Mapping Constituents Using FIELDS

FIELDS is a software system developed by the U.S. Environmental Protection Agency (EPA) to support sampling and remedial decision-making. This project used FIELDS to assist in the development of a preliminary systematic plan for remediation at the Marino Scrap Yard site (the site).

FIELDS Software

FIELDS was developed on an ArcView platform using many ArcView commands, but FIELDS incorporates additional modules, several of which were used during the course of this project. FIELDS is intended to provide a means to:

- Query a database and develop shapefiles

- Contour data

- Create maps

- Calculate removal volumes

Each one of these steps is discussed in detail below.

Querying the Database and Process Shapefiles

FIELDS' query tool can be used to select data to meet specific criteria, then process the data into shapefiles to be used as themes in ArcView. The Query dialog box indicates data can be selected by identifying a depth interval and analyte, and choosing one of several query options. The query options include: select the maximum concentration of a constituent in a specific depth interval; select the maximum concentration of a constituent at a single location; average the concentrations of a constituent within a specific depth interval; or average all data for a constituent at one location. The resulting 2 dimensional array of values can be converted to a shapefile for contouring through the "save as" command.

In practice, the query tool was unable to sort by analyte or depth interval, requiring these steps to be conducted external to the FIELDS program. This deficiency has been reported to the software developers, who are working to correct it for the next version.

Contour the Data

Two themes (shapefiles) must be loaded prior to running one of the contouring algorithms: a point theme (created in the previous step) and a polygon theme (which can be imported or created in FIELDS using ArcView tools). The point theme contains the scattered data (constituent concentrations) to be contoured. The polygon theme provides the boundary within which the contours will be calculated. Two contouring algorithms are currently available in FIELDS: natural neighbor and inverse distance. Natural neighbor was selected based on the recommendations of the FIELDS development team. The natural neighbor algorithm calculates a concentration value at each node based on the surrounding measured data values; the measured values are weighted according to their proximity to the node (neighboring values carry the most weight). FIELDS currently supports only 2 dimensional contouring.

Creating the Maps

Maps created with the FIELDS contouring algorithms can be sent to a plotter or plotted to a postscript file for later conversion to portable document format (PDF) format. The ArcView platform provides

substantial flexibility in output options. Layouts can be saved and reused for different analytes and depth intervals. Aerial photos and AutoCAD base maps can be incorporated into output plots.

Calculating Volumes of Soil Exceeding Site-Specific Standards

FIELDS provides several tools to analyze and evaluate remedial options. These include a mass/volume calculator that calculates the volume enclosed within a contour interval specified by the user. The user can specify the site-specific standard to provide an estimate of the volume of soil to be removed within a specified depth interval.

APPLICATION TO MARINO SCRAP YARD PROJECT

FIELDS mapping and analysis was conducted to support the development of a systematic plan for remediation at the site.

Processing of Soil Data

Data were processed using Microsoft Access before entry into FIELDS because the query tool did not perform as expected. The soil data were analyzed using STATISTICA to identify those constituents with maximum reported values that exceeded the appropriate Pennsylvania Department of Environmental Protection (PADEP) medium-specific concentrations (MSC) from the Act 2 Technical Guidance (PADEP, 2002). Analytes that had maximums exceeding the PADEP MSCs were considered chemicals of potential concern (COPC) and were evaluated using FIELDS.

Because FIELDS is a 2 dimensional mapping program, the data were grouped into the following 2-foot depth intervals for mapping and analysis: 0.0 to 2.0 feet below ground surface (bgs), 2.0 to 4.0 feet bgs, 6.0 to 8.0 feet bgs, and 10 to 12 feet bgs. These intervals correspond to the greatest data density. The 4.0-to 6.0-foot interval, by contrast, contained too few data to contour. Attachment 1 provides a list of the COPCs for the site.

A contouring program, such as the natural neighbor algorithm used in FIELDS, interpolates between scattered data points to calculate concentrations at nodes on a regular grid. The resulting matrix of values is smoothed because of the averaging of multiple data points at each grid node. The greater the density of data, the more smoothing will occur. Therefore, the maximum calculated value is lower than the maximum point value in the input data set. However, this smoothing effect provides a more realistic estimate of ambient concentrations, particularly if used in a risk-based decision-making process. Maximum calculated values for each COPC and depth intervals that could be mapped are listed on the table provided as part of this attachment.

Analysis Based on PADEP Residential MSCs

Contour maps were created for each COPC and depth interval that had maximum calculated concentration exceeding the identified appropriate residential MSCs for soil based on PADEP's Act 2 Technical Guidance (PADEP, 2002). Twenty-seven maps depicting the areal extent of COPC concentrations that exceed PADEP residential MSCs were created. Ten COPCs were found to exceed PADEP residential MSCs in at least one of the four depth intervals. Lead, arsenic and iron exceeded the PADEP residential MSCs in all four depth intervals, while mercury, cadmium, and the three polychlorinated biphenyls (PCBs) only exceeded PADEP residential MSCs in the upper four feet; antimony exceeded the PADEP residential MSC in the upper three depth intervals.

The distribution and magnitude of some of the COPCs, such as lead, mercury and the PCBs (Aroclor 1248, 1254 and 1260), are indicative of site-related contamination. Certain inorganic COPCs, such as

arsenic, however, may exceed the PADEP residential MSCs primarily as a result of high background concentrations created by the presence of slag commonly used as fill throughout the region.

Analysis Based on Site -Specific Standards

In order to provide a more realistic risk-based estimation of the remedial action possibly required at the site, site-specific standards were developed. A FIELDS analysis was again conducted by mapping COPC concentrations exceeding the site-specific standards. Less than half of the COPCs that exceeded the PADEP residential MSCs were found to exceed the site-specific standards. Arsenic, cadmium, and zinc drop off the list of COPCs when site-specific standards values are used. Only lead exceeds the site-specific standard at depths greater than 4 feet, and only near a single sample location.

Calculating Removal Volume with FIELDS

The mass/volume calculator included in FIELDS was used to provide a conservative estimate of the volume of soil removal necessary to bring soil concentrations below site-specific standards for all of the COPCs. The mass/volume calculator was used to develop a conservative estimate of soil volume to be removed (all soil exceeding site-specific standards is included in the total volume).

Lead was found to be the most widespread COPC. The maps developed for the site-specific standards showed that areas where other COPCs exceeded the site-specific standards were encompassed by the area where lead exceeded the standard. Therefore, lead was used as an indicator COPC for the purpose of performing volume calculations. Lead maps were used as the input data matrices; specifically, the matrices of calculated lead values in the 0.0 to 2.0-foot and the 2.0 to 4.0-foot depth intervals were input to the mass/volume calculator. The site-specific standard for lead (1,300 milligrams per kilogram [mg/kg]) was used as the cutoff; lead concentrations exceeding this value were assumed to require removal. These areas were multiplied by the 2 foot thickness to arrive at the volumes to be removed. FIELDs did not calculate a removal volume for the 6.0 to 8.0-foot interval. The estimated value for the missing depth interval (4.0 to 6.0 feet) was an arithmetic interpolation by Tetra Tech based on the adjacent depth intervals. This is a conservative approach because no removal volume was calculated for the lower interval. The total volume calculated to remove all soil exceeding site-specific standards is 18,043 cubic yards.

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Table 1

Cleanup Standards for Soil and FIELDS Results

Chemical Risk Driver	Site-Specific Standard (mg/kg)	PADEP Residential MSC[1] (mg/kg)	Depth Interval (feet)	Maximum Interpolated Concentration[2] (mg/kg)	Maps Made	
					Site-Specific Standard[3]	PADEP Residential MSC[3]
Antimony	520	27	0-2	1,461	X	X
			2-4	237		X
			6-8	37		X
			10-12	15		
Arsenic[4]	196	12	0-2	205		X
			2-4	86		X
			6-8	41		X
			10-12	53		X
Cadmium	2,059	38	0-2	602		X
			2-4	242		X
			6-8	33		
			10-12	57		X
Iron	389,944	66,000	0-2	511,842	X	X
			2-4	421,667	X	X
			6-8	280,626		X
			10-12	290,934		X
Lead	1,300	450	0-2	29,144	X	X
			2-4	9,422	X	X
			6-8	1,376	X	X
			10-12	1,100		X
Mercury	390	10	0-2	20,127	X	X
			2-4	72		X
			6-8	1.8		
			10-12	7.7		
Zinc	389,944	12,000	0-2	325,262		X
			2-4	74,247		X
			6-8	2,438		
			10-12	3,473		

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Aroclor 1248	59	9.9	0-2	2,449	X	X
			2-4	36.9		X
			6-8	0.7		
			10-12	3.1		
Aroclor 1254	59	4.4	0-2	33,009	X	X
			2-4	121	X	X
			6-8	2.5		
			10-12	1.5		
Aroclor 1260	59	4.4	0-2	1,753	X	X
			2-4	114	X	X
			6-8	4.8		X
			10-12	1		
Total Number of Maps:					**12**	**29**

Notes:

1 PADEP residential MSCs for arsenic, iron, aroclor 1248, aroclor 1254 and aroclor 1260 represent soil direct contact standards; remaining PADEP residential MSCs represent generic standards.

2 Maximum value interpolated by FIELDS' Natural Neighbor contouring algorithm. Contouring algorithm interpolates values of concentration at each node of a calculation grid by averaging all sample results and weighting sample results according to distance from node.

3 Only interpolated values greater than the standard (site-specific or PADEP residential MSCshown on maps. Maps were not made for constituents/depth intervals where interpolated values did not exceed the standard.

4 Contouring algorithm did not plot an area above the site-specific standard even though it assigned an upper bound of the highest contour interval above the site-specific standard of 196 mg/kg..

PADEP = Pennsylvania Department of Environmental Protection
MSC = Medium Specific Concentration

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					Site-Specific Standard[3]	PADEP Residential MSC[3]

mg/kg = milligrams per kilogram