Technical Guidance Document for Hydrodynamic Modeling

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Environmental Quality Sector	* Corporate Management Representative	Secretary General
Originated By	Reviewed By	Approved By
* Refer to SG Circular S.G/C-08/12 Concerning Appointment and Responsibilities of the Corporate Management Representative at the Environment Agency – Abu Dhabi.		

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Abbreviations

2-D	two dimensional
3-D	three dimensional
ADCP	Acoustic Doppler Current Profiler
AWQO	ambient water quality objectives
EAD	Environment Agency–Abu Dhabi
HDM	hydrodynamic model
QA	quality assurance
TGD	Technical Guidance Document

Definition of Terms

Acoustic Doppler Current Profiler—A hydroacoustic current meter similar to sonar that measures water current velocities over a depth range by using the Doppler effect of sound waves scattered back from particles within the water column.

Area of Probable Impact—The extent of a physical area occupied by an environmental component that is likely to be impacted by at least one of the phases of the proposed project (i.e., construction, operation, and decommissioning activities and processes). The boundary of the area of probable impact is determined by measurements, previous studies, models, or best professional judgment and may vary by environmental component.

Competent Authority—The local authority within the Emirate of Abu Dhabi responsible for environmental affairs, that is the Environment Agency – Abu Dhabi (EAD).

Construction—The time period that corresponds to any event, process, or activity that occurs during the Construction Phase (e.g., building of site, buildings, processing units) of a proposed project. The Construction Phase terminates when the project enters the Operation Phase.

Cumulative Impacts—Effects on the environment that are caused by the combined results of past, current, and forseeable future direct and indirect activities.

Decommissioning—The time period that corresponds to any event, process, or activity that occurs during the Decommissioning Phase (destruction or dismantling) of the proposed project. The Decommissioning Phase follows the Operation Phase.

Environmental Impact—Positive or negative impacts that occur to an environmental component as a result of a project. Impacts can be directly or indirectly caused by the project's different phases (i.e., construction, operation, and decommissioning).

Hydrodynamic Model—A tool that is used to describe or represent in some way the motion of water either by a physical model built to scale or computational numerical models, which are primarily used nowadays.

Method Statement—Outlines the activities to be performed by the contractor and the methods to be implemented for minimizing environmental impacts and ensuring compliance with environmental regulations.

Mitigation Measures—Methods used to minimize or eliminate adverse impacts to human health or the environment from project-related activities.

Model Boundary—Same as *Modeling Domain*.

Modeling Domain—The area that is covered by the model to describe the flow characteristics of ambient seawater and pollutants; includes all sensitive receptors.

Operation—The time period that corresponds to any event, process, or activity that occurs during the Operation Phase (fully functioning) of a proposed project (the Operation Phase follows the Construction Phase, and then terminates when a project enters the Decommissioning Phase).

Project Area—The physical area within which all phases (i.e., Construction, Operation, and Decommissioning), processes, and activities of a proposed project will take place (the boundary of project area is defined by the titled property boundary). The project area is equivalent to the project site.

Project Site—Same as *Project Area*.

Proponent—The developer, permit applicant, company, or agency associated with the proposed project.

Sensitive Receptors—Populations or ecosystems which are more sensitive to pollutants or environmental disturbances that could be adversely affected by the project. These include, but are not limited to, hospitals, housing developments, schools, protected areas, and protected or endangered species.

Sensitivity Test—**T**ests that are conducted to evaluate the linkages between the different assumptions introduced to the Hydrodynamic Model and the outcomes of the model.

Purpose of This Technical Guidance Document

This Technical Guidance Document (TGD) outlines the requirements for developing both a hydrodynamic modeling study and report in Abu Dhabi Emirate for review and evaluation by the Environment Agency–Abu Dhabi (EAD), which is the Competent Authority in the environmental field.

1.0 Introduction

This TGD provides general guidance for conducting a hydrodynamic modeling study, including selection of a model, general data requirements, and reporting. A hydrodynamic modeling study is required as part of the environmental reporting process when potential hydrodynamic impacts could affect a waterbody either directly or indirectly because of a project or project activity. Projects and activities that are likely to warrant a hydrodynamic modeling study include, but are not limited to, performing dredging and reclamation activities, constructing bridges, adding a new storm or process water outfall, or increasing the capacity of existing outfall(s).

2.0 Purpose of Hydrodynamic Modeling

The purpose of conducting a hydrodynamic modeling study is to characterize the hydrodynamics of the waterbody and predict the movement of water, temperature, sediment, and discharges in a specified area before, during, and after anticipated activities related to a proposed or existing project.

The results of a hydrodynamic modeling study inform decision makers about the need for project alternatives, proper mitigation measures, and/or pollution control equipment during the life cycle of a project. For example, if hydrodynamic modeling shows that a new project is likely to cause undesired changes to the physical, chemical, or biological marine characteristics, then modifications or additional mitigation measures can be evaluated and implemented, if environmentally sound and economically feasible.

3.0 Components of a Hydrodynamic Modeling Study

A hydrodynamic modeling study must be designed and carried out to answer questions about the movement of water, temperature, sediment, and discharges in a specified area. Appropriate models and related tools must be used with high-quality data (e.g., data that meet quality standards for data collection and processing and are appropriate for use in the study). Hydrodynamic modeling study reports include the following components, which are each further described in the following subsections of this TGD:

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- Project scope
- Data collection
- Hydrodynamic model (HDM) selection
- Model construction and parameter selection
- Model calibration and validation
- Modeling simulation
- Post-processing analysis.

Although these components are generally sequential, some may need to be repeated and refined based upon results obtained during a later phase (e.g., revision of the scope to expand model boundaries to include the entire boundary of a plume), new data sources identified, or the recognized need for running an alternate model (e.g., two dimensional [2-D] versus three dimensional [3-D]). The Competent Authority should be kept apprised of progress being made, difficulties that may require assistance of the authority, and results at pre-determined milestones. For example, a screening model may show the furthest distance from a source where an impact may be expected. Prior to beginning the next stage of the hydrodynamic modeling study, the results from the screening model can be used in consultation with the Competent Authority to determine the size and placement of the modeling domain for a more refined model. Such consultations are expected to increase efficiency of the overall modeling study and its review procedures.

3.1 Project Scope of Work

The scope of each hydrodynamic modeling study must be determined in consultation with the Competent Authority. A project's Scope of Work must consider the life cycle of the project; the types of project activities and their potential to impact sensitive receptors; and the proposed final outcome of the project. Other aspects to consider during the scoping process include the following:

- **Modeling domain**—HDMs require data on the region, which is the entire modeling domain. The modeling domain encompasses all of the sources and receptors, extending to the entire area of interest or potential for impact. The size of the modeling domain depends upon the types of sources, the mass of emissions, the types of discharges being emitted (i.e., nutrients may need to be modeled for longer distances due to concern of aesthetic and eutrophication impacts), and the models being used in the hydrodynamic modeling study.
- **Sensitive receptors**—A sensitive receptor is a specific location in the modeling domain where the model needs to provide results (e.g., concentration, sediment erosion or deposition) so that the impact to the receptors can be evaluated. The identity and location of each receptor must be considered as part of the scoping process to help inform the data collection process.
- **Cumulative impacts**—In addition, other pollution sources and hydrodynamic impacts such as nearby storm water outfalls, marinas and harbors, construction and demolition activities, and dredging from nearby activities and projects must be included in the project scoping phase to ensure that cumulative impacts have been taken into consideration.

The Scope of Work can also help identify the types of data required for collection for the hydrodynamic modeling study. For example, if a project activity is likely to include wastewater effluent, then the concentrations of discharges likely to be contained in the effluent and the ambient water and sediment quality baseline concentrations of those discharges will be required as part of the data collection process for the study.

A Scope of Work must be approved by the Competent Authority prior to data collection. The Scope of Work must include a description of existing data to be used; data to be collected (including sampling design if applicable); the HDM to be used; and model construction and parameter selection. The Scope of Work submitted to the Competent Authority for approval must also describe all assumptions which will be used.

3.2 Data Collection

Many types of data are required for a hydrodynamic modeling study. General classes of data are included below; specific data elements are determined by the types of activities, potential impacts, and models selected for the study.

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The use of high-quality data is one of the most important elements of the hydrodynamic modeling study. The better the data, the more likely it is that the HDM's outcome and results can accurately inform decision makers. The modeler must ensure that data used in the model are up to date, reflect the current status of the project area, are from a reliable source, are valid, and were collected by using calibrated, properly functioning tools and equipment.

3.2.1 Expected Discharges from the Project Activities

Typically, HDMs do not estimate the discharge loadings (e.g., lead, nitrate, enterococci) or effluent characteristics (e.g., temperature, salinity, and dissolved oxygen) from sources. Instead, the modeler must estimate the expected concentrations and volumes for input into the model. These estimations are usually based on similar projects in the vicinity and/or sampling from other projects, in addition to recorded data for governmental and non-governmental institutions and the private sector. The estimated discharges must meet the HDM's requirements for format, time period and frequency, flux or mass, continuous or patch, chemical species, and units of measure.

3.2.2 Bathymetry Survey and Coastline Data

The bathymetry survey and coastline data are crucial factors in the HDM because these data will affect the flow of water and the change in the flow due to variation in depths and coastline with tidal currents. The accuracy of the collected data is important because it might interfere with the capabilities of the modeler to make finer mesh for the model. If the available bathymetry survey and coastline data are inadequate and/or not of sufficient quality to the extent that the information will negatively impact the quality of modeled predictions, then new surveys and data must be collected and used in the HDM.

3.2.3 Tidal Data

Tidal amplitude, phase, velocity, and direction are all required inputs for the HDM. Abu Dhabi waters are subject to continuous changes due to the highly dynamic coastal projects there. To account for these changes, at least one Acoustic Doppler Current Profiler (ADCP) must be installed in the project area and provide input data, in addition to any available data. Data must be collected for at least 15 days, covering the continuous full neap and spring cycle in the project location. Additional data should be collected to account for seasonal changes in tidal cycles.

Data collected within one year via an ADCP may be used if it is representative of the current status of the project and its surrounding and if the area has not experienced any variations in the water flow (e.g., no changes in the bathymetry, no additional navigation channels have been dredged in the vicinity of the project since the ADCP was installed, the ADCP's location is within the project area). The modeler must provide sufficient evidence that the area has not experienced any changes; otherwise, new data must be collected.

3.2.4 Meteorology

The tides in Abu Dhabi are highly affected by wind and other related meteorological parameters; therefore, it is very important to take these factors into consideration in order to run the HDMs properly. In addition, the meteorological data source must be within 50 kilometers from the project and must accurately represent the conditions at the site, otherwise a meteorological station must be provided. Also, the time when data were collected must match the timeline of when the ADCP was installed at the site because this helps to ensure high-quality and accurate data, as well as optimal performance.

Modelers must follow quality assurance (QA) procedures to ensure that the instrumentation is in good working order and that only high-quality data are used in the hydrodynamic modeling study. At a minimum, the following must be documented as part of QA:

- **Data source:** The data source must be an accredited source within 50 kilometers from the project and must accurately represent the conditions at the site (e.g., EAD stations, airport station or esteemed firms that are specialized in the field of ambient air quality data collection).
- **Calibration certificate:** The certificate for the equipment used during the hydrodynamic modeling study must be available and valid.

- **De-spiking:** The collected or provided data must be filtered to ensure that no errors were made when recording the data (e.g., an unreasonable increase or decrease in the temperature, humidity reading is zero).

3.2.5 Ambient Marine Water and Sediment Quality Data

Ambient marine water and sediment samples must be collected wherever needed, and the number of samples depends on the extent of the project. Samples must be analyzed in reference to the recommended ambient water quality objectives (AWQOs) for Abu Dhabi Emirate, and the results must be used as background information for the model to detect the areas that will exceed the AWQOs.

Data that were collected from the project area in the past year will be accepted if they meet EAD's requirements and conditions, if they do not exceed the AWQOs, and if the area has not experienced any variations or modifications that might provide inaccurate information about the water quality in the project area (e.g., new projects or channels are in the Construction or Operation Phase, new storm water outfalls).

The HDM must take into consideration background concentrations and the other sources of pollution to the potential impact area. Additional samples may be required for other pollution sources in order to develop a comprehensive and representative model.

3.3 Hydrodynamic Model Selection

Model selection must include an established and proven model that was previously and successfully used in the region. Selection between a 2-D and 3-D model will depend on the nature of the emissions source, the source's characteristics, and the surrounding environment. A 3-D model is preferred unless the modeler provides sufficient justification regarding why a 2-D model should be used instead. The following characteristics are used to determine whether a 3-D model should be selected:

- The emissions have characteristics which separate it from surrounding ambient marine water and cause stratification. Examples of characteristics include the difference in
  - Temperature (hotter or colder water than the temperature of ambient marine water)
  - Density (saltier or sweeter water the salinity of the ambient marine water)
  - Viscosity (more or less viscous emissions than the ambient marine water, which could occur because of temperature, density, and/or pollution loads)
- The emissions flow in canals
- The emissions flow in deep water.

The HDM must also be able to effectively handle the unique characteristics and nature of Abu Dhabi waters, including the variation in depths, intertidal areas (including mangroves), the nature of canals (similar to an estuary), wind- and tidal-driven currents. A suitable HDM must be carefully selected to ensure that the model can simulate the nature of Abu Dhabi waters with the highest possible accuracy and precision.

It is important to note that some modeling systems are open source from the developer and are available at no cost through government or non-governmental agencies, some systems are proprietary and require a purchase payment and possibly annual fees, and others provide a user interface that executes the open-source models, but for a purchase cost. When considering which model to use for a study, the modeler should choose and implement peer-reviewed models that are state-of-the-science, widely used, and appropriate for the specific hydrodynamic modeling study. Explain which model was chosen and provide a detailed explanation of why it was chosen.

3.4 Model Construction and Parameter Selection

Model construction and parameter selection must meet or include, at a minimum, the following criteria:

- The tides must be illustrated by the ADCP(s) and gage data.
- The mesh size must be suitable for the project area, for instance

  - Channels must have at least five elements.
  - Finer mesh must be in the proximity of the pollution sources.
  - There must be a maximum growth rate of 10% in the mesh size.
- The selection of near, mid, and/or far fields must be defensible.
- Boundary conditions must cover at least the 110% of maximum extent where discharges and sediments could travel because of project activities.

3.5 Model and Data Calibration, Validation, and Analysis

The HDM must be calibrated against at least one well-calibrated and certified ADCP in the project location and tide data from at least one location. Additional calibrations will be required, depending on the size of the model boundaries and the potential for impacts. The model must take into consideration the seasonality of data (summer and winter), as well as worst case scenarios.

The QA process for data used in the HDM is very similar to the process previously mentioned in Section 3.2.4 of this TGD. Specifically, the modeler must evaluate and document the data source, calibration, and de-spiking.

3.6 Modeling Simulation

The simulation process must represent background conditions (i.e., not be built as a project case). This will, then be simulated against the discharges from other sources in the project area (e.g., sediment, thermal plumes, brackish or sweet water, nutrients, herbicides and pesticides) with background conditions. Finally, the simulation must be conducted after adding the discharges from the different project phases (e.g., Operation, Construction), the activities for all proposed alternatives to the background conditions, and the discharges from other sources which in total are the known as cumulative impacts.

To address the potential cumulative environmental impacts, the modeler should include a description of any project-related activities or processes that may result in cumulative effects associated with impacts from the following:

- Off-site adjacent facilities, projects, or activities within or near the area of probable impact
- Other project components, activities, and processes at the proposed project site
- Additional projects planned at the site
- New processes planned for the site
- Effects across Construction, Operation, or Decommissioning Phases at the proposed project
- Effects across resources; these are impacts from activities that can affect more than one resource (e.g., increased truck traffic affects air quality and can also impact traffic congestion and noise patterns).

The modeling simulation must take into consideration the typical condition and the worst case scenario. The worst case scenario might have more than one form. Scenario(s) might be related to quantities, concentrations, or timing. The modeler must determine what the worst case scenario is and why other possibilities were eliminated. For example, the worst case scenario for storm water outfalls is the maximum expected storm flow, but it could be the minimum expected flow, which will drag all pollutants from the storm water network into the Gulf with little dilution. The modeler is responsible for considering all possibilities.

The modeling simulation must run against the characteristics of discharges (e.g., dissolved chemicals or sediments, primary or secondary discharges), and the methodology of introducing the discharges into the marine water might be continuous, discrete, or a mix; therefore, many factors must be taken into consideration when simulating the discharges.

The simulation must take into consideration the results without any mitigation measures and the results with the most suitable mitigation measures.

Table 1 shows the expected system for the buildup of the possible simulation scenarios. Simulations should be run for all hydrodynamic parameters that may be affected by the proposed project (e.g., temperature change scenarios, erosion and depositional change scenarios, pollutant flushing scenarios).

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Table 1. System for Simulation Scenarios.

No.	Simulation Case	Alternatives	Phases	Scenarios	Conditions	Mitigation Measures
1	No project (background conditions)	—	—	—	—	—
2	Other sources	—	—	—	—	—
3	Project (cumulative impacts, which include the background conditions with other sources in the region and the project itself)	Alternative 1	Construction Phase and sub-phases	Scenario 1	Normal	With
						Without
					Worst	With
						Without
				Scenario 2	Normal	With
						Without
					Worst	With
						Without
			Operation Phase	Scenario 1	Normal	With
						Without
					Worst	With
						Without
				Scenario 2	Normal	With
						Without
					Worst	With
						Without
		Alternative 2	Construction Phase and sub-phases	Scenario 1	Normal	With
						Without
					Worst	With
						Without
				Scenario 2	Normal	With
						Without
					Worst	With
						Without
			Operation Phase	Scenario 1	Normal	With
						Without
					Worst	With
						Without
				Scenario 2	Normal	With
						Without
					Worst	With
						Without

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The HDM simulation for a project must be run per the following regarding short- and long-term impacts:

- Flushing of pollutants during the Construction and Operation Phases
- Transport of sediments during the Construction and Operation Phases
- Shear stress during the Operation Phase, if required.

Furthermore, the simulation process must be developed based on the concentration of the emissions, not on the percentage. The HDM will identify the affected areas that are exceeding the AWQOs, the locations of sediment precipitation during Construction and Operation Phases, and the long-term impacts of the project on sensitive habitat areas (e.g., mangrove trees).

Finally, the outcomes and recommendations must clearly define the recommended alternatives regarding short- and long-term impacts, the recommended scenario regarding Construction and Operation Phases, and the best mitigation measures to be used during the Construction and Operation Phases to avoid or minimize the areas affected by emissions.

3.7 Post-Processing Analysis

HDMs are prediction tools that are used to simulate water movement and discharges in water. Some analyses may be needed after modeling to ensure that no further actions are required in order to enhance the prediction and to derive more accurate outcomes. Modelers must conduct sensitivity tests for all assumptions undertaken to evaluate the connectivity between the modeling inputs and outputs.

The first step of post-processing analysis is to conduct the mesh size sensitivity test. This text involves taking a portion of the project area, reducing the mesh size to a smaller size, and re-running the model. Once the outcomes perfectly match (100%) the previous result, then the selected mesh size is appropriate; therefore, no further reduction in the mesh size is required. The modeler must provide the results of the sensitivity test as part of the submitted report.

Depending on the types of project activities occurring at a site, additional specific post-processing analyses might be required that include, but are not limited to, the temperatures of thermal plumes at the edge of the mixing zone and the particle size and the behavior of sediments in the water column.

4.0 Document Development and Reporting

Modelers must document the entire process of conducting a hydrodynamic modeling study, including all of the assumptions and estimations that were made in a Hydrodynamic Modeling Report. The modeler conducting the study must produce and submit interim hydrodynamic modeling reports to the Competent Authority for review. Once the Competent Authority has reviewed the interim reports and has determined that the all modeling tasks were performed to its satisfaction, then the modeler must produce and present the final hydrodynamic modeling report to the Competent Authority for review. The final report documents the entire modeling process, including data sources and processing steps, assumptions and estimates, problems that were identified and how they were addressed with QA procedures, and the results of the hydrodynamic modeling study. Animation videos for all simulations conducted must be submitted along with the HDM report. The Competent Authority will determine the structure of the final hydrodynamic modeling report, but it is expected that the results should be presented in a manner that is understandable and includes adequate interpretation, justification of assumptions, and discussions of uncertainties regarding the results. The final report should also contain sufficient details to ensure that the hydrodynamic modeling study is a credible and reliable source of information for future efforts.The hydrodynamic modeling report must discuss the data and information collected and used in the model that include, but are not limited to, baseline survey, bathymetry data, navigation charts, tidal currents, meteorological data, quality of water and sediment, and pollution sources (including sufficient details of the information needed to run the model including the cumulative impacts). The hydrodynamic modeling report must also clearly differentiate between the existing data and the collected data and must provide information about the source for the available data, the timing of data collection, and the reliability and validity of the data. The elements required in the report are discussed in the remainder of this TGD.

The final Hydrodynamic Modeling Report must include the information in sections 4.1 through4.6, below.

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4.1 Project Description

The Project Description section of the Hydrodynamic Modeling Report should include information about the location, scope, overall project and planned construction and operation activities, as discussed in the following subsections.

4.1.1 Location

The Location section of the hydrodynamic modeling report should include a general description of the location and environment at the project site and surrounding area. In this section, the modeler should also provide maps that clearly identify the geographic location of the project area and surroundings and include all necessary information, such as a key, a scale bar, a North arrow, a legend, the locations of sensitive receptors, and distances to sensitive receptors.

4.1.2 Scope

The Scope section of the report should discuss the objectives and scope of the proposed project. For example, if activities will be conducted during separate phases, and the hydrodynamic modeling study is being submitted only for one particular phase of the development, then this section should describe those activities to be addressed by this specific plan. Scope activities for discussion may include but are not limited to excavation, reclamation, works related to earthworks, dewatering, piling, enabling works, and site remediation.

4.1.3 Overall Project and Planned Construction and Operation Activities

This Overall Project and Planned Activities section of the report should include information about the baseline conditions, identify sensitive receptors, and provide a method statement that describes the planned activities during the Construction and Operation Phases. This section should also identify the time period when the activities will occur outside of typical work hours. The following subsections provide instructions regarding the required information that proponents should include for this section of the hydrodynamic modeling study.

4.1.3.1 Environmental Baseline, Current Conditions, and Sensitive Receptors

This section of the report should include details about the current condition of the environment at areas potentially impacted by activities conducted during the Construction and Operation Phases at the site and should accomplish the following tasks:

- Briefly describe the existing environment for each environmental component at the site and surrounding areas. Relevant information may include previous or current land use, the presence of soil or groundwater contamination, meteorological conditions or water quality measurements, the presence of wildlife, and marine resources.
- Reference baseline data taken from the Environmental Impact Assessment or Preliminary Environmental Review conducted for the project or other studies in which baseline data adequately represent the condition of the environment on the proposed project site and adjacent surroundings. If EAD previously determined that no additional data collection was required, then the hydrodynamic modeling report should provide information about this decision, including the date when this decision was made and the EAD staff members who were involved in making the decision.
- Identify the sensitive receptors located in the vicinity of the proposed project site, including justification for how the sensitive receptors were determined.
- Provide maps that show the relative locations of these receptors in relation to the project site, including the distance to sensitive receptors.

4.1.3.2 Construction Project Description

This section of the report should include a description of construction processes and equipment to be used as outlined in the Scope of Work. For more complex construction activities, the hydrodynamic modeling study should provide more details about the activities that could potentially impact personnel, the public, and the environment. The hydrodynamic modeling report should provide sufficient technical details because this will assist the EAD reviewers in determining the potential impacts from these processes and equipment. The study should also detail the hours of the day when construction activities will occur.

4.1.3.3 Operation Project Description

This section of the report must include the following background information:

- Descriptions and flow diagrams of processes and operations.
- Descriptions and environmental process flow diagrams that show all pollution produced (e.g., gases, liquids, solids, noise, vibration) during project start up, commissioning, and continuous operation; provide the locations and sources of these emissions; and identify monitoring control units.
- Information about the types and quantities of equipment and machinery installed and used for the project, including both process and non-process equipment.
- Description of the operational methodology, if applicable, that lists the steps, key stages, and phases of the proposed operation.

The owner and EAD must verify and assess any significant technical modifications from the contractor before incorporating them into the HDM study. Furthermore, EAD staff will consider whether any deviation from the final design by the contractor or owner should be incorporated into the HDM study; however, it will be necessary for the modeler to ensure that the level of environmental performance within the final design is as good as or better than the environmental protection standard within the previously approved HDM.

4.2 Baseline Description

This section of the report should describe the current status (baseline condition) of the environmental component and the methods and/or sources of information used to determine the baseline condition. This section should also include specific emphasis about the areas and conditions that may be directly and indirectly affected by any of the proposed project activities conducted during the Construction, Operation, and/or Decommissioning Phases (if applicable). An analysis should be performed to identify the existing and valid baseline data and the additional baseline monitoring and surveying efforts that are required based on extent of the project footprint and existing data, the validity of the existing data in manner of time, conformance with EAD standards, and applicability of these data with anticipated impacts because of the project.

For the hydrodynamic modeling report, environmental baseline data should be collected to provide comprehensive, accurate, and detailed descriptions of the current environmental conditions regarding marine waters. The proponent should reference the EAD document titled *General Guidelines for Submission of Baseline Environmental Data* and the technical guidelines within the Environment, Health, and Safety Management System Regulatory Framework. The proponent should also adhere to the guidance regarding data collection, formatting, and reporting methods. If pre-existing, relevant, and current baseline data are available for the project site and the area of probable impact (e.g., those data identified in the Terms of Reference), then this information can be used to supplement the data that are collected as part of the hydrodynamic modeling effort. However, the hydrodynamic modeling report should clearly describe the sources of these data and clearly demonstrated that these data adequately represent the condition of the environment. Potentially suitable data sources include results from previous baseline condition assessments conducted at the project site and data from studies, literature, or reference documents that describe the environmental condition of a sufficiently comparable site. For data from such sources, the hydrodynamic modeling report should contain detailed descriptions of the sources and the methods used to collect the data (to the level of detail contained within the source document).

Baseline conditions that should be addressed include all existing physical, chemical, and biological conditions relevant to the environmental component. These conditions should be evaluated in the project area (i.e., site of proposed project) and in the area of probable impact (i.e., the extent of the area outside of the project area that is likely to be directly or indirectly impacted by the proposed project). Both the project area and the area of probable impact should be clearly described and delineated with maps in the hydrodynamic modeling report. The area of probable impact may differ by environmental component; such differences should be reflected in the maps for each component. In addition, the maps for each environmental component should contain information that is important and relevant to the component. Specific information that should be addressed in this section includes the following:

- For the meteorological data component, temperature, wind speed and direction, humidity, and current levels of pollutants, should be evaluated and described.

- For the marine water environmental component, all relevant pollutants, contaminants, turbidity, and temperature should be assessed in both the water and sediments, and information about bathymetry, currents, water flow patterns, and existing intakes and outfalls (at the project site and in the area of probable impact) should be presented.
- For each environmental component, maps and other relevant visual information should be included that orient reviewers to the distribution of important features (e.g., project area, ecology, human activities in the project area, other activities associated with the general study area) and their proximities to the project site (covering the project site and the area of probable impact). A consistent format should be used in all maps that includes a title (indicating what the map illustrates, the location, and the date when the map was produced), a legend, a scale bar, and a North arrow.
- Sensitive receptors within and around the project area (wherever the impacts of project activities and phases will reach) and pollution resource within and around the project area (wherever the impacts of project activities and phases will reach) must be described. Sufficient maps and photographs should be included.

4.3 Methodology

This section of the report must document how the components of the hydrodynamic modeling study were selected and evaluated. This section must include the following:

- Project Scope—Describe how the boundary for the HDM was identified and how the modeler ensured that all of the sensitive receptors are within the project boundary.
- Data Collection—Include a table that summarizes the types of data collected and gathered for the modeling effort, including the sources of the data, date ranges, and units of the data. Document how the discharge loadings used as inputs were calculated or obtained. If the calculations were not performed by using a standard model, then include the equations (Note: The calibration certificate for the equipment and tools used during the project must be provided). Include the spatial coordinates and the type of activity or the nature of the project for each potential cumulative impact identified.
- HDM Selection—Describe the model and the reasons selecting it, including why the HDM is appropriate for the scale and for Abu Dhabi's environmental conditions.
- Model Construction and Parameter Selection—Provide detailed descriptions of the assumptions and model inputs (e.g., friction coefficients, whether discharges were considered to be conservative)
- Model Calibration and Validation—Include figures and text that support the claim that the HDM is sufficiently calibrated and that the baseline simulation has been validated against real data. Include the length of time during which the model was calibrated and why it is considered a representative time period. Provide comparisons of modeled and measured tide data and ADCP data.
- Modeling Simulation—Describe the baseline and project scenarios.
- Results and Post-Processing Analysis—Describe the outputs and sensitivity analyses conducted.

All of the existing and collected data and information must be provided to EAD as per the *General Guidelines for Submission of Baseline Environmental Data* so they can be uploaded to the Environmental Theater.

4.4 Results

In this section of the report, the following information and results mustbe provided for presentation to the Competent Authority:

- Characteristics of the baseline scenario, which includes the following:
  - Current velocities and flow rates during minimum and maximum ebb and flood tides (information should be described in text and visually depicted)
  - Flushing rates or residence times for discharges
  - Temperature and salinity
- Characteristics of each of the study scenarios
  - Current velocities and flow rates during minimum and maximum ebb and flood tides (information should be described in text and visually depicted)
  - Flushing rates or residence times for discharges

   - Temperature and salinity
   - Changes in deposition and erosion
- Discussions of potential impacts from each of the scenarios on surrounding environment and current site uses by human and aquatic life
   - Comparison of hydrodynamic changes to the baseline
- Discussions about why any receptors (e.g., habitats, uses) were removed or their results changed.

If any predicted total concentration is close to or exceeding any applicable ambient seawater quality standard, then EAD may have additional requirements. Work may need to be conducted to reduce uncertainty in the modeling results (e.g., by gathering additional site-specific data), or control strategies may need to be tested to determine whether control procedures, control equipment, or process changes may be required.

4.5 Environmental Impact Prediction and Evaluation

This section of the report must address the potential and anticipated impacts of the project on sensitive receptors. This section should also include the direct and indirect impacts in the project area and the area of probable impact and a description of how it was delineated. The impacts associated with the Construction, Operation, and/or Decommissioning Phases (if relevant) should be addressed. The following information must be included and described in this section:

- Identify all of the potential impacts and their respective sources, including a description of the cause-and-effect relationships between planned project activities and the environmental impacts.
- Identify the locations of the impacts in relation to the project activities and site boundaries.
- Describe the probable significance of predicted impacts (i.e., magnitude of change or effect). When possible, include estimations or quantifications of the impacts.
- Identify the permanence and reversibility of the predicted impacts.
- Use quantitative assessment to predict the impacts whenever possible, providing ranges and confidence limits. When possible and relevant, include a list that identifies the stated assumptions that affect the predicted impacts, their probability of occurrence, the time scale, and the degree of impact.
- Demonstration by the proponent that the model and data used to determine the impacts are appropriate for the current application and environmental component.
- If no impacts are anticipated, then include a statement about this and provide supporting justification for the conclusion.
- Evaluate and provide detailed descriptions of the potential cumulative environmental effects.
- For marine water environmental components, the probable impacts of the proposed project and project activities on the sediment quality, water quality, water temperature, and water currents and flows should be described and supported by the appropriate HDMs. The locations of facility intakes and outfalls associated with the project should be presented with maps, along with estimates of water intake and output quantities and rates.

4.6 Conclusions

This section of the report must discuss the range of impacts predicted by the HDM, the mitigation measures that are proposed, and a justification for the proposed option based on the results. Previous sections of the report can be referenced to explain the conclusions made as a result of the hydrodynamic modeling study.

Hydrodynamic Modeling

Document Change History

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