INFORMATION BULLETIN

GUIDELINES FOR RISK ASSESSMENT OF WASTEWATER DISCHARGES TO WATERWAYS

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EXECUTIVE SUMMARY

Water businesses, industries and others discharging wastewater to waterways (including freshwater and marine environments) need to know the nature and extent of impacts associated with wastewater discharges. This allows better decision making on the acceptability of current discharges, the need for upgrades and actions to reduce mixing zones. Our drying climate has increased the need to consider these issues, including the potential discharge of appropriately treated and managed wastewater to a waterway to provide water for the environment.

EPA has developed these "Guidelines for Risk Assessment of Wastewater Discharges to Waterways" to provide guidance on what is expected from practitioners conducting wastewater discharge risk assessments.

The rigour and transparency of a risk assessment process produces information that is more targeted and defensible than less formal processes. This information is particularly useful to decision makers and managers who must evaluate alternatives, compare or prioritise risks, evaluate the most cost-effective actions to maximise environmental gains or determine the extent to which stressors must be reduced to achieve a given outcome.

These Guidelines provide the risk assessment framework and guidance on its implementation. It is based on current, nationally and internationally accepted risk assessment approaches. The framework ensures all potential risks can be clearly identified and appropriately assessed. It also enables the required interactions between technical experts, risk managers and interested stakeholders.

There are three main phases in the risk assessment process: problem formulation, risk analysis and risk characterisation.

Problem formulation determines the focus and scope of the risk assessment and the management information it needs to provide. This includes identifying: the scope of the risk assessment; beneficial uses and values that need protection; potential threats to these values; factors influencing the likelihood of the risk occurring; and, the impacts from these. The problem formulation phase also includes developing a conceptual model of the environmental system, the wastewater discharge and the interactions between them.

Risk analysis determines the probability and magnitude of an adverse effect with specific consequences occurring to beneficial uses and values.

Risk characterisation is the evaluation and reporting of the problem formulation and risk analysis results for decision-making and risk management purposes.

A number of risk assessment pilot applications were conducted in the year following the release of the draft Guidelines (EPA Victoria, 2008). Summaries of these are presented in Appendix B. The pilot applications provide practical examples of how to implement the risk assessment process for wastewater discharges.

1 INTRODUCTION

The impact of wastewater discharges to inland and marine water bodies is attracting greater interest, particularly given predictions of a drier climate in the future. Impacts are often exacerbated by drought conditions, with low flows reducing the dilution of discharges. In other cases, the flow from some wastewater discharges can be an important contribution to waterway health, if they are of the right environmental quality and managed well.

These issues are driving the need for a more detailed assessment of the impact of wastewater discharges to support decision making.

1.1 What is risk assessment?

Risk is the likelihood of an undesirable event. We often assess risk when we need to decide between alternative courses of action. Risk assessment is used by a wide range of industries and organisations in areas such as engineering, economics, public health, medicine, natural resource management, irrigation and biosecurity.

Environmental risk assessment evaluates the interactions between environmental values, the stressors to these and management actions for protecting the values. This is used to assess the potential impacts of stressors to the environmental values. This is done in a consistent, clear and structured way using the risk assessment framework (Figure 1).

This framework is based on nationally and internationally accepted risk assessment frameworks (Suter, 1993; USEPA, 1998; ANZECC and ARMCANZ, 2000; USEPA, 2001; Hart *et al.*, 2005; Burgman, 2005).

The framework ensures that all potential risks can be clearly identified and appropriately assessed. It also facilitates the required interactions between technical experts, risk managers and interested stakeholders.

The outcomes of a risk assessment are:

- an estimation of the likelihood that values may be impacted, and how the impact changes given alternative scenarios
- detailed information and tools that help in better understanding how systems work
- targeted management actions and monitoring programs.

1.2 Why use risk assessment for wastewater discharges to waterways?

Managers and regulators of wastewater discharges need to make management decisions to protect natural systems impacted by varied stressors, where information and data may be scarce and uncertain. Risk assessment is an effective and transparent way of assessing wastewater discharges. It will clearly provide information needed for managing these discharges for the protection of beneficial uses.

EPA has already developed guidance on how to undertake risk assessments in ambient waters (EPA publication 961, 2004). The purpose of this guideline is to provide specific guidance on how to undertake risk assessments for wastewater discharges to waterways.

1.3 What is the scope of these Guidelines?

Risk assessment and risk management are different processes; the outcomes of the former are used to inform the latter. Risk assessment is the formal process of understanding and evaluating the magnitude and probability of risks posed to values from stressors. Risk management combines these risk characterisations with statutory, legal, social, economic, environmental and political factors in assessing options to manage risk (USEPA, 2001).

The focus of these Guidelines is on the risk assessment process, including the assessment of risk to beneficial uses in the *State environment protection policy (Waters of Victoria)* (SEPP (WoV)).

This document provides a risk assessment framework and guidance on its implementation. It allows flexibility for businesses to use the appropriate method for each situation, and to implement new and improved approaches when available.

The intended users of these Guidelines are the businesses and industries discharging to surface waters that are required to conduct a risk assessment (Section 2) and the risk assessors/consultants (Box 2) conducting risk assessments on their behalf.

1.4 Roles and responsibilities

EPA Victoria (EPA)

Under the *Environment Protection Act 1970* and SEPP (WoV), EPA is responsible for developing environmental Guidelines within the regulatory framework that encourages best practice. In particular, it produces guidance on recycling and discharges to waterways to ensure that schemes are both safe and sustainable.

SEPP (WoV) has a risk-based approach to the protection of beneficial uses. The SEPP identifies that, where an environmental quality objective is not met, further investigation is needed to assess the risk to beneficial uses. SEPP (WoV) indicates that EPA will provide guidance on the implementation of this risk-based approach to the protection and assessment of beneficial uses in Victoria's waterbodies. These Guidelines provide such guidance.

Water authorities, Industries and other businesses

Water authorities, industries and other businesses discharging to waterways are expected to manage the risks associated with these schemes (Box 1). Where a risk assessment is required, it is their responsibility to obtain suitably qualified risk assessors to conduct the risk assessment (Box 2). Water authorities, industries and other businesses will also be responsible for supplying information required by EPA to make informed decisions about conducting risk assessments and subsequent risk management.

Box 1: Risk managers

Risk managers are the individuals or organisations that have the responsibility or authority to take or require action to mitigate identified risk. This may be one individual, an organisation (e.g., water authority, industry, catchment management authority) or there may be several groups that have responsibility and authority for risk mitigation, forming a risk management team (e.g., State and local government organisations, industry and a catchment management authority).

Box 2: Risk assessors

Risk assessors are professionals with experience in undertaking the risk assessment process. For relatively narrowly scoped and well defined risk assessments only one trained individual may be needed to do a risk assessment. For more complex risk assessments one individual can rarely provide the necessary breadth or expertise needed, and a risk assessment team is required. A risk assessment team should include at least one professional who is knowledgeable and experienced in using the risk assessment process. Other team members bring specific expertise on the local area, stressors, values (such as ecosystem and human health issues), scientific issues, facilitation of community consultations and any other type of expertise required for the assessment.

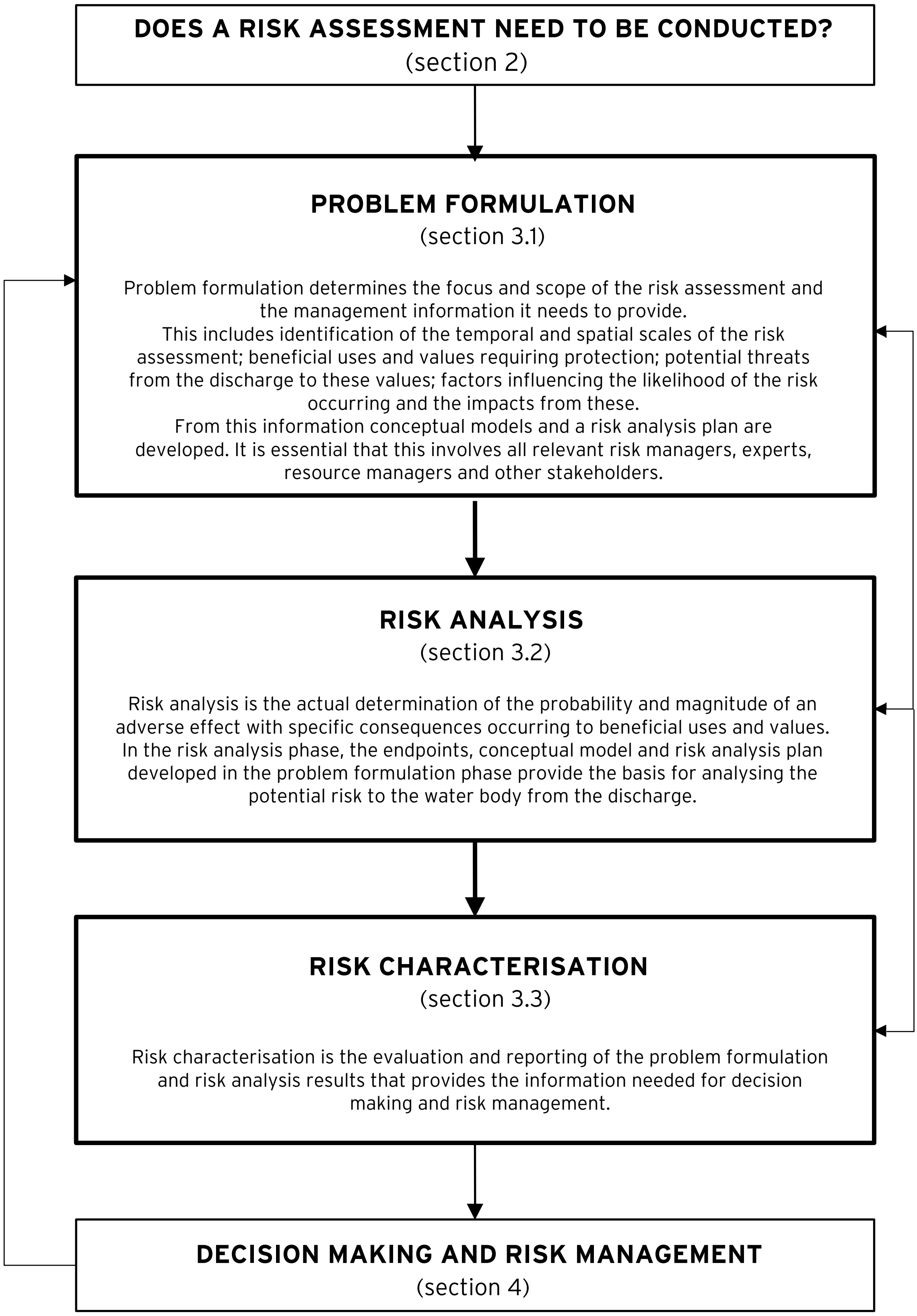

Figure 1: Risk assessment framework for wastewater discharges to waterways

2 WHEN SHOULD A RISK ASSESSMENT BE CONDUCTED?

The decision to conduct a risk assessment should in most cases be initiated directly by the wastewater discharger. A business may consider undertaking a risk assessment, where it is identified as useful for the assessment and management of the discharge. In making decisions on whether a risk assessment should be conducted, and the level of assessment required, consideration should be given to the following:

- The SEPP (WoV) beneficial uses and regional values (Box 3) of a water body that may be impacted, and the importance of these values. Local water body values and their importance (e.g., high values) can be identified through state, national and international designations such as aquatic reserves, RAMSAR wetlands, heritage rivers; regional processes such as regional river health strategies and coastal plans; and local community processes.
- The vulnerability of a water-body to impacts. For example, estuaries, lakes and wetlands are particularly vulnerable systems.
- The potential level of impact to beneficial uses, including consideration of:
  - the discharge constituents, including their concentrations, level of toxicity and persistence in the environment
  - the dilution capacity of the water body under low-flow conditions. This is particularly important if low-flow conditions are predicted to increase from climate change impacts
  - the size of the mixing zone.
- Whether the potential impacts from a discharge are well understood. If the impacts to beneficial uses and values are not well understood, a risk assessment may be required to provide the information needed to make decisions and manage these. If the impacts are well understood, then a risk assessment may not be required.

Guidance on the scenarios for when a risk assessment may be required and the appropriate level of risk assessment (qualitative or semi-quantitative/quantitative) is presented in Table 1.

Where the required level of assessment is not clear at the outset, a tiered approach can be taken. Each tier involves an increasing level of assessment complexity and resources to gain a better understanding of the risks. The risk assessment can be conducted, increasing the effort put into the analysis, until adequate information is provided. This can help ensure that the most effective level of resources and amount of time are invested to gain the knowledge needed to make management decisions.

It should be noted that, even where the level of assessment is determined at the outset, findings emerging during the risk assessment might indicate a need for a more detailed level of assessment. For example, if the impact is found to be greater than previously assumed, a more quantitative and detailed risk assessment may be required.

Where EPA identifies the need to conduct a risk assessment for a wastewater discharge it will most often be in the context of an application for a works approval, a licence review or the development of a corporate licence.

Box 3: Beneficial uses and values of waterbodies

Beneficial uses are described in SEPP (WoV) as current or future environmental values or uses of surface waters that communities want to protect. The beneficial uses identified in SEPP (WoV) are: aquatic ecosystems; primary and secondary contact recreation; aesthetic enjoyment; indigenous and non-indigenous cultural and spiritual values; agriculture and irrigation; aquaculture; industrial and commercial use; human consumption after appropriate treatment; and fish, crustacea and molluscs for human consumption.

Specific local values within these beneficial uses are identified though regional planning processes such as regional river health strategies (RRHS) and coastal planning processes, and state, national and international designations such as aquatic reserves, RAMSAR wetlands and heritage rivers.

For example, for SEPP (WoV)'s aquatic ecosystems beneficial use, local values may be identified for specific river reaches in RRHSs such as: Golden perch populations, migratory fish populations, macroinvertebrate community diversity and growling grass frogs.

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Table 1: Guidance on deciding whether a risk assessment should be conducted and the level of assessment required

Water body values[a] and/or vulnerability	Potential impacts[b] to water body values from discharge	Knowledge and understanding[c] of water body values and risks	Is a risk assessment required?	What level of assessment should be conducted?
High	Moderate to high	Substantial	If the values and risks are well understood, a risk assessment may not initially be required. Instead, the impacts can be directly managed using the available information. Monitoring should be conducted to assess the effectiveness of management actions and whether the prior assumptions of risk are correct.	If monitoring shows that management actions are not effective or the prior assumptions of risk are incorrect, then a semi-quantitative or quantitative risk assessment should be conducted.
High	Moderate to high	Minimal	A risk assessment should be conducted.	A semi-quantitative or quantitative risk assessment should be conducted.
High	Minor	Substantial	If the values and risks are well understood, a risk assessment may not initially be required. Monitoring should be conducted to assess whether the impact to values remains minor.	If monitoring shows that the prior assumption of a low impact is incorrect (i.e., there is the potential for a moderate to high impact to values), then a semi-quantitative to quantitative risk assessment should be conducted.
High	Minor	Minimal	A risk assessment should be conducted.	Initially, a qualitative risk assessment may be conducted to assess the prior assumption of a low impact to values. If the qualitative risk assessment indicates the prior assumption of minor impact to values is correct, then monitoring should be conducted to assess whether the impact to values remains minor. If the qualitative risk assessment, or monitoring, indicates the potential for a moderate to high impact, then a further semi-quantitative to quantitative risk assessment should be conducted.
Low	Moderate to high	Substantial	If the values and risks are well understood, a risk assessment may not initially be required. Instead, the impacts can be directly managed using the available information. Monitoring should be conducted to assess the effectiveness of management actions and whether the prior assumptions of risk are correct.	If monitoring shows that management actions are not effective or the prior assumptions of risk are incorrect, then a qualitative risk assessment may be conducted initially. If this level of assessment is insufficient to fully understand the risks for management, then a further, semi-quantitative risk assessment may be required.
Low	Moderate to high	Minimal	A risk assessment should be conducted.	A qualitative risk assessment may be conducted initially. If this level of assessment is insufficient to fully understand the risks for management, then a further semi-quantitative to quantitative risk assessment may be required.

Water body values[a] and/or vulnerability	Potential impacts[b] to water body values from discharge	Knowledge and understanding[c] of water body values and risks	Is a risk assessment required?	What level of assessment should be conducted?
Low	Minor	Substantial	A risk assessment may not initially be required. Monitoring should be conducted to assess whether the impact to values remains minor	If monitoring shows that the prior assumption of a low impact is incorrect (i.e., there is the potential for a moderate to high impact to values), then a qualitative risk assessment should be conducted initially. If this level of assessment is insufficient to fully understand the risks for management, then a further semi-quantitative risk assessment may be required.
Low	Minor	Minimal	A preliminary qualitative desktop risk assessment should be conducted to better understand the potential risks.	If the desktop risk assessment indicates the potential for moderate to high impacts to values, then a further, more detailed qualitative assessment or semi-quantitative risk assessment should be conducted. If the desktop risk assessment indicates the prior assumption of minor impact to values is correct, then monitoring should be conducted to assess that the impact to values remains minor. If monitoring shows that there is potential for moderate to high impact to values in the future, then a qualitative risk assessment should be conducted initially. If this level of assessment is insufficient to fully understand the risks for management, then a further, semi-quantitative risk assessment may be required.

[a] Values: These include environmental, social and economic aspects of the beneficial uses and values of a water body (Box 3). High-value waterbodies can be identified through state, national and international designations such as aquatic reserves, RAMSAR wetlands and heritage rivers; regional processes such as regional river health strategies and coastal plans; and local community processes.

[b] Impacts: Examples of scenarios that might be considered to have a high impact are: an impact that may alter the ecosystem (i.e., from which there isn't recovery but which results in a change in the system); an impact from which recovery would be very slow; a continuous downward trend in biota health; an impact that prohibits any identified beneficial use (such as primary or secondary recreational activities) from being protected in the water body. Examples of scenarios that might be considered a minor impact are: occasional small impact from which biota can recover quickly back to previous levels; where all beneficial uses are still protected continuously (i.e., all SEPP (WoV) objectives still met).

[c] Knowledge and understanding: Substantial knowledge and understanding would be considered as having:

- clearly and objectively identified all the key values of the water body
- characterised the discharge effluent and identified key threats to water body values
- conducted extensive monitoring and assessment of the biota and water quality to evaluate potential impacts to values
- determined a mixing zone and assessed the level of impact to beneficial uses within the mixing zone.

Minimal knowledge and understanding would exist where none of the above evaluations had been undertaken.

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3 CONDUCTING A RISK ASSESSMENT OF WASTEWATER DISCHARGES

Environmental risk assessment is a formal process to understand and evaluate the magnitude and probability of risks posed to ecosystems and human health from environmental stressors (USEPA, 2001). It provides a structured and transparent way to deal with the difficulty of assessing multiple stressors and interactions in naturally variable and complex aquatic systems.

The risk assessment process systematically organises and evaluates data, information, assumptions and uncertainties to assess risks. It also identifies key knowledge gaps and can be used to assess the effectiveness of various management actions in reducing risks.

Risk assessments can be conducted to predict the likelihood of future adverse effects or evaluate the likelihood that effects are caused by current or past events or activities. Where water bodies have a history of previous impacts and the potential for future impacts from multiple chemical, physical or biological stressors, there may be a need to address both future and past risks (USEPA, 1998).

Figure 1 provides the framework for conducting a risk assessment of wastewater discharges to waterways, and how this links to decision making and risk management. It is intended to provide general guidance that can be tailored to meet the needs of varied and often complex assessments.

There are three main phases in the risk assessment process (Figure 1):

- problem formulation (Section 3.1)
- risk analysis (Section 3.2)
- risk characterisation (Section 3.3).

While these are shown in a linear fashion, risk assessments are often interactive and iterative processes and the framework should be interpreted in this way. For example, as more is learnt about the potential risks, this may lead to a re-evaluation of previous assumptions and problem formulation, and/or collection of new data and other analyses being conducted.

As more than one risk may be of concern at a site, and in many cases multiple risks do not operate independently, an integrated assessment approach needs to be taken. This will include all aspects of the discharge that may affect the beneficial uses and values being assessed. For example, assessment of aquatic ecosystems needs to include factors such as water quality and quantity, physical habitat requirements and seasonal and physical biotic cues (e.g., for migration or reproduction).

3.1 Problem formulation

The problem formulation phase determines the focus and scope of the risk assessment and the type of management information required.

It is essential that the risk assessors involve risk managers, technical and scientific experts, resource managers and other relevant stakeholders in the problem formulation phase. Doing so will ensure that the scope of the investigation is appropriate, all potential risks from the discharge are identified and clearly defined, and the investigation outcomes are practical for risk management. Stakeholders may include industry representatives, regulators/decision-makers, relevant state agencies and natural resource managers, local government, scientific and technical experts, adjacent landholders, downstream users and local communities. Section 5 provides more guidance on stakeholder participation.

Problem formulation involves:

- clearly defining management goals
- collating and integrating available information and data
- defining the potential risks, including identification of the:
  - beneficial uses and values (Box 3) requiring protection
  - potential stressors (or threats) to these key values from the discharge
  - factors influencing the likelihood of the risk occurring and the magnitude of the impacts
  - temporal and spatial scales of the risk assessment.
- developing conceptual models that visually describe the relationships between key values, threats and factors influencing the likelihood of the risk occurring and the magnitude of the impacts to values
- identifying endpoints that effectively assess the risks from the discharge to key values
- a risk analysis plan.

The steps outlined above may initially be performed sequentially, but the process of problem formulation is often iterative as more information becomes available.

3.1.1 Management goals

Management goals provide direction for the focus of the assessment. They are statements that embody broad objectives. For example, management goals could be: a river/stream to be free of toxicants and pathogens; ensuring that primary recreation in the water body (e.g., swimming) can occur; or maintaining a healthy aquatic ecosystem.

Natural resource management goals are often already determined in local strategies (for example, regional river health strategies and regional catchment strategies). A particular management goal can consist of a series of management objectives that help in interpreting the goal and aid in the selection of appropriate endpoints for assessment (Section 3.1.5).

For example, the management goal 'maintaining a healthy aquatic ecosystem' could be defined by these management objectives:

- prevention of algal blooms in water bodies
- reduction in the concentrations of toxic metals in the water column and sediments to levels that are not harmful to biota
- maintaining healthy fish populations and their habitat
- maintaining healthy macroinvertebrate communities.

3.1.2 Collation of available data and information

Risk assessors need to gather and integrate all available data and information on a water body's beneficial uses and values, and the potential stressors to these from the discharge. This may include monitoring data, data and information from models, previous research, literature reviews and local plans and strategies. This information should provide a sound basis on which to identify and define potential risks.

If key information and data are unavailable for assessment of the discharge and its potential impacts on the beneficial uses and values, this may need to be identified for collection as part of the risk analysis phase.

3.1.3 Defining the potential risks

Risk assessors need to identify and clearly define potential risks from wastewater discharges. In doing so, it is important that they involve all relevant risk managers, technical and scientific experts, resource managers and other local stakeholders.

Identification of the beneficial uses and values to be protected occurs through consultation with all relevant stakeholders and review of local and statewide resource management and environment protection strategies and policies (such as regional river health strategies, SEPPs). From this process the beneficial uses and values - and management priorities for these - are clearly identified, providing a focus for the risk assessment.

Examples of ecological values could be:

- aquatic ecosystems
- biodiversity
- macroinvertebrate communities
- native fish populations
- threatened flora and fauna.

Examples of human values could be:

- primary recreational use of the water body
- aesthetic enjoyment.

Stressors are defined as any physical (e.g., scouring, sediment deposition), chemical (e.g., toxicants) or biological entity (e.g., bacteria) that can induce a harmful response in a value.

Stressors and the adverse effects they may cause to water body values must be identified. Relevant experts and stakeholders work together to identify potential stressors from the discharge and their impacts by considering applicable information, evidence and knowledge of biological, chemical and physical processes and mechanisms that are relevant to the aquatic system under investigation. It is important to also consider the possible interactions between multiple stressors.

Factors that influence the likelihood of the risk occurring also need to be identified. For example, if you are looking at the risk of an algal bloom occurring:

- the stressor is high nutrient concentrations
- factors that may influence a bloom occurring in the presence of high nutrient levels are light levels in the water column, flow velocity and temperature.

Box 4 provides a simple example of management goals and identification of values, stressors and factors influencing the likelihood of risks occurring for a wastewater discharge.

The spatial scale is the area appropriate for the risk assessment, which is the scale in which impacts may occur. The temporal scale is an appropriate time frame for the risk assessment that meets management outcomes and is protective of water body values. These scales may alter for different threats and values. Temporal variability (for example, seasonality and climatic influences) should also be incorporated into the scope of the risk assessment. Box 5 provides an example of considerations in temporal and spatial scales.

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Box 4: An example of management goals, values and stressors for a discharge

Example
Tertiary treated effluent from a sewage treatment plant (STP) is discharged into a nearby stream.

Management goals

- maintaining and protecting a healthy aquatic ecosystem
- clean water suitable for recreational purposes, e.g., swimming, fishing, boating.

Identification of values:

- fish populations.
- macroinvertebrate communities.
- recreation - swimming and fishing.

Identification of stressors from the discharge the risks they present and factors influencing the likelihood of the risk occurring are provided in the table below

Stressors	**Risk**	**Other factors influencing the likelihood of the risk occurring**
Fish populations and macroinvertebrate communities		
Nutrients	Algal blooms causing low dissolved oxygen.	Light, flow and temperature
Organic matter	Low dissolved oxygen	Microbial activity
Salinity	Direct toxicity	*Flow, evaporation*
pH	Low and high pH can induce toxic effects in a range of substances, as well as being directly harmful to organisms	*Buffer capacity, geology*
Ammonia	Direct toxicity	pH, temperature
Metals	Direct toxicity	pH and hardness
Recreation		
Nutrients	Toxic algal blooms, which may cause skin and eye irritations, or more serious complications if ingested	Light, flow and temperature
Pathogens and viruses	Ingestion by humans causing various illnesses	*Age and health of people exposed, time of exposure*
Metals	Direct toxicity	pH and hardness

Box 5: Example of spatial and temporal scales and variability

Potential risk

The potential risk of algal blooms in an inland stream from an STP discharge.

Spatial considerations

Spatial scale: In this case, the area included in the risk assessment would be the point of discharge, upstream of this point (background levels) and downstream to the point where nutrient concentrations have returned to background levels or met SEPP (WoV).

Temporal considerations

Temporal scale: This determines the periods of time the risk assessment needs to consider; for example, one year, five or 50 years. The temporal scale may be based on the timing of management plans, climatic variability or seasonality.

Seasonal and climatic variability

In this example, seasonal influences could be low summer flows. At such a time, nutrients in the discharge will become more concentrated in the receiving aquatic ecosystem. In addition, the climatic influence of drought would further exacerbate low flows and nutrient concentrations.

3.1.4 Conceptual models

A conceptual model is a diagram or picture of the relationships between:

- human activities, sources, stressors and the environment
- factors influencing the likelihood of risk occurring
- impacts to the beneficial uses and values.

Creating a conceptual model is an important initial step in the analysis of multiple stressors and provides the basis for developing hypotheses on potential cause-effect relationships (Ferenc and Foran, 2000).

The development of a conceptual model has several benefits. Conceptual models:

- aid in simplifying complex processes that may not always be completely understood
- compel risk assessors to think through and clarify their assumptions about cause-effect relationships
- identify knowledge gaps and determine research/data needs
- can easily be updated as information becomes available
- provide an easily understandable communication tool for conveying the risks, assumptions and uncertainties to risk managers and stakeholders.

Development of conceptual models should involve risk managers, technical and scientific experts, resource managers and other relevant stakeholders.

Hart et al (2005) outlined the positive outcomes of stakeholder involvement in building conceptual models as:

- providing the stakeholders with some ownership of the process
- bringing out knowledge that is not formally documented
- providing a useful means for increasing participants' knowledge of the ecosystems being assessed.

Conceptual models are most commonly flow diagrams that use arrows to represent relationships between sources, stressors and values (see Appendix A for examples).

Conceptual models will vary in complexity, depending on the risks and systems being assessed. If there are many complex relationships, it may be more desirable and less confusing to represent the relationships and processes as a set of interrelated models. Such models could progress from a broad scale (such as the catchment level), working towards a finer scale showing more detail (for example, the relationship between wastewater pathogens and toxicants to human health issues (Appendix A).

Depending on the complexity of the conceptual model, supplementary text may be important for providing explanations of the relationships. This helps to prevent confusion. It is also important that the underlying assumptions of the model and key knowledge gaps are identified, reviewed and documented as sources of uncertainty. This avoids the inclusion of incorrect information or misrepresentation of the actual risks. Data and information can be collected to address these knowledge gaps and incorporated into the model as they become available throughout the investigation.

3.1.5 Identification of endpoints

Endpoints are selected to measure/monitor the health of the beneficial uses and values being assessed. Assessment endpoints are explicit expressions of the value to be protected. Measurement endpoints are the aspect of the assessment endpoint that can be measured.

For example, if the risk to aquatic ecosystem health is being investigated, the endpoints selected may be:

- assessment endpoint – macroinvertebrate community diversity
- measurement endpoint – biological indices, such as AUSRIVAS, SIGNAL, or number of families

and/or

- assessment endpoint – a native fish population (e.g., Murray cod)
- measurement endpoint – native fish (e.g., Murray cod abundance).

If the risk of an algal bloom occurring in a river is being investigated, the endpoints selected may be:

- assessment endpoint – the river phytoplankton community
- measurement endpoint – chlorophyll a and/or phytoplankton diversity and abundance.

Endpoints are distinguished from management goals by their neutrality and specificity. Endpoints do not represent a desired achievement (or goal), they are defined by specific measurable components, and provide a means of measuring stress-response relationships.

Endpoints need to be:

- susceptible to the wastewater stressor
- predictable and measurable
- biologically relevant to the beneficial uses and values.

There is often a trade-off in selecting an endpoint between the costs of ambiguity if endpoints are loosely defined and a loss of generality in endpoints that are very precisely defined. In some cases more than one endpoint may be required for a risk assessment, to cover the complexity of aquatic systems and the cause-and-effect relationships within these.

The strengths and limitations of potential endpoints should be assessed to select the most appropriate endpoint to analyse the risks. Selection of endpoints requires expert knowledge of aquatic processes and the assessment of these. It also requires local knowledge of the area and management concerns.

3.1.6 Risk analysis plan

The risk analysis plan summarises the problem formulation phase and details the design for the risk analysis phase. The plan is developed based on the conceptual model and information and data collected during problem formulation. It defines the endpoints that will be used to assess risk to the ecosystem and how the risk analysis will be undertaken. Plans will vary in complexity and length, depending on the risk assessment concerned. In any case it is important to have a sound analysis plan before entering the risk analysis phase.

For more information on conducting the problem formulation phase refer to USEPA (1998), USEPA (2001) and Hart *et al*. (2005).

3.2 Risk analysis

Risk analysis is the determination of the probability and magnitude of an adverse effect with specific consequences occurring to the beneficial uses and values within a certain time frame (Suter, 1993, Hart *et al*., 2005). In the risk analysis phase, the endpoints, conceptual model and risk analysis plan developed in problem formulation are used to analyse risk to the beneficial uses and values of the water body.

The analysis tools required will vary on a case-by-case basis. A tiered approach to the risk analysis can be taken, beginning with a simple analysis and increasing the effort and resources being applied as needed.

Qualitative analyses of risk are based on subjective assessments, where cultural, personal and professional experiences and values all affect the perception of risk and ultimately the risk analysis. Consequently, it should be recognised that these estimates of risk represent views or opinions to which there are likely to be many alternatives (Burgman, 1999). Issues of potential bias in qualitative estimates can be limited by wide consultation.

Semi-quantitative and quantitative risk analysis methods provide more rigour in the assessment and more detailed information for managing risks. They also provide better internal consistency and better assessment of uncertainties and assumptions in the analysis.

Table 1 provides guidance on the level of analysis (qualitative to semi-quantitative/quantitative) that may be required under different scenarios.

Examples of the types of analysis methods that can be used are given below. In all cases, the guidance in Section 3.2.1 for assessing uncertainty needs to be incorporated into the analysis.

- Conducting a desktop study of currently available information and data for the discharge effluent and receiving water body.

  This may involve data trends, patterns and correlations analysis, dilution modelling (including low-flow conditions), decay curves and comparison to available criteria and cause-effect relationships. The spatial and temporal (for example, seasonal or climatic) variability of the receiving waters and discharge effluent needs to be taken into account in these analyses.

  The desktop study may also include the use of a risk matrix to conduct a preliminary prioritisation of risks. It should be noted that risk matrices are often subjective, qualitative and not transparent, so they do not replace the need to conduct a more robust analysis of risks. However, where a large number of potential risks have been identified, a matrix can be a useful tool for identifying the key risks to prioritise for analysis (Hart *et al.*, 2005). The potential bias in risk matrices can be limited by wide consultation.
- Where the existing data does not meet all the risk assessment needs, additional data may need to be collected. Once the new data is collected, a desktop study similar to that outlined above can be conducted that specifically addresses the risk analysis needs. The type of new data required may include flow, water quality and/or biological monitoring of the receiving waters, and chemistry screening of the effluent to better characterise both of these.
- Incorporating additional information and/or more detailed analyses from specialised technical experts (such as ecologists with expertise in the particular

biota being assessed, hydrologists, ecotoxicologists, microbiologists or other human health experts).

- Analysis and interpretation of biological data, including: calculation of standard indices, expert interpretation of family or species data and multivariate analyses.
- Conducting ecotoxicity testing. This may include whole effluent toxicity testing (WET), direct toxicity assessment (DTA) of the receiving waters (Chapman & van Dam, 2001) and/or toxicity identification evaluation (TIE).
- Application of a formal 'multiple lines and levels of evidence' (MLLE) approach (an MLLE approach is described in Section 9.2 of Downes *et al.*, 2002).
- Quantitative predictive modelling, sensitivity analysis and management scenario testing (for example, Bayesian networks, Monte Carlo analyses, regression models, quantitative structure-activity relationships (QSARs), mathematical dynamic simulation models, deterministic process models). Examples of a range of these models and discussion of these are provided in Hart *et al.* (2005).

As the analysis is conducted and more information becomes available, it may also be necessary to re-evaluate how the risks will be assessed. This may include the need to update the conceptual model and analysis plan developed in the problem formulation phase, and/or to conduct further field investigations to fill key knowledge gaps identified in the risk analysis or further quantify specific cause and effect relationships.

A risk analysis may be terminated or suspended when the risks and management of these are sufficiently understood.

3.2.1 Uncertainty analysis

The interactions within water bodies, particularly ecosystem interactions, are not always fully understood. Even when understanding is high, a degree of uncertainty exists with all data and information and their analyses, and there is a natural variability in all aquatic system processes.

There are limitations in the type and amount of data that are available or can be collected, and uncertainties associated with the accuracy and/or quality of this data. In addition, there are uncertainties and limitations associated with different methods used for analysing the data and information. For these reasons, uncertainties in the data and information from the problem formulation and risk analysis phases should be identified, estimated and/or described. This provides transparency and credibility for the assessment and confidence that more informed and appropriate management decisions can be made. The uncertainty analysis should include:

- identification and description of any key knowledge gaps
- identification of assumptions made in the risk analysis and the rationale for these assumptions
- identification and description of data limitations. This includes limitations in both the type and amount of data available, and also uncertainties in the accuracy and/or quality of the data
- identification and description of the strengths and limitations of the analysis methods and models used
- where possible, quantitative estimates of the uncertainties in the analyses conducted.

More information on assessing uncertainties in risk assessment can be found in Warren-Hicks and Moore (1998), USEPA (1998), Hart *et al.* (2005) and Burgman (2005).

3.3 Risk characterisation

Risk characterisation is the evaluation and reporting of the problem formulation and risk analysis results that provides the information needed for decision making and risk management.

The main outputs from the risk characterisation phase that need to be clearly reported to risk managers and decision makers are:

- identification of what the risks are to each of the beneficial uses/values of the water body
- for each risk identified above, an evaluation of the level of change or impact to the water body value and likelihood of the risk occurring, including the conditions under which the risk is likely to occur
- identification and evaluation of the interactions between the risks identified
- comparison and prioritisation of the risks identified
- reporting of the assumptions, uncertainties (see Section 3.2.1) and strengths and limitations of the risk analyses
- a discussion of all the information gained during the assessment that is relevant to decision making and risk management. It is important that risk assessors pass on not only the information in the above five dot points, but also any other information, advice or opinions that may assist in managing the risk to water body values. This includes where risk is predicted as low, advice about the potential for risk to beneficial uses and values to occur under changed conditions
- a summary of the stakeholder and expert participation throughout the risk assessment
- suggested monitoring and assessment program to assess risk assessment predictions and potential effectiveness of management actions.

It is important to note that the risk assessment is a relatively objective and transparent process that evaluates the risk of adverse effects to the water body values. Factors such as social and economic implications are not incorporated in the process until the decision-making and risk management stage (Section 4).

4 DECISION MAKING AND RISK MANAGEMENT

Risk assessments are conducted to provide information to risk managers and decision makers about the potential adverse effects of anthropogenic activities and the effectiveness of management actions for addressing these. The rigour and transparency in the risk assessment process results in information that is more targeted and defensible than less formal processes. This information is particularly useful to decision makers and managers who must evaluate trade-offs, examine different alternatives, compare or prioritise risks, evaluate the most cost-effective management actions for achieving maximum environmental gains or determine the extent to which stressors must be reduced to achieve a given outcome.

Risk management combines the information and outcomes from the risk assessment with statutory, legal, social, economic, environmental and political factors in assessing options to manage risk (USEPA, 1998). Decisions must be made and clearly articulated in a management plan such as an environment improvement plan (EIP). Management plans include the overall management goals, specific management targets (with specified timeframes) that work towards achieving these goals and actions to achieve these goals.

The effectiveness of actions in meeting defined targets must be monitored, evaluated and, where necessary, updated. It is important that a monitoring program is developed with appropriate indicators to evaluate management actions. These will often include the endpoints selected in the risk assessment. Where appropriate, the collection of new monitoring data can also be used to update the risk assessment, providing increasingly more robust predictions and information for management of risks.

Risk managers also need to appropriately communicate the risk management plan to all relevant stakeholders and interested parties; in particular, the:

- results of the risk assessment (the risk characterisation reporting outlined in Section 3.3 provides the basis for what is required)
- management goals and targets for addressing the risk identified and management actions for achieving these
- monitoring and assessment plan (and results when available) for assessing management actions.

5 STAKEHOLDER PARTICIPATION

A planned approach to stakeholder participation and ongoing dialogue with stakeholders is an important part of any risk assessment. It is beneficial to involve specialist and non-specialist people and organisations in the risk assessment process. Stakeholders may include industry representatives, regulators/decision makers, relevant state agencies and natural resource managers, scientific and technical experts, local government, adjacent landholders, downstream users, local communities and NGOs.

While the key stakeholders should be kept involved throughout the entire risk assessment process, it is particularly important that they are actively involved in the problem formulation step (Hart *et al.*, 2005). If this level of involvement is not achieved, important beneficial uses and values, threats and key local knowledge may not be considered in the risk assessment.

5.1 Benefits of stakeholder participation

Stakeholder participation benefits businesses, industry and stakeholders. The benefits of successful participation for businesses include:

- outcomes of the risk assessment being relevant to local management needs
- access to a wider range of information and local knowledge from stakeholders
- obtaining all ideas and new information at the outset of the risk assessment, rather than part way through
- lowering the risk of negative stakeholder reactions
- a better understanding of the issues that communities face
- developing good relationships with stakeholders and identifying collaboration possibilities on issues of concern
- increasing the transparency and accountability of businesses and industries
- increasing business and industry's reputation.

The benefits of successful participation for stakeholders include:

- having the opportunity to provide their expertise and local knowledge
- being aware of and involved in projects being undertaken in their region
- a sense of ownership of solutions to problems and an involvement in decision making processes
- a greater acceptance, respect and recognition of their needs
- an opportunity for a wide range of opinions to be voiced and listened to
- an increase in understanding of risks considered and the knowledge base of stakeholders

- being aware of information sources that could be useful to their own organisation
- a sense of empowerment on issues of concern to them.

5.2 Planning process for stakeholder participation

The process outlined below helps risk assessors think through the steps for developing a stakeholder participation plan.

Identify the issues/opportunities

Why do you want to involve the public, community, stakeholders and/or technical specialists?

Identify the stakeholders

Who do you need to talk to? Who is demanding to be let in? Whose input do you need? Who is legitimately part of this discussion? Whose interests are affected (positively or negatively) by the wastewater discharge? Who will be outraged later if excluded now? Whose buy-in do you need?

Analyse stakeholders' goals and constraints

What do the stakeholders want from the process? What possible benefits and costs are posed to them by your activities? What possible benefits and costs are posed to them by participating in the risk assessment? How much power do they currently have to influence the outcome/decision? How much would they like to have? How would they like to be involved? What type of involvement might stakeholders be expecting?

Analyse your goals and constraints

What are you hoping to get from stakeholders in order to achieve your goals? What does success look like? What does failure look like? What are you allowed to do or not to do? What is compulsory/non-negotiable? What decisions are predetermined? What is negotiable/flexible/open for debate? What are your timelines, budget and mandate/role? How would you like stakeholders to be engaged? What type of stakeholder participation is your organisation expecting?

Determine your purpose, process and tools

Based on all of the above, what is your overall stakeholder participation purpose with this risk assessment? How might different people/stakeholders be engaged differently? What tools are appropriate?

The IAP2 model developed by the International Association for Public Participation provides a good approach to working with stakeholders and answering these questions. In using the IAP2 spectrum, a plan for the level of participation required for each stakeholder group can be clearly determined. A summary of the IAP2 approach is provided in Table 2.

Outline how participation risks will be managed

Based on the above analysis, what are the risks if you don't engage with stakeholders? What are the risks if you do engage with stakeholders? What is the likelihood of these risks occurring? What would be the impact if they did occur? How will risks be managed?

Outline how success will be measured/evaluated

What is the purpose of the evaluation? Who wants to know what from the evaluation? What evidence will be collected and how? When will the evaluation occur and what resources are required for it?

Write up your plan and implement it

Get buy-in internally and externally when you write up the plan. Evaluate and revise as you go along.

More information on the above stakeholder participation planning process can be found in EPA publication 1145, *A planning process for community engagement*.

Table 2: Summary of the IAP2 Public Participation Spectrum, developed by the International Association for Public Participation

INFORM	CONSULT	INVOLVE	COLLABORATE	EMPOWER
GOAL	**GOAL**	**GOAL**	**GOAL**	**GOAL**
To provide stakeholders and the broader public with balanced and objective information to assist them in understanding the problems, alternatives and/or solutions.	To obtain feedback from stakeholders and the broader public on analysis, alternatives and/or decisions.	To work directly with stakeholders and the broader public throughout the process to ensure that their issues and concerns are consistently understood and considered.	To partner with stakeholders and the broader public in each aspect of the decision, including the development of alternatives and the identification of a preferred solution.	To place final decision making in the hands of stakeholders and the broader public.
PROMISE TO THE PUBLIC	**PROMISE TO THE PUBLIC**	**PROMISE TO THE PUBLIC**	**PROMISE TO THE PUBLIC**	**PROMISE TO THE PUBLIC**
We will keep you informed.	We will keep you informed, listen to and acknowledge concerns and provide feedback on how your input influenced the decision.	We will work with you to ensure that your concerns and issues are directly reflected in the alternatives developed, and provide feedback on how your input influenced the decision.	We will look to you for direct advice and innovation in formulating solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible.	We will implement what you decide.
EXAMPLE TOOLS	**EXAMPLE TOOLS**	**EXAMPLE TOOLS**	**EXAMPLE TOOLS**	**EXAMPLE TOOLS**
• Fact sheets • Newsletters • Field trips/open days • Web sites • Stakeholder information sessions	• Surveys • Focus groups • Workshops • Polling	• One-on-one discussions • Workshops • Meetings • Development of conceptual models • Feedback tools on how input has been incorporated (e.g., documentation sent to stakeholders or verbal feedback sessions)	• One-on-one discussions • Workshops • Meetings • Development of conceptual models • Participatory decision making • Consensus-building • Steering committees • Advisory panels	• Delegated decisions • Ballots

6 MIXING ZONES AND THE RISK ASSESSMENT PROCESS

SEPP (WoV) describes a mixing zone as 'an area contiguous to a licensed waste discharge point and specified in that licence, where the receiving environmental quality objectives otherwise applicable under the Policy do not apply to certain indicators as specified in the license. This means that some or all beneficial uses may not be protected in the mixing zone'.

SEPP (WoV) also states certain conditions that must be met within a mixing zone, including:

- Clause 27 (4) – 'EPA will not approve a wastewater discharge that, according to toxicity tests approved by EPA, displays acute lethality at the point of discharge or causes chronic impacts outside any declared mixing zone, except that a waste discharge containing a non-persistent substance that degrades within any declared mixing zone may be approved'.
- Clause 30 (1) – 'EPA will not approve a mixing zone if it will result in: a) environmental risks to beneficial uses outside the mixing zone; b) harm to humans, unacceptable impacts on plants and animals or where it will cause a loss of aesthetic enjoyment or an objectionable odour'.

SEPP (WoV) (Clause 28 (3)) also states circumstances under which EPA will not approve any new discharges, these are:

- Aquatic Reserves, Wetlands and Lakes or Estuaries and Inlets segments or to waters in areas of high conservation significance;
- Waters in special water supply catchments or where a discharge will impact on authorised potable supplies; and,
- Where a discharge would pose an environmental risk to beneficial uses and best management practice has not been adopted.
- It is also a requirement that mixing zones do not present barriers to the free movement of aquatic biota, such as: barriers to migration of local species, spawning migrations and repopulation of areas with planktonic organisms, aquatic invertebrates and drifting eggs and embryos.

Mixing zones are used as a tool for responsible management of the environment. They are designed to limit the impact on the environment that would otherwise occur if discharges were allowed to flow unchecked into waterways.

In issuing a licence, EPA may approve a mixing zone where it is not practicable to avoid, reuse or recycle wastewater. However, the mixing zones must be kept to the smallest area possible, and the size and impact of the mixing zone on the environment needs to be decreased over time.

The temporal and spatial extents of mixing zones are determined as part of the works approval and licensing processes. Where a risk assessment is not required for a discharge, the mixing zone extent is determined by using the approach previously used as part of the works approval process. This primarily uses the SEPP (WoV) environmental quality objectives as the basis for determining the extent of a mixing zone.

Where a risk assessment is required for a wastewater discharge (Section 2), the risk assessment process can instead be used to measure the mixing zone extent. The risk assessment process provides more detailed information and understanding of the impacts and processes occurring in the mixing zone. This allows:

- a clear determination of the temporal and spatial extent of the mixing zone
- a better understanding of the impacts to specific beneficial uses and values, including factors that may influence the probability and level of impact
- prioritisation of the key risks to be managed within a mixing zone
- targeted information to ensure designated mixing zones are kept to the smallest area possible, and to assist in reducing the size and impact on the environment continuously over time.

Decisions on the acceptability of and requirements within a mixing zone need to reflect the range of environmental, social and economic considerations. The above information from a risk assessment will greatly assist in this decision-making.

7 PILOT STUDIES

Barwon Water, Goulburn Valley Water and North East Water conducted pilot study risk assessments in collaboration with EPA in 2008. These pilot applications were conducted to provide practical examples of the implementation of the risk assessment process for wastewater discharges. In addition, these pilot studies have been used to refine and finalise these Guidelines.

Summaries of the three pilot applications are given in Appendix B. More detailed information is provided in reports developed by the Water Authorities as part of the pilot risk assessments.

8 ACKNOWLEDGEMENTS

EPA wishes to thank Barwon Water, Goulburn Valley Water and North East Water for their participation in the pilot applications for these Guidelines.

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APPENDICES

APPENDIX A: EXAMPLES OF SIMPLIFIED CONCEPTUAL MODELS ADDRESSING COMMON WASTEWATER DISCHARGE ISSUES

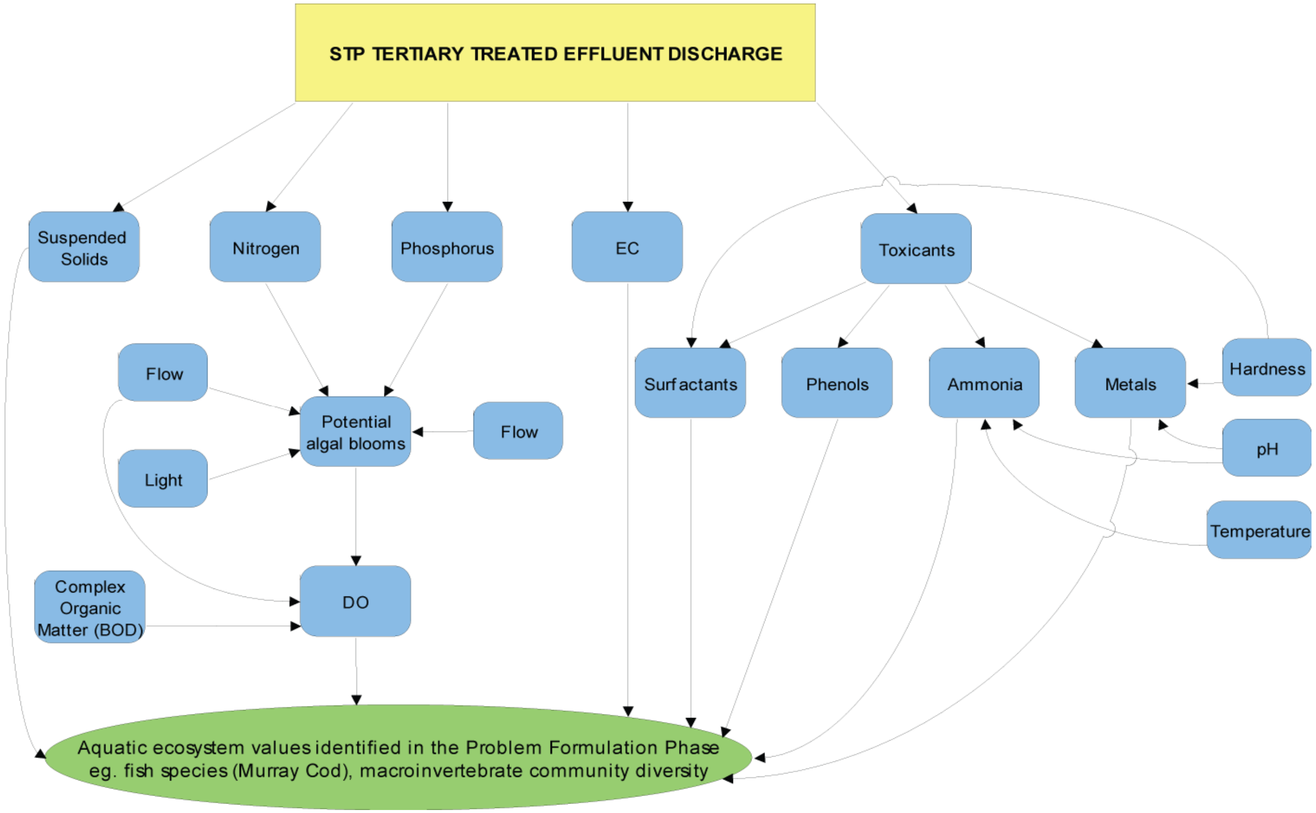

Figure 2: Simplified conceptual model of the potential risks to a river aquatic ecosystem from a tertiary treated STP effluent

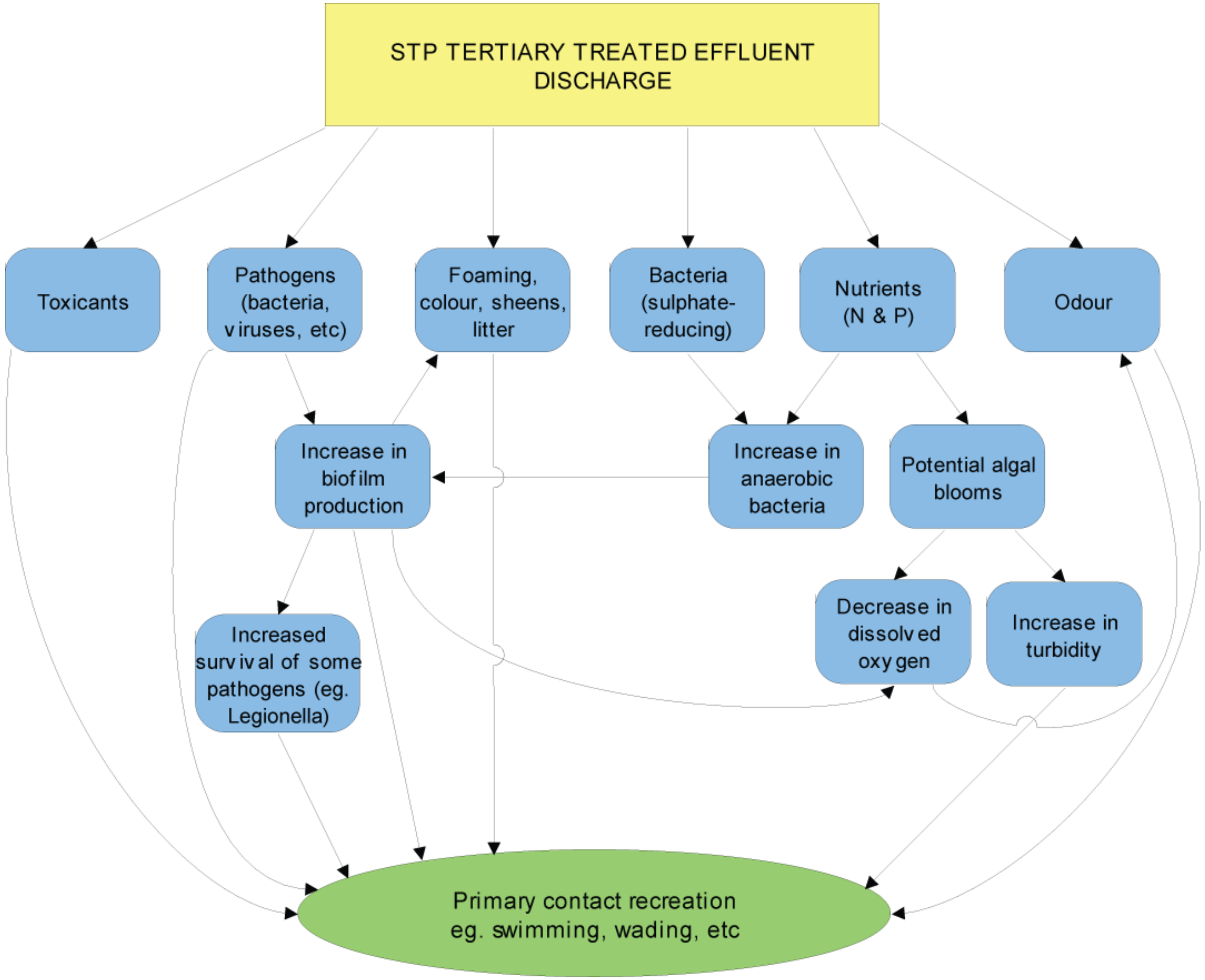

Figure 3: Simplified conceptual model of the potential risks to the beneficial use of primary contact recreation from a tertiary treated STP effluent

APPENDIX B: PILOT STUDIES

B1 Barwon Water - Black Rock treatment plant

The Black Rock wastewater treatment plant (WWTP) is near Thirteenth Beach, south of Geelong. It treats domestic and industrial wastewater from Geelong and surrounding towns. The plant has a strict Trade Waste Policy and a natural biological treatment process (Intermittently Decanted Extended Aeration (IDEA)) that produces water suitable for reuse.

Recycled water from the Black Rock WWTP is used on golf courses and for turf, potato and flower production. About 18,000ML per year is also discharged to the ocean between Barwon Heads and Torquay. The ocean outfall is about 1.1km offshore and 16m below the ocean surface. The outfall has a diffuser that was designed to direct the discharge away from the high value shoreline and produce a high initial dilution. The EPA licence for Black Rock WWTP defines the discharge mixing zone as a 424m x 200m area surrounding the diffuser.

B1.1 Problem formulation

The focus of this risk assessment was to investigate the potential risks posed by the Black Rock WWTP discharge to the beneficial uses of the receiving marine waters, both in and out of the mixing zone area.

The problem formulation included the following:

- Identification of Barwon Water's key management goals to be informed by the risk assessment. These goals were to: ensure the discharge complies with the EPA licence requirements in the mixing zone; and protect the SEPP (WoV) beneficial uses outside the mixing zone from discharge impacts. Barwon Water also defined specific management objectives under these broader goals for each of the beneficial uses (Table 3).
- Identification of the receiving waters beneficial uses and values (Table 4 and Figure 4).
- Collation of information and monitoring data on the discharge and receiving waters.
- Identification of the potential stressors from the discharge and the pathways for risks occurring.
- Development of conceptual models showing the key interactions between stressors and beneficial uses/values. Conceptual models were developed for aquatic ecosystem values (Figures 5) and recreational, cultural, and aesthetic values (Figure 6).

In identifying the potential stressors from the discharge and pathways for risks to be investigated, the risk assessors considered the:

- source of the original wastewater
- composition of the treated discharge water, that is, the potential stressors and their concentrations and loads
- volume of discharge water
- nature of the beneficial uses/values
- nature of exposure and proximity of beneficial uses/values to the discharge water.

Table 3: Barwon Water management objectives

Beneficial Use	Management Objectives
Aquatic ecosystem	Comply with EPA requirements within the mixing zone. Outside the mixing zone: Maintain biodiversity and ecosystem processes No acute or chronic toxicity No assemblage impact due to salinity effects No suspended solids effects above background levels – smothering and turbidity No dissolved oxygen depletion No bioaccumulation/concentration/magnification of toxic substances No primary or secondary enrichment No synergistic effects due to combinations of discharge effects
Primary contact recreation	Comply with EPA requirements within the mixing zone. Outside the mixing zone: Maintain microbiological levels below EPA prescribed limits for primary contact recreation No toxic effluent effects No oils, slicks, scums or films No impact on background turbidity No odour No algal blooms
Secondary contact recreation	Comply with EPA requirements within the mixing zone. Outside the mixing zone: Maintain microbiological levels below EPA prescribed limits for secondary contact recreation No toxic effluent effects No oils, slicks, scums or films No impact on background turbidity No odour No algal blooms
Aesthetic enjoyment	Comply with EPA requirements within the mixing zone. Outside the mixing zone: No oils, slicks, scums or films No impact on background turbidity No odour No algal blooms
Indigenous and non-indigenous cultural and spiritual values	Comply with EPA requirements within the mixing zone. Outside the mixing zone: No loss of biodiversity – particularly species of cultural or spiritual significance No loss of amenity No loss of primary or secondary contact opportunities
Aquaculture	Comply with EPA requirements within the mixing zone. Outside the mixing zone: Maintain microbiological levels below EPA prescribed limits No toxic effects No biological uptake of toxic/harmful chemicals
Fish, crustacean and molluscs for human consumption	Comply with EPA requirements within the mixing zone. Outside the mixing zone: Maintain microbiological levels below EPA prescribed limits No bioaccumulation, concentration or magnification of toxins in marine organisms for human consumption No reduction in ecosystem health (such as biodiversity impacts)

Table 4: Beneficial uses and values identified for the Black Rock discharge receiving waters

Beneficial Use	Values
Aquatic Ecosystem	The marine ecosystem in the region of the outfall comprises a range of habitats and associated biota.
Primary contact recreation	The waters within 200m of the shoreline in the Barwon Heads region are highly valued by surfers and swimmers, including Thirteenth Beach, Bancoora and Point Impossible. There is no particular focus for recreational divers in the area, the ships' graveyard more than 10km east of the outfall is the closest popular dive area.
Secondary contact recreation	Recreational fishing is generally concentrated in the Barwon River estuary and surf beaches. Recreational boat fishing is relatively dispersed in the area, with no focal point in the outfall region.
Aesthetic enjoyment	The beaches, dunes and elevated vantage points are valued for their aesthetic qualities.
Indigenous and non-indigenous cultural and spiritual values	Indigenous and non-indigenous cultural values may be associated with the dunes and land behind the dunes.
Aquaculture	There is currently no aquaculture in the region.
Fish, crustacean and molluscs for human consumption	The region of the outfall is not intensively commercially fished.

Figure 4: General location of beneficial uses at Black Rock

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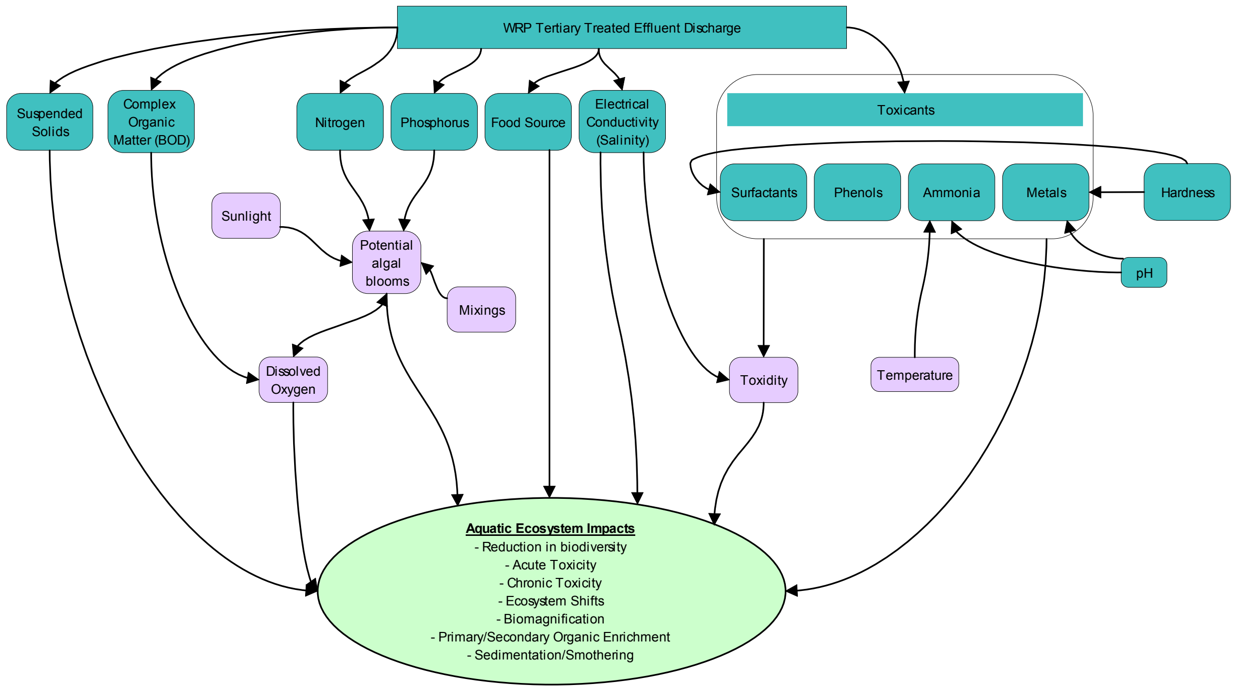

Figure 5: Conceptual model of the direct interactions of a WWTP discharge with a marine aquatic ecosystem

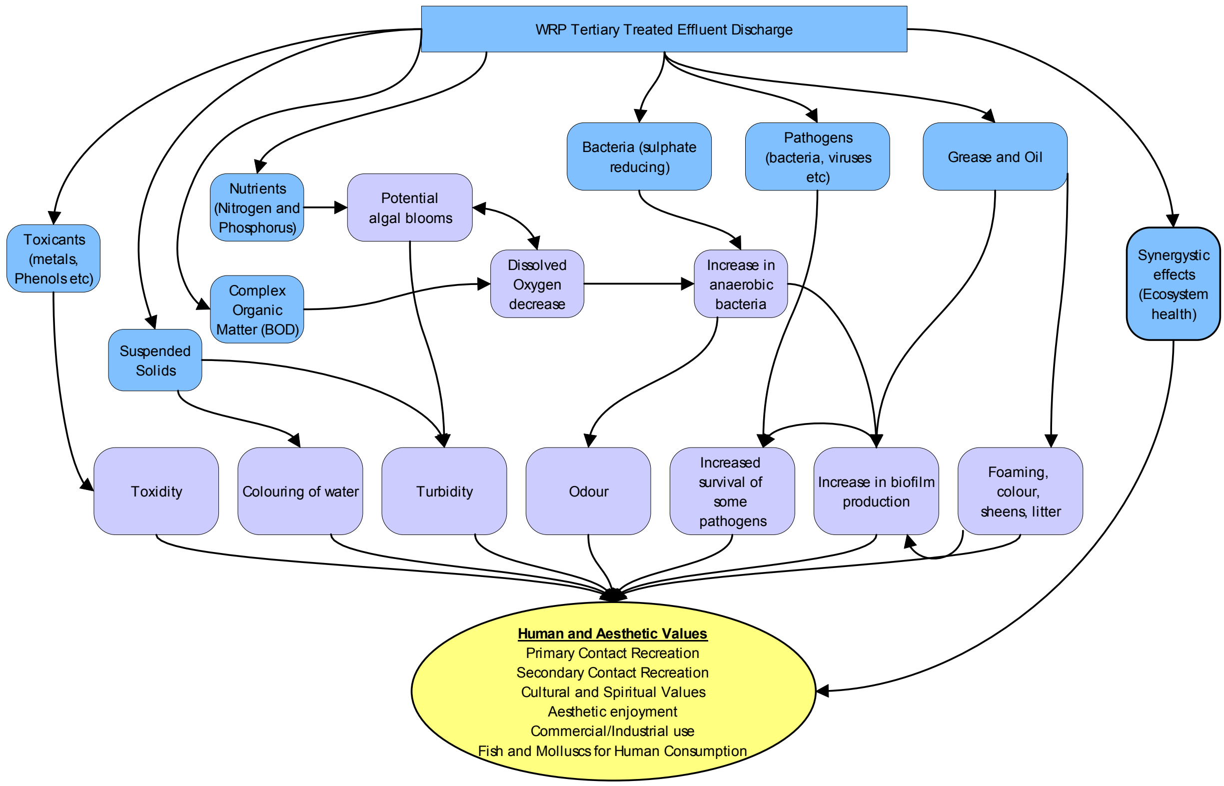

Figure 6: Conceptual model of the interactions of recreational, cultural and aesthetic values with a WWTP discharge

B1.2 Risk analysis

The risk analysis was conducted using the semi-quantitative approach in the Australian/New Zealand Standards AS/NZS 4360 (2004). The likelihood and consequence definitions were clearly defined (Tables 5 and 6) for the risk analysis. To increase the robustness and transparency of the analysis, the consequence ratings were defined in very specific terms for each of the different marine beneficial uses (Table 6). Evaluation of risk to the beneficial uses was determined from the consequence and likelihood levels using a risk matrix (Table 7).

A group of three scientific and technical experts determined the risk likelihood and consequence levels for each of the beneficial uses being investigated. Enough monitoring data and information was available on the discharge and marine receiving waters to determine these levels, without the need for further monitoring or modelling as part of the analysis. The information and data used included:

- mixing and transport - tidal data, temperature, salinity, stratification, currents, dispersion and dilution characteristics
- ecotoxicity testing – acute toxicity testing (Allorchestes compressa LC5096hr), chronic toxicity testing (Hormosira germination test, Doughboy scallop larval development, Nizschia cell division)
- marine ecology – species present/abundance and multivariate analysis of infauna sampling data from around the discharge and reef sampling data
- bacteriology – Enterococci and E.coli data of the effluent and surrounding beaches
- effluent water quality and toxicants – e.g. nutrients, ammonia, salinity, pH, biological oxygen demand, suspended solids, metals.

A brief summary of the above data analysis to determine the consequence, likelihood and risk levels is given below for each beneficial use.

Aquatic ecosystem

- The aquatic ecosystem in the mixing zone discharge region comprises a rocky reef kelp dominated community, a sparse soft seabed infauna community and pelagic and planktonic water column communities.
- Exposure to the discharge water is greatest for the fixed benthic communities on the seabed close to the outfall diffuser (rocky reef kelp and soft seabed infauna) and lowest on the other communities (pelagic and planktonic).
- Exposure of benthic communities will decrease with distance from the outfall.
- Analysis of the biological monitoring data showed: minor differences between reef communities on the outfall compared to those within five metres of the outfall; and a wide natural variability in infauna communities, with no obvious differences between the infauna community close to the outfall and those distant from the outfall.
- There are no State listed species (Flora and Fauna Guarantee Act) likely to occur in the discharge region. Several nationally listed species (Environment Protection and Biodiversity Conservation Act) may occur in the region at times. However, the area is not a known significant breeding, feeding, calving or aggregation area for any of these listed species, and the discharge is not a threatening process for any of these species.
- Ecotoxicity test results showed the discharge water is not acutely toxic to test organisms and has no to very mild chronic effects. Where a chronic response was detected, it was very low and varied between test organisms and between the years tested.

Recreation – primary and secondary contact

- *Enterococci* monitoring results indicated that all the beaches were suitable for primary and secondary recreation during all sampling times.
- *E. coli* monitoring results indicated that all the beaches were suitable for secondary recreation during all sampling times.
- *E. coli* monitoring results indicated that three of the four beaches were suitable for primary recreation during all sampling times, and one beach was suitable for primary recreation 95% of the sampling times.

Aesthetic, non-contact recreational, cultural and spiritual values

- The outfall is relatively remote from beaches and has a high level of dilution and dispersion.
- Source control and high treatment levels have reduced the nuisance constituents of the discharge to very low levels.
- Monitoring at Bancoora beach has reported no foams or slicks.

Fisheries and aquaculture

- There is no aquaculture in the region of the discharge.
- There is no or very limited filter-feeding shellfish collection in the region.
- Recreational and commercial fishing in the region is mostly for species that are not eaten whole and are not likely to accumulate bacteria in edible tissue.
- Fisheries resources are widely dispersed and there is no known aggregation of fisheries targeted species close to the discharge.

The results of the above analysis (i.e. the final risk characterisation) are summarised in Section B1.3.

Table 5: Likelihood definitions

Descriptor	Likelihood
Almost certain	The event is expected to occur in most circumstances
Likely	The event will probably occur in most circumstances
Possible	The event should occur at some time
Unlikely	The event could occur at some time
Rare	The event may occur only in exceptional circumstances

Table 6: Environmental consequence descriptions

Beneficial Use	Consequence	Descriptor	Level
Aquatic ecosystem	Highly modified ecological assemblage dominated by a few low salinity and stress tolerant species; Deformities or reduced metabolic function in species over a wide area; High levels of cumulative contaminants in biological tissues over a wide spatial area; Acute toxicity NOEC <10 percent, unknown cause.	Severe	5
	Highly modified ecological assemblage dominated by filter and deposit feeders, grazers and blue green and green algae; Deformities or reduced metabolic function in species in identifiable area; Elevated contaminants in some species; Acute toxicity NOEC <100 percent, unknown cause, chronic toxicity NOEC < 5 percent cause due to non-persistent substances, unlikely to satisfy SEPP (WoV).	Major	4
	Modified ecological assemblage dominated by certain rapid growing algae, grazers and lacking sensitive species; Acute toxicity NOEC >100 percent, chronic toxicity NOEC > 5 percent cause due to non-persistent substances, may meet SEPP (WoV) with mixing zone and outfall diffuser.	Moderate	3
	Modified ecological assemblage with detectable difference in species proportions and lacking some sensitive species; No acute toxicity, chronic toxicity NOEC > 25 percent cause due to non-persistent substances, likely to meet SEPP (WoV) with mixing zone and outfall diffuser.	Minor	2
	Minor change in species composition with difference in species proportions and sensitive species present; No acute toxicity, chronic toxicity NOEC > 50 percent cause due to non-persistent substances, likely to meet SEPP (WoV) with mixing zone.	Insignificant	1
Contact recreation	Recreational waters over a substantial area unsuitable for primary and secondary contact recreation at all times due to high and frequent microbiological levels.	Severe	5
	Many recreational waters frequently unsuitable for primary and secondary contact recreation due to high microbiological levels.	Major	4
	Many recreational waters occasionally unsuitable for primary and secondary contact recreation due to high microbiological levels.	Moderate	3
	Some recreational waters occasionally unsuitable for primary contact recreation due to elevated microbiological levels.	Minor	2
	Recreational waters almost always suitable for primary contact recreation.	Insignificant	1
Aesthetic, non-contact recreational, cultural and spiritual values	Offensive suspended solids, discolouration, odour, foams and slicks.	Severe	5
	Obvious suspended solids, discolouration, odour, foams and slicks.	Major	4
	Frequent detectable discolouration, odour and slicks.	Moderate	3
	Occasional detectable discolouration, odour and slicks.	Minor	2
	No detectable discolouration, odour and slicks.	Insignificant	1
Fisheries and aquaculture	High potential for mortality of targeted species due to effects on water quality; Deformities or reduced metabolic function in species; High levels of cumulative contaminants in tissue over a wide spatial area.	Severe	5
	Deformities or reduced metabolic function in species; Contaminants above edible standards in edible tissue.	Major	4
	Contaminants in tissue in some species significantly higher than reference sites, but comply with edible standards.	Moderate	3
	Contaminants in tissue in some species higher than reference sites, but well within edible standards.	Minor	2
	Contaminants in tissue in species within range of reference sites, and well within edible standards.	Insignificant	1

Table 7: Environmental Risk Matrix

Likelihood	Consequences: Insignificant 1	Minor 2	Moderate 3	Major 4	Severe 5
A almost certain	Negligible	Moderate	High	Extreme	Extreme
B Likely	Negligible	Moderate	Moderate	High	High
C Possible	Negligible	Low	Moderate	High	High
D Unlikely	Negligible	Low	Low	Moderate	Moderate
E Rare	Negligible	Negligible	Negligible	Low	Moderate

B1.3 Risk characterisation and management

The risk characterisation involved:

- clearly defining the level of risk posed to the different beneficial uses
- identifying management responses for addressing the above risks
- documentation of the risk assessment.

Barwon Water defined the management actions they would implement for different levels of risk (Table 8). This provided a consistent and transparent approach for dealing with the risks identified in the assessment.

Table 8: Management Response to Risk Levels

Risk Level	Management Response
Extreme risk	Immediate action required
High risk	Senior management attention needed
Moderate risk	Investigate cause, mitigation measures and mixing zone considerations
Low risk	Monitor and report
Negligible risk	Short justification only

The final risk characterisation (i.e. the assessed level of risk posed to the beneficial uses) and management actions for addressing these risks are summarised below.

Aquatic ecosystem

- Risk – low
- Management action - continue monitoring the marine ecosystem and effluent toxicity testing.

Recreation – primary and secondary contact

- Risk – low
- Management action – continue monitoring the regulatory recreation indicators at all beaches. The overall risk to primary and secondary recreation was low, however Barwon Water has chosen a higher management response to further investigate an individual beach that occasionally (5%) triggers a risk to primary recreation.

Aesthetic, non-contact recreational, cultural and spiritual values

- Risk – negligible
- Management action – continue monitoring aesthetic indicators at high value beaches.

Fisheries and aquaculture

- Risk – negligible
- Management action – continue to monitor related reef ecosystem values.

A further management action being implemented by Barwon Water for all beneficial uses is an investigation of the mixing zone using water quality or dye indicators to confirm dilution gradients and dispersion pathways. Barwon Water has previously conducted a number of dilution/dispersion investigations in the mixing zone

The risk assessment was extensively documented in a risk characterisation report. This report includes a detailed presentation of: background material; information and monitoring data; analysis methods and results; the assumptions made throughout the risk assessment; and, the results of the risk posed to the beneficial uses and management actions for these.

B2 Goulburn Valley Water – Shepparton, Alexandra and Eildon treatment plants

Goulburn Valley Water (GVW) manage three wastewater treatment plants (WWTPs) in north eastern Victoria. The WWTPs are at Shepparton, Alexandra and Eildon.

The Shepparton WWTP treats domestic and trade wastewater from Shepparton. The trade waste is from food processing industries, with no heavy industrial inputs. About 60 percent of the treated water is recycled and used for irrigated agricultural production. The remaining treated water, about 3,000ML per year, is discharged to the Goulburn River downstream of Shepparton between late autumn and early spring. The plant treatment process includes pre-treatment that involves screening and then a High Rate Anaerobic Lagoon process, followed by tertiary treatment involving phosphorus removal.

The Alexandra WWTP mainly treats domestic waste and has minor trade waste inputs from retail enterprises. About 50 percent of the treated water is recycled and used for irrigated agricultural production. The remaining treated water, about 180ML per year, is discharged to the Goulburn River downstream of Alexandra between late autumn and early spring. The plant treatment process includes: coarse manual screening; aerated lagoons; winter storage; chemically assisted clarification and rapid sand filtration plant.

The Eildon WWTP mainly treats domestic waste and has minor trade waste inputs from retail enterprises. It discharges about 116ML per year to the Goulburn River downstream of Eildon. The discharge is continual throughout the year. The plant treatment process includes: screening and grit removal; primary sedimentation; trickling filter; humus tank; lagoon detention; and, Dissolved Air Flotation and Filtration (DAFF) tertiary treatment.

The extent of the mixing zones for all three WWTPs had not been determined prior to the risk assessment.

B2.1 Problem formulation

The focus of this risk assessment was to investigate the potential risks posed by the Shepparton, Alexandra, and Eildon discharges to the beneficial uses/values of the Goulburn River. This also included assessing the extent of the mixing zones for all three WWTP discharges. GVW's key management goals in conducting the risk assessment were to:

- determine the mixing zones and level of impact to beneficial uses/values for each of the WWTPs
- protect the beneficial uses/values outside the mixing zones
- develop appropriate monitoring programs
- support decision-making on where to invest resources for the most desirable environmental, economic, and social outcomes
- ensure continuous improvement in management of WWTP facilities.

GVW held a problem formulation stakeholder workshop in August 2008. The workshop involved a wide range of stakeholders including representatives from: GVW, the appointed consulting firm, EPA Victoria, Department of Sustainability and Environment (Water and Sustainability group), Goulburn Broken CMA, and the Shepparton and Murrindindi Councils.

Prior to the workshop GVW and their consultant compiled and summarised all available information and data on the discharge effluents and receiving waters. This was made available to participants at the workshop.

At the problem formulation workshop stakeholders and experts:

- identified the beneficial uses/values to be protected for each site based on existing regional strategies and local/expert knowledge (Table 9)
- identified the potential stressors from the discharges and potential environmental effects from these (Tables 10 and 11).
- developed conceptual models showing the key interactions between the beneficial uses/values and stressors to be investigated in the risk analysis. Conceptual models were developed for biodiversity (Figure 7), recreational values (Figure 8), economic values (Figure 9), and heritage values (Figure 10)
- determined the mixing zone for the Shepparton wastewater discharge using available data on the Goulburn River receiving waters. It was not possible to determine the extent of the mixing zones at Alexandra and Eildon, as there was not enough available data on the receiving waters for these discharges
- identified the knowledge gaps and assumptions made.

Table 9: Beneficial uses and values of the Goulburn River identified by stakeholders

Beneficial use/value	Shepparton	Alexandra	Eildon
Environmental values			
Macroinvertebrates	✓	✓	✓
Native fish (including rare and threatened)	✓	×	×
Introduced Fish (target recreational species)	✓	✓	✓
Amphibians	✓	✓	✓
Other Aquatic Fauna (turtles, birds, platypus	✓	✓	✓
Algae (phytoplankton)	✓	✓	✓
Aquatic Macrophytes	✓	✓	✓
Riparian Vegetation (River Red Gums)	✓	✓	✓
Economic values			
Aquaculture	×	✓	✓
Irrigation	✓	✓	✓
Caravan Parks	×	✓	✓
Tourism	×	✓	✓
Turf farms	×	✓	×
Domestic consumption (indirect)	✓	✓	✓
Recreational values			
Boating / canoeing	✓	✓	✓
Camping	✓	✓	✓
Recreational fishing	✓	✓	✓
Swimming	✓	✓	✓
Cultural values			
Heritage values (landscape and aesthetics)	✓	✓	✓
Indigenous values	✓	✓	✓
Icon species	✓	✓	✓
Trout fishery	×	✓	✓
Aquaculture	×	✓	✓

Shading indicates that stakeholders considered the value as particularly significant at the location.

Table 10: Potential stressors identified for GVW WWTP discharges.

Stressors	Shepparton	Alexandra	Eildon
Nutrients	✓	✓	✓
Toxicants	✓	✓	✓
Electrical Conductivity	✓	×	×
Endocrine disruptors (EDCs)	✓	✓	✓
Nuisance organisms (algae)	✓	✓	✓
Human pathogens	✓	✓	✓
Whirling disease*	✓	✓	✓
Discharge volume	✓	✓	✓
Total suspended solids	✓	✓	✓
pH	✓	✓	✓

* Literature reviewed subsequent to the workshop suggested that Whirling disease is not known to occur in Australia. It was therefore not considered further in the risk assessment.

Table 11: Potential environmental effects of GVW WWTP discharges

Effects	Shepparton	Alexandra	Eildon
Increased macrophyte growth	✓	✓	✓
Algal blooms	✓	✓	✓
Loss of species	✓	✓	✓
Reduced health of individual organisms (condition)	✓	✓	✓
Water quality as a barrier to fish movement	✓	✓	✓
Community composition changes	✓	✓	✓
Human health impacts	✓	✓	✓
Reduced recreational potential	✓	✓	✓
Livestock health (agriculture)	✓	✓	✓
Fish health (aquaculture)	✗	✓	✓
Altered hydrological regime	✓	✗	✗

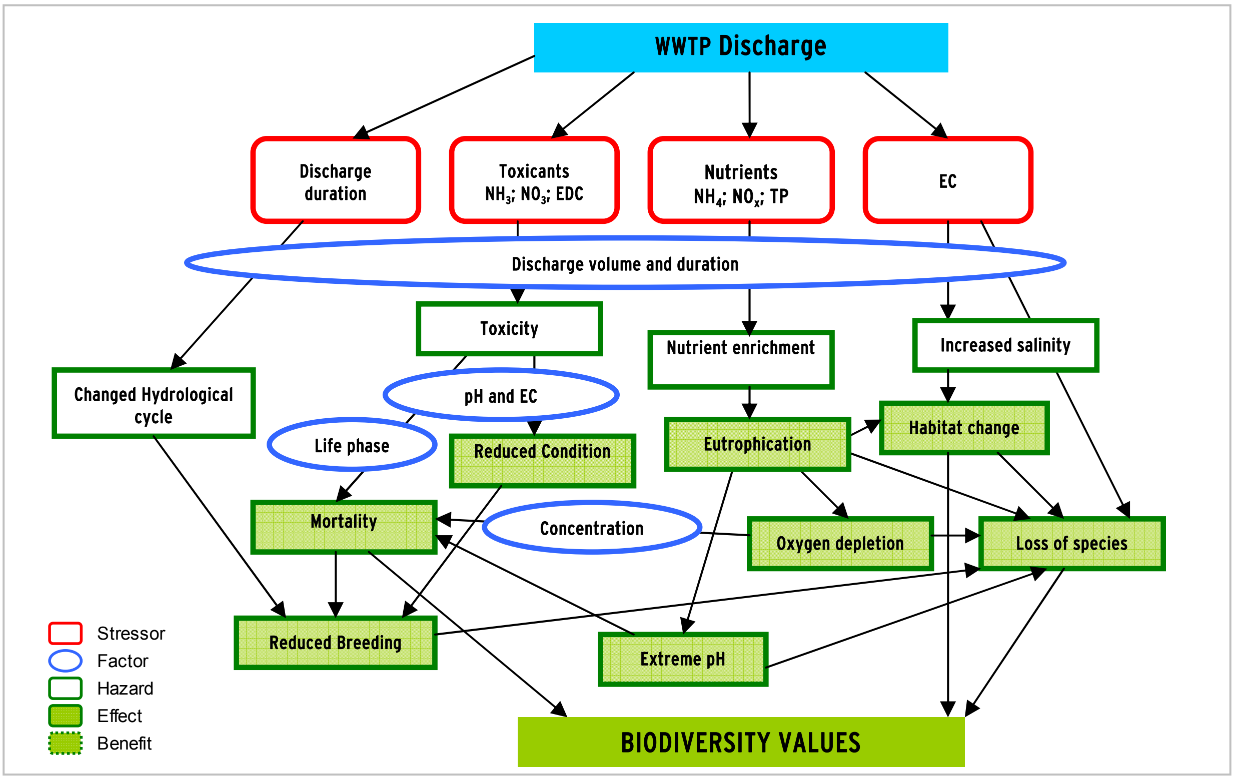

Figure 7: Conceptual model of the relationship between a WWTP discharge and the biodiversity values of the Goulburn River

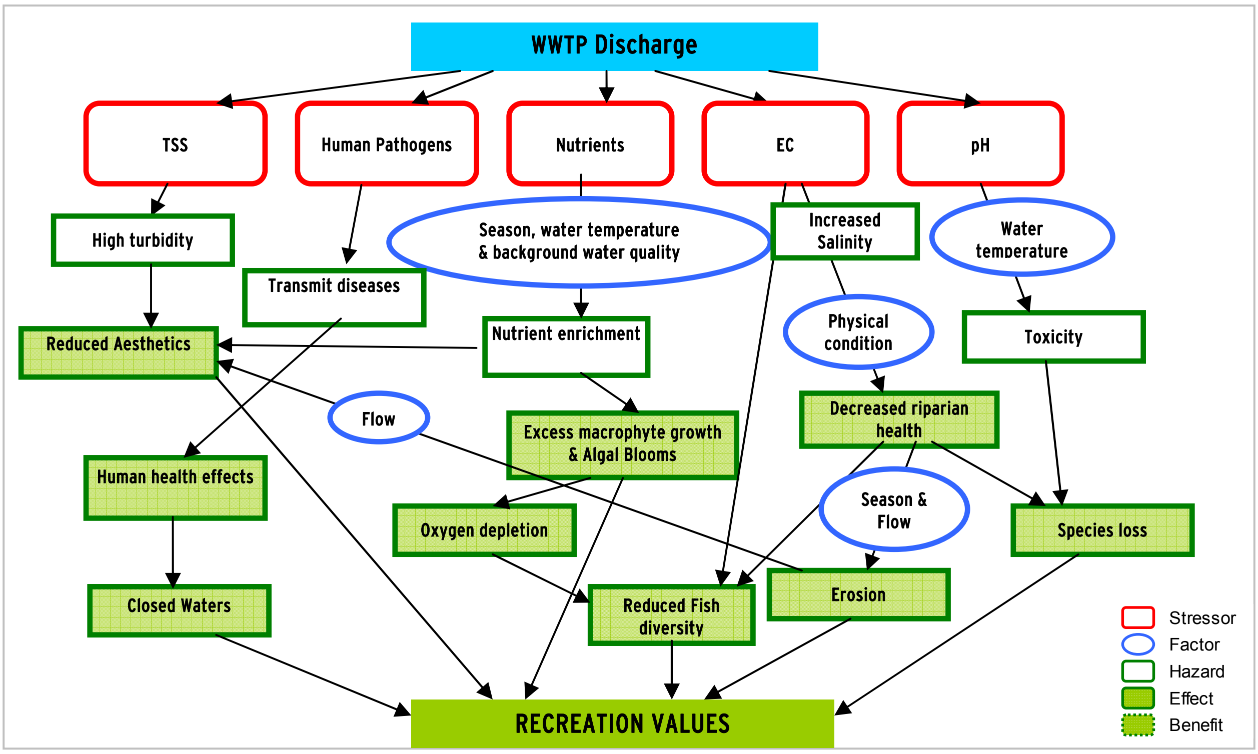

Figure 8: Conceptual model of the relationship between a WWTP discharge and the recreational values of the Goulburn River

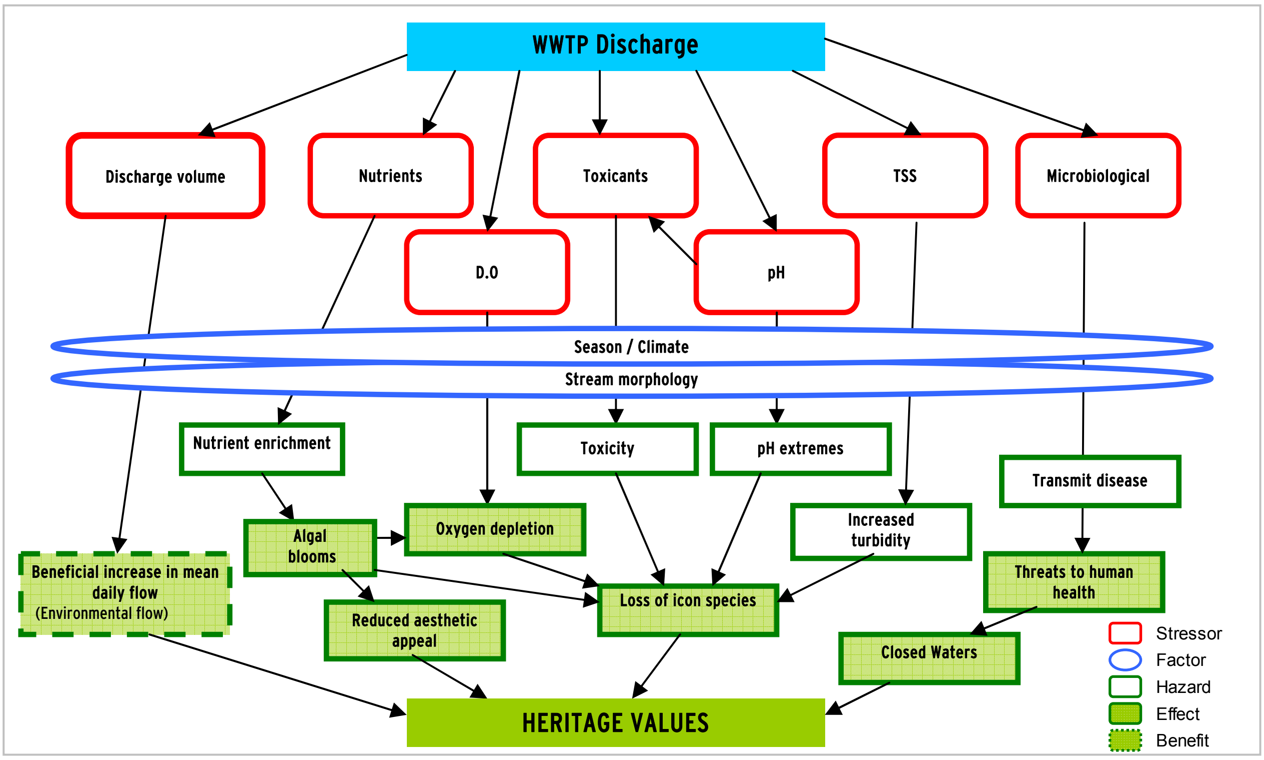

Figure 9: Conceptual model of the relationship between a WWTP discharge and the heritage values of the Goulburn River

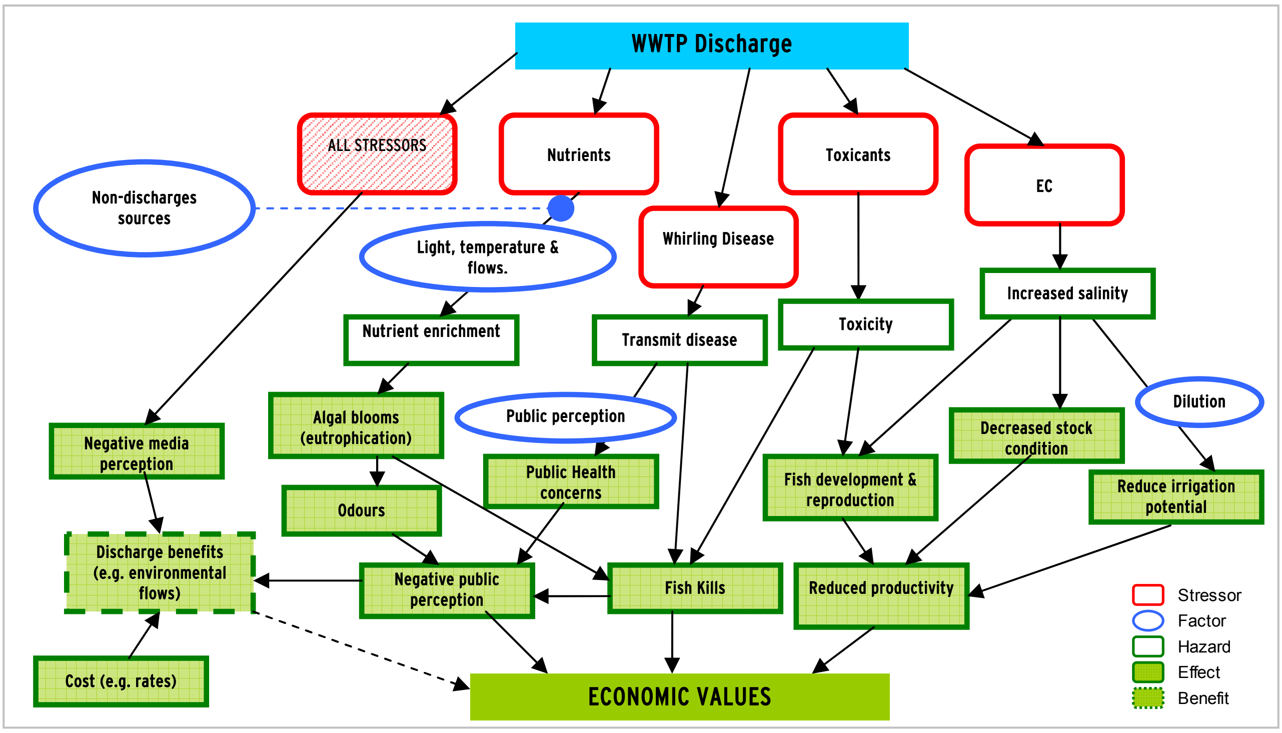

Figure 10: Conceptual model of the relationship between a WWTP discharge and the economic values of the Goulburn River

B2.2 Risk analysis

A semi-quantitative approach was used to conduct the risk analysis for the Shepparton WWTP. This was done using a risk matrix adapted from GVW's existing management systems (Table 12).

A group of scientific experts determined the risk likelihood and consequence levels for each of the beneficial uses being investigated. Enough monitoring data was available on the discharge and Goulburn River receiving waters to determine these levels, without the need for further monitoring as part of the analysis. Five years of monitoring data (2001 – 2005) was available for the receiving waters upstream and downstream of the discharge and included:

- physicochemical water quality data (e.g. nutrients, dissolved oxygen, turbidity, pH, temperature, pH, salinity)
- ammonia toxicity data
- microbial data (*E. coli*)
- macroinvertebrate community diversity data.

There was insufficient data available for the receiving waters of the Alexandra and Eildon discharge to conduct a thorough risk analysis. Therefore, a preliminary risk analysis was conducted for these discharges using the effluent water quality data and receiving waters flow gauge data from 2003 – 2006. The daily discharge volume and mean daily flow of the receiving waters were used to calculate the minimum dilution capacity of the receiving waters for this period. This was used along with water quality data of the effluent to estimate the potential concentrations of stressors in the receiving waters from the discharge. These estimates were then used to conduct a preliminary risk analysis using the matrix in Table 12. The purpose of this preliminary analysis was to provide information to assist in prioritising the receiving water monitoring needed to conduct a more thorough risk analysis.

Table 12: Environmental risk matrix

				Consequence (with Criteria)				
				1	**2**	**3**	**4**	**5**
				Small	**Minor**	**Moderate**	**Major**	**Catastrophic**
				Minimal on-site impact	Moderate on-site impacts	High level on-site impact	Catastrophic on-site short term uncontrolled impact	Catastrophic on-site irreversible impact
				No local impact	Minimal local impact	Moderate local impact	High local impact	Catastrophic local impact
				No external area impact	No external impact	Minimal offsite area impact	Moderate external area impact	High external area impact
				No long term cumulative effects	No long term cumulative effects	No long term cumulative effects	May cause long term cumulative effects	Known to cause long term cumulative effects
Likelihood of Effect	5	**Certain**	**Weekly-Monthly**	High	Very high	Extreme	Extreme	Extreme
	4	**Likely**	**Monthly-Yearly**	Medium	High	Very high	Extreme	Extreme
	3	**Possible**	**Yearly-10 yrs**	Low	Medium	High	Very high	Extreme
	2	**Unlikely**	**10yrs-100yrs**	Negligible	Low	Medium	High	Extreme
	1	**Rare**	**100yrs+**	Negligible	Negligible	Low	Medium	Extreme

B2.3 Risk characterisation and management

The risk characterisation involved:

- clearly defining the level of risk posed to the different beneficial uses
- identifying management responses for addressing the above risks
- documentation of the risk assessment.

The final risk characterisation (i.e. the assessed level of risk posed to the beneficial uses) are summarised below.

Shepparton WWTP

The risk analysis of the Shepparton WWTP showed:

- a negligible to low risk from all potential stressors to all the beneficial uses.

GVW's management plan in response to the level of risk identified for the Shepparton WWTP to beneficial uses is to:

- develop and implement an appropriate monitoring plan that can assess if risk levels change in the Goulburn River from the discharge (including biological, water quality and human health indicators)
- continually assess the above monitoring data as it becomes available and implement management actions if the risk levels change.

Alexandra and Eildon WWTPs

A preliminary risk analysis was conducted for Alexandra and Eildon on the effluent data and dilution capacity of the receiving waters. This preliminary analysis indicated:

- an occasional high risk (four occurrences between 2001-2003) from human pathogens to primary recreation from the Eildon discharge
- a low risk to beneficial uses from all other potential stressors for both discharges.

GVW's management plan in response to the risks indicated for the Alexandra and Eildon WWTPs beneficial uses is to:

- further investigate the occasional high risk posed to primary recreation at Eildon by human pathogens (this will include monitoring of *E.coli* levels in the Goulburn River)
- monitor the receiving waters to assess if the risk assessment assumptions of other risks being low are correct
- monitor all key indicators to determine the extent of the mixing zone
- develop a long term monitoring plan for continual assessment of risk levels.

The risk assessment for all three WWTPs was extensively documented in a risk characterisation report. This report includes a detailed presentation of: background material; information and monitoring data; analysis methods and results; the key knowledge gaps and assumptions made throughout the risk assessment; and, the results of the risk posed to the beneficial uses and management actions for these. This report can be obtained from GVW Water (Ph 5832 0704).

B3 North East Water – Beechworth treatment plant

Beechworth wastewater treatment plant (WWTP) is in north-east Victoria, about 3km downstream of Beechworth in the Upper Ovens Catchment. The WWTP has secondary treatment in lagoons with a chemically assisted sedimentation plant to remove algae and phosphorus prior to discharge.

In the warmer months, secondary treated water from the WWTP is used for irrigation. During winter, an average of 150ML of tertiary treated effluent is discharged to Spring Creek over a four month period. Spring Creek is a tributary of Reedy Creek, which flows into the Ovens River about 14km north-west of Wangaratta. The extent of the mixing zone for the Beechworth discharge had not been determined prior to the risk assessment.

B3.1 Problem formulation

The focus of this risk assessment was to investigate the potential risks posed by the Beechworth WWTP winter discharge to the beneficial uses of Spring and Reedy Creeks. This also included assessing the extent of the mixing zone for the discharge. NE Water's management goal for the risk assessment was to obtain information to assist their management decisions on the future upgrade of the WWTP. In particular, to provide:

- a greater understanding of the current impact of the discharge to the creeks
- information to help assess how effective different WWTP upgrade scenarios would be in improving the health of the creeks downstream of the discharge.

NE Water had a problem formulation stakeholder workshop in February 2008. The workshop was attended by the risk assessment consultant, NE Water, North East Catchment Management Authority, Indigo Shire, Wooragee Landcare Group and an ecological expert from La Trobe University. Prior to the workshop NE Water and their consultant compiled and summarised all available information and data on the discharge effluent and receiving waters.

At the problem formulation workshop stakeholders and experts:

- identified the beneficial uses and values of Spring and Reedy Creeks (Table 13)
- identified the potential stressors and issues from the discharge that needed to be assessed in the risk assessment (Table 14)
- developed a conceptual model of the relationship between the discharge and potential issues influencing water quality and ecological conditions in Spring and Reedy Creeks (Figure 11).

Table 13: Beneficial uses and values identified for Spring and Reedy Creeks

Beneficial use	Values
Aquatic ecosystems	Macroinvertebrate communities, native fish populations, natural in-stream habitat, natural flow regime, natural plant and algae community composition and distribution, water quality
Agriculture and irrigation	Water quality
Recreation	Water quality
Aesthetic enjoyment	Natural plant and algae community composition and distribution

Table 14: Potential stressors and issues from the Beechworth discharge to be addressed by the risk assessment

Environmental Issue	Environmental Indicator and Effect
Physical	
Smother habitat	Fine solids and sediment accumulate on bed and smother habitat
Scour or remove habitat	Scouring following dredging or very high discharge rate
Light attenuation	Significant change in colour, particulates or turbidity
Flow patterns	Changes in currents and flow patterns
Colour, foam, slick	Visible colour, odour, slick or litter arising from discharge
Odour	Odour apparent or reported
Ecosystem	
Primary modification (dissolved oxygen, light, pH, salinity)	Change in species composition – modified ecological assemblage, with detectable changes in species composition and lacking sensitive species from reference sites
Primary enrichment (ammonia, nitrogen, phosphorus, micro-nutrients, organic carbon)	Stimulatory effect of discharge – modified ecological assemblage dominated by filter and deposit feeders, grazers and increased green and blue-green algae
Secondary enrichment (nitrogen, phosphorus)	Stimulatory effect of discharge – modified ecological assemblage, with detectable changes in species composition and lacking sensitive species from reference sites
Secondary modification (ecological interactions)	Minor changes in species composition, with sensitive species present but some differences in species proportions from reference sites
Biochemical	
Toxicity	Detectable acute and chronic toxicity in bioassay
Bioaccumulation	Metals and pesticides accumulate in biota
Dissolved oxygen depletion	Lower dissolved oxygen due to high biological oxygen demand or low mixing
Public health issues	
Microbiological – pathogens	Elevated levels of pathogens and indicator micro-organisms in waters used for water supplies, bathing or secondary recreation
Fish – contamination	Elevated levels of metals, pesticides or pathogens in fish and other aquatic organisms
Sediments – contamination	Elevated levels of metals, pesticides or pathogens in sediments

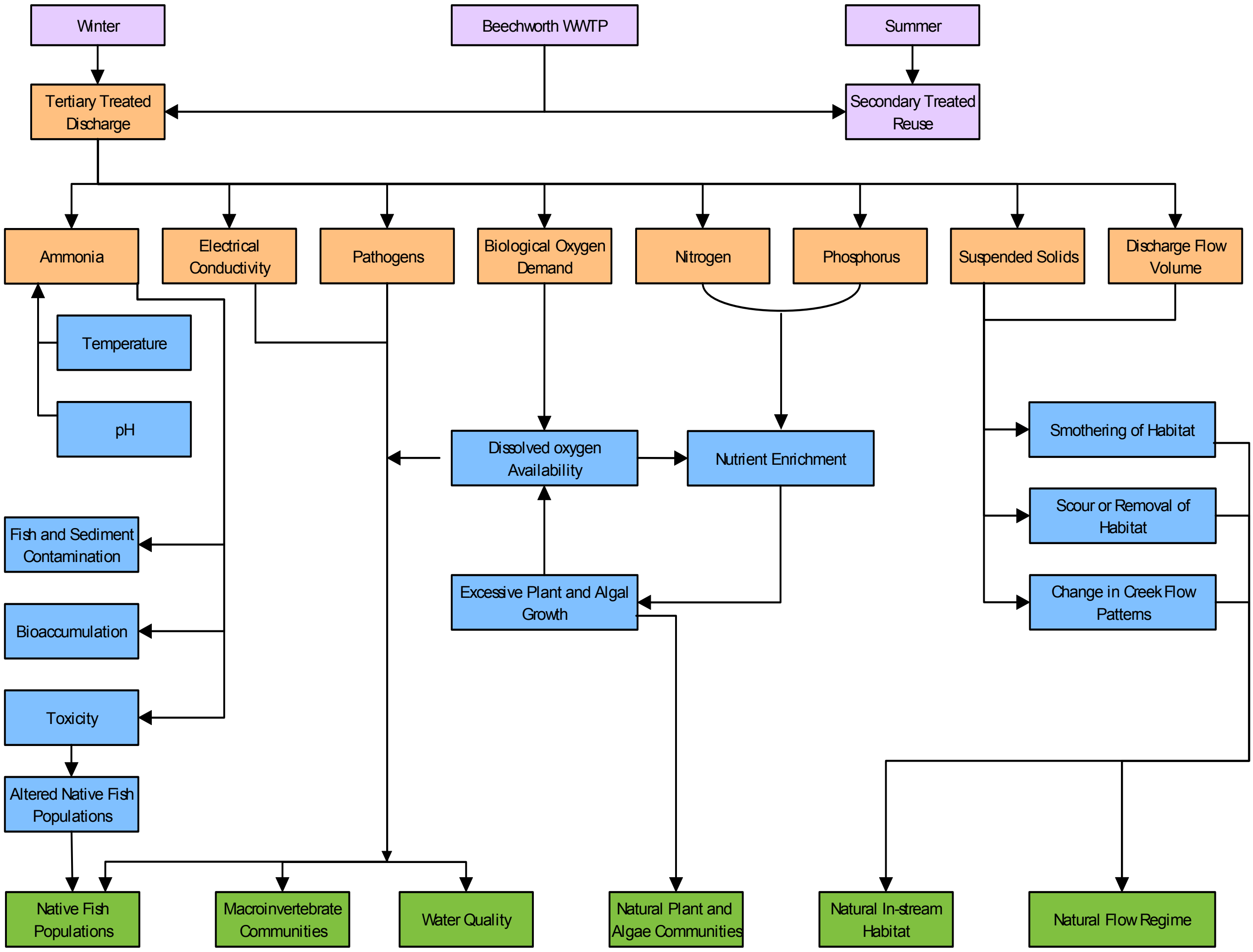

Figure 11: Conceptual model of the relationships between the discharge and potential issues influencing water quality and ecological conditions in the Spring and Reedy Creek systems

After the problem formulation workshop, the findings from the workshop and available data were used to identify the key issues for investigation and develop the risk analysis plan. The data examined included water quality (monthly 2006–08) and biological (spring and autumn 2000, 2004–06) data of the receiving waters, as well as water quality (monthly 2006–07) and discharge rates (monthly data from 2005) of the effluent.

The risk analysis plan that was developed provided:

- background information on the WWTP discharge and receiving waters
- documentation of the problem formulation phase
- detail on how the key risks identified in the problem formulation would be further assessed through a two year monitoring program (Table 15) and subsequent data analysis.

Table 15: Summary of the key risks to be investigated and the monitoring/studies to be conducted

Key risks for analysis	Monitoring/studies
Reduced light attenuation	Turbidity and diatom growth monitoring
Nutrient enrichment and primary modification of the ecosystem through effects from increased nutrients and DO depletion	Nutrient, dissolved oxygen, attached algae, artificial substrate (diatom *chlorophyll* a and phytoplankton) macroinvertebrate and groundwater monitoring
Ammonia toxicity	Ammonia and macroinvertebrate monitoring, desktop investigation of local fish communities and their tolerances
Change in flow patterns	Hydrological study to determine daily flows in Spring and Reedy Creeks with and without the input of the discharge

More detailed information on the problem formulation phase and risk analysis plan can be found in The *Beechworth Wastewater Treatment Plant Wastewater Discharge to Waterways Risk Analysis Plan*, which can be obtained from NE Water (Ph 1300 361 622).

B3.2 Risk analysis

The risk analysis phase was still being conducted at the time these Guidelines were published. NE Water had completed the first winter discharge season of field studies over 2008. A further field sampling season will be conducted in 2009. This data and information will then be analysed by the appropriate experts to determine the risks to the ecosystem.

B3.3 Risk characterisation and management

Risk characterisation was to be conducted in 2009 when the field studies and risk analysis had been completed. The resultant information was to be used to guide decision making for risk management. This will include further assessment of WWTP upgrade options. The final risk assessment report was scheduled for completion in December 2009.