STATE WATER QUALITY CONTROL BOARD, SAN DIEGO REGION
INFORMAL PEER REVIEW DOCUMENT

STATEMENT OF: Todd M. Thornburg, Ph.D.

DATE: March 9, 2000

ISSUE: Is it appropriate to apply the Campbell Shipyard Apparent Effects Threshold (AET) as the sediment cleanup level for the NASSCO and Southwest Marine Shipyards?

In my opinion, the AET values developed for Campbell Shipyard are appropriate to apply to NASSCO and Southwest Marine Shipyards. My opinion is based on the following:

- **Shipyard Processes, Discharges, and Sediment Characteristics are Similar**. Shipyards engage in much the same industrial processes, resulting in characteristic contaminant signatures in sediments, which are primarily derived from vessel sandblasting, painting, and ancillary activities. Campbell, Southwest Marine, and NASSCO are within about a mile of one another, and, therefore, share the same sedimentary and ecological environments within the bay.

- **Sediments at NASSCO and Southwest Marine exhibit Relatively Low Toxicity**. Sediment bioassays conducted with *Rhepoxynius abronius* exhibited toxicity above the in-bay reference areas in only 3 of 14 samples from the shipyards, and all of these locations failed to show toxicity when re-sampled at a later date. With minimal dilution, as may be expected in the natural environment, sediment pore waters were not toxic to sea urchin larvae.

- **Campbell AET Values are Consistent with Sediment Management Standards**. Campbell AET values are within a factor of two of the Sediment Management Standards for the State of Washington, where nearly a decade of sediment quality regulation and cleanup has demonstrated the reliability and robustness of the AET approach.

- **Shipyards are Planning to Dredge down to AET Values, thereby providing Long-Term Protection of the Bay**. The sediment cleanup plans proposed by the shipyards provide for complete dredging and removal to an upland disposal facility of all sediments above the AET values. Dredging provides greater long-term environmental protection compared to other remedial technologies that are commonly implemented in areas of low to moderate contamination, such as in-place capping or natural recovery.

- **Campbell AET Values will address Majority of Site Risk at Shipyards**. The largest mass of contamination at the shipyards is concentrated in nearshore hot spots adjacent to shipbuilding and repair structures. The sediment cleanup plans proposed by the shipyards have effectively delineated these hot spots, and the proposed plans will permanently remove a majority of the site risk.

These points are further elaborated below. Per instructions from John Robertus and David Barker, I have not included mercury in my review since this value was not derived from the Campbell Shipyard data.

Shipyard Processes, Discharges, and Sediment Characteristics are Similar from One Site to the Next

I have worked on a number of contaminated sediment investigations at shipyard sites, including the following:

- Foss Maritime Shipyard (Seattle, Washington)
- Martinac and former Todd Shipyards (Tacoma, Washington)
- Puget Sound Naval Shipyard (Bremerton, Washington)
- Bellingham Bay Shipyard (Bellingham, Washington)
- Cascade General Shipyard (Portland, Oregon)
- Charleston Shipyard (Charleston, Oregon)
- Southern Oregon Marine (Coos Bay, Oregon)

In my work at these various sites, I have found consistent patterns of contaminant signatures and sediment quality impacts. These consistent patterns result from similar industrial processes and waste characteristics that are common to all shipyards. Most prominently, contamination is derived from antifoulants in paints and primers—copper and zinc, in particular, as well as tributyltin in recent history and mercury in the more distant past. Some metals (copper and others) are also contained in sandblast grit, which may be derived from processed metal slag. PCBs and PAHs may come from a variety of sources, including waste oils, cutting oils, hydraulic fluids, and historical coal-tar-based bottom paints. The nature of contamination may change over the historical operational period of the shipyard, but these typical signatures emerge at all yards. Invariably, the contamination is concentrated around the drydocks, railways, and other waterside repair and construction structures where blasting and painting occur.

Given the similarities between industrial processes, facilities, and wastes generated at all shipyards, it can be expected that shipyard contaminants will produce a similar toxic response from one site to the next. Also, the yards are within about a mile of each other. Therefore, the sedimentary and ecological environments in the receiving water should also be comparable. It is therefore reasonable to assume that the AET values developed at Campbell Shipyard are also appropriate to guide sediment cleanup actions at NASSCO and Southwest Marine.

Relatively Low Sediment Toxicity at NASSCO and Southwest Marine Indicates Problems are Localized

Biological toxicity tests (bioassays) have recently been performed throughout the bay by the interagency Bay Protection and Toxic Cleanup Program (SWRCB, 1996). These tests show that sediments in the NASSCO and Southwest Marine leasehold areas contain relatively low toxicity. In addition, none of the stations within the leasehold areas have been proposed for designation as “toxic hot spots” (San Diego RWQCB, 1998). Considering the general lack of toxicity in sediments at NASSCO and Southwest Marine, and their corresponding low to moderate priority for cleanup, it is noteworthy that the San Diego RWQCB and the shipyards are proactively engaging in cleanup investigations. The toxicity test results indicate that problem areas are restricted to nearshore sediments in the vicinity of shipbuilding structures (marine railways, drydocks, graving docks) where remedial dredging is currently proposed. A summary of toxicity test results in the shipyard leaseholds is presented in Table 1 and is discussed below.

Amphipod (Sediment-Phase) Bioassays. Sediment-phase bioassay tests using the amphipod *Rhepoxynius abronius* measure percent mortality of the test organism. These tests are best interpreted using the “reference envelope” approach, consistent with the interpretation used by the San Diego RWQCB (RWQCB, 1998). The toxicity in a test sediment (shipyard sediment) is compared to the toxicity of an in-bay reference sediment from a relatively unimpacted part of the bay to separate biological effects that are caused by chemical contamination from biological effects that are caused by environmental factors unrelated to contamination, such as grain size or organic decomposition. Sediment toxicity is similarly assessed using reference site comparisons in dredge management programs from California, Oregon, and Washington (EPA and Corps of Engineers, 1991; Corps of Engineers, et al., 1998; Corps of Engineers, et al., 2000).

Bioassay test results exhibiting less than 48 percent survival of amphipods are significantly different from unimpacted areas of the bay and may contain pollutants that are contributing to toxicity (SWRCB, 1996). Even in unimpacted reference areas, a significant percentage of the amphipods died in bioassay tests because these animals have an aversion to fine-grained, organic-rich sediments like those typically found in San Diego Bay (the amphipods are harvested in clean sands containing about 5 to 10 percent fines and are then introduced to bay muds containing 80 or

90 percent fines in laboratory tests). It has been shown that grain size and organic matter content can negatively impact the survival of *Rhepoxynius* (see Dewitt et al., 1988).

Only three of fourteen bioassay test results in the shipyard leaseholds exhibited survival rates below 48 percent and are significantly different from unimpacted reference areas, and may therefore contain toxic pollutants that contribute to decreased animal survival (Table 1). In all three cases, however, the sediments were resampled at a later date, and subsequent bioassay test results from these same locations showed no discernable toxicity. Giving precedence to the most recent test results, no significant toxicity to amphipods is observed in the shipyard leaseholds.

Sea Urchin (Pore Water) Bioassays. A second type of bioassay test was performed to assess the morphological development of sea urchin larvae exposed to sediment pore waters. Because these larvae live in the water column and not in the pore spaces of sediments, they will not be directly exposed to pore waters, but may be exposed to diluted pore waters that have diffused into the overlying water. To compensate for this indirect exposure, bioassays were performed using 100 percent (full strength) pore water and using serial dilutions with clean seawater at 50 percent and 25 percent solutions.

No toxicity is indicated in the sea urchin bioassay if normal larval development is at least 80 percent, and larval development in the test solution is not significantly different from the laboratory control. Normal development did not occur in any of the full-strength pore water solutions at the shipyards (Table 1), probably because of toxic buildups of ammonia in the pore waters, a natural decomposition product in fine-grained, organic-rich sediments. This result is typical—the majority of pore-water samples from all parts of the bay exceeded the ammonia tolerance limit for echinoderms (0.04 mg/L unionized ammonia; Paul Dinnel, personal communication), and, as a result, echinoderm development in full-strength pore water was probably caused by organic matter decay unrelated to environmental contamination.

However, no toxicity was observed at dilutions of 50 percent and 25 percent, solutions that better represent actual exposure conditions in the water column. These dilutions also help to mitigate the confounding effects of ammonia buildup in the pore waters. Considering that sea urchin larvae are not exposed to full-strength pore waters in the natural environment and that successful larval development occurred in minimally diluted solutions, the shipyard sediments do not appear to be significantly toxic to sea urchin larvae.

Campbell AET Values are Consistent with Sediment Management Standards in the State of Washington

The development of Apparent Effects Thresholds (AETs) for use as sediment quality standards was pioneered by the State of Washington and was formalized with the promulgation of the Sediment Management Standards in 1991. Washington is one of the most accomplished and proactive states in investigating and remediating contaminated sediments, having had a clear set of regulations in place for nearly a decade.

The chemical criteria in the Washington State Sediment Management Standards (Sediment Quality Standards and Minimum Cleanup Levels) have been tested numerous times with confirmatory biological testing at many contaminated sites, and these criteria have been found to be robust and conservative. They are conservative because toxicity effects are not usually observed in site-specific testing until the chemical concentration in the sediments exceeds the Sediment Quality Standard (SQS), and experience has shown that sediment concentrations may be two or three times the SQS before toxicity is actually observed.

A comparison of Washington State Sediment Quality Standards with the Campbell AET values (in mg/kg-dry wgt) is provided below:

	Campbell AET	*Washington SQS*
Copper	810	390
Zinc	820	410
Lead	231	450
PCBs	0.95	0.45*

*Note: Because PCB values in the SMS are normalized to organic carbon, AET values expressed on a dry weight basis were obtained from Gries and Waldow, 1996, based on the most stringent of amphipod, echinoderm, oyster, and benthic AET values. The PCB value presented is based on the echinoderm AET.

As can be seen from the table, the Washington SQS values and Campbell AET values are reasonably consistent and within a factor of two of one another. The SQS value for lead is approximately twice as high as the proposed Campbell AET; thus, there is no reason to doubt the protectiveness of the lead cleanup level. The Campbell AET values for copper, zinc, and PCBs are approximately twice as high as the SQS values for these chemicals, suggesting that the toxicity of the shipyard chemicals is less than expected. Because many of the shipyard chemicals are bound up in sandblast grit or exfoliated paint chips, thereby reducing the availability of these contaminants to aquatic life, it is not surprising that the shipyard-specific AET values (Campbell AET values) are somewhat higher than the generic AET values (Washington Sediment Quality Standards). This is also consistent with the relatively low levels of toxicity that have been observed at NASSCO and Southwest Marine, as discussed previously.

Proposed Cleanup Actions are Protective in that Complete Sediment Removal will occur for All Sediments above Campbell AET Values

The proposed remedial actions at NASSCO and Southwest Marine are conservative in that the Campbell AET values are being used to define dredging boundaries and less aggressive technologies, such as capping or natural recovery, are not part of the remedial design. All sediments above the AETs will be permanently removed from the bay to a permitted upland disposal facility, resulting in an immediate reduction in site risk. NASSCO is proposing to remove approximately 11,400 cubic yards (CY) of contaminated sediment and Southwest Marine proposes to remove approximately 18,000 CY.

Based on my experience at federal and state-level contaminated sediment investigations, dredging is typically proposed for the highest contaminant enrichments or "hot spots," whereas less aggressive remedial technologies, such as capping or natural recovery, are often applied to lower-level exceedences of the cleanup level. These less aggressive technologies may leave some low-risk sediments in place, and continued low-level exposures may continue to occur based on risk management decisions. The cleanup goal may not be achieved for several years if some measure of natural recovery is allowed. In other words, the remedial action level may be set at a higher concentration than the sediment quality goal. In the State of Washington, for example, the "Sediment Quality Standard" for zinc (corresponding to the AET) is 410 mg/kg; however, the "Minimum Cleanup Level" for zinc is 960 mg/kg. The State has the flexibility to direct active remediation (dredging or capping) at the Minimum Cleanup Level if the Sediment Quality Standard can be achieved in the future through natural recovery in areas not remediated.

In the case of the shipyards, the remedial action level for dredging is conservatively set at the cleanup goal (Campbell AETs). Dredging is among the most protective long-term remedies that can be implemented for contaminated sediments. This technology results in an immediate reduction in site risk and a decreased risk of remobilizing contaminants in the future, as may occur with in-place capping or natural recovery. The shipyards' proposals for complete removal of all contamination above the Campbell AETs ensures that the remedy will be immediate and permanent.

Campbell AETs will address the Majority of Site Risk

The largest mass of contamination at the shipyards is concentrated in nearshore hot spots adjacent to shipbuilding and repair structures, such as drydocks, graving docks, and marine railways. The Campbell AETs are effective at delineating these enrichments, and the proposed removal actions should address a high percentage of the mass of contaminants.

Inspection of the PCB data at Southwest Marine, for example, suggests that 90 to 95 percent of the PCB mass (pounds of contaminant) is concentrated in sediments above the Campbell AET value. The proposed dredging action will therefore remove a large majority of the PCB mass and will provide an immediate, order-of-magnitude (factor of ten) reduction in site risk. Sediment removal to the AET value (0.95 mg/kg) will also reduce the peak concentrations (the highest recorded at 21 mg/kg) by over an order-of-magnitude, thereby alleviating the more acute risks. An immediate reduction in site risk by a factor of ten or more must surely be good for the health of the bay.

Because the most contaminated sediments are concentrated in localized enrichments along the shorelines of the shipyards, comparable reductions in site risk can also be expected for copper, zinc, and other contaminants under the proposed removal actions. As is typical of contaminated sediment sites, however, the marginal cost of removing low-level contamination becomes less and less cost-effective in terms of reducing site risk. At NASSCO, for example, the cost of removing contamination to the Campbell AET (810 mg/kg for copper, 820 mg/kg for zinc) is estimated at $1.2 million, whereas the cost of removing contamination down to the ER-M—an alternative sediment quality value developed by NOAA, but not specific to shipyards or California (e.g., 270 mg/kg for copper, 410 mg/kg for zinc)—is estimated at $7.5 million. Thus, it would cost more than six times the money to reduce the copper and zinc concentrations by an additional factor of two to three.

______________________________ _________________

Todd M. Thornburg, Ph.D. Date

References

Dewitt, T.H., G.R. Ditsworth, and R.C. Schwartz, 1988, Effects of Natural Sediment Features on the Survival of the Phoxocepalid Amphipod, *Rhepoxynius abronius*. Marine Env. Res., v. 25, pp. 99-124.

Gries, T., and K.H. Waldow, 1996, Progress Re-evaluating Puget Sound Apparent Effects Thresholds (AETs), vol. I: Amphipod and Echinoderm Larval AETs. Prepared by Washington Department of Ecology for PSDDA agencies.

San Diego Regional Water Quality Control Board (RWQCB), 1999, Staff Report on the Establishment of Shipyard Sediment Cleanup Levels for National Steel and Shipbuilding Company and Southwest Marine, Inc.

State Water Resources Control Board (SWRCB), National Oceanic and Atmospheric Administration, California Department of Fish and Game, and Moss Landing Marine Laboratories, 1996, Chemistry, Toxicity, and Benthic Community Conditions in Sediments of the San Diego Bay Region.

U.S. Corps of Engineers, Seattle District, U.S. Environmental Protection Agency, Washington Department. of Natural Resources, Washington Department of Ecology, 2000, Dredged Material Evaluation and Disposal Procedures, Puget Sound Dredge Disposal Analysis Program (PSDDA).

U.S. Corps of Engineers, Portland and Seattle Districts, U.S. Environmental Protection Agency, Washington Department of Ecology, Oregon Department of Environmental Quality, and Washington Department of Natural Resources, 1998, Dredged Material Evaluation Framework, Lower Columbia River Management Area.

U.S. Environmental Protection Agency, and U.S. Corps of Engineers, 1991, Evaluation of Dredged Material Proposed for Ocean Disposal, Testing Manual. EPA-503/8-91/001.