The Highway Runoff Database (HRDB) is a data warehouse and preprocessor for the new FHWA-USGS Stochastic Empirical Loading and Dilution Model (SELDM)

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Abstract

The USGS, in cooperation with the FHWA developed the Highway Runoff Database (HRDB) as a data warehouse and preprocessor for the new Stochastic Empirical Loading and Dilution Model (SELDM). The HRDB is data rich. The latest version of the highway runoff database includes 54,384 event-mean concentrations (EMCs), from 4,186 storm events monitored at 117 study sites across the United States. The HRDB includes data for 194 highway-runoff constituents. Most of the constituents of greatest interest for highway-runoff characterization have more than 500 EMC samples in the database. The HRDB is easy to use. Data and statisics in the HRDB are readily available in easy-to-use formats with just a few mouse-clicks. Availability of this highway-runoff data in a standard format and the ease of use of the graphical user interface should provide information to improve highway-project delivery without compromising environmental protection.

The HRDB supports SELDM analyses

The Stochastic Empirical Loading and Dilution Model (SELDM) is designed to transform complex scientific data into meaningful information about the risk of adverse effects of highway runoff on receiving waters, the potential need for mitigation measures, and the potential effectiveness of such management measures for reducing these risks (Granato, 2013). SELDM is a lumped parameter model because the highway site and the the receiving-water basin each are represented as a single homogeneous unit with a few simple basin characteristics. SELDM uses information about a highway site, the associated receiving-water basin, precipitation events, stormflow, water quality, and the performance of mitigation measures to produce a stochastic population of runoff-quality variables. SELDM uses a mass-balance approach to calculate stormwater flows, concentrations, and loads from the highway, from the upstream basin, and in the downstream receiving waters (figure 1).

As SELDM was developed, it was realized a highway-runoff database was needed for storage, retrieval, and analysis of highway-runoff data in a consistent format. The HRDB provides data on runoff coefficients to model stormflows and data on runoff quality to model concentrations and loads of highway-runoff (Granato and Cazenas, 2009; Smith and Granato, 2010).

Figure 1. Schematic diagram showing the mass balance approach for a hypothetical site.

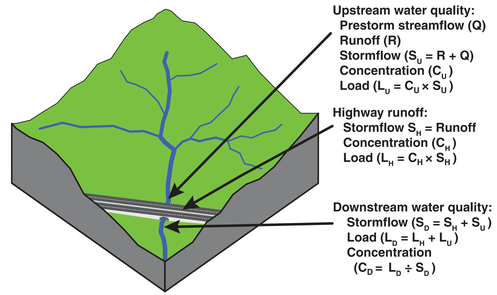
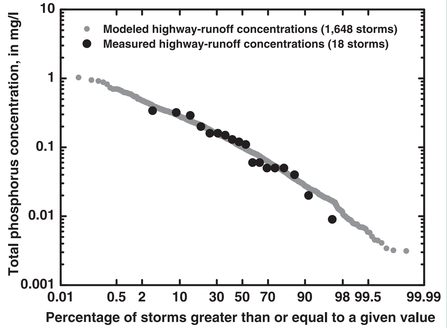


Figure 2 shows the measured and modeled concentrations of total phosphorus in highway runoff from State Route 2 in Littleton, Massachusetts. The USGS monitored the quality and quanity of runoff at this site during the 2005-2007 period (Smith and Granato, 2010). Measured event mean concentrations (EMCs) ranged from 0.009 to 0.34 milligrams per liter (mg/l) during the 18 storms monitored during this period with a median concentration of 0.115 and an average concentration of 0.129 mg/l. The HRDB was used to document the highway runoff data and to calculate the statistics used in the model. SELDM was used to generate runoff-quality values from 1,648 storm events over a 29-year simulation period to assess potential effects of runoff on receiving waters. Modeled concentrations of total phosphorus in highway runoff ranged from 0.003 to 1.03 mg/l during the 29-year simulation period. In this area, highway-runoff concentrations are not substantially different from streamflow concentrations.

Figure 2. Measured and modeled highway runoff.



The HRDB is data rich

The HRDB (Granato and Cazenas, 2009; Smith and Granato, 2010) currently includes the results from 9 datasets (figure 3). Data from the 1990 FHWA database (FHWA 1990) are included in the HRDB to supplement and to provide a basis for comparison with newer data sets. The California dataset (CA 2003) currently is one of the largest and most robust datasets. The Massachusetts data sets (MA 2002 and MA 2010), from a BMP study and a state-wide runoff characterization study, also are robust. The Michigan dataset (MI 1998) is from a highway stormwater-runoff characterization study. The Ohio dataset (OH 1997) is from a small highway stormwater-runoff characterization study in Cincinnati, Ohio. The Texas dataset (TX 1997) represents results from a characterization study and a BMP study. The Washington State datasets (WA 2005) include highway-runoff characterization data for NPDES permits and BMP monitoring data. The Wisconsin dataset (WI 2000) documents highway-runoff quality with and without street sweeping.

Currently, the database includes data for 117 stations, 4,186 storms, and 54,383 individual stormwater quality measurements (figure 3). Most of the constituents of greatest interest for highway-runoff characterization including sediment, nutrients, metals, oxygen demand, and organic constituents have more than 500 EMC samples in the database. The storm events in the highway-runoff database span a period of more than three decades from 1975 to 2009.

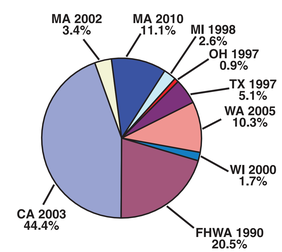
There are opportunities to improve and expand the highway runoff database. In 2006, researchers for the National Cooperative Highway Runoff Program (NCHRP) concluded that it is efficient and important to keep a National highway-runoff database up-to-date and available to the public. The HRDB was designed to meet that need. We know that additional highway-runoff data are available from a number of states including CA, FL, LA, MD, NC, OR, SC, and WI. In some areas regulators and environmental groups select statistics from the Nationwide Urban Runoff Program (NURP) or the 1990 FHWA dataset, with concentrations that can be much greater than the concentrations measured in recent studies. Furthermore the USGS-FHWA National Data and Methodology Synthesis (NDAMS) results indicate that knowledge of the details of highway-runoff studies is not persistent or pervasive and that detailed data and documentation for studies more than 5 years old often are unobtainable because of changes in personnel and computer systems. If you are aware of other highway-runoff data sets please let us know so we can obtain the data for future inclusion in the HRDB.

Figure 3. Summary of the highway-runoff data in version 1.0.0a of the HRDB

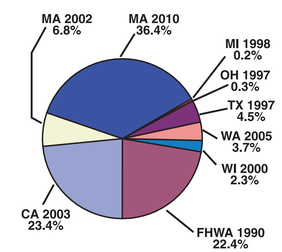
A. Count of sites, storm events, and event-mean concentration (EMC) values

Highway-Runoff Data Set	Count of Sites	Storms	EMCs
Federal:			
FHWA 1990	24	937	8,039
State:			
CA 2003	52	981	26,104
MA 2002	4	285	1,236
MA 2010	13	1,523	14,501
MI 1998	3	9	198
OH 1997	1	13	169
TX 1997	6	187	1,925
WA 2005	12	155	1,486
WI 2000	2	96	725
Sum	117	4,186	54,383

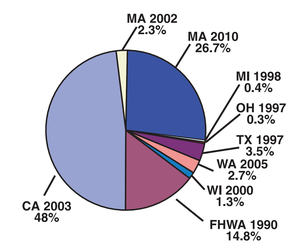
B. Percentage (%) of sites in each data set



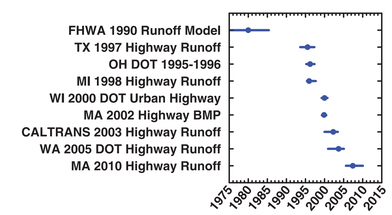
C. Percentage (%) of storm events in each data set



D. Percentage (%) of event mean concentration values in each data set



E. Range of dates and average date of monitored storms in each highway-runoff data set.



The HRDB is easy to use

The HRDB application, can be used to facilitate estimation of statistical properties of runoff coefficients, runoff-quality statistics, and relations between water-quality variables in highway runoff from the available data. The HRDB application is the system of user-forms and underlying queries that constitute the graphical-user interface (figure 4). This allows the user to extract data and statistics with only a minimal knowledge of the Microsoft Access software.

The HRDB application was designed retrieve data in formats that would facilitate use of the data with other computer applications such as spreadsheets, statistical packages, the Multiple Detection Limit (MDL) Software and the Kendall-Theil Robust Line analysis software (Granato and Cazenas, 2009). The database application also is designed to facilitate calculation of the statistics necessary for analysis of highway-runoff data.

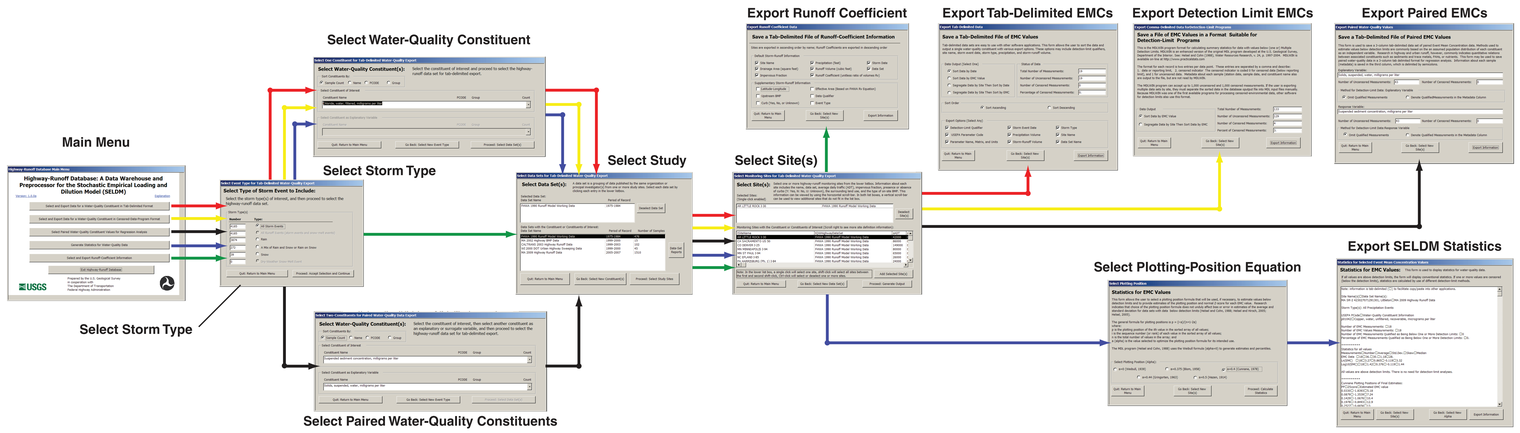
The HRDB application provides the ability to export:

- water-quality data in a tab-delimited format for use with other software packages;
- water-quality data in a format for use with detection-limit software;
- paired water-quality data in a tab-delimited format for regression analysis;
- summary statistics for water-quality data with (or without) censored data; and
- information and data necessary to evaluate storm-by-storm runoff coefficients for different sites.

These five options are provided so that the user may select from all available data or a custom data set and do the analysis necessary to estimate runoff quality and flows that are representative of a site of interest. The user may select any of these options from the HRDB application main menu and follow a series of specification forms to select all the options necessary to complete the desired operation. The main menu provides an interface for selecting each of these output options and an option for exiting the database application.

The sequence of specification forms that are used to complete a desired operation is shown in figure 4. Although common forms are used for different options, the forms have customized features (such as titles and explanations) to cue the user about the currently selected operation. For water-quality options, the user must (1) select the event type(s), (2) specify the constituent of interest, (3) select a data set or data sets that include the constituent of interest, and (4) select a monitoring site or sites with site characteristics—for example, the average daily traffic (ADT), location, impervious fraction, the presence of curbs, or the type of surrounding land use—that are similar to the characteristics of the site of interest. Once the user navigates through these common-use data-specification forms, the application forwards the user to the form that is specific to the individual task. Similarly, if exporting runoff-coefficient data, the user must select the event type(s), data set(s), and site(s) that have rainfall and runoff data and an estimated drainage area with the common-use data-specification forms. In each data-specification sequence, the user may either return to the previous form (by use of a "Go Back" button on each form) or exit the process and return to the main menu (by use of a "Quit" button).

Figure 4. Schematic diagram showing the HRDB interface forms that are used to export highway-runoff data and statistics.



Free SELDM training on-line and in the classroom

On-line: We will be hosting a few short (1.5 hour) sessions to introduce people to SELDM and invite them to classroom sessions sign up at: http://www.doodle.com/yvx4hmph34dpg4eq

Classroom: We will be hosting 3-day classroom sessions to train model experts in Massachusetts during September 2013, in Oregon during October 2013, and in Washington DC during Spring 2014

References

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