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Regional Morphology Analysis Package (RMAP): Part 2. User's Guide and Tutorial

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PURPOSE: This technical note is a user's guide for the Regional Morphology Analysis Package (RMAP), an integrated set of calculation tools developed for manipulating, analyzing, visualizing, and archiving data on shoreline positions and beach profiles in a georeferenced environment on a personal computer. The software interface, options, data importation/ exportation, and data analysis are described. A step-by-step tutorial is provided to familiarize the user with RMAP.

BACKGROUND: RMAP evolved from the Beach Morphology Analysis Package (BMAP) (Sommerfeld et al. 1993, 1994; Wise 1995), which was conceived to simplify and automate numerical modeling work flow and associated analysis of beach profile data and results of computations from the Storm-induced BEAch CHange model (SBEACH) (Larson and Kraus 1989; Larson, Kraus, and Byrnes 1990). Although BMAP provides a robust toolset for profile analysis, it is limited to data in distance-elevation space. BMAP requires the user to discard the geospatial aspect of profile data, essential in data assembly and quality control. Regional analysis requires manipulation of another type of two-dimensional (2-D) data, the shoreline, which is georeferenced. Numerical simulation models under development in the System-Wide Water Resources Program (SWWRP) involve manipulation of data and corresponding outputs in a georeferenced coordinate system, often over wide geographic areas and different coordinate systems. These and other U.S. Army Corps of Engineers needs identified at a field-data collection workshop were the stimulus for creation of RMAP.

Typically, analysis of beach profile and shoreline position data requires several software packages. On the other hand, the engineering and numerical modeling work environment calls for tools directly supporting workflow from the original surveys to quality control, analysis, and input to a project report or model. RMAP contains a comprehensive set of analysis and visualization tools required for project workflow, from the import of raw data and coordinate conversion through detailed analysis to report-quality graphics. RMAP supports analysis of beach profile, channel or river cross-sectional data, and shoreline position data for engineering and science applications. Capabilities extend from generation of spatially referenced shoreline change maps to a large suite of beach profile analysis tools. Data can be examined in both cross-sectional and map views to simplify data assembly, quality control and assurance, data analysis, and generation of report figures. The map viewer supports the display of profiles, shorelines, aerial imagery and ArcView® shapefiles in a geospatial environment. Data options allow storage, organization, and analysis of data in a single application, with support for a variety of import/export formats. Chart options allow tailoring of graphics to personal needs, supporting export of images and direct copy and paste into word processing software. Metadata can be stored at project, group, or individual data item levels. RMAP is backwards compatible with BMAP project files and supports calculation of geographic coordinates from reduced distance-elevation data pairs. An overview of RMAP functions is given in Batten and Kraus (2004).

RMAP INTERFACE: RMAP runs in the Microsoft Windows® environment and requires computer resources available on typical personal computers. The RMAP interface consists of four main features (Figure 1).

1. *File menu and toolbar.* Data import/export, analysis functions, and viewer controls are accessed through the file menu and toolbar.

2. *Data tree.* The data tree displays data items present in the software package and allows selection of multiple items for batch conversion or analysis.

3. *Graph/map viewer.* The graph/map view window supports visualization of data by cross-section in graph mode and plan view in map mode.

4. *Data table.* The data table allows the user to view and edit data for each item in the data tree. This area also stores the time stamp of the data entry and allows the user to store comments on each item in the data tree.

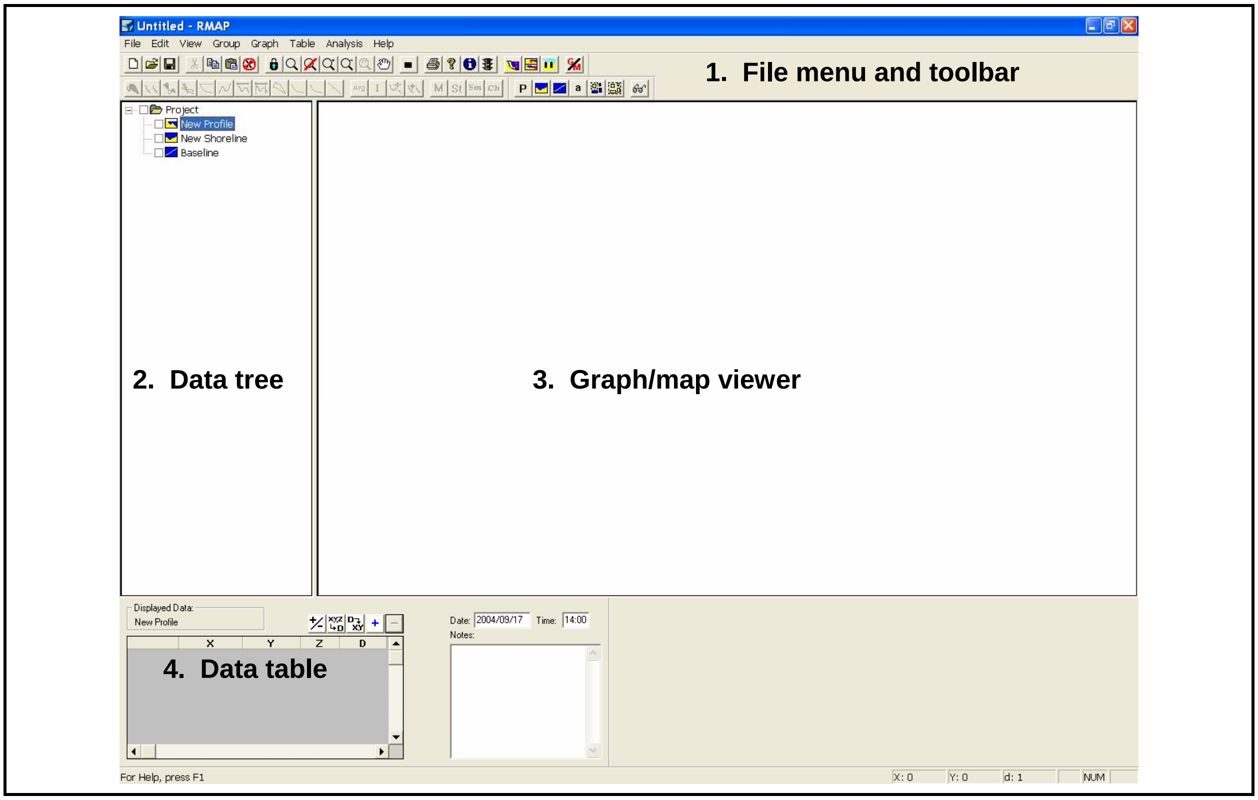
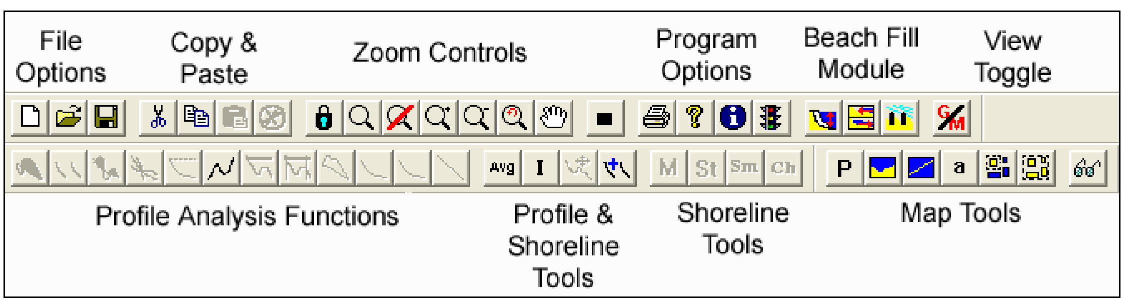


Figure 1. RMAP interface comprises (1) file menu and toolbar, (2) data tree, (3) graph/map viewer, and (4) data table

File Menu and Toolbar. The RMAP file menu provides access to functions common in Windows applications (such as **Save**, **Open**, etc.), and those functions unique to RMAP, such as graph controls, data grid functions and profile and shoreline analysis tools. Many functions can also be accessed from the RMAP toolbar, where they are grouped by functionality (Figure 2). Functions unique to RMAP are discussed here.

File menu. Items under the *File* menu support import/export of project data from ASCII text files, ISRP (Interactive Survey Reduction Program), BMAP, or the RMAP free-format. The RMAP free-format allows users to import entire datasets at once, or archive RMAP projects into an ASCII text file that can be accessed by spreadsheet applications or text viewers. The *Edit* menu allows access to data management functions for the data tree, project options and settings. The *View* menu allows the user to toggle the toolbars, status bar, and data table on or off. The *Group* menu allows the user to add or delete groups or data tree items. The *Graph* menu accesses options for the graph control. The graph appearance is customizable by the user, including background colors, line colors, width, axes scaling, etc. The *Table* menu allows the user to insert and delete rows in the data table, as well as write protecting data. The *Analysis* menu contains analysis tools and algorithms for beach profile and shoreline data. Finally, the *Help* menu provides user support and access to documentation on the analysis routines.

Toolbars. The RMAP toolbar provides quick access to programs functions and analysis routines. The toolbar is organized by file and program functions, zoom controls, beach-fill module tools, profile analysis functions, shared profile and shoreline tools, shoreline tools and analysis, and map tools. Individual button functions are not described here. To view the function of a button, place the mouse pointer over the icon in the RMAP window (mouse-over description will appear).



File Functions

- new project
- open project
- save project
- cut data
- copy data
- paste data

Zoom Controls

- zoom selection rectangle
- release zoom
- zoom in
- zoom out
- return to previous zoom level
- pan

Figure 2. RMAP toolbar (Continued)

Data Functions

find invalid x-values

display data point markers in viewer

Program Functions

print

about RMAP

help topics

getting started

Beach Fill Module Tools

depth of closure calculator

erosion accretion predictor

planform evolution model

Profile Analysis

bar properties analysis

profile comparison

cut and fill analysis

align profiles

least-square analysis

calculate cross-shore transport rate

profile volume analysis

profile sectional volume analysis

construct beach-fill template

create equilibrium beach profile

create modified equilibrium beach profile

create planar profile

Profile and Shoreline Tools

calculate average profile (or shoreline), profile envelope and standard deviation.

interpolate profile or shoreline

translate profile/shoreline

combine profiles or shorelines

Shoreline Tools

calculate mean shoreline

calculate shoreline statistics

smooth shoreline

calculate shoreline change

Map Tools

map properties

draw shoreline

draw baseline

add annotation

draw selection rectangle

select all

view map items

Data Grid Toolbar

add row button

delete row button

calculate distance from X Y coordinates

calculate X Y coordinates from distance (requires monument location)

toggle negative sign for elevation of selected points

Figure 2. (Concluded)

Data Tree. Data sets are managed and selected for analysis in the data tree. The data tree in RMAP displays and organizes project data into three categories: beach profiles, shorelines and baselines, each identified by a unique icon (Figure 3). Items can be arranged into groups and subgroups under the *Project* menu. Data items can be sorted by date or name, or manually sorted by the user by dragging and dropping in desired order. A data item is plotted in the graph/map viewer and made available for analysis by activating the selection box beside the data type icon. The selection box also provides a means of copying, pasting, moving, and deleting multiple data items in the tree. In addition, selection boxes are used to conduct analysis functions, coordinate conversion, and distance calculations for multiple items. Right-clicking in the data tree window brings up the data options.

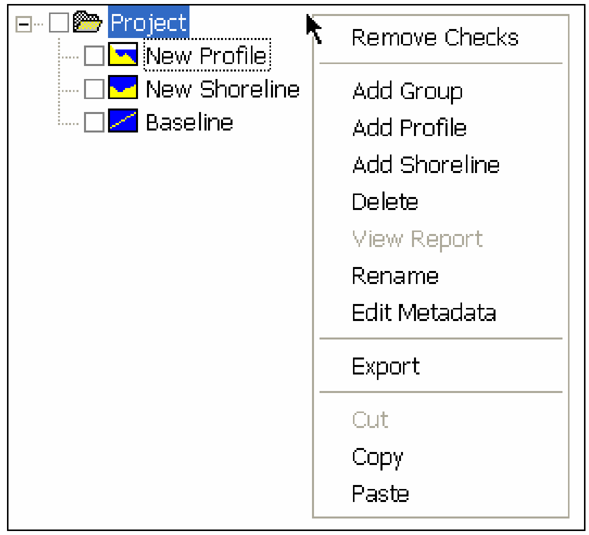


Figure 3. RMAP data tree and data tree options

Graph/Map Viewer. The graph/map viewer provides visualization of both profile and shoreline data in graph (cross-section) or map (plan) views. The window is toggled between the two views by means of the RMAP toolbar (Figure 2). Data are plotted in the viewer by activating the selection box (check box) next to the item. In graph view, a typical cross-section plot is generated in the viewer. The plot legend is automatically generated on the plot as data are added. Plot axes adjust to the full extent of plotted data; however, the user can manually set the axis extent. The user can zoom into areas of interest and pan around the viewer to investigate data. Data values in the view automatically refresh as the data table is edited. The user has full control over graph appearance with the options available under the *Graph* menu.

Data Table. The data table allows the user to view and edit the time stamp, coordinate, elevation and distance values for each item in the data tree (Figure 4). A *Notes* window is also provided to allow storage of metadata for individual items. Data in the grid are edited in a fashion similar to standard spreadsheet applications. Formats for the different data types are described here.

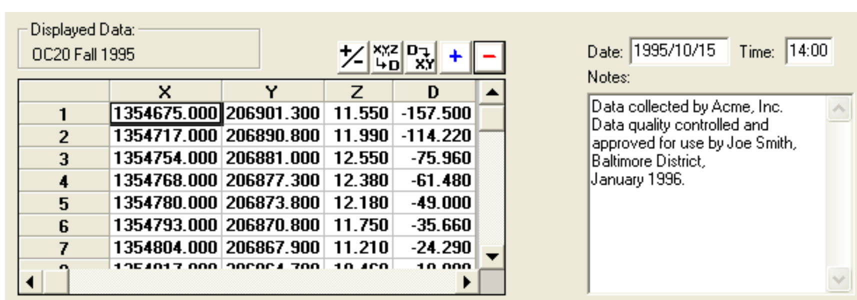


Figure 4. The RMAP data grid contains point attributes in a spreadsheet format and metadata

For beach profile data, the grid contains four columns: geographic horizontal coordinates (X and Y), elevation (Z), and distance (D). Tools are provided in the data grid for calculation of distances along the transect from the geographic coordinates, in addition to calculation of the geographic coordinates from distance elevation pairs given profile origin coordinates and transect azimuth. Consideration was given for accommodating BMAP project files while implementing RMAP coordinate capabilities. BMAP data columns (distance/elevation pairs) are automatically assigned to the Z and D columns upon opening. In addition, data are assigned to different columns depending on the number of columns present: pasting two columns places data in the D and Z columns; pasting three columns places data in the X, Y and Z columns; or pasting four columns places data X, Y, Z, and D columns. Shoreline and baseline data types have three data columns: geographic horizontal coordinates (X and Y) and elevation (Z), though in the case of baseline data, the Z column is not applicable.

Graph Options. RMAP provides users with a full set of options to tailor graph plots to their personal preference (Figure 5). To access the graph options, click *Graph* on the file menu and select *Plot Options*. Options available under each tab are describedin the following paragraphs.

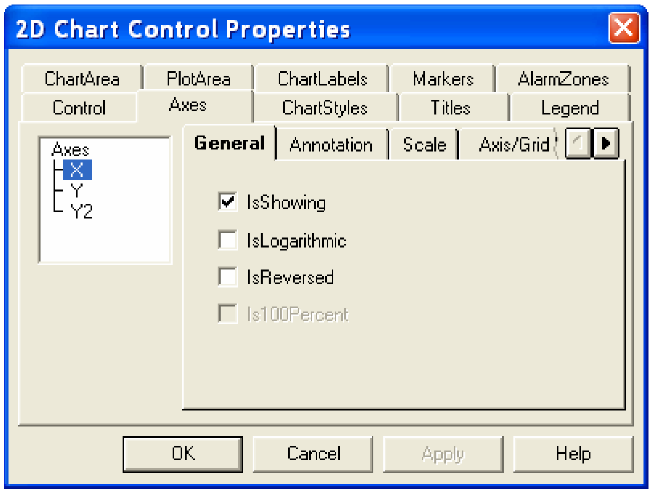


Figure 5. Graph control properties

Chart area. Chart area location, border and background color options.

a. *General*: Swap x- and y-axis (IsHorizontal), other options are not applicable.

b. *Location*: Allows adjustment of the height and width of the chart. The chart width and height are anchored to the top and left axes, these locations may also be adjusted.

c. *Border*: Add border around chart axes. Options for border style and width. The border is drawn between the chart title and axis titles (default is none).

d. *Interior*: Allows selection of background color for chart area inside of the chart border (default is white). Foreground color option allows adjustment of axis lines and labels color (default is black).

Plot area. Plot area size and color options.

a. *General:* Allows adjustment of amount of whitespace between chart axes and edge of chart window.

b. *Interior:* Allows selection of background color for chart interior. Foreground color option is not applicable in this application.

Chart labels. Options for adding and formatting labels.

a. *General:* Options for adding labels, rotation, text justification, label position (attach method), and anchor position.

b. *Label:* Label text.

c. *Border:* Allows insertion of label border, with options for border type and width.
d. *Interior:* Settings for label interior background color and label text color (foreground color).
e. *Font:* Font type, style and size options.
f. *Location and Image:* Not applicable for RMAP.

Markers. Reference line options.
a. *General:* Toggle reference line markers on or off
b. *Attach:* Assign line positions relative to X and/or Y grid locations
c. *Line Style:* Options for line format, line width and color.

Alarm zones. Allows user to delineate a zone of interest in the vertical axis of the graph view.
a. *General:* Options for adding, removing, and delineating vertical extent of alarm zone. Allows user to hide or make alarm zone visible and select a background pattern.
b. *Colors:* Allows user to select foreground and background colors for the alarm zone.

Control. Border and color options for the extent of the graph view window.
a. *Border:* Allows user to select and specify width of a border for the graph view.
b. *Interior:* Options for background and foreground (axis and text) color for of entire graph control area.

Axes. Options for tick and label placement, axis scale, line, tick label and grid line options.
a. *General:* Options for on/off toggle of axis lines, and setting logarithmic or reverse axis.
b. *Annotation:* Options for axis annotation, number spacing, tick spacing, precision, number format, and rotation angle of tick labels for selected axis.
c. *Scale:* Shows minimum and maximum extent of data plotted in the graph view (data min/max). Allows user to specify the minimum, maximum, and origin of the selected axis.
d. *Axis/grid lines:* Options for specifying tick lengths and adding grid lines to the graph view at a user-specified spacing along the selected axis.
e. *Axis style:* Allows user to specify a line style and color for the selected axis.
f. *Grid style:* User options for specifying a line style, width, and color of gridlines along the selected axis.
g. *Font:* Font options for tick labels.

Chart styles. Plot line width and color options. Options set for line selected in left pane of window under “ChartGroups”.
a. *Fill style:* Set line color, pattern.
b. *Line style:* Set line color, pattern, and width.
c. *Symbol style:* Options for shape, size, and color for data marker symbols. Markers are turned on/off with the *Markers* option under *Graph* on the file menu, or by selecting the marker button  on the toolbar.

Titles.
a. *General:* Options for turning titles and footers on or off.
b. *Label:* Title, footer text entry.

c. *Location:* Adjust title/footer location in graph viewer.
d. *Border:* Add border around title or footer, options for style and width.
e. *Font:* Font type, style and size options.

Legend.
a. *General:* Options for turning legend on or off and legend position on plot (anchor position). Orientation option not applicable in RMAP.
b. *Title:* Text entry for legend title.
c. *Location:* Adjusts horizontal or vertical location of the legend at each anchor position.
d. *Border:* Add border around legend contents, options for style and width.
e. *Interior:* Options for legend interior background and font (foreground) colors.
f. *Font:* Font type, style, and size options.

Map Options. Map view options are available in the *Map Properties* form (Figure 6), accessed by selecting the *Map Properties* button on the toolbar 

or by right-clicking within the viewer window while in map mode. This form provides the user access to the project coordinate system, addition and removal of background imagery and ESRI® shapefiles, background layer management, and visual display properties for profiles, shorelines, baselines, and rate graphs.

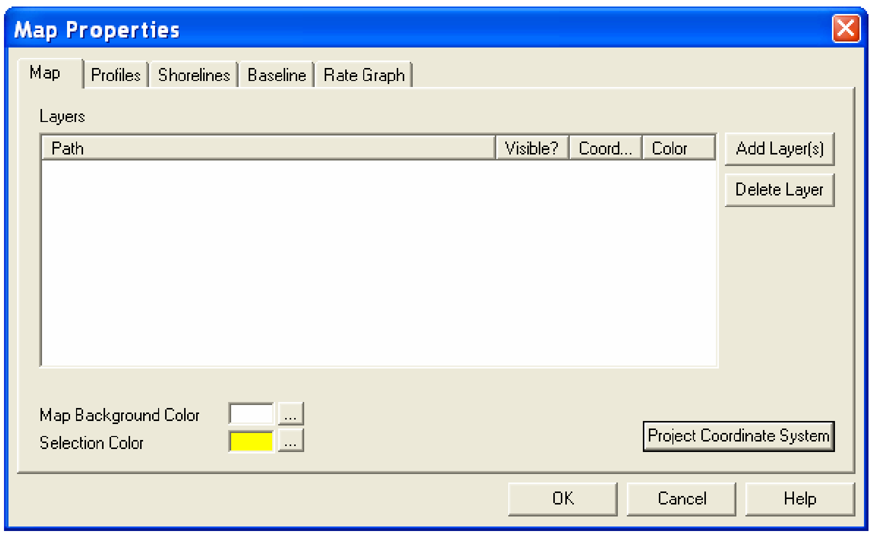


Figure 6. *Map Properties* form

TUTORIAL: The following portion of the document provides a step-by-step tutorial to familiarize the user with project setup, organization, and data analysis within RMAP. Each of the following sections walks a user through part of the process of using RMAP with provided beach profile and shoreline data. To begin the tutorial, launch RMAP and select “Load an application session” when prompted. Browse to the RMAP Tutorial folder and select the file “Tutorial.rma.”

Setting Project Units and Coordinate System. Before importing data into RMAP, the user should set project units and the project datum.

To set project units, click **Edit** on the file menu and select *Project Options* (Figure 7). This form allows the user to select either American customary units (ft) or metric units (m), in addition to allowing the user to enter a project title, investigator name, and metadata (Notes) associated with the project.

Under *Project*, enter “Ocean City, MD,” enter your name under *Investigator*, and select *American Customary Units* for the project and click **Ok**.

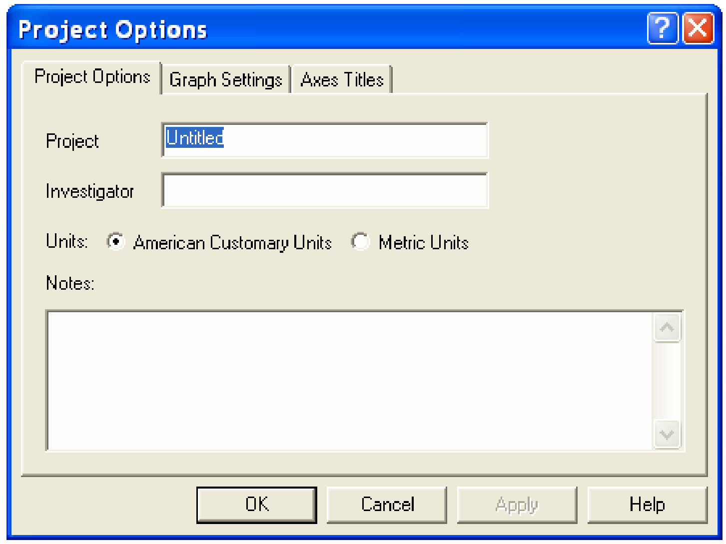


Figure 7. Project options form

To set up the project coordinate system, RMAP needs to be in map mode. It is not necessary to select a project coordinate system, though this eases conversion of geospatial data between datums. RMAP supports both geographic (for example, latitude/longitude) and projected coordinate systems (Universal Transverse Mercator, State Plane). The *Map Properties* form allows tailoring of the appearance of profiles, shorelines, baselines and the rate graph to personal preferences. Background imagery and shapefiles are also loaded and deleted here.

The project coordinate system is Maryland State Plane, North American Datum (NAD) 1983 in units of feet.

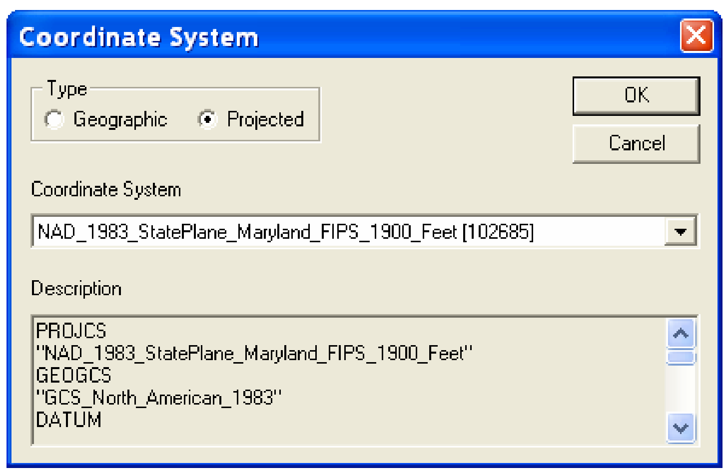


Figure 8. Coordinate system window

By default, RMAP is in graph mode when the application is launched. Switch RMAP over to map mode, by selecting the **Graph/Map** toggle  button on the toolbar. Next, click the **Map Properties** button  on the toolbar (map properties are only accessible in map mode). Select the **Project Coordinate System** button on the *Map Properties* window to access the coordinate selection window (Figure 8). Under *Type* select *Projected* and click the drop-down list under coordinate system. Scroll down the list and select “NAD_1983_StatePlane_Maryland_FIPS_1900_Feet,” located about halfway down the list and click **Ok**, then **Ok** again to close the *Map Properties* window.

The next section of the tutorial walks the user through importing data, click the *graph/map mode toggle* to return to graph mode.

Importing Data. RMAP has the capability to handle three kinds of project data: cross sections (beach profile or channel), shorelines, and baselines. These data can be brought into RMAP by importing from ASCII files, BMAP, and older ISRP data files, copying and pasting from spreadsheet applications, or manually entering points into the data grid.

Importing ASCII files. This section describes importation of profile data from a XYZ ASCII textfile. Shoreline and baseline data, or XYZD profile data may also be imported using this process.

To begin, go the file menu and click **File**, then **Import**. The following window gives the user the choice of importing RMAP free-format files, ASCII text, BMAP files, and ISRP files. Select ASCII text (default) and click **Next**. You will then be prompted for a file type. RMAP supports three data types, shorelines, profiles, and baselines. Select *Profile* from the menu and click **Finish**. When prompted for the file location, click **Browse** and navigate to the RMAP tutorial files directory, locate and open the file "OC_Oct1997.xyz," then click **Next** at the bottom of the window.

The *Data Organization* window (Figure 9) provides a preview of the first 20 lines of the textfile, and allows the user to specify column delimiters and remove header rows. Header rows often cause problems when importing textfiles, as they are not delimited in the same manner as the following data. The example file has seven header rows. Metadata for the profile is contained in the first six rows, and column headers (X Y Z) are in the seventh.

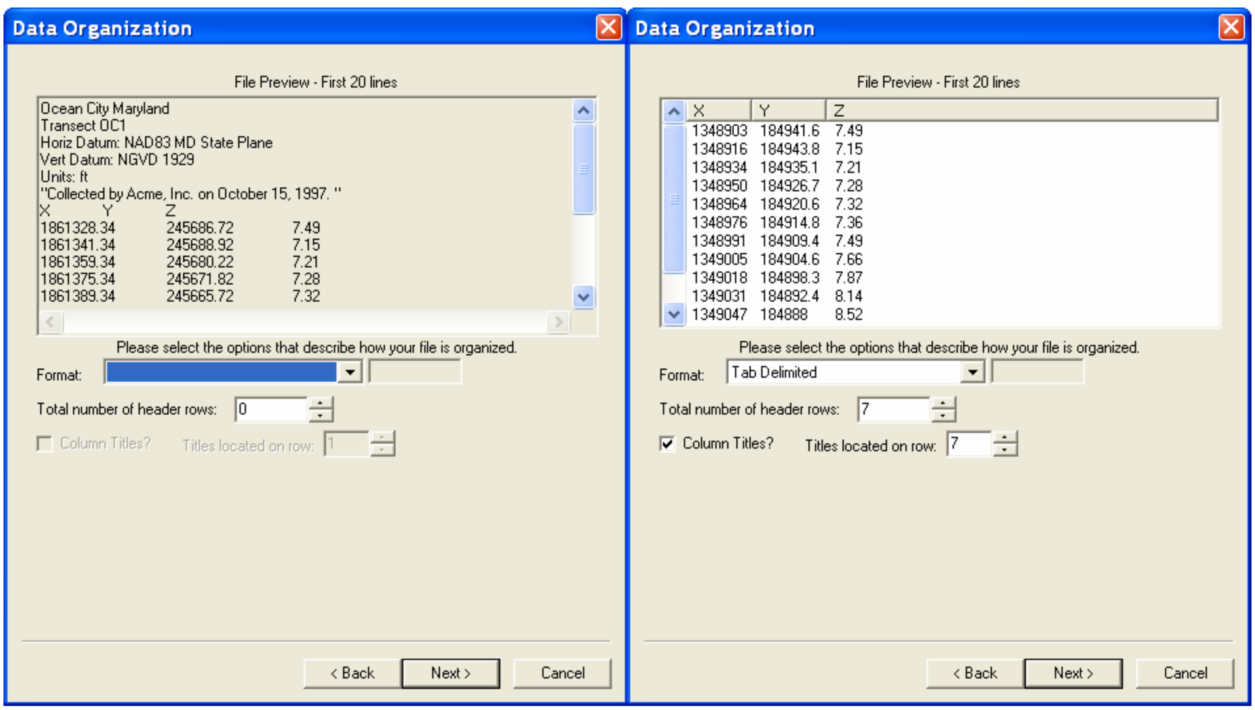


Figure 9. RMAP has ability to import most types of ASCII files

Select “Tab delimited” under import format. The header rows remain in a block, and only the X data column is visible. This is due to the presence of the header rows. Select “Whitespace delimited” under import format. The header rows are now divided into three blocks, and the data columns are properly separated. To exclude the header rows, set total number of header rows to “7.” The header rows have been removed and only the data remains. Select the check box beside *Column Titles* and set *Titles located in Row* to “7.” This sets the column titles to X, Y, and Z from the labels contained in the last header row. RMAP also allows the user to specify the delimiter if it is not present in the menu by selecting “Other Delimited ->” and entering the delimiter in the provided space. Click **Next** to proceed.

The *Import Information* window allows the user to tailor the data column order. By default, RMAP imports data in the order of X (horizontal grid X coordinate), Y (horizontal grid Y coordinate), Z (elevation), and Dist (distance from reference/baseline). If data columns in the imported file are not in this order, the user can select the column and click the **move up/down** buttons to arrange the columns in the desired order. Columns may be removed by selecting the column name and clicking **Remove**. The columns in the example file are in the default order, click **Finish** to proceed.

RMAP now prompts for the date of the data in YYYY/MM/DD format. The example file was collected on 15 October 1997. Enter “1997/10/01” for the date. Metadata may also be added to the data item at this time by entering text into the *Notes* form. Enter “NAD83 MD State Plane, NGVD 1929, ft” in the *Notes* form and click **Ok** to complete the import process.

To view the imported data item, expand the data tree by clicking the [+] symbol beside the Project group. The imported data item appears in the data tree under the name of the file it was imported from. Select the item by single-clicking it with the mouse pointer. The XYZ data are now present in the data grid, as well as the date of the profile. The profile datums should appear in the *Notes* text field. Check the selection box beside the data item. A plot of the profile appears in the graph viewer. Click the *map/graph* toggle to switch to map mode. You are now viewing the profile in planview. If you do not see an object in the viewer, select the **Release Zoom** button . Look for the object label (OC1_Oct1997) and use the **Zoom** button  to zoom into the object location. Selection of the **Zoom Lock** button  allows for repeated use of the zoom commands.

Copying and pasting data into RMAP. Spreadsheets are a common method of storing profile, shoreline, and baseline data. Data may be copied and pasted directly into RMAP from spreadsheet applications.

Use Windows Explorer to browse to the RMAP tutorial files directory and open the file “OCProfiles.xls.” The first worksheet in this file contains XYZD data, and second sheet contains distance and elevation pair data for profile OC1, collected on 15 November 1998, and 15 December 1999. Select the XYZD data columns for profile OC1 from row 10 to 145 (do not select headers) and click the copy button on the Excel® toolbar or simultaneously press the **ctrl** and **c** buttons on the keyboard. Return to the RMAP application and navigate the mouse pointer to the data tree window and right-click. Select *Add Profile* and name the new item “OC1_Nov1998.” Ensure that the new profile is selected and click the **paste** button on the toolbar, or simultaneously press the **ctrl** and **v** buttons on the keyboard. RMAP displays a warning that the data table has fewer rows than the clipboard data. Click **Yes** to expand the items data table to the size of the data on the clipboard. Now the data appear in the data table. Edit the date in the data grid to "1998/11/15." Enter "NAD83 MD State Plane, NGVD 1929, ft" in the notes form to keep track of the items metadata.

Non-georeferenced profile data are in distance/elevation pair format, and geoferenced profile data sets have typically been reduced to this format for analysis. RMAP automatically reorders distance/elevation columns when pasting from spreadsheet applications. Return to the Excel spreadsheet and select the December 1999 tab. Select and copy the data rows for the distance\elevation pair data for December 1999 profile in the Excel spreadsheet. Return to RMAP, create a new profile named "OC1_Dec1999" and paste the data. Note that the distance/elevation columns are automatically moved to the appropriate locations in RMAP. Edit the date in the data grid to "1999/12/15."

Try to plot the November and October profiles simultaneously by checking both selection boxes. The plots do not plot correctly. This is because there are no distances associated with the point data in the October profile. If no distance data are available, the horizontal coordinate column is substituted for the distance column. Calculation of distance values are discussed in the following paragraphs.

Importing data from shapefiles. RMAP has the capability to convert ESRI ArcView® polyline shapefiles into shoreline or baseline data types. Shapefiles are first imported as background in the map view and then converted into data items. RMAP creates individual data items for each line segment present in the polyline file. These can be merged into a single data item after conversion.

To begin, unselect any active graph items, click the *graph/map toggle* button  and transfer to map mode. Click the **Map Properties** button, then click *Add Layer(s)* and select *Add ESRI Shapefile Layer.* Browse to the RMAP tutorial files directory and select "shr_1942_OC_NAD83UTMZ18_m.shp" and click **Open**. RMAP returns to the map properties window. Click **Ok** on the **Map Properties** form to return to the map viewer. If the shapefile does not appear, click the **Release Zoom** button . It is sometimes necessary to activate a map object to see background shapefiles. If you do not see a shoreline, activate the OC1_Oct1998 profile in the viewer and click the **Release Zoom** button again. Zoom into the extent of the shoreline shapefile.

To convert the shapefile into an RMAP shoreline object, place the mouse pointer in the map viewer and click the right-mouse button. Select *Convert Polyline to Shoreline* from the list. When prompted, select "hwl" for the shoreline type and click **Ok**. Draw a box around the entire shapefile using the mouse pointer while holding down the left mouse button; release the button when the box is complete. RMAP automatically converts the coordinate system of the shapefile to the project datum when generating shorelines or baselines. A message appears notifying the user of the conversion, click **Ok** to continue. The conversion notification message is followed by the *Geo-Transformation* window. A transformation must be applied when converting between datums. For example, a conversion between NAD 1927 and NAD 1983, or NAD 1983 to WGS 1984 datums would require a single-stage transformation, while conversion from NAD 1927 to WGS 1984 would require a two-stage transformation (NAD 27 to NAD 83, then NAD 83 to WGS 84). In this case, a datum transformation is not necessary, click **Ok** to proceed. Two shoreline items will appear in the data tree. Click the **Map Propertie***s* button, select and delete the shoreline shapefile layer. Return to the map viewer and activate both shoreline segments in the map viewer.

The shapefile contained two shoreline segments, each of which was converted to a separate date item. These segments must now be combined into a single shoreline. To successfully combine the shorelines, the segments must be in order from either north to south (top to bottom) or west to east (left to right). Likewise, for RMAP to properly merge shapefile segments, the segments must flow in these directions. Turn off the second shoreline segment in the data tree. This segment is the northern section of the shoreline. To reorder the segments in the data tree, select this segment with the mouse pointer then drag and drop it above the first segment. To combine the shorelines, activate both shoreline segments in the data tree, select *Analysis* from the file menu, and then select *Combine Profiles/Shorelines*. A new data item titled "Combined Shoreline" will appear in the data tree. To delete the two shoreline segments (checked items), click **Edit** on the file menu, then **Delete Checked Items**. Rename the shapefile to "1942 Shoreline" and enter 1942/01/01 for the date attribute. The shoreline is referenced to the high-water line (hwl) line. Enter "hwl" as metadata in the *Notes* text box. Shoreline definition may also be attributed under the items metadata. To access this, right-click on the data item, select **Edit Metadata**, then select the *Shoreline* tab. The shoreline definition for the item can be selected from the drop-down list. For discussion of shoreline definitions, see Kraus and Rosati (1998).

Entering data in data grid. In addition to importing and copying/pasting data into RMAP, data may also be entered directly into the data grid. This is helpful when establishing a baseline, editing profiles or shorelines, and adding a datum reference lines.

Data is entered into the data grid in a similar fashion as spreadsheet applications. Rows can be added or removed by clicking the **Add Row** button + or the **Remove Row** button − on the data grid toolbar.

A datum reference line can be added to the plot by creating a new profile and entering two points of reference. If RMAP is in map mode, switch back to graph mode. To add a datum line to the plot, right-click in the data tree, select *Add Profile*, and rename it as "MWH." Click the add row button on the data grid toolbar and enter "2" beside *Number of Rows.* Since there are no data in the table, it does not matter where the rows are added.

The vertical datum for the Ocean City Project is the National Geodetic Vertical Datum of 1929 (NGVD 1929). Relative differences between geodetic and tidal datums in the United States can be found at the National Oceanographic and Atmospheric Administration Center for Operational Oceanographic Products and Services (NOAA CO-OPS, http://co-ops.nos.noaa.gov/) and through the National Geodetic Survey (http://www.ngs.noaa.gov/). Benchmark data sheets from NOAA CO-OPS show that at the Ocean City Fishing Pier NGVD 1929 is 0.6 m (2.01 ft) lower than mean high water (mhw).

Select the first row of the D column (Distance) with the mouse pointer and enter “-500,” and then “3500” in the second row. The active cell in the data grid can be changed with the arrow keys. In the Z column (Elevation), enter 2.01 in both the first and second rows. No entries are required in the X or Y columns.

Activate both the MHW datum line and the OC1_Nov1998 profile in the data tree. The MHW profile provides a line of reference above 0 NGVD.

Adding background imagery. RMAP supports georeferenced background images in jpeg (.jpg), bitmap (.bmp), and TIFF (.tif) formats. For RMAP to properly position the image in geographic space, the image must be georeferenced to the project coordinate system. If images are not in the project coordinate system, they can be converted using image analysis software packages or Corpscon can be used to convert the coordinates in the image world file (.jpgw or .tifw).

Deselect all items in the data tree by clicking each individual item or using the **Remove All Checks** command under *Edit* on the file menu. To import an image into RMAP, switch to map mode and select the **Map Properties** button. Under the *Map* tab, click the **Add Layer(s)** button and select *Image Layer*. Browse to the “Aerial Photos” directory under the RMAP tutorial files folder and select “Ocean317.tif” and “Ocean417.tif” and click **Ok** until you return to the map view. Select the **Release Zoom** button to zoom to the full extent of the photographs. Activate the “OC1_Oct1997” profile to overlay it on the aerial photo.

Ocean City transect 1 lies just above Ocean City Inlet. To view the profile, use the **Zoom** button and draw a box around the inlet, including a portion of the updrift and downdrift beaches.

To access the visual attributes of the profile object, click the **Map Properties** button and select the *Profiles* tab, or select the profile object with the mouse pointer, right-click and select *Visual Properties*. Profiles plotted in the map view are gradationally colored from shallow to deep elevations. The gradational colors, label font, and line thickness can be adjusted from this form (Figure 10).

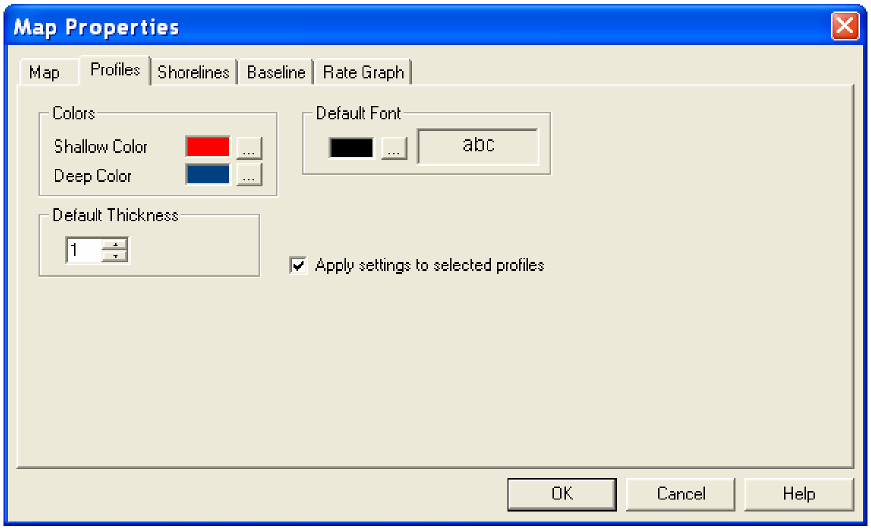


Figure 10. Visual attributes of map objects can be changed through *Map Properties* window

Working with Data. This section describes how to organize data in the data tree, calculate distance and/or reproject profile data, and reproject data into the project coordinate system.

Organizing data. The data tree provides the user with a space to organize project data. Data can be organized into *Groups*, which can represent types of data, times series data at a location, etc.

To create a group, right-click in the data tree and select *Add Group* or select *Group* on the file menu and *Group*, *Add Group*. Rename the group "Profile Data."

Data items can be moved into a group by dragging and dropping with the mouse cursor, or for multiple items, by selecting the items and using commands under the *Edit* menu. To move the profiles into the new group, check the boxes beside all profile items, select *Edit* on the file menu, then *Move Checked Items* (Data items can also be copied and deleted by this method). A form appears showing all groups in the project. Select the *Profile Data* box and click **Ok**. The profile items are now located in the Profile Data group.

Expand the Shoreline Data group and use the drag-and-drop method to move the 1942 shoreline into the group.

Calculating distance for XYZ profiles. To properly plot and analyze a time-series of beach profiles, each profile must have distances associated with the XYZ data. Typically, distances along a profile are referenced to the survey monument or a baseline. RMAP calculates the distance of each XY point along the transect azimuth from the known profile origin coordinate. Distances can be calculated for single or multiple transects at a time.

Select the October 1997 profile (OC1_Oct1997). On the data grid toolbar, click the **Calculate Distances** button. RMAP allows you to specify a row in the profile as the transect origin, or enter the origin coordinates and transect azimuth. Select "Use monument coordinates" and click **Ok**. Enter the following values into the profile origin form (Figure 11): (X) 1860862.11, (Y) 245876.77, (Azimuth) 111, and click **Ok** (The profile origin form may also be accessed by right-clicking on a data item in the data tree and selecting *Edit Metadata*). The distances for each point now appear in the D column of the data grid.

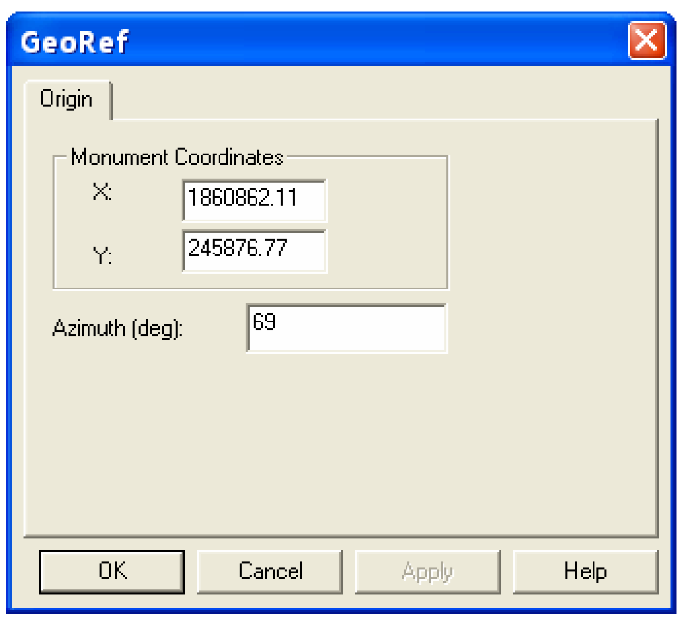


Figure 11. Profile origin form

It is now possible to plot and compare all profiles at once. Select all profiles by checking the selection box on the Profile Data group.

In this example, all XY points were in front (seaward) of the origin. For instances when the profile contains points both seaward and landward of the origin, positive and negative distance values occur. In these cases, RMAP calculates all distances as positive. To convert distances behind (landward) the origin to negative values, the user can select the landward rows and click the **Toggle Sign** button  on the data grid toolbar.

Calculating XY points from distance and elevation pairs. RMAP also has the built-in capability to calculate XY points from distance and elevation pair data. The transect origin coordinates and azimuth are required to perform this function. As with the distance calculation, this function can be performed for single or multiple profiles.

Select the December 1999 profile under Beach Profile data in the graph viewer. The data grid shows that this profile contains only distance and elevation data.

Uncheck the other profiles and select only the December 1999 profile. Click the **Calculate Coordinates** button  on the data grid toolbar, and then enter the profile origin coordinates into the form: (X) 1860862.11, (Y) 245876.77, (Azimuth) 111, and click **Ok** when complete. The XY coordinates for the profile now appear in the data grid.

Toggle RMAP to map mode, and zoom to location of the profile, just north of Ocean City Inlet. If the label for the OC1_Dec1999 profile is not present, select the profile object, right-click, and select *Center Label*. Activate the October 1997 profile in the viewer. Because the XY coordinates of the December 1999 profile are calculated, it appears perfectly straight, while the October 1997 profile has some variations along the line. These variations are expected during the data collection process.

Coordinate conversion. RMAP allows the user to import data from different coordinate systems and convert to a common project coordinate system. When performing this operation, new data items are generated in the data tree. This section demonstrates how to convert this data to the project coordinate system.

In the initial project set-up, the project coordinate system was defined as NAD 1983 Maryland State Plane with units of feet. Later, shoreline data were imported from a shapefile that was in NAD 83 UTM coordinates. This item was automatically converted during the import process. The 2002 shoreline is in the UTM coordinate system and must be converted to Maryland State Plane to perform comparative analysis.

Uncheck all items, expand the Shoreline Data group in the data tree and select the 2002 shoreline data item. Select *Edit* from the file menu, the *Convert Checked Coordinates*. The *Select Coordinate System* window appears. This window allows the user to select the coordinate system of the items currently selected in the data tree. UTM coordinates are a projected coordinate system. Select *Projected*, then browse the drop-down list and select “NAD_1983_UTM_Zone_18N” (approximately 2/3 down the list). Click **Ok** when finished.

After selecting the data coordinate system, the *Geo-Transformations* window appears (Figure 12). A transformation must be applied when performing a datum conversion. For example, a conversion between NAD 1927 and NAD 1983, or NAD 1983 to WGS 1984 datums would require a single-stage transformation, while conversion from NAD 1927 to WGS 1984 would require a two-stage transformation (NAD 27 to NAD 83, then NAD 83 to WGS 84). This window allows the user to specify the desired transformation, and direction of transformation (forward or reverse).

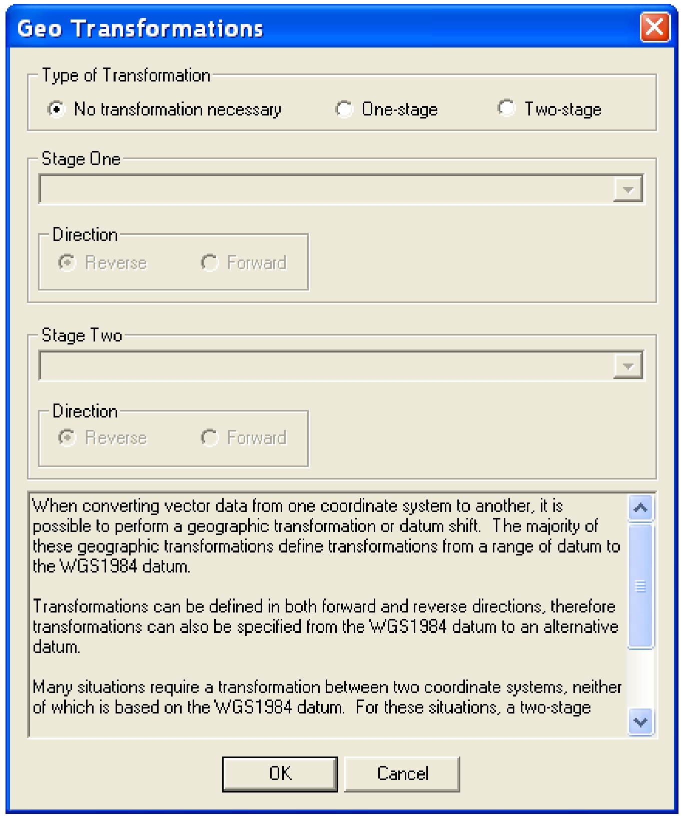


Figure 12. RMAP supports forward and reverse single and two stage geo-transformations

The datums of the example data are the same (NAD83), so a transformation is not necessary. Click **Ok** to proceed. A new data item “2002 Shoreline Converted” will appear in the Shoreline Data group. The coordinate conversion has been appended to the metadata (Notes) of the new item. Unselect all items and activate the 1942 shoreline and the converted 2002 shoreline in the data tree, click the **Release Zoom** button, and then zoom back into the extent of the data. Both shorelines should appear overlaid on the aerial photography. The visual properties of each shoreline and label can be changed by selecting the item with the mouse cursor, right-clicking, and selecting visual properties.

DATA ANALYSIS: This section treats two topics, shoreline analysis and profile analysis. Shoreline change rate analysis is demonstrated first, building on the Ocean City example. Profile data analysis is described next using a separate RMAP project file containing profile data from several study areas.

Shoreline Analysis. RMAP supports end-point shoreline change rate analysis between two shorelines. Transects are established perpendicular to the baseline at a user-defined interval; the distance of each shoreline is measured at each transect. The difference between the two measurements is then divided by the time interval to determine the shoreline change rate at each transect. The analysis is limited to the common spatial extent of the two shorelines. A summary report is generated for the analysis reach, then a spatially reference shoreline change graph is generated for the map view in addition to a shoreline change rate graph that is available in the graph view (shoreline change rate along the baseline).

Before the shoreline change analysis can be conducted, a baseline must be established on the landward side of the shoreline data set. A baseline can be imported from text or a shapefile, or drawn in the map viewer. Here, the baseline will be established on the landward side of the shorelines.

To enhance viewing of the shoreline positions, first turn off the background imagery. Toggle RMAP to map mode if in graph mode and uncheck all data tree items except for the two shorelines, then click the **Release Zoom** button. Open the map properties window and in the *Layers* box, turn all background imagery off by selecting the “x” under the *Visible* column for each image. Click **Ok** to close the map properties window when complete.

To draw the baseline, select the **Draw Baseline** button on the toolbar. The mouse cursor will now appear as a pencil when placed in the map viewer. Place the cursor landward of the northern extent of the two shorelines and click the left-mouse button to begin drawing. Follow the general trend of the shorelines and set additional points for the baseline to follow the general curvature of the coast by clicking the mouse. The drawing can be cancelled at any time by selecting the **Esc** key. To complete the drawing, double-click the mouse button to at the southern limit of the 2002 shoreline.

Figure 13. Creating a baseline using the *draw baseline* tool

A baseline data item appears in the data tree, and the completed baseline appears in the viewer. The baseline should be similar to Figure 13.

Shoreline change rates can be calculated once two shorelines and a baseline are available in the data tree. Activate the 1942 and 2002 shorelines and the baseline in the data tree. Select the **Shoreline Change Rate** button to begin the analysis. The sampling interval window appears; enter “500” and select **Ok**. The shoreline change report now appears, providing a summary and basic statistics of the analysis. This report can be exported to text or copied and pasted into a spreadsheet application.

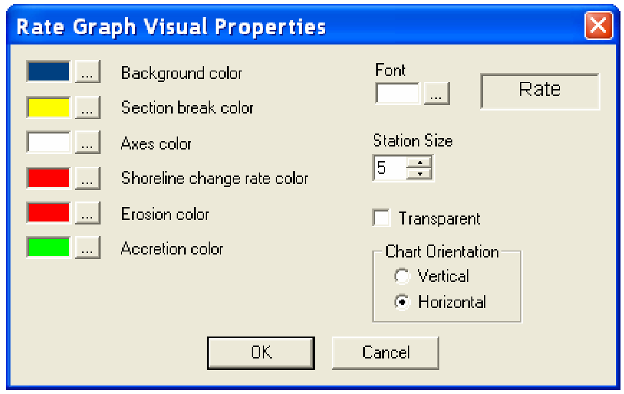


Figure 14. Rate graph properties

Close the report, activate the *Shoreline Change Map* in the data tree and click the **Release Zoom** button. By default, the map appears in the horizontal direction. To rotate the map to the vertical direction, select the graph, right-click, and then select *Visual Properties* (Figure 14). Change the chart orientation to vertical and click **Ok**. The shoreline rate map can be moved by dragging the item with the mouse, or resized by selecting the graph and dragging the handles on the side of the graph (Figure 15). If desired, the size of the map view window may be increased by turning off the data grid by selecting *View*, then *Data*. To view the shoreline change rate graph, uncheck all items, switch to graph view and activate the shoreline rate graph item. This displays a plot of the shoreline change rate along the baseline. The shoreline change rate is stored at each distance along the baseline for the rate graph item, and at the geographic location of each transect along the baseline for the map item. Both the shoreline change rate map and graph are editable using the data grid table functions. This concludes the shoreline analysis tutorial.

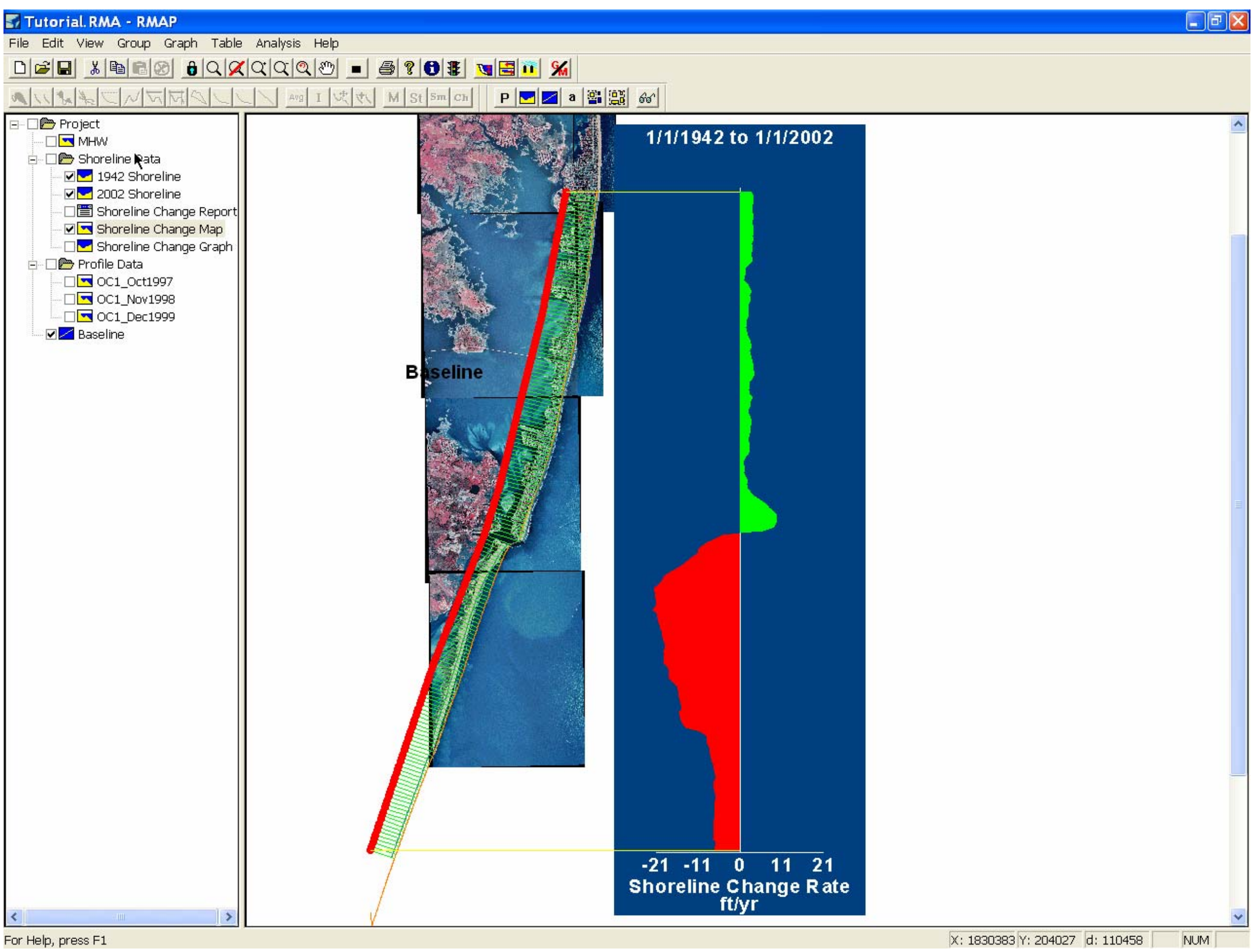


Figure 15. Shoreline change rate graph plotted in map viewer

Beach Profile Analysis. RMAP provides a robust suite of cross-section analysis tools. A report is generated for each analysis, which can be exported as text, printed, or copied and pasted into spreadsheet applications. Walkthroughs of various functions and analysis routines are given in this section.

To begin, open the "ProfileAnlaysisTutorial.rma" file found in the tutorial file directory.

Bar properties. Bar properties are analyzed in RMAP by drawing a selection box around the bar form. Although defining a bar feature visually is subjective, negligible differences in bar volume typically result from this method when executed by an experienced user. Bar volume, length, center of mass, minimum depth and location, and maximum depth and location are given in the analysis report.

The bar properties analysis may only be performed on a single profile at a time. Expand the *Bar Properties* group and select the profile. Select *Analysis*, then *Bar Properties* from the file menu, or click the **Bar Properties** button  on the toolbar. Next, manually draw a selection box around the bar form with the mouse cursor (Note: it is usually easier to draw the box from the left to the right). Drawing is initiated by depressing the left mouse button and completed with the release of the button. The bar form, highlighted in black, should extend to the slope breaks at both the landward and seaward extent of the bar feature (Figure 16). When the drawing is complete, RMAP prompts the user to accept the bar location. Selecting **No** allows the user to redraw the area, selecting **Yes** accepts the delineation of the bar and opens the analysis report (Figure 17). To view the report again, right-click on the report item in the data tree and select **View Report.**

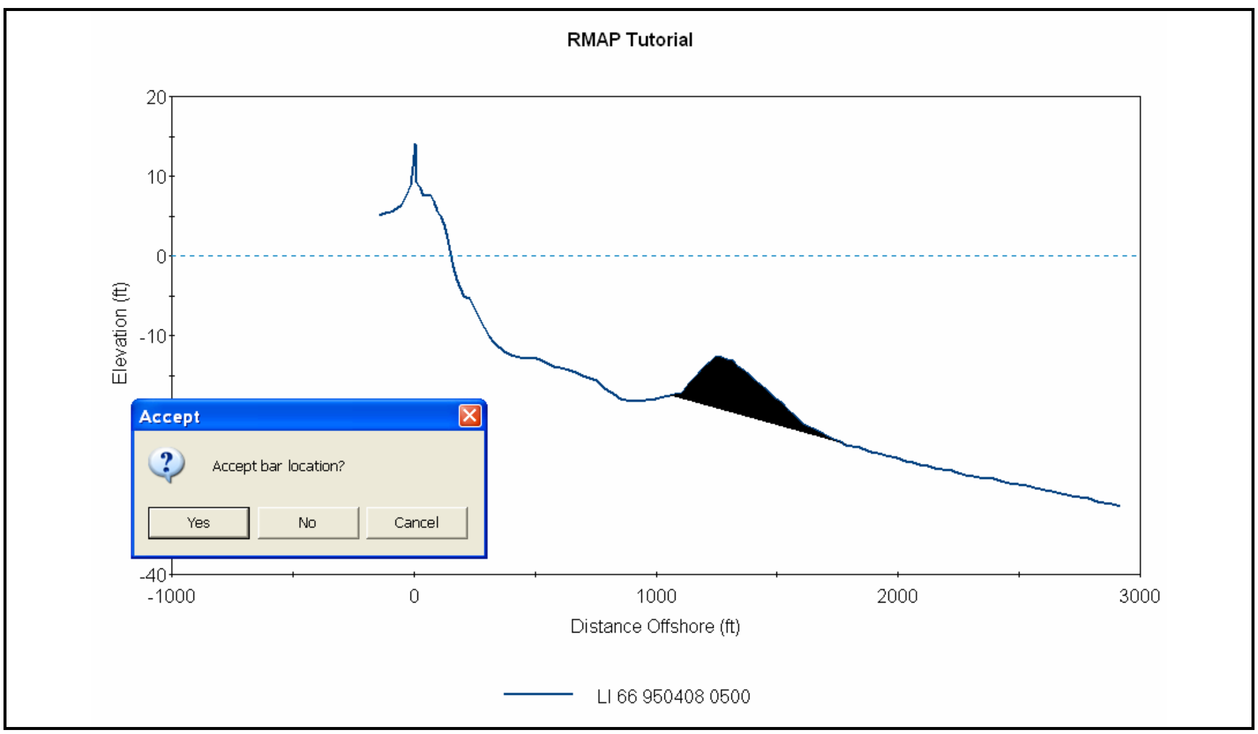


Figure 16. Bar form selection

Profile comparison. The profile comparison routine calculates the volume and contour location change for two profiles within a user-defined area (*Xon*, *Xoff*, *Contour*).

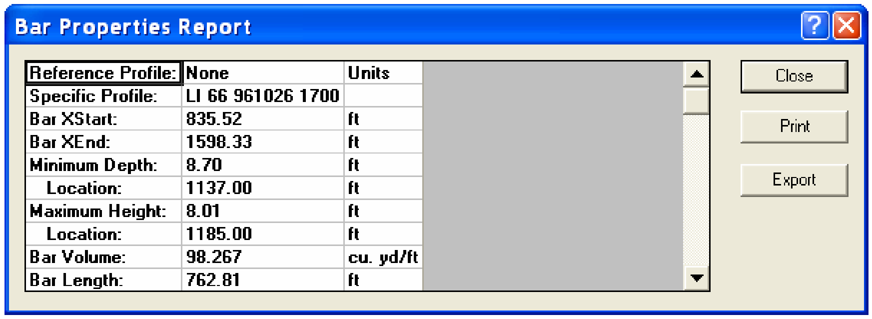


Figure 17. Bar properties analysis report

The *Profile Comparison* group contains two cross sections of a navigation channel in Freeport, TX. Expand the group and select both cross-sections, then select *Analysis*, *Profile Comparison* from the file menu, or click the **Profile Comparison Bar Properties** button on the toolbar. RMAP displays the analysis bounds in the analysis input window (Figure 18). The *Xon*, *Xoff*, fields are automatically populated with the overlapping portion of the two cross sections, and the *Contour* is populated with the deepest extent of the two profiles. Accept the bounding values. Next, the bounding box of the analysis will be displayed in the viewer (Figure 19). Accept the boundaries and the analysis report appears (Figure 20) in addition to a data tree item for the calculated profile difference (Figure 21).

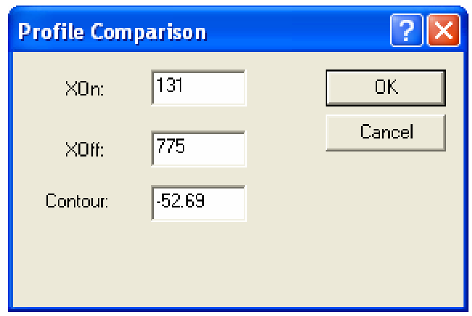


Figure 18. Enter analysis boundaries

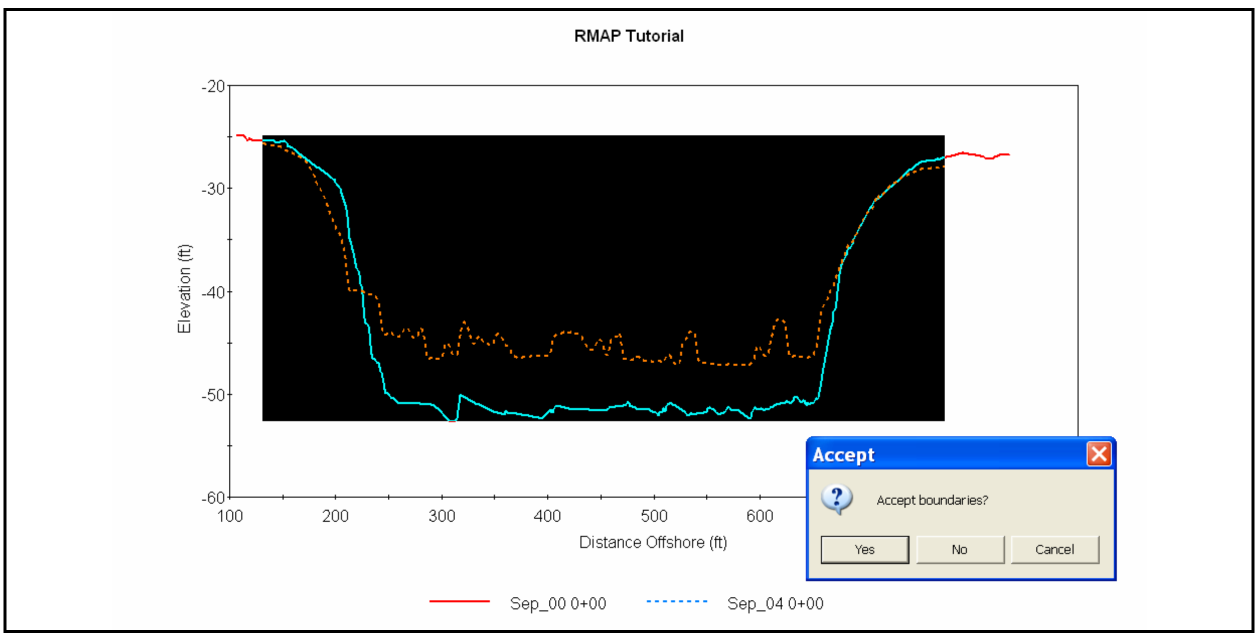


Figure 19. Bounding box allows visual confirmation of analysis boundaries, which may be revised at this time

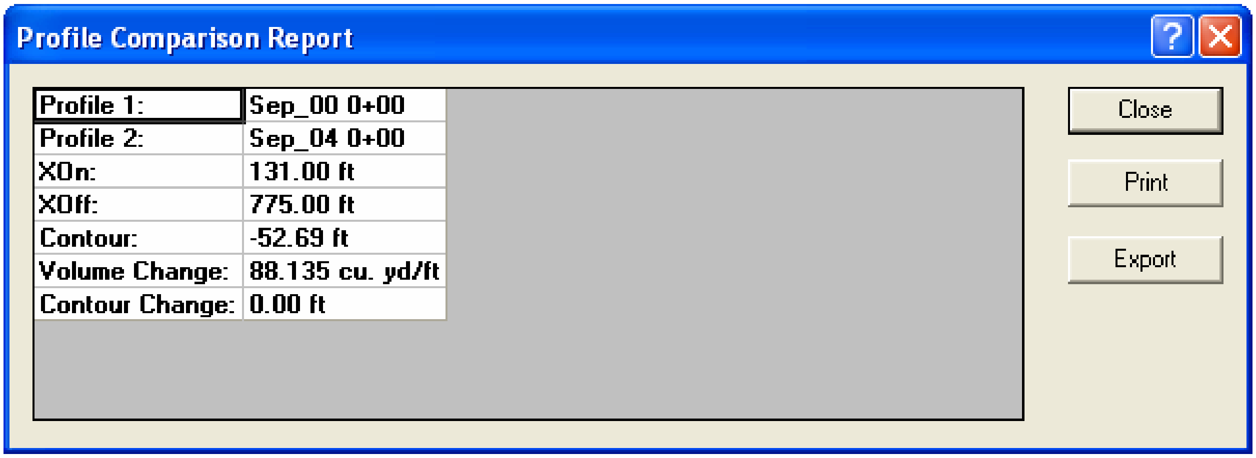


Figure 20. Profile comparison report

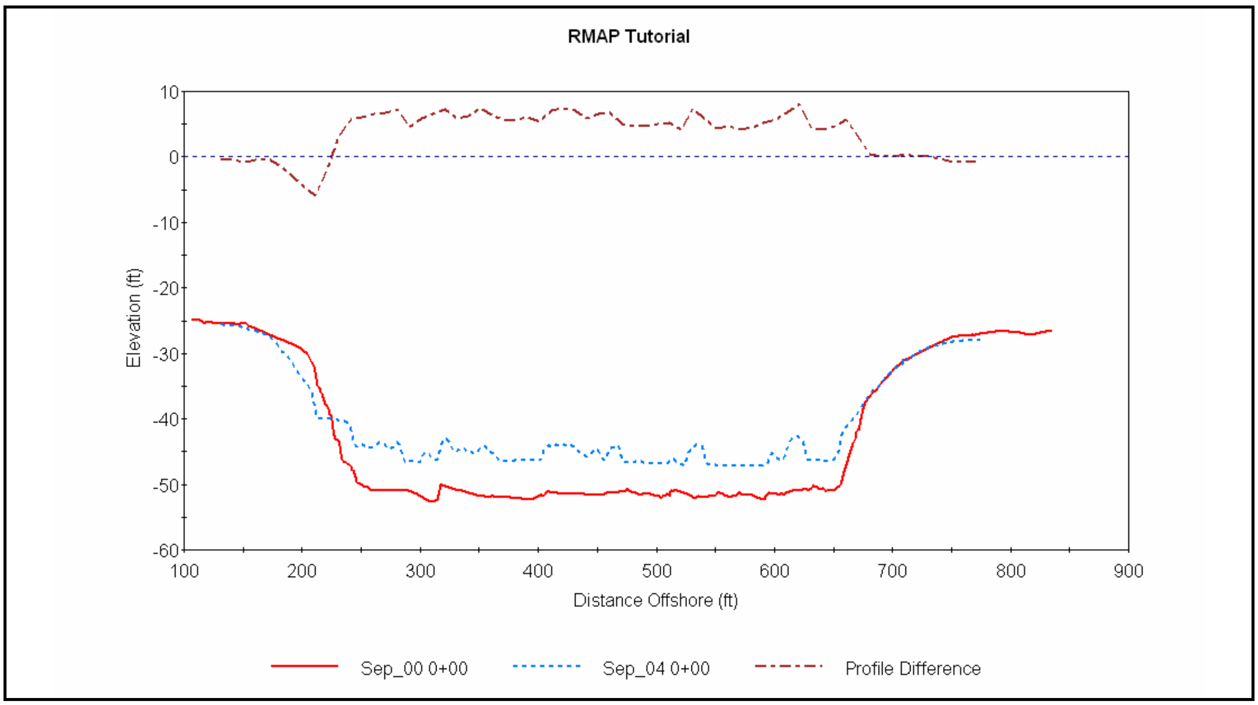


Figure 21. Profile difference plotted against the two channel cross sections

Cut and fill. The cut and fill routine compares two profiles and defines cells defined by intersections between two profiles. The analysis report gives the distance and elevation boundaries of each cell, in addition to volume change within the cell. Total volume change, volume change above and below the vertical datum, and shoreline change at the datum are also calculated.

The *Cut and Fill* group contains two profiles from East Hampton, NY. Expand the group and activate both profiles in the data tree, and then select *Analysis*, and *Cut and Fill* from the file menu, or click the **Cut and Fill** button on the toolbar. Sections of volume gain and loss are plotted in the graph view (Figure 22) and an analysis report (Figure 23) is generated. To change display back to normal plot mode, select any item in the data tree.

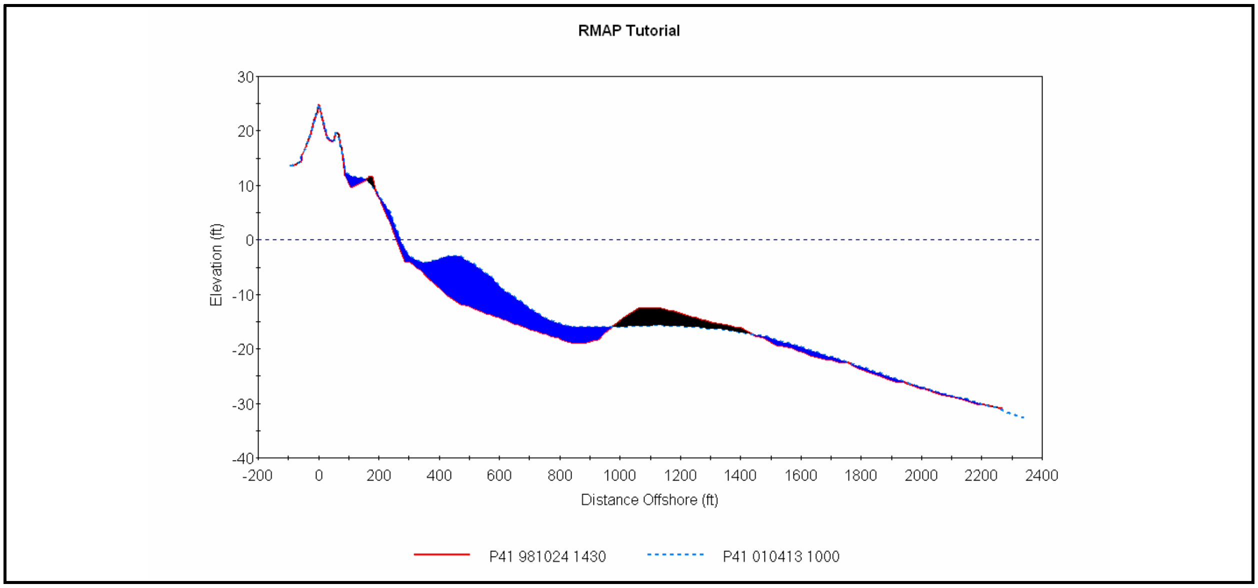


Figure 22. Cut and fill analysis results

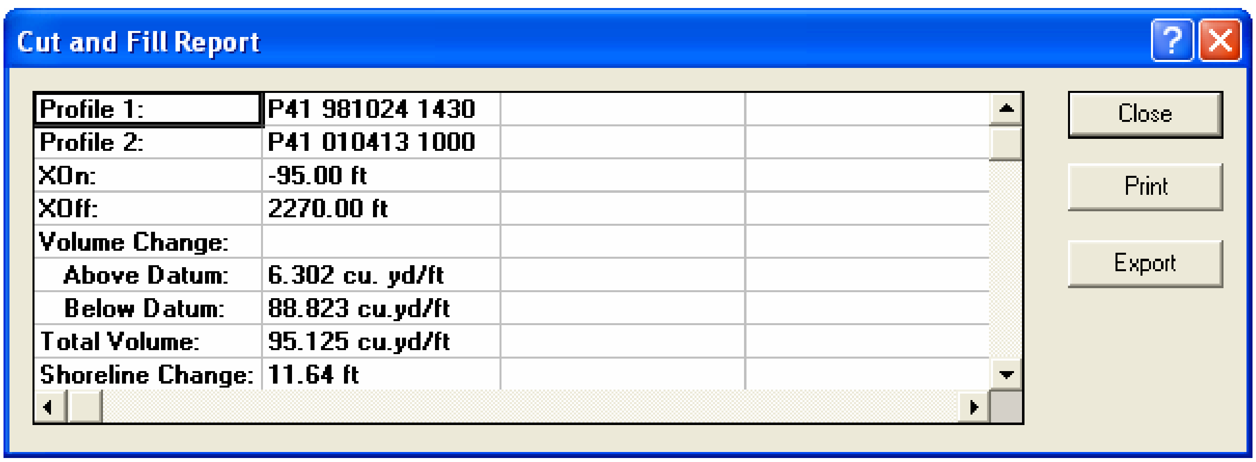


Figure 23. Cut and fill analysis report

Horizontal alignment. The horizontal alignment routine translates profiles an arbitrary distance to horizontally align all selected profiles to the user-specified elevation contour.

The *Alignment* group contains profiles from South Padre Island, TX. To horizontally align a series of profiles, expand and select all profile items in the group. Then select *Analysis*, and

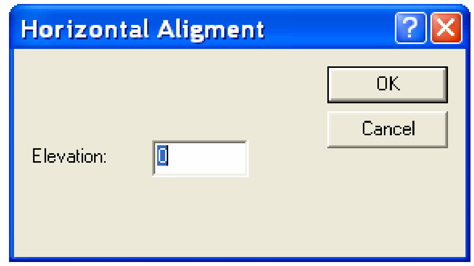


Figure 24. Horizontal alignment elevation

Horizontal Alignment from the file menu, or click the **Align Profiles** button  on the toolbar (Note: select multiple items at once by selecting the first, press and hold the shift key, then select the last). RMAP prompts the user to enter the desired profile elevation for alignment (Figure 24). If one or more selected profiles do not intersect the specified elevation and error message will appear and the alignment is cancelled. Enter "0" for the alignment elevation and continue. Next, a new window will appear to set the desired distance reference for the alignment (Distance coordinate desired for the alignment elevation, Figure 25). This window allows the user to view the distance of the desired alignment elevation for each profile. The distance of the elevation for a particular profile can be selected, or the user can specify the reference distance. Enter "0" and click **Ok** to complete the alignment (Figure 26).

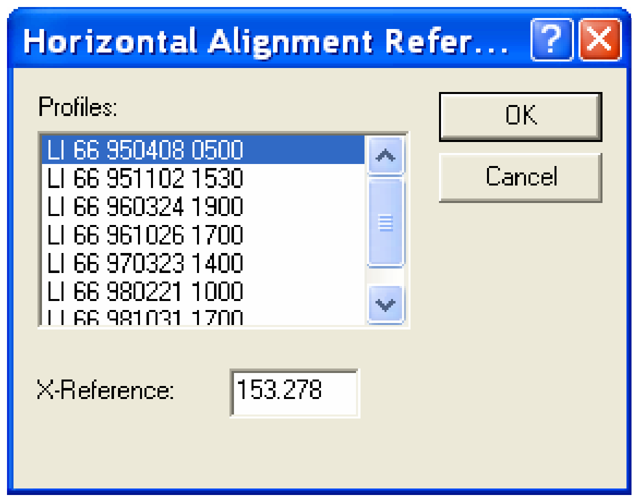


Figure 25. Horizontal alignment reference distance

Volume and sectional volume. The volume function calculates the volume of the profile above a user-specified contour for the entire extent of the profile, while the sectional volume function allows the user to specify a specific section and contour for the analysis. Analysis reports include volume and contour location. The algorithm interpolates profiles or modifies analysis bounds if profile extent does not meet the analysis extent. The volume of the profile is derived by extrapolating the area under the curve for one unit length of shoreline (cubic yard per linear foot or cubic meter per linear meter of shoreline).

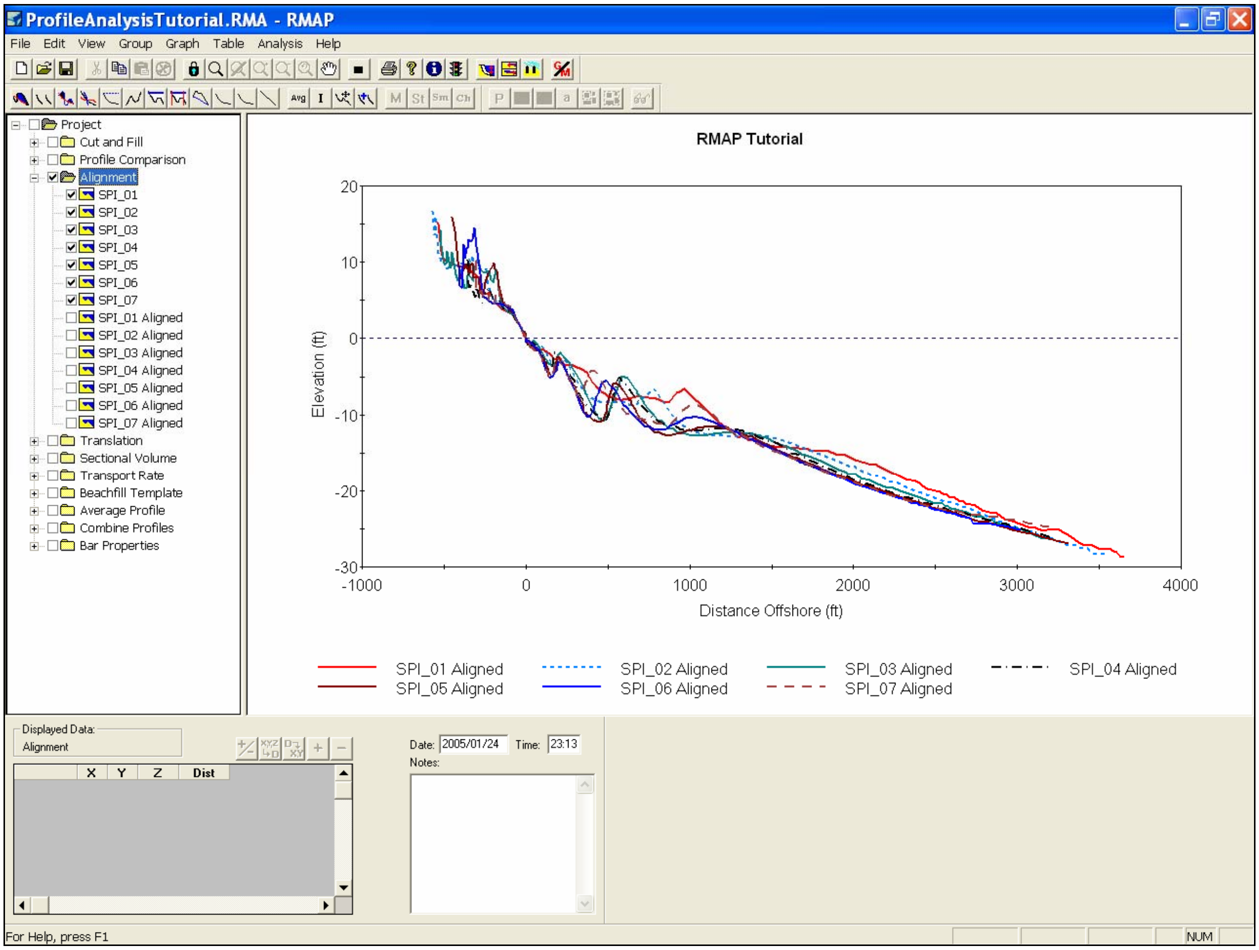


Figure 26. Profiles after alignment at zero contour with a zero-horizontal reference

Profile Volume Report

Contour Level:	0.00 ft			
Profile	XOn(ft)	XOff(ft)	Volume(cu. yd/ft)	Contour Location(ft)
LI 66 950408 0500	-140.00	2918.00	70.778	153.28
LI 66 951102 1530	-197.00	2734.00	83.708	155.64
LI 66 960324 1900	-141.00	2953.00	79.999	266.45
LI 66 961026 1700	-52.00	2672.00	101.107	279.50
LI 66 970323 1400	-129.00	2942.00	97.696	257.00
LI 66 980221 1000	-79.00	2761.00	46.850	173.00
LI 66 981031 1700	-109.00	2965.00	100.580	242.57

Close
Print
Export

Figure 27. Volume analysis report

The *Sectional Volume* group contains profiles from Fire Island, NY. To evaluate the volume of each profile, select all profiles in the group and select *Analysis*, *Volume* from the file menu, or select the **Volume** button  on the toolbar. When prompted for the volume contour, enter "0." The profile volume is then generated (Figure 27). Note the *Xon* and *Xoff* values in the analysis report. The analysis describes the volume over the full extent of each profile. If these values are inconsistent, the sectional volume function should be used for comparative analysis.

Sectional volume analysis may be performed for single or multiple profiles. To perform sectional volume analysis for all available profiles, select all profiles in the data tree, then select *Analysis*, and *Sectional Volume* from the file menu, or click the **Sectional Volume** button on the toolbar. RMAP prompts the user to enter the bounds of the analysis (*Xon*, *Xoff*, and *Contour*) (Figure 28). By default, the contour is zero, and *Xon* and *Xoff* are populated with the maximum landward (*Xon*) and seaward (*Xoff*) bounds in the set of profiles. For *Xon*, enter "0" (approximate position of dune crest) and for *Contour*, enter "-25" (approximate depth of closure). The extent of the analysis is then displayed in the viewer (Figure 29). If the extent of the analysis is not satisfactory, the user can select **No** and revise the bounds. To continue with the analysis, select **Yes**. RMAP then evaluates the extent of each profile against the analysis bounds. If the profile does extend to the analysis bounds, the user has the option to *Extend* (extends last elevation point of profile to *Xoff* distance) the profile, *Modify* (limits the analysis to the seaward-most extent of each profile) the analysis bounds, or *Omit* the profile from the analysis (Figure 30). *Modify* is the best option for data sets that consistently reach to the desired elevation, but do not extend the same distance offshore. Choose the *Modify* option for each profile; when finished, the *Profile Volume Report* will appear (Figure 31).

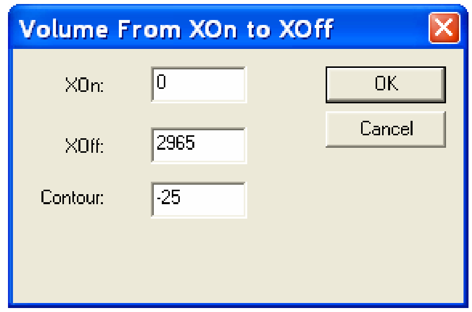


Figure 28. Sectional volume boundary form

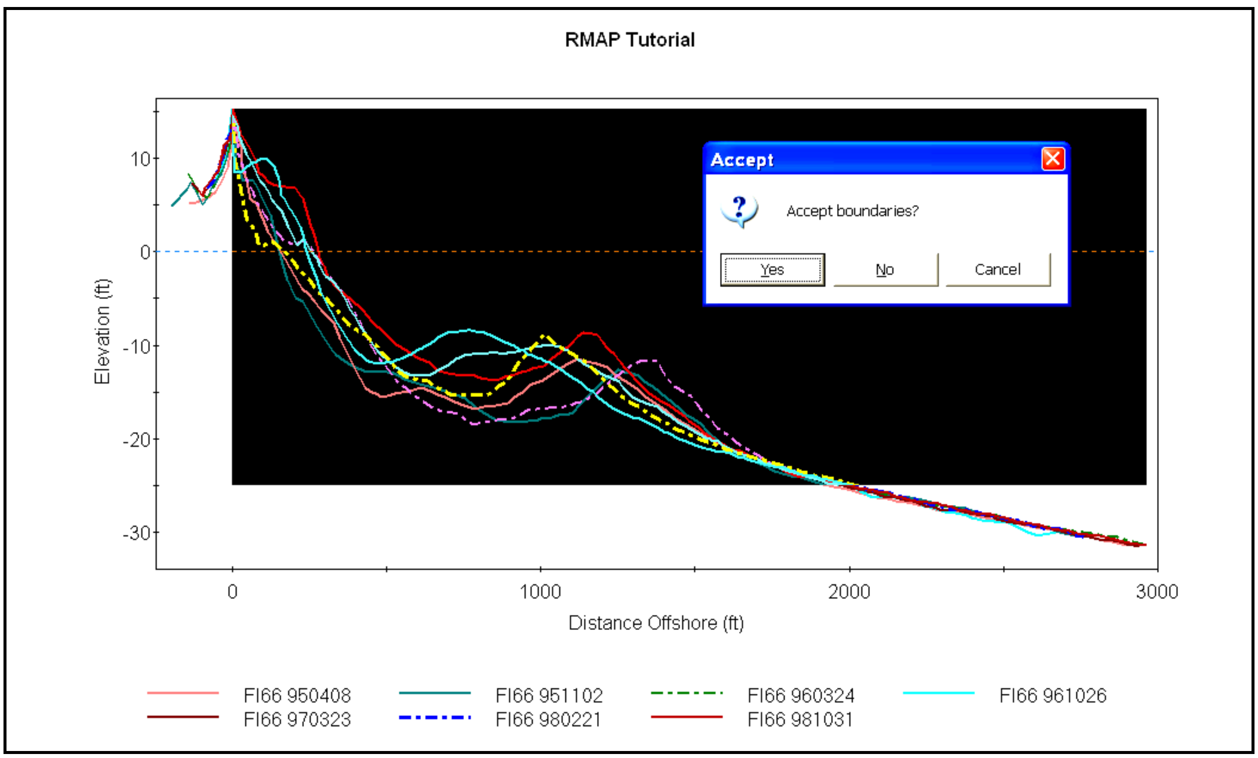


Figure 29. Extent of sectional volume analysis is shown in viewer prior to completion, if desired, the analysis bounds may be adjusted at this time

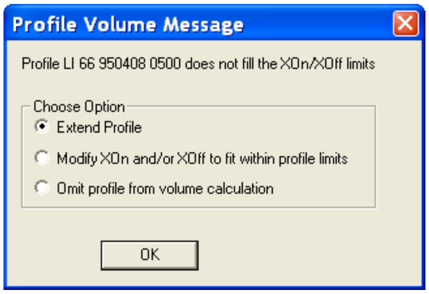
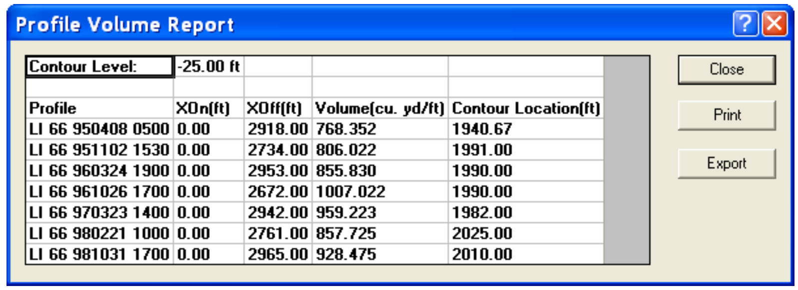


Figure 30. Boundary options window



Contour Level:	-25.00 ft			
Profile	XOn(ft)	XOff(ft)	Volume(cu. yd/ft)	Contour Location(ft)
LI 66 950408 0500	0.00	2918.00	768.352	1940.67
LI 66 951102 1530	0.00	2734.00	806.022	1991.00
LI 66 960324 1900	0.00	2953.00	855.830	1990.00
LI 66 961026 1700	0.00	2672.00	1007.022	1990.00
LI 66 970323 1400	0.00	2942.00	959.223	1982.00
LI 66 980221 1000	0.00	2761.00	857.725	2025.00
LI 66 981031 1700	0.00	2965.00	928.475	2010.00

Figure 31. Sectional volume analysis report

Average. This function is commonly used to determine the depth of closure at a profile location. The average, maximum, and minimum profiles (profile envelope), in addition to the standard deviation, are calculated, plotted, and generated as data items. The profile envelope is derived from the maximum and minimum elevations of the entire data set.

The *Average* profile group contains a time series of profiles from the Corps Field Research Facility (FRF) at Duck, NC (Figure 32). To calculate the average profile, profile envelope and the standard deviation from these data, select all profiles from the group, then select *Analysis* and *Average* from the file menu, or select the **Average Profile** button  from the toolbar. The average profile, profile envelope, and standard deviation appear in the viewer (Figure 33) and corresponding items appear in the data tree.

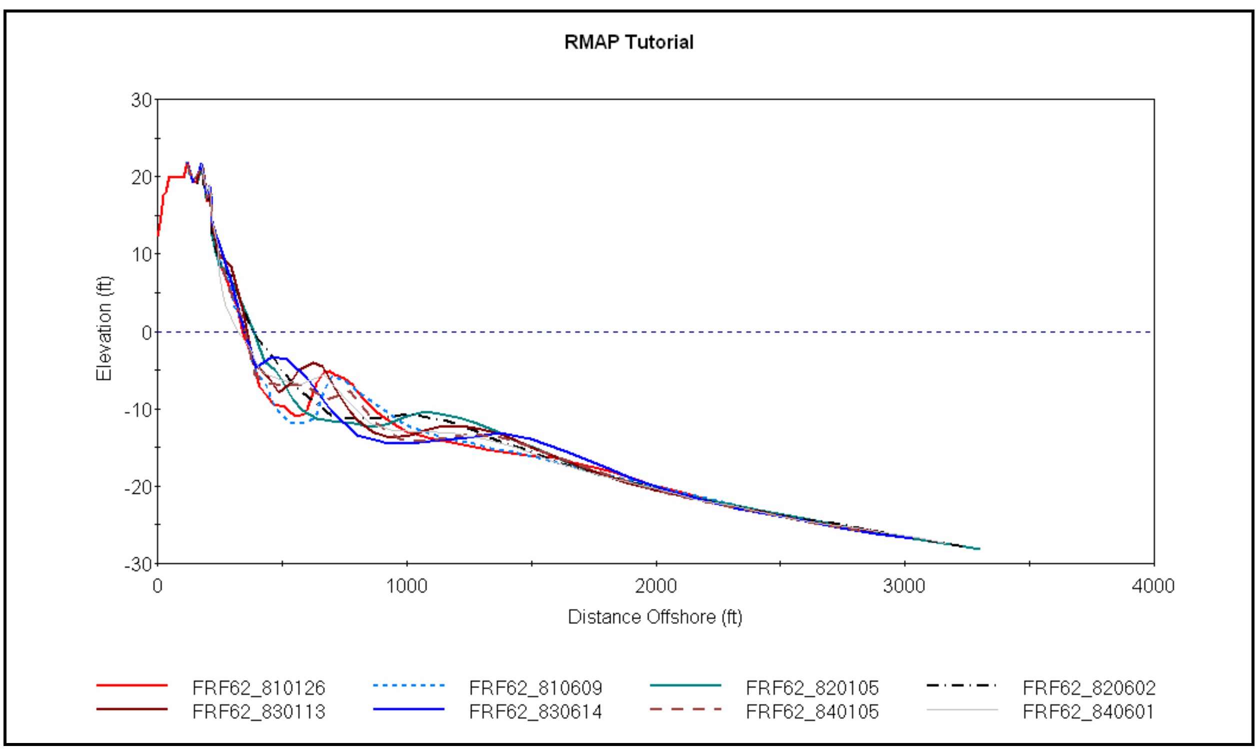


Figure 32. Profile time series at FRF sta 62

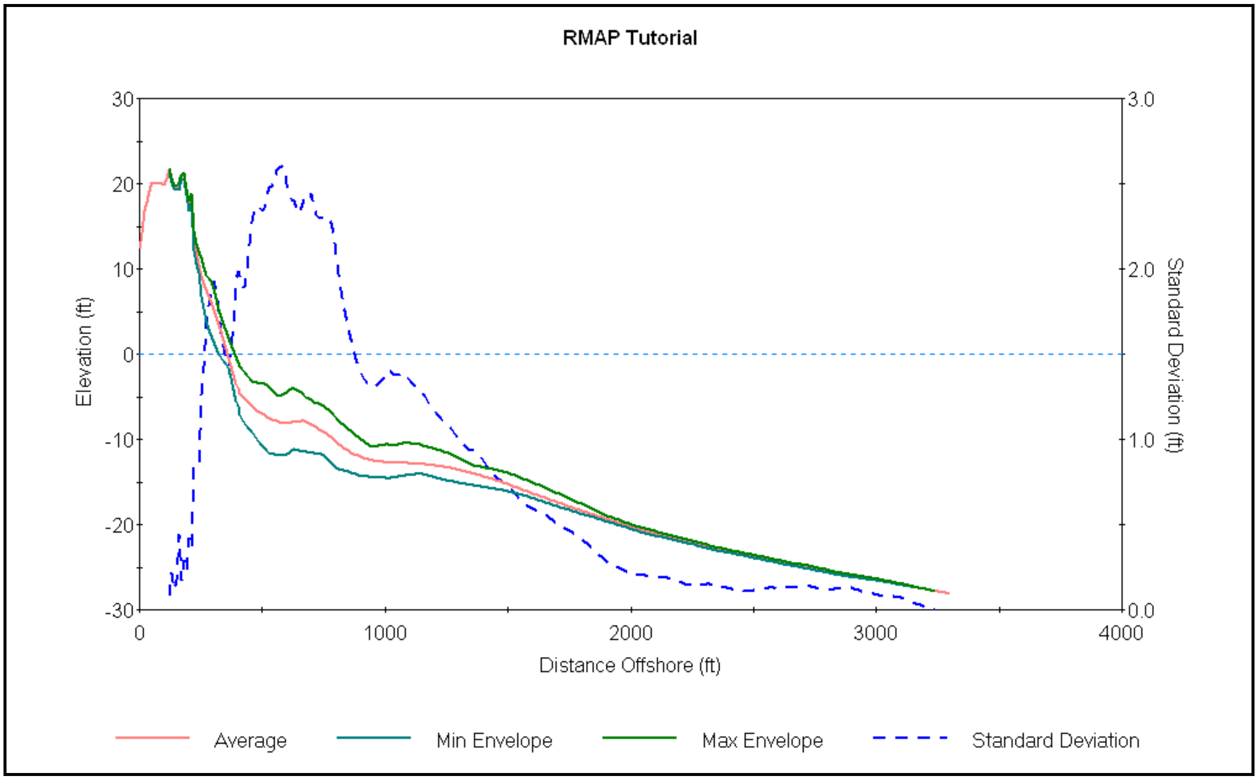


Figure 33. The *Average Profile* function generates the average profile, profile envelope (maximum and minimum elevations of data set), and standard deviation of time-series

Translation. The translation function allows the user to translate individual or multiple cross sections or shorelines. This function is typically used to correct vertical or horizontal offsets in profiles caused by errors during data collection. Translation options include vertical, horizontal (distance), or to the X and Y coordinates if the profile is in geographic space.

The *Translation* group contains a series of profiles from Coney Island, NY. Expand the group, plot all the profiles in the viewer, and zoom into the subaerial portion of the profile. Note that one profile is not aligned at the seawall near-vertical portion of the profile (Figure 34). Zoom in further, and use the pointer and coordinate display in the bottom right hand corner to determine the offset. Unselect all profiles, then select only the 2001 profile (CI10 010515), select *Analysis*, *Translate* from the file menu, or the **Translate** button  on the toolbar.

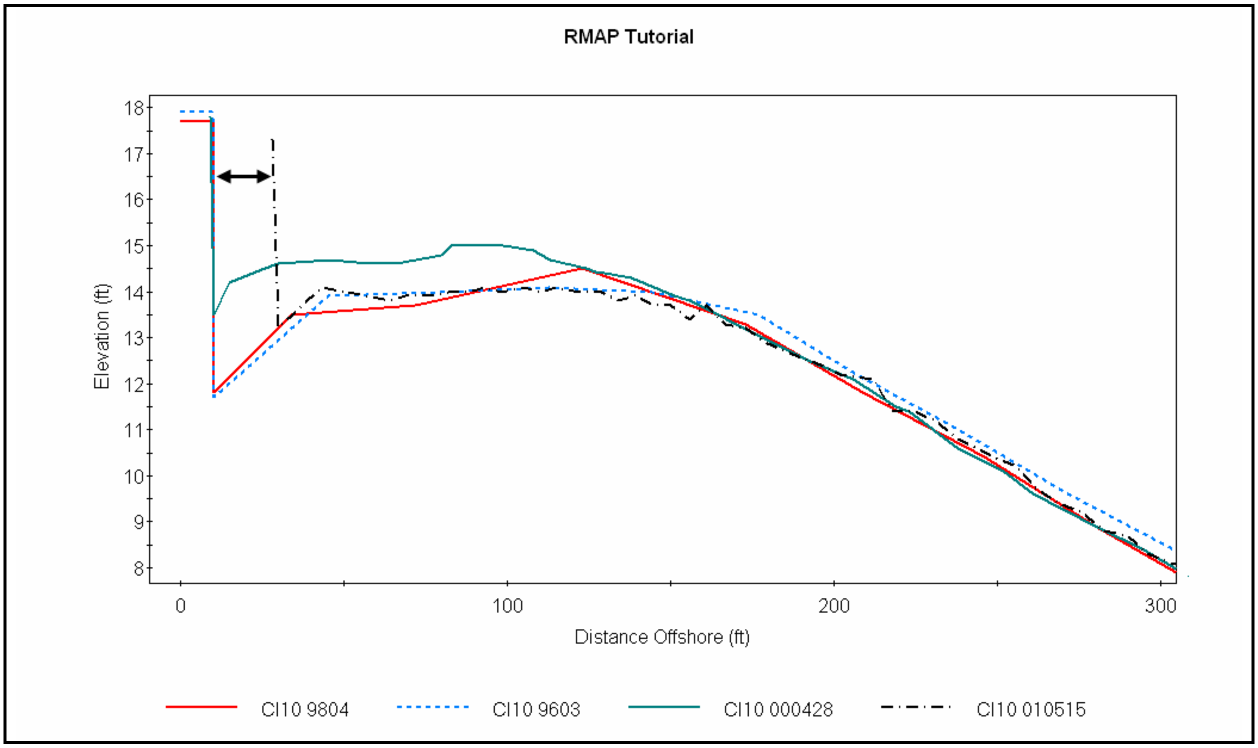


Figure 34. Offset of profile CI10 010515 at seawall indicates an error in data collection

Select the option for distance translation and enter “-19” and click **Ok** (Figure 35). The translated profile will appear under the group in the data tree. Select the translated profile. Note that the translation has been appended to the item’s metadata under *Notes*.

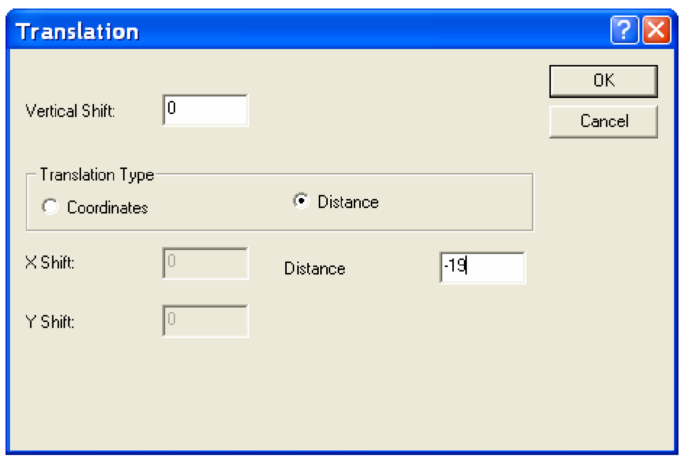


Figure 35. Profile translation options

Combine profiles. This function is helpful for combining subaerial and sub-aqueous portions of cross-section data, in addition to shoreline segments. Profiles are selected using the check box in the data tree and then combined at a user-defined distance or elevation value in the zone of overlap. The combined profile is generated under the data tree as a new item upon completion.

The *Combine* group contains an unmerged profile from Bald Head Island, NC. Expand the group, activate both segments of the profile, and zoom into the area of overlap. The offshore segment appears to tie well at the beginning 339 ft from the transect origin (Figure 36). Select *Analysis*, *Combine Profiles/Shorelines* from the file menu, or select the **Combine Profiles/ Shoreline** button  from the toolbar. Select the distance option, enter “339” in the form

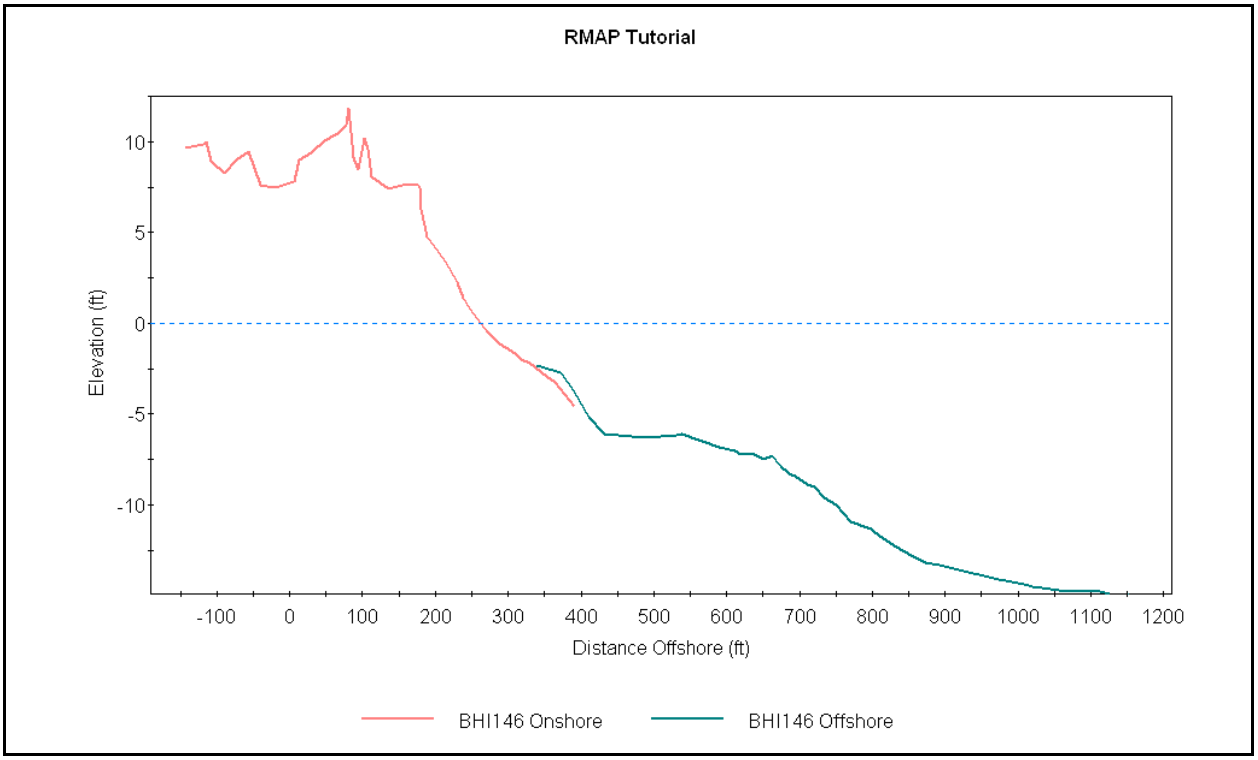


Figure 36. Subaerial and subaqueous portions of profile

(Figure 37), and click **Ok** to complete the procedure. The combined profile appears in the data tree and in the data viewer (Figure 38).

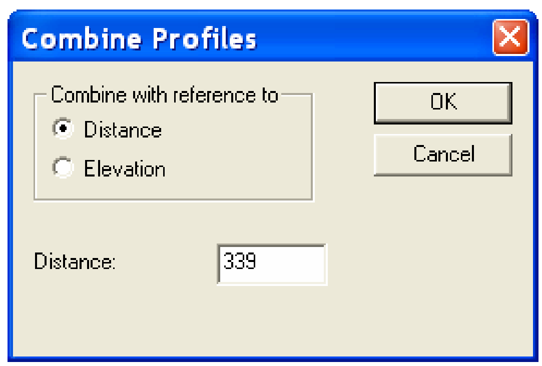


Figure 37. Profiles can be combined either by a user-defined distance or elevation

Synthetic Profiles. RMAP allows the user to generate several types of synthetic beach profiles, including beach-fill templates, equilibrium profile (Dean 1991), and modified equilibrium profiles (Larson 1991), interpolated profiles, and plane sloping profiles.

Beach-fill template. This option allows a user-defined beach-fill template to be attached to an existing profile, or allows the addition of beach width to an existing profile for estimation of beach-fill volume requirements. A new profile and volume report are generated upon completion.

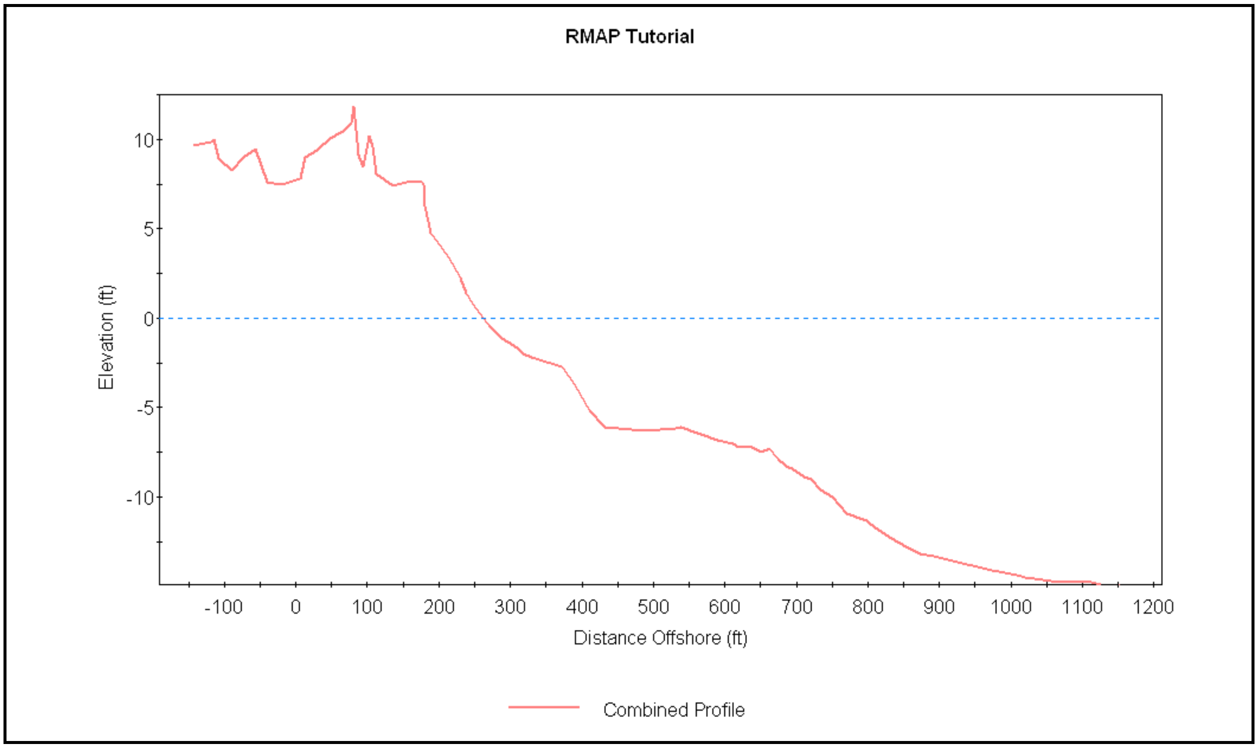


Figure 38. Combined profile

To add a beach width to an existing profile for estimation of nourishment volume requirements, go to the file menu and select *Analysis*, *Synthetic Profiles*, *Beach Fill Template*, or select the **Beach Fill Template** button from the toolbar. The first window allows the user to define a construction template, click **Next** to bypass this window and access the template placement window. The template placement window (Figure 39) allows the user to specify the fill *Width*, the *Elevation at tie in* (where template begins, the profile seaward of this elevation is translated by the *width*), and the *Depth of Closure* (where the translation of the profile ends). If fill material is incompatible, the *non-compatible* option is available to estimate the additional volume required.

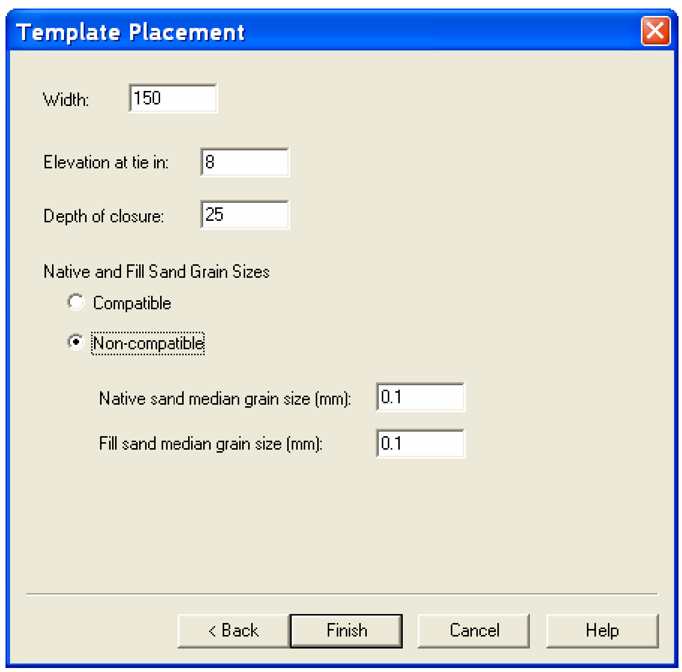


Figure 39. Template placement window allows user to designate fill width, tie-in elevation, depth of closure, and compatibility of sand to estimate volume requirements

Enter the values of 150 for *Width*, 8 for *Elevation at tie in*, and 25 for *Depth of Closure* and click **Ok**. The Beach-Fill report (Figure 40) will appear. When finished, select *Close*, and the nourished profile will appear in the viewer (Figure 41).

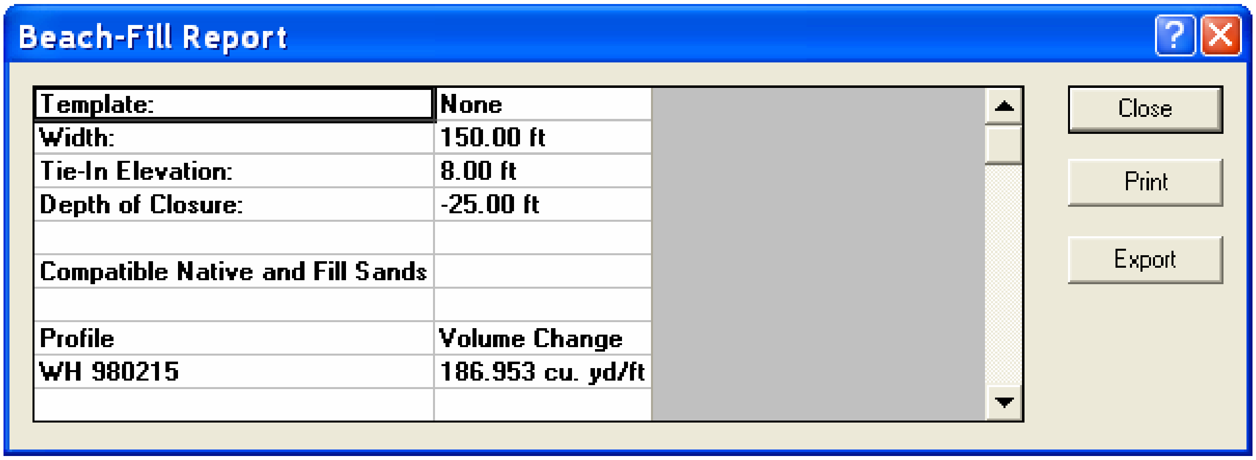


Figure 40. Beach-fill report records input values and gives volume estimate

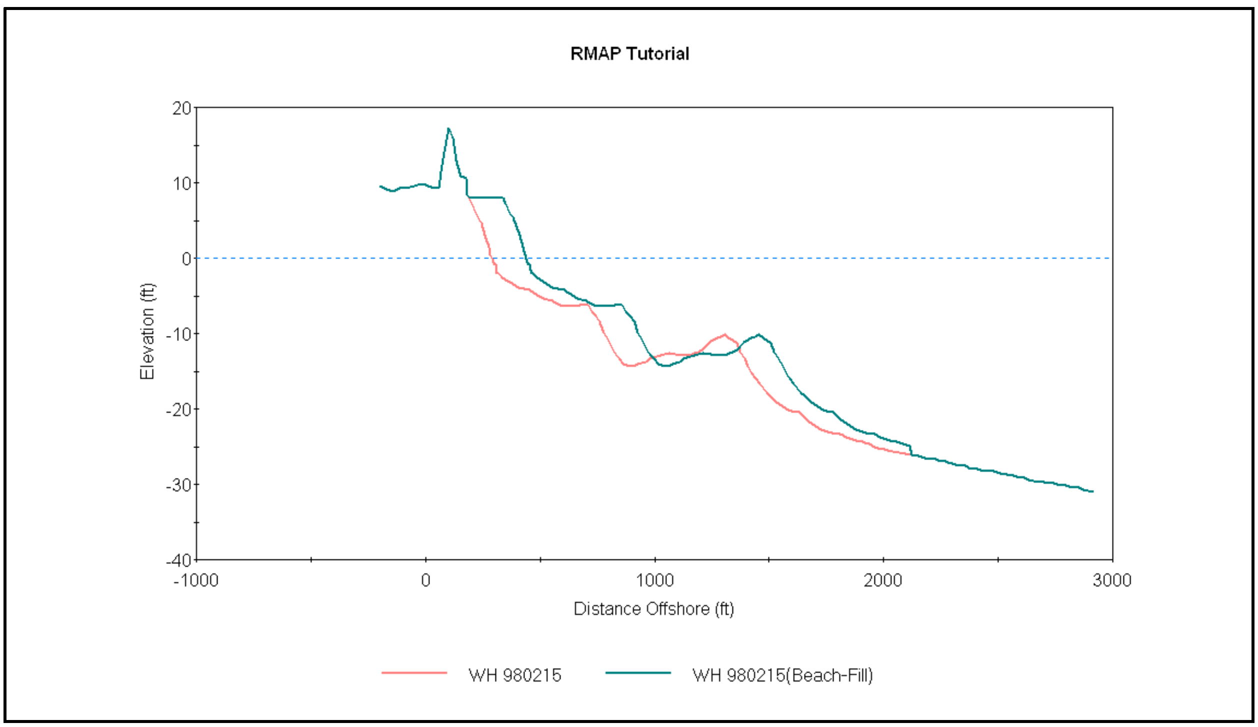


Figure 41. New profile has been translated within the parameters of fill to estimate volume requirements

Equilibrium profile. The Dean equilibrium profile is a concave monotonic profile given by the power-law relation $h = Ax^{2/3}$, where h is water depth, A the shape parameter, and x the distance offshore from the shoreline. The shoreline is defined as $h = 0$ and $x = 0$. The parameter A is a function of median grain size d_{50}. This user is required to input *Xon*, *Xoff*, the calculation interval (dx), and either the median grain size (mm) or the A-parameter ($ft^{1/3}$ or $m^{1/3}$).

To generate an equilibrium profile, select the **Equilibrium Profile** button, or select *Analysis*, *Synthetic Profiles*, *Equilibrium Profile* on the file menu. Enter "1000" in *Xoff*, 25 in *dX*, select the *Grain Size* option and enter "0.22" and select **Ok** (Figure 42). An "Equilibrium" profile item is generated under the data tree, and the profile appears in the viewer (Figure 43).

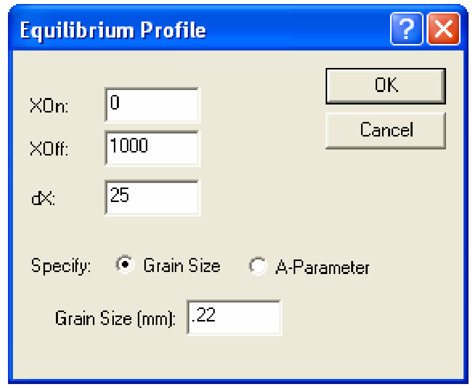


Figure 42. Input options for the equilibrium profile

Modified equilibrium profile. The modified equilibrium profile is a concave monotonic profile shape developed to describe beaches that may be steeper near to shore than in the offshore, corresponding to a decrease in grain size from coarser near the shoreline to finer in the offshore. This profile depends on two additional parameters, the energy dissipation ratio, *dRatio*, and the decay coefficient (Λ), which controls change in grain size from coarser to finer. These parameters allow fitting of the profile to the shape of the native profile. This user is required to input *Xon*, *Xoff*, the calculation interval (*dX*), either the native grain size (d_{50}) or the *A*-parameter, the *dRatio*, and the decay coefficient. Values of *dRatio* typically lie between 1 and 5; and lambda between 0.005 and 0.03 1/m (Larson 1991).

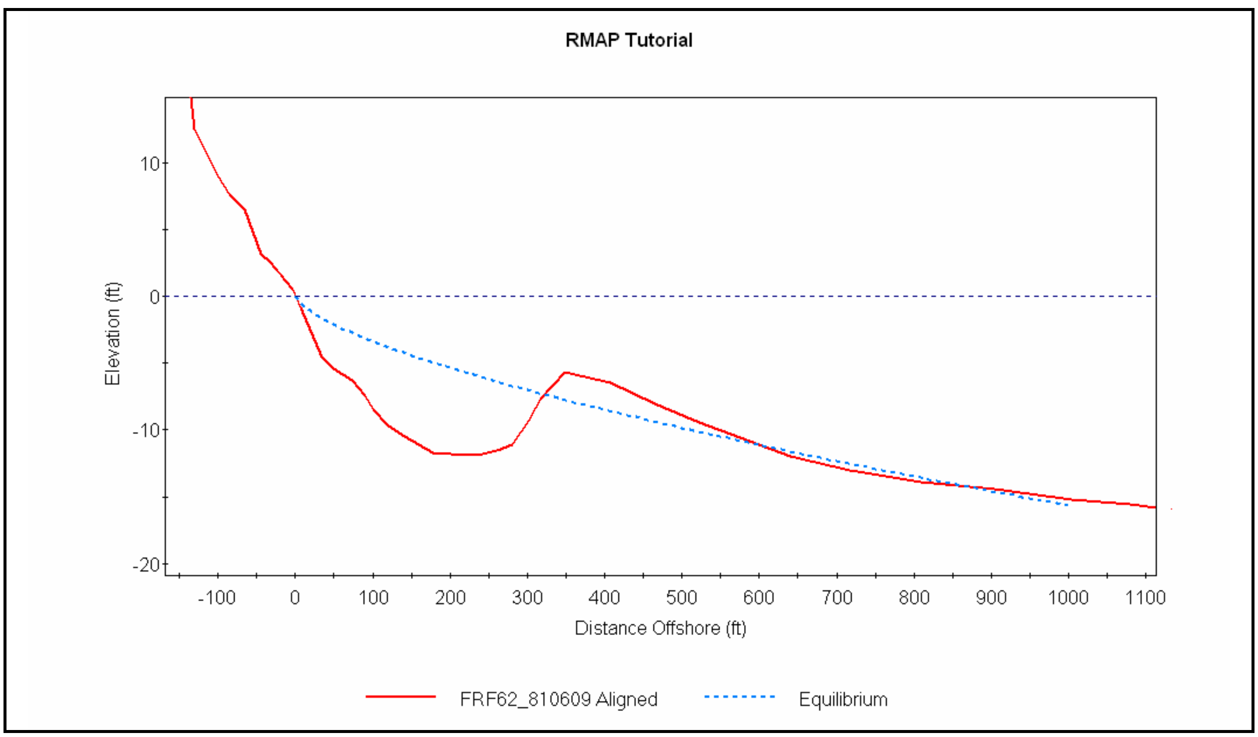


Figure 43. Equilibrium beach profile generated for a d_{50} of 0.22 mm compared to a natural profile. Note that bar complex is smoothed out by equilibrium profile

To generate a modified equilibrium beach profile, select the **Modified Equilibrium Profile** button on the toolbar, or select *Analysis*, *Synthetic Profiles*, *Modified Equilibrium Profile* on the file menu. Enter “300” for *Xoff*, “25” for *dX*, “0.22” for *Grain Size*, “5” for *dRatio*, “0.007” for *Decay Coefficient* and select **Ok** to generate the profile (Figure 44). A “Mod. Equilibrium” profile item is generated under the data tree and the calculated profile is automatically plotted in the viewer (Figure 45).

Plane sloping profile. This function generates a plane sloping profile, which is often used for testing purposes in numerical modeling studies. The user is required to input *Xon*, *Xoff*, *dx*, and the elevations at *Xon* and *Xoff* to determine the slope of the profile.

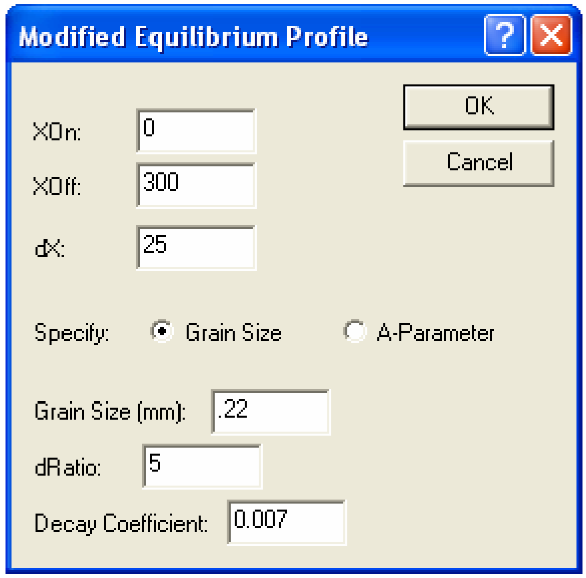


Figure 44. Input options for modified equilibrium beach profile

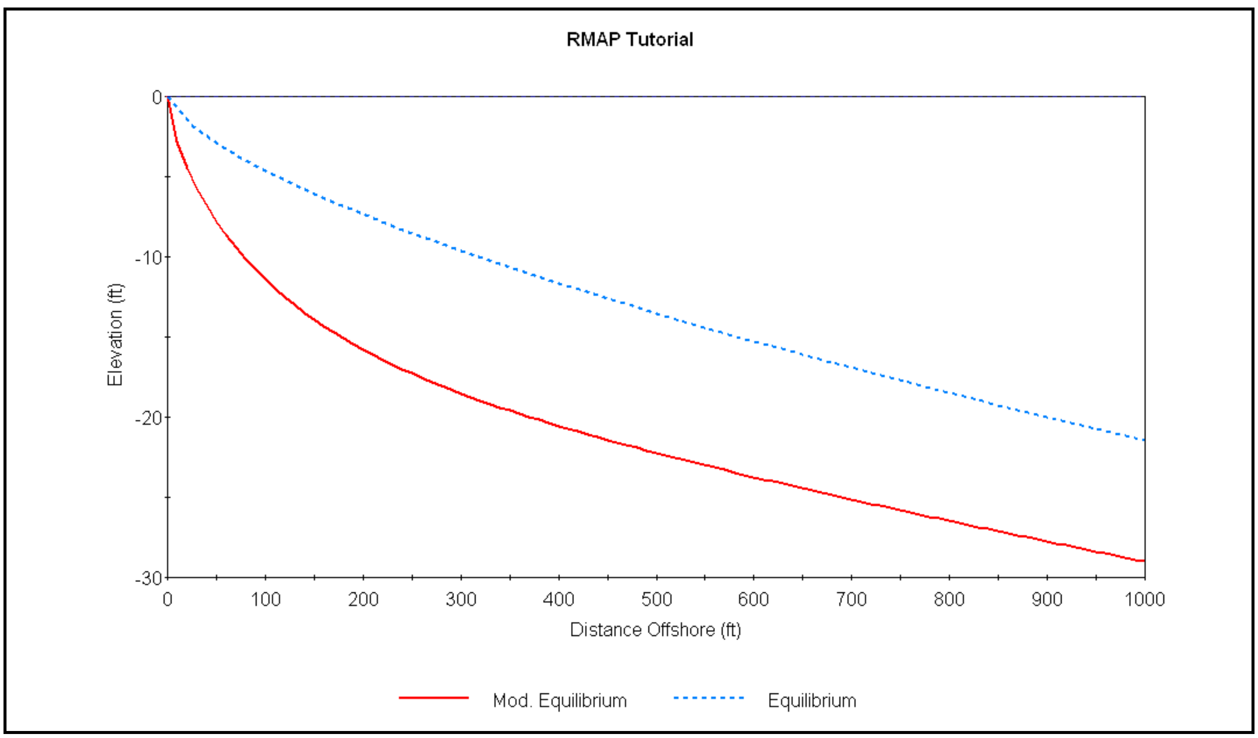


Figure 45. Modified equilibrium profile compared to equilibrium profile calculated for a d_{50} of 0.4

To generate a planar profile, select the **Plane Sloping Profile** button or select *Analysis*, *Synthetic Profiles*, *Plane Sloping Profile* on the file menu. In the input window, enter "1000" for *Xoff*, "25" for *dX*, and "-30" for *Elevation at Xoff* (Figure 46). A "Plane Slope" item is generated under the data tree and the calculated profile is automatically plotted in the viewer (Figure 47).

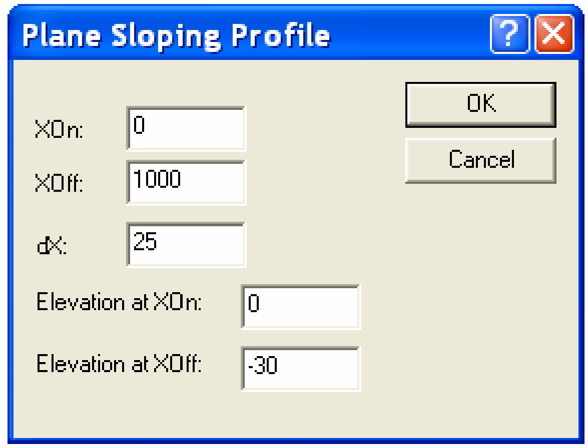


Figure 46. Plane sloping profile input window

Beach-Fill Module. The Beach-Fill module comprises several components that assist the engineer in the design of a beach-fill project. The module includes tools to calculate the depth of closure, prediction of erosion or accretion from cross-shore transport, and a planform evolution model. These components are described in the following text.

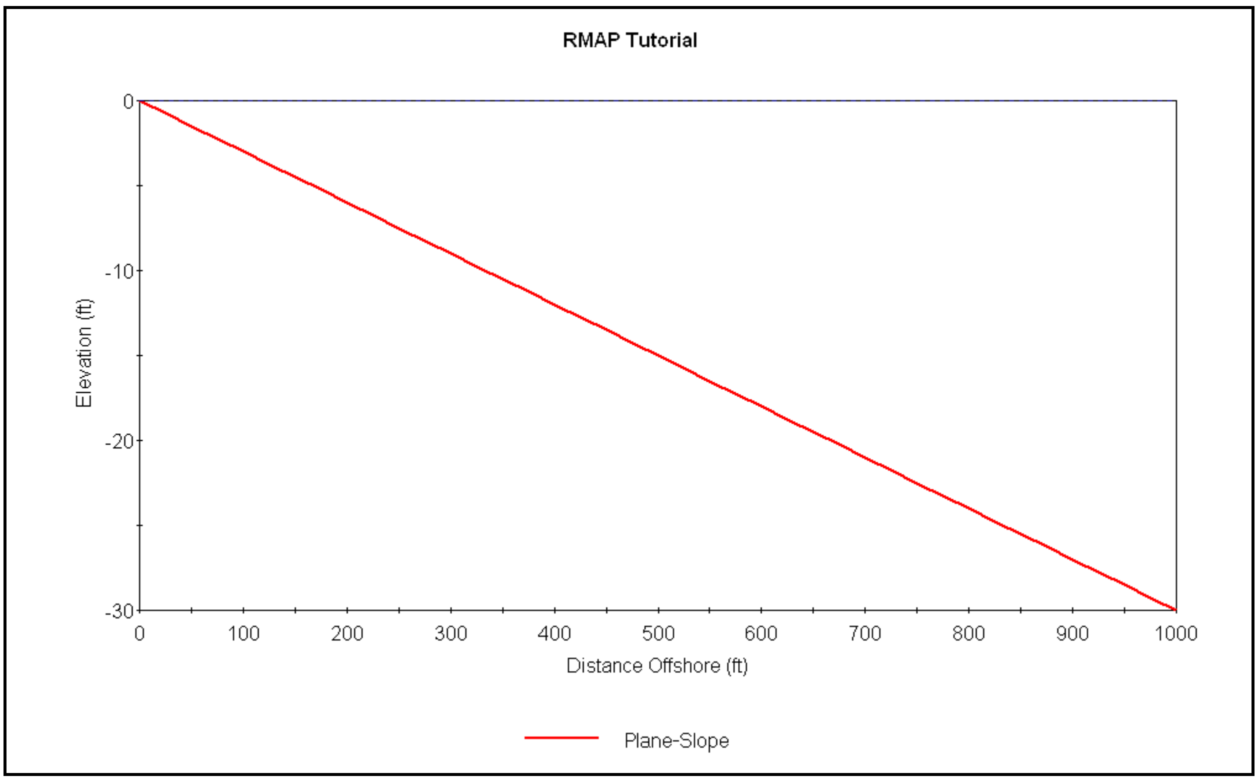


Figure 47. Example of a plane sloping profile generated by RMAP

Depth of closure calculator. This function estimates the depth of closure (Kraus et al. 1998) calculated by the Hallermeier (1978) equation for local significant wave height exceeded in a 12-hr interval, or through the mean annual significant wave height for a coastal area. Units can be toggled from standard to metric.

Determine the calculated depth of closure relative to NAVD 88 from the following. Analysis of a time series of wave data collected offshore of Fire Island, NY, during a 3-month interval results in a significant wave height of 3.1 m and wave period of 6 sec. The National Geodetic Survey station at the Fire Island Coast Guard Station indicates that NAVD 88 is 0.364 m above the mlw datum.

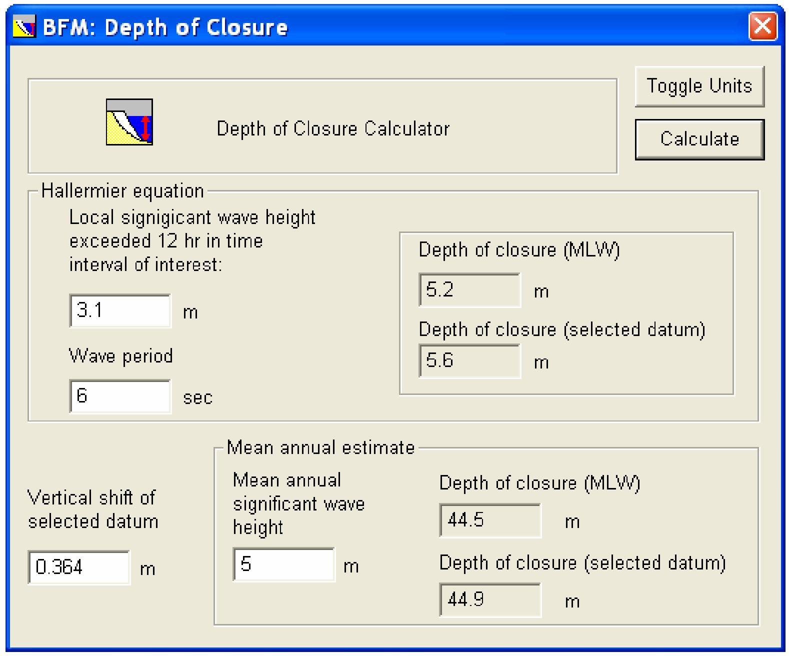


Figure 48. The depth of closure can be estimated from local significant wave height and/or mean annual significant wave height

Access the Depth of Closure Calculator, by selecting the **Depth of Closure** button on the toolbar . Under the Hallermier equation, enter "3.1" for Local Significant Wave Height, "6" for Wave Period, and "0.364" for the Vertical shift of selected datum (Figure 48). Select the **Calculate** button to execute the calculation. Results relative to mlw and the selected datum (NAVD 88) are shown on the upper right side of the calculator. For this example, the depth of closure was 5.2 m relative to mlw and 5.6 m relative to NAVD 88.

Erosion/accretion predictor. Predicts erosion or accretion based on the sediment fall speed parameter for either deep water or finite depth based on equations in Kraus et al. (1991). Results depend on deep water or finite depth wave height, sediment fall speed, and the prediction is based on wave steepness (criterion 1) and the fall speed parameter (criterion 2).

The input window for the erosion accretion criteria is shown in Figure 49. The user is required to input the significant wave height and corresponding wave period, water temperature and grain size. The calculation can be performed for deep water or finite depth. Units can be toggled from standard to metric.

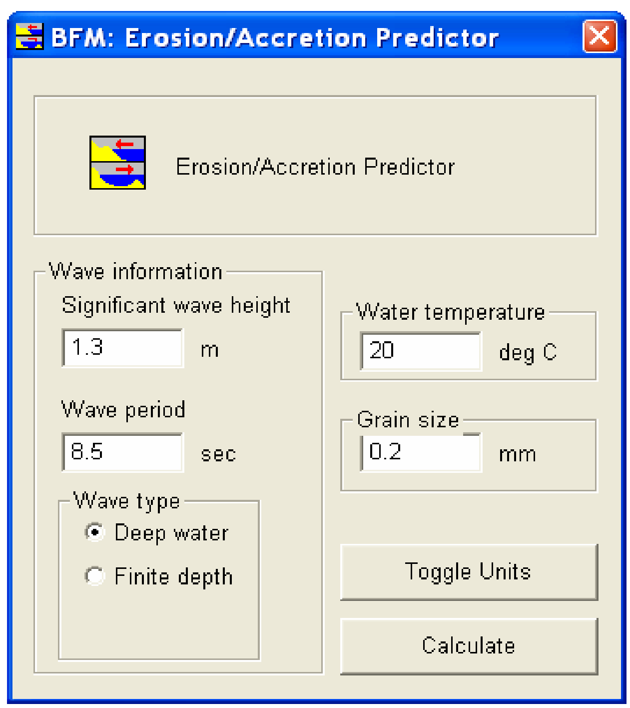


Figure 49. Erosion and accretion predictor input options

Determine the potential for erosion or accretion for fine (0.2 mm), medium (0.4 mm), and coarse (0.6 mm) sand grains given a significant wave height and period of 1.3 m and 8.5 sec. Assume a water temperature of 20° C.

Open the calculator by selecting the **Erosion/ Accretion Predictor** button on the toolbar . Toggle units to meters and enter "1.3" for the *Significant Wave Height*, "8.5" for the *Wave Period*, and "0.2" for the *Grain Size*. Leave the *Water Temperature* at the default value of 20° C and select *Deep Water* under *Wave Type* (Figure 49). Select the **Calculate** button to execute the calculation. For a 0.2-mm grain size, the results show that both criteria predict that erosion is highly probable (Figure 50). Repeat the calculation with the 0.4-mm and 0.6-mm grain sizes.

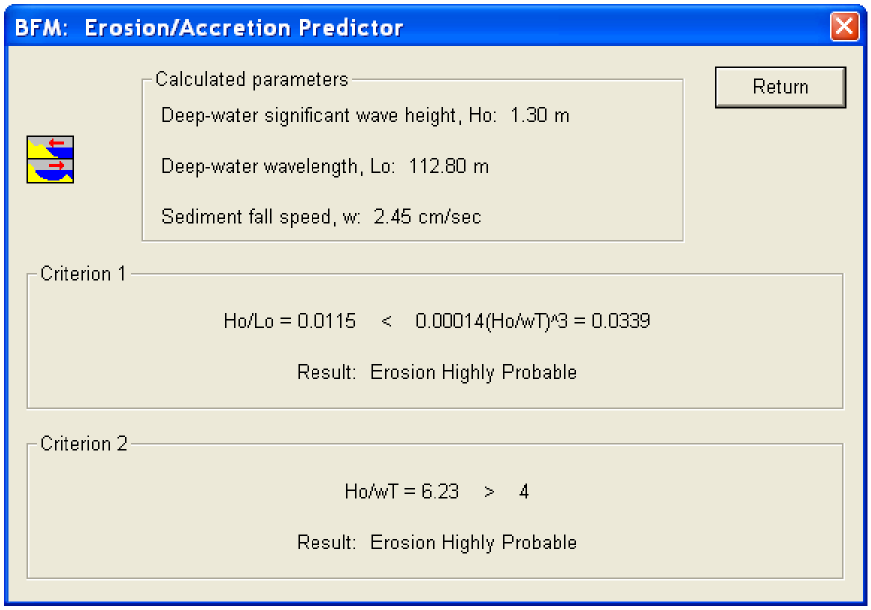


Figure 50. Erosion/accretion predictor results

Planform evolution model. The Planform Evolution model provides an estimate of the alongshore redistribution of beach nourishment material resulting from the interaction between the fill material and wave conditions at the fill site. The model incorporates the concept of background erosion in the prediction of shoreline change and has the capability to impose the effect of a user-specified rate of background erosion. The methodology is based on Dean and Grant (1989).

An example for the planform evolution model is provided with RMAP. To access the example, open the Planform Evolution model , browse to the RMAP installation directory (typically C:\Program Files\Veri-Tech\CEDAS40\RMAP\ ), locate the folder "BFM Data" and open the file "save1.pfe." This file will populate the input parameters for the model (Figure 51). To initiate the model and view results, select the **Run Model** button on the Planform Evolution Model toolbar . Model output includes a plot showing planform evolution over the simulated time frame (Figure 52), and numerical output of the fraction of added planform remaining along the baseline, background erosion rates along the baseline, and calculated shoreline locations by year.

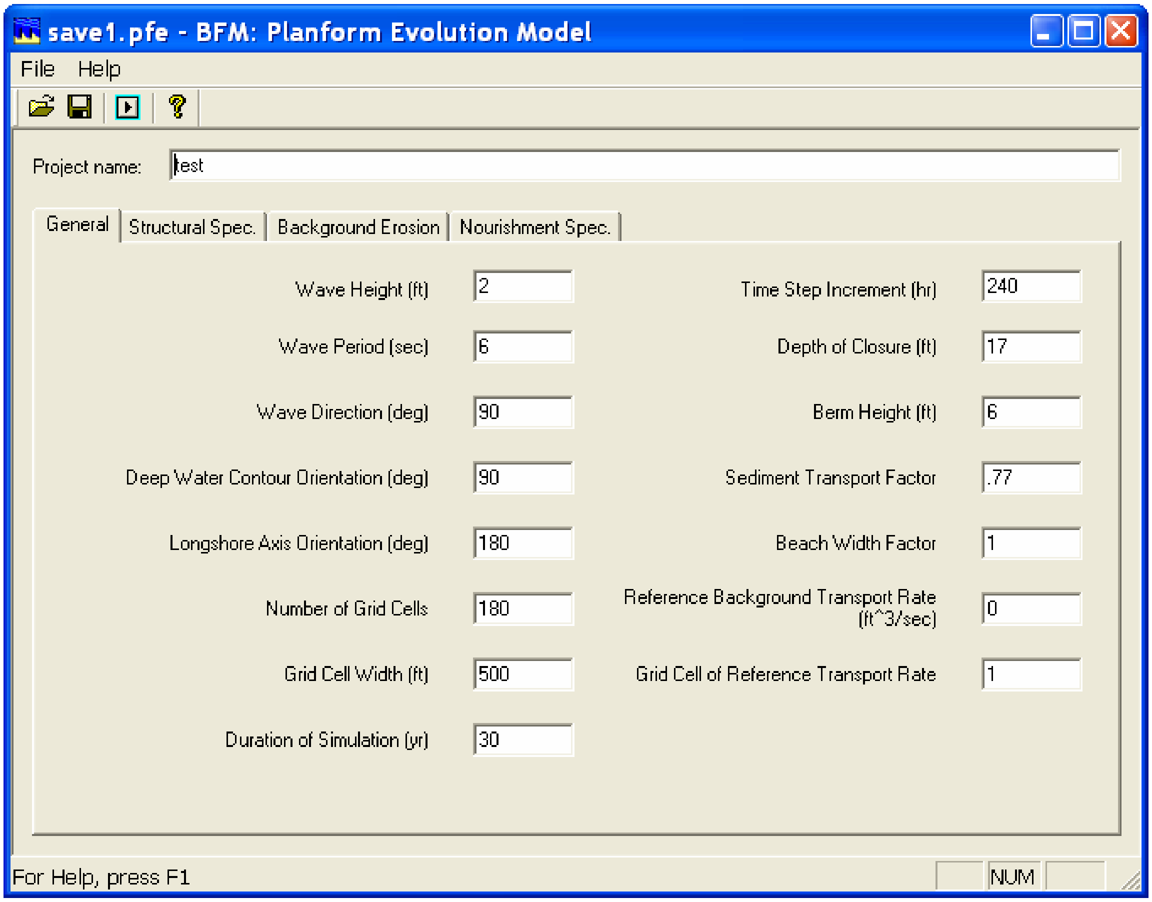


Figure 51. General input parameters for planform evolution model

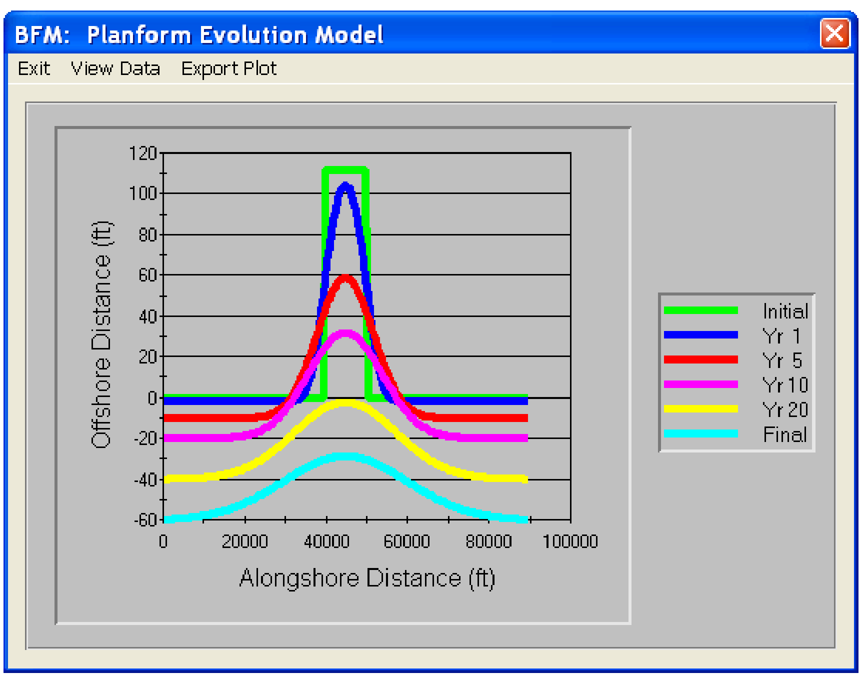


Figure 52. Time series plot of planform evolution generated by planform evolution model

PRODUCT DEVELOPMENT AND AVAILABILITY: SWWRP develops products to support engineers in the workforce. Improvements or additions to RMAP are dependent on user comments. Please forward comments and suggestions to RMAP point of contact listed below.

ADDITIONAL INFORMATION: This Technical Note was prepared by Dr. Brian K. Batten, research physical scientist and by Dr. Nicholas C. Kraus, senior scientist, Coastal and Hydraulics Laboratory, U.S. Army Engineer Research and Development Center. The study was conducted as an activity of the Coastal Morphology Modeling and Management work unit of the System-Wide Water Resources Program (SWWRP). For information on SWWRP, please consult https://swwrp.swwrp.army.mil/ or contact the Program Manager, Dr. Steven L. Ashby at Steven.L.Ashby@erdc.usace.army.mil. Questions about this Technical Note can be addressed to Dr. Batten at (601-634-3563; Brian.K.Batten@erdc.usace.army.mil). This Technical Note should be cited as follows:

> Batten, B. K., and Kraus, N. C. (2005). "Regional Morphology Analysis Package (RMAP), Part 2: Users guide and tutorial," *SWWRP Technical Notes Collection*, ERDC TN-SWWRP-05-1, U.S. Army Engineer Research and Development Center, Vicksburg, MS. https://swwrp.usace.army.mil/

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