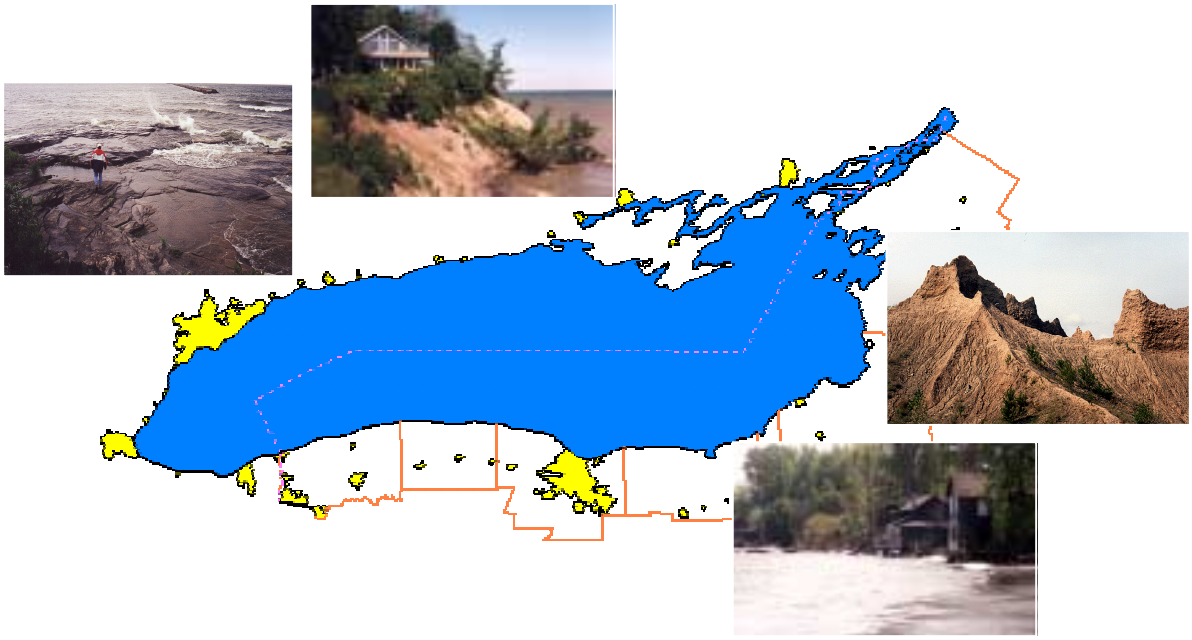
U.S. Army Corps of Engineers - Buffalo District

A REVIEW OF POTENTIAL DATA SOURCES FOR USE IN THE DETERMINATION OF PRE AND POST-REGULATION RECESSION RATES ON LAKE ONTARIO

LOWER GREAT LAKES EROSION STUDY



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A Review of Potential Data Sources for Use in the Determination of Pre and Post-Regulation Recession Rates On Lake Ontario

Introduction

In 1998, the Buffalo District of the U.S. Army Corps of Engineers (USACE) initiated the Lower Great Lakes Erosion Study (LGLES). The goal of this study is to develop a tool for the assessment of local and regional impacts associated with coastal projects. The tool will be applied to assist a wide range of USACE activities on the St. Lawrence River, Lake Ontario, the Niagara River and Lake Erie including:

- Regional sand management issues
- Maintenance of federal navigation projects
- Federal coastal erosion and flooding projects
- Permitting of activities in the coastal zone
- Technical assistance and advice
- Public education activities
- Lake level regulation responsibilities
- State and local coastal zone management.

The first year of this project involved substantial collection and analysis of a range of data including that related to erosion rates (long-term and short-term), shore type and geology, shore protection, land use, land use trends. This information was entered into a database management system (Recession Rate Analysis System) for purposes of data query, analysis and display purposes (see Stewart, 1998).

During the recession rate data collection phase of this activity, it became apparent that there was very little data available to illustrate short-term trends in erosion that may be associated with extended periods of higher or lower-than average water levels on Lake Ontario. More specifically, there was very little data to illustrate the effects that the construction of the St. Lawrence Seaway and the St. Lawrence River control structures in 1958 may have had on these erosion rates, given the long-term changes in water level regime that these structures have had on Lake Ontario and the St. Lawrence River. This is of particular interest today, as there are a number of individuals and interest groups along the shoreline who feel that the construction and long-term mis-management of the

control structures has had an adverse impact on erosion rates along the Lake Ontario shoreline.

Given this, the LGLES Study Team is interested in determining, if and where possible, accurate recession rates along the Lake Ontario shoreline in both the pre-regulation time period (prior to 1958) and the post-regulation time period (1958 to present). To do this requires comparison (ideally) of two (or more) pre-1958 shoreline position data sets and two (or more) post-1958 shoreline position data sets.

To initiate this activity, a more in-depth search of data sets that could be used in determining these recession rates needed to be undertaken. Generally speaking, recession rate data analysis of this type is usually conducted through analysis of aerial photography. The availability of adequate historical and present-day photography for this shoreline thus needs to be documented. In addition, given advances in technology over the years and the intensive use of Geographic Information Systems, other data sets have evolved that can also be of use in determining shoreline recession rates in these periods. This includes various digital products such as digital elevation models (DEMs), digital orthophotos and digital raster graphics (DRGs).

This report provides a review of a range of data sets and available aerial photography that potentially could be used in calculating pre and post-regulation recession rates. This report also highlights existing recession rate data sets that might help in providing additional information. Essentially, this report is a review of digital mapping, digital photography and aerial photography sources available for the Lake Ontario shoreline. While not all will be useful for calculation and establishment of pre and post-regulation recession rates, some of the sources may be applicable simply as base map data, or for general display purposes. As such they are briefly reviewed here.

Description of Potential Data Sources

United States Geological Survey Data

NAPP Aerial Photography

General Description

The National High Altitude Photography (NHAP) program was initiated in 1980 and coordinated by the U.S. Geological Survey (USGS) to acquire aerial photography of the 48 conterminous states every five years. This interagency program was designed to eliminate duplicate efforts in various government programs and to maximize the use of government funds to build a uniform archive for multiple uses. In 1987 the program name was changed to the National Aerial Photography Program (NAPP) in recognition of modifications in the user requirements and flight specifications.

NHAP photography was acquired at 40,000 feet above mean terrain and flight lines were centered on the 1:24,000-scale USGS map series. Two different camera systems were used; a 6 inch focal length lens was used to acquire black-and-white film at an approximate scale of 1:80,000 and an 8.25 inch lens was used to acquire color-infrared film at an approximate scale of 1:58,000. A duel port camera system was used to acquire simultaneous coverage.

NAPP photography are acquired at 20,000 feet above mean terrain with a 6 inch focal length lens. The flight lines are quarter quad-centered on the 1:24,000-scale USGS maps. NAPP photographs have an approximate scale of 1:40,000, and are flown in black-and-white or color infrared (see examples in Figure 1), depending on state or federal requirements.

Data Characteristics

The NAPP/NHAP archive contains over 10,000 rolls of cartographic quality aerial photography acquired since 1980. On the average, 700 new rolls are acquired each year based upon a pre-determined flight schedule and season. All photographs are cloud free, and only contract-acceptable photographs are indexed to the map line plots. The photographic frames are maintained as original and working master archives by two

Figure 1 - Examples of NAPP color infrared (left) and black and white photography.

support facilities, the EROS Data Center and the U.S. Department of Agriculture's Aerial Photographic Field Office (APFO).

All photographs are manually assessed to ensure that they meet the photographic, cartographic, coverage accuracy, and quality standards of each contract. Commercial flight contractors must meet a stringent list of acceptance criteria and provide proof of camera certification in order to fulfill contract requirements.

Spatial Resolution

The NAPP/NHAP film can be used to resolve objects as small as one to two meters in size. The photography can be manipulated to a variety of non-standard enlargements to generate products of desired scales.

Extent of Coverage

While it was the intent of both the NHAP and NAPP programs to acquire complete coverage of the conterminous United States every five years, that has varied somewhat due to budgetary constraints. Nevertheless, these programs do provide nearly complete

coverage of the entire United States on a fairly regular basis. The next cycle of NAPP coverage is planned for 1997 - 2003.

For the Lake Ontario shoreline in New York State, NAPP photography is currently available for 1994 and 1995 depending on the county and can be ordered through USGS. The next scheduled update is 2001.

Digital Elevation Model Data

General Description

The USGS Digital Elevation Model (DEM) data files are digital representations of cartographic information in a raster form. DEMs consist of a sampled array of elevations for a number of ground positions at regularly spaced intervals. These digital cartographic/geographic data files are produced by the U.S. Geological Survey (USGS) as part of the National Mapping Program and are sold in 7.5-minute, 15-minute, 2-arc-second (also known as 30-minute), and 1-degree units. The 7.5- and 15-minute DEMs are included in the large scale category while 2-arc-second DEMs fall within the intermediate scale category and 1-degree DEMs fall within the small scale category.

Large scale

The DEM data for 7.5-minute units correspond to the USGS 1:24,000 and 1:25,000 scale topographic quadrangle map series for all of the United States and its territories. Each 7.5-minute DEM is based on 30- by 30-meter data spacing with the Universal Transverse Mercator (UTM) projection. Each 7.5- by 7.5-minute block provides the same coverage as the standard USGS 7.5-minute map series.

The 7.5-minute Alaska DEM data correspond to the USGS 1:24,000 and 1:25,000 scale topographic quadrangle map series of Alaska by unit size. The unit sizes in Alaska vary depending on the latitudinal location of the unit. The 7.5-minute Alaska DEM data consist of a regular array of elevations referenced horizontally to the geographic (latitude/longitude) coordinate system of the North American 1927 Datum (NAD 27) or the North American 1983 Datum (NAD 83). The spacing between elevations along profiles is 1 arc second in latitude by 2 arc seconds of longitude.

The 15-minute DEM data correspond to the USGS 1:63,360 scale topographic quadrangle map series of Alaska by unit size. The unit sizes in Alaska vary depending on the latitudinal location of the unit. The 15-minute DEM data consist of a regular array of elevation referenced horizontally to the geographic (latitude/longitude) coordinate system of NAD 27. The spacing between elevations along profiles is 2 arc seconds of latitude by 3 arc seconds of longitude.

Intermediate scale

The 2-arc-second DEM data cover 30-minute by 30-minute areas which correspond to the east half or west half of the USGS 30- by 60-minute topographic quadrangle map series for the conterminous United States and Hawaii. Each 2-arc-second unit is produced and distributed as four 15- by 15-minute cells. The spacing of elevations along and between each profile is 2 arc seconds.

Small scale

The 1-degree DEM (3- by 3-arc-second data spacing) provides coverage in 1- by 1-degree blocks for all of the contiguous United States, Hawaii, and most of Alaska. The basic elevation model is produced by or for the Defense Mapping Agency (DMA), but is distributed by the USGS, in DEM data record format. In reformatting the product, the USGS does not change the basic elevation information. The 1-degree DEMs are also referred to as 3-arc-second or 1:250,000 scale DEM data.

The EROS Data Center (EDC) also concatenated the 1- by 1-degree blocks for the contiguous United States in the Land Analysis System (LAS) environment using the elevation data from the photographic sources. This is referred to as the 1-degree DEM mosaic data set. Nine strips of concatenated imagery comprise the data set.

Extent of Coverage

Large scale

The UTM-based 7.5-minute DEM data are available for much of the contiguous United States, Hawaii, and Puerto Rico. Data availability for the New York State region is presented on the status map in Figure 2 and shows this data being available for the entire Lake Ontario shoreline.

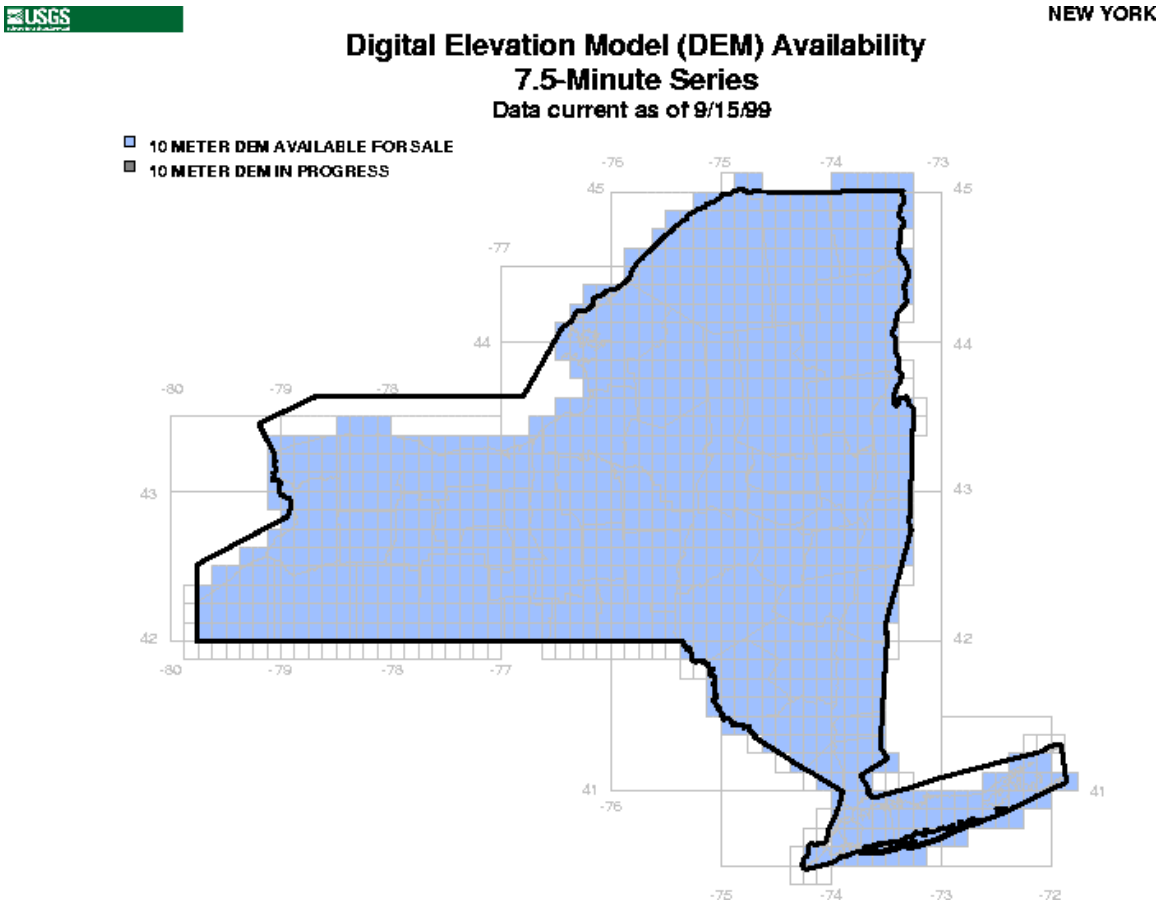

Figure 2 - Digital Elevation Model (10 Meter) Availability, New York State

Intermediate scale

The 2-arc-second DEM data are available for portions of the contiguous United States and Hawaii. For New York State, Figure 3 shows that this data is presently available for portions of the Lake Ontario shoreline near Oswego and the Eastern Lake Ontario sand dunes, as well as for a small portion of shoreline in Orleans and Monroe County.

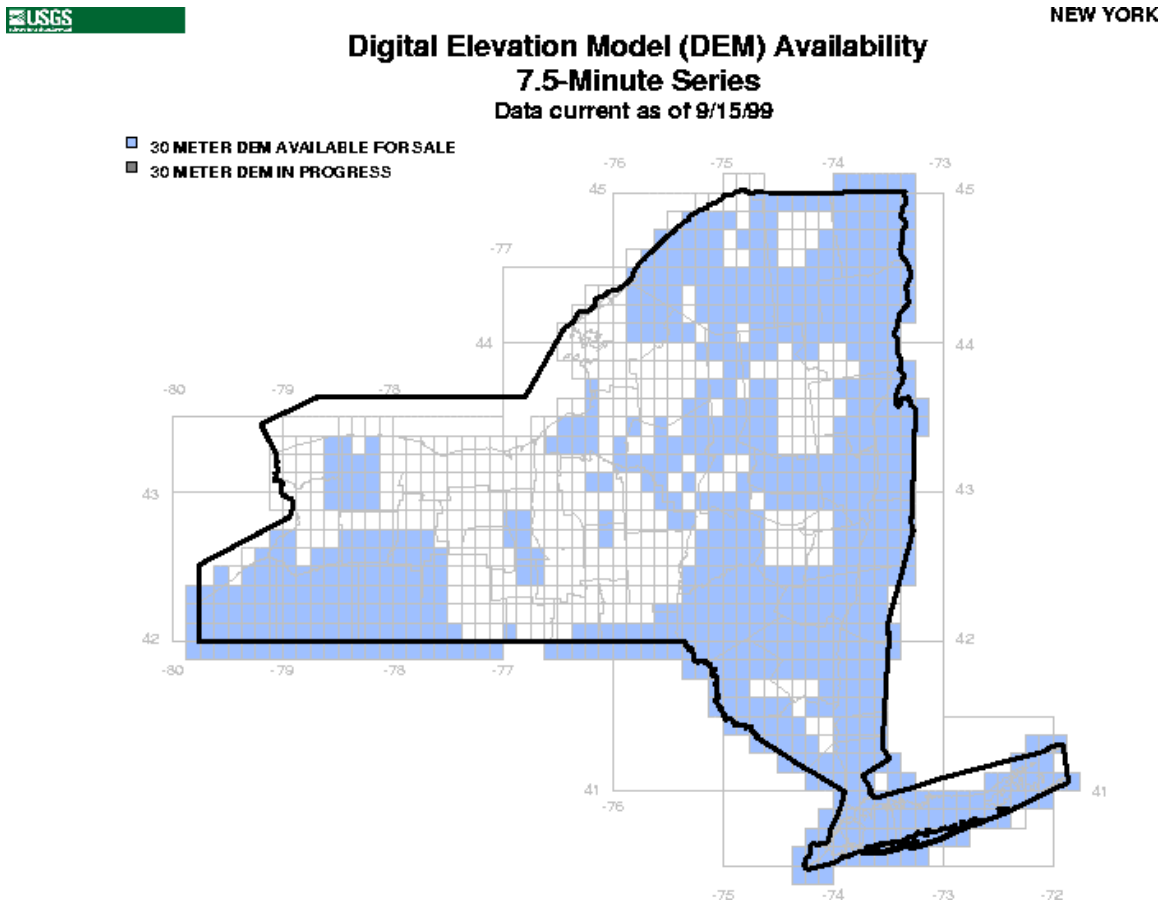

Figure 3 - Digital Elevation Model (30 Meter) Availability, New York State

Small scale

The 1-degree DEM data are available for all of the contiguous United States, Hawaii, and most of Alaska. The concatenated images (1-degree mosaic data) cover only the contiguous United States. Coverage for New York state was unable to be determined.

Digital Orthophoto Quarter Quads

General Description

Orthophotos combine the image characteristics of a photograph with the geometric qualities of a map. They serve a variety of purposes, from interim maps to field references for Earth science investigations and analyses. The digital orthophoto is useful as a layer of a geographic information system (GIS) and as a tool for revision of digital line graphs and topographic maps.

Unlike a standard aerial photograph, relief displacement in orthophotos has been removed so that ground features are displayed in their true ground position. This allows for the direct measurement of distance, areas, angles, and positions. Also, an orthophoto displays features that may be omitted or generalized on maps (see example in Figure 4).

The National Aerial Photography Program (NAPP) imagery and NAPP-like photography are the primary sources of aerial photography used in the production of 1-meter digital orthophotos for the National Digital Orthophoto Program (NDOP). NAPP photography is quarter-quadrangle centered (3.75-minutes of latitude by 3.75-minutes of longitude in geographic extent) and taken at an aircraft altitude of approximately 20,000 feet above mean terrain using a 152-millimeter focal-length camera. The scale of the NAPP photography is approximately 1:40,000. Orthophoto quadrangles may also be produced through the mosaicking of digital orthophoto quarter-quadrangles. Color infrared (CIR) photography may be used as a source. However, the resulting DOQ may either be a single black-and-white composite of all bands or a color DOQ with all three bands. Although NAPP is the primary image source, this does not prevent the use of additional aerial photographs or digital images in the future.

Extent of Coverage

The DOQ coverage area includes the conterminous United States, Alaska, Hawaii, and Puerto Rico. Coverage for New York State is shown in Figure 5 and indicates that DOQs are available for the entire Lake Ontario shoreline.

Figure 4 - Digital Orthophoto Example

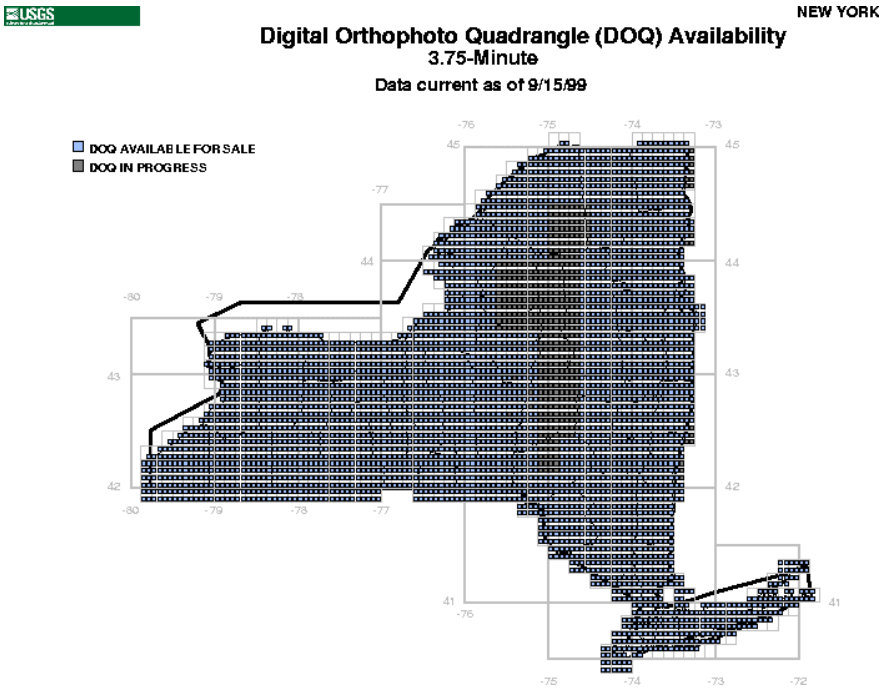

Figure 5 - Digital Orthophoto Quad Availability, New York State

Digital Raster Graphics

General Description

A digital raster graphic (DRG) is a scanned image of a U.S. Geological Survey (USGS) standard series topographic map (Figure 6), including all map collar information. The image inside the map neatline is georeferenced to the surface of the earth and fit to the Universal Transverse Mercator projection. The horizontal positional accuracy and datum of the DRG matches the accuracy and datum of the source map. The map is scanned at a minimum resolution of 250 dots per inch.

A DRG can be used on-screen to collect, review, and revise other digital data, especially digital line graphs (DLG). When the DRG is combined with other digital products, such as digital orthophoto quadrangles (DOQ) or digital elevation models (DEM), the resulting image provides additional visual information for the extraction and revision of base cartographic information.

Figure 6 - Example of USGS Digital Raster Graphic

The DRGs are georeferenced to the Universal Transverse Mercator (UTM) grid. A DRG may be used as a source or background layer in a geographic information system, as a means to perform quality assurance on other digital products, and as a source for the collection and revision of digital line graph (DLG) data. The DRGs also can be merged with other digital data (e.g., digital elevation model (DEM) or digital orthophotoquad (DOQ) data) to produce a hybrid digital file. These DRG data are produced by the USGS through cooperative agreements with private industry and other Federal, State, and local agencies.

Data Characteristics

A DRG is a scanned image of a USGS topographic map. The scanned image includes all map collar information. The image inside the map neatline is georeferenced to the surface of the Earth. The DRG can be used to collect, review, and revise other digital data, such as DLG data. The USGS is producing DRGs from 1:24,000-, 1:24,000/1:25,000-, 1:63,360- (Alaska), 1:100,000-, and 1:250,000-scale topographic map series.

Spatial Resolution

The DRG uses a standard palette to ensure uniform color throughout a particular map series. The values for a particular color, therefore, will remain consistent throughout that DRG series. Although the color values of the DRG may sometimes match those of the paper source map, a user will usually notice small differences between the colors on the digital image and on the paper map. Also, the quality of the user's monitor affects the DRG color displayed. Although the DRG generally contains the complete content of the source map, features may occasionally be blurred because of substandard source materials. The DRG also may contain misclassified pixels (color noise).

The horizontal positional accuracy of the DRG matches the accuracy of the published source map. To be consistent with other USGS digital data, the image is cast on the UTM projection, and therefore, will not always be consistent with the credit note on the image collar. Only the area inside the map neatline is georeferenced, so minor distortion of the text may occur in the map collar.

Extent of Coverage

Figure 7 shows DRG status for the entire United States. For New York, DRGs are available in 1:24,000, 1:100,000, and 1:250,000 scale for the entire Lake Ontario

Shoreline. These may be obtained via free download on the New York State GIS Clearinghouse web site (**http://www.nysl.nysed.gov/gis**/).

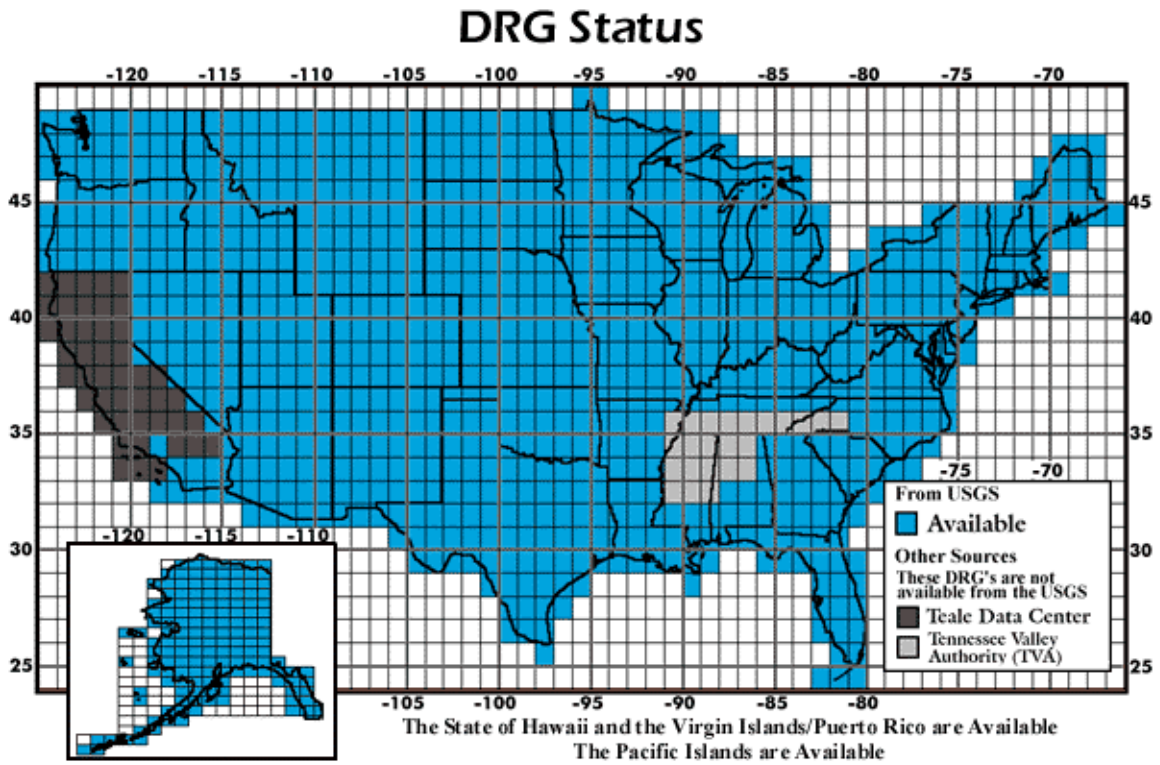

Figure 7 - Digital Raster Graphic Status, USA

Digital Line Graphs

General Description

The U.S. Geological Survey's (USGS) digital line graph (DLG) files are digital vector representations of cartographic information. Data files of topographic and planimetric map features are derived from either aerial photographs or from cartographic source materials using manual and automated digitizing methods.

Large Scale

The large-scale DLG data primarily are derived from USGS 7.5-minute topographic quadrangle maps at 1:24,000 and 1:25,000 scales (1:25,000 and 1:63,360 scales for Alaska). An example is shown in Figure 8.

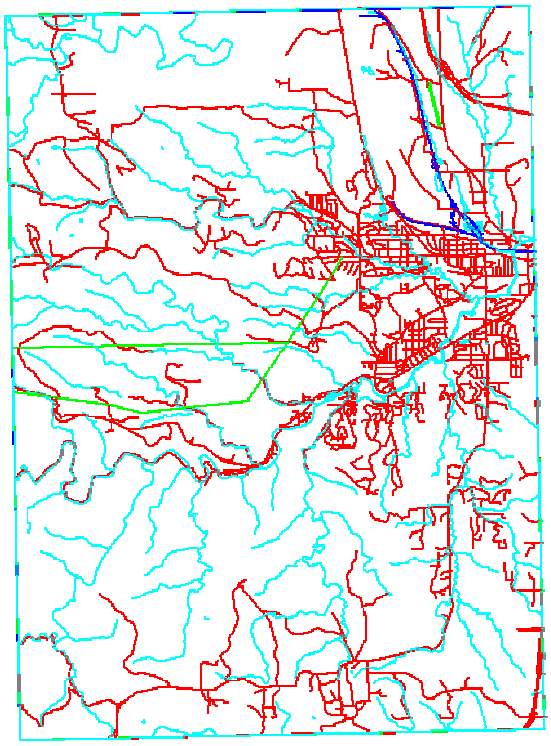

Figure 8 - Large Scale Digital Line Graph

Intermediate Scale

Intermediate or 100,000-scale DLG data are derived from USGS 1:100,000-scale, 30- by 60-minute quadrangle maps. If these maps are not available, Bureau of Land

Management (BLM) planimetric maps at a scale of 1:100,000 are used. An example is shown in Figure 9.

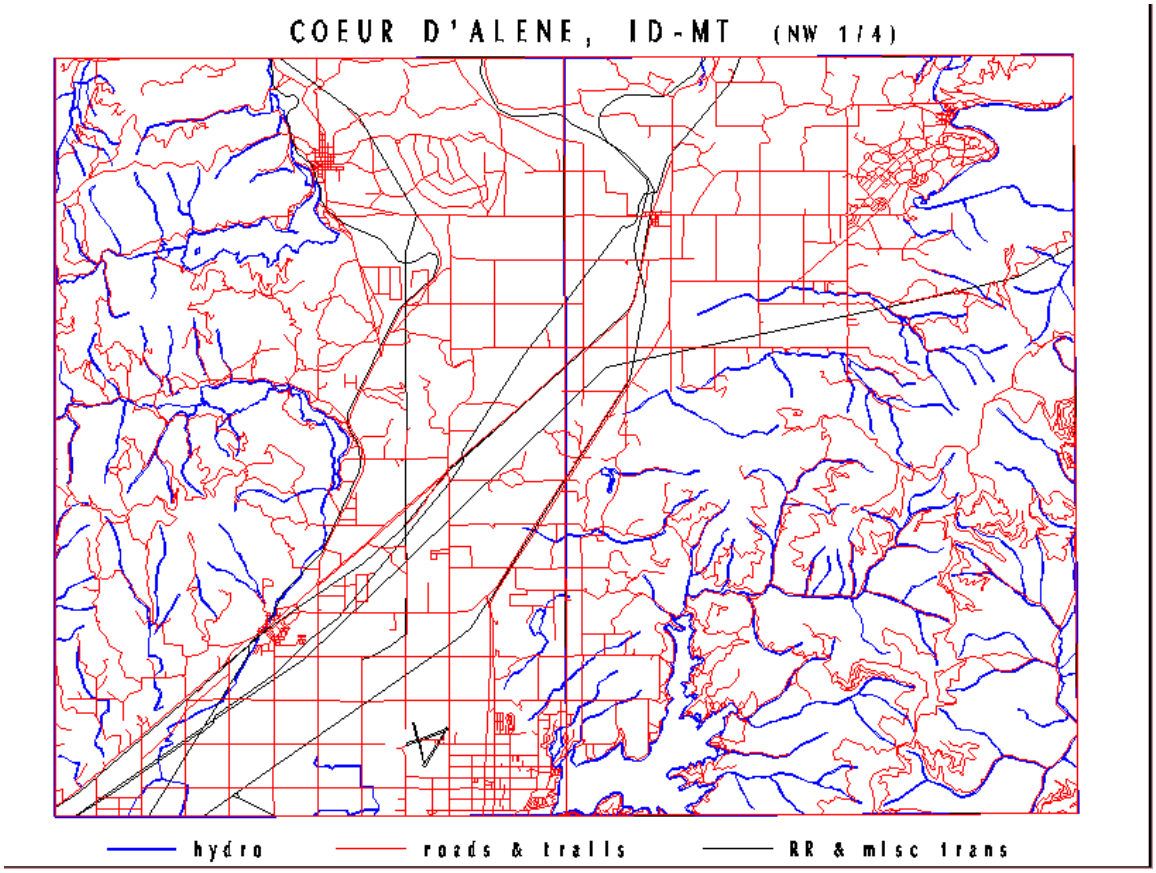

Figure 9 - Intermediate Scale Digital Line Graph

Small Scale

Small or 1:2,000,000-scale DLG data are organized two ways (by section or by State) and contain information on planimetric base categories, including transportation, hydrography, and boundaries for all 50 States. The Section DLG data files are historical files dating between 1973 and 1980 that are organized by sections of the United States (e.g., northeastern States). The State data files are recent files dating between 1990 and 1994 that are organized by State. An example is shown in Figure 10.

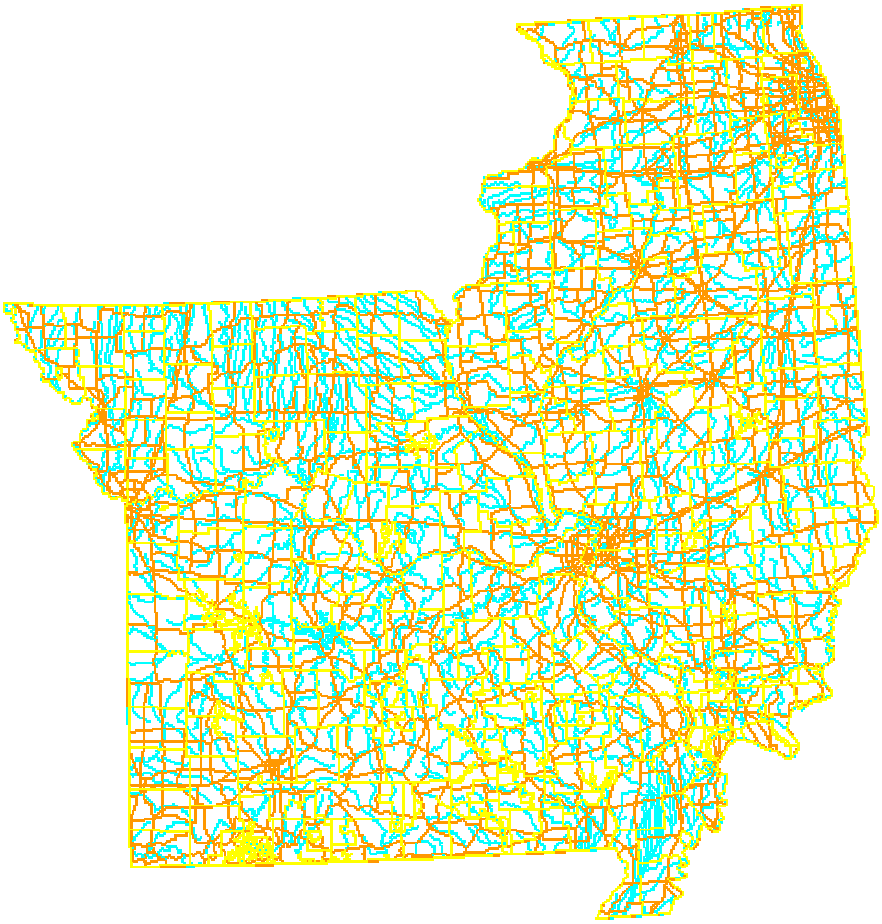

Figure 10 - Small Scale Digital Line Graph

Extent of Coverage

Large Scale

These DLGs are produced from the largest scale topographic quadrangle maps available, which are usually the USGS 7.5-minute, 1:24,000-scale topographic maps for the contiguous United States, Hawaii, and the Virgin Islands. Large-scale DLGs also are

produced from 1:25,000- and 1:63,360-scale maps for Alaska and 1:30,000-scale maps for Puerto Rico.

The DLG data are being collected for all 50 States, and the 1:24,000-scale series eventually will provide complete national coverage. For New York State coverage at this level is only available for hydrography (Figure 11), although portions of Niagara and Orleans county have not been completed. Boundary and hypsography (contour) information are not yet available.

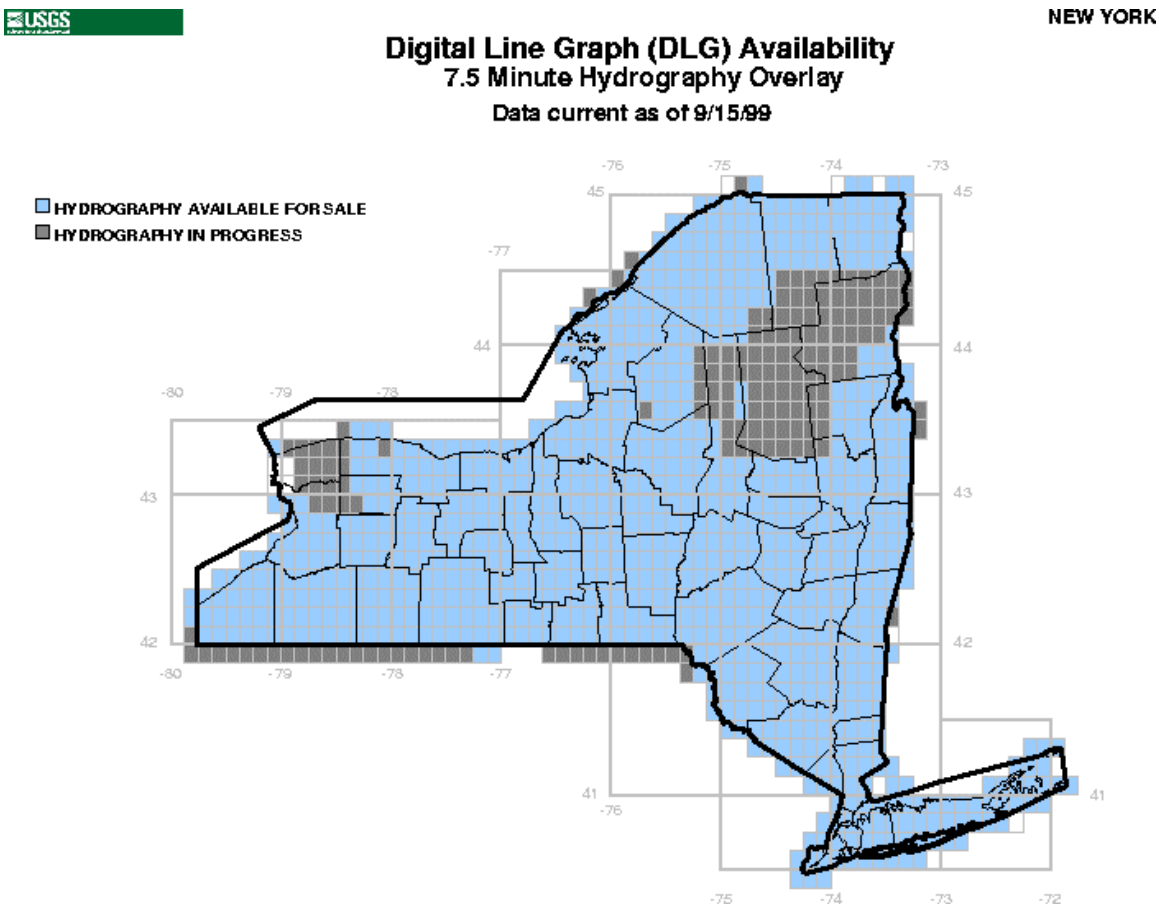

Figure 11 - DLG (Hydrography) Availability, New York State

Intermediate Scale

The 1:100,000-scale DLG data are being collected for the contiguous United States and Hawaii. The hydrography and transportation categories are complete, and the series will eventually provide complete national coverage for all categories. Boundary and hydrography information for New York State have been completed. Hypsography (contour) information has not (Figure 12).

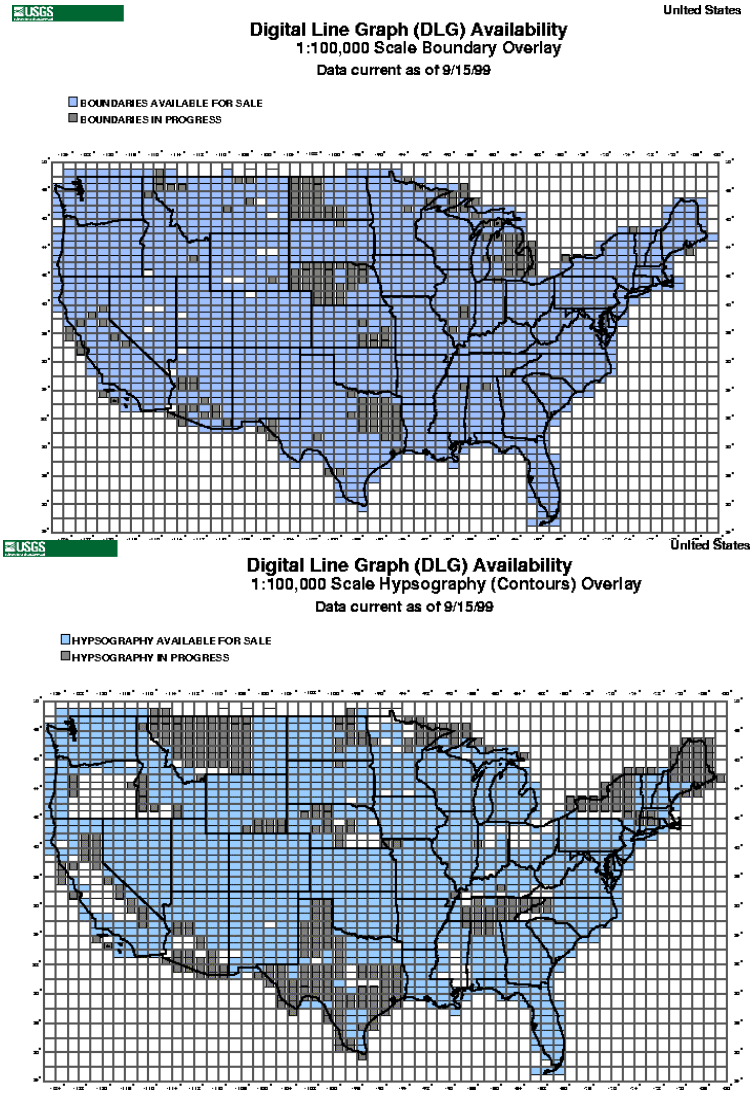

Figure 12 - DLG (Boundary (top) and Contours (bottom) Availability

Small Scale

The 1:2,000,000-scale DLG data files do not appear to be available for New York State.

USGS Aerial Photography

Background

The U.S. Geological Survey (USGS) Aerial Photography data set includes over 2.5 million film transparencies. Beginning in 1944, photographs were acquired for mapping purposes at different altitudes using various focal lengths and film types. The resultant black-and-white photographs contain less than 5 percent cloud cover, and were flown under rigid quality control and project specifications (i.e., stereo coverage, continuous area coverage of map or administrative units).

Prior to the initiation of the National High Altitude Photography (NHAP) program in 1980, the USGS photography collection was one of the major sources of aerial photographs used for mapping the United States. Since 1980 the USGS has acquired photographs over project areas that require larger scale photographs than those available through the NHAP and NAPP programs.

Spatial Resolution

The spatial resolution varies depending on the scale of the USGS photograph. The USGS aerial photography collection ranges in scale from 1:8,000 to 1:80,000.

Data Organization

The USGS aerial photographs are geographically referenced on photographic indices. An individual photographic index is compiled by mosaicking a series of consecutive and adjacent overlapping photographs over a specified geographic area. These indices of mosaicked photographs provide information (i.e., project, roll, and frame numbers) required for the ordering process.

Extent of Coverage

The coverage area includes the conterminous U.S., Alaska, Hawaii, and Puerto Rico. Specific coverages available for the Lake Ontario shoreline of New York State will need to be determined by querying USGS.

Other Government Aerial Photography

Background

The United States (U.S.) Government Aerial Photography data set includes film received from the Bureau of Indian Affairs (BIA), the Bureau of Land Management (BLM), the Bureau of Reclamation (BOR), the Environmental Protection Agency (EPA), the National Park Service (NPS), the U.S. Air Force, the U.S. Army, and the U.S. Navy that is archived at the EROS Data Center. Originally, the photographs were acquired for a variety of agency projects, thus, providing irregular coverage over the conterminous U.S., Alaska, Hawaii, and Micronesia. The film types, scales, acquisition schedules, and available end products differ according to individual agency project requirements. Low-, middle-, and high-altitude photographs using a variety of film types were collected.

Data Organization

Except for EPA and NPS photography, data are compiled into black-and-white photographic indexes that are available for viewing on microfilm or microfiche and are available as paper print products.

EPA, NPS, and some U.S. Air Force photographs are plotted onto large-scale topographic maps. The frame corner points are digitized for retrieval using geographic (latitude/longitude) coordinates.

Spatial Resolution

Spatial resolution varies according to the scale of the photographs. The U.S. Government Aerial Photography data set base-scale ranges follow:

Agency	Scale Range
BIA	1:15,000
BLM	1:12,000 - 1:31,600
BOR	1:3,000 - 1:48,000
EPA	1:5,000 - 1:80,000
NPS	1:10,000 - 1:30,000
U.S. Air Force	1:25,000 - 1:80,000
*U.S. Army	1:5,000 - 1:80,000
U.S. Navy	1:17,000 - 1:60,000

**Army Map Service and Corps of Engineers photography*

Extent of Coverage

Geographic and temporal coverage is irregular and varies by agency and program. Coverage areas for agency photography include the conterminous United States, Alaska, Hawaii, and Micronesia.

Agency	Temporal Coverage
BIA	03/16/58 - 09/13/89
BLM	07/17/61 - 08/24/82
BOR	04/21/39 - 11/14/76
EPA	02/12/72 - 10/12/88
NPS	02/09/79 - 03/03/90

U.S. Air Force	12/21/40 - 10/15/80
*U.S. Army	12/23/42 - 06/30/78
U.S. Navy	01/01/48 - 03/31/72

**Army Map Service and Corps of Engineers photography*

Specific coverages available for the Lake Ontario shoreline of New York State will need to be determined by querying USGS.

U.S. Army Corps of Engineers - Buffalo District Data

There are a number of data sources available at the Buffalo District office of the U.S. Army Corps that may be of use in the recession rate determination exercise.

Aerial Photography

A number of aerial photography sets are available including:

1986 - These are 1:4800 scale, black and white prints of good quality. They were used as baseline information to supplement the 1999 shoreline video used in re-classifying the Lake Ontario shoreline. Bluff edge and shoreline determination should be easy to accomplish. This set would need to be used as the most recent set of photos for recession rate determination.

1974 - These are 1:6000 scale color prints of fair to good quality. Generally they are at the limit of scale useful for recession rate determination. These could be used with the 1986 photos to establish post-regulation recession rates in appropriate areas.

1964 - These are 1:40,000 scale(?) black and white prints taken in October of 1964. The photos are generally clear and sharp, however their scale could lead to accuracy problems in determining bluff edge and shoreline position, even with the aid of zoom transfer scopes and other photgrammetry techniques. The preference would be to use other photo sets, but these could likely be used in some areas to establish, for example, 1964-1974 recession rates.

1938 - These are 1:12,000 scale (appox.) black and white prints taken in June. They are fair quality and are likely the earliest set of air photos that might be found for this area.

Ground Photos

Buffalo District has a number of ground level photographs on hand that have been taken over the course of various coastal investigations along the Lake Ontario shoreline. These could be used in providing qualitative descriptions of shore change in areas of coverage. Sets of available photos include 1935 photos at Webster, New York, 1939 photos in the Olcott and Wilson areas, 1953, 1954 and 1960 black and white Polaroids with associated index maps for various spots along the shoreline, and plenty of modern day photos including those taken in 1998 and 1999 as part of site study investigations associated with the Lower Great Lakes Erosion Study.

Video tape

In April of 1999, the Buffalo District flew the entire shoreline of Lake Ontario and the St. Lawrence River by helicopter and obtained good quality videotape. This tape can be used effectively with air photos, ground photos or other mapping information to make qualitative assessments of shoreline erosion and recession. It could also be compared to previous video of the shoreline that is available, including 1995 video of the eastern Lake Ontario shoreline flown by New York Sea Grant, or other video that may reside in Buffalo District.

NY State Department of Transportation

Planimetric Maps

NY State DOT provides black and white planimetric maps that include a wide range of information. Statewide coverage includes 968 7.5-minute quadrangles. They are also available as raster digital files for quads produced since 1990. Each map covers approximately 6x8 miles (see example in Figure 13). Transportation data includes all roads and most major trails, railroads, airfields and ferry lines. Roads are symbolized to

tell if they are divided or undivided and all ramps and other interchange details are shown. Boundary lines are shown for all cities, villages, towns, and counties as well as for miscellaneous state lands, Indian reservations and federal lands. Individual buildings are shown. Larger building outlines are shown and many landmark buildings (schools, churches, etc.) are separately symbolized. A gray tint is used to identify heavily built-up areas. Within the tint areas only landmark buildings are shown. Virtually all water features in the state, from small streams to the Great Lakes are also shown. (Content differs slightly on pre-1972 maps.) An index map is available which shows the name and limits of each 1:24,000 scale map.

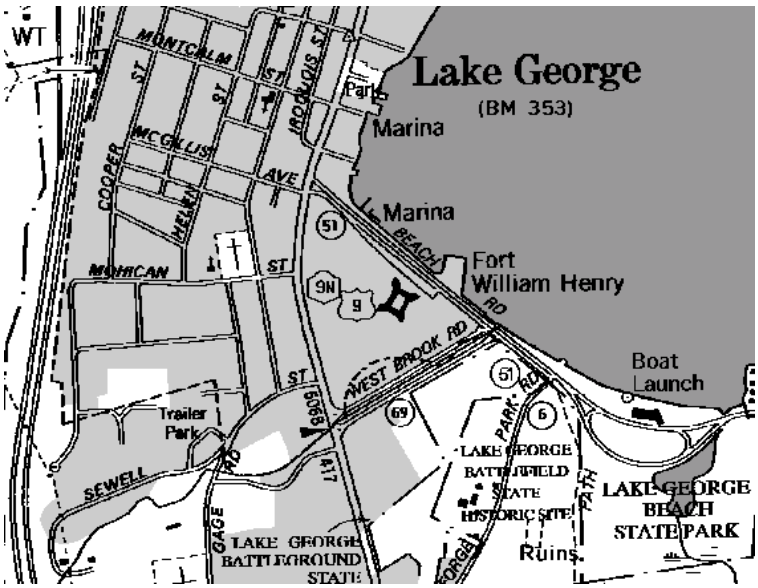

Figure 13 - NY DOT Planimetric Map

Topographic Maps

NY State DOT topographic maps combine the Planimetric Map image with elevation contours from the corresponding U. S. Geological Survey map (see example in Figure 14). The contours generally appear in light brown, the Planimetric Map image is black. Although the Planimetric Map has been extensively revised, in most cases the contours

are reproduced exactly as they appear on the U. S. Geological Survey map. This means that in areas of major new construction the contours may be incorrect.

Within the Adirondack area Topographic Maps are black and white, brown is not used to show contours. An index map is available on request from the Map Information Unit which shows the name and limits of each 1:24,000 scale map.

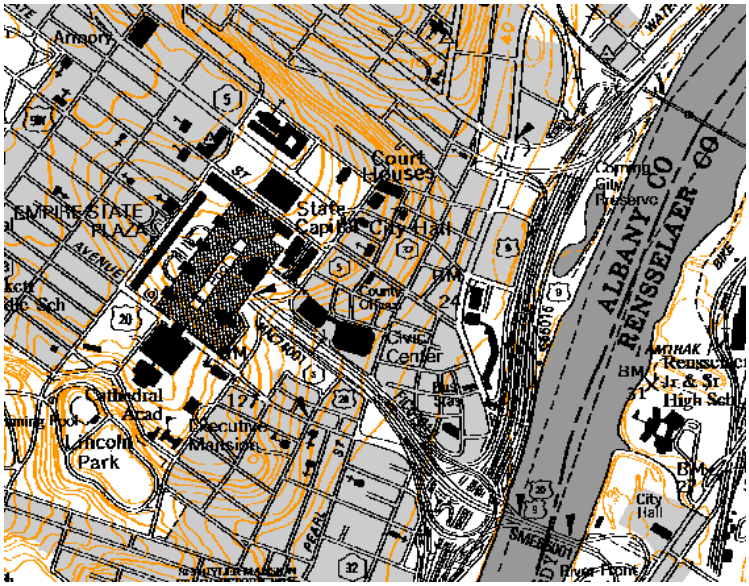

Figure 14 - NY DOT Topographic Map

County Base Map Files

General Description

NY State DOT's County Base Map files cover whole counties and are separated into five themes:

Roads - all public roads digitized as centerlines; classified by jurisdiction, access control, divided/undivided status, and number of lanes; road names and route numbers.

Boundaries - municipalities, Indian reservations, state recreational lands, state facilities, federal lands, county and municipal parks.

Hydrography - rivers and streams > 1 mile in length, water bodies > 500 feet in the shortest dimension, swamps > 2000 feet in the shortest dimension, and other hydrographic features (waterfalls, dams, etc).

Miscellaneous Transportation - active and abandoned railroads, public airports, major electric, gas, and telephone lines, state and federal trails, ferry routes, and state and county boat launches.

Names - all populated place names (with populations > 50) route numbers, major road names, and feature names shown on the body of the printed County Base Map; compiled for use at publication scale.

These files are used to publish the County Base Map Series. It will be several years before all maps are published. For those counties which lack County Base Map coverage, unrevised CLASS files are available (see sample in Figure 15).

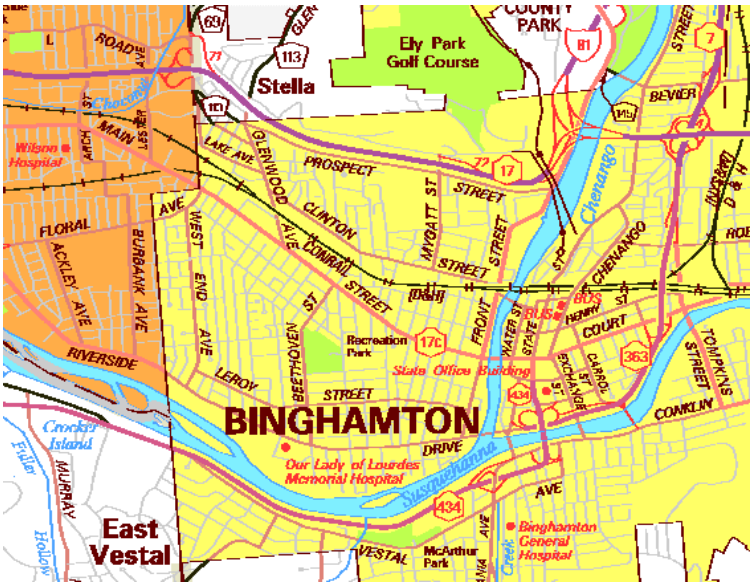

Figure 15 - NY DOT County Basemap

These files are offered in either ARC/INFO coverage format or MicroStation design file format.

Coordinate System

All NY State DOT digital base map files use the New York Transverse Mercator (NYTM) projection/grid system based on the North American Datum of 1927 (NAD-27). NYTM is an east and west mathematical extension of Zone 18 of the Universal Transverse Mercator (UTM) projection/grid system to accommodate all of New York State in a single zone with a single origin point.

Data Sources

Two data sources form the foundation of the County Base Map digital files. 1:100,000 scale Digital Line Graph (DLG) files from the U.S. Geological Survey are the basis for the Hydrography and Miscellaneous Transportation themes. The DLG data is converted to NYTM coordinates, edge matched, substantially updated using revised NYSDOT 1:24,000 scale quadrangles, reclassified, and integrated with other files. For the Roads and Boundaries themes, NYSDOT Centralized Local Accident Surveillance System (CLASS) files are used. For use in the County Base Map Series, these files are updated using recently revised NYSDOT quadrangles and aerial photographs, merged to form county files, reclassified to depict road jurisdiction and physical characteristics, and selectively generalized as appropriate for publication at county map scale. Boundaries are also updated using official boundary descriptions from administering agencies. All other features in the County Base Map Series are table digitized from stable base (Mylar) copies of NYSDOT 1:24,000 scale quadrangles.

Spatial Resolution

The positional accuracy of features in the file is no better than the sources used for digitizing. Data sources for information in the files range from 1:24,000 to 1:100,000. For this reason, the files are not recommended for use in applications requiring greater positional accuracy than can be obtained from 1:24,000 or 1:100,000 mapping, depending on the theme file used. In addition, some features have been selectively repositioned for symbolization at final map scale. In these cases, the original position of the feature is retained on a separate level.

1" = 200' Topographic Maps Highway Corridor Maps

These maps may be of use where state highways are found near the shoreline. They are black and white maps that show a wide range of detailed information. Among the features shown on most of the maps are: all roads, with identifying route numbers and names, railroads, airports, transmission lines, individual buildings, hydrography, civil boundaries, fence lines, and in some cases, property lines. The State Plane Coordinate System usually is shown.

The 1"=200' Topographic Maps are produced by photogrammetric methods usually on 30x54 inch sheets. Individual sheets generally cover a 1x2 mile area. Most Highway Corridor Maps were produced prior to 1970.

These maps are generally only available in narrow corridors along state highways, highways which often were built after the production of the map. The limits of coverage, date, and sheet identification numbers are shown on a four sheet Index Map. The Index Map, which should be consulted before ordering any 1"=200' maps, can be purchased or inspected in the Map Information Unit or in any of the Department of Transportation's region offices.

New York Department of Environmental Conservation

In order to determine erosion hazard areas along the Lake Ontario shoreline in New York State, the Department of Environmental Conservation (DEC) has calculated long-term recession rates for the period 1875-1979.

Comparisons were made between shoreline positions on 1875 Hydrographic Survey maps with the shoreline position on 1979 aerial photographs. Baselines were established on the 1875 maps using road intersections and other landmarks that also exist on the 1979 air photos. Transects were established approximately every 244 meters along the baseline and baseline to bluff-crest measurements were made for each. Similar measurements were made along the same transects on the 1979 photos, and the net shoreline change was calculated by subtracting the two values. Appropriate scale adjustments were made in order to allow accurate comparisons between the maps and the air photos, and average annual recession rates were calculated simply by dividing the total shoreline change by the 104 year period of record. In some areas of Lake Erie, 1875 hydrographic charts

were not available and 1938 air photos were utilized and compared with the 1979 maps, producing a 40 year period of record.

Transect and associated recession rate information were plotted on a series of 1:2400 scale Coastal Erosion Area maps, which use enlarged prints of the 1979 photography as a base and include other reference information. These maps are next scheduled for update in 2003.

NY Department of State, Coastal and Waterfront Resources Division

General Mapping Activities

The Division of Coastal Resources is using Geographic Information Systems (GIS) technology to assist in the management of coastal resources by providing traditional mapping products to assist communities in waterfront planning, assessing regional distribution of natural resources and relationships to upland development, and undertaking applications and research based on aerial- and satellite-based remote sensing. The types of spatial data used in the GIS for coastal management include vector (line work) and raster (image-based) data.

Many levels of government and private industry have been involved in the development of GIS capabilities and data. The approach to implementing GIS for management of coastal resources at the Division of Coastal Resources has been to avoid duplicating efforts underway through other programs and to focus efforts on meeting needs not currently being addressed. As a member of the New York State GIS Clearinghouse, the Department of State actively coordinates with the state's data cooperative members including federal agencies, other state agencies, local governments, and not-for-profit organizations.

Areas where the Division of Coastal Resources has focused effort include comprehensive plan development in communities lacking GIS capabilities, regional coastal program development (currently focused on the South Shore Estuary Reserve on Long Island), natural coastal resource mapping, erosion and hazards management, high-accuracy digital orthophotography development, land cover mapping based on satellite remote sensing data, and applied research in new satellite remote sensing technology.

A principal focus of the Division of Coastal Resources continues to be support of local comprehensive waterfront revitalization programs, harbor management plans, and regional coastal management programs. Each of these includes an extensive mapping and analysis component to support decision-making as it relates to appropriate development and local protection of coastal resources. Program support has included direct technical involvement in producing GIS products; this role has grown recently to providing assistance in establishing GIS capability in local government and not-for-profit groups both by providing technical assistance and providing funding opportunities.

Many programs have focused on high-quality spatial line work; however, few programs have focused on high-quality digital imagery. As an early initiative under the South Shore Estuary Reserve program, the Division of Coastal Resources completed development of a digital orthophotography base covering 500 square miles of the south shore of Long Island. This data product provided accurate (within 4 feet) presentation of features captured using color-infrared photography in the spring of 1994 by the National Aerial Photography Program. Unfortunately, no such activity has taken place on the Great Lakes shoreline.

The Division of Coastal Resources has actively been involved in land cover mapping initiatives since 1993 when it first participated in NOAA's Coastal Change Analysis Program. The first products completed under this program include a 9-class land cover map based on spring 1994 imagery covering Nassau and Suffolk County on Long Island. More recent efforts involve research on use of new satellite imagery in coastal resource detection. The principal focus of this work is on use of radar imagery in combination with optical Landsat imagery funded under a grant from the NOAA Coastal Ocean Program and the National Environmental Satellite, Data, and Information Service. The purpose of the study is to determine the enhancement offered by radar in wetland detection, flood plain analysis, and land cover mapping. Both spectral and spatial enhancements are considered in the study. Applications of land cover data in use by the Division of Coastal Resources include change analysis for mapping trends of development and resource change and mapping potential non-point source pollution. Both of these techniques have been used in support of the South Shore Estuary Reserve plan underway at the Division of Coastal Resources for mapping change in land cover from 1984 to 1994 and for general mapping of runoff potential throughout the Reserve.

In addition to providing support for the state's coastal management program, the Division of Coastal Resources GIS Unit leads GIS development in the Department of State as GIS capability is being extended to other divisions within the agency. Participation with statewide issues is also a notable responsibility. For example, the GIS Unit provided

power outage mapping following the North Country ice storm. Current activities include participating in delivery of GIS data through development of the state's GIS clearinghouse, chairing an initiative under the state's GIS Cooperative to develop high spatial resolution digital orthoimagery on a statewide basis (**http://nysgis.nysed.gov/gis/digi_rpt.htm**), and participating in disaster preparedness planning.

FEMA Erosion Hazard Study - Monroe County, New York

As part of an overall, country wide assessment of coastal erosion hazard areas, the Federal Emergency Management Agency, in cooperation with the NY Department of State conducted an erosion hazard assessment "pilot study" along the Monroe County shoreline of New York. This study is referred to in a paper by Leatherman and Anders (1999), but did not provide any detail on the data used or available for the Monroe County area. It is assumed that data for Monroe county would be available from the Department of State.

Waterfront Revitalization Reports

The Department of State oversees the Local Waterfront Revitalization Program which over the years has produced a series of Waterfront Revitalization Reports for a number of communities along the Lake Ontario shoreline. These reports provide detailed descriptions of the areas of concern, however the focus is on historical development and opportunity for future waterfront development, recreation and other uses. Some of the reports contain information on the geology of the shoreline and on recession rates (usually referring to recession rates calculated by the NY DEC on the Coastal Erosion Area maps). There are some reports however that briefly describe site specific erosion problems, which may be of benefit is making qualitative assessments of both pre and post regulation recession rates, in some of these areas.

Other U.S. Studies and Data Sources

Lake Ontario Recession Rate Data (Drexhage and Calkin, 1981)

This study measured rates of bluff line recession at 250 sites in six counties along the Lake Ontario coastline in order to determine historic rates of recession and to provide information on their spatial and temporal distribution as well as on those factors that influence local differences in recession rates. Long-term recession rates were determined for the 99 year period from 1875-1974 and for the 13 year period from 1938-1951.

Short-term (13 year) recession rates were calculated using 1938 and 1951-1955 U.S. Department of Agriculture aerial photographs. A Bausch and Lomb optical micro-rule was used to directly measure distances between fixed points on land and the bluff line. Measurement locations were indicated on USGS topographic quadrangles. Distances along the east side of a convenient road (or other recognizable line) leading to the shore from a road intersection (or other suitable landmark visible in both sets of photos) to the bluff line were then computed. According to the scale of the photos, the distances determined were then converted to true distances in meters. The difference between distances was then determined and divided by the number of years between photos to give a mean recession rate at that point.

Long-term recession changes were determined using 1:10,000 scale 1874-1875 U.S. Army Corps of Engineers Lake Survey Sheets and 1:9,000 scale 1974 U.S. Army Corps of Engineers aerial photographs. Bluff line positions on the 1875 maps were traced onto a transparent overlay. The bluff line position from the 1974 air photos was projected and traced to scale on the same overlay with the aid of an overhead projector. Sufficient development of the Lake Ontario coastal area by 1875 made correlation with present landmarks for scale matching relatively easy. Sites utilized in the short-term rate determinations were then transferred onto the overlay and recession rates were then determined for the 1875-1974 period for these sites.

Other New York Studies

Other than the comprehensive studies listed above, only a few researchers have examined the New York coast of Lake Ontario. The U.S. Army Corps of Engineers have undertaken most of the work in this area (e.g. U.S. Army Corps of Engineers, 1954, 1955

and 1970), having conducted a number of site specific erosion related investigations. Other studies have been conducted by: Palm (1975), who assessed 1938-1974 recession rates and high water damage along the Oswego County shoreline; Brownlie and Calkin (1981), who examined the relationship between the jetties constructed at Sodus Bay and shoreline recession; and Brennan and Calkin (1984), who investigated the sedimentology and one-year recession rates of bluffs along the southern coastline of Lake Ontario. Finally, a report by L.R. Johnston Associates (1989) provides a discussion of resources, problems and management guidelines for New York's Eastern Lake Ontario sand dunes, including descriptive discussions of various erosion problems.

Canadian Data Sources

Data sources for the analysis of pre and post-regulation recession rates on Lake Ontario need not be limited to the United States shoreline, since the response of a particular shore type to a long-term water level change, whether located in Canada or the United States, would be assumed to be somewhat similar. As such, there are a number of datasets available on the Canadian shoreline of Lake Ontario that may prove useful.

Environment Canada

Air Photography

Environment Canada in Burlington, Ontario has a number of sets of aerial photography available that could be of use (Ralph Moulton, personal communication). This includes the following:

1955 - entire Lake Ontario shoreline; 1:16,000 scale
1973 - entire shoreline; 1:20,000 scale
1986 - entire shoreline; 1:8,000 scale (approx.)
1988 - Niagara Peninsula area; 1:8,000 scale
1989 - entire shoreline except Niagara Peninsula; 1:8,000 scale.

The photos from 1988 and 1989 were used to make Flood Damage Reduction maps for the shoreline at a scale of 1:2,000. The maps were done in a digital format, that was suitable to load into SPANS GIS at that time.

Environment Canada Recession Rate Data

As part of the IJC Water Level Reference Study (1986-1993), Environment Canada retained the services of Geomatics International (1992) to complete a shoreline classification of the Canadian shoreline of the Great Lakes. A component of this study was the collection of all available recession rate data and it's incorporation into a reach-by-reach data base. For each reach, mean, median, maximum and minimum values of recession were provided, along with a number of other related statistics.

The majority of data used in compiling the base data set was obtained from the Canada-Ontario Great Lakes Shore Damage Survey (Boulden, 1975) and Coastal Zone Atlas (Haras and Tsui, 1976), which examined erosion hazard problems on the lower Great Lakes (southern Georgian Bay to Lake Ontario). The combination of these two data sets provides one of the earliest comprehensive sources of recession rate data for the Canadian Great Lakes shoreline. For the most part, this data is still the best available, although, as will be described shortly, new data is slowly becoming available.

The recession rates calculated in these reports were compiled using three different methods. First, historical recession and accretion rates were determined from the assessment of linear changes in shoreline property dimensions upon comparison of late 1960's - early 1970's land surveys with similar surveys from the past (primarily 1920's-1930's). This provided coverage of all erodible shoreline of the Great Lakes at spacings of not more than 10 km.

Second, recession rates were determined photogrammetrically using aerial photography flown during 1952-1955 and 1973. For this comparison, edge-of-bluff measurements were utilized where available. In areas of non-bluff shoreline, the water's edge was used as a reference point. Measurement spacing along the shoreline was approximately 1 kilometer, thereby providing relatively continuous values for recession along the shoreline.

The final method utilized was to conduct a series of ground surveys along a network of over 160 "erosion monitoring stations" (EMS) that were established between 1971-1972 along the shores of Lakes Huron, Erie and Ontario. Each of these stations was selected to represent a typical reach of shoreline having similar physical characteristics of bluff height and composition, beach material, width of beach, and angle of wave approach. For the Shore Damage Survey, these sites provided short-term recession rate information (1971/1972-1973) which was related to the high water level period occurring at that time.

However, the Canada/Ontario Great Lakes Erosion Monitoring Programme (Boyd, 1981) which was established in 1973, provided additional funding for the continued re-surveying of these profiles on an annual basis between 1973-1980, thereby providing a longer period of record for these sites.

Ontario Conservation Authority Data

In 1986 and 1987, Conservation Authorities around Lake Ontario began implementing shoreline management plans and conducting a number of mapping initiatives to update and record recession rate data for their shorelines. In many cases this included restablishing and continuing to monitor the EMS profiles established by Boyd (1981). The information presented below is taken from a review of Canadian recession rate data conducted by Stewart (1994) in late 1994. Updates to recession rate data undertaken between 1994 and the present are not known.

Recession rates for the section of Lake Ontario shoreline from the Niagara River west to Fifty Point were updated by the Niagara Peninsula Conservation Authority (Dillon, 1994). In this update, Dillon (1994) utilized previous data sets (Hegler, 1974; Matyas, 1976; Haras and Tsui, 1976; Boyd, 1981; and NPCA EMS updates from 1988 to 1990) to calculate "representative average annual recession rates" for defined reaches along the shoreline. As these representative rates were used to define the "regulatory erosion standard" in the NPCA Shoreline Management Plan, they are deemed to be best available data for this section of Lake Ontario (circa 1994).

For the shoreline between Fifty Point and Hamilton, shoreline recession data was provided by the Hamilton Region Conservation Authority and is outlined in the Stoney Creek Waterfront Study (Reinders, 1980). This data was derived through a comparison of air photos from 1931, 1934, 1969 and 1973. Using these photos, recession rates were established for approximately 27 points along the shoreline. These data points were analyzed and average annual rates were calculated for the appropriate reaches.

Recession rates for the shoreline between Burlington and Oakville (under the jurisdiction of the Halton Region Conservation Authority) were calculated using the original EMS profiles and were included in the original 1992 Environment Canada data set. No updates to this data were available. Data for the Mississauga shoreline were updated in

1994 from the original EMS data as part of the Credit Valley Conservation Authority's Shoreline Management Planning process.

For the City of Toronto, the base data set prepared by Geomatics (1992), includes recession data provided by the Metro Toronto Region Conservation Authority. For the most part, this data consists of the original EMS data, but selected stations were updated to included 1990 information. It should also be noted that a large portion of the Toronto shoreline is artificial in nature, or extremely well protected, and thus has no recession data associated with it.

Recession rate data for the section of shoreline from Pickering to Trenton is outlined in a Lake Ontario Shoreline Management Plan prepared for the Central Lake Ontario, Ganaraska Region and Lower Trent Region Conservation Authorities (Sandwell, 1990). Once again, this data is taken primarily from the original EMS data, but some stations have been updated to include data up to 1988. In addition to this, Sandwell (1990), provided recession rate estimates for a number of reaches not initially covered by the base data set. Where these were available they were used to fill appropriate gaps. Sandwell (1990) also calculated "100 year erosion set-backs" for each "reach" in this study area. This also allowed a determination of an average annual recession rate for the reach. This data, while useful for determining areas of erosion hazard, is less accurate than direct measurement of shoreline positions, because it includes an allowance for the formation of a stable slope (i.e. the 100 year set-back is 100 year recession, plus the stable slope allowance). Thus the actual average annual recession rate is likely less than what is reported in the data base. This data was only used where no other data was available.

Recession data for the remainder of the Canadian shoreline of Lake Ontario is scarce. A number of EMS stations are scattered along the shore from Trenton to Kingston and their original data is included in the original Environment Canada data set. No new information was available for these stations from either the Prince Edward or Cataraqui Region Conservation Authorities.

Ontario Ministry of Natural Resources (OMNR)

Air Photography

OMNR in the past has maintained a catalog of aerial photography and has flown a range of photography for use in its various divisions. For the purposes of this report, we were unable to determine the status of the air photography catalogue, or whether OMNR still retains this function. Aerial photography is likely available for portions of the shoreline, but a more in depth search will have to be conducted.

Ontario Base Maps

Ontario Base Maps (OBMs) are monochrome topographic maps that will eventually cover the entire province of Ontario. OBMs have been produced for most of northern Ontario at a scale of 1:20,000 (with 10 metre contours) and for part of southern Ontario at a scale of 1:10,000 (with 5 metre contours). An example is found in Figure 16.

Figure 16 - Example of Ontario Base Map

Canada Ontario Floodplain Mapping Program

In cooperation with Environment Canada, the OMNR produced a series of digital shoreline floodplain maps at scale of 1:2000 in early 1990s for use by various Conservation Authorities. The maps detail both flood and erosion hazards along the shoreline and were created from 1988 and 1989 aerial photography (Ralph Moulton, Environment Canada, personal communication).

Natural Resources Canada National Air Photo Library

The Canadian National Air Photo Library (NAPL) has over six million aerial photographs covering all of Canada, some dating back 70 years. The Library, located in Ottawa, indexes and stores all federal aerial photography for Canada, and maintains a comprehensive historical archive and public reference centre.

An inquiry with the Library indicated that a number of sets of air photos are available for the shoreline of Lake Ontario for Toronto (table below). It was not specified if this was for the city only, or for shorelines surrounding the city.

DATE	SCALE
1988	1:40,000
1984	1:25,000
1976	1:50,000
1970	1:26,000
1959	1:30,000
1950	1:12,000(?)
1946	1:20,000
1939	1:20,000

Other Canadian Sources

The Shore Damage Survey final report (Boulden, 1975) references a report by Langford (1952)(not obtained for this review) that presented recession rates obtained from surveyors records up to 1946 and included the area from Niagara-on-the Lake to Scarborough. Comparison of this pre-1946 data with recession rate data for the same area after 1958 may be useful.

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