FIELD MODIFICATION FORM
LOWER PASSAIC RIVER RESTORATION PROJECT

Date: October 30, 2008

Document: QAPP/FSP Addendum, December 2007 and Final QAPP, August 2005

Activity: Sedflume Consolidation Analysis

Requested Modification: At the request of the United States Environmental Protection Agency (USEPA) Region 2 and the United States Army Corps of Engineers-Kansas City District (USACE-KC), Malcolm Pirnie, Inc. personnel will collect approximately 15 gallons of depositional surface sediment for Sedflume Consolidation Analysis. This material will be collected from within the top 15 centimeters of sediment surface between river mile (RM) 2 and RM 2.2 of the study area (see Figure 1), and submitted to Sea Engineering Inc. (SEI) for analysis.

Rationale: The Sedflume Consolidation Analysis will determine the sediment erosion rates on the surface sediments based on laboratory reconstructed sediment cores. Four reconstructed cores will be prepared and evaluated to determine the effects of consolidation on erosion rates and sediment density over time. SEI will perform Sedflume Consolidation Analysis on this sediment by the procedures described in the Sedflume Quality Assurance Project Plan (see Attachment 1). The direct measurement of sediment stability will be used to determine the potential for sediment mobility in the natural system of the Lower Passaic River. The information collected in this study will be used to provide parameters for a sediment/contaminant transport model to estimate storm-induced re-suspension of sediment and subsequent release of contaminants within the River.

The availability of sufficient sediment depth will be identified by probing. The sediment will be collected by an Ekman or Ponar dredge following the procedures previously documented in the SOPs listed in Worksheet 21 of the December 2007 QAPP/FSP Addendum for Lower Passaic River Restoration Project Empirical Mass Balance Evaluation. The sediment will be shipped to SEI in three 5 gallon plastic buckets, and will not require any preservation.

Attachments:
Figure 1- Map showing the location of the sediment sample collection
Attachment 1- Lower Passaic River Sedflume Consolidation Analysis Quality Assurance Project Plan, Sea Engineering, Inc.

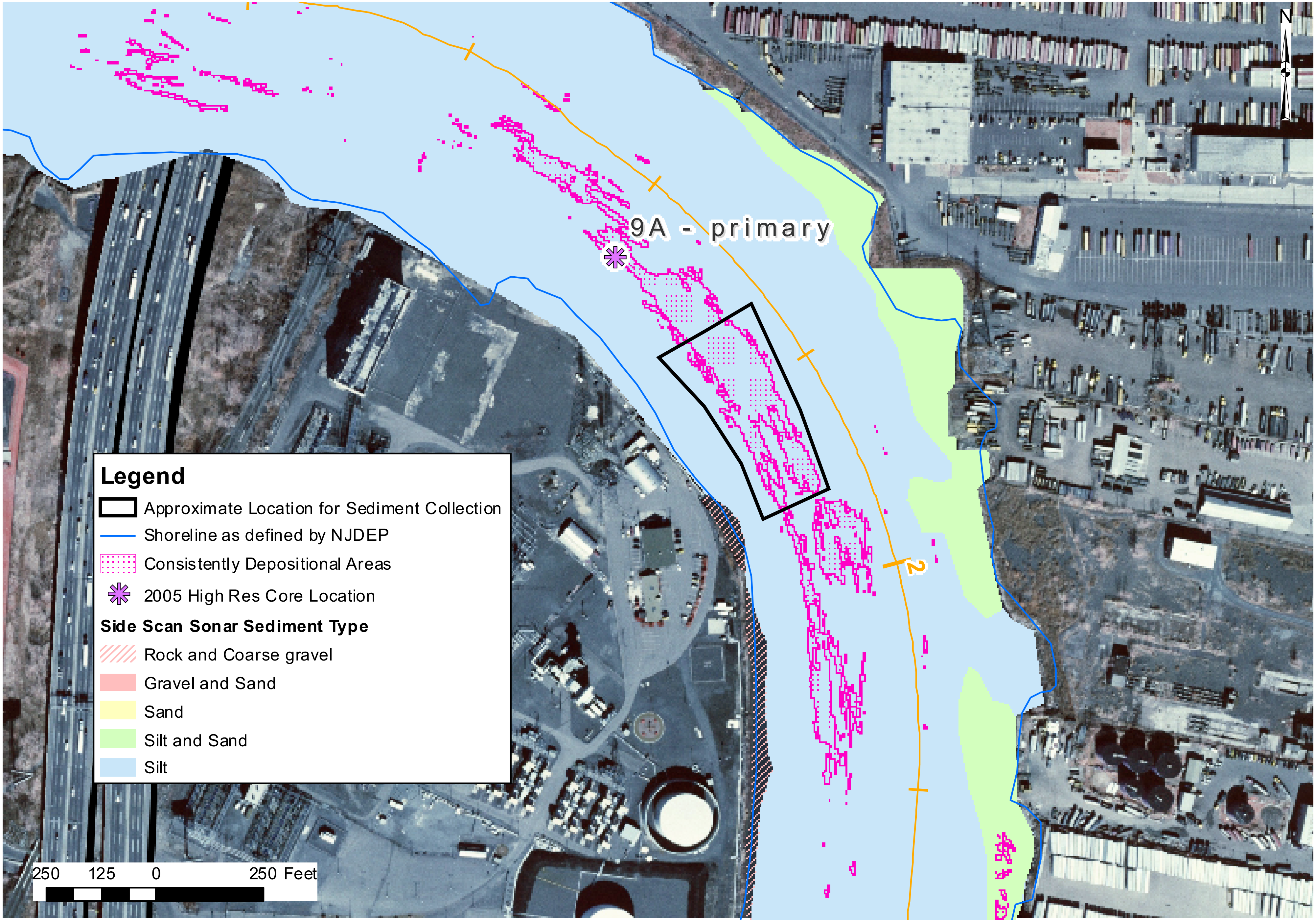
References:

1. Lower Passaic River Restoration Project, Quality Assurance Project Plan, August 2005.
2. QAPP/FSP Addendum for Lower Passaic River Restoration Project Empirical Mass Balance Evaluation, December 2007.

Malcolm Pirnie Project Manager:_________________________________

Malcolm Pirnie Deputy Project Manager: __________________________

Malcolm Pirnie Site QC Officer:________________________________



P:\0285924\Mapping\EMBM_FieldWork\Consolidation_Test_Maps.mxd

MALCOLM PIRNIE
INDEPENDENT ENVIRONMENTAL ENGINEERS, SCIENTISTS AND CONSULTANTS

Approximate Location for Sediment Collection for Consolidation Test Experiment

Figure 1

October 2008

Attachment 1

Lower Passaic River
Sedflume Consolidation Analysis
Quality Assurance Project Plan

Lower Passaic River
Sedflume Consolidation Analysis
Quality Assurance Project Plan

Prepared by:

Sea Engineering, Inc.
200 Washington Street, Suite 210
Santa Cruz, CA 95060

Tel: (831) 421-0871
Fax: (831) 421-0875

Sedflume Quality Assurance Project Plan

Introduction

Sedflume sampling will be undertaken by Sea Engineering, Inc. (SEI) to determine sediment erosion rates laterally and with depth on laboratory reconstructed sediment cores. Surface sediments will be collected from a location that has been identified as depositional for fine material in the Lower Passaic River (LPR). The material will all be collected from the same location and will be mixed together (i.e. composited) and reconstructed into four laboratory Sedflume cores. The four reconstructed cores will be evaluated to determine the effects of consolidation on erosion rates and sediment density over time. A core from the batch will be tested in the Sedflume at 1-day, 7-days, 14-days, and 28-days to determine the effects of consolidation on the stored sediments.

Reconstructed Sedflume cores up to 1 m in length will be taken for the analysis of erosion rates. The direct measurement of sediment erosion rates via Sedflume provides a quantitative measurement of sediment stability that can be used to determine the potential for sediment mobility in a natural system (McNeil et al., 1996). It has additionally been demonstrated that erosion rates are strongly dependent on the bulk density of the sediments (Jepsen et. al, 1997; Roberts et. al, 1978). Because of this, the densities of the Sedflume cores will be determined by sub-sampling locations within each core so that the bulk density can be determined through wet/dry sample weight. Particle size analysis will be performed at sub-sampled locations in the cores to provide additional characterization of the sediments.

Figures 1 and 2 show sample Sedflume data from independent studies conducted at test sites in San Francisco Bay by SEI. Figure 1 shows variation of sediment erosion rates with depth into the sediments and shear stress. It can be seen in this plot that the surficial sediments erode easily at lower shear stresses, but at lower levels in the core the sediments are much more difficult to erode requiring much larger shear stresses. Figure 2 shows particle size and bulk density variation for the same core as Figure 1.

The objective of the present Sedflume study is to characterize the properties of deposited sediments during the consolidation process. Sediment characteristics such as erosion rates, mean particle size, particle size distribution, and bulk density will be determined with depth for each reconstructed core. Although particle size is not expected to vary in the reconstructed cores, particle size samples will be collected to ensure that the reconstructed cores are representative of the composited sediment. The consolidation experiments will provide site-specific data for consolidation parameterization in the Lower Passaic River sediment transport model.

Data collected in the study will be gathered into and summarized in a detailed data report. Plots of erosion rate versus core depth and bulk parameters versus core depth will be presented for each core obtained and average erosion rates and average bulk properties will be plotted with binned depth. General trends in the data set will be noted and variations between different regions will be characterized. Quality assurance objectives and results will be discussed in the report. Measurements to be made by Sea Engineering, Inc. (SEI) are shown in Table 1. These measurements will be made by instrumentation provided by the laboratory of SEI. No other special personnel or equipment is necessary for core analysis.

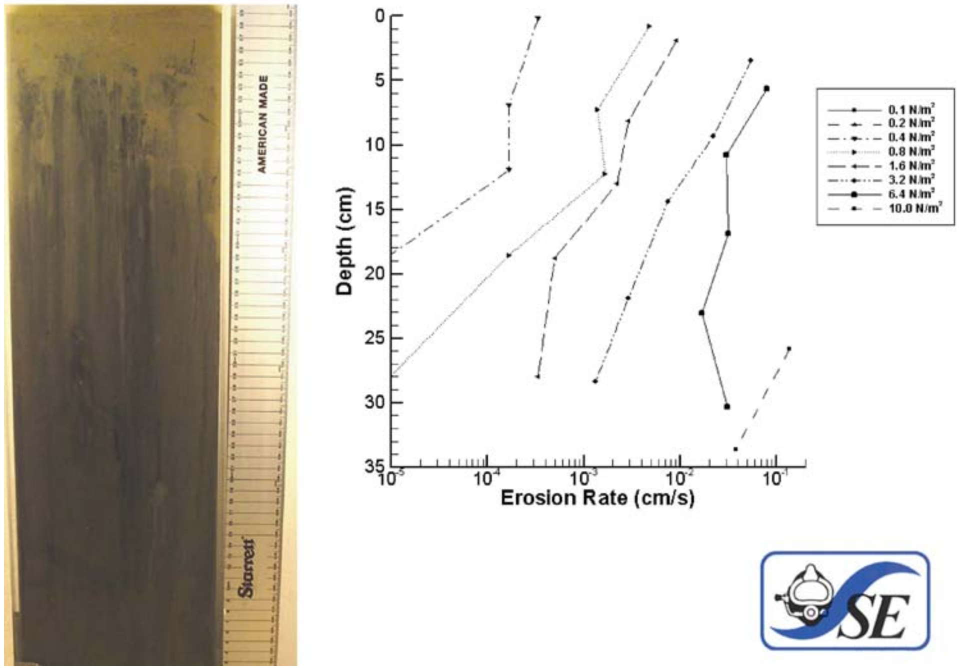


Figure 1. Erosion rate variation with depth and shear stress for San Francisco Bay location.

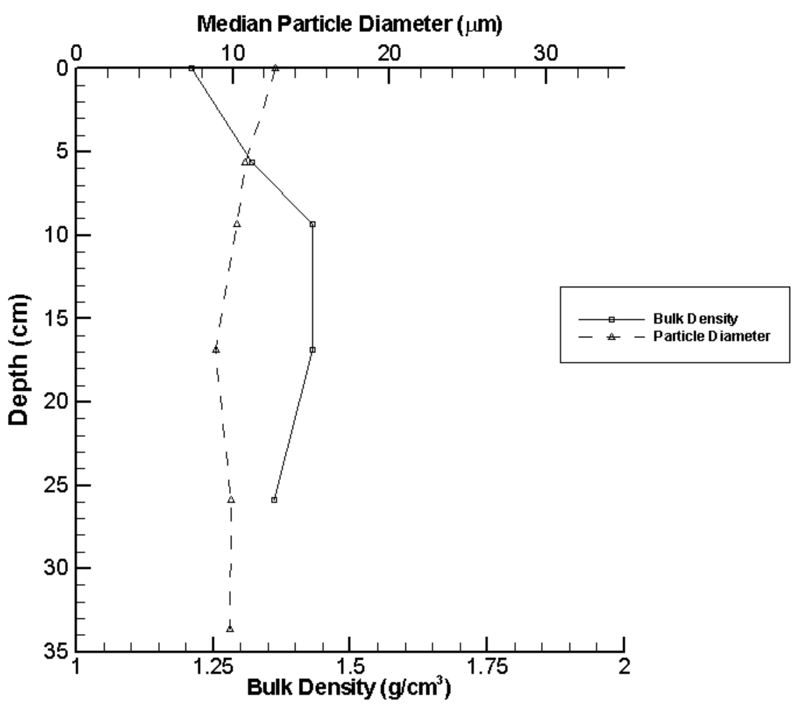


Figure 2. Variation of particle size and bulk density with depth for San Francisco Bay location.

Data Quality Objectives for Measurement Data

To achieve the project's overall data quality objectives, measurements will be made to ensure sufficient characterization of sediment bulk properties and erosion rates. The bulk properties to be measured by SEI have been established as a standard for Sedflume analyses (McNeil et al, 1996; Taylor et al, 1996; Jepsen et al, 1997; and Roberts et al, 1998). The parameters to be measured in the Sedflume cores are listed in Table 1. Procedures for all measurements are included in the following sections.

Table 1

	Definition	Units	Detection Limit	Int. Consistency
Bulk Density, ρ_b (wet/dry weight)	$\rho_b = \frac{\rho_w \rho_s}{\rho_w + (\rho_s - \rho_w)W}$	g/cm^3	Same as water content	$\rho_w < \rho_b < 2.6\rho_w$
Grain Size	Volume weighted distribution including median and mean size	μm	0.0375 μm – 2000 μm	
Water Content	$W = \frac{M_w - M_d}{M_w}$	none	0.1g in sample weight ranging from 10 to 50 g	$0 < W < 1$
Erosion Rate	$E = \Delta z/T$	cm/s	$\Delta z > 0.5$mm $T > 15$s	None

M_w = wet weight of sample
M_d = dry weight of sample
Δz = amount of sediment eroded
T = time
ρ_w = density of water
ρ_s = density of sediments
All essential bulk properties will be measured from the same core.

Laboratory Methods

Sampling Process Designs

Erosion rates will be measured as a function of shear stress and depth for each core. Sediment bulk properties will also be measured for each erosion core. Bulk properties of the sediments (particle size distribution, organic content, mineralogy, and gas content) will be measured using samples from the erosion core. All essential bulk properties (including erosion rates) will be measured for the same core using this method. All measurements to be taken (Table 1) are classified as critical measurements.

Four cores will be processed in Sedflume to determine how sediment erosion potential and bulk parameters vary for consolidating sediments. The number of cores is chosen to characterize the temporal variation due to consolidation, while not making the study's duration prohibitively long. Approximately one half day is required to process a core in Sedflume, so four cores represents approximately 3 days in the laboratory. Erosion rates are dependent upon, at least, the following parameters: bulk density, mean grain size, grain size distribution, gas content and organic content.

Sediment Collection and Preparation

In situ sediment collection will be done in the following manner aboard the vessel selected for coring. Fifteen gallons of sediment will be collected from the top 15 cm of the sediment bed. These sediments will be shipped to the SEI Santa Cruz, Ca laboratory. The sediments will be composited with water in the SEI laboratory and poured into 4 prepared core barrels. Sediment of 50 cm in length will be reconstructed by this method. Cores will immediately be visually inspected for length and quality. Approved cores will be capped and stored in the laboratory for 1, 7, 14, or 28 days depending on the test to be performed on that core. Samples taken from the core for bulk property analysis will be placed in appropriate sized containers, labeled, sealed, and preserved until delivered to the laboratory for analysis. Dr. Craig Jones will be responsible for corrective action regarding sample method requirements.

Sample Handling and Custody Requirements

Samples will be analyzed by SEI personnel. Chain of custody will be recorded as required by project specifications.

All samples will be uniquely labeled and logged by the sampler. Samples designated for Sedflume study will be under the continuous custody of SEI personnel so the sample integrity can be assured. Dr. Craig Jones of SEI will supervise all Sedflume operations.

Analytic Methods

Description of Sedflume

A detailed description of Sedflume and its application are given in McNeil et al, 1996. Sedflume is shown in Figure 3 and is essentially a straight flume that has a test section with an open bottom through which a rectangular cross-section coring tube containing sediment can be inserted. The main components of the flume are the coring tube; the test section; an inlet section for uniform, fully-developed, turbulent flow; a flow exit section; a water storage tank; and a pump to force water through the system. The coring tube, test section, inlet section, and exit section are made of clear acrylic so that the sediment-water interactions can be observed. The coring tube shown in Figure 3 has a rectangular cross-section, 10 cm by 15 cm, and can be up to 1 m in length. Sea Engineering, Inc. additionally uses a 10 cm diameter circular core for Sedflume analysis to facilitate field collection of cores.

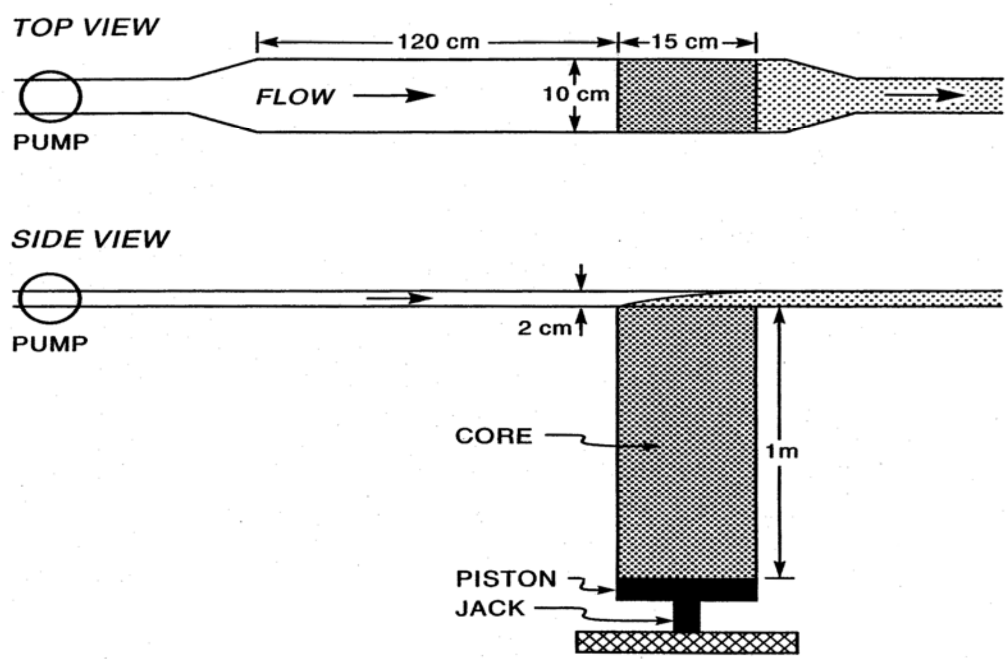


Figure 3. Schematic of Sedflume

Water is pumped through the system from a 120 gallon storage tank, through a 5 cm diameter pipe, and then through a flow converter into the rectangular duct shown. This duct is 2 cm in height, 10 cm in width, and 120 cm in length; it connects to the test section, which has the same cross-sectional area and is 15 cm long. The flow converter changes the shape of the cross-section from circular to the rectangular duct shape while maintaining a constant cross-sectional area. A three-way valve regulates the flow so that part of the flow goes into the duct while the remainder returns to the tank. Also, there is a small valve in the duct immediately downstream from the test section that is opened at higher flow rates to keep the pressure in the duct and over the test section at atmospheric conditions.

At the start of each test, the coring tube is filled with undisturbed sediments from the bottom of the body of water of interest or reconstructed sediments for consolidation studies. The coring tube and the sediment it contains are then inserted into the bottom of the test section. An operator moves the sediment upward using a piston that is inside the coring tube and is connected to a screw jack with a 1 m drive. The jack is driven by either electric motor or hand crank. By these means, the sediments can be raised and made level with the bottom of the test section. The speed of the jack movement can be controlled at a variable rate in measurable increments as small as 0.5 mm.

Water is forced through the duct and the test section over the surface of the sediments. The shear produced by this flow causes the sediments to erode. As the sediments in the core erode, they are continually moved upwards by the operator so that the sediment-water interface remains level with the bottom of the test and inlet sections. The erosion rate is recorded as the upward movement of the sediments in the coring tube over time.

Measurements of Sediment Erosion Rates

The procedure for measuring the erosion rates of the sediments as a function of shear stress and depth will be as follows. The sediment cores will be obtained as described above and then moved upward into the test section until the sediment surface is even with the bottom of the test section. A measurement is made of the depth to the bottom of the sediment in the core. The flume is then run at a specific flow rate corresponding to a particular shear stress. Erosion rates are obtained by measuring the remaining core length at different time intervals, taking the difference between each successive measurement, and dividing by the time interval.

In order to measure erosion rates at several different shear stresses using only one core, the following procedure is used. Starting at a low shear stress, the flume is run sequentially at higher shear stresses with each succeeding shear stress being twice the previous one. Generally about three shear stresses are run sequentially. Each shear stress is run until at least 2 to 3 mm but no more than 2 cm are eroded. The time interval is recorded for each run with a stopwatch. The flow is then increased to the next shear stress, and so on until the highest shear stress is run. This cycle is repeated until all of the sediment has eroded from the core. If after three cycles a particular shear stress shows a rate of erosion less than 10^{-4} cm/s, it will be dropped from the cycle; a higher shear stress will be included in the cycle as needed so that a minimum of 3 erosion rate measurements are obtained in each interval.

Measurements of Critical Shear Stress for Erosion

A critical shear stress can be quantitatively defined as the shear stress at which a very small, but accurately measurable, rate of erosion occurs. In the present study, this rate of erosion is chosen to be 10^{-4} cm/s; this represents 1 mm of erosion in approximately 15 minutes. Since it would be difficult to measure all critical shear stresses at exactly 10^{-4} cm/s, erosion rates are generally measured above and below 10^{-4} cm/s at shear stresses which differ by a factor of two. The critical shear stress is then linearly interpolated to an erosion rate of 10^{-4} cm/s. Critical shear stresses will be determined as a function of depth for the laboratory sediment cores.

Description of Consolidation Studies

Wet sediments obtained from a selected field site will be mixed separately into homogeneous mixtures. These well-mixed sediments will be poured into several 20 cm cores and then allowed to consolidate for time periods up to 28 days. All bulk properties for each sediment mixture will remain constant except for bulk density. Particle size will be sampled in each core to ensure no variation among cores. Bulk density as a function of depth will be measured periodically during the test and some cores will be sacrificed and tested in the Sedflume for erosion rates. The methodology outlined above for the Sedflume will determine erosion rates as a function of bulk density for each reconstructed core.

Measurements of Sediment Bulk Properties

In addition to erosion rate measurements, samples will collected to determine the water content, bulk density, and particle size of the sediments. Sub-samples will be collected from the surface of the Sedflume cores at the end of each erosion cycle. This allows up to 5 samples to be collected approximately every 5 cm for analysis.

Bulk density will be determined in the SEI Sedflume laboratory by water content analysis using methods outlined in Hakanson and Jansson (2002) and ASTM procedures for the determination of water content. This consists of determining the wet and dry weight of the collected sample to determine the water content, W, from Equation 1.

$$W = \frac{M_w - M_d}{M_w} \tag{1}$$

W = water content
M_w = wet weight of sample
M_d = dry weight of sample

Once the water content is calculated, the bulk density, ρ_b, is determined from Equation 2.

$$\rho_b = \frac{\rho_w \rho_s}{\rho_w + (\rho_s - \rho_w)W} \tag{2}$$

ρ_w = density of water (1 g/cm^3)
ρ_s = density of sediment particle (2.65 g/cm^3)

Particle size distributions are determined using laser diffraction analysis. Samples collected from the Sedflume core are prepared and sieved at 2000 μm. Any fraction over 2000 μm is weighed and compared to total sample weight to determine the weight percentage by weight greater than 2000 μm. The fraction of the sample less than 2000 μm is analyzed in a Beckman Coulter LS 13 320. Each sample is analyzed in three 1-minute intervals and the results of the four analyses were averaged.

Laboratory manuals for detailed analysis procedures are available upon request.

Quality Control Requirements

Although great care will always be taken, quality control will be performed routinely during sampling and measuring.

Sediment erosion rates are related to shear stresses that are applied at particular flow rates in the channel of the Sedflume. The initial flow rate used will be that which sediment erosion is observed to begin. The flow rates, as measured by the flow meter, will be checked daily by directly measuring the volume of water collected over time at the outlet of the channel. If the flow rates are not correct, the paddle wheel of the flow meter will be cleaned and inspected. If this does not correct the problem, a new flow meter will be installed.

All instruments (i.e. drying oven and digital scale) used for bulk density analysis will be tested with standards before and after each testing period. If either instrument fails to perform to the testing standards the instrument will be calibrated or repaired until laboratory standards are met.

Particle size measurements will be run in duplicate to check for accuracy. Also, known standards will be measured before and after each testing period. Any failure of laboratory standards will be remedied by a visit from a manufacturer qualified technician.

Instrument/Equipment Testing, Inspection and Maintenance Requirements

The Sedflume flow rates and all instrumentation will be tested daily before each test run. The particle size measurements will be tested against known standards.

Sedflume is designed as a field device and as such is a fairly robust system. Spare parts for Sedflume and for the coring operation are either available at any hardware store, or may be made by any competent machine shop.

Instrument Calibration and Frequency

No instruments used in the Sedflume study require calibration. All instruments will be tested with standards as described previously and any failure to meets standards will be immediately corrected.

References

Hakanson, L., and M. Jansson, 2002, Principles of Lake Sedimentology. Blackburn Press, Caldwell, New Jersey, USA.

Jepsen, R., J. McNeil, and W. Lick, 1999. Effects of Gas Generation on the Density and Erosion of Sediments from the Grand River, Report, Department of Mechanical and Environmental Engineering, University of California, Santa Barbara, CA 93106.

Jepsen, R., J. Roberts, and W. Lick, 1997, Effects of Bulk Density on Sediment Erosion Rates, Water, Air, and Soil Pollution,Vol. 99, pp. 21-31.

McNeil, J., C. Taylor, and W. Lick, 1996, Measurements of Erosion of Undisturbed Bottom Sediments with Depth, J. Hydraulic Engineering, 122(6) pp. 316-324.

Roberts, J., R. Jepsen, and W. Lick, 1998, Effects of Particle Size and Bulk Density on the Erosion of Quartz Particles, J. Hydraulic Engineering, 124(12) pp. 1261-1267.

Taylor, C. and W. Lick, 1996, Erosion Properties of Great Lakes Sediments, UCSB Report.

Appendix A –Laboratory Data Sheets

SEDFLUME LABORATORY DATASHEET

Sample Designation: ______ **Photo:** ______

Date/Time: ______

Core Height: ______ cm

Reference Height for the top of the core: ______ cm

Location: ______

Reference Contact: ______

Project: ______

Item Number	Shear Stress (dynes/cm^2)	Starting Height (mm)	Ending Height (mm)	Time (min, sec)	NOTES	

SEDFLUME LABORATORY DATASHEET

Sample Designation: ______________________ **Photo:** ______________

Date/Time: ______________________

Core Height: __________ cm

Reference Height for the top of the core: __________ cm

Reference Contact: ______________________

Location: ______________________

Project: ______________________

Item Number	Shear Stress (dynes/cm^2)	Starting Height (mm)	Ending Height (mm)	Time (min, sec)	NOTES	

Bulk Density Datasheet

Sample Designation:

Date/Time:

Core Height: cm

Photo:

Location:

Project:

Reference Contact:

Bulk Density Sample

Sample ID	Depth	Tray Weight (g)	Wet Wt. (g)	Dry Wt. (g) 1 Date and Time	% water content	Dry Wt. (g) 2 Date and Time	% water content	Dry Wt. (g) 3 Date and Time	% water content	Bulk Density (g/cm3)

Particle Size Sample

Tray Weight (g)	Dry Weight (g)	Beaker Weight (g)	Dry + Beaker (g)