CHAPTER 8

TIER II: PHYSICAL AND CHEMICAL TESTING

8.1 OVERVIEW

Consistent with the tiered testing approach, and following an assessment of existing information in Tier I, physical and/or chemical characterization of the dredged material will be required. Tier II is designed to provide a reliable screen to predict potential contaminant effects from discharge of that material. The pathways of concern for potential effects are through the bulk sediment itself and/or through the water column. The collective experience in this region, as well as nationally, has shown that significant releases of chemicals of concern do not occur in the water column during dredging and disposal. Accordingly, this manual focuses on requirements and procedures for testing bulk sediments. When judged necessary by the Regional Management Team (RMT), water column testing will be required as outlined in this manual.

For this manual, Tiers IIA and IIB are subtiers which may be pursued individually. Tier IIA involves two conventional tests: grain size and total volatile solids. The term conventionals refers to a group of physical and chemical parameters often measured to aid in the interpretation of chemical and biological test results. Tier IIB involves a more complex combination of physical and chemical tests which measure concentrations of individual or groups of chemicals specified for the project or project area. Following testing, the results of the analysis for each dredged material management unit is compared to the appropriate decision guidelines. Determinations are then made concerning whether the sediment is suitable for unconfined aquatic disposal or whether further testing is required (Tier III or Tier IV).

There are three categories of “chemicals of concern” that will be considered in developing specific testing requirements for dredging projects: a standard list of chemicals of concern (CoC), a list for limited areas, and CoCs with bioaccumulation potential, which is typically a subset of the two lists. Although performed as part of Tier III, the determination whether bioaccumulation testing should be conducted is made in Tier II and depends upon the concentration of the chemical present in the sediment. The model to make this determination for ocean disposal (Theoretical Bioaccumulation Potential) requires sediment chemistry data.

8.2 PROTOCOLS

Sediment testing protocols to be used in Tiers IIA and IIB are generally those summarized in the latest version of the *Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound* (PSEP 1996) for marine sediments. Freshwater sediment protocols will follow Appendix F: Methods for Chemical and Physical Analysis, from the *Great Lakes Dredged Material Testing and Evaluation Manual* (EPA/USACE 1994). The Regional Management Team must approve any modifications of these protocols. This should occur during the preparation and finalization of the project sampling and analysis plan (see Chapter 6).

Standard protocols should be followed in assessing conventional parameters, with the following specifications:

Grain size: Measurement of grain size will be determined following the measurement techniques specified in ASTM D 422 (modified). Measurement requires use of a sedimentation sieve series consisting of the following sieve sizes: 5 inch, 2.5 inch, 1.25 inch, 5/8 inch, 5/16 inch, No. 5, No. 10, No. 18, No. 35, No. 60, No. 120, and No. 230. Material passing the 230 sieve determines the percent fines. Reporting shall include both the percent of sediment retained in each sieve as well as the percent passing. Hydrogen peroxide will not be used in preparations for grain-size analysis. (Hydrogen peroxide breaks down organic aggregates and its use may provide an overestimation of the percent fines found in undisturbed sediment. Incorrect grain size matches could result when reference sediments are collected.) Hydrometer analysis should be used for particle sizes finer than the 230 mesh. Water content will be determined using ASTM D 2216. Sediment classification designation will be made in accordance with U.S. Soil Classification System, ASTM D 2487 using the above sieves as an approximation.

Total Volatile Solids (TVS): Standard Method 2540 E, contained in the 19th Edition of Standard Methods of the Examination of Water and Wastewater (Franson 1995), is the required method for TVS analysis. Data must be presented as percent total volatile solids in the sample.

Total Organic Carbon (TOC): Detailed methods for analyzing TOC samples may be found in the 18th Edition of Standard Methods for Examination of Water and Wastewater (Franson, 1992). Method 5310B is recommended, slightly modified for sediment samples. A description of the modified TOC method is provided as a clarification in the proceedings from the PSDDA Fifth Annual Review Meeting (Bragdon-Cook, 1993).

Ammonia: Analyses should be conducted according to standard EPA/Corps procedures (Plumb, 1981). Reports detailing conventional tests should report detection limits and also report QA/QC.

Water quality tests: Program experience has shown that in most cases the existing data are sufficient to make water column determinations. However, Tier I evaluation may show that existing information is insufficient to make a determination. If a determination cannot be made in Tier I, Tier II evaluation is necessary. There are two approaches for the Tier II water column evaluation. One approach is to use the numerical models provided in the Inland Testing Manual (Appendix C) as a screen, assuming that all of the contaminants in the dredged material are released into the water column during the disposal process. The other approach applies the same model with results from chemical analysis of the elutriate test (DiGiano 1995, Ludwig 1988).

8.3 TIER IIA TESTING

Tier IIA is designed to characterize sediments likely to have minimal amounts of fine-grained material and therefore lower potential for concentrations of chemicals of concern. Sediments are sampled and analyzed for grain size and total volatile solids (TVS), the latter to assess the organic content of the sediment. However, other conventional parameters (such as TOC, total solids, and ammonia) may be required as determined applicable to the proposed dredging location. If the results of the grain size analysis are greater than 20 percent fines and TVS is less than 5 percent, then the dredged material may qualify for unconfined aquatic disposal based on exclusionary status (see Table 5-1). If the results fail either guideline then the sediment must undergo bulk sediment analysis to test for chemicals of concern.

8.4 TIER IIB TESTING

Due to the relationship between CoCs and biological effects, chemical testing for these substances can be used to relate the potential for adverse biological effects in the environment to specific contaminants. Chemical data by themselves are useful surrogates for potential biological effects. Knowledge of the specific types of chemicals is also important to the management of dredged material, because different chemicals may require different controls.

Chemicals of concern are differentiated into three categories in this manual; a standard list, a list of chemicals that occur in limited areas, and chemicals which may bioaccumulate. In general, it is preferable to have a relatively limited list of chemicals of concern for routine testing, and to add chemicals to this list on a project-specific basis. However, few chemicals can be tied to a specific geographic area, because they are widespread and have multiple sources. For those chemicals which can be linked to specific sources or activities, testing will be required only when those activities have been present in the vicinity.

Tier IIB testing is designed to assess the presence of the conventionals and chemicals of concern listed in Table 8-1. Chemicals of concern generally have the following characteristics:

< A demonstrated or suspected adverse biological or human health effect.

< A relatively widespread distribution and high concentration when compared to natural or background conditions.

< A potential for remaining in a toxic form for long periods in the environment (persistent).

< A potential for entering the food web (bioavailable).

8.4.1 Standard List of Chemicals of Concern. The chemicals of concern on the standard list have been shown to be present in developed areas in the Pacific Northwest. The CoCs listed on Table 8-1 and 8-2 are considered to be applicable to the LCRMA. If data collected in accordance with the guidelines in Chapters 6 and 7 shows that certain CoCs are not present in the project vicinity, these chemicals need not be included in any further testing.

Table 8-1 presents the dry weight interpretive guideline values for each chemical, including a bioaccumulation trigger. Table 8-2 presents preparation methods, analytical methods, and method detection limits. These are recommended methods, and ones that have been able to achieve the analyte-specific detection limits on past projects. Other methods may be proposed and will be considered during the sampling and analysis plan review. Exceedance of the bioaacumulation trigger indicates that the chemical may accumulate at levels that pose a risk to aquatic biota and/or human health. Use of the guideline values is discussed in Section 8.5.

Table 8-1
Screening Levels (SL), Bioaccumulation Triggers (BT)
and Maximum Levels (ML)

CHEMICAL	**CAS (1) NUMBER**	**SCREENING LEVEL**	**BIOACCUM TRIGGER**	**MAXIMUM LEVEL**
METALS (mg/kg)				
Antimony	7440-36-0	150	150	200
Arsenic	7440-38-2	57	507.1	700
Cadmium	7440-43-9	5.1	---	14
Copper	7440-50-8	390	---	1,300
Lead	7439-92-1	450	---	1,200
Mercury	7439-97-6	0.41	1.5	2.3
Nickel	7440-02-0	140	370	370
Silver	7440-22-4	6.1	6.1	8.4
Zinc	7440-66-6	410	---	3,800
ORGANOMETALLIC COMPOUNDS (ug/L)				
Tributyltin (2) (interstitial water)	56573-85-4	0.15	0.15	---
ORGANICS (ug/kg)				
Total LPAH	---	5,200	---	29,000
Naphthalene	91-20-3	2,100	---	2,400
Acenaphthylene	208-96-8	560	---	1,300
Acenaphthene	83-32-9	500	---	2,000
Fluorene	86-73-7	540	---	3,600
Phenanthrene	85-01-8	1,500	---	21,000
Anthracene	120-12-7	960	---	13,000
2-Methylnaphthalene	91-57-6	670	---	1,900

TABLE 8-1 (CONTINUED)

CHEMICAL	CAS (1) NUMBER	SCREENING LEVEL	BIOACCUM TRIGGER	MAXIMUM LEVEL
Total HPAH	---	12,000	---	69,000
Fluoranthene	206-44-0	1,700	4,600	30,000
Pyrene	129-00-0	2,600	---	16,000
Benz(a)anthracene	56-55-3	1,300	---	5,100
Chrysene	218-01-9	1,400	---	21,000
Benzofluoranthenes (b+k)	205-99-2 207-08-9	3,200	---	9,900
Benzo(a)pyrene	50-32-8	1,600	3,600	3,600
Indeno(1,2,3-c,d)pyrene	193-39-5	600	---	16,000
Dibenz(a,h)anthracene	53-70-3	230	---	1,900
Benzo(g,h,i)perylene	191-24-2	670	---	3,200
CHLORINATED HYDROCARBONS				
1,3-Dichlorobenzene	541-73-1	170	1,241	---
1,4-Dichlorobenzene	106-46-7	110	120	120
1,2-Dichlorobenzene	95-50-1	35	37	110
1,2,4-Trichlorobenzene	120-82-1	31	---	64
Hexachlorobenzene (HCB)	118-74-1	22	168	230
PHTHALATES				
Dimethyl phthalate	131-11-3	1,400	1,400	---
Diethyl phthalate	84-66-2	1,200	---	---
Di-n-butyl phthalate	84-74-2	5,100	10,220	---
Butyl benzyl phthalate	85-68-7	970	---	---
Bis(2-ethylhexyl) phthalate	117-81-7	8,300	13,870	---
Di-n-octyl phthalate	117-84-0	6,200	---	---

TABLE 8-1 (CONTINUED)

CHEMICAL	CAS (1) NUMBER	SCREENING LEVEL	BIOACCUM TRIGGER	MAXIMUM LEVEL
PHENOLS				
Phenol	108-95-2	420	876	1,200
2-Methylphenol	95-48-7	63	---	77
4-Methylphenol	106-44-5	670	---	3,600
2,4-Dimethylphenol	105-67-9	29	---	210
Pentachlorophenol	87-86-5	400	504	690
MISCELLANEOUS EXTRACTABLES				
Benzyl alcohol	100-51-6	57	---	870
Benzoic acid	65-85-0	650	---	760
Dibenzofuran	132-64-9	540	---	1,700
Hexachloroethane	67-72-1	1,400	10,220	14,000
Hexachlorobutadiene	87-68-3	29	212	270
N-Nitrosodiphenylamine	86-30-6	28	130	130
PESTICIDES				
Total DDT (sum of 4,4'-DDD, 4,4'-DDE and 4,4'-DDT)	72-54-8 72-55-9 50-29-3	6.9	50	69
Aldrin	309-00-2	10	37	---
alpha-Chlordane	12789-03-6	10	37	---
Dieldrin	60-57-1	10	37	---
Heptachlor	76-44-8	10	37	---
gamma-BHC (Lindane)	58-89-9	10	---	---
Total PCBs	---	130	38 (3)	3,100

(1) Chemical Abstract Service Registry Number.
(2) See *Testing, Reporting, and Evaluation of Tributyltin Data in PSDDA and SMS Programs* at URL *http://www.nws.usace.army.mil/dmmo/8th_arm/tbt_96.htm*
(3) This value is normalized to total organic carbon, and is expressed in mg/kg (TOC normalized).

8.4.2 Chemicals of Special Occurrence. The following chemicals are known to be associated with specific activities or industries. They are not believed to be widespread in the Lower Columbia River. Testing for these chemicals or other chemicals will be required when there is a reason-to-believe that they might be present.

Guaiacols. Guaiacols and chlorinated guaiacols are measured in areas where kraft pulp mills are located. Only guaiacols will be measured near sulfite pulp mills (chlorinated guaiacols are not expected in processes that do not involve bleaching).

Resin Acids. May include abietic acid, dehydroabietic acid, dichlorodehydroabietic acid, isopimaric acid, and sandaracopimaric acid.

Chromium. Chromium appears to derive largely from the natural erosions of crustal rocks, but localized sources of chromium also exist in industrial locations where plating took place or in the vicinity of chemical manufacturers. Testing will be required when sources are present.

Butyltins. Butyltin testing is indicated in various areas, such as those near boat and vessel maintenance and construction. Pore water analysis is recommended over bulk sediment analysis. Details concerning TBT analysis are contained in Appendix 8-A.

Dioxin/furans. Testing will generally be required when projects are in areas potentially impacted by known sources of dioxin/furan or in areas where the presence of dioxin/furan compounds has been demonstrated in past testing. It is anticipated that those projects indicating previously low levels of concern for dioxin/furan compounds will not need to provide dioxin/furan data on a routine basis in the future unless there is a reason-to-believe that existing conditions have changed. A P450 biomarker test may be utilized in screening for the presence of dioxin/furan.

8.5 INTERPRETIVE GUIDELINES

The purpose of evaluating dredged material is to anticipate (and manage) the potential biological effects, rather than merely the chemical presence, of the possible CoCs. Biological tests serve to integrate chemical and biological interactions of contaminants present in a sediment sample, including the availability for biological uptake, by measuring the effects on test organisms through bioassays and bioaccumulation. Such testing, however, is expensive.

Within the Pacific Northwest, scientists and regulatory personnel have developed sediment quality values to predict potential adverse biological effects based on demonstrated toxicity in bioassay tests (not bioaccumulation) involving appropriately sensitive benthic organisms and a decision model for their use. The use of sediment quality values as regulatory screens has proven to be environmentally protective as well as economically efficient. Both Washington and Oregon have used the approach as the basis for developing water quality standards for sediments. EPA Region 10 has used the approach and specific values for sediment management decisions throughout the Pacific Northwest, including the lower Columbia and Willamette Rivers for the past several years.

These screening values were developed for the marine environment. Freshwater values are under development. In the interim, the marine/estuarine values are useful as indicators of the need for effects-based testing. A comparison with the draft Washington Department of Ecology freshwater AETs show the screening levels contained in Table 8-1 to be conservative for a freshwater environment.

A screening level (SL) value for each chemical identifies chemical concentrations at or below which there is no reason-to-believe that dredged material disposal would result in unacceptable adverse effects due to toxicity measured by sediment bioassays. Sediments containing chemical concentrations at or below all SL values are judged to be suitable for aquatic disposal without the need for biological testing.

A second, higher maximum level (ML) is identified for each chemical above which there is reason-to-believe that the material would likely fail the standard suite of biological tests and thus be unacceptable for unconfined aquatic disposal. Recent biological testing at one location in Puget Sound indicated “suitable” responses in the standard bioassay tests although the chemical data measured several compounds well above the ML. These data suggest that the ML is not a de facto “failure” criterion and should not be assumed to be such. However, regional experience still indicates that there is a significantly greater likelihood of failing the bioassay tests when chemical levels in dredged material exceed the ML.

A third chemical screen, the bioaccumulation trigger (BT) has been determined for some chemicals of concern. This may be an important factor in determining sediment suitability for sediments at or above the ML.

8.5.1 Interpretive Guidelines for Bioassay Testing. Results of chemical testing will be compared to chemical guideline values presented in Table 8-1 (dry weight normalized).

For each dredged material management unit, the SL guideline values will be used to determine if biological testing is required. The following two situations are possible: 1) all chemicals are at or below the SL guideline; no biological testing is required and the management unit is considered suitable for unconfined, aquatic disposal, or 2) one or more chemicals are present at levels above the SL guideline; standard biological testing (including bioaccumulation if triggered) is required (see Chapter 9).

When chemicals of concern exceed the ML values, the dredging proponent will have two options regarding the evaluation of the dredged material. First, the proponent may elect to accept the indication of the ML and conclude that the material is unsuitable for unconfined, aquatic disposal. Biological testing is not required for this decision. The second option is to conduct biological testing rather than rely on the indications of the ML. For this option, the proponent would conduct the standard suite of bioassays, bioaccumulation (if a bioaccumulation trigger is exceeded), and other additional tests required by the RMT in order to determine final biological suitability of the material for unconfined, aquatic disposal. The RMT will make its decision as to whether specific, effect-based tests beyond the standard suite should be required based on the type and number of chemicals and best available scientific knowledge. Such non-standard testing may involve Tier IV (see Chapter 10).

8.5.2 Interpretive Guidelines for Bioaccumulation Testing. In addition to comparisons to SL and ML and subsequent determinations outlined above, chemical concentrations are used as triggers for determining when bioaccumulation testing is required. These values are found in Tables 8-1. If any listed chemical of concern exceeds the BT value, bioaccumulation testing will be required in order to determine whether dredged material is suitable for unconfined, aquatic disposal. When dioxins/furans and/or butyltins are the only CoCs that are detected above SL values, bioaccumulation testing may be triggered rather than toxicity tests. Specific discussion on conducting bioaccumulation tests is presented in Chapter 9.

8.5.3 The Role of Detection Limits in Interpretation. Where detection limits are above SL, sample-specific detection limits will be used to determine biological testing requirements. The guidelines for detected chemicals of concern apply equally to detection limits. The (sub)contractor performing the chemical testing should strive to achieve limits of detection below the screening levels, including additional cleanup steps, re-extraction, etc. This is the only way to preclude the biological testing requirement. If problems or questions arise, the dredger or chemical testing (sub)contractor should contact the RMT through the appropriate DMMO/DMMT. The following scenarios are possible and need to be understood and handled appropriately:

One or more CoCs have limits of detection exceeding screening levels while all other CoCs are quantitated or have limits of detection at or below the SL. The requirement to conduct biological testing will be triggered solely by limits of detection.

One or more CoCs have limits of detection exceeding screening levels for a lab sample, but below respective BTs and MLs, and other CoCs have quantitated concentrations above screening levels. The need to conduct bioassays is based on the detected exceedances of SLs and the limits of detection above SL become irrelevant. No further action is necessary.

One or more CoCs have limits of detection exceeding SL and exceeding BT or ML, and other CoCs have quantitated concentrations above screening levels. The need to conduct bioassays is based on the detected exceedances of SLs. All other limits of detection must be brought below BTs and MLs to avoid bioaccumulation testing or Tier IV testing.

In all cases, sediments or extracts should be kept under proper storage conditions until the chemistry data are deemed acceptable by the regulatory agencies (see Table 7-1). This retains the option for retesting or higher level quantitation. Quality assurance and quality control are an important element of chemical testing. Chemistry QA requirements are listed in Chapter 11.

TABLE 8-2

TESTING METHODS
(Testing Parameter, Preparation Method, Analytical Method, Sediment Method Detection Limit (MDL)

PARAMETER	PREP METHOD (recommended)	ANALYSIS METHOD (recommended)	SEDIMENT MDL (1)
CONVENTIONALS:			
Total Solids (%)	---	Pg.17 (2)	0.1
Total Volatile Solids(%)	---	Pg.20 (2)	0.1
Total Organic Carbon (%)	---	Pg.23 (2, 3)	0.1
Total Sulfides (mg/kg)	---	Pg.32 (2)	1
Ammonia (mg/kg)	---	Plumb 1981 (4)	1
Grain Size	---	Modified ASTM with Hydrometer	---
METALS (ppm):			
Antimony	APNDX D (5)	GFAA (6)	2.5
Arsenic	APNDX D (5)	GFAA (6)	2.5
Cadmium	APNDX D (5)	GFAA (6)	0.3
Chromium	APNDX D (5)	GFAA (6)	0.3
Copper	APNDX D (5)	ICP (7)	15.0
Lead	APNDX D (5)	ICP (7)	0.5
Mercury	MER (8)	7471 (8)	0.02
Nickel	APNDX D (5)	ICP (7)	2.5
Silver	APNDX D (5)	GFAA (6)	0.2
Zinc	APNDX D (5)	ICP (7)	15.0
ORGANOMETALLIC COMPOUNDS (ug/L):			
Tributyltin (interstitial water)	NMFS	Krone	0.01

TABLE 8-2 (CONTINUED)

ORGANICS (ppb):			
LPAH			
Naphthalene	3550 (9)	8270 (10)	20
Acenaphthylene	3550 (9)	8270 (10)	20
Acenaphthene	3550 (9)	8270 (10)	20
Fluorene	3550 (9)	8270 (10)	20
Phenanthrene	3550 (9)	8270 (10)	20
Anthracene	3550 (9)	8270 (10)	20
2-Methylnaphthalene	3550 (9)	8270 (10)	20
Total LPAH			
HPAH			
Fluoranthene	3550 (9)	8270 (10)	20
Pyrene	3550 (9)	8270 (10)	20
Benzo(a)anthracene	3550 (9)	8270 (10)	20
Chrysene	3550 (9)	8270 (10)	20
Benzofluoranthenes	3550 (9)	8270 (10)	20
Benzo(a)pyrene	3550 (9)	8270 (10)	20
Indeno(1,2,3-c,d)pyrene	3550 (9)	8270 (10)	20
Dibenzo(a,h)anthracene	3550 (9)	8270 (10)	20
Benzo(g,h,i)perylene	3550 (9)	8270 (10)	20
Total HPAH			
CHLORINATED HYDROCARBONS			
1,3-Dichlorobenzene	P&T (12)	8260 (11)	3.2
1,4-Dichlorobenzene	P&T (12)	8260 (11)	3.2
1,2-Dichlorobenzene	P&T (12)	8260 (11)	3.2
1,2,4-Trichlorobenzene	3550 (9)	8270 (10)	6
Hexachlorobenzene (HCB)	3550 (9)	8270 (10)	12

TABLE 8-2 (CONTINUED)

PHTHALATES			
Dimethyl phthalate	3550 (9)	8270 (10)	20
Diethyl phthalate	3550 (9)	8270 (10)	20
Di-n-butyl phthalate	3550 (9)	8270 (10)	20
Butyl benzyl phthalate	3550 (9)	8270 (10)	20
Bis(2-ethylhexyl)phthalate	3550 (9)	8270 (10)	20
Di-n-octyl phthalate	3550 (9)	8270 (10)	20
PHENOLS			
Phenol	3550 (9)	8270 (10)	20
2 Methylphenol	3550 (9)	8270 (10)	6
4 Methylphenol	3550 (9)	8270 (10)	20
2,4-Dimethylphenol	3550 (9)	8270 (10)	6
Pentachlorophenol	3550 (9)	8270 (10)	61
MISCELLANEOUS EXTRACTABLES			
Benzyl alcohol	3550 (9)	8270 (10)	6
Benzoic acid	3550 (9)	8270 (10)	100
Dibenzofuran	3550 (9)	8270 (10)	20
Hexachloroethane	3550 (9)	8270 (10)	20
Hexachlorobutadiene	3550 (9)	8270 (10)	20
N-Nitrosodiphenylamine	3550 (9)	8270 (10)	12
PESTICIDES			
Total DDT	---	---	---
p,p'-DDE	3540 (13)	8081 (13)	2.3
p,p'-DDD	3540 (13)	8081 (13)	3.3
p,p'-DDT	3540 (13)	8081 (13)	6.7
Aldrin	3540 (13)	8081 (13)	1.7
Chlordane	3540 (13)	8081 (13)	1.7
Dieldrin	3540 (13)	8081 (13)	2.3
Heptachlor	3540 (13)	8081 (13)	1.7
Lindane	3540 (13)	8081 (13)	1.7
Total PCBs	3540 (13)	8081 (13)	67

* Total PCBs BT value in ppm carbon-normalized.

1. Dry Weight Basis.
2. Recommended Protocols for Measuring Conventional Sediment Variables in Puget Sound, Puget Sound Estuary Program, 1997.
3. Recommended Methods for Measuring TOC in Sediments, Kathryn Bragdon-Cook, Clarification Paper, Puget Sound Dredged Disposal Analysis Annual Review, May, 1993.
4. Procedures For Handling and Chemical Analysis of Sediment and Water Samples, Russell H. Plumb, Jr., EPA/Corps of Engineers, May, 1981.
5. Recommended Protocols for Measuring Metals in Puget Sound Water, Sediment and Tissue Samples, Puget Sound Estuary Program, 1997.
6. Graphite Furnace Atomic Absorption (GFAA) Spectrometry - SW-846, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1986.
7. Inductively Coupled Plasma (ICP) Emission Spectrometry - SW-846, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1986.
8. Mercury Digestion and Cold Vapor Atomic Absorption (CVAA) Spectrometry - Method 747I, SW-846, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1986.
9. Sonication Extraction of Sample Solids - Method 3550 (Modified), SW-846, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1986. Method is modified to add matrix spikes before the dehydration step rather than after the dehydration step.
10. GCMS Capillary Column - Method 8270, SW-846, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1986.
11. GCMS Analysis - Method 8260, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1986.
12. Purge and Trap Extraction and GCMS Analysis - Method 8260, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1986.
13. Soxhlet Extraction and Method 8080, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1997.