7 SAMPLING

7.1 TIMING OF SAMPLING

Sampling must be conducted using a SAP that has been approved by the DMMP agencies and accomplished well in advance of dredging to allow time for testing, data review and permitting.

Areas that receive large volumes of material due to shoaling during winter storm events also need to be sampled prior to dredging. Because these projects are typically dredged within a short time after deposition by winter storms, insufficient time is available to completely characterize all the material that will eventually be dredged. Instead, material that is already in place prior to the winter storm season is sampled and tested. This sampling strategy assumes that sediments deposited annually by winter storms will have a chemical composition very similar to the sediments that are in place at the time sampling and testing is conducted. This strategy is a compromise that includes consideration of the need to provide representative sampling and the need to provide an evaluation process adaptable to the fast shoaling pattern found in these areas. This compromise will also help avoid reliance on "emergency dredging" whereby sediment sampling and testing is not possible prior to dredging. Accordingly, the number of DMMUs and field samples will be based on pre-sampling bathymetric surveys, records from previous dredging events and best professional judgment.

7.2 SAMPLING APPROACH

If full characterization sampling and analysis is required for a project, the applicant will be required to sample the sediment for chemical and, if necessary, biological analyses. There are three sampling approaches that the dredging proponent may take:

1. **Concurrent Testing:** Collect sufficient sediment for all chemical and biological tests potentially required. Run these tests concurrently.
2. **Tiered Testing:** Collect sufficient sediment as above, but archive adequate sediment for biological testing pending the results of the chemical analysis.
3. **Tiered Testing/Resampling:** Collect only enough sediment to conduct the chemical analyses and, if biological testing is required, re-sample the site.

The proposed sampling approach should be clearly documented in the sampling and analysis plan. The selection of either option 1 or 2 is encouraged because these alternatives provide chemical and biological data on sub-samples of a single homogenized sediment sample. These alternatives are also advantageous because they both preclude the cost involved with collection of additional sediment. Concurrent testing is the least time consuming, and is likely the most economical when the need for biological testing is expected. For tiered testing, the biological samples must be stored in the dark at 4 degrees C with zero headspace (or with headspace purged with nitrogen) while chemical tests are completed. **Maximum holding time for biological testing is 56 days. Holding time starts the day the first cores or grabs representing a DMMU are collected.**

Tiered testing with re-sampling should only be considered if biological testing is not expected. If biological testing does occur, a limited concurrent analysis of sediment chemistry may also be required. Biological samples must be taken from the same stations as the previous sediment chemistry samples.

7.3 POSITIONING METHODS

A precision navigation system should be used to navigate to and record all sediment sampling locations to a geodetic accuracy of ± 3 meters. In most cases, samples should be obtained as near as possible to the target locations provided in the project sampling plan. Such accuracy can be obtained with a range of positioning hardware, such as microwave transponders, differential GPS, real-time kinematic GPS, electronic measuring devices, etc. The exact positioning system to be used and associated QA/QC procedures should be documented in the sampling and analysis plan.

Sampling location data will be entered into Ecology's Environmental Information Management (EIM) system referenced to North American Datum of 1983 (NAD 83) or the World Geodetic System 1984 (WGS 84). If sampling locations are referenced to a local coordinate grid, the local grid should be tied to NAD 83 or WGS 84 to allow conversion to latitudes and longitudes. The North American Datum of 1927 (NAD 27) is outdated and should not be used. **Table 7-1** outlines the required level of accuracy.

Table 7-1. Required accuracy for sample positioning

Coordinates in:	Level of Accuracy
Degrees Minutes Seconds	2 decimal places
Degrees Minutes	4 decimal places
Decimal Degrees	6 decimal places
State Plane	Nearest foot
UTM	meters, with 1 decimal place

7.4 SAMPLING METHODS

The goal of sediment sampling for characterization of each individual DMMU is to collect a sample (or a number of composited samples) which will be representative of the DMMU. The accuracy of this representation can be increased vertically by taking core samples from the sediment/water interface down to the maximum proposed depth of dredging (including overdepth) and horizontally by increasing the number of samples taken. The DMMP agencies have established minimum sampling requirements (see Chapter 5) based on volumetric measurements. The type of sampling required, however, depends on the type of project. The sampling methodology to be used should be presented in the sampling and analysis plan along with the rationale for its use.

7.4.1 Core Sampling

For projects with heterogeneous sediment and for new-work dredging, the proponent will be required to take core samples from the sediment/water interface down to the maximum depth of dredging, including overdepth and Z-samples.

There are numerous gear options available for obtaining core samples. These include impact corers, hydraulic push corers, vibracorers, augers with split spoons or Shelby tubes, etc. The methodology chosen will depend on availability, cost, efficacy, presence of debris or rip rap, type of sediment, and anticipated sediment recoveries.

7.4.2 Grab Sampling

Sediments in frequently dredged areas (e.g. Grays Harbor navigation channel) are assumed to be relatively homogeneous. Therefore, for homogenous projects not in high-ranked areas, grab

samples will be considered adequate to represent the dredged material, even if shoaling results in sediment accumulation greater than four feet. The minimum number of grab samples required can be calculated from the tables in Chapter 5.

7.5 SAMPLE COLLECTION AND HANDLING PROCEDURES

Proper sample collection and handling procedures are vital for maintaining the integrity of the sample. If the integrity of the sample is compromised, the analysis results may be skewed or otherwise unacceptable. Procedures for decontamination, sampler deployment, sample logging, sample extrusion, compositing, sample transport, chain of custody, archiving and storage all need to be discussed in the sampling and analysis plan.

In general, seven (7) liters of composited and homogenized sediment will be needed to provide adequate volume for physical, chemical and standard biological analysis (Section 7.5.7). Bioassay analysis requires a minimum of five (5) liters while physical and chemical analysis requires approximately one (1) liter of sediment. The additional liter should be archived for possible chemical retesting.

Bioaccumulation testing requires a minimum of 15-20 liters of sediment beyond the amount needed for standard testing. Because of the large volume required for bioaccumulation testing, most dredging proponents do not collect this additional material during the initial sampling event, but wait to see if any bioaccumulation triggers are exceeded. In the event that bioaccumulation testing is triggered, a second round of sampling would become necessary, along with physical and chemical re-testing of the DMMU(s) in question. For all projects where samples are taken with coring devices, sediment that will be exposed by dredging must also be sampled. Please refer to Section 5.9 (Z-samples).

7.5.1 Decontamination Procedures

It is recommended that sampling containers be decontaminated by the laboratory or manufacturer prior to use. All sampling equipment and utensils such as spoons, mixing bowls, extrusion devices, sampling tubes and cutter heads, etc., should be made of non-contaminating materials and be thoroughly cleaned prior to use. The intention of these procedures is to avoid contaminating the sediments to be tested, since this could possibly result in dredged material, which would otherwise be found acceptable for open-water disposal, being found unacceptable. While not strictly required, an adequate decontamination procedure is highly recommended. Typical decontamination procedures for sampling equipment include the following steps:

1. Remove excess sediment with a brush and *in situ* water
2. Clean with a phosphate-free detergent solution (such as Alconox)
3. Rinse equipment thoroughly with clean *in situ* water
4. Triple rinse with analyte-free de-ionized water

The dredging proponent assumes a higher risk of sample contamination by not following an established protocol. Additional decontamination steps such as a solvent rinse or dilute acid rinse may be necessary for contaminated sites or sites with a higher possibility of encountering contamination. Consult the Puget Sound Protocols and Guidelines for more specific guidance.

After decontamination, sampling equipment should be protected from recontamination. Any sampling equipment suspected of contamination should be decontaminated again or removed from use. During core sampling, extra sampling tubes should be available on-site to prevent interruption

of operations should a sampling tube become contaminated. Sampling utensils should be decontaminated again after all sampling has been conducted for a given DMMU to prevent cross-contamination. Disposable gloves are typically used and disposed of between DMMUs.

7.5.2 Sample Collection

Sampling procedures and protocols will vary depending on the sampling methodology chosen. Whatever sampling method is used, measures should be taken to prevent contamination from contact with sources of contamination such as the sampling platform, grease from winches, engine exhaust, etc. Core sampling methodology should include the means for determining when the core sampler has penetrated to the required depth. If the core is driven deeper than required, field records and core logging must be adequate to allow the proper core section(s) to be taken post-sampling for inclusion in the sample composite(s), as well as for the Z-sample. The sampling location must be referenced to the actual deployment location of the sampler, not to another part of the sampling platform such as the bridge of a sampling vessel.

7.5.3 Core Acceptability and Percent Recovery

In order for the samples collected to be a good representation of the DMMU, each core collected needs to be representative of the sediment column being characterized. The criteria that will be used to determine if a core is acceptable for use need to be outlined in the SAP. At a minimum these should include acceptance criteria for core penetration and percent recovery.

Percent recovery is defined as the length of sediment retrieved divided by the length of the core penetration. Under ideal conditions percent recovery would be 100%, but due to variability in sediment type and coring conditions this is rarely the case. In order to assure that the dredge prism is being adequately characterized, **the recommended core acceptance criterion for percent recovery is at least 75%. If project specifics dictate that a 75% recovery may not be possible, justification for use of a different percent recovery threshold must be provided**.

7.5.4 Holding Times

For some large projects, many cores are collected and composited together to form an analytical sample. Sometimes cores are collected over multiple days and stored over ice or in a refrigerated room until all cores to be composited for a DMMU are collected. **In this situation, the holding time for the composited sample begins on the day that the first core is collected.** Cores should be held for the minimum time possible before processing.

7.5.5 Sulfides Sampling

The DMMP now recommends analyzing total bulk sulfides on composited sediment, rather than on sediment from a single core prior to compositing (DMMP, 2015b). This change will provide a more realistic assessment of the concentration of total sulfides in sediment archived for bioassays. Exceptions to this procedure for total sulfides might need to be made for sediment testing performed for both cleanup and DMMP characterization; and for projects where wood waste in new surface material may be an issue. In those cases, total sulfides should continue to be performed on single cores.

For sulfides sampling, 5 mls of 2 Normal zinc acetate per 30-g of sediment should be placed in a 4-ounce sampling jar. It is recommended that jars containing the zinc acetate be prepared in advance in order to reduce the possibility of zinc cross-contamination in the field. The sulfides sample sediments should be placed in the jar, covered, and shaken vigorously to completely expose the sediment to the zinc acetate.

The sulfides sampling jars should be clearly labeled with the project name, sample/composite identification, type of analysis to be performed, date and time, and initials of person(s) preparing the sample, and referenced by entry into the log book. The sulfides sampling jars should indicate that zinc acetate has been added as a preservative.

7.5.6 Sampling Logs

As sediment is collected, whether by core or grab, sampling/field logs must be completed. The following should be included in this log:

1. Date and time of collection of each sediment sample.
2. Names of field supervisors and person(s) collecting and logging in the sample.
3. Weather conditions.
4. The sample station number and individual designation numbers assigned for individual core sections.
5. Penetration depth and notation of any resistance of the sediment column to coring.
6. Percent recovery of each core and percent recovery calculations.
7. The measured water depth at each sampling station and the tidal stage at the time of sampling at each station. The measured water depth should then be corrected to mean lower low water (MLLW) by subtracting the tidal stage. The method/procedure used to determine the real-time tidal stage should be documented in the log.
8. For grab samples: physical sediment description, including type, density, color, consistency, odor, stratification, vegetation, debris, biological activity, presence of an oil sheen or any other distinguishing characteristics or features.
9. Any deviation from the approved sampling plan.

7.5.7 Extrusion, Core Logging, Compositing and Sub-sampling

Depending on the sampling methodology and procedure proposed, sample extrusion, core logging, compositing and subsampling may take place. If core sampling is conducted, these activities can either occur at the sampling site (e.g., on board the sampling vessel) or at a remote facility. Grab samples are processed immediately upon sampling. If cores are to be transported to a remote facility for processing, they should be stored upright on ice onboard the sampling vessel and during transport. The cores should be sealed in such a way as to prevent leakage and contamination. If the cores will be sectioned at a later time, thought needs to be given to core integrity during transport and storage to prevent loss of stratification. For cores or split-spoon sampling, the extrusion method should include procedures to prevent contamination.

Core logging can provide valuable information, not only for sediment characterization, but also for the dredging contract itself. It is recommended that core logging be conducted using the Unified Soil Classification System. The core logs must include a qualitative physical description, including density, color, consistency, odor, stratification, vegetation, debris, biological activity, presence of an oil sheen or any other distinguishing characteristics or features. Finally, the core logs should also record the penetration, recovery and indicate the core sections representing the DMMUs and Z-samples. Core depths should be logged based on collected depths prior to any corrections made for percent recovery.

For composited samples, representative volumes of sediment should be removed from each core section or grab sample comprising a composite. The composited sediment should be thoroughly

mixed until homogenized to a uniform color and consistency, and should occasionally be stirred while individual samples are taken of the homogenate. This will ensure that the mixture remains homogenous and that settling of coarse-grained sediments does not occur.

Seven (7) liters of homogenized sample needs to be prepared to provide adequate volume for physical, chemical and standard biological laboratory analyses. Bioassays require a minimum of five (5) liters while physical and chemical testing requires approximately one (1) liter of sediment. **Additional sample volume may be necessary for analysis of additional special COCs – such as porewater TBT – and for archive material.** Physical, chemistry and bioassay samples should be taken from the same homogenate. Portions of each composite sample will be placed in appropriate containers obtained from the testing laboratories (**Table 7-2**).

After compositing and sub-sampling are performed, the sample containers should be refrigerated or stored on ice until delivered to the analytical laboratory. The samples reserved for bioassays should be stored in the dark at 4 degrees C in containers or polyethylene bags with zero headspace, or with headspace purged with nitrogen, for **up to 56 days** pending initiation of any required biological testing. Each sample container should be clearly labeled with the project name, sample/composite identification, type of analysis to be performed, date and time, and initials of person(s) preparing the sample, and referenced by entry into the log book.

Table 7-2. Sample storage criteria

SAMPLE TYPE	HOLDING TIME	TEMP [2]	SAMPLE SIZE [1]	CONTAINER
Particle Size	6 Months	4 ± 2 degrees C	100-200 g (75-150 ml)	16 oz. Glass or HDPE
Total Solids	14 Days	4 ± 2 degrees C	125 g (100 ml)	8 oz. Glass or HDPE
	6 Months	-18 ± 2 degrees C		
Total Volatile Solids	14 Days	4 ± 2 degrees C	125 g (100 ml)	
	6 Months	-18±2 degrees C		
Total Organic Carbon	14 Days	4 ± 2 degrees C	125 g (100 ml)	
	6 Months	-18±2 degrees C		
Metals (except Mercury)	6 Months	4 ± 2 degrees C	50 g (40 ml)	4 oz. Glass
	2 years	-18±2 degrees C		
Mercury	28 Days	-18±2 degrees C	50 g (40 ml)	
Semi-volatiles, Pesticides And PCBs	14 Days until extraction	4 ± 2 degrees C	150 g (120 ml)	SVOC: 8 oz. Glass Pesticides/PCBs: 8 oz. Glass
	1 Year until extraction	-18±2 degrees C		
	40 Days after extraction	4 ± 2 degrees C		
Total Petroleum Hydrocarbons	14 Days	4 ± 2 degrees C	100 g	8 oz. Glass
Ammonia	7 Days	4 ± 2 degrees C	25 g (20 ml)	4 oz. Glass
Total Sulfides	7 Days	4 ± 2 degrees C [3]	50 g (40 ml)	4 oz. Glass
Tributyltin (porewater)	7 Days	4 ± 2 degrees C [4]	Sediment sufficient to collect 200-500 ml of porewater	(2) 32 oz. Glass
Tributyltin (bulk sediment)	6 Months	-18 ± 2 degrees C	50 g (40 ml)	4 oz. Glass
Dioxins/Furans	14 days until extraction	4 ± 2 degrees C	100 g (80 ml)	8 oz. Amber Glass Jar
	1 year until extraction	-18 ± 2 degrees C		
Bioassay	8 Weeks	4 ± 2 degrees C [4]	5 liters	(5) 1 liter Glass or HDPE Jars or Polyethylene Bags
Bioaccumulation	8 Weeks	4 ± 2 degrees C [4]	variable [5]	Glass or HDPE
Archive	Variable	-18 ± 2 degrees C	1 liter	min. 16 oz. Glass

[1]Recommended minimum field sample sizes for one laboratory analysis. Actual volumes to be collected have been increased to provide a margin of error and allow for retests.
[2] During transport to the lab, samples will be stored on ice. The mercury and archived samples will be frozen immediately upon receipt at the lab. Jars to be frozen must include headspace to prevent breakage.
[3]The sulfides sample will be preserved with 5 ml of 2 Normal zinc acetate for every 30 g of sediment.
[4]Headspace purged with nitrogen.
[5] See **Table 10-3**.

7.5.8 Sample Transport and Chain of Custody Procedures

Sample transport and chain-of-custody procedures should follow the PSEP protocols, which include the following guidelines:

1. If sediment cores are taken in the field and transported to a remote site for extrusion and compositing, chain-of-custody procedures should commence in the field for the core sections and should track the compositing and subsequent transfer of composited samples to the analytical laboratory. If compositing occurs in the field, chain-of-custody procedures should commence in the field for the composites and should track transfer of the composited samples to the analytical laboratory.
2. Samples should be packaged and shipped in accordance with U.S. Department of Transportation regulations as specified in 49 CFR 173.6 and 49 CFR 173.24.
3. Individual sample containers should be packed to prevent breakage and transported in a sealed ice chest or other suitable container.
4. Blue ice is recommended; if ice is used it should be double-bagged and well-sealed.
5. A temperature blank should be included in each cooler.
6. Each cooler or container containing sediment samples for analysis should be delivered to the laboratory within 24 hours of being sealed.
7. A sealed envelope containing chain-of-custody forms should be enclosed in a plastic bag and taped to the inside lid of the cooler.
8. Signed and dated chain-of-custody seals should be placed on all coolers prior to shipping.
9. The shipping containers should be clearly labeled with sufficient information (name of project, time and date container was sealed, person sealing the container and consultant's office name and address) to enable positive identification.
10. Upon transfer of sample possession to the analytical laboratory, the chain-of-custody form should be signed by the persons transferring custody of the sample containers. The shipping container seal should be broken, and the condition of the samples should be recorded by the receiver, including the temperature of the temperature blank.
11. Chain-of-custody forms should be used internally in the lab to track sample handling and final disposition.

7.6 PRE-SAMPLING CONFERENCE CALL

A pre-sampling conference call with the dredging proponent's sampling team may be required by the DMMP agencies. The pre-sampling call will include: review of project sampling details, establishment of vertical control and adjustment of sampling depths for changes in mudline elevation, and coordination with DMMP during the sampling event.