LimnoTech
Water Environment | Scientists Engineers

MEMORANDUM

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To: Liz Berg
Core Team

Date: July 31, 2026
Project: Great Lakes Coastal Wetland Conservation Framework
CC: Steering Team

SUBJECT: **Proposed Approach for Current and Desired Status of Coastal Wetland Indicators for the Great Lakes Coastal Wetland Conservation Framework**

Introduction

The Great Lakes Coastal Assembly (GLCA) is a binational, voluntary partnership of researchers and organizations committed to large-scale conservation of coastal wetlands in the Great Lakes region. The GLCA collaborated with over 30 organizations to develop a framework to advance Great Lakes coastal wetland conservation in the U.S. and Canada. Three objectives were defined to develop this framework:

1. Establish existing baseline extent and condition of Great Lakes coastal wetlands;
2. Determine extent and condition of coastal wetland types needed to help achieve the goals of a net gain in coastal wetland habitat and healthy Great Lakes and coastal communities; and
3. Identify where to focus coastal wetland efforts to achieve healthy Great Lakes and coastal communities.

The GLCW Framework is intended to provide information on the current state of various ecosystem services and to allow users to plan improvements to or preservation of those services through targeted conservation activities, which may include restoration, enhancement, and/or protection actions. Monitoring the response of coastal wetlands following the implementation of conservation

strategies is an integral part of the overall GLCW Framework to assess the realized benefits of restoration, enhancement, and protection activities.

A technical team, led by LimnoTech, was tasked with developing a Lake Erie pilot of the GLCW Framework to address Objectives Two and Three, while drawing on information produced by NOAA and its contractor in support of Objective One. This technical memorandum documents the development of a draft approach and preliminary results for the current and desired status for indicators of coastal wetland health in support of the ecological services/functions and human well-being services identified for GLCWs (LimnoTech 2023). The selection of ecosystem services and indicators for the GLCW Framework is documented in a separate technical memorandum (LimnoTech 2026).

Approach and Methodology

Assessment of coastal wetland conservation options within the GLCW Framework requires developing a set of ecosystem service indicators and defining the current and desired statuses for each indicator. The preliminary set of ecosystem service indicators includes wetland condition and extent indicators, as described in the Ecosystem Services and Indicators technical memorandum (LimnoTech 2026). Wetland condition indicators generally relate to taxa group indices that describe the state of wetland health (e.g., Bird Index of Biotic Condition (IBC), Fish Index of Biotic Integrity (IBI)). Wetland extent indicators describe the quantity of coastal wetland area, in terms of total extent, the degree to which it is maintained, and the area affected by conservation actions. Table 1 lists the preliminary set of coastal wetland indicators that were developed for this pilot study. At this stage of the GLCW Framework development effort, human well-being indicators have not been fully developed. They therefore are not the focus of this documentation (see LimnoTech 2026 for further discussion). It is anticipated that the current and desired status concepts and evaluation will be extended to cover indicators of human well-being needs once they have been established.

Table 1. Coastal wetland indicators selected for the GLCW Framework.

Indicator Group	Indicator Name[1]	Description
Wetland Condition	Vegetation IBI	Wetland plant presence, abundance, and diversity at the site scale. (Dybiec et al. 2020)
	Invertebrate IBI	Diversity of macroinvertebrate community quantified at the site scale; used to infer water quality, habitat suitability, and biological integrity. (Uzarski et al. 2004)
	Fish IBI	Composition and diversity of fish community quantified at the site scale; used to infer suitability of habitat and water quality. (Cooper et al. 2018)
	Amphibian IBC	Composition and occurrence of wetland breeding amphibians quantified at the site scale (Howe et al. 2023)

Indicator Group	Indicator Name[1]	Description
	Bird IBC	Composition and occurrence of wetland birds quantified at the site scale (Howe et al. 2023)
Wetland Extent	Total Wetland Maintenance	Determination of whether annual *total* wetland extent meets or exceeds the Minimum Expected Area (MEA) in at least 80% of years within a rolling 10-year window (based on Objective One datasets and water-level regression models)
	Emergent Wetland Maintenance	Determination of whether annual *emergent* wetland extent meets or exceeds the MEA in at least 80% of years within a rolling 10-year window (based on Objective One datasets and water-level regression models)
	Restored Area	Cumulative area (acres) of coastal wetland restored through conservation actions supported by the GLCW Framework, tracked from the Framework baseline year.
	Enhanced Area	Cumulative area (acres) of coastal wetland enhanced through conservation actions supported by the GLCW Framework, tracked from the Framework baseline year.
	Protected Area	Cumulative area (acres) of coastal wetland protected through conservation actions supported by the GLCW Framework, tracked from the Framework baseline year.

[1] IBI refers to *index of biotic integrity,* and IBC refers to *index of biotic condition*.

The following sections discuss spatial-scale considerations and the specific approaches proposed to quantify the current and desired statuses of indicators of wetland condition and wetland extent.

Spatial Scale

The status of wetland indicators can be assessed at a variety of spatial scales, ranging from wetland site scale to Great Lakes basin-wide scale. Note that different scales may be used for different purposes. For example, assessing the current state of wetland health may be most meaningful and useful at a regional or lake-wide scale, whereas planning restoration activities is more appropriate at the individual site level. Therefore, it is important to be able to aggregate and visualize indicator status at multiple spatial scales. The current GLCW Framework proposes using two spatial scales to visualize current and desired status: lake-wide and *shoreline regions*.

The lake-wide scale entails aggregating all spatial information into a single status for each indicator. For example, all of Lake Erie and the Huron-Erie Corridor could be assessed as a single unit using a weighted average or a sum of the site-specific results that support the indicator. The *shoreline region* scale segments the Lake Erie system into subregional areas corresponding to the Western, Central,

and Eastern Basins of Lake Erie, and the Huron-Erie Corridor. The *shoreline regions* used by the GLCW Framework align with those established in the Lake Erie Lakewide Action and Management Plan. Further, these four regions are segmented by the international border to account for different restoration initiatives and prioritization approaches between the United States and Canada (Figure 1). Similar to the lake-wide scale, the indicator scores for each shoreline region are based on aggregating the indicator scores for individual wetland sites within each region (i.e., by summing or area-weighted averaging of results).

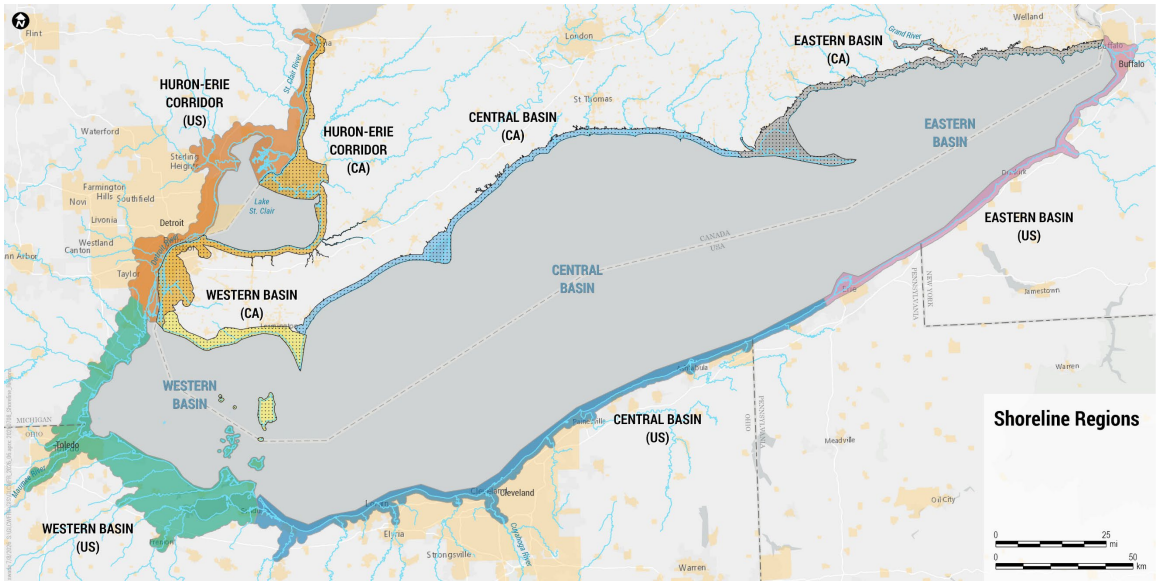

Figure 1. Shoreline Regions for the Lake Erie pilot of the GLCW Framework.

Wetland Condition Indicators

Wetland condition indicators (Table 1) are defined to be consistent with metrics developed and calculated by the Great Lakes Coastal Wetland Monitoring Program (CWMP). The CWMP has computed *indices of biotic integrity* (IBIs) and *indices of biotic condition* (IBCs) for various wetland condition indicators for 2011-2025, with the program's data collection efforts and indicator calculations expected to continue into the foreseeable future. The methodologies for computing the taxa-based indicator scores are documented for the vegetation IBI (Dybiec et al. 2020), fish IBI (Cooper et al. 2018), invertebrate IBI (Uzarski et al. 2004, 2017), and amphibian and bird IBCs (Howe et al. 2023). The approach for quantifying the status of wetland condition indicators at the shoreline region scale is based on the area assessed by the CWMP for the monitored wetland sites within a given region. Specifically, the *assessed area* of a site is defined based on the area of the site-specific polygons established circa 2010 and consistently used by the CWMP to guide the selection of sampling locations at the sites. This approach to defining the assessed area represents the wetland areas where monitoring has actually occurred, while avoiding the complexities of varying the assessment area based on year-over-year landscape changes or the uncertainty of extrapolating site-specific results to unmonitored areas.

It should be noted that because the assessed area for a given site is static, it will not precisely match the total wetland area in the vicinity of the site as identified in the Objective One wetland coverage data products. Figure 2 illustrates the differences between the CWMP assessed area (blue outline in panel "a") and the wetland area identified by the Objective One analysis (emergent, shrub/scrub, and forested wetland in panel "b") for the Swan Creek Wetland (site 1915), which is located along the Ohio shoreline of Lake Erie. The points depicted in panel "a" represent specific locations that the CWMP has sampled for amphibians, birds, fish, invertebrates, and vegetation during the 2011-22 monitoring timeframe. The sampling points are all clustered within or immediately adjacent to the CWMP polygon (panel "a"). By comparison, the wetland coverage based on Objective One in panel "b" includes emergent, scrub/shrub, and forested areas that extend beyond the CWMP polygon boundary. For example, there are roughly 50 acres of emergent wetland upstream along the southern bank of Swan Creek that are not included in the CWMP polygon. As indicated by the points in panel "a", monitoring has not been conducted in that area. This illustration highlights that defining the assessed area based on the CWMP polygon area appropriately represents the area monitored by the program.

The CWMP does not monitor all coastal wetlands within a given shoreline region. To be eligible for CWMP monitoring, a wetland must meet several site selection criteria established in the CWMP Quality Assurance Project Plan: (1) the wetland must be at least 4 hectares (~10 acres) in size; (2) it must have a surface water connection to the lake; (3) it must fall within the zone of lake hydrologic influence; and (4) it must contain herbaceous (emergent or aquatic) vegetation. As a result, the acreages and condition ratings reported here represent the subset of coastal wetland area that meets CWMP eligibility criteria, not necessarily the total coastal wetland area within each shoreline region.

The aggregation of site-level IBI and IBC scores for the wetland condition indicators is derived by tabulating site-specific scores and associated assessed areas, then calculating area-weighted results for a given shoreline region based on the sites within that region. The availability of site data and the magnitude of assessed area vary considerably by region. For example, data are available for more than 20 sites in the "Western Basin (US)" region, while five (5) or fewer sites have been monitored in the "Central Basin (US)" and "Eastern Basin (US)" regions. Further details regarding the number of sites assessed and the assessed area for individual shoreline regions and indicators are provided in the *Current and Desired Status of Indicators* section.

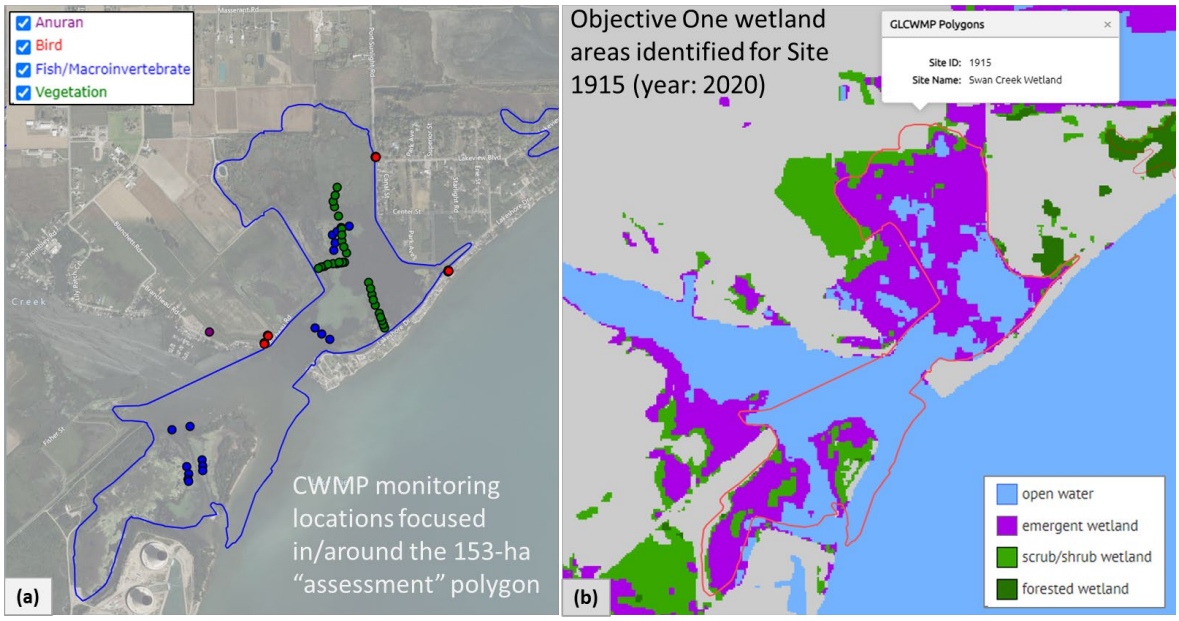

Figure 2. Comparison of CWMP "Assessed Area" to Objective One (draft) wetland coverage for Swan Creek Wetland (Site 1915).

Wetland Extent Indicators

Wetland extent is characterized in the GLCW Framework via management activity-tracking extent indicators, as well as maintenance of total and emergent wetland classes (Table 1).

Wetland Management Activity-tracking Indicators

The GLCW Framework tracks three management activity-tracking extent indicators: Restored Area, Enhanced Area, and Protected Area. These indicators measure the cumulative area of coastal wetland conservation actions completed within each shoreline region relative to the Framework baseline year (defined as the publication year of the Framework DST), providing a direct record of on-the-ground conservation progress. Unlike the *maintenance* indicators, which assess whether existing wetland extent is being sustained relative to a water-level-adjusted expected baseline, the *management activity-tracking* indicators track incremental outcomes from active conservation investment. The current status of all three management activity-tracking indicators is zero (acres) at the Framework baseline year, as these indicators track actions completed after Framework adoption. The definitions of Restored, Enhanced, and Protected areas provided below are consistent with the definitions provided in the **Compensatory Mitigation for Losses of Aquatic Resources under CWA Section 404** final rule document published by the U.S. Army Corps of Engineers (USACE) and USEPA (USACE and EPA 2008).

Restored Area measures the cumulative area of coastal wetland re-established or substantially restored in areas where wetlands had previously been converted to other land cover/use.

Restoration activities typically involve re-establishing natural hydrology, facilitating the return of native wetland vegetation, and providing conditions for the recovery of associated biotic communities. Of the three management activity-tracking indicators, restoration most directly contributes to the expansion of total coastal wetland extent.

Enhanced Area measures the cumulative area of coastal wetland that has received targeted management interventions to improve ecological function, quality, or resilience. Enhancement activities may include invasive species control, hydrologic reconnection, substrate amendment, and other active management practices that improve wetland condition without necessarily adding new wetland area. Enhancement actions focus on existing wetland areas where active management can yield meaningful ecological improvements.

Protected Area measures the cumulative area of coastal wetland secured against future degradation, conversion, or loss through durable legal or institutional mechanisms. Protection activities include conservation easements, voluntary land acquisition, stewardship agreements, and similar instruments that establish long-term or permanent safeguards for existing wetland areas. By capturing the area brought under formal protection, this indicator reflects the Framework's contribution to preventing net loss of coastal wetland assets in the Lake Erie basin.

Maintenance of Wetland Extent Indicators

The maintenance of existing total and emergent wetland classes is tracked as extent indicators in the GLCW Framework (Table 1). Unlike the *management activity-tracking* indicators, which measure the cumulative area of completed conservation activities, the *maintenance* indicators assess whether the existing areal extent of each wetland class is being sustained relative to a water-level-adjusted baseline. Estimates of historical and recent areal extent for these indicators can be obtained via the geospatial data products from Objective One for years 2000-2020 (draft products produced in December 2024). These spatial data products provide explicit geospatial estimates of the historical and current (i.e., most recent) status of wetland extent for these two maintenance indicators. The following sections describe the approach for quantifying changes over time to the maintenance wetland extent indicators and the supporting rationale.

For the purposes of assessing conservation priorities and realized benefits from wetland project implementation within the GLCW Framework, the maintenance wetland extent indicators need to account for natural variability due to water-level fluctuations. The extent, position, and distribution of wetland plant communities are functions of the local water-level regime, as interannual fluctuations can cause wetlands to migrate upslope or downslope in response to changes in wetting/drying cycles. Extended high-water periods can promote upslope migration of the wetland, with trees and shrubs replaced by marsh plant species. Conversely, extended low-water periods tend to promote downslope plant migration, with submerged aquatic vegetation (SAV) and emergent communities shifting towards the lake, and trees/shrubs replacing marsh plants further upslope. Because water level fluctuations have such a strong influence on wetland extent, it is essential to

distinguish between the influence of water level fluctuations and the net effect of GLCW conservation activities.

The importance of establishing an expected wetland extent as a function of water levels is illustrated in Figure 3, which provides example time series of wetland extent under both a "status quo" (dotted blue line) and a restorative scenario (solid orange line) under the influence of fluctuating water levels. While hypothetical, this example provides a realistic view of why it is necessary to establish an expected (reference) wetland extent for a given water-level regime. In the example, the total wetland extent for a particular region is ~48,000 acres in 2025, the reference year. In the "status quo" scenario (water-level impact only), we assume that no restoration activities are taking place in the region and that the dynamic response of the total wetland area is solely due to water-level fluctuations. Increasing water levels between 2025 and 2030 temporarily reduce the total wetland area due to compression of emergent communities. Decreasing water levels between 2030 and 2040 result in the total wetland area returning to the original (2025) coverage, then further expanding after 2035. This line represents the expected wetland extent – i.e., the total wetland area expected when water levels change but all other influencing factors are held (roughly) constant.

In this example, the total wetland area for the restoration scenario ("realized/observed wetland extent") remains strongly influenced by water-level fluctuations. Without an assessment of the expected reference extent (blue line), perceptions of the change vary by year. If the 2025 wetland area is being used as a reference point, the perceived changes in 2030, 2035, and 2040 are -9%, 0%, and +15%, respectively. Because those perceived changes do not account for the varying impacts of water levels over time, they provide an inconsistent and confusing picture of how the system is responding to restoration activities. A more meaningful and consistent picture emerges if we quantify the change relative to the expected reference area for each year. Under that approach, the realized changes in total wetland area are +2.0%, +2.5%, and +5.0% for years 2030, 2035, and 2040, respectively. In the GLCW Framework, zones that show a status quo or net gain in extent would be considered "maintained." In contrast, zones that demonstrate a net loss after accounting for the natural water level related response would be considered "not maintained." Additional details on the underlying calculations used to determine the GLCW extent response in individual shoreline regions to water-level fluctuations are presented in Appendix A.

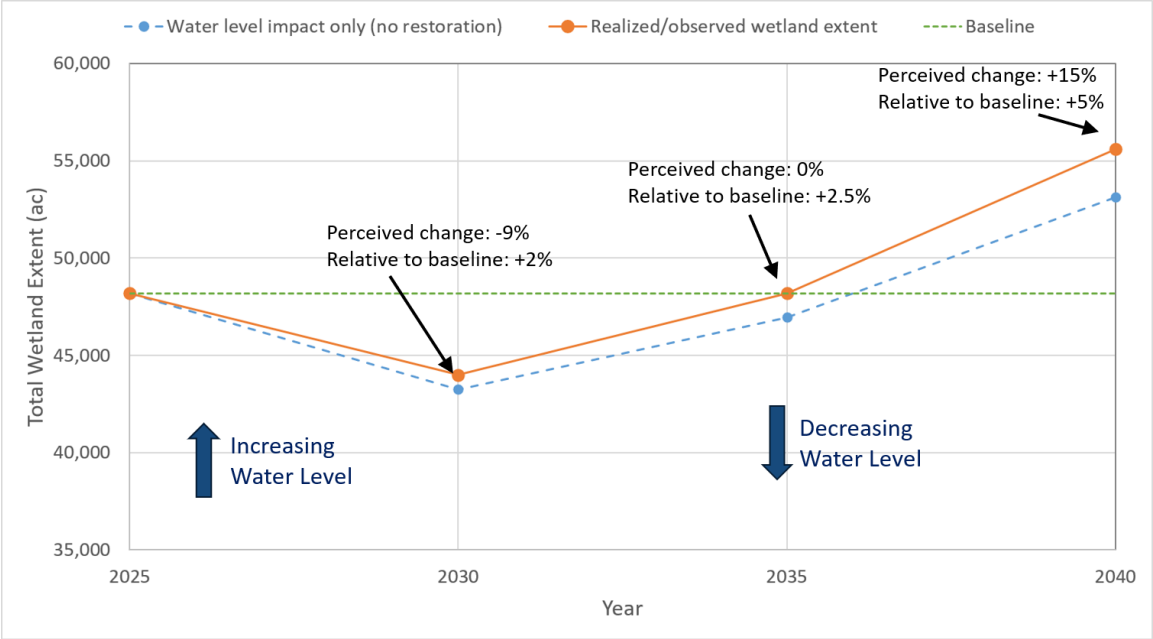

Figure 3. Illustration of natural and restorative changes in wetland extent under changing water level regimes.

Current and Desired Status of Indicators

This section summarizes *the current status and provides draft recommendations to define* the *desired status* for the wetland condition and extent indicators described above. Current and desired status are assessed at the shoreline region scale (Figure 1). Once desired status has been finalized based on partner feedback, the results will also be aggregated to the lake-wide scale to provide an overall current and desired status for Lake Erie (including the Huron-Erie Corridor) for each indicator.

Wetland Condition Indicators

This section describes the specific steps to quantify the current status and the desired status for the wetland condition indicators via the proposed approaches described in the previous section and then presents the results of those analyses.

Scoring Methodology

For the wetland condition indicators, both current and desired status can be calculated as the percentage of the assessed area that meets or exceeds a specific condition quality rating. As discussed in the previous section, the *assessed area* for a specific wetland site is not the same as the total area of a wetland site/complex estimated via Objective One. Rather, the assessed area is intended to be representative of the wetland area monitored for the indicator by the CWMP during the 2011-2025 monitoring timeframe. Monitoring protocols and time and resource constraints limit the extent of monitoring activities, even for a comprehensive program like the CWMP. Therefore, it

is important to compare the current and desired status of indicators based solely on the wetland area assessed through monitoring activities. Based on the site-specific monitoring and indicator calculation results, each site can be assigned a relative quality condition (or relative state of degradation), based on the following condition rating categories (listed in order of high → low condition/quality):

- High Quality/Reference
- Mildly Impacted
- Moderately Impacted
- Moderately Degraded
- Degraded

These rating categories generally correspond to the five quintiles between the 0^{th} and 100^{th} percentile (e.g., "High Quality/Reference" corresponds to the 80^{th}-100^{th} percentile of all Great Lakes site scores). While these categories differ from the three ratings (poor, fair, good) used by the State of the Great Lakes (SOGL) program, the proposed rating categories above allow smaller incremental improvements to be captured and communicated, highlighting progress over time. Additionally, it should be noted that while the "High Quality/Reference" category is based on all Great Lakes site scores, we do expect that the current status and desired endpoints to be "higher" in healthier lakes (e.g., Superior) and "lower" in more degraded lakes (e.g., Erie).

Current Status

Defining the *current status* of coastal wetlands provides the foundation needed to evaluate and define desired conditions, and to track progress towards that desired state over time. The current status of each wetland condition indicator was assessed using the most recently available monitoring data and IBI/IBC results from CWMP monitoring of individual GLCW sites in the Lake Erie system (including the Huron-Erie Corridor). For most sites, indicator results were available within the past 1-5 years (roughly 2018-2025), although the latest results for some sites were based on monitoring data collected before 2018. The following steps were followed to evaluate the current status for each indicator within each of the 12 shoreline regions:

1. The most recent condition rating (e.g., "Moderately Degraded", "Mildly Impacted") for the indicator was compiled along with the assessed area (i.e., CWMP polygon area) for each site within the shoreline region.
2. The total assessed area associated with each condition rating (by indicator) was summed for each shoreline region.
3. The percent distribution of each condition rating for a specific indicator was calculated based on the overall assessed area for the indicator within the shoreline region.

The steps outlined above culminated in the generation of pie charts that visualize the distribution of condition ratings for each shoreline region/indicator combination. For example, Figure 4 shows the

condition rating distributions for the fish and vegetation IBIs and the amphibian and bird IBCs for the "Western Basin (US)" shoreline region. (Note that invertebrate IBI results are not available for this shoreline region and are therefore not represented in Figure 4.) The results summarized in this figure indicate that the distribution of condition ratings varies considerably across the indicators in this shoreline region. For example, the fish IBI and amphibian IBC indicators show that over 50% of the assessed area is rated as "Degraded", while 10% or less of the assessed area is rated as "Degraded" for the other two indicators.

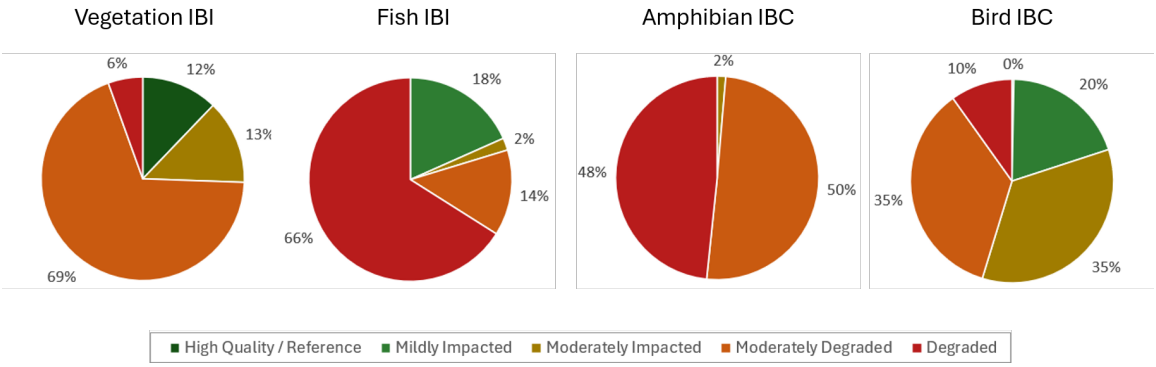

Figure 4. Distribution of wetland condition indicator condition ratings for the Western Basin (US) shoreline region.

Based on an overall assessment of the current status for the various shoreline region/indicator combinations, it is proposed that the current status and also desired status be based on the percentage of assessed area that is rated as ***"Moderately Impacted"* or better**. Another way to state this is that the current and desired status quantify the area that does not fall into one of the "degraded" categories. To extend the example for the "Western Basin (US)" shoreline region, the following statements of current status can be made based on the results in Figure 4:

- The **vegetation IBI indicator** in the "Western Basin (US)" shoreline region has a "Not Degraded" condition for 25% of the assessed area.
- The **fish IBI indicator** in the "Western Basin (US)" shoreline region has a "Not Degraded" condition for 20% of the assessed area.
- The **amphibian IBC indicator** in the "Western Basin (US)" shoreline region has a "Not Degraded" condition for 2% of the assessed area.
- The **bird IBC indicator** in the "Western Basin (US)" shoreline region has a "Not Degraded" condition for 55% of the assessed area.

Analogous statements of current status can be developed for these indicators (and the invertebrate IBI indicator, where available) for the other shoreline regions.

The proposed use of the "Not Degraded" (i.e., "Moderately Impacted" or better) threshold recognizes that it is likely not realistic to move significant fractions of the assessed area into the

"High Quality/Reference" category or even the "Mildly Impacted" category in the various Lake Erie shoreline regions. While incremental improvements relative to the current status should be possible, a variety of factors will limit the degree of improvement that can be achieved, including: the wetland's current state of degradation, historic and recent land development activities within the contributing watershed, structures (e.g., dikes) affecting water levels and water movement through the wetland, and the resources available to enhance/restore wetland areas in some regions.

Desired Status

The *desired status* statements for indicators of coastal wetland condition are intended to represent specific future target conditions to be achieved through a combination of GLCW restoration, enhancement, protection, and restoration activities implemented across the various shoreline regions to enhance ecological function and human well-being in those regions. Consistent with the above discussion, it is proposed that specific statements of desired status for the wetland condition indicators be based on the percentage of assessed area that is rated as *"Moderately Impacted" or better* (or, alternatively stated, the percentage of assessed area that is "not degraded"). A given desired status statement may reflect an improvement over the current state or continuation of an already achieved desirable state for a given shoreline region/indicator combination. In addition to quantifying what is to be achieved, the desired status statements must also incorporate a time scale for achieving the targeted condition. It should also be noted that CWMP site coverage varies across shoreline regions; on the Canadian side of Lake Erie in particular, the number and distribution of monitored sites varies by lake, which may affect the confidence of current and desired status estimates in some regions.

The proposed workflow for developing desired status statements is illustrated in Figure 5, which depicts the progression from quantifying the current status to formulating the desired status statement for the fish IBI indicator in the "Western Basin (US)" shoreline region. As discussed above, quantifying the current status is a prerequisite to defining the desired status. For the specific case of the fish IBI indicator in the "Western Basin (US)" region, the current status is that 20% of the assessed area is rated as "Moderately Impacted" or better. It is proposed that the desired status represents a 15% incremental improvement relative to the current status and that this improvement be achieved within a 20-year interval. In the Decision Support System (DSS) being developed as a Framework product, the current status will be tracked relative to the initial status (representing the baseline year) and the desired status. The current status will be updated at least once every 5 years to reflect changes in the system. Updates to the current status of the indicators may also depend on the availability of data, such as the Objective One products. There are a variety of specific approaches that could be followed to achieve the desired status for the fish IBI in the "Western Basin (US)" region. As described at the bottom of Figure 5, one approach would involve (for example):

1. Maintaining the existing 20% of assessed area (~2,700 ac) at "Moderately Impacted" or better condition ratings, and
2. Improving ~15% of assessed area (~2,000 ac) that currently falls into the "Degraded" / "Moderately Degraded" categories to a "Moderately Impacted" or better rating.

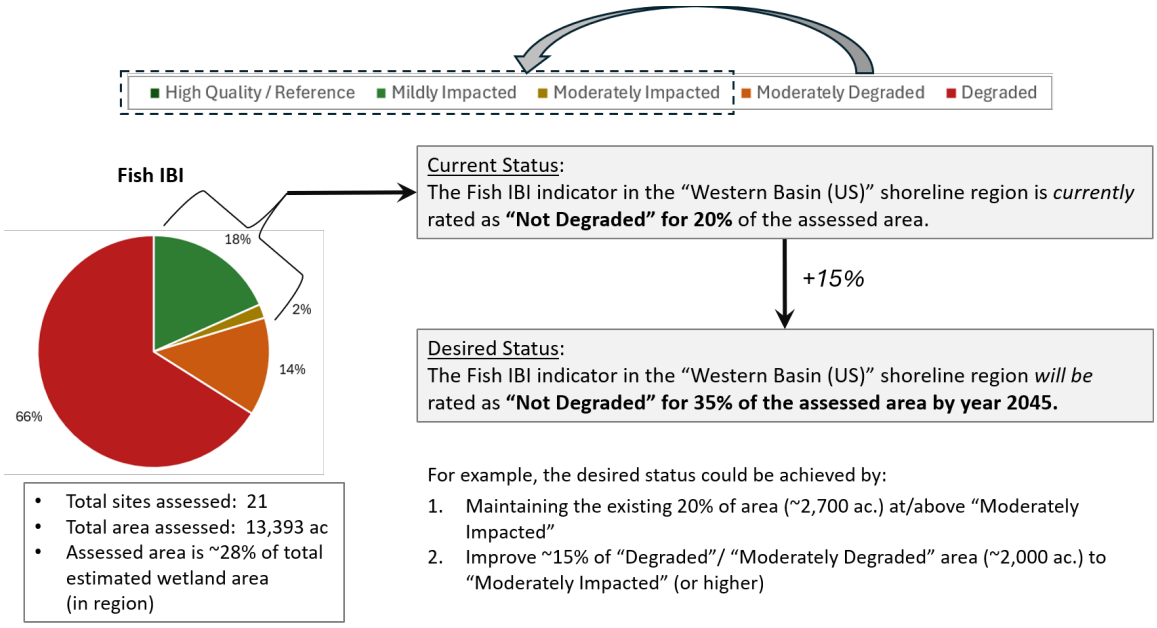

Figure 5. Workflow for Establishing Desired Status for the Fish IBI Indicator in the Western Basin (US) shoreline region.

The approach outlined above and illustrated in Figure 5 can be applied to each combination of shoreline region and wetland condition indicator. A few considerations must be kept in mind when working through the process of formulating the full set of desired status statements for the "Western Basin (US)" and other shoreline regions:

- For shoreline regions that already have a significant fraction of coastal wetland area that is rated as "Moderately Impacted" or better (i.e., not degraded), it is logical to maintain the current status into the future rather than set an overly aggressive target that will likely not be achievable (e.g., 100%).
- For any given wetland site, IBI/IBC indicator scores will vary to some degree due to natural dynamics in the wetland's environment (e.g., water level fluctuations). Therefore, it is not reasonable to expect a consistent upward trajectory for every indicator at every site being enhanced through conservation activities.
- The incremental improvements captured in the desired status statements should seek to balance the above factors and provide a target that is achievable within a 20-year timeframe.

Achieving the desired status for a given shoreline region and indicator will typically require improving the indicator's rating from a "degraded" to a "non-degraded" condition for one or more CWMP-monitored sites while avoiding (or minimizing) the degradation of "non-degraded" sites. Figure 6 provides one example scenario for how the desired status of the fish IBI indicator in the "Western Basin (US)" shoreline region could be achieved. The 21 wetland sites in this list are ordered by largest to smallest surface area of the CWMP polygon for each site. This example scenario represents

improving the rating of three sites from "Moderately Degraded" to "Moderately Impacted": Howard Marsh (ID: 7072), Woodtick Peninsula (1898), and Toledo Beach (1903). This transitions ~1,440 acres of assessed area from a "degraded" to "non-degraded" condition, resulting in an overall "non-degraded" status for 31% of the region's area. An analogous site-specific approach would be used for any of the wetland condition indicators in any of the shoreline regions.

Site ID	Site Name	Area (ac)	Area Weight	Current Rating	→	Target Rating
1885	Toussaint River Wetland	2,669	20%	Degraded	→	Degraded
1917	Mouillee Marsh	2,459	18%	Mildly Impacted	→	Mildly Impacted
1888	Ottawa National Wildlife Refuge Wetland	1,886	14%	Degraded	→	Degraded
1928	Monroe City Area Wetland	1,285	10%	Degraded	→	Degraded
1866	Bay View Wetland	1,084	8%	Degraded	→	Degraded
7072	Howard Marsh	710	5%	Moderately Degraded	→	Moderately Impacted
1933	North Maumee Bay Area Wetland	436	3%	Degraded	→	Degraded
1898	Woodtick Peninsula Wetland	431	3%	Moderately Degraded	→	Moderately Impacted
1915	Swan Creek Wetland	377	3%	Moderately Degraded	→	Moderately Degraded
1903	Toledo Beach Wetland	296	2%	Moderately Degraded	→	Moderately Impacted
1867	Willow Point Wetland	292	2%	Degraded	→	Degraded
1904	Otter Creek Wetland	233	2%	Degraded	→	Degraded
1918	Rockwood Road Wetland	213	2%	Degraded	→	Degraded
1889	Metzger Marsh	192	1%	Moderately Impacted	→	Moderately Impacted
1870	Port Clinton Wetland	189	1%	Degraded	→	Degraded
7066	Monroe Dikes B	186	1%	Degraded	→	Degraded
1896	Halfway Creek Wetland	178	1%	Degraded	→	Degraded
7062	Monroe Dikes A	130	1%	Degraded	→	Degraded
1919	Cherry Isle Wetland	68	1%	Moderately Impacted	→	Moderately Impacted
1913	Stony Point Wetland	64	0%	Degraded	→	Degraded
1880	East Harbor Wetland #2	13	0%	Moderately Degraded	→	Moderately Degraded

	Current Status		Target Status
% Not Degraded	20%	→	31%

Figure 6. Example scenario for achieving the Desired Status for the Fish IBI Indicator in the Western Basin (US) shoreline region.

A full set of desired status statements was developed for the "Western Basin (US)" shoreline region and the other shoreline regions based on the guidelines outlined above. Table 2 provides statements developed for the "Western Basin (US)" region, along with supporting information on the wetland site count and area assessed, and the current status (i.e., based on the "Moderately Impacted" or better threshold). The following limitations and caveats should be noted:

- For the Huron-Erie Corridor (HEC), the current and desired status are based on a combined assessment of data available for the U.S. and Canadian shorelines between the Lake Huron outlet and the Detroit River mouth. Because no CWMP monitoring data are available for sites on the St. Clair River, the overall HEC assessment is based solely on data from Lake St. Clair and the Detroit River.
- Results for the invertebrate IBI are not available for sites within all of the shoreline regions. So the current and desired statuses for this indicator may be indicated as "n/a" (not available), as is the case in Table 2.

All desired status statements and associated incremental improvement targets represent preliminary drafts at this time. It is anticipated that the desired status approach and specific targets will be further refined through ongoing collaboration with the GLCW Framework's partner workshops and Steering Team. Ultimately, the current and desired status information will be integrated into the Great Lakes Coastal Wetland Decision Support System (GLCW-DSS) being developed to support the GLCW Framework, and made broadly accessible to coastal wetland managers, conservation partners, and the general public through that portal.

Table 2. Proposed Desired Status Statements for Wetland Condition Indicators in the "Western Basin (US)" Shoreline Region.

Indicator	Not Degraded (Current)	Not Degraded (Target)	% Increase	Desired Status Statement	Sites Assessed (#)	Area Assessed (%)
Vegetation IBI	26%	>= 40%	>= 14%	Vegetation IBI in 'Western Basin (US)' will be rated as 'Not Degraded' for >= 40% of the assessed area by year 2045.	23	32%
Fish IBI	20%	>= 35%	>= 15%	Fish IBI in 'Western Basin (US)' will be rated as 'Not Degraded' for >= 35% of the assessed area by year 2045.	21	28%
Invertebrate IBI	n/a	n/a	n/a	n/a	0	0%
Amphibian IBC	1%	>= 15%	>= 14%	Amphibian IBC in 'Western Basin (US)' will be rated as 'Not Degraded' for >= 15% of the assessed area by year 2045.	32	47%

Indicator	Not Degraded (Current)	Not Degraded (Target)	% Increase	Desired Status Statement	Sites Assessed (#)	Area Assessed (%)
Bird IBC	55%	>= 65%	>= 10%	Bird IBC in 'Western Basin (US)' will be rated as 'Not Degraded' for >= 65% of the assessed area by year 2045.	32	47%

Static Maps of Desired Status

Due to the large number of shoreline regions in Lake Erie, it is effective to display current and desired status information on a static map that provides a spatial representation of the entire lake and its individual regions in a single view. Based on discussions with the Steering Team, an approach has been developed to display current and desired status on a single map, depicting the trajectory from current to desired status. Draft static maps displaying this information are provided for the vegetation IBI (Figure 7), fish IBI (Figure 8), invertebrate IBI (Figure 9), amphibian IBC (Figure 10), and bird IBC (Figure 11) indicators. These maps show the scores at the shoreline regional scale, with each region labeled to indicate the current assessment of “moderately impacted or better” areas, and an arrow indicating the desired/target percentage. An inset map located to the left of the legend provides the lake-wide aggregate current and desired status for each indicator. The color symbology of the maps represents only the desired status, with green and red indicating, respectively, higher and lower percentages of the assessed area at or above the “Moderately Impacted” condition threshold. Note that for the invertebrate indicator (Figure 9), several zones lack an assessment of current or desired status; therefore, no information is shown on the map for those regions.

The draft versions of the desired status maps have been developed based on discussions with and initial feedback from the GLCW Framework Technical Team and Steering Team. The GLCW-DSS will allow users to rapidly visualize current and desired status for the various indicators and also “drill down” into more detail for wetland condition at the shoreline region and shoreline planning zone levels.

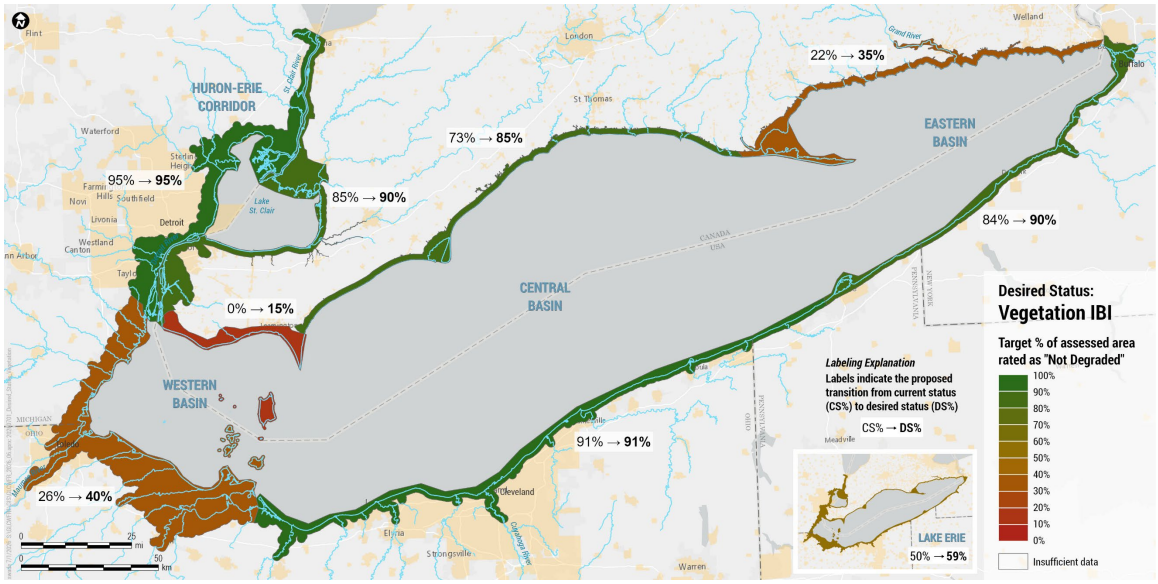

Figure 7. Current-to-Desired Status of Vegetation IBI indicator on the shoreline region scale.

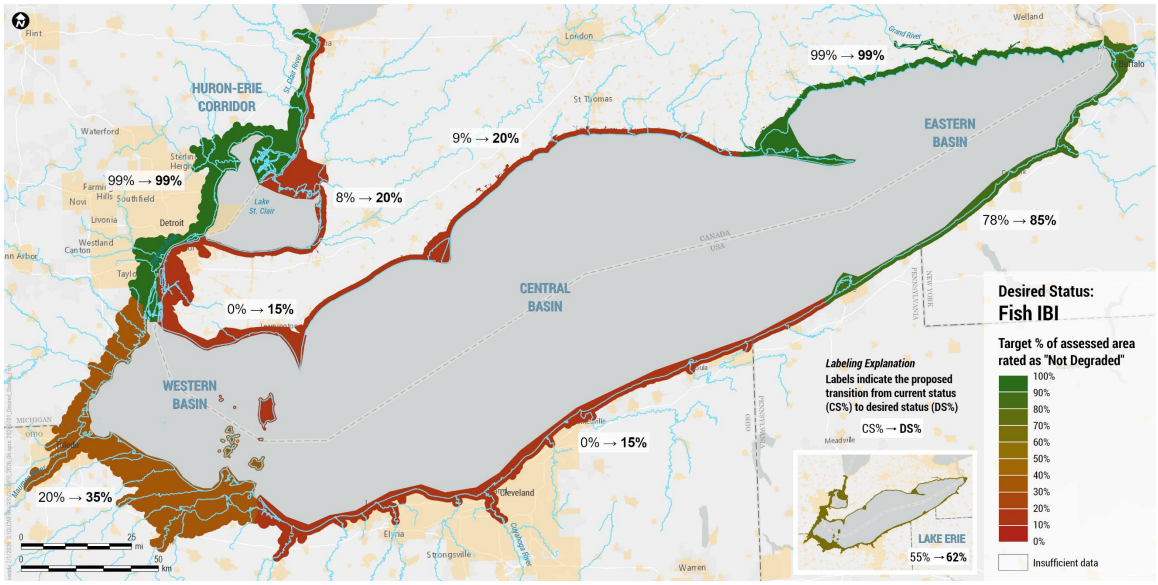

Figure 8. Current-to-Desired Status of Fish IBI indicator on the shoreline region and lake-wide scales.

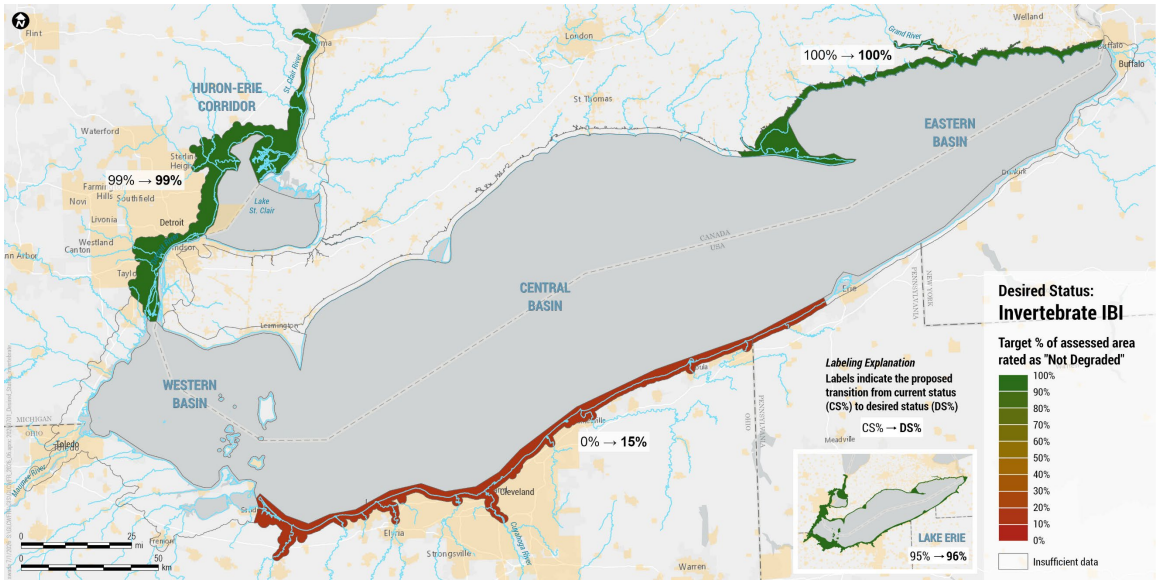

Figure 9. Current-to-Desired Status of Invertebrate IBI indicator on the shoreline region and lake-wide scales.

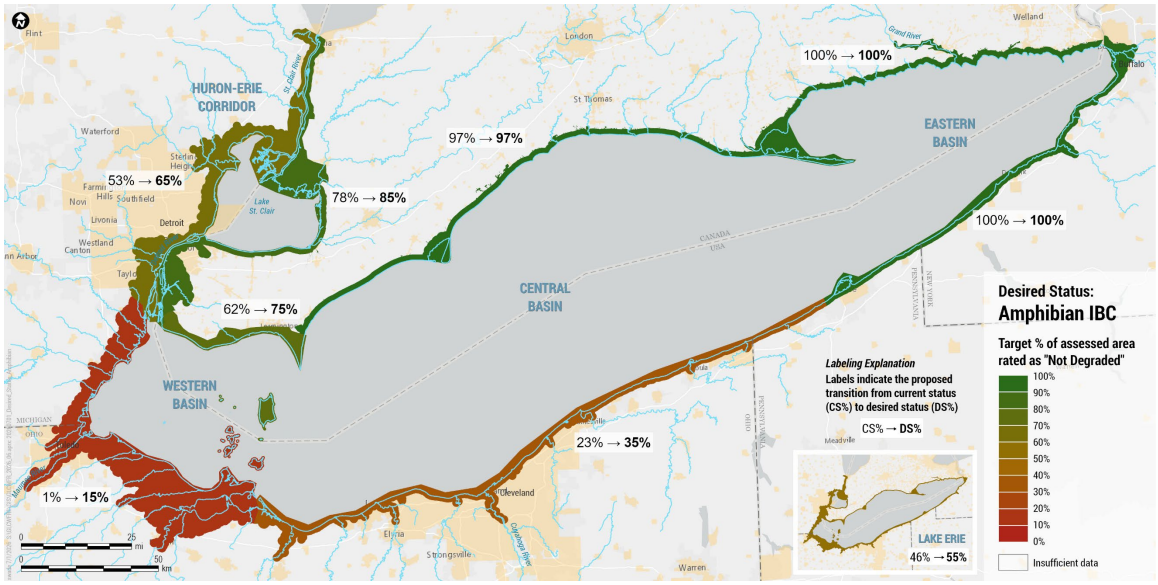

Figure 10. Current-to-Desired Status of Amphibian IBC indicator on the shoreline region and lake-wide scales.

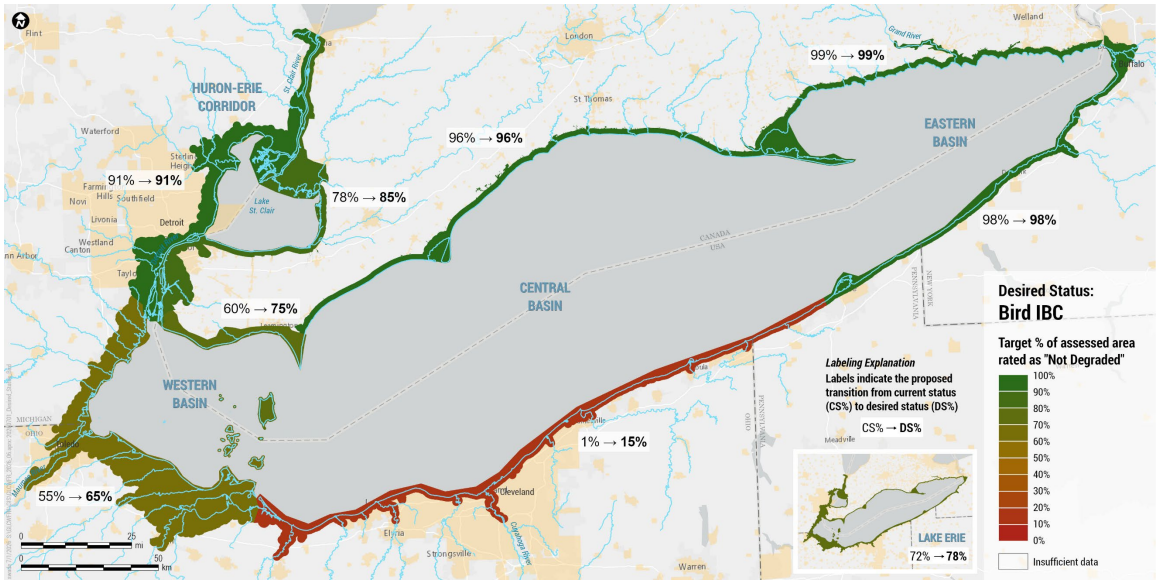

Figure 11. Current-to-Desired Status of Bird IBC indicator on the shoreline region and lake-wide scales.

Wetland Extent Indicators

This section describes the proposed steps for quantifying the current status and defining the desired status for the wetland extent indicators and presents draft desired status results based on those analyses.

Current Status

The management activity-tracking wetland extent indicators (Restored Area, Enhanced Area, and Protected Area) are defined as areal changes relative to the current state for each of the eight shoreline regions. As such, the current status for all three indicators is defined as zero (acres) as a baseline referenced to the year of Framework adoption; however, the baseline definition may change based on partner workshop discussions and associated recommendations.

The current status of the wetland extent maintenance indicators is defined as “maintained” based on use of the Objective One products to define baseline wetland extent conditions for years 2000-2020. Future tracking of whether these indicators are determined as “maintained” or “not maintained” is assessed using the regression-based baseline described in Appendix A, which estimates the expected Minimum Expected Area (MEA) of wetland for each analysis zone as a function of water-level history.

Desired Status

All desired status targets presented in this memorandum are proposed values intended to serve as starting points for discussion at the August 2026 partner workshops. Specific targets are expected to be refined via the broader partner workshops and through collaboration with the GLCW Framework Steering Team and Core Team.

Management Activity-Tracking Indicators

Table 3 presents proposed desired status targets for the management activity-tracking wetland extent indicators (Restored, Enhanced, and Protected Area) for each of the eight shoreline regions. The current status of all three indicators is set to zero (acres) in the Framework baseline year (2025). All target values are proposed starting points and will be refined through discussion at the August 2026 partner workshops.

The key reference used for developing the initial estimates for restoration, enhancement, and protection areas was *Measure of Progress 4.1.1* under Focus Area 4 (Habitats and Species) in the Great Lakes Restoration Initiative Action Plan IV (USEPA et al. 2025). This measure defines a target of 568,000 acres of "*coastal wetland, nearshore and other habitats protected or enhanced"* by FY 2029 relative to the FY 2024 baseline across the entire Great Lakes basin. This represents a total increase in the area addressed by conservation actions of ~7.2% over a 5-year period, corresponding to a 1-2% year-over-year increase basin-wide. The percentage-based estimates were used as the basis for estimating Lake Erie shoreline region target acreage for restoration, enhancement, and protection based on the following stepwise approach:

- The initial (i.e., year 0) coastal wetland area in Lake Erie was roughly estimated to be 74,200 acres based on the emergent area estimated by Objective One for 2020, the most recent year available. This represents ~14% of the 530,000-acre baseline area defined in Action Plan IV.
- The year-over-year percentages defined for Measure of Progress 4.1.1 were used to estimate the total GLCW area to be addressed by conservation actions during years 1-5 (e.g., 2027-2031) of the Framework (~5,320 acres). For the purposes of these estimates, it was assumed that the percentages applied to all conservation actions defined under the Framework, including restoration, enhancement, and protection activities.
- For years 6-20 under the GLCW Framework timeline, the year-over-year increase of acreage addressed by conservation actions was estimated at 0.60% per year, representing roughly half of the rate projected in Action Plan IV for FY 2025-2029. This rate is more conservative but assumes ongoing GLRI (and supplemental) funding to sustain GLCW conservation work at ~50% of current levels.
- Based on the above approach, the cumulative acreage of Lake Erie GLCW area addressed by conservation actions is estimated at ~12,800 acres by 2045. This corresponds to roughly 17% of the estimated initial area of 74,200 acres for Lake Erie.
- The total conservation area (~12,800 acres) was subdivided into restoration, enhancement, and protection area contributions. For simplicity, it was assumed that restoration, enhancement, and protection areas would account for 20%, 50%, and 30% of the total conservation acreage, respectively. This produced estimates of 2,560 acres for restoration, 6,400 acres for enhancement, and 3,840 acres for protection.

- As a final step, the restoration, enhancement, and protection areas were assigned to individual shoreline regions based on the average percentage of emergent wetland area represented in that shoreline area based on the Objective One products (December 2024 version) for 2000-2020. The results of this final step are reflected in Table 3.

The approach outlined above for assigning desired status for restored, enhanced, and protected areas is not intended to be prescriptive. Rather, it is intended to provide technically defensible initial estimates based on the relevant measure of progress for Focus Area 4 of GLRI Action Plan IV.

Table 3. Proposed Desired Status for Wetland Extent Management Activity-Tracking Indicators by Year 2045 for each Shoreline Region.

Shoreline Region	Current Status (ac)	Restored Area Target (ac)	Enhanced Area Target (ac)	Protected Area Target (ac)
Huron-Erie Corridor (US)	0	340	850	510
Huron-Erie Corridor (CA)	0	650	1,620	970
Western Basin (US)	0	780	1,950	1,170
Western Basin (CA)	0	120	290	180
Central Basin (US)	0	70	190	110
Central Basin (CA)	0	60	150	90
Eastern Basin (US)	0	50	120	70
Eastern Basin (CA)	0	490	1,230	740

Maintenance Indicators

The desired status for the maintenance indicators is that all shoreline regions are classified as "maintained" for both total and emergent wetland area. A shoreline region is classified as "maintained" when the areal extent estimated by the Objective One methods meets or exceeds the Minimum Expected Area (MEA) for the respective analysis zones, as derived from the regression-based baseline described in Appendix A, for 80% of the years over a 10-year rolling period. This approach accounts for natural water-level-driven variability, ensuring that the maintained/not maintained determination is dictated by realized changes in wetland area conditions rather than year-to-year hydrological fluctuations. While these indicators are computed using a 10-year retrospective analysis, it is anticipated that the status will be reassessed every 5 years.

Maps of Desired Status

Figure 12 illustrates the proposed desired status for the Restored Area indicator for each Lake Erie shoreline region. Wetland restoration activities involve re-establishing wetland extent and function in areas where wetlands have been degraded or lost, typically by restoring hydrology, native

vegetation, and associated biotic communities. An initial proposal for acreage targets for each shoreline region is presented in Table 3 (and Figure 12) and will be discussed and refined at the August 2026 partner workshops.

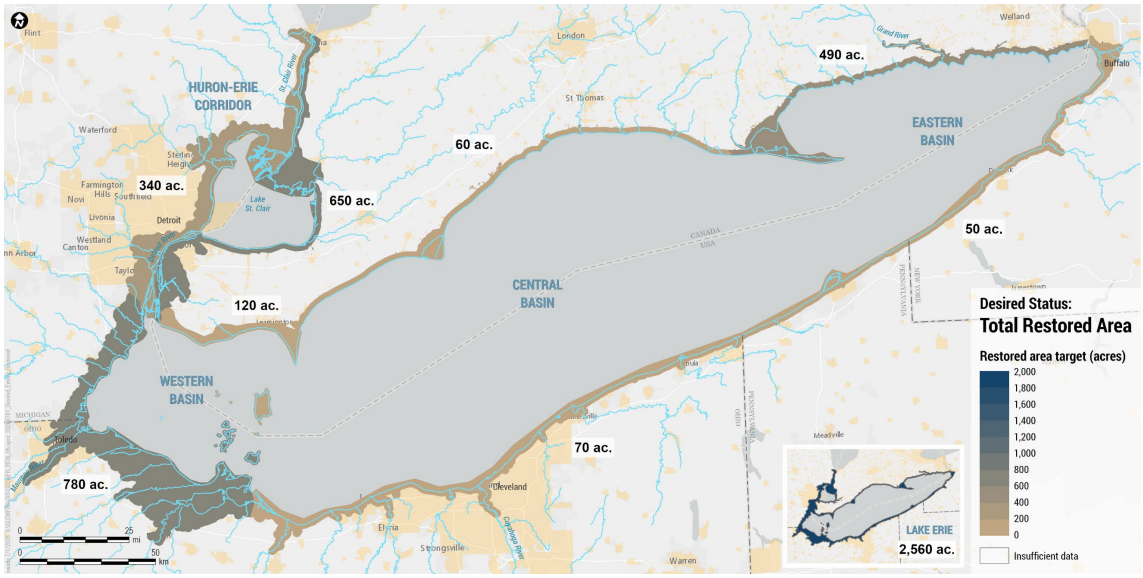

Figure 12. Desired Status of Restored Area indicator.

Figure 13 illustrates the proposed desired status for the Enhanced Area indicator for each Lake Erie shoreline region. Wetland enhancement activities include management interventions, such as invasive species control, hydrologic reconnection, or substrate amendment, that improve the ecological function and quality of existing wetland areas without necessarily increasing total wetland extent. An initial proposal for acreage targets for each shoreline region is presented in Table 3 (and Figure 13) and will be discussed and refined at the August 2026 partner workshops.

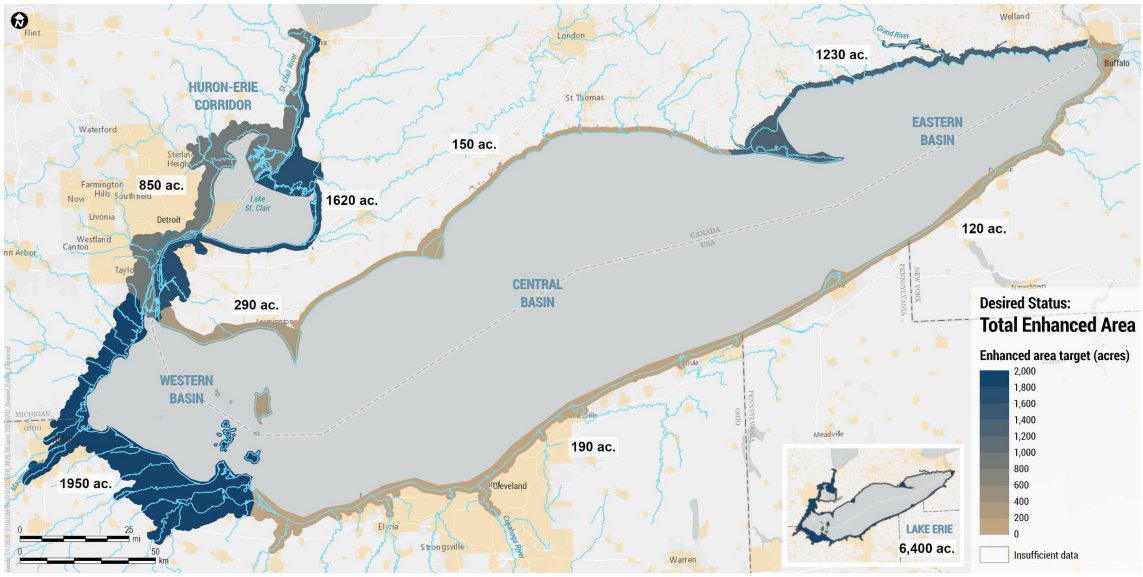

Figure 13. Desired Status of Enhanced Area indicator.

Figure 14 illustrates the proposed desired status for the Protected Area indicator for each Lake Erie shoreline region. Wetland protection activities focus on securing existing wetland areas through conservation easements, land acquisition, or stewardship agreements to prevent future degradation, conversion, or loss. An initial proposal for acreage targets for each shoreline region is presented in Table 3 (and Figure 14) and will be discussed and refined at the August 2026 partner workshops.

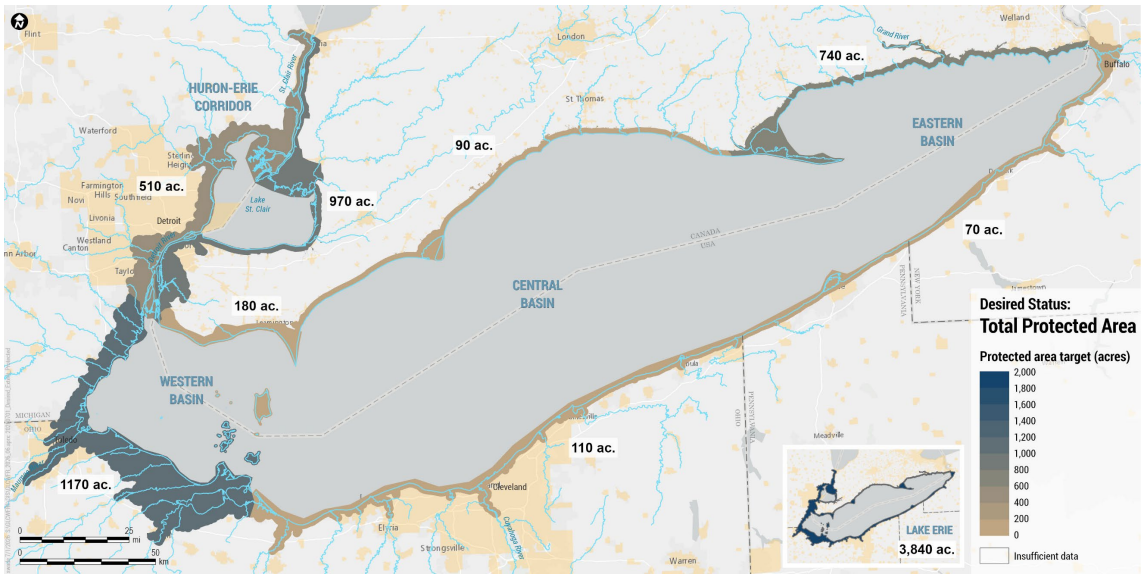

Figure 14. Desired Status of Protected Area indicator.

Static maps of the desired status of the maintenance indicators are not presented in this technical memorandum, as each zone's desired status is for the wetland extent to be maintained.

Summary

A suite of five (5) wetland condition indicators and five (5) wetland extent indicators have been developed for a Lake Erie pilot of the Great Lakes Coastal Wetland Framework and are discussed in detail in a companion technical memorandum (LimnoTech 2026). The current status of these indicators has been established for shoreline regions in Lake Erie based on the following data sources:

1. Wetland Condition Indicators: Taxon group-specific IBI and IBC scores have been developed by the Coastal Wetland Monitoring Program (CWMP) based on monitoring of Lake Erie wetland sites during the 2011-2025 timeframe.

2. Wetland Extent Indicators: Supporting data sources and estimates include:

    a. Wetland extent geospatial products developed under Objective One of the GLCW Framework project detailed the total and emergent wetland coverage for each year within the 2000-2020 timeframe.

b. The GLRI Action Plan IV (USEPA et al. 2025) outlines annual targets for Measure of Progress 4.1.1: "*acres of coastal wetland, nearshore and other habitats protected or enhanced*" under Focus Area 4: Habitats and Species. The targets suggest a 1-2% year-over-year increase in protected and enhanced coastal wetland area through FY 2029.

In collaboration with the GLCW Framework Steering Team, draft desired status targets and statements have also been prescribed for these indicators for the shoreline regions defined for Lake Erie. The desired status statements for the various indicator/shoreline region combinations are intended to identify discrete improvements (or no further degradation) relative to the current status over a given time frame. An example set of desired status statements for the "Western Basin (US)" shoreline region and maps depicting the trajectories from current to desired status for all shoreline regions are provided in this memorandum. All specific desired status targets and statements are considered draft versions that will be refined through partner workshops and in collaboration with the Steering Team and Core Team. Once a final desired status has been defined for each indicator/shoreline region combination for Lake Erie, progress towards achieving those statuses will be tracked through the GLCW Framework as conservation activities are implemented throughout the system. Ultimately, the implementation of a combination of coastal wetland restoration, enhancement, and protection projects will be required to meet the desired statuses identified for the suite of wetland condition and extent indicators. Current and desired status of human well-being indicators have not yet been established. As more information and methods become available for tracking quantifiable measures of human well-being needs surrounding coastal wetlands, the current and desired statuses will be incorporated into the GLCW Framework.

Looking forward, it is anticipated that the general approaches described herein for quantifying current status and establishing desired status can be readily applied to the other Great Lakes as well. Application of the methods to other lakes will necessarily involve customization of the statistical approaches and thresholds (e.g., for condition rating) used. For example, for Lake Superior and parts of Georgian Bay, a rating of "Mildly Impacted" or even "High Quality/Reference" might be most appropriate to use as a threshold for establishing a "Not Degraded" condition to define current and desired statuses for shoreline regions in that system.

The final versions of the current and desired status and other products outlined in this document will be incorporated into the GLCW-DSS, enabling partners to visualize data at the shoreline region and lake-wide spatial scales. A draft version of the GLCW-DSS (**https://glcwframework.org**) has been developed and can be used to:

- Visualize the data collected by Objective One and the CWMP (e.g., site-scale indicator scores).
- Generate interactive versions of the current and desired status maps and support data evaluations at finer scales (e.g., for shoreline planning zones).

- Support user investigations for the potential impacts of restoration efforts on wetland extent and condition indicators.

References

Cooper, M.J., Lamberti, G.A., Moerke, A.H. et al. 2018. An expanded fish-based index of biotic integrity for Great Lakes coastal wetlands. Environ Monit Assess 190, 580. **https://doi.org/10.1007/s10661-018-6950-6**

Dybiec, J.M., D.A. Albert, N.P. Danz, D.A. Wilcox, and D.G. Uzarski. 2020. Development of a preliminary vegetation-based indicator of ecosystem health for coastal wetlands of the Laurentian Great Lakes. Ecological Indicators 199 (2020).

Howe, R. W., G. J. Niemi, A. M. Bracey, V. Brady, L. Elliott, G. E. Fiorino, W. Gaul, T. M. Gehring, E. E. Gnass Giese, G. Lawrence, C.J. Normant, H. Panci, D.C. Tozer, D. Uzarski, N.G. Walton, and B. Wheelock. (2023). An index of biotic condition (IBC) using birds as indicators of coastal wetland quality in North America's Laurentian Great Lakes. Ecological Indicators 156:111174.

LimnoTech. 2023. Great Lakes Coastal Wetland Framework: Synthesis of Relevant Studies and Assessment of Lake Erie Current Conditions and Trends. Final report developed for the U.S. Fish & Wildlife Service. October 2, 2023.

LimnoTech. 2026. Proposed Ecosystem Services and Indicators for the Great Lakes Coastal Wetland Framework (FINAL deliverable for Tasks 5 and 6). Technical memorandum developed for the U.S. Fish & Wildlife Service. July 15, 2026.

Pearsall, D., P. Carton de Grammont, C. Cavalieri , C. Chu, P. Doran, L. Elbing, D. Ewert, K. Hall, M. Herbert, M. Khoury, D. Kraus, S. Mysorekar, J. Paskus and A. Sasson. 2012. Returning to a Healthy Lake: Lake Erie Biodiversity Conservation Strategy. Technical Report. A joint publication of The Nature Conservancy, Nature Conservancy of Canada, and Michigan Natural Features Inventory. 340 pp. with Appendices.

Uzarski, D.G., T.M. Burton, and J.A. Genet. 2004. Validation and performance of an invertebrate index of biotic integrity for Lakes Huron and Michigan fringing wetlands during a period of lake level decline. Aquatic Ecosystem Health and Management. 7(2):269-288.

Uzarski, D.G., Brady, V.J., Cooper, M.J. et al. 2017. Standardized Measures of Coastal Wetland Condition: Implementation at a Laurentian Great Lakes Basin-Wide Scale. Wetlands 37, 15–32. **https://doi.org/10.1007/s13157-016-0835-7**

USACE and USEPA. 2008. Compensatory Mitigation for Losses of Aquatic Resources; ; Final Rule. Federal Register 73(70):19594–19705. Available at: **https://www.epa.gov/sites/default/files/2015-03/documents/2008_04_10_wetlands_wetlands_mitigation_final_rule_4_10_08.pdf**

USEPA et al. 2025. Great Lakes Restoration Initiative Action Plan IV. Available at: **https://www.glri.us/actionplan**.

Appendix A. Regression Methodology for Wetland Extent Baseline

A.1 Overview

This appendix describes the regression-based methodology developed to estimate a water-level-adjusted expected wetland extent for each of the 12 analysis zones in the Lake Erie pilot of the GLCW Framework. The expected extent serves as a baseline against which observed annual wetland coverage from Objective One can be compared, thereby distinguishing water-level-driven variability from the effects of conservation activities or degradation. The minimum expected area (MEA) derived from this baseline is used as the threshold for the "Total Wetland Maintenance" and "Emergent Wetland Maintenance" desired status indicators.

A.2 Model Development

A total of 48 regression models were developed: one for each combination of 12 analysis zones, 2 response variables (total wetland extent and emergent wetland extent, each in acres), and 2 model types (ordinary least squares [OLS] and ridge regression). Response variables were also modeled as a percentage of zone area (percent total and percent emergent), yielding four response types per zone. The panel dataset represents annual observations for each of the 12 analysis zones over the 2000-2020 Objective One data period. Model performance statistics and tier ratings varied by zone-response combination; key performance findings are summarized in Section A.6 and predictor importance findings are summarized in Section A.7.

A.3 Predictor Variables

All predictor variables were derived from daily water-level time series for gauge stations proximate to each analysis zone. Predictors were organized into five categories totaling 31 individual metrics, as summarized in Table A-1.

Table A-1. Categories of water-level predictor variables used in the regression models.

Predictor Category	Description
Basic statistics (8 metrics)	Annual mean, minimum, maximum, standard deviation, range, coefficient of variation, median, and interquartile range of daily water levels
Threshold metrics (3 metrics)	Number of months per year exceeding the long-term 75th-percentile water level; months above the long-term annual mean; months below the 25th percentile
Hydrologic behavior (6 metrics)	Number of water-level threshold crossings per year; maximum consecutive wet months; maximum consecutive dry months; peak month of water level; growing-season mean and standard deviation

Predictor Category	Description
Lagged and rolling means (12 metrics)	1- and 2-year lagged annual mean; 3- and 5-year rolling means of annual water-level mean, maximum, range, and standard deviation
Trend and anomaly (2 metrics)	Annual water-level anomaly from the long-term mean; 5-year linear trend metric

A.4 Predictor Selection and Model Fitting

For OLS models, predictor selection was guided by stepwise and best-subset methods using the Akaike Information Criterion (AIC) to balance model fit and parsimony. Selected predictors varied by zone-response combination, reflecting the distinct water-level dynamics and wetland characteristics of each zone. For ridge regression, the regularization parameter (alpha) was tuned over a log-spaced grid; the best-performing alpha for each model was retained for use in the framework calculations.

A.5 Aggregation from Analysis Zones to Shoreline Regions

Regression models are developed and evaluated at the analysis zone scale (12 zones). For reporting in the GLCW-DSS and in this memorandum, analysis zone results are aggregated to the 8 shoreline regions used for current and desired status assessment. Because the response variables are areal extents (acres), aggregation is performed by summing analysis zone values within each shoreline region. For the Huron-Erie Corridor shoreline regions, this means:

HEC (US) = St. Clair River (US) + Lake St. Clair (US) + Detroit River (US)

HEC (CA) = St. Clair River (CA) + Lake St. Clair (CA) + Detroit River (CA)

The MEA for each HEC shoreline region is likewise the sum of the sub-zone MEAs. The mapping between the 12 analysis zones and the 8 shoreline regions is provided in Table A-2.

Table A-2. Mapping of 12 analysis zones to 8 shoreline regions for the Lake Erie pilot of the GLCW Framework.

Zone No.	Analysis Zone	Shoreline Region
1	St. Clair River (US)	Huron-Erie Corridor (US)
2	St. Clair River (CA)	Huron-Erie Corridor (CA)

Zone No.	Analysis Zone	Shoreline Region
3	Lake St. Clair (US)	Huron-Erie Corridor (US)
4	Lake St. Clair (CA)	Huron-Erie Corridor (CA)
5	Detroit River (US)	Huron-Erie Corridor (US)
6	Detroit River (CA)	Huron-Erie Corridor (CA)
7	Western Basin (US)	Western Basin (US)
8	Western Basin (CA)	Western Basin (CA)
9	Central Basin (US)	Central Basin (US)
10	Central Basin (CA)	Central Basin (CA)
11	Eastern Basin (US)	Eastern Basin (US)
12	Eastern Basin (CA)	Eastern Basin (CA)

A.6 Model Validation and Tier Ratings

Four validation methods were applied to assess model performance and generalizability:

1. K-fold cross-validation R^2: general predictive skill.
2. Leave-one-year-out R^2: time-series-appropriate validation.
3. Last-N holdout R^2: simulates forward projection.
4. Repeated random holdout with 80% confidence interval: stability assessment.

Based on these validation results, each zone-response model was assigned a tier rating: “Strong” (high in-sample R^2 with consistent cross-validation performance), “Moderate” (acceptable in-sample fit with some cross-validation degradation), or “Weak” (poor generalization despite potentially adequate in-sample R^2). Zone 1 (St. Clair River, US) is rated “Weak” across all response variables,

with in-sample R^2 approximately 0.50 but near-zero or negative holdout R^2 across all validation methods. The ridge regression best-alpha for Zone 1 hit the grid ceiling, indicating severe overfitting. This pattern is consistent with the zone's approximately 97% hardened shoreline, which physically limits water-level influence on wetland extent. Results for Zone 1 should be interpreted with caution.

A.7 Key Findings from Predictor Importance Analysis

Predictor importance was assessed by refitting OLS models with standardized predictors and computing partial R^2 for each predictor. Key findings include:

- The number of months exceeding the long-term 75th percentile water level is the dominant predictor, appearing in approximately 67% of all zone-response models and consistently showing the highest partial R^2.
- Annual mean water level is rarely selected (due to multicollinearity with other predictors) but shows the highest mean partial R^2 when it does appear.
- Lagged and rolling-mean predictors (3-year and 5-year rolling means) are important in many zones, consistent with multi-year vegetation response lags to water-level change.
- Zones with higher percentages of natural shoreline are hypothesized to show stronger model performance, though this has not been formally tested.

A.8 Quantifying the Expected Reference Wetland Extent

The maintenance extent indicators (Total Wetland Maintenance and Emergent Wetland Maintenance) require a means of distinguishing water-level-driven fluctuations in coastal wetland extent from conservation-relevant gains or losses. To accomplish this, a regression-based modeling framework was developed to estimate the expected wetland extent for each analysis zone under prevailing water-level conditions, establishing a water-level-adjusted reference against which observed trends can be evaluated. Full details of the modeling approach, predictor selection, validation, and performance are provided in Sections A.2 through A.6 above.

All predictor variables are derived from daily water-level time series recorded at gauge stations proximate to each analysis zone. These predictors are grounded in the well-established relationship between Great Lakes water levels and coastal wetland extent: sustained high water levels inundate and stress emergent and meadow-marsh communities. At the same time, prolonged periods of low water promote terrestrial encroachment and gradual wetland loss. The predictor set captures this dynamic across multiple time scales; from single-year statistics (annual mean, minimum, maximum, and variability) to threshold metrics such as the number of months exceeding the long-term 75th-percentile water level, to multi-year rolling averages; reflecting the lagged, cumulative nature of wetland vegetation response to water-level history.

For each analysis zone, the regression model yields both a predicted expected extent and an associated prediction interval. The lower bound of the 80th percentile prediction interval is defined as the Minimum Expected Area (MEA), i.e., the threshold below which wetland extent is considered deficient given prevailing water-level conditions in that year. The desired status criterion for both maintenance indicators is that observed extent meets or exceeds the MEA in at least 80% of years within any rolling 10-year window. Figure A.1 shows an example of this approach for total wetland extent in the Western Basin (US) shoreline region.

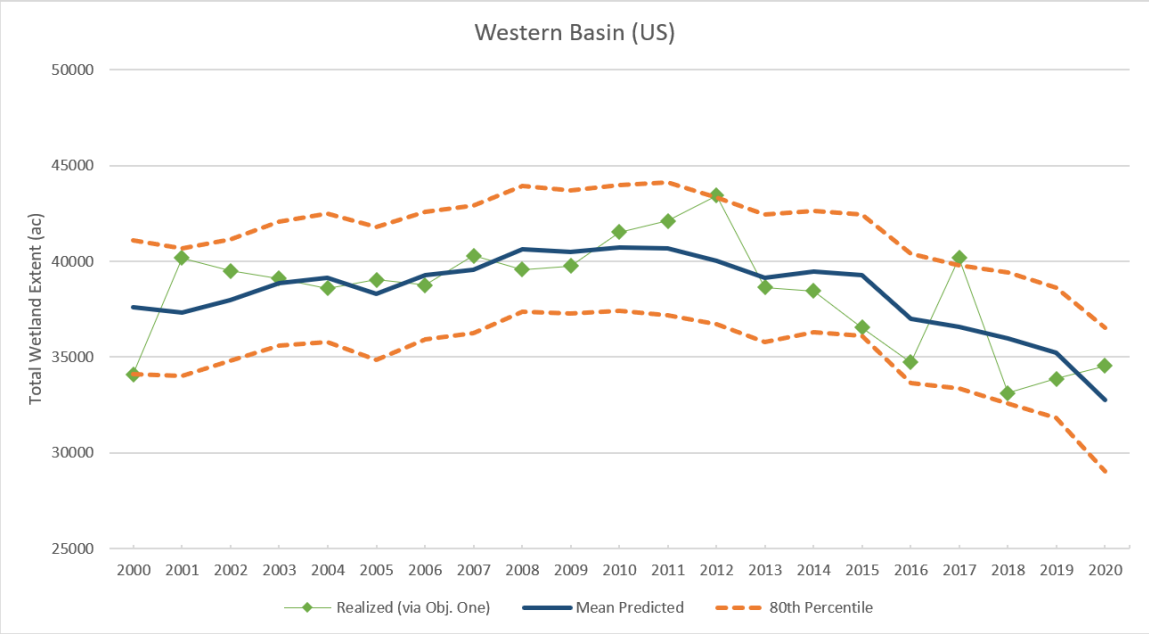

Figure A.1. Time-series of observed (green) and predicted (solid blue, dashed orange) total wetland extent for shoreline regions in the Western Basin (US).

Figures A.2 through A.4 illustrate three example evaluation scenarios for total wetland extent in the Western Basin (US), demonstrating how observed extent is assessed against the MEA. In the status quo scenario (Figure A.2), observed extent meets or exceeds the MEA in 9 of 10 evaluation-period years (90%), achieving the desired status criterion.

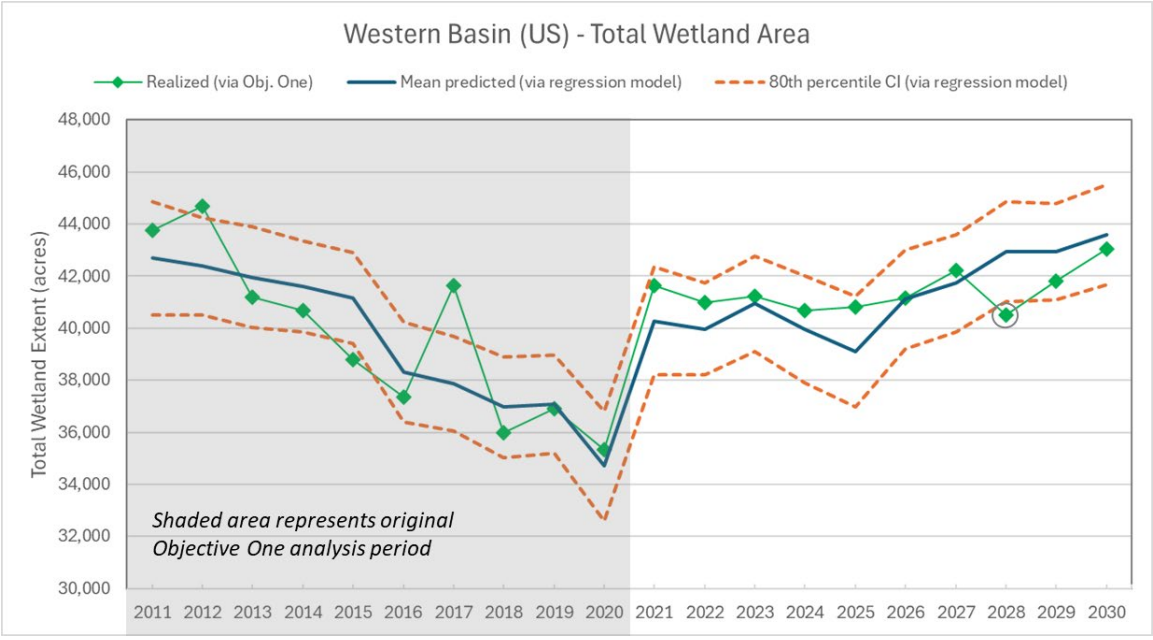

Figure A.2. Time-series of observed (green) and predicted (solid blue, dashed orange) total wetland extent for shoreline regions in the Western Basin (US), under a status quo scenario.

In the apparent loss scenario (Figure A.3), observed extent meets the MEA in only 6 of 10 evaluation-period years (60%), falling below the desired status criterion.

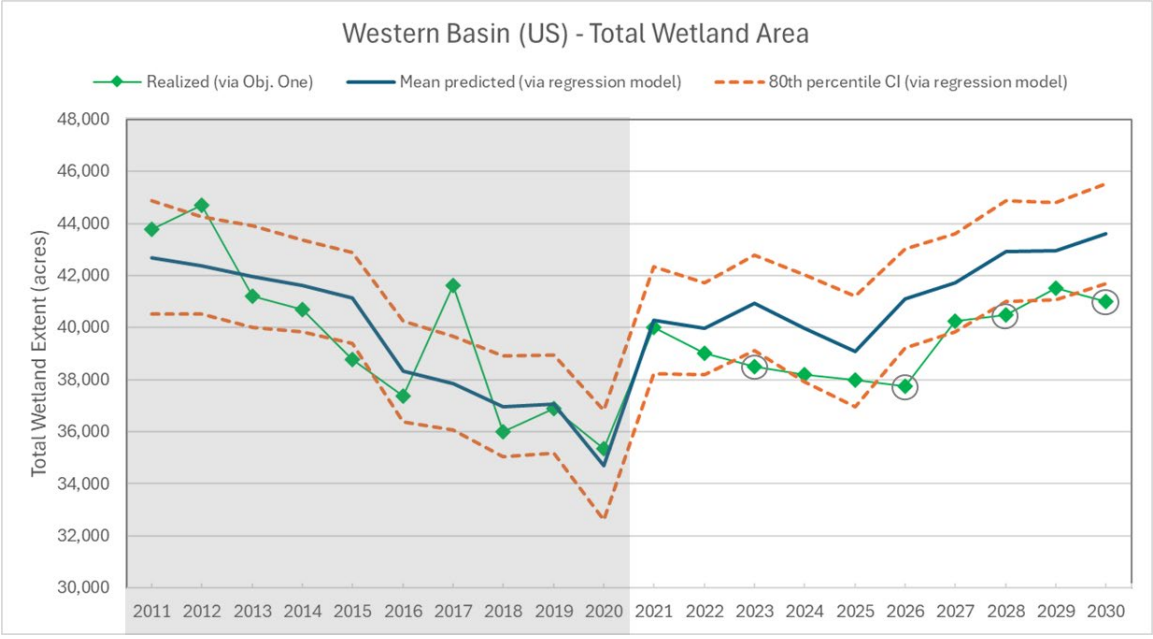

Figure A.3. Time-series of observed (green) and predicted (solid blue, dashed orange) total wetland extent for shoreline regions in the Western Basin (US), under an apparent loss scenario.

In the apparent net gain scenario (Figure A.4), observed extent exceeds the MEA in all 10 evaluation-period years (100%), comfortably exceeding the desired status criterion.

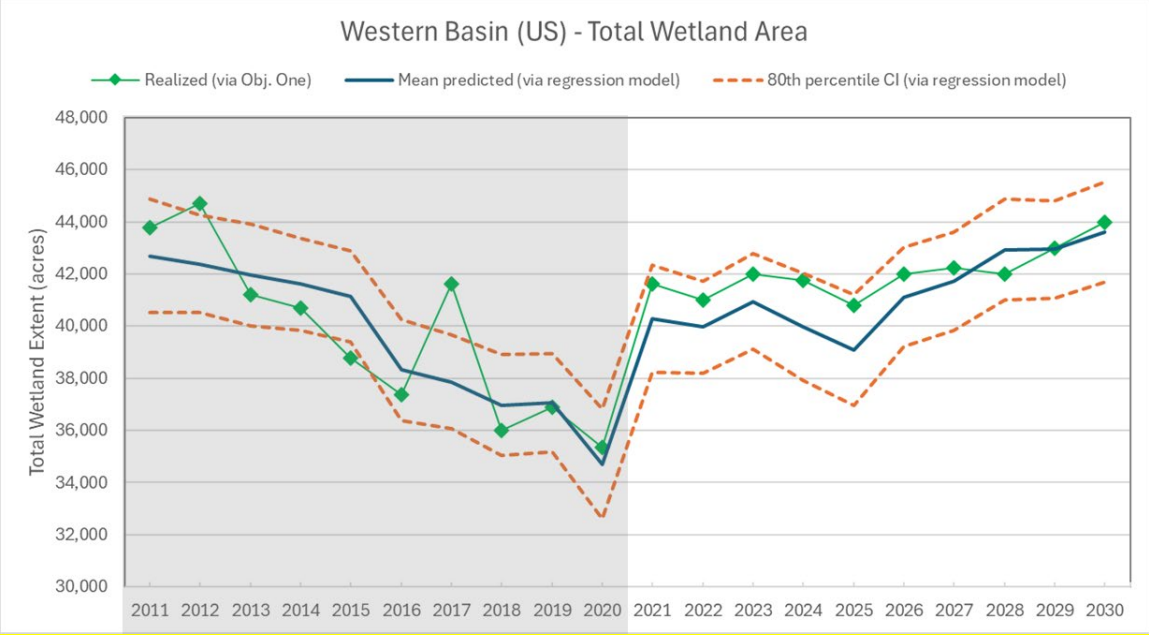

Figure A.4. Time-series of observed (green) and predicted (solid blue, dashed orange) total wetland extent for shoreline regions in the Western Basin (US), under an apparent net gain scenario.

A.9 Use of Model Outputs in the Framework

The regression models are used in two primary ways within the GLCW Framework:

1. Establishing the expected (baseline) wetland extent: for each analysis zone and year, the OLS model predicts the expected total and emergent wetland area given the observed water-level conditions. This prediction is compared to the Objective One observed extent to assess whether an apparent net gain, maintenance, or loss has occurred relative to water-level expectations.

2. Calculating the Minimum Expected Area (MEA): the MEA for each analysis zone is defined as the lower bound of the 80th percentile prediction interval of the zone-specific OLS model. The desired status criterion for the "Total Wetland Maintenance" and "Emergent Wetland Maintenance" indicators is that observed extent meets or exceeds the MEA in at least 80% of years within any rolling 10-year window. For HEC shoreline regions, the MEA is the sum of sub-zone MEAs, and the criterion is evaluated at the summed shoreline-region level.