REGIONAL SEDIMENT MANAGEMENT
Tools and Technologies

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Regional Sediment Management: Integrated Solutions for Sediment Related Challenges

Regional Sediment Management Tools and Technologies: Volume II, Inland

1. Introduction

This document provides a summary of tools and technologies available to facilitate implementation of Regional Sediment Management (RSM) for the Nation's inland systems, including watersheds, rivers, lakes, reservoirs, and wetlands. This document is a companion to the RSM Tools and Technologies Volume I for the coastal environment. Together, they provide an overview of the most commonly used inland and coastal capabilities available.

The National RSM Program develops, enhances, and applies tools and technologies for regional approaches in collaboration with research programs (U.S. Army Corps of Engineers [USACE], other Federal and non-Federal agencies), USACE Divisions and Districts, academia, stakeholders and partners, and Non-Governmental Organizations (NGOs).

1.1 Regional Sediment Management

The U.S. Army Corps of Engineers (USACE) National RSM Program was initiated in 1999 to take a regional or systems approach to address sediment related issues and support sustainable solutions across multiple projects (primarily navigation, flood risk management, and ecosystem restoration) in coordination with partnering organizations, governments, and stakeholders. RSM strategies along with the data and knowledge made available through RSM also provide valuable information for emergency management operations. To date, USACE Districts from all Divisions, the Engineer Research and Development Center (ERDC), and the Institute for Water Resources (IWR) have participated in the National RSM Program in collaboration with other Federal and non-Federal stakeholders and partners, Academia, and NGOs (Non-governmental organization). Because sediment related challenges and their solutions vary in different regions of the Nation, regional RSM Teams have been established across the nation to address region specific challenges to managing sediments.

RSM is a philosophy that implements regional and systems approaches to utilize best management practices across multiple projects to improve the management and use of sediments in coastal, estuarine, and inland environments. The overarching goal is to achieve short and long-term sustainable environmental, social, and economic benefits both locally and regionally: increasing benefits while maintaining or reducing costs.

The RSM approach includes multiple components including 1) engagement, communication, and collaboration with entities interested in the management and use of sediments (USACE, Federal and non-Federal agencies, NGOs, States, stakeholders, sponsors, resource agencies, and local communities). This includes participating in or establishing an Interagency Working Group which focuses on sediment management; 2) Integration across multiple projects, communities, programs, authorities, funding and other resources, and USACE Business Lines to allow contributions from all resources in order to achieve success; 3) sound engineering and science in the application of tools and technologies to understand the region, identify and evaluate RSM strategies, overcome challenges, assist in decision making, and adaptive management.

RSM is accomplished by adhering to the following RSM Operating Principles:

1. Recognize sediments as a resource (local and regional) and prioritize use across projects, environments, and/or communities
2. Link and leverage across multiple projects and authorities
3. Improve operational efficiencies and natural exchange of sediments
4. Evaluate and recommend economically viable and environmentally sustainable solutions
5. Consider regional and local implications of project scale actions and benefits
6. Apply/Enhance tools and technologies for regional approaches
7. Share lessons learned, information, data, tools, and technologies
8. Improve Relationships: Communicate and collaborate with Stakeholders, Partners, Resource Agencies, Federal/Non-Federal Agencies, Academia, and Non-Governmental Organizations.

Benefits of applying these principles are: improved management and use of sediments, reduced lifecycle costs, improved communication, enhanced partnerships, and more resilient and sustainable projects and systems.

1.2 Communication and Collaboration

The National RSM Program works with USACE Districts, Divisions, and regional RSM teams to integrate the RSM principles into existing and new projects. The Districts and Divisions reach out to their stakeholders, partners, and resource agencies in order to communicate and collaborate decision making to prioritize and implement RSM actions. Limited resources and growing needs require RSM practitioners to creatively leverage partner relationships and existing resources to improve the management and use of sediments across coastal, estuarine, and inland systems to create or maintain efficient sustainable solutions resulting in thriving watershed systems.

1.3 RSM Process

The process to implement RSM is illustrated in Figure 1. It is important to utilize appropriate tools, technologies, and science based information and data throughout the RSM process.

Phase 1: Understand the Region
In order to successfully implement RSM, practitioners must develop an understanding of the sediment sources and needs, sediment processes, morphologic evolution, ecological conditions, endangered species, pertinent engineering activities, gaps in knowledge, sediment related challenges, and stakeholder and partner goals within a region.

Phase 2: RSM Strategies Project Scale
RSM strategies to improve the management and use of sediments are identified and evaluated at the project scale to understand how projects behave within the existing system and how they would evolve with various RSM strategies under future conditions. Pilot projects are implemented to evaluate new technologies or concepts in order to overcome challenges in improving the use of sediments.

Phase 3: RSM Strategies Regional Scale
Phase 3 is programmatic to integrate the project-level strategies into a regional strategy. Implementation of the strategies are prioritized, regulatory and permitting requirements are identified, and the authorities, policies, projects, and resources through which the strategies will be constructed are identified. Stakeholder and partner participation is integral to decision-making, prioritizing, and overcoming challenges in Phases 2 and 3.

Phase 4: Take Action – Construct and Adaptive Management
Once a project is coordinated and constructed under Phase 4, it is important to monitor the evolution of the project, adaptively manage the project to ensure the project is performing as expected, quantify the value and benefits, share lessons learned, and incorporate the strategy as standard practice.

Figure 1. The Regional Sediment Management Process

1.4 Development and Enhancement of Tools and Technologies: Coastal RSM

The National RSM Program collaborates with USACE Research, Development, and Technology (RD&T) programs, USACE Districts and Divisions, stakeholders, partners, and academia, and NGOs to enhance or develop tools and technologies for efficient and effective management of sediments. This document shares tools and technologies available to successfully implement RSM approaches for inland systems; however, it is not all encompassing due to the broad nature and methods to which the RSM principles can be applied and the continual development that creates new tools and technologies for RSM implementation. RSM has supported a large number of pilot demonstrations of new technologies across the Nation which have been integrated across USACE projects including Operations and Maintenance [O&M] dredging and placement, Streambank Protection Projects [SPP], Feasibility Studies, Dredged Material Management Plans [DMMP], and Continuing Authorities Program [CAP].

The RSM tools and strategies found within this document are organized to mirror the major phases of the RSM process (Figure 1): 1) Understand the Region; 2) Evaluate RSM Strategies (Project Scale); 3) RSM Strategies (Regional Scale); and 4) Take Action – Construct and Adaptive Management. Through the RD&T programs, a large suite of tools and technologies, ongoing research, and data collection programs are available for application at multiple scales (regional and project scales) and for multiple zones of a watershed, including rivers and reservoirs, wetlands, estuaries, and the coastline (dunes, beaches, and the nearshore).

Figure 2 summarizes the tools appropriate for phases 1-3 of the RSM process. Many of these tools can be applied throughout the RSM process at project and regional scales, as noted throughout the document. Tools that can apply to many portions of the watershed are shown as cross-cutting tools. For more information about the tools listed within this document, refer to the Appendix: Applicable Tools and Point of Contacts, which includes fact sheets describing the tools and a point of contact. This document will focus on the inland and estuarine tools. Please refer to Regional Sediment Management Tools and Technologies Volume I for a summary of coastal tools and technologies. For more information on these capabilities and emerging technologies under development, please contact the RSM Program manager. Contact information for the RSM Program is at http://rsm.usace.army.mil.

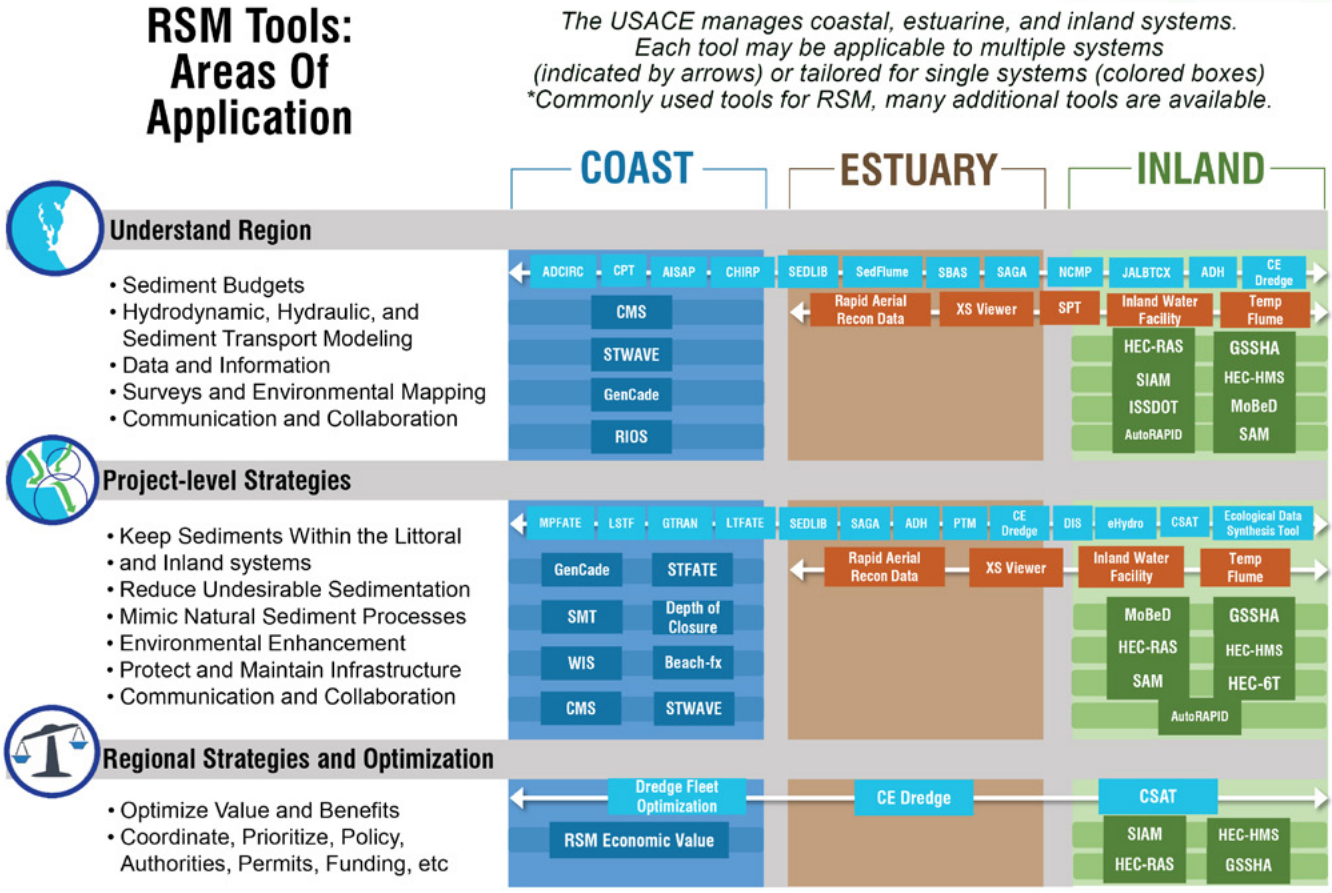

Figure 2. RSM Tools for Coastal, Estuarine, and Inland Systems

2. Understand the Region

The National RSM Program assists in identifying sustainable, cost-effective, and environmentally acceptable solutions for managing sediments. The first phase in the RSM process is to develop an understanding of the region: what we know and what we do not know (gaps). This starts by understanding the interests and requirements of stakeholders, resource agencies, and partners, followed by identifying existing projects as well as the sediment sources, needs, transport processes, and characteristics of the hydrodynamic and hydrologic processes, morphology, ecological conditions, and engineering activities. A framework is then developed to keep systems as close to a state of natural equilibrium as possible, while meeting stakeholders' needs (flood risk management, navigation, eco-system restoration, etc.), and addressing gaps in knowledge. In this section, regional level concepts, tools, and technologies are discussed.

2.1 Concepts, Tools, and Technologies at the Regional Scale

Key tools and technologies to understand the region include regional sediment budgets as well as application of regional hydrodynamic, hydrologic, sediment transport, and ecological numerical models. Data that may be required to support these tools and technologies include bathymetric and topographic surveys, aerial and hyperspectral imagery, hydrodynamic and hydrologic data, sediment characteristics, and ecological data. Additional data about engineering activities such as dredging histories and flood risk management, erosion control, and ecosystem restoration projects are similarly useful. Utilizing Geographic Information System (GIS) capabilities, enterprise databases, and web-based visualization tools greatly enhances the ability to understand and share information on regional scales. The tools, models, and data are available through various programs and databases. These concepts, tools and technologies are divided into several categories.

2.1.1 Regional Sediment Budgets

Regional sediment budgets are an analysis of sediment sources, sinks, and fluxes within a specified region over a given timeframe that provide a conceptual and qualitative understanding of the sediment patterns and pathways over a region. Developing a sediment budget requires an understanding of the sediment sources, pathways, sinks, and transport rates, areas of erosion and accretion, morphologic changes, and engineering actions over the region. Sediment budgets can be formulated for a range of conditions and the project, regional and/or watershed level scales to provide insights into potential near- and long-term morphologic response to engineering activities and assist with connecting sediment sources to sediment needs. Numerical models may be used to develop, evaluate, or validate provisional sediment budgets.

Applicable Tools (see Appendix for more information): Sediment Budget Analysis System (SBAS). Numerical models used to assist in developing sediment budgets (see Appendix for more information): HEC-RAS Sediment Transport, HEC-RAS Hydraulic Design Calculators, Hydraulic Design Package for Channels, Sediment Impact Analysis Method (SIAM).

2.1.2 Comprehensive Regional Surveys and Environmental Mapping

Comprehensive, high resolution, regional bathymetric and topographic Light Detection and Ranging (Lidar) data, aerial imagery, and hyperspectral imagery are available from the Joint Airborne Lidar Bathymetry Technical Center of Expertise (see JALBTCX Fact Sheet). The Lidar datasets are used in developing numerical model grids, shoreline and morphologic (volume) change calculations, feature mapping, and sediment budgets. The hyperspectral and true-color aerial imagery provide data for habitat and benthic mapping, classifying sediment types and submerged aquatic vegetation, understanding vulnerable areas, and creating landscape metrics.

The Rapid Aerial Recon and Analysis tool (see Fact Sheet in the Appendix) uses a sensor array to conduct aerial data collection and also produce terrain maps. It provides the technology to facilitate the rapid production of sediment-related measurements needed after short-term events like the flash floods produced during monsoon season in the southwestern United States.

Bathymetric surveys maybe collected using multi-beam or single-beam sonar. Bathymetric survey data may be supplemented with terrestrial Lidar to define river banks and with topographic data from various sources to define flood plains. Geomorphic assessments of bathymetric survey data can

provide insight into historical changes in the sediment erosion and deposition within a river system. The Cross Section Viewer (see Fact Sheet) facilitates computing the volume of bed change and other geomorphic information from repeated cross sections.

The Integrated Section Surface Difference Over Time, version II (see ISSDOTv2 Fact Sheet) uses multi-beam sonar to measure the bedload sediment transport in large sand bed rivers. Ship-mounted units (e.g. Compressed High Intensity Radar Pulse; see CHIRP Fact Sheet) provide on sub-bottom profiling data used to determine sediment sources, which are used to inform sediment transport pathways for sediment budgets.

2.1.3 Regional Hydrodynamic and Hydrologic Data

Typical information gathered for hydrodynamic and hydrologic models is weather and climatological data, stream surveys, flood history information, stream-gage data, bed and bank sediment composition, sediment transport rates, watershed-erosion data, land-use data, existing erosion and flood-control features, bridge plans, and aerial photography. Real-time and historical stage, flow, and sediment flux data for calibration and validation of hydrodynamic and hydrologic models are available through several National programs such as the United States Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA), Agricultural Research Service (ARS), Natural Resources Conservation Service (NRCS), National Climatic Data Center (NCDC), and Soil Conservation Service (SCS). State, flow, and sediment data collected by the USGS (often with USACE funding) is available on USGS websites. River stage data collected by the USACE is available through RiverGages.com. Data from operation of Corps dams is available the Corps Water Management System (CWMS) Data Dissemination tool at water.usace.army.mil.

Traditional gaging stations may be unable to measure flow and stage during high energy floods and debris flows because gaging stations may be not functioning or destroyed during the event. To capture that type of events, the Mobile Bed Discharge technique (*see MoBED Fact Sheet*) uses non-contacting instrumentation to capture channel bed point cloud topography, velocity data, and stage.

The National Weather Service operates 13 River Forecast Centers that provide official short-term stage and discharge forecasts to the public (https://water.weather.gov/ahps/rfc/rfc.php). The Streamflow Prediction Tool (*see SPT Fact Sheet*) also provides both historical and 15-day forecasted flows and flood inundation estimates for a dense network of streams worldwide.

2.1.4 Regional Hydrodynamic, Hydrologic, and Sediment Transport Modeling

For inland systems, it is important to understand the regional hydrodynamic and hydrologic processes that transport sediments. Large-scale numerical models are applied to predict these processes, and the models listed below can be used to develop and refine the sediment budget. The models can be applied at both regional and project level scales.

Applicable Tools (see Appendix for more information): Gridded Subsurface Hydrological Analysis (GSSHA), Adaptive Hydraulics Model (ADH), Auto Routing Application for Parallel Computation of Discharge (AutoRAPID), Channel Shoaling Analysis Tool (CSAT), HEC-HMS Sediment Yield, Integrated CHIRP Sub-Bottom Profiler and Dual Frequency Sidescan Sonar (CHIRP), Mobile Bed Discharge Gaging (MoBED), Integrated Section Surface Difference Over Time version II (ISSDOTv2), Particle Tracking Model (PTM), HEC-RAS Sediment Transport, HEC-RAS Hydraulic Design Calculators, Sediment Transport Library (SEDLIB), Sediment Impact Analysis Method (SIAM), Streamflow Prediction Tool (SPT), Cross Section Viewer (XS Viewer), and Advanced Circulation Model (ADCIRC).

3. Identify and Evaluate RSM Strategies (Project-Scale)

Once the regional system is understood, RSM strategies to improve the management of sediments are identified and evaluated at the project scale. Continued communication and coordination with stakeholders and partners is key to identifying potential strategies, defining metrics for success, and to making decisions throughout the evaluation process. This section provides an overview of common RSM strategies and tools that are available to evaluate strategies that address specific needs and challenges. Fact sheets are available in the Appendix to provide further information on the tools discussed in this section.

3.1 Applying RSM Goals to Projects

The overall goals of RSM are to reduce unwanted sedimentation that must be managed later, mimic natural sediment processes when appropriate, enhance the environment, and maintain and protect infrastructure. While there are numerous types of RSM strategies that can be used, the most common strategies are outlined below. Where appropriate, tools that aid in identifying and evaluating the specific RSM strategy are discussed.

3.1.1 Reduce Sedimentation

Reservoir Sedimentation

When a dam is placed in a river, the natural balance between stream flow and sediment transport is interrupted. Flow velocity decreases, affecting its capacity to transport sediment, resulting in sediment deposition inside the reservoir. The coarser sediment settles faster at the upstream end of the reservoir, forming the delta. This delta continues migrating into the reservoir, claiming part of the storage capacity of the lake. Finer particles travel further downstream, settling closer to, or passing through the dam. Deposition of sediment in the reservoir reduces the storage capacity which reduces the ability of the reservoir to provide its designed benefits. The most common benefits associated with reservoirs are hydropower, water supply, irrigation, flood risk reduction, and recreation.

Navigation Channel Sedimentation

The Corps navigation mission is to provide safe, reliable, efficient, and environmentally sustainable waterborne transportation systems for movement of commerce, national security needs, and recreation. Sedimentation in navigation channels, inlets, and harbors impedes the ability execute this mission. Dredging may be required to maintain safe navigation depths in river crossings and lock approaches. Awareness of sediment transport processes in the vicinity of dredging sites provides information necessary to place sediments in manner that will minimize future shoaling.

Applicable Tools (see Appendix for more information): Adaptive Hydraulics Model (ADH), Auto Routing Application for Parallel Computation of Discharge (AutoRAPID), Channel Portfolio Tool (CPT), Channel Shoaling Analysis Tool (CSAT), Hydrologic Modeling System (HEC-HMS), Mobile Bed Discharge Gaging (MoBED), Integrated Section Surface Difference Over Time version II (ISSDOTv2), Particle Tracking Model (PTM), River Analysis System (HEC-RAS), HEC-RAS Sediment Transport, HEC-RAS Hydraulic Design Calculators, Hydraulic Design Package for Channels, Sediment Transport Library (SEDLIB), Sediment Impact Analysis Method (SIAM), Streamflow Prediction Tool (SPT), and Cross Section Viewer (XS Viewer).

3.1.2 Mimic Natural Sediment Processes

RSM seeks to aid in maintaining natural features and mimicking natural sediment processes by keeping sediments moving through the watershed. On geological time scales, rivers transport sediment generated by mountain and prairie erosion to the oceans, temporarily storing a portion of the sediment in floodplains. On engineering time scales, it is usually desirable to maintain river systems in a state of dynamic equilibrium, where the rivers ability to transport sediment is in balance with the sediment supply, to the extent that desire is compatible with stakeholder interests. In practice, maintaining or restoring equilibrium may be difficult, or even impractical, due to changes within the watershed (e.g., land-use or climate) or continued operation of previous water resources engineering projects. However, shifting the system towards equilibrium may reduce future long-term maintenance costs.

Applicable Tools (see Appendix for more information): Gridded Subsurface Hydrologic Analysis (GSSHA), Adaptive

Hydraulics Model (ADH), Auto Routing Application for Parallel Computation of Discharge (AutoRAPID), Channel Portfolio Tool (CPT), Channel Shoaling Analysis Tool (CSAT), Hydrologic Modeling System (HEC-HMS), HEC-RAS Sediment Transport, HEC-RAS Hydraulic Design Calculators, Hydraulic Design Package for Channels, Mobile Bed Discharge Gaging (MoBED), Integrated Section Surface Difference Over Time version II (ISSDOTv2), Particle Tracking Model (PTM), River Analysis System (HEC-RAS), Sediment Transport Library (SEDLIB), Sediment Impact Analysis Method (SIAM), Streamflow Prediction Tool (SPT), and Cross Section Viewer (XS Viewer).

3.1.3 Environmental Enhancement

RSM alternatives may include some type of environmental enhancement. This may include erosion control, restoration of habitat for endangered and native species, wetland/marsh creation or enhancement, restoring natural turbidity levels downstream from dams, and demonstrations of more environmentally friendly construction methods (i.e. biodegradable containment structures).

Applicable Tools (see Appendix for more information): Ecological Data Synthesis Tool (EDST), Adaptive Hydraulics Model (ADH), Sediment Transport Library (SEDLIB), Gridded Subsurface Hydrologic Analysis (GSSHA), Particle Tracking Model (PTM), River Analysis System (HEC-RAS), Hydrologic Modeling System (HEC-HMS), and Integrated Section Surface Difference Over Time version II (ISSDOTv2).

3.1.4 Protect and Maintain Infrastructure

Finally, RSM can assist with maintaining and protecting infrastructure. Channel degradation can threaten the integrity of bridges and related infrastructure. Reductions in river stages induced by degradation can affect operations of water supply intakes. Additionally, degradation can induce bank failures, increase sediment loads, and cause channel aggradation downstream. In turn, channel aggradation can reduce the reliability of flood risk reduction infrastructure and lead to channel avulsions. Proper management of sediments minimize potential adverse impacts to infrastructure.

3.2 Evaluating Alternatives

A wide variety of models, tools, and databases may be utilized to evaluate RSM alternatives and identify the strategies that are best suited for the project and system. The following are commonly applied tools:

- Hydrodynamic and Sediment Transport Modeling

Applicable Tools (see Appendix for more information): Adaptive Hydraulics Model (ADH), Particle Tracking Model (PTM), Sediment Transport Library (SEDLIB), Gridded Subsurface Hydrologic Analysis (GSSHA), and River Analysis System (HEC-RAS).

- Analyze Dredging, Placement, and Navigation Channels

Applicable Tools (see Appendix for more information): CE-Dredge, CE-Dredge Decision Support Tool, Multiple Placement FATE (MPFATE), General Transport/Long-term FATE (GTRAN/LTFATE), Channel Shoaling Analysis Tool (CSAT), Automatic Identification System Analysis Package (AISAP), Channel Portfolio Tool (CPT), eHydro Navigation Channel Condition Reporting (eHydro), Adaptive Hydraulics Model (ADH), River Analysis System (HEC-RAS), and Sediment Transport Library (SEDLIB).

- Identifying Sediment Characteristics

Applicable Tools (see Appendix for more information): Sediment Analysis Geo-App (SAGA), Integrated Section Surface Difference Over Time version II (ISSDOTv2), Mobile Bed Discharge Gaging (MoBED), and Integrated CHIRP Sub-Bottom Profiler and Dual Frequency Sidescan Sonar (CHIRP).

4. RSM Strategies (Regional Scale)

Once RSM strategies are evaluated at the project level, the next phase in the RSM process is to develop a regional RSM strategy that integrates the projects across the region and identifies economic value, avenues for construction (authorities, funding, etc.), timelines, necessary coordination, and prioritization.

Tools designed to aid in the decision-making phase of USACE projects integrate information on how the system is behaving and synthesize measurements and metrics into indicators of system operation. Peak system operation is best achieved through optimizing available resources. For USACE projects, these resources often fall into three categories: sediment or natural resources, authorities and financial resources, and equipment.

4.1 Inland RSM Optimization Tools

When considering inland RSM optimization strategies, the goal is to develop tools capable of evaluating multiple alternatives and scenarios to best determine what combination of practices would be the most efficient for planning purposes. A generalized systematic approach to regional sediment management is needed to address projects that may range from localized erosion problems that can be addressed using a simple reference reach methodology, to severe basin-wide problems that require a concentrated analysis and design effort.

4.1.1 Watershed Strategies

Watershed sediment management is essential to providing long-term sustainable inland systems. Understanding the sediment yield and delivery within the watershed helps address problems associated with watershed instability like erosion, sediment deposition, flooding, and environmental degradation. Tools like the Gridded Surface Subsurface Hydrologic Analysis (see GSSHA Fact Sheet) and Hydrologic Modeling System (see HEC-HMS Fact Sheet) help evaluate multiple alternatives and scenarios in order to find the most efficient combination of practices leading to optimal infrastructure design and maintenance.

The Gridded Surface Subsurface Hydrologic Analysis (GSSHA) is a multidimensional modeling technology that uniformly couples overland, surface, and subsurface flow for accurate watershed simulation. It helps predict and mitigate watershed management problems associated with weather, urban development, construction activities, hydrologic modifications, and forestry, mining, and agricultural practices.

The Hydrologic Modeling System (HEC-HMS) is designed to simulate complete hydrologic processes of dendritic watershed systems. This tool helps solving a wide range of problems, including large river basin water supply and flood hydrology, and small urban or natural watershed runoff. Hydrographs produced by the program are used directly or in conjunction with other software for studies of water availability, urban drainage, flow forecasting, future urbanization impact, reservoir spillway design, flood damage reduction, floodplain regulation, and systems operation.

4.1.2 Hydraulic Strategies

In order to implement effective regional sediment management, a common goal of many RSM projects is the reduction of sediment delivery from the watershed. While features like grade control structures, bank stabilization, dams, and land treatments are implemented to reduce sediment delivery to downstream areas, the spatial and temporal impacts of these features on the sediment regime of the system are far from straightforward, and often result in unexpected morphologic changes in the channel system. Consequently, the challenge in regional sediment management projects is to select the appropriate sediment-management features that produce the desired reductions in sediment delivery, while minimizing the disruption to the stability of the channel systems.

The Sediment Impact Analysis Method (see SIAM Fact Sheet) model was developed to provide for rapid assessment of the impact of sediment management practices on sedimentation trends. It provides a framework to combine sediment sources and computed sediment transport capacities into a model that can evaluate sediment imbalances and downstream sediment yields for different alternatives. As a result, potential impact of local alterations in sediment regime on channel stability can be assessed.

The River Analysis System (see HEC-RAS Fact Sheet) is a one-dimensional steady flow, one and two-dimensional unsteady flow, sediment transport/mobile bed, and water temperature/water quality modeling

tool. HEC-RAS is capable of simulating long-term trends of erosion and deposition in stream channels that might result from modifying the frequency and duration of the water discharge and stage, or modifying the channel geometry. It has been applied to many RSM problems, including reservoir sediment flushing models. It can be used to evaluate sediment deposition in reservoirs, design channel contractions required to maintain navigation depths, predict the influence of dredging on the rate of deposition, estimate maximum possible erosion and sediment transport during large flood events, and evaluate sedimentation in fixed channels.

4.1.3 Dredge Fleet Optimization

The Dredge Fleet Scheduling component identifies additional efficiencies that can be gained by evaluating the dredge plants assigned to navigation projects and the planned schedule over the course of the dredging season. The optimization model considers localized constraints such as minimum dredging requirements, scheduling due to environmental windows, and suitability of particular dredge plants for specific navigation and/or beach nourishment projects. The result is an optimized dredge utilization schedule synchronized with navigation projects identified for a dredging season. More information on the Dredge Optimization Tool can be located on the *Dredge Fleet Assignment/ Scheduling Optimization Model Fact Sheet*

5. Take Action – Improve Water Management, Construct and Adaptive Management

Once Phases 1, 2, and 3 of the RSM process are completed: 1) the regional sediment system is understood, 2) the RSM strategies are identified and evaluated at the project scale, and 3) a regional strategy has been developed, the next phase in the process is to take action and construct. Once the project is constructed it is important to monitor and adaptively manage to ensure the project is performing as expected, and to improve as needed to achieve expected performance. The value and/or benefits gained through the improved use of sediments are quantified to document and outreach successes. Projects are also monitored to validate tools and technologies that were applied. It is important to document and share lessons learned in order to assist others working to implement similar strategies. Continued collaboration and communication with stakeholders, resource agencies, and partners is necessary to incorporate the RSM strategies into standard practice. The tools, technologies, and programs summarized in previous sections apply to this section.

6. Summary

The purpose of this document is to provide information on some of the more common tools, technologies, approaches, and best practices to assist in the implementation of Regional Sediment Management (RSM) in riverine and reservoir systems. RSM is a systems approach which uses best management practices for more efficient and effective use of sediments across coastal, estuarine, and inland environments and, therefore, is not limited to the strategies outlined in this document. This document reviews RSM approaches and tools that assist in accomplishing the following RSM Operating Principles:

1. Recognize sediments as a regional resource (local and regional).
2. Link and leverage across multiple projects, business lines, and authorities
3. Improve operational efficiencies and the natural exchange of sediments
4. Evaluate and recommend economically viable and environmentally sustainable solutions
5. Consider regional implications of local sediment actions which benefit the region
6. Enhance technical knowledge and tools for regional approaches
7. Share lessons learned, information, data, tools, and technologies
8. Improve Relationships: Communicate and collaborate with stakeholders, partners, sponsors, federal and non-federal agencies, academia, non-governmental organizations.

Benefits of applying these principles are improved sediment management, increased value and benefits, reduced lifecycle costs, enhanced partnerships, and more resilient and sustainable projects and systems.

7. Acknowledgments

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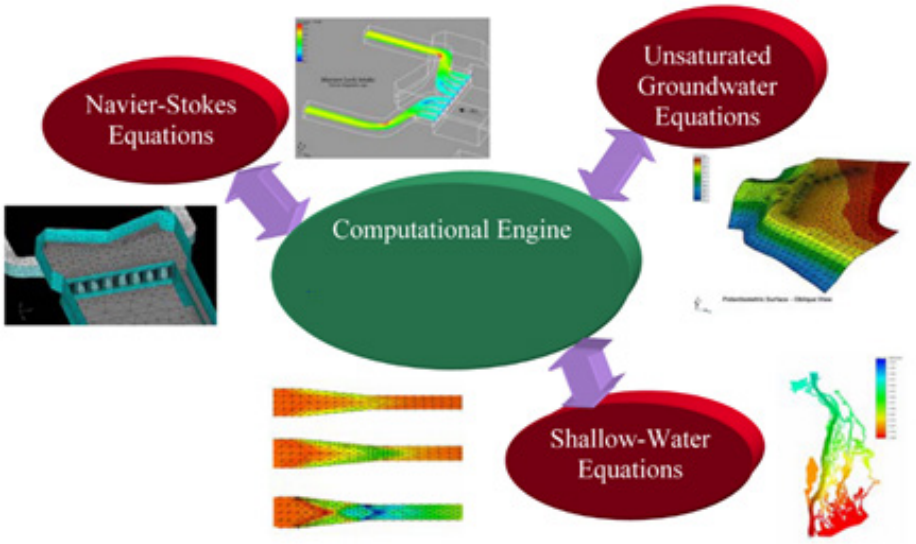
8. Appendix – Applicable Tools and Points of Contact

Adaptive Hydrology/Hydraulics Model System (ADH)

Adaptive Hydrology/Hydraulics (ADH) is a modular, parallel, adaptive finite-element model for one-, two- and three-dimensional flow and transport. ADH is a module of the Department of Defense (DoD) Surface-Water Modeling System and Ground-Water Modeling System. ADH simulates groundwater flow, internal flow and open channel flow. The ADH module was developed in the Engineer Research and Development Center's Coastal and Hydraulics Laboratory and is a product of the System-Wide Water Resources Program. The program is available to the Corps of Engineers and other DoD agencies at no charge.

Example Studies

ADH was developed to address the environmental concerns of the DoD in estuaries, coastal regions, river basins, reservoirs and groundwater. It can address a wide range of modeling applications including the design of channel improvements, guardwall porting design, design of fish passage structures, measurements of flood inudation, and the impacts of vessel traffic on hydrodynamics, salinity, and sedimentation.



Products

Overview of features, technical manuals, publications, and software can be found at the following site: https://adh.usace.army.mil/new_webpage/main/main_page.htm

Benefits

The general features in ADH that benefit the user include:

• Adaptation: The user needs only to generate a general mesh to capture the geometry of the problem. ADH will automatically refine it to provide accurate solutions and more stable and less expensive simulations.

• Portability: ADH can run efficiently on a wide variety of platforms ranging from standard PCs to high-end supercomputers.

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Advanced Circulation Model (ADCIRC)

Prediction of potential storm surge water levels is critical in the design of flood and storm damage reduction projects and protection of facilities and infrastructure and beneficial to planning and evacuation of low-lying areas if a storm event occurs. Comprehensive models of hydrodynamic simulations can support operations and maintenance and help minimize dredging, maintain channel reliability, manage inlet and adjacent beach sediment, and predict navigation project performance. To predict storm surge water level and help control the impact of storm damage, experts in hydrodynamic engineering at the ERDC Coastal and Hydraulics Laboratory (CHL) helped to develop the ADvanced CIRCulation Model (ADCIRC).

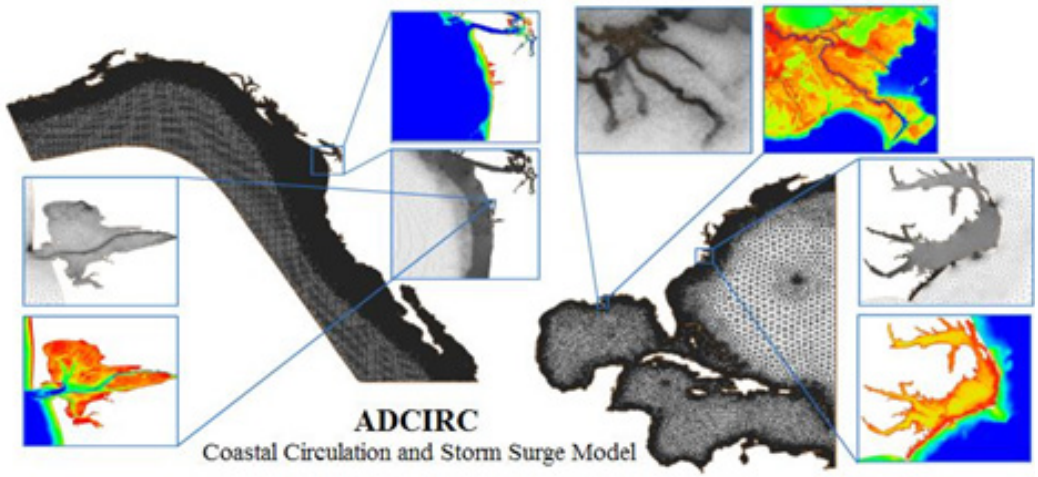
Certified by the Federal Emergency Management Agency (FEMA) for use in performing storm surge analyses, ADCIRC is a hydrodynamic modeling technology that conducts short- and long-term simulations of tide and storm surge elevations and velocities in deep-ocean, continental shelves, coastal seas, and small-scale estuarine systems.

Products

In a single simulation, ADCIRC can provide tide and storm surge elevations and velocities corresponding to each node over a very large domain, encompassing regional domains such as the western North Atlantic Ocean, the Caribbean Sea, and the Gulf of Mexico. As an unstructured coastal ocean circulation model used to compute surface water elevation and currents, ADCIRC runs as a two-dimensional depth integrated (2DDI) model or as a three-dimensional (3D) model to solve time-dependent, free surface circulation and transport problems.

Typical ADCIRC applications include the following:

- Modeling tides and wind driven circulation
- Analysis of hurricane storm surge and flooding
- Dredging feasibility and material disposal studies
- Inlet sediment transport, morphology change, and larval transport studies
- Nearshore marine operations



Benefits

The use of an unstructured grid allows for high localized grid resolution where solution gradients are large and low grid resolution where solution gradients are small, minimizing both local and global error norms for a given computational cost. ADCIRC simulates tidal circulation and storm surge propagation over large computational domains, eliminating the need for imposing approximate open-water boundary conditions that can create inaccuracies in model results, while simultaneously providing high resolution in areas of complex shoreline and bathymetry where it is needed to maximize simulation accuracy.

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Automatic Identification System Analysis Package (AISAP)

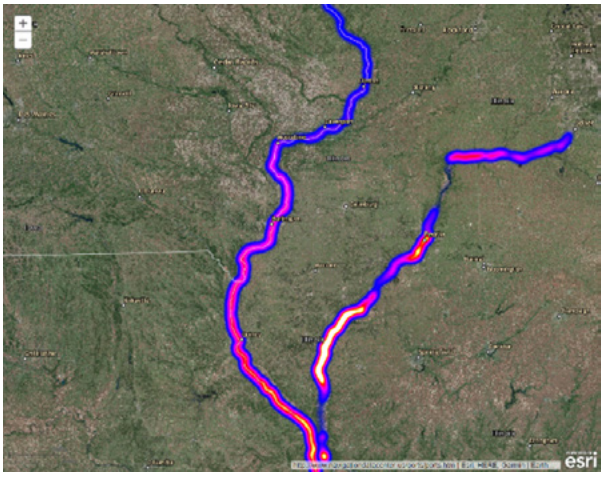
The Automatic Identification System Analysis Package (AISAP) is a web-based tool for acquiring, analyzing, and visualizing real-time and archival data from the U.S. Coastal Guard. Archived AIS data include location, time, speed-over-ground, direction, vessel draft, beam, length, and vessel type information. Through AISAP, USACE personnel can define spatial and temporal filters, visualize traffic density patterns, and analyze vessel utilization patterns. The tool allows for unprecedented access to quantitative and statistically robust measures of navigation project performance through time and the coupling of environmental measurements routinely employed in navigational engineering studies at both inland and coastal projects. AISAP has been applied to a wide variety of USACE District projects including (but not limited to) analyzing incident response, inland waterway travel times, Atlantic sturgeon strikes, Asian carp and barge entrainment, hurricane resilience, and port performance metrics.

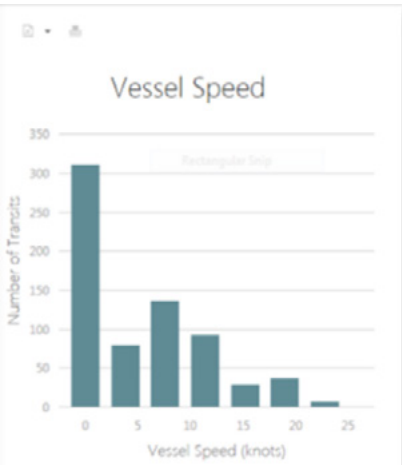
Products

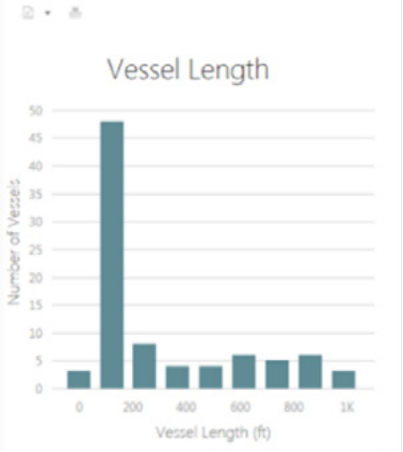
The AISAP is available to all USACE personnel, is enabled for user collaboration, and features customizable maps and data outputs including AIS signal heat maps, vessel track lines with customizable filters (e.g. draft, speed, or vessel type), and statistical reporting outputs.
The AISAP web interface is located at: https://ais-portal.usace.army.mil.

Benefits

By allowing users to visualize recorded vessel traffic within a larger navigation network, the AISAP supports informed decision making for USACE project managers. In addition, by providing insights into commercial vessel freight movements AISAP can contribute to improved understanding of intermodal freight flows and the subsequent need for maintenance resources. The AISAP can be used to investigate questions of historical travel time, capacity limitations, and the effects of weather or accidents on the flow of freight through waterways.







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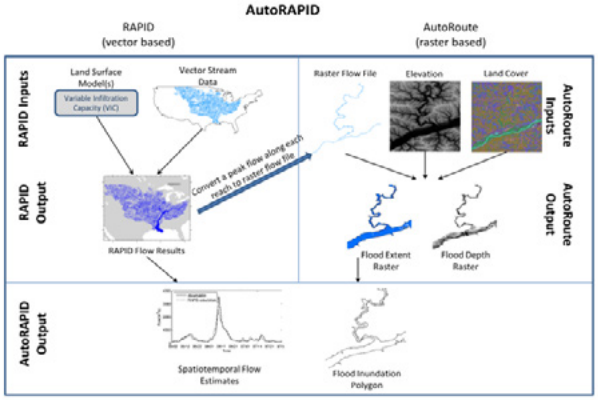
AutoRAPID

AutoRAPID is a numerical model used by the U.S. Military to assess forecast/hindcast flows, high-resolution flood-inundation maps, and mobility analysis for millions of stream reaches around the world. AutoRAPID couples the RAPID flow model with the AutoRoute flood-extent model. RAPID is the open-source river routing component which simultaneously computes time series of water discharge in thousands of reaches in large river networks. The AutoRoute component produces hyper resolution flood inundation and depth maps. AutoRAPID is the core modeling component of the ERDC- operational Streamflow Prediction Tool to generate efficient flow analysis/forecasting and flood inundation maps around the world. AutoRAPID was officially introduced in 2016 and has undergone several revisions to improve its accuracy and speed.



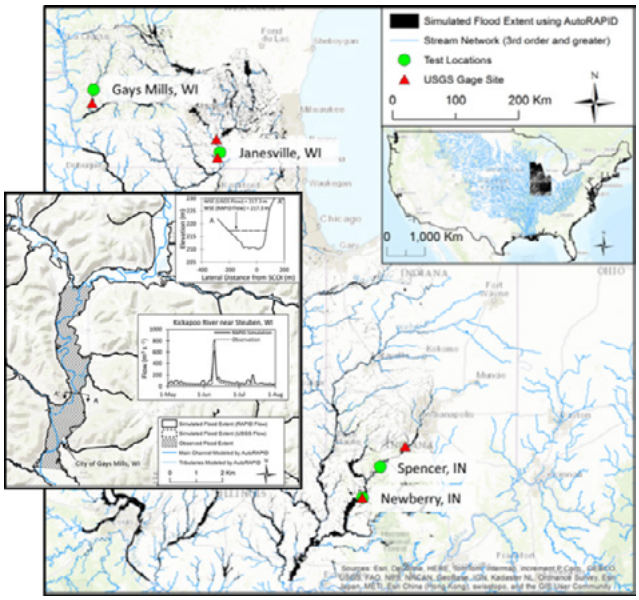
Example Studies

AutoRAPID has been evaluted and applied on both regional and local scales in the United states and Outside the Continental United States (OCONUS). AutoRAPID has been successfully applied to the Midwest (area of 230,000 km2); Mississippi Delta (area of 109,500 km2); Black Warrior River, AL; Sava River Basin, Europe; the entire South American Continent, and several other sensitive locations.

Products

Main Products:

- 35+ Years of Historical Flow Simulations in each stream reach for ~70% of the world (e.g. Mississippi River has >2 million stream reaches)
- 2-week flow forecast for several OCONUS basins.
- Ad-Hoc flood inundation mapping (e.g. initial flood maps at 10m resolution for entire Navjo Nation in U.S. were generated in less than a week).
- Web-based platform (requires username and password): https://umip.erdc.dren.mil
- Follum, M. L., Tavakoly, A. A., Niemann, J. D., & Snow, A. D. (2017). AutoRAPID: A Model for Prompt Streamflow Estimation and Flood Inundation Mapping over Regional to Continental Extents. JAWRA, 53(2), 280-299.
- Several more journal papers and conference papers highlighting methods and applications.



Benefits

The main benefit of AutoRAPID is to quickly generate flow and inundation estimates with a reasonable amount of accuracy over large areas using globally available datasets.

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CE Dredge

CE-Dredge is a program to assist with the planning, monitoring, and management of USACE dredging operations. Under the program, custom GIS and database applications support data access for dredging management. The tool provides a standardized, national database for access to dredging information and applications that are intended to improve planning and management, reduce duplication of manual data entry, and improve the analytical capabilities for datasets relevant to dredging operations (including budgets, schedules, and environmental data).

Products

The CE-Dredge platform has several applications for both public and USACE users, available at https://ce-dredge.usace.army.mil

- **CE-Dredge: Decision Support Tool** (USACE ArcGIS Webmap, USACE employees)
  - A web-based viewer that integrates selected Corps enterprise data, knowledge, tool results, and limited external data to allow more efficient and effective planning, communication, and decision-making regarding activities to improve the management and beneficial use of dredge material, optimize placement area usage, improve channel availability, and streamline technical analysis.
- **CE-Tools: Data Viewer** (ArcGIS Desktop Application, Public and USACE)
  - This data access toolbar is for use within the ArcGIS desktop application and allows easy connection to participating District databases. The public can download this toolbar and configure it to link to their local data sources.
- **CE-Tools: Sediment Sampling Tool** (ArcGIS Desktop Application, Public and USACE)
  - The Sediment Sampling Toolbar allows users to organize and access all data related to a core boring or sediment testing activity. This ArcMap toolbar allows users to retrieve detailed sediment sample properties in correlation with any relevant sediment testing results and links related documents such as core boring, gradation curves, or sediment testing reports.
- **Dredging Manager Inspector** (USACE website, USACE employees and contractors)
  - This website allows inspectors, to record inspection results using online forms that facilitate the recording of timesheets for rental contracts, the logging of dredging operations, and the evaluation of disposal area maintenance. Users must register in order to interact with the website.
- **Dredging Manager Viewer** (USACE hosted viewer, USACE employees)
  - With the Dredging Manager Viewer, District project engineers can spatially monitor and manage dredging activities within their project areas: dredging contracts, daily logs of operations, contractor timesheets, consolidated history cards, beneficial usage agreements, disposal area placement and maintenance, and sediment sampling.
- **SEDMAN: Sediment Management Technologies** (MS Silverlight Application, Public & USACE)
  - An interactive decision support tool that helps users select available resources, applications, tools, and other technologies by assisting users with identifying problems based on physical processes, environmental parameters, and other sorting criteria.

Benefits

CE-Dredge provides a centralized agency-wide approach to organizing and approaching dredging related projects.

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CE Dredge: Decision Support Tool

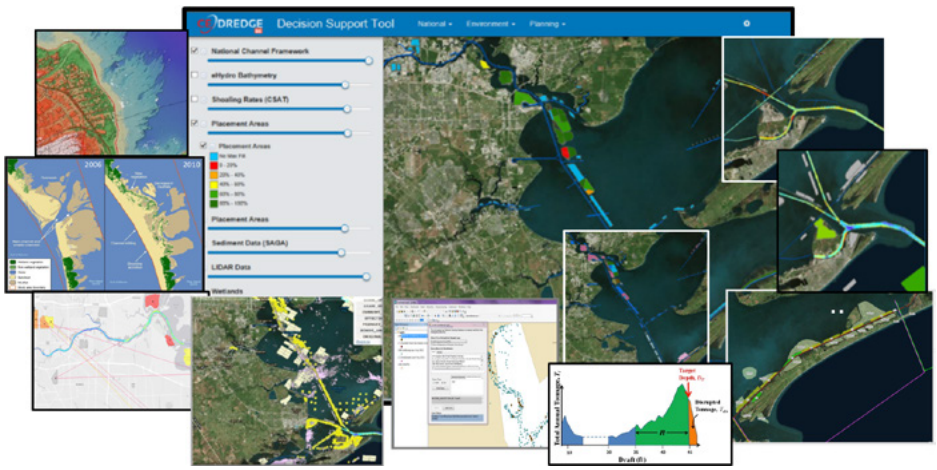
The CE-Dredge Decision Support Tool (DST) is a web-based dashboard providing an integrated, comprehensive approach for strategic dredged material management. The DST integrates selected Corps enterprise data, knowledge, tool results, and limited external data to allow more efficient and effective real time and long-term planning, communication (internal and external), and collaborative decision-making regarding activities to improve the management and beneficial use of dredged material. The goal is to streamline preliminary or DMMP assessments by utilizing the USACE Navigation Data Integration Framework (NDIF) to develop a "living" DMMP capability.

Example Studies

The CE-Dredge DST was developed through collaboration with SWG, SAM, and ERDC for the Gulf Intracoastal Waterway from High Island to Brazos River, Houston Ship Channel, and Galveston Bay.
The CE-Dredge Natural Infrastructure Opportunities Tool (NOIT) under development through the Caterpillar Natural Infrastructure Initiative (CAT NII), builds on the NDIF and CE-Dredge DST to incorporate public data to identify and evaluate collaborative opportunities for beneficial use.

Products

Access DST at http://coe samgsp05mob.sam.ds.usace.army.mil/webapplications/A104_DMMPViewer/ and on the Navigation Portal (http://Navigation.usace.army.mil). The DST integrates data from the National Channel Framework, eHydro, Channel Shoaling and Analysis Tool (CSAT), National Coastal Mapping Program (NCMP) elevation, imagery, and landscape metric data, Dredging Manager, National Placement Area Manager, Sediment Analysis and GeoApp (SAGA), Sediment Budget and Analysis System (SBAS), Channel Portfolio Tool (CPT), Ecological Data Synthesis Tool, Beneficial Use of Aquatic Dredged Material Management (BUADMM) Tool, and Dredged Material Management Decisions (D2M2).



Benefits

CE-Dredge DST provides improved data access, visualization, and decision support for Corps dredging operations managers, engineers, planners, HQ, and R&D. The modernization and streamlining of preliminary or DMMP assessments through the USACE NDIF to develop a "living" DMMP capability increases DMMP quality, usability, and adaptability while reducing required steps, costs, and timeframes.

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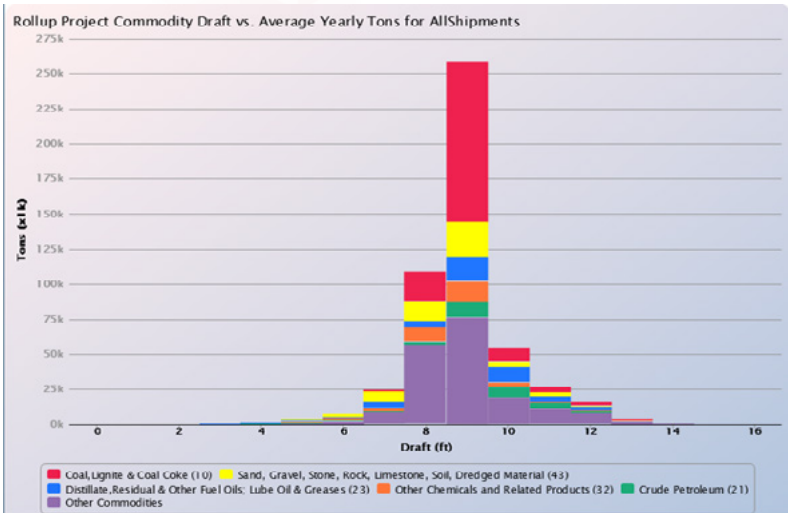
Channel Portfolio Tool (CPT)

The Channel Portfolio Tool (CPT) is a web-based decision-support package for determining the extent to which Corps-maintained navigation channel depths are utilized by commercial shipping. CPT uses the proprietary, dock-level tonnage database maintained by the Waterborne Commerce Statistics Center (WCSC), part of the Corps' Navigation Data Center (NDC). CPT provides an objective, consistent basis by which channels may be quickly compared to others for prioritization of Operation & Maintenance (O&M) funding, thereby providing improved justification for annual dredging budget items.



CPT provides decision makers with relevant data concerning commercial shipping activity that is directly supported by Corps dredging activities. CPT conducts nearest-neighbor matching of WCSC's Master Docks database with a spatial network representing Corps-maintained channels and waterways. Entries in the tonnage database are routed from origin to destination docks through this network using well-established shortest-path logic. The cumulative statistics for tons, $-value, vessel draft, commodity types and traffic types are then compiled for each channel segment in the network.

Products

- Mitchell, K. N. 2012. "A Review of Coastal Navigation Asset Management Efforts Within the Coastal Inlets Research Program (CIRP): Part 2: The Channel Portfolio Tool." ERDC/CHL CHETN-IV-29. Vicksburg, MS: U.S. Army Engineer Research and Development Center. http://chl.erdc.usace.army.mil/chetn

- Mitchell, K. N. 2009. "Depth-Utilization Analysis for Estimating Economic Activity Supported by Dredging." Terra et Aqua. International Association of Dredging Companies. Number 116.

- Mitchell, K. N., Wang, B., Khodakarami, A. 2013. "Selection of Dredging Projects for Maximizing Waterway System Performance" Transportation Research Record: Journal of the Transportation Research Board, No. 2330, Transportation Research Board of the National Academies, Washington, D.C., pp. 39–46. DOI: 10.3141/2330-06

- Dunkin, L., Mitchell, K. 2015. "Quantitative Approach to Navigation Channels Asset Management." Proceedings of Western Dredging Association and Texas A&M University Center for Dredging Studies' Dredging Summit and Expo 2015. June.

Benefits

CPT data can be easily accessed, queried, and visualized. By allowing users to consider channels as part of a larger navigation network, and navigation as part of a global freight network, the Channel Portfolio Tool supports informed decision making and optimized prioritization of freight system maintenance resources.

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Channel Shoaling Analysis Tool (CSAT)

The Channel Shoaling Analysis Tool (CSAT) calculates channel-shoaling volumes using historical channel surveys and uses the shoaling rates to predict future dredging volumes. The CSAT leverages ongoing efforts by the USACE to standardize the manner in which hydrographic surveys are uploaded and processed through its eHydro program. The CSAT estimates future localized shoaling rates through a hindcasting algorithm and is designed to incorporate new hydrographic surveys.

Example Studies

The CSAT has been run for USACE navigation channels that are high or medium tonnage around the coastal U.S.

Products

Average, maximum, and minium shoaling rates are calculated for the different channel reaches. Volume tables are generated for varying depth and time increments which are used to provide predicted dredging requirments.

Average annual shoaling rate - spatial understanding of shoaling magnitudes (warm colors - higher shoaling rates; cool colors - lower shoaling rates).

Benefits

The shoaling rates are used to predict future volumes required for dredging at various depth and time intervals. The forecasted shoaling volumes from CSAT are combined with the detailed Waterborne Commerce annualized tonnage figures with the Channel Portfolio Tool (CPT), enabling a straightforward, quantitative comparison of cargo supported by dredging to any specified target depth to the requisite dredging costs.

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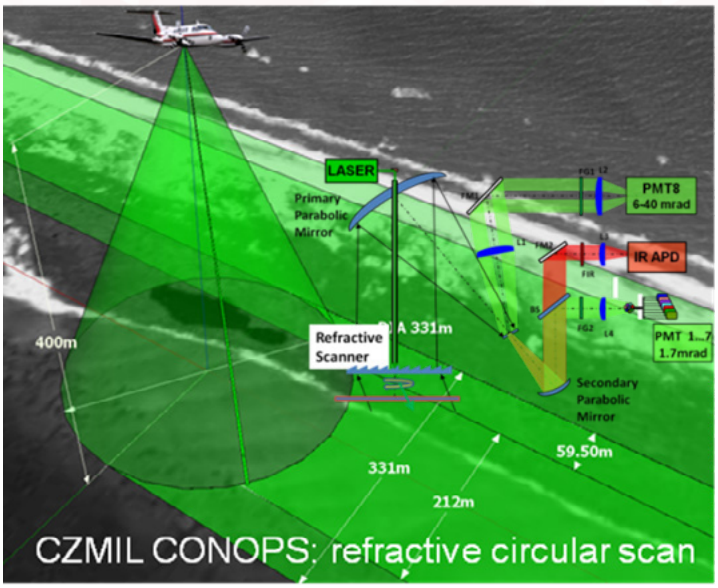
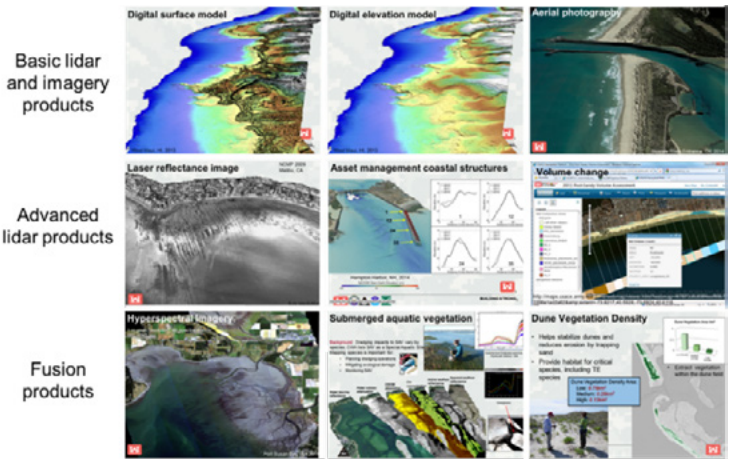
Coastal Zone Mapping and Imaging LiDAR (CZMIL)



The Coastal Zone Mapping and Imaging LiDAR is a new sensor development effort within the National Coastal Mapping Program that is executed by the Joint Airborne LiDAR Bathymetry Technical Center of Expertise (JALBTCX). During the past 5 years, the NCMP has produced high-quality, high-resolution information products from airborne LiDAR bathymetry, topography, and accompanying RGB and hyperspectral imagery data: 1-m bathy/topo rasters, 1-m bare earth rasters, 20-cm RGB image mosaics, 1-m, 36-band hyperspectral image mosaics, 1-m landcover classifications, 2-m bottom reflectance images, and shoreline vectors. All of these products have been generated from data collected by airborne LiDAR bathymeters designed to measure primarily water depth, and using available COTS software packages in a cumbersome processing flow that challenges the throughput of the programs, or applies them in a non-standard manner to achieve desired results.

Products

CZMIL is an integrated LiDAR and imagery sensor suite and software package designed for highly automated generation of physical and environmental information products for the coastal zone, including those currently generated for the NCMP, along with water column attenuation, chlorophyll concentration, CDOM concentration, and automated bottom classification. Below are examples of data outputs that are available from over 20,000km of mapped shoreline along the Gulf, East, and West coasts, Great Lakes, and the Hawaiian Islands:



Benefits

The new sensor suite and accompanying software will improve the speed of data and product delivery, the quality of information products derived from fused LiDAR and imagery datasets, and the performance of the LiDAR sensor in problematic areas like turbid water and in the surf zone.

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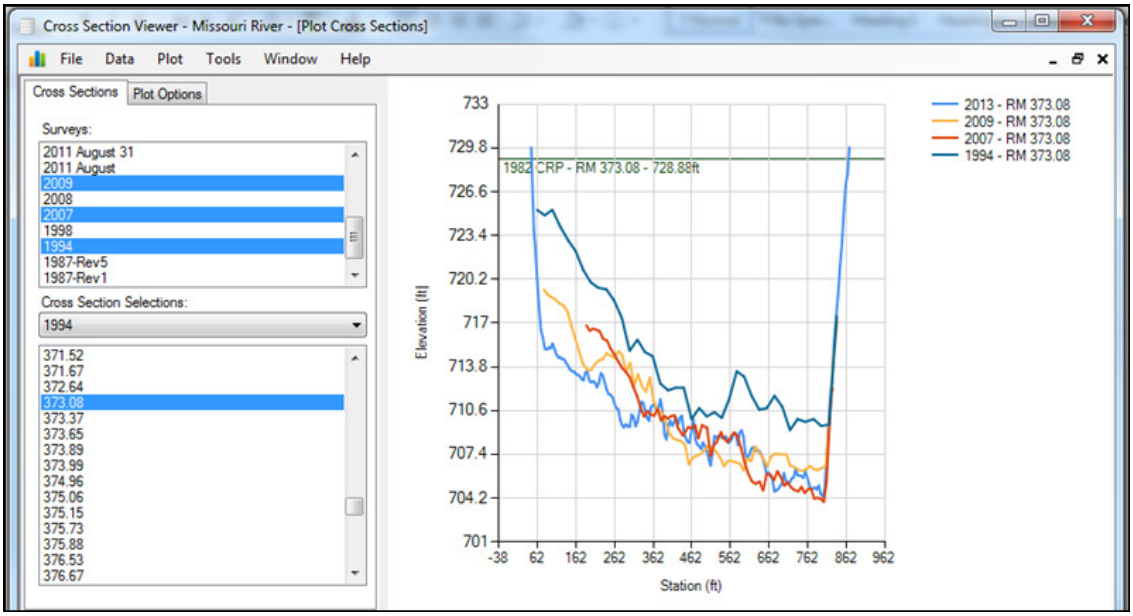
Cross Section Viewer

The Cross Section Viewer is a software tool for storing, displaying, and automating common geomorphic analysis with riverine cross section data. The software was developed by North Arrow Research under contract and in collaboration with the Kansas City District.

Software download and online help are available at http://xsviewer.northarrowresearch.com/

Example Studies

The Cross Section Viewer has been applied for various anlayses including building volume change curves for sediment model calibration, depth distribution analysis for habitat quantification, QA/QC on survey deliverables, survey campaign planning, bed change analysis for regulation of channel mining, and assessing the geomorphic effects of major floods. The software has been used to analyze rivers in multiple states including Kansas, Missouri, Mississippi, Nebraska, South Dakota, Oregon, and Washington.



Products

The online help features visual and textual documentation, example calculations, and how-to videos. Shelley and Bailey (2018), available at https://erdc-library.erdc.dren.mil/xmlui/handle/11681/26284 documents the computational proceedures and provides examples. Tutorials and Cross Section Viewer help is available from John Shelley at john.shelley@usace.army.mil.

Benefits

The Cross Section Viewer facilitates the rapid creation of geomorphic information from cross section data. Analyses that would take weeks using spreadsheets or other manual tools can be done in minutes. Repeat surveys can be easily and quickly loaded, QA/QC-ed, and compared with previous surveys to compute longitudinal volume change curves, depth distributions, longitudinal profiles, and lateral change analysis.

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Dredging Information System (DIS)

IWR

One of the major Information Technology (IT) systems that supports the Corps' navigation mission is the Dredging Information System (DIS). The DIS, established in 1991, formalized and standardized the data elements and process as mandated by the Director of Civil Works, and functions as the primary database of the Dredging Statistics Program. The database is used to compile, verify, and distribute data on all contracted and Corps performed dredging activities for the life cycle of a dredging project. DIS is maintained and supported by the Institute for Water Resources Navigation and Civil Works Decision Support Center in Alexandria, VA. The information collected in DIS is disseminated to the public at http://www.navigationdatacenter.us/dredge/dredge.htm.

Related Reports

- Long-Term Dredging Costs Analysis, Annually
- Actual Costs/Quantity
- Dredging Summaries of Contracts by Fiscal Year
- Summary by Corps District, Dredge Type, and Disposal Method
- Data Dictionary
- Data File Contracts
- Corps Dredges

(Top to Bottom) – USACE Hopper Dredges ESSAYONS, WHEELER, MCFARLAND

Products

DIS is used to track each dredging contract. Information in the database includes general contract data on name and location of the dredging site, estimated quantity of material to be removed, type of dredge, type of material disposal, dates of bid advertisement, bid opening and contract award, units of contract measurement, small business set-aside restrictions, dredging window restrictions, Government cost estimate, number of bids submitted, winning bid and bidder, small business status of bidders, and actual contract cost and quantity dredged.

Benefits

DIS is used to produce the Corps' advertising schedule for the current, previous and next fiscal year. It also displays contracts awarded, bid abstracts, the Industry-Corps Hopper Dredge fleet status, as well as the Corps Dredging Schedule. DIS is used to plan annual dredging activities across the nation. It is also a singular point of information for industry and the public to find bid open dates and dredging project information. It allows for tracking of equipment, availability, and environmental windows. DIS is used by headquarters to manage the national dredging program, to prepare briefings, and to conduct stakeholder meetings.

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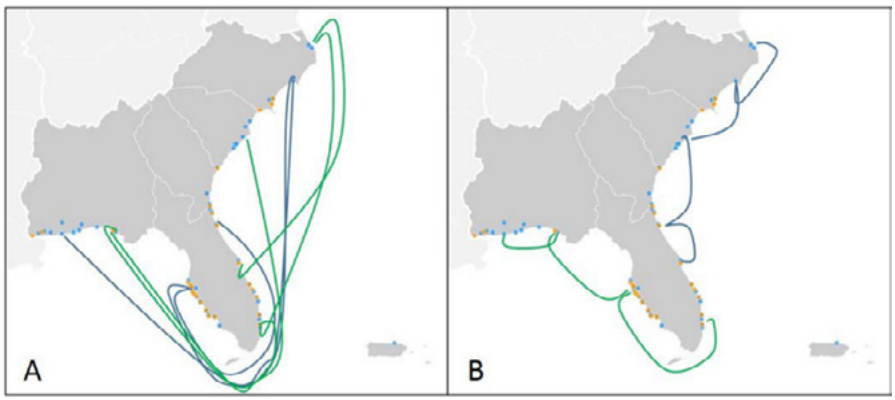
Dredge Fleet Assignment/ Scheduling Optimization Model

The ERDC Dredging Innovations Group (DIG) program utilized its Dredge Fleet Assignment/Scheduling Optimization Model in collaboration with the RSM Economic Value pilot project across SAD in order to identify additional efficiencies in the USACE Navigation (NAV) and Flood Risk Management (FRM) programs over the course of the dredging season. The model uses established optimization methods from the Operations Research field to determine dredging schedules that maximize dredged volume while keeping mobilization costs to a minimum. The model also satisfies local constraints such as scheduling windows due to environmental restrictions and suitability of particular dredge plants for specific projects.

RSM Economic Value Pilot at SAD

The model has been applied across the South Atlantic Division (SAD) and resulted in significant reductions in dredge mobilization costs. In the SAD pilot study, mobilization costs are reduced by more than half relative to those incurred in the present real-world SAD dredging program (from 16 – 21% of total program costs to approximately 5 – 8% of total costs). Combined SAD dredging for both NAV and FRM totals around $250M annually, and with full implementation of the results from the Dredge Fleet Optimization model, the division could save $20-40M on mobilization costs alone. This was in addition to the roughly $100M in additional value achieved through the RSM implementation for the Navigation and FRM business lines across all of SAD.



Schematic representation of an inefficient dredge plan seasonal itinerary (A) and an idelaized seasonal dredged plant itinerary with optimzal scheduling (B). Figure represents two dredge plans with seasonal schedule indicated by colored paths (blue, green) and SAD dredging project locations indicated by blue (NAV) and orange (FRM) circles.

Products

Work on this product is ongoing. Please visit the RSM website for more information: http://rsm.usace.army.mil. Alternately, check on the status of the Dredge Fleet Assignment/Scheduling Optimization Model via ERDCpedia: https://wiki.erdc.dren.mil/ERDCpedia

Benefits

The Dredge Fleet Optimization Model provides a quantiative way to evaluate the cost-effectiveness of various approaches to dredging program execution. It can also serve as as starting point for exploring the most promising candidate groups of projects for regional contracting and helps to quantify the constraining effects created by environmental work restrictions – and provide guidance for future research.

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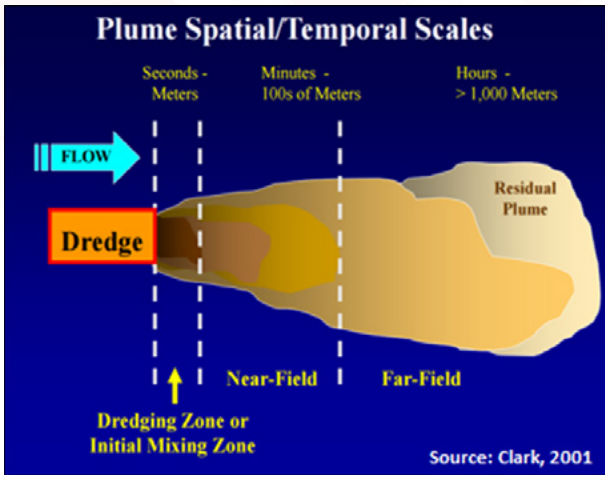
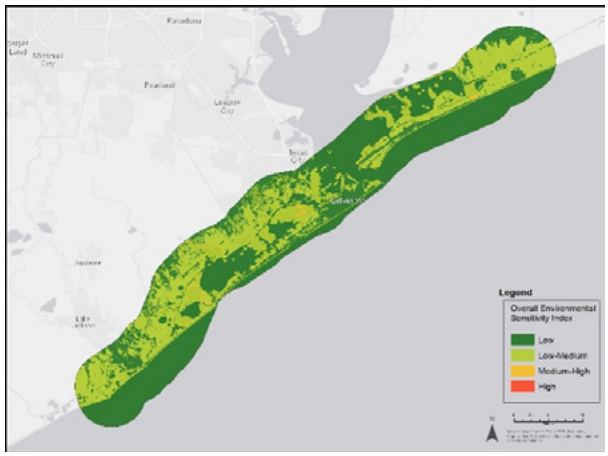
Ecological Data Synthesis Tool

The Ecological Data Synthesis Tools is a spatially-explicit visualization tool that combines ecological resource layers into a single layer representing relative environmental sensitivity of dredging impacts to provide decision support. The tool incorporates multiple geospatial ecological data layers such as oyster reef habitat and submerged aquatic vegetation, and utilizes existing studies and data to scale the relative risk of each ecological resource to dredging and/or placement activities. The integrated impacts are then weighted across all layers providing an indication of the relative risk of negative project impacts on the environment. The tool was developed as a planning tool to assist Dredged Material Management Plans (DMMP) and Preliminary Assessments (PA) project development teams to prioritize efforts and resources in areas of high environmental concern.



Example Studies

Prior to dredging and dredge material placement activities, determining areas of potential environmental impact within and near a project area is essential. This planning tool provided an environmental sensitivity assessment for proposed dredging and placement activities for the Gulf Intracoastal Waterway (GIWW) from High Island to Brazos River in Galveston Bay as requested by the Galveston District (SWG). The assessment included four specific ecological resources of concern as identified by SWG; potential threatened and endangered species habitat, wetlands and wildlife refuges, oyster reef habitat, and potential submerged aquatic vegetation habitat. An overall environmental sensitivity index was developed from these four ecological resources and provided SWG with a geospatial data layer displaying the area of high to low environmental sensitivity to dredging and placement activities.



Products

Ecological sensitivity layers can be visualized on the web through the CE DREDGE Decision Support Tool viewer, incorporated into GIS applications, and/or used as valuable graphics for inclusion in PA/DMMP reports. The ecological sensitivity data can also be integrated into the Dredged Material Management Decisions (D2M2) Optimization tool as part of the multi-criteria decision analysis.

Benefits

This visualization tool benefits Districts by providing quantitative, data informed methods to determine environmental sensitivity indices from dredging impacts. In addition, the tool weighs competing environmental impacts (positive/negative) and provides standardized, repeatable, transparent decision support while facilitating assessment of multiple environmental factors in one location.

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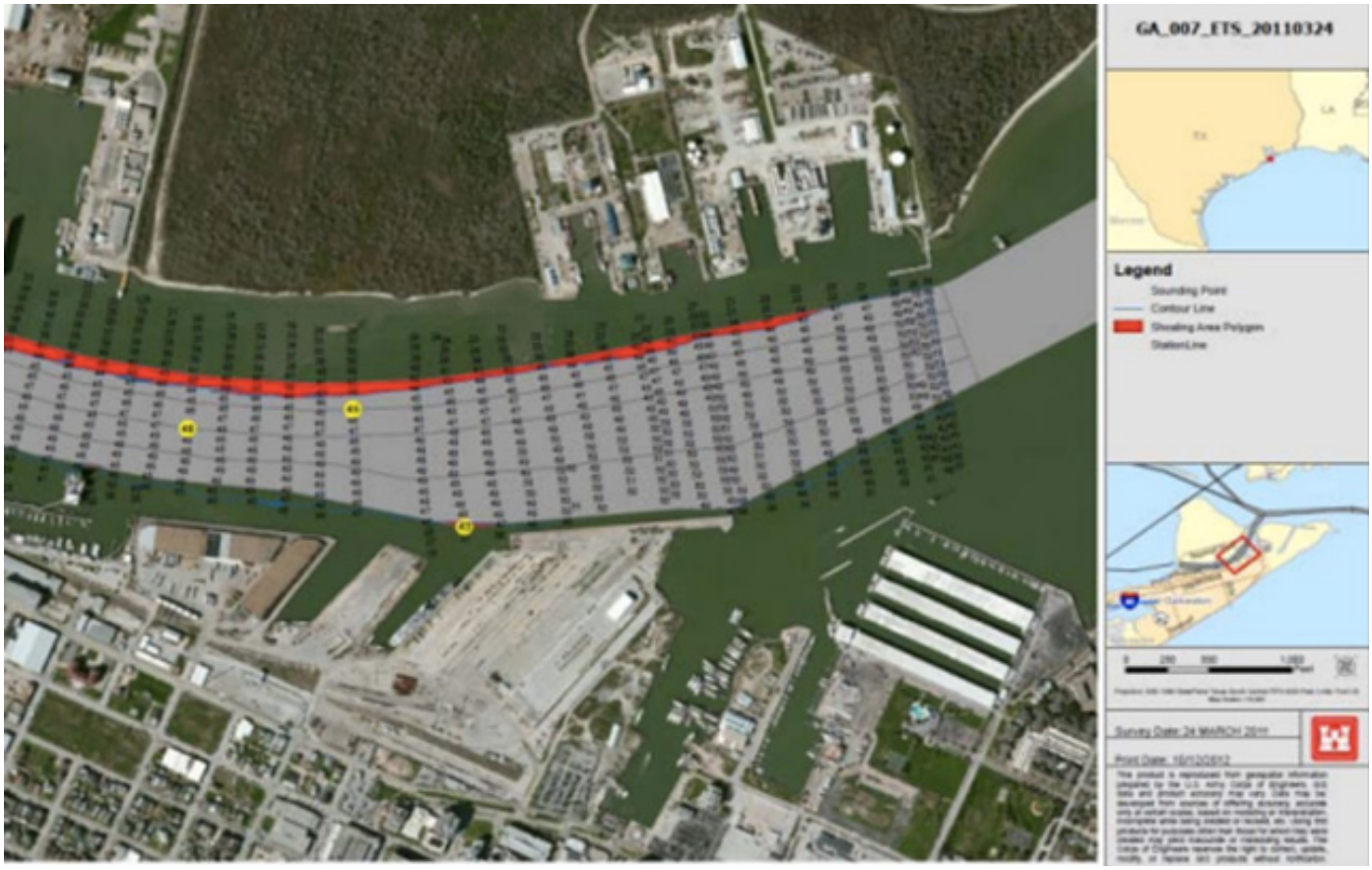
US Army Corps of Engineers®

eHydro

US Army Corps of Engineers® Portland District

Spatial Data

The eHydro application enables Districts to produce consistent survey plots, channel tabulations, and metadata from survey soundings. The application also uses a framework of channel boundaries, project depths, stationing and channel quarters, ensuring consistent and reliable reference. eHydro is based on ESRI® ArcGIS software, and reads HYPACK™ hydrographic survey data to produce least depths for channel quarters, channel condition reports and indices, planning quantities, and metadata files. The application also applies background imagery and feature data to produce condition plots. Data for outside reporting, such as condition reports and indices, soundings and contours, are automatically uploaded to an enterprise server for outside dissemination. The software and user procedures are designed to easily integrate in a District's normal survey data processing workflow.



Issue

Navigation channel condition information is critically needed by users outside normal hydrographic survey functions. USACE Districts routinely produce channel plot sheets and channel quarter tabulations for outside navigation interests and for NOAA from hydrographic survey data. However, the format, data content, frequency of availability and age of the data varies with each District.

Benefits

This research will reduce the time and costs required to produce channel plot sheets and channel quarter tabulations.

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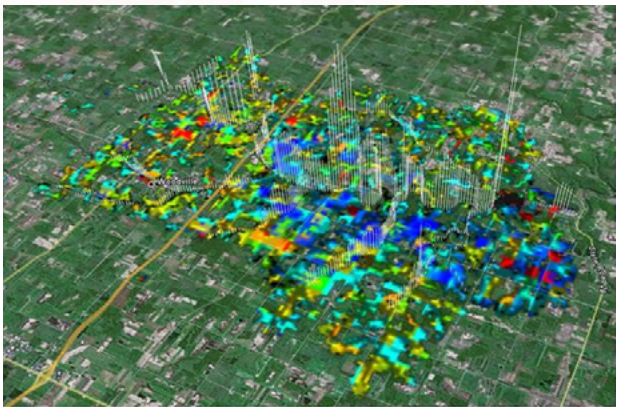
Gridded Subsurface Hydrologic Analysis (GSSHA)

The Gridded Subsurface Hydrologic Analysis (GSSHA) model was created by the Coastal and Hydraulics Laboratory to perform complex studies of atmospheric, land-based, wetland, riverine, and coastal systems to help predict and mitigate watershed management problems. GSSHA is a multidimensional modeling technology that uniformly couples overland, surface, and subsurface flow for accurate watershed simulation. Features include two dimensional (2-D) overland flow, 1-D stream flow, 1-D infiltration, 2-D groundwater, and full coupling between the groundwater, shallow soils, streams, and overland flow. Sediment and constituent fate and transport are simulated in the shallow soils, overland flow plane, and in streams and channels. GSSHA can be used as an episodic or continuous model where soil surface moisture, groundwater levels, stream interactions, and constituent fate are continuously simulated. GSSHA's new features include parallel processing and improved in-stream sediment transport and automated calibration. More information about GSSHA can be found online: -http://chl.erdc.usace.army.mil/gssha



Mass of a dissolved nutrient, in-field (colors) and in-stream (lines), and Spring Reservoir (teal arrow). Woodville, WI.

Example Studies

GSSHA fully couples ground and surface water interactions an can model both aird and humid environments. Coupling of the watershed hydrology to the river and reservoir portions of the code allows it to be used for complete assessment of sediment fate, from erosion on the uplands to deposition in the reservoir. The fate of associated pollutants can also be tracked through the coupled system. It has been applied successfully to many sites including effectively forcasting inland flooding effect during Hurricane Irene in New York City and Long Island on August 25th, 2011. GSSHAs outputs included depth and location and were animated using Google Earth and shown to the leadership of New York City to inform evacuation plans.

Products

GSSHA 5.7's new features include parallel processing and improved in-stream sediment transport and automated calibration. More information about GSSHA can be found online or by contacting the POC (listed below).

Benefits

The scalability of GSSHA is a key component of its robust watershed modeling power. CHL engineers use it for large studies, such as the management of military training lands, and for smaller projects where detail at the street level is critical, such as urban flooding. GSSHA also does the following:

- Tracks the fate of associated pollutants through the coupled system
- Provides soil moisture, runoff, and flooding predictions that can be used to asses fire threat, irrigation needs, and effects on natural systems
- Analyzes future conditions and management scenarios—such as land use changes and wetland restoration
- Helps develop Best Management Practices (BMP) and Total Maximum Daily Load (TMDL) values for flood control, sediment transport, and pollutant transport
- Utilizes unique boundary conditions to simulate coastal flooding due to storm surge

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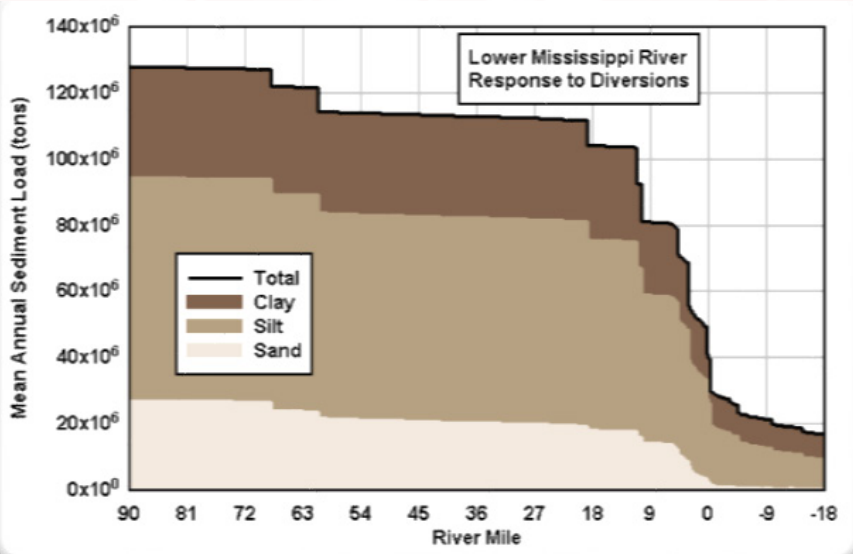
HEC-6T Sedimenation in Stream Networks

HEC-6T supports one-dimensional (1D), quasi-unsteady flow and sedimentation numerical modeling of rivers and reservoirs. HEC-6T can be used to simulate long-term (years to decades) bed degradation (general scour) and aggradation (deposition) within a stream network. A dynamic balance exists between the sediment moving in a natural stream or constructed channel, the size and gradation of bed material, sediment inflows and diversions, and the flow hydraulics. HEC-6 can be used to predict the impact of changing one or more of those characteristics on the river hydraulics, sediment transport rates, and channel geometry.



Example Studies

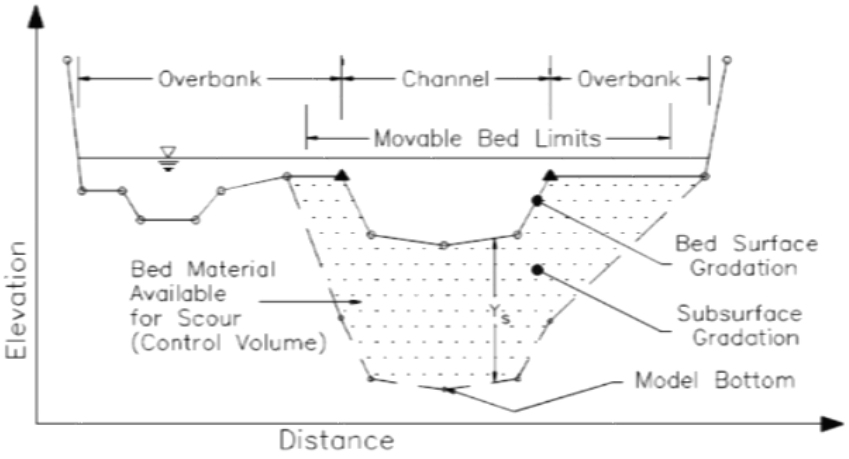
HEC-6T and its predecessors have been widely applied, most recently to evaluate the long-term sedimentation impacts, including maintainance dredging, of existing and proposed diversions from the Lower Mississippi River for the Mississippi River Hydrodynamic and Delta Management Study. A regional scale HEC-6T model of the Lower Mississippi from Cario, Illinois, to the Gulf of Mexico has been applied to assess potential decadnal scale impacts of channel aggradation and degradation on the Mississippi River and Tributaries project flood flowline.

Products

HEC-6T is a proprietary, enhanced version of the USACE HEC-6 and HEC-6W computer programs. Software and documentation are available from Mobile Boundary Hydraulics, PLLC. The ERDC Coastal & Hydraulics Laboratory can provide technical assistance with development, operation, and evaluation of project specific HEC-6T models. Much of the functionality of HEC-6T has been incorporated into HEC-RAS.

Benefits

HEC-6T can be used to evaluate deposition in reservoirs (both the volume and location of deposits) and sedimentation impacts from changes in flow regulation, design channel contractions required to maintain navigation depths or decrease the volume of maintenance dredging, predict the influence that dredging has on the rate of deposition, estimate possible maximum scour during large flood events, and evaluate sedimentation in fixed channels.



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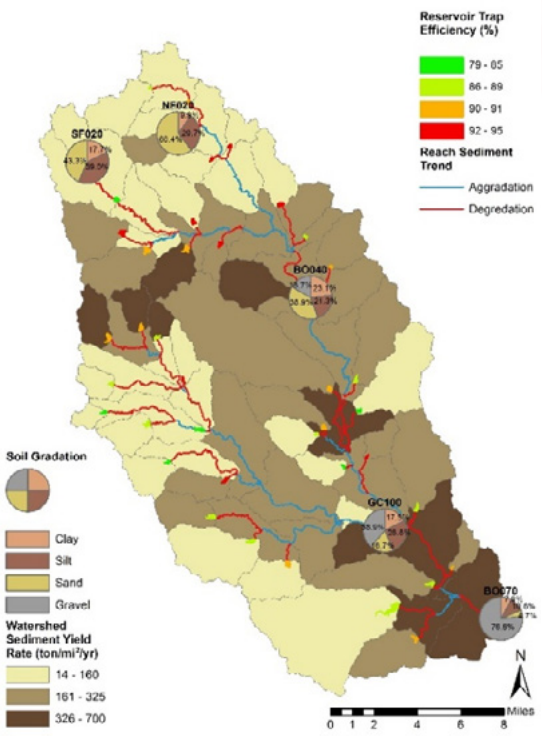
HEC-HMS: Hydrologic Modeling System

The Hydrologic Modeling System (HEC-HMS) simulates the precipitation-runoff processes of dendritic watershed systems. The software is applicable in a wide range of geographic areas and solves diverse problems including large river basin water supply and flood hydrology, and small urban or natural watershed runoff. The HEC-HMS sediment transport module builds on the existing hydrology modelling framework. Subbasin elements include a Modified Universal Soil Loss Equation (MUSLE) for modelling pervious segments or a build-up/wash-off method for impervious segments. Reach elements model erosion, deposition, sediment routing, and gradational evolution in the channel. Reservoir elements model sediment settling and sediment transport through reservoirs. Source, junction, diversion, and sink elements pass sediment through the channel network.

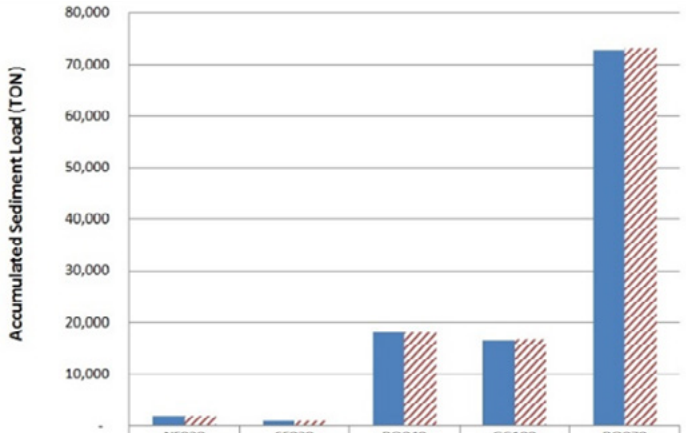


Applications

The Upper North Bosque River in Texas served as a proving ground for the HEC-HMS sediment transport module during development. Subsequent applications by CEIWR-HEC include sediment loading studies at Fort Hood, Texas and Goodwin Creek experimental watershed, Mississippi. Beyond CEIWR-HEC, researchers and engineers have applied the HEC-HMS sediment transport module across the United States and around the world.

Distribution

HEC-HMS is available free of charge at the CEIWR-HEC website: http://www.hec.usace.army.mil/software/hec-hms/downloads.aspx. The HEC-HMS User's Manual describes initialization and parameterization and Applications Guide provides a sample sediment modelling application. Additionally, HEC-HMS sediment modelling workshops are available on request to CEIWR-HEC.



	NF020	SF020	BO040	GC100	BO070
Measured (Jan95-Dec96)	1,943	969	18,040	16,574	72,880
HMS (Jan95-Dec96)	1,949	965	17,992	16,621	73,124

Benefits

Sediment transport modeling in HEC-HMS is within the existing modelling framework. Users can initialize and parameterize a sediment model on their desktop through the familiar HEC-HMS user interface. Users can add sediment modelling to existing HEC-HMS hydrology models without having to create a model from scratch. The modular design of HEC-HMS provides users a flexible framework to create a custom sediment model for their application, i.e. users can mix and match sediment modelling methods within an HEC-HMS project.

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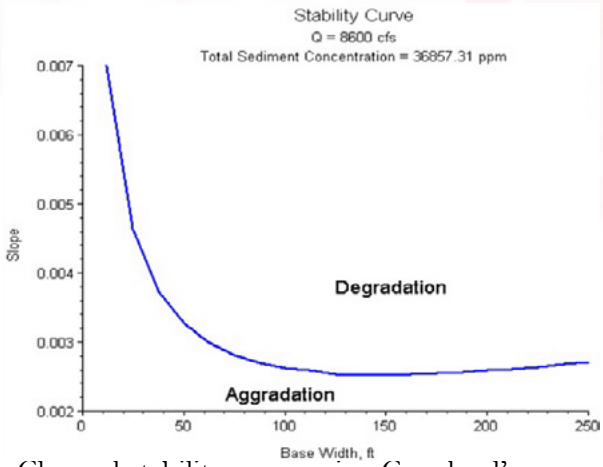
HEC-RAS: Hydraulic Design Calculators

HEC-RAS includes a suite of simple sediment calculators in the Hydraulic Design (HD) module. These are entry level tools in the USACE sediment modeling toolbox that provide very approximate answers relatively quickly. The sediment calculators in the HD tool box can compute a stable channel geometry using the Copeland method (see figure), Regime Theory, or Tractive Force computations (including Lane and Shields equations). The stable channel tools compute critical transport conditions for a range of channel widths, flows, slopes, and bed material types with minimal user input. The HD tool box in HEC-RAS also includes a sediment capacity calculator. The sediment transport capacity calculator uses steady flow hydraulics to generate a snapshot of transport capacity at each cross section (at one or more flows). Users can choose one or several sediment transport functions to develop a sense of the potential variability in the answer.



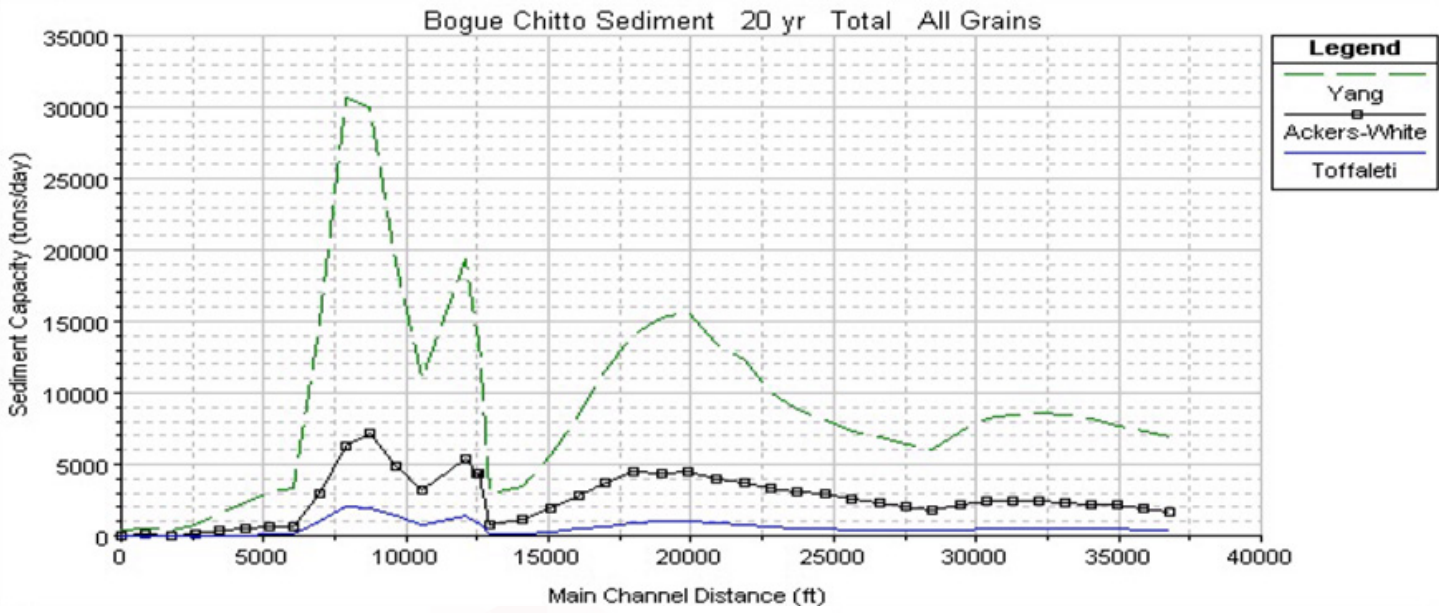
Channel stability curve using Copeland's method in the HEC-RAS HD toolbox.

Example Studies

Many projects use the HD calculator tool to screen preliminary alternatives. Most recently, the Kansas City District used the HD calculator to size a channel restoration alternative on Locus Creek.

Benefits

The sediment calculators in the HD tool box help project delivery teams screen morphological failure modes in the tight constraints of SMART planning. If a project requires an HEC-RAS model, a hydraulic engineer can do a preliminary sediment analysis without much additional work, and decide whether potential morphological failure modes require more analysis.



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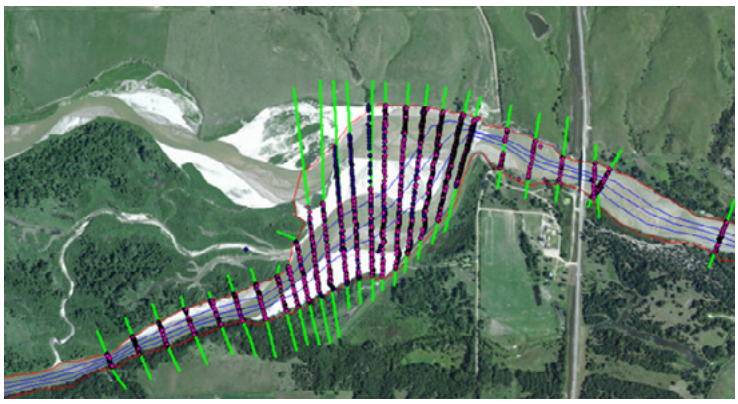
HEC-RAS: Sediment Transport

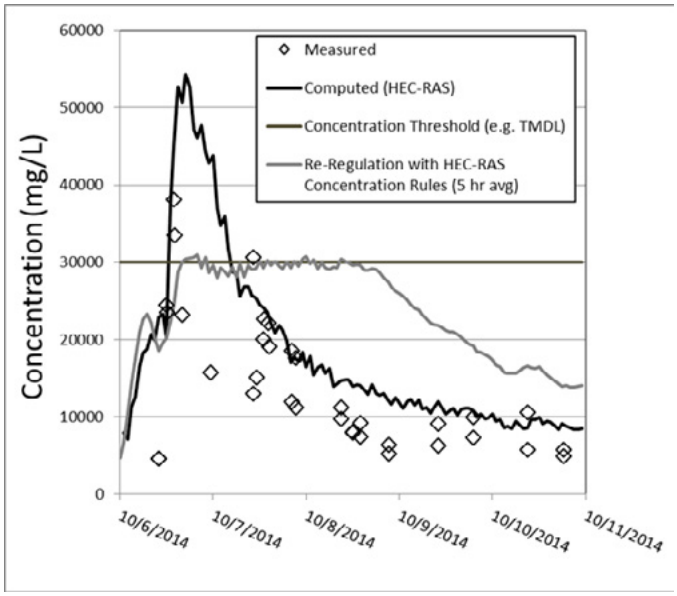
The Hydrologic Engineering Center's River Analysis System (HEC-RAS) is the US Army Corps of Engineers' (USACE) one-dimensional (1D), open channel river model. HEC-RAS is the industry standard tool for 1D open channel hydraulics, with new, popular, 2D, hydraulic capabilities. However, this model has included sediment transport capabilities for over a decade. USACE districts have applied HEC-RAS to many sediment transport problems, including a number of Regional Sediment Management questions. In particular, the Omaha and Portland Districts have applied HEC-RAS to reservoir flushing models and have compared them to measured concentrations during the reservoir flush.

Example Studies

USACE districts, centers, and laboratories, as well as universities and contractors, have applied HEC-RAS to a wide variety of sediment transport problems and scales. Applications have ranged to flume transport analyses to significant reaches of the Missouri (500 miles), Madeira (300 miles) and Mississippi (300 miles) rivers. Figures 1 and 2 illustrate the model set-up and results of the RSM funded Spencer Reservoir flush study, where HEC-RAS simulated a drawdown flush and then applied "operational rules" to automatically design an alternate flush that reduced the maximum downstream sediment concentration.



HEC-RAS cross sections developed from surveys of the Spencer Reservoir flush.toolbox.



Computed and measured concentration time series downstream of the Spencer Reservoir sediment flush, and a re-regulation simulation where HEC-RAS automatically computed the reservoir operations required to observe a downstream concentration constraint (TMDL<30,000 mg/L).

Products

The latest version of HEC-RAS is available on the HEC website www.hec.usace.army.mil. RSM has generated several papers highlighting HEC-RAS applications to RSM problems including: Gibson, S. and Boyd, P. (2016) "Monitoring, Measuring, and Modeling a Reservoir Flush on the Niobrara River in the Sandhills of Nebraska," Proceedings, River Flow 2016, ed Constantinescu et al., 1448-1455.

Benefits

The hydraulic model in HEC-RAS is widely applied to USACE managed systems. Most of these systems already have HEC-RAS hydraulic models, reducing the cost and effort involved in a sediment analysis.

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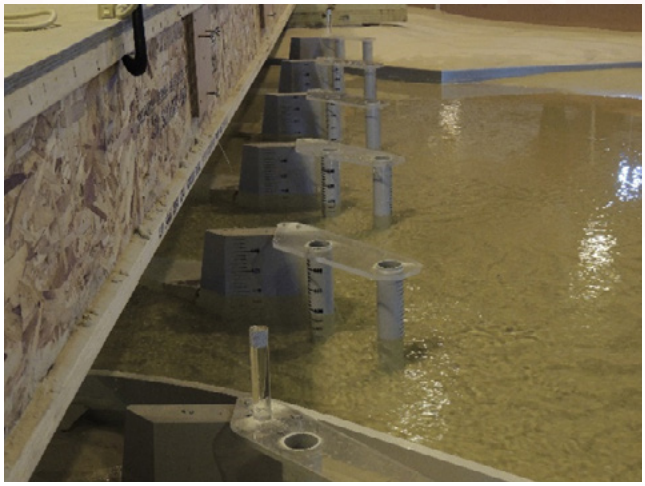
Inland Waterway Research Facility

COASTAL & HYDRAULICS LABORATORY

The Inland Waterway Research Facility is 100 feet (ft) wide, 3 ft deep, and 200 ft long and is currently subdivided longitudinally into a 45 ft and 55 ft wide sections. Its highest discharge is 20 cubic feet per second (cfs). Flow in the facility can be directed from either direction. The Inland Waterway Research Facility is ideally in size for many applications where river meandering and sediment transport for large riverine systems are an issue.



Example Studies

The flume was designed in the 1970's to evalute the impacts of riverine structures on sediment transport in meandering systems. These initial studies where done as coal bed studies where the impact of bendway weirs, dikes, and other structures where tested to determine their respective usability. Continuing with this histroic tradition of sediment related work, in recent years, the Santa Ana general movable bed model was conducted. In this recent effor the flume was used to determine the pier scour reducing potential of proposed pier nose extensions. The Santa Ana model was a Froude scalled sand bed model that was 45 ft wide and 108 ft long. From this study effort SPL was able to save an estimated $20 million in construction cost.

Products

A Technical Report along with multiple Technical Notes, and Letter Reports have been published as a result of the work done in the Inland Waterway Research Facility. Additionally, procured data sets have been used to evaluate and analyze the above processes for the production of quantitative approaches both analytically and numerically.

Benefits

The Inland Waterway Research Facility serves a multi-functional role for large scale physical modeling efforts for both research and reimbursable efforts. It allows for the collection of data sets for the verification and validation of numerical models. Data collection includes water surface profile, discharge, bedload transport rate, velocity (ADV and LDV), particle tracking, bed tracking, and slope data. For large scale efforts the Inland Waterway Research Facility is the ideal facility.

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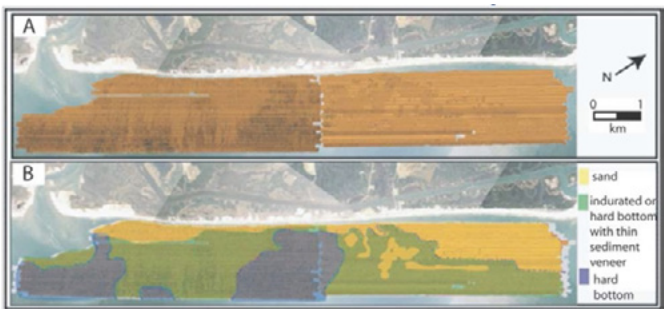
Integrated CHIRP Sub-Bottom Profiler and Dual Frequency Sidescan Sonar

Understanding sediment dynamics in aquatic systems is a critical component of the USACE's mission. For example, the volume of sand in a nearshore profile has significant impact on shoreline stability, and the type of sediment characterizing the seafloor influences not only the type and distribution of benthic habitats but also influences sediment transport. Traditional sediment characterization techniques, such as estimates of sediment volume derived from repeated bathymetric mapping or characterization of aquatic habitats by sidescan sonar alone, neglect the subsurface geology and thus provide an incomplete picture of a region. To address this gap, the Coastal and Hydraulics Laboratory's Coastal Observation and Analysis Branch (under the Coastal Field Data Collection Program) has acquired an Edgetech 2000-CSS: a Compressed High Intensity Radar Pulse (CHIRP) sub-bottom profiler integrated with a dual simultaneous frequency CHIRP sidescan sonar. Sidescan sonar generates spatial maps of surficial sediment type (e.g., rock, sand, mud) via variations in the reflection of high-frequency acoustic pulses off of the seafloor. The Edgetech 2000-CSS has a dual-frequency side-scan sonar (300 kHz/600 kHz), allowing simultaneous characterization of surficial bottom type (see figure).



Applications

Cross- and alongshore variations in the total nearshore volume of transport-relevant sand, as defined using chirp seismic data, have been shown to be strongly related to decadal-scale shoreline change rates in many coastal regions, including along the Outer Banks of North Carolina as well as along Fire Island, NY. Along the northern Outer Banks in particular, nearshore sand volumes as defined by CHIRP profiles provided greater prediction accuracy of heightened shoreline erosion than did simply estimating sand availability along a more traditional, depth of closure-defined volume estimate.

Products

The Edgetech 2000-CSS is comprised of the following: full spectrum sub-bottom control and amplifier, topside controller with dual monitors, a four-transducer SB-512i CHIRP towfish with a frequency range of 500 Hz – 12 kHz, integrated with a 300/600 kHz dual simultaneous frequency CHRIP sidescan sonar, communication tow/cable, optional catamaran towing vessel, a single-beam and/or interferometric swath bathymetry system that can be simultaneously operated.

Benefits

The CHIRP sub-bottom profiler allows for high resolution and deep penetrating power through substrates and yields powerful regional insights (e.g. structural controls on draining systems by indentifying where subsurface channels still influence modern drainage patterns, optimizing colleciton of borehole data to characterize a region). The integrated sidescan sonar allows for detailed seafloor surface mapping, simultaneous collection of data allows for quantificaiton of the seafloor type, sediment resources, and sediment dynamics of a region. These integrated data play a critical role in quantifying the sediment dynamics of region.

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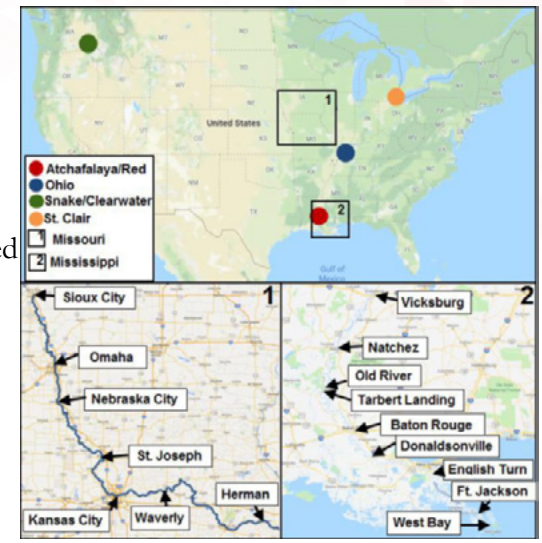
Integrated Section Surface Difference Over Time, version II (ISSDOTv2)

Many District Offices within the Corps of Engineers must deal with bedload sediments. In large sand bed rivers, measuring bedload in the past has been problematic to impossible. The ISSDOTv2 (Integrated Section Surface Difference Over Time, version 2) methodology provides a solution to this problem. Bedload sediments can be a nuisance or a resource. In either case the ability to measure the bedload is an essential step in developing a management plan. The method uses time sequenced bathymetric swaths obtained across a river section. An automated and validated process has been developed to relate the incremental scoured volume of the sequential swaths to the average transport in the sand waves (dunes). The values computed for each swath are summed to provide a total value for the measured section.



Example Studies

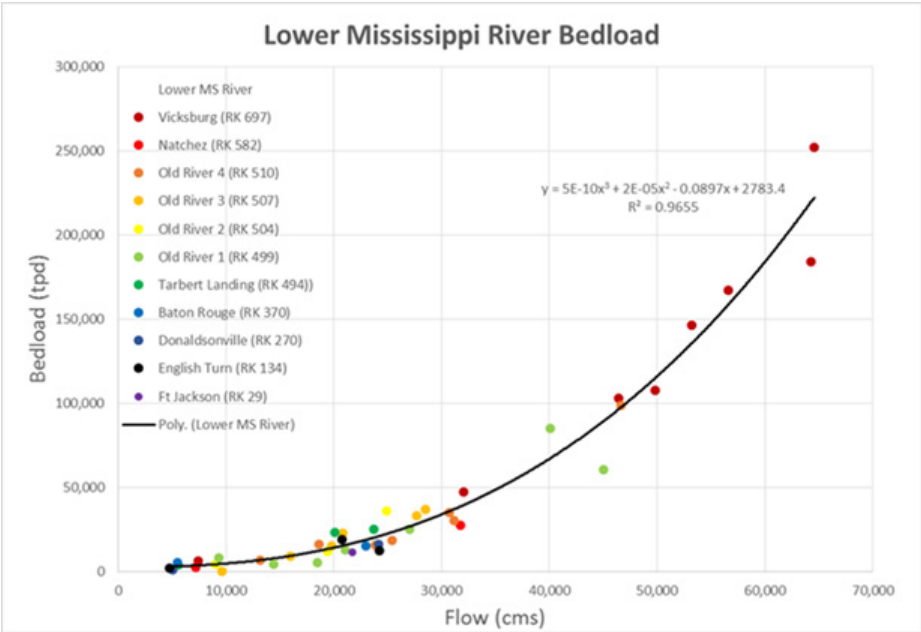
The figure to the top-right shows example study locations where the methodology has been used. 8- USACE Districts (MVP, NWK, MVK, NWO, MVN, NWW LRL, and LRE) have asked ERDC-CHL to apply the ISSDOTv2 method as of Dec 2016 (~$3.3 million).

Products

Total bedload flux in a river cross section can be determined, the lateral variability of the bedload flux can be shown, bed load rating curves (Bed load vs Flow) can be developed, and bed load delivery for any time period can be estimated using a rating curve.

Benefits

Habitat suitability can be quantified with bed load measurement values, dredging requirements can be determined, dredging permits can be obtained more expeditiously through mitigation of mussel surveys, measurements can be used to validate sediment models, and transport functions can be verified. River managers now have an extremely useful and dependable management tool to help in their decision making process.



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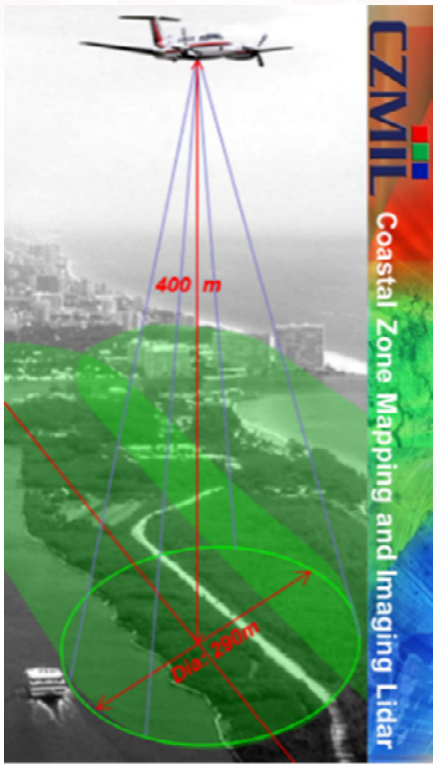
Joint Airborne Lidar Bathymetry Technical Center of Expertise (JALBTCX)

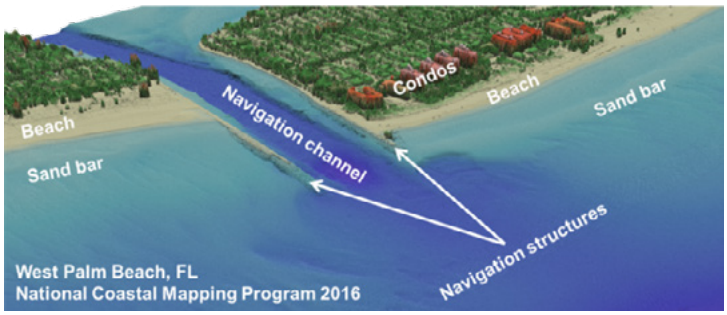
The Joint Airborne Lidar Bathymetry Technical Center of Expertise (JALBTCX) (https://shoals.sam.usace.army.mil/) provides a unique airborne topographic and hydrographic mapping capability for the U.S. Army Corps of Engineers (USACE). JALBTCX owns and operates CZMIL (Coastal Zone Mapping and Imaging Lidar) year-round and world-wide in support of the USACE National Coastal Mapping Program, USACE District reimbursable surveys, Naval Oceanographic Office Airborne Coastal Surveys, and work for other agencies. CMZIL is the 3rd generation of airborne systems and products developed by JALBTCX to meet USACE requirements for coastal mapping.



CZMIL specifications	
Bathymetric and Topographic lidar	2 points per square meter (land and shallow water) 1 point per 2 square meters (deep water) 10 cm RMSE (land) 15 cm RMSE (water)
Aerial photography	5 cm on ground resolution
Hyperspectral imagery	1 m on ground resolution 48 spectral bands from 380-1050 nm

Products

JALBTCX simultaneously maps above and below the water surface using blue-green lidar. The data provide a comprehensive picture of the coastal zone: beaches and dunes, buildings, trees and shrubs, navigation channels and structures, and offshore sand bars and shoals. Aerial photography and hyperspectral imagery are collected at the same time as the lidar data and provide a visual context for the elevation data. Hyperspectral imagery provides enhanced visual capabilities for detailed feature identification and extraction. Imagery can be combined with elevation data to develop land cover and seafloor classifications, identifying classes like roads, buildings, dune vegetation, sand, submerged aquatic vegetation, and hard bottom. JALBTCX has developed a suite of standard GIS products from the lidar and imagery data including Digital Elevation Models (bare earth models), Digital Surface Models (with vegetation and man-made structures), aerial photo and hyperspectral image mosaics, laser reflectance images, volume and shoreline change, and coastal structure metrics.



Benefits

- JALBTCX provides a cost-effective, easily accessible, state-of-the-art airborne bathymetric and topographic mapping capability to USACE. The lidar and imagery data are high-resolution and high-accuracy, and each flight covers a large area of coast (10+ square miles per flight hour). After storms or other disasters, data is delivered within 24 hours, with no personnel at risk in the impact areas. Standard products and change analysis products are expedited using automated processes.

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US Army Corps of Engineers®

Large-scale Sediment Transport Facility (LSTF)

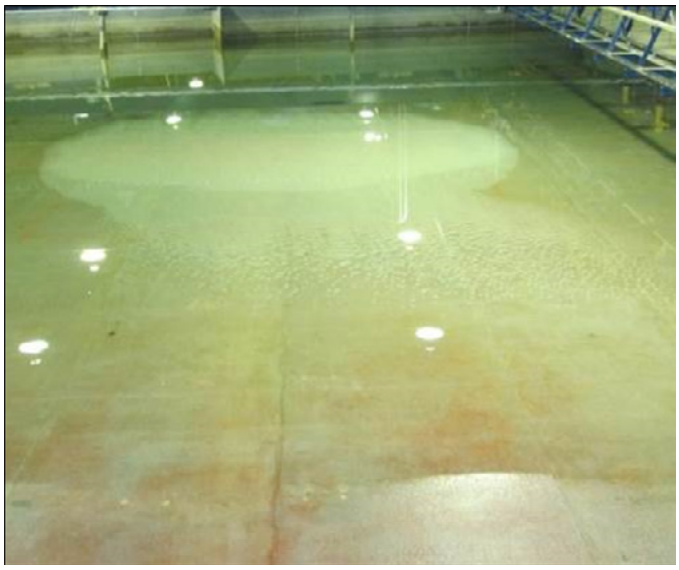
COASTAL & HYDRAULICS LABORATORY

Dredged sediment is a resource useful in beach nourishment, improving coastal resilience, and maintaining growing wetlands. As numerical models expand in capability, datasets must be improved so that the models can be validated. Often, these critical data required to improve the understanding of coastal sediment transportation are deficient. Field data often lacks hydrodynamic conditions and is challenging to track sediment because of mixing with native sediment. The Large Sediment Transport Facility (LSTF) is located at the Coastal and Hydraulics Laboratory in Vicksburg, MS, and is the only basin in the western hemisphere capable of simulating an infinite shoreline. The LSTF can produce large-scale laboratory waves, pump and recirculate longshore current, measure the quantity of sands that moves along the beach, and contains a fully programmable instrumentation bridge and data acquisitions system.

Products

The LSTF is being utilized to address several cutting-edge research questions.

Mixed Sediment Berm Transport - A research effort that aims to fill in knowledge gaps by conducting a physical model study of mixed sediment berms. Mixed sediment berms will be constructed in this facility and subjected to a range of hydrodynamic forcing conditions to allow the material to transport downstream. The cross-shore and longshore sediment transport rates of sand and fine material will be measured as well as the wave and current hydrodynamic forcing conditions to improve predictive capabilities. This is the first large-scale, three-dimensional physical model to ever measure the transport of mixed sediment nearshore berms.



LTSF is employed for study of mixed sediment nearshore berm transport

Benefits

For the Mixed Sediment Berm Transport study, the transport rates of sand and fine material simulating dredged mixed sediment nearshore berms are being measured in a large-scale, three-dimensional physical model using a range of hydrological forcing conditions. The study will measure critical data that is necessary to improve the understanding of dredged mixed sediment nearshore berm migration. This and other studies that utilize the LSTF will help to create a complete dataset to validate numerical models for application to District navigation projects.

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Mobile Bed Discharge Gaging (MoBED)

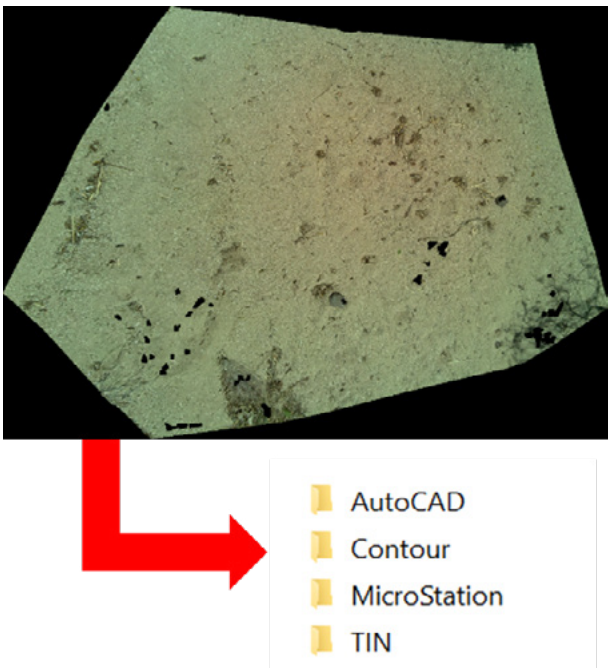
A cornerstone to calibration of hydrologic, hydraulic, and sediment transport models is accurate flood discharge data. High energy floods and debris flows destroy pressure transducers and associated gaging stations downstream of burn scars leaving non-contacting instrumentation as the only viable option for capturing events. Current non-contact technologies are ineffective in mobile bed channel systems due to changing channel geomorphology. Channel cross sections need to be surveyed after each flood event. Additionally, velocities vary depending upon channel slope and event recurrence interval. The Mobile Bed Discharge (MoBeD) gage was developed with Arduino and Raspberry Pi hardware capable of controlling an array of sensors that may collect channel bed point cloud topography, velocity data, and stage.

Example Studies

The MoBeD Gaging is currently in advanced benchtop prototype. Field deployment is planned in FY2018/19 at the Arroyo de los Pinos sediment research station in collaboration with the USBR, USGS, and NMT.

Products

Data collected by the system returned 4-band orthoimagery, terrain point clouds, and laser rangefinder cross sections. Workflows, scripts, executable files, and applicable hardware for sensor triggering, collection, storage and retrieval of topographic, velocity, and discharge data have been developed.



Benefits

Affordable, automated, non-contact geomorphologic gaging will provide critical discharge, sediment, and vegetation data in currently ungagable systems. Collecting observed hydrologic measurement will allow refined model calibration and validation for a full range of frequency events. High resolution terrain data before and after storm events will increase engineering understanding of high frequency channel geomorphology.

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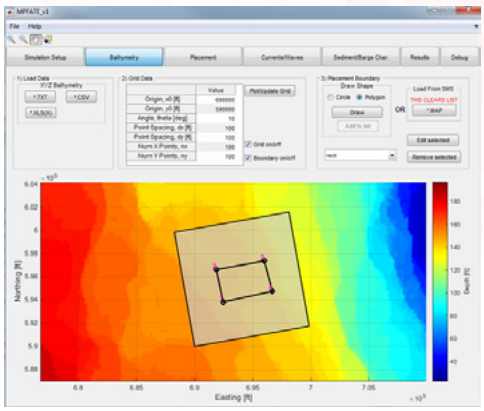
MPFATE, GTRAN, and LTFATE



Dredged sediment management often incorporates regional sediment management objectives and principles. Multiple models have been developed to support dredged sediment management. This fact sheet describes three models developed under the Dredging Operations and Environmental Research program. The General TRANsport (GTRAN), Multiple-Placement FATE (MPFATE) and Long-Term FATE (LTFATE) numerical models are tools available to assist in the development of sediment management plans and regional sediment transport initiatives. Although these tools can be applied individually, often they are applied together.

GTRAN is a numerical tool to estimate sand transport under combined wave-current forcing at single points in space. GTRAN does not perform the bookkeeping required to calculate erosion and accretion, but when applied to a distribution of points over a region, can indicate sediment transport pathways and relative trends of erosion and accretion. GTRAN applies pre-determined hydrodynamic solutions developed through application of wave and current models, to resolve transport magnitude and direction at each point for a selected time domain.

MPFATE is a numerical tool to determine the accumulation of sediment resulting from dredged sediment placement by barge or hopper dredge. Through applications of MPFATE, the user can determine the evolution of a dredged sediment placement site under varying dredged material management schemes. MPFATE output (dredged material mound configuration and composition) is frequently used as input to the LTFATE or GTRAN models.

LTFATE is a fully three-dimensional numerical model applied to quantify the erosion, transport, and deposition of sediment by currents and waves over large areas and/or long times. LTFATE is a hydrodynamic and sediment transport model that includes the effects of waves and currents on the transport processes. The model simulates transport of multiple classes of sediments (sands, silts and clays) and includes morphology change and composition change due to transport.

Example Studies

The three models have been applied at numerous sites. Three examples where models were applied in conjunction with each other include Grays Harbor, Savannah River, and James River.

Products

Products demonstrating the application of models applied in support with each other include technical reports (Grays Harbor) and a journal publication (Savannah River).

Benefits

- These tools address how sediments will move in a complex system with currents and waves. Although the original application was for dredigng, the GTRAN and LTFATE models have been generalized to be applicable to all open water sediment transport issues composed of sand, silt and clay.

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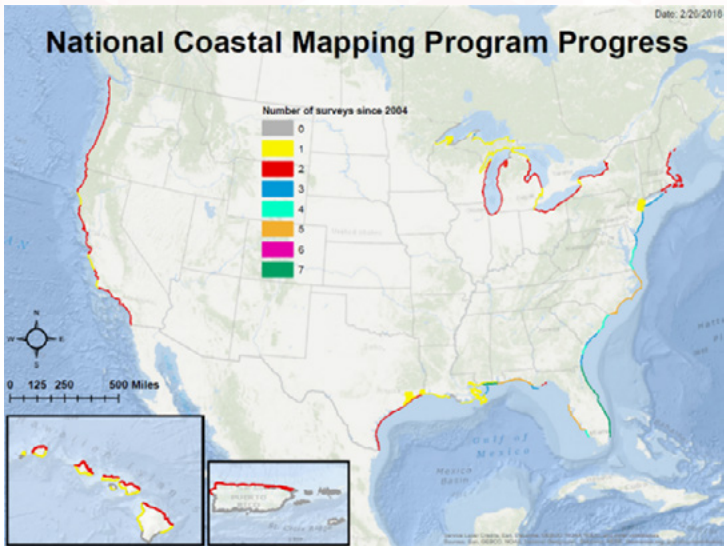
National Coastal Mapping Program (NCMP)

COASTAL & HYDRAULICS LABORATORY

The U. S. Army Corps of Engineers (USACE) National Coastal Mapping Program (NCMP) (http://shoals.sam.usace.army.mil/Mapping.aspx) provides high-resolution bathymetric and topographic lidar elevation data, as well as hyperspectral and true-color aerial imagery along a 1-mile swath of the coastal U.S. on a recurring basis. NCMP regional data and products are a unique information asset immediately available to support regional sediment management, quantifying coastal resilience, coastal asset management, regulatory, flood damage risk reduction, emergency operations, and environmental stewardship in the coastal zone.



Products

NCMP lidar and imagery data are developed into a suite of standard GIS-ready products including Digital Elevation Models (bare earth models), Digital Surface Models (with vegetation and man-made structures), aerial photo and hyperspectral image mosaics, laser reflectance images, volume and shoreline change, and coastal structure metrics. Geomorphic and environmental features extracted from the standard products are measureable indicators of the condition of the coastal zone, such as dune height, beach width, shoreline change, shoal volumes, coverage and characteristics of land cover/use, critical habitats (e.g. submerged aquatic vegetation, wetlands, etc.), and impervious surface. The features may be used to track vulnerabilities to coastal hazards, develop sediment budgets, evaluate coastal resilience, model habitat suitability, and monitor restoration.

Benefits

NCMP provides consistent, re-occurring, regional data to characterize physical, environmental, and economic conditions along the shoreline, and how they change over time. Quantification of regional conditions and changes leads to improved management practices of entire regions and projects within those regions. Without these data, the Corps cannot fulfill its goal of a resilient, systems approach to coastal management of navigation, coastal flood risk reduction, and ecosystem restoration projects.

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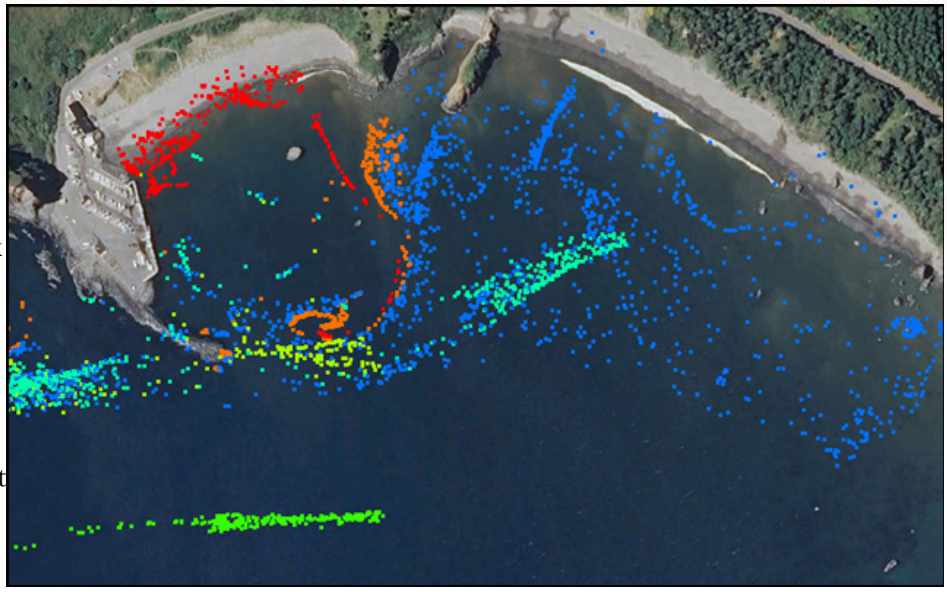
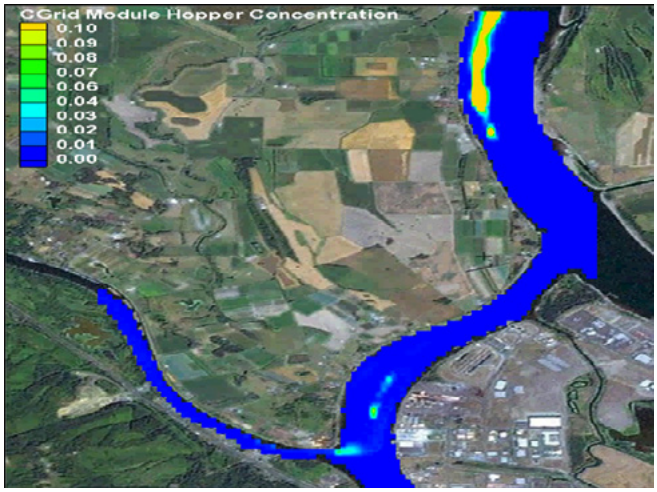
The Particle Tracking Model (PTM)



The Particle Tracking Model (PTM) is a Lagrangian particle tracker designed to determine the fate of multiple constituents (sediment, chemicals, debris, biota, etc.) released from local sources (dredges, placement sites, outfalls, propeller wash, etc.) in complex hydrodynamic and wave environments. Each local source is defined independently and may have several constituents. Model results include the fate of each constituent from each local source. PTM simulates particle transport using pre-calculated, periodically saved hydrodynamic (and wave) model output from state of the art models. PTM uses processes vital to constituent transport including but not limited to advection, diffusion, settling, deposition, and resuspension. The PTM interface is in the Surface-water Modeling System, which provides a user-friendly environment for input development, model execution, data analysis, and visualization.

Example Studies

- Coos Bay dredged sediment placement study (Portland District)
- Port Orford breakwater sediment transport study (Portland District
- James River dredged sediment placement study (Norfolk District)
- West Maui region nearshore sedimentionation (Honolulu District)



Products

Guidance, Model access, and PTM documentation can be found at the following sites:

- https://doer.el.erdc.dren.mil/ptm.html
- http://spatialdata.sam.usace.army.mil/DredgingTechnologies

Benefits

PTM supports environmental risk assessment, beneficial sediment use and habitat protection. The computational efficiency of PTM permits simulation of multiple predictive scenarios to determine transport pathways and exposure in environmentally sensitive areas, thereby identifying options which can ultimately reduce anticipated expenditures, risk, and consequences in coastal, estuaries, and inland waterways. In addition, PTM is independent of any one specific hydrodynamic model, allowing the user flexibility with regard to hydrodynamics.

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Rapid Aerial Recon and Analysis

USACE has collaborated with the UNM GIScience for Environmental Management Lab, the U.S. Air Force Civil Air Patrol, and Bureau of Land Management to implement the sensor array and conduct aerial data collection. Movement of sediment in the southwestern United States tends to be initiated by flash flood events due to monsoons. These events are short-term and occur under monsoonal weather conditions, which make it difficult to accurately measure sediment volumes and movement using common terrain mapping technologies such as aerial Lidar. The major impediments to using these methods are the short notice to activate flight missions and the inability to rapidly develop maps. This project develops tools to facilitate the rapid production of sediment-related measurements. Initial flights have been conducted with promising provisional results, and work is being done to produce additional tools for ongoing monitoring.

Example Studies

In FY2017, this project conducted multiple flights along the Rio Grande. Data collected during peak spring runoff captured floodplain habitat and levee inundation. Flights were conducted of the Arroyo de los Piños research site in Socorro, NM, the focus of extensive, ground based, instrumented bedload and suspended sediment monitoring by USBR, USGS, and NMT. The Rio Chama was imaged between El Vado Reservoir and Abiquiu Lake in cooperation with BOR and UNM's CWE and GEM lab. The imagery from these flights will be used for high resolution geomorphic and vegetation analysis.

Products

Immediate products are high resolution aerial imagery of the area of interest. Derivative products include high resolution georeferenced orthophotography and digital terrain models. Four band imagery allow for creation of vegetation indexes for ecosystem health.

Benefits

Sediment transport volume data provide critical geomorphic snapshots for the calibration of hydraulic models. These models provide the foundation for Rio Grande tributary and main stem operations and dredging, restoration efforts and efficient endangered species protections measures.

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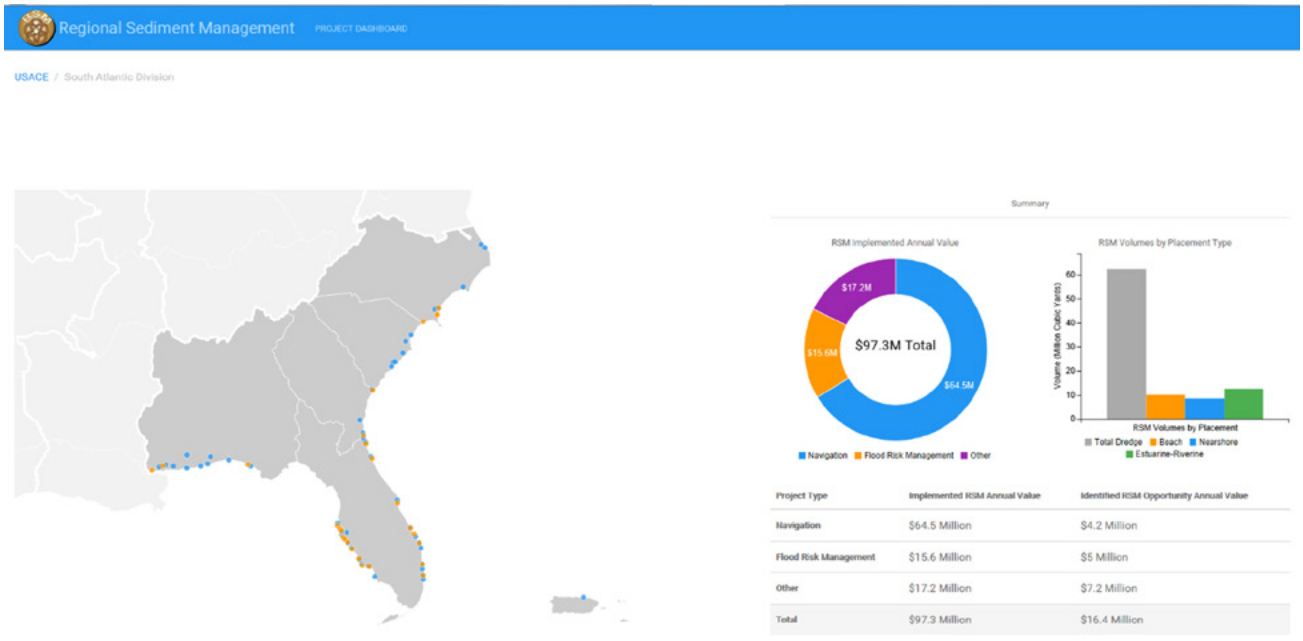
RSM Economic Value and Dredge Fleet Scheduling Optimization Pilot

The Regional Sediment Management (RSM) Economic Value and Dredge Fleet Scheduling Optimization Pilot (OP) was developed as a pilot study with the South Atlantic Divison (SAD) to quantify the economic value of applying RSM principles and practices across multiple projects and business lines (Navigation and Flood Risk Management) as well as identify additional efficiencies that can be gained by evaluating the dredge plants assigned to navigation projects and the planned schedule over the course of the dredging season. The result is an actionable and optimized RSM strategy that will most efficiently execute the Navigation (NAV) and Flood Risk Management (FRM) program budgets which maximizes the amount of dredging while also increasing the amount of RSM opportunities implemented to create value for the nation. The OP provides placement options and associated project costs for NAV and FRM for projects throughout SAD, providing decision-makers with the information they need to manage and execute RSM projects.

Products

The products for the RSM OP include a web application (currently available at sajgeo.saj.usace.army.mil/rsm-dash, will be migrated to the USACE Navigation Portal at navigation.usace.army.mil) and a report.



Benefits

All coastal NAV/FRM projects in SAD were analyzed and $97 million in annual value was calculated from implemented RSM strategies and identified an additional $16 million in opportunities. Annual value to USACE Federal projects was estimated at $65 million for the NAV program, $16 million for the FRM program. Non-Federal value to partners and stakeholders which is provided at no extra cost to the Federal government was valued at $17 million annually. In addition to fiscal efficiencies, RSM projects foster positive relationships and provide for more resilient and sustainable projects and programs.

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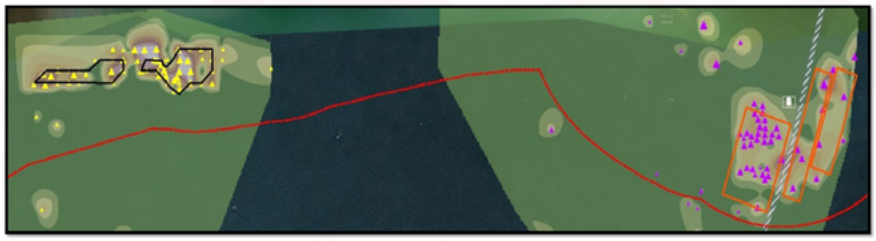
Sediment Analysis & Geo-App (SAGA)

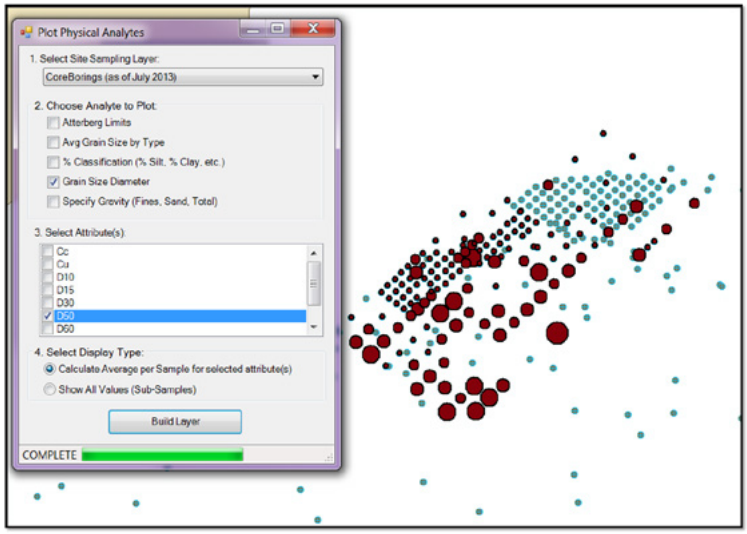
Analysis of sediment resources is not a standardized process. It is also often time-consuming due to the lack of a consistent archive method and data storage format. As a result, most analyses are completed with dated techniques that cannot fully realize the potential of the digital dataset. The Sediment Analysis and Geo-App (SAGA) database and application were developed to address this problem.



SAGA database and geoprocessing tools used to assist in the identification of potential borrow areas.

SAGA database and tools provide a comprehensive user interface to assist in the data entry, organization, and presentation of sediment sampling events and testing results. Supporting both coastal and riverine environments, SAGA is an archive for borings, grab samples, wells, monitoring areas, and river gages, and any associated information to the sampling activity. Per site, a user can retrieve information available for the site, including digital documents, record of the drilling log, lithology, and results of sediment testing for physical, biological, and chemical charateristics.

The SAGA database and reporting tools are available as a resource on the Navigation portal accessed through, http://navigation.usace.army.mil/SEM/Analysis. This read-only portal is publically available and allows all users to retrieve sediment property details. Users can download data entry templates and ArcGIS Desktop tools through USACE's GeoPlatform, http://geoplatform.usace.army.mil/home/item.html?id=43303eada70f45b5bc25322662f85140



Mapping tools change the symbology of the sites based on grain size diameter.

Example Studies

The SAGA contains data from the USACE Louisville District (LRL), Memphis District (MVM), New Orleans District (MVN), St. Louis District (MVS), Vicksburg District (MVV), Omaha District (NWO), Philadelphia District (NAP), Charleston District (SAC), Jacksonville District (SAJ), Mobile District (SAM), Galveston District (SWG), and ERDC's Field Research Facility (FRF).

Benefits

Primary benefits of SAGA include providing a standard data schema, a home for data storage, and an easy access point for data discovery. The objective of the SAGA database is to provide the District with rapid assessment tools to make informed decisions regarding physical characteristics of a project. SAGA is designed to fit into the Data Intergration Framework (DIF); therefore, components and data can easily be leveraged by other tools or applications that could benefits from access to characteristics of sediment data.

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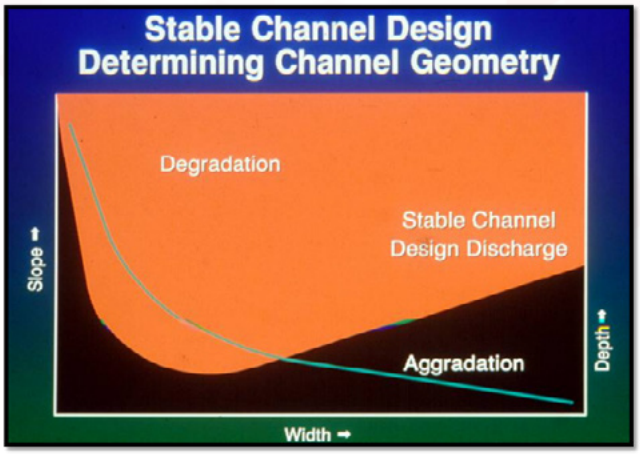
SAM: Hydraulic Design Package for Channels

SAM is an integrated system of programs developed to aid engineers in analyses associated with designing, operating, and maintaining flood control channels and stream restoration projects. SAM was designed primarily to satisfy the need for qualitative, easy-to-use methodology, especially for use in preliminary screening of alternatives. SAM provides the computational capability to evaluate erosion, entrainment, transportation, and deposition in alluvial streams. Channel stability can be evaluated, and this evaluation can be used to estimate the cost of maintaining a constructed project. Where appropriate, SAM implements guidance from:

- EM 1110-2-1418, Channel Stability Assessment for Flood Control Projects, and
- EM 1110-2-1601, Hydraulic Design of Flood Control Channels.



Example Studies

SAM has been applied in numerous studies including stable channel design for the Truckee River and sediment impact assessments for Rio Hondo and San Juan, Alabama, and Apalachicola Rivers.

Products

SAM includes three main modules that can be used separately or in tandem for various channel design situations:

SAM.hyd calculates the width, depth, slope and n-values for stable channels in alluvial material, and can calculate riprap size as well as normal depth and composite hydraulic parameters for a cross section with variable roughness.

SAM.sed calculates sediment transport capacity according to a wide range of sediment transport functions, usually using the hydraulic parameters calculated in SAM.hyd.

SAM.yld integrates flow duration with the sediment transport capacity calculated in SAM.sed to calculate sediment yield over a given time frame.

SAM modules can be operated as stand-alone executables or through a Windows interface, SAMwin. SAM and SAMwin may be freely distributed within the US Army Corps of Engineers. Ayres Associates of Fort Collins, Colorado, developer of the SAMwin interface, holds distribution rights outside the Corps of Engineers.

Benefits

SAM can be used to rapidly identify potential channel instability, and then determine the magnitude of that instability. SAM can also be used to evaluate the relative effects on channel stability, in terms of reducing aggradation and/or degradation, of various project proposals. SAM provides an inexpensive way to make a reliable determination of the extent of investigation a project will require.

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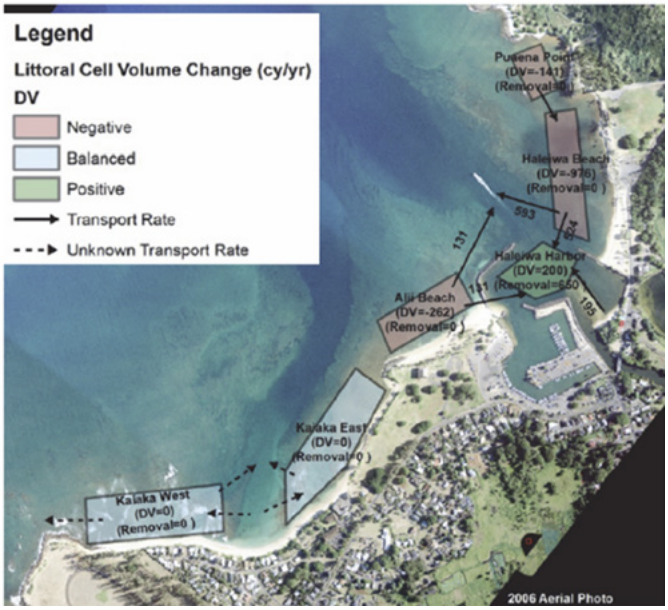
Sediment Budget Analysis System (SBAS)

The Sediment Budget Analysis System (SBAS) is a tool run within ArcGIS 10.1 and higher which provides the framework for formulating, documenting, and calculating sediment budgets, including estimation of uncertainty and reliability of the budget. A sediment budget is created to develop an understanding of sediment sources, sinks, transport pathways, and magnitudes for a selected region over a specific period of time. It is a balance of volumes of sediments entering and leaving a defined section of coast which results in erosion or accretion in the area.

SBAS is available on the Regional Sediment Management (RSM) Website (http://rsm.usace.army.mil) under Tools & Databases. The newest version of the tool is called SBAS-A Desktop Tool. The link opens the Geospatial Platform where the tool can be downloaded. ArcGIS 10.1 or higher must be installed in order to use the SBAS tool. Older versions of the tool (ArcGIS AddIn and the stand-alone PC version) can be downloaded on the CIRP Website (http://cirp.usace.army.mil/products/sptools.php).



Example Studies

BAS has been used to successfully illustrate sediment budgets for RSM for more than 15 years. Some recent applications using SBAS include Assateague Island and Ocean City Inlet, MD; Saco Bay, ME; Galveston, TX; and North Illinois from Wilmette, IL, to the Illinois-Wisconsin border.

Products

The RSM and CIRP Websites include several Technical Notes and Journal Papers describing how to develop and calculate a sediment budget. The RSM and CIRP Websites also have documentation on how to create a sediment budget in the older versions of SBAS. A user's guide which describes how to set up and use the tool is included in the download of the newest version of SBAS. There are also many Technical Notes and Technical Reports describing sediment budget studies using SBAS.

Benefits

Sediment budgets provide an understanding of the magnitudes and pathways of sediment transport at inlets and adjacent beaches over a given time period. SBAS helps Districts formulate sediment budgets, because the color-coded, visual capabilities provide an integrated picture of the processes and allow for variations in the budget to be examined quickly.

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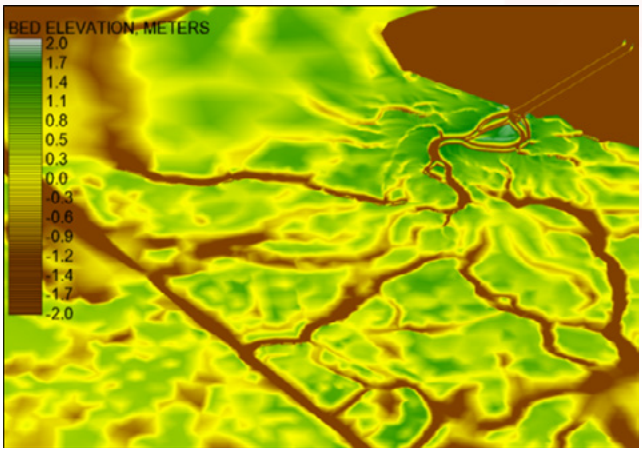
Sediment Transport Library (SEDLIB)



SEDLIB is a sediment transport library. It is capable of solving problems consisting of multiple grain classes, cohesive and cohesionless sediment types, and multiple bed layers. It calculates erosion and deposition processes simultaneously, and simulates such bed processes as armoring, consolidation, and discrete depositional strata evolution.
The SEDLIB library system is designed to link to any appropriate numerical model. The main requirement of the numerical model is that it must be capable of performing both hydrodynamic calculations, and advection diffusion calculations for a constituent. SEDLIB interacts with the numerical model by providing sources and sinks to the advection diffusion solver in the model. The solver is then used to calculate suspended load transport (for silt and clay classes), both bedload and suspended load transport (for sand classes) and bedload transport (for gravel classes), for each grain class. The sources and sinks are passed to the numerical model via a fractional-step formulation of the source/sink bed sediment flux, for both suspended load and bedload.

SEDLIB has been linked in this fashion to both the AdH and the GSSHA numerical modeling systems. SEDLIB forms the basis of all sediment transport computations performed with AdH. SEDLIB has very recently been linked with GSSHA. All future releases of GSSHA will rely on SEDLIB for all in-channel sediment transport calculations.

Background documentation for SEDLIB is available at the AdH Website (https://chl.erdc.dren.mil/adh/main/index.html).

Example Studies

SEDLIB, linked to AdH, has been applied broadly within the Corps of Engineers, on both regional and local scales. For RSM studies, SEDLIB/AdH has been successfully applied to The Mississippi River at Head of Passes, The Mississippi River at St. Louis, Missouri, and The Calcasieu Ship Channel.

Products

SEDLIB is generally invoked via the numerical model with which it is associated. For AdH, SEDLIB is fully integrated into the AdH framework. Hence, SEDLIB documentation and guidance are available through AdH workshops, webinars, and the AdH webpage (https://chl.erdc.dren.mil/adh/main/index.html). For GSSHA, the attendant documentation will be made available when the release version of SEDLIB/GSSHA is made available.

Benefits

SEDLIB provides robust, broadly applicable sediment transport capability, that is currently associated with both AdH and (most recently) GSSHA. It can be used to address a wide array of sediment transport issues within the Corps of Engineers.

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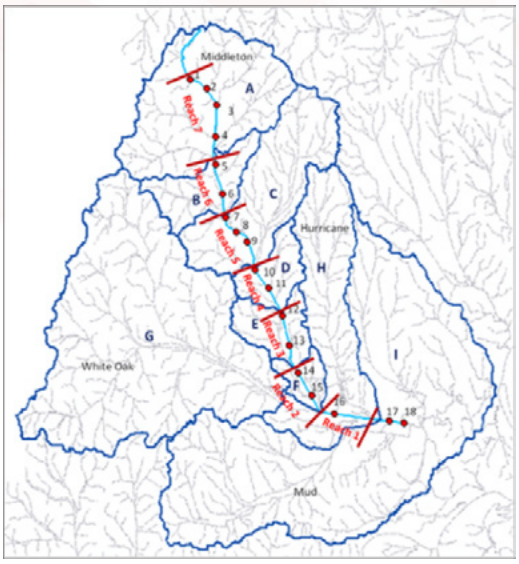
Sediment Impact Analysis Method (SIAM)



The Sediment Impact Analysis Method (SIAM) is designed to provide a sound technical basis for sediment management on a watershed scale. The common goal of many regional sediment management projects is the reduction of sediment derived from the watershed. This is usually accomplished by a combination of measures, including grade control, bank stabilization, storm water management, and land treatment. While these measures are often intended to reduce sediment loads to downstream reservoirs, flood control channels, or wetlands, they may have unanticipated negative consequences on the stream channel network. For instance, watershed-wide streambank stabilization measures may cause channel incision or induce erosion of sand bars valuable as nesting habitat. Until now, it has been difficult to evaluate the cumulative impacts of sediment reduction strategies. SIAM is an excellent tool for the rapid assessment of multiple rehabilitation alternatives, particularly in the reconnaissance and feasibility phases of a project. It provides a framework to combine sediment sources and computed sediment transport capacities into a model that can evaluate sediment imbalances and downstream sediment yields for different alternatives.

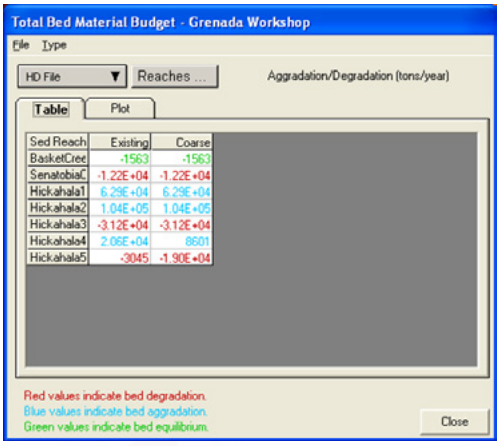
SIAM aims to integrate watershed-scale sediment continuity concepts into stream rehabilitation and management. The analysis will provide an intermediate step between qualitative evaluations and comprehensive mobile boundary numerical models. SIAM provides a framework to combine hydrology, hydraulics, and sediment supply into a geomorphic assessment and rehabilitation design. With sediment as the number one ranking pollutant in streams and a contributing agent in many others, the addition of SIAM into the river-engineering toolkit will empower designers and planners to more easily consider sediment supply and transport in management and rehabilitation of channel systems.

Example Studies

SIAM has been applied to river systems around the world, including the Mississippi River; Mt. St. Helens, WA; Judy's Branch, IL; the Delta Headwaters Project, MS; Bronx River, NY; Hawkcombe Stream, UK; Kankakee River, IL & IN; and White Oak Creek, TN.

Products

SIAM is available within HEC-RAS from the Hydraulic Design Functions menu. Interested Districts may also request SIAM training and assistance through the WOTS and DOTS programs.



Benefits

SIAM is intended as a screening-level tool to look at the impact of river engineering projects on aggradation and degradation throughout a watershed. Typical SIAM model runs take less than a minute on a desktop PC, allowing for the rapid assessment of the impacts of multiple scenarios before proceeding to detailed sediment transport modeling.

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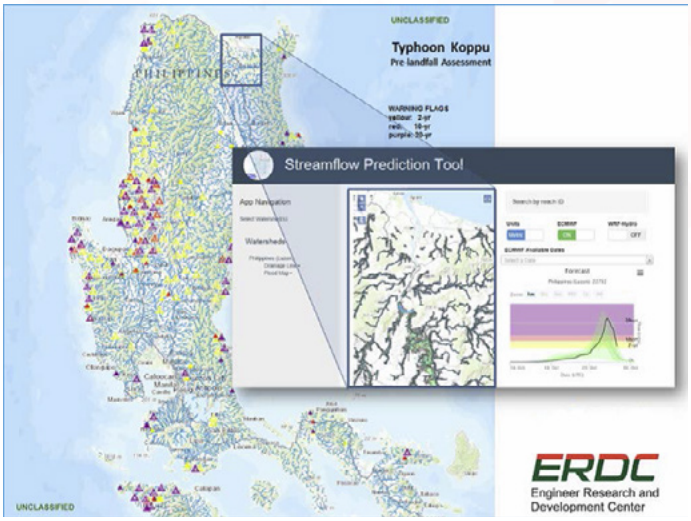
Streamflow Prediction Tool (SPT)

The Streamflow Prediction Tool (SPT) is the newest capability developed by ERDC and university partners to provide actionable flood forecasting assistance to the military. The SPT provides both historical and 15-day forecasted flows and flood inundation estimates for a dense network of streams worldwide. Streamflow forecasts are produced using input meteorological forecasts from the European Centre for Medium-Range Weather Forecasting (ECMWF), which are routed into streamflow values using the Muskingum method employed by the Routing Application for Parallel computation of Discharge model (RAPID). Model performance is robust, and is improved through the inclusion of reservoir routing information.



The Streamflow Prediction Tool is currently hosted through the Hydrologic Systems Branch of the Coastal and Hydraulics Laboratory at the Engineering Research and Development Center. Daily operational forecast values are available for regions of interest and can be accessed through the research team. Technical and performance documentation for the routing model is available at http://rapid-hub.org/index.html.

Example Studies

The Streamflow Prediction Tool was used to provide situational awareness for potential humanitarian assistance efforts from Typhoon Koppu. ERDC personnel developed and deployed a model for Luzon, Philippines, days prior to landfall. A flow forecast and flood inundation map for every river reach on the island was developed within hours of notification. The tool is also used to provide reachback support to deployed units in austere environments. Current efforts include aligning the tool with other input data sets, and potentially using the tool to predict the temporal effects of inland high flows on dredging needs at coastal ports.

Products

The Streamflow Prediction Tool is currently available through a Tethys web application. Users need to request access through the Hydrologic Systems Branch. The tool interface allows users to download a flow time series for selected reaches for both the historical modeled flows (for years 1980–2014) and the current 15-day forecast for operational basins. Basins are added to the forecast operations as needed.

Benefits

The Streamflow Prediction Tool forecasts flow and flood inundations using globally-available data. This provides planners and personnel with a responsive first look at flood inundations. It makes available streamflow time series for reaches which are ungaged and would otherwise not have data available. The SPT was developed to provide immediate rapid flow information in parts of the world where data is sparse, without requiring labor- and computation-intensive modeling.

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Temperature Flume

The Temperature Flume is 3 feet (ft) wide, 1 ft deep, and 80 ft long and tilts up to a 1.8% grade. Its highest discharge is 5.25 cubic feet per second (cfs). The Temperature Flume is ideal in size for many applications where funding, materials, or time is limited. The ability to tilt the flume is invaluable asset in the evaluation and isolation of free surface hydraulic phenomenon. By adjusting the flumes slope a wide range of normal depth is possible. Normal depth eliminates local acceleration of flow; thus, simplifying the laboratory procedures and data collection.

Example Studies

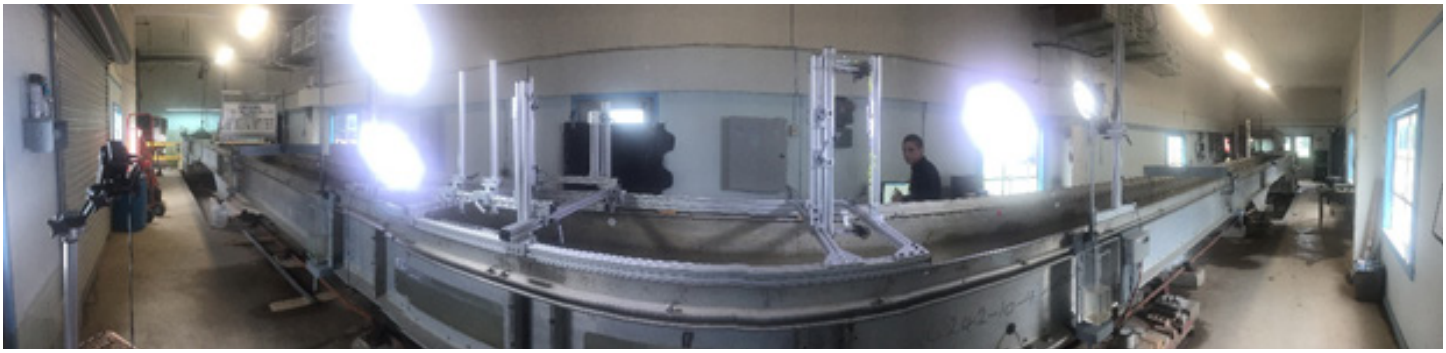
The flume was designed in the 1950's to evalute the impacts of water temperature on sediment transport. Continuing with this histroic tradition of sediment related work, a majority of the studies in recent years have focused on sediment transport and include: gradational disequilibrium and bed load dispersion experiments, surface roughness tests, pier scour, Santa Ana section model, initiaition of motion testing,and scour testing. Additionally, hydrodynamic work has been done to include Improved Ribbion Bridge evaluation and rapid repair of levees and locks.

Products

Multiple Technical Notes, Letter Reports, and Journal Papers have been published as a result of the work done in the Temperature Flume. Additionally, procured data sets have been used to evaluate and analyze the above processes for the production of quantitative approaches both analytically and numerically.

Benefits

The Temperature Flume serves a multi-functional role for physical modeling efforts for both research and reimbursable efforts. It allows for the collection of high fidelity data sets for the verification and validation of numerical models. Data collection includes water surface profile, discharge, bedload transport rate, velocity (ADV and LDV), particle tracking, bed tracking, and slope data. For rapid small scale efforts the Temperature flume is the ideal facility.



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