The Hydrologic Engineering Center

Training Course on

SEDIMENT TRANSPORT ANALYSIS WITH HEC-RAS

Davis, California

Course Objectives

This course is intended to prepare engineers to perform studies using various methods of calculating or estimating sediment movement and stream behavior. Use of hand methods, utility programs and computer program HEC-6 "Scour and Deposition in Rivers and Reservoirs" will be emphasized. Topics to be discussed include: terminology and sediment transport mechanics, methods for developing and conducting sediment engineering assessments at the reconnaissance, feasibility, PED, and design and specifications levels, sediment transport theories; collection of data; numerical model selection, calibration and application; and river engineering.

Prerequisites

Participants need a thorough understanding of open channel hydraulics; particularly the assumptions, limitations, and use of procedures for computing open channel flow properties such as water surface elevation and velocity. Familiarity with use of HEC-2 input data for description of river channel geometry is required. It is also required that course participants be in positions, or anticipate being in positions within the next year or two, that require involvement in sediment studies.
SEDIMENT TRANSPORT IN RIVERS AND RESERVOIRS

(Week One)

Introduction to Sediment Transport Mechanics, Problem Identification and Level-I Sediment Assessment Methods

Monday

8:00- 9:00 a.m.  INTRODUCTORY PROCEDURES

9:15-10:15 a.m. Lecture 1: INTRODUCTION TO RIVER BEHAVIOR/PROCESSES/PROBLEMS

Interaction and importance of fluvial processes with reference to Corps' mission. Definition of the time scales that we need to be cognizant of: geological, project, event. Classification of alluvial channels.

10:15-10:30 a.m. Break

10:30-12:00 noon Lecture 2: PHYSICAL PROPERTIES OF SEDIMENT AND TERMINOLOGY

Physical characteristics of sediment; classification by grain size and other physical properties, significance and calculation of settling velocity, material density, initiation of particle motion; Shield's criteria and usage; definition of bed load, suspended load, total load, with example calculations.

12:00- 1:30 p.m. Ice Breaker Luncheon

1:30- 3:00 p.m. Lecture 3: SEDIMENT TRANSPORT MECHANICS

Sediment and flow interaction, determination of incipient motion, determination of bed and bank stability, occurrence of scour and deposition, example calculations.
Monday March - Continued

3:00- 3:30 p.m. Break

3:30- 4:30 p.m. Lecture 4: OVERVIEW OF SEDIMENTATION
EM 1110-2°4000

Purpose, content, study procedures, definition of sediment assessment, concept of staged approach to sediment studies, OCE study and report requirements, review philosophy of sediment studies.

Reading Assignment: Chapters 1 and 2, Appendix A, D, E in Sediment EM; Appendix B: Nomenclature and Terms (glossary)
Tuesday

8:00- 8:45 a.m. REVIEW

8:45- 9:45 a.m. Lecture 5: DEVELOPING A SEDIMENT STUDY WORK PLAN

Problem I.D. Procedures, Components of the SSWP, Phased Approach, Review requirements from EC 1110-2-265 and ER 1110-2-1405, Examples.

9:45-10:15 a.m. Break

10:15-11:45 a.m. Lecture 6: COMPONENTS OF, AND PROCEDURES FOR CONDUCTING RIVER AND RESERVOIR SEDIMENT STUDIES - REVIEW OF SEDIMENT EM PROCEDURES

Sediment Assessment Procedures, the Does and Don'ts, Tools to Use, Methods, Data Requirements, reporting requirements, case Study Examples.

11:45-12:45 p.m. Lunch

12:45-1:45 p.m. Lecture 7: REVIEW OF OPEN CHANNEL HYDRAULICS

Purpose of hydraulic studies, Data requirements, Assumptions, Limitations, Methods and Procedures.

1:45-2:15 p.m. Break

2:15-3:15 p.m. Lecture 8: METHODS FOR COMPUTING OPEN CHANNEL FLOW PROPERTIES

Hand methods, Corps utilities, HEC-2, Accuracy Assessment Methods.

3:15-4:45 p.m Workshop 1: COMPUTING OPEN CHANNEL FLOW PROPERTIES USING VARIOUS

Reading Assignment: "Designing for Sediment Transport," by Walter Linder
Wednesday

8:00- 8:30 a.m. REVIEW

8:30- 9:45 a.m. Lecture 9: ESTIMATING BASIN SEDIMENT YIELD AND METHODS FOR DEVELOPING SEDIMENT BUDGETS

Overview of land surface erosion, basin sediment yield concepts, procedures for estimating sediment production and yield, comparison of watershed delivery with channel bed and bank erosion, development of pre- and past-project sediment budgets, example calculations.

9:45-10:15 a.m. Break

10:15-11:45 a.m. Lecture 10: SEDIMENT IMPACT ASSESSMENT PROCEDURES - I

Overview of Sediment Impact Assessment Procedures. Purpose, Data Requirements, Methods, Limitations, Hardware and Software Requirements, Explanation of sediment transport functions, their limitations, capabilities, and how to select the proper function.

11:45-12:45 p.m Lunch

12:45- 1:45 p.m. Lecture 11: SEDIMENT IMPACT ASSESSMENT PROCEDURES-II

Procedures continued, Selection of Assessment Method, Range of Applicability, and Examples.

1:45-

2:10 p.m. Break

2:10- 4:30 p.m. Workshop 2: APPLICATION OF SEDIMENT ASSESSMENT PROCEDURES

Reading Assignment: "Rethinking Flood-Control Channel Design," by Philip Williams

"Executive Summary" from the Caliente Creek Sediment Assessment Report.
Thursday

8:00- 8:45 a.m. Review

8:45-10:00 a.m. Lecture 12: INTRODUCTION TO ENGINEERING GEOMORPHOLOGY


10:00-10:20 a.m. Break

10:20-11:45 a.m. Lecture 13: SYSTEMS APPROACH TO RIVER AND WATERSHED ANALYSES

Overview of Systems Approach, Procedures, Data Requirements, Limitations, Case Study Examples.

11:45-12:45 p.m. Lunch

12:45- 2:00 p.m. Lecture 14: CALIENTE CREEK CASE STUDY

Example application of engineering geomorphology and sediment impact assessment procedures.

2:00- 2:30 p.m. Break

2:30- 3:45 p.m. Lecture 15: INSTRUMENTS AND PROCEDURES FOR CONDUCTING SEDIMENT DATA COLLECTION INVESTIGATIONS

Overview of the USGS Sediment Monitoring Procedures.

3:45- 4:30 p.m. Lecture 16: INTRODUCTION TO TOMORROW'S FIELD TRIP AND WORKSHOP 3

7:00- 9:00 p.m. Evening Lecture: "Hydraulic Processes on Alluvial Fans"

Reading Assignment: Background information provided regarding the field trip tomorrow to Cache Creek, CA.
Friday March

7:30 a.m. Assemble in HEC Classroom (MacArthur)

7:45 a.m. Board Bus for Soils Lab at U.C. Davis

8:00-9:00 a.m. **Laboratory Workshop**

Lecture, demonstrations and workshop at U.C. Davis' soils engineering laboratory; demonstration of several kinds of laboratory and field analyses that are typically conducted to evaluate the properties of sediment; methods of computing sediment characteristics from measured laboratory results.

9:00-10:00 a.m. Board Bus and Drive to Upstream End of Cache Creek Project Reach

10:00-12:00 noon Conduct Field Inspection of Upper Cache Creek Basin

12:00-1:00 p.m. Lunch in Capay, California

1:00-2:30 p.m. View Downstream Reach of Cache Creek

2:30-3:15 p.m. Return to HEC on Bus

3:15-4:45 p.m. **Workshop 3: PREPARE FIELD RECONNAISSANCE TRIP REPORTS**

Prepare Trip Reports, Summarize Observations, Data Needs, Key Concerns, Recommendations. Group presentations of Trip Reports.
SEDIMENT TRANSPORT IN RIVERS AND RESERVOIRS

(Week Two)

Level II Sediment Assessment Methods

Monday

8:00-9:00 a.m. Lecture 17: INTRODUCTION TO NUMERICAL MODELING OF RIVER MECHANICS

Definition of numerical models. Physical processes being modeled. Fundamental processes incorporated in models. Special Requirements and Limitations.

9:00-9:15 a.m. Break

9:15-10:30 a.m. Lecture 18: INTRODUCTION TO HEC-6 AND BASIC DATA REQUIREMENTS

History, basic principles, capabilities and limitations, computational sequence. Distinction between run data and calibration data, data sources, use of commercial Post Processing and Graphics.

10:30-10:45 a.m. Break

10:45-12:00 noon Lecture 19: DEVELOPMENT OF HYDROLOGIC DATA FOR HEC-6

Use of USGS stream gage data with CD-ROM input, data compression via the "histogram" generator program, maintenance of flow and sediment volumes, use of flow-duration concepts. Single event analyses vs. long term analyses.

12:00-1:00 p.m. Lunch

1:00-2:00 p.m. Lecture 20: INTERPRETATION OF HEC-6 RESULTS

Explanation of input and output information, control of output, interpretation of results, accuracy assessment procedures. Procedures for running HEC-6 in a fixed vs. mobile bed mode.

2:00-2:20 p.m. Break
Monday - Continued

2:20- 3:00 p.m.  Lecture 21: INTRODUCTION TO WORKSHOP AND USE OF HEC-6 ON MICROCOMPUTERS
Use of Menus, COED, Plotting Routines

3:00- 4:30 p.m.  Workshop 4: DEVELOPMENT OF HYDROLOGIC DATA FOR HEC-6 AND PROGRAM EXECUTION IN FIXED BED MODE

4:30- 4:45 p.m.  Workshop Review
Tuesday

8:00- 9:30 a.m. Lecture 22: DEVELOPMENT OF BED MATERIAL AND INFLOWING LOAD DATA FOR HEC-6

Development of the sediment boundary condition information required by HEC-6, definition of terms, sediment data requirements of the program, sources of data, costs, sampling procedures, where to collect samples, sensitivity of computed results to data variations, variations and reliability of field data, strategy for developing a sampling program.

9:30-10:00 a.m. Break

10:00-11:30 a.m. Lecture 23: REVIEW AND SELECTION OF SEDIMENT TRANSPORT FUNCTIONS

Computation of sediment transport rate for given hydraulic conditions by several procedures; Toffaleti, Yang, DeBois, Schoklitch, Einstein and others. Use of Multiple Transport Functions. Emphasize the assumptions made and exactly what (bed load, bed material load, suspended load, etc.) is calculated by each approach. Discuss original data sources (laboratory, field) for development of the function. Limitations and recommendations for selecting and using the various functions, warning of misuses.

11:30-12:30 p.m. Lunch

12:30- 1:30 p.m. Lecture 24: CASE STUDY OF SAN LORENZO RIVER, CA

Presentation of the San Lorenzo River Case Study with emphasis on input data, model calibration and interpretation of modeling results.

1:30- 1:45 p.m Break

1:45- 4:00 p.m. Workshop 5: DEVELOPMENT OF SEDIMENT DATA FOR HEC-6

Program execution in movable bed mode.

4:00- 4:30 p.m. WORKSHOP REVIEW

Reading Assignment: EC-1110-2-265, "Engineering and Design for Civil Works Projects."
Wednesday

8:00-9:30 a.m. Lecture 25: RESERVOIR SEDIMENTATION

Characteristics of reservoir sediment deposits, distribution of reservoir deposits, use of HEC-6 for reservoir studies, impact of reservoir deposits on reallocation studies, summary of EM procedures.

9:30-10:00 a.m. Break

10:00-11:30 a.m. Lecture 26: HYDRAULIC SORTING AND ARMORING

Procedures used in HEC-6, the concept of a sediment control volume, definition of active and inactive layers, relationship of active and inactive layers to bed material sampling procedures, limitations and assumptions of the procedure, accuracy assessment.

11:30-12:30 p.m. Lunch

12:30-1:30 p.m. Lecture 27: TRANSVERSE DISTRIBUTION OF SCOUR/DEPOSITION

Bank erosion mechanisms, use and interpretation of HEC-6 results for problems that relate to lateral migration, other techniques available, Stable Channel Assessment Procedures, Methods used in HEC6 to distribute scour and deposition within a cross section, assumptions and limitations of the method.

1:30-1:50 p.m. Break

1:50-3:15 p.m. Lecture 28: CALIBRATION/VALIDATION TECHNIQUES/INTERPRETATION OF RESULTS

Calibration and validation techniques, estimating roughness in alluvial streams, selection of computational time interval, geometric adjustments, accuracy assessment and calibration data requirements; parameter
Wednesday - Continued

3:15- 4:45 p.m.  Workshop 6: TESTING SENSITIVITY AND BOUNDARY EFFECTS WITH HEC-6

Program execution in movable bed mode, experimentation with data and parameter adjustments to reproduce field observations (validation of results). How does the model respond to changing boundary conditions.

7:00- 9:00 p.m.  Evening Lecture: CAPABILITIES AND APPLICATIONS OF TABS-II AND OTHER HYBRID MODELING APPROACHES
Thursday

8:00–8:45 a.m. REVIEW

8:45–9:45 a.m. Lecture 29: SPECIAL FEATURES/APPLICATIONS OF HEC-6

Summary of special features of HEC-6, application to single flood events, dredging, gravel mining, stream network analysis, cohesive bed modeling methods.

9:45–10:15 a.m. Break

10:15–11:30 a.m. Lecture 30: SEDIMENT ASSESSMENT CASE STUDY

Nonconnah Creek Case Study, including: Reconnaissance, Feasibility, and Design Assessments.

11:30–12:30 p.m. Lunch

12:30–1:30 p.m. Lecture 31: ANALYSIS OF RIVER PROBLEMS USING PHYSICAL MODELS

Model laws, scale distortion, applicability of physical models, costs. Example studies.

1:30–4:15 p.m. WORKSHOP 7 AND REVIEW: A NETWORK APPLICATION OF HEC-6

Application of HEC-6 to evaluate a river system consisting of a main channel and tributaries.

Reading Assignment: ER-1110-2-1405
Friday

8:00-9:00 a.m. Lecture 32: ENGINEERING AND DESIGN FOR CIVIL WORKS PROJECTS: A SUMMARY

Review of EC-1110-2-265 and ER 1110-2-1405, summary of the purpose, components and regulations pertaining to the conduct of engineering planning, analysis and design of civil works projects. Discuss goals, and purpose of Corps in Civil Works arena along with the draft engineering regulations used for guidance for implementing the new procedures, requirements and responsibilities for engineering and design of Civil Works Projects. Reconnaissance, Feasibility, PED, Code of Accounts and Contingencies.

9:00-9:20 a.m. Break

9:20-10:45 a.m. Lecture 33: GOALS AND RESPONSIBILITIES OF H&H STUDIES - THE DISTRICT'S PERSPECTIVE

Goals and responsibilities of the H&H staff during Reconnaissance, Feasibility, PED and GDM phases of Civil Works Projects. How do technical studies fit into the planning system, what are the responsibilities and goals of Life Cycle Project Management, discuss in-kind services and cost sharing arrangements, summary of the District's perspective, and examples of project management problems.

10:45-11:00 a.m. Break

11:00-11:30 a.m. Closing Procedures