Identifying and assessing water sources

Guidance document for the onshore oil and gas industry

Water

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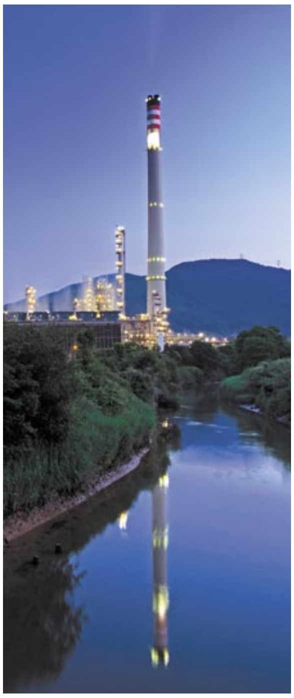


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Executive summary

Water management is an essential component of onshore oil and gas operations, both in upstream exploration and production and in downstream refining and petrochemicals. These operations may need both to access significant quantities of water and to manage large volumes of produced water, waste water and rainfall run-off. Consequently, oil and gas operations may be significant users and managers of water at local and regional levels. For this reason, good practice guidance and effective stakeholder engagement—central themes of this document—are important elements for effective integrated water management and control of associated operational and strategic risks.

This document presents a systematic process to enable the effective identification and selection of potential water sources to meet the needs of onshore oil or gas operations within the broader context of local or regional water management. It is applicable both to new projects and, when significant changes in operating conditions occur, to existing operations.

The process is not prescriptive: every project is different and needs a customized approach. It is therefore expected that individual companies will use the concepts and approaches to guide the development of their existing procedures. Case studies based on first-hand experience are presented throughout the document, providing practical examples of most aspects contained in the guidance.

Key sections of the document, which detail the steps of the process, are summarized below.

Stakeholder and regulatory engagement

For the wider community of stakeholders (including regulators) within the orbit of an oil or gas project, water is often one of the most valued local resources. For this reason, effective engagement can be particularly important when identifying, selecting and managing water supplies. Indeed, it is often a critical requirement for successful implementation of an oil or gas

operation, especially when the security of local water supplies is potentially at risk.

Engagement approaches described include a stakeholder consultation method, whereby the oil and gas company retains ownership of the problem and the solution, and a collective action method, in which ownership of risks and solutions is shared between project developers and stakeholders. In some cases, stakeholder engagement may be mandated and/or mediated by relevant local authorities. Alignment and integration with other project-related activities such as environmental, social and health impact assessment (ESHIA) studies can ensure that stakeholder engagement is implemented efficiently.

Project water requirements

Prior to identifying and assessing the water sources available to a project, the water requirements of the project should be determined. The demand profile of a project will be dependent on the type and scale of the project, as well as the scope for water efficiency within the project.

Identification of water sources in the project area

Identifying potential water sources is often a key feasibility aspect during project initiation. Knowledge of the general physical, social and legislative environment within which the project will operate may often provide a high-level understanding and information on the likely viability of water source options. Accordingly, an emphasis on this stage may be appropriate during early screening, allowing important actions to be identified and targeted for subsequent more detailed quantitative phases. Additional sources of local data will usually be required, along with a defined project 'area of influence'—both geographic and social—that enables the extent of a project and information-gathering to be bounded.

Status of water in the area

Having defined a project's water requirements and the range of potential water resources available, this stage in the process will provide an indication of the water quantities and

qualities available for use from these sources. It will also indicate whether the available resources can meet project demands, now and for the future duration of the operations, accounting for potential changes in water use and availability during the estimated life of the project. On completing this stage, guidance stresses the importance of reviewing previous stages to reconfirm their applicability and modify objectives as necessary.

Assessment of impacts, risks and uncertainty

Once water sources in the project area have been characterized, the potential impacts, risks and opportunities of the project water demand within the area should be identified and assessed for the lifetime of the project, taking account of uncertainty in the information available. Potential risks to the project from changes to water availability and the use of alternative sources should also be assessed.

Water source selection

The final process stage is the assessment and comparison of the potential supply options previously identified and characterized. This will enable selection of the water source(s) that best meet the project needs, while minimizing any adverse effects on the wider drainage basin and balancing other financial and environmental factors such as waste and energy. The section includes a brief description of general reporting requirements, although it is accepted that companies may have their own reporting requirements. Study findings should be made available for use in any subsequent iteration of the assessment process, enabling the source selection to be refined, and improvements made in project design and operation. Both internal and external reporting of the water source identification, assessment and selection procedure needs to be transparent and credible.

Section 1: Introduction

Water management is an essential component of oil and gas operations, both in upstream exploration and production, and downstream refining. Although the global volume of fresh water used by the oil and gas industry is considerably lower than in the agriculture, power and some other sectors (AQUASTAT: FAO, 2012), the oil and gas industry can be a significant user of water at the local and regional scale. Oil and gas operations also require the handling and management of large volumes of produced water, waste water and rainfall run-off. The effective identification and selection of water sources is a key aspect of a company's water management approach and is the focus of this document.

This guidance document is not intended as a single prescriptive approach, nor is it setting a standard for the oil and gas industry. Rather, it is designed to introduce a set of underlying principles and to explain how they can be met by implementing a series of practical steps.

IPIECA Water Management Framework

In 2013, to promote and facilitate the implementation of good practice in water management within the oil and gas industry, IPIECA published a Water Management Framework. This provides:

- a template for integrated water resource management, addressing multidisciplinary aspects over the life of oil and gas operations;
- a strategic direction for IPIECA and its members linked to future priorities as industrial management practices develop;
- a structured industry approach outlining necessary steps to meet current and future water management practices;
- an outline of available or pending guidance, and tools—available or required—to implement good water management practices across oil and gas operations, of which this guidance document is one component; and
- a platform for the industry to develop its own strategies and to consult and communicate water management activities and achievements to external stakeholders, including communities, regulators and governments, trade associations and non-governmental organizations (NGOs)

Context of this document

This document supports IPIECA's Water Management Framework by issuing good practice guidance for water management at onshore oil and gas facilities. It has been developed for use by IPIECA members and the wider industry in conjunction with existing codes of practices. Content has been shaped through consultation and agreement on overall objectives, focus, target readership, input sources and technical input to maximize its utility and benefit.

This guidance complements the IPIECA publication entitled, *The biofuels and water nexus: guidance document for the oil and gas industry* (the principles stated therein are also applicable when identifying and assessing water sources), and is also designed to complement a companion guidance document entitled, *Optimizing water use through efficiency* (IPIECA, 2014—in progress).

Scope of document

This document provides guidance on good practice in identifying and assessing water supply sources to meet the requirements of onshore oil and gas industry activities. It is applicable to new projects and also to existing operations when significant changes in operating conditions occur. It is also applicable to all types of water resource, including fresh, brackish and saline. The document applies to all oil and gas operations including upstream exploration and production, and downstream refining and petrochemicals.

The scope addresses the technical aspects within the boundary of a project in terms of meeting water requirements, as well as the wider environmental and social issues. Although the focus is on water sources, many concepts discussed may also apply to waste water discharge and disposal, particularly stakeholder engagement (Section 2), baseline conditions (Section 5), the assessment of risks, impacts and opportunities (Section 6) and options appraisal (Section 7). In many cases, decisions on the source of water and waste water discharge and disposal options will be made at the same time.

Guiding principles

The process of identifying and assessing water resources centres on the concept of water stewardship. It involves the consideration of integrated water resource management principles, the identification of, and engagement with, key stakeholders in the project, and the assessment of risks associated with the development of a resource. The overall process is recognized to be iterative, developing throughout the life of the project.

These principles do not replace but rather are intended to complement full compliance with all applicable laws and regulations, which is assumed as a baseline minimum.

Water stewardship

In some industries and areas of the world, the current focus on industrial water management is for companies to adopt water stewardship rather than simply manage risks and impacts from water use in their operations. Water stewardship has been defined by the Alliance for Water Stewardship (AWS) as '*the use of water that is socially equitable, environmentally sustainable and economically beneficial, achieved through a stakeholder-inclusive process that involves site and catchment-based activities*' (AWS, 2013). The intent of water stewardship is captured in four elements, as follows:

- **Water governance:** this addresses how water is governed and managed both internally within a project and externally within the wider drainage basin. It covers the issues of access, rights, policy and claims, and it is strongly linked to the concepts of responsibility and accountability.
- **Water balance:** addresses the amount and timing of water use, including abstractions, consumption and discharges, and whether the volumes involved are sustainable relative to renewable water supplies.
- **Water quality:** addresses the physical, chemical and biological properties of water and whether the water quality within the site and drainage basin is within acceptable local norms and not undergoing significant deterioration.
- **Important water related areas:** addresses the spatial aspects of water at the site and within the wider drainage basin, and concerns the land features, e.g. wetlands, which are a linked component of water systems either for cultural or ecological reasons and fisheries (AWS, 2013).

The term 'sustainable' is referenced above, and in recent years has been used extensively to describe a wide variety of planning activities, often without any definition being provided. The need for 'sustainable development' or 'sustainable use of resources' may have different meanings depending on the user's perspective. A definition provided in the Brundtland Report (WCED, 1987) has been adopted in this document: '*a system that is sustainable should meet the needs of the present without compromising the ability of future generations to meet their own needs*'.

Integrated water resource management

Similar to water stewardship, integrated water resource management (IWRM) promotes the coordinated development and management of water, land and related resources (e.g. energy consumption, greenhouse gas emissions) with a view to maximizing economic and social welfare while protecting the environment (Global Water Partnership, 2013). The underlying principle of IWRM is that water is a shared resource and that many of its uses are interdependent. Therefore, in the assessment of any given water resource for use by a project, consideration should be given to the impacts of its use on other users, to the impact of other users on the project, and to its importance in terms of biodiversity and ecosystem services.

Stakeholder engagement

In all except the most remote locations, human activities will already be using, and be dependent on, local water resources to some extent. Recognition of these stakeholders together with cultural values that may be assigned to water, and involving them in the development process can be crucial to project success. Other stakeholders will include those who manage the water resources and those who have an interest in addition to the existing users, e.g. regulators and non-governmental organizations (NGOs).

Inclusivity is a key principle underlying stakeholder engagement (AccountAbility, 2008). Where appropriate, stakeholders that may be affected by the project should be identified and engaged with as early as possible. In some circumstances, where projects may have an impact on indigenous communities, companies must enter into a process of gaining community consent for a project. Companies receiving finance from the International Finance Corporation (IFC) are obliged to satisfy their conditions in relation to projects that have an impact on Indigenous Peoples. In particular, the IFC's Performance Standards are often used as a reference for environmental and social performance by companies and their stakeholders, including Performance Standard 7 on Indigenous Peoples, even where they are not receiving finance directly from the IFC.

Risk assessment

There will always be risks associated with water use by a project, be they financial, environmental, social or political. These should be identified during the early stages of the project and assessed on an ongoing basis bearing in mind that, as a project evolves, its associated risks may change.

Continuous improvement

Management of water should involve a continuous cyclical process of improvement throughout the life of oil and gas operations. Typically, a greater level of detail is provided during each of the planning and design phases until water source selection is complete. During the subsequent construction and operational phases this updated plan can be implemented to optimize use of external water resources, minimize the associated risks, and take account of changes in the operating environment.

The overall process

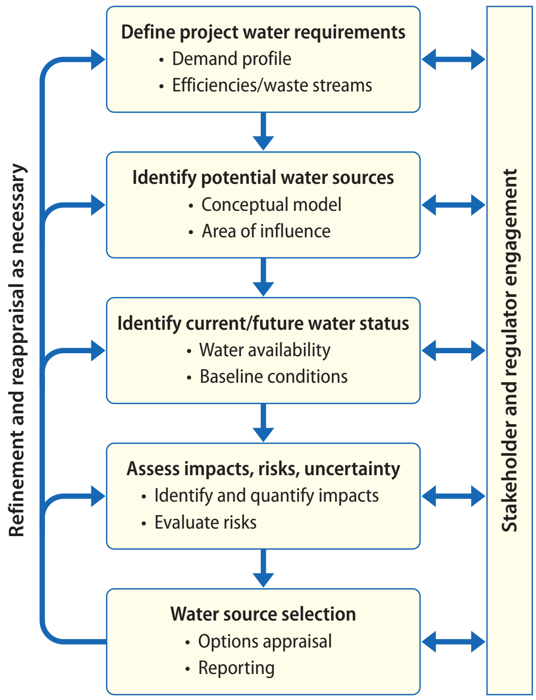
A decision making process for identifying and assessing water sources typically follows a sequence such as:

- identifying the:
  - operating environment and constraints;
  - objectives;
  - options for achieving the objectives; and
  - criteria to be used to compare the options;
- analysis of the options;
- making choices; and
- feedback.

The main steps in the water source identification and appraisal process presented in this document follow this sequence and are shown in Figure 1. These steps should not be considered to be prescriptive, because every project is different and each will need a customized approach. However, they provide a logical procedure incorporating all key principles outlined above, and when suitably implemented will meet the guiding principles outlined on pages 5–7 of this document.

Details of the process that can be applied for each of these steps are presented in the following sections of this document.

Figure 1 *Outline water source identification and appraisal process*

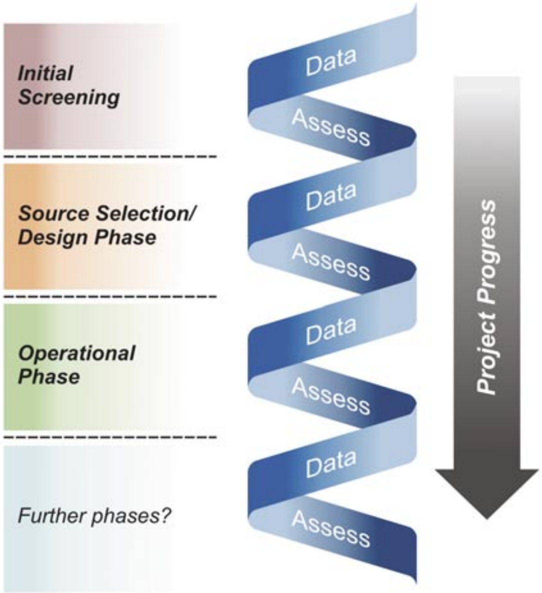


Stakeholder engagement is essential at all stages, and needs to be managed responsibly. It should take place at the appropriate time during the planning phases of the project, and it should be recognized that stakeholders' requirements may change throughout the life of the project. The approach and level of stakeholder engagement will vary between location, regulatory regime and project specifics (refer to Section 2 for more details).

It is suggested that the water source identification and appraisal process is implemented in an iterative way, aligned with major project phases as illustrated schematically in Figure 2 (overleaf). This approach allows the principle of continuous improvement to be implemented throughout the project. The steps relevant to a specific project can be selected, and then revisited in more detail as the project moves through different phases.

While each project is different and will require a customized approach, the process shown in Figure 1 provides a logical procedure which, if suitably implemented will meet the guiding principles outlined on pages 5–7 in this document.

Figure 2 *Iterative implementation of the process*



For example, an initial screening phase can be used to target the key areas of action for the assessment, and/or reduce the number of source options to be assessed in more detail. Points addressed during the screening could include identification of stakeholders and planning for engagement, initial contact with key stakeholders, definition of the regulatory regime and relevant legislation, and a high-level assessment of the current status of water availability or stress in the area.

A subsequent main assessment phase would collect more detailed data, engage with a wider range of stakeholders, evaluate the local availability of particular water sources and potential environmental impacts in more detail, etc.

The process should continue throughout the life of the project, to allow changing external or internal conditions to be identified and evaluated. For example, during the operational phase local conditions may change, resulting in greater demand and competition for the resource being used.

Finally, the procedures suggested in this guidance for the identification, assessment and selection of water sources should be undertaken in the broader context of overall project impact and risk assessment. Accordingly, coordination with ESHIA studies undertaken for the whole project is usual. This will allow water impacts and benefits to be assessed alongside other project aspects such as energy efficiency, waste amount reduction, carbon balance, facilities footprint, safety and health, etc.

Section 2: Stakeholder and regulatory engagement

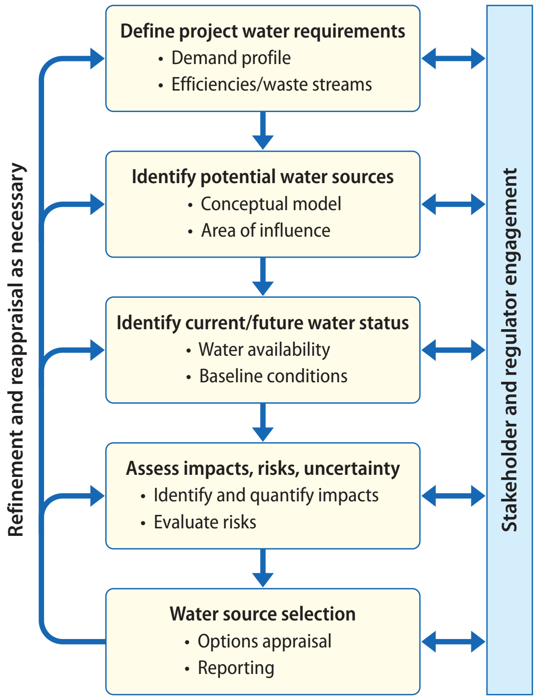
Stakeholders are any individuals, groups of individuals or organizations that can affect, or are potentially affected by, an organization or its activities. In the context of identifying and assessing water sources, stakeholders comprise two main groups:

1. **Primary stakeholders:** those individuals or organizations (such as community representative organizations) directly affected (positively or negatively) by the project, potentially including all water users within the project's vicinity.
2. **Secondary stakeholders:** those individuals or organizations that have an influence on the project's water use but are not directly affected by it, for example regulators and international NGOs.

Engagement with both types of stakeholders will usually be necessary to some degree for any project, although the extent of engagement will vary widely depending on the local circumstances. As shown schematically in Figure 3, engagement with stakeholders may take place throughout the process, with different aspects of engagement being undertaken at each stage. Although the approach will vary between locations and will depend on the project type, stakeholder consultation on water sourcing and management should not be initiated until there is some understanding of water demand, use and disposal. Engaging without information on the different options and volumes being considered could raise stakeholder concerns and uncertainties.

A detailed understanding of applicable legislation is essential for a project, and gaining this information and implementing relevant procedures will usually require direct engagement with the regulators. For other stakeholders water is often one of the most valued local resources, so effective engagement can be particularly important when identifying, selecting and managing water supplies. Some degree of stakeholder engagement is often mandated by national legislation, usually within the requirement to undertake an ESHIA (or similar) study. Sometimes the overall engagement process will be mediated by the relevant local authorities. It is suggested that a comprehensive ESHIA is undertaken to fully understand the range of potential impacts and their synergies, including in circumstances where this is not required by local regulators. Where appropriate, emerging good practice would also encourage undertaking an assessment of human rights impacts, which may relate to community access to water.

Figure 3 *Identifying and assessing water sources—engaging with stakeholders*



Engagement with stakeholders may take place throughout the process, with different aspects of engagement being undertaken at each stage.

Although there are many forms of approach, two main approaches to stakeholder engagement can be broadly distinguished:

- The 'stakeholder consultation approach' where the company follows a procedure to identify and liaise with stakeholders, but effectively retains ownership of the problem and solution. This approach is described in

detail in the AA1000 Stakeholder Engagement Standard (AccountAbility, 2011).
- A 'collective action approach', where the aim is to develop joint relationships and joint solutions to undertake some degree of collective action, as described by the UN Global Compact's CEO Water Mandate in the *Guide to Water-Related Collective Action* (CEO Water Mandate, 2013).

In many cases the stakeholder consultation approach will meet the requirements and expectations of all parties. Good practice would suggest that it may be beneficial to consult stakeholders as early as possible within the project life-cycle process, including identifying risks with water supply in relation to community usage. However, consideration can be given to applying a collective action approach when significant risks are recognized with regard to the security of the water supply required to meet project needs, or when a resource is at risk due to multiple users. Flexibility should be retained, allowing the form of engagement to evolve as new information is obtained in each step.

Good practice stakeholder engagement will also seek to ensure that the FPIC concept (free, prior and informed consent) is considered where Indigenous Peoples are involved. For more conventional situations where indigenous stakeholders are not involved, the ICP (informed, consultation and participation) process may be more appropriate (IFC, 2012). Stakeholder engagement also overlaps with other project considerations that have a social focus, for example social responsibility and human rights (IPIECA, 2012a, 2012b, 2012c). A combined approach which addresses these aspects alongside water issues may be beneficial, in order to acknowledge the interrelated nature of potential impacts.

Stakeholder consultation approach

A summary of the stakeholder consultation process is provided by Business for Social Responsibility (BSR, 2012). A five-step iterative approach is described under the following headings:

1. **Engagement strategy:** set the expectation and level of engagement anticipated to be appropriate for the project.
2. **Stakeholder mapping:** define criteria for identifying and prioritizing stakeholders and select engagement method(s).
3. **Preparation:** focus on short- and long-term goals, determine logistics for the engagement and set the rules.
4. **Engagement:** conduct the engagement itself, ensuring equitable stakeholder contribution and mitigating tension while remaining focused on the issues.
5. **Action plan:** identify opportunities from feedback and determine actions, revisit goals and plan next steps for follow-up and future engagement.

These steps would run in parallel with the technical components described in Sections 3 to 7.

Though this approach is common, the specific activities arising from these steps will be very different depending on the project phase. For example, intensive consultations planned in the initial phases gradually give way to continuous improvement cycles for community programmes, hotlines and grievance procedures of established and ongoing operations.

Engagement strategy

A stakeholder engagement plan (SEP) defines the strategy to be followed for the project. It should be developed as early on as possible, and can follow, at a minimum, a phased approach through subsequent iterations of the water source assessment process. The SEP would normally have a wider scope than water issues only and be conducted within the framework of the project ESHIA. The SEP should also reflect the preferred consultation methods of individual stakeholder groups. The SEP should complement and be consistent with local regulatory requirements for stakeholder consultation. In addition the SEP could be mediated by third parties or include relevant local authorities. It should aim to be a transparent process and to:

- establish a basis for constructive ongoing dialogue about water issues with relevant project stakeholders that will continue throughout project planning and implementation;
- provide a regular flow of information about the project to stakeholders;
- provide opportunities for stakeholders to offer feedback to the project regarding their views and concerns with regard to water issues;
- document these for consideration and response as appropriate; and
- enable the project, regulatory authorities and potential lenders to gauge the level of community support for the project.

Stakeholder mapping

This step can be broken down into four phases:

- **Identifying:** listing relevant groups, organizations, and appropriate representatives for groups of people.
- **Analysing:** understanding stakeholder perspectives, influence and relevance.
- **Mapping:** depicting the relationships between stakeholders and evaluating the potential for impacts from the project to affect stakeholders, as well as stakeholders' potential effect upon the project.
- **Prioritizing:** ranking stakeholder relevance and identifying issues.

The list of local stakeholders may be related to the project's 'area of influence', as defined in Section 4. Accordingly, it can be useful to coordinate the stakeholder identification phase with determination of the area of influence.

Note that the relevant stakeholders may change through the course of a project due to variations in their relationship with the project, the level of impact of the project or changes in water use, quality and infrastructure in the area of influence. Changes in the local external conditions (e.g. political unrest, climate change or other new large projects) may also alter the composition and/or number of water-related stakeholders. The list of stakeholders should therefore be revised at appropriate times during the course of the project, with re-mapping and prioritizing when necessary.

Preparation

The prior steps in the engagement process have defined strategic objectives and prioritized the stakeholders. Consideration of these two key aspects will allow the engagement approach and format to be defined. Logistics also have to be planned to adequately cover aspects before, during and after the engagement.

In order to achieve effective stakeholder engagement it is important to consider the skills available within the project team. Specific training or external assistance may be required to achieve this.

Because the water-related stakeholder map may not remain static over the project life, levels of interest and communication requirements may also change with time.

Engagement

Stakeholder engagement and consultation should seek to develop relationships, communicate company plans, understand and act on stakeholder concerns, as well as to collect data to feed into the conceptual model of the potential water resources (discussed in Section 4). Important information that should be collected includes:

- Stakeholder uses of water in the project area, their views on current water availability, quality and seasonal variations, any issues they might already face with regard to water use, and concerns they might have about potential impacts of the proposed project: this could, for example, influence the quantity of water that can realistically be abstracted from a particular resource, or it may highlight the importance of additional engagement to communicate how existing uses will not be affected.
- The location of 'important water areas': these are water-related areas that are considered important by stakeholders for the ecosystem services that they provide, including cultural, spiritual, recreational, economic or biodiversity values. Examples include aquifer recharge zones, sites of religious significance or drinking water reservoirs.
- Potential future uses or changes to the use of water within the project's area of influence during the lifetime of the project, e.g. through agricultural, industrial or urban development, or as a result of external factors such as climate change. This information may be available through water management plans and forecasts developed by local authorities, water utilities and/or government ministries. Where this information is not available, the project may need to undertake studies to develop a long-term forecast of socio-economic development and its associated demand on the local water system.

Companies should document how comments made during consultation are taken into account and how they have affected the development of the water strategy.

CASE STUDY: Stakeholder engagement

Company:	**Total**
Location:	**Yemen**
Aims:	**To fully appraise the social impacts from the project**

For the Yemen Liquefied Natural Gas (YLNG) Project, Total recruited public participation specialists to draft and implement a Community Consultation and Disclosure Plan (PCDP) as part of the impact assessment process. In line with the PCDP, a range of communication initiatives were undertaken to ensure effective company engagement with local communities. This included:

- meetings with local sheikhs or other community leaders to provide a clear explanation of the project, its potential impacts, and the need for their participation in the project;
- collective village visits to ensure all information was being cascaded down;
- separate meetings held by female personnel from the YLNG Project, specifically for women from the villages to ensure they received the same level of information as men, and to understand potential project impacts from the women's point of view; and
- project information distributed through posters and leaflets in both Arabic and English, explaining project activities and potential impacts (e.g. associated with blasting, helicopters, dust etc.) in accessible language.

These steps were taken to ensure effective engagement, to enable appraisal by the local communities of all potential impacts, and to ensure accessibility of information in terms of language and literacy.

Action plan

The aim of the action plan is to translate the findings, insights, discussions and agreements from the engagement into action and to communicate these actions to the stakeholders. A dual plan approach allows content to be divided between internal and external stakeholders. Each action should define roles and responsibilities for implementation, milestones, and a realistic timeline for completion.

The action plan should also be used as a progress report for goals and objectives, informing development and refinement of the engagement strategy to improve future iterations of the overall cyclic process.

A key action is to communicate with the stakeholders. An external reporting document can be built from the action plan that explains the relevant project aspects, including prior engagement activities and noting future plans. Stakeholder feedback on the report can be invited to further improve the engagement strategy and future activities.

Collective action approach

The water stewardship concept (AWS, 2013; CEO Water Mandate, 2013) is promoting the concept of 'collective action' to manage catchments and local areas, sharing risks and solutions. The collective action approach to stakeholder engagement involves the company entering into some form of joint relationship with external parties and undertaking some degree of collective action. This approach allows all stakeholders to work towards an agreed method for addressing water-related concerns through joint efforts that generate common understanding, strategies and solutions.

This type of external engagement by a company is usually associated with a relatively mature degree of water stewardship practice, and is generally adopted when the context is such that the company working on its own may not be able to effectively manage the particular combination of physical, regulatory or reputational risks associated with meeting the project water demand. In some cases, collective action may be the only way to genuinely overcome complex water supply challenges.

Other potential benefits include learning from stakeholder's local experience, gaining fresh ideas and perspectives, developing local skills and infrastructure to sustain solutions, enhancing project credibility and legitimacy, increasing the momentum for tackling a water challenge, pooling resources to address common objectives, or simply becoming better stewards of a water resource. However, a collective action process generally requires greater levels of input than the customary consultation approach, including the development of new skills and knowledge, usually embedded within the community engagement team.

CASE STUDY: Stakeholder engagement

Company: ExxonMobil

Location: Cepu Block, Indonesia and Mapun Island, Philippines

Aims: To ensure sustainable, community-led development goals

ExxonMobil's affiliate in Indonesia, Mobil Cepu Ltd. (MCL), financed a community-based clean water programme to reduce the incidence of waterborne diseases and promote healthier living in the Cepu Block of Indonesia. During the dry season, many residents in this area lack reliable access to clean water. To help manage this programme, the community established a committee responsible for managing the budget, constructing and monitoring water facilities and handling distribution of water. For example, in the Ngasem Village, a new water tower serves as the key source of potable water which is distributed to community households through an installed pipeline network. The programme has to date benefited more than 25,000 community members in 17 villages.

ExxonMobil worked with a non-governmental organization (NGO) to assess community priorities on Mapun Island (Philippines). The result was a programme in 2010 to strengthen the infrastructure supplying potable water to 13,000 residents, about half the island's population. The NGO continued working with the residents, and with local government, to prepare them to take ownership of the water distribution system and to ensure that the project continues to serve the community sustainably in the years ahead.

The suggested procedure for implementing a collective action approach involves the following stages:

1. Characterize the water supply risks and clearly identify the underlying causes.
2. Identify the most relevant parties to engage with, in the context of the specific water supply problem and the potential action options.
3. Identify the potential collective action intervention options that directly or indirectly address the causes of the problem.
4. Select the appropriate level of engagement.
5. Design the collective action engagement.
6. Structure and manage the collective action initiative.

Full details of this procedure are provided in the publication by CEO Water Mandate, 2013.

An important aspect of managing any form of collective action is to clearly define and communicate an end point, so that the company can avoid significant long-term dependencies by exiting from a primary role. A key requirement for achieving this outcome is that the interest and capacity of the other parties to manage water supply risks must have reached a sustainable level; hence capacity building must usually be included within the overall approach.

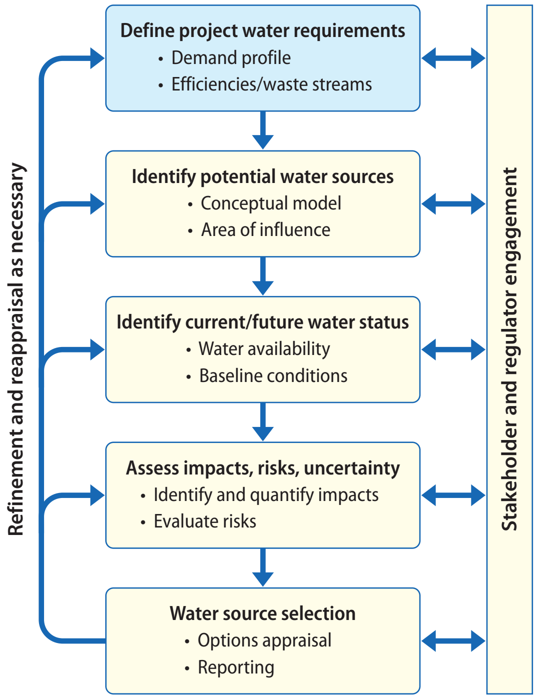
Section 3: Project water requirements

Prior to identifying and assessing the water sources available to a project, the water requirements of the project should be determined (Figure 4). The demand profile of a project will be dependent on the type and scale of the project, as well as the scope for water efficiency within the project.

Water demand profile

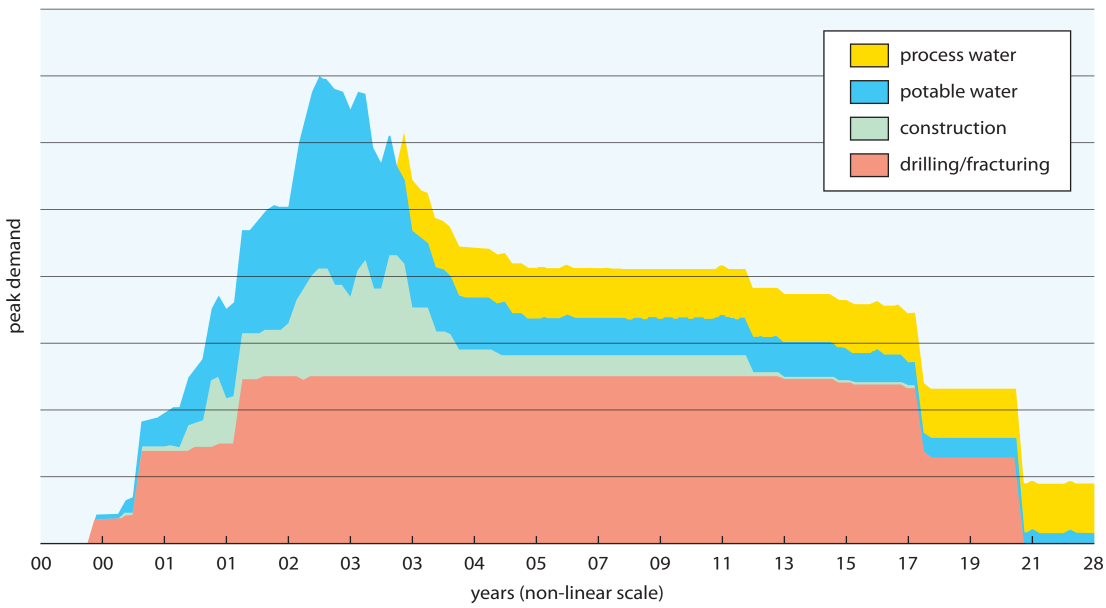
For each stage of the project, for example resource appraisal, construction, operation and decommissioning, the water demand for each component of the project (e.g. the processing facility, residential camps, etc.), should be assessed and a demand profile should be developed. The demand profile should not only show the water quantity required over the life of the project, but it should also identify the different uses of the water and the quality of the water that is needed for each use, e.g. water for hydraulic fracturing, potable water, etc. An example of a water quantity demand profile is shown in Figure 5.

Figure 4 *Identifying and assessing water sources—defining the project's water requirements*



The project water requirements should be determined at the outset, and a demand profile developed to reflect water use over the life of the project.

Figure 5 *Example project water demand profile*



An understanding of water quality requirements for the project will allow each water source identified to be assessed not only for its suitability with regard to the quantity available, but also with regard to its quality. This will enable the required levels of treatment to be determined and taken into account in the source selection process.

It can be useful to consider aggregate demand where similar projects may be ongoing or planned in the same region. This may be difficult to establish accurately, or to estimate, and may require liaison with other stakeholders; a high-level assessment of other oil and gas industry activities in the same watershed could also provide useful information. This approach can give stakeholders a better sense of overall water supply versus demand, and hence the relative significance of the project.

As the design of the project evolves, the demand profile is likely to change. It is important that the water source assessment is reviewed on an iterative basis in order to ensure that all demand changes are taken into account and source utilization is optimized. The assessment should be part of a broader iterative assessment of present and future demand within the area of influence (see *Area of influence* in Section 4) based on demographic modelling and input from master economic/development plans, etc.

CASE STUDY: Reducing freshwater intake and usage

Company: ExxonMobil

Location: Worldwide

Aims: To develop and implement local water risk mitigations

ExxonMobil environmental management standards encourage mitigation options that reduce fresh water consumption. Facilities in water-scarce areas are also expected to include a local water risk mitigation programme within the facility's five-year Environmental Business Plan. This may entail a review of fresh water consumption rates to identify improvement opportunities, and in some cases, application of the GEMI® *Local Water Tool*™. This tool is useful to systematically identify and rank risks associated with the availability and reliability of local water sources and waste water discharge locations. Example mitigations include the following:

- Due to arid conditions in Southern California (USA), ExxonMobil's Torrance refinery purchases and uses recycled waste water from a local municipal treatment plant for cooling tower makeup and boiler feed water, representing nearly 70 per cent of total water consumption at this facility.
- In De-Kastri (Russia), hydro testing of storage tanks at the oil export terminal used seawater as a replacement for fresh water. This saved approximately 115,000 cubic metres of fresh water and reduced stress on local infrastructure during construction.
- Due to regional interest in managing freshwater consumption by the oil and gas industry in Alberta (Canada), ExxonMobil affiliate Imperial Oil designed the Kearl oil sands project to run on stored water in order to reduce withdrawal from the Athabasca River during low flow winter periods.
- Cold Lake (Canada): to significantly reduce water consumption, Imperial Oil's Cold Lake facility treats, recycles, and re-injects most of the produced water as steam, which has reduced fresh water demand by 50 per cent since 1985. Allied with continuous improvement in water management, the Cold Lake facility now uses one third of a barrel of fresh water for each recovered barrel of bitumen.

Water efficiency

Water efficiency should be addressed at an early stage in the project for the following reasons:

- There is a general requirement to adjust the design to minimize the quantity of water needed and to utilize the lowest quality sources available to optimize environmental and social sustainability of any project.
- Using less water through end-use efficiency usually means lower operational costs such as water tariffs, energy use from pumping, waste water disposal volumes, etc. A reduction in water withdrawals arising from the implementation of water re-use and recycling initiatives can however lead to increased operational costs and energy use. These aspects can be assessed by undertaking a cost-benefit analysis, which ideally should be conducted irrespective of water availability.
- Water efficiency strategies can lead to significant improvement in management and rationalization of other environmental aspects such as land footprint, carbon, heat, odour, sludge and brine streams.
- The water stress status of the area may also change throughout the life of the project, reducing the future availability of water.

The applicable regulatory regime and any known future regulations should be reviewed and taken into account as this may also influence the water demand and resource requirements. For example, regulation limiting disposal volumes may lead to increased reuse and recycling of water within a project's operations, and to lower overall water demand.

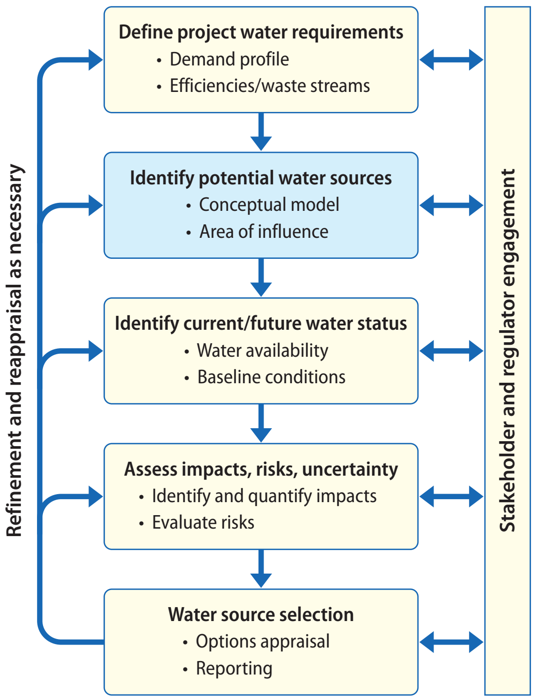
Water conservation should thus be an integral goal from the very start of the project. Equipment selection, i.e. choosing units that use water efficiently, can be a key factor in achieving this. However, the amount of effort put into meeting these general criteria will usually be a function of the water availability in the project area. Where water stress is high this can be critical to the project viability and significant resources may need to be assigned to meet these objectives.

The IPIECA guideline document, *Optimizing Water Use through Efficiency* (IPIECA, 2014) provides a comprehensive review of techniques for minimizing water consumption and waste water generation.

Section 4: Identification of water sources in the project area

It is important to identify potential water sources during early stage screening, and to develop a clear understanding of their suitability for use by the project.

Figure 6 *Identifying and assessing water sources—identifying potential water sources*



Identifying potential water sources is often one of the most important feasibility aspects during the initiation phase of a project. Knowledge of the general physical, social and legislative environment within which the project will operate may often provide a high level of understanding of the available water source options and their likely viability. Accordingly, an emphasis on this stage may be appropriate during early screening, allowing important actions to be identified and targeted for subsequent more detailed quantitative phases.

Conceptual model

It is important to develop a clear understanding of the available water resources so that they can be systematically appraised for their suitability for use by the project. In addition, the project needs to consider the water-related impacts that it may have on other stakeholders within its area of influence.

A conceptual model based on the hydrological cycle should be developed (see Box 1). Ideally this should include all significant water resources (including water storage systems and waste water where appropriate), existing and future water users, the proposed project water withdrawals and discharges, the quality of the water resource and the interactions between each of these entities. Where relevant, the conceptual model should also include existing municipal supplies, with reference to infrastructure (treatment and pipeline capacities and availability to stakeholders), and the potential impact of additional municipal draw on raw water sources. The level of detail required will depend upon the nature of the project and on local conditions, and should be assessed prior to starting data collection.

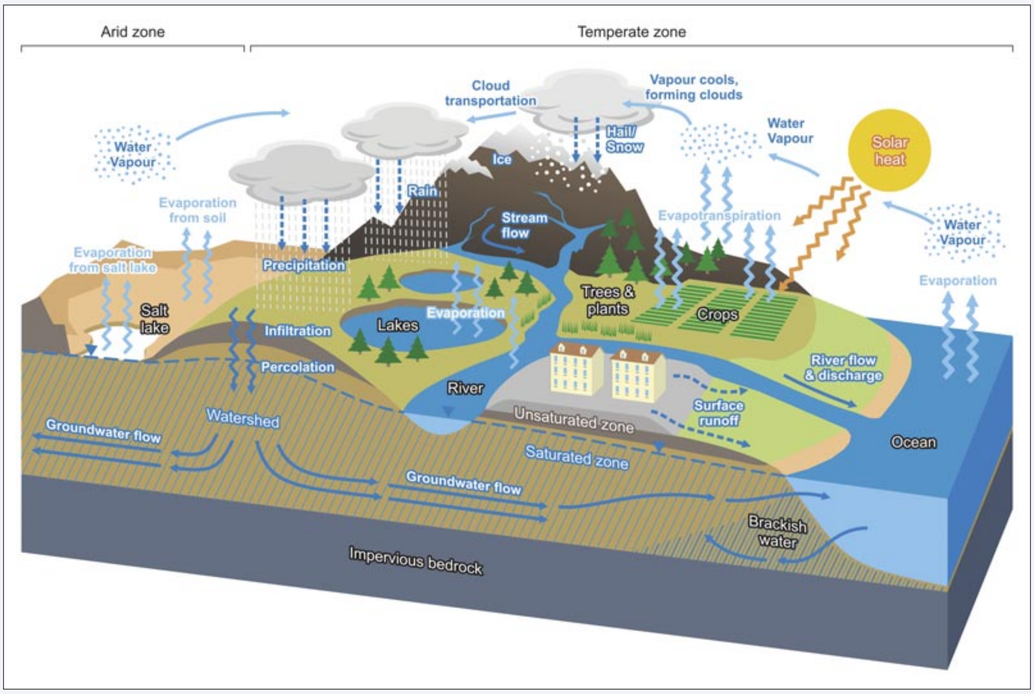
Initially, this model may be purely qualitative, but it could subsequently form the basis for quantitative evaluation and numerical modelling, where appropriate.

Due to the interconnected nature of the storage units in the hydrological cycle, any anthropogenic activities that directly affect one part may have an indirect affect on another. For example, the abstraction of water from a groundwater aquifer will reduce the volume of water in that aquifer, thus reducing the discharge of groundwater to rivers and wetlands, and in some cases resulting in leakage from the rivers and wetlands into the aquifer. If the aquifer is located in a coastal zone, abstraction may result in increased seawater intrusion into the aquifer, compromising the quality of the water being abstracted. For this reason, the study area selected for the conceptual model needs to be carefully considered.

The first stage of constructing the conceptual model is to undertake a desktop study. The component parts of the hydrological system in the project area, the water-related infrastructure and existing water users (stakeholders) should

Box 1 *The hydrogeological cycle*

The hydrological cycle describes the movement and storage of all forms of water under, on and above the earth's surface, as illustrated below.



The standard hydrological unit is referred to as a drainage basin, which is the area of land from which all surface run-off flows through a sequence of streams, rivers and, possibly, lakes to the same outlet. For any given drainage basin, there will be a series of associated water storage units, for example:

- the atmosphere;
- land surface (ponds, lakes, oceans, etc.);
- soil moisture storage;
- groundwater storage (aquifer); and
- sea water in near-coastal areas and river deltas.

It should be noted that water storage units are not necessarily coincident with a drainage basin unit. For example, a drainage basin may be underlain by an aquifer that has a much greater extent than the drainage basin, or conversely, a single basin may be underlain by a series of smaller aquifers.

Water moves continuously through and between these storage units via a number of mechanisms as shown in the diagram, and the transfers themselves represent additional potential water sources (e.g. rainwater harvesting). The nature and size of the storage units and the transfers between them will vary depending on factors such as the climate, soil type and geology. The diagram illustrates the hydrological cycle in both an arid and a temperate environment.

be identified, as should their potential interactions with each other and the project. Elements to consider include:

- drainage basins and their watersheds;
- overall annual precipitation to a drainage basin or project area;
- evapotranspiration, and hence effective precipitation (the amount of water actually infiltrating into the ground);
- surface water bodies, e.g. rivers, streams, ponds, lakes, oceans, etc.;
- groundwater aquifers with their lateral and vertical extent, recharge and discharge mechanisms and locations, abstractions and any artificial storage/recovery schemes;
- water quality;
- water-dependent ecosystem services;
- climatic events, such as drought or flooding;
- potential effects of long-term climate change;
- captured precipitation in artificial dams and reservoirs;
- intercepted rainfall from hard surfaces;
- significant waste water flows, e.g. treated municipal or industrial effluents, acid mine drainage, produced water from other extractive industries;
- artificial water transfers, e.g. aqueducts and pipelines, road and sea tankers;
- existing water uses, allocations and entitlements, including consumptive and non-consumptive uses (abstractions from surface and groundwater);
- regulatory requirements, e.g. demonstration that options for using saline groundwater or other low-quality sources have been assessed and prioritized over the use of non-saline (fresh) groundwater; and
- project waste water streams that may be treated, re-used, recycled or discharged to the natural environment.

This information can be obtained from the review and analysis of a range of generally available data, as detailed in Table 1.

Table 1 *Suggested information to be collected during a desktop study (if available)*

Information	Imagery	Reports	Other
Physical, geographic	Topographic maps (showing contours, watercourses and water bodies) Aerial photographs	Drainage basin management or development plans	Surveys Digital elevation model (DEM)
Meteorological	Climate and rainfall maps, tables	Meteorological, agricultural reports	Precipitation, evapotranspiration data, climate change projections
Hydrology	Satellite and aerial photos	Hydrological reports	Surface water flow records, existing hydrological models
Geology	Maps and tables Satellite images	Geological reports	Borehole drilling logs
Groundwater	Maps	Hydrogeological reports	Vegetation (as an indicator), groundwater level records, existing groundwater models
Infrastructure	Water supply and waste water	Government and municipal reports	Existing water supply sources

Table 2 *Example useful sources of information and data*

USGS Hydrosheds Database	http://hydrosheds.cr.usgs.gov/index.php
WHYMAP	www.whymap.org/whymap/EN/About/about_node_en.html
Google Earth	www.google.co.uk/intl/en_uk/earth/index.html
Flash Earth	www.flashearth.com
EROS Centre	http://eros.usgs.gov/#/Find_Data/Products_and_Data_Available
GeoCommunity	http://data.geocomm.com
Earth Explorer	http://earthexplorer.usgs.gov
GEMI® *Local Water Tool*™	www.gemi.org/localwatertool
The University of Maryland's Global Landcover Facility (GLCF)	http://glcf.umd.edu
IPCC projections of future climate change	https://www.ipcc.ch/publications_and_data/ar4/wg1/en/spmsspm-projections-of.html

Local, municipal and national authorities, including the ministry for the environment or equivalent (where available) and water utilities, are generally a good starting point for information and should be contacted in the first instance to ascertain the availability of mapping, aerial imagery, photographs, surveys and relevant reports, as well as details of recent industrial applications within a region. Agencies active in the area (for example local and international NGOs) may also have relevant information. Other potentially useful sources of online information are detailed in Table 2.

The desktop study should also identify applicable local, national and international guidance and legislation, so that any requirements can be included in the conceptual model. It is expected that there may be legislation and/or regulations relating to water entitlements, abstraction and discharge rates, locations and timings, diversion schemes, water quality, flood risk, etc., which may be relevant to the project and will therefore need to be addressed.

At the conclusion of the desktop study, the basic framework for the qualitative conceptual model should have been established including:

- project water supply and discharge requirements;
- hydrological system components, seasonal fluctuations and long-term trends in climate change;
- imported water from outside the drainage area, and waste water streams available for treatment, reuse or recycling;
- quality of potential water sources and discharge points;
- existing uses and water-dependent ecosystems;
- key regulators and stakeholders;
- applicable guidance, legislation and the permitting regime; and
- interactions between hydrological system components, stakeholders and the project.

Depending on the information available, there may be significant gaps identified during the desktop study that require further investigation. The best way to achieve this is to visit the project area and undertake a preliminary survey, for example to identify abstraction and discharge points of existing water users, to review water-dependent ecosystem services, etc. A visit can also be useful to verify assumptions based on the desktop study information, as well as getting to know the area at first hand.

Area of influence

Central to developing a conceptual model for the project is the need to define a project's 'area of influence'. There are increasing pressures for government, businesses and civic society to recognize that water is a shared resource and that a project will have an effect on the water environment (both hydrological and socio-economic) beyond its immediate site boundary (e.g. WBCSD, 2013a). Determination of a project's area of influence allows existing and future water users that may be impacted by the project to be identified, the severity of the impact to be assessed and the requirement for stakeholder engagement to be determined.

Figure 7 *Factors defining the project area of influence*

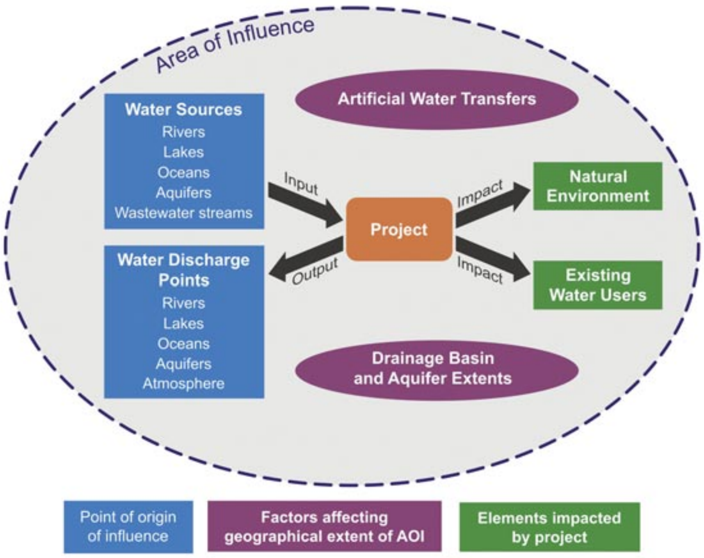


Figure 8 *Methods of estimating the detectable limit of the project area of influence from a point of origin*

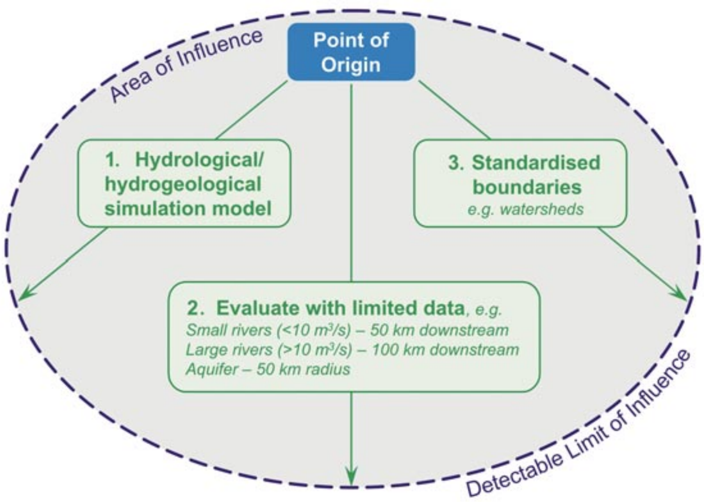
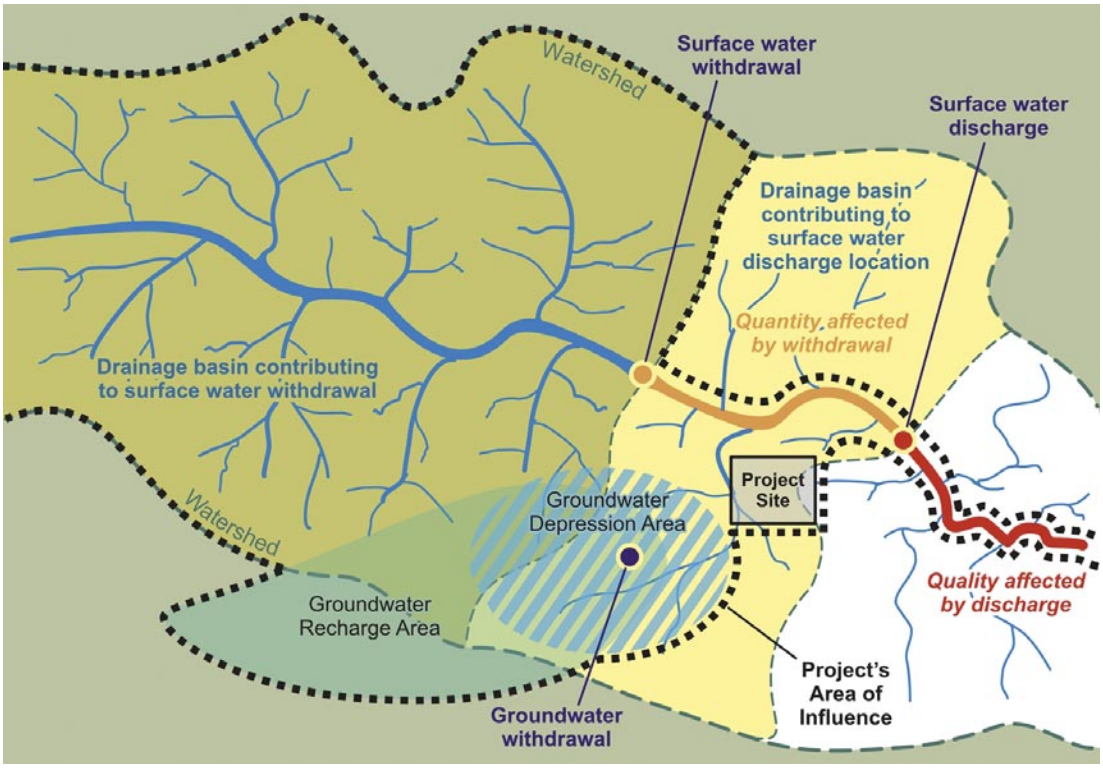


Figure 7 illustrates the concept of a project's area of influence, showing how it is defined by both the relationship of the project with existing users and the spatial extent of the project's impact due to water abstraction and discharge. The extent of the area may also change over the lifetime of the project due to variations in overall water supply and demand, and any such changes should also be taken into account.

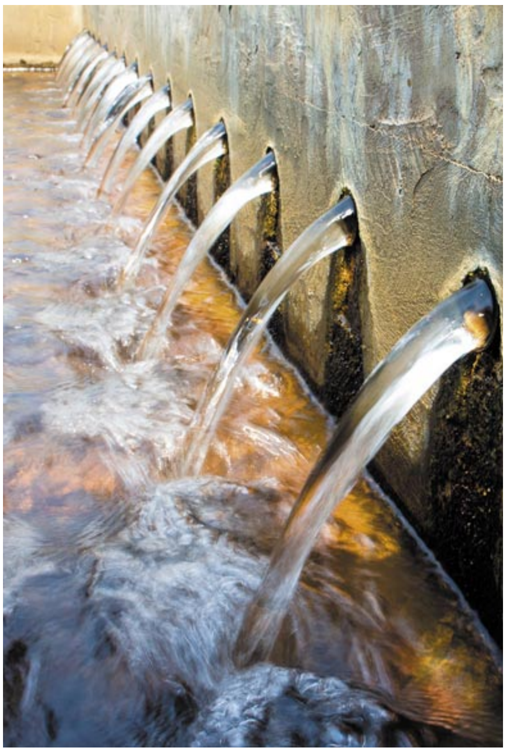
Figure 8 summarizes possible methods that can be used to determine the geographical extent of a project's area of influence from a point of origin, i.e. a point of water withdrawal or discharge. Method 1 typically utilizes numerical models to define the spatial distribution of impacts and is generally the best approach, being the most technically defensible and creditable. However, it can be time consuming, expensive and data-intensive, and may be inappropriate for smaller projects or areas that are less complex. Method 2 is the next best and most commonly used approach, using experience and limited data to make appropriate assumptions. Method 3 is the least desirable approach, as predetermined boundaries are likely to be considerably larger than the site's actual area of influence (AWS, 2013).

Figure 9 provides an illustration of a project's area of influence with respect to its surrounding hydrologic systems. Multiple points of origin are identified in this case (abstraction and discharge points) and therefore multiple areas of influence are associated with the project. In the context of water source assessment it is primarily the total area of influence associated with water withdrawal points that needs to be determined.

Figure 9 *Illustration of a project's hydrologic area of influence*



However the area of influence associated with water discharge points should also be considered, as discharged water may affect the hydrological functioning of the drainage basin or the quality of water, thereby affecting the viability of water sources. For example, sourcing water from a river and disposing of waste to the subsurface is likely to have a very different effect on surface flows than using the same source but returning treated water to the river. These constraints and opportunities need to be taken into account where relevant and, in turn, may drive selection of the treatment processes and discharge arrangements.



CASE STUDY: Risk to water availability during exploration and development of unconventional resources

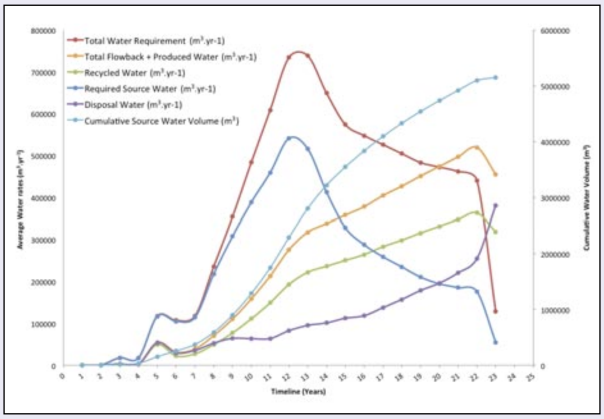
Company: Shell

Location: North Africa

Aims: To establish potential water resources and their availability

Shell is considering the exploration and development of an unconventional resource in North Africa. The project is located in a semi-arid zone and most of the area is farmland with mixed cultivated land (~95%). The area consists of numerous small villages surrounded by open farmland, plantations, livestock farms and isolated dwellings. Shell projects and operations are required to assess the risks of water availability on their assets and on the surrounding environment. In particular, in areas of water scarcity, projects and operations are required to develop water management plans. A high-level assessment of life-cycle water needs has been developed based on analogous developments (see Figure A).

Figure A *Total water recurrents*



To understand whether groundwater could satisfy the project's water needs, a preliminary hydrogeological conceptual model for the area has been developed based on available data from regional studies together with discussions with in-country stakeholders (regulators and academics). Three aquifers have been identified:

- Quaternary sands and clays (< 50 m). Identified as a sensitive resource which is currently overdrawn and vulnerable.
- Miocene interbedded sandstones (~200–700 m). Identified as being a resource suitable to provide sufficient groundwater for the exploration phase.
- Oligocene sandstones (~1,500–2,000 m). Currently unexploited and will be investigated further to assess available groundwater resources for full field development.

Future work will depend on obtaining the necessary licences and will involve the determination of a suitable short-term water source for the exploration phase. Further stakeholder engagement will be carried out to determine the most feasible, cost-effective and sustainable long-term water sourcing solution while considering opportunities to add a net positive impact to the area.

Section 5: Status of water in the area of the project

The previous stages of the process have defined the project's water requirements and the range of potential water resources available. This stage will provide an indication of the water quantities and qualities available for use from these sources and whether they are therefore able to meet the project demand, both at the outset and for the future duration of the operations.

Following this stage, it is important to review the previous stages to reconfirm their applicability and modify objectives as necessary.

Screening for water availability and stress

During the first iteration of the water source assessment process, a high-level review of the current status of water in the area should be undertaken. This will provide an indication of the potential water availability associated with the project, i.e. whether the project is located in an area of water stress. This stage can act as a screening tool, enabling early identification of the importance of water supply as a risk factor for the project and allowing the necessary resources to be allocated to manage this issue. Future changes that may occur during the life of the project will also need to be taken into account; see *Future variation*, on page 32.

Several tools are available that can be used to give an overview of the potential water stress in the project area, some of which are listed in

Figure 10 *Identifying and assessing water sources—identifying the current/future water status*

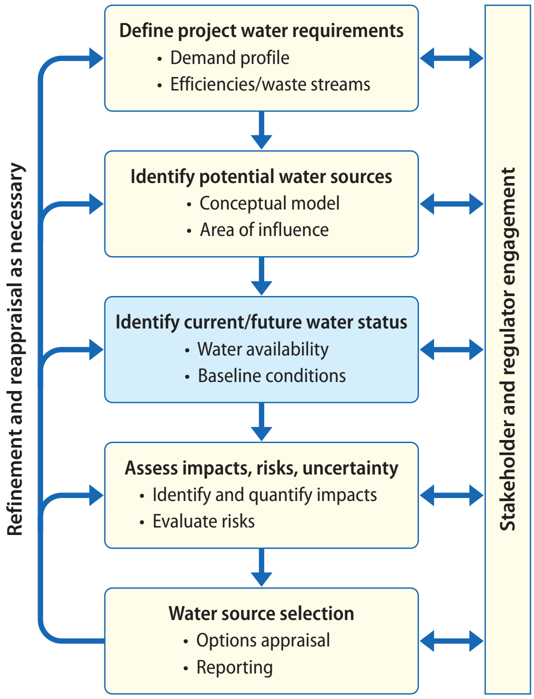


Table 3. Note that these high-level tools are generally for screening and provide a country-level assessment with a corresponding degree of uncertainty at the local scale. Some provide a greater degree of detail, but the amount of data required to utilize them is still relatively low.

Water stress is also commonly evaluated by comparing the volume of renewable water resources per capita at a national level, using the 'relative water stress index' (UNESCO, 2006).

This stage provides an indication of the quantities and qualities of water available to meet the project demand, both at present and in the future.

Table 3 *Tools for identifying areas of water stress*

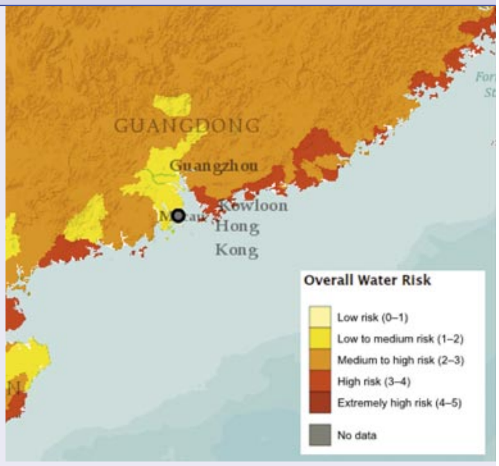
WRI Aqueduct™ Water Risk Atlas	http://aqueduct.wri.org/atlas
IPIECA *Global Water Tool© for Oil and Gas* (customized version of WBCSD GWT)	www.ipieca.org/topic/water/global-water-tool
WFN WaterStat Database	www.waterfootprint.org/?page=files/WaterStat-WaterScarcity
WWF Water Risk Filter	http://waterriskfilter.panda.org/Default.aspx
Water Footprint Assessment Tool	www.waterfootprint.org/tool/home

Water availability can be defined as the quantity of water a project can access after accounting for existing losses, consumptive uses (including entitlements) and ecosystem service requirements; i.e. it is the total amount of unallocated water in the project's area of influence. It should also take into account seasonal variations in water supply and long-term projections of supply and demand. In practice many drainage basins are over-allocated, although individual users may not be utilizing all of their allocations.

More detailed estimates of water availability can be developed in later iterations of the water source assessment process, after the initial screening phase. This process requires quantitative data, which can be collected during the establishment of baseline conditions for the project area (see *Area of influence* on page 22). For further information about preliminary screening of water availability and stress at a new facility, see the case study, below.

CASE STUDY: Assessment of water availability and water stress at a new facility

Company:	**BP**
Location:	**Zhuhai, Guangdong, China**
Aims:	**To understand and plan for the potential constraints in water supply and availability**



AQUEDUCT™ Measuring and Mapping Water Risk

Global Water tool® for Oil and Gas

BP is developing and constructing a third Purified Terephthalic Acid (PTA) Plant in Guangdong Province, China. As part of BP's approach to assessing the environmental and social impacts and risks for new projects, the IPIECA *Global Water Tool*© (GWT) *for Oil and Gas* and the World Resources Institute Aqueduct™ water risk atlas were used to help understand and predict current and future constraints in water availability.

The overall water demand for all three PTA plants is around 14.4 million m^3 per annum, sourced from a municipal water supply company who abstract and treat water from the Pearl River.

All three PTA plants are located on the same site, along the coast in a rapidly expanding industrial area. Understanding the potential constraints in water supply availability was, therefore, an essential element of the planning for the project. An initial understanding of fresh water availability was developed by applying the tools and associated maps, collating readily available literature on the availability of water resources in the local area, and from discussions with the local regulator. The GWT indicated that there was no existing water stress in the region, defined as a per capita fresh water availability greater than 1,700 m^3/year, while the overall water risks from Aqueduct™, combining quantity, quality and regulatory risk, was assessed as 'low to medium'. Further investigation revealed that the highest risk was from seasonal variations in river flows (low dry season flows) and increased competition for water from urbanization and industrial growth in the area.

Separately, these risks have been recognized by the local authorities who had recently invested in new storage reservoirs (2010–12) in the watershed to increase security of the water supplies.

At the same time, BP has been investing in new PTA technology, which lowers the water demands by as much as 75% compared with conventional technologies. This will contribute to lowering risks to the PTA plant in the long term.

In some instances, local legislation may require that an accurate account of water availability is provided by, or developed in conjunction with, the regulatory authorities. Where necessary (for example in areas of high water stress or when required by the regulatory environment) water availability can be quantified through the development of a 'water mass balance'. This considers all sources of water (water supply), losses, consumptive uses and environmental requirements for each water source in the project's area of influence:

water availability = supply – (losses + consumptive uses + ecosystem services)

In this context, ecosystem services include any minimum flows or water levels that need to be maintained in rivers, lakes, reservoirs, aquifers, etc. These may be defined by regulatory requirements, which may use statistical techniques to define minimum acceptable flows based on measured river flow data. Other methods are available to evaluate and define environmental flows, many of which are summarized on the eFlowNet website (eflownet.org), maintained by the Global Environmental Flows Network.

The water mass balance should be based on the conceptual model, which identifies the potential water sources and flows within the project's area of influence. Water quality is an important factor to take into account, as the combination of the quality of potential water sources and the project requirements will affect both the amount of raw water required, the water treatment needed and the waste water quality. Mapping of the water chemistry can help with: identifying recharge zones; defining zones of undesirable or economically unmanageable water quality; highlighting major flow paths; and identification of zones were there is co-mingling of different water storage units.

For areas where there are a number of potential water sources, it is necessary to prepare an

individual water mass balance for each source, particularly if there are several consumptive uses or discharges associated with those sources. In this case, the individual water balances should be combined into an overall model to ensure that any interdependencies between the sources are fully accounted for. Uncertainty in the values associated with the individual mass balance components, resulting from lack of knowledge of existing systems and/or poorly constrained future variability, can be assessed by re-calculating the water mass balance with likely upper and lower bounding values.

The water mass balance will allow all potential sources of water to be assessed in terms of water availability. If the supply is less than or equal to the combined losses, consumptive uses and ecosystem services, then water availability will be zero. Conversely, if it exceeds the combined losses, consumptive uses and ecosystem requirements, then there will be water available.

Larger projects may require the development of a dynamic water resource simulation. This type of water resources supply and demand model can take into account seasonal changes as well as potential climate change and future changes in demand, to dynamically assess the ability of a catchment to continue to support current uses plus the project needs, now and in the future.

Baseline conditions

Once a general indication of the water availability and stress in the project area of influence has been obtained, a more detailed assessment of water sources identified during initial screening can be undertaken. To do this, the baseline conditions within the project's area of influence should be established. These are the existing conditions prior to project development and should include characterization of hydrology, hydrogeology, sensitive environmental areas, seasonal fluctuations and anthropogenic influences. The initial conceptual model will give an indication of which conditions will require consideration, through its early identification of potential water sources and discharge points.

Knowledge of the baseline conditions will allow the conceptual model to be expanded with quantitative data, which can then be used where necessary to develop analytical and numerical models to identify:

- the amount and quality of water potentially available to the project;
- possible abstraction and discharge points;
- periods of low flows or water levels during which abstraction may need to be restricted or when discharges may be beneficial; and
- periods of high flows or water levels during which abstraction may be beneficial or discharges may need to be restricted.

The establishment of baseline conditions can build on data collected during the initial desktop study, supported by field data collection as required. The requirement for field work will largely depend on the existing qualitative data available for the project area of influence and the level of detail required by the project. Data collected in the field may mean actual measurements, but could also include information provided by neighbouring users, regulators, etc., as well as undertaking more detailed and complex studies such as groundwater yield studies or sampling water bodies for quality analysis. It is recommended that meteorological data covering the project area of influence should always be collected where possible, as this will provide an insight into the hydrological conditions and allow a simple water balance to be estimated. There is often significant overlap between the water source baseline data and the data required for ESHIA studies, and it is recommended that data collection should be coordinated.

Planning efforts for baseline studies should ensure that sufficient time is allocated for field data acquisition or monitoring of seasonal fluctuations to ensure reliable data collection. For example, monitoring of seasonal fluctuations will require collection of data for a full year.

Data types that may be required are listed in Table 4, although the level of detail will depend on the baseline conditions to be established and the project phase. Local, municipal and national authorities, e.g. the ministry for the environment, meteorological office or equivalents, should be contacted in the first instance to ascertain the availability of quantitative baseline data which can also be found in other regulatory applications for the area. Other potentially useful global sources of information are also detailed in Table 4.

Stakeholder mapping may also identify local community organizations that hold baseline data relevant to the project requirements. Dialogue with these stakeholders and acquisition of their data may prevent the need for other obtrusive studies to be undertaken. This process can also help to define the actual water allocations within the project's area of influence.

The parameters for which water quality data need to be collected will vary depending on a number of factors, including whether there are any municipal or industrial waste water discharges in the project area of influence, the

likelihood of any historical impacts to surface or groundwater, and the water quality requirements of the project.

Collection of water chemistry data also provides fundamental assistance in forming the conceptual model and defining the prevailing water quality regime (saline, brackish, etc.). For example, recent replenishment of groundwater (recharge) will typically be indicated by the presence of water with relatively low mineralization. Mineral content then tends to increase along the groundwater flowpath as the water has longer contact with the host formation materials enabling it to dissolve and assimilate more minerals. A multi-seasonal assessment may also be required if it is anticipated that there might be significant changes in water chemistry over an annual cycle.

The data collected should be the highest quality possible appropriate to the planning needs for the current phase of the project. All data should be checked for quality and reviewed as appropriate, to assess its suitability for use, gain an idea of uncertainty associated with the data, and identify any significant spatial or temporal gaps. Data gaps can be addressed by: using trend interpolation, reference datasets or models; additional targeted searches for existing data; or undertaking field work to collect new data. After being checked and reviewed, the data can then be used to build a profile of baseline conditions, including:

- low and high river flows: there may be local or national standards that specify the flows that constitute low and high flows, and where this is the case, these standards should be adopted;
- groundwater recharge rates;
- losses, e.g. through evaporation, infiltration, recharge between aquifers etc.; and
- quantification of the interdependencies between different water storage units within the project area of influence, e.g. infiltration from rivers to groundwater, recharge of rivers via groundwater springs, etc.

The baseline data may result in the need to change and improve the conceptual model; this should be done before proceeding. The information can then be used to develop a water balance for the project's area of influence if required, and thus the water availability for the project can be estimated (see *Screening for water availability and stress* on page 25).

Table 4 *Data types required to establish baseline conditions*

Data type	Possible sources
Meteorological • Precipitation depths and type (e.g. rainfall, snow, etc.) • Evaporation or evapotranspiration rates • Potential effects of climate change	• International Agencies, for example: - United Nations Food and Agriculture Agency (www.fao.org/geonetwork/srv/en/graphover.show?id=7416&fname=7416.gif&access=public) - Intergovernmental Panel on Climate Change, including *Managing the Risks of Extreme Events and Disasters to Advance Climate Change (SREX)* (hipcc-wg2.gov/SREX) - SREX—Summary for Policy Makers (https://ipcc-wg2.gov/SREX/images/ uploads/SREX-SPMbrochure_FINAL.pdf) - National Oceanic and Atmospheric Administration, National Climate Data Centre (www.ncdc.noaa.gov/oa/climate/climatedata.html) • National Agencies, e.g.: - Meteorological Office - Environment Ministry - Agricultural Ministry - Ministry for Transport and Infrastructure • The Weather Underground (http://www.wunderground.com) • Tutiempo (http://www.tutiempo.net/clima) • World Meteorological Organization (www.wmo.int/pages/summary/progs_struct_en.html)
Geological • Topography • Lithology • Porosity • Academic research and publications	• Intergovernmental organizations • National Geological/Geographic Society: - Libraries - Published literature
Hydrogeological • Groundwater levels • Water quality • Aquifer properties and geology, including interdependencies with other aquifers and surface water • Current groundwater users (quantitative) • Abstraction and disposal rates and locations • Academic research and publications	• Intergovernmental Organizations, e.g.: - Southern African Development Community - Pacific Institute - International Groundwater Resources Assessment Centre • National Geological/Geographic Society: - Libraries - Published literature • GEMStat (http://www.gemstat.org/default.aspx) • United Nations Environment Programme Environmental Data Explorer (geodata.grid.unep.ch)

Table 4 Data types required to establish baseline conditions (continued)

Data type	Possible sources
Hydrological • River flows and levels • Water levels and volumes in reservoirs, lakes, ponds, etc. • Water quality • Maximum abstraction and discharge volumes or rates of other stakeholders. • Academic research and publications	• Intergovernmental Organizations, e.g.: - Southern African Development Community - Organization for Social Science Research in Eastern and Southern Africa - Regional development banks • National Agencies, e.g.: - Meteorological Office - Environment Ministry - Agricultural / Fisheries Ministry - Ministry for Transport and Infrastructure - Master Economic Development Plan or similar regional/country initiative as input to modelling future demand • National Geological/Geographic Society - Libraries - Published literature • GEMStat (www.gemstat.org/default.aspx) • River Discharge Database (http://www.sage.wisc.edu/riverdata) • United Nations Environment Programme Environmental Data Explorer (http://geodata.grid.unep.ch) • United States Geological Society Hydrosheds Database (http://hydrosheds.cr.usgs.gov/index.php) • International Water Management Institute water data portal (http://dw.iwmi.org/index.php)
Municipal • Capacity of water supply infrastructure (sufficient to meet the project requirements) • Capacity of waste water infrastructure (to accommodate the discharge of waste water from the project) • Trade waste policies • Water supply and demand profiles • Waste water discharge profiles • Academic research and publications	• National Agencies, e.g.: - Local water supply companies - Planning Authorities - Environment Ministry - Agricultural / Fisheries Ministry
Industrial • Water quality • Discharge profile	• Environment Ministry • Agricultural / Fisheries Ministry • Local water supply companies • Planning Authorities
Imported water • From outside the drainage basin area	• Local water supply companies • Planning Authorities • Intergovernmental Agencies • Environment Ministry • Agricultural / Fisheries Ministry

Separate seasonal, and possibly drought, water balances may be essential to understand the long-term water availability.

Comparison of available water with the project water demand should be undertaken to assess whether the needs of the project can be reliably and sustainably met, or whether refinement of the demand is required. Demand reduction may be achieved through internal efficiency measures such as recycling, cascading, reuse, etc., as described in the IPIECA guidance document, *Optimizing Water Use through Efficiency* (IPIECA, 2014).

Key stakeholder engagement activities during this stage of the process are centred on information sharing and data acquisition to establish the current water usage and its importance (e.g. cultural, livelihood) to individual stakeholders.

Future variation

All of the external factors controlling the availability of water for the project are likely to vary over the lifetime of the project, and are generally outside the control of the project. To provide resilience for the project, the potential range of variability in these factors should be assessed and appropriate mitigation for significant risks incorporated in the project design. These factors should be considered for the anticipated life of the project.

Factors that may be important and that should be considered include:

- long-term changes to the local hydrological cycle due to, for example, climate change or salt-water intrusion;
- demographic change, in terms of population density and distribution;
- changes in agricultural, domestic and industrial demand and future competition; and
- new or amended legislation that may affect permitted abstractions or discharges.

Climate change may have significant impacts on the quantity or quality of water resources in the area of interest, or may even result in the definition of the area changing with time. Local studies have been carried out for many parts of the world and can provide information on predicted changes in meteorological conditions together with an indication of uncertainty.

The general trend of increasing national and urban populations means that there may be significant changes in the quantity of water required and the distribution of this demand over the project lifetime. Competition for local water resources may be greater in the future due to increasing demand. The potential for other industrial water users to enter the area of interest should be identified, and the cumulative effects on water source availability assessed. These users may have an overriding interest, and

Table 5 *Potential sources of data for future variability*

Type of change	Data source	
Local hydrological cycle	WRI Aqueduct™ Water Risk Atlas	http://aqueduct.wri.org/atlas
	WFN WaterStat Database	www.waterfootprint.org/?page=files/WaterStat-WaterScarcity
	UN Water	www.unwater.org
	Inter-governmental Panel on Climate Change	www.ipcc.ch
	Pacific Institute	www.pacinst.org
Demography	UN Department for Economic and Social Affairs	www.un.org/popin/data.html
	International Food Policy Research Institute	www.ifpri.org
	Population Reference Bureau	www.prb.org
	Geohive	www.geohive.com
Legislation	National Agencies	- Local water supply companies - Planning Authorities - Environment Ministry - Agricultural / Fisheries Ministry www.waterlex.org/waterlex-legal-database
Demand (agriculture, etc.)	Food and Agriculture agency	www.fao.org
	World Bank	http://data.worldbank.org/topic/infrastructure
	Pacific Institute	www.pacinst.org
	International Food Policy Research Institute	www.ifpri.org

the continued availability of water to the project, even if established before the changes, cannot always be assumed.

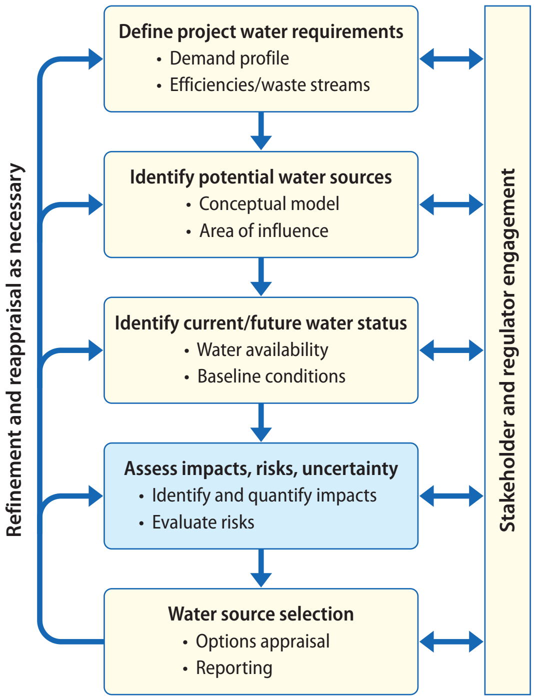
Legislation can also be subject to change, especially where the current regulatory regime is at a relatively low level of maturity. Increasingly restrictive legislation may be established in response to increasing pressure on resources.

Uncertainty in these future predictions is usually significant. The possible range of uncertainty should be quantified where possible and considered in the final decision making process.

Section 6: Assessment of impacts, risks and uncertainty

Following on from completion of the previous stages, the potential impacts, risks and opportunities should be assessed over the life of the project.

Figure 11 *Identifying and assessing water sources—assessing the impacts, risks and uncertainty*



Once the water sources in the project area have been characterized, the potential impacts, risks and opportunities of the project water demand within the area should be identified and assessed over the life of the project, taking account of uncertainty in the information available. Likewise, potential risks to the project from changes in water availability and the use of alternative sources should be assessed.

Impact assessment

An assessment of both the potential beneficial (positive) and detrimental (negative) impacts of water use associated with the project is necessary. However, water-related impacts should also be assessed in the overall project context, and the impact of alternative supply options on other environmental aspects (such as energy consumption impact, carbon balance, waste quantity, etc.) should be considered.

At the level of investigation required for this process, each potentially viable water supply option needs to be considered separately within the assessment. The impacts associated with the project demand can be quite different depending on the type of water source being considered: for example, desalination of brackish groundwater will have a different set of costs and benefits compared with the use of impounded water on a dammed river or treated municipal waste water. However, the potential interconnections between different water storage units (as developed in the conceptual model—see page 18) need to be taken into account, as impacts on one source may propagate through to a second potential source.

Depending on the regulatory environment, some form of ESHIA may be required by legislation before the project can proceed. In this case, water aspects will form an integral part of the process and the findings from the full assessment can be taken into account in the water source assessment process.

For smaller projects where a formal ESHIA is not necessary, a series of impact indicators can be defined and assessed as part of a water risk analysis or sustainability assessment. The following categories may be vulnerable to impacts from the project's water use, and could be considered as part of the assessment (GEMI, 2012):

- Physical source characteristics: availability and quality.
- Social context: availability of water suitable for human needs and the local food supply.
- Ecosystem requirements: including land take, greenhouse gas emissions, etc.

Alternatively, the following examples of specific water-related impacts that may be significant for a particular supply source can be considered (based on AWS, 2013):

Social, cultural and health impacts

- Access to improved source(s) of drinking water (impacts on quantity or quality).
- Abundance of commercial fish species, shellfish and/or edible aquatic plants.
- Area of floodplain or lakeshore farming opportunities.
- Productivity of floodplain or lakeshore grazing (capacity).
- Abundance of wildlife/bird populations (hunting opportunities).
- Abundance of floodplain/lakeshore plants for food, medicine, fuel or construction.
- Loss of access to shallow groundwater for farming, drinking and cooking.
- Time spent to access areas to perform clothes washing or bathing (sanitation opportunities).
- Percentage access to sanitation.
- Prevalence of disease (e.g. cholera, typhoid).
- Number of days where water-based transportation or trade routes may not be navigable due to water withdrawals.
- Rated scale (and, as required, monetization) of perceived loss of recreational opportunities (hunting, fishing, wildlife viewing, boating, swimming, etc.).
- Rated scale (and, as required, monetization) of perceived loss of cultural or spiritual practices.
- Proportion of local population reliant on tourism.

Environmental (species and habitats) impacts

- Abundance of freshwater species within the area of influence that are threatened or endangered.
- Stream flow reduction.
- Reduced base flow.
- Area of high-value habitats.
- Groundwater recharge capacity.
- Water purification capacity.
- Amount of saltwater intrusion into freshwater supplies.
- Amount of sediment delivery to downstream areas (increases or decreases).
- Amount of carbon trapping ('sequestration') capacity.
- Alteration of nutrient cycling and deposition on floodplains.
- Capacity to flush/leach salts or acids from floodplain and lakeshore soils.
- Ratio of soil erosion and sediment deposition to natural soil erosion and sediment deposition processes.
- Natural controls on pests and disease vectors.
- Flood retention capacity.

Economic (financial and livelihood) impacts

- Value of tourism / number of tourists and local population reliant on tourism.
- Value of hydropower generation potential / amount of hydropower generated.
- Value of navigation / estimated distance of water-based travel.
- Value of agricultural production / total agricultural production by crop.
- Value of water supply / number of days of disrupted water supply.
- Value of recreation opportunities / number of recreation enthusiasts.
- Costs for cleaning poor-quality water.
- Regulatory fines for improper waste discharge and associated litigation, insurance, etc.
- Rated scale of perceived changes to reputation (social licence to operate).
- Business costs of regulatory changes (escalating permitting fees, etc.).
- Business costs of standards, laws etc., that affect ability to operate, viability and bottom line.
- Market share increase/decrease in value attributed to perceptions, disclosure, response, actions, inactions, inconsistent supply etc.
- Number of water-related jobs created.

Other factors that should be taken into account include capital and operating costs required to implement the supply across the full life cycle of the project, engineering considerations such as maintainability and expandability, energy usage and carbon emissions, consumables usage, and health and safety aspects.

The impact assessment process can take the form of a workshop session, involving technical and environmental experts with knowledge of the hydrologic systems involved and the practical requirements and constraints of the project under consideration. However, it is important to involve key stakeholders when appropriate, as individuals with local knowledge and interests will often have a much greater understanding of water-related issues in the area, and may identify aspects that others are unaware of.

It is important to recognize that some impacts can be immediate, as a direct result of changes created by the project water use. However, there can also be more subtle impacts that result from cumulative effects over time (e.g. geomorphological changes to a river from reduced flows due to abstraction) or as the result of the combination of other impacts. The assessment needs to consider potential impacts across the whole project life cycle, including closure requirements.

Assessment of risks and opportunities

Once the potential impacts associated with the use of available water sources have been identified, both the risks to, and opportunities for, the project need to be assessed.

The risks associated with the availability of suitable water (quantity and quality) over the life of a project are critical to its continued operation, as are regulatory and economic risks with respect to water withdrawal, treatment, consumption and disposal. Additionally, the risks associated with impacts on the social and ecological environment in the area of influence of the project will determine the company's 'licence to operate', and thus can be just as important. Social aspects include local reputation, local activism, availability of suitable water for human needs and the local food supply. Finally, beneficial water-related impacts associated with the project may significantly affect the project viability and also need to be considered.

Risk can be considered as a combined estimate of potential importance (severity) and likelihood of either the harm or the benefit occurring. Some risks may also provide opportunities by way of management and mitigation measures. For example, recognition of water stress should create a focus, within the project, on achieving high levels of water conservation and efficiency. This in turn can often lead to further benefits associated with long-term cost, energy or waste reduction (see the IPIECA document on *Optimizing Water Use through Efficiency* (IPIECA, 2014).

Both positive and negative impacts have to be evaluated for an adequate assessment to be made, and a semi-quantitative scoring system is often used. Actual measures of a potential impact can be used to inform this process, but are usually impossible to collect for all impacts and thus expert opinion is an important input. As the detrimental and beneficial external impacts usually involve stakeholders it is essential to incorporate their views, because stakeholders' perception of the importance of impacts can be as important, or more important than the actual measured impact.

Measures required to mitigate potential risks associated with the different potential supply options should be identified and characterized at this stage. Mitigations identified during stakeholder engagement need to be tabled as part of the consultation process so that unintended consequences (both positive and negative) are not missed. Mitigation measures can reduce the potential severity of an impact, the likelihood of the impact occurring, or some combination of both. When suitable measures can be implemented they will change the impact, reducing risks and increasing benefits, thus potentially altering the outcome of the source assessment and selection process. Re-assessment of the risks is required, taking into account the mitigation measures identified.

An environmental net effects assessment can be used to summarize any environmental effects remaining after the application of mitigation measures (net effects), and to determine their potential significance. Significance can be assessed by asking the following questions:

- What is the value of the resource affected?
- What is the geographic extent of the net effect?
- Is this net effect likely to occur for a short or long time period? How frequently is the net effect likely to occur?
- How does the net effect compare to the baseline condition? Does it represent a substantive or order of magnitude change (negative or positive) in the baseline condition?
- Is there a substantive public or agency concern? What is the ecological and social context for the net effect?
- Is the net effect reversible?

The results of this assessment, together with details of the proposed mitigation measures, can be taken through to the subsequent source selection stage for inclusion in the options appraisal process.

A number of tools have been developed to assist companies in the process of assessing water risks

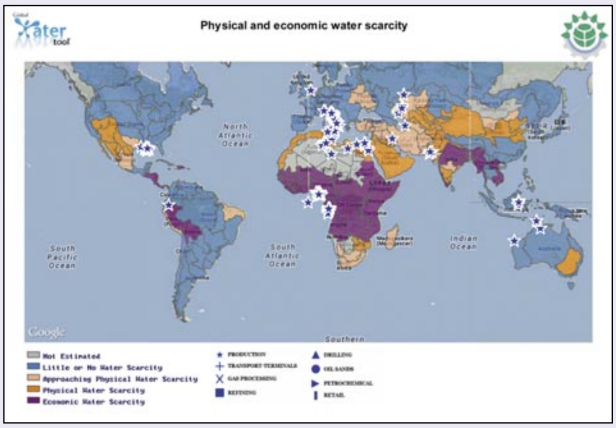
CASE STUDY: Use of water stress identification tools

Company:	Eni
Location:	Worldwide
Aims:	**To assess water-related risks, increase internal awareness of water issues, shape water management plans, and communicate and report to external stakeholders**

Eni has more than 270 sites operating in 80 countries (2011), where water availability is low or predicated to become increasingly scarce. In order to prioritize actions and identify appropriate mitigation projects, a methodology for assessing water risk was developed.

A range of different risk screening tools were applied to assess water-related risks at several scales:

- The IPIECA *Global Water Tool© for Oil and Gas*, a customized version of the WBCSD *Global Water Tool©*, was used as an initial screening tool.
- Module 2 of the GEMI® *Local Water Tool™* was used to identify the origins of risk.
- The GEMI® *Local Water Tool™ for Oil and Gas* was used to gain insight into local impacts and the external context.



This approach allowed the water risk for the portfolio of assets to be mapped by country and drainage basin. Using this information, actions for enhancing policies, operational activities and management systems could then be identified and implemented.

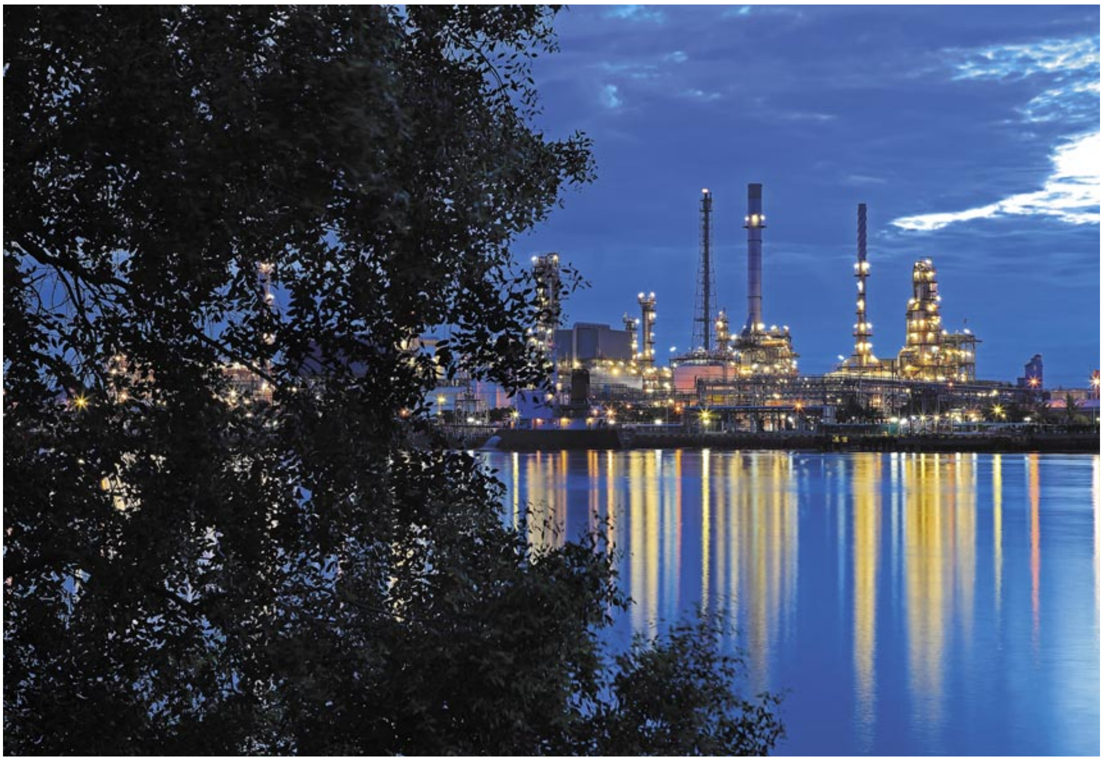
A key lesson learned was that clear policy, guidelines and knowledge transfer through a community of practice within the company are important factors for achieving improvements in water management. Each project or facility, guided by consistent tools can thus generate solutions appropriate to local basin and site-specific conditions.

associated with their operations (see Table 3 and the case study on *Use of water stress identification tools*) on a global, regional or drainage basin basis. However, the GEMI® *Local Water Tool*™ (LWT) *for oil and gas* (www.gemi.org/localwatertool) has been specifically developed to address the needs of the oil and gas industry. It may be used to enable companies to assess external impacts, business risks and opportunities, and to manage water-related issues at specific sites where existing projects are already operating, as well as integrating many of the steps needed to summarize impacts and risks associated with water source selection.

Uncertainty

Uncertainty is a critical factor to take into account during both the impact identification and risk assessment stages. Due to the typical decade-scale duration of many hydrocarbon-related resource projects, there is a high likelihood of change in factors relating to the security of the water supply over the life of a project, some of which may be poorly constrained. Change may be related to a wide variety of factors including physical (e.g. climate), social (e.g. population or industrial growth), environmental (e.g. ecosystem service needs) or regulatory factors.

During water source impact identification and risk assessment, the degree of uncertainty should be estimated where possible. One effective way to do this is to identify the most reasonably optimistic, most likely, and most reasonably pessimistic cases for each of the potential factors. This information can be captured within the risk assessment as a range of inputs that will influence the mitigations identified and the quantified risks. This process will result in a range of scenarios covering the most significant areas of uncertainty that can be taken forward to the options appraisal stage described in the following Section.



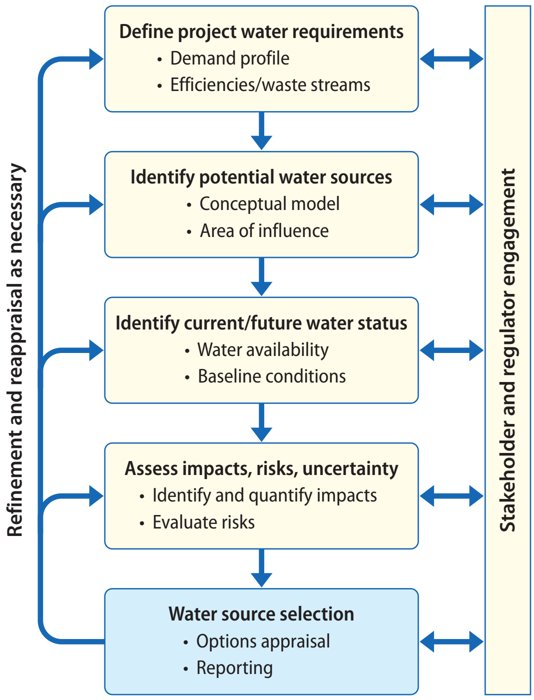
Section 7: Water source selection

This stage assesses and compares the potential supply options previously identified and characterized. Information is gained to enable the water source(s) that best meet the project needs to be selected, while minimizing any adverse effects on the wider drainage basin.

A brief description of general reporting requirements is included, although it is understood that companies may have their own reporting requirements.

The findings of the study should then be made available to be fed back into a subsequent iteration of the assessment process. This enables the source selection to be refined, allowing improvements in the project design and operation to be achieved.

Figure 12 *Identifying and assessing water sources—selecting the most appropriate water source*



In this stage, the water supply options are compared, and the findings reported for assessment so that the most appropriate sources may be selected.

Options appraisal

The decision on which water supply source to use will need to take account of the availability of water in the area, the potential impacts of use by the project, the regulatory environment, current and future risks and opportunities associated with these factors, and any mitigation measures deemed necessary. Other relevant engineering, environmental and social impacts, as well as stakeholder concerns, related to each option also need to be taken into account. Both positive and negative impacts need to be included.

There is often a need to choose between different environmental considerations in the different options. The assessment of options should not only include consideration of the costs, technical feasibility, impacts and risks relating to the water environment; it should also consider other relevant factors such as energy use, carbon emissions and waste. For example, the use of poorer quality water sources (which may have lesser impacts on available water resources) generally requires greater levels of treatment (with higher energy use and increased emissions) and results in larger waste streams that are more difficult to manage. Accordingly, when more than one potential water supply source is available, some type of formal options appraisal is required to enable all the relevant factors to be summarized in a format that allows a transparent and auditable decision to be made about which water source or sources are to be utilized.

A number of different approaches to options appraisal can be used depending on the planning needs, data availability and project phase. These range from qualitative to quantitative analysis and may use indicators that are benchmarked according to performance standards that are being followed by the project. Options appraisal enables a defensible and robust way of eliminating non-feasible options, and ranking acceptable options by preference.

Appraisal techniques can be broadly divided into those that do not necessarily rely wholly or largely on monetary valuations, and those that do. These two approaches are described separately below, with a discussion of their relative advantages and applicability. However, both approaches should be considered together if possible, to ensure optimal decisions are reached.

Framing

The framing stage establishes a clear description of the project context, and defines the external and internal parameters to be taken into account so that participants in an assessment can identify and explore all potential sources of risk. An incomplete or incorrect context can affect the assessment and bias the results.

Internal context includes all of the internal parameters and factors that influence how a company manages risk and tries to achieve its objectives. These factors include its internal stakeholders, its approach to governance, its contractual relationships, and its capabilities, culture and standards.

External context includes all of the external parameters and factors that influence how the company manages risk and tries to achieve its objectives. These include its external stakeholders, its local, national and international environment, as well as key drivers and trends that influence its objectives. The factors include stakeholder values, perceptions and relationships, as well as the organization's social, cultural, political, legal, regulatory, financial, technological, economic, natural and competitive environment.

Many of the key framing elements in the appraisal process (e.g. additional options, criteria, weightings, scores, uncertainties) can be discussed and generated by the appraisal team during this stage. For framing to be successful, it should develop a concise definition of what constitutes a 'successful outcome' for selecting an optimal water source that is agreed by all stakeholders. Once this is achieved, the rest of the options evaluation process can proceed on a sound footing.

Non-monetary appraisal

Multi-criteria analysis (MCA) is a general term that can be applied to a range of techniques that do not rely on monetary valuation and so can incorporate factors that may be quantified but not valued or which can only be assessed in qualitative terms, as well as fully monetized factors (DCLG, 2009). Although this can make the approach more versatile, especially during the early stages of a project when less hard data may be available, use of these techniques can require more experienced assessors to achieve robust and defensible decisions. Accordingly, this type of technique might be considered for an early screening phase, when the full range of available water supply options is being narrowed down.

MCA techniques can be used to identify a single most preferred option, to rank options, to short-list a limited number of options for subsequent detailed appraisal, or simply to distinguish acceptable from unacceptable possibilities.

A large range of MCA variations have been developed, but a standard feature of multi-criteria analysis is a 'performance matrix', in which each row describes an option and each column describes the performance of the options against a specified criterion. The criteria should be clearly specified, ideally measurable (at least semi-quantitatively) and, so far as possible, mutually independent.

In a basic form of MCA, this performance matrix may be the final product of the analysis. The decision makers then have to assess the extent to which the objectives are met by the entries in the matrix. Such intuitive processing of the data can be speedy and effective, but it may also lead

Figure 13 *Simplified example of a multi-criteria analysis options appraisal format*

Criteria rating: good (green), average (yellow), poor (orange), unacceptable (red)

SUPPLY OPTION	Technical selection criteria							Total score	Weighted score
	Reliability	Availability	Environmental impact/ sustainability	Operability	Maintainability	Inherently safe design	Flexibility and expandability		
Weightings (1–10)	8	8	10	6	6	10	5		
1. Marine desalination and pipeline	1	1	2	1	3	1	1	10	75
2. Freshwater aquifer	1	2	1	3	1	1	1	10	73
3. Brackish aquifer and desalination	3	3	3	3	2	3	3	20	153
4. Marine desalination and trucks	2	1	2	2	2	2	2	13	98

to the use of unjustified assumptions, causing incorrect ranking of options.

In a more analytically sophisticated approach to using MCA techniques, the information in the basic matrix is converted into consistent numerical values. Numerical analysis is usually applied to a performance matrix in two stages:

1. **Scoring:** the expected consequences of each option are assigned a numerical score on a strength-of-preference scale for each option for each criterion. The more preferred options score higher on the scale, and the less preferred options score lower. For example, scales extending from 0 to 10 could be used, where 0 represents a real or hypothetical least preferred option, and 10 is associated with a real or hypothetical most preferred option. All options considered in the MCA would then fall between 0 and 10.
2. **Weighting:** numerical weights are assigned to define, for each criterion, the relative valuations of a shift between the top and bottom of the chosen scale.

These two components are then combined to give an overall assessment of each option being appraised. The most common approach used is to calculate a simple weighted average of the scores for the criteria, with the option providing the highest weighted score being the one that is 'best'. A simplified and partial example of this type of approach is shown in Figure 13 to demonstrate how the results can be presented. As well as the technical criteria shown, stakeholder and commercial considerations should also be incorporated.

One potential complication is that this technique depends on the assumption of 'mutual independence of preferences'. This means that within a single option, the judged strength of preference on one criterion should be independent of the judged strength of preference on another. Consequently, it is important to recognize that significant biases in the results can be produced if criteria overlap or represent similar or related objectives.

Risk can be taken directly into account within MCA by including relevant aspects within the performance matrix as criteria. Scoring and weighting can then be applied in the standard way. Uncertainty is generally best not modelled explicitly, but can be incorporated in the process by undertaking sensitivity testing, implemented as a series of systematic changes in scoring inputs and/or criteria weights.

Monetary appraisal

Among several decision-support techniques which are based primarily on monetary valuation of the impacts or benefits of options, one of the most applicable to water source selection is cost-benefit analysis (CBA). Potential advantages include more precise discrimination between options, clear comparison due to a uniform measurement system (monetary value), direct incorporation of future costs and benefits, and a robust assessment of the effects of risk and uncertainty. However, the time and cost requirements for this type of analysis can be significantly greater than that required to complete an MCA.

A standard approach to this type of analysis includes the following steps:

1. Select criteria and assign values to all cost/benefit elements.
2. Predict the outcome of costs and benefits over the project design life.
3. Convert all costs and benefits into a common currency.
4. Apply an agreed discount rate to convert the future expected costs and benefits into present value amounts.
5. Calculate the net present value and/or benefit-cost ratio of the different water source options, to act as a performance or decision criterion.
6. Perform a sensitivity analysis.

Determining monetary values for impacts and benefits is usually the most problematic aspect of this process. Some values will be clearly defined, but many will be much more difficult to evaluate and may represent peoples' behaviour or choices. Environmental costs and benefits are typically assessed by valuing ecosystem services to humans, such as air and water quality and pollution. These values may be derived using a well-developed economic theory of valuation based on willingness to pay or to accept compensation for loss. This theory can act as a guide to how valuation should be achieved, and as a referee in disputes about valuation. A comprehensive guide to water valuation methods is provided in WBCSD, 2013b. The WBCSD has also published a companion guide covering ecosystem valuation (WBCSD, 2011).

The unit value assigned to the water supply is often a weak constraint on decision making, as water is generally priced well below market value as a social good. For facilities and projects located in areas identified as water-scarce, a practice that may be considered is to assign a conservative cost for fresh water in internal economic feasibility assessments in order to encourage facilities to find solutions beyond the local market price for water.

In practice it is rarely realistic to value all the potential costs and benefits of options in monetary terms. Most cost-benefit analyses will incorporate some additional items which it is either not possible to value, or not economical to do so. However, where the most important costs and benefits have been valued, the others can be set alongside and included in the decision process.

Sensitivity analysis can be used to take account of uncertainty and in assessing and treating project risks. A common approach is to test combinations of key variables in three scenarios: a pessimistic scenario, most probable or base scenario, and an optimistic scenario. Consequently this approach can be used to test the robustness of the analysis as well as to assess the potential effects of uncertainty about future conditions.

The risk associated with project options is usually handled using probability theory. The key parameters whose variation has a significant effect on the outcome can be determined by sensitivity analysis. Then, by assigning appropriate probability distributions to the critical variables, probability distributions for the performance indicators can be estimated by running the model a large number of times with the different values of the chosen parameter each time (Monte Carlo simulations).

Figure 14 provides an example to show how the output from a monetized and probabilistic cost-benefit analysis can be presented in terms of the calculated net present value of the different options.

Other approaches

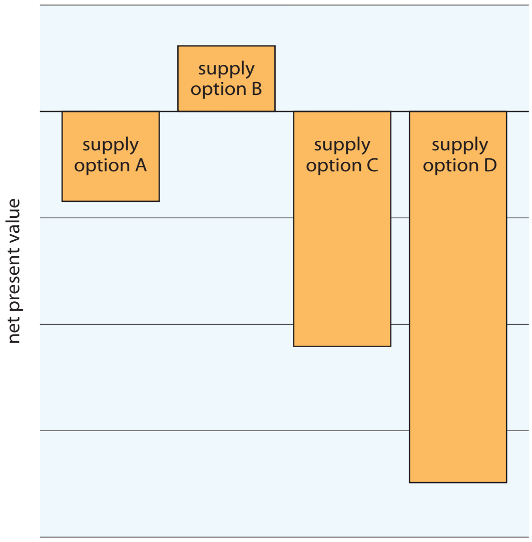
There is an increasing trend in the water management industry to use mathematical decision theories and evolutionary multi-objective optimization to find the most robust water management strategy for future operations, given all the uncertainty in the system's input variables. These approaches also provide a unique way to characterize the type of future conditions to which the system is vulnerable.

Examples of these approaches include Robust Decision Making, Info-Gap Decision Theory or Real-Options Analysis (Matrosov *et al.*, 2013). These techniques for analysing the robustness of design options can also capture elements of uncertainty (climate change, water demand, energy costs), and the outcomes often highlight the particular weaknesses of a potential water management option as well as its strengths. Parameters in this type of analysis can also be monetary (CAPEX, OPEX), which therefore provides a more holistic assessment of an option's robustness when compared to MCA.

Economics of Balancing Supply and Demand (EBSD) is another approach that enables the assessment of the performance of a chosen option within the context of the physical catchment, taking account of its economic strengths and weaknesses (UKWIR, 2002).

For large complex systems more sophisticated methods may be considered, such as the use of evolutionary and heuristic multi-objective/multi-modal optimization. These are used to assess the pereto-optimal (i.e. best or best set of) solutions to all the uncertainty ranges in the input data to the assessment (e.g. Kasprzyk *et al.*, 2012).

Figure 14 *Example of output from a water supply option cost-benefit analysis*



Reporting

Internal reporting of the results of the water source assessment should clearly present the costs, impacts, uncertainty and risks associated with different options, and should identify the preferred option(s) to be taken forward into the project design process. However, external reporting may also be required to explain to stakeholders what the potential benefits, impacts and proposed mitigating measures associated with the water usage are, and this should include a discussion of the alternatives that were considered, and the environmental, social and health impacts of each (i.e. an alternatives analysis needs to be documented). External reporting may also be part of the licensing obligations for regulatory bodies and for meeting environmental accreditation requirements.

A water resource assessment report can present the important parts of the assessment process, for example a summary of the conceptual model, the current and future status of water in the project area of influence, identification of the potential impacts and quantification of the risks/benefits, stakeholder consultation and outcomes, and final source selection. This type of report should aim to:

- inform the water source selection and project design process;
- communicate data relating to sustainability aspects of the project water usage;
- be transparent, credible and science based; and
- include human health, environmental impacts and social responsibility.

Water source assessment should be considered to be an iterative process, as described under *Guiding principles* on pages 5–7. Accordingly, it is likely that the initial results of the water source assessment will not be the end of the process, but will be used to inform and direct the progressive development of the project design. For example, if significant quantity constraints are identified during the assessment process, additional measures to reduce the project demand might become cost-effective and would then form part of the input to a further iteration of the assessment.

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Definitions

Numerous lists of definitions have been compiled which describe the various water-related terms. The following list conforms to usage in other IPIECA publications where possible.

Aquifer	A subsurface formation that is sufficiently permeable to hold and conduct groundwater and to yield economically significant quantities of water to wells and springs.
Area of influence	The spatial extent of the project's impact due to water abstraction and discharge.
Drainage basin	The area of land from which all surface run-off flows through a sequence of streams, rivers and, possibly, lakes to the same outlet.
Economically sustainable water use	Water use that is secure, reliable and financially viable in the long term. (AWS, 2013)
Ecosystem	A dynamic complex of communities of living organisms and their non-living environment interacting as a functional unit. (IPIECA, 2010)
Ecosystem services • Provisioning • Regulating • Cultural • Supporting	The benefits (direct and indirect) that people derive from ecosystems. (IPIECA, 2010) Ecosystem services comprise: • natural products (provisioning services) such as water, fish and timber; • natural functions (regulating services), such as flood control, waste assimilation and climate regulation; and • other social benefits (cultural services) such as recreational, aesthetic and spiritual benefits. These services are also supported by underpinning natural processes (supporting services) such as nutrient cycling and photosynthesis.
Environmental flow	The water regime provided within a river, wetland or coastal zone to maintain ecosystems and their benefits. (eFlowNet)
Environmentally responsible water use	Maintains or improves biodiversity and ecological processes at the watershed level. (AWS, 2013)
Existing water users	Individuals, groups of individuals, organizations or other species that currently make use of water within the project's area of Influence. They are also '*Stakeholders*'.
Flow back	The fracture fluids that return to surface after a hydraulic fracture is completed and prior to the well being brought into production.
Groundwater	Subsurface water occupying the saturated zone. (GEMI, 2012)

continued …

Groundwater depression area	That area of an aquifer where abstraction has had an impact on the stored quantity of water by lowering hydraulic heads.
Groundwater recharge area	That area of the land surface where precipitation or other sources of water recharge an aquifer.
Hydraulic fracturing	Injecting fracturing fluids into the target formation at a force exceeding the parting pressure of the rock, thus inducing fractures through which oil or natural gas can flow to the wellbore.
Important water areas	The specific ecological, socio-cultural, and economic areas of a drainage basin that, if impaired or lost, would have an adverse impact on the environmental, social, cultural or economic benefits derived from the watershed in a significant or disproportionate manner. This includes areas that are legally protected or under a conservation agreement, areas that have been identified by local or indigenous communities as having significance for cultural, spiritual, religious or recreational values, and areas that are recognized as providing important ecosystem services. (AWS, 2013)
Land take	The area of land that is 'taken' by infrastructure itself and other facilities that necessarily go along with the infrastructure, such as filling stations on roads and railway stations. (European Commission)
Municipal supply	Supply of drinking quality water by, or on behalf of, a public organization.
Operation	A generic term used to denote any kind of business activity. (IPIECA, 2010)
Opportunity	Potential top line business enhancements created by voluntary sustainable water management actions. (GEMI, 2012)
Process	Specific activities within an operation. One site/operation may have multiple processes which use or discharge water. For example, a manufacturing operation may have a cooling process, a cleaning process and a chemical reaction process. (GEMI, 2012)
Produced water	Water that is brought to the surface during operations which extract hydrocarbons from oil and gas reservoirs. (IPIECA, 2010)
Recycled water	Used water/waste water employed through another process cycle after treatment, before discharge for final treatment and/or discharge to the environment.
Reporting	Disclosing relevant information and data to internal and external stakeholders such as management, employees, governments, regulators, shareholders, the general public, local communities or specific interest groups. (IPIECA, 2010)

Reused water — Used water/waste water employed through another process cycle with no or minimal treatment, before discharge for final treatment and/or discharge to the environment. Reuse includes waste water used for irrigation and harvesting of rainwater (both within a facility boundary).

Risk — The combination of likelihood (frequency) and severity (consequence) of potential adverse impacts, from actions or events, on the environment or people. (IPIECA, 2010)

Site — A unique location of a business operation. (GEMI, 2012)

Socially beneficial Water Use — Recognizes basic human needs and ensures long-term benefits (including economic benefits) for local people and society in general. (AWS, 2013)

Sphere of influence — See '*Area of influence*'.

Stakeholders — People that affect, or are affected by, company activities or operations (e.g. customers, shareholders, management, employees, suppliers, local communities, advocacy groups and government). (IPIECA, 2010)

- ***Primary stakeholders:*** those individuals or groups who are directly impacted (positively or negatively) by the project, including beneficiaries of the project. Primary stakeholders typically have a heightened interest in the project and have the ability to strongly influence its progress (positively or negatively).
- ***Secondary stakeholders:*** those individuals or groups with an interest in the project, including local and national government, policy makers, regulators, advocacy groups and NGOs, that are not directly impacted by the project but nonetheless have a legitimate interest in and influence over it.

Surface water — Water that flows over or is stored on the ground surface. (GEMI, 2012)

Sustainability — A system that is sustainable should meet the needs of the present without compromising the ability of future generations to meet their own needs. (Brundtland Report—WCED, 1987)

Water availability — The hydrologic capacity of a water source (surface water body, groundwater, municipal water) to sustain additional water demands after considering other current water uses and water conditions. (GEMI, 2012)

Water balance — The relationship between input and output of water across a defined system boundary, e.g. a watershed or the project site boundary. If input > output, then storage within the system increases; if input < output, then storage decreases. (DRET, 2008)

continued …

Water consumption	The difference between water withdrawal and water discharge to/from the same source (or watershed).
Water demand	The total water requirements of a project.
Water discharge	Water effluents discharged outside a reporting organization boundary to subsurface waters, surface waters, sewers that lead to rivers, oceans, lakes, wetlands, treatment facilities, and groundwater. (GEMI, 2012)
Water governance	Encompasses the internal and external mechanisms by which the water-related aspects of an entity are controlled and by which the entity is accountable to its stakeholders, including which decisions are made, how and by whom. It defines the relationships between different stakeholders and between different parts of the system. The term governance applies to all entities and is distinct from the term government. (AWS, 2013, adapted from ISEAL Alliance, 2007: *ISEAL Emerging Initiatives Module 4: Models of Governance, July 2007*.)
Water intensity	The ratio between water intake and a defined unit of production. (Organisation for Economic Co-operation and Development)
Water quality	The quality of a specific water body is defined by the suitability or condition of the water for a particular use based on its physical, chemical, and biological characteristics. (GEMI, 2012)
Water scarcity	The point at which the aggregate impact of all users impinges on the supply or quality of water under prevailing institutional arrangements to the extent that the demand by all sectors, including the environment, cannot be satisfied fully (United Nations, 2006). One measure is the Falkenmark Indicator, which defines water security as when annual water supplies in a country or region drop below 1,000 cubic metres per person per year.
Water security	The reliable availability of an acceptable quantity and quality of water for health, livelihoods and production, coupled with an acceptable level of water-related risks.
Water stress	Occurs when the demand for water exceeds the available amount of water over a given period, or when the poor quality of available water restricts its use (AWS, 2013). Leflaive *et al.* (2012) explain that water stress can be quantified by taking a ratio of water demand to water availability, and define four categories of water stress ranging from 'no stress' to 'severe stress' based on these ratios. Another measure is the Falkenmark Indicator, which defines water stress as when annual water supplies in a country or region drop below 1,700 cubic metres per person per year (United Nations).
Water supply	The total water available for use on a project.

Water stewardship	Use of water that is socially beneficial, environmentally responsible and economically sustainable. (AWS, 2013).
Water storage unit	Any body in which water collects and resides for a period of time, e.g. the atmosphere, ponds, lakes, oceans, aquifers, etc.
Water table	The upper surface of groundwater.
Water withdrawal	The sum of all water drawn into the boundaries of the reporting organization from external sources. (GEMI, 2012)
Watershed	The hydrologic divide between drainage basins.

Abbreviations

API	American Petroleum Institute
AWS	Alliance for Water Stewardship
CAPEX	Capital Expenditure
CBA	Cost-Benefit Analysis
DEM	Digital Elevation Model
DRET	Department of Resources, Energy and Tourism (of the Australian Government)
EBSD	Economics of Balancing Supply and Demand
ESHIA	Environmental, Social and Health Impact Assessment
EROS	Earth Resources and Observation Sciences
FAO	Food and Agriculture Organization (of the United Nations)
FPIC	Free, Prior and Informed Consent (concept in stakeholder engagement)
GEMI	Global Environmental Management Initiative
GWP	Global Water Partnership
ICP	Informed, Consultation and Participation (concept in stakeholder engagement)
IFC	International Finance Corporation
IP	Indigenous People
IPIECA	The global oil and gas industry association for environmental and social issues
ISEAL	International Social and Environmental Accreditation and Labelling
IWRM	Integrated Water Resource Management
MCA	Multi-Criteria Analysis
NGO	Non-governmental Organization
NOAA	National Oceanic and Atmospheric Administration
OPEX	Operating Expenditure
REA	Rapid Environmental Assessment
RO	Reverse Osmosis
SEP	Stakeholder Engagement Plan
SIA	Strategic Impact Assessment
USGS	United States Geological Survey
WBCSD	World Business Council for Sustainable Development
WCED	World Commission on Environment and Development
WFN	Water Footprint Network
WHYMAP	World-wide Hydrogeological Mapping and Assessment Programme
WRI	World Resources Institute

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IPIECA is the global oil and gas industry association for environmental and social issues. It develops, shares and promotes good practices and knowledge to help the industry improve its environmental and social performance, and is the industry's principal channel of communication with the United Nations.

Through its member-led working groups and executive leadership, IPIECA brings together the collective expertise of oil and gas companies and associations. Its unique position within the industry enables its members to respond effectively to key environmental and social issues.

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