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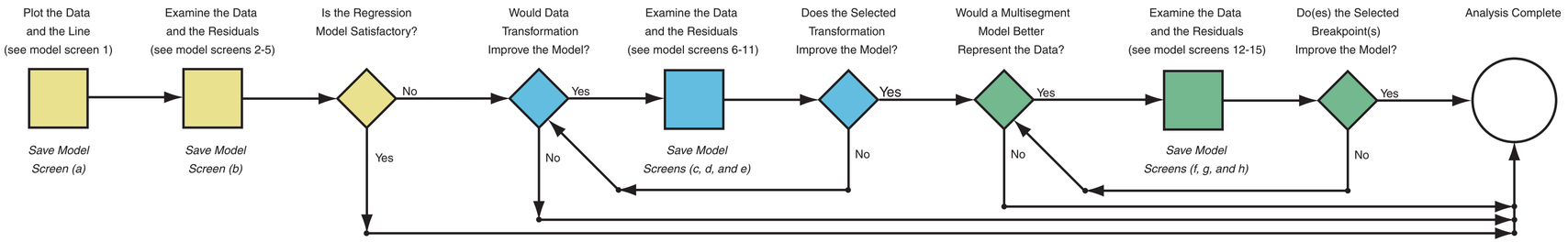
FEDERAL HIGHWAY ADMINISTRATION ENVIRONMENTAL PLANNING REPORT FHWA-HEP-09-003
Example of a Water-Quality Transport Curve Developed with the Kendall-Theil Robust Line Software (Version 1.0.0)—PLATE
Granato, G.E., Carlson C.S., and Sniderman, B.S., 2009,
Methods for Development of Planning-Level Estimates of Water Quality at Unmonitored Stream Sites in the Conterminous United States

OVERVIEW OF THE WATER-QUALITY ANALYSIS PROCESS

Water-quality transport curves are regression relations used to estimate constituent concentrations from measured or estimated water-discharge values. Water-quality transport curves were developed using the nonparametric Kendall-Theil robust line method as implemented in a software program (KTRLine version 1.0.0) developed for this study. Transport curves were developed because concentrations of many constituents commonly vary as a result of washoff and dilution processes in receiving waters. Three constituents, total phosphorus, total hardness, and suspended sediment, were selected for regression analysis to develop transport curves for each U.S. Environmental Protection Agency level III nutrient ecoregion. Examination of transport curves developed with these data indicates that these curves are appropriate models describing the underlying processes of washoff or dilution expected for each constituent, and that predictions made by using these transport curves are comparable with published estimates for each water-quality constituent.

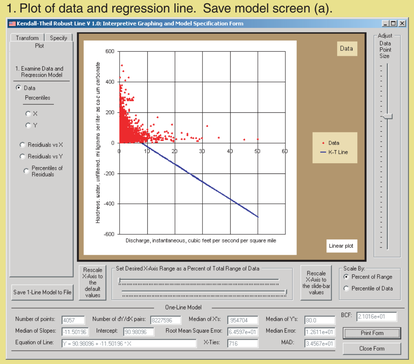
Data for total hardness from ecoregion 67, the Ridge and Valley ecoregion in the southeastern Appalachian Mountains, was selected to demonstrate the process of developing a multisegment regression model that defines the transport curve. The input data, the output file, and 15 regression-model development screen files documenting each step of the multisegment model-development process are recorded in the total hardness "p00900TH" subdirectory of the "Regress" directory on the CD-ROM accompanying this report. The KTRLine regression-model development screens for examination of a linear model, a model of the log-transformed data, and a multisegment model of log-transformed data are shown to illustrate this process. The process-flow diagram for the water-quality analysis corresponds to these model-development screens. Model-development screens that are saved to disk are designated by letters in parentheses. The CD-ROM directory structure is illustrated to facilitate use of the summary regression tables, the input and output files, and the model-output screens, which document the results of analysis.

PROCESS-FLOW DIAGRAM FOR THE WATER-QUALITY ANALYSIS

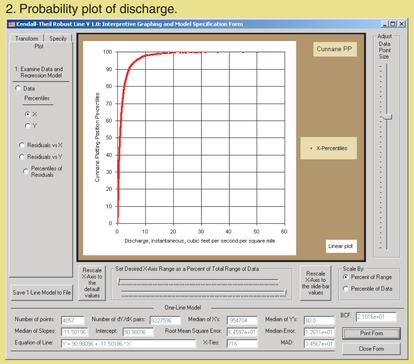


INITIAL LINEAR MODEL EVALUATION

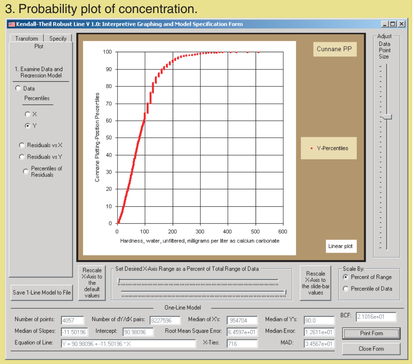
1. Plot of data and regression line. Save model screen (a).



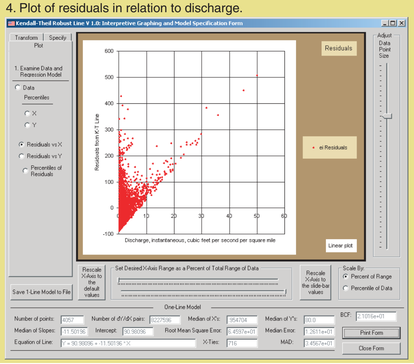
2. Probability plot of discharge.



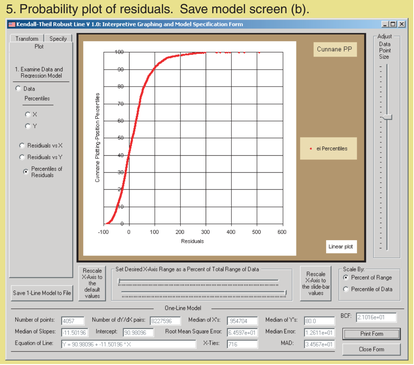
3. Probability plot of concentration.



4. Plot of residuals in relation to discharge.

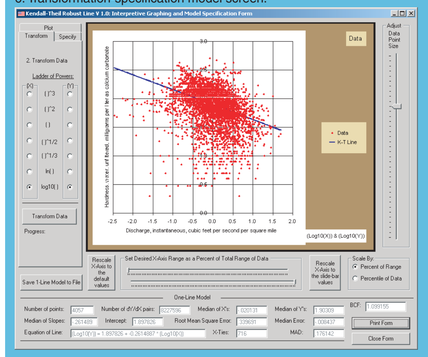


5. Probability plot of residuals. Save model screen (b).

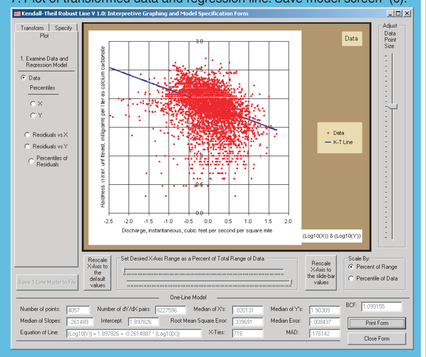


DATA TRANSFORMATION AND (LOG)-LINEAR MODEL EVALUATION

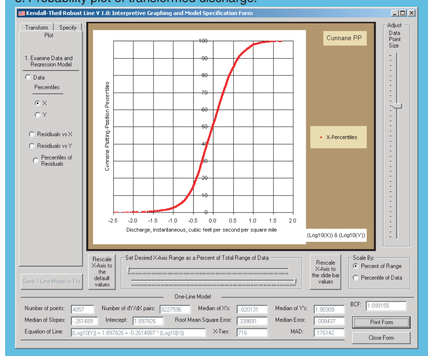
6. Transformation-specification model screen.



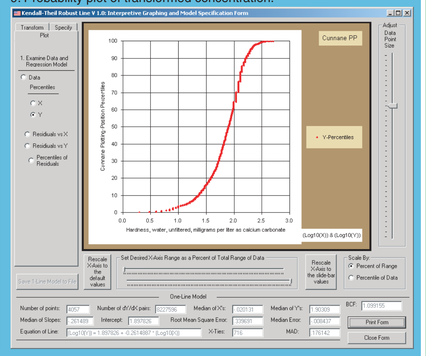
7. Plot of transformed data and regression line. Save model screen (c).



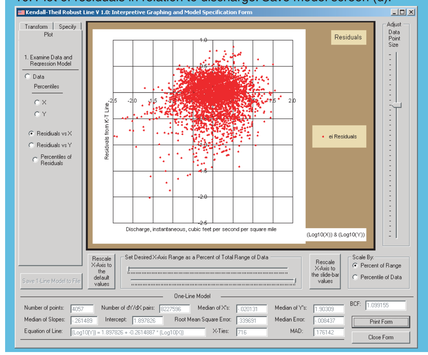
8. Probability plot of transformed discharge.



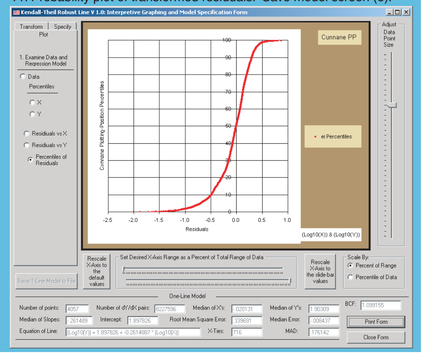
9. Probability plot of transformed concentration.



10. Plot of residuals in relation to discharge. Save model screen (d).

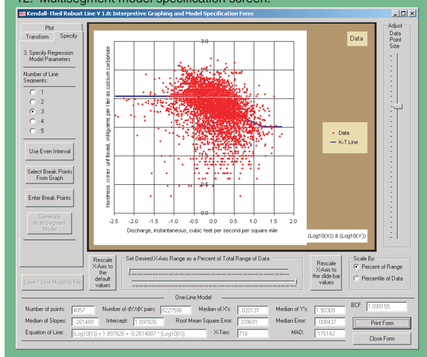


11. Probability plot of transformed residuals. Save model screen (e).

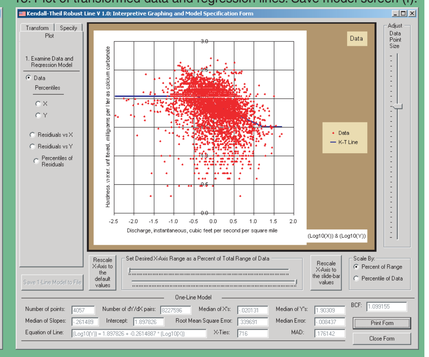


MULTISEGMENT MODEL EVALUATION

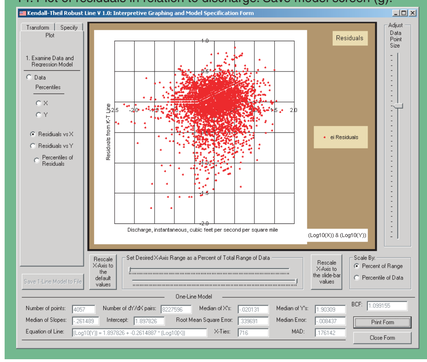
12. Multisegment model specification screen.



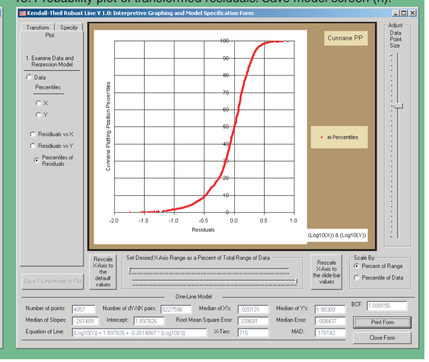
13. Plot of transformed data and regression lines. Save model screen (f).



14. Plot of residuals in relation to discharge. Save model screen (g).



15. Probability plot of transformed residuals. Save model screen (h).



EVALUATING REGRESSION RESULTS ON THE CD-ROM BY WATER-QUALITY CONSTITUENT AND ECOREGION

Kendall-Theil Robust Line (Version 1.0.0) regression-model development screens designated with the letters (a) and (b) were saved for all models. Screens designated as (c), (d) and (e) were saved for all transformed models. Screens designated as (f), (g), and (h) were saved for all multisegment models. Please see the detailed Adobe portable document format (PDF) files for each model in the Regress directory on the appropriate CD-ROM accompanying this report. The files are segregated into subdirectories by water-quality constituent and the file names indicate the ecoregion and the screen-shot designation. The Regress directory contains the summary regression tables for each constituent by ecoregion and the subdirectories include input and output files designated by ecoregion. (Note: software names are provided only for informational purposes and do not imply endorsement by the U.S. Government.)

CD-ROM directory structure

- Applications (software applications developed for the project)
- Data (tab-delimited ASCII files with water-quality monitoring data and station information)
- Database (Microsoft Access Runtime Software)
- GIS (Geographic Information System Files)
- Images (graphic and logo files)
- **Regress (Summary Regression tables)**
  - **p00665TP (Total-phosphorus regression files and Adobe PDF screen-shots)**
  - **p00900TH (Total-hardness regression files and Adobe PDF screen-shots)**
  - **p80154SSC (Suspended-sediment concentration regression files and Adobe PDF screen-shots)**
- Software (Adobe Acrobat Reader)

USGS science for a changing world

EXAMPLE OF A WATER-QUALITY TRANSPORT CURVE DEVELOPED WITH THE KENDALL-THEIL ROBUST LINE SOFTWARE (Version 1.0.0)
By Gregory E. Granato, Carl S. Carlson, and Becca S. Sniderman
2009

U.S. Department of Transportation
Federal Highway Administration