# Wetland Mitigation Monitoring at the Fernald Preserve - 13200

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## ABSTRACT

The U.S. Department of Energy is responsible for 7.2 hectares (17.8 acres) of mitigation wetland at the Fernald Preserve, Ohio. Remedial activities affected the wetlands, and mitigation plans were incorporated into sitewide ecological restoration planning. In 2008, the Fernald Natural Resource Trustees developed a comprehensive wetland mitigation monitoring approach to evaluate whether compensatory mitigation requirements have been met. The Fernald Preserve Wetland Mitigation Monitoring Plan provided a guideline for wetland evaluations. The Ohio Environmental Protection Agency (Ohio EPA) wetland mitigation monitoring protocols were adopted as the means for compensatory wetland evaluation. Design, hydrologic regime, vegetation, wildlife, and biogeochemistry were evaluated from 2009 to 2011. Evaluations showed mixed results when compared to the Ohio EPA performance standards. Results of vegetation monitoring varied, with the best results occurring in wetlands adjacent to forested areas. Amphibians, particularly ambystomatid salamanders, were observed in two areas adjacent to forested areas. Not all wetlands met vegetation performance standards and amphibian biodiversity metrics. However, Fernald mitigation wetlands showed substantially higher ratings compared to other mitigated wetlands in Ohio. Also, soil sampling results remain consistent with other Ohio mitigated wetlands. The performance standards are not intended to be "pass/fail" criteria; rather, they are reference points for use in making decisions regarding future monitoring and maintenance. The Trustees approved the *Fernald Preserve Wetland Mitigation Monitoring Report* with the provision that long-term monitoring of the wetlands continues at the Fernald Preserve.

## INTRODUCTION

The Fernald Preserve is a former uranium-processing facility that operated from 1951 to 1991 as part of the U.S. Department of Energy (DOE) weapons complex. The site has since undergone remediation pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and the DOE Office of Legacy Management now maintains it. Wetland restoration projects were intended to satisfy wetland mitigation obligations as outlined in the *Fernald Preserve Natural Resource Restoration Plan* (NRRP), which is Appendix B of the *Consent Decree Resolving Ohio's Natural Resource Damage Claim against DOE*[1]. In November 2008, DOE and the Ohio Environmental Protection Agency (Ohio EPA) signed a consent decree that settled a long-standing natural resource damage claim under Section 107 of CERCLA. As a result, the Fernald Natural Resource Trustees (NRTs) (DOE, Ohio EPA, and the U.S. Department of the Interior) developed a comprehensive wetland mitigation monitoring approach to evaluate whether compensatory mitigation requirements have been met.

In 1993, 14.5 ha (35.9 acres) of jurisdictional wetlands were delineated at the Fernald site. According to the Operable Unit 5 Record of Decision, remediation activities would impact an estimated 4.0 ha (10 acres) of wetlands (primarily cattail marsh impoundments). Compensatory mitigation pursuant to Section 404 of the Clean Water Act was subsequently negotiated with regulators. In 1995, DOE committed to compensating for impacted wetlands on site at a 1.5-to-1 ratio. As remediation progressed, DOE became responsible for 7.2 ha (17.8 acres) of compensatory wetlands. Mitigation plans were incorporated into sitewide ecological restoration planning through the NRRP. DOE completed the NRRP wetland mitigation projects during 1999 through 2006.

The *Fernald Preserve Wetland Mitigation Monitoring Plan*[2] was developed using Ohio EPA performance standards and monitoring protocols. The NRTs agreed to adopt Ohio EPA wetland mitigation monitoring protocols as the means for compensatory wetland evaluation. Mack et al.[3] established a set of monitoring protocols and performance standards for mitigation wetlands, which are designed to ensure that both the processes (functions) and ecological services (values) that an impacted wetland provided are sufficiently restored through the mitigation process. To do this, a multistep evaluation process has been developed to efficiently estimate the size, type, and quality of impacted wetlands. This evaluation results in a set of performance standards that subsequent mitigation wetlands must meet, to ensure that impacted wetlands are replaced with new wetlands that are similar to them in size, type, and quality.

For the Fernald Preserve, wetland impacts occurred years ago as part of remedial activities. The size and type of impacted wetlands can be approximated from the 1993 wetland delineation, but the quality of the wetlands must be inferred from this original jurisdictional delineation and subsequent discussions with regulators. The *Fernald Preserve Wetland Mitigation Monitoring Plan* (WMMP) used existing information to estimate the size and type of wetlands impacted, as well as an approximation of impacted wetland quality at the site[2]. This resulted in the establishment of standards associated with a cattail marsh impoundment. Performance standards include wetland acreage, basin morphometry, hydrology, vegetation, wildlife, and soil biogeochemistry. Table I presents the standards established for Fernald mitigation wetlands.

Table I. Fernald Preserve Mitigation Wetland Performance Standards

| **Standard/Parameter** | **Value** |
|---|---|
| Acreage | 17.85 acres |
| Basin morphometry | Less than or equal to 15:1 side slope (6.7%) |
| Perimeter-to-area ratio | Greater than or equal to 75% of impacted perimeter length |
| Hydrologic regime | |
| Water in root zone (<30 cm) | 53% of time |
| Mean depth to water | 29.4 cm |
| Flashiness Index | 2.0 |
| Unvegetated open water | <10% |
| Native perennial hydrophytes | >75% |

| Standard/Parameter | Value |
|---|---|
| Invasive species | <5% |
| Vegetation Index of Biotic Integrity | 48–63 |
| Amphibian Index of Biotic Integrity | NA |
| Other taxa groups | NA |
| Soil biogeochemistry | |
| % solids | <46.6% |
| % total organic carbon | >3.9% |
| % total N | >0.5% |

Once standards were established, the Trustees developed a 3-year monitoring program that was designed to compare site wetlands to these parameters. Table II shows the monitoring schedule that was established in the WMMP[2].

Table II. Fernald Preserve Wetland Mitigation Monitoring Schedule

| Monitoring Activity | 2009 | 2010 | 2011 |
|---|---|---|---|
| Delineation | | | X |
| Basin morphometry | | | X |
| Perimeter-to-area ratio | | | X |
| Hydrologic monitoring | | X | X |
| Vegetation sampling | X | | X |
| Amphibian sampling | X | X | X |
| Soil and water sampling | | X | X |
| Other taxa group sampling | X | X | X |

## METHODS

Evaluation criteria for Fernald mitigation wetlands included parameters associated with design (e.g., size and shape), hydrologic regime, vegetation, wildlife, and biogeochemistry. Twenty three wetland basins were identified, within five different wetland areas across the site.

### Design Parameters

Design parameters for mitigation wetlands include acreage, basin morphometry, and perimeter-to-area ratio. Mitigation wetland acreage was estimated via a jurisdictional wetland delineation. The 1987 U.S. Army Corps of Engineers *Corps of Engineers Wetland Delineation Manual*[4] and the associated Midwest regional supplement[5] were used to delineate wetland boundaries within all wetland basins evaluated . Fieldwork commenced in late May 2011 and continued through July. Field personnel identified major landscape or vegetation units within each of the 23 wetland areas to be evaluated. One or more sample points were selected from each basin. Three indicator tests were applied to determine the presence of hydrophytic vegetation, hydric soil and hydrology in order to determine whether the sample point fell within a wetland area,

thus determining the wetland boundary. Landscape-level photographs and photographs of vegetation and soil were taken at each sample point. Each sample point was documented with a Midwest Region Wetland Determination Data Form. Pursuant to Ohio EPA monitoring protocols, net wetland acreage was calculated by subtracting the area of unvegetated open water (above 10 percent) from the total acreage within the delineation boundary.

Basin morphometry and perimeter-to-area ratio were estimated using Graphical Information System (GIS) measurement and analytical tools. Delineation boundaries were used to calculate morphometry via slope histograms. Slope percentage was determined for all areas within the wetland boundary. Slopes less than or equal to 6.7 percent meet the 15:1 performance standard.

The perimeter-to-area ratio was also calculated using delineation boundaries. Ohio EPA protocol calls for a comparison of the mitigation basin to the impacted wetland basin. Since previously constructed wetlands were being evaluated, a "basin to basin" comparison was not possible. Instead, the perimeter-to-area ratio was calculated as a summed value across all wetland basins evaluated. Perimeter lengths for all impacted wetlands were determined via GIS and summed. This value was then multiplied by 0.75 and compared to the total perimeter lengths of all mitigation wetlands evaluated.

**Hydrologic Regime Parameters**

Performance standards associated with the hydrologic regime include the amount of time water is present in the root zone, the mean depth to water, and the Flashiness Index of mitigation wetlands. These parameters were measured by installing shallow monitoring wells (piezometers). One piezometer was installed in each of the 23 wetland basins. Pursuant to Ohio EPA guidance, piezometer locations were selected in the field based on soil types encountered, the boundary of the wetland, and the presence of standing water[3].

Transducers and data loggers allowed for hourly water level measurements. From these datasets, twice-daily readings were used to calculate performance standard values and develop hydrographs.

**Vegetation Parameters**

Vegetation parameters include Vegetation Index of Biotic Integrity (VIBI), percentage of native perennial hydrophytes, and percentage of invasive species. All vegetation data were obtained via fixed-plot sampling pursuant to Ohio EPA methodology[6]. Field personnel laid out a 1,000-square-meter grid across representative vegetation within each of the 23 wetland basins evaluated. The typical plot arrangement consisted of modules (which measured 10 m by 10 m) arranged in a 20-m-by-50-m grid. In order to ensure representative conditions, plots were sometimes arranged in a 10-m-by-100-m configuration. For each basin, 4 of the 10 modules were intensively surveyed, and species richness and cover estimates were collected. Biomass samples were also collected from each of the four intensive modules. The use of four biomass samples is a slight deviation from Ohio EPA protocols, which recommend eight samples. The number of samples was reduced due to the number of basins evaluated.

Vegetation monitoring took place between June and August in 2009 and 2011. All field data were entered into an Access database, and VIBI scores were calculated for emergent wetlands pursuant to Mack[6]. VIBI Metrics include carex species richness, dicot species richness, shrub species richness, hydrophyte species richness, annual-to-perennial species ratio, Floristic Quality Assessment Index (FQAI), percentage of sensitive species, percentage of tolerant species, percentage of invasive species, and biomass. Percentages of native hydrophytes and invasive species were also calculated based on total species richness for each basin. All vegetation characterization information was obtained from the Ohio FQAI database[7].

**Wildlife Parameters**

As Table I shows, there are no specific performance standards for evaluating wildlife parameters. However, the NRTs agreed that wildlife parameters would help with determining success. Field personnel collected amphibians and macroinvertebrates with funnel traps pursuant to Ohio EPA protocols[8]. This process involves placing 10 funnel traps within a basin, at intervals that ensure complete coverage of the water's edge. The traps are retrieved after 24 hours and consolidated, and the amphibian species richness and abundance is recorded. Field personnel also determine richness and abundance for macroinvertebrates. Three monitoring events take place in the spring and early summer, in order to ensure that the full season of amphibian larval development is sampled. Amphibian Index of Biotic Integrity (AIBI) was calculated for selected basins within each mitigation wetland area. Data were collected during spring 2010 and spring 2011.

**Biogeochemistry Parameters**

Soil and water samples were collected for each wetland basin in 2010 and 2011. A project-specific sampling plan was developed in accordance with standard sampling procedures at the Fernald Preserve[9]. The sampling plan was consistent with Ohio EPA monitoring protocols (Mack et al. 2004). Soil sampling locations depended on wetland morphometry and size. Five samples were collected from each wetland basin, in a Y-shaped pattern that extended from the piezometer location through the primary wetland area. A sixth soil sample was collected at the center point of each vegetation fixed plot. Samples were collected using a 7.6 cm (3-inch) stainless-steel core sampler with a butyrate liner. Samples collected below the water surface were collected so that the loose, saturated sediment at the surface was not lost while retrieving the liner from below the water. Surface water samples were also collected in each basin, in order to obtain additional information for each wetland area. Surface water samples were collected from the edge of each wetland basin, nearest the piezometer. Samples were collected annually, in May, as close to the original sampling location as possible. Samples were analyzed for inorganics (iron, magnesium, and potassium), general chemistry parameters (ammonia as N, total Kjeldahl nitrogen, total organic carbon, chloride, nitrate/nitrite, total phosphorous, total suspended solids, and total solids), and field parameters (pH, specific conductance, dissolved oxygen, and temperature).

## RESULTS

Comparing wetland areas to the Ohio EPA performance standards shows mixed results. Tables III through V provide a "performance matrix" across all basins and years, with an indication as to whether the performance standard was met for a particular basin and year.

Table III. Design and Hydrologic Parameter Results

| Wetland Area | | Design Parameters | | Hydrologic Regime Parameters | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Performance Standard | Delineation | Morphometry | Water in Root Zone | | Mean Depth of Water | | Flashiness Index | |
| | | 17.85 Acres | >50% with at least 15:1 side slope | >53% | | 29.4 cm | | <2.0 | |
| | Basin/Year | 2011 | 2011 | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 |
| Borrow Area | BAPW2 | NA | NA | 6% | 61% | 66 | 25 | 0.7 | 0.6 |
| | BAPW3 | 2.75 | 84% | 71% | 76% | 25 | 13 | 0.5 | 0.8 |
| | BAPW4 | 3.03 | 86% | 73% | 76% | 14 | 17 | 0.5 | 0.8 |
| | BAPW7 | NA | NA | 68% | 73% | 32 | 26 | 0.4 | 0.4 |
| | BAPW9 | 7.32 | 76% | 67% | 71% | 28 | 18 | 0.7 | 0.9 |
| Former Production Area | FPAW2 | 2.01 | 84% | 67% | 73% | 32 | 27 | 0.6 | 0.4 |
| | FPAW4 | 1.43 | 76% | 78% | 81% | 19 | 16 | 0.4 | 0.3 |
| | FPAW5 | 1.20 | 85% | 71% | 73% | 15 | 23 | 0.6 | 0.4 |
| | FPAW7 | 1.39 | 48% | 77% | 78% | 22 | 20 | 0.4 | 0.9 |
| | FPAW9 | 0.53 | 68% | 30% | 76% | 53 | 30 | 0.6 | 0.3 |
| | PREW6 | 2.78 | 75% | 75% | 80% | 13 | 7 | 0.3 | 0.5 |
| Northern Pine Plantation | NPPW4 | 0.71 | 73% | 65% | 70% | 28 | 18 | 0.3 | 0.7 |
| | NPPW5 | 0.18 | 98% | 67% | 67% | 28 | 24 | 0.5 | 0.6 |
| Wetland Mitigation Phase I | WM1W1 | 0.94 | 68% | 34% | 52% | 49 | 41 | 0.7 | 0.7 |
| | WM1W2 | 1.13 | 91% | 67% | 68% | 36 | 32 | 0.5 | 0.4 |
| | WM1M3 | 0.76 | 80% | 63% | 63% | 41 | 38 | 0.5 | 0.7 |
| | WM1W4 | 0.78 | 88% | 77% | 77% | 24 | 22 | 0.4 | 0.4 |
| | WM1W5 | 0.23 | 71% | 53% | 61% | 38 | 29 | 1.2 | 1.3 |
| | WM1W6 | 1.45 | 83% | 66% | 50% | 30 | 52 | 0.4 | 0.6 |
| | WM1W7 | 0.53 | 76% | 61% | 58% | 37 | 25 | 0.8 | 0.6 |
| Wetland Mitigation Phase II | WM2W1 | 1.17 | 55% | 97% | 96% | 15 | 4 | 0.5 | 0.9 |
| | WM2W2 | 0.55 | 89% | 73% | 71% | 18 | 20 | 0.5 | 0.7 |
| | WM2W3 | 0.46 | 53% | 66% | 76% | 31 | 0 | 0.5 | 0.6 |
| | All Basins | 31.33 | | 64% | 71% | 30 | 23 | 0.5 | 0.6 |

**Legend:**

| | |
|---|---|
| | Performance Standard Met |
| | Performance Standard Not Met |

Table IV. Vegetation Parameter Results

| Wetland Area | Performance Standard | Vegetation Parameters | | | | | |
|---|---|---|---|---|---|---|---|
| | | Unvegetated Open Water | | Native Perennial Hydrophytes | | VIBI | |
| | | <10% | | >75% | | 48–63 | |
| | Basin/Year | 2009 | 2011 | 2009 | 2011 | 2009 | 2011 |
| Borrow Area | BAPW2 | 0.1% | 1.3% | 89.7% | 84.3% | 50 | 46 |
| | BAPW3 | 0.1% | 2.0% | 81.2% | 67.2% | 32 | 42 |
| | BAPW4 | 4.4% | 1.3% | 16.3% | 61.8% | 36 | 23 |
| | BAPW7 | 3.3% | 1.8% | 52.4% | 55.5% | 50 | 50 |
| | BAPW9 | 4.8% | 3.0% | 41.8% | 70.2% | 59 | 29 |
| Former Production Area | FPAW2 | 0.0% | 40.0% | 63.4% | 96.1% | 25 | 40 |
| | FPAW4 | 9.4% | 26.0% | 53.2% | 42.0% | 50 | 18 |
| | FPAW5 | 25.0% | 11.5% | 46.9% | 56.0% | 51 | 54 |
| | FPAW7 | 0.0% | 1.0% | 55.3% | 29.1% | 34 | 13 |
| | FPAW9 | 0.0% | 2.8% | 23.6% | 58.3% | 50 | 56 |
| | PREW6 | 0.4% | 17.3% | 55.9% | 46.2% | 43 | 25 |
| Northern Pine Plantation | NPPW4 | 0.0% | 5.3% | 42.0% | 72.1% | 51 | 58 |
| | NPPW5 | 0.3% | 3.8% | 32.2% | 79.6% | 51 | 61 |
| Wetland Mitigation Phase I | WM1W1 | 0.0% | 1.3% | 62.9% | 47.2% | 40 | 39 |
| | WM1W2 | 0.1% | 2.1% | 65.9% | 60.6% | 71 | 61 |
| | WM1M3 | 0.0% | 3.8% | 95.6% | 75.6% | 61 | 46 |
| | WM1W4 | 1.1% | 8.0% | 67.9% | 60.2% | 61 | 54 |
| | WM1W5 | 0.0% | 0.0% | 71.7% | 71.0% | 26 | 32 |
| | WM1W6 | 0.0% | 1.3% | 35.2% | 42.8% | 67 | 48 |
| | WM1W7 | 0.1% | 2.9% | 79.4% | 64.0% | 54 | 42 |
| Wetland Mitigation Phase II | WM2W1 | 12.5% | 1.0% | 78.7% | 63.8% | 50 | 53 |
| | WM2W2 | 4.5% | 13.8% | 89.4% | 81.0% | 43 | 49 |
| | WM2W3 | 13.3% | 20.5% | 82.7% | 55.6% | 57 | 51 |
| | All Basins | 3% | 7% | 60% | 63% | 46 | 43 |

**Legend:**

| | |
|---|---|
| | Performance Standard Met |
| | Performance Standard Not Met |

Table V. Soil Chemistry and Other Wildlife Parameters

| Wetland Area | Performance Standard | Soil Chemistry Parameters | | | | | | Other Wildlife Parameters | |
|---|---|---|---|---|---|---|---|---|---|
| | | Percent Solids | | Percent TOC | | Percent Total Nitrogen | | AIBI | |
| | | <46.6 % | | >3.9% | | >0.5% | | NA | |
| | Basin/Year | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 |
| Borrow Area | BAPW2 | 76.6% | 75.4% | 0.7% | 1.2% | 0.1% | 0.2% | 0 | 0 |
| | BAPW3 | 66.4% | 74.3% | 1.0% | 0.5% | 0.1% | 0.1% | NA | NA |
| | BAPW4 | 76.1% | 74.6% | 0.9% | 0.9% | 0.1% | 0.1% | 0 | 0 |
| | BAPW7 | 72.9% | 67.3% | 1.6% | 1.6% | 0.1% | 0.2% | 0 | 13 |
| | BAPW9 | 80.1% | 85.7% | 1.5% | 1.5% | 0.2% | 0.4% | NA | NA |
| Former Production Area | FPAW2 | 56.6% | 75.0% | 5.7% | 6.0% | 0.3% | 0.2% | 0 | 13 |
| | FPAW4 | 69.5% | 60.0% | 2.9% | 4.5% | 0.1% | 0.1% | NA | NA |
| | FPAW5 | 77.6% | 55.3% | 3.6% | 3.3% | 0.1% | 0.2% | NA | NA |
| | FPAW7 | 65.1% | 79.6% | 5.3% | 5.7% | 0.3% | 0.2% | 0 | 0 |
| | FPAW9 | 73.2% | 85.9% | 1.7% | 4.3% | 0.1% | 0.1% | 0 | 10 |
| | PREW6 | 70.3% | 74.9% | 0.5% | 0.4% | 0.1% | 0.1% | 13 | 13 |
| Northern Pine Plantation | NPPW4 | 62.0% | 78.0% | 2.7% | 0.8% | 0.2% | 0.1% | 16 | 33 |
| | NPPW5 | 68.6% | 71.2% | 0.8% | 0.6% | 0.1% | 0.1% | 24 | 0 |
| Wetland Mitigation Phase I | WM1W1 | 67.0% | 78.2% | 2.5% | 1.7% | 0.2% | 0.1% | 0 | 3 |
| | WM1W2 | 69.1% | 77.8% | 1.0% | 1.1% | 0.1% | 0.3% | NA | NA |
| | WM1M3 | 71.8% | 83.8% | 1.3% | 1.3% | 0.1% | 0.2% | NA | NA |
| | WM1W4 | 72.8% | 76.3% | 1.8% | 0.6% | 0.0% | 0.1% | 13 | 3 |
| | WM1W5 | 73.4% | 79.5% | 2.3% | 1.5% | 0.1% | 0.1% | NA | NA |
| | WM1W6 | 67.5% | 85.5% | 1.1% | 1.1% | 0.1% | 0.1% | NA | NA |
| | WM1W7 | 69.2% | 84.3% | 3.8% | 1.9% | 0.3% | 0.1% | 0 | 0 |
| Wetland Mitigation Phase II | WM2W1 | 70.7% | 73.9% | 3.4% | 0.5% | 0.1% | 0.0% | 3 | 6 |
| | WM2W2 | 77.9% | 85.0% | 1.1% | 0.1% | 0.1% | 0.1% | 3 | 6 |
| | WM2W3 | 80.1% | 78.6% | 1.5% | 0.3% | 0.0% | 0.0% | 16 | 12 |
| | All Basins | 71% | 77% | 2.1% | 1.8% | 0.1% | 0.1% | 5.87 | 7.47 |

**Legend:**

| | |
|---|---|
| | Performance Standard Met |
| | Performance Standard Not Met |

Results of vegetation monitoring varied greatly. Nearly half of the basins met the VIBI standards, including all basins within the Wetland Mitigation Phase II project and the North Pines Plantation project. Most basins met the standard for unvegetated open water. Only five basins met the standard for native perennial hydrophytes in 2011.

## DISCUSSION

Comparison to vegetation parameters is best within wetlands that are near existing forested communities. Both the NPP and WM2 wetland basins met the VIBI standard in 2011. These basins had a relatively low amount of adventive vegetation establishment. Perhaps the location of

these wetlands in perimeter areas provided a higher-quality base of soil and seedbank for vegetation establishment. Also, several basins are exhibiting a high frequency of volunteer woody vegetation establishment. This may further act as a deterrent for undesirable vegetation. It should be noted that the location of the WM2 and NPP wetlands also appears to be a factor in amphibian community development. The two highest AIBI scores across all wetland basins were from WM2W3 and NPPW4 (Table V). Ambystomatid salamander larvae and adults have been observed in both the WM2 and NPP wetlands in recent years. These observations are consistent with GIS-based evaluations that Ohio EPA conducted, where the presence of existing amphibian habitat (specifically vernal pools) is an important factor in mitigation site selection[10].

For other wetland basins, it is difficult to discern a pattern for vegetation at this time. Portions of all other wetland areas (BAP, FPA, and WM1) met the vegetation VIBI performance standard in 2011. Data show some reduction in native perennial hydrophytes across a number of basins (Table IV). However, field observations did not indicate any major shift in vegetation community structure.

The 2011 VIBI scores compare favorably with Ohio EPA's recent investigations of mitigation wetlands. Researchers characterized 26 mitigation wetland projects across Ohio in 2010, via VIBI and AIBI [11]. The mean 2011 VIBI score of 43 for the basins at the Fernald Preserve (Table IV) is higher than mean VIBI score of 34.35 for the mitigation projects that Ohio EPA evaluated. Amphibian monitoring shows a similar trend. The mean 2011 AIBI score of 7.47 (Table 40) is over twice as high as the mitigation average of 3.50, and it is very similar to the average of 7.48 for the natural emergent wetlands evaluated.

Results of soil biogeochemical sampling are consistent with other mitigation wetland evaluations in Ohio[12]. The hard clay pan that is typically constructed to retain surface water limits the establishment of a loose, organic soil column. Field sampling often showed strong stratification, with a relatively thin organic layer sitting on a very dense, low organic clay horizon. It is interesting to note that the FPA wetlands came closest to meeting the performance standard for both percentage of solids and percentage of total organic carbon. It could be argued that the construction of these wetlands was the most challenging on site, since remediation activities left large stretches of subsoil as the starting point for restoration. The resulting use of yard-waste compost as a soil amendment in FPA may have provided a good base for a buildup of organic soils in wetland basins.

Soil biogeochemistry is expected to improve over time. Monitoring of the hydrologic regime and vegetation was consistent across site wetlands and showed that basins are sufficiently inundated and supporting diverse wetland communities. The presence of vegetation and anoxic conditions due to prolonged periods of inundation will result in a buildup of organic matter, less bulk density, and a lessoning of the line of distinction between organic layer and mineral layer[13]. Indeed, the jurisdictional wetland delineation conducted in 2011 demonstrated that hydric soils have developed within all of the wetlands evaluated.

## CONCLUSIONS

The entirety of monitoring results indicates successful establishment of created wetlands at the Fernald Preserve. While not all performance standards were met, the data show that hydrology is

supporting wetland vegetation establishment and hydric soil development. The performance standards are not intended to be "pass/fail" criteria. They are instead reference points for use in making decisions regarding future monitoring and maintenance.

Although the monitoring results show mixed compliance with performance standards, the field data collected, along with wildlife observations and progress photographs, indicate that quality wetlands are forming. The approximately 31 acres of mitigation wetlands on the Fernald Preserve are likely of higher quality than the cattail marsh impoundments that were replaced. Therefore, for the purposes of compensatory mitigation, the 17.85-acre wetland creation goal has been met.

The three-year monitoring effort was summarized in a report submitted to the Natural Resource Trustees following the 2011 field season[14]. The *Fernald Preserve Wetland Mitigation Monitoring Report* was approved by the Trustees in April 2012. The Trustees approved with the provision that long-term monitoring of the wetlands continues at the Fernald Preserve. Monitoring activities provide pertinent data that are needed to make informed ecosystem management decisions and that are an important component of the adaptive management process. Continued wetland mitigation monitoring will be accomplished through the site functional monitoring program. This effort, which was also established in the NRRP, involves an ecosystem-level evaluation of major community types at the Fernald Preserve[1]. Wetlands, prairies, and forest communities are evaluated on a 3-year rotation. Reporting will continue through annual Site Environmental Reports, with periodic updates to the Natural Resource Trustees and other stakeholders as needed.

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