# Development and Implementation of the

# Great Lakes Coastal Data Model / GLIN Digital Coast Viewer


Great Lakes Commission des Grands Lacs

**In cooperation with the**

**National Oceanic and Atmospheric Administration (NOAA)**

**Coastal Service Center**

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# Table of Contents

## Executive Summary

The Great Lakes Commission (GLC), in cooperation with the National Oceanic and Atmospheric Administration Coastal Services Center (NOAA-CSC) under a Joint Project Agreement (JPA) has developed a data modeling and framework to facilitate numeric modeling of complex physical, social environmental changes affecting the Great Lakes coastal zone.

The Great Lakes Coastal Data Model (GLCDM) provides a machine-level template for storage and management of a wide array of geospatial datasets, including those for elevation, sediment and soil types, adjacent wetlands, transportation and cultural features and other related biologic observations.

A companion Great Lakes “Digital Coast” viewer provides a one-stop online resource for users to easily: 1) discover what geospatial datasets are available; 2) evaluate the metadata for these datasets for appropriateness; and 3) facilitates downloading of datasets that meet user needs. The tools use powerful free and open-source software which allow for future expansion of the content and function of these products in a cost-effective manner. The digital coast viewer is now embedded within a new Great Lakes Information Network Geographic Information System (GLIN-GIS) web page, providing wide public access across the region.

This report describes the work completed under the JPA between NOAA-CSC and the GLC, including the logic behind and methods employed in the design and development of the GLCDM and its companion digital coast viewer. This report also includes recommendations for incorporation of additional geospatial data themes and promotion for wider public access and use.

## 1.0 Background

The GLC, in cooperation with NOAA-CSC, began working with regional stakeholders in 2007 to identify, organize, link and distribute high value geospatial datasets that can assist the Great Lakes coastal zone management (CZM) community. These datasets are needed to promote modeling of geomorphic changes in the coastal environment including beach erosion, bluff recession and other littoral processes, or as input to ecological prediction tools. Many of these datasets are applicable to supporting adaptive management approaches to maximize economic benefits, minimize public health risk and support ecological protection and restoration.

The design and development of the GLCDM is focused on developing a database schema that includes terrain, geopolitical, physical attributes, biologic and chemical observations which are frequently used to support CZM activities across the region. The companion Great Lakes Digital Coast Viewer, embedded in the GLIN-GIS web pages, provides an efficient approach for discovery, evaluation and access to geospatial datasets needed by GIS users and their managers. The viewer also facilitates easy downloads of datasets from networked servers residing elsewhere in the Great Lakes region or in national data clearinghouses across the United States and Canada. The GLIN-GIS viewer directs users to the NOAA-CSC Digital Coast web site to facilitate requests for DVD production of large datasets for elevation, land use and other related geospatial data.

The NOAA-CSC Digital Coast web pages are an information delivery system that efficiently serves geospatial datasets, and includes training materials, application tools, and examples needed to turn data into useful information. In this way, the national Digital Coast effort is designed to play a pivotal role in ensuring the wise use and management of coastal resources. NOAA-CSC launched the Digital Coast web site in 2008 and continues to lead this effort. While initial emphasis has been placed on providing user access to products generated by the NOAA, subsequent phases are adding content from other sources, including other federal organizations, state and local governments, and the private and nonprofit sectors.

An important part of the national Digital Coast effort is creation of a partnership network, the guiding team that represents a wide array of user groups and content providers. The partner network identifies Digital Coast priorities and then works together to address coastal issues. One of the goals behind the creation of the Digital Coast effort was to unify groups that might not otherwise work together. This partnership concept is building not only a website, but also a strong collaboration of coastal professionals intent on addressing CZM needs. The GLCDM and the companion GLIN-GIS Viewer is an effort led by the GLC to consolidate and serve geospatial data holdings within the Great Lakes region as a regional component of the national Digital Coast effort.

### 1.1 Applicability of the Great Lakes Data Model and Viewer

The Great Lakes coastal zone is a complex environment includes both terrestrial and freshwater components. It is subjected to significant spatial and temporal variability, making management of natural resources even more challenging. It has been estimated that for any environmental impact assessment, 50% to 80% of the costs is directly related to gathering and organizing the relevant data and information for the area in question. An argument can be made that a lack of dissemination of knowledge can be a major factor in loss of coastal resources.

The design of the GLCDM has an objective to tie related protocols and existing data themes together in a new framework using recognized reference material, definitions, semantics, and structures. It is expected that harmonizing datasets will lead to cost saving by reducing the time in re-design, re-use, training, and implementation of inappropriate datasets. In addition, a unified data model could assist in areas as coastal research, historical shoreline change analysis, shoreline change prediction analysis, and other fields that require a comprehensive and consistent data framework. The GLCDM provides a critical first step in coordinated regional data development, sharing, data transformation and fusion.

A host of regional programs and project should benefit from this unified data modeling and data management framework, including all of the following application areas:

- Great Lakes Restoration Initiative (GLRI) habitat protection/restoration projects;
- International Joint Commission (IJC) water level regulation studies (LOSLRS and IUGLS);
- Great Lakes Water Quality Agreement implementation and reporting (LaMPs, AOCs and SOLEC);
- Integrated Ocean Observing Systems (GLOS and NY-O&GLECC);
- Great Lakes Protection Fund activities;
- Development of climate change predictions and adaptation strategies;
- Development of effective control strategies for aquatic invasive species;
- Wetlands protection and enforcement;
- Reduction of coastal hazard risks;
- Restoration of fishery habitat;
- Bathing beach management;
- Border security, search and rescue, spill response and recovery;
- Alternative energy sources including assessing impacts of offshore wind energy platforms;
- Nutrient management (HABs, algal blooms); and
- Sediment management and control / littoral transport mechanisms.

## 1.2 Prior Investments and Community Desires

The development of the GLCDM and the companion GLIN-GIS viewer has been built upon significant prior efforts and investments. In 1999, the U.S. Army Corps of Engineers (USACE) commissioned a study to identify how it could better manage its geospatial data resources with emphasis on coastal operations.[1] The work completed under the JPA between NOAA-CSC and the GLC is built upon the cursory database schema developed under this effort.

In 2002, the Federal Geographic Data Committee (FGDC) commissioned a project, which was coordinated by the GLC, to support the IJC's Lake Ontario-St. Lawrence River Study (LOSLRS).[2] This project consolidated and "edge matched" critical geospatial data themes across the international boundary between the United States and Canada. This project developed important protocols that are needed for creating cross-border consistent data between countries across the entire Great Lakes basin.

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[1] *Requirements for Coastal Zone GIS Operations*, PlanGraphics and GRW Aerial Survey Report to the U.S. Army Corps of Engineers, Detroit District, January 1999.

[2] *Lake Ontario – St. Lawrence River Data Framework Project*, FGDC, 2002.

In 2004, the National Research Council reported on national needs for coastal mapping and charting, which included several findings and recommendations promoting consistent geospatial data management approaches both regionally and nationally.[3] The FGDC Marine and Coastal Data Subcommittee generated a draft report in 2007 promoting a new data content standard for coastal and marine datasets for the nation.[4]

Under the NOAA-CSC/GLC JPA, a formal needs assessment process was conducted in 2006 to evaluate the "data information Integration and dissemination (DIID)" needs within the Great Lakes CZM community[5]. The DIID needs assessment identified the following focal areas:

- Improve data discovery and access (including implementation of a regional geospatial data clearinghouse/network);
- Improve coordination and communication;
- Improve data consistency, including promotion of data standards and development of consistent classification methods;
- Coordinate geospatial data production, with emphasis on LIDAR elevation data collection as well as more detailed cultural and biological inventories within the coastal zone; and
- Provide tools and technical assistance, through outreach and extension services.



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[3] *Geospatial Framework for the Coastal Zone: National Needs for Coastal Mapping and Charting*, NRC, 2004.

[4] *National Shoreline Data Content Standard* – Draft Report, FGDC, 2007.

[5] *Great Lakes Needs Assessment, Issue Area: Data Information Integration and Distribution*, Desotelle Consulting, PLC, Community Growth Institute, and Beaster Consulting, July 2006.

Meanwhile, ESRI, Incorporated, with significant user-community input has been building application-specific data models for ArcGIS software, including a marine data model, published in 2007[6]. The Arc Marine data model is a new evolving initiative involving a wide array of GIS specialists to create and define a broad data schema for ESRI users to support coastal and marine resource decisionmaking and management. Arc Marine aims to provide more accurate representation of the location and spatial analyses of geospatial data, including the creation of a common structure – a geodatabase template for assembling, managing, and publishing marine data in ArcGIS applications.

As a consequence of these prior efforts to promote consistent and comprehensive data management and modeling for the Great Lakes, the GLC conducted two focused workshops under its Regional Data Exchange (RDX) community forums to identify the needs, interests and content for the GLCDM/F web based tools.[7] These two workshops, conducted in May 2008 in Chicago, IL and Buffalo, NY helped to define the objectives and scope of the work described in this report.

Of particular importance, the two RDX workshops showcased the role for a comprehensive geospatial data management/retrieval system to support resource management decision making across the region. Over thirty experienced GIS managers and process modelers attended these two workshops. The group consensus at these meeting included the following recommendations:

- The region should strive to define a consistent data model for all five Great Lakes;
- The region should use open source technologies and promote data standards;
- The Great Lakes geospatial community should fully populate the National States Geographic Information Council's (NSGIC) GIS Inventory system (powered by Ramona)[8] and improve data cataloguing;
- The region needs enhanced data discovery and distribution tools; and
- A consistent data model would improve ecological predictions and modeling of potential climate change impacts.

Figure 1 showcases the anticipated role that the GLCDM and the companion GLIN-GIS Viewer can provide to the region to meet expressed requests from the Great Lakes CZM, GIS and modeling communities. This diagram explains the detailed procedures which were employed in arriving at Version 1.0 (V1.0) of the GLCDM and the GLIN-GIS Viewer. From the decisionmaker

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[6] *Arc Marine: GIS for a Blue Planet*, Dawn J. Wright, et al, ESRI Press, 2007.

[7] http://rdx.glc.org/workspring08.html

[8] http://gisinventory.net/

viewpoint, data needed to support modeling and assessment are identified (contextual list) and evaluated for interrelationships (conceptual model) to create a logical model that identifies machine-level attributes that can manage data for use by GIS specialists and numerical modelers to produce products that are fed back to the decisionmaker.

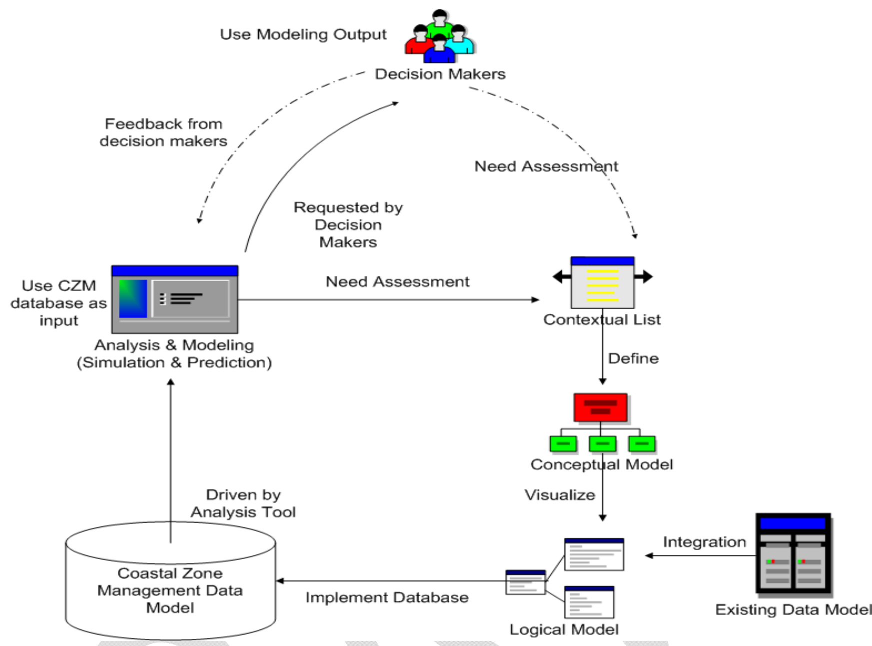


**Figure 1 – Role of GLCDM in Decision Making**

## 1.2 Need for Consistent and System-Wide Process Modeling

There are numerous process models that have been generated to simulate, predict or evaluate complex physical, biological, chemical and social interactions across the Great Lakes region. Many of the numeric computer models rely upon similar geospatial data themes (e.g., coastal sediment loading and movement, fishery responses to changing habitat). Coastal process models are most notable in the areas of erosion and flood prediction and in forecasting ecological trends as a consequence of human activity or climate change. Due to the complexity and diversity of Great Lakes nearshore environments and varying sub-regional management needs, there are few consistent process models in place that provide a holistic perspective of what is happening or likely will happen to the entire regional system. As such, emphasis is placed in the design and implementation of the GLCDM and digital coast viewer in the GLIN-GIS to support implementation system-wide on two target modeling packages that have been widely recognized as important regional tools.

The first of these is the Flooding and Erosion Prediction System (FEPS) developed by Baird and Associates, a consulting engineering and software development company.[9] The FEPS is a deterministic modeling tool that links GIS technology, engineering models, automated mapping tools and custom visualization in a modular system. The FEPS has been implemented for two major projects; the first being the Lake Michigan Potential Damages Study conducted by the U.S. Army Corps of Engineers. This study's objectives were to develop defensible estimates of potential lake-wide economic and environmental damages resulting from extreme lake levels and altered climate scenarios. The second application was within the IJC Lake Ontario – St. Lawrence River Study to evaluate the impacts of water levels for the alternative outflow regulation on flooding and erosion hazards for riparian property. The CZM community has expressed interest in seeing the FEPS package implemented across the region.



[9] http://www.bairdsoftware.com/bairdsoftware/en_html/feps.html

The second process modeling toolkit that has regional interest in expanding for system-wide implementation is the Integrated Ecological Response Model (IERM) developed by Limno-Tech, Inc. an environmental consulting firm. The IERM was also applied in support of the IJC Lake Ontario – St. Lawrence River Study, with an objective to assess likely environmental responses to potential alternative lake level scenarios.[10] The Great Lakes CZM community has consistently supported implementation of this type of predictive tools to better manage coastal resources. Both the IERM and FEPS packages rely heavily on consistency and accuracy of coastal datasets and could be implemented system-wide for comprehensive assessments, if input data are better managed and accessible.

# 2.0 Great Lakes Coastal Data Model/Digital Coast Viewer

## 2.1 FOSS Tools Utilized

Free and open source software (FOSS) is software that can be modified and improved by users through direct access to source codes without having to pay for purchase, subscriptions or royalties. The GLCDF project relies on free and open source software as described herein.

### 2.1.1 Backend Storage Tools

The data themes that had been identified for the GLCDF project were imported into a PostgreSQL database, which is an open-source relational database system that supports storing, manipulating, and interpreting spatial data with the extension PostGIS. The PostgreSQL/PostGIS package is fully compliant with Open Geospatial Consortium (OGC) standards and is interoperable with proprietary vendor software such as the ESRI Arc product suite.

### 2.1.2 Backend Map/Feature Generation Tools

Two leading open source GIS software packages were chosen to serve as backend mapping engines for the GLCDF; they are: MapServer and GeoServer. MapServer was originally developed in the 1990s at the University of Minnesota with the support from NASA. It is now considered as the one of the most successful open source GIS software packages available. MapServer supports most existing and evolving OGC standards. Some datasets are only available via services provided through MapServer. GeoServer, on the other hand, is a new platform developed by Java. It provides a much friendlier user interface than MapServer and supports most of the popular OGC standards, such as Web Mapping Services (WMS) and Web Feature Services (WFS).

[10] http://www.limno.com/ierm/IERM_report_draft-042905.pdf

### 2.1.3 Frontend Data Access Tools

All data themes for the GLCDF project were published as services through WMS and can be retrieved by all software that understands a WMS feed. OpenLayers is the library selected for this project for development of the web data access/discovery tool. OpenLayers is an open source JavaScript library that integrates map services in web page designs. It has the ability to handle various map data sources by discriminating between identical interfaces. OpenLayers is compatible with most OGC standards and supports projection transformation on-the-fly.

## 2.2 Data Organization and Structure

The design of the GLCDM is predicated on a three-stage process: 1) define the overall scope and content of the data model and identify the common, essential data used in most process modeling projects; 2)
create an analysis diagram to depict the major thematic groups and an initial set of object classes within each group (e.g., common marine data type diagram); and 3) develop an initial data model using open source GIS tools and associated schema that are amenable for use in large-scale regional modeling applications.

### 2.2.1 Contextual List – GLCDM V1.0

A contextual listing of key geospatial datasets was compiled to drive the design and implementation of the GLCDM. Major headings for data elements of this listing are included in Appendix A to this report. This listing also includes the format types likely to be encountered for each major data element, being raster, point, line, polygon or network structures. It was clear early on during this project under the JPA that only a limited set of these datasets could be effectively designed and implemented within the available budget and timeline. Hence, the table in Appendix A showcases first those data elements currently incorporated in V1.0 of the GLCDM, second, those elements that can be easily adopted into the data model if modest additional resources became available, and third, those elements that should be addressed if and when V2.0 is generated for the GLCDM.

Significant emphasis was placed in the design of the GLCDM on discriminating between datasets that already have data content standards developed by national and international standards organizations like the Open Geospatial Consortium (OGC), which are "Framework Data" themes and those that may not have more limited and regional applicability, and hence less documentation and universal agreement, considered to be "Non-Framework Data" themes. These datasets are listed below.

<u>Framework Data</u>

- Imagery
- Elevation
  - Bathymetry
  - Topography
- Hydrologic Features
  - Shorelines
  - Rivers, Lakes and Streams
  - Watersheds

- Transportation Features
- Political Units
- Land Use/Land Cover

Non-Framework Data

- Shoreline Characteristics
  - Beach Morphology
  - Subaqueous Types
  - Historic Erosion Rates
  - Predicted Bluffines
  - Water Intakes / Outfalls / Pipelines
  - Shore Protection
  - Navigation Structures
  - Boat Ramps / Piers / Docks
- Environmental Data
  - Wetlands Extent and Type
  - Fisheries Data
  - Exotic and Invasives
  - Contamination Areas
- Economic Features
  - Parcel Data
- Hydrologic Data
  - Levels, Flows, Datums
  - Climatic Variables
- Hydraulic Characteristics
  - Circulation Dynamics
- Other Themes

Furthermore, some datasets, like the National Hydrology Database (NHD), have established data schema that allow for building conjunction tables to connect them to other data themes in the GLCDM. Other data themes may have data content standards but no established schema that require creation of an appropriate schema. Others have no schema or data standards, requiring development of the schema from scratch. Appendix A includes a data dictionary of the primary data elements incorporated into V1.0 of the GLCDM, along with the database attributes associated with each data entity.

### 2.2.2 Conceptual Model – GLCDM V1.0

The conceptual model phase of this effort is broken into three tasks: 1) descriptions of the semantics of data organization; 2) definition of the primary entities and relationships; and 3) visualization of the underlying Logical Model based upon an Entity-Relationship (ER) Diagram.

Figure 2 on the following page illustrates the major components of V1.0 of the GLCDM. The National Hydrography Dataset (NHD) is a cornerstone element of this approach, since it depicts the Great Lakes shoreline, interconnecting waterways and tributary rivers and streams in a consistent and comprehensive manner. Each feature in NHD has a 10-digit integer value that only occurs once across the nation, which is a perfect foreign key for other datasets to link with. On the other hand, from the NHD side, features from other data themes can be linked through the NHD "reach code".

To improve the positional fidelity of the Great Lakes shoreline in the NHD, this line string should be replace in the near future with the commensurate linear elements generated in the IJC Levels Reference Study published in 1993.[11]

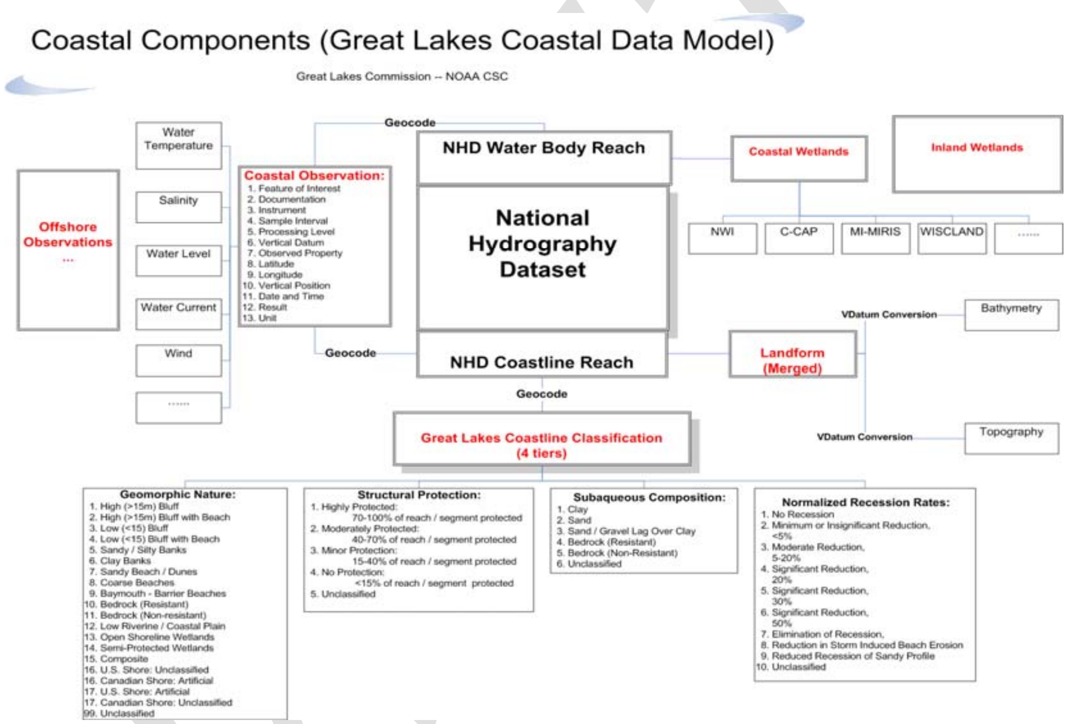


**Figure 2 – Conceptual Model for GLCDM, V1.0**

The IJC Levels Reference Study shoreline line string is the linear elements that the geomorphic, structural protection, nearshore sediment types (subaqueous composition) and normalized recession rate datasets are attributed on. This line string was created from detailed photo

[11] Stewart, C.J. and Pope, J., 1993. Erosion Processes Task Group Report, Report Prepared for the Erosion Processes Task Group, Working Committee 2, Phase II, International Joint Commission Water Level Reference Study

interpretation of aerial photography acquired around 1990, which is much more representative of current conditions than the NHD shorelines which are derived from the U.S. Geological Survey quadrangles that may be 40-50 years old for many areas of the Great Lakes.

The conceptual model also indicates that primary emphasis is placed in the design and implementation of V1.0 of the GLCDM on integrating shoreline characteristic information with elevation data, principally those recently collected through airborne LIDAR collections and with coastal wetland mapping products already compiled under a parallel project funded by the Federal Geographic Data Committee (FGDC).[12] Additionally, data ingestion techniques developed by the GLC for the Great Lakes Observing System's Data Management and Communication (GLOS-DMAC) system allow for quick expansion of the GLCDM and the Great Lakes Digital Coast Viewer to include real-time observations on winds, water levels, currents, waves and other physical and chemical observations.

### 2.2.3 Logical Model - Entity Relationships

The ER Diagram for V1.0 of the GLCDM is provided in Appendix B to this report. It is recognized that this diagram will need to be adapted over time, as more knowledge is attained about the characteristics of individual data elements and relationships between entities become better defined to expand the scope of process modeling applications.

[12] http://www.glc.org/wetlands_sdss/

## 3.0 Great Lakes Digital Coast Viewer

### 3.1 Geospatial Data Discovery

A major objective in the design and implementation of the GLCDM was to facilitate improvements for discovery, evaluation and access to important Great Lakes coastal geospatial datasets. Work under the NOAA-CSC/GLC JPA has allowed for completion of an inaugural regional "digital coast viewer" which is a major component of the newly designed GLIN-GIS web page suite. The GLIN-GIS web page is built using OpenLayers and Google Maps to deliver renderings of available geospatial data themes using layer control compatible with the GLCDM. GLIN has been operating since 1994 (beginning of the Internet era) and now has over 300,000 unique visitors each month, providing a built-in audience for these new products.

Figure 3 below shows an area along the Lake Ontario shoreline near Rochester, NY with recently acquired merged topographic/bathymetric LIDAR, overlaying bathymetric contours, SSURGO hydric soils and C-CAP 2001 wetlands land cover classifications. The GLIN-GIS digital coast viewer can be accessed at: erie.glin.net/glin_viewer/.


**Figure 3 – GLIN-GIS Viewer**

### 3.2 Metadata Access

Each data theme that is showcased on the GLIN-GIS web page is linked through hypertext to reference information about the datasets. The Toolkit pull-down menu of the viewer provides abilities to the user to “identify” various data elements in a dual fashion.  First, the user can identify the specific classification type of a dataset that is shown and second, the user can access a hypertext link to metadata for each data theme. The metadata access feature allows the user to evaluate the legacy, accuracy, methods of creation and appropriateness of use for each data theme that they may want to download and use in more sophisticated GIS analyses.

### 3.3 Geospatial Data Downloads

The GLIN-GIS web page is being modified to allow users to directly download available geospatial datasets, either from the GLIN-GIS Data Clearinghouse or from collaborating agencies using networked servers. Publishing geospatial data through the GLIN-GIS is a free service provided for researchers and GIS collaborators as an inherent function of the Great Lakes Information Network (GLIN).The GLIN-GIS Data Clearinghouse allows registered users to submit and upload geospatial data themes that they generate along with appropriate metadata through a convenient web form. The data user upload requires that users undergo QA/QC checks before their data are published and made available to the public. After validation by GLC staff, data are published on the website and can be accessed through various formats. All format and projection conversions are conducted on-the-fly. Users can choose the format they prefer and download them anytime. If changes are made to the original dataset, the owner of the dataset has the privilege to update the dataset as they see fit.

The GLIN-GIS is built completely on a FOSS framework, leveraging open standards and open source software throughout. This includes PostgreSQL/PostGIS databases, GDAL/OGR-based automatic parsing scripts, Mapserver and Geoserver for generating geospatial products on the backend, and OpenLayers on the frontend for displaying web-based maps. Figure 4 is an example of a few geospatial data themes published on the GLIN-GIS Data Clearinghouse, along with standard formats.

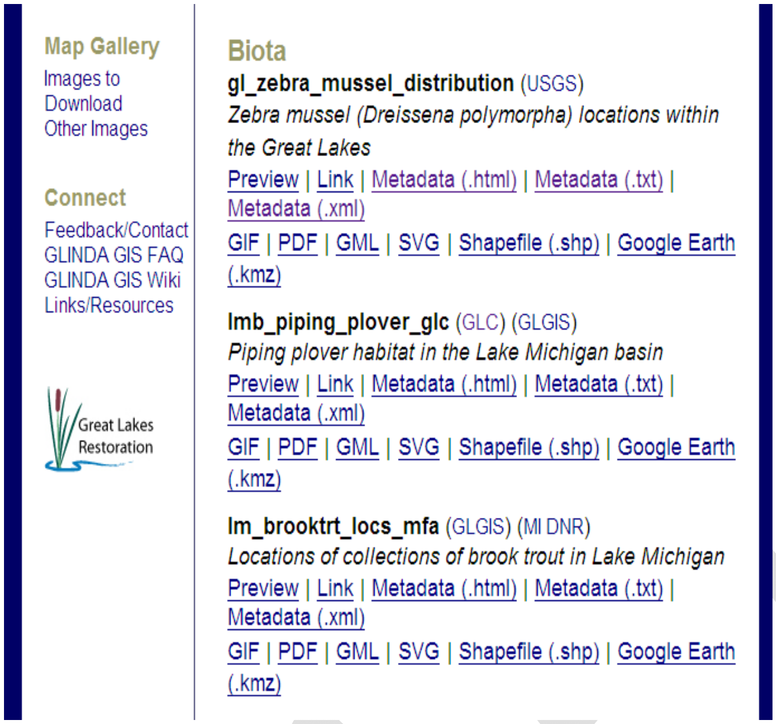


**Figure 4 – GLIN-GIS Data Clearinghouse Example**

The GLC is expecting to continue engagement with the NOAA-CSC after the JPA to direct data users from the Great Lakes to access digital datasets served through the national Digital Coast server network, with particular emphasis on coastal LIDAR data and imagery served from the USGS EROS Data Center.

## 4.0 Anticipated V2.0 Expansion

Through the JPA between the NOAA-CSC and the GLC, a significant amount of important work has been accomplished to improve CZM user access to coastal datasets. This effort, however, is not complete as there are additional geospatial datasets not linked to this integrated data model and digital coast viewing environment, particularly those dealing with biological, chemical and social factors affecting the Great Lakes. A few logical areas for expansion or follow-on work in the near future are provided below.

### 4.1 Additional Physical Datasets

- Convert NHD Great Lakes shoreline to 1993 IJC shorelines linear elements;
- Incorporate available FEMA flood hazard digital mapping;
- Incorporate gridded bathymetric and topographic datasets;
- Incorporate topographic contour datasets; and
- Incorporate beach/bluff profiles.

### 4.2 Land Cover / Use Dataset Updates

- Import in all state-derived land cover/land use datasets including WISCLAND, MIRIS and OGRIP; and
- Expand C-CAP coverages for 1996 and 2001 to include all land cover/use classes

### 4.3 Biological Datasets

- "Normalize" NWI, C-CAP, USACE and State wetland mapping, and utilizing SSURGO hydric soil datasets along with the highest detail terrain data, so that errors of omission are resolved and that a "confidence" measure can be generated for every square meter of the Great Lakes basin about whether they are wetlands by nature; and
- Import all available biological datasets served through the GLIN-GIS Clearinghouse;

### 4.5 Social and Cultural Information

- Add in datasets dealing with Great Lakes channel maintenance programs including authorized channels, dredging activities and disposal methods, including locations of all Confined Disposal Facilities (CDFs).
- Add major vector datasets on transportation features, including roads, trails, rail networks, pipelines and maritime corridors.

- Add datasets developed for the Area Contingency Planning program, including locations of intakes and outfalls from municipal water treatment and wastewater plants, power plants, toxic and hazardous storage facilities; and
- Add digital coverages for marinas and ports;

### 4.6 Real-Time Observations

- Import in all available real-time observations generated for the GLOS-DMAC, including winds, waves, currents, water levels and ice; and
- Link to archival datasets for historic observations of the same parameters.

# Appendix A:  GLCDM– V1.0 Contextual List and Data Dictionary

# Great Lakes Coastal Data Model Features/Processes and Potential Data Types

Datasets incorporated in the design and implementation of GLCDM V1.0 under the NOAA/GLC JPA are shown in green;
Datasets in yellow are readily available for incorporation

| Feature/Process | Typical Geospatial Data Types | | | | |
|---|---|---|---|---|---|
| | **Raster** | **Point** | **Line** | **Polygon** | **Network** |
| **Water and Water Bodies** | | | | | |
| Watersheds | | | | X | |
| River and Stream Segments | | | X | | X |
| Inland Lakes and Impoundments | | | | X | |
| Great Lakes | | | | X | |
| Dredged Channels | | | X | | X |
| **Shoreline Characteristics** | | | | | |
| Geomorphology | | | X | X | |
| Structural Protection | | X | X | | |
| Nearshore Stratigraphy | X | | X | X | |
| Erosion and Recession Rates | | | X | | |
| **Elevation** | | | | | |
| Topography | X | X | | X | |
| Bathymetry | X | X | | X | |
| Slope and Aspect | X | | X | | |
| Profiles | | | X | | |
| **Soils** | | X | | X | |
| **Human Infrastructure/Impacts** | | | | | |
| Land Use and Zoning | X | | | X | |
| Real Property/Parcels | | X | X | X | |
| Transportation Features | X | | X | | X |
| Ports and Harbors | | X | | X | X |
| Public Water Systems and Intakes/Outfalls | | X | X | | X |
| **Dynamic Natural Phenomena** | | | | | |
| Water Levels | X | X | | | |
| Wind | X | X | | X | |
| Waves | X | X | | | |
| Currents and Circulation | X | X | | | |
| Sediment Transport | X | X | | | |
| Ice | X | X | | X | |
| **Flora** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Land Cover | X | | | X | |
| Upland Vegetation | X | | X | X | |
| Riverine | X | | X | X | |
| Emergent Vegetation | X | | X | X | |
| Submergent Vegetation | X | | X | X | |
| Wetlands | X | | X | X | |
| **Fauna** | | | | | |
| Fisheries | X | X | | X | |
| Avian | X | X | | X | |
| Invertebrates | X | X | | X | |
| Mammals | X | X | | X | |
| **Contaminants** | | | | | |
| Biological | X | X | | X | |
| Nutrients | X | X | | X | |
| Chemical and Radiological Contaminants | X | X | | X | |

## Bathymetric Contours

**Definition:** Bathymetry is the representation of the topography of the river and lake bottoms. It is comparable to the representation of the terrain above the water level, but presents unique difficulties for measurement and interpretation. This entity captures the representation of these features through contours.

**Implementation Notes:** This entity will be implemented as a linear feature. They will close but the polygon topology is not available for use.

**Layout for Entity Attributes**:

| *Description* | *Item Name* | *Item Definition* | *Issues/Comments* |
|---|---|---|---|
| Key | BCONTOUR_ID | Numeric (16) | Primary key, Must be unique within dataset |
| | BCONTOUR_ELE | Numeric (6,2) | |
| | BCONTOUR_BASE | Character (9) | |
| | BCONTOUR_UNITS | Character (1) | |
| | BCONTOUR_DATE | Date | |
| | BCONTOUR_SOURCE | Character Varying (80) | |
| | LAKE_CODE | Numeric (2) | |

**Description of Attributes:**

| *Description* | *Item Name* |
|---|---|
| BCONTOUR_ID | Primary Key; dataless key |
| BCONTOUR_ELE | Elevation represented by contour |
| BCONTOUR_BASE | Indicates datum of contour elevations shown. |
| BCONTOUR_UNITS | Indicates units of linear measurement used. Valid values include: M – Meters and F – Feet |
| BCONTOUR_DATE | Date of soundings or other data from which contours are derived |
| BCONTOUR_SOURCE | Indicates study or other source of data. |
| LAKE_CODE | Indicates which lake the bathymetry is compiled for. |

# Bluffs

**Definition:** Bluffs consist of the steeply sloping land separating the landscape from the beach. Some terrain many not have a bluff. Where present, a bluff is bounded by a top and a toe. This entity represents the spatial extent of the bluff as of a certain date, and is assumed to be a valid representation of the current bluff. Note that bluffs not along shorelines are not part of this entity.

**Implementation Notes:**

1) This entity will be implemented as a polygonal feature. This will indicate approximate spatial extent of the feature, operationally defined as the horizontal distance between the top of the bluff and the toe of the bluff at a particular transect.

2) It is possible that a bluff may have a zero width, in circumstances where the face is sheer. For purposes of this database, a minimum bluff width of 1 foot is assumed. Also, an overhang is treated the same as an inclined bluff face – width is difference between toe and top.

**Layout for Entity Attributes**:

| *Description* | *Item Name* | *Item Definition* | *Issues/Comments* |
|---|---|---|---|
| Key | BLUFF_ID | Numeric (8) | Primary key, Must be unique within dataset |
| | BLUFF_NAME | Character Varying (80) | |
| | BLUFF_COMPOSITION | Numeric (2) | FK to NEARSHORE SEDIMENT |
| | BLUFF_HEIGHT | Numeric (4,1) | |
| | BLUFF_DATE | Date | |

**Description of Attributes:**

| *Description* | *Item Name* |
|---|---|
| BLUFF_ID | Primary Key |
| BLUFF_NAME | Common name of the site. |
| BLUFF_COMPOSITION | Geomorphic classification, based on overall Geomorphic Classification. |
| BLUFF_HEIGHT | Average height of bluff. (If height varies greatly, split into multiple entities and record average height of each subset) |

| | |
|---|---|
| BLUFF_DATE | Date bluff delineation looked like this representation. A spot along the shoreline may have very different appearances at different dates due to erosion processes. |

# Channels

**Definition:** Channels are designated areas of the hydrography which are especially important for water flow or marine transportation. They are the target of ongoing monitoring and maintenance activities to ensure that they meet design parameters. They may be coextensive with the natural feature (where the entire width of a river is under maintenance as a channel), or may consist only of a relatively narrow portion of the lake where shipping is expected to travel (e.g. the shipping channel through the middle of Lake St. Clair).

**Implementation Notes:**

1) These features are implemented as polygons and complex polygons in the datatabase to indicate the approximate spatial extent of the channel.

**Layout for Entity Attributes**:

| *Description* | *Item Name* | *Item Definition* | *Issues/Comments* |
|---|---|---|---|
| Key | CHANNEL_KEY | Numeric (6) | Dataless key |
| | CHANNEL_NAME | Character Varying (80) | |
| | LOCATION | Character Varying (60) | |
| | PROJECT DEPTH | Numeric (6,2) | |

**Description of Attributes:**

| *Description* | *Item Name* |
|---|---|
| CHANNEL_KEY | Dataless key. |
| CHANNEL_NAME | Official name of the channel or harbor. |
| LOCATION | Description of the location of the project |
| PROJECT DEPTH | Indicates project design depth for channel or harborage. |

# Hydrologic Unit Codes

**Definition:** A hydrologic unit is a nested structure of increasingly small drainage basins. A drainage basin is that portion of the earth's surface where a drop of falling water would theoretically flow into a central stream of lake. The edges of drainage basins are defined by a ridge of higher ground separating two adjacent watersheds. The United States and Canada are divided and sub-divided into successively smaller hydrologic units which are classified into six levels; these being: Regions, Sub-regions, Accounting Units, Cataloguing Units, Watersheds and Sub-watersheds. The hydrologic units are arranged within each other, from the smallest (sub-watershed) to the largest (regions). Each hydrologic unit is identified by a unique hydrologic unit code (HUC) consisting of two, four, six, eight, eleven or fourteen digits based on the six levels of classification in the hydrologic unit system.

**Implementation Notes:**
1) Hydrologic units will be implemented within the database as polygonal features. These will be nested in a hierarchical manner, preserving the fact that smaller basins are components of larger basins.
2) The standard coding arrangement identifies the nested structure of the Hydrologic Unit system; each two digits of a full 14-digit HUC represent a unique characteristic for a piece of real estate; for example
01 – the region; 0108 – the sub-region; 010802 – the accounting unit; 01080204 – the cataloguing unit;
0108020401 – the watershed; and 010802040101 – the subwatershed. An 00 in the two-digit accounting unit field (or in subordinate fields), indicates that he accounting unit (is identical to the sub-region.

**Layout for Entity Attributes**:

| *Description* | *Item Name* | *Item Definition* | *Issues/Comments* |
|---|---|---|---|
| Key | HUC_KEY | Numeric (8) | Primary key, dataless key |
| | REGION_NUM | Numeric (2) | Hydrologic Unit for Region |
| | SUBREGION_NUM | Numeric (4) | Hydrologic Unit for Sub-region |
| | AC_NUM | Numeric (6) | Hydrologic Unit for Accounting Units |
| | CAT_NUM | Numeric (8) | Hydrologic Unit for Cataloguing Units |
| | WAT_NUM | Numeric (11) | Hydrologic Unit for Watershed |
| | SUBWAT_NUM | Numeric (14) | Hydrologic Unit for Sub-watershed |
| | BASINS_NAME | Character (50) | |

| | | | |
|---|---|---|---|
| | HUC _SCALE | Character (10) | |

**Description of Attributes:**

| *Description* | *Item Name* |
|---|---|
| HUC_KEY | Primary key; dataless key. |
| REGION_NUM | USGS Hydrologic Units for Region |
| SUBREGION_NUM | USGS Hydrologic Units for Sub-Region |
| AC_NUM | USGS Hydrologic Units for Accounting Units |
| CAT_NUM | USGS Hydrologic Units for Cataloguing Units |
| WAT_NUM | USGS Hydrologic Units for Watersheds |
| SUBWAT_NUM | USGS Hydrologic Units for Sub-Watersheds |
| BASINS_NAME | Common name for the basin |
| HUC_SCALE | Scale information for source material from which boundaries were delineated. |

# Land Use/Land Cover Classes

**Definition:** Land use is the classification of the natural or human activity associated with an area of the earth's surface. Land cover is the classification of the type of vegetation actually existing on an area of the earth's surface. Combination classifications like the ones used in this database combine attributes from the two concepts. Mapping via photo-interpretation lends itself to land use classifications, while satellite and airborne image processing lends it better towards land cover classifications

**Implementation Notes:**

1) These features may be implemented in the overall database as either polygons or raster, depending on the data source.

**Layout for Entity Attributes**:

| *Description* | *Item Name* | *Item Definition* | *Issues/Comments* |
|---|---|---|---|
| Key | LU_LC_KEY | Numeric (12) | Primary key, dataless key; must be unique within dataset |
| | INTEREST_CAT | Character (3) | |
| | LU_LC_CODE_1 | Character (1) | |
| | LU_LC_CODE_2 | Character (1) | |
| | LU_LC_CODE_3 | Character (1) | |
| | LU_LC_NUM | Numeric (3) | Foreign Key |

**Description of Attributes:**

| *Description* | *Item Name* |
|---|---|
| LU_LC_KEY | Dataless key; must be unique within data set |
| INTEREST_CAT | Interest category for CZM planning or impact assessments |
| LU_LC_CODE_1 | First digit of Land Use/Land Cover Category |
| LU_LC_CODE_2 | Second digit of Land Use/Land Cover Category |
| LU_LC_CODE_3 | Third digit of Land Use/Land Cover Category |
| LU_LC_NUM | Composite Land Use/Land Cover Category |

# Nearshore Sediment Classes

**Definition:** This entity is a look-up table storing the valid types of Nearshore Sediment Classifications developed for International Joint Commission lake level control studies and includes sediment types underwater immediately offshore of the shoreline.

**Implementation Notes:** This entity is implemented as a RDBMS table, to be used as a look-up table.

**Layout for Entity Attributes**:

| *Description* | *Item Name* | *Item Definition* | *Issues/Comments* |
|---|---|---|---|
| Key | NSED_ID | Numeric (2) | Primary key, Database Key, Must be unique within dataset |
| | NSED_CLS_NAME | Character Varying (40) | |
| | NSED_CLS_DESC | Character Varying (240) | |

**Description of Attributes:**

| *Description* | *Item Name* |
|---|---|
| NSED_ID | Primary Key |
| NSED_CLS_NAME | Common label of the classification |
| NSED_CLS_DESC | Description of the Nearshore Sediment Class |

**Domain List:**

| *NSED_ID* | *NSED_CLS_NAME* |
|---|---|
| 1 | Clay |
| 2 | Sand |
| 3 | Sand / Gravel Lag over Clay |
| 4 | Bedrock, Resistant |
| 5 | Bedrock, Non-Resistant |
| 6 | Unclassified |

## Normalized Recession Rates

**Definition:** This entity captures recession rate estimates for various time periods. It corresponds to Appendix 1 of "Recession Rate and Land Use Analyses – Lake Michigan Potential Damages Study" December 1997. Recession rates are normalized so that all recession rate data are related to a 1 kilometer segment of the shoreline.

**Implementation Notes:**
1) These features will be implemented within the overall database as a detail table relating to the shoreline reach.
2) This entity stores the processed recession rate information from a series of prior recession rate studies. Should it prove worthwhile, this design could be enriched by storing details of each recession rate study in a table, plus storing rates for spatial extents as determined in the source study.

**Layout for Entity Attributes**:

| *Description* | *Item Name* | *Item Definition* | *Issues/Comments* |
|---|---|---|---|
| Key | REACH_KEY | Numeric (9) | Primary key, Foreign Key |
| | RRATE_STUDY | Numeric (3) | Primary Key |
| | STUDY_DATE | Date | |
| | MEAN_FT | Numeric (8,3) | In feet/year |
| | MEAN_M | Numeric (8,3) | In meters/year |
| | MEDIAN_FT | Numeric (8,3) | In feet/year |
| | MEDIAN_M | Numeric (8,3) | In meters/year |
| | MAX_FT | Numeric (8,3) | In feet/year |
| | MAX_M | Numeric (8,3) | In meters/year |
| | MIN_FT | Numeric (8,3) | In feet/year |
| | MIN_M | Numeric (8,3) | In meters/year |
| | VARIANCE_FT | Numeric (8,3) | In feet/year |
| | VARIANCE_M | Numeric (8,3) | In square feet/year |
| | NUM_SAMPLES | Numeric (3) | In square meters/year |
| | DATA_TYPE | Numeric (2) | |
| | CONFIDENCE | Numeric (2) | |
| | YEAR_OF_RECORD | Date | |
| | REMARKS | Character Varying (50) | |
| | COMMENTS1 | Character Varying | |

| | | | |
|---|---|---|---|
| | | (40) | |
| | COMMENTS 2 | Character Varying (40) | |

## Normalized Recession Rates (Continued)

**Description of Attributes:**

| *Description* | *Item Name* |
|---|---|
| REACH_KEY | Primary key; dataless key; Foreign Key to SHORELINES |
| RRATE_STUDY | Primary Key; Sequential indicator of studies for a reach. |
| STUDY_DATE | Date of study, indicating when the analyses was done |
| MEAN_FT | Mean Recession Rate |
| MEAN_M | Mean Recession Rate |
| MEDIAN_FT | Median Recession Rate |
| MEDIAN_M | Median Recession Rate |
| MAX_FT | Maximum Recession Rate |
| MAX_M | Maximum Recession Rate |
| MIN_FT | Minimum Recession Rate |
| MIN_M | Minimum Recession Rate |
| VARIANCE_FT | Variance |
| VARIANCE_M | Variance |
| NUM_SAMPLES | Number of Samples |
| DATA_TYPE | Indicates nature of data in original source material; valid values are:<br>1 – Point location, discrete value<br>2 – Point location, range value<br>3 – Linear zone, discrete value<br>4 – Linear zone, range value<br>5 – Point location, descriptive value<br>6 – Linear zone, descriptive value |
| CONFIDENCE | Indicates ranking of original source material for quality and accuracy; valid values are:<br>1 – Accurate (superior survey data)<br>2 – Highly Certain (survey or photogrammetrically derived)<br>3 – Moderately Certain<br>4 – Reasonable Inference<br>5 – Poor |
| YEAR_OF_RECORD | Years of Record |
| REMARKS | Free form text. Often contains citation of source study. May contain notation “no data available). |
| COMMENTS1 | Free form text. |
| COMMENTS2 | Free form text. |

<u>**Shoreline Classifications**</u>

**Definition:** The shorelines of the Great Lakes are the key element of the coastal zone database. They are defined in one kilometer segments (reaches) along the U.S. portion of the shoreline starting at the confluence of its outlet and running clockwise around the lake. A different reach classification system has been created for the Canadian shoreline; this entity is only applicable to the U.S. shoreline. Although the reach system is fairly arbitrary, it is retained for consistency with numerous studies and data resources linked to this line string over time. The concept of the shoreline also is arbitrary, as the line string length, and hence one kilometer segmentation thereof, is based upon a water level that fluctuates, changing the distance along the line string as it varies.

This entity corresponds to Appendix 5 of “Recession Rate and Land Use Analysis – Lake Michgian Potential Damages Study” December 1997. This identifies the “RRA Sites” referenced in the various studies, where the site is a centroid of the linear one kilometer reach feature.

**Implementation Notes:**

1) Shore data requires graphical representations as linear features, as done in SHORELINES. Centroid coordinates are also stored there, as attributes of the linear feature.

2) The classification attributes have been separated from the graphical representation in order to allow multiple classifications for the same reach.

**Layout for Entity Attributes**:

| *Description* | *Item Name* | *Item Definition* | *Issues/Comments* |
|---|---|---|---|
| Key | REACH_KEY | Numeric (9) | Primary key, Dataless Key; must be unique within dataset |
| | CLS_DATE | Date | Primary Key |
| | SHORE_TYPE | Numeric (2) | FK to SHOREGEOCLAS |
| | SHORE_PROT | Numeric (1) | FK TO SHORELINE |
| | NEAR_SED | Numeric (1) | FK TO NEARSHOCLAS |
| | COMPOSITE | Character (2) | FK TO COMPOSITE CLASS |

**Description of Attributes:**

| *Description* | *Item Name* |
|---|---|
| REACH_KEY | Dataless key; must be unique within reach data set. |

| | |
|---|---|
| CLS_DATE | The effective date of the classification. |
| SHORE_TYPE | Defines the aggregate shoreline geomorphology of the reach; also called Shoreline Geomorphic class. |
| SHORE_PROT | Defines the aggregate level of protection for the reach. |
| NEAR_SED | Defines the aggregate characteristics of  nearshore sediments |
| COMPOSITE | Defines an aggregate erosion risk factor for the reach; sometimes known as the “fourth “ class. |

# Shoreline Geomorphology Classes

**Definition:** This entity includes definition of the geomorphic class of the shoreline above the water surface, using a standard shoreline classification scheme developed for the Great Lakes. This is a look-up table storing the valid types of Shoreline Geomorphic Classifications recognized for this classification.

**Implementation Notes:** This entity is implemented as a RDBMS table, to be used as a look-up table.

**Layout for Entity Attributes**:

| *Description* | *Item Name* | *Item Definition* | *Issues/Comments* |
|---|---|---|---|
| Key | SHOREGEOCLAS_ID | Numeric (2) | Primary key, Database Key, Must be unique within dataset |
| | SHOREGEOCLAS_NAME | Character Varying (40) | |
| | SHOREGEOCLAS_DESC | Character Varying (240) | |
| | SHOREGEOCLAS_CODE | (Numeric 2) | |

**Description of Attributes:**

| *Description* | *Item Name* |
|---|---|
| SHOREGEOCLAS_ID | Primary Key |
| SHOREGEOCLAS_NAME | Common label of the classification. |
| SHOREGEOCLAS_DESC | Description of the Shore Geomorphic Class |
| SHOREGEOCLAS_CODE | Numeric Code for the Shore Geomorphic Class |

**Domain List:**

| SHOREGEOCLAS_ID | SHOREGEOCLAS_NAME |
|---|---|
| 1 | High (>15M or 50 ft) Bluff |
| 2 | High (>15M or 50 ft) Bluff with Beach |
| 3 | Low (<15M or 50 ft) Bluff |
| 4 | Low (<15M or 50 ft) Bluff with Beach |
| 5 | Sandy or Silty Banks |
| 6 | Clay Banks |

| | |
|---|---|
| 7 | Sandy Beach / Dunes |
| 8 | Coarse Beach |
| 9 | Bay Mouth or Barrier Beach |
| 10 | Bedrock, Resistant |
| 11 | Bedrock, Non-Resistant |
| 12 | Low Riverine or Coastal Plains |
| 13 | Open Shoreline Wetlands |
| 14 | Semi-Protected Wetlands |
| 15 | Composite |
| 16 | Artificial |
| 17 | Unclassified |

# Shoreline Protection Classes

**Definition:** This entity is a look-up table storing the valid types of Shoreline Protection Classifications developed for International Joint Commission lake level control studies.

**Implementation Notes:** This entity is implemented as a RDBMS table, to be used as a look-up table.

**Layout for Entity Attributes**:

| *Description* | *Item Name* | *Item Definition* | *Issues/Comments* |
|---|---|---|---|
| Key | SPROT_ID | Numeric (2) | Primary key, Database Key, Must be unique within dataset |
| | SPROT_CLS_NAME | Character Varying (40) | |
| | SPROT_CLS_DESC | Character Varying (240) | |

**Description of Attributes:**

| *Description* | *Item Name* |
|---|---|
| SPROT_ID | Primary Key |
| SPROT_CLS_NAME | Common label of the classification |
| SPROT_CLS_DESC | Description of the Shore Protection Class |

**Domain List:**

| *SPROT_ID* | *SPROT_CLS_NAME* | *SPROT_CLS_DESC* |
|---|---|---|
| 1 | Highly Protected | 70-100% of segment protected |
| 2 | Moderately Protected | 40-70% of segment protected |
| 3 | Minor Protection | 15-40% of segment unprotected |
| 4 | No Protection | >85% of segment unprotected |
| 5 | Non-Structural Protection | Native and non-native vegetation |
| 6 | Unclassified | Protection unknown or effectiveness not estimated |

# Shorelines

**Definition:** The shorelines of the Great Lakes are the key element of the coastal zone database. They are defined in one kilometer segments (reaches) along the U.S. portion of the shoreline starting at the confluence of its outlet and running clockwise around the lake. A different reach classification system has been created for the Canadian shoreline; this entity is only applicable to the U.S. shoreline. Although the reach system is fairly arbitrary, it is retained for consistency with numerous studies and data resources linked to this line string over time. The concept of the shoreline also is arbitrary, as the line string length, and hence one kilometer segmentation thereof, is based upon a water level that fluctuates, changing the distance along the line string as it varies.

**Implementation Notes:**

1) Shore data requires graphical representation as linear features.
2) The combination of LAKE_CODE and REACH_CODE is a compound alternate key for identifying a reach. Reaches are numbered uniquely within a lake. The single primary key, REACH_KEY, is used for simplicity of maintain relationships within the database. It also supports the recession rate datasets and other studies conducted on any of the Great Lakes and their interconnecting waterways.
3) It has been proposed to redefine reaches to a tenth-kilometer extent. Should this be implemented, both the old and new reaches can co-exist with this data element by adding a new field, REACH_SIZE as Character (1) with values (K – 1 kilometer; T – tenth-kilometer).

**Layout for Entity Attributes**:

| *Description* | *Item Name* | *Item Definition* | *Issues/Comments* |
|---|---|---|---|
| Key | REACH_KEY | Numeric (9) | Primary key, Database Key, Must be unique within dataset |
| | LAKE_CODE | Numeric (2) | |
| | REACH_CODE | Numeric (6) | |
| | DELINEATION_DATE | Date | |
| | SITE_LATITUDE | Numeric (12, 6) | Decimal degree format of Latitude |
| | SITE_LONGITUDE | Numeric (12, 6) | Decimal degree format of Longitude |

**Description of Attributes:**

| *Description* | *Item Name* |
|---|---|

| | |
|---|---|
| REACH_KEY | Dataless key; must be unique within reach dataset. |
| LAKE_CODE | Identifies the lake the reach is defined as belonging to. |
| REACH_CODE | Identifies the reach; unique within a lake. This is a sequential number assigned from the outlet of the lake in a clockwise direction proceeding around the lake. |
| DELINEATION_DATE | The effective date of the classification. |
| SITE_LATITUDE | Centroid coordinate, used to define the “site” for display purposes. |
| SITE_LONGITUDE | Centroid coordinate, used to define the “site” for display purposes. |

# Soils

**Definition:** Soil characteristics affect many aspects of regional planning. The digital representation of USDS Natural Resource Conservation Service soil series, as defined in the SSURGO project by that agency, will be used. See that agency for detailed documentation.

**Implementation Notes:**

1) Soils data requires graphical representation as polygonal features for map units of reasonable area. Lines and points represent breaklines or very small areas, respectively.

**Layout for Entity Attributes**: ***for Polygons***

| *Description* | *Item Name* | *Item Definition* | *Issues/Comments* |
|---|---|---|---|
| Key | MUID | Character (6) | Primary key, defined by NRCS |
| Soil District Code | SSAID | Character (3) | Soil Survey Area |
| Soil Association Code | MUSYM | Character (3) | Map Unit Symbol |
| State | STATE | Character (2) | FIPS code for state. |
| | CLASCODE | Character (20) | Taxonomy |

**Description of Attributes:**

| *Description* | *Item Name* |
|---|---|
| MUID | Map Unit Identification.; primary key, defined by NRCS. Is concatenation of SSAID and MUSYM, where both are left padded with zeroes as needed. |
| SSAID | Identifies the Soil Survey Area. |
| MUSYM | Identifies the Map Unit Symbol within. |
| STATE | FIPS State Code |
| CLASCODE | Abbreviation of Taxonomic Classification of the soil in question. |

**Layout for Entity Attributes**: ***for Linear Features***

| *Description* | *Item Name* | *Item Definition* | *Issues/Comments* |
|---|---|---|---|
| Soils Breakline ID | MUID | Character (6) | Primary key |

**Description of Attributes:**

| *Description* | *Item Name* |
|---|---|
| MUID | Map Unit ID for breakline, a.k.a, “special features”. Breaklines are areas of abrupt change, such as a cliff. |

**Layout for Entity Attributes**: ***for Points***

| *Description* | *Item Name* | *Item Definition* | *Issues/Comments* |
|---|---|---|---|
| Soils Microfeature ID | MUID | Character (6) | Primary key |

**Description of Attributes:**

| *Description* | *Item Name* |
|---|---|
| MUID | Map Unit ID for microfeatures, a.k.a. "conventional features". These are very small features that need to be tracked in analyzing soils, including rock outcrops, small ponds, small wetlands, etc. |

# Toe of Bluff

**Definition:** The toe of a bluff is the transition zone between the bluff and the beach (if any) or the normal pool elevation. Although the toe may be an indefinite transition rather than a sharply defined boundary, it is treated as if it were an abrupt change.

**Implementation Notes:**

1) This entity will be implemented as a linear feature.
2) The toe of the bluff is coterminous with the waters edge of the corresponding BLUFF polygon. If a BEACH polygon exists it will also be coterminous with that inland edge.

**Layout for Entity Attributes**:

| *Description* | *Item Name* | *Item Definition* | *Issues/Comments* |
|---|---|---|---|
| Key | TOE_ID | Numeric (8) | Primary key, Database Key, Must be unique within dataset |
| | BLUFF_ID | Numeric (8) | |

**Description of Attributes:**

| *Description* | *Item Name* |
|---|---|
| TOE_ID | Dataless key; must be unique within reach dataset |
| BLUFF_ID | Identifies the BLUFF with which the toe is associated. |

# Top of Bluff

**Definition:** The top of a bluff is the transition zone between the bluff and the inland area. Although the top may be an indefinite transition rather than a sharply defined boundary, it is treated as if it were an abrupt change.

**Implementation Notes:**
1) This entity will be implemented as a linear feature.
2) The toe of the bluff is coterminous with the inland edge of the corresponding BLUFF polygon.

**Layout for Entity Attributes**:

| *Description* | *Item Name* | *Item Definition* | *Issues/Comments* |
|---|---|---|---|
| Key | TOP_ID | Numeric (8) | Primary key, Database Key, Must be unique within dataset |
| | BLUFF_ID | Numeric (8) | |

**Description of Attributes:**

| *Description* | *Item Name* |
|---|---|
| TOP_ID | Dataless key; must be unique within reach dataset |
| BLUFF_ID | Identifies the BLUFF with which the top is associated. |

# Wetlands NWI

**Definition:** The presence of substantial amounts of water in or on the surface of a tract can indicate an important ecological resource. Wetlands are an officially recognized and delineated portion of such an environment. Generally, wetlands mean those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support "a prevalence of vegetation typically adapted for life in saturated soil conditions." The ecological parameters and more formal definitions and criteria are included in 33 CFR 32.93. The USEPA and USACE have somewhat differing definitions of wetlands, as do several states – this entity represents wetlands as defined in the National Wetlands Inventory (NWI), recognized explicitly by many Federal programs.

**Implementation Notes:** These features will be implemented as polygonal features in the database.

**Layout for Entity Attributes**:

| *Description* | *Item Name* | *Item Definition* | *Issues/Comments* |
|---|---|---|---|
| Key | NWI_WET_KEY | Numeric (6) | Primary key, Database Key, Must be unique within dataset |
| | WET_SYSTEM | Character (1) | System level of classification |
| | WET_SUBSYSTEM | Character (1) | Subsystem level of classification |
| | WET_CLASS | Character (1) | Class level of classification |

**Description of Attributes:**

| *Description* | *Item Name* |
|---|---|
| NWI_WET_KEY | Dataless key; must be unique within coverage. This will be used as the primary key for linkages to additional attribute tables. |
| WET_SYSTEM | System level of classification; top level of USF&WS classification* |
| WET_SUBSYSTEM | Subsystem level of classification; middle level of USF&WS classification* |
| WET_CLASS | Class Level of classification; lowest level of USF&WS classification* |

*USDI, USF&WS, "Classification of Wetlands and Deepwater Habitats of the United States." FWS/OBS-79/31, December 1979.

## Appendix B:  GLCDM Entity Relationship Diagram – V1.0

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# Great Lakes Coastal Data Model - Version 1.0

## ER Diagram August 1, 2009

Entities currently incorporated through NOAA/GLC JPA in bright green

Entities ready to be incorporated in light green

Entities considered for incorporation in version 2.0 in gray