# CUBE in MBMAX64

By Mike Kalmbach

## INTRODUCTION

This article describes the addition of CUBE to MBMAX64 (64-bit HYSWEEP® EDITOR). Previous HYPACK® versions provided CUBE as a stand-alone program, and 32-bit HYCUBE is still available. It has some nice graphical editing not available in MBMAX64.

But having CUBE in the editor is convenient. It saves a step of saving / reloading files. It's interactive; soundings may be edited out then one click regenerates CUBE. And 64-bit processing is nice too, allowing for larger data sets.

CUBE is optional. It's there if you want to use it, but out of the way if you don't.

## CUBE

CUBE (Combined Uncertainty and Bathymetry Estimator) is software that applies Bayesian statistics and modeling to multibeam data and provides uncertainty and depth estimation over a gridded surface. For more information, Google "CUBE" "CCOM/JHC". A nice "hands-on" publication is at http://ccom.unh.edu/sites/default/files/publications/Calder_07_CUBE_User_Manual.pdf.

The CUBE software library is licensed by HYPACK, Inc. from CCOM/JHC at the University of New Hampshire. Dr. Brian Calder is the scientist behind CUBE.

## GETTING STARTED – TPU

To work properly, CUBE needs decent uncertainty estimates of the soundings going into it.

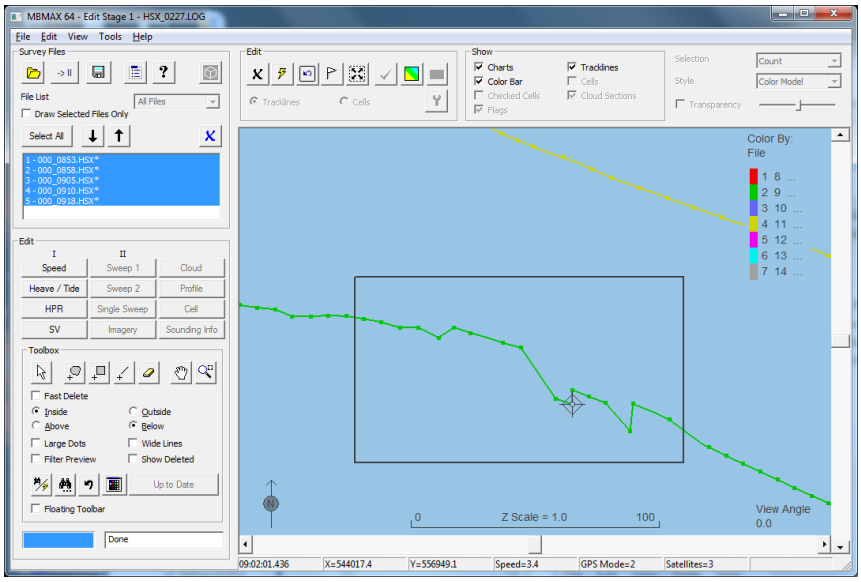
Sounding uncertainty in MBMAX64 comes from HYPACK® TPU calculations. The May, 2013 edition of "Sounding Better" explains TPU setup for MBMAX64. You will need some familiarity with this.

It's good to remember that there is sounding uncertainty and there is CUBE uncertainty. Although one (CUBE) follows the other (sounding TPU), they are not the same.

## GETTING STARTED – MBMAX64

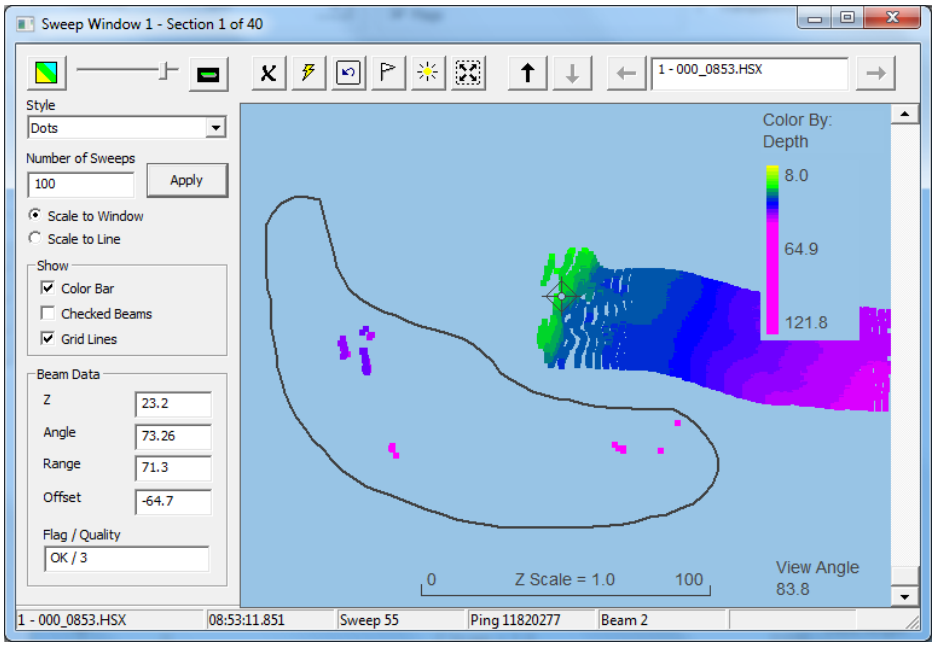
CUBE stays quiet until you reach the depth edit stage—stage 2 in MBMAX64. Before that, GPS position and tide, MRU heave and sensor sound speed measurements need to be cleaned and/or adjusted with other methods. MBMAX64 is good at that! Bad data from the support sensors may render CUBE results invalid. (This is true also for basic statistical results like median, average, etc.) It may seem obvious, but it's a good reminder that there are no fully automatic methods and there's no substitute for paying attention to the sensor data.

***FIGURE 1.*** *Position Spikes That Need to be Removed Before CUBE.*



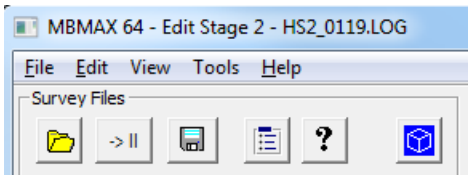

The same is true of soundings. Obvious errors should be removed with automatic or manual methods before CUBE.

***FIGURE 2.*** *Bad Soundings That Should be Removed Before CUBE.*




CUBE comes to life in stage 2. That is, the CUBE button lights up and you may click it to enter settings and kick off the calculations.

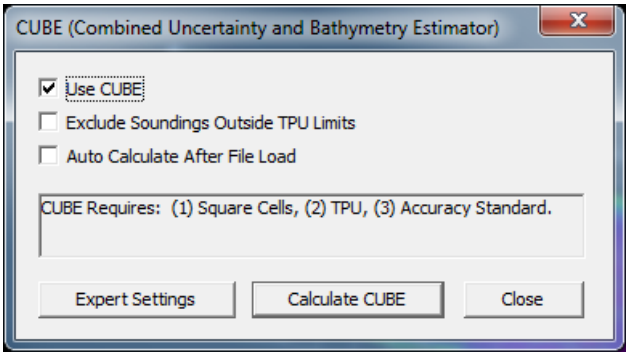
***FIGURE 3.*** *CUBE is Available in Stage 2. Can you guess the button?*




# CUBE Settings

After preliminary data cleaning, you are ready for CUBE. The basic options are shown in Figure 4.

***FIGURE 4.*** *Basic CUBE Options in 64-bit Beta Version.*




**Exclude Soundings** makes sure every sounding included in the CUBE surface meets survey specification.

**Auto Calculate** can be used with large surveys for overnight file loading and CUBE.

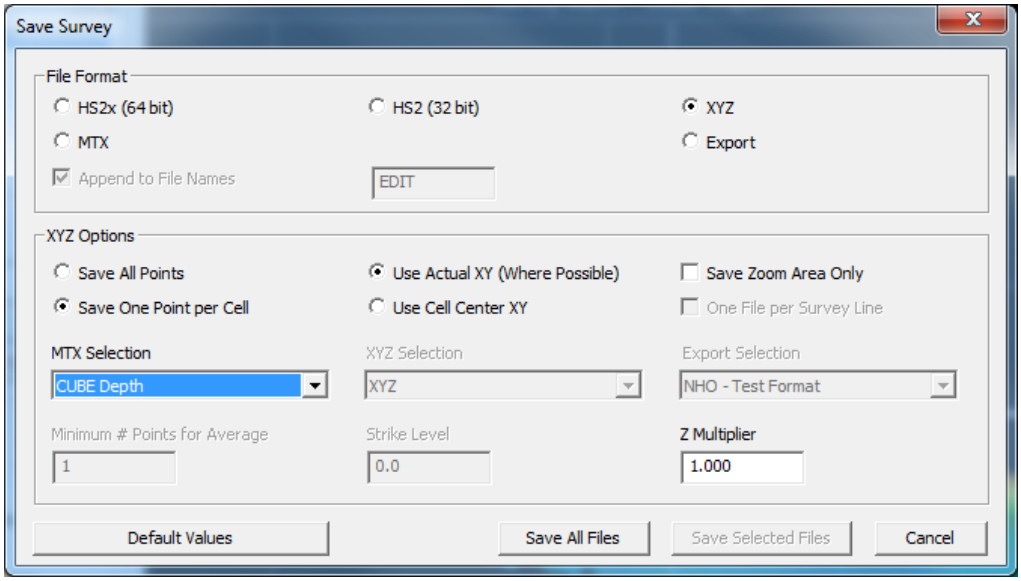
**Expert Settings** are for users who understand CUBE and want to tweak the results slightly. The expert settings are described in the CCOM/JHC CUBE User's Manual. The default values are perfectly acceptable.

Click "Calculate CUBE" to go on. CUBE may take a while, depending on the size of the survey area and number of soundings. When CUBE is finished, results are drawn in the Survey Window.

# Saving a CUBE Surface

If you just need CUBE depths, and don't care about CUBE as an edit tool, you're almost there. Save survey with the options from Figure 5.

***FIGURE 5.*** *To Save CUBE Depths, Use XYZ File Format, One Point per Cell and MTX Selection = CUBE Depth.*




Select CUBE Uncertainty to save the corresponding uncertainty surface. CUBE uncertainty is at the 95% confidence interval.

Two other CUBE values may help you with editing:

- **Hypothesis Count** (abbreviated CUBE H Count) gives the number of CUBE hypotheses each cell.
- **Ratio or Hypothesis Strength** (abbreviated CUBE H Ratio) quantifies the strength of the selected hypothesis in each cell: 0 = best, 5 = worst.

## What's a Depth Hypothesis?

Simply put, a depth hypothesis is a CUBE depth estimate.

Why not call it a depth estimate? Perhaps we should. But … there is a world of statistics that distinguishes CUBE (Bayesian) methods from other (NHST = Non-Hypothesis Statistical Testing) methods. The concept of a result as a hypothesis is a big deal.

Going a tad deeper, every time a sounding is added to CUBE it is tested against the soundings already included. That is, the existing depth hypothesis. The result of that test, the famous Bayes factor, indicates whether the sounding agrees or disagrees with what is already known. If it agrees, the hypothesis is updated to include the sounding. If it does not agree, a new, alternate hypothesis is created. Contrast that to simple median (for example) and you can see how CUBE might be considered superior.

On the other hand, CUBE requires good estimation of sounding uncertainty, which is not easy to come by. CUBE uses unfamiliar terminology that makes it difficult to explain and understand. And the results usually compare closely to simple median (although median does not provide uncertainty).

## What's a CUBE Node?

CUBE nodes form the regularly spaced grid of estimation points. Node positions exactly equal the center of MBMAX64 matrix cells.

## What about Disambiguation?

CUBE nodes (matrix cells) can only have one depth value. But sometimes CUBE modeling gives more than one. CUBE disambiguation automatically chooses the depth hypothesis it believes best represents the node.

Three methods are available in CUBE Expert Settings. The default method (Prior) works well by simply choosing the depth hypothesis with the most soundings.

## Putting it Together

Given all that, the matrix selection of "CUBE H Count" makes good sense. When CUBE nodes have one depth hypothesis, things are simple. When nodes have more than one hypothesis, some attention may be required. You can manually select in MBMAX64 Cell and Profile windows.

"CUBE H Ratio" applies in the case of multiple hypotheses. It is a value designed to show the 'strength' of the depth hypothesis selected by disambiguation.

RATIO = 5 – NS / (NA – NS)

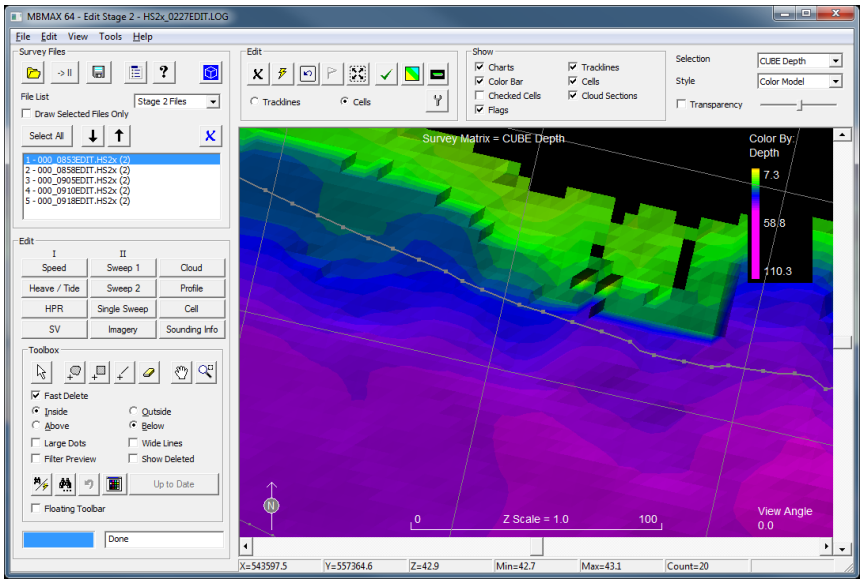
Where NS is sounding count, selected hypothesis and NA is sounding count, all hypotheses. Lower ratios are considered better.

### *CUBE Displays in the Survey Window*

Use the Survey Window to show CUBE in matrix view. The "Selection" list is in the upper right corner.

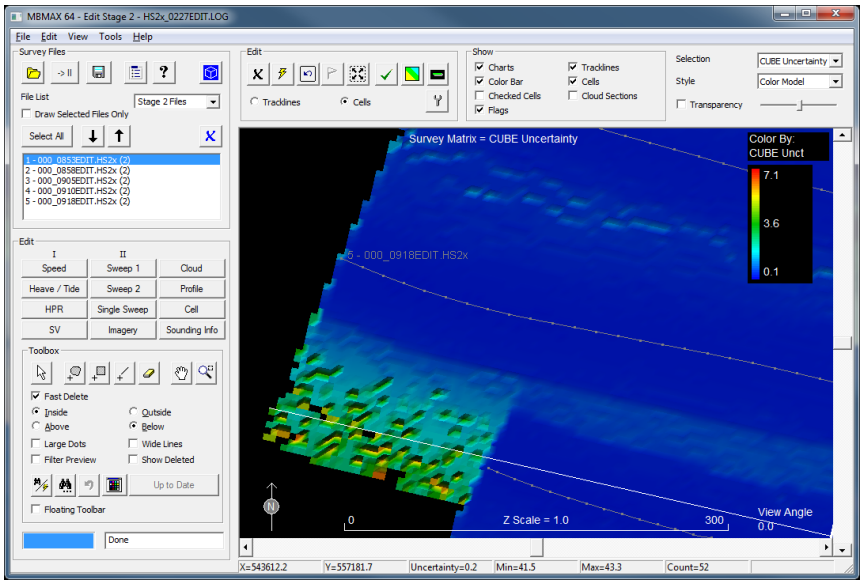
CUBE Depth (Figure 6) is the most useful. Use it to inspect the survey as you would median, average or any other cell statistic.

***FIGURE 6.*** *CUBE Depth in the Survey Window.*




CUBE uncertainty (Figure 7) comes from sounding uncertainty (TPU) and the modeling process.

***FIGURE 7.*** *CUBE Uncertainty in the Survey Window—The area without overlap (lower left) has higher uncertainty than areas with overlap because of lower sounding density.*



CUBE H Count (Hypothesis Count) over bridge piers (Figure 8). Nothing wrong with the soundings, but CUBE is properly unable to provide a single depth estimate.

***FIGURE 8.*** *CUBE H Count in the Survey Window. Bridge piers resulted in multiple (up to eight) depth hypotheses.*

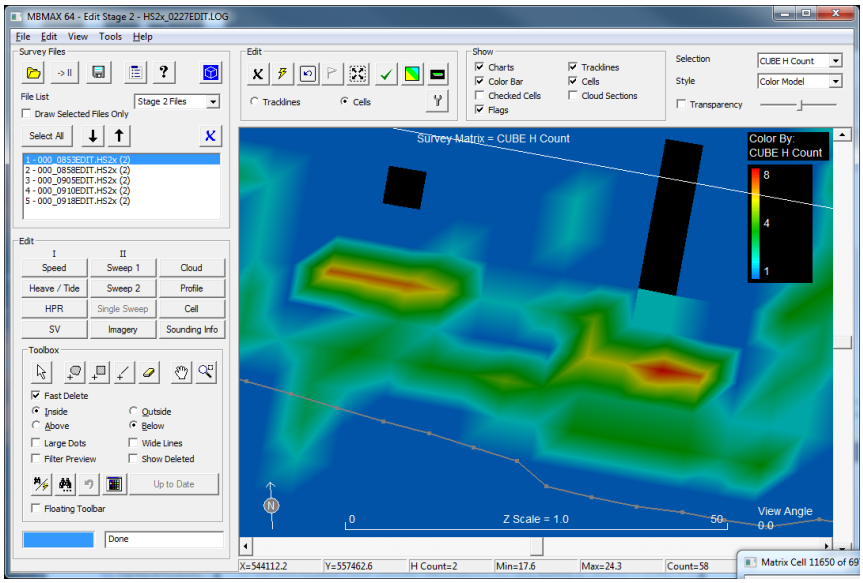
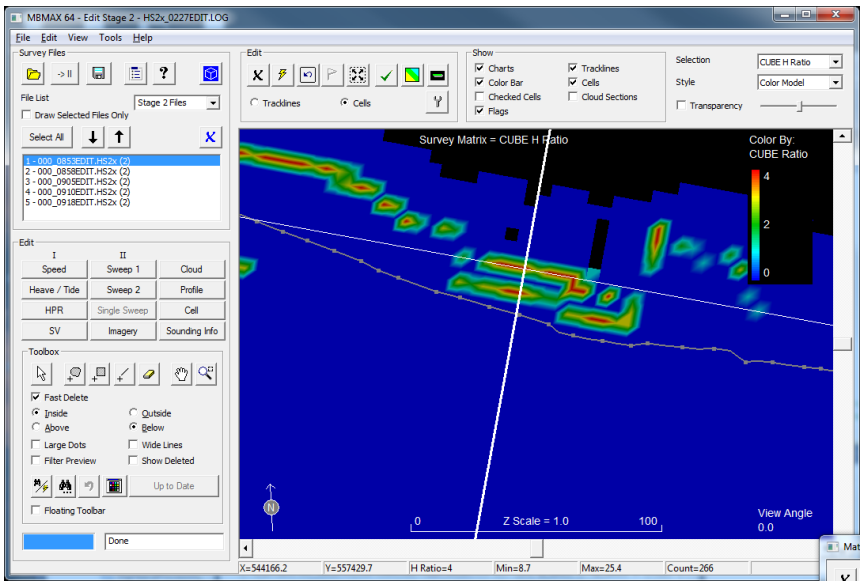



***FIGURE 9.*** *CUBE H Ratio in the Survey Window.*




## *CUBE Display in the Sweep and Cloud Windows*

These windows only show soundings. CUBE is statistics. You won't see it!

# CUBE Depth Editing

There are three ways to change CUBE depths.

- **Select an alternate hypothesis.** Done in Cell, Profile and A-B Cross Section Windows.
- **Edit soundings and recalculate CUBE**.
- **Flag a Golden Sounding**, which overrides CUBE and assigns cell depth = golden sounding depth.

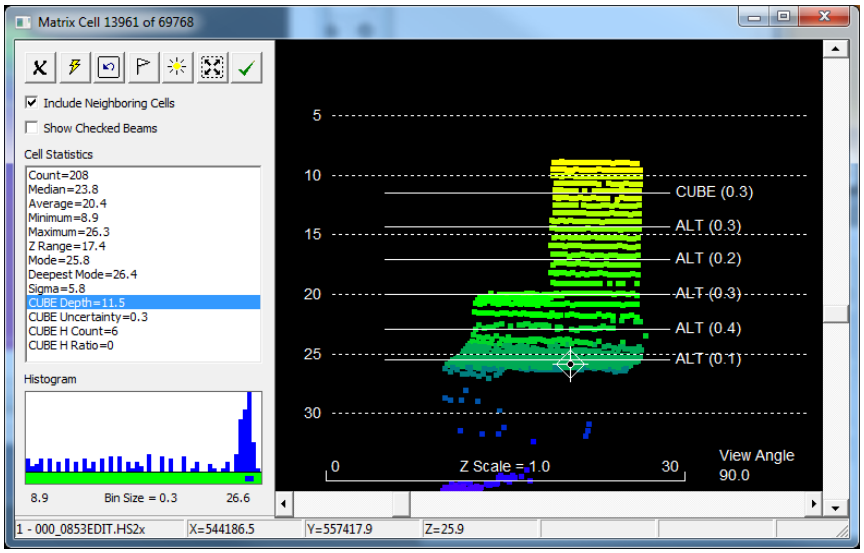
## *CUBE in the Cell Window*

This is where you find the most detail. Figure 10 shows CUBE depth and five alternate hypotheses. The number in parentheses is the uncertainty.

**To change CUBE depth**, click an alternate hypothesis.

While this is a nice, detailed display, it's cumbersome to do your editing here. That's better done in the Profile (or A-B Section) Window.

***FIGURE 10.*** *Detailed CUBE Display in the Cell Window.*




## *CUBE in the Profile Window*

This is the place to edit CUBE. For the best view, check "Matrix Points" and uncheck "Beams".

The profile line connects selected depths and the short horizontal bars show all the possibilities.

**To select an alternate depth**, click on a horizontal bar.

***FIGURE 11.*** *Bad Depth Selection in CUBE is Easy to See in the Profile Window.*

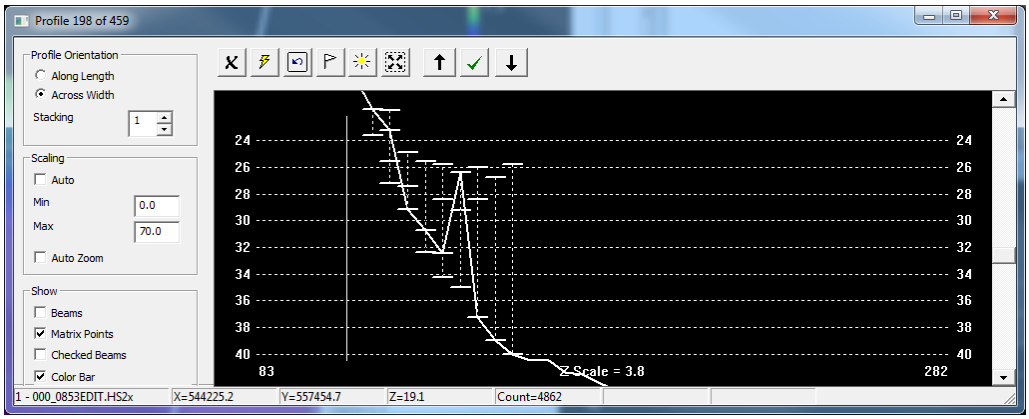
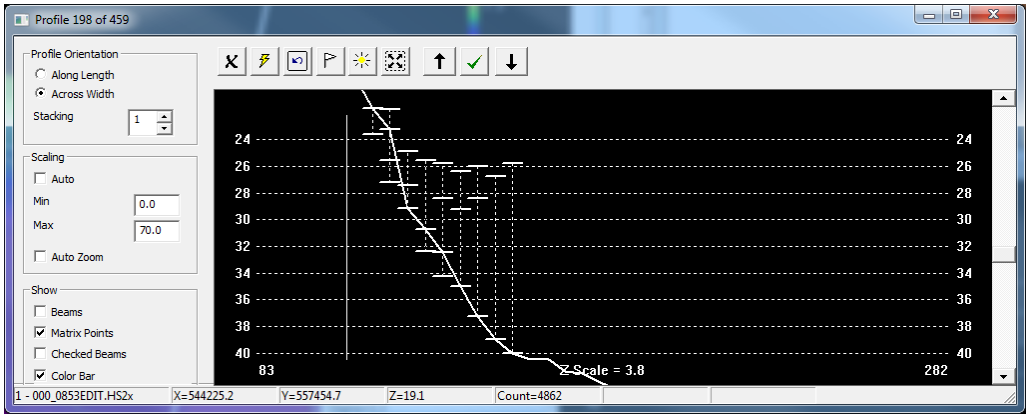



***FIGURE 12.*** *Fixed by Selecting an Alternate CUBE Depth.*




## *CUBE IN THE A-B CROSS SECTION*

This works exactly like the Profile window.