications. These practices will be based on the latest scientific research among utilities, manufacturers, applicators, regulators, and universities;
- Strive to reduce the level of herbicide application through the proper selection and use of application methods, equipment, and technology which promote and facilitate minimal application rates;
• Support research and development initiatives for reduced-risk pesticides and for improved herbicide handling (storage, transport, mixing, and application) that lead to improved worker protection. The utilities will, where available, adopt those developments that are proven to reduce risk and are cost-effective;

• Encourage the accelerated approval of any risk reduction recommendations to be included on the labels of herbicides used for vegetation control

4.3.2 Edison Electric Institute and Federal Agencies MOU

In 2006, Edison Electric Institute, federal land management agencies, and the Environmental Protection Agency signed a Memorandum of Understanding stating that all parties would endorse the use of integrated vegetation management on electric utility rights-of-way on federal lands (EEI et al. 2006). This action not only formalized practices on federal lands, but also will help establish sound Integrated Vegetation Management (IVM) practices as the standard for utility rights-of-way management, including (EPA 2008):

• Promoting IVM and environmental stewardship as an integral part of managing rights-of-way by electric utilities;
• Establishing guidance on good IVM practices;
• Publishing IVM practices currently employed by utilities that demonstrate good environmental stewardship in managing rights-of-way;
• Facilitate the use of IVM as the utility rights-of-way industry standard;
• Develop sound working relationships between the utility industry and land management agencies to achieve both electric reliability and ecological goals.

4.3.3 American National Standards Institute

While EEI offers a strategy, the American National Standard Institute ANSI A300 (Part 7) – 200613, outlines minimum performance standards for IVM for use in arboricultural specifications for electric rights-of-way (IVM Partners n.d.):

1. Define the objectives;
2. Define action thresholds
3. Inspect the site to determine if thresholds are met and what control is necessary;
4. Pre-control evaluation should include ROW use, type of electric line, general conditions, ownership, intended uses, adjacent uses, existing vegetation; topography, soils, fire risk, sensitive or protected areas or species, water resources and regulations;
5. Proactively communicate

13Available for purchase from the Association of Tree Care Professionals http://www.treecareindustry.org/standards/ANSIFAQs.htm
6. Choose and implement appropriate control methods;
7. Post control evaluation, quality assurance and documentation.

The standards embrace a border zone-wire zone approach to management (Figur 18). ANSI A300 provides direction on what to do. The International Society of Arborists is currently writing Best Management Practices on how to do it (see section 4.3.4 below).

4.3.4 International Society of Arboriculture  IVM Best Management Practices

In 2007, the International Society of Arboriculture developed best management practices (BMP) for integrated vegetation management (IVM) to serve as a field guide, as well as an aid for managers for planning purposes. The BMP document is a how-to companion to the American National Standards Institute ANSI A300 (Part7) standards (see section 4.3.1 above) The BMP’s are designed to be used to fulfill the mission of managing vegetation for the efficient and safe provision of electrical service and can also be used to fulfill other objectives, such as restoring ecosystems, controlling invasive weeds.

BMP’s call for a systematic way of planning and implementing a vegetation-management program and consists of six elements (Derek 2009):

1. **Set the objective**
   
   The overriding focus for the objectives should be on environmentally sound, cost-effective control of species that potentially conflict with the electric facility while promoting compatible, early successional, sustainable plant communities.

2. **Evaluate the site**
   
   Vegetation managers often use site evaluations to assess field conditions for planning purposes, establish or modify objectives, set budgets, and determine human and equipment resource requirements.

3. **Define action thresholds**
   
   The action thresholds are vegetation height and density targets that trigger specific control methods. A qualified vegetation manager should set the thresholds, which will vary from utility to utility and project to project.

4. **Select control methods**
   
   Managers can achieve objectives through control methods such as manual, mechanical and herbicides to biological and cultural processes.
5. **Implement IVM**

Vegetation management professionals must implement minimum clearance distances (FAC-003-1).

6. **Monitor treatment and quality assurance**

Utility vegetation management programs should have system processes in place for documenting and verifying that vegetation management work is completed to specifications. Post-control reviews can be comprehensive or based on a statistically representative sample.

### 4.3.4.1 Cultural Control Methods

Cultural control methods, when attainable, are the most desirable methods for vegetation control in the long run. The method requires skillful and adaptive use of herbicide and mechanical controls. Miller (2007) describes the management concept:

*Cultural control methods modify habitat to discourage incompatible vegetation and establish and manage desirable, early successional plant communities. Cultural methods take advantage of seed banks of native, compatible species lying dormant on site. Cultural control, also known as cover-type conversion, provides a competitive advantage to short-growing early successional plants, allowing them to thrive and eventually out-compete unwanted tree species for sunlight, essential elements and water. The early successional plant community is relatively stable, tree-resistant and reduces the amount of work, including herbicide application, with each successive treatment.*

### 4.3.4.2 Wire-Border Zone

The wire-border zone technique is a management philosophy that can be applied through cultural control. This approach to vegetation management was formally introduced in the 1980’s by two natural resource scientists from Purdue University, William C. Bramble and William R. Byrnes while studying a ROW in Pennsylvania that is the site of the State Game Lands 33 Research and Demonstration Project—a long-term research site now over 50 years old.

The wire zone is the section of a utility transmission ROW directly under the wires and extending outward about 10 ft on each side. The wire zone is managed to promote a low-growing plant community dominated by grasses, herbs and small shrubs. The border zone is the remainder of the ROW, managed to establish small trees and tall shrubs. When properly managed, diverse, tree-resistant plant communities develop in wire and border zones. The communities not only protect the electric facility and reduce long-term maintenance, but also enhance wildlife habitat, forest ecology and aesthetic values. Stream and wetland protection may be enhanced by this type of management. In 1991, Bramble and Byrnes published a study of the State Game Lands 33 Research and Demonstration site that reporting that the method was so successful that it is possible to predict the pattern of vegetation development following the
application of common maintenance treatments (Bramble and Byrnes, 1991 cited in Dow Agro Sciences, 2003).

In 2003 the Federal Energy Regulatory Commission and the North American Electric Reliability Corporation endorsed the use of the Wire Zone-border zone concept. Since that time, the concept has been widely circulated in the industry. Ballard, et al. (2007), however, examined the application of the concept as illustrated by Bramble and Byrnes to a range of ROW configurations typical in the industry. They recommend a broader interpretation of the approach to adapt management to local conditions. For example, some rights-of-way, such as in New York State, may value woody vegetation in the center zone where height clearances allow. In addition, the investigators suggest that the traditional Bramble et al. depiction of a ROW cross-section should be updated to more accurately depict ROW dimensions and that plan and profile views should be added to represent a three-dimensional system (Figure 18).

![Wire Zone-Border Zone Concepts](http://joa.isa-arbor.com/request.asp?JournalID=1&ArticleID=3023&Type=2)

Figure 18
Wire Zone-Border Zone Concepts
(Ballard et al. 2007)

(A) ROW cross-section based on Bramble et al. (1985, 1986) figure dimensions (atypical), scaled for a 345-kV powerline with a horizontal conductor configuration.
(B) ROW cross-section redrawn with a more conventional ROW width for a 345-kV powerline with a horizontal conductor configuration.
4.3.4.3 Research about Vegetation Management Methods

Research into improved technologies for vegetation management is ongoing. In addition to efforts to reduce risk to workers and the environment from herbicides, other areas of study include, for example, types of vegetation that slow down the invasion of incompatible tree species through allelopathy- the suppression of growth of one plant species through the natural toxics released by another plant species. Finally, there are many variables in establishing goals for management and responding to biological and edaphic factors of each site. These variables can be addressed only by continuing on-going research to develop a large body of knowledge and expertise in the industry. A detailed discussion of these variables and comprehensive review of the present body of knowledge is beyond the scope of this review.

5. FORESTRY BEST MANAGEMENT PRACTICES

There is a wealth of information about forestry best management practices to protect water quality. In 2005 the Environmental Protection Agency developed a guidance document to provide technical assistance on the best available, economically achievable means to reduce nonpoint source pollution of water resources from forestry activities. EPA identified nine management measures to apply BMP’s to address water quality.

- Preharvest planning
- Streamside management areas
- Road construction/reconstruction
- Road management
- Timber harvesting
- Site preparation and forest regeneration
- Fire management
- Revegetation of disturbed areas
- Forest chemical management
- Wetland forest management

Numerous BMPs are associated with each management measure.

The wetland forest management measure in the EPA guidance document is to

“plan, operate, and manage normal, ongoing forestry activities (including harvesting; road design, construction, and maintenance; site preparation and regeneration; and chemical management) to adequately protect the aquatic functions of forested wetlands”.

Eight states in the Southern Appalachian Region have BMP manuals. Many of these manuals have separate guidelines for wetlands as well as Streamside Management Zones, however, the wetland BMP’s are directed almost exclusively to Coastal Plain. One observation of particular note in how it may relate to utility rights-of-way is that wide-tired equipment significantly reduces soil compaction (Aust et al, 1993 and McDonald et al, 19954 in Rummer, 2004).
Maryland has a draft *Erosion and Sediment Control Standards and Specifications for Forest Harvest Operations (2005)* that includes a section on wetland considerations, streamside management zones and temporary waterway crossings.

### 5.1. Wetland Road Design and Construction Practices in Forestry

A major focus of the BMP’s in the forestry industry address roadways (Adapted from EPA, 2005):

*Locate, design, and construct forest roads according to preharvest planning.*

Improperly located, designed, or constructed forest roads can cause changes in hydrology, accelerate erosion, reduce or degrade fisheries habitat, and destroy or damage existing stands of timber.

*Use temporary roads in forested wetlands.*

A temporary road in a wetland needs to provide adequate cross-road drainage at all natural drainageways. Temporary drainage structures include culverts, bridges, and porous material such as corduroy or chunkwood.

Construct permanent roads only to serve large and frequently used areas, as approaches to watercourse crossings, or to provide access for long-term fire protection. Use the minimum design standard necessary for reasonable safety and the anticipated traffic volume.

Grade the surface of a wetland to be as flat as possible prior to constructing a temporary road (Hislop and Moll, 1996, cited in Blinn et al., 1998). Do not disturb the root mat in any wetland that has grass mounds or other uneven vegetation. Any temporary wetland crossing is enhanced by using a root or slash mat to provide additional support to the equipment.

*Construct fill roads only when absolutely necessary for access since fill roads have the potential to restrict natural flow patterns.*

Where construction of fill roads is necessary, use a permeable fill material (such as gravel or crushed rock) for at least the first layer of fill. The use of pervious materials helps maintain the natural flow regimes of subsurface water. Permeable fill material is not a substitute for using bridges where needed or for installing adequately spaced culverts at all natural drainageways. Use this practice in conjunction with cross drainage structures to ensure that natural wetland flows are maintained (i.e., so that fill does not become clogged by sediment and obstruct flows).

Provide adequate cross drainage to maintain the natural surface and subsurface flow of the wetland. This can be accomplished through adequate sizing and spacing of water crossing
structures, proper choice of the type of crossing structure, and installation of drainage structures at a depth adequate to pass subsurface flow.

Construct roads at natural ground level to minimize to restricting water flow

Float the access road fill on the natural root mat. If the consequences of the natural root mats’ failing are serious, use reinforcement materials such as geotextile fabric, geo-grid mats, or log corduroy. Protect the root mat beneath the roadway from equipment damage by diverting through traffic to the edge of the right-of-way, shear-blading stumps instead of grubbing, and using special wide-pad equipment. Also, protect the root mat from damage or puncture by using fill material that does not contain large rocks or boulders.

5.2 Practices for Crossing Wetlands in Winter

Winter provides an opportunity to cross wetlands with little effect. Roads are often constructed across wetlands in winter to take advantage of frozen ground with a range of best management practices (Wiest 1998):

- For permanent roads, follow BMP installation guidelines for permanent roads.
- Select the shortest practical route to minimize potential problems with drifting snow and crossing of open water.
- Avoid crossing open water or active springs. If crossing is unavoidable, temporary crossings are preferred over permanent crossings. These can be ice bridges, temporarily installed bridges, or timber mats.
- Avoid using soil fill.
- Install structures that block water flow so that they can be easily removed prior to the spring thaw. Remove these structures during a winter thaw.
- Use planking, timber mats, or other support alternatives to improve the capability of the road to support heavy traffic. If removal would cause more damage than leaving them in place, these structures can be left as permanent sections on frozen roads. Avoid clearing practices that result in berms of soil or organic material, which can disrupt normal water flow in wetlands.
- Do not operate machinery during a winter thaw. Resume operations only when conditions are adequate to support equipment.
- Remove temporary fills and structures to the extent practical when no longer needed.
- Install buffer strips near open water.
- Anchor temporary structures at one end only to movement aside during high water.
- To avoid excessive damage, equipment operations are best avoided on any portion of a road where ruts are deeper than 6 inches below the water surface for a continuous distance of more than 100 yards.
6. RECOVERY OF WETLANDS FROM PERTURBATIONS

A perturbed ecosystem will recover or change depending on the impacts of both the physical or biological environment. Structure of woody plant communities is often shaped by the history of disturbance (Grubb, 1977; Whittaker and Levein 1977; cited in Jordan, 1996).

6.1 Wetland Restoration after Pipeline Construction

Two major studies were performed in an effort to identify the impacts of gas pipelines on wetlands:


6.1.1 Findings of the Federal Energy Regulatory Commission

In 2004, the Federal Energy Regulatory Commission (FERC) with the assistance of Northern Ecological Associates, Inc. and Tetra Tech, undertook a study to evaluate the effectiveness of the 1994 version of the Wetland and Waterbody Construction and Mitigation Procedures (Procedures) to determine whether natural gas pipeline companies across diverse geographic regions of the United States were successful in restoring wetlands after construction. Researchers sampled 960 wetlands located in 13 different pipeline projects within 15 different states.

The criteria for success for the study was 80 percent vegetative cover by native species, plant diversity at least 50% of the pre-construction condition, and conditions that comply with the federal methodology for identifying and delineating wetlands. Wetlands designated “passing” were required to meet all three of the criteria. In addition to measuring the criteria for success, investigators examined the influence of several factors that might influence success:

- Ecoregion;
- Evidence of construction debris;
- Evidence of erosion;
- Meeting preconstruction grade (or not);
- Waterbar within 100 feet;
- Evidence of human disturbance;
- Wetland position in the landscape;
- Soil texture; and
- Evidence of top soil mixing.

The investigators developed conclusions, trends and recommendations, as summarized below:

- Wetland monitoring reports tend to be unavailable from pipeline companies. Based on reports that were received, the pipeline industry does not have a consistent approach to post-construction wetland monitoring. The FERC's revised 2003 Procedures now requires filing a report with the Secretary on the status of wetland revegetation three years
• Two thirds of all wetlands studied achieved all three wetland restoration success criteria. The most common criterion in failed wetlands was insufficient vegetative cover.

• The presence of human disturbance (such as ATV traffic and change in land use) was associated with higher failure rates and nearly half the sites were disturbed by human activity. The most common human disturbance was farming.

• Wetlands established to pre-construction grades were more successful than wetlands that did not meet pre-construction grades.

• Soil conditions have some influence on success, with wetlands underlain by clay-dominated soils having a greater failure rate than wetlands dominated by other soil types. (Although a noticeable trend, soil texture was not significant based on the statistical analysis).

• Waterbars placed at the base of slopes near the boundary between wetlands and adjacent upland slopes (required by the Procedures) were observed on one third of all wetlands surveyed and restoration was successful at three-quarters of those sites.

• There were no major patterns of success relative to landscape location, however, the low success rates for a small sampling of vernal pools may warrant further investigation.

• Emergent wetlands with surface water depths of 1” to 12” at time of study had relatively rapid recovery following disturbance.

• All Palustrine Forested wetlands of the Warm Continental and Hot Continental ecoregions (Maryland straddles the Hot Continental and Subtropical Divisions) converted to Palustrine Emergent cover and there was a similar trend throughout most of the United States. This trend is inconclusive because the study observed sites at a relatively short period of time after disturbance, relative to the time necessary for the re-establishing woody vegetation. However, researchers expect this trend to persist over portions of the ROW because woody vegetation is commonly removed to facilitate aerial monitoring required by the U.S. Department of Transportation to ensure pipeline integrity.

• There was no correlation observed between success rate and time since construction.

### 6.1.2 Findings of the Gas Research Institute

Ten years prior to the FERC study (6.1.1 above), the Gas Research Institute contracted the Reclamation Engineering and Geosciences Section, Energy Systems Division at Argonne National Laboratory to develop the Wetlands Corridors Program. The goal of the study was to identify impacts of existing pipeline construction on wetlands. Researchers surveyed 17 wetland communities on ten wetland crossings. Three crossings were located in the gulf coast states, two in Wisconsin, and four in the northeastern United States. The closest site to Maryland was in Peabody, New Jersey, 100 miles northeast of Baltimore in the Coastal Plain Physiographic Region. The sites differed in time elapsed since pipeline installation (from 8 months to 31 years), wetland type, installation technique, and maintenance practice. Each wetland disturbed by the pipeline crossing was also compared to an adjoining undisturbed wetland of similar type.
According to the investigators, the study was only a small sample of wetland crossings, representing ROW’s of a variety of ages in diverse ecosystems and community types. Not all ages, ecosystems, community types construction techniques, and maintenance regimes were represented. However, the study was the most comprehensive survey and vegetation sampling of existing pipeline ROW’s up to 1994. In addition to vegetation monitoring, qualitative changes in topography, soils, and hydrology were documented for each site.

6.1.2.1 Wetland and Waterbody Construction and Mitigation Procedures

Based on the findings of the study, the investigators concurred that a number of the provisions of the Wetland and Waterbody Construction and Mitigation Procedures promulgated by the Federal Energy Regulatory Commission, can be expected to minimize impacts at pipeline ROW’s on wetlands, including:

Paragraph 380.14.c.3

vi. Cut vegetation off only at ground level, leaving exiging root systems intact, and remove from wetland for disposal;

vii. Limit pulling of tree stumps and grading activities to directly over the trench. Do not remove stumps or root systems from the rest of the right-of-way in wetlands unless...safety-related construction constraints require...;

viii. Segregate the top one foot of topsoil from the area disturbed by trenching, except where standing water or saturated soils are present, and then return it to its original position over the backfilled trench;

xii. Use no more than two layers of timber or equipment pads to stabilize the right-of-way. In the event that more than two layers of timber riprap must be used...the following information must be included in the applications: ...B. A detailed plan which addresses the procedures to be used to remove all timber riprap, specific measures (including the import of additional fill material) to restore preconstruction surface contours, and specific measures (including planting of herbaceous and shrub species) to ensure successful revegetation of the construction right-of-way with native wetland plant species within three years after construction;

xiii. Remove all timber pads, prefabricated equipment pads and geotextile fabric overlain with gravel fill upon completion of construction.

c.5 Revegetation techniques

i. Do not use fertilizer or lime, unless required in writing by appropriate state permitting agency;

ii. Restore topsoil to original horizon and temporarily revegetate disturbed areas with annual ryegrass at a rate of 40 pounds per acre, unless standing water is present;
iii. Ensure that all disturbed areas are permanently revegetated with native herbaceous and woody plant species;

iv. Develop specific procedures in coordination with the appropriate state agency to prevent the invasion or spread of undesirable exotic vegetation (e.g. purple loosestrife and Phragmites).

v. Right-of-way maintenance practices. Vegetation maintenance practices over the full width of the permanent right-of-way are prohibited. However, to facilitate periodic pipeline corrosion/leak surveys, a corridor centered on the pipeline up to 10 ft. wide may be maintained in a herbaceous state. In addition, trees that are located within 15 ft. of the pipeline and are greater than 15 ft. in height may be selectively cut and removed from the right-of-way.

6.1.2.2 Seedling Recruitment

Through both site observation and literature review, investigators of the Wetland Corridor Program concluded that the replacing wetland topsoil with its component seedbank is an important part of wetland restoration in order to recruit wetland plants from seed and propagules. Where topsoil was stockpiled and replaced, and they were not covered with standing water, sites revegetated quickly; in addition, unless standing water is present, seeding is unnecessary and counterproductive, especially at sites where topsoil is salvaged and the site is graded to original elevations. The practice of planting annual ryegrass or other grasses may shade the surface and prevent germination. The authors summarized their findings in the literature regarding seedling recruitment:

- Several studies document the sufficiency of seedbanks for re-vegetating wetlands (Kirkman and Shariz, 1994; Leck and Simpson 1994; Schneider and Sharitz 1986; Terheerdt and Drost 1994; Welling et al 1988 a, b.
- Welling (1988b) documented the importance of high soil moisture, moderate to high temperatures, and low soil conductivity in seedling recruitment and conditions that favor seed germination during marsh draw-down (1994);
- Connor et al (1981) discuss the importance of light in seedling recruitment (Connor et al, 1981);
- Van der Valk (1981) documented the inhibitory effects of litter on seedling recruitment for cattails;
- Mitsch and Gosselink (1993) provide an excellent discussion on seedling recruitment from seedbankds in various types of wetlands.

6.1.2.3 Species Diversity

Investigators of the Wetland Corridor Program were interested in how the pipeline disturbance impacted species diversity in the wetlands. All ROWs contained species not found in the adjacent natural wetlands. The ROWs enhanced diversity of the wetlands by 34%. The number of non-native species was related to previous disturbances and whether the site was stabilized.
after construction with non-native species. ROWs through forested areas added more diversity than ROWs through emergent wetlands because management practices retard the wetlands from succeeding to a forested community. The authors caution that the positive environmental value of increasing diversity needs also to be considered against the negative environmental impacts of habitat fragmentation.

6.1.2.4 Other Findings of the Wetland Corridor Program

- Re-establishing the original grade of the site is important-- minor differences in the final surface elevation can produce significant impacts on the type of vegetation that reestablishes itself.
- When topsoil is salvaged and ROW grading is successfully executed, dense vegetative communities of native species can regenerate within two growing seasons (e.g. a shrub scrub community) and eventually return to a natural community indistinguishable form an adjacent community with similar conditions;
- Emergent wetlands will recover more quickly than others;
- Both the literature and study results recommend against using lime or fertilizer amendments (Moore et al. 1989 cited in Van Dyke et al. 1994);
- Re-establishing drainage patterns throughout the right-of-way is important;
- Depressions that occurred in the pipeline area, especially where the depression is below water level, were observed to be devoid of plants;
- Topsoil salvaging may be difficult in wetlands, especially in areas of standing water and saturated unconsolidated soil--vegetative cover is enhanced by timing wetlands construction so that the topsoil can be saved (i.e. during the dryer seasons);
- The one site where directional drilling was used and the only disturbance of the soil surface was from clearing the forest, rapidly developed a rich and diverse plant community of 96% native species;
- Sites that were fertilized and/or seeded had a higher percentage of introduced species than the adjacent natural areas. Fertilization may shift the nutrient regime in favor of less desirable species, including agronomic, introduced, and nuisance species;
- The sites studied showed no evidence that the ROW was a pathway for introduced or aggressive species into adjacent wetlands;
- Artificial seeding, even with annual ryegrass, creates competition for reestablishment of native species;

6.2 Mechanisms of Recovery

Various researchers find that recovery is probabilistic rather than a predictable pathway—that the interaction between individual species and their immediate environment will vary, affecting the pathway of succession (Thibodeau, 1986). Most plants will reestablish themselves if there is not
a major change in the substrate (Catellino 1979; Drury and Nisbett, 1973; Horn 1976; and Holliday et al. 1979). These findings and others suggest that when all vegetation in a wetland or ecosystem is removed from a mature plant community, the site will reestablish itself directly back to the community existing prior to the disturbance, providing the substrate has not been substantially covered by fill or altered (Thibodeau, 1986), or re-planted.

6.3 Methods for Measuring Recovery

In the Central Platte River region in Nebraska, researchers are interested in establishing methods to measure recovery in wetlands that were previously disturbed and so during spring 2003 and 2004 they sampled macroinvertebrates in restored (5-16 years old) and natural slough wetlands to assess the success of wetland restoration. Management histories of the restored wetlands, e.g., grazing and burning, were similar among all sites chosen, and restoration procedures, e.g., land contouring and seeding, were similar. The study region is a 90-km stretch of the Central Platte River. Researchers found that the communities were similar in natural and restored wetlands, but observed some taxonomic differences. This observation suggested that macroinvertebrates are good candidates for assessing recovery and the authors propose a leach and mollusk ratio to assess recovery. In addition, they found that wetland macroinvertebrate communities in the region are resilient and recover rapidly after restoration, but that ongoing restoration and management efforts should focus on hydrology, which is a critical factor shaping wetland macroinvertebrate communities. Other potential indicator metrics recommended for further investigation were sedge and rush cover and productivity, plant wetland indicator status, soil organic matter and soil bulk density (Myer and Whiles, 2008).

6.4 Recovery Where Substrate has been Substantially Altered

Numerous practices can help to avoid compaction during construction or reverse it after it occurs including: selective grading, special construction equipment, reforestation, mechanical loosening, and the use of soil amendments (Schueler, 2000). Alleviating soil compaction after it has already occurred, however, is difficult. Good soil structure is the result of many years of physical and biological activity. No universally successful technique is available to replace the natural process after compaction occurs through construction practices. Compaction restricts woody plant growth, but the nature and causes of the restriction are not completely understood. Many amelioration methods involve soil aeration. Day and Bassuck (1994), however, report that as long as drainage is adequate, aeration is most likely not the primary grow-restricting factor resulting from soil compaction. Techniques that physically reduce mechanical impedance and improve soil tilth are approaches that merit further exploration.
6.5 Recovery after Removing Tree Canopy from Forested Wetlands

When the tree canopy is removed from a forested wetland, such as may happen in the clearing of a right-of-way, or temporary access road, the understory plant community will respond to the disturbance. Jordan (1996) found that when a gap was opened in a forested wetland with an understory of Clethra alnifolia that the shrubs responded with an increase in seasonal growth, density of stems and flowering rates. When the wetland forest cover was removed in a transmission right-of-way, total stem density, extension growth, and flowering significantly increased and were directly related to distance from the ROW edge. The number of new seedlings and their density also increased significantly in the disturbed area. The reproductive pattern of Clethra alnifolia varied with canopy disturbance. In established forests, the shrub regenerates primarily through vegetative reproduction and in disturbed areas requires significant or long-term canopy disruption to increase sexual reproduction. In the disturbed canopy the shrub had greater areal cover.

6.6 Recovery from Differential Sedimentation Textures and Loading Rates

Dittmar and Neely (1999) studied the effects of both sediment loading rate and sediment texture and found that seedling recruitment from the seed bank of a wetland was nearly seven times higher than treatments that received sediment loads. Large sediment loads decreased total seedling density more when compared to low sediment loads. Jurik and others (1994) found that sediment loads as low as 0.25 cm reduced the number of species and total number of individuals recruited from wetland seed banks.

Sediment texture may not significantly alter seedling density and species richness. Diversity was significantly greater under low sediment loading than high sediment loading. (Dittmar and Neely, 1999). The response to sedimentation by individual plant taxa was not consistent. Sediment decreased the number of individuals appearing for most, but not all, species and larger-seeded species (i.e. seed mass) showed the least impact.

6.7 Effectiveness of Techniques to Avoid Compaction during Construction

Often the management practice to rectify soil compaction is to require contractors to loosen soil by tillage, ripping or other techniques before lawns are established (Schueler, 2000). Researchers, however find little or no improvement in soil compaction with these practices (Randrup, 1998; and Paterson and Bates, 1994). Similarly, selective grading, where certain areas of a plan are marked for no grading also may result in extensive compaction by construction equipment, stockpiling and vehicular traffic (Randrup 1998; Lichter and Lindsay, 1994 cited in Schueler, 2000) The only soils where compaction was prevented were areas that were fenced to exclude all construction activity. Lichter and Lindsey (1994) found that while applying plywood beneath a front-end loader did not reduce compaction, bulk densities under mulch and gravel treatments were significantly lower than the unprotected control, though not completely protective of compaction.
7.0 CASE STUDIES

During the course of this literature survey, several case studies were notable either for good practices at the local level or at the national level that serve as a model for consideration in Maryland. These case studies are presented here in brief as an introduction of example programs, not a comprehensive presentation of content. The reader can refer to the sources cited in each example for further information. The case studies include:

7.1 PEPCO Holdings, Inc.: Integrated Vegetation Management

Pepco Holdings, Inc. (PHI) is an energy holding company engaged in regulated utility operations and sale of energy products and services. PHI owns Potomac Electric Power Company (PEPCO), an electric power utility and Delmarva Power, an electric and gas utility -- two of the largest power utilities in Maryland. PHI begins its environmental policy statement:

“Pepco Holding, Inc. is dedicated to conducting its business activities with respect and care for the environment. Among PHI’s highest corporate priorities is achieving environmental excellence through proactive environmental management.”

In partnership with the United States Environmental Protection Agency’s Pesticide Environmental Stewardship Program, PHI implements integrated vegetation management strategies to minimize overall risk to people and the environment while providing safe and reliable electric service. Treatments may include manual, mechanical, cultural chemical, or biological controls that are used to change the plant community from species that may interfere with the utility’s goals to species that are more compatible (e.g., a shrub/scrub meadow community). According to PHI, they are the only electric utility whose vegetation management program is certified by the Wildlife Habitat Council. PHI’s program was also used as the guideline for New Jersey Department of Environmental Protection Integrated Pest Management Prerequisites and Minimum Criteria for Utility Rights-of-Way (PHI 2009).

The methods used are directed by an arborist, forester, or biologist and are implemented to discourage tall growing incompatible tree species and select for low growing compatible species, resulting in a stable shrub/scrub meadow habitat. The first step typically involves various methods of cutting undesirable woody vegetation with subsequent strategic applications of herbicide. The herbicides are used selectively, are low in toxicity, and are biodegradable.

Specific methods are prescribed based on the physical and biological factors of the site. The techniques chosen are based on the density, height and type of incompatible trees, the present or lack of compatible species, terrain, water, wetlands, rare or endangered species, adjacent land uses, accessibility, worker and public safety, and economics.
7.1.1 PEPCO: Meadow Management Program

Potomac Electric Power Company (PEPCO), headquartered in Washington D.C., is a subsidiary of PEPCO holdings and practices a Meadow Management Program that promotes the germination and growth of dormant annual and perennial wildflower seeds. The targeted ecosystem is a low profile shrub/scrub plant community.

The first phase of the project is to mow and treat the area with herbicide to limit undesirable woody species. The right-of-way is then maintained on a four-year cycle and only a select basal application of herbicide is used on undesirable species and species over 10 feet are removed.

PEPCO has an easement at the U.S. Fish and Wildlife Service’s Patuxent Wildlife Research Center (PWRC) and for decades the right-of-way has been managed consistent with the mission of the visitor’s center. Experience at this facility became part of the basis for vegetation control throughout the PEPCO system.

The Butterfly Enhancement Program is located in western Montgomery County and is a joint project of the Washington Area Butterfly Club, the International Butterfly Breeders Association, Maryland national Capital Park and Planning Commission and PEPCO. Located on the Dickerson to Potomac River 230 kv transmission line right-of-way, the project will introduce as many native butterfly nectars and larva host plans as possible, along with the naturally occurring herbaceous vegetation.
### 7.1.2 Further Information

Converting Power Easements into Butterfly Habitats by Stephen M. Genua,  
http://butterflybreeders.org/public/powerease_sg.html

Pepco Holdings, Inc. Interated Vegetation Management Program  
http://www.powerpathway.com/images/mapps/jpaarmymd1/Attachment_A_-_Environmental_Review_Documents/Potomac_River_Crossing_ERD/Appendix_B_-_Integrated_Vegetation_Management_Plan/FINAL_IVMP.PDF

### 7.2 Baltimore Gas & Electric Company: Integrated Vegetation Management Plan Pilot

Baltimore Gas and Electric Company (BGE), is a subsidiary of Constellation Energy, and is Maryland’s largest gas and electric utility. In a recent press release, Brian C. Daschbach Sr., a Senior Vice President of BGE noted,

> “BGE is committed to responsible environmental stewardship and is enhancing its vegetation management strategy to ensure that it not only protects the integrity of the electric delivery system but also creates environments which allow animal and plant life to thrive in their natural habitats. Our efforts along this section of transmission right-of-way and other areas where we plan to implement this approach clearly demonstrate that maintaining the electric grid and creating sustainable environments for native plants and animals are not mutually exclusive.”

The BGE Transmission Vegetation Management Program restricts wire zone vegetation height to no more than 5 feet at maturity. In fulfillment of BGE’s commitment to environmental stewardship, BGE is exploring Integrated Vegetation Management through a pilot project in Davidsonville, Anne Arundel County. According to Rich Mason, U.S. Fish and Wildlife Service, “If the outcome of the pilot project allows for reliable transmission of electricity, is cost competitive with traditional vegetation management, and benefits wildlife, then Integrated Vegetation Management techniques can be used on several thousand acres of right-of-way in the BGE service area.” (USFWS 2010).

The Davidsonville project is located along 5 miles of 500kv transmission line right-of-way. The project uses management methods that integrate strategic cutting and herbicide treatment to improve conditions for animal and plant life by restoring natural ecosystems, while at the same time ensuring the safe and reliable delivery of electricity.

The U.S. Environmental Protection Agency (EPA), U. S. Fish and Wildlife Service and environmental advocacy groups toured a section of the pilot, as part of a day-long workshop requested by the EPA Office of Pesticide Programs to enhance the agency’s understanding of vegetation management practices that promote environmental sustainability. The workshop was organized by the non-profit corporation Integrated Vegetation Management (IVM) Partners, with participation from Chesapeake Wildlife Heritage and industry experts.
**7.2.1 IVM Partners, LLC**

IVM Partners is a private non-profit organization that acts as a liaison between industry, public agencies, conservation and academia so that best vegetation management practices are used to resolve vegetation problems, control invasive weeds, improve wildlife and endangered species habitat and lower the risk of wildfire. The organization acts as an advisor and trainer for federal and state land management agencies and conducts IVM and Ecosystem Management Workshops that include field tours of botanically documented case study sites with equipment demonstrations. Much of the Integrated Vegetation Management protocols developed in the northeast over the last decade were developed in consultation with IVM personnel.

Work in the mid-Atlantic region includes assisting Eastern Neck National Wildlife Refuge in controlling invasive weeds and improving wildlife habitat, and is administering vegetation and ecosystem management best practice case studies for Baltimore Gas & Electric. IVM Partners is presently also assisting Columbia Gas and CenterPoint Energy.

**7.3 Northeast Utilities System — Transmission Rights-of-Way Vegetation Management**

Northeast Utility (NU), the largest utility in the northeast United States, was the first utility in the country to receive the U.S. Environmental Protection Agency’s Champion Award for excellence in pesticide environmental stewardship by reducing the risks to the environment through the use of low-risk vegetation management strategies (NU, n.d.). NU maintains 36,359 acres of transmission rights-of-way in Connecticut, Massachusetts, and New Hampshire and promotes environmental stewardship in a variety of ways. The goal of the Northeast Utilities in vegetation management is to maintain stable low-growing grass, shrub, and wildflower communities to not only provide safe and reliable service, but to also enhance wildlife habitat. The Connecticut Audubon Society noted that the power line rights-of-way provide an important habitat for scrubland birds, one of the fastest declining bird groups in the United States NU publishes their own Overhead Transmission Line Standards, Specifications for Rights-of-Way Vegetation Management, and Best Management Practices Manuals.

**7.3.1 Northeast Utilities Transmission Line Standards**

NU Overhead Transmission Line Standards (2008) describe the vegetation clearing along rights-of-way for the construction of 115kV and 345 kV electric transmission lines. The initial clearance requirements of NU provide for adequate clearances for a period of four years. Subsequently, on-going scheduled maintenance reestablishes or maintains the initial clearance. The standards are consistent with the North American Electric Reliability Council (NERC) Vegetation Management Standard, The New England Independent System Operator’s vegetation clearing standard, and the National Electrical Safety Code as adopted by the Connecticut Department of Public Utility Control. Among the other provisions, the standards provide guidance for minimizing tree removal by:

1. *Designing new lines to keep the positions of new conductors as much as possible within an existing cleared right-of-way to avoid additional clearing:*
2. Removing non-compatible vegetation (trees and tall growing shrub species) from the area directly under the conductors and extending 15 feet horizontally outward from the outermost line conductors;

3. Allowing existing low-maturing tree species such as dogwoods to remain within the side zones (area outside of the conductor clearance zone extending to the edge of the Right-of-way clearing limits;

4. Re-establishing pre-existing access roads for construction vehicles to minimize the clearing of low growth within the existing corridor for access;

5. Locating new line structures close to old structures and overlapping the work areas of old structures to reduce to the amount of clearing for the new structure work areas;

6. Where feasible, using existing conductors to pull in new conductors, to reduce damage to low growth vegetation along the cleared corridor;

7. Engaging an arborist to determine individual “danger trees” for removal considering
   1) Species
   2) Soil conditions
      a) including wetland vs. upland
      b) susceptibility to flooding
      c) depth to rock (and adaptability of the species to those conditions)
   3) Health of the tree
   4) Inclination of trunk
   5) Shape of crown

NU Overhead Transmission Line Standards establishes criteria for six additional conditions. 

1. Clearance between conductors and woody vegetation for the construction of new lines.
2. Clearing for New Construction
3. Clearing for Structure Maintenance or the Replacement of an Existing Line
4. Decision Responsibility for Retention of Non-standard Woody Vegetation
5. Approving Managers and SME
6. Deviations

7.3.2 Northeast Utility Best Management Practices

Northeast Utilities publishes a Best Management Practices Manual for construction and maintenance for each of the three states where they manage utilities. Company policy directs workers to use environmentally sound best management practices, in order to follow clear and
enforceable environmental performance standards, regardless of whether a permit requires this level of environmental compliance. Where certain construction elements are not addressed by permit conditions, or where permitting is not required, the BMP manuals are considered Northeast Utilities’ standard.

The BMP’s address the disturbance of soils, water, and vegetation incidental to construction within utility corridors, and substations including the establishing access roads and work areas, in and near wetlands, watercourses, or other sensitive natural areas. Many projects are required to go through a full permit review by the NU Siting and Permitting Department.

7.3.2.1 Northeast Utility BMPS and Wetlands

Prior to any construction, all jurisdictional wetlands are delineated by a qualified professional and flagged in the field. Avoidance and minimization is the first option to avoid impacts to wetlands and sensitive areas. Alternate access routes and staging areas are considered as well as minimizing road widths, the use of low impact vehicles, coordinating time of work between July 1 and October 1, using swamp, timber, or similar mats in wetlands, and conducting work manually whenever possible. Preconstruction meetings are convened with interested parties and an environmental inspector may be hired. If work occurs in a wetland resource area or special habitat area, construction may be monitored by a qualified and pre-approved wetland or wildlife specialist. Signage is installed to identify critical boundaries and setbacks. The Northeast Utilities Best Management Practices Manual describes 28 different BMP’s (Table 11. These are described in detail in the manual.
<table>
<thead>
<tr>
<th>BMP Type</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hay (or straw) Bales</td>
<td>Erosion control; mulch</td>
</tr>
<tr>
<td>Silt Fencing</td>
<td>Sedimentation control; work limits; temporary animal barrier</td>
</tr>
<tr>
<td>Erosion Control Blankets</td>
<td>Slope stabilization</td>
</tr>
<tr>
<td>Straw Wattles</td>
<td>Erosion and sedimentation control</td>
</tr>
<tr>
<td>Wood Chip Bags</td>
<td>Erosion and sedimentation control</td>
</tr>
<tr>
<td>Temporary Swales</td>
<td>Stormwater management</td>
</tr>
<tr>
<td>Water Bars</td>
<td>Stormwater management ; erosion control</td>
</tr>
<tr>
<td>Temporary Sediment Basins</td>
<td>Stormwater management ; dewatering</td>
</tr>
<tr>
<td>Swamp Mats—as Bridges</td>
<td>Stream crossings</td>
</tr>
<tr>
<td>Culverts</td>
<td>Stream crossings</td>
</tr>
<tr>
<td>Poled Fords</td>
<td>Stream crossings</td>
</tr>
<tr>
<td>Swamp/Timber mats</td>
<td>Wetland crossings/rut minimization</td>
</tr>
<tr>
<td>AlturnaMATS</td>
<td>Wetland crossings/rut minimization</td>
</tr>
<tr>
<td>Low Ground Pressure Equipment</td>
<td>Wetland crossings/rut minimization</td>
</tr>
<tr>
<td>Wide Tires</td>
<td>Wetland crossings/rut minimization</td>
</tr>
<tr>
<td>Rubberized Tracks</td>
<td>Wetland crossings/rut minimization</td>
</tr>
<tr>
<td>Lightweight Equipment</td>
<td>Wetland crossings/rut minimization</td>
</tr>
<tr>
<td>Timing of Work</td>
<td>Overall minimization/avoidance of impacts</td>
</tr>
<tr>
<td>Manual Access</td>
<td>Overall minimization/avoidance of impacts</td>
</tr>
<tr>
<td>Overhead/Aerial Access</td>
<td>Overall minimization/avoidance of impacts</td>
</tr>
<tr>
<td>Construction Entrance Track Pads</td>
<td>Prevention of roadway damage</td>
</tr>
<tr>
<td>Inlet/Catch Basin Sediment Filters</td>
<td>Dewatering</td>
</tr>
<tr>
<td>Discharge Hose Filter Socks</td>
<td>Dewatering</td>
</tr>
<tr>
<td>Frac Tanks</td>
<td>Dewatering; managing contaminated groundwater</td>
</tr>
<tr>
<td>Coffer Dam and Stream Bypass</td>
<td>Dewatering/ diversions</td>
</tr>
<tr>
<td>Pumping</td>
<td>Dewatering/ diversions</td>
</tr>
<tr>
<td>Coffer Dam and Stream Bypass via Gravity</td>
<td>Dewatering/ diversions</td>
</tr>
<tr>
<td>Mulching with Hay/Straw/Woodchips</td>
<td>Erosion control; site restoration</td>
</tr>
<tr>
<td>Coir Log Use for Bank Stabilization</td>
<td>Bank stabilization; site restoration</td>
</tr>
</tbody>
</table>
7.4 New Hampshire Department of Environmental Services-- BMP Manual for Utility Maintenance in and Adjacent to Wetlands and Waterbodies

The New Hampshire Department of Environmental Services published the Best Practices Manual for Utility Maintenance in and adjacent to Wetlands and Waterbodies in New Hampshire in 2009. This case study is included as an example of a state agency providing guidance to electric, gas and other utilities and their contractors in order to identify appropriate means and methods for vegetation management in or within the vicinity of jurisdictional wetlands. The manual does not address new construction of utilities or access roads or herbicide or pesticide application for vegetation management.

7.4.1 Identifying Wetlands

The manual provides a 15-page introduction with illustrations to identifying wetlands including:

- Wetland types
- Wetland Vegetation
- Hydric soils
- Wetland Hydrology
- How To Identify Wetlands (basic guidelines, not a complete review of the USACE 1987 method)
- Invasive species (introduction to Purple Loosetrife and Common reed only).

7.4.2 Maintenance Activities Covered

The activities that are covered by the manual include:

- Cyclical and Emergency Vegetation Management
- Line Maintenance and Repair
- Inspection Activities
- Ground Line Treatment Programs.

7.4.3 General Management Practices

Several measures are summarized to occur prior to any maintenance practice:

- Avoidance and minimization;
- Selectively cut trees in low-growing native wetlands;
- Maintain equipment in good operating order;
- Pre-job briefing between utility owner and subcontractors to communicate location of existing wetlands and expected methods around and in wetlands;
- Areas dominated by invasive plants should be manually cut if possible;
- Use established access-ways;
- Contact the utility service provider immediately with problems;
• Do not store fuel, hydraulic fluids and dust control or other materials within 100 feet of wetlands;
• Dispose of waste products properly;

7.4.4 Operating Adjacent to Wetlands and Waterbodies

• Preserve all low growing vegetation;
• Do not remove rocks or stumps, do not excavate, or grade;
• Dispose of sediments in uplands and stabilize;
• No parking equipment or fueling; minimize equipment operation.

7.4.5 Crossing Wetlands

• Cross if possible without disturbing soils or rutting landscape, e.g. using tracked machines;
• Restore ruts less than 8” within 72 hours;
• Use mats if ruts are expected to be more than 8”;
• Areas disturbed over 100 SF should be over-seeded with seed mix specified in BMP manual [specs include annual and perennial turf grasses- including tall fescue, which is disallowed by MDE, and birds-foot trefoil, an exotic invasive perennial legume used in pastures (USDA 2006)]

7.4.6 Invasive Species

• Avoid disturbing invasive species;
• Hand-cut woody vegetation instead of mechanically cutting in order to avoid disturbance;
• Limit disturbance;
• Completely clean machinery after working in a stand of invasive plants prior to moving to another location;

7.4.7 Restoration of Disturbed Areas

Table 12 shows summarizes the restoration requirements based on type of disturbance.
Table 12

**Restoration Requirements**

(New Hampshire Department of Environmental Services 2009)

<table>
<thead>
<tr>
<th>Restoration Table</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Ruts &lt; 8&quot;</td>
</tr>
<tr>
<td>Ruts &gt; 8&quot;</td>
</tr>
<tr>
<td>Exposed soil in Wetland</td>
</tr>
<tr>
<td>Exposed soil in Upland*</td>
</tr>
<tr>
<td>Impacts &lt; 3000 sq. ft.</td>
</tr>
<tr>
<td>Impacts &gt; 3000 sq. ft.</td>
</tr>
</tbody>
</table>

*Note - Action would only be required if disturbed upland soils could adversely impact an adjacent wetland or waterbody

**Note – Standard Dredge and Fill Application or Emergency Permit**

**7.4.8 Regrading**

- Hand methods preferred
- Mechanical methods allowed if they do not cause additional rutting.

**7.4.9 BMP’s**

The manual provides details on (14) best management practices listed below and includes the appropriate application, limitations, standards and specifications, materials, installation, maintenance and inspection of each.

1. Silt Fence
2. Weed Free Bale Barrier
3. Silt Fence / Weed Free Bale Barrier
4. Seeding Options
5. Appropriate Mulching Material
6. Prefabricated Mats
7. Corduroy
8. Poled Ford
9. Access Way Stabilization
10. Reinforced Silt Fence
11. Sediment Filter
12. Stone Check Dams
13. Earth Dike / Drainage Swale and Lined Ditch
14. Dewatering
7.4.10 More Information


7.5 Dairyland Power Cooperative—Manual for Transmission Lines and Substation Construction and Maintenance Activities

Dairyland Power Cooperative (DPC) is a generation and transmission cooperative based in La Crosse, Wisconsin that provides wholesale electrical energy to 25 member cooperatives and 20 municipalities. DPC service area comprises 62 counties in Illinois, Iowa, Minnesota. The Manual for Transmission Lines and Substation Construction and Maintenance Activities provides DCP’s staff, consultants, and contractors with a comprehensive source for BMPs related to earth disturbing activities during construction, repair, and maintenance work associated with transmission lines, substations, and other cooperative projects.

The manual in its content is similar to other examples of BMP manuals reviewed above. The content, however, is presented in a graphically appealing way with some photographs of practices which give a clear illustration of how they are applied in the landscape (Figure 20). In addition, each practice is footnoted with websites on the page where they appear so that further information can be quickly retrieved.

The major difference in content between the Dairyland manual and others is 20 pages devoted to vegetative stabilization, with native species represented by state, and a section on revegetation at wetland crossings. Summary examples of the content on vegetative stabilization and revegetation are presented below.

Figure 20

Timber Bridge
(Dairyland Power 2007)
7.5.1 Vegetative Stabilization

Vegetative stabilization is identified as temporary or permanent. Temporary stabilization is a means of growing vegetative cover for less than five years on areas that will not be brought to final grade for a period over 14 days. Permanent stabilization is recommended for areas that will be stabilized for over five years.

Dairyland provides seeding information particular to each of the states in their jurisdiction—Illinois, Minnesota, Iowa, and Wisconsin, including: soil characteristics, temporary and permanent seeding recommendations, sodding, required maintenance and local seed vendors. Of the four states in Dairyland’s jurisdiction, the Minnesota specifications, from the Department of Transportation are the most detailed, and so are presented here as an example.

7.5.1.1 Minnesota Vegetative Stabilization

Minnesota has highly erodible soils in much of the eastern and central part of the state, requiring detailed attention to scheduling and site preparation. Winter months when ground is frozen, and periods of low rain are recommended for site disturbances.

Seed specifications are adapted from the Minnesota Department of Transportation14. MDOT uses 21 different seed mixtures on road construction projects—nine of the mixtures of native grasses or forbs; eight consist primarily of non-native grasses and legumes; and three are temporary or interim cover crops. A number of non-native mixtures contain some native grasses as well as non-native grasses. This diversity of mixes allows MDOT to adapt plantings to specific environments. For example, two of the mixes are salt tolerant, several consist of shorter species, some are lawn/boulevard mixes, and some are very low maintenance. There are two types of native seed mixtures: (1) tall grasses and forbs and (2) short and mid-height grasses.

7.5.1.1.2 Temporary Seeding

Table 7 lists the species recommended for temporary seeding. The manual lists three different mixes of these species depending on the planting season and years of cover needed (up to 5 years). Lime is recommended when subsoils are pH of 6.2 or less, at a rate of 2 tons per acre.

Seedbed preparations, fertilizer recommendations and seeding methods are covered in the manual for four methods of temporary seeding:

- Drop Seeding;
- Hydroseeding;
- Broadcast Seeding;
- Interseeding.

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Table 7

Species for Temporary Seeding in Minnesota
(Dairyland 2007)

<table>
<thead>
<tr>
<th>Common Name</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rye-grass, perennial</td>
<td>Alfalfa, creeping</td>
</tr>
<tr>
<td>Wheat-grass, slender</td>
<td>Brome grass, smooth</td>
</tr>
<tr>
<td>Red clover</td>
<td>Rye-grass, perennial</td>
</tr>
<tr>
<td>Alfalfa, vernal</td>
<td>Vetch, hairy</td>
</tr>
<tr>
<td>Alsike Clover</td>
<td></td>
</tr>
</tbody>
</table>

7.5.1.1.3 Permanent Seeding

Some of the recommended species for permanent seeding and maintenance of turf, pasture, and native grasses are listed in Table 8.
<table>
<thead>
<tr>
<th>Land Use</th>
<th>Species</th>
<th>Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Roadside</td>
<td>Brome grass, smooth Swirtch grass Went-grass, slender Rye-grass, perennial Timothy Redtop Alfalfa, creeping White clover</td>
<td>Mow up to 3 times per year</td>
</tr>
<tr>
<td>Commercial Turf</td>
<td>Bluegrass, “Kentucky Certified Park” Bluegrass, Canada Bluegrass, Kentucky Low Maintenance Fescue, hard Rye-grass, perennial</td>
<td>Mow a minimum of once per 2 weeks</td>
</tr>
<tr>
<td>Residential Turf</td>
<td>Bluegrass, “Kentucky –Elite Bluegrass, Kentucky-Improved Bluegrass, Kentuckyk-Low Maintenance Red fescue, creeping Rye-grass, perennial</td>
<td>Mow a minimum of once per 2 weeks</td>
</tr>
<tr>
<td>Agricultural Area Roadside</td>
<td>Alfalfa, creeping Brome grass, smooth Redtop Rye-grass, perennial Switch grass Timothy Wheat-grass, slender</td>
<td>Mow up to 3 times per year</td>
</tr>
<tr>
<td>Ponds &amp; wet areas</td>
<td>Bluestem, big Indian grass Wild-rye, Virginia Switch grass Blue-joint grass Green bulrush Wool grass Giant bur reed Cordgrass, prairie</td>
<td>To reduce weed establishment, mow 2 to 3 times (30 days apart) during 1st year with the mower deck about 6”-8” off the ground. Mow one time during 2nd year before weeds set their seeds. Burn or mow once every 3 to 5 years following the initial 2 years of maintenance to remove dead plant material and stimulate new seed.</td>
</tr>
<tr>
<td>Sandy, dry areas</td>
<td>Gramma, sideoats Gramma, blue Bluestem, little June grass Dropseed, sand Wild-rye, Canadian Bluestem, big Switch grass Bluegrass, Canada</td>
<td></td>
</tr>
<tr>
<td>General Roadside</td>
<td>Bluestem, big Indian grass Bluestem, little Grama, sideoats Wild-rye Canadian Switch grass</td>
<td></td>
</tr>
</tbody>
</table>
7.5.1.1.2 Wetland Vegetation

The Dairyland Manual includes some general provisions when revegetating wetland crossings,

- Do not apply fertilizer or lime, unless required in writing by the appropriate state permitting agency.
- State approval is necessary for mulching in wetlands. Straw or hay can be used as mulch but must be free of noxious weed contaminants. Mulching is more successful if it is applied in “air dried” condition, and is anchored by disking.
- Temporarily vegetate disturbed areas with the appropriate seed specified... unless standing water is prevalent or permanent planting or seeding with native wetland vegetation is established.
- [For permanent seeding, consult with a wetland scientist for a vegetation plan.

For wetland revegetation specifications, the MDOT Seeding Manual references the Minnesota Board of Water and Soil Resources (MBWSR) for wetland seeding specifications. MBWSR specifies native seeds in conformance with recent legislation of the State of Minnesota:

“To the extent possible, any person conducting a restoration with money appropriated in this section must plant vegetation or sow seed only of ecotypes native to Minnesota, and preferably of the local ecotype, using a high diversity of species originating from as close to the restoration site as possible, and protect existing native prairies from genetic contamination.”

Minnesota BWSR, MD/DOT and DNR recently revised and consolidated their standard seed mixes in 2010. Seed mix numbers provide information about the use and content of the mix. This numbering system can be used to guide the user in choosing the right mix for a given project. Wetland seed mixes are listed below (Table 15.
### Table 15

**Wetland Seed Mixes**

(MBWSR 2010)

**Wetland Rehabilitation**

Use: Inter-seeding into establishing wetlands after weed control spraying. Also suitable for two to five year short term soil stabilization for areas with saturated soils.

Range: Statewide

**Emergent Wetland**

Use: Emergent wetland restoration for use in wetland mitigation, shoreline restoration, wet stormwater ponds where emergent vegetation is desired. Usually used in a 10 ft. band around open water.

Range: Statewide

**Riparian South & West**

Use: Native riparian and floodplain plantings for wetland mitigation, ecological restoration, or general permanent cover. Tolerates partial shade.

Range: Tallgrass Aspen Parklands, Prairie Parkland, and Eastern Broadleaf Forest Provinces.

**Wet Prairie**

Use: Wet prairie reconstruction for wetland mitigation or ecological restoration.

Range: Tallgrass Aspen Parklands, Prairie Parkland, and Eastern Broadleaf Forest Provinces.

**Wet Meadow South & West**

Use: Wet meadow / Sedge meadow reconstruction for wetland mitigation or ecological restoration projects.

Range: Tallgrass Aspen Parklands, Prairie Parkland, and Eastern Broadleaf Forest Provinces.

**Riparian Northeast**

Use: Native riparian and floodplain plantings for wetland mitigation, ecological restoration, or general permanent cover. Tolerates partial shade.

Range: Laurentian Mixed Forest Province.