

SCOPE OF WORK

HSRC Project: “Contaminant Release During Removal and Resuspension”

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YEAR - 04

This HSRC project is divided into two interrelated parts. The Rice University group is conducting the laboratory test aimed at simulating key elements of the metal release process following dredging resuspension of bed-sediment residing solid particles. The LSU group is attempting to develop a theory-based simple and practical model to track the metal release process kinetics. Data generated by the Rice University group will be utilized by the LSU group in model development, refinement and testing. The overall product will be an algorithm to estimate metal concentrations in solution emanating from the mud clouds produced during dredging or storm events. It will contain a combination of empirical data and semi-theoretical modeling. From all evidence we have collected a purely *a priori* theoretical model approach is not currently possible.

Being able to predict the concentrations of metals is key in evaluating aquatic organism exposure levels and uptake quantities for risk assessment purposes. Algorithms are needed for both the water column and the bed-sediment surface layers. Providing these algorithms is the overall goal of this combined Rice U. and LSU project.

APPROACH TO MODEL DEVELOPMENT FOR METALS RELEASE

The objective of this aspect of the project is to adopt this existing bi-phasic kinetic model and use it for the metal release process. Its rationale for its adoption is based on the following findings:

1. A kinetic-based chemical release model is more realistic. Equilibrium based resuspension models have been used and are being used for contaminant release from re-suspended particles. Although appropriate for some applications equilibrium models will uniformly over-predict the soluble fraction in the water column; this is the key fraction. Transport kinetics based models allow the characterization to the rate of approach to the equilibrium state and the incorporation of other key rate processes.
2. Simple Laboratory experiments are involved in generating the necessary site-specific empirical for inclusion in the semi-theoretical bi-phasic release algorithm. Several experimental protocols have evolved and are “standardized” so that they realistically reflect the process of desorptive release experienced by sediment particles resuspended into the water column. The key environmental chemistry conditions that need to be maintain in order to realistically mimic the re-suspension process are: rapid particle contact with water, appropriate field values of the solid-to-water ratios, aerobic water conditions and an infinite sink for the de-

sorbing fractions. For organic chemicals, the protocols have reach a mature state of development, whereas for metals the apparatus and protocols are still being developed. Maintaining constant pH and aerobic conditions in the slurry has been a challenge; these being two most important parameters that effect the metal release process.. However, it appears that the Rice University group has developed an apparatus and a protocol that provides the necessary control of these parameters.

3. In the case of organic chemical an extensive set of data has accumulated in the literature over the past five years based on the bi-phase model that includes a fast fraction release rate constant (k_{fast} , day^{-1}), a slow fraction rate constant (k_{slow} , day^{-1}) and the fast fraction mass N_{fast} , on the sediment ($N_{\text{slow}} = 1 - N_{\text{fast}}$). Our review of this literature indicates it does an excellent job of fitting virtually all data sets for both field samples and laboratory inoculated samples alike. These organic chemicals include the volatile hydrocarbons, volatile hydrocarbons, PAHs, PCBs and pesticides. One outstanding feature of the data we have assembled to date is that both rate constants appear to be chemical independent. The data on the fast fraction mass quantity appears to follow no discernible behavior pattern. The effect of particle size on the model parameters is unknown. This parameter is typically not measured or not reported. Although numerous theoretical models have been proposed based on classical kinetic transport and thermodynamic processes none have been found to that provide a consistent explanation to the empirical evidence observed for the range of properties displayed by the five classes of compounds noted (Birdwell et.al., 2004).
4. The simple form of the bi-phase model allows its direct incorporation into species mass balance for developing algorithms of the chemical release from re-suspended particles. The chemical flux from the mobile (i.e., fast) fraction and the desorption-resistant (i.e., slow) fraction are both first order. This feature facilitates easy mathematical incorporation of the other processes involved. The other processes in addition to the flux from the two fractions include: a) the rate of solid particle placement into the water column, b) the particle settling rates, c) the kinetic approach to thermodynamic equilibrium, d) the evaporation to air and e) the on-bottom continued desorption rate. A dredge resuspension kinetic-based chemical release model has been developed and tested using conditions at a dredging site where Aroclor-1242 was the contaminant of interest. For proof-of- concept purposes a simple version was used in which longitudinal dispersion was absent and a single particle sediment size was assumed. A closed analytical algorithm was the result; these inclusion of dispersion and several particle sizes will likely require a numerical solution (Thibodeaux and Birdwell, 2004).

Recommendations and Rationale for Close-out Budget

The modeling aspects of this project are mature. The bi-phase model has been theoretically rationalized and developed to the state that it will be proposed for use in applications of dredging in the remediation of contaminated sediments. The publication of this kinetic model will provide the users with an alternative to the traditional chemical equilibrium modeling approach. Based on the data and findings developed in year '04 at Rice U. the model will be extended to include metal releases from contaminated sediments. The budget proposed below is to cover the cost of finishing the development of the model to the extent it can be cast in a user friendly format and placed upon the HSRC S/SW Website for access by potential users. Manuscript presentation, review and acceptance in an appropriate journal must proceed the website offering. These two tasks will involve one half month time of the P.I. and 2 months time of a graduate assistant. A total of \$15,000 is requested.

Summary Year Budgets - LSU Group

'01- \$23,651.00

'02- \$29,400.00

'03- \$25,000.00

'04- \$15,000.00(Requested)