Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh

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Chapter 8
DSM2 Grid Map Tool

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8 DSM2 Grid Map Tool

8.1 Introduction

DSM2 is a 1-dimensional hydrodynamic and water quality model that simulates flow, stage, and conservative and non-conservative constituents in the Sacramento–San Joaquin Delta. The physical geometry is represented in DSM2 by channel lengths, channel cross sections, reservoir areas, and reservoir bottom elevations. These inputs are derived from geographical data, which are now available in computer systems and referred to as Geographical Information Systems (GIS).

Since 1998, DSM2 geometry has been handled with the Cross-Section Development Program (DWR, Delta Modeling Section 1998). CSDP has worked well for many years, but it is not inherently geo-referenced and has reached the end of its useful life. The DSM2 Grid Map Tool offers all the capabilities of CSDP and several more, and may serve to replace CSDP for DSM2 bathymetry and channel development.

This tool links the information contained in GIS with the DSM2 input text files. It provides a way to view the DSM2 grid of channels, reservoirs, and gates overlaid on a map. This provides a much needed visual context for understanding how elements of the DSM2 grid map onto the physical features they represent. The map can be changed to a US topographical, elevation contour map and a Satellite view for different perspectives.

The grid map tool enables the user to search the grid for a particular element and to measure the lengths of arbitrary line segments and areas of polygons. Elevation and elevation profiles along a line are also readily accessible.

Furthermore, the grid map tool has an edit mode for editing the locations of the nodes, the flow lines of channels, and the outline of reservoir areas.

The grid map tool is built on the Google Maps API and is designed to be used within a modern Web browser. Data are hosted online for ease of accessibility for a wide audience of users and to support the large data sets required to provide the elevation functionality. The application is secured using Google accounts with ability to add other OpenID [http://openid.net/] providers in the future.

8.2 Geographical Information

The basic information used is the digitized base maps available via Google Maps services [http://code.google.com/apis/maps/documentation/javascript/v2/services.html]. Google Maps serves the DSM2 grid map at a particular zoom level using image tiles that are assembled in a Web browser to provide a seamless stitched map. These image tiles are customized in the grid map tool to provide US topographical image tiles and depth-based color-coded image tiles for depth context over a spatial area.

Length and area calculations are provided using Google Maps APIs, which use a modified Mercator projection. This is sufficiently accurate (within +/- 0.2%) in an area the size of the Delta (MTL n.d.).

Elevation information used to calculate the channel cross-sections and reservoir bottom elevations are provided from a Digital Elevation Model (DEM) raster with a 10mx10m cell size. The DEM information currently being used is derived from best bathymetry data and LIDAR data available as of November 2010 and may be revised in the future as more recent data are available.

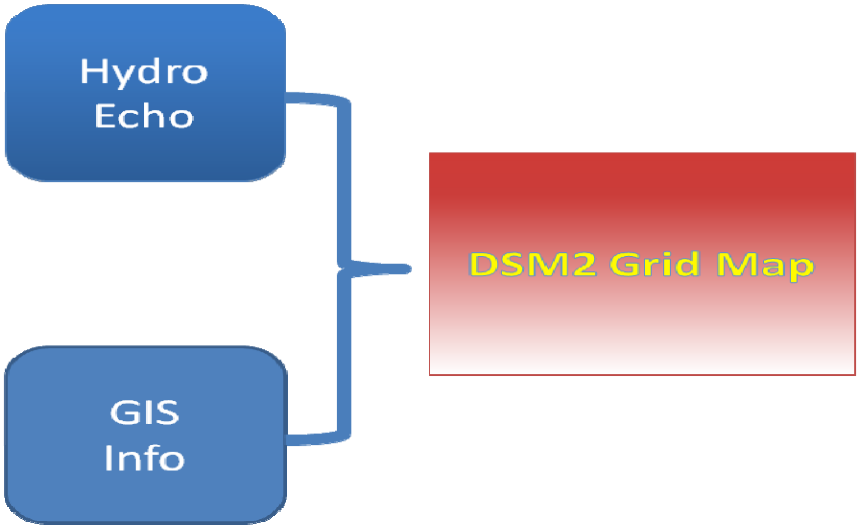

Figure 8-1 Data flow for DSM2 grid map

8.3 Design

DSM2 Hydro is a hydrodynamic model. The input to this program is provided as text files, and the time series as a US Army Corps of Engineers' Hydrologic Engineering Center Data Storage System (HEC-DSS) file. This information is copied to a file at runtime, which is referred to as the echo file. It contains all the text information from the various input files reproduced in one large file.

The structure of the text information for DSM2 Hydro consists of tables of information. Each table consists of a name, followed by a line of column names, followed by rows of data, and ending with the END keyword. This echo file serves as one of the inputs to the DSM2 Grid Map Tool.

The other file is a text file with table input similar to GIS data. A description is provided in the storage format section. The GIS data input file is required only for the DSM2 Grid Map Tool and is not directly used by the DSM2 Hydro program (Figure 8-1).

If GIS data are missing for any element, there is a fallback strategy to placing the element, the location of which can then be edited using this tool.

The grid map tool works on the information from these 2 files—hydro echo and GIS information—and can change the GIS data based on user activities. The user can always extract the latest echo and GIS data inputs from the tool. The echo file will reflect any changes made using the tool. Furthermore, the echo file can be used with minor configuration changes to run the DSM2 Hydro program with this updated information.

8.4 Implementation Details

The grid map tool is written to be an online Web application. The application is designed to be used with a modern browser such as Google Chrome 9+, Firefox 3+, Safari 4+, or IE 9+. Older browsers such as IE 8 and below are prompted to install a Google Chrome plug-in, which enables the functionality for older browsers [http://en.wikipedia.org/wiki/Web_browser#Standards_support].

For hosting and user management, Google's infrastructure is leveraged using the Google App Engine. This enables a cost effective and proven security platform and relieves DWR from having to maintain commodity infrastructure. Google Maps now require users to obtain a Google account. If needed, the authentication for the user can be moved to any OpenID [http://openid.net/] compliant account in the future.

An online application was chosen because no proprietary software other than a browser needs to be downloaded, which allows for quicker updates. Also, the large amount of elevation data needed for this application doesn't have to be packaged, distributed, and downloaded, removing yet another updating task.

Finally, the application stores its data in a text format (rather than a proprietary binary format), which allows us to move to another tool, if needed.

The application is written in Java. Parts of the Java program are translated to JavaScript using the Google Web Toolkit [http://code.google.com/webtoolkit/] because the application is designed to be an online application for use in a modern browser [http://en.wikipedia.org/wiki/Web_browser#Standards_support].

The source code is released under GPL v3 and is available from http://code.google.com/p/dsm2-grid-map/.

8.5 Storage Format

The GIS data are stored in text files using the table format similar to the DSM2 input format. A description of each element and its data and storage is detailed in Table 8-1.

The GIS data are stored in a separate file because the data are not needed as input for DSM2. However, the information in the data-linked Hydro echo file is calculated again as the GIS data changes.

Table 8-1 GIS data format

Element type	GIS data	Storage
Node or Junction	Latitude and longitude in decimal degrees	Table with each row containing node ID and a pair of latitude and longitude values
Channel length	A line represented as many pairs of latitude and longitude excluding the beginning and ending points (derived from node data)	Table with each row containing channel ID and all the pairs of latitude and longitude values separated by commas
Reservoir areas	A closed loop represented by many pairs of latitude and longitude	Table with each row containing the reservoir ID and all the pairs of latitude and longitude values separated by commas
Channel Cross sectional profile	The line on the surface represented by origin and end points. The profile is then stored as points with distance from origin along the line and the elevation at that point.	Table with each row representing the channel ID and cross section's distance from upstream node to identify cross section. The origin and end points are stored as latitude and longitude values. The profile is stored as a pair of values representing the distance along the line and the elevation at that point

Note: All latitude and longitude are stored to the 8th decimal place in decimal degrees.

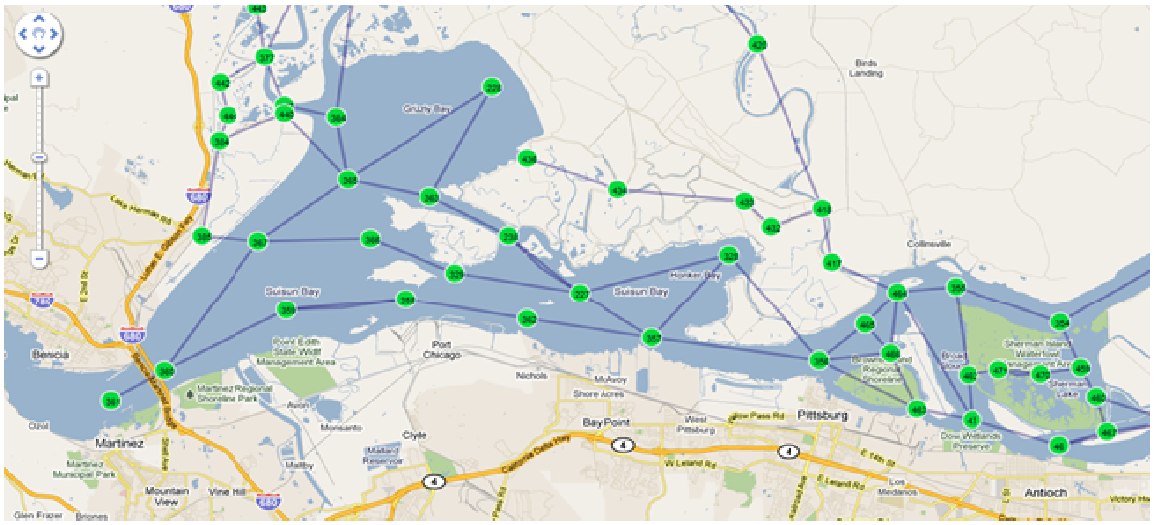

Figure 8-2 Sample grid

8.6 User Interface Overview

This section describes the application and includes screen snapshots to highlight the various features. The application can be accessed at http://dsm2grid.appspot.com

Figure 8-2 is a view of a version of DSM2 Grid zoomed into the western Delta region. The blue lines are the channel connections, the green labeled circles are the nodes.

8.6.1 Login

Once setup with a login account with Google, simply follow this link [http://dsm2grid.appspot.com/] in your browser (Google Chrome is recommended). Click on the "Sign in" Button, and enter your username and password (Figure 8-3).

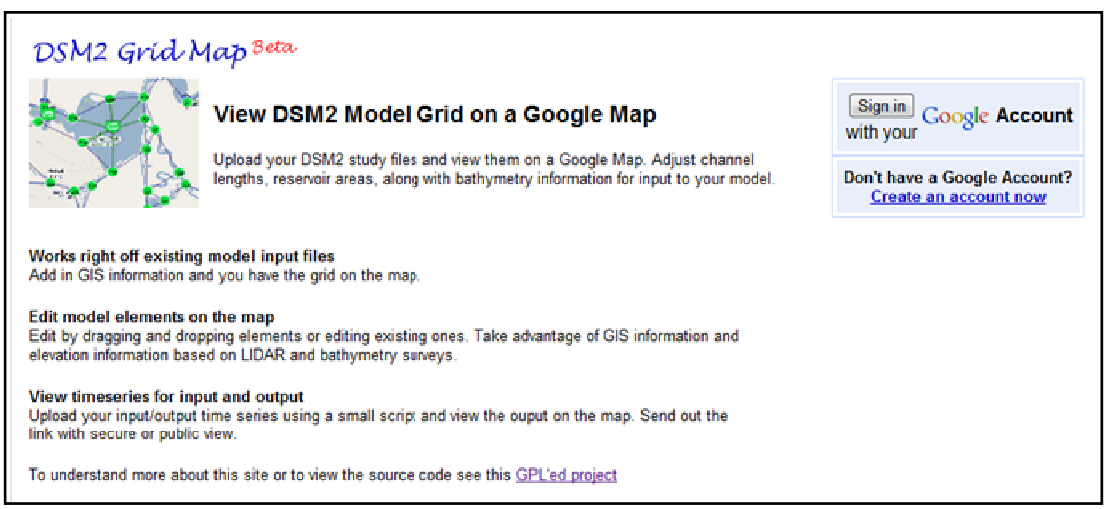

Figure 8-3 Example log in page

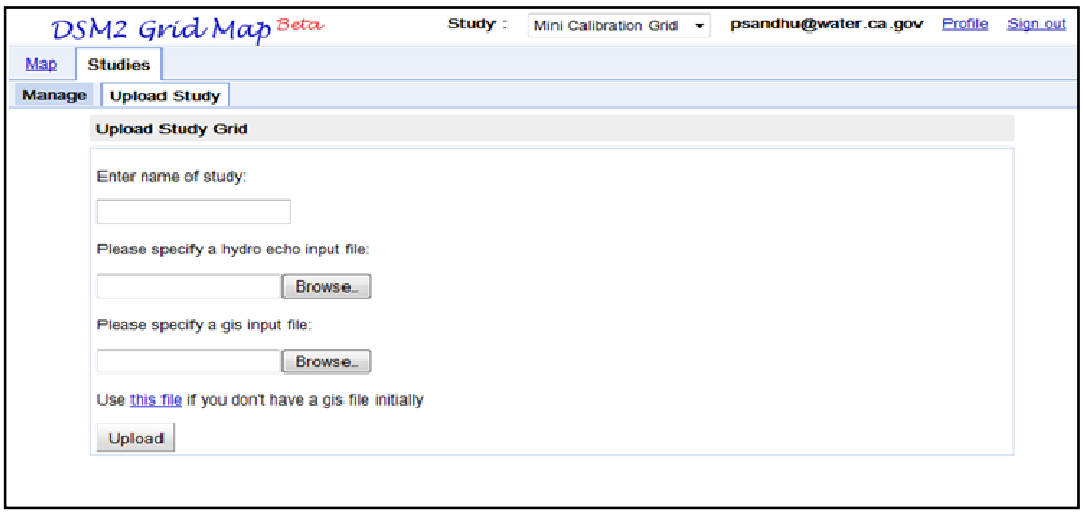

Figure 8-4 Example study upload

8.6.2 Upload

To get started with the application, 2 files must be uploaded. A Hydro echo file is needed. This may be generated from a DSM2 setup by running Hydro with the "-e" option, which generates this file in the output folder without running the hydrodynamics.

The second file that is needed is a GIS input file. If a file is not available, the nodes will be placed in a predefined location (south of Sacramento). However, to get started with the Sacramento-San Joaquin Delta, GIS file input file is provided here: http://dsm2-grid-map.googlecode.com/files/gis.inp . This is a preliminary version and should be taken as a draft product.

Once logged in, click on the Studies link and then on the Upload Study tab (Figure 8-4). Enter a name for the study, browse to the Hydro echo file generated from Hydro for the second input, and browse to the GIS input file. Once these fields are specified, click on the upload button.

8.6.3 Viewing the Grid

The grid is displayed as lines for channels: circular green makers for nodes, green square markers for reservoirs, and blue markers for gates (Figure 8-5 and Figure 8-6 on next page).

To navigate to different areas of the map, use either the panning and zooming controls toward the top left; or the mouse drag for panning and mouse wheel for zoom; or the arrow keys for panning and +/- for zoom in/out.

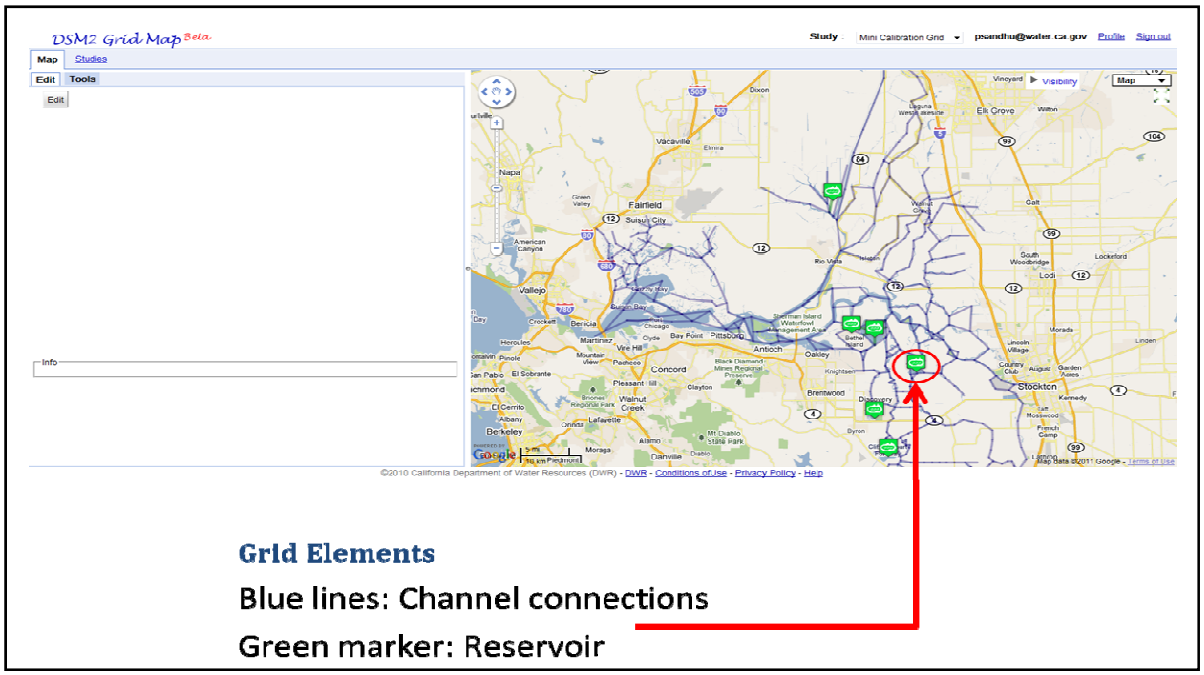

Figure 8-5 Example grid elements: reservoirs

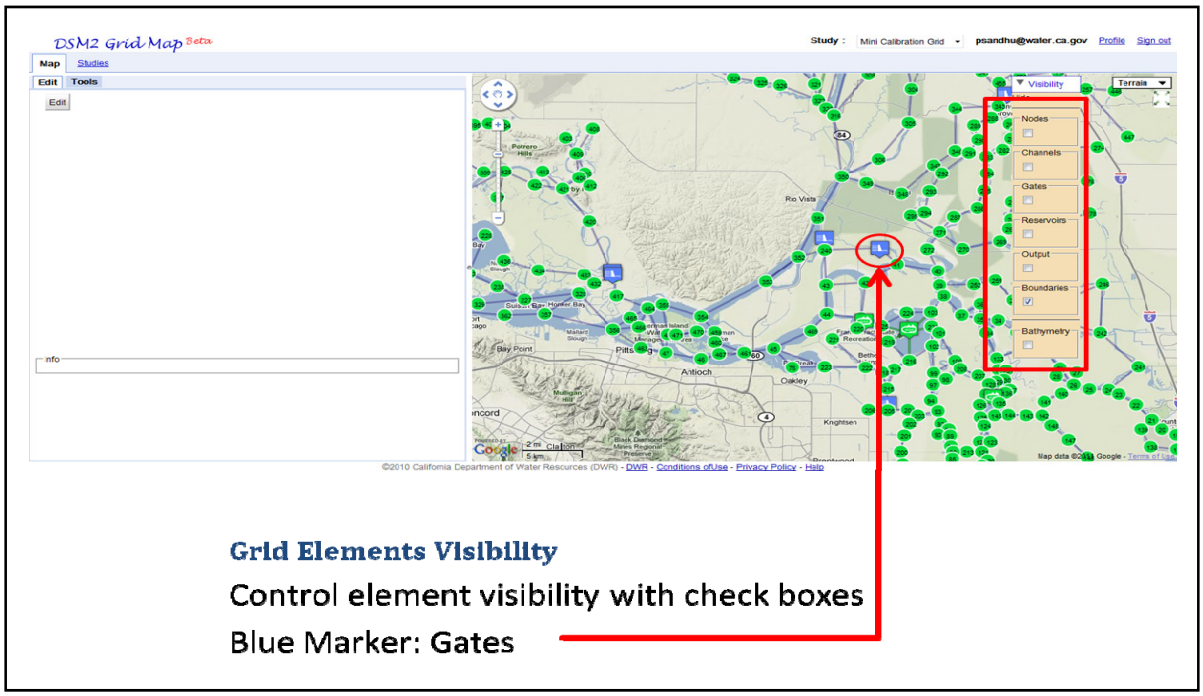

Figure 8-6 Example grid elements: gates

Base maps that form the background can be switched using the control highlighted in Figure 8-7. In addition to the base map from Google, the satellite view, terrain view, and US topographical area are available. Other custom base maps may be added if available and needed in the future.

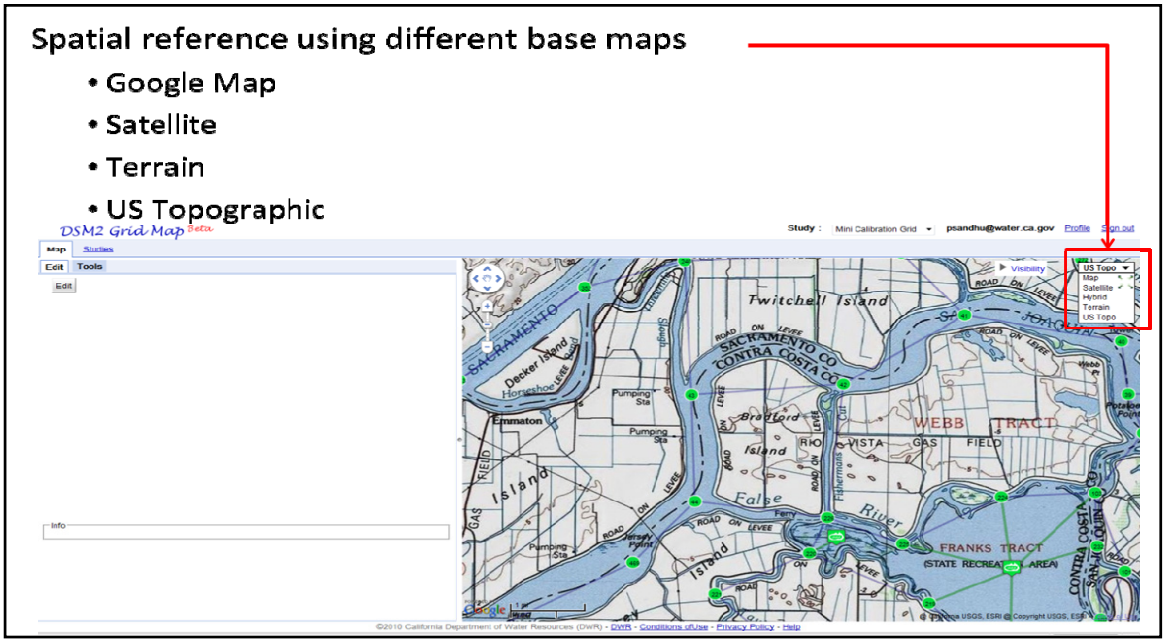

Figure 8-7 Example base maps

8.6.4 Viewing Channel Information

Channels are displayed as straight blue connection lines between nodes. By clicking on a channel connection line, the flow line and cross sections are displayed. The flow line is displayed as a red line, and its length is used to calculate the length of the channel. The cross sections are calculated from DSM2 input where they are represented as elevation vs. area, wetted perimeter, and top width relationships. The direction of the channel is represented in square brackets next to its ID as upstream node → downstream node (Figure 8-8).

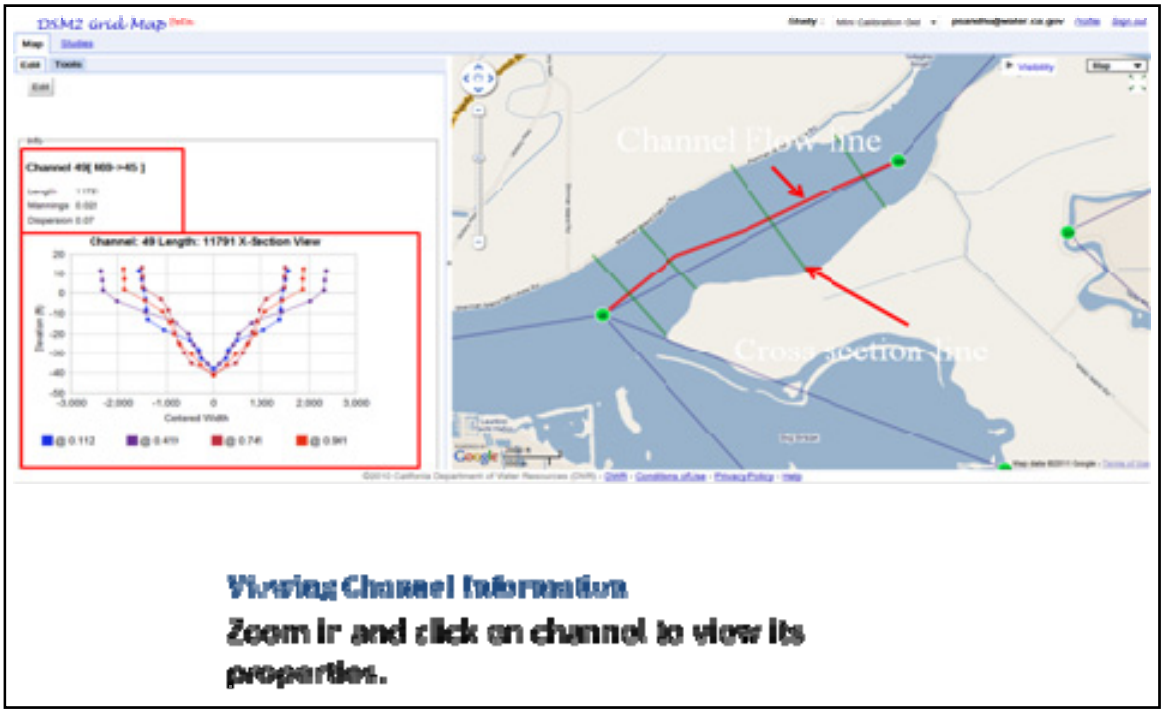

Figure 8-8 Example channel display

8.6.5 GIS Tools

Tools to measure lengths and areas are available under the Tools tab (Figure 8-9). The elevation and elevation profile along a line can also be obtained using the tools highlighted.

The flow lines for all channels can be displayed by clicking the flow line button.

A channel or node can be quickly located by typing its ID into the box and clicking "Find …" button. The map will center at the found element.

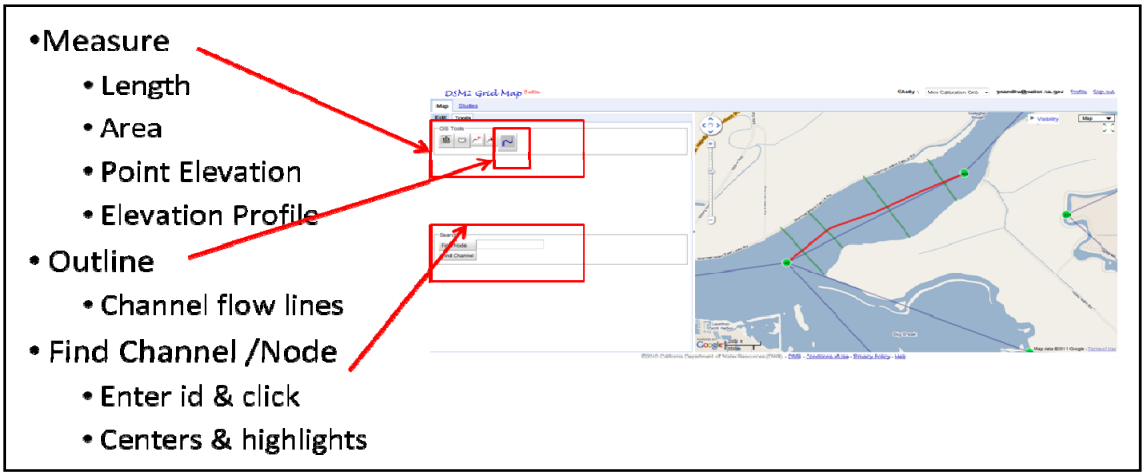

Figure 8-9 GIS tools

8.6.6 Managing Studies

A study is the combination of the Hydro input file and the GIS input file. Studies are given names during the upload process. A management screen allows a user to delete or share the selected studies (Figure 8-10).

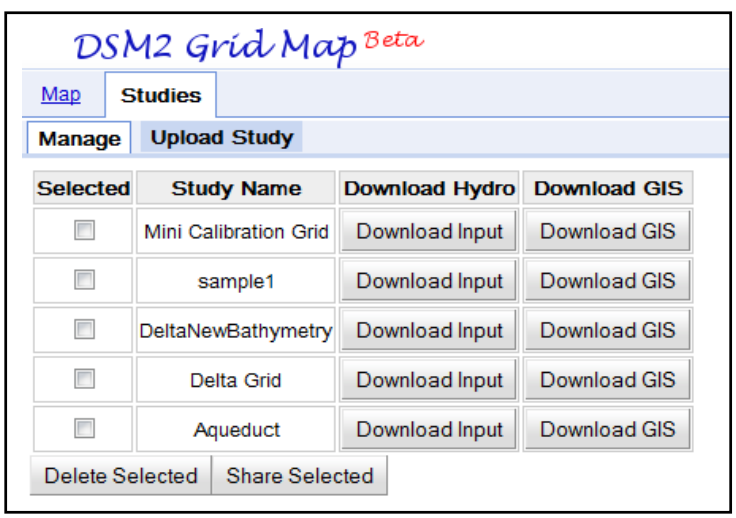

Figure 8-10 Example study inputs

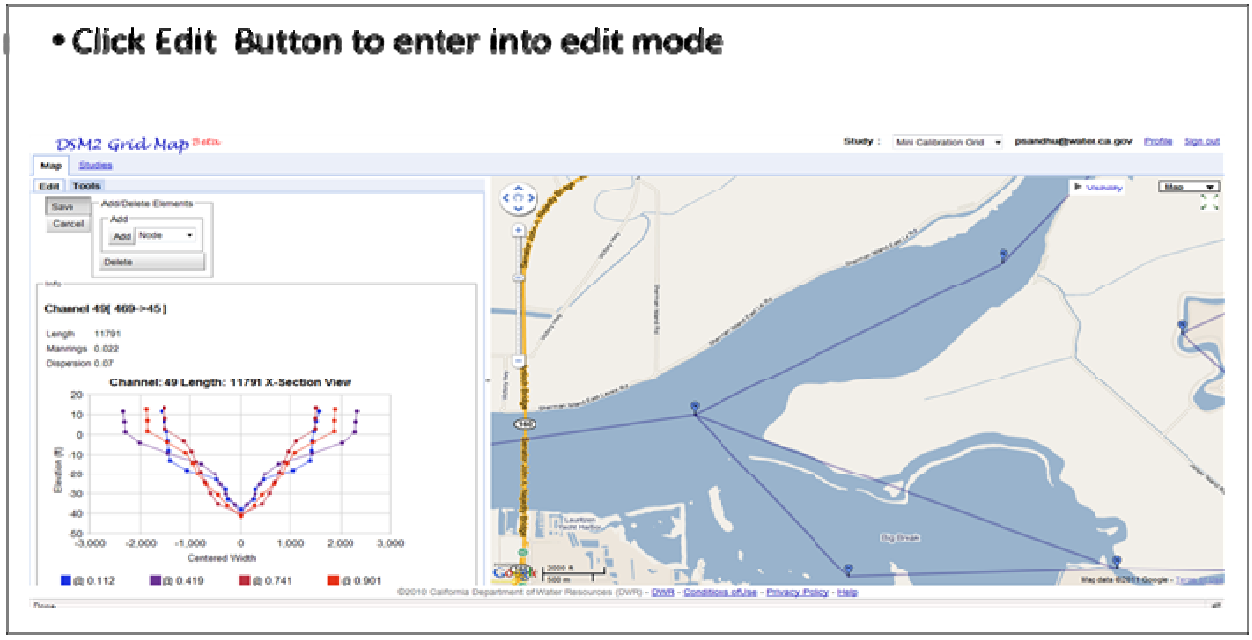

Figure 8-11 Node editing

8.6.7 Editing Mode

Clicking the edit button changes the node representation to blue balloons with an “N” symbol.

8.6.8 Editing Nodes

Hovering over a node highlights the node ID. In this mode the nodes can be dragged and placed at desired location (Figure 8-11).

8.6.9 Editing Channels

Click on channels to display the flow lines as red lines with square dots that can be dragged and placed to change the shape of the flow line (Figure 8-12). Click on the channel connection line (blue line) to display green lines perpendicular to the red flow line. These are the top view representation of channel cross sections. Click on a particular green channel cross section line to display the cross sections profile, the elevation profile from the DEM, and the bathymetry points projected onto the cross section surface from up to 400 feet upstream and downstream of that point (Figure 8-13 and Figure 8-14). Cross sections can be edited by dragging and placing existing profile points or adding new ones (Figure 8-15). These cross sections can be made to conform to the elevation profile by clicking the “Snap to elevation profile” button (Figure 8-16). The channel cross sections can be cleared en-mass and generated at reasonable distances using the “Clear XSections” and “Generate XSections” buttons (Figure 8-17).

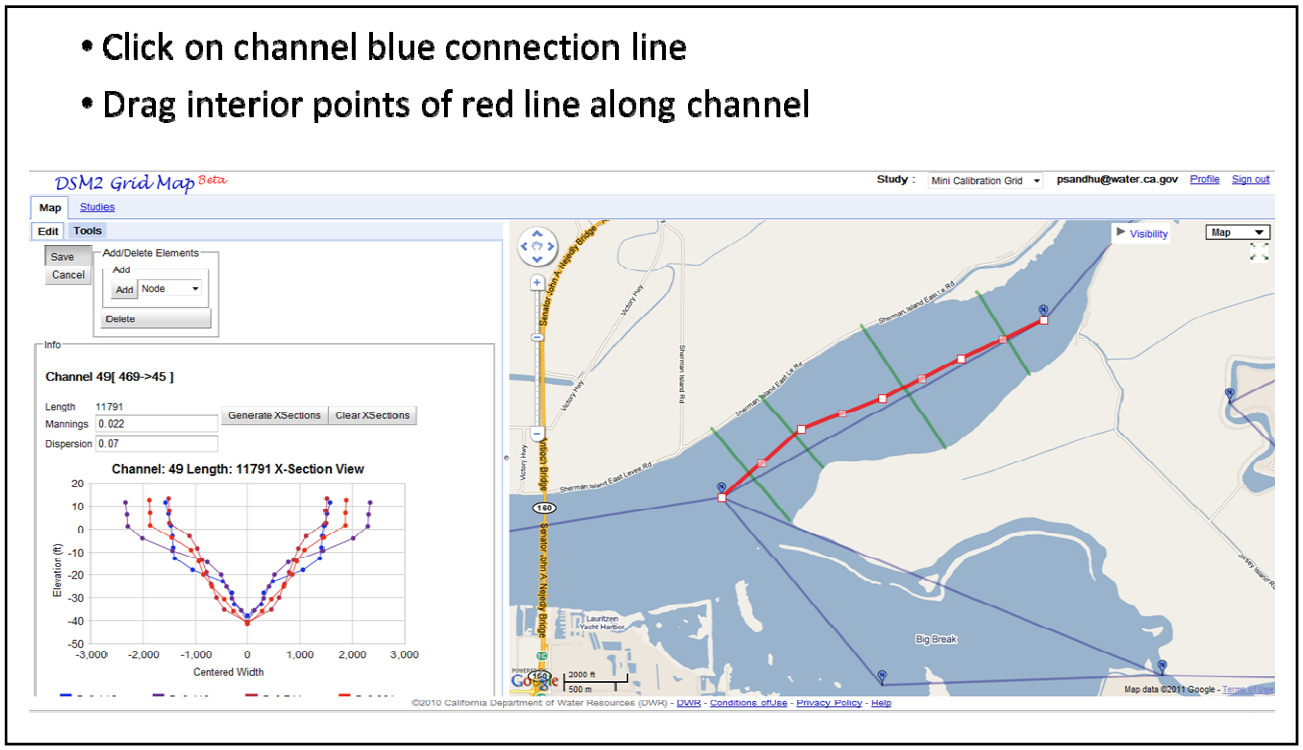

Figure 8-12 Flow line editing

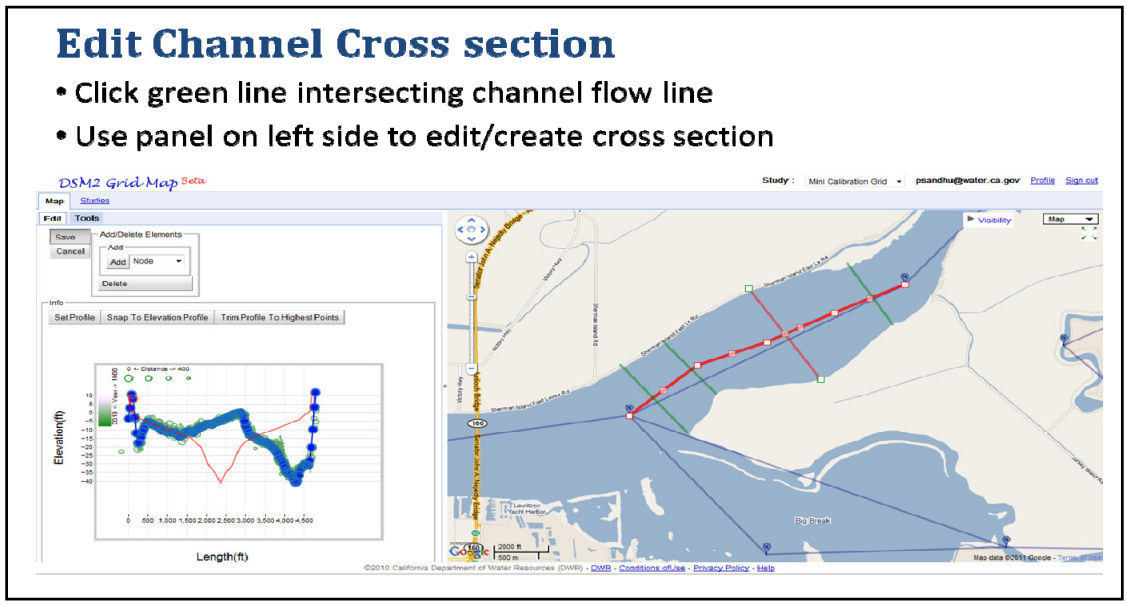

Figure 8-13 Edit Channel Cross section

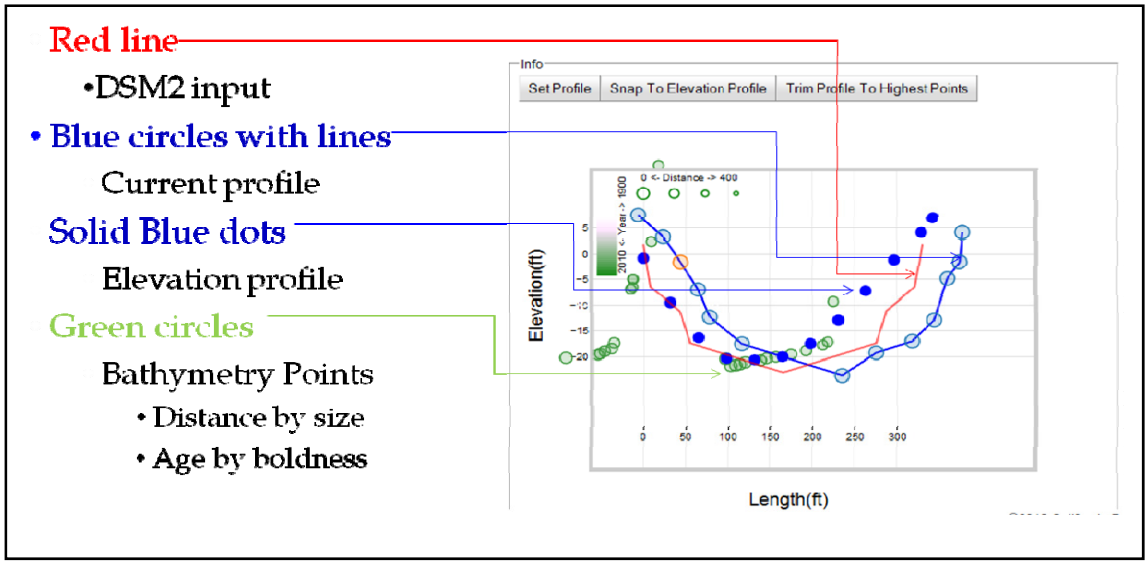

Figure 8-14 Edit Channel Cross section (detail)

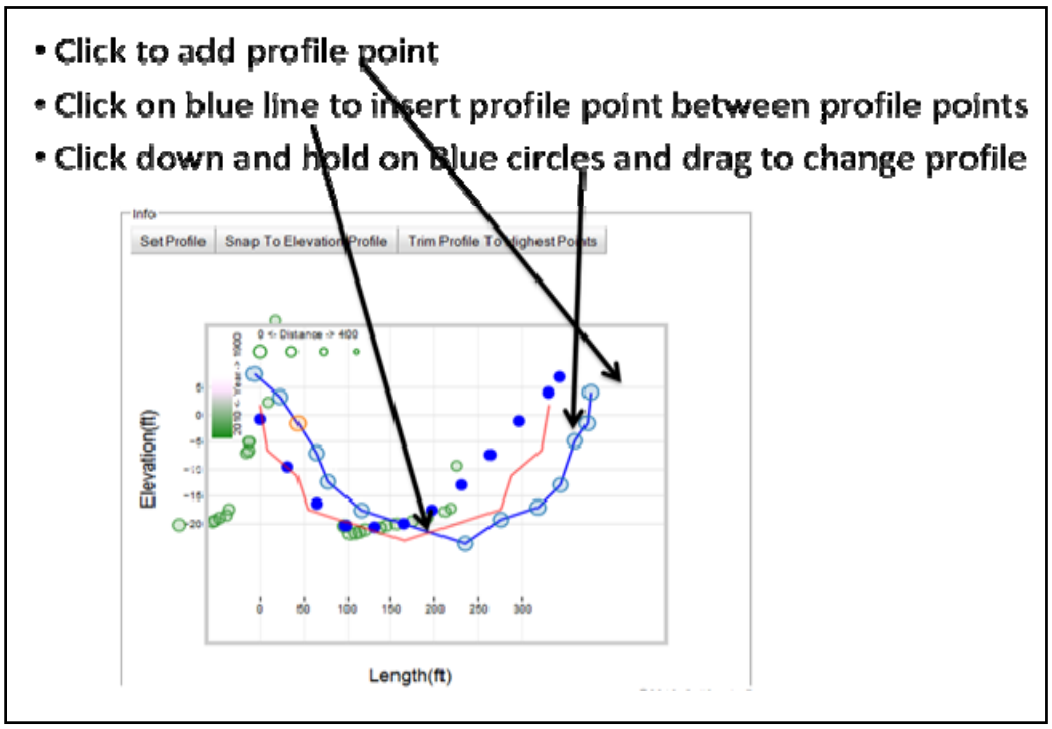

Figure 8-15 Edit Channel Cross section (profile points)

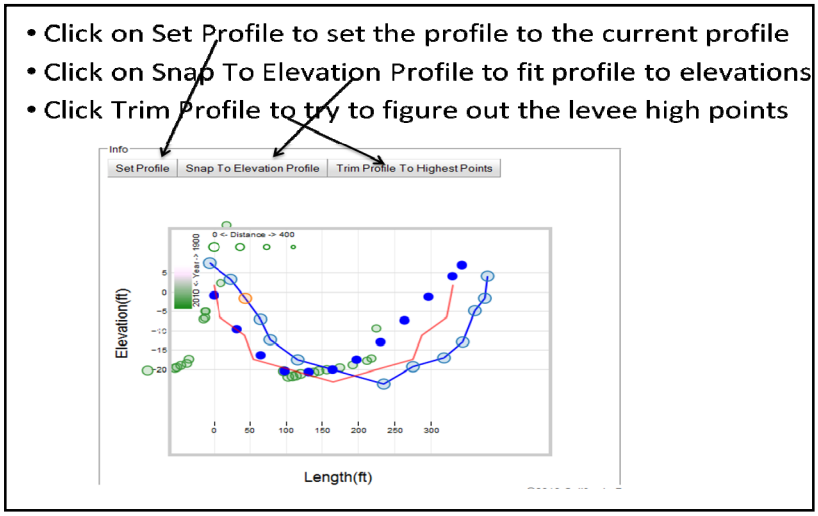

Figure 8-16 Edit Channel Cross section (elevation profile)

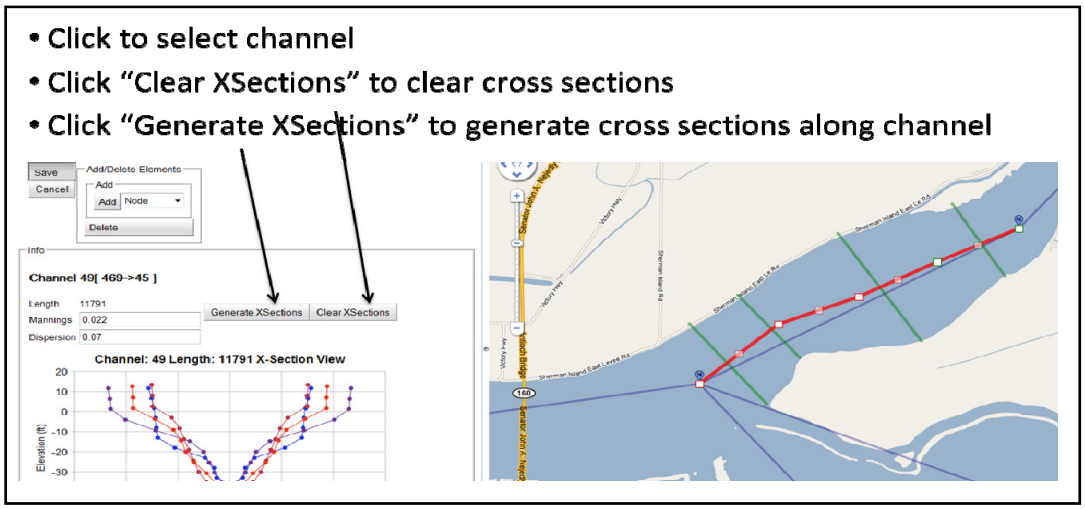

Figure 8-17 Edit Channel Cross section (generate or clear)

8.6.10 Editing Reservoirs

Reservoirs are represented as green markers. Click these in the edit mode to highlight the area as a blue-filled region. The outline of this region has square dots that can be dragged and placed to define the area (Figure 8-18). The "Recalculate Bottom Elevation" button uses the DEM data to calculate the average bottom elevation for the area defined and update the bottom elevation of that reservoir.

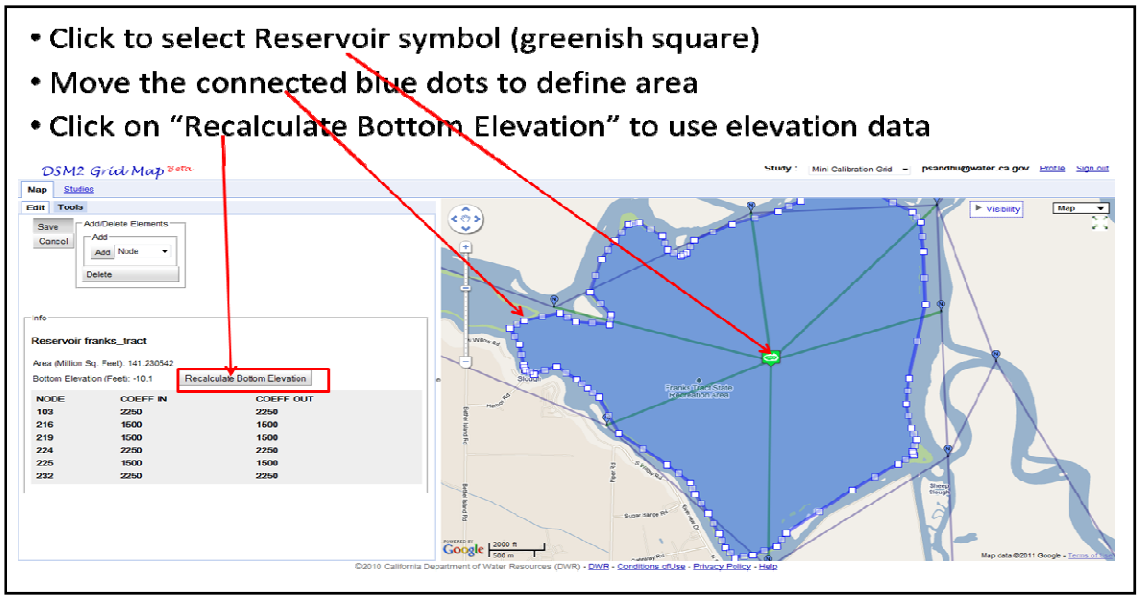

Figure 8-18 Editing reservoirs

8.6.11 Editing Gates

Gates are blue markers. Their locations can be edited by moving them to the desired location of the gate. GIS data for the gate location are not a direct input to the hydrodynamics. The gates can be defined at node locations only; the user should match as closely as possible the node at which the gate is defined.

8.7 Conclusion

GIS has evolved to a level where a direct integration is possible between derived model inputs and the original GIS data. This is a needed step in understanding how physical features are represented in the model.

This approach also highlights how far the Web browser has come and can now be used as a GIS application leveraging Google Maps. It also highlights the advantages of such an approach, e.g., support for multiple platforms, no software downloads, and doing away with bulk data downloads needed to support GIS activities. This allows easier access to information by the public and non-GIS personnel.

However, this tool is not a replacement for general purpose GIS applications such as ArcGIS. In fact, it is complementary to those applications and needs the capabilities provided in such tools.

We are currently evaluating how to integrate the features provided here with ArcGIS.

8.8 References

DWR, Delta Modeling Section. "19th Annual Progress Report to the State Water Resources Control Board, Chapter 6." *California Dept. of Water Resources.* June 1998. http://modeling.water.ca.gov/delta/reports/annrpt/1998/1998Ch6.pdf (accessed April 2011).

DWR, Delta Modeling Section. "32nd Annual Progress Report to the State Resources Control Board." Delta Modeling Section, 2011.

MTL. *Calculate distance, bearing and more between Latitude/Longitude points.* http://www.movable-type.co.uk/scripts/latlong.html#ellipsoid.