And the goal of this presentation is to….

- Describe how Site Condition II was envisioned by the founders of the program
- Get everyone on the same page on the definition of Site Condition II and how this relates to bioaccumulation
- Discuss Site Condition II's role enabling/limiting DMMP's flexibility relative to disposal of bioaccumulatives at open water sites.

Puget Sound Dredged Disposal Analysis

- 4.5 years, $4.5M Corps-led study, 3 workgroups
  - Evaluation Procedures
  - Disposal Site Selection
  - Management Plans

- Phase I: Central Puget Sound
- Phase II: North and South Sound

PSDDA Study – Objectives

- ✓Identify acceptable multi-user unconfined open-water disposal sites for dredged material that passes evaluation guidelines
- ✓Define consistent and objective dredged material evaluation procedures
- ✓Develop Site Management plans, including monitoring, to provide controls on site use and assure program accountability

Defining a preferred site management condition

Step 1 – Select general management approach to dredged material evaluation

Step 2 - Define and evaluate various degrees of adverse biological effects that might occur at the sites (=“Site Conditions”)

Step 3 – Develop evaluation procedures (chemical & biological tests and guidelines to interpret results)

Step 4 – Assess environmental and economic consequences of alternative site conditions

Step 5 – ID preferred biological effects condition for site management

Source: PSDDA Evaluation Procedures Technical Appendix - Phase I

Step 2 - Define and evaluate various “Site Conditions”

7 examined – increasing severity of adverse effects from “no chemically-related effects” to “severe adverse effects”

- 4 extreme options excluded because impractical (no disposal) or not permissible under Federal and State law (CWA)
- 3 alternatives evaluated in detail

PSDDA Site Condition Alternatives Examined

Site Condition I

- “no adverse effects”
- “no significant sub-lethal or acute toxicity”

Site Condition II

- “minor adverse effects”
- “no significant acute toxicity”

Site Condition III

- “moderate adverse effects”
- “no severe acute toxicity”

Basis for Selected Site Condition

Site Condition II

- Environmentally protective - No adverse effects (acute toxicity) onsite and sub-lethal adverse effects confined to disposal site (monitored and managed).
- Consistent with WA State WQ Standards
- Reflects the way CWA 404(b)(1) guidelines historically applied – “avoid significant acute toxicity”.
- Estimated disposal costs are significantly lower than Site Condition I and similar to Site Condition III

Source: EPTA Phase 1 (page ES-17)

Definition of Site Condition II

Minor adverse effects

- Some chronic sublethal effects on-site
- Potential increase in mortality of more sensitive, but less abundant, crustacean species
- No significant effects off-site
- Some bioaccumulation expected on-site, but not enough to pose a human health problem

Source: EPTA - Phase I

SC II – "Some chronic sublethal effects on-site"

Sublethal effects linked to bioaccumulatives

- "Chronic sublethal effects include bioaccumulation, and possibly reproductive and other physiological impacts" (EIS-I).
- "Potential effects of bioaccumulation include impairment of molting, reduced reproductive capacity, decreased feeding ability, and decreased resistance to disease organisms" (EIS-I,II).
- "Cumulative effects expected to include reduction in population and community biomass and an increase in tissue concentrations" (EPTA-I).
- "Chronic sublethal effects may produce changes to the organism during its life (e.g., behavioral changes or growth depression) or to its reproductive success (e.g., reduced numbers of fertilized eggs) or effects on the next generation of the organism." (MPR-II).

SC II – "Some chronic sublethal effects on-site"

Species affected

- "Long-term exposure could result in reproductive and growth impairment of individual sea cucumbers, but is not expected to significantly impact sea cucumber populations" [Anderson-Ketron] (EIS-II).
- "Possible onsite impacts could be due to exposure of shrimp immigrating to the site with subsequent chronic, sublethal effects, including bioaccumulation, and possibly reproductive, and other physiological impacts…because of the low numbers of shrimp that utilize the site, overall potential impact to bay shrimp resources is considered insignificant." [Commencement Bay] (page 4-37, EIS-I).

SC II – "Some chronic sublethal effects on-site"

What was the intent of the PSDDA agencies regarding chronic sublethal effects?

- "…neither non-mobile organisms living near the site nor mobile predator species visiting the site should experience chronic sublethal effects due to chemicals disposed on the site. An example of such an undesirable effect is cancerous lesions caused by bioaccumulated chemicals in bottomfish feeding on benthic organisms at the site." (MPR-II).
- "The definition of acceptable adverse biological effects is not a simple, 'black or white' determination" (EIS-I page 2-31).
  - What constitutes "unacceptable adverse effects" at the site, per the CWA requires substantial professional judgment.
  - Uncertainty exists in scientific understanding of cause and effect relationships
  - There is a large "gray area" in terms of the degree of biological effects that can exist at disposal sites and still not result in unacceptable adverse effects.

SC II – "Some chronic sublethal effects on-site"

Questions

- What would we use to assess chronic sublethal effects <u>from bioaccumulatives</u>?
  - DMMP currently tests for chronic sublethal effects with the *Neanthes* growth endpoint.
  - What type/level of chronic sublethal effects associated with bioaccumulation would be allowed?
  - Reproductive effects? Imposex? Population effects?

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SC II – "Potential increase in mortality of more sensitive, but less abundant, crustacean species"

Species affected

- Refers primarily to physical impacts, but also includes impacts from contaminants.
- "Probably early recolonizers of the disposal site may consist predominantly of polychaete opportunists…small crustaceans (e.g., ostracods, cumaceans and gammarid amphipods) impacted by the disposal activities may be permanently displaced on site due to a greater sensitivity to physical and chemical stresses" (EIS II, pg 4-34).

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Source: PSDDA Evaluation Procedures Technical Appendix - Phase I

SC II – "No significant effects off-site"

Mechanisms for off-site COC movement via bioaccumulation

- Offsite impacts involving shrimp could possibly occur when shrimp with tissue body burdens of chemicals migrate offsite, or when shrimp from offsite forage on benthic species inhabiting the disposal area [Port Gardner] (EIS-I)
- Offsite impacts could occur when crabs with substantial tissue body burdens move offsite and are preyed upon by higher food chain organisms, such as bottomfish and octopus. Should this occur, bioaccumulation of chemicals in these predators would be expected [Bellingham Bay] (EIS-II)
- Bottom fish foraging on these opportunistic species may bioaccumulate chemicals through dietary intake of prey. Direct accumulation of chemicals might also occur through skin and gill membranes as a result of their intimate association with the bottom sediments, particularly when buried in the sediments. (EIS-1)

SC II – "No significant effects off-site"

Off-site effects from bioaccumulated COCs

- The degree of food web transfer is unknown, but should not be significant, due to the nature of the site management requirements, and because few mobile invertebrate species (crabs and shrimp) are present at the selected site [Anderson Ketron] (EIS-II)
- Because the area of the disposal site only represents a relatively small portion of the foraging habitat for demersal bottom feeding fish in Commencement Bay, and documented fish food habitat resources on site are uniformly low, only very low levels of chemical bioaccumulation in fish predators are possible [Commencement Bay] (page 4-39, EIS-1).
- However, no food web biomagnification of contaminants is expected, and environmental monitoring of sessile benthic populations near the site will detect the potential for such effects should they be present (page 4-35, EIS - II].

SC II – "No significant effects off-site"

Questions

- What are the relevant effects endpoints? (Reduced survival, growth, reproduction, carcinogenesis, liver disease)
- How do we measure them?
- What level of expression is "significant"?
- Is monitoring program adequately structured to catch off-site migration of COCs from bioaccumulation?

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SC II – "Some bioaccumulation expected on-site, but not enough to pose a human health problem"

Biological disposal guideline re. bioaccumulation

"No bioaccumulation levels exceeding a human health tissue guideline"

SC II – "Some bioaccumulation expected on-site, but not enough to pose a human health problem"

Focus on Human Exposure

- The chronic/sublethal ecological effects of observed body burdens are essentially unknown at present (though research is currently underway to better determine effects of tissue chemical accumulation).
- Many key chemicals of concern are metabolically altered into different forms (e g., conversion of PAH or PCB's to oxygen-containing metabolites), thus complicating any possible thorough analytical approach.
- Despite metabolic alterations, the remaining body burdens are still available to humans consuming the containing chemicals of concern organisms.

(page II-72, EPTA)

SC II – "Some bioaccumulation expected on-site, but not enough to pose a human health problem"

Calculation of Target Tissue Concentrations

$$\text{Target Tissue Conc} = \frac{[\text{Risk} * \text{Weight}]}{[\text{Potency} * \text{Ingestion}]}$$

Source: EPTA Phase I

SC II – "Some bioaccumulation expected on-site, but not enough to pose a human health problem"

Assumptions about the relationship between COCs in prey tissue and potential human health concerns

- Human exposure route is primarily through consumption of fish that could be directly exposed to bottom sediments at disposal sites (i.e., flatfish)
- Exposure of the flatfish population is directly proportional to the area of the home range covered by the disposal site (EPTA, page 11-124)

SC II – "Some bioaccumulation expected on-site, but not enough to pose a human health problem"

Risk Analysis Parameters

- Cancer risk level of 10^{-5}
- Seafood ingestion rate of 11 g/day for recreational anglers in urban bays
- Adjusted seafood ingestion to reflect portion that was flatfish only. This was only 2.5% of the 11 g/day, or 0.28 g/day
- Ingestion further adjusted to reflect the fraction of the home range for bottom fish covered by the Elliott Bay disposal site (17%) reducing the seafood ingestion rate to **0.05 g/day**.

Source: EPTA Phase 1

SC II – "Some bioaccumulation expected on-site, but not enough to pose a human health problem"

Comparison of TTC to Reference Tissues

"…based on data for bioaccumulation levels in PS species, only arsenic and PCB's are likely to indicate a human health problem…these values are not likely to be exceeded in dredged material bioaccumulation tests because the values reported for bioaccumulation represent **maximum values for urban bays and are probably not representative of levels expected for organisms exposed to moderately containing chemicals of concern dredged material** (e.g., less than the maximum level allowed for open-water disposal)." (EPTA Phase I)

SC II – "Some bioaccumulation expected on-site, but not enough to pose a human health problem"

Conclusions related to the effects of human exposure

- Measurable tissue contaminant levels may result at Site Condition II, but these levels are **not expected** to present a human health problem. Predators that include the disposal site as part of their home range will also exhibit increases in tissue contaminant concentration from contact with sediments and ingestion of infaunal species. These increases are **not expected** to pose a human health problem (EPTA Phase I, page II-144).
- Some recolonizers may experience minor increases in body burden levels of chemicals of concern within the site [Elliott Bay, Commencement Bay, Port Gardner]. These levels would not cause acute effects, nor would the levels exceed values considered to be harmful to human health, **if any fish foraging at the extreme depths of the sites were captured and eaten (which is** not likely)(EIS-I)

SC II – "Some bioaccumulation expected on-site, but not enough to pose a human health problem"

Nearshore versus deep water

"The human health risk analysis conclusions for PSDDA sites are necessarily different from those derived from other programs (such as Commencement Bay Superfund) dealing with shallow, nearshore environments. In shallower areas, fish are more abundant and more available for harvest. Different exposure routes occur in deep-water sites." (Phase II MPR, page 5-14).

SC II – "Some bioaccumulation expected on-site, but not enough to pose a human health problem"

Questions

- How would TTC and conclusions change with an updated risk assessment?
  - Consumption level associated with sites?
  - Home range of bioaccumulating species?
  - Exposure scenario?
  - Risk level – 10^{-5} or 10^{-6}?
- Are there COCs (in addition to cPAHs) with incomplete exposure pathways?

Site Condition II versus Anticipated Condition

Actual Site Conditions likely to be better than SC II:

- "The selected disposal guidelines would only result in site condition II if all the material discharged at a site was at the upper limits of biological effects allowed by the guidelines. This will not be the case" (Phase I ROD, page 13).
- "In laboratory terms, dredged material creating this condition (SC II) does not result in significant toxicity to sensitive test species exposed to the sediment to be dredged or significant bioaccumulation. It should be recognized that the bulk of dredged material placed at the disposal sites is expected to produce no adverse biological effects due to chemicals. Consequently, actual effects at the disposal site are expected to be less than described for the selected site condition. This is viewed as a conservative approach to site management." (Phase I MPR, page 4-5)

Single versus Multiple Site Management Conditions

- “Siting investigations for the Phase I area support using the same site condition for each site. The proposed sites are very similar in physical characteristics (low energy areas, deep water, and generally depositional in nature) and biological resources (soft-bottom communities, with crab and/or shrimp present in the bay, as well as bottomfish and salmon), and do not appear to warrant different management strategies”
- ”When sites have different management conditions, sites with more lenient requirements will likely receive material that cannot go to other sites, from other areas of the Sound. This results in the perception that "one community is receiving the wastes of another," a socially and politically difficult situation to manage”

(Phase I EIS, page 2-34,)

The End?

Any thoughts on Site Condition II's role enabling/limiting DMMP's flexibility relative to disposal of bioaccumulatives at open water sites?