Government of Gibraltar

Department of the Environment

GUIDELINES FOR THE ASSESSMENT OF DREDGED MATERIAL

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1 INTRODUCTION

1.1 Dredging is essential to maintain navigation in ports, harbours, marinas and inland waterways; for the development of port facilities; for flood mitigation; and for removal of sediments from structures, basins and water intakes. Much of the material removed during these necessary activities may require disposal at sea. The greater proportion of the total amount of material dredged worldwide is, by nature, similar to undisturbed sediments in inland and coastal waters. A proportion of dredged material, however, is contaminated by human activity to an extent that major environmental constraints need to be applied when considering disposal or use of these sediments.

1.2 Environmental impacts may result from both dredging activities and the disposal of dredged material. These Guidelines have been adopted from the London Convention 1972 and the 1996 Protocol, that is, the disposal of dredged material, and modified accordingly by the Department of the Environment, Government of Gibraltar.

They are currently the Departmental guidelines for the Assessment of Dredged Material. Any request for an application for the disposal of dredged material at sea must have due regard to these guidelines.

Evaluation of need for dredging and disposal

1.3 There are a number of dredging activities, which may give rise to the need to relocate or dispose of sediments. These include:

.1 *Capital dredging* - for navigation, to enlarge or deepen existing channel and port areas or to create new ones; and for engineering purposes; e.g., trenches for pipes, cables, immersed tube tunnels, removal of material unsuitable for foundations, removal of overburden for aggregate extractions;

.2 *Maintenance dredging* - to ensure that channels, berths or construction works, etc., are maintained at their designed dimensions; and

.3 *Clean up dredging* - deliberate removal of contaminated material for human health and environmental protection purposes.

.4 *Creation/construction dredging* – dredging of material for the reclamation of land.

Before beginning a full assessment of the material and the disposal options the question should be asked, “Is dredging necessary?” In the event of a subsequent full assessment

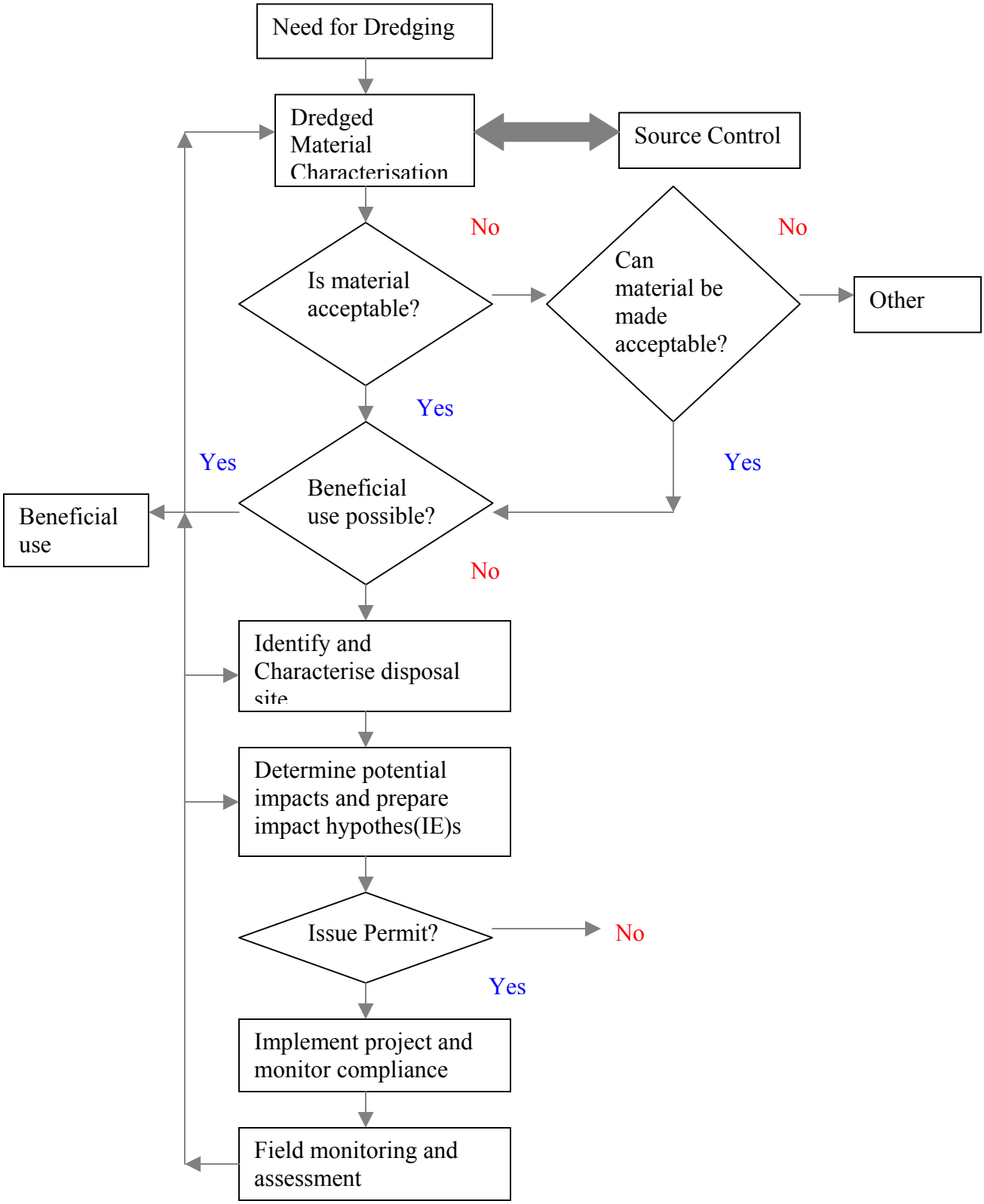
indicating no acceptable options for disposal it will be necessary to re-address this question in a broader context.

1.4 The Guidelines for the Assessment of Wastes or Other Matter that May be Considered for Dumping, referred to in short as the "Generic Guidelines", as well as the Guidelines for Assessment of Dredged Material addressed in this document are intended for use by national authorities responsible for regulating dumping of wastes and embody a mechanism to guide national authorities in evaluating applications for dumping of wastes in a manner consistent with the provisions of the London Convention 1972 or the 1996 Protocol thereto. Industry should refer to these guidelines in their assessment of dredged material prior to the application of a permit regarding the disposal of material at sea. Annex 2 to the 1996 Protocol places emphasis on progressively reducing the need to use the sea for dumping of wastes. Furthermore, it recognizes that avoidance of pollution demands rigorous controls on the emission and dispersion of contaminating substances and the use of scientifically based procedures for selecting appropriate options for waste disposal. When applying these Guidelines uncertainties in relation to assessments of impacts on the marine environment will need to be considered and a **precautionary approach** applied by the Department of the Environment in addressing these uncertainties. They should be applied with a view that acceptance of dumping under certain circumstances does not remove the obligation to make further attempts to reduce the necessity for dumping.

1.5 The schematic shown in Figure 1 provides a clear indication of the stages in the application of this guidance where important decisions should be made. In general, national authorities should use this schematic in an iterative manner ensuring that all steps receive consideration before a decision is made to issue a permit. Figure 1 contains the following elements:

.1 Dredged Material Characterization;
.2 Waste Prevention Audit and Evaluation of Disposal Options;
.3 Is Material Acceptable;
.4 Identify and Characterize Dump-site;
.5 Determine Potential Impacts and Prepare Impact Hypothesis(es);
.6 Issue Permit;
.7 Implement Project and Monitor Compliance; and
.8 Field Monitoring and Assessment.

Figure 1 Dredged Material Assessment Framework



2 WASTE PREVENTION AUDIT

2.1 For dredged material, the goal of waste management should be to identify and control the sources of contamination. Contaminant source evaluation and control should be carried out as follows:

.1 contamination of estuarine and coastal marine sediments both as a consequence of historical and present day inputs presents a continuing problem for the management of dredged material. High priority should be given to the identification of sources, reduction and prevention of further contamination of sediments and should address both point and diffuse sources. Successful implementation of prevention strategies will require collaboration among agencies with responsibility for the control of point and diffuse sources of contamination;

.2 in developing and implementing the source control strategy, appropriate agencies should take into account:

.A the continuing need for dredging;
.B the hazards posed by contaminants and the relative contributions of the individual sources to these hazards;
.C existing source control programmes and other regulations or legal requirements;
.D technical and economic feasibility;
.E the evaluation of the effectiveness of measures taken; and
.F consequences of not implementing contaminant reduction;

.3 in cases where there has been historical contamination or where control measures are not fully effective in reducing contamination to acceptable levels, disposal management techniques, including the use of containment or treatment methods may be required.

3 EVALUATION OF DISPOSAL OPTIONS

3.1 The results of the physical/chemical/biological characterization will indicate whether the dredged material, in principle, is suitable for disposal at sea. This is to be decided by the Department of the Environment. Where sea disposal is identified as an acceptable option it is nonetheless important, recognizing the potential value of dredged material as a resource, to consider the availability of beneficial uses.

Beneficial Uses

3.2 There is a wide variety of beneficial uses depending on the physical and chemical characteristics of the material. Generally, a characterization carried out in accordance with Chapter 4 of these Guidelines will be sufficient to match a material to possible uses such as:

.1 *Engineered uses* - land creation and improvement, beach nourishment, offshore berms, capping material and fill;

.2 *Agriculture and product uses* - aquaculture, construction material, liners; and

.3 *Environmental enhancement* - restoration and establishment of wetlands, upland habitats, nesting islands, and fisheries.

The technical aspects of beneficial uses are well established and described in the literature.

Management Options

3.3 Where the characteristics of the dredged material are such that its disposal would not meet the requirements of the Department of the Environment, treatment or other management options should be considered. These options can be used to reduce or control impacts to a level that will not constitute an unacceptable risk to human health, or harm living resources, damage amenities or interfere with legitimate uses of the sea.

3.4 Treatment, such as separation of contaminated fractions, can make the material suitable for a beneficial use and should be considered before opting for sea disposal. Disposal management techniques may include placement on or burial in the sea floor followed by clean sediment capping, utilization of geo-chemical interactions and transformations of substances in dredged material when combined with sea water or bottom sediment, selection of special sites such as abiotic zones, or methods of containing dredged material in a stable manner.

3.5 A permit to dump wastes or other matter shall be refused if the Department of the Environment determines that appropriate opportunities exist to re-use, recycle or treat the waste without undue risks to human health or the environment or disproportionate costs. The practical availability of other means of disposal should be considered in the light of a comparative risk assessment involving both dumping and the alternatives.

4 DREDGED MATERIAL CHARACTERIZATION

A typical sediment characterization required by the Department of the Environment will constitute sediment testing in one or a combination of the following:

.A physical characterization
.B chemical characterization
.C biological characterization

The testing is to be undertaken by an EU accredited laboratory.

Physical characterization

4.1 Evaluation of the physical characteristics of sediments for disposal is necessary to determine potential environmental impact and the need for chemical and/or biological

testing. The basic physical characteristics required are the amount of material, particle size distribution and specific gravity of solids.

Further guidance can be found in Technical Annex I.

Exemptions from detailed characterization

4.2 Dredged material may be exempted from the full characterization requested in paragraphs 4.3 to 4.9 below if it meets *one* of the criteria listed below:

.1 dredged material is excavated from a site away from existing and historical sources of appreciable pollution, so as to provide reasonable assurance that the dredged material has not been contaminated, *or*

.2 dredged material is composed predominantly of sand, gravel and/or rock, *or*

.3 dredged material is composed of previously undisturbed geological materials.

Dredged material that does not meet one of these criteria will require a full characterization to assess its potential impact.

Chemical characterization

4.3 Sufficient information for chemical characterization may be available from existing sources: in such cases new measurements may not be required of the potential impact of similar material at similar sites, provided that this information is still reliable and has been obtained within the last 5 years, with the Department of the Environment having sole and full discretion on this. Further details of the substances recommended to be determined are listed in Technical Annex I.

4.4 Considerations for additional chemical characterization of dredged material are as follows:

.1 major geo-chemical characteristics of the sediment including redox status;
.2 potential routes by which contaminants could reasonably have been introduced to the sediments;
.3 data from previous sediment chemical characterization and other tests of the material or other similar material in the vicinity, provided this information is still reliable;
.4 probability of contamination from agricultural and urban surface runoff;
.5 spills of contaminants in the area to be dredged;
.6 industrial and municipal waste discharges (past and present);
.7 source and prior use of dredged materials (e.g., beach nourishment); and
.8 substantial natural deposits of minerals and other natural substances.

4.5 Sampling of sediments from the proposed dredging site should represent the vertical and horizontal distribution and variability of properties of the materials to be dredged.

4.6 Further information may also be useful in interpreting the results of chemical testing, such as grain size distribution, total organic carbon (TOC), and other normalizing constituents. The chemical parameters to be included in the testing are the following full suite of contaminants (Further guidance can be found in Technical Annex I):

.1 Heavy metals,
.2 Petroleum Hydrocarbons including TPH (and their speciation),
.3 Polycyclic Aromatic Hydrocarbons' including TPAH,
.4 Polychlorinated Biphenyls including TPCB and oganotin compounds,
.5 Screening for asbestos
.6 Determinands for pesticides and herbicides
.7 Mineral Oils
.8 pH, total organic content, sulphate, sulphide, chloride, phosphate, oxidised nitrogen and ammonia cal nitrogen.

Biological characterization

4.7 If the potential impacts of the dredged material to be dumped cannot be assessed on the basis of the chemical and physical characterization and available biological information, biological testing should be conducted. Further detailed guidance on the biological characterization can be found in Technical Annex I.

4.8 It is important to ascertain whether an adequate scientific basis exists on the characteristics and composition of the material to be dumped and on the potential impacts on marine life and human health. In this context, it is important to consider information about species known to occur in the area of the disposal site and the effects of the material to be dumped and of its constituents on organisms.

4.9 Biological tests should incorporate species that are considered appropriately sensitive and representative and exposures should be to representative materials so as to determine the potential for:

.1 acute toxicity;
.2 chronic toxicity such as long-term sub-lethal effects, covering an entire life cycle;
.3 the potential for bioaccumulation; and
.4 the potential for tainting

at and in the vicinity of the disposal site.

4.10 If dredged material is so poorly characterized that proper assessment cannot be made of its potential impacts on human health and the environment, it shall not be dumped.

5. DREDGED MATERIAL SAMPLING

Sampling for the purpose of issuing a dumping permit

5.1 Dredged material that is not exempted under paragraph 4.2 will require analysis and testing (Technical Annex I) to obtain sufficient information for permitting purposes. Judgement and knowledge of local conditions will be essential when deciding what information is relevant to any particular operation.

5.2 A survey of the area to be dredged may be required (referred to as an "In and Out Survey"). The distribution and depth of sampling should reflect the size and depth of the area to be dredged, the amount to be dredged and the expected variability in the horizontal and vertical distribution of contaminants. Core samples should be taken where the depth of dredging and expected vertical distribution of contaminants suggest that this is warranted. In other circumstances, grab sampling may be sufficient. Sampling from dumping vessels or barges will not be considered for permitting purposes.

5.3 The following table gives an indication of the number of separate sampling stations required to obtain representative results, assuming reasonably uniform sediment in the area to be dredged:

Amount dredged (m3)	Number of Stations
Up to 25 000	3
25 000 - 100 000	4 - 6
100 000 - 500 000	7 - 15
500 000 - 2 000 000	16 - 30
>2 000 000	extra 10 per million m3

The number of sample stations can also be determined on the basis of the area to be dredged. The number of sample stations should take account of the exchange characteristics of the area; more samples may be required in enclosed and semienclosed areas and less in open areas.

5.4 Normally, the samples from each sampling station should be analysed separately. However, if the sediment is clearly homogenous with respect to sediment texture, it may be possible to analyse composite samples from two or more adjacent sampling stations at a time, providing care is taken to ensure that the results allow derivation of valid mean contaminant values. The original individual samples should, however, be retained until the permitting procedure has been completed, and in case further analyses are necessary. Guidance is to be sought from the Department of the Environment before composite samples are taken.

Frequency of sampling

5.5 If the results of the analyses indicate that the material is essentially 'clean'[1], sampling in the same area need not be repeated more frequently than once every 3-5 years, provided that there is no indication that the quality of the material has deteriorated.

[1] The definition of what constitutes "clean" material is to be determined by the Department of the Environment.

5.6 It may be possible, following assessment of the results of an initial survey, to reduce either the number of sampling stations or the number of determinants and still provide sufficient information for permitting purposes. If a reduced sampling programme does not confirm the earlier analyses, the full survey should be repeated.

If the list of determinants is reduced, consent must be sought from the Department of the Environment. Further analysis of the complete list of determinants is advisable on average every 3-5 years, although specific time scales will be set by the Department of the Environment.

5.7 In areas where there is a tendency for sediments to exhibit high levels of contamination, analysis of all the relevant determinants should be frequent and linked to the permit renewal procedure.

6 DUMP-SITE SELECTION

Site selection considerations

6.1 Proper selection of a dump-site at sea for the reception of waste is of paramount importance and will be determined by the Department of the Environment.

6.2 Information required to select a dump-site shall include:

.1 physical, chemical and biological characteristics of the water-column and the seabed;
.2 location of amenities, values and other uses of the sea in the area under consideration;
.3 assessment of the constituent fluxes associated with dumping in relation to existing fluxes of substances in the marine environment; and
.4 economic and operational feasibility.

6.3 Required information includes:

.1 the nature of the seabed, including its topography, geo-chemical and geological characteristics, its biological composition and activity, and prior dumping activities affecting the area;

.2 the physical nature of the water column, including temperature, depth, possible existence of a thermocline/pycnocline and how it varies in depth with season and weather conditions, tidal period and orientation of the tidal ellipse, mean direction and velocity of the surface and bottom drifts, velocities of storm-wave induced bottom currents, general wind and wave characteristics, and the average number of storm days per year, suspended matter; and

.3 the chemical and biological nature of the water column, including pH, salinity, dissolved oxygen at surface and bottom, chemical and biochemical oxygen demand, nutrients and their various forms and primary productivity.

6.4 Some of the important amenities, biological features and uses of the sea to be considered in determining the specific location of the dump-site are:

.1 the shoreline and bathing beaches;
.2 areas of beauty or significant cultural or historical importance;
.3 areas of special scientific or biological importance, such as sanctuaries;
.4 fishing areas;
.5 spawning, nursery and recruitment areas;
.6 migration routes;
.7 seasonal and critical habitats;
.8 shipping lanes;
.9 military exclusion zones; and
.10 engineering uses of the seafloor, including mining, undersea cables, desalination or energy conversion sites.

Size of the dump-site

6.5 Size of the dump-site is an important consideration for the following reasons:

.1 it should be large enough, unless it is an approved dispersion site, to have the bulk of the material remain either within the site limits or within a predicted area of impact after dumping;

.2 it should be large enough to accommodate anticipated volumes of solid waste and/or liquid wastes to be diluted to near background levels before or upon reaching site boundaries;

.3 it should be large enough in relation to anticipated volumes for dumping so that it would serve its function for many years; and

.4 it should not be so large that monitoring would require undue expenditure of time and money.

Site capacity

6.6 In order to assess the capacity of a site, especially for solid wastes, the following should be taken into consideration:

.1 the anticipated loading rates per day, week, month or year;
.2 whether or not it is a dispersive site; and
.3 the allowable reduction in water depth over the site because of mounding of material.

Evaluation of potential impacts

6.7 An important consideration in determining the suitability of a waste for dumping at a specific site is the degree to which this results in increased exposures of organisms to substances that may cause adverse effects.

6.8 The extent of adverse effects of a substance is a function of the exposures of organisms (including humans). Exposure, in turn, is a function, *inter alia*, of input flux and the physical, chemical and biological processes that control the transport, behaviour, fate and distribution of a substance.

6.9 The presence of natural substances and the ubiquitous occurrence of contaminants mean that there will always be some pre-existing exposures of organisms to all substances contained in any waste that might be dumped. Concerns about exposures to hazardous substances thus relate to additional exposures as a consequence of dumping. This, in turn, can be translated back to the relative magnitude of the input fluxes of substances from dumping compared with existing input fluxes from other sources.

6.10 Accordingly, due consideration needs to be given to the relative magnitude of the substance fluxes associated with dumping in the local and regional area surrounding the dumpsite.

In cases where it is predicted that dumping will substantially augment existing fluxes associated with natural processes, dumping at the site under consideration should be deemed inadvisable.

6.11 In the case of synthetic substances, the relationship between fluxes associated with dumping and pre-existing fluxes in the vicinity of the site may not provide a suitable basis for decisions.

6.12 Temporal characteristics should be considered to identify potentially critical times of the year (e.g., for marine life) when dumping should not take place. This consideration leaves periods when it is expected that dumping operations will have less impact than at other times. If these restrictions become too burdensome and costly, there should be some opportunity for compromise in which priorities may have to be established concerning species to be left wholly undisturbed. Examples of such biological considerations are:

.1 periods when marine organisms are migrating from one part of the ecosystem to another (e.g., from an estuary to open sea or vice versa) and growing and breeding periods;
.2 periods when marine organisms are hibernating on or are buried in the sediments; and
.3 periods when particularly sensitive and possibly endangered species are exposed.

Contaminant mobility

6.13 Contaminant mobility is dependent upon several factors, among which are:
.1 type of matrix;
.2 form of contaminant;
.3 contaminant partitioning;
.4 physical state of the system, e.g., temperature, water flow, suspended matter;
.5 physico-chemical state of the system;

.6 length of diffusion and advection pathways; and
.7 biological activities e.g., bioturbation.

7 ASSESSMENT OF POTENTIAL EFFECTS

7.1 Assessment of potential effects should lead to a concise statement of the expected consequences of the sea or land disposal options, i.e., the "Impact Hypothesis". It will provide a basis for deciding whether to approve or reject the proposed disposal option and for defining any environmental monitoring requirements. As far as possible, waste management options causing dispersion and dilution of contaminants in the environment should be avoided and preference given to techniques that prevent the input of the contaminants to the environment.

7.2 The assessment for dumping should integrate information on waste characteristics, conditions at the proposed dump-site(s), fluxes and proposed disposal techniques and specify the potential effects on human health, living resources, amenities and other legitimate uses of the sea. It should define the nature, temporal and spatial scales and duration of expected impacts based on reasonably conservative assumptions.

7.3 The assessment should be as comprehensive as possible. The primary potential impacts should be identified during the dump-site selection process. These are considered to pose the most serious threats to human health and the environment. Alterations to the physical environment, risks to human health, devaluation of marine resources and interference with other legitimate uses of the sea are often seen as primary concerns in this regard.

7.4 In constructing an impact hypothesis, particular attention should be given to, but not limited to, potential impacts on amenities (e.g., presence of floatables), sensitive areas (e.g., spawning, nursery or feeding areas), habitat (e.g., biological, chemical and physical modification), migratory patterns and marketability of resources. Consideration should also be given to potential impacts on other uses of the sea including: fishing, navigation, engineering uses, areas of special concern and value, and traditional uses of the sea.

7.5 Even the least complex and most innocuous wastes may have a variety of physical, chemical and biological effects. Impact hypotheses cannot attempt to reflect them all. It must be recognized that even the most comprehensive impact hypotheses may not address all possible scenarios such as unanticipated impacts. It is therefore imperative that any monitoring programme be linked directly to the hypotheses and serve as a feedback mechanism to verify the predictions and review the adequacy of management measures applied to the dumping operation and at the dump-site. It is important to identify the sources and consequences of uncertainty.

7.6 The expected consequences of dumping should be described in terms of affected habitats, processes, species, communities and uses. The precise nature of the predicted effect (e.g., change, response, or interference) should be described. The effect should be quantified in sufficient detail so that there would be no doubt as to the variables to be

measured during any field monitoring. In the latter context, it would be essential to determine "where" and "when" the impacts can be expected.

7.7 Emphasis should be placed on biological effects and habitat modification as well as physical and chemical change. However, if the potential effect is due to substances, the following factors should be addressed:

.1 estimates of statistically significant increases of the substance in seawater, sediments, or biota in relation to existing conditions and associated effects; and

.2 estimate of the contribution made by the substance to local and regional fluxes and the degree to which existing fluxes pose threats or adverse effects on the marine environment or human health.

7.8 In the case of requests for repeated or multiple dumping operations, impact hypotheses should take into account the cumulative effects of such operations. It will also be important for the Department of the Environment to consider the possible interactions with other waste dumping practices in the area, both existing and planned.

7.9 An analysis of each disposal option should be considered in light of a comparative assessment of the following concerns: human health risks, environmental costs, hazards (including accidents), economics and exclusion of future uses. If this assessment reveals that adequate information is not available to determine the likely effects of the proposed disposal option, including potential long-term harmful consequences, then this option should not be considered further. In addition, if the interpretation of the comparative assessment shows the dumping option to be less preferable, a permit for dumping should not be given.

7.10 Each assessment shall conclude with a statement by the Department of the Environment supporting a decision to issue or refuse a permit for dumping.

7.11 Where monitoring is required, the effects and parameters described in the hypotheses should help to guide field and analytical work so that relevant information can be obtained in the most efficient and cost-effective manner.

8 MONITORING

8.1 Monitoring may be used to verify that permit conditions are met - compliance monitoring – and that the assumptions made during the permit review and site selection process were correct and sufficient to protect the environment and human health - field monitoring. It is essential that such monitoring programmes have clearly defined objectives. The need for monitoring will be determined by the Department of the Environment.

The party to carry out the monitoring shall also be determined by the Department of the Environment.

8.2 The Impact Hypothesis forms the basis for defining field monitoring. The measurement programme should be designed to ascertain that changes in the receiving environment are within those predicted. The following questions must be answered:

.1 What testable hypotheses can be derived from the Impact Hypothesis?
.2 What measurements (type, location, frequency, performance requirements) are required to test these hypotheses?
.3 How should the data be managed and interpreted?

8.3 It may be that suitable specifications of existing (pre-disposal) conditions in the receiving area are already contained in the application for dumping. If the specification of such conditions is inadequate to permit the formulation of an Impact Hypothesis, the licensing authority (Department of the Environment) will require additional information before any final decision on the permit application is made.

8.4 The Department of the Environment is encouraged to take account of relevant research information in the design and modification of monitoring programmes. The measurements can be divided into two types - those within the zone of predicted impact and those outside.

8.5 Measurements should be designed to determine whether the zone of impact and the extent of change outside the zone of impact differ from those predicted. The former can be answered by designing a sequence of measurements in space and time that ensures that the projected spatial scale of change is not exceeded. The latter can be answered by the acquisition of measurements that provide information on the extent of change that occurs outside the zone of impact as a result of the dumping operation. Frequently, these measurements may be based on a null hypothesis - that no significant change can be detected.

8.6 The results of monitoring (or other related research) should be reviewed by the Department of the Environment at regular intervals in relation to the objectives and can provide a basis for the Department to:

.1 modify or terminate the field-monitoring programme;
.2 modify or revoke the permit;
.3 redefine or close the dump-site; and
.4 modify the basis on which applications to dump wastes are assessed.

9 PERMIT AND PERMIT CONDITIONS

9.1 A decision to issue a permit will only be made if all impact evaluations are completed and the monitoring requirements determined. The provisions of the permit shall ensure, as far as practicable, that environmental disturbance and detriment are minimized and the benefits maximized. Any permit issued will be required to contain data and information specifying:

.1 the types, amounts and sources of materials to be dumped;
.2 the location of the dump-site(s);
.3 the method of dumping; and
.4 monitoring and reporting requirements.

9.2 If dumping is the selected option, then a permit authorizing dumping will have to be issued in advance, provided all pre-requisites can be met. In granting a permit, the hypothesized impact occurring within the boundaries of the dump-site, such as alterations to the physical, chemical and biological compartments of the local environment will be accepted by the permitting authority.

9.3 The Department of the Environment will strive at all times to enforce procedures that will result in environmental changes as far below the limits of allowable environmental change as practicable, taking into account technological capabilities as well as economic, social and political concerns.

9.4 Permits will be reviewed at regular intervals, taking into account the results of monitoring and the objectives of monitoring programmes. Review of monitoring results will indicate whether field programmes need to be continued, revised or terminated, and will contribute to informed decisions regarding the continuance, modification or revocation of permits. This provides an important feedback mechanism for the protection of human health and the marine environment.

Technical Annex I - Analytical Requirements for Dredged Material Assessment

1. This Technical Annex has been extracted and modified from the analytical requirements of the OSPAR Guidelines for the Management of Dredged Material. It is necessary for the implementation of section 4 of these guidelines.

2. A tiered approach to testing is recommended. At each tier it will be necessary to determine whether sufficient information exists to allow a management decision to be taken or whether further testing is required. The Department of the Environment will make such decisions.

3. In the absence of appreciable pollution sources and if the visual determination of sediment characteristics leads to the conclusion that the dredged material meets one of the exemption criteria under paragraph 4.2 of the Guidelines, then the material will not require further testing. However, if all or part of the dredged material is being considered for beneficial uses, then it will usually be necessary, in order to evaluate these uses, to determine at least some of the physical properties of the material indicated in Tier I.

4. The sequence of tiers is as follows:
- assessment of physical properties
- assessment of chemical properties
- assessment of biological properties and effects

The Department of the Environment reserves the right to circumvent the tier system and require various properties to be tested simultaneously.

A pool of supplementary information, determined by local circumstances may be used to augment each tier (cf. section 4.4 of the Guidelines).

5. At each stage of the assessment procedure account must be taken of the method of analysis. Analysis should be carried out on the whole sediment (< 2mm) or in a fine-grained fraction. If analysis is carried out in a fine-grained fraction, the results should be appropriately converted to whole sediment (< 2 mm) concentrations for establishing total loads of the dredged material.

6. The physical composition of samples, and therefore the chemical and biological properties, can be strongly influenced by the choice of sampling sites, the method of sampling and sampling handling. These possible influences should be taken into account when evaluating data.

Tier I: PHYSICAL PROPERTIES.

Physical analyses are important because they help to indicate how the sediment may behave during dredging and disposal operations and indicate the need for subsequent

chemical and/or biological testing. In addition to the visual determination of sediment characteristics required in section 4.1 of the Guidelines, it is strongly recommended that the following determinations be carried out:

Determinant	Indicating
▪ grain size (% sand, silt, clay) ▪ percent solids (dry matter)	▪ Cohesiveness, settling velocity/resuspension potential, contaminant accumulation potential
▪ density/specific gravity	▪ Consolidation of placed material, volume *in situ* vs. after deposit
▪ organic matter (as total organic carbon)	▪ Potential accumulation of organic associated contaminants

When dredged material is being considered for beneficial uses, it may also usually be necessary to have available details of the engineering properties of the material e.g. permeability, settling characteristics, plasticity and mineralogy.

Tier II: CHEMICAL PROPERTIES

The following trace metals should be determined in all cases:

Cadmium (Cd)	Chromium (Cr)
Copper (Cu)	Lead (Pb)
Mercury (Hg)	Nickel (Ni)
Zinc (Zn)	

The following organic/organo-metallic compounds should be determined:

- Polychlorinated biphenyl (PCB) congeners - IUPAC nos 28, 52, 101,118, 138, 153 and 180.
- Polycyclic aromatic hydrocarbons (PAHs)
- . Tri-Butyl Tin compounds and their degradation products

However, the determination of PCBs, PAHs and Tri-Butyl Tin compounds and its degradation products may not be necessary when:

a) sufficient information from previous investigations indicating the absence of contamination is available; or
b) - there are no known significant sources (point or diffuse) of contamination or historic inputs; and
- the sediments are predominantly coarse; and
- the content of total organic carbon is low.

The necessity for the above mentioned analysis is to be determined by the Department of the Environment. Based upon local information of sources of contamination (point

sources or diffuse sources) or historic inputs, other determinants may require analysis, for instance:

arsenic	other chlorobiphenyls	organophosphorus pesticides	petroleum hydrocarbons
	organochlorine pesticides	other organotin compounds	Polychlorinated Dibenzodioxins (PCDDs)/polychlorinated dibenzofuransn (PCDFs)
	other anti-fouling agents		

In deciding which individual organic contaminants to determine, guidance is to be sought from the Department of the Environment who will make reference to existing priority substance lists, such as those prepared by the EU (for example under the Water Framework Directive 2000/60/EC).

Tier III: BIOLOGICAL PROPERTIES AND EFFECTS

In a number of cases the physical and chemical properties described above do not provide a direct measure of the biological impact. Moreover, they do not adequately identify all physical disturbances and all sediment-associated constituents present in the dredged material. If the potential impacts of the dredged material to be dumped cannot be adequately assessed on the basis of the chemical and physical characterisation, biological measurements will be required.

The selection of an appropriate suite of biological test methods will depend on the particular questions addressed, the level of contamination at the dredging site and the degree to which the available methods have been standardised and validated.

To enable the assessment of the test results, an assessment strategy will be used with regard to granting a permit authorising disposal at sea. The extrapolation of test results on individual species to a higher level of biological organisation (population, community) is unlikely to be acceptable as this is considered as being very difficult and requires good knowledge of assemblages that typically occur at the sites of interest.

1. Toxicity bioassays:
The primary purpose of toxicity bioassays is to provide direct measures of the effects of all sediment constituents acting together, taking into account their bioavailability. For ranking and classifying the acute toxicity of harbour sediment prior to maintenance dredging, short-term bioassays may often suffice as screening tools.

- To evaluate the effects of the dredged material, acute bioassays can be performed with pore water, an elutriate or the whole sediment. In general, a set of 2-4

- In most bioassays, survival of the test species is used as an endpoint. Chronic bioassays with sub-lethal endpoint (growth, reproduction etc) covering a significant portion of the test species life cycle may provide a more accurate prediction of potential impact of dredging operations. However, standard test procedures are still under development;

The outcome of sediment bioassays can be unduly influenced by factors other than sediment-associated chemicals. Confounding factors like ammonia, hydrogen sulphide, grain size, oxygen concentration and pH should therefore be determined during the bioassay.

Guidance on the selection of appropriate test organisms, use and interpretation of sediment bioassays is given by e.g. EPA/CE (1991/1994) and IADC/CEDA (1997) while guidance on sampling of sediments for toxicological testing is given by e.g. ASTM (1994).

2. Biomarkers:
Biomarkers may provide early warning of more subtle (biochemical) effects at low and sustained levels of contamination. Most biomarkers are still under development but some are already applicable for routine application on dredged material (e.g. one which measures the presence of dioxin-like compounds - Murk *et al*., 1997) or organisms collected in the field (e.g. DNA strand/breaks in flat fish).

3. Microcosm experiments:
There are short-term microcosm tests available to measure the toxicant tolerance of the community e.g. Pollution Induced Community Tolerance (PICT) (Gustavson and Wangberg, 1995)

4. Mesocosm experiment:
In order to investigate long-term effects, experiments with dredged material in mesocosms can be performed, for instance to study the effects of PAHs in flatfish pathology. Because of the costs and time involved these experiments are not applicable in the process of authorising permits but are useful in cases where the extrapolation of laboratory testing to field condition is complicated. Environmental conditions are very variable and hinder the identification of toxic effects as such. The results of these experiments would be then available for future permitting decisions.

5. Field observation of benthic communities:
Monitoring in the surrounding of the disposal site of benthic communities e.g. *in situ* (fish, benthic invertebrates) can give important clues to the condition of marine sediments and are relevant as a feed-back or refinement process for authorising permits. Field observations give insight into the combined impact of physical disturbance and chemical contamination. Guidelines on the monitoring of benthic communities are provided by e.g. OSPAR, ICES, HELCOM.

6. Other biological properties:
Where appropriate, other biological measurements can be applied in order to determine e.g. the potential for bioaccumulation and for tainting.

SUPPLEMENTARY INFORMATION
The need for further information will be determined by local circumstance and may form an essential part of the management decision. Appropriate data may include: redox potential, sediment oxygen demand, total nitrogen, total phosphorus, iron, manganese, mineralogical information. Consideration will also be given to chemical or biochemical changes that contaminants may undergo when disposed of at sea.

Literature References related to Technical Annex I
ASTM, 1994. Standard guide for collection, storage, characterisation and manipulation of sediment for toxicological testing. American Society for Testing and Material, Annual Book of Standards. Vol. 11.04, E1391-96.

EPA/CE, 1991. Evaluation of Dredged Material Proposed for Ocean Disposal: Testing Manual EPA-503/8-91/001. US-EPA Office of Water (WH-556F).

EPA/CE, 1994. Evaluation of Dredged Material Proposed for discharge in Waters of the US. Testing Manual (Draft): Inland Testing Manual EPA – 823-B-94-002. (will be replaced by "*coast of waters manual"*).

International Association of Dredging Companies (IADC)/Central Dredging Association (CEDA), 1997. Environmental Aspects of Dredging. Guide 3 (Investigation, Interpretation and Impact). ISBN 90-75254-08-3.

Gustavson, K. and Wangberg, S.A.,1995. Tolerance induction and succession in microalgae communities exposed to copper and atrazine. Aquatic Toxicology. 32: 283-302.

HELCOM, 1997. Draft Manual for Marine Monitoring in the Cooperative Monitoring in the Baltic Marine Environment (COMBINE Programme) of HELCOM. Part C - Programme for Monitoring of Eutrophication and its Effects. Annex C-4: Directives for sampling and analysis of hydrographic, chemical and biological variables. Annex C-8: Soft bottom macrozoobenthos.

Murk *et al.*, 1996. Chemical-activated luciferase gene expression (CALUX): a novel in vitro bioassay for Ah receptor active compounds in sediments and pore water. Fund. & Applied Tox. 33: 149-160.
OSPAR, 1997 (available from the OSPAR Secretariat)

JAMP Eutrophication Monitoring Guidelines: Benthos - Technical Annex 1 (Hardbottom macrophytobenthos and hard-bottom macrozoobenthos) - Technical Annex 2 (Soft-bottom macrozoobenthos)

Rees, H.L., C. Heip, M. Vincx and M.M. Parker, 1991. Benthic communities: use in monitoring point-source discharges. ICES Techniques in Marine Environmental Sciences No. 16.

Rumohr, H.,1990. Soft-bottom macrofauna: collection and treatment of samples. ICES Techniques in Marine Environmental Sciences No. 8.