Stack Symbols: A New Methodology for

Mapping Complex Environmental Data in ArcView GIS

Abstract

Stack Symbols ArcView extension was developed by WESTON to automate the repeated mapping of very large three-dimensional environmental data. *Stack Symbols* extension demonstrates an innovative use of graphics for data symbolization using Avenue and customized font-set. Use of the extension reduced the task completion period from 4 persons a week (160 hrs) to two persons a day (16 hrs), along with aesthetically pleasing and understandable maps. The paper describes the process of developing *Stack Symbols* and its associated tools in ArcView GIS, that would help environmental agencies implement more communicative maps with significant time-savings.

Authors

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Introduction

Stack Symbols were developed specifically for an environmental assessment/remediation project that contained a very complex and large dataset Typical data types in this database included sample identifier information, sample collection information, sample matrix, chemical parameters of interest, and spatial reference information. A significant amount of paper bound historical data had to be integrated into the database that would also include newly collected environmental sampling data.

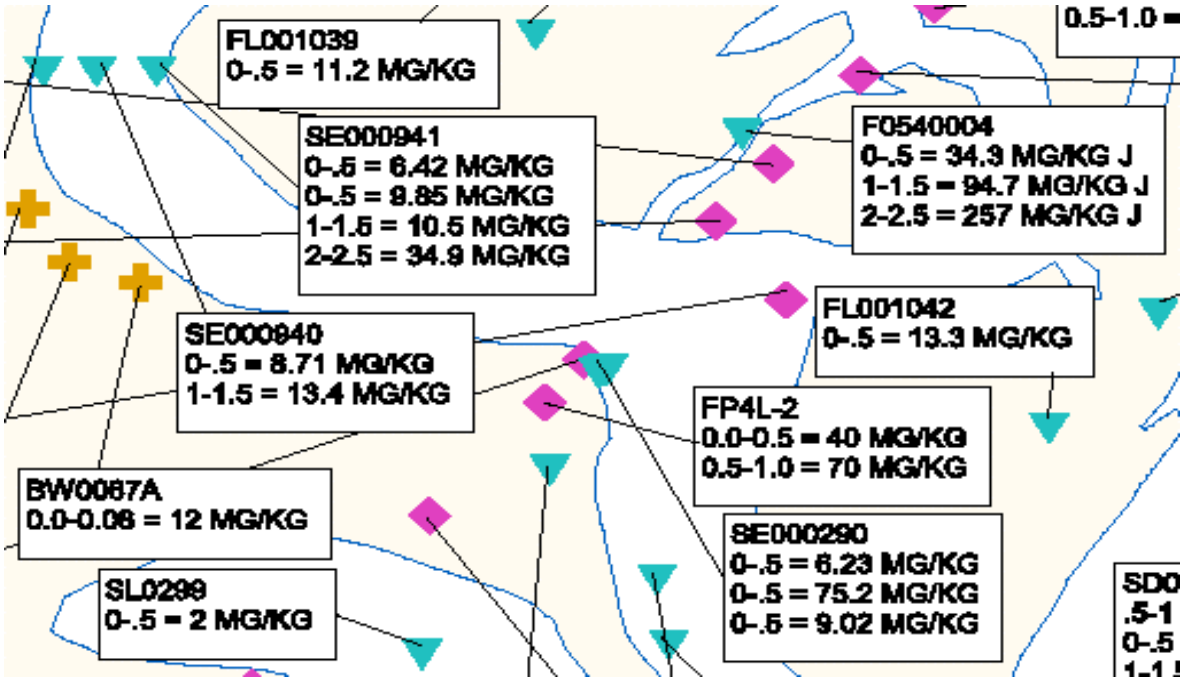
The project currently holds more than one million records stored in a Microsoft Access and Microsoft Sequel Server databases. The data is arranged with the samples as the basic unit of information, uniquely identified by a sample identifier (**Sample_id)**. Generally, each sample is taken at a specific point in space, at a specific depth interval, and includes specific analyses for chemicals of interest. Chemical parameters and depth intervals of the samples are not consistent throughout the dataset. At a single location, the total number of samples could vary from 1 to 48, at various depth intervals.

A location identifier (Location_id) identifies every unique location (in Plan view)**.** New samples were added to the dataset almost every day for a period of 18 months. The central database was updated daily with new sample information and extractions (e.g. smaller results databases) were produced twice a week. ArcView was used to create event themes, based on location information coming directly from the MS Access database.

The client for this project (Regulator) had specifically requested the reporting of sample results on paper maps, in a format that was understandable and informative to the public.

Initial Attempts

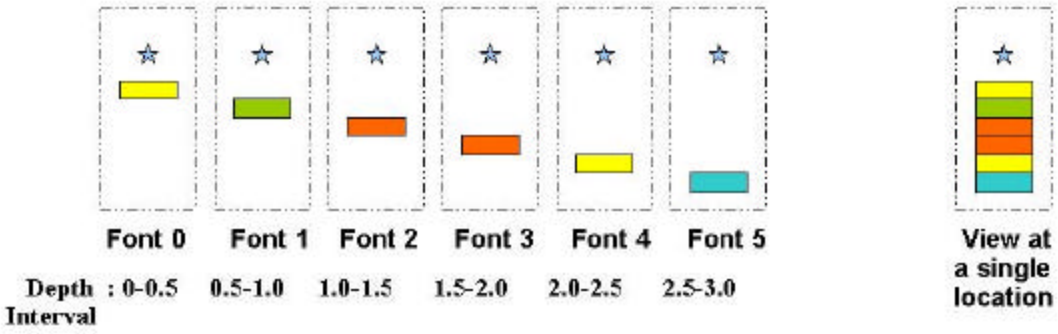
Generating maps that displayed all the chemical results in postings boxes was a very time consuming exercise. It took about four analysts working full time to finish all the maps in a week. By the time the maps were done, they had to be updated again because the data had changed. The following illustration (Figure 1) shows the initial layout of the posting map. This style and format was part of a legacy effect from the historical data presentations. Previous work was completed in AutoCAD, with chemical results presented in call out boxes tied to sample locations, as illustrated below.



Since the mapping was no longer being accomplished in AutoCAD, initial attempts endeavored to utilize the capabilities of ArcView. The default symbol sets available in ArcView could not accommodate the project's large number of sample types. The results had to be posted with information that came from multiple fields within the database. The shear size of the dataset that had to be posted could not be easily managed within the weekly schedule.

The Stack Symbols Solution

The idea to create stack symbols came out of the realization that a customized font type could be used to symbolize sample data for each location. The fonts would have same point of reference but different horizontal bands that could be colored to display result values (see Figure 2).



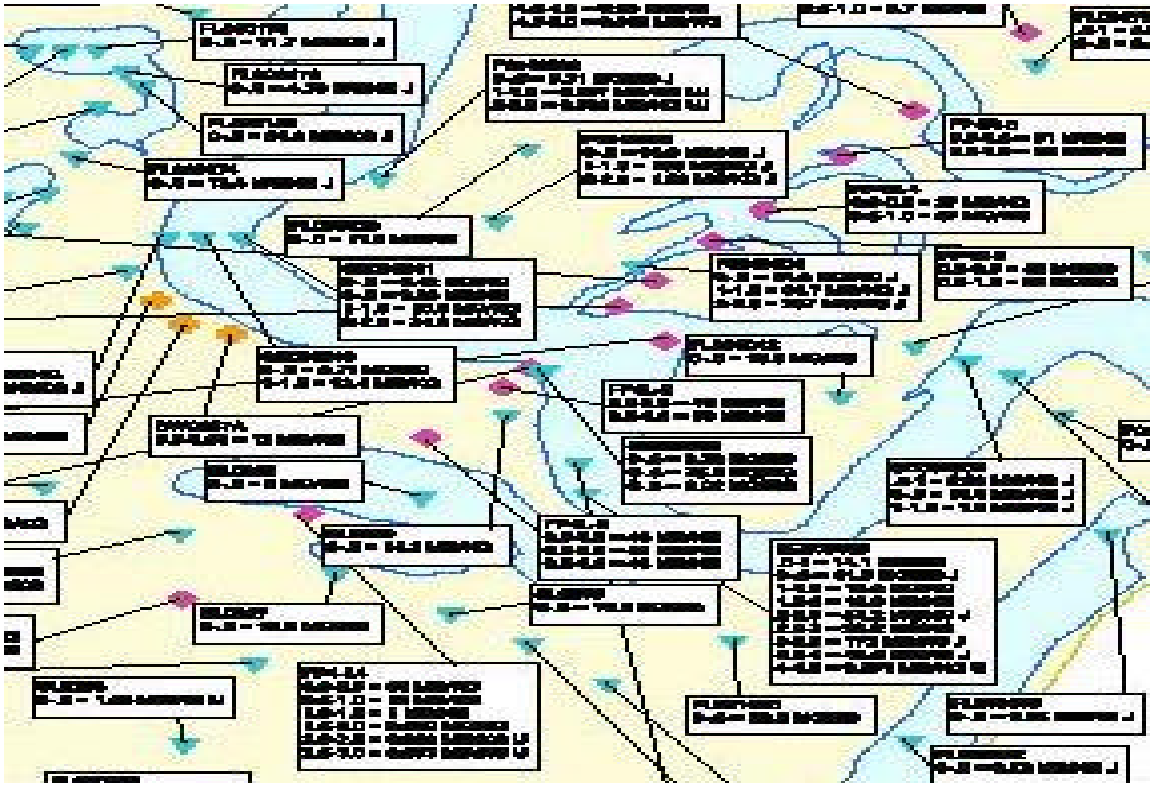
Hence a new custom font type called Stacked Bar Symbols was developed. Macromedia Fontographer version 4.1 was used to design and generate the new True Type font. A composite marker palette was created in ArcView using the characters from this new font. Twenty-one separate characters formed the basis for each bar in the stacked symbol representation. Character sizing and placement in Fontographer was critical to the proper display in ArcView, and special care was taken to ensure that characters overlaid one another cleanly.

Attempts to use the fonts to symbolize the data revealed that they could not be used directly.

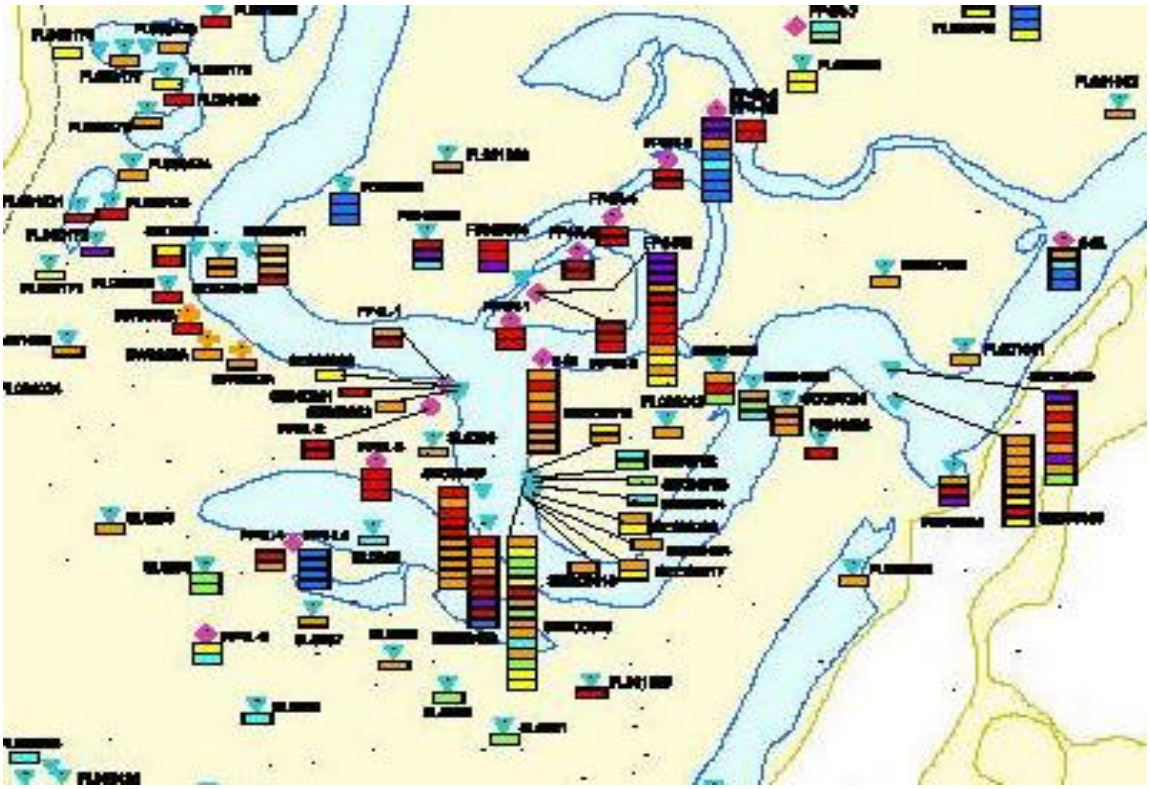
The Need for Stack Symbols

The idea of Stacked Bar Symbols could not be easily implemented with standard symbolization. A single ArcView theme can only accommodate one legend. In this case, we had to first use the depth interval value to decide the font type and then use the result value to symbolize the font color.

This is when we thought of creating ***symbolized graphics*** on top of the location theme features. These graphics were to be generated using stacked bar symbols font set. The challenge was to make these graphics look and feel like a single symbol for each location_ID (NOT sample_ID). At the same time these stack symbols had to be easy to move around, and intelligent enough to retain their respective Location_ID and all the Sample_Ids that formed them. This was achieved through the use of Object Tags.



Map with results Before Stack Symbols:



Map with results using Stack Symbols

Development Environment for Stack Symbols

Stack Symbols were exclusively developed in Avenue, the programming language of ArcView GIS. Stack Symbols were developed for use by two kinds of users:

a. Map production cartographers, who would use the ArcView project file and perform some of the tasks manually. The Stack Symbols gives them more flexibility in developing the project maps.
b. Environmental Engineers, who as the ultimate end users, are supplied with the Stack Symbols ArcView Extension. Most of the data processing tasks as run in the background thus minimizing unnecessary complexity and confusion.

How Stacks Are Generated

To generate Stack Symbols about 8000 records are processed:

a. Depth Intervals for each location_ID are ranked and used to populate a new field in the database called "Rank".
b. Locations with total number of samples greater than 21 are flagged in a new Boolean field named "RankAbv21"

Whenever a new project is created for Stack Symbols, the ArcView palette containing the Stacks font set is saved with the ArcView project so that it would always be available in the memory when the project is loaded.

Finally, Stack Symbols are generated for each location_ID with topmost stack showing results of sample with Rank value 1. The color of the stack symbol is determined by a logic that depends upon the depth and result value of a sample.

The Steps and the Logic followed by the Stack Symbols scripts:

- Check for required field names and types
- Select only those records that could be accommodated within 21 Stacks font set ([RankAbv21] = False)
- ***For each unique Location_ID in the select set***

Get a new copy of Stack Palette
For each unique Sample_ID at the location

1. ***Get the Rank Value***
2. ***Set the appropriate font type and create graphic***
3. ***Get Sample result value***
4. ***Use logic to identify the color for the stack graphic (blue, cyan, green, yellow, orange, red, violet)***
5. ***Set graphic color***
6. ***Set object tag for the graphic to Sample_ID***

End

Group all the graphics for the location

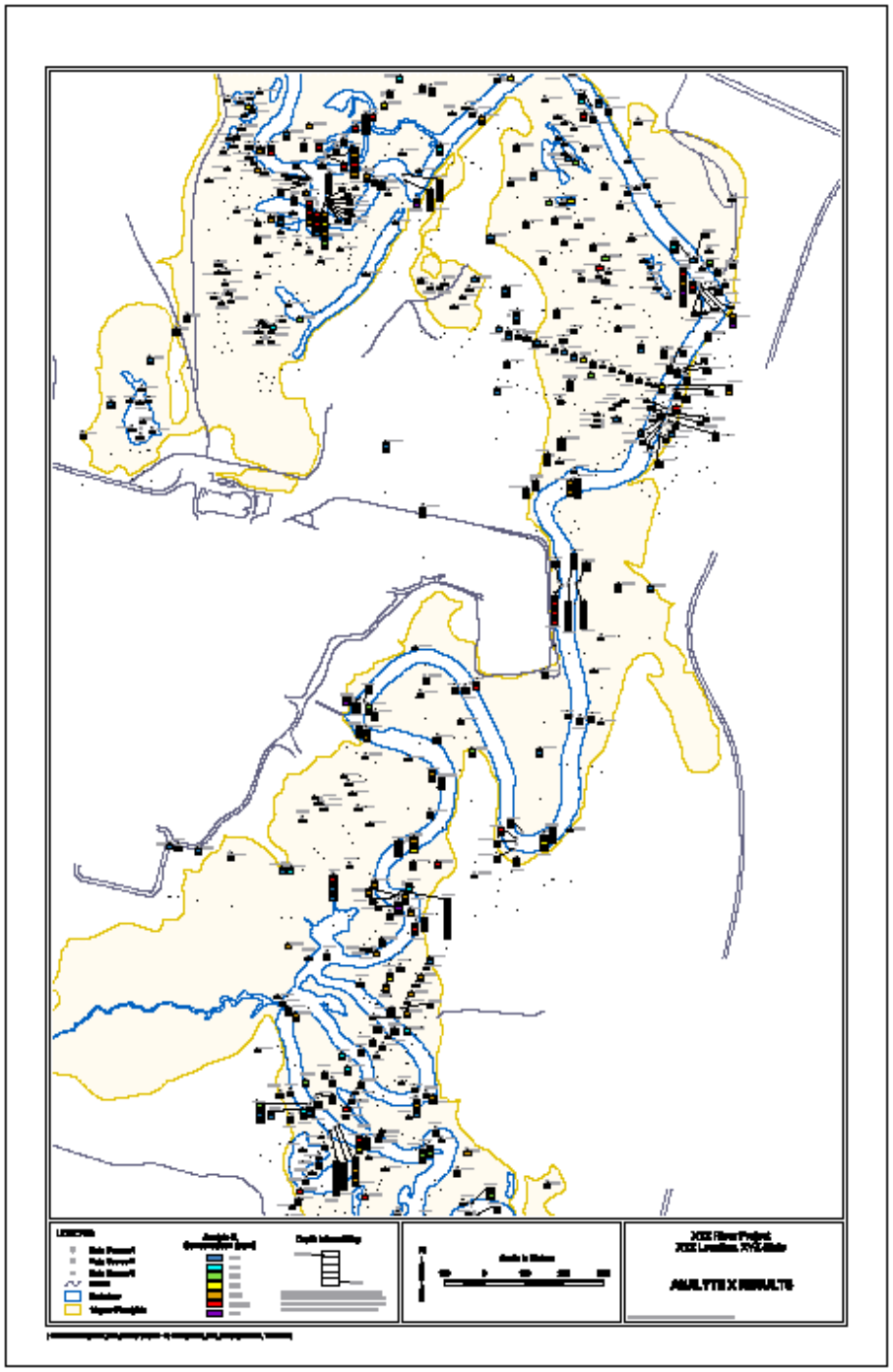
Set object tag for the final stack symbol to Location_ID

- ***End***

Once the stacks are generated, they are resized using customized tools that would increase or decrease Stack Symbol sizes.

Overlapping stacks are manually moved around alittle by the cartogropher to get a more legible and aesthetically pleasing map. An automated line generating tool draws a line between a stack and its source location. This helps minimize the confusion about the source location for a stack symbol when it is moved.

Sample Map



Limitations of current Stack Symbols Extension

1. Gaps in Depth Intervals:

If there is a gap between the two sample depths, it is not visible in the Stack Symbols.

2. Overlapping Depth Intervals:

If the depth intervals among the samples overlapped, then the Stack Symbols could show misleading information.

3. Actual Result Value is not shown.

4. Limit of 21 Depth Intervals:

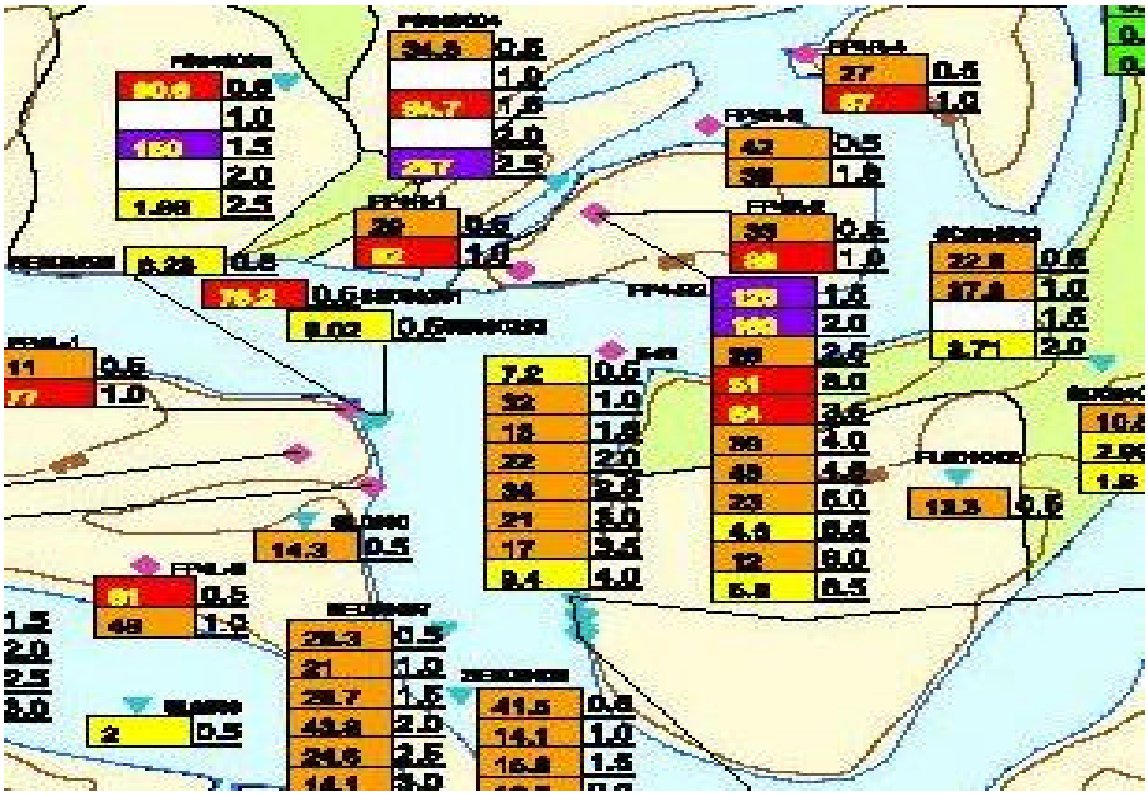
The database contained Locations where the total number of samples exceeded 21. Ideally speaking, the stack symbols should be able to accommodate any number of samples and depth intervals.

Future Developments

Stack Symbols extension will eventually develop into an end user tool that will help clients create stack symbols as part of the larger interface that has been developed by WESTON.

- We intend to automate most of the steps involved in processing the data.
- Additional tools will be developed that would allow the user to save the stack symbol set separately, and reload them whenever needed.
- Stack symbols will behave more like a regular theme, users shall be able to click on the symbol and see detailed information about its Location ID, and additional information identified as useful by the clients.
- In the ***Stacks-2000*** version, we have already gone beyond what we envisioned earlier. The latest version of Stack Symbols overcomes many of the shortcomings of original stack symbols utility:

    1. It uses a set of graphics instead of fonts. This lends a new level of flexibility with the stacks. Now an unlimited number of samples and depth intervals can be accommodated.
    2. Gaps between the stacks are shown in the stack symbols graphics.
    3. Actual result values are also posted inside the stacks.
    4. Depth intervals are also labeled to minimize confusion when depth intervals are overlapping.



Current Look of Stack Symbols

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