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GUIDE FOR APPLYING WORKING WITH NATURE TO NAVIGATION INFRASTRUCTURE PROJECTS

The World Association for Waterborne Transport Infrastructure

4 WwN FRAMEWORK

WwN encourages consideration of site specific ecosystem characteristics during the project design phase, to achieve project objectives for the development, expansion or growth of ports and navigable waterways. Ideally, WwN requires development of a fully integrated approach with input in to the development of project objectives, and before design begins. While it is possible to implement WwN at virtually all phases of a project, incorporating WwN applications during conception, design and early implementation, provides the most promising opportunities to affect positive outcomes for the environment. Greater effort is generally needed to introduce WwN concepts later in the design process, and those efforts may not be as effective as when WwN is introduced during project initiation.

Consistent with the approaches established in the 2011 PIANC Position Paper, and as introduced in Section 2.2, the life cycle of a project can be split into the following steps (Figure 4.0-1):

- Step 1: Establish project needs and objectives.
- Step 2: Understand the environment.
- Step 3: Make meaningful use of stakeholder engagement to identify possible win-win opportunities.
- Step 4: Prepare initial project proposal and design to benefit navigation and nature.
- Step 5: Build and implement.
- Step 6: Monitor, evaluate and adapt.

This section describes how these steps are executed.

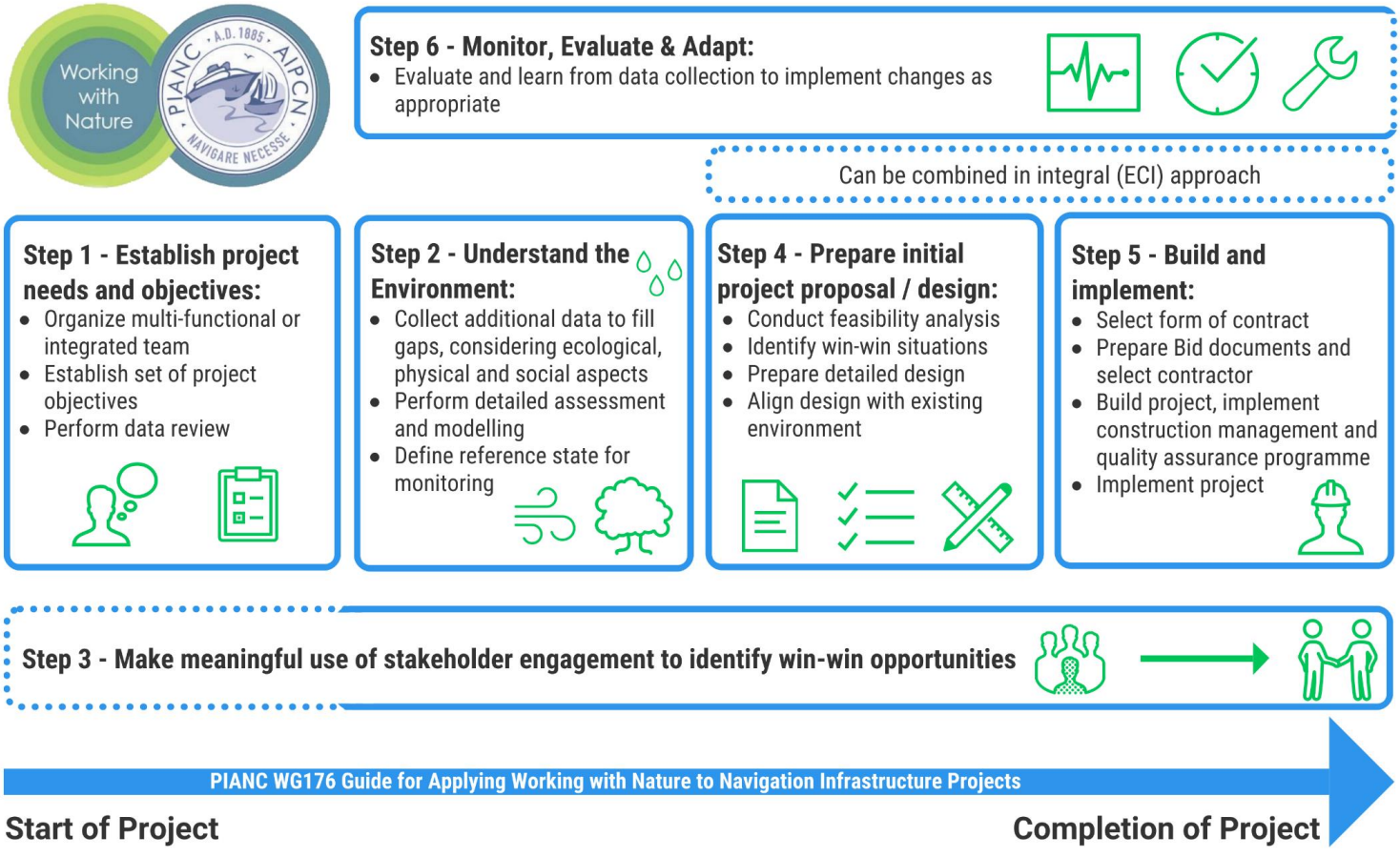

Figure 4.0-1: The Working with Nature Approach

4.1 Step 1: Establish Project Needs and Objectives

All successful projects must define and meet objectives. Objectives traditionally are centred on the required functions of the new development or project expansion as well as ongoing economic and operational requirements. WwN principles facilitate a wider view of project objectives by considering benefits to the environment and the broader community.

- **Environmental:** Environmental objectives ideally go beyond impact avoidance and actively seek opportunities for habitat enhancement and creation, such as the creation of a bird island for the Le Havre Port 2000 project (Section 5).
- **Economic:** Budget is often a primary driver of navigation projects. WwN can provide additional sources of revenue and has the potential to provide cost savings for project owners and the local community.
- **Social, Cultural and Recreational:** These objectives can include the development of new or better employment opportunities, creation of recreational areas for public enjoyment, environmental improvements that provide social benefits through aesthetic improvement or that meet cultural values of ecological protection or provide environmental compensation for negatively affected communities or stakeholders. These objectives include creation, protection, and enhancement of cultural resources, such as the Fehmarnbelt project (Section 5), which adds recreational opportunities in the form of beaches, wetlands and bird viewing as part of the landscaping works.
- **Other Aspects:** Other needs and objectives may be defined related to local requirements or site-specific conditions, protection of endangered species, minimisation of unintended environmental impacts during construction or reduced energy requirements associated with dredging and dredge materials management.

Large infrastructure projects often involve multidisciplinary teams and stakeholder groups. Once the primary project objectives are defined (e.g. deepening, expansion), larger stakeholder groups can identify opportunities to help authorities achieve win-win solutions that benefit the economy, the public and the environment, whilst also identifying and minimising potential economic, social and environmental risks. Thus, public consultation and stakeholder engagement play important roles in defining objectives. WwN relies on a framework to solicit diverse stakeholder views and perspectives, to provide feedback to stakeholders when establishing and agreeing to a set of project objectives.

The definition of objectives is a dynamic process. Whilst project needs and objectives are typically defined during the early stages of a project, as a better understanding of the environment is achieved (Step 2; Section 4.2), new win-win opportunities may be identified, which can support the formulation of new objectives. Conversely, if it is determined that a certain objective is unfeasible as defined, it may be necessary to modify or remove it.

4.2 Step 2: Understand the Environment

In the context of WwN, understanding the environment is a key element to success, and extends beyond the standard environmental impact assessment approach. Understanding the environment requires understanding the physical and biological environment so that site owners and stakeholders can identify new opportunities for environmental protection and enhancement.

WwN encourages consideration of site specific ecosystem characteristics to achieve the project objectives (see inset below). By understanding the environment within the project area and its vicinity, a baseline is created that serves as a reference point going forward in the project design. This baseline can be used to identify opportunities for ecological enhancements and improvements and in the monitoring and evaluation of long-term environmental and socio-economic changes.

Understanding the environment requires the evaluation of the various elements that contribute to understanding natural forces, habitat, and social conditions. Understanding this baseline condition is key in the identification of project opportunities and potential challenges. The baseline evaluation may require extended monitoring to identify seasonal or annual variations and trends.

Experience from similar projects or from reviews of similar areas can provide useful information, particularly in the early stages of the development or for smaller projects that may be more constrained by budget. The scope and method of the evaluation should be defined by a multi-disciplinary team engaged in the project that fully understands the project objectives and environmental enhancement aims.

Understanding the environment is usually based on data collection; however, numerical models, supported by data, can be established to produce a detailed description of both spatial and temporal environmental conditions and to evaluate the potential implications of identified win-win opportunities. Numerical models must be adequately constrained by site-specific data and local expert knowledge of input parameters to provide a reasonable representation of the proposed project.

Exhibit 6. Tunnel across Fehmarnbelt between Denmark and Germany

Through a careful understanding of the existing environment and planning, the Fehmarnbelt was designed to be integrated with the existing landscape. The beneficial use of 19 million cubic metres of material will provide an opportunity to re-establish former lost coastal areas, landscape and habitats at both the Danish (Lolland) and German (Fehmarn) ends of the tunnel. The design of nature areas at the eastern land reclamation on the Island of Lolland will close the gap between the nearby Natura 2000 area, creating a 15-square kilometre marsh meadow area, important for wildlife (e.g. migrating and staging birds). At sea, a protective layer of stones on the tunnel will create artificial reefs and establish new habitat for fish, birds and marine mammals, thereby enhancing the biodiversity of the Fehmarnbelt. New beaches for recreational purposes and cliff type shoreline is defined to mitigate a long term chronic erosive process experienced in nearby beaches.

All of this was identified through a detailed understanding of the environment and an extensive public engagement process carried out in early stages of the project (2005/2006). The public, NGOs and authorities were asked to express their views on the environmental issues and opportunities

The process of understanding the environment generally involves the following elements (see Appendix C for additional details):

Physical and Chemical (Abiotic) Environment: The physical and chemical environment is composed of non-living aspects of the environment, both natural and constructed. Examples include local and regional hydrodynamics, sediment lithology and physical characteristics, sediment transport, deposition and erosion, and subsurface and nearshore morphology. Chemical environment examples include water quality measurements (e.g. dissolved oxygen, pH, turbidity, light penetration, organic carbon), nutrients and nutrient loading, and organic and inorganic chemicals in the water column or associated with sediments.

Ecological (Biotic) Environment: The ecological environment is composed of all living organisms (plants, animals and micro-organisms) and their interactions within the biotic community and the abiotic environment. Biological systems and habitat ecology are inherently dynamic and complex because they include numerous biotic and abiotic interacting processes. Careful understanding is required to protect existing ecosystems and promote the development of new ecosystems. Measurements of the ecological environment may include the benthic habitat, surface water habitat and higher-trophic wildlife including fish, birds and mammals.

Socio-Economic and Cultural (Human) Environment: Understanding the human environment involves the study and analysis of the project within the context of existing and future inhabited spaces and the economic and social functions that interact with the existing resource. The objectives and design of a proposed navigation project should consider its relationship, connectivity to, and effect on existing and planned small- to large-scale urban developments for in-water, nearshore and upland areas.

Environmentally Sensitive Areas – Reserves, Conservation Areas and Heritage Areas: Most sites that receive protection under a conservation or heritage status, contain a diversity of habitats that are protected for their unique ecology. Sensitive and endangered habitats and endangered species are

protected under most legal frameworks and should be protected to the maximum extent practicable. More resilient or common habitats are often less of a priority. Understanding the environment means understanding the potential presence of sensitive and endangered habitats and species, recognising ways that navigation infrastructure can negatively or positively impact those conditions, while also protecting and conserving common habitats.

Governance Framework and Regulations: Governmental frameworks may vary significantly across the globe or regionally. Different governmental frameworks offer varying approaches to navigation infrastructure projects, requirements to protect the environment and offset damage caused by infrastructure growth. Specific attention should be paid to environmental protection policy and legislation that can affect project construction and operation.

4.3 Step 3: Make Meaningful Use of Stakeholder Engagement to Identify Possible Win-Win Opportunities

Section 3 introduced the importance of stakeholder engagement as a key to successful project design and implementation. In this section we discuss guidelines for engaging stakeholders throughout the project development and implementation process. The goal of the stakeholder engagement process is to seek out and discover win-wins for the project sponsor and the stakeholders and ideally build unanimity of support for the project as a measure of success.

As indicated in Figure 4.0-1., stakeholder engagement should be thoughtfully and carefully planned as an integral part of the WwN process through all steps of the WwN process and should be conducted in a collaborative environment. Activities discussed in this section are differentiated from, but should be coordinated with, legally-mandated public engagement processes that are officially established in law.

Who Are Stakeholders?

A project stakeholder is a person or organisation with a political, social, environmental, or economic interest in the project. Depending on project parameters, stakeholders may include local community members, concerned NGOs, regulators, government officials, local businesses and customers.

What Are the Benefits of Stakeholder Engagement

Meaningful stakeholder engagement requires the project sponsor to create a system that is well integrated into the project design, provides sufficient time to allow stakeholders to become informed about the project and provides input into decision making processes. The process may require additional time and expenditure throughout the project design; however, ultimately, stakeholder engagement helps to develop win-win project design outcomes for both the project sponsor and the stakeholders themselves. Benefits to the project that may be realised include:

- Stakeholder engagement delivers greater transparency and understanding, and narrows the gap between stakeholders, the project sponsor, and government regulators. This process can help counter public mistrust of the project and project owner (private or government).
- Stakeholder engagement may generate other successful solutions for the project due to the incorporation of diverse expertise or experiences that otherwise may not have been considered.
- Stakeholder engagement allows for stakeholder concerns and insights to be factored into the decision-making process. There is a potential for extraneous factors or disputes to stall the project at an early stage, however, conducted at an early stage, stakeholder engagement can positively influence the project approach and outcome. The project gains important support and the risk of appeals and project delays is diminished.

Key Aspects for Successful Stakeholder Engagement

- Provide meaningful information in a format and language that is readily understandable and tailored to the needs of the target stakeholder group(s).
- Provide information in advance of legal consultation activities and regulatory decision-making.
- Disseminate information in ways and locations that allow ease of access by stakeholders.
- Respect local traditions, languages, timeframes and decision-making processes.
- Provide a two-way dialogue that gives both sides the opportunity to exchange views and information, to listen and to have their issues heard and addressed.
- Provide clear mechanisms for responding to people's concerns, suggestions and grievances.
- Incorporate feedback into project design and report back to stakeholders.
- Be clear about the process and timings (manage expectations).

Exhibit 7. South Bay Salt Pond Restoration Project, San Francisco Bay, California, USA

The goal of the South Bay Salt Pond Restoration Project was to restore and enhance wetlands in the project area in South San Francisco Bay, while providing for flood management and wildlife-oriented public access and recreation.

The primary task of the project and its management team of local, state and federal agency property owners and environmental regulators was to adopt an Adaptive Management Plan for restoration of 15,000 acres (6,100 hectares) of former industrial salt ponds in the urbanised San Francisco Bay estuary.

A *Stakeholder Forum* was established, made up of approximately 30 invited members representing a diversity of interested organisations, agencies and individuals to exchange facts and information and provide ongoing feedback and input on project planning actions and applied studies.

The Stakeholder Forum was successfully led for three years by a neutral mediator/facilitator, the Centre for Collaborative Policy, based at the Sacramento State University, CA. The process employed a consensus-building process, which involved technical experts and the stakeholders for ongoing decision making, information exchange and resolution of conflicts. This process resulted in the final approval of the Adaptive Management Plan by the Forum and adoption by the Management Team.

The Adaptive Management Plan implementation is ongoing. The Stakeholder Forum continues to meet annually and provide input to restoration actions.

The Role of a Neutral/Social Mediator

Due to the inherent complexity of designing navigation and port-related projects, particularly when applying WwN principles, a necessary focus in stakeholder engagement is to find common ground among the diverse interest groups that will be affected by the project and who may be instrumental in its long-term and successful implementation.

Most projects require cooperation and collaboration among stakeholders, including local communities directly impacted by port-related activities. Such collaboration can be achieved through consensus-driven dialogue, managed by a neutral, social mediator. Trained in the consensus-based approach, the facilitator assists the group to understand points of agreement and disagreement, frames issues in perspectives that all parties can understand, helps identify options and associated benefits through dialogue with participants and moves the process forward to find common ground in a respectful and authentic process.

Stakeholder Engagement Plan

A guide for the successful implementation of a stakeholder engagement plan is included in Appendix D of this report.

4.4 Step 4: Prepare Initial Project Proposal/Design to Benefit Navigation and Nature

Design is a key element of WwN to meet the project objectives outlined in Step 1. The multi-disciplinary team identified in Step 1 looks at the project from different perspectives to ensure that all parts work together in balance and with nature. The following considerations are recommended for the design process:

Exhibit 8. Incorporation of Seabed Landscaping for Sustainable Sand Mining

▲ Areas of the seabed with natural sand waves have been found to be ecologically richer than more uniform areas

▲ After sand mining, the borrow areas used to be left relatively flat, discouraging the process of recolonization.

▲ Building with Nature is experimenting with selective dredging, leaving artificial sand ridges in the borrow areas

Seabed landscaping has been incorporated into subaqueous sand mining in the Netherlands for the sand extraction site of the Maasvlakte 2 project as a sustainable solution that helps with the recovery and sustainability of the benthic population. This approach came about through the engagement of multiple experts including project owners and directors, hydrodynamic specialists, biologists and dredgers. The very simple and elegant design relies on sand mining in furrows, leaving some sediment behind to protect existing benthos and stimulate benthic recolonisation in dredged areas.

- Understand the existing environment (Section 4.2).
- Define project limitations, including physical constraints, environmental features and social constraints.
- Apply a holistic, interdisciplinary approach to include all relevant facets of the design.
- Mimic nature, where possible to define or strengthen the project geometry and design using natural dynamics. For example, when developing an engineered beach, survey and consider the structure and processes of other beaches with similar characteristics and in the vicinity of the proposed project

Natural beach in Portugal

Man-made development in Egypt

Figure 4.4-1.: Artificial Beach Design based on an Existing Natural Beach

(see Figure 4.4-1.).[4] [5]

- Identify structures and methods that can serve more than one purpose, to enhance usage and both aesthetic and biological features of the development. For example; the Ecoshape project (seabed landscaping) integrates sand extraction with habitat protection (See Exhibit above and further discussion in Section 5).
- Evaluate the proposed development with appropriate methods from the context of the proposed functionality and potential maintenance challenges. Many tools are available to address potential challenges and evaluate win-win solutions.

[4] De Vriend, H.J. and Van Koningsveld, M. (2012): "Building with Nature: Thinking, acting and interacting differently", EcoShape, Building with Nature, Dordrecht, the Netherlands.

[5] Mangor, K. (2011): "Designet Natur – fortællingen om et nyt kystlandskab på Lolland og andre kunstige kystmiljøer", Wiljelm +10 Natur i Danmark Conference, Copenhagen, Denmark, 18 November 2011.

- Learn from experience by studying other projects (Sections 3 and 5). Incorporate strategies and positive components of successful WwN projects, while avoiding the pitfalls of unsuccessful projects.
- Consider the long-term implications of the project as they relate to the financial plan and social, technical and environmental requirements. A phased approach to development may be beneficial and allow for adaption of the project (see Step 6).
- Consider potential changes in the environment, particularly climate change impacts or other human activities that could affect the project in the long term.
- Recognise that design is a dynamic process. Depending on the outcome of monitoring activities, designs may need to adapt to meet changing conditions, whilst maintaining focus on the project objectives. The dynamic nature of the WwN process can often be moderated through open communication and mutual agreements with the various stakeholders:
    - Ecological basis: Understand the natural variability and create designs with sufficient flexibility and buffer to accommodate unforeseen changes.
    - Requirements: Ensure there is an agreed minimum and maximum range that meets the natural variability, but still ensures that the overall aims are achieved (maintain control).
    - Communication: The public and Stakeholders need to understand what WwN is and why it is acceptable and positive to embrace natural variability.
    - Monitoring: Monitor and publish the results. Ensure that an action plan is in place in the event that monitoring identifies that design objectives are no longer being met.
    - Contract: Include long-term maintenance plans that allow for monitoring and adjustments to be made.
    - Risk sharing: Owners, designers and contractors need to agree beforehand on the risks and how they are shared with regards to environmental variability.

Integrating WwN into the Design Process

Ideally, WwN concepts are introduced early, during conceptual and feasibility assessment stages of the project design to identify and compare options, costs and expected outcomes. Initial costs, project phases and the design and implementation schedule are defined during this conceptual stage. As part of the feasibility assessment process, alternatives and project sites may be proposed and evaluated.

WwN requires a conscious and deliberative plan to protect and enhance the environment by integrating the project design with the natural features of the environment. From the start of the project design phase, designers should work with multidisciplinary teams to identify how and where WwN can be incorporated into the project design.

WwN options should evaluate such features as:

- **Hydrodynamics and Sediment Transport.** How does the proposed project (e.g. channel maintenance, channel deepening, port expansion, pollution control) work with or against natural forces? By adopting a WwN approach, project owners and designers can work with engineers and scientists to find nature-based solutions to address sedimentation processes and dredging needs. For example, in the Fehmarnbelt project, a new engineered cliff area was designed, based on the beneficial use of sediments from the tunnel area. This cliff area will naturally and progressively erode to nourish downstream beaches that have been suffering from chronic, long-term erosion. Cliffs are typical natural features of the Danish coastline and have therefore been incorporated into the design as a win-win solution to reverse the existing shoreline erosion.

  Hydrodynamic and sediment transport solutions can include the following elements:

    - Narrowing river flows with physical barriers (e.g. the use of chevron structures or island formation, shown in Section 5) to increase current velocities in navigable portions of a river and to promote sediment deposition in non-navigable areas.
    - Upstream sediment management to lessen sediment loads from agricultural and urban landscapes.
    - Regional port management to focus deep channel dredging towards one regional port, whilst allowing other ports to manage shallower cargo vessels. This approach makes it possible to optimise channel deepening projects, potentially targeting areas that are less prone to sedimentation. However, this also requires a regional economic analysis and regional cooperation.

- **Beneficial Use.** Sediment dredging cannot be avoided entirely. One of the largest challenges to beneficial sediment use is cost and competition with conventional engineering methods. Aggregate materials in many regions are extremely inexpensive to produce, and thus are usually less costly than producing material from dredged sediment. However, to the extent that sediment can be reused economically, beneficial use can serve multiple functions:
    - Conserve natural resources by minimising use of engineered disposal facilities
    - Rejuvenate wetlands and other habitats
    - Provide fill material for upland development
    - Serve as land cover
    - Provide materials for use in the manufacture of construction products, such as bricks and light-weight aggregate
    - Improve agricultural soils

- **Siting of New Ports, Harbours, and Navigation Channels.** Project proponents must examine natural conditions, including hydrodynamics, sediment transport, and ecological conditions, to optimise new development locations and the opportunity to enhance habitat, while minimising long-term maintenance requirements and negative habitat impacts. Early optimisation of WwN in the design layout should consider the location and orientation of the proposed navigation features to develop innovative solutions that provide win-win opportunities for the project owner, the public and the environment. If this optimisation is left to later stages, after specific features are defined and designed, many opportunities will be lost.
- **Restore Existing Habitat and Create New Habitat.** Whether they are built from dredged material or other means, habitat creation projects meet a very broad range of objectives. Types of habitat have included new land from reclaimed disposal facilities, mudflats, wetlands, islands and subaqueous structures. These new habitats may support riparian or invasive species management or protect and promote sensitive and endangered species. Such projects may include the creation of recreational areas such as trails and visitor centres.

4.5 Step 5. Build and Implement

During project implementation, the following WwN considerations are recommended:

- **Contract Structuring:** Structure the contract to allow flexibility during building and implementation. Inflexible contractual specifications restrict the ability to develop creative alternative approaches based on latest insights and innovative methods. Flexibility provides opportunities to change and adapt proposed designs based on added data collection, new information, and lessons learnt during construction. Inflexibility makes the application of the WwN principles difficult and ultimately expensive. It is important that all parties agree and understand responsibilities related to project design and ownership of the risks and opportunities. This will help to facilitate communication and coordination during construction.
- **Early Contractor Involvement:** With all parties involved at the start of the project, an integrated and inclusive WwN design can be made based on actual construction means and methods, equipment, schedules and operations. Contractors often have a unique understanding of the environment, based on work experience, and can introduce ideas of means and methods that may not be available to design engineers. Thus, working with contractors (i.e. the companies responsible for construction) during design can help tailor the design to protect nature during construction; this can also limit delays associated with changes that occur after contracts are awarded.
- **Construction Planning:** Construction planning requires numerous considerations related to logistics, scheduling, and permitting. From a WwN perspective, it is important to consider the following:
    - Plan mobilisation and execution methods and optimise logistics, economic and environmental outcomes.
    - Minimise the footprint of the areas impacted by construction equipment to minimise environmental impacts and limit required mitigation.

- Plan work windows, if necessary, to minimise impacts to migration and growth cycles of sensitive aquatic and terrestrial species. Construction windows can limit turbidity and water quality impacts; conversely, such requirements can be relaxed if work is implemented outside the time and areas that could impact sensitive fish. Work windows, however, can be costly, because they slow or delay construction. When identifying work windows, it is important that they are related to actual baseline studies in which sensitive receptors are identified at an ecosystem scale. See, for example, the Teluk Rubiah, Lumut, Malaysia case-study inset.
- Plan work cycles and environmental controls that can be supervised by efficient, project specific, real-time monitoring and such that construction methods and monitoring efforts can be adapted as needed as environmental conditions change.
- Describe and agree upon an adaptive management process through environmental monitoring plans (Step 6).
- Identify opportunities for affordable beneficial use of dredged, excavated or removed materials (Section 3.2.2.).

Exhibit 9. Dredging Works at Teluk Rubiah, Lumut, Malaysia

For the Teluk Rubiah dredging project, natural flow conditions were evaluated to help define a WwN dredging strategy based on environmental windows (dredging specifications at different locations and at times when the flow conditions were adequate), to allow 'no significant impacts' to sensitive areas. Adaptive monitoring was conducted on a frequent basis during project implantation and the results assessed via modelling to confirm that turbidity levels were consistent with predicted values, and thus safe to for local sensitive receptors. Continuous communication among the project team allowed dredging activities to be managed daily to avoid stoppages due to environmental impacts. Extensive stakeholder engagement with authorities and local fishermen was key to successful implementation of the work.

This approach allowed the project to finish ahead of schedule and within budget, while also limiting impacts to the surrounding environment.

- **Choice of Construction Materials:** Choice of construction materials are an integral component of habitat design. Considerations include:
  - Incorporate habitats into the final infrastructure through choice of material, and final shape of the constructed environment.
  - Use site-specific, natural materials to the extent practicable.
  - Introduce native species or ecological structures (e.g. oyster reefs, salt marshes and mangroves) that can evolve naturally with the changing local physical environment, including as a result of climate change.

- **Choice of Construction Methods/Equipment:** Construction phasing and implementation methods for navigation and port infrastructure projects should minimise negative impacts and unintended consequences that can negatively impact the natural environment.
  - Implement construction methods and phasing to work with nature and not against it (i.e. design project phasing to minimise disruption to the existing environment, while ensuring that the overall project schedule is not negatively impacted).
  - Select construction equipment that minimises impacts to the aquatic and terrestrial habitat. For instance, in environmentally sensitive areas or when dredging contaminated sediments, it may be necessary to use specialised dredging equipment to minimise turbidity and secondary releases.

Collaboration with construction contractors will help the project design team to better understand what may or may not be feasible during the implementation stages. This approach can also identify and define appropriate contractual arrangements that allow for innovation in the project execution and may create added value for the project and the environment.

4.6 Step 6. Monitor, Evaluate and Adapt

Monitoring, evaluation, and adaptation are key to assessing the progress of a project against the stated environmental objectives and to achieving WwN goals. Pre-project, baseline conditions established under Step 2 are used in conjunction with the project objectives established in Step 1 and refined during design to develop metrics to track progress on whether the project has met or will meet the objectives as planned. The evaluation may help in reassessing the viability of the project objectives and, if required,

update them. Monitoring also helps identify new actions or measures that may be required, should deviations from project objectives become necessary (see inset).

Implementing a *Monitor-Evaluate-Adapt* process during and following construction will contribute to improved environmental quality outcomes through the incorporation of feedback mechanisms into the monitoring process. The process provides a framework with which to assess the inherent uncertainties associated with the design and to adapt and implement corrective measures. The cyclic concept provides greater project quality assurance and continuous attention and improvement.

Elements that should be monitored include effectiveness of WwN design and construction methods, and environmental, social and economic outcomes of the project. Project teams should carefully consider monitoring methods and evaluation tools available to meet specific project requirements.

Environmental monitoring involves the tracking of physical, chemical and biological processes before, during and after project implementation. Monitoring (data collection) at the design stage (before construction and implementation) is essential to understanding baseline conditions. Monitoring during and after construction and implementation is used to confirm expectations and to control conditions to protect the environment, or to optimise implementation to achieve WwN objectives.

Exhibit 10. New containership port for Le Havre, France

A 10-year monitoring program was proposed as part of the Port 2000 Le Havre and Seine Estuary project by the Le Havre Port Authority. The monitoring proposal was agreed to by an independent scientific committee active in the Seine estuary, before official approval by local state government.

Specific attention was given to fish, bird and amphibian surveys. The monitoring program also extended to sediments, water quality, benthos species and many types of species living in the estuary. A socio-economic monitoring component was added for the fishing industry, to give assurance to fishermen that the new port would not adversely impact their activities.

Monitoring results were regularly presented to the scientific committee, which was an active player in interpreting the results and requesting additional surveys. The committee also asked that certain components of the monitoring be extended past the original 10-year timeframe.

- Short-term monitoring tracks the progress of construction and assesses compliance with permitting and regulatory requirements. Identified impacts may require additional environmental controls or adjustments to the construction process.
- Long-term monitoring assesses progress toward WwN environmental objectives. Lessons learnt from monitoring may be used to further optimise design. Targets of long-term monitoring include the WwN habitat that is protected or created, biogeochemistry of sediments, flora and fauna, or presence of invasive species; in general, monitoring is used to assess habitat conditions compared to an appropriate baseline or reference condition.

Monitoring Objectives should address progress towards WwN objectives and be designed to capture unintended consequences and unexpected positive effects that can be used for future concepts and designs.

Short- and long-term costs, including costs to monitor nature, should be incorporated into project plans and project stewardship. The costs associated with implementing short- and long-term monitoring programs are typically offset by early identification of potential problems that have the potential to result in expensive (and potentially unfeasible) modifications in the future.

Environmental monitoring is not just about the identification of impacts and risks; monitoring should provide information on the overall ecosystem after project implementation.

Long-term monitoring should be designed to track changes associated with global phenomena (e.g. climate change) that may have regional impacts and assess whether the project design and implementation is sufficiently resilient.

Social and economic monitoring tracks social metrics such as community benefits (e.g. recreational use features), employment and economic opportunities derived from the project (e.g. from greater cargo handling, new tourism and recreational opportunities), and other similar metrics aimed at community welfare. Social and economic features (and corresponding monitoring metrics) may extend beyond the project footprint.

The following guidelines are suggested for effective implementation of the WwN *Monitor-Evaluate-Adapt* process:

1. Plan the monitoring programme in the early stages of the project (ideally when project objectives are established, and the existing conditions are well understood or data gaps have been identified during Step 2).
2. Identify monitoring goals in an adaptive strategy to identify lessons learnt for the larger navigation infrastructure community.
3. Tailor the evaluation process around the intended audience so that stakeholders have an opportunity to provide input and contribute to the project.
4. Communicate results early and routinely to stakeholders.
5. Adapt the project, as necessary, in accordance with monitoring results. Rules for adapting the project should be documented as part of the monitoring plan.
6. Document monitoring results and evaluation approaches to allow for a transparent public review.