
# GUIDELINES ON UNDERTAKING DREDGING AT MAJOR PORTS

**GOVERNMENT OF INDIA**
**MINISTRY OF SHIPPING**
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# CONTENTS

# Guidelines on undertaking dredging at Major Ports

## 1. Background:

1.1 Dredging is broadly classified into two categories, namely, Capital and Maintenance dredging. Capital dredging is one-time dredging in port areas like harbour basin and navigational channel to create/increase depths to receive the ships and is of one time capital expenditure. Maintenance dredging is done periodically to maintain the depths so created by capital dredging at ports and the expenditure is of recurring nature.

1.2 Major Ports award Maintenance/Capital dredging contract works with payments linked to

- Quantity based on Pre and Post dredging depths
- Guaranteed depth basis
- Hopper Measurement of the dredger
- Daily hire charges of the dredger

Even though most of the major ports use the services of third party survey/ certification agencies including Minor Port Survey Organization (MPSO) for pre dredge and post dredging surveys, some major ports do not follow third Party certifications in dredging contracts. Some of the Major ports leave the geo-technical investigations required for capital dredging to the dredging firms. There are many instances of dredging contracts at major ports ending up with serious disputes and arbitrations.

1.3 During March, 2015, Govt. of India gave its 'in principle' approval for the concept and institutional framework of Sagarmala Project which, inter alia, envisages development of ports on a large scale by way of improvement of existing ports and creation of new ports and also development of Water Transport Sector in a big way. These initiatives, in turn, are expected to lead to extensive dredging activities. Thus there is need for evolving guidelines for undertaking capital and maintenance dredging works covering the various aspects discussed above.

1.4. Hence, the Ministry of Shipping constituted an Expert Committee in March 2015 to prepare the Standard Operating Procedures for undertaking dredging contracts at major ports, which will act as guidelines for all major ports to carry out

Capital and Maintenance dredging works. The committee submitted its report in June 2015. Considering the same, the "Guidelines on undertaking dredging at major ports" was prepared which was circulated to major ports and based on the inputs the same has been finalized.

2**. Formulation of proposal for Capital Dredging**:

2.1 When the major ports plan to take up a capital dredging project irrespective of the size of the project, the following actions have to be taken up by the ports simultaneously so that proposal can be taken to approval stage at the earliest possible time.

(i) Engaging Marine survey, Geo technical/Geo physical survey agencies to carry out bathymetric surveys, geo technical investigations etc., if the same is not available with the port

(ii) Preparation of Detailed Project Report/Feasibility Report/other port specific investigation required if any by consultants or by Port themselves.

**(iii)** Engaging Agencies wherever required as per the provision, for preparation of Environment Impact Assessment.

**2.2. Surveys/studies/ Investigations required prior to Capital Dredging:**

**(A) Capital dredging inside and outside the harbor basin of existing Port**

When capital dredging have to be carried out like Dredging in front of berths, deepening of harbour basin, channel etc., costing up to Rs 200 crores, the following pre-dredging surveys/studies/investigations may be carried out: -

- Geo technical and Geo physical investigations of the sea bed to identify the type of soil and rock to be dredged and to define physical and mechanical properties like particle size, bulk density standard penetration test value (SPT-N value) etc.

- Bathymetric surveys to define the water depths in and around dredging area and disposal site

**(B) Capital dredging inside and outside the harbor basin of new Port**

When capital dredging has to be carried out for creation of new dock arm inside the harbour basin, Deepening of harbour approach channel, Development of outer harbour etc., costing more than Rs 200 crores, the following Pre-dredging surveys/Studies/Investigations may be carried out:

- Topography Survey of the area.

- Bathymetric surveys to define water depths in and around the dredging and disposal sites which consists of two parts *before commencement of dredging.*

  **Part-I:** Pre-tender Survey-The port is responsible for this comprehensive survey which has to be given to the dredging contractor along with request for tender.

  **Part-II:** Pre dredging survey has to be done after award of work which will be carried out by the port, selected authorized third party survey agency, PMC (if any) and dredging contractor.

- Geo-physical investigations like Side Scan Sonar, Sub Bottom Profiling and Magnetometer surveys to identify obstacles on or under the sea-bed (shipwrecks, pipes, debris, etc.)

- Geological Desk Study

- Geo-technical investigations of the sea bed to identify the types of soil and rock to be dredged and to define the physical and mechanical properties.

- Investigations of the environmental conditions (Oceanographic, meteorological, etc.) which affect the dredging operations.

- Environment Impact Survey & CRZ clearance wherever required as per the provision.

- Selection of Disposal Area (offshore or onshore Reclamation) for dredged Material
- Geo Technical investigations in case of onshore disposal and investigation on settlement properties, soil improvement techniques etc.,
- Physical and Mathematical Model Studies.
  A Note on the above Surveys/Investigations is enclosed at **Annexure -1**

2.3 If required, other investigations to establish operational, statutory and legal constraints may also be carried out.

2.4 A feasibility report has to be prepared by the port which will also consist of cost estimates, Type of dredger to be deployed, Design of the channel, Stability of berths in case of existing ports and if required cost of strengthening of berths if feasible, Design vessel size, additional capacity and traffic envisaged, viability calculations, identification of dumping area, feasibility of using the dredged material for reclamation, adequate evacuation facilities for the additional cargo likely to be handled at the port etc.,

2.5 The time duration of the capital dredging contract has to be worked out based on the Assessed volume of in situ quantity to be dredged, Number of dredgers expected to be deployed, Output of dredgers considering the bulking factor of the material to be dredged and distance to the dumping ground, Reasonable time for mobilisation, Expected non working period due to bad weather and other port specific parameters.

2.6 The possibility of using the dredged material for beneficial use including land reclamation and also as a foundation material for roads construction, beach nourishment, shore protection works etc., in an environmentally sustainable manner and the impact on cost reduction of dredging operations shall be explored by all Major ports. A Note on 'Materials for Reclamation" has been enclosed as **Annexure -2**.

In case the dredged material is suitable for reclamation, the Port has to make an exercise of "Cost-benefit analysis" on Reclamation Vs Disposal at designated dumping grounds and the details of the findings have to be furnished to the Board of Trustees of the Port/ Government of India before approval of cost estimates of dredging.

## 3. Engagement of Project management Consultants:

### 3.1 Capital Dredging:

After the financial sanction of the capital dredging project by the competent authority, the Port may engage Project Management Consultants (PMCs) if the cost of capital dredging is more than Rs 200 crores. The role of the PMC is for

comprehensive supervision of the project and the PMC shall be the "Engineer" for the project. The broad scope of the services of PMC is as under:

The PMCs shall study the survey Reports, DPR/ Feasibility Report etc., available with the Port, prepare the bill of quantities, finalize the tender documents, assist in invitation of global bids, scrutiny and analysis of bids, presentations, recommendation for award of work, initiate actions for handing over of site and timely issue of drawings, scrutinize the dredging methods proposed by the contractor and approve the same including the contractor's charts and drawings as required for execution , Preparation of Implementation Methodology, Regular Inspection of Contractor's dredger, equipment, plant, machinery etc., to ensure whether they are as per the terms and conditions of contract, assist the port in engagement of third party survey agency with Steel/FRP survey boats having hull mounted transducers to carry out the contractor's payment surveys, Associate with the third party surveys, Certification of navigational charts, Maintenance of up to date records of dredging quantity, Check and certify all request for advances, all monthly bills, interim bills, escalation bills and final bill, Monitoring the progress of dredging and submission of periodical progress Reports and final Report on completion of services etc.,

3.2 **Maintenance dredging:**

Generally there is no requirement of Project Management Consultants (PMC) for the maintenance dredging contracts and the same can be carried out by the port themselves except for Kolkata port for which an agency has to be fixed for the "Technical Auditing of the Maintenance dredging in Hooghly estuary" as communicated to the Port by the Ministry.

Considering the huge quantum of annual maintenance dredging, Cochin and Kandla ports may engage PMCs for maintenance dredging also which may assist the port in completion of maintenance dredging without backlog quantity and also for evaluation of dredgers engaged for the project.

4. **Pre-Qualification Criteria of dredging firms:**

4.1 The pre qualification/ Minimum eligibility criteria shall be based on the dredging firm's experience considering both Quantity and Value based criteria of successful executed dredging projects

4.2 The dredger to be deployed for the project may be of absolute ownership, disponent ownership, time charter and bare boat charter and hiring of dredgers

shall be considered. The prequalification criteria for dredging firm's works, efficiency parameters of dredgers, Definition of Indian dredging company, Types of dredgers etc., are enclosed at **Annexure-3**

4.3 In case the dredging firm do not own the dredger and plans to execute the capital/maintenance dredging works by other modes of arranging the dredger by wet leasing, hiring etc., the above firm has to pay additional security deposit of 5% in addition to the security deposit indicated in the tender which will be returned without interest after satisfactory completion of dredging work, in case the firm gets the contract. In addition to above, the details of arranging the dredgers for the work with " Irrevocable Letter of Authority" from the owner to be produced by the bidder to the effect that the dredger so charted/hired shall not be withdrawn till completion of the work.

4.4 In case of rock dredging works, the dredging firm should have the experience of rock dredging of at least 20% of the estimated cost of the project and have necessary equipment considering the classification of rock either by own or by hiring and in that case the assurance letter from the owner about sparing the dredging equipment shall be furnished at the time of prequalification.

4.5 At the time of prequalification of dredging firms, "Details of dredgers to be deployed" furnished by the dredging firms may have to be examined by the port so that sufficient and efficient dredgers are available for the project.

4.6 Indian Ports Association, New Delhi shall make a suggestive shortlist of consultants for (a) Third Party Marine Survey agencies, (b) Preparation of Detailed Project Report (DPR) for capital dredging projects (c) Environmental Impact Assessment and (d) Project Management Consultants for a period of 3 years. After issue of the suggestive list, during the 3 years period also if any consultancy firm fulfills the pre qualification criteria and wants to be shortlisted, it can approach Indian Ports Association, New Delhi for short-listing.

## 5. **Tendering:**

5.1 All major ports shall invite open competitive bids for capital/maintenance dredging works.

5.2 All the major ports may go for long term contract maintenance dredging for a maximum period of 5 years wherever feasible. However the ports namely VOC,

Chennai & Kamarajar ports are exempted considering the zero/very limited annual maintenance dredging requirement.

5.3 **a) Maintenance Dredging:**

Considering the annual siltation pattern of major ports, the following methodology may be adopted.

- Among the major ports, the "Depth based dredging contract" may be adopted in ports like Kolkata, Cochin and Kandla where (i) sufficient data of previous years are available (ii) the dredging is required throughout the year and the contract may be linked with incentive and disincentive mode of payment for guaranteeing the depth.

- When the dredging is only seasonal, Quantity based on in-situ quantity measurement or hopper volume measurement of specific densities may be adopted for payment. In exceptional circumstances where the dredging is required to be done for very short period, day hire charges of dredgers may also be adopted.

**b) Capital Dredging:**

The payment for the quantity based on Pre & Post dredging level survey levels can be adopted.

5.4 The Government of India through Ministry of Shipping reserves the right to assign, in public interest, any contract for dredging work in any of the major ports to DCI on nomination.

5.5 Major ports at present follow the "Standardised procedure and award of contract including the model tender documents" (STD) as circulated by Ministry's letter PW-12012/12/2007- DO (PO) dated 4$^{th}$ June 2010 which needs to be modified considering the present scenario of dredging requirements. The Ministry through I.P. A., New Delhi will update this document and circulate to the Ports for their use. Till the revised document is circulated, Major Ports may continue to follow the STD circulated earlier with modifications wherever required with the approval of the Board.

5.6 As indicated in the Technical Specifications clause 4.2 & 8.0 of STD circulated by the Ministry in 4.6.2010, the individual port may have to indicate the

port specific details like Horizontal and vertical dredging tolerance limits, Slope tolerances, Methods of measurement, the Spacing of hydrographic survey lines and cross sections, frequency of echo sounders etc., in the tender documents as the above factors depend on the type of soil at the port, extent of depths to be achieved and other physical conditions.

5.7 The "Amicable Settlement- Clause 19.2 of General conditions of contract in the STD" circulated by the Ministry does not have a mechanism to settle the disputes. The major ports may incorporate the new mechanism in the tender papers namely a Committee under the chairmanship of Chairman with Chief Engineer, FA& CAO and Deputy Port Conservator of the Port may examine the dredging related dispute and give its recommendation and the Board for taking a view on the dispute. If the dispute is not settled amicably, the same shall be settled by Arbitrations.

5.8 As per the STD clause 12.3 of General conditions of contract, no price adjustment is permissible in respect of contract less than six months duration and with the estimated cost of Rs 1 crores. In view of frequent variation in price due to de-regulation of fuel prices, the price adjustment shall be allowed irrespective of contract duration and this may be incorporated in the tender papers.

5.9 The Indian companies owning Indian flag dredgers including Dredging Corporation of India shall have the first right of Refusal if the rate is within 10% of the lowest valid offer. This would apply to both capital and maintenance dredging. If more than one company owning Indian flag dredger participates in the tender, the right of first refusal will go to that Indian company which has quoted the lowest rate and is within 10% of the lowest offer.

5.10 **Assessment of dredging quantum:**

(i) The methodology namely Triangulated Irregular Network (TIN) may be adopted to calculate the volumes of dredged material in single beam echo sounder surveys. TIN volumes are based on the true positions of depths to calculate the volume of the surface. TIN methodology may be adopted for harsh terrain like rock.

(ii) The methodology namely "Hyperbolic volume" could yield better results in case of smooth bottom topography like sand in full density multi beam echo sounder surveys.

(iii) Cell Average shall only be considered for Sounding Reduction Using Mapper tool in Hypack, and averaging to be done with similar tools in other softwares, while processing either single beam or multi-beam survey data.

5.11 Considering the absence of specific national standards for classification of soil for dredging, it is suggested to adopt the PIANC classification of soils for dredging work as published in the "Supplement to Bulletin no. 47(1984) in case of international dredging contracts. The details of PIANC classification of soils is at **Annexure-4**

5.12 It is the responsibility of the port to take geotechnical and Standard Penetration Test investigation details, hydraulic data and also inform about the location of dumping ground etc., to the shortlisted dredging firms based on which the dredging firms will decide on the type of dredgers to be deployed.

5.13 Major ports have to judiciously assess the unit dredging rates by comparing already executed rate after escalation, dredger availability scenario in the world market, budgetary quotations, rates at the nearby port with a similar type of soil profile etc., The International/Indian standards for estimation of costs can be used.

5.14 A Data Bank with details of dredging contracts has to be created at IPA New Delhi. A proforma for furnishing the information on dredging contracts executed by the Ports is enclosed at **Annexure-5**. After completion of dredging contract in case of capital dredging and yearly once in case of long term contracts, the ports have to furnish the details to IPA, New Delhi for purpose of storing the data in the Data Bank.

5.15 Request For Proposal (RFP) process for award of dredging contract should commence only after approval/sanction of the proposal, statutory clearances etc., by the competent authorities.

## 6. Monitoring Mechanism at Ports:

6.1 At most of the ports, the contract part of dredging is handled by the Civil Engineering Department, whereas the Marine Department does the hydrographic Survey and signing of pre and post survey navigational charts, Release of portion of areas in case of navigational channel for dredging etc., There should be proper coordination between the departments and the dredging contractor and the Deputy Chairman of the Port may oversee the implementation of the dredging contract.

6.2 While carrying out capital/maintenance dredging in the Port area, minimum hours per day for ship movements have to be identified with the minimum number of hours per day available for dredging in one or two spells depending upon the ship movements during the period of dredging works. The same may be indicated in the tender papers and has to be monitored during execution.

6.3 Specific dredging targets considering the period of completion of dredging has to be indicated in the tender documents and the Engineer appointed for the contract/Project Management Consultant if any has to monitor the progress and give recommendations on monthly payments.

6.4 The guidelines on Pre and Post Dredging surveys issued by Naval Hydrographic office (NHO), Dehradun dated 16.7.2014 may be adopted for pre and post dredging surveys in addition to port specific recommendations. The details and a copy of NHO circular are at **Annexure-6.**

6.5 Pre and post dredging hydro graphic surveys pertaining to capital and maintenance dredging works should be witnessed and certified by Third Party Survey agencies/ MPSO. The periodicity of survey, type of echo sounder to be used whether multi beam or Dual frequency echo sounder shall be decided and incorporated in the tender itself by the individual ports. The frequency of the survey should not vary between Pre and Post dredging surveys.

6.6 The cost of all payment surveys to the dredging contractor may be borne by the port. The surveys shall be carried out in the owned/hired steel /FRP survey boats of third survey agency with hull mounted transducer, with survey boats having maximum speed of 10 knots. The monitoring survey for the progress etc., may be carried out in the survey boats of dredging contractor. The navigational survey charts for payments have to be signed by the dredging contractor, representative of the port, PMC (if any) and Third Party survey agencies /Minor Port Survey Organization.

## 7. Recommendations for the future:

### 7.1 Nautical Depth Concept:

By adoption of this nautical depth concept Ship's keel may appear to touch the sea bottom but ship navigates through this layer without causing damage to ship's keel. In addition to that it has to be ensured that controllability and maneuverability of ship is within the acceptable limits. The nautical depth concept has been implemented in ports like Rotterdam and Zeebrugge. In Zeebrugge it has

been found from the studies that the critical density of mud at the port is 1.2 ton/m3. The Study has also shown that in addition to density the rugosity of the material is also of relevance.

Considering the soil nature the west coast ports from Mumbai to Cochin Ports can explore the feasibility of adaptation of nautical depth concept after the required research studies.The adoption of nautical depth if feasible will reduce the annual maintenance dredging quantum and thus the cost.

## 7.2 **Training Needs**

In order to address the non availability of trained man power to dredgers Dredging Corporation of India and Indian Maritime University, may identify the "Training needs of Dredging- onshore and offshore" like dredger maintenance, project management, hydro graphic survey etc., and the required training courses may be developed by Indian Maritime University in consultation with Dredging Corporation of India.

## 7.3. Strengthening of MPSO &Survey Divisions of the Ports:

There is a need to strengthen MPSO with new marine survey equipments like multi beam echo sounders, Beacon Receiver GPS, Hydrographic software etc., and it should function as an independent 'entity' to give third party opinion of Marine surveys to major ports etc.

Similarly, there is a need to strengthen the Marine Survey Divisions of the ports by deployment of suitable employees and providing the required training. The ports can finalize the minimum required survey equipments in consultation with NHO, Dehradun.

## 7.4 Possible Causes of Disputes in dredging contracts

The main causes for disputes between dredging firms and the ports & suggested solutions are as under:

(a) Change in the soil conditions between the tender documents and the material as actually encountered during the progress of work which could be avoided by proper soil investigation.

(b) Change in the environmental conditions which could be avoided by proper site investigation and making available to the contractor including data relating to wave, currents, littoral drift etc. available with the department.

**(c)** Delay in payment to the contractor/Dredging firms: Most of the contract specifies that, when the payment is certified by the engineer nominated in the contract, the payment has to be released as specified in the contract. However, the department takes its own time in releasing the payments due to the contractor by repeated scrutiny by the department. Normally, this could be avoided by specifying reasonable payment schedules in the contract and once specified in the contract the payment schedule has to be followed without any deviations.

(d) The contractual clauses, especially technical specifications should be equitable both to the employer and the contractor and should be possible for implementation in actual practice.

(e) When number of contractors is working in the site, there should be least interference in the work. This could be achieved by proper meetings with all the contractors by the employer from time to time. Proper interface meeting has to be held regularly.

## 8. Others

8.1 All major ports shall strictly adhere to the guidelines issued by the Central Vigilance Commission from time to time for processing the tenders in a transparent manner. Ports may ensure that a prequalification criterion is fixed in advance and should not be very stringent to restrict competition. The prequalification conditions should be exhaustive but specific. The prescribed conditions should be clearly specified in the bid documents to ensure fair competition and transparency.

8.2 Guidelines issued by DG (Shipping), Mumbai, from time to time in terms of the relevant provisions of Merchant Shipping Act, shall be applicable.

8.3 The guidelines issued by Ministry of Shipping for processing the security clearance of bidders including dredging projects in December 2012 and any modifications issued after December 2012, shall be applicable.

8.4 In case the port wants port-specific deviation from the above guidelines the reasons for the deviation have to be recorded and the port should get the approval of the "Board of Trustees of the Port" before implementation.

**Annexure-1**

# Pre-dredging surveys, studies and investigations

1.0 The pre-dredging surveys, studies and investigations required before undertaking a capital dredging project which can be broadly grouped as follows:

- Topography Survey of the area.

- Bathymetric surveys to define water depths in and around the dredging and disposal sites which consists of two parts before commencement of dredging.

  **Part-I:** Pre-tender Survey-The port is responsible for this comprehensive survey which has to be given to the dredging contractor along with request for tender.
  **Part-II:** Pre dredging survey has to be done after award of work which will be carried out by the port, selected authorized third party survey agency, PMC (if any) and dredging contractor.

- Geo-physical investigations like Side Scan Sonar, Sub Bottom Profiling and Magnetometer surveys to identify obstacles on or under the sea-bed (shipwrecks, pipes, debris, etc.)
- Geological Desk Study
- Geo-technical investigations of the sea bed to identify the types of soil and rock to be dredged and to define the physical and mechanical properties.
- Investigations of the environmental conditions (Oceanographic, meteorological, etc.) which affect the dredging operations.
- Environment Impact Survey
- Selection of Disposal Area (offshore or onshore Reclamation) for dredged Material
- Geo Technical investigations in case of onshore disposal and investigation on settlement properties, soil improvement techniques etc.,
- Physical and Mathematical Model Studies.

The details of the abovementioned surveys, studies and investigations are elaborated below.

## 1.1 Topographic Survey:

Topographic Survey is one of the first requirements in conjunction with Hydrographic Survey to establish shore controls, etc. In addition, a survey of the land areas is also required for locating reclamation areas.

## 1.2 Hydrographic (Bathymetric) Survey:

1.2.1 The seabed measuring instruments are called Echo Sounders based on reflection of ultrasonic pulses from the seabed. They differ in operating frequency, power and beam shape.

1.2.2 The imaging sonars are designed to provide image of the seabed rather than a map.

1.2.3 Echo Sounders: The Echo Sounders are used for measuring the water depth. The two types of echo sounders are generally used are Single Beam Echo Sounder and Multi Beam Echo Sounder.

Single Beam Echo Sounder measures the depth along the vessel track below the transducer but not between the tracks. For normal bathymetric surveying, these instruments usually operate at a frequency of 200-220 KHZ. In areas where mud layers and hard surfaces are encountered dual frequency namely 30/210 KHz are commonly used. High and low frequencies are often used together to provide an indication of the presence of hard bed and low density mud, the higher frequency indicating the low density mud and lower frequency indicating the hard bed.

Multi Beam Echo Sounder measures the water depth along a cross track profile called a 'swath'. By running parallel profiles at appropriate spacing, complete seabed coverage can be obtained. These instruments constitute today's state of art in terms of commercial bathymetric mapping.

Normally, multi-frequency echo sounders are collectively used in the present day survey works. The most commonly used multi-frequency echo sounder has a frequency range of 33/210 KHZ.

The frequency of the survey should not vary between Pre and Post dredging surveys.

## 1.3 Geo-physical investigations:

1.3.1 Geophysical investigations are employed to identify and characterize layers of sediment or rock under the sea floor. Normally, three systems are in use.

- High-resolution reflection systems (Remote Seismic)
- Seismic Refraction Systems
- Electrical Resistivity Systems

**High-resolution reflection systems (Remote Seismic)**

The system is similar in principle to echo sounding. Sound waves of low frequency and high energy are transmitted from the source at the water surface and the reflected signals are received from inter-faces between soil and harder soil. This permits recording of the such inter-face, but the vertical scale of recording as well as soil properties need to be determined from the borings, sampling and testing.

**Seismic Refraction Systems**

Seabed refraction seismic is a method of acquiring high-resolution information of soil sedimentary structures. Refraction systems are typically employed where fine detail is required of the first 3 m of the seabed, and especially the topmost 1 m. The most common application is as a burial assessment tool for submarine cable installation and for pipeline route investigations. Other applications include site investigations for harbours and coastal developments and pre-dredge areas.

**Electrical Resistivity Systems**

Seabed electrical resistivity profiling is a semi-continuous method of measuring the bulk resistivity of a volume of soil near the seabed. The technique uses a towed sled from which is towed a multi-electrode streamer cable. However, for soil investigation for marine works, including dredging etc. where soil information for sufficient depths is required the High-resolution Reflection Systems (Remote Seismic) is preferred. A number of different systems such as Sparker, Boomer and Pinger have been developed mostly working on the same principle.

1.3.2 **Side scan sonar:**

Side Scan Sonar provides an acoustic oblique photo-like image of the sea floor. Side scan sonar is used to detect obstacles such as wrecks, pipelines etc. It

also shows morphological features (rock outcrop, ridges, depressions, etc.) and enables differentiation based on the nature (e.g. grain size) of the seabed.

### 1.3.3 Sub Bottom Profiling:

Sub-bottom profiling systems are employed to identify and characterize layers of sediment or rock under the seafloor. These systems also can be helpful in locating hard objects buried beneath the seafloor, such as shipwrecks.

In sub-bottom profiling, sound source directs a pulse toward the seafloor. Parts of this sound pulse reflect off of the seafloor, while other parts penetrate the seafloor. The portions of the sound pulse that penetrate the seafloor are both reflected and refracted as they pass into different layers of sediment. These signals return toward the surface, where they are detected by hydrophones towed by a surface vessel.

The time it takes for the reflected sound pulses to return to the surface vessel can be used to determine the thickness of the sub-bottom layers in the seafloor and how the layers are positioned (e.g., level or sloped). The reflected sound also gives some limited information about the composition of the various layers.

Refracted sound pulses, which follow a more complex path, provide additional information about the sub-bottom layers. Through analysis of the seismic refraction, a more comprehensive understanding of the density of various sub-bottom layers can be developed. The variability in density shows the relative differences of the seafloor, with greater density showing harder materials.

### 1.3.4 Magnetometer Surveys

Marine Magnetometer is the best tool for locating sunken ships, lost anchors, buried pipelines and other underwater objects containing ferrous metal.

Magnetometer sensor is towed 60 to 70m behind the survey vessel to prevent the magnetometer data from being influenced by ferrous metal aboard the survey boat. To minimize uncertainties in the location of the towed sensor, the survey vessel tows the magnetometer at a slow speed of 4 knots and stays within 1 to 1.5 m of the intended survey line. Small or deeply buried metal objects are detected by surveying along closely spaced lines and keeping the towed sensor as close to the seafloor as possible.

## 1.4 Geological Desk Study:

The desk study aims to obtain and to synthesise the available data like Site investigation projects from previous projects in the area, Nautical charts and geological maps and papers.

The information gathered at this stage is used to provide general information concerning the site and to identify the key ground parameters and potential risks which need to be investigated.

## 1.5 Geotechnical investigations/Jet probing:

1.5.1 The main objective of geotechnical investigations is to identify the sub bottom layers of seabed, determination of the in-situ physical and mechanical properties of the materials and sampling of materials for laboratory tests. The investigation techniques include a wide range of sampling, drilling, coring and testing techniques. The general details are as under:

- Grabs provide disturbed samples of the upper few decimetres below seabed, they are operated from the vessels.
- Vibro-coring and Standard Penetration Test.
- Jet Probing
- Drilling rigs are operated from a drilling barge or from a Jack-up platform depending upon environmental conditions. They achieve penetration of 10 m to 100 m or more depending upon the rig and ground characteristics.
- Qualified and certified underwater divers services can also be utilized to scoop out material from close to the sea bed floor for sampling purposes.

1.5.2 Borings and vibro-cores can be efficiently supplemented with jet probes to thoroughly document the type of rock (or) hard material surface. Water jet probes (high pressure water jetted through a pipe probe) are inexpensive can be used reliably and practically to document the top of the rock or hard material formation throughout the dredge or borrow area. Jet probes are used as a supplement to borings to define the hard surface.

### 1.5.3 Classification of soils

In order to form an opinion as to the most suitable equipment for dredging under water, and to estimate performance of dredging equipment, it is vital to know the nature, location, transportation and disposal quantities of materials to be dredged. The soil classifications as per Indian Standards and PIANC Soil Classification (1984) are as under:

(a) Classification of soil as per Indian Standards IS: 1498-1970 (Reaffirmed in 2007) is shown below:

| **S.No.** | **Material size** | **Soil type** |
|---|---|---|
| 1 | Rocks | Rock |
| 2 | Boulders (larger than 300 mm) | Coarse-grained components |
| 3 | Cobbles (80mm to 300 mm) | |
| 4 | Gravels (4.75mm to 80mm) | |
| 5 | Sands (0.075mm to 4.75mm) | |
| 6 | Silts (0.002mm to 0.075mm) | Fine-grained components |
| 7 | Clay (less than 0.002mm) | |

(b) **PIANC Soil Classification (1984)**

It is vital to know the nature, location and quantities of material to be dredged before taking up the actual dredging work

It is also essential that all those have to communicate information on soils and rocks should use the common technical classification In this context, the PIANC Classification of Soils & Rocks to be Dredged (1984) has wider international acceptance and the same is attached at **Annexure-7.** Subsequently PIANC has brought out a Report of MARCOM working group Report 144 on "Classification of Soils and Rocks for the Maritime Dredging Process" in November 2014.

In the absence of specific national standard for classification of soil for dredging, adoption of PIANC Classification of Soils for Dredging work as published in the 'Supplement to Bulletin No.47 (1984) is recommended to be followed in case of international dredging contracts.

1.5.4 The following properties can be assessed by carrying out Borehole investigations for normal soils:

- Particle Size Analysis and Atterberg Limits
- Density and Moisture content
- Shear Strength
- Cohesion
- Bulk Density
- Standard Penetration Test Value (SPT/ N-Value)

1.5.5 **Guidelines to Plan Geotechnical Investigation**

- Consistent and regular geotechnical profiles can have large spacing for boreholes. However, complex profiles need detailed investigation.

  The following formula has been suggested in case of non-rocky areas to get an indication of the number of borings needed for dredging project is

  $$\mathbf{N= 3+ (A^{1/2})/40}$$

  Where N= the number of borings to be taken, A= the dredging area in square meters. For example considering a channel of 10 Kms length 300metres width, the number of bore holes required would be 46 numbers.

- The location of borehole to be arranged in a staggered way so that the entire profile of the area can be covered.
- Depending upon the intricacies of the project and probable subsurface profile, intermediate boreholes can be planned.
- Borehole depth is to be 1.5 to 2.5 meters more than the ultimate design dredging depth envisaged.

- A Desk Study of the Geology of the region and past investigations records of nearby projects help to plan Geotechnical Investigations.
- Factors such as Design Dredge depth, blasting requirements help in determining depth of investigation.
- Vertical accuracy is critical and tides have to be correctly accounted to boring depths.

1.5.6 In rock dredging, the investigations assume great importance since its results significantly affect the design and cost of the work. Seismic Profile Survey to be carried out which shall give general extent of rocky profile and correlation boreholes should later to be sunk at selected positions to prove the seismic profile. The number of bore holes in rocky area has to be assessed by the port after seeing the results of seismic profile survey / correlation bore holes.

1.5.7 The following properties can be assessed by carrying out drilling for Rock & other hard strata:

- Compressive/Tensile Strength
- Density and porosity
- Hardness and Abrasiveness
- Core Recovery and RQD(Rock Quality Designation)
- Logging and Fracture State

1.5.8 Geotechnical reports:

Geotechnical site investigations are to be well documented. A typical geotechnical investigation report should be narrative and contain data regarding all equipment used (marine, sampling, laboratory), positioning, datum, water depth measurements, boring logs, full laboratory test descriptions and results and field and lab notes. These reports have to be provided to the bidders for their interpretation.

## 1.6 **Investigation of Environmental Conditions:**

### 1.6.1 **Meteorological Data:**

Meteorological Data is an important input for dredging operations since meteorological conditions affect the selection of dredging plants and their efficiency of operation. Strong winds, in addition to causing waves, may affect the

anchorage of certain items of the plant and may even require the dredgers to move to sheltered or open sea locations. Reduced visibility may cause down-time of dredging works. Excessive Rain fall and extreme temperatures can also affect the efficiency of the plant and personnel .Rough sea conditions/long-heavy persistent swell adversely affect the dredging operations.

### 1.6.2 **Oceanographic Data:**

- Data on water levels, currents, wave regime of the site, traffic density, dumping areas, types of soil to be dredged are essential for the dredging firms for selection of proper types of dredgers, selection of working method, estimation of operational delays etc.,

- The important parameters to be analysed in the study of the **wave climate** are wave height, period and direction. Wave characteristics can be obtained from Ship observed data, Instrument recorded data, and Hind-casting from Synoptic Charts.

- **Currents** have both velocity and direction and they normally vary with time. The two main effects of current on dredging are interaction between water and dredger affecting the stability and interaction between water and soil affecting the erosion/siltation. The measurements are normally carried out by Floats and Current meters.

- The important **sea water parameters** consist of Temperature, Salinity, Density, Turbidity, Chemical constituents of water and Pollution. These data are important for control and monitoring of erosion, sedimentation and environmental impact survey, etc.

- It is desirable to have the above data for a period of two years or atleast for a period of one year.

### 1.6.3 **Environmental Impact Survey:**

- This is carried out to identify the potential effects of dredging work on the environment during execution and completion and also to establish the base line conditions with which later environmental monitoring can be compared. A special survey is required to assess the dredging impact, to select the dumping ground and to control the damage. The disposal of

dredged material at sea is regulated internationally under the Convention of 1972 on "Prevention of Marine Pollution by dumping of Wastes and other Matter".

- Environmental Impact Assessment forms an essential part of capital dredging and must be integrated in the whole sequence of processes that constitute the port project appraisal, planning, design and operation process.

### 1.6.4 **Dumping Grounds:**

a. There has been considerable investigation in recent years of dumping areas receiving dredge spoils. The effects of the disposal of such wastes include the physical blanketing of the bottom. In addition, these spoils may be contaminated with heavy metals, oil, or organo chlorine compounds, causing adverse effects on fish populations and marine biology.

b. New dredge spoil disposal sites should be selected on the basis of non interference with navigation. The studies have to be done before selection of dumping site covering economic and environmental considerations.

c. Following are the essential requirements for selection of dumping ground for a dredging project:

- The selection of dumping ground should be such that the dredged material disposed at the dumping ground should not come back in to the port channel.
- Detailed current observations/tracer studies are to be carried out to assess the silt flow direction from the dumping ground and also the littoral drift in the particular port.
- The material shall be disposed off evenly spread at the dumping ground to see that the depths should not get reduced unevenly.
- The depths normally at dumping ground should be more than the ultimate dredging depth of the port for the next 20 years.
- It should be spread in a wide area of minimum 2 km diameter
- While selecting dumping ground area having extensive flora and fauna may be avoided.

- Dumping ground should be located within the port limits i.e. within the port jurisdiction.
- Dumping ground should not be located close to any fishing harbor. Also it should not be close to "Naval Exercise Area."
- Dumping grounds should be marked with "Yellow Marker Buoys" to avoid interference of fishing vessels and fishing activity in the above locations.

1.6.5 It is recommended that as complement to post dredging bathymetric survey Side ***Scan Sonar/ Sweep Survey*** may also to be carried out to detect obstacles on the sea-bed which can be a danger to navigation and also to define areas of rock outcrops and sand waves, etc.

## 1.7 Physical and Mathematical Model Studies:

- The laboratory studies have to be undertaken for Ports & harbour Development, Coastal Protection against erosion, Expected Additional maintenance dredging quantity in case of capital dredging etc., in Physical/Mathematical Models.

- The results obtained from the investigations on littoral drift, erosion and sedimentation in movable bed model can help the port authorities on viability of the project before undertaking a capital dredging project. In addition to that the stability of break water cross sections and their armour layers, wave disturbances inside the basin etc., can also be investigated in physical models.

- Mathematical models are useful tools for simulating the coastal hydrodynamics and morphological changes. Tidal hydrodynamics and wave simulations provide information on flow and tranquility conditions which is vital for designing the layouts of ports and harbors and is essential for economical design and construction of coastal structures. Most of the physical phenomena to be considered while designing the harbor layout can be faithfully simulated using mathematical models.

## Annexure-2

### Materials for Reclamation

2.1 The choice of material for use in land reclamation is mainly influenced by the materials that exist locally, which can be transported economically.

2.2 The most ideal material is a well graded, free draining sand, with particle size in the range of 0.10 mm to 0.60 mm. Sand and gravel mixtures are also suitable, but materials with a significant content coarser than 0.6 mm, is likely to cause problems, if the materials are to be pumped over long distances requiring higher energy for pumping. Materials that are finer than 0.1 mm are likely to cause excessive losses during dredging and placement.

2.3 The maximum percentage of fines that is acceptable in materials for land reclamation, depends to some extent on the overall grading of the material. A well graded material containing a high percentage of coarse material may be better able to absorb higher percentage of fines without any adverse effect due to the greater voids ratio. Significant percentage of fines if present has a natural tendency for fines to segregate, during dredging and placement. Materials that are not well graded are likely to have problems during consolidation.

2.4 During dredging and placement, fines are released with the draining water when flow velocities within the area of reclamation are sufficiently high to maintain fine particles in suspension. Hence, it is necessary to provide containment bunds with adjustable weirs to prevent escape of fine materials. (The weirs are so located that,discharge water takes a longer path, giving enough time for the material to settle.)

## 2.5. Design of Containment Areas

An efficient containment system must

- Remove excessive pollutants and solids from the dredged material
- Confine the material within the dredged area
- Prevent the damage to surrounding areas by inundation and
- Have a sufficient area for maximum rate of drying of the spoil

The containment facility must be so designed that sufficient time is allowed for the settlement of the solids. The degree of containment will depend upon the type of material. For coarse granular material, which maintains a slope of 1:3 or 1:4, requires containment only at the edges of the containment area. However, the fine cohesive materials must be contained on all the sides. The excess water is drained, either through an adjustable overflow weir or a drop inlet overflow.

## Annexure-3

**Pre-qualification criteria, Efficiency parameters, Definition of Indian Dredging Company, Types of Dredgers**

### 1. Pre Qualification criteria for Dredging Works

As regards the qualifying criteria with respect to experience, both quantity and value based criteria needs to be considered. In line with the above, the qualification criteria shall be as follows:

a) Experience of having successfully undertaken similar dredging works during last seven years –

(i) Three similar works – each work not less than 30% of estimated cost/quantity of the work put to tender;

(ii) Two similar works – each work not less than 40% of estimated cost/ quantity of the work put to tender;

(iii) One similar work of not less than 60% of estimated cost/ quantity of the work put to tender;

Notes: (i) Given the fact the dredging may be of different soil or strength of rock and the different conditions prevailing at different ports, each port will have to indicate the exact mix of various types of materials to be dredged while satisfying the Eligibility Criteria on quantity basis.

(ii) In case of Rock dredging works, the pre-qualification criteria shall include experience of rock dredging of at least 20% of the estimated for the project, or such large experience in rock dredging linking to specific equipment ensuring high productivity as may be decided by the port.

b) The average annual turnover during the last three years ending previous financial year shall be at least 30% of the estimated cost put to tender;

c) Definition of similar works to make no distinction between experience on maintenance and/or capital dredging unless specific projects require specific dredging technology such as exclusive rock dredging.

d) Each Port may prescribe daily/weekly dredging outputs, environmental parameters, Location of dumping ground, details of soil classification and the dredging companies can decide the size and type of dredgers to be deployed based on the draft available for dredging. This would give flexibility to the contractor to meet the output by drawing of plans without affecting the port operations. While prescribing the capacity and number of dredgers, care should be taken that the conditions are not so stringent to limit the competition.

e) With regards to equipment, absolute ownership, disponent ownership, time charter, and bare boat charter be considered. However, in case of chartering the dredger, an "Irrevocable letter of Authority" from the owner to be produced by the bidder to the effect that the dredger so chartered shall not be withdrawn till completion of the work.

f) The above-relaxed eligibility criteria be considered and adopted for a limited period of at least five years and a review is made thereafter taking into consideration dredging scenario prevailing at that time.

g) In case of capital and maintenance dredging works pre and post dredging hydro graphic surveys should be witnessed and certified by third party survey agencies/ MPSO. The periodicity of survey, type of echo sounder to be used whether multi beam or Dual frequency echo sounder shall be decided and incorporated in the tender itself by the

individual ports. The cost of the payment surveys may be borne by the port the contractor and the contractor may arrange for surveys for progress reports etc., The frequency of the survey should not vary between pre and post dredging surveys.

h) For measurement of dredging works, to have proper depth and width survey purchase by ports of latest high frequency multi-beam echo sounder equipment with capacity of feeding data to GPS/DGPS system with proper software or insistence on the contractor for deployment of this equipment is recommended.

i) Considering the long term contract for maintenance dredging the estimated cost/quantity for pre qualification pertains to single year shall be considered.

Source: Extracts of Standardization of Procedures and Documents for award of contracts -Constitution of Committee and its recommendations- Ministry's letter PW-12012/12/2007- DO (PO) dated 4th June 2010 to all major port Trusts & Dredging Corporation of India, after updating.

## 2. Efficiency Parameters of Dredgers

### 2.1 Trailing Suction Hopper Dredgers (TSHDs)

a). It should be fitted with twin screw with bow thrusters

b). The load and draft indicators, to be inspected and certified by a Classification Society being a member of IACS. The certificate issue date should be within a years' period or the certificate to be renewed annually

c). It should have efficient Dredge position control monitoring system consisting of DGPS, necessary software capable of being loaded with survey data like Hypack or similar software.

d). It should have efficient dehoppering/dewatering system

e). It should have preferably 2 suction pipes capable of dredging to a depth equal to the design depth plus 4mtrs.

f). It should have the capability to produce jet pressure of 6 bars for maintenance dredging and 10 bars for capital dredging projects.

g). It should have the capability to maintain an average speed of 8 knots

2.2 **Cutter Suction Dredgers (CSDs)** to have adequate cutter power for dredging of the specified soil and the dredge pumps capable of pumping to a distance to reach the reclamation/discharge area. It should have efficient Dredge Position control Monitoring System consisting of DGPS, necessary software capable of being loaded with survey data and track plotter and recorder.

2.3. Both TSHDs and CSDs are required to be fitted with production meters.

2.4. For Backhoe and Grab dredgers, the depth to be dredged and daily output may be specified. It should have efficient Dredge Position control Monitoring System consisting of DGPS, necessary software like Hypack or similar software capable of being loaded with survey data.

2.5. For an operating port, deployment of the number of TSHDs whether for maintenance or capital dredging works may be limited to 2 or as per density of the traffic in the port/ dredging requirements the port may decide number of TSHDs to be deployed.

2.6. Daily output of a TSHD depends on various factors like location of the dumping ground, depth and nature of bottom, prevailing weather conditions, downtime due to operations, breakdowns of the dredger, fishing activities near the port where dredging is being carried out etc., Hence the bidder may be asked to submit the same in the techno-commercial bid for verification. Similarly for CSDs the daily output may be calculated considering 20 operating hours, 4 hours being provided for positioning, attending to cutter and port operation etc. The project period could be assessed from the above information.

2.7 TSHDs engaged for shore pumping/reclamation works whether by rain bowing or through pipe line need to have required equipments and capacity.

2.8 The dredger should have the facility to oversee the electronic survey chart of the dredged area in their view terminals and integrate the survey in their dredging operation.

## 3. Definition of Indian Dredging Company:

An Indian dredging Company can be defined as a company registered under the companies Act 1956 and engaged in dredging works and having all its dredgers under Indian flag.

## 4. Types of Dredgers

The selection of the most suitable dredger depends upon the material to be dredged, the depth of dredging, the quantity and disposition of the material, the location of the dumping ground, the rate of production required and also on whether the dredger may have complete or partial possession of the waterway.

### 4.1 Trailing Suction Hopper Dredger (TSHD)

A TSHD trails its suction pipe when working and loads the dredged spoil into one or more hoppers in the vessel. When the hoppers are full, the TSHD sails to a disposal area and either dumps the material through the doors in the hull or pumps the material out of the hoppers. TSHDs are used mainly for Maintenance Dredging works. However where the soil is of silt, sand and soft clay TSHD with adequate jet pressure, Capital Dredging also can be done. While deployment of TSHD is considered adequate sea room for the vessel to manoeuvre should be available.

This type of dredger is widely used in the maintenance of channels, where its ability to maneuver as a ship is a distinct advantage. A further advantage of this type of vessel, when compared with the other types discussed, is its ability to remain effective in rough water and offshore locations. It is, however, suitable only for relatively loose materials as would be found in maintenance dredging.

## 4.2. Cutter Suction Dredger (CSD)

A CSD suction tube has a cutting mechanism at the suction inlet. The cutting mechanism loosens the bed material and transports to the suction mouth. The dredged material is usually sucked by a water-resistant centrifugal pump and discharged either through the pipeline or to a barge. CSD being capable of dredging harder material is preferred for the capital dredging works. These dredgers are normally carried out dredging work in the protected areas of the Port. If required to deploy in open sea condition the height of the prevailing swell at the site need to be taken into account.

## 4.3 Combination of Dredgers TSHD/CSD and Grab Dredgers:

For berth frontage dredging a combination of TSHD/CSD and Grab Dredgers may be considered.

## 4.4 Water Injection Dredging:

Water injection dredging (WID) injects large volumes of water at a low pressure into the sediment, using pumps with a series of nozzles on a horizontal jet bar. This fluidises the sediment and it is flowing down to deeper areas. The nature takes care of horizontal sediment transport instead of mechanical transportation. The success of the Water injection Dredging depends on the fluidisation of soil layer, gradient of the harbour approach channel etc., Highly plastic soils like clay or rocks, granular sand etc., cannot be dredged through WID. The WID is normally used to dredge berth pockets and other shallow areas with amenable soil conditions and in tidal ports. The WID can be combined with other forms of dredgers like TSHDs.

## 4.5 Backhoe Dredgers:

A backhoe dredger dredges like excavators. A crude but usable backhoe dredger can be made by mounting a land-type backhoe excavator on a pontoon. Usually backhoe dredgers material is loaded in barges. These dredgers are mainly used in harbours and shallow waters.

## 4.6 **Grab dredger**.

The grab dredger is usually a self-propelled vessel with a hopper and a grab crane. A simpler version which requires attendant barges is simply a crane on a pontoon.

## 4.7 **The bucket dredger**.

The modern bucket dredger comprises a continuous chain of buckets mounted on a ladder adjustable for depth. Each bucket discharges its load at the top of the ladder, into chutes which direct the material into a hopper barge.

Bucket dredgers are best confined to work in sheltered locations and are useful for fairly accurate trimming of the bed. They can deal with some hard material but large pieces in the bucket can cause serious delays.

## 4.8 Dredgers for Rock Dredging:

The most commonly employed method of rock-breaking under water is that of drilling and blasting, although jointed rock with thin bedding layers may also be fragmented by a heavy chisel or a pneumatic hammer on the rock surface. Drilling and blasting under water is a specialized, slow and expensive operation and many trials may be needed to obtain the right results for the dredgers to be used. The dredging of coral or cemented sand causes frequent problems. These can sometimes be easily fragmented and dredged by a powerful cutter suction dredger. However, only careful investigation will show whether this is likely, and massive formations may need to be treated as rock before dredging.

The type and capacity of the dredger for a dredging project need to be finalized considering various aspects by project duration, location of the dumping/reclamation area, time available for dredging works considering port operations etc.

**ANNEXURE-4**

## IDENTIFICATION & CLASSIFICATION OF SOILS FOR DREDGING PURPOSES

<table>
<tr><th>Sl.no.</th><th>Main soil type</th><th>Particle size distribution(in mm)</th><th colspan="2">Strength</th></tr>
<tr><td>1</td><td>Rock</td><td>Not available</td><td>Term<br>Very weak<br>Weak<br>Moderately weak<br>Moderately strong<br>Strong<br>Very strong<br>Extremely strong</td><td>Compressive strength MN/m2<br>Less than 1.25<br>1.25 to 5.0<br>5 to 12.5<br>12.5 to 50<br>50 to 100<br>100 to 200<br>Greater than 200</td></tr>
<tr><td>2</td><td>Boulders<br>Cobbles</td><td>Larger than 200mm<br>Between 200-60 mm</td><td colspan="2">Not available</td></tr>
<tr><td>3</td><td>Gravels</td><td>Coarse 60-20<br>Medium 20-6<br>Fine 6-2 mm</td><td colspan="2" rowspan="2">Term SPT N-value blows/300mm penetration<br>Very loose 0-4<br>Loose 4-10<br>Medium Dense 10-30<br>Dense 30-50<br>Very Dense Over 50</td></tr>
<tr><td>4</td><td>Sands</td><td>Coarse 2-0.6<br>Medium 0.6-0.2<br>Fine 0.2-0.06 mm</td></tr>
</table>

| | | | |
|---|---|---|---|
| 5 | Silts | Coarse 0.06-0.02<br>Medium 0.02-0.006<br>Fine 0.006-0.002 mm | Non plastic or plastic depending on coarse sand or clay association. Very often intermixed with fine sands and clays. |
| 6 | Clays | Below 0.002 mm | Varies between very soft to hard |
| 7 | Peats & organic soils | varies | May be firm or spongy in nature. Strength may vary in horizontal & vertical directions |

**Annexure-5**

## Details on Dredging Contract for Data Bank to be maintained at IPA

1. Nature of Dredging (Capital/ Or Maintenance or both)

2. Scope of Contract and Unit rate of Dredging (Quantum of dredging and Rate/$m^3$ / Day hire charges etc.

3. Contract Value

4. Name of Contractor and date Of award of contract

5. Details of Dredgers deployed

6. Payment terms on depth basis (or) In situ Quantity basis (or) Day basis, etc.

7. Date of commencement of Dredging

8. Scheduled time of completion

9. Actual Date of Completion

10. Nature of soil to be Dredged

11. Any other relevant data like Unexpected soil condition

12. Mode of Disposal (Reclamation/dumping)

13. Remarks

Annexure – 5

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DRG/PSK 30/7/14

HO/H/1101/1

16 Jul 14

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**PRE AND POST DREDGING SURVEYS**

1. Refer to agenda point No 10 of HSC Meeting 2013 regarding standardisation of procedural/mechanism for witnessing the tripartite monitoring of hydrographic survey for dredging work.

2. The guidelines for conduct of hydrographic surveys in harbours and Ports for pre and post dredge surveys and volume computations for arriving at dredged volumes have been prepared and are placed at enclosure to this letter. These are guidelines based on experience of this office and are to be read in conjunction with various hydrographic manuals and publications.

(Peush Pawsey)
Captain
Director (Operations)
for Chief Hydrographer

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# GUIDELINES FOR PRE AND POST DREDGING SURVEYS

## Introduction

1. Various methodologies exist for the collection, processing and presentation of hydrographic survey information. Whilst the presentation of such information is largely determined by the end user, the fundamentals of hydrographic data collection remain the same involving accurate measurement of the depth of water above a stated datum and the position of this measured depth. The conduct of survey operations when it comes to pre and post dredging requirement needs planning with few important aspects which are brought out in detail in succeeding paragraphs.

## Survey Preparation and Planning

2. Survey preparation includes the planning of hydrographic task and ancillary activities which are necessary to support the collection of data which includes activity such as equipment calibrations, setting up of monitoring station, carrying out check leveling etc.

## Equipment Calibrations

3. Equipment calibrations need to be conducted at regular intervals and documented in order to support the quality estimate given to the final survey data set.

(a) **SBES Calibration.** Calibration of SBES is to be achieved by the bar check method.

(b) **MBES Calibrations.** Frequent check-calibrations or rigorous confidence checks are required at regular intervals (which can be as frequent as 1-2 weeks) and after significant component swap outs of key sensors.

(c) **Tide Gauge Calibrations.** It is good practice to confirm automatic gauge readings with the level of the tide observed on a co-located tide pole, referenced to Chart Datum, at least weekly, if not daily, during survey operations. These comparisons provide a valuable record of the gauge performance and should be retained

(d) **Miscellaneous Checks and Calibrations.** Regular confidence checks of the vessel positioning system should be conducted at least weekly, preferably daily, during the course of a survey. A static check of the vessel's derived position against a mark ashore (e.g. a pin on a wharf) established to a higher order of accuracy is recommended. Calibration of ancillary equipment e.g. Sound Velocity probes, should be carried out by the equipment manufacturer and latest check certificates verified.

## Scale of Survey

4. All pre-dredging surveys are to be carried out on largest possible scale. The recommended scale of survey being 1: 1000 and 1:2000.This will enable data collection with line spacing between 5- 10 meters.

## Horizontal Datum

5. Hydrographic surveys to be carried out based on WGS-84 datum using UTM as a grid.

## Horizontal Control

6. Primary shore control points should be located by ground survey methods and the survey operations are to be carried out using Differential GPS for achieving horizontal accuracy of +/- 1.5 to 2 mtrs.

## Vertical Control

7. Following is to be borne in mind whilst establishing vertical control for the survey:-

(a) Tide to be referred to preferably to a SOI benchmark and all depths to be reduced to Chart Datum.

(b) Tide to be observed for the entire duration of survey and no predicted tide is to be applied.

(c) Period of observation of tide should be between 10-15 minutes, depending on range of tide.

(d) The data collected is to be invariably compared with predicted tides to rule out gross errors.

(e) Check levelling is to be carried out in case of established guage from Bench Mark to Tide Pole/ATG.

## Data Collection.

8. Different methods for sounding are required when using either SBES or MBES. SBES involves the running of systematic parallel lines at set distances apart and MBES operations include the orientation of the survey lines in relation to depth contours and the varying of the line spacing dependent on the least depth of water, which determines the effective swath width.

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## Check Lines

9. However regardless of the type of equipment in use, the running of additional lines (check or cross-lines) for the sole purpose of checking data quality at the data analysis stage is considered essential.

## Monitoring Station

10. Monitoring station to be established and analysis carried out for any deviations in the positions for the horizontal control.

## Effects of Squat and Settlement

11. The effects of squat and settlement on the small vessels typically used for sounding operations in ports and harbours for pre and post dredging are likely to be significant, particularly where the vessel survey speed is above 5 knots in shallow water. It is therefore recommended that trials are conducted to quantify squat and settlement, and corrections are applied as appropriate.

## Data Processing

12. It is recommended that data processing be conducted using a dedicated hydrographic processing package that preserves data integrity through audit functions and is capable of shoal bias thinning.

13. All data to be logged digitally .The position and depth strings to be preferably digitally logged in hydrography software and processed using standard hydrography practices.

## Data Analysis

14. Data collected during survey operations should be monitored closely to ensure the required standard and the desired extent of coverage is being met; however, it is not possible to fully assess the overall quality until all data can be viewed together or insuitably sized blocks. Cross-line comparisons and various other consistency checks are undertaken at this time. Statistical analysis tool, where available are to be used for data validation and quality assurance. Areas requiring re-running, either because of gaps in coverage or due to suspect data, are identified at this stage.

15. **Sounding Accuracy.** The Total Vertical Uncertainty (TVU) will be as given for special order surveys enumerated in SP-44.

$$TUV = \sqrt{a^2 + (b \times d)^2}$$

, where a = 0.06 and b = 0.0075 and d being the depth measured.

16. Statistical evidence for quality assurance viz the main line vs cross line) comparison at 95% confidence level and depth bias verses beam angle in case of mutibeam are to be

resorted to provide for quality check and quality assurance. This will provides for a check on data consistency and acceptance, prior volume computations.

17. **Points to be Considered**. Following points needs to be considered during conduct of survey:-

(a) It is important that the limitations of the survey equipment in use are fully considered during sounding operations. In particular, the performance of motion sensor equipment to be carefully monitored and survey operations suspended when it is apparent that the equipment is not coping with existing sea conditions. This is particularly important in MBES operations where error tolerances are much smaller.

(b) **Sea condition** Survey operation should be ideally carried out in calm seas. In case of any swell motion sensor to be utilized and interfaced with echo sounder in order to compensate for roll/pitch.

(c) Preferably higher frequency in range 200-220 Khz to be used for single beam echo sounder.

(d) The frequency should not vary between pre and post dredging surveys.

(e) Sound Velocity to be observed each day and in case of mulitibeam observation should be done with every change of tide.SV to be observed and applied with special care while in estuarine waters to cater for temporal/spatial variation.

**Volume Computation**

18. In order to calculate volumes in dredging surveys, the methodology would be determined by following factors:-

(a) Technique of Sounding i.e. Single Beam or Multi Beam.

(b) Nature of seabed i.e. smooth (sand or mud), harsh (rocky).

(c) Shape of the channel i.e. vertical walls or sloped non-horizontal surface.

19. Based on above factors, one of the following methodologies in any hydrographic software may be adopted:-

(a) **TIN Volumes**. Triangulated Irregular Network (TIN) Volumes are based on the true positions of depths to calculate the volume of a surface. This calculation involves modelling the surface as a collection of small planes. TIN's can either be derived from a gridded bathymetry source (i.e. surface) or from a point cloud. One advantage in using the TIN method (particularly for point data) is that the true position of the source depths will be utilized in the volume calculation. Entire sounding data

within the area in question can be considered. This is the historically preferred meth for most dredging type applications where volume is critical.

(b) Hyperbolic Volumes. For this method, a hyperbolic cell is created from the centres of every four adjacent grid cells. The depths from the grid cells are used as the depths for the corners of the hyperbolic cell. For this calculation, the surface is modelled as a collection of hyperbolic paraboloid sections, with a hyperbolic paraboloid created to smoothly pass through the points of each hyperbolic cell. This gives a smooth approximation of the surface and good volume results, but is processing intensive and time consuming.

(c) Rectangular. In this method, a single depth value from each cell (or bin) in the surface is used to calculate the volume. The surface is modelled as a collection of disjointed rectangular prisms, with the depth for each grid cell becoming the depth of the prism. In comparison to the previous hyperbolic method, this results in a much more 'simple' volume calculation which is processed much faster, however the accuracy of the computed volume may not be as reliable. One limitation on the rectangular volume method is the inability to perform a volume calculation against a sloped or non-horizontal surface in a reference model (for example the bank of a channel). This is because by definition, a rectangular prism cannot have a sloped edge, so only horizontal reference surfaces are supported.

20. Volume Comparisons. As previously outlined, there are a number of different methods available to the Hydrographic Surveyor or Engineer for volume determination. Depending on the technology available to conduct the survey, different methods may be adopted to calculate and derive the volumes but one approach may produces a more realistic solution. If the user only has access to a single beam echo sounder, they will be limited to end area volumes and TIN volumes. For a full density multibeam survey, rectangular and hyperbolic volumes can also be taken into consideration.

21. The nature of the seafloor (or riverbed/reservoir) could be another factor in determining the most suitable volume method to be used. If the bottom topography is smooth (such as with sand), hyperbolic volumes, which produce a smooth estimate of the terrain using constructed hyperbolic paraboloids could yield the best results. For a harsher, rocky terrain, TIN volumes utilizing the true positions of each depth may be the most robust answer. It's necessary to test and validate the possible solutions on a number of data sets to assess their merit.

22. Prior to arriving as the dredged volume adequate attention is to be paid vis-à-vis provision on the contract in terms of over dredge allowance permissible and other factor that would have a bearing on dredged volume to be computed.

23. These guidelines are to be read in conjunction with professional manuals and publications on hydrography and hydrographic equipment.

ADDITIONAL GUIDELINES FOR PRE- AND POST-SURVEYS WITH SPECIAL REQUIREMENTS OF MAJOR PORTS

| Sl. No. | NHO Guidelines dated 16.7.14 | Suggestions of Expert Committee | Reasons |
|---|---|---|---|
| 1 | 4. **Scale of survey**<br>All pre-dredging surveys are to be carried out on largest possible scale. The recommended scale of survey being 1: 1000 and 1: 2000. This will enable data collection with line spacing between 5-10 meters | 4. **Scale of survey**<br>All pre-dredging surveys are to be carried out on largest possible scale. The recommended scale of survey being 1: 1000, 1: 2000 and 1: 500 (alongside berths). This will enable data collection with line spacing between 2.5-10 meters | Grid spacing alongside berth defined. |
| 2 | **17. Points to be considered**<br><br>(a) to (e). | **17. Points to be considered**<br><br>(a) to (e) No change<br><br>(f) The survey launch for sounding work shall be of steel/FRP with hull mounted transducer having a draught of around 1 meter. It should have maximum speed of 10 knots with excellent control and maneuverability at low speed. While sounding the speed of vessel should be kept between 5 – 7 knots for quality logging of the data. | Survey launch specifications defined. |

Note: ***NHO, DEHRADUN GUIDELINES DATED 16.7.2014 MAY ALSO BE FOLLOWED IN TOTAL***