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A Review of Wetland Preservation and Restoration Techniques Following Natural Gas Pipeline Construction

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March 2004

Research of Wetland Construction and Mitigation Activities for Certificated Section 7(c) Pipeline Projects

Washington, D.C. 20426

RESEARCH OF WETLAND CONSTRUCTION AND MITIGATION ACTIVITIES FOR CERTIFICATED SECTION 7(c) PIPELINE PROJECTS

Federal Energy Regulatory Commission
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EXECUTIVE SUMMARY

The Federal Energy Regulatory Commission (FERC) undertook this study, *Research of Wetland Construction and Mitigation Activities for Certificated Section 7(c) Pipeline Projects*, to evaluate the effectiveness of the wetland provisions in the 1994 *Wetland and Waterbody Construction and Mitigation Procedures* (1994 Procedures) and to determine if natural gas pipeline companies were successful in restoring wetlands following pipeline construction, according to the FERC's criteria for success. These criteria require that the post-construction wetlands have at least 80 percent vegetative cover by native species, that the plant diversity of the restored wetland be at least 50 percent that of the pre-construction condition, and that the wetland satisfies the requirements of the current Federal methodology for identifying and delineating wetlands.

A fundamental objective of this study was to evaluate the success of wetland restoration for pipeline projects from diverse geographic regions throughout the United States to determine if there was a regional difference. The study design was based on Robert G. Bailey's *Ecoregions of the United States*, and six separate ecoregion divisions were sampled throughout the United States. Field data were collected at 80 on-right-of-way (ROW) and 80 off-ROW sites within each of the six ecoregions, resulting in a total of 960 wetlands sampled. These wetlands were located along 13 different pipeline projects within 15 different states. Field data collection started in August 2002 and was completed in June of 2003.

Collected data were then entered into a Microsoft© Access Database specifically designed for the project. Queries were written to test each wetland against the success criteria established by FERC staff in the 1994 Procedures (Appendix A). Query results were then reviewed to identify trends that could be attributed to wetland restoration success or failure. These trends were then tested to determine statistical significance (Appendix B).

Results

Wetlands designated as "passing" the FERC criteria were required to meet all three of the

Restoration criteria. Wetlands identified as "failing" failed one or more of the three criteria. Wetland restoration success rates ranged from 89% in the humid eastern ecoregions, to 32% in the arid western ecoregions. The overall nationwide wetland restoration success rate based on the 1994 Procedures was 65% (313 wetlands) and the failure rate was 35% (167 wetlands). A total of 86% (411) of the wetlands surveyed met the definition for a federal wetland following construction. The most common single factor contributing to restoration failure was wetlands having less than 80% percent vegetative cover by native species.

Statistical tests, including nine independent factors, revealed three factors as having a significant influence on whether or not a wetland was successfully restored. These three factors were, ecoregion, evidence of human disturbance (post-construction), and whether or not the wetland was restored to preconstruction grades (construction). Based on statistical testing, wetlands located in the Midwestern and eastern ecoregions had a statistically greater success rate than those in the western ecoregions. Wetlands exhibiting evidence of human disturbance were less likely to be successfully restored. Wetlands not restored to preconstruction grades were also less likely to be successfully restored.

Conclusions

A variety of factors that could potentially influence success were examined and are presented in Section 4 of this report. The following is a summary of conclusions and notable trends:

- Existing wetland monitoring reports were largely unavailable from pipeline companies contacted. Based on post-construction wetland monitoring reports that were received, it is evident that the pipeline industry does not have a consistent approach to performing post-construction wetland monitoring. The FERC's revised 2003 Procedures (VI.D.3.) now requires that a report be filed with the Secretary identifying the status of the wetland revegetation efforts at the end of three years following construction. This requirement is anticipated to improve the status of post-construction wetland monitoring for pipeline projects.

- Based on detailed quantitative field studies, approximately two thirds of all wetlands studied nationwide achieved all three wetland restoration success criteria identified in the 1994 Procedures. Most wetlands that failed the FERC success criteria failed due to insufficient vegetative cover.

- The study revealed strong differences in overall success by ecoregion. Eastern and Midwestern wetlands have significantly higher success rates than Western ecoregions. Regional climates and weather conditions reveal noticeable trends in relative wetland restoration success and failure.
- The presence of human disturbance in wetlands was associated with higher failure rates, likely due to its influences on the percent vegetative cover criterion. The most common human disturbance category was farming, which includes cattle grazing, and could be a contributing factor to the lower success rate for wetlands occurring in the western ecoregions.
- Wetlands that achieved pre-construction grades (i.e., grading of the wetland was reestablished to pre-construction conditions) were significantly more successful than wetlands that did not meet pre-construction grades.
- Soil conditions appear to have some influence on wetland revegetation success, with wetlands underlain by clay-dominated soils having a greater failure rate than wetlands dominated by other soil types. Although this was a noticeable trend, soil texture was not a significant factor based on the statistical analysis.
- The data showed a strong trend of conversion of forested and scrub-shrub wetlands to emergent wetlands. This observation may be the result of the short period of time since implementation of the 1994 Procedures relative to the expected time frame for the re-establishment of arboreal vegetation. Therefore, this trend is considered inconclusive. In addition, we expect this trend to persist over portions of the ROW because ROW vegetation maintenance (removal of woody vegetation over the pipeline) is commonly used to facilitate monitoring required by the U.S. Department of Transportation to ensure pipeline integrity.

Recommendations

The following is a summary of recommendations resulting from this study:

- Methods used to monitor wetland restoration success should be standardized to ensure that wetland restoration can be evaluated consistently between Projects and geographic regions over time. The wetland monitoring dataform used for this study (Appendix D) should be used as a template for future wetlands monitoring.

- Wetlands in the arid western ecoregions have a much higher rate of failure than wetlands in more humid regions of the country. This stark contrast warrants consideration of a modified version of the Procedures for the western regions that takes into consideration climate differences and local successional processes. Duration of monitoring and success criteria may need to be modified for these regions (i.e., longer monitoring periods, lower cover and diversity requirements, etc.).

- Evidence of human disturbance was associated with lower success rates regardless of ecoregion, and, evidence of human disturbance was more prevalent for the western ecoregions than the eastern ecoregions. Post-construction monitoring to evaluate the effects of human disturbance on wetland restoration should be encouraged so that remedial measures can be suggested.

- Although only 23 of the 480 wetlands were not restored to pre-construction grades, this factor had a substantive effect in determining success. Therefore, current procedures that enforce the restoration of pre-construction grades should continue to be developed.

- FERC may want to consider modifying the criteria, as follows:

  - Wetlands with standing water commonly have areas of vegetation interspersed with open water, and therefore are characterized as having less than 80% cover of vegetation (due to greater than 20% open water). The open water/vegetation mix is generally considered to be a positive habitat feature and thus should not be discouraged except in instances where standing water indicates that post-construction grades were established lower than pre-construction conditions.

- Pipeline companies should be encouraged to identify "problem wetlands" (i.e., wetlands with greater than 20% surface rock or open water, shallow to bedrock soils, or wetlands dominated by annual plant species) to the FERC staff prior to construction and provide ample pre-construction photographic documentation for these wetlands. These wetlands should be considered “successfully restored” following construction, if pre-construction conditions are reestablished and this can be documented to the satisfaction of FERC staff.

- Farmed wetlands – Once a ROW is cleared, farmers often take advantage of the additional area and moist soils of seasonally saturated wetlands to plant additional crops or graze cattle. The presence of agricultural activity greatly reduces the chances that a wetland will meet the criteria for restored wetland. This issue was addressed in the revised 2003 Procedures (Section I.B.2.) where wetlands that are actively cultivated, or are considered rotated cropland, are excluded from the definition of a "wetland".

- Post-construction human disturbance is observed on two-thirds of all failed wetlands and is likely a contributing factor in failure. These extenuating circumstances should be considered when evaluating wetland restoration success.

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1.0 INTRODUCTION

In 1994, the staff of the Federal Energy Regulatory Commission (FERC) established its minimum guidelines for minimizing wetland impacts during construction of natural gas pipelines by issuing the "*Wetland and Waterbody Construction and Mitigation Procedures*" (1994 Procedures). These 1994 Procedures were developed based on a compilation of FERC staff (Staff) project experience and many years of project feedback relating to pipeline construction and wetland impact minimization from local, state, and Federal regulators across the United States. Adherence to the measures prescribed in the 1994 Procedures is generally considered by the FERC staff to be the baseline (minimal) mitigation appropriate for construction of natural gas projects.

Since issuance of the 1994 Procedures, the FERC has generally required all jurisdictional pipeline construction projects to adopt the 1994 Procedures, or similar approved, company-identified procedures, that offer a comparable or greater level of environmental protection. The FERC staff has gained valuable insight into the effectiveness of the 1994 Procedures through their ongoing construction inspection program. However, attempts to quantify the effectiveness of the 1994 Procedures in relation to wetland restoration had not previously been examined. The FERC initiated this study to evaluate the long-term effectiveness of the 1994 Procedures and to determine if changes to the Procedures are warranted.

The 1994 Procedures identified three success criteria that must all be met for the wetland to be considered successfully restored:

1. The area must satisfy the requirements of the current Federal methodology for identifying and delineating wetlands (Section I.C.2.)
2. The wetland must have at least 80 percent vegetative cover by native species (Section VI.E.3.)
3. The diversity of native species must be at least 50 percent of the diversity originally found in the wetland (Section VI.E.3.)

2.0 STUDY OBJECTIVES

A number of objectives were established to meet the goal of determining if the 1994 Procedures were facilitating successful restoration of wetlands. These objectives were a direct outcome of a project scoping meeting held during October 2001 at the FERC office in Washington, D.C. At this meeting, FERC biologists, regulatory staff, and FERC's environmental consultants, Northern Ecological Associates, Inc. (NEA) and Tetra Tech, (the Team) worked together to refine study objectives, and to identify the most appropriate means for achieving both the overall goal and the objectives.

The following objectives were identified:

1. Compile information from pipelines and wetlands in diverse regions of the United States;
2. Examine wetlands of various cover types in approximate proportion to their abundance in that region of the country;
3. Examine the influence of physical factors on the success of wetland restoration, including hydrology, landscape position, soil textural class, subsoil/topsoil mixing, etc.;
4. Examine the significance of human-caused factors on success of wetland restoration, including improper construction of waterbars, inadequate removal of construction debris, and post-construction disturbances such as ATV traffic, farming, logging, or residential/commercial development;
5. Document trends in post-construction vegetation communities; and,
6. Evaluate a subset of the most frequently requested exceptions (variances) to the 1994 Procedures.

A number of other items related to the scope, objectives, and methods of the study were discussed at the October 2001, and subsequent June 2002, Team meetings.

An initial aspect of the study was to establish the quality and quantity of existing post-construction monitoring data previously compiled by pipeline companies. Section 3.1 of this report (Data Sources) addresses this in detail. Depending on these data, a set of regionally diverse pipeline projects, certificated after the issuance of the 1994 Procedures (December 1994), were selected for inclusion in the study.

The project also included design and application of a specially designed Microsoft© Access Database (hereafter "the Database") for organizing and analyzing all data collected for the study. A unique data form was created to facilitate the timely collection of the data. The data form was designed to operate on a handheld field computer (PDA device) and to allow for easy transfer to the Database. Data were then analyzed to identify trends associated with successful and unsuccessful wetland restoration. These trends were analyzed to allow a critical review of the 1994 Procedures and their implementation by the natural gas industry, and to identify whether modifications to the 1994 Procedures may be warranted to improve wetland restoration success

3.0 METHODS

3.1 DATA SOURCES

An original directive of the project was to use existing monitoring data previously compiled by individual pipeline companies to the greatest extent possible. Section VI.E.3, *Post Construction Maintenance*, of the 1994 Procedures requires certificate holders[1] to monitor the success of wetland revegetation annually for the first 3 to 5 years after construction. However, because the FERC did not require formal filing of wetland monitoring reports during the study period, it was necessary to obtain this information from the pipeline companies directly. Because both the availability and quality of the existing data was uncertain, the following phased approach was used for this assessment of data sources:

- Phase I - Existing monitoring data would be collected from pipeline companies for pipeline projects constructed between 1994 and 1999. (The 1999 end date was established to allow for a minimum of three growing seasons following construction; 1994 is the effective date of the Procedures.)
- Phase II - Field verification would be conducted to supplement existing monitoring data. The original proposal assumed that existing data would be supplemented with newly collected data from 250 wetlands. This phase would include on-site wetland monitoring of selected pipeline projects based on an ecologically significant division of the United States.
- Phase III – Post-construction wetland monitoring data derived from Phases I and II would then be transferred into a project-specific Database, analyzed, trends identified, and presented in draft and final reports to the FERC.

Following the initial scoping meeting, the FERC compiled a list of 117 pipeline construction projects constructed between 1994 and 1999. These projects were constructed by 24 different pipeline companies. For each pipeline company, the Team identified a single point of contact for acquisition of the required data. A letter formally

1 A certificate holder is an individual or company that has received a Certificate of Public Convenience and Necessity pursuant to Section 7(c) of the Natural Gas Act.

requesting copies of existing wetlands monitoring data was sent to each of these companies in January of 2002. Follow up telephone calls were made to ensure the letter was received, and to answer questions regarding the request. Table 3-1 provides a summary of the Phase I Existing Monitoring Data Collection Task.

Table 3-1. Results of Phase I – Existing Wetlands Monitoring Data Collection.

Result	Companies	Projects
Information Received and of Good Quality[1]	9	14
Information Not Available	7	72
Information Available, but Not Submitted	3	8
No Response or Wetlands Not Crossed	5	23
Totals	24	117

[1] Wetland monitoring reports were considered "good quality" if they included data for percent cover and diversity and identified the methods used to obtain the data.

Wetland monitoring reports of relatively good quality were received from 9 pipeline companies representing 14 pipeline projects. However, further review revealed that the data collected varied widely in sampling methods, types of information collected, and the format of monitoring results.

Following this phase of the project, another status meeting was held at the FERC's Washington, D.C. offices in June of 2002. During this meeting the Team presented the results of the Phase I data collection. The Team agreed that insufficient existing monitoring data were available and that additional field data collection would be necessary. After thorough review, a revised study approach was approved by the FERC in August of 2002.

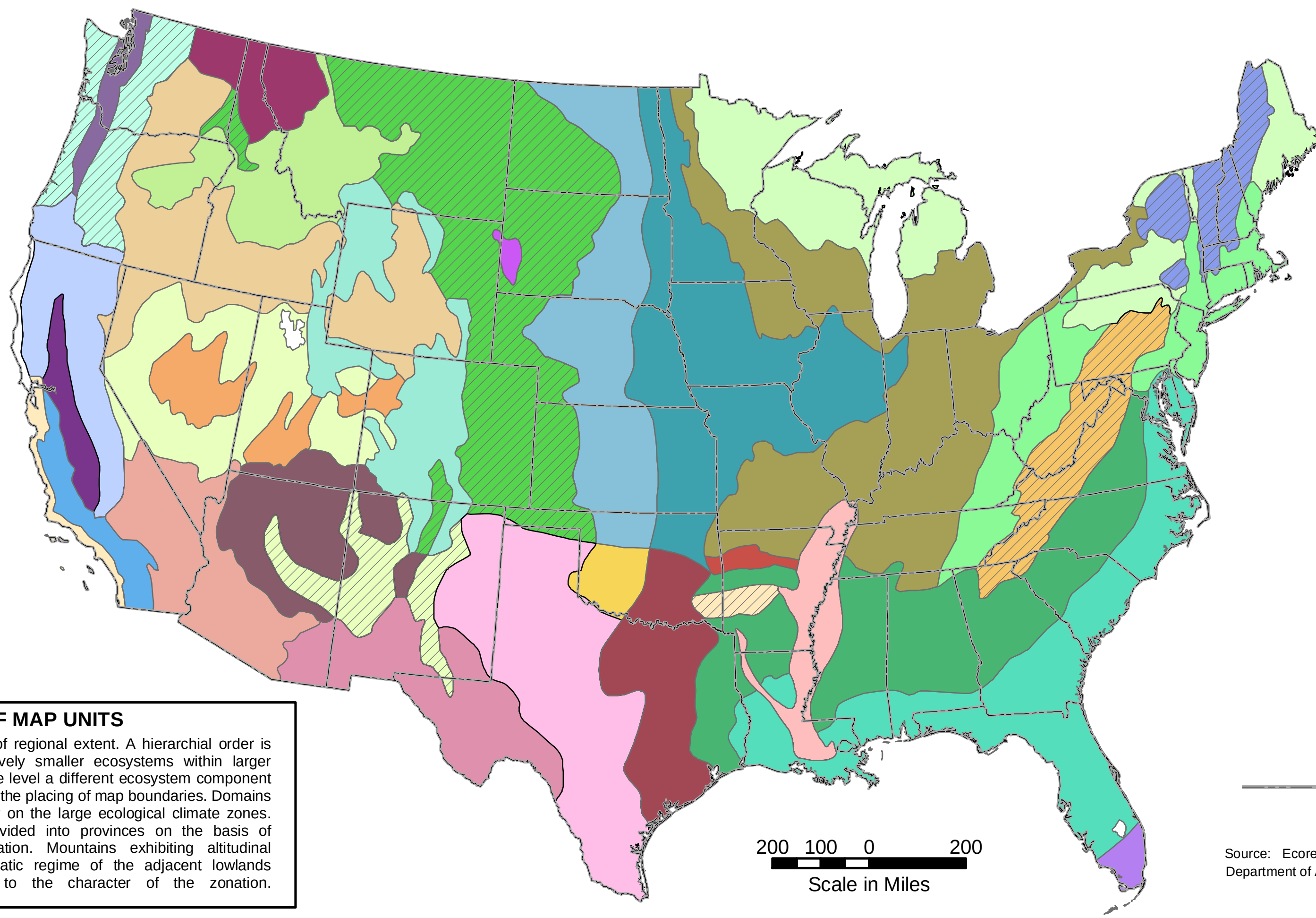
The new approach proposed collection of all new field data to ensure a standardized data set for all wetlands surveyed. Additionally, to account for the preconstruction condition of the on-ROW wetland, a reference wetland would also be sampled. The reference wetland would be an undisturbed wetland, ideally a portion of the same wetland located adjacent to the construction ROW, but not impacted by construction. Best professional judgment would be used to select a reference wetland that would best represent the on-ROW wetland's preconstruction conditions.

This approach ensured that consistent qualitative and quantitative survey methods, criteria, and methods of analysis were applied to the study. New data would be collected from pipeline projects sampled from major ecoregions throughout the United States.
For maximum efficiency, pipeline projects to be sampled would be based on location within ecoregions, length of ROW, number of total wetlands along ROW, and access considerations.

3.2 STUDY DESIGN AND SITE SELECTION

A fundamental component of the study design was to evaluate projects from different regions throughout the United States and to evaluate differences in restoration results throughout the country. The Team determined that Robert G. Bailey's *Ecoregions of the United States*, (Figure 3-1) best represents the different climate zones within the conterminous United States and would yield the most meaningful results from an ecological perspective. In this system, ecoregions (regions of ecological significance) are mapped based on climate and vegetation. The result is a hierarchy containing three levels, *domains*, *divisions*, and *provinces*. *Domains* and *divisions*, the two broadest levels, are based on large ecological and climatic zones. The third level, *provinces*, is based on vegetational micro features. There are 4 *domains*, 13 *divisions*, and 52 *provinces* within the United States.

The *division* ecoregion level (Figure 3-2) was selected as the most appropriate for meeting study objectives. This was due largely to the logistics of collecting data sets large enough to allow meaningful analyses in 52 *provinces* and the limitations associated with evaluating only four *domains*, two of which (Polar and Humid Tropical) were likely to have very few, if any, pipeline projects to survey.



Source: Ecoregions of North America, Revised-1997. U.S. Department of Agiriculture, Forest Service Washington D.C.

BASIS OF MAP UNITS

This map depicts ecosystems of regional extent. A hierarchial order is obtained by defining successively smaller ecosystems within larger ecosystems. At each successive level a different ecosystem component is assigned prime importance in the placing of map boundaries. Domains and divisions are based largely on the large ecological climate zones. Each division is further subdivided into provinces on the basis of macro-features of the vegetation. Mountains exhibiting altitudinal zonation and having the climatic regime of the adjacent lowlands are distinguished according to the character of the zonation.

ECO-REGIONS

- Adirondack-New England Mixed Forest-Coniferous Forest-Alpine Meadow Province
- American Semi-Desert and Desert Province
- Arizona-New Mexico Mountains Semi-Desert-Open Woodland-Coniferous Forest-Alpine Meadow Province
- Black Hills Coniferous Forest Province
- California Coastal Chapparral Forest and Shrub Province
- California Coastal Range Open Woodland-Shrub-Coniferous Forest-Meadow Province
- California Dry Steppe Province
- Cascade Mixed Forest-Coniferous Forest-Alpine Meadow Province
- Central Appalachian Broadleaf Forest-Coniferous Forest-Meadow Province
- Chihuahuan Semi-Desert Province
- Colorado Plateau Semi-Desert Province
- Eastern Broadleaf Forest (Continental) Province
- Eastern Broadleaf Forest (Oceanic) Province
- Everglades Province
- Great Plains Steppe Province
- Great Plains Steppe and Shrub Province
- Great Plains-Palouse Dry Steppe Province
- Intermountain Semi-Desert Province
- Intermountain Semi-Desert and Desert Province
- Laurentian Mixed Forest Province
- Lower Mississippi Riverine Forest Province
- Middle Rocky Mountain Steppe-Coniferous Forest-Alpine Meadow Province
- Nevada-Utah Mountains-Semi-Desert-Coniferous Forest-Alpine Meadow Province
- Northern Rocky Mountain Forest-Steppe-Coniferous Forest-Alpine Meadow Province
- Ouachita Mixed Forest - Meadow Province
- Outer Coastal Plain Mixed Forest Province
- Ozark Broadleaf Forest - Meadow Province
- Pacific Lowland Mixed Forest Province
- Prairie Parkland (Subtropical) Province
- Prairie Parkland (Temperate) Province
- Sierran Steppe-Mixed Forest-Coniferous Forest-Alpine Meadow Province
- Southeastern Mixed Forest Province
- Southern Rocky Mountain Steppe-Open Woodland-Coniferous Forest-Alpine Meadow Province
- Southwest Plateau and Plains Dry Steppe and Shrub Province

Figure 3-1. Ecoregions of the United States
Robert G. Bailey
U.S. Forest Service

Federal Energy Regulatory Commission

Date: 01/04

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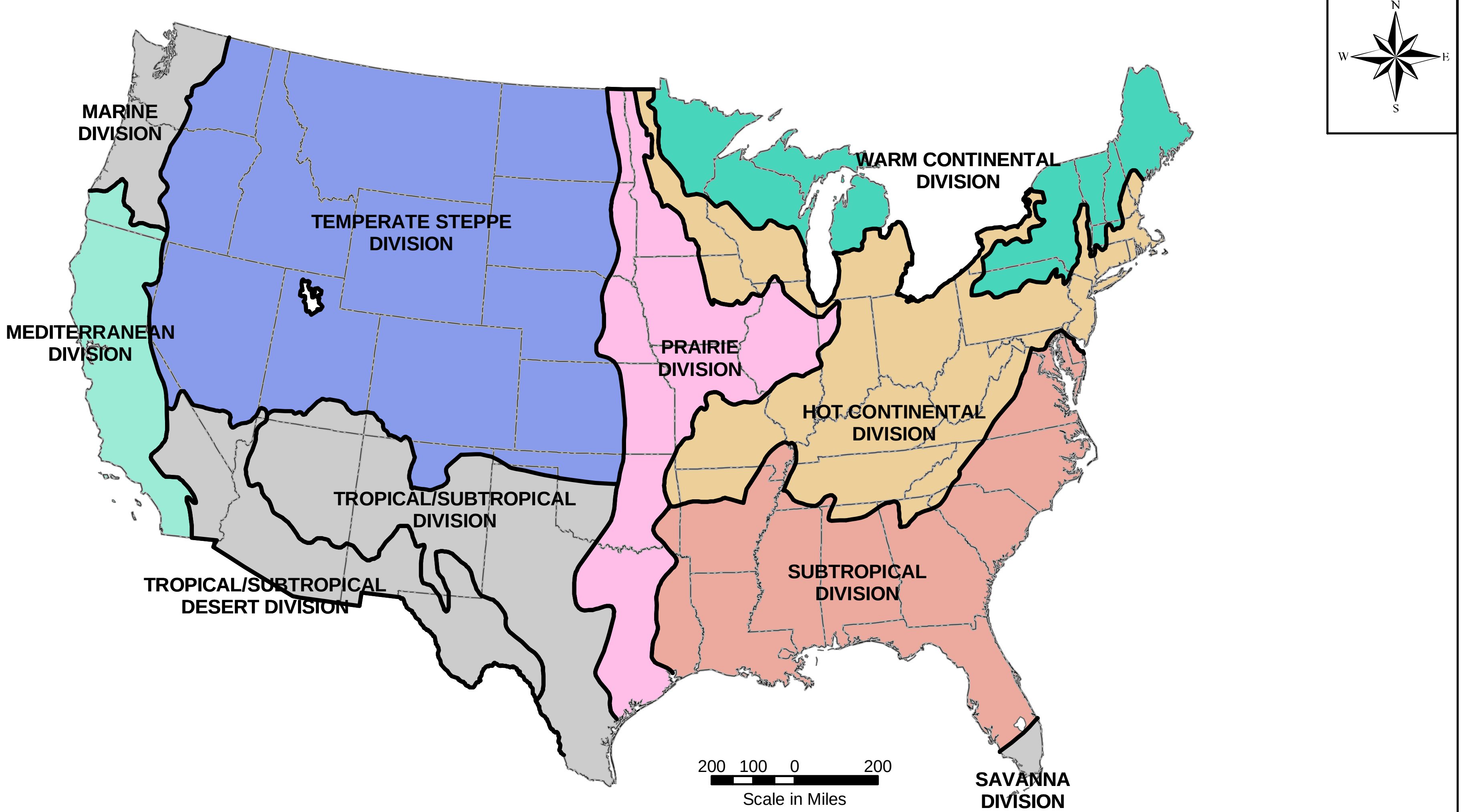

BASIS OF MAP UNITS

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Source: Ecoregions of North America, Revised-1997. U.S. Department of Agriculture, Forest Service Washington D.C.

Figure 3-2. Eco-Divisions Used to Select Wetlands to be Monitored

Federal Energy Regulatory Commission

Date: 01/04

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The "Ecoregions of the United States" map (revised 1994) was obtained in ARC/ INFO (GIS format) at a scale of 1:7,500,000 (1 inch=118 miles) from the U.S. Forest Service. Overlaying the 117 pipeline projects identified by the FERC on the ecoregion map, the Project Team determined that 6 of the 11 division-level ecoregions were well represented: Warm Continental, Hot Continental, Subtropical, Prairie, Temperate Steppe, and Mediterranean. Further, it was concluded that a minimum of 80 wetlands per division would be required for a valid sample size, such that, a total of 480 wetlands on ROW, and 480 reference wetlands (total of 960 wetlands) were proposed for monitoring in the six major ecoregions across the United States.

Projects were selected based on those with the maximum number of impacted wetlands and those within reasonable geographic proximity to other pipeline projects; so that the necessary 80-study area and 80 control wetlands per ecoregion could be efficiently surveyed. Pipeline projects surveyed within each ecoregion are presented in Figures 3-3 through 3-8 at the end of Section 3.

3.3 VEGETATION SAMPLING AND RIGHT-OF-WAY CHARACTERIZATION

A number of biological and physical parameters were identified that were critical for determining success of wetland restoration and for providing insight into the other study objectives. These parameters were measured using both qualitative and quantitative sampling methods, as described below.

3.3.1 Qualitative Assessment

Qualitative assessments included a general site reconnaissance of the wetland and visual assessment of the overall condition of the site. Visual observations were made and recorded on a variety of variables, including: surface grade, hydrology (surface water and drainage patterns), soil type, dominant plant species, vegetative cover, vegetation vigor, community composition, presence of stump resprouting, evidence of nuisance weed invasion, residual construction impacts (waterbars, construction debris, rock fragments, and topsoil and subsoil mixing), and land use impacts (off-road vehicle damage, erosion, farming, and residential or roadway construction). Additionally, an assessment based on best professional judgment was made in the field as to whether the wetland was, or was not, successfully restored.

Similar data were also collected for a "matching" reference wetland. The selected reference wetland was ideally an undisturbed portion of the same wetland located adjacent to the construction ROW, but not affected by construction. If an undisturbed portion of the same wetland was not available, best professional judgment was used to select an off-ROW reference wetland in close proximity that best represented the on-ROW wetland's preconstruction conditions.

For both the on-ROW and reference wetlands, observations were documented on the data form, sketches were recorded, digital photographs were taken, and GPS location data recorded.

3.3.2 Quantitative Assessment

The Braun-Blanquet Relevé Method (Barbour et. al. 1987), an established plant sampling technique, was utilized by field teams to collect data on species richness and vegetative cover. The Relevé Method involves an overall assessment of the wetland to determine the location that best represents the wetland plant community as a whole. This location then becomes the center of the sample plot. Minimum plot sample size is established based on an assessment of nested quadrats. For this study the initial quadrat consisted of a 1-meter radius, circular plot. The sample size is then increased until the sample plot contains 90 - 95% of the dominant species present in the plant community, identified during the initial qualitative assessment phase.

Several parameters are recorded within each quadrat. The parameters include percent cover of each species present and the number of plant species within each quadrat. Percent cover estimates were visually estimated within cover classes defined by the Braun-Blanquet cover scale (Table 3-2 [Barbour et al. 1987]).

Table 3-2. Cover Classes of Braun-Blanquet.

Class	Range of % Cover	Mean
5	75-100	87.5
4	50-75	62.5
3	25-50	37.5
2	5-25	15.0
1	1-5	2.5
T[1]	<1	0.1

[1] Individuals occurring seldom or only once: cover contribution assumed to be insignificant.

3.4 COLLECTION PROTOCOL

10 wetland biologists working in two-person field teams implemented the field data collection process. The teams sampled 13 pipeline projects in 15 states across six ecoregions, starting in August 2002 and ending in June of 2003. The study design targeted peak growing season for data collection within each of the ecoregions.

To ensure consistency in the field data collection, a two-day training session was conducted for all biologists participating in field surveys. The first half of the training consisted of an in-office review of the data form specifically designed for this study, and the format and objectives of the data to be collected. Data management protocols were also established for both paper and electronic data. Electronic data would be downloaded each night to avoid the possibility of losing data due to equipment failure or damage. Training was also provided on how to select reference wetlands as the best representation of what was likely the pre-construction condition of the on ROW wetland.

The second half of the training was in the field to ensure consistent interpretations of the field data collection protocol and to provide an opportunity for on-site discussions pertaining to any topic that might be unclear. Field teams were also instructed to prepare field sketches of wetland systems, take additional photographs where appropriate, and record observations relating to wetland field conditions.

Following field surveys, field teams immediately photocopied field survey notes and secured originals in appropriately designated binders to ensure that no data was lost or misfiled. Copies of the field notes were then used to perform quality assurance\quality control (QA\QC) on photo logs and for data entry into the specifically designed Database.

Preliminary queries were run on the Database following data entry to ensure accurate data entry and that no null values were observed in query results. Preliminary Vegetation and Diversity Summary Reports were also printed and reviewed for accuracy following each field survey event.

3.5 DATA ANALYSIS

After information on field data forms was entered into the Database, queries were written to test each wetland against the success criteria set by the FERC in the 1994 Procedures. Additionally, results from each of the queries were reviewed to identify trends that could be attributed to wetland restoration success or failure. Fields that were reviewed included pipeline construction year, current land use practices, climatic conditions, human disturbance, landscape position, soil type, and ecoregion. Reports for these analyses were designed into the Database and are included in Appendix A.

3.5.1 Analyses Relative to FERC Success

Total Vegetative Cover Criterion

Eighty percent (80%) vegetative cover was determined based on visual estimation of total vegetative cover for the portion of the wetland located on ROW. If the subject wetland had a vegetative cover of 80% or greater, the vegetative cover criterion was met. If the total vegetative cover was less than 80%, then the wetland failed to meet this success criterion.

Wetland Vegetation Criterion

Hydrophytes are species of plants adapted for life in wet conditions and that are typically found in wetland habitats. *The National List of Plant Species that Occur in Wetlands* (Reed 1988) (hereafter "National list") was used to determine which species are considered hydrophytes. A digital version of each regional list was obtained from the United States Fish and Wildlife Service (USFWS) and was inserted in the Database as the best representation of the National list. Regional lists were used to ensure that species occurring in more than one region were assigned the appropriate indicator status for the geographic region in which it was found.

Using the Database, the cover class midpoints (Table 3-2) for all hydrophytes were summed and the relative cover of hydrophytes was calculated by expressing the sum of the hydrophytes as a percentage of the sum of the midpoints for all the species recorded in the sample plot. To exclude the contribution of non-native species from the calculation, all nonindigenous species, as identified by the United States Geological Survey Nonindigenous Aquatic Species database (USGS 2003), were assigned a hydric class of "NA", excluding their midpoints from the calculation for relative cover of hydrophytes. If the relative cover of hydrophytes was 50 percent or greater, then this success criterion was met. If the relative cover of hydrophytes was less than 50 percent, then the wetland failed to meet the hydrophytic vegetation criterion for jurisdictional wetlands as defined in the United States Army Corps of Engineers (USACE) Wetland Delineation Manual, Technical Report Y-87-1 (USACE 1987).

Diversity Criterion

Diversity is a measurement of the number of species within a unit area (species richness) and the relative abundance or distribution (evenness) of those species. The FERC success criterion for diversity requires that the post-construction wetland have at least 50% of the diversity of the original wetland. For this study, the Shannon-Weiner Index, one of the simplest and most extensively used diversity indices in plant ecology, was used.

The formula for the Shannon-Weiner function is:

$$H' = (3.3219)\left[\log_{10}N - {}^{1}/_{N}\ \Sigma(p_i \log_{10} p_i)\right]$$

Where:

H'=	Diversity index
N =	Sum of the cover class mean for all species
p_i =	Proportion of all individuals in the sample which belong to species *i*
$\log_{10}p_i$ =	the log to the base 10 of that proportion

The Database calculates and compares the diversity index of the wetland located on ROW to that of the reference wetland. If the diversity of the on-ROW wetland is 50 percent or greater than the reference wetland, then the success criterion is met. If the diversity of the subject wetland was less than 50 percent of the diversity of the reference wetland, then the wetland failed to meet the diversity success criterion. Copies of both Vegetation and Diversity Summary Reports for each of the wetlands surveyed, organized by ecoregion, are presented in Appendix C.

3.5.2 Trends Analysis

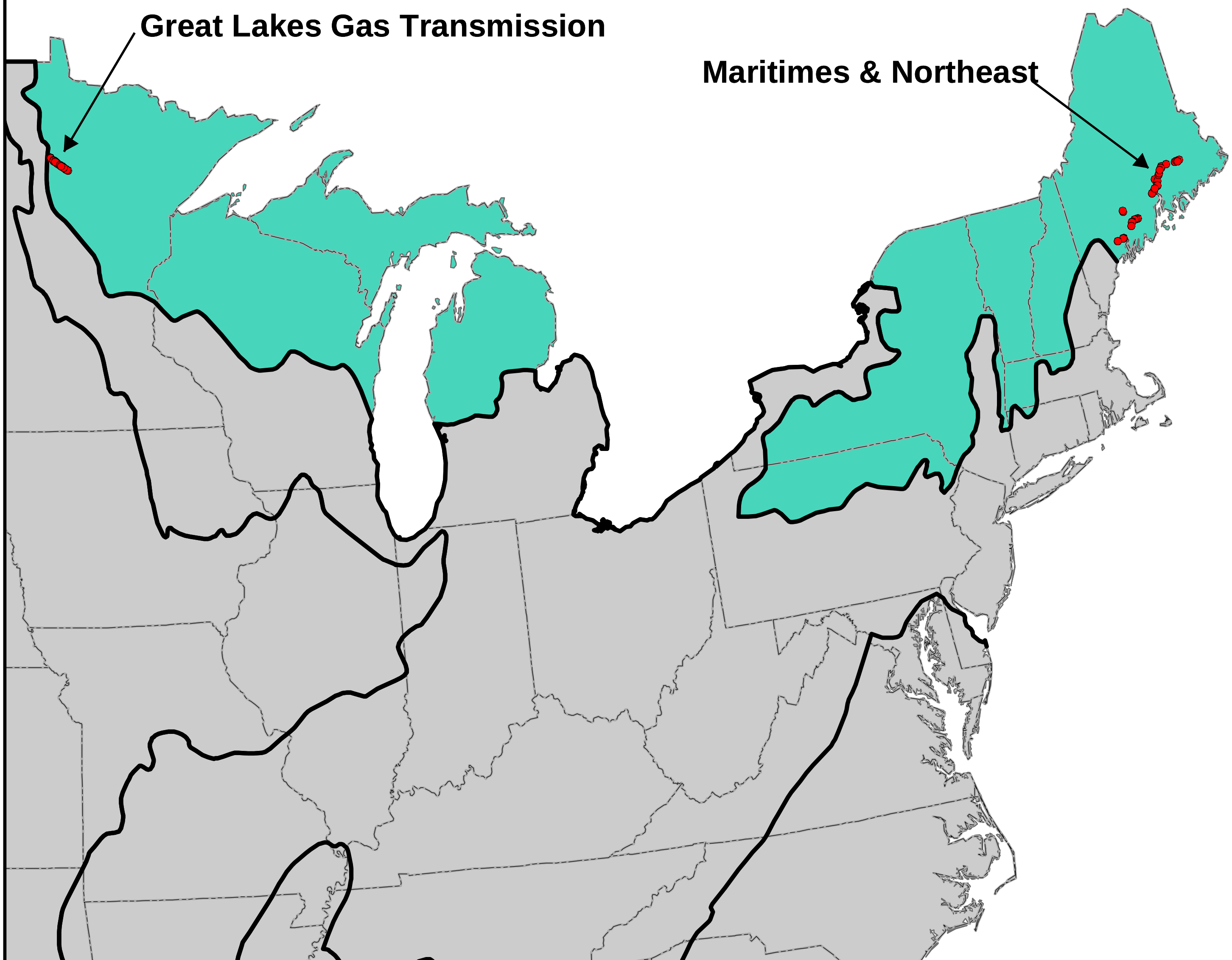
Data collected during the field effort were reviewed for completeness and then entered into the Database. Reports were then generated and analyzed to identify trends in the data (Appendix B). Study objectives were to observe trends in the results and to identify relationships between those results and the 1994 Procedures. Queries were run in the Database to tally total number of passing and failing wetlands based on the 1994 Procedures. Summary reports were generated to display all fields of passing and failing wetlands. A committee of experienced wetland biologists, FERC staff, pipeline environmental inspectors, and regulatory experts were then assembled to review the preliminary results and to identify the formulation of additional queries to run with the Database. Study results were then subjected to statistical analyses, presented in Section 3.5.3.

3.5.3 Statistical Analysis

Statistical methods were used to examine the influence of several factors on the success of wetland restoration. For these analyses the dependent variable was identified as "success" (1 = success, 0 = unsuccessful) and nine field variables were chosen to be independent factors. These nine independent factors were: ecoregion, evidence of construction debris, evidence of erosion, meets preconstruction grade, waterbar within 100 feet, evidence of human disturbance, wetland position in the landscape, soil texture, and evidence of top soil mixing.

A factorial design analysis of variance (ANOVA) (F Statistic) with a randomized complete block design was used to test for significant independent variables. A Tukey HSD (Honestly Significantly Different) all-pairwise comparisons test was used to examine differences between groups where ANOVA models indicated a difference was present. Contingency tables and the Chi-square test (X^2 Statistic) were used to test for homogeneity of the proportions between groups (e.g., ecoregions) for each of the variables. The results of this statistical analysis are presented in Section 4.4. The Statistical Analysis Summary Report for this study is provided in Appendix B.

WARM CONTINENTAL DIVISION



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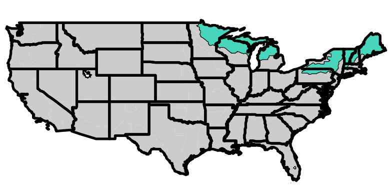

150 75 0 150
Scale in Miles

Figure 3-3. Wetlands Monitored in Warm Continental Division

Source: Ecoregions of North America, Revised-1997. U.S. Department of Agiriculture, Forest Service Washington D.C.

Federal Energy Regulatory Commission

Date: **01/04**

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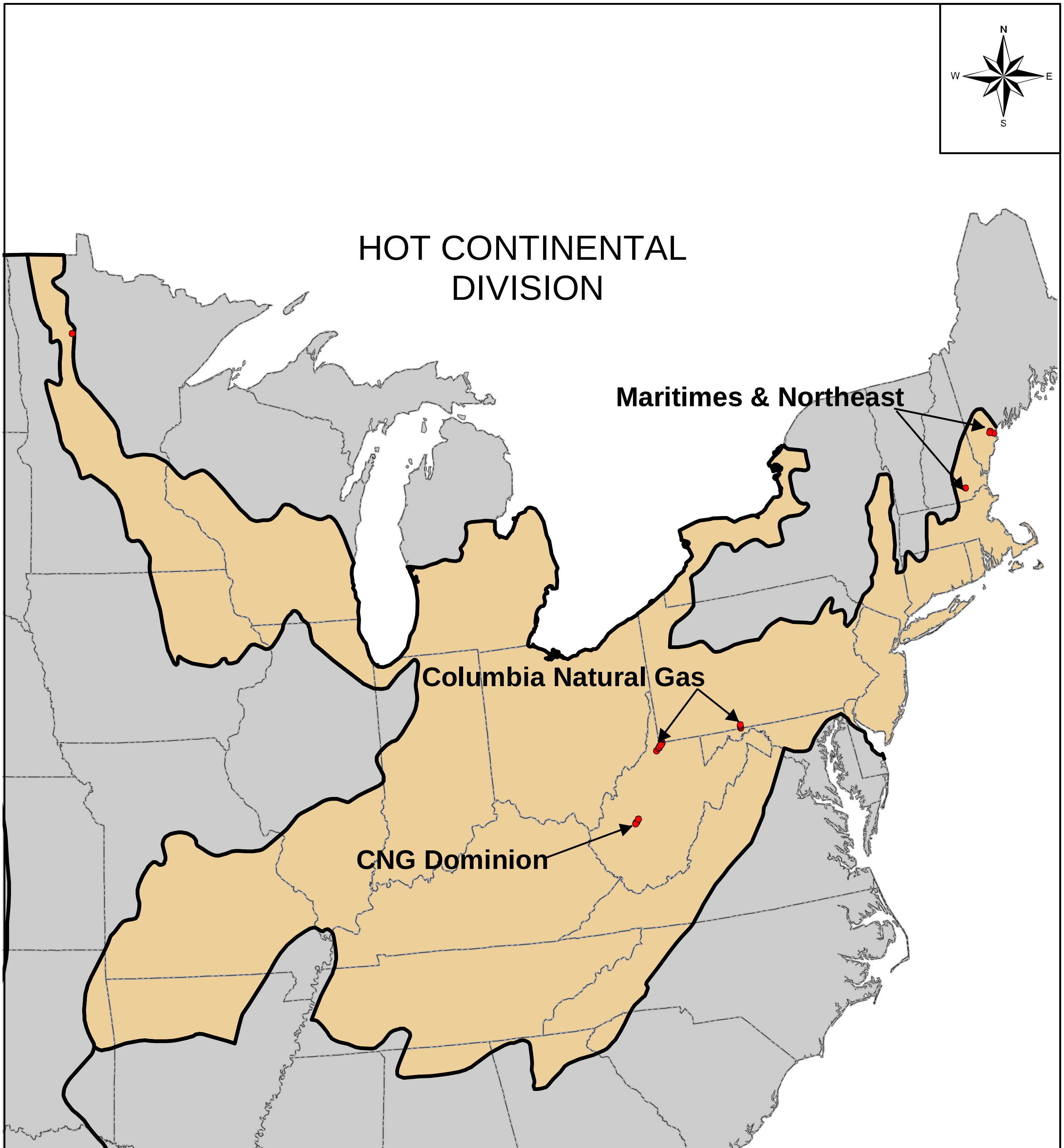

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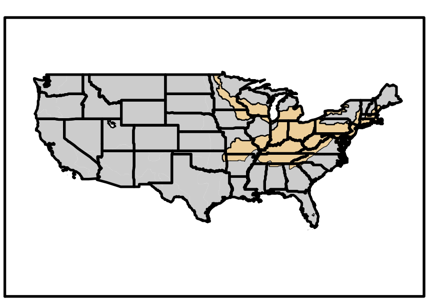

150 75 0 150

Scale in Miles

Figure 3-4. Wetlands Monitored in Hot Continental Division

Source: Ecoregions of North America, Revised-1997. U.S. Department of Agiriculture, Forest Service Washington D.C.

Federal Energy Regulatory Commission

Date:

01/04

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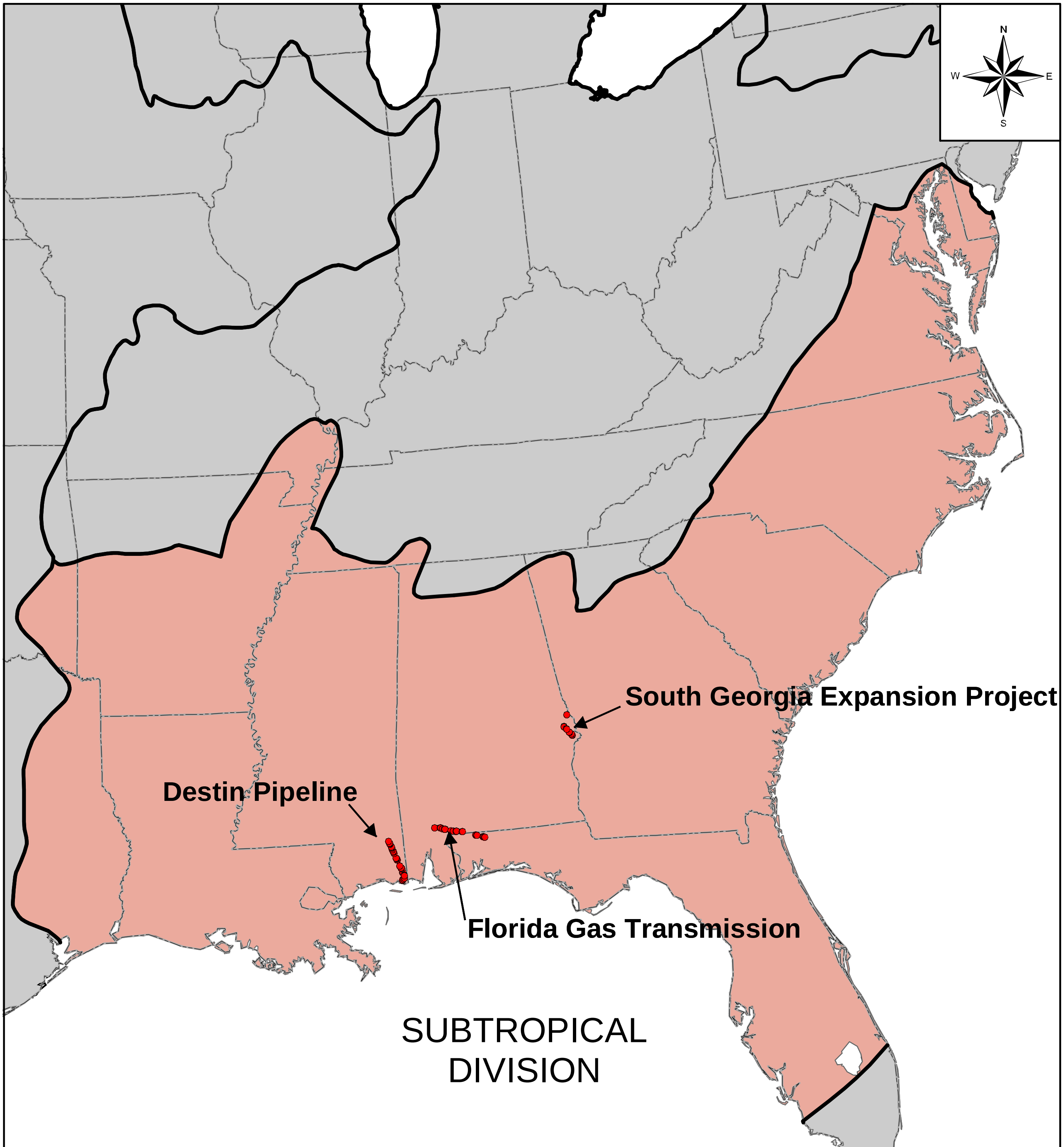

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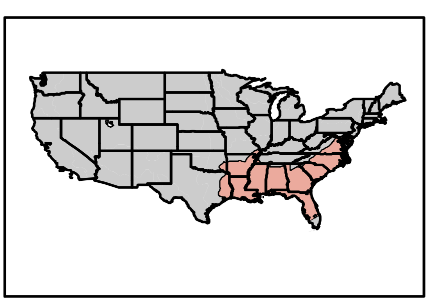

100 50 0 100

Scale in Miles

Figure 3-5. Wetlands Monitored in Subtropical Division

Source: Ecoregions of North America, Revised-1997. U.S. Department of Agiriculture, Forest Service Washington D.C.

Federal Energy Regulatory Commission

Date: 01/04

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Division Location

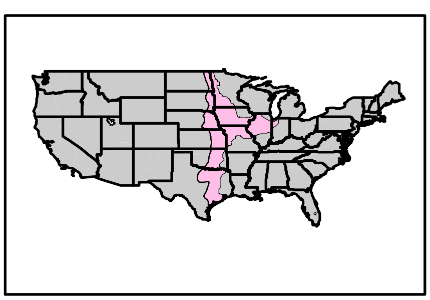

Figure 3-6. Wetlands Monitored in Prairie Division

Source: Ecoregions of North America, Revised-1997. U.S. Department of Agiriculture, Forest Service Washington D.C.

Federal Energy Regulatory Commission

Date: 01/04

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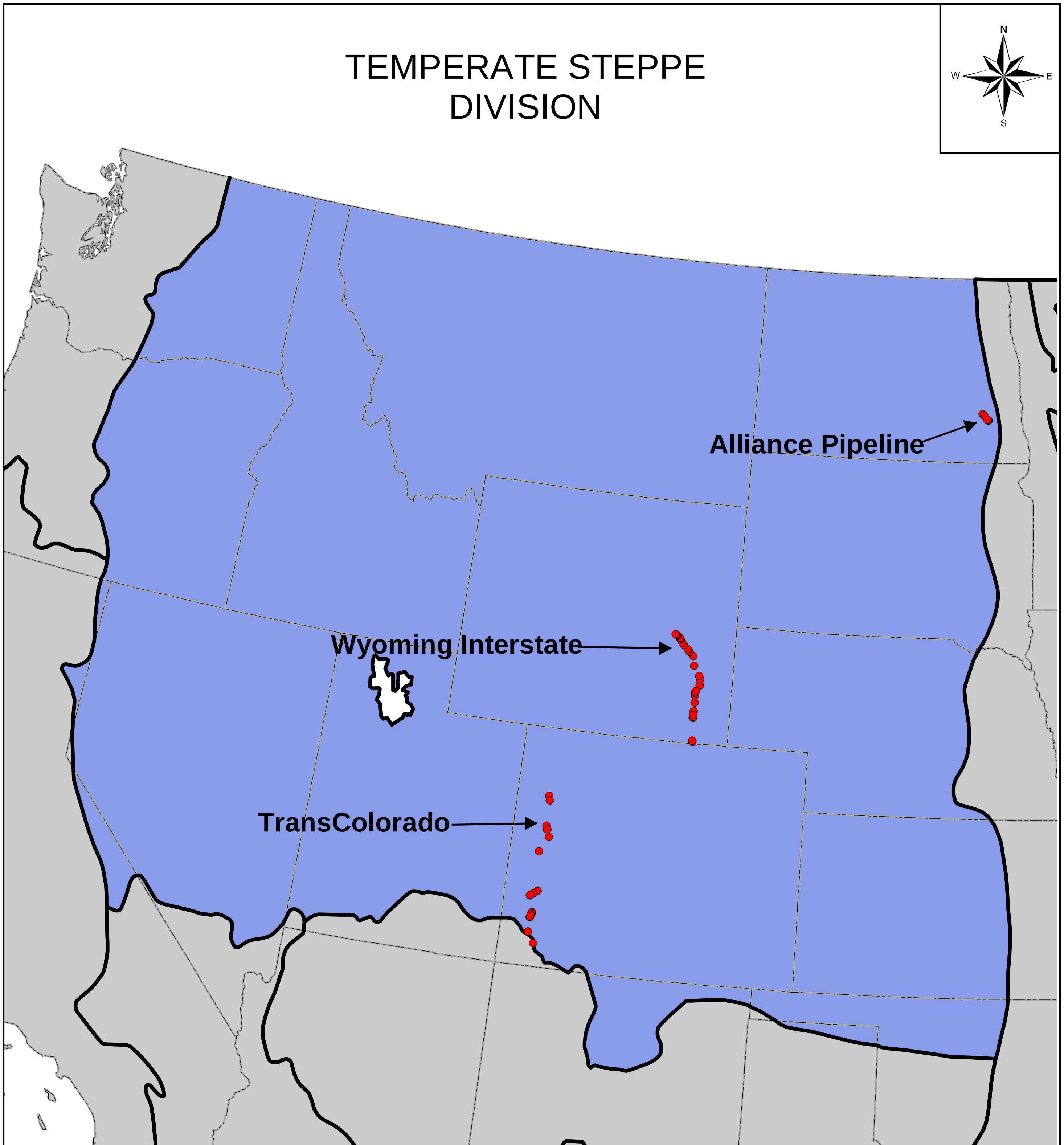
TEMPERATE STEPPE DIVISION



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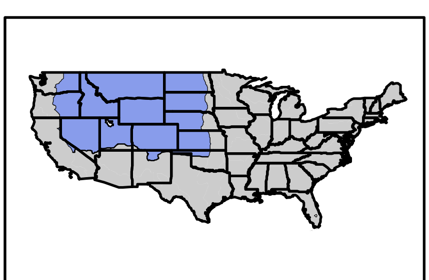

150 75 0 150

Scale in Miles

Figure 3-7. Wetlands Monitored in Temperate Steppe Division

Source: Ecoregions of North America, Revised-1997. U.S. Department of Agiriculture, Forest Service Washington D.C.

Federal Energy Regulatory Commission

Date:

01/04

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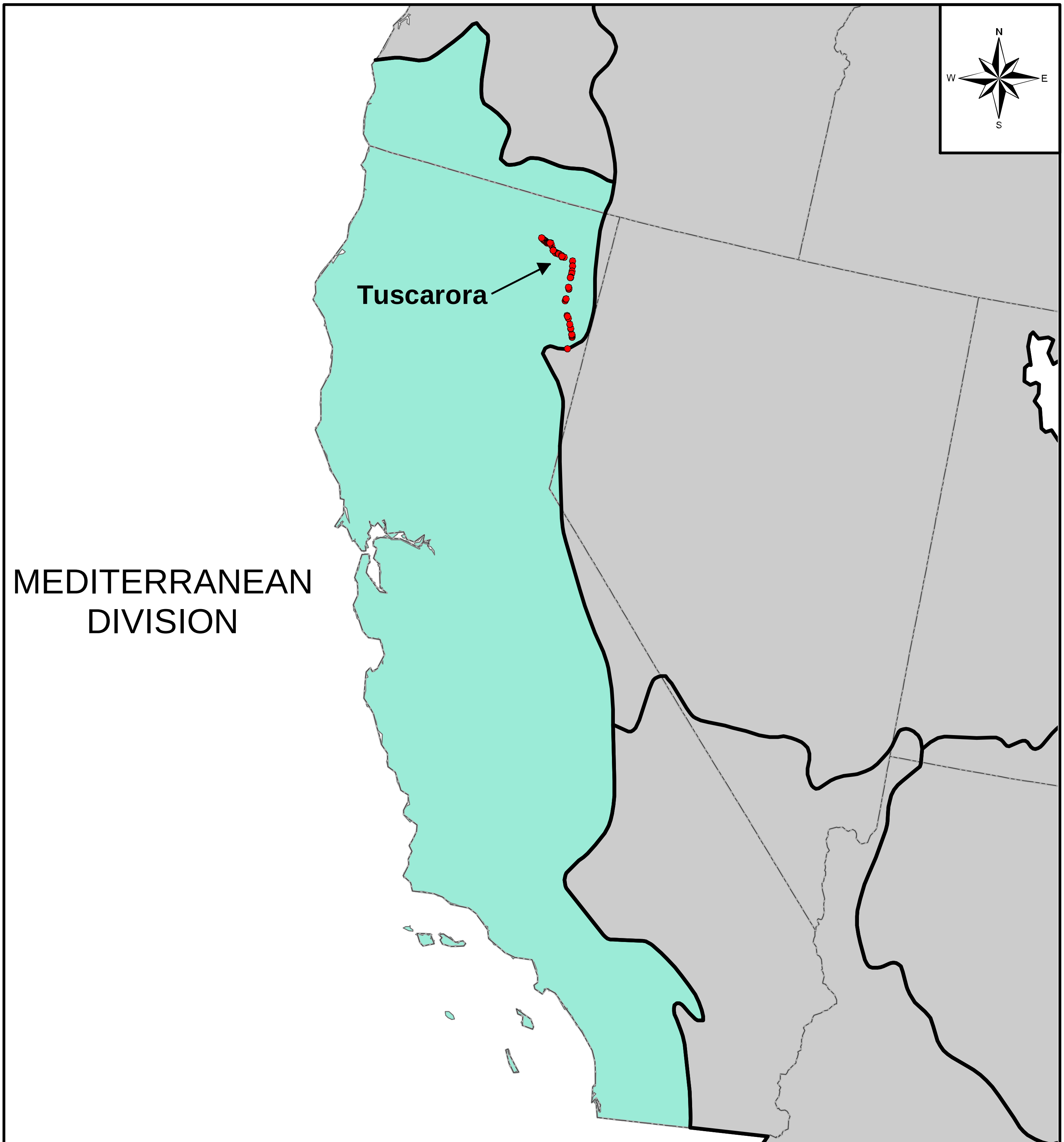

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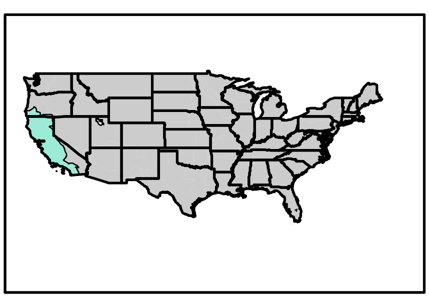

100 50 0 100

Scale in Miles

Figure 3-8. Wetlands Monitored in Mediterranean Division

Source: Ecoregions of North America, Revised-1997. U.S. Department of Agiriculture, Forest Service Washington D.C.

Federal Energy Regulatory Commission

Date:

01/04

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4.0 RESULTS AND DISCUSSION

This section provides a summary of results and a discussion of major trends observed through analysis of the data. Section 4.1 provides an overall summary of the relative success or failure of the wetlands studied and general trends in the plant community composition and condition. Section 4.2 provides a summary of trends observed in physical factors that may have an effect on relative success or failure. Section 4.3 summarizes trends related to post-construction human disturbance and their suggested effects on restoration success.

Summary reports for major variables analyzed are included in Appendix A. Each summary report includes a tally of total wetlands successfully restored and a breakdown of wetland failures by ecoregion. The following sections provide results and discussion for these analyses.

4.1 GENERAL RESULTS AND TRENDS IN POST-CONSTRUCTION PLANT COMMUNITIES

4.1.1 Project Wetland Restoration Summary

Of the total 480 wetlands surveyed, 313 (65%) wetlands passed the 1994 Procedures restoration success criteria and 167 (35%) failed. Table 4-1 provides a breakdown of total wetlands passing and failing the wetland restoration criteria and a breakdown of wetland failures by criterion. Wetlands designated "passing" were required to meet all three of the restoration criteria. Wetlands identified as "failing" only needed to fail one of the three criteria (but may have failed more than one criterion). The most common single factor for failure was less than 80% vegetative cover by native species.

Table 4-1. Overall Wetland Restoration Summary.

Factor Evaluated	Number	Percent of Total
TOTAL WETLANDS MONITORED	480	100
WETLANDS PASSING PROCEDURES CRITERIA[1]	313	65
WETLANDS FAILING PRODECURES CRITERIA[2]	167	35
Wetlands Failing More Than One Criterion	44	9
Wetlands Failing Cover and Diversity Wetlands Failing Cover and Wetland Vegetative Cover Wetlands Failing Diversity and Wetland Vegetative Cover Wetlands Failing All Three Criteria	5 35 0 4	1 7 0 <1
Wetlands Failing Only One Criterion	123	26
Wetlands Failing 80% Cover Only Wetlands Failing Diversity Only Wetlands Failing Wetland Vegetation Criterion Only	73 20 30	15 4 6
SUMMARY OF WETLAND FAILURES BY CRITERION[3]	-	-
Total Wetlands Failing 80% Cover Criterion	117	24
Total Wetlands Failing Diversity Criterion	29	6
Total Wetlands Failing l Wetland Vegetation Criterion	69	14

1 Wetlands must pass all three criteria identified in the 1994 Procedures to be considered a passing wetland.
2 Wetlands only needed to fail one criterion to be considered a failed wetland.
3 The sum of "wetland failures by criterion" exceeds the total number of wetland failures because some wetlands failed two or more of the success criteria.

Figure 4-1 illustrates the distribution of wetland failures by FERC criterion, total number of wetland failures per criterion, and the overlap of wetlands failing for more than one criterion. As indicated in both Table 4-1 and Figure 4-1, failure to meet the 80% cover by native species criterion was the most common reason for wetland failure. One hundred and seventeen (117) wetlands failed to achieve 80% cover by native vegetation, this is 24%, or almost one fourth of the total wetlands surveyed.

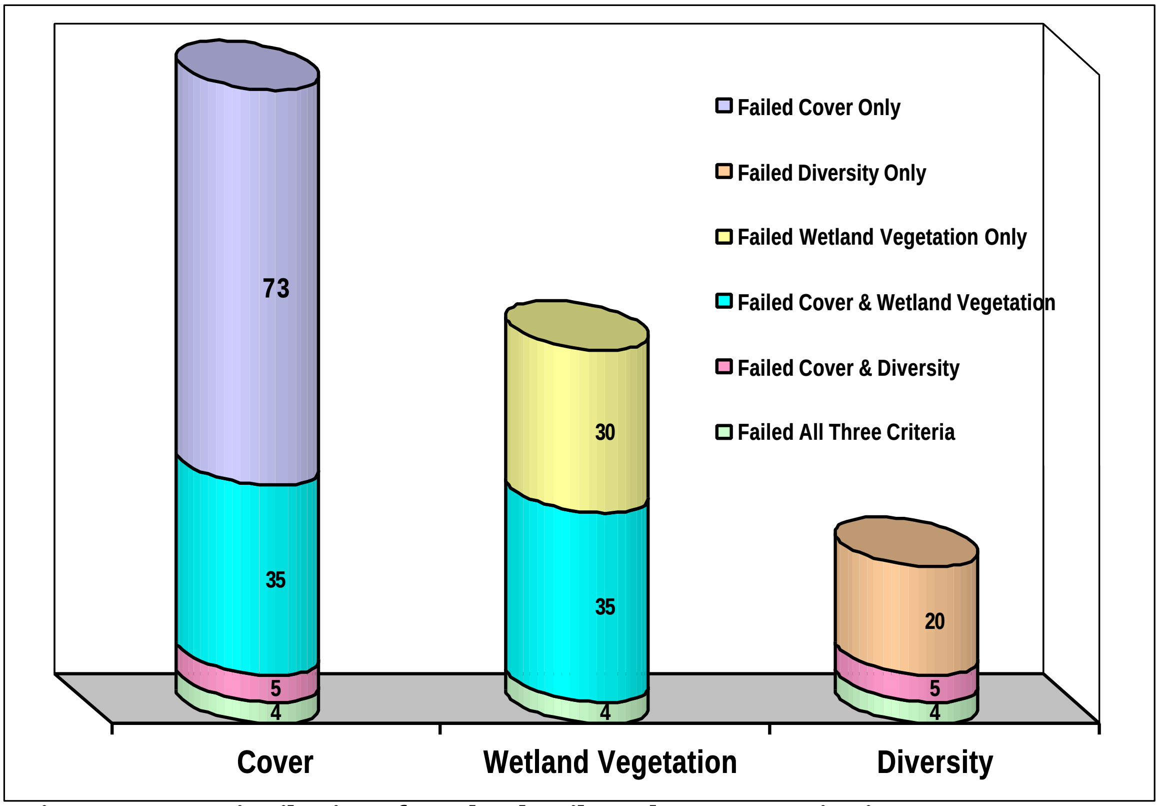


Figure 4-1. Distribution of Wetland Failures by FERC Criterion.

4.1.2 Wetland Restoration Success by Ecoregion

The distribution of wetland success and failure for each ecoregion was assessed for all parameters evaluated in subsequent sections and are included in Appendix A. As discussed in Section 3.2 Study Design, pipeline projects were selected for survey based on their location within division-level ecoregions across the United States. Table 4-2 presents a summary of wetland restoration success and failure by ecoregion.

The objective of collecting field data across several ecoregions was to determine if regional climatic conditions affect wetland restoration. Results of the study by ecoregion indicate differences in the relative success rate across the country. The average failure rate was 35% (range 11–68%). As illustrated in Figure 4-2, failure rates were highest in the Temperate Steppe (68%) and Mediterranean (66%) ecoregions, and wetland failure rates were lowest in the Warm Continental (14%) and Hot Continental (11%) ecoregions.

Because the 1994 Procedures are applied consistently on projects regardless of geographic region, other variables, likely climatic and edaphic, are suspected of having a determining effect.

Table 4-2. Distribution of Wetland Restoration Success and Failure by Ecoregion

Ecoregion	Passing Wetlands		Failing Wetlands	
	Number	Percent	Number	Percent
Warm Continental	69	86%	11	14%
Hot Continental	69	86%	11	14%
Subtropical	64	80%	16	20%
Prairie	56	70%	24	30%
Temperate Steppe	26	32%	54	68%
Mediterranean	27	34%	53	66%

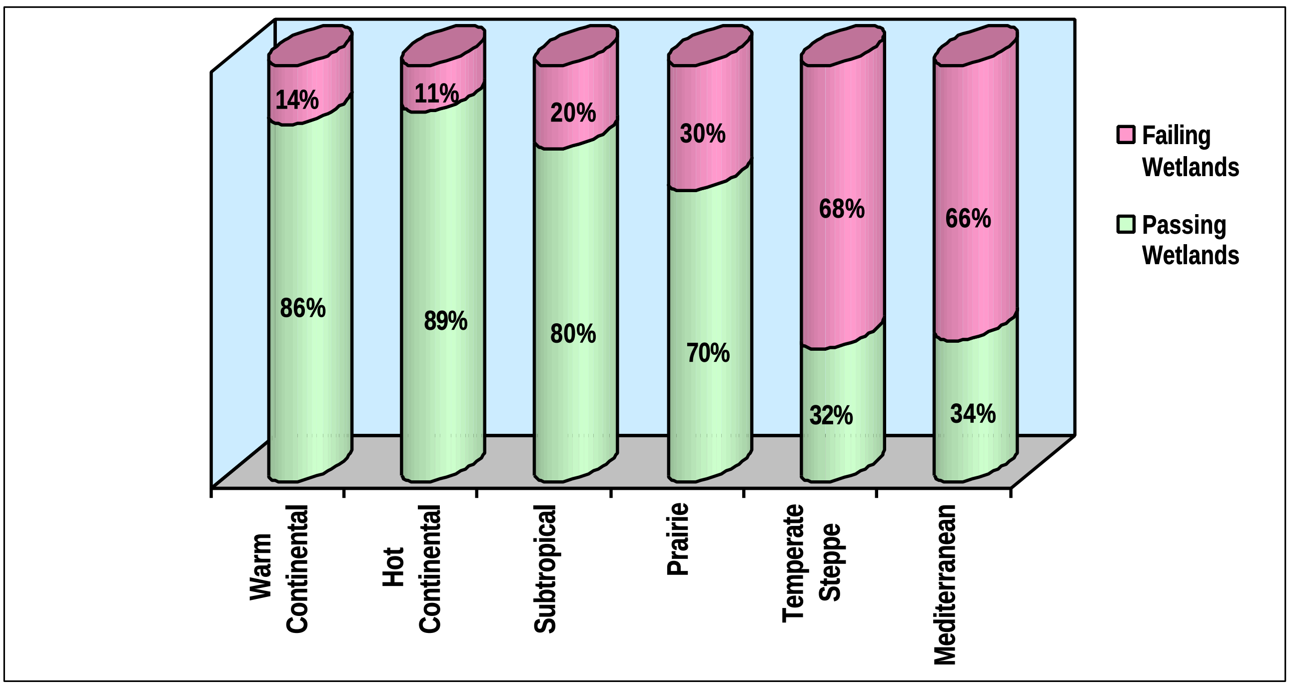
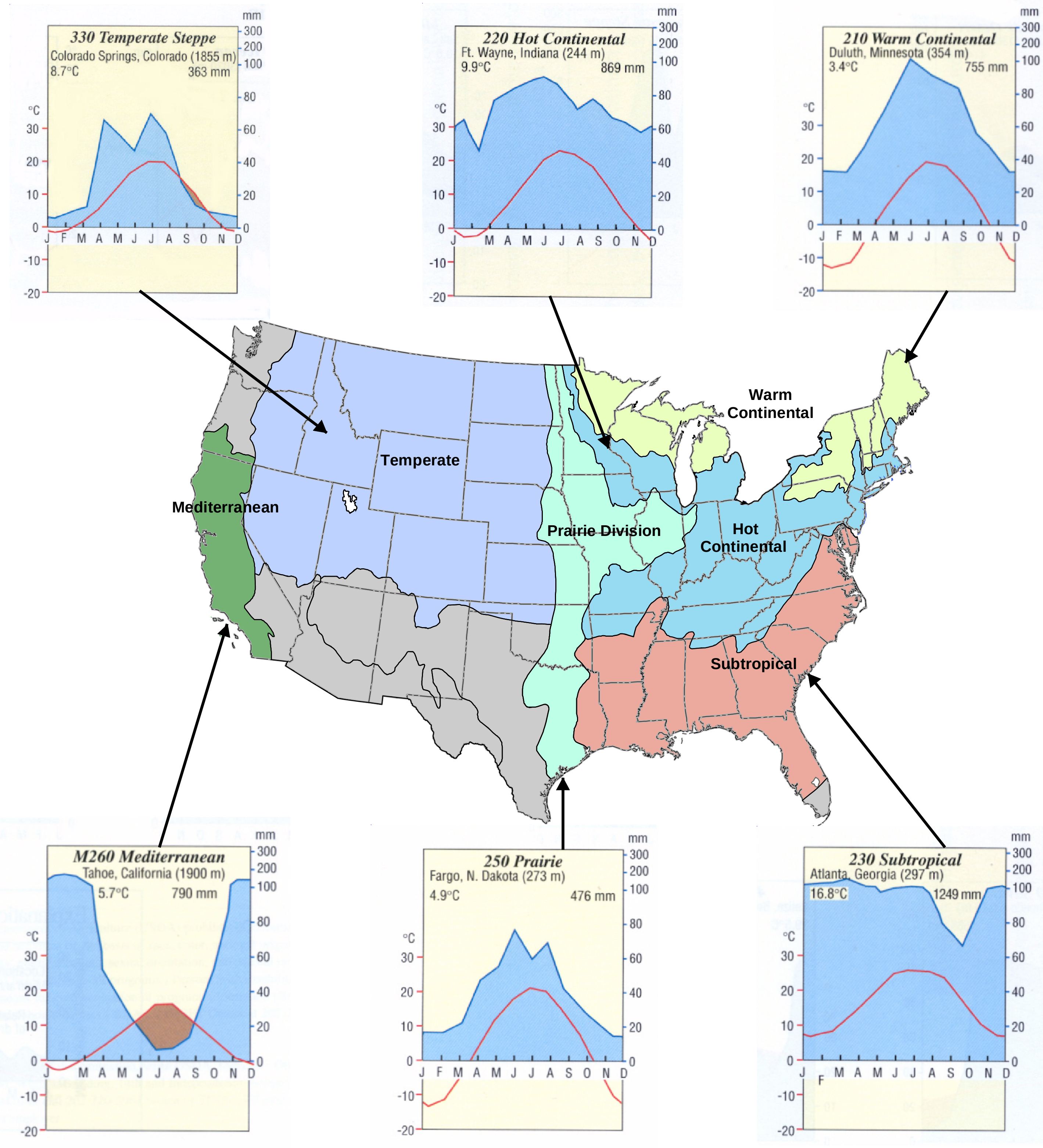
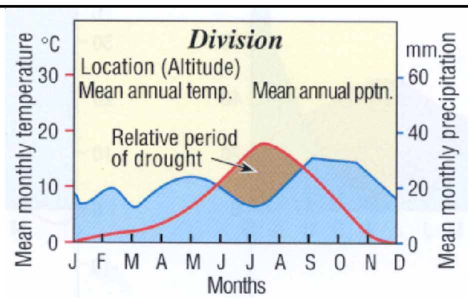


Figure 4-2. Wetland Success and Failure by Ecoregion.

Climate diagrams of representative climate stations within each of the ecoregions surveyed are presented in Figure 4-3. These provide a long-term average comparison of mean monthly precipitation and temperature for 12 months of the year for each ecoregion surveyed (Bailey 1995). As depicted in Figure 4-3, three of the six ecoregions studied have wetland restoration success rates that were substantially higher than the average of 65% (86% Warm Continental, 89% Hot Continental, and 80% Subtropical). In each of these three ecoregions mean monthly precipitation exceeded mean monthly temperature. The wetland restoration success rate for the Prairie ecoregion was 70%. There is a corresponding difference in the climate diagram for the Prairie ecoregion (compared to the Warm and Hot Continental and Subtropical) i.e., the mean monthly precipitation line is substantially closer to the mean monthly temperature line.

In both the Temperate Steppe and Mediterranean ecoregions, the mean monthly temperature is depicted as exceeding mean monthly precipitation lines for certain months during the year (Figure 4-3). These areas are shown in brown on the Temperate Steppe and Mediterranean climate diagrams and are identified as relative periods of drought. These diagrams indicate that climatic conditions support periods of drought during parts of August, September, and October in the Temperate Steppe ecoregion, and during late May through September in the Mediterranean ecoregion. The establishment and persistence of hydrophytic vegetation is tied to the presence of moist hydrologic conditions. These data may provide an indication as to why both the Temperate Steppe and Mediterranean restoration failure rates (68% and 66% respectively) were substantially higher than the study average of 35%. Reference wetlands within these ecoregions exhibited identical wetland failure rates as those located on ROW, supporting the hypothesis that wetland failures were not construction related but more likely attributed to climatic conditions. In addition, wetland scientists noted evidence of drought conditions during field surveys for the Temperate Steppe ecoregions.





CLIMATE DIAGRAM KEY

Mean Annual Precipitation

Mean Annual Temperature

Figure 4-3. Climate Diagrams for Study Ecoregions

Source: Ecoregions of North America, Revised-1997. U.S. Department of Agriculture, Forest Service Washington D.C.

Federal Energy Regulatory Commission

Date: 01/04

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Because the climate diagrams provided in Figure 4-3 represent “average” climatic conditions over a period of many years, additional research was performed in an effort to document “drought conditions” in these regions. Maps from the U.S. Drought Monitor were used for this study because they are based on a synthesis of multiple drought indices and represent a consensus of Federal and academic scientists (http://www.drought.unl.edu/dm/monitor). The U.S. Drought Monitor is a partnership consisting of the U.S. Department of Agriculture (Joint Agricultural Weather Facility and National Water and Climate Center), the National Weather Service's Climate Prediction Center, National Climatic Data Center, and the National Drought Mitigation Center at the University of Nebraska.

Figure 4-4 is the U.S. Drought Monitor Map for the week ending September 10, 2002, the same time period field surveys were performed in the Temperate Steppe ecoregion. This map shows severe, extreme, and exceptional drought conditions within the Temperate Steppe ecoregion at the time of survey. Table 4-3 defines the categories used in the classification system employed by the U.S. Drought Monitor.

Figure 4-5 shows the U.S. Drought Monitor Map for the time period corresponding with field surveys in the Mediterranean ecoregion. This map indicates abnormally dry and moderate drought conditions at the time of survey. A review of the historic maps from the U.S. Drought Monitor archives revealed abnormally dry conditions in the Temperate Steppe ecoregions in 1999; however, actual drought conditions were not depicted on the maps until February of 2000. Drought conditions ranging from moderate to exceptional have consistently been reported in the Temperate Steppe ecoregion since that time. Abnormally dry conditions were also observed within some portions of the Mediterranean ecoregion in 1999, and moderate and minor areas of severe drought conditions were reported from 2000 to 2003.

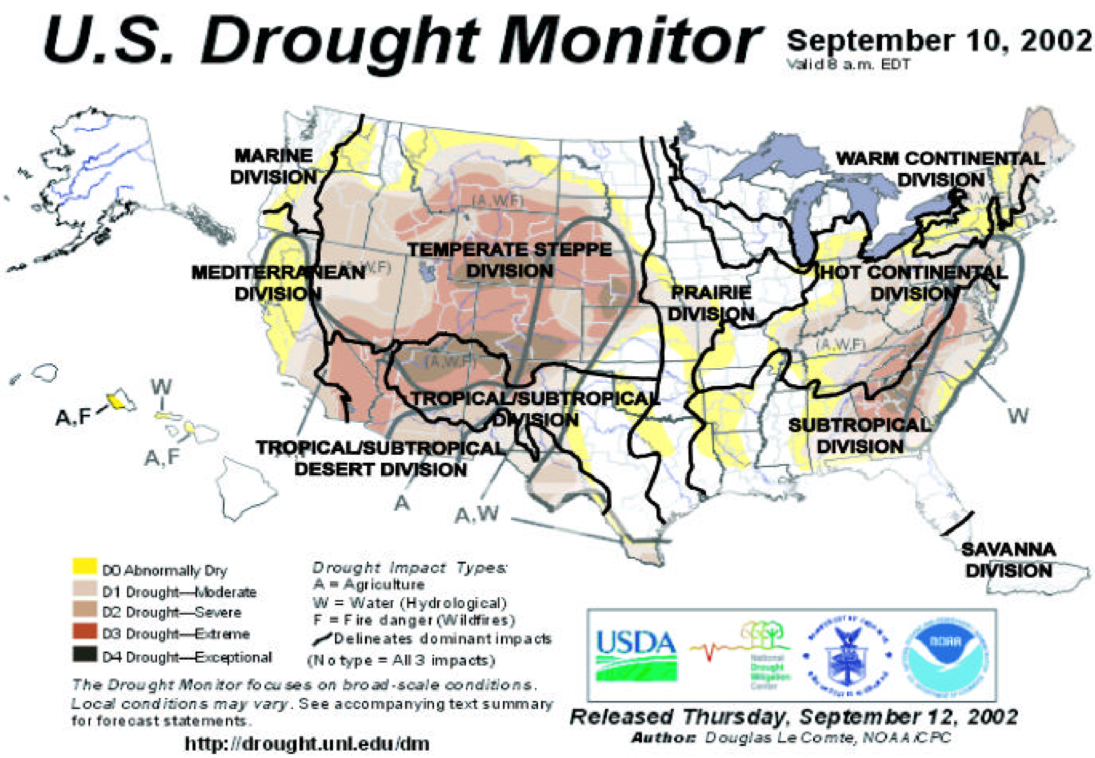

Figure 4-4. U.S. Drought Monitor Map for Week Ending September 10, 2002.

Table 4-3. U.S. Drought Monitor Drought Severity Classifications.

Category	Description	Possible Impacts
D0	Abnormally Dry	Going into drought: short-term dryness slowing planting, growth of crops or pastures, fire risk above average. Coming out of drought: some lingering water deficits; pastures or crops not fully recovered.
D1	Moderate Drought	Some damage to crops, pastures; fire risk high; streams, reservoirs, or wells low, some water shortages developing or imminent, voluntary water use restrictions requested
D2	Severe Drought	Crop or pasture losses likely; fire risk very high; water shortages common; water restrictions imposed
D3	Extreme Drought	Major crop/pasture losses; extreme fire danger; widespread water shortages or restrictions
D4	Exceptional Drought	Exceptional and widespread crop/pasture losses; exceptional fire risk; shortages of water in reservoirs, streams, and wells, creating water emergencies

Other potential explanations for the high rate of failure of the wetlands in the Temperate and Mediterranean ecoregions, are a high incidence of wetlands with clay soils and human- related wetland disturbances. These results are discussed in Sections 4.2 and 4.3 respectively.

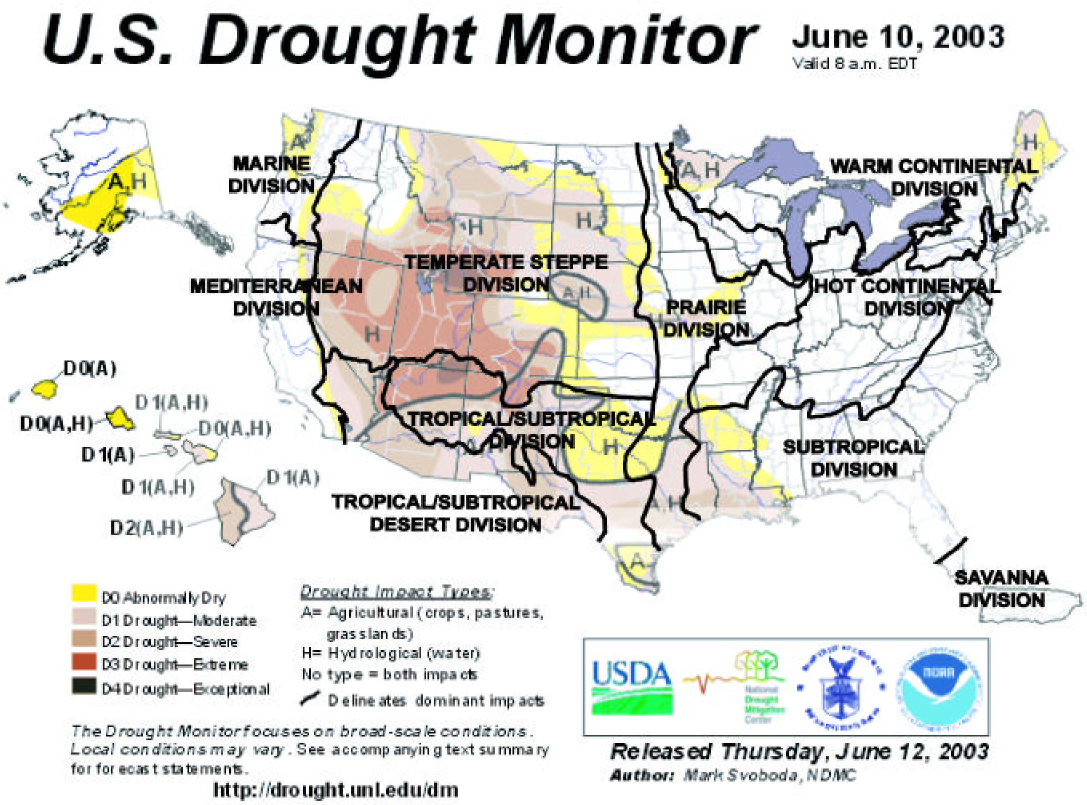

Figure 4-5. U.S. Drought Monitor Map for Week Ending June 10, 2003

4.1.3 Wetland Cover Classes

A total of 480 wetlands, comprising nine Cowardin wetland classes (Cowardin et al. 1979), were surveyed from among the six ecoregions studied (80 wetlands/ecoregion). Table 4-4 identifies the wetland Cowardin classes (preconstruction) for the wetlands surveyed and provides a summary of their success or failure for each of the ecoregions. The most common wetland class surveyed was palustrine emergent (PEM), with 279 wetlands (55.5%). The other commonly surveyed wetland types were palustrine forested (PFO) (91 wetlands; 18.1%) and palustrine scrub-shrub (PSS) (49 wetlands; 9.7%). Although the distribution of wetland classes was not in exact proportion to their abundance within each ecoregion, in general a fairly good representation of the wetland classes found commonly in each ecoregion was surveyed.

Table 4-4. Wetland Cowardin Classification Distribution by Ecoregion and Restoration Results.

Pre-construction Cowardin Classification	Warm Continental			Hot Continental			Subtropical			Prairie			Temperate Steppe			Mediterranean			Total
	Total	Pass	Fail	Total	Pass	Fail	Total	Pass	Fail	Total	Pass	Fail	Total	Pass	Fail	Total	Pass	Fail	
PEM	39	32	7	35	30	5	5	3	2	65	45	20	57	20	37	78	27	51	279
PSS	17	15	2	2	1	1	11	10	1	3	3	-	15	4	11	1	-	1	49
PFO	18	16	2	23	22	1	37	28	9	5	3	2	8	2	6	0	-	-	91
POW	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	1	-	1	1
PEM/POW	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0
PEM/PSS	4	4	-	8	7	1	8	6	2	4	3	1	0	-	-	0	-	-	24
PEM/PFO	0	-	-	11	10	1	2	1	1	2	1	1	0	-	-	0	-	-	15
PSS/POW	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0
PSS/PFO	2	2	-	1	1	-	17	16	1	1	1	-	0	-	-	0	-	-	21
Total	**80**	69	11	**80**	71	9	**80**	64	16	**80**	56	24	**80**	26	54	**80**	27	53	**480**

[1] PEM Palustrine Emergent; PSS Palustrine Scrub-Shrub; POW Palustrine Open Water; PFO Palustrine Forested.

Construction of a pipeline ROW requires that vegetation be cleared. Furthermore, the conversion of the vegetation in ROW wetlands to early successional stages following construction is well documented (Santillo 2000). Consistent with this, a comparison of the post-construction cover classes to their preconstruction types (Table 4-5) revealed a relatively large shift to early successional cover classes; over 78% of the ROW wetlands (394) were classified as PEM following construction while only 58% (279) were classified as PEM prior to construction. Comparing ROW wetlands to the preconstruction wetland classes, the number of wetlands in all wetland classes dominated by woody vegetation was reduced.

Table 4-5. Comparison of Pre-Construction and Post Construction Wetland Cowardin Classifications.

Cowardin Class[1]	Pre-Construction	On-ROW Post Construction	Difference
1. PEM	279	394	+ 115
2. PEM/PSS	24	31	+ 7
3. PEM/POW	0	21	+ 21
4. PSS	49	20	+ 29
5. PFO	91	9	- 82
6. PSS/POW	0	2	+ 2
7. PSS/PFO	21	2	- 19
8. POW	1	1	0
9. PEM/PFO	15	0	- 15
TOTAL	480	480	-

[1] PEM Palustrine Emergent; PSS Palustrine Scrub-Shrub; POW Palustrine Open Water; PFO Palustrine Forested.

Cowardin wetland classifications are made based on the plants that constitute the upper-most layer of vegetation and that possess an areal coverage of at least 30%. For example, a wetland with 50% areal coverage by trees over a shrub layer with a 60% areal coverage, would be classified as forested wetland (PFO); an area with 20% areal coverage of trees over the same 60% shrub layer would be classified as scrub-shrub (PSS). When trees or shrubs cover less than 30% of the wetland, but the total cover of vegetation (except pioneer species) is 30% or greater, the wetland is assigned the appropriate class based on the predominant life form below the shrub layer.

In addition, tree species need to reach a certain size (greater than six meters in height) to be classified as a tree and not a shrub/sapling. Therefore, in order for a wetland to be classified as forested, tree species would have to have grown larger than 6 meters (19.2 feet) and comprise at least 30% areal coverage of the wetland. Considering that pipeline projects surveyed were constructed beginning in 1994, it is reasonable to conclude that forested wetlands may not have had enough time to develop following construction to meet the classification criteria.

4.1.4 Conversions of Wetland Cowardin Classes Following Construction

Consistently throughout the ecoregions, PEM wetlands were restored as PEM, with exceptions in the Prairie where one (out of 65) PEM is now PSS and Subtropical where one (out of 5) is now PEM/PSS.

All PFO's were converted to PEM in Warm Continental and Hot Continental ecoregions. Whereas in the Prairie and Temperate Steppe ecoregions roughly 60% (3 out of 5 and 5 out of 8, respectively) of the PFO's were converted to PEM with the remaining wetlands restored as PFO's. In the Subtropical ecoregion 20 out of 37 of the PFO's were converted to PEM, 10 were converted to PEM/PSS, 5 were converted to PSS, 1 was converted to PSS/PFO, and 1 wetland was restored to PFO.

Similar to the PFO's, all PSS/PFO's were converted to PEM in Warm Continental, Hot Continental, and Prairie ecoregions. In the Subtropical ecoregion 3 out of 17 of the PSS/PFO's were converted to PEM, 9 were converted to PEM/PSS, 1 was converted to PSS, 3 were converted to PFO, and only 1 wetland was restored to PSS/PFO. Figure 4-6 shows a comparison of each Cowardin cover class pre- and post-construction.

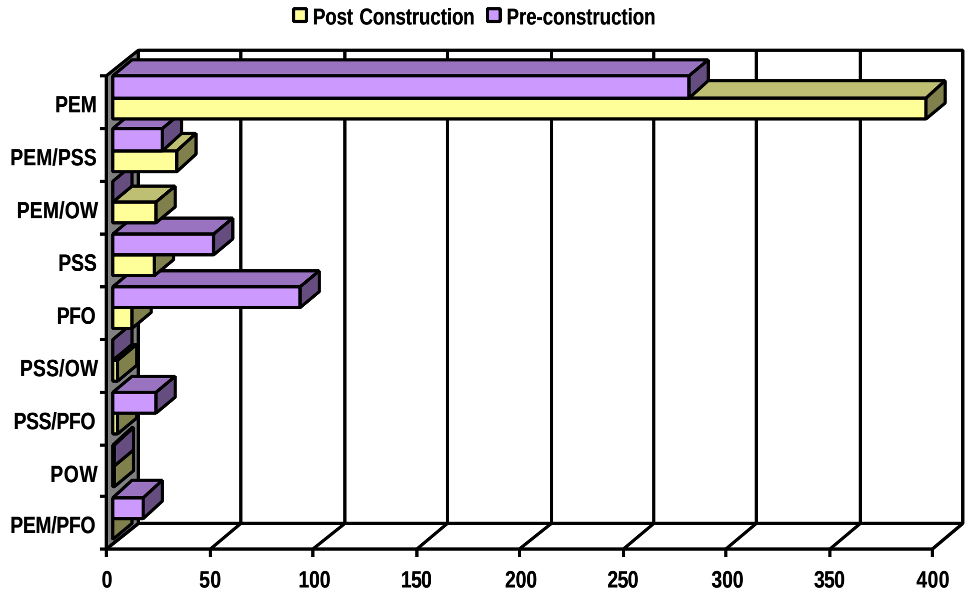

Figure 4-6. Changes in Cowardin Classification from Pre- to Post-construction Conditions.

Study results showed an overall increase in PEM wetlands and decrease in PFO and PSS wetlands following construction. These trends may be the result of the short period of time since implementation of the 1994 Procedures relative to the expected time frame for the re-establishment of arboreal vegetation. However, we expect this trend to persist over portions of the ROW because vegetation maintenance is commonly used to facilitate monitoring required by the U.S. Department of Transportation to ensure pipeline integrity. The 1994 Procedures (Section VI.E.1) allows for vegetation maintenace within the ROW to facilitate aerial corrosion and leak surveys. More specifically, the Procedures allow for maintenance of vegetation in an herbaceous state within a 10 foot wide corridor (centered over the pipeline) and the removal or selective cutting of trees greater than fifteen feet in height from within 15 feet of the pipeline, or a 30 foot corridor centered over the pipeline.

This trend is considered inconclusive due to the relatively short timeframe since construction for many of the pipelines surveyed and, therefore, insufficient time for plant succession to occur. Overall, conversions of Cowardin classes were consistent with what would be expected following construction based on climatic conditions within ecoregions, and time since construction.

4.2 INFLUENCE OF PHYSICAL FACTORS ON RESTORATION SUCCESS

A number of key physical factors were identified by the Team for testing relative to their effect on wetland revegetation success or failure. Although data on numerous physical parameters were collected, the factors analyzed in this section were those considered by the Team to have the greatest likelihood of having an effect on wetland revegetation success.

4.2.1 Wetland Landscape Position

Five wetland landscape positions were evaluated to determine if restoration success varied among these types following pipeline construction. Table 4-6 presents results for wetland landscape position and lists the percent passing and failing wetlands in each landscape position. Sixty percent (228) of all wetlands surveyed were located in the bottom landscape position. Sixty-eight percent (197 wetlands) of wetlands located in the bottom landscape position passed the FERC criteria.

Table 4-6 Summary of Wetland Restoration Relative to Position of Wetland in Landscape.

Landscape Position	Overall Distribution		Passing Wetlands		Failing Wetlands		Percent of All Failures
	Number	Percent	Number	Percent	Number	Percent	
Bottom	228	60%	197	68%	91	32%	54%
Vegetated Swale	100	21%	64	64%	36	36%	22%
Sidehill	14	3%	10	71%	4	29%	2%
Riparian	66	14%	39	59%	27	41%	16%
Other	12	3%	3	25%	9	75%	5%
Total	480	100%	313	65%	167	35%	100%

Vegetated swales are typically relatively narrow and shallow vegetated wetlands. Sidehill wetlands are found mid-slope or along a grade and are often supported by side hill seeps or surface hydrology. Riparian wetlands are those found along moving water bodies (river, streams, brooks) and are usually hydrologically connected to the adjacent water body. The wetlands in the "other" category were identified as vernal pools.

The average failure rate for wetlands, regardless of landscape position was 35%, and the range for landscape position was 29–75%. However, if the relatively small number of vernal pools (12) are omitted, then the percent of wetlands failing among the various landscape positions fell within a relatively narrow range of 29 to 41%. Accordingly, there were no major patterns in the success of wetland restoration relative to landscape location. Although the low success rates for vernal pools may warrant consideration on future projects.

4.2.2 Soil Type

Soils were sampled within on-ROW and reference wetlands using the United States Department of Agriculture's (USDA's) soil textural classification system. This system includes the 12 soil textural classes shown in Figure 4-7. For this study, these 12 USDA soil textural classes were used to record soil textural classes in the field. These soil types were then grouped into six smaller classes based on dominant soil textural class. The six classes used in the soils analyses were rock, organic, sand, silt, clay, and loam. These groupings resulted in larger sample sizes for each soil type.

Table 4-7 presents the relative distribution of soil types found in the wetlands surveyed, along with the number and percent of passing and failing wetlands for each category of soils. Wetlands with clay dominated soils were the most common (38%) wetland type surveyed; sand dominated soils were the second most common (31%); and wetlands with loam-dominated soils were the third most common (18%).

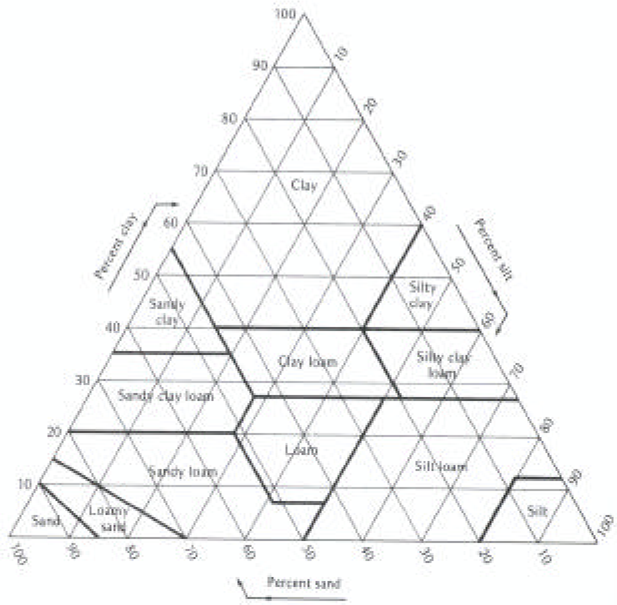

Figure 4-7. USDA Soils Textural Classes

Table 4-7. Wetland Restoration Success Related to Soil Type.

Soil Texture Class	Overall		Passing Wetlands		Failing Wetlands		Percent of All Failures
	Number	Percent	Number	Percent	Number	Percent	
Rock	2	0%	1	50%	1	50%	1%
Organic	26	5%	20	77%	6	23%	4%
Sands	151	31%	113	75%	38	25%	23%
Silts	21	4%	15	71%	6	29%	4%
Clays	183	38%	95	52%	88	48%	53%
Loams	86	18%	64	74%	22	26%	13%
Inundated	11	2%	5	45%	6	55%	4%
Total	480	100%	313	65%	167	35%	100%

As indicated in Table 4-7, the percent of wetlands that failed was greatest in clay soils from among the five non-rock soil types; 48% of wetlands with clay soils were not successfully restored. Eighty-four (84%) of these wetland failures were found in wetlands located in the Temperate Steppe ecoregion, which was experiencing drought conditions at the time of survey (see Section 4.1.2). Clay soils can be especially challenging during construction because of their capacity to hold water. Fine colloidal clays have approximately 10,000 times as much surface area as the same weight of medium-sized sand (Brady 1984). Clay soil particles are also platy in shape causing them to be plastic when wet and extremely hard to cemented when dry, a condition that might be expected under drought conditions. These soil characteristics can also pose significant challenges for wetland restoration. In addition, fine-grained soils, such as clays, support relatively low rates of germination, establishment, and survival of seeds (Leck et al. 1989). Further evidence of this was observed by Santillo (2000) who found that vegetation recovery was lower on portions of pipeline ROWs where topsoil-subsoil mixing resulted in clay subsoil at the surface. The failure rates for the other four non-rock soil types (organic, sand, silt, and loam) fell within a narrow range of 23 to 29%.

4.2.3 Wetland Hydrology

Wetland hydrology was recorded to determine if there was any relationship between saturation and depth of surface water and wetland restoration success and failure. In general, reestablishment of natural surface hydrologic conditions is regarded as a major key to wetland restoration (Mitsch and Gosselink 1993), and the amount of water present has been documented to be a driving factor that determines what plant species become established (Van der Valk 1981). For this study, surface water depth was separated into four categories <1 inch, 1 to 6 inches, 6 to 12 inches, and >12 inches. Table 4-8 presents the depths of surface water observed in wetlands surveyed.

Table 4-8. Wetland Restoration Related to Depth of Surface Water.

Surface Water Depth	Overall Distribution		Passing Wetlands		Failing Wetlands		Percent of All Failures
	Number	Percent	Number	Percent	Number	Percent	
< 1"	287	60%	172	60%	115	40%	69%
1" - 6"	157	33%	124	79%	33	21%	20%
6" - 12"	24	5%	15	63%	9	38%	5%
>12"	12	3%	2	17%	10	83%	6%
Total	480	100%	313	65%	167	35%	100%

Sixty (60%) of wetlands surveyed were observed with <1 inch of surface water at the time of survey; this hydrologic class encompassed wetlands that had no standing water at the time of the survey. In addition, 33% had between 1 and 6 inches, 5% had between 6 and 12 inches, and 3% had >12 inches of standing water at the time of survey. For wetlands with between 0 and 12 inches of water depth, the success rate was between 60 and 79%. In general, this is consistent with other studies that have documented relatively rapid recovery of flooded emergent wetlands following disturbance (Farnsworth 1979, Odegard 1978).

The hydrologic class with the highest rate of failure was > 12 inches of water; 83% of wetlands with >12 inches of water failed to meet the FERC criteria. The relatively high failure rate for wetlands in >12 inches of water was primarily related to not meeting the 80% vegetative cover criterion. Before categorizing these wetlands as failures, however, these wetlands should be compared to preconstruction conditions, to establish if an area of open water (and lacking vegetative cover) was the normal condition that existed prior to construction. Such wetlands may not in fact be “failures” if they had areas of open water prior to construction and did not have 80% cover in their preconstruction state.

4.3 INFLUENCE OF HUMAN DISTURBANCE ON RESTORATION SUCCESS

4.3.1 Wetlands Affected by Human Disturbance

Six categories of human disturbance were identified as potentially having an effect on wetland restoration success, including: all terrain vehicle (ATV) use, paving or fill activities, farming, residential development or lawns, and other. Other types of wetland disturbance reported included: pond construction for recreational use, trampling by cattle, and various drainage-related construction. Table 4-9 presents study results for wetlands affected by human disturbance. No failures were reported for logging, therefore, logging results were not included in Table 4-9.

Table 4-9. Wetlands Affected by Human Disturbance.

Type of Human Disturbance	Total Wetlands Affected	Percent of Wetlands Surveyed	Passing Wetlands		Failing Wetlands		Percent of All Failures
			Number	Percent	Number	Percent	
Farming	130	27%	40	31%	90	69%	54%
ATV	78	16%	65	83%	13	17%	8%
Other	18	4%	10	56%	8	44%	5%
Lawn	3	1%	2	67%	1	33%	1%
Paved/Fill	1	0%	1	100%	0	0%	0%
Total	225	47%	115	51%	110	49%	66%

Forty-seven percent (47%) of all wetlands surveyed contained some evidence of human disturbance. Of the wetlands affected by human disturbance, 51% were successfully restored and 49% failed to meet the FERC wetland restoration criteria. However, 66% of all failed wetlands overall had evidence of human disturbance, thus suggesting this to be a contributing factor to failure.

Of the wetlands with evidence of human disturbance and not successfully restored, 75% failed the cover criterion, 49% failed the wetland vegetation criterion, and 9% failed the diversity criterion. Figure 4-8 shows the distribution of types of human disturbance observed within wetlands during field surveys. A breakdown of wetlands affected by human disturbance by ecoregion is provided in Appendix A. Seventy-two percent (72%) of failed wetlands with human disturbance were located in the Temperate Steppe Ecoregion, and 97% of these wetlands were reported to have farming-related human disturbance.

A relatively high percentage (47%) of all wetlands surveyed were disturbed by human activity. The obvious explanation is that most natural gas pipelines are constructed within easements that allow property owners continued use of their land, and a cleared ROW invites various uses by landowners and the general public.

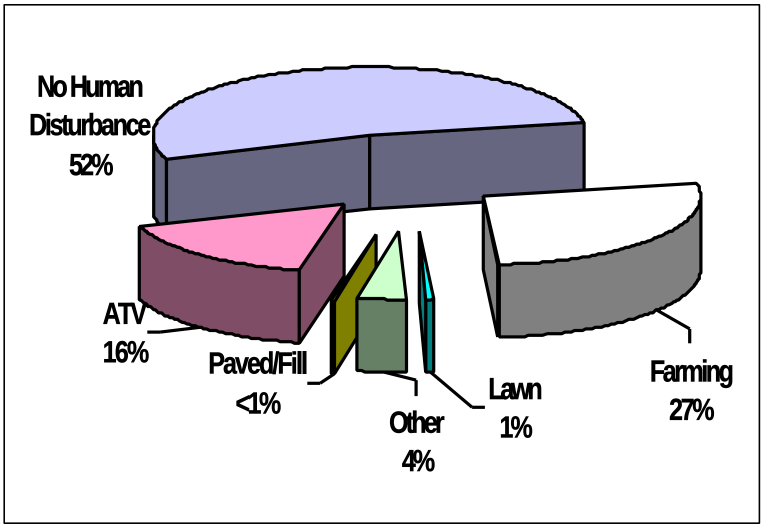

Figure 4-8. Breakdown of Types of Human Disturbance Observed in Wetlands.

The large proportion (58% or 130 wetlands) of farmed wetlands can be explained because farmed land and subsurface pipelines are generally considered compatible land uses. The existence of the subsurface pipeline does not inhibit continued cultivation of the land and the existence of crops does not affect pipeline operations.

The study revealed that 35% (78 of 225) of wetlands affected by human disturbance, were disturbed by ATVs (Figure 4-9); 83% of these wetlands damaged by ATVs passed, and only 17% failed, the restoration criteria. Smaller wetlands had a higher failure rate than larger wetlands, potentially because the ATV trail covers a larger percentage of the area of the whole wetland. The portions of wetlands that are affected (the ATV trail) often are devoid of vegetation and have compacted soils, or are deeply rutted. ATV trails that run parallel to the direction of slope (straight down hill) and that damage permanent slope breakers making them ineffective generally cause the greatest damage.

Figure 4-9. Wetland Failing Cover Criterion Due to Impacts from ATV's.

These ATV trails can become problematic sources of sedimentation in down-gradient and adjacent water resources, and can modify normal drainage patterns.

There was ample evidence observed in the field that pipeline companies have gone to great lengths to deter ATV use on the ROWs, including: gates and fencing; signs with warnings of severe penalties; and, placement of large boulders, logs, or trees across the trails. However, signs are often vandalized, boulders and logs are moved, and new trails are created in other locations to allow access by the ATVs.

4.3.2 Waterbar Placement

The 1994 Procedures (Section VI.D.2.) require the placement of permanent slope breakers or waterbars at the base of slopes near the boundary between wetlands and adjacent uplands. Waterbars are permanent slope breakers, usually earthen berms, constructed perpendicular to the direction of slope. The purpose of waterbars is to slow the accumulation and velocity of surface water runoff (with sediments) and to divert water off the ROW before it causes soil erosion. Table 4-10 presents wetland restoration results for wetlands observed with associated waterbars.

Table 4-10. Wetland Restoration Relative to Existence or Placement of Waterbars.

Waterbar Position	Overall Distribution		Passing Wetlands		Failing Wetlands		Percent of All Failures
	Number	Percent	Number	Percent	Number	Percent	
No Waterbar	311	65%	187	60%	124	40%	74%
Upgradient	146	30%	108	74%	38	26%	23%
Downgradient	1	0%	0	0%	1	100%	1%
Both	22	5%	18	82%	4	18%	2%
Total	480	100%	313	65%	167	35%	100%

For the purpose of this study, it was assumed that wetlands surveyed that did not have waterbars did not require waterbars due to flat topographic conditions. Waterbar placement was evaluated in this study because of the potential for waterbars to affect the amount of surface water entering a wetland, and because the absence of waterbars can lead to the accumulation of sediment within wetlands. Where wetlands are dependent on upgradient surface water hydrology, a waterbar placed at the base of a slope could conceivably divert enough surface water away from the wetland, that it begins to transition into an upland community. However, the results did not support this concept.

Waterbars were observed adjacent to 35% of all wetlands surveyed. Of the wetlands observed with upgradient waterbars, 74% (126) were successfully restored and passed the 1994 Procedures.

4.3.3 Pipeline Construction Dates

Pipeline construction dates were evaluated to determine if there is a relationship between wetland restoration success and the amount of time the wetlands have had to recover following construction.

Table 4-11 shows the distribution of pipeline construction dates for the pipeline projects included in the study, along with the percent of passing and failing wetlands. The highest wetland restoration success rate (88%) was observed in the oldest pipeline construction year (1995). The lowest wetland success rate (39%) was observed in the second oldest pipeline construction year (1996). The second highest success rate (80%) was observed in the youngest (2001).

Table 4-11. Wetland Restoration Summary for Pipeline Construction Years.

Pipeline Construction Year	Years Since Wetland Disturbance	Overall Distribution		Passing		Failing		Percent of all Failures
		Number	Percent	Number	Percent	Number	Percent	
1995	7	25	5%	22	88%	3	12%	2%
1996	6	90	19%	35	39%	55	61%	33%
1998	4	174	36%	132	76%	42	24%	25%
1999	3	151	31%	96	64%	55	36%	33%
2000	2	10	2%	4	40%	6	60%	4%
2001	1	30	6%	24	80%	6	20%	4%
Total	-	480	100%	313	65%	167	35%	100%

The results of this study do not present a clear correlation between relative success rate and time since construction. Although the best success rate (88%) was achieved in the oldest projects surveyed (1995), the lowest rate (39%) was achieved only one year later

(1996). The remaining results show similar variability from year to year, thus indicating that other factors aside from time since construction are having an overriding effect on wetland restoration success and failure.

4.3.4 Post-construction Grading

Post-construction grading was evaluated to determine if there is a correlation between wetland restoration success and the re-establishment of pre-construction grades within wetlands. Qualitative judgments were made by field crews to determine if grading within the wetland was reestablished to preconstruction conditions. This observation was then recorded as a "yes" or "no" on the dataform. Typical field observations that indicate grades were not reestablished to pre-construction conditions include: obvious deviations from off-ROW topographic conditions (i.e., excess fill material higher than surrounding topography or large depressions atypical of surrounding conditions.) Of the wetlands that were restored to preconstruction grades 67% were successful, whereas in wetlands where preconstruction grades were not restored, only 35% of the wetlands were successful.

4.4 STATISTICAL ANALYSIS

Statistical methods were used to examine the influence of nine independent variables on the success of wetland restoration (Section 3.5.3). Each of the statistical models and test values are provided in Appendix B. Three factors were found as having a significant influence on whether or not a wetland would be successfully restored (Table 4-12). These three factors are discussed as follows.

The ecoregion from which the wetland was sampled had a significant influence on the success of the restored wetlands (Table 4-12). Further testing indicated that the success rate of the wetlands in the Hot Continental, Warm Continental, Subtropical, and Prairie ecoregions were not statistically different from each other, but the rates were significantly different than those of the Temperate Steppe and Mediterranean ecoregions. The success rate of the Temperate Steppe and Mediterranean ecoregions were found to be similar.

Table 4-12. Multiple Factor Analysis of Variance Effects Test on Success.

Source	Df	SS	MS	F	p
*Ecoregion	5	12.0580	2.4116		
Construction Debris	1	0.0425	0.0425	0.25	0.6159
Evidence of Erosion	1	0.0006	0.0006	0.00	0.9518
*Meets Preconstruction Grade	1	1.0100	1.0100	5.99	0.0148
Water Bar within 100 Feet	1	0.0766	0.0766	0.45	0.5007
*Evidence of Human Disturbance	1	1.6755	1.6754	9.93	0.0017
Wetland Position in Landscape	4	0.6179	0.1544	0.92	0.4545
Soil Texture	13	3.0706	0.2362	1.40	0.1551
Top Soil Mix	1	0.0007	0.0007	0.00	0.9505
Error	451	46.0699	0.1686		
Total	479	Grand Mean 1.47		CV 27.88	

Notes: The whole model was significant ($F = 6.95$, $P < 0.0001$).
* Indicates significant factor.
Similar results were obtained using grouped soil texture categories (e.g., sands, clays).

The "eastern" (i.e., Hot Continental, Warm Continental, Subtropical, and Prairie) ecoregions had an 82% success rate whereas those in the extreme west (i.e., Temperate Steppe and Mediterranean) had a 33% success rate (Table 4-13).

Whether or not a wetland exhibited evidence of human disturbance was also found to be a significant factor in determining the success of a restored wetland. Wetlands with evidence of human disturbance were associated with higher failure rates. Of the wetlands that exhibited evidence of human disturbance only 37% were successful, whereas if this evidence was absent 67% of the wetlands were successful (Table 4-12). In addition, in the more successful eastern ecoregions only 34% of the wetlands exhibited evidence of human disturbance when compared to the 72% for the western ecoregions (Table 4-13).

Whether or not a wetland was restored to preconstruction grade was the third factor found to be a significant in determining the success of a restored wetland. Wetlands not restored to preconstruction grade were associated with failure. Of the wetlands that were restored to preconstruction grade 67% were successful, whereas if preconstruction grade was not restored 35% of the wetlands were successful (Table 4-12).

Table 4-13. Significant Factors in Determining Successful Restoration.						
	% Successful					
	Hot Continental	Warm Continental	Subtropical	Prairie	Mediterranean	Temperate Steppe
Ecoregion	86	86	80	70	34	32
	Yes			No		
Evidence of Human Disturbance	37			63		
Meets Pre-Construction Grade	67			35		

Table 4-14. Significant Explanatory Factors Between Eastern and Western Grouped Ecoregions.

Ecoregion Group (wetland restoration success rate)	**% Wetlands w/Evidence of Human Disturbance**	**% of Wetlands Restored to Pre-Construction Grade**
East (83)	34	97
West (17)	72	92

Note: East group is comprised of the Hot Continental, Warm Continental, Subtropical, and Prairie ecoregions and the west group is comprised of the Temperate Steppe and Mediterranean ecoregions.

5.0 CONCLUSIONS AND RECOMENDATIONS

The FERC's 1994 Procedures were designed for the purpose of minimizing impacts to wetlands crossed by construction of natural gas pipelines and have been applied during pipeline construction since 1994. This study was designed to evaluate the effectiveness of the 1994 Procedures by analyzing the success and failure of wetland restoration following pipeline construction. A variety of factors that could potentially influence success were examined and presented in previous sections of this report. The following is a summary of substantive conclusions and notable trends:

- Existing wetland monitoring reports were largely unavailable from pipeline companies contacted. Based on post-construction wetland monitoring reports that were received, it is evident that the pipeline industry does not have a consistent approach to performing post-construction wetland monitoring. The FERC's revised 2003 Procedures (VI.D.3.) now requires that a report be filed with the Secretary identifying the status of the wetland revegetation efforts at the end of three years following construction. This requirement is anticipated to improve the status of post-construction wetlands monitoring for pipeline projects.
- Based on detailed quantitative field studies, approximately two thirds of all wetlands studied nationwide achieved all three wetland restoration success criteria identified in the 1994 Procedures. Most wetlands that failed the FERC success criteria failed due to insufficient vegetative cover.
- The study revealed strong differences in overall success by ecoregion. Eastern and Midwestern wetlands have significantly higher success rates than western ecoregions. Regional climates and weather conditions reveal noticeable trends in relative wetland restoration success and failure.
- The presence of human disturbance in wetlands was associated with higher failure rates, likely due to its influences on the percent vegetative cover criterion. The most common human disturbance category was farming, which includes cattle grazing, and could be a contributing factor to the lower success rate for wetlands occurring in the western ecoregions.

- Wetlands that achieved pre-construction grades (i.e., grading of the wetland was reestablished to pre-construction conditions) were significantly more successful than wetlands that did not meet pre-construction grades.
- Soil conditions appear to have some influence on wetland revegetation success, with wetlands underlain by clay-dominated soils having a greater failure rate than wetlands dominated by other soil types. Although this was a noticeable trend, soil texture was not a significant factor based on the statistical analysis.
- The data showed a strong trend of conversion of forested and scrub-shrub wetlands to emergent wetlands. This observation may be the result of the short period of time since implementation of the 1994 Procedures relative to the expected time frame for the re-establishment of arboreal vegetation. Therefore, this trend is considered inconclusive. In addition, we expect this trend to persist over portions of the ROW because ROW vegetation maintenance (removal of woody vegetation over the pipeline) is commonly used to facilitate monitoring required by the U.S. Department of Transportation to ensure pipeline integrity.

5.1 RECOMMENDATIONS

The following is a summary of recommendations resulting from this study:

- Methods used to monitor wetland restoration success should be standardized to ensure that wetland restoration can be evaluated consistently between projects and geographic regions over time. The wetland monitoring data form used for this study (Appendix D) should be used as a template for future wetlands monitoring.

- Wetlands in the arid western ecoregions have a much higher rate of failure than wetlands in more humid regions of the country. This stark contrast warrants consideration of a modified version of the Procedures for the western regions that takes into consideration climate differences and local successional processes. Duration of monitoring and success criteria may need to be modified for these regions (i.e., longer monitoring periods, lower cover and diversity requirements, etc.).

- Evidence of human disturbance was associated with lower success rates regardless of ecoregion, and, evidence of human disturbance was more prevalent for the western ecoregions than the eastern ecoregions. Post-construction monitoring to evaluate the effects of human disturbance on wetland restoration should be encouraged so that remedial measures can be suggested.

- Although only 23 of the 480 wetlands were not restored to pre-construction grades, this factor had a substantive effect in determining success. Therefore, current procedures that enforce the restoration of pre-construction grades should continue to be developed.

- FERC may want to consider modifying the criteria, as follows:

  - Wetlands with standing water commonly have areas of vegetation interspersed with open water, and therefore are characterized as having less than 80% cover of vegetation (due to greater than 20% open water). The open water/vegetation mix is generally considered to be a positive habitat feature and thus should not be discouraged except in instances where standing water indicates that post-construction grades were established lower than pre-construction conditions.

  - Pipeline companies should be encouraged to identify "problem wetlands" (i.e., wetlands with greater than 20% surface rock or open water, shallow to bedrock soils, or wetlands dominated by annual plant species) to the FERC staff prior to construction and provide ample pre-construction photographic documentation for these wetlands. These wetlands should be considered “successfully restored” following construction, if pre-construction conditions are reestablished and this can be documented to the satisfaction of FERC staff.

  - Farmed wetlands – Once a ROW is cleared, farmers often take advantage of the additional area and moist soils of seasonally saturated wetlands to plant additional crops or graze cattle. The presence of agricultural activity greatly reduces the chances that a wetland will meet the criteria for restored wetland. This issue was addressed in the revised 2003 Procedures (Section I.B.2.) where wetlands that are actively cultivated, or are considered rotated cropland, are excluded from the definition of a "wetland".

- Post-construction human disturbance is observed on two-thirds of all failed wetlands and is likely a contributing factor in failure. These extenuating circumstances should be considered when evaluating wetland restoration success.

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Appendix A

Database Results Summary Reports

WETLANDS AFFECTED BY HUMAN DISTURBANCE

Restoration Summary

Type of Human Disturbance	Total Wetlands Affected	Percent of Wetlands Affected	Passing Wetlands		Failing Wetlands		Percent of All Failures	Percent of All Wetlands
			Number	Percent	Number	Percent		
ATV	78	16%	65	83%	13	17%	8%	3%
Paved/Fill	1	0%	1	100%	0	0%	0%	0%
Logging	0	0%	0	0%	0	0%	0%	0%
Farming	130	27%	40	31%	90	69%	54%	19%
Lawn	3	1%	2	67%	1	33%	1%	0%
Other	18	4%	10	56%	8	44%	5%	2%
Total	225	47%	115	51%	110	49%	66%	23%

Note: The Total does not equal the sum of the column because a wetland may exhibit multiple forms of human disturbance.

Summary of Wetland Failures by Criterion

Type of Human Disturbance	80% Cover		Diversity		Jurisdictional Wetland	
	Number	Percent	Number	Percent	Number	Percent
ATV	7	6%	2	2%	5	5%
Paved/Fill	0	0%	0	0%	0	0%
Logging	0	0%	0	0%	0	0%
Farming	72	65%	7	6%	48	44%
Lawn	0	0%	0	0%	1	1%
Other	6	5%	1	1%	1	1%
Total	83	75%	10	9%	54	49%

Note: Sums for wetland failures by criterion may not equal total wetland failures due to some wetlands failing for more than one of the success criteria.

WETLANDS AFFECTED BY HUMAN DISTURBANCE

Summary of Wetland Failures By Ecoregion

Type of Human Disturbance	Warm Continental			Hot Continental			Subtropical			Prairie			Temperate Steppe			Mediterranean		
	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing
ATV	15	2	13%	23	7	30%	33	3	9%	5	0	0%	2	1	50%	0	0	0%
Paved/Fill	0	0	0%	1	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Logging	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Farming	7	2	29%	1	0	0%	2	1	50%	9	7	78%	59	44	75%	52	36	69%
Lawn	0	0	0%	0	0	0%	2	1	50%	1	0	0%	0	0	0%	0	0	0%
Other	0	0	0%	0	0	0%	5	3	60%	10	4	40%	1	0	0%	2	1	50%
Total	22	4	18%	25	7	28%	39	7	18%	24	11	46%	61	44	72%	54	37	69%

Note: The Total row represents the total number of wetlands affected by human disturbance in each ecoregion.

WETLAND LANDSCAPE POSITION

Restoration Summary

Landscape Position	Overall		Passing Wetlands		Failing Wetlands		Percent of All Failures
	Number	Percent	Number	Percent	Number	Percent	
Bottom	288	60%	197	68%	91	32%	54%
Veg. Swale	100	21%	64	64%	36	36%	22%
Sidehill	14	3%	10	71%	4	29%	2%
Riparian	66	14%	39	59%	27	41%	16%
Other	12	3%	3	25%	9	75%	5%
Total	480	100%	313	65%	167	35%	100%

Summary of Wetland Failures by Criterion

Landscape Position	80% Cover		Diversity		Jurisdictional Wetland	
	Number	Percent	Number	Percent	Number	Percent
Bottom	64	38%	16	10%	31	19%
Veg. Swale	25	15%	8	5%	19	11%
Sidehill	1	1%	1	1%	4	2%
Riparian	20	12%	4	2%	11	7%
Other	7	4%	0	0%	4	2%
Total	117	70%	29	17%	69	41%

Note: Sums for wetland failures by criterion may not equal total wetland failures due to some wetlands failing for more than one of the success criteria.

Summary of Wetland Failures By Ecoregion

Landscape Position	Warm Continental			Hot Continental			Subtropical			Prairie			Temperate Steppe			Mediterranean		
	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing
Bottom	60	9	15%	48	4	8%	68	13	19%	22	10	45%	51	29	57%	39	26	67%
Veg. Swale	2	0	0%	16	4	25%	5	1	20%	42	9	21%	7	5	71%	28	17	61%
Sidehill	5	1	20%	3	0	0%	2	1	50%	2	1	50%	2	1	50%	0	0	0%
Riparian	13	1	8%	13	1	8%	5	1	20%	14	4	29%	18	17	94%	3	3	100%
Other	0	0	0%	0	0	0%	0	0	0%	0	0	0%	2	2	100%	10	7	70%
Total	80	11	14%	80	9	11%	80	16	20%	80	24	30%	80	54	68%	80	53	66%

SOIL TEXTURAL CLASS

Restoration Summary

Soil Texture Class	Overall		Passing Wetlands		Failing Wetlands		Percent of All Failures
	Number	Percent	Number	Percent	Number	Percent	
Rock	2	0%	1	50%	1	50%	1%
Organic	26	5%	20	77%	6	23%	4%
Sands	151	31%	113	75%	38	25%	23%
Silts	21	4%	15	71%	6	29%	4%
Clays	183	38%	95	52%	88	48%	53%
Loams	86	18%	64	74%	22	26%	13%
Inundated	11	2%	5	45%	6	55%	4%
Total	480	100%	313	65%	167	35%	100%

Summary of Wetland Failures by Criterion

Soil Texture Class	80% Cover		Diversity		Jurisdictional Wetland	
	Number	Percent	Number	Percent	Number	Percent
Rock	1	1%	0	0%	0	0%
Organic	4	2%	3	2%	0	0%
Sands	31	19%	4	2%	9	5%
Silts	4	2%	1	1%	4	2%
Clays	63	38%	13	8%	49	29%
Loams	9	5%	8	5%	6	4%
Inundated	5	3%	0	0%	1	1%
Total	117	70%	29	17%	69	41%

Note: Sums for wetland failures by criterion may not equal total wetland failures due to some wetlands failing for more than one of the success criteria.

SOIL TEXTURAL CLASS

Summary of Wetland Failures By Ecoregion

Soil Texture Class	Warm Continental			Hot Continental			Subtropical			Prairie			Temperate Steppe			Mediterranean		
	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing
Rock	1	0	0%	0	0	0%	0	0	0%	1	1	100%	0	0	0%	0	0	0%
Organic	18	2	11%	1	1	100%	0	0	0%	1	0	0%	6	3	50%	0	0	0%
Sands	31	6	19%	36	5	14%	43	4	9%	5	0	0%	32	20	63%	4	3	75%
Silts	4	2	50%	5	0	0%	0	0	0%	3	0	0%	9	4	44%	0	0	0%
Clays	23	1	4%	27	2	7%	2	1	50%	25	9	36%	31	26	84%	75	49	65%
Loams	3	0	0%	10	1	10%	27	7	26%	45	14	31%	1	0	0%	0	0	0%
Inundated	0	0	0%	1	0	0%	8	4	50%	0	0	0%	1	1	100%	1	1	100%
Total	80	11	14%	80	9	11%	80	16	20%	80	24	30%	80	54	68%	80	53	66%

WETLAND HYDROLOGY

Restoration Summary

Surface Water Depth	Overall		Passing Wetlands		Failing Wetlands		Percent of All Failures
	Number	Percent	Number	Percent	Number	Percent	
< 1"	287	60%	172	60%	115	40%	69%
1"- 6"	157	33%	124	79%	33	21%	20%
6"- 12"	24	5%	15	63%	9	38%	5%
> 12"	12	3%	2	17%	10	83%	6%
Total	480	100%	313	65%	167	35%	100%

Summary of Wetland Failures by Criterion

Surface Water Depth	80% Cover		Diversity		Jurisdictional Wetland	
	Number	Percent	Number	Percent	Number	Percent
< 1"	79	47%	21	13%	54	32%
1"- 6"	20	12%	6	4%	14	8%
6"- 12"	8	5%	2	1%	0	0%
> 12"	10	6%	0	0%	1	1%
Total	117	70%	29	17%	69	41%

Note: Sums for wetland failures by criterion may not equal total wetland failures due to some wetlands failing for more than one of the success criteria.

Summary of Wetland Failures By Ecoregion

Surface Water Depth	Warm Continental			Hot Continental			Subtropical			Prairie			Temperate Steppe			Mediterranean		
	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing
< 1"	50	5	10%	41	4	10%	18	2	11%	65	18	28%	53	40	75%	60	46	77%
1"- 6"	20	1	5%	38	5	13%	45	6	13%	12	4	33%	25	13	52%	17	4	24%
6"- 12"	5	2	40%	1	0	0%	13	4	31%	1	0	0%	2	1	50%	2	2	100%
> 12"	5	3	60%	0	0	0%	4	4	100%	2	2	100%	0	0	0%	1	1	100%
Total	80	11	14%	80	9	11%	80	16	20%	80	24	30%	80	54	68%	80	53	66%

WATERBAR PLACEMENT

Restoration Summary

Waterbar Position	Overall		Passing Wetlands		Failing Wetlands		Percent of All Failures
	Number	Percent	Number	Percent	Number	Percent	
No Waterbar	311	65%	187	60%	124	40%	74%
Up gradient	146	30%	108	74%	38	26%	23%
Down gradient	1	0%	0	0%	1	100%	1%
Both	22	5%	18	82%	4	18%	2%
Total	480	100%	313	65%	167	35%	100%

Summary of Wetland Failures by Criterion

Waterbar Position	80% Cover		Diversity		Jurisdictional Wetland	
	Number	Percent	Number	Percent	Number	Percent
No Waterbar	82	49%	25	15%	52	31%
Up gradient	30	18%	3	2%	13	8%
Down gradient	1	1%	0	0%	1	1%
Both	4	2%	1	1%	3	2%
Total	117	70%	29	17%	69	41%

Note: Sums for wetland failures by criterion may not equal total wetland failures due to some wetlands failing for more than one of the success criteria.

Summary of Wetland Failures By Ecoregion

Waterbar Position	Warm Continental			Hot Continental			Subtropical			Prairie			Temperate Steppe			Mediterranean		
	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing
No Waterbar	33	5	15%	53	8	15%	26	7	27%	78	23	29%	48	32	67%	73	49	67%
Up gradient	44	6	14%	27	1	4%	37	7	19%	2	1	50%	29	19	66%	7	4	57%
Down gradien	0	0	0%	0	0	0%	0	0	0%	0	0	0%	1	1	100%	0	0	0%
Both	3	0	0%	0	0	0%	17	2	12%	0	0	0%	2	2	100%	0	0	0%
Total	80	11	14%	80	9	11%	80	16	20%	80	24	30%	80	54	68%	80	53	66%

WATERBAR PLACEMENT

Summary of Wetland Failures By Landscape Position

Waterbar Position	Vegetated Swale		Sidehill		Bottom		Riparian		Other	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
No Waterbar	32	7%	1	0%	69	14%	13	3%	9	2%
Up gradient	3	1%	2	0%	20	4%	13	3%	0	0%
Down gradient	0	0%	0	0%	0	0%	1	0%	0	0%
Both	1	0%	1	0%	2	0%	0	0%	0	0%
Total	36	8%	4	1%	91	19%	27	6%	9	2%

COWARDIN CLASSIFICATION

Restoration Summary

ROW Cowardin Class	Overall		Total Passing		Total Failing		Percent of All Failures
	Number	Percent	Number	Percent	Number	Percent	
PSS/PFO	2	0%	2	100%	0	0%	0%
PSS/OW	2	0%	0	0%	2	100%	1%
PEM/PSS	31	6%	26	84%	5	16%	3%
PEM/PFO	0	0%	0	0%	0	0%	0%
PEM/OW	21	4%	1	5%	20	95%	12%
PEM	394	82%	267	68%	127	32%	76%
PSS	20	4%	11	55%	9	45%	5%
PFO	9	2%	6	67%	3	33%	2%
POW	1	0%	0	0%	1	100%	1%
Total	480	100%	313	65%	167	35%	100%

On-ROW Cowardin Class	Percent of Total Failures	Percent of Total Wetlands
PSS/PFO	0%	0%
PSS/OW	1%	0%
PEM/PSS	3%	1%
PEM/PFO	0%	0%
PEM/OW	12%	4%
PEM	76%	26%
PSS	5%	2%
PFO	2%	1%
POW	1%	0%
Total	100%	35%

Summary of Wetland Failures by Criterion

ROW Cowardin Class	80% Cover		Diversity		Jurisdictional Wetland	
	Number	Percent	Number	Percent	Number	Percent
PSS/PFO	0	0%	0	0%	0	0%
PSS/OW	2	1%	0	0%	2	1%
PEM/PSS	0	0%	1	1%	4	2%
PEM/PFO	0	0%	0	0%	0	0%
PEM/OW	20	12%	1	1%	0	0%
PEM	84	50%	26	16%	54	32%
PSS	7	4%	0	0%	7	4%
PFO	3	2%	1	1%	2	1%
POW	1	1%	0	0%	0	0%
Total	117	70%	29	17%	69	41%

Note: Sums for wetland failures by criterion may not equal total wetland failures due to some wetlands failing for more than one of the success criteria.

COWARDIN CLASSIFICATION

Summary of Wetland Failures By Ecoregion

ROW Cowardin Class	Warm Continental			Hot Continental			Subtropical			Prairie			Temperate Steppe			Mediterranean		
	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing
PSS/PFO	0	0	0%	0	0	0%	2	0	0%	0	0	0%	0	0	0%	0	0	0%
PSS/OW	0	0	0%	0	0	0%	1	1	100%	0	0	0%	1	1	100%	0	0	0%
PEM/PSS	0	0	0%	1	0	0%	28	4	14%	1	0	0%	0	0	0%	1	1	100%
PEM/PFO	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
PEM/OW	6	5	83%	1	1	100%	8	8	100%	2	2	100%	3	3	100%	1	1	100%
PEM	73	6	8%	77	7	9%	30	3	10%	74	22	30%	63	39	62%	77	50	65%
PSS	1	0	0%	1	1	100%	7	0	0%	1	0	0%	10	8	80%	0	0	0%
PFO	0	0	0%	0	0	0%	4	0	0%	2	0	0%	3	3	100%	0	0	0%
POW	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	1	1	100%
Total	80	11	14%	80	9	11%	80	16	20%	80	24	30%	80	54	68%	80	53	66%

Summary of Wetland Failures By Landscape Position

ROW Cowardin Class	Vegetated Swale		Sidehill		Bottom		Riparian		Other	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
PSS/PFO	0	0%	0	0%	0	0%	0	0%	0	0%
PSS/OW	0	0%	0	0%	1	0%	1	0%	0	0%
PEM/PSS	0	0%	1	0%	2	0%	2	0%	0	0%
PEM/PFO	0	0%	0	0%	0	0%	0	0%	0	0%
PEM/OW	0	0%	0	0%	15	3%	5	1%	0	0%
PEM	36	8%	3	1%	68	14%	11	2%	9	2%
PSS	0	0%	0	0%	4	1%	5	1%	0	0%
PFO	0	0%	0	0%	0	0%	3	1%	0	0%
POW	0	0%	0	0%	1	0%	0	0%	0	0%
Total	36	8%	4	1%	91	19%	27	6%	9	2%

ATYPICAL CLIMATIC CONDITIONS AT TIME OF SURVEY

Restoration Summary

Abnormal Conditions	Overall		Passing Wetlands		Failing Wetlands		Percent of All Failures
	Number	Percent	Number	Percent	Number	Percent	
Normal	345	72%	236	68%	109	32%	65%
Drought	134	28%	77	57%	57	43%	34%
Flooding	1	0%	0	0%	1	100%	1%
Total	480	100%	313	65%	167	35%	100%

Summary of Wetland Failures by Criterion

Abnormal Conditions	80% Cover		Diversity		Jurisdictional Wetland	
	Number	Percent	Number	Percent	Number	Percent
Normal	68	41%	21	13%	42	25%
Drought	48	29%	8	5%	27	16%
Flooding	1	1%	0	0%	0	0%
Total	117	70%	29	17%	69	41%

Note: Sums for wetland failures by criterion may not equal total wetland failures due to some wetlands failing for more than one of the success criteria.

Summary of Wetland Failures By Ecoregion

Abnormal Conditions	Warm Continental			Hot Continental			Subtropical			Prairie			Temperate Steppe			Mediterranean		
	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing
Normal	50	10	20%	57	8	14%	80	16	20%	80	24	30%	0	0	0%	78	51	65%
Drought	30	1	3%	23	1	4%	0	0	0%	0	0	0%	80	54	68%	1	1	100%
Flooding	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	1	1	100%
Total	80	11	14%	80	9	11%	80	16	20%	80	24	30%	80	54	68%	80	53	66%

ATYPICAL CLIMATIC CONDITIONS AT TIME OF SURVEY

Summary of Wetland Failures By Landscape Position

Abnormal Conditions	Vegetated Swale		Sidehill		Bottom		Riparian		Other	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Normal	31	6%	3	1%	58	12%	10	2%	7	1%
Drought	5	1%	1	0%	32	7%	17	4%	2	0%
Flooding	0	0%	0	0%	1	0%	0	0%	0	0%
Total	36	8%	4	1%	91	19%	27	6%	9	2%

CONSTRUCTION YEAR

Restoration Summary

Construction Year	Overall		Passing Wetlands		Failing Wetlands		Percent of All Failures
	Number	Percent	Number	Percent	Number	Percent	
1995	25	5%	22	88%	3	12%	2%
1996	90	19%	35	39%	55	61%	33%
1998	174	36%	132	76%	42	24%	25%
1999	151	31%	96	64%	55	36%	33%
2000	10	2%	4	40%	6	60%	4%
2001	30	6%	24	80%	6	20%	4%
Total	480	100%	313	65%	167	35%	100%

Summary of Wetland Failures by Criterion

Construction Year	80% Cover		Diversity		Jurisdictional Wetland	
	Number	Percent	Number	Percent	Number	Percent
1995	0	0%	0	0%	3	2%
1996	40	24%	4	2%	29	17%
1998	24	14%	15	9%	6	4%
1999	46	28%	7	4%	28	17%
2000	5	3%	2	1%	0	0%
2001	2	1%	1	1%	3	2%
Total	117	70%	29	17%	69	41%

Note: Sums for wetland failures by criterion may not equal total wetland failures due to some wetlands failing for more than one of the success criteria.

CONSTRUCTION YEAR

Summary of Wetland Failures By Ecoregion

Construction Year	Warm Continental			Hot Continental			Subtropical			Prairie			Temperate Steppe			Mediterranean		
	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing	Total	Failed Wetlands	% Failing
1995	0	0	0%	25	3	12%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
1996	0	0	0%	0	0	0%	10	2	20%	0	0	0%	0	0	0%	80	53	66%
1998	38	10	26%	16	0	0%	40	8	20%	80	24	30%	0	0	0%	0	0	0%
1999	42	1	2%	39	6	15%	0	0	0%	0	0	0%	70	48	69%	0	0	0%
2000	0	0	0%	0	0	0%	0	0	0%	0	0	0%	10	6	60%	0	0	0%
2001	0	0	0%	0	0	0%	30	6	20%	0	0	0%	0	0	0%	0	0	0%
Total	80	11	14%	80	9	11%	80	16	20%	80	24	30%	80	54	68%	80	53	66%

WETLAND RESTORATION SUMMARY

Total Number of Wetland Records (80 Wetlands Per EcoRegion)	480
Number Wetlands Per Eco-Region	80
Wetlands Passing FERC Criteria (passing all three criteria)	313
Wetlands Failing FERC Criteria (only need to fail one criterion)	167
Wetlands Failing Diversity Criterion Only	20
Wetlands Failing 80% Vegetative Cover Criterion Only	73
Wetlands Failing 50% Relative Cover by Hydrophytes (RCH) Criterion Only	30
Wetlands Where Reference Wetland Failed RCH Criterion and On-ROW Failed	31
Wetlands Where Reference Wetland Passed RCH and on On-ROW Failed	38
Wetlands Failing Diversity and Vegetative Cover Criteria Only	5
Wetlands Failing Diversity and RCH Criteria Only	0
Wetlands Failing Vegetative Cover and RCH Criteria Only	35
Wetlands Failing All Three Criteria	4
Wetlands Failing Diversity Criterion	29
Wetlands Failing 80% Vegetative Cover Criterion	117
Wetlands Failing 50% Relative Cover by Hydrophytes (RCH) Criterion	69

Appendix B

Statistical Analysis Summary Report

Research of Wetland Construction and Mitigation Activities for Certificated Section 7(c) Natural Gas Pipeline Projects
Statistical Analysis

All statistical tests were set at a 0.05 significance level. Significant factors are highlighted in yellow. Df = Degrees of Freedom, SS = Sum of Squares, MS = Mean Square, F= F Statistic, P = calculated level of significance.

I. All Ecoregions

A randomized complete block design was used to reduce experimental error by blocking on the variable ecoregion. A factorial design ANalysis Of VAriance (ANOVA) (F Statistic) was used with the dependent variable success (1 = yes success, 0 = no success) and nine independent variables. Interaction terms were not possible because of the presence of empty cells.

Multiple factor ANOVA effects table on success (the whole model was significant [F = 6.95, P < 0.0001]):

Source	Df	SS	MS	F	p
Ecoregion	5	12.0580	2.4116		
Construction Debris	1	0.0425	0.0425	0.25	0.6159
Evidence of Erosion	1	0.0006	0.0006	0.00	0.9518
Meets Preconstruction Grade	1	1.0100	1.0100	5.99	0.0148
Water Bar within 100 Feet	1	0.0766	0.0766	0.45	0.5007
Evidence of Human Disturbance	1	1.6755	1.6754	9.93	0.0017
Wetland Position in Landscape	4	0.6179	0.1544	0.92	0.4545
Soil Texture	13	3.0706	0.2362	1.40	0.1551
Top Soil Mix	1	0.0007	0.0007	0.00	0.9505
Error	451	46.0699	0.1686		
Total	479	Grand Mean 1.47		CV 27.88	

Notes: SS are marginal (Type III) sums of squares.
Similar results were obtained using grouped soil texture categories (e.g., sands, clays).

A Tukey HSD all-pairwise comparisons test was used to examine differences between successes for each ecoregion (unlike letters indicate a significant difference between the two groups):

Ecoregion	Mean Success	% Successful	Homogeneous Groups
Hot Continental	0.72	86%	A
Warm Continental	0.71	86%	A
Subtropical	0.63	80%	A
Prairie	0.55	70%	A
Mediterranean	0.32	34%	B
Temperate Steppe	0.23	32%	B

Wetland restoration was significantly more successful in the Hot Continental, Warm Continental, Subtropical, and Prairie Ecoregions than the Mediterranean and Temperate Steppe Ecoregions (P < 0.05).

The multiple factor ANOVA test above also indicates two groups in which the means for success were significantly different from one another; evidence of human disturbance and meets preconstruction grade (unlike letters indicate a significant difference between the two groups).

Evidence of Human Disturbance	Mean Success	% Successful	Homogenous Groups
Yes	0.46	37	A
No	0.59	63	B

Evidence of human disturbance was a significant factor in determining the success of wetland restoration (P = 0.0148). More evidence of human disturbance was associated with less success.

Meets Preconstruction Grade	Mean Success	%Successful	Homogenous Groups
Yes	0.64	67	A
No	0.41	35	B

Meets preconstruction grade was a significant factor in determining the success of wetland restoration (P = 0.0017). Wetlands not restored to preconstruction grades were less successful.

II. Grouped Ecoregions

Based on the above analysis in Section I the ecoregions were pooled into "East" and "West" categories to examine if any of the variables could explain the difference in wetland restoration success between eastern and western located wetlands. The eastern category included the Hot Continental, Prairie, Subtropical, and Warm Continental ecoregions. The western category included the Mediterranean and Temperate Steppe ecoregions.

One-way ANOVA on Success:

Source	Df	SS	MS	F	P
Ecoregion (East/West)	1	24.704	24.7042	1.40	0.0000
Error	478	84.194	0.1761		
Total	479	108.898	Grand Mean 0.6521		CV 64.36

Location	N	Mean Success	%Successful	SE
East	320	0.81	83	0.0235
West	160	0.33	17	0.0332

As expected the one-way ANOVA results indicates a significant difference in success for the pooled ecoregion categories:

Analysis of Variance Table on success with the grouped ecoregion covariate (the whole model was significant [F = 7.76, P < 0.0001]):

Source	Df	SS	MS	F	P
Soil Texture	13	3.2656	0.2512	1.48	0.1211
Construction Debris	1	0.0705	0.0705	0.42	0.5196
Sign of Erosion	1	0.0073	0.0073	0.04	0.8355
Preconstruction Grade	1	0.9127	0.9127	5.38	0.0209
Water Bar within 100 Feet	1	0.2196	0.2196	1.29	0.2561
Evidence of Human Disturbance	1	1.9157	1.9157	11.28	0.0008
Wetland Position in Landscape	4	0.6243	0.1561	0.92	0.4525
Topsoil Mix	1	0.0021	0.0021	0.01	0.9116
Location (East/West)	1	10.8743	10.8743	64.05	0.0000
Error	455	77.2536	.1698		
Total	479	Grand Mean 0.5117		CV 80.53	

Evidence of Human Disturbance was a significant factor in determining the success of wetland restoration (P = 0.0008). More Evidence of Human Disturbance was associated with less success.

Meets Preconstruction Grade was a significant factor in determining the success of wetland restoration (P = 0.0209). Wetlands not restored to preconstruction grades were less successful.

III. Chi-Square Tests

Contingency tables and the Chi-square test (X^2 Statistic) were used to test for homogeneity of the proportions between east and west groups for each of the variables in the ANOVA preformed in Section I:

Meets Preconstruction Grade	East	West
No	10 (3%)	13 (8%)
Yes	310 (97%)	147 (92%)
Total	320 (100%)	160 (100%)

There is a significant difference between the proportion of wetlands that met preconstruction grade between the east and west groups (?^{2} = 5.85, P = 0.0156, Df = 1). However, this proportion is only separated by five percentage points (97% of the eastern wetlands met preconstruction grade, whereas 92% of the western wetlands met preconstruction grade). A greater proportion of eastern wetlands were restored to meet preconstruction grade and this could potentially be an explanatory variable as to why the east group wetlands were more successful. This finding is further supported by the ANOVA model test in Section II.

Evidence of Human Disturbance	East	West
No	210 (66%)	45 (28%)
Yes	110 (34%)	115 (72%)
Total	320 (100%)	160 (100%)

There is a significant difference between the proportion of wetlands that exhibited evidence of human disturbance between the east and west groups (?^{2} = 60.24, P = 0.0000, Df = 1). A smaller proportion of eastern wetlands exhibited evidence of human disturbance and this could potentially be an explanatory variable as to why the east group wetlands were more successful. This finding is further supported by the ANOVA model test in Section II.

Evidence of Construction Debris	East	West
No	299 (93%)	154 (96%)
Yes	21 (7%)	6 (4%)
Total	320 (100%)	160 (100%)

A significant difference was not found between the proportion of wetlands that exhibited evidence of construction debris between the east and west groups (?^{2} = 1.59, P = 0.2074, Df = 1).

Evidence of Erosion	East	West
No	298 (93%)	146 (96%)
Yes	22 (7%)	14 (4%)
Total	320 (100%)	160 (100%)

A significant difference was not found between the proportion of wetlands that exhibited evidence of erosion between the east and west groups (?^{2} = 0.541, P = 0.4622, Df = 1).

Water Bar Within 100 Ft	East	West
No	189(59%)	121 (76%)
Yes	130 (41%)	39 (24%)
Total	320 (100%)	160 (100%)

There is a significant difference between the proportion of wetlands that had a water bar within 100 feet between the east and west groups (?^{2} = 12.35, P = 0.0004, Df = 1). A larger proportion of eastern wetlands had water bars within 100 feet of the wetlands and this could potentially be an explanatory variable as to why the east group wetlands were more successful. However, the existence of a water bar within 100 feet in the context of all of the other variables analyzed was not a significant factor in determining the success of a wetland as indicated by the ANOVA and ANCOVA models in Sections I and II. Therefore these results should be viewed with caution.

Wetland Position in Landscape	East	West
Bottom	198 (62%)	90 (56%)
Other	0	12 (8%)
Riparian	45 (14%)	21 (13%)
Sidehill	12 (4%)	2 (1%)
Vegetated Swale	65 (20%)	35 (22%)
Total	320 (100%)	160 (100%)

There is a significant difference between the distribution of the proportions of the wetland positions between the east and west groups (?2 = 27.04, P < 0.0001, Df = 21). These results should be viewed with caution because there are cells with expected values less than 5.

Soil Texture	East	West
Clays	77 (24%)	106 (66%)
Inundated	9 (3%)	2 (1%)
Loams	85 (27%)	1 (.6%)
Organic	20 (6%)	6 (4%)
Rock	2 (6%)	0
Sands	115 (36%)	36 (6%)
Silt	12 (4%)	9 (33%)
Total	320 (100%)	160 (100%)

There is a significant difference between the distribution of the proportions of the soil types between the east and west groups (?2 = 100.19, P < 0.0001, Df = 21). These results should be viewed with caution because there are cells with expected values less than 5.

Top Soil Mixing	East	West
No	274 (86%)	146 (91%)
Yes	46 (14%)	14 (9%)
Total	320 (100%)	160 (100%)

A significant difference was not found between the proportion of wetlands that exhibited evidence of top soil mixing between the east and west groups ($?^2$ = 3.09, p = 0.0790, Df = 1).

Appendix C

Vegetation and Diversity Summary Reports

(Included in Appendix E on CD)

Appendix D

Wetlands Monitoring Dataform

Wetland Monitoring Form
Pipeline Right of Way

Pipeline Company: ____ **Field Crew:** ____ **Survey Date:** ____

Docket Number: ____ **Construction Year:** ____ **Construction Season:** ____

Wetland Name or Location: ____ **Town/County/State:** ____

Proposed Construction Method: ____ **Photographic Documentation:** ____

Cowardin Wetland Classification: ____ **Latitude/Longitude:** ____

General Condition of Wetland:

Vegetation:

Total Percent Veg. Cover:			
Vegetation Vigor:		Dead/Dying	
	Low	Medium	High
Percent Bare Ground:			
Evidence of Resprouting:	Yes		No
Resprouting Species:			
O Horizon Thickness (inches):			
Soil Textural Class (Top 12 inches):			Rock
Sand	Sandy Loam	Loam	Loamy Sand
Sandy Clay Loam	Sandy Clay	Clay	Clay Loam
Silty Loam	Silty Clay Loam	Silty Clay	Silt
Topsoil/Subsoil Mixing: Yes		% Topsoil	No
Rock Fragments at the Surface:			None
Gravel (<3" dia.): %		Stone (11-24" dia.): %	
Cobble (3-10" dia.): %		Boulder (>25" dia.): %	
New or Existing ROW:		New	Existing
Meets Pre-Construction Grade:		Yes	No
Evidence of Erosion: Yes		% of Wetland	No

Hydrology:

Percent Open Water:				
Depth of Surface Water:	0"	1 to 6"	6 to 12"	12"+
Saturated Soil:		Yes	No	
Drainage Patterns:		Normal	Blocked	Altered
Abnormal Conditions:		Drought	Normal	Flooding
Wetland Position in Landscape:			Bottom	Vegetated Swale
	Sidehill Wetland	Riparian	Other:	
Waterbar Within 100 Feet:	None		Upgradient	Downgradient

Evidence of Human Disturbance:		None	
ATV	%	Farming	%
Paved/Fill	%	Lawn	%
Logging	%	Other:	%

Evidence of Construction Debris:		None	Timber %
Blast Rock	%	Rip-Rap	%
Wood Chips	%	Slash	%
Mats	%	Other:	%

QUALITATIVE ASSESSMENT

Strata of Vegetation	Species Code	Wetland Indicator	% Cover

QUANTITATIVE ASSESSMENT

Plot Number	Species Code	% Cover	Cover Class

COMMENTS/RECOMMENDATIONS

Percent Cover Class	
Class	Percent
t	<1
1	1-5
2	5-25
3	25-50
4	50-75
5	75-100

Wetland Monitoring Form
Reference Area Wetland

Pipeline Company:

Wetland Name:

Cowardin Wetland Classification:

Latitude/Longitude:

Field Crew:

Date:

Photographic Documentation:

General Condition of Wetland:

Vegetation

Total Percent Veg. Cover:

Vegetation Vigor: Dead/dying | Low | Medium | High

Percent Bare Ground:

Percent Open Water:

Other

O Horizon Thickness (inches):

Soil Textural Class (Top 12 inches):			Rock
Sand	Sandy Loam	Loam	Loamy Sand
Sandy Clay Loam	Sandy Clay	Clay	Clay Loam
Silty Loam	Silty Clay Loam	Silty Clay	Silt

Rock Fragments at the Surface: None

Gravel (<3" dia.): %	Stone (11-24" dia.): %
Cobble (3-10" dia.): %	Boulder (>25" dia.): %

Hydrology

Depth of Surface Water: 0" | 1 to 6" | 6 to 12" | 12"+

Saturated Soil: Yes | No

Drainage Patterns: Normal | Blocked | Altered

Abnormal Conditions: Drought | Normal | Flooding

Wetland Position in Landscape: Bottom | Vegetated Swale | Sidehill Wetland | Riparian | Other:

Evidence of Human Disturbance: None

ATV	%	Farming	%
Lawn	%	Paved/Fill	%
Logging	%	Other:	%

Evidence of Erosion: Yes % | No

QUALITATIVE ASSESSMENT

Strata of Vegetation	Species Code	Wetland Indicator	% Cover

QUANTITATIVE ASSESSMENT

Plot Number	Species Code	% Cover	Cover Class

COMMENTS/RECOMMENDATIONS

Percent Cover Class	
Class	Percent
t	<1
1	1-5
2	5-25
3	25-50
4	50-75
5	75-100

Appendix E

Wetlands Monitoring Database and Technical Documentation

Wetland Monitoring Database

Technical Documentation

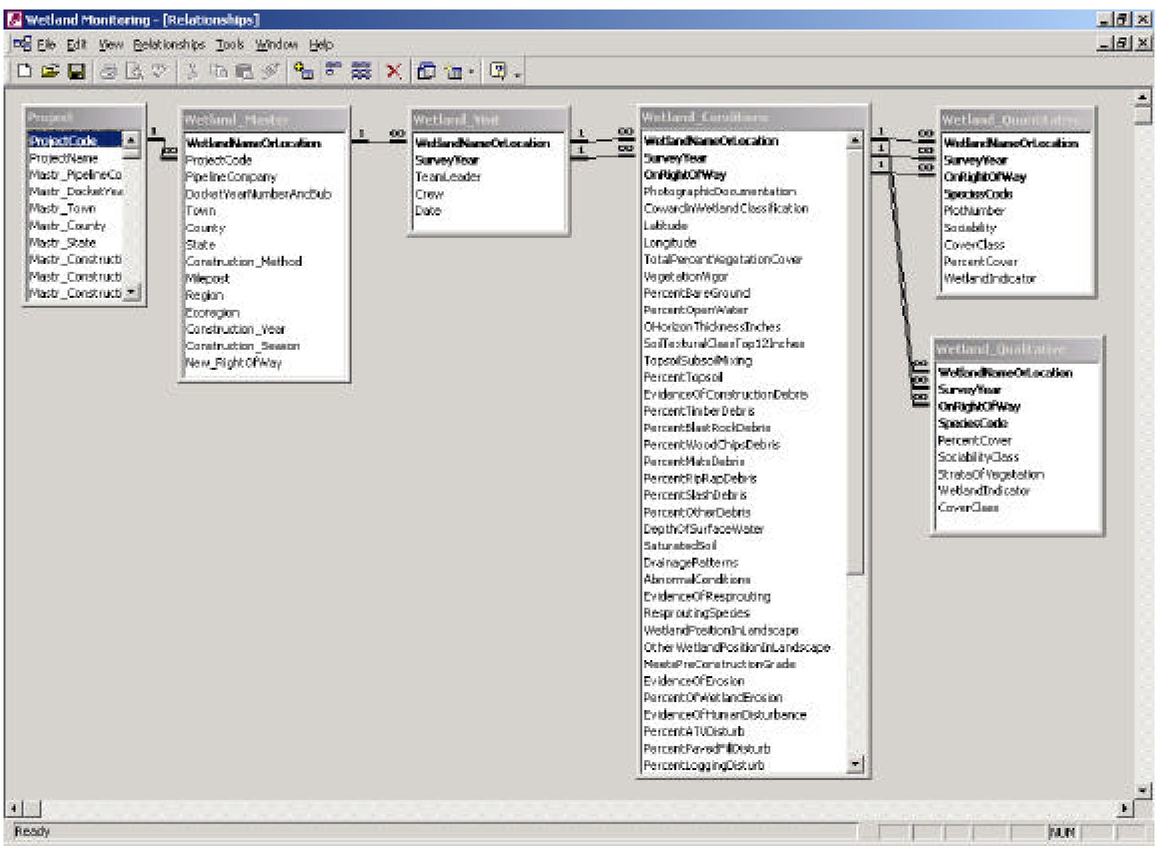
March 25, 2004

Introduction

The Wetland Monitoring Database is a Microsoft© Access 2000 database. It is a single file database (Wetland Monitoring.mdb) with forms designed for display on a screen with area settings of 1024 by 768 pixels. All database objects and source code are open for modification.

Wetland Data Tables

Data regarding wetland monitoring is stored in six normalized tables that are linked to enforce referential integrity. The structure will support multiple visits to the same wetland (subsequent year monitoring) without duplication of data. Cascade updates and cascade deletes have been enabled on the relationships to maintain integrity. The table structure is displayed in the database's relationship window (see below).



The Project table stores information for each project including data field specifications. The Wetland_Master table stores static information for each wetland. The Wetland_Visit table stores a short header record for each trip to the wetland.

The Wetland_Conditions table stores the single-entry data from the wetland monitoring dataform. The OnRightOfWay yes/no field allows this table to store records for both the on right of way and it's reference wetland. This field and data structure is repeated in the Wetland_Qualitative and Wetland_Quantitative tables, which store the qualitative and quantitative data respectively.

Lookup Tables

The database contains 21 lookup tables that govern data entry in corresponding wetland data fields. The tables are named to indicate their purpose. With the exception of the LkpSpecies and the LkpNonNative table, the text following the “Lkp” prefix corresponds to the wetland data field(s) that the lookup table governs. All tables using this naming convention are listed below:

LkpAbnormalConditions	LkpSociability
LkpCoverClass	LkpSoilTexturalClass
LkpCowardinWetlandClassification	LkpStates
LkpCrew*	LkpStrataOfVegetation
LkpDepthOfSurfaceWater	LkpType
LkpDocketYearNumberAndSub	LkpVegetationVigor
LkpDrainagePatterns	LkpWaterbarGradient
LkpPipelineCompany	LkpWetlandIndicator
LkpRegion	LkpWetlandPositionInLandscape
LkpRockFragmentsAtSurface	

**LkpCrew is used for the Crew field and the Team Leader field*

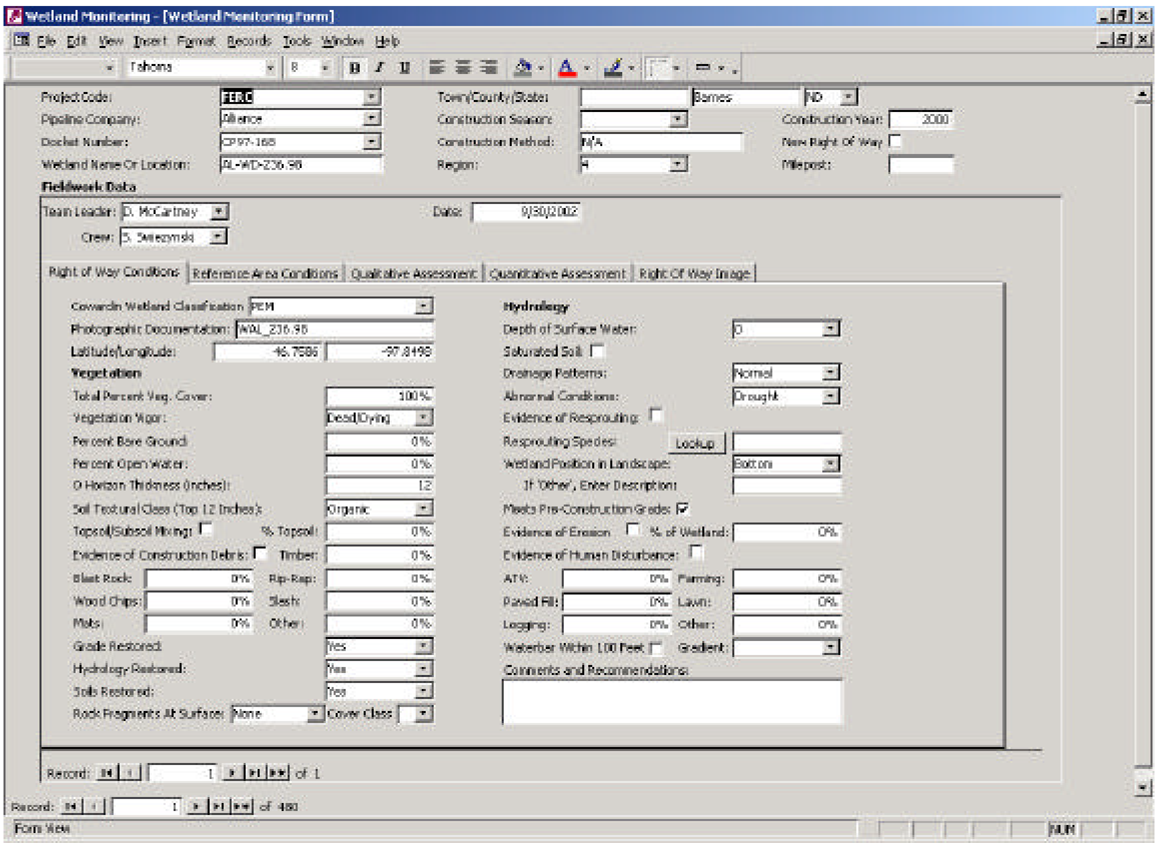
The LkpSpecies table is used for the SpeciesCode field, but it also contains important reference information for each species. The table contains Yes/no fields and WetlandIndicator text fields with the prefix “Region_” followed by a number or letter indicating a region. The region referenced in this section corresponds to the U.S. Fish and Wildlife Service's (FWS's) jurisdictional regions, and not ecoregions. This link is required because the same plant species may have a different wetland indicator status depending on the FWS region in which it is found. The Yes/no field indicates whether the species should be listed in the particular region and the WetlandIndicator field gives the respective wetland indicator status for that plant within the identified U.S. Fish and Wildlife Service region.

The LkpNonNative table is used in a coded procedure behind the data entry form. The procedure automatically populates the Wetland Indicator on the data entry form with a zero value if the species is considered non-native for the particular region. The

LkpNonNative table supports a state-based lookup that overrides the Wetland Indicator with a Non-Native flag where appropriate. This supports the exclusion of non-native species in diversity, and relative cover by hydrophytes, calculations within the database.

Wetland Monitoring Data Entry Form

The Wetland Monitoring Data Entry Form allows for data entry in the five data tables that have the prefix "Wetland_". The form uses subforms to mimic the normalized structure of the data. The lookup tables support the drop-down menus on the form. The SpeciesCode drop-down menus adjust according to the designated region. Users can add species from the Add New Species pop-up form that is launched from this form.

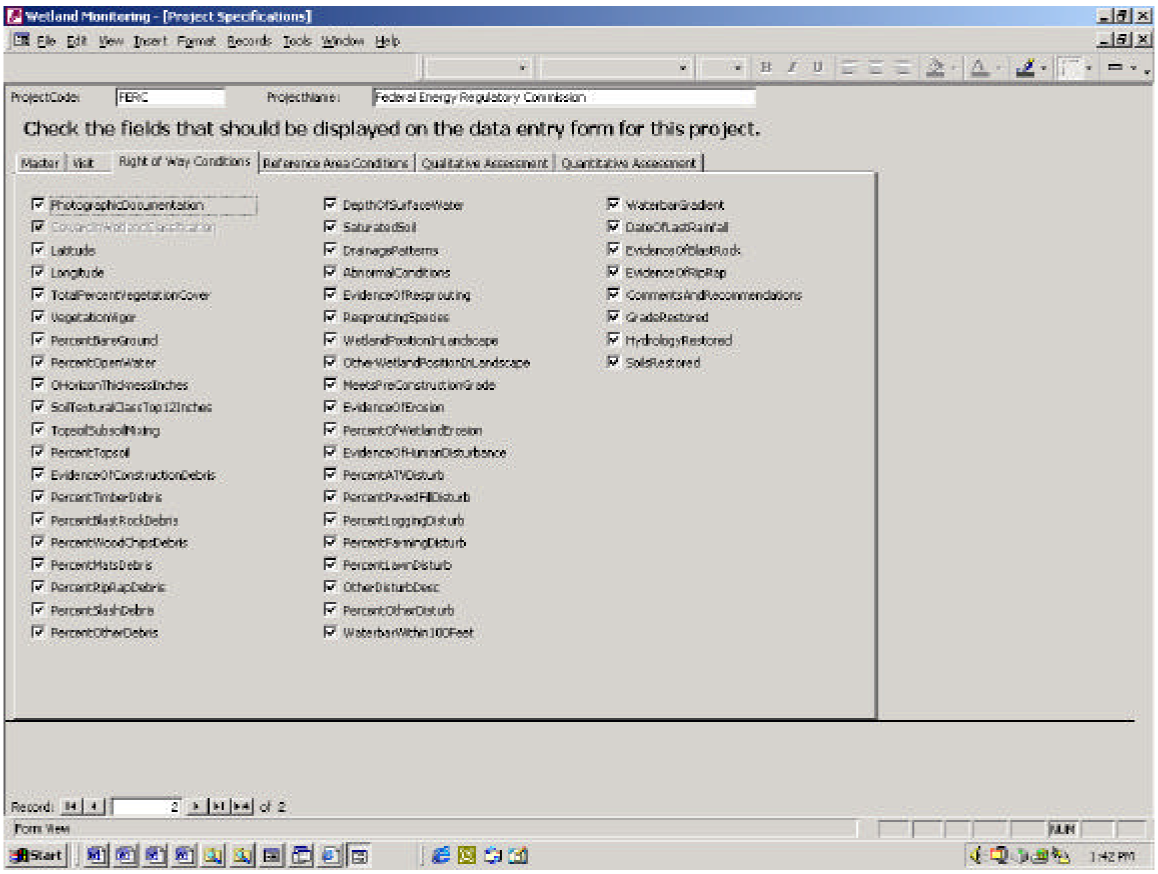


Please Note: In order to maintain data integrity, records must exist in the Wetland_Conditions table before corresponding records are created in the Wetland_Qualitative and Wetland_Quantitative tables. During data entry, the users must enter some data on a conditions tab before they attempt to enter qualitative or quantitative data for the respective portion of the wetland (right of way or reference). The simplest way is to enter a Cowardin Wetland Classification for the given portion of the wetland before proceeding to either of the assessment tabs.

The Navigation Bar at the very bottom of the screen lists the number of records in the Wetland_Master table. The Navigation Bar at the bottom of the Fieldwork Data subform lists the number of visits to the given Wetland.

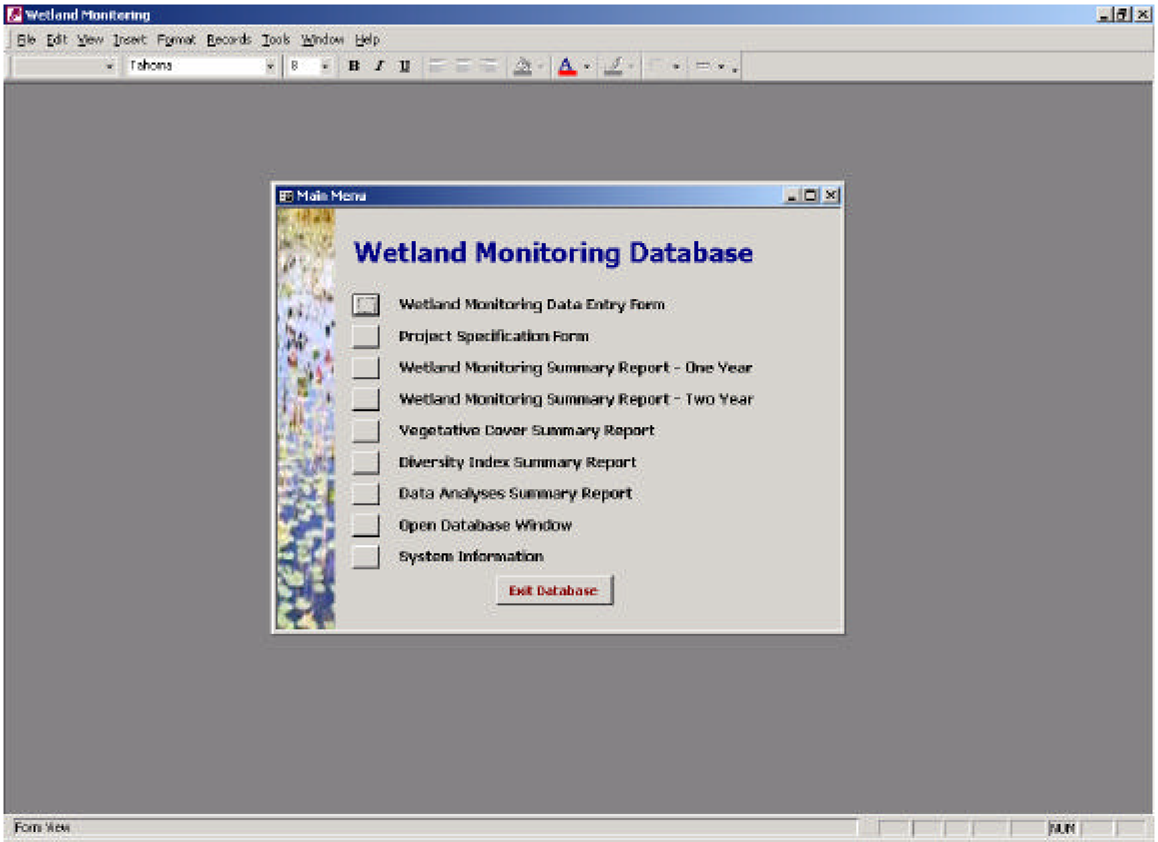
Project Specification Form

The Project Specification form allows data entry to the project table as well as customization of the Wetland Monitoring Data Entry form for each project. Users can deselect or select the fields they wish to be displayed on the Wetland Monitoring Data Entry form. The default is for all fields to be displayed. The fields that are grayed out on the Project Specification form cannot be hidden due to the fact that they are the first fields in their given form.



Main Menu Form

The Main Menu provides access to the forms, reports, and the database window. The menu is automatically displayed when the database is opened.

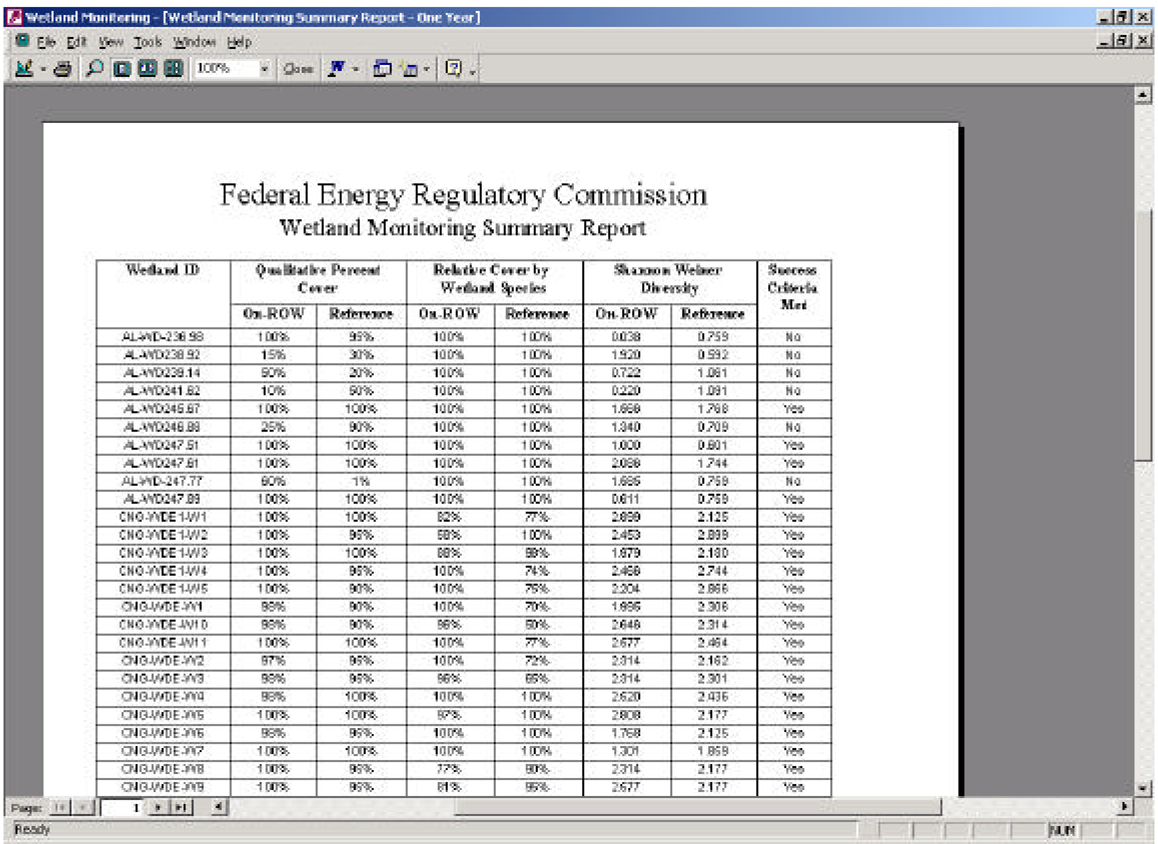


Wetland Monitoring Summary Report

The Wetland Monitoring Summary Report displays success criteria for each wetland with indication as to whether the success criteria were met. Two versions of the report exist in the current database: A version for one year of data and a version for two years of data. Using the models given for years 1 and 2, users can create additional query and report objects to support additional years (see the Adding A Year section below).

In order for a wetland to meet its success criteria, the following three conditions must exist:

1. Qualitative Percentage Cover is greater than or equal to 80%
2. Relative Cover by Wetland Species is greater than or equal to 50%
3. The Shannon Weiner Diversity Index of the Right of Way is at least 50% of the Shannon Weiner Diversity Index of the Reference Area.



Federal Energy Regulatory Commission
Wetland Monitoring Summary Report

Wetland ID	Qualitative Percent Cover		Relative Cover by Wetland Species		Shannon Weiner Diversity		Success Criteria Met
	On-ROW	Reference	On-ROW	Reference	On-ROW	Reference	
AL-WD-236.98	100%	95%	100%	100%	0.038	0.759	No
AL-WD238.92	15%	30%	100%	100%	1.920	0.592	No
AL-WD239.14	50%	20%	100%	100%	0.722	1.081	No
AL-WD241.62	10%	50%	100%	100%	0.220	1.091	No
AL-WD245.67	100%	100%	100%	100%	1.668	1.768	Yes
AL-WD246.88	25%	90%	100%	100%	1.340	0.709	No
AL-WD247.51	100%	100%	100%	100%	1.000	0.601	Yes
AL-WD247.61	100%	100%	100%	100%	2.058	1.744	Yes
AL-WD-247.77	60%	1%	100%	100%	1.685	0.759	No
AL-WD247.89	100%	100%	100%	100%	0.611	0.759	Yes
CNG-WDE1-W1	100%	100%	82%	77%	2.859	2.125	Yes
CNG-WDE1-W2	100%	95%	58%	100%	2.453	2.899	Yes
CNG-WDE1-W3	100%	100%	88%	98%	1.879	2.180	Yes
CNG-WDE1-W4	100%	95%	100%	74%	2.468	2.744	Yes
CNG-WDE1-W5	100%	90%	100%	75%	2.204	2.866	Yes
CNG-WDE-W1	95%	90%	100%	70%	1.995	2.306	Yes
CNG-WDE-W10	95%	90%	96%	50%	2.648	2.314	Yes
CNG-WDE-W11	100%	100%	100%	77%	2.677	2.464	Yes
CNG-WDE-W2	97%	95%	100%	72%	2.314	2.162	Yes
CNG-WDE-W3	95%	95%	96%	65%	2.314	2.301	Yes
CNG-WDE-W4	95%	100%	100%	100%	2.620	2.436	Yes
CNG-WDE-W5	100%	100%	97%	100%	2.808	2.177	Yes
CNG-WDE-W6	95%	95%	100%	100%	1.768	2.125	Yes
CNG-WDE-W7	100%	100%	100%	100%	1.301	1.859	Yes
CNG-WDE-W8	100%	95%	77%	90%	2.314	2.177	Yes
CNG-WDE-W9	100%	95%	81%	95%	2.677	2.177	Yes

The Qualitative Percentage Cover is equal to the Total Percent Vegetative Cover for the right of way portion of the wetland.

The Relative Percent Vegetative Cover for Wetland Species is equal to the sum of the Cover Class midpoints for the wetland species divided by the sum of Cover Class midpoints for all species (based on quantitative assessment records). Wetland species are defined as species with the following wetland indicators: "FAC","FAC+", "FACW", "OBL", "FAC>wetter". The FAC>wetter status is used in instances where dominant plants can not be identified to species level at time of survey due growing season limitations, absent plant parts necessary to make the identification, or human or animal alteration (i.e., mowing or grazing). To avoid these plants being discounted in calculations and possible "false failure" of the wetland, this provision was added to the database. However, this requires the biologist in the field to make a "best professional judgment" call as to whether the plant would be considered to have a "faculative or wetter" wetland indicator status. The Relative Percent Vegetative Cover for Wetland Species is calculated in the queries with the name pattern qry_RelativeCover_*.

The Shannon Weiner Diversity Index is defined below.

Shannon Weiner Diversity Index Calculation

Glossary and explanation of the equation:

N = Total Number of Individuals of all Species
This value is calculated as the sum of the midpoint of the cover class of all species.

Pi = Proportion of all individuals in the sample which belong to species i.
For calculation purposes this is the Midpoint of the cover class percentage range as defined in the LkpCoverClass table.

Log10( ) = A function that returns the base-10 logarithm of the value in the following ( ).

Log2( ) = A function that returns the base-2 logarithm of the value in the following ( ).

Sum( ) = A function that sums all the records in a given recordset.
The queries with the name pattern qryDiversity_*_Base perform the summation of each midpoint for each species for each wetland grouped by reference and right-of-way records (* is the wild card symbol; right-of-way and reference records have separate queries.)

H' = Diversity Index.
You cannot store apostrophes in database field names, so the database uses the variable DiversityIndex. Defined as follows:

DiversityIndex = Log2(10) * (Log10(N) – (Sum(Midpoint * Log10(Midpoint)) / N)

The Shannon Weiner Diversity Index is calculated in the queries with the name pattern qry_Diversity_*.

Adding A Year to the Wetland Monitoring Summary Report (for tracking specific wetlands over time)

The following process will create a Wetland Monitoring Summary report with an additional year.

1. Create a copy of the query qry_Success_Criteria_Year_1 and rename it qry_Success_Criteria_Year_X where X is the number of the year you wish to add.
2. Modify qry_Success_Criteria_Year_X so that the fields with the suffix Year_1 have the suffix Year_X. Also change the criteria on the SurveyYear field from 1 to X.
3. Create a copy of the query qry_Success_Summary_Two_Year and rename it qry_Success_Summary_X_Year.
4. Modify qry_Success_Summary_X_Year by adding qry_Success_Criteria_X joining it with the Wetland_Master table on the WetlandNameOrLocation field. The join should show all records in Wetland_Master and only those in qrySuccess_Criteria_X that match.
5. Add all the fields with the suffix Year_X to the result set of the modified query. To prevent the display of blank records, add "Is Not Null" criteria to the Date_Year_X field. Add this criteria on a new line so that it functions as an Or criteria rather than And criteria. This allows each wetland with any data to be displayed even if it does not have record in each year.
6. Create a new report with qry_Success_Summary_X_Year as the recordsource. The report named rpt_Success_Summary_Two_Year provides a basic model of the layout for a multiple year report.

Security

The following procedure allows users to add a password to a copy of the database:

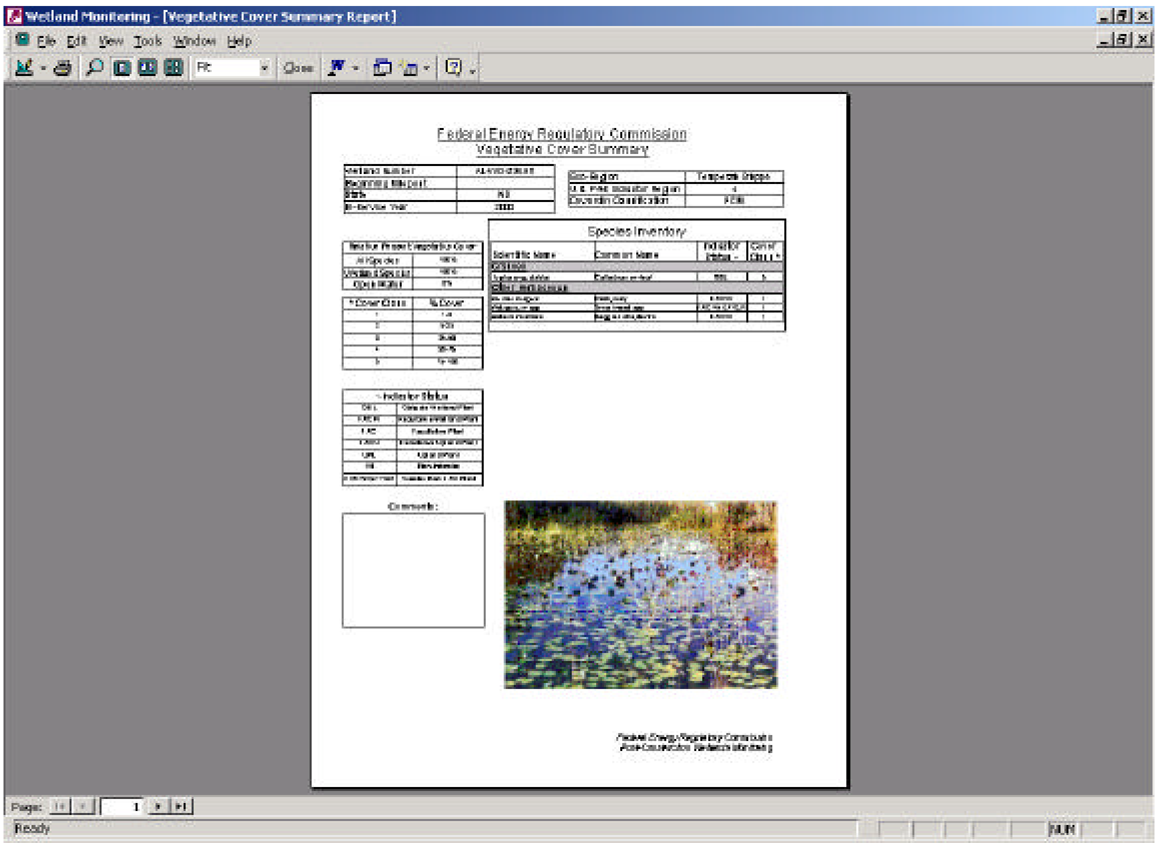
1. From the File>Open Dialog in Microsoft Access, open a copy of the database using the Open Exclusive option available as a drop-down from the Open button.
2. From the Tools menu select Security>Set Database Password and proceed to enter and confirm the Password.

To remove or change a password, the database must be opened in Exclusive mode.

Additional Report:

Vegetative Cover Summary Report

The Vegetative Cover Summary report displays the detail records from the quantitative assessment of right of way wetland portions as well as summary statistics on the percentage of cover for wetland species and all species. The report also displays general wetland information, comments, and reference tables for cover class and indicator status. Each page of the report represents one wetland.



The Relative Percent Vegetative Cover value for All Species comes directly from the Total percent vegetative cover field on the Wetland Dataform for the right-of-way portion of the wetland. The Relative Percent Vegetative Cover value for Wetland Species is calculated as follows, using right-of-way data:

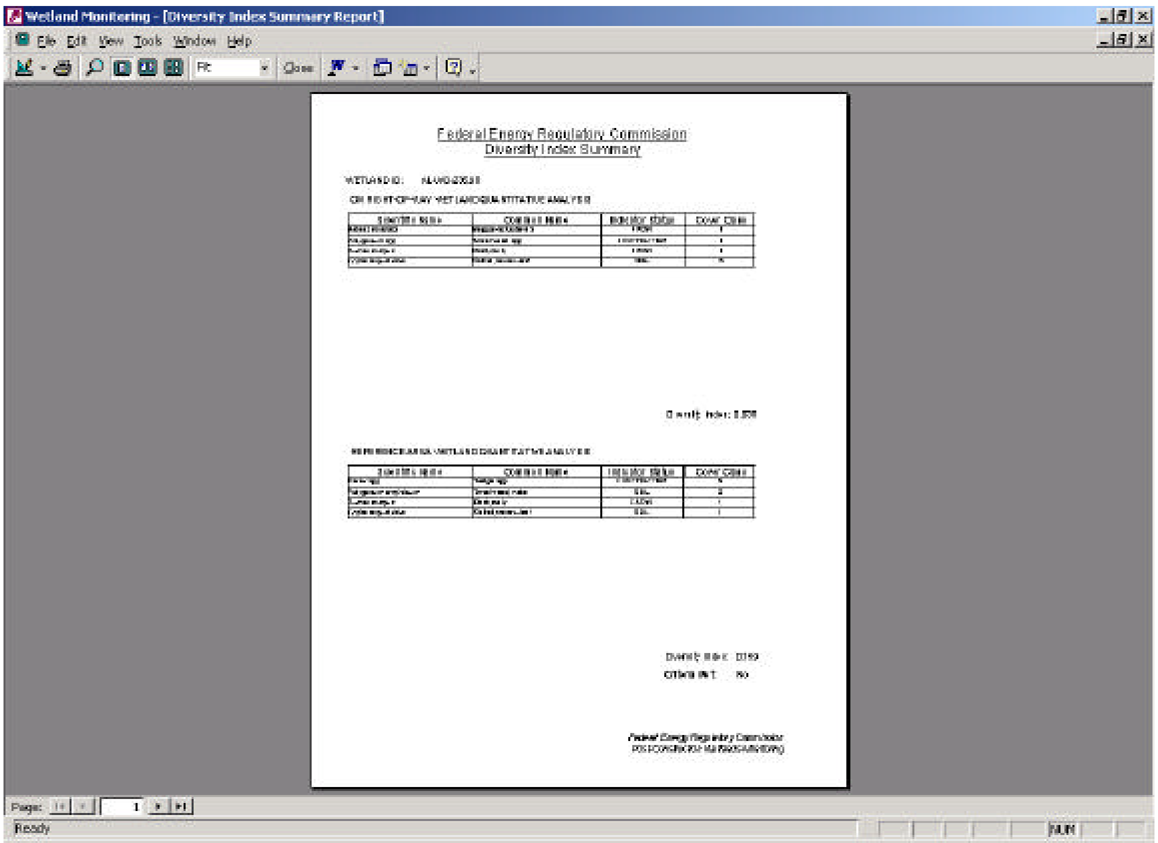
<u>S mid point of the cover class wetland species</u>
=S mid point of the cover class all species

The Vegetative Cover Summary Report also displays an image for each wetland per survey year visit. The file paths for the image files are stored in the database. Image file paths are added to wetland records on the Right Of Way Image tab of the Wetland Monitoring data entry form.

Additional Report:

Diversity Index Summary Report

The Diversity Index Summary report displays the detail quantitative assessment records for both the right of way and reference portions of the wetland. The calculated Shannon Weiner Diversity Index for each is also displayed with an indication as to whether the right of way diversity index is at least half of the reference area diversity index. This criteria is only one component of the success criteria given in the Wetland Monitoring Summary report. The report displays one page for each wetland.



Additional Report:

Data Analyses Summary Report

The Data Analyses Summary Report is a multiple page report with tables that summarize the conditional trends in the wetlands relative to their success. Wetlands are analyzed based on the following eight data elements:

Evidence of Human Disturbance	Landscape Position
Soil Textural Class	Wetland Hydrology
Waterbar Placement	Cowardin Classification
Atypical Climatic Conditions	Construction Year

For each element, there is a Restoration Summary table, a Summary of Wetland Failures by Criterion table and a Summary of Wetland Failures by Ecoregion. There is an additional Summary of Wetland Failure by Landscape Position for Waterbar Placement, Cowardin Classification and Atypical Climatic Conditions. The final page of the report displays overall summary data. The report design is based on the nationwide survey conducted by NEA, which surveyed 80 wetlands in 6 ecoregions for a total of 480 wetlands.