CREATING INDICATORS OF WETLAND STATUS
(QUANTITY AND QUALITY)

FRESHWATER WETLAND MITIGATION IN NEW JERSEY

NJ Department of Environmental Protection
Division of Science, Research, & Technology

March 2002

State of New Jersey

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Dear Reader:

Attached is a copy of the report of the research project entitled, " Creating Indicators of Wetland Status (Quantity and Quality): Freshwater Wetland Mitigation in New Jersey." The primary objectives of this study were to assess New Jersey's progress toward wetlands mitigation goals and develop indicators of progress toward these goals. The research was conducted by Amy S. Greene Environmental Consultants, Inc. (ASGECI), and co-managed by scientists from both the New Jersey Department of Environmental Protection's (NJDEP) Division of Science, Research and Technology (DSRT) and NJDEP's wetlands regulatory program (Land Use Regulation Program or LURP). This study was supported by NJDEP's Water Assessment and Environmental Indicators Research Programs. Relevant NJDEP managers were kept apprised of interim results and a peer review committee of leading state and national wetland scientists provided guidance throughout the duration of the study.

Background

Approximately 15% of New Jersey's land is freshwater wetlands, while 4% is tidal wetlands. Wetlands are critical natural resources because they perform a suite of important functions including: improvement of water quality through nutrient cycling; flood attenuation; groundwater recharge; prevention of shoreline erosion; critical habitat for a great diversity of plant and animal species; as well as providing aesthetic and recreational opportunities. It has been estimated that New Jersey lost 39% of its wetlands between the 1870s and 1970s and perhaps 20% between the 1950s and 1970s. The importance of tidal and freshwater wetlands was recognized when the New Jersey Legislature enacted the New Jersey Wetlands Act of 1970 and the New Jersey Freshwater Wetlands Protection Act of 1987 (considered to be one of the most stringent wetland laws in the United States). These state statutes provide additional protection beyond federal law by regulating more than dredge and fill activities, as well as providing protection in buffer areas for freshwater wetlands.

Yet, as the most densely populated state in the country, experiencing a population increase of approximately 1% annually over the last 10 years, New Jersey's wetland resources are subject to increasing stress. Recent data for New Jersey show a loss of approximately 1,755 acres of wetlands per year between 1986 and 1995, a period of time before the Freshwater Wetlands Protection Act had become fully operative. Even after that period, the implementation of the Act has still allowed for the disturbance of approximately 150 acres of freshwater wetlands per year. Recognizing their importance, as well as these challenging trends, NJDEP has established a strategic planning goal for wetlands: *"improve quality and function and achieve a net increase by 2005. Explore innovative techniques for creation, enhancement and maintenance of New Jersey wetlands*."

Techniques to mitigate the loss of wetlands from permitted activities include wetland creation, enhancement, restoration, preservation and banking. The attached report describes research that was specifically developed to measure progress toward the wetlands strategic planning goal with respect to mitigating wetland losses at freshwater sites. Freshwater sites were chosen as the study focus because these are the wetlands types with the most acreage in New Jersey, yet least studied in terms of mitigation. The research provides a standardized protocol to measure the quantity of wetlands constructed, compliance with approved plans and a means to evaluate the potential of the constructed wetland to evolve to a mature, functional system. In addition, a revised data management system was developed which enhanced NJDEP's mitigation database with a Geographic Information System.

Results, Recommendations and On-going NJDEP Adaptive Management Measures

The results of the ninety-site study indicate that on average, for each acre of wetland impact that required mitigation, 0.78 acres of wetlands were actually constructed. On average, 48% of the study sites concurred with their design specifications; some sites achieved no wetlands while others achieved in excess of 100% proposed. Field indicators of relative wetland quality found an average score of 0.51 out of an index of 1, demonstrating that about one-half of the criteria were met to indicate sites have the potential to function as natural wetlands system over time.

The study also provided LURP with recommendations that could be implemented to strengthen the existing wetland mitigation program. In addition, while inspecting the sites, ASGECI staff took field notes, which included broad recommendations to improve success of each site. Hence, these results have not only helped to develop adaptive management measures within NJDEP, but also to reinforce the utility of recently revised wetland mitigation regulations (that had been under development concurrent with this study). These new regulations codify requirements for very detailed performance-based mitigation plans.

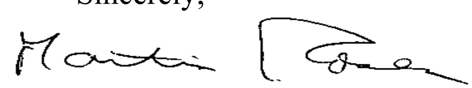
The investigators did identify created freshwater wetland projects that met the goals for acreage and/or demonstrated relatively high field indicators of quality. Prior to undertaking this study, LURP recognized problems within their mitigation program and began implementation of many of the recommendations echoed in this report. Some of the changes currently being implemented include:

- Assignment of experienced staff to work exclusively on mitigation related issues for recent proposed mitigation projects
- Development of checklists for mitigation proposals and monitoring reports
- Requirement of a water budget for all constructed mitigation projects
- Requirement of on-site meetings with construction contractors prior to implementation of the project

- Requirement of a post grading, on-site meeting to evaluate compliance with construction plans
- Aggregation of small mitigation projects to a single large site
- Directing small mitigation projects to available mitigation banks
- Requirement for invasive and nuisance species vegetative control and herbivore management plans
- Requirements for letter of credit or other form of financial surety.

DSRT is continuing its collaboration with LURP scientists, as well as other wetland scientists, throughout New Jersey via other wetland research studies (some of which build specifically upon this study). We would like to thank our colleagues in NJDEP's Land Use Regulation Program, Amy S. Greene Environmental Consultants, NJDEP staff participants in the National Environmental Performance Partnership System (NEPPS) Land and Natural Resources Workgroup, and members of our Peer Review Committee for their assistance with this research. For additional copies or technical information regarding this study, please contact the New Jersey Department of Environmental Protection, Division of Science, Research, and Technology at (609) 984-6071, or visit our website at www.state.nj.us/dep/dsr.

Sincerely,



Martin Rosen, Director
Division of Science, Research and Technology

Creating Indicators of Wetland Status
(Quantity and Quality):
Freshwater Wetland Mitigation in New Jersey

March 2002

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Executive Summary

This study included the development of three indicators to measure attainment of the New Jersey Department of Environmental Protection's (NJDEP) goals for wetland resources outlined in both its Strategic Plan and National Environmental Performance Partnership System (NEPPS) Agreement with the U.S. Environmental Protection Agency:

> *"Improve quality and function and achieve a net increase. Explore innovative techniques for creation, enhancement and maintenance of New Jersey wetlands."*

Specifically, this study was initiated to determine the extent to which approved freshwater wetland mitigation sites had been constructed in terms of area achieved; concurrence with approved plans; and relative quality of constructed wetlands. In addition to these indicators of current conditions, this research developed a standard rapid assessment method that can be used to monitor New Jersey's wetland mitigation trends into the future. The study also enhanced NJDEP's Mitigation Database by establishing a geographic information system application. A peer review committee consisting of leading wetland scientists from academic institutions, government and non-governmental organizations, and the private sector provided guidance and oversight throughout the study.

Methods

Field evaluation was conducted for 90 freshwater wetland mitigation sites (out of 171 approved freshwater wetland mitigation projects in NJDEP's database at time of study commencement) that were distributed throughout 17 of New Jersey's 20 Watershed Management Areas (WMAs). Study sites included a total of 326 acres of proposed wetland mitigation area and ranged in size from 0.08 to 41.20 acres, with an average proposed size of 3.62 acres. Forested (PFO) and emergent (PEM) wetlands were the most common type of freshwater wetland proposed, accounting for 41% and 33% of total proposed freshwater wetland mitigation area, respectively. Sixty-four percent of the sites, representing 60% of the total area evaluated, were greater than 5 years old.

Wetland Area Achieved was determined for 85 mitigation sites and calculated based upon the results of a wetland delineation performed following the procedure in the *1989 Federal Manual for Identifying and Delineating Jurisdictional Wetlands*. Delineation methodology included observation of hydrology, soil, and vegetation characteristics of wetland and upland communities. Five sites were eliminated from this evaluation because mitigation site boundaries distinct from pre-existing wetlands could not be readily discerned in the field. A visual estimate of wetland community type (i.e. forested, scrub/shrub, emergent, State open water) was made during delineation and recorded as percent of total wetland area. Wetland Area Achieved was expressed in terms of total acreage achieved based on the area delineated in the field using a Global Positioning System (GPS) unit.

Concurrence was determined for 88 mitigation sites and consisted of a field inspection to verify and measure the extent to which the constructed mitigation site conforms to and is consistent with NJDEP-approved mitigation plans. Concurrence evaluations could not be performed on two of the study sites due to insufficient plan information in the mitigation files. Scoring was based upon visual estimates of several variables that could be readily observed in the field: grading; hydrology; soil; vegetation cover; vegetation survival; and design. Raw scores for each variable were expressed as a percent from 0-100 representing the relative degree to which the constructed mitigation site was consistent with approved plans and specifications. A weighting factor was assigned to differentiate the relative importance of each variable to the final score. Observations were made to identify specific corrective action necessary to comply with approved plans and specifications, as well as improve status of the mitigation site.

Relative quality was determined using a Wetland Mitigation Quality Assessment (WMQA) tool developed through this research and determined for 74 mitigation sites. The WMQA was only applied to areas delineated as jurisdictional wetlands. A relative wetland quality value (rating scale of 0 to 3) was based on the presence or absence of readily observed field indicators of the following variables: hydrology; soils; wildlife suitability; vegetation; site characteristics; and landscape features. The variables were considered representative of the relative probability that the mitigation site would develop into a natural wetland system and provide desirable wetland functions over time. A weighting factor was assigned to differentiate the relative importance of each variable to the final score.

All field data were collected using a Trimble Pathfinder Pro XRS© GPS unit. All field observations were recorded on standardized data forms. Photographs were taken at every site.

Results

The average percent freshwater wetland area achieved was 45%, indicating that approximately 0.45 acre of wetland**s** was achieved for each acre of mitigation proposed. The range of wetland area achieved was 0 to 140%; six sites achieved more than 100% of proposed acreage while 16 sites failed to achieve any wetlands. On average, 92% of proposed emergent wetland acreage was achieved, while 1% percent of proposed forested wetland acreage was achieved. Open water acreage was achieved almost three times in excess of that proposed.

The Concurrence Evaluation indicated that, on average, sites concur with 48% of the designs and specifications in permit plans. Concurrence Evaluation scores ranged from 0 to 100%. Corrective actions identified through the concurrence evaluation included: re-grading consistent with permit plans at 84% of the sites (partially accounting for low concurrence with permit plan hydrology); application of supplemental topsoil at 47% of the sites; and replanting at 84% of the sites to conform with permit plans.

Average WMQA index score was 0.51 out of a maximum possible score of 1, finding that freshwater wetland creation sites, on average, met half the criteria that would indicate they have the potential to function as natural wetlands over time. WMQA scores ranged from 0.25 to 0.83. Low scores for hydrology, the variable weighted highest in the WMQA based upon independent judgment of 15 wetland scientists in New Jersey surveyed for this research, were found to result from extremes in water conditions -- either too much or too little. In both cases, it appeared as if low hydrology scores resulted from inappropriate or inadequate sources of hydrology or established grades that were inconsistent with the hydrologic regime of the site. In areas where the mitigation site exhibited favorable hydrology and soil conditions, natural recruitment of desirable wetland vegetation was generally observed. Establishment of invasive species or persistent grasses was evident on numerous sites and in some instances precluded the establishment of desirable wetland plants.

A compensation ratio (mitigation proposed/mitigation achieved to wetland losses in a single permit action) in excess of 1:1 is required to attain a net increase in wetland area. Examination of compensation ratios based on the 90 study sites revealed that for each acre of impact to wetlands approved by NJDEP, on average 1.80 acres of compensatory mitigation were required. The actual ratio of acres of mitigation wetlands achieved to those impacted for the 75 mitigation sites, for which sufficient information was available to determine ratios, was calculated to be 0.78:1. On average, for each acre of impact to wetlands approved by NJDEP, 0.78 acres were actually achieved through mitigation, a net loss of 22%.

Compensation ratios can be examined by wetland type to determine replacement of ecological value lost from permitted disturbances. When analyzed by type of wetland compensation, emergent wetlands (n = 14 sites) were the only types where mitigation exceeded impacts (average compensation ratio of 1.29:1); this was still below the approved compensation ratio of 1.85:1. Forested wetlands achieved an average compensation ratio of 0.01:1 (n = 31 sites). These results suggest that for the two most commonly permitted freshwater mitigation wetlands (forested and emergent), New Jersey has achieved a net increase of emergent wetlands but not forested wetlands.

Several other analytical applications of the data were explored: analysis by New Jersey Watershed Management Area (WMA); site size; site age; and source of hydrology. Site age did not correlate with the study indicators. Other analyses suggested possible relationships with study indicators (watershed-based local conditions and site size); however, small sample sizes limit the ability to confirm these possibilities and further research would be needed to explore these hypotheses. More sites greater than one acre in size would be needed to further examine the influence of site size on mitigation outcome.

The data were analyzed to determine effect of hydrologic source on project indicators. Although Wetland Area Achieved remained relatively constant among sources of hydrology, stream diversion resulted in the highest average score of 61%, well above the mean value of 45% when all sites are combined. Stormwater-driven wetlands scored substantially lower for the WMQA Index values than wetlands with other hydrologic sources. Stormwater-driven mitigation wetlands were also found to be more likely to have in excess of 50% cover of nuisance and invasive vegetation than mitigation wetlands driven by other sources of hydrology.

Recommendations

NJDEP could facilitate NEPPS goals for wetland resources and improve future mitigation projects through several mechanisms. Continued focus should be on avoiding impacts to wetlands and minimizing the effects of permitted activities on wetlands. Refinement and standardization of permitting, mitigation planning, monitoring and maintenance, and compliance inspections/enforcement of mitigation sites should continue. Some of these issues have been addressed in the recently adopted revisions to the New Jersey Freshwater Wetland Protection Act Rules that specifically outline the performance and pre-construction requirements for wetland mitigation proposal submissions. Increased resources should be devoted to implementation, oversight and tracking of mitigation projects once they have been approved by NJDEP. Tracking of approved mitigation projects should include an up-to-date, well-maintained data management system for filing and retaining monitoring reports and other administrative documents. Research on New Jersey's wetlands resources should continue and the results provided to regulatory staff.

Conclusions

Based on a subset of 90 New Jersey freshwater wetland mitigation sites, NJDEP has not yet met its goal to improve wetland quality and function and achieve a net increase. Emergent and open water wetland projects were more likely to succeed than forested wetland projects. Some high quality wetlands of all proposed mitigation types, however, were observed during the course of this study. These successful projects provide evidence that wetland creation is possible for all community types given the level of knowledge currently available.

1. INTRODUCTION

The New Jersey Department of Environmental Protection (NJDEP) is committed to providing a high quality of life for the residents of New Jersey. Central to that vision is maintaining a sustainable environment. Protecting healthy, functioning wetland systems is a vital element of a sustainable environment.

A wetland is defined in the New Jersey Freshwater Wetlands Protection Act rules (N.J.A.C. 7:7A-1.4) as "an area that is inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions, commonly known as hydrophytic vegetation…". The term "wetland" can refer to many diverse areas such as swamps, marshes, fens, and wet meadows, but they are all generally characterized by the frequent or prolonged presence of water at or near the soil surface, by soils that form under flooded or saturated conditions, and by plants that are adapted to life in these types of water levels and soils.

Wetlands are a critical natural resource because they perform a suite of functions which includes improvement of water quality through nutrient cycling and sediment trapping; protection from flooding by attenuation of peak flows in streams and rivers; recharge of groundwater supplies; protection of shorelines from excessive erosion; aesthetic and recreational opportunities; and habitat for a great diversity of plants and animals including some of New Jersey's most rare, endangered and commercially valuable species. However, through agriculture, urban and suburban development, mosquito control, and other draining and filling activities that have benefited our society, we have lost much of the wetland resources in New Jersey and with them many of the important functions that wetlands provide.

By the 1980's as much as 50% of the original wetland resources in the United States had been lost and were disappearing at a rate of approximately 300,000 to 400,000 acres per year (Dahl, 1990; Tiner, 1984). Dahl (1990) estimated that New Jersey lost 39% of its wetlands between the 1870s and 1970s. Tiner (1985) estimated that New Jersey may have lost at least 20% of its wetlands resources since the mid-1900s. Within New Jersey, the Department of Environmental Protection (NJDEP) has developed an aerial-photo based data set that shows changes in land-use between 1986 and 1995. During this time, New Jersey lost 15,798 acres of wetlands, or an equivalent loss of 1,755 acres of wetlands per year (Thornton et al., 2001).

The Federal Clean Water Act of 1972 33 U.S.C. 1344 et seq. (and amended in 1977) was enacted to restore and maintain the chemical, physical and biological integrity of the Nation's waters The Clean Water Act regulates the discharge of dredged or fill material into navigable waters of the United States, including wetlands. In March 1994, the State of New Jersey officially assumed Clean Water Act Section 404 authority from the U.S. Army Corps of Engineers through implementation of the State's freshwater wetlands protection program, joining Michigan as the only states so far to have assumed authority. The State program, administered through the *1987 Freshwater Wetlands Protection Act*, was modeled after the Section 404 program, but it regulates activities not covered under 404, such as the regulation of upland buffers or transition areas. New Jersey also regulates activities in mapped coastal wetlands under the NJ Wetlands Act of 1970. As such, the New Jersey State Legislature has taken additional steps beyond those of the federal law to protect wetlands through the regulation of nearly all activities within tidal and freshwater wetlands, respectively. In doing so, they recognized that wetlands serve important functions that provide great value and benefit to New Jersey. Protection of wetland resources is an important part of sustaining a high quality of life, protecting public health and property, and maintaining economic vitality for all New Jersey residents. The US Environmental Protection Agency (USEPA) oversees the State program through the review of selected permit applications ("major discharges") based on such factors as acreage of impacts and Endangered Species Act concerns as well as by programmatic yearly reviews of the State program.

Under the provisions of New Jersey's *Freshwater Wetland Protection Act*, which is considered to be one of the most stringent wetlands laws in the nation (Torok et al., 1996), the alteration, disturbance, or erection of structures in and around freshwater wetland areas and the discharge of dredged or fill material into State open waters are subject to review and authorization by NJDEP. Because the statutory authority regulating activities in and around wetlands also includes the regulation of placement of dredged or fill material in State open waters, we have treated open water as a wetland resource for purposes of this study.

The NJDEP, through its land use regulation programs, is responsible for instituting a systematic review of land development activities to ensure that wetlands and State open waters are protected from undesirable and unnecessary loss, alteration or disturbance. One management tool the NJDEP uses to compensate for wetland/open water losses resulting from land development and management activities is compensatory wetland mitigation. When required, mitigation is intended to replace values and functions of wetlands/open waters impacted as a result of development activities. Compensatory wetland mitigation helps NJDEP make progress toward its goal of sustaining economic development without compromising the integrity of our natural resources.

In the context of environmental regulation, the term “mitigation” refers to the broad range of actions that might be taken to avoid, reduce, or compensate for the effects of environmental damage. Compensatory mitigation refers to the practice by which unavoidable impacts to wetlands are permitted with the condition that they be replaced. The NJDEP recognizes and authorizes various forms of mitigation depending on the circumstances of the disturbance (N.J.A.C. 7:7A-1.5). Creation, enhancement, restoration, upland preservation, mitigation banking, land donation and monetary contributions to the Wetlands Mitigation Fund can all be acceptable methods of mitigation.

Generally the NJDEP requires in-kind mitigation unless because of certain circumstances, out-of-kind mitigation would be more likely to provide equal functions and values. In-kind mitigation means mitigation that provides similar functions and values as the area disturbed including similar wildlife habitat, similar vegetative species coverage and density and equivalency of other relevant values and functions. However, the NJDEP can provide some flexibility in the type of wetland mitigation proposed if the design of the mitigation site provides a clear demonstration that replacement of ecological value can be achieved. For example, a mitigation site that includes a variety of wetland community types, including elements of open water, to compensate for impacts to degraded wetlands, may provide increased ecological benefit relative to in-kind replacement.

Questions about the advisability and success of compensatory wetland mitigation projects surfaced over a decade ago (Race and Christie, 1982) and many subsequent studies suggest that there is room for improvement in compensatory mitigation techniques. Previous studies conducted in Virginia (Maguire, 1985), Florida (Erwin, 1991; Redmond, 1992; Lewis, 1992), Louisiana, Alabama, and Mississippi (Sifneos et al., 1992), Oregon and Washington (Kentula et al., 1992), and California (Holland and Kentula, 1992), have found success and/or compliance rates ranging from 4.6% to 50%. A recent study conducted by the National Research Council (NRC, 2001) has found that the regulatory objectives of offsetting wetland losses through compensatory wetland mitigation are not being achieved. A previous study conducted in New Jersey also indicated poor success of wetland mitigation (USFWS, 1994). From 1985 to 1992, as much as 40% of approved mitigation sites were found to be inconsistent with approved plans and permit conditions. Although these studies suggest a low success rate for compensatory wetland mitigation and are cause for concern, comparison among studies or use of these studies as a basis of regulatory decision making are problematic due to varying methodologies used for assigning rates of success and/or compliance. In response, NJDEP wanted to develop a systematic approach to evaluate, quantify and monitor the effectiveness of wetland mitigation in compensating for unavoidable wetland losses, that could be readily implemented in the field.

Since 1995, NJDEP has been an active participant in the National Environmental Performance Partnership System (NEPPS). NEPPS is a performance-based management system that relies on the use of environmental indicators to measure attainment of goals and upon which future allocation of resources can be based (Kaplan and McGeorge, 2001). As a participant in NEPPS, NJDEP will be better prepared to address future challenges toward achieving a sustainable environment.

Through the NEPPS process, NJDEP has developed the following goal for its wetland resources:

"Improve quality and function and achieve a net increase. Explore innovative techniques for creation, enhancement and maintenance of New Jersey wetlands."

However, it was unknown to what extent freshwater wetland mitigation sites approved by NJDEP had been constructed, whether they had been constructed in substantial conformance with approved plans, or whether the mitigation project was successful in achieving desired wetland quantity and quality. This study was designed to determine to what extent compensatory wetland mitigation is consistent with NJDEP's NEPPS goals for wetlands.

The purpose of this study was to:

- Provide an indicator of performance in attaining NEPPS wetlands goals.

- Develop standard methods for monitoring progress.

- Establish a vehicle whereby future performance can be measured.

This study includes the development of three indicators (described in section 2.3 of this report) to measure attainment with NJDEP's NEPPS goals for wetlands and monitoring wetland mitigation performance in New Jersey. This method is intended to generate an efficient and reliable source of data regarding NJDEP's mitigation program. This study also includes the development of a GIS-enabled wetland mitigation database, which allows for both spatial and site-specific analyses. This study is intended to provide a basic template for tracking and measuring the status of compensatory freshwater mitigation projects in New Jersey. Finally, this study provides performance-based recommendations based upon best professional judgment as to the steps that can be taken on a site-specific basis to optimize attainment of wetland goals.

The primary focus of the study is freshwater wetland creation (see Section 2.2 of this report for a discussion of how study sites were chosen). As such, it does not represent an inventory of all authorized wetland impacts and required mitigation. NJDEP maintains a database of mitigation sites including general information on the location, size, type and status of individual mitigation sites approved by the department. As of the spring of 1999, the NJDEP mitigation database included data on 223 mitigation proposals, accounting for approximately 1,249 acres of wetland mitigation. Of this total, 177 sites (562 acres) were designed as non-tidal, freshwater wetland systems. The remaining sites primarily consisted of tidal wetland systems and mitigation sites that had not yet been constructed and were not included in this study.

This study is intended to provide an indicator of wetland mitigation status in relation to permitted wetland activities within the jurisdiction of NJDEP. Therefore, a subset of 90 freshwater wetland mitigation sites (Appendix A) was selected for which sufficient information was available to allow an independent reviewer to conduct a thorough and consistent evaluation.

The study design and methods were a collaborative effort among the staff at Amy S. Greene Environmental Consultants, Inc. and an internal NJDEP project team composed of scientists from multiple program areas. A peer review committee consisting of leading wetland scientists from academic institutions, government and non-governmental organizations, and the private sector provided guidance and oversight throughout the study.

2. DESIGN AND METHODS

2.1 Site Selection

The NJDEP has historically maintained a database of approved wetland mitigation sites including the location, size and type of mitigation proposed. The NJDEP database was reviewed to select sites for inclusion in this study. Given the limitations of study scope, and the need for evaluation consistency, the NJDEP project team recommended that only freshwater wetland mitigation sites be further evaluated.

A total of approximately 177 freshwater wetland mitigation sites were contained in the NJDEP database upon commencement of the study in July 1999. Based on database information, 135 mitigation sites had been constructed and were therefore selected for a file review and potential field evaluation. Study sites were selected from this group based on the availability of sufficient information regarding the size and type of mitigation to accommodate a thorough and consistent evaluation.

2.2 File/Plan Review

A review was conducted of the NJDEP files for each of the 135 constructed freshwater wetland mitigation sites. The files were reviewed to obtain and verify available information on the plans and specifications of the mitigation site including, when available, the type and amount of wetland disturbance authorized by the NJDEP permit and the type and amount of proposed mitigation approved by NJDEP. The file review included identification of the specified amount of proposed mitigation, mitigation type (i.e. forested, scrub/shrub, emergent or open water) and goals (creation, restoration, etc.).

Initially, files were reviewed to determine the level of completeness and details of mitigation plans and specifications. During initial review, determinations were made regarding suitability for subsequent field evaluation for each site. Based upon the review of mitigation files, the NJDEP recommended that the study concentrate on freshwater wetland creation. This recommendation was based upon the general inconsistency in mitigation details and specifications provided for other wetland mitigation goals (i.e. restoration and enhancement), and difficulty in locating the field limits of the wetland restoration and enhancement sites to allow a consistent and complete evaluation. Sites for which the files did not contain sufficient details to accommodate a consistent and complete evaluation were omitted from further consideration. Examples of sites that were omitted from further consideration included large linear projects (e.g. utility projects with typically small mitigation areas distributed over several miles), sites that were comprised of numerous small mitigation areas that had poorly defined limits, and sites whose mitigation plans and specifications were incomplete and/or insufficient in detail to accommodate a complete field evaluation (e.g. no mitigation type or area specified on the plan, no indication of discernable site boundaries, no planting specifications, etc.). The results of the file review were recorded on standardized data sheets (Appendix B).

Of the 135 potential freshwater wetland mitigation sites that had been constructed, 90 sites (67%) were selected for inclusion in this study and subject to subsequent field evaluations (see Appendix A). These study sites represent approximately 326 acres of proposed freshwater wetlands mitigation.

2.3 Introduction to Study Indicators

The study included the development of three study indicators to measure attainment with NJDEP's NEPPS goals and monitor performance of New Jersey’s wetland mitigation program. Field evaluations were conducted on each of the 90 study sites. Field evaluations consisted of measuring an individual site's attainment of the three (3) study indicators, including: Wetland Area Achieved, Concurrence Evaluation and Wetland Mitigation Quality Assessment (Table 1). The following sections provide an overview of the methods employed for each study indicator.

Wetland Area Achieved
A measure of the type and amount of wetlands provided through mitigation.

Concurrence Evaluation
A measure of the relative degree to which the mitigation achieved is consistent with the specifications of the mitigation plan approved by NJDEP.

Wetland Mitigation Quality Assessment (WMQA)
A measure of the relative quality of mitigated wetlands as it relates to their potential to provide desirable wetland functions and values.

Table 1: Introduction to Study Indicators

2.3.1 Wetland Area Achieved

The Wetland Area Achieved indicator was calculated based upon the results of a wetland delineation. The delineation was performed to determine if wetlands or open water were present and to establish the location of the wetland/open water boundary in the field. Wetland delineations were performed following the 1989 *Federal Manual for Identifying and Delineating Jurisdictional Wetlands* (Federal Interagency Committee) for a routine field determination based on examination of hydrology, soil and vegetation. In many of the mitigation wetlands it was not possible to rely on all three parameters (soils, hydrology, and vegetation) due to the disturbed nature of the sites and therefore the Disturbed Area Routine of the manual was often employed.

Documentation of typical hydrology, soils and vegetation characteristics of the wetland and upland communities of the site and photographs was collected as part of the wetland delineation. A visual areal estimate of the type of wetland communities present (i.e. forested, scrub/shrub, emergent, etc.) was made during the delineation and expressed as a percent.

The type and area of wetlands achieved were determined on 85 of the study sites. Some study sites were excluded from the area determination in cases where the boundaries of the mitigation area could not be readily determined in the field (n=5).

The location of the wetlands boundary and area of wetlands achieved expressed in acres were documented using a Global Positioning System (GPS) that complies with applicable NJDEP GIS/GPS standards. Upland inclusions or islands were delineated in the field using GPS and omitted from the calculation of total Wetland Area Achieved.

In instances where the total wetland mitigation area proposed on a particular site consisted of several distinct areas, only a portion of the proposed mitigation may have been included in the field delineation. Only the area included in the field delineation (Area Evaluated) was used to calculate the percent of Wetland Area achieved. For example, a particular site included a total of 2 acres of wetlands, including 1.8 acres of wetland creation and 0.2 acres of wetland restoration.

If the limits of the restoration areas were not clearly defined (i.e. distributed throughout a particular site with no discernable boundaries), they were not included in the field delineation. The Area Evaluated was therefore limited to the 1.8-acre creation site. To correct for this discrepancy, only the area of wetland creation was included in the calculation of percent area achieved. The Area Evaluated was based upon a review of the mitigation plans contained within the NJDEP file.

The Wetland Area Achieved indicator was expressed as a percent and calculated according to the following formula:

*Wetland Area Achieved (%) = (Area Achieved/Area Evaluated) * 100*

2.3.2 Concurrence Evaluation

The Concurrence Evaluation indicator consisted of a field inspection to verify and measure the extent to which the constructed mitigation site conforms and is consistent with NJDEP approved mitigation plans and specifications. A Concurrence Evaluation was performed on 88 sites. No Concurrence Evaluation was performed on two sites due to insufficient plan specifications.

The Concurrence Evaluation indicator assigned an overall concurrence score according to the degree to which a site was constructed consistent with approved plans, independent of the area of wetland achieved. Theoretically, a site may have been constructed in accordance with approved plans and specifications, and receive a relatively high concurrence score yet the site did not achieve any wetlands according to the field delineation. The Concurrence Evaluation was based upon several variables that could be readily observed in the field in relation to the plan specifications: Grading; Hydrology; Soil; Vegetation Cover; Vegetation Survival; and Design (Table 2).

Raw scores for each variable are expressed as a percent from 0-100 representing the relative degree to which the constructed mitigation site was consistent with approved plans and specifications. The raw score is assigned based on visual examination and collective best

Concurrence Evaluation Variables and (Weighting Factors)

A. **Grading (4.1)** – The degree to which topography is consistent with approved grading plans.

B. **Hydrology (4.7)** – The degree to which the duration and/or frequency of inundation or saturation is consistent with mitigation goals, type, and specifications. Includes a field determination of the source of hydrology and the status of monitoring devices and/or water control structures, if specified.

C. **Soils (3.5)** – The degree to which soil placement and stabilization conforms with specifications. Includes an evaluation of topsoil placement, soil stabilization, and acid soil specifications.

D. **Vegetation Cover (2.9)** – The extent to which the specified vegetation type was established. Includes percent cover of hydrophytes, seed mix specifications, presence of persistent grasses, such as fescue, and percent cover of invasive vegetation species.

E. **Vegetation Survival (2.3)** – The degree to which vegetation species planted in accordance with plans survived. Includes percent survival of trees, shrubs, and herbaceous vegetation specified in plans.

F. **Design Characteristics (4.2)** – The extent to which as-built conditions conform to approved plans. Includes an examination of the size and shape of the wetland transition (adjacent) area if specified, and the degree to which maintenance is required/provided.

Table 2: Description of Variables Included in the Concurrence Evaluation. Weighting Factors shown in parentheses (). **Note:** Weighting Factors were assigned a value from 1 (least important) to 5 (most important) and reflect the average values assigned by 15 independent wetland scientists in New Jersey.

professional judgment of at least two trained wetland scientists with practical experience in wetland mitigation design and plan interpretation.

In some cases, sufficient information was not available in the mitigation files to facilitate an accurate review of all variables. When there was not sufficient information available to make an informed evaluation of a specific variable, that variable was deemed not to be applicable and was not scored. The final score of the concurrence evaluation was based only on those variables deemed applicable based upon availability of information contained in the mitigation plans and specifications.

A weighting factor was assigned to differentiate the relative importance of each variable to the final score. Weighting factors reflect the input from 15 contributors. Each contributor assigned a relative score for each variable ranging from 1 (least important) to 5 (most important). The final weighting values are an average of all individual scores and are shown in parentheses in Table 2. Weighting of variables was used to help distinguish between those variables that are more important in achieving the stated goals in the approved plans. For example, it was generally felt by the research team that achieving the approved grade and hydrology of the mitigation site were more important than achieving the stated vegetation cover. This may have been in part a result of the recognition that vegetation cover would be more likely to be achieved over time given the proper growing conditions as determined by grading and hydrology.

The final Concurrence Evaluation indicator score is expressed as a percent. It is calculated by dividing the sum of the weighted values for all the applicable variables by the sum of the applicable weighting factors (Table 3).

Observations were also made during the Concurrence Evaluation to identify specific corrective action necessary to comply with approved plans and specifications, and that would serve to improve the status of the mitigation site. All field observations were recorded on standardized data forms (see Appendix B).

Concurrence Evaluation Weighted Values
(Weighted Value = Raw Score * Weighting Factor)

Grading
+ Hydrology
+ Soil
+ Vegetation Cover
+ Vegetation Survival
+ Design

= Sum of Applicable Weighted Values
÷ Sum of Applicable Weighting Factors

= Concurrence Evaluation Score (Percent)

Table 3: Method for calculating Concurrence Evaluation Score

2.3.3 Wetland Mitigation Quality Assessment (WMQA)

The Wetland Mitigation Quality Assessment (WMQA) indicator consisted of assigning a score based on readily observable field indicators of wetland variables, including hydrology, soils, and vegetation, using a standard rating index. The WMQA consists of qualitative field determinations of the presence or absence of designated field indicators that were selected to be representative of the relative probability that a constructed wetland will develop into a natural wetland system and provide desirable wetland functions over time (Appendix C). The WMQA was performed on only those sites that resulted in wetlands according to the wetland delineation (n=74). The procedure was not applied if wetlands were not present.

The WMQA was developed as a qualitative, results-based evaluation procedure to measure status and monitor changes in the relative quality of mitigation sites following construction. The method is intended to accomplish several objectives: 1) establish a simple, consistent and timely assessment tool based on readily observable field indicators; 2) be applicable to a wide range of wetland community types and field conditions; and 3) offer consistency and guidance in evaluating NJDEP's NEPPS goal.

The WMQA assigns a standardized rating index from 0 to 1 based upon the use of professional judgment to provide a consistent and practical measure of relative mitigation quality. It is probable that a constructed wetland that receives a high rating index score of 1 will have a greater potential to function as a natural system over time.

The procedure relies on observation of field indicators and use of best professional judgment to identify the relative value that best describes the variable being measured. This method relies on the basic assumption that function will follow form. For example, if observable indicators of hydrology are present such as drift lines, hummocks, and/or plant morphological adaptations, it is assumed that the wetland has the potential to perform hydrologic functions analogous to a natural wetland of the same type. For examples of predictors of wetland function, see Adamus and Stockwell (1983) and Keddy (1999 and 2000).

The WMQA assigns a score for each of six (6) variables including: Hydrology, Soils, Vegetation Composition/Diversity, Wildlife Suitability, Site Characteristics and Landscape Characteristics. A description of the variables included in the WMQA is provided in Table 4.

The WMQA procedure assigns a value (V) on a scale from 0 to 3 for each variable being evaluated. A value of 3 is used if the variable is thought to have the greatest probability of simulating a natural wetland system over time. A value of 0 is assigned if the variables are severely impeded or not present. The Vegetation and Landscape variables include two or more sub-categories (see Table 4) that are each assigned an individual score. The average of the sub-category scores is used to assign a raw score for the applicable variable.

The raw score for each wetland variable is multiplied by a weighting factor to differentiate the relative importance of each variable's contribution to the final score. Weighting factors reflect input from 15 contributors. Each contributor assigned a relative score for each variable ranging from 1 (least important) to 5 (most important). The final weighting factors are an average of all individual scores and are shown in Table 4.

The method for calculating the WMQA index score is provided in Table 5. An index score from 0 to 1 is calculated based on the sum of the weighted values for all applicable variables (VTOTAL). VTOTAL is divided by the sum of the weighting factors to provide the WMQA score. The WMQA score is then divided by 3 (the maximum score achievable for each variable) to express the total WMQA Index score as a relative value from 0-1. All WMQA scores were recorded on standardized data sheets (see Appendix B).

The WMQA is a rapid assessment tool that is useful for monitoring attainment with NJDEP's NEPPS goals. It is practical, allowing for an assessment based on a single site visit during the growing season and provides enough flexibility to be applicable to multiple wetland habitat types and field conditions. Rapid assessment methodologies have been reported in other studies and reviews (e.g. Maguire, 1985; Redmond, 1991; USFWS, 1994; Bartoldus, 1999) for use in determining relative wetland quality and ecological success; however, none provided the

Wetland Mitigation Quality Assessment (WMQA) Variables
and Weighting Factors

A. Hydrology (4.8) -- Provides a measure of the degree to which wetland hydrology is present through observation of field evidence of surface inundation or saturation.

B. Soils (3.6) -- Evaluates whether existing conditions are favorable for the establishment/development of hydrophytic vegetation.

C. Vegetation Composition/Diversity (3.7) -- Assesses the presence, abundance, composition and condition of plant species within the mitigation site. Also measures the extent of colonization by undesirable (i.e. invasive) plant species. This variable includes two sub-categories: **C.1 - Overstory Layer (plants >3' in height) and C.2 - Ground Cover (plants <3' in height)**.

D. Wildlife Suitability (2.1) -- Provides an indication of the extent to which the wetland provides suitable wildlife habitat.

E. Site Characteristics (3.0) -- Evaluates the degree to which the location and design of the mitigation site affects its capacity to perform wetland functions. Includes an evaluation of design factors such as shape and size.

F. Landscape Characteristics (3.6) -- Evaluates the nature of surrounding land use as it affects the functional capacity of the mitigation site including transition area quality and quantity, and contiguity with adjacent habitats. This variable includes three sub-categories:

F.1 - Adjacent Buffer
Provides a description of the vegetation characteristics of uplands within 50 feet of the wetland boundary.

F.2 - Contiguity
The extent to which the site adjoins other wetlands or open space

F.3 - Land Use
Describes the predominant type of land use within proximity of the wetland.

Table 4: Description of the Variables Included in the Wetland Mitigation Quality Assessment (WMQA). See Appendix C (WMQA Procedure Manual) for details on each parameter. Weighting Factors are shown in parentheses (). **Note:** Weighting Factors were assigned a value from 1 (least important) to 5 (most important) and reflect the average values assigned by 15 independent wetland scientists in New Jersey.

Wetland Mitigation Quality Assessment (WMQA) Weighted Values (V)
(Weighted Value = Raw Score * Weighting Factor)

Hydrology
\+ Soils
\+ Vegetation Composition/Diversity Total =
(Overstory + Ground Cover) / 2
\+ Wildlife Suitability
\+ Site Characteristics
\+ Landscape Characteristics Total =
(Adjacent Buffer + Contiguity + Land Use) / 3

= Sum of Weighted Values (VTOTAL)
÷ Sum of Weighting Factors

= WMQA Score
÷ 3

= WMQA Index Score (0 - 1)

Table 5: Method for Calculating the Wetland Mitigation Quality Assessment (WMQA) Index Score

comprehensive tool developed here in concert with simultaneous field delineations of acreage achieved, including relationship to permit requirements.

The WMQA procedure does not allow for direct quantitative measurement of wetland functions and it is not intended to provide a numerical value that can be used to establish absolute quality of an individual wetland mitigation project or be a surrogate for more quantitative procedures that may be necessary to evaluate mitigation success.

A more precise index of quality would be based on the use of "reference sets" of sites that provide some indication of the range of conditions normally encountered in particular types of wetlands. This type of index would allow for a more precise measurement of the performance of a range of wetland functions. Efforts are underway in New Jersey and in other states to develop such an assessment technique. This type of assessment is time-consuming to develop (on the order of years for one wetland type, such as "riverine depressional") and none were completed at the time this study was conducted. Therefore, use of such a procedure was considered to be impractical for the purposes of this study.

Due to the large spatial and temporal variations that are characteristic of wetland systems, an extended study period would be required to develop a more predictive wetland mitigation quality assessment procedure (Zedler and Calloway, 1999). After conducting a seven-year study on an estuarine wetland in the State of Washington, Simenstad and Thom (1996) suggested that time series in excess of 10 years would be required. Another study (NRC, 2001), suggests that as many as 20 years may be needed for some wetland restoration or creation sites to achieve functional goals. Additionally, there is an increased level of difficulty and associated cost in accurately measuring wetland functions (Bedford, 1996; Mitsch and Wilson, 1996; Race and Fonseca, 1996) using more predictive or quantitative assessment tools.

The science of evaluating wetland quality and function is evolving, especially in relation to constructed wetland mitigation projects. When placed in the context of regulatory review, a rapid assessment procedure that provides NJDEP with a relative and consistent indicator of the potential of a wetland to achieve functional goals is considered a practical approach. The NJDEP is currently sponsoring companion research to test the WMQA method at reference wetlands in New Jersey, and compare it with other functional assessment tools.

Although the results of the assessment technique are represented in numerical form, it should be noted that these numbers do not reflect a quantitative representation of actual processes. At the current time, this procedure is not intended for regulatory evaluation and does not replace performance criteria that NJDEP may use to determine mitigation status in accordance with permit requirements.

2.4 Data Collection and Management Techniques

2.4.1 Global Positioning System (GPS)

All field data were collected using a Trimble Pathfinder Pro XRS unit. Trimble reports sub-meter accuracy for the Pathfinder Pro XRS (Trimble 1998). The use of GPS has the benefit of providing a geographic reference and date stamp for all data points. The GPS unit was also used as a portable data collection tool. With all data fields pre-programmed into the GPS unit, sampling procedures were easily standardized and streamlined. Drop-down menus provided a fixed number of available responses, reduced the potential for sampling error and unintentional omissions, and assured compatibility of data. All field data were entered into and stored in the GPS unit in the field and later downloaded to a PC running Trimble Pathfinder Office software.

2.4.2 Geographic Information System (GIS) Application

This study was designed to be compatible with NJDEP GIS standards. GIS allows the data and results generated to be integrated with other GIS data presently available at NJDEP such as digital aerial photographs and land use data. ESRI ArcView GIS 3.2© software was used in order to be compatible with the Department's GIS. All field data obtained from the GPS unit were converted into ArcView GIS shapefiles. This information can ultimately be integrated into any NJDEP database application and the NJDEP's GIS.

Using GIS, a particular mitigation site can be digitally linked to an aerial photograph showing the location of the site and the boundary of the wetland created or restored. Information available in other GIS coverages can be linked to the results of this study including the study indicators and other supporting documentation. GIS can also be used to illustrate performance measures by using graphs or charts generated from the results of this study. Figure 1 provides an illustration of these capabilities.

2.4.3 Wetland Mitigation Database

The NJDEP mitigation database has been expanded to include all data generated as part of this study. The new wetland mitigation database includes all raw data and supporting information generated during file reviews and field evaluations such as the wetland delineation, concurrence evaluation, and quality assessment. Wetland indicators were calculated for each mitigation site. The wetland mitigation database was designed to automatically apply weighting factors and calculate study indicator values including Area Achieved, Concurrence Evaluation score and WMQA Index score. All data were summarized for analysis using Lotus 123©. Each mitigation site was assigned a unique four-digit number. All data were summarized using these unique mitigation site number references. Statistical analyses were performed using Lotus 123© and SAS©.

Currently, NJDEP maintains its mitigation database in a Paradox© 3.5 format. The database contains fields for the date mitigation was authorized, the type of mitigation, proposed acreage, and other pertinent data. The database was copied for use in the study. The data remained in Paradox© 3.5 format. ASGECI exported the field data from the GPS unit as ArcView shapefiles. Shapefiles are actually comprised of multiple files, some of which contain geographic information, and one which contains attribute data in Dbase4© format.

The database program used in the study was specifically chosen to be compatible with both existing NJDEP database information and NJDEP GIS standards. Lotus Approach 9.5© (a database management software program) was picked because it allowed the NJDEP mitigation

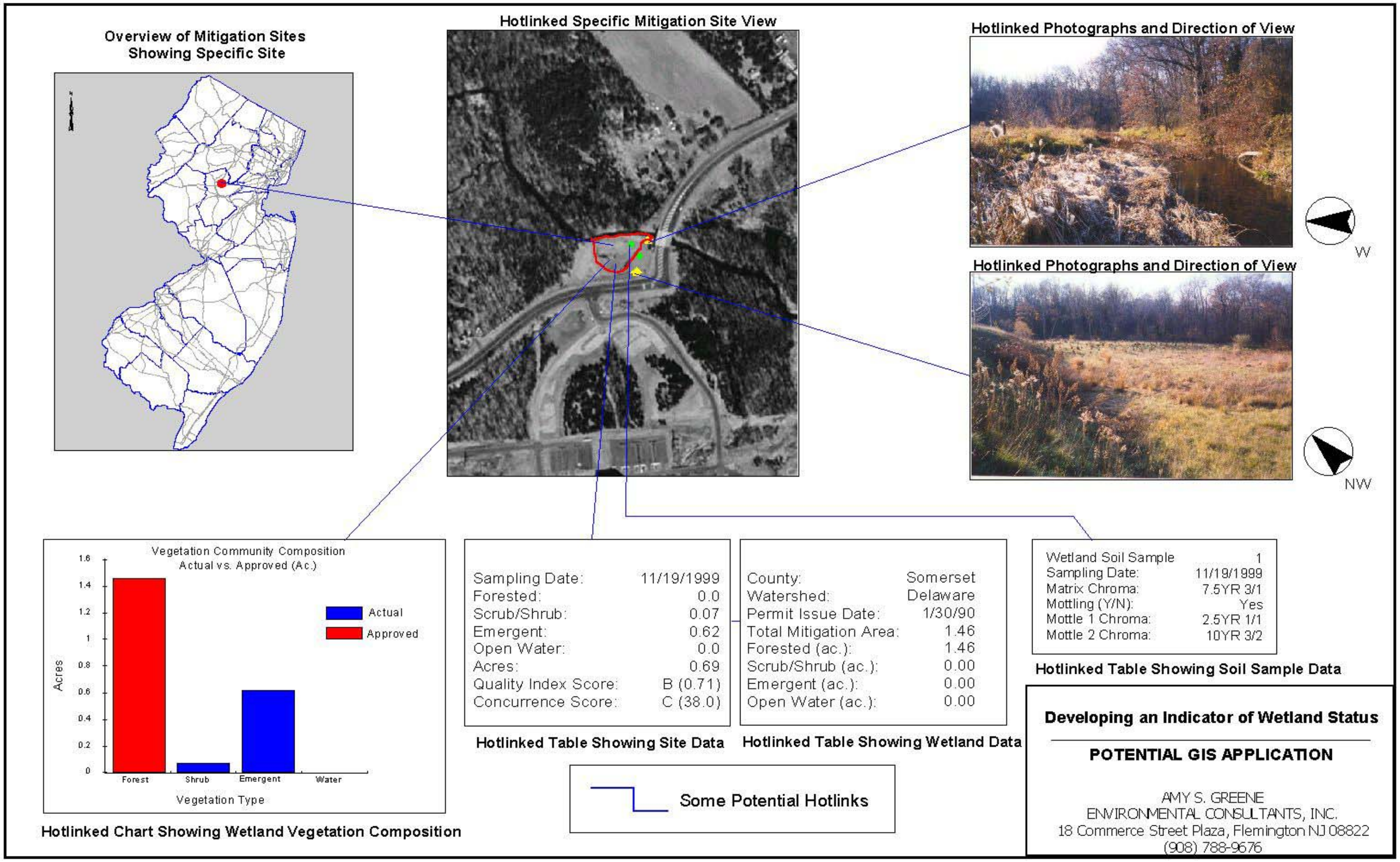


Figure 1: Illustration Showing a Potential Geographic Information System GIS) Application

database to remain in its native Paradox© format, while simultaneously using ArcView© shapefile attribute tables in their native Dbase© format.

The Lotus Approach© application joined together NJDEP mitigation data with information obtained from the field investigations in a multi-table relational database system. Joins were performed based on the unique mitigation site number field.

The updated database and GIS/GPS meta data descriptions for all added fields will be provided to NJDEP as a deliverable separate from this report.

3. QUALITY ASSURANCE PROGRAM

3.1 Quality Assurance Plan

A Quality Assurance Plan was developed for this study. All sampling plans and analytical procedures were prepared under the direction of a Project Director who also served as the Principal Investigator. The Project Director was responsible for establishing and monitoring the overall technical direction of the study.

A Project Manager was assigned to work under the direction of the Project Director and was responsible for providing technical supervision of field staff to assure consistency of sampling procedure. A Data Management Specialist was assigned to this study to oversee data validation and storage in compliance with established procedures and standards. A Project Coordinator was assigned to facilitate transfer of data from field staff to the Data Management Specialist, provide quality review of field data, and coordinate staff training of sampling procedures under the supervision of the Project Manager. All field staff were trained in the use of GPS.

Field staff from the NJDEP Land Use Regulation Program conducted independent field evaluations and provided quality assurance oversight of sampling methods and data collection techniques. All field data were subject to NJDEP review prior to entering information into the wetland mitigation database.

The Project Director coordinated with the internal NJDEP project team during study development and implementation. The NJDEP project team consisted of two Project Managers representing the NJDEP Division of Science, Research and Technology, and the Land Use Regulation Program. In addition, the Bureau of Geographic Information and Analysis and the NJDEP NEPPS Land and Natural Resources Workgroup members collaborated on study design. A Peer Review Committee was established to review and comment on development of the sampling procedures and analysis of results. The Peer Review Committee included representatives from academic institutions, resource agencies, government and non-government organizations and the private sector. Regular communications with members of the project team and peer review committee were maintained throughout the duration of the study to facilitate exchange of information and ideas and allow for collaborative problem solving and planning.

All data collection followed established sampling protocols utilizing standardized data collection procedures. The data collection procedures specified sampling parameters and frequency (see Appendix D). All field evaluations were restricted to the growing period from April 1 through September 15 to minimize the effect of seasonal variability.

3.2 Field Trials

Initial field trials of the Concurrence Evaluation and WMQA procedures were conducted on sixteen (16) separate mitigation sites in July of 1999. Results of the field trials were used to refine sampling procedures and data management techniques. Trial wetland delineations were conducted on two (2) sites in November 1999 using the GPS data collection techniques to assist in the development of the data management system and assure that all data generated by the study would be compatible with NJDEP GIS/GPS mapping standards.

3.3 Inter-rater Variability Analysis

An analysis of inter-rater variability was conducted on six (6) study sites in July of 1999 to determine the repeatability of the WMQA and concurrence scores. Two to three study teams, consisting of two individuals per team, independently evaluated each of the six sites. A permutation test (Efron and Tibshirani, 1993) was performed to calculate inter-rater variability for each WMQA variable, the total WMQA Index score, and the total Concurrence Evaluation score. Confidence intervals were calculated for each parameter. The permutation tests did not reveal a statistically significant difference in mean scores between study teams for any of the parameters ($P \geq 0.44$). Although the permutation test provides no evidence of differences between study teams, the sample size is too small for the tests to have adequate power to detect differences. NJDEP recognizes this, however, and the reliability of the WMQA assessment procedure is being tested in an independent, NJDEP-funded Rutgers University study, currently underway.

Confidence intervals for most parameters were very wide, probably due to the large variability inherent in wetland systems evident in the sites evaluated. As a result of the inter-rater variability analysis, sampling procedures were adjusted to provide additional clarification in scoring those variables exhibiting wide confidence intervals. For example, a matrix was included in the WMQA procedure for ease of reference and to provide additional guidance to the field staff in assigning a raw score (see Appendix C).

4. RESULTS AND DISCUSSION

4.1 Study Site Summary

In July 1999, the NJDEP mitigation database included a total of approximately 223 proposed mitigation sites and included both freshwater and tidal wetland mitigation projects. These sites comprised nearly 1,249 acres of proposed mitigation. The most common type of mitigation goal proposed, both in terms of total area and number of sites, was wetland creation. Wetland creation accounted for 670 acres, representing 54% of all proposed mitigation area. In contrast, restoration accounted for only 134 acres or 11% of the total proposed mitigation area. The average proposed size of all mitigation sites in the NJDEP database was approximately 5.6 acres.

The NJDEP database included 177 approved sites identified as freshwater wetland mitigation, consisting of a total of 562 acres (Table 6) or 45% of the total wetland mitigation contained in the NJDEP database. The most common freshwater wetland community type proposed was forested (PFO), representing 228 acres or 41% of the total approved freshwater wetland mitigation area. Emergent (PEM) accounted for 33% of the total approved freshwater wetland mitigation area. Scrub/shrub (PSS) wetlands and open water (SOW) accounted for the least amount of freshwater mitigation area approved by NJDEP, representing 14% and 13%, respectively. The average proposed size of freshwater mitigation sites was 3.2 acres.

Completeness of information contained in each mitigation file was found to be highly variable precluding a thorough and consistent review of all mitigation sites contained in NJDEP's database. This factor limited the number of field evaluations that could be performed. Most of the files contained some statement regarding goals and area. However, only 71% of sites clearly stated the type of wetland proposed to be built. The proposed source of hydrology was only specified 68% of the time. The availability of grading and landscape plans was 89% and 78%, respectively. For those files that did contain information regarding these goals, the level of this information was often not specific enough to facilitate a complete and reliable field evaluation.

Summary of NJDEP Mitigation Database

		Proposed Wetland Mitigation Type			
	Proposed Freshwater Wetland Mitigation	**Forested (PFO)**	**Scrub/Shrub (PSS)**	**Emergent (PEM)**	**Open Water (SOW)**
Sum	561.91	228.28	76.94	183.91	72.78
Mean	3.17	2.24	1.71	2.70	3.03
Min	0.01	0.01	0.01	0.01	0.07
Max	30.00	30.00	19.00	29.90	29.00
n	177	102	45	68	24
%	-----	41	14	33	13

Table 6: Summary of Proposed Freshwater Wetland Mitigation Sites in the NJDEP Mitigation Database. Includes summary of the type, in acres, of proposed freshwater wetland mitigation sites for which proposed wetland mitigation by community type is identified. Creation and restoration sites are represented. **Note:** Each mitigation site may include more than one type of proposed mitigation.

A total of 90 sites were selected for field evaluation. These study sites were widely distributed throughout the State (Figure 2) including sites within 17 of New Jersey's twenty Watershed Management Areas (WMAs). The study sites included a total of 326 acres of proposed wetland mitigation area. Mitigation goals included 285 acres of creation and 34 acres of restoration. The remaining acres of mitigation goals were identified as enhancement or "other". Study sites ranged in size from 0.08 to 41.20 acres, with an average size of 3.62 acres. Forested (PFO) and emergent (PEM) were the most common type of wetland proposed, accounting for 43% and 33% of total mitigation area, respectively (Table 7). The study sites were generally representative of both size and proposed type in comparison with all freshwater sites contained in the NJDEP mitigation database. Of the 326 acres of proposed mitigation included the study, field delineations were performed on 297 acres (91%) (see section 2.3.1 for an explanation of wetland area evaluated).

The average age of the study sites was six years since implementation (see Appendix A). Study sites ranged from less than one year old to in excess of 12 years old representing a study period from 1988 through 1999. The majority of sites (64%) were implemented more than five years ago, representing 60% of the total area evaluated. Only three sites (3%) were less than two years old.

This study focused on freshwater wetland creation mitigation sites. The majority of the proposed mitigation goals included in the study sites consisted of wetland creation (88%). Wetland restoration and enhancement accounted for only 10% and 2% of the total proposed wetland mitigation, respectively (see Appendix A).

4.2 Wetland Area Achieved

Study findings indicate that a relatively low percentage of proposed mitigation achieved the stated area of wetlands and the wetland type achieved was largely inconsistent with approved plans and specifications. Of the proposed 297 acres of mitigation wetlands evaluated, only 187 acres of wetlands were created suggesting that wetland mitigation is not contributing to the NJDEP's NEPPS wetland resource goal of a net increase in wetland area.

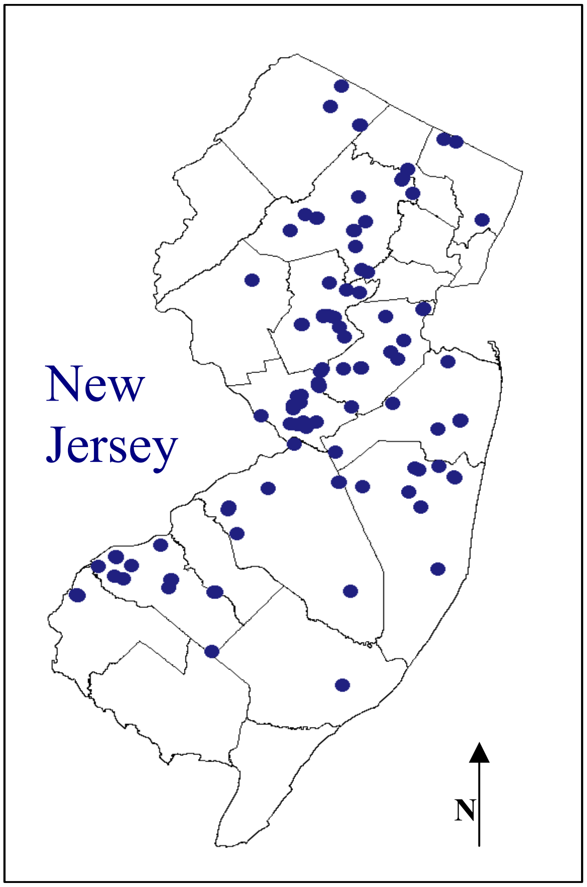


Figure 2: Study Site Location Map

Wetland Mitigation Study Sites

	Proposed Acreage	PFO	PSS	PEM	SOW
Sum	325.60	139.71	21.93	105.77	26.69
Mean	3.62	2.49	0.91	2.78	1.91
STD	6.28	4.89	0.90	5.41	2.82
Min	0.08	0.04	0.01	0.12	0.19
Max	41.20	25.50	3.23	29.90	11.30
n	90	56	24	38	14
%	-----	43	7	33	8

Table 7: Summary of Proposed Wetland Type for 90 Study Sites for which proposed wetland mitigation by type is identified including PFO=Forested, PSS=Scrub/Shrub, PEM=Emergent and SOW=Open Water. Note: Each mitigation site may include more than one type of proposed mitigation.

Wetland Area Achieved was assigned for each mitigation site. The average Wetland Area Achieved indicator score was 45% (Table 8). This represents, on average, approximately 0.45 acres of wetland achieved for every 1.0 acres of mitigation proposed . The total area of wetlands achieved (187 acres) in relation to proposed acreage (297 acres) suggests a higher overall percent wetlands area achieved (63%); however, the average Wetland Area Achieved indicator score of 45% provides a more appropriate measure of percent area achieved. Averaging across all sites is appropriate because this measure reflects a sample of 90 mitigation sites. As Table 8 shows, some sites achieved in excess of the amount of wetland area proposed while some sites achieved no wetlands.

Of the 85 wetland delineations conducted, six sites achieved in excess of 100% of the approved acreage. However, 16 sites failed to achieve any wetlands and 93% of all sites achieved less wetland area than proposed. Although forested (PFO) wetland accounted for in excess of 47% of the total mitigation proposed, only 1% of forested wetland area was achieved on average. On average, scrub/shrub (PSS) wetland was achieved only 11%. Emergent (PEM) wetland was created at close to the same area proposed, with 92% of area achieved. The Percent Wetland Type Achieved value was based upon field evaluation of existing conditions with respect to consistency with approved plans and specifications.

Nearly three times the area of open water was achieved through mitigation as compared with the amount of open water proposed in mitigation plans (Figure 3). Because the statutory authority in New Jersey that regulates activities in and around wetlands also regulates placement of fill in State open waters, and in consideration that mitigation plans are regularly approved by NJDEP that include an open water component, open water was treated as a wetland resource for purposes of this study. For example, if a mitigation site proposed 1 acre of mitigation and a 1 acre open water pond was achieved it would be assigned a Wetland Area Achieved value of 100%.

Of the 90 mitigation sites included in this study, 14 sites proposed a total of 27 acres of open water. However, in excess of 77 acres of open water were achieved, representing in excess of 41% of the total area of "wetlands" achieved through mitigation. This raises a question as to whether the replacement of wetlands of equal ecological value is occurring. If excess open water

	Total Acres Evaluated	Total Acres Achieved	Wetland Area Achieved (%)
Mean	3.49	2.20	45.09
Range	.05-41.20	0-51.51	0-140
Total	296.87	186.91	

Table 8: Results of Wetland Area Achieved Indicator
Note: Mean wetland area achieved represents the average among all study sites.

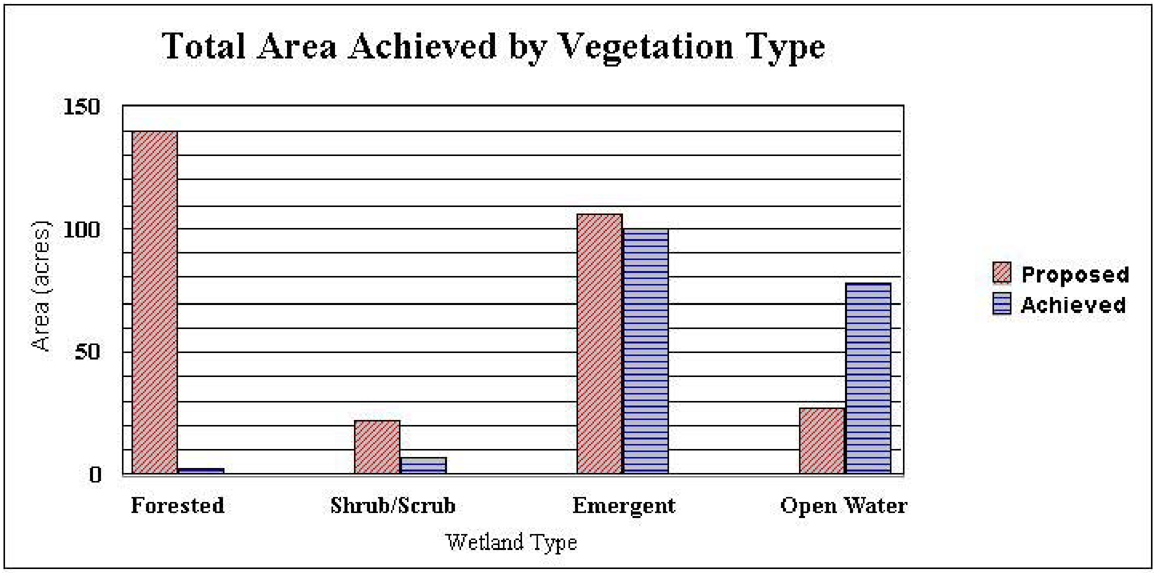


Figure 3: Results of Total Wetland Area Achieved by Vegetation Type Proposed (in acres)

were deleted from the Wetland Area Achieved calculation, the results of this indicator would be lower than 45%, suggesting that type of wetland achieved through mitigation is an important consideration in evaluating the success of mitigation in achieving NJDEP's NEPPS goals.

4.3 Concurrence Evaluation

The results of the Concurrence Evaluation indicator suggest that as-built conditions, on average, are inconsistent with plans and specifications approved by NJDEP. Of the 88 concurrence evaluations performed, the average weighted score was 48% (Table 9). Weighted scores ranged from 0 to 100% concurrence with approved plans. Concurrence evaluations could not be performed on two of the study sites due to insufficient plan information in the mitigation files. Sample size varied with each variable (i.e. Soils, n=53 vs. Hydrology, n=81) reflecting the inability to assign concurrence values for all variables due to insufficient mitigation specifications for a particular site.

Hydrology, the variable that was assigned the highest weighting factor (see Table 2), achieved an average raw score of 47%. Typically, the grading and design variables were most consistent with approved plans. Both of these parameters achieved a raw score of 56%. Vegetation variables of percent cover and percent survival achieved the lowest concurrence scores of 39% and 28%, respectively. There was a high standard deviation evident for all scores suggesting a wide variability in degree of consistency with approved plans among study sites.

As part of the Concurrence Evaluation, a determination was made as to what corrective actions would be needed on each site to make them consistent with their stated goals and objectives. It was found that no corrective actions were needed on only 3% of sites

The following is a brief overview of the findings for each variable, focusing on major reasons for low scores for each variable.

A. Grading – For the 68 sites for which enough information was available in the mitigation file to conduct an evaluation, 56% of grading was consistent with NJDEP approved plans. Low

Concurrence Evaluation Indicator Scores (%)

	Grading	Hydrology	Soil	Veg. Cover	Veg. Survival	Design	Concurrence Score
Mean	55.51	47.28	50.94	39.46	28.31	56.38	47.52
SD	31.90	31.22	35.90	29.89	27.09	29.97	24.87
Min	0	0	0	0	1	0	0
Max	100	100	100	100	100	100	100
n	68	81	53	80	62	80	88

Table 9: Summary of Concurrence Evaluation Indicator Scores
Note: Table shows individual raw scores and weighted total score.

concurrence scores for grading were attributed primarily to the failure to achieve proposed grade or elevations on part or in some cases the entire site, because too little or too much soil had been removed from the site. It was found that 61 of the 90 study sites (68%) would require some form of re-grading to be consistent with approved plans and specifications.

B. Hydrology – Hydrology was consistent with approved plans, on average, 47% of the time. Sufficient specifications were available in the mitigation file to allow a hydrology concurrence evaluation on 81 study sites. Low hydrology scores were most often attributed to inadequate grading or failure of hydrologic specifications to adequately or sufficiently address the naturally occurring hydrologic regime in the area, including availability of an adequate water supply, seasonal and annual variations, or extreme events such as drought. Only 6 (7%) of the 90 mitigation study sites contained some form of device to monitor whether appropriate hydrology had been achieved.

C. Soil - For the 53 sites for which enough information was available in the mitigation file to conduct an evaluation, soil conditions on 51% of proposed mitigation was consistent with approved plans and specifications. The low sample size reflects a general absence of sufficient soil specifications in mitigation plans among study sites. The most commonly observed departure from plans and specifications was the lack of placement of any topsoil on the site. In some cases, soil was placed, but the soil did not meet topsoil specifications in plans (e.g. depth and/or organic content). A total of 42 of the 90 study sites (47%) required some form of supplemental topsoil.

D. Vegetation Cover - Sufficient information was available for 80 sites to conduct an evaluation for this variable. Vegetation cover was accomplished, on average, on 39% of sites in concurrence with plans and/or the NJDEP requirement that mitigation sites achieve 85% or greater cover of native non-nuisance hydrophytes. Mitigation sites that failed to achieve this goal did so due to high mortality of planted vegetation, lack of propagation of planted vegetation, lack of natural recruitment of hydrophytes, invasion by nuisance and invasive plants (including persistent grasses planted for erosion control purposes), or a combination of all three factors (see Appendix C for a list of nuisance and invasive plants). In some cases low vegetation cover scores were attributable to the failure to plant specified plant stock consistent with the species, stock type and/or numbers specified in the mitigation plan. In some cases, planted vegetation failed but natural recruitment was sufficient to meet the goal of 85% or greater cover achieved. Based upon field evaluations conducted as part of this study, 76 or 84% of the 90 study sites were determined to require some form of supplemental planting to make them consistent with approved plans and specifications.

E. Vegetation Survival – For the 62 sites for which sufficient information was available in the mitigation file to conduct an evaluation, an average of 28% of vegetation planted survived. Major factors contributing to vegetation mortality were too little or too much water, herbivory by geese or deer, poor planting techniques, poor vegetation stock or failure to comply with the planting specifications contained in the approved mitigation plan. The lower sample size for this variable may be attributed to fewer sites containing sufficient planting specifications such as plant stock type or plant numbers to accommodate a thorough evaluation. Seventy-six of the 90 study sites (84%) were found to need supplemental planting.

F. Design – 80 sites contained sufficient design criteria in the mitigation file to conduct an evaluation for the design variable. This variable was consistent with NJDEP approved plans an average of 56% of the time. Design specifications primarily consisted of general information on proposed size and shape of the mitigation site. Design criteria such as establishment of transition areas and ongoing maintenance requirements were rarely addressed in mitigation plans. Some form of maintenance was needed at 31 of the 90 study sites (34%).

4.4 Wetland Mitigation Quality Assessment (WMQA)

Wetland Mitigation Quality Assessments (WMQAs) were performed on 74 study sites that achieved 187 acres of wetlands. No WMQAs were performed on those 16 sites that did not achieve wetlands based upon the results of the wetland delineations. Relative quality of wetlands achieved was evaluated with respect to individual variables including hydrology, soils, vegetation, wildlife suitability, site characteristics, and landscape features based upon a rating scale of 0 to 3 (see Table 4). A final WMQA indicator score was based upon an index from 0 to 1.

The average WMQA index score was 0.51 out of a maximum possible score of 1 (Table 10). Scores ranged from 0.25 to 0.83. Overall, scores were low compared to what would be expected if the mitigation sites evaluated had a high potential to function as natural wetlands. With respect to individual variables evaluated, soils and site characteristics achieved the highest scores on a scale of 0 to 3 with scores of 1.67. Hydrology also achieved a relatively high average score of 1.61 out of a possible score of 3. Wildlife achieved the lowest average score of 1.22. A high variability among all parameters was observed suggesting that no one parameter consistently drives the WMQA index.

The following is a brief overview of the findings for each variable, focusing on major reasons for low scores for each variable.

A. Hydrology – Average Score: 1.61. Hydrology of the sites evaluated ranged from areas with too little water to areas with too much water. Areas with too little water included encroachment of transitional and upland vegetation species, high mortality of planted wetland species, and lack of other hydrologic indicators such as plant morphological adaptations, sediment deposition, and hummocks. Areas with too much water generally supported large expanses of open water with little or no vegetated fringe. In both cases, it appeared as if low hydrology scores resulted from inappropriate or inadequate source of hydrology or established grades that were inconsistent with the hydrologic regime of the site.

B. Soil – Average Score: 1.67. Low soil scores were often the result of insufficient or absent topsoil or soil of poor quality for establishing vegetation. In areas where topsoil was inadequate, the soil was often too dry or compacted to the extent that recruitment of desirable wetland plant species was precluded.

C. Vegetation – Average Score: 1.42. Vegetation (both canopy – above 3 ft. in height, and ground cover – below 3 feet in height) often lacked diversity and density that would be expected

WMQA Score

	Hydrology	Soil	Veg. Total	Wildlife	Site Char.	Landscape	Total WMQA Index
Mean	1.61	1.67	1.42	1.22	1.67	1.43	0.51
SD	0.64	0.77	0.52	0.56	0.57	0.55	0.14
Min	0.5	0	0.5	0	0.5	0.33	0.25
Max	3	3	2.5	2.5	2.5	2.67	0.83
n	74	73	74	74	74	74	74

Table 10: Summary of Wetland Mitigation Quality Assessment (WMQA) Scores. **Note:** Table shows individual raw scores based on rating scale from 0-3. Weighted WMQA Score based on index from 0-1.

in a system that was becoming a highly functioning wetland. Extensive mortality was evident from deer and goose herbivory, inadequate hydrology, poor planting stock, improper planting techniques, poor growing media, or a combination of several of these factors. In areas where the mitigation site exhibited favorable hydrology and soil conditions, natural recruitment of desirable wetland vegetation negated most of these problems. Establishment of invasive species or persistent grasses was evident on numerous sites and in some instances precluded the establishment of desirable wetland plants.

D. Wildlife – Average Score: 1.22. Mitigation areas often lacked structural or plant species diversity needed to support feeding or breeding requirements for wildlife. Many mitigation sites were located in areas where human disturbances such as housing were incompatible with or detracted from wildlife utilization.

E. Site Characteristics – Average Score: 1.67. Many mitigation sites scored low for this variable due to small size and location in an area with incompatible land uses (e.g. adjacent to a residential or industrial development or in a clover leaf of a highway interchange). Many sites also lacked heterogeneity (e.g. contained 100% State open water with minimal or no littoral fringe). Most sites required at least some ongoing maintenance, such as control of invasive species or periodic maintenance of water control structures. Although the shape of sites was generally designed to be conducive to wetland functions – most sites tended to be more square or circular as opposed to being designed as long, narrow features – this variable may have been influenced by site selection methods.

F. Landscape – Average Score: 1.43. Mitigation areas evaluated often scored low in terms of all three landscape subcategories. Buffers were often narrow or of marginal benefit to the adjoining wetland (e.g. sparsely vegetated or exhibiting high rates of erosion), sites were often not compatible with the surrounding landscape (e.g. a wetland was not contiguous with adjoining wetlands or open space), and the surrounding land use was often developed, contributing to increased rates of stormwater runoff into the mitigation wetland.

5. DATA ANALYSIS

The study included the development of an improved and expanded data management system, which contains a wealth of information and allows for numerous analytical opportunities that can be used to evaluate wetland mitigation performance standards (e.g. Wetland Area Achieved) and measured attainment of NJDEP's NEPPS strategic goals. As part of this study, data analysis is primarily concentrated on the use of the study indicators themselves in hopes of identifying trends that may be useful in measuring the effectiveness of existing wetland mitigation in achieving a goal of a net gain in wetland area. However, we have explored a number of additional analytical options to illustrate the capabilities of the system. The following discussion serves to illustrate the analytical capabilities of the system, but is by no means exhaustive of all the possibilities.

5.1 Compensation Ratios

NJDEP has established a NEPPS strategic goal to improve wetland quality and function and achieve a net increase in wetlands through innovative techniques for the creation, enhancement and maintenance of New Jersey wetlands. Based upon the results of this study, mitigation was found, on average, to achieve the goal of wetland area created only 45% of the time, or a ratio of 0.45 acres of wetlands created for each 1.0 acres of mitigation proposed. This result suggests that current freshwater wetland mitigation practices are not resulting in a net increase in freshwater wetlands.

Compensation ratios were evaluated to determine to what extent the existing mitigation program offsets the permitted losses to wetlands. Compensation ratios are a comparison between the amounts of mitigation proposed/achieved in relation to the amount of wetland losses permitted in a single permit action. A compensation ratio achieved in excess of 1:1 is required to attain a net increase in wetland area. It is important to note that not all permitted losses require mitigation (some general permits do not require mitigation), and as such wetland losses at a program level would be expected to be greater than this analysis suggests. Additionally, wetlands replaced through mitigation may not be of comparable ecological value to wetlands lost.

A total of 75 files contained sufficient data regarding area of wetland impacts and were therefore used to calculate proposed and achieved mitigation ratios. Impacts authorized by NJDEP for these 75 files accounted for a total of 234 acres of wetlands lost. Corresponding mitigation approved by NJDEP for these sites was 324 acres. The majority of the mitigation proposed was wetland creation. Proposed ratios ranged from 0.55:1 to 3.96:1. By comparing the area of wetland impacts authorized with the amount of wetland mitigation approved, on a site-by-site basis, the compensation ratio approved by NJDEP was calculated to be 1.80:1 (Figure 4). For each acre of impact to wetlands approved by NJDEP, on average 1.80 acres of compensatory mitigation were required.

The total wetland area achieved through mitigation on these sites was only 187 acres. Achieved ratios ranged from 0:1 to 3.96:1. By comparing the average amount of wetland mitigation required with the actual amount of wetlands achieved through mitigation, on a site-by-site basis, the actual ratio of acres of mitigation wetlands achieved to those impacted was calculated to be 0.78:1. On average, for each acre of impact to wetlands approved by NJDEP, 0.78 acres were actually achieved through mitigation, a net loss of 22%.

Average proposed and achieved mitigation ratios were calculated by comparing the area of wetland impact authorized to the area of wetland mitigation approved or achieved on a site-by-site basis, rather than a comparison of total acres authorized to total acres approved or achieved. As a simplified example, suppose a study with two mitigation sites as follows: Site A, with 3 acres wetland impacts, 6 acres proposed wetland creation (2:1 ratio), and 2 acres achieved wetland creation (0.66:1 ratio); and Site B, with 2 acres wetland impacts, 8 acres proposed wetland enhancement (4:1 ratio), and 4 acres achieved wetland enhancement (2:1 ratio). To calculate the average proposed mitigation ratio, we would take the average of 2:1 and 4:1, for an average ratio of 3:1. To calculate the average achieved mitigation ratio, we would take the average of 0.66:1 and 2:1, for an average ratio of 1.33:1. Note that these results are different from the result one would get if all impacts, proposed mitigation acres, and achieved mitigation acres were totaled and the ratio of those totals reported (for our simplified case, the results for proposed and achieved mitigation would be 2.8:1 and 1.2:1, respectively).

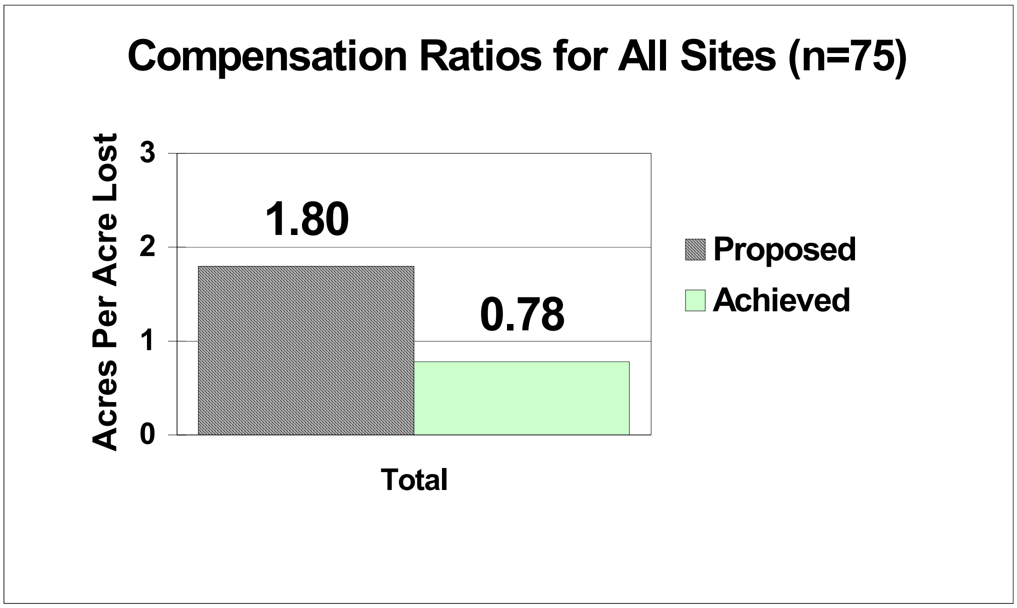


Figure 4: Comparison of Average Mitigation Compensation Ratios (Proposed vs. Achieved)

The results indicate that from 1988 to 1999 the wetland mitigation program in New Jersey resulted in a net loss in wetland area.

5.2 Replacement of Ecological Value

Within New Jersey, the NJDEP requires compensatory mitigation that is adequate to achieve the replacement of wetlands or State open waters of equal ecological value. Depending on the circumstances under which wetlands or State open waters are lost or disturbed, different types of mitigation may be acceptable. Generally, however, in-kind replacement is desirable to achieve replacement of ecological value. In-kind replacement generally refers to the creation, enhancement or restoration of the same type of wetland community (e.g. forested, scrub/shrub, emergent or open water) as that lost or disturbed by a permitted activity.

Nearly three times the area of open water was achieved through mitigation as compared with the amount proposed in mitigation plans subsequently approved by NJDEP. Open water represents 41% of all "wetlands" achieved through mitigation but only accounts for approximately 5% of the area lost or disturbed through permit action. This raises a question as to whether the requirement of replacing wetlands of equal ecological value is being met.

For purposes of this analysis we used type of wetland achieved as a surrogate for ecological value to further evaluate whether NJDEP's NEPPS goal of "improve quality and function and achieve a net increase in wetland resources" is being achieved. Table 11 provides a breakdown of compensation ratios by wetland type proposed. This analysis included only study sites that included information on the type of wetland impacted and mitigated. No credit was assigned if in excess of 100% of a particular wetland type was achieved. For example, a permittee proposed a total of 1 acre of mitigation consisting of 0.5 acres of forested wetland and 0.5 acres of open water, yet, they achieved 0.75 acres of open water only. The amount of open water proposed would therefore be applied to calculating the compensation ratio. In this case the compensation ratio achieved by type would be 0:1 for forested and 0.5:1 for open water.

Vegetation Type	Total Impact (ACRES)	Total Mitigation Proposed (ACRES)	Proposed Compensation Ratio	Mitigation Area Achieved (ACRES)	Achieved Compensation Ratio
Forested (n=31)	64.26	108.534	2.04	1.99	0.01
Shrub/Scrub (n=9)	6.93	9.01	2.78	2.18	0.91
Emergent (n=14)	17.63	22.74	1.85	10.54	1.29
Open Water (n=5)	4.6	4.116	1.07	0.71	0.28

Table 11: Summary of Compensation Ratios by Vegetation Type

The only wetland type where actual mitigation exceeded impacts was emergent wetlands (n=14), which achieved an average compensation ratio of 1.29:1 (Figure 5). However, this ratio still fell below the approved ratio of 1.85:1. Forested wetlands, in contrast, achieved the lowest average compensation ratio of 0.01:1. In a sample of 31 sites, of the 64 acres of forested wetland losses approved by NJDEP, 109 acres of forested wetland mitigation was proposed and only 2 acres of potential forested wetland was achieved through mitigation. Scrub/shrub wetland was found to achieve a compensation ratio of 0.91:1.

Although nearly three times the area of open water was achieved through mitigation in comparison to the amount approved by NJDEP, open water achieved a compensation ratio of only 0.28:1 based on a sample of 5 sites. This suggests that open water is being achieved in large part on sites that did not include open water in the approved mitigation plan and is therefore inconsistent with what was approved by NJDEP.

The results indicate that mitigation is not replacing wetlands in-kind and, as such, may not be adequate to replace wetland ecological values. See Photos 1 and 2 for examples of mitigation sites for which created wetland community types were inconsistent with those specified in the approved mitigation plans.

5.3 Effect of Wetland Type on Study Indicators

It was found that the type of wetland created through mitigation was generally inconsistent with the stated goals of the mitigation plan approved by NJDEP. This is particularly evident for forested wetlands. Of particular concern is that forested wetland was the most prevalent type of wetland mitigation proposed yet, only a small portion of sites resulted in potential forested wetland achieved. In contrast, although open water accounted for a very small proportion of wetland mitigation approved by NJDEP, nearly 40% of the total wetland type achieved through mitigation was open water.

The relationship between wetland type proposed and study indicators was examined to determine if wetland type proposed had any effect on the resulting study indicators. Data were analyzed for

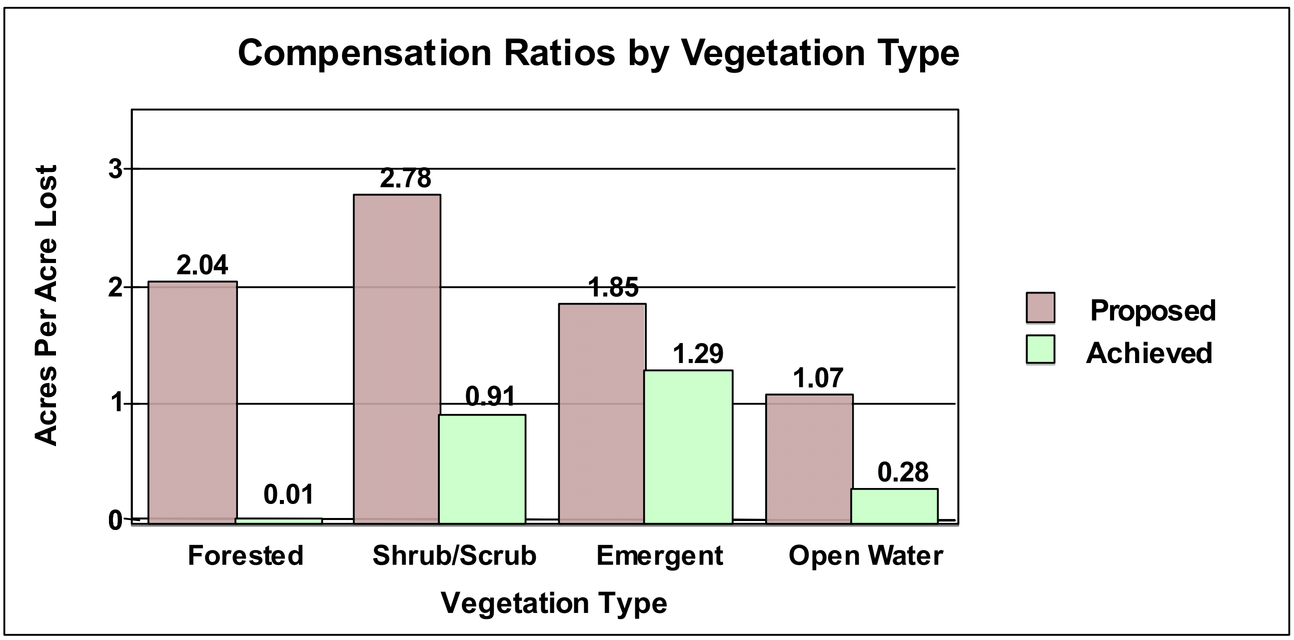


Figure 5: Comparison of Average Mitigation Compensation Ratios (Proposed vs. Achieved) by Vegetation Type

Mitigation Site ID = 123

Wetland Achieved = 84.02%
Concurrence Score = 37.84
WMQA Index = 0.41

Size (acres) = 13.20

Wetland Type (acres)

	Impacted	Proposed	Achieved
Forest			
Shrub		2.90	0.55
Emergent		6.57	1.11
Open Water		3.73	9.42

Compensation Ratio (x:1)

Proposed	Achieved
2.09	1.75

Photo 1: Mitigation Site with Disproportionately High Amount of Open Water Created.

Although open water has many ecological benefits, it may not replace the wetland qualities lost through permitted disturbances.

Mitigation Site ID = **011**

Wetland Achieved = **36.63%**
Concurrence Score = **27.58**
WMQA Index = **0.30**

Size (acres) = **1.01**

Wetland Type (acres)

	Impacted	Proposed	Achieved
Forest	0.27		
Shrub			
Emergent	0.21	1.01	0.37
n Water			

Compensation Ratio (x:1)

Proposed	Achieved
2.11	0.77

Photo 2: Emergent Wetlands Created to Compensate for Impacts to Forested Wetlands.

In some cases, forested wetland losses are being compensated through the creation of other wetland types such as emergent wetlands.

only those study sites for which wetland type was specified in the approved mitigation plan. Figure 6 compares the average value for each study indicator based on the type of wetland proposed in the mitigation plan including forested, scrub/shrub, emergent and open water. Although statistical analysis was not performed on these data, there appears to be a reduction in all study indicators when forested wetland type is proposed.

The results of the analysis suggest that the type of wetland mitigation proposed may affect wetland mitigation status in terms of both wetland area and quality achieved through mitigation. The most prevalent mitigation type proposed, forested, has the lowest likelihood of succeeding. Open water in contrast is being created through mitigation at much greater rates than envisioned in mitigation plans approved by NJDEP.

5.4 Watershed Management Areas

New Jersey consists of 20 designated inland Watershed Management Areas (WMAs). Utilizing the spatial analysis capabilities of GIS, indicator values were plotted by WMAs (Figure 7) to determine if geographic factors may contribute to wetland mitigation status.

The highest Wetland Area Achieved was from WMA 5 (Hackensack) and WMA 7 (Elizabeth/Rahway), which each achieved in excess of 100%, although sample size was small for each (n=1). WMA 2 (Walkill) achieved the highest Concurrence score of 94% and WMA 17 (Maurice/Salem River) achieved the highest WMQA index score of 0.74. The highest overall scores were achieved in WMA 2 (Walkill) and WMA 17 (Maurice, Salem River, Cohansey). The lowest overall scores were achieved in WMA 19 (Rancocas Creek). Figure 8 shows the distribution of the number of study sites and the total area evaluated for each WMA. This study includes sites in all WMAs except WMA 1 (Upper Delaware River), WMA 4 (Lower Passaic, Saddle) and WMA 16 (Cape May). Although there was good representation among WMAs, sample size was small for some, particularly WMA 5 (Hackensack), WMA 7 (Elizabeth, Rahway, Woodbridge), WMA 14 (Mullica, Wading River), and WMA 19 (Rancocas). The majority of the study sites were located in WMA 9 (Lower Raritan), WMA 11 (Central

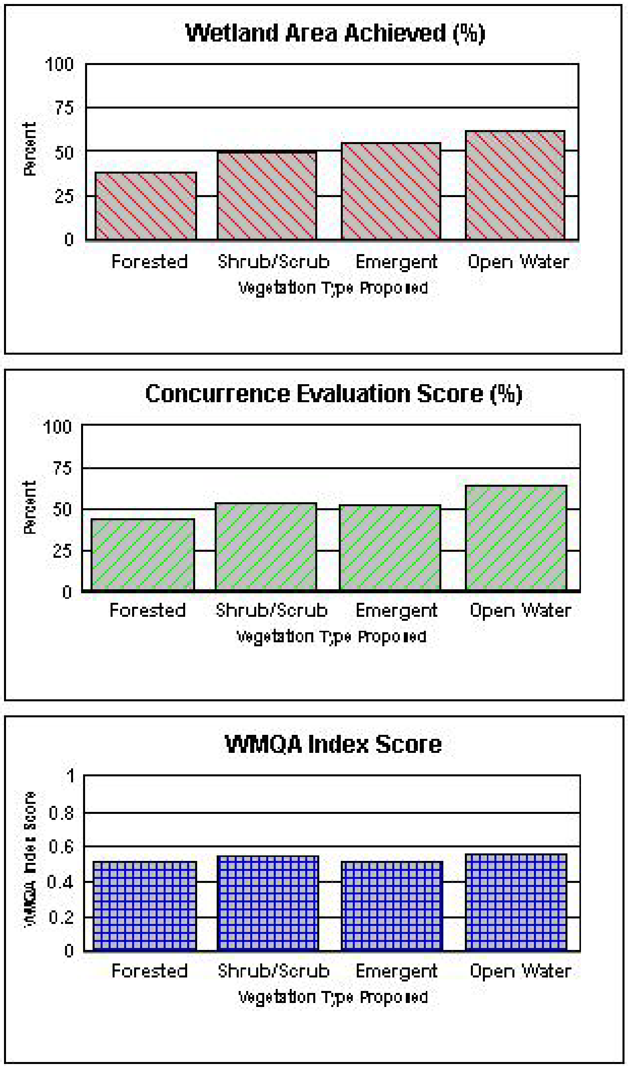


Figure 6: Changes in Study Indicators Based on Type of Wetland Mitigation Proposed

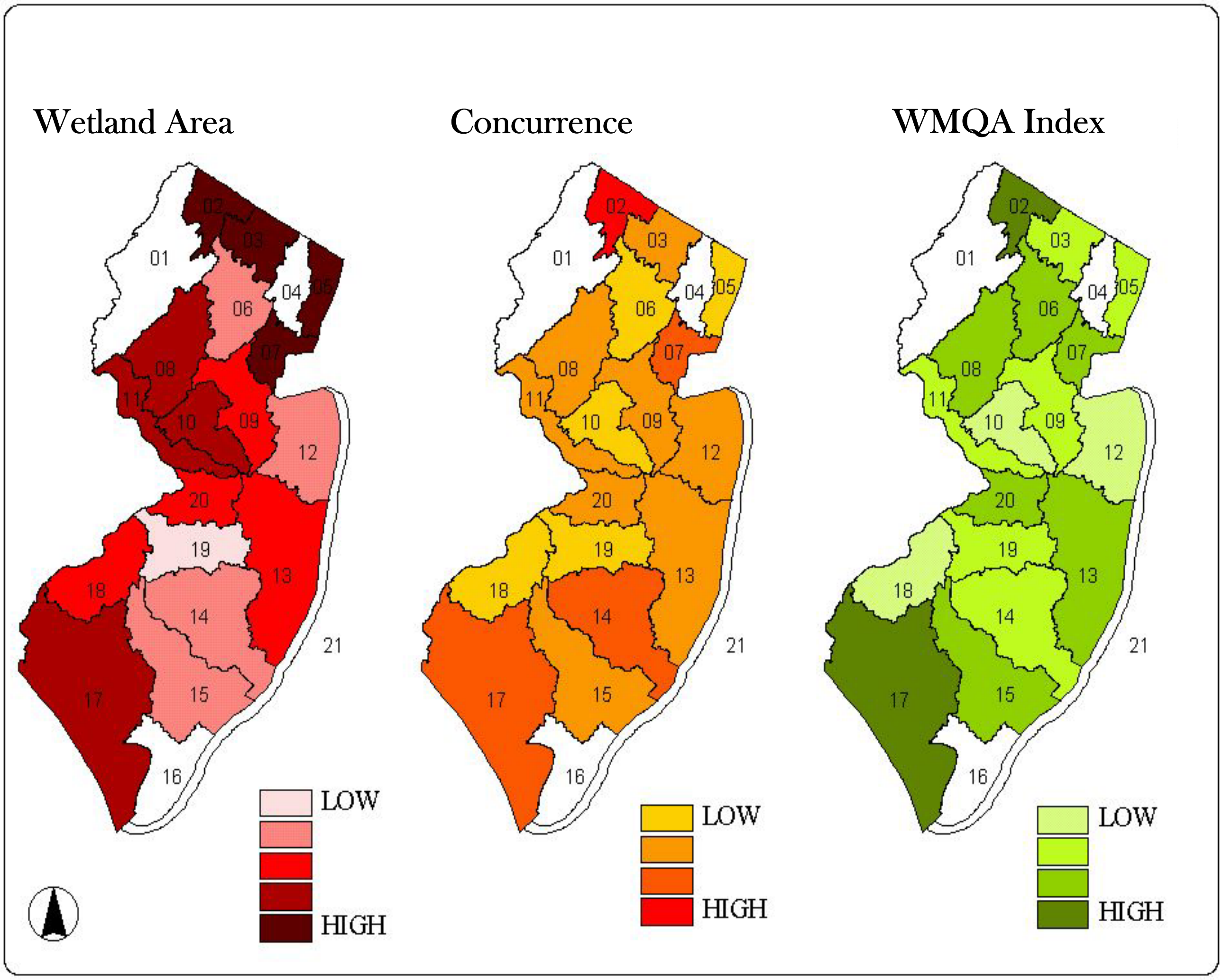


Figure 7: Spatial Analysis of Study Indicators by Watershed Management Areas (WMAs)

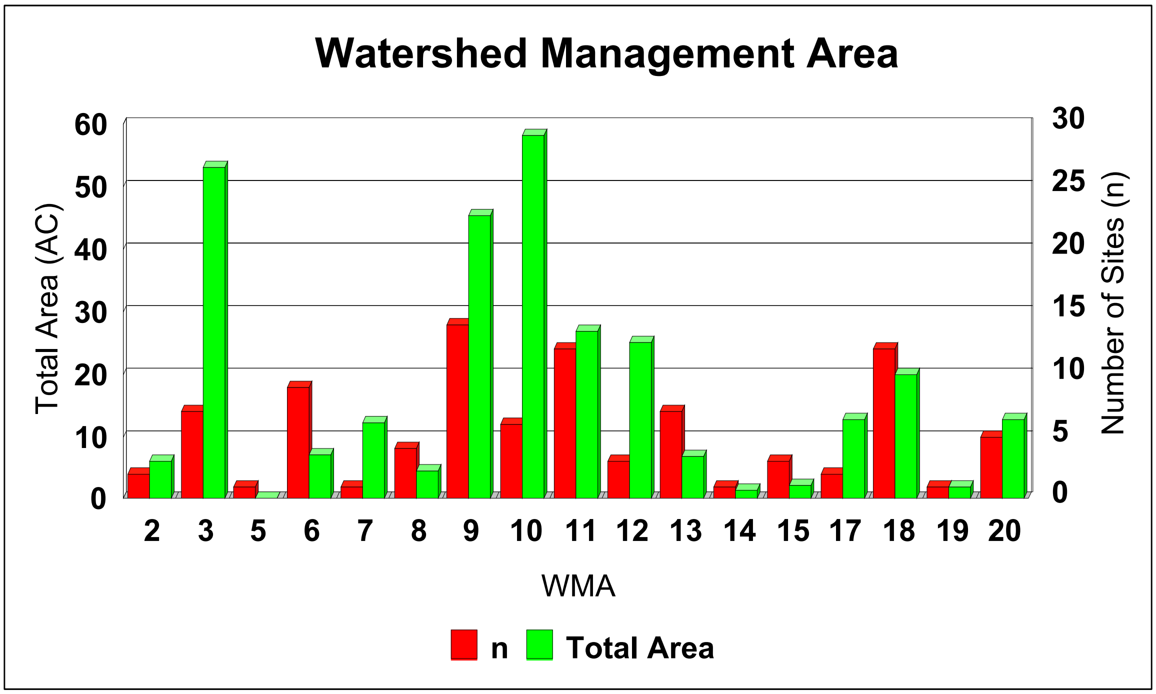


Figure 8: Number of sites and total area in each Watershed Management Area

Delaware), and WMA 18 (Lower Delaware). The majority of the mitigation area evaluated (acres) was located in WMA 3 (Ramapo), and WMA 10 (Millstone).

The high geographic variability in all indicator scores suggests that there may be localized factors that contribute to the suitability and success of mitigation sites in New Jersey. However, in some WMAs small sample size limits extrapolation of findings across the WMA. Additional study would be necessary to confirm these findings.

5.5 Wetland Size

The size of wetland mitigation sites evaluated in the field as part of this study averaged 3.49 acres with a range from 0.05 acre to 41.2 acres. Smaller sites are much more prevalent although the majority of mitigation area is contained in sites greater than 10 acres. Mitigation sites less than one acre in size accounted for 45% of the total sites included in this study. Sites with area of less than five acres account for 82% of all sites. However, in terms of area, ten sites (approximately 11% of sites) larger than 10 acres, accounted for approximately 60% of the total mitigation area evaluated.

The data were analyzed to determine if the proposed size of a mitigation site has an influence on either the quality or quantity of wetlands achieved through mitigation. The comparison between the size of a mitigation site and the study indicators suggested a small increase in all indicators as size of the mitigation site increases (Figure 9). Wetland Area Achieved ranged from an average of 33% of proposed wetland area achieved for sites less than 0.5 acres to 66% for sites greater than 10 acres in size. Concurrence Evaluation Score ranged from 37% for sites less than 0.5 acres to 51% for sites greater than 10 acres. WMQA Index Score exhibited the smallest increase from 0.44 for sites less than 0.5 acres to 0.67 for sites 5 to 10 acres. After the peak it decreased to 0.49 for sites greater than 10 acres (Figure 9).

A linear regression analysis was performed and determined that there is a positive correlation between Wetland Area Achieved and proposed size of the mitigation site ($r = 0.26$, $p<0.05$) (Figure 10). This suggests that on average, large sites are more conducive to increasing quantity

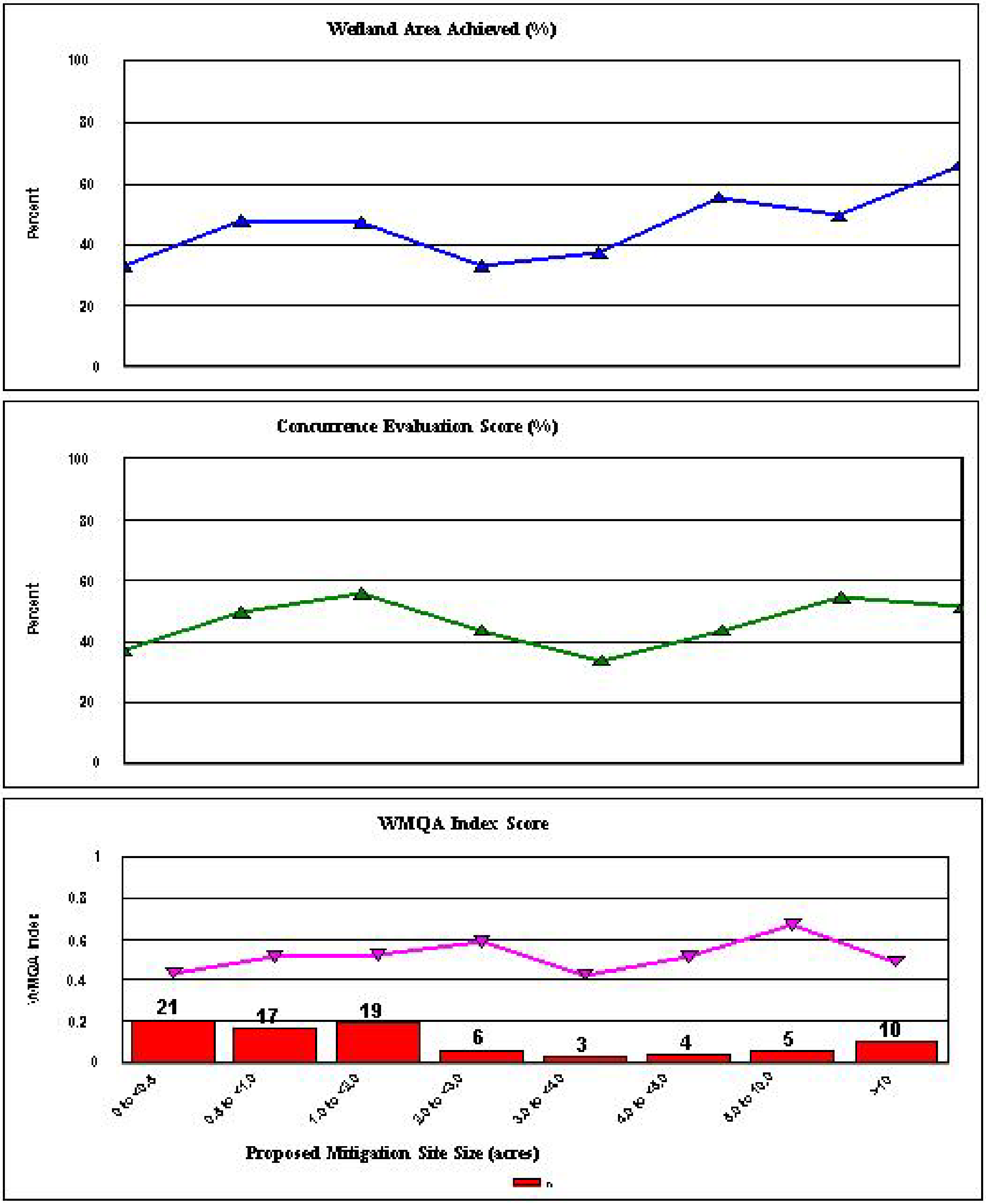


Figure 9: Distribution of Study Indicators by Size of Site

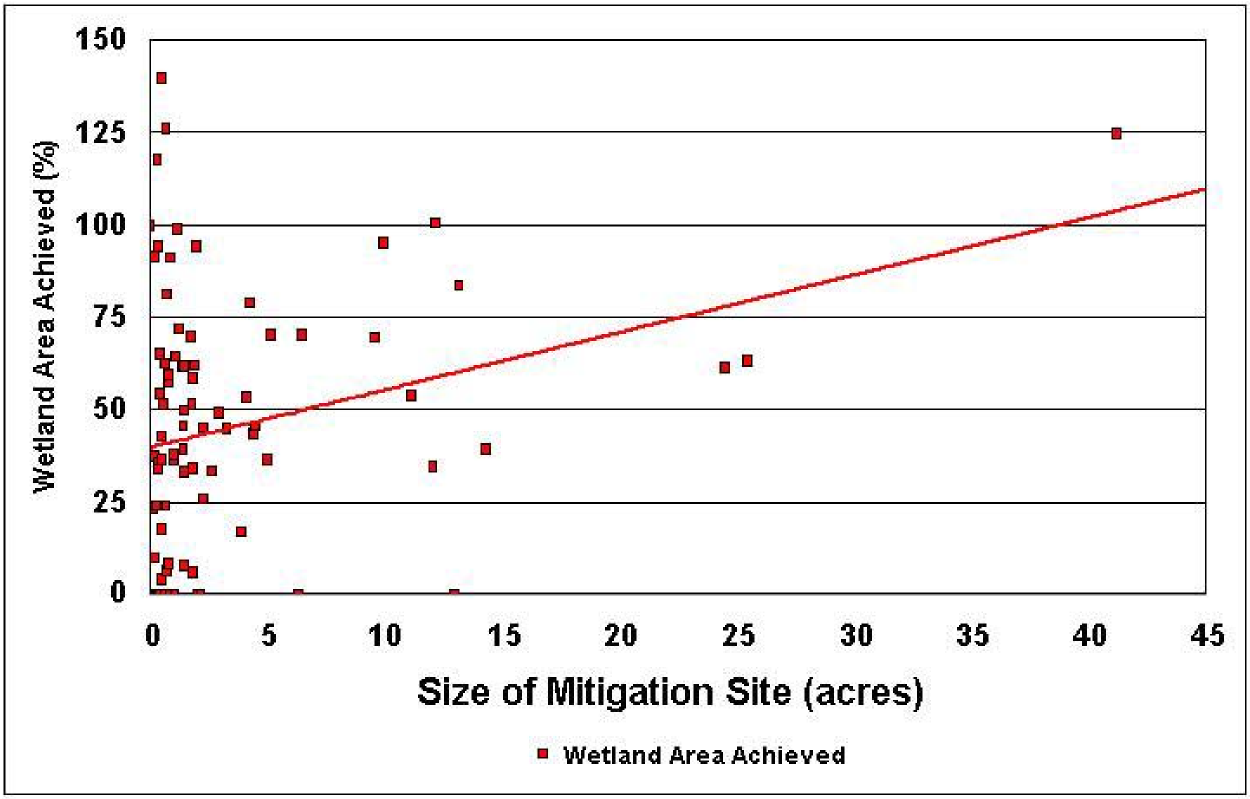


Figure 10: Linear Regression Analysis. Shows comparison between proposed size of site and percent wetland area achieved ($r=0.26, p<0.05$)

of wetlands achieved. However, the correlation is likely due to the single outlier on the right side of the graph (42 acres). There appears to be very little correlation for those mitigation sites smaller than 10 acres. Additional study of a greater number of larger mitigation sites would be necessary to test the hypothesis that the size of the mitigation site contributes to the attainment of goals. No significant correlation was found between Concurrence Evaluation or WMQA Index scores and size of site. Although it may be possible to increase success in terms of acreage created by increasing the proposed size of the site, this does not necessarily translate into increased compliance or improvements to the quality of mitigated wetlands.

5.6 Mitigation Site Age

The study included mitigation sites constructed during an eleven-year period from 1988 through 1999. The average site age was approximately 6 years old with good distribution of study sites among all age classes. The majority (97%) of study sites were in excess of two years of age.

The effect of age of the mitigation site on study indicators was explored to determine if there are any discernable trends in the quantity or quality of wetlands achieved during the study period. Figure 11 illustrates the changes in study indicators based upon age of site representing the period from 1988 (at right) to 1999. There was no improvement in study indicators detected during the study period.

The results of the analysis suggest there are not recent improvements in mitigation design and construction that would suggest a trend toward increasing attainment with goals. Improvement in these values may be expected in the future as NJDEP implements its performance-based standards for mitigation.

5.7 Mitigation Site Hydrology

The quality of hydrologic source was shown to be related to the quantity of wetlands achieved. Figure 12 illustrates the average Wetland Area Achieved, WMQA Index scores and the prevalence of invasive species for each of four dominant sources of hydrology including groundwater, sheetflow, stream diversion and stormwater.

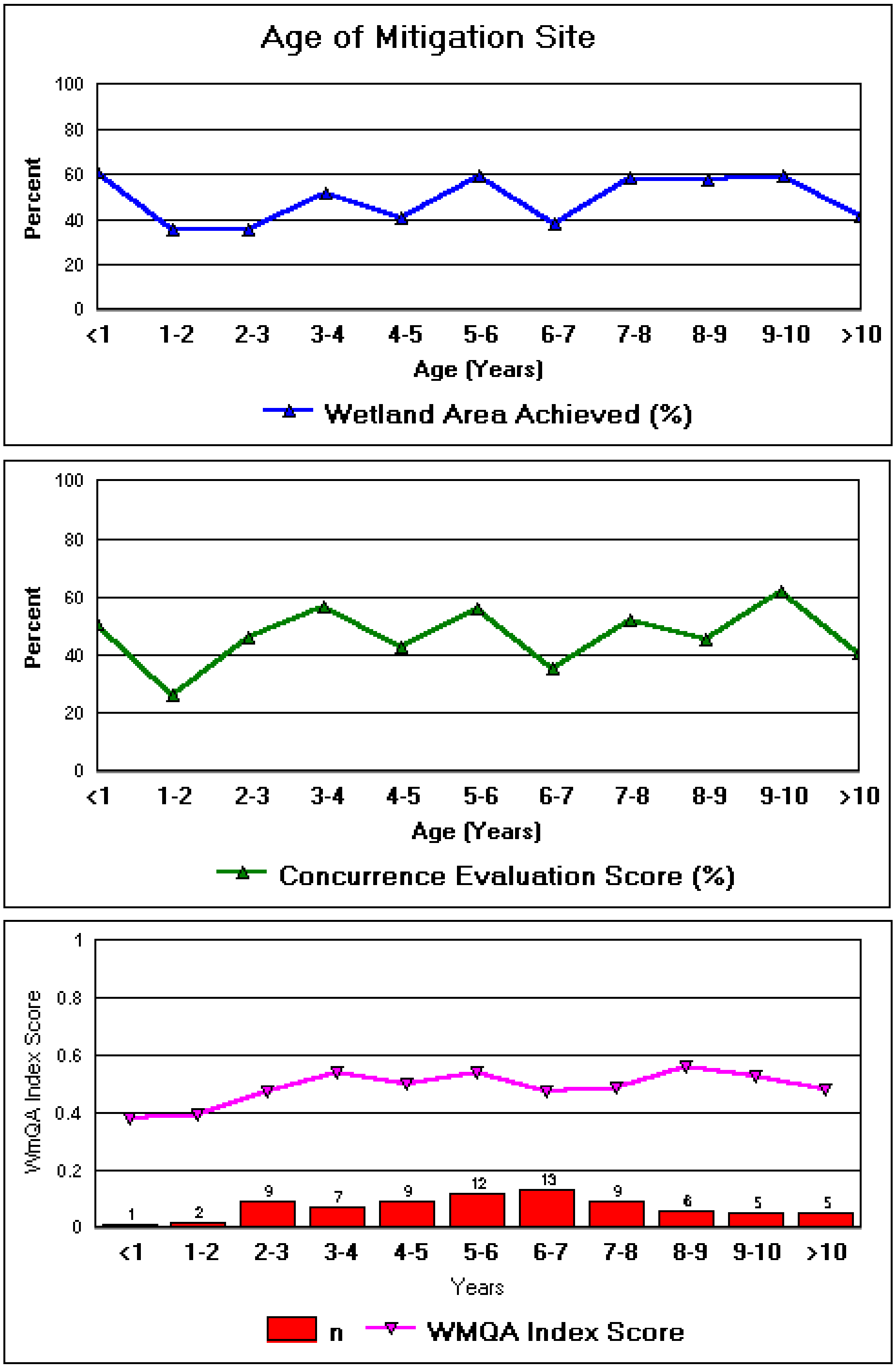
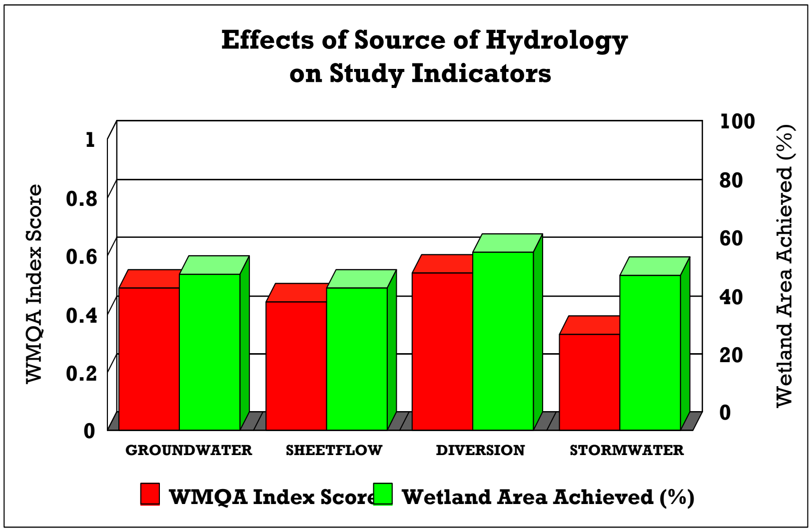


Figure 11: Distribution of Study Indicators by Age of Site



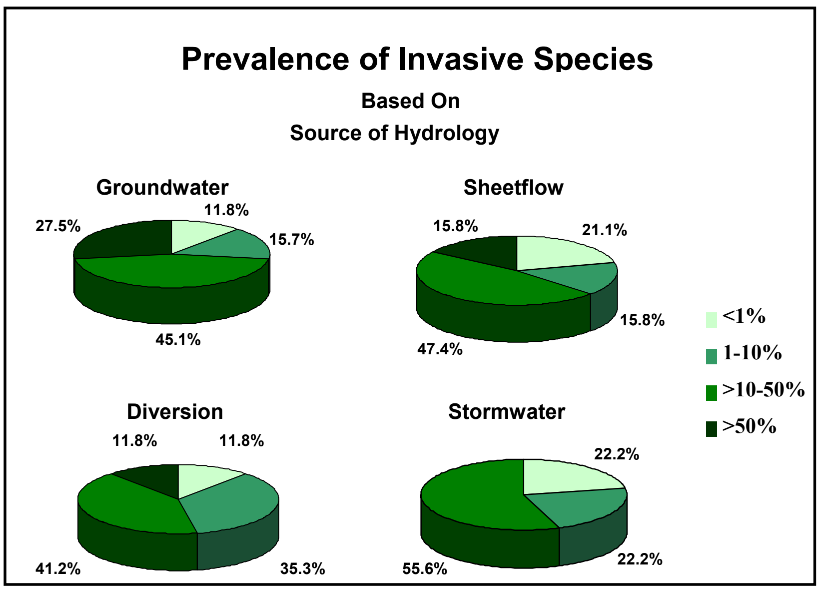


Figure 12: Effects of Hydrology on Study Indicators (top chart) and Effect of Source of Hydrology on Prevalence of Invasive Species (bottom chart)

The data suggest that source of hydrology does have a bearing on the attainment of study goals. We found that although Wetland Area Achieved remained relatively constant among sources of hydrology, stream diversion resulted in the highest average score of 61%, well above the mean value of 45% when all sites are combined. In terms of WMQA Index Score, stormwater-driven wetlands scored substantially lower than wetlands with other sources of hydrology. Stormwater-driven mitigation wetlands were also found to be more likely to have in excess of 50% cover of nuisance and invasive vegetation than mitigation wetlands driven by other sources of hydrology. This suggests that stream diversion as a source of hydrology is more likely to result in improvements to wetland mitigation quantity, and stormwater results in detriments to the quality of the wetlands achieved.

6. CONCLUSIONS AND RECOMMENDATIONS

The evaluation of 90 select freshwater wetland mitigation sites around the State of New Jersey indicates that between 1988 and 1999 wetland mitigation practices have not been effective in meeting NJDEP's NEPPS goals for increasing wetland quantity and quality in New Jersey. Less than one out of every two acres of proposed mitigation resulted in achieving a freshwater wetland. These findings are generally consistent with a study conducted by the National Research Council (NRC 2001). Mitigation projects most likely to be successful in terms of quantity of wetlands achieved were emergent and open water wetland creation and restoration projects that rely on stream diversion as the major source of hydrology. The mitigation sites included in this study were selected, in part, based upon the quality and availability of mitigation plans and specifications. It is reasonable to assume, therefore, that if an evaluation of all remaining mitigation sites (that had been approved prior to NJDEP's more recent implementation of performance-based mitigation plans) were conducted, the findings would result in a further reduction of indicator scores. However, it should be noted that some high quality wetlands of all proposed mitigation types were observed during the course of this study. For example, see Photo 3 (forested and scrub/shrub communities), Photo 4 (emergent community), and Photo 5 (State open water and emergent communities). These successful projects provide evidence that high quality wetland creation is possible given the level of knowledge currently available.

Presented below are conclusions and recommendations of this study regarding planning and design; implementation, oversight, and training; data management; tracking and research; and avoiding and minimizing impacts to wetland resources. In general, many of these findings are comparable to those presented in the National Research Council's national study mentioned above.

Planning and Design

One of the major difficulties encountered during this study involved the lack of clearly defined mitigation plans and specifications that could be readily and consistently measured. This issue

Mitigation Site ID = **130**

Wetland Achieved = **126.39%**
Concurrence Score = **76.18**
WMQA Index = **0.74**

Size (acres) = **0.72**

Wetland Type (acres)

Compensation Ratio (x:1)

Proposed	Achieved
1.00	1.26

Photo 3: Created Wetland Trending Toward Forested Community

Although forested wetlands are difficult to create, a reliable source of hydrology and good soil conditions were the most common factors among successful mitigation sites.

Mitigation Site ID = **105**

Wetland Achieved = **91.30%**
Concurrence Score = **96.32**
WMQA Index = 0.56

Size (acres) = **0.92**

Wetland Type (acres)

	Impacted	Proposed	Achieved
Forest			
Shrub			
Emergent	0.92	0.92	0.84
Open Water			

Compensation Ratio (x:1)

Proposed	Achieved
1.00	0.91

Photo 4: Created Emergent Wetland

Emergent wetlands generally achieved the highest Wetland Achieved and Concurrence scores.

Mitigation Site ID = **059**

Wetland Achieved = **100.82%**
Concurrence Score = **65.85**
WMQA Index = **0.56**

Size (acres) = **12.2**

Wetland Type (acres)

	Impacted	Proposed	Achieved
Forest			
Shrub			
mergent		9.20	0.62
Open Water		3.00	11.69

Compensation Ratio (x:1)

Proposed	Achieved
1.00	1.01

Photo 5: Created Wetland Containing Predominantly Open Water

This created wetland is comprised of mostly open water with an emergent wetland fringe.

may have been addressed in the recently adopted revisions to New Jersey's Freshwater Wetland Protection Act Rules that specifically outline the requirements to submit a wetland mitigation proposal. These efforts should continue, and the standard application guidance should be linked to standardized success criteria and monitoring report requirements that should be applied consistently where possible.

Mitigation was not always conducted in suitable locations. Mitigation was also often divided into very small parcels of wetland creation. These small, isolated mitigation areas often did not become wetlands as planned, or, if wetlands were created, they were of low quality. Mitigation should always be located in an area that has a reliable, predictable hydrologic source. A hydrologic or water budget that includes a demonstration that the identified hydrologic source is reliable and adequate should be a requirement for all mitigation proposals. Inadequate hydrology was a major contributing factor to low Wetland Area Achieved indicator scores (see Photo 6).

All mitigation plans should include provisions for regular inspections, maintenance, and, if needed, mid-course corrections. For example, grading may have to be corrected to accommodate field conditions and the wetland may require regular maintenance after the implementation phase to control invasive vegetation. Performance standards implemented through a series of site inspections and standardized monitoring requirements are needed to ensure that corrective action, if needed, can and will be implemented.

Mitigation plans and monitoring report requirements should include a statement of the mitigation goals in each report, including wetland acreage and type, and should clearly indicate to what extent these goals can or have been met. Very few monitoring reports reviewed for this study contained such information. Consistent application of these requirements would facilitate compliance efforts and would greatly increase NJDEP's ability to measure the success of such efforts in achievement of programmatic and/or NEPPS goals. The setting of clear, realistic goals prior to the implementation of a mitigation project may also increase chances of success (Ehrenfeld, 2000; Keddy, 1999).

Mitigation Site ID = **051**

Wetland Achieved = **0.00%**
Concurrence Score = **65.83**
WMQA Index = **n/a**

Size (acres) = **13.01**

Wetland Type (acres)

	Impacted	Proposed	Achieved
Forest	2.84	10.61	
Shrub	2.93	1.20	
Emergent	2.77	1.20	
Open Water			

Compensation Ratio (x:1)

Proposed	Achieved
1.52	0.00

Photo 6: Proposed Creation Site with Inadequate Hydrology to Support a Wetland

Although this mitigation site was generally consistent with approved plans in terms of design, the site failed to achieve wetlands due to inadequate hydrology. Inadequate hydrology was a major contributing factor to low Wetland Achieved scores.

Given the low level forested wetland creation success, NJDEP should focus special attention on the mitigation plan review and follow-up work required for this mitigation type. It appears that the low level of forested wetland creation was due at least in part to lack of sufficiently detailed hydrologic and planting specifications in mitigation plans, the failure of contractors to plant trees in accordance with specifications, and high mortality of trees due to herbivory and/or poor stock. In general, higher standards of performance should be applied to forested wetland creation projects.

Mitigation wetlands that were stormwater-driven scored relatively low in terms of wetland quality and had relatively high levels of nuisance and invasive plant species. NJDEP should continue to discourage stormwater as a source of water for mitigation wetlands.

Only 47.5% of approved mitigation area was constructed in accordance with NJDEP approvals. Although this score represents a qualitative assessment, ongoing efforts to refine and apply standardized design requirements will only be beneficial if coupled with compliance monitoring and regulatory oversight.

Given the low level of success found during this study, it is clear that NJDEP should continue to require and strengthen financial assurance for mitigation projects. The financial assurance should be in an amount sufficient for the NJDEP to hire an independent contractor to complete and maintain the mitigation project should the mitigator default.

Lastly, in light of the general findings of this study, and in particular the failure of the majority of proposed forested wetland creation sites, the Department may want to consider an increase in the regulatory mitigation ratio for specific types of wetlands, especially forested wetlands, to reach programmatic and NEPPS goals.

Implementation, Oversight and Training

Many of the problems encountered in successful mitigation implementation could be corrected with increased follow-up conducted early in the implementation phase of the mitigation project. During the course of this study, we found that the most ecologically successful sites were generally those that had received follow-up work in the form of maintenance, replanting, or improvements to grading or water control structures in accordance with recommendations made by NJDEP and other regulatory agencies after initial compliance inspections revealed problems. These observations are consistent with mitigation studies in other states (e.g. Redmond, 1992). An increase in compliance inspections, possibly coupled with increased construction oversight by experienced wetland ecologists would likely increase all indicators evaluated in this study. At a minimum, NJDEP should consider conducting two site inspections during construction of each mitigation site including immediately after initial grading, and again after planting is implemented.

NJDEP should develop requirements for increased oversight of mitigation construction by qualified wetland ecologists. It was found during field inspections that even for sites that were well-planned and included clear construction and planting specifications, mitigation often was not in compliance with permit requirements and did not achieve the amount or type of wetlands required. Field oversight during implementation could increase compliance with mitigation plans and result in substantial increases in mitigation success. Requiring the applicant to retain a trained and experienced wetland ecologist as an environmental supervisor for mitigation projects could provide the necessary oversight while reducing the burden on NJDEP staff resources.

As standardized design and monitoring requirements are developed, increased technical support and training should be provided to the Land Use Regulation staff. This will increase the likelihood that improved standards for mitigation plans and documents will lead to successful mitigation and effective enforcement.

Data Management, Tracking and Research

An integral part of any effort to implement successful compliance efforts is the continued implementation of an up-to-date, well-maintained system for tracking, filing, and retaining monitoring reports and other administrative documents. Effective compliance/enforcement is not possible without such records of what is required for each plan, including records of the dates monitoring reports are due, results of past field visits, etc. During the course of this study we found that in many cases, mitigation files contained little or no monitoring or reporting information. NJDEP should consider posting tracking forms and other relevant information regarding mitigation sites on the Internet. Public input may assist in on-going monitoring efforts.

Continued research efforts should be encouraged by NJDEP. Wetland mitigation, especially for freshwater systems, is still a relatively new field in which many basic assumptions have not been rigorously tested over time (Simenstad and Thom, 1996). However, ongoing research is being conducted within the State of New Jersey and nationwide to provide information regarding our basic assumptions regarding the organization and function of wetland systems. This information should be made available to Land Use Regulation staff on a regular basis so that permitting decisions can be made with up-to-date information. Monitoring data could be made available to key decision makers using the GIS capabilities of this study. Ample flexibility should be provided within rules and policy to integrate new information as it becomes available.

In order to measure the effectiveness of any changes in the mitigation program, NJDEP should continue to collect indicator data regarding implementation of the mitigation program. Requirements could be included in approved mitigation plans for the permittee to be responsible for the collection of information compatible with that collected for this study. This would facilitate continued input of information to the database and tracking of results of the mitigation program. The database and GIS integration developed for this study provide a template for addition of further information. Continued tracking of the indicators for more recently approved and implemented projects is essential to gauge the effectiveness of changes in mitigation plan review and approval procedures that are currently being implemented by NJDEP's Land Use Regulation Program.

Minimizing Impacts to Wetland Resources

Given the low levels of compliance and success of mitigation sites included in this study, the primary focus of the NJDEP Land Use Regulation Program should continue to be on avoiding or minimizing impacts to wetlands. This can be accomplished through the permit review process including a rigorous review of alternatives in an effort to reduce the amount of permitted wetland losses.

Although standardization, consistency and accountability are important, the ecological systems that are being impacted by development and the steps needed to mitigate for these impacts are sufficiently complicated. Existing wetland mitigation engineering and science currently falls short of adequately replacing comparable wetland area or ecological value.

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Creating Indicators of Wetland Status (Quantity and Quality):
Freshwater Wetland Mitigation in New Jersey

APPENDIX

A

Mitigation Study Site Summary Table

Wetland Mitigation Study Site Information Worksheet

ASGECI Project #1706, October 3, 2001

Mitsite #	WMA	Age (in years)	Total Proposed (in acres)	Mitigation Goals			Mitigation Type				Wetland Area Evaluated	Wetland Area Achieved	Percent Area Achieved	Concurrence Evaluation Indicator Score	Wetland Mitigation Quality Assessment Index Score
				Creation	Restoration	Enhancement	PFO	PSS	PEM	SOW					
002	15	4.34	0.50	0.50			0.50				0.50	0.09	18.00	40.32	0.56
004	05	7.90	2.60		2.60		2.60				0.05	0.05	100.00	28.62	0.44
006	20	4.17	0.10	0.10			0.10				0.10	0.00	0.00	50.00	0.00
007	20	3.76	5.04	5.04			5.04				5.04	1.86	36.90	46.32	0.69
008	19	5.92	1.86		1.86		0.86		1.00		1.86	0.11	5.91	29.53	0.46
009a	18	6.48	0.29	0.00	0.00	0.29			0.29		0.29	0.07	24.14	17.97	0.31
009b	18	6.48	0.56	0.00	0.56	0.00			0.56					18.17	0.29
009c	18	6.48	0.12	0.12	0.00	0.00			0.12		0.12	0.00	0.00	0.00	0.00
010	14	2.36	1.50	1.50					1.50		1.50	0.12	8.00	65.02	0.49
011	20	5.92	1.01		1.01				1.01		1.01	0.37	36.63	27.58	0.30
013	15	7.87	0.17	0.17			0.17				0.17	0.04	23.53	31.15	0.39
017	18	4.07	1.20	1.20			1.20				1.20	1.19	99.17	51.52	0.45
018	17	7.23	12.10	12.10			10.60		0.50	1.00	12.10	4.21	34.79	63.99	0.79
020	18	3.53	1.42	1.42					1.42		1.42	0.56	39.44	38.47	0.33
022	18	7.79	4.14	4.14			3.42		0.72		4.14	2.22	53.62	24.13	0.49
024	18	4.22	8.13		8.13		7.72		0.41		4.50	2.06	45.78	45.67	0.48
025	18	5.06	2.30		2.30			2.33			2.30	1.04	45.22	66.35	0.53
027	18	2.34	1.03	1.03			1.03				1.03	0.39	37.86	33.13	0.31
028	18	1.23	1.96	1.96				0.39	0.50	1.07	1.96	1.22	62.24	45.33	0.42
031	08	5.75	1.50	1.50				1.50			1.50	0.50	33.33	35.67	0.60
033	11	7.59	0.37		0.37		0.17			0.20	0.37	0.00	0.00	100.00	0.00
034	11	0.00	1.90	0.90	0.20	0.80		0.90	0.20	0.80	1.90	0.65	34.21	71.36	0.58
035a	11	6.99	0.70	0.70			0.70				0.70	0.17	24.29	36.24	0.57
035b	11	6.99	3.90	3.90			3.90				3.90	0.67	17.18	8.53	0.46
037	11	3.01	1.73	1.73					1.73		1.73	1.21	69.94	71.96	0.53
038	11	9.35	0.60	0.60				0.60			0.60	0.31	51.67	60.55	0.31
039a	11	6.45	0.66	0.66			0.66				0.66	0.00	0.00	13.36	0.00
039b	11	6.45	1.10	1.10			0.50	0.20	0.40		1.13	0.73	64.60	86.28	0.68
039c	11	6.45	2.67	2.67			1.51	0.46	0.70		2.67	0.90	33.73	48.76	0.50
040	11	2.70	3.31	3.31			1.74	0.54	0.84	0.19	3.31	1.49	45.02	60.30	0.47
042	10	2.14	2.20	2.20			2.20				2.20	0.00	0.00	3.80	0.00
046	09	6.37	0.24		0.24		0.24				0.24	0.09	37.50	48.99	0.29
050a	10	4.27	4.25	4.25			1.64	0.76	1.55	0.30	4.25	3.36	79.06	44.70	0.42
050b	10	4.27	11.15	11.15			4.93	3.23	2.99		11.15	6.03	54.08	34.37	0.33
051	09	0.00	13.01	13.01			10.61	1.20	1.20		13.01	0.00	0.00	65.83	0.00
053	09	0.00	0.36		0.36			0.36						73.01	0.56
055	09	7.71	14.38	14.38							14.38	5.65	39.29	36.45	0.53
056	09	0.00	1.80	1.80			1.00			0.80	1.80	0.93	51.67	65.60	0.56
059	07	7.55	12.20	12.20					9.20	3.00	12.20	12.30	100.82	65.85	0.56
061	12	0.00	0.50	0.50			0.50				0.50	0.02	4.00	35.69	0.32
064	09	0.00	0.38	0.38			0.38				0.38	0.00	0.00	11.10	0.00
066	20	5.95	0.08	0.08			0.04	0.04						77.88	0.83
068	08	5.47	1.88	1.88			0.33	0.37	1.18		1.88	1.10	58.51	60.83	0.69
070	06	4.83	0.16	0.16			0.16				0.16	0.00	0.00	23.60	0.00
073	06	9.24	1.50	1.50			1.50				1.50	0.93	62.00	76.39	0.52
074a	06	10.26	0.41	0.41					0.41		0.41	0.14	34.15	57.05	0.48
074b	06	10.26	0.20	0.20			0.20				0.20	0.00	0.00	4.65	0.00
077	06	0.00	1.02	1.02				0.49	0.53		0.49	0.32	65.31	NA	0.75
078a	03	5.70	0.24	0.24			0.24				0.24	0.22	91.67	78.36	0.33
078b	03	5.70	0.37	0.37					0.37		0.37	0.35	94.59	52.14	0.33
079	08	9.26	0.30		0.30		0.15	0.15			0.51	0.22	43.14	44.06	0.48
082	13	3.45	1.29		1.29					1.29	1.29	0.93	72.09	92.17	0.60
083	13	6.71	0.46	0.46			0.46				0.46	0.25	54.35	61.94	0.61
084	13	3.24	0.87	0.47		0.40	0.87				0.87	0.00	0.00	5.06	0.00

Wetland Mitigation Study Site Information Worksheet

ASGECI Project #1706, October 3, 2001

Mitsite #	WMA	Age (in years)	Total Proposed (in acres)	Mitigation Goals			Mitigation Type				Wetland Area Evaluated	Wetland Area Achieved	Percent Area Achieved	Concurrence Evaluation Indicator Score	Wetland Mitigation Quality Assessment Index Score
				Creation	Restoration	Enhancement	PFO	PSS	PEM	SOW					
085a	13	9.34	2.00	2.00				2.00			2.00	1.89	94.50	65.23	0.73
085b	13	8.34	0.45	0.45				0.45			0.45	0.00	0.00	1.00	0.00
086	13	5.28	0.86	0.86			0.68		0.18		0.86	0.51	59.30	60.81	0.64
089a	03	5.44	41.20	41.20					29.90	11.30	41.20	51.51	125.02	50.00	0.62
089c	03	12.44	10.00	10.00					10.00		10.00	9.54	95.40	71.56	0.46
093	06	9.50	1.46	1.46			1.46				1.46	0.67	45.89	62.67	0.58
096	09	5.60	4.46		4.46				1.90	2.56	4.46	1.95	43.72	60.11	0.67
097	10	0.00	2.93	2.42	0.51		2.93				2.06	0.00	0.00	28.88	0.00
098	09	3.46	1.19		1.19		0.63		0.56					43.96	0.53
100	09	5.91	0.80	0.80					0.80		0.80	0.46	57.50	69.08	0.47
102a	09	7.63	6.62		6.62				6.62					NA	0.25
102b	09	0.00	6.39	6.39							6.39	0.00	0.00	35.04	0.00
104	09	0.00	0.52		0.52			0.52			0.52	0.19	36.54	85.74	0.56
105	02	3.62	0.92	0.92					0.92		0.92	0.84	91.30	96.32	0.56
107	03	8.55	0.36	0.36			0.36				0.36	0.13	36.11	48.75	0.52
108	02	4.39	13.70	13.70					13.70		5.20	3.66	70.38	92.23	0.76
111	20	2.10	6.50	6.50				1.90	4.60		6.50	4.57	70.31	55.28	0.68
112	17	0.00	0.75	0.75			0.12	0.02	0.35	0.26	0.75	0.61	81.33	76.57	0.69
113	13	1.86	0.84	0.84			0.84				0.84	0.07	8.33	7.52	0.36
116	09	8.55	3.00	3.00			3.00				3.00	1.48	49.33	32.66	0.35
118	12	0.83	24.52	24.52			24.52				24.52	15.07	61.46	50.45	0.38
119	10	2.57	25.50	25.50			25.50				25.50	16.15	63.33	35.82	0.35
121	06	4.08	0.28		0.28		0.14	0.01	0.13		0.28	0.00	0.00	5.00	0.00
123	10	8.07	13.20	13.20				2.90	6.57	3.73	13.20	11.09	84.02	37.84	0.41
125	11	11.02	9.60	9.60			0.60				9.60	6.69	69.69	44.91	0.56
126	15	8.17	1.50		1.50		1.50				1.50	0.75	50.00	76.16	0.79
127	06	2.61	4.10	1.41		2.69	3.90			0.20	1.41	0.87	61.70	63.13	0.53
128a	03	6.66	0.64	0.00		0.64	0.00	0.64			0.64	0.40	62.50	38.48	0.42
128b	03	6.66	0.25	0.25		0.00	0.25	0.00			0.25	0.00	0.00	0.00	0.00
129	12	2.46	0.20	0.20			0.20				0.20	0.02	10.00	48.99	0.36
130	08	8.80	0.72	0.72			0.51		0.21		0.72	0.91	126.39	76.18	0.74
131	09	6.38	0.55	0.11		0.44	0.55				0.55	0.77	140.00	77.89	0.60
132	11	7.61	1.72	0.33		1.39					0.33	0.39	118.18	67.99	0.46
133	06	0.00	1.10	1.10			1.10				1.10	0.00	0.00	4.58	0.00
134	18	2.39	2.30	2.30			2.30				2.30	0.60	26.09	50.15	0.59
135	18	10.24	0.75	0.75			0.75				0.75	0.05	6.67	24.71	0.42
SUM		-	325.60	284.65	34.30	6.65	139.71	21.96	105.77	26.69	296.87	186.91	-	4181.49	37.68
AVG		5.13	3.62	3.85	1.63	0.67	2.45	0.88	2.78	1.91	3.49	2.20	45.09	47.52	0.42
MEDIAN		5.65	1.24	1.10	0.56	0.42	0.75	0.52	0.82	0.90	1.20	0.50	43.72	48.87	0.47
SD		3.12	6.31	6.88	2.20	0.83	4.90	0.92	5.48	2.93	6.37	6.28	35.23	24.87	0.23
MIN		0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.12	0.19	0.05	0.00	0.00	0.00	0.00
MAX		12.44	41.20	41.20	8.13	2.69	25.50	3.23	29.90	11.30	41.20	51.51	140.00	100.00	0.83

APPENDIX

B

Standardized Data Summary and Field Data Sheets

MAIN MENU
NJDEP Wetland Mitigation Monitoring
Database Application

Plan/File Review- (before site visit)

- [ ] **File Evaluation Checklist**

Site Assessment

- [ ] **Wetland Area Determinations**
- [ ] **Wetland Mitigation Quality Assessment (WMQA)**
- [ ] **Concurrence Evaluation**
- [ ] **Observation Point Data**
- [ ] **Photographs**

File Evaluation Checklist - pg. 1 of 2

Mitsite# | Municipal_code | Yr | Sequence_number | Study Site?

Date MIT Site Const. Complete

Age in Years: 0.0

Permitted/Responsible

Mit. Consultant/Contact | Firm_Name

MIT Site Name | MIT Site Municode | MIT County

MIT Site Block | MIT Site Lot | MIT Drainage Basin Code | WMA | MITSite Wetclass | Acres Mit. in Permit

MIT Site Waterway | MIT Site Quad Map

PROPOSED ACREAGE TOT. MITIGATION PROPOSED | TOTAL AREA EVALUATED

PFO | PSS | PEM | SOW | TDW | ISS | Type Not Specified | Total Mitigation Goals: 0

MIT Goals Create | MIT Goals Restore | MIT Goals Enhance | MIT Goals Other | Total Mitigation Goals: 0

FILE CHECKLIST:

Refer to Other Mitsite #: | Area Specified? | Goals Specified? | Type Specified? | # of Mitig. Areas

Preimpact Veg Provided? | Quad Map Provided? | Mit Site Plan Provided? | Grading Plan Provided?

Topsoil Specified? | Hydrologic Source Specified? | Plant List Provided? | Planting Specs Provided?

Linear Site? | Landscape Plan Provided? | Seed Mix Specifications Provided?

Site Location/Boundary Findable?

NOTES:

File Evaluation Checklist - pg. 2 of 2

Plants/Seed Mix Specifications for Mitigation Site #

Municipal_code Yr Sequence_number

Name	Common Name	Scientific Name	Indicator R	Layer	# or %

Wetland Area Determination

Mitsite#	Municipal_code	Yr	Sequence#	DATE	OBSERVER

LINE	AREA (sf)	ACRES	ISLAND	X	Y

Total Acres Achieved	Total Acres Evaluated	% Area Achieved
		0.00

	Type Achieved %	Type Achieved (ac.)	Proposed (ac.)	Achieved %
PFO		0.00		NA
PSS		0.00		NA
PEM		0.00		NA
SOW		0.00		NA

Type Not Specified	Total Target Achieved
	NA

Wetland Mitigation Quality Assessment

Mitsite# | Municipal_code | Yr | Sequence_number | Permitted/Responsible | OBSERVER | DATE

HYDROLOGY

Hydrology | Undesirable Plant Colonization? | Plant Stress? | Plant Mortality?

Surface Inundation? | Channelization? | Redoximorphic Features? | Hydric Soils?

Hydrology Score

SOILS

Topsoil Depth | Erosion | Compaction | Debris

Soil Score

VEGETATION COMPOSITION/DIVERSITY

Overstory

Plant Cover | Invasive Species | Natural Recruitment | Plant Growth | Insects & Herbivory | Plant Stress | Diversity

Veg. Overstory Score

Ground Cover

Plant Cover | Invasive Species | Natural Recruitment | Plant Growth | Insects & Herbivory | Plant Stress | Diversity

Veg. Ground Cover Score

Vegetation Score NA

WILDLIFESUITABILITY

Cover | Adjacent Resources | Human Impediments | Nest/Breeding Activity

Wildlife Score

SITE CHARACTERISTICS

Maintenance | Edge: Area Ratio | Heterogeneity | Location

Size

Site Score

LANDSCAPE CHARACTERISTICS

Adjacent Buffer Width | Invasive Species | Wildlife Suitability | Cover | Slope | Buffer Score

Contiguity Contiguity Score

Land Use Land Use Score

Landscape Score NA

WETLAND QUALITY ASSESSMENT SCORE

Raw Scores		Weighted Factor	Weighted Scores
Hydrology Score		NA	NA
Soil Score		NA	NA
WQAVegTotal	NA	NA	NA
Wildlife Score		NA	NA
Site Score		NA	NA
WQALandTotal	NA	NA	NA

Total WQA Score 0.00

Sum of Factors 0.00

WQA Index Score NA

Concurrence Evaluation - pg. 1 of 2

Mitsite# | Municipal_code | Yr | Sequence_number | Permitted/Responsible | MIT Site Const. Completed | DATE

OBSERVER | Mitsite Boundary Discernable

GRADING

Grading Plan Adequate? | % Site Graded | % Grading Conducive to Goals | Is Regrading Recommended?

% Grading Concurrence

HYDROLOGY

Specified Hydrologic Source #1 | Specified Hydrologic Source #2

Dominant Source Hydrology = Diversion | Dominant Source Hydrology = Groundwater | Dominant Source Hydrology = Sheetflow

Dominant Source Hydrology = Stream Diversion | Dominant Source Hydrology = Stormwater | Stormwater Outfalls Evident?

Monitoring Device Approved? | Monitoring Device Installed? | Is Drainage Provided? | Is Drainage Functional?

Water Control Structure Approved? | Water Control Structure Installed? | Water Control Structure Functioning?

% Hydrology Conducive to Goals | % Wetland Hydrology Acheived | % Site Impounded | Is Impoundment Detrimental?

% Hydrology Concurrence

SOILS

Topsoil Specified? | Topsoil Provided? | Acid Soil Specified? | Soil Stabilized in Accordance w/Plan? | % Soil Conducive to Hydrophytes

% Soil Conducive to Goal | Is Topsoil Placement Recommended?

% Soil Concurrence

VEGETATION

% Site Vegetated | % Site Dominated by Hydrophytes | Adequate Planting Specifications?

Site >85% Hydrophytes? | Site >10% Invasive? | % PFO | % PSS | % PEM | % SOW

% Vegetation Consistant w/Goals | Is Replanting Recommended?

Are Trees Specified in Plan? | % Survival Trees | Are Shrubs Specified in Plan? | % Survival Shrubs

Are Herbaceous Plants Specified in Plan? | % Survival Herbaceous | Is a Seed Mix Specified in Plan? | % Cover of Persistant Grasses

Wetland Overstory Present?

% Concurrence Vegetation Cover

% Concurrance Veg Survival

Concurrence Evaluation - pg. 2 of 2

Mitsite#	Municipal_code	Yr	Sequence_number	Permitted/Responsible	MIT Site Const. Completed

DESIGN CHARACTERISTICS

Maintenance Specified in Plan?

Maintenance Required?

Maintenance Access Provided?

Inflow/Outflow Specified?

Inflow/Outflow Provided?

Wetland Type Specified in Plan?

Wetland Type Consistant w/Goals?

Transition Area Specified in Plan?

Transition Area Consistant w/Goals?

Planting Specifications for TA Provided?

% 50 Ft. Transition Area Forested

% 50 Ft. Transition Area Scrub/Shrub

% 50 Ft. Transition Area Herbaceous

Shape/Location of Wetland Specified in Plan?

Shape/Location of Wetland Consistant w/Plan?

Evidence of Human Disturbance?

Was Design Based on Hydrology?

% of Design Conducive to Goals

% Design Concurrence

OVERALL CONCURRENCE SCORE

Raw Scores	Weighting Factor	Weighted Scores
% Grading Concurrence	4.1	0
% Hydrology Concurrence	4.7	0
% Soil Concurrence	3.5	0
% Concurrence Vegetation Cover	2.9	0
% Concurrence Veg Survival	2.3	0
% Design Concurrence	4.2	0

Sum of Weighting Factors	Sum of Weighted Scores	Overall Concurrence Score
21.7	0	0.00

Observation Point Data

Municipal_code	Yr	Sequence_number	Mitsite#	Date	Observer

Type	Satur?	DepthSat	DepthWat	Ponding?	WetHyd	Soilmin	Soilmax	Matrix	Redox	Gleyed?	Motdep	Mot1Chr	Mot2Chr	Hydric?

Photographs

Municipal_code	Yr	Sequence_number	Mitsite#	Date	Observer

Scroll Down for More Photographs of this Mitigation Site

Photo_ID	Direction_	Northing	Easting

Creating Indicators of Wetland Status (Quantity and Quality):
Freshwater Wetland Mitigation in New Jersey

APPENDIX

C

Wetland Mitigation Quality Assessment (WMQA)
Procedure Manual

DEVELOPING AN INDICATOR OF WETLAND STATUS

FRESHWATER WETLAND MITIGATION QUALITY ASSESSMENT PROCEDURE

April 20, 2000

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DEVELOPING AN INDICATOR OF WETLAND STATUS

FRESHWATER WETLAND MITIGATION QUALITY ASSESSMENT PROCEDURE

Table of Contents

I. Introduction

As an active participant in the National Environmental Performance Partnership System (NEPPS), the New Jersey Department of Environmental Protection (NJDEP) has established the following goal for New Jersey wetlands:

"Improve quality and function and achieve no net loss.
Explore innovative techniques for creation, enhancement
and maintenance of New Jersey wetlands"

NJDEP is developing an indicator of wetland mitigation status to evaluate current conditions of mitigation sites in relation to the NEPPS wetlands goals. The indicators of wetland mitigation status include: 1) the extent to which mitigation conforms with approved plans, 2) the amount of wetland achieved through mitigation, and 3) the probability that the mitigation will function as a natural wetland system. It is this third mitigation indicator that is addressed through the Freshwater Wetland Mitigation Quality Assessment Procedure.

The Freshwater Wetland Mitigation Quality Assessment Procedure was developed as an interim assessment tool to evaluate the relative probability that a constructed freshwater wetland will develop into a natural wetland system over time. This standardized rating index can be used in combination with professional judgment to provide a consistent measure of relative mitigation success. It is probable that a constructed wetland that receives a high rating index will have a greater potential to function as a natural system over time. Therefore, this method is intended to accomplish a number of objectives: 1) establish a simple, consistent and timely assessment tool based on readily observable field indicators; 2) be applicable to a wide range of wetland community types and field conditions; and 3) offer consistency and guidance in evaluating the NEPPS goal of no net loss of wetland function and value. It is similar to the Wetland Rapid Assessment Procedure developed by the South Florida Water Management District (Miller and Gunsalus, 1997).

The science of evaluating wetland quality and function, especially in relation to constructed wetland mitigation projects, is evolving. Establishment of predictive wetland mitigation quality indicators would require a prospective study over many years to determine what factors in the early years of a created or restored wetland are most predictive of its future success. Therefore, this procedure does not allow for direct measurement of wetland functions and it is not intended to provide a numerical value that can be used to establish absolute quality of an individual wetland mitigation project or be a surrogate for more quantitative procedures that may be used to evaluate mitigation success. At the current time, this procedure is not intended for regulatory evaluation and does not replace performance criteria that NJDEP may use to determine mitigation success. Instead, this method provides NJDEP with some relative indicators of constructed mitigation site potential. NJDEP is currently conducting research in collaboration with Rutgers University scientists to review wetlands quality assessment methods and test these at NJ reference wetlands. Future plans include testing this rapid mitigation site quality assessment tool at these NJ reference wetlands, as well.

The assessment of the mitigation site requires both office and field preparation. Office preparation includes a review of pertinent data including maps, plans and specifications. Field preparation includes a determination of the extent of wetlands following the *1989 Federal Manual for Identifying and Delineating Jurisdictional Wetlands*. This assessment procedure is only applied within jurisdictional wetlands.

The procedure provides a method to describe variables and assign a relative value on a scale from 0 to 3 for each variable being evaluated. The procedure relies on observation of field indicators and use of best professional judgement to identify the relative value that best describes the variable being measured. The variables include the following:

- A. Hydrology
- B. Soils
- C. Vegetation Composition/Diversity
- D. Wildlife Suitability
- E. Site Characteristics
- F. Landscape Characteristics

The value for both the Vegetation Composition/Diversity Variable and the Landscape Variable are further sub-divided. The value of each variable is calculated as an average of applicable sub-categories. A sub-category that is not applicable to the wetland being evaluated (i.e. Vegetation Composition/Diversity – Overstory) is assigned a score of NA. Sub-categories include:

- C. Vegetation Composition/Diversity
  - C.1 Overstory Layer
  - C.2 Ground Cover

- F. Landscape Characteristics
  - F.1 Adjacent Buffer
  - F.2 Contiguity
  - F.3 Land Use

This procedure anticipates that the reviewers are experienced in wetland identification, delineation, and mitigation construction techniques. It also anticipates that a team of two (2) wetland scientists will collaborate to assign a relative value.

For each variable, a range of field indicators is provided that can be used by the reviewers to assign a relative value for each variable. These field indicators are included to provide general guidance for the reviewers. It is anticipated that all field indicators provided will not fit all mitigation sites. Therefore, the reviewers should assign the value for each variable (from 0-3) based on the "best fit" for a particular site. Not all field indicators need to be met in order for a site to obtain a given score. If the reviewers observe additional field indicator(s) that are not listed, they can use these indicators to assign a value in addition to those indicators listed. In this case, it is important to document these additional indicators in the field notes. There is no significance assigned to the order in which the field indicators are listed. The reviewers should assign weight to those field indicators that are most characteristic of the wetland being evaluated based on field observations. The weight assigned to each field indicator may vary from site to site based on the best professional judgment of the reviewers. The reviewers should record the basis for their determination by identifying the field indicators used to make their determination. The reviewers should also record other field observations that may have influenced their determination.

For example, if the reviewers are assigning a value for hydrology on a mitigation site, they may observe field indicators such as abundant target hydrophytes that exhibit no signs of stress, no evidence of mortality of these target hydrophytes, no evidence of colonization by upland or transition species, abundant evidence of surface inundation such as hummocks, ponding, etc., and no evidence of erosion or other channelization of water flow. However, if it is a recently established site, redoximorphic features and hydric soil development may not be observed. In this case, the site would be assigned a score of 3 if the reviewers felt the site had the potential to develop other field indicators over time.

A value (V) of 3 is used if the characteristic is thought to have the greatest probability of simulating a natural wetland system over time. A value of 0 indicates that the wetland variable is severely impaired or non-existent. The evaluator has the option to assign a value for each variable in half (0.5) increments. This allows flexibility to score a variable that is not accurately described or fitted to the field indicators provided for each variable. The recorded value for each variable can be used to determine why a particular final score was attained. For example, were most sites affected by design characteristics, inadequate hydrology, etc.?

The final rating index score is expressed as a number between 0 and 1. A final index score of 1 indicates the highest potential to provide desirable wetland functions. The final score is calculated by taking the sum of all variables values (VTOTAL) and dividing it by the total maximum value (VMAX). VMAX is calculated by multiplying the number of applicable variables by 3.

This final score can also be expressed as an alphabetic score as follows:

Relative Rank	**Corresponding Index Score**	**Potential to Provide Desirable Wetland Functions and Values**
A	0.75 to 1.0	HIGH
B	0.50 to <0.75	MODERATE
C	0.25 to <0.50	LOW
D	0.00 to <0.25	POOR

II. Constructed Wetland Mitigation Variables

G. Hydrology:

Provides a measure of the degree to which wetland hydrology is present through observation of field evidence of surface inundation or saturation, such as hydric soil development, redoximorphic features, adventitious roots, shallow roots, vegetated tussocks, drift lines, sediment deposition, secondary flow channels, and plant species composition and vigor.

H. Soils:

Evaluates whether existing conditions are favorable for the establishment/development of hydrophytic vegetation.

C. Vegetation Composition/Diversity:

Assesses the presence, abundance, composition and condition of plant species within the mitigation site. Also measures the extent of colonization by undesirable (i.e. invasive) plant species. This variable includes two sub-categories:

C.1 Overstory Layer

Describes the characteristics of the overstory layer including trees and shrubs greater than 3 feet in height.

C.2 Ground Cover

Describes the characteristics of the understory vegetation layer including herbaceous and woody plants 3 feet or less in height.

D. Wildlife Suitability:

Evaluates the degree to which the wetland provides suitable habitat characteristics for wildlife.

E. Site Characteristics:

Evaluates the degree to which the location and design of the mitigation site affects its capacity to perform wetland functions. Includes an evaluation of design factors such as shape and size.

F. Landscape Characteristics:

Evaluates the nature of surrounding land use as it affects the functional capacity of the mitigation site including transition area quality and quantity, and contiguity with adjacent habitats. This variable includes three sub-categories:

F.1 Adjacent Buffer

Provides a description of the vegetation characteristics of uplands within 50 feet of the wetland boundary.

F.2 Contiguity

The extent to which the site adjoins wetlands or open space

F.3 Land Use

Describes the predominant type of land use within proximity (approximately ¼ mile) of the wetland.

III. Variable rating Index

A. HYDROLOGY

Objective:

This variable evaluates the hydrologic regime based on observed field indicators for the subject wetland. The evaluation considers predicted hydroperiod duration and magnitude. It is generally interpreted by using the field indicators such as morphological adaptations, plant community structure, human induced alterations to hydrology and other physical evidence such as rafted debris, drift lines, stained leaves, secondary flow channels, and sediment deposition. Plants exhibit morphological adaptations such as adventitious/shallow roots, buttressed roots, lichen lines, vegetated hummocks. Plants that are well established can also be used as an indicator of hydroperiod. Hydrophytes will exhibit signs of stress if there is too much or too little water. Signs of stress may include wilting, dieback, prevalence of disease and mortality. If too much water is present on the mitigation site, target hydrophytes may die off and not recruit, resulting in an unvegetated open water community. If too little water is present, the result may be transition to an upland community. External features that can interfere with or alter wetland hydrology include roads, drainage canals, levees, ditches, culverts and reductions in drainage area. Diffuse water flow through the wetland can be used as an indicator of natural hydroperiod. Channelized flow as indicated by areas where the water follows a defined path rather than a diffuse area may be used as an indicator of inadequate or altered hydroperiod. Soils that have redoximorphic features, including mottling, manganese concretions, and low chroma matrix, in areas where soils that have been in place for sufficient time to develop these characteristics, can also be used as a field indicator of wetland hydrology.

Relative Score:

STRONG EVIDENCE THAT HYDROLOGIC REGIME IS ADEQUATE TO MAINTAIN A VIABLE WETLAND SYSTEM **3**

a. Wetland hydrology is **adequate** to maintain wetlands and there is an absence of external features that may interfere with hydroperiod.
b. **Negligible** evidence of colonization by transitional/upland plants.
c. Hydrophytes healthy and exhibit **no stress**, plant morphologic adaptations are evident.
d. **Negligible** evidence of hydrophyte mortality due to inappropriate hydrology.
e. **Abundant** evidence of surface inundation appropriate to support wetland vegetation.
f. **Negligible** water flow channelization.
g. Redoximorphic features **distinct and/or clearly distinguishable** from upland/transition zone.
h. **Strong** evidence of hydric soil development

A. **HYDROLOGY** (continued)

Relative Score:

MODERATE EVIDENCE THAT HYDROLOGIC REGIME IS ADEQUATE TO MAINTAIN A VIABLE WETLAND SYSTEM **2**

i. Wetland hydrology is **slightly impaired** due to presence of external features that may interfere with hydroperiod.
j. **Minimal** evidence of colonization by transitional/upland plants.
k. Hydrophytes healthy and exhibit **minimal** stress, plant morphologic adaptations are evident.
l. **Minimal** evidence of hydrophyte mortality due to inappropriate hydrology.
m. **Moderate** evidence of surface inundation appropriate to support wetland vegetation.
n. **Minimal** water flow channelization.
o. Redoximorphic features **present and/or moderately distinguishable** from upland/transition zone.
p. **Moderate** evidence of hydric soil development.

HYDROLOGIC REGIME IS INADEQUATE TO MAINTAIN VIABLE WETLAND **1**

q. Wetland hydrology is **inadequate**.
r. **Moderate** evidence of colonization by transitional/upland plant.
s. Hydrophytes exhibit **moderate** stress, plant morphologic adaptations are minimal.
t. **Moderate** evidence of hydrophyte mortality due to inappropriate hydrology.
u. **Minimal** evidence of surface inundation appropriate to support wetland vegetation including evidence of prolonged ponding which is detrimental to the establishment of wetland vegetation.
v. **Moderate** water flow channelization.
w. Redoximorphic features **minimal and/or indistinguishable** from upland/transition zone.
x. **Minimal** evidence of hydric soil development.

HYDROLOGIC REGIME IS SEVERELY LIMITED WITH STRONG EVIDENCE OF SUCCESSION TO UPLAND OR OPEN WATER COMMUNITY **0**

y. Wetland hydrology **severely limited**.
z. **Extensive** evidence of colonization by transitional/upland plants.
aa. Hydrophytes exhibit **severe** stress, and lack morphologic adaptations.
bb. **Extensive** evidence of hydrophyte mortality due to inappropriate hydrology.
cc. **Absence** of evidence of surface inundation including prolonged ponding that precludes the establishment of wetland vegetation.
dd. **Extensive** water flow channelization.
ee. Redoximorphic features **absent and/or indistinguishable** from upland/transition zone of site.
ff. **Negligible** evidence of hydric soil development.

B. SOILS

Objective:

The soil variable is a measure of suitability of soils to support and enhance the recruitment and growth of desirable wetland vegetation. The reviewers should inspect the site for signs that soils are stabilized, and suitable to wetland vegetation growth. Field evidence that can be used to evaluate the suitability of soils may include depth, texture, and compaction.

	Relative Score:
STRONG EVIDENCE THAT SOILS ARE FAVORABLE FOR THE GROWTH OF WETLAND VEGETATION	**3**

a. Topsoil depth **6" or greater** and conducive to growth of wetland vegetation.
b. **Negligible** evidence of erosion or loss of topsoil (e.g. cracking, subsidence, etc.).
c. **Negligible** evidence of soil compaction that inhibits growth of vegetation.
d. **Negligible** amount of debris, concrete or garbage.

MODERATE EVIDENCE THAT SOILS ARE FAVORABLE FOR THE GROWTH OF WETLAND VEGETATION	**2**

e. Topsoil depth **3-6"** and conducive to growth of wetland vegetation.
f. **Minimal** evidence of erosion or loss of topsoil (e.g. cracking, subsidence, etc.).
g. **Minimal** evidence of soil compaction that inhibits growth of vegetation.
h. **Minimal** amount of debris, concrete, or garbage.

MINIMAL EVIDENCE THAT SOILS ARE FAVORABLE FOR THE GROWTH OF WETLAND VEGETATION	**1**

i. Topsoil **present, up to 3" deep**, and conducive to growth of wetland vegetation.
j. **Moderate** evidence of erosion or loss of topsoil (e.g. cracking, subsidence, etc.).
k. **Moderate** evidence of soil compaction that inhibits growth of vegetation.
l. Soils contain **moderate** amounts of debris, concrete, or garbage.

ABSENCE OF THAT SOILS ARE FAVORABLE FOR THE GROWTH OF WETLAND VEGETATION	**0**

m. Topsoil **absent** or not conducive to growth of wetland vegetation.
n. **Strong** evidence of erosion or loss of topsoil (e.g. cracking, subsidence, etc.).
o. **Strong** evidence of soil compaction that inhibits growth of vegetation.
p. Soils contain **extensive** amounts of debris, concrete, or garbage.

C. VEGETATION COMPOSITION/DIVERSITY –

C.1 OVERSTORY (TREE AND SHRUB) LAYER

Objective:

The vegetation composition/diversity - overstory layer variable evaluates the presence, health, and abundance of the wetland's tree and shrub layer 3 feet or more in height, where applicable. Desirable plant species are those plants that one would expect to see in a comparable undisturbed wetland and those that do not have a tendency to become invasive. Undesirable plant species are plant species that are not usually considered nuisance species, however may be indicative of other problems (i.e. - improper hydrology) and may dominate a particular stratum. Nuisance or invasive plant species have the potential to dominate plant communities (e.g. tree-of-heaven, multiflora rose, Russian olive). This variable is not applicable to emergent habitats where overstory layers are typically not present. In this case a score of NA (not applicable) should be noted on the field data sheets. (Note - Overstory trees >15' height, Shrub = >3-15' height).

Refer to Appendix A - list of plants defined by NJDEP to be "nuisance or invasive" species.

	Relative Score:
ABUNDANT AMOUNT OF DESIRABLE WETLAND OVERSTORY LAYER PRESENT	**3**

a. **Abundant** wetland overstory layer present (75-100% cover).
b. Wetland contains negligible nuisance or invasive trees and shrubs **(<1%).**
c. **Strong** evidence of natural recruitment of desirable tree and shrub seedlings.
d. **Abundant** signs of recent growth.
e. **Negligible** evidence of insect damage and/or herbivory.
f. **Negligible** signs of abnormal growth patterns, chlorosis, or other abnormalities.
g. **High** tree and shrub diversity.

MODERATE AMOUNT OF DESIRABLE WETLAND OVERSTORY LAYER PRESENT	**2**

h. **Moderate** wetland overstory layer present (50-74% cover).
i. Wetland contains minimal nuisance or invasive trees and shrubs **(1-10%)**.
j. **Moderate** evidence of natural recruitment of desirable tree and shrub seedlings.
k. **Moderate** signs of recent growth.
l. **Minimal** evidence of insect damage and/or herbivory.
m. **Minimal** signs of abnormal growth patterns, chlorosis, or other abnormalities.
n. **Moderate** tree and shrub diversity.

C. 1 OVERSTORY (TREE AND SHRUB) LAYER (continued)

Relative Score:

LIMITED AMOUNT OF DESIRABLE WETLAND OVERSTORY LAYER PRESENT **1**

o. **Minimal** wetland overstory layer present (25-49% cover).
p. Nuisance or invasive trees and shrubs are well-established **(>10-50%)**.
q. **Minimal** evidence of natural recruitment of desirable tree and shrub seedlings.
r. **Minimal** signs of recent growth.
s. **Moderate** evidence of insect damage and/or herbivory.
t. **Abundant** signs of abnormal growth patterns, chlorosis, or other abnormalities.
u. **Minimal** tree and shrub diversity.

UNDESIRABLE WETLAND OVERSTORY LAYER PRESENT **0**

v. **Negligible** wetland overstory layer present (0-24% cover).
w. Wetland is dominated by nuisance or invasive trees and shrubs **(>50%)**.
x. **Negligible** signs of natural recruitment of desirable tree and shrub seedlings.
y. **Negligible** signs of recent growth.
z. **Strong** evidence of insect damage and/or herbivory.
aa. **Extensive** signs of abnormal growth patterns, chlorosis, or other abnormalities.
bb. **Negligible** tree and shrub diversity.

C. VEGETATION COMPOSITION/DIVERSITY –

C.2 GROUND COVER

Objective:

The vegetation composition/diversity - ground cover variable evaluates the presence, abundance, regrowth, and condition of herbaceous and woody plants 3 feet or less in height. Such impacts as hydroperiod, herbivory, disease, insect damage, nutrient deficiencies, mechanical human disturbance (e.g. – ATV use, tramping, etc.), and chemical disturbances (e.g. herbicides, nutrient shifts, etc.) affect this variable. Undesirable plant species are plant species that are not usually considered nuisance species, however may be indicative of other problems (i.e. - improper hydrology) and may dominate a particular stratum (e.g. *Rubus* sp. in an emergent wetland). Nuisance or invasive plant species have the potential to dominate plant communities and form large monocultures (e.g. *Phragmites,* reed canary grass, Japanese knotweed, etc.). Desirable plant species are those plants that one would expect to see in an undisturbed example of a comparable wetland type and that do not have a tendency to become invasive.

Refer to Appendix A - list of plants defined by NJDEP to be “nuisance or invasive” species.

	Relative Score:
ABUNDANT AMOUNT OF DESIRABLE WETLAND GROUND COVER PRESENT	**3**

a. **Abundant** wetland groundcover layer present (75-100% cover).
b. Wetland contains negligible nuisance or invasive groundcover **(<1%).**
c. **Strong** evidence of natural recruitment of desirable plants.
d. **Abundant** signs of recent growth.
e. **Negligible** evidence of insect damage and/or herbivory.
f. **Negligible** signs of abnormal growth patterns, chlorosis, or other abnormalities.
g. **High** groundcover diversity.

MODERATE AMOUNT OF DESIRABLE WETLAND GROUND COVER PRESENT	**2**

h. **Moderate** wetland groundcover layer present (50-74% cover).
i. Wetland contains minimal nuisance or invasive groundcover **(1-10%)**.
j. **Moderate** evidence of natural recruitment of desirable plants.
k. **Moderate** signs of recent growth.
l. **Minimal** evidence of insect damage and/or herbivory.
m. **Minimal** signs of abnormal growth patterns, chlorosis, or other abnormalities.
n. **Moderate** groundcover diversity.

C.2 GROUND COVER (continued)

Relative Score:

LIMITED AMOUNT OF DESIRABLE WETLAND GROUND COVER PRESENT **1**

- o. **Minimal** wetland groundcover layer present (25-49% cover).
- p. Nuisance or invasive groundcover is well-established **(>10-50%)**.
- q. **Minimal** evidence of natural recruitment of desirable plants.
- r. **Minimal** signs of recent growth.
- s. **Moderate** evidence of insect damage and/or herbivory.
- t. **Abundant** signs of abnormal growth patterns, chlorosis, or other abnormalities.
- u. **Minimal** groundcover diversity.

UNDESIRABLE WETLAND GROUND COVER PRESENT **0**

- v. **Negligible** wetland groundcover layer present (0-24% cover).
- w. Wetland and is dominated by nuisance or invasive groundcover **(>50%)**.
- x. **Negligible** signs of natural recruitment of desirable plants.
- y. **Negligible** signs of recent growth.
- z. **Strong** evidence of insect damage and/or herbivory.
- aa. **Extensive** signs of abnormal growth patterns, chlorosis, or other abnormalities.
- bb. **Negligible** groundcover diversity.

D. WILDLIFE SUITABILITY

Objective:

The wildlife suitability variable evaluates habitat quality as an alternative to direct observation. It evaluates wildlife suitability through the noted presence or absence of wildlife food and water sources, nesting areas, roosting areas, and protective cover. The presence of signs and suitable habitat are used as field indicators of wildlife use due to the time constraints of the assessment procedure and the secrecy, mobility, habits and seasonality of many species of wildlife. For a mitigation area to get a high relative score on this variable there must be evidence of diverse habitat characteristics suitable to support a wide range of species.

	Relative Score:
WETLAND EXHIBITS STRONG EVIDENCE OF WILDLIFE SUITABILITY	**3**

a. **Abundant** (in type and distribution) protective cover is available.
b. **Abundant** adjacent food sources and nesting habitat.
c. **Negligible** human impediments to wildlife use, such as roads or other disturbances.
d. **Strong** evidence that habitat can support nesting/breeding activity.

WETLAND EXHIBITS MODERATE EVIDENCE OF WILDLIFE SUITABILITY	**2**

e. **Adequate** (in type and distribution) protective cover is available.
f. **Available** adjacent food sources and nesting habitat.
g. **Minimal** human impediments to wildlife use, such as roads or other disturbances.
h. **Moderate** evidence that habitat can support nesting/breeding activity.

WETLAND EXHIBITS MINIMAL EVIDENCE OF WILDLIFE SUITABILITY	**1**

i. **Limited** (in type and distribution) protective cover is available.
j. **Limited** adjacent food sources and nesting habitat.
k. **Moderate** human impediments to wildlife use, such as roads or other disturbances.
l. **Limited** evidence that habitat can support nesting/breeding activity.

WETLAND EXHIBITS NO EVIDENCE OF WILDLIFE SUITABILITY	**0**

m. **Inadequate** (in type and distribution) protective cover for wildlife.
n. **Inadequate** adjacent food and nesting habitat sources are available.
o. **Extensive** human impediments to wildlife use, such as roads or other disturbances.
p. Habitat is **inadequate** to support nesting/breeding activity.

E. SITE CHARACTERISTICS

Objective:
Measures the degree to which site or design characteristics affects the wetland's capacity to perform desirable functions. Includes an evaluation of design factors such as shape, size, community type, and required maintenance. Edge: area ratio can be used to distinguish between a large circular depression (low edge:area ratio) and a long linear ditch (high edge:area ratio). Heterogeneity is a measure of the degree of structure and species composition variability in the vegetation community distinguishing between those sites consisting of a single wetland community type or a combination of multiple community types. For this variable the evaluator(s) should list specific reasons the design was adequate or inadequate to achieve desirable wetland functions. Desirable functions may include flood flow alteration, sediment deposition, wildlife habitat, etc.

Relative Score:

SITE CHARACTERISTICS ARE CONDUCIVE TO PERFORM WETLAND FUNCTIONS — 3

a. Wetland is **stable,** requiring little or no maintenance to achieve desirable wetland functions.
b. **Low** edge:area ratio.
c. Wetland contains **distinct** community type heterogeneity.
d. Location is **conducive** to achieving desirable wetland functions.
e. Size is **conducive** to achieving desirable wetland functions.

SITE CHARACTERISTICS MODERATELY SUITABLE TO PERFORM WETLAND FUNCTIONS — 2

f. Wetland requires **some** periodic maintenance to achieve desirable wetland functions.
g. **Moderate** edge:area ratio.
h. Mitigation area contains **moderate** community type heterogeneity.
i. Location is **adequate** to support desirable wetland functions.
j. Size is **adequate** to perform desirable wetland functions.

SITE CHARACTERISTICS MINIMALLY SUITABLE TO PERFORM WETLAND FUNCTIONS — 1

k. Wetland requires **extensive** maintenance to achieve desirable wetland functions.
l. **High** edge:area ratio.
m. Mitigation area contains **low** community type heterogeneity.
n. Location **impedes** desirable wetland functions.
o. Size **impedes** desirable wetland functions.

SITE CHARACTERISTICS INADEQUATE TO PERFORM WETLAND FUNCTIONS — 0

p. Wetland requires **continuous** maintenance or alteration to achieve desirable functions.
q. Edge:Area ratio is **extreme**.
r. Mitigation area contains **no** community type heterogeneity.
s. Location **inadequate** to achieve desirable functions.
t. Size is **inadequate** to perform desirable wetland functions.

F. LANDSCAPE CHARACTERISTICS

F.1 ADJACENT BUFFER

Objective:

The landscape characteristics - adjacent buffer variable is a measure of the relative quality of the 150 foot buffer or transitional area adjoining the subject jurisdictional wetland. This variable is evaluated based on the size and the ecological attributes (e.g., vegetative cover, wildlife use, sedimentation control) of the adjoining buffer in relation to the wetland being assessed. If the mitigation site has a buffer that varies in width, the reviewers should average the different buffers. For example, a site bordered on 25% of its boundary by a parking lot with no buffer, and on 75% by a >150 foot wide vegetated buffer, would have an average width equal to 112.5 feet [(.25 x 0) + (.75 x 150) = 112.5].

	Relative Score:
ADJACENT BUFFER STRONGLY COMPLEMENTS WETLAND FUNCTIONS	**3**

a. Vegetated buffer **≥150 feet** average width.
b. Buffer contains **negligible** nuisance or invasive plant species **(<1%)**.
c. Contains **predominantly** plant species that provide cover, food source, and roosting areas for wildlife.
d. Plant cover provides **adequate** nutrient retention, water flow moderation, and erosion prevention for mitigation site.
e. Buffer slope averages **less than 10%.**

ADJACENT BUFFER MODERATELY COMPLEMENTS WETLAND FUNCTIONS **2**

f. Vegetated buffer **greater than 50 feet but less than 150 feet** average width.
g. Buffer **established with (<50%)** nuisance or invasive plant species.
h. Contains **some** plant species that provide cover, food source, and roosting areas for wildlife.
h. Plant cover provides **limited** nutrient retention, water flow moderation, and erosion prevention for mitigation site.
j. Buffer slope averages **10-20%**

ADJACENT BUFFER IMPEDES WETLAND FUNCTIONS **1**

k. Vegetated buffer **50 feet or less** average width.
l. Buffer **dominated (> 50%)** by nuisance or invasive plant species.
m. Contains **limited** plant species that provide cover, food source, and roosting areas for wildlife.
n. Plant cover provides **inadequate** nutrient retention, water flow moderation, and erosion prevention for mitigation site.
o. Buffer slope averages **greater than 20%.**

ADJACENT BUFFER SEVERLY IMPAIRS WETLAND FUNCTIONS **0**

p. No vegetated buffer.

F. LANDSCAPE CHARACTERISTICS

F.2 CONTIGUITY

Objective:

Measures the extent to which the project contributes to maintenance of the natural ecological mosaic of the landscape. In order to score high for this variable the position of the mitigation site within the landscape must provide a direct connection with adjoining open space on the majority of its perimeter, without interruptions such as roads, canals, developments, etc. An example would be a site located along a stream within an undeveloped area adjoining an existing state park.

		Relative Score:
a.	**SITE CONTIGUOUS ON 75-<100% OF ITS PERIMETER**	**3**
b.	**SITE CONTIGUOUS ON 50-<75% OF ITS PERIMETER**	**2**
c.	**SITE CONTIGUOUS ON 25-<50% OF ITS PERIMETER**	**1**
d.	**SITE CONTIGUOUS ON <25% OF ITS PERIMETER**	**0**

F. LANDSCAPE CHARACTERISTICS

F.3 LAND USE

Objective:

This variable examines the dominant surrounding land use within 1/4 mile of the mitigation site as an indicator of water quality within the wetland system. It can be assumed that for selected pollutants, water quality varies with land use (Whalen and Cullum, 1988). Pollutant-load rates from undeveloped open space that is not managed for active recreational use (i.e. golf courses) via pesticides, herbicides, mowing, etc., are much lower than any other category. Pollutant-load rates for residential land uses increase steadily from low-density to high density. Commercial and industrial pollutant-load rates also vary with development intensity. Finally, contributions of nutrients from agricultural uses are much greater than loading rates for undeveloped open space (Harvey, 1990). Therefore when evaluating this variable an emphasis should be placed upon that surrounding land area which contributes to the hydrology of the mitigation site. The land use categories include low-density residential (1 unit/ acre), high-density residential (<1 unit/acre), low intensity commercial and industrial (<50% impervious), highways, agriculture, recreation/golf courses and high intensity commercial/industrial developments (>50% impervious).

If the reviewers determine there to be more than one surrounding land use that affects the mitigation site, this is mathematically expressed as follows:

[(%surrounding x LU1) + (%surrounding x LU2)]/2 = LU total

For example, if the site is 50% surrounded by industry and 50% by open space the score would be:

[.5 X .5) + (.5 X 3)}/2 = 0.9

Land Use Category:		**Relative Score:**
a.	undeveloped open space	3
b.	low density residential	2
c.	low intensity commercial	1.5
d.	high density residential	1
e.	recreation/golf course	1
f.	agriculture	1
g.	highway	0.5
h.	industrial	0.5
i.	high intensity commercial/industrial	0

IV. Scoring Matrix - See introduction for instructions on how to apply these guidance field indicator lists. Letters for these field indicators correspond to Section III which should be used to assign a value based on the "best fit" method.

A. HYDROLOGY

Relative Score	Wetland Hydrology	Undesirable Plant Colonization	Plant Stress	Plant Mortality	Surface Inundation	Water Flow Channelization	Redoximorphic Features	Hydric Soils
3	a. adequate	b. negligible	c. no stress	d. negligible	e. abundant	f. negligible	g. distinct	h. strong
2	i. impaired	j. minimal	k. minimal	l. minimal	m. moderate	n. minimal	o. present	p. moderate
1	q. inadequate	r. moderate	s. moderate	t. moderate	u. minimal	v. moderate	w. minimal	x. minimal
0	y. limited	z. extensive	aa. severe	bb. extensive	cc. absent	dd. extensive	ee. absent	ff. negligible

B. SOILS

Relative Score	Topsoil	Erosion	Soil Compaction	Debris
3	a. >6"	b. negligible	c. negligible	d. negligible
2	e. 3-6"	f. minimal	g. minimal	h. minimal
1	i. present, up to 3"	j. moderate	k. moderate	l. moderate
0	m. absent	n. strong	o. strong	p. extensive

C.1 VEGETATION COMPOSITION/DIVERSITY - OVERSTORY (TREE AND SHRUB) LAYER

Relative Score	Plant Cover	Invasive Plants	Natural Recruitment	Plant Growth	Insects & Herbivory	Plant Stress	Diversity
3	a. abundant	b. <1%	c. strong	d. abundant	e. negligible	f. negligible	g. high
2	h. moderate	i. 1-10%	j. moderate	k. moderate	l. minimal	m. minimal	n. moderate
1	o. minimal	p. >10-50%	q. minimal	r. minimal	s. moderate	t. abundant	u. minimal
0	v. negligible	w. >50%	x. negligible	y. negligible	z. strong	aa. extensive	bb. negligible

C.2. VEGETATION COMPOSITION/DIVERSITY - GROUND COVER

Relative Score	Plant Cover	Invasive Plants	Natural Recruitment	Plant Growth	Insects & Herbivory	Plant Stress	Diversity
3	a. abundant	b. <1%	c. strong	d. abundant	e. negligible	f. negligible	g. high
2	h. moderate	i. 1-10%	j. moderate	k. moderate	l. minimal	m. minimal	n. moderate
1	o. minimal	p. >10-50%	q. minimal	r. minimal	s. moderate	t. abundant	u. minimal
0	v. negligible	w. >50%	x. negligible	y. negligible	z. strong	aa. extensive	bb. negligible

IV. Scoring Matrices (continued)

D. WILDLIFE SUITABILITY

Relative Score	Cover	Adjacent Resources	Human Impediments	Nest/Breeding Activity
3	a. abundant	b. abundant	c negligible	d. strong
2	e. adequate	f. available	g. minimal	h. moderate
1	i. limited	j. limited	k. moderate	l. minimal
0	m. inadequate	n. inadequate	o. extensive	p. inadequate

E. SITE CHARACTERISTICS

Relative Score	Maintenance	Edge:Area Ratio	Heterogeneity	Location	Size
3	a. stable	b. low	c. distinct	d. conducive	e. conducive
2	f. some	g. moderate	h. moderate	i. adequate	j. adequate
1	k. extensive	l. high	m. low	n. impedes	o. impedes
0	p. continuous	q. extreme	r. none	s. inadequate	t. inadequate

F.1. LANDSCAPE CHARACTERISTICS - ADJACENT BUFFER

Relative	Width	Invasive Species	Wildlife Suitablitiy	Cover	Slope
3	a. ≥150.	b. <1%	c. predominantly	d. adequate	e. <10%
2	f. >50-<150 ft.	g. <50%	h. some	i. limited	j. 10-20%
1	k. ≤50 ft.	l. >50%	m. limited	n. inadequate	o. >20%
0	p. 0 ft.	q. not applicable	r. not available	s. not available	t. not available

F.2 LANDSCAPE CHARACTERISTICS - CONTIGUITY **F.3 LANDSCAPE CHARACTERISTICS – LAND USE**

Relative Score	Contiguity	Land Use (Score shown in parenthesis)	
3	a. 75-100%	a. undeveloped open space (3)	f. agriculture (1)
2	b. 50-<75%	b. low density residential (2)	g. highway (0.5)
1	c. 25-<50%	c. low intensity commercial (1.5)	h. industrial (0.5)
0	d. <25%.	d. high-density residential (1)	i. high intensity commercial/industrial (0)
		e. recreation/golf courses (1)	

Appendix A: Nuisance and Invasive Plant List

reed canary grass (*Phalaris arundinacea*)
common reedgrass (*Phragmites australis*)
kudzu (*Pueraria montana*)
broad-leaf cattail (*Typha latifolia*)
narrow-leaf cattail (*Typha angustifolia*)
purple loosestrife (*Lythrum salicaria*)
tree-of-heaven (*Ailanthus altissima*)
Japanese barberry (*Berberis thunbergi*)
common barberry (*Berberis vulgaris*)
Russian olive (*Elaeagnus angustifolia*)
autumn olive (*Elaeagnus umbellata*)
Japanese privet (*Ligustrum obtusifolium*)
common privet (*Ligustrum vulgare*)
multiflora rose (*Rosa multiflora*)

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