

# **Stochastic Empirical Loading and Dilution Model (SELDM) Version 1.0.0—Appendix 4. Navigating the Graphical User Interface**

By Gregory E. Granato

Prepared in cooperation with the  
U.S. Department of Transportation, Federal Highway Administration,  
Office of Project Development and Environmental Review

Techniques and Methods 4–C3

**U.S. Department of the Interior  
U.S. Geological Survey**

**U.S. Department of the Interior**  
KEN SALAZAR, Secretary

**U.S. Geological Survey**  
Suzette M. Kimball, Acting Director

U.S. Geological Survey, Reston, Virginia: 2013

For more information on the USGS—the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environment, visit <http://www.usgs.gov> or call 1-888-ASK-USGS.

For an overview of USGS information products, including maps, imagery, and publications, visit <http://www.usgs.gov/pubprod>

To order this and other USGS information products, visit <http://store.usgs.gov>

Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Although this information product, for the most part, is in the public domain, it also may contain copyrighted materials as noted in the text. Permission to reproduce copyrighted items must be secured from the copyright owner.

Suggested citation:

Granato, G.E., 2013, Stochastic empirical loading and dilution model (SELDL) Version 1.0.0—Appendix 4, Navigating the graphical user interface: U.S. Geological Survey Techniques and Methods, book 4, chap. C3, 66 p., CD-ROM. (Also available at <http://pubs.usgs.gov/tm/04/c03/>.)

# Contents

|   |    |
|---|----|
| Introduction.....   | 1  |
| The Opening Form.....   | 3  |
| Information Forms.....  | 3  |
| Documentation Forms.....  | 5  |
| The Analyst Identification Form .....   | 5  |
| The Project Identification Form.....  | 7  |
| The Analysis Identification Form.....   | 9  |
| Site and Region Forms .....   | 11 |
| The Highway Site Form.....  | 11 |
| The Review Geographic Information System (GIS) Grid Form.....                                   | 13 |
| The Ecoregion Form.....   | 15 |
| The Upstream Basin Form.....  | 17 |
| The Lake Basin Form .....   | 20 |
| Hydrology Forms .....   | 20 |
| Synoptic Storm Event Precipitation Statistics Forms .....                                       | 20 |
| The Synoptic Storm Event Precipitation Statistics Form .....                                    | 22 |
| The Create or Modify a Precipitation-Station List Form.....                                     | 27 |
| Streamflow Statistics Forms.....  | 27 |
| The Streamflow Statistics Form .....  | 29 |
| The Create or Modify a Streamgage List Form.....  | 34 |
| The Volumetric Runoff Coefficient (Rv) Statistics Form .....                                    | 36 |
| Water Quality Forms.....  | 38 |
| The Water-Quality Selection Form.....   | 38 |
| The Water-Quality Random Statistics Form for Highway Runoff and Upstream<br>Water Quality ..... | 43 |
| The Dependent Water-Quality Statistics Form for Highway and Upstream<br>Water Quality .....     | 46 |
| The Transport Curve Statistics Form for Upstream Water Quality .....                            | 50 |
| The Downstream Water Quality Constituent Pairs Form .....                                       | 53 |
| The Best Management Practice (BMP) Performance Form .....                                       | 56 |
| The Run SELDM Form.....   | 61 |
| References Cited.....   | 65 |

## Figures

|       |  |    |
|-------|--|----|
| 4-1.  | Schematic diagram showing the flowchart for entering input data and for running an analysis .....  | 2  |
| 4-2.  | SELDM Opening form.....  | 3  |
| 4-3.  | Examples of the information forms used in SELDM: <i>A</i> , Explanation, <i>B</i> , Information, and <i>C</i> , Analysis Status .....  | 4  |
| 4-4.  | Analyst Identification form, showing the <i>A</i> , Name and <i>B</i> , Role tabs with required information.....   | 6  |
| 4-5.  | Project Identification form, showing the <i>A</i> , General Project Information and <i>B</i> , System Variables tabs with required information .....   | 8  |
| 4-6.  | Analysis Identification form, showing the <i>A</i> , Name and <i>B</i> , Analysis Options tabs with required information.....  | 10 |
| 4-7.  | Highway Site form, showing the <i>A</i> , Name and Location and <i>B</i> , Hydraulics tabs with required information.....  | 12 |
| 4-8.  | Review Geographic Information System (GIS) Grid form, showing <i>A</i> , a properly specified site latitude and longitude, and <i>B</i> , a red warning accompanying an improperly specified site location.....  | 14 |
| 4-9.  | Ecoregion form, showing the <i>A</i> , Ecoregion Information and <i>B</i> , Neighboring Ecoregions tabs .....  | 16 |
| 4-10. | Upstream Basin form, showing the <i>A</i> , Basin Information tab; <i>B</i> , Hydraulics tab; and <i>C</i> , the Hydrograph Recession tab with required information .....  | 18 |
| 4-11. | SELDM Information form showing hydrograph-recession statistics calculated using input values for the triangular distribution .....   | 19 |
| 4-12. | Lake Basin form showing the <i>A</i> , Basin Information and <i>B</i> , Hydraulics input tabs with required information.....   | 21 |
| 4-13. | Synoptic Storm-Event Precipitation Statistics form showing the Definition tab <i>A</i> , before any precipitation options are selected for a new project; <i>B</i> , after a regional selection has been made; <i>C</i> , after the Enter New Definition option is selected; and <i>D</i> , after the Edit Current Definition is selected while using the Selected Station Average option..... | 23 |
| 4-14. | Synoptic Storm-Event Precipitation Statistics form, showing <i>A</i> , the Storm Event Statistics tab, and <i>B</i> , the Annual Statistics and Station Count tab as they appear for user-defined input.....   | 26 |
| 4-15. | Create or Modify a Precipitation-Station List form showing <i>A</i> , the precipitation stations available for selection; <i>B</i> , the message box confirming the selection; <i>C</i> , the statistical summary for the selected stations; and <i>D</i> , the input box for a Short Name for the selected statistics .....   | 28 |
| 4-16. | Streamflow Statistics form showing the Definition tab <i>A</i> , before any streamflow options are selected for a new project; <i>B</i> , after a regional selection has been made; <i>C</i> , after the Enter New Definition option is selected; and <i>D</i> , after the Edit Current Definition is selected while using the Selected Station Average option .....                           | 30 |
| 4-17. | Streamflow Statistics form, showing the <i>A</i> , Streamflow Statistics, in CFM and <i>B</i> , Low-Flow Statistics and Station Count tabs as they appear for user-defined input .....   | 33 |
| 4-18. | Create or Modify a Streamgauge List form showing <i>A</i> , the streamgages available for selection; <i>B</i> , the message box confirming the selection; <i>C</i> , the statistical summary for the selected stations; and <i>D</i> , the input box for a Short Name for the selected statistics.....   | 35 |

|       |   |    |
|-------|---|----|
| 4-19. | Create Volumetric Runoff Coefficient (Rv) Statistics form, showing <i>A</i> , the Highway Site tab before clicking Accept Updates, and <i>B</i> , the upstream basin tab before clicking Accept Updates .....   | 37 |
| 4-20. | Water-Quality Menu form showing the <i>A</i> , Explanation, <i>B</i> , Highway Random, <i>C</i> , Highway Dependent, <i>D</i> , Upstream Random, <i>E</i> , Upstream Transport Curve, and <i>F</i> , Upstream Dependent information and data entry tabs .....   | 39 |
| 4-21. | Water-Quality Menu Form showing the Downstream Pairs data entry tab.....  | 42 |
| 4-22. | Water-Quality Random Statistics form, showing the <i>A</i> , Water Quality Statistics and <i>B</i> , Constituent Definition Information tabs for highway-runoff quality constituents and the <i>C</i> , Water Quality Statistics and <i>D</i> , Ecoregion tabs for the upstream water-quality constituents .....                | 44 |
| 4-23. | Dependent Water-Quality Statistics form, showing the <i>A</i> , Water-Quality Equation Description, <i>B</i> , Equation Parameters, <i>C</i> , Constituent Definition Information tabs, and <i>D</i> , the form as it appears after clicking the Accept Updates button for the Highway Runoff Quality version of the form ..... | 48 |
| 4-24. | Transport Curve Water-Quality Statistics form for upstream water quality, showing the <i>A</i> , Water-Quality Equation Description, <i>B</i> , Equation Parameters, <i>C</i> , Ecoregion, and <i>D</i> , Constituent Definition Information tabs.....  | 51 |
| 4-25. | Downstream Water Quality Constituent Pairs form, showing the <i>A</i> , Identification, <i>B</i> , Concentration of Concern, <i>C</i> , Lake Analysis, and <i>D</i> , Description tabs for editing a Constituent Pair.....  | 54 |
| 4-26. | Best Management Practice Performance form, showing the <i>A</i> , BMP Overview, <i>B</i> , Hydraulics, <i>C</i> , Water Quality Parameters, and <i>D</i> , Water Quality Treatment Definition tabs .....  | 57 |
| 4-27. | Best Management Practice Performance form showing the configuration for the No BMP In Place selection .....   | 60 |
| 4-28. | Best Management Practice Performance form, showing the configuration for the copy option .....  | 60 |
| 4-29. | Run SELDM Form, showing the <i>A</i> , initial and <i>B</i> , post-analysis views and the <i>C</i> , post lake analysis view of the Run SELDM tab, and <i>D</i> , Output File Locations, and <i>E</i> , Explanation and Disclaimer tabs .....   | 62 |

## Abbreviations

|                |   |
|----------------|---|
| BMP            | best management practice  |
| CD-ROM         | compact disk-read only memory   |
| CFSM           | cubic foot per second per square mile (ft <sup>3</sup> /s/mi <sup>2</sup> ) |
| EA             | environmental assessment  |
| EIS            | environmental impact statement  |
| EMC            | event mean concentration  |
| FHWA           | Federal Highway Administration  |
| GIS            | geographic information system   |
| GNIS           | Geographic Names Information System   |
| GUI            | graphical user interface  |
| HRDB           | Highway Runoff Database   |
| ID             | identification number   |
| KTRLLine       | Kendall-Theil Robust Line   |
| LMPV           | lower most probable value   |
| MAD            | median absolute deviation   |
| MIC            | minimum irreducible concentration   |
| MPV            | most probable value   |
| NAD83          | North American Datum of 1983  |
| NEPA           | National Environmental Policy Act   |
| NURP           | Nationwide Urban Runoff Program   |
| NWIS           | National Water Information System   |
| PCode          | parameter code  |
| PLACER         | Point Location and Calculation of Error (a computer program)                |
| R <sub>v</sub> | volumetric runoff coefficient   |
| SELDM          | Stochastic Empirical Loading and Dilution Model                             |
| SPAF           | Synoptic Precipitation Analysis Facilitator                                 |
| SSC            | suspended sediment concentrations   |
| TSS            | total suspended solids  |
| UMPV           | upper most probable value   |
| USEPA          | U.S. Environmental Protection Agency  |
| USGS           | U.S. Geological Survey  |
| VBA            | Microsoft Visual Basic for Applications®                                    |

# Stochastic Empirical Loading and Dilution Model (SELDM) Version 1.0.0—Appendix 4. Navigating the Graphical User Interface

By Gregory E. Granato

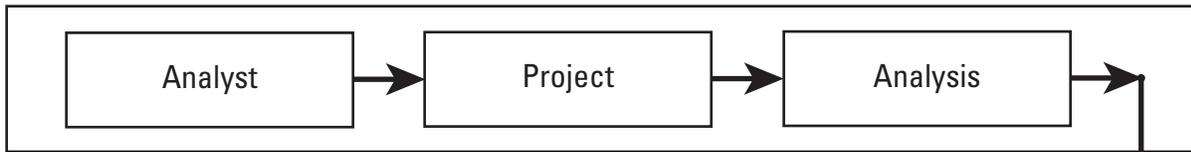
## Introduction

The Stochastic Empirical Loading and Dilution Model (SELDM) was developed as a Microsoft Access® database application to facilitate storage, handling, and use of the hydrologic datasets with a simple graphical user interface (GUI). The SELDM GUI is designed to populate the database with data and statistics for the analysis and to specify index variables that are used by the program to query the database when SELDM is run. Four categories of input data, which include (1) documentation, (2) site and region information, (3) hydrologic statistics, and (4) water-quality statistics, are needed to run SELDM. The SELDM GUI has one or more forms that are used to enter or edit each of the four categories of input data (fig. 4–1). The documentation data include information about the analyst, the project, and the analysis. The site and region data include the highway site characteristics, the ecoregions, the upstream basin characteristics, and if a lake analysis is selected, the lake basin characteristics. The hydrologic data include precipitation, streamflow, and runoff coefficient statistics. The water-quality data include highway-runoff quality statistics, upstream water-quality statistics, downstream water-quality definitions, and best management practice (BMP) performance statistics. There also is a GUI form for running the model and accessing the distinct set of output files. The data entry process follows a linear progression through the input forms (fig. 4–1). Thus, it is necessary to step through the input forms each time an analysis is run. However, you may step through each form by clicking the Proceed button without modifying input data once the required data have been specified.

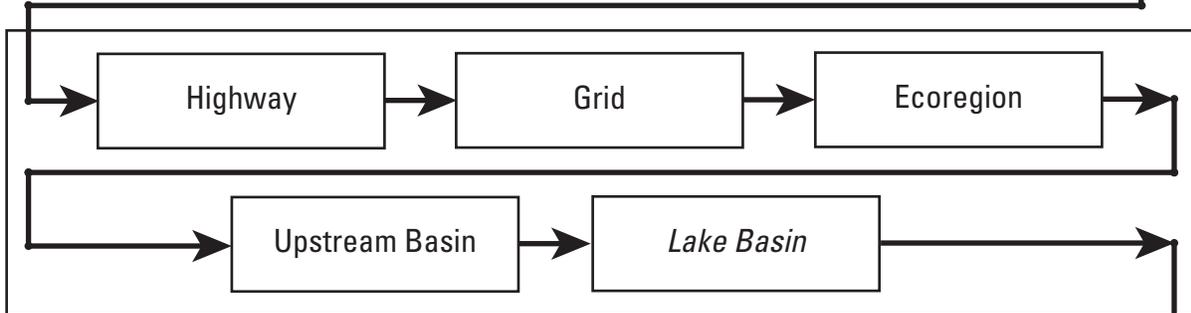
The program's menu-driven GUI uses standard Microsoft Visual Basic for Applications® (VBA) interface controls to facilitate entry, processing, and output of data. These controls include option-group frames for making choices, listboxes and comboboxes (which are sometimes called dropdown lists) for selecting predefined values, textboxes for entering data, and command buttons for navigating through the model forms and for running the model. A detailed discussion of basic form controls in the SELDM GUI is provided in the section titled “Navigating the Graphical User Interface” in the main SELDM manual.

The purpose of this appendix is to provide a description of each form in the GUI with figures showing the configuration of each form to help you navigate through the GUI. This appendix documents the controls on each form to facilitate the use of the form. This appendix also documents the type of data to be entered or selected on each form with references to the associated information on the theory and implementation of the model that is documented in the main SELDM manual.

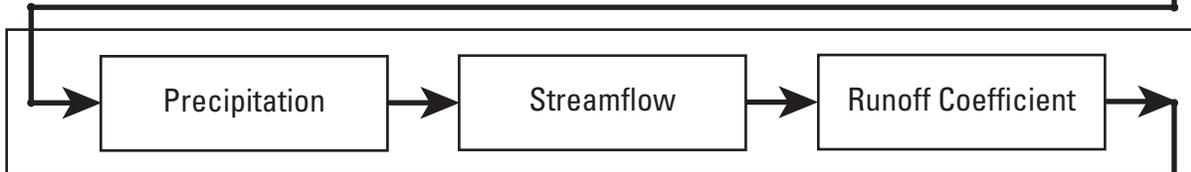
**Documentation:**



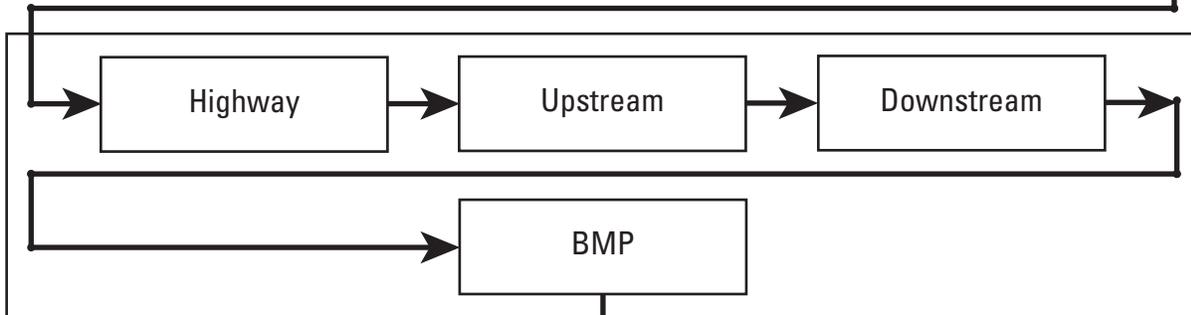
**Site and Region:**



**Hydrology:**



**Water Quality:**



**Figure 4–1.** Schematic diagram showing the flowchart for entering input data and for running an analysis. The component “Lake Basin” is italicized because this form is not used in all analyses. BMP, best management practice.

## The Opening Form

Opening the SELDM model automatically launches the Opening form (frmOpen, fig. 4-2). Clicking the Version 1.0.0 command button on the form provides the SELDM version number and detailed version information, including citations to model documentation. The version number on this form will automatically be updated by SELDM when new versions are specified in the table tblVersionInformation. The Explanation command button opens the explanation form that includes a short narrative explaining the purpose of and uses for SELDM. The Disclaimer command button opens the explanation form with a standard governmental disclaimer for usage of software. The Proceed command button closes the Opening Form and opens the Analyst Information Form. The Close Form command button closes the Opening Form without opening another form or exiting the database application. Clicking the Close Form command button closes the GUI without closing the database and provides the option to reveal the Microsoft Access® database-window navigation pane. This option is useful for working directly in the database, which is by default hidden from the user. Please note that any changes to the names or the designs of forms, tables, and fields will corrupt the existing GUI. Also, manual changes or deletion of data in the database window may corrupt analyses that use those data records. The Exit SELDM command button closes the Opening form and also exits the database application.

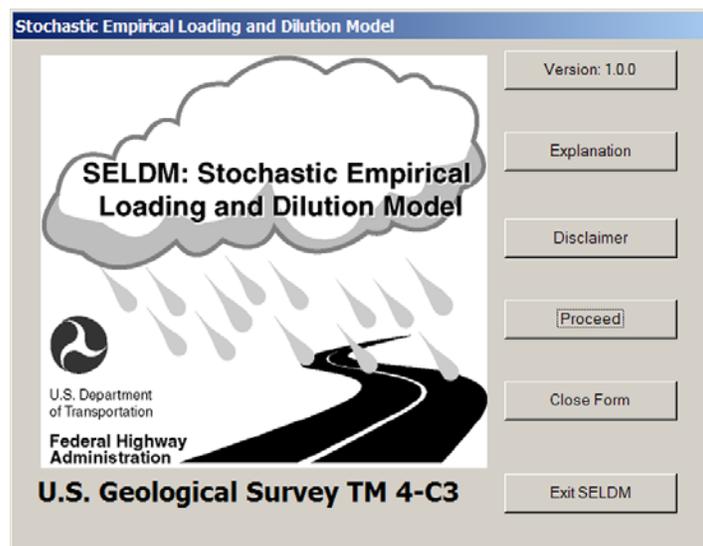


Figure 4-2. SELDM Opening form.

## Information Forms

Three information forms are used throughout the SELDM GUI (fig. 4-3). These are the Explanation (frmExplanation), Information (frmInformation), and Analysis Status (frmAnalysisStatus) forms. The Explanation and Information forms look similar, but they are run and used differently. The Explanation form (fig. 4-3A) provides context-sensitive help by querying the tblExplanationMemo table using an explanation identification number supplied from the source form. The Information form (fig. 4-3B) provides information and data provided directly from the VBA source code running in the appropriate source form. The Explanation and Information forms have a title, a large textbox that contains output, an option group for selecting font size, and a Close command button. The textbox is designed with a scroll bar on the right-hand side so that you can scroll down to read any content that may extend beyond the height of the box. These textboxes also are designed so that you can copy the text and paste it into another file. In addition, the Explanation form has a subtitle and a command button labeled See Analysis Status that opens the Analysis Status Form. The Information form has an Information button that provides information about using that form.

**A**

**SELDM: Stochastic Empirical Loading and Dilution Model**

**Disclaimer and Copyright**

Software Disclaimer and Copyright Statement: See analysis status

The information, data, and metadata in this application were prepared by the U.S. Geological Survey (USGS) in cooperation with the Federal Highway Administration (FHWA); both are agencies of the U.S. Government. This model was compiled for planning-level analysis of runoff data on a national, regional, or local scale. Although the methods and data have been subjected to rigorous review and are substantially complete and accurate, this information was generated from original data from other sources. The USGS and the FHWA reserve the right to revise the data and methods pursuant to further analysis and review. These data and this software have been used by the USGS, and are released on condition that the USGS, the FHWA, or the U.S. Government may not be held liable for any damages resulting from their use. Information and numerical methods used in this relational database are attributable to the cited works. Copyright protection under Title 17 is not available for any work of the United States Government (U.S. Copyright Office, 2000). This database application is provided solely for the purposes of private study, scholarship, or research. Therefore, the information in this database is in the public domain for these purposes, but may not be available for some commercial use. Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Explanation Font Size:  Regular  Large Close Form

**B**

**Stochastic Empirical Loading and Dilution Model Output**

**View Information About the Ecoregion**

Ecoregion selected for streamflow definition:  
 Ecoregion Group:  
 USEPA Level III Nutrient Ecoregion  
 U.S. Environmental Protection Agency, 2003, Level III ecoregions of the continental United States: Washington, D.C., U.S. Environmental Protection Agency National Health and Environmental Effects Research Laboratory, 1 pl.

Ecoregion 67: Central Appalachian Ridges and Valleys  
 This northeast-southwest trending, relatively low-lying, but diverse ecoregion is sandwiched between generally higher, more rugged mountainous regions with greater forest cover. As a result of extreme folding and faulting events, the region's roughly parallel ridges and valleys have a variety of widths, heights, and geologic materials, including limestone, dolomite, shale, siltstone, sandstone, chert, mudstone, and marble. Springs and caves are relatively numerous. Present-day forests cover about 50% of the region. The ecoregion has a diversity of aquatic habitats and species of fish.

Information Explanation Font Size:  Regular  Large Close Form

**Figure 4-3.** Examples of the information forms used in SELDM: *A*, Explanation, *B*, Information, and *C*, Analysis Status.

The Analysis Status form (fig. 4–3C) shows the short title of the current analysis and indicates the components of the selected highway-runoff analysis that have been completed. This form can be used as a progress report and can be used to assess the status of an analysis. This may be helpful to prevent copying an incomplete analysis specification dataset. If you have entered or selected data on an input form, the associated title on the Analysis Status form will be checked. The queries behind the Analysis Status form check to see only whether data are entered, not whether the data are complete and correct, because automatic queries for the wide range of potential applications for SELDM would be impossible to develop.

**C**

The screenshot shows a window titled "Analysis input status" with a close button in the top right corner. The main content area is titled "Completion Status for the Analysis" and includes a sub-header "Example Analysis (I-81)". Below this, there is a paragraph of text: "This form provides a completion-status update that can be used to assess model-specification progress. The user may not want to copy an analysis if the input is not complete". The main body of the window contains a list of 14 items, each with a checked checkbox: Highway Site Characteristics, Ecoregion, Upstream Basin Characteristics, Lake Basin Analysis, Lake Basin Definition, Precipitation Statistics, Streamflow Statistics, Runoff Coefficients, Highway Site, Upstream Basin, Highway Runoff Quality, Upstream Water Quality, Downstream Water-Quality Pair(s), and Best Management Practices. At the bottom center, there is a button labeled "Close Form".

**Figure 4–3.** Examples of the information forms used in SELDM: *A*, Explanation, *B*, Information, and *C*, Analysis Status.—Continued

## Documentation Forms

SELDM has three forms, the Analyst Identification form, the Project Identification form, and the Analysis Identification form, which are used to document each SELDM model run (fig. 4–1). The information entered on these forms is meant to help satisfy Federal policies and guidelines (for example, Sevin, 1987) that were written to address the National Environmental Policy Act (NEPA; 40 CFR 1502). Information entered in the project and analysis identification forms also is used to organize inputs to and outputs from SELDM. Any fields that include an asterisk in the field name are fields that are required to be completed for each analysis. Any tabs that include an asterisk in the tab name are tabs that include required fields.

### The Analyst Identification Form

The Analyst Identification form (frmAnalyst, fig. 4–4) provides the interface for documenting information about each analyst who works on a SELDM analysis. An analyst is any person who is involved in the process of preparing a SELDM analysis. One of the main objectives for having developed the SELDM model is to support analyses that meet regulatory requirements for highway projects. The Federal policies and guidelines (for example, Sevin, 1987) were written to address the NEPA requirement that the environmental impact statement (EIS) and related documentation provide information about the people who are preparing the documents (40 CFR 1502). Specifically, these documents require that the names of the persons and their qualifications, including their expertise, experience, and professional disciplines, be listed in the EIS, in each basic component of the statement, and in all significant background papers. This form also may be used informally to identify the author(s) of analyses that are not intended to meet regulatory requirements. The Anonymous option can also be used when designating an analyst is neither necessary nor desired. All the information that users enter into the Analyst Identification form will be printed in the output files, but only the Initials/Short Name field on the Name tab and the analyst role selection are required for data entry.

## 6 Stochastic Empirical Loading and Dilution Model (SELDM) Version 1.0.0—Appendix 4. Navigating the User Interface

The Analyst Identification form has five data-entry tabs (fig. 4–4). The Name tab has textboxes for the analyst’s name and organization. The Role tab has an option group for selecting the user’s role as an analyst. The contents of the Address, Contact, and Notes tabs are not displayed in figure 4–4. These tabs have textboxes for entering the user’s mailing address, contact information (telephone number, fax number, email address, and Web page address), and notes, respectively. The text field for the Notes tab accepts a text string to supplement the other information about the analyst.

SELDM has four categories of analyst on the Role tab: Primary, Secondary, Reviewer, and Examiner (fig. 4–4B). The primary analyst originates the analysis information. For example, a primary analyst collects site information, selects the appropriate statistics, and runs the model. A secondary analyst either completes an existing analysis or modifies information in response to questions or concerns raised by decisionmakers. A reviewer reviews and, if necessary, modifies an existing analysis. A reviewer usually is someone within the organization that is formulating the SELDM analysis. An examiner examines a predefined analysis without making modifications to the analysis. An examiner usually is someone who is not within the organization that is formulating the SELDM analysis. Because there must be at least one primary analyst, Primary is the default selection for each person who opens SELDM to work through an analysis. To select a different role, click the desired role option.

A

Stochastic Empirical Loading and Dilution Model: Analyst Identification

Analyst Identification: Log in to Enter Data and Run SELDM Information

Select Analyst (Required Fields\*)

Anonymous

Analyst Selection Options

Select Current Analyst  Edit Current Analyst  Enter New Analyst

Analyst Information

Name\* | Role\* | Address | Contact | Notes

Initials/Short Name\* (45 Characters): Anonymous

Last Name:

First Name:

Middle Initial:  Salutation:

Organization:

Exit SELDM Accept Updates Proceed Go Back

**Figure 4–4.** Analyst Identification form, showing the *A*, Name and *B*, Role tabs with required information.

**B**

Stochastic Empirical Loading and Dilution Model: Analyst Identification

Analyst Identification: Log in to Enter Data and Run SELDM Information

Select Analyst (Required Fields\*)

Anonymous

Analyst Selection Options

Select Current Analyst  Edit Current Analyst  Enter New Analyst

Analyst Information

Name\* Role\* Address Contact Notes

Define Your Role as an Analyst\*

Primary: Originate Analysis Information

Secondary: Complete/Modify Analysis Information

Reviewer: Review/Modify Predefined Analysis Information

Examiner: Examine Predefined Analysis Without Modification

Please Note: The analyst role will be set to the default (primary) each time you enter SELDM. The selected role will be assigned to the selected analysis (not the analyst) once the analysis form is complete.

Exit SELDM Accept Updates Proceed Go Back

**Figure 4-4.** Analyst Identification form, showing the *A*, Name and *B*, Role tabs with required information.—Continued

## The Project Identification Form

The Project Identification form (frmProject, fig. 4-5) provides the interface for documenting information about each SELDM project. Each project may be an actual highway construction or improvement project, a scientific investigation, or just a series of related analyses. In SELDM, the project acts like a drawer in a filing cabinet that holds related information. Each project will contain one or more analyses. An analysis created in one project will not be available in another. Each project also will contain the information related to each analysis (for example, highway-site definitions, upstream-basin definitions, lake-basin definitions, and custom precipitation or streamflow definitions). These input-data definitions will be available for selection as standard choices on the associated forms when the project is selected. The analysis-specific information created in one project will not be available in another. However, generic information, such as standard precipitation and streamflow definitions, water quality, and BMP definitions, will be available for use in any project once a project analysis is created.

The Project Identification form has three data-entry tabs. The General Project Information tab has textboxes for the project short name, title, identification (ID) number, the primary organization, and the secondary organization associated with the project (fig. 4-5A). The System Variables tab has comboboxes for selecting the system variables, which are the geographic information system (GIS) grid, the ecoregion group, and the rain zone group (fig. 4-5B). The Project Abstract tab has a large textbox with a vertical scroll bar to hold the project abstract. There is no limit for the length of text in the project abstract because it is stored in a memo field in the database.

By default, the alphanumeric project ID number (fig. 4-5A) will be used as the primary name for the output directory when SELDM is run. If the Project ID Number field is empty, then the project short title will be used as the primary output directory name. In either case, only letters, numbers, and dashes will be retained. Spaces will be converted to underscores when the output directory name is built.

**A**

**Stochastic Empirical Loading and Dilution Model**

**Project Identification: Identify a Project to Organize Analyses** Information

Select Project (Required Fields\*)

z01 Example Project

Project Selection Options

Select Current Project  Edit Current Project  Enter New Project

Project Information

General Project Information\* System Variables\* Project Abstract

Project Short Title\* (50 characters): z01 Example Project

Project Title: Example Project Z01

Project ID Number: FHWA-EIS-200X-XX-D

Primary Organization: Federal Highway Administration

Secondary Organization:

Exit SELDM Accept Updates Proceed Go Back

**B**

**Stochastic Empirical Loading and Dilution Model**

**Project Identification: Identify a Project to Organize Analyses** Information

Select Project (Required Fields\*)

z01 Example Project

Project Selection Options

Select Current Project  Edit Current Project  Enter New Project

Project Information

General Project Information\* System Variables\* Project Abstract

The system variables define the Geographic Information System (GIS) Grid, the Ecoregion Group, and the Rain Zone Group. These variables cannot be changed by the user without first defining a custom grid with the associated grided values for the ecoregions and rain zones. These variables must be selected and tested as default values for an entire project and all associated analyses. These changes must be made by the user in the appropriate database tables.

GIS Grid\*: SELDM 0.25 degree Conterminous U.S.

Ecoregion Group\*: USEPA Level III Ecoregion

Rain Zone Group\*: USEPA 1989 15-Rain-Zone Map

Exit SELDM Accept Updates Proceed Go Back

**Figure 4-5.** Project Identification form, showing the *A*, General Project Information and *B*, System Variables tabs with required information.

The current version of SELDM (1.0.0) is published with only one selection for the GIS Grid, Ecoregion Group, and the Rain Zone Group fields; the pull-down selections in the comboboxes on the System Variables tab (fig. 4–5B) therefore include only the default selection. The GIS grid named SELDM 0.25 degree Conterminous United States is a fishnet grid that was created using Esri ArcGIS® software to discretize the ecoregions of the United States so that water-quality data, streamflow, and precipitation could be associated with user-specified latitude and longitude coordinates in SELDM and in related applications (Omernik, 1995; U.S. Environmental Protection Agency, 2003; Granato and others, 2009; Granato, 2010). The GIS grid also is used to define the rain zone associated with a given latitude and longitude coordinate. This default GIS grid has latitudes that range from 24.5 to 49.5 degrees (°) north and longitudes that range from -66.75° to -125° west. This default GIS grid has a resolution (grid-cell size) of 0.25° with a geographic projection based on the North American Datum of 1983 (NAD 83). The Ecoregion Group field is used to identify the U.S. Environmental Protection Agency (USEPA) Level III ecoregions in the conterminous United States (Omernik, 1995, 2004; U.S. Environmental Protection Agency, 2003), which are used by the Federal Highway Administration (FHWA) in the Eco-logical approach to land and water-resource management (Brown, 2006). The USEPA 1989 15-Rain Zone Map is the current USEPA rain zone definition (Driscoll, Palhegyi, and others, 1989).

The ecoregion and rain zone statistics are defined within the grid for land areas of the United States and for major outlying islands. These variables cannot be changed by the user without first defining a custom grid with the associated gridded values for the user-defined ecoregions and rain zones. These variables must be selected and tested as default values for an entire project and for all associated analyses. To add or edit the grids, ecoregions, or rain zones you must make changes in the appropriate database tables. A data dictionary (SELDMv.01.00aDataDict.pdf) describing the SELDM database is available on the compact disk-read only memory (CD–ROM) accompanying this report. The project data structure in appendix 3 shows the tables defining the grid, the ecoregion groups, and the rain-zone group in relation to the project data table. The GIS files for these system variables are available on the CD–ROM accompanying the SELDM stormflow report (Granato, 2010).

## The Analysis Identification Form

The Analysis Identification form (frmAnalysis) provides the interface for documenting information about each SELDM analysis. The Analysis Identification form has three data entry tabs (fig. 4–6). The Name tab has the Analysis Short Name and Analysis Short Description fields (fig. 4–6A). The Analysis Options tab has option groups for the Status of Analysis Options, Master Random Seed Options, and Analysis Output Options fields (fig. 4–6B). The Analysis Description tab has a large textbox with a vertical scroll bar to hold the (full) analysis description. There is no limit for the length of text in the Analysis Description textbox because it is stored in a memo field in the database.

The first option group on the Analysis Options tab is Status of the Analysis (fig. 4–6B), which is for information only. The selections are Draft Analysis, Final Analysis, and Supplemental Analysis. The default value is Draft Analysis. The primary use for these selections is for a NEPA analysis to designate the formal status in an EIS or an environmental assessment (EA). In an informal analysis or a scientific study, these selections may be used to indicate the level of peer review that has been done.

The second option group on the Analysis Options tab is the Master Random Seed Options (fig. 4–6B), which is used to initialize the random-number specification process for the Monte Carlo module in SELDM. Detailed information about use of the master random seed is described in the “Monte Carlo Simulation Methods” section of the main report and in appendix 1. Use of the master random seed ensures that rerunning the exact same analysis will produce the exact same results. Using an existing random seed and changing the hydrologic or water-quality variables will indicate the sensitivity of results to the different input options. Changing the master seed will produce somewhat different results because of differences in the random combinations of hydrologic and water-quality variables included in a SELDM analysis. This will indicate the sensitivity of results to a different set of conditions using the same hydrologic statistics, which is in effect running an alternate reality with the same input parameters.

The third option group on the Analysis Options tab is the Analysis Output Options (fig. 4–6B), which controls the variables that are produced by SELDM. The selections are Stream Basin Output, Stream and Lake Basin Output, and Lake Basin Output. The default value is the Stream Basin Output. If the Stream Basin Output option is selected, then SELDM will produce highway runoff and upstream stormflows, runoff quality, and runoff loads by storm and by year. This option also will produce downstream flows, concentrations, and loads for each selected runoff constituent by storm and by year. If the Lake Basin Output option is selected, then SELDM will produce annual highway-runoff loads, annual lake-basin loads, and annual average lake concentrations. SELDM will produce both sets of output values if Stream and Lake Basin Output is selected.

**A**

Stochastic Empirical Loading and Dilution Model

**Analysis Identification: Identify a Highway-Runoff Analysis** Information

Select Analysis (Required Fields\*)

Example Analysis (I-81)

Analysis Selection Options

Select Current  Edit Current  Copy Current  Enter New ?

Analysis Information

Name\* Analysis Options\* Analysis Description

**Analysis Short Title\* (50 characters):**

Example Analysis (I-81)

Analysis Short Description (250 characters):

Example highway analysis I-81 Near Harrisburg PA

Exit SELDL Copy Analysis Accept Updates Proceed Go Back

**B**

Stochastic Empirical Loading and Dilution Model

**Analysis Identification: Identify a Highway-Runoff Analysis** Information

Select Analysis (Required Fields\*)

Example Analysis (I-81)

Analysis Selection Options

Select Current  Edit Current  Copy Current  Enter New ?

Analysis Information

Name\* Analysis Options\* Analysis Description

Status of Analysis:

Draft Analysis  Final Analysis  Supplemental Analysis ?

Master Random Seed Options:

Use the existing value  Generate a new value ?

Analysis Output Options:

Stream Basin Output  Stream and Lake Basin Output  Lake Basin Output ?

Exit SELDL Copy Analysis Accept Updates Proceed Go Back

**Figure 4-6.** Analysis Identification form, showing the *A*, Name and *B*, Analysis Options tabs with required information.

## Site and Region Forms

SELDM has five input forms that are used to define the location and basin characteristics of the highway site, the upstream basin, and the lake basin (fig. 4–1). Information entered on these forms about the location and hydrologic characteristics of the contributing areas is used to calculate precipitation variables, prestorm streamflows, runoff volumes, and stormflow timing variables. Information entered on these forms also is used to document site characteristics that may be used to evaluate model results.

### The Highway Site Form

The Highway Site form (`frmHighwaySite`) provides the interface for entering or editing data about the highway site characteristics used in a SELDM analysis. A highway site may be defined literally, semiliterally, or conceptually. If the hydraulic characteristics of a site represent the flow path from the site to a single outfall, then the site can be defined literally. If the hydraulic characteristics of a site can be specified so that they approximate the volume and timing of runoff that occurs during a storm, then the site can be defined semiliterally. For example, if a highway site straddles a stream and the timing of runoff from each side is comparable, then the highway on both sides of the stream can be modeled as one site. Similarly, if a highway follows a stream and has many outfalls with comparable drainage characteristics, then a number of outfalls can be combined by using the total drainage area and impervious fraction of the site and the length and slope of a representative segment. If a literal or semiliteral definition is used to do an analysis, then all the results from SELDM can be used. If the hydraulic characteristics of a site cannot be used to represent a modeled flow path then the site must be defined conceptually. For example, you may model a single acre of pavement to generate normalized storm concentrations and loads and normalized annual loads per acre of pavement. Alternatively, you may model all the acreage of a given road class in a drainage basin to calculate the total storm concentrations and loads and annual loads from that road class in a drainage basin. If a conceptual definition is used to do an analysis, then the receiving-stream results will not be representative of receiving water quality at any given stream crossing, but the annual lake results may be representative.

SELDM also can be used to model other land-use areas that can be defined by a drainage area and impervious fraction (for literal, semiliteral, and conceptual runoff modeling) and a drainage length, slope, and basin development factor (BDF, for literal or semiliteral runoff modeling). For example, these hydrologic characteristics may be used to model storm runoff from the site before the highway was built. These hydrologic characteristics also may be used to model storm runoff from a maintenance facility, a parking lot, a commercial development, or a residential area. In such cases the optional highway-specific data items may be left blank.

The Highway Site form has four data-entry tabs. The Name and Location tab has the short name, the full name, and the latitude and longitude of the highway site (fig. 4–7A). The full name can be a short description (250 characters or less) of the site. The Hydraulics tab has the hydraulic variables that control characteristics of runoff from the highway site (fig. 4–7B). The Other tab, which is not shown in figure 4–7, has five optional highway-site descriptors—total number of lanes, lane width (in feet), average daily traffic in vehicles per day, the pavement material, and the type of curbing—that are commonly used in highway-runoff studies, but are not used in the SELDM analysis. The Site Description tab, which is not shown in figure 4–7, has a large textbox with a vertical scroll bar to hold the full site description. There is no limit for the length of text in the site description because it is stored in a memo field in the database.

The latitude and longitude of the highway site (fig. 4–7A) are critical variables for defining precipitation, streamflow, and ecoregion-based water-quality statistics. The latitude and longitude coordinates must be entered as decimal degrees with negative values of longitude for sites in the western hemisphere. Precipitation statistics are automatically specified for the rain zone and ecoregion associated with the GIS grid square that contains a highway site. Streamflow statistics are automatically specified for the ecoregion associated with the GIS grid square that contains the specified highway site. Granato (2010) describes the process for estimating synoptic precipitation statistics and streamflow statistics by region. The latitude and longitude of the highway site also may be used to select one or more precipitation stations and streamgages by their proximity to the specified coordinates. The upstream water-quality statistics also may be specified by ecoregion. Granato and others (2009) describe methods for obtaining and regionalizing background water-quality statistics and for developing water-quality transport curves, which are relations between streamflow and constituent concentrations. Granato and others (2009) developed transport curves for suspended sediment, total phosphorus, and total hardness by ecoregion. These relations are preloaded in SELDM and are available based on the selected latitude and longitude.

The latitude and longitude of the highway site may be identified using a variety of methods. For example, the U.S. Geological Survey (USGS) geographic names information system (GNIS, available at <http://geonames.usgs.gov/>) will provide latitude and longitude coordinates for a place-name. The USGS interactive National Map viewer (available at <http://nationalmap.gov/>) will provide latitude and longitude coordinates for a selected location. Google Earth (available from

A

**Stochastic Empirical Loading and Dilution Model**

**Highway Site: Identify Site Characteristics** Information

Select Highway Site (Required Fields\*)

I-81 Near Harrisburg PA

Highway Selection Options

Select Current  Edit Current  Copy Current  Enter New

Site Information

Name and Location\* | Hydraulics\* | Other | Site Description

**Site Short Name\* (50 characters):** I-81 Near Harrisburg PA

Full Name: I-81 Near Harrisburg PA at intersection of RT-944 Wertzville Rd, p21 FHWA-RD-81-045

**Latitude in decimal degrees\*:** 40.292249 **Longitude in decimal degrees\*:** -76.980517 ?

The decimal latitude and longitude are used to establish the ecoregion (which may be used to estimate streamflow statistics and background water-quality values) and synoptic precipitation statistics. Latitudes are positive numbers in the northern hemisphere, longitudes are negative numbers in the western hemisphere. Latitudes and longitudes must be within the GIS grid specified for the current project.

Exit SELDM Copy Site Accept Updates Proceed Go Back

B

**Stochastic Empirical Loading and Dilution Model**

**Highway Site: Identify Site Characteristics** Information

Select Highway Site (Required Fields\*)

I-81 Near Harrisburg PA

Highway Selection Options

Select Current  Edit Current  Copy Current  Enter New

Site Information

Name and Location\* | Hydraulics\* | Other | Site Description

**Drainage Area in Acres\*:** 18.5 ?

**Drainage Length in Feet\*:** 2000 ?

**Mean Basin Slope in Feet per Mile\*:** 105 ?

**Impervious Fraction (0-1)\*:** 0.27 ?

**Basin Development Factor (0-12)\*:** 6 ?

Exit SELDM Copy Site Accept Updates Proceed Go Back

**Figure 4-7.** Highway Site form, showing the *A*, Name and Location and *B*, Hydraulics tabs with required information.

<http://www.google.com/>) also provides latitude and longitude coordinates for a selected location. Latitude and longitude coordinates can be interpolated from measurements on paper maps by using the computer program PLACER (Granato, 1999). The GIS grid resolution is  $0.25^\circ$ . The land-surface distances per degree of latitude and longitude vary by location, but each  $0.25^\circ$  grid square covers about 17 by 13 miles. Finding the exact coordinates of a specific site is not critical unless the site is near the boundary of a grid square and the adjacent grid square is in a different ecoregion or rain zone. If a site is on a boundary (exactly on a  $0.25^\circ$  coordinate), then SELDM assigns the site to the grid square that lies to the east of the longitude coordinate and to the north of the latitude coordinate. If the selected site location is outside the currently selected GIS grid coverage, a confirmation message box will appear to notify you which of the selected coordinates are outside the grid system. If you are outside the selected GIS grid coverage, then data for ecoregions and rain zones will not be available.

The Hydraulics tab on this form includes the basin characteristics that control the volume and timing of runoff from the highway site. These variables are the drainage area in acres, the drainage length in feet, the mean-basin slope in feet per mile, the impervious fraction, and the basin development factor (fig. 4–7B). Appendix 2 contains detailed definitions and descriptions of the methods for specifying these variables. Clicking the Help buttons (denoted “?”) immediately to the right of each textbox also provides the descriptions of the variables. Specification and use of these variables also were described in the SELDM stormflow report (Granato, 2010) and in the report that describes the development of the basin lagtime regression equations and hydrograph-timing indexes (Granato, 2012). If a basin development factor between 0 and 12 is entered for the highway, then SELDM will calculate the basin lagtime by using the drainage length, mean basin slope, and basin development factor with equation 21 as described in the section “Storm-Event Hydrographs” of the main report. However, if a basin development factor of  $-1$  is entered, then SELDM will calculate the basin lagtime by using the drainage length, mean basin slope, and impervious fraction with equation 22 in the main report. Similarly, if a basin development factor of  $-2$  is entered, then SELDM will calculate the basin lagtime by using the drainage area and impervious fraction. Granato (2012) indicated that the equation using the BDF is the most accurate equation, especially for drainage areas with impervious fractions less than about 40 percent.

## The Review Geographic Information System (GIS) Grid Form

The Review Geographic Information System Grid form (frmGISGrid, fig. 4–8) provides the interface for reviewing the currently selected grid characteristics and to ensure that the specified highway-site location is within the grid selected for the SELDM analysis. This is a review form rather than a data entry form so it does not include any data-entry tabs or an Accept Updates button. The form repeats the latitude and longitude specified for the highway site to help identify potential errors in specifying those coordinates. It has textboxes that indicate the grid row and column for the specified location and a series of textboxes for the data to define the currently selected grid. If a site location outside the current grid is selected, then a red warning message appears in place of the grid coordinates for the site when this form is loaded (fig. 4–8B). You will need to return to the highway site to correct an error in specifying a site location.

A

**Stochastic Empirical Loading and Dilution Model**

**Review Geographic Information System (GIS) Grid Specifications** Information

Site Latitude and Longitude: Latitude in decimal degrees: Longitude in decimal degrees:

The GIS Grid system in the SELDM database is used to specify regional data. If the site is not within the specified grid some regional-specification options may not be available. For more details click the "Information" button.

Site Grid Cell Row:  Site Grid Cell Column:

Current GIS Grid Properties

Grid Name:

Grid ID Number:  Number of Rows:  Number of Columns:

Grid Latitude: Northern:  Southern:  Grid Cell Size (degrees):

Grid Longitude: Western:  Eastern:  Grid Cell Size (degrees):

**Note: This form is for information and grid verification; not for data entry.**

B

**Stochastic Empirical Loading and Dilution Model**

**Review Geographic Information System (GIS) Grid Specifications** Information

Site Latitude and Longitude: Latitude in decimal degrees: Longitude in decimal degrees:

The GIS Grid system in the SELDM database is used to specify regional data. If the site is not within the specified grid some regional-specification options may not be available. For more details click the "Information" button.

**WARNING: The site coordinates are not in the specified GIS Grid**

Current GIS Grid Properties

Grid Name:

Grid ID Number:  Number of Rows:  Number of Columns:

Grid Latitude: Northern:  Southern:  Grid Cell Size (degrees):

Grid Longitude: Western:  Eastern:  Grid Cell Size (degrees):

**Note: This form is for information and grid verification; not for data entry.**

**Figure 4–8.** Review Geographic Information System (GIS) Grid form, showing A, a properly specified site latitude and longitude, and B, a red warning accompanying an improperly specified site location.

## The Ecoregion Form

The Ecoregion form (frmEcoregion) provides the interface for selecting an ecoregion and for viewing the definition of the selected ecoregion (fig. 4–9). The default ecoregion for the specified highway site is selected based on the input latitude and longitude coordinates for the site. The Ecoregion Selection Method, Number, Name, and USEPA Description fields are provided on the Ecoregion Information tab (fig. 4–9A). You can manually select any ecoregion in the ecoregion group that was specified on the System Variables tab of the Project form by using the Select Ecoregion combobox near the top of the form. The ecoregions were not assigned numbers according to geographic proximity, so knowledge of appropriate ecoregions is needed to make a proper selection using the combobox. The USEPA Level III ecoregion map (U.S. Environmental Protection Agency, 2003) is provided on the CD-ROM containing this manual to facilitate ecoregion selection.

You also can view and select neighboring ecoregion numbers using the interactive grid-square navigator on the Neighboring Ecoregions tab (fig. 4–9B). When the form is loaded, the three-by-three-box matrix is populated with the ecoregion numbers. The matrix square containing the specified highway-site coordinates is highlighted in green. The five command buttons to the right of the matrix can be used to navigate from matrix cell to matrix cell. For example, clicking the Go North button will shift the focus by one grid square to the north (shifting the highway-site matrix cell to the south) so that you can see what ecoregions are available to the north. Similarly, clicking the Go East button will shift the focus by one grid square to the east (shifting the highway-site matrix cell to the west) so that you can see what ecoregions are available to the east. Clicking the RECENTER button will bring the cell with the selected highway-site coordinates back to the center of the grid. You also can navigate within the matrix to bring the desired ecoregion number into the center of the matrix and select it for the current analysis by clicking the Select Center Ecoregion button. For example, ecoregion 64 is in the grid squares to the south and southeast of the specified highway site location (fig. 4–9B). If the statistics associated with ecoregion 64 characterize conditions at the highway site better than statistics in ecoregion 67, you can click the Go South command button to bring the GIS grid square to the center cell of the matrix then click the Select Center Ecoregion button to make your selection. If you make a manual selection and want to revert to the default selection, you can do this by clicking the Set Ecoregion from Lat/Long button on the bottom row of the form.

The Neighboring Ecoregion feature was added to this form because the statistics associated with a neighboring ecoregion may better represent conditions at the site of interest. Also, the ecoregion discretization process, which assigns the ecoregion with the highest proportion of area in each grid square to that grid square, may have affected the ecoregion selection. This discretization process does not violate the intent of the original delineation, because the 15-minute-grid square is relatively small in comparison to the scale of the Level III ecoregions. Although ecoregion boundaries are shown on maps as lines, transitions between regions actually occur over large amorphous zones along the edges of each region (J.M. Omernik, U.S. Environmental Protection Agency, written commun., 2004).

**A**

**Stochastic Empirical Loading and Dilution Model**

**Ecoregion: Select an Ecoregion** Information

Current Latitude and Longitude:      Latitude in decimal degrees:      Longitude in decimal degrees:

Select Ecoregion           

Ecoregions in the surrounding GIS Grid Cells (Display neighboring values in Grid):

Ecoregion Information | **Neighboring Ecoregion**

Ecoregion Selection Method:

Number:      Name:

USEPA Description:

This northeast-southwest trending, relatively low-lying, but diverse ecoregion is sandwiched between generally higher, more rugged mountainous regions with greater forest cover. As a result of extreme folding and faulting events, the region's roughly parallel ridges and valleys have a variety of widths, heights, and geologic materials, including limestone, dolomite, shale, siltstone, sandstone, chert, mudstone, and marble. Springs and caves are relatively numerous. Present-day forests cover about 50% of the region. The ecoregion has a diversity of aquatic habitats and species of fish.

**B**

**Stochastic Empirical Loading and Dilution Model**

**Ecoregion: Select an Ecoregion** Information

Current Latitude and Longitude:      Latitude in decimal degrees:      Longitude in decimal degrees:

Select Ecoregion           

Ecoregions in the surrounding GIS Grid Cells (Display neighboring values in Grid):

Ecoregion Information | **Neighboring Ecoregion**

Note: Click on the grid square to see ecoregion information in the status bar or hover the mouse over the grid square to see the information as tool-tip text.

Long: -77.25

Lat 40.75

Note: One grid square is about 17.3 miles North-South by 13.2 miles East-West.

Lat 40

Long: -76.5

**Figure 4-9.** Ecoregion form, showing the *A*, Ecoregion Information and *B*, Neighboring Ecoregions tabs.

## The Upstream Basin Form

The Upstream Basin form (frmUpstreamBasin) provides the interface for entering or editing data about the upstream basin characteristics used in a SELDM analysis. The Upstream Basin form has three data-entry tabs. The Basin Information tab has the short name, the full name (250 characters or less), and the basin description (fig. 4–10A). The Basin Description field has a vertical scroll bar to display the full description. There is no limit for the length of text in the basin description because it is stored in a memo field in the database. The Hydraulics tab has the hydraulic variables that control characteristics of runoff from the upstream basin (fig. 4–10B). The Hydrograph Recession tab has textboxes for entering the statistics for the hydrograph recession factor (fig. 4–10C).

The Hydraulics tab on this form includes the basin characteristics that control the volume and timing of runoff from the upstream basin. These variables are drainage area in square miles, drainage length in feet, mean-basin slope in feet per mile, impervious fraction, and basin development factor (fig. 4–8B). Appendix 2 contains detailed definitions and descriptions of the methods for specifying these variables. Clicking the Help buttons (denoted “?”) immediately to the right of each textbox also makes available the descriptions of the variables. Specification and use of these variables also were described in the SELDM stormflow report (Granato, 2010) and in Granato (2012), which describes the development of the basin lagtime regression equations and hydrograph-timing indexes. If a basin development factor between 0 and 12 is entered for the highway, then SELDM will calculate the basin lagtime by using the drainage length, mean basin slope, and basin development factor with equation 21 as described in the “Storm-Event Hydrographs” section of the main report. However, if a basin development factor of –1 is entered, then SELDM will calculate the basin lagtime by using the drainage length, mean basin slope, and impervious fraction with equation 22 in the main report. Similarly, if a basin a basin development factor of –2 is entered, then SELDM will calculate the basin lagtime by using the drainage area and impervious fraction. Granato (2012) indicated that the equation using the BDF is the most accurate equation, especially for drainage areas with impervious fractions less than about 40 percent.

The Hydrograph Recession tab on this form includes variables for the minimum, the most probable value, and the maximum hydrograph recession factor, which also control the timing of runoff from the upstream basin (fig. 4–10C). A description of the hydrograph recession factor, which is the ratio of the falling limb to the rising limb of the hydrograph, and example values are provided in the “Storm-Event Hydrographs” section of the main report. Specification and use of these variables also were described in the SELDM stormflow report (Granato, 2010) and in the report that describes the development of the basin lagtime regression equations and hydrograph-timing indexes (Granato, 2012). Examples of the triangular hydrograph recession ratio statistics estimated from 20 or more storm-event hydrographs measured at each of the 41 streamgages in the multi-State dataset are shown in figure 16 of the main report.

In SELDM, the hydrograph recession factor is modeled as a triangular distribution, which is defined by a minimum value, a most probable value (the mode), and a maximum value. The triangular distribution was incorporated into the model because relations between hydrograph recession factors and basin properties are not well defined in the literature and the input values can be estimated by using professional judgment. The Calculate Trial Statistics, command button was provided on the Hydrograph Recession tab (fig. 4–10C) to calculate statistics from the triangular distribution. This utility helps you assess the effects of input values on hydrograph recession-factor statistics. When you enter the parameters for the hydrograph recession factor, then click the Calculate Trial Statistics command button, SELDM calculates the statistics and displays them on the Information form (fig. 4–11). The form displays the input statistics, selected percentiles, and the average, standard deviation, and percentile skew coefficient of a triangular distribution with the input values.

**A**

Stochastic Empirical Loading and Dilution Model

**Upstream Basin: Identify Basin Characteristics** Information

Select Basin Characteristics: (Required Fields\*)

Upstream Basin I-81 PA

Basin Selection Options

Select Current  Edit Current  Copy Current  Enter New

Upstream Basin Properties\*

Basin Information\* | Hydraulics\* | Hydrograph Recession\*

**Basin Short Name\* (50 characters):** Upstream Basin I-81 PA

Full Name: Conodoguinet Creek Tributary near Enola PA

Basin Description:

A forested (60 percent), rural/agricultural basin with two farm ponds. Developed area is 3.13 percent. The basin's northern border is a steep straight ridge line.

Exit SELDM Copy Basin Accept Updates Proceed Go Back

**B**

Stochastic Empirical Loading and Dilution Model

**Upstream Basin: Identify Basin Characteristics** Information

Select Basin Characteristics: (Required Fields\*)

Upstream Basin I-81 PA

Basin Selection Options

Select Current  Edit Current  Copy Current  Enter New

Upstream Basin Properties\*

Basin Information\* | Hydraulics\* | Hydrograph Recession\*

**Drainage Area in Square Miles\*:** 0.5 ?

**Drainage Length in Feet\*:** 6500 ?

**Mean Basin Slope in Feet per Mile\*:** 669 ?

**Impervious Fraction (0-1)\*:** 0.007 ?

**Basin Development Factor (0-12)\*:** 0 ?

Exit SELDM Copy Basin Accept Updates Proceed Go Back

**Figure 4-10.** Upstream Basin form, showing the A, Basin Information tab; B, Hydraulics tab; and C, the Hydrograph Recession tab with required information.

C

**Stochastic Empirical Loading and Dilution Model**

**Upstream Basin: Identify Basin Characteristics** Information

Select Basin Characteristics: (Required Fields\*)

Upstream Basin I-81 PA

Basin Selection Options

Select Current  Edit Current  Copy Current  Enter New

Upstream Basin Properties\*

Basin Information\* | **Hydraulics\*** | Hydrograph Recession\*

The hydrograph recession factor is the ratio of the falling limb to the rising limb of a runoff hydrograph. For example, a value of 2 would indicate that the falling limb is twice as long as the rising limb. The rising-limb duration (time from start of flow to the peak) is calculated from basin characteristics using a basin-lag equation. The hydrograph recession factor cannot be less than 1 in SELDM. The maximum value must be greater than the minimum value. To obtain an essentially constant value set the most probable value equal to the minimum value and increase the maximum value by a very small amount.

Minimum\*:  Most Probable Value\*:  Maximum\*:

Calculate Trial Statistics ?

Exit SELDM Copy Basin Accept Updates Proceed Go Back

**Figure 4-10.** Upstream Basin form, showing the A, Basin Information tab; B, Hydraulics tab; and C, the Hydrograph Recession tab with required information.—Continued

**Stochastic Empirical Loading and Dilution Model Output**

**Hydrograph Recession Factor Statistics**

Input Statistics:  
 Minimum: 1  
 Most Probable Value (MPV): 2  
 Maximum: 4  
 =====

Calculated Statistics:  
 =====

Percentiles:  
 1st percentile: 1.173  
 5th percentile: 1.387  
 10th percentile: 1.548  
 25th percentile: 1.866  
 Median: 2.268  
 75th percentile: 2.775  
 90th percentile: 3.225  
 95th percentile: 3.452  
 99th percentile: 3.755  
 =====

Average: 2.333  
 Standard Deviation: 0.624  
 Percentile Skew: 0.152

Information Explanation Font Size:  Regular  Large Close Form

**Figure 4-11.** SELDM Information form showing hydrograph-recession statistics calculated using input values for the triangular distribution.

## The Lake Basin Form

The Lake Basin form (frmLakeBasin) provides the interface for entering or editing data about the lake basin characteristics used in a SELDM analysis. The Lake Basin form has two data entry tabs. The Basin Information tab has the short name, the full name (250 characters or less), and the basin description (fig. 4–12A). The basin description textbox has a vertical scroll bar to display the (full) description. There is no limit for the length of text in the basin description because it is stored in a memo field in the database. The Hydraulics tab has the hydraulic variables for the lake basin, which include drainage area of the lake basin (in square miles), the surface area of the lake in acres, and the average depth in feet (fig. 4–12B). The drainage area of the lake basin is used to estimate the total water and solute fluxes coming from the basin. The drainage area of the lake basin is the entire contributing area to the lake (including the area of the lake) upstream of the lake outfall (if there is a surface-water outfall) minus the area of the highway. The surface area and the average depth of the lake are used to calculate the volume of the lake, which affects residence time and dilution in the lake. The average depth of the lake also is used to estimate attenuation of water-quality loads by settling. Detailed definitions and descriptions of the methods for specifying these variables are described in the “Lake-Basin Analysis” section of the main report.

## Hydrology Forms

SELDM has five input forms that are used to define three sets of hydrologic variables, which are (1) the synoptic storm event precipitation statistics, (2) the streamflow statistics, and (3) the runoff coefficients (fig. 4–1). The statistics selected on these forms determine the storm event precipitation characteristics, prestorm flow rates, and runoff volumes. The precipitation and prestorm flow can be defined by using the location (latitude and longitude) of the site of interest. Runoff volumes are defined by using runoff coefficient statistics, which are calculated using the imperviousness of each contributing drainage area. User-defined statistics also may be entered for each variable on these input forms.

### Synoptic Storm Event Precipitation Statistics Forms

SELDM has two input forms that are used to define synoptic storm event precipitation statistics. If you are using regional statistics (from data grouped by ecoregions or rain zones) or user-defined statistics, then you will use the Synoptic Storm Event Precipitation Statistics form. If you are using statistics from one or more nearby sites then you will also use the Create or Modify a Precipitation-Station List form. Detailed definitions and descriptions for using the storm event precipitation statistics are described in the “Storm-Event Characteristics” section of the main report. Specification and use of these statistics also were described in the SELDM stormflow report (Granato, 2010). If you want to create an updated regional or national dataset or calculate statistics for a given rain gage, all the precipitation statistics can be calculated using the Synoptic Precipitation Analysis Facilitator (SPAF) provided with the SELDM stormflow report (Granato, 2010).

**A**

**Stochastic Empirical Loading and Dilution Model**

**Lake Basin: Identify Basin Characteristics** Information

Select Lake-Basin Characteristics: (Required Fields\*)

My lake

Lake Basin Selection Options

Select Current
  Edit Current
  Copy Current
  Enter New

Lake Basin Properties\*

Basin Information\* | Hydraulics\*

Basin Short Name\* (40 characters): My lake

Full Name: My lake

Basin Description:

Exit SELDM Copy Basin Accept Updates Proceed GoBack

**B**

**Stochastic Empirical Loading and Dilution Model**

**Lake Basin: Identify Basin Characteristics** Information

Select Lake-Basin Characteristics: (Required Fields\*)

My lake

Lake Basin Selection Options

Select Current
  Edit Current
  Copy Current
  Enter New

Lake Basin Properties\*

Basin Information\* | Hydraulics\*

Drainage Area in Square Miles\*: 5 ?

Lake Surface Area in Acres\*: 10 ?

Average Lake Depth in Feet\*: 10 ?

Exit SELDM Copy Basin Accept Updates Proceed GoBack

**Figure 4–12.** Lake Basin form showing the *A*, Basin Information and *B*, Hydraulics input tabs with required information.

## The Synoptic Storm Event Precipitation Statistics Form

The Synoptic Storm-Event Precipitation Statistics form (frmPrecipSelect) provides the interface for selecting predefined precipitation statistics or for entering user-defined statistics. Predefined precipitation statistics can be selected by using the previously defined rain zone or ecoregion designation or by selecting statistics from one or more local precipitation monitoring stations using the Create or Modify a Precipitation-Station List form (frmPrecipGetSites). The Synoptic Storm-Event Precipitation Statistics form has three data-entry tabs: the Definition tab, the Storm Event Statistics tab, and the Annual Statistics and Station Count tab (fig. 4–13).

When you first open the Synoptic Storm-Event Precipitation Statistics form within a given project, no selections appear in the Select an Existing Precipitation Definition combobox, and the default selection in the Synoptic Storm-Event Precipitation-Statistics Selection Options group will be the Rain Zone Average (fig. 4–13A). The focus is on the Select a Precipitation Statistics Dataset. To specify the first precipitation definition, click an option in the Synoptic Storm-Event Precipitation-Statistics Selection Options group and follow the context-sensitive instructions on the message boxes. (Please note: If you want to use the Rain Zone Average option, first click another option, then click back to the Rain Zone Average option). Generally (fig. 4–13D), you will (1) select an option, (2) choose the desired dataset from the Select a Precipitation-Statistics Dataset combobox, (3) click the Generate/Examine Statistics command button, and (4) click the Accept Updates command button to add the definition to the dataset for current and future use. Precipitation statistics are entered as arithmetic values.

Modifying the initial selection requires a few steps, and different options on the form are enabled or disabled, depending on your selections. Once a regional selection (either rain zone or ecoregion) has been made, the edit option is disabled (fig. 4–13B) because you cannot edit precipitation statistics that were calculated using all precipitation stations in a region. You can, however, select Enter New Definition and select a regional option to calculate the same statistics using data from a different dataset. Selecting Enter New Definition also lets you modify regional statistics by clicking Yes when prompted to create a new definition based on the current selection, then editing the precipitation statistics using the existing values (fig. 4–13C). To select a different method, click No when prompted to create a new definition based on the current selection, then click one of the selected precipitation station options (fig. 4–13D).

**A**

Stochastic Empirical Loading and Dilution Model

**Synoptic Storm-Event Precipitation Statistics: Select Statistics** Information

Select an Existing Precipitation Definition (Required Fields\*)

Selection Options

Select Current Definition  Edit Current Definition  Enter New Definition

Select a Precipitation-Statistics Dataset

FHWA 2010

Precipitation-Statistics Information:

Definition\* Storm Event Statistics\* Annual Statistics and Station Count\*

Define the Synoptic Storm-Event Statistics\*: View Region Information

Current Selection\*:

Synoptic Storm-Event Precipitation-Statistics Selection Options

Rain Zone Average  Ecoregion Average  Selected Station Average  User-Defined

Rain Zone Median  Ecoregion Median  Selected Station Median

Generate/Examine Statistics ? View Related Sites

Exit SELDM Accept Updates Proceed Go Back

**B**

Stochastic Empirical Loading and Dilution Model

**Synoptic Storm-Event Precipitation Statistics: Select Statistics** Information

Select an Existing Precipitation Definition (Required Fields\*)

Avg of Rain Zone 3: Midatlantic DS: 3

Selection Options

Select Current Definition  Edit Current Definition  Enter New Definition

Select a Precipitation-Statistics Dataset

FHWA 2010

Precipitation-Statistics Information:

Definition\* Storm Event Statistics\* Annual Statistics and Station Count\*

Define the Synoptic Storm-Event Statistics\*: View Region Information

Current Selection\*: Avg of Rain Zone 3: Midatlantic DS: 3

Synoptic Storm-Event Precipitation-Statistics Selection Options

Rain Zone Average  Ecoregion Average  Selected Station Average  User-Defined

Rain Zone Median  Ecoregion Median  Selected Station Median

Generate/Examine Statistics ? View Related Sites

Exit SELDM Accept Updates Proceed Go Back

**Figure 4-13.** Synoptic Storm-Event Precipitation Statistics form showing the Definition tab *A*, before any precipitation options are selected for a new project; *B*, after a regional selection has been made; *C*, after the Enter New Definition option is selected; and *D*, after the Edit Current Definition is selected while using the Selected Station Average option.

**C**

Stochastic Empirical Loading and Dilution Model

**Synoptic Storm-Event Precipitation Statistics: Select Statistics** Information

Select an Existing Precipitation Definition (Required Fields\*)

Avg of Rain Zone 3: Midatlantic DS: 3

Selection Options

Select Current Definition  Edit Current Definition  Enter New Definition

Select a Precipitation-Statistics Dataset

User Defined

Precipitation-Statistics Information:

Definition\* **Storm Event Statistics\*** Annual Statistics and Station Count\*

Define the Synoptic Storm-Event Statistics\*: View Region Information

Current Selection\*: User Defined: 02/12/2013 12:52:58

Synoptic Storm-Event Precipitation-Statistics Selection Options

Rain Zone Average  Ecoregion Average  Selected Station Average  User-Defined

Rain Zone Median  Ecoregion Median  Selected Station Median

Generate/Examine Statistics ? View Related Sites

Exit SELDM Accept Updates Proceed Go Back

**D**

Stochastic Empirical Loading and Dilution Model

**Synoptic Storm-Event Precipitation Statistics: Select Statistics** Information

Select an Existing Precipitation Definition (Required Fields\*)

FHWA 2010: Avg. of 2 stations 02/12/2013 12:58:43

Selection Options

Select Current Definition  Edit Current Definition  Enter New Definition

Select a Precipitation-Statistics Dataset

FHWA 2010

Precipitation-Statistics Information:

Definition\* **Storm Event Statistics\*** Annual Statistics and Station Count\*

Define the Synoptic Storm-Event Statistics\*: View Region Information

Current Selection\*: FHWA 2010: Avg. of 2 stations 02/12/2013 12:58:43

Synoptic Storm-Event Precipitation-Statistics Selection Options

Rain Zone Average  Ecoregion Average  Selected Station Average  User-Defined

Rain Zone Median  Ecoregion Median  Selected Station Median

Generate/Examine Statistics ? View Related Sites

Exit SELDM Accept Updates Proceed Go Back

**Figure 4-13.** Synoptic Storm-Event Precipitation Statistics form showing the Definition tab *A*, before any precipitation options are selected for a new project; *B*, after a regional selection has been made; *C*, after the Enter New Definition option is selected; and *D*, after the Edit Current Definition is selected while using the Selected Station Average option.—Continued

The storm event statistics are shown on the second data-entry tab (fig. 4–14A) and the annual statistics are shown on the third data-entry tab (fig. 4–14B). Although most of the precipitation inputs are mandatory, SELDM calculates the statistics automatically for the regional options and for the selected precipitation-station options. Please note that the median statistics for the regional options may take almost a minute to calculate because the data must be queried, sorted, and the median value identified for each of the synoptic precipitation statistics.

The default rain zone or ecoregion is preselected using the latitude and longitude of the highway site. The default rain zone or ecoregion is the one selected for the analysis. If you change the latitude or longitude of the highway site and this change puts the site in a different ecoregion or rain zone after specifying an initial region, then you will receive a warning message that the coordinates and the region do not match. Similarly, if you select an ecoregion that does not match the ecoregion for the specified coordinates, then a warning message will indicate that the selected region does not represent the highway-site location. You can respecify the regional average or median selections to generate a definition that matches the proper region. If the selected regional precipitation statistics do not match the site location, then the discrepancy will be noted in the warning message displayed on the information form if you click the View Region Information button on the Definition tab (fig. 4–13).

If you wish to use one or several specific stations instead of the stations for an entire ecoregion or rain zone, then choose the Selected Station Average or Selected Station Median option in the Synoptic Storm-Event Precipitation-Statistics Selection Option group on the Definition tab (fig. 4–13). Then the Synoptic Storm Event Precipitation Statistics form will prompt you to select a precipitation-statistics dataset. Then click the Generate/Examine Statistics button to open the form for site selection.

**A**

**Stochastic Empirical Loading and Dilution Model**  
**Synoptic Storm-Event Precipitation Statistics: Select Statistics** Information

Select an Existing Precipitation Definition (Required Fields\*)  
 FHWA 2010: Avg. of 2 stations 02/12/2013 12:58:43

Selection Options  
 Select Current Definition  Edit Current Definition  Enter New Definition

Select a Precipitation-Statistics Dataset  
 User Defined

Precipitation-Statistics Information:  
 Definition\* | **Storm Event Statistics\*** | Annual Statistics and Station Count\*

|  |      |                                   |      |  |
|--|------|-----------------------------------|------|--|
| <b>Storm Event Volume, in Inches*:</b>         | Avg: | <input type="text" value="0.68"/> | COV: | <input type="text" value="1.06"/>                      |
| <b>Storm Event Duration, in Hours*:</b>        | Avg: | <input type="text" value="7.72"/> | COV: | <input type="text" value="0.9"/>                       |
| <b>Time Between Storm Events, in Hours*:</b>   | Avg: | <input type="text" value="167"/>  | COV: | <input type="text" value="1.28"/>                      |
| <b>Minimum Total Storm Volume, in inches*:</b> |      | <input type="text" value="0.1"/>  |      |  |
| <b>Minimum Interevent Time (in hours) *:</b>   |      | <input type="text" value="6"/>    |      | <input style="float: right;" type="button" value="?"/> |

Exit SELDLM    Accept Updates    Proceed    Go Back

**B**

**Stochastic Empirical Loading and Dilution Model**  
**Synoptic Storm-Event Precipitation Statistics: Select Statistics** Information

Select an Existing Precipitation Definition (Required Fields\*)  
 FHWA 2010: Avg. of 2 stations 02/12/2013 12:58:43

Selection Options  
 Select Current Definition  Edit Current Definition  Enter New Definition

Select a Precipitation-Statistics Dataset  
 User Defined

Precipitation-Statistics Information:  
 Definition\* | Storm Event Statistics\* | **Annual Statistics and Station Count\***

|   |      |                                    |      |                                   |
|---|------|------------------------------------|------|-----------------------------------|
| <b>Number of Storm Events Per Year*:</b>            | Avg: | <input type="text" value="48"/>    | COV: | <input type="text" value="0.27"/> |
| <b>Total Annual Precipitation (in inches):</b>      | Avg: | <input type="text" value="32.28"/> | COV: | <input type="text" value="0.27"/> |
| <b>Number of Stations Used to Calculate Values:</b> |      | <input type="text" value="2"/>     |      |                                   |

Exit SELDLM    Accept Updates    Proceed    Go Back

**Figure 4-14.** Synoptic Storm-Event Precipitation Statistics form, showing *A*, the Storm Event Statistics tab, and *B*, the Annual Statistics and Station Count tab as they appear for user-defined input.

## The Create or Modify a Precipitation-Station List Form

The Create or Modify a Precipitation-Station List form (`frmPrecipGetSites`) provides the interface for selecting stations of interest and generating statistics from the selected list (fig. 4–15A). When the form loads, the title will read Create a Precipitation-Station List if you are creating a new definition or Modify a Precipitation-Station List if you are editing a predefined list. The lower listbox on this form (Precipitation Stations) lists all the precipitation stations in the dataset ranked in order of their proximity to the latitude and longitude entered for the highway site using the Haversine method (Sinnott, 1984; Drexel University Math Forum, 1999; Granato and others, 2009). This site-selection listbox shows the longitude, latitude, the National Oceanic and Atmospheric Administration (NOAA) station name, the State, the number of storms per year (Storms/Yr), and the total annual precipitation for runoff events (in inches; Annual Precip. (in)) for each site. These statistics will help you select the most representative precipitation station for the site of interest. Generally, nearby stations with physiographic settings similar to the site of interest and precipitation statistics that do not substantially diverge from the local norm would be logical selections unless there are special conditions at the site of interest (Granato, 2010). To select a precipitation station, click the data line containing the name of the station. A confirmation message appears with a detailed summary of all the precipitation statistics for the selected precipitation station. Select Yes to keep the current selection (fig. 4–15B).

The upper listbox on this form (Selected Stations) lists the precipitation stations that have been selected to calculate precipitation statistics for the site of interest (fig. 4–15A). The precipitation stations in this listbox also are ranked in order of their proximity to the latitude and longitude entered for the highway site. After selecting one or more precipitation stations, click the Preview Average (fig. 4–15A) or Preview Median button to see a message box (fig. 4–15C) with the values that the SELDM analysis will use. To remove a selected precipitation station, click the data line containing the name of the station in the upper listbox (fig. 4–15A). A message box will appear to confirm that you want to deselect that precipitation station. To abandon any changes without saving, click the Close Form button at any time. To save the selections, click the Create New button if you are creating a new definition or the Modify Existing button if you are editing a predefined list. When you save the selections, a pop-up input box will appear requesting the short name for the selections (fig. 4–15D). The default name for the selection is made up of the dataset, the type of statistic (average or median of selected sites), the number of stations, and the date and time the selection was made (for example, FHWA 2010: Avg. of 2 stations 02/12/2013 12:58:43). You may change the name of the selection, being careful not to use a predefined name. After you accept a name, you will be returned to the main Synoptic Storm-Event Precipitation Statistics form (fig. 4–13) and this new precipitation-statistics definition will become the default selection.

## Streamflow Statistics Forms

SELDM has two input forms that are used to define streamflow statistics. If you are using regional statistics (from data grouped by ecoregions) or user-defined statistics, then you will use the Streamflow Statistics form. If you are using statistics from one or more nearby sites, then you will also use the Create or Modify a Streamgage List Form. Detailed definitions and descriptions for using the streamflow statistics to model prestorm flow rates are described in the “Prestorm Streamflow Volumes” section of the main report. Specification and use of these statistics also were described in the SELDM stormflow report (Granato, 2010). If you want to create an updated regional or national dataset or calculate statistics for a given streamgage, then all the necessary streamflow data and statistics calculated for use with SELDM can be obtained in the proper format by using the suite of software developed by Granato (2009).

**A**

**Stochastic Empirical Loading and Dilution Model**

**Create a Precipitation-Station List** Information

Highway Site Coordinates: Longitude:  Latitude:

Selected Stations (left-click to remove station) Dataset:

| Longitude    | Latitude    | NOAA Station Name | State | Storms/Yr | Annual Precip. (in) |
|--------------|-------------|-------------------|-------|-----------|---------------------|
| -77          | 40.1        | HUNTSDALE         | PA    | 48        | 30.63               |
| -77.36666667 | 40.26666667 | BLOSERVILLE 1 N   | PA    | 47        | 33.92               |

Precipitation Stations: (left-click to select a station)

| Longitude    | Latitude    | NOAA Station Name   | State | Storms/Yr | Annual Precip. (in) |
|--------------|-------------|---------------------|-------|-----------|---------------------|
| -77          | 40.1        | HUNTSDALE           | PA    | 48        | 30.63               |
| -77.36666667 | 40.26666667 | BLOSERVILLE 1 N     | PA    | 47        | 33.92               |
| -76.46666667 | 40.33333333 | LEBANON 2 W         | PA    | 44        | 29.97               |
| -76.73333333 | 39.93333333 | YORK 1 S FLTR PLT   | PA    | 47        | 30.7                |
| -76.8633     | 39.86917    | SPRING GROVE        | PA    | 47        | 29.26               |
| -76.43333333 | 40.11666667 | LANDISVILLE 2 NW    | PA    | 54        | 34.07               |
| -77.41666667 | 39.98333333 | FAYETTEVILLE 10 ENE | PA    | 49        | 35.3                |
| -77.58333333 | 40.3        | BLAIN 5SW           | PA    | 50        | 32.36               |
| -76.86666667 | 40.78333333 | SELINSGROVE 2 S     | PA    | 54        | 35.44               |
| -76.46666667 | 40.61666667 | JOLIETT             | PA    | 40        | 29.49               |

**B**

**Station Selection Information:**

The selected precipitation station is defined as follows:

SYNOP Precipitation Dataset: FHWA 2010  
 Federal Highway Administration Synoptic Analysis  
 Period of Record for Dataset: 1965-1989  
 NOAA Precipitation Station: 364166  
 HUNTSDALE  
 State: PA  
 Elevation: 620

| Parameter:      | Average | COV  |
|-----------------|---------|------|
| Storms/Year:    | 48      | 0.24 |
| Precip./Year:   | 30.63   | 0.25 |
| Event Volume:   | 0.64    | 1.13 |
| Event Duration: | 8.29    | 0.92 |
| Event Delta:    | 162.85  | 1.24 |

Do you want to include this station in the analysis?

**C**

**Average of Station values**

Average of values for the 2 selected station(s):  
 in SYNOP Precipitation Dataset: FHWA 2010  
 Federal Highway Administration Synoptic Analysis

Minimum Interevent Time (hours): 6  
 Minimum Total Storm Volume (in): 0.1

| Parameter:      | Average | COV  |
|-----------------|---------|------|
| Storms/Year:    | 48      | 0.27 |
| Precip./Year:   | 32.28   | 0.27 |
| Event Volume:   | 0.68    | 1.06 |
| Event Duration: | 7.72    | 0.9  |
| Event Delta:    | 167     | 1.28 |

(volumes are in inches, durations are in hours)

**D**

**Precipitation Statistics Name:**

Please enter/edit an identifiable precipitation statistics name  
 (up to 65 characters including spaces):

**Figure 4–15.** Create or Modify a Precipitation-Station List form showing *A*, the precipitation stations available for selection; *B*, the message box confirming the selection; *C*, the statistical summary (the average or median of station values) for the selected stations; and *D*, the input box for a Short Name for the selected statistics. The form shown in the Create a Precipitation-Station List mode; the Modify a Precipitation-Station List mode has, with the exception of the title, the same appearance and functionality.

## The Streamflow Statistics Form

The Streamflow Statistics form (`frmStreamflowSelect`) provides the interface for selecting predefined streamflow statistics or for entering user-defined statistics (fig. 4–16). Predefined streamflow statistics can be selected by using the previously defined ecoregion designation or by selecting statistics from one or more local streamgages using the Create or Modify a Streamgage List form (`frmStreamflowGetSites`). The Streamflow Statistics form has three data-entry tabs: the Definition tab, the Streamflow Statistics, in CFSM tab, and the Low-Flow Statistics and Station Count tab.

When you first open the Streamflow Statistics form within a given project, no selections appear in the Select an Existing Streamflow Statistics Definition combobox, and the default selection in the Streamflow-Statistics Selection Options group will be the Ecoregion Average (fig. 4–16A). The focus is on the Select a Streamflow-Statistics Dataset. To specify the first streamflow definition, click an option in the Streamflow-Statistics Selection Options group and follow the context-sensitive instructions on the message boxes. (Please note: If you want to use the Ecoregion Average option, first click another option, then click back to the Ecoregion Average option). Generally (fig. 4–16D), you will (1) select an option, (2) choose the desired dataset from the Select a Streamflow-Statistics Dataset combobox, (3) click the Generate/Examine Statistics command button, and (4) click the Accept Updates command button to add the definition to the dataset for current and future use. The streamflow statistics entered into this form are a combination of arithmetic statistics, retransformed logarithmic values (the average and standard deviation of the logarithms of nonzero flows), and logarithmic values (the skew coefficient of the logarithms of nonzero flows). Streamflow statistics are entered in units of cubic feet per second per square miles ( $\text{ft}^3/\text{s}/\text{mi}^2$  or as shown on the forms, CFSM) to facilitate comparisons between sites and the application of statistics to hydrologically similar sites.

Modifying the initial selection requires a few steps, and different options on the form are enabled or disabled, depending on your selections. Once an ecoregion selection has been made, the edit option is disabled (fig. 4–16B) because you cannot edit streamflow statistics that were calculated using all streamgages in a region. You can, however, select Enter New Definition and select a regional option to calculate the same statistics using data from a different dataset. Selecting Enter New Definition also lets you modify regional statistics by clicking Yes when prompted to create a new definition based on the current selection, then editing the streamflow statistics using the existing values (fig. 4–16C). To select a different method, click No when prompted to create a new definition based on the current selection, then click one of the selected streamgage options (fig. 4–16D).

**A**

Stochastic Empirical Loading and Dilution Model

**Streamflow Statistics: Select Statistics** Information

Select an Existing Streamflow Statistics Definition (Required Fields\*)

Selection Options

Select Current Definition  Edit Current Definition  Enter New Definition

Select a Streamflow-Statistics Dataset

FHWA 2010

Streamflow-Statistics Information

Definition\*  Streamflow Statistics, in CFM\* Low-Flow Statistics and Station Count\*

**Define the Streamflow Statistics\*:** View Region Information

Current Selection\*:

Streamflow-Statistics Selection Options

Ecoregion Average  Selected Station Average  User-Defined

Ecoregion Median  Selected Station Median

Generate/Examine Statistics ? View Related Sites

Exit SELDM Accept Updates Proceed Go Back

**B**

Stochastic Empirical Loading and Dilution Model

**Streamflow Statistics: Select Statistics** Information

Select an Existing Streamflow Statistics Definition (Required Fields\*)

Avg of Ecoregion: 67 Central Appalachian Ridges and Valleys DS: 2

Selection Options

Select Current Definition  Edit Current Definition  Enter New Definition

Select a Streamflow-Statistics Dataset

FHWA 2010

Streamflow-Statistics Information

Definition\*  Streamflow Statistics, in CFM\* Low-Flow Statistics and Station Count\*

**Define the Streamflow Statistics\*:** View Region Information

Current Selection\*:

Avg of Ecoregion: 67 Central Appalachian Ridges and Valleys DS: 2

Streamflow-Statistics Selection Options

Ecoregion Average  Selected Station Average  User-Defined

Ecoregion Median  Selected Station Median

Generate/Examine Statistics ? View Related Sites

Exit SELDM Accept Updates Proceed Go Back

**Figure 4-16.** Streamflow Statistics form showing the Definition tab *A*, before any streamflow options are selected for a new project; *B*, after a regional selection has been made; *C*, after the Enter New Definition option is selected; and *D*, after the Edit Current Definition is selected while using the Selected Station Average option.

**C**

**Stochastic Empirical Loading and Dilution Model**

**Streamflow Statistics: Select Statistics** Information

Select an Existing Streamflow Statistics Definition (Required Fields\*)

Avg of Ecoregion: 67 Central Appalachian Ridges and Valleys DS: 2

Selection Options

Select Current Definition     Edit Current Definition     Enter New Definition

Select a Streamflow-Statistics Dataset

User Defined

Streamflow-Statistics Information

Definition\* | Streamflow Statistics, in CFSM\* | Low-Flow Statistics and Station Count\*

Define the Streamflow Statistics\*: View Region Information

Current Selection\*: User Defined: 02/12/2013 13:04:36

Streamflow-Statistics Selection Options

Ecoregion Average     Selected Station Average     User-Defined

Ecoregion Median     Selected Station Median

Generate/Examine Statistics    ?    View Related Sites

Exit SELDM    Accept Updates    Proceed    Go Back

**D**

**Stochastic Empirical Loading and Dilution Model**

**Streamflow Statistics: Select Statistics** Information

Select an Existing Streamflow Statistics Definition (Required Fields\*)

FHWA 2010: Avg. of 2 stations 02/12/2013 13:20:42

Selection Options

Select Current Definition     Edit Current Definition     Enter New Definition

Select a Streamflow-Statistics Dataset

FHWA 2010

Streamflow-Statistics Information

Definition\* | Streamflow Statistics, in CFSM\* | Low-Flow Statistics and Station Count\*

Define the Streamflow Statistics\*: View Region Information

Current Selection\*: FHWA 2010: Avg. of 2 stations 02/12/2013 13:20:42

Streamflow-Statistics Selection Options

Ecoregion Average     Selected Station Average     User-Defined

Ecoregion Median     Selected Station Median

Generate/Examine Statistics    ?    View Related Sites

Exit SELDM    Accept Updates    Proceed    Go Back

**Figure 4-16.** Streamflow Statistics form showing the Definition tab *A*, before any streamflow options are selected for a new project; *B*, after a regional selection has been made; *C*, after the Enter New Definition option is selected; and *D*, after the Edit Current Definition is selected while using the Selected Station Average option.—Continued

The arithmetic statistics for all daily mean streamflows and the retransformed statistics of the logarithms of nonzero daily mean streamflows in  $\text{ft}^3/\text{s}/\text{mi}^2$  are shown on the second data entry tab (fig. 4–17A). The low-flow statistics for all daily mean streamflows are shown on the third data entry tab (fig. 4–17B). Although most of the streamflow inputs are mandatory, SELDM calculates the statistics automatically for the regional options and for the selected-station options. To calculate prestorm flows, SELDM uses only the average, the standard deviation, and the skew coefficient of the logarithms of nonzero daily mean streamflows and the fraction of daily mean streamflow values recorded as zero flow (Granato, 2010). The other statistics are provided to help users evaluate the selected regional or selected site statistics in context with local conditions at the site of interest. All these streamflow statistics can be calculated using the programs developed for the SELDM project (Granato, 2009). Please note that the median statistics for the regional options may take almost a minute to calculate because the data must be queried, sorted, and the median value identified for each of the streamflow statistics.

The default ecoregion is preselected using the latitude and longitude of the highway site. The default ecoregion is the one selected for the analysis. If you change the latitude or longitude of the highway site and this change puts the site in a different ecoregion after specifying an initial region, then you will receive a warning message that the coordinates and the region do not match. Similarly, if you select an ecoregion that does not match the ecoregion for the specified coordinates, then a warning message will indicate that the selected region does not represent the highway-site location. You can respecify the regional average or median selections to generate a definition that matches the proper region. If the selected regional streamflow statistics do not match the site location, then the discrepancy will be noted in the warning message displayed on the information form if you click the View Region Information button.

If you wish to use one or several specific streamgages instead of the streamgages for an entire ecoregion, then choose the Selected Station Average or Selected Station Median option in the Streamflow-Statistics Selection Option group on the Definition tab (fig. 4–16). Then the Streamflow Statistics form will prompt you to select a streamflow-statistics dataset. Then click the Generate/Examine Statistics button to open the form for site selection.

A

**Stochastic Empirical Loading and Dilution Model**

**Streamflow Statistics: Select Statistics** Information

Select an Existing Streamflow Statistics Definition (Required Fields\*)

FHWA 2010: Avg. of 2 stations 02/12/2013 13:20:42

Selection Options

Select Current Definition     Edit Current Definition     Enter New Definition

Select a Streamflow-Statistics Dataset

User Defined

Streamflow-Statistics Information

Definition\* Streamflow Statistics, in CFSM\* **Low-Flow Statistics and Station Count\***

**Fraction of Daily-Mean Streamflows Recorded as Zero Flow\*:**

**Arithmetic Statistics for All Daily-Mean Streamflow Values\*:**

Average:  Standard Deviation:  Skew:  ?

Median:

**Retransformed Log10 Arithmetic Statistics for Nonzero Daily-Mean Streamflow Values\*:**

Average:  Standard Deviation:  Skew:  ?

Median:

Exit SELDM    Accept Updates    Proceed    Go Back

B

**Stochastic Empirical Loading and Dilution Model**

**Streamflow Statistics: Select Statistics** Information

Select an Existing Streamflow Statistics Definition (Required Fields\*)

FHWA 2010: Avg. of 2 stations 02/12/2013 13:20:42

Selection Options

Select Current Definition     Edit Current Definition     Enter New Definition

Select a Streamflow-Statistics Dataset

User Defined

Streamflow-Statistics Information

Definition\* Streamflow Statistics, in CFSM\* **Low-Flow Statistics and Station Count\***

**Low-Flow Statistics for All Streamflow Values Calculated Using the USEPA DFLOW3.0 Program. in Cubic Feet Per Second Per Square Mile\*:**

7Q10:  1B3:  4B3:  ?

Number of Streamgages Used to Calculate Values:

Exit SELDM    Accept Updates    Proceed    Go Back

**Figure 4-17.** Streamflow Statistics form, showing the A, Streamflow Statistics, in CFSM and B, Low-Flow Statistics and Station Count tabs as they appear for user-defined input.

## The Create or Modify a Streamgage List Form

The Create or Modify a Streamgage List form (`frmStreamflowGetSites`) provides the interface for selecting streamgage of interest and generating statistics from the selected list (fig. 4–18A). When the form loads, the title will read Create a Streamgage List if you are creating a new definition or Modify a Streamgage List if you are editing a predefined list. The lower listbox on this form (Streamgages) lists all the streamgages in the dataset ranked in order of their proximity to the latitude and longitude entered for the highway site using the Haversine method (Sinnott, 1984; Drexel University Math Forum, 1999; Granato and others, 2009). This site-selection listbox shows the longitude, latitude, drainage area (Area), median flow in  $\text{ft}^3/\text{s}/\text{mi}^2$  (Med. Q(cfsm)), the proportion of daily flows that are zero (Zed Q), and the station name for each site, as shown in the USGS National Water Information System database. These statistics will help you select the most representative streamgage for the site of interest. Generally, nearby streamgages with drainage areas that are similar to the site of interest, median streamflows that do not substantially diverge from the local norm, and Zed Q values that represent the status of the site of interest (perennial, intermittent, or ephemeral) would be logical selections unless there are special conditions at the site of interest (Granato, 2010). To select a streamgage, click the data line containing the name of the station. A confirmation message appears with a detailed summary of all the streamflow statistics for the selected streamgage (fig. 4–18B). Select Yes to keep the current selection.

The upper listbox on this form (Selected Gages) lists only the streamgages that have been selected to calculate streamflow statistics for the site of interest (fig. 4–18A). The streamgages in this listbox also are ranked in order of their proximity to the latitude and longitude entered for the highway site. After selecting one or more streamgages, click the Preview Average or Preview Median button to see the values that the SELDL analysis will use on a message box (fig. 4–18C). To remove a selected streamgage, click the data line containing the name of the station in the upper listbox (fig. 4–18A). A message box will appear to confirm that you want to deselect that streamgage. To abandon any changes without saving, click the Close Form button at any time. To save the selections, click the button, which will be labeled Create New if you are creating a new definition or Modify Existing if you are editing a predefined list. If you save the selections, a pop-up input box will appear requesting the short name for the selections (fig. 4–18D). The default name for the selection is made up of the dataset, the type of statistic (average or median of selected sites), the number of streamgages (stations), and the date and time the selection was made (for example, FHWA 2010: Avg. of 2 stations 02/12/2013 13:20:42). You may change the name of the selection, being careful not to use a predefined name. After you accept a name, you will be returned to the main Streamflow Statistics Form (fig. 4–16) and this new streamflow-statistics definition will become the default selection.

**A**

**Stochastic Empirical Loading and Dilution Model**

**Create a Streamgage List** Information

Highway Site Coordinates: Longitude:  Latitude:

Selected Gages (left-click to remove station) Dataset:

| Longitude   | Latitude   | Area | Med. Q(cfs) | Zed Q | Station Name                             |
|-------------|------------|------|-------------|-------|--|
| -77.0210877 | 40.2523108 | 470  | 0.734043    | 0     | CONODOGUINET CREEK NEAR HOGESTOWN, PA    |
| -76.8980292 | 40.2248125 | 216  | 0.981482    | 0     | YELLOW BREECHES CREEK NEAR CAMP HILL, PA |

Streamgages: (left-click to select a station) Med Q: median flow, cfs: cubic feet per second per square mile. Zed Q: Fraction of zero flows. Area: square miles

| Longitude   | Latitude   | Area | Med. Q(cfs) | Zed Q    | Station Name                             |
|-------------|------------|------|-------------|----------|--|
| -77.0210877 | 40.2523108 | 470  | 0.734043    | 0        | CONODOGUINET CREEK NEAR HOGESTOWN, PA    |
| -76.8980292 | 40.2248125 | 216  | 0.981482    | 0        | YELLOW BREECHES CREEK NEAR CAMP HILL, PA |
| -77.1394244 | 40.2348102 | 216  | 1.759259    | 0        | LETORT SPRING RUN NEAR CARLISLE, PA      |
| -77.1688702 | 40.3234191 | 207  | 0.681159    | 0        | SHERMAN CREEK AT SHERMANS DALE, PA       |
| -76.6677469 | 40.2984236 | 483  | 0.908903    | 0        | SWATARA CREEK NEAR HERSHEY, PA           |
| -76.7513577 | 40.4603644 | 225  | 0.284445    | 0        | CLARK CREEK NEAR CARSONVILLE, PA         |
| -76.9119197 | 40.6111958 | 162  | 0.734568    | 0        | EAST MAHANTANGO CREEK NEAR DALMATIA, PA  |
| -76.5771883 | 40.4025897 | 337  | 0.916914    | 0        | SWATARA CREEK AT HARPER TAVERN, PA       |
| -77.4022092 | 40.3709161 | 15   | 0.646667    | 0        | BIXLER RUN NEAR LOYSVILLE, PA            |
| -76.7552458 | 39.9462097 | 222  | 0.594595    | 0        | CODORUS CREEK NEAR YORK, PA              |
| -76.7489576 | 39.9265417 | 117  | 0.530016    | 0.007592 | SOUTH BRANCH CODORUS CREEK NEAR YORK, PA |

**B**

**Station Selection Information:**

The selected streamflow gaging station is defined as follows:  
 Streamflow-Statistics Dataset: FHWA 2010  
 Federal Highway Administration Analysis  
 Period of Record for Dataset: 1961-2004

USGS Gaging Station: 01570000  
 CONODOGUINET CREEK NEAR HOGESTOWN, PA

Drainage Area: 470  
 Number of daily measurements: 13241  
 Proportion of zero flows: 0  
 Median streamflow, in cfs: 0.734  
 7Q10, in cfs: 0.1614

Statistics for the common logarithms of nonzero streamflow values:  
 Geometric mean, in cfs: 0.7967  
 Geometric Standard Deviation: 2.5305  
 Geometric Skew Coefficient: 0.4678

Do you want to include this station in the analysis?

**C**

**Average of Station values**

Average of values for the 2 selected station(s):  
 In Streamflow-Statistics Dataset: FHWA 2010  
 Federal Highway Administration Streamflow Analysis

Proportion of zero flows: 0  
 Statistics for the common logarithms of nonzero streamflow values (cfs):  
 Geometric Mean: 0.9383  
 Geometric Standard Deviation: 2.2056  
 Geometric Skew Coefficient: 0.6563  
 Median of non-zero flows: 0.8578

Statistics for all streamflow values (cfs):  
 Mean: 1.3365  
 Standard Deviation: 1.6732  
 Skew Coefficient: 9.7188  
 Median streamflow: 0.8578

Low-Flow Statistics for all streamflow values (cfs):  
 1-day, 3-year (183) biological lowflow: 0.252  
 4-day, 3-year (483) biological lowflow: 0.26  
 7-day, 10-year (7Q10) lowflow: 0.293

**D**

**Streamflow Statistics Name:**

Please enter/edit an identifiable streamflow statistics name  
 (up to 100 characters including spaces):

**Figure 4-18.** Create or Modify a Streamgage List form showing *A*, the streamgages available for selection; *B*, the message box confirming the selection; *C*, the statistical summary (the average or median of station values) for the selected stations; and *D*, the input box for a Short Name for the selected statistics. The form is shown in the Create a Streamgage List mode; the Modify a Streamgage List mode has, with the exception of the title, the same appearance and functionality.

## The Volumetric Runoff Coefficient (Rv) Statistics Form

The Volumetric Runoff Coefficient (Rv) Statistics form (frmRvSelect) provides the interface for selecting predefined Rv statistics or for entering user-defined statistics for the highway site and for the upstream basin (fig. 4–19). The Highway Site and Upstream Basin data-input tabs repeat the name and total impervious fraction of the respective areas that were defined on the site forms. These textboxes are locked because these data are provided on this form only for informational purposes. Both data-input tabs also have a definition combobox, and textboxes for the average, standard deviation, and skew coefficient of the Rv, which are used to generate a population of Rv values in the Monte Carlo simulations by using a Pearson type III distribution (Chow and others, 1988; Stedinger and others, 1993). The two methods for defining Rv are (1) selecting predefined statistics and (2) entering user-defined statistics. User-defined values may provide the best estimate if sufficient data are available for the site of interest. You can enter user defined values by using the Edit Current Definition or Enter New Definition options. In either case, you specify user-defined values by modifying the average, standard deviation, and skew coefficient of the Rv values calculated using the predefined regression equations. Alternatively, you may enter entirely new values of these statistics. User-defined values are saved in the analysis table (tblHighwayAnalysis) rather than the predefined value table (tblRvEquations) in the SELDM database. Therefore, changes in user-defined values or in your subsequent selection of predefined values will overwrite any user-defined values associated with the analysis. You can copy an analysis one or more times to test the effects of using different predefined values or user-defined Rv values.

The predefined statistics are calculated from the impervious fractions using published regression equations. SELDM provides three default equations. The default regression equations for calculating the average, standard deviation, and skew coefficient of the runoff coefficients for the highway site, which are labeled SELDM Highway Sites, were developed by Granato and Czenas (2009) using data from 58 highway monitoring sites with impervious fractions ranging from 0.27 to 1.0. The default regression equations for the upstream basin, which are labeled SELDM Upstream Basin, were developed by Granato (2010) using data from 167 monitoring sites with impervious fractions ranging from 0.0001 to 0.994. The regression lines for these equations are shown in figure 10 of the main report. The third predefined selection, which is labeled Schueler Trimmed Nationwide Urban Runoff Program (NURP) is based on Schueler's (1987) selection of 43 sites with impervious fractions ranging from 0.01 to 1.0 from the USEPA NURP report (Athayde and others, 1983). Detailed definitions and descriptions of the theory and implementation of the Rv statistics are described in the "Storm-Runoff Volumes" section of the main report. Specification and use of these statistics also were described in the SELDM stormflow report (Granato, 2010). You may also define your own regression equations using methods described by Granato (2010), and you may enter your own equations in table tblRvEquations (appendix 3). Once you define the regression equations, they will appear as a standard selection in the Definition comboboxes.

**A**

Stochastic Empirical Loading and Dilution Model

**Volumetric Runoff Coefficient (Rv) Statistics** Information

**(Required Fields\*)**

Selection Options

Select Current Definition   
 Edit Current Definition   
 Enter New Definition

**Highway Site\*** | **Upstream Basin\***

Site Name (defined on site form):

Total Impervious Fraction (defined on site form):

Definition\*:  
 ?

Average\*:

Standard Deviation\*:

Skew Coefficient\*:

**B**

Stochastic Empirical Loading and Dilution Model

**Volumetric Runoff Coefficient (Rv) Statistics** Information

**(Required Fields\*)**

Selection Options

Select Current Definition   
 Edit Current Definition   
 Enter New Definition

**Highway Site\*** | **Upstream Basin\***

Basin Name (defined on upstream basin form):

Total Impervious Fraction (defined on upstream basin form):

Definition\*:  
 ?

Average\*:

Standard Deviation\*:

Skew Coefficient\*:

Rank Correlation Coefficient with Prestorm Flow (0 to 1)\*:  
 ?

**Figure 4-19.** Create Volumetric Runoff Coefficient (Rv) Statistics form, showing *A*, the Highway Site tab before clicking Accept Updates, and *B*, the upstream basin tab before clicking Accept Updates.

## Water Quality Forms

SELDM has six input forms that are used to define the quality of highway runoff and upstream stormflows, the water-quality characteristics of downstream pairs, and performance characteristics of the selected stormwater BMPs (fig. 4–1). The statistics selected on these forms have a large effect on the computed risks for adverse effects of highway runoff on the quality of receiving waters. The statistics selected to model the concentrations, flows, and loads of BMP discharges indicate the ability of such BMPs to mitigate those risks.

### The Water-Quality Selection Form

The Water Quality Menu form (frmQWMenu) provides the interface for selecting water-quality constituents for analysis. This menu form can be used for selecting predefined water-quality statistics or for launching an interface for defining water-quality statistics. The Explanation tab provides a general explanation of the water-quality module, instructions for the form, and (because many water-quality definitions are available by ecoregion) information about the currently selected ecoregion. In addition to the Explanation tab, the form has six tabs (fig. 4–20) for selecting water-quality statistics: two for selecting highway-runoff statistics (the Highway Random and Highway Dependent tabs), three for selecting upstream runoff statistics (the Upstream Random, Upstream Dependent, and Upstream Transport Curve tabs), and one for defining downstream water-quality pairs (Downstream Pairs). The Water Quality Menu form is used to select or deselect constituents or downstream constituent pairs that are defined in the random, dependent, transport curve, or downstream-pairs water-quality definition forms described in the next four subsections of this appendix.

These six data-entry tabs let you input and select different types of water-quality statistics. The random water-quality definitions for highway runoff and upstream stormflow are calculated from the input average, standard deviation, and skew coefficient of a selected water-quality constituent. The dependent water-quality definitions for highway runoff and upstream flow are calculated using a regression equation that calculates the concentration for the constituent of interest from the concentration of another selected water-quality constituent. For example, an equation for estimating suspended sediment concentrations (SSC) from total suspended solids (TSS) developed by Granato and Cazenais (2009) is available in SELDM on the Highway Dependent tab. The water-quality definitions for the upstream transport curves are calculated using a regression equation that calculates the constituent concentration of interest from the upstream stormflow value. Regional planning-level transport curves for SSC, total hardness, and total phosphorus were calculated for each of the 84 ecoregions in the conterminous United States by Granato and others (2009); these equations are available within the SELDM database.

All the water-quality selection tabs share six common controls (figs. 4–20B–F, 4–21). The two listboxes on each tab are the Selected Constituents or Selected Constituent Pairs and the Available Constituents or Available Constituent Pairs. The lower listbox shows the available constituents and the upper listbox shows the constituents that have been selected for a given highway-runoff analysis. There also is an On Selection option group associated with each listbox that controls the actions taken by SELDM when the associated listbox is clicked. There is a Define New command button associated with the Available Constituents listbox. There is an information command button (labeled “?”), which opens an information form with a definition of the associated type of water-quality variable.

The option group for the Available Constituents listbox has four selections that control the action taken by SELDM when you click an available constituent. Clicking a constituent opens a message box confirming your selection or opens an information form showing the water-quality definition. Clicking the default option Select includes a constituent in an analysis. The View option opens an information form showing the water-quality definition. The Edit option opens a message box, and clicking Yes opens the associated water-quality specification form with the definition for the selected constituent. Selecting Delete opens a confirmation form, and clicking Yes deletes the water-quality definition. If the definition of that constituent is used in the current analysis, then you must deselect it and then delete it. If the constituent definition is used in a dependent-constituent definition in the current analysis, then you must deselect the dependent definition to deselect it from the current analysis. If the constituent definition is used in a dependent-constituent definition, then you must delete the dependent definition before deleting the water-quality constituent. Alternatively, you may redefine the dependent relation to use a different constituent definition. You cannot delete a constituent if it is associated with a dependent relation. Similarly, you cannot deselect or delete a constituent if it is associated with a downstream water-quality definition in the current analysis. You cannot delete a constituent if it is associated with a downstream water-quality definition in any analysis in your SELDM database.

The option group associated with the Selected Constituents listbox has two selections that control the action taken by SELDM when you click an available constituent. The View option is the default selection; it opens an information form showing the water-quality definition. The Deselect option removes the constituent from the Selected Constituents listbox and from the current analysis. This selection, however, does not delete the water-quality definition from the SELDM database. If the constituent definition is used in a dependent-constituent definition, then you must delete or redefine the dependent definition before deleting the water-quality constituent.

A

**Stochastic Empirical Loading and Dilution Model**

**Water-Quality Menu: Select Constituents for the Analysis** Information

Explanation **Highway Random** Highway Dependent Upstream Random Upstream Transport Curve Upstream Dependent Downstream Pairs

View:  General Explanation  Instructions for this Form  Ecoregion

The Stochastic Empirical Loading and Dilution Model (SELDM) allows the user to specify one or more highway-runoff-quality and one or more upstream-stormflow-quality constituents. SELDM will calculate concentrations and loads for all the selected highway-runoff constituents. However SELDM will only calculate upstream and downstream concentrations and loads for user-defined constituent pairs. This form provides an interface for selecting predefined constituents and constituent pairs with links to forms that allow users to view, edit, or define a new constituent or constituent pair.

Users have two choices (random and dependent) for specifying highway-runoff-quality constituents and three choices (random, dependent and transport curve) for specifying upstream-stormflow-quality constituents. These choices are defined as follows:

**RANDOM:** A random water-quality definition is based on sample statistics from monitoring studies. Users can specify a random water-quality definition by entering the mean, standard deviation, and coefficient of skew of each constituent (or the logarithm of each constituent).

**DEPENDENT:** A dependent water-quality definition is based on a relationship between the concentration of a constituent of interest and the concentration of a related constituent. For example, the U.S. Geological Survey has an extensive database defining trace-metal concentrations in soil and sediments. This data can be used with suspended-sediment concentrations to estimate the total concentration of trace metals in the upstream stormflow. The dependent water-quality definition may have an empirical component to define the relation between constituents and stochastic component to define random variations in this relation. Users can specify a dependent water-quality definition by entering the relation between constituents and an estimate of the random variability in that relation.

**TRANSPORT CURVE:** A water-quality transport curve is a relation between streamflow and the concentration of a constituent. For example, the concentration of a constituent associated with stormflow, such as suspended sediment, may increase with increasing flow as more sediment is

Exit SELDM Proceed Go Back

B

**Stochastic Empirical Loading and Dilution Model**

**Water-Quality Menu: Select Constituents for the Analysis** Information

Explanation Highway Random **Highway Dependent** Upstream Random Upstream Transport Curve Upstream Dependent Downstream Pairs

On Selection:  View  Deselect

**Selected Constituents:**

|                                 |        |
|---------------------------------|--------|
| FHWA 1990 NonUrban TSS          | p00530 |
| FHWA 1990 UltraUrban TSS        | p00530 |
| FHWA 1990 Urban TSS             | p00530 |
| MA 2009 Total Phosphorus p00665 | p00665 |

On Selection:  Select  View  Edit  Delete

**Available Constituents:**

|   |               |
|---|---------------|
| FHWA 1990 NonUrban TSS                            | p00530        |
| FHWA 1990 UltraUrban TSS                          | p00530        |
| FHWA 1990 Urban TSS                               | p00530        |
| <b>MA 2009 Total Phosphorus p00665</b>            | <b>p00665</b> |
| MA 2009-10 pH                                     | p00403        |
| MA 2009-10 Suspended sediment concentration (SSC) | p80154        |
| MA 2009-10 Total Cadmium                          | p01027        |
| MA 2009-10 Total Chromium                         | p01034        |
| MA 2009-10 Total Copper                           | p01042        |
| MA 2009-10 Total Hardness                         | p00900        |
| MA 2009-10 Total Lead                             | p01051        |

Exit SELDM Proceed Go Back

**Figure 4-20.** Water-Quality Menu form showing the A, Explanation, B, Highway Random, C, Highway Dependent, D, Upstream Random, E, Upstream Transport Curve, and F, Upstream Dependent information and data entry tabs.

C

Stochastic Empirical Loading and Dilution Model

**Water-Quality Menu: Select Constituents for the Analysis** Information

Explanation | Highway Random | Highway Dependent | Upstream Random | Upstream Transport Curve | Upstream Dependent | Downstream Pairs

On Selection:  View  Deselect 

Selected Constituents:

|                              |        |
|------------------------------|--------|
| SSC from TSS (HRDB Equation) | p80154 |
|------------------------------|--------|

On Selection:  Select  View  Edit  Delete

Available Constituents:

|                              |        |
|------------------------------|--------|
| SSC from TSS (HRDB Equation) | p80154 |
|------------------------------|--------|

D

Stochastic Empirical Loading and Dilution Model

**Water-Quality Menu: Select Constituents for the Analysis** Information

Explanation | Highway Random | Highway Dependent | Upstream Random | Upstream Transport Curve | Upstream Dependent | Downstream Pairs

On Selection:  View  Deselect 

Selected Constituents:

|                     |        |
|---------------------|--------|
| pH (random) Eco: 67 | p00403 |
|---------------------|--------|

View:  Ecoregion Values  User Defined Values  Both

On Selection:  Select  View  Edit  Delete

Available Constituents:

|                     |        |
|---------------------|--------|
| pH (random) Eco: 67 | p00403 |
|---------------------|--------|

**Figure 4-20.** Water-Quality Menu form showing the A, Explanation, B, Highway Random, C, Highway Dependent, D, Upstream Random, E, Upstream Transport Curve, and F, Upstream Dependent information and data entry tabs.—Continued

E

Stochastic Empirical Loading and Dilution Model

Water-Quality Menu: Select Constituents for the Analysis Information

Explanation | Highway Random | Highway Dependent | Upstream Random | **Upstream Transport Curve** | Upstream Dependent | Downstream Pairs

Selected Constituents:

|                        |        |
|------------------------|--------|
| TC: p80154 SSC Eco: 67 | p80154 |
|------------------------|--------|

On Selection

View

Deselect

Available Constituents:

View:  Ecoregion Equations  User Defined Equations  Both

|                              |        |
|------------------------------|--------|
| TC: p80154 SSC Eco: 67       | p80154 |
| TC: Total Hardness Eco: 67   | p00900 |
| TC: Total Phosphorus Eco: 67 | p00665 |

On Selection

Select

View

Edit

Delete

F

Stochastic Empirical Loading and Dilution Model

Water-Quality Menu: Select Constituents for the Analysis Information

Explanation | Highway Random | Highway Dependent | Upstream Random | Upstream Transport Curve | **Upstream Dependent** | Downstream Pairs

Selected Constituents:

|  |  |
|--|--|
|  |  |
|--|--|

On Selection

View

Deselect

Available Constituents:

View:  Ecoregion Equations  User Defined Equations  Both

|  |  |
|--|--|
|  |  |
|--|--|

On Selection

Select

View

Edit

Delete

**Figure 4-20.** Water-Quality Menu form showing the A, Explanation, B, Highway Random, C, Highway Dependent, D, Upstream Random, E, Upstream Transport Curve, and F, Upstream Dependent information and data entry tabs.—Continued

The upstream water-quality constituent tabs (fig. 4–20D–F) also have an option group for selecting the water-quality definitions that appear in the Available Constituents listbox. The selections are Ecoregion Values or Ecoregion Equations, User Defined Values or User Defined Equations, and Both. These options can be used to distinguish between the types of definitions of available constituents and also to reduce the number of constituents in the Available Constituents listbox to facilitate selection. Selected water-quality constituents will remain in the Selected Constituents listbox even if they are not currently visible in the Available Constituents listbox.

The upstream water-quality definitions (fig. 4–20D–F) can be selected by ecoregion. This selection method was included in SELDM because of the large number of constituents that users may define. For example, SELDM includes transport curves for SSC, total phosphorus, and total hardness for each of the 84 ecoregions in the conterminous United States. If upstream water quality constituent selections were not filtered by ecoregion, all 252 of these transport-curve selections would appear in the Available Constituents listbox on the Upstream Transport Curve tab. Filtering by ecoregion, however, can lead to the seemingly odd circumstance that, if the ecoregion is changed after selecting water-quality constituents for analysis, then the selected ecoregion-based constituents will not appear on the upstream constituents and downstream pairs data selection tabs.

The Downstream Pairs tab (fig. 4–21) is different from the other tabs in that it is used to specify relations between the selected highway and upstream constituents rather than concentration statistics for a single constituent. This tab has a listbox for Available Constituent Pairs and a listbox for Selected Constituent Pairs, associated option groups, an information button labeled “?”, and a Define New command button. These controls behave like similar controls on the other tabs, but the downstream pairs are defined using a completely different water-quality definition form. Available Constituents are limited to definitions that appear in both the highway and upstream water-quality definitions. Thus, the Define New command button on this tab will define a new pair of preselected highway and upstream constituents, but will not allow you to specify a new constituent.

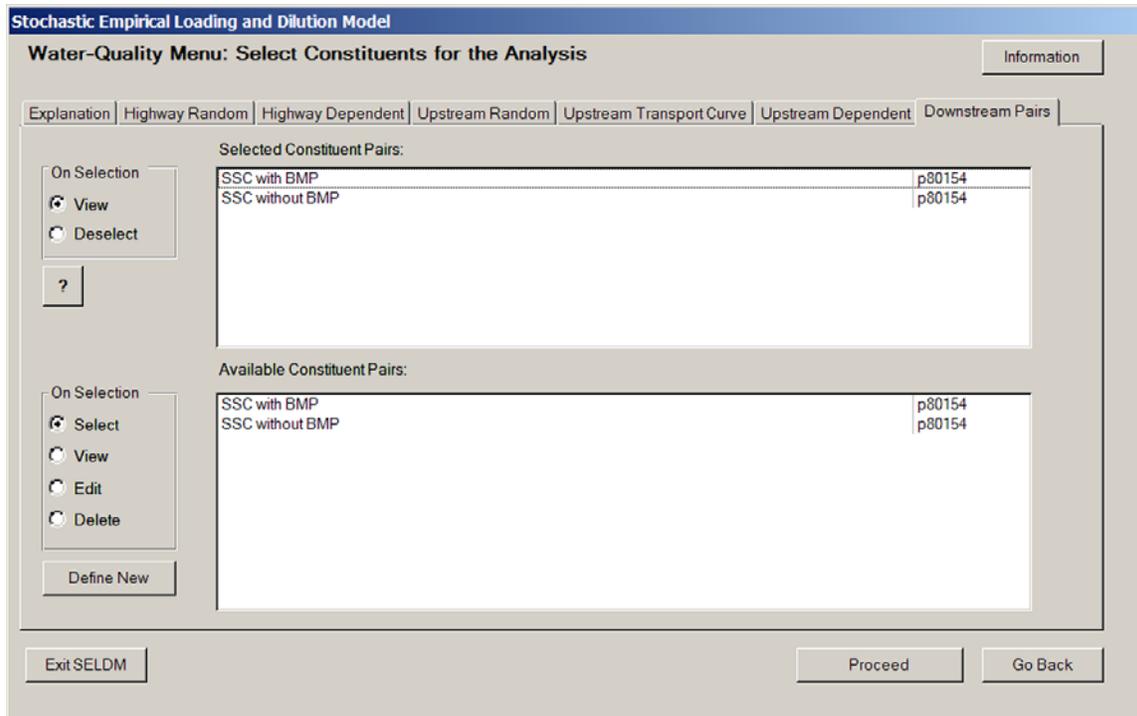


Figure 4–21. Water-Quality Menu Form showing the Downstream Pairs data entry tab.

## The Water-Quality Random Statistics Form for Highway Runoff and Upstream Water Quality

The Water Quality Random Statistics form (frmQWRandom) provides the interface for entering or editing statistics for constituents that are defined as random variables by using the average, standard deviation, and skew coefficient of the constituent concentrations (fig. 4–22). Random water-quality statistics definitions can be specified for highway runoff and for upstream stormflow. The title of this form is context sensitive. If you are entering or editing highway-runoff statistics the title will be Highway Runoff Quality: Random Statistics. If you are entering or editing upstream stormflow statistics the title will be Upstream Water Quality: Random Statistics. Figure 19 in the main report is an example of a random water-quality dataset.

The Water-Quality Random Statistics form is similar to many other SELDM forms in that it has a selection combobox, a selection option group, and a series of data-entry tabs (fig. 4–22). The selection options are context sensitive. If you launched the form by selecting Edit Current Definition from the Water Quality Menu form, then the Select Current Definition and Enter New Definition options will be disabled. Similarly, if you launched the form by using the Define New command button on the Water Quality Menu form, then the Select Current Definition and Edit Current Definition options will be disabled. After the initial definition is complete, click the Accept Updates command button to save the input data. All selection options and the combobox will be enabled. If you click the Close Form command button before clicking the Accept Updates command button, your changes will be lost. To prevent a loss, a message box will prompt you to save your edits. Then, after clicking Accept Updates, the Add Another Constituent button will be enabled to allow further additions. As with the other forms, changing the selection options will change the appearance and behavior of the form.

The Sort Water Quality Constituent Selections option group (fig. 4–22) provides four options for sorting the constituents in the Constituent Selection combobox to help you find the constituent you want (SELDM has 4,657 water-quality constituent selections listed in table tdsUSEPAPParameterCodes in the database). The Common Parameters option sorts the list so that the constituents that are frequently measured in highway and urban runoff studies appear at the top of the list. The Parameter Name option sorts the list in descending alphabetical order. The list is sorted in descending alphabetical order so that the large number of organic chemicals that begin with a number will appear at the end of the list. The USEPA PCode selection sorts the list by parameter code (PCode) in ascending order, which is helpful for finding a parameter with a familiar PCode.

The Constituent Selection combobox lets you select the water-quality definition being entered or edited (fig. 4–22). Clicking the arrow-head symbol on the right of the Constituent Selection combobox and scrolling up or down lets you select the desired constituent. The comboboxes have an autocomplete feature: if you highlight the field with the mouse and start typing the (official) constituent name, then the combobox will present choices as you type subsequent letters.

The highway-runoff quality (fig. 4–22A) version of the Water-Quality Random Statistics form has two data-entry tabs, and the upstream water-quality (fig. 4–22C) version has three data-entry tabs. Both versions of this form have the Water Quality Statistics input tab, which includes a constituent short-name textbox and textboxes for the Average, Standard Deviation, and Skew Coefficient of the random water-quality constituent. The Water Quality Statistics tab has a Transformation Factor combobox that provides three transformation selections (Untransformed, Base 10 Log, and Natural Log) that can be used to model water-quality data. If the Base 10 Log or Natural Log options are selected, then you should enter the average, standard deviation, and skew coefficient of the logarithms of data. The Water Quality Statistics input tab has a command button, See Arithmetic Equivalents, to display the arithmetic statistics for the data that would result if the data were a pure lognormal distribution (that is, the skew coefficient of the logarithms of data was equal to zero). The logarithmic options can be used to model lognormal and log-Pearson type III distributions, which are similar to the lognormal but have nonzero skew coefficient values (Stedinger and others, 1993). Using the logarithmic options ensures that no water-quality values that are less than or equal to zero will be generated. The Untransformed option can be used to model normal and Pearson type III distributions, which include the gamma and exponential distributions. Care must be taken, however, to ensure that these arithmetic statistics will not produce values that are less than or equal to zero. SELDM will convert such values to a logarithmic lower tail, but the results may not accurately model the input statistics. To see whether the untransformed statistics are safe, use the frequency factor equation (equation 1 in the main report) with the arithmetic average and the standard deviation and use the Pearson type III frequency factor for the input skew coefficient value representing minus four standard deviations. Granato (2010) provides tables, polynomial equations, and algorithms for obtaining frequency factors for the Pearson type III (and log-Pearson type III) for a given skew coefficient value. Four standard deviations are likely to be the lowest frequency factor encountered in many Monte Carlo runs; if the associated water-quality value is greater than zero, then using an arithmetic distribution will generally be safe. Specification of statistics for some constituents (for example, pH) requires special consideration.

The SELDM project has provided the data, the methods, and many of the statistics necessary for modeling highway and upstream water quality as random water-quality data. Detailed information on the statistical methods used to calculate statistics and apply them in the Monte Carlo model is described in the “Random Water-Quality Modeling” section of the main report and in appendix 1. The Highway Runoff Database (HRDB) automatically calculates these statistics for highway-runoff water-quality data (Granato and Cazenias, 2009). These statistics may be calculated for upstream water-quality constituents using spreadsheet or statistical software. Granato and others (2009) used the USGS National Water Information System (NWIS) Web database to

A

**Stochastic Empirical Loading and Dilution Model**

**Highway Runoff Quality: Random Statistics** Information

Water-Quality Selection: (Required Fields\*)

MA 2009 Total Phosphorus p00665

Selection Options

Select Current Definition  Edit Current Definition  Enter New Definition

Sort Water Quality Constituent Selections:

Common Parameters  Parameter Name  USEPA PCode  Parameter Group

Constituent Selection:

Phosphorus, water, unfiltered, milligrams per liter

Water Quality Statistics\* Constituent Definition Information

Constituent Short Name\* (25 characters): MA 2009 Total Phosphorus p00665 ? Transformation Factor\*: Base 10 Log

Average\*: -1.05 Standard Deviation\*: 0.423

Skew Coefficient\*: -0.679 See Arithmetic Equivalents

Note: Please enter statistics for the common logarithms (Log10) of the data. See the highway runoff database.

Exit SELDM Accept Updates Add Another Constituent Proceed Close Form

B

**Stochastic Empirical Loading and Dilution Model**

**Highway Runoff Quality: Random Statistics** Information

Water-Quality Selection: (Required Fields\*)

MA 2009 Total Phosphorus p00665

Selection Options

Select Current Definition  Edit Current Definition  Enter New Definition

Sort Water Quality Constituent Selections:

Common Parameters  Parameter Name  USEPA PCode  Parameter Group

Constituent Selection:

Phosphorus, water, unfiltered, milligrams per liter

Water Quality Statistics\* Constituent Definition Information

Information about the selected water-quality definition:

MA 2009 Highway Runoff Data Site SR-2 423027071291301, Littleton (Smith and Granato, 2010, USGS-SIR-2009-5269)

Exit SELDM Accept Updates Add Another Constituent Proceed Close Form

**Figure 4–22.** Water-Quality Random Statistics form, showing the A, Water Quality Statistics and B, Constituent Definition Information tabs for highway-runoff quality constituents and the C, Water Quality Statistics and D, Ecoregion tabs for the upstream water-quality constituents.

C

**Stochastic Empirical Loading and Dilution Model**

**Upstream Water Quality: Random Statistics** Information

Water-Quality Selection:  Exclude Statistics From Other Ecoregions:  **(Required Fields\*)**

Random Total Phosphorus Eco: 67

Selection Options

Select Current Definition  Edit Current Definition  Enter New Definition

Sort Water Quality Constituent Selections:

Common Parameters  Parameter Name  USEPA PCode  Parameter Group

Constituent Selection:

Phosphorus, water, unfiltered, milligrams per liter

Water Quality Statistics\* | Constituent Definition Information | Ecoregion\*

Constituent Short Name\* (25 characters):  ? Transformation Factor\*:

Average\*:  Standard Deviation\*:  Note: Please enter statistics for the common logarithms (Log10) of the data. See the highway runoff database.

Skew Coefficient\*:

D

**Stochastic Empirical Loading and Dilution Model**

**Upstream Water Quality: Random Statistics** Information

Water-Quality Selection:  Exclude Statistics From Other Ecoregions:  **(Required Fields\*)**

Random Total Phosphorus Eco: 67

Selection Options

Select Current Definition  Edit Current Definition  Enter New Definition

Sort Water Quality Constituent Selections:

Common Parameters  Parameter Name  USEPA PCode  Parameter Group

Constituent Selection:

Phosphorus, water, unfiltered, milligrams per liter

Water Quality Statistics\* | Constituent Definition Information | Ecoregion\*

**The Random Variable is an Ecoregion Definition\***

Ecoregion\*

Central Appalachian Ridges and Valleys

**Figure 4-22.** Water-Quality Random Statistics form, showing the A, Water Quality Statistics and B, Constituent Definition Information tabs for highway-runoff quality constituents and the C, Water Quality Statistics and D, Ecoregion tabs for the upstream water-quality constituents.—Continued

compile and publish more than 1,876,000 paired streamflow and water-quality measurements made throughout the conterminous United States. This dataset includes 21 constituents commonly studied in highway- and urban-runoff studies. Many of these data may be used to estimate random water-quality statistics for upstream streamflow.

The Water-Quality Random Statistics form for the highway-runoff and the upstream-stormflow constituents have a Constituent Definition Information data entry tab (fig. 4–22B). The textbox on this tab can be used to enter ancillary information about the constituent definition. For example, if the statistics are obtained from a published report, the citation to the report can be entered in this textbox. There is no limit for the length of text in the Constituent Definition Information data textbox because it is stored in a memo field in the database. This information will be printed to the water-quality output files when SELDM is run.

The Water-Quality Random Statistics form for upstream water-quality constituents has an Ecoregion data entry tab that allows you to designate a definition as the value for an ecoregion and then to select the ecoregion (fig. 4–22D). If the check box labeled The Random Variable is an Ecoregion Definition is checked, then the current selection has been designated as representing water quality in an ecoregion. Use the Ecoregion combobox to assign a definition to a specific ecoregion. The default value will be for the currently selected ecoregion. If you select an ecoregion that is different from the one selected for the current analysis, this definition will not appear in the Upstream Random tab on the Water Quality Menu form (fig. 4–20D) because that form filters out specifications for other ecoregions to limit the list to a manageable number of appropriate choices. To identify a set of statistics by ecoregion, click the check box for The Random Variable is an Ecoregion Definition, select an ecoregion from the dropdown list, and then click the Accept Updates command button.

## The Dependent Water-Quality Statistics Form for Highway and Upstream Water Quality

The Dependent Water-Quality Statistics Form (frmQWDependent) provides the interface for entering or editing statistics for constituents that are defined by a regression relation to another constituent (fig. 4–23). Figure 20 in the main report is an example of a dependent water-quality relation for generating SSC from TSS in highway runoff. Dependent water-quality relations can be defined for highway-runoff and for upstream-stormflow constituents (fig. 4–20).

The Dependent Water-Quality Statistics form is similar to many other SELDM forms in that it has a selection combobox, a selection option group, and a series of data-entry tabs (fig. 4–23). The selection options are context sensitive. If you launched the form by selecting Edit Current Definition from the Water Quality Menu form, then the Select Current Definition and Enter New Definition options will be disabled. Similarly, if you launched the form by using the Define New command button on the Water Quality Menu form, then the Select Current Definition and Edit Current Definition options will be disabled. After the initial definition is complete, click the Accept Updates command button to save the input data. All selection options and the combobox will be enabled. If you click the Close Form command button before clicking the Accept Updates command button, then your changes will be lost. To prevent that, a message box will prompt you to save your edits. Then, after clicking Accept Updates, the Add Another Constituent button will be enabled to allow further additions. As with the other forms, changing the selection options will change the appearance and behavior of the form.

Four controls are used to select the water-quality definition being entered or edited (fig. 4–23A): the Sort Water Quality Constituent Selections option group, the Explanatory Variable (X) Parameter Selection combobox, the Explanatory Variable (X) Water-Quality Definition combobox, and the Dependent Variable (Y) Parameter Selection combobox. The use of the option group to sort water-quality parameters in the Explanatory Variable (X) Parameter Selection and Dependent Variable (Y) Parameter Selection comboboxes is described in detail in the section describing the Water-Quality Random Statistics form. The Explanatory Variable (X) Water-Quality Definition shows the short name of each water-quality definition that has the parameter code selected in the Explanatory Variable (X) Parameter Selection combobox. For example, if you select Total Hardness, only the selections that were identified as total hardness statistics would appear in the Explanatory Variable (X) Water-Quality Definition combobox. To define a constituent pair, select the water-quality parameter that you will use as the independent (explanatory) variable, then select from the water-quality definitions that are available for the selected parameter. The Explanatory Variable (X) Water-Quality Definition combobox will show all the predefined random variables and transport curves for the parameter of interest. Random highway-runoff constituents may be used to define dependent highway-runoff constituents. Random upstream water-quality constituents and transport curves may be used to define dependent upstream water-quality constituents. However, one dependent constituent cannot be used to define another. If there are no selections for a given parameter, then you must go back to the Water Quality Menu form to define the proper explanatory variable. You may use the same explanatory variable with one or more regression relations, and you may use one regression relation with one or more explanatory variables of the same parameter. For example, the equation developed by Granato and Czenas (2009) relating TSS concentrations to SSC (fig. 20 in the main report) may be used with the random statistics for the FHWA urban or nonurban TSS to estimate the SSC in highway runoff from a given site.

To define the regression relation, select the equation-definition options on the Equation Parameters tab (fig. 4–23B). The regression relation may be defined as arithmetic, semilogarithmic, or logarithmic. To define an arithmetic equation, select Untransformed in both the X Transformation Factor and Y Transformation Factor comboboxes. To define a semilogarithmic equation, select Untransformed in the X Transformation Factor or Y Transformation Factor comboboxes and one of the logarithmic selections (Natural Log or Base 10 Log) in the other. To define a logarithmic equation, select one of the logarithmic selections in both of the comboboxes. As with the random water-quality variables, use of a semilogarithmic or logarithmic regression line will preclude negative concentration values. If a concentration that is less than or equal to zero is generated by a dependent relation, then SELDM resets the concentration to equal the arbitrarily selected value of 0.002. Thus, output from SELDM that includes multiple concentration values that are equal to 0.002 may indicate that the input statistics produce concentration values that are less than or equal to zero. Specification of statistics for some constituents (for example, pH) requires special consideration.

You can enter a one-, two-, or three-segment regression model for modeling dependent water-quality relations in SELDM. Use the Number of Segments option group (fig. 4–23B) to make your selection; the input rows that are enabled or disabled depend on your selection. The intercept and slope define the regression relation. The Median Absolute Deviation (MAD) variable is used with the Monte Carlo model to reproduce the scatter in water-quality data around the regression relation. The Max X variable is the maximum value of the explanatory variable in the data used to develop each segment of the regression equation. SELDM uses the Max X variable to identify the proper segment in a multisegment model. This information also may be used by an analyst to examine the proportion of X values that are beyond the limit of the defined regression equation. The statistical methods used to calculate statistics and apply them in the Monte Carlo model are described in the Dependent Water-Quality Modeling section of the main report and in appendix 1.

The menu bar at the bottom of the form has five command buttons besides the standard Exit SELDM button. Accept Updates saves changes to the database. Add a New Constituent clears the form and puts it in the Enter New Definition mode at the first level of selections near the top of the form. Copy facilitates duplication of the regression relation using different predictor variables; for example, you may predict SSC concentrations from the existing rural TSS, urban TSS, and ultra-urban TSS in order to examine different sediment concentrations for the same highway under different development scenarios. Proceed returns you to the Water Quality Menu form after saving changes. Close Form takes you back to the Water Quality Menu form without saving the current changes on the form. However, if you click the Accept Updates button first, clicking the Close Form button will not undo the saved changes.

The Kendall-Theil Robust Line (KTRLLine) program developed as part of the SELDM project was designed to produce multisegment regression relations using nonparametric methods (Granato, 2006). The KTRLLine program provides the regression statistics for the regression models in a format similar to the input format on the Equation Parameters data-entry tab. Granato and Czenas (2009) used the KTRLLine program to develop the dependent water-quality relation between TSS and SSC using 94 paired measurements in the HRDB. Similarly, the Surface Water Quality Data Miner database developed by Granato and others (2009) can be queried to get data necessary for developing dependent water-quality relations between water-quality measurements from streams and rivers using the KTRLLine program.

For upstream water-quality constituents, the Dependent Water-Quality Statistics form has an Ecoregion data entry tab to designate a definition as the value for an ecoregion and to select the ecoregion. If the check box labeled The Random Variable is an Ecoregion Definition is checked, then this designates that the current selection represents water quality in an ecoregion. The Ecoregion combobox is used to assign a definition to a specific ecoregion. The default value will be for the currently selected ecoregion. If you select an ecoregion that is different from the one selected for the current analysis, then this definition will not appear in the Upstream Dependent tab of the Water Quality Menu form (fig. 4–20F) because that form filters out specifications for other ecoregions. Such filtering is necessary to limit the list to a manageable number of appropriate choices. To identify an equation by ecoregion, click the check box, select an ecoregion from the combobox, and click Accept Updates.

**A**

**Stochastic Empirical Loading and Dilution Model**

**Highway Runoff Quality: Dependent Relation** Information

Water-Quality Selection: (Required Fields\*)

SSC from TSS (HRDB Equation)

Selection Options

Select Current Definition  Edit Current Definition  Enter New Definition

Water-Quality Equation Description\* | Equation Parameters\* | Constituent Definition Information

Water-Quality Definition Short Name\*: SSC from TSS (HRDB Equation) ?

Sort Water Quality Constituent Selections:

Common Parameters  Parameter Name  USEPA PCode  Parameter Group

Explanatory Variable (X) Parameter Selection\*: (Note: Only predefined water-quality parameters can be selected)

Solids, suspended, water, milligrams per liter

Explanatory Variable (X) Water-Quality Definition\*: ?

FHWA 1990 NonUrban TSS

Dependent Variable (Y) Parameter Selection\*:

Suspended sediment concentration, milligrams per liter

Exit SELDM Accept Updates Add a New Constituent Copy Proceed Close Form

**B**

**Stochastic Empirical Loading and Dilution Model**

**Highway Runoff Quality: Dependent Relation** Information

Water-Quality Selection: (Required Fields\*)

SSC from TSS (HRDB Equation)

Selection Options

Select Current Definition  Edit Current Definition  Enter New Definition

Water-Quality Equation Description\* | Equation Parameters\* | Constituent Definition Information

X Transformation Factor\*: Y Transformation Factor\*: Number of Segments\*

Base 10 Log Base 10 Log  1 Segment  2 Segments  3 segments

Segment 1: ?  $Y_i = \text{Slope} * X_i + \text{Intercept} +/- \text{MAD} * \text{Random } Z_i$

Intercept\*: -0.02626746 Slope\*: 1.129232 MAD\*: 0.189728 Max X\*: 3.089905

Segment 2: (Mad: Median Absolute Deviation of residuals)

Intercept\*: Slope\*: MAD\*: Max X\*:

Segment 3:

Intercept\*: Slope\*: MAD\*: Max X\*:

Exit SELDM Accept Updates Add a New Constituent Copy Proceed Close Form

**Figure 4–23.** Dependent Water-Quality Statistics form, showing the A, Water-Quality Equation Description, B, Equation Parameters, C, Constituent Definition Information tabs, and D, the form as it appears after clicking the Accept Updates button for the Highway Runoff Quality version of the form.

C

**Stochastic Empirical Loading and Dilution Model**

**Highway Runoff Quality: Dependent Relation** Information

Water-Quality Selection: **(Required Fields\*)**

SSC from TSS (HRDB Equation) ▼

Selection Options

Select Current Definition  Edit Current Definition  Enter New Definition

Water-Quality Equation Description\* | Equation Parameters\* | Constituent Definition Information

Information about the selected water-quality definition:

Regression adjustment from TSS to SSC (Granato and Cazenias, 2009, FHWA-HEP-09-004)

Exit SELDM | Accept Updates | Add a New Constituent | Copy | Proceed | Close Form

D

**Stochastic Empirical Loading and Dilution Model**

**Highway Runoff Quality: Dependent Relation** Information

Water-Quality Selection: **(Required Fields\*)**

SSC from TSS (HRDB Equation) ▼

Selection Options

Select Current Definition  Edit Current Definition  Enter New Definition

Water-Quality Equation Description\* | Equation Parameters\* | Constituent Definition Information

X Transformation Factor\*: Y Transformation Factor\*: Number of Segments\*

Base 10 Log Base 10 Log  1 Segment  2 Segments  3 segments

Segment 1: ?  $Y_i = \text{Slope} * X_i + \text{Intercept} \pm \text{MAD} * \text{Random } Z_i$

Intercept\*: -0.02626746 Slope\*: 1.129232 MAD\*: 0.189728 Max X\*: 3.089905

Segment 2: (Mad: Median Absolute Deviation of residuals)

Intercept\*:  Slope\*:  MAD\*:  Max X\*:

Segment 3:

Intercept\*:  Slope\*:  MAD\*:  Max X\*:

Exit SELDM | Accept Updates | Add a New Constituent | Copy | Proceed | Close Form

**Figure 4–23.** Dependent Water-Quality Statistics form, showing the A, Water-Quality Equation Description, B, Equation Parameters, C, Constituent Definition Information tabs, and D, the form as it appears after clicking the Accept Updates button for the Highway Runoff Quality version of the form.—Continued

## The Transport Curve Statistics Form for Upstream Water Quality

The Transport Curve Water-Quality Statistics form (frmQWDependent) provides the interface for entering or editing statistics for constituents that are defined by a regression relation to upstream stormflow. Figure 21 in the main report is an example of a transport curve developed to estimate total hardness from upstream stormflow. Many of the considerations for generating values for upstream water quality using transport curves are similar to considerations for generating water-quality values using dependent relations. The Transport Curve Water-Quality Statistics form is the same as the Dependent Water-Quality Statistics form, with a few exceptions. One substantial difference is that the options for the explanatory variable are limited to one selection: normalized streamflow in  $\text{ft}^3/\text{s}/\text{mi}^2$  (fig. 4–24). Another substantial difference is that the menu bar at the bottom of the form does not include the Copy command button because a transport curve is limited to the one predictor variable.

The Transport Curve Water-Quality Statistics form has an Ecoregion tab (fig. 4–24C) that can be used to identify a transport curve as an ecoregion relation. If the check box labeled The Random Variable is an Ecoregion Definition is checked, then this designates that the current selection represents water quality in an ecoregion. The Ecoregion combobox is used to assign a definition to a specific ecoregion. The default value will be for the currently selected ecoregion. If you select an ecoregion that is different from the one selected for the current analysis, then this definition will not appear in the Upstream Transport Curve tab of the Water Quality Menu form (fig. 4–20E) because that form filters out specifications for other ecoregions. Such filtering is necessary to limit the list to a manageable number of appropriate choices. To identify an equation by ecoregion, click the check box, select an ecoregion from the combobox, and click Accept Updates.

The SELDM development project has provided the data, the methods, and many of the statistics necessary for modeling upstream water-quality constituents as water-quality transport curves (Granato and others, 2009). A series of computer programs were developed to obtain and analyze water-quality data from the USGS NWIS Web database, and more than 1,876,000 paired measurements of streamflow and water quality were obtained and published in order to facilitate generation of transport curves by region or by site (Granato and others, 2009). Granato and others (2009) used the KTRLLine program to develop transport curves for suspended sediment concentration, total hardness, and total phosphorus for the 84 ecoregions in the United States, and SELDM includes these transport curves. Detailed information on the statistical methods used to calculate water-quality transport curve regression statistics and apply them in the Monte Carlo model is described in the “Upstream Water-Quality Transport-Curve Modeling” section of the main report and in appendix 1.

A

**Stochastic Empirical Loading and Dilution Model**

**Upstream Water Quality: Transport Curve** Information

Water-Quality Selection: Exclude Equations for Other Ecoregions:  **(Required Fields\*)**

TC: Total Phosphorus Eco: 67

Selection Options

Select Current Definition  Edit Current Definition  Enter New Definition

Water-Quality Equation Description\* | Equation Parameters\* | Ecoregion\* | Constituent Definition Information

**Water-Quality Definition Short Name\*:** TC: Total Phosphorus Eco: 67 ?

Sort Water Quality Constituent Selections:

Common Parameters  Parameter Name  USEPA PCode  Parameter Group

**Explanatory Variable (X) Constituent Selection\*:**

Streamflow, normalized, cubic feet per second per square mile

**Dependent Variable (Y) Parameter Selection\*:**

Phosphorus, water, unfiltered, milligrams per liter

Exit SELDM | Accept Updates | Add a New Constituent | Proceed | Close Form

B

**Stochastic Empirical Loading and Dilution Model**

**Upstream Water Quality: Transport Curve** Information

Water-Quality Selection: Exclude Equations for Other Ecoregions:  **(Required Fields\*)**

TC: Total Phosphorus Eco: 67

Selection Options

Select Current Definition  Edit Current Definition  Enter New Definition

Water-Quality Equation Description\* | Equation Parameters\* | Ecoregion\* | Constituent Definition Information

**X Transformation Factor\*:** Base 10 Log

**Y Transformation Factor\*:** Base 10 Log

**Number of Segments\*:**  1 Segment  2 Segments  3 segments

$Y_i = \text{Slope} * X_i + \text{Intercept} +/- \text{MAD} * \text{Random } Z_i$

**Segment 1:** ?

**Intercept\*:** -1.30103 **Slope\*:** 0 **MAD\*:** 0.39794 **Max X\*:** 0.175794

**Segment 2:** (Mad: Median Absolute Deviation of residuals)

**Intercept\*:** -1.384815 **Slope\*:** 0.476606 **MAD\*:** 0.328344 **Max X\*:** 2.50101

**Segment 3:**

**Intercept\*:** **Slope\*:** **MAD\*:** **Max X\*:**

Exit SELDM | Accept Updates | Add a New Constituent | Proceed | Close Form

**Figure 4-24.** Transport Curve Water-Quality Statistics form for upstream water quality, showing the A, Water-Quality Equation Description, B, Equation Parameters, C, Ecoregion, and D, Constituent Definition Information tabs.

**C**

Stochastic Empirical Loading and Dilution Model

Upstream Water Quality: Transport Curve Information

Water-Quality Selection: Exclude Equations for Other Ecoregions:  **(Required Fields\*)**

TC: Total Phosphorus Eco: 67

Selection Options

Select Current Definition  Edit Current Definition  Enter New Definition

Water-Quality Equation Description\* | Equation Parameters\* | **Ecoregion\*** | Constituent Definition Information

The Random Variable is an Ecoregion Definition\*

**Ecoregion\***

Central Appalachian Ridges and Valleys

Exit SELDM | Accept Updates | Add a New Constituent | Proceed | Close Form

**D**

Stochastic Empirical Loading and Dilution Model

Upstream Water Quality: Transport Curve Information

Water-Quality Selection: Exclude Equations for Other Ecoregions:  **(Required Fields\*)**

TC: Total Phosphorus Eco: 67

Selection Options

Select Current Definition  Edit Current Definition  Enter New Definition

Water-Quality Equation Description\* | Equation Parameters\* | Ecoregion\* | **Constituent Definition Information**

Information about the selected water-quality definition:

Granato and others, 2009, FHWA-HEP-09-003

Exit SELDM | Accept Updates | Add a New Constituent | Proceed | Close Form

**Figure 4–24.** Transport Curve Water-Quality Statistics form for upstream water quality, showing the *A*, Water-Quality Equation Description, *B*, Equation Parameters, *C*, Ecoregion, and *D*, Constituent Definition Information tabs.—Continued

## The Downstream Water Quality Constituent Pairs Form

The Downstream Water Quality Constituent Pairs form (frmQWDefinePairs) provides the interface for entering or editing relations between highway-runoff and upstream-stormflow constituents that form downstream constituent pairs. A constituent pair is defined by selecting a highway-runoff constituent definition and an upstream stormflow water-quality constituent definition that has the same parameter code (fig. 4–25). This input form has a selection combobox, a selection option group, and a series of data-entry tabs. The selection options are context-sensitive. If you launch the form from the Water Quality Menu form by selecting Edit Current Definition, then the Select Current Definition and Enter New Definition options will be disabled. Similarly, if you launch the form by using the Define New command button on the Water Quality Menu form, then the Select Current Definition and Edit Current Definition options will be disabled. When the initial definition is complete and you click Accept Updates, all selection options and the combobox become enabled. If you click Close Form before clicking Accept Updates, then your changes will be lost. A message box will prompt you to save the edits when you click Close Form to help prevent accidental data loss. Changing the selection options will change the appearance and behavior of the form.

The Identification data input tab has five controls (fig. 4–24A). Use the Short Name textbox for entering the name that will identify the pair in the Downstream Pair Selection combobox and on the Downstream Pairs tab on the Water Quality Menu form (fig. 4–21). The Parameter, Highway Runoff Selection, and Upstream Selection comboboxes work in conjunction with one another to let you select a water-quality parameter for a pair, and then select the highway-runoff and upstream-stormflow constituents of the pair. Specifically, the Parameter combobox on the Identification tab shows the parameter code selected for a water-quality pair. If you select Edit Current on the Water Quality Menu form (fig. 4–21), then the parameter code on the Downstream Water Quality Constituent Pairs form will be disabled (fig. 4–25A). This is because the Edit option from the On Selection option group of the Available Constituent Pairs listbox on the Water Quality Menu form (fig. 4–21) allows you to select highway-runoff and upstream-runoff constituents only for the predefined water-quality pair that you chose to edit. However, if you have opened this input form by clicking the Define New command button on the Water Quality Menu form, then the Parameter combobox on the Downstream Water Quality Constituent Pairs Form will be enabled. This combobox dropdown list shows all parameters that are defined and selected in the Current Analysis for both the highway runoff water quality (random or dependent) and the upstream water quality (random, dependent, or transport curve). Once you select a parameter (or have preselected it by using the Edit mode on the Water Quality Menu form), then all the constituents that have been selected for analysis with that parameter code will be available in the Parameter combobox dropdown list.

SELDM is designed so that you can assess the potential effects of runoff mitigation measures during the same model run. To compare downstream concentrations and loads with and without the effects of highway runoff treatment by a selected BMP, define two downstream parameter pairs that have the same definitions for highway-runoff and for upstream water quality. Use the check box on the bottom of the Identification tab (fig. 4–25A) to indicate if you want (or do not want) to apply the BMP treatment selections for the selected pair of parameters. Comparison of results in the output file with and without BMP treatment will indicate the potential effects of the BMP defined on the Best Management Practice Performance form.

The Concentration of Concern tab (fig. 4–25B) has a check box, four textboxes, and a command button. The check box is used to designate the use of adverse-effect ratios for calculating the concentration of concern for each downstream event mean concentration (EMC). The four textboxes are for entering the Adverse Effect Ratio Statistics. The Calculate Trial Statistics command button is for information only: it calculates the average, standard deviation, percentile skew coefficient, median, and selected percentiles by using the input trapezoidal-distribution statistics to help relate textbox inputs to these more familiar and commonly used statistics.

The adverse-effect ratios entered on the Concentration of Concern data tab (fig. 4–25B) are defined as the proportion of each downstream EMC that can potentially cause adverse effects in the receiving waters. SELDM does not do geochemical equilibrium modeling directly, nor will the downstream mixture of runoff from a highway and from upstream stormflow reach full geochemical equilibrium throughout the duration of a runoff event. Furthermore, partial or full speciation of geochemical fractions can occur during flow through a BMP. The result of these complexities is to impart a high degree of uncertainty in the proportion of any given constituent that may have an adverse effect on water quality. SELDM is designed to provide a generalized stochastic representation of the adverse-effect ratio parameters. SELDM uses a simplified trapezoidal distribution to represent these values. The check box is used to indicate whether or not this option will be used for the selected pair. The four textboxes Minimum Value, Lower Most Probable Value, Upper Most Probable Value, and Maximum Value are for entering the parameters needed to define a trapezoidal distribution. The Minimum Value must be greater than or equal to zero. The Lower Most Probable Value (LMPV) must be greater than or equal to the Minimum Value and less than or equal to the Upper Most Probable Value (UMPV). The UMPV must be greater than or equal to the LMPV and less than or equal to the Maximum Value. The Maximum Value must be greater than the Minimum Value, greater than or equal to the LMPV and the UMPV, and it must be less than or equal to one. If the values for the LMPV and UMPV are equal, then SELDM will model the fractions using a triangular distribution. If the LMPV is set equal to the Minimum Value and the UMPV is set equal to the Maximum Value, then SELDM will model the fractions using a rectangular (uniform) distribution. These simple distributions are widely used in Monte

**A**

Stochastic Empirical Loading and Dilution Model

**Downstream Water Quality: Constituent Pairs** Information

Downstream Pair Selection: (Required Fields\*)

SSC with BMP

Selection Options

Select Current  Edit Current  Enter New

Identification\* | Concentration of Concern\* | Lake Analysis\* | Description

**Short Name\* (50 characters):** SSC with BMP ?

Parameter\* (Only parameters with a highway and upstream definition are available):

Suspended sediment concentration, milligrams per liter

**Highway-Runoff Selection\*:**

SSC from TSS (HRDB Equation)

**Upstream Selection\*:**

TC: p80154 SSC Eco: 67

Use BMP flow and water-quality treatment to modify highway discharge ?

Exit SELDM Accept Updates Proceed Close Form

**B**

Stochastic Empirical Loading and Dilution Model

**Downstream Water Quality: Constituent Pairs** Information

Downstream Pair Selection: (Required Fields\*)

SSC with BMP

Selection Options

Select Current  Edit Current  Enter New

Identification\* | Concentration of Concern\* | Lake Analysis\* | Description

**Proportion of Downstream Concentration that May Have an Adverse Effect\*:** ?

The concentration of concern is the concentration in the receiving water downstream of the highway that may have an adverse effect on natural or human water use. For example, estimates of the bioavailable fraction of water-quality constituents may be of concern. SELDM uses a simplified stochastic method to estimate the risk of exceeding a water-quality target by calculating the fraction of the downstream concentration that may have an adverse effect (the Adverse Effect Ratio, which must be between zero and one).

Calculate the Concentration of Concern using the Adverse Effect Ratio\*

**Adverse Effect Ratio Statistics (0-1)\*:**

Minimum Value:\* 0 Lower Most Probable Value:\* 0.5

Upper Most Probable Value:\* 0.5 Maximum Value:\* 1

Calculate Trial Statistics

Exit SELDM Accept Updates Proceed Close Form

**Figure 4–25.** Downstream Water Quality Constituent Pairs form, showing the A, Identification, B, Concentration of Concern, C, Lake Analysis, and D, Description tabs for editing a Constituent Pair.

C

**Stochastic Empirical Loading and Dilution Model**

**Downstream Water Quality: Constituent Pairs** Information

Downstream Pair Selection: **(Required Fields\*)**

SSC with BMP

Selection Options

Select Current  Edit Current  Enter New

Identification\* | Concentration of Concern\* | **Lake Analysis\*** | Description

The Lake-Basin Analysis produces a population of annual-average steady-state constituent concentrations to assess potential effects of highway runoff on the water-quality in a downstream lake or pond. The concentration is estimated from measures of lake volume, annual loadings, flux through the lake, and an attenuation factor (which may include physical settling and other attenuation mechanisms).

Use this definition in Lake-Basin Analysis\*

Apparent Annual-Average Attenuation Factor (per year):  ?

The attenuation factor is a first-order decay rate. If sedimentation is the primary constituent-removal mechanism the attenuation factor is simply the settling velocity divided by the mean depth of the lake. Chapter 5 in U.S. Environmental Protection Agency report EPA-440/4-87.002 describes first-order decay rate calculations for various mechanisms including sedimentation, adsorption, desorption, photolysis, hydrolysis, and biodegradation for use with simple lake models.

Exit SELDM | Accept Updates | Proceed | Close Form

D

**Stochastic Empirical Loading and Dilution Model**

**Downstream Water Quality: Constituent Pairs** Information

Downstream Pair Selection: **(Required Fields\*)**

SSC with BMP

Selection Options

Select Current  Edit Current  Enter New

Identification\* | Concentration of Concern\* | Lake Analysis\* | **Description**

Information about the selected water-quality definition:

Suspended sediment concentrations with BMP treatment

Exit SELDM | Accept Updates | Proceed | Close Form

**Figure 4-25.** Downstream Water Quality Constituent Pairs form, showing the A, Identification, B, Concentration of Concern, C, Lake Analysis, and D, Description tabs for editing a Constituent Pair.—Continued

Carlo analyses because they approximate more complex distributions and they can be parameterized using expert judgment or by fitting the distribution to data (Johnson, 1997; Back and others, 2000; Saucier, 2000; U.S. Environmental Protection Agency, 2001; Kacker and Lawrence, 2007). The methods for using these distributions and applying them in the Monte Carlo model are described in the “Concentration of Concern” section of the main report and in appendix 1.

The Lake Analysis tab (fig. 4–25C) appears only if a lake-basin analysis is included in the analysis definition. The tab has a check box that lets you select whether to include a constituent pair in the lake analysis and a textbox for entering the apparent annual-average attenuation factor, which is a first-order decay rate for each modeled constituent. The apparent annual-average attenuation factor with selected examples for calculating this variable is described in the “Attenuation Factors” section of the main report.

The Description tab (fig. 4–25D) has a single textbox with a vertical scroll bar to display the full constituent-pair description. There is no limit for the length of text in the description because it is stored in a memo field in the database. The potential complexity of selecting the concentration of concern statistics may require explanation. For example, if published water-sediment partitioning coefficients are used to estimate adverse effect ratio statistics for a metal, then citing the source document may help support your SELDM modeling results.

## The Best Management Practice (BMP) Performance Form

The Best Management Practice Performance form (frmBMPDefinition) provides the interface for entering or editing statistics defining the capability of the selected BMP to reduce stormflows, extend the duration of the runoff hydrograph, and reduce the concentration of constituents in runoff (fig. 4–26). This input form has a selection combobox, an option group, and four data-entry tabs. The BMP Overview tab has textboxes for the Short Name, the Full Name, and the Description of the BMP. The Description textbox has a scroll bar to display the full BMP description, which may include a citation to the source of data, design information, or any other explanatory text. There is no limit for the length of text in the description because it is stored in a memo field in the database.

The Hydraulics tab (fig. 4–26B) has checkboxes and textboxes for entering statistics to simulate BMP flow reduction (Ratio of BMP outflow to inflow) and runoff hydrograph extension (Outflow hydrograph extension). The checkboxes are used to indicate whether the selected BMP provides volume reduction or hydrograph extension. Both variables are modeled using the trapezoidal distribution and both variables can be modeled using rank correlation to the inflow volume. The trapezoidal distribution (which includes the rectangular (or uniform) and triangular distributions) is used in Monte Carlo models because trapezoidal distributions approximate more complex distributions and can be parameterized using expert judgment or by fitting the distribution to data (Johnson, 1997; Back and others, 2000; Saucier, 2000; U.S. Environmental Protection Agency, 2001; Kacker and Lawrence, 2007). The trapezoidal distributions for volume reductions and hydrograph extension times are characterized by a Minimum Value (Min), a Lower Most Probable Value (Lower MPV), an Upper Most Probable Value (Upper MPV), and a Maximum Value (Max). Each of these values must be less than or equal to the next higher value, and the Max must be greater than the Min value. The “Runoff Modification by Best Management Practices (BMPs)” section in the main report describes methods for estimating and modeling these variables.

The volume-reduction options on the Hydraulics tab, which are labeled Ratio of BMP outflow to inflow (Ratio  $\geq 0$ ), let you model the mass balance of stormflows within the selected BMP. Volume reduction is the capability of a given BMP for retaining water onsite for subsequent infiltration or evapotranspiration. The BMP runoff volume reduction checkbox (fig. 4–26B) indicates whether this option will be used. If unchecked, then the data-input textboxes are disabled, and SELDM will not calculate volume reductions. Volume reductions are modeled using a trapezoidal distribution of the ratio of outflow to inflow volumes. A ratio of zero would indicate that the highway runoff has been completely retained, a ratio of one would indicate that there is no reduction, and a ratio greater than one would indicate that the BMP has another source of water for a given storm. If monitoring data are correct, then BMP outflows can exceed inflows if the BMP receives a high volume of precipitation in relation to its capability to retain runoff or if groundwater discharge to the BMP is causing excess flows.

SELDM uses the rank correlation between the inflow volume and the volume-reduction ratio to model BMP volume reduction. If the capability of a BMP to retain water is a fixed volume that is small in comparison to most stormflows, then the ratio of outflow to inflow would be close to one and would have a strong positive correlation with increasing inflows because outflows would increase proportionally. If the capability of a BMP to retain water is a fixed volume that is large in comparison to most stormflows, then the ratios of outflow to inflow would be small and would have a weak positive correlation with increasing inflows. Such correlations would be weak because many inflows would be less than the control volume (outflows would be almost zero), but the inflows that exceed the control volume would increase with increasing inflow volumes. If outflow volumes are independent of inflow volumes, the rank correlations would be small. If a BMP were designed to release a fixed volume and retain the rest (for example, for infiltration to a drinking-water aquifer), then the rank correlation would be negative.

A

**Stochastic Empirical Loading and Dilution Model**

**BMP: Best Management Practice Performance** Information

Select an Existing BMP Definition: (Required Fields\*)

Flow Reduction & SSC BMP

Selection Options

Select Current  Edit Current  Copy Current  Enter New

BMP Definition Information

BMP Overview\* | Hydraulics\* | Water Quality Parameters\* | Water Quality Treatment Definition\*

Short Name\* (50 characters): Flow Reduction & SSC BMP ?

Full Name: Flow Reduction BMP

Description:

Exit SELDM Copy BMP Accept Updates Proceed Go Back

B

**Stochastic Empirical Loading and Dilution Model**

**BMP: Best Management Practice Performance** Information

Select an Existing BMP Definition: (Required Fields\*)

Flow Reduction & SSC BMP

Selection Options

Select Current  Edit Current  Copy Current  Enter New

BMP Definition Information

BMP Overview\* | Hydraulics\* | Water Quality Parameters\* | Water Quality Treatment Definition\*

Ratio of BMP outflow to inflow (Ratio >=0)\*:  BMP runoff volume reduction\* ?

Min:\* 0 Lower MPV:\* 0 Upper MPV:\* 0 Max:\* 1.43

Rank correlation to inflow volume (-1 to 1)\*: -0.23 Calculate Trial Statistics

Outflow hydrograph extension (hours >= 0)\*:  BMP hydrograph extension\* ?

Min:\* 0 Lower MPV:\* 1 Upper MPV:\* 4 Max:\* 6

Rank correlation to inflow volume (-1 to 1)\*: 0 Calculate Trial Statistics

Exit SELDM Copy BMP Accept Updates Proceed Go Back

**Figure 4-26.** Best Management Practice Performance form, showing the A, BMP Overview, B, Hydraulics, C, Water Quality Parameters, and D, Water Quality Treatment Definition tabs.

C

D

Figure 4-26. Best Management Practice Performance form, showing the A, BMP Overview, B, Hydraulics, C, Water Quality Parameters, and D, Water Quality Treatment Definition tabs.—Continued

The hydrograph extension options on the Hydraulics tab, which are labeled Outflow hydrograph extension (hours  $\geq 0$ ), let you model the timing of runoff releases from the selected BMP to the receiving waters. Hydrograph extension is the capability of a given BMP for detaining the runoff and releasing the water at a slower rate than the inflow from the highway site. Hydrograph extension is designed to more closely approximate the predevelopment hydrograph but has the effect of diluting the runoff into a larger volume of upstream flow. The BMP hydrograph extension checkbox indicates whether this option will be used. If unchecked, then the data-input textboxes are disabled, and SELDM will not calculate hydrograph extension. The hydrograph extension is modeled using a trapezoidal distribution of the number of hours beyond the unmodified duration of the highway runoff because BMPs are commonly designed to have a controlled rate of release.

SELDM uses the rank correlation between the inflow volume and the hydrograph extension because the controlled rate of release commonly is head-dependent. If the rate of release increases with increasing head in the detention structure and the detention volume is small, then the detention time may decrease with increasing volume, yielding a negative correlation. If detention is independent of inflow volume, then the correlation should approximate zero. If the detention volume is large in comparison to most storm volumes, then the hydrograph extension may increase with increasing inflow and therefore with detention volume.

The water-quality treatment definitions used for a particular BMP are defined using the Water Quality Parameters and Water Quality Treatment Definition tabs on the form (fig. 4–26). The Water Quality Parameters tab has controls for managing the water-quality modification selections. The Water Quality Treatment Definition tab is designed for entering statistics to simulate changes between the inflow and outflow concentration of each selected constituent. The Water Quality Parameters tab has a listbox showing the treatment definitions that have been defined for the selected BMP (fig. 4–26C). The On Selection option group controls the action taken when a constituent definition in the listbox is clicked. The View Details option launches a message box that lists the specifications for the parameter that you select. The Edit Definition option launches a confirmation message box, and if you click Yes, then this option moves the focus to the Water Quality Treatment Definition tab where the definition for the parameter you have selected becomes available for editing. The Delete Definition option launches a confirmation message box, and if you click Yes, then this option deletes the water-quality parameter that you selected. Clicking the Define New command button moves the focus to the Water Quality Treatment Definition tab with all the values cleared for data entry.

The Water Quality Treatment Definition tab (fig. 4–26D) provides the interface for entering or editing a water-quality statistics that define the capability of a given BMP to reduce concentrations of each selected constituent. Water-quality treatment in structural BMPs includes a number of physical and chemical processes that change the concentrations of runoff constituents in the inflow before discharging runoff to receiving waters. The Water Quality Treatment Definition tab has a Select Parameter combobox that lets you select a USEPA parameter code to define the treatment statistics and textboxes for the Minimum Irreducible Concentration, the Min, Lower MPV, Upper MPV, and Max water-quality treatment ratio statistics and the Rank correlation to inflow concentration. This tab also has a Calculate Trial Statistics command button to provide information about the input values and an Accept Updates command button to save input values.

The Minimum Irreducible Concentration textbox is for defining the physical or chemical lower limit of effluent concentrations that a BMP can produce for the selected constituent. The minimum irreducible concentration (MIC) is commonly defined as lowest outflow concentration achievable for a well-designed example of each type of BMP (Schueler, 1996; Barrett 2005, 2008; Geosyntec Consultants and Wright Water Engineers, Inc., 2009). If SELDM calculates a BMP effluent concentration that is less than the MIC, then the model will set that value equal to the MIC. An apparent MIC in a dataset may represent a measurement below an analytical detection limit rather than an actual physiochemical treatment limit.

The water-quality treatment ratios are the ratios of the outflow to inflow concentration and are modeled using a trapezoidal distribution. The trapezoidal distribution of ratios is characterized by a Min, an LMPV, a UMPV, and a Max. Each of these values must be less than or equal to the next higher value, and the Max must be greater than the Min value.

SELDM also uses the rank correlation between the inflow concentration and the water-quality treatment ratio to model the data. If outflow concentrations are fairly constant, then the rank correlations would be negative because the ratios would tend to decrease with increasing inflow concentrations. If the treatment capability of a BMP is fairly constant, then the rank correlations would tend to be positive because outflow concentrations would tend to increase with increasing inflow concentrations. If output concentrations are random, then the rank correlations would tend to be close to zero.

The default selection for each new analysis is No BMP In Place (fig. 4–27). When this option is selected, there is only one data-entry tab and all editing options are locked and disabled and the BMP discharge concentrations, flows, and loads will equal the highway runoff values in the output files.

To use BMP runoff treatment in an analysis, you can select a predefined BMP. First click the Select Current option (fig. 4–26A) to activate the Select an Existing BMP Definition combobox. Then select a predefined BMP definition using the combobox. When you select a BMP, the specifications appear on the data entry tabs, but the controls are disabled. To change the definition, click the Edit Current option, make the desired changes, and then click Accept Updates to save the changes.

The Best Management Practice Performance form has a Copy Current option to facilitate data entry. Each BMP specification includes hydraulic and water-quality treatment options. The Copy Current option lets you model similar BMPs or do a sensitivity analysis by varying different treatment options for a similar BMP definition. If you click the Copy Current option, then a confirmation message box will appear. If you proceed, then an input box will appear for entering the Short Name for a new BMP. The Copy BMP button will be enabled, and the Cancel Copy button replaces the Accept Updates button (fig. 4–28). There are three ways to exit the copy process before clicking the Copy BMP command button: you can click the Cancel Copy button, click the Go Back button to exit the form, or click the Select Current option.

The screenshot shows the 'Stochastic Empirical Loading and Dilution Model' window. The title bar reads 'Stochastic Empirical Loading and Dilution Model'. The main window title is 'BMP: Best Management Practice Performance'. There is an 'Information' button in the top right. Below the title, it says 'Select an Existing BMP Definition: (Required Fields\*)'. A dropdown menu shows 'No BMP In Place'. Under 'Selection Options', there are four radio buttons: 'Select Current' (selected), 'Edit Current', 'Copy Current', and 'Enter New'. The 'BMP Definition Information' section has a 'BMP Overview\*' tab. It contains three text input fields: 'Short Name\* (50 characters):' with 'No BMP In Place', 'Full Name:' with 'Best Management Practices are not used to modify runoff', and 'Description:' with an empty text area. At the bottom, there are three buttons: 'Exit SELDM', 'Proceed', and 'Go Back'.

Figure 4–27. Best Management Practice Performance form showing the configuration for the No BMP In Place selection.

The screenshot shows the same software window. The title bar and main window title are the same. The 'Selection Options' section now has 'Copy Current' selected. The 'BMP Definition Information' section has the 'BMP Overview\*' tab with sub-tabs for 'Hydraulics\*', 'Water Quality Parameters\*', and 'Water Quality Treatment Definition\*'. The 'Short Name\* (50 characters):' field contains 'Flow Reduction & SSC BMP Copy'. The 'Full Name:' field contains 'Flow Reduction BMP'. The 'Description:' field is empty. At the bottom, the buttons are 'Exit SELDM', 'Copy BMP', 'Cancel Copy', 'Proceed', and 'Go Back'.

Figure 4–28. Best Management Practice Performance form, showing the configuration for the copy option.

## The Run SELDM Form

The Run SELDM form (frmRunAnalysis) provides the interface for specifying output options, running the Monte Carlo model, writing the output files, and displaying output file names (fig. 4–29). The Run SELDM form is the last form in the model-specification process (fig. 4–1). This form substantially differs from other forms because it is not designed for entering or editing input data. The form has three tabs: Run SELDM, Output File Locations, and Explanation and Disclaimer. Two command buttons and an option group are at the bottom of the form: the Exit SELDM button clears the database output tables and closes the application; the Go Back button closes this form and opens the form specified in the Go Back To option group.

The Run SELDM tab is the interface for running the model. The Selected Analysis Option textbox in the upper right corner of this tab indicates whether the user selected a stream analysis, a stream and lake analysis, or a lake analysis on the Analysis Identification form (fig. 4–6). The 2. Run SELDM command button will be enabled for all three types of analyses. The 3. Run The Lake Package command button will be enabled only after running SELDM for a stream and lake analysis or for a lake analysis. The Re-Run Analysis command button will be enabled only after running SELDM. This button reinitializes the form so that you can rerun SELDM using different output and format options. Four option groups immediately below the label 1. Set Basic Options on the form (fig. 4–29) control output formats, and a status message and progress meter are also included.

The Plotting-Position Output option group lets you select the format for your plotting position values. The options are either Fractions, which will produce values between 0 and 1, or Percentiles, which will produce values between 0 and 100. The software that you use to make the probability plots may dictate your selection. Some software packages need percentiles to construct probability axes. The default value is Percentiles.

The Sorting Order option group lets you select the type of plotting position. If you select Ascending, the values will be sorted so that the values of output variables increase with increasing plotting positions. This option will indicate the percentage (or fraction) of values that are less than a given data value. If you select Descending, the values will be sorted so that the values of output variables decrease with increasing plotting positions. This option will indicate the percentage (or fraction) of values that exceed a given data value. The default value is Descending.

The Output Significant Figures option group lets you select the number of significant figures that will be output for data values. These specifications are for significant figures rather than for the number of places after the decimal point. SELDM calculates all environmental variables using double precision, but the USGS publishes most environmental data using two to three significant figures because of the uncertainty in measuring environmental processes. However, using three significant digits can lead to some apparent discrepancies in outputs. For example, if the highway flow or load for a given storm is less than 0.5 percent of the upstream load or flow, then rounding to three significant figures would not show an increase from upstream to downstream in the output file. Similarly, annual flows or loads may not equal the sum of individual stormflows or loads because of rounding differences. You may use a larger number of significant figures to better reconcile rounding differences, but the added significant figures may imply a higher degree of certainty in results than available information warrants. The Double Precision option (15 significant digits) should be used only for checking or verifying SELDM calculations. The default value is three significant digits as a compromise between rounding precision and the perceived accuracy of results. For example, Harmel and others (2006) estimated that cumulative probable uncertainties for loads of dissolved nutrients, total nutrients, and sediment in receiving streams commonly are on the order of plus or minus 8 to 104 percent, 8 to 110 percent, and 7 to 53 percent, respectively.

The Output Units option box lets you select the units that are used to write the output values. The options are either USA (the default value) or Metric. If USA is selected, then SELDM prints the input data using the input units and it prints the output precipitation totals, stormflows, and loads in inches, cubic feet, and pounds, respectively. If you select Metric, all input and output values in the output files are converted to the commonly used metric equivalents.

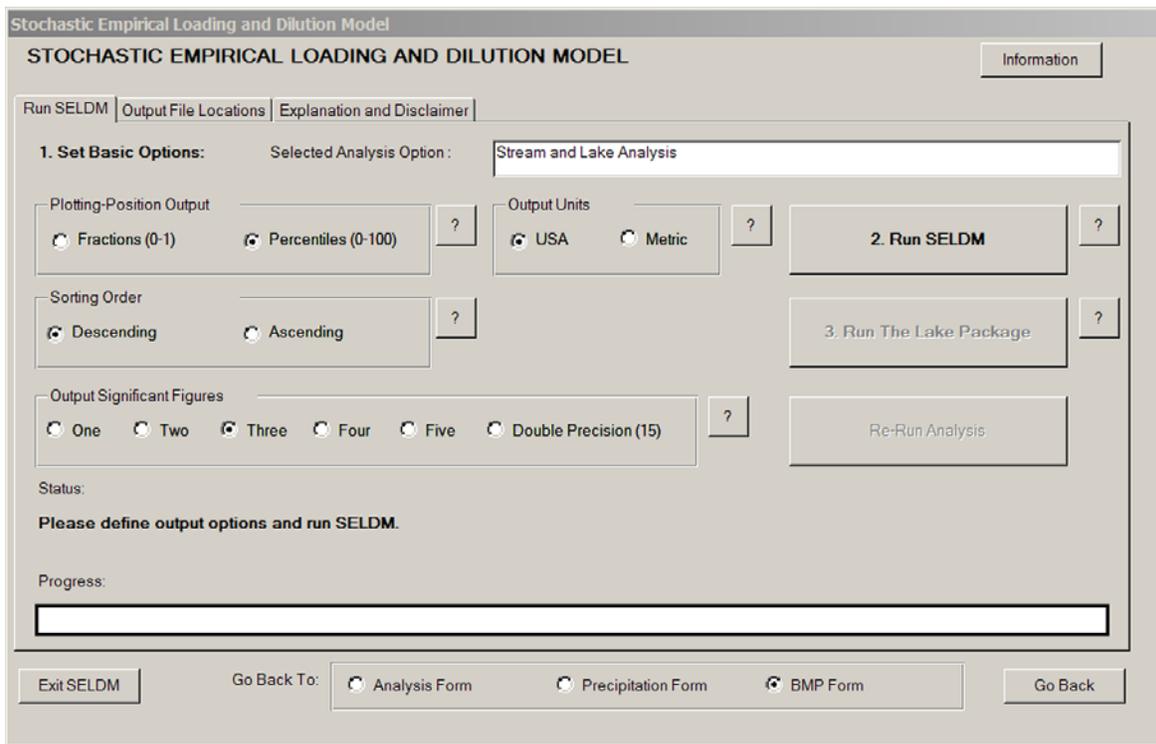
To run SELDM, click the 2. RUN SELDM button. This command first clears the database output tables, then runs the Monte Carlo model. As SELDM runs and writes the output files, it will update the status text and the progress meter. Running SELDM will disable the 2. RUN SELDM command button (fig. 4–29B). If the Stream and Lake or Lake analyses are selected for the analysis, SELDM will activate the 3. Run The Lake Package command button. To run the Lake Package, click this button. As SELDM runs and writes the lake output file, it will update the status text and the progress meter (fig. 4–29C). Running the SELDM lake package will disable the 3. Run The Lake Package command button.

Once an analysis is complete, the Output File Locations tab lists the output path and the individual file names (fig. 4–29D). SELDM saves the output files in a systematic directory structure and puts a time stamp in each file to help verify the contents for regulatory applications of the model. SELDM finds the root drive of the computer and constructs a directory structure starting with the folder FHWA-SELDM. If you get an error while running the model, then you will need to have someone with administrative rights create and give you full control rights to this directory. It creates (1) a project folder based on the project number or short name, (2) an analysis folder based on the analysis short name, (3) a folder for the current date, and (4) a folder for each run number made on that date. There are two ways to open the output file folder; you can (1) copy the address from the Path textbox and paste it into the Address combobox on an open Microsoft folder window or (2) click the Open Output Folder

command button. The files that are created, and therefore, the filenames that appear on this tab depend on your selections during the analysis process. For example, the Lake Analysis output file will be created only if you select either a Stream and Lake analysis or a Lake analysis. Also, if you do not select any downstream pairs, then the upstream quality, downstream quality, and the lake-basin output files will not be created or displayed on this form.

The Explanation and Disclaimer tab has a textbox describing the analysis and two command buttons. The Explanation button opens a form with information about SELDL. The Disclaimer button opens a form with a general disclaimer for SELDL.

A



**Figure 4–29.** Run SELDL Form, showing the *A*, initial and *B*, post-analysis views and the *C*, post lake analysis view of the Run SELDL tab, and *D*, Output File Locations, and *E*, Explanation and Disclaimer tabs.

**B**

**Stochastic Empirical Loading and Dilution Model**

STOCHASTIC EMPIRICAL LOADING AND DILUTION MODEL Information

Run SELDM | Output File Locations | Explanation and Disclaimer

**1. Set Basic Options:** Selected Analysis Option : Stream and Lake Analysis

Plotting-Position Output  
 Fractions (0-1)  Percentiles (0-100) ?

Output Units  
 USA  Metric ?

Sorting Order  
 Descending  Ascending ?

Output Significant Figures  
 One  Two  Three  Four  Five  Double Precision (15) ?

Status:  
**Done**

Progress:  
 \_\_\_\_\_

Exit SELDM    Go Back To:  Analysis Form  Precipitation Form  BMP Form    Go Back

**C**

**Stochastic Empirical Loading and Dilution Model**

STOCHASTIC EMPIRICAL LOADING AND DILUTION MODEL Information

Run SELDM | Output File Locations | Explanation and Disclaimer

**1. Set Basic Options:** Selected Analysis Option : Stream and Lake Analysis

Plotting-Position Output  
 Fractions (0-1)  Percentiles (0-100) ?

Output Units  
 USA  Metric ?

Sorting Order  
 Descending  Ascending ?

Output Significant Figures  
 One  Two  Three  Four  Five  Double Precision (15) ?

Status:  
**Done**

Progress:  
 \_\_\_\_\_

Exit SELDM    Go Back To:  Analysis Form  Precipitation Form  BMP Form    Go Back

**Figure 4–29.** Run SELDM Form, showing the *A*, initial and *B*, post-analysis views and the *C*, post lake analysis view of the Run SELDM tab, and *D*, Output File Locations, and *E*, Explanation and Disclaimer tabs.—Continued

**D**

**E**

**Figure 4–29.** Run SELDM Form, showing the *A*, initial and *B*, post-analysis views and the *C*, post lake analysis view of the Run SELDM tab, and *D*, Output File Locations, and *E*, Explanation and Disclaimer tabs.—Continued

## References Cited

- Athayde, D.N., Shelley, P.E., Driscoll, E.D., and Boyd, G.B., 1983, Results of the nationwide urban runoff program, volume I—Final report: U.S. Environmental Protection Agency, Water Planning Division Report WH-554, 186 p.
- Back, W.E., Boles, W.W., and Fry, G.T., 2000, Defining triangular probability distributions from historical cost data: *Journal of Construction Engineering*, v. 126, no. 1, p. 29–37.
- Barrett, M.E., 2005, Performance comparison of structural stormwater best management practices: *Water Environment Research*, v. 77, no. 6, p. 78–86.
- Barrett, M.E., 2008, Comparison of BMP performance using the international BMP database: *Journal of Irrigation and Drainage Engineering*, v. 134, no. 5, p. 556–561.
- Brown, J.W., ed., 2006, Eco-logical—An ecosystem approach to developing infrastructure projects: Federal Highway Administration Report FHWA-HEP-06-011, 96 p.
- Chow, V.T., Maidment, D.R., and Mays, L.W., 1988: *Applied hydrology*: New York, McGraw-Hill, Inc., 572 p.
- Devroye, Luc, 1986, *Non-uniform random variate generation*: New York, Springer-Verlag, 843 p.
- Drexel University Math Forum, 1999, Deriving the Haversine formula: Philadelphia, Pa., Drexel University, accessed August 2, 2004, at <http://mathforum.org/library/drmath/view/51879.html>.
- Driscoll, E.D., Palhegyi, G.E., Strecker, E.W., and Shelley, P.E., 1989, Analysis of storm event characteristics for selected rainfall gages throughout the United States: U.S. Environmental Protection Agency OCLC 30534890, 43 p.
- Geosyntec Consultants and Wright Water Engineers, 2009, Urban stormwater BMP performance monitoring: Geosyntec Consultants and Wright Water Engineers, accessed January 1, 2012, at <http://www.bmpdatabase.org/Docs/2009%20Stormwater%20BMP%20Monitoring%20Manual.pdf>.
- Granato, G.E., 1999, Computer program for point location and calculation of error (PLACER): U.S. Geological Survey Open-File Report 99-99, 36 p.
- Granato, G.E., 2006, Kendall-Theil robust line (KTRLLine—version 1.0)—A visual basic program for calculating and graphing robust nonparametric estimates of linear-regression coefficients between two continuous variables: U.S. Geological Survey Techniques and Methods, book 4, chap. A7, 31 p., CD-ROM, accessed February 6, 2013, at <http://pubs.usgs.gov/tm/2006/tm4a7/>.
- Granato, G.E., 2009, Computer programs for obtaining and analyzing daily mean streamflow data from the U.S. Geological Survey National Water Information System web site: U.S. Geological Survey Open-File Report 2008-1362, 5 appendixes, 123 p., CD-ROM, accessed February 6, 2013, at <http://pubs.usgs.gov/of/2008/1362/>.
- Granato, G.E., 2010, Methods for development of planning-level estimates of stormflow at unmonitored sites in the conterminous United States: Federal Highway Administration Report FHWA-HEP-09-005, 90 p., CD-ROM.
- Granato, G.E., 2012, Estimating basin lagtime and hydrograph-timing indexes used to characterize stormflows for runoff-quality analysis: U.S. Geological Survey Scientific Investigations Report 2012-5110, 47 p., accessed February 6, 2013, at <http://pubs.usgs.gov/sir/2012/5112/>.
- Granato, G.E., Carlson, C.S., and Sniderman, B.S., 2009, Methods for development of planning-level estimates of water quality at unmonitored stream sites in the conterminous United States: Federal Highway Administration Report FHWA-HEP-09-003, 53 p., CD-ROM.
- Granato, G.E., and Cazenias, P.A., 2009, Highway-runoff database (HRDB version 1.0)—A data warehouse and preprocessor for the stochastic empirical loading and dilution model: Federal Highway Administration Report FHWA-HEP-09-004, 57 p.
- Harmel, R.D., Cooper, R.J., Slade, R.M., Haney, R.L., and Arnold, J.G., 2006, Cumulative uncertainty in measured streamflow and water quality data for small watersheds: *Transactions of the American Society of Agricultural and Biological Engineers*, v. 49, no. 3, p. 689–701.

- Johnson, David, 1997, The triangular distribution as a proxy for the beta distribution in risk analysis: *The Statistician*, v. 46, no. 3, p. 387–398.
- Kacker, R.N., and Lawrence, J.F., 2007, Trapezoidal and triangular distributions for type B evaluation of standard uncertainty: *Metrologia*, v. 44, no. 2, p. 117–127.
- Omernik, J.M., 1995, Ecoregions—A spatial framework for environmental management, chap. 5 of Davis, W.S., and Simon, T.P., eds., *Biological assessment and criteria—Tools for water resource planning and decision making*: Boca Raton, Fla., Lewis Publishers, p. 49–66.
- Omernik, J.M., 2004, Perspectives on the nature and definition of ecological regions: *Environmental Management*, accessed July 28, 2005, at <http://springerlink.metapress.com/openurl.asp?genre=article&id=doi:10.1007/s00267-003-5197-2>.
- Saucier, Richard, 2000, Computer generation of statistical distributions: U.S. Army Research Laboratory Report ARL–TR–2168, 105 p.
- Schueler, T.R., 1987, Controlling urban runoff—A practical manual for planning and designing urban BMPs: Washington, D.C., Metropolitan Washington Council of Governments, Department of Environmental Programs, no. 87703, 275 p.
- Schueler, T.R., 1996, Irreducible pollutant concentrations discharged from stormwater practices: *Watershed Protection Techniques*, v. 2, no. 2, p. 361–363.
- Sevin, A.F., 1987, Guidance for preparing and processing environmental and section 4(f) documents: Washington, D.C., Federal Highway Administration Technical Advisory T–6640.8A, 62 p., accessed August 13, 2012, at <http://environment.fhwa.dot.gov/projdev/impta6640.asp>.
- Sinnott, R.W., 1984, Virtues of the Haversine: *Sky and Telescope*, v. 68, no. 2, p. 159.
- Stedinger, J.R., Vogel, R.M., and Foufoula-Georgiou, Efi, 1993, Frequency analysis of extreme events, chap. 18 of Maidment, D.R., ed., *Handbook of hydrology*: New York, McGraw-Hill, Inc., p. 18.1–18.66.
- U.S. Environmental Protection Agency, 2001, Process for conducting probabilistic risk assessment, v. 3, part A of Risk assessment guidance for superfund: U.S. Environmental Protection Agency EPA 540–R–02–002, 385 p.
- U.S. Environmental Protection Agency, 2003, Level III ecoregions of the continental United States: U.S. Environmental Protection Agency, 1 sheet, accessed January 1, 2005, at [http://www.epa.gov/wed/pages/ecoregions/level\\_iii\\_iv.htm](http://www.epa.gov/wed/pages/ecoregions/level_iii_iv.htm).