Water Accounting Framework for the Minerals Industry

USER GUIDE
Version 1.2 - April 2012
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1 Background to the framework

The Minerals Council of Australia (MCA) has recognised the vital role of water in mining both as an asset that produces value and as a shared natural resource that requires responsible stewardship. To assist its members in managing both of these roles the MCA has, in conjunction with the Sustainable Minerals Institute of the University of Queensland, developed a water accounting framework.

The strength of the MCA Water Accounting Framework (WAF) is that it allows sites to account for, report on and compare site water management practices in a rigorous, consistent and unambiguous manner that can easily be understood by non-experts. It has also been designed to align with frameworks for the Global Reporting Initiative (GRI) and Australian Water Accounting Standard (AWAS).

The sections in the manual detail the following information:

1. The ‘Background’ presents the history of the WAF and justification for its use. ‘The Business Case lists the advantages for sites in adopting the WAF. The ‘MCA Water Accounting Framework’ introduces the MCA WAF.
2. ‘Definitions’ describes the terms used in the WAF.
3. ‘Account Development’ details how to create a water account in a generic way.
4. An example of a contextual statement is given.
5. ‘Case Studies’ provide example accounts for specific situations.
6. ‘Reporting to other organisations’ shows how to use the WAF to report according to the Global Reporting Initiative and the Australian Water Accounting Standards.
7. The bibliography provides the source material that was used in preparation of the manual.

BACKGROUND AND OVERVIEW

Introduction

Members of the Minerals Council of Australia (MCA), representing over 85% of minerals production in Australia, have a long-standing commitment to sustainable development including the responsible stewardship of natural resources. Whilst only impacting on 0.02% of the Australian landscape, and using around 3.6% of water resources, minerals operations contribute:

- 8% national GDP;
- 42% of goods and services exports; and
- Tax and royalties in 2008/9 of $21.019 billion and in 2009/10 of $23.4 billion.

Membership of the MCA requires companies to be signatories to Enduring Value - The Minerals Industry Framework for Sustainable Development. Enduring Value provides operational guidance on the implementation of the International Council on Mining and Metals’ 10 principles of sustainable development.

Companies that are signatories to Enduring Value are required in their operations in Australia to [amongst others]:

- Seek continual improvement in environmental performance; and
- Implement effective and transparent engagement, communication and independently verified reporting arrangements with stakeholders.

As a high-value and responsible manager of water resources, the minerals industry strongly supports the development of water accounting frameworks, so that water use by all users in the landscape, can be compared in a quantified and transparent manner. Additionally, the minerals industry sees the development of water accounting as a key facilitating mechanism for the fruition of functional water markets.

The MCA water accounting project has been undertaken as a research and development project in conjunction with the Sustainable Minerals Institute at the University of Queensland from 2007-11. The framework has been piloted in partnership with the NSW Minerals Council at a number of operations in Australia. The results have been used to develop the framework presented here for use by the minerals industry in Australia.
How has the Framework been Developed?

The Water Accounting Framework (WAF) development began in 2005 as part of a strategic program led by the MCA to gain improved understanding of minerals industry water use and use requirements, amongst stakeholders involved in the water reform process, and regionally with operations. The MCA’s Sustainable Development (SD) Committee, which reports to the MCA Board, has overseen the strategic development of framework, with the Water Working Group (WWG), and the MCA Secretariat responsible for the ‘hands-on’ development.

Initially, the WWG engaged the Sustainable Minerals Institute (SMI) to ‘develop a suite of metrics’ to enable consistent reporting within industry. This work involved reviewing existing monitoring and reporting activities within industry, and identifying a ‘path of least resistance’ for adoption of an industry-wide consistent water use reporting framework. This included understanding an operation’s water balance, its reporting obligations under annual environmental reports, and voluntary corporate reporting initiatives.

At the same time as the SMI work was unfolding, the National Water Initiative water policy reform program was investing in developing water accounting frameworks, and potentially, regulatory instruments. Additionally, at a similar time, the Bureau of Meteorology received additional powers under the Water Act 2007 to collect water information from anyone who held it.

In mid-2008 SMI delivered its preliminary framework for consideration by the MCA’s WWG and SD Committee. In the second half of 2008, the MCA commissioned a third-party review of the work, and undertook targeted stakeholder engagement, with industry, government and non-government representatives, including an open workshop at the SD08 conference, and a joint industry-government workshop in Perth. During this time, there was also in-principle support from industry and government to run a pilot accounting exercise with the Commonwealth Government’s Water Accounting Development Committee.

In 2009 a pilot project in Central NSW was undertaken. This was a joint initiative of the MCA, SMI and the NSW Minerals Council.

Building on the feedback from industry and governments during the stakeholder engagement in 2008, the Minerals Industry Water Accounting Pilot Project, a partnership involving the MCA, the NSW Minerals Council, the National Water Accounting Development Committee and the SMI, was established in 2009. The objectives of this pilot project were to:

- Map minerals industry water accounting definitions and concepts to the Standards and other documentation previously developed by NWI’s Water Accounting Development Committee;
- Explore the incorporation of water quality into the accounting framework;
- To update and refining the presentation of accounts, based on industry and other stakeholder feedback, and where possible to align with water accounting approaches being developed by the Water Accounting Development Committee;
- To provide feedback to government agencies developing water accounting methods on the utility, challenges and opportunities, in the accounting approaches being developed from an industrial water user perspective; and
- To undertake an accounting exercise across either, a region of mines, to test the refined accounting framework and inform capacity building requirements.

The pilot project was completed in October 2009 and following its completion the MCA engaged with industry and other stakeholders. Based upon the pilot study and feedback the framework was amended to its current form.
The Business Case for Minerals Industry Water Accounting?

Many minerals operations, and companies, already have in place frameworks for measuring, monitoring and reporting water use. However, these frameworks are often:

- Not consistent across operations within companies and ignore ‘whole-of-site’ impacts;
- Not consistent across companies within the minerals industry, thereby, making it difficult to compare between sites;
- Not consistent with the way other sectors report water use, thereby, making it difficult to compare across sectors; and
- Very complex and therefore difficult to communicate water performance to a wide range of stakeholders.

However, in almost all cases, minerals operations record the same type of data, and it simply requires repackaging to promote consistency. The business case for nationally consistent water accounting for the minerals industry is, therefore, founded in:

- Improved capability for the industry to report sustainable use of water resources, in a consistent and contextual manner;
- The ability to identify water associated business risks (e.g. securing a sufficient water to meet production demands) in consistent manner;
- Supporting strategic land use planning processes, so that over-allocation of water resources is avoided;
- Benchmarking opportunities for operations within a region to support identification of potential efficiency measures;
- Regulatory reform to promote efficiencies in current reporting arrangements;
- Better reputation thorough an increased recognition of industry as a responsible steward of natural resources, through development, application and reporting of water accounts; and
- Increased capability of the markets and regulators to quantify water quality and therefore support water access pricing arrangements that reflect water quality and source.

The Minerals Industry Water Accounting Framework

What is Water Accounting?

Water accounts bridge the site water balance - GRI divide
Water accounting is the application of a consistent and structured approach to identifying, measuring, recording and reporting information about water.

Water accounting is a framework which provides measurement, monitoring and reporting protocols, to support public and investor confidence in the amount of water being traded, extracted for consumptive use, and recovered and managed for environmental and other public benefit outcomes (National Water Initiative, 2004).

It is important to distinguish between water accounting and water reporting. Accounting concerns the consolidation of water balance information, as discussed throughout the framework description. Reporting concerns the presentation of water balance information in formats tailored to the needs of various reporting uses and users. Water reporting and information demands are ever-expanding for minerals operations. The WAF aims to provide a ‘one-stop-shop’ for water information.

**Scope and Objectives**

The MCA Water Accounting Framework provides:

- A consistent approach for quantifying flows into, and out of, reporting entities, based on their sources and destinations;
- A consistent approach for reporting of ‘water use’ by minerals operations that enables comparison with other users, and relates to water sharing planning processes;
- A consistent approach in quantifying and reporting water ‘reuse’ and ‘recycling’ efficiencies such that the reliance on sourced water is reduced; and
- A model for the more detailed operational water balance as guidance for those businesses which currently do not have an effective operational water model or see an opportunity to develop this new approach.

The framework is not a tool. Tools can be developed to support reporting in alignment with the framework, or existing tools can be modified.

**How Can the Framework be Applied?**

The framework can be applied at two levels:

1. The Input-Output Model provides a consistent approach for quantifying flows into, and out of, reporting entities, based on their sources and destinations, and
2. The Operational Model provides guidance for companies for water processes within their operations. This is of more value to businesses which currently do not have an effective operational water model or see an opportunity in developing this new approach.

The framework typically requires a combination of existing data, and modelled estimates, depending on an operation’s existing data holdings. It is envisaged that with a standardised reporting platform across industry, government agencies may be amenable to reforming regulatory arrangements and enabling national consistency.

Further, it is likely that the process of generating water accounts, will lead in the medium-term, to the acquisition and communication of water data that helps manage an operation’s water supply risks. Accuracy or reliability statements associated with water accounts are provided in a consistent format, with data collections fit-for-purpose and related to an operations water supply risks and regulatory requirements.

1. The Water Accounting Framework produces the following four reports: The **Input-Output Statement** lists flows for all input and output categories for the reporting period, along with the change in storage.
2. **Statement of Operational Efficiencies** lists the total flows into the tasks, volume of reused water, reuse efficiency, the volume of recycled water and recycling efficiency.
3. **The Accuracy Statement** lists the percentage of flows that were measured, simulated and estimated.
4. **Contextual Information** ensures that numbers in the report are not divorced from the context in which a facility is operating. It gives information about the water resources of the region and the catchment in which the sites are located.
2 Definitions of terms used in the Water Accounting Framework

This section defines the terms of the framework.

There are three components of the framework: the Input-Output model, the Operational Model and the Water Quality Description. Representing the site according to the models enables consistent reporting.

The reports generated are

i. the Input-Output statement,
ii. the Accuracy statement,
iii. the Statement of Operational Efficiencies and
iv. the Contextual statement.

The Input-Output Statement is a list of the inputs, outputs and diversions with their associated water quality category. The accuracy of accounts is communicated through an Accuracy Statement, which shows the proportions of flows by volume, which are measured, estimated or simulated. The Statement of Operational Efficiencies shows the proportion of reuse and recycled flows in relation to the total flows into the tasks. The purpose of the Contextual Statement is to provide background information about the water resources of the operational facility as well as any conditions that have an impact on the management of those water resources such as climate information.

2.1 System Boundary

The boundary of the Operational Facility is defined by the mining company to meet its reporting requirements as necessary. Typically it will consist of the mine site including mineral processing operations if present.

2.2 The Input-Output Model

The Input-Output Model shown in Figure 1: The Input-Output Model describes the flows between the environment and the boundary of the operational facility i.e. the inputs, the outputs and diversions.
2.2.1 Definition of Inputs

An input is a volume of water which is received by the operational facility for intended use by the operational facility. It includes water that has become available from within the operational facility, for instance groundwater accessed during dewatering of the ore body. Inputs are reported with their source of which there are four categories as shown in Table 1 below. Inputs into the operational facility exclude diversion flows (described in Section 2.2.3).

Table 1: List of Inputs with their corresponding Sources

<table>
<thead>
<tr>
<th>Source</th>
<th>Definition</th>
<th>Input</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Water</td>
<td>All water naturally open to the atmosphere, except for water from oceans, seas and estuaries</td>
<td>Precipitation and Runoff</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rivers and Creeks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>External Surface Water Storages</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Water beneath the earth’s surface that fills pores or cracks between porous media such as soil, rock, coal, and sand, often forming aquifers. For accounting purposes, water that is entrained in the ore can be considered as groundwater</td>
<td>Aquifer Interception (Dewatering)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bore Fields</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ore Entrainment</td>
</tr>
<tr>
<td>Sea Water</td>
<td>Water from oceans, seas and estuaries</td>
<td>Estuary</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sea/Ocean</td>
</tr>
<tr>
<td>Third Party</td>
<td>Water supplied by an entity external to the operational facility. Third-party water contains water from the other three sources. When the source is known, the physical source (surface water, groundwater, sea water) should prevail.</td>
<td>Contract/Municipal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Waste Water</td>
</tr>
</tbody>
</table>

For further guidance, definitions for individual Inputs (recommended only) are provided in Table 1B. These are not prescriptive and can be removed, modified or new categories added depending on the specific needs of a company or operation. However these should fit into an existing Source category.

Table 1B: Definitions for Individual Inputs (recommended only)

<table>
<thead>
<tr>
<th>Source</th>
<th>Input</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Water</td>
<td>Precipitation and Runoff</td>
<td>Rainfall and runoff. Precipitation is a broader term than rainfall and includes snow and hail.</td>
</tr>
<tr>
<td></td>
<td>Rivers and Creeks</td>
<td>Water extracted from rivers and creeks. May or may not run through the site lease.</td>
</tr>
<tr>
<td></td>
<td>External Surface Water Storages</td>
<td>Water extracted from dams and lakes external to the site.</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Aquifer Interception (Dewatering)</td>
<td>Groundwater that is extracted as part of ore body dewatering during mining operations.</td>
</tr>
<tr>
<td></td>
<td>Bore Fields</td>
<td>Bore water specifically for water supply.</td>
</tr>
<tr>
<td></td>
<td>Entrainment</td>
<td>Water in the raw material, typically the ore to be processed.</td>
</tr>
<tr>
<td>Sea Water</td>
<td>Estuary</td>
<td>Water extracted from an estuary.</td>
</tr>
<tr>
<td></td>
<td>Sea/Ocean</td>
<td>Water extracted from the sea or ocean.</td>
</tr>
<tr>
<td>Third Party Water</td>
<td>Contract/Municipal</td>
<td>Water that is purchased or traded.</td>
</tr>
<tr>
<td></td>
<td>Waste Water</td>
<td>The waste water of an organisation or community external to the site.</td>
</tr>
</tbody>
</table>
2.2.2 Definition of Outputs

An output is a volume of water which is removed from the operational facility after it has been through a task, treated or stored for use. Outputs are grouped according to their destination of which there are five categories as shown in Table 2 below. Outputs from the operational facility exclude diversion flows (described in Section 2.2.3).

### Table 2: List of Outputs with their corresponding Destinations

<table>
<thead>
<tr>
<th>Destination</th>
<th>Definition</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Water</td>
<td>All water naturally open to the atmosphere, except for water from oceans, seas and estuaries</td>
<td>Discharge</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Environmental Flows</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Water beneath the earth’s surface that fills pores or cracks between porous media such as soil, rock, coal, and sand, often forming aquifers.</td>
<td>Seepage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aquifer reinjection</td>
</tr>
<tr>
<td>Sea Water</td>
<td>Water to oceans, seas and estuaries</td>
<td>Estuary</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sea/Ocean</td>
</tr>
<tr>
<td>Third Party</td>
<td>Water supplied to an entity external to the operational facility.</td>
<td>Third Party</td>
</tr>
<tr>
<td>Other</td>
<td>Includes evaporation, entrainment, task loss and any other destination that is not covered by the other pathways.</td>
<td>Evaporation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Entrained water in waste material (tailings, coarse rejects) and concentrate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Task loss</td>
</tr>
</tbody>
</table>

For further guidance, definitions for individual Outputs (recommended only) are provided in Table 2B. These are not prescriptive and can be removed, modified or new categories added depending on the specific needs of a company or operation. However these should fit into an existing Destination category.

### Table 2B: Definitions for Individual Outputs (recommended only)

<table>
<thead>
<tr>
<th>Destination</th>
<th>Output</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Water</td>
<td>Discharge</td>
<td>Uncontrolled or controlled discharge to surface water.</td>
</tr>
<tr>
<td></td>
<td>Environmental Flows</td>
<td>Discharged water used to support environmental initiatives.</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Seepage</td>
<td>Seepage from the site.</td>
</tr>
<tr>
<td></td>
<td>Reinjection</td>
<td>Water that is deliberately managed (as opposed to natural processes) by the site to recharge an aquifer.</td>
</tr>
<tr>
<td>Sea Water</td>
<td>Discharge to Estuary</td>
<td>Uncontrolled or controlled discharge to estuary.</td>
</tr>
<tr>
<td></td>
<td>Discharge to Sea/Ocean</td>
<td>Uncontrolled or controlled discharge to the sea or ocean.</td>
</tr>
<tr>
<td>Supply to Third Party</td>
<td></td>
<td>Water on-supplied to third parties.</td>
</tr>
<tr>
<td>Other</td>
<td>Evaporation</td>
<td>Evaporation from the site, including but not limited to evaporation from stores, the tailings dam and dust suppression.</td>
</tr>
<tr>
<td></td>
<td>Entrainment</td>
<td>Water in waste and product streams, typically the water in the concentrate, tailings, coarse rejects.</td>
</tr>
</tbody>
</table>
2.2.3 Definition of Diversions

Water is classified as a diversion when it flows from an input to an output without being utilised by the operational facility. The flow is not stored with the intention of being used in a task or treated.

Diversions include water that is diverted away from extraction operations, (not used for any operational purpose within the operational facility). A diversion is water that is actively managed by the minerals operation, but is not used in a traditional consumptive sense. Surface water diversions do not include re-alignment of a stream or river channel flowing through a site because the water is not actively managed by the operational facility.

Diversion flows are not included in the reporting of inputs and outputs for the operational facility. Instead, a statement of diversions is appended to the Input-Output Statement. Diversions have their own list of inputs and outputs which are grouped into the same Source and Destination categories as provided in Tables 1 and 2.

Examples of Diversions and their associated Source/Destination and input/output categories are provided below:

1) Water withdrawn from a river for use in mixing for release of dilution flows or water that has entered a site from a flooding river which is subsequently transferred to surface water external to the operational facility (i.e. river or stream):
   - **Source**: Surface Water, **Input**: Rivers and Streams
   - **Destination**: Surface Water, **Output**: Rivers and Streams

2) Water from a rainfall event which is directed away from the operation and may be collected in ponds or pits but is not intended for use in a task. Water may be discharged to a river. Depending on retention time, ponds may experience significant evaporation:
   - **Source**: Surface Water, **Input**: Precipitation and Runoff
   - **Destination**: Surface Water, **Output**: Rivers and Streams
   - **Destination**: Other, **Output**: Evaporation

3) Water produced as a result of aquifer interception (dewatering) that is subsequently reinjected into groundwater:
   - **Source**: Groundwater, **Input**: Aquifer Interception
   - **Destination**: Groundwater, **Output**: Reinjection
   - If the dewatered volume was on-supplied to a third party, the output is third party:
   - **Destination**: Supply to Third Party, **Output**: (Not applicable).

The case studies show how this can be presented.

2.3 Materiality of Flows

When preparing the accounts, only include those flows important for the overall account. A flow is material in the framework if its omission from a report can influence the water-related decisions of users of that report. For example, rainfall incident on a small store may constitute such a small input compared to the much larger runoff inputs that the flow is not considered material and is not included as an input.

The volume of the flow is not the only consideration. An environmental water flow may be relatively small in volume, but critical for maintaining ecosystem health, hence the flow would be considered material.

2.4 Water Quality Description

The purpose of the Water Quality Description is to assign a water quality category to each input and output. The use of consistent water quality categories is currently under consideration in the adoption of the water accounting framework, and companies may wish to use their existing water quality reporting categories as appropriate. In the absence of an internal process, the following approach to water quality categorisation has been provided: Generic water quality category definitions and a decision tree have been provided below. The water quality categories can be qualitatively described as follows:
**Category 1** - Close to the drinking water standards, as it only requires minimum treatment (disinfection) to be safe for human consumption. It can be used for all purposes.

**Category 2** - Suitable for some purposes. Treatment will be required to remove total dissolved solids and/or to adjust other parameters to be safe for human consumption and more sensitive agricultural and recreational purposes.

**Category 3** - Water unsuitable for most purposes due to the high salinity (>5000mg/L TDS) or highly unsuitable pH (<4 and >10). Category 3 water will require significant treatment to be suitable for Category 1 and Category 2.

*Figure 2: Decision tree to assign a water quality category*

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**TDS**: Total Dissolved Solids. A measure of all dissolved salts and minerals within the water and expressed in mg/L.

**Coliforms**: Common sources of faecal contamination are the input of third-party water from a wastewater treatment plant that produces Class C or D water, and runoff generated over catchments with livestock raising land use.

**pH**: This is routinely measured by operations.

**Turbidity**: Turbidity varies with the seasons since rainfall can stir up particulates in water sources and water stores. Many mines have sedimentation ponds and will have a good understanding of turbidity values.

**Pesticides and herbicides**: If the land use of the catchment area is agriculture, the runoff water is likely to contain pesticides and herbicides.

**Other constituents**: It is recommended that users defer to the drinking water guidelines - if the water meets them, then it can be put into Category 1. However these values can be relaxed because Category 1 water is only close to potable water standard; it cannot be consumed without treatment. In general, if the guidelines indicate that there may be a lower value for reasons of taste or aesthetics and a higher value for health based reasons, the higher level is the trigger level. For some parameters, no health based trigger level is provided because the constituent is either harmless or there is insufficient data to provide a level.
2.5 The Operational Model

The Operational Model (Figure 3) describes the flows internal to the operational facility i.e. the flows between the stores, tasks and treatment plants.

![Figure 3: The Operational Model](image)

2.5.1 Water Status

The water within the operational model is either considered raw, worked or treated. It is necessary to define the water status in order to create the stores of the operational model and to calculate the reuse and recycling efficiency.

- **Raw water** is water that is received as an input and has not been used in a task.
- **Worked water** is water that has been through a task.
- **Treated water** is water that has been treated on-site to provide water of a suitable quality for a particular purpose. It can include raw water treated once received on-site or water used in the process then treated to allow further use or release to an output destination.

2.5.2 Water Stores

For the purposes of the framework, all stores on-site are represented by two stores: the raw water store and the mixed water store.

- A raw water store only receives raw water so by definition, the water entering the store must come from the inputs to the site.
- A mixed water store receives both worked water from tasks and raw water in the form of precipitation and runoff inputs. The mixed water store may also receive raw water from the inputs or from the raw water store. This is illustrated in Figure 4: Diagram to show possible water flows to the raw and mixed water stores.

![Figure 4: Diagram to show possible water flows to the raw and mixed water stores](image)
The difference between water inputs and water outputs over the reporting period should equal the measured change of water storage from the start to the end of the reporting period. Comparing site inputs, outputs and change of storage enables an assessment of any error in the water balance.

### 2.5.3 Tasks

Tasks are operational activities that use water. When listing the tasks, they tend to be grouped according to a broader purpose. For example grinding and flotation operations will be grouped within the task ‘ore processing’. Aggregating the tasks means that it is not necessary to know the flows of all unit operations.

Typical tasks are listed below. Not all tasks will be relevant for each site.

- Dust suppression
- Underground mining
- Haul road dust suppression
- Ore processing
- CHPP (coal handling and processing plant)
- Tailings Storage Facility (TSF)
- Co-disposal
- Amenities use

The tailings storage facility is a special type of task. It is classed as a task because its purpose is to store the tailings, but it can store water too. In practice, it is very poor management to have water accumulate in the tailings storage facility however the copper-gold mine case study contains an example where water is allowed to accumulate to show how this should be represented in the framework.

The combination of the Input-Output model, the Operational model and the Water Quality Description is represented in the following Figure 5.

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**Figure 5: Water system concept model for accounting purposes**
3 Account Development

The terms of the framework have been defined in the Framework Overview provided in Section 2. This section shows you in a step-by-step manner how to develop the statements within the Water Accounting Framework for the Minerals Industry.

The following provides a complete list of the information that you will need prior to developing an account:

- Flowcharts for water flows
- Information on stores
  - store volumes at beginning and end of reporting period
  - water quality of stores
  - surface areas of stores and catchment areas (including the proportion of undisturbed land)
- A list of tasks with an average yearly water demand
- A list of water sources, volumes and water quality
- Discharge or any other water flows that leave the site boundary with any water quality monitoring data
- Flow volumes from
  - thickeners (if applicable) to process water store
  - tailings storage facility to process water store
  - any return flows from tasks to stores
  - ore dewatering
- Tonnage of ROM going to the concentrator with moisture content of ore
- Tonnage of product and/or coarse rejects with moisture content
- Flow volumes around water treatment plants
- Estimates, simulations or measurements (if available) for:
  - seepage
  - rainfall and runoff
  - evaporation

It is recognised that sites may not have all the information available to them to build a water account on metered or measured flows. This should not discourage sites from proceeding with the framework because calculations and typical values may be used to obtain a reasonable estimate. Obviously the accuracy of the account decreases with an increasing amount of estimated values but the process will highlight gaps in data acquisition.

3.1 The Framework Representation

It is expected that the site will at least have a flowchart to work from and the aim is to convert it to the elements of the framework: stores, inputs, outputs, treatment plants, tasks and diversions. The manual provides guidance on how to do this.

The following convention will be used when representing the elements of the framework:

- Inputs are coloured green
- Outputs are coloured red
- Diversions are coloured yellow
- Stores are coloured blue
- Tasks are coloured grey
- Treatment plants are coloured purple
3.2 Constructing the Input – Output model

In this sub-section of Account Development you will construct your Input – Output model which is required to generate the Input – Output statement. You will list the inputs, outputs and diversions in terms of the volume, quality and source or destination as applicable. Inputs such as rainfall and runoff, and outputs such as evaporation and seepage require the site to have some understanding of its hydrology however some simple calculations are provided in the following sections so that you may obtain a simple estimate. Knowledge of your storage levels at the start and end of your specified reporting period will enable you to finish the Input-Output Statement.

All steps are relevant for a reporting period chosen by you. It will typically be a year but can be longer or shorter.

3.2.1 Inputs

**Step 1:** Looking at both the flowchart of your site and Table 1: List of inputs with their corresponding sources the list of typical water Inputs, choose the relevant inputs for the site. Add any others if necessary. For all inputs include the flow volume, source and water quality.

**Lakes And Rivers, Engineered Storages, Bore fields, Seas And Oceans, Third Party Water**

Water sourced from water bodies that are managed by parties external to the site is usually metered and monitored so it should be easy to get the volume and quality.

**Entrained water in ore**

The volume of water that is entrained in the ore \( V_{\text{ent}} \) (ML) can either be known or estimated. To calculate this value:

\[
V_{\text{ent}} = 1000 \times P \times m
\]

where \( P \) is the incoming ore processed in the reporting period (Mt) and \( m \) is the moisture content as a fraction.

The moisture content is specific to the ore body and should be known by the site. However, in the absence of such information a reasonable estimate of the entrainment volume can be assumed by using a moisture content between 0.02 to 0.03.

The water quality can be considered poor and therefore placed into Category 3.

**Rainfall and runoff**

*Data extraction from existing site specific water system models*

If there is a site specific model that contains or can simulate data needed for the rainfall and runoff volumes into stores use this.

While the MCA does not endorse any particular rainfall and runoff model, the following common models have been provided for reference:

- AWBM
- Sacramento
- SimHyd
- SMAR
- Tank

It should be emphasised that the Water Accounting Framework is independent of software or hydrological models. The water volumes to create the water account can be generated through a combination of measurements, simulations and estimates and the methodology and the reporting of the framework still applies.

**Manual calculations**

If a hydrological model is not available, manual calculations can be used to derive rainfall and runoff values.
**Store aggregation**

Stores are grouped in the framework representation so it is not necessary to calculate the rainfall and runoff separately for each store. You will need to look at the flowchart and for each store, identify whether it is a raw water store or a mixed water store.

If the store only receives:
- rainfall and runoff or/and
- water from site inputs,
then it is a raw water store.

If a store receives:
- flows directly from task(s) or
- water that originates from a store that receives water from a task,
then the store contains worked water and it is labelled a mixed water store. Mixed water stores will also receive raw water from site inputs (at the very least rainfall) or the raw water store.

There may even be an instance where the site has worked water returning to each store or all stores are linked in which case there is only the mixed water store.

---

**As represented by site flowchart**

*Figure 6: Example of how the site water system is to be represented for the water accounting framework*

In Figure 6, what is not shown in a site flowchart is that rainfall is incident on all the dams and this is made explicit in the framework version.

Dam 1 is clearly a mixed water store because it receives worked water from the ore processing task and it receives site input water in the form of rainfall and runoff.

Similarly Dam 2 is a mixed water store because it indirectly receives worked water from Dam 1.

Dam 3 receives creek water and rainfall and runoff which are all site inputs so it is a raw water store.

Dam 4 only receives rainfall and runoff and is a raw water store.

Thus all stores are grouped into the raw and mixed water stores. Once you have identified the stores, total the raw water store surface areas and catchments. Do the same for the mixed water store.
Table 3: Grouping the stores

<table>
<thead>
<tr>
<th>Dam name</th>
<th>Raw or Mixed Water Store?</th>
<th>Surface Area (ha)</th>
<th>Undisturbed Catchment area (ha)</th>
<th>Disturbed Catchment area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dam 1</td>
<td>Raw</td>
<td>SA₁</td>
<td>UC₁</td>
<td>DC₁</td>
</tr>
<tr>
<td>Dam 2</td>
<td>Raw</td>
<td>SA₂</td>
<td>UC₂</td>
<td>DC₂</td>
</tr>
<tr>
<td>Raw water store</td>
<td>Total</td>
<td>SA₁ + SA₂</td>
<td>UC₁ + UC₂</td>
<td>DC₁ + DC₂</td>
</tr>
<tr>
<td>Dam 3</td>
<td>Mixed</td>
<td>SA₃</td>
<td>UC₃</td>
<td>DC₃</td>
</tr>
<tr>
<td>Dam 4</td>
<td>Mixed</td>
<td>SA₄</td>
<td>UC₄</td>
<td>DC₄</td>
</tr>
<tr>
<td>Mixed water store</td>
<td>Total</td>
<td>SA₃ + SA₄</td>
<td>UC₃ + UC₄</td>
<td>DC₃ + DC₄</td>
</tr>
</tbody>
</table>

To calculate the volume of rainfall incident on the stores and tailings facility $V_{\text{rainfall}}$ (ML):

$$V_{\text{rainfall}} = 0.01 \times R \times SA_{RM}$$

where $R$ is the rainfall measured during the reporting period (mm) and $SA_{RM}$ is the surface area of the raw water store or the mixed water store (calculate separately). Redo the calculation for the wet surface area of the tailings storage facility (ha).

To calculate the run-off volume $V_{\text{runoff}}$ (ML) use

$$V_{\text{runoff}} = 0.01 \times R \times A \times \beta$$

where $R$ is the rainfall measured during the reporting period (mm), $A$ is the undisturbed/disturbed catchment area (ha) and $\beta$ is a volumetric rainfall/runoff factor.

An undisturbed catchment area is one where the runoff does not come into contact with the by-products of the mine site. An estimate for $\beta_{\text{undisturbed}}$ is 0.05. Otherwise the catchment area is disturbed and an estimate for $\beta_{\text{disturbed}}$ is 0.15.

Runoff from an undisturbed catchment may be water of quality category 1 whilst water from disturbed catchments may be of category 2 or 3.

Ore body dewatering

Ore body dewatering is clearly an input because this water has not been used for a task. If the water is stored, treated or put directly to a task then the water becomes part of the Operational Model and it is to be reported in the ‘Input-Output Table’. It is suggested that the flow volumes and quality may be obtained from the mining team.

3.2.2 Outputs

Step 2: Looking at both the flowchart of your site and Table 2: List of outputs with their corresponding destinations the list of typical water Outputs, choose the relevant outputs for the site. Add any others if necessary. For all outputs include the flow volume, destination and water quality.

Discharge

Because of the legal obligations surrounding discharge from a site, the water volume and quality is generally well monitored.

Third party supply

Similarly, output to third-party supply is usually well monitored. Third party supply also includes situations where no money changes hands but there is an understanding that the site will provide water to community groups or local landholders.
**Entrained water in waste material and product**

Water entrained in product and coarse reject material is often monitored by process engineers. The water entrained in the tailings is the water that cannot be recovered via decant. Typically tailings entrainment can be found by conducting a water balance around the tailings dam assuming that the site is recovering all the water it can. The coal mine case study shows an example of this. There is an exception to this and that is when a site is using its tailings storage facility as a water store. It is anticipated that this would be rare because it is poor practice to do this but the copper-gold mine shows an example of this. Entrained water is of quality category 2 or 3.

**Task loss**

Task losses can be found through balancing the water around tasks since a task cannot store water. This will be covered in more detail in the Operational Model.

**Evaporation**

All stores will experience significant volumes of evaporation from them unless the site employs measures to limit it. The simplest method to calculate evaporation losses $V_{\text{evap}}$ (ML) from stores is to use:

$$V_{\text{evap}} = 0.01 \times S_{\text{evap}} \times \text{PanEvap} \times f$$

$S_{\text{evap}}$ is the average surface area (ha) occupied by water in the store during the calculation period, and is estimated based information about the geometry of the store (to understand how $S_{\text{evap}}$ varies with the depth of water) and water levels in the store during the calculation period. Do the calculation for the raw water store, the mixed water and the tailings storage facility.

PanEvap is the value of measured rates of pan-evaporation (mm) during the reporting period, based on the use of evaporation pans that hold water and from which losses via evaporation are monitored. Long-term sequences of measured pan evaporation rates can be obtained from the Bureau of Meteorology. Ideally, they would be measured on-site via automatic weather stations.

$f$ is a correction factor to convert measurements of pan evaporation into evaporation losses from open storages. For pan evaporation rates measured with a Class A pan, the correction factor is often around 0.75.

Other ways to obtain evaporation are direct measurements such as the micro-lysimeter method and the eddy covariance method, or a combination of evaporation models (Penman – Monteith – Unsworth) plus measurements to supply the input parameters of the models. As with the rainfall and runoff component, use site specific models if available to simulate evaporation.

The water quality of evaporated water is of category 1.

**Seepage**

Calculation methods for modelling seepage losses from stores tend to be complex. Simpler ways are to calculate seepage losses to close the water balance of a store if all other inputs and outputs are known (or calculated) and variations in water levels in the stores are well monitored. For instance, monitor the piped inputs and outputs to the store closely during a period of no rainfall, measure the change in store depth and measure the evaporation. The seepage value will close the balance.

It is only necessary to calculate evaporation and seepage losses from stores that actively store water and experience significant evaporation and seepage losses (significant enough to affect the yearly water balance). Stores whose main purpose is to transfer water to other active stores, can assume to have minor evaporation and seepage losses.

The water would be of low quality, typically in Category 2 or 3.
3.2.3 Diversions

Step 3: Record any diversions. They can be identified as water flows that do not go to a task, or a treatment plant or a store that is part of the operational model of the site.

Examples of diversions include creek diversions, runoff diversions; and aquifer dewatering with either subsequent groundwater reinjection or transfer to surface water external to the site. They can be identified when water flows from a site input to a site output without coming into contact with a task, a treatment plant or a store that is used by the operational facility.

Diversions should be appended to the Input-Output Statement. Diversions have their own list of inputs and outputs.
At this stage, there is enough information to fill in the first three data entry columns of the Input - Output Statement.

### Table 4: Input-Output Statement

<table>
<thead>
<tr>
<th>Input-Output</th>
<th>Element</th>
<th>Sub-element</th>
<th>Volume of Water in Quality Category Number</th>
<th>Accuracy (high, medium, low)</th>
<th>Notes (1,2..)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 (ML)</td>
<td>2 (ML)</td>
<td>3 (ML)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sub-Element Total (ML)</td>
<td>Measured</td>
<td>Estimated</td>
</tr>
<tr>
<td>Inputs</td>
<td>Surface Water</td>
<td>Precipitation and Runoff</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rivers and Creeks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>External Surface Water Storages</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Groundwater</td>
<td>Aquifer Interception</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bare Fields</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Entainment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sea Water</td>
<td>Estuary</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sea/Ocean</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Third Party Water</td>
<td>Contract/Municipal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Waste Water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TOTAL INPUTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outputs</td>
<td>Surface Water</td>
<td>Discharge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Environmental Flows</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Groundwater</td>
<td>Seepage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reinjection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sea Water</td>
<td>Discharge to Estuary</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Discharge to Sea/Ocean</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Supply to Third Party</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>Evaporation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Entainment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other (define)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TOTAL OUTPUTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**DIVERSIONS**

<table>
<thead>
<tr>
<th>Input-Output</th>
<th>Element</th>
<th>Sub-element</th>
<th>Volume of Water in Quality Category Number</th>
<th>Accuracy (high, medium, low)</th>
<th>Notes (1,2..)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 (ML)</td>
<td>2 (ML)</td>
<td>3 (ML)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sub-Element Total (ML)</td>
<td>Measured</td>
<td>Estimated</td>
</tr>
<tr>
<td>Inputs</td>
<td>Surface Water</td>
<td>Precipitation and Runoff</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Groundwater</td>
<td>Aquifer Interception</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TOTAL DIVERSION INPUTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outputs</td>
<td>Surface Water</td>
<td>Discharge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Groundwater</td>
<td>Reinjection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>Evaporation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TOTAL DIVERSION OUTPUTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes disclosures provide information about how each element was calculated (for example, “Note 1: rainfall and runoff calculated with a simple method outlined in Document X”). They are an essential part of the Input-Output statement. The case studies give examples of them.
3.3 Accuracy Statement

The Accuracy Statement shows the proportions of flows by volume which are measured, estimated or simulated along with the level of confidence with which that number is known; e.g. high, medium or low.

The main advantage to the site of the accuracy statement is that it highlights where effort can be made to reduce the gaps in data acquisition.

**Measured flows** are flows that are metered or measured. For example, third party water may be metered. The entrainment in the ore can be considered to be a measured flow if the moisture content is measured and the throughput of the feed ore is measured.

**Simulated flows** are ones that are simulated by a model. Rainfall and runoff values obtained from a hydrological model that has been calibrated for the site would be considered simulated flows.

**Estimated flows** may be flows that are calculated to close a balance, or there is a calculation for them but the input parameters may not be well known, or they are a 'guess' based on typical values. For instance, a runoff value that was obtained using the formula given in Step 1, could be considered a low level estimated flow because the coefficients are approximate numbers and not specific for the site.

**Step 4**: Record in the Input-Output Statement which flows were measured, simulated or estimated and give a confidence level of the accuracy of the flow i.e. high, medium or low.

For the Inputs, Outputs and Diversion sum the volume of flows that were measured:

- with a high confidence level. Record this number in Table 5: Interim step to calculate the accuracy statement for the inputs, outputs and diversions.
- with a medium confidence level. Record this number in Table 5: Interim step to calculate the accuracy statement for the inputs, outputs and diversions.
- with a low confidence level. Record this number in Table 5: Interim step to calculate the accuracy statement for the inputs, outputs and diversions.

Do the same for the estimated flows and the simulated flows.

**Table 5: Interim step to calculate the accuracy statement for the inputs, outputs and diversions.**

<table>
<thead>
<tr>
<th>Flow types**</th>
<th>Confidence level</th>
</tr>
</thead>
<tbody>
<tr>
<td>(ML)</td>
<td>High</td>
</tr>
<tr>
<td>Measured</td>
<td></td>
</tr>
<tr>
<td>Estimated</td>
<td></td>
</tr>
<tr>
<td>Simulated</td>
<td></td>
</tr>
</tbody>
</table>

** How were the flows measured?

Sum the total volume of all flows in Table 5. Convert the numbers to percentages of all flows by volume in Table 6.
### Table 6: Accuracy statement for the inputs, outputs and diversions.

<table>
<thead>
<tr>
<th>Flow Types</th>
<th>% of all Flows</th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimated</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simulated</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 3.4 Input-Output Water Balance Summary

The purpose of the summary (Table 7: Input-Output Water Balance Statement) is to answer the question:

Does the input-output = change in storage?

### Table 7: Input-Output Water Balance Statement

<table>
<thead>
<tr>
<th>1. Input-Output Water Balance Statement</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Inputs</td>
<td>ML</td>
</tr>
<tr>
<td>Total Outputs</td>
<td>ML</td>
</tr>
<tr>
<td>Inputs - Outputs</td>
<td>ML</td>
</tr>
<tr>
<td>Storage at Start</td>
<td>ML</td>
</tr>
<tr>
<td>Storage at End</td>
<td>ML</td>
</tr>
<tr>
<td>Change of Storage</td>
<td>ML</td>
</tr>
</tbody>
</table>

**Step 5**: Record the water levels of all stores at the start and end of the reporting period.

The difference between the sum of inputs and the sum of outputs should equal the difference between the volume of water stored at the start of the reporting period and the volume of water stored at the end of the reporting period.

### 3.5 Constructing the Operational Model

In this sub-section of Account Development you will construct your Operational Model which you need to generate the Statement of Operational Efficiencies. You will list the tasks, stores and treatment plants of the site and the flows between them. The stores may have already been grouped into the raw water store and mixed water store when calculating the rainfall and runoff. However, if you have not done so because you had access to site-specific hydrological models to simulate the rainfall and runoff, then it will be necessary to do it now.

**Step 6**: With the assistance of a flowchart, list the tasks, the treatment plants and the stores. Group tasks and stores according to purpose.

Treatment plants – only on-site treatment plants need to be listed for the purposes of calculating the recycling efficiency. If the site receives treated effluent from an external party, then this is considered third party water.

Stores – For the purposes of the operational model, there is no need to consider the stores individually. The operational model is a conceptual model to simplify the calculations in Steps 8-10. In this step, it does not matter if physically there are 6 stores. Please refer to store aggregation step under *Rainfall and Runoff* in Section 3.2.1 so as to obtain two stores: the raw water store and the mixed water store.

Tasks – A task is any activity that uses water. Where possible, group tasks to simplify the Operational Model. For the framework there is no need to know the intermediate flows between unit operations. The activities list provided in Section 2.5.3 should cover most processes.
Step 7: Work out the inflows and outflows of remaining elements.

The site’s flowchart should show the relationship between the individual stores and tasks and recreate the relationships between the grouped stores and tasks in the framework representation. You must include the elements that are not usually shown in site flowcharts of the water system. For instance, the flowchart represented in Figure 8 below does not show rainfall and runoff, evaporation, task loss, seepage and tailings entrainment but they have been identified as a site input in the case of rainfall and runoff and the rest are site outputs. They are shown explicitly in Figure 9.

![Figure 8: Site flowchart representation](image)
A task cannot store water (except in the case of the tailings storage facility) so the water into a task must equal the water out including any losses. Thus in Figure 9 each task box must have an outflow either to another task, the mixed water store or to a site output (e.g. evaporation, task loss or seepage.

Typical examples where water is returned to the mixed water store are water from the thickeners inside of the ore processing task and decant from the tailings storage facility (see Figure 9). The tailings storage facility is a special type of task because technically it can store water so in this instance the inflows do not have to equal the outflows. In practice, it is poor management to have water accumulate in the tailings storage facility. Besides decant water, the other outflows of the tailings storage facility are evaporation and entrained water in the tailings which cannot be recovered.

### 3.6 Statement of Operational Efficiencies

The Statement of Operational Efficiencies shows the proportion of reuse and recycled flows in relation to the total flows into the tasks. By this stage the framework representation should be complete with flow values. Steps 8-10 require you to work off the framework representation of your site.

**Step 8**: Referring to your framework representation, add up all the inflows to the tasks.

Figure 8 indicates that there are three tasks. In order to calculate the total inflows to tasks, so let it be supposed that the flow values to the tasks are as shown in Figure 10. Figure 10 is not a new representation but an extract of the framework representation simply to highlight the inflows to the tasks.

The inflows to the tasks are not just the yearly task demands from the stores. All elements of the framework must be included which for this example includes rainfall and runoff, and ore entrainment. The total inflow to tasks is the sum of all flows to tasks (100+180+5,796+4,296+160): 10,532 ML/year.

![Figure 10](image-url)  
*Figure 10: Extract from Figure 9 to show the inflows to the tasks. Values are in ML/year*

**Step 9**: From the same framework representation, add up the worked water that goes to a task.

Given a mixed water store contains raw water, you must first work out the proportions of water that are raw and worked water.
3.6.1 Reuse and Recycling Efficiency

Reused water is worked water that is used in a task without treatment beforehand. The Re-use Efficiency is the sum of worked water flows to the tasks as a proportion of the sum of all flows into the tasks.

\[
\text{Reuse Efficiency} = \frac{\text{Sum of Worked Water Flows to Tasks}}{\text{Sum of All Flows to Tasks}}
\]

Recycled water is worked water that is treated before it is used in a task. Recycling Efficiency is the sum of treated worked water flows to tasks as a proportion of the sum of all flows into the tasks.

\[
\text{Recycling Efficiency} = \frac{\text{Sum of Treated Worked Water Flows to Tasks}}{\text{Sum of All Flows to Tasks}}
\]

To obtain the Reuse Efficiency it is necessary to calculate the sum of worked water flows to tasks. This is not as simple as reading a meter from the process water store to the tasks as this method will overestimate the amount of worked water because the mixed water store holds both raw and worked water. The proportion of worked water in the mixed water store must be calculated. Although it will change over the course of a reporting period depending on rainfall events, a simple approximation is sufficient.

Let it be supposed that in Figure 9, the flow values into the mixed water store are as shown in Figure 11.

![Figure 11: Extract from Figure 9 to show the inflows to the mixed water store. Values are in ML/year.](image)

The tailings storage facility is considered a task so all the water from there is worked. The flow back from the ore processing plant is worked. Hence, it can be seen that 4,092 ML/year (1,500+2,592) of worked water enters the mixed water store.

Raw water from the raw water store (1,320ML) and from the rainfall and runoff input (175ML) totals 1,495 ML over the course of the year. Thus 4,092/(4,092+1,495) which is equal to 73% of the inflow is worked water. If it is assumed that the proportion of raw and worked water in the mixed water store is in the same proportion then only 73% of the water in the mixed water store is worked water.
To calculate the worked water flow to tasks from Figure 10: Extract from Figure 9 to show the inflows to the tasks. Values are in ML/year, the flow from the ore processing task to the tailings storage facility is all worked (4,296 ML). Only 73% of the 5,796 ML of mixed water to the ore processing task is worked (4,231 ML). So the total worked water to tasks (i.e. the reused water) is (4,296+4,231) 8,527 ML/year.

The reuse percentage is 8,527/10,532 which is equal to 81%.

**Step 10:** Referring to your framework representation, add up the volume of treated worked water that goes to tasks.

For water to be labelled “recycled” it must meet the criteria of treated worked water that is used in a task. Raw water that is treated and goes to a task does not count towards this volume. The water must have gone through a task to become worked water, then through a treatment plant to become treated worked water. To be considered recycled, this volume of treated worked water must then go to a task either directly (as indicated in Figure 12) or via the mixed water store. If the treated worked water goes to the mixed water store prior to going to a task then you must calculate the proportion of treated worked water in the mixed water store using the method in Step 9. It is anticipated that because the mining industry is able to utilise low quality water, the reuse proportion will be a great deal larger than the recycled proportion.

![Diagram to show the definition of treated worked water](image)

Figure 12: Diagram to show the definition of treated worked water

The Statement of Operational Efficiencies for the framework representation given in Figures 8 – 10 is given in Table 8.

<table>
<thead>
<tr>
<th>Operational efficiencies</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total volume to tasks (ML/year)</td>
<td>10,532</td>
</tr>
<tr>
<td>Total volume of reused water (ML/year)</td>
<td>8,527</td>
</tr>
<tr>
<td>Reuse efficiency (%)</td>
<td>81</td>
</tr>
<tr>
<td>Total volume of recycled water (ML/year)</td>
<td>0</td>
</tr>
<tr>
<td>Recycling efficiency (%)</td>
<td>0</td>
</tr>
</tbody>
</table>

*The site does not have a treatment plant so there is no recycled water.

4 The Contextual Statement

The Contextual Statement should provide background on the water resources of the facility as well as any conditions that have an impact on the management of those resources. This should include:

- Description of geographical terrain in which the operational facility is sited
- Catchment details
- Climatic conditions during the reporting period
- Information on water policy and rules applicable to the operational facility
- Administrative changes (i.e. changes to water sharing plans)

An example of the type of information to be included in the Contextual Statement is provided in the following sections.
4.1 System boundary description
The operational facility, for which the contextual information is prepared, is the International Mining Company (IMC). The water system comprises of:

- XYZ Creek
- ABC River – regulated
- International Mining Company processing and mining facilities
- Township supply network
- Groundwater supply

4.2 Water Resources
The IMC reporting entity has a diverse number of water sourcing options which include the harvest of runoff, interception of groundwater and precipitation, groundwater bores, extraction from creeks and rivers and from nearby township supply networks.

Third party water, between the IMC reporting entity and nearby township supply networks, is the principal water resource for the IMC. This resource accounts for 44% of the total water sourcing activities onsite in the reporting period, which is closely followed by the 40% sourced from surface water rivers and creeks. The site holds a licence to extract water from ABC River and XYZ Creek.

Groundwater sourced through interception and extraction accounts for approximately 10% of the IMC’s water sourcing activities.

Further surface water resources sourced through direct precipitation interception and runoff harvesting reported for approximately 6% of the total water inputs to site.

Long term data for assessment of long term average dependencies is unavailable at this point.

4.3 Water Infrastructure
The IMC reporting entity relies on two major stores to accommodate the volume of water required to adequately supply current demand as well as mitigate future risk. This management structure is further supported by smaller stores that hold small amounts of water needed to manage the onsite operational use of water.

The two principal stores are the Large Dam and XYZ Creek Dam. These dams have maximum holding capacities of 4,200ML and 3,700ML respectively, and are owned and operated by the operational facility.

4.4 Water Resource Management Instruments
Water sourcing activities managed by the IMC must follow the rules as set out in the water sharing plan for the ABC regulated river as well as those in the macro groundwater sharing plan for the groundwater supply. Moreover, International Mining Company has its own operational management policies and regulations aimed at maintaining water supply and minimising discharge risk. Project approvals requirements include an additional layer of regulatory access requirements.

4.5 Water Management Bodies
The main bodies with responsibility for the management of the water resources that constitute the IMC water system are:

- State Water – This corporation is responsible for the management of water delivery and compliance with the rules set out in water sharing plans.
- Department of Water and Energy (DWE) – This department is responsible for the development of policies, regulations and plans regarding water resource management. Specifically, their responsibility lies in the development of water sharing plans which are then enforced by State Water.
The particular regional Catchment Management Authority – This group is responsible for engaging with the community on natural resource management within the region.

International Mining Company water team – This group manages the site's internal specific water needs in compliance with legislative requirements regulated by the above main bodies.

The particular local councils from which third party water is sourced. These organisational bodies comply and cooperate with State Water which in turn is compliant with regional water plans set by the Department of Water and Energy.

4.6 Climatic Conditions
The average temperature for the reporting period was 13.3 degrees Celsius which is similar to the long term average (1907-2007) of 13.2 degrees Celsius. The total rainfall for the reporting period was 710mm. To compare, the long term yearly rainfall average from 1907-2007 was 817mm. (Climate data sourced from BoM SILO.)

4.7 Inputs and Outputs
The major source of inflows into the IMC entity came from the contractually agreed third party water sourced from other supply networks, regulated surface water extraction from affiliated system rivers and creeks, as well as unregulated surface water harvesting via runoff and rainfall (3,800ML, 40.8%; 2,535ML, 27.3%; and 1,132ML, 12.2% respectively). These flows were supplemented by regulated and unregulated groundwater flows as well as entitlement transfers, which constitutes the remainder.

The major outflows include evaporation, which accounted for 4,202ML (46.6%), and entrainment (3,895ML, 43.2%). The remainder was lost via seepage, miscellaneous task losses and environmental flows.

4.8 Allocations and Restrictions
IMC holds 5 State Water licences which entitles the entity to general security, high security and surface water extracted from onsite creeks as well as groundwater via extraction and interception. The entitlement licences are as follows:

- General security – 4,080ML/Yr (~0.7% of the total general security access available)
- High security – 3,125ML/Yr (11.8% of the total high security access available)
- Onsite surface water extraction – 4,200ML/Yr (~0.7% of the total general security access available)
- Exploration interception – 931ML/Yr (14.8% of the total entitlement for the ground water supply)
- Bore field extraction – 371ML/Yr (5.9% of the total entitlement for the groundwater supply)

Monthly allocations are set by the DWE and water restrictions are as per the rules set out in the water sharing plan for the regulated river systems.

The conditions for extraction from onsite creeks are as follows:

- Water is released from the dam to maintain a flow of 0.4ML/day at the metering point
- When inflows are between 0.4 and 3.4 ML/day, water is released from the dam to achieve a flow rate at the metering point equal to the inflow into the dam.
- When inflows are greater than 3.4ML/day, water is released from the dam to maintain a flow of 3.4ML/day at the metering point
- Once per quarter a medium flow event is to be achieved at the metering point. A medium flow event involves a flow of greater than 10ML/day for at least 3 days.

4.9 Trading Activity
The sale and purchase of water rights to and from neighbouring water entities is common in the minerals industry of Australia and must adhere to the water sharing plans under which the reporting entity falls. In 2007/08 period entitlements were purchased from land owners on the ABC river catchment. This transfer accounted for 4.8% of the overall water sourcing activities onsite.

The next section presents two case studies. The accounts of the two case studies should be presented with contextual statements however the sites are an amalgamation of many sites in order to illustrate aspects of the framework, therefore mock contextual statements have not been provided.
5 Case Studies

Two example case studies have been provided to illustrate the application of the framework. These include a coal mine and a copper-gold mine case studies.

In addition to the above case studies, examples of applying the framework to a high rainfall (wet) and low rainfall (dry) sites have been provided for comparison.

5.1 A Coal Mine Case Study

The case study shows how to convert the site water flowchart to the framework level representation and gives you guidance on how to gather the information. The explanations, assumptions and calculations that have been given for this case study are examples only. Please use site specific knowledge where it exists.

The block diagram provided for the coal mine is typical of site water flowcharts. The framework representation needs to show the elements that are not usually made explicit such as rainfall and runoff, moisture in products and rejected material, evaporation, task loss and seepage.

5.1.1 Coal Mine Input-Output Model

![Coal mine water flowchart]

Figure 13: Coal mine water flowchart

**Step 1:** Looking at both the flowchart of your site and the list of typical water Inputs (Section 2.2.1, Table 1), choose the relevant inputs for the site. Add any others if necessary. For all inputs include the flow volume, source and water quality.

The only input that is shown in the block diagram is town water. But from the list of inputs, you must include:

- rainfall and runoff into the stores and tailings storage facility,
- the moisture in the coal to be processed.
Town water
Town water volumes are well monitored and easily obtained from Operations. 468 ML/year enters the raw water dam. The water quality is monitored and from working through the decision tree ( ), is found to be water of category 1. The water is purchased and the site is unaware of the source so the category ‘third party water’ applies to it.

Moisture in coal
The moisture in the coal can be found from the engineering department. Use the formula

\[ V_{\text{ent}} = 1000 \times P \times m \]

where \( P \) is the incoming ore processed in the reporting period (Mt) and \( m \) is the moisture content as a fraction to obtain the volume of entrained water \( V_{\text{ent}} \).

The moisture content of the coal is 4% so 0.04.

The throughput is 11.4Mt/year so the volume of water entrained is 442ML/year. It is poor quality water: Category 3. The source of entrained water is groundwater.

Rainfall and runoff
For this example it will be assumed that the site does not have a hydrological model and so manual calculations will be shown.

Store aggregation
Following the procedure under Rainfall and Runoff in Section 3.2.1, group the stores so that there is only a raw water store and a mixed water store. From the block diagram, the raw water dam only receives town water and rainfall and runoff which are both site inputs so it is a raw water store.

The mine water store receives the decant water from the tailings storage facility which is worked water so it is grouped in with the mixed water store.

The disused pit is used as a water store and receives water from the mine water store so it too contains worked water and is considered part of the mixed water store.

The remaining stores are a series of sedimentation ponds that are used to settle the solids of runoff from disturbed land prior to the runoff entering the creek. The ponds’ inflows are rainfall and runoff (site input). The ponds’ outflow is to the creek. In this instance the water path does not come into contact with the Operational Model. The sedimentation ponds are not acting as stores for the mine site but meet the definition of a diversion. The sedimentation ponds are not to be grouped with the raw water store but you will still have to calculate the rainfall and runoff to them.
Table 9: Grouping the stores for the coal mine case study

<table>
<thead>
<tr>
<th>Dam name</th>
<th>Raw or Mixed Store?</th>
<th>Surface Area (ha)</th>
<th>Undisturbed Catchment area (ha)</th>
<th>Disturbed Catchment area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw water Dam</td>
<td>Raw</td>
<td>23</td>
<td>300</td>
<td>0</td>
</tr>
<tr>
<td>Raw water store</td>
<td>Total</td>
<td>23</td>
<td>300</td>
<td>0</td>
</tr>
<tr>
<td>Mine water store</td>
<td>Mixed</td>
<td>4</td>
<td>24</td>
<td>100</td>
</tr>
<tr>
<td>Disused pit 1</td>
<td>Mixed</td>
<td>2</td>
<td>10</td>
<td>90</td>
</tr>
<tr>
<td>Mixed water store</td>
<td>Total</td>
<td>6</td>
<td>34</td>
<td>190</td>
</tr>
<tr>
<td>Sedimentation ponds</td>
<td>N/A</td>
<td>Unknown</td>
<td>unknown</td>
<td>141</td>
</tr>
<tr>
<td>TSF</td>
<td>N/A</td>
<td>30</td>
<td>unknown</td>
<td>unknown</td>
</tr>
</tbody>
</table>

To calculate the volume of rainfall incident on the stores, sedimentation ponds and tailings facility $V_{\text{Rainfall}}$ (ML):

$$V_{\text{Rainfall}} = 0.01 \times R \times SA$$

$R$ is the rainfall measured during the reporting period (mm). The rainfall may be measured on site or otherwise, you can obtain rainfall measurements from the Bureau of Meteorology. For this case study, it was obtained from the Bureau of Meteorology and had a value of 600 mm/year for the reporting period.

$SA$ are the surface areas of the grouped stores and have been given in the table.

138 ML/year of rainfall entered the raw water store, 36 ML/year of rainfall entered the mixed water store and 180 ML/year entered the tailings storage facility. Because the water is directly incident on the stores, the rainfall is assumed to be of good quality so it is Category 1 water.

To calculate the run-off volume $V_{\text{Runoff}}$ (ML) use:

$$V_{\text{Runoff}} = 0.01 \times R \times A \times \beta$$

where $R$ is the rainfall measured during the reporting period (600 mm), $A$ is the undisturbed/disturbed catchment area (ha) and $\beta$ is a volumetric rainfall/runoff factor. An estimate for $\beta_{\text{undisturbed}}$ is 0.05. An estimate for $\beta_{\text{disturbed}}$ is 0.15.

An undisturbed catchment area is one where the runoff does not come into contact with the by-products of the mine site. The quality of water should be good so Category 1 can be assigned to it. Therefore the runoff from the undisturbed catchment into the raw water store is 90 ML/year. The runoff from the undisturbed catchment into the mixed water store is 171 ML/year.

The disturbed catchment area is 190 ha. The runoff from the disturbed catchment into the mixed water store is 171 ML/year. The runoff from the disturbed catchment into the sedimentation ponds is 127 ML/year. This water will usually be of a poorer quality therefore it can be assigned to Category 2.

The runoff into the sedimentation ponds is diverted flow - not an input of the operational model – and is recorded in the diversion section of the Input – Output statement.

Regarding the unknown amounts in the table; it is recommended that you work with the data that you have, rather than wait until you can create a complete account. It is unlikely that you will have all the data required. The accuracy of the account will be communicated in the Accuracy Statement.

**Outputs**

**Step 2:** Looking at both the flowchart for your site and the list of typical water Outputs, choose the relevant outputs for the site. Add any others if necessary. For all outputs include the flow volume, destination and water quality.

For the coal mine the outputs are to the creek, task losses, evaporation, seepage and entrainment in the product and reject material. Note that the creek output is to be recorded in the diversion section of the Input-Output table.
**Entrained water in the product and waste material**

The volume of entrained water in the product was obtained from the processing team (744 ML/year). It is assumed that this will be of very poor quality water so Category 3. The water in the entrained waste material in the tailings dam (T) will be calculated in the Coal Mine Operational Model.

**Task losses**

The task losses (L) are worked out during the generation of the Operational Model and so will be left out for now. They are found through balancing the water around tasks since a task cannot store water.

**Evaporation**

Evaporation $V_{\text{Evap}}$ (ML/year) from the raw store (345 ML/year), mixed water store (90 ML/year) and tailings (450 ML/year) were calculated using:

$$V_{\text{Evap}} = 0.01 \times S_{\text{Evap}} \times P_{\text{Evap}} \times f$$

1. $S_{\text{Evap}}$ is the average surface area (ha) occupied by water in the store during the reporting period.
2. $P_{\text{Evap}}$ is the value of measured rates of pan-evaporation (2000 mm/year) during the reporting period. They were obtained from the Bureau of Meteorology.
3. $f$ is a correction factor to convert measurements of pan evaporation into evaporation losses from open storages. An estimate of 0.75 was used.

There will also be evaporation of the water used for dust suppression on the haul roads (E).

The water quality of evaporated water is of Category 1.

**Seepage**

This coal mine has no hydrological model and no value for seepage losses (S). At this stage of generating the account, a flow value for seepage cannot be calculated. Seepage is calculated after Step 8, to close the balance.

**Diversions**

**Step 3:** Record any diversions.

The runoff from the disturbed catchment into the sedimentation ponds is 127ML/year, Category 2.

**Creek**

The flow to the creek is not an output of the operational model but a diversion output and is reported in the relevant part of the Input-Output Statement. Although the sedimentation ponds can at any given time store water, it will be assumed that over the course of the year, the same volume entered and exited the ponds – 127ML/year.

Figure 14 shows the completed framework representation with all flows volumes but at this stage, it is worthwhile drawing the framework representation and filling in the Input - Output Statement with the numbers that you have. When entering the data, make sure you are in the correct column for the water quality category.
Table 10: Interim Input-Output statement for coal mine case study

<table>
<thead>
<tr>
<th>Input-Output</th>
<th>Element</th>
<th>Sub-element</th>
<th>Water Quality</th>
<th>Category 1 (ML)</th>
<th>Category 2 (ML)</th>
<th>Category 3 (ML)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inputs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
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<tr>
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<td>Rivers and Creeks</td>
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<td></td>
<td>External Surface Water Storages</td>
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<tr>
<td>Groundwater</td>
<td>Aquifer Interception</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Bore Fields</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Entrainment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sea Water</td>
<td>Estuary</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sea/Ocean</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Third Party Water</td>
<td>Contract/Municipal</td>
<td></td>
<td></td>
<td>468</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Waste Water</td>
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<tr>
<td><strong>TOTAL INPUTS</strong></td>
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<td>943</td>
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<td>442</td>
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<tr>
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<tr>
<td>Surface Water</td>
<td>Discharge</td>
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</tr>
<tr>
<td></td>
<td>Environmental Flows</td>
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<td>Seepage</td>
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<tr>
<td></td>
<td>Reinjection</td>
<td></td>
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<tr>
<td>Sea Water</td>
<td>Discharge to Estuary</td>
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<td></td>
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<td>Discharge to Sea/Ocean</td>
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<tr>
<td>Supply to Third Party</td>
<td>Evaporation</td>
<td></td>
<td></td>
<td>885+E</td>
<td></td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
<td>744+T</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Task loss</td>
<td></td>
<td></td>
<td>L</td>
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<tr>
<td><strong>TOTAL OUTPUTS</strong></td>
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<td></td>
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<td>744</td>
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**DIVERSIONS**

<table>
<thead>
<tr>
<th>Input-Output</th>
<th>Element</th>
<th>Sub-element</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inputs</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>Precipitation and Runoff</td>
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<td>Groundwater</td>
<td>Aquifer Interception</td>
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</tr>
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<td>0</td>
<td></td>
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<td><strong>Outputs</strong></td>
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<tr>
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<td>Discharge</td>
<td></td>
<td>127</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Groundwater</td>
<td>Reinjection</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>Evaporation</td>
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<tr>
<td><strong>TOTAL DIVERSION OUTPUTS</strong></td>
<td></td>
<td></td>
<td>127</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
**Step 4:** Record in the Input-Output Statement which flows were measured, simulated or estimated and provides a confidence level of the accuracy of the flow i.e. high, medium or low.

The climate data – rainfall/runoff and evaporation – were found using very simple formulas and generic coefficients. They are estimated flows with low confidence level in the accuracy of them.

The entrained water in the coal was obtained from the processing team based on the measured values of the throughput and the moisture content so it can be considered a high accuracy, measured flow.

The third party flow was monitored so it too is a high accuracy, measured flow.

**Step 5:** Record the water levels of all stores at the start and end of the reporting period.

The level of the stores (both raw and mixed) was 4,653 ML at the beginning of the reporting period. At the end of the reporting period the level of the stores was 2,701 ML. The change in storage for the year was 1,952 ML.

5.1.2 Coal Mine Operational Model

**Step 6:** With the assistance of the site flowchart, list the tasks, the treatment plants and the stores. Group tasks and stores according to purpose.

The site has no treatment plants.

The stores have already been grouped into two stores during step 1 for the rainfall calculation.

The grouped tasks are:

- CHPP which refers to the water used in the coal handling and preparation plant
- Underground - Miscellaneous Use which refers to the water used for underground conveyor dust suppression and vehicle cooling
- Tailings Storage Facility (TSF) which refers to the water that is disposed along with the tailings
- Haul Road Water which is the water used for dust suppression of the haul roads and includes both truck fill points

**Step 7:** Work out the inflows and outflows of remaining elements.

Task demands are well monitored at the coal mine. Flows measured with high accuracy include flows to Underground Use (70 ML/year), CHPP (3,240 ML/year) and Haul Road (648 ML/year).

Other measured flows are the flow to the tailings dam from CHPP (2,609 ML/year) and the tailings decant to the mine water store (1,860 ML/year).

From the engineering department, the raw water dam feeds the mine water store as needed. On average, this amount is 300 ML/year.
Tasks cannot store water so the inflows must equal the outflows. The only exception to this is the tailings storage facility. Where the task’s water outflow does not go to another task, it is necessary to assign it to an output destination category: evaporation, seepage, entrainment, supply to third-party or other mechanisms i.e. task loss.

The water demand for the CHPP is well monitored (3,240 ML/year) and comes from the mixed water store. The water in the coal entering the CHPP is 442 ML/year. The outflow of the CHPP is to the tailings storage facility and is also well monitored (2,609 ML/year). The water contained in the product was found in the Outputs section (744ML/year). Balancing the water around the CHPP gives a discrepancy of 329ML/year which is assumed to be the task loss for the CHPP.

All the water for Underground Use is assumed to go to task loss (70 ML/year) hence the total amount to task loss is 399 ML/year. This value for task loss can now be entered into the Input-Output Statement.

The inflows for the Tailings Storage Facility comes from the rainfall calculated in Step 1 (180 ML/year) and water from the CHPP (2609 ML/year). The outflows are the decant water back to the mixed water store which was a measured flow (1860 ML/year), evaporation (450 ML/year) and entrainment in waste product (T) which was calculated to close the balance. It is assumed that the inflows and outflows must balance since it is poor practice to have water accumulate in the TSF over the course of a year and there is no evidence of water ponding for this site. Therefore:

\[ T = 180 + 2,609 - 1,860 - 450 \]

Entrained water is 479 ML/year. This value can be added to entrainment volume in the product of 744 ML/year. Total entrainment in the Input-Output Statement is 1,223 ML/year.

The water for Haul Road Water comes from the mixed water store (648 ML/year) and the total amount is evaporated. This number must now be added to the existing 885 ML/year that was estimated as the evaporation from the stores and the Tailings Storage Facility. Thus the total evaporation amount is 885 + 648 = 1,533 ML/year. This is an estimate of medium accuracy.

At this stage the missing seepage flows can be completed, since seepage will close the balance of the Input-Output Model. The total inputs to the system were 1556 ML/year, the total outputs we have so far equal 3,155 ML/year. This is a difference of - 1599 ML/year. The change in storage was - 1,952 ML/year. Since the inputs minus the outputs needs to equal the change in storage, the missing output amount is 353 ML/year of seepage. This could be classed as an estimate with a low to medium confidence level.

The Input – Output Statement is now complete.
### Table 11: Completed Input-Output Statement for coal mine case study

**Reporting period:** 1/1/10 to 31/12/10

<table>
<thead>
<tr>
<th>Input-Output</th>
<th>Element</th>
<th>Sub-element</th>
<th>Water Quality</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inputs</strong></td>
<td></td>
<td></td>
<td>Cat 1 ML</td>
<td>Cat 2 ML</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Precipitation and Runoff</td>
<td>475</td>
<td>171</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rivers and Creeks</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>External Surface Water Storages</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aquifer Interception</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bore Fields</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Entrainment</td>
<td>442</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Estuary</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sea/Ocean</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Contract/Municipal</td>
<td>468</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Waste Water</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL INPUTS</strong></td>
<td></td>
<td></td>
<td>943</td>
<td>171</td>
</tr>
<tr>
<td><strong>Outputs</strong></td>
<td></td>
<td>Discharge</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Environmental Flows</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seepage</td>
<td>353</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Re injection</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Discharge to Estuary</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Discharge to Sea/Ocean</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Supply to Third Party</strong></td>
<td></td>
<td>Evaporation</td>
<td>1533</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Entrainment</td>
<td>1223</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Task loss</td>
<td>399</td>
<td>7</td>
</tr>
<tr>
<td><strong>TOTAL OUTPUTS</strong></td>
<td></td>
<td></td>
<td>1533</td>
<td>399</td>
</tr>
<tr>
<td><strong>DIVERSIONS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Inputs</strong></td>
<td></td>
<td>Precipitation and Runoff</td>
<td>127</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aquifer Interception</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL DIVERSION INPUTS</strong></td>
<td></td>
<td></td>
<td>127</td>
<td>0</td>
</tr>
<tr>
<td><strong>Outputs</strong></td>
<td></td>
<td>Discharge</td>
<td>127</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Re injection</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL DIVERSION OUTPUTS</strong></td>
<td></td>
<td></td>
<td>127</td>
<td>0</td>
</tr>
</tbody>
</table>
Notes for Input-Output statement

1. Rainfall 600mm/year. The runoff coefficients were 0.05 for undisturbed catchments and 0.15 for disturbed catchments.
2. The moisture content of the coal is 4% and the throughput is 11.4Mt/year.
3. Metered flow
4. Calculated to close the balance
5. Evaporation rate 2000mm/year. Pan evaporation factor 0.75
6. Water in product obtained from the processing team. Water in tailings calculated to close the balance around the tailings dam.
7. Task loss calculated to close the balance around the tasks
8. Runoff from disturbed catchment is diverted to sedimentation ponds prior to discharge in the river

For the Inputs, Outputs and Diversion sum the flows that were measured:

- with a high confidence level.
- with a medium confidence level.
- with a low confidence level.

Do the same for the estimated flows and the simulated flows.

Sum all flows and represent the numbers as percentages of all flows.

<table>
<thead>
<tr>
<th>Flow Types</th>
<th>Confidence level (ML)</th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured</td>
<td>910</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Estimated</td>
<td>0</td>
<td>1,975</td>
<td>2,433</td>
<td>0</td>
</tr>
<tr>
<td>Simulated</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**How were the flows measured?**

Sum the total of all flows in Table 12 (5,318 ML/year). Convert the numbers to percentages of all flows in Table 13.

<table>
<thead>
<tr>
<th>Flow Types</th>
<th>% of all Flows</th>
<th>Confidence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured</td>
<td>17%</td>
<td>17% 0% 0%</td>
</tr>
<tr>
<td>Estimated</td>
<td>83%</td>
<td>0% 37% 46%</td>
</tr>
<tr>
<td>Simulated</td>
<td>0%</td>
<td>0% 0% 0%</td>
</tr>
<tr>
<td>Total</td>
<td>17% 37% 46%</td>
<td></td>
</tr>
</tbody>
</table>

Table 12: Interim step for the accuracy statement

Table 13: Accuracy statement for coal mine case study
Statement of Operational Efficiencies

To generate the statement of operational efficiencies:

**Step 8:** Referring to your framework representation, add up all the inflows to the tasks.

Note: It is important to add **ALL** inflows into the grey boxes.

For this site, total inflow into tasks = 70+648+180+2,609+3,240+442

= 7,189 ML/year.

**Step 9:** From the same framework representation, add up the worked water that goes to a task.

Assume the proportion of worked water in the mixed water store is the same as the proportion of worked water that enters the mixed water store during the course of a year. The detailed procedure is in Section 3.6.1.

Raw water (flows from green inputs) to mixed water store = 300+31+36+171

Worked water (flows from grey tasks) to mixed water store = 1,860

So the proportion of worked water in the mixed water store = 78%

Worked water to tasks = (flows from tasks to tasks) + ((proportion of worked water in mixed water store) X (flow from mixed water store to tasks))

=(2,609) + 0.78 X (648+3,240)

=5,642

Reuse Efficiency = Worked water flows to tasks as a proportion of the total flows to tasks

= 5,642/7,189

= 78%
**Step 10:** Referring to your framework representation, add up the volumes of treated worked water that goes to tasks. There is no treatment plant on-site so there is no recycled water.

**Table 14: Statement of Operational Efficiencies for the coal mine case study**

<table>
<thead>
<tr>
<th>Operational efficiencies</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total volume to tasks (ML/year)</td>
<td>7,189</td>
</tr>
<tr>
<td>Total volume of reused water (ML/year)</td>
<td>5,642</td>
</tr>
<tr>
<td>Reuse Efficiency (%)</td>
<td>78</td>
</tr>
<tr>
<td>Total volume of recycled water (ML/year)</td>
<td>0</td>
</tr>
<tr>
<td>Recycling Efficiency (%)</td>
<td>0</td>
</tr>
</tbody>
</table>

### 5.2 A Copper-Gold Mine Case Study

The copper-gold mine case study provides an example where water accumulates in the tailings dam and how this should be handled in the framework.

How to build the framework representation from the site water flowchart has already been shown. In this example, the starting point will be the framework representation. The inputs of the site are green, the outputs of the site are red, tasks are grey, the stores are in blue and the treatment plant is in purple. The numbers are the average volume flows in ML/year.

The copper-gold mine has a mature water management system, and has a hydrological model to provide simulated numbers for rainfall, runoff, seepage and evaporation. In addition to the hydrological models, a water balance model was used to converge the results of measurements, simulations and estimates.
5.2.1 Site summary

The raw water store physically consists of two dams that have been grouped. The mixed water store is one dam. Both stores collect rainfall and runoff.

The river water goes to an onsite dam which is part of the raw water store. Some of the river water is used to maintain vegetation along the river, denoted as an environmental flow in the framework representation.

The bore water is of a high quality and is used as the potable water for the site.

Aquifer interception is the water released from and surrounding the ore body during underground mining and goes to the mixed water store.

The town effluent is the waste water from the town that has been treated off site.

The copper-gold mine has both underground and open pit mining, sourcing their water from the mixed store.

There is an on-site treatment plant to treat the waste water generated on-site.

The ore processing plant water demand is met by the mixed water store and because it contains thickeners, returns water back to the mixed store.

Decant from the tailings storage facility goes to the mixed water store but water accumulated in the tailings dam over the course of the year.

Water leaves the site through evaporation, seepage, task loss and entrained water in the tailings.

5.2.2 Copper-Gold Mine Input-Output Model

Inputs

Step 1: Looking at both the flowchart of your site and the list of typical water inputs, choose the relevant inputs for the site. Add any others if necessary. For all inputs include the flow volume, source and water quality.

The inputs are rainfall, runoff from undisturbed land, runoff from disturbed land, river water, the entrainment in the ore, bore water, aquifer interception, and town effluent.

The rainfall and runoff values shown on the framework representation were obtained from site-calibrated hydrological models. The source of this water is surface water. The quality of rainfall and runoff from undisturbed land is good and so can be given a quality category of 1. The runoff from disturbed land is poorer and was assigned a quality category of 2.

The entrainment in the ore was not known so an estimate was used. The throughput rate (22.5Mt/year) was obtained from the processing team but the ore water content was not known so a low confidence level estimate of 0.025 was used. The formula gives 562 ML/year.

Bore water, river water, aquifer interception and town effluent were metered flows with values shown in the flowchart in ML/year.

The source of river water is surface water. Bore water, aquifer interception and entrainment are classed as groundwater. Treated town effluent is a raw water input because it has not been used within the Operational Model. Its source category is third party water because it is purchased.

The results of water quality testing of samples were obtained from the Environmental Department. Using the decision tree, a 1, 2 or 3 was assigned to each input. The results are shown in the Input - Output statement. The bore water is a potable water source and monitoring showed that its quality category was 1. River water had a water quality of 1. Aquifer interception, entrainment and treated town effluent is of water quality category 2.
Outputs

Step 2: Looking at both the flowchart of your site and the list of typical water Outputs, choose the relevant outputs for the site. Add any others if necessary. For all outputs include the flow volume, destination and water quality.

The outputs are seepage, evaporation, task loss and tailings entrainment.

The hydrological models provide the values for seepage (301 ML/year) and evaporation (4,302 ML/year). The destination for seepage is groundwater and evaporation is a line item under ‘other’.

Because a model has been used to balance the water around the site, the task losses are known. The loss from the Underground Mining was 175 ML/year and the loss from potable water use was 47 ML/year so the total task losses are 222 ML/year. The site was missing data for the flow from the thickeners inside the ore processing task to the mixed water store. This was found by difference given all other flows around the ore processing task were known but this means there is no task loss for ore processing. The task loss water quality cannot be monitored but it can be assigned to category of 3.

Because a model has been used to balance the water around the site, the task losses are known. The loss from the Underground Mining was 175 ML/year and the loss from potable water use was 47 ML/year so the total task losses are 222 ML/year. The site was missing data for the flow from the thickeners inside the ore processing task to the mixed water store. This was found by difference given all other flows around the ore processing task were known but this means there is no task loss for ore processing. The task loss water quality cannot be monitored but it can be assigned to category of 3.

The tailings entrainment was an estimated value from knowledge of the void volume of the tailings dam (4,300 ML/year). The destinations for the water are shown in bold in the Input-Output report; seepage is groundwater, evaporation, task loss and entrainment are line items under the destination of ‘other’.

When the water quality is monitored you can use the decision tree to help you assign a water quality category. But for outputs that are not usually monitored, the descriptions under Outputs in Section 3.2.2 can help. They give typical quality categories for the line items under the destinations.

Diversions

Step 3: Record any diversions.

The environmental flow comes directly from an input and goes to an output. It is not used in a task, has not been stored on-site, so it is a diversion. The environmental flow is unmetered but the total amount taken from the river is metered and is known to be 1,452 ML/year with only 1,132 ML going to the raw water store. That leaves 320 ML/year as a high confidence estimate of the environmental flow. The water quality of the river is monitored and has a water quality category of 1.
Table 15: Input-Output statement of copper-gold mine case study

<table>
<thead>
<tr>
<th>Reporting period 1st January 2010 to 31st December 2010</th>
<th>Water Quality</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cat 1 ML</td>
<td>Cat 2 ML</td>
</tr>
<tr>
<td><em><strong>Inputs</strong></em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface Water</td>
<td>Precipitation and Runoff</td>
<td>5016</td>
</tr>
<tr>
<td></td>
<td>Rivers and Creeks</td>
<td>1452</td>
</tr>
<tr>
<td></td>
<td>External Surface Water Storages</td>
<td></td>
</tr>
<tr>
<td>Groundwater</td>
<td>Aquifer Interception</td>
<td>487</td>
</tr>
<tr>
<td></td>
<td>Bore Fields</td>
<td>354</td>
</tr>
<tr>
<td></td>
<td>Entrainment</td>
<td>562</td>
</tr>
<tr>
<td>Sea Water</td>
<td>Estuary</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sea/Ocean</td>
<td></td>
</tr>
<tr>
<td>Third Party Water</td>
<td>Contract/Municipal</td>
<td>4218</td>
</tr>
<tr>
<td></td>
<td>Waste Water</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL INPUTS</strong></td>
<td>6822</td>
<td>6209</td>
</tr>
<tr>
<td><em><strong>Outputs</strong></em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface Water</td>
<td>Discharge Environmental Flows</td>
<td></td>
</tr>
<tr>
<td>Groundwater</td>
<td>Seepage</td>
<td>301</td>
</tr>
<tr>
<td></td>
<td>Reinjection</td>
<td></td>
</tr>
<tr>
<td>Sea Water</td>
<td>Discharge to Estuary</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Discharge to Sea/ Ocean</td>
<td></td>
</tr>
<tr>
<td>Supply to Third Party</td>
<td>Evaporation</td>
<td>5019</td>
</tr>
<tr>
<td></td>
<td>Entrainment</td>
<td>4300</td>
</tr>
<tr>
<td></td>
<td>Other (task loss)</td>
<td>222</td>
</tr>
<tr>
<td><strong>TOTAL OUTPUTS</strong></td>
<td>5019</td>
<td>523</td>
</tr>
<tr>
<td><em><strong>DIVERSIONS</strong></em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inputs</td>
<td>Environmental Flows</td>
<td>320</td>
</tr>
<tr>
<td></td>
<td>Aquifer Interception</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL DIVERSION INPUTS</strong></td>
<td>320</td>
<td>0</td>
</tr>
<tr>
<td>Outputs</td>
<td>Discharge</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reinjection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Water to maintain vegetation</td>
<td>320</td>
</tr>
<tr>
<td><strong>TOTAL DIVERSION OUTPUTS</strong></td>
<td>320</td>
<td>0</td>
</tr>
</tbody>
</table>
Notes:
1. Simulated using a hydrological model. Assumed rainfall incident on process water pond and tailing split was 50:50 because missing surface areas. Low confidence in simulation.
2. Metered flows
3. Estimated the moisture content. The throughput was known.
4. The tailings entrainment was an estimated value from knowledge of the void volume of the tailings dam. The tailings dam is accumulating water.
5. A water balance model provided an estimate for task loss
6. The diversion flow was unmetered but can be found through a water balance.

Step 4: Record in the Input-Output Statement which flows were measured, simulated or estimated and give a confidence level of the accuracy of the flow i.e. high, medium or low.

Details on how to do this have already been provided, therefore only the completed Accuracy Statement has been provided (Table 16).

<table>
<thead>
<tr>
<th>Table 16: Accuracy statement for copper-gold mine case study</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Accuracy Statement</strong></td>
</tr>
<tr>
<td>Flow Types</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>Measured</td>
</tr>
<tr>
<td>Estimated</td>
</tr>
<tr>
<td>Simulated</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

The difference between the above accuracy statement and the accuracy statement for the coal mine case study (Table 13) is that for this case study, half the flows by volume are simulated and there is a greater degree of confidence in the accuracy of the flows.

Step 5: Record the water levels of all stores at the start and end of the reporting period.

In this example, it can be seen that 2,324 ML of water accumulated in the tailings storage facility over the course of the year. Whilst this situation is highly unusual, it can happen if sites have inadequate storage facilities. In this instance the tailings storage facility is acting as a store. The excess water must be included in the store volume in the Input-Output Statement. The level of all storage water including the water in the tailings storage facility was 4,072 ML at the beginning of the reporting period. At the end of the reporting period the level of the stores was 7,261 ML. The change in storage for the year was 3,189 ML.
5.2.3 Copper-Gold Mine Operational Model

The starting point of this case study site was the framework representation. Constructing the Operational Model contains the details on how to convert a water flowchart to the framework representation.

**Step 6** List the tasks, the treatment plants and the stores. Group tasks and stores according to purpose.

**Stores**

The raw water store is comprised of two dams. The mixed water store is physically one pond. It contains the return water (worked water) from the tailings dam, the thickeners inside the ore processing plant and recovered water from the underground mining task.

This site is using its tailings storage facility both as a task and as a water store. The amount stored (2,324 ML) is material in comparison to the total water stored (7,261 ML). In the same way that the water in the mixed water store had to be separated into raw and worked before calculating the reuse efficiency, the water in the TSF must be separated. You can follow the same procedure as before in Section 3.6.1 Reuse and Recycling Efficiency. The rainfall, runoff and any other raw water volumes into the TSF must be summed and compared against the volume of all flows into the TSF to get the proportion of raw water in the TSF. The rest is worked.

**Treatment plants**

The site has a treatment plant to treat the wastewater that is created on site.

**Tasks**

The tasks are shown in the framework representation:

- potable water use
- the ore processing plant
- tailings storage facility
- open cut mining
- underground mining

The flow from the mixed water store to the ore processing plant is the plant demand (40,150 ML/year). The ore processing plant contains the thickeners that thicken the tailings and concentrate and return the water to the mixed water store. The thickeners are contained within the ore processing plant so the flow can be seen coming from the ore processing plant to the mixed water store (22,884 ML/year).

**Step 7** Work out the inflows and outflows of each element.

The flowchart was created by the water balance model and shows the flows between all elements.

**Statement of Operational Efficiencies**

To generate the statement of operational efficiencies:

**Step 8** Add up all the inputs to the tasks.

Inputs to tasks: Underground mining (UG) 871 ML/year, Ore Processing 40,736 ML/year, Open cut mining 430 ML/year, Potable water 71 ML/year, TSF 19,760 ML/year.

For this site, the total input into tasks = 61,868 ML/year.
Step 9. Add up all the volumes of reused water i.e. the worked water that goes to a task. Since a mixed water store contains raw water, you must work out the proportions of water that are raw and worked.

In the Coal Mine Case Study Operational Model, 100% of the water coming from the tailings to the mixed water store was considered worked water because it had been through a task.

But in the Copper-gold mine case study, with the the Tailings Storage Facility (TSF) acting as a water store, the flow coming out of it is not 100% worked water but a mix of raw and worked. The proportion in the TSF must be calculated prior to calculating the worked water in the mixed water store.

Raw water (flows from green inputs) to TSF = 1,908

Worked water (flows from grey tasks) to TSF = 17,852

The proportion of worked water in the TSF = 90%

The worked water flow from the TSF to the mixed water store is 90% of 9,636 = 8,706 ML/year.

Raw water (flows from green inputs) to mixed water store = 283+942+487+4,218+1,102+1,908+(9,636-8,706) = 9,870 ML/year

Worked water (flows from grey tasks) to mixed water store = 22,884+696+8,706 =32,286 ML/year

So the proportion of worked water in the mixed water store = 77%

Worked water to tasks = flows from tasks to tasks + proportion of worked water in mixed water store X flow from mixed water store to tasks

The flow from the ore processing plant to the TSF is the only flow from task to task (17,852 ML/year). The worked water from the mixed water store to tasks = 0.77 X (430+40,150)

Reuse Efficiency = Worked water flows to tasks as a proportion of the total flows to tasks

= 49,099/61,868

= 79 %

Step 10. Add up the volumes of recycled water i.e. treated worked water that goes to tasks.

The volume of recycled water is the water from the on-site waste water treatment plant (24 ML/year). Note that the effluent town water does not count in this step because the treatment plant is off-site, which is why in Step 1 it was classed as Third Party water.

| Table 17: Statement of Operational Efficiencies for copper-gold mine case study |
|----------------------------------|--------|
| Operational efficiencies         |        |
| Total volume to tasks (ML/year)  | 61,868 |
| Total volume of reused water (ML/year) | 49,099 |
| Reuse efficiency (%)             | 79     |
| Total volume of recycled water (ML/year) | 24     |
| Recycling efficiency (%)         | 0.04   |
5.3 Comparison of “Wet” and “Dry” Sites

5.3.1 Site Summary
This case study shows how a mine with the same configuration will produce different accounts under two very different climate scenarios: a drought (a ‘dry’ site) and a flood (a ‘wet’ site). This site used in this study will have the same configuration as the site in the Case Study 1. Therefore, it is assumed that you have read and understood that case study before reading this one. For the dry case study the site loses water, whereas, for the wet case study the site accumulates water – some of which would be accumulated in the Tailings Dam. Based on this, the water in the Tailings Dam in both case studies is assumed to be a mixture of worked and raw water, as in Case Study 2, rather than all worked water as in Case Study 1.

5.3.2 Input Output Model

Inputs
Step 1: The site used in this case study is the same as in Case Study 1 which had three main inputs: water that is supplied by the town, moisture in Ore Entrainment and rainfall and runoff. It is assumed that the volume of water sourced from the town and entrained in ore will are unchanged at 468ML/Yr and 442 ML/Yr respectively. For the dry scenario the volume of rainfall and runoff has decreased to one-sixth of its original value to 108 ML/Yr. For the wet scenario the volume of rainfall has increased six times from its original value to 3,876 ML/Yr. Although these volumes may be extreme, that are used to illustrate how the same site configuration will produce different accounts under different climate conditions.

Outputs
Step 2: Again, the outputs for this case study are similar to those in the same as in Case Study 1 which were: diverted water to the creek (127 ML/Yr); miscellaneous task losses (399 ML/Yr), evaporation from the stores (885 ML/Yr) and entrainment in the product and reject material (1,223 ML/Yr). The only difference for outputs occurs due to seepage since: the dry scenario will be storing less water than Case Study 1 and therefore, have a lower volume of seepage while the wet scenario will be storing more water than Case Study 1 and therefore, have a higher volume of seepage. Assume that the same procedure used in Case Study 1 (i.e. deriving a seepage volume by balancing the account) was followed to derived seepage values of 233 ML/Yr for the dry scenario and 473 ML/Yr for the wet scenario.

Diversions
Step 3: The site contains a set of sedimentation ponds that are used to settle the solids of runoff from disturbed land prior to entering the creek. These ponds are regarded as diversions since they are not used to store water used on site. In this case, the volume of water following into the ponds is equal to the volume of water flowing out of the ponds (127 ML/Yr).

Step 4: Record in the Input-Output Statement which flows were measured, simulated or estimated and give a confidence level of the accuracy of the flow i.e. high, medium or low. It is assumed that the flows were obtained in the same way and with the same confidence level as for Case Study 1 for both the wet and dry scenarios. Because the input volumes (rainfall and runoff) and output volumes (seepage) have changed, the percentages in the Accuracy Statement will change. (See Table 19 and Table 20.)

Step 5: Record the storage at the start and end of the reporting period.
For both scenarios the storage at the start of the reporting period is the same as for Case Study 1 at 4,653 ML. For the dry scenario the storage at the end of the reporting period was 2,283 ML, meaning that the change in storage was a loss of 2,370 ML. For the wet scenario the storage at the end of the reporting period was 5,811 ML, meaning that the change in storage was an accumulation of 1,158 ML.
### Table 18: Summary of changes for the Wet and Dry sites of the coal mine case study.

<table>
<thead>
<tr>
<th></th>
<th>Dry site</th>
<th>Wet site</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INPUT: Rainfall and runoff (ML/Year)</strong></td>
<td>108</td>
<td>3,876</td>
</tr>
<tr>
<td><strong>OUTPUT: Seepage (ML/Year)</strong></td>
<td>233</td>
<td>473</td>
</tr>
<tr>
<td><strong>Change in store (ML/Year)</strong></td>
<td>-2,370</td>
<td>+1,158</td>
</tr>
</tbody>
</table>

### Table 19: Dry site Accuracy Statement

<table>
<thead>
<tr>
<th>Flow Types</th>
<th>% of all Flows</th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured</td>
<td>20%</td>
<td>20%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Estimated</td>
<td>80%</td>
<td>0%</td>
<td>40%</td>
<td>41%</td>
</tr>
<tr>
<td>Simulated</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Total: 20% 40% 41%

### Table 20: Wet site Accuracy Statement

<table>
<thead>
<tr>
<th>Flow Types</th>
<th>% of all Flows</th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured</td>
<td>10%</td>
<td>10%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Estimated</td>
<td>90%</td>
<td>0%</td>
<td>24%</td>
<td>65%</td>
</tr>
<tr>
<td>Simulated</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Total: 10% 24% 65%

### 5.3.3 Operational Model

**Step 6:** Aggregate store and tasks.

The tasks and stores are grouped together as in Case Study 1. This results two stores: a raw water store that consist of the raw water dam and a mixed water store that consist of the mine water store and the disused pit. The tasks for the site are the Tailings Dam, water used in underground mining (underground use), coal handling and processing plant (CHPP) and suppressing dust on the haul road (haul road water).

**Step 7:** List the operational flows.

With the exception of the rainfall and runoff and seepage flows (identified in Steps 1 and 2) all other flows are the same as the site in Case Study 1.
Statement of Operational Efficiencies

Step 8: Determine the volume of water input into a task. With the exception of the tailings dams the inflows to the tasks are the same as in Case Study 1, these are: underground use (70 ML/Yr), CHPP (3,682 ML/Yr) and haul road water (648 ML/Yr). The volume of water flowing into the Tailings Storage Facility TSF is different for each scenario since different volumes of rainfall and runoff are flowing into it. The water flowing into the tailings dam in the dry scenario is 2,639 ML/Yr, while the water flowing into the TSF in the wet scenario is 3,689 ML/Yr. Therefore, the total volume of water flowing into tasks for the dry scenario is 7,039 ML/Yr while the total volume of water flowing into tasks for the wet scenario is 8,089 ML/Yr.

Step 9: To calculate the total volume of reused water you need to calculate the volumes of raw and worked water flowing into each task. However, first the proportions of raw and worked water in the stores and TSF need to be calculated. As with tasks this is based upon inflows into the stores.

Raw Water Store
By definition all water in the raw water store must be raw.

Tailings Storage Facility (TSF)
The Tailings Dam receives both worked and raw water. The total volume of water flowing into the TSF in both scenarios has been calculated in Step 8. Some of the water flowing to the TSF is worked as it comes from the CHPP, with the remainder being raw water from rainfall. Based on inflows, in the dry scenario the TSF is split into 99% worked (3,609 ML / 3,639 ML) and 1% raw (30 ML / 3,639 ML). In contrast, in the wet scenario the TSF is split into 71% worked (2,609 ML / 3,689 ML) and 29% raw (1,080 ML / 3,689 ML).

Mixed Store
Like the tailings Dam the Mixed Water Store contains both raw and worked water. The Mixed Water Store receives water from rainfall and runoff (raw), the Raw Store (raw) and the TSF (a mixture of raw and worked). Therefore, the volume of raw water flowing into the Mixed Water Store is equal to the sum of the rainfall and runoff, the transfer from the Raw Store and the raw water from the TSF, while the volume of worked water flowing into the Mixed Water Store is equal to the worked water from the TSF.

For the dry scenario the volume of the worked water volume is 1,839 ML/Yr (worked water from TSF). While the raw water flowing into the Mixed Water Store is: 34 ML/Yr (rainfall/runoff) plus 340 ML/Yr (Raw Store Transfer) plus 21 ML/Yr (raw water from TSF) which equals 355 ML/Yr. Therefore, under the dry scenario the Mixed Water Store has a worked proportion of 84% and a raw proportion of 16%.

For the wet scenario the volume of the worked water volume is 1,315 ML/Yr (worked water from TSF). While the raw water flowing into the Mixed Water Store is: 1,212 ML/Yr (rainfall/runoff) plus 340ML/Yr (Raw Store Transfer) plus 545 ML/Yr (raw water from TSF) which equals 2,057 ML/Yr. Therefore, under the dry scenario the Mixed Water Store has a worked proportion of 39% and a raw proportion of 61%.

Once the proportions of raw and worked water for each of the stores are calculated the proportion of raw and worked water flowing into the tasks can be calculated.

Underground Use
For both scenarios, the easiest task to calculate is the Underground Use as it receives 70 ML/Yr, all of which is raw since it is sourced from the Raw Water Store.
**CHPP**

The CHPP receives 3,240 ML/Yr from the Mixed Water Store and 442 ML/Yr from water entrained in ore. The flow from the Mixed Store contains a mixture of raw and worked water while the ore entrained in ore is all considered raw. Therefore, for the dry scenario the volume of worked water that flows into the store is 2,715 ML/Yr (0.84 X 3,240 ML/Yr) while the volume of raw water is 966 (442 + 0.16 X 3,240 ML/Yr). In the wet scenario this consists of 1,264 ML/Yr (0.39 X 3,240 ML/Yr) of worked water and 2,418 ML/Yr (442 ML/Yr + 0.61 X 3,240 ML/Yr) of raw water.

**Haul Road**

The Haul Road receives 648 ML/Yr from the Mixed Water Store. In the dry scenario this consists of 543 ML/Yr (0.84 X 648 ML/Yr) of worked water and 104 ML/Yr of raw water (0.16 X 648 ML/Yr). In the wet scenario this consists of 258 ML/Yr (0.39 X 648 ML/Yr) of worked water and 295 ML/Yr (0.61 X 648 ML/Yr) of raw water.

Now that all the worked water flows to tasks have been calculated it is possible to derive the Reuse Efficiency. For the dry scenario the total volume of worked water flowing into tasks is equal to 5,868 ML/Yr (2,609 ML/Yr + 2,716 ML/Yr + 543 ML/Yr) divided by the total volume of water flowing into tasks (7,039 ML/Yr) gives a Reuse Efficiency of 83%. For the wet scenario the total volume of worked water flowing into tasks is equal to 42,126 ML/Yr (2,609 ML/Yr + 1,264 ML/Yr + 256 ML/Yr) divided by the total volume of water flowing into tasks (8,089 ML/Yr) gives a Reuse Efficiency of 51%.

**Step 10.** Determine the recycled water volume. In this case study there is no treatment plant on site.

### Dry Case Study

<table>
<thead>
<tr>
<th>Operational efficiencies</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total volume to tasks (ML/year)</td>
<td>7,039</td>
</tr>
<tr>
<td>Total volume of reused water (ML/year)</td>
<td>5,867</td>
</tr>
<tr>
<td>Reuse efficiency (%)</td>
<td>83</td>
</tr>
<tr>
<td>Total volume of recycled water (ML/year)</td>
<td>0</td>
</tr>
<tr>
<td>Recycling efficiency (%)</td>
<td>0</td>
</tr>
</tbody>
</table>

### Wet Case Study

<table>
<thead>
<tr>
<th>Operational efficiencies</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total volume to tasks (ML/year)</td>
<td>8,089</td>
</tr>
<tr>
<td>Total volume of reused water (ML/year)</td>
<td>3,963</td>
</tr>
<tr>
<td>Reuse efficiency (%)</td>
<td>51</td>
</tr>
<tr>
<td>Total volume of recycled water (ML/year)</td>
<td>0</td>
</tr>
<tr>
<td>Recycling efficiency (%)</td>
<td>0</td>
</tr>
</tbody>
</table>
6 Reporting to other organisations

6.1 GRI

The Global Reporting Initiative is a sustainability reporting framework used internationally across various sectors including the minerals industry. The GRI indicators that are concerned with water management are:

1. EN8 total withdrawal by source,
2. EN9 a list of water sources significantly affected by the withdrawal of water,
3. EN10 the percentage and total volume of water recycled and reused,
4. EN21 total water discharged by quality and destination and
5. EN25 size, protected status and biodiversity of water bodies affected by discharge and runoff.

EN8 Total water withdrawn by source (m$^3$/year).

The following source categories are provided within GRI:

- Surface Water: Includes water from wetlands, rivers, lakes and oceans
- Groundwater: No definition supplied
- Rainwater: Collected directly and stored by the reporting organization
- Waste Water: Waste water supplied by other organizations
- Municipal/Utilities: Includes water supplies from municipal and other water utilities

The relevant line items can be transferred from the Input-Output Statement. Table 21: GRI and Water Accounting Framework – Source Definitions Mapping shows the mapping between GRI and the Water Accounting Framework for EN8.

Table 21: GRI and Water Accounting Framework – Source Definitions Mapping

<table>
<thead>
<tr>
<th>GRI Category</th>
<th>Water Accounting Framework</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WAF Source Category</td>
</tr>
<tr>
<td>Surface Water</td>
<td>Surface Water</td>
</tr>
<tr>
<td></td>
<td>Surface Water</td>
</tr>
<tr>
<td></td>
<td>Sea Water</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Groundwater</td>
</tr>
<tr>
<td>Rainwater</td>
<td>Surface Water</td>
</tr>
<tr>
<td>Waste Water</td>
<td>Third Party Water</td>
</tr>
<tr>
<td>Municipal/utilities</td>
<td>Third Party Water</td>
</tr>
</tbody>
</table>

EN21 Total water discharge by quality and destination (m$^3$/year).

The discharge destinations are subsurface waters, surface waters, sewers that lead to rivers, oceans, lakes, wetlands, treatment facilities, and ground water.

Based on the GRI destinations, the following broad categories can be derived from the Input-Output Statement:

- Surface Water: Water discharged to wetlands, rivers, lakes and oceans, (Framework Destination categories: Surface Water and Sea Water).
- Third-party Water: Water supplied to an entity external to the operational facility, including water for re-use and waste water for treatment, (Framework Destination category: Third Party).
EN21 requires reporting on the following:

1. Destination
2. Treatment method
3. Whether it was reused by another organization.

While data for items (1) and (3) can be obtained through the Water Accounting Framework Input-Output model, (2) Treatment Method would require additional contextual information.

**EN9 Water sources significantly affected by withdrawal of water.**

This indicator includes the total number of significantly affected water sources by type indicating the size of the water source, whether or not the source is designated as a protected area (nationally and/or internationally) and its biodiversity value.

This information should be contained in the Contextual Statement.

**EN25 Identity, size, protected status, and biodiversity value of water bodies and related habitats significantly affected by the reporting organization’s discharges of water and runoff**

This information should be contained in the Contextual Statement.

**EN10 Percentage and total volume of water recycled and reused.**

This is the total volume of water recycled/reused by the organisation (m³/year) and is also reported as a percentage of the total water withdrawal reported under the indicator EN8.

The volume of water that is considered to be recycled/reused also includes rainwater in the GRI guidance notes because it is considered ‘grey water’. This is not the position of the Minerals Industry Water Accounting Framework which clearly defines rainfall and runoff as raw water inputs and so are not included in the reuse/recycling volumes.

The second difference between the two frameworks is that the Minerals Industry Water Accounting Framework reports the Operational Efficiencies against the total volume of water to tasks. This was chosen as a more robust parameter because the amount of reuse that can be achieved depends on the availability of worked water.

It can be seen that if the rainfall increases and there are no other changes to the site’s operation, this will change both the input volume and the reused volume which will change the reuse percentage according to the GRI definition. With the Minerals Industry Water Accounting Framework definition there will be no change in the reuse efficiency in the event of increased rainfall because neither the volume of worked water will change, nor the volume flows to the tasks proving that it is a robust measure.

These differences in definitions mean that there is not a one-to-one correlation between GRI and the Water Accounting Framework however it is recommended that companies adopt the Minerals Industry Water Accounting Framework definitions of the reuse efficiency and recycle efficiency. In their reporting, companies can reproduce the Water Accounting Framework Statement of Operational Efficiencies but it must be acknowledged that the Minerals Industry Water Accounting Framework methodology was used to obtain the efficiencies. We have provided an example of how it can be presented ( ).

<table>
<thead>
<tr>
<th>Minerals Industry Water Accounting Framework Operational Efficiencies</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total volume to tasks (ML/year)¹</td>
<td>10,532</td>
</tr>
<tr>
<td>Total volume of reused water² (ML/year)</td>
<td>8,527</td>
</tr>
<tr>
<td>Reuse efficiency (%)</td>
<td>81</td>
</tr>
<tr>
<td>Total volume of recycled water³ (ML/year)</td>
<td>0</td>
</tr>
<tr>
<td>Recycling efficiency (%)</td>
<td>0</td>
</tr>
</tbody>
</table>
Indicator EN10 has been reported using the Minerals Industry Water Accounting Framework definitions of reuse and recycled water within the Water Accounting Framework for the Minerals Industry.

1. The efficiencies are reported against the total volume flows to tasks not the site inputs.
2. Reused water is water that has been through a task and is again sent to the same or another task. The volume does not include rainwater.
3. Recycled water is water that has been through a task, undergone water treatment and is again sent to the same or another task.

6.2 Australian Water Accounting Standards

In 2010 the Water Accounting Standards Board developed the exposure draft of the Water Accounting Standards (ED-AWAS). The purpose of the exposure draft of the Australian Water Accounting Standards (ED-AWAS) is for companies and regions to provide information on the allocations, entitlements and trading of water between regions as well as actual use.

A water accounting report prepared to the exposure draft of the Australian Water Accounting Standards should contain:

- A contextual statement,
- An accountability statement,
- Statement of water assets and liabilities
- Statement of changes in water assets and water liabilities
- Statement of physical flows
- Notes disclosures
- Assurance statement.

From the preliminary Australian Water Accounting Standards, the concept of materiality of flows, the contextual statement and notes disclosures has been incorporated into the MCA framework. The alignment between the MCA framework and the ED-AWAS is closest in the Statement of Physical Flows in that the operational facility can simply reproduce the Input-Output statement of the MCA framework.

The main difference between ED-AWAS and the Minerals Industry Water Accounting Framework is that the framework only considers physical flows that occurred during the reporting period. The ED-AWAS also requires reporting of contractual requirements. Transactions and events are reported in the period when the decisions or commitments are made, not when they actually happen. They are recorded in the Statement of Water Assets and Liabilities and the Statement of Changes in Water Assets and Water Liabilities in the reporting period. The Statement of Physical Flows is a record of the flows that occurred during the reporting period.

Notes disclosures in the MCA framework explain how quantities were calculated. This is necessary for ED-AWAS but extra notes must be provided to address explain Future Prospects, Contingent Water Assets and Liabilities, why any items under the control of the operational facility failed to meet a water asset or liability status and also disclosures on water market activity within its catchment.

The Future Prospects section of the ED-AWAS aims any impact on future volumes of water to be acquired or committed within 12 months of the reporting date including future estimates of rainfall and runoff. For a mine site this will require running a calibrated surface hydrology model to estimate future runoff into raw and worked water storages under ‘Dry’, ‘Wet’ and ‘Median’ conditions. This capability will need to be met either in-house or through a third party provider (e.g. a consulting company preparing the water accounts).

The concept of ‘segments’ has also been introduced into the ED-AWAS. Typically if the water reporting entity is a mining company, segments will consist of the individual mine sites.
7 Bibliography


