A Risk-based Methodology for Disposal of Arsenic-Containing Sediments

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ABSTRACT: A cost effective risk-based disposal methodology was developed for a project with limited funds available for hazard identification and possible media disposal. Excavation in littoral and upland areas was required for an auxiliary mooring facility that had exceedences of risk-based cleanup criteria for arsenic and a polycyclic aromatic hydrocarbon (PAH). Further sampling was conducted to determine vertical and lateral extent of compound concentrations within the limits of the planned excavation (~ 160,000 yd^3). PAHs met residential soil screening criteria. Aluminum:arsenic ratios for all samples fell within the 95% prediction limit determined for background sediments, but 27 of 67 samples exceeded the arsenic residential cleanup target level and 7 of 67 exceeded its industrial cleanup target level. In-water sediments had higher arsenic concentrations than upland soils. Volume-weighted average arsenic concentrations were calculated for the sampling points and analysis showed that by combining the in-water sediments and upland soil with arsenic concentrations greater than 3.7 ppm, offsite disposal of clean fill (i.e. meets the residential arsenic target cleanup level) could occur for 71% of the excavated material. The remainder, to be disposed of onsite, would meet industrial criteria. Iterative evaluation of disposal options allowed for maximizing safe offsite disposal that met regulatory requirements while minimizing waste disposal costs.

To accommodate an additonal 4.5-acre small vessel berthing area at Naval Station Mayport, Jacksonville, Florida, approximately 128,000 cubic yards (yd^3) of upland soils and 34,500 yd^3 in-water sediment needed to be excavated and disposed. Initial investigations into concentrations of chemicals in the sediment and upland soils indicated that levels of arsenic and polycyclic aromatic hydrocarbons (PAH) exceeded default soil screening criteria for the State of Florida (soil cleanup target levels [SCTL]). Maximum soil arsenic was 13.7 mg/kg which exceeded both residential (0.8 mg/kg) and industrial (3.7 mg/kg) SCTLs; the industrial SCTL for benzo(a)pyrene was exceeded in one soil sample. Therefore, a subsequent investigation was undertaken to more fully characterize arsenic and PAH concentrations in the planned excavation area so that disposal options could the considered *a priori*. Fifty-four soils and sediment samples were collected from eighteen borings. When combined with the earlier data, 67 soil/sediment samples would be available for analysis.

In surface soils, industrial SCTLs were not exceeded by concentrations reported for arsenic and carcinogenic and noncarcinogenic PAHs. However, four of the five surface soil samples exceeded the residential SCTL for arsenic of 0.8 mg/kg.

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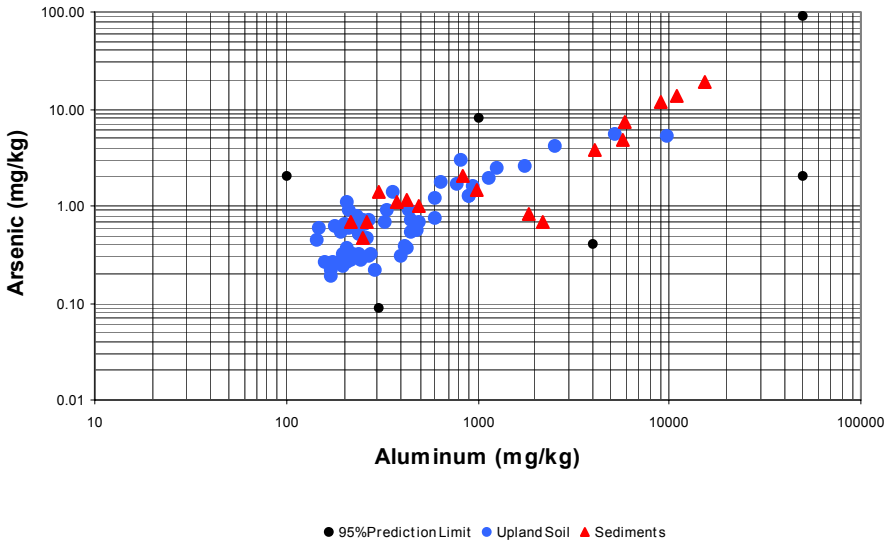
In subsurface samples, the soil horizon represented by the data varies in depth across the planned excavation area since there is a slope towards the surface water of the turning basin.
For all subsurface soils, PAH concentrations did not exceed industrial direct contact or leachability SCTLs. However, comparing soil arsenic concentrations to the industrial SCTL showed that for the shallow, mid-depth, and deep soil horizons, one to three samples per soil horizon exceeded the direct contact industrial SCTL. Maximum arsenic concentrations in the shallow and deep soil horizons were 13.4 and 18.7 mg/kg, respectively. In mid-depth soils, the only concentration that exceeded the industrial SCTL was 4.3 mg/kg.

Earlier investigations of background soil concentrations at Naval Station Mayport (ABB 1995) and personal communication with FDEP staff (FDEP 2000) indicate that background concentrations at Naval Station Mayport may be on the order of four to five mg/kg. A number of data points for soil arsenic exceed such a background level. However, the relationship of soil arsenic to a ubiquitous and abundant inorganic analyte such as aluminum can be compared to background between these two metals at "pristine" estuarine environments (FDER 1988).

Figure 1 provides a graphical representation of the relationship between soil arsenic and aluminum in soils proposed to be excavated at Harbor Ops. The bounding lines shown on Figure ? are the upper and lower 95% prediction limits specified in FDER (1988) as being bounds on background ratios for arsenic:aluminum in sediments. As shown, all of the data on soil arsenic collected in the proposed excavation area had arsenic:aluminum ratios that fell within the 95% prediction limits specified for background. The data in Figure 1 do indicate that higher arsenic concentrations were found in sediment samples, but that these values could still be construed as being within the range of background.

Fig. 1: Relation of Arsenic to Aluminum in Excavated Soils



Volume-weighted average concentration estimates were made according to Fetter (1980) in order to determine suitability of excavated soils for disposal . Disposal of excavated material on-site

or off-site, requires that industrial or residential SCTLs, respectively, be met. Upland soils and the total soils to be excavated met industrial criteria but in-water sediments exceed the criterion. None of these combinations would allow off-site disposal since the residential SCTL is exceeded. Therefore, volume-weighted average concentrations were determined for various combinations of sampling locations to determine the feasibility of off-site disposal for some portion of the excavated material. The limits set for disposal (based on current SCTL values) included a volume-weighted average concentration of less than 3.7 mg/kg arsenic for material disposed at Naval Station Mayport and 0.8 mg/kg arsenic for material disposed off-site. FDEP is considering changes to SCTL values in FS Chap. 62-777 that would result in the residential SCTL for arsenic decreasing to 0.7 mg/kg and the industrial SCTL changing to 4.1 mg/kg. To be conservative and to meet any of these criteria for arsenic, limits set for on-site and off-site disposal of excavated material were set at 0.7 mg/kg and 3.7 mg/kg, respectively.

Since the data available for the Harbor Ops project indicated a greater probability for detecting arsenic in sediments and for exceeding the industrial SCTL in these sediments, it was presumed that all of the in-water sediments as well as any upland soil sample greater than the industrial SCTL would remain on-site. Table 1 shows the results of the evaluation of three possible mixing scenarios. In the first scenario, the "contaminated" soil is mixed with upland soils that have arsenic concentrations greater than 0.5 mg/kg. The resulting concentration for soils to remain on-site would be 2 mg/kg and off-site soil (i.e., upland soil samples less than 0.5 mg/kg arsenic) would have an arsenic concentration of 0.3 mg/kg but only 41% of the excavated material could be disposed off-site. In the next scenario, the cut-off for upland soils was assumed to be 1 mg/kg. With this assumption, on-site excavated material would have an arsenic concentration of 3.0 mg/kg and would satisfy the current industrial SCTL and off-site soil arsenic would be 0.5 mg/kg which satisfies the lowest of the residential SCTLs for arsenic. Almost 70% of the excavated material could be disposed of off-site. For the third iteration, the upland soils with arsenic above 1.5 mg/kg was assumed to be mixed with the "contaminated" soils and this resulted in an arsenic concentration of 4.2 mg/kg which would be too high for on-site disposal as industrial soil. Therefore, combination of upland soils with arsenic concentrations greater than 1 mg/kg with the in-water sediments and any upland soil above the industrial SCTL yielded soils appropriate for on-site disposal (i.e., arsenic concentration less than 3.7 mg/kg) and off-site disposal (arsenic concentration less than 0.7 mg/kg).

Table 1
Potential Mixing Scenarios for Excavated Soil
Mayport Harbor Ops, Mayport, Florida

Soil Mixing Procedure	Volume-Weighted Avg Conc. (mg/kg)		Soil Volume (cu yd)		% Offsite Disposal
	On-Site	Off-Site	On-Site	Off-Site	
Inwater soil & Upland > 3.7 + Upland soil > 0.5 ppm As	2.0	0.3	104,707	73,116	41%
Inwater soil & Upland > 3.7 + Upland soil > 1 ppm As	3.0	0.5	55,246	122,577	69%
Inwater soil & Upland > 3.7 + Upland soil >1.5 ppm As	4.2	0.6	32,891	144,932	82%