1. Working with Bathymetry

The CMS setup for Shark River Inlet provides a succinct example for illustrating a number of methods and SMS tools that can be applied to most engineering projects. The area is heavily structured, with a jettied inlet (and a jetty spur), developed bay shoreline (seawalls and riprap), and densely spaced groins, some of which on the south (up-drift) side have been notched. The overall goal of this guided example is to allow the user to work with real datasets, many of which were provided by the U.S. Army Corps of Engineers, New York District (NAN).

The original datasets for creating the Shark River Inlet grid are provided in sub-folders described throughout this document. Bathymetry can come from various sources and often is given in various horizontal and vertical projections. Before bathymetry datasets can be used to build a CMS grid, they must all reside in the same horizontal plane and have the same datum reference and units. This section explains how to convert all loaded data over to the same reference.

The following files, located in the "**Bathymetry**" folder will be used for this tutorial on working with bathymetry:

- Channel_Survey_NJ-DEP_0609_ft_MLW.xyz
- Coastal_Relief_Model_ll_m_msl.xyz
- 3364_0409_ft_MLW.xyz
- LIDAR_ft_NAVD.xyz
- Field_Team_Measurements_0809_m_NAVD.xyz
- 0.75m_Contour.xyz

There is not enough time to go through this entire hands-on document for this short course. The instructor will go through these steps for only some of the survey. The final merged bathymetry file can be loaded from the "**Bathymetry/merged/**" folder.

1.1. Horizontal Projections

In the SMS 10.1 and later, the term "projection" refers to a map projection such as "State Plane" or "Geographic". Within the software, a global projection can be associated with a project. Individual datasets may also have their own projections. Previous versions of the SMS software referred to projections as "coordinate systems" and reprojection as "coordinate conversion".

The present projection for the project can be specified from the *Edit | Projection* pull-down menu command. Changing the projection does not alter the XYZ coordinates of the project data. The CMS models operate in a Cartesian coordinate system such as State Plane or UTM and units must always be specified in meters.

1.1.1. Set initial project projection.

- Choose *Edit | Projection* from the pull down menu. The resulting dialog is shown in Figure B 5.1-1.

- Click "Set Projection" and choose Projection - State Plane Coordinate System, Zone - New Jersey, Planar Units – Meters, Datum NAD83.
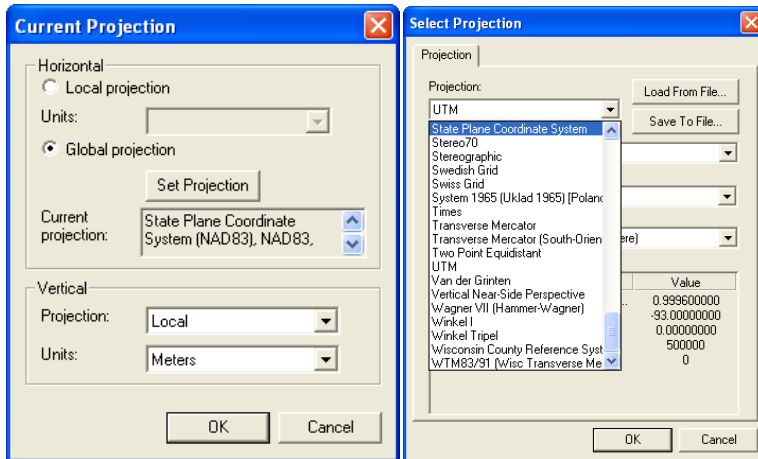- Click Ok twice to exit back to the interface.

Figure B 5.1-1. Current Projection dialogs

1.1.2. Open XYZ files.

- Open the "Bathymetry" folder and observe the various data files.
- Select the six files with your mouse and drag them into the SMS graphical window. SMS will attempt to open each file in the format as defined by their extension (such as .xyz or .pts for columnar data).
    - o During the import process, there are several screens that appear for each dataset (Figure B 5.1-2). Simply hit *Next* or *Finish* through each.
    - o Also, there is a default tolerance that is assigned. When loading certain very dense datasets or datasets that are relative to degrees (Latitude and Longitude), there may be a message that appears stating that a certain number of points have been removed due to the tolerance factor (Figure B 5.1-3).
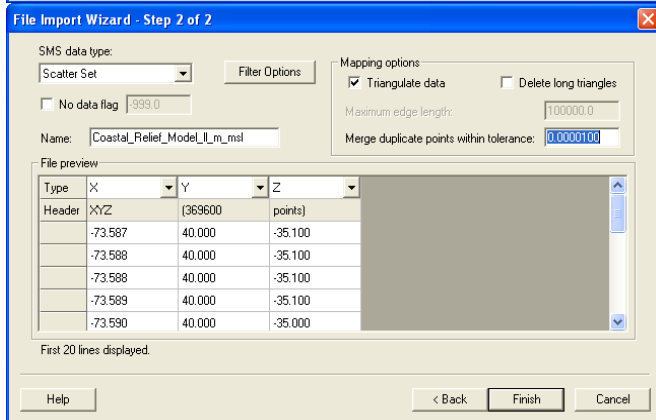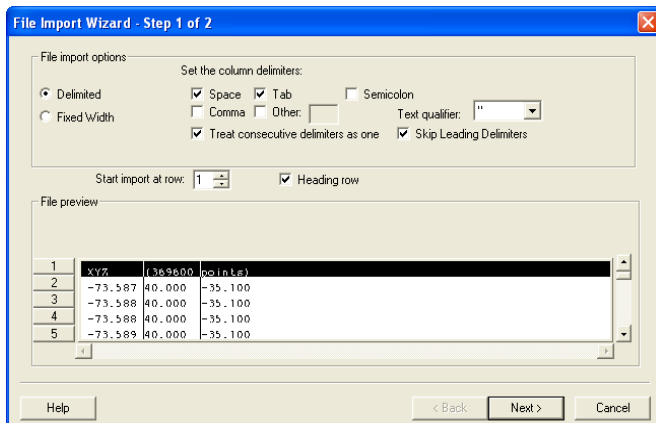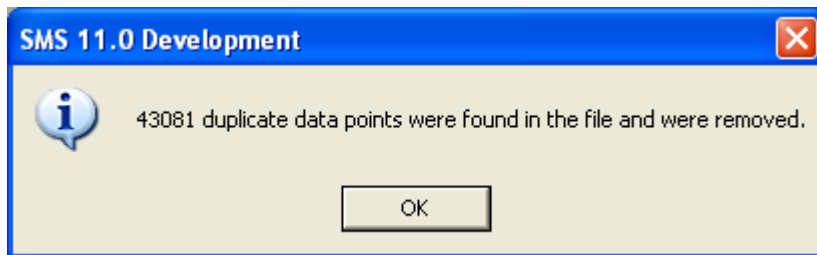
Figure B 5.1-2. File Import Wizard

Figure B 5.1-3. Duplicate data points

- For convenience, the file names have been altered to give a description of a) the data contained, and b) the projection and units associated with the data. For example, the file "Channel Survey NJ-DEP 0609_ft_MLW.xyz" contains channel survey data obtained in June 2009 and the values are in feet relative to mean lower water (MLW).
- Because the 6 datasets loaded are not all in the same frame of reference (projection), the graphical interface screen will zoom to an area that contains all three, shown in Figure B 5.1-4.
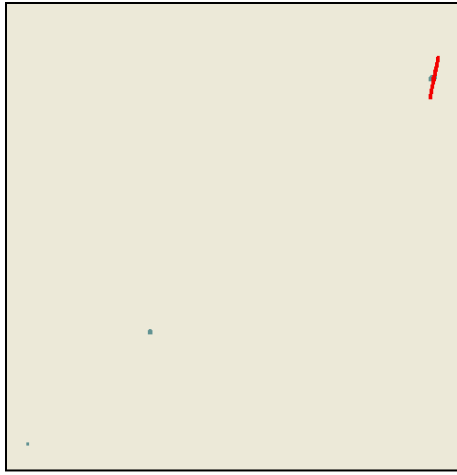
Figure B 5.1-4. After loading 6 datasets.

1.2. Saving your progress

Working with bathymetry files can be a lengthy process. This tutorial loads only six surveys, but some projects may have many more. To be on the safe side and to keep from having to duplicate effort because of a SMS bug, computer glitch, or user mistake, it is a wise idea to save your project frequently during this stage.

1.2.1. Saving the Project in SMS

There are few different ways to save your progress. One of the most useful in the early stages of grid development in the SMS is to save the entire project. This saves everything that is listed in the data tree under a project name. Images are handled differently due to their possible size and only a link to the files is stored.

- Under the *File* pull-down menu, choose the "Save New Project" option (shown in Figure B 5.2-1).
- Choose the directory where you wish to save the project and enter "Workshop" as the filename.
    - o Just choose the present directory as the location.
    - o The filename that you choose should be descriptive in a manner that you are able to understand.
    - o Note that all datasets loaded in the data tree will have the filename chosen as a prefix.
    - o This means that the entire filename for each dataset can be long.
    - o For this example, I have used the name Workshop as the project filename. Figure B 5.2-2 shows the list of files after the project has been saved so far. Notice that the original files still exist.

The next time you start SMS, you can simply load the file "Workshop.sms" to load all associated files with this project. Also, after a project has been saved or loaded, the *File* menu changes to "Save Project" and simply resaves all the data under the previously saved filename.

Periodically through the following sections, it is good to save the project, so as to save your progress. I will mark this step with the word SAVE.
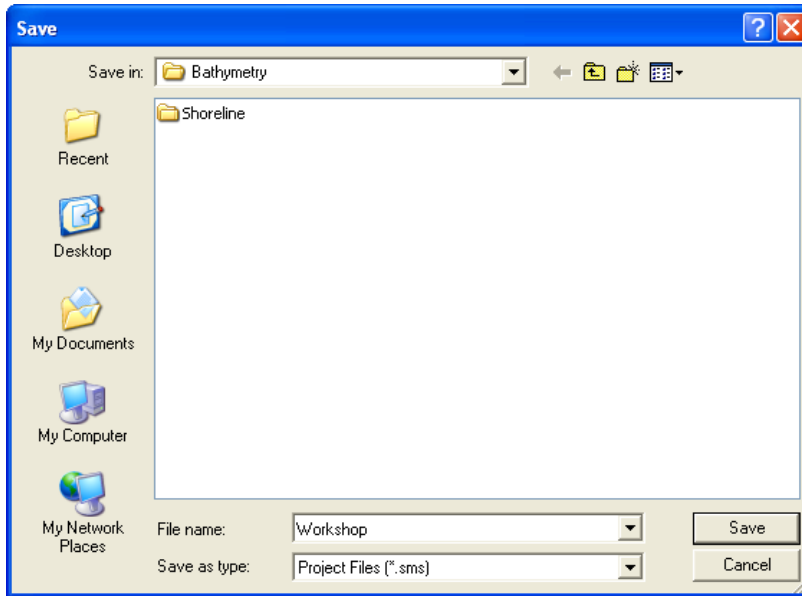

Figure B 5.2-1. File | Save New Project dialog

Figure B 5.2-2. List of files after project saved.

1.2.2. Reproject datasets.

- Since we have previously set the Project projection, we can now reproject each dataset individually.
- Right-click on each dataset within the data tree, and select *Reproject*.
- A dialog box will come up for the reprojection (Figure B 5.2-3).
    - The left side is reserved for the projection in which each individual dataset (survey) resides. Each dataset will be converted FROM this projection.
    - The right side is for the projection that you want to work in. Each dataset will be converted TO this projection.

- o At the bottom of both sides is an area for vertical reprojection. We will handle Vertical Datum conversions next. For now, make sure that the values are the same on both the Object and Project side of the dialog (i.e. both Local, Meters)
- Set the left side to the projection that the datasets are in. Table 5.2.1 is shown below with projection information for all six datasets.
- Repeat this process for each of the six datasets.
- When finished, all datasets will be in a common horizontal projection and the graphics screen should look similar to Figure B 5.2-4.
- SAVE
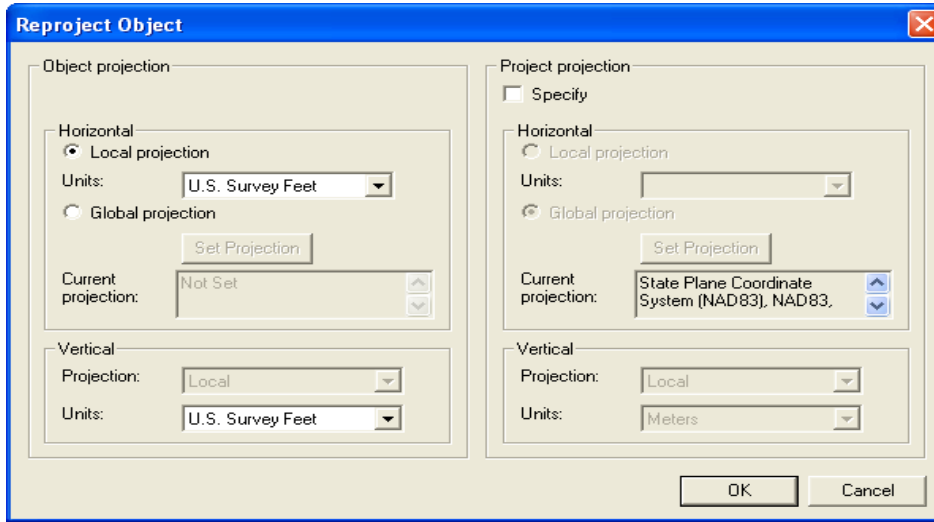
Figure B 5.2-3. Reprojection Dialog

Table B 5.2.1. Survey list with Horizontal Projection Information

Filename	Horizontal Projection information
Channel_Survey_NJ-DEP_0609_ft_MLW.xyz	State Plane, New Jersey, U.S. Feet, NAD83
Coastal_Relief_Model_ll_m_msl	Geographic (Lat/Long), Arc Degrees, NAD83
3364_0409_ft_MLW.xyz	State Plane, New Jersey, U.S. Feet, NAD83
LIDAR_ft_NAVD	State Plane, New Jersey, U.S. Feet, NAD83
Field_Team_Measurements_0809_m_NAVD.xyz	State Plane, New Jersey, Meters, NAD83 (Reprojection not needed)
0.75m_Contour	State Plane, New Jersey, Meters, NAD83 (Reprojection not needed)

Figure B 5.2-4. Graphics screen after reprojection of 6 surveys

1.3. Vertical Datums

In preparing the vertical reference for the survey datasets, one must consider the various datum references and the sign and units of the data values. The Coastal Modeling System suite of models (CMS-Flow and CMS-Wave) require that all bathymetry be oriented so that the values are positive as the water gets deeper and also that the data are in metric units.
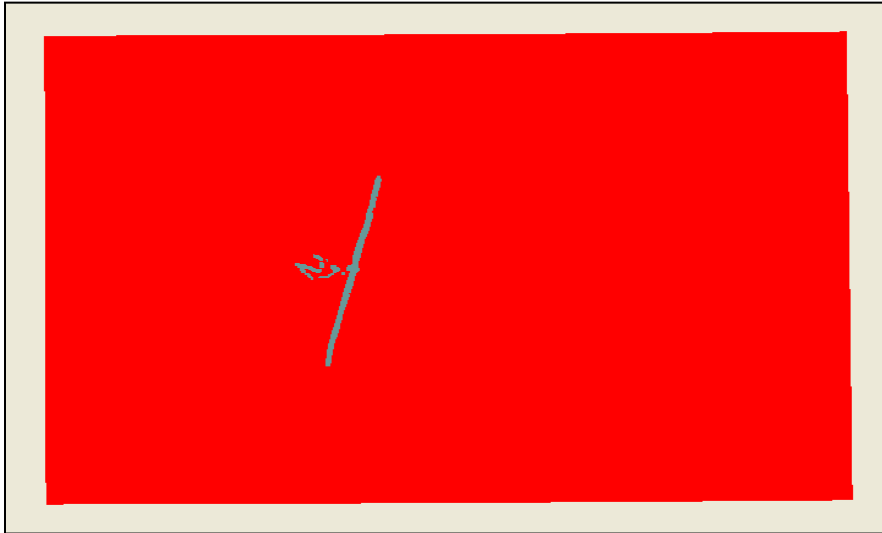
1.3.1. Convert Elevations to Depths

The files that are obtained from various sources may be in positive elevations rather than positive depths. This information for each survey should accompany the data by means of a metadata file. Each of the six datasets used in section B5.2.2 have vertical references that are positive elevations.

An easy way to convert from elevations to depths is to use the *Data | Transform* from the SMS pull-down menu for each survey dataset in the data tree.

- On the dialog, shown in Figure B 5.3-1, select "Depths ⟵⟶ Elevations" and enter a water surface elevation (WSE) value of zero.
- When OK is clicked, the signs of all values in that dataset will be reversed.
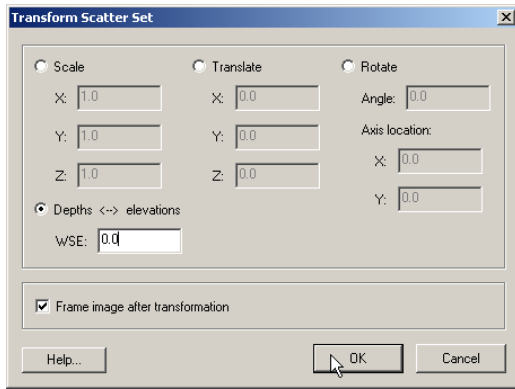- Repeat for all 6 survey datasets
- SAVE

Figure B 5.3-1. Transform dialog box

1.3.2. Local and Regional Datums

There are two types of vertical datums. Some use local references (such as mean low water or mean higher high water) and others use national or regional references (such as NAVD88). NOAA maintains a list of many locations and offers a benchmark sheet that explains the relationship between the available datums for a given location. Not all references are available at each location. A sample benchmark sheet for Long Branch Fishing Pier, NJ, NOAA station 8531991, is shown in Figure B 5.3-2. These datum relationships are needed to convert from one to another. For example, for NOAA station 8531991, the value for mean lower low water (MLLW) is 19.00 ft and the value for mean sea level (MSL) is 21.44 ft. To convert from MLLW to MSL, the user must subtract desired vertical datum from the individual datum. So, to convert MLLW to MSL, the following expression must be evaluated - MSL – MLLW = 21.44 – 19.00 = 2.44 ft. This is generally easy to figure out for local datums. Be aware that regional or national datums in some locations may be higher than MSL and in other locations be lower than MSL.

Additionally, there may be additional benchmark information from where the survey was obtained that gives relationships for datums in the area. If one is provided, use this information over what is given by NOAA. It is often beneficial to draw a graphical representation of the relationships of the various benchmarks. One such diagram is shown in Figure B 5.3-3 and shows both NOAA and the Corps of Engineers (COE) benchmarks for this region.

```
May  5 2010 14:45          ELEVATIONS ON STATION DATUM
                           National Ocean Service (NOAA)

Station:  8531991                                    T.M.:        75 W
Name:     LONG BRANCH,FISHING PIER, NJ               Units:       Feet
Status:   Accepted                                   Epoch:  1983-2001


          Datum       Value  Description
          ---------   ------ -------------------------------------
          MHHW         23.93  Mean Higher-High Water
          MHW          23.59  Mean High Water
          DTL          21.46  Mean Diurnal Tide Level
          MTL          21.39  Mean Tide Level
          MSL          21.44  Mean Sea Level
          MLW          19.19  Mean Low Water
          MLLW         19.00  Mean Lower-Low Water
          GT            4.93  Great Diurnal Range
          MN            4.40  Mean Range of Tide
          DHQ           0.34  Mean Diurnal High Water Inequality
          DLQ           0.19  Mean Diurnal Low  Water Inequality
          HWI          12.26  Greenwich High Water Interval (in Hours)
          LWI           6.04  Greenwich Low  Water Interval (in Hours)
          NAVD         21.68  North American Vertical Datum
          Maximum      27.13  Highest Water Level on Station Datum
          Max Date  19870102  Date Of Highest Water Level
          Max Time     09:12  Time Of Highest Water Level
          Minimum      14.40  Lowest  Water Level on Station Datum
          Min Date  19780110  Date Of Lowest Water Level
          Min Time     21:00  Time Of Lowest Water Level


To refer Water Level Heights to a Tidal Datum, apply the desired Datum Value.

Click HERE for further station information including New Epoch products.


To refer Water Level Heights to either
   NGVD (National Geodetic Vertical Datum of 1929) or
   NAVD (North  American  Vertical Datum of 1988), apply the values located at:
   National Geodetic Survey
```

Figure B 5.3-2. NOAA Benchmark sheet for Long Branch Fishing Pier, NJ
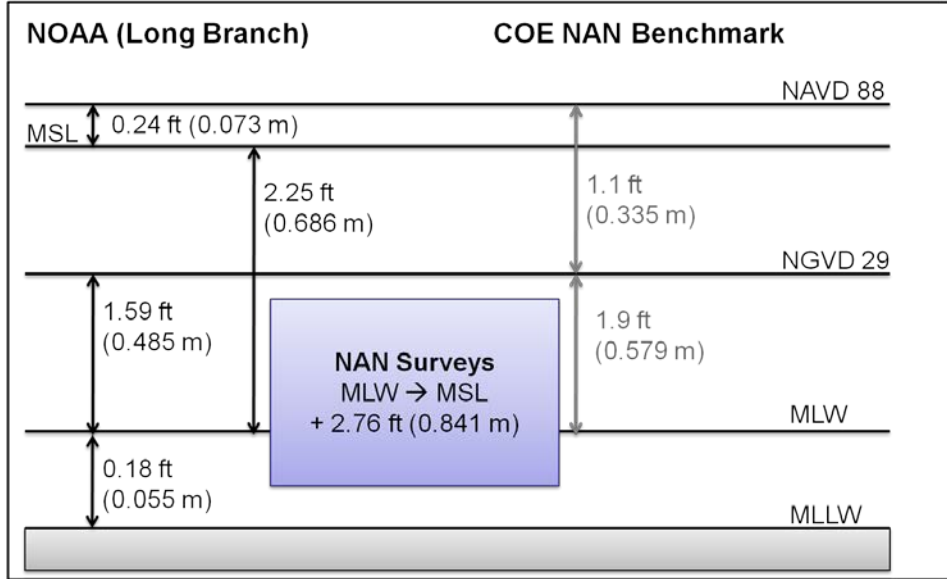

Figure B 5.3-3. Graphical representation of datum relationships from NOAA and the COE

Using these datasets with CMS, all datasets must have both units and datums converted. MSL in meters is the preferred datum for bathymetry and forcing files in CMS. The following process is used to switch from one datum (and unit) to another.

1.3.2.1. Datum conversion

- Select the "Channel_Survey…" dataset from the data tree.
- Obtain necessary information about the data.
    o From Table B 5.2.2, the datum for this file is MLW in feet.
    o From Figure B 5.3-3, the information can be derived to get the conversion from MLW to MSL.
        ▪ In the COE Benchmark (right side), the distance from MWL to NAVD88 is 3.0 ft. No information is available for MSL.
        ▪ From the NOAA Benchmark (left side), the distance from MSL to NAVD88 is 0.24 ft.
        ▪ A combination of these two is used (3.0 ft – 0.24 ft) to get the total distance from MLW to MSL which is 2.76 ft.
        ▪ The final column in Table B 5.2.2 has been updated to reflect the conversion values for each survey.
    o Make sure you get the conversion value for the appropriate units (feet or meters) to change the datum reference. The next section covers changing the units from feet to meters, where necessary.
- Choose *Data | Dataset Toolbox* from the SMS pull-down menu, shown in Figure B 5.3-4.
- Select "Data Calculator" and note the item assignment for the Z dataset. It may be different on your computer than in this figure. In the figure, the item is assigned "d1". Select the Z dataset and choose "Add to expression".
- For the expression in the "Calculator" blank, add the conversion information so that the expression reads "d1 + 2.76".
- Give a new dataset name (bottom of middle pane) such as "MSL, ft" and click the "Compute" button. Do not hit Enter because we want to stay in this dialog for the next step.

Table B 5.2.2. Survey list with Vertical Datum information.

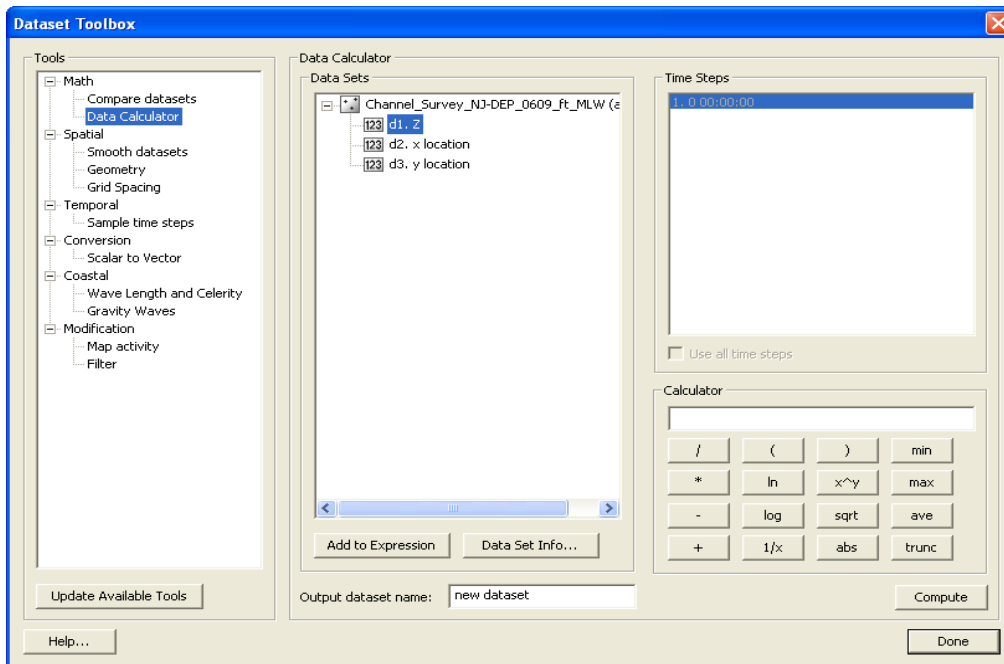| Filename	Vertical Datum, Units	Conversion to MSL (feet and meters)
Channel_Survey_NJ-DEP_0609_ft_MLW.xyz	MLW, ft	2.76 ft
Coastal_Relief_Model_ll_m_msl	MSL, m **(not accurate for nearshore)**	--------
3364_0409_ft_MLW.xyz	MLW, ft	2.76 ft
LIDAR_ft_NAVD	NAVD88, ft	-0.24 ft
Field_Team_Measurements_0809_m_NAVD.xyz	NAVD88, m	-0.073 m
0.75m_Contour	MSL, m	--------

Figure B 5.3-4. Dataset Toolbox Dialog

1.3.2.2. Unit Conversion

- From the dataset toolbox, you now see that there is a new entry listed and its assigned number is "d4".
- Now we want to convert this new dataset from feet to meters.
- Select the new dataset and then hit "Add to Expression".
- Enter the conversion from feet to meters in the calculator expression blank, "d4 * 0.3048".
- Enter a new name for the converted units, such as "MSL, m" and hit "Compute".

Repeat sections 5.3.2.1 and 5.3.2.2 for the where appropriate for datasets loaded into SMS. The datasets "0.75m Contour" and "Coastal_Relief_Model_ll_m_msl" need no datum or unit conversion, since those datasets are already in MSL, m.

SAVE your progress before continuing.

1.3.3. Merging Multiple Surveys

When generating a CMS-Flow grid, one bathymetry set is needed to provide depth values for each cell. We have shown so far in this tutorial how to bring in several surveys and perform horizontal reprojections and datum corrections on them. The next step is to merge all surveys together into one full dataset.

Merging all scattersets will integrate all points. Overlapping areas of scattersets should either be deleted, or use a separate method of merging (by prioritizing using triangles). Figure B 5.3-5 shows the SMS dialog for merging scattersets.

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- From the pull-down menu, select *Scatter | Merge Sets*.
- Select each dataset by clicking the Merge check box next to each dataset or by choosing the "Select All" button.
- For each dataset, select the appropriate value to use for the merge (MSL, m).
- Choose a name for the merged scatter set. The default is "Merged".
- Choose "Merge all scatter points" and click OK.

Once the merge has been completed and you are satisfied with the results, you can delete the old datasets from the SMS data tree since they are no longer needed. Removing from the data tree will not erase the actual file, it is only deleted from memory and when the next Save of the project is made, these datasets will no longer be included. Go ahead and SAVE your project now.

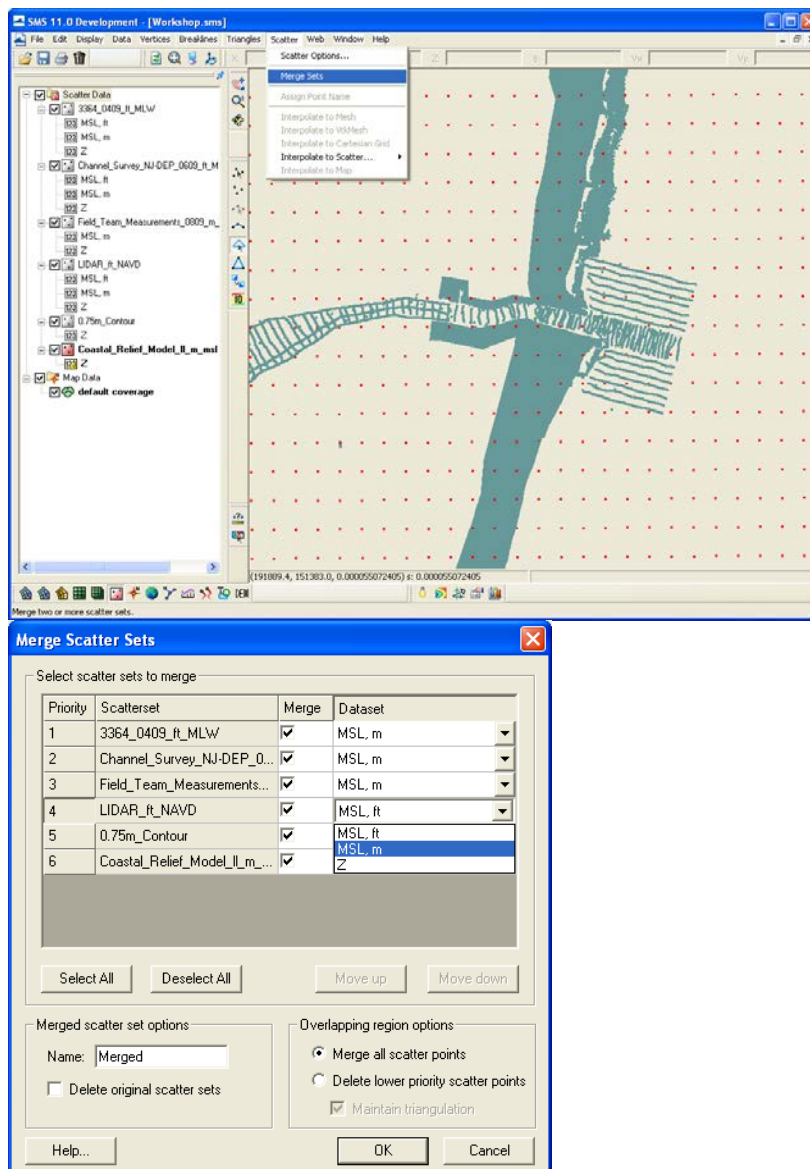In Section B6, we will be loading a different set of files where all of the conversions and merging has already been completed.

Figure B 5.3-5. Merge scatter points dialog.