VELOCITY MAPPING TOOLBOX (VMT) USER GUIDE

VERSION 2.42 BETA

CONTENTS

PRELIMINARY NOTES

- Any errors or issues should be reported to Dan Parsons, University of Leeds, (parsons.daniel@btinternet.com) or Ryan Jackson, USGS, pjackson@usgs.gov

- VMT is best run inside the Matlab environment, but we have provided a compiled version of the program that will run without Matlab. To use the compiled version, one must have the Matlab Runtime Library 2012a (v 7.17) installed (see http://hydroacoustics.usgs.gov/software/MCR1.shtml). Note that versions of VMT prior to 2.4b require the older Matlab Runtime Library 2010a (v 7.13).

- Be patient, processing speed depends greatly on CPU and RAM. Status of processing is shown in the Matlab command window (and in limited status windows). A message will alert the user when processing and plotting are complete. Alternatively, the user should check the lower left hand corner of the main MatLab screen to ensure a "busy" statement is not visible (the program may appear to be idle at times of heavy computations). However, in some cases, "busy" does not appear and program is still running (not sure why). The figures are plotted last, so if your figures have not appeared (or been updated), the program is likely still running. Users running the compiled versions of VMT must rely on the status windows to alert you of progress.

- The program has not been tested extensively on many platforms. Some issues may result with plotting, saving figures, etc. on platforms with different graphics capabilities and screen resolution. Please report these issues.

- Due to forward compatibility issues, the current version of VMT (2.4b) is not compatible with older versions of Matlab (e.g. 7.0.4). If you experience issues of matlab crashing when running VMT, please either upgrade Matlab to the newest version or run the compiled version of VMT.

- VMT includes some error handling, however, not all errors have been encountered. Matlab users will encounter error reports in the command window that identify the problem, however, users of the compiled version of VMT will not get such error reports. We have tried to identify the most common errors and provide the user with feedback in the status window. Please report errors and crashes if encountered. If VMT fails to respond, an unexpected crash may have occurred; however, some large data sets take time to process and plot. To check if the program crashed, try loading only a single transect to determine the apparent crash was simply a processing time issue.

- Take time to play with the program and the vertical exaggeration, vector scaling, vector spacing, and smoothing window parameters to obtain a clear figure. The initial figure may be poor if the default values do not represent the cross section well (likely in many cases). Within about a minute, the user can quickly find the suitable settings for the cross section and velocity field by varying the settings (start with vertical exaggeration, then vector spacing, then vector scaling—also leave smoothing windows set to 1 initially (you can later turn off smoothing to see the effect it has on the plot)) and pressing the 'Replot Button'. These settings will likely work for other cross sections in the study reach.

- Some example plots are located in the 'Examples' subdirectory in the VMT directory. This directory also contains some example data to get you started. This data is for example purposes only and should not be published under any circumstances.

- I suggest outputting bathymetry once for a batch of transects. Turn off plotting and save options (*.mat, *.kmz) and select "Output Multibeam Bathymetry" and push the load data button. Select a batch of ascii output files for a reach. Batch processing in this way creates one xyz file for the whole set of transects rather than individual files. Output format is (ensemble, x, y, z). One also has the option to output time of the sample, pitch, roll, and heading in addition to XYZ data.

NOTE: This document contains a list of known problems/bugs. If you experience problems, please look here first.

INSTALLATION OF VMT AND UTILITIES

Running VMT in Matlab (recommended if possible):

Copy the 'VMT' directory and all its contents to your computer and set the directory within Matlab to the VMT directory. All custom functions called by VMT should be included in this directory and Matlab will look for them within this directory. Matlab will also look to the Matlab program files for some built-in functions. Errors may result if using old versions of Matlab and built in functions are not present. Also, errors may result if the source code or functions are moved from the VMT directory, renamed, or modified.

To run VMT, simply type 'VMT' at the Matlab command prompt. To run stand-alone utilities, simply type 'ASCII2KML_GUI' or 'ASCII2GIS_GUI' at the command prompt.

Running the compiled version of VMT (for those without Matlab):

The compiled version of VMT 2.4b and later requires the installation of the Matlab Runtime Library 2012a (v 7.17) on the host machine. See http://hydroacoustics.usgs.gov/software/MCR1.shtml for instructions on downloading and installing this library.

With the library installed, simply copy the 'VMT.exe' program to your computer and run the executable to launch the VMT program. Note that some errors and output that are displayed in the Matlab command window will not be visible in the compiled version. Stand-alone utilities (ASCII2KML & ASCII2GIS) are both run by double clicking the appropriate executable file.

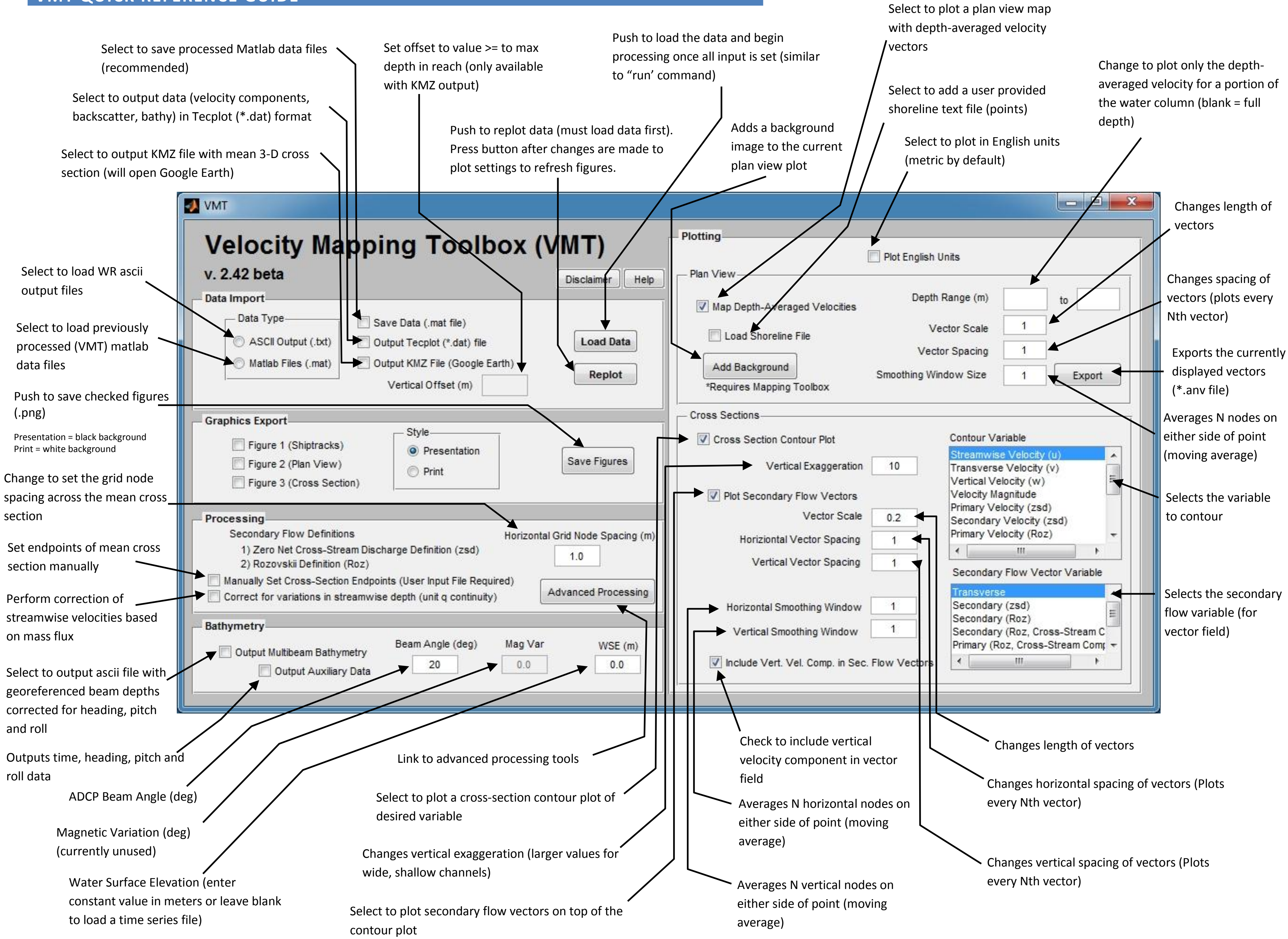
INPUT DATA REQUIREMENTS AND FORMAT

Data input requirements and format for VMT are as follows:

1. Currently, the required input data format is the "ascii output" file format from WinRiver II
    a. Classic format
    b. Backscatter output
    c. **METRIC** units (all input data is in metric units, but figures can be plotted in English units)
    d. Ensure no spaces are in the file names (replace with underscore if necessary). Spaces can cause problems in MatLab.
    e. Files should be of the standard format "*_ASC.TXT" (case does matter). If the files you have do not work (maybe from a previous version of WR or WRII), try outputting new ascii files from the latest version of WRII and run VMT again.
2. Data must include valid **GPS** data within the ascii file (currently does not read the *GPS.txt files).
3. Google Earth must be installed if outputting KMZ files (free download from Google).
4. VMT is best suited for repeat transects at a single cross section (they will be used to compute an average cross section and velocity distribution). The software will handle a single transect however. Note that transects at a site with significant variation in the channel bathymetry and/or variation in the position of the transect may result in unusual averaging for the bathymetry and water velocities. Processing single transects in this case is recommended and will preserve bathymetry and flow variation.
5. It is helpful for the user to know the maximum depth within a study reach for setting the vertical offset and vertical exaggeration. When multiple cross sections are mapped in a reach, the user should set these values for the transect with the maximum depth and keep these values constant for the remaining transect sites in the reach. This ensures that vertical scaling and offsets are consistent throughout the reach (especially true for the KMZ offset—see below).
6. The user should have notes handy that list the repeated transects at each cross section. The user will be asked to select these ASCII output files at each cross section to determine the average cross section and velocity field for the cross section. If filed notes are poor, the user can determine the spatial locations of each transect by using the ASCII2KML_GUI utility (generates a Google Earth KML file for each transect shiptrack for easy identification of spatial positions).

Note: VMT 2.4b does not currently support data from other ADCP manufactures (e.g. SonTek M9 data) or data with dynamic bin size and/or frequency switching. However, we are currently testing algorithms to handle this data and compatibility with other data types will be included in an upcoming version.

VMT QUICK REFERENCE GUIDE



GETTING STARTED WITH VMT

Data Preparation:

There are several steps that the user should take prior to running VMT to ensure that all input data files are available for processing. These steps include:

1. Perform preprocessing (QA/QC) in WinRiver II and generate ascii export files (*_ASC.txt).

2. Download or generate a background image if required. If the user prefers to overlay the data on a background image (e.g. aerial imagery), a background image is required. The required coordinate system for any georeferenced background is UTM coordinates in meters. Acceptable file input formats include GeoTIFF, Shapefile, TIFF/JPEG/PNG (with a world file), ARC ASCII GRID, or SDTS raster. Aerial imagery in UTM coordinates can be obtained from http://seamless.usgs.gov or other sources.

3. Create a shoreline file if necessary. Use this option in place of a background image to delineate the shoreline in the figures. A shoreline file is a csv text file (.txt or .csv) with two columns (UTM easting and UTM northing) representing the coordinate pairs of the shoreline points. Note: the shoreline is represented as a continuous line (closed loop). If a break is necessary, i.e. to plot the shoreline of an island within the main channel, insert '-9999' in the text file at the point where each break should occur. Multiple breaks are supported. Below is an example of a method to generate such a file using an aerial photo and ArcGIS:

    a. Download DOQQ (http://seamless.usgs.gov) aerial photo

    b. Import into ArcGIS

    c. Use ET GeoWizards (free download http://www.ianko.com/) to create new shape file

        i. Choose point file type

        ii. Use edit toolbar to edit new shapefile by digitizing shoreline (pencil tool)

        iii. Save edits

    d. Use ET GeoWizards to export shapefile to txt file (comma delimited)

    e. In Excel or other program, remove first column (point numbers) to leave txt file as only northing and easting in two columns.

    f. Save file as .csv

4. Determine the mean water surface elevation (in meters) at each cross section (if required).

5. Determine the UTM coordinates of the start and end points of each cross section (if using the "user defined endpoints" option).

6. Estimate the maximum depth in the study reach in meters (can use WinRiver II for this).

Processing a Set of Transects in VMT:

With the required files and input data collected, one can start processing transects with VMT. The following steps are required to process a set of repeat transects (at one cross section) in VMT:

1. Launch VMT in Matlab or run the executable. The VMT GUI interface window will be displayed.

2. Begin by processing ASCII files (select ASCII output as data type option in the upper left hand corner). Ensure that the 'Matlab Files (.mat)' option is not selected.

3. Check "Save Data" if you wish to save the processed data as a .mat file—recommended). Do not choose "Output KMZ File" until you are happy with the scaling (see below).

4. Select "Manually set cross-section ends points" if you wish to manually force the mean cross section line (to which the data re mapped) to have fixed, user defined ends points (rather than a best fit line to the data). Requires a text file with UTM coordinates of end points (2 X 2 matrix; i.e. row 1: x_1, y_1; row 2: x_2, y_2).

5. Select "Correct for variations in streamwise depth" if you wish to have VMT correct streamwise velocities by enforcing continuity of mass in the along channel coordinate. This correction occurs before computation of the secondary flow definitions[1].

6. Choose plotting options (defaults recommended for initial run) and whether you will import a shoreline file. Leave scaling, spacing, vertical exaggeration and smoothing options at default values for the first run (you will adjust these based on your cross section). You should leave "Map Depth-Averaged Velocities" checked for every set of transects you process if you intend to compile all the transects into one plan view flow map after processing (see step 12). Leaving this checked makes sure the code completes the necessary computations and saves the data to a Matlab data structure for future use.

7. Click "Load Data" to select the files and run the processing routines

    a. You will be prompted to browse to the directory with the data

    b. Select the repeat transect data files for a single cross section

    c. Click "OK"

    d. Browse to the shoreline file if prompted to do so (only if 'Plot Shoreline' is selected)

[1] For more information about this correction, see Hoitink, A. J. F., F. A. Buschmann, and B. Vermeulen. 2009. Continuous measurements of discharge from a horizontal acoustic Doppler current profiler in a tidal river. *Water Resources Research* 45, W11406, doi:10.1029/2009WR007791.

8. Review the plan-view and cross section figures. If unhappy with plot settings, adjust vertical exaggeration and scaling, vector spacing parameters and smoothing windows and select "Replot". Repeat until you are satisfied with the figures.

9. Change plotting variables by selecting the desired variable from the listboxes and selecting 'Replot'. Version 2.1 and later also allows the user to select the desired velocity components for the vector field overlay. The vertical component of velocity can be removed from the secondary flow vectors by unchecking the 'Include Vert. Vel. Comp. in Sec. Flow Vectors' box.

10. If required, select "Output KMZ File" and choose a vertical offset (set >= to the maximum depth of the cross section or reach). Google Earth will open and display the 3-D mean cross section (you will have to rotate your view from the default plan view in Google earth to see it). It is recommended that the user set the vertical exaggeration and vertical offset for the deepest site and leave it constant while processing data from additional cross sections within the study reach. (i.e. if mapping a river bend, determine the deepest portion and set the vertical offset greater than this value and the vertical exaggeration appropriate for the width, then leave these values constant for all other transects on the bend). Outputting data to GE may cause issues in VMT when this option is selected and one replots the data several times. I have noticed that a previously loaded data set may reappear when replotting. It is unclear why this is happening, but closing GE and unselecting the GE output checkbox after each data set is loaded seems to solve the problem. If GE is left open, the data set which it was first opened may reappear when running the "replot" command even after a new data set has been loaded.

11. Repeat steps 4-10 to process data for set of transects at another cross section

12. If you saved the .mat files, they will be saved to the directory 'VMTProcData' in the current data directory. The file name for the process cross section *.mat file is auto generated using the file format of the input transects and a suffix made up of the first and last transect numbers of the set processed (i.e. ClintonLake_000_003.mat). You can reload the files by selecting "Matlab Files" as the data type and pressing the load button. This option does not reprocess the data, it simply loads the processed data files. KMZ files are in this directory as well.

13. If a plan view map showing depth-averaged vectors for more than one cross section is desired (i.e. showing depth-averaged flow through a bend), load the processed data (step 11) and select all the processed data files (i.e. cross sections) you wish to view, ensuring that "Map Depth-Averaged Velocities" and "Plot shoreline" (if you loaded a shoreline file when processing the ascii data files) are selected.

14. For any plan view plot currently displayed, the user can press the "Add Background" button and overlay the vectors on a georeferenced background image. The required coordinate system for any georeferenced background is UTM coordinates in meters. Acceptable file input formats include GeoTIFF, Shapefile, TIFF/JPEG/PNG (with a world file), ARC ASCII GRID, or SDTS raster. If the "replot" button is pressed after adding a background, the background will be lost and the user will need to add the background again. It is recommended that a background be added only once the user is satisfied with the plot. Zooming and panning are allowed within the background

image; however, the aspect ratio of the original background image is locked by the plotting routine.

15. At any time, the user can choose to save the current figures by selecting the figure numbers in the 'Graphics Export' pane and pushing the 'Save Figures' button. It is recommended that the user only export the figures when they are happy with the scaling, vertical exaggeration, and vector spacing. The figures will be saved to the VMTProcFiles directory within the user's data directory in a PNG or EPS format (user choice). The user also has the option to export a figure directly from the figure window in a variety of formats and resolutions.

REPORTED PROBLEMS

1. VMT will become unresponsive if one version of VMT is open and another version is opened at the Matlab command prompt. Resolve this problem by closing and restarting VMT.

2. Primary (streamwise) velocities may appear to be negative in the contour plot for cross sections oriented such that the left bank easting value is west of the right bank easting value (original program assumed the left back is the easternmost bank). The plots are correct, rather than looking downstream in the contour plots, these plots are shown looking upstream and primary velocities are negative. (**Fixed in version 1.1**)

3. Two users have experienced an error related to the x grid node spacing. I could not reproduce the error on my system. If such an error is reported, please let me know (it appears to be system dependent or possibly related to a previous version of Matlab). I believe this problem is solved, so please let me know if it happens to you. (**Fixed in version 1.1**)

4. Sometimes a MatLab error will result in the command window (something like "undefined variable z") when trying to Replot the figures. This has only occurred when KMZ output is selected and Google Earth is open. It appears to be an issue between MatLab and Google Earth. To fix the problem, simply close Google Earth and Replot (you can leave 'Output KMZ File' checked). Google Earth will reopen with the updated plot. I will try to solve this issue when I can reproduce it.

5. An error has been reported involving too many input parameters to the function 'nansum'. Older versions of Matlab have a version of nansum that does not allow summing over specified dimensions of a matrix. I have included in the VMT directory the function 'nansum' that works. This should solve this problem. (**Fixed in version 1.1**)

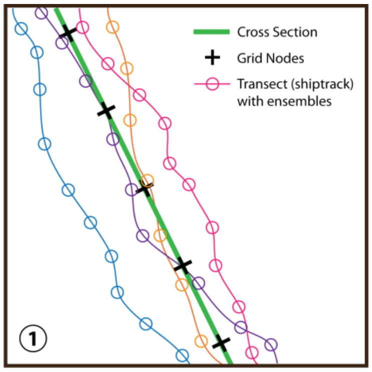
6. If Google Earth is left open, the data set with which it was first opened may reappear when running the "replot" command even after a new data set has been loaded (I am working in a fix for this). Close Google Earth after each cross section is processed and try to only select the KMZ output box after all replotting is done (replot command reruns the GE export each time the button is pressed).

7. VMT appears not to work with MatLab 6.5. There seems to be an issue with loading the GUI related to forward compatability. Try using the compiled version or update Matlab.

8. VMT Google Earth output may not properly plot with newer versions of GE and VMT 2.3b and earlier due to a change in the data format by GE. Try updating VMT to 2.4b or later if you have this issue.

VMT TRANSECT-AVERAGING PROCEDURE

Below is a schematic showing the transect-averaging procedure used in VMT. See Parsons et al. 2011 for more information.

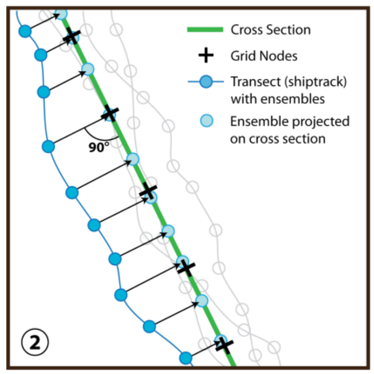


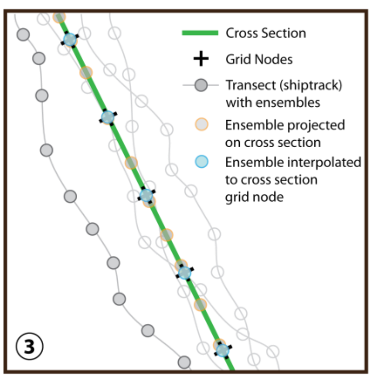
Step 1. Define the average cross section orientation and grid

Options:

1. Least-squares fit of data cloud
2. User-defined end points

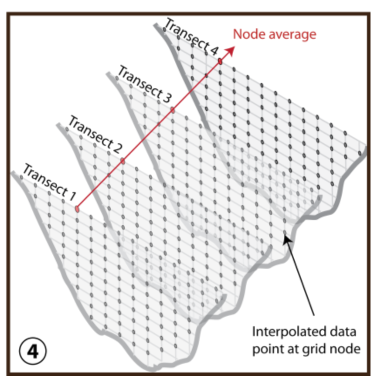
Step 2. Project transect data to the cross section plane using an orthogonal translation





Step 3. Interpolate projected data to the cross section grid for each transect (no interpolation in vertical is required when using a vertical grid defined by the bin size)

Step 4. Compute arithmetic average of all transects at each grid node for basic variables (e.g. velocity components)



EXPLANATION OF VMT OUTPUT FIGURES

Figure 1:

Transects (blue lines) are fit with a line (mean transect, green line) and data points (ensembles, blue dots) from each transect are mapped to mean transect and interpolated to the specified grid (black +). Transect data are then averaged at each node to arrive at a mean data set.

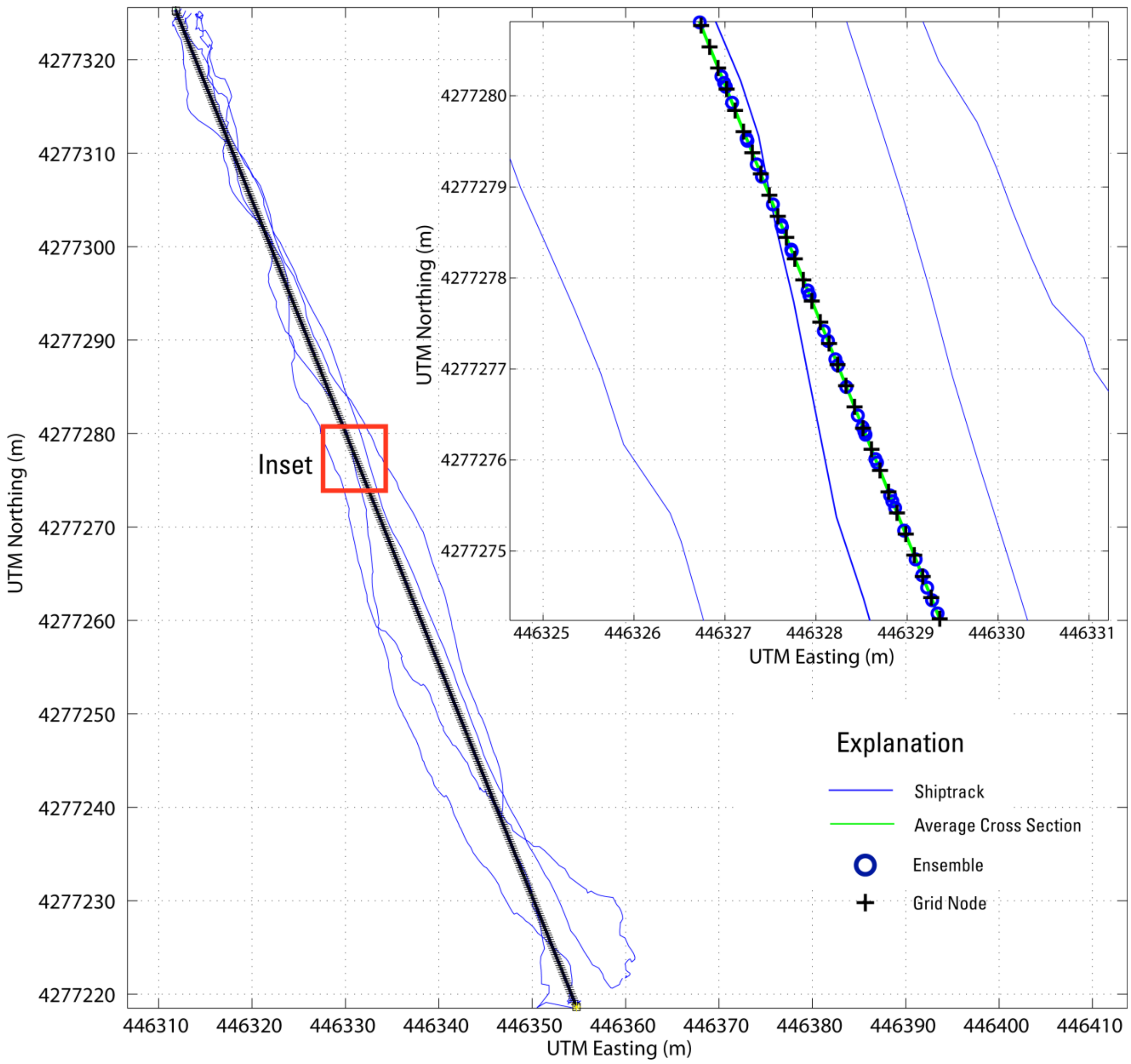


Figure 2:

Figure 2 is a planform plot of depth- or layer-averaged velocity. When processing ASCII output data for a single cross section, the figure will contain only one (average) set of vectors along the average cross section. Multiple cross sections can be viewed at once and all referenced to the same scale by loading *.mat files for preprocessed cross sections. In the figure below, a background image containing the bathymetry (from the ADCP) has been loaded. Bathymetry data was extracted from the ASCII files using VMT and imported into ArcGIS for krigging. The final background image was exported from ArcGIS in UTM coordinates and imported into VMT.

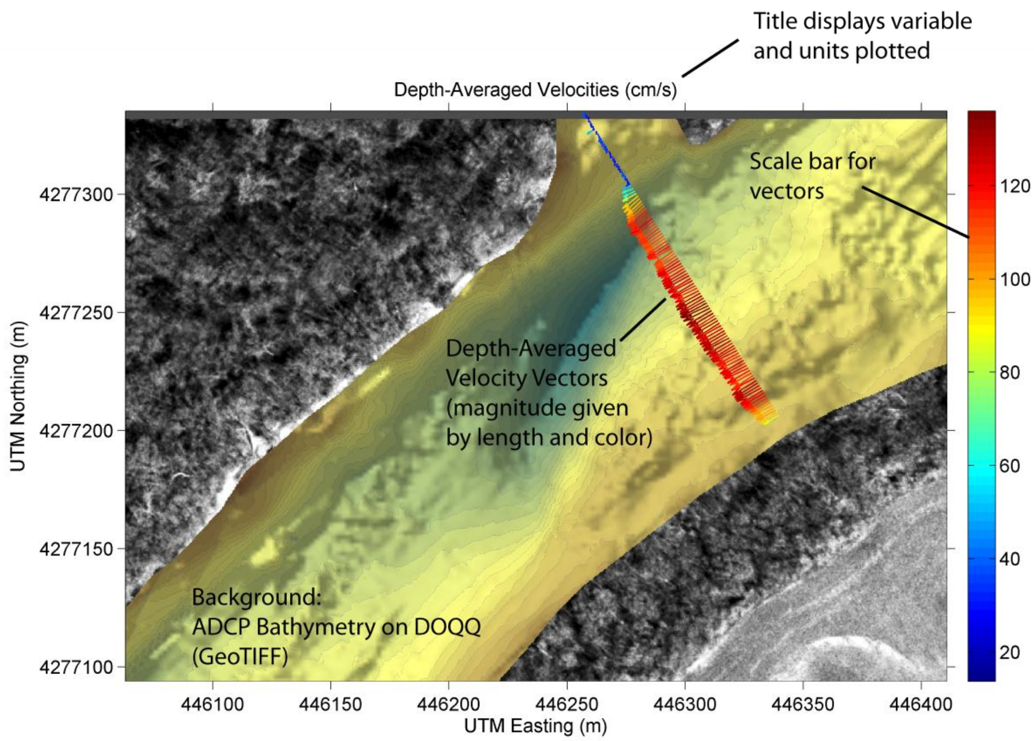
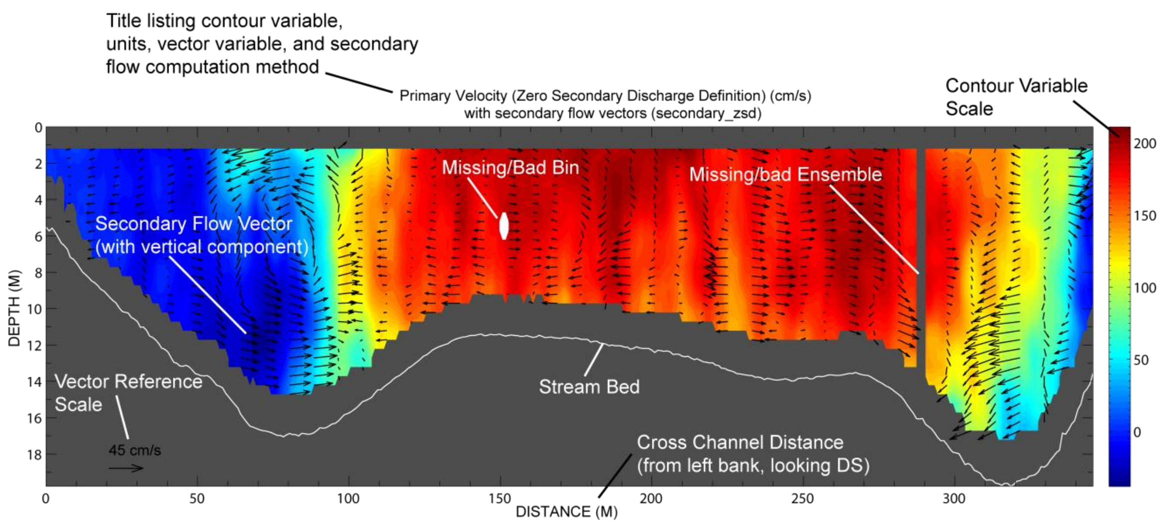


Figure 3:

Figure 3 displays the transect-averaged data in both a color-coded contour plot and a vector field. The user controls what variables are plotted for both the contour plot and the vector field. In addition, the user has the option to not include the vertical velocity component in the vector field. Unmeasured area near the surface and bed is shown and no data is interpolated into these regions. A colorbar provides the scale for the contour plot and a reference vector is provided for the vector field.



OUTPUT FILE FORMATS

Data files can be exported from VMT that contain the processed data for archiving, use in other programs, and for review. File formats include Matlab data files (*.mat), Tecplot data files (*.dat), iRIC vector files (*.anv), multibeam XYZ bathymetry files (*_mbxyz.csv), Google Earth files (*.KML and *.KMZ), and GIS compatible ascii files (*_GIS.csv). Below is a summary of each data file format and a description of the data they contain.

Matlab data files (*.mat):

Files contain Matlab data structures with the raw ADCP data, intermediate variables used in computations, and final processed and averaged data. The data structures are extensive and will not be discussed in detail here. Please contact Dan Parsons, University of Leeds, (parsons.daniel@btinternet.com) or Ryan Jackson, USGS, pjackson@usgs.gov with questions concerning the structure of these files.

Tecplot Data files (*.dat):

Files contain processed and averaged ADCP data formatted for direct import into Tecplot. Choosing the Tecplot export option will export the average cross-section data only with no smoothing or data reduction (vector spacing) applied. Data files contain a header with all necessary information. One data file (*_TECOUT.dat) contains the velocity and backscatter data array for the cross section while the other data file (*_TECOUT_XSBathy.dat) contains the georeferenced bed depth and bed elevation data. The data files contain the following variables:

**_TECOUT.dat*

NAME	*DESCRIPTION*
X	*UTM Easting (m)*
Y	*UTM Northing (m)*
Depth	*depth (m)*
Dist	*dist across XS, oriented looking u/s (m)*
u	*stream-wise velocity magnitude per bin (cm/s)*
v	*cross-stream velocity magnitude per bin (cm/s)*
w	*vertical velocity magnitude per bin (cm/s)*
vp	*primary vel. component-0 discharge meth. (cm/s)*
vs	*secondary vel. comp.-0 discharge meth. (cm/s)*
U (Rotated)	*depth-avg. stream-wise magnitude (cm/s)*
V (Rotated)	*depth-avg. cross-stream magnitude (cm/s)*
ux (Rotated)	*component of vel. in X dir., rotated (cm/s)*
uy (Rotated)	*component of vel. in Y dir., rotated (cm/s)*
uz (Rotated)	*component of vel. in Z dir., rotated (cm/s)*
Mag	*vel magnitude (need better desc.) (cm/s)*
Bscat	*backscatter (dB)*
Dir	*direction deviation (degrees)*
vp (Roz)	*primary vel. per bin using Rozovskii (cm/s)*
vs (Roz)	*secondary vel. per bin using Rozovskii (cm/s)*

vpy (Roz)	*cross-stream comp. of primary vel. (cm/s)*
vsy(Roz)	*cross-stream comp. of secondary vel. (cm/s)*
phi_deg (Roz)	*depth-avg. vel. vector angle (degrees)*
theta_deg (Roz)	*individual bin vel. vector angle (degrees)*

**_TECOUT_XSBathy.dat*

NAME	*DESCRIPTION*
X	*UTM Easting (m)*
Y	*UTM Northing (m)*
BedDepth	*Bed depth (m)*
Dist	*dist across XS, oriented looking u/s (m)*
BedElev	*Bed Elevation (m) (Only accurate if user entered value in VMT GUI)*

iRIC Vector Data Files (*.anv):

The iRIC river modeling interface allows input of vector velocity data for model calibration and validation (2-D) in the form of ANV files. Currently (VMT v2.4beta) will export ANV files from the ASCII2GIS utility (depth-averaged velocity along the curvilinear boat path) and ANV files containing the depth- or layer-averaged velocity as displayed in the plan view plot with vector spacing and smoothing applied. The format of these data files is as follows:

The vector files contain x, y, z, vx, and vy values in each line and separated by spaces. Units are MKS.

x: x position (UTM Easting in m)

y: y position (UTM Northing in m)

z: z position - Presently the z- value is unused and can be set to zero.

vx: the x or easting component of velocity

vy: the y or northing component of velocity.

There is no header with the number of points in the file.

The extension for vector files is .anv

Example:

324149.52 855806.24 0 -0.157983784 0.003032246

324149.36 855806.27 0 -0.223229456 0.039234629

324149.26 855806.32 0 -0.124340297 0.073863539

324149.02 855806.33 0 -0.205609318 0.079592921

324148.7 855806.35 0 -0.056268607 0.036997848

324148.36 855806.36 0 -0.326218383 0.032733164

324148.09 855806.39 0 -0.352748183 0.081762639

324147.78 855806.5 0 -0.605494602 0.625695435

Multibeam XYZ Bathymetry Files (*_mbxyz.csv):

These files contain the bathymetry data from the four individual beams of the ADCP, corrected for heading, pitch, and roll using an algorithm provided by TRDI and in use in Dave Mueller's ADMAP. The data is formatted as a simple CSV (comma-separated value) file that is easily imported into ArcGIS using the XY data import tool. The user has the option to add ancillary data to the data file. A description of the data files with and without the ancillary data is as follows:

Without Ancillary Data

NAME	*DESCRIPTION*
EnsNo	*Ensemble Number*
Easting	*Easting (UTM, WGS84)*
Northing	*Northing (UTM, WGS84)*
Elev_m	*Elevation in meters*

With Ancillary Data

NAME	*DESCRIPTION*
EnsNo	*Ensemble Number*
Easting	*Easting (UTM, WGS84)*
Northing	*Northing (UTM, WGS84)*
Elev_m	*Elevation in meters*
Year	*Year of sample*
Month	*Month of sample*
Day	*Day of sample*
Hour	*Hour of sample*
Minute	*Minute of sample*
Second	*Second of sample*
Heading_deg	*Heading reading at time of sample in degrees from true north*
Pitch_deg	*Pitch reading at time of sample in degrees*
Roll_deg	*Roll reading at time of sample in degrees*

NOTE: UTM coordinates referenced to the WGS84 reference frame if that was set in the GPS unit used during data collection (typical).

Google Earth files (*.KML and *.KMZ):

These files are generated to allow the user to display the transect shiptracks (*.kml) and mean cross sections (*.kmz) in Google Earth. The KML files are generated using the VMT utility ASCII2KML and the KML files must be loaded into Google Earth for display. The KMZ files are generated at the request of the user in the VMT interface and will open automatically in Google Earth through a request in the VMT code. The KMZ files are best viewed as 3-D cross sections so the user should adjust the view in Google Earth to get the best display of the cross section. In order to display each KMZ file as a 3-d cross section, the user must enter an offset in the VMT interface that is greater than or equal to the max depth in the reach. This will ensure the cross section is fully displayed above the image plane in Google Earth. Failure to enter an offset will place the cross section below the plane of the background image in Google Earth, thus blocking the view of the data.

GIS Compatible ASCII Files (*_GIS.csv):

These files contain georeferenced depth- or layer-averaged data for every ensemble along the curvilinear shiptrack. The file also includes ancillary data. Data is formatted in a CSV file with a header that allows direct import in to ArcGIS using the XY data import tool. A description of the data contained in the file is as follows:

**_GIS.csv files*

NAME	*DESCRIPTION*
EnsNo	*Ensemble Number*
Year	*Year of sample*
Month	*Month of sample*
Day	*Day of sample*
Hour	*Hour of sample*
Min	*Minute of sample*
Sec	*Second of sample*
Lat_WGS84	*Latitude in WGS84*
Lon_WGS84	*Longitude in WGS84*
Heading_deg	*Heading reading at time of sample in degrees from true north*
Pitch_deg	*Pitch reading at time of sample in degrees*
Roll_deg	*Roll reading at time of sample in degrees*
Temp_C	*Temperature at time of sample in deg. C*
Depth_m	*Mean bed depth at time of sample in meters*
B1Depth_m	*Beam 1 bed depth at time of sample in meters*
B2Depth_m	*Beam 2 bed depth at time of sample in meters*
B3Depth_m	*Beam 3 bed depth at time of sample in meters*
B4Depth_m	*Beam 4 bed depth at time of sample in meters*
Backscatter_db	*Acoustic backscatter in dB*
DAVeast_cmps	*Depth- or Layer-averaged velocity (east component) in cm/s*
DAVnorth_cmps	*Depth- or Layer-averaged velocity (north component) in cm/s*

DAVmag_cmps	*Depth- or Layer-averaged velocity magnitude in cm/s*
DAVdir_deg	*Depth- or Layer-averaged velocity direction in degrees from true north*
DAVvert_cmps	*Depth- or Layer-averaged velocity (vertical) in cm/s (+ is up)*
U_Star_mps	*Shear velocity estimate in m/s (currently disabled pending testing)*
Z0_m	*Roughness length estimate (currently disabled pending testing)*

AN (INCOMPLETE) LIST OF UPDATES

Version 1.1:

- Added the capability to compute and output multibeam bathymetry (individual beam depths) corrected for heading, pitch and roll. Routine taken from ADMAP by D. Mueller.
- Added the ability to manually set the mean cross section end points. Input file is a CSV file with two sets of easting and northing coordinates (x,y). Can be used to ensure data is mapped to the same line for comparison between repeated surveys. (suggested by B. Rhoads)
- Added the ability to choose the vertical vector spacing in secondary vector contour plot (fixed in previous versions to 2)
- Changed some plotting routines to improve figures
- Fixed some minor bugs (see above)

Version 2.1:

- Added the Rozovskii definition for secondary flow computation. Routine taken from code by F. Engel (UIUC).
- Added ability to export velocity and backscatter data to Tecplot. Routine taken from code by F. Engel (UIUC). Unsmoothed data is exported to Tecplot.
- Added Status windows reporting progress.
- Expanded the list of variables to select for contour plotting
- Added a user selectable list of variables for secondary flow vector field
- Added the ability to remove the vertical velocity from the secondary flow vectors
- Made smoothing parameters accessible to user within the GUI. No longer tied to vector spacing parameters (ver 1.1). Smoothing can be turned off by setting all window sizes to zero.
- Smoothing filter now smoothes both the vector field and contour plot data before plotting.
- Updated the GUI interface
- Updated appearance of plots

Version 2.3b:

- 4-8-10: Updated VMT_RepBadGPS.m to prescreen latitudes and longitude values that fall outside of the possible range. Values outside this range caused the program to crash when converting to UTM.
- 4-8-10: Added header to Multibeam export file (VMT_MBbathyV2.m)
- 9-28-10: Fixed bug in VMT_GridData2MeanXS_INT(z,A,V)where the interpolation of north flow directions (0 and 360) resulted in south flow. Now converts to radians and interpolates the sine of the direction and converts back to degrees.—ALSO Flawed near 180 degrees. See below

- 9-28-10: Switched from nonmoving_average2 to smooth2a.m for 2-d spatial averaging (same except for edges—see Test_interp.m) in VMT_SmoothV3. Don't actually use this script anymore, see 9-30-10 update.
- 9-29-10: Fixed bug with flow direction computations. Now computing the mean flow direction in each cell from the interpolated and averaged cross section velocity components (rather than interpolating and averaging the flow direction reported by the adcp). This bypasses issues with averaging the flow direction which wraps from 0-360 degrees.
- 9-30-10: Updated VMT_SmoothVar to use either smooth2a.m or nanmoving_average2. User choice.
- 9-30-10: Fixed bug in plotting of color bar in ASCII input plan view plot. Axes were plotting as black rather than white.
- 9-30-10: Fixed bug where figure 2 axes titles would not change color during graphic export.
- 9-30-10: Added Print and Presentation options for graphics export format.
- 9-30-10: Changed "Flow angle—theta (ROZ)" contour option to Flow Direction (deg from north). Flow direction now should be the same as what is displayed in WinRiver (but contouring around 0 or 360 can look a little funny).
- Oct 2010: Added DOQQ overlay
- Jan 2011: Added computation of longitudinal dispersion coefficient (currently disabled pending testing)
- Feb 16, 2011: Removed standard deviation screening of backscatter as it was causing unnecessary loss of data due to variation between backscatter in beams.
- Spring 2011: Added English units plotting option
- Spring 2011: Added advanced processing button link (currently disabled)
- Spring 2011: Changes magnitude variable to include vertical velocity in computation (previously only N and E values used).
- Spring 2011: Added computation of bed elevation given WSE in meters provided by the user in the bathymetry export box. Default is 0.0 m above MSL (yields negative elevations). Depth is still ised in plotting.
- Spring 2011: Added second Tecplot output file with cross section bathymetry (X,Y,depth,distance,elev).
- Spring 2011: Created GUIs for ASCII2KML and ASCII2GIS
- Spring 2011: Added the ability to plot depth- or layer-averaged vectors on background without snapping to a line (see ASCII2GIS_GUI)
- Spring 2011: Added *.anv file output from ASSCII2GIS_GUI script (vector input files for iRIC modeling interface).
- Spring 2011: Added *.anv file export capability for plan view data (currently locked pending testing).

Version 2.4b:

- 11-7-11: Fixed bug in TecPlot bathy export file that caused files to not load properly into Tecplot.
- 11-22-11: Fixed issue with ASSCII2KML not outputting coordinates properly (Google Earth changed the format of their input in the latest GE release).
- 3-20-12: Added temporal averaging capability to ASCII2GIS utility
- 3-20-12: Added sensor screening to tfile.m (heading, pitch, roll, temperature)
- 3-23-12: Fixed issue with GE output in VMT (3-D cross section compatibility issue with latest GE).
- 3-23-12: Added error dialog for failed *.MAT file read.

- 3-28-12: Fixed bug related to plan view vector scale inconsistency between ASCII file and MAT file when using same vector scale settings. Problem was related to NAN values in the ASCII data fed to quiverc.m causing slight changes in the output vector scale. Omitted all Nan values prior to feeding vector components to quiverc.m (changes made in PlotPlanViewQuiversASCv3.m and PlotPlanViewQuiversMATv3.m).
- 3-29-12: Updated VMT_PlotXSContQuiverV4.m to use the maximum of the absolute value of the secondary velocity as the reference vector magnitude (it use to take the max without the absolute value possibly leading to a negative value if all secondary vectors are negative such as with a large flow angle and the secondary flow component set to transverse).
- 4-9-12: (PRJ) Added error handling for all inputs in GUI trying to catch situations when users enter bad values for parameters (non integer values, negative values, zero, etc).
- 4-9-12: (PRJ) Added a HELP button on the GUI that links to user manual PDF. Requires a file VMTUserGuide.pdf to be in the VMT directory with the code else it returns an error.
- 4-9-12: (PRJ) Added a TRY/CATCH statement on the tfile.m execution in VMT_ReadFiles.m to catch any errors when reading ASCII files. VMT now reports the unknown error when reading the ASCII files and reports to the user the error in a window along with the problem file name.
- 6-19-12: (PRJ, FEL) Added transect number to the CSV output from VMT_MBBathyV2.m
- 8-7-12: (PRJ) Added export button for ANV file creation for depth- and layer-averaged vectors
- 8-7-12: (PRJ) Turned off option for KMZ offset unless KMZ output is selected
- 8-7-12: (PRJ) Added capability to handle WSE time series files
- 8-7-12: (PRJ) Added EPS figure export option
- 8-7-12: (PRJ) Added help and disclaimer buttons

Version 2.41b:

- 10-15-12: (FLE) Optimized tfile.m runtime performance. The new tfile runs approx. 4-5 times faster, and also includes a waitbar for user feedback.
- 10-15-12: (FLE) Added the capability to correct for streamwise variations in depths. Updated the GUI to allow access to this functionality (the default is to have this functionality turned off).

TUTORIALS

Users can work through several tutorials developed to highlight some of the main capabilities of VMT. These recorded tutorials (MP4 files) are designed to guide the user through various tasks quickly and efficiently thus allowing the user to quickly become proficient with VMT. Data for these tutorials are provided and are for demonstration purposes only and should not be published for any reason without the consent of the authors of VMT. Users are encouraged to run the VMT tutorial and follow along with the example data set and/or user-provided data.

The following settings in the VMT interface produce good results for the White-Wabash data set:

Setting	**Tutorial #2: White-Wabash**
Horizontal Grid Node Spacing	1.0 m
Plan View Vector Scale	2
Plan View Vector Spacing	3
Plan View Smoothing Window Size	1
Vertical Exaggeration	10
Contour Plot Vector Scale	0.5
Contour Plot Horizontal Vector Spacing	5
Contour Plot Vertical Vector Spacing	1
Contour Plot Horizontal Smoothing Window	3
Contour Plot Vertical Smoothing Window	1
Cross section contour variable	Primary Velocity (ROZ; downstream component)
Secondary flow vector variable	Secondary Velocity (ROZ; Cross-stream component)