EXECUTIVE SUMMARY

Under the Disposal Area Monitoring System (DAMOS), sponsored by the New England District (NAE) of the U.S. Army Corps of Engineers (USACE), Science Applications International Corporation (SAIC) conducted a comprehensive field data measurement effort and follow-on modeling program to study the behavior of the dredged material placed at the Portland Disposal Site (PDS) during the 1998-1999 dredging season. Building upon the results of the 1995-1997 capping demonstration project at PDS, this follow-on study was intended to monitor the large-scale 1998-1999 Portland Harbor dredging project and to evaluate how well the Short Term Fate (STFATE) and Multiple Dump Fate (MDFATE) models forecasted the results of dredged material disposal operations at PDS. Both of these models were developed by the USACE Waterways Experiment Station (WES) and are widely used within the dredged material management field to predict the behavior of dredged material during different phases of overboard placement operations. The STFATE model is used to predict the extent and behavior of the sediment plume associated with a single disposal event, while the MDFATE model is used to predict the location and extent of the disposal mound resulting from multiple barge placements.

Dredged material generated from many of the dredging projects in New England is deposited at ten regional open water dredged material disposal sites. The DAMOS Program utilizes a flexible, tiered management approach centered on comprehensive environmental monitoring to oversee the placement of sediments at these open water disposal sites. These disposal sites are regularly monitored to ensure that the environmental impacts associated with dredged material placement are minor and temporary. PDS is located approximately 13.16 km east of Dyer Point, Cape Elizabeth, Maine and encompasses a 3.42 km^2 area of rocky and irregular seafloor, with water depths that range from 42 to 74 m. The regulated and monitored placement of dredged material has been occurring at this site since 1977. However, documented use of this area for dredged material placement dates back to 1946, when material was disposed over a 17.7 km^2 irregularly-shaped area of seafloor surrounding the current PDS boundaries. During the 1998-1999 and 1999-2000 Portland Harbor dredging projects, a total of 488,900 m^3 of material was deposited within PDS.

SAIC conducted a variety of field surveys over a two year period (1998-2000) to address the following two broad objectives: 1) obtain information on the physical characteristics of the dredged material and on the characteristics of the water column and seafloor at PDS for use as input to the numerical models, and 2) obtain information on the actual settling of dredged material out of the water column and the actual distribution of dredged material on the seafloor at PDS for use in evaluating the accuracy of the model predictions.

To address the first objective, SAIC conducted multibeam bathymetric and side-scan sonar surveys at PDS, obtained gravity cores and surface grab samples to characterize the sediments in the dredging areas and at the disposal site, and performed studies of water column currents, density and meteorology at PDS. To address the second objective, sediment traps were deployed in and around PDS to measure water column transport and settling of dredged material, and both multibeam bathymetric and REMOTS® sediment-profile imaging surveys were conducted to evaluate the morphology and delineate the footprint of the dredged material deposit on the seafloor. In addition, a special investigation was undertaken to determine whether there were any unique microscopic characteristics (e.g., mineralogy or microfossil composition) that might serve to distinguish the Portland Harbor dredged material from naturally-occurring surface sediments on the seafloor at PDS. The existence of one or more unique "tracers" would be of potential use in determining the origin of material captured in the sediment traps at various locations in and around the disposal site.

The seafloor in the PDS region is characterized by numerous steep, bedrock ridges and a prominent northwest-southeast trending trough. The high-resolution, full-bottom coverage multibeam and side-scan sonar surveys conducted prior to the 1998-1999 Portland Harbor dredging project provided better insight into the complexity of the PDS seafloor relative to previous single-beam surveys. These data also highlighted numerous natural basin features that could potentially serve as containment cells for future dredging projects. The multibeam data were used to provide the background bathymetry for both the MDFATE and STFATE model runs. More than a year after the completion of the 1998-1999 dredging project, a second high-resolution multibeam survey and a REMOTS® sediment-profile imaging survey were conducted over PDS. Based on the combined REMOTS® and multibeam depth difference results, it appeared that most of the deposited dredged material had settled in the deeper depositional areas, though a relatively thin surface layer of recent dredged material existed over the surrounding bedrock areas.

The sediment sampling and subsequent geotechnical analyses that were conducted on the Portland Harbor and PDS sediments produced the Portland Harbor sediment characterization data needed for input into the STFATE and MDFATE models. Samples were also analyzed for the presence of unique tracers that could be used to differentiate between the Portland Harbor sediments and those that existed within PDS prior to the disposal operations. These results showed that the Portland Harbor sediments were comprised of mostly clay and silt, with primarily marsh and shallow water foraminifera, while the PDS sediments were primarily comprised of mostly fine sand with shelf foraminifera. However, there was considerable variability in the number of individuals and taxa among different samples from the same area, and there was also evidence of estuarine taxa at the PDS sample locations (likely due to historic disposal activities) and continental shelf taxa in the Portland Harbor samples (likely due to cross-shelf transport processes).

During Phase 3 of the Portland Harbor dredging project, sediment traps were deployed around the perimeter of PDS in an attempt to capture sediment settling through the water column. Due primarily to disturbance from fishing activity, only three of the ten traps were recovered with any analyzable material present. Despite the limitations noted above in the use of microfossils, comparisons of the occurrence of freshwater, estuarine and continental shelf microfossils provided supporting evidence used to evaluate the likely sources of material collected in sediment traps. A combination of qualitative comparisons of the volume of material in the traps, trap location and local hydrodynamic processes, and the microfossil evidence were used to draw conclusions about the source of material in the sediment traps. Based on that evidence, it was concluded that the traps likely contained material that had settled out of the dredged material disposal plumes, as well as sediments resuspended from the surrounding substrate by storms such as the March 1999 storm event that occurred shortly after trap deployment.

Deployment of an acoustic Doppler current profiler (ADCP) for 31 days provided information on hydrodynamics in the vicinity of PDS. The data indicated moderate tidal current velocities at depth, with conditions in the near-surface portion of the water column affected by wind waves (near-surface maximum velocity during the deployment period of 50 $cm \cdot s^{-1}$), which is expected given the open fetch in this region. In general, the water column currents displayed a strong northwest-southeast trend, likely related to tidal oscillations within Casco Bay. Filtering of the high-frequency data revealed residual currents related to the counterclockwise gyre driving circulation in the Gulf of Maine. Besides documenting current flow over PDS, the ADCP data were also used as inputs to multiple STFATE and MDFATE model runs.

The STFATE model results depicted the expected plume migration pattern associated with the placement of a barge-load of “average” Portland Harbor dredged material subjected to hydrodynamic forces documented over PDS. Using a representative flood and ebb cycle from the current record, the STFATE model results depicted the expected plume migration pattern associated with the placement of a barge-load of typical Portland Harbor dredged material. Entrained material would migrate northwest from its point of origin with the water mass movement driven by a flood tide. Conversely, an ebb tide would transport the sediment plume to the southeast. Based on the model results, the sediment plume would increase in size as time progressed with a corresponding decrease in the peak suspended sediment concentrations. Seafloor topography would often impact the morphology of the sediment plume, as steep ridges in the path of a moving plume served as containment features at depth.

In addition, the STFATE model was run utilizing averaged currents acquired over PDS to evaluate a worse case scenario for sediment transport. These results showed the sediment plume migrating in a southwest direction away from the PDA 98 buoy in response to the counterclockwise gyre in Gulf of Maine. Once again, the sediment plume increased in size as time progressed with a corresponding decrease in the peak suspended sediment concentrations. The modeled plume migration path was consistent with the sediment trap results that indicated the presence of recent Portland Harbor dredged material along the southern PDS boundary. The relatively sparse sediment trap results show the cumulative effects from all of the disposal events that occurred within PDS while the traps were deployed, while the STFATE results show the expected plume associated with a single, representative disposal event at the PDA 98 buoy position.

The MDFATE model results depicted the predicted seafloor deposit resulting from the 197 individual disposal events associated with all of PDS placement activity between the 1998 and 2000 multibeam surveys. The disposal mound morphology depicted by the MDFATE model was very closely correlated with the positions of the disposal events. The MDFATE results showed the largest accumulations of material over the shallower bedrock outcrop south of the PDA 98 buoy, where the highest numbers of large scow releases were recorded. In contrast, the depth difference results showed little or no accumulation over these exposed bedrock areas. In the time between the completion of disposal operations and the final multibeam survey, it is likely that a large percentage of the material had settled into the fault and crevice features within the areas of exposed bedrock or was advected out of these areas by natural processes and re-deposited into deeper depositional areas adjacent to the PDA 98 buoy location.