SEDIMENT CHOREOGRAPHY FOR COMMODITIZATION OF DREDGED SEDIMENTS

James White
Cleveland- Cuyahoga County Port Authority
Cleveland, Ohio, USA

ABSTRACT

The Cleveland- Cuyahoga County Port Authority (the Port) has been developing and implementing innovative techniques to harness the natural tendencies of water and sediments to sort and harvest marketable sediments dredged from the Cuyahoga River Ship Channel. In an effort to conserve expensive remaining air space at its Confined Disposal Facility (CDF), the Port designed and built a series of sluiceways and settling basins to process hydraulically delivered dredged materials. In June, 2015, 62,000 cubic yards were delivered to the Port's reconfigured Confined Disposal Facility. The system allowed the harvest of 40,000 Cubic yards. In a related action, the Port also led implementation of a system (patented by Streamside Systems of Findley OH) to intercept bed load sediments from the natural flowing river approximately 4.6 river miles upstream of the head of navigation. Bed load interception is intended to reduce dredging requirements and produce marketable material. In its first few months of operations the system produced 1,800 cubic yards of high quality, clean coarse sands and small gravels all of which were sold. Bed load harvest is expected to be self-funding. Ohio EPA has approved the dredged material for a variety of engineering uses. Some of the harvested material will be used to fill the basements of derelict homes which are being demolished by the Regional Land Bank, thus providing a cost effective and reliable material for civic benefit in urban renewal. Both techniques empirically demonstrate that water, sediments and energy can be managed to routinely harvest merchantable commodity from dredged sediments.

Keywords: Harvest, Commoditization, Bed load, Choreography

MARITIME COMMERCE IN THE CLEVELAND, OHIO REGIONAL ECONOMY

The 2011 Strategic Plan of the Port of Cleveland documented 18,000 jobs attributable to maritime commerce emanating from Port of Cleveland. Over 13 million tons of cargo move through the port. The benefitting companies paid $112 million in state and local taxes and produced $1.8 billion in annual economic activity. Cleveland's origins was as a cross roads connecting commerce from the Great Lakes to a multitude of in-land locations. Cleveland was and remains a port city with global connections.

CLEVELAND HARBOR (NOAA CHART 14839)

Cleveland Harbor is comprised of an outer harbor, protect by 6 miles of breakwater running SW to NE parallel to the shoreline, and a 5.9 mile-long ship channel which runs south up the Cuyahoga River to the blast furnaces of ArcelorMittal Steel. Navigable depths are maintained by US Army Corps of Engineers (USACE). The outer harbor is maintained to a navigable depth of 28 feet in order to accommodate the ocean traffic coming to Cleveland through the Saint Lawrence Seaway. The ship channel is almost completely lined with sheet steel bulkheads and is maintained at depths to 23 feet to accommodate the river class bulk commodity freighters.

EROSION AND SEDIMENT PRODUCTION IN THE CUYAHOGA RIVER

The Cuyahoga River flowing north from Akron is substantially out of equilibrium. The river is widening and lengthening its cross section, resulting in significant and highly visible evidence of bank erosion, sediment mobilization and transport. Computer Models commissioned by the Port have shown the current sediment quantities to be in excess of what would be expected in a river which is in equilibrium. Much of the bank erosion occurs along the banks in the Cuyahoga Valley National Park (CVNP). The park has a bank management strategy of allowing the river to naturally define its shape and gradient, thus presenting few opportunities for upstream erosion management.

The natural Cuyahoga River, south of the ship channel is 4 to 6 feet deep and flows north from Akron at an average speed of 4.5 miles per hour. As the river enters the ship channel the flow rate drops to .25 miles per hour

which significantly reduces the river's sediment carrying energy. Water that takes 10 hours to flow the 45 river miles from Akron to the head of navigation takes 10 days to flow the final six miles into Lake Erie. As a result the ship channel acts as an efficient and effective sediment settling basin. Large grain sediments fall out quickly in the first few hundred yards of the ship channel. Fine grains and silts settle out slightly further downstream. Annually about 250,000 cubic yards of sediments must be dredged from the Ship Channel of the Cuyahoga River in order to maintain the authorized 23 foot navigation depth needed for maritime commerce.

Annually, a fleet of 630-711 foot river class freighters deliver 12.5 to 16 million tons of bulk cargo via 800 to 900 bulk commodity freighter trips in the ship channel. Iron ore, limestone, aggregate, cement and salt are the typical commodities and provide cost effective materials largely for the steel and construction industries of Northeast Ohio. The dredged depth of 23 feet allows 15,000 to 23,000 tons per delivery. A loss of 1 inch of draft results in a loss of cargo capacity from 107 to 115 tons. Maintaining adequate navigable depths is critical for the regional economy.

URBAN IMPACTS ON SEDIMENT AND PLACEMENT IN CONFINED DISPOSAL FACILITES

The dredged materials are impacted by urban run-off, combined sewer overflows, and upstream sources. Principle pollutants found in sediment samples are PAHs, PCBs, and metals. Since the enactment of the Clean Water Act in 1972 the dredged materials have been placed in three contiguous Confined Disposal Facilities (CDFs), which are located north of and adjacent to Burke Lakefront Airport along Lake Erie.

USACE placement technique to date has been to pump sediment as slurry into the CDFs, which limits capacity of the CDFs to the brim full dimensions. The remaining capacity is also restricted by extended onsite retention of slurry water. In 2012, the Port's consulting engineers found 800,000 cubic yards of water entrained on the CDFs. In 2010 USACE noted the need for new CDF capacity, but also noted that a new CDF would cost at least $150 million, with 35% of the capital costs having to be paid by a non- Federal sponsor.

Sampling data and water quality trends indicate that much if not all of the dredged material will continue to need to be placed in CDFs to avoid negative impact to the aquatic environment. However, if properly planned and managed, some material has become clean enough for harvest and beneficial upland uses.

PORT OF CLEVELAND 217 PLAN

Pursuant to the provisions of the Water Resources Development Act (WRDA) Sec. 217, a local sponsor may assume responsibility for the management of the CDF and placement of sediments. Under a Sec. 217 Agreement, USACE would pay a tipping fee for use of the Port-managed facility. While unusual on the Great Lakes, where USACE-owned capacity remains for most dredging locations, WRDA 217 agreements and their tipping fee arrangements have been successfully implemented in Baltimore, MD, and Brown County (Green Bay), WI.

Port of Cleveland wanted to assure adequate capacity for management of dredge materials would be available so that there would no risk of interruption to maritime commerce, and recruited its own engineers to develop a sediment management plan. The Port's proposed 217 Plan is science and data-based. Under the Port's 217 Plan, the Port assumes all risks and costs associated for site preparation and sediment management. The plan relies on mechanical placement of dredge material into the CDFs, mounding safely under the FAA airspace limits imposed by Burke Airport, and aggressive systematic dewatering and compaction of material. The Port's Plan provided 7 million cubic yards (CYs) of new capacity (28 years at 250,000 per year) at the existing CDFs, without any harvest or reuse of materials. The Plan avoids the need for a costly new CDF.

The Port presented the initial plan to USACE in January 2013, which included a proposed Tipping Fee to USACE of $11.50 per CY. The Plan was approved by the Asst. Sec. Army for Civil Works in November 2014. The Tipping Fee agreement remains under negotiation. In the absence of the formal agreement the Port has been developing and implementing additional techniques to extend CDF life and also promote civic benefit.

SEDIMENT CHOREOGRAPHY BY PORT OF CLEVELAND

The Port uses the term "Sediment Choreography" to allude to the practice of developing cost effective sediment management techniques which rely on the natural, physical characteristics of water, energy and sediments. The technique also recognizes the opportunity to harvest and market sediments as a commodity with value. Sediment is regarded as inventory which is annual delivered to us by the Cuyahoga River. The river can be used to assist in its harvest.

Reacquiring Airspace with a Sediment Processing Center

Any harvest and use of sediments will extend the useful life of CDFs. Some sediments, especially the larger grains dredged from the upper end of the Ship Channel while unsuitable for disposal in the aquatic environment, have been found to be suitable for a wide variety of upland applications such as: a component in compost soils, aggregate, fill, brownfield redevelopment and as fill in basements of demolished Land Bank houses.

In 2015, the Port refined its CDF operations strategy to include engineered features which would allow sorting and recovery of harvestable material of approximately 95,000 CYs each year of the typical 250,000 CYs dredged, for land-based beneficial uses. Harvesting is expected to increase the useful life of the CDF from 28 to to 42 years. At its CDF, the Port constructed systems of sluiceways and settling basins into which the hydraulically delivered sediments can be sorted by grain size. The larger sandy material is harvest for market purposes. Any un-merchantable material is placed in areas for permanent storage.

The Port retained a Site Operator whose role is to remove and market qualified material. In 2015, 62,000 Cys of dredged materials were received and successfully processed. Over 40,000 CYs were harvested from the CDF for OEPA approved beneficial upland purposes.

Reducing Dredging by Bed Load Interception

Sediment transport is generally described as moving as either suspended sediments or as bed load. Suspended sediments are typically comprised of very small particles, fines and organics which are carried suspended in the water column. Pollutants are typically found attached to the fines and organics. Bed load sediments are larger grain sizes and typically heavier material that tumble or bounce along the river bottom. Bed load sediments tend to be sands and small gravels. Suspended sediments move mostly during higher energy discharge periods and are evidenced by murky water following storm events. Storm drain and CSO discharge add pollutants to the waters and impact sediment quality.

Bed load sediments move constantly with more material moving during higher energy flow periods. Bed load interception relies on the natural energy of the flowing river to passively intercept sediment before it enters and settles in the ship channel. Any intercepted bedload will reduce the need for dredging. The Bed load collector used by the Port is a patented device developed by Streamside Systems of Findley, Ohio. The collector is comprised of a ramp laid on the bottom of the river perpendicular to the flow. Bed load sediments tumble up the ramp, slowing and losing latent energy. The bed load material simply falls into a trough at the top of the ramp, which is part of the assembly. The captured material is fluffed with water pumped in via manifolds from underneath and then pumped as a slurry out the side to a dewatering auger onshore. The water is recycled. The dewatered sands move up a stacker and ready for delivery to market.

Over a period of five years the Port conducted a suite of incremental studies to evaluate and verify: proof of technical concept, susceptibility of Cuyahoga River sediments to bed load interception, suitability of harvested sediments for beneficial upland applications and evaluations that bed load interception would produce a material benefit. The results consistently produced favorable outcomes. Cuyahoga bed load sediments could be intercepted in direct correlation to the discharge curve of the river; the sediments were of a favorable coarse grain size- suitable for a wide variety of market applications, and the sediments were determined by OEPA to be clean enough for use in unrestricted applications. The evaluations also determined the unit operated passively with no disruption to stream ecology.

As a result of the favorable outcomes the Port, Ohio EPA and a site operator invested $1.2 million in a full scale, multi-year pilot study. The bedload interceptor was installed at a site 4.6 miles upstream from the head of navigation. The in-river unit was placed in April 1st 2015. The pumping and dewatering devices were completed in July. The unit has performed as expected.

Market Applications

Actual data and modeling suggest the unit will harvest approximately 20,000 CYs of sediments per year. Bedload interception is extremely cost effective. The collector produces material ready for market for a cost of $1.00 per cubic yard. Dredging and CDF processing cost $17.50 per CY in 2015.

Harvesting bedload sediments creates a commodity by extracting a valuable resource out of what had been considered a waste stream. Bed load sediments are being used for structural fill, custom soil blends, and raw material for concrete mixes. Potential application for use as beach nourishment are under evaluation by Ohio DNR.

CONCLUSION

The Port of Cleveland's Sustainable sediment management plan – Sediment Choreography- provides additional CDF life to 47years. The plan increases existing CDF capacity through aggressive dewatering, mechanical placement and vertical stacking; recaptures additional CDF capacity through a regular program to harvest and reuse qualified sediments; reduces dredging requirements by systematic interception and marketing of high quality bed load sediments.