

Dredged Material Spatial Management, Analysis, and Record Tool (DMSMART)

PURPOSE: This technical note describes the Dredged Material Spatial Management, Analysis, and Record Tool (DMSMART), a personal-computer- (PC-) based software package being developed to assist Corps staff in managing their dredging and dredged material placement activities. Feedback on its features and implementation is requested. Also described is an existing software package, the Disposal Analysis Network for New York (DAN-NY), currently available from Science Applications International Corporation, which formed the basis for DMSMART.

BACKGROUND: Managing dredging and dredged material placement has become more complicated as the number of regulations applicable to these activities has increased, and resource agencies and environmental groups have subjected the Corps to greater scrutiny on dredging projects. A customized Geographic Information System- (GIS-) based software system can be used to greatly facilitate dredging project management. Recent advances in computer hardware and software have allowed the development of sophisticated, but easy-to-use GISs for PCs.

Challenges faced by the U.S. Army Engineer District, New York, in managing their open-water disposal site, the Mud Dump site, led to their funding development of a district-specific software package for site management, DAN-NY. Delivered in June 1997, DAN-NY was developed as a joint effort between two contractors (Science Applications International Corporation (SAIC) and Applied Science Associates (ASA)) and the U.S. Army Engineer Waterways Experiment Station (WES). Present users of DAN-NY (including the New York District, WES, and SAIC) have all been impressed with its ability to facilitate site management.

WES association with the New York District and DAN-NY development, along with general site management experience, led to the conclusion that a Corps-wide software package for managing various aspects of the dredging and placement process would be valuable. Under the Dredging Operations and Environmental Research (DOER) Program, WES is heading the development of DMSMART. Like DAN-NY, DMSMART will be a GIS-based software package customized for the dredging/placement application, and it will also include several WES models. To effectively use DMSMART once the initial software development is complete, Corps Districts need to begin developing databases of dredging project and placement site monitoring data.

This technical note consists of a description of dredging and placement site management challenges that are well-suited to the capabilities of a GIS-based software system. This is followed by descriptions of the New York District site management difficulties that led to DAN-NY development, DAN-NY specifications, a discussion of DMSMART, and finally a description of the DMSMART implementation plan.

SITE MANAGEMENT CHALLENGES

Federal regulations require that dredging and dredged material placement be done at minimum cost while being consistent with sound engineering principles and proper concern for the environment. Over the past two and a half decades, knowledge of the environmental impacts associated with dredging and dredged material disposal has increased. The emphasis has shifted from one that was most concerned with low cost to a much more balanced view with environmental concerns playing an increasingly larger role in dredging project management. Also, the awareness that dredged material should be considered a resource that can be used beneficially in an increasing number of ways has greatly influenced dredging project management.

For the reasons mentioned above, managing dredging projects is now much more complicated than in the past. In addition to the ever-increasing number of regulations and statutes that govern dredging and dredged material placement, many State resource agencies and environmental groups now subject dredging projects to greater scrutiny. Just doing a good job is no longer sufficient. To improve or maintain its credibility, the Corps must be able to conclusively demonstrate that dredging projects are being effectively managed.

Management of dredging and dredged material placement, referred to hereafter as dredging project management, has a number of facets. Dredging project management provides answers to the following questions:

- What is being dredged?
- How much is being dredged?
- When will dredging take place?
- Where did dredged material come from?
- Where will dredged material be placed?
- How will material be dredged and placed?
- What will happen to the environment at the dredging site? At the placement site?
- Was material dredged correctly? Placed correctly?
- Could dredged material be used more beneficially?
- Could project have been completed at a lower cost?

In more general terms, dredging project management is controlling the dredging project to meet regulatory guidelines of low cost, sound engineering, and environmental stewardship. A more detailed discussion of managing open-water dredged material placement can be found in Walls et al. (1994). An important facet of dredging project management is long-term planning, developing placement options that have sufficient site capacity for the next 20 to 50 years.

The increase in regulations, number of contaminants tested for, and projects for which tests are conducted has vastly increased the amount of data collected during execution of the dredging project. This has resulted in greater numbers of bioassay and bioaccumulation tests. At the

placement site, tests for sediment chemistry and tissue chemistry are becoming more routine. Use of sediment profile imagery (SPI) is becoming more routine to detect layers of dredged material at thicknesses below those resolvable from bathymetric surveys.

Dredged material placement is now receiving much greater interest. Confirming that the contractor is meeting contract specifications for placing material in precise locations inside the disposal site (not outside the site, which could potentially damage nearby resources) is considerably more important and more practical. A related issue is the increased time and cost required to designate new sites. This makes controlling placement within the disposal site to maximize site capacity while minimizing environmental impacts even more significant.

The ability to manage all these diverse data and use them effectively meshes well with the strengths of a GIS-based system. A GIS is an excellent tool to archive, display, and analyze spatial data. Many of the difficulties of site management result from the inability to easily access the data and display it on a common datum. Using the spatial nature of the data, the GIS's database can contain the many different types of data in layers that can be easily retrieved and displayed.

In addition to dredging project management, resource agencies and environmental groups have become more involved in the dredging process, resulting in substantial increases in the number of requests for information. Also, the number of lawsuits associated with dredging projects has increased, adding to the number of requests Districts receive for information. Providing timely answers with a minimum of effort can be difficult. The relational database included as part of the GIS allows a range of queries to be made with minimal effort.

Concerns over the fate of dredged material during dredging and during and after placement in the disposal site are increasing. The ability to predict water column impacts during dredging and placement, the area of the bottom covered by a placement operation, the height of the mound created during a placement operation, and the long-term stability of a dredged material mound can all be crucial to obtaining resource agency permission to execute a given dredging project. Reliable prediction of long-term mound stability is critical to both maximizing site capacity and to creating effective site management plans.

Over the years, WES has developed or refined a number of numerical models that predict various aspects of dredged material fate that can be used to address concerns such as those just discussed. However, the ability of District staff to use these models has often been limited by less than user-friendly interfaces combined with difficulties in accessing the data needed to drive the models. A number of the WES dredged material fate models are to be included in DMSMART. Prior limitations on difficulty of use and access of input data will be overcome.

The above discussions show that a GIS software package with access to WES dredged material fate models could facilitate dredging project management. The following section describes the specific site management challenges faced by the New York District that prompted the development of a District-specific open-water site management software system.

DAN-NY

Background

Historically, the New York District has had a difficult open-water dredged material placement site to manage. The Mud Dump site, a 2.1- by 3.7-km rectangle located 11 km east of Sandy Hook, NJ, has been used since interim designation in 1973. The site's proximity to commercial and recreational fishing areas, historic disposal sites, and heavy shipping through the approaches to New York Harbor create a unique set of circumstances from a site management perspective. For most of the time since site designation, the site has received an average of 4.3 M m³ per year of mostly fine-grained maintenance material (Massa et al. 1996) from an average of 20+ Federal and private projects.

Over the years, challenges in three different areas led the New York District to fund development of the first software package for managing open-water disposal sites, DAN-NY (Clausner, McDowell, and May 1997). The first management challenge was concern over site capacity. The desire to maximize site capacity (and not to exceed safe navigation depths) and contain the sediments inside the site was a major driving factor for developing a computerized GIS system to provide a more sophisticated level of site management. The second concern was the desire to improve capping of contaminated dredged materials placed in the Mud Dump site. The third major need resulted from the variety of locations and media on which the New York District stored information relevant to site management. It was difficult to access and display the data needed to make decisions.

Both WES and SAIC have supported the New York District in their site management activities for many years. SAIC collected a considerable amount of monitoring data at the Mud Dump site and assisted with operational details for capping operations, while WES assisted in capping project design (Randall, Clausner, and Johnson 1994) and computations of site capacity (Clausner and Greges 1995). In 1994, SAIC proposed joint development of a software system, DAN-NY, to assist the New York District with open-water site management. In the joint effort, SAIC's expertise in monitoring and data collection was combined with the strengths of ASA, a firm specializing in hydrodynamic numerical modeling using GIS, and WES' expertise in capping, fate modeling, and site capacity.

Phased Implementation

DAN-NY is being developed in phases. Phase 1 was a system design study, which defined data types, hardware, software, costs, and schedule for implementing subsequent phases. Phase 1 was completed in May 1996 (SAIC 1996). Phase 2 was to design and implement the system including developing and documenting data management systems and training of New York District and WES staff. Concurrent with Phase 2 was Phase 3, which selected the data needed and then populated the databases. Phases 2 and 3 were completed in June 1997. Phase 4, now underway, is to maintain the system, add enhanced software and analysis, and continue populating the database with additional data sets.

DAN-NY functions at two levels. It has quick access to maps and summary information for use by upper level management or in-depth (extended analysis) capabilities for the technical user. Quick access features (available by selecting one or two options from the opening menu) allow the user to view and print any bathymetric surveys in the database along with the more recent barge placement locations. In the extended capabilities mode, the user has access to an array of tools that will apply to many day-to-day activities as well as longer term planning and design related studies. Figure 1 shows the range of tasks that can be done in DAN-NY. In addition to the more obvious abilities to display bathymetric survey data in a wide range of options, DAN-NY can accomplish the following:

- Compute site capacity.
- Predict mound geometry using the Multiple Dump FATE of dredged material (MDFATE) model developed as part of the Dredging Research Program (DRP) (Moritz and Randall 1995).
- Display the mound created and compute volumes.
- Associate mounds with buoy locations.

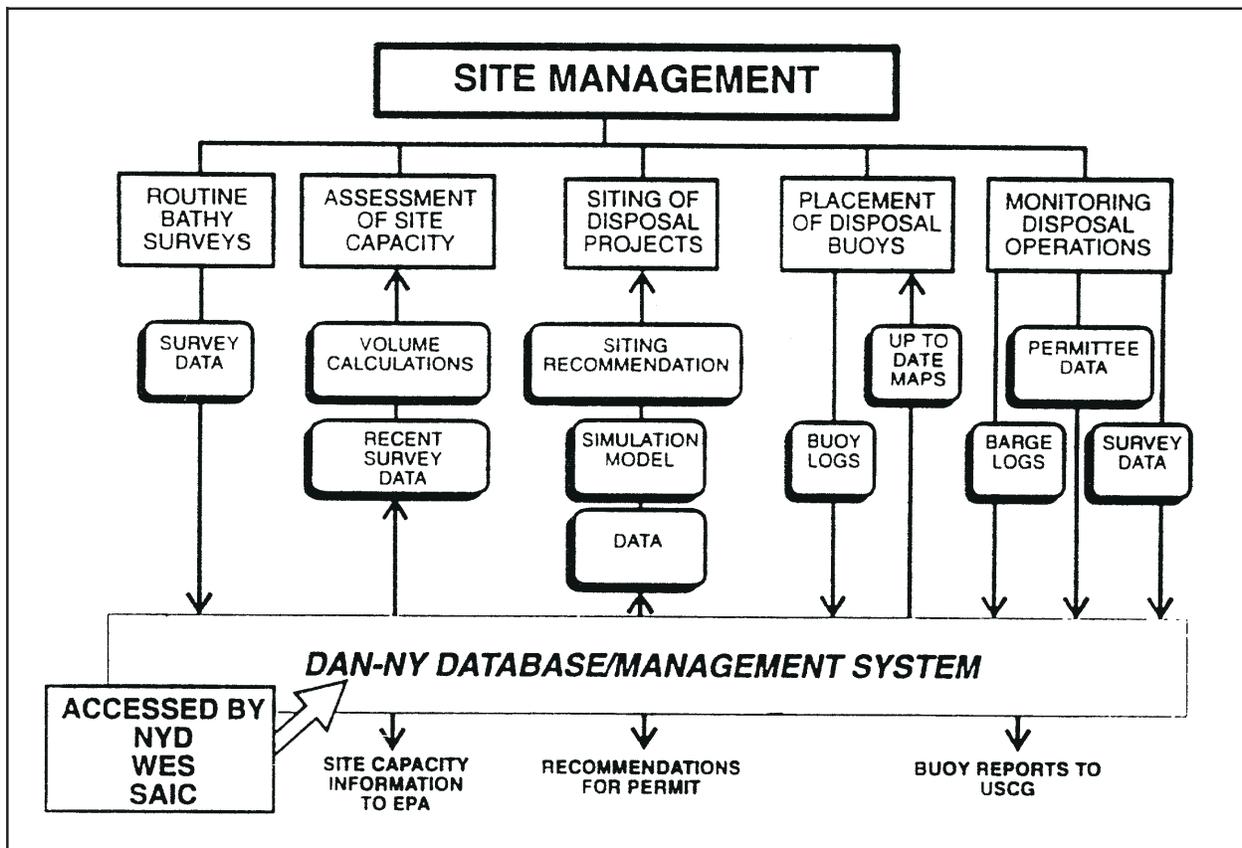


Figure 1. Site management activities supported by DAN-NY

- Review barge disposal logs.
- View SPIs.

DAN-NY Hardware and Software

With the exception of the specialized software applications developed by SAIC and ASA, all hardware and software for DAN-NY are nonproprietary and readily available. DAN-NY is used on a PC with minimum capabilities of a 166-MHz CPU, 32 Mbytes of RAM, 2-Gbyte hard drive, and 6x CD-ROM. All software is 32-bit to increase operating speed; the operating system is Windows NT 4.0; the GIS system is ArcView 3.0; and the database is Microsoft Access. A GIS expert is not required to operate DAN-NY. Most of the functions a site manager would require have already been built in. Present users of DAN-NY were proficient with the software after 2 days of training. Training for the quick access features takes 2-3 hr.

DAN-NY Databases

Table 1 lists the data types and the number of each type of data populated in DAN-NY during Phase 3. SAIC made a considerable effort to meet the METADATA standards now required. All data entered into the database met SAIC's quality assurance/quality control (QA/QC) specifications. All data are provided on CD-ROMs, with periodic updates via new CD-ROMs.

Table 1 Data Types Initially Included in DAN-NY
Bathymetry (>27 surveys)
Sediment profile imagery (10 surveys)
Sediment chemical and physical analyses (7 surveys)
Barge disposal logs (1,785 logs)
Side-scan sonar (2 surveys/1 image)
Planform photographs (5 surveys)
Tissue analyses (chemical and physical) (4 surveys)
Disposal buoy locations (645 logs)

DAN-NY Application to the 1997 Capping Project

The beta version of DAN-NY was used to assist in the design of the capped contaminated sediment mound project placed in the Mud Dump site during the summer of 1997 (Clausner et al. 1998). This early version of DAN-NY proved to be extremely valuable in designing the operational plan for placing 253 barge loads containing nearly 530 k m³ of contaminated material (McDowell et al. 1998). The resulting mound was being capped with approximately 1.5 M m³ of sand. During the 1997 capping project, DAN-NY's ability to display barge disposal locations, most of which were provided by a barge-mounted silent inspector, proved to be invaluable for managing the project (Pace et al. 1998).

DMSMART

Knowledge of dredging project management challenges and involvement with DAN-NY led WES to propose development of DMSMART under the DOER Program's Comprehensive Open Water Site Management System work unit. DMSMART will build on the experience gained with DAN-NY. Because of the complexity of site management problems, DAN-NY already has many features that will be helpful to other Corps Districts, and will be considered for DMSMART. However, DMSMART will be an improvement over DAN-NY in several key ways. DMSMART will include data on the dredging site in addition to the disposal site. This should greatly increase its utility. In addition to open ocean sites, the types of disposal sites allowed within DMSMART will be expanded to include riverine and estuarine sites. The ability to manage confined disposal facilities will also be included. DMSMART will include access to a greater number of WES models for predicting dredged material fate. DMSMART will be owned by the Corps; therefore, DMSMART software will be available without cost to Corps Districts. Corps Districts will be responsible for funding/developing databases.

Based on experience with DAN-NY and District input, the following concepts will guide DMSMART development. The initial version will be simple, concentrating on including dredging site data and expanding the fate models to include the Short Term Fate of Dredged Material (STFATE) (Schroeder and Palermo 1990, Johnson and Fong 1995) and Long Term Fate of Dredged Material (LTFATE) (Scheffner et al. 1995) models in addition to the MDFATE model. DMSMART will be flexible, so that additional models (e.g., some of the Automated Dredging and Disposal Alternatives Management System (ADDAMS) or DOER models) or other data types can be added later. In developing requirements for DMSMART, features that the majority of Districts agree are necessary will be included. However, if a District has a special requirement, the program and standards should be sufficiently documented so the feature can be added.

The key to maintaining flexibility is to develop standards for data and modeling. Standards will allow the software to be easily implemented Corps-wide, the program to be software independent, and allow the Districts to easily contract data collection and database creation. As part of the DMSMART effort, guidance documents with instructions for electronic formats and standards for data will be provided. Modeling standards will include methods for handling input and output files.

Additional models may be included in DMSMART based on the following principles. First, a significant number of Districts must indicate that a specific model will be useful. Second, a model must not require "in-depth" training for execution. For those models that may be useful to a District for managing dredging projects, but require WES staff for execution, an attempt will be made to include the capability to archive and display the model output file. If a District has developed software or specific applications for dredging project management that can be of general use, an attempt will be made to include the District development. For example, the Seattle District has demonstrated output of an ArcView-based application for tracking and displaying sediment contaminant concentrations. WES expects to use this or a similar application in developing DMSMART.

Another guiding principle is to continue to be aware of other databases and reporting requirements related to dredging project management and to allow DMSMART to extract or import data as

necessary. Potential databases with which DMSMART might interact include the Dredging Information System (DIS), the contaminated sediments database, and the regulatory database RAMS (Regulatory Analysis and Management System).

Data Types and Analysis Capabilities Planned For DMSMART

For the dredging site, data types included in DMSMART will be bathymetry, project locations, channel dimensions, sediment grain size data, and project history data such as past contractors and equipment used. If possible, the DIS database will be accessed for project history data. Probably the major effort for dredging sites will be to include the vast amount of sediment chemistry and biological testing data routinely collected. Disposal site data included in DMSMART will be similar to those in DAN-NY listed in Table 1. One of the principal efforts over the next few months will be to finalize the data types and analysis capabilities. Any District staff members that desire a more complete list of data types or analysis capabilities are urged to contact the author directly. A future technical note will provide more details on the data types and capabilities selected for inclusion in DMSMART.

Database Development

Of equal importance to software development is creation of each District's database of dredging project history and the dredging and disposal site monitoring data. Without the data, DMSMART is useless. Districts must populate their own databases using the guidance developed by the work unit. Therefore, one of the early products of the contract to develop DMSMART will be guidance documents on how to create the database, along with cost estimates for creating the database. Based on the number of sites, time, and funds available, each District will be able to decide how much data will go into the database initially, and make plans to have additional historical data entered at a later date. Obviously, data recently collected in electronic format will very likely cost less and require less time to put into the database. Depending on the District's needs and staff, database creation can be done in-house, under contract, or with a combination of the two. One method would be to contract out an initial block of data required for database entry of ongoing projects, then create future databases in-house as funds permit. It is important to assure that data have been QA/QC'd and meet METADATA standards.

Maintaining an up-to-date database will be a continuing activity after DMSMART is on-line. As with the database creation, this could be done in-house or by contractor.

Compatibility with Silent Inspector Data

During the DRP, theory, procedures, and standards were developed for a Silent Inspector (SI) to monitor hopper dredging operations (Cox, Maresca, and Jarvela 1995). The SI facilitates contract monitoring. It consists of a set of standards for collecting information on the dredge, processing this information to obtain dredge state and load, storing the information, and providing the data via reports. Some of this reported information may be transferred in real-time via a cell phone or radio link to the District. The full data set is then downloaded periodically. Under the DOER Program, the SI for hopper dredges will be taken from the prototype system developed under the DRP to a

working system for the Districts. In addition, plans to extend the SI to cutterhead and mechanical dredges/barge combinations are planned.

Some portions of the SI data will be quite valuable for inclusion into DMSMART. WES staff developing DMSMART and the SI are working closely so that the archived SI data can be accessed by DMSMART. Once again, a consistent set of standards and intelligent database design will be crucial for ensuring compatibility.

Schedule for Implementation

The present plan is to develop requirements for DMSMART through early CY98 with a scope of work (SOW) completed in spring of 98. A contract is expected to be awarded by early FY99, with delivery of DMSMART 1.0 during the summer of 99. Initial distribution to the Districts and training are planned for Sep-Nov 99.

As noted earlier, one of the first products from the contract will be a set of guidance documents describing how to create District databases. A training course is planned at WES to provide detailed instructions for District staff on database creation. The course would likely be offered in late winter or early spring of CY99.

Steering Committee/District Input

To assist WES staff in developing DMSMART, several different methods will be used. At the workshop, a steering committee was developed. The members are listed below:

- Dr. Tom Fredette (New England District)
- Mr. Paul Bradley (Mobile District)
- Mr. David Kendall (Seattle District)
- Mr. Don Borkowski (Buffalo District)
- Mr. Jim Aidala (Rock Island District)
- Mr. Tom Verna (Headquarters)

The steering committee members will be reviewing in detail the requirements, SOW, etc. Steering committee members will be asked to attend 1-2 meetings to assist in developing requirements. Other Corps District staff who would like to provide input are being solicited. These persons will be provided draft copies of the requirements, etc., and asked to provide comments.

To both inform District and Division staff of DMSMART and gain feedback, WES will be attending various meetings and providing briefings on DMSMART. In early August 1997, WES staff presented a DAN-NY demonstration and DMSMART overview to the Mobile District. In early September 1997, WES presented an overview of DMSMART to the East Coast Dredging Team meeting in St. Augustine, FL, and presented a DAN-NY demonstration and DMSMART overview to the Jacksonville District. Briefings on DAN-NY, DMSMART, and the SI were provided to

Seattle, Portland, and San Francisco Districts in December 1997. Other briefings are planned; interested readers should contact Mr. Clausner directly.

SUMMARY

Computer hardware and software have now advanced to the point where a GIS-based software package customized for managing dredging projects is a reality. The New York District has recently funded development of a District-specific software package (DAN-NY) for managing their open-water disposal site. DAN-NY has proved its value during a contaminated sediment capping project conducted during the summer of 1997. Under the DOER Program, a Corps-wide software package for managing dredging projects (dredging and disposal) is now being developed, the Dredged Material Spatial Management and Record Tool (DMSMART).

POINTS OF CONTACT: For additional information on DMSMART, contact the author of this technical note, Mr. James E. Clausner (601-634-2009, clausnj@ex1.wes.army.mil) or the DOER Program Managers, Mr. E. Clark McNair, Jr., (601-634-2070, mcnairc@ex1.wes.army.mil), or Dr. Robert M. Engler (601-634-3634, englerr@ex1.wes.army.mil). This technical note should be cited as follows:

U.S. Army Engineer Waterways Experiment Station. (1998). "Dredged material spatial management, analysis, and record tool (DMSMART)," Technical Note DOER-N2, Vicksburg, MS.

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